ftn Associates Ltd.
water resources / environmental consultants

Arkansas WATERplan
Essential For Life

ARKANSAS WATER PLAN UPDATE
TASK NO. 6 - WEST-CENTRAL ARKANSAS WATER RESOURCES PLANNING REGION

AUGUST 11, 2014

ARKANSAS WATER PLAN UPDATE
TASK NO. 6 - WEST-CENTRAL ARKANSAS
WATER RESOURCES PLANNING REGION

Prepared for

Arkansas Natural Resources Commission
101 East Capitol Avenue, Suite 350
Little Rock, AR 72201-3813

Prepared by

FTN Associates, Ltd.
3 Innwood Circle, Suite 220
Little Rock, Arkansas 72211

FTN No. 03015-0003-001

August 11, 2014

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF APPENDICES

LIST OF FIGURES

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF ACRONYMS

ADEM	Arkansas Department of Emergency Management
ADEQ	Arkansas Department of Environmental Quality
ADH	Arkansas Department of Health
ADPCE	Arkansas Department of Pollution Control and Ecology (now ADEQ)
AECC	Arkansas Electric Cooperative Corporation
AGFC	Arkansas Game and Fish Commission
AHTD	Arkansas State Highway and Transportation Department
ANHC	Arkansas Natural Heritage Commission
ANO	Arkansas Nuclear One
ANRC	Arkansas Natural Resources Commission
APCEC	Arkansas Pollution Control and Ecology Commission
ARPMC	Arkansas Plant Materials Center
ARRA	American Recovery and Reinvestment Act
ASWCC	Arkansas Soil and Water Conservation Commission (now ANRC)
AWAG	Arkansas Watershed Advisory Group
AWP	Arkansas Water Plan
BCE	Before Common Era
BMP	Best Management Practice
CAW	Central Arkansas Water
CCA	Copper Chromated Arsenate
CE	Common Era
cfs	Cubic feet per second
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
CWA	Clean Water Act
DO	Dissolved Oxygen
E. coli	Escherichia coli
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
GCGW	Governor's Commission on Global Warming
gpm	Gallons per minute
gpd	Gallons per day
HUD	United States Department of Housing and Urban Development
L&D	Lock and Dam
mgd	Million gallons per day
mg/L	Milligrams per liter
MKARNS	McClellan-Kerr Arkansas River Navigation System
MS4	Municipal Separate Storm Sewer System
NCDC	National Climatic Data Center

n.d.	No date
NFIP	National Flood Insurance Program
NLRE	North Little Rock Electric
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRC	United States Nuclear Regulatory Commission
NRCS	United States Department of Agriculture Natural Resources Conservation Service
NWR	National Wildlife Refuge
NWS	National Weather Service
PADD	Planning and Development District
PAH	Polynuclear aromatic hydrocarbons
PCB	Polychlorinated biphenyl
PCP	Pentachlorophenol
PDSI	Palmer Drought Severity Index
RCRA	Resource Conservation and Recovery Act
RSWMD	Regional Solid Waste Management District
SDWA	Safe Drinking Water Act
SFHA	Special Flood Hazard Area
SGCN	Species of greatest conservation need
SPL	State priority list
TDS	Total dissolved solids
TMDL	Total maximum daily load
TOC	Total organic carbon
TSS	Total suspended solids
U of A	University of Arkansas at Fayetteville
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
USFS	United States Forestry Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WAWRPR	West-central Arkansas Water Resources Planning Region
WIP	Western Interior Plains
WMA	Wildlife Management Area
WRDA	Water Resources Development Act

1.0 INTRODUCTION

The Arkansas Natural Resources Commission (ANRC) is responsible for and preparing and periodically updating a statewide water resources planning document. The previous update of the Arkansas State Water Plan (AWP) was completed in 1990. In 2012, ANRC initiated an update of the 1990 State Water Plan to be completed in 2014.

This document was prepared as part of the 2014 update of the AWP, Project Task 6. This document provides background information about the West-central Arkansas Water Resources Planning Region (WAWRPR) that will be used in the 2014 AWP update. The WAWRPR is one of five state planning regions being addressed in the 2014 AWP update. The information in this document will serve as background for ongoing discussion and analysis of state water supply, water demand, and alternatives for meeting the water resources needs in this planning region. This background information includes a description of the history of the planning region, its physical characteristics, natural resources, water resources, demographics, and economy. Finally, the regulatory and institutional framework for water resources management in this planning region is outlined.

2.0 GEOGRAPHY AND HISTORY

This section provides a general description of the geography of the WAWRPR, a brief history of the regional culture, and an overview of historical water resources management.

2.1 Geography

The WAWRPR encompasses approximately 7,800 square miles in central Arkansas (Figure 2.1). This region is bounded on the west by Oklahoma. The rest of the boundary of WAWRPR roughly corresponds to the hydrologic boundary of the Arkansas River basin upstream of Little Rock, following county boundaries to facilitate the use of data (e.g., economic, census, and water use data) aggregated at the county level. Eleven full counties and part of Pulaski County fall within the planning region. Table 2.1 lists these counties, the area of each county that is in the planning region, and the corresponding percentage of the county in the planning region. Major cities in the WAWRPR include Fort Smith, Little Rock, North Little Rock, Conway, and Russellville.

2.2 History

The WAWRPR has historically been a region of significance due in large part to the Arkansas River. The Arkansas River valley has supported Native Americans, transported European explorers, and held an important strategic value in American expansion to the west and during the Civil War. Today, the Arkansas River serves as a major economic transportation corridor as well as providing a level of flood protection in the areas contributing to the Arkansas River valley. The cultural history of the region is outlined below. The history of water resources development in the planning region is summarized separately.

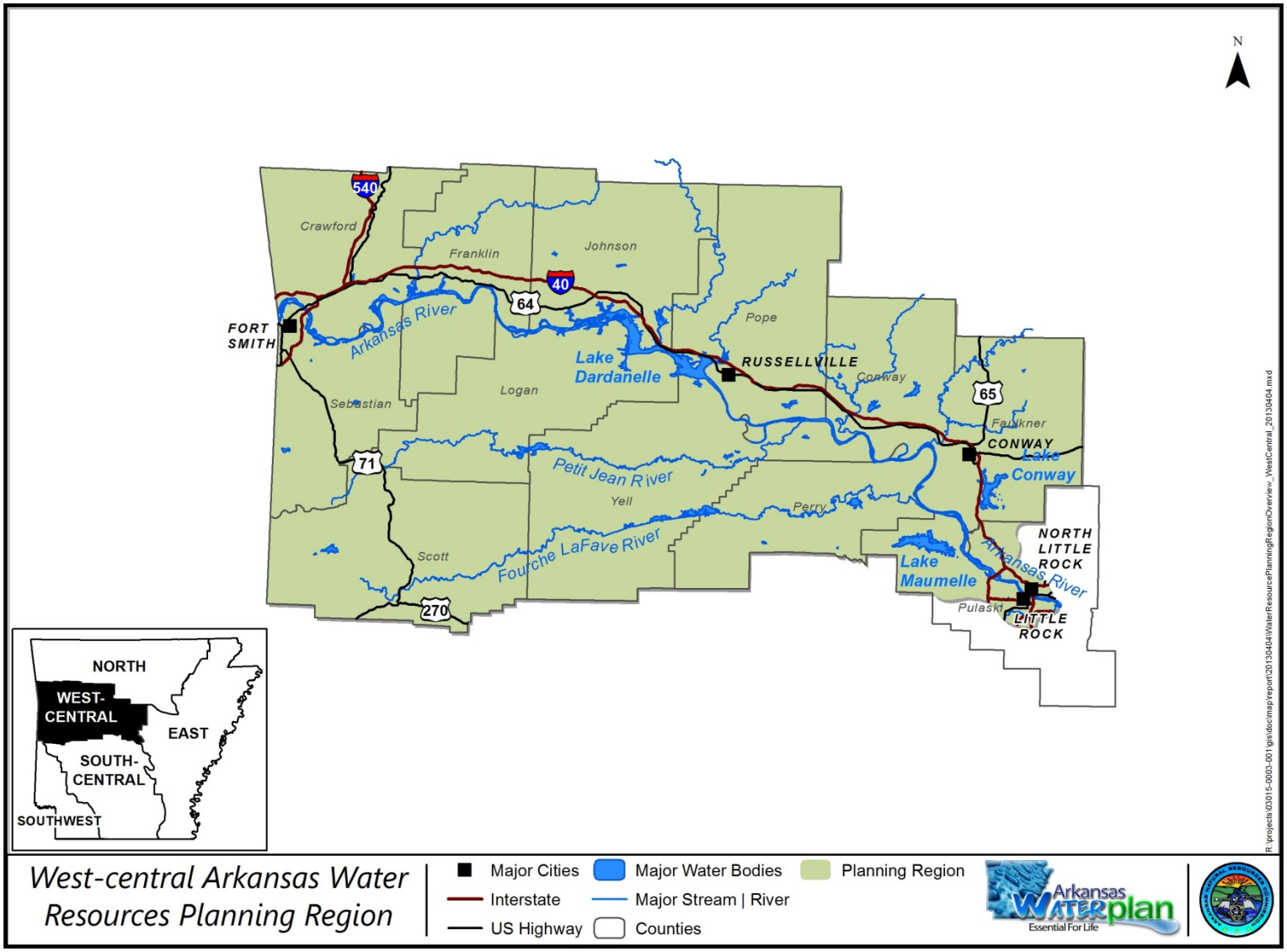

Figure 2.1. Map of the WAWRPR.

Table 2.1. Counties in the WAWRPR.

County	County Area in WAWRPR (square miles) (US Census Bureau 2012a)	Percentage of County Area in WAWRPR
Conway	552.25	100%
Crawford	593.09	100%
Faulkner	647.88	100%
Franklin	608.86	100%
Johnson	659.80	100%
Logan	708.13	100%
Perry	551.40	100%
Pope	812.55	100%
Pulaski	325.75	41%
Scott	892.32	100%
Sebastian	531.91	100%
Yell	929.98	100%
Total	**7813.92**	

2.2.1 Cultural

Native Americans likely settled the WAWRPR prior to European exploration and settlement, however there is no archeological evidence in the region of the presence of sophisticated native cultures from the Woodland Period (1000 BCE to 1000 CE) or Mississippian Period (900 to 1600 CE) (Early 2011). Just prior to European exploration of the region in the mid-1500's, Native Americans of the Caddo, Quapaw, and Osage cultures inhabited the WAWRPR (Bell 2013, Department of Arkansas Heritage 2013). Around 1815, Cherokee moved into the Arkansas River valley from eastern Arkansas (Stewart-Abernathy 2011a). In the 1830s, one of the "Trail of Tears" routes followed the Arkansas River through Arkansas. This route was used by a number of tribes, including the Choctaw, Chickasaw, Muscogee, Seminole, and Cherokee (Sloan 2011).

The Arkansas River valley was an important travel route for both Native Americans, and the first Europeans in the region (Foti 2011a). Hernando de Soto's Spanish expeditionary forces were the first Europeans in the region, arriving in 1541. Hernando de Soto's expedition is believed to have travelled along the Arkansas River from Fort Smith almost to its mouth

(Key 2012). The French explorer Henri de Tonti visited the area in the early 1700's (Department of Arkansas Heritage 2013). In the 1780's LaHarpe led the first French expedition up the Arkansas River to near present-day Morrilton (Key 2012). European settlements existed in the region as early as the 1790s (Bell 2013).

In 1817, American troops began construction of Fort Smith on the Arkansas River. The purpose of the fort was to house troops to keep peace between the resident Osage tribe and the immigrant Cherokee tribe moving into the Arkansas River valley. This planning region is included in the Arkansas Territory established in 1819 (Boulden 2012). After the establishment of the Arkansas Territory, European settlement in the region increased. In 1821, the territorial capital moved to Little Rock, which became the state capital when Arkansas became a state in 1836 (Bell 2013). Fort Smith became an important stop for settlers traveling farther west (Boulden 2012). By the late 1850's the Butterfield Overland Express route extended through Arkansas, travelling west from Memphis along the Arkansas River and south from Missouri, both connecting in Forth Smith (Foti 2011a)

The Arkansas River was of strategic importance during the Civil War. Given this, and the location of the state capital, battles and skirmishes were common in the region during the Civil War (Bell 2013, Gleason 2011).

Into modern times, the Arkansas River valley has remained an important transportation corridor. This, and other amenities present in the region, makes it one of the major regions in the state for population growth and industrial development (Foti 2008).

2.2.2 Water Resources Development

The development of the water resources located in the WAWRPR have included multi-purpose construction projects that serve as a major transportation artery, provide some level of flood control, supply local communities with safe drinking water sources, provide power in the form of electricity and nuclear power, and provide recreational opportunities.

2.2.2.1 Waterborne Transportation

The Arkansas River has been an important transportation artery through the WAWRPR since before Europeans arrived. Early European travelers in the region used flatboats and keelboats on the Arkansas River. Around 1822, the first steamboats began operating on the Arkansas River in the planning region (Stewart-Abernathy 2011b). In 1946 Congress passed the Rivers and Harbors Act authorizing the building of the McClellan-Kerr Arkansas River Navigation System (MKARNS) to provide waterborne transportation on the Arkansas River from the Mississippi River upstream to Catoosa, Oklahoma (Figure 2.2). In addition to transportation the MKARNS plan was to provide hydropower, flood control, and recreation. The system was, and still is, overseen by the US Army Corp of Engineers (USACE). In 1958, construction began on the MKARNS, in 1968 navigation was opened to Little Rock, and in 1971 it was completed to the Port of Tulsa in Catoosa, Oklahoma (Goss 2012). The Arkansas River continues to be a major commercial transportation corridor. The MKARNS averages 12 million tons of commodities shipments annually. Based on prices obtained from the USACE Institute for Water Resources and the National Agricultural Statistics Service, the value of the commodities shipped averages from $2 to $3 billion per year (USACE Little Rock District n.d.).

Other rivers in the planning region were also historically used for transportation including the Fourche La Fave River. In 1879 the US Congress approved deepening the channel for navigation and in 1889 this river was navigable as far upstream as Alpin, in Perry County (Lancaster 2011a).

2.2.2.2 Flood Control

Rivers in the WAWRPR are prone to flooding. During the period from 1833 through 1969, there were 42 major flood events on the Arkansas River. Rivers in this planning region were affected by both the Floods of 1927 and 1937 (Branyan 2012, Lancaster 2011a, Goss 2012). Reservoirs were constructed by the USACE in the region in the 1940s as part of a comprehensive plan for flood control and development of water resources in the Lower Arkansas River Valley. These included Blue Mountain Lake on the Petit Jean River, and Nimrod Lake on the Fourche La Fave River (Lancaster 2011a, 2011b, USACE n.d.).

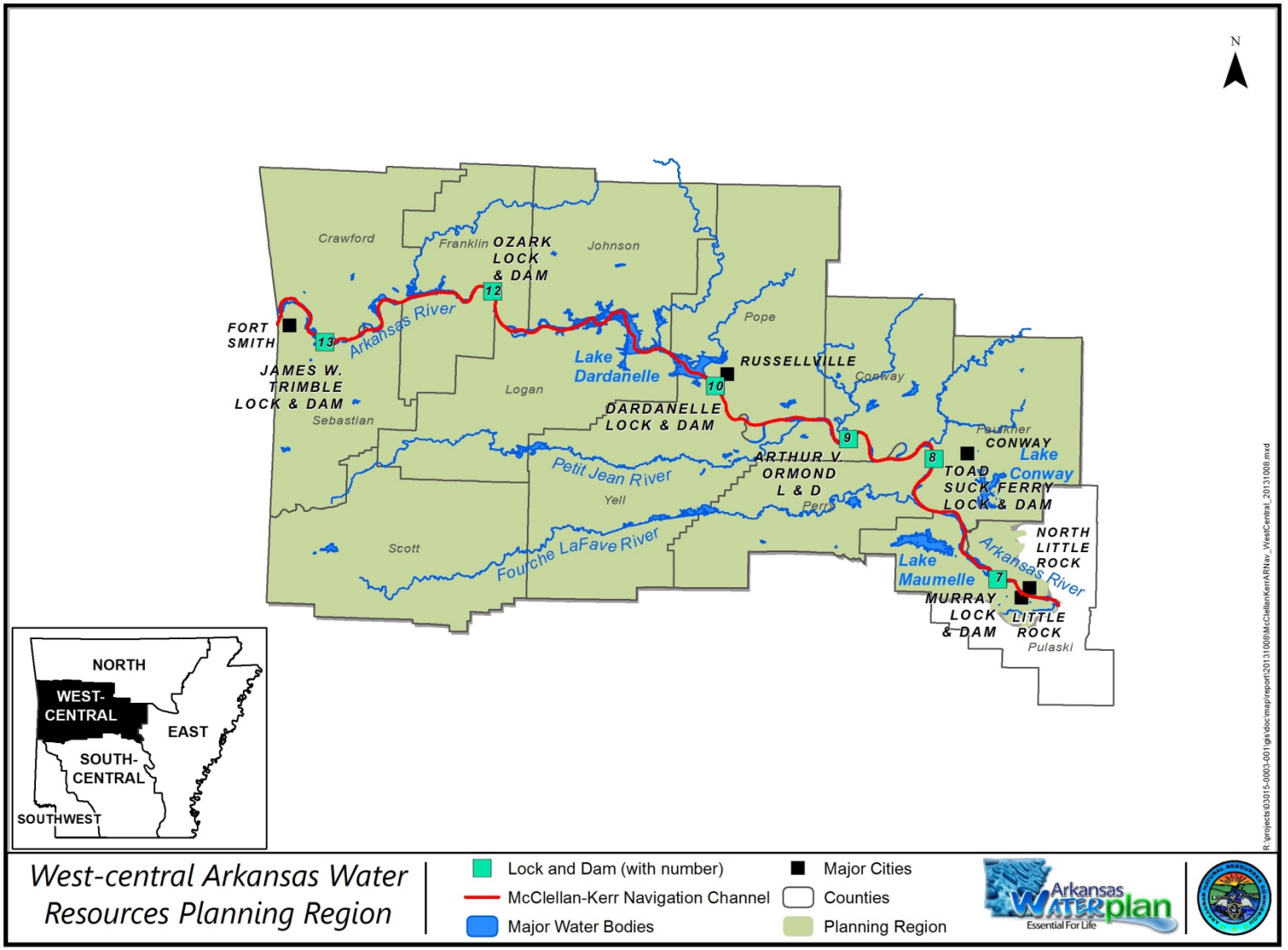

Figure 2.2. McClellan-Kerr Arkansas River Navigation System (MKARNS).

The MKARNS also contributes to flood control on the Arkansas River (Goss 2012). According to the USACE's Little Rock District, flood damages prevented within the District as a result of the Arkansas River Basin projects totaled over $187 million in 2011, and cumulative damages prevented through 2011 total approximately $1.9 billion (Oklahoma Waterways Branch 2012). The WAWRPR is almost completely contained within the jurisdiction of the Little Rock District of the USACE, with the exception of the southeast corner of Faulkner County, which is in the Memphis District, and small portions along the southern edge of the planning region that are part of the Vicksburg District.

In 1879, the US Congress created the Mississippi River Commission to oversee flood control along the entire Mississippi River. Between 1905 and 1915, the Arkansas General Assembly passed laws creating a flood control program for the Mississippi River Valley region of the state. The majority of these levee districts were created in the East Arkansas Water Resources Planning Region, but one district, District Number 1 of Faulkner County, was created in the WAWRPR in 1905. The levee associated with the Faulkner County levee district extends from Toad Suck Ferry Lock and Dam to Tupelo Bayou along the Arkansas River.

Subsequent to the original Mississippi River Commission, levees have been constructed and levee districts created along the Arkansas River. There are 42 levees along the Arkansas River in Arkansas that protect more than 753,180 acres of residential and farm land, much of which is located in the WAWRPR (USACE 2012).

2.2.2.3 Water Supply

In the 1950's, several large water supply reservoirs were constructed in the region. These include Lake Winona, constructed in 1938, and Lake Maumelle, constructed in 1958, as water supply lakes for Little Rock and North Little Rock, and Lake Fort Smith, completed in 1936, and Lake Shepherd Springs, completed in 1954, serving as water supply for the Fort Smith area (Tradewind n.d.). In 2006, construction was completed on the removal of the Lake Shepherd Springs dam and the enlargement of the Lake Fort Smith dam resulting in a single combined and much larger Lake Fort Smith.

Smaller water supply reservoirs in the planning region include Lake Brewer, constructed in 1982 and located in Conway County on Cypress Creek, to serve as the primary water supply for the City of Conway (Conway Corporation 2007), the Huckleberry Creek Reservoir, constructed in 1996 to serve as the primary water supply for the City of Russellville, and James Fork Creek Reservoir completed in 1992.

2.2.2.4 Hydropower

Arkansas has the potential to produce a significant amount of its electrical energy from hydroelectricity, however only 3% of the electricity produced in 2006 was from hydroelectric sources. There are four hydroelectric power plants in the WAWRPR, all of them on the Arkansas River, as presented in Table 2.2.

Table 2.2. Hydroelectric plants in the WAWRPR (Reynolds 2012).

Plant	County	River	Year Completed	Agency
Ozark	Franklin	Arkansas	1973	USACE
Ellis	Crawford/Sebastian	Arkansas	1988	AECC
Murray	Pulaski	Arkansas	1988	NLRE
Whillock	Conway	Arkansas	1993	AECC

AECC Arkansas Electric Cooperative Corporation.
NLRE North Little Rock Electric.
USACE United States Army Corps of Engineers.

2.2.2.5 Nuclear Power

The WAWRPR includes Arkansas' only nuclear power plant, Arkansas Nuclear One (ANO), located on the Arkansas River at Lake Dardanelle, in Russellville. ANO began operating in December of 1974 using water from the Arkansas River for cooling. It is owned by Entergy Arkansas and operated by Entergy Nuclear.

2.2.2.6 Waterfowl and Aquatic Habitat Conservation

Individuals and federal and state agencies have realized the importance of the wetlands, forests, and stream and rivers in the WAWRPR for support of wildlife. Just after the turn of the Twentieth Century, preservation of migratory waterfowl game birds became a national priority.

The Arkansas Game and Fish Commission (AGFC) began establishing wildlife management areas (WMAs) in the region after World War II. In 1957, the Holla Bend National Wildlife Refuge (NWR), overseen by the US Fish and Wildlife Service (USFWS), was established along a bend in the Arkansas River that was cut off when the river was straightened for flood control. The refuge provides a winter home for millions of duck and geese, but also brings in thousands of migratory songbirds in the spring that use the refuge as a resting area (USFWS n.d.a.). National wildlife refuges and state wildlife management areas and natural areas continued to be established to conserve aquatic habitats in the WAWRPR throughout the Twentieth Century (Table 2.3).

Table 2.3. National Wildlife Refuge and State Wildlife Management Areas in the WAWRPR.

Name	Type	Area (acres)	Counties	Year established	Management	Purpose
Bell Slough	WMA	2,040	Faulkner	1951		Migratory bird habitat, hunting
Camp Robinson	WMA	26,675	Faulkner, Pulaski	--	AGFC	
Ed Gordon/Pt. Remove	WMA	8,694	Conway, Pope	--	AGFC	Migratory bird habitat
Galla Creek	WMA	3,329	Pope, Yell	--	AGFC	
Harris Brake	WMA	3,769	Perry	--	AGFC	
Holla Bend	NWR	7,000+	Pope, Yell	1957	USFWS	Migratory bird habitat
Mt. Magazine	WMA	120,000	Logan, Yell	--	AGFC	
Muddy Creek	WMA	146,206	Montgomery, Scott, Yell	--	AGFC	
Petit Jean River	WMA	15,502	Yell	--	AGFC	
Piney Creeks	WMA	176,000	Johnson, Pope	1967	AGFC	Protect species, provide recreation
Ring Slough	WMA	83	Perry	--	AGFC	
Winona	WMA	160,000	Perry	--	AGFC	
Goose Pond	Natural area	392	Pope, Conway	1981	ANHC, AGFC	Protect wetland ecosystem and waterfowl habitat
Cove Creek	Natural area	228	Faulkner	1976	ANHC	Protect riparian and upland habitats

In 1968, the US Congress created the National Wild and Scenic Rivers System to preserve free-flowing rivers with outstanding recreational, cultural, and/or natural features (Arkansas Natural Heritage Commission 2012). In 1992, portions of three rivers in the WAWRPR were added to the National Wild and Scenic Rivers System (Table 2.4).

Table 2.4. Wild and scenic rivers in the WAWRPR (Interagency Wild and Scenic Rivers Council n.d.).

River	Total Length (miles)	Wild (miles)	Scenic (miles)	Recreational (miles)	County
Big Piney Creek	45.2	0	45.2	0	Pope
Hurricane Creek	15.5	2.4	13.1	0	Franklin
Mulberry River	56.0	0	19.4	36.6	Franklin

2.2.2.7 Arkansas River Basin Compact

In 1955, the US Congress authorized Oklahoma and Arkansas to begin negotiating a compact to resolve disputes over rights to water in the Arkansas River and its tributaries, as well as preventing future disputes. In 1970, after 15 years of negotiations, the states of Arkansas and Oklahoma signed an agreement concerning water apportionment in the Arkansas River Basin along the Arkansas-Oklahoma border. In addition to the Arkansas River, the compact addresses water resources of the Lee Creek Watershed and Poteau River Watershed in the WAWRPR. In this compact, the two states agree that Arkansas has the rights to water in both subbasins within the state's borders. Within the Poteau River Watershed, Arkansas water use is limited by the compact so annual yield to Oklahoma is not depleted by more than 60%. Oklahoma's use of the Arkansas River is limited by the compact so that annual yield to Arkansas is not depleted by more than 60%. There are no use restrictions specified for Lee Creek waters in the compact for other either state. (Arkansas River Compact Committee 1970). This compact is described in greater detail in Section 6.1.8.

3.0 PHYSICAL CHARACTERISTICS

This section summarizes the physical characteristics of the WAWRPR. This includes the physiography, geology, climate, and land use, as well as descriptions of the ecological, surface water, and groundwater resources within the planning region.

3.1 Physiography

Arkansas is typically divided into two major physiographic regions; the Interior Highlands in the northeast and the Gulf Coastal Plain in the south and east. These regions are further divided into smaller physiographic provinces based on topography and geology. The "fall line" is where these two physiographic regions meet.

The WAWRPR is located in the Interior Highlands physiographic region. Physiographic provinces of the Interior Highlands that occur in this planning region include the Ozark Plateaus and the Ouachita Mountains. (Figure 3.1) (Arkansas Geological Survey n.d.). A tiny portion of the Gulf Coastal Plain is found in this planning region. Because it comprises such a small part of the planning region, the physiography of the Gulf Coastal Plain will not be described in this document. Descriptions of this physiographic province can be found in the background reports for other planning regions.

3.1.1 Ouachita Mountain Province

The Ouachita Mountain physiographic province accounts for the majority of the area in the WAWRPR. The physigraphic subdivisions of the province that are present in the planning region are the Arkansas River Valley and Fourche Mountains. The Arkansas River Valley physiographic subdivision accounts for the majority of the area in the WAWRPR (Figure 3.1). The valley is up to 40 miles wide, and contains a variety of physiographic features, including narrow ridges similar to the Fourche Mountains, and flat-topped mountains similar to the Boston Mountains, broad hilly plains, and alluvial bottomlands (Foti 2011a, 2011b). To the north of the Arkansas River, the physigraphy of the valley is characterized by low hills eroded from ancient

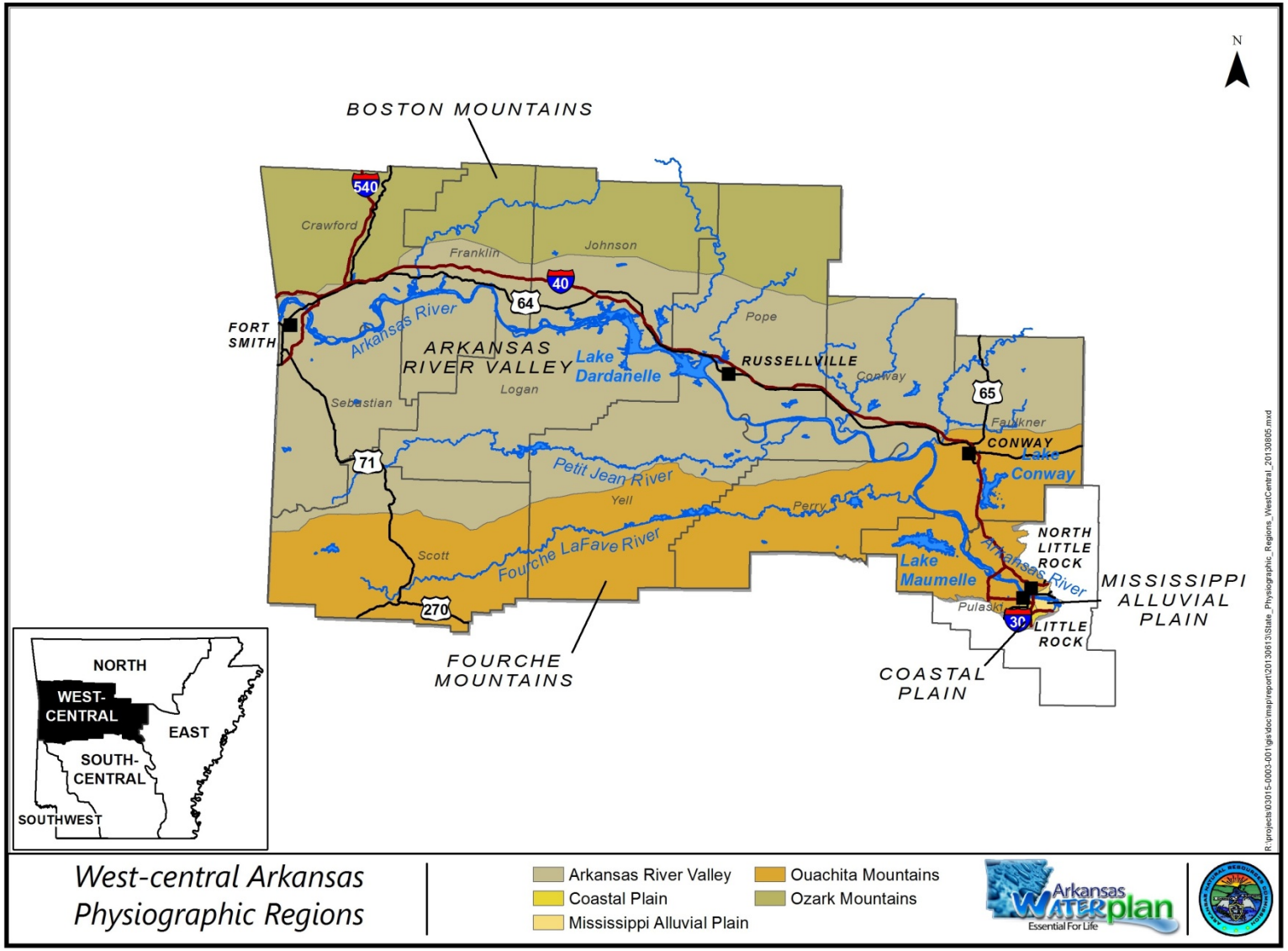

Figure 3.1. Physiography of the WAWRPR.

plateaus, similar to the Ozark Mountains, but lower in elevation (Foti 2011a, Woods et al. 2004). Along the Arkansas River and to the south, the physiography of the valley is characterized by level plains interspersed with high mountains (Foti 2011a).Elevations of valleys generally are 500 feet, declining to around 250 feet above sea level along the Arkansas River at the eastern boundary of the planning region (Woods et al. 2004). Mt. Magazine, the highest point in the state at 2,823 feet, is in the Arkansas River Valley, as are Mount Nebo and Petit Jean Mountain. These prominent "mountains" are known by geologists as monadnocks, isolated, prominent hills, often formed by fluvial erosion, and generally found in a flat plain. Physiographic features in the valley are generally oriented east to west, and the river valley slopes generally to the east.

The Fourche Mountains make up the entire southern portion of the planning region and contain several major ridges including the Poteau Mountains, which crest at just less than 2,500 feet (Foti 2011c). The Fourche Mountains are one of the dominant range geophysical features of western Arkansas. These mountains consist of sedimentary rock that has been folded to create generally parallel ridges and valleys that have east-west orientation. Most of the mountain ridges are narrow, with steep slopes, sharps crests, and narrow valleys. Valley floors are broad and often at high elevations. Principal streams in the Fourche Mountains flow eastward.

3.1.2 Ozark Plateaus Province

The Boston Mountains physigraphic subdivision consists of the higher southern edge of the Ozark Plateaus province and makes up the northern boundary of the planning region (Figure 3.1). These mountains are primarily flat-topped, summit ridges representing the original erosion surface of the plateau. Great stream dissection has occurred, creating steep sided mountains and deep narrow valleys. There are several cliffs and bluffs. Elevations typically range from 200 feet above sea level in the valleys to 1,900 feet above sea level in the highlands. However, elevations of up to 2,300 feet above sea level occur (Woods et al. 2004). The mountains descend rather sharply to the Arkansas Valley.

3.2 Geologic Setting

Geologic formations underlying the WAWRPR range in stratigraphic order from the earliest deposited layers of the Ordovician in the Fourche Mountains to Quaternary Alluvium in the Arkansas River Valley. Figure 3.2 displays the surface geology of the planning region.

Generally, the hydrogeology of the Interior Highlands can be described as an area of consolidated formations which yield relatively low volumes of water to wells. The low specific capacity in these wells is a direct result of the lithological nature of the strata itself. The consolidated formations typically are confined with most of the water yielded to wells coming through secondary porosity found in fractures and bedding plains. The Atoka Formation is significant as a source of shallow domestic wells in the Ouachita Mountains and Arkansas River Valley, but yields are typically small and therefore, limited for other purposes. The best source of groundwater, with respect to quantity, is the Arkansas River Valley alluvium. Groundwater resources of the WAWRPR are further described in Section 3.8.

3.2.1 Geology of the Boston Mountains

The Boston Mountains are characterized by outcropping Pennsylvanian-age sedimentary rocks composed mainly of sandstone and shale, with some limestone units occurring near the base. The massive Atoka Formation, over 1,500 feet thick, is the most prominent geologic formation (Figure 3.2). The Ozarks, which include the Boston Mountains, in general have experienced extensive erosion and have deeply dissected stream valleys throughout. The sedimentary rocks of the Ozarks generally are nearly flat-lying and dip toward the south. Gentle, low-amplitude folds have been observed in the Ozarks (McFarland 2004). The majority of the faults in the Ozarks are normal faults, with displacement generally occurring downward on the southern side of the fault. The rocks of the Ozarks were deposited on a relatively shallow continental shelf that was exposed at numerous times during the Paleozoic resulting in erosional surfaces throughout the stratigraphic sequence (McFarland 2004, Renken 1998, Imes and Emmett 1994, Manger 1983).

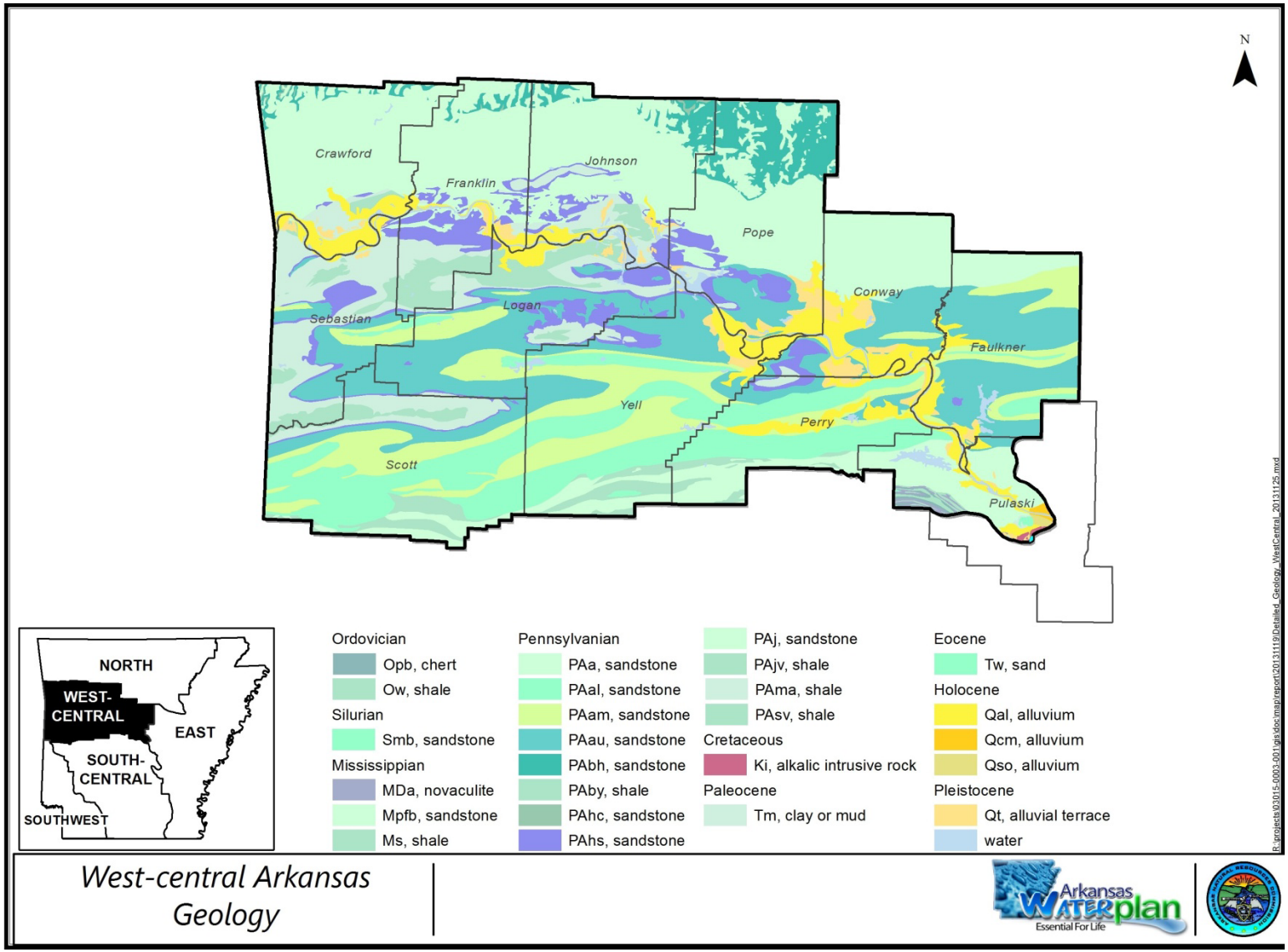

Figure 3.2. Surface geology of the WAWRPR (Haley et al. 1993).

3.2.2 Geology of the Arkansas River Valley

The Arkansas River Valley section of the Ouachita Mountain province lies within the Arkoma Basin between dipping rocks of the Boston Mountains to the north and the highly folded rocks of the Ouachita Mountains to the south of the Arkansas River. The Arkoma Basin (Figure 3.3) is a structural low trending east-west across central Arkansas that was created by compression from the Ouachita orogeny (Adamski, Freiwald and Davis 1995). The structural geology of the area consists of relatively broad synclinal folds with relatively narrow intervening anticlinal folds that trend east-west (McFarland 2004).

The geology of the Arkansas River Valley is dominated by Pennsylvanian age clastic sediments that were deposited on the margin of a continental shelf primarily by deltas and subsequently reworked by marginal marine processes (McFarland 2004). The sedimentary section in the Arkoma Basin is reported to range in thickness from 3,000 to 35,000 feet (Manger and Lloyd 2008). The western part of the Arkansas River Valley is composed of the Savanna Sandstone, Paris Shale, Spadra Shale, and Harthshorne Sandstone is all significant. Coal is important in the Paris and Spadra Shale. The central and eastern portions of the valley are dominated by the alternating sandstone and shale of the Hartshorne and Atoka Formation. There are numerous natural gas fields in this region, producing a dry gas. Currently, the Arkoma Basin is the focus of a major unconventional gas play targeting the Fayetteville Shale. All counties in the planning region are considered a part of the Fayetteville Shale Geologic Formation. Conway and Faulkner Counties house active gas well sites (Figure 3.4).

Alluvial deposits overlie consolidated rocks along the Arkansas River and its major tributaries and comprise terrace and floodplain deposits, which occur along the river in discontinuous segments three to 40 miles in length and one to five miles wide across the river valley (Kresse et al. 2013). In some locations, the alluvium and terrace deposits are absent and the river is bordered by consolidated rocks of the Interior Highlands (Cordova 1963, Bedinger, Emmett and Jeffery 1963). Tops of older terraces lie 50 feet or more above the present floodplain and consist of interbedded gravel, clay, and sand. Younger terrace deposits lie 20 to 40 feet above the present floodplain and are composed of a coarsening downward sequence of clay, sand, and gravel; floodplain alluvial deposits consist of gravel, sand, silt, and clay. The alluvial

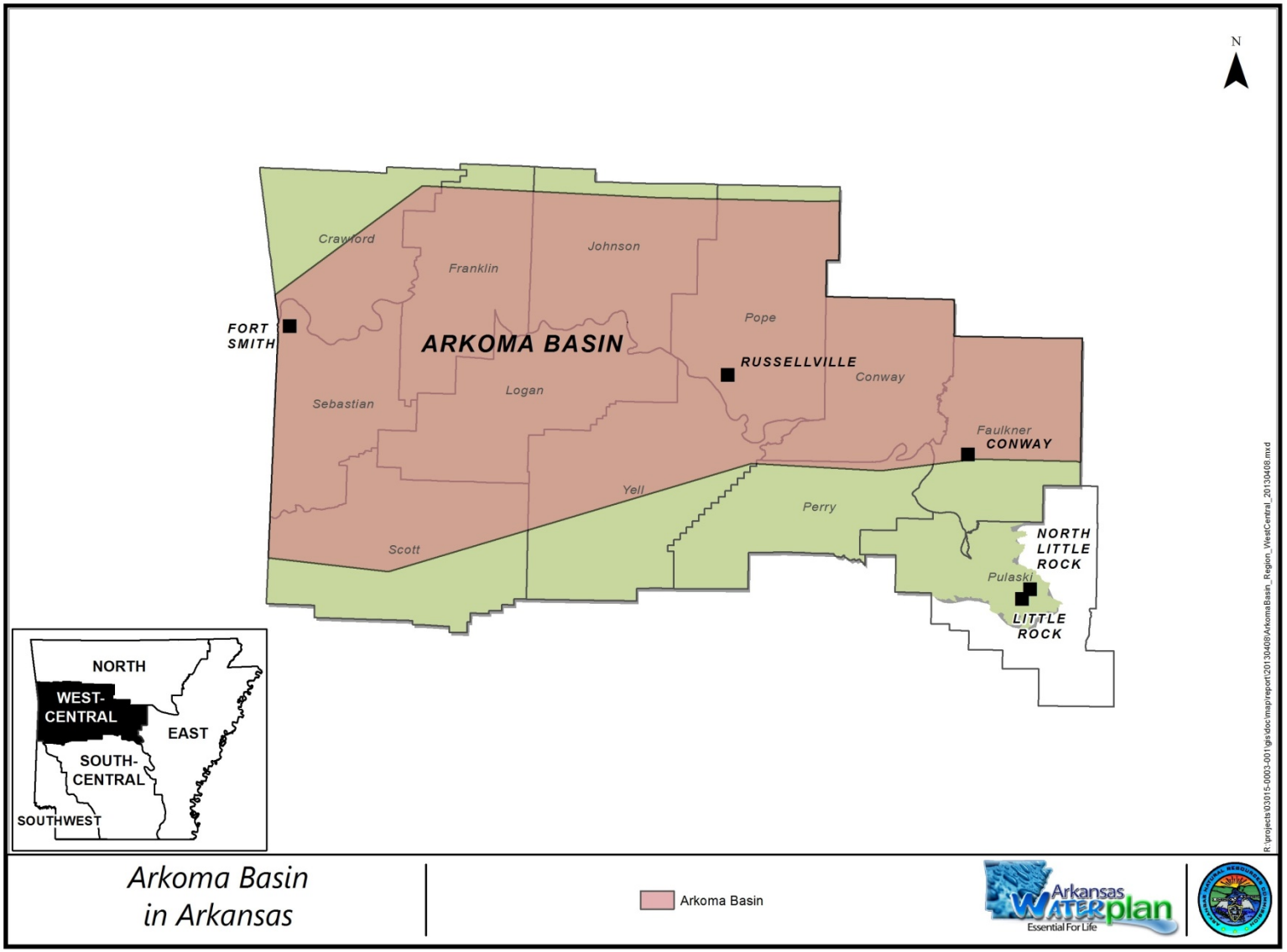

Figure 3.3. Location of Arkoma Basin in the WAWRPR.

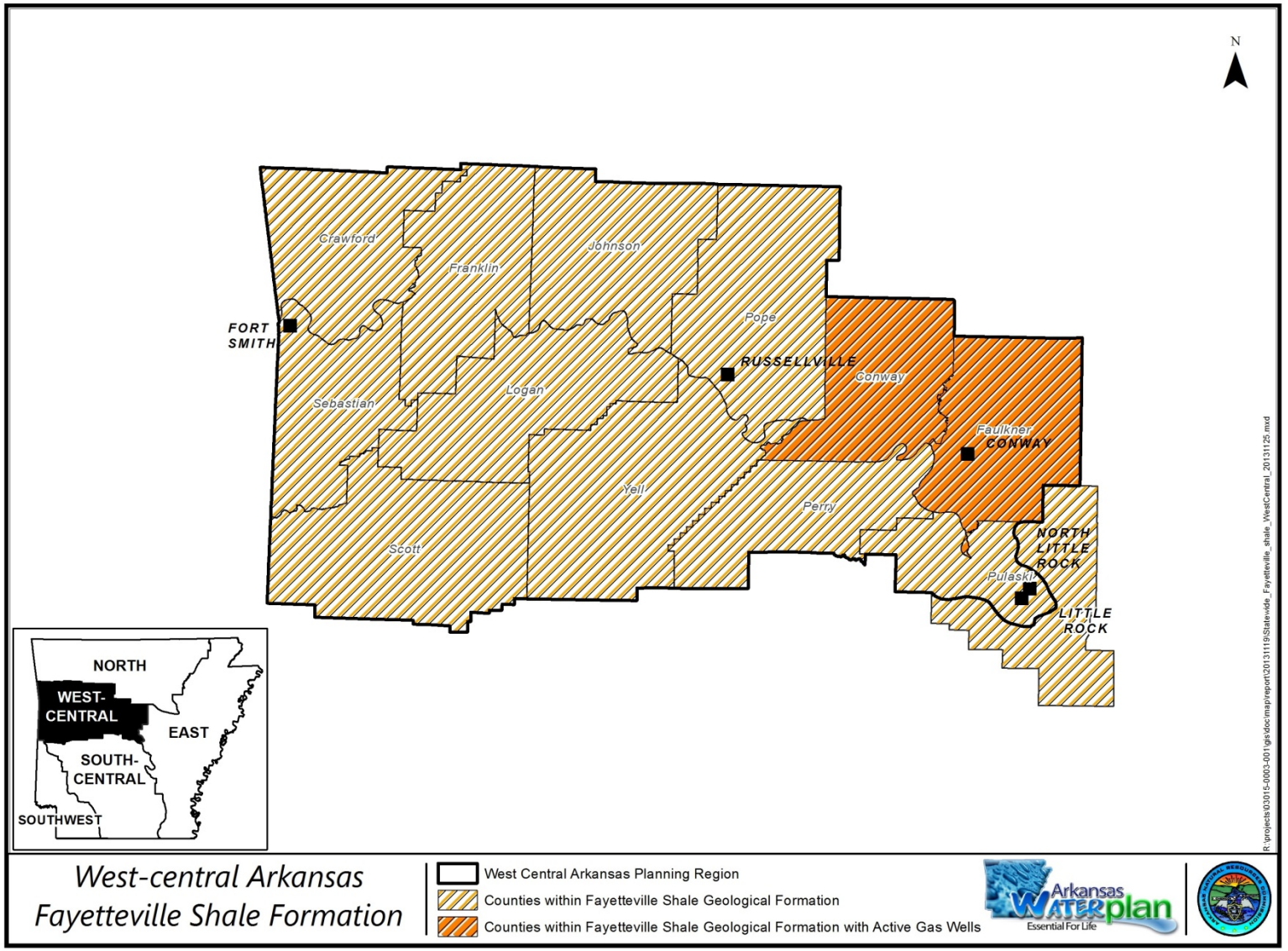

Figure 3.4. Location of Fayetteville Shale Formation in the WAWRPR.

deposits typically are about 40 feet thick in the area near Fort Smith and thicken downstream to about 80 feet near Little Rock (Cordova 1963). The alluvium represented several environments of deposition and characteristic deposits—point bar, swale, channel fill, natural levee, and back swamp—which can be distinguished on the basis of lithologic character and topographic expression.

3.2.3 Geology of the Fourche Mountains

The sedimentary rocks of the Fourche Mountains consist of a thick sequence of shale, chert, sandstone, conglomerates, novaculite, and volcanic tuff deposited during the Paleozoic Era within an elongate, subsiding trough (Renken 1998). The rock types exposed are sandstones and shales of the Atoka Formation. The Jackfork Sandstone is particularly important in the major mountain ridges. The Stanley Shale is the most widespread formation (Figure 3.2).

The Ouachita Mountains are true geosynclinal mountains formed from strata deposited in deep water settings and uplifted and deformed by the compressional events associated with continental collision. The general structure of the Ouachita Mountains is a broad uplift with complex folds and numerous complex faults (McFarland 2004, Manger 1983). Sediments of the Ouachita Mountains are well indurated and generally well cemented as a result of deep burial, intense compression, and complex rock-forming history (Renken 1998).

3.3 Ecoregions

Ecoregions are areas within which ecosystems and the type, quality, and quantity of environmental resources are generally similar. The US Environmental Protection Agency (EPA) has defined 9 Level IV Ecoregions within the WAWRPR (EPA 2013a) (Figure 3.5). The Arkansas Valley, which makes up the central and largest part of the planning region, includes four of the nine ecoregion subdivisions. Characteristics of all of the ecoregions in the WAWRPR are summarized in Table 3.1.

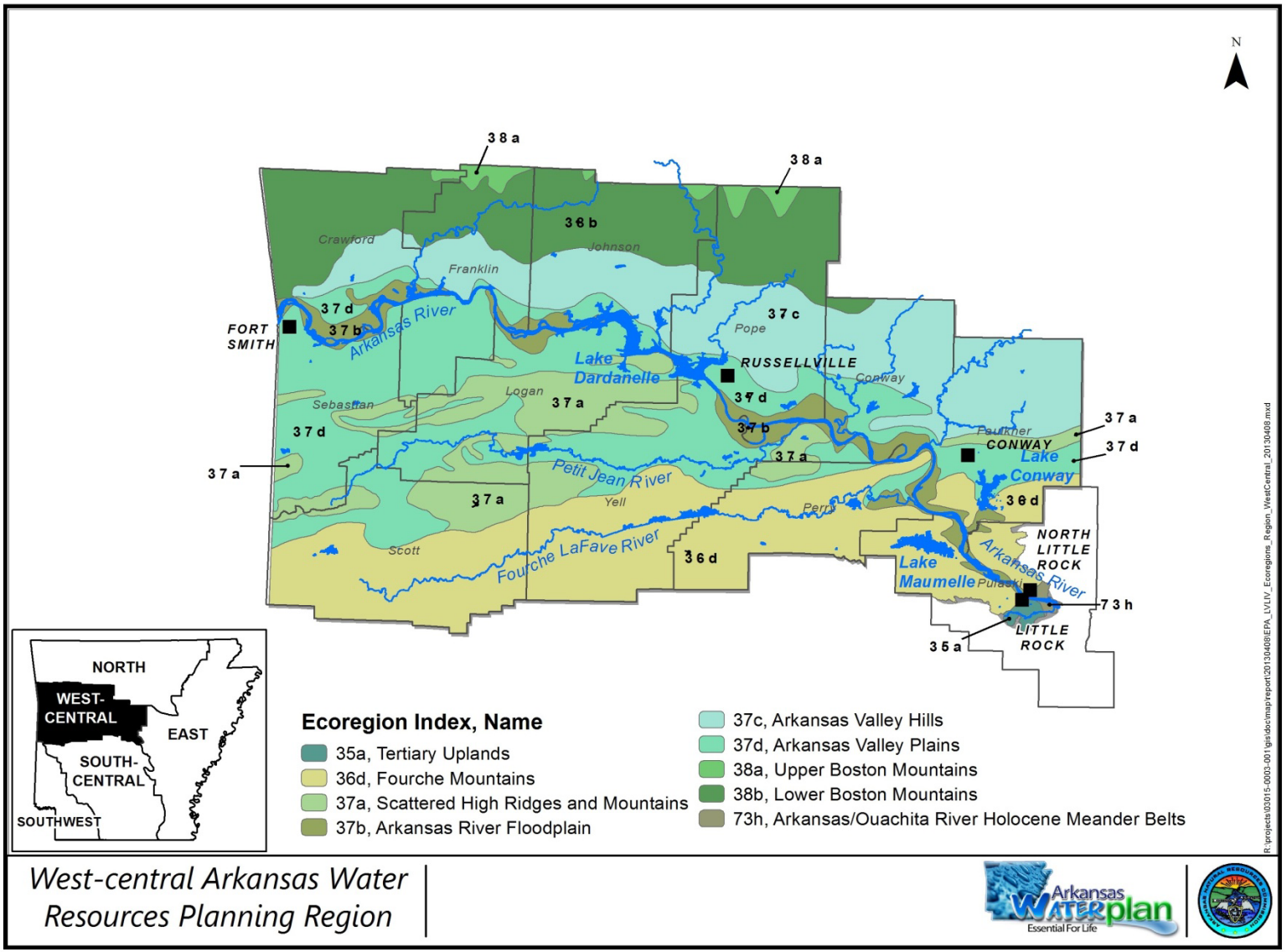

Figure 3.5. EPA-defined Level IV ecoregions of the WAWRPR (Woods et al. 2004).

Table 3.1. Ecoregions in the WAWRPR (Weakley et al. 2013, Woods et al. 2004).

Level III Ecoregion	Level IV Ecoregion	Native Vegetation	Hydrology	Other
Arkansas Valley	Scattered High Ridges and Mountains	Oak-hickory and oak-hickory-shortleaf pine forests	High to average stream gradients	Magazine Mountain, the highest point in Arkansas, is in this ecoregion
Arkansas Valley	Arkansas River Floodplain	Southern floodplain forest i.e., bottomland oaks, sycamore, willow, green ash, pecan, and others	Low gradient streams	Some native forest land remains in the frequently flooded areas.
Arkansas Valley	Arkansas Valley Hills	Oak-hickory and oak-hickory-pine forests	Low gradient streams	
Arkansas Valley	Arkansas Valley Plains	Historically a unique prairie, savanna, woodland collection; currently oak-hickory and oak-hickory-pine forests	Average to low gradient streams	In the rain shadow of Fourche Mountains; Cherokee Prairie (Franklin County) remnant native prairie
Boston Mountains	Upper Boston Mountains	Oak-hickory forest	High gradient streams; low to no flow during summer; pools fed by interstitial flow occur	Water quality in streams typically exceptional, distinctive freshwater communities
Boston Mountains	Lower Boston Mountains	Oak-hickory-pine forest	High gradient streams; low to no flow during summer; pools fed by interstitial flow occur	Water quality in streams typically exceptional, distinctive freshwater communities
Ouachita Mountains	Fourche Mountains	Oak-hickory-pine forest	High gradient streams	Water quality in streams typically exceptional
South-Central Plains	Tertiary Uplands	Oak-hickory-pine, mixed shortleaf pine-loblolly pine, and upland deciduous forests; bottomland forest along rivers	Low gradient streams; low to no flow in summer with the exception of spring-fed streams in sandhills.	Waterfowl habitat; oil and gas are produced in the region
Mississippi Alluvial Plain	Arkansas/ Ouachita River Holocene Meander Belts	Bottomland hardwood forest and woodland; northern limit of palmetto and Spanish moss	Flat floodplain; existing Arkansas River channel; low gradient streams	In the WAWRPR this area is the active Arkansas River

In the Fourche Mountains, steep east to west trending ridges are present which result in primarily north and south-facing slopes. Differences in temperature and moisture on the north and south facing slopes influence the plant communities present. On steep north-facing slopes

magnolia and sugar maple occur, while on south-facing slopes, short-leaf pine is the predominant natural vegetation. Overall, oak-hickory-pine forest is the dominant natural vegetation. Streams in the Fourche Mountains have high gradients, and substrates are made up of gravel, cobbles, boulders, or bedrock (ASWCC 1987, Woods et al. 2004). Fish communities in these streams are dominated by sensitive species (Woods et al. 2004).

The Boston Mountains, one of the Ozark Mountain plateaus where folding and faulting has occurred, but the strata is much less deformed than in the Ouachita Mountains. Oak-hickory-pine forest is the dominant natural vegetation. Pine is more common here than in the other ecoregions within the planning region, being particularly wide-spread on south and west facing sandstone slopes. Water quality in this ecoregion is generally exceptional. Fish communities in Boston Mountain streams tend to be diverse and may include sensitive species (Woods et al. 2004). The Boston Mountains contain habitat for a number of cave species (Anderson 2006).

The Arkansas Valley ecoregion includes floodplains, terraces, hills, plains, and scattered mountains. Natural vegetation in the uplands is a mix of woodland, forest, savanna, and prairie. In the lowlands, bottomland hardwoods are the dominant natural vegetation (Anderson 2006). Oak-hickory forest and oak-hickory-pine forest are the most common forest communities in this ecoregion. The area south of the Arkansas River, in the western portion of the ecoregion, where soils are thinner and drier, was historically prone to wildfires, resulting in large areas of savanna and prairie, and the presence of fire-adapted forest communities in the uplands (Woods et al. 2004). The Cherokee Prairie Natural Area, the largest tall grass prairie remnant in Arkansas is located in the Arkansas River Valley just north of Charleston in Franklin County. Streams in the Arkansas Valley have the lowest gradients in the planning region (Anderson 2006). Fish communities typically include a number of sensitive species (Woods et al. 2004).

3.4 Aquatic Biodiversity

While the aquatic habitats in the WAWRPR have been modified in the past, particularly with the construction of the MKARNS, there is still considerable aquatic biodiversity in this planning region. Within the Ouachita ecoregion, which includes the Arkansas River valley, is home to at least 190 native species of fish, which is 18% of all native freshwater fishes on the

continent (The Nature Conservancy 2006). Of the 268 aquatic and semi-aquatic animal species that have been identified as being of greatest conservation need in Arkansas, 116 are present in the WAWRPR (Anderson 2006). Figure 3.6 provides a summary of the aquatic and semi-aquatic animal species of greatest conservation need found within the planning region. Of the over 180 aquatic and semi-aquatic plant species tracked by the Arkansas Natural Heritage Commission (ANHC), 50 occur in the WAWRPR (ANHC 2013). Of the 42 Arkansas endemic species (found nowhere else in the world), 10 occur in the planning region (Figure 3.7) (Anderson 2006). While endemic and threatened and endangered species are present in the planning region, none of the waterbodies of the WAWRPR have been designated as state Ecologically Sensitive Waterbodies (APCEC 2011). Additional information on threatened and endangered species in the planning region is provided in Section 5.6.

The water resources of the WAWRPR are important waterfowl habitat. The planning region is located in the Mississippi River bird migration corridor, and the Arkansas River and associated wetlands are important habitat for migrating and wintering waterfowl and shorebirds. Audubon Arkansas has classified Lake Dardanelle and the Holla Bend National Wildlife Refuge as Important Bird Areas (Audubon Arkansas n.d.). Up to 100,000 ducks have been seen at once in the Holla Bend National Wildlife Refuge during the winter. Fourteen species of ducks and four species of geese visit this refuge each winter. Bald Eagles also use the refuge in the winter (Spurgeon 2011).

3.5 Climate

The climate of the WAWRPR is classified as humid subtropical with long summers, relatively short winters, and a wide range of temperatures. Parts of this planning region experience a milder climate, allowing the cultivation of crops unique to this region, such as wine grapes in Franklin County (Buckner 2011). Information on temperature, precipitation, evaporation, and climate trends were obtained from the National Oceanographic and Atmospheric Administration National Climatic Data Center (NOAA NCDC) and the PRISM Climate Group, and are discussed below. The State of Arkansas is divided into nine climate divisions, the WAWRPR is represented by climate divisions 4 and 5 (Figure 3.8).

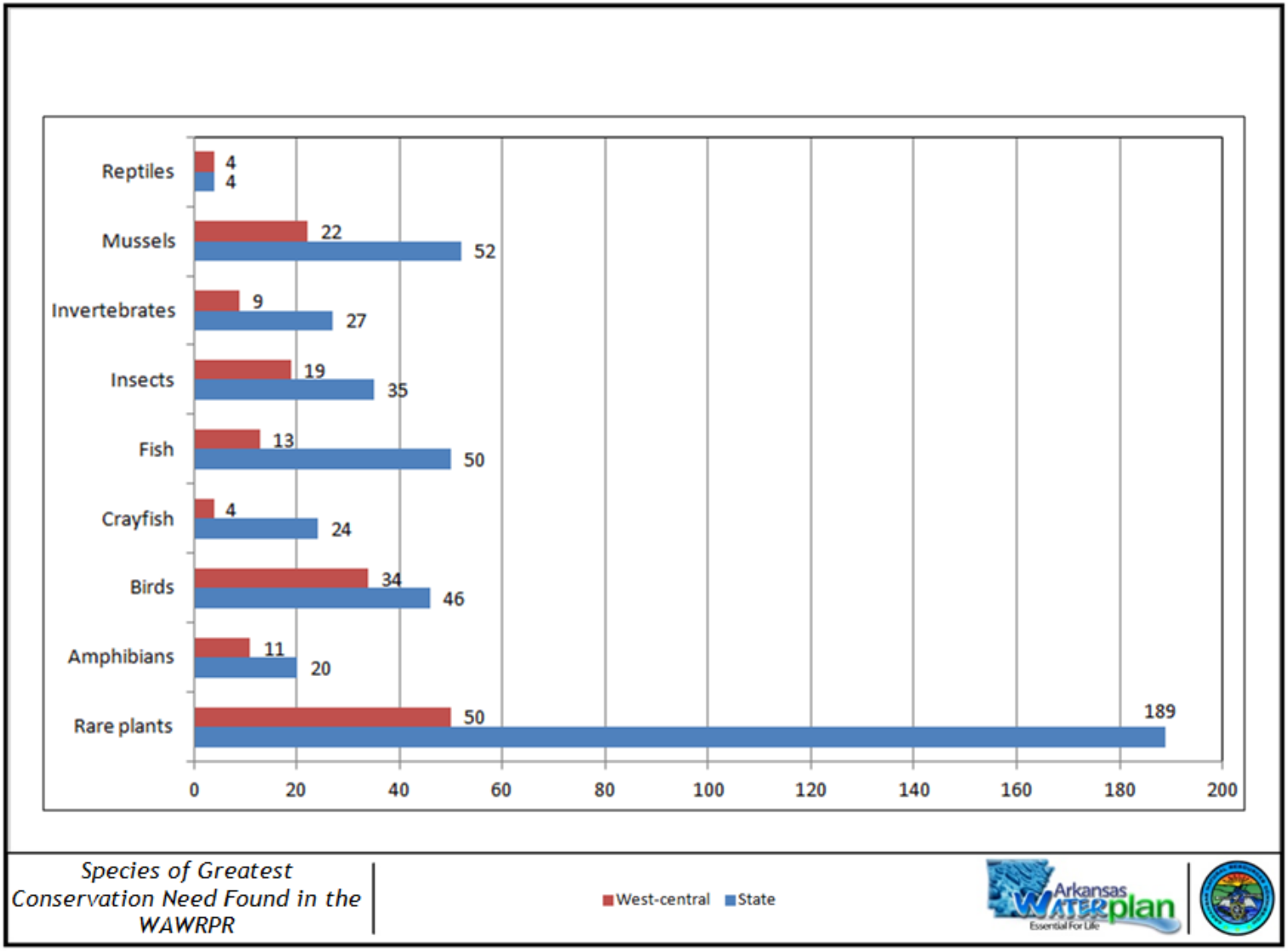

Figure 3.6. Species of greatest conservation need found in the WAWRPR (Anderson 2006, ANHC 2013).

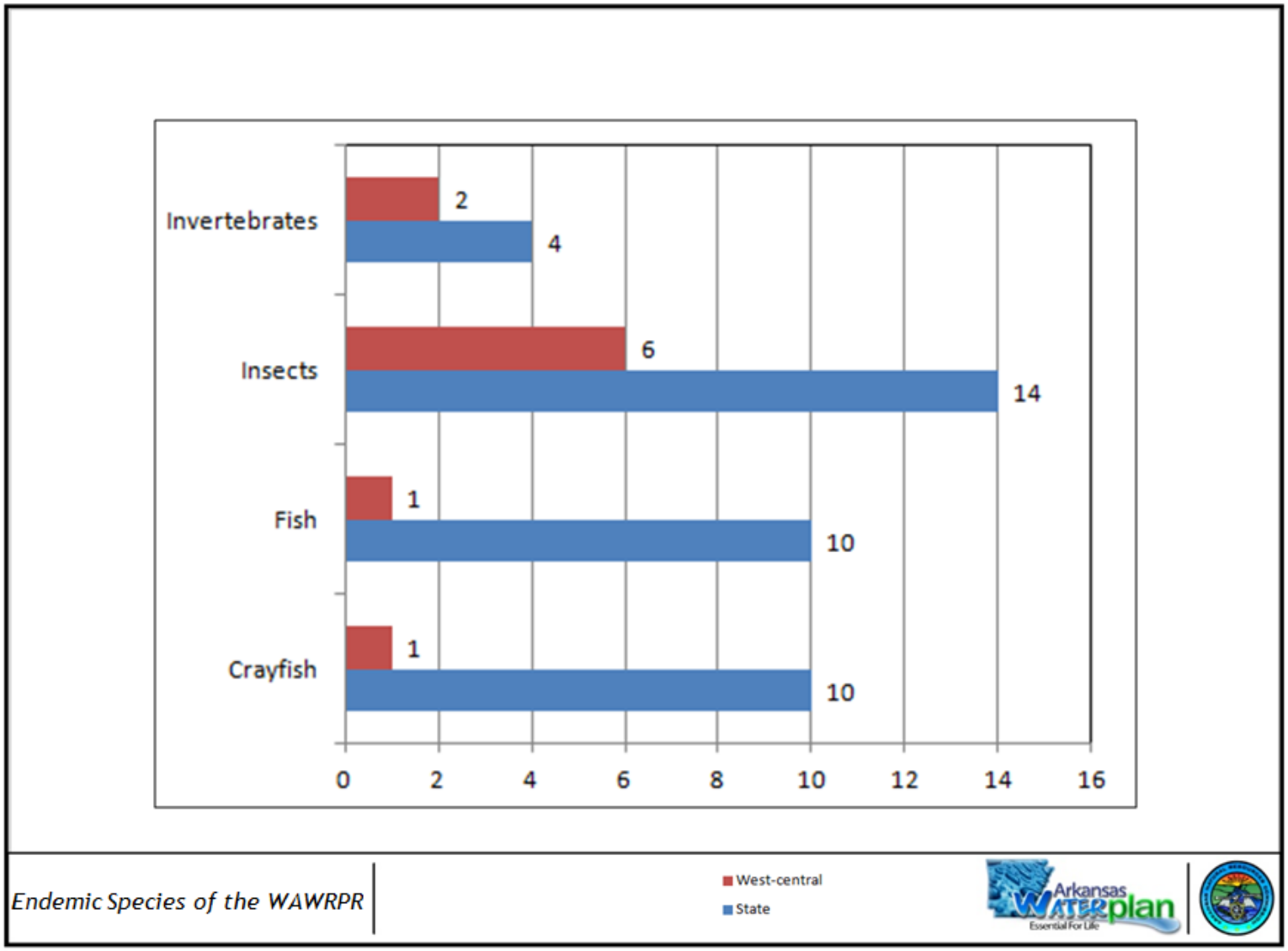

Figure 3.7 Endemic species of the WAWRPR (Anderson 2006).

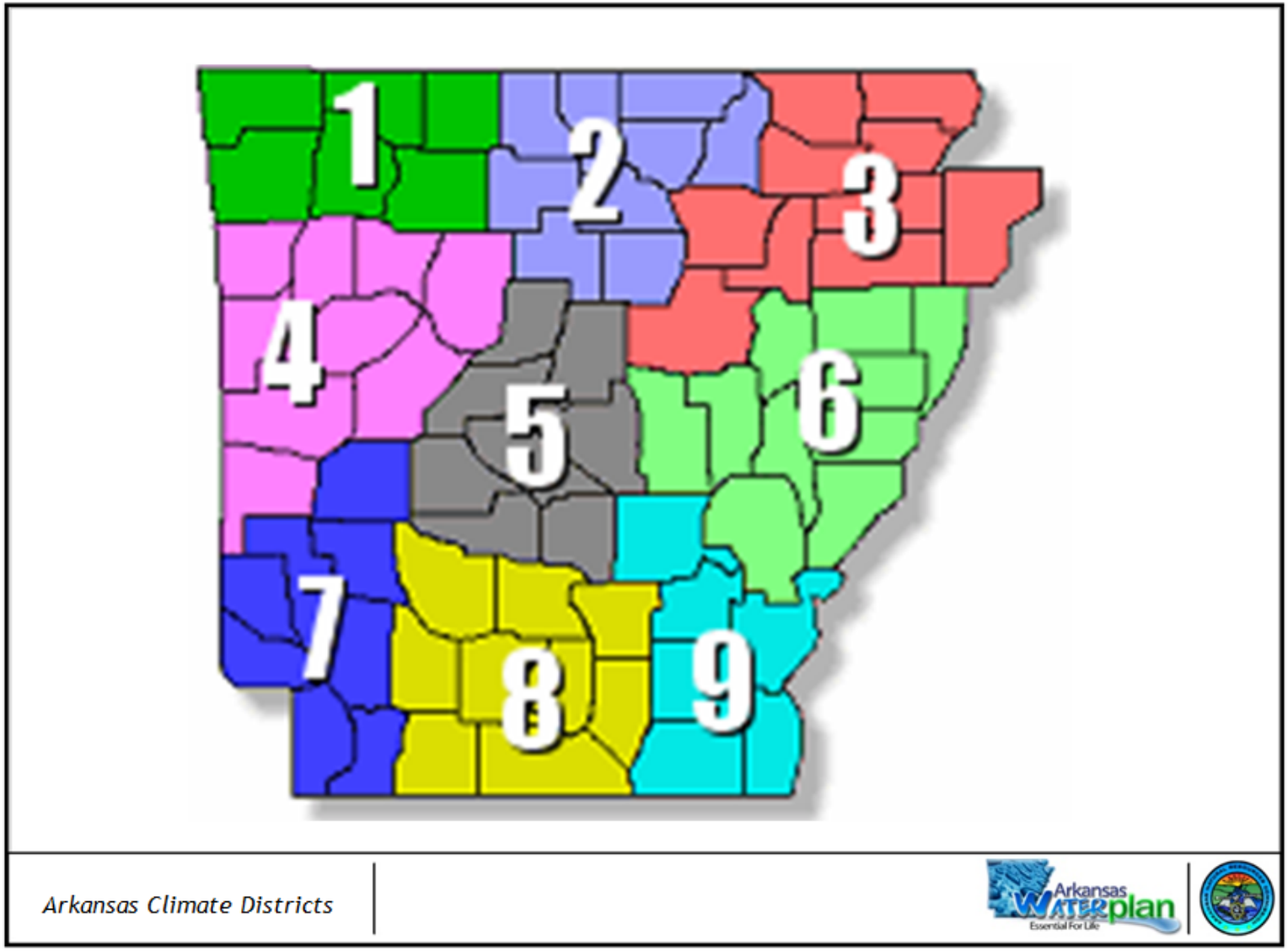

Figure 3.8. Arkansas climate divisions (NOAA NWS 2013).

3.5.1 Temperature

Average monthly high air temperatures in this planning region range from 92 degrees Fahrenheit in the summer to 49 degrees Fahrenheit in the winter (Figure 3.9). Normal monthly minimum air temperatures range from 69 degrees Fahrenheit in the summer to 29 degrees Fahrenheit in the winter. The average difference between normal monthly maximum and minimum air temperatures is 22 degrees Fahrenheit. A map of the average annual maximum daily temperatures for this planning region is provided on Figure 3.10 and demonstrates the wide variation within this particular planning region as compared to the rest of the State. The record high temperature in Arkansas is 120 degrees and was recorded on August 10, 1936 in Ozark, Franklin County, located in the Arkansas River Valley (Buckner 2011).

The growing season in this planning region ranges from 180 days in the mountains to 230 days in the river valley (Woods et al. 2004). Extremes in air temperatures may vary from winter lows around 0 degrees Fahrenheit, usually caused by Canadian air masses, to summer highs above 100 degrees Fahrenheit. Extreme temperatures may occur for short periods of time at any location within the WAWRPR.

3.5.2 Precipitation

Average annual precipitation in the WAWRPR ranges from approximately 47 inches to greater than 60 inches, see Figure 3.11. The variation in the average annual rainfall across the planning region indicates a slight general decrease from east to west, but more prominent is the lower average annual precipitation in the central portion of the planning region as opposed to the north and south. The western portion of the WAWRPR lies in the rain shadow of the Ouachita Mountains, and is influenced by dry winds from Oklahoma (Foti 2011a). In this planning region, the highest precipitation amounts occur in areas of higher elevations. Average monthly precipitation for the period from 1981 through 2010 is shown on Figure 3.12. Precipitation is well distributed throughout the year with the driest months being August and January respectively.

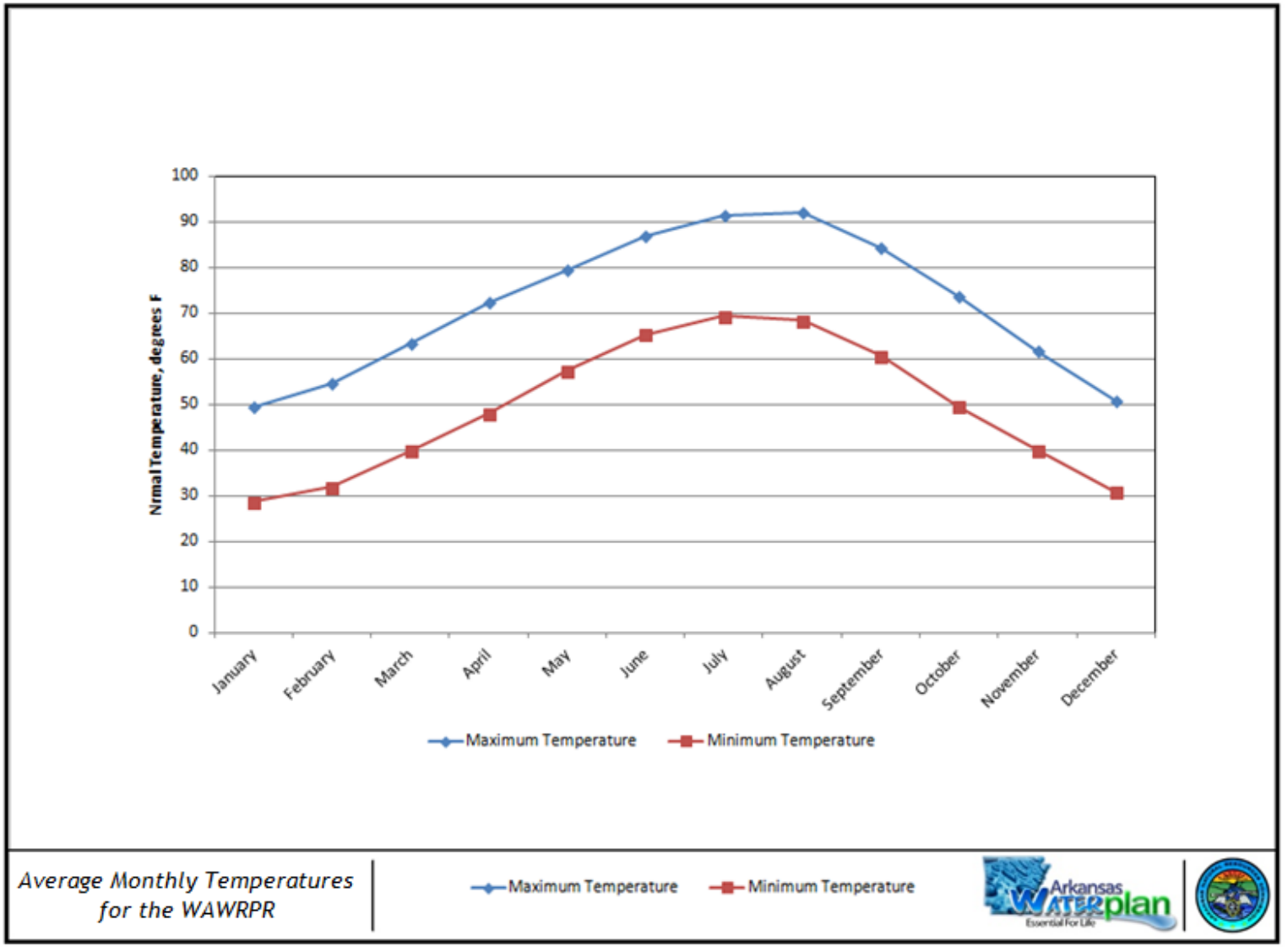

Figure 3.9. Average monthly (Maximum/Minimum) temperatures for the WAWRPR (PRISM Climate Group 2004).

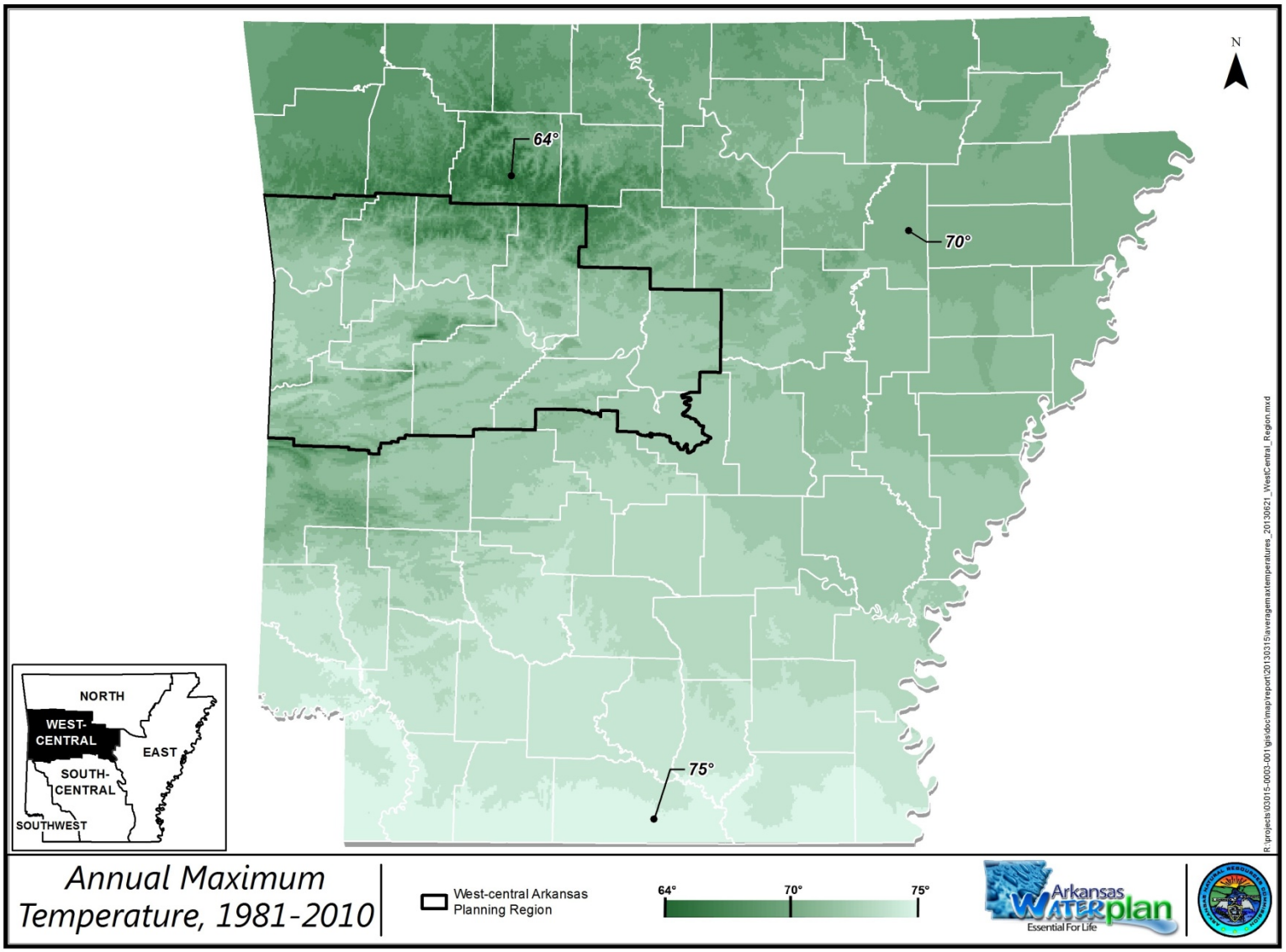

Figure 3.10. Average annual maximum temperatures (°F) across the WAWRPR (PRISM Climate Group 2004).

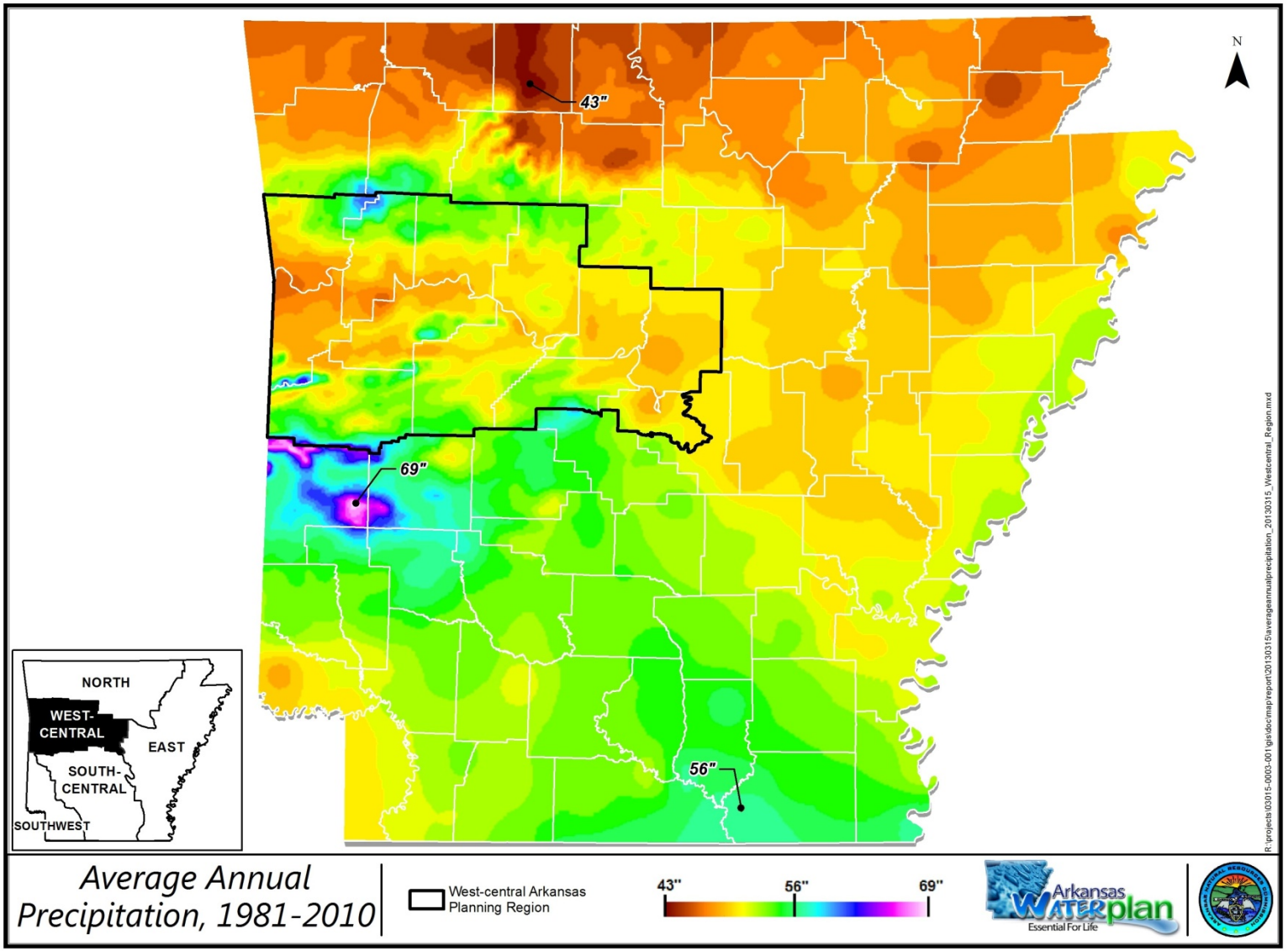

Figure 3.11. Average annual precipitation (inches) for the WAWRPR (PRISM Climate Group 2004).

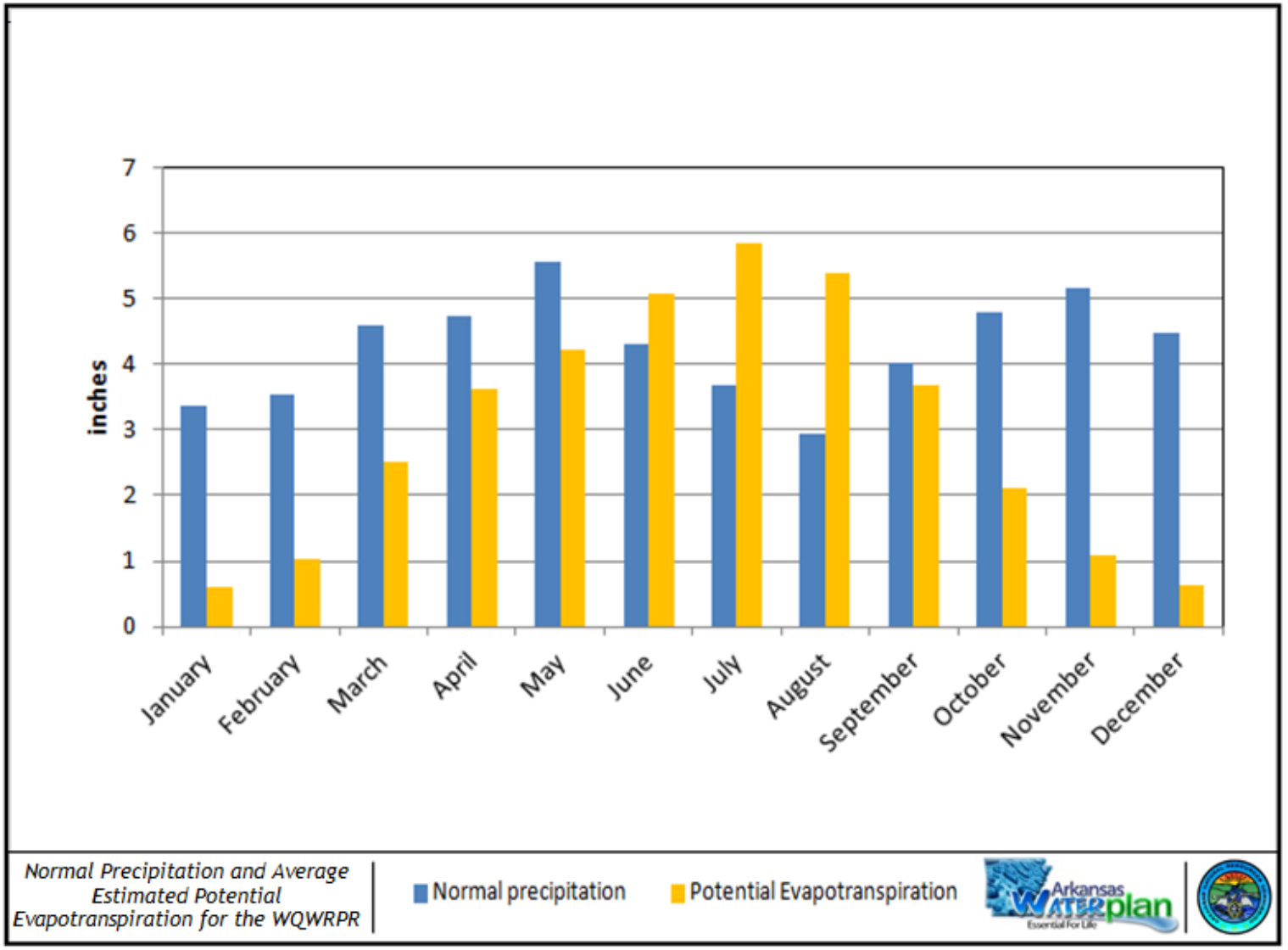

Figure 3.12. Normal precipitation and average estimated potential evapotranspiration for the WAWRPR (1981 – 2010) (PRISM Climate Group 2004, NOAA NCDC 2013b).

3.5.3 Evaporation

Evaporation is the process by which water changes from liquid in soil or waterbodies to gaseous water vapor. When the conversion from liquid to water vapor occurs on leaves, the process is called transpiration. Evapotranspiration is the combination of these processes. The amount of evapotranspiration is controlled primarily by sunlight, but is influenced by humidity and wind (Scott et al. 1998).

Potential evapotranspiration is the maximum rate at which water in soil and on plants would change to water vapor, assuming there is no shortage of water to be changed. Actual evapotranspiration is usually less than the potential. Potential evapotranspiration is difficult to measure, but can be estimated from the meteorological measurement, pan evaporation. Pan evaporation is the rate of evaporation of water from a specific style of open pan at a weather station. In humid climates, like in the WAWRPR, potential evapotranspiration is similar to pan evaporation. In this planning region, the ratio of potential evapotranspiration to pan evaporation is assumed to be 0.85. Evaporation exhibits less variation from year to year and place to place than precipitation (Scott et al. 1998).

There is one weather station in the WAWRPR where pan evaporation has been measured consistently since 2000, Blue Mountain Dam, located in Yell County. Monthly average potential evapotranspiration estimated from available pan evaporation measurements at this weather station for the period 1981 through 2010, and the normal precipitation, are provided on Figure 3.10.

The estimated potential evapotranspiration measured at this site is greater than the normal precipitation for three months out of the year, June through August, however, in general, this planning region has a natural excess of water.

3.5.4 Drought

The WAWRPR does experience drought. One of the tools NOAA uses to determine when drought conditions exist is the Palmer Drought Indices. These indices are based on the differences of precipitation and temperatures from normal. The Palmer Drought Severity Index (PDSI) also takes into account the length of time that drought conditions last. PDSI values less than zero indicate drought conditions. An index of -2 indicates moderate drought, -3 indicates

severe drought, and -4 indicates extreme drought (NOAA 2012). Figures 3.13 and 3.14 show time series plots of PDSI values for the two Arkansas climate divisions that cover the majority of the WAWRPR, divisions 4 and 5 (see Figure 3.6 for a map of Arkansas climate divisions). Periods of multiple consecutive years classified as drought have occurred frequently in the planning region. Drought conditions occur more frequently in Climate Division 5, which covers the eastern portion of the planning region than in Climate Division 4, which includes the western portion of the planning region. The entire WAWRPR experienced a period of severe to exceptional drought that began in 2010 and has only recently lessened in portions of the planning region (NOAA NCDC 2013a).

3.5.5 Climate Variability

In 2007, the Governor's Commission on Global Warming (GCGW) was established to, among other tasks; evaluate the potential impacts of global warming on the state citizens, natural resources, and economy. The literature review conducted by the GCGW identified the following climate change effects that could be anticipated for the WAWRPR: (GCGW 2008)

- Increased incidence of severe weather events,
- Increased incidence of flooding,
- Increased incidence of drought, and
- Changes in climatic zones.

Plots of annual average temperature and historic annual precipitation from 1895 to 2013 for the Arkansas climate divisions in the WAWRPR are shown on Figures 3.15 and 3.16, respectively. The temperature data appear to exhibit a cycle of change, where temperatures in the first half of the 20th century were warmer than the second half, but appear to be warming again in the early 21st century (Figure 3.15). The US Department of Agriculture (USDA) develops a plant hardiness zone map which shows annual average minimum winter temperature. The 2012 update of the USDA map shows warmer minimum temperatures in the state as compared to the 1990 zone map, which follows the cycle shown on Figure 3.15 (Clark and Karklis 2012).

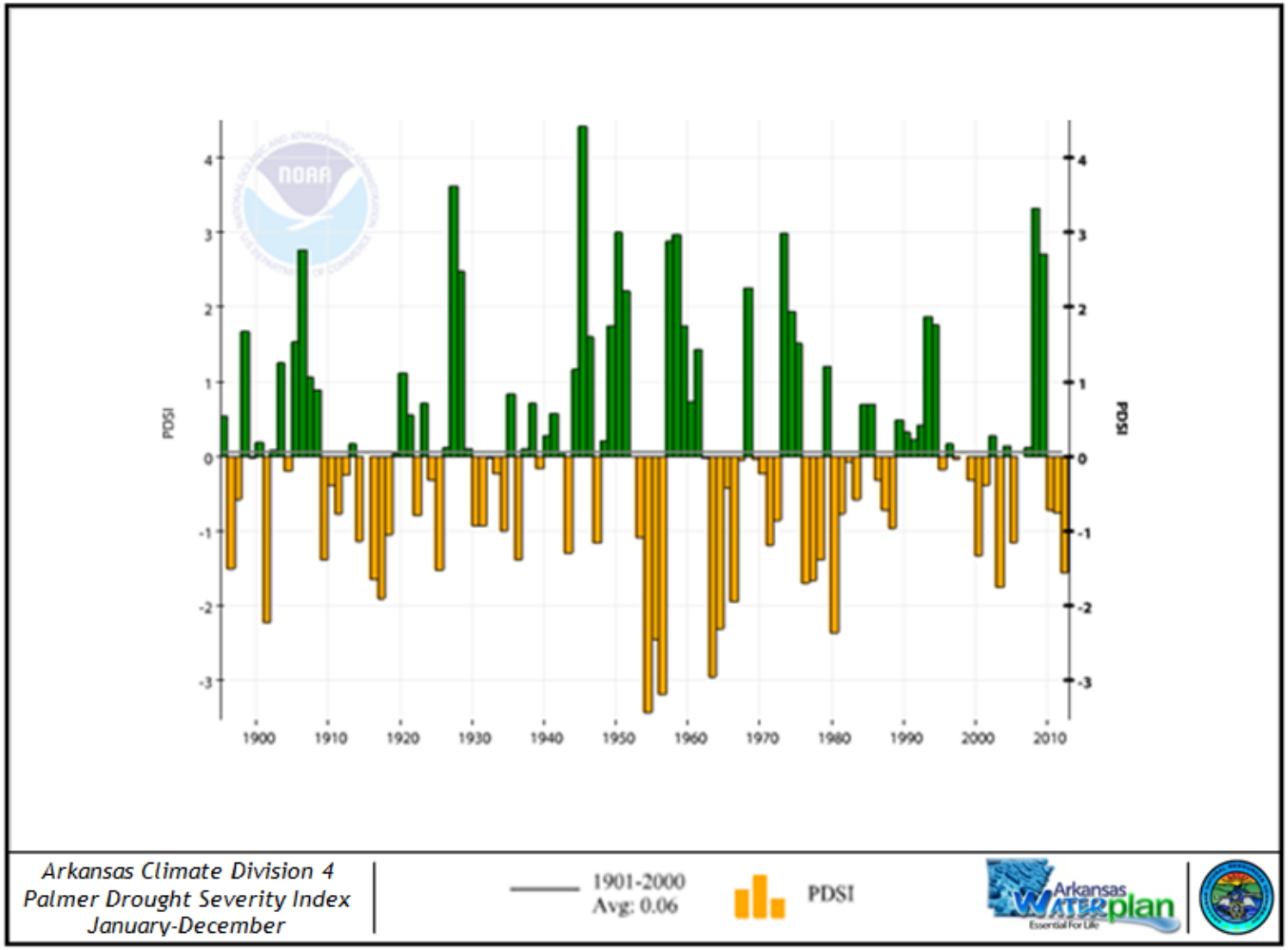

Figure 3.13. Historic PDSI values for climate division 4 in the WAWRPR (NOAA NCDC 2013a).

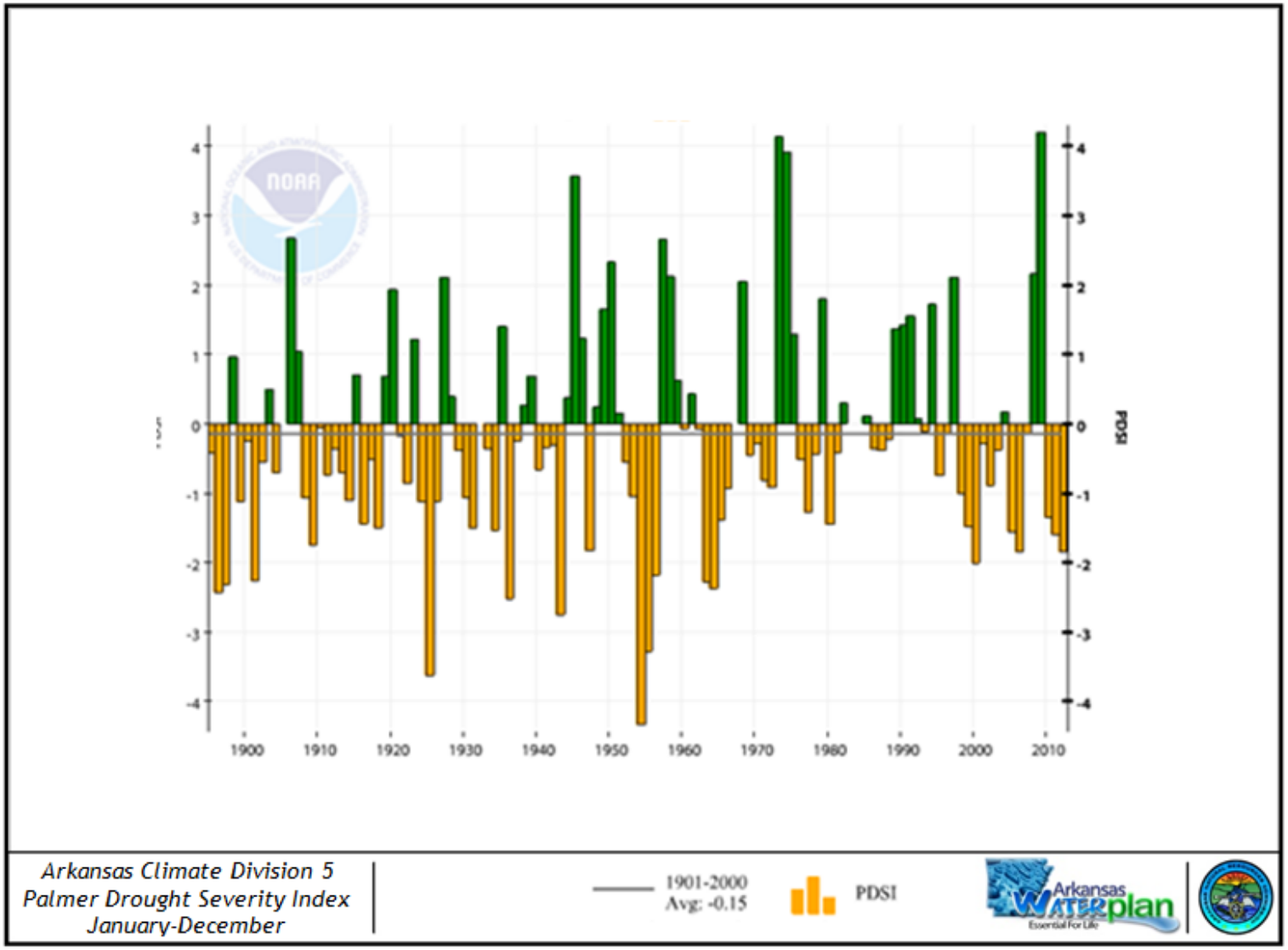

Figure 3.14. Historic PDSI values for climate division 5 in the WAWRPR (NOAA NCDC 2013a).

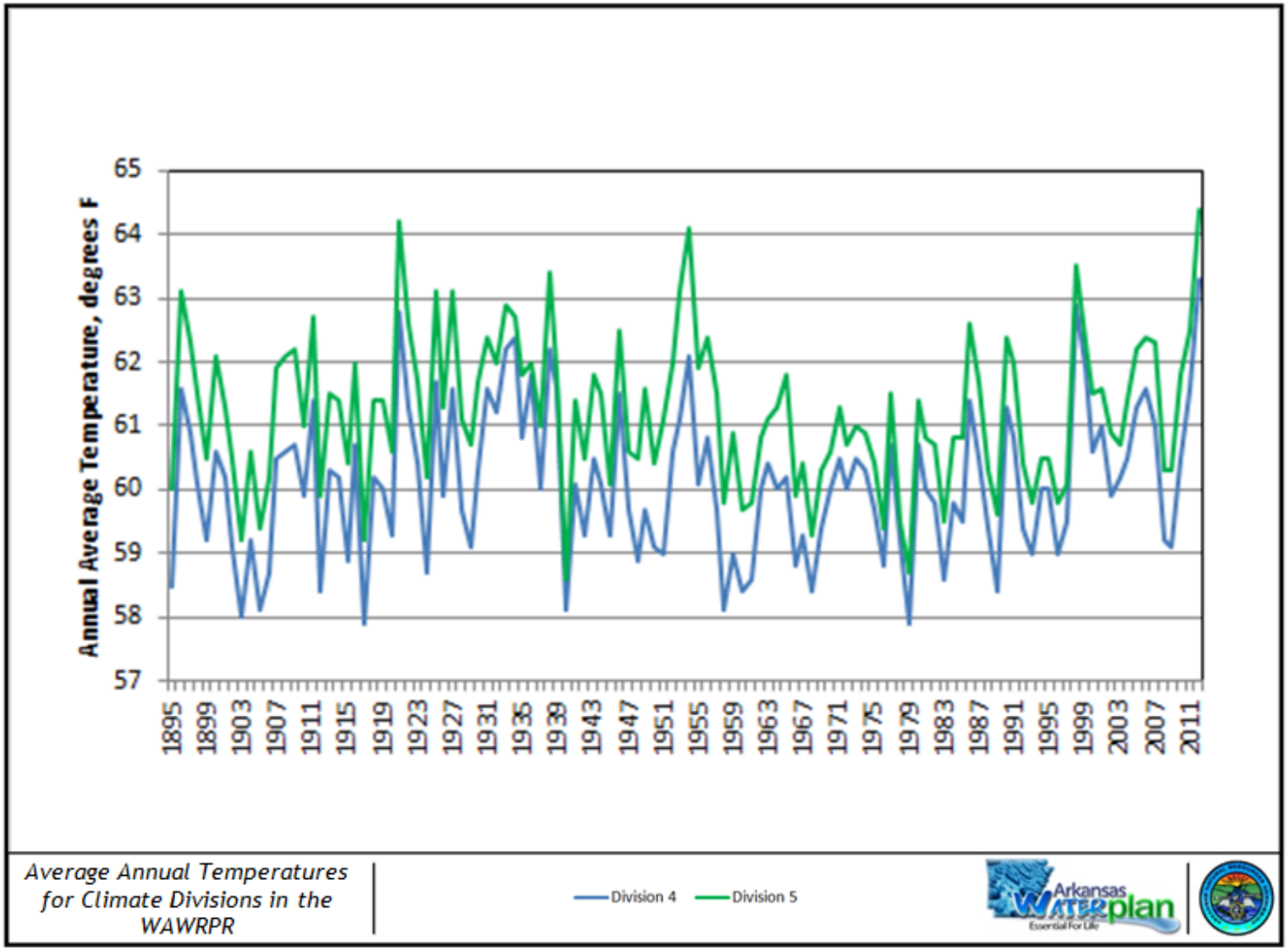

Figure 3.15. Average annual temperatures for climate divisions in the WAWRPR (NOAA NCDC 2013b).

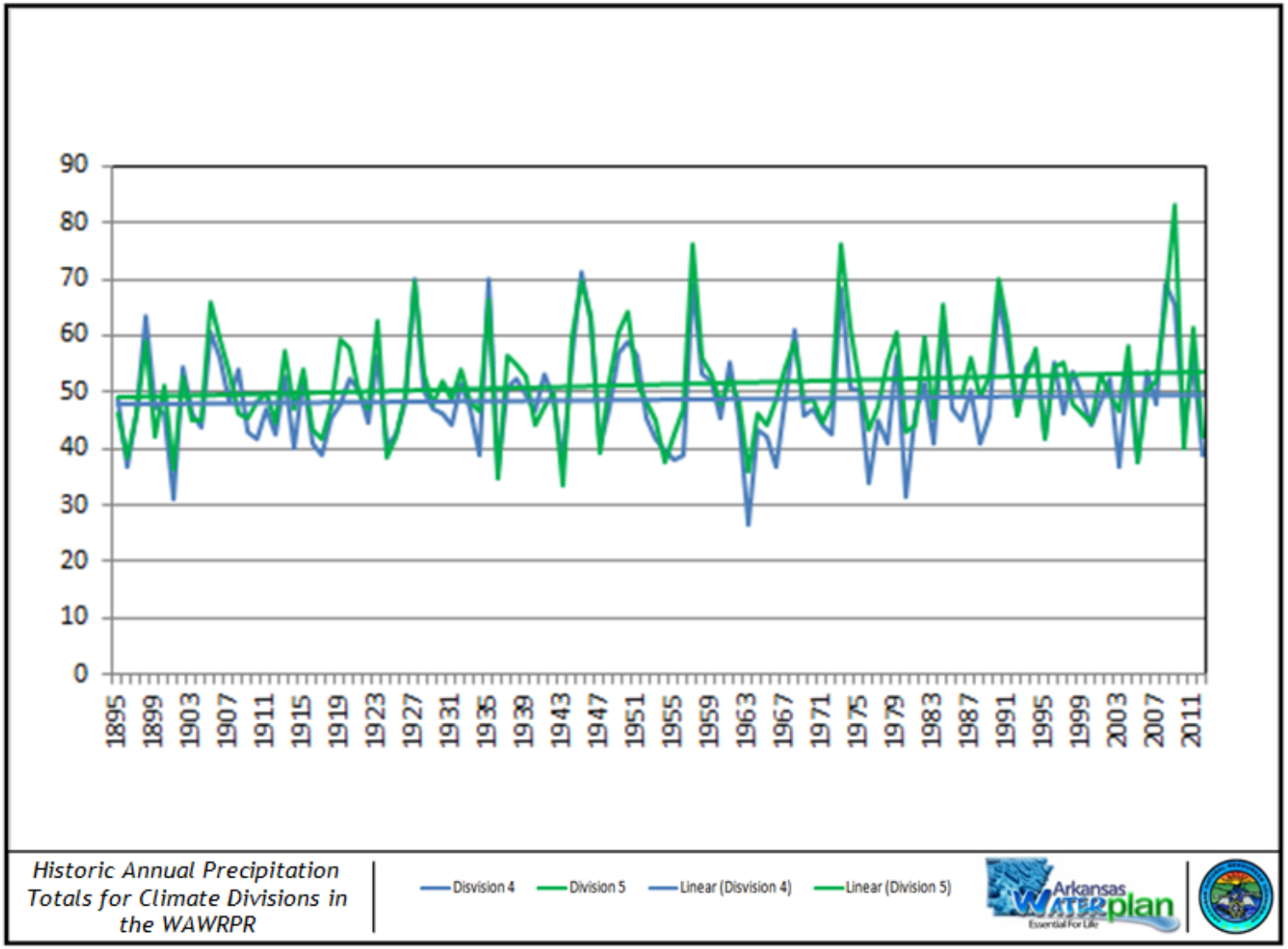

Figure 3.16. Historic annual precipitation totals for climate divisions in the WAWRPR (NOAA NCDC 2013b).

Precipitation totals for Climate Divisions 4 and 5, presented on Figure 3.16, appear to exhibit a slight long-term increasing trend as depicted by the linear trend lines. A detailed analysis of long-term precipitation trends across the state is being prepared as part of the 2014 water plan update.

3.6 Land Use

Land use in the WAWRPR is summarized on Figure 3.17 and mapped on Figure 3.18. Major land use categories are discussed in the sections below, including present day extent, and changes since the 1990 AWP.

3.6.1 Forest

Over 61% of WAWRPR was forested land in 2006 (the most recent year for which detailed land cover data is available). The USDA Forest Service (USFS) 2012 forest land inventory for the counties of the WAWRPR indicates there are over 3.4 million acres of timber. Table 3.2 provides a county summary of the forest land acreage reported. Yell and Scott counties include over 450,000 acres each, which accounts for approximately 28% of the forest land in the planning region. The majority of the forest land in these counties is part of the Ouachita National Forest. Pulaski and Sebastian counties account for the least amount of forestland, which is indicative of the higher population and urban centers in these counties The majority of the forest land in the planning region counties (98%) is classified by the USFS as timberland, or commercial forest land (USFS 2013).

Table 3.2 also includes the forest land areas from the 1977 Resource Inventory Data System reported by county in the 1990 AWP reports. These data are from different sources, so their comparability is uncertain. However, in comparing these areas, there may have been a slight increase in the amount of forest land in the planning region counties during the period since the 1990 AWP update. Some counties appear to have experienced increases in forest area, while other experienced declines in forest area.

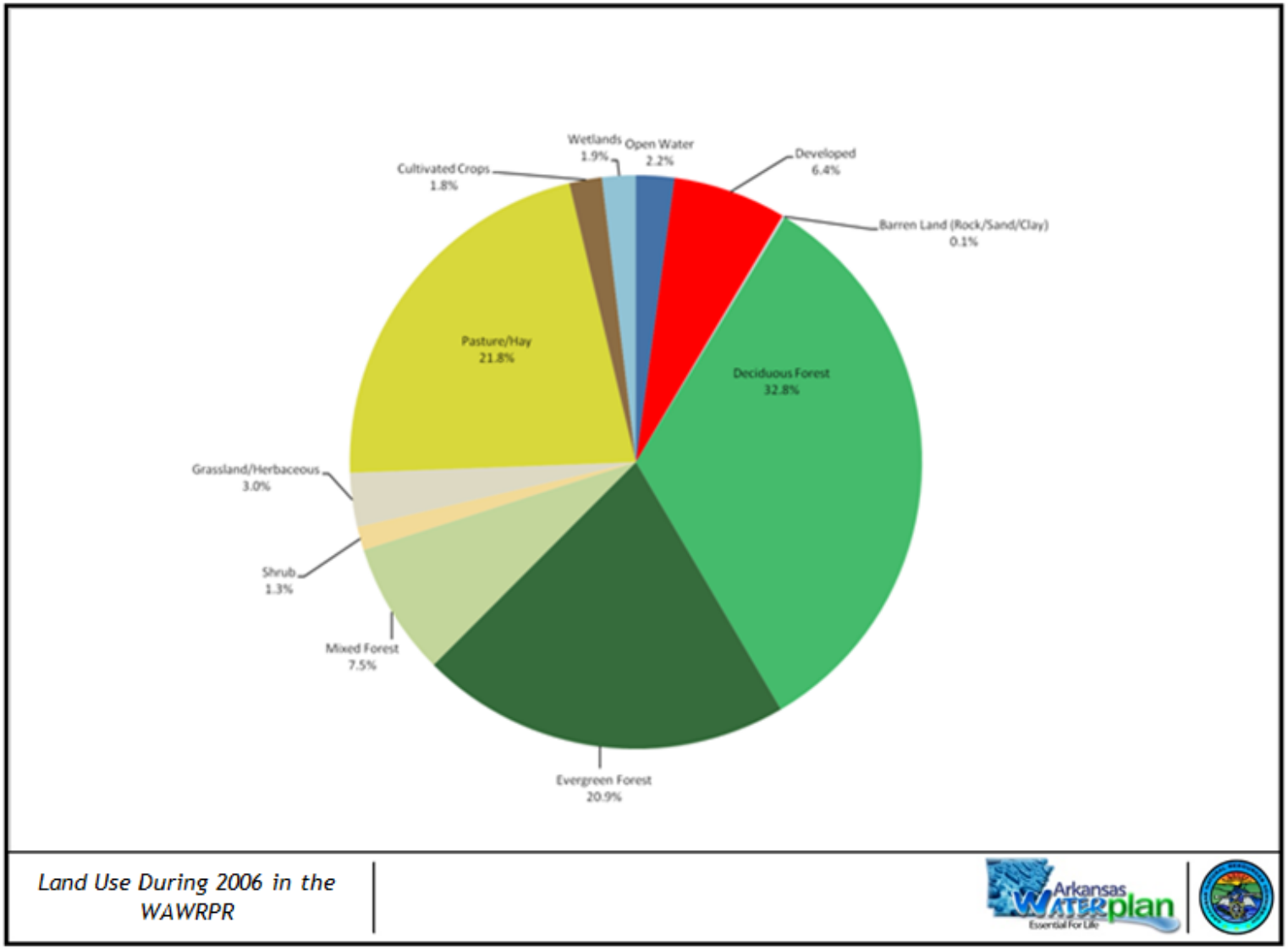

Figure 3.17. Land use during 2006 in the WAWRPR (Fry et al. 2011).

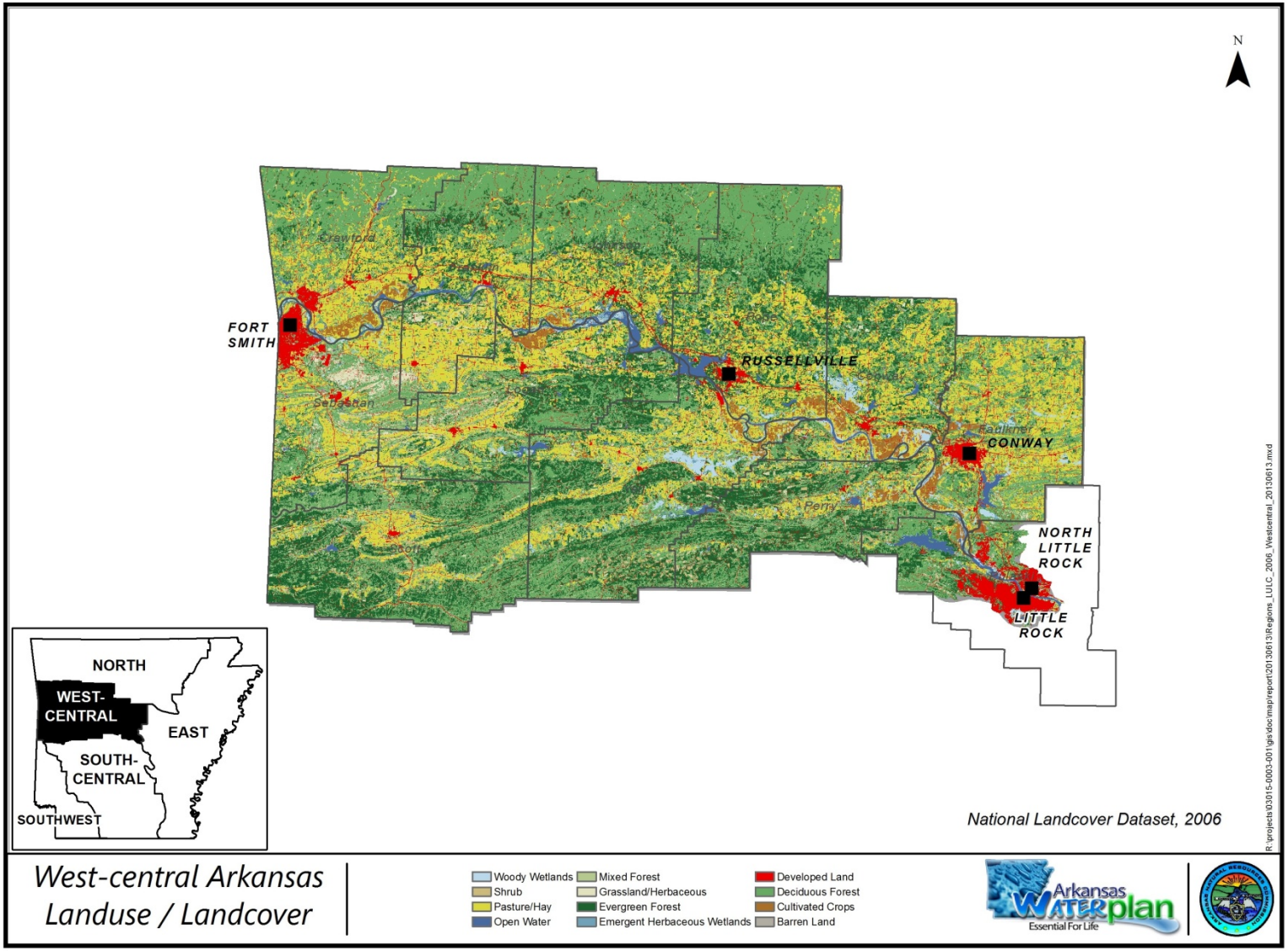

Figure 3.18. Land use map of the WAWRPR (Fry et al. 2011).

Table 3.2. Forest acreage by county in the WAWRPR.

County	1990 AWP Forest Land (acres)	2012 Forest Land[e] (acres)	Change
Conway	159,930[a,b]	196,120	+
Crawford	224,032[a,b]	208,511	-
Faulkner	161,452[a]	219,793	+
Franklin	181,250[a,b]	219,399	+
Johnson	326,628[a]	309,141	-
Logan	232,451[a]	266,414	+
Perry	286,677[a,c,d]	267,630	-
Pope	344,242[a,b]	384,897	+
Pulaski*	199,139[a,d]	234,669	+
Scott	455,108[a,b]	464,581	+
Sebastian	130,917[a]	158,539	+
Yell	412,986[a,b]	482,884	+
Total	**3,114,272**	**3,412,578**	**+**

* Note: the acreage reported is for the entire county, but part of this county is in other planning regions.
a. USACE Little Rock District 1988a
b. USACE Little Rock District 1988b
c. ASWCC 1987a
d. ASWCC 1987b
e. USFS 2013

3.6.2 Agriculture

Agriculture land accounts for the next largest proportion of the planning region at approximately 24% (Figure 3.17). Pasture and haylands account for the majority of this land use category (93%). In the 2007 Census of Agriculture, the total of pasture in the counties within the planning region was 906,330 acres, with 546,276 acres of cropland (USDA National Agricultural Statistics Service 2009). In the WAWRPR livestock production, associated with pasture and haylands, accounts for the bulk of the agricultural activity in the planning region. In the 1990 AWP, the acreage reported for pasture was 1.5 million, with 284,382 acres of cropland. Because these data are from different sources, their comparability is uncertain (See Table 3.3). Comparing pasture and cropland areas from the 1987 and 2007 Census of Agriculture indicates there has been a slight decline in pasture area in the counties of the WAWRPR since 1990, but no significant change in the amount of cropland (US Census Bureau 1989, USDA National Agricultural Statistics Service 2009).

Table 3.3. Comparison of agriculture land use of the WAWRPR.

County	Cropland (acres)			Pasture (acres)		
	1987 Census of Agriculture[a]	1990 AWP	2007 Census of Agriculture[a]	1987 Census of Agriculture[b]	1990 AWP	2007 Census of Agriculture[b]
Conway	65,115	42,997	76,615	107,050	133,261	88,745
Crawford	45,940	21,520	42,777	92,069	105,912	64,417
Faulkner	63,498	39,469	55,546	183,130	157,933	112,162
Franklin	39,204	7,069	42,002	148,371	198,379	102,253
Johnson	28,359	10,214	31,930	93,777	88,111	64,091
Logan	47,835	19,469	53,636	155,019	194,986	94,013
Perry	23,543	17,442	28,163	52,886	43,775	35,700
Pope	40,055	18,890	51,935	125,862	139,179	86,233
Pulaski*	86,400	62,868	55,575	48,896	35,264	30,576
Scott	22,079	0	26,017	102,356	121,008	59,729
Sebastian	23,627	19,652	27,314	114,552	143,178	73,058
Yell	64,059	24,792	54,766	152,468	150,537	95,353
Total	549,714	284,382	546,276	1,376,436	1,511,523	906,330

* Note: the acreage reported is for the entire county, but part of this county is in other planning regions.
a Note: sum of "harvested cropland" and "other cropland" reported in census
b Note: sum of "pastureland, all types" and "cropland used only for pasture" reported in census

The acreage of cropland harvested in the planning region counties in 2007 was only slightly greater than reported for 1987. Approximately 12% of the cropland in the counties of the planning region was irrigated in 2007. Both the percentage and the acreage of irrigated cropland in 2007 is double what it was in 1987 (US Census Bureau 1989, USDA National Agricultural Statistics Service 2009).

The crop items with the largest acreage within the planning region counties in 2007 were forage, soybeans, and wheat (USDA National Agricultural Statistics Service 2009). There are several counties in the planning region that grow select crops a little more unique to their area. These include grapes (Franklin County), peaches (Johnson County), peas and cantaloupes (Scott County), field and grass seed (Perry County), and sod (Sebastian County) (USDA National Agricultural Statistics Service n.d.). Soybeans and cotton were identified in the 1990 AWP as the two crops with the largest acreages in the Arkansas River basin (USACE Little Rock District 1988).

3.6.3 Developed Land

Developed land accounts for over 6% of the land area in the planning region. Several large urban areas are located within the WAWRPR, including Fort Smith, Russellville, Conway, and portions of Little Rock and North Little Rock. These urban areas have expanded since the 1990s. Table 3.4 compares areas for urban and built-up lands in the counties of the WAWRPR reported in the 1990 AWP, and from the most recent land use data set. These data indicate that developed land has increased in all of the counties of the planning region. Some of the differences in these numbers are likely the result of differences in the methodologies for classifying land use, however, population changes in these counties suggest that not all of the increase is due to differences in methodology (See Section 4.1).

Table 3.4. Comparison of urban/built-up area reported for counties in the WAWRPR (USACE Little Rock District 1988, Fry et al. 2011).

County	Urban/Built-up from 1990 AWP (acres)	Urban/Built-up 2006 (acres)
Conway	4,233	19,250
Crawford	18,228	23,951
Faulkner	18,216	34,778
Franklin	2,710	19,726
Johnson	2,911	22,502
Logan	7,760	20,505
Perry	2,746	15,860
Pope	14,815	27,146
Pulaski*	65,955	108,721
Scott	0	21,701
Sebastian	37,694	42,636
Yell	0	24,708
Total	**175,268**	**381,484**

* Note: the acreage reported is for the entire county, but part of this county is in other planning regions.

3.6.4 Wetlands

Open water and wetlands each account for 2% of the land area in the WAWRPR. The amount of wetlands that existed in the Arkansas River Basin at the time of the 1990 AWP update was estimated to be approximately 50,000 acres (USACE Little Rock District 1988). Based on the 2006 land cover dataset, 95,826 acres of wetlands are within the WAWRPR (note that the

WAWRPR is a smaller area than the Arkansas River Basin of the 1990 AWP) (Fry et al. 2011). This suggests that there has been an increase of wetland area in the region since the 1990 AWP update.

3.6.5 Public Land

There are over 2.4 million acres of public lands in the planning region, including parks, wildlife refuges and management areas, wilderness areas, and military installations, see Table 3.5 (AGFC 2009, AHTD 2006). Almost half of the WAWRPR (48%) is public land. The majority of the public land is National Forest, which accounts for approximately one-third of the area of the planning region.

Table 3.5. Public lands in the WAWRPR (AGFC 2009, AHTD 2006).

Public Land Use	Acreage	Count	Percent of Total Public Land
National Forest	1,782,717	2	73.7%
National Wildlife refuges	5,895	1	0.2%
Wildlife management areas	506,916	30	21.0%
State Park	9,575	7	0.4%
Military land	74,470	2	3.1%
National Parks	25	1	0.0%
Wilderness Areas	39,513	5	1.6%
TOTALS	2,419,111	48	100%

3.7 Surface Water

There are over 2,084 miles of streams and over 100,000 acres of impoundments in the WAWRPR (ADEQ 2012d, ASWCC 1981). The Arkansas River, which flows through this planning region, is one of the state's major rivers and is an important waterborne transportation route. Other principal water courses in the planning region include the Fourche La Fave and Petit Jean Rivers, both tributaries of the Arkansas River (refer to Figure 2.1).

3.7.1 Rivers and Streams

The Arkansas River is the primary river flowing through the center of WAWRPR. It traverses the planning region generally from east to west, making up the largest physiographic

region, the Arkansas River Valley (Figure 3.1). The Arkansas River originates in Colorado, entering Arkansas from Oklahoma at Fort Smith, as the boundary between Crawford and Sebastian Counties. The Arkansas River flows to the east as far as Clarksville, in Johnson County, where it turns more to the southeast. The Arkansas River leaves the planning region at Little Rock, in Pulaski County. The Arkansas River receives runoff from the entire planning region. The portion of the Arkansas River in this planning region is entirely contained in the MKARNS, including Lock & Dams 7 through 10, 12, and 13 (See Figure 2.2).

The Fourche La Fave River originates in the planning region, in the Fourche Mountains, in Scott County. The Fourche La Fave River flows eastward until it empties into the Arkansas River in Perry County.

The Petit Jean River also originates in the planning region, in the Fourche Mountains, at the confluence of several streams near Waldron, in Scott County (Lancaster 2011b). The river flows eastward until it empties into the Arkansas River as the boundary between Yell and Conway Counties.

The historical average annual surface runoff in the WAWRPR ranges from 10 inches in the far north-western area of the planning region to 15 inches in the southern area of planning region (Figure 3.19). Seasonal variation in surface runoff mirrors seasonal variation in precipitation (Pugh and Westerman 2014).

Average monthly flows for selected streams in the WAWRPR are shown on Figure 3.20. At all of the stations, streamflow is highest during the winter to spring months, which is consistent with the normally higher precipitation during this same period (see Figure 3.9). A map displaying the locations of the US Geological Survey (USGS) gages used is on Figure 3.21. As would generally be expected, all of the stations report streamflow is generally lowest during the summer months, particularly August. This is due to the decrease in precipitation and an increase in evapotranspiration that occurs during the growing season (USACE Little Rock District 1988). Many streams in the planning region flow only after rainfall, having little or no base flow. As a result, many of the small streams in this planning region are dry at least part of the year (Woods et al. 2004).

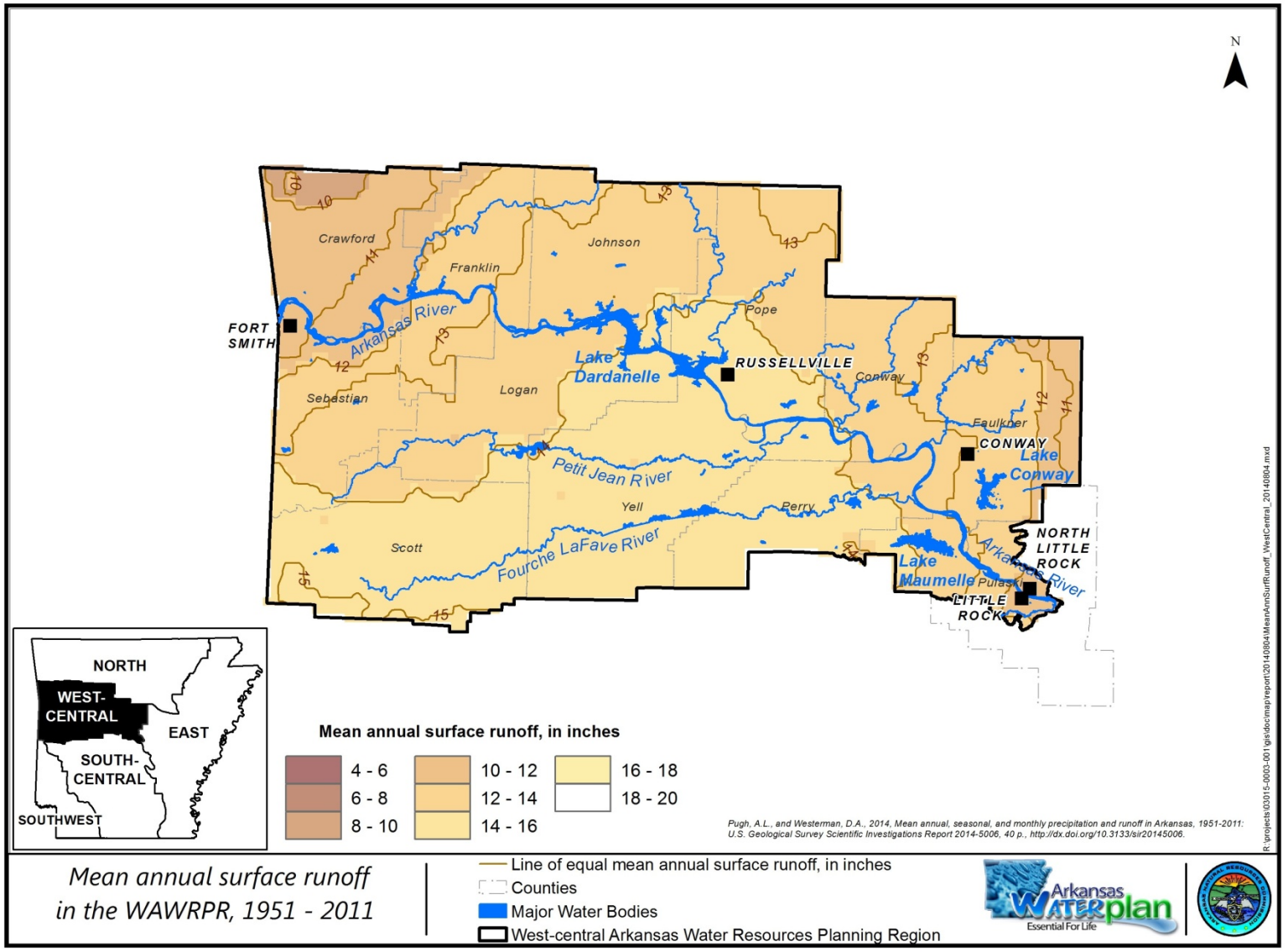

Figure 3.19 Average annual surface runoff in the WAWRPR, 1951 to 2011 (Pugh and Westerman 2014).

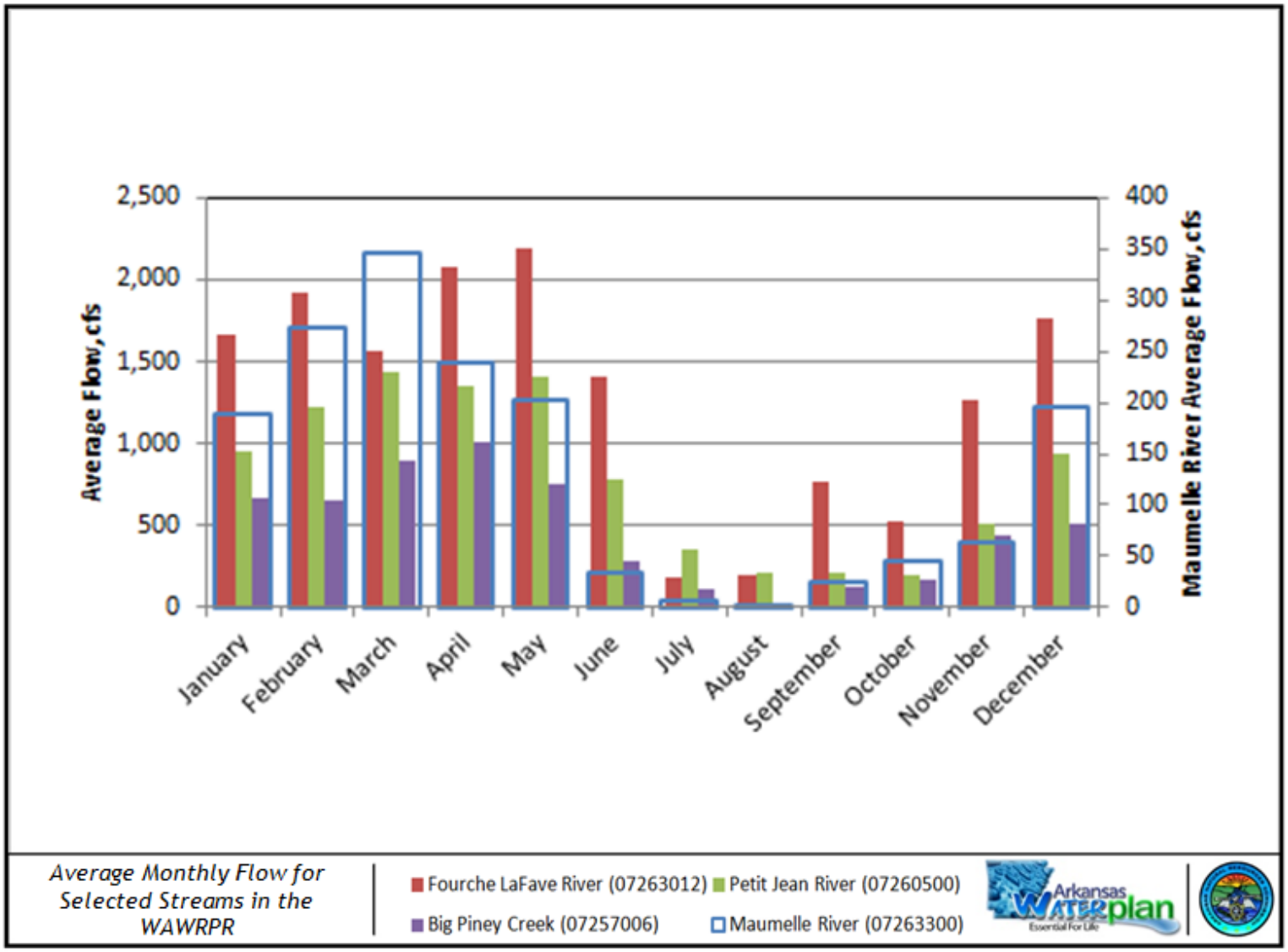

Figure 3.20. Average monthly flow for selected streams in the WAWRPR (USGS 2013a).

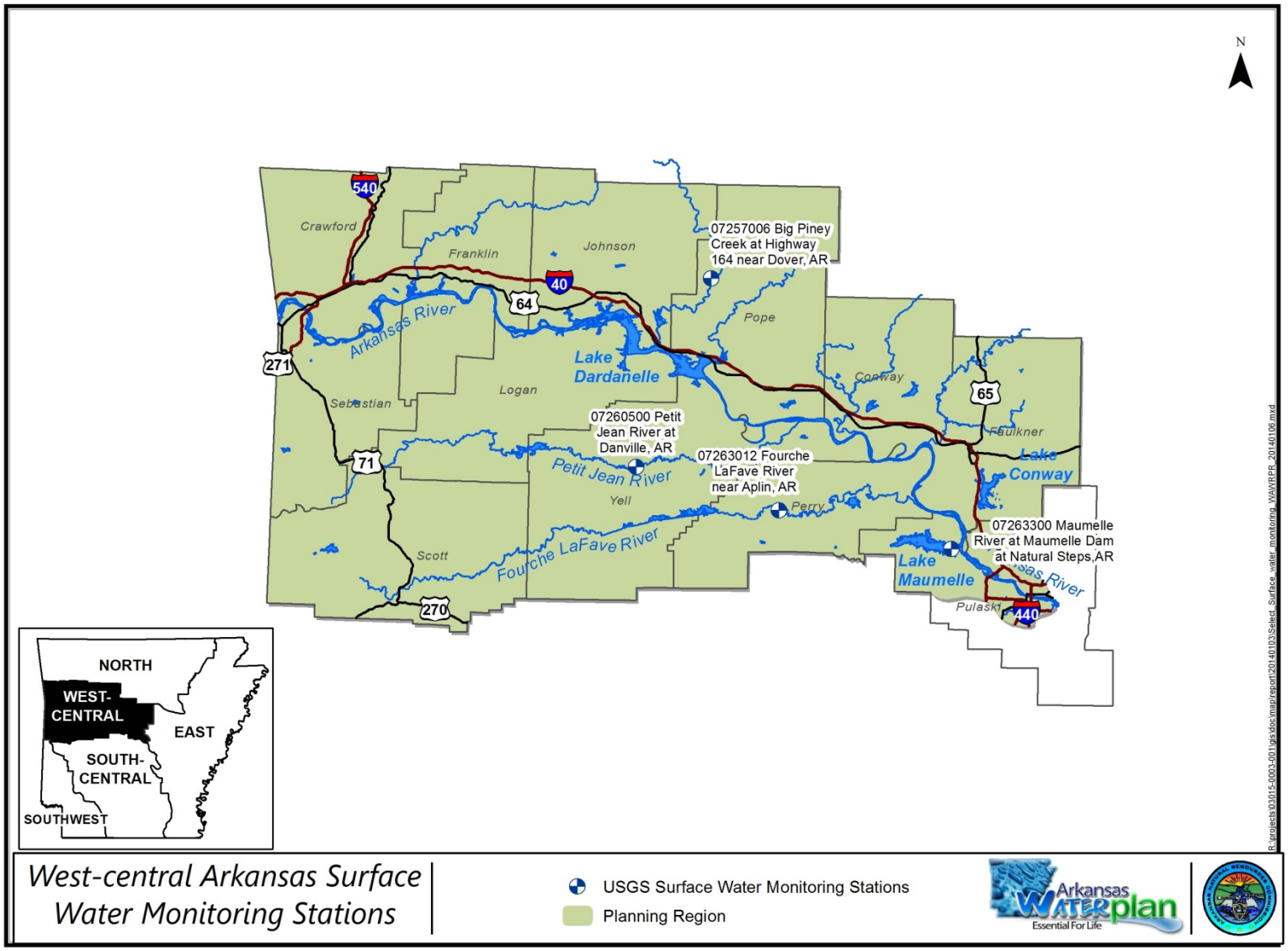

Figure 3.21. Select USGS surface water gage stations.

3.7.2 Lakes and Impoundments

In 1981 there were over 100,000 acres of lakes and impoundments in the planning region, with the largest being the Dardanelle and Ozark impoundments on the Arkansas River. Some of the other notable impoundments in the planning region include Blue Mountain Lake, Nimrod Lake, and Lake Fort Smith. The majority of the smaller impoundments are used for agricultural purposes, such as for livestock. Table 3.6 gives a summary of impoundments in the region. An updated state-wide inventory of impoundments is being prepared for the 2014 water plan update.

The Arkansas Department of Environmental Quality (ADEQ) has identified 21 significant publicly owned lakes in the planning region. These are lakes that are at least 100 acres and have access designed to enhance public use (ADPCE 1990). Information for the significantly publicly owned lakes within the WAWRPR is summarized in Table 3.7.

Table 3.6. Summary of lakes and impoundments in the WAWRPR (ASWCC 1981).

	Number of Lakes and Impoundments	Area (acres)	Capacity (acre-feet)
Conway County	3,015	3,509	10,626
Crawford County	2,322	2,264	62,861
Faulkner County	4,072	3,298	27,995
Franklin County	1,990	2,408	25,101
Johnson County	1,379	2,641	18,282
Logan County	2,898	1,403	10,890
Perry County	1,085	2,250	29,422
Pope County	2,741	3,230	15,322
Pulaski County [1]	806	13,798	236,921
Scott County	2,867	1,910	12,234
Sebastian County	1,805	1,466	24,305
Yell County	2,382	1,267	11,819
USACE	2	6,460 (conservation pool)	53,650 (conservation pool)
USACE[2]	2	44,900 (top of power pondage)	679,500 (top of power pondage)

Table 3.6. Summary of lakes and impoundments in the WAWRPR (continued).

	Number of Lakes and Impoundments	Area (acres)	Capacity (acre-feet)
USFS	5	343	4,173
Parks & Tourism	3	168	1,024
AGFC	9	11,404	85,820
Total[3]	**27,381**	**96.259**	**1,256,295**

1 Not included entirely in the WAWRPR.
2 Arkansas River Impoundments.
3 Totals based on power pondage area and capacity

Table 3.7. Information for significant publicly owned lakes/reservoirs in the WAWRPR (ADEQ 2012d).

Name	County	Lake type	Surface area (acres)	Average Depth (feet)	Capacity (acre-feet)	Purpose[1]
Lake Dardanelle	Johnson, Logan, Pope, and Yell	Reservoir	34,300	14	480,200	N/P/R
Ozark Lake	Franklin	Reservoir	10,600	14	148,400	N/P/R
Lake Maumelle	Pulaski	Reservoir	8,900	23	204,700	WS
Lake Conway	Faulkner	Reservoir	6,700	5	33,500	A
Nimrod Lake	Yell	Reservoir	3,550	8	28,400	FC/R
Blue Mountain Lake	Logan	Reservoir	2,910	9	26,190	FC/R
Lake Fort Smith	Crawford	Reservoir	1,390	66	91,420	WS
Harris Brake Lake	Perry	Reservoir	1,300	6	7,800	A
Brewer Lake	Conway	Reservoir	1,165	20	23,300	WS
Overcup Lake	Conway	Reservoir	1,025	4	4,100	A
Hinkle Lake	Scott	Reservoir	965	5	14,475	A
Beaver Fork	Faulkner	Reservoir	900	10	9,000	R
Atkins Lake	Pope	Reservoir	750	5.5	4,125	A
Lee Creek	Crawford	Reservoir	634	11	6,974	WS
Nolan	Sebastian	Reservoir	350	9	3,150	A
Sugarloaf	Sebastian	Reservoir	250	12	2,000	A
Cove Lake	Logan	Reservoir	160	10	1,600	R
Lake Bailey	Conway	Reservoir	124	8	992	R
Horsehead Lake	Johnson	Reservoir	100	16	1,600	R
Spring Lake	Yell	Reservoir	82	23	1,886	R
Shores Lake	Franklin	Reservoir	82	10	820	R

1 A = Angling (fishing), FC = Flood Control, N = Navigation, P = Power, R = Recreation, WS = Water Supply

The physiography and geology of the WAWRPR is conducive to dam construction as groundwater resources in the region are limited. As a result, a large number of the streams in the planning region are dammed and their flow regulated. These include the Arkansas River, Petit Jean River, Lee Creek, Frog Bayou, Little Clear Creek, Little Mulberry Creek, Galla Creek, Ouachita Creek, Tupelo Bayou, West Fork Point Remove Creek, East Fork Point Remove Creek, Fourche La Fave River, Upper Poteau River, Sixmile Creek, Cypress Creek (in Conway County), Maumelle River, and Flat Rock Creek (in Sebastian County).

3.7.3 Waterborne Transportation

Waterborne transportation of commodities occurs in the WAWRPR on the Arkansas River, which is part of the MKARNS through the entire length of the planning region (Figure 2.2). The MKARNS system includes 18 locks spanning 450 miles and 420 feet of elevation change. In the WAWRPR there are six MKARNS lock and dam facilities: W.W. Trimble Lock and Dam No. 13 in Barling, Ozark-Jeta Taylor Lock and Dam No. 12 in Ozark, Dardanelle Lock and Dam No. 10 in Russellville, Arthur V. Ormond Lock and Dam No. 9 in Morrilton, Toad Suck Ferry Lock and Dam No. 8 in Conway, and Murray Lock and Dam No. 7 in Little Rock (Goss 2012). All of the lock and dams are maintained and operated by the Little Rock USACE. The MKARNS navigation channel is maintained to 9 feet. In 2005 Congress authorized construction of a 12 foot navigation channel along the entire length of the MKARNS, but funding has been limited. Therefore, the 12 foot navigation channel will not be maintained until a complete funding package is provided by Congress. There are two public ports on the MKARNS in the planning region, at Fort Smith and Little Rock, and one private owned multi-modal port, Five Rivers Distribution, at Van Buren. In addition to the locks and dams, channel stabilization structures, and routine dredging are required to maintain the MKARNS navigation channel. Commercial navigation on the MKARNS is generally feasible year-round.

3.7.4 Wetlands

Several types of wetlands exist in the WAWRPR, including mountaintop depressions and sandstone glades, which can be found along the mountaintop areas in the Ozark National Forest.

Several floodplain wetland types and wetlands associated with impoundments also occur in the planning region. Wet tallgrass prairie has also historically occurred in the planning region (Arkansas Multi-Agency Wetland Planning Team 2001).

3.7.5 Surface Water Quality

Surface water quality in the Boston Mountains region of the WAWRPR is exceptional overall, with concentrations of most biochemical and nutrient characteristics being very low. Water quality in the Arkansas River Valley region is influenced more by land use that geology. While the overall water quality in this region is generally good, dissolved oxygen levels tend to be lower than in the Boston and Fourche Mountains, while turbidity, nutrients, and biochemical oxygen demand tend to be higher. Water quality in the Fourche Mountains surface waters tends to be exceptional, with low mineral, nutrient, and biochemical parameter concentrations (Woods, et al. 2004). Surface water quality issues within the WAWRPR are discussed in detail in Section 5.5.

3.8 Groundwater

In general, groundwater of the WAWRPR is of good quality. Compared to the Gulf Coastal Plain, the Interior Highlands have less reported groundwater use. This usage has been attributed to the prevalent use of surface water, less agriculture, lower population and industry densities, lower yield from geologic formations, and lack of detailed reporting in the Interior Highlands. The various aquifers of the Interior Highlands generally occur in shallow, fractured, and discontinuous bedrock. These bedrock characteristics result in lower porosity, lower storage, and lower yields than the laterally extensive, coarse-grained, and unconsolidated sediments of the Gulf Coastal Plain. The dominant use of groundwater in the Interior Highlands is domestic supply, with minor industrial, small-municipal, and commercial-supply uses (Kresse et al. 2013). A discussion on the groundwater quality in the WAWRPR is presented in Section 5.

3.8.1 Aquifers

There are two recognized aquifers in the WAWRPR, which are listed in Table 3.8 and mapped on Figure 3.22. These aquifers are considered minor and are only important as local sources of water. Kresse and others (2013) provide a comprehensive review of the aquifers of Arkansas to include the geologic setting, hydrologic characteristics, water levels, water use, and water quality. Much of the information presented in this section was summarized from the Kresse and others (2013) report.

Within the Ouachita province, fractured Paleozoic rocks of the Ouachita Mountains comprise the Ouachita Mountains aquifer (Kresse et al. 2013). Unconsolidated alluvial deposits underlying some areas of the Arkansas River also serve as a source of groundwater supply. The Arkansas River Valley alluvial aquifer is one of the most productive aquifers in the Interior Highlands and is capable of producing greater than 500 gallons per minute (gpm) for both municipal and irrigation use (Kresse et al. 2013).

The Boston Mountains Plateau and a portion of the Arkansas River Valley belong to the Western Interior Plains (WIP) confining unit and there are no formally recognized aquifers. However, there are several shallow, undifferentiated, and saturated rocks of limited extent that serve as groundwater supply for domestic and small community purposes (Adamski, Freiwald and Davis 1995).

Table 3.8. Nomenclature, geologic age, and use of aquifers in the WAWRPR.

Major Division	Province	Section	Formation or Group of Formations	Geologic Age	Hydrogeologic Unit Name	Aquifer Use[1]
Interior Highlands	Ouachita Province	Arkansas Valley	Arkansas River Valley Alluvium	Quaternary	Arkansas River Valley alluvial aquifer	PS, IR, D
		Ouachita Mountains	Boggy Formation Savanna Formation McAlester Formation Hartshorne Sandstone Atoka Formation Johns Valley Shale Jackfork Sandstone	Pennsylvanian	Ouachita Mountains aquifer	D
	Ozark Plateaus	Boston Mountains	Atoka Formation Bloyd Formation Hale Formation Imo Shale Pitkin Limestone Fayetteville Shale Batesville Sandstone Ruddell Formation Moorefield Formation	Mississippian and Pennsylvanian	Western Interior Plains Confining System	D

[1]IR= irrigation, PS = public supply, IN = industrial, D = domestic. Listed in order of highest use by volume. Primary use in capital letters; secondary use in small caps.

3.8.1.1 Western Interior Plains Confining Unit

The Boston Mountains Plateau and a portion of the Arkansas River Valley are represented by a group of formations referred to as the Western Interior Plains (WIP) Confining Unit. These formations are comprised primarily of fractured shale, sandstone, and siltstone rocks of Mississippian and Pennsylvanian age that are characterized by low porosity, permeability, and yields. While there are no formally recognized aquifers, there are numerous shallow, undifferentiated, and saturated rocks of limited extent that are used for domestic and small community supply (Kresse et al. 2013).

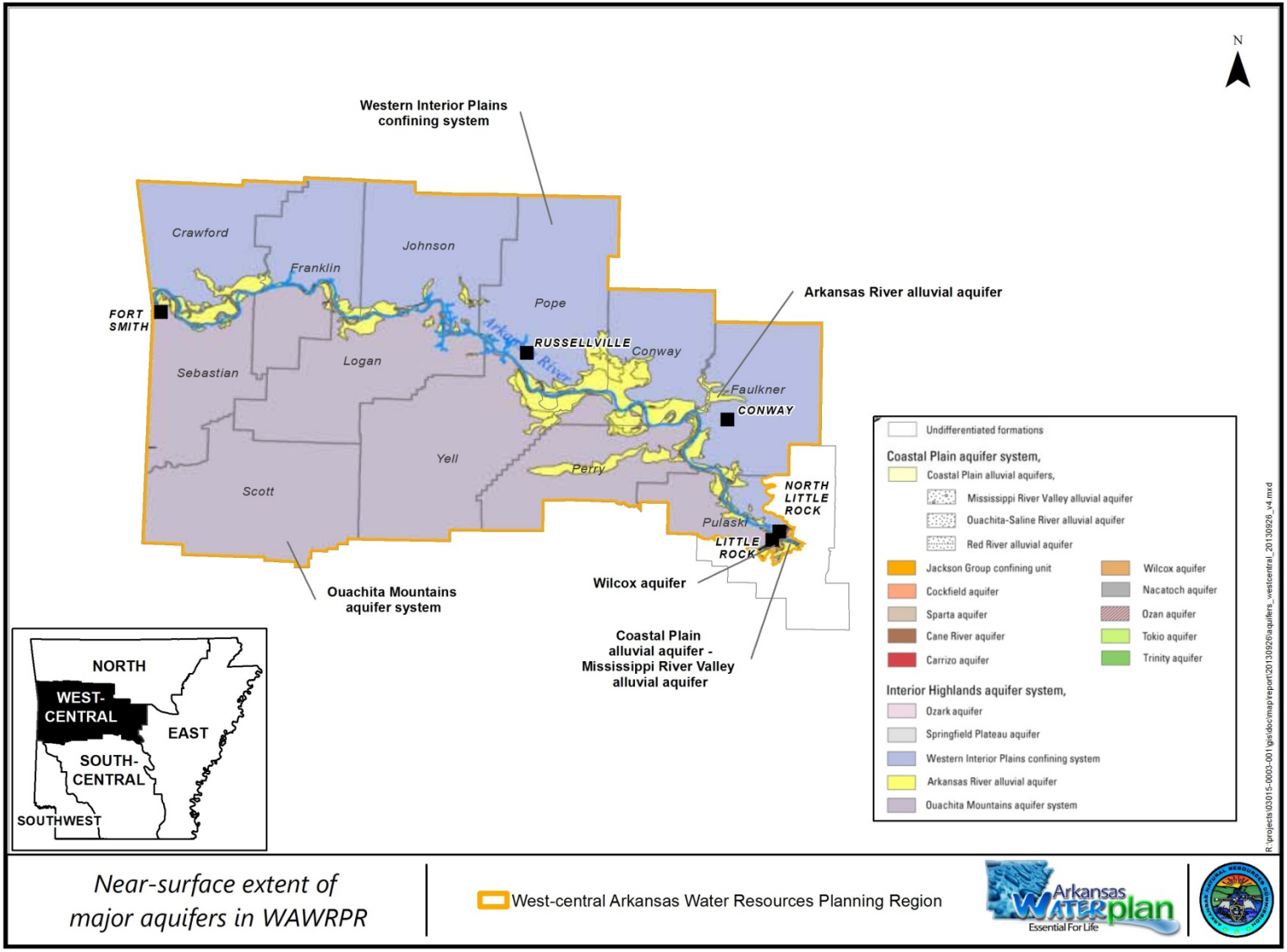

Figure 3.22. Aquifers of the WAWRPR (Kresse et al. 2013).

For this system, recharge occurs as precipitation that infiltrates the ground in upland areas and percolates to the water table. Groundwater flow paths are defined by small-scale topographic features where flow occurs from elevated areas to valley floors terminating in small stream systems. Groundwater storage in these aquifers is limited primarily to fractures and faults. Typical well yields range from 1 to 5 gpm, and thicker sandstone units in the eastern part of the WIP system commonly yield 5 to 10 gpm. It is not uncommon for wells in the WIP system to go dry during pumping, especially during dry periods. Water levels in the WIP confining system range from near land surface to approximately 50 feet below ground surface. Seasonal fluctuations are about 10 feet, with drawdowns from pumping increasing fluctuations to as much as 45 feet (Kresse et al. 2013).

3.8.1.2 Arkansas River Valley Alluvial Aquifer

Unconsolidated alluvial deposits underlying some areas of the Arkansas River valley are able to store large volumes of groundwater and are an important source of municipal water supply. Groundwater in the Arkansas River Valley alluvial aquifer is largely unconfined. Recharge to the aquifer is primarily by downward percolation of precipitation, in addition to leakage from the river (Bedinger, Emmett and Jeffery 1963; Kilpatrick and Ludwig 1990). In most places 30 to 60 feet of saturated sand and gravel is present, and the saturated thickness of the aquifer generally increases with distance downstream from Fort Smith. Wells completed in the sands and gravels in the lower part of the Arkansas River Valley alluvial aquifer are capable of yielding 300 to 700 gpm of water and are used predominantly for irrigation and municipal water supply (Bedinger, Emmett and Jeffery 1963; Kilpatrick and Ludwig 1990). Water levels range from approximately 5 to 30 feet below the ground surface (Kilpatrick and Ludwig 1990).

3.8.1.3 Ouachita Mountains Aquifer

A thick sequence of Paleozoic rock formations in the Ouachita Mountains 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 shallow saturated section of the combined formations in the Ouachita Mountains is referred to as the Ouachita Mountains aquifer

(Kresse et al. 2013). Formations comprising the aquifer are predominated by thick sequences of shale, siltstones, sandstones, and other quartz formations (i.e., chert, novaculite), with minor occurrences of carbonates and other rocks.

For this system, recharge occurs as precipitation that infiltrates the ground in upland areas and percolates to the water table. Groundwater flow paths are defined by small-scale topographic features where flow occurs from elevated areas to valley floors terminating in small stream systems. Groundwater storage in these aquifers is limited primarily to fractures and faults. Quartz formations such as the Bigfork Chert and Arkansas Novaculite are very brittle and prone to dense fracturing, and most researchers working in the Ouachita Mountains identified the Bigfork Chert as the most productive aquifer in the region (Albin 1965; Halberg, Bryant and Hines 1968; Stone and Bush 1984; Cole and Morris 1986; Kresse and Hays 2009).

Yields from wells completed in the Ouachita Mountains aquifer have a fairly large range depending on individual formations and lithology, but are typically low throughout the aquifer. Albin (1965) noted that most wells in the Ouachita Mountains aquifer yielded less than 10 gpm, and yields greater than 50 gpm were rare; however, one well completed in the Bigfork Chert was recorded as yielding 350 gpm (Kresse et al. 2013). In spite of the upper range for reported yields and other hydrologic characteristics for various formations constituting the Ouachita Mountains aquifer, caution was expressed by all authors for planning and management purposes that groundwater should not be considered as a source of supply for municipal growth and economic development unless the required quantity was small (Albin 1965; Halberg, Bryant and Hines 1968; Stone and Bush 1984).

Most wells in the Ouachita Mountains aquifer are less than 100 feet deep, but can range up to approximately 700 feet deep, with static water levels generally less than 20 feet below land surface, and flowing-artesian wells found throughout the region (Albin 1965, Kresse and Hays 2009). Pumping water levels may be as much as 150 feet below land surface in deeper wells. Seasonal water-level fluctuations in wells generally are less than 10 feet; however, larger fluctuations are common in abnormally wet or dry years because the groundwater reservoirs generally have small storage capacities and are recharged by rapid infiltration of local precipitation (Albin 1965).

3.8.2 Groundwater Quality

In general, ground water quality in the WAWRPR is considered good. Groundwater chemistry in the planning region is primarily calcium-bicarbonate. Water quality characteristics of the aquifers in the planning region are described below.

3.8.2.1 Western Interior Plains Confining Unit

In general groundwater in the undifferentiated aquifers of the WIP is of good quality. Groundwater from the undifferentiated aquifers of the WIP system is typically a strongly calcium-bicarbonate to sodium bicarbonate water type. Groundwater with elevated iron, sulfate, and chloride may be encountered in localized areas (Kresse et al. 2006, 2012). Constituent concentrations were attributed to the rock type, groundwater residence times (degree of water rock interaction), and microbially mediated processes. Nitrate concentrations are relatively low in WIP aquifers.

3.8.2.2 Arkansas River Valley Alluvial Aquifer

Groundwater in the Arkansas River Valley alluvial aquifer is of overall good water quality. Groundwater from this aquifer is characterized by a strongly calcium-bicarbonate type water and wide variations in the dissolved-solids content (Bedinger, Emmett and Jeffery 1963; Kresse et al. 2006, 2013). Groundwater is subject to reducing conditions in various parts of the aquifer that control the distribution and concentration of nitrate, iron, and sulfate.

3.8.2.3 Ouachita Mountains Aquifer

Water quality and type generally are defined by the two major rock types in the Ouachita Mountains: quartz rocks (sandstone, chert, and novaculite) and shale. Groundwater from quartz formations tend to have low pH values, low dissolved solids concentrations, and are very soft water of a mixed water type representative of precipitation concentrated by evapotranspiration processes. Groundwater from shale rock in the system is characterized by strongly calcium- to sodium-bicarbonate water type, with varying constituent concentrations defined by residence time along the flow path. Sulfate and chloride concentrations tend to be elevated in some areas

for groundwater from shale formations. No spatial relation was noted, however, for the distribution of iron concentrations, and high and low concentrations occurred in shale and quartz formations. Iron is abundant in numerous mineral forms in sedimentary rocks throughout Arkansas, and elevated iron in the Ouachita Mountain aquifer were attributed to microbially mediated processes (Kresse et al. 2013).

3.9 Groundwater-Surface Water Connections

During normal and low river stages, the water-table surface slopes toward the Arkansas River and larger tributary streams. Local water-table highs are common beneath the more permeable surface materials where recharge rates are high. During high river stages, the groundwater gradient is reversed near the river, and water-table troughs form along each side of the river. Locally, pumping can modify the shape of the water table. Pumping for irrigation has little pronounced effect, because irrigation wells are widely spaced and pumpage is small. However, withdrawals for municipal supply are near continuous and are concentrated in small areas. Bedinger and others (1963) noted that pumping at the Atkins municipal well field had a pronounced effect on the groundwater table. The well fields of Ozark and Dardanelle, which are near the river, had cones of depression extending from the well fields to the river, inducing recharge from the river. Studies by Kresse and others (2006) of influx of river water into the Dardanelle well field suggests that the alluvial aquifer may not be hydraulically connected with the river in some sections. Studies by Bedinger and others (1963) and Kresse and others (2013) indicate that any appreciable influx of water will potentially occur from the Arkansas River only where wells are in close proximity to the river and pumping is on a continual basis (municipal use, rather than seasonal pumping for irrigation).

4.0 SOCIO-ECONOMIC CHARACTERISTICS

The socio-economic characteristics of the WAWRPR include demographics, income and employment, and industry. This section describes these characteristics within the planning region and how they have changed since the 1990 AWP update. In addition, the waste generated by the communities and industries in the WAWRPR are discussed since the management of these wastes may have the potential to impact water quality in the planning region.

4.1 Demographics

Demographic information from the 2010 US census for the counties within the WAWRPR are presented below. This data includes population totals and changes, the percentage of people living in urban and rural areas, populations above or below selected ages, and populations based on race. The information collected from the 2010 census is compared to the information from the 1990 census to identify the changes that have occurred in the population of the planning region since the 1990 AWP update. Although the 1990 AWP update reported demographic data from the 1980 census, the 1990 census data better represents conditions at the time of the previous AWP update.

4.1.1 2010 Population

Population data for the counties within the WAWRPR from the 2010 census is mapped on Figure 4.1 and summarized in Table 4.1 and. The 2010 population of the planning region was over 876,000 (US Census Bureau 2012a). The counties with the largest populations, all over 100,000, are Pulaski, Sebastian, and Faulkner Counties. While not all of Pulaski County is included in the planning region, a large part of the cities of Little Rock and North Little Rock, and therefore a large part of the population, are located within the planning region. The counties with the smallest populations, less than 20,000, are Perry, Scott, and Franklin Counties.

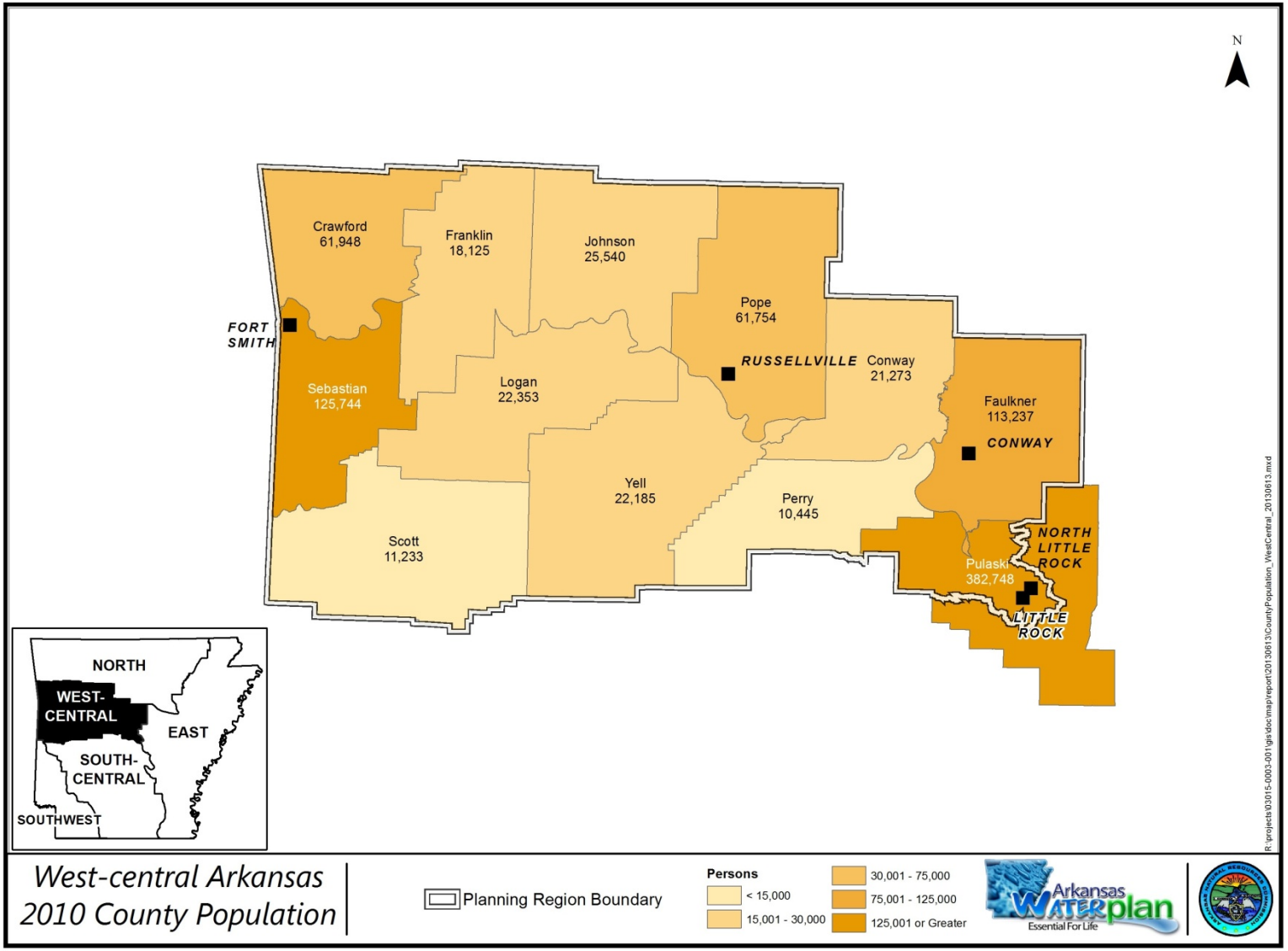

Figure 4.1. Population total from the 2010 census for counties in the WAWRPR.

Parts of two Large Metropolitan Statistical Areas are located within the WAWRPR; Fort Smith, and Little Rock-North Little Rock-Conway (US Census Bureau 2012b). Three Urbanized Areas are located in the planning region; Conway, Fort Smith, and Little Rock, along with nine areas identified as Urban Clusters in the 2010 census (Figure 4.2) (US Census Bureau 2011a). The majority of the population (nearly 68%) live in urban areas (Table 4.1). The percentage of people living in urban areas varied from 0% in Perry County, to close to 90% in Pulaski County (US Census Bureau 2012a).

Table 4.1. County populations in the WAWRPR (US Census Bureau 2003, 2012a).

	Total Population			Percent urban population		
County	**1990**	**2010**	**Change 1990 to 2010**	**1990[+]**	**2010**	**Change in percent urban population 1990 to 2010**
Conway	19,151	21,273	11%	32.1%	29.5%	-2.6
Crawford	42,493	61,948	46%	41.9%	48.0%	6.1
Faulkner	60,006	113,237	89%	43.5%	61.2%	17.7
Franklin	14,897	18,125	22%	19.0%	17.4%	-1.6
Johnson	18,221	25,540	40%	23.6%	28.6%	5.0
Logan	20,557	22,353	9%	30.7%	29.0%	-1.7
Perry	7,969	10,445	31%	0%	0%	0
Pope	45,883	61,754	35%	43.3%	45.5%	2.2
Pulaski*	349,660	382,748	9%	87.9%	87.7%	-0.2
Scott	10,205	11,233	10%	29.2%	29.6%	0.4
Sebastian	99,590	125,744	26%	79.8%	79.2%	-0.6
Yell	17,759	22,185	25%	20.4%	20.9%	0.5
Totals	**706,391**	**876,585**	**24%**	**67.5%**	**67.7%**	**0.2**

* Part of this county is in another planning region.
[+] These percentages calculated using the current urban area definition, not the 1990 definition (US Census Bureau 2003, 2012a)

Demographic data on race in the WAWRPR are summarized in Table 4.2. The WAWRPR is not racially diverse, having a 70% White non-Hispanic population. The Black, Hispanic, and Asian populations make up 18%, 7%, and 2% of the population respectively, with all other races accounting for less than 1% of the population respectively. Demographic data on age, education level, and sex are summarized in Table 4.3. In this planning region, almost two-thirds of the population is made up of people between the ages of 18 and 65 years of age, 27% of the adults are high school graduates, and 20% have college degrees.

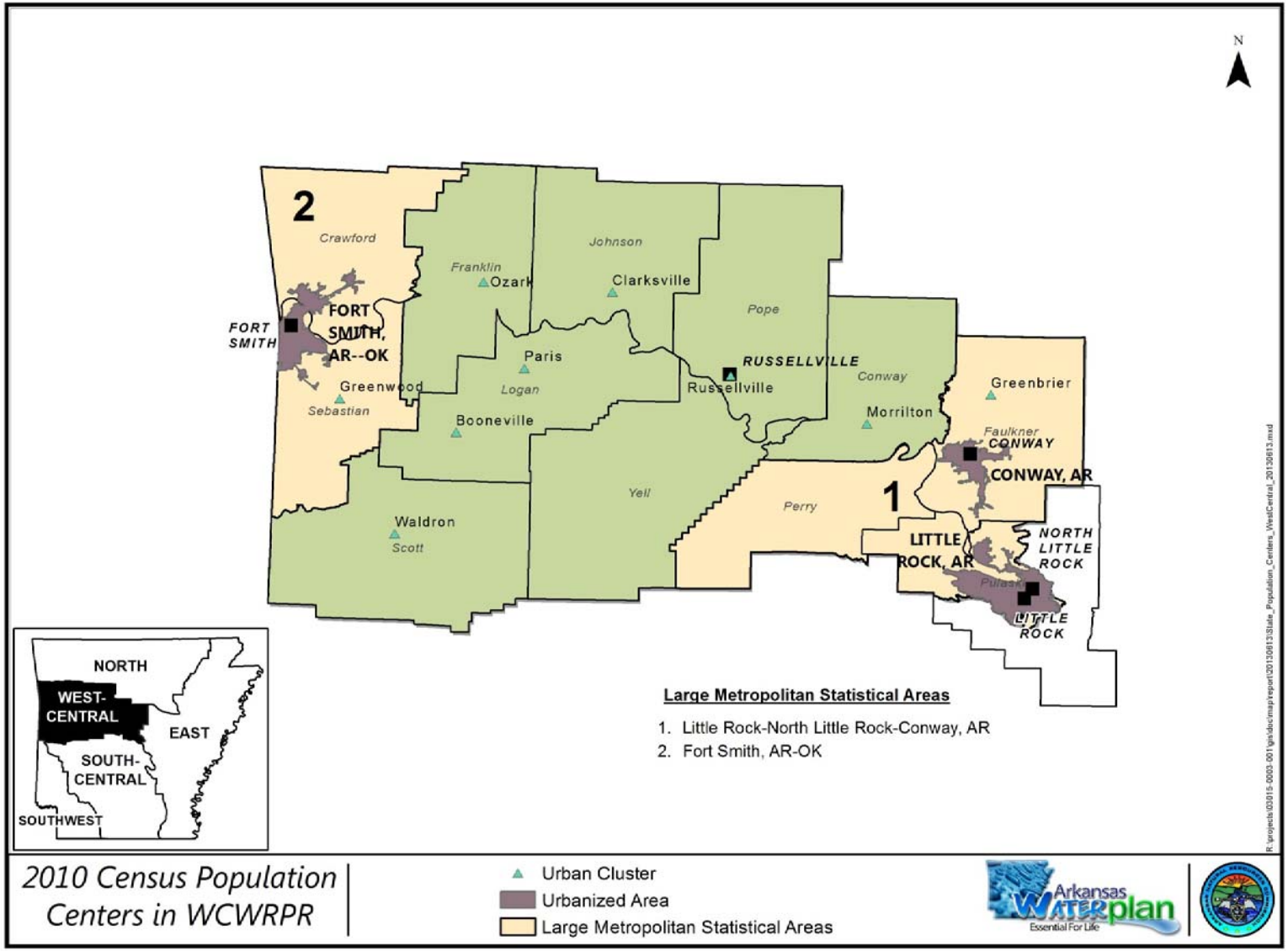

Figure 4.2. Large metropolitan statistical areas for 2010 urban areas and urban clusters in the WAWRPR.

Table 4.2. Demographic summary for counties in the WAWRPR (US Census Bureau 2012a).

County	White Non-Hispanic	Black	Hispanic	Asian	American Indian	Pacific Islander	Other Single Race	Multiple Race
Conway	17,533	2,376	757	76	147	4	10	370
Crawford	53,770	696	3,760	874	1,331	19	38	1,460
Faulkner	93,326	11,495	4,435	1,266	612	42	109	1,952
Franklin	16,997	124	371	162	183	24	3	261
Johnson	21,328	336	3,094	175	209	17	19	362
Logan	20,608	285	510	361	228	4	4	353
Perry	9,779	196	247	17	59	2	3	142
Pope	53,667	1,748	4,168	597	397	18	36	1,123
Pulaski*	211,697	133,242	22,168	7,425	1,267	155	515	6,279
Scott	9,587	51	782	379	190	3	3	238
Sebastian	91,585	7,848	15,445	5,039	2,186	69	82	3,490
Yell	17,020	288	4,230	278	127	2	7	233
Total	**616,897**	**158,685**	**59,967**	**16,649**	**6,936**	**359**	**829**	**16,263**
Percent	**70%**	**18%**	**7%**	**2%**	**<1%**	**<1%**	**<1%**	**2%**

*Part of this county is in another planning region.

Table 4.3. Additional demographic characteristics of counties in WAWRPR (US Census Bureau n.d.a., n.d.b.).

County	Total female population	Total population under 18 years	Total population over 65 years	High school graduates	College graduates
Conway	10,740	5,145	3,592	6,209	1,987
Crawford	31,377	16,350	8,233	14,068	5,252
Faulkner	57,614	27,742	11,318	20,873	17,154
Franklin	9,148	4,431	3,007	4,991	1,515
Johnson	12,881	6,329	3,749	6,466	2,614
Logan	11,155	5,491	3,842	6,470	1,699
Perry	5,262	2,402	1,747	3,157	840
Pope	31,144	14,241	8,113	13,191	7,796
Pulaski*	198,810	92,185	45,908	69,368	79,162
Scott	5,570	2,883	1,915	2,993	819
Sebastian	64,111	31,882	16,518	25,953	15,395
Yell	11,115	5,831	3,417	5,827	1,507
Total	**448,927**	**214,912**	**111,359**	**179,566**	**135,740**
Percent	**51%**	**24%**	**13%**	**27%**	**20%**

*Part of this county is in another planning region.

4.1.2 Changes from 1990

The population of the planning region and the percentage of the population located in urban areas in 1990 and 2010 are presented in Table 4.1. Also included are the changes in total population and the changes in the percent of urban population over the 20 year period, from 1990 to 2010. The change in population in the planning region is also represented by Figure 4.3. The population of the WAWRPR in 2010 was over 876,000, an increase of over 170,000, or 24%, since 1990 (US Census Bureau 2012a). All of the counties in the WAWRPR experienced a population increase between 1990 and 2010. These increases ranged from 9% in Logan and Pulaski Counties, to 89% in Faulkner County. The most significant increase in total population occurred in Faulkner County, where the population increased 89% between 1990 and 2010; followed by Crawford and Johnson counties with increases of 46% and 40% respectively. Similarly, the change in the percent of the urban population from 1990 to 2010 in Faulkner County was the largest at nearly 18%, which was followed by Crawford and Johnson counties at 6% and 5% respectively. Despite the large Faulkner County population increase, within the WAWRPR the majority of the counties within the planning region experienced very little change in the percent of the population living in the urban settings. The overall increase from 1990 to 2010 of the percent of the population living in urban areas in the planning region is very small, only 0.2%, while the change in the overall population for the same time period is 24%. But overall, the majority of the population (nearly 68%) continues to live in urban areas.

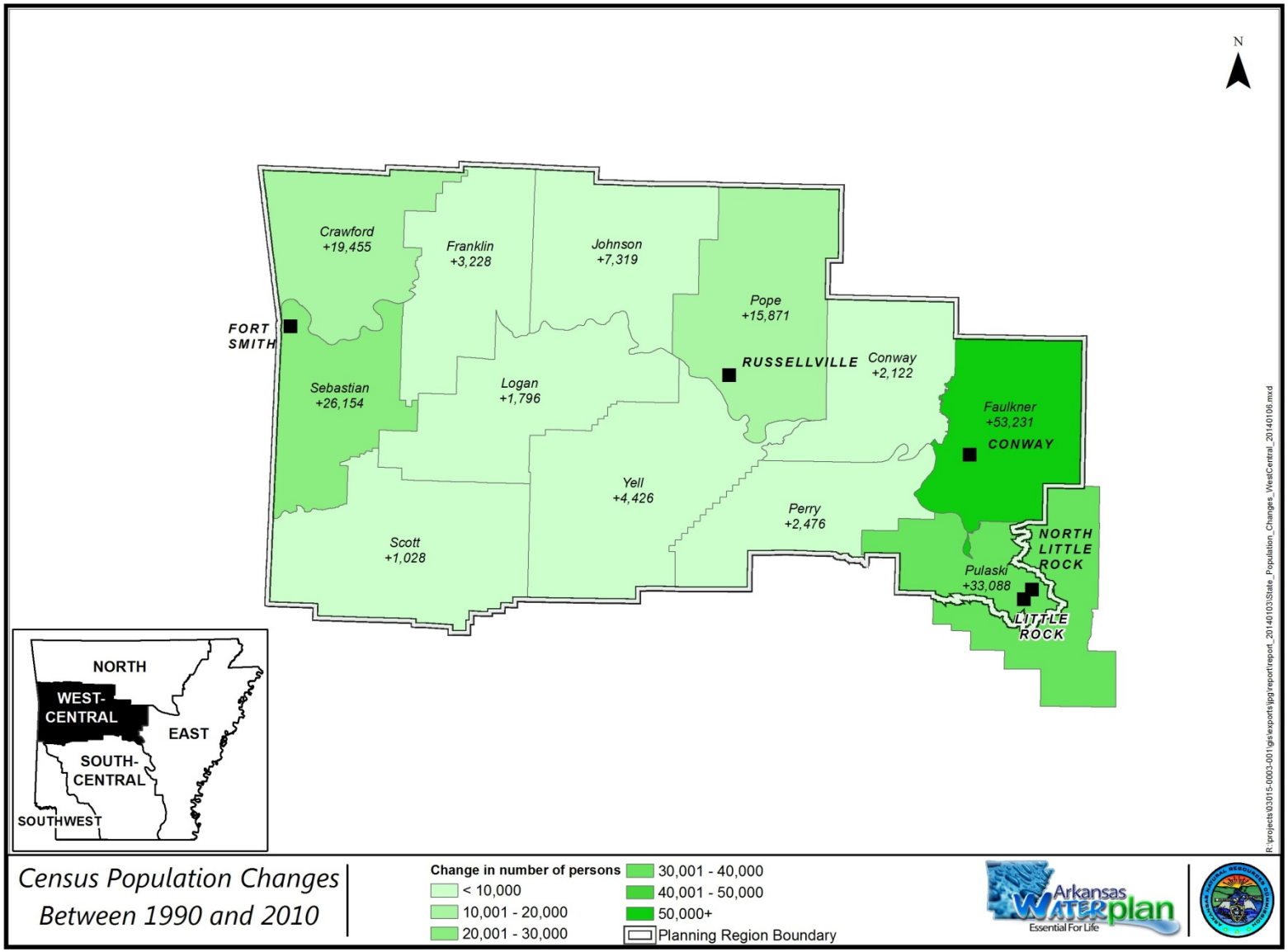

Figure 4.3. Population change from 1990 to 2010 in the WAWRPR.

4.2 Income and Employment

The income and employment data available by county from the US Census Bureau is presented below in Table 4.4 to characterize the current income and employment levels within the WAWRPR. Data from 1989 and 1990 are also presented for comparison, to provide insight into changes that have occurred in the planning region since the 1990 AWP update.

Table 4.4. Income and employment characteristics for counties in WAWRPR (US Census Bureau n.d.a.).

	Median household income		Families with income below the poverty level		Population with income below poverty level		Unemployment	
County	**1989**	**2007-2011**	**1990**	**2007–2011**	**1990**	**2007–2011**	**1990**	**2007-2011**
Conway	$20,538	$31,890	12.6%	15.3%	16.5%	21.9%	7.0%	9.3%
Crawford	$21,574	$40,409	13.1%	13.7%	16.3%	17.6%	6.3%	6.7%
Faulkner	$23,663	$47,649	9.8%	9.7%	13.8%	15.4%	6.9%	7.5%
Franklin	$18,408	$34,819	16.4%	17.0%	20.4%	20.1%	7.1%	9.9%
Johnson	$18,225	$31,400	15.6%	15.1%	20.1%	19.9%	8.7%	6.9%
Logan	$18,992	$38,447	16.0%	11.1%	19.3%	15.6%	6.7%	8.8%
Perry	$17,626	$42,514	14.4%	10.7%	20.3%	14.4%	7.4%	5.1%
Pope	$22,326	$40,325	12.5%	14.8%	15.4%	18.9%	6.4%	7.6%
Pulaski*	$26,883	$45,897	10.5%	12.5%	14.1%	16.7%	5.3%	8.1%
Scott	$16,470	$38,910	18.4%	18.1%	21.9%	22.8%	6.4%	8.7%
Sebastian	$24,037	$40,680	10.0%	14.7%	13.1%	19.5%	5.6%	6.6%
Yell	$19,647	$37,477	14.3%	14.5%	17.1%	18.5%	5.3%	7.3%
Average	**$20,699**	**$39,201**	**13.6%**	**13.9%**	**17.4%**	**18.4%**	**6.6%**	**7.7%**
Statewide Average	$21,147	$40,149	14.8%	13.8%	19.1%	18.4%	6.8%	5.0%

4.2.1 Current Income and Employment Levels

Median household incomes reported by the US Census Bureau in the 2007 – 2011 American Community Survey (ACS) for the counties included in the WAWRPR are shown in Table 4.4. The average median household income for the planning region is $39,201, which is

just below the state-wide median household income of $40,149, but is the second highest of the five planning regions. Johnson County had the lowest median household income in the planning region at $31,400 and Faulkner County had the highest median household income in the planning region at $47,649. Six of the 12 counties in the planning region had median household incomes greater than the state-wide median household income, while six counties were below the state-wide median household income (US Census Bureau n.d.).

The 2007-2011 Community Survey shows that the counties in the WAWRPR have families and population with income below the poverty level consistent with the overall state-wide averages. The average percentage of families with income below poverty level in the planning region is 13.9% and the state-wide average for Arkansas as a whole is 13.8%. Similarly, the average percentage of the population with income below poverty level in the planning region is 18.4%, which equals the percentage of Arkansas population with income below the poverty level. Although the planning region as a whole seems to be consistent with the state average for families and population with income below the poverty level, the range across the counties represented in the planning region is 9.7% in Faulkner County to 18.1% in Scott County for families, and 14.4% in Perry County to 22.8% in Scott County for overall population, living below the poverty level (US Census Bureau n.d.a.).

Unemployment across the planning region ranges from 5.1% in Perry County to 9.9% in Franklin County. The overall planning region average for unemployment is 7.7%. The overall state unemployment rate is 5%, which is below the rate for all of the counties and the planning region as a whole. Perry County, which had the lowest percentage of population with income below the poverty level (14.4%) and the second lowest percentage of families with income below the poverty level (10.7%), also had the lowest unemployment rate in the region, 5.1%.

4.2.2 Changes in Income and Employment from 1990

Information on income and employment from the 1990 census (1989 data) for the counties included in the WAWRPR is included in Table 4.4. This information demonstrates a general downturn in the economic status of the population in the planning region. While the median household income has increased from the 1990 data to the current data, the percentage of

families and overall population living below the poverty level have increased, as has the percentage of unemployment. Statewide the percentage of families and people with income below the poverty level has decreased as has the unemployment percentage, however the changes in the West-central Arkansas planning region are opposite of what has occurred with the state as a whole.

4.3 Economic Drivers

A variety of industries make up the economic drivers in the WAWRPR, contributing to both the regional and the state economy. These industries vary in their demands on regional water resources. There have been changes in the types of industries present in the planning region since the 1990 AWP update; including the expansion of the natural gas industry. This section describes the current industries operating in the planning region, using information from the most recent US Economic Census, the US Census Bureau, Census of Agriculture, industry annual reports, and economic analyses. Information from these sources was used to describe the economic landscape in 1990 and to compare the current conditions to those at the time of the 1990 AWP update.

4.3.1 Current Regional Economic Drivers

Agriculture (including timber), tourism, manufacturing, education, government and resource extraction are important economic drivers in the WAWRPR (Association of Arkansas Counties 2013). In addition to the agriculture economic sector, livestock agriculture and timber generate revenue and jobs in the manufacturing, real estate, wholesale trade, and transportation and warehousing economic sectors (U of A Divison of Agriculture 2012). Tourism generates revenue and jobs in several economic sectors including recreation, accommodation and food services, retail trade, and real estate. Transport of commodities on the Arkansas River in the planning region is important to both the regional and the state economy. The economic impact of agriculture, tourism, and waterborne commodity transportation in the WAWRPR are discussed in detail in the following sections. Part of the Fayetteville Shale Play is located within the WAWRPR, and influences the economy of the region.

The US Census Bureau conducts an economic census every 5 years. This includes information on the value of sales, and the number of people employed in each economic sector by county. The value of sales and receipts reported for the counties within the WAWRPR in the 2007 economic census is summarized on Figure 4.4. Manufacturing and wholesale trade are the economic sectors with the greatest value in the region.

The number of people employed in the WAWRPR by economic sectors, as reported in the 2007-2011 American Community Survey (ACS) and the 2007 economic census are summarized in Figure 4.5. The economic sectors for which employment is reported in these two sources are slightly different. However, both sources indicate that health care and education, manufacturing, and retail trade provide the majority of employment in the WAWRPR. In these three economic sectors, Pulaski County and Sebastian County account for at least two-thirds of the reported totals.

4.3.1.1 Agriculture

Agriculture is the largest industry in the State of Arkansas and is a prevalent and growing industry within the WAWRPR. As noted in Section 3.6, agriculture is the second largest land use in the planning region, preceded only by forested land, and pasture land is the largest land use classification within the agricultural land use designation. The market value of the agricultural products sold in the planning region in 2007 was over $1 billion (USDA National Agricultural Statistics Service 2009).

Agriculture is the main industry for several counties in the planning region (Association of Arkansas Counties 2013). Crops and livestock cultivated in the region include soybeans, rice, assorted fruit and vegetables, beef cattle, hogs, and poultry. Timber production is important for two of the counties in the planning region (Association of Arkansas Counties 2014). Another regionally important agricultural industry in the WAWRPR is winemaking, with several vineyards located in Franklin County.

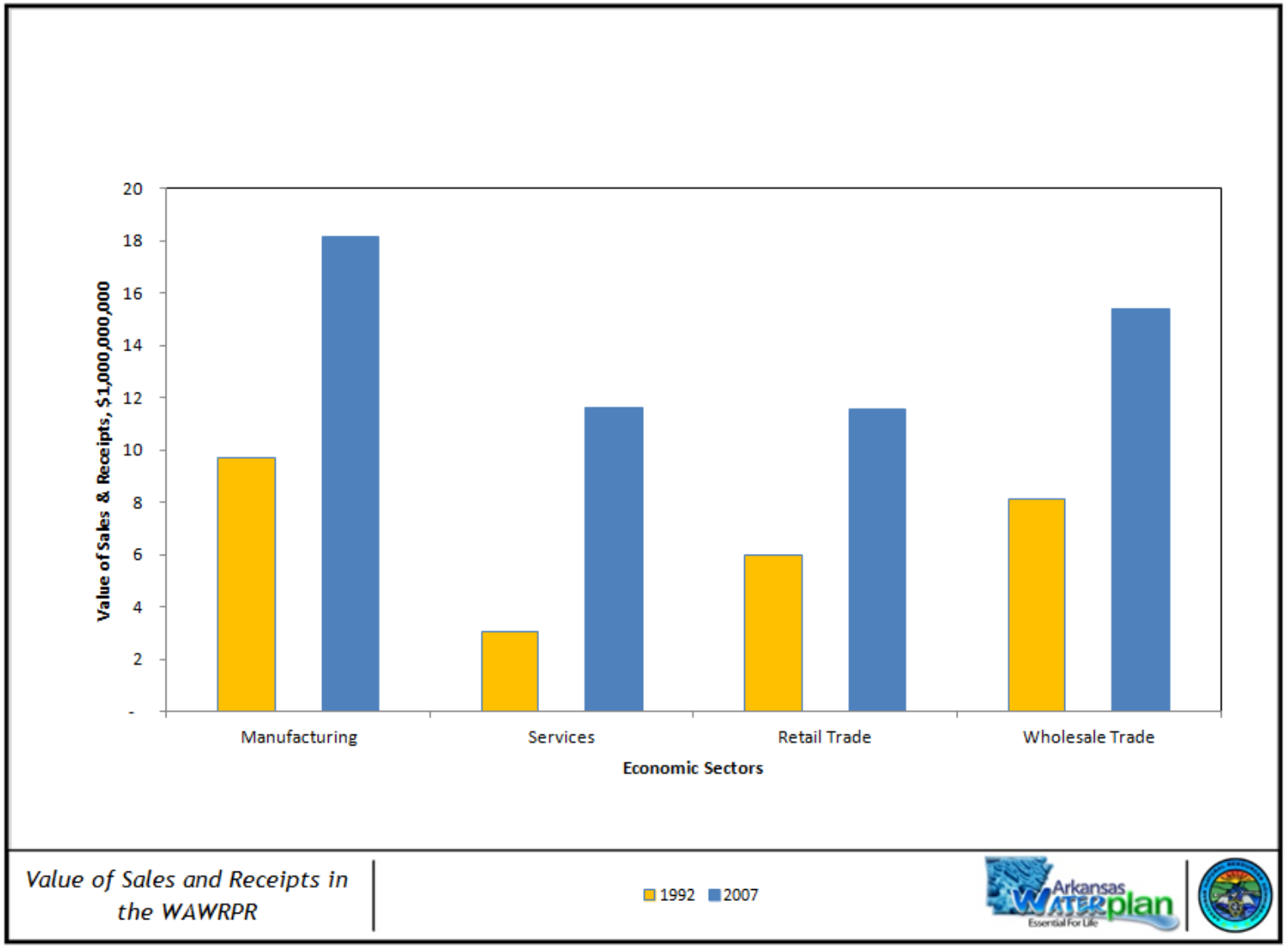

Figure 4.4. Value of sales and receipts in the WAWRPR (US Census Bureau 1992, US Census Bureau 2011b, USDA NASS 2007).

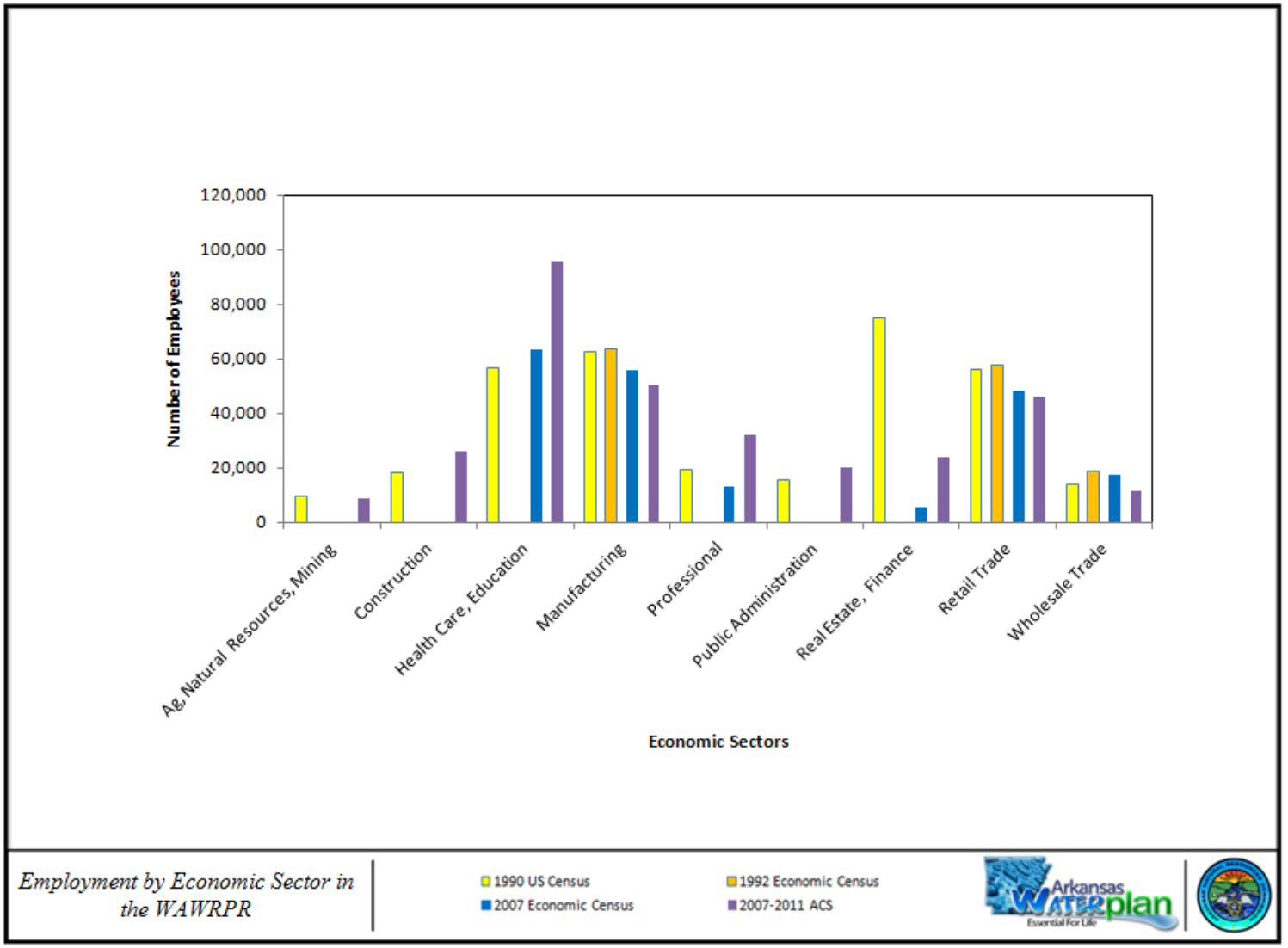

Figure 4.5. Employment by economic sectors in the WAWRPR (US Census Bureau 1992, 2011b, University of Arkansas at Little Rock Institute for Economic Advancement 2002).

4.3.1.2 Tourism

The Arkansas Department of Parks and Tourism estimated that tourism contributed over $2.9 million to the planning region economy in 2012, and is presently the state's 2nd largest industry (Table 4.5), however, the economic impact of recreation and outdoor activities is captured under several different economic sectors, making it difficult to represent.

Table 4.5. Tourism and its economic impact in the counties in the WAWRPR (Arkansas Department of Parks and Tourism 1991, 2012).

.

	Visitors		Jobs		Total Expenditures, $1,000		State tax revenue, $1000		Local tax revenue, $1,000		Payroll, $1,000	
County	**1990**	**2012**	**1990**	**2012**	**1990**	**2012**	**1990**	**2012**	**1990**	**2012**	**1990**	**2012**
Conway	64,691	97,720	189	246	$9,070	$21,846	$426	$1,343	$109	$500	$1,642	$3,886
Crawford	170,407	172,911	482	394	$23,183	$40,309	$1,090	$2,507	$278	$699	$4,196	$6,651
Faulkner	281,339	350,146	790	951	$37,968	$81,429	$1,784	$4,995	$456	$1,368	$6,872	$15,185
Franklin	28,747	58,482	86	151	$4,130	$13,918	$194	$861	$50	$305	$748	$2,565
Johnson	73,521	111,703	231	296	$11,118	$25,217	$523	$1,545	$133	$494	$2,012	$4,795
Logan	22,437	41,514	69	107	$3,309	$10,802	$156	$685	$40	$314	$599	$1,806
Perry	22,431	57,909	61	112	$2,938	$15,729	$138	$942	$35	$521	$532	$2,249
Pope	360,377	552,779	1,025	1,204	$49,261	$133,649	$2,315	$5,855	$591	$1,886	$8,916	$19,924
Pulaski	2,998,431	5,653,505	10,169	12,972	$488,767	$1,612,014	$22,972	$63,066	$5,865	$27,674	$88,467	$335,126
Scott	23,330	21,473	69	61	$3,301	$5,741	$155	$351	$40	$141	$598	$997
Sebastian	900,006	1,190,136	2,867	2,779	$137,809	$345,209	$6,477	$12,443	$1,654	$4,226	$24,943	$56,035
Yell	18,943	46,449	56	103	$2,695	$12,855	$127	$774	$32	$346	$488	$1,751
Total	4,964,660	8,354,727.	16,094	19,376	$773,549	$2,318,718	$36,357	$95,367	$9,283	$38,474	$140,013	$450,970

Recreational opportunities on the Arkansas River expanded with the construction of the MKARNS, in part through the commercial economic contribution to the planning region and by establishing the linear corridor, which encouraged the development of parks, camping areas, hiking and biking trails, and river access for boating and fishing. The Arkansas River continues to be an important resource in the planning region recreationally as marinas in the Little Rock / North Little Rock are being planned, the expansion of trails along and across the river continues, and city riverfronts are redeveloped, including Clarksville, Fort Smith, Little Rock, and North Little Rock.

The planning region boasts a number of state parks, including those at Lake Dardanelle, Lake Fort Smith, and Wooly Hollow, that provide opportunities for water-based recreation such

as hunting, fishing, boating, and bird watching. The planning region also includes 11 wildlife management areas, 6 wilderness areas, and over 21 public lakes allowing ample opportunities for water-based recreation through the planning region. ADEQ has designated 335 miles of streams in the planning region as Extraordinary Resource Waterbodies for "scenic beauty, aesthetics, broad scope recreation potential, and intangible social values" (Figure 4.6) (APCEC 2011). Over 106 miles of streams in the planning region are designated as Natural and Scenic Waterways (Figure 4.6). Portions of Big Piney Creek, Hurricane Creek, and the Mulberry River are designated National Wild and Scenic Rivers. Two counties within the planning region, Pulaski and Sebastian, were ranked in the top five counties within the state with the highest total tourism travel expenditures during 2012. (Table 4.5). USACE has estimated economic impacts of recreation associated with the reservoirs located in the WAWRPR. Overall, the two USACE reservoirs and the MKARNS generate over 1,900 jobs, and over $175 million in revenue and wages from recreation (Table 4.6).

Table 4.6. Economic benefits from USACE reservoirs in the WAWRPR in 2012 (USACE 2011).

USACE reservoir	Visitors per year	Sales per year	Number of jobs as a result of lake visits	Labor Income
Blue Mountain Lake	405,025	$7,867,000	144	$2,740,000
Lake Dardanelle (navigation pool)	1,304,569	$31,899,000	550	$11,261,000
Davie D. Terry Lake (navigation pool)*	1,256,852	$36,013,000	490	$14,122,000
John Paul Hammerschmidt Lake (navigation pool)	473,808	$12,370,000	191	$4,564,000
Murray Pool (Arkansas River)	461,504	$14,979,000	202	$5,801,000
Nimrod Lake	226,048	$4,698,000	90	$1,587,000
Ozark Lake (navigation pool)	519,159	$13,656,000	213	$5,092,000
Winthrop Rockefeller Lake (navigation pool)	74,187	$1,514,000	25	$533,000
Toad Suck Ferry Pool (Arkansas River)	146,983	$5,191,000	70	$2,022,000
Total	4,868,135	$128,187,000	1975	$47,722,000

* Part of this reservoir is in another planning region.

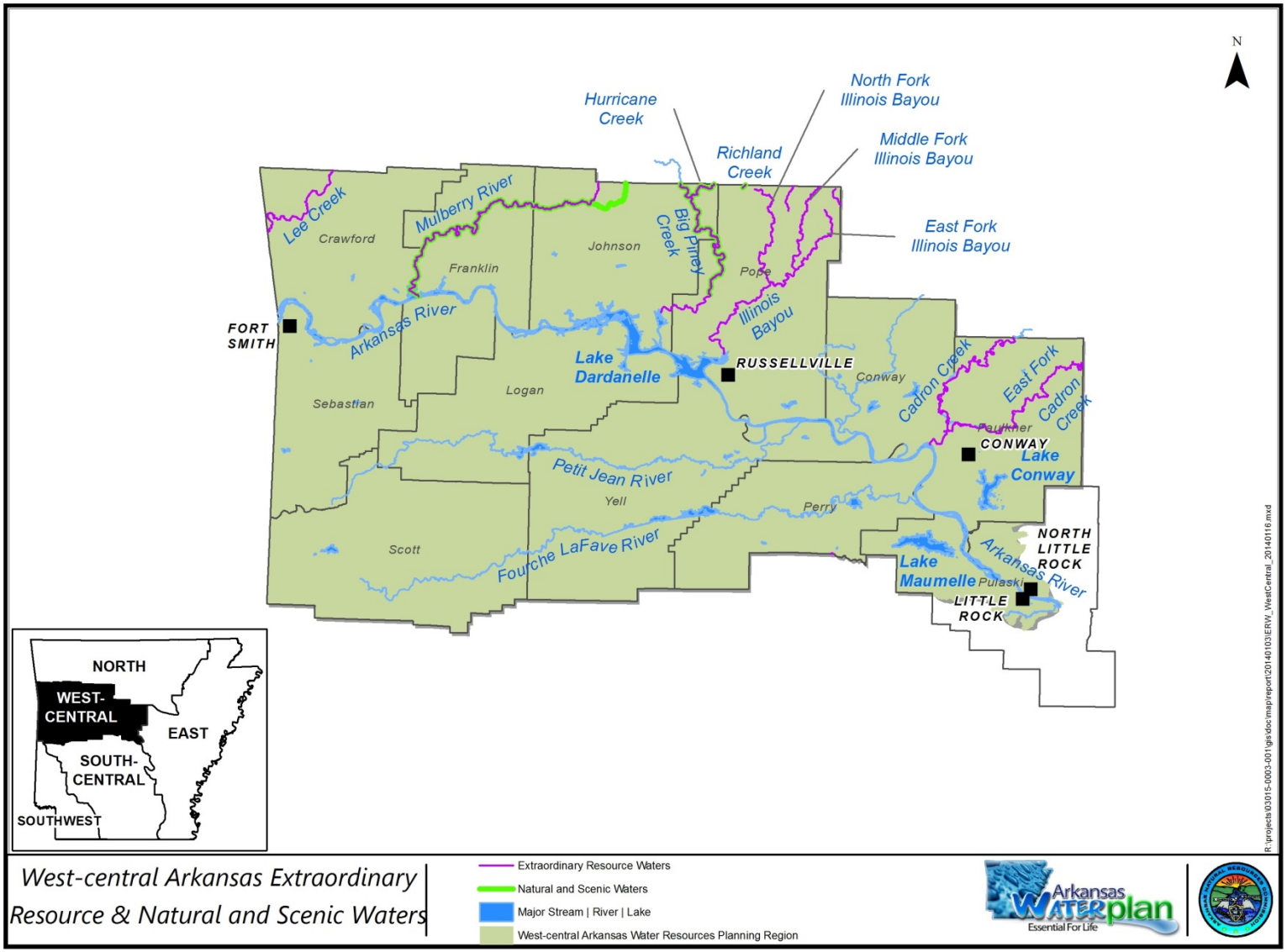

Figure 4.6. Designated extraordinary resource waters and natural and scenic waterways in the WAWRPR.

The 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, published by the USFWS and the US Census Bureau does not provide county or regional data, however, it is apparent that fishing, hunting, and wildlife-watching are significant economic activities as well as activities in which a significant part of the Arkansas population participates. Economic contributions from wildlife recreation in Arkansas are summarized in Table 4.7. In the State of Arkansas there are over 555,000 anglers, 363,000 hunters, and over 852,000 wildlife-watching participants. In 2011, expenditures related to wildlife recreation in Arkansas totaled $1.8 billion (US Fish and Wildlife Service; US Department of Commerce Census Bureau 2013).

Table 4.7. Economic contributions from wildlife recreation in Arkansas.

Activity	Total Expenditures (Million $)		2011 Retail Sales (Million $)[c]	2011 State/Local Tax Revenue (Million $)	2011 Federal Tax Revenue (Million $)
	1991[a]	2011[b]			
All Hunting	$85.0	$1,018.8	$877.4	$99.2	$99.5
Waterfowl Hunting	Nr	$288.0	$236.7	$29.1	$23.9
Sport Fishing	$216.9	$495.6	$508.0	$49.4	$49.8
Wildlife Watching	NR	$216.1	NR	NR	NR

a USFWS, US Department of Commerce Bureau of the Census 1993
b USFWS, US Department of Commerce Census Bureau 2013
c AGFC 2013b

4.3.1.3 Waterborne Commodity Transport

Waterborne transportation of commodities directly and indirectly contributes to the economic growth of the State, and the EAWRPR, through economic value, employment, and earnings (Nachtmann 2002). A recent study determined that the total economic impact of river transportation of commodities on the Arkansas economy is $811 million annually (Arkansas Waterways Commission 2013). The MKARNS, which traverses the entire planning region, averages 12 million tons of commodities shipments annually, with an estimated value of $2 to $3 billion per year (USACE 2012). The Arkansas River continues to be an important resource in the planning region economically as expansion of regional freight management in Fort Smith and Van Buren is being investigated.

4.3.1.4 Fayetteville Shale Natural Gas Production

The recent expansion of the natural gas industry in the planning region, specifically the Fayetteville Shale, has had direct economic effects from drilling wells to the increased need for supporting activities including construction, transportation, storage, and distribution. Within the planning region, the Fayetteville Shale includes the counties of Conway, Faulkner, Franklin, Johnson and Pope. Extensive natural gas exploration and production has been occurring in these counties, with the exception of Johnson County where there has been limited activity. The economic impacts of the industry expansion have reached Arkansas residents via mineral leases and subsequent royalty payments, and jobs with higher than average pay. Within the planning region, Conway, Faulkner, and Pope Counties experienced a rate of payroll employment growth from 2001 to 2010 that was higher than the state average. Drilling permit fees and severance tax revenues from the Fayetteville Shale activities have generated more than $92 million for the State from 2004 to 2011. During 2012, and continuing through 2013, sustained low natural gas prices have reduced the expected expenditures of the exploration and production companies and could have significant economic impacts beyond the counties included in the Fayetteville Shale area (Center for Business and Economic Research 2012).

4.3.1.5 Coal Production

The WAWRPR is home to commercially viable coal deposits. Historically, coal mining occurred in six counties in the planning region. Currently there are active coal mines in Sebastian, Scott, and Johnson Counties (Arkansas Geological Survey 2012). In 2011, approximately 99,200 tons of coal was produced by the mines in the planning region, contributing $307 million to the state GDP, directly and indirectly employing 3,030 people and providing $172 million in wages, and contributing $21 million in state and local taxes (National Mining Association 2013, Arkansas Geological Survey 2014).

4.3.1.6 Timber

The timber industry contributes to the economy of the WAWRPR. Pine plantations are located throughout the panning region. In 2012, the USDA Forest Service (USFS) reported over

3 million acres of timberland in the counties of the planning region (Table 4.8) (USFS 2013). In addition, there are sawmills at Russellville and Plumerville, a paper mill at Morrilton, and lumber manufacturing facilities at Ola and Waldo, as well as container plants in Fort Smith, Conway, and Russellville (Cottingham 2011). Statewide, paper mills, sawmills, paperboard container manufacturing, sanitary paper product manufacturing, and logging contribute 16,300 jobs, $880 million in wages, $971 million in labor income, and $1,736 million in value added to the state economy (U of A Divison of Agriculture 2012). The market value of the forest products sold in the planning region in 2007 was $2.5 million (USDA National Agricultural Statistics Service 2009).

Table 4.8. Timberland acreage within the counties of the WAWRPR (USFS 2013, Hines and Vissage 1988).

County	Timberland (acres)		Forest Industry Owned (acres
	1988	2012	1988
Conway	163,872	191,787	14,200
Crawford	211,633	208,511	0
Faulkner	168,401	219,793	0
Franklin	231,221	219,399	0
Johnson	285,208	303,070	0
Logan	242,474	254,233	12,100
Perry	260,832	267,630	135,800
Pope	353,727	367,614	11,200
Pulaski	201,803	234,669	41,400
Scott	442,655	458,490	5,700
Sebastian	149,593	140,605	0
Yell	401,521	476,793	78,100
Total	3,112,940	3,342,594	298,500

Water use in the timber industry is primarily during processing. Timberlands are not generally irrigated. Timberlands can impact water quality through erosion of forest roads, stream crossings, and harvested areas; and runoff of chemicals used in timber management.

4.3.2 Changes in Region Economy since 1990

Figure 4.4 also shows the value of sales and receipts reported in the 1992 economic census. Note that the 1992 economic census reported values only for the manufacturing, services,

retail trade, and wholesale trade sectors. The 2007 value for services shown on Figure 4.4 is a summation of values reported for economic sectors that reportedly were in included in the 1992 value for services (US Census Bureau 2011c). It appears that all of the economic sectors have experienced expansion.

Employment data from the 1990 census and 1992 economic census are included in Figure 4.5. The economic sectors used to report employment are slightly different for the two sources and the different time periods shown in Figure 4.5. While these differences make direct comparisons uncertain, using the information from different sources during similar time periods allows us to have greater confidence when identifying changes over time. It appears that employment in manufacturing, real estate and finance, and retail trade has declined since the 1990 AWP update. Other economic sectors, such as construction, and health care and education, appear to be employing more people now than in the early 1990s. Overall, however, it appears that the same economic sectors provided the majority of employment in the region in 1990 as do now; manufacturing, health care and education, and retail trade.

4.3.2.1 Agriculture

The market value of the agricultural products sold in the planning region in 1992 was over $639 million compared to over $1 billion in 2007. Although the planning region has seen a 36% decrease in designated cropland from 1992 to 2007, the number of farms, the value of the crops, and the value of the livestock have increased 19%, 71%, and 97% respectively (USDA National Agricultural Statistics Service 1992, 2007).

4.3.2.2 Tourism

Table 4.5 provides a summary of the tourism travel expenditures in 1990 and 2012 (preliminary values) for the counties within the planning region (Arkansas Department of Parks and Tourism 2012). In all counties the travel expenditures have increased from 1990 to 2012. Increases range from 74% to 435%. In Pulaski County alone, there has been increase in the total number of visitors of over 2.6 million. The economic contribution of hunting and fishing in the state has also increased since 1990 (Table 4.7).

4.3.2.3 Waterborne Commodity Transportation

On the MKARNS, a total of 8.8 million tons was transported during 1990 (Bolton 1995). Information on the value of commodities transported on the MKARNS in 1990 was not available (US Census Bureau 1996). Information on the types of commodities shipped is discussed below.

During the period from 1971 through 1994, sand and gravel made up the majority (38%) of the commodities transported on the MKARNS (Bolton 1995). In 2011, sand and gravel accounted for only around 5% of the shipping, while agricultural products (including grains, soybeans, and animal feed) made up 30% of the shipping (Table 4.9). Exported grains and soybeans accounted for an average of 21% of the commodities shipped on the MKARNS during the period from 1971 through 1994 (Bolton 1995). This is similar to 2011, when exported grains and soybeans accounted for 25% of the shipping on the MKARNS.

4.3.2.4 Fayetteville Shale Natural Gas Production

At the time of the 1990 AWP update, the Fayetteville Shale Natural Gas Play was not active in Arkansas. A new horizontal fracturing technique established in the late 1990s in the natural gas industry made it possible to extract natural gas from shale formations. Beginning in the mid-2000s, gas production began in the Fayetteville Shale formation in Central Arkansas, including Conway, Faulkner, Franklin, Johnson and Pope Counties. The introduction of this new industry in the region has had a very positive impact on the economy, providing new employment opportunities and also boosting other industries in the region, including transportation, hospitality, education, and finance (Center for Business and Economic Research, U of A 2012). The development of the Fayetteville Shale natural gas is the largest change in the regional economy since 1990.

4.3.2.5 Coal Production

Arkansas coal production was lower in the 1990s than currently. In 1990, 69,100 tons of coal was produced in the planning region. Underground mining of coal expanded in the early 21st Century (Arkansas Geological Survey 2014). Information on the economic impact of coal mining in the 1990s was not found.

4.3.2.6 Timber

Table 4.8 includes information on the acreage of timberland in 1988. The acreage of timberland in the planning region counties is slightly greater in 2012 than in 1988. In 1988, timber industry owned 298,500 acres in the planning region counties (Table 4.8). The market value of forest products sold in the planning region counties in 1987 was $641,000 (USDA National Agricultural Statistics Service 1992).

As today, in the 1990s, forestry was an important economic driver in the state, contributing over $4 billion annually to the state economy (Gray 1993). Lumber and wood products companies dominated the manufacturing sector of the state economy during this period (Advameg, Inc. 2010). Roundwood production in the state increased between 1990 and 2005 but declined to levels similar to 1990 between 2005 and 2009 (Brandeis et al. 2011).

4.4 Waste Generation and Disposal

Industries and communities produce wastes that must be properly managed to protect water quality, which contributes to water availability for the water users of the state. ADEQ is the state agency responsible for regulating solid waste, hazardous waste, and wastewater. These three waste streams are managed through separate permitting programs overseen by the EPA. Arkansas Nuclear One (ANO), located in the planning region, is regulated by the U.S. Nuclear Regulatory Commission (NRC), which includes the management of nuclear materials and waste (US Nuclear Regulatory Commission 2013). Waste management in the WAWRPR is quantified below, along with changes in waste management that have occurred since the 1990 AWP Update.

4.4.1 Solid Waste

All of three and part of one Regional Solid Waste Management Districts (RSWMDs) are located in the WAWRPR. Information on solid waste generation and disposal for each of these districts is summarized in Table 4.9 and illustrated on Figure 4.7. For the most part, the RSWMDs report that their solid waste disposal facilities and collection services are sufficient to meet demand. However, a number of illegal dump sites have been identified that could pose

local threats to water quality (Sebastian County RSWMD 2011, West River Valley RSWMD 2011, Faulkner County RSWMD 2011, Pulaski County RSWMD 2011).

Table 4.9. Solid waste generation and disposal information for RSWMDs in the WAWRPR.

RSWMD Name	Number of counties in RSWMD	Number of Counties in planning region	Number of landfills in planning region	2010 Solid Waste Generated In-district (tons)	2010 Solid Waste Disposed In-district (tons)	Number Illegal Dump Sites Identified 2010
Sebastian	1	1	1	189,261	189,261	1
West River Valley	9	9	3	122,077	120,059	53
Faulkner	1	1	2	102,092	88,430	13
Pulaski*	1	1	4	901,037	910,037	0
Total	**12**	**12**	**10**	**1,314,467**	**1,307,787**	**67**

*Part of this district is located in another planning region.

There have been significant changes in the solid waste arena since 1990, driven by the need to protect water quality. Subtitle D of the 1991 amendment of the Resource Conservation and Recovery Act (RCRA) introduced specifications for how landfills were to be constructed and managed to protect groundwater quality. In addition, the new regulations required monitoring of groundwater quality around landfills (EPA 2012a, ADEQ 2011). This led to sweeping changes in solid waste management across the country and in Arkansas (APCEC 2011).

At the same time, state regulations set up programs to fund cleanup of groundwater contamination from landfills, and for collection and recycling of batteries and waste oil, both of which pose risks to surface and groundwater quality when disposed of improperly. Around 1995, the Arkansas General Assembly established a policy to eliminate illegal dumping, another threat to surface and groundwater quality. State legislation to implement this policy was passed in 1997. In 2005, state legislation was passed that resulted in the development and implementation of a comprehensive mercury minimization program for the state. Mercury is a surface water quality issue throughout the state (ADEQ 2011). State programs initiated since 1990 for the collection and recycling of electronics, and collection of household hazardous wastes also protect water quality.

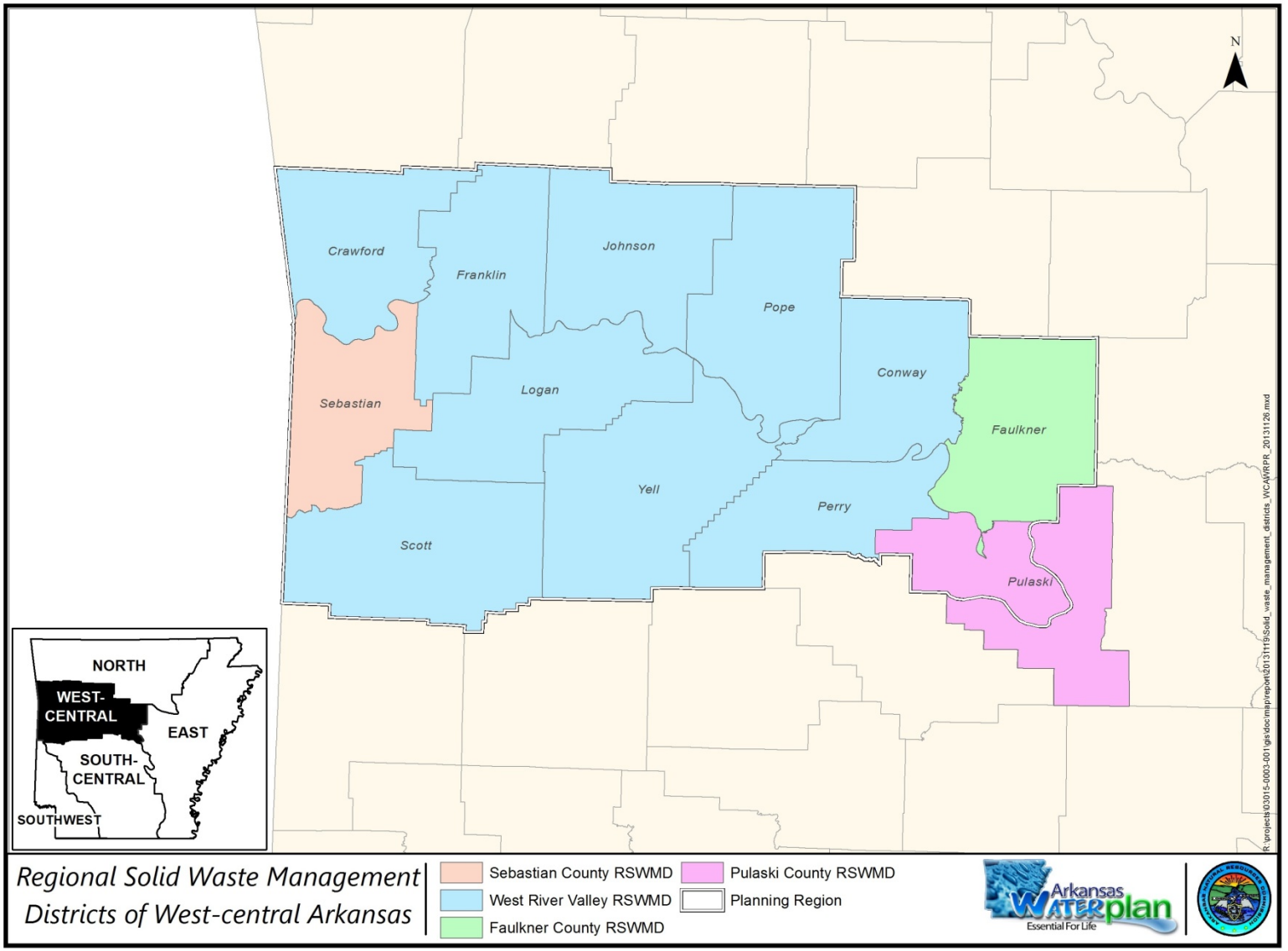

Figure 4.7. Solid Waste Management Districts in the WAWRPR.

4.4.2 Hazardous Waste

There are 160 permitted hazardous waste generators in the counties within the WAWRPR (Table 4.10). The majority of these facilities are located in Pulaski County, which is only partially located in the planning region, followed by Sebastian and Faulkner counties. Forty-eight of the facilities in the counties within the WAWRPR are classified as large quantity generators, meaning they generate at least 1,000 kilograms of hazardous waste per month (EPA 2012b). One hundred twelve of the facilities are classified as small quantity generators, meaning they generate between 100 and 1,000 kilograms of hazardous waste per month (EPA 2012c). One of the 10 facilities in the state that generated the most hazardous waste in 2011 is located in the WAWRPR (EPA 2012d). There is one hazardous waste treatment/storage/disposal facility in the region, in Pulaski County (ADEQ 2012a).

Table 4.10. Permitted hazardous waste generators in counties in the WAWRPR (ADEQ 2012a).

County	Large Quantity	Small Quantity
Conway	0	3
Crawford	5	2
Faulkner	3	15
Franklin	0	1
Johnson	1	4
Logan	1	1
Perry	0	0
Pope	5	4
Pulaski*	25	63
Scott	0	0
Sebastian	8	18
Yell	0	1
Total	**48**	**112**

*Part of this county is in another planning region

Hazardous waste generation data is compiled annually, but this program was not implemented in Arkansas until after 1990. Information from 1990 on the number of hazardous waste generators is also not readily available. Therefore, a comparison with 1990 conditions is not made in this document.

4.4.3 Wastewater and Stormwater

There are over 3,000 point sources permitted to discharge wastewater and stormwater in the WAWRPR (Table 4.11). Nearly half of these are located in Pulaski County. These discharges are permitted by ADEQ through the federal National Pollutant Discharge Elimination System (NPDES). Industrial, municipal, and domestic wastewater discharges are permitted through NPDES as well as discharges of stormwater and runoff associated with industrial sites, municipalities (MS4s), and temporary construction sites. Please refer to Section 6 for more details on wastewater regulations and permitting in Arkansas.

Table 4.11. NPDES permitted discharges in the WAWRPR (ADEQ 2013a, 2013b, 2013c, 2013d)

County	NPDES Industrial	NPDES Municipal	NPDES Domestic	NPDES Large MS4	NPDES Small MS4	NPDES Construction Stormwater[1]	NPDES Industrial Stormwater	NPDES Other[2]	Total
Conway	10	2	1	0	0	51	16	5	85
Crawford	13	5	4	0	3	83	67	5	180
Faulkner	27	7	23	0	2	278	77	4	418
Franklin	7	3	2	0	0	31	27	2	72
Johnson	19	3	1	0	0	51	39	1	114
Logan	6	4	3	0	0	39	26	4	82
Perry	3	2	1	0	0	14	3	2	25
Pope	18	5	5	0	0	84	66	5	183
Pulaski*	109	15	67	1	8	844	434	19	1497
Scott	3	1	1	0	0	22	9	1	37
Sebastian	38	10	2	0	2	229	150	6	437
Yell	8	4	1	0	0	29	11	6	59
Total	261	61	111	1	15	1755	925	60	3189

*Part of this county is in another planning region.
[1]Construction stormwater permits are temporary.
[2]Includes filter backwash, process water, agricultural, cooling water, toxics, and saltwater discharges.

Approximately 143 surface water bodies in the planning region receive wastewater discharges. Several of these water bodies receive wastewater discharges from more than one point source (ADEQ 2008).

Table 4.12 compares the number of NPDES permits for municipal, domestic, and industrial wastewater reported for the WAWRPR in the 1990 state-wide water quality assessment with the current numbers for the same categories of NPDES permits. Overall, the

number of permitted wastewater discharges in the planning region has increased over 180% since the 1990 AWP update, with the biggest change being in industrial permitting. Note that the state-wide water quality assessment reports do not include permits for municipal, industrial, or construction stormwater runoff. The first industrial and construction stormwater runoff NPDES permits were issued by ADEQ in 1992 (ADEQ 2013b, 2013c). ADEQ did not issue permits for small municipalities' stormwater runoff until 2004 (ADEQ 2013d).

Table 4.12. Numbers of NPDES wastewater permits reported for the WAWRPR in 1990 and 2013 (ADEQ 2013a, ADPCE 1990).

Permit type	1990	2013	Change
Industrial	44	261	217
Municipal	42	61	19
Domestic	65	111	46
Cooling water	8	3	-5
Filter backwash	1	25	24
Process water	0	18	18
Agricultural	0	0	0
Other	14	13	-1
Total	174	492	318

5.0 WATER RESOURCES ISSUES

Water resources issues in the WAWRPR include concerns about the amount of water that is available, how the water is used, and the chemical and biological quality of water resources. In addition, there are concerns in the region about how water is managed in terms of flood control, water supply infrastructure, commodity transport, and wastewater treatment infrastructure. These issues are discussed and, to some extent, quantified below. Changes in regional water resources issues since the 1990 AWP update are also discussed.

5.1 Flooding

Flooding is common in the WAWRPR along the Arkansas River and its tributaries, with the flash flooding events likely to occur in the Ouachita Mountain streams and tributaries to the Arkansas River, and in the urban centers located along the Interstate 40 corridor. Since 1957, there have been 34 major disaster declarations involving flooding in the State of Arkansas. According to the Arkansas Department of Emergency Management (ADEM), some or all of the counties included in the West-central Region of Arkansas have been included in 14 flooding disaster declarations between 2003 and 2010 (ADEM 2010).

A recent significant flood event in the planning region occurred in the spring of 2004 when heavy precipitation fell in the western half of the State that contributed to flash flooding along the Arkansas River and subsequently saw the Arkansas River rise to, and remain at, flood stage for nearly the entire month of May (ADEM 2010)

The most recent significant flood event in the planning region occurred in May 2013. A record flood stage was recorded along the Fourche La Fave River in Yell County, with the river stage rising from 2.34 feet prior to the storm event to 32.6 feet at its peak. USGS estimated that the storm event was between and 100-year and 500-year event (USGS 2013b). Six deaths were attributed to this flood (5News Web Staff 2013).

5.2 Wetland Loss

Significant wetland loss has occurred in Arkansas making it the inland state having lost the most wetlands in the nation (Dahl 1990). The most significant losses were in the eastern part of the state in the Mississippi Delta area, however, the WAWRPR has not been exempt from wetland losses. This planning region has lost wetlands through conversion to agricultural lands and silviculture practices. Other wetland losses have occurred through the disruption of the connectivity between the wetland and adjacent rivers by modifications for flood control and commercial navigation, such as MKARNS (Adams et al. 2007). Wetland losses appear to continue in Arkansas but at a significantly reduced rate, while wetland mitigation and restoration projects continue to take place in the planning region, such as the Seven Lakes Wetland Project in Yell County (NRCS n.d.b.)

5.3 Water Supply

Arkansas is generally thought of as a water-rich state, and the WAWRPR has experienced little or no serious water supply issues outside of drought. The planning region has a much greater abundance of accessible surface water resources than groundwater resources.

5.3.1 Surface Water

Many of the municipalities in the WAWRPR utilize surface water impoundments for their water supply. This includes, but is not limited to, the cities of Fort Smith, Clarksville, Alma, Ozark, Russellville, Conway, and Little Rock, as well as many of the surrounding cities and towns. Typically surface water supply is only an issue during periods of drought (Winthrop Rockefeller Foundation 2008).

Presently, water supply in Central Arkansas (through Central Arkansas Water) is meeting the needs of its citizens, and is projected to meet demands for 60 years (Wiest 2011). Some members of the Mid-Arkansas Water Alliance have pursued the use of water from Lake Ouachita. Central Arkansas Water had secured future water rights for its users for DeGray Lake, and recently sold some of those rights to the City of Hot Springs. This deal has caused issue

among users of Central Arkansas Water, who believe those water rights should have been saved rather than sold (Petrimoulx 2013).

Lake Fort Smith was expanded in 2006 to include Lake Shepherd Springs, providing a water supply to meet the needs of the Fort Smith region to 2060 (The City Wire 2009).

Currently, the Arkoma Basin is the focus of a major unconventional gas play targeting the Fayetteville Shale. A new horizontal fracturing technique established in the late 1990s in the natural gas industry has made it possible to extract natural gas from shale formations. Beginning in the mid-2000s, production began in the Fayetteville Shale formation in Central Arkansas, including several counties within the WAWRPR. The hydrofracking process uses large volumes of surface water, and development of the Fayetteville Shale has increased regional water demand..

5.3.2 Groundwater

In the WAWRPR there are three primary groundwater resources that are considered with regard to water supply. These include the Western Interior Plains (WIP) Confining Unit and Ouachita Mountains aquifer and the Arkansas River Valley alluvial aquifer.

5.3.2.1 Water Level Monitoring

There is little official routine monitoring of groundwater levels in the aquifers underlying the WAWRPR. The USGS monitors water levels at one USGS master well located in the planning region, in Faulkner County (T. Fugitt, ANRC, personal communication 9/4/2013). The ANRC collects data on groundwater in areas where water-level problems are a known issue (Kresse et al. 2013). ANRC is not currently collecting data on groundwater levels in the WAWRPR (ANRC 2013).

5.3.2.2 WIP Confining Unit and Ouachita Aquifer

In the WIP confining unit, owing to poor well yields and limited groundwater resources, water use is limited to domestic, small community, and non-irrigation agricultural supply. The greatest use of groundwater from the Ouachita Mountains aquifer is for domestic-supply

purposes. Since domestic and water supply systems producing less than 50,000 gallons per day (gpd) are not required to report groundwater use, there is no way to accurately quantify the number of domestic and livestock wells in use in these regions. As of 2010, water use from 13 wells completed in the Atoka Formation of the WIP confining unit was reported. These wells were primarily used for public supply at parks, schools, stores, and some commercial business (Kresse et al. 2013).

Although Albin (1965) noted that wells in the Ouachita Mountains yielding greater than 10 gpm were considered "large-yield wells", some wells commonly can yield between 10 and 50 gpm—yields more than sufficient for many community-supply systems. A review of community supply wells from the Arkansas Department of Health identified 72 wells used by various entities including camps and other recreational areas, conference centers, rest areas, stores, and even sources of public supply; and five separate communities using wells completed in the Atoka, Bigfork Chert, Stanley Shale, and Arkansas Novaculite Formations for purpose of public supply, demonstrating that many formations constituting the Ouachita Mountains aquifer are capable of supplying volumes sufficient to supply small communities (Kresse et al. 2013).

5.3.2.3 Arkansas River Valley Alluvial Aquifer

Groundwater from the Arkansas River Valley alluvial aquifer is, and historically has been, an important source of irrigation and municipal supply. Currently, only the cities of Dardanelle and Maumelle, Arkansas, are using the Arkansas River Valley alluvial aquifer as a source of municipal supply water. In the past, the cities of Atkins, Morrilton, Dardanelle, and Ozark used the aquifer for municipal supply. Of these four cities, only Dardanelle has continued and expanded the use of the aquifer as its sole municipal water source. Bedinger and others (1963) outlined use from these four cities during 1959 and calculated the remaining development potential of the Arkansas River Valley alluvial aquifer based on aquifer thickness, extent, and average yields. Atkins pumped about 162,000 gpd during 1959 from three wells yielding approximately 75 to 250 gpm each; Dardanelle used three wells yielding about 300 gpm and pumped approximately 225,000 gpd; Morrilton used four wells yielding 200-500 gpm and averaged approximately 681,000 gpd; and Ozark used five wells to pump an average of

approximately 300,000 gpd. Assuming natural recharge to the aquifer of 10 inches per year, Bedinger and others (1963) calculated that throughout the Arkansas River Valley, one could potentially pump 130 million gpd (mgd) without over of groundwater storage or induction from the river. In 1959, groundwater was pumped at average rate of 3.2 mgd, or less than 3 % of the amount regionally available from natural recharge.

The City of Dardanelle, Arkansas, continues to depend solely upon groundwater for municipal supply, and recent drilling efforts are part of plans for continued long-term use of this aquifer. A review of data from 2003 through 2009 revealed total withdrawals increasing from 1.1 to 2.2 mgd from nine wells completed at depths ranging from approximately 60-69 feet in the Arkansas River alluvial aquifer and each well pumping at approximately 200 gpm – three times the number of wells used in 1959. In 2010, the City of Dardanelle completed construction of a horizontal interceptor well system 300 feet from the river (a 13 by 16 feet caisson installed 45 feet below ground level with five 12-inch diameter lateral screens ranging from 150 to 250 feet in length) that produced more than 2.5 mgd in 2010. The collector well system has replaced the nine production wells as primary supply since January 2011, though these nine wells are maintained as backup supply (Kresse et al. 2013). By 2012, the City reported the capability of pumping greater than 3.0 mgd (Smith 2012). As such, with improved directional-drilling techniques and innovative well design, the City of Dardanelle has demonstrated that groundwater from the Arkansas River Valley alluvial aquifer may contain great potential as a valuable and productive water supply in other areas along the extent of the aquifer. Total reported use for the City of Dardanelle in 2010 was 2.03 mgd.

In Maumelle, Arkansas, pumping from the Arkansas River Valley alluvial aquifer began in 1941, when the Maumelle Ordnance Plant installed two wells to provide production water; water use continued through March 1945 when the plant was deactivated. In 1972, the City of Maumelle converted those wells for municipal supply and installed two additional wells. Nine additional wells were installed to provide water for the growing municipality from 1995 through 2012. Maumelle, which pumped from 13 wells completed in the Arkansas River Valley alluvial aquifer at the time of this report, reported an average use of 2.74 mgd in 2010.

In addition to the important use as a source of municipal supply water, the Arkansas River Valley alluvial aquifer continues to be a valuable source of irrigation water for cropland along the Arkansas River. For 2010, the reported use for irrigation from the Arkansas River Valley alluvial aquifer was 2.6 mgd, which was pumped from 34 wells supplying approximately 2,960 acres of cropland (T. Holland 2013). Kresse and others (2013) noted that in the City of Van Buren, dry-land farming was common throughout the area, and irrigation occurred only where water-producing sands and gravels of sufficient thickness occurred in the complex depositional environment of the meandering Arkansas River Valley alluvial deposits.

5.4 Waterborne Commodity Transport Infrastructure

As discussed in Section 3.7.3, in the WAWRPR, the Arkansas River (as part of MKARNS) is used for the transport of goods and materials. Maintenance of this waterway, and the associated public port facilities, which is a significant economic driver in the region and the State, is a constant and expensive activity. USACE is responsible for planning, improving and maintaining the river system to provide for flood control, navigation and recreation. The USACE operates most of the locks and dams and administers the Section 10 and Section 404 federal permit programs (Arkansas Waterways Commission 2013).

The Arkansas Waterways Commission, whose mission is to develop, promote, and protection the commercially navigable waterways of Arkansas for waterborne transportation and economic development to benefit the people of Arkansas, reported the following on the Arkansas River:

- The USACE (Tulsa District and Little Rock District) have a backlog of critical maintenance issues (maintenance that if not conducted will cause failure in 5 years or less) on MKARNS, estimated at $38 million (Arkansas Waterways Commission 2013). The USACE's total operation and maintenance budget for MKARNS-AR for Fiscal Year 2013 (October 2012 – September 2013) was approximately $25 million (USACE 2012).
- A project to deepen the MKARNS navigation channel to a minimum of 12 feet was authorized by the US congress in 2005, and the work was initiated. However, funding for the project has been sporadic and was not appropriated in 2012 or 2013. As a result, work on this project has ceased.

5.5 Water Quality Issues

Federal law requires states to assess the water quality of the waters of the state (both surface water and groundwater) and prepare a comprehensive report documenting the water quality, which is to be submitted to EPA every two years. ADEQ is the agency in Arkansas responsible for enforcing the water quality standards and preparing the comprehensive report for submittal to EPA. This section discusses surface water and groundwater quality issues that have been identified in the WAWRPR. These issues include non-attainment of surface water quality standards, non-attainment of drinking water standards and water quality guidelines in groundwater, fish consumption advisories, nonpoint source pollution of surface water and groundwater, and contaminants of emerging concern.

5.5.1 Water Quality Monitoring

To assess water quality, it is necessary to collect water quality data through monitoring programs. Monitoring of water quality in the planning region occurs under a range of programs, including routine ambient, special project, and research-oriented monitoring. Multiple agencies are responsible for the various water quality monitoring programs, and numerous entities assist with monitoring activities. Surface water and groundwater monitoring programs in the planning region are outlined below.

5.5.1.1 Surface Water

ADEQ monitors water quality of surface waters through several programs. ADEQ relies on chemical data from its ambient water quality monitoring network to assess whether surface waterbodies are meeting their designated uses. Biological surveys are also conducted on a site-specific basis to further document whether an aquatic life use is being attained. There are 129 surface water ADEQ water quality monitoring station locations in the WAWRPR (ADEQ 2013e). Twenty-four of these monitoring stations are part of the Ambient Water Quality Monitoring Network (ADEQ 2004). Monthly water quality data are collected at these stations (ADEQ 2012d). There are 22 stream water quality monitoring stations in the WAWRPR that are part of the Roving Water Quality Monitoring Network (ADEQ 2004). These stations are sampled

bimonthly over a two year period every six years (ADEQ 2012d). Twenty-seven of the water quality monitoring stations are on lakes, and the remaining are being sampled as part of special studies in the region.

ADEQ publishes a biennial report in order to comply with Section 305(b) of the federal Clean Water Act (CWA). This report includes water quality data collected by ADEQ as well as other available sources. It also lists impaired waters and proposed actions to correct water quality problems (ADEQ 2013f).

The USGS also monitors water quality in the region. There are 8 continuous USGS water quality monitoring stations in the WAWRPR although 5 of the stations are in Pulaski County (USGS 2013c). The locations of surface water quality monitoring stations in the WAWRPR are displayed on Figure 5.1.

Through its nonpoint source management program, ANRC oversees water quality monitoring programs in 10 nonpoint source priority watersheds. Two of these watersheds, Lake Conway Point Remove Watershed and Poteau River Watershed, are located in the planning region. These programs involve universities, contractors, and nonprofit organizations. Parameters monitored by these programs typically include nutrients and sediment, turbidity, and/or total suspended solids.

The monitoring and reporting requirements for surface water used for human consumption are authorized by both federal and state regulations. A summary of these requirements can be found in Chapter 5 of *Arkansas Public Water System Compliance Summary*, "Microbial Disinfection By-Products Rules" (ADH 2012). Only 15 public water supply systems in the WAWRPR do not use surface water as their water source, and two of those are under the direct influence of surface water (ADH n.d.). Depending on the treatment methods used and the number of customers served by the public water supply utilizing surface water, the monitoring requirements for the source water will vary and may include turbidity, *Escherichia coli* (*E. coli*), cryptosporidium, total organic carbon (TOC), and alkalinity.

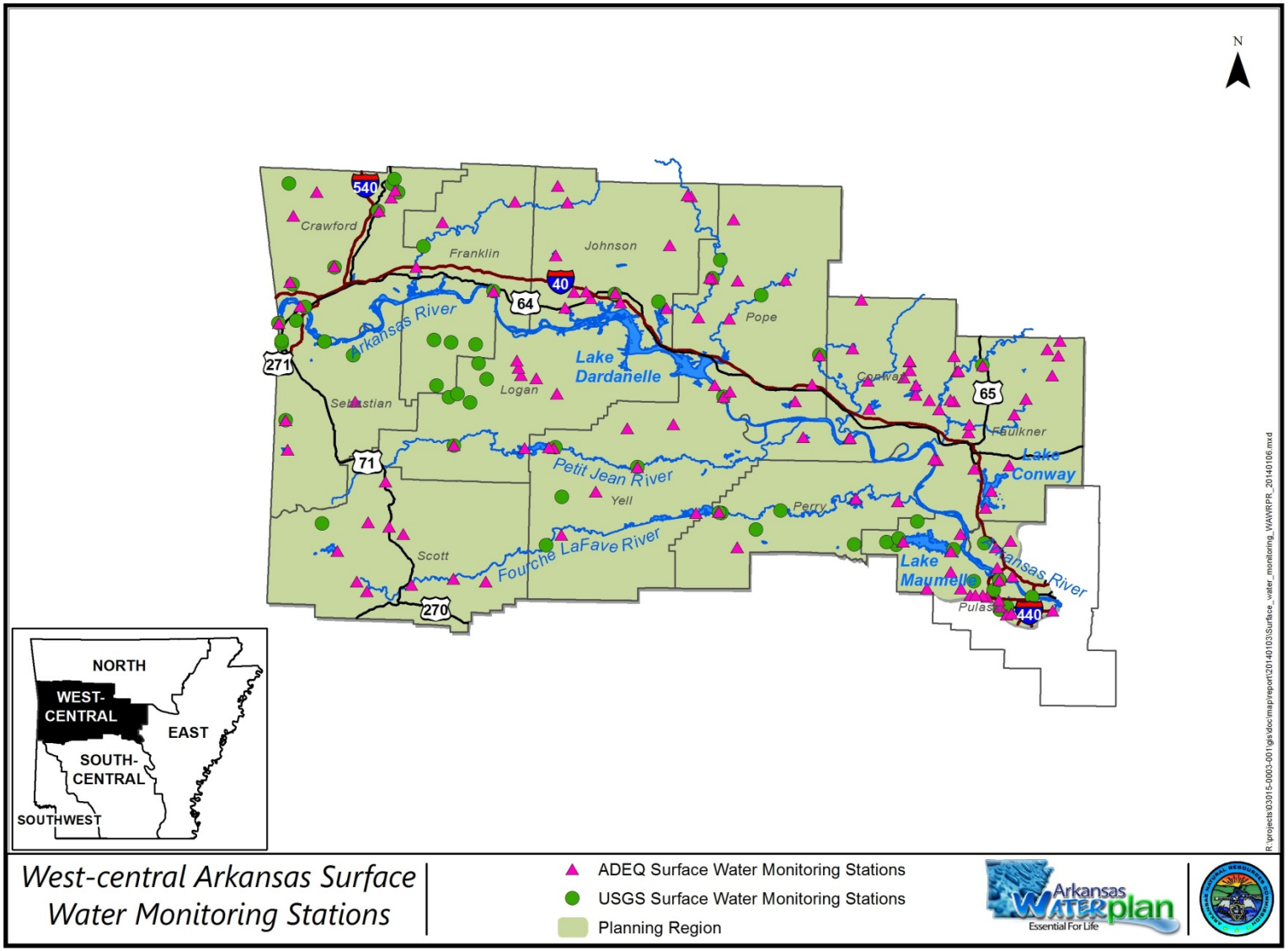

Figure 5.1. Surface water quality monitoring stations in the WAWRPR.

5.5.1.2 Groundwater

In the WAWRPR, groundwater quality monitoring is performed through a number of programs ranging from ambient to research-oriented and mandated monitoring. Multiple agencies are responsible for the various groundwater monitoring programs, and numerous entities assist with monitoring activities. Divisions of ADEQ administer mandated groundwater monitoring programs at various sites that are regulated by state and federal programs. The purpose of this monitoring is to evaluate potential and actual impacts to groundwater resulting from human activities and natural phenomenon (ADEQ 2008).

ADEQ developed the Arkansas Ambient Ground Water Monitoring Program in 1986, which currently consists of 12 monitoring areas and approximately 250 wells and springs throughout the state (ADEQ 2012d, Kresse et al. 2013). Two monitoring areas are within the WAWRPR, Frontal Ouachitas and North Central (Figure 5.2). The Frontal Ouachita Monitoring Area is located along the Pulaski and Saline County boundaries within the planning region. Samples are collected largely from the Ouachita Mountains aquifer for analysis of inorganic constituents and nutrients to evaluate impacts from multiple land uses. The monitoring wells are affected by agricultural, industrial, or a combination of both sources. The North Central Monitoring Area includes portions of Conway and Faulkner Counties. Samples are collected from the Atoka and Hale formations, above the Fayetteville Shale. This monitoring area was established in 2010 to address concerns related to natural gas development in the Fauetteville Shale gas play. Samples are collected on a three-year rotational basis and include a comprehensive suite of analytes. Data are presented in various ADEQ publications available on their website and in the EPA's STORET database (ADEQ 2012d).

The University of Arkansas (U of A) has conducted a significant amount of groundwater research that has resulted in scientific data and information necessary to understand, manage, and protect water resources within the state (Kresse et al. 2013). Hard-copy or digital reports, theses, dissertations, and journal articles are available at the U of A Mullin's Library, Arkansas Water Resources Center technical library, or through various online sources.

The Arkansas Department of Health (ADH) is the primary state agency for the federal Safe Drinking Water Act (SDWA) and is responsible for monitoring public water-supply wells.

ADH maintains a statewide database that consists of 1,300 wells (Kresse et al. 2013). Every three years, these wells are sampled for inorganic, organic (including pesticides, herbicides, synthetic organic compounds, and volatile organic compounds), and radiochemical contaminants. The Total Coliform Rule of the SDWA requires sampling on monthly basis, where the number of samples required is dependent upon the population size. Nitrate monitoring is performed on a yearly basis unless a sample greater than or equal to 50 % of the maximum contaminant level is detected and prompts the need for increased frequency. Additionally, the Disinfection Byproduct Rule of the SDWA requires monitoring of trihalomethanes and haloacetic acids (byproducts of chlorine and other disinfectants used to treat drinking water) on a quarterly or annual basis. While all of the programs above collect samples from treated drinking water, ADH also collects samples from untreated water sources (surface and groundwater) that include bacteria, particulates, algae, organics, pathogens, total organic carbon on a weekly or monthly basis as required by the SDWA (ADEQ 2008).

The USGS has 24 groundwater wells or springs scattered throughout the state that they monitor, with one of these sites located in the planning region (Faulkner County) (Figure 5.2). Samples are collected on a five-year rotational basis and analyzed for a variety of constituents including nutrients, metals, organics, radioactivity, and selected primary and secondary drinking water standard constituents (Kresse et al. 2013). In addition, the USGS samples many other wells and springs for purposes of water quality and quantity investigations or as part of other monitoring programs, such as the National Water Information System. Data from these investigations and monitoring programs are presented in reports or available for download online at the Arkansas Water Science Center (http://ar.water.usgs.gov/) or similar USGS websites (ADEQ 2009a, Kresse et al. 2013).

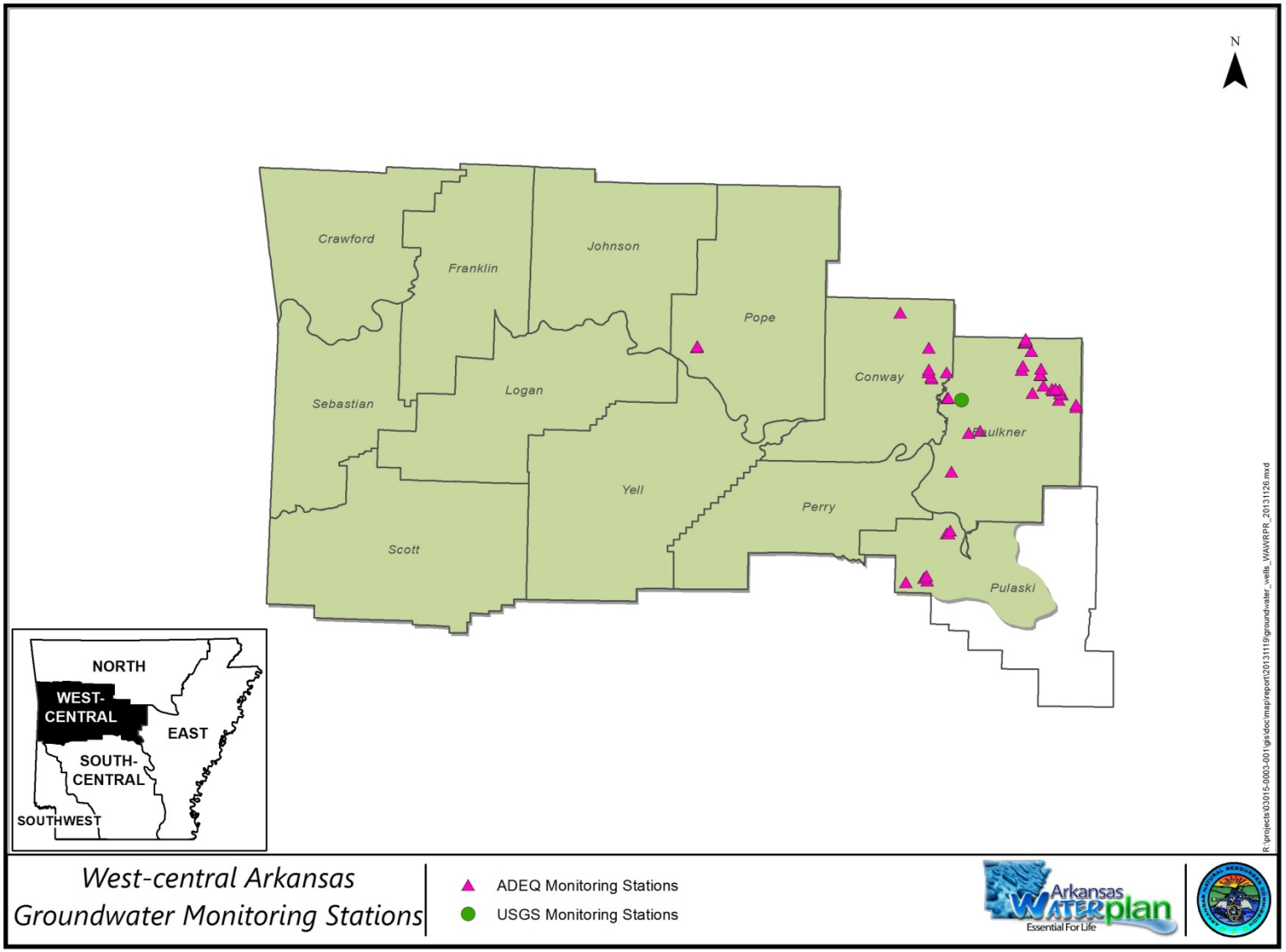

Figure 5.2. Ambient groundwater quality monitoring sites in the WAWRPR.

5.5.2 Non-attainment of Surface Water Quality Standards

In 2008, around 1,378 of the 1,781 miles of waterways in the WAWRPR were assessed for water quality. Of the miles assessed, 394 miles did not meet numeric water quality criteria or did not support all of their designated uses, along with 9,521 acres of lakes and impoundments. Siltation/turbidity, low dissolved oxygen, minerals (chloride, sulfate, and total dissolved solids [TDS]), and metals were the causes of impaired water quality in the majority of the stream miles assessed (Table 5.1) (ADEQ 2008, 2009). A detailed list of WAWRPR stream impairments is included in Appendix A. Beryllium, mercury, and siltation/turbidity were the sources of impairment for lakes in the planning region. Figures 5.3 through 5.5 show locations of impaired waterbodies in the WAWRPR.

In the Arkansas River Valley, soil types in much of the area are highly erosive and tend to easily go into colloidal suspension which can cause long-lasting high turbidity values (ADEQ 2008). It should be noted that while a waterbody may be impaired due to sediment, there is no numeric water quality standard for sediment. Arkansas has a numeric water quality standard for turbidity but not total suspended solids (TSS); thus turbidity is the chemical parameter that is assessed to determine if sediment impairment exists. There is currently no other method that is consistently used by EPA or ADEQ to measure sediment or siltation in water.

Table 5.1 Summary of impaired waters in the WAWRPR (ADEQ 2009)

Pollutant	Miles of impaired stream	Acres of impaired lakes
Beryllium	39.5	2,675
Chlorides	17.6	0
Copper	42.7	0
Dissolved Oxygen	180.0	0
Pathogens	68.2	0
pH	52.9	0
Siltation/Turbidity	91.1	2,900
Total Dissolved Solids (TDS)	28.4	0
Zinc	34.0	0
Mercury	8.7	3,946
Sulfates	6.6	0
Total Phosphorus	6.6	0
Ammonia	3.0	0
Nitrate	13.0	0

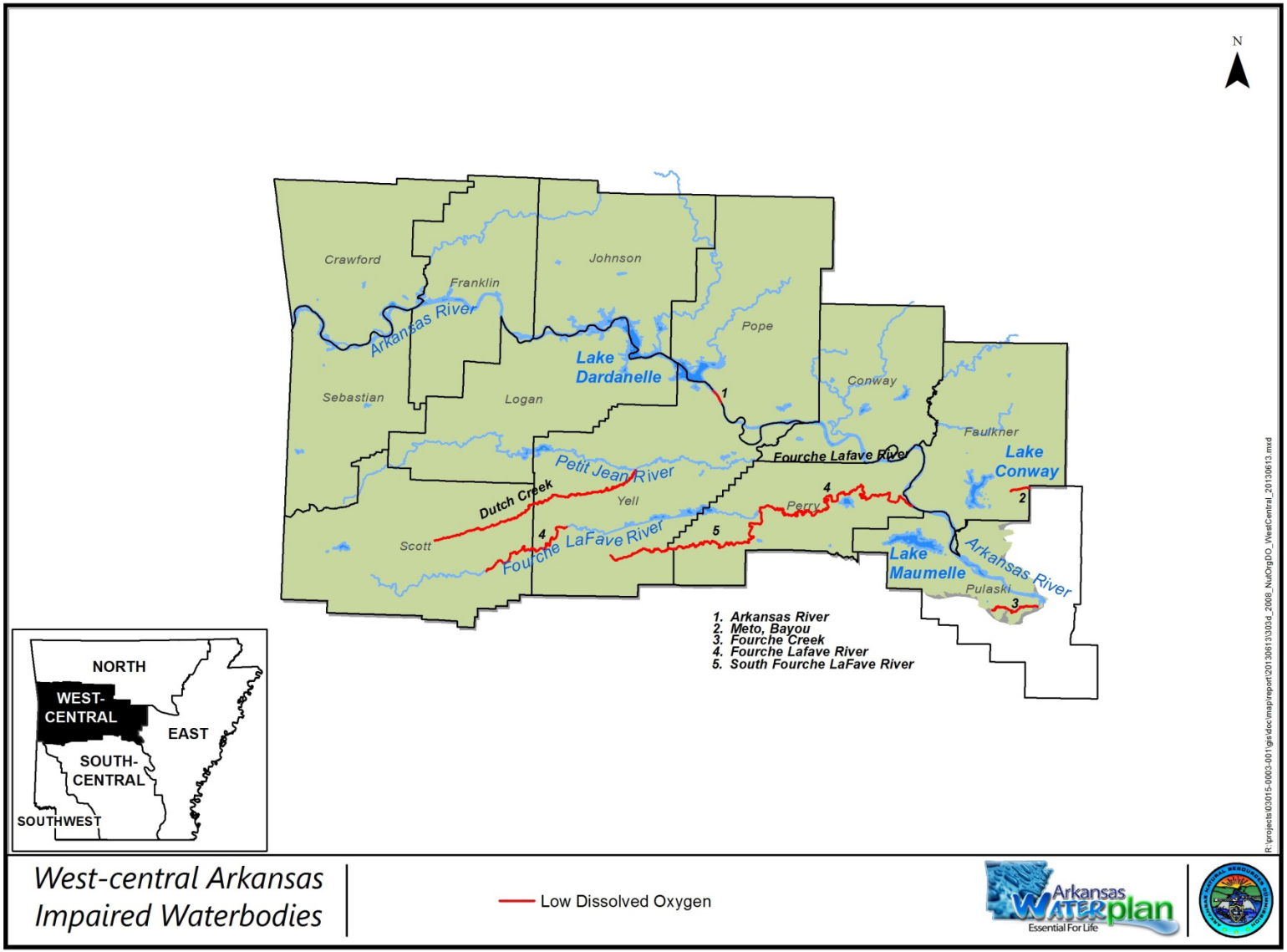

Figure 5.3. Waterbodies in the WAWRPR listed as impaired due to low dissolved oxygen on the 2008 303(d) list.

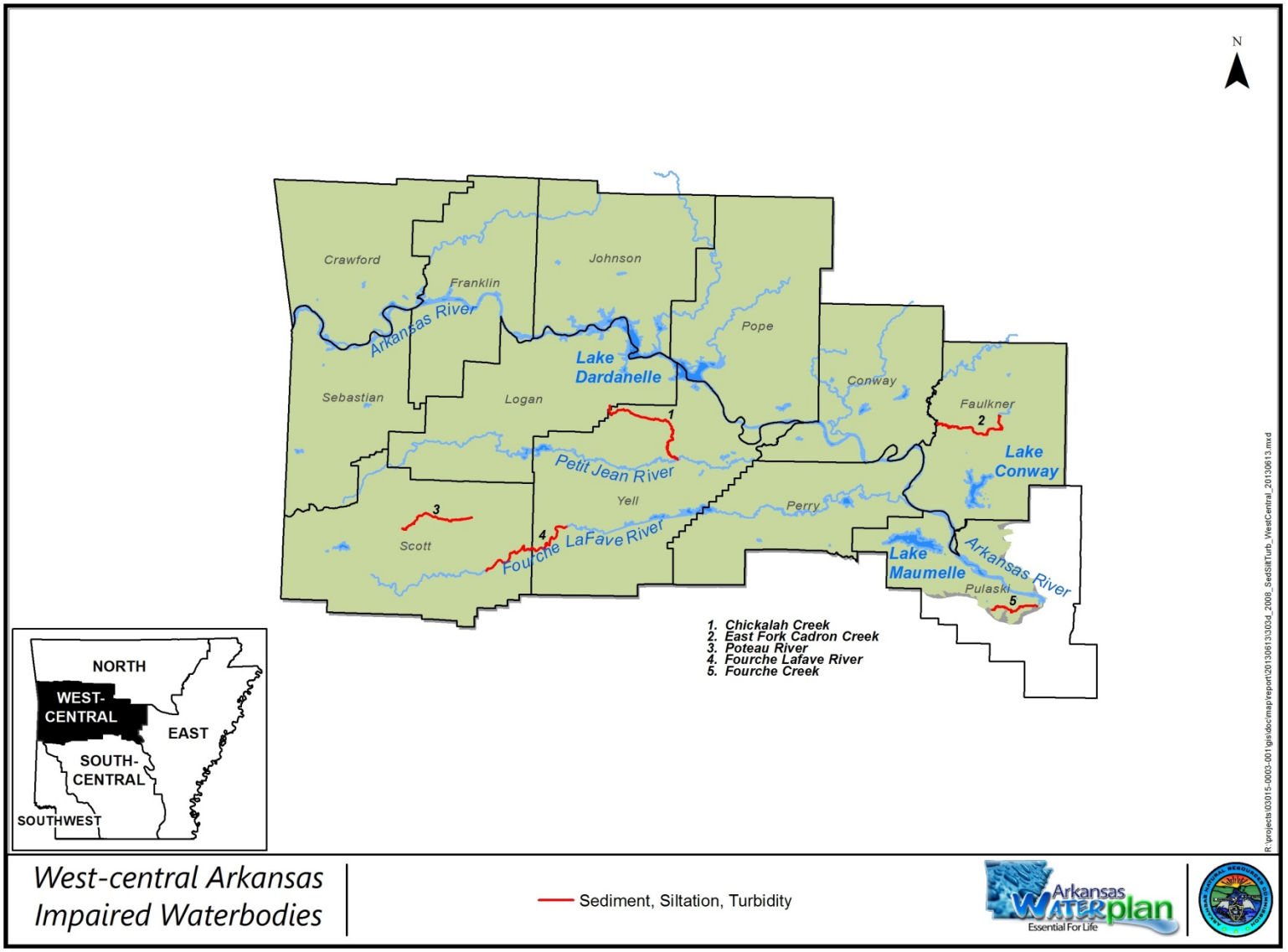

Figure 5.4.Waterbodies in the WAWRPR listed as impaired due to siltation / turbidity on the 2008 303(d) list.

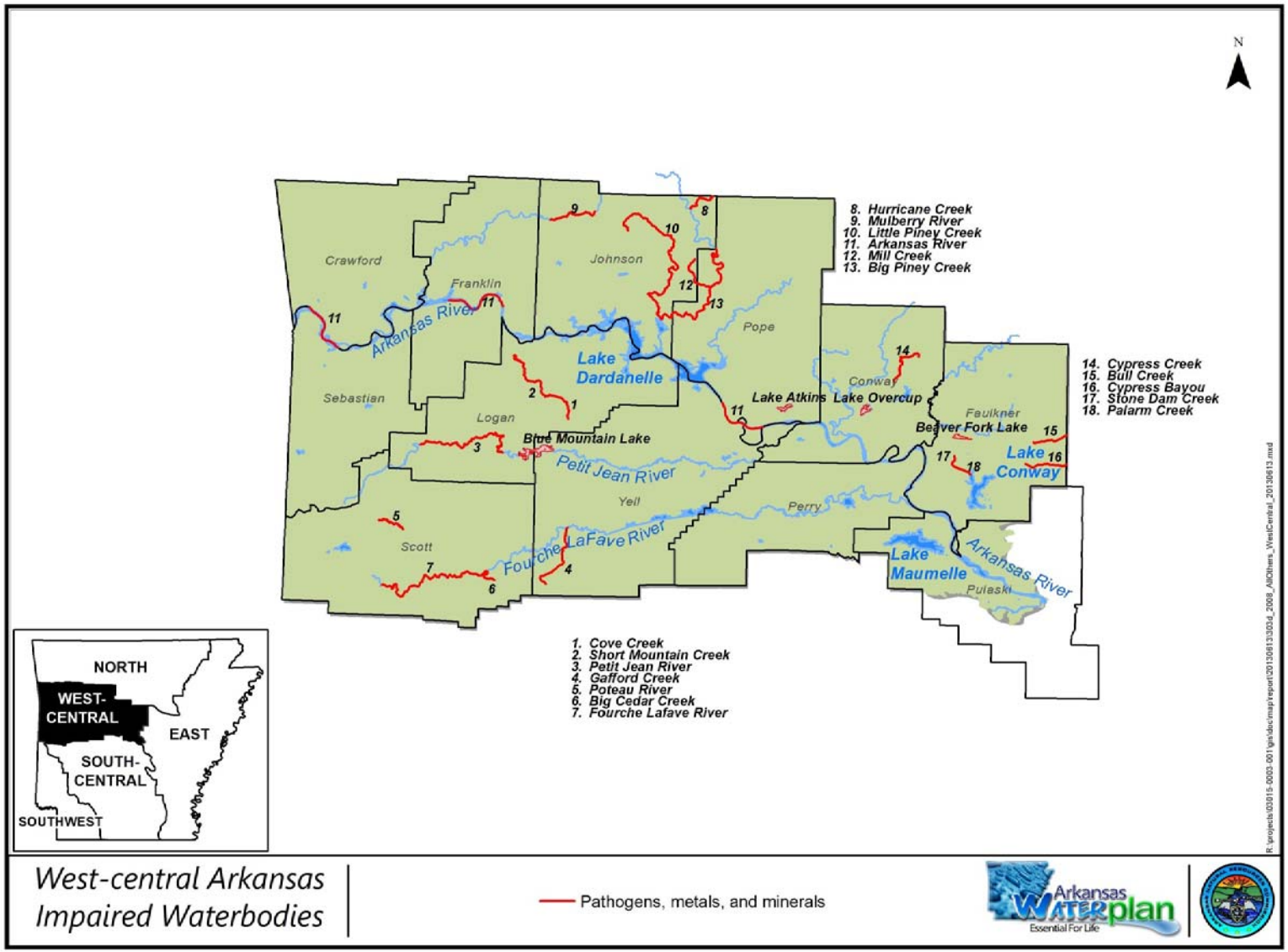

Figure 5.5. Waterbodies in WAWRPR classified as impaired due to pathogens, metals, and/or minerals on the 2008 303(d) list.

In cases where exceedances of water quality criteria are preventing the attainment of a designated use, a total maximum daily pollutant load (TMDL) must be developed. A TMDL is the maximum amount of a pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant, resulting in the waterbody being listed as impaired. A TMDL allows for the allocation of pollutant loads between point sources and nonpoint sources discharging to the waterbody, as well as a margin of safety. TMDL reports have been prepared for a number of waterbodies in the WAWRPR addressing sediment/turbidity, minerals, metals, nutrients, and low dissolved oxygen (Table 5.2).

Table 5.2. TMDLs for waterbodies in WAWRPR (ADEQ 2012b)

Waterbody	Impaired Uses	Pollutants	TMDL Status
Cadron Creek	Aquatic life	Turbidity	Final 1/05/2006
Dry Fork lake	Fish consumption	Mercury	Final 9/17/2002
Fourche La Fave River	Fish consumption	Mercury	Final 9/17/2002
Lake Nimrod	Fish consumption	Mercury	Final 9/17/2002
Stone Dam Creek	Aquatic life, domestic water supply	Ammonia, Nitrate	Final 11/01/2003
Whig Creek	Aquatic life, domestic water supply	Nitrate	Final 12/08/2000
Whig Creek	Aquatic life, domestic water supply	Copper	Final 11/01/2003
White Oak Creek	Aquatic life	Turbidity	Final 1/06/2006
Spring Lake (Yell County)	Fish consumption	Mercury	Final 1/16/2007
Cove Creek Lake	Fish consumption	Mercury	Final 9/17/2002
Mulberry River	Aquatic life	pH	Final 8/01/2008
Shepherd Springs Lake	Fish consumption	Mercury	Final 9/17/2002
Poteau River near Fort Smith	Aquatic life	Turbidity	Final 12/29/2005
Poteau River near Waldron	Aquatic life	Phosphorus, Copper, Zinc	Final 1/10/2006

5.5.3 Nutrient Surplus Areas

Controversy over phosphorus concentrations in streams that cross the Arkansas-Oklahoma border, primarily the Illinois River, prompted actions in Arkansas to reduce nutrients in these streams. One of these actions was the declaration of eight watersheds in Arkansas as Nutrient Surplus Areas. Two of these watersheds – Upper Arkansas River (Lee Creek) and Poteau River are in the WAWRPR (Figure 5.6). This designation requires that nutrient

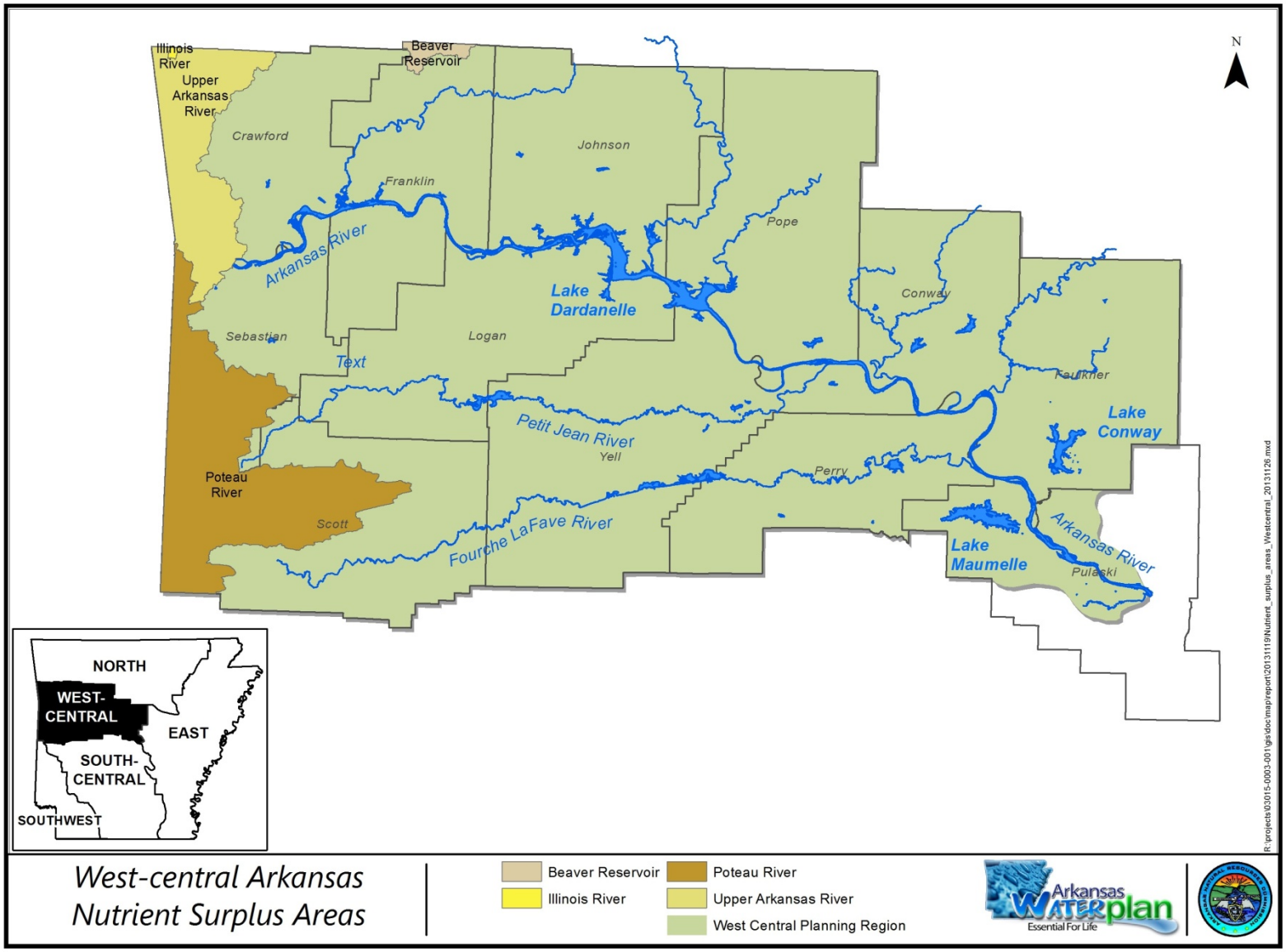

Figure 5.6. Nutrient surplus areas in the WAWRPR.

management practices be used in these areas to help to reduce nitrogen and phosphorus levels in the surface and ground water. Nutrient management training and planning is also required.

The Upper Arkansas River watershed is designated as a Nutrient Surplus Area because the State of Oklahoma has designated Lee Creek downstream of the Arkansas border as a scenic river, and set phosphorus limits for scenic rivers at 0.037 mg/L (Oklahoma Statute § 82-1451 et seq., Oklahoma Water Resources Board 2013). The U.S. Supreme Court has ruled that a downstream state's water quality requirements must be met at the state line.

The Poteau River in Oklahoma does not have a numeric phosphorus criterion. However, the Oklahoma Water Resources Board has set phosphorus limits for Lake Wister, into which the Poteau River drains after leaving Arkansas (Oklahoma Water Resources Board 2013). Therefore, the Poteau River watershed in Arkansas is designated as a Nutrient Surplus Area.

5.5.4 Non-attainment of Drinking Water Quality Standards and Water Quality Guidelines by Groundwater

No groundwater quality standards have been set by state agencies in Arkansas; although there are state regulations to protect groundwater quality (see Section 6). However, groundwater used as a drinking water source is required to meet state and federal drinking water quality standards. Other groundwater users, such as farmers and industries, have developed guidelines that they use to determine if groundwater quality is suitable for their uses.

Groundwater quality in the WAWRPR is discussed in the following sections by dividing the planning region into three distinct resources areas. The Western Interior Plains (WIP) Confining Unit, which lies north of the Arkansas River valley, the Arkansas River Valley alluvial aquifer, in the central portion of the planning region, and the Ouachita Mountains aquifer, located south of the Arkansas River valley.

5.5.4.1 Western Interior Plains Confining Unit

Due to the limited groundwater resources of the area, there is very little groundwater quality data available for the WIP Confining Unit. Of the few groundwater quality studies published, most focus on the WIP Confining Unit in the northern portion of the Arkansas River

Valley. Recent groundwater studies that were conducted to evaluate impacts of development of the Fayetteville Shale gas play to water quality in central Arkansas provide the most comprehensive evaluation of the WIP aquifers (Kresse et al. 2006, 2012). These studies include the portion of the Arkansas River Valley in the WAWRPR. The studies found no evidence of groundwater contamination associated with natural gas extraction activities in the study area (Kresse et al. 2012).

Groundwater with elevated iron, sulfate, and chloride may be encountered in localized areas, and occasionally exceed Federal secondary drinking water standards (Kresse et al. 2006; 2012). Constituent concentrations were attributed to the rock type, groundwater residence times (degree of water rock interaction), and microbially mediated processes.

Nitrate concentrations in the WIP aquifers are relatively low; however, elevated nitrate concentrations were associated with shallow sandstone aquifers overlain by sandy soils. In these areas, the soil is more permeable and aquifers are more susceptible to surface-derived contamination (Kresse et al. 2013). Since the Boston Mountains Plateau and Arkansas River Valley are not considered karst terrains, less impact from surface derived contaminates would be expected due to diffuse recharge allowing for natural attenuation to occur to a greater extent in the unsaturated zone.

5.5.4.2 Arkansas River Valley Alluvial Aquifer

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 in backswamp areas or where influenced by influx of water from the Arkansas River but rarely exceeded the Federal secondary drinking water regulation of 250 milligrams per liter (mg/L) (Kresse et al. 2013). Groundwater from this aquifer is characterized by a strongly calcium-bicarbonate type water and wide variations in the dissolved-solids content (Bedinger, Emmett and Jeffery 1963; Kresse et al. 2006; 2013). Groundwater is subject to reducing conditions in various parts of the aquifer that control the distribution and concentration of nitrate, iron, and sulfate.

Nitrate concentrations ranged from 0.01 to 67 mg/L, with a median of 1.1 in sample data reviewed by Kresse and others (2013). Twelve percent of the samples had concentrations exceeding the Federal maximum contaminant level of 10 mg/L. The median concentrations for all other aquifers in Arkansas, with the exception of the Springfield Plateaus and Ozarks aquifers, were less than 0.3 mg/L. The shallow depths and relatively high recharge values of the Arkansas River Valley alluvial aquifer are consistent with increased vulnerability to surface (for example, fertilizer and manure) and near-surface (for example, septic tanks) sources of nitrogen. The greatest density of elevated nitrate concentrations were along the western extent of the aquifer (Crawford County) and eastern extent (Yell, Pope, Conway, and Faulkner Counties), compared to lower concentrations in the central part of the aquifer in Franklin, Logan, and Johnson Counties. The lower concentrations of nitrate in the central part of the aquifer are theorized to result from natural denitrification processes in the aquifer (Kresse et al. 2013).

5.5.4.3 Ouachita Mountains Aquifer

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. Water quality and type generally are defined by the two major rock types in the Ouachita Mountains: quartz rocks (sandstone, chert, and novaculite) and shale. Groundwater from quartz formations tend to have low pH values, low dissolved solids concentrations, and are very soft water of a mixed water type representative of precipitation concentrated by evapotranspiration processes. Groundwater from shale rock in the system is characterized by strongly calcium- to sodium-bicarbonate water type, with varying constituent concentrations defined by residence time along the flow path. Sulfate and chloride concentrations tend to be elevated in some areas for groundwater from shale formations. No spatial relation was noted, however, for the distribution of iron concentrations, and high and low concentrations occurred in shale and quartz formations. Iron is abundant in numerous mineral forms in sedimentary rocks throughout Arkansas, and elevated iron in the Ouachita Mountain aquifer were attributed to microbially mediated processes (Kresse et al. 2013).

5.5.4.4 Groundwater Contamination

Elevated nitrate concentrations are associated with all three aquifer systems. In these areas, the soil is more permeable and aquifers are more susceptible to surface-derived contamination. The relatively high median concentration of nitrate in the Arkansas River Valley alluvial aquifer especially compared to other aquifers in Arkansas, with the exception of the Springfield Plateaus and Ozarks aquifers in northern Arkansas, is indicative of the vulnerability of groundwater contamination from fertilizer, manure, and septic tanks. Hydraulic fracturing and associated impact on water quality is a concern of many citizens; however, a recent study conducted by Kresse and others (2012) found groundwater quality throughout the region to be consistent with natural processes.

5.5.5 Fish Consumption Advisories

There are active fish consumption advisories due to mercury for several waterbodies in the WAWRPR. Details of these advisories are given in Table 5.3. The locations of these water bodies are shown on Figure 5.7.

5.5.6 Contaminants of Emerging Concern

There is growing interest, nationally and in Arkansas, in the occurrence of a group of chemicals called contaminants of emerging concern, which include pharmaceuticals, personal care products (e.g., soap and shampoo), natural and synthetic hormones, surfactants, pesticides, fire retardants, and plasticizers primarily in surface waters, but also starting to be measured in groundwater across the nation. The risks to human health and the environment from the majority of these chemicals are unknown, which is why they are referred to as “contaminants of emerging concern.” Contaminants of emerging concern have been detected in surface waters in Arkansas (Galloway et al. 2005). Detection, however, does not indicate there is an effect.

Table 5.3. Fish consumption advisories in the WAWRPR (ADH, AGFC, ADEQ 2011, ADEQ 2012d).

Waterbody	Miles Affected	Pollutant of Concern	Restrictions for high risk groups[1]	Restrictions for general public
Fourche La Fave River – from Nimrod Dam to South Fourche	8.7	Mercury	Should not eat largemouth bass (16 inches or longer)	Eat no more than 2 meals per month of largemouth bass (16 inches or longer)
Nimrod Lake	N/A	Mercury	Should not eat largemouth bass (16 inches or longer)	Eat no more than 2 meals per month of largemouth bass (16 inches or longer)
Cove Creek Lake	N/A	Mercury	Should not eat largemouth bass (12 inches or longer)	Should not eat largemouth bass (over 16 inches). No more than 2 meals per month of largemouth bass (12-16 inches)
Lake Sylvia	N/A	Mercury	Should not eat largemouth bass (16 inches or longer)	Eat no more than 2 meals per month of largemouth bass (16 inches or longer)
Dry Fork Lake	N/A	Mercury	Should not eat largemouth bass (16 inches or longer)	Eat nor more than 2 meals per month of largemouth bass (16 inches or longer)
Shepherd Springs Lake	N/A	Mercury	Should not eat black bass (16 inches or longer)	Should not eat black bass (over 20 inches). No more than 2 meals per month of black bass (16-20 inches)
Spring Lake (Yell Co.)	N/A	Mercury	Should not eat largemouth bass (16 inches or longer)	Eat no more than 2 meals per month of largemouth bass (16 inches or longer)

[1] pregnant or breastfeeding women, women who plan to become pregnant, and children under 7 years of age.

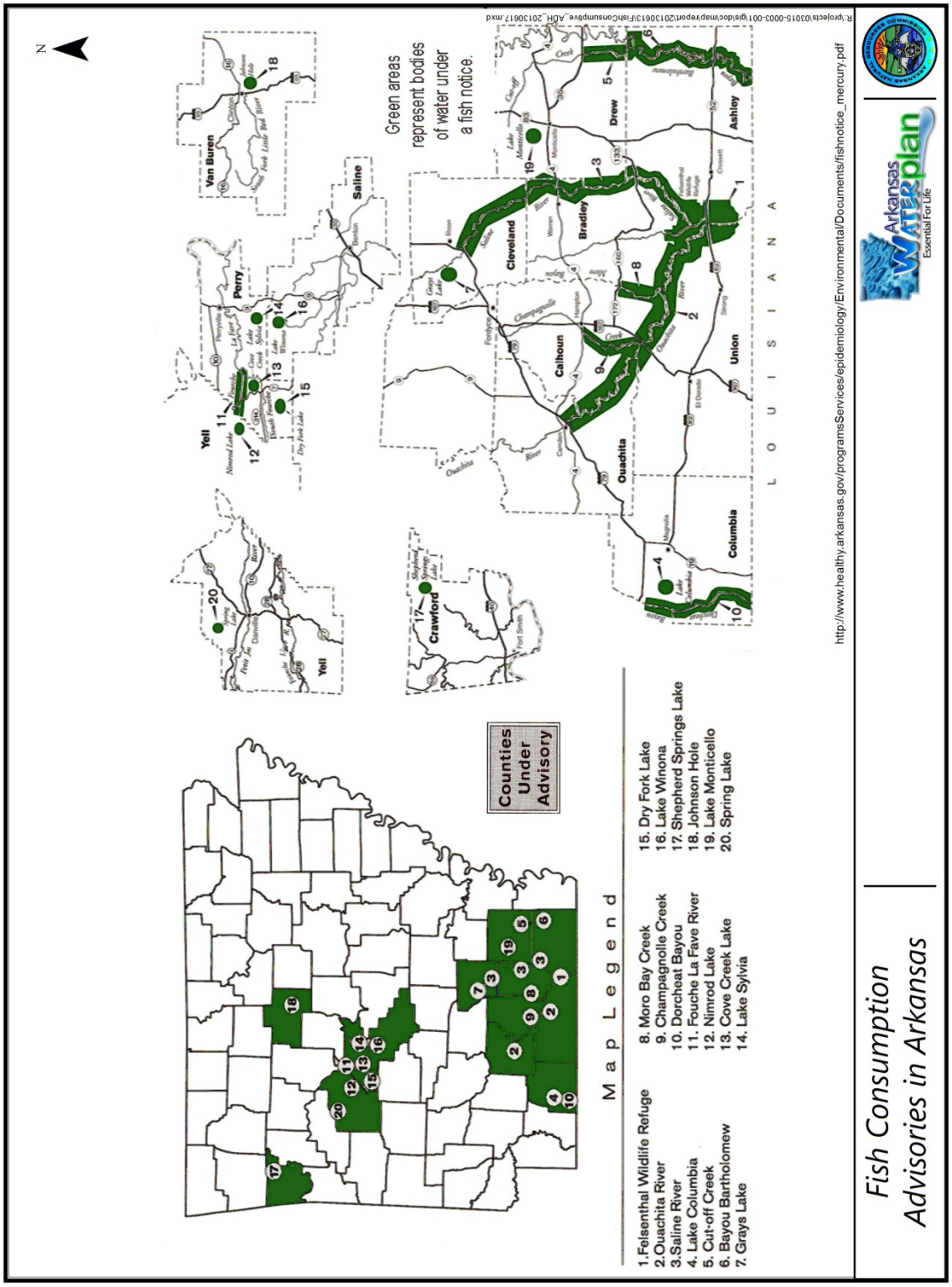

Figure 5.7. Waterbodies in the WAWRPR for which fish consumption advisories have been issued (ADH, AGFC, ADEQ 2011)

5.5.7 Nonpoint Source Pollution

Nonpoint source pollution was identified as a water resources issue in the 1990 AWP. Nonpoint source pollution is still a concern with respect to surface water and groundwater quality issues in the WAWRPR.

5.5.7.1 Nonpoint Source Priority Watersheds

Ten watersheds in Arkansas have designated as nonpoint source priority watersheds. These are 8-digit HUC watersheds where impairments or threats to water quality are known to occur. These priority watersheds either have or will have an approved Nine Element Plan and are eligible for Section 319(h) funding from the EPA (ANRC 2011b). Sections of four of these designated watersheds are located in the WAWRPR. These watersheds are displayed on Figure 5.8.

5.5.7.2 Hazardous Waste Remedial Action Priority Sites

Hazardous waste sites and resource extraction activities in the planning region also contribute nonpoint source pollution. There are six sites in the WAWRPR identified as priority for hazardous waste cleanup (i.e., Superfund sites) due to contamination of water resources. These are summarized in Table 5.4 (ADEQ 2013g). There are also eight properties in the state's Brownfields program that are currently being evaluated; one site that is on the State Priority List (SPL) that is monitored; two sites in the Elective Cleanup program; three Class I solid waste landfills; and an unknown number of hazardous waste sites (e.g. Whirlpool in Fort Smith) and leaking underground storage tank sites that are being evaluated or monitored through other regulatory mechanisms.

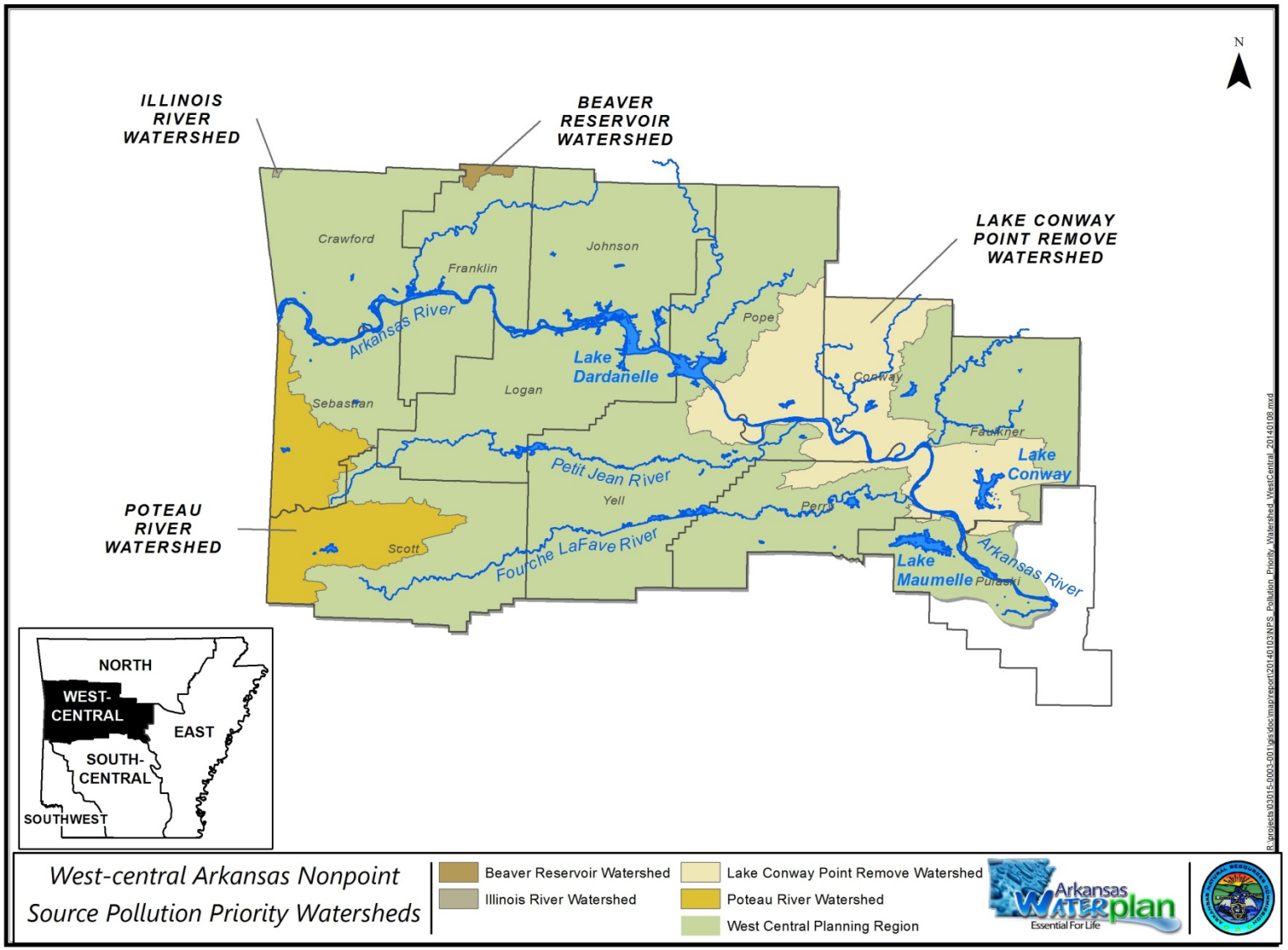

Figure 5.8. Nonpoint source pollution priority watersheds in the WAWRPR.

Table 5.4.Status of Superfund sites in the WAWRPR (ADEQ 2013h).

Site name	EPA ID	Site Location	Pollutants of concern	Contaminated water resources	Remediation Status	List
Industrial Waste Control	ARD980496368	Sebastian County	Methylene chloride, toluene, polynuclear aromatic hydrocarbons (PAHs), heavy metals	Unnamed tributary to Prairie Creek. groundwater	Completed 1991	Removed from National Priority List (NPL) April 2008
Mountain Pine Pressure Treating	ARD049658628	Yell County	Pentachlorophenol (PCP), copper chromate arsenate	Surface water (not specified), groundwater	Completed September 2005	NPL
Jimelco, Little Rock	ARD062144308	Pulaski County	Polychlorinated biphenyl (PCB), hydraulic oil, emthalite	Ditch to Fourche Creek (potential)	Completed May 2009	Removed from SPL June 2013
Plainview Lumber Company	ARD006349187	Yell County	PCP, Copper chromate arsenate (CCA)	Porter Creek & Prairie Creek (potential)	Now listed as part of Mount Pine Pressure Treating Site on NPL	Removed from SPL January 2009
United States Forgecraft	ARD006341747	Sebastian County	Arsenic, lead, cadmium, total chromium, and PAHs	In proximity to Poteau River	Completed 2009	Removed from SPL June 2010
Old Midland Products	ARD980745665	Yell County	PCP, PAHs	Groundwater	Completed 2006	NPL

Note: Highlighted rows indicate sites that were added to the NPL after the 1990 AWP update.

5.5.7.3 Resource Extraction

There is concern that natural gas extraction from the Fayetteville Shale Play could affect groundwater quality. However, a study conducted in 2011 did not find evidence of groundwater contamination associated with natural gas extraction in north-central Arkansas (Warner et al. 2013, EPA 2013c).

5.6 Loss of Aquatic Species

In a 2002 report, NatureServe ranked Arkansas 13th in the nation for the level of reportedly extinct species (NatureServe 2002). In 2005, 369 animal species of greatest conservation need were identified for Arkansas by a team of specialists (Anderson 2006). These species of greatest conservation need include 116 species associated with aquatic and semi-aquatic habitats that occur in the WAWRPR (see Figure 3.6). Figures 5.9 through 5.12 show the numbers of aquatic species of greatest conservation need present in watersheds within the WAWRPR. The greater the number of aquatic species of greatest conservation need present in a watershed, the more important it is to protect and restore water resources and their aquatic habitats in the watershed. The condition of aquatic habitats depend on characteristics such as water levels, flow volumes, and seasonal variability in both. Five aquatic and semi-aquatic animal species present in the planning region are on the federal list of threatened and endangered species (Table 5.5). One, the Arkansas River Shiner, is considered to be extirpated from Arkansas (USFWS n.d.b.).

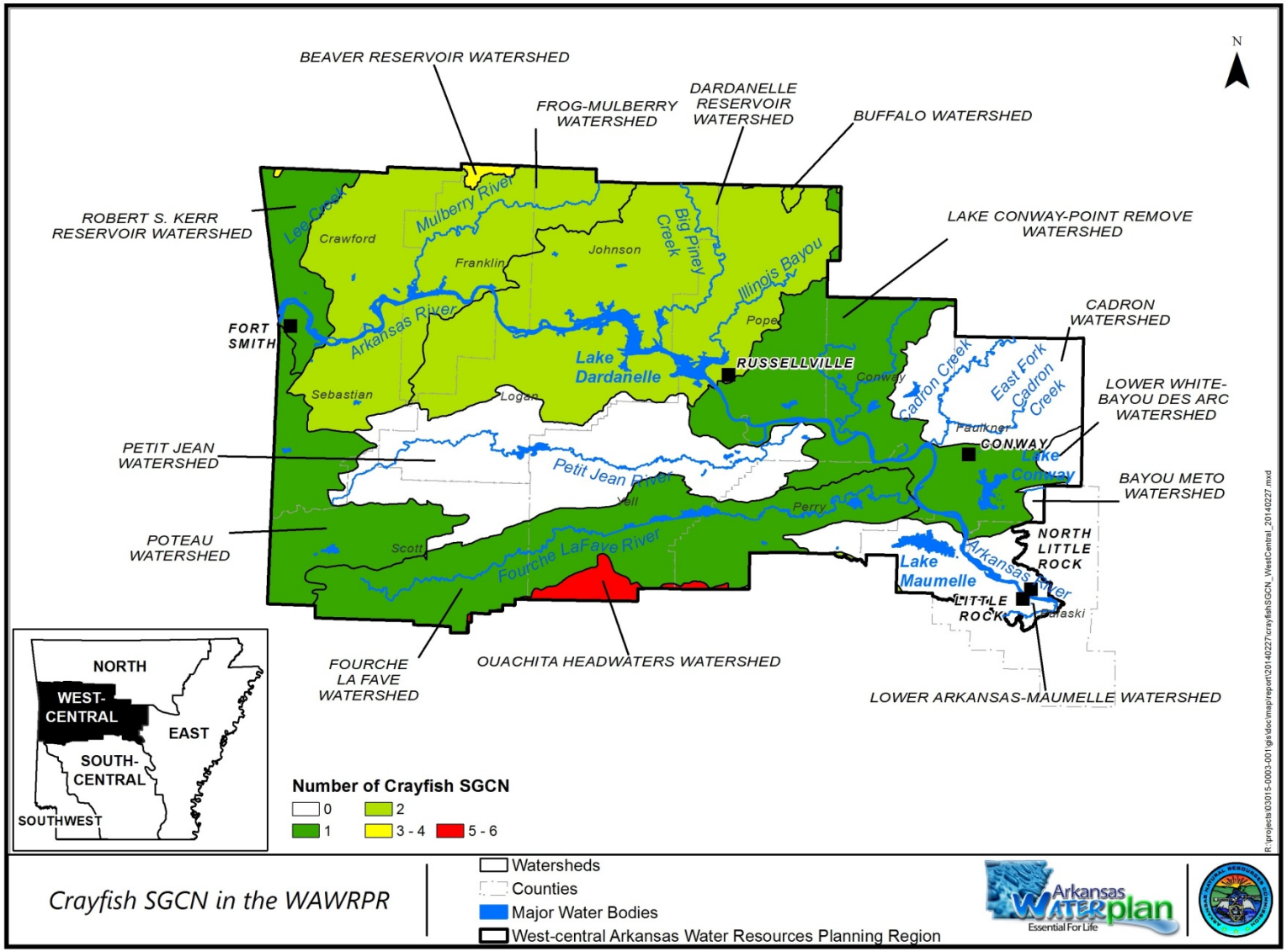

Figure 5.9. Numbers of crayfish Species of Greatest Conservation Need (SGCN) in watersheds of the WAWRPR.

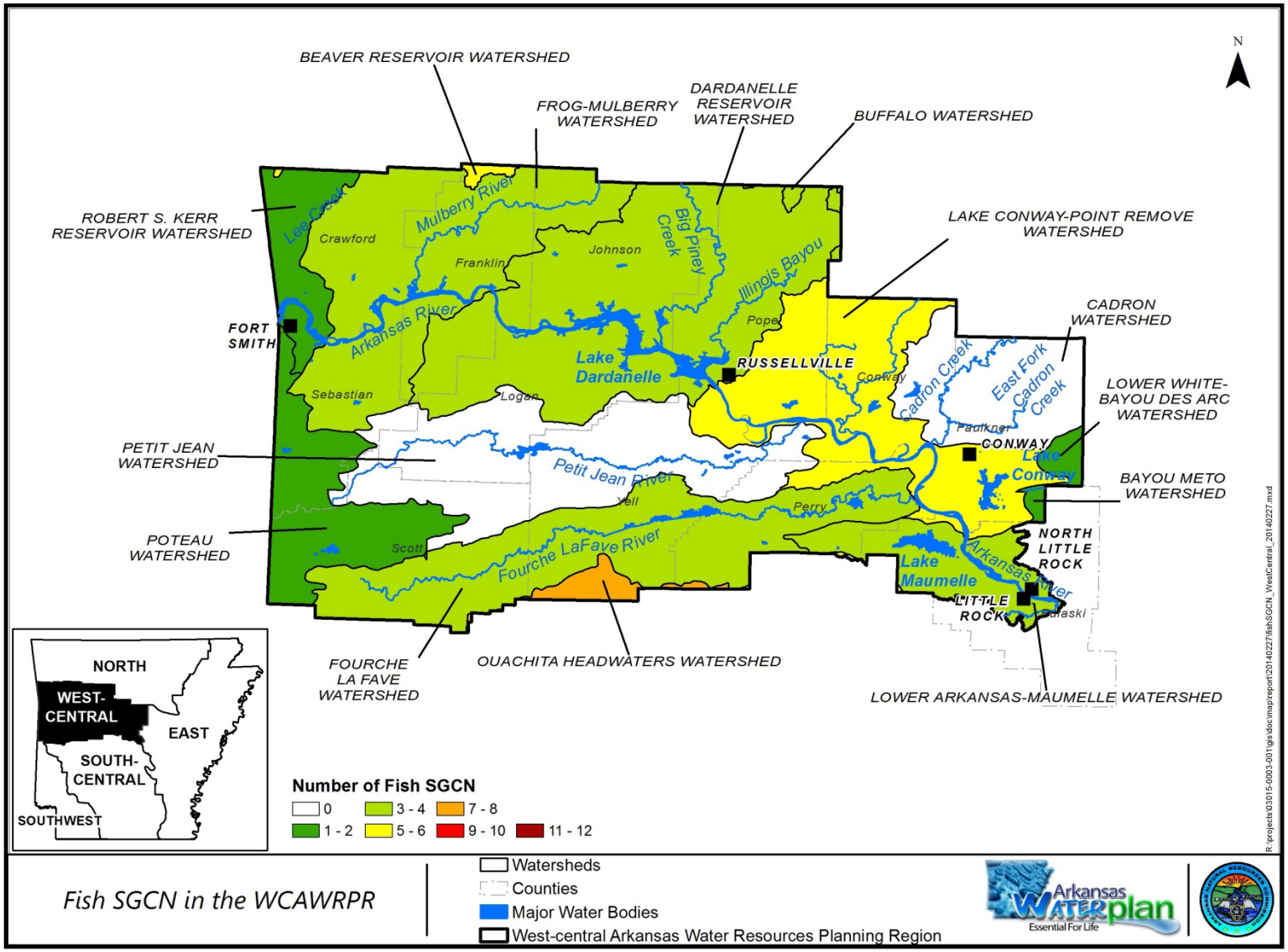

Figure 5.10. Numbers of fish SGCN in watersheds of the WAWRPR.

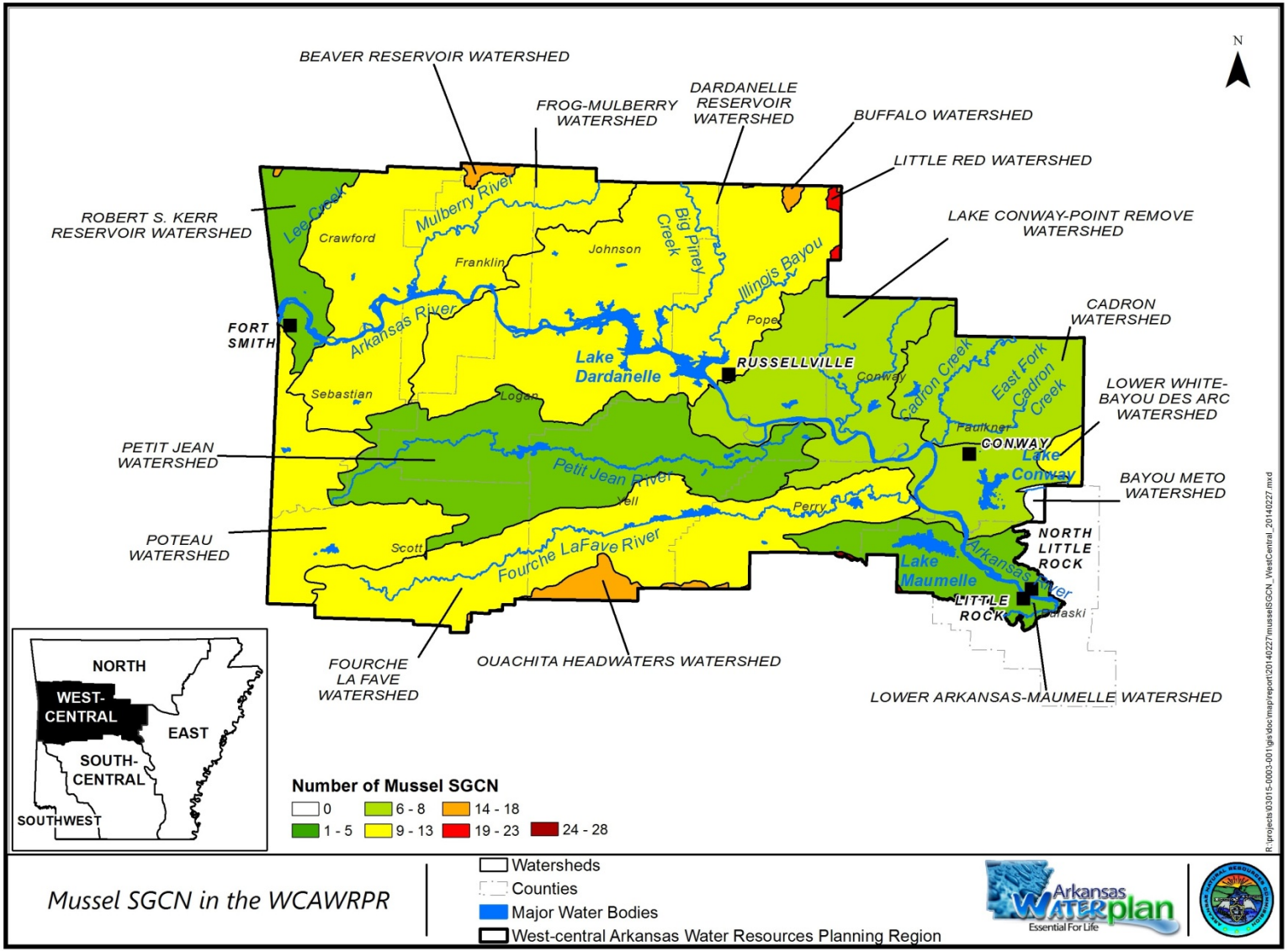

Figure 5.11. Numbers of mussel SGCN in watersheds of the WAWRPR.

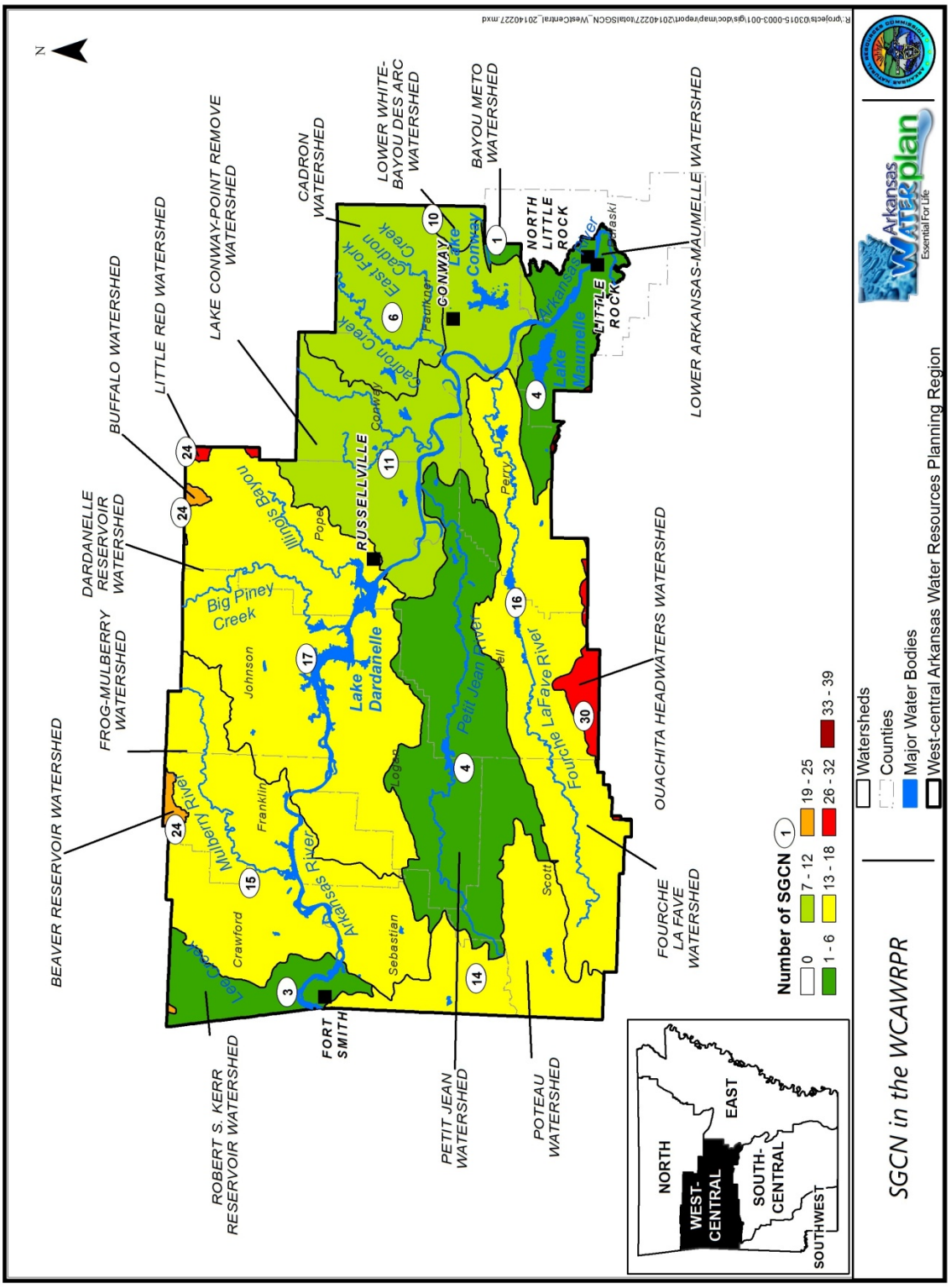

Figure 5.12. Total numbers of crayfish, fish, and mussel SGCN in the watersheds of the WAWRPR.

Table 5.5. Federally listed threatened and endangered species associated with aquatic and semi-aquatic habitats occurring in the WAWRPR (ANHC 2013, Anderson 2006, USFWS n.d.b.)

Common Name	Species Name	Status	WAWRPR habitat
Arkansas River shiner	Notropis girardi	Threatened	Turbid waters of broad, shallow, unshaded creek channels, small to large rivers, with mostly silt and shifting sand bottoms; Larvae seek backwater pools and side channels; extirpated from Arkansas River system
Harperella or piedmont mock bishopweed (herb)	Ptilimnium nodosum	Endangered	rocky/gravelly shoals or cracks in bedrock outcrops beneath the water surface in clear, swift-flowing streams, edges of intermittent pineland ponds; granite outcrop seeps
Scaleshell (freshwater mussel)	Leptodea leptodon	Endangered	Interior highlands division; typically associated with riffles, relatively strong currents, and substrate of mud, sand, or assemblages of gravel, cobble, and boulder; Currently it is more restricted to rivers with relatively good water quality in stretches with stable channels.
Spectaclecase (freshwater mussel)	Cumberlandia monodonta	Endangered	Large rivers with areas sheltered from current, i.e. beneath rock slabs, between boulders
Interior Least Tern	Sterna antillarum athalassos	Endangered	Mud flats, ponds, lakes
Piping Plover	Charadrius melodus	Threatened	Open sand, gravel, beaches; island and river riparian areas

In addition to the animals of greatest conservation need, the ANHC has identified 50 species of rare aquatic and semi-aquatic plants that occur in the WAWRPR. Seven semi-aquatic plant species present in the planning region are on the state threatened and endangered plant species list (Table 5.6). These plant species of concern are affected by water quality, water levels, flow rates, and/or seasonal changes in water levels or flow.

Table 5.6. State-listed threatened and endangered plant species occurring in aquatic and semi-aquatic habitats in WAWRPR (ANHC 2013).

Common Name	Species Name	Status	WAWRPR Counties
Slender rose-gentian	*Sabatia campanulata*	Endangered	Pulaski
Opaque Prairie Sedge	*Carex opaca*	Endangered	Faulkner, Franklin, Logan, Sebastian
White-top sedge	*Rhynchospora colorata*	Endangered	Pulaski
Small-head pipewort	*Eriocaulon koernickianum*	Endangered	Conway, Franklin, Johnson, Logan, Pope, Pulaski
Southern tubercled orchid	*Platanthera flava*	Threatened	Conway, Pulaski
Purple fringeless orchid	*Platanthera peramoena*	Threatened	Faulkner, Pulaski
Spinulose wood fern	*Dryopteris carthusiana*	Threatened	Logan, Yell

In some cases, the presence of non-native aquatic species is believed to affect aquatic biodiversity. There are 30 non-native aquatic animal species known to occur in the planning region (Table 5.7). The majority of the non-native fish species present in the region are sport fish species that have been introduced purposely and are regularly stocked. Some of the non-native fish species are believed to have been released from private aquariums. The impact of many of these species on native species is unknown. Some species, such as carp, are suspected to affect native species as a result of modifying aquatic habitats, e.g., removing vegetative cover and increasing turbidity. Other species, such as non-native sport fish and exotic clams, are suspected to affect native species by competing with them for food and/or habitat (USGS 2013d). There are also 11 species of invasive aquatic plants are known to occur in the planning region (Table 5.8) (University of Georgia - Center for Invasive Species and Ecosystem Health 2013).

Table 5.7. Non-native aquatic species occurring in the WAWRPR.

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
magnificent bryozoan	*Pectinatella magnifica*	East of Mississippi River	a pond in Elm Park, just off of Highway 23	2013	Unknown	Clog water pipes
freshwater jellyfish	*Craspedacusta sowerbyi*	China	Van Buren City Park Lake, Mulberry River, Rock Quarry near Altus, Old coal pit in Hartman, Paris City Lake, Hurricane Creek, Jeffrey Quarry, Kiwanis Pond in Little Rock	1999	Accidental	Unknown
waterflea	*Daphnia lumholtzi*	Africa, Australia, India	Dardanelle Reservoir	1994	Unknown	Competes with native species
a calanoid copepod	*Eurytemora affinis*	Ponto-Caspian region, North American Atlantic and Pacific Coasts, western European coast, parts of Asia	Dardanelle Reservoir, Nimrod Lake	1967, 1982	Accidental	Unknown
Inland Silverside	*Menidia beryllina*	Eastern North America, Mexico	Arkansas River, Dardanelle Reservoir	1987	Stocked	Competes with native species
Rock Bass	*Ambloplites rupestris*	St. Lawrence River, Great Lakes, Hudson Bay, Mississippi River basin in eastern Canada and U.S.	Lee Creek, Mulberry River, Dardanelle River, Big Piney Creek, Horshead Lake	1980, 1997	Stocked	Hybridization, competes with native species
Redbreast Sunfish	*Lepomis auritus*	Atlantic and Gulf Slope drainages	Spring Lake	1966	Stocked	Competes with native species
Unidentified pacu	*Colossoma or Piaractus sp.*	Tropical America	Arkansas River, Lake Valencia, Lakewood Lake #1	1992, 1995	Aquarium release	Unknown
Threadfin Shad	*Dorosoma petenense*	Ohio River, Mississippi River to gulf; Atlantic Slope, Gulf drainages	Jones Creek, Gap Creek	1988	Unknown	Competes with native species
Goldfish	*Carassius auratus*	Eastern Asia, China	Hollis Lake, Lake Conway, Arkansas River, Dardanelle Reservoir	1988	Introduced to propogate species in America	Unknown

Table 5.7. Non-native aquatic species occurring in the WAWRPR (continued).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
Grass Carp	*Ctenopharyngodon idella*	Eastern Asia	Lake Conway, Dardanelle Reservoir, Sixmile Creek, Lake Maumelle, Black Fork, Poteau drainage, Nimrod Lake	1988	Stocked	Competes with native species
Common Carp	*Cyprinus carpio*	Eurasia	Frog Bayou, Hurricane Creek, Lake Conway, Arkansas River, Mulberry Creek, Dardanelle Reservoir, Piney Creek, Fourche LaFave River, Illinois Bayou, Indian Creek, Lake Maumelle, Gap Creek, Poteau drainage, Blue Mountain Lake, Nimrod Lake	1988	Stocked	Destroys vegetation, causes turbidity
Silver Carp	*Hypophthalmichthys molitrix*	Eastern Asia	Lake Conway, Arkansas River	1988	Stocked	Unknown
Fathead Minnow	*Pimephales promelas*	Parts of North America	Dardanelle Reservoir, Lake Maumelle, Gap Creek, Blue Mountain lake	1988	Accidental (baitfish)	Unknown
Northern Pike	*Esox lucius*	Atlantic, Arctic, Pacific, Great Lakes, Mississippi River basins	Jones Creek	1988	Stocked	Reduce prey density
White Catfish	*Ameiurus catus*	Atlantic and Gulf Slope drainages	Flat Cypress Creek, Lake Conway	1988	Stocked	Loss of native species
Brown Bullhead	*Ameiurus nebulosus*	Atlantic and Gulf Slope drainages, St Lawrence-Great Lakes, Hudson Bay, Mississippi River basins	Lake Conway-Point Remove drainage, Fourche La Fave daraigne, Jones Creek, Sugar Loaf Lake, Blue Mountain Lake	1988	Stocked	Reduce prey density

Table 5.7. Non-native aquatic species occurring in the WAWRPR (continued).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
Blue Catfish	*Ictalurus furcatus*	Mississippi River Basin, Gulf Slope	Frog Bayou, Lake Forth Smith, Lake Shepherd Springs, Ozark Lake, Mulberry River, Shores Lake, Big Piney Creek, Horsehead lake, Big Shoal Creek, Cove Lake, Lake Dardanelle, Illinois Bayou, Jonew Creek, Lake Hinkle, Gap Creek, Sugar Loaf Lake, Kingfisher Lake, Blue Mountain Lake, Petit Jean River, Spring Lake	1988, 1997	Stocked	Hybridization
Wiper (Sunshine Bass)	*Morone chrysops x M. saxatilis*	None (artificially hybrid)	Lake Maumelle	1981	Stocked	Backcrossing of several species
Striped Bass	*Morone saxatilis*	St. Lawrence River, Gulf Slope drainage	Arkansas River, Ozark Lake, Dardanelle Reservoir, Blue Mountain Lake, Lake Maumelle, Nimrod Lake	1967, 1984, 1988, 1997	Stocked	Preys on small fish
Walleye	*Sander vitreus*	St. Lawrence-Great Lakes, Arctic, and Mississippi River basins	Lee Creek, Dardanelle Reservoir, Blue Mountain Lake, Nimrod Lake	1950, 1988	Stocked	Preys on native species, depletes the forage base
Cutthroat Trout	*Oncorhynchus clarkii*	Pacific Coast drainages	Arkansas River, North Fork River	1992, 1997	Stocked	Hybridization
Rainbow Trout	*Oncorhynchus mykiss*	Pacific Slope	Arkansas River, North Fork River	1988, 1992, 1997	Stocked	Hybridization, predation of native species
Brown Trout	*Salmo trutta*	Europe, Northern Africa, western Asia	Arkansas River	1997	Stocked	Reduce native fish population
Brook Trout	*Salvelinus fontinalis*	Eastern Canada, Atlantic, Great lakes, Mississippi River Basin	Arkansas River, North Fork River	1992, 1997	Stocked	Loss of native species
Lake Trout	*Salvelinus namaycush*	Canada, Alaska, New England, Great Lakes basin	Arkansas River	1997	Stocked	Loss of native species

Table 5.7. Non-native aquatic species occurring in the WAWRPR (continued).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
Nutria	*Myocastor coypus*	Southern South America	Conway, Crawford, Faulkner, Franklin, Johnson, Logan, Perry, Pope, Pulaski, Sebastian, Yell Counties	1978	Imported for fur farming	Over-grazing of wetland habitats
Asian clam	*Corbicula fluminea*	Southern Asia, Africa, Asian islands, Australia	Arkansas River, Frog Bayou, Illinois Bayou	1974, 1980, 1983, 1985	Food of immigrants	Biofouling, damage to structures, modfication of predator diets
zebra mussel	*Dreissena polymorpha*	Black, Caspian, Azov Seas	Arkansas River, Dardanelle Reservoir, Holla Bend National Wildlife Refuge	1992, 1994, 1995, 1997, 2005	Accidental	Biofouling, decline of native species
Common octopus	*Octopus vulgaris*	Atlantic Ocean	Lake Conway	2003	Aquariumrelease	N/A

Table 5.8. Invasive aquatic plants occurring in the WAWRPR.

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
Alligatorweed	*Alternanthera philoxeroides*	South America	Perry, Pulaski Counties	1988	Accidental - ballast water	Displace native species, clog waterways, diminished water quality
Brazilian waterweed	*Egeria densa*	South America	Conway, Pulaski Counties	1988	Aquariumrelease	Displace native species, interferes with recreational activities
Common water hyacinth	*Eichhornia crassipes*	South America	Pope, Pulaski Counties	1999, 2006	Imported-ornamental plant	Reduce light levels, diminished water quality
Hydrilla	*Hydrilla verticillata*	Europe, Old World	Pulaski County	Not Available	Aquariumrelease	Restrict native species, irrigation, recreation, hydroelectirc production, water flow
Yellow iris	*Iris psedacorus*	Asia, Africa, Europe	Pulaski County	1997	Imported-ornamental plant	Not Available
European water-clover	*Marsilea quadrifolia*	Europe, Asia	Pulaski County	Not Available	Not Available	Not Available
Eurasian water-milfoil	*Myriophyllum spicatum*	North America, Europe, Asia, Africa	Pulaski County	Not Available	Accidental	Displace native species, reduce light levels, reduce habitat for others
Watercress	*Nasturtium officinale*	Not Available	Crawford, Franklin Counties	1988	Not Available	Not Available
Reed canarygrass	*Phalaris arundinacea*	North America, Europe	Sebastian County	Not Available	Escapedcultivars	Excludes other vegetation
Water fern	*Salvinia minima*	Mexico, South America	Pulaski County	Not Available	Not Available	Not Available
Narrow-leaved cattail	*Typha angustifolia*	Not Available	Faulkner County	Not Available	Not Available	Not Available

5.7 Water Infrastructure

Communities throughout the state struggle to provide and maintain drinking water and wastewater infrastructure, including treatment plants and distribution lines. Several communities in the WAWRPR are experiencing growth that is requiring expansion of water supply and wastewater capacity. For example, Lake Fort Smith was expanded to serve the growing water supply needs in the Fort Smith area. The James Fork Regional Water District has expanded over the last 10 years from serving only south Sebastian County to including residents in Scott County, and the cities of Greenwood and Booneville with quality drinking water (James Fork Regional Water District 2014). Central Arkansas Water (CAW) serving the Little Rock metropolitan area, has expanded their Pleasant Valley treatment plant most recently in 2008 from a capacity of 100 mgd to 133 mgd. In 2007, CAW began construction on expanding their water supply distribution north of the Arkansas River to include north Pulaski County and the cities of Jacksonville and Cabot (Central Arkansas Water n.d.a.). In other areas within the planning region, maintaining aging infrastructure with limited financial resources is an issue.

Expansion of water supply service areas, at times, results in conflict between water providers. For example, in 2003, the City of Forth Smith water utility proposed to expand its service area into areas already being served by the James Fork Regional Water District. This expansion was opposed by the James Fork Regional Water District. The two water utilities ended up in litigation over this issue, settling in 2005 (James Fork Regional Water District 2014).

The recent increased focus on nutrients in wastewater discharges is affecting infrastructure in the WAWRPR. Historically, permitted point source discharges in Arkansas were not limited with regard to the amount of nutrients that could be in the wastewater they discharge. Current regulations require that all point source discharges in watersheds of waterbodies included on the Arkansas list of impaired waters due to phosphorus, be limited in the amount of phosphorus that can be present in their discharge. Point source discharges in designated nutrient surplus watersheds can also be subject to limits for phosphorus in their discharge under this regulation (Arkansas Regulations 2.509). Upgrades to remove nutrients from wastewater are often expensive, placing an additional financial burden on utilities. As of

2013, at least 10 municipal facilities in the WAWRPR have current discharge permits that require monitoring the discharge for phosphorus and/or nitrate (ADEQ 2013i).

6.0 INSTITUTIONAL AND REGULATORY SETTING

This section provides a description of the regulatory and institutional framework for water resources management in WAWRPR. It includes general descriptions of federal and state laws, regulations, and programs that deal with water resources management in the region, as well as a listing of federal, state, and local governmental and nonprofit institutions that are involved in water resources management in the region. In addition, the interrelationships between regulations and institutions at the federal, state, and local levels in the planning region are illustrated.

6.1 Legal Framework

The legal framework for management and use of water resources in Arkansas is based on court case law, laws enacted by the Arkansas General Assembly, and rules and regulations enacted by state agencies. Federal laws and regulations also influence the regulation of water resources in the state (ANRC 2011a). The discussion below identifies and summarizes the laws and regulations and associated programs that guide water management in WAWRPR, and summarizes changes that have occurred in this legal framework since the 1990 AWP update.

6.1.1 Federal Laws and Regulatory Programs

Federal policy recognizes that states have primary authority for regulation of water usage within their borders. Therefore, the federal laws, regulations, and associated programs that influences water resources management in the WAWRPR primarily relate to water quality. Federal legislation and programs also deal with other aspects of management of water resources in the region such as conservation and protection of waterbodies, flood control, and navigation.

6.1.1.1 Water Quality

The current federal laws and programs that guide management of water quality in the WAWRPR are summarized in Table 6.1. The Clean Water Act (CWA) of 1972 (most recently amended in 2002) and the Safe Drinking Water Act (SDWA) of 1974 (most recently amended in 1996) are two important pieces of federal water quality legislation that authorize a number of

Table 6.1. Federal laws and regulatory programs that address WAWRPR water quality.

Federal Law	Federal Water Quality Regulatory Programs	Responsible Federal Agency
Clean Water Act	Ambient nutrient water quality standards	EPA
	Biosolids regulations	
	Impaired waters	
	Nonpoint source pollution management	
	NPDES point source permitting	
	NPDES stormwater permitting	
	NPDES pesticide application permitting	
	NPDES confined animal feeding operations permitting	
	State ambient water quality standards	
	State biennial water quality assessment	
	Total maximum daily loads (TMDL)	
	Dredge and fill permitting	USACE
Safe Drinking Water Act	Source water protection	EPA
	Underground injection wells	
Underground storage tank regulations	Underground storage tank program	EPA
Resource Conservation and Recovery Act	Hazardous waste management	EPA
	Solid waste management	
	Subtitle D	
Comprehensive Environmental Response, Compensation, and Liability Act	Hazardous waste site clean up	EPA
Federal Insecticide, Fungicide, and Rodenticide Act	Endangered species protection program	EPA
	Labeling requirements	
	Registration	
Surface Mining Control and Reclamation Act	Mine reclamation	US Department of the Interior (USDI)
	Surface mining control	
Toxic Substances Control Act	Polychlorinated Biphenyls (PCB) Program	EPA
Soil and Water Resources Conservation Act	Conservation Effects Assessment Program	USDA
Arkansas Wilderness Act	National forests	USDA Forest Service
National Forest Management Act		
Weeks Act		
Oil Pollution Act	Oil spill response planning	EPA
Pollution Prevention Act	Pollution prevention planning	EPA
National Environmental Policy Act	Environmental impact analysis of Federal projects, with mitigation	EPA, Council on Environmental Quality

Note: Highlighted laws and programs were promulgated after the 1990 AWP update.

federal water quality programs. Legislation related to forest conservation, such as the Cooperative Forestry Assistance Act, is included here because forests can protect and improve water quality. The EPA is responsible for administering the majority of these laws and programs; however, EPA has delegated some of this authority to state agencies such as ADEQ and the Arkansas Department of Health.

The CWA of 1972 established the NPDES that regulates point source discharges through a permit program. The NPDES program is managed by EPA, but ADEQ has been delegated authority to issue NPDES permits. NPDES permits are based on a combination of technology-based and water quality based standards. Technology-based standards are developed by EPA for certain industry categories based on the performance of pollution control technologies available to the industry without regard for the receiving water body. Water quality based standards are developed after consideration of the designated uses of the receiving water body and the water quality criteria necessary to protect those uses. In 1987, Congress amended the CWA to include nonpoint sources of pollution such as stormwater runoff from industries, construction sites, and municipalities. NPDES permits for the WAWRPR are summarized in Section 4. The 1987 amendments also addressed management of biosolids (sewage sludge). The CWA also requires permits for dredge and fill activities in wetlands, lakes, streams, rivers, and other waters of the US. These permits are issued by the USACE.

The TMDL program was established by the CWA in 1972; however, TMDLs were rarely developed for waterbodies until the 1990s, after environmental groups began suing the EPA over the lack of TMDLs being performed (EPA 2008). The CWA requires that a TMDL study be conducted for waterbodies identified as having impaired water quality. The TMDL study is conducted to determine the maximum amount of a pollutant that a waterbody can receive and still meet ambient water quality standards. This maximum load is split between point sources and nonpoint sources. These loads are then compared to the estimated existing point source and nonpoint source loads to determine the amount of reduction required for the waterbody to meet its water quality standards. The first TMDLs for waterbodies in the WAWRPR were completed in 2000. Prior to this, beginning in the 1980s, ADEQ routinely performed Wasteload Allocation Studies as part of the NPDES permitting process to determine the amount of a pollutant that

could be discharged to a waterbody. Since 2000, 15 TMDLs have been completed for waterbodies in the WAWRPR (see Section 5).

In 1998, EPA initiated a program to develop ambient water quality criteria for nutrients, i.e., nitrogen and phosphorus. At the time, nutrients were identified as a leading cause of water quality issues across the nation, including such high profile events as the hypoxic zone in the Gulf of Mexico and algal blooms along the national seacoast. In 2001, EPA published recommended nutrient criteria development plans (EPA 2013c).

The drinking water source water protection program was initiated as a result of the 1996 amendment to the SWDA. The purpose of this program is to prevent the need for increased treatment of drinking water (resulting in increased treatment costs and costs to customers) due to water quality degradation, by protecting the quality of the drinking water source. In the majority of cases, the cost of protecting drinking water sources from pollution is far lower than the cost of upgrading water treatment to remove increased pollution. There are approximately 90 public water utilities in the WAWRPR that are subject to SDWA regulations (ADH n.d.).

Subtitle D of the 1991 amendment of the Resource Conservation and Recovery Act (RCRA) introduced specifications for how landfills were to be constructed and managed to protect water quality. This led to sweeping changes in solid waste management across the country and in Arkansas (ADEQ 2011).

6.1.1.2 Water Resources Management

The federal regulations and programs that address non-water quality aspects of water resources management are summarized in Table 6.2. These include regulations and programs that address flood control, river navigation, wetlands tracking, or water-based recreation. Programs related to drinking water infrastructure are also included in Table 6.2 and discussed below. The dredge and fill permitting program of the CWA both protects water quality and preserves the extent and physical quality of aquatic habitats. Federally appropriated water, such as the water required to maintain navigation on MKARNS, is not available for other uses. Federal water appropriations preempt other beneficial water uses, such as irrigation.

Table 6.2. Federal laws and regulatory programs that address aspects of WAWRPR water resources other than water quality.

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Clean Water Act	Wetland and stream mitigation	USACE	Physical protection of waterbodies, including wetlands
Safe Drinking Water Act	Consumer confidence reports	EPA	Protects/improves public water supply
	Finished water criteria		Protects human health
	Operator certification		Informs the public
Endangered Species Act	Freshwater species protection	USFWS	Mechanism for physical protection of waterbodies that are habitats for endangered species
	Waterfowl protection		
Soil and Water Resources Conservation Act	Census of Agriculture	USDA	Irrigation and agriculture
	Conservation Effects Assessment Program		Water resources protection/improvement
	Natural Resources Inventory		Characterize water resources
National Environmental Policy Act	Environmental Impact Statements and Mitigation	EPA, Council on Environmental Quality	Water resources protection/mitigation
Flood Control Act/Water Resources Development Act	Dam safety	USACE	Water storage, water supply, flood reduction, flow management, restoration of physical aquatic habitat
	Flood control reservoirs		
	Levees		
	Navigation systems		
Arkansas Wilderness Act	National forests	USDA Forest Service	Well managed forestlands improve and protect water resources
National Forest Management Act			
Weeks Act			
Rivers and Harbors Act	Navigation	USACE	Federal navigation systems in Arkansas
	Section 10	USACE	Protects waterbodies, including wetlands
Migratory Bird Hunting and Conservation Stamp Act	Small wetland acquisition program	USFWS	Protects wetlands
Emergency Wetlands Resources Act	National Wetlands Inventory	USFWS	Track wetland resources
Dam Safety and Security Act	National Dam Safety Program	Federal Emergency Management Agency (FEMA)	Protection of lives and property

Table 6.2. Federal laws and regulatory programs that address aspects of WAWRPR water resources other than water quality (continued).

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
National Parks Acts	National Parks	USDI National Park Service	Protection of water resources associated with national parks
Migratory Bird Conservation Act	Acquisition of lands for wildlife refuges	Migratory Bird Conservation Commission	Preservation of water resources for bird habitat
National Wildlife Refuge System Improvement Act	National Wildlife Refuges	USFWS	Preservation of water resources for habitat
Pittman-Robertson Wildlife Restoration Act	Wildlife and sport fish restoration	USFWS	Preservation of water resources for fish and wildlife habitat
National Flood Insurance Act	National Flood Insurance Program	FEMA	Insurance against flood losses
	Floodplain management		Reduction of flood damage
	Flood hazard mapping		Identification of flood hazard areas
None	Climate monitoring	NOAA	Tracking precipitation and evaporation – water availability
	Climate prediction		Future water availability
	Drought status		Enactment of water shortage specific management

Note: Highlighted programs were initiated after the 1990 AWP update

An important federal program for mitigating impacts to wetlands and streams is part of the dredge and fill permitting program of the CWA (Section 404), overseen by the USACE. This mitigation program was initiated in 1990, when the EPA and the USACE signed a memorandum of agreement establishing a process for determining the need for mitigation of impacts to wetlands, streams, and other water resources under the CWA Dredge and Fill Permitting program. This program provides a means for dredge and fill permit applicants to compensate for unavoidable destruction of aquatic habitat by either restoring or creating similar habitat either on site or at another location (EPA 2013d). The program is a mechanism for implementing the federal policy of no-net-loss of wetlands. Revised regulations governing this mitigation program were issued in 2008. Located in the WAWRPR is the privately managed 2,064 acre Cadron

Creek Mitigation Bank and the 160-acre Hartman Bottoms Wetland Mitigation Bank created by the AHTD (NRI Group 2010, Federal Highway Administration n.d., USACE 2013, AHTD 2001).

The Endangered Species Act provides for protection and recovery of imperiled terrestrial, freshwater, and marine plant and animal species (except pest insects) (USFWS 2013)

The 1996 amendments to the SDWA directed EPA and the states to develop requirements for certification of water treatment system operators (EPA 2012e). These amendments also initiated a program that required public water suppliers that operate community water systems to provide annual reports to drinking water utility customers on the quality of their drinking water.

Under the National Flood Insurance Act, flood hazard maps have been completed for much of the WAWRPR, and most of the mapping has been modernized within the last 8 years, with the exception of Perry and Scott Counties (Figure 6.1). Flood hazard maps for Perry County range from 13 to 15 years old. In Scott County, the unincorporated areas have never been mapped, but the Town of Mansfield and City of Waldron have maps that range from 3 to 33 years old. Modernized flood hazard maps typically include updated Special Flood Hazard Areas (SFHAs), and are created in a digital countywide format. For the communities participating in the National Flood Insurance Program (NFIP), the flood hazard maps identify the regulatory SFHA whereby the community floodplain administrator applies the locally adopted and enforced floodplain management ordinance. Participation in the NFIP is voluntary; however non-participation results in federal flood insurance not being available to residents and limits post-disaster financial assistance. The NFIP provides some water quality protection through reducing changes in hydrology by restricting development in the floodplain. All of the counties except Scott County in the planning region participate in the NFIP, as well as around 75 individual communities (FEMA 2013).

The Flood Control Act provided the authority for construction of federal flood control projects, constructed and maintained by the US Army Corps of Engineers. The Water Resources Development Act (WRDA) has superseded the Flood Control Act in 1974.

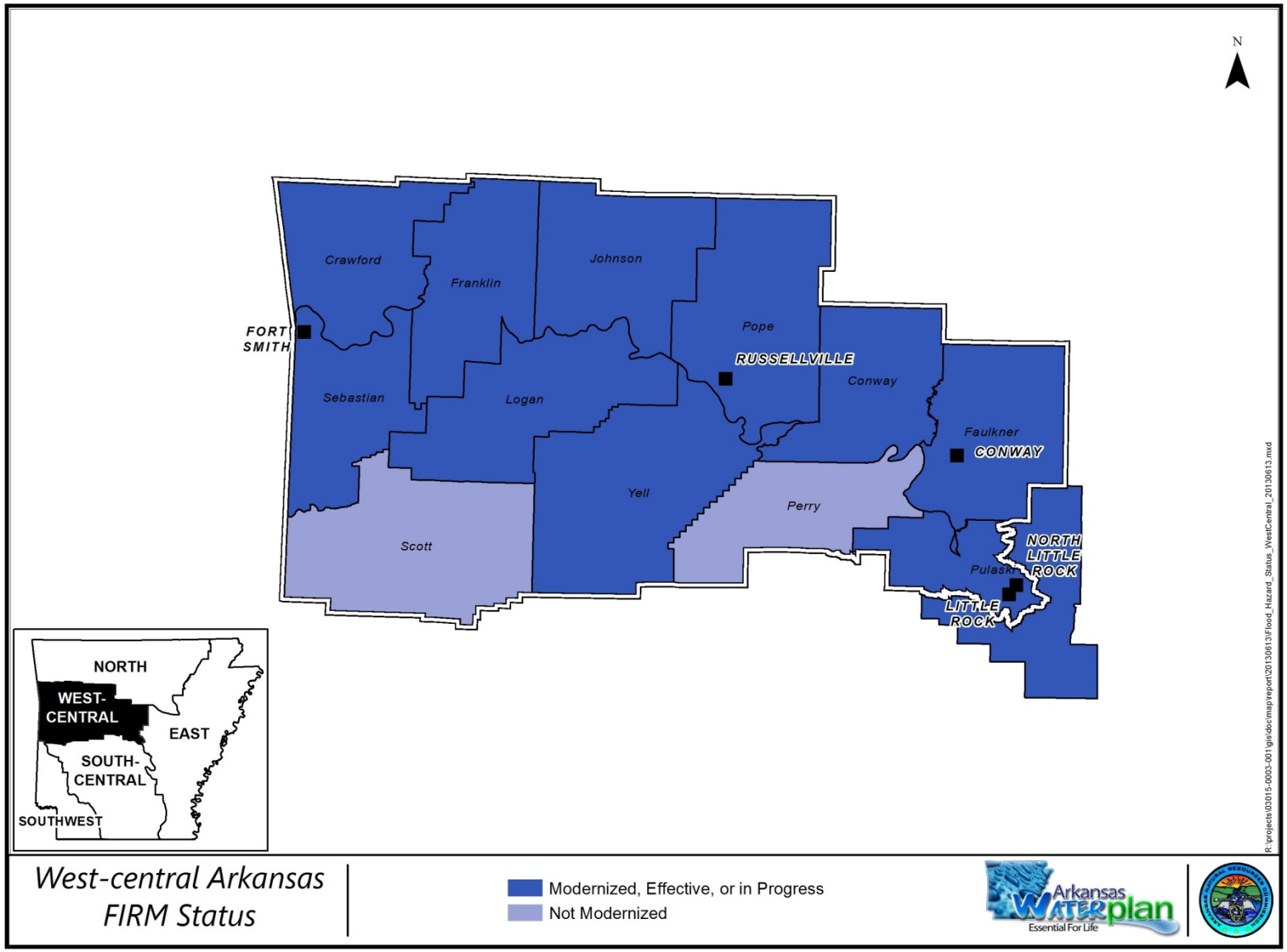

Figure 6.1 Flood hazard map status.

Surface waters in the WAWRPR that are under some degree of federal management include the Arkansas River (MKARNS and Holla Bend NWR), Petit Jean River (Blue Mountain Lake and the Ouachita National Forest), Fourche La Fave River (Nimrod Lake), Mulberry River (Ozark National Forest), Lee Creek (Ozark National Forest), and Poteau River (Ouachita National Forest). Streams considered navigable in the Little Rock District of the USACE include, in addition to the previous list, Illinois Bayou in Pope County, Lee Creek in Crawford County, and the Little Maumelle River in Pulaski County (USACE Little Rock District 2004)

MKARNS was a federal flood control project. In addition, reservoirs were constructed by the USACE in the region in the 1940s as part of a comprehensive plan for flood control and development of water resources in the Lower Arkansas River Valley. These included Blue Mountain Lake on the Petit Jean River, and Nimrod Lake on the Fourche La Fave River (Lancaster 2011a, 2011b). The Holla Bend NWR is located on a bend of the Arkansas River that was cut off during river straightening by the USACE for flood control. The Holla Bend NWR provides a winter home for some of the millions of ducks and geese that use the Mississippi Flyway annually. Federally authorized uses for the portions of the Arkansas River in this planning region include navigation and flood control. However, the Arkansas River is also authorized for hydropower, and provides a variety of additional benefits including water supply, fish and wildlife conservation and recreation.

Federally appropriated water, such as the water required to maintain navigation on MKARNS, is not available for other uses. Federal water requirements preempt other beneficial water uses. The Arkansas River minimum flow at Little Rock (Murray Lock and Dam 7) required for navigation is 3,000 cubic feet per second (cfs).

6.1.2 Federal Laws and Assistance Programs

Federal laws have also established a number of programs to provide technical and financial assistance for water resources management, that are available in Arkansas. Assistance programs for management of water quality and other aspects of water resources are discussed in the following sections.

6.1.2.1 Water Quality

Table 6.3 summarizes current federal assistance programs available in the WAWRPR and the associated federal laws. The majority of the federal assistance programs listed originated through the Farm Bill. The Farm Bill has been amended four times since 1990, most recently in 2013 (National Agricultural Law Center 2012). New conservation programs that are intended to assist farmers in protecting and restoring water quality have been added with each amendment. In 2012, nearly $9 million in funding was provided for water quality practices from Farm Bill programs on over 60,000 acres. Due to the extreme drought that occurred from 2010 through 2012 over 33,000 of the acreage in the conservation programs were in drought specific programs (Table 6.4) (NRCS 2012).

Table 6.3 Federal water quality assistance programs available in the WAWRPR.

Federal Law	Federal Water Quality Funding Assistance Programs	Responsible Federal Agency
CWA	Clean water state revolving fund	EPA
	Nonpoint source pollution management grants	
	Water pollution control program grants	
Comprehensive Environmental Response, Compensation, and Liability Act	Hazardous waste site clean up	EPA
Cooperative Forestry Assistance Act	Forest Stewardship Program	USDA Forest Service
	Forest Legacy Program	
	Urban and Community Forestry Program	
Housing and Community Development Act	Community development block grants programs	US Department Housing and Urban Development (HUD)
Consolidated Farm and Rural Development Act	Water and waste disposal systems for rural communities	USDA Rural Utilities Service
	Water and Waste Disposal Loans and Grants	
	Solid Waste Management Grants	
	Grant Program to Establish a Fund for Financing Water and Wastewater Projects	

Table 6.3 Federal water quality assistance programs available in the WAWRPR (continued).

Federal Law	Federal Water Quality Funding Assistance Programs	Responsible Federal Agency
Farm Bill	Agricultural Water Enhancement Program	USDA Natural Resources Conservation Service (NRCS)
	Conservation Reserve Program (CRP)	USDA Farm Services Agency
	Conservation Innovation Grants Program	NRCS
	Conservation Stewardship Program (CSP)	
	Cooperative Conservation Partnership Initiative	
	Environmental Quality Incentives Program (EQIP)	
	Farm and Ranch Land Protection Program	
	Grassland Reserve Program	
	Grazing Lands Conservation Initiative	
	Mississippi River Basin Healthy Watersheds Initiative	
	National Water Management Center	
	National Water Quality Initiative	
	Organic Initiative	
	Plant Materials Program	
	Watershed protection and flood prevention	
	Wetlands Reserve Program	
	Wildlife Habitat Incentives Program	
American Recovery and Reinvestment Act	Clean water state revolving fund, Clean up of leaking underground storage tanks	Recovery Accountability and Transparency Board
Clean Vessel Act	Funding for pumpout stations and waste reception facilities for recreational boaters	USFWS

Note: Highlighted laws and programs were promulgated after the 1990 AWP update.

A component of the NRCS conservation activities provided for in the Farm Bill is the Plant Materials Program, which hosts a regional Plant Material Center in the WAWRPR, the Arkansas Plant Materials Center (ARPMC). The ARPMC is operated by the NRCS on the Dale Bumpers Small Farm Research Center in Booneville. The ARPMC develops plants and plant science that focuses on the protection and enhancement of water quality through conservation methods specific to the Ozarks and areas into Oklahoma (NRCS Plant Materials Program n.d.).

Table 6.4. NRCS conservation programs summary for 2012 (NRCS 2012).

County	CRP			Drought / EQIP			EQIP (All initiatives and Funding Categories			Drought / Wildlife Habitat Incentive Program			Wetlands Reserve Program		
	Contracts	acres	$ obligated	Contracts	acres	$ obligated	Contracts	acres	$ obligated	Contracts	acres	$ obligated	Contracts	acres	$ obligated
Conway	0	0	0	43	3836.7	$ 824,420	81	13126	$ 2,175,446	1	25	$ 1,251	1	99.14	$ 90,764
Crawford	0	0	0	0	0	$ -	6	1009.2	$ 116,754	4	824	$ 65,293	1	132.5	$ 230,000
Faulkner	0	0	0	48	3886	$ 1,035,232	56	4824.3	$ 1,234,784	7	279.1	$ 31,155	0	0	$ -
Franklin	0	0	0	0	0	$ -	9	700	$ 99,352	0	0	$ -	0	0	$ -
Johnson	0	0	0	0	0	$ -	23	1295	$ 236,784	0	0	$ -	0	0	$ -
Logan	0	0	0	0	0	$ -	16	447.4	$ 240,889	2	482	$ 35,642	0	0	$ -
Perry	1	814.3	$ 17,539	23	2165.3	$ 563,777	30	2901.3	$ 702,037	1	20	$ 4,316	0	0	$ -
Pope	0	0	0	42	4416.5	$ 560,293	79	9263.1	$ 1,415,746	13	1774.7	$ 192,803	0	0	$ -
Pulaski*	0	0	0	0	0	$ -	4	12.7	$ 33,604	1	28	$ 6,772	0	0	$ -
Scott	0	0	0	0	0	$ -	3	259.8	$ 119,659	0	0	$ -	0	0	$ -
Sebastian	0	0	0	0	0	$ -	8	1186.7	$ 125,938	5	879	$ 74,314	0	0	$ -
Yell	0	0	0	47	12001.2	$ 887,795	80	16563.8	$ 1,561,522	7	3273.1	$ 174,535	0	0	$ -
Total	1	814.3	$ 17,539	203	26305.7	$ 3,871,517	395	51589.3	$ 8,062,515	41	7584.9	$ 586,081	2	231.64	$ 320,764

* A portion of this county is located in another planning region

The CWA authorizes EPA to provide federal funding assistance to states and local entities through three funding programs. Through the Clean Water State Revolving Fund, federal funds are provided to ANRC to fund a low interest loan program for wastewater treatment, nonpoint source pollution control, and watershed management projects in the state. Grants for nonpoint source pollution control projects are authorized under Section 319 of the CWA. Finally, Section 106 of the CWA authorizes federal funding assistance to states and interstate agencies through grants for pollution control programs such as discharge permitting and water quality monitoring.

The American Recovery and Reinvestment Act (ARRA) was promulgated in 2009 to save and create jobs during the recession that began in 2008. This act initiated several programs that provide money to states for a range of activities, including improvements to wastewater treatment infrastructure and cleanup of contaminated leaking underground storage tanks (EPA 2013e). Over $25 billion of recovery money was awarded to the Arkansas State Clean Water Developing Loan Fund. ARRA funds were also awarded to two leaking underground storage tank cleanup projects in Crawford County (EPA n.d.). Another ARRA project in the planning region that could be considered a water quality project is the wetland restoration at the Presidential Park in Little Rock (State of Arkansas 2009).

The Clean Vessel Act was promulgated in 1992. This act established a program to provide grants to states to pay for construction, maintenance, operation, or renovation of boat pumpout stations and waste reception facilities (US Congress 1992, ADH 2011). In June 2013 USFWS announced that the Arkansas Department of Health was awarded $1.5 million for construction, purchases, renovations, and the operation and maintenance of pump-out facilities, docks and stations, and assistance in sewage hauling. They will also continue their campaign to increase awareness, understanding and compliance with the goals of the Clean Vessel Act program in its state (Heartland Boating 2013).

Forestry assistance programs are included in Table 6.3 because forest improvement can improve water quality.

6.1.2.2 Water Resources Management

The federal assistance programs that address non-water quality aspects of water resources management are summarized in Table 6.5. These include programs that address flood control, water conservation, water supply systems, fisheries, and aquatic habitat for wildlife. Some of the programs that provide assistance for addressing water quality also address other aspects of water resources management. For example, some Farm Bill programs support practices that conserve water, as well as practices that protect water quality. As a result, there is some duplication in Tables 6.3 and 6.5.

Table 6.5 Federal assistance programs for aspects of WAWRPR water resources other than water quality.

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Safe Drinking Water Act	Drinking water state revolving fund	EPA	Protects human health
Farm Bill	Agricultural Water Enhancement Program	NRCS	Water conservation
	Cooperative Conservation Partnership Initiative	NRCS	Water conservation
	Conservation Innovation Grants Program	NRCS	Water conservation
	Emergency Watershed Protection	NRCS	Flooding reduction, recovery
	Groundwater Decline Initiative	NRCS	Water Conservation
	National Water Management Center	NRCS	Waterbody protection/restoration
	On-farm Energy Initiative	NRCS	Water conservation
	Plant Management Center	NRCS	Watershed management, native plant management
	Watershed protection and flood prevention	NRCS	Flooding management
	Wetlands Reserve Program	NRCS	Physical waterbody protection/restoration
	Wildlife Habitat Incentives Program	NRCS	Physical waterbody protection/restoration
Cooperative Forestry Assistance Act	Urban and Community Forestry Program	USDA Forest Service	Trees in communities reduce stormwater runoff, improving hydrology
	Forest Stewardship Program	USDA Forest Service	Well-managed forestlands improve and protect water resources
	Forest Legacy Program		

Table 6.5. Federal assistance programs for aspects of WAWRPR water resources other than water quality (continued).

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Flood Control Act/Water Resources Development Act	Habitat restoration	USACE	Water storage, water supply, flood reduction, flow management, restoration of physical aquatic habitat
	Flood control and water supply projects		
Housing and Community Development Act	Community development block grants programs	HUD	Protects/improves public water supply
American Recovery and Reinvestment Act	Funding for drinking water state revolving fund	Recovery Accountability and Transparency Board	Protects/improves public water supply
Consolidated Farm and Rural Development Act	Water and waste disposal systems for rural communities	USDA Rural Development	Protects/improves public water supply
	Water and waste disposal loans and grants		
	Household water well system grant program		
	Grant program to establish a fund for financing water and wastewater projects		
	Emergency community water assistance grants		
Land and Water Conservation Fund Act	Matching grants for acquisition and development of public recreation areas and facilities	USDI National Park Service	Preservation of water resources for recreation
Pittman-Robertson Wildlife Restoration Act	Wildlife restoration grant programs	USFWS	Preservation of water resources for fish and wildlife habitat
Sport Fish Restoration Act	Boating infrastructure grants	USFWS	Recreational boating and fishing
	Multistate conservation grants	USFWS	Aquatic habitat research and education
	Sports fish restoration grants	USFWS	Preservation of water resources for fish and wildlife habitat

Note: Highlighted laws and programs were initiated after the 1990 AWP update.

The 1996 amendment of the SDWA established the Drinking Water State Revolving Fund to assist drinking water utilities in financing infrastructure improvements. Using this fund, states can offer utilities low-cost loans and other types of assistance. In the WAWRPR, ARRA funds awarded to the Arkansas Drinking Water State Revolving Fund were awarded to Central Arkansas Water in Little Rock, and Franklin and Sebastian Counties, to maintain compliance with the SDWA (State of Arkansas 2009).

Farm Bill amendments and associated assistance programs were discussed previously in Section 6.1.2. Farm Bill programs address water conservation, flood control, and conservation and restoration of aquatic habitat.

Several water resources projects have been authorized in Arkansas since 1990 under WRDA. Projects located in the WAWRPR that have been authorized through WRDA are described in Table 6.6.

Table 6.6. WRDA projects in WAWRPR initiated after 1990.

Project Name	Location	Description	Authority	Status
Rehabilitation of Federal Flood Control Levees	Arkansas River	Rehabilitation and reconstruction of Federal flood control levees including repairs of deficiencies and replacement of deteriorated drainage structures and appurtenances (fiscal years 1992 – 1996)	WRDA 1990	Unknown[1]
Flood damage reduction, May Branch, Fort Smith	May Branch, Fort Smith	The project for flood damage reduction, May Branch, Fort Smith, Arkansas.	WRDA 2007	Unknown[2]
Pine Mountain Dam, Arkansas	Lee Creek, Crawford County	Construction of Pine Mountain Dam on Lee Creek, Arkansas for water supply and flood control	WRDA 2007	Suspended in 2010[3,4]

[1] http://www.fws.gov/habitatconservation/omnibus/wrda1990.pdf
[2] http://www.gpo.gov/fdsys/pkg/PLAW-110publ114/pdf/PLAW-110publ114.pdf
[3] http://www.gpo.gov/fdsys/pkg/PLAW-110publ114/pdf/PLAW-110publ114.pdf and [4] http://www.thecitywire.com/node/11537#.UoUpKJ3nbcs
(Inquiry on this information sent to USACE on 1/10/14; info may be updated at a later time)

6.1.3 State Laws and Regulations

State water use law is based on a policy where riparian land owners, i.e., persons owning land that abuts a waterbody, have the right to reasonable use of the water within that waterbody. The reasonable use policy means that all landowners along a stream have the right to free and

unrestricted use of the stream flow, provided that their use does not negatively affect the availability of water for other riparian users. Similarly, landowners have the right to reasonable use of groundwater under their property, as long as that use does not adversely affect the ability of other landowners to use the groundwater. 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 2011a).

6.1.3.1 Water Use Regulations

In Arkansas, at the state level, regulations and programs authorized by the General Assembly that are related to water use are generally administered by ANRC. In addition, the Arkansas Water Well Construction Commission promulgates rules for construction of water supply wells, and the Arkansas Public Services Commission regulates private water utility fees. State incentive programs for water conservation, as well as funding for water resources development projects, have also been legislated. Table 6.7 summarizes selected Arkansas water use regulations that apply in the WAWRPR.

Table 6.7. State regulations related to water use.

State Water Use Regulations	Subjects Addressed by Regulations	Related State Legislation
Title 3: Rules for the Utilization of Surface Water[1]	Registration of surface water withdrawals	Arkansas Code §15-22-215
	Minimum streamflows	Arkansas Code §15-22-222
	Surface water transfers to non-riparian users	Arkansas Code §15-22-304
	Regulation of dam construction	Arkansas Code §15-22-210 - 214
	Allocation during periods of water shortage	Arkansas Code §15-22-217
Title 4: Rules for the Protection and Management of Groundwater[1]	Registration of groundwater withdrawals	Arkansas Code §15-22-302
	Groundwater protection program	Arkansas Groundwater Protection and Management Act (Arkansas Code §15-22-901 et seq.)
Arkansas Water Well Construction Commission Rules and Regulations[2]	Licensing of water well contractors Construction requirements Well reporting requirements	Arkansas Code §17-50-201 et seq.
Affiliate Transaction Rules[3]	Requirements for utility rates	Arkansas Code §23-2-101 et seq.

Table 6.7. State regulations related to water use (continued).

State Water Use Regulations	Subjects Addressed by Regulations	Related State Legislation
General Service Rules[3]	Standards of service for utilities	
Special Rules Water[3]	Standards of service for water utilities	

1 Enforcement by ANRC
2 Enforcement by Arkansas Water Well Construction Commission
3 Enforcement by Arkansas Public Service Commission
Note: Highlighted legislation was promulgated after the 1990 AWP update

State law requires ANRC to "establish and enforce minimum stream flows for the protection of instream water needs" (Arkansas Code § 15-22-222). Minimum streamflow is defined by Arkansas Code §15-22-202(6) as "…the quantity of water required to meet the largest of [specified] instream flow needs as determined on a case-by-case basis." The needs to be met that are specified in the statute are interstate compacts, navigation, fish and wildlife, water quality, and aquifer recharge. This definition is used to set minimum streamflows by rulemaking under Arkansas Code §15-22-222. Where no minimum flow is set by rule, these factors are used to make a case-by-case determination of minimum flow. ANRC has adopted minimum streamflow by rule for the main stem of the Arkansas River (1990).

The minimum streamflow, set by rule or determined on a case-by-case basis, represents the trigger point for a "shortage" requiring allocation of water use. Because of the critical low flow conditions which may exist at the minimum streamflow level, the 1990 AWP recommended taking steps to reduce water withdrawals before water levels drop to minimum streamflow levels. The ANRC may allocate water among uses during a shortage.

Prior to adoption of Act 593 of 2013, minimum streamflows were classified as a "reserved" use when allocating water during a shortage, along with drinking water use and federal water rights. The legislation removed this reserved status and demoted minimum streamflows to a position below agriculture and industry in the allocation hierarchy, and ahead of hydropower and recreation. The intent was to ensure that agricultural and industrial surface water use is not curtailed during a shortage in an effort to protect instream flow needs (interstate compacts, navigation, fish and wildlife, water quality, and aquifer recharge). This change,

especially as it applies a state law limitation on federal interests in navigation, interstate compacts and water quality, including wastewater discharge permits for sewer systems and industries, has not been tested.

In 1985, the Arkansas General Assembly adopted a departure from traditional riparian law by allowing transfer of water for use on non-riparian land. Prior to determining how much water is available to transfer, ANRC must first calculate the amount of water that must remain in the stream. The amount of water that must remain in the stream must be enough to cover: (1) existing riparian water rights as of June 28, 1985; (2) water needs of federal water projects as they existed on June 28, 1985; (3) firm yield of all reservoirs in existence on June 28, 1985; (4) maintenance of instream flows for fish and wildlife, water quality, aquifer recharge requirements, and navigation; and (5) future water needs of the basin of origin as projected in the AWP. The General Assembly limited the amount of excess surface water that may be permitted for non-riparian transfer to 25% of the average annual yield from the watershed after the greatest of the instream needs listed above is met.

Minimum streamflow is often mistakenly equated with fish and wildlife flow requirements. Fish and wildlife flows are one of the five elements of minimum streamflow, which also includes interstate compacts, navigation, water quality, and aquifer recharge. Two different methods are used to calculate fish and wildlife flows for different situations. For case-by-case determinations of minimum flow for use in characterizing shortage and allocating water during a shortage, fish and wildlife flow requirements are estimated using a modified Tennant Method (ASWCC 1988). To calculate fish and wildlife flow requirements when determining the amount of excess water available for transfer to nonriparian users, the "Arkansas Method" (Filipek, Keith and Giese 1987) is used.

Arkansas water law requires that major users of either surface or ground water register with the state, and report the amount of water they use annually. Major water users are those that divert more than one acre-foot of water in a year, or use water from non-household wells with a capacity greater than 50,000 gallons annually.

In 1991, the Arkansas Ground Water Protection and Management Act was signed into law (Arkansas Code §15-22-915), providing ANRC with authority to designate critical

groundwater areas, of which none are currently located in the WAWRPR. This law also mandated that ANRC evaluate the condition of the state's aquifers on a biennial basis, and make recommendations concerning safe yield and the designation of critical groundwater areas (ANRC 2011a). ANRC publishes annual reports on the condition of the state's groundwater resources, including recommendations concerning aquifer safe yield and designation of critical groundwater areas.

6.1.3.2 Water Quality Regulations

Water quality regulations are promulgated by the General Assembly, the Arkansas Pollution Control and Ecology Commission (APCEC), the State Board of Health, and ANRC. State regulations and laws, along with associated federal laws that address water quality, are identified in Table 6.8 below.

.

Table 6.8. State regulations that protect water quality in the WAWRPR.

State Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Regulation 1: Prevention of Pollution by Salt Water and Other Oil Field Wastes Produced by Wells in All Fields or Pools[1]	Environmental protection during oil drilling	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 2: Water Quality Standards for Surface Waters of the State of Arkansas[1]	Water quality standards (designated uses and numeric criteria)	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 3: Licensing of Wastewater Treatment Operators[1]	Licensing program for wastewater treatment operators	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 4: Disposal Permits for Real Estate Subdivisions in Proximity to Lakes and Streams[1]	State wastewater permit	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 5: Liquid Animal Waste Systems[1]	State wastewater permit	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act

Table 6.8. State regulations that protect water quality in the WAWRPR (continued).

State Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Regulation 6: Regulations for State Administration of the NPDES Program[1]	Federal wastewater permits (NPDES)	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Regulation 15: Open-Cut Mining and Land Reclamation Code[1]	Environmental protection during non-coal mining activities, restoration of non-coal mining sites	Arkansas Open Cut Land Reclamation Act (Arkansas Code §15-57-301 et seq.) Arkansas Quarry Operation, Reclamation, and Safe Closure Act (Arkansas Code §15-57-401 et seq.)	None
Regulation 17: Underground Injection Control Code[1]	Underground injection of wastewater	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Safe Drinking Water Act
Regulation 20: Surface Coal Mining and Reclamation Code[1]	Environmental protection during coal mining activities, restoration of coal mining sites	Arkansas Surface Coal Mining and Reclamation Act (Arkansas Code § 15-58-101 et seq.)	Surface Mining Control and Reclamation Act
Regulation 22: Solid Waste Management[1]	Landfill construction specifications, acceptable materials for landfill disposal, regional solid waste management districts, pollution prevention	Arkansas Solid Waste Management Act (Arkansas Code § 8-6-201 et seq.), Arkansas Pollution Prevention Act (Arkansas Code § 8-10-201 et seq.)	Resource Conservation and Recovery Act, Pollution Prevention Act
Regulation 23: Hazardous Waste Management[1]	Hazardous waste management, pollution prevention	Arkansas Hazardous Waste Act (Arkansas Code § 8-7-201 et seq.), Arkansas Hazardous Materials Transportation Act (Arkansas Code § 27-2-101 et seq.), Arkansas Pollution Prevention Act (Arkansas Code § 8-10-201 et seq.)	Resource Conservation and Recovery Act, Pollution Prevention Act

Table 6.8. State regulations that protect water quality in the WAWRPR (continued).

State Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Regulation 27: Licensing of Landfill Operators and Illegal Dumps Control Officers[1]	Licensing of landfill operators, licensing of illegal dumps control officers	Arkansas Code § 8-6-901 et seq., Illegal Dump Eradication and Corrective Action Program Act (Arkansas Code § 8-6-501 et seq.)	Resource Conservation and Recovery Act
Regulation 29: Brownfields Redevelopment[1]	Clean-up and redevelopment of contaminated sites, clean-up funding	Arkansas Hazardous Waste Act (Arkansas Code § 8-7-201 et seq.), Remedial Action Trust Fund Act, Arkansas Voluntary Clean-up Act (Arkansas Code § 8-7-1101 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Regulation 32: Environmental Professional Certification[1]	Certification program for professionals involved in clean-up of contaminated sites	Phase I Environmental Site Assessment Consultant Act (Arkansas Code § 8-7-1301 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Regulation 34: State water permit regulation[1]	Regulation of systems with the potential to pollute water resources, that are not otherwise regulated	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	Clean Water Act
Rules and regulations pertaining to general sanitation[3]	Groundwater pollution, surface water pollution, sewage treatment	Arkansas Sewage Disposal Systems Act (Arkansas Code § 14-236-101 et seq.)	Clean Water Act
Rules and regulations pertaining to public water systems[3]	Safety of drinking water supplied by public water systems	Arkansas Code § 20-7-101 et seq.	Safe Drinking Water Act
Rules and regulations pertaining to semi-public water systems[3]	Safety of drinking water supplied by semi-public water systems	Arkansas Code § 20-7-101 et seq.	Safe Drinking Water Act
Rules and regulations pertaining to water operator licensing[3]	Licensing for drinking water treatment systems	Arkansas Code § 17-51-101 et seq.	Safe Drinking Water Act

Table 6.8. State regulations that protect water quality in the WAWRPR (continued).

State Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Rules and regulations pertaining to onsite wastewater systems, designated representative, and installers[3]	Permitting of onsite wastewater treatment systems (septic systems), licensing of designated representatives for onsite wastewater treatment systems, licensing of installers of onsite wastewater treatment systems	Arkansas Sewage Disposal Systems Act (Arkansas Code § 14-236-101 et seq.)	Clean Water Act
Rules and regulations pertaining to mobile home and recreational vehicle parks[3]	Water supply, wastewater disposal, solid waste management	Arkansas Code § 20-7-101 et seq.	Clean Water Act, Safe Drinking Water Act, Resource Conservation and Recovery Act
Arkansas regulations on pesticide classification[4]	Pesticide classification	Arkansas Pesticide Control Act (Arkansas Code § 2-16-401 et seq.), Arkansas Pesticide Use and Application Act (Arkansas Code § 20-20-201 et seq.)	Federal Insecticide, Fungicide, and Rodenticide Act
Arkansas regulations on pesticide applicator licensing[4]	Licensing of pesticide applicators	Arkansas Pesticide Use and Application Act (Arkansas Code § 20-20-201 et seq.)	Federal Insecticide, Fungicide, and Rodenticide Act
Arkansas Water Well Construction Commission Rules and Regulations	Specifications for construction of water wells to provide safe drinking water	Water Well Construction Act (Arkansas Code § 17-50-101 et seq.)	Safe Drinking Water Act
Rules and Regulations pertaining to outdoor bathing places[3]	Swim beach water quality	Arkansas Code § 20-7-101 et seq.	Clean Water Act
Marine sanitation[3]	Marine sanitation	Arkansas Code § 27-101-401 et seq.	Clean Vessel Act
Title 12: Rules Governing the Arkansas Wetlands Mitigation Bank Program[2]	Wetland mitigation banks	Arkansas Wetlands Mitigation Bank Act (Arkansas Code § 15-22-1001 et seq.)	Rivers and Harbors Act, Clean Water Act
Title 19: Rules Governing the Poultry Feeding Operations Registration Program[2]	Registration of poultry feeding operations	Arkansas Poultry Feeding Operations Registration Act (Arkansas Code § 15-20-901 et seq.)	Clean Water Act

Table 6.8. State regulations that protect water quality in the WAWRPR (continued).

State Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Title 20: Rules Governing the Arkansas Nutrient Management Planner Certification Program[2]	Training and certification of nutrient management planners	Arkansas Soil Nutrient Management Planner and Applicator Certification Act (Arkansas Code § 15-20-1001 et seq.)	Clean Water Act
Title 21: Rules Governing the Arkansas Nutrient Management Applicator Certification Program[2]	Training and certification of nutrient applicators	Arkansas Soil Nutrient Management Planner and Applicator Certification Act (Arkansas Code § 15-20-1001 et seq.)	Clean Water Act
Title 22: Rules Governing the Arkansas Soil Nutrient and Poultry Litter Application and Management Program[2]	Nutrient surplus areas, nutrient management plans, poultry litter management plans, poultry litter transport	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.), Arkansas Poultry Feeding Operations Registration Act (Arkansas Code § 15-20-901 et seq.), Arkansas Soil Nutrient Management Planner and Applicator Certification Act (Arkansas Code § 15-20-1001 et seq.), Arkansas Soil Nutrient Application and Poultry Litter Utilization Act (Arkansas Code § 15-20-1101 et seq.)	Clean Water Act

Note: Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update.
1 Responsible state agency is ADEQ
2 Responsible state agency is ANRC
3 Responsible state agency is Arkansas Department of Health
4 Responsible state agency is Arkansas State Plant Board

As illustrated in Table 6.8, there are several state regulations covering a range of activities that address water quality. The most basic of these are the regulations that set criteria for water quality of surface waters in the state. These regulations identify the uses that state waterbodies should support, and specify narrative and numeric criteria for surface water quality

to ensure that the identified uses can be supported. In Arkansas, numeric water quality criteria for dissolved oxygen, turbidity, temperature, and minerals are ecoregion-based (APCEC 2011). Arkansas is in the process of developing numeric criteria for nutrients in surface water to meet federal requirements (ADEQ 2012c). State numeric water quality criteria for groundwater are in development.

A summary of designated uses assigned to surface waterbodies in the West-central Arkansas Planning Region under Regulation 2 is provided in Table 6.9. The Boston Mountains eco-region, Arkansas River Valley eco-region, and Ouachita Mountains eco-region numeric surface water quality criteria apply in the respective areas of the planning region. Numeric surface water quality criteria for the water bodies in the planning region are listed in Tables 6.10 through 6.12. Figure 6.2 shows the ADEQ Water Quality Planning Segments that are located in the planning region.

Table 6.9. State designated uses for waters in the WAWRPR (APCEC 2011).

Designated Use	Waterbodies
Extraordinary Resource Waters	Archey Creek, Big Piney Cree, Cadron Creek, East Fork Cadron Creek, East Fork Illinois Bayou, Falling Water Creek, Hurricane Creek, Illinois Bayou, Lee Creek, Middle Fork Illinois Bayou, Mulberry River, North Fork Illinois Bayou
Natural and Scenic Waterways	Mulberry River, Big Piney Creek, Hurricane Creek
Ecologically Sensitive Waterbodies	None
Primary Contact Recreation	all streams with watersheds of greater than 10 square miles and all lakes and reservoirs
Secondary Contact Recreation	All waters
Domestic, Industrial, and Agricultural Water Supply	All waters except a portion of the Poteau River and Unnamed tributary to Poteau River at Waldron
Fishery	All lakes and reservoirs
Seasonal Fishery	All waters with watersheds of less than 10 square miles
Perennial Fishery	All waters with watersheds greater than 10 square miles and discharge of at least 1 cfs

Table 6.10 Temperature and turbidity numeric criteria that apply in the WAWRPR (APCEC 2011).

Water body	Temperature (^{o}C)	Turbidity base flow (NTU)	Turbidity all flows(NTU)
Boston Mountain Streams	31	10	19
Lakes & reservoirs	32	25	45
Arkansas River	32	50	52
Arkansas River Valley Streams	31	21	40
Dardanelle Reservoir	35	50	52
Ouachita Mountain streams	30	10	18

Table 6.11. Dissolved oxygen (DO) numeric water quality criteria that apply in the WAWRPR (APCEC 2011).

Water body	DO Primary* (mg/L)	DO Critical+ (mg/L)
Boston Mountain and Ouachita Mountain streams with watershed < 10 square mile	6	2
Boston Mountain and Ouachita Mountain streams with watershed > 10 square mile	6	6
Arkansas River Valley streams with watershed < 10 square mile	5	2
Arkansas River Valley streams with watersheds 10 to 150 square mile	5	3
Arkansas River Valley streams with watersheds 151 to 400 square mile	5	4
Arkansas River Valley streams with watersheds > 400 square mile	5	5
Lakes and reservoirs	5	N/A

* At water temperatures ≤10°C or during March, April and May when stream flows are 15 CFS and greater, the primary season D.O. standard will be 6.5 mg/l.

\+ When water temperatures exceed 22°C, the critical season D.O. standard may be depressed by 1 mg/l for no more than 8 hours during a 24-hour period.

Table 6.12 Numeric water quality criteria for minerals that apply in the WAWRPR (APCEC 2011).

Water body	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
Arkansas River Lock and Dam (L&D) #7 to L&D #10	250	100	500
Cadron Creek	20	20	100
Arkansas River L&D #10 to Oklahoma state line, including Dardanelle Reservoir	250	120	500
Poteau River from Business Highway 71 to state line	120	60	500
Unnamed tributary to Poteau River at Waldron	150	70	660
Boston Mountains Reference Streams	17.3	15	95.3
Arkansas River Valley Reference Streams	15	17.3	112.3
Ouachita Mountain Reference Streams	15	20	142

To protect surface water and groundwater quality, there are state regulations and laws that regulate discharge of wastewater, discharge of stormwater, underground storage tanks, underground injection of fluids, management of livestock, and disposal of solid waste. The state source water and wellhead protection programs address protection of the quality of surface waters and aquifers used as public drinking water supplies. There are 133 active public water supply utilities in the WAWRPR. Of the 133, 12 of these utilities use groundwater from their own wells are subject to the state wellhead protection program. Surface water is the most utilized water supply in the WAWRPR. There are 25 utilities identified as drawing surface water, 94 utilities are purchasing surface water, and 2 doing both for their customers. The utilities using surface water are subject to the state source water protection program (ADH n.d.). The Arkansas Marine Sanitation Act requires all vessels with marine sanitation devices to lock them to prevent direct sewage discharge, increasing the need for operational pumpout facilities.

In 2003, Acts 1059, 1060, and 1061 (Arkansas Code §15-20-901 et seq., §15-20-1001 et seq., §15-20-1101 et seq.) were enacted to encourage wise practices regarding application and management of soil nutrients and poultry litter to protect and enhance the state's surface water quality, while allowing for optimum soil fertility and proper plant growth in the designated nutrient rich watersheds of the State. Several watersheds have been declared nutrient surplus areas in northern and western Arkansas by the State Legislature (Arkansas Code §15-20-1104).

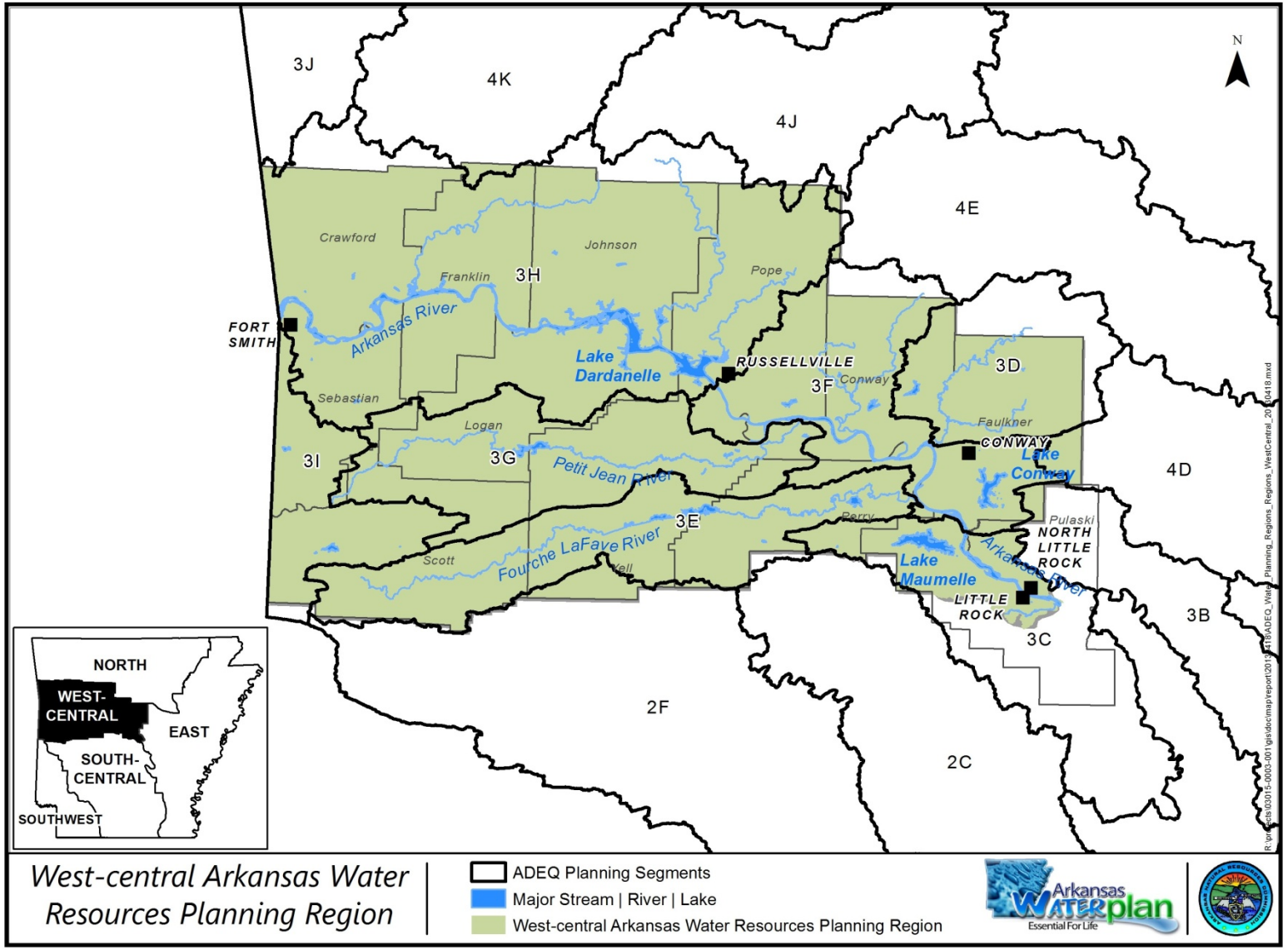

Figure 6.2 ADEQ Water Quality Planning Segments in WAWRPR.

Portions of Crawford County, Sebastian County, and Scott County are included in the designated nutrient surplus areas (Figure 5.8). Within the nutrient surplus areas, land application of any nutrient soil amendments is required to be done in accordance with time, manner, place, and rate restrictions outlined within state regulations. In addition, development of nutrient management plans is required (subject to approval by county conservation districts), all poultry feeding operations are required to develop litter management plans, and nutrient soil amendments are required to be applied by, or under the direction of, a certified nutrient applicator (ANRC 2010).

6.1.3.3 Floodplain Management

Arkansas Code provides that it is the policy of the state to encourage and support actions to prevent and lessen flood hazards and losses. The State has the authority to adopt measures that will discourage development in flood-prone land, assist in reducing damage caused by floods, and improve long-range land management in flood-prone areas (Arkansas Code §14-268-101 et seq.).

Arkansas statute also requires each county, city, or town that is participating in the NFIP to designate a "person to serve as the floodplain administrator to administer and implement the ordinance and any local codes and regulations relating the management of flood-prone areas" (Arkansas Code §14-268-106[a]). The designated floodplain administrator must also be accredited by the ANRC under the commission's authority regarding flood control. State accreditation of floodplain administrators is regulated under ANRC Title 18 rules. Continuing education for the floodplain administrator is an especially important component of the State's accreditation program (Arkansas Code §14-268-106, 15-24-102, and 15-24-109).

6.1.3.4 Water Management Regulations

Other state regulations and programs address additional aspects of water resources and their management. Table 6.13 summarizes these regulations, and the associated federal legislation.

Table 6.13 Additional state water resources regulations.

State Water Resources Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Title 6: Water plan compliance review procedures[1]	AWP	Arkansas Code § 15-22-503 and 504	None
Title 7: Rules governing design and operation of dams[1]	Dam safety	Arkansas Code § 15-22-201 et seq.	Water Resources Development Act/Dam Safety and Security Act
Title 12: Rules governing the Arkansas wetland mitigation bank program[1]	Wetland mitigation bank	Arkansas Wetlands Mitigation Act (Arkansas Code § 15-22-1001 et seq.)	Rivers and Harbors Act, Clean Water Act
Rules and regulations of the Arkansas Natural Heritage Commission[2]	Preservation of natural/wild and scenic rivers for recreation	Arkansas Natural and Scenic Rivers System Act (Arkansas Code § 15-23-301 et seq.)	Wild and Scenic Rivers Act
Arkansas Wildlife Resources Regulations[3]	Allowance for fish passage at dams.	Arkansas Code § 15-44-110	
	Screens required on surface water intakes to protect fish	Arkansas Code § 15-44-111	

1 Responsible state agency is ANRC
2 Responsible state agency is Arkansas Natural Heritage Commission
3 Responsible state agency is Arkansas Game and Fish Commission

The Arkansas Wetland Mitigation Banking Program (Arkansas Code §15-22-1002), authorized in 1995, is a state-sponsored initiative that promotes, in cooperation with federal, state, nonprofit, and other interested entities, the restoration, creation, enhancement, and conservation of aquatic resources, including wetlands, streams, and deep-water aquatic habitat. This legislation authorizes ANRC to operate wetland and stream mitigation banks and to sell mitigation "credits" to private, nonprofit, and public entities required to provide mitigation for dredge and fill activities under the Clean Water Act. The "credits" represent the accrual or attainment of aquatic resource function at the mitigation bank site which results from restoration, creation, enhancement, or conservation efforts. The state wetland mitigation bank provides a cost-effective alternative for mitigating impacts. The Corps of Engineers regulates both public and private mitigation banking and is responsible for approving the number of "credits" available within any individual bank. When an individual or entity is required to provide compensatory mitigation for unavoidable loss of function, the Corps of Engineers can approve the purchase of

"credits" from the state mitigation bank to satisfy all regulatory mitigation requirements. There are no mitigation banks under this program in the planning region at this time.

6.1.4 State Financial Assistance Programs

Arkansas has several state programs that provide financial incentives and assistance for water resources management. The federal government has also delegated authority to the state to administer federal assistance programs of the Clean Water Act, the Safe Drinking Water Act, and the Housing and Community Development Act.

6.1.4.1 Financial Assistance for Public Water and Wastewater Projects

ANRC is responsible for managing and distributing monies from several federal assistance programs intended to assist communities in constructing and maintaining drinking water and wastewater systems (Table 6.14). There are also state-funded programs that provide financial assistance for drinking water and wastewater (Table 6.15). ANRC also manages these incentive programs. Programs shown in both Table 6.14 and 6.15 utilize both federal and state funds.

Table 6.14. Federal assistance programs for public water projects that are administered by ANRC.

Federal Program	Federal funding source	State Program
Community Development Block Grant Program	Housing and Urban Development	Arkansas Community and Economic Development Program
Drinking water state revolving fund	EPA	Water resources cost share revolving fund program
		Construction assistance revolving loan fund
Clean water state revolving fund	EPA	Water resources cost share revolving loan fund
		Construction assistance revolving loan fund Construction

Table 6.15. State programs for public water system assistance (administered by ANRC).

State Water Use Regulations	State Assistance Programs	Related State Legislation
Title 5: Administrative rules and regulations for financial assistance	Water resources development	Arkansas Water Resources Cost Share Finance Act (Arkansas Code § 15-22-801 et seq.),
	General obligation bond fund	
	Water development fund program	
	Water resources cost share revolving fund program	
	Water, sewer, and solid waste management systems program	
	Water, waste disposal, and pollution abatement facilities general obligation bond fund program	Arkansas Water, Waste Disposal, and Pollution Abatement Facilities Financing Act (Arkansas Code § 15-20-1301 et seq.)
Title 15: Rules governing loans from the safe drinking water revolving loan fund	Safe drinking water revolving loan fund	Arkansas Code §15-22-1101
	Construction Assistance revolving loan fund	Arkansas Code § 15-5-901
Title 16: Rules governing the Arkansas clean water revolving loan fund program	Clean water revolving loan fund	Arkansas Code §15-5-901 et seq.
	Construction assistance revolving loan fund	
Title 23: Rules governing water and wastewater project funding through the Arkansas community and economic development program	Funding for construction or improvement of community treatment facilities for drinking water and waste water treatment	Arkansas Code § 15-5-901 et seq.
Title 5: Administrative rules and regulations for financial assistance	Water resources development general obligation bond fund	Arkansas Water Resources Cost Share Finance Act (Arkansas Code § 15-22-801 et seq.),
	Water development fund program Water resources cost share revolving fund program	
	Water, sewer, and solid waste management systems program	
	Water, waste disposal, and pollution abatement facilities general obligation bond fund program	Arkansas Water, Waste Disposal, and Pollution Abatement Facilities Financing Act (Arkansas Code § 15-20-1301 et seq.)
Title 15: Rules governing loans from the safe drinking water revolving loan fund	Safe drinking water revolving loan fund	Arkansas Code §15-22-1101
	Construction Assistance revolving loan fund	Arkansas Code § 15-5-901
Title 16: Rules governing the Arkansas clean water revolving loan fund program[2]	Clean water revolving loan fund	Arkansas Code §15-5-901 et seq.
	Construction assistance revolving loan fund	

Table 6.15. State programs for public water system assistance (continued).

State Water Use Regulations	State Assistance Programs	Related State Legislation
Title 23: Rules governing water and wastewater project funding through the Arkansas community and economic development program	Funding for construction or improvement of community treatment facilities for drinking water and waste water treatment	Arkansas Code § 15-5-901 et seq.

6.1.4.2 State Financial Incentive and Assistance Programs for Promoting Water Quality and Water Resources Management

ADEQ and ANRC administer a number of incentive and assistance programs related to water resources management (Table 6.16). These include programs to assist with clean-up of hazardous waste contamination, reduction of nonpoint source pollution, and management of solid wastes to protect water quality. In addition, there are state programs to encourage water conservation and preservation of wetlands. All but one of the programs listed in Table 6.16 are funded by state sources. The state nonpoint source pollution management grant program is federally funded under the authority of the Clean Water Act Section 319.

Table 6.16. State incentive and assistance programs that protect water quality.

State Regulation	State Assistance Programs	Related State Legislation	Related Federal Legislation
Regulation 11: Solid Waste Disposal Fees, Landfill Post-Closure Trust Fund, and Recycling Grants Programs[1]	Recycling Fund	Solid Waste Management Recycling Fund Act (Arkansas Code §8-6-601 et seq.)	Resource Conservation and Recovery Act
Regulation 12: Storage Tank Regulations[1]	Petroleum storage tank trust fund	Petroleum Storage Tank Trust Fund Act (Arkansas Code § 8-7-901 et seq.)	Clean Water Act, Underground Storage Tank Regulations, including Energy Policy Act of 2005
Regulation 29: Brownfields Redevelopment[1]	Clean-up funding	Arkansas Hazardous Waste Management Act (Arkansas Code § 8-7-201 et seq.), Remedial Action Trust Fund Act (Arkansas Code § 8-7-501 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act

Table 6.16. State incentive and assistance programs that protect water quality (continued).

State Regulation	State Assistance Programs	Related State Legislation	Related Federal Legislation
Regulation 30: Remedial Action Trust Fund, Site Priority List[1]	Clean-up funding, prioritization of contaminated sites for clean-up	Remedial Action Trust Fund Act (Arkansas Code § 8-7-501 et seq.)	Comprehensive Environmental Response, Compensation, and Liability Act
Title 5: Administrative rules and regulations for financial assistance[2]	Sewer and solid waste management systems program	Arkansas Code § 14-230-101 et seq., § 15-22-601 et seq., § 15-22-701 et seq.	None
	Waste disposal and pollution abatement facilities		
	General obligation bond program		
	Water, waste disposal, and pollution abatement facilities general obligation bond fund program		
Title 10: Rules governing the Arkansas water resource agricultural cost-share program	Arkansas water resources agricultural cost-share program	Arkansas Code § 15-22-913 through 914, § 15-22-507	Title 10: Rules governing the Arkansas water resource agricultural cost-share program
Title 11: Surplus Poultry Litter Removal Incentives Cost-Share Program[2]	Transport of poultry litter from nutrient surplus areas	Surplus Nutrient Removal Incentives Act (Arkansas Code § 15-20-1201 et seq.)	CWA
Title 13: Rules governing the tax credit program for the creation and restoration of private wetland and riparian zones[2]	Wetlands and Riparian Zone Tax Credit Program	Arkansas Private Wetland Riparian Zone Creation and Restoration Incentive Act (Arkansas Code § 26-51-1501 et seq.)	None
Title 14: Rules for implementing the Water Resources Conservation and Development Incentives Act	Groundwater conservation tax incentives	Water Resource Conservation and Development Incentives Act (Arkansas Code § 26-51-1001 et seq.)	Title 14: Rules for implementing the Water Resources Conservation and Development Incentives Act

Table 6.16. State incentive and assistance programs that protect water quality (continued).

State Regulation	State Assistance Programs	Related State Legislation	Related Federal Legislation
Title 23: Rules governing water and wastewater project funding through the Arkansas community and economic development program[2]	Funding for construction or improvement of community treatment facilities for wastewater	None	Housing and Community Development Act
None	Nonpoint source pollution grant program[2]	None	Clean Water Act (Section 319)
Marine Sanitation[3]	Clean Vessel Act Grant Program, Arkansas Marine Sanitation Fund	Arkansas Code §27-101-408, § 19-6-301, § 19-6-490	Clean Vessel Act

Note: Highlighted regulations, programs, and legislation were promulgated after the 1990 AWP update.
1 Responsible state agency is ADEQ; 2 Responsible state agency is ANRC 3 Responsible state agency is Arkansas Department of Health

6.1.5 Non-regulatory State Water Management Programs

There are state agency programs for natural resources protection and management that apply to water resources. These include planning, guidance, and incentive programs. These programs do not necessarily have regulations associated with them. However, they guide the activities of state agencies related to water resources. The AWP is one such program. Others are described below.

6.1.5.1 Arkansas Wildlife Action Plan

A state wildlife action plan was prepared by the Arkansas Game and Fish Commission, and approved by USFWS in 2007. This plan prioritizes activities to protect species of concern and their habitats throughout the state. This plan addresses amphibians, birds, fish, crayfish, insects, mammals, mussels, and reptiles. There are 116 species of greatest conservation need identified for Arkansas in this plan that are found in the aquatic and semi-aquatic habitats of the WAWRPR. Within the three primary eco-regions that make up the planning region, habitat restoration/improvement is the most recommend conservation activity for the Arkansas Valley and Ouachita Mountains, while habitat protection is the most highly recommend conservation activity in the Boston Mountains (Anderson 2006).

6.1.5.2 Arkansas Wetland Strategy

A state wetland strategy was ed in 1995 by a team of Arkansas agencies. This strategy consisted of 10 elements that are intended to address conservation and restoration of wetlands, and improving understanding of wetlands, both by the scientific and natural resources community and by the public. Implementation of this strategy resulted in legislation that created the Arkansas Mitigation Banking Program, and the Arkansas Riparian Zone and Wetland Creation Tax Credit Program (Arkansas Multi-agency Wetlands Planning Team 1995).

6.1.5.3 Arkansas Nonpoint Source Pollution Management Plan

ANRC regularly prepares a state nonpoint source pollution management plan. The purpose of this plan to provide a guide and focus for public agencies, nonprofit organizations, interest groups, and other stakeholders to work together to "develop, coordinate, and implement programs to reduce, manage or abate" nonpoint source pollution. The plan is updated every five years. The current plan was updated in 2010.

6.1.5.4 Arkansas Forestry Best Management Practices

The Arkansas Forestry Commission has prepared a booklet of approved guidelines for conducting forest management practices in a way that minimizes water quality impacts. Implementation of these best management practices is voluntary. These management practices are applicable to commercial and private timber operations on public or private land.

6.1.6 Local Regulations

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

6.1.7 Regional Water Resources Management Programs

Several agencies and organizations have developed management or restoration programs for areas within the WAWRPR. The purpose of some of these programs is to support a state or

federal regulation or policy, such as ambient water quality standards or conservation of rare and endangered wildlife. These programs constitute a framework that provides opportunities for leveraging resources (personnel and funding) to accomplish water resources management goals. Examples of these regional water resources management programs are described below.

6.1.7.1 Nine-element Watershed Plans

Watershed plans are required by the CWA to guide activities for reducing pollution in waterbodies for which TMDLs have been developed. EPA has prepared guidance describing the nine elements that should be included in watershed plans to achieve TMDLs calculated for impaired waterbodies. A nine-element watershed plan must be completed and approved by EPA before restoration projects in the watershed can receive funding from the CWA Nonpoint Source Program (Section 319 funding). The Lake Maumelle Watershed Management Plan is an approved nine-element watershed management plan completed in the planning region (Central Arkansas Water n.d.b).

6.1.7.2 Fayetteville Shale Best Management Practices

A team consisting of multiple agencies has developed best management practices (BMPs) for natural gas activities in the Fayetteville Shale area intended to protect natural resources, including water quality (USFWS 2007).

6.1.7.3 Nonprofit Organizations

There are several nonprofit organizations that have active programs within the WAWRPR. These include The Nature Conservancy, Ducks Unlimited, and others. The Nature Conservancy manages a preserve on the Mulberry River (The Nature Conservancy 2013). Ducks Unlimited, along with multiple partners, have restored wetlands at the Ed Gordon Point Remove WMA near Morrilton and Lake Dardanelle WMA near Russellville, and restored bottomland hardwood forest land and seasonally flooded wetlands at Frog Bayou WMA near Fort Smith (Ducks Unlimited n.d.).

6.1.8 Interstate Water Compacts

The Arkansas River is subject to the Arkansas River Basin Compact. The Arkansas River Basin Compact of 1970 between the States of Arkansas and Oklahoma provides for the administration of the water apportionment agreed to by each of the state partners. The compact describes which state may use specific waters, promotes the orderly development of the river, encourages an active pollution abatement program to further the reduction of pollution, man-made or natural, into the waters of the Arkansas River basin, and facilitates cooperation between the appropriate administrative agencies in each state in the total development and management of the water resources of the Arkansas River Basin. The Arkansas River Basin subject to the compact includes all of the drainage basin of the Arkansas River and its tributaries from just below the confluence of the Grand-Neosho River with the Arkansas River near Muskogee, OK, to a point just below the confluence of Lee Creek with the Arkansas River near Van Buren, AR, and the drainage basin of Spavinaw Creek in Arkansas, but excluding the drainage basin of the Canadian River below Eufaula Dam (Figure 6.3). The compact is further defined by the following Articles (State of Oklahoma 1970).

Article IV: The following apportionment of the waters of the Arkansas River Basin have been agreed upon by the State of Arkansas and Oklahoma:

A. The State of Arkansas shall have the right to develop and use the waters of the Spavinaw Creek Subbasin subject to the limitation that the annual yield shall not be depleted by more than fifty percent (50%).
B. The State of Arkansas shall have the right to develop and use the waters of the Illinois River Subbasin subject to the limitation that the annual yield shall not be depleted by more than sixty percent (60%).
C. The State of Arkansas shall have the right to develop and use all waters originating within the Lee Creek Subbasin in the State or Arkansas, or the equivalent thereof.
D. The State of Oklahoma shall have the right to develop and use all waters originating within the Lee Creek Subbasin in the State of Oklahoma, or the equivalent thereof.
E. The State of Arkansas shall have the right to develop and use the waters of the Poteau River Subbasin subject to the limitation that the annual yield shall not be depleted by more than sixty percent (60%).

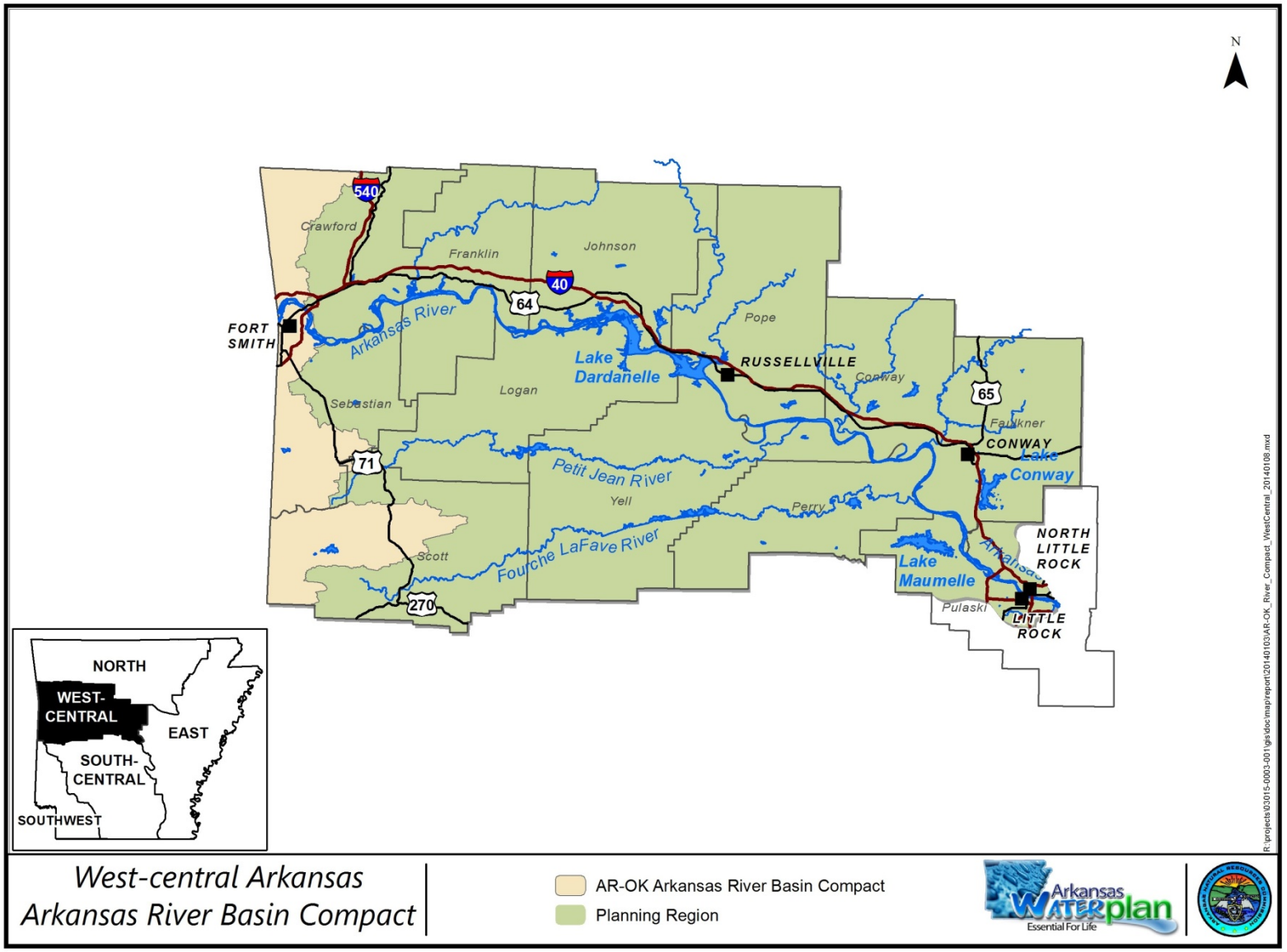

Figure 6.3. Arkansas River Basin Compact boundaries within the WAWRPR.

F. The State of Oklahoma shall have the right to develop and use the waters of the Arkansas River Subbasin subject to the limitation that the annual yield shall not be depleted by more than sixty percent (60%).

Article V:

A. On or before December 31 of each year, following the effective date of this Compact, the Commission shall determine the stateline yields of the Arkansas River Basin for the previous water year.
B. Any depletion of annual yield in excess of that allowed by the provisions of this Compact shall, subject to the control of the Commission, be delivered to the downstream State, and said delivery shall consist of not less than sixty percent (60%) of the current runoff of the basin.
C. Methods for determining the annual yield of each of the sub-basins shall be those developed and approved by the Commission.

Article VI:

A. Each state may construct, own and operate for its needs water storage reservoirs in the other state.
B. Depletion in annual yield of any subbasin of the Arkansas River Basin caused by the operation of any water storage reservoir either heretofore or hereafter constructed by the United States or any of its agencies, instrumentalities or wards, or by a state, political subdivision thereof, or any person or persons shall be charged against the state in which the yield therefrom is utilized.
C. Each state shall have the free and unrestricted right to utilize the natural channel of any stream within the Arkansas River Basin for conveyance through the other state of waters released from any water storage reservoir for an intended downstream point of diversion or use without loss of ownership of such waters; provided, however, that a reduction shall be made in the amount of water which can be withdrawn at point of removal, equal to the transmission losses.

Article VII: The States of Arkansas and Oklahoma mutually agree to:

A. The principle of individual state effort to abate man-made pollution within each state's respective borders, and the continuing support of both states in an active pollution abatement program;
B. The cooperation of the appropriate state agencies in the States of Arkansas and Oklahoma to investigate and abate sources of alleged interstate pollution within the Arkansas River Basin;
C. Enter into joint programs for the identification and control of sources of pollution of the waters of the Arkansas River and its tributaries which are of interstate significance;

D. The principle that neither state may require the other to provide water for the purpose of water quality control as a substitute for adequate waste treatment;
E. Utilize the provisions of all federal and state water pollution laws and to recognize such water quality standards as may be now or hereafter established under the Federal Water Pollution Control Act in the resolution of any pollution problems affecting the waters of the Arkansas River Basin.

Article VIII: Creates the agency to be known as the "Arkansas-Oklahoma Arkansas River Compact Commission," which consists of three Commissioners representing the State of Arkansas and three Commissioners representing the State of Oklahoma.

Article IX: Describes the powers of the Commission.

Articles X – XIII: Further defines the powers and binding authority of the Compact.

6.2 Institutional framework

Governmental responsibility for water resources management in the WAWRPR is split among many agencies on three levels (Federal, State and Local). As a result, management of water resources can require coordination among a number of government entities. In addition, there are a number of nonprofit organizations that participate in water resources management in the planning region.

6.2.1 Federal Agencies

There are more than 15 different federal agencies involved in water resources management in the WAWRPR. These federal agencies are listed in Table 6.17, along with their respective activities in this planning region.

Table 6.17 Federal agencies with water resources related responsibilities in the WAWRPR.

Federal Agency	Responsibility
EPA	• Oversees state agencies in implementation of management and funding programs under o CWA, o SDWA, o Superfund, o Federal Insecticide, Fungicide, and Rodenticide Act, and o Surface Mining Control and Reclamation Act • Conducts TMDL studies and other water quality studies in the

Table 6.17 Federal agencies with water resources related responsibilities in the WAWRPR (continued).

Federal Agency	Responsibility
	state • Implements programs under the Toxic Substances Control Act
Federal Energy Regulatory Commission (FERC)	Oversees environmental matters related to natural gas and hydropower projects in the state
FEMA	Prepares flood hazard maps for the state and encourages State and local governments to guide development decisions away from defined flood hazard risk areas through participation in the National Flood Insurance Program
HUD	Provides funding for water and wastewater infrastructure improvements
NOAA	Participates in monitoring precipitation and climate in the state
NRCS National Water Management Center	• Located in Little Rock • Serves as a water resources information exchange • Provides support and training related to o environmental compliance, o hydrology and hydraulics, o stream geomorphology and restoration, o water quality and quantity, o watershed and dam rehabilitation, and o technology outreach
Nuclear Regulatory Commission	Regulates nuclear power plants in Arkansas to protect the environment, including disaster preparedness planning for flood events
Southwestern Power Administration	Markets and delivers hydroelectric power produced at two USACE hydropower projects in the planning region
USACE (the Little Rock and Memphis Districts are located in the WAWRPR)	• Manages the McClellan-Kerr Navigation System, Blue Mountain Lake, and Lake Nimrod • Manages federal water, navigation, flood control, and hydropower projects in the state • Implements sections of the Clean Water Act related to impacts to navigable waters and wetlands • Constructs flood control, irrigation, and water supply projects authorized by the Water Resources Development Act • Oversees dam safety for federal dams
USDA	• Conducts the Census of Agriculture • Conducts the Natural Resources Inventory • Manages Conservation Effects Assessment Projects (watershed and regional)
USDA Farm Services Agency	Implements the Conservation Reserve Program for erosion control and habitat restoration in the state

Table 6.17 Federal agencies with water resources related responsibilities in the WAWRPR (continued).

Federal Agency	Responsibility
USFS	• Manages the Ozark and Ouachita National Forests and associated surface waters • Forest management incentive programs • Participates in forest inventory • Manages Urban and Community Forestry Program
USDA Rural Development	• Implements UDSA rural utilities financial assistance programs
NRCS	• Implements over 25 Farm Bill erosion control and habitat restoration funding and technical assistance programs in the state • Appraises the status and trends of soil, water, and related resources on non-federal land in the state and assesses their capability to meet present and future demands
USFWS	• Implements the Endangered Species Act and programs to o Promote management of ecosystems, o Promote conservation of migratory birds, o Promote preservation of wildlife habitat, o Promote restoration of fisheries, o Combat invasive species, and o Promote international wildlife conservation • Manages national wildlife refuges in the planning region • Conducts the National Wetland Inventory • Oversees state wildlife planning through the State Wildlife Grant Program
USDI National Park Service	• Manages national parks within the planning region, and their associated water resources • Provides funds for land and water conservation projects
USGS	• Flow and stage monitoring of rivers and streams • Groundwater level monitoring • Water quality monitoring • Groundwater modeling • Water quality modeling • Water data storage and management

6.2.2 Arkansas Agencies

There are over 20 Arkansas agencies involved in water resources management in the WAWRPR. These state agencies are listed in Table 6.18, along with a description of their water resources management responsibilities within the planning region.

Table 6.18. Arkansas agencies and entities with responsibilities related to water resources in the WAWRPR.

State Entity	Responsibility
ADEQ	• Implements state water quality policy and the Clean Water Act NPDES program • Develops and enforces water quality standards • Investigates citizen complaints regarding water pollution • Oversees solid waste management • Operates the hazardous waste management program • Manages contaminated site clean-up and redevelopment programs • Develops and enforces mining and mine site reclamation regulations • Manages the storage tank regulation program • Permits no-discharge facilities and underground injection operations • Water quality monitoring and assessment
ANRC	• Regulates, permits, and tracks water use and dam construction • Monitors climate • Administers federal water resources funding programs • Prepares water resources and nonpoint source pollution management plans • Develops and maintains mitigation banking and restoration incentive programs for aquatic resources • Supports conservation districts • Registers poultry feeding operations • Certifies nutrient management planners and applicators • Promotes public health and safety and minimize flood losses through o training, o education, o technical assistance in floodplain management, and o accrediting floodplain administrators
Arkansas Department of Health (ADH)	• Regulates public water supply systems • Implements the Safe Drinking Water Act source water protection programs • Issues fish consumption advisories • Implements state health rules and regulations that apply to water resources • Regulates septic tanks and licenses septic tank cleaners • outdoor bathing and swimming • Implements state marine sanitation program
Arkansas Department of Parks and Tourism	• Manages the 7 state parks in the region and associated water resources • Prepares comprehensive outdoor recreation plan • Manages outdoor recreation grant program

Table 6.18. State agencies and entities with responsibilities and authority related to water resources in the West-central Arkansas Planning Region (continued).

State Entity	Responsibility
Arkansas Forestry Commission	• Provides guidelines for protection of water resources in forestry operations • Monitors use of forestry BMPs • Participates in forest inventory • Implements forest management incentive programs • Implements Urban and Community Forestry program • Designates and manages state forests for a variety of purposes, including o watershed protection o erosion and flood control
Arkansas Game and Fish Commission (AGFC)	• Manages protection, conservation and preservation of various species of fish and wildlife in Arkansas through o habitat management, o wildlife management areas, o fish stocking, o hunting and fishing regulations, and o education and outreach programs • Prepares state Wildlife Action Plan • Implements conservation grant program • Manages 9 lakes in the planning region
Arkansas Geological Survey	• Participates in research of, and provides information and education about, state water resources • Mapping • Water well construction records
Arkansas Livestock and Poultry Commission	Regulates disposal of livestock carcasses
Arkansas Multi-agency Wetland Planning Team	Developed the State Wetland Strategy and is the lead for developing state numeric nutrient criteria for wetlands
Military Department Arkansas National Guard	Manages land and surface water resources within the boundaries of Fort Chaffee and Camp Robinson
Arkansas Natural Heritage Commission (ANHC)	• Surveys and conducts research on natural communities in the state • Acquires natural areas for preservation • Manages the Arkansas Natural and Scenic Rivers system
Arkansas Oil and Gas Commission	• Provides technical assistance related to protection of water resources from wastes associated with production of natural gas • Issues permits for drilling and operation of o natural gas production wells o injection and disposal wells
Arkansas Pollution Control and Ecology Commission (APCEC)	Environmental policy-making body for the state
Arkansas Public Service Commission	Regulates rates and services of private water utilities, as well as utilities water crossings

Table 6.18. State agencies and entities with responsibilities and authority related to water resources in the West-central Arkansas Planning Region (continued).

State Entity	Responsibility
Arkansas State Board of Health	Promulgates health rules and regulations for the state
Arkansas State Highway and Transportation Department (AHTD)	• Hazardous waste transportation permits • Stormwater management • Develops and implements construction BMPs
Arkansas State Plant Board	Implements • Insecticide, Fungicide, and Rodenticide Act programs, o pesticide registration o user and applicator training o dealer licensing • state pesticide management plan for groundwater protection, • groundwater quality monitoring, and • climate/weather monitoring
Arkansas Water Well Construction Commission	• Regulates development of groundwater through licensing water well contractors and registering drillers and pump installers • Regulates specifications for construction of water wells • Maintains water well construction records
Arkansas Waterways Commission	Studies and promotes navigable waterways for transportation and economic development
University of Arkansas (U of A) Cooperative Extension Service	Provides technical assistance to Arkansans related to water conservation, and protection and restoration of water quality
U of A Water Resources Center	Participates in research related to water resources, and in water resources management projects

6.2.3 Federal - State Organizations

There are at least three federal-state organizations involved in water resources management in the WAWRPR:

- Arkansas-Oklahoma Arkansas River Compact Commission,
- Arkansas Conservation Partnership, and
- Arkansas Watershed Advisory Group.

The Arkansas-Oklahoma Arkansas River Compact Commission administers the Arkansas-Oklahoma Arkansas River Compact, which applies to Lee Creek and Poteau River basins in the WAWRPR (see Section 6.18). The commission is made up of three representatives

each from Arkansas and Oklahoma, the director of the state water agency and two residents appointed by the state governor, as well as one federal representative, appointed by the US president (Arkansas River Compact Committee 1970).

The Arkansas Conservation Partnership supports locally-led natural resources conservation through coordination of education, financial, and technical assistance to landowners. Water resources and implementation of Farm Bill programs are two of the six natural resource issues that are the focus of the partnership. Members of the partnership include federal agencies, as well as ANRC, the NRCS, Arkansas Association of Conservation Districts, U of A Cooperative Extension, U of A at Pine Bluff, and Arkansas Forestry Commission. This partnership was formed in 1992 (ANRC 2011b, Cooperative Conservation America n.d.).

The Arkansas Watershed Advisory Group (AWAG) provides technical assistance to form local watershed groups, hosts an annual water quality conference, and facilitates quarterly discussions of voluntary water quality management approaches. AWAG is a consortium of federal and state agencies with private citizens (ANRC 2011b).

6.2.4 Regional and Local Entities

There are numerous regional and local entities in the WAWRPR that are involved in activities related to water resources management. Examples of the types of local and regional entities present in this planning region are shown in Table 6.19, along with descriptions of their activities related to water resources management.

Table 6.19. Some of the regional and local entities involved in water resources management in the WAWRPR.

Regional or Local Entity	Water Resources Involvement
Local Conservation Districts	Work with state and federal agencies to implements measures for the control of erosion and flooding, and conservation of soil and water resources
County Government	Responsible for unincorporated areas, sometimes including floodplain management and zoning
Levee Districts	Provide for the construction and maintenance of levees for flood protection
Arkansas-Oklahoma Arkansas River Compact Commission	Administers the Arkansas-Oklahoma Arkansas River Compact

Table 6.19. Some of the regional and local entities involved in water resources management in the WAWRPR (continued).

Regional or Local Entity	Water Resources Involvement
Regional Planning and Development Districts (PADD) o Central Arkansas PADD o West Central Arkansas PADD o Western Arkansas PADD o White River PADD	• Provide assistance in grant applications • Economic development projects that may include water resources management • Water supply and wastewater infrastructure improvements
Regional Solid Waste Management Districts	Manage collection, disposal, and recycling of solid waste
Universities	Water resources and management research, education, and outreach
Water districts and associations	Water supply planning and management

6.2.5 Nonprofit Organizations

There are several nonprofit organizations that conduct activities in the WAWRPR that are related to water resources management. These organizations are listed in Table 6.20 with a description of their water resources related activities in the planning region.

Table 6.20. Examples of nonprofit groups involved in water resources management in the WAWRPR.

Nonprofit	Water Resources Involvement
Arkansas Farm Bureau	Advocate for agriculture
Arkansas Waterways Association	Promotes and protects Arkansas inland transportation waterways
Arkansas Wildlife Federation	Conservation of aquatic habitat for fish and wildlife
Ducks Unlimited	Conservation and restoration of aquatic habitat for waterfowl
The Nature Conservancy	Mulberry River Preserve Presson-Oglesby Preserve
Watershed organizations (at least 2)	Water resources planning, Sponsor for water quality and quantity projects
Arkansas Environmental Federation	Advocate for industry

6.2.6 Institutional Interactions in Water Resources Management

As noted at the beginning of this section, water resources management in the WAWRPR involves numerous entities at multiple scales. Examples of the interactions among federal, state,

and local entities that occur in water resources management in the planning region are presented in Table 6.21.

Table 6.21. Examples of interactions of federal, state, and local entities in water resources management within the WAWRPR.

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
Water use registration	USGS (houses registration database)	ANRC (program lead)	Water utilities
Dam safety	USACE (federal dams) FEMA (oversight)	ANRC (program lead), AGFC (dam builder), Arkansas Department of Parks and Tourism (dam builder)	Water utilities, municipalities, counties (dam builders)
State climate monitoring	NOAA National Weather Service, NOAA National Climatic Data Center, USGS (precipitation monitoring), USACE (climate monitoring),	ANRC (State Climatologist), Arkansas State Plant Board (monitoring)	Community Collaborative Rain, Hail & Snow Network
Safe Drinking Water Act funding	EPA (funding)	ANRC (program lead)	Water utilities, municipalities/ communities, water districts
Water Resources Conservation Tax Incentives	NRCS	ANRC (program lead), U of A Cooperative Extension Service	Conservation districts
Conservation district grants program	None	ANRC (program lead)	Conservation districts
Community development block water and wastewater grants	HUD (funding)	ANRC (program lead), Arkansas Economic Development Commission	Water utilities, wastewater utilities, water districts, sewer districts
Floodplain management	FEMA	ANRC (State liaison)	Levee districts, counties, and municipalities
Nonpoint source pollution management	EPA (funding), NRCS (conservation programs), USFS (BMPs), The Nature Conservancy (projects), USDA Farm Services Agency (conservation program)	ANRC (program lead), Universities, Arkansas Water Resources Center, Audubon Arkansas, U of A Cooperative Extension Service, Arkansas Farm Bureau, ADEQ (TMDLs)	Watershed organizations, Conservative districts, water districts, stream teams, nonprofit organizations
Clean Water Act funding program (including nonpoint source and clean water revolving loan fund)	EPA (funding)	ANRC (program lead)	Watershed organizations, sewer districts, municipalities, nonprofit organizations

Table 6.21. Examples of interactions of federal, state, and local entities in water resources management within the WAWRPR (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
Wetland and riparian zone tax credit program	None	ANRC (program lead)	Watershed organizations
Wetland and stream mitigation	USACE (lead)	ANRC (state mitigation bank), AHTD, AGFC, ADEQ, ANHC	Local conservation districts, nonprofit organizations, watershed organizations
Non-riparian water use permitting	None	ANRC (program lead)	Water utilities
Arkansas Recovery Act water and wastewater funding	Recovery Accountability and Transparency Board	ANRC (program lead)	Water utilities, wastewater utilities, water districts, sewer districts
State water utility funding	None	ANRC (program lead)	Water utilities, water districts
State wastewater utility funding	None	ANRC (program lead)	Wastewater utilities, sewer districts
NPDES discharge permits	EPA (oversight, guidance)	ADEQ (program lead)	Dischargers
Underground injection control	EPA	ADEQ (program lead), Arkansas Oil and Gas Commission (program lead)	Dischargers
Wastewater pretreatment program	EPA	ADEQ (program lead)	Dischargers
Water quality standards	EPA	APCEC (regulations), ADEQ (implementation, enforcement), ANRC (groundwater standards), Multi-agency Wetland Planning Team (nutrient criteria for wetlands)	Local government, regulated entities, interest groups
Water quality assessment	EPA (oversight, guidance), USGS (data), USACE (data)	ADEQ (implementation)	None
TMDLs	EPA (oversight, guidance), USGS (data), USACE (data)	ADEQ (program lead)	None
Storage tank regulation	EPA	ADEQ (program lead)	None
Solid waste management	EPA (oversight)	ADEQ (program lead)	Regional solid waste management districts
Landfill post-closure trust fund	None	ADEQ (program lead)	Regional solid waste management districts
Hazardous waste management	EPA	ADEQ (program lead), AHTD (transport)	Interest groups

Table 6.21. Examples of interactions of federal, state, and local entities in water resources management within the WAWRPR (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
Remedial action trust fund	None	ADEQ	Interest groups
Brownfields	EPA	ADEQ	Municipalities
Superfund	EPA	ADEQ	Interest groups
Mining reclamation	US Department of the Interior	ADEQ	Interest groups
Water quality monitoring	EPA (oversight, studies), USGS (monitoring, studies), USACE (monitoring, studies)	ADEQ, ANRC, U of A Arkansas Water Resources Center (studies), AGFC (stream teams), Arkansas State Plant Board (groundwater monitoring)	Stream teams (monitoring), water utilities (monitoring)
Fish tissue sampling	None	ADEQ (program lead), ADH (consumption advisories), AGFC (sampling)	None
Stormwater management	EPA	ADEQ, U of A Cooperative Extension Service	Counties, municipalities
Spill prevention	EPA	ADEQ	None
Finished drinking water criteria	EPA	ADH	Water utilities, water districts
Source Water Protection	EPA	ADH, Arkansas Water Well Construction Commission	Water utilities (planning)
Consumer Information	EPA	ADH	Water utilities
Regulation of drinking water utilities	EPA	ADH, Arkansas Public Service Commission	Water utilities
Pesticide registration, labeling and classification	EPA	Arkansas State Plant Board	Pesticide distributors and users
Community Forestry	USDA Forest Service	Arkansas Forestry Commission, Arkansas Urban Forestry Council	Municipalities
Forest stewardship	USDA Forest Service, USDA Farm Services Agency, NRCS	Arkansas Forestry Commission, AGFC, ANRC, Arkansas Historic Preservation Program, U of A Cooperative Extension Service, Arkansas Natural Heritage Commission	Landowners
Forest Legacy	USDA Forest Service (funding), Land Trust Alliance	Arkansas Forestry Commission	Landowners

Table 6.21. Examples of interactions of federal, state, and local entities in water resources management within the WAWRPR (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
State parks	USACE, National Park Service (funding)	Arkansas Department of Parks and Tourism	Arkansas Master Naturalists
Stream teams	None	AGFC	Region I / Region II Arkansas Master Naturalists
Wildlife management areas, refuges	USFSW	AGFC	Holla Bend National WMA
Fishing and boating programs	USACE, USFWS	AGFC, Arkansas Department of Parks and Tourism	None
Pollution prevention program	EPA	ADEQ	None
Commercial navigation	USACE Little Rock District	Arkansas Waterways Commission	None

7.0 REFERENCES

5News Web Staff. 2013. *Scott County Flood Victim Dies from Medical Complications.* 5newsonline.com: 1.

Adams, S. Reid, Bradley S. Williams, Matt D. Schroeder, and Robert L. and Clark. 2007. *Abundance and Distribution of Fishes in Riparian Wetlands of the Arkansas River.* Conway: University of Central Arkansas,

Adamski, J.C., D.A. Freiwald, and J.V. Davis. *Environmental and Hydrologic Setting of the Ozark Plateaus Study Unit, AR, KS, MO, and OK.* USGS Water Resources Investigations 94-4022, USGS, 1995, 69.

ADEM. 2010.*All Hazard Mitigation Plan - State of Arkansas.* Little Rock, AR: Arkansas Department of Emergency Management.

ADEQ. 2004. *2004 Integrated Water Quality Monitoring and Assessment Report.* Little Rock, AR: Arkansas Department of Environmental Quality.

ADEQ. 2008 **.** *2008 Integrated Water Quality Monitoring and Assessment Report.* Water Division, Little Rock, AR: Arkansas Department of Environmental Quality, 350.

ADEQ. 2009. *Approved Arknasas 2008 Section 303(d) List.* Little Rock, AR: Arkansas Department of Environmental Quality, Water Division.

ADEQ. 2011. *Timeline of Historical Events of Arkansas Solid Waste Management, 1971 - 2011.* Little Rock: Arkansas Department of Environmental Quality.

ADEQ. 2012d. *2012 Integrated Water Quality Monitoring and Assessment Report.* Little Rock: Arkansas Department of Environmental Quality.

ADEQ. 2012a. *Arkansas Hazardous Waste Generators Facility Summary.* http://www.adeq.state.ar.us/hazwaste/rcra2/facil_sum.asp (accessed November 11, 2013).

ADEQ. 2012b. *Arkansas TMDLs.* http://www.adeq.state.ar.us/water/tmdls/default.asp (accessed November 8, 2013).

ADEQ. 2012c. *State of Arkansas Nutrient Criteria Development Plan.* Little Rock: Arkansas Department of Environmental Quality.

ADEQ. 2013a. *ADEQ Facility and Permit Summary.* http://www.adeq.state.ar.us/home/pdssql/pds.asp (accessed March 13, 2013).

ADEQ. 2013b. *NPDES Industrial Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/industrial/npdes_industrial_permit_tracking.asp (accessed November 11, 2013).

ADEQ. 2013c. *NPDES Construction Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/construction/npdes_constructionstormwater_permit_tracking.asp (accessed November 11, 2013).

ADEQ. 2013d. *NPDES MS4 Small Storm Water Permits Searchable Database.* http://www.adeq.state.ar.us/water/branch_permits/general_permits/stormwater/ms4/npdes_ms4_stormwater_permit_tracking.asp (accessed November 11, 2013).

ADEQ. 2013e. *Surface Water Quality Monitoring Station Data Search Page.* http://www.adeq.state.ar.us/techsvs/water_quality/water_quality_station.asp (accessed October 1, 2013).

ADEQ. 2013f. *ADEQ Water Quality Planning Branch.* http://www.adeq.state.ar.us/water/branch_planning/ (accessed January 28, 2014).

ADEQ. 2013g. "Star Starrett Facility." *Arkansas's Remedial Action Trust Fund.* http://www.adeq.state.ar.us/ftproot/Pub/hw/PriorityList/pdf/Star%20Starrett%20SPL%20Summary.pdf (accessed January 17, 2014).

ADEQ. 2013h. *Arkansas's Remedial Action Trust Fund.* http://www.adeq.state.ar.us/hazwaste/branch_tech/ratf.aspx (accessed November 11, 2013).

ADEQ. 2013i. *Final Permits.* http://www.adeq.state.ar.us/water/branch_permits/individual_permits/finalpermits/finalpermits.aspx#Display (accessed January 28, 2014).

ADH. n.d. *Drinking Water Information for Arkansans.* http://www.healthy.arkansas.gov/eng/autoupdates/pwslist0.htm (accessed March 20, 2013).

ADH. 2011. *Marine Sanitation.* Arkansas Department of Health. http://www.healthy.arkansas.gov/programsServices/environmentalHealth/MarineSanitation/Pages/MarineSanitation.aspx (accessed July 26, 2013).

ADH. 2012. *Arkansas Public Water System Compliance Summary.* Arkansas Department of Health, Environmental Health, Engineering, Reports and Forms. http://www.healthy.arkansas.gov/programsServices/environmentalHealth/Engineering/Documents/Reports/Compliance/ComplianceSummary.pdf (accessed July 30, 2013).

ADH, AGFC, ADEQ. 2011. *Fish Consumption Notice - Mercury in Fish.* Little Rock, AR: Department of Health.

ADPCE. 1990. *Arkansas Water Quality Inventory Report 1990.* Little Rock: Arkansas Department of Pollution Control and Ecology.

AGFC. 2009. *Wildlife Management Area Boundary (polygon), Arkansas*. Geocommons. http://geocommons.com/overlays/18197 (accessed April 25, 2013).

AHTD. 2001. *Mitigation Bank Instrument for the Hartman Bottoms Wetland Mitigation Bank Arkansas.* Little Rock: Arkansas State Highway and Transportation Department.

AHTD. 2006. *Public Land Boundaries Database*. Little Rock, AR: AHTD, 8 29,

Albin, D.R. *Water-resources Reconnaissance of the Ouachita Mountains, AR.* USGS Water Supply Paper 1809-J, USGS, 1965, 14.

Anderson, J.E. (ed.). 2006. *Arkansas Wildlife Action Plan.* Little Rock: Arkansas Game and Fish Commission.

ANRC. 2010. *Rules Governing the Arkansas Soil Nutrient and Poultry Litter Application and Management Program, Title 22.* Little Rock: Arkansas Natural Resources Commission.

ANRC. 2011a. *Water Law in Arkansas.* Little Rock: Arkansas Natural Resources Commission.

ANRC. 2011b. *2011-2016 Nonpoint Source Pollution Management Plan*. August http://arkansaswater.org/data/Full_NPSPlan_Document.pdf (accessed April 17, 2013).

APCEC. 2011. *Regulation No. 2, Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas.* Little Rock: Arkansas Pollution Control and Ecology Commission.

Arkansas Department of Parks and Tourism. 1991. *1990 Arkansas Travel and Tourism Report.* Little Rock, AR: Arkansas Department of Parks and Tourism.

Arkansas Department of Parks and Tourism. 2012. *2012 Annual Report*. Arkansas Tourism Official Site. http://www.arkansas.com/!userfiles/editor/docs/apt-annual-report-financials-2012.pdf (accessed June 2013).

Arkansas Geological Survey. n.d. *Physiographic Regions.* http://www.geology.ar.gov/education/physio_regions.htm (accessed March 2013).

Arkansas Multi-agency Wetlands Planning Team. 1995. *Arkansas Wetland Resource Information System, Arkansas State Wetland Strategy.* http://awrims.cast.uark.edu/home/ar-wetland-strategy.aspx (accessed March 2013).

ANHC. 2012. *River Designations*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2623 (accessed January 31, 2014).

ANHC. 2013. *Rare Species Search Engine: Find Arkansas Endangered Species.* http://www.naturalheritage.com/research-data/rarespecies-search.aspx (accessed July 2013).

Arkansas Multi-Agency Wetland Planning Team. 2001. *Clasification of Arkansas Wetlands.* http://www.mawpt.org/wetlands/classification/classes.asp (accessed September 19, 2013).

Arkansas River Compact Committee. 1970. *Arkansas River Basin Compact, Arkansas-Oklahoma, 1970.* Austin, TX: Office of Representaive, United States.

Arkansas Waterways Commission. 2013. *2011-2012 Biennial Report.* News - Biennial report. http://waterways.arkansas.gov/Documents/___BiennialReportFInal.pdf (accessed February 7, 2014).

ArkansasWater. *ArkansasWater.org.* 2012. www.arkansaswater.org (accessed March 22, 2013).

Association of Arkansas Counties. 2014. *http://www.arcounties.org/.* http://www.arcounties.org/ (accessed January 24, 2014).

ASWCC. 1981. *Arkansas State Water Plan, Lakes of Arkansas.* Little Rock: Arkansas Soil and Water Conservation Commission.

ASWCC. 1987. *Arkansas State Water Plan, Upper Ouachita Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

ASWCC. 1988. *Arkansas State Water Plan Eastern Arkansas Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

Audubon Arkansas. n.d. *Important Bird Areas in Arkansas.* http://ar.audubon.org/important-bird-areas-arkansas (accessed March 22, 2013)

Audubon Arkansas. n.d. *Audubon Arkansas IBA Site Descriptions.* http://ar.audubon.org/iba-site-descriptions (accessed April 2, 2013).

Bedinger, M.S., L.F. Emmett, and H.G. Jeffery. 1963. *Ground-water Potential of the Alluvium of the Arkansas River between Little Rock and Fort Smith, AR.* USGS Water Supply Paper 1669-L, USGS, 29.

Bell, James W. 2013. *Little Rock (Pulaski County)*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=970 (accessed March 25, 2013).

Boulden, Benjamin. 2012. *Fort Smith (Sebastian County)*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=988 (accessed March 25, 2013).

Branyan, Scott. 2012. *Floods.* The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=5148 (accessed March 25, 2013).

Buckner, Ed. 2011.*Climate and Weather.* Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=4579 (accessed March 15, 2013).

Center for Business and Economic Research. 2012. *Revisiting the Economic Impact of the Natural Gas Activitiy in the Fayetteville Shale: 2008-2012.* Fayetteville: University of Arkansas Sam M. Walton School of Business.

Central Arkansas Water. n.d.a. *Water Treatment*. http://www.carkw.com/water-source-info/water-treatment/ (accessed February 7, 2014).

Central Arkansas Water. n.d.b. *Watershed Management Plan.* http://www.carkw.com/water-source-info/watershed-management/watershed-management-plan/ (accessed February 7, 2014).

Clark, Patterson, and Laris Karklis. *USDA Upgrades Plant Hardiness Zone Map*. Washington Post. January 25, 2012. http://www.washingtonpost.com/wp-srv/special/local/planthardinesszones/index.html (accessed March 2013).

Cole, E.F., and E.E. Morris. 1986. *Water Resources of the Ouachita National Forest, AR.* USGS Water-Resources Investigations Report 86-4166, USGS, 1.

Conway Corporation. 2007. *James H Brewer Lake.* https://www.conwaycorp.com/About/History/BrewerLake.aspx (accessed October 8, 2013).

Cooperative Conservation America. n.d. *Cooperative Conservation Case Study, Arkansas Conservation Partnership.* http://www.cooperativeconservation.org/viewproject.asp?pid=103 (accessed July 29, 2013).

Cordova, R.M. 1963. *Reconnaissance of the Ground-water Resources of the Arkansas Valley Region.* USGS Water Supply Paper 1669-BB, USGS 33.

Dahl, T.E. 1990. *Wetlands - Losses in the United States, 1780's to 1980's.* Washington, DC: US Fish and Wildlife Service.

Department of Arkansas Heritage. 2013. *Discover Arkansas History, Regions - Arkansas River Valley.* http://www.arkansasheritage.com/discover/natural_environments/regions/rivervalley.aspx (accessed March 2013).

Ducks Unlimited. n.d. *Ducks Unlimited - Arkansas.* http://www.ducks.org/viewTag.aspx?tagID=533 (accessed 11 20, 2013).

Early, Ann M. 2011. *Pre-European Exploration (Prehistory - 1540).* Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=395 (accessed September 2013).

EPA. 2008. *Handbook for Developing Watershed TMDLs.* Washington, DC: US Environmental Protection Agency, Office of Wetlands, Oceans & Watersheds.

EPA. 2012a. *Landfills.* http://www.epa.gov/osw/nonhaz/municipal/landfill.htm (accessed June 3, 2013).

EPA. 2012b. *Large Quantity Generators.* http://www.epa.gov/osw/hazard/generation/lqg.htm (accessed July 9, 2013).

EPA. 2012c. *Small Quantity Generator.* http://www.epa.gov/osw/hazard/generation/sqg/index.htm (accessed July 9, 2013).

EPA. 2012d. *State Detail Analysis, The National Biennial RCRA Hazardous Waste Report (Based on 2011 Data).* Washington DC: US EPA.

EPA. 2012e. *Basic Information.* http://water.epa.gov/infrastructure/drinkingwater/pws/dwoperatorcert/basicinformation.cfm (accessed June 11, 2013).

EPA. 2013a. *Western Ecology Division.* www.epa.gov/wed/pages/ecoregions.htm (accessed June 2013).

EPA. 2013b. *Consumer Confidence Reports.* http://water.epa.gov/lawsregs/rulesregs/sdwa/ccr/index.cfm (accessed September 29, 2013).

EPA. 2013c. *Regulatory Topics.* http://www.epa.gov/lawsregs/topics/#water (accessed March 2013).

EPA. 2013d. *Compensatory Mitigation.* http://water.epa.gov/lawsregs/guidance/wetlands/wetlandsmitigation_index.cfm (accessed June 17, 2013).

EPA. 2013e. *EPA Information Related to the American Recovery and Reinvestment Act of 2009. EPA.* July 12, http://www.epa.gov/recovery/basic.html (accessed April 1, 2014).

EPA. n.d. *EPA Recovery Mapper.* http://epamap17.epa.gov/arra/# (accessed April 2014).

Faulkner County RSWMD. 2011. *Annual Plan Update.* Little Rock: ADEQ.

Federal Highway Administration. n.d. *FHA Water, Wetlands, and Wildlife.* http://www.environment.fhwa.dot.gov/ecosystems/eei/ar05.asp (accessed 11 18, 2013).

FEMA. 2013. *The National Flood Insurance Program Community Status Book.* http://www.fema.gov/national-flood-insurance-program/national-flood-insurance-program-community-status-book (accessed March 20, 2013).

Filipek, Steve, William E. Keith, and John Giese. 1987. *The Status of the Instream Flow Issue in Arkansas*. Proceedings Arkansas Academy of Science Vol. 41: 43-48.

Fortune. 2012. *Fortune 500, States.* CNNMoney. http://money.cnn.com/magazines/fortune/fortune500/2012/states/AR.html (accessed March 2013).

Foti, Thomas. 2008. *The Natural Divisions of Arkansas.* Little Rock: Arkansas Natural Heritage Commission.

Foti, Thomas. 2011a. *Arkansas Valley.* The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=441&type=Category&item=Six+Natural+Divisions&parent=Geography&grandparent=Land+and+Resources (accessed March 25, 2013).

Foti, Thomas. 2011b. *Geography and Geology.* http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Foti, Thomas. 2011c. *Ouachita Mountains*. The Encyclopedia of Arkansas History & Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=442 (accessed 9 2013).

Fry, J. et al. 2011. *Completion of the 2006 national land cover database for the conterminous United States.* PE&RS, Vol.77(9): 858-864.

Galloway, JM, BE Haggard, MT Meyers, and WR Green. 2005. *Occurence of Pharmaceuticals and Other Organic Wastewater Constituents in Selected Streams in Northern Arkansas, Scientific Investigations Report 2005-5140.* Reston, Va: USGS.

GCGW. 2008. *Arkansas Governor's Commission on Global Warning Final Report.* Little Rock: Arkansas Governor's Commission on Global Warming (GCGW).

Gleason, Mildred Diane. 2011. *Dardanelle (Yell County)*. The Encyclopedia of Arkansas History and Culture.

http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=1020 (accessed March 25, 2013).

Goss, Kay C. 2012. *McClellan-Kerr Arkansas River Navigation System (MKARNS).* The Encyclopedia of Arkansas History & Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=2309 (accessed September 2013).

Halberg, H.N., C.T. Bryant, and M.S. Hines. 1968. *Water Resources of Grant and Hot Spring Counties, AR.* USGS Water Supply Paper 1857, USGS, 64.

Heartland Boating. 2013. *Heartland Boating June 2013*. Heartland Boating. http://www.heartlandboating.com/June-2013/14-Million-in-Grants-Support-Clean-Waters-and-Recreational-Boating/ (accessed November 13, 2013).

Holland, Terry. 2013. *Written Communication.*

Imes, J.L., and L.F. Emmett. 1994. *Geohydrology of the Ozark Plateaus Aquifer System in Parts of Missouri, Arkansas, Oklahoma, and Kansas.* USGS Professional Paper 1414-D, USGS, 127.

Interagency Wild and Scenic Rivers Council. *National Wild and Scenic Rivers Program Arkansas.* http://www.rivers.gov/arkansas.php (accessed October 2013).

Jackson, R. Scott, Daniel J. Stynes, Dennis B. Propst, and Bruce D. Carlson. 1996. *A Summary of the National and State Economic Effects of the 1994 U.S. Army Corps of Engineers Recreation Program.* Technical Report R-96-1, Washington: US Army Corps of Engineers.

James Fork Regional Water District. 2014. *About Us.* http://www.jamesforkwater.com/about-us (accessed February 7, 2014).

Key, Joseph Patrick. 2012. *European Exploration and Settlement, 1541 through 1802*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2916&type=Time+Period&item=European+Exploration+and+Settlement+%281541+-+1802%29&parent=&grandparent= (accessed March 25, 2013).

Kilpatrick, J.M., and A.H. Ludwig. 1990. *Ground-water Resources of the Arkanasas River Basin in Arkansas.* USGS Open-File Report 88-725, USGS, 45.

Koon, David. 2012. *Arkansas Times.* http://www.arktimes.com/arkansas/whirlpool-withdrawal-in-fort-smith-careers-shattered/Content?oid=2552554 (accessed October 22, 2013).

Kresse, T. M., J.A. Fazio, R.A. Miller, and S.W. and Kline. 2006. *The Arkansas River's Alluvial Aquifer in Central Arkansas: Geochemistry of the Aquifer at Dardanelle*. Proceedings of the Arkansas Water Resources Center Annual Conference. Fayetteville.

Kresse, T. M., and P. D. Hays. 2009. *Geochemistry, comparative analysis, and physical and chemical characteristics of the thermal waters east of Hot Springs National Park, AR 2006-2009.* USGS Scientific Investigations Report 2009-5263, USGS, 48.

Kresse, T. M., N. R. Warner, P. D. Hays, A. Down, A. Vengosh, and R. B. Jackson. 2012. *Shallow groundwater quality and geochemistry in the Fayetteville Shale gas-production area, north-central Arkansas.* US Geological Survey Scientific Investigations Report 2012-5273, USGS.

Kresse, T.M. et al. 2013. *In review: Aquifers of Arkansas: protection, management, and hydrologic and geochemical characteristics of Arkansas' groundwater resources.* Little Rock: USGS.

Lancaster, Guy. 2011a. *Fourche La Fave River.* The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=6247 (accessed March 28, 2013).

Lancaster, Guy. 2011b. *Petit Jean River*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=6252 (accessed March 28, 2013).

Manger, W.L. 1983. *The Geologic Provinces of Arkansas*. Arkansas Naturalist 1, no. 7: 1-6.

Manger, W.L., and J. Lloyd. 2008. *An Introduction to the Geology of Northwestern Arkansas.* Field Trip Guide, U Of A Dept of Geosciences, 55.

McFarland, John David. 2004. *Stratigraphic Summary of Arkansas.* Information Circular 36, Little Rock: Arkansas Geologic Commission.

National Agricultural Law Center. 2012. *United States Farm Bills.* http://www.nationalaglawcenter.org/farmbills/ (accessed June 11, 2013).

NatureServe. 2002. *Number of Extince Species in Each State.* http://www.natureserve.org/consIssues/ivoryBilled_table1.htm (accessed December 19, 2013).

Nelson, Rex. 2012. *Stephens, Inc*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryid=6985 (accessed June 5, 2013).

NOAA NCDC. 2013a. *Historical Palmer Drought Indices.* http://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers.php (accessed May 15, 2013).

NOAA NCDC. 2013b. *Climate at a Glance.* http://www.ncdc.noaa.gov/cag/time-series/global (accessed May 24, 2013).

NOAA. 2012. *NOAA's Drought Information Center, the Palmer Drought Severity Index.* http://www.drought.noaa.gov/palmer.html (accessed June 12, 2013).

NOAA NWS. 2013. *Little Rock, AR - Daily Climate Data.* http://www.srh.noaa.gov/lzk/?n=wxcntl3.htm (accessed December 19, 2013).

NRCS. n.d.a. *Arkansas, Major Land Resource Areas.* http://www.ar.nrcs.usda.gov/soils/mo16_mlra.html (accessed March 2013).

NRCS. n.d.b. *Seven Lakes Wetland Project.* http://www.nrcs.usda.gov/wps/portal/nrcs/detail/ar/home/?cid=nrcs142p2_035182 (accessed 11 21, 2013).

NRCS. 2012. *Arkansas Annual Report 2012*. NRCS Arkansas. http://www.ar.nrcs.usda.gov/news/annual_report_2012.html (accessed July 15, 2013).

NRCS Plant Materials Program. n.d. *AR Plant Materials Program.* http://www.nrcs.usda.gov/wps/portal/nrcs/main/plantmaterials/pmc/southeast/arpmc/ (accessed 11 13, 2013).

NRI Group. 2010. *Cadron Creek Mitigation Bank.* http://tnrig.com/Cadron_Creek_Mitigation_Bank.php (accessed 11 18, 2013).

Oklahoma Waterways Branch. 2012. *McClellan-Kerr Arkansas River Navigation System 2012 Inland Waterway Fact Sheet.* Waterways Advisory Board. http://www.okladot.state.ok.us/waterway/pdfs/fact_sheet_2012.pdf (accessed 10 01, 2013).

Oklahoma Water Resources Board. 2013. Title 785 Chapter 45 Oklahoma's Water Quality Standards. Oklahoma City: Oklahoma Water Resources Board.

Ouachita Ecoregional Assessment Team. 2003. *Ouachita Mountains Ecoregional Assessment.* Arkansas Wildlife Action Plan. http://www.wildlifearkansas.com/materials/updates/Appendix_3%5B1%5D.2_Ouachita_Ecoregional_Assessment.pdf (accessed January 31, 2014).

Petrimoulx, Drew. 2013. *Deal to Sell Water Rights Irks LR City Directors* . arkansasmatters.com.

PRISM Climate Group. 2004. Corvallis: Oregon State University.

Pugh, A.L., D.A. Westerman. 2014. *Mean Annual, Seasonal, and Monthly Precipitation and Runoff in Arkansas, 1951-2011.* US Geological Survey Scientific Investigations Report 2014-5006. Reston, VA: USGS.

Pulaski County RSWMD. 2011. *Regional Solid Waste Management Plan.* Little Rock: ADEQ.

Renken, R.A. 1998. *Groundwater Atlas of the United States: Segment 5, Arkansas, Louisiana, Mississippi*. US Geological Survey Hydrologic Atlas 730-F: 28.

Reynolds, Jerry. 2012. *Hydroelectricity*. Encyclopedia of Arkansas History & Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=5527 (accessed 09 2013).

Scott, H. Don, James A. Ferguson, Linda Hanson, Todd Fugitt, and Earl Smith. 1998. *Agricultural Water Management in the Mississippi Delta Region of Arkansas. Research Bulletin 959.* Fayetteville: University of Arkansas.

Sebastian County RSWMD. 2011. *Combined Regional Solid Waste Management Plan, Regional Needs Assessment, Annual Waste Tire Site Report, and Annual Recycling Program Report.* Little Rock: ADEQ.

Sloan, Kitty. 2011. Trail of Tears. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2294 (accessed March 25, 2013).

Smith, Bill. 2012. *Dardanelle Water Works*. Personal Communication.

Spurgeon, John. 2011. *Holla Bend National Wildlife Refuge*. The Arkansas Encyclopedia of History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2465 (accessed March 28, 2014)

State of Arkansas. 2009. *Recovery.Arkansas.Gov.* http://recovery.arkansas.gov//programs.php?do:home=1 (accessed 11 14, 2013).

State of Oklahoma. 1970. *Arkansas River Basin Compact.* The Oklahoma State Courts Network. http://www.oscn.net/applications/OCISWeb/DeliverDocument.asp?CiteID=97776 (accessed February 7, 2014).

Stewart-Abernathy, Leslie C. 2011a. *Cherokee*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Stewart-Abernathy, Leslie C. 2011b. *Steamboats*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=4466&type=Category&item=Water&parent=Transportation&grandparent= (accessed March 18, 2013).

Stone, C.G., and W.V. Bush. 1984. *General Geology and Mineral Resources of the Caddo River Watershed.* Information Circular 29, AR Geologic Commission, 32.

The City Wire. 2009. *Lake Fort Smith*. TheCityWire.com. http://www.thecitywire.com/node/4656#.Uo4s6Z3nbcs (accessed 11 21, 2013).

The Nature Conservancy. 2013. *Arkansas Mulberry River Preserve.* http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/arkansas/placesweprotect/mulberry-river-preserve.xml (accessed April 2, 2013).

The Nature Conservancy. 2006. *Multi-site Management Plan - Ecoregional Conservation for the Ouachita Ecoregion Arkansas and Oklahoma*. DENIX: DoD Environment, Safety, and Occupational Health Network and Information Exchange. http://www.denix.osd.mil/nr/upload/Multisite-Management-Plan-for-Ouachitas.pdf (accessed January 31, 2014).

Tradewind. n.d. *Find Lakes: Lake Shepherd Springs.* http://findlakes.com/lake_shepherd_springs_arkansas~ar00445.htm (accessed September 2013).

University of Arkansas at Little Rock Institute for Economic Advancement. 2002. *Index for Arkansas State and Counties Population and Social/Economic Characteristics by County 1990 Census of Population and Housing.* http://iea.ualr.edu/arkansas-census-data.html?id=174:index-for-arkansas-state-and-counties&catid=1 (accessed June 18, 2013).

University of Georgia - Center for Invasive Species and Ecosystem Health. 2013. *Invasive Plant Atlas of the United States.* www.invasiveplantatlas.org (accessed December 20, 2013).

US Census Bureau. n.d.a. *DP03 - Selected Economic Characteristics, 2007-2011 American Community Survey 5-year Estimates.* http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_11_5YR_DP03 (accessed March 18, 2013).

US Census Bureau. n.d.b. *American FactFinder*. DP-1 Profile of General Population and Housing Characteristics:2010. http://factfinder2.census.gov/faces/nav/jsf/pages/community_facts.xhtml#none (accessed March 25, 2013).

US Census Bureau. 1989. *1987 Census of Agriculture Volume 1 Geographic Area Series Part 4 Arkansas State and County Data.* Washington, DC: US Government Printing Office.

US Census Bureau. 1992. *1992 Economic Census Area Profiles - AR.* http://www.census.gov/epcd/www/92profiles/www/EC92AR.HTM.

US Census Bureau. 1993. *1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR), Arkansas.* Washington, DC: US Government Printing Office.

US Census Bureau. 2003. *Arkansas: 2000 Population and Housing Unit Counts.* Washington DC: US Census Bureau.

US Census Bureau. 2011a. *Urban Area Criteria for the 2010 Census*. Federal Register, 76(164): 5303-53043.

US Census Bureau. 2011b. *EC0700A1, All Sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007 Economic Census*. American FactFinder. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_00A1&prodType=table (accessed March 26, 2013).

US Census Bureau. 2012a. *Arkansas 2010: Population and Housing Unit Counts.* Washington, DC: US Department of Commerce.

US Census Bureau. 2012b. *Table 20. Large Metropolitan Statistical Areas - Population: 1990 to 2010.* Washington, DC: US Census Bureau.

US Census Bureau. 2014. *National Survey of Fishing, Hunting, & Wildlife-Associated Recreation (FHWAR).* http://www.census.gov/prod/www/fishing.html (accessed February 4, 2014).

US Congress. 1992. *Clean Vessel Act of 1992.* Digest of Federal Laws of Interest to the U.S. Fish and Wildlife Service. http://www.fws.gov/laws/lawsdigest/clenves.html (accessed July 12, 2013).

US Nuclear Regulatory Commission. 2013. *About NRC.* July http://www.nrc.gov/about-nrc.html (accessed October 31, 2013).

USACE. n.d. *US Army Corps of Engineers Little Rock District.* http://www.swl.usace.army.mil/Missions/Recreation/Lakes/ (accessed September 2013).

USACE. 2011. V*alue to the Nation Fast Facts. State Level Report - Arkansas.* http://www.corpsresults.us/recreation/fastfacts/stateReport.cfml?State=12 (accessed October 2013).

USACE. 2012. *www.swd.usage.army.mil.* http://www.swd.usace.army.mil/Portals/42/docs/civilworks/Fact%20Sheets/Little%20Rock/FY13%20Arkansas%20River%20Levees,%20AR.pdf (accessed October 09, 2013).

USACE. 2012. *Fiscal Year 2013 - Civil Works Budget for the US Army Corps of Engineers*. US Army Corps of Engineers. http://www.usace.army.mil/portals/2/docs/civilworks/press_book/budget2013.pdf (accessed January 10, 2014).

USACE. 2013. *Regulatory In-lieu Fee and Bank Information Tracking System (RIBITS).* https://rsgisias.crrel.usace.army.mil/ribits/f?p=107:158:2210333181022334::NO:RP:P27_BUTTON_KEY:1 (accessed November 18, 2013).

USACE Little Rock District. n.d. *Navigation.* http://www.swl.usace.army.mil/Missions/Navigation.aspx (accessed 09 2013).

USACE Little Rock District. 1988a. *Arkansas State Water Plan, Arkansas River Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

USACE Little Rock District. 2004. *Navigable Streams*.

USDA National Agricultural Statistics Service. 1992. *The Census of Agriculture*. 1992 Census Publications - Arkansas. http://www.agcensus.usda.gov/Publications/1992/Volume_1_Chapter_2_County_Tables/Arkansas/index.asp (accessed February 4, 2014).

USDA National Agricultural Statistics Service. 2007. *2007 Census of Agriculture State Profile, Arkansas.* Washington, DC: USDA National agricultural Statistics Service.

USDA National Agricultural Statistics Service. 2009. *2007 Census of Agriculture Arkansas State and County Data Volume 1 Geographic Area Series Part 4.* Washington, D.C.: USDA National Agricultural Statistics Service..

USFS. 2013. *Forest Inventory Data Online (FIDO).* http://apps.fs.fed.us/fia/fido/index.html (accessed September 13, 2013).

USFWS. n.d.a. *Holla Bend National Wildlife Refuge.* http://www.fws.gov/refuges/profiles/index.cfm?id=43590 (accessed January 31, 2014).

USFWS. n.d.b. *Arkansas' Federally Endangered, Threatened, and Candidate Species.* http://www.fws.gov/arkansas-es/docs/ESDay/Photographs%20of%20Endangered%20Species%20in%20Arkansas.pdf (accessed January 28, 204).

USFWS. 2007. *Best Management Practices for Fayetteville Shale Natural Gas Activities.* Conway: US Fish and Wildlife Service.

USFWS. 2013. *Endangered Species Act: Overview.* http://www.fws.gov/endangered/laws-policies/index.html (accessed March 13, 2013).

USGS. 2013a. *Surface-water monthly statistics for the nation.* http://waterdata.usgs.gov/nwis/monthly/?referred_module=sw (accessed June 19, 2013).

USGS. 2013b. *Friday Storms Caused Record Flooding on Fourche LaFave River in Scott and Yell Counties.* USGS Newsroom: 1.

USGS. 2013c. *USGS Water-Quality Data for Arkansas.* http://waterdata.usgs.gov/ar/nwis/qw (accessed October 1, 2013).

USGS. 2013d. *NAS - Non Aquatic Species.* http://nas.er.usgs.gov/default.aspx (accessed December 19, 2013).

Vance, David L. 2012. *Russellville (Pope County).* The Encylopedia of Arkansas History & Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=963 (accessed October 22, 2013).

Warner, Nathaniel R., et al. 2013. *Geochemical and isotopic variations in shallow groundwater in areas of the Fayetteville shale development, north-central Arkansas.* Applied Geochemistry. http://dx.doi.org/10.1016/j.apgeochem.2013.04.013 (accessed May 31, 2013).

Weakley, A., E. Dinerstein, R. Noss, S. Robinson, J. Strittholt, and J. Adams. 2013. *Ozark Mountain forests.* http://worldwildlife.org/ecoregions/na0412 (accessed December 18, 2013).

West River Valley RSWMD. 2011. *West River Valley RWSMD Regional Solid Waste Management Plan.* Little Rock: ADEQ.

Wiest, Jason. 2011. D*oes the Future Hold Water For Arkansas?* inarkansas.com,

Winthrop Rockefeller Foundation. 2008. *Water Issues in Arkansas: A Companion Report to "Water Issues in Arkansas - An Unfinished Story" Summary Report.* Little Rock, AR: Winthrop Rockefeller Foundation.

Woods, Alan J et al. 2004. *Ecoregions of Arkansas (color poster with map, descriptive text, summary tables, and photographs).* Reston, VA: US Geological Survey.

APPENDIX A

2008 303(d) List of Impaired Waterbodies in the WAWRPR

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
3C – Arkansas River & tributaries: Lock & Dam 4 and 7*	96.3	96.3	Aquatic life	20.4	DO	20.4	Unknown
					Copper	20.4	Unknown
					Zinc	11.2	Unknown
			Drinking water	11.2	Sediment/ siltation	11.2	Unknown
					Beryllium	17.9	Unknown
			Primary contact recreation	20.4	Pathogens	20.4	Unknown
			Total	20.4			
3D – Arkansas River & tributaries: Lock & Dam 7 to Morillton*	179.3	168.2	Aquatic life	26.8	Copper	11.2	Agriculture
					Sediment/ siltation	15.6	Erosion
					Zinc	11.2	Agriculture
3E – Fourche LaFave River	211.5	201.3	Fish consumption	8.7	Mercury	8.7	Unknown
			Aquatic life	145.3	DO	126.7	Unknown
					Sediment/ siltation	20.2	Erosion
					pH	43.8	Unknown
			Total	154			
3F – Arkansas River*	283.2	164.3	Aquatic life	28	DO	2	Hydropower
					Ammonia	3	Municipal WWTP
					Copper	10	Municipal WWTP
					Nitrate	13	Municipal WWTP
					Zinc	3	unknown
					Sediment/ siltation	10	Unknown

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
			Agriculture & industrial water supply	9.4	TDS	9.4	Unknown
			Total	34.4			
3G – Petit Jean River & tributaries	198.5	153.5	Aquatic life	48.2	DO	28.9	Unknown
					Sediment/ siltation	19.3	Unknown
			Drinking water supply	21.6	Beryllium	21.6	Unknown
			Total	50.2			
3H – Arkansas River & tributaries: state line to river mile 210*	707.2	539.3	Aquatic life	24	Copper	14.9	Municipal WWTP
					pH	9.1	Unknown
			Agriculture & industrial water supply	12.4	TDS	12.4	Unknown
			Agriculture & industrial water supply, drinking water	11	Chloride	11	Unknown
			Primary contact recreation	47.8	Pathogens	47.8	Unknown
			Total	115.7			
3I – Poteau River	105.3	55.8	Aquatic life	14.8	DO	2	Unknown
					Copper	6.6	Industrial point source
					Total phosphorus	6.6	Municipal WWTP
					Sediment/ siltation	14.8	Erosion

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
					Zinc	8.6	Unknown, municipal WWTP
			Drinking water, agriculture & industrial water supply	6.6	Chloride	6.6	Municipal WWTP, industrial point source
					Sulfate		
					TDS		
			Total	21.4			
Total	1781.3	1378.7		394.1			

* A portion of this planning segment is in another water resources planning region. Values shown are for stream segments in the WAWRPR.