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Arkansas WATERplan
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ARKANSAS WATER PLAN UPDATE
TASK NO. 6 - EAST ARKANSAS WATER RESOURCES PLANNING REGION

AUGUST 6, 2014

ARKANSAS WATER PLAN UPDATE
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WATER RESOURCES PLANNING REGION

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AUGUST 6, 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)

TABLE OF CONTENTS (CONTINUED)

LIST OF ACRONYMS

ACS	American Community Survey
ADEQ	Arkansas Department of Environmental Quality
ADPCE	Arkansas Department of Pollution Control and Ecology (now ADEQ)
ADH	Arkansas Department of Health
AGFC	Arkansas Game and Fish Commission
AHTD	Arkansas State Highway and Transportation Department
ANHC	Arkansas Natural Heritage Commission
ANRC	Arkansas Natural Resources Commission
APCEC	Arkansas Pollution Control and Ecology Commission
ASPB	Arkansas State Plant Board
ASWCC	Arkansas Soil and Water Conservation Commission (now the ANRC)
AWAG	Arkansas Watershed Advisory Group
AWP	Arkansas Water Plan
BCE	Before the common era
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	Cubic Feet Per Second
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
CWA	Clean Water Act
EAWRPR	East Arkansas Water Resources Planning Region
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentive Program
FEMA	Federal Emergency Management Agency
GCGW	Governor's Commission on Global Warming
gpm	Gallons per minute
HUD	United States Department of Housing and Urban Development
MCL	Maximum Containment Level
MERAS	Mississippi Embayment Regional Aquifer Study
mg/L	Milligrams per liter
mgd	Million gallons per day
MKARNS	McClellan-Kerr Arkansas River Navigation System
MRV	Mississippi River Valley
MS4	Municipal Separate Storm Sewer System
n.d.	No date
NCDC	National Climatic Data Center
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRCS	United Stated Department of Agriculture Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
NWR	National wildlife refuge
NWIS	National Water Information System

TABLE OF CONTENTS (CONTINUED)

PCB	Polychlorinated biphenyl
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
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
U of A	University of Arkansas
US	United States
USACE	United States Army Corps of Engineers
USDA	United Stated Department of Agriculture
USDI	United States Department of the Interior
USFS	United States (USDA) Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WMA	Wildlife management area
WRDA	Water Resources Development Act

1.0 INTRODUCTION

The Arkansas Natural Resources Commission (ANRC) is responsible for preparing, and periodically updating, a statewide water resources planning document. The previous update of the Arkansas Water Plan (AWP) was completed in 1990. In 2012, ANRC initiated an update of the 1990 AWP 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 East Arkansas Water Resources Planning Region (EAWRPR) that will be used in the 2014 AWP update. The EAWRPR is one of five state water resources planning regions being addressed in the 2014 AWP update. The information in this document will serve as background for updated discussion and analysis of state water supplies, water demand, and alternatives for meeting the water resources needs in the EAWRPR. 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 EAWRPR, a brief history of the regional culture, and an overview of historical water resources management.

2.1 Geography

The EAWRPR encompasses approximately 15,900 square miles in eastern Arkansas (Figure 2.1). This region is bounded on the north by Missouri, to the south by Louisiana, and to the east by Mississippi. The western boundary of the EAWRPR north of Little Rock roughly corresponds to the geologic boundary between the Gulf Coastal Plain and the Interior Highlands physiographic regions. South of Little Rock, this boundary roughly corresponds to the hydrologic boundary between the Saline River, and Bayou Bartholomew or the White River. All or part of 25 counties are included in this 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 planning region include Jonesboro, Paragould, Pine Bluff, Forrest City, West Memphis, Blytheville, Stuttgart, and Helena.

2.2 History

Water resources have influenced the history of this region, and the current condition of water resources in the region is a product of human activities throughout its history. The cultural history of the region is outlined below. The history of water resources development in the planning region is summarized separately.

2.2.1 Cultural

Native Americans settled the EAWRPR prior to European exploration and settlement. There is archeological evidence in the region of the presence of sophisticated native cultures beginning around 500 BCE. From this time until the first Europeans came to the region in the 1500s, the mound-building Plum Bayou Culture was active in the region (Early 2011).

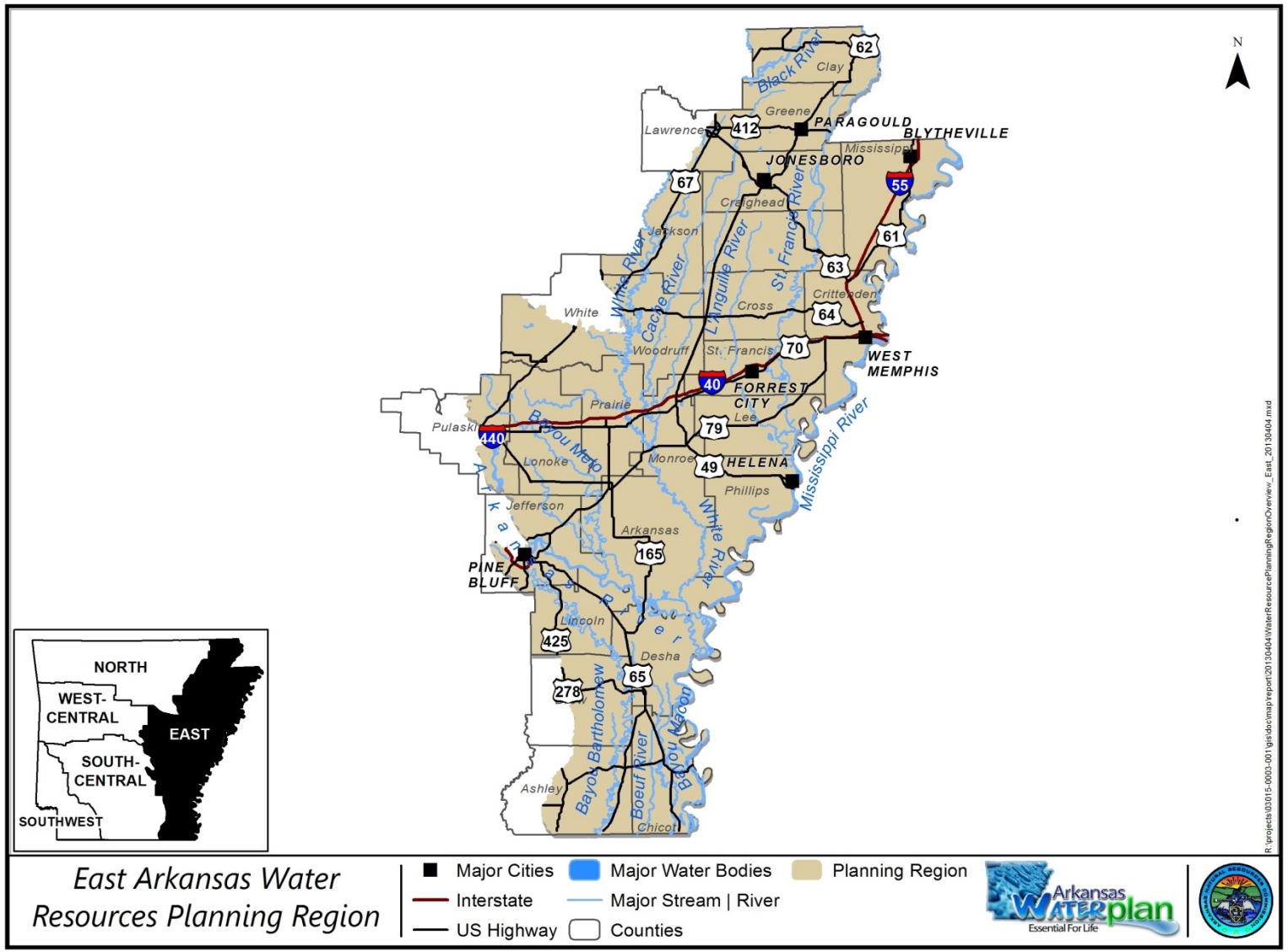

Figure 2.1. East Arkansas Water Resources Planning Region.

Table 2.1. Counties in the EAWRPR.

County	County Area in Planning Region (square miles) (US Census Bureau 2012a)	Percentage of County Area in Planning Region
Arkansas	988.77	100%
Ashley	624.81	68%
Chicot	644.30	100%
Clay	639.47	100%
Craighead	707.21	100%
Crittenden	609.76	100%
Cross	616.38	100%
Desha	768.15	100%
Drew	520.27	63%
Greene	577.70	100%
Jackson	633.94	100%
Jefferson	663.65	76%
Lawrence	217.13	37%
Lee	602.62	100%
Lincoln	561.52	100%
Lonoke	770.73	100%
Mississippi	900.57	100%
Monroe	607.12	100%
Phillips	695.66	100%
Poinsett	758.39	100%
Prairie	647.96	100%
Pulaski	337.48	44%
St. Francis	634.77	100%
White	624.69	60%
Woodruff	586.79	100%
Total	**15939.84**	

Because early European exploration and settlement utilized the Mississippi River, early explorers, missionaries, and settlers entered Arkansas via the EAWRPR. Hernando de Soto's Spanish expeditionary force were the first Europeans in the region, arriving in 1541. At this time, the region was heavily populated by natives who farmed extensively. De Soto died in 1542, in Chicot County. The Spanish then left the region in 1543 (Key 2012).

Over 100 years later, in 1673, French explorers came to the region. By this time, the native culture of the region was the Quapaw, and the native population was sparser than when the Spanish expedition traveled here. A French explorer established the first settlement west of

the Mississippi River, Arkansas Post, in 1686 on the Arkansas River in what is now Arkansas County, although it was abandoned approximately 10 years later. In the 1700s, Arkansas Post was re-established by the French as a military outpost. The European focus, prior to the Louisiana Purchase in 1803, was primarily on exploitation of the abundant wild game in the region for trade, rather than immigration.

During the 1700s the Quapaw population of the region was decimated by smallpox epidemics (Key 2012). Cherokee migrated from the eastern United States (US) and established settlements along the St. Francis River beginning around 1780 (Stewart-Abernathy 2011a). The Cherokee left the region in 1817 (Bolton 2012).

American settlement of the EAWRPR did not begin in earnest until after the War of 1812. Arkansas Post, located in the region, was the territorial capital until 1821. In the 1830s, population in the region increased rapidly. The bottomland forests were cleared, swamps drained, and large-scale, southern-style, cotton plantations developed, making this region the center of Arkansas wealth and power (Bolton 2012, DeBlack 2012). Cotton thrived in the deep, rich soils of the region, and the proximity to river transportation contributed to the economic strength of the region (Hawkins 2011). Many of the early settlers in the region lived on Crowley's Ridge, while owning and operating farms in the lowlands (Turner 2001, Foti 2008).

After the Civil War, cotton plantations in the EAWRPR were converted to tenant farms, or were operated using paid labor. However, cotton prices fell after the war, remaining low through the 1890s. As a result, many cotton operations were forced to shut down. In the 1930s, cotton production in the region declined, and soybean and rice production began to increase (Hawkins 2011). Agricultural production remains the foundation of the economy of the EAWRPR.

2.2.2 Water Resources Development

A range of water resources development activities have occurred in this region throughout its history, as attitudes and policies have changed. Historically, human activities that have affected water resources in this planning region have included draining and clearing of wetlands, channelization of rivers and streams, levee building, river transportation and

navigation, development of surface water and ground water for irrigation, changes in cropping, development of aquaculture, wildlife habitat and wetland conservation, and development of the recreation industry in the region.

2.2.2.1 Flood Control and Drainage

Early settlers in the EAWRPR constructed systems of canals to drain the wetlands for agriculture, and levees to protect this reclaimed land from flooding, These levees were not very tall, nor very effective (Jackson 2011). By 1958 a system of levees had been constructed by local interests along the Mississippi River in Arkansas (Mississippi River Commission 2007). However, this levee system did not adequately protect the region from flooding.

In 1879, the US Congress created the Mississippi River Commission to oversee flood control along the entire Mississippi River. Levee and drainage districts in Arkansas were formed shortly thereafter (Table 2.2). Between 1905 and 1915, the Arkansas General Assembly passed laws creating a flood control program for the Mississippi River Valley region of the state, i.e., the EAWRPR (Jackson 2011, Mississippi River Commission 2007).

Table 2.2 Levee and drainage districts in the EAWRPR (Jackson 2011).

Organization date	District Name	Counties included
1883	Chicot	Chicot
1887	Clay and Greene	Clay, Greene
1891	Laconia	Desha, Phillips
1891	Red Fork	Desha
1893	St. Francis	Crittenden, Cross, Lee, Mississippi, Phillips, Poinsett, St. Francis
1905	Linwood and Auburn	Lincoln
1905	Plum Bayou	Jefferson, Lonoke, Pulaski
1905	French Town	Jefferson
1905	Tucker Lake	Jefferson

The 1928 Flood Control Act, passed in response to the widespread damage caused by the 1927 Mississippi River flood, authorized the federal Mississippi River and Tributaries Project. This project consisted of a unified and coordinated system of flood protection structures in the

lower Mississippi River Valley. This system includes levees along the Mississippi River, Arkansas River, and St. Francis River. In addition, backwater storage areas at the mouth of the St. Francis River and the White River are part of the Mississippi River flood protection system (Mississippi River Commission 2007, 2008).

Despite the work undertaken by levee and drainage districts in the EAWRPR, and the Corps of Engineers along the Mississippi River, over half of the region was still undeveloped in 1940. Machinery improvements that occurred during World War II made it possible to drain, dredge, and clear swampland at a much faster rate after the war than previously. Crop diversification also occurred at this time and spurred the increased rate of land drainage and conversion, as soybeans and rice could be grown on lands not suitable for cotton (Williams 2012).

In the late 1950s, after passage of the 1954 Watershed Protection and Flood Prevention Act, 11 watershed districts were formed in the EAWRPR to implement flood control projects. Through these projects, over 400 miles of streams in the EAWRPR were channelized and 4.7 million acres of land drained by 1970 (Williams 2012).

2.2.2.2 Wetland Loss

Prior to European settlement, there were approximately 8 million acres of wetlands in the EAWRPR (Dahl 1990). In 1849 and 1850, the US Congress passed the Swamp Land Acts, to encourage settlement of the lowlands along the Mississippi River, including eastern Arkansas. Through these Acts, land in eastern Arkansas was sold for pennies to settlers so the land could be developed. After the Civil War, timber clearing and wetland draining in eastern Arkansas increased as the timber industry and agriculture expanded in this region. Completion of the Cotton Belt railroad from St. Louis to Pine Bluff in 1883 increased the rate of the expansion of the timber industry and agriculture in the region (Balogh 2012, Zbinden 2011).

By 1920, most of the virgin timber in Arkansas had been cut, and 3.5 million acres of east Arkansas land had been organized into drainage districts. By the mid 1930s approximately 40% of the wetlands in eastern Arkansas had been drained and developed (Arkansas Multi-agency Wetland Planning Team 2001). However, in 1935, the White River National Wildlife Refuge

was established in Monroe, Arkansas, Phillips, and Desha counties, preserving 160,000 acres of bottomland hardwood forested wetlands (Rogers 2013).

After World Water II, the rate of wetland loss in eastern Arkansas increased as a result of the use of mechanized equipment (Arkansas Multi-agency Wetland Planning Team 2001). The rate of wetland loss in eastern Arkansas began to decrease in the late 1970s, as awareness of the importance of wetlands for migratory bird habitat and other important environmental functions increased, and national legislation, policies, and programs were enacted that encourage conservation and restoration of wetlands (Dahl 1990).

2.2.2.3 Irrigation

The early development and expansion of irrigation in the EAWRPR is closely tied to the introduction and expansion of rice production. From 1900 to 1950, 96.6 to 99.9 % of the irrigated land in Arkansas was irrigated rice. Irrigated rice produce began in Arkansas, Prairie, and Lonoke counties in 1900. Between 1900 and 1910 irrigated rice acreage in Arkansas increased from 25 acres to almost 60,000 acres. By 1920, 180,000 acres of irrigated cropland (rice) were in production in the EAWRPR (Green 1986). Groundwater from the Mississippi River Valley alluvial aquifer was used for rice irrigation (Scott, et al. 1998). After this initial period of expansion, the amount of irrigated cropland in the region stayed fairly constant until 1940 (Green 1986).

The period from 1940 through 1954 was one of expansion of irrigated rice production in the EAWRPR. During this period, the amount of irrigated cropland in the region increased by 430 %, to over 850,000 acres. While some of the additional irrigated land was in rice production, the use of irrigation for other crops began during this period. During this time, irrigation began to be used in production of cotton, soybeans, corn, and vegetables in the EAWRPR (Green 1986).

Expansion of irrigated land slowed dramatically during the period between 1954 and 1974, increasing by only 9.5 %. During this period, modern irrigation technology became common in the region. In 1960, 87.5 % of irrigated cropland was irrigated using groundwater. Eighty-seven % of the 1960 irrigated cropland was irrigated using furrow irrigation, and 12.5 % was irrigated using sprinklers (Green 1986).

Further advancements in irrigation technology, including pumps and sprinkler pipe, in the 1970s contributed to another period of expansion of irrigated land in the EAWRPR (Green 1986). Between 1974 and 1978, the amount of irrigated cropland in Arkansas increased by 32 % (301,700 acres), primarily as a result of expansion of rice production (Scott, et al. 1998). Between 1978 and 1982, the area of irrigated cropland in Arkansas increased by 345,811 acres, a 21 % increase (US Department of Commerce Bureau of the Census 1984). This increase was primarily due to increased irrigation of soybeans and cotton (Scott, et al. 1998). Irrigated acreage in the EAWRPR has continued to increase, through 2007, when 4,295,000 acres was irrigated in this region.

Groundwater is used for the majority of the irrigation in the EAWRPR. However, concern about the ability of the aquifers in the EAWRPR to sustain the high water volumes used for irrigation has led to the development of large-scale surface water irrigation projects. In 2013 there are three irrigation projects under development in the EAWRPR, and one completed, that supply surface water for irrigation. Three additional surface water irrigation projects located in the EAWRPR are under study (US Department of Agriculture Natural Resources Conservation Service [NRCS] 2011). Information about these projects is summarized in Table 2.3.

Table 2.3. Surface water irrigation projects in the EAWRPR (NRCS 2011).

Project Name	Counties	Cropland Area (acres)	Water Source	Status
Grand Prairie	Arkansas	246,000	White River	Incomplete
Bayou Meto	Arkansas, Jefferson, Lonoke, Prairie, Pulaski	268,000	Arkansas River	Incomplete
Boeuf-Tensas	Ashley, Chicot, Desha, Drew, Jefferson, Lincoln	800,000	Arkansas River	Incomplete
Plum Bayou	Lonoke, Pulaski	14,200	Arkansas River	Complete
Bayou DeView	Craighead, Poinsett	105,500	White River?	Under study
Upper L'Anguille	Craighead, Poinsett	123,498	White River?	Under study
North Prairie	Prairie	111,080	White River?	Under study

2.2.2.4 Navigation

During the early years of European settlement in eastern Arkansas, rivers in the region were important transportation corridors, because travel overland in this region was difficult. In the 1820s, steamboats began operating on the Arkansas River and White River. By the 1830s, steamboats were active also on the Cache River and Black River. By 1875, steamboats were also navigating the St. Francis River and Bayou Bartholomew (Stewart-Abernathy 2011b, Cavaneau 2012). The Arkansas River and the White River are the only two rivers in the EAWRPR still used for commercial transportation (Figure 2.2) (Arkansas Waterways Commission 2012a). In the 1960s, the McClellan-Kerr Arkansas River Navigation System (MKARNS) was constructed on the Arkansas River and White River (Goss 2012).

2.2.2.5 Hydropower

The Arkansas Electric Cooperative Corporation operates a hydropower project located at Wilbur D. Mills Dam on the Arkansas River in the EAWRPR (part of the MKARNS). This hydropower plant is a low-head, run-of-the-river project and releases are controlled by the USACE. Construction of this power plant was begun in 1994 and completed in 1999. The plant is capable of generating power at flows between 4,000 cubic feet per second (cfs) and 200,000 cfs. The maximum discharge capacity of the plant is 53,400 cfs (Arkansas Electric Cooperative Corporation n.d.).

2.2.2.6 Aquaculture

Warm water aquaculture in the US originated in the EAWRPR. The first commercial fish farms began production here in the 1940s, raising goldfish (Engle 2012). In the mid 1940s, fish farms began producing baitfish. In 1952, there were 536 acres of fish farms in the EAWRPR (Stone, Dorman and Thomforde 2010). In the late 1950s catfish production began in the EAWRPR. Trout and tropical fish (i.e., goldfish) production were reported in the 1978 census of agriculture, when there were 24,996 acres of fish farms in Arkansas, primarily in the EAWRPR (US Department of Commerce Bureau of the Census 1977).

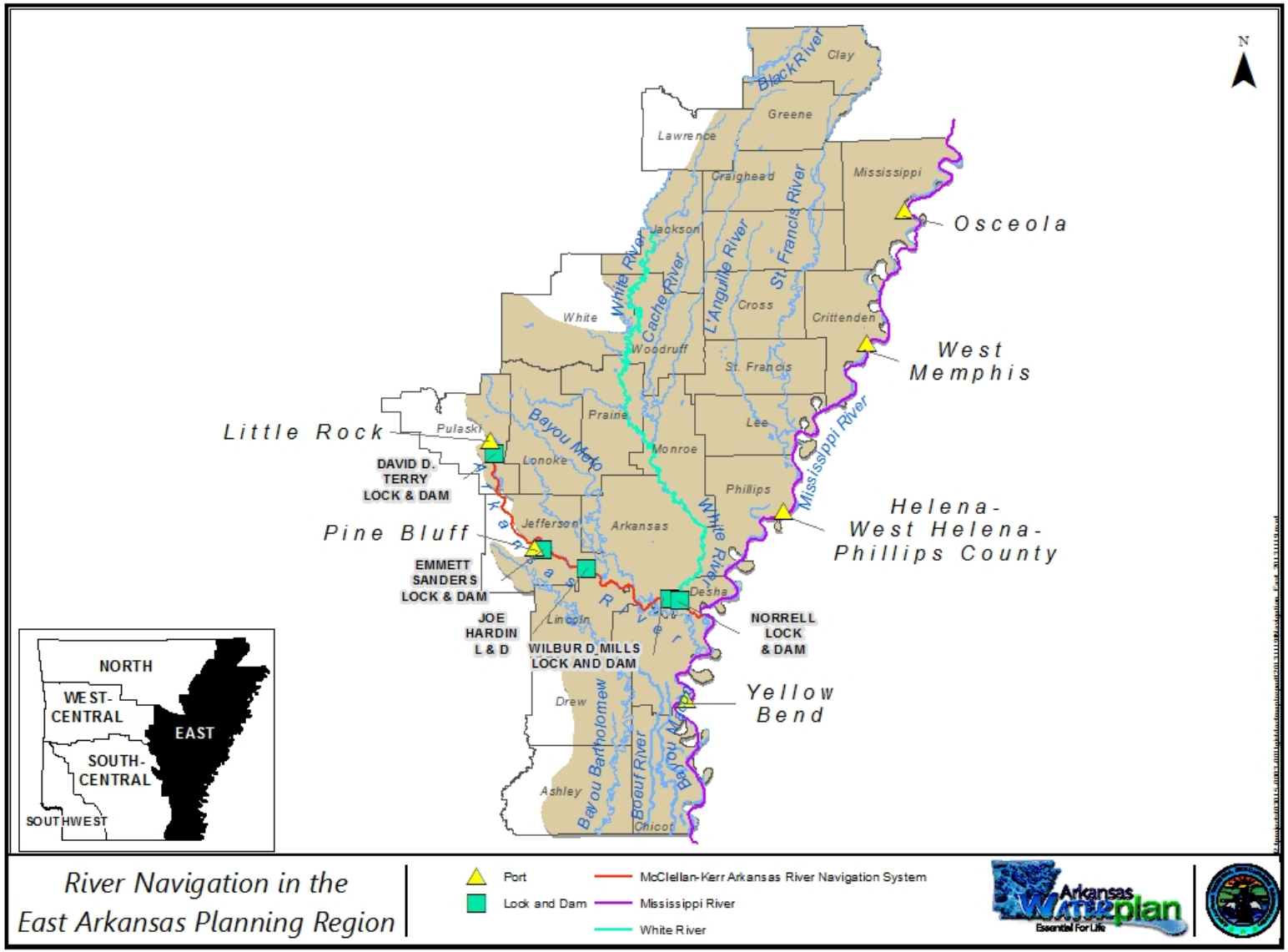

Figure 2.2. Navigation systems in the EAWRPR for water borne commodity transport.

In 2005, there were 61,135 acres of fish farms in Arkansas, with the majority in the EAWRPR. Groundwater is the primary source of water used for aquaculture ponds (USDA National Agricultural Statistical Service 2006). In 2005, 241 million gallons of groundwater and 10 million gallons of surface water were used for aquaculture (US Geological Survey 2005). Best management practices for aquaculture are focused on reducing water use and minimizing discharges from ponds (Stone, Dorman and Thomforde 2010).

2.2.2.7 Pearl Industry

Freshwater pearls found in both the White River and Black River set off a "pearl rush" in northeast Arkansas in the late 1880s (Shoults 2011). A pearl button factory was established in northeast Arkansas around 1900 to take advantage of the large freshwater mussel populations in the White River and Black River. This was a thriving industry in the area until the late 1940s (Cavaneau 2012).

2.2.2.8 Waterfowl and Aquatic Habitat Conservation

Even while large tracts of land in the EAWRPR were being cleared and drained, individuals and federal and state agencies realized the importance of the wetlands and forests in this region for support of wildlife, especially migrating waterfowl. Just after the turn of the Twentieth Century, preservation of migratory waterfowl game birds became a national priority. At this time, eastern Arkansas was already a popular hunting destination, and the region was dotted with hunting clubs where members hunted waterfowl, primarily ducks, and/or deer. The quality of the waterfowl habitat in this region was well known regionally and nationally. The enthusiasts that hunted in eastern Arkansas also recognized the threat this prime habitat faced due to the agricultural development taking place in the region. The first wildlife refuges in Arkansas were designated in this region in the early Twentieth Century by the federal government (Table 2.4) (Morrow n.d.). The Arkansas Game and Fish Commission (AGFC) began establishing wildlife management areas in the region after World War II, the majority in the 1950s. Many of these management areas were originally hunting clubs. National wildlife refuges and state wildlife management areas continued to be established in the EAWRPR throughout the Twentieth Century (Table 2.4).

Table 2.4. History of refuges and management areas for waterfowl and wet habitats in the EAWRPR (USFWS 2013a).

Name	Type[a]	Area (acres)	Counties	Year Established	Management[b]	Purpose	Other Info
Big Lake	NWR	11,038	Mississippi	1915	USFWS	Habitat	2013 National Blueway, one of the largest bottomland forests in Mississippi River valley
White River	NWR	95 million	Arkansas, Monroe, Phillips, Desha	1935	USFWS		
Bayou Meto	WMA	33,832	Arkansas, Jefferson	1948	AGFC	Waterfowl habitat and hunting, fishing	
Big Lake	WMA	12,320	Mississippi	1950	AGFC	Habitat	
Dr. Lester Sitzes III Bois D'Arc	WMA	13,626	Hempstead	1950s	AGFC	Waterfowl habitat and hunting	
Shirley Bay Rainey Brake	WMA	10,711	Lawrence	1950s	AGFC	Waterfowl hunting, fishing, habitat	
Sheffield Nelson Dagmar	WMA	7,976	Monroe	1952	AGFC	Waterfowl refuge	
Seven Devils	WMA	512	Drew	1954	AGFC	Fishing, waterfowl habitat and hunting	
St. Francis River Sunken Lands	WMA	26,000	Craighead, Greene, Poinsette	1955	AGFC	Waterfowl hunting, habitat	
Dave Donaldson Black River	WMA	25,000	Clay, Greene, Randolph	1957	AGFC	Waterfowl hunting, bottomland habitat	
Earl Buss Bayou Deview	WMA	4,254	Poinsett	1958	AGFC	Waterfowl habitat, fishing	
Wapanocca	NWR	5,486	Crittenden	1961	USFWS	Habitat	
Rex Hancock Black Swamp	WMA	6,394	Woodruff	1971	AGFC	Waterfowl hunting, fishing, habitat	
Trusten Holder	WMA	4,406	Arkansas, Desha	1973	AGFC, USFWS, USACE	Habitat	
Singer Forest	Natural Area	519	Poinsett	1973	ANHC, AGFC	Habitat	
Smoke Hole	Natural Area	455	Lonoke, Prairie	1976	ANHC	Habitat	
Chalk Bluff	Natural Area	54.9	Clay	1977	ANHC	Habitat	
Louisiana Purchase	Natural Area	35	Lee, Monroe, Phillips	1977	ANHC, Arkansas State Parks	Habitat, history	
Holloway Memorial	Natural Area	75	Prairie	1978	ANHC	Habitat	
Konecny Grove	Natural Area	22	Prairie	1979	ANHC	Habitat	
Striplin Woods	Natural Area	30	Arkansas	1979	ANHC, USFWS	Habitat	Part of White River NWR
Overflow	NWR	13,000	Ashley	1980	USFWS	Habitat	

Table 2.4. History of refuges and management areas for waterfowl and wet habitats in the EAWRPR (USFWS 2013a) (continued).

Name	Type[a]	Area (acres)	Counties	Year Established	Management[b]	Purpose	Other Info
Wittsburg	Natural Area	168	Cross	1980	ANHC	Habitat	
Cache River	Natural Area	937	Woodruff	1983	ANHC, AGFC	Habitat	Part of Rex Hancock Black Swamp WMA
Holland Bottoms	WMA	5,558	Lonoke	1985	ANHC, AGFC	Habitat, fishing, waterfowl hunting	
Cache River	NWR	56,000	Jackson, Woodruff, Monroe, Prairie	1986	USFWS	Habitat	Ramsar Wetlands of International Importance
Holland Bottoms	Natural Area	632	Lonoke	1986	ANHC, AGFC	Habitat	Part of Holland Bottoms WMA
Cypress Bayou	WMA	1503	Lonoke, White	1989	AGFC	Waterfowl habitat, fishing	
Little Bayou	WMA		Ashley	1991	AGFC	Habitat, fishing	
Big Creek	WMA	240	Lee	1992	AGFC	Habitat, fishing	
Benson Creek	WMA	610	Monroe	1993	ANHC	Habitat	
Benson Creek	Natural Area	1,459	Monroe, Woodruff	1993	ANHC, The Nature Conservancy	Habitat	
Stateline Sand Ponds	Natural Area	140	Clay	1994	ANHC	Habitat for endangered Pondberry	
Departee Creek	WMA	448	White	1998	AGFC	Habitat	
Swifton Sand Ponds	Natural Area	60	Jackson	2008	ANHC	Habitat for endangered Pondberry	
St. Francis Sunken Lands	Natural Area	80	Poinsett	2009	ANHC	Habitat for endangered Pondberry	
Cattail Marsh	WMA	78	Greene		AGFC	Waterfowl habitat, fishing, hunting	
Ethel	WMA	176	Arkansas		AGFC	Habitat, hunting	
Ring Slough	WMA	86	Clay		AGFC	Waterfowl habitat and hunting, fishing	
White Hall	WMA	111	Poinsett		AGFC	Waterfowl habitat and hunting, fishing	
Brushy Creek	WMA	220	Cross		AGFC	Habitat	
Lee County	WMA	221	Lee		AGFC	Habitat	
Cut-off Creek	WMA	8,728	Drew		AGFC	Waterfowl habitat and hunting	

a NWR = National Wildlife Refuge, WMA = Wildlife Management Area

b AGFC = Arkansas Game and Fish Commission, ANHC = Arkansas Natural Heritage Commission, US FWS = US Fish and Wildlife Service

Some areas of the EAWRPR have long supported the combination of agriculture and waterfowl habitat. The town of Stuttgart, in Arkansas County, brands itself the "Rice and Duck Capital of the World," and held its first Wings Over the Prairie duck hunting festival in 1936 (Shrum 2012). Today, support of migratory waterfowl has widespread support from the agricultural community in the EAWRPR and nationally. A number of recent Farm Bill programs encourage conservation and enhancement of waterfowl habitat in the region with economic incentives for activities such as setting up wetland conservation easements, and flooding fields in the winter (NRCS 2013a).

2.2.2.9 Commercial Fishing

Commercial fishing was an important activity during early settlement and development in the EAWRPR (Lochmann 2013). By the 1800s, commercial fishing was widespread on the White River. Fish from the White River were shipped by railroad throughout the US (Arkansas Department of Parks and Tourism 2005a). In the 1890s, the Iron Mountain Railway transported commercial game and fish out of the region in refrigerated railcars. In the early Twentieth Century, hundreds of families in the planning region made their living from commercial fishing (Morrow n.d.).

Construction of dams on the White River in the middle of the Twentieth Century changed the fish populations, resulting in a decline in commercial fishing on that river (Arkansas Department of Parks and Tourism 2005a). Despite this, over the period from 1975 through 1985, the amount of fish taken commercially from the White River and Arkansas River approximately doubled (Robison and Buchanan 1988). In the present, commercial fishing is greatly reduced. Regulations prevent the sale of most wild caught game fish in the state. One exception is paddlefish, which are commercially fished for their eggs for caviar (Lochmann 2013). Other fish that may still be caught in the wild and sold include buffalo, catfish, carp, drum, gar, suckers, and shovelnose sturgeon (AGFC 2013a).

2.2.2.10 Red River Compact

In 1955, the US Congress authorized Texas, Oklahoma, Arkansas, and Louisiana to begin negotiating a compact to resolve disputes over rights to water in the Red River and its tributaries, as well as preventing future disputes. In 1978, after 23 years of negotiations, representatives of Texas, Oklahoma, Arkansas, and Louisiana signed the Red River Compact (Lancaster 2011). The purpose of the compact is to provide for equitable apportionment of the waters of the Red River and its tributaries among the four states to ensure conservation and protection of this shared resource.

3.0 PHYSICAL CHARACTERISTICS

This section summarizes the physical and biological characteristics of the EAWRPR. 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 north and the Gulf Coastal Plain in the south and east. These regions are further subdivided into smaller physiographic provinces based on topography and geology. The "fall line" is where these two physiographic regions meet.

The EAWRPR is located primarily in the Gulf Coastal Plain physiographic region, with small areas of the Interior Highlands included along the northwestern boundary of the planning region. Physiographic provinces of the Gulf Coastal Plain that occur in the planning region include the Mississippi Alluvial Plain, including Grand Prairie and Crowley's Ridge, and a small part of the western edge of the southeastern West Gulf Coastal Plain (Figure 3.1) (Arkansas Geological Survey n.d.).

The physiographic province of the Interior Highlands that occurs in the planning region is the Ouachita Mountain physiographic province. This province includes part of the western edge of the planning region (Figure 3.1) (Arkansas Geological Survey n.d., Woods, et al. 2004). As it comprises such a small part of the planning region, the physiography of the Ouachita Mountain province will not be described in this document. Descriptions of this physiographic province can be found in the background reports for other planning regions.

The Mississippi Alluvial Plain accounts for the largest portion of the planning region. This physiographic region is characterized as having primarily flat to irregular terrain with a uniform slope. The West Gulf Coastal Plain has similar physiography, characterized as a south sloping plain with gently rolling hills and broad, level to nearly level stream valleys (Arkansas Geological Survey 2012, NRCS n.d.). The principal topographic features in the planning region include abandoned stream channels, natural levees, and backswamp areas. Elevations in the flatlands range from the 90 to 320 feet above sea level, decreasing southward.

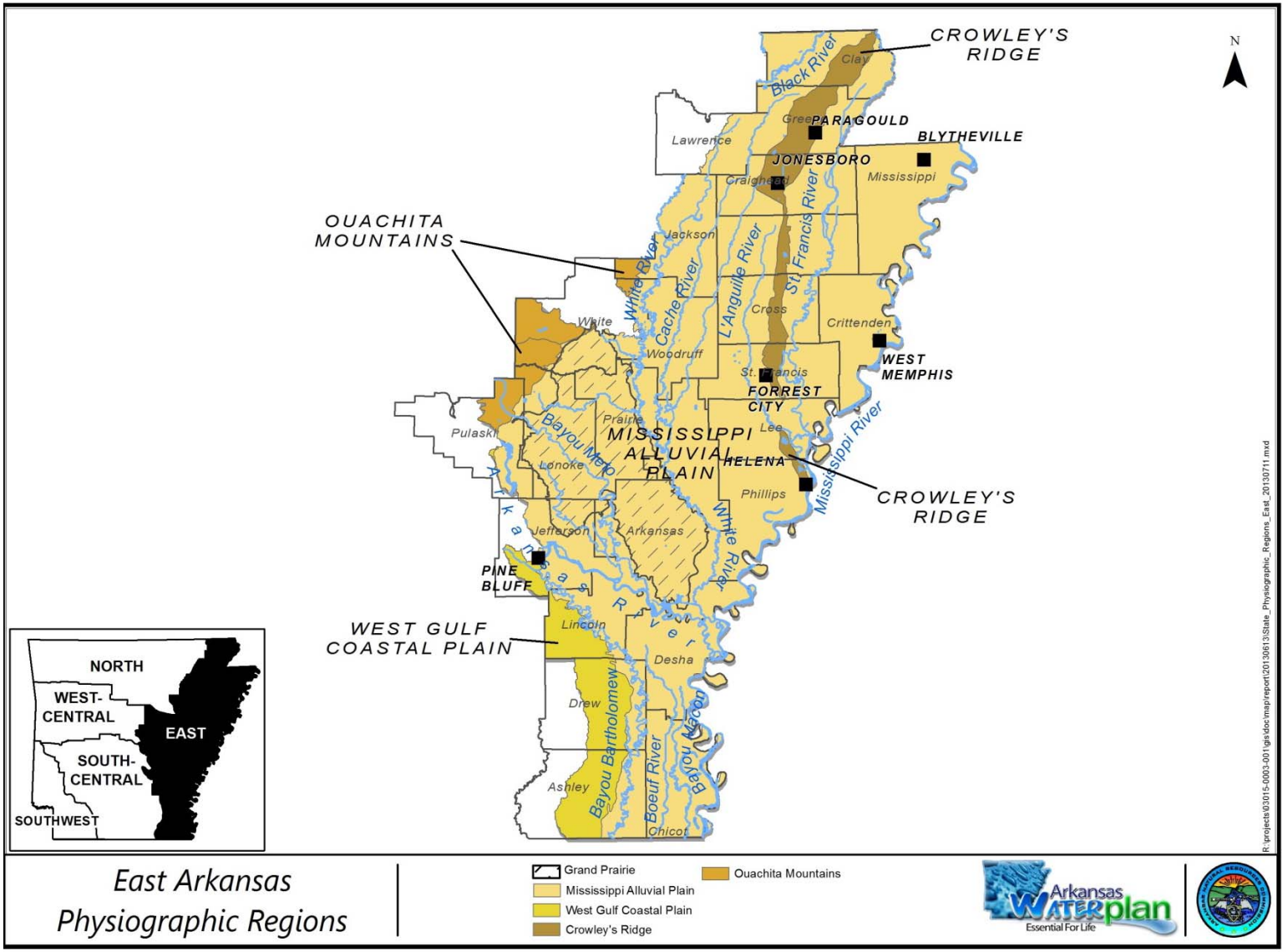

Figure 3.1. Physiographic regions within the EAWRPR (C. Kelley, ANRC, personal communication, April 25, 2013).

3.2 Geologic Setting

Geologic formations underlying the EAWRPR range in stratigraphic order from the earliest deposited layers of the Cretaceous Period to Quaternary Alluvium and Loess. Figure 3.2 displays the surface geology of the planning region.

The Mississippi Alluvial Plain province is characterized by largely unconsolidated formations. Geologic formations comprising the Mississippi Alluvial Plain in Arkansas are contained within the Mississippi Embayment which is a low lying basin that is filled with Cretaceous age to recent sediments. The Mississippi Embayment is a geosyncline (trough) formed from downwarping and rifting related to the Ouachita orogeny. This activity resulted in a deep catch basin for sediment deposition. The axis of this syncline plunges southward, with the axis roughly parallel to the Mississippi River (Clark, Hart and Gurdak 2011). The Mississippi Alluvial Plain is a predominantly Quaternary outcrop belt of the Mississippi Embayment (Manger, Zachry and Garrigan 1988). The Cretaceous-age deposits represent shallow, marginal, and usually restricted marine environments. The Tertiary-age sediments represent marginal marine and alluvial deposits. The Quaternary-age alluvial deposits consist of alternating layers of water-washed gravel, sands, silts, and clays (McFarland 2004, Clark, Hart and Gurdak 2011). For a complete description of the geologic formations in the planning region, refer to McFarland (2004).

The formation of the Mississippi Alluvial Plain is related to the structural geology and the erosional history of the area. The boundary between unconsolidated sediments of the Mississippi River Alluvial Plain and sedimentary rocks of the Interior Highlands (also known as the “fall line”) is formed by faults. These faults have allowed for the older sedimentary rocks underlying the Mississippi River Alluvial Plain to subside over time and for thick sequences of unconsolidated sediments to be deposited on top (Adamski, et al. 1995). Cycles of rising and falling sea levels from the Cretaceous through the Tertiary periods resulted in older deposits cropping out on the periphery of the embayment, which is a diagnostic feature of synclinal structures (Clark, Hart and Gurdak 2011). Subsequent erosion by the Mississippi River and its tributaries has formed occasional bluffs and ridges in the area (Adamski, et al. 1995).

A surface geology feature of the planning region that has received much attention is the north-south, linear ridge known as Crowley's Ridge. This erosional remnant of the ancestral Mississippi and Ohio Rivers is generally capped by Quaternary-age loess (wind-blown dust), with minor exposures of Tertiary-age deposits along the margins (McFarland 2004). For a comprehensive review of the geography, regional geologic framework, and stratigraphy of the Lower Mississippi Valley, refer to Saucier (1994).

Small areas of the Ouachita Mountain geological province are located in White, Lonoke, and Pulaski Counties in the EAWRPR. Due to limited occurrence of this geologic province in this planning region, it is not described in this report. Descriptions of the Ouachita Mountain geological province are provided in the background reports for the other planning regions.

Industrial minerals available in the EAWRPR include clay, sand, and gravel (Mayfield 2001, USGS 2012).

The hydrogeology of the Mississippi Aluvial Plain in the planning region can be described as layers of unconsolidated silt, sand, and gravel which function as aquifers, yielding large quantities of water to wells. These aquifers are separated by clays which store greater volumes of water but have relatively low hydraulic conductivity, and therefore do not yield adequate volumes of water to wells. The tertiary formations of Crowley's Ridge act as a barrier to flow in shallow aquifers from the east of the ridge to the west. Ground water resources of the planning region are discussed in detail in Section 3.8.

Much of the surface geology of the planning region consists of Pleistocene alluvial terrace deposits (Figure 3.2). Generally, these deposits consist of fine clays with low hydraulic conductivity near the surface, with water-bearing sands and gravels underneath. This geology has contributed to some of the groundwater quantity issues in the planning region, particularly in the Grand Prairie area (USACE Vicksburg District 1984). This is discussed in greater detail in sections 3.8, 3.9, and 5.4.1.

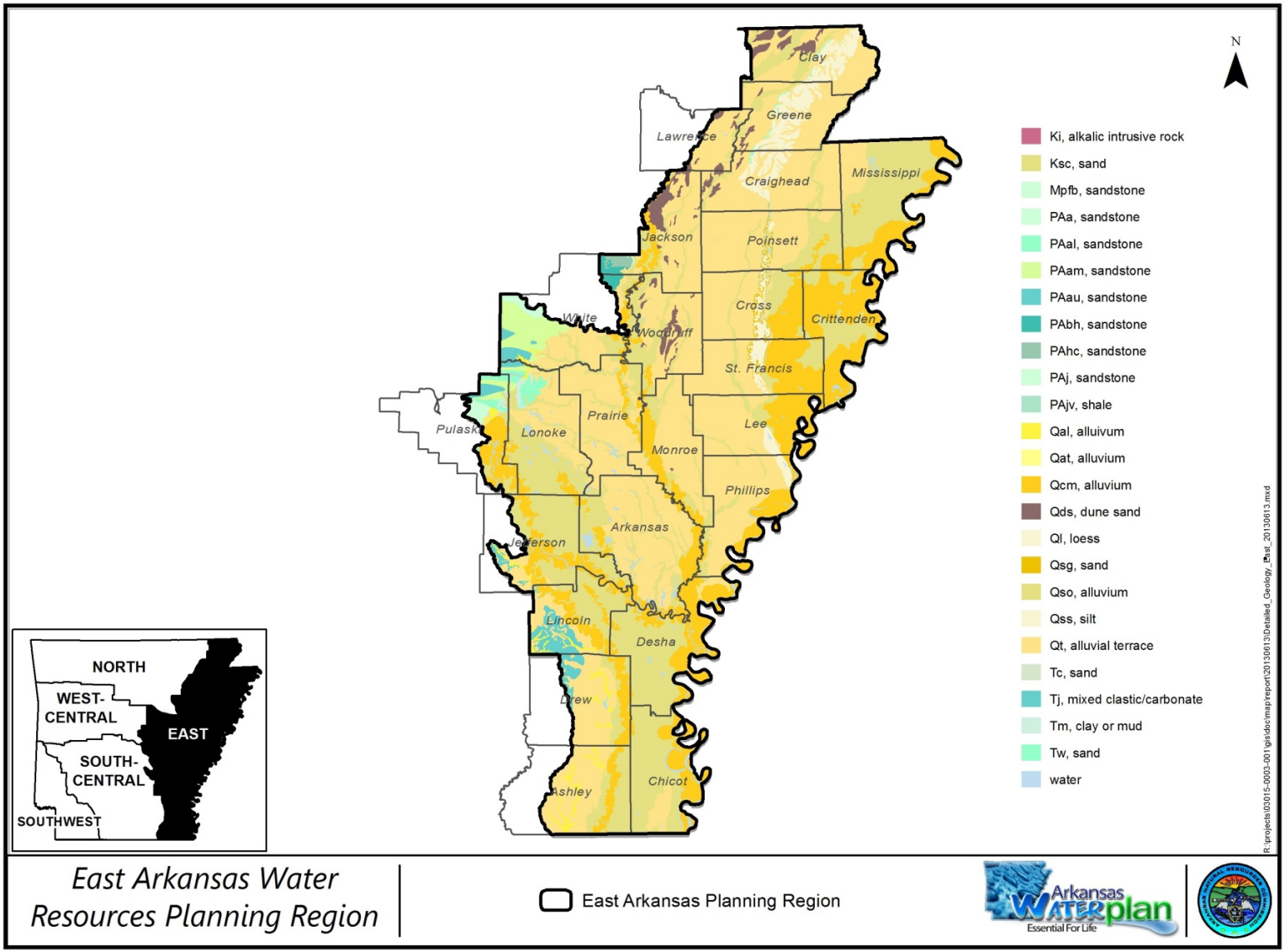

Figure 3.2. Surface geology of the EAWRPR (Haley et al. 1993).

3.3 Ecoregions

Ecoregions are areas within which ecosystems and the type, quality, and quantity of environmental resources are generally similar (EPA 2013a). The US Environmental Protection Agency (EPA) has defined 15 ecoregions within the EAWRPR (Figure 3.3). Ten of these ecoregions occur in the Mississippi Alluvial Plain. Two of the ecoregions are in the West Gulf Coastal Plain. Characteristics of all of the ecoregions in the EAWRPR are summarized in Table 3.1.

The natural vegetation of the Mississippi Alluvial Plain is southern floodplain forest, except in the Grand Prairie. In this ecoregion, aquatic and semi-aquatic freshwater habitats such as oxbow lakes, streams, and wetlands, are common. The majority of the wetlands in Arkansas are in this ecoregion. Streams in the Mississippi Alluvial Plain have very low gradients and fine-grained substrates. Streams and rivers within the meander belt ecoregions have the lowest gradients, with the greatest amount of meandering channels. Fish communities are generally characterized by few or no sensitive species. However, one of the most species-rich streams on the continent is located in the Mississippi alluvial plain (Woods, et al. 2004, Foti 2008, Stroud 2012).

The natural vegetation in the Mississippi Valley Loess Plains in the EAWRPR includes oak-hickory forest mixed with areas of beech-maple forest similar to those present in the Appalachian Mountains. This is the only region in the state where tulip poplar occurs naturally. Pines occur in sandier soils at the northern part of the ridge plain (Woods, et al. 2004, Foti 2008, Stroud 2011).Only headwater streams occur in this ecoregion, being shallow and having steep gradients. Streams in this ecoregion have finer-grained substrates. Fish communities present in these streams are dominated by headwater species (Fulmer and Harp 1977).

Because they comprise such small areas within the EAWRPR, the ecoregions of the Arkansas Valley, Ouachita Mountains, and South Central plains are not described in further detail here. Additional information about these ecoregions can be found in Woods et al. (2004) and in the West-central Arkansas Water Resources Planning Region and South-central Arkansas Water Resources Planning Region reports.

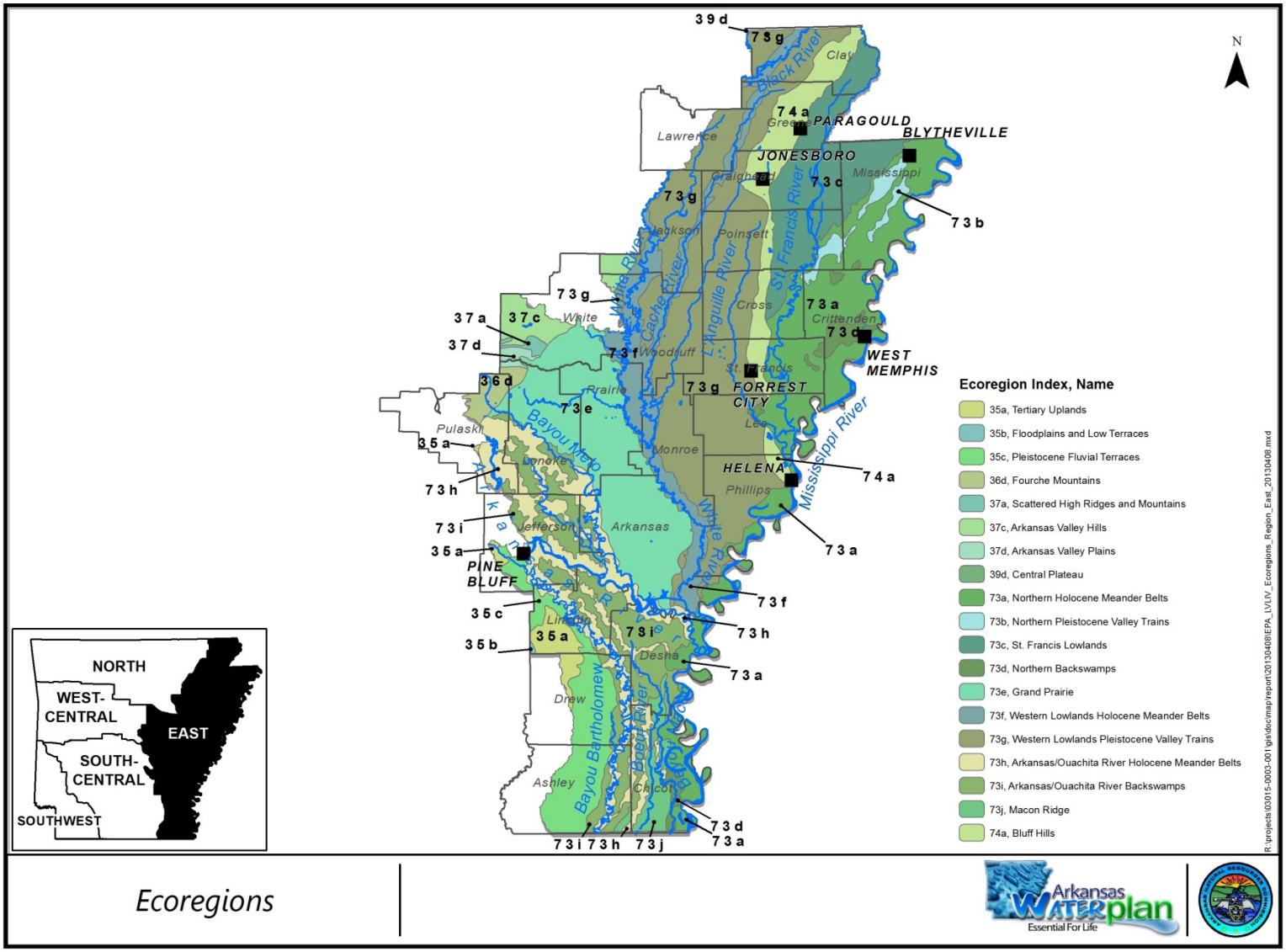

Figure 3.3. Ecoregions of the EAWRPR (Woods, et al. 2004)

Table 3.1. Ecoregions in the EAWRPR (Woods, et al. 2004).

Level III Ecoregion	Level IV Ecoregion	Native Vegetation	Hydrology
Arkansas Valley	Arkansas Valley Hills	Oak-hickory forest and oak-hickory-pine	Low gradient streams
Ouachita Mountains	Fourche Mountains	Oak-hickory-pine forest	High gradient streams
South-Central Plains	Tertiary Uplands	Oak-hickory-pine forest, mixed shortleaf pine-loblolly pine forest, upland deciduous forest, bottomland forest along rivers	Low gradient streams
South-Central Plains	Pleistocene Fluvial Terraces	Pine flatwoods of loblolly pine and oak, hardwood wetlands, pine savannah, prairie	Low gradient streams
Mississippi Alluvial Plain	Northern Holocene Meander Belts	Bottomland hardwood forest with species tolerant of wet and frequent flooding, e.g., willow, sycamore, cottonwood, water oak	Former Mississippi River channels, oxbow lakes common, low gradient streams
Mississippi Alluvial Plain	Northern Pleistocene Valley Trains	Bottomland hardwood forest with oak species typical of higher bottomlands, e.g., Nuttall oak	Low gradient streams
Mississippi Alluvial Plain	St. Francis Lowlands	Bottomland hardwood forest, cypress and tupelo in wettest areas, grassland on sandy terraces	Low gradient streams
Mississippi Alluvial Plain	Northern Backswamps	Bottomland hardwood forest, woodland, forested canebrake	Poorly drained flats & swales, marshes, swamps, oxbow lakes, low gradient streams
Mississippi Alluvial Plain	Grand Prairie	Tall grass prairie, oak-hickory open woodland and savannah	Low gradient streams
Mississippi Alluvial Plain	Western Lowlands Holocene Meander Belts	Bottomland hardwood forest and woodland of primarily oaks	Runoff from Ozark Highlands and Boston Mountains feeds most streams, former and current river channels of White, Black, Cache Rivers, low gradient streams
Mississippi Alluvial Plain	Western Lowlands Holocene Valley Trains	Bottomland hardwood forest, some loblolly pine, oak forest on ancient dunes, bottomland oak-hickory and pondberry in dune depressions and sand ponds	Ancient sand dunes with ponds in depressions between dunes, i.e., sandponds; low gradient streams
Mississippi Alluvial Plain	Arkansas/Ouachita River Holocene Meander Belts	Bottomland hardwood forest and woodland, palmetto and Spanish moss occur	Former river channels of Arkansas and Ouachita Rivers, existing Arkansas River channel, oxbow lakes common, low gradient streams, streams in abandoned channels, e.g., Bayou Bartholomew, Bayou Meto, Plum Bayou

Table 3.1. Ecoregions in the EAWRPR (continued).

Level III Ecoregion	Level IV Ecoregion	Native Vegetation	Hydrology
Mississippi Alluvial Plain	Arkansas/Ouachita River Backswamps	Bottomland hardwood forest, woodland, forested canebrake	Slackwater areas along Arkansas River, marshes, swamps, oxbow lakes, ponds, sloughs
Mississippi Alluvial Plain	Macon Ridge	Bottomland hardwood forest, upland hardwood forest, tall grass prairie, loblolly pine	Low gradient streams
Mississippi Valley Loess Plains	Bluff Hills	Oak-hickory forest mixed with areas of beech-maple forest similar to those present in the Appalachian Mountains, including tulip poplar.	Headwater streams are shallow with steep gradients and fine substrates

3.4 Aquatic Biodiversity

While it is true that much of the aquatic and wetland habitat in the EAWRPR has been significantly modified in the past, there is still considerable aquatic biodiversity in this planning region. Bayou Bartholomew is home to a diverse fish community, which ranks third in North America in terms of the number of fish species present. Habitats in this planning region support 107 of the 268 Arkansas species of greatest conservation need (Anderson 2006, ANHC 2013). Figure 3.4 provides a summary of the aquatic and semi-aquatic species of greatest conservation need found in the planning region. Of the over 180 aquatic and semi-aquatic plant species tracked by the Arkansas Natural Heritage Commission, over 70 occur in the EAWRPR (ANHC 2013). One of 14 Arkansas endemic (not found anywhere else in the world) insects, and the single Arkansas endemic plant are found in this planning region (Anderson 2006). Approximately 140 miles of streams in the planning region have been designated by ADEQ as Ecologically Sensitive Waterbodies because they provide habitat for endemic, threatened, or endangered species (Figure 3.5) (APCEC 2011). Additional information on threatened and endangered species in the planning region is provided in Section 5.3.7.

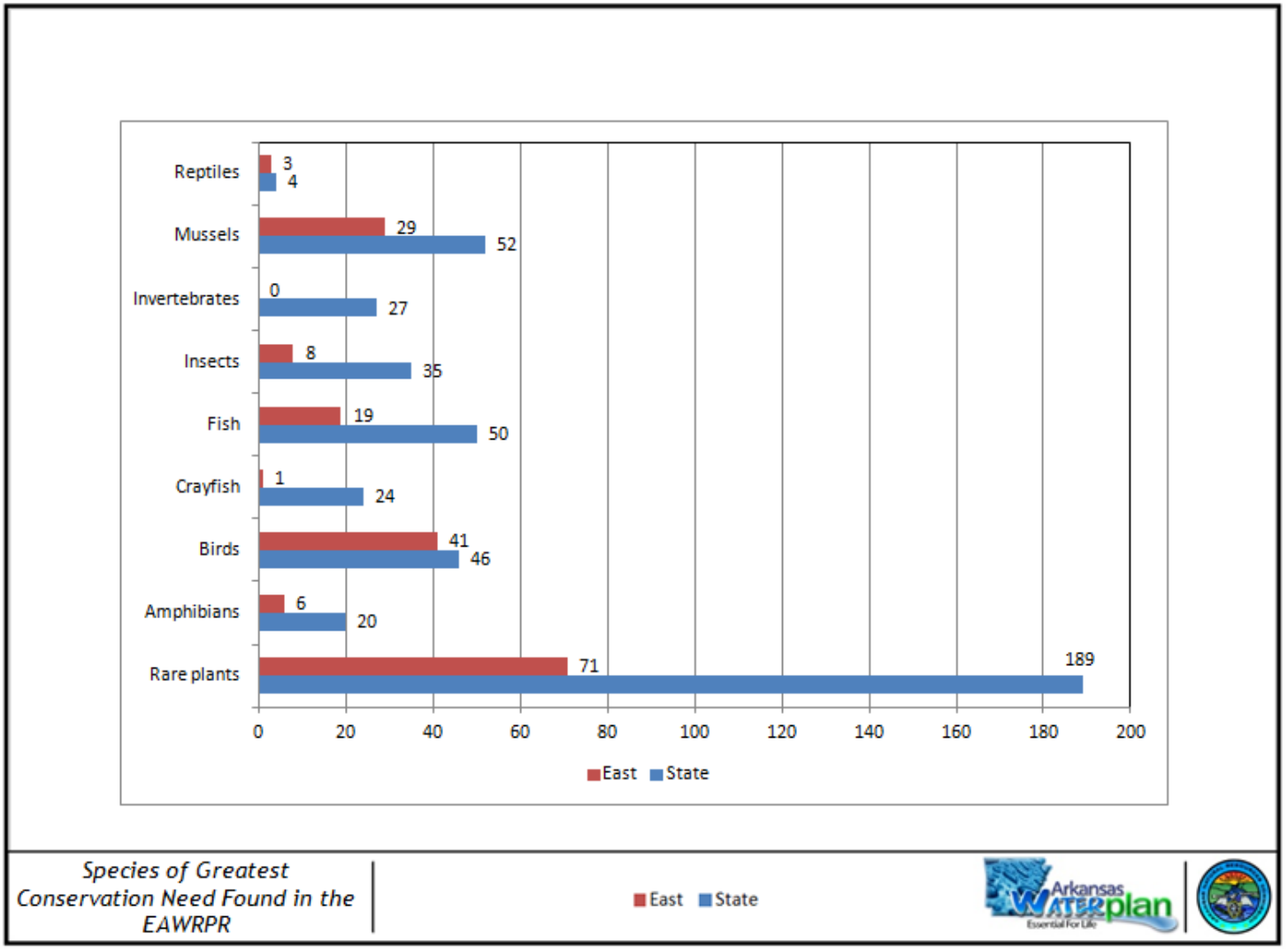

Figure 3.4. Species of greatest conservation need found in the EAWRPR (Anderson 2006, ANHC 2013).

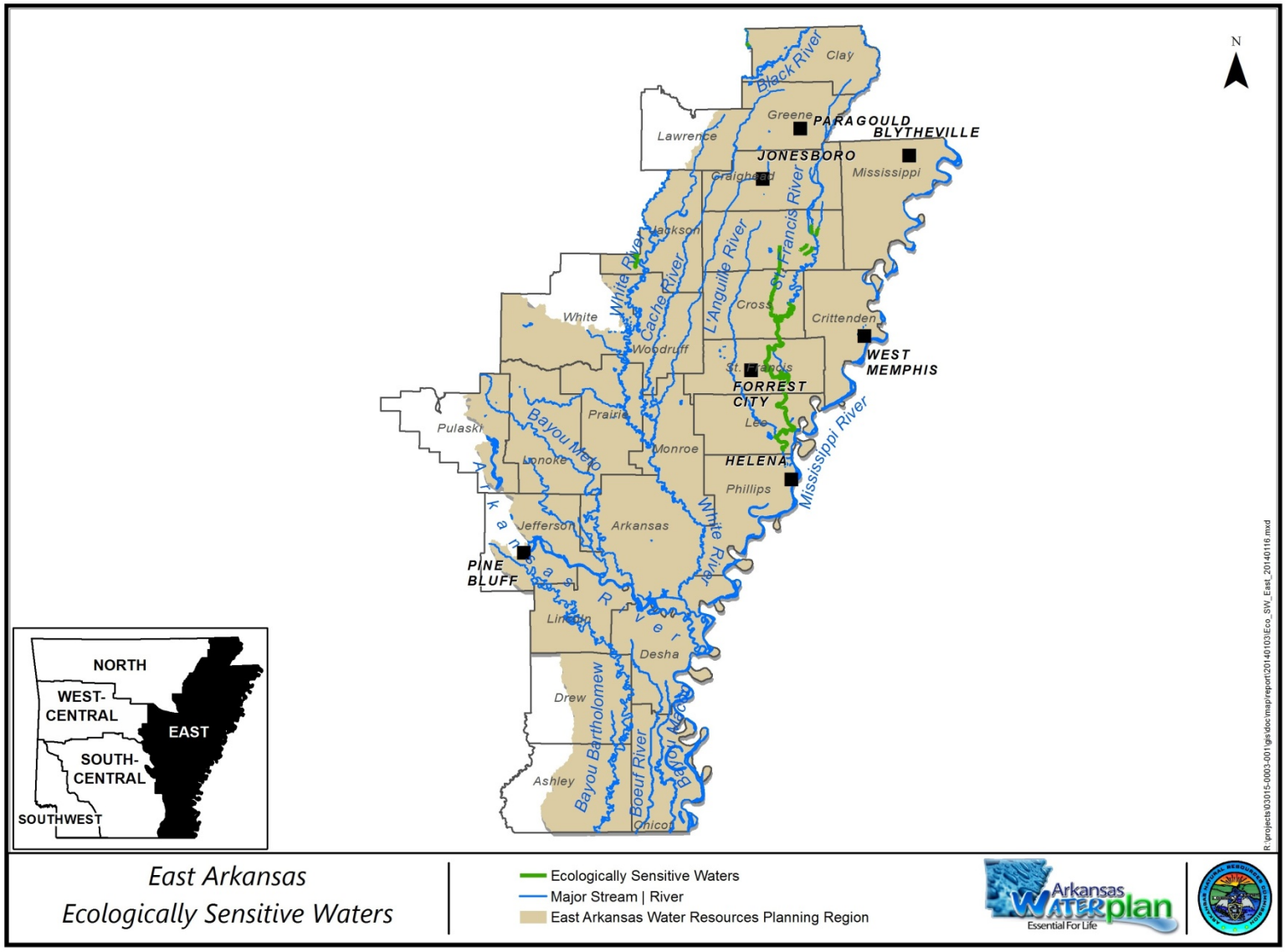

Figure 3.5. Ecologically sensitive waterbodies in the EAWRPR (APCEC 2011).

The water resources of the EAWRPR are important waterfowl habitat, 41 of the 46 aquatic bird species of greatest conservation need occur here (Figure 3.4). The planning region is located in the Mississippi River bird migration corridor, thus the wetlands and waterways in this region are internationally important as habitat for migrating and wintering waterfowl and shorebirds. In 1989, 145,690 hectares of wetlands within the watersheds of the Cache River and White River within the EAWRPR were designated as Wetlands of International Importance because of their importance for the support of wintering waterfowl and shorebirds (Ramsar Convention 2013). The designated area includes the White River National Wildlife Refuge and four state preserves containing wetland habitat.

Between 3,000 and 10,000 Canada geese, and up to 30,000 ducks, winter over in the White River National Wildlife Refuge each year. This is approximately one-tenth of the birds that use the Mississippi River migration corridor annually (Stroud 2012). Other bird species that migrate through the region include plovers, sandpipers, gulls, terns, pelicans, and cormorants. Over a dozen duck species winter in Arkansas, as well as geese, loon, cormorant, and gull species. This region hosts one of the world's largest wintering populations of mallard ducks every year, and is considered the most important wintering area for these birds in North America (White 2010, 2011).

3.5 Climate

The climate of the EAWRPR is humid sub-tropical and is characterized by long summer and relatively short winters. Temperature, precipitation, and evaporation data for the planning region were obtained from the National Weather Service, National Oceanic and Atmospheric Administration National Climatic Data Center (NOAA NCDC), and the PRISM Climate Group and reviewed. These data are available for each of the climate divisions in Arkansas (Figure 3.6). Data for climate divisions 3, 6, and 9 were used to characterize climate in the EAWRPR. Summaries of these data are presented below, along with discussions of factors that influence climate in the EAWRPR and long-term climate trends in the region.

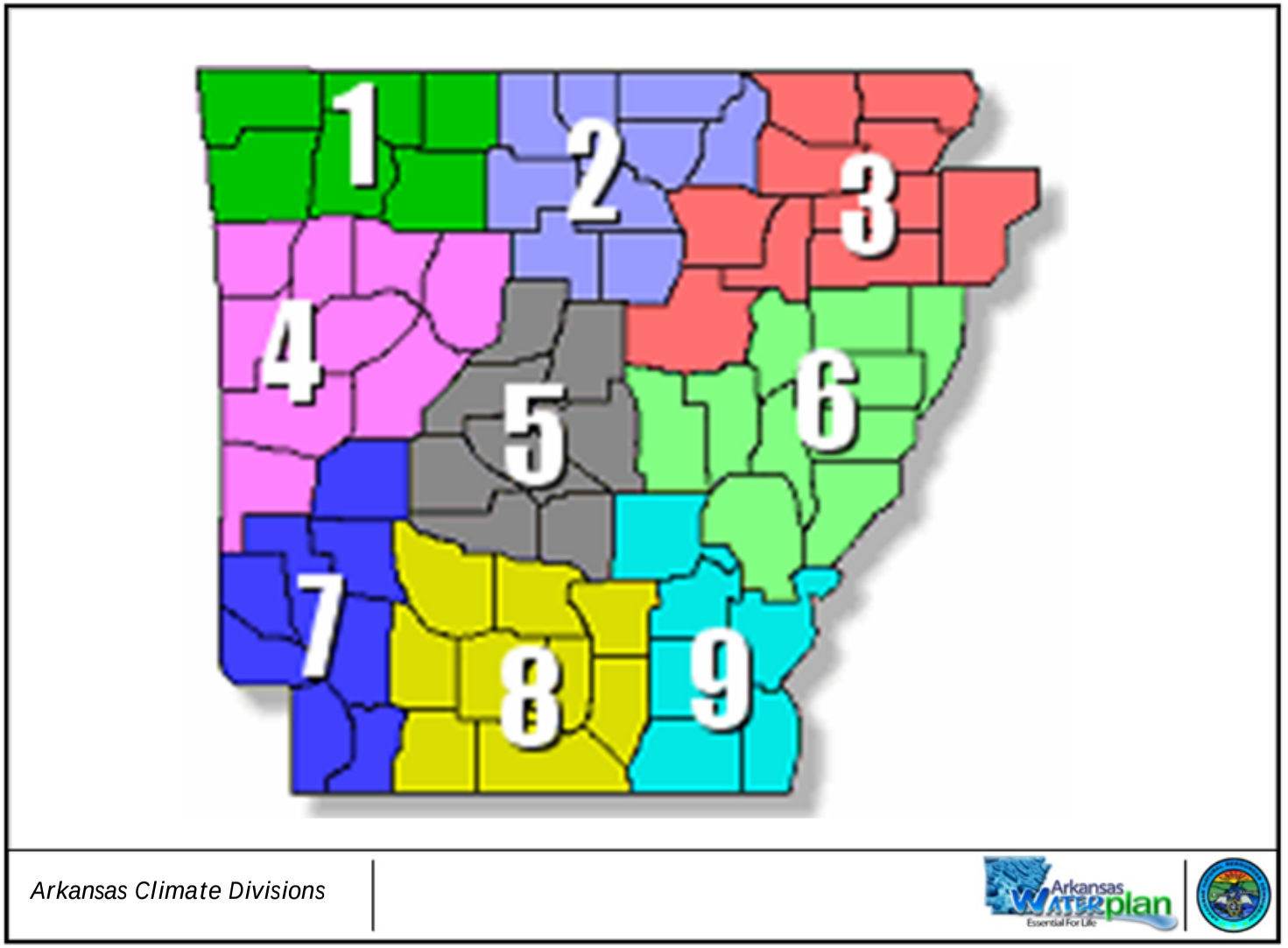

Figure 3.6. Arkansas climate divisions
(National Weather Service Weather Forecast Office Little Rock AR 2013)

3.5.1 Temperature

The average annual temperature in the EAWRPR is approximately 60 degrees Fahrenheit (ASWCC 1988). Normal daytime maximum temperatures range from 91 degrees Fahrenheit in July and August to 49 degrees Fahrenheit in January (Figure 3.7). Normal minimum nighttime air temperatures range from 69 degrees Fahrenheit in July to 26 degrees Fahrenheit in January. The average difference between the monthly normal minimum and maximum air temperatures is 24 degrees Fahrenheit (Woods, et al. 2004). Variations in annual maximum daily temperatures across the planning region are shown in Figure 3.8. Temperatures increase slightly from north to south. The growing season (frost free days) in the planning region ranges from 200 to 220 days in the north to 220 to 240 days in the south (Woods, et al. 2004).

3.5.1 Precipitation

The average annual precipitation (1981 – 2010) in the EAWRPR ranges from 45 inches to 56 inches. Annual precipitation increases from north to south (Figure 3.9) (Anderson 2006, Scott, et al. 1998). Average monthly precipitation for the EAWRPR for the period from 1981 through 2010 is shown in Figure 3.10. The months in late spring and late fall to early winter are generally the wettest. Precipitation is lowest during the summer growing season.

Summer precipitation primarily occurs during rainstorms, where locally high rainfall amounts can occur over a short period of time. During the fall, winter, and early spring, precipitation events are usually less intense and of longer duration. The majority of the precipitation in the EAWRPR falls as rain; snow rarely occurs here (NOAA NCDC n.d., Buckner 2011).

3.5.2 Evaporation

Evaporation is the process by which water changes from liquid in soil 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).

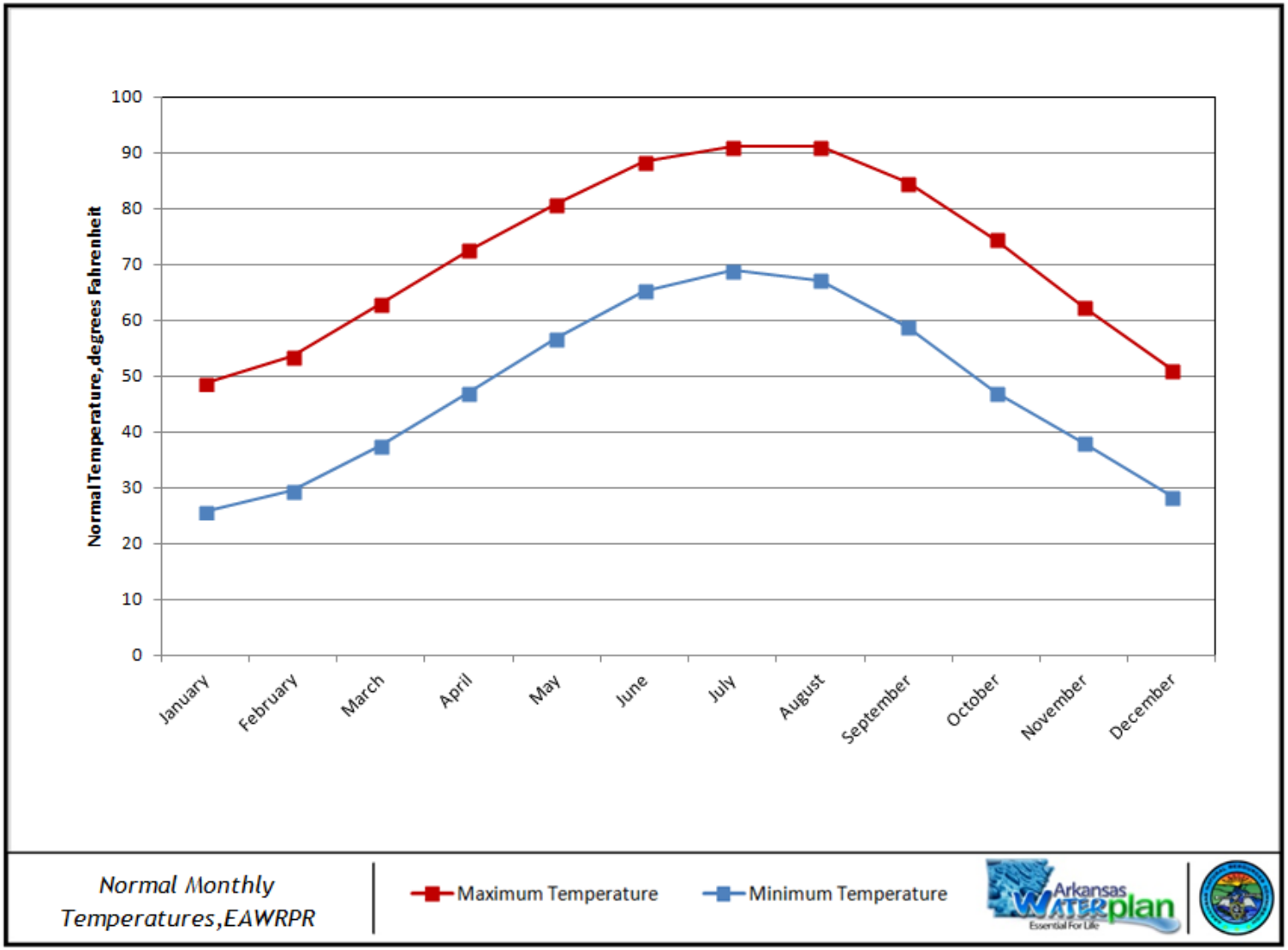

Figure 3.7. Normal monthly temperatures for the EAWRPR (PRISM Climate Group 2004).

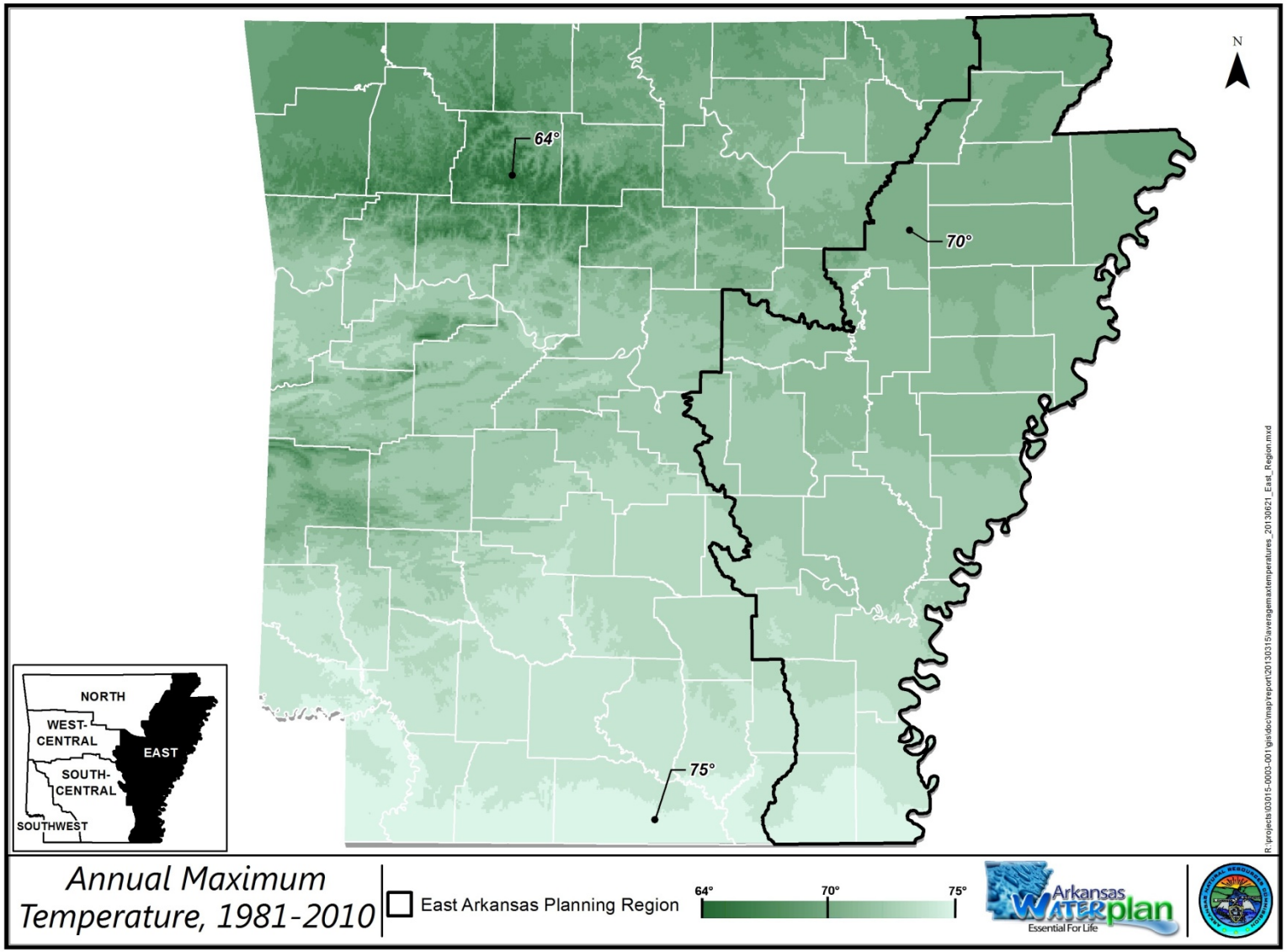

Figure 3.8. Average annual maximum daily temperature in degrees Fahrenheit, 1981-2010 (PRISM Climate Group 2004).

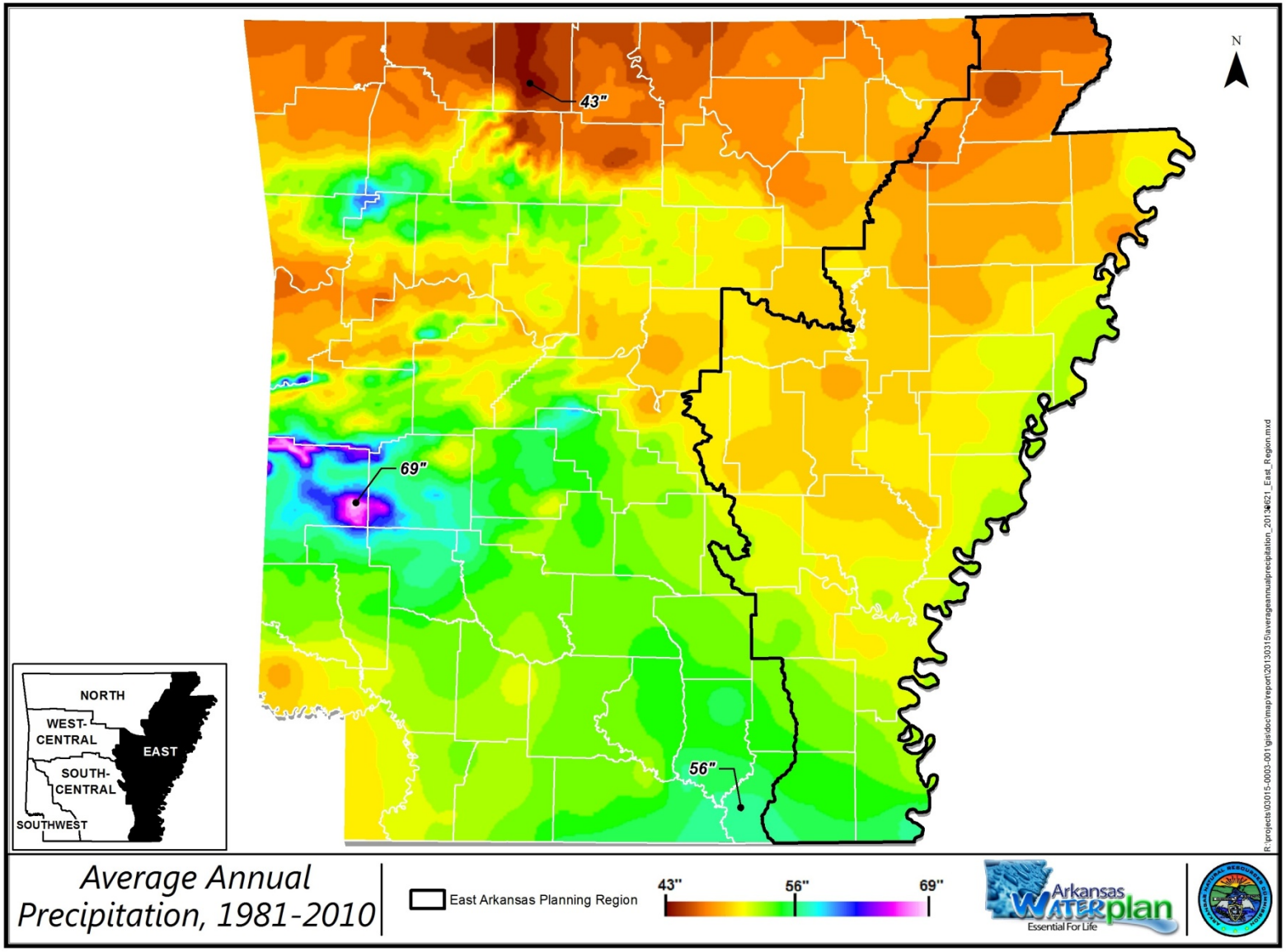

Figure 3.9. Average annual precipitation (inches) in the EAWRPR (PRISM Climate Group 2004).

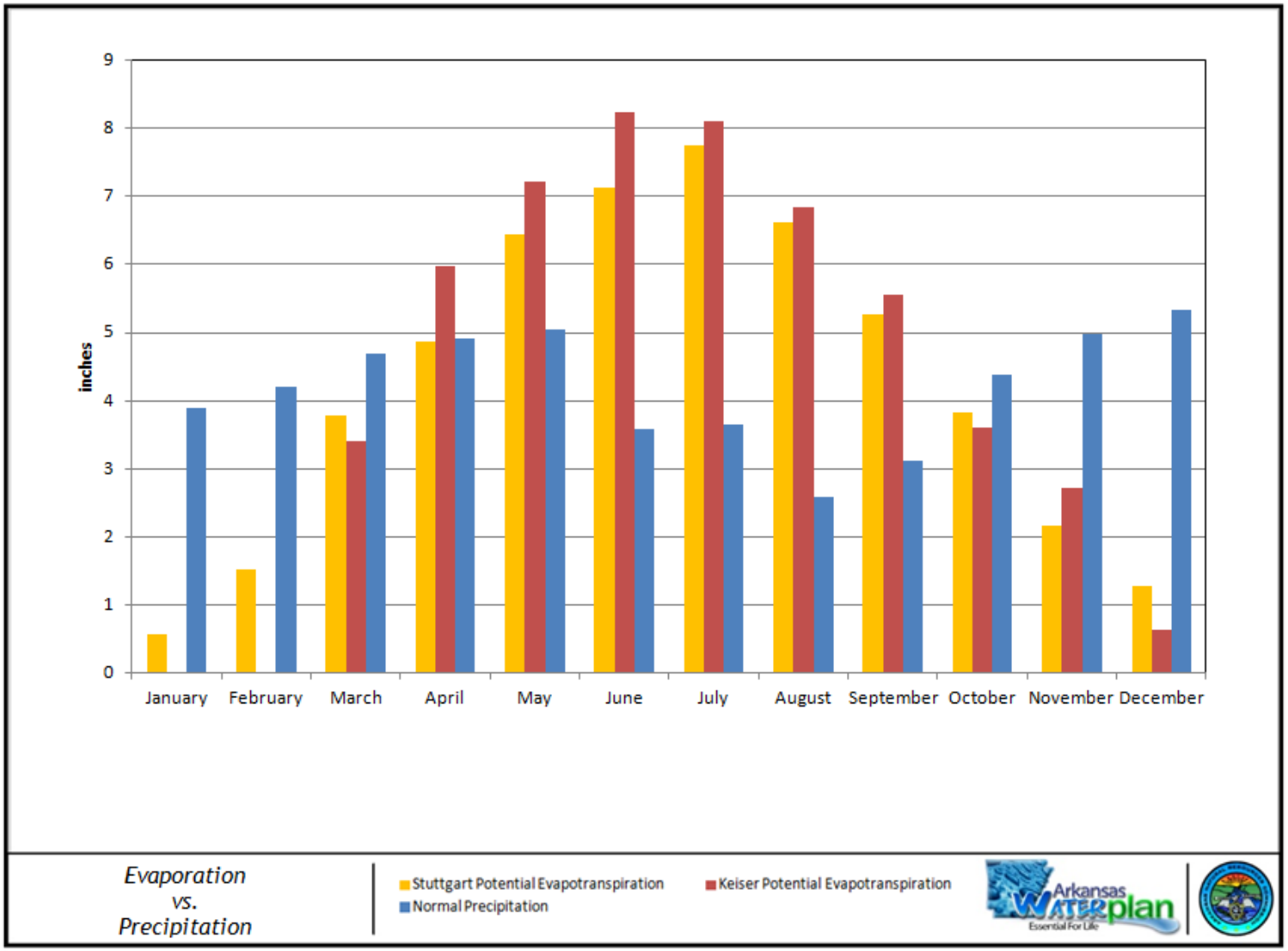

Figure 3.10. Average monthly precipitation compared to average monthly potential evapotranspiration, 1981 – 2010 (PRISM Climate Group 2004, NOAA NCDC 2013a).

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 regions like East Arkansas, potential evapotranspiration is similar to pan evaporation. In this 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). Figure 3.10 shows monthly average potential evapotranspiration estimated from pan evaporation measurements at Keiser in Mississippi County for the period 1981 – 2010, and at Stuttgart in Arkansas County for the period 1981 – 1997 (the available period of record for this station). The estimated potential evapotranspiration exceeds the normal precipitation six months out of the year (April – September).

3.5.3 Drought

Although the EAWRPR receives precipitation throughout the year, drought conditions occur in the region. 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). Figure 3.11 shows a time series plot of PDSI values for climate division 6 in Arkansas (see Figure 3.6 for a map of Arkansas climate divisions). Periods with multiple consecutive years of drought have occurred frequently in this climate division (Figure 3.11). The planning region is currently experiencing a period of drought that began in 2009 (NOAA NCDC 2013b).

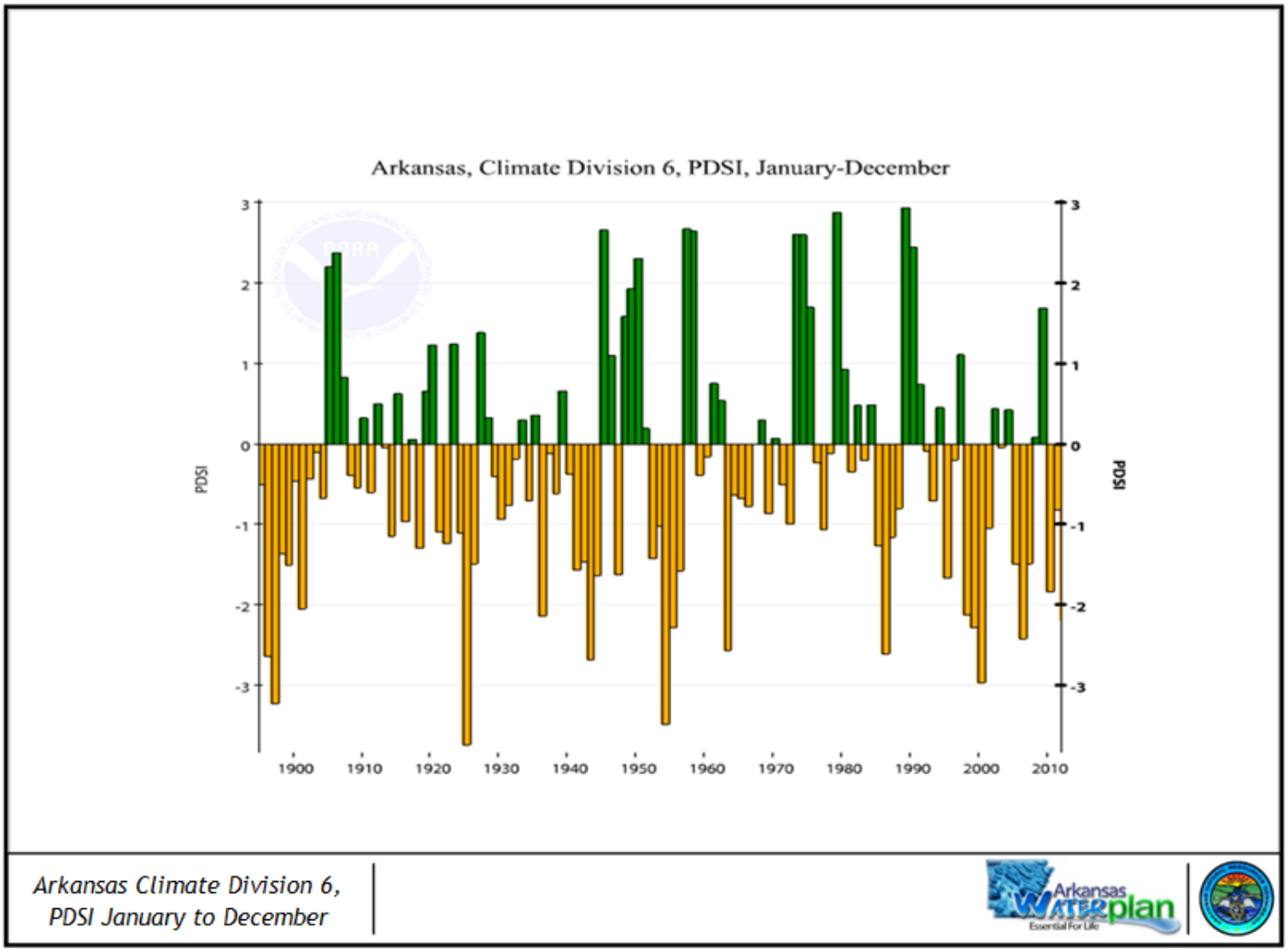

Figure 3.11. Historical values of the Palmer Drought Severity Index climate division 6 (east-central) (NOAA NCDC 2013b)

3.5.4 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 anticipated for the state (GCGW 2008):

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

Plots of annual average temperature and total annual precipitation from 1895 to 2013 for the eastern Arkansas climate divisions (3, 6, and 9) are shown in Figures 3.12 and 3.13, 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 3.12). 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 3.12 (Clark and Karklis 2012). Precipitation totals for climate divisions 6 (east-central) and 9 (southeast) appear to exhibit a slight long-term increasing trend, while the precipitation totals for climate division 3 (northeast) does not exhibit any trend (Figure 3.11). A detailed analysis of long-term precipitation trends across the state is being prepared as part of the 2014 water plan update and reported separately.

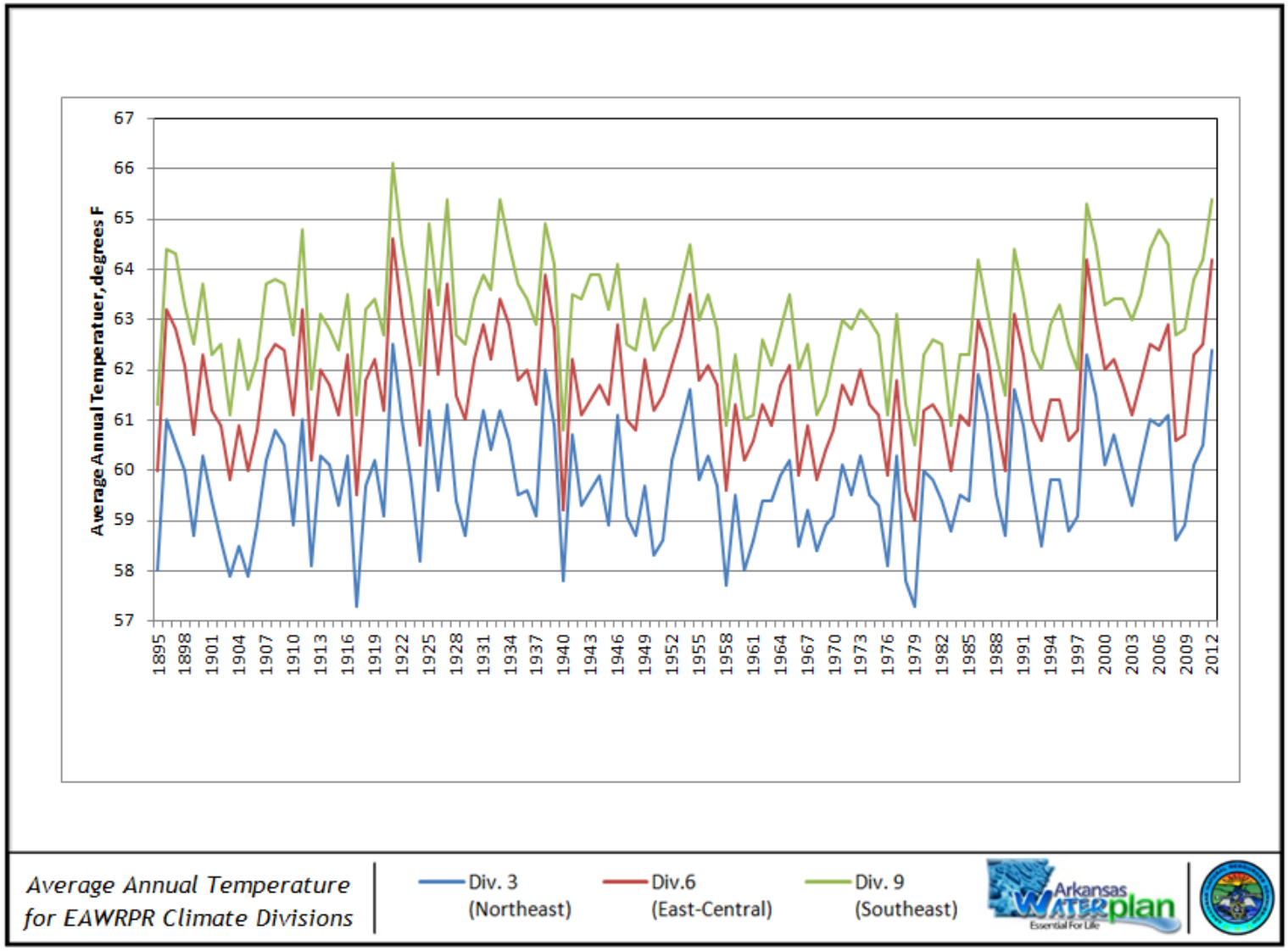

Figure 3.12. Average annual temperatures for the EAWRPR climate divisions (NOAA NCDC 2013c).

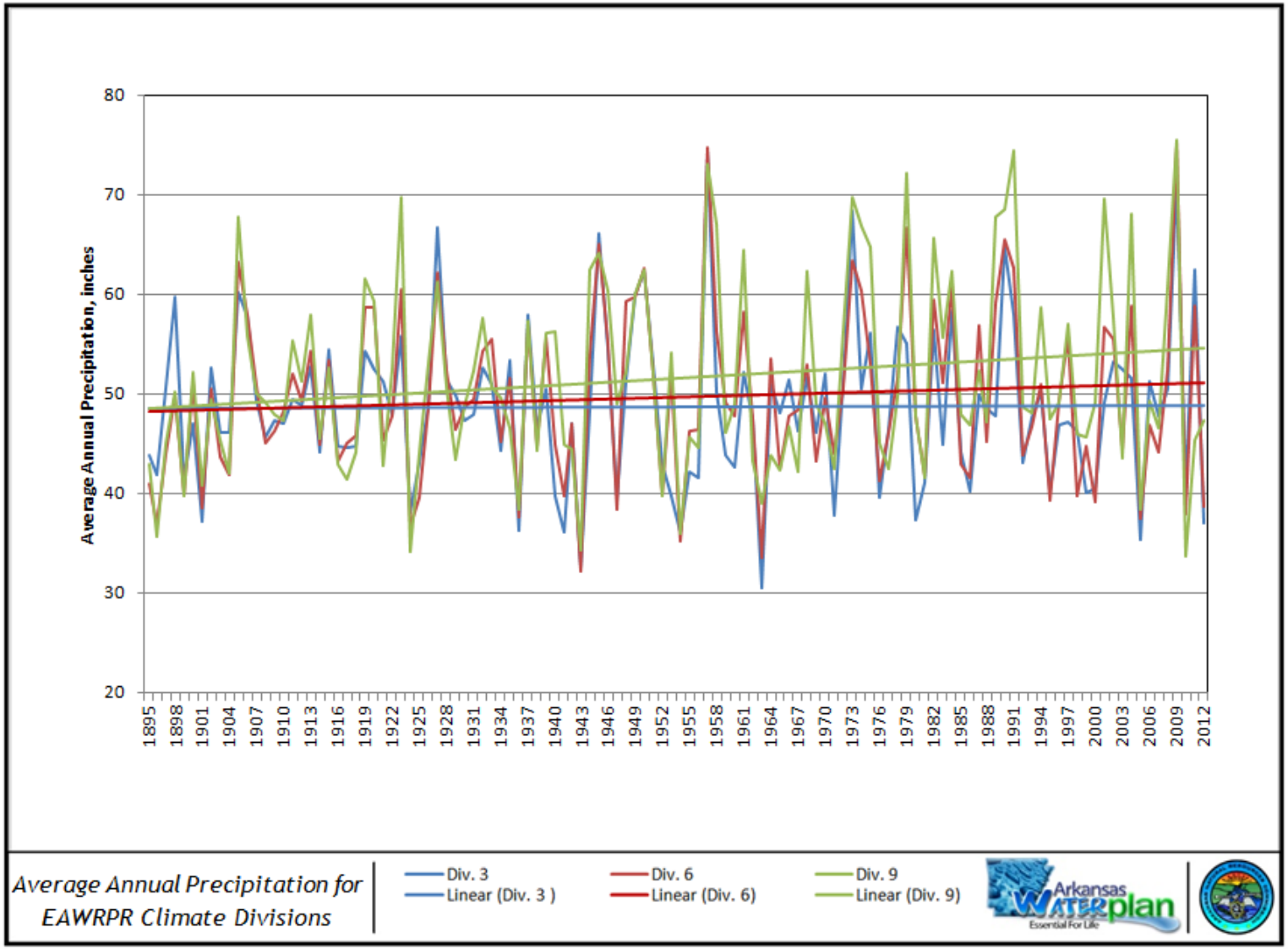

Figure 3.13 Average annual precipitation totals for eastern Arkansas climate divisions (NOAA NCDC 2013c).

3.6 Land Use

Land use in the EAWRPR is summarized in Figure 3.14 and mapped in Figure 3.15. Major land use categories are discussed in the sections below, including present day extent, and changes since the 1990 AWP.

3.6.1 Agriculture

The majority of the land in the EAWRPR is devoted to agricultural crop production (Figure 3.14). The major crops reported for the planning region in the 2007 Census of Agriculture were rice and soybeans, unchanged since the 1990 AWP update (ASWCC 1984, 1988; USDA National Agricultural Statistics Service 2007). The 2007 Census of Agricultural reported 6.1 million acres of cropland (harvested and other) in the counties within the planning region. The 1990 AWP reported 7.1 million acres of cropland in these counties. Because these cropland areas are from different sources, their comparability is uncertain. As a check, the 1987 Census of Agriculture reported 6.5 million acres of cropland in the counties of the EAWRPR. These numbers indicate that there has been a decline in the amount of cropland in the planning region since the 1990 AWP updates.

In the 2007 Census of Agriculture, approximately 71% of the cropland within the counties of the planning region was irrigated (USDA National Agricultural Statistics Service 2007). It was not possible to determine the amount of irrigated cropland for the EAWRPR from the information reported in the 1990 AWP. In the 1987 Census of Agriculture, the amount of cropland (harvested and other) in these counties reported as irrigated was 23% (note that the amount of irrigated land was not reported for 10 of the 26 counties in 1987 to protect farmers' privacy) (US Department of Commerce Bureau of the Census 1989). This indicates that while there has been a small decline in cropland land since the 1990 AWP update, there has been a significant increase in the amount of irrigated cropland during that time period.

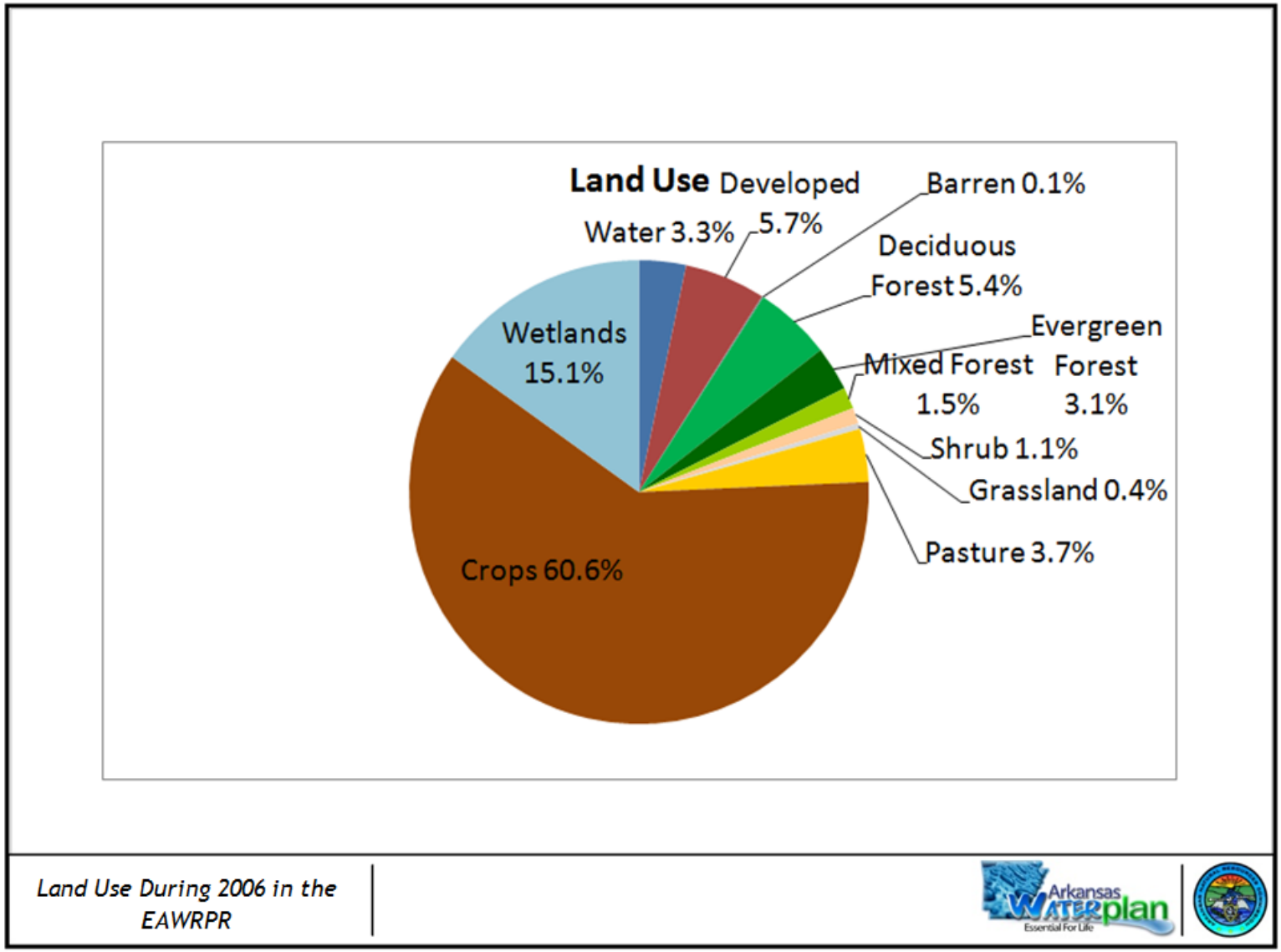

Figure 3.14. EAWRPR land use, 2006 (Fry, et al. 2011).

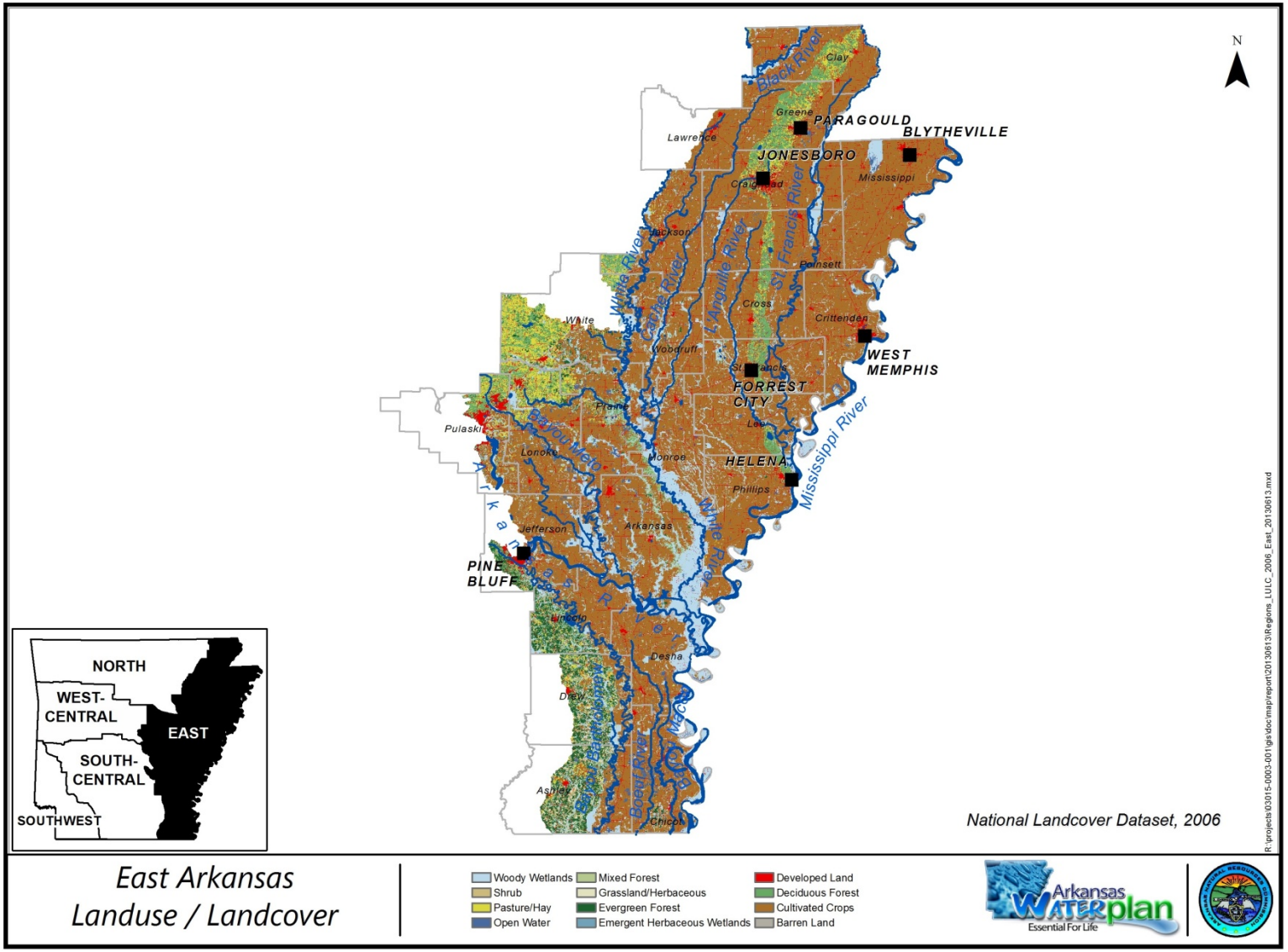

Figure 3.15. Land use map of the EAWRPR (Fry, et al. 2011).

3.6.1 Wetlands

After cropland, the next largest land use category for this planning region is wetlands, 15% of the land area, or 1.5 million acres. Despite the fact that the majority of the wetlands in this region have been converted to cropland, the majority of the state's wetlands are located in this planning region. Wetlands in this region are primarily located in the White River National Refuge and along the Cache River (see Figure 3.15). Wetland resources of the planning region are further described in Section 3.7.5.

In the 1990 AWP update, the area of wetlands in the Eastern Arkansas basin was estimated to be 0.6 million acres (ASWCC 1988). The wetland area in the Beouf-Tensas basin was estimated to be 5,154 acres (ASWCC 1984). Together, these two basins are roughly equivalent to the EAWRPR. Based on the wetland areas reported for these basins in the 1990 AWP update, the area of wetlands in the EAWRPR has increased since the 1990 AWP update.

3.6.2 Forest

Forest land use categories account for the third largest area in the EAWRPR ,10% of the land area. As can be seen in Figure 3.15, the majority of the forest in the region occurs outside of the Mississippi Alluvial Plain (see Figure 3.1 for the extent of the Mississippi Alluvial Plain). The St. Francis National Forest on Crowley's Ridge accounts for only 2% of the forest land in the planning region.

Data on forest area by county from the 1990 AWP basin reports is listed in Table 3.2, along with data from the 2012 USDA Forest Service (USFS) forest inventory. Because these data are from different sources, their comparability is uncertain, however, it does appear that the amount of forest land in the planning region has increased. In all of the counties, except Ashley, Clay, and Lincoln, the reported 2012 area is greater than the area reported in the 1990 AWP basin reports. It appears that forest area has increased by double or more since the 1990 AWP in approximately half of the counties within the EAWRPR. For the remaining counties, the pre-1990 areas and the 2012 areas are similar. Conservation and restoration efforts in this region may account for at least some of the increase in forest.

Table 3.2 Forest land comparison in the EAWRPR

County	Pre-1990 Forest Area (acres)	2012 Forest Area (acres)[e]	Change
Arkansas	73,885[b]	201,331	+
Ashley*	434,604[a,f]	408,851	-
Chicot	19,998[a]	131,190	+
Clay	108,574[b,d]	71,233	-
Craighead	47,938[b]	58,574	+
Crittenden	29,158[b]	37,026	+
Cross	45,220[b]	51,831	+
Desha	27,488[a,f]	154,046	+
Drew*	394,532[f]	407,198	+
Greene	87,785[b,d]	104,571	+
Jackson	61,704[b,d]	71,765	+
Jefferson*	200,007[a,c,f]	201,198	+
Lawrence*	110,589[d]	207,707	+
Lee	81,791[b]	94,129	+
Lincoln	171,139[a,f]	153,167	-
Lonoke	26,765[b,c]	123,237	+
Mississippi	22,981[b]	29,708	+
Monroe	61,035[b]	177,941	+
Phillips	66,471[b]	96,981	+
Poinsett	42,255[b]	73,238	+
Prairie	77,591[b]	111,910	+
Pulaski*	199,139[c,f]	234,669	+
St. Francis	63,259[b]	91,213	+
White*	144,001[c,d]	241,113	-
Woodruff	51,900[b,d]	117,240	+
Total	**2,649,809**	**3,651,067**	+

* part of this county is in another water resources planning region
a (ASWCC 1984)
b (ASWCC 1988)
c (USACE Little Rock District 1988)
d (USACE Little Rock District 1987)
e (USFS 2013)
f (ASWCC 1987)

3.6.3 Public Land

There are approximately 538,000 acres of public land in the EAWRPR, around 5% of the land in the planning region. Table 3.3 reports the number and acreage of each type of public land as reported by the Arkansas State Highway and Transportation Department (AHTD). Wildlife refuges and management areas account for the majority of this public land (Table 3.3). There is also the St. Francis National Forest, several state parks, a national park, natural areas, and

military land (Pine Bluff Arsenal, Little Rock Air Force Base) in the planning region. There is some overlap of public land classes. For example, one natural area is located in the White River NWR.

Table 3.3. Public lands in the EAWRPR (AHTD 2006, AGFC 2009).

Public Land	Acreage	Percent of Area	Count
National Forest	29,571	5.6%	1
National Wildlife Refuges	247,393	46.8%	5
Wildlife Management Areas	198,909	37.6%	33
State Parks	10,143	1.9%	19
Military Land	19,485	3.7%	2
National Park	238	<1%	1
Natural Areas	5,930	1.1%	19
Total	**528,223**		

There have been additions to the public lands in the EAWRPR since the 1990 AWP. A few wildlife management areas have been established in the region since 1990 (see Table 2.4) (AGFC 2011). Four new state natural areas have been established in this region since 1990 (see Table 2.4) (ANHC 2010). The Delta Heritage Trail State Park was initiated in the early 1990s (Arkansas Department of Parks and Tourism 2005b).

3.7 Surface Water

There are approximately 44,000 miles of rivers, streams, and ditches in the EAWRPR, approximately 680 miles of waterways used for commodity transport, and over 150,000 acres of impounded water (ASWCC 1981, Arkansas Waterways Commission 2013, USGS 2013a). There is also one hydropower project in the planning region. Major rivers in the region include the Arkansas River and White River. The largest impoundments in this region are the navigation pools on the Arkansas River. Surface water availability issues, both water quantity and water quality, are discussed in detail in Section 5.

3.7.1 Rivers and Streams

Two of the state's major rivers flow through the EAWRPR, the Arkansas and the White. Additional principal streams in the planning region include the St. Francis River, and Bayou Bartholomew. The St. Francis River originates in Missouri, enters the planning region as the eastern border of Clay County, and empties into the Mississippi River in Lee County, draining the northeastern portion of the planning region (Figure 2.1). Tributaries of the St. Francis River include the Tyronza River, Right Hand Chute of Little River, and the L'Anguille River. The Tyronza River and the Right Hand Chute of Little River lie to the east of Crowley's Ridge. The Tyronza River originates in Mississippi County. The Little River originates in Missouri. The L'Anguille River originates on Crowley's Ridge and lies west of the ridge for almost its entire length, cutting through the ridge near its southern end.

The White River originates outside of the planning region, in northwestern Arkansas. The White River enters the planning region in Jackson County, near Newport, and empties into the Mississippi River in Desha County, draining the northwestern portion of the planning region. Tributaries of the White River in the planning region include the Black River, Cache River, Bayou DeView, Big Creek, and Cypress Bayou. All of these tributaries, except the Black River, originate in the planning region. The Black River originates in Missouri.

The Arkansas River originates in Colorado. It enters the planning region in Pulaski County, at Little Rock, and empties into the Mississippi River in Desha County, draining the central portion of the planning region. Tributaries of the Arkansas River include Bayou Meto and Wabbeseka Bayou, both of which originate in the planning region.

Bayou Bartholomew originates in Jefferson County, near Pine Bluff, and flows out of the state in Ashley County, draining the southern portion of the planning region. Tributaries of Bayou Bartholomew in the planning region include Cutoff Creek, Beouf River, and Bayou Macon. These tributaries all originate in the planning region. The Beouf River and Bayou Macon join Bayou Bartholomew outside of the state, in Louisiana.

Numerous manmade changes to waterways in the planning region to facilitate drainage of the land for cultivation and to improve the hydraulics of stream channels, have significantly altered surface water flow in the planning region. Drainage projects such as dredging of

channels, construction of levees, and construction of drainage ditches have altered channels and drainage patterns to such an extent that they no longer resemble their natural state. Flow in both the White River and the Arkansas River is regulated. Flow in the Arkansas River is regulated by the dams that make up the McClellan-Kerr Arkansas River Navigation System. Flow in the White River is regulated by four mainstem reservoirs and two tributary reservoirs, all located outside of the EAWRPR.

The historical average annual surface runoff in the EAWRPR ranges from approximately 7 inches in the northwestern part of the planning region to approximately 11 inches in the western areas of the planning region (Figure 3.16). Seasonal variation in runoff mirrors seasonal variations in precipitation (Pugh and Westerman 2014).

Streamflow in the EAWRPR is generally highest from December through May because of the large amount of precipitation during this period (Figure 3.10). Similarly, streamflow is generally lowest during June through November due to lower precipitation and increased agricultural water use and evapotranspiration that occur during the growing season (see Figure 3.10). Mean monthly discharges at selected gaging stations are summarized in Figure 3.17. The location of these flow gages are shown in Figure 3.18.

Long term flow records in the EAWRPR have recently been analyzed for trends. Several flow gage stations on streams in this region exhibit declining trends. (Ludwig 1992, Czarnecki, Hays and McKee 2002). An updated state-wide analysis of long term trends in flow runoff is being conducted by the USGS and USACE as part of the 2014 AWP update.

3.7.2 Waterborne Commodity Transport

Commercial commodity transport occurs on federal navigation projects on two rivers in the EAWRPR, McClellan-Kerr Arkansas River Navigation System (MKARNS) and White River. Although commodity transport also occurs on the Mississippi River, which borders the EAWRPR, the Mississippi River is not generally considered waters of the state. There are three public ports on the Mississippi River that are located in the EAWRPR, at Osceola, West Memphis, and Helena-West Helena (Figure 2.2).

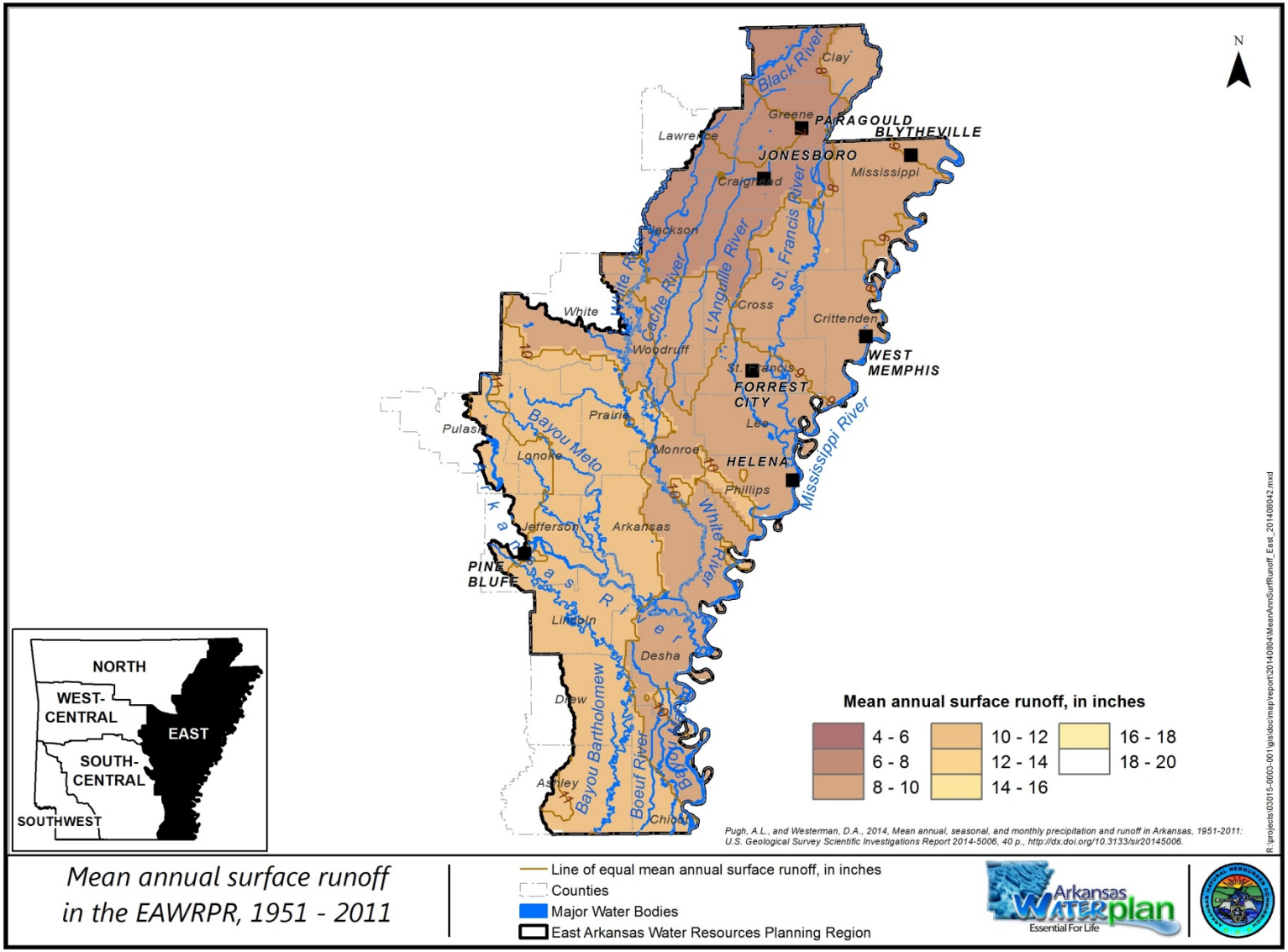

Figure 3.16. Average annual surface runoff in the EAWRPR, 1951 to 2011 (Pugh and Waterman 2014).

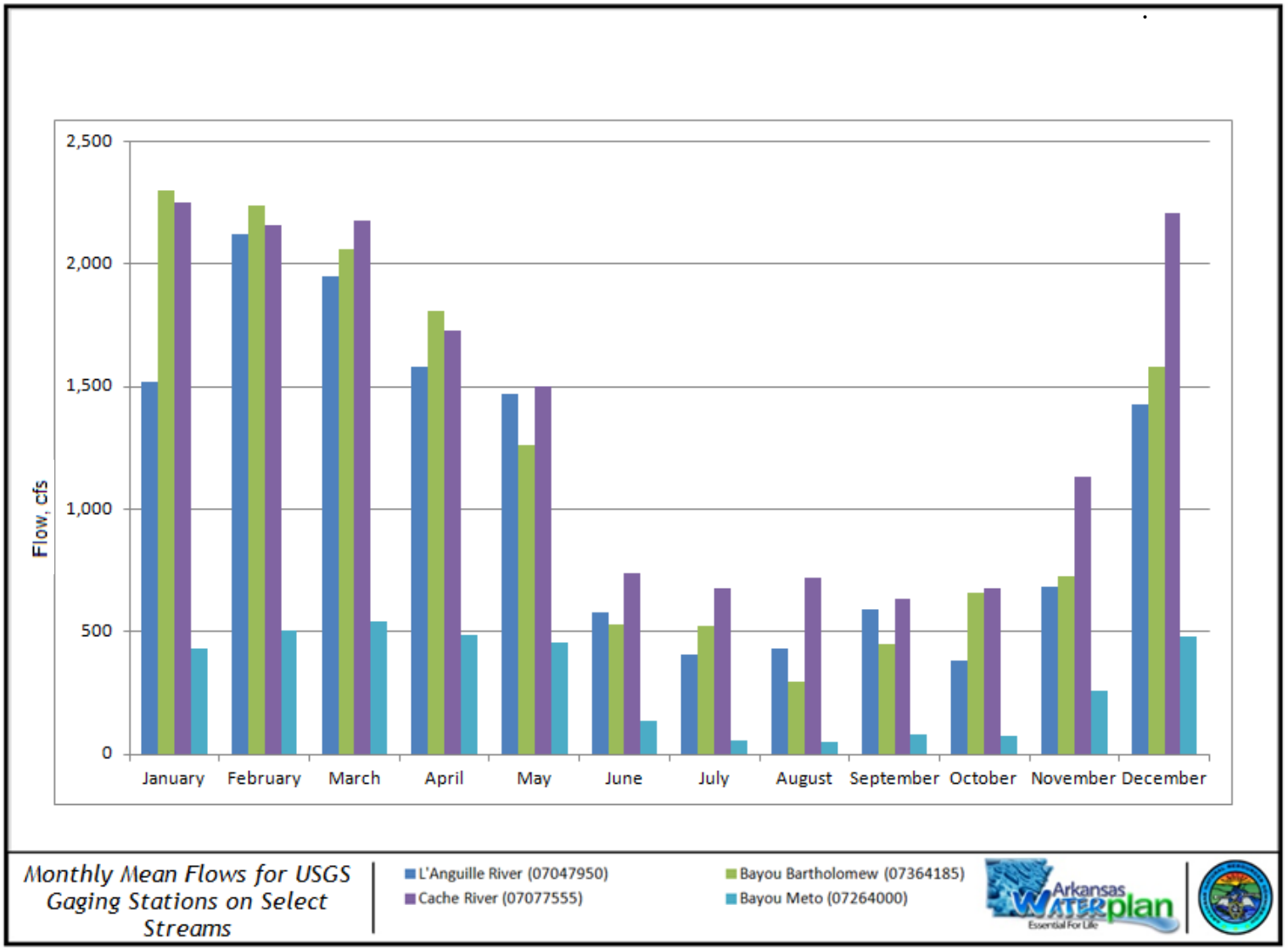

Figure 3.17. Mean monthly flows reported for USGS gaging stations on selected streams in the EAWRPR (USGS 2013b).

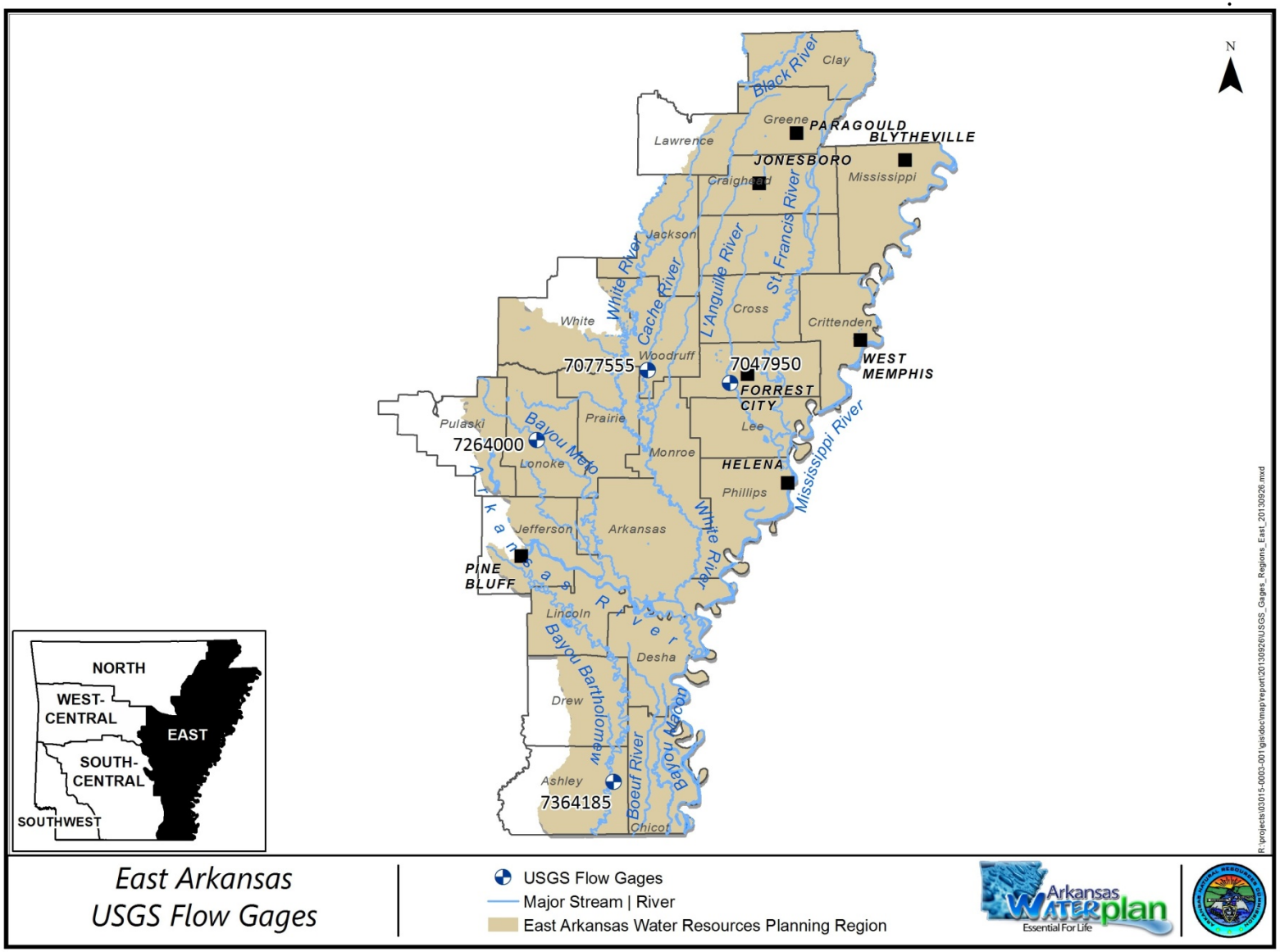

Figure 3.18. Flow gage locations in the EAWRPR.

In the EAWRPR, the MKARNS consists of a series of seven lock and dam structures and one dam, maintained and operated by the USACE Little Rock District. The system begins at the Mississippi River, at the mouth of the White River, at the Montgomery Point Lock & Dam at White River navigation mile 0.5 and continues approximately 10 miles up the White River. At that point, the approximately 10 mile long Arkansas Post Canal connects the White River to the Arkansas River. There are two locks and dams on the canal, Norrell Lock (Lock 1) and Lock 2. Wilbur D. Mills Dam (Dam 2), on the Arkansas River just downstream of the mouth of the Arkansas Post Canal maintains navigation depth on the Arkansas River upstream of Dam 2. The rest of the MKARNS in the planning region consists of a series of five more locks and dams on 90 miles of the Arkansas River. The MKARNS navigation channel is maintained to 9 feet. In 2005 Congress authorized construction of a 12 feet navigation channel along the entire length of the MKARNS, but funding has been limited. Therefore, the 12 feet 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 Pine Bluff and Little Rock. 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.

On the White River upstream of the MKARNS, a navigation channel 125 feet wide and 8 feet deep, when the water level is at 12 feet at the Clarendon gage, is maintained by the Memphis District USACE to Augusta, approximately 190 miles. Between Augusta and Newport, approximately 57 miles, a 100 foot wide channel with minimum depth of 4.5 feet at a gage reading of 3.5 feet at Newport is maintained. There are no structures on the White River navigation project, and no public ports. The navigation channel is maintained solely through dredging and snagging. The Memphis District also maintains nine harbors along the White River. Commercial navigation on the White River is dependent on river stage, and is currently feasible to Newport during only 57% of the year (Arkansas Waterways Commission 2012b). When the navigation channel is maintained, commercial navigation to Augusta is usually possible year round.

3.7.3 Impoundments

In 1981 there were over 15,000 acres of impoundments in the planning region (Table 3.4). The majority of these impoundments were irrigation and aquaculture ponds (ASWCC 1981). An updated state-wide inventory of impoundments is being prepared for the 2014 AWP update. The Arkansas Department of Environmental Quality (ADEQ) has identified 18 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 EAWRPR is summarized in Table 3.5.

Table 3.4. Summary of lakes and impoundments in the EAWRPR (ASWCC 1981).

County	Lakes	Area (acre)	Capacity (acre-feet)
Arkansas	545	21,207	113,283
Ashley*	485	4,064	17,244
Chicot	136	10,971	89,116
Clay	840	1,291	5,155
Craighead	634	923	4,323
Crittenden	89	7,697	97,017
Cross	365	887	5,618
Desha	27	9,564	72,819
Drew*	1,346	3,698	14,010
Greene	1,293	2,394	7,145
Jackson	371	1,090	6,649
Jefferson*	421	4,661	24,293
Lawrence*	915	1,242	6,574
Lee	256	1,292	4,841
Lincoln	809	3,027	15,053
Lonoke	1,760	21,452	77,751
Mississippi	59	6,950	12,351
Monroe	167	4,537	27,061
Phillips	57	3,782	16,428
Poinsett	391	2,612	10,434
Prairie	594	11,832	57,467
Pulaski*	806	13,798	236,921
St. Francis	377	3,680	17,470
White*	2,547	2,468	14,178
Woodruff	85	2,052	10,061
US Forest Service	2	1,045	11,000
Parks & Tourism	4	181	2,528
AGFC	27	5,616	41,851
Total	15,408	154,013	1,018,641

*Only part of county is in the EAWRPR; number of lakes shown is only those within this region

Table 3.5. Information for significant publicly owned lakes in the EAWRPR (ADEQ 2009a).

Name	County	Lake type	Surface area (acres)	Average Depth (feet)	Capacity (acre-feet)	Purpose
Lake Barnett	White	Reservoir	245	27	6,615*	Fishing
Lake Frierson	Greene	Reservoir	335	7.5	2,570	Fishing
Storm Creek Lake	Phillips	Reservoir	420	7.0	2,940*	Recreation
Lake Poinsett	Poinsett	Reservoir	550	7.0	16,296	Fishing
Bear Creek Lake	Lee	Reservoir	625	10.0	6,250*	Recreation
Cane Creek Lake	Lincoln	Reservoir	1,620	6.0	9,720*	Fishing
Lake Enterprise	Ashley	Oxbow	200	5.0	1,000*	Fishing
Pickthorne Lake	Lonoke	Reservoir	207	5.0	1,035*	Fishing
Lake Hogue	Poinsett	Reservoir	280	4.4	1,220	Fishing
Marion McCollum Greenlee Lake	Monroe	Reservoir	300	6.0	2,560	Fishing
Mallard Lake	Mississippi	Reservoir	300	6.0	2,400	Fishing
Lake Grampus	Ashley	Oxbow	334	6.0	1,200	Fishing
Lake Des Arc	Mississippi	Reservoir	350	6.0	2,100	Fishing
Lake Wallace	Drew	Oxbow	362	5.2	1,235	Fishing
Lake Ashbaugh	Greene	Reservoir	500	5.0	2,500	Fishing
Old Town Lake	Phillips	Oxbow	900	3.5	3,150*	Recreation
Horseshoe Lake	Crittenden	Oxbow	1,200	10	12,000*	Recreation
Upper Chicot Lake	Chicot	Oxbow	1,270	15	19,050*	Recreation
Lower Chicot Lake	Chicot	Oxbow	4,030	15.4	62,062*	Recreation
Grand Lake	Chicot	Oxbow	1,400	7.0	9,800*	Fishing

* capacity = surface area * average depth, info from ADEQ

3.7.1 Wetlands

The majority of the wetlands within Arkansas are located in the EAWRPR. In 2006, there were over 1.5 million acres of wetlands within this planning region (Fry, et al. 2011). These wetlands perform important functions, including storage of floodwaters, filtering of water to improve water quality, and storage of carbon. In addition, these wetlands provide habitat for a number of important bird and animal species (Anderson 2006, Ramsar Convention 2013). The White River National Wildlife Refuge in the planning region comprises the largest area of contiguous bottomland hardwood habitat within the Lower Mississippi River Valley (ADEQ 2009a).

3.7.2 Surface Water Quality

Surface water quality in the EAWRPR tends to be strongly influenced by land use. In general, surface waters in this planning region tend to have relatively high levels of turbidity and suspended solids. In addition, dissolved oxygen levels tend to be low, and biochemical oxygen demand in surface waters tends to be relatively high (Woods, et al. 2004). Surface water quality issues within the EAWRPR are discussed in detail in Section 5.

3.8 Groundwater

Groundwater in the EAWRPR represents one of the most valuable natural resources in the State. The primary water use of these aquifers is for agriculture, with crop irrigation accounting for 84% of water used in 2005 (USGS 2009). Additional water uses include commercial, industrial, and public-water supply.

3.8.1 Aquifers

Aquifers in the EAWRPR consist of various geologic units mainly of unconsolidated and alternating layers of sands, gravels, silts, and clays. In this setting, fine-grained material impedes flow and serves as confining units, and coarse-grained material serves as aquifers. There are eight recognized aquifers in the EAWRPR that are listed in Table 3.6 and mapped on Figure 3.19. Most of these aquifers are designated as regional aquifers and encompass parts of

several states, whereas a few of these aquifers are considered minor and are only important as local sources of water. For a detailed description of the geologic formations that comprise the aquifers in the EAWRPR, refer to McFarland (2004). Kresse and others (2013) provide a comprehensive review of the aquifers of Arkansas including 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.

The primary aquifers in the EAWRPR are the Mississippi River Valley (MRV) alluvial and Sparta-Memphis aquifers. The remainder of the discussion in this section and following sections will focus on these two aquifers, with a brief description of the remaining aquifers (Cockfield, Wilcox, and Nacatoch) that have limited use in the EAWRPR.

Table 3.6. Summary of geologic formations in the EAWRPR and associated hydrogeologic unit names.

Province	Section	Group	Formation		Hydrogeologic Unit Name
Coastal Plain	Mississippi Alluvial Plain and West Gulf Coastal Plain		Alluvium and Terrace Deposits		Mississippi River Valley alluvial aquifer
		Jackson	Jackson		Vicksburg-Jackson confining unit
		Claiborne	Cockfield Formation		Cockfield aquifer
			Cook Mountain Formation		Middle Claiborne confining unit
			Sparta Sand	Memphis Sand	Sparta-Memphis aquifer
			Cane River Formation		
			Carrizo Sand		
		Wilcox	Undifferentiated		Upper*– Lower Wilcox aquifer
		Midway	Porters Creek Clay		Midway confining unit
			Clayton Formation		
			Arkadelphia Marl		
			Nacatoch Sand		Nacatoch aquifer

* Upper Wilcox aquifer includes sands in the Carrizo Sand that are in hydraulic connection with sands of the upper Wilcox Group

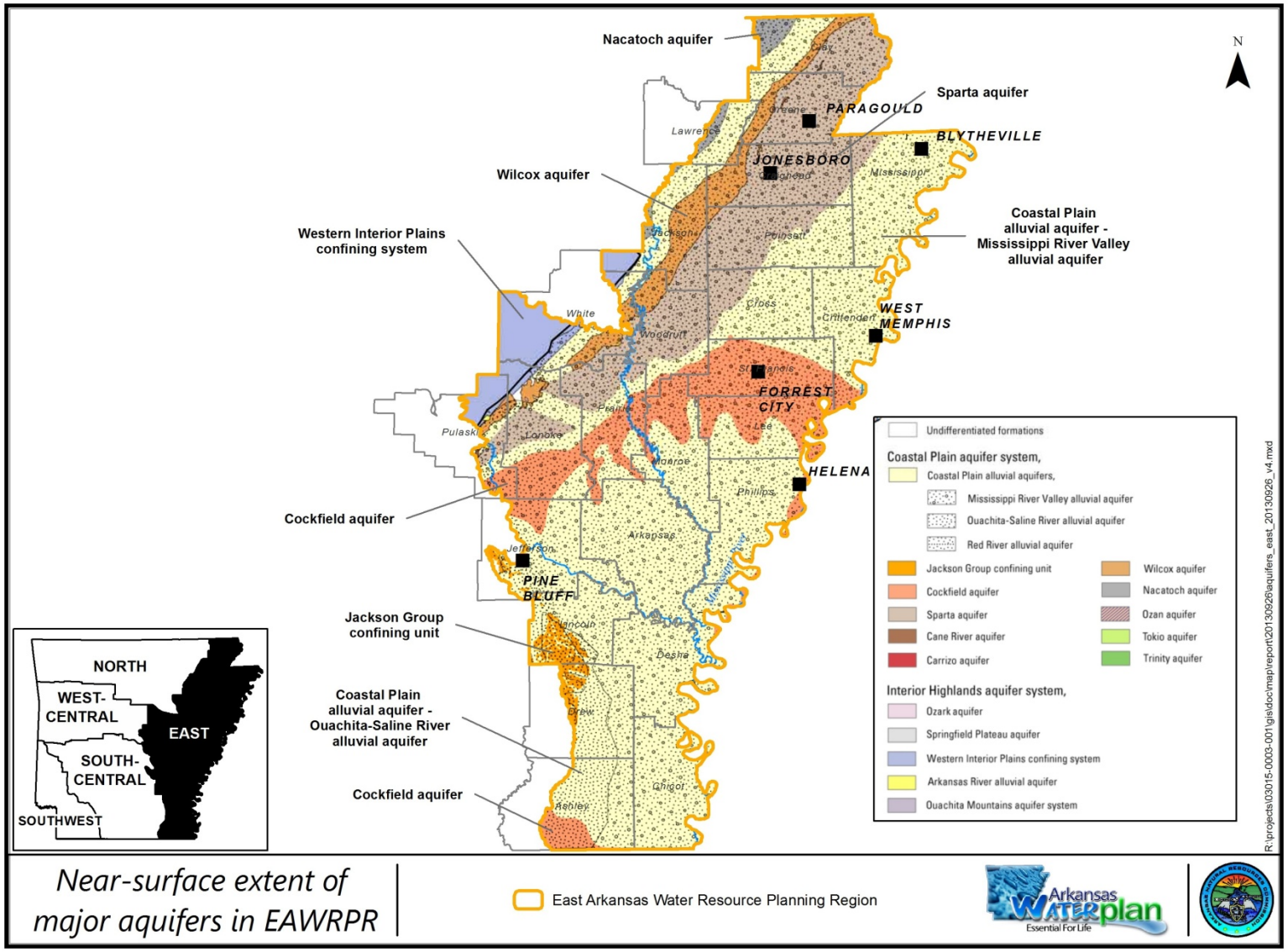

Figure 3.19. Major aquifers of the EAWRPR (Kresse, et al. 2013).

3.8.1.1 Mississippi River Valley alluvial aquifer

The MRV alluvial aquifer in terms of use is the most important aquifer in Arkansas. Nationally, the State ranks fourth in groundwater use, and 94 % of all groundwater used is from the MRV alluvial aquifer. As of 2010, there were over 47,000 wells reported as located in the MRV alluvial aquifer. The primary water use of this aquifer is to support irrigation agriculture. Secondary water uses include aquaculture, flooding of fields to provide duck hunting habitat, public supply, industrial, and domestic (Kresse, et al. 2013).

The MRV alluvial aquifer is the uppermost aquifer in eastern Arkansas (Figure 3.20) and consists of unconsolidated sediments of sand, gravel, silt, and clay of Quaternary age deposited in fluvial environments. The MRV alluvial aquifer is typically divided into two hydrologic units based on lithologies: a lower unit consisting of coarse sands and gravels that serves as the primary aquifer, and an upper unit that consists of fine sand, silt, and clay that can serve as a confining unit in some locations. The lower part of the alluvial aquifer ranges in thickness from 0 to 140 feet for an average thickness of 100 feet. Near the boundary between the Interior Highlands and the Coastal Plain, the gravels in the lower unit may be absent replaced by clay layers instead (Kresse, et al. 2013).

Primary recharge to the MRV alluvial aquifer occurs as precipitation over the extent of the aquifer in areas where the upper clay layer is thin to absent. Major rivers (such as the Arkansas, White, and Mississippi Rivers) may act as a source of recharge or serve as a regional drain depending on river stage. Reported yields range from 400 to 5,000 gallons per minute (gpm), with yields of 2,000 gpm commonly cited. The yield appears to be dependent on the thickness, sediment size and distribution, and other physical characteristics. Predevelopment water levels for the MRV alluvial aquifer were near ground surface (< 20 feet). Locally, groundwater flow tends to follow the topographic gradient, and regionally, groundwater flow is to the southern and eastern parts of the Mississippi Embayment. Sustained and intense pumping of the aquifer has resulted in widespread water-level declines and altered flow directions. Natural groundwater flow paths may range from tens to hundreds of miles before encountering a major river, which acts as a hydrologic flow boundary and serves as a regional drain (Kresse, et al. 2013).

As a result of its geology, Crowley's Ridge acts as a barrier to flow in the alluvial aquifer from the east side of the ridge to the west side. The exception to this constraint is found in areas, such as Poinsett County, where the Memphis Sand sub crops beneath the silt and loess deposits of the ridge. Here the Sparta-Memphis aquifer may act as a conduit through the ridge allowing for some induced flow from the east side, where the aquifer transmissivity is higher, and recharge from the Mississippi River is available. However, the amount of clay in the Memphis Sand in this area is uncertain and the flow through the ridge is not easily quantified.

3.8.1.2 Sparta-Memphis aquifer

The Sparta-Memphis aquifer is the second most used aquifer in the State. In 2010, over 700 wells were reported as located in the Sparta-Memphis aquifer. The Sparta-Memphis aquifer produced 196.64 million gallons per day (mgd), which accounts for 2.5 % of all groundwater use in Arkansas. The Sparta-Memphis aquifer is used primarily for agriculture followed by public and industrial supply (Kresse, et al. 2013).

The Sparta-Memphis aquifer is present throughout the entire extent of the Coastal Plain (i.e., Gulf Coastal Plain) in Arkansas. This aquifer is composed of the Sparta Sand and the Memphis Sand. In northeastern Arkansas, the Sparta Sand is indistinguishable from the underlying Cane River Formation and Carrizo Sand, and these formations are grouped together as the Memphis Sand and commonly referred to as the Memphis aquifer (Kresse, et al. 2013). To avoid confusion, in this document the term "Sparta-Memphis aquifer" will be used when referring to the sequence of saturated, productive, and hydraulically connected geologic formations that constitute the Sparta (Sparta Sand) and Memphis (Memphis Sand) aquifers. When referring to properties specific to one of the geologic units, the geologic formation names will be used.

The Sparta Sand consists of varying amounts of sand and occasionally gravel interspersed with layers of silt, clay, shale, and lignite. The occurrence, continuity, and thickness of the sand beds which constitute the aquifer are quite variable but in general appear to be hydraulically connected. The Sparta Sand outcrops in southern Arkansas and is unconfined at its western extent within the Mississippi Embayment. The sand becomes confined towards the axis of the

Mississippi Embayment and southward towards the Gulf of Mexico by the overlying Cook Mountain Formation and the underlying Cane River Formation (Kresse, et al. 2013).

Where the Sparta Sand underlies the MRV alluvial aquifer (Figure 3.19), the alluvial aquifer serves as a source of recharge. Additional sources of recharge include direct infiltration in the outcrop area, streams in the outcrop area, and leakage from overlying aquifers. Natural discharge occurs by leakage through the confining and adjacent units and discharge to rivers within the outcrop area. The natural groundwater flow is toward the axis of the Mississippi Embayment and southward toward the Gulf of Mexico. Intense development and sustained and intense pumping of the aquifer has resulted in widespread water-level declines and altered flow directions (Kresse, et al. 2013).

The Memphis Sand is primarily composed of thick bedded sands with minor clay layers that may hydraulically separate the sand beds. Except for some exposed erosional remnants along Crowley's Ridge, the Memphis Sand does not outcrop in northern Arkansas. In the Memphis Sand subcrop area, the Memphis Sand underlies the MRV alluvial aquifer and is hydraulically connected to the alluvial aquifer (Figure 3.19). This hydraulic connection serves as an important recharge source to the Memphis Sand. Groundwater in the Memphis Sand generally flows east towards the axis of the Mississippi Embayment and then southward (Kresse, et al. 2013).

Hydraulic properties in the Sparta-Memphis aquifer vary widely, and water appears to be more easily transmitted in the thickest sand intervals. Reported well yields range from hundreds to thousands of gallons per minute (Kresse, et al. 2013).

3.8.1.3 Minor Aquifers

Aquifers that have limited use but still serve as important sources of water to some areas in the EAWRPR include the Cockfield, Wilcox, and Nacatoch aquifers. The Cockfield aquifer is present throughout southeastern and eastern Arkansas. In the outcrop area and where overlain by Quaternary alluvium, the aquifer is unconfined (Figure 3.19). Where overlain by the Jackson Group, the aquifer is confined. The Cockfield Formation consists of silt, clay, and lignite in the upper portions and sand beds near the base, which form the more permeable portions of the

Cockfield aquifer. There is considerable variability in unit thickness. Regional groundwater flow is to the southeast; however, sustained and intense pumping in some areas of southeastern Arkansas have led to the development of cones of depression and altered flow towards these pumping centers. Recharge to the aquifer occurs as precipitation in the outcrop area and as seepage from overlying Quaternary alluvium in the subrcop area. Discharge from the aquifer occurs to streams in the outcrop area, to adjacent units, and wells. In and near the outcrop area, well depths are typically shallow (less than 200 feet) and yields are generally less than 30 gpm . Further away from the outcrop area, well depths can exceed 600 feet and yields range from 100 to 500 gpm (Kresse, et al. 2013).

The Wilcox Group is present throughout the Coastal Plain of Arkansas. Three aquifer units are used to represent the Wilcox Group: lower Claiborne-upper Wilcox aquifer (hereafter referred to as the upper Wilcox), the middle Wilcox aquifer, and the lower Wilcox aquifer. In the northeastern Arkansas, the upper and lower Wilcox aquifers are present. The upper Wilcox aquifer consists of thin interbedded layers of sands and clays with lignite. The upper Wilcox aquifer includes sands of the overlying Carizzo Sand that are hydraulically connected with sands of the upper Wilcox Group. The lower Wilcox aquifer consists of three major sand units that are collectively referred to as the lower Wilcox. The lower sand unit known as the “1,400-foot sand” is recognized throughout most of the Mississippi Embayment, which is a common term used for the lower Wilcox aquifer in northeastern Arkansas. The lower Wilcox aquifer is considered confined (Kresse, et al. 2013). Remaining discussion of the lower and upper Wilcox aquifers will simply refer to the units as the Wilcox aquifer.

The Wilcox aquifer outcrops in the area of Crowley’s Ridge in Clay, Greene, and Craighead Counties. Recharge to the Wilcox aquifer primarily occurs as precipitation in the outcrop area (Figure 3.19) and as leakage from overlying sandy beds of the Claiborne Group in northern Arkansas. Wells completed in the Wilcox aquifer typically yield from 500 to greater than 2,000 gpm . Discharge from the Wilcox aquifers is mainly to wells (Westerfield 1994). Regional groundwater flow for the Wilcox aquifer is towards the axis of the Mississippi Embayment; however, sustained and intense pumping in some areas of have led to the

development of cones of depression and altered flow towards these pumping centers (Kresse, et al. 2013).

While the Nacatoch aquifer is present throughout the extent of the Coastal Plain of Arkansas, use of the aquifer in EAWRPR is limited to the extreme northeastern portion (Clay, Greene, and Lawrence Counties). Compared to other aquifers in the EAWRPR, the Nacatoch aquifer has not been as studied. The Nacatoch Sand includes three distinct sand units, with the upper unit (a fine-grained quartz sand) forming the principle aquifer. The Nacatoch aquifer is overlain by the MRV alluvial aquifer in parts of northeastern Arkansas (Figure 3.19); otherwise, the aquifer is overlain by Eocene-aged deposits. Most wells completed in the Nacatoch aquifer have relatively low yields, although yields up to 500 gpm have been reported in Greene and Clay Counties (Broom and Lyford 1981). In Jackson County, wells could be developed to yield between 200 and 500 gpm; however, based on electric logs the water in this area is suspected to be saline (Albin, Hines and Stephens 1967). In some areas east of the fall line, the aquifer is believed to contain petroleum rather than water. In northeast Arkansas, regional groundwater flow is to the southeast (Kresse, et al. 2013).

3.8.2 Ground Water Quality

In general, ground water quality in the EAWRPR 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 Mississippi River Valley Alluvial Aquifer

In general, groundwater quality of the MRV alluvial aquifer is good when compared to EPA primary drinking water standards. Groundwater within the majority of the MRV alluvial aquifer is classified as calcium-bicarbonate water type. In addition, sodium, magnesium, chloride, sulfate, silica, and iron comprise the major constituents by weight. These constituents show a wide variability based on residence time of groundwater and flow paths. Levels of dissolved solids in the groundwater throughout most of this aquifer are low enough for the water to be suitable for most uses (Kresse, et al. 2013).

3.8.2.2 Sparta-Memphis Aquifer

The Sparta-Memphis aquifer in eastern Arkansas generally provides water of excellent quality. Throughout most of its extent, the Sparta-Memphis aquifer is a sodium-bicarbonate water type. In the northeastern part of the state where the aquifer has lower clay content, the groundwater is reported as a calcium-bicarbonate water type. In localized areas, calcium and magnesium are reported as occurring in appreciable amounts. In general, pH values and bicarbonate and dissolved solids concentrations increase in the Sparta-Memphis aquifer as water moves downgradient from the outcrop area. An exception to this observation occurs in areas where the Sparta-Memphis aquifer underlies the MRV alluvial aquifer (Kresse, et al. 2013).

3.8.2.3 Minor Aquifers in the EAWRPR

The Cockfield aquifer contains groundwater that is typically of high quality, but is not used much in the EAWRPR. The groundwater is typically a calcium-bicarbonate water type in the outcrop and subcrop areas and transitions to a sodium-bicarbonate type downgradient of these areas (Kresse, et al. 2013).

The Wilcox aquifer produces water of generally excellent quality, and consumers often refer to the aquifer as having the best water quality in the state (Scott et al. 1998). In general, water quality is better in the eastern extent of the aquifer in northeastern Arkansas. For dissolved solids concentrations below 100 milligrams per liter (mg/L), the groundwater is a calcium-bicarbonate water type. For dissolved solids concentrations above 100 mg/L, the groundwater is a sodium-bicarbonate water-type. When dissolved solids concentrations exceed 800 mg/L, the groundwater is a strongly sodium-chloride water type (Kresse, et al. 2013).

In the EAWRPR, the Nacatoch aquifer is a viable and important source of water for the extreme northeastern part of the state. Very little groundwater data exists for the northeastern portion of the Nacatoch aquifer in Arkansas. In this area, bicarbonate is the dominant constituent present; pH values tend range from near neutral to basic (7.6 to 8.5); and nitrate, sulfate, and chloride concentrations are low. Iron is ubiquitous in aquifers throughout Arkansas; however, iron concentrations in the Nacatoch aquifer of northeastern Arkansas are some of the lowest in the State (all samples less than 0.05 mg/L) (Kresse, et al. 2013).

3.9 Groundwater-Surface Water Connections

Groundwater recharge throughout the EAWRPR generally comes from precipitation which percolates into the groundwater system, especially where major aquifers are exposed at land surface. Statewide groundwater recharge has been estimated at about 2 inches per year, and as low as 0.4 inches per year (Broom and Lyford 1981). Another estimate ranges from 3 to 8 inches depending on the permeability of the surface material (Bedinger and Jeffrey 1964). Other sources of groundwater recharge include rivers that are hydraulically connected to aquifers and lateral and vertical flow from adjacent and underlying water-bearing strata.

Purely by coincidence, the MKARNS on the Arkansas River has functioned for years as one of the most successful artificial recharge projects in the world. Water-level change data in the form of tables, maps, and hydrographs all indicate that the Grand Prairie groundwater supply has been augmented by the development of the navigation pools on the Arkansas River. The difference between the river stage elevation and the potentiometric surface of the groundwater system creates a hydraulic gradient in which water flows from the river to the MRV alluvial aquifer. The water moves into the aquifer through riverbank storage and floodplain percolation, then flows down-gradient toward the center of the cone of depression in the Grand Prairie near Stuttgart and DeWitt.

Wetlands may best be understood to be a natural expression of a high water table, often in an area where the surface material is of low permeability. The role of wetlands as a source of groundwater recharge is minor compared to other factors in the overall water budget. In one wetland study in the Cache River Basin, groundwater flow was a minor component of the water budget, accounting for less than one percent of both inflow and outflow (Gonthier and Kleiss 1996).

4.0 SOCIO-ECONOMIC CHARACTERISTICS

The socio-economic characteristics of the EAWRPR include demographics, income, employment, and industries. This section describes these characteristics and presents changes in these regional characteristics since the 1990 AWP update. In addition, the wastes generated by the communities and industries in the EAWRPR are characterized. These wastes must be properly managed to protect water quality in the EAWRPR.

4.1 Demographics

Demographic information from the 2010 US census for the counties within the EAWRPR are presented below. Demographic data presented include population totals, the percentages of people living in urban and rural areas, above or below selected ages, and of different races. Information from the 2010 census is compared to information from the 1990 census, to identify population changes that have occurred since the 1990 AWP update. Although the 1990 AWP update reported population data from the 1980 census, the 1990 census data better represents conditions at the time of the previous update. Population changes affect the need and demand for water resources, not just for drinking water, but also for recreation, food supply, irrigation, and aesthetics. Population demographics also affect the potential tax base to pay for water infrastructure upgrades, expansion, and repairs.

4.1.1 2010 Population

Population data from the 2010 census for the counties within the EAWRPR are summarized in Table 4.1 and mapped in Figure 4.1. The population of the EAWRPR in 2010 was just over one million. Pulaski and Craighead counties had the highest 2010 populations.

Table 4.1. County populations in EAWRPR from 2010 and 1990 census (US Census Bureau 2012a, U of A at Little Rock Institute for Economic Advancement 2002).

	Total Population			Percent Urban Population		
County	**1990**	**2010**	**Change 1990 to 2010 (%)**	**1990+**	**2010**	**Change in percent urban population 1990 to 2010**
Arkansas	21,653	19,019	-12%	64.0%	65.3%	1.2
Ashley*	24,319	21,853	-10%	50.4%	48.3%	-2.1
Chicot	15,713	11,800	-25%	65.7%	45.7%	-20.
Clay	18,107	16,083	-11%	37.7%	41.1%	3.4
Craighead	68,956	96,443	40%	61.3%	67.8%	6.5
Crittenden	49,939	50,902	2%	77.0%	79.1%	2.1
Cross	19,225	17,870	-7%	41.8%	43.2%	1.3
Desha	16,798	13,008	-23%	63.9%	68.6%	4.7
Drew*	17,369	18,509	7%	46.8%	51.4%	4.6
Greene	31,804	42,090	32%	50.7%	58.5%	7.8
Jackson	18,944	17,997	-5%	42.0%	34.9%	-7.1
Jefferson*	85,487	77,435	-9%	69.5%	69.1%	-0.4
Lawrence*	17,457	17,415	0%	37.8%	36.4%	-1.4
Lee	13,053	10,424	-20%	43.5%	36.5%	-7.0
Lincoln	13,690	14,134	3%	0%	0%	0
Lonoke	39,268	68,356	74%	36.6%	55.2%	18.6
Mississippi	57,525	46,480	-19%	69.5%	63.7%	-5.8
Monroe	11,333	8,149	-28%	36.1%	31.0%	-5.1
Phillips	28,838	21,757	-25%	59.7%	52.0%	-7.7
Poinsett	24,664	24,583	0%	37.4%	28.9%	-8.5
Prairie	9,518	8,715	-8%	0%	0%	0
Pulaski*	349,660	382,748	9%	87.9%	87.7%	-0.2
St. Francis	28,497	28,258	-1%	48.3%	48.4%	0.1
White*	54,676	77,076	41%	40.2%	45.7%	5.5
Woodruff	9,520	7,260	-24%	27.0%	0%	-27.0
Total	1,046,013	1,118,364	7%	64.7%	65.6%	0.9

*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).

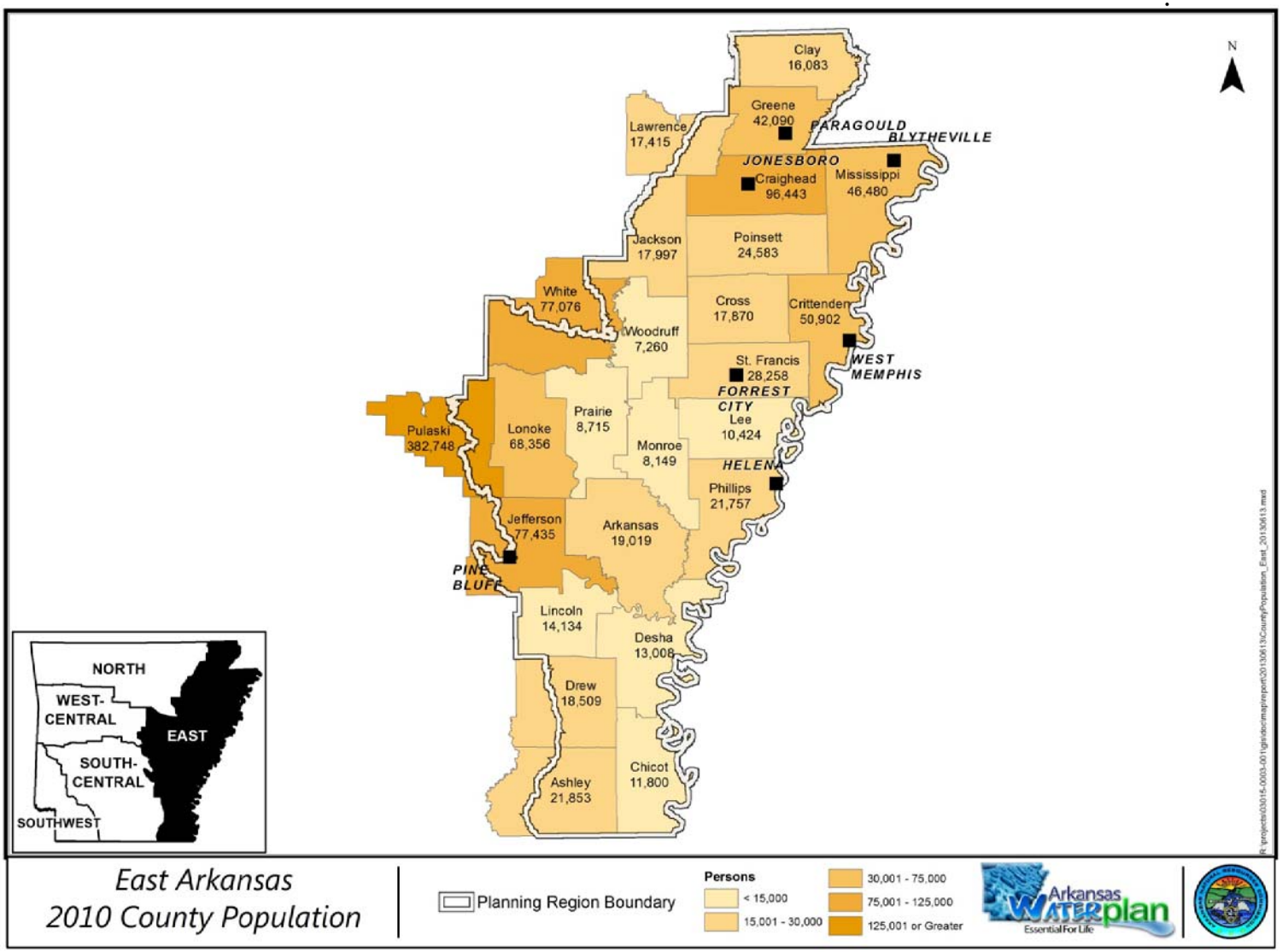

Figure 4.1. Population totals from the 2010 census for counties in the EAWRPR (US Census Bureau 2012a)

Parts of two Large Metropolitan Statistical Areas are located within the EAWRPR; Memphis, and Little Rock-North Little Rock-Conway (Figure 4.2) (US Census Bureau 2012b). Large Metropolitan Statistical Areas are geographic regions, defined by the US Office of Management and Budget, where an area of high population density has close economic ties. There are four Urbanized Areas identified in the 2010 census that are located in the EAWRPR; Pine Bluff, Little Rock, West Memphis, and Jonesboro (Figure 4.2). These are areas with population of at least 50,000 people at a density of 1,000 to 500 people per square mile (US Census Bureau 2011a). In addition, 23 areas within the planning region were identified as Urban Clusters in the 2010 census (Figure 4.2). Urban Clusters are areas with population densities of 500 to 1,000 people per square mile, which contain a total of 25,000 to 50,000 people (US Census Bureau 2011a, 2012a). The majority of the population in the EAWRPR (66%) lives in urban areas (Table 4.1). The percentage of the county population living in rural areas varies from 100% in Lincoln, Prairie, and Woodruff Counties, to 21% in Crittenden County (Table 4.1) (US Census Bureau 2012a).

Demographic data on race for the counties within the EAWRPR are summarized in Table 4.2. The racial make-up of the population is primarily white non-Hispanic (65%), black non-Hispanic (29%), and Hispanic (4%). Other races each account for 1% or less of the population. Demographic data on age, sex, and education level for the counties within the EAWRPR are summarized in Table 4.3. The majority of the population in this region is between the ages of 18 and 65, 23% of adults are high school graduates, and 13% have college degrees.

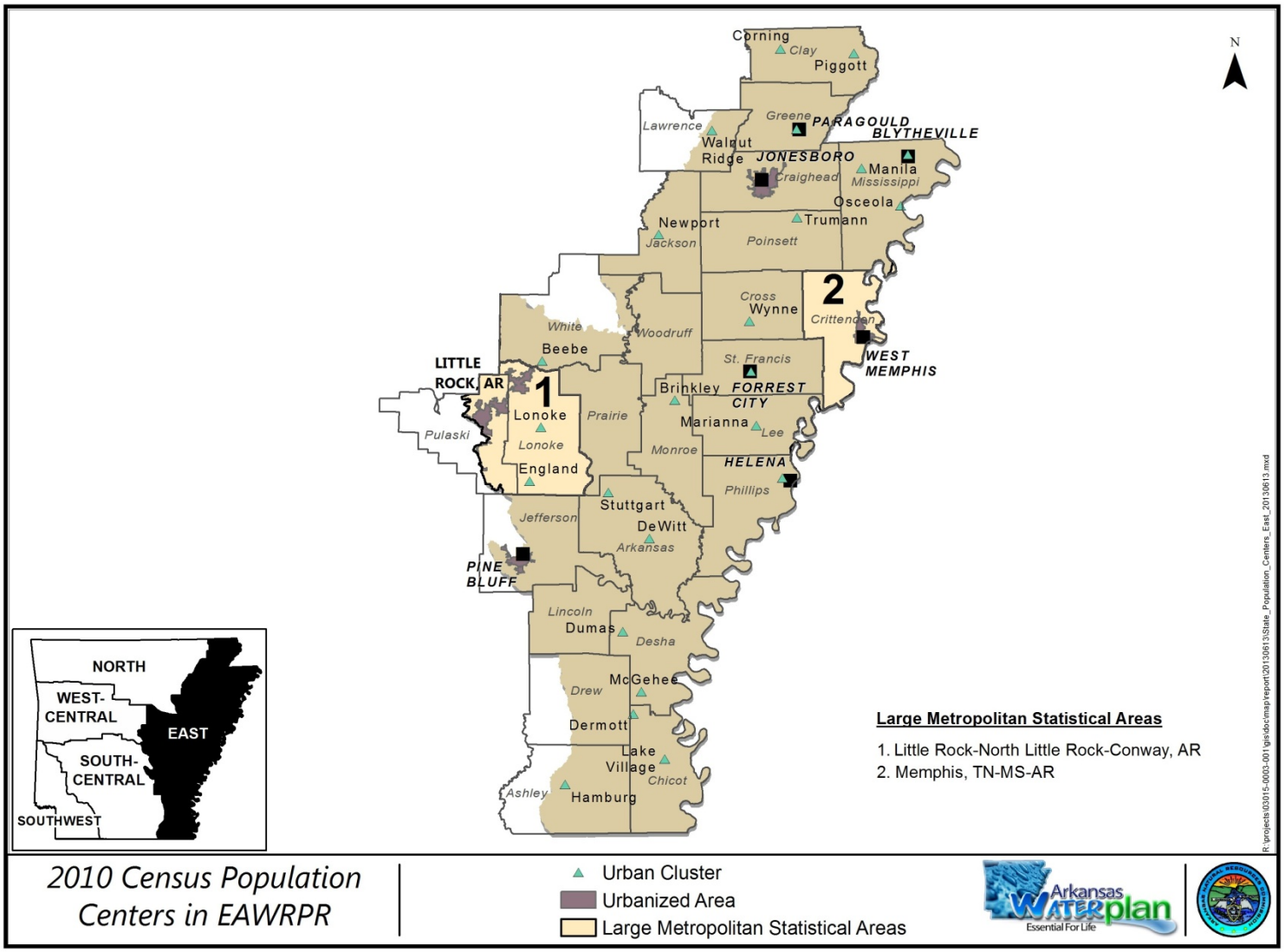

Figure 4.2. 2010 population centers located in the EAWRPR (US Census Bureau 2012a)

Table 4.2. 2010 demographic summary for counties in EAWRPR (US Census Bureau n.d.a).

County	White Non-Hispanic	Black	Hispanic	Asian	American Indian	Pacific Islander	Other Single Race	Multiple Race
Arkansas	13,659	4,661	513	92	36	2	320	249
Ashley*	15,143	5,640	1,069	40	70	3	709	248
Chicot	4,864	6,381	542	55	23	4	381	92
Clay	15,682	56	217	20	42	1	80	202
Craighead	78,323	12,640	4,277	1,075	342	29	2,339	1,695
Crittenden	23,446	26,051	1,014	301	135	8	404	557
Cross	13,495	3,972	266	83	47	3	83	187
Desha	6,230	6,216	578	42	35	2	364	118
Drew*	12,739	5,144	454	95	43	5	270	213
Greene	40,578	233	901	108	209	7	390	565
Jackson	14,363	3,000	436	53	91	16	205	269
Jefferson*	32,507	42,639	1,219	601	213	9	529	937
Lawrence*	16,952	137	158	22	63	4	32	205
Lee	4,381	5,761	168	41	49	2	69	121
Lincoln	9,407	4,223	452	27	38	1	298	140
Lonoke	61,353	4,075	2,246	532	363	32	766	1,235
Mississippi	28,653	15,817	1,695	233	136	3	943	695
Monroe	4,584	3,330	132	36	29	0	74	96
Phillips	7,618	13,719	287	67	51	1	95	206
Poinsett	22,089	1,775	543	45	59	4	281	330
Prairie	7,529	1,064	81	6	26	0	10	80
Pulaski*	220,051	133,858	22,168	7,505	1,555	272	11,646	7,861
St. Francis	12,502	14,667	1,149	136	148	9	386	410
White*	70,425	3,074	2,879	419	449	36	1,259	1,414
Woodruff	5,075	1,994	87	15	18	5	49	104
Total	741,648	320,127	43,531	11,649	4,270	458	21,982	18,229
Percentage	66%	29%	4%	<1%	<1%	<1%	2%	2%

*Part of this county is in another planning region.

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

County	Total female population	Total population under 18 years	Total population over 65 years	High School graduates	College graduates
Arkansas	9,799	4,425	3,115	5,276	1,705
Ashley*	11,255	5,330	3,544	6,573	1,855
Chicot	6,007	2,724	2,149	3,300	1,068
Clay	8,212	3,590	3,220	4,641	1,048
Craighead	49,366	24,141	11,740	20,479	14,102
Crittenden	26,736	14,809	5,477	10,940	4,195
Cross	9,249	4,494	2,759	5,547	1,457
Desha	6,905	3,377	1,970	3,506	1,164
Drew*	9,524	4,361	2,735	4,349	2,339
Greene	21,448	10,590	6,034	12,086	3,351
Jackson	9,067	3,734	2,856	5,803	1,011
Jefferson*	39,368	18,428	10,255	19,182	8,515
Lawrence*	8,947	3,992	3,160	4,957	1,098
Lee	4,618	2,160	1,607	3,021	476
Lincoln	5,633	2,743	1,758	3,978	874
Lonoke	34,727	18,831	7,625	15,218	7,473
Mississippi	23,982	13,104	5,685	10,982	3,682
Monroe	4,254	1,840	1,541	1,925	772
Phillips	11,627	6,113	3,254	4,251	1,683
Poinsett	12,646	5,959	3,900	6,979	1,563
Prairie	4,401	1,878	1,717	2,854	614
Pulaski*	198,810	92,185	45,908	69,368	79,162
St. Francis	12,865	6,677	3,447	7,220	1,920
White*	39,274	18,433	10,848	18,146	8,892
Woodruff	3,808	1,672	1,293	2,261	492
Total	572,528	275,590	147,597	252,842	150,511
Percentage	51%	25%	13%	23%+	13%+

*Part of this county is in another planning region.

+Percentage based on population 18 years of age or older

4.1.2 Changes from 1990

The population of the EAWRPR increased by 7% between the 1990 and 2010 census (Table 4.1). In 1990, Pulaski and Jefferson counties had the greatest total populations in the region. Fifteen of the 36 counties within the EAWRPR experienced population declines between 1990 and 2010 (Figure 4.3). Declines ranged from 1% in St. Francis County to 28% in Monroe County. Poinsett County did not experience a significant change in total population. The remaining counties in the EAWRPR experienced population increase between 1990 and 2010, ranging from 2% in Crittenden County to 74% in Lonoke County (Table 4.1). Population growth in Lonoke County is the result of growth of several of its northern cities as bedroom communities of the Little Rock metropolitan area and the Little Rock Air Force Base (McGraw 2013).

4.2 Income and Employment

Income and employment data are available by county from the US Census Bureau. Recent data are presented below to characterize the current income and employment levels within the EAWRPR. Data from 1990 are also presented for comparison, to provide insight into changes that have occurred in the region since the 1990 AWP update.

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 counties in the EAWRPR are shown in Table 4.4. The average median income in the region is $34,356, less than the state-wide median household income of $40,149 (US Census Bureau n.d.b). This region has the lowest per capita personal income in the state. Counties within the EAWRPR have some of the lowest median household incomes in the state, including Chicot County, which has the lowest median household income in the state, $23,954. However, Lonoke County has the third highest median household income in the state, and Pulaski County has the sixth highest.

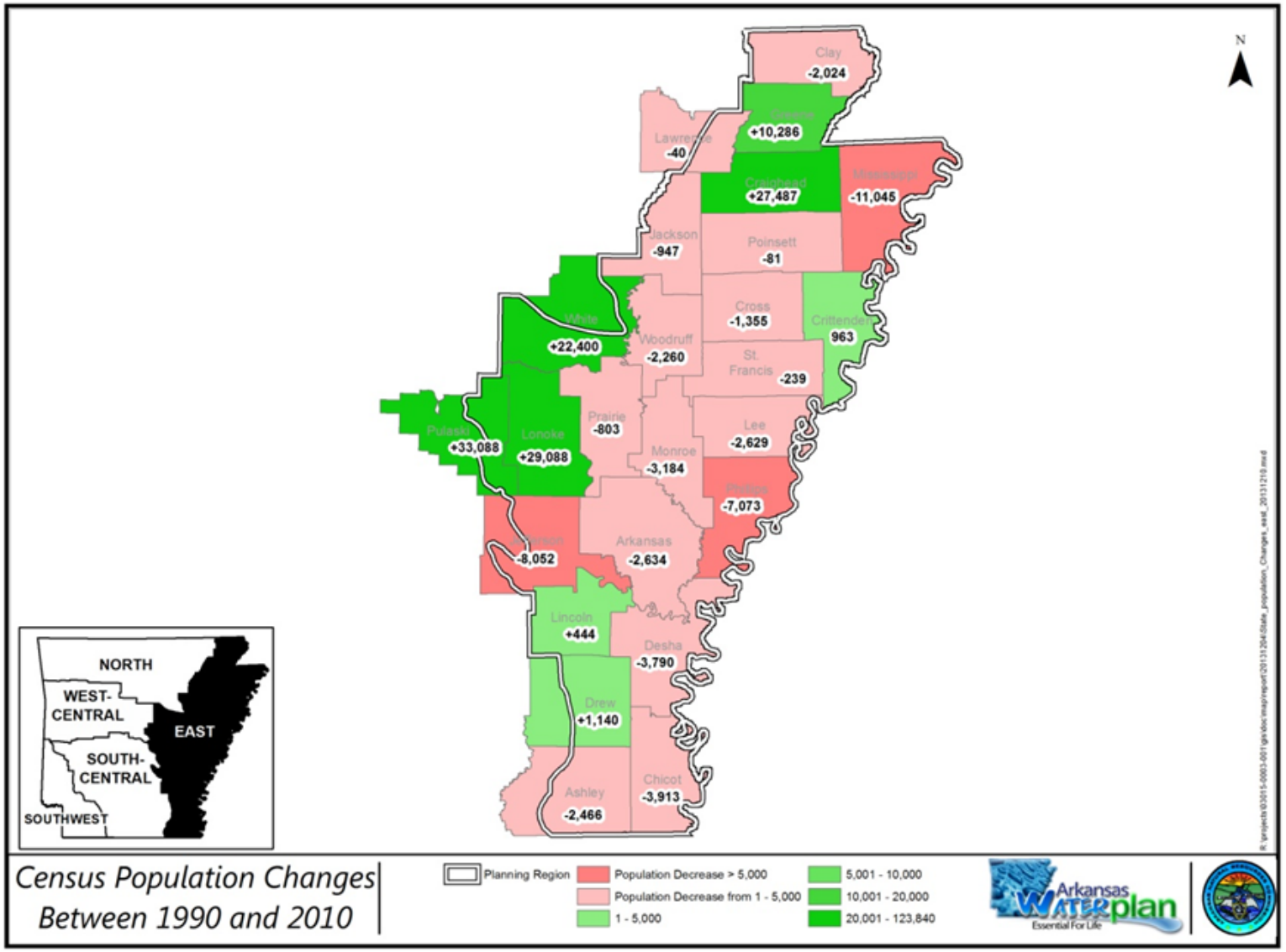

Figure 4.3 Population change from 1990 to 2010 in the EAWRPR.

Table 4.4 Income and employment characteristics for counties in the EAWRPR (US Census Bureau n.d.b).

County	Median household income		Families with income below poverty level		Population below poverty level		Unemployment	
	1989	2007 - 2011	1990	2007 – 2011	1990	2007 – 2011	1990	2007 – 2011
Arkansas	$19,516	$38,986	15.7%	12.3%	20.4%	18.2%	4.6%	7.6%
Ashley*	$20,609	$35,657	17.4%	16.1%	20.9%	17.9%	5.9%	9.7%
Chicot	$12,680	$23,954	32.3%	25.5%	40.4%	32.5%	10.3%	10.7%
Clay	$16,219	$35,410	16.1%	12.7%	21.2%	17.8%	6.9%	13.0%
Craighead	$22,150	$40,221	13.1%	16.1%	17.0%	20.3%	5.7%	8.7%
Crittenden	$20,948	$35,264	21.3%	23.1%	27.1%	27.9%	7.3%	12.7%
Cross	$19,049	$38,432	21.3%	12.6%	25.4%	16.7%	8.3%	8.8%
Desha	$15,719	$30,786	27.3%	19.9%	34.0%	23.8%	10.3%	12.6%
Drew*	$18,906	$32,038	20.2%	19.3%	24.2%	25.0%	8.7%	11.8%
Greene	$19,940	$39,090	13.6%	12.7%	17.9%	15.8%	6.8%	8.0%
Jackson	$16,641	$31,352	21.4%	20.0%	26.6%	25.1%	11.3%	12.2%
Jefferson*	$21,322	$37,682	19.3%	17.3%	23.9%	22.9%	8.9%	14.1%
Lawrence*	$15,337	$32,337	20.6%	19.0%	25.0%	23.3%	10.6%	9.2%
Lee	$11,949	$25,270	39.1%	24.5%	47.3%	28.7%	11.6%	17.7%
Lincoln	$18,457	$31,480	19.6%	18.1%	26.2%	23.9%	7.6%	10.8%
Lonoke	$23,831	$51,096	14.6%	10.7%	14.9%	13.4%	5.9%	7.2%
Mississippi	$18,522	$34,267	20.8%	21.2%	26.2%	26.1%	9.3%	12.6%
Monroe	$13,633	$28,306	29.1%	21.4%	35.9%	25.4%	7.5%	10.2%
Phillips	$13,071	$28,225	34.8%	26.1%	43.0%	31.6%	11.0%	17.7%
Poinsett	$16,858	$31,939	20.8%	21.7%	25.6%	26.0%	9.6%	12.9%
Prairie	$17,044	$36,194	19.2%	13.4%	22.7%	17.2%	6.4%	5.2%
Pulaski*	$26,883	$45,897	10.5%	12.5%	14.1%	16.7%	5.4%	8.1%
St. Francis	$15,029	$26,360	30.8%	25.2%	36.6%	29.7%	11.6%	13.2%
White*	$19,722	$41,618	14.7%	12.5%	18.7%	16.4%	9.6%	7.4%
Woodruff	$14,024	$27,047	28.3%	19.9%	34.5%	23.1%	10.3%	9.6%
Average	**$17,309**	**$34,356**	**21.7%**	**18.2%**	**26.8%**	**22.6%**	**8.5%**	**10.9%**

*Part of this county is in another planning region.

The 2007-2011 ACS shows that counties in the EAWRPR have some of the highest percentages of families and population with income below poverty level. The average percentage of families with income below poverty level in these counties is 18.2%, but county values range from 10.7% in Lonoke County to 26.1% in Phillips County. The percentage of families with income below poverty level for Arkansas as a whole is 13.8%. The average percentage of county

population with income below poverty level is 22.6%, with values ranging from 13.4% in Lonoke County to 32.5% in Chicot County. The percentage of Arkansas population with income below poverty level is 18.4% (US Census Bureau n.d.a). All of the counties in this planning region, except Pulaski County, are classified as economically distressed (Delta Regional Authority 2013a). Unemployment is higher in this planning region than in the rest of the state, and the unemployment rates for all of the counties in the EAWRPR are higher than the overall state unemployment rate of 5% 149 (US Census Bureau n.d.b).

4.2.2 Changes in Income and Employment from 1990

Information on income and employment from the 1990 census (1989 data) for the counties in the EAWRPR is included in Table 4.4. This information indicates that the income characteristics of this region have not changed significantly over the past two decades. The average median income in the EAWRPR in 1989 was less than the state-wide median income of $21,147. In 1989, counties within the EAWRPR had some of the lowest median household incomes in the state, with Lee County having the lowest median household income in Arkansas. The 1989 median household income in Pulaski County was the second highest in the state, and Lonoke County had the sixth highest 1998 median household income in the state. Counties within the EAWRPR also had the highest percentages of families and people with incomes below the poverty level, and unemployment in 1990. Median incomes have increased since 1990, and there have been slight reductions in percentages of families and population with incomes below the poverty level. However, the unemployment rate has increased since 1990.

4.3 Economic Drivers

The EAWRPR is the primary crop-growing area of the state, and has been since statehood. The economy of the region is dependent upon agriculture and agriculture-related industries. Crop irrigation is the largest water user in the state (Holland 2007). As a result, water resources are very important to the economy of this region. There have not been significant changes in the regional economic landscape since the 1990 AWP update.

4.3.1 Current Regional Economic Drivers

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 EAWRPR in the 2007 economic census is summarized in Figure 4.4. Manufacturing and wholesale trade are the economic sectors with the greatest value of sales and receipts in the region. Note that Pulaski County contributes 30% to 80% of the totals shown in Figure 4.4.

The number of people employed in the EAWRPR by economic sectors, as reported in the 2007-2011 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, retail trade, and manufacturing provide the majority of employment in the EAWRPR. It should be noted that, in these three economic sectors, Pulaski County accounts for at least one-third of the reported totals. Despite its economic importance to the region, less than 5% of the civilian workforce in the counties within the EAWRPR is engaged in farming.

Crop agriculture is the largest industry in the EAWRPR. Tourism also contributes significantly to the regional economy. In addition to the agriculture economic sector, crop agriculture generates revenue in the manufacturing, real estate, wholesale trade, and transportation and warehousing economic sectors, and generates jobs in all of the economic sectors shown in Figure 4.5 (U of A Divison of Agriculture 2012). Tourism generates revenue and jobs in many economic sectors, including recreation, accommodation and food services, retail trade, and real estate. Transport of commodities on the Arkansas and White Rivers 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 EAWRPR are discussed in detail in the following sections.

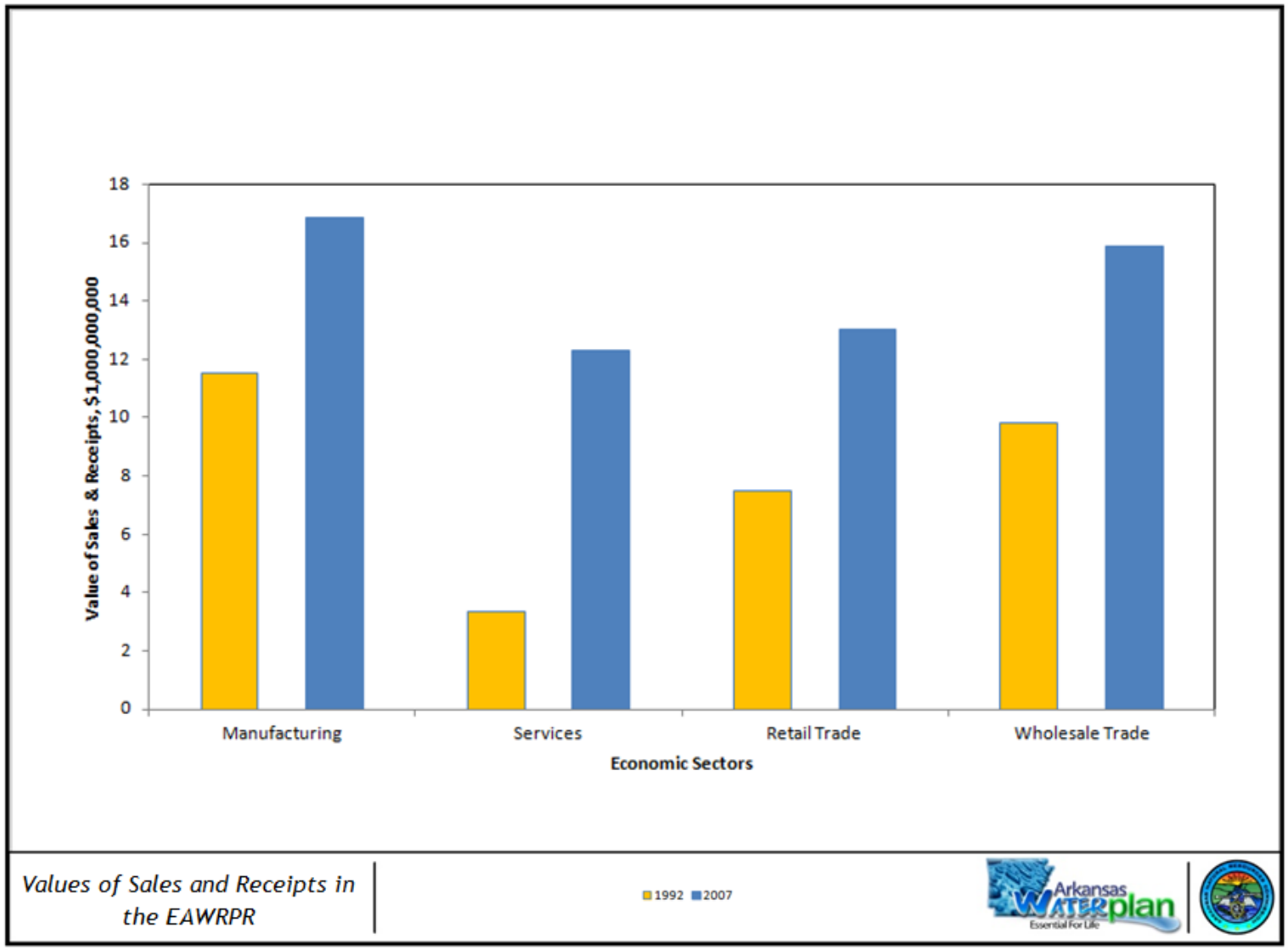

Figure 4.4. Value of sales and receipts in the EAWRPR (US Census Bureau 1993, 2011b).

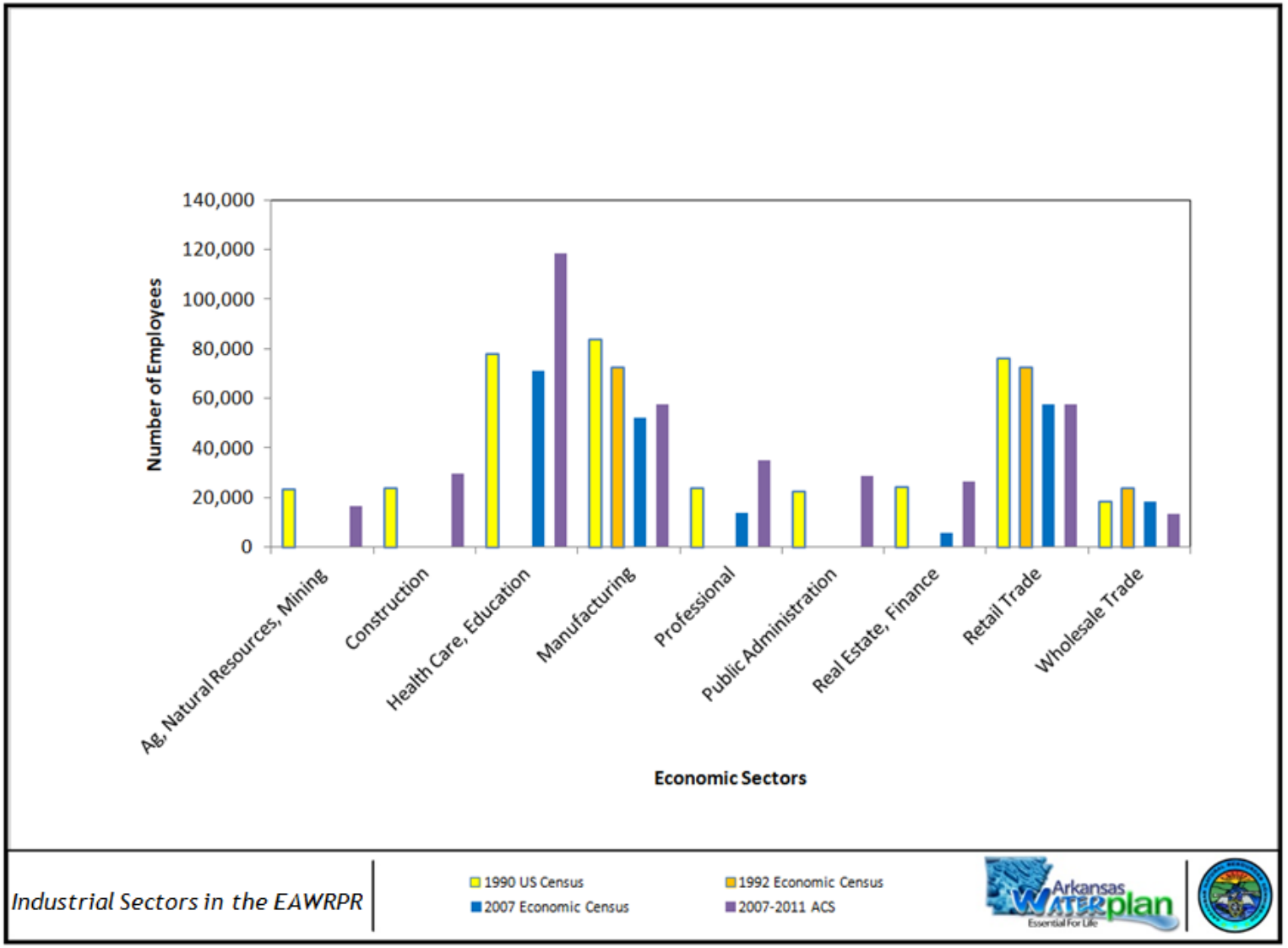

Figure 4.5. Employment by industrial sectors in the EAWRPR (US Census Bureau n.d.b, 2011b, University of Arkansas at Little Rock Institute for Economic Advancement 2002)

4.3.1.1 Agriculture

The predominant crops grown in the EAWRPR region include rice, cotton, corn, and soybeans. Arkansas is the country's largest producer of rice, and 96% of Arkansas rice is grown in this planning region. Arkansas is also third in the nation for cotton production, 94% of which is produced in this planning region (Arkansas Farm Bureau 2012, 2013, USDA National Agricultural Statistics Service 2007). The production of soybeans, rice, wheat, corn, grain sorghum, oats, and cotton, the majority of which are grown in this region (ranging from 70% of oats to 96% of rice), account for 35% of the economic contribution of crop production to the state economy. Processing of crops contributes almost twice as much as crop production to the state economy (U of A Divison of Agriculture 2012, USDA National Agricultural Statistics Service 2009). In 2007, approximately 68% of the cropland in the planning region was irrigated, primarily using groundwater (USDA National Agricultural Statistics Service 2009).

Aquaculture is also a major revenue generator and economic driver in the EAWRPR. Arkansas ranks second among aquaculture states, and is the nation's largest producer of baitfish, largemouth bass for stocking, hybrid striped bass fry, and Chinese carp; and third in the nation for catfish production. Aquaculture facilities in the planning region also produce crawfish, shrimp, prawns, turtles, and ornamental fish, such as goldfish and koi (Engle 2012). Catfish sales accounted for two-thirds of the reported fish sales revenue in the planning region in 2007. The majority of Arkansas aquaculture facilities and production are located in the EAWRPR (Table 4.5) region (Arkansas Farm Bureau 2012, 2013, USDA National Agricultural Statistics Service 2007). Aquaculture ponds in the EAWRPR are supplied almost exclusively by groundwater (USDA National Agricultural Statistical Service 2006).

Table 4.5 Fish production in the EAWRPR counties (US Department of Commerce 1994, USDA National Agricultural Statistics Service 2009).

	Fish Sales ($1,000)				Fish Farms (number)		
County	1987	1992	2007	Catfish 2007	1987	1992	2007
Arkansas	$138	$2,010	D	D	3	11	3
Ashley*	D	$3,808	$8,526	$8,522	10	10	14
Chicot	$4,790	$9,231	$43,153	$43,139	25	23	72
Clay	D	D	D	D	7	5	3
Craighead	D	D	D	NR	7	4	2
Crittenden	NR	NR	NR	NR	NR	NR	0
Cross	D	$258	D	NR	4	7	1
Desha	NR	$620	$3,021	$2,391	NR	6	10
Drew*	NR	NR	D	D	NR	NR	1
Greene	D	$526	$7,993	$3,803	5	10	7
Jackson	D	$562	D	D	5	4	4
Jefferson*	Nr	NR	D	D	NR	NR	1
Lawrence*	69	D	D	D	7	3	1
Lee	NR	NR	D	D	NR	NR	7
Lincoln	$2,120	NR	$1,206	$1,206	5	NR	4
Lonoke	$1,681	$15,230	$20,736	$2,697	5	51	30
Mississippi	NR	NR	NR -	NR	NR	NR	0
Monroe	NR	300	$3,209	NR	NR	4	9
Phillips	NR	NR	NR -	NR	NR	NR	0
Poinsett	D	$1,018	$209	$158	20	20	6
Prairie	D	$4,431	$4,952	D	5	20	14
Pulaski*	NR	NR	D	D	NR	NR	3
St. Francis	NR	NR	D	D	NR	NR	2
White*	D	$296	$769	$433	4	11	7
Woodruff	$14	$50	D	D	4	7	3
Total[+]	$8,812	$38,340	$93,774	$62,349	116	196	204
State total	$28,647	$44,394	$118,744	$78,133	270	251	248

* part of this county is included in another Water Resources Planning Region
D=data withheld to protect privacy
NR=not reported

4.3.1.2 Tourism

Tourism is the second-largest industry in Arkansas. The EAWRPR offers a variety of tourism and recreation opportunities, making this industry an economic driver for the region. Water resources are an important element of attractions in this region, including 20 public lakes for swimming, fishing, and boating; 19 state parks; the St. Francis National Forest; 33 wildlife management areas; 19 natural areas; 5 National Wildlife Refuges; and the MKARNS. ADEQ has designated 97.6 miles of streams in the planning region as Extraordinary Resources Waterbodies for "scenic beauty, aesthetics, …broad scope recreation potential, and intangible social values" (Figure 4.6) (APCEC 2011). The Arkansas Department of Parks and Tourism reports that, in 2012, over $836 million of travel expenditures were made in the counties within the EAWRPR, and tourism generated over $66 million in tax revenue (Table 4.6). Note that Pulaski County data are excluded from these totals because the majority of tourism in Pulaski County is associated with Little Rock.

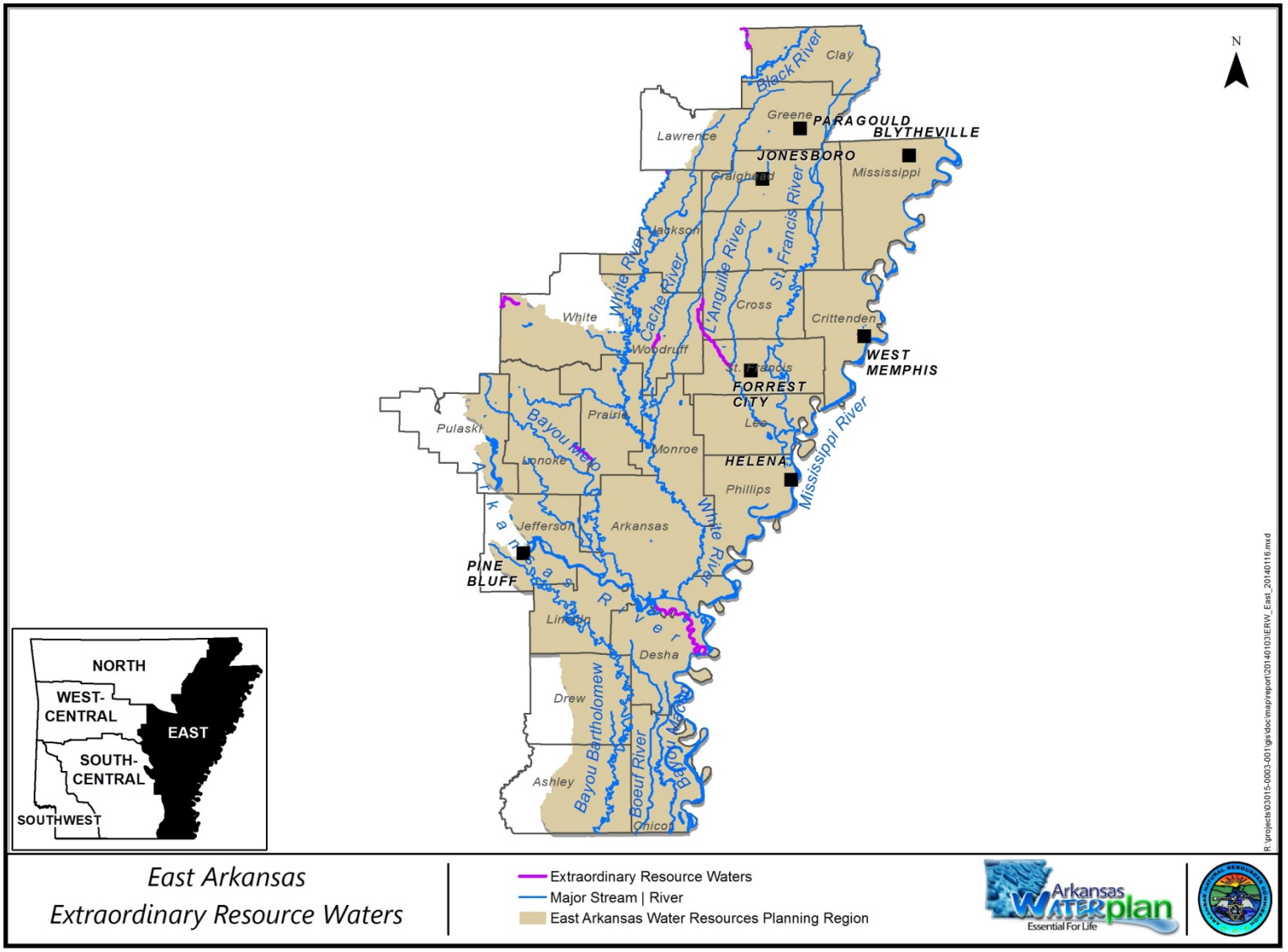

Figure 4.6 Extraordinary Resource Waters within the EAWRPR (APCEC 2011).

Table 4.6. Tourism and its economic impact in the counties of the EAWRPR (Arkansas Department of Parks and Tourism 1991, 2012)

County	Visitors		Total expenditures		State tax revenue		Local tax revenue		Jobs		Payroll	
	1990	2012	1990	2012	1990	2012	1990	2012	1990	2012	1990	2012
Arkansas	100,075	135,721	$14,016,555	$31,625,454	$658,778	$1,929,845	$168,199	$691,167	292	306	$2,536,997	$5,087,247
Chicot	35,294	48,303	$5,092,420	$11,453,727	$239,344	$699,790	$61,109	$236,276	106	132	$921,728	$2,322,578
Clay	35,936	53,291	$4,612,981	$12,955,075	$216,810	$788,469	$55,356	$321,530	96	118	$834,950	$1,989,545
Craighead	306,863	371,298	$44,679,496	$85,909,632	$2,099,936	$5,298,599	$536,154	$1,412,605	930	1,039	$8,086,989	$16,707,996
Crittenden	440,096	635,164	$60,608,494	$146,760,837	$2,848,599	$9,202,922	$727,302	$2,677,919	1,261	1,709	$10,970,137	$26,602,491
Cross	33,235	57,788	$4,804,242	$13,200,213	$225,799	$809,561	$57,651	$251,252	100	142	$869,568	$2,360,521
Desha	81,237	93,783	$11,035,830	$21,049,408	$518,684	$1,290,150	$132,430	$393,730	230	250	$1,997,485	$3,821,022
Drew*	70,154	95,329	$10,159,056	$22,235,266	$477,476	$1,367,912	$121,909	$402,649	211	282	$1,838,789	$4,236,627
Greene	29,980	90,447	$4,168,942	$20,671,926	$195,940	$1,259,164	$50,027	$441,222	87	248	$754,578	$3,807,174
Lee	9,497	11,205	$1,256,054	$3,485,118	$59,035	$212,334	$15,073	$97,850	26	34	$227,346	$499,153
Mississippi	376,004	409,584	$53,331,375	$91,384,478	$2,506,575	$5,621,897	$639,977	$1,827,062	1,110	1,156	$9,652,979	$19,408,644
Monroe	166,358	108,754	$23,363,832	$26,272,514	$1,098,100	$1,609,156	$280,366	$478,547	486	292	$4,228,854	$4,498,702
Phillips	95,556	120,960	$13,353,819	$29,112,641	$627,629	$1,795,890	$160,246	$632,197	278	289	$2,417,041	$4,821,137
Poinsett	53,640	51,836	$7,923,924	$11,311,595	$372,424	$719,725	$95,087	$204,757	165	82	$1,434,230	$1,366,431
St. Francis	164,223	158,427	$22,438,900	$36,924,745	$1,054,628	$2,300,188	$269,267	$739,961	467	390	$4,061,441	$6,492,622
Jackson	59,871	57,980	$8,430,287	$13,555,407	$396,223	$838,913	$101,163	$246,526	175	141	$1,525,882	$2,319,360
Lawrence*	100,511	54,949	$14,176,492	$12,892,326	$666,295	$799,970	$170,118	$289,655	295	122	$2,565,945	$1,913,952
White*	123,560	200,637	$18,063,196	$47,956,518	$848,970	$2,922,023	$216,758	$822,898	376	526	$3,269,439	$8,042,399
Woodruff	6,938	19,848	$1,071,569	$5,625,179	$50,364	$344,518	$12,859	$154,095	22	44	$193,954	$755,590
Lonoke	134,376	129,247	$19,262,937	$31,765,943	$905,358	$1,955,527	$231,155	$550,714	401	299	$3,486,592	$5,443,886
Prairie	5,249	18,012	$665,816	$4,237,167	$31,293	$268,364	$7,990	$97,170	14	43	$120,513	$642,570
Jefferson*	357,784	442,069	$49,703,500	$110,788,911	$2,336,065	$6,163,996	$596,442	$2,252,045	1,034	1,308	$8,996,334	$20,900,407
Lincoln	9,540	15,634	$1,270,450	$3,851,322	$59,711	$241,530	$15,245	$81,623	26	28	$229,951	$539,645
Ashley*	77,060	121,243	$10,797,773	$27,910,389	$507,495	$1,688,524	$129,573	$581,887	225	322	$1,954,397	$5,322,679
Total	2,873,037	3,501,509	$404,289,952	$822,937,781	$19,003,543	$50,128,967	$4,851,456	$15,885,337	10,425	11,292	$73,176,119	$149,902,378

* Part of this county is in another planning region.
Note: Highlighted counties are involved in the Rural Heritage Development Initiative.

Hunting, fishing, and wildlife watching account for a significant portion of the tourism economy of the EAWRPR. In 2011, Arkansas ranked seventh in the nation in hunting-related sales, and more mallard ducks were harvested in Arkansas than any other state (AGFC 2013b). Stuttgart, in Arkansas County, is the "Duck Capital of the World." Economic contributions from wildlife recreation in Arkansas are summarized in Table 4.7. Regional data are not available. Mack's Prairie Wings, a waterfowl outfitter, and Rich n Tone Duck Calls are two national leaders in the waterfowl hunting industry that are headquartered in Stuttgart.

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
NR=not reported

The USACE has estimated economic impacts of recreational use of the Arkansas River navigation pools located in the EAWRPR. Overall, recreation associated with the Arkansas River navigation system in the planning region generates 95 jobs, and over $17 million in revenue, wages, and taxes (Table 4.8).

Table 4.8 Economic benefits from USACE reservoirs in the surrounding 30 miles in the EAWRPR in 2012 (USACE 2011).

Reservoir	Total Sales	Jobs	Payroll	Visitor Spending
Norrell Lock (Pool 1)	$681,000	12	$257,000	$1,469,000
Lock 2 (Pool 2)	$3,939,000	68	$1,434,000	$7,871,000
Joe Hardin Lock (Pool 3)	$852,000	15	$307,000	$1,651,000
Total	**$5,472,000**	**95**	**$1,998,000**	**$10,991,000**

In 2006, the Rural Heritage Development Initiative was initiated in the 15 counties in eastern Arkansas linked by the Great River Road and Crowley's Ridge Parkway National Scenic Byways. One of the purposes of this program is to promote tourism in this area of the state, centered around the history, musical heritage, and natural resources of the region, including duck hunting and bird watching. In addition, this initiative promoted local business development, historic preservation, and branding of locally produced products (Rural Heritage Development Initiative 2008, Lake 2010). The Arkansas Department of Parks and Tourism reports that in 2012, over 2 million visitors to these 15 counties spent over $564 million, generating over $104 million in payroll, and $10 million in local taxes (Table 4.6) (Arkansas Department of Parks and Tourism 2012).

4.3.1.3 Waterborne Commodities Transportation

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). There are three inland waterways in the EAWRPR used to transport commodities into and out of the region, and the state; Mississippi River, MKARNS, and White River. There are six public ports and an additional 14 private terminals located on these waterways within the planning region (Figure 4.7).

Imports and exports of commodities reported for selected public Mississippi River ports and waterways located in the EAWRPR are listed in Table 4.9. The MKARNS accounts for the majority of commodity transportation in the planning region. In 2011, 8,161 thousand short tons of goods and materials passed through the lock and dam on the White River at the downstream end of the MKARNS (USACE Institute for Water Resources n.d.). The MKARNS is responsible for between $1 billion and $2 billion in trade transportation annually in Arkansas (Goss 2012).

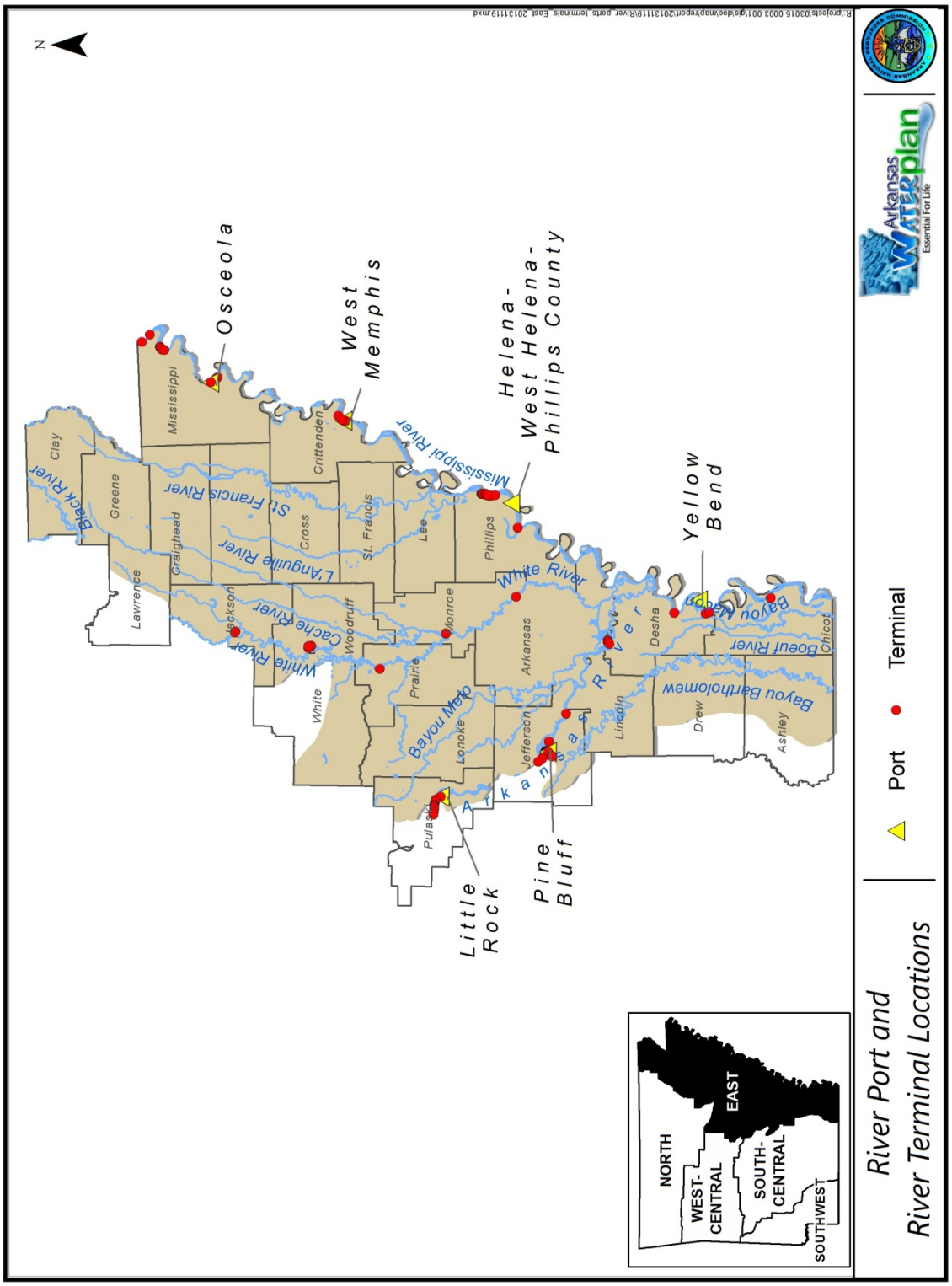

Figure 4.7. River port and river terminal locations.

Table 4.9 Tonnage of commodities transported through the EAWRPR reported for 2011 (USACE Institute for Water Resources 2011).

Port or System in EAWRPR	Import commodities	Import tonnage (1,000 short tons)	Export commodities	Export tonnage (1,000 short tons)
Helena	Fertilizer,	131	Fertilizer	2
	limestone	8	Grain and soybeans	1,294
	steel pipe	< 0.5	Manufactured goods	2
	Total	140	Total	1,298
Osceola	-	0	Grain, soybeans	409
MKARNS	Coal	123	Coal	278
	Petroleum products	324	Petroleum products	586
	Fertilizer	1,586	Fertilizer	293
	Sodium hydroxide	86	Ammonia	140
	Clay	93	Wood chips	47
	Sand, gravel, stone, rock	156	Sand, gravel, stone, rock	284
	Iron ore and scrap	22	Iron ore and scrap	767
	Other metal ore	32	Other metal ore	12
	Slag	2	Slag	81
	Other minerals	25	Other minerals	3
	Manufactured goods	900	Manufactured goods	71
	Grain	51	Grain	1,014
	Oil seeds	11	Oil seeds	1,147
	Animal feed	261	Animal feed	5
	Other Ag products	66	Machinery and other manufactured products	32
	Machinery and other manufactured products	4		
	Total	**3,743**	**Total**	**4,760**
St. Francis and L'Anguille Rivers and Blackfish Bayou	Fertilizer	3	-	0
White River below Batesville	Iron and steel scrap	1	-	0
Total		**7,629**		**12,525**

Waterborne transportation is important to crop agriculture in the planning region; the majority of the exported tonnage reported for 2011 (60%) consisted of grain and soybeans, and the majority of the imported tonnage (44%) consisted of fertilizer (Table 4.9). The steel industry in the planning region also utilizes waterborne transportation on the White River (iron and steel scrap) and Mississippi River, and sand and gravel mined in the planning region may be transported on the MKARNS.

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 included in the 1992 Value for Services (US Census Bureau 2011c). As in 2007, the economic sectors with the greatest value of sales and receipts in the region in 1992 were manufacturing and wholesale trade. It appears that all of the economic sectors have experienced expansion. The greatest increase appears to have occurred in the services economic sectors.

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, retail trade, and wholesale trade has declined slightly since the 1990 AWP update. Other economic sectors, such healthcare and education, construction, and public administration, 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

As noted in Section 3.5.1, there has been little change in the crops grown in the EAWRPR counties between 1987 and 2007 (Figure 4.8). In the 1987 Census of Agriculture, approximately 28% of the cropland in the planning region was irrigated (note that the amount of irrigated land was not reported for 10 of the 26 counties in 1987 to protect farmers' privacy) (US Department of Commerce Bureau of the Census 1989). Thus, there has been a significant increase in the amount of irrigated cropland between 1987 and 2007 (over 150%).

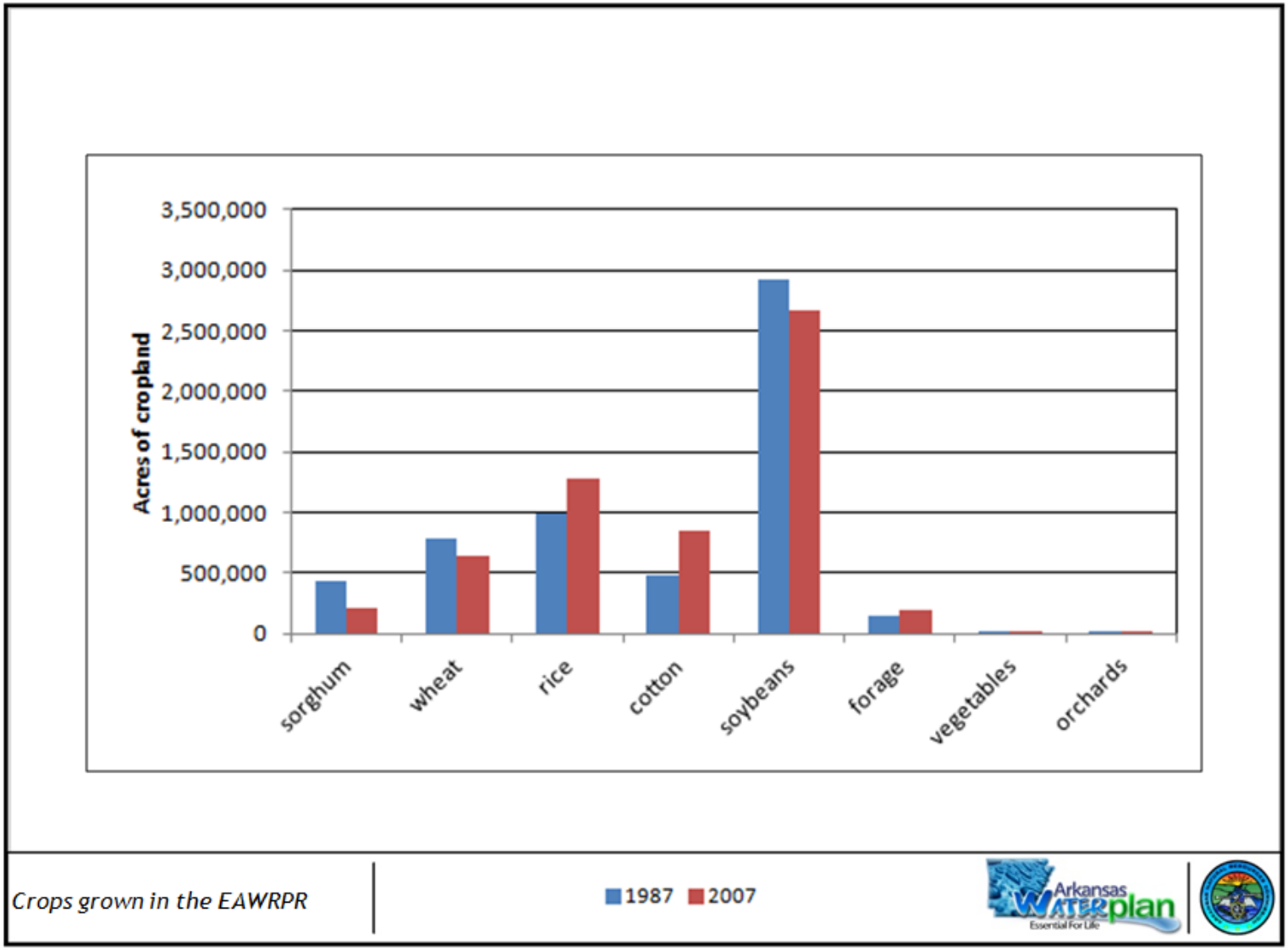

Figure 4.8. Crops grown in the EAWRPR (USDA National Agricultural Statistics Service 2009, US Department of Commerce 1994).

Table 4.5 includes information about aquaculture from the 1987 and 1992 agricultural census. Due to the fact that much of the information on fish production and sales in the agricultural census is not reported at the county level, it is uncertain whether the number of fish farms in the EAWRPR has increased or declined since 1990. For example, county data were reported only for catfish production in the 1987 agricultural census. In any case, revenues from fish sales do appear to have increased in the planning region since 1990. Statewide, catfish sales in 1987 accounted for only 42% of fish sales revenue, and baitfish sales accounted for 55%. Therefore, the proportion of fish sales revenue from catfish production has increased in the planning region since 1987. Aquaculture in the planning region is also more diverse today than in 1987. In 1987, revenues were reported only for catfish, trout, and "other fish" (US Department of Commerce Bureau of the Census 1989). In the 2007 census, revenue was reported also for "other food fish", baitfish, crustaceans, mollusks, sportfish, and ornamental fish (USDA National Agricultural Statistics Service 2009). Around 2002, farmers in the planning region began experimenting with growing marine shrimp (Green 2004). Ornamental fish production in the region has expanded since 1987 (Engle 2012).

4.3.2.2 Tourism

Overall, the number of visitors and the amount of the economic contribution of tourism in the EAWRPR has increased since 1990 (Table 4.6). Greene, Prairie, Lincoln, Ashley, and Woodruff Counties saw the largest increases in trips, visitors, and tourism revenue in the region. Several of the counties in the planning region had fewer visitors in 2013 than in 1990. In all of these counties, this decline resulted in a decline in tourism jobs, but not necessarily revenues (e.g., Lonoke County). 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

Data on waterborne commodity transportation on all of the waterways in the EAWRPR during 1990 was not readily available. However, data on shipping on the MKARNS in the 1990s was available. 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 (Table 4.9).

4.4 Waste Generation and Disposal

Industries and communities in the EAWRPR produce wastes that must be properly managed to protect water quality, which contributes to water availability for the water users of the EAWRPR. 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. Waste management in the EAWRPR is quantified below, along with changes in waste management that have occurred since the 1990 AWP update.

4.4.1 Solid Waste

There are four Regional Solid Waste Management Districts (RSWMDs), and portions of three RSWMDs, within the EAWRPR (Figure 4.9). Information on solid waste generation and disposal for each of these districts for 2010 is summarized in Table 4.10. For the most part, the RSWMDs report that their solid waste disposal facilities and collection services are sufficient to meet demand. However, illegal dumping that occurs in the districts could pose local threats to water quality (East Arkansas RSWMD 2011, Central Arkansas RSWMD 2011, White River RSWMD 2011, Southeast Arkansas RSWMD 2011, Northeast Arkansas RSWMD 2011, Craighead County RSWMD 2011, Mississippi County RSWMD 2011).

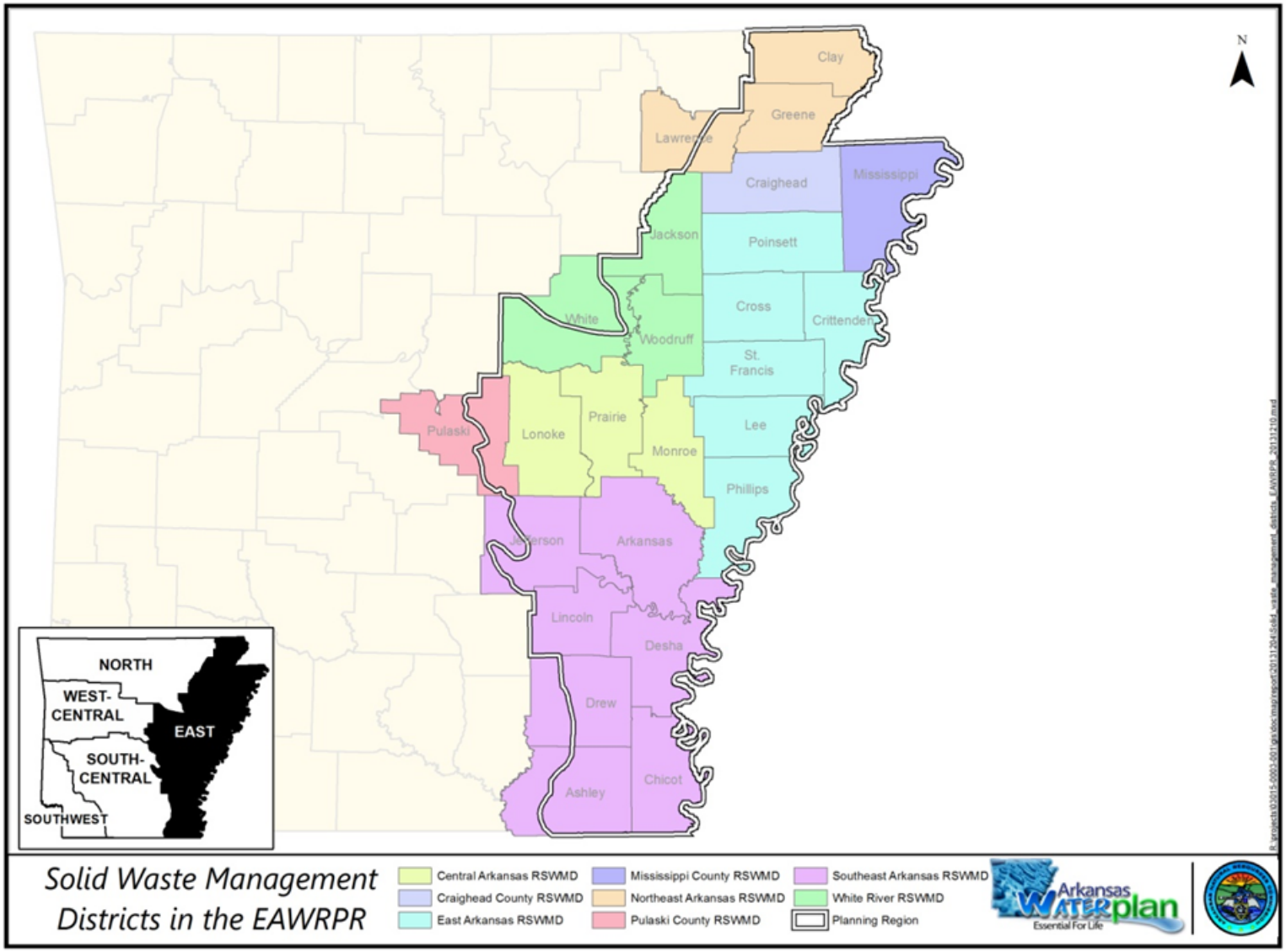

Figure 4.9 Regional Solid Waste Management Districts of the EAWRPR.

Table 4.10. 2010 solid waste generation and disposal information for RSWMDs in the EAWRPR.

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
Northeast	4	2		70,558		Not available
Craighead	1	1	1	101,055	101,055	Not available
Mississippi	1	1	1	22,269	22,269	2
East Arkansas	6	6	5	252,065	242,065	8
Central Arkansas	3	3	2	2,766,053	2,766,053*	0
White River	10	2 + 1 partial	1	127,845	101,794	12
Southeast Arkansas	10	4 + 3 partial	5	350,000*	340,000+	0

*estimated annual projection
+ 8,634 tons reportedly hauled out of district annually

There have been significant changes in the solid waste arena since 1990, driven by the need to protect water quality. In 1991, federal regulations changed, requiring improvements in the way landfills were constructed in order to protect groundwater quality. In addition, the new regulations required monitoring of groundwater quality around landfills (EPA 2012a, ADEQ 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.

4.4.2 Hazardous Waste

There are 201 permitted hazardous waste generators in the counties within the EAWRPR (Table 4.11). The majority of these facilities are located in Pulaski County. Seventy-one of the facilities in the counties within the EAWRPR are classified as large quantity generators, meaning they generate at least 1,000 kilograms of hazardous waste per month (EPA 2012b). One hundred thirty 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). Three of the 10 facilities in the state that generated the most hazardous waste in 2011 are located in the EAWRPR (EPA 2012d). There are also two hazardous waste treatment/storage/disposal facilities in the region; one in Lonoke County and one in Jefferson County (ADEQ 2012a).

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.

Table 4.11. Permitted hazardous waste generators in counties within the EAWRPR (ADEQ 2012a).

County	Large Quantity	Small Quantity
Arkansas	1	4
Ashley*	3	2
Chicot	0	0
Clay	0	1
Craighead	3	10
Crittenden	6	6
Cross	1	1
Desha	0	5
Drew*	2	2
Greene	4	4
Jackson	1	2
Jefferson*	5	10
Lawrence*	0	2
Lee	0	0
Lincoln	0	0
Lonoke	1	2
Mississippi	8	9
Monroe	0	0
Phillips	6	2

Table 4.11. Permitted hazardous waste generators in counties within the EAWRPR (continued).

County	Large Quantity	Small Quantity
Poinsett	0	3
Prairie	0	0
Pulaski*	24	56
St. Francis	0	0
White*	5	9
Woodruff	1	0
Total	71	130

*Part of this county is in another planning region.

4.4.3 Wastewater and Stormwater

There are around 2,000 point sources permitted to discharge wastewater and stormwater in the EAWRPR (Table 4.12). 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. See Section 6 for more details on wastewater regulations and permitting in Arkansas.

Approximately 150 surface water bodies in the planning region receive discharges from permitted entities. Several of these water bodies receive discharges from more than one point source (ADEQ 2009a).

Table 4.12. NPDES permitted discharges in the EAWRPR (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
Arkansas	17	6	0	0	0	5	25	4	57
Ashley*	5	6	1	0	0	3	13	5	33
Chicot	3	4	2	0	0	5	6	4	24
Clay	2	11	0	0	0	3	9	0	25
Craighead	30	12	6	0	3	81	81	4	217
Crittenden	14	8	3	0	2	18	41	2	88
Cross	8	5	5	0	0	4	8	4	34
Desha	7	6	1	0	0	3	13	4	34
Drew*	6	2	1	0	0	2	12	1	24
Greene	14	4	2	0	0	18	29	1	68

Table 4.12. NPDES permitted discharges in the EAWRPR (continued).

County	NPDES Industrial	NPDES Municipal	NPDES Domestic	NPDES Large MS4	NPDES Small MS4	NPDES Construction Stormwater[1]	NPDES Industrial Stormwater	NPDES Other[2]	Total
Jackson	9	8	0	0	0	1	13	9	40
Jefferson*	26	7	6	0	4	23	60	11	137
Lawrence*	8	9	1	0	0	7	14	0	39
Lee	1	5	3	0	0	3	4	0	16
Lincoln	6	3	2	0	0	4	2	0	17
Lonoke	18	8	21	0	1	30	21	11	110
Mississippi	27	16	6	0	0	21	50	11	131
Monroe	2	3	0	0	0	9	7	2	23
Phillips	9	6	1	0	0	2	22	4	44
Poinsett	5	6	0	0	0	3	22	5	41
Prairie	4	5	0	0	0	6	4	2	21
Pulaski*	123	16	69	1	8	151	212	25	605
St. Francis	9	7	2	0	0	7	15	2	42
White*	39	15	2	0	0	34	45	11	146
Woodruff	5	4	1	0	0	1	8	0	19
Total	397	182	135	1	18	444	736	122	2035

*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.

Table 4.13 compares the number of NPDES permits for municipal, domestic, and industrial wastewater reported for the EAWRPR 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 EAWRPR has increased approximately 25% since the 1990 AWP update. 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 4.13. Numbers of NPDES wastewater permits reported for the EAWRPR in 1990 and 2013 (ADPCE 1990, ADEQ 2013a).

Permit type	1990	2013	Change
Industrial	27	57	30
Municipal	145	160	15
Domestic	45	75	30
Cooling water	8	5	-3
Filter backwash	6	1	-5
Process water	0	2	2
Agricultural	1	1	0
Other	12	3	-9
Total	244	304	60

5.0 WATER RESOURCES ISSUES

Water resources issues in the EAWRPR 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, 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

The EAWRPR includes several large waterways, including the St. Francis River, Cache River, the lower Arkansas and White Rivers, Bayou Bartholomew, and the Mississippi River, which runs along the entire eastern border of the state. As was noted in Section 3.1, the EAWRPR is an area that generally has little topographic relief and includes flat, broad floodplains. Flooding occurs routinely throughout the planning region, but many of these are isolated events that affect only small areas, or are limited to a few watersheds. Large, widespread disasters also occur. Since 1957, there have been 34 major disaster declarations involving flooding in Arkansas. From 2003 to 2010, some or all of the counties included in the EAWRPR were included in 15 flooding disaster declarations (Arkansas Department of Emergency Management 2010).

The most recent significant flood event in Arkansas occurred largely in the EAWRPR. Major flooding occurred during April and May of 2011 that included the White River, Black River, Cache River, and Mississippi River, as well as the tributaries to these major rivers. The magnitude of the flooding was on a scale comparable to the historic 1927 flood and resulted in 22 of the 25 counties in the EAWRPR being declared disaster areas. For the Mississippi River, the White River, and the St. Francis River within the EAWRPR, the 2011 flood was classified as a 100-year flood (Westerman, et al. 2013).

5.2 Wetland Loss

Prior to development, there were approximately 8 million acres of wetlands in the EAWRPR (Dahl 1990). Over 6 million acres of those wetlands have been converted to cropland (Fry, et al. 2011). Loss of wetlands in the EAWRPR has altered the hydrology of the region (loss of flood storage and groundwater recharge), affected water quality (increased sediment and nutrients in surface water), and impacted numerous plant, animal, bird, and fish species (species loss and decline). Since the 1970's the rate of wetland loss has been declining. The majority of the lost wetlands will never be restored, however, there are numerous wetland restoration and construction projects active in the EAWRPR.

5.3 Channelization

The majority of the waterways in the EAWRPR are channelized drainage ditches. The digging of drainage ditches and straightening and channelization of natural streams in this region have made the large-scale crop production that is characteristic of this region possible. However, it has also reduced wetland area and in-stream fishery habitat, and impacted water quality.

5.4 Water Supply

Expansion of water-intensive industries in this region, such as irrigated agriculture, aquaculture, and hydrofracking, has resulted in concern over whether there is sufficient water available to supply current and future demands in the EAWRPR.

5.4.1 Groundwater

Groundwater depletion has been an issue in the EAWRPR since the 1920s (Kresse, et al. 2013). The agricultural economy of the planning region is dependent on the continued sustainability of groundwater resources in the region to supply water for irrigation and aquaculture. There is concern in this planning region about water level declines in several of the aquifers in the planning region. This is a somewhat localized issue as water use and groundwater recharge rates for these aquifers vary throughout the planning region.

5.4.1.1 Groundwater Water Level Monitoring

ANRC sponsors monitoring of water levels in five study areas within the EAWRPR. Water-level monitoring is a cooperative effort between the ANRC, USGS, NRCS, and local water-resources agencies. Each spring approximately 700 water levels are collected from wells in the MRV alluvial aquifer, resulting in the largest number of water-level measurements for any one aquifer in the state. Similarly, each spring there are approximately 300 water levels collected from wells in the Sparta-Memphis aquifer. Measurements are collected in the spring to minimize effects of groundwater drawdown from seasonal irrigation. To assess the drawdown caused by seasonal irrigation use, the NRCS and ANRC collect additional measurements from the MRV alluvial aquifer in the fall. Results of the monitoring program are published in the annual Arkansas Groundwater Protection and Management Report available on the ANRC website.

The USGS also conducts water-level monitoring independently as part of the National Water Information System (NWIS). Since 1969, the USGS has operated continuous groundwater-level recorders at real-time stations throughout the planning region. These data provide a valuable dataset for improved understanding of water resources of the State. Data from this program may be retrieved at the NWIS website (Kresse, et al. 2013). The USGS is performing a regional groundwater-assessment study that includes the EAWRPR. The Mississippi Embayment Regional Aquifer Study (MERAS) is designed to assess groundwater availability throughout the Embayment. In Arkansas, this study focuses on the MRV alluvial aquifer (Kresse, et al. 2013).

5.4.1.2 Mississippi River Valley alluvial aquifer

Groundwater withdrawal rates exceeding natural recharge rates and subsequent water-level declines have been a concern for the MRV alluvial aquifer since the 1920s. The agricultural economy of the planning region is dependent upon the continued sustainability of groundwater resources for irrigation. Water- use rates for the MRV alluvial aquifer have increased steadily from 1965 to 2010, with the majority of this use attributed to irrigation. In 1965, the average water use by county was 22.69 mgd, and in 2010, the average water use by county was 148.64 mgd. Water-use increases have focused in specific counties where agricultural use is

intensive, such as Randolph, Independence, and Greene Counties and parts of the Grand Prairie region (Arkansas, Lonoke, and Prairie Counties). In addition to groundwater depletion, water-level declines in the MRV alluvial aquifer have resulted in extensive areas where portions of the aquifer have transitioned from confined to unconfined conditions; massive cones of depression; and reduction of hydraulic pressure, saturated thickness, storage volume, lateral flow, yield, and baseflow to streams; and aquifer compaction. In some areas, groundwater depletion has occurred to an extent that groundwater can no longer be pumped at rates to meet demand (Kresse, et al. 2013).

5.4.1.3 Sparta-Memphis aquifer

In the EAWRPR, the highest withdrawals from the Sparta-Memphis aquifer occur in the Grand Prairie area. Traditionally, the Sparta-Memphis aquifer was used for public and industrial supply. Multiple counties in the Grand Prairie, southern, and southeastern areas of Arkansas exclusively use the Sparta-Memphis aquifer as a drinking water source. As water levels continue to decline in the MRV alluvial aquifer, the use of the Sparta-Memphis aquifer as an irrigation supply source continues to increase. Reported withdrawals from the Sparta-Memphis aquifer doubled from 1965 to 2000, with the highest percent increases in Lonoke (over 6,500%) and Arkansas (234%) Counties, which were attributed to irrigation use. As of 2010, the primary use of the Sparta-Memphis aquifer is to support agriculture (Kresse, et al. 2013).

Water level data collected from the Sparta-Memphis aquifer over a 25-year period shows a long-term decline of 0.8 feet/yr. The estimated sustainable yield for the aquifer is 87 mgd. In 2009, groundwater withdrawals were estimated to be 142.42 mgd (ANRC 2012a). Large cones of depression in the Sparta-Memphis aquifer have been observed in Poinsett, Jefferson, and Crittenden Counties. In Crittenden County, the water-level declines are attributed to large pumping centers for the West Memphis and Memphis, TN, metropolitan area. In Poinsett and Cross Counties, the water-level declines are attributed to agricultural uses or recharge of the depleted MRV alluvial aquifer. Large water-level declines and an extensive cone of depression in the Grand Prairie led to the ANRC listing the Sparta-Memphis aquifer along with the MRV alluvial aquifer as a Critical Groundwater Area in 1998. Two surface-water diversion projects are

planned for the Grand Prairie area to provide irrigation water and decrease dependence on the MRV alluvial and Sparta-Memphis (Kresse, et al. 2013).

5.4.1.4 Minor aquifers

The Cockfield aquifer is an important groundwater resource throughout eastern Arkansas. The aquifer is primarily used for domestic purposes, but in some areas, such as Ashley County, yields are high enough to support municipal and industrial supply. As a result of sustained and intense pumping of the Cockfield aquifer, water level declines have led to cones of depression in western Drew and Chicot Counties in this planning region (Kresse, et al. 2013).

Owing to good water quality and high yields, the Wilcox aquifer is used for municipal, domestic, and industrial supply. Public supply accounts for 65% of the water use for this aquifer. Water use is the greatest in northeastern Arkansas in the Counties of Mississippi, Crittenden, and Greene, which heavily depend on the Wilcox aquifer. As of a result of heavy and sustained pumping, water-level declines and coalescing cones of depression were observed at major pumping centers in Paragould (Greene County) and West Memphis (Crittenden County). While water-level declines have been observed near Blytheville (Mississippi County), pumping in this area does not appear to have made as large of an impact (Kresse, et al. 2013).

Use of the Nacatoch aquifer in eastern Arkansas has been restricted to areas near its outcrop. Poor water quality has prevented the use of the aquifer in areas further away from the outcrop area. Primary use of the aquifer has been for public and industrial supply (Terry, et al. 1986). In 2010, the primary reported use in northeastern Arkansas was for public-water supply by the Clay County Regional Water District and the Cities of Piggott and Rector (also located in Clay County). Prior to 1990, water-decreases were noted in wells in northeastern Arkansas. Since then, water levels appear to have stabilized in these areas owing to decreased use of the aquifer (Kresse, et al. 2013).

5.4.1.5 Critical Groundwater Areas

The 1990 Arkansas Water Plan update advocated sustainable, conjunctive use of groundwater and surface water resources in this region to meet water resources needs. A number

of voluntary programs have been initiated to try to reduce the rate of groundwater depletion in areas where groundwater level declines are the greatest. These include federal irrigation projects utilizing surface water in the Grand Prairie, Bayou Meto, and the Beouf-Tensas basin; federal and state agricultural water conservation incentive programs; and designation of Critical Groundwater Areas (Figure 5.1). Designation of Critical Groundwater Areas focuses resources, providing enhanced tax credits for conservation activities, focused educational programs, priority for federal programs and funding, and enhanced opportunities for locally-led groundwater conservation programs (ANRC 2010). In 2000, the NRCS initiated a cost-share program to assist with the construction of on-site farm structures (surface-water reservoirs and tail-water recovery systems) to assist in water conservation measures. As of 2012, more than 250 reservoir and tail-water recover systems were completed (Kresse, et al. 2013).

In 1998, the ANRC designated the Grand Prairie Area (Figure 5.1) as a Critical Groundwater Area due to drastic water-level declines in the MRV alluvial and Sparta aquifers. Two surface-water diversion projects were planned to provide irrigation water and decrease dependence upon groundwater in this region. The Grand Prairie Area Demonstration Project is planned to divert surface water from the White River to supply users in Arkansas and Prairie Counties. A similar project, known as the Bayou Meto Project, is planned to divert surface water from the Arkansas River to farmland in Lonoke, Prairie, Jefferson, and Arkansas Counties. Despite numerous delays over the years associated with political and environmental concerns, lawsuits, and other problems, planning and construction of these projects still continues (Kresse, et al. 2013).

In 2010, the ANRC declared the Cache Study Area (Figure 5.1) a Critical Groundwater Area for excessive water-level declines in the MRV alluvial aquifer and Sparta-Memphis aquifer. From 2006 to 2011, the MRV alluvial aquifer in this study area showed an average water-level decline of 1.65 feet, with 95 of the 127 (74.8%) wells monitored showing decreases. For this time period, the highest average declines in water levels occurred in Craighead (3.80 feet) and Cross (3.47 feet) Counties. From 2006 to 2011, the Sparta-Memphis aquifer in this study area showed an average water level decline of 2.23 feet, with 22 of the 30 (73.3%) wells monitored showing decreases. For this time period, the highest average declines in water

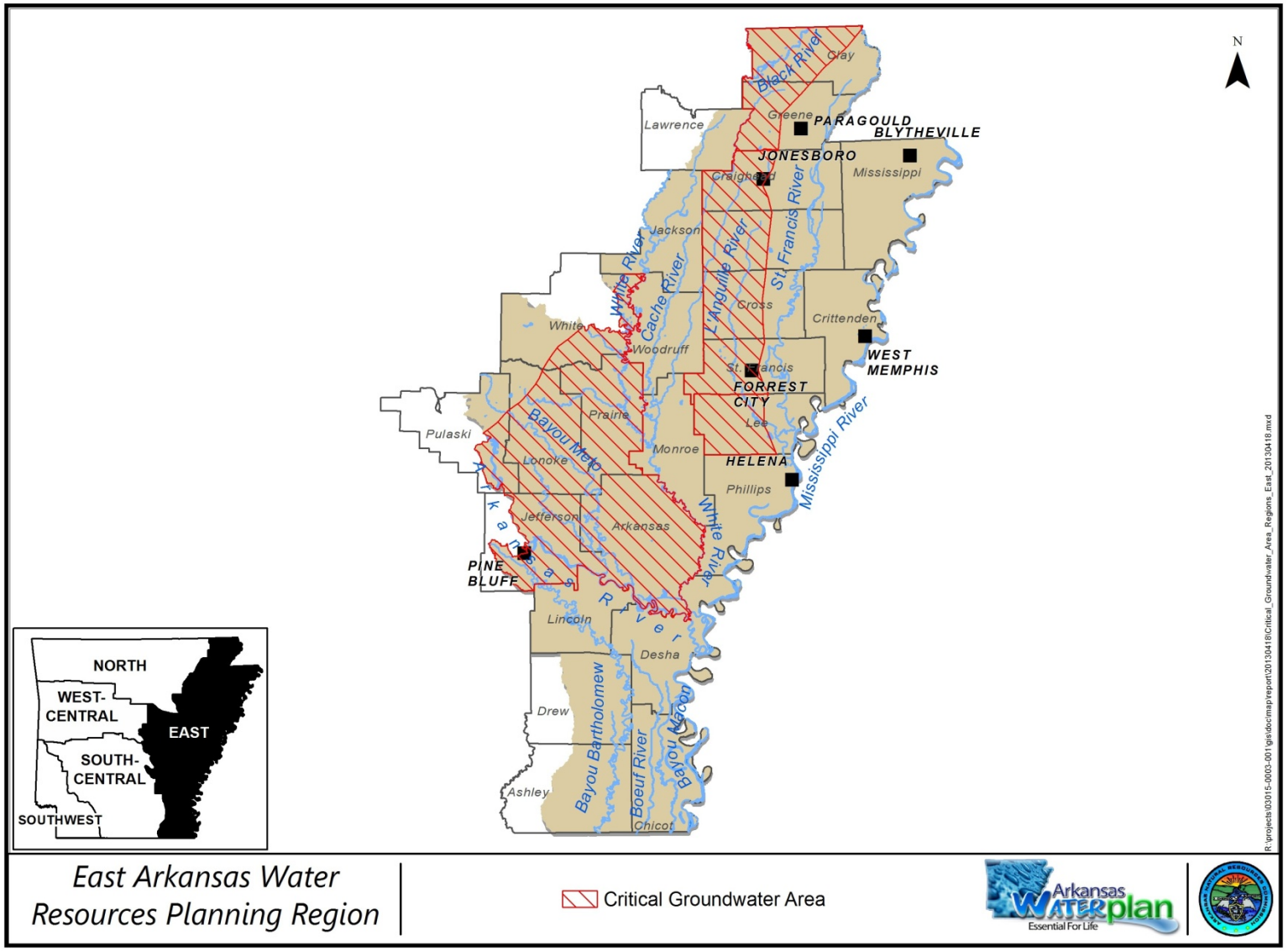

Figure 5.1. Critical groundwater areas in the EAWRPR Planning Region.

levels occurred in Poinsett (3.90 feet) and Woodruff (3.40 feet) (ANRC 2012b). Designation as a Critical Groundwater Area provides enhanced tax credits for conservation activities, focused educational programs, and places the area as a priority for potential federal programs and funding.

5.4.2 Surface Water

Surface water flow in several streams in the EAWRPR has been shown to be declining (Ludwig 1992, Czarnecki, Hays and McKee 2002). In addition, demand for surface water is increasing as users are being encouraged to convert from groundwater to surface water.

5.4.2.1 Surface water depletion due to groundwater withdrawals

Streams in the EAWRPR are being impacted by the lowering of the groundwater table resulting from the large volume of groundwater withdrawals in the region. Prior to the large scale use of the MRV alluvial aquifer, the water levels in the aquifer were high enough that groundwater contributed to flow in rivers and streams in the EAWRPR. Currently, water levels in the MRV alluvial aquifer are too far below ground, and the rivers do not cut deeply enough into the aquifer, for water to move directly from the aquifer to the rivers. Water from these rivers and streams flowing over the MRV alluvial aquifer does percolate into the aquifer (Czarnecki, Hays and McKee 2002). As a result, there is less flow in many East Arkansas rivers and streams. Several flow gage stations on streams in the planning region exhibit declining trends (Ludwig 1992, Czarnecki, Hays and McKee 2002).

Aquifer recharge from streams during high-flow is a natural process. However, when the groundwater gradient is altered by pumping from wells, additional aquifer recharge is induced. Recharge is induced when water is withdrawn from an aquifer adjacent to a stream or other surface water source, to which it is hydrologically connected. This process is also commonly referred to as “stream capture”. This scenario was identified in the EAWRPR by the USGS as early as the 1960’s. Analysis of the potentiometric map for the fall of 1959 indicates that during this period water was moving from the Arkansas River into the alluvial aquifer in Lincoln and Arkansas counties at a rate of about 12 mgd. The spring potentiometric surface indicated a flow from the river to the alluvial aquifer of about 9 mgd (Bedinger and Jeffrey 1964). In 1968, the

USGS reported that withdrawals of water for rice irrigation had resulted in a cone of depression centered in Arkansas County and stretching to the White River, and that movement of water from the river into the aquifer had apparently begun (Kresse, et al. 2013). These early observations of stream capture occurred before the construction of the lock and dam system on the Arkansas River.

Another observed case of stream capture is in the MRV alluvial aquifer along the Cache River west of Crowley's Ridge. As early as 1981, digital-model analysis indicated that 430,000 acre-feet per year of water was moving from the Cache River into the aquifer as a direct result of agricultural pumping (Broom and Lyford 1981).

In 2003, the USGS groundwater flow model reported data was evaluated to determine the volume of White River flow being diverted/intercepted by irrigation wells in the MRV alluvial aquifer. It was determined that 20,231,644 cubic feet per day of water was being indirectly withdrawn from the White River due to stream capture, reducing base flow to the river from the aquifer (Kresse, et al. 2013).

5.4.2.2 Increased Surface Water Demand/Use

There are two large irrigation projects under construction in the EAWRPR intended to supply surface water to producers to supplement groundwater for irrigation. The Grand Prairie project is designed to supply water from the White River to 362,662 acres of cropland in Arkansas, Lonoke, and Prairie Counties. The Bayou Meto irrigation project is designed to supply water from the Arkansas River to approximately 268,000 acres of cropland and 22,000 acres of aquaculture ponds in Arkansas, Jefferson, Lonoke, Prairie, and Pulaski Counties (ANRC 2012c).

The Arkhoma Basin Fayetteville Shale, a geologic formation being heavily developed for natural gas resources in the state, extends into parts of White County and Jackson County. The gas is being extracted from this formation using the hydrofracking process at several active wells within the EAWRPR (Arkansas Oil and Gas Commission 2013). This process uses large volumes of surface water. As natural gas production has increased in the Fayetteville Shale Play, the demand for surface water has also increased.

5.5 Waterborne Commodity Transport Infrastructure

As discussed in Section 3.7.2, there are three waterways in the EAWRPR that are used for the transport of goods and materials, the Mississippi River, MKARNS and the White River. Maintenance of these waterways and their associated public port facilities so that they can continue to support the economy of the region, and the State, is a constant and expensive activity. Needs identified by the Arkansas Waterways Commission are summarized below.

5.5.1 Mississippi River

Low water levels on the Mississippi River during the summer of 2012 and winter 2013 resulted in closure of one of the four Arkansas ports on the river. This raised concerns that additional dredging may be needed in Arkansas harbors to maintain their usefulness during low water conditions. No funding was appropriated in the USACE 2013 budget for this activity (Arkansas Waterways Commission 2013).

5.5.2 Arkansas-White River Cutoff

The White River channel is migrating toward the Arkansas River channel downstream of the Arkansas Post Canal. A connection between these two rivers at that point could temporarily shut down transportation on the MKARNS, impacting the regional and State economy, and result in the loss of thousands of acres of bottomland hardwoods. There are temporary structures in place to prevent the White River from joining the Arkansas River. The USACE has proposed a reconnaissance study to determine potential permanent solutions. However, this study has not yet been federally funded (Arkansas Waterways Association 2011, USACE Little Rock District 2012). The Arkansas Waterways Commission has proposed a private study to be funded by the Arkansas General Assembly. This study has not yet been funded (Arkansas Waterways Commission 2013).

5.5.3 MKARNS Maintenance

The USACE is having difficulty obtaining funding for maintenance activities, such as dredging, required to keep the MKARNS operational. At the end of 2012, there were 15 critical maintenance projects currently on hold (Arkansas Waterways Commission 2013).

5.5.4 MKARNS Twelve Foot Channel

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 nor 2013. As a result, work on this project has ceased.

5.5.5 White River

The navigation channel in the White River upstream of the MKARNS has not been dredged since 2009 (USACE Memphis District 2013). Concerns about impacts of dredging on the surrounding wetlands ecosystem have resulted in opposition to maintaining the White River navigation channel (Rogers 2013).

5.6 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 2 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 EAWRPR. 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.

5.6.1 Water Quality Monitoring

To assess water quality, it is necessary to collect water quality data through monitoring programs. Monitoring of water quality in the EAWRPR 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.

5.6.1.1 Surface Water

ADEQ monitors water quality of surface waters through several programs. The ambient water quality monitoring network includes 23 sites on rivers and streams in the EAWRPR that are sampled monthly for chemical analysis (Figure 5.2). The roving water quality monitoring network includes 56 stream sites in the planning region. These sites are divided into four regional groups. Each group of roving sites is sampled for chemical and bacterial analysis on a rotating basis, bimonthly over a 2-year period, every 6 years. Bacterial analysis is also performed on samples from the ambient water quality monitoring network within the active region of the roving water quality monitoring network. In addition, ADEQ conducts water quality monitoring during "intensive surveys." These surveys can involve water sampling for chemical and bacterial analysis, as well as biological sampling to evaluate water quality. Intensive surveys are conducted for a variety of purposes, including determination of total maximum daily loads (TMDLs), and to augment water quality information from the routine water quality monitoring networks for more accurate assessment of designated use support. ADEQ also routinely monitors water quality in 18 significant publicly owned lakes within the planning region (ADEQ 2009a, 2012b, 2013e).

Through its nonpoint source management program, ANRC oversees water quality monitoring programs in 10 nonpoint source priority watersheds. Three of these watersheds, Bayou Bartholomew, Cache River, and L'Anguille River, are located in the EAWRPR. These programs involve universities, contractors, and nonprofit organizations. Parameters monitored by these programs typically include nutrients and sediment, turbidity, and/or total suspended solids.

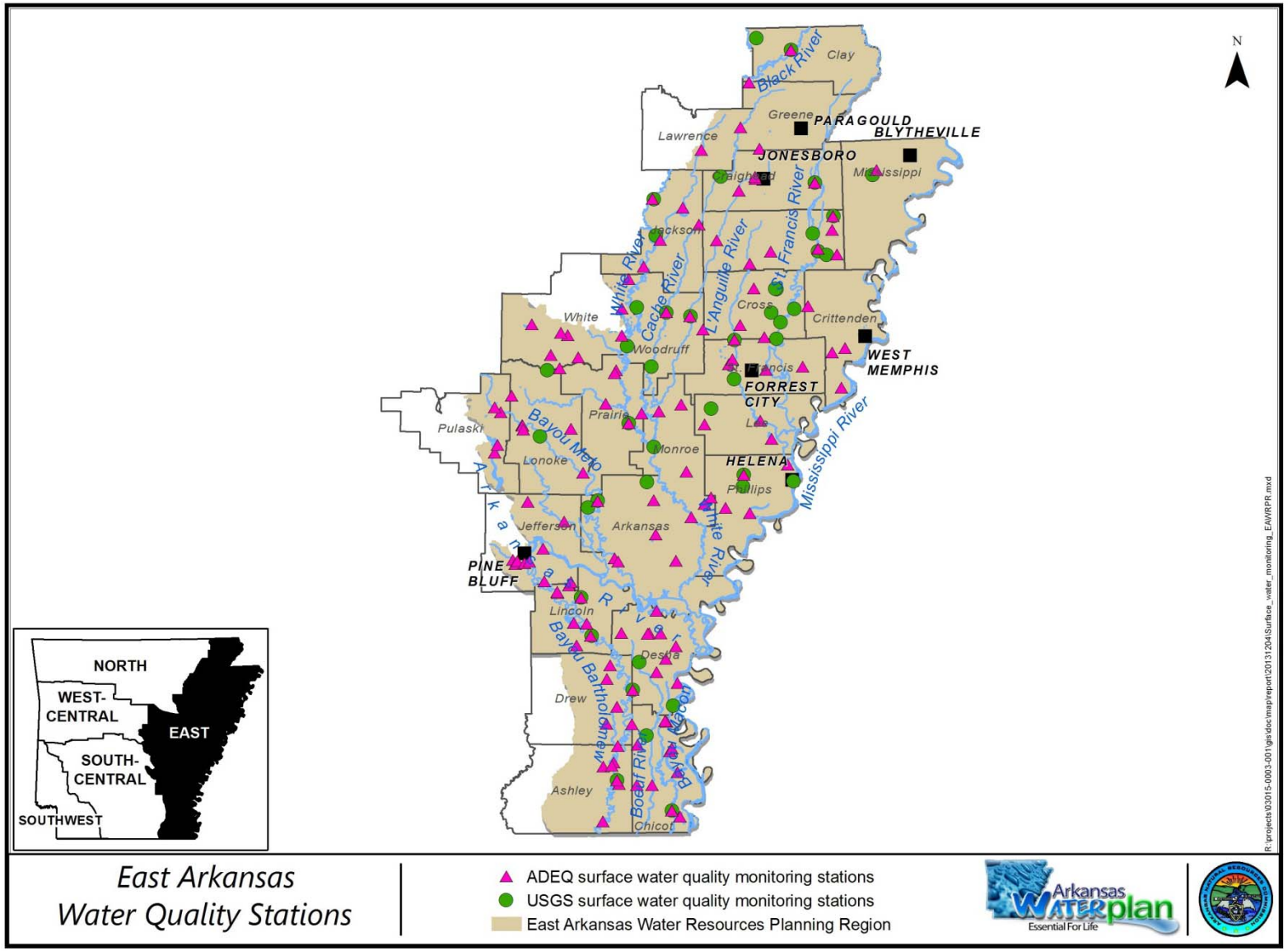

Figure 5.2. Routine surface water quality monitoring stations in the EAWRPR.

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). There are less than 20 public water supply systems in the EAWRPR that use 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 raw surface water, or source water, will vary and may include turbidity, *Escherichia coli* (*E. coli*), cryptosporidium, total organic carbon (TOC), and alkalinity.

The USGS also routinely monitors surface water quality data in the EAWRPR. Data from USGS monitoring stations may also be used in the biennial assessment. There are six active USGS water quality monitoring stations in the EAWRPR. Samples are collected at these stations monthly, bi-weekly, or quarterly (USGS 2013c). The USGS National Water Quality Assessment Program Mississippi Embayment Study Unit includes the EAWRPR. The USGS conducted an intensive study of water quality in this region during the period from 1995 through 1998 (Kleiss et al 2000).

5.6.1.2 Groundwater

In the EAWRPR, groundwater quality monitoring is performed on many levels 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 2009a, 2012c). For example there are seven Superfund sites located within the planning region and six of these have active groundwater monitoring. Within the planning region are four properties in the State's Brownfields program that are currently being evaluated; three sites that are on the State Priority List that are monitored; two sites in the Elective Cleanup program; six Class I solid waste landfills; and an unknown number of hazardous waste sites and

leaking underground storage tank sites that are being evaluated or monitored through other regulatory mechanisms.

ADEQ developed the Arkansas Ambient Ground Water Monitoring Program in 1986, which currently consist of 12 monitoring areas and approximately 250 wells and springs throughout the state (ADEQ 2012d, Kresse and others 2013). Five of the ADEQ groundwater quality monitoring areas are located in the EAWRPR: Brinkley, Chicot, Jonesboro, Lonoke, and Pine Bluff (Figure 5.3). Under this ADEQ program, samples are collected from wells complete in the MRV alluvial aquifer, the Sparta/Memphis aquifer, the Wilcox aquifer, and the Cockfield aquifer (Table 5.1) to develop baseline conditions and monitor potential impacts of agriculture and industry on groundwater. Data from this monitoring program are presented in ADEQ publications available on their website, and in the EPA STORET database (ADEQ 2009).

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.

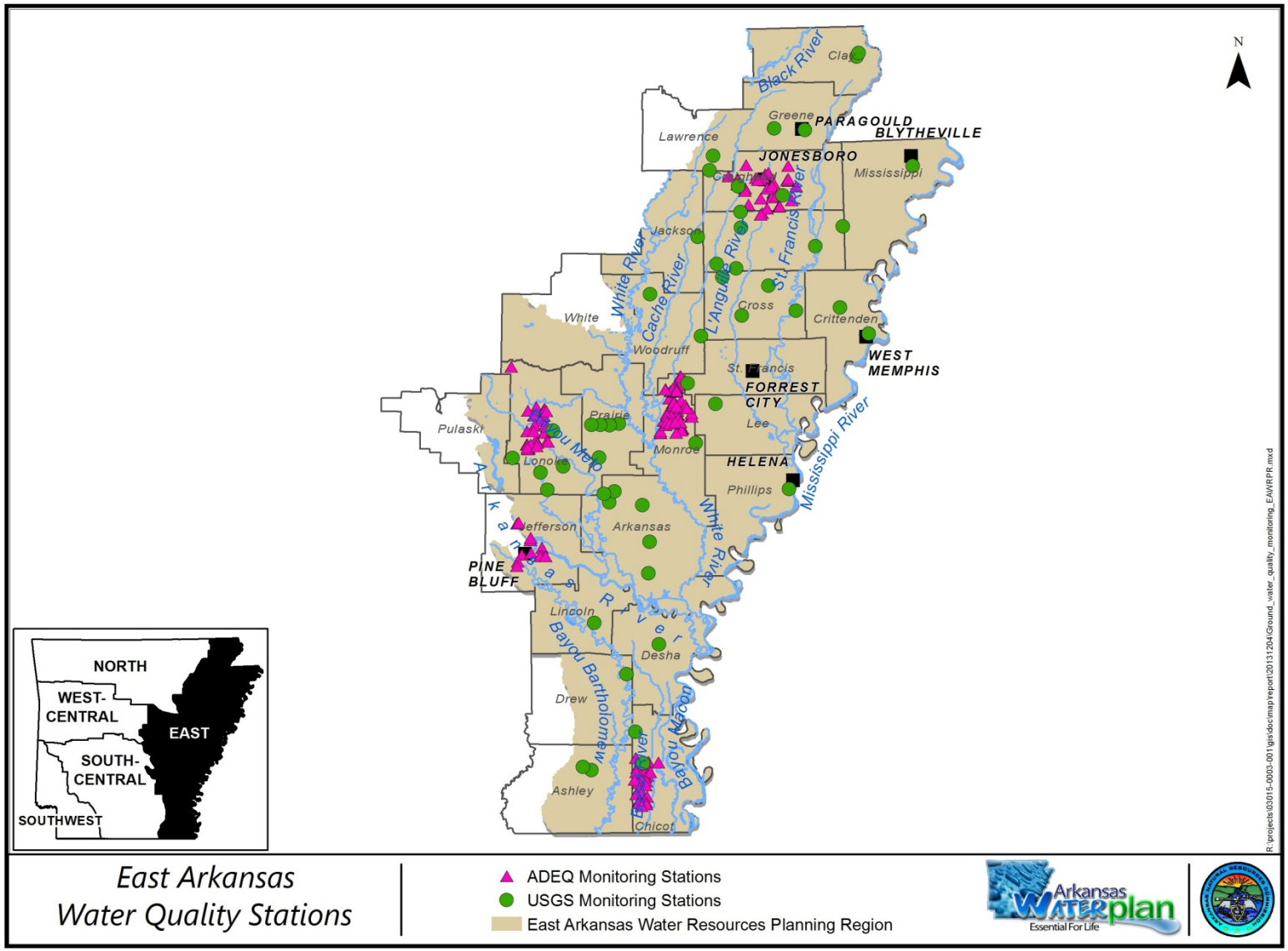

Figure 5.3. Ambient groundwater quality monitoring locations in the EAWRPR.

Table 5.1. ADEQ groundwater quality monitoring sites in the EAWRPR (ADEQ 2012d).

Monitoring Area	Most recent sampling	Total number of wells	Aquifer	Number of wells
Brinkley	2011	29	MRV alluvial	29
Chicot	1997	26	MRV alluvial	26
Jonesboro	2009	17	MRV alluvial	9
			Sparta/Memphis	4
			Wilcox	1
			Unknown	3
Lonoke	2010	16	MRV alluvial	8
			Sparta/Memphis	3
			Unknown	5
Pine Bluff	2011	16	MRV alluvial	3
			Sparta/Memphis	11
			Cockfield	2

The Arkansas Department of Health (ADH) is the primary 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 1300 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 containment levels (MCL) 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 2009a, 2012c).

The Arkansas State Plant Board (ASPB) monitors groundwater throughout the state to detect pollution by agricultural chemicals, such as pesticides. If agricultural chemicals are found,

the ASPB takes measures to respond appropriately. The groundwater program is voluntary. Since the program initiated in 2004, ASPB has sampled 271 wells in 30 counties. Results of sampling activities are included in annual reports and posted on the Plant Board web site (Kresse, et al. 2013).

Several ambient groundwater quality monitoring programs exist that involve cooperative efforts among the USGS, ANRC, and ADEQ. Ambient groundwater-quality monitoring activities are primarily funded by EPA grants under Sections 106 and 319 of the Clean Water Act.

The USGS collects groundwater quality data at a number of wells in the EAWRPR. There are 63 active USGS groundwater quality sites in the planning region (USGS 2013c). Ten of the twenty-five USGS master wells are located in this planning region. These wells are sampled for water quality every five years. The USGS, in cooperation with ANRC, also collects water quality samples from 100 wells in the MRV alluvial aquifer and 100 wells in the Sparta/Memphis aquifer every 3 years in a rotating sampling program. In addition, conductivity is measured in 50 of the wells in each aquifer every year (ADEQ 2009a).

ANRC collects groundwater data statewide in areas where water-level declines or water-quality degradation have been historically observed (Kresse, et al. 2013). In EAWRPR, ANRC performs water quality monitoring of groundwater at locations throughout the MRV alluvial aquifer (36 sites) and Sparta-Memphis aquifer (6 sites). These wells were installed as part of the Section 319 Core Program Monitoring Enhancement Wells program to establish long-term water quality trends and assist with the development of water quality standards for groundwater. Samples are collected for the analysis of major water quality parameters and metals (Jay Johnston, ANRC, written communication, 2013). When water quality samples are collected, analytical results are published in the annual Arkansas Groundwater Protection and Management Report available on the ANRC website (ANRC 2008).

5.6.2 Non-attainment of Surface Water Quality Standards

In 2008, 3,369 of the 44,000 miles of streams and 15,428 of the 150,000 acres of lakes in the EAWRPR were assessed for water quality. Of the waterbodies assessed, 1,664 stream miles and 5,817 lake acres did not meet numeric water quality criteria or did not support all of their

designated uses. Sediment/siltation, low dissolved oxygen, minerals (chloride, sulfate, and total dissolved solids [TDS]), and lead were the causes of impaired water quality in the majority of the stream miles assessed (Table 5.2) (ADEQ 2009a, b). Nutrients, copper, and sediment/siltation were the sources of impairment for lakes in the EAWRPR (Table 5.2). A detailed listing of EAWRPR stream water quality impairments identified in the Arkansas 303 (d) list is included in Appendix A. The cause of impairment was unknown for over 1,000 acres of lakes in the EAWRPR. Figures 5.4 through 5.6 show locations of impaired waterbodies in the EAWRPR.

It should be noted that while a waterbody may be impaired due to sediment, there is no numeric water quality standard for sediment/siltation. 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 5.2 Summary of impaired waters in the EAWRPR (ADEQ 2009b).

Pollutant	Miles of impaired stream	Acres of impaired lakes
Sediment/Siltation	584.5	335
Dissolved Oxygen	861.6	0
Chloride	605.1	0
Lead	363.7	0
TDS	454.8	0
Pathogens	297.9	0
Zinc	224.1	0
Sulfate	106.3	0
Copper	51.4	335
Mercury	101.9	0
Aluminum	20.3	0
Nutrients	0	4,425
Unknown	0	1,057

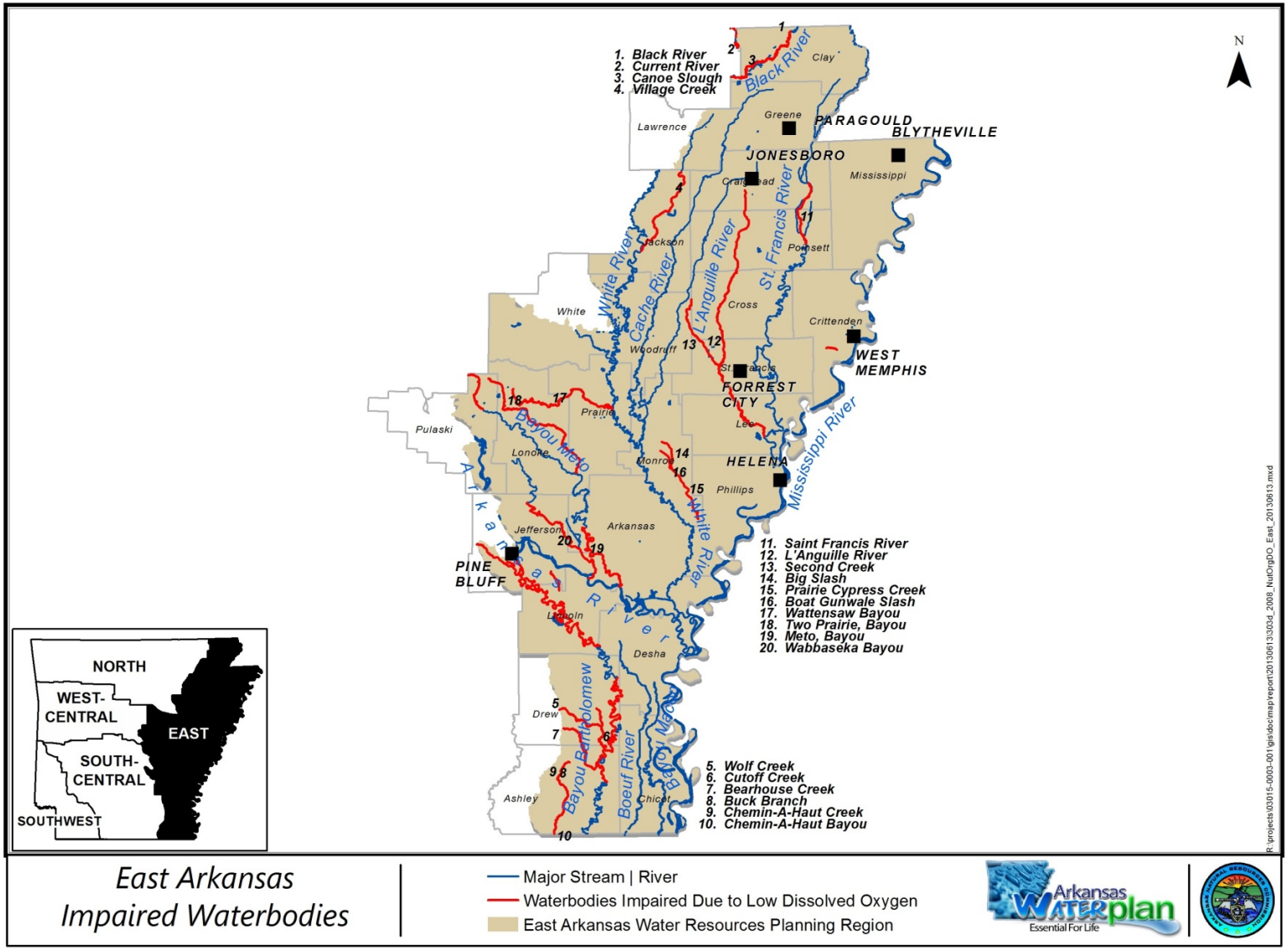

Figure 5.4. Waterbodies in the EAWRPR classified as impaired due to low dissolved oxygen in the 2008 303(d) list (ADEQ 2009b).

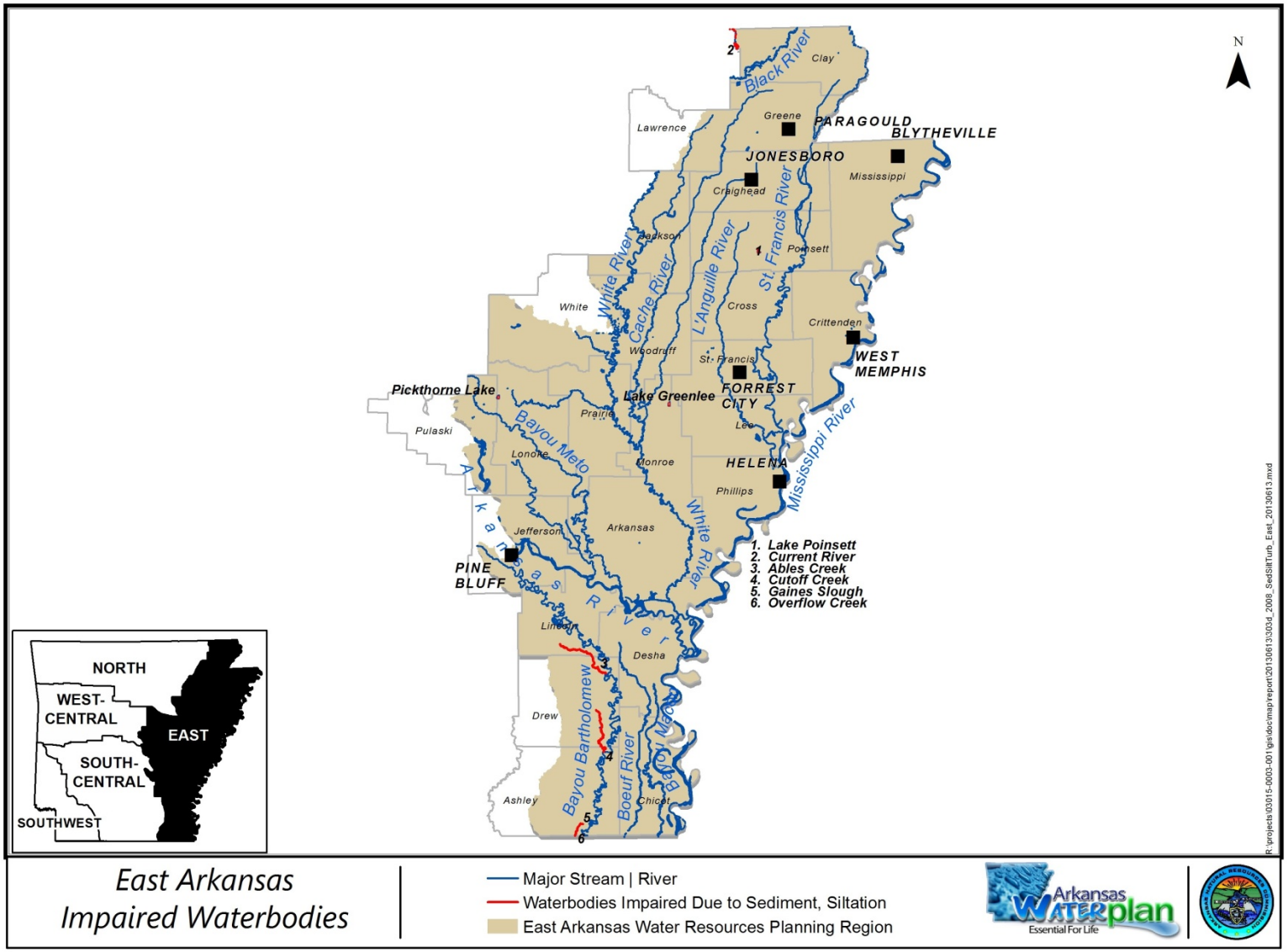

Figure 5.5. Waterbodies in the EAWRPR classified as impaired due to sediment/siltation in the 2008 303(d) list (ADEQ 2009b).

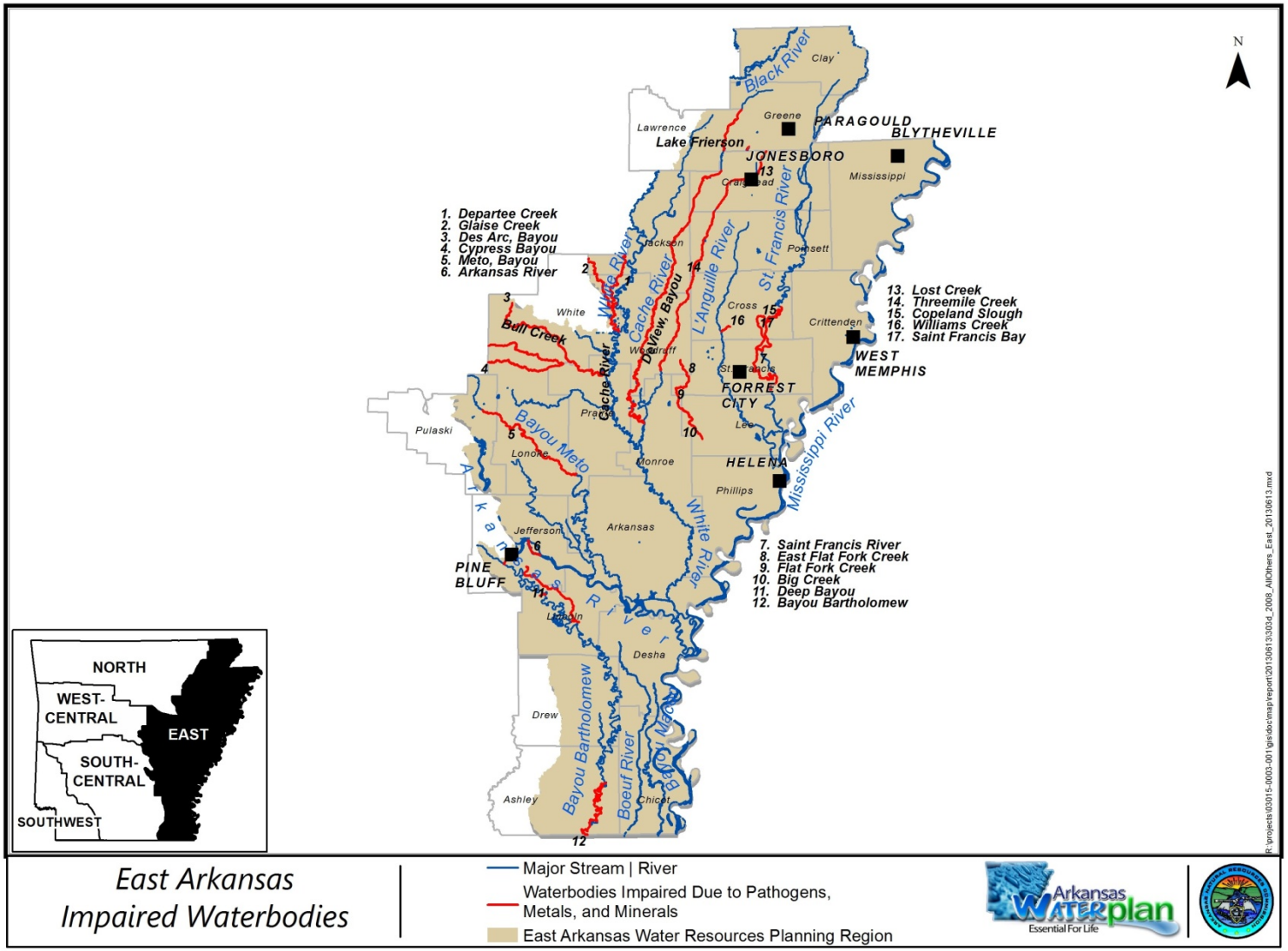

Figure 5.6. Waterbodies in the EAWRPR classified as impaired due to pathogens, metals, and minerals in the 2008 303(d) list (ADEQ 2009b).

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Row-crop agriculture is the most frequently identified source of pollutants causing water quality impairment in the EAWRPR, including sediment, chloride, pathogens, TDS, sulfate, lead, and zinc (ADEQ 2009b). Bayou Bartholomew, L'Anguille River, and Cache River watersheds are classified as nonpoint source priority watersheds by ANRC. Nonpoint source pollutants of concern identified by ANRC for these watersheds include siltation/turbidity, pathogens, minerals (TDS, chlorides, and sulfates), nutrients, and low dissolved oxygen. Factors contributing to nonpoint source water quality issues include lack of riparian buffers/vegetation, localized urbanization, row crop agriculture, septic systems, and surface mining (e.g., topsoil, gravel, sand) (ANRC 2012d).

Low dissolved oxygen levels are a naturally occurring problem throughout the EAWRPR. Low dissolved oxygen levels occur in streams in this region during the summer when flows are low and temperatures are high. ADEQ will address this issue either through changing the dissolved oxygen water quality standards for this region, or changing the assessment methodology used to identify oxygen impaired waterbodies in this region (ADEQ 2009a).

In cases where exceedances of water quality criteria are preventing the attainment of a designated use, a 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 EAWRPR addressing sediment/turbidity, minerals, metals, nutrients, and low dissolved oxygen (Table 5.3). Plans for implementing TMDLs have been developed for the Bayou Bartholomew and L'Anguille River watersheds (Arkansas Water 2013).

Table 5.3. TMDLs for waterbodies in the EAWRPR (ADEQ 2012b).

Waterbody	Impaired Uses	Pollutants	TMDL Status
Bayou Bartholomew	Aquatic life	Chloride, copper, lead, turbidity, zinc	2012
	Fish consumption	Mercury	Final 5/3/2002
	Primary contact recreation	pathogens	Final 6/1/2007
	Agricultural and industrial water supply	Chloride, sulfate, TDS	Final 3/31/2008
Bayou DeView	Aquatic life	Chloride, copper, lead, zinc	2012
		Turbidity	Final 1/6/2006
Bayou Macon	Aquatic life	Turbidity	Final 3/3/2005
Bear Creek Lake	Aquatic life	Nutrients	Final 1/16/2007
Bearhouse Creek	Primary contact recreation	Pathogens	Final 6/1/2007
Big Bayou	Aquatic life	Chloride, turbidity	Final 3/3/2005
Blackfish Bayou	Aquatic life	Turbidity	Final 3/27/2008
Boeuf River	Aquatic life	Chloride, sulfate, TDS, turbidity	Final 3/3/2005
Cache River	Aquatic life	Chloride, sulfate, lead	2013
		Turbidity	Final 1/6/2006
Chemin-A-Haut Creek	Primary contact recreation	Pathogens	Final 6/1/2007
Cross Bayou	Primary contact recreation	Pathogens	Final 6/1/2007
Cut-off Creek	Aquatic life	Turbidity	Final 3/31/2008
	Fish consumption	Mercury	Final 5/30/2002
Cypress Bayou	Primary contact recreation	Pathogens	Final 9/1/2009
Deep Bayou	Aquatic life	Turbidity	Final 10/8/2002
	Primary contact recreation	Pathogens	Final 6/1/2007
Harding Creek	Secondary contact recreation	Pathogens	Final 6/1/2007
Horseshoe Lake	Aquatic life	Nutrients	Final 1/16/2007
Jack's Bayou	Primary contact recreation	Pathogens	Final 6/1/2007
L'Anguille River	Aquatic life	Turbidity	Final 10/1/2001
	Primary contact recreation	Pathogens	
Lake Frierson	Aquatic life	Turbidity	Final 1/16/2007
Lake Monticello	Fish consumption	Mercury	Final 11/20/2003
Mallard Lake	Aquatic life	Nutrients	Final 1/16/2007
Melton's Creek	Primary contact recreation	Pathogens	Final 6/1/2007
Oak Bayou	Aquatic life	Chloride, TDS, turbidity	Final 3/3/2005
Old Town Lake	Aquatic life	Nutrients	Final 1/16/2007
Tyronza River	Aquatic life	Turbidity	Final 1/6/2005
Village Creek	Aquatic life	Turbidity	Final 1/6/2005
Wabbaseka Bayou	Aquatic life	Turbidity	Final 1/6/2005

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

Most of the aquifers in the planning region are considered to have good to very good water quality. However, areas of poor water quality have been identified. In some areas, poor groundwater quality is a natural phenomenon. In other areas, human activities have caused contamination of the groundwater. In Arkansas, groundwater quality issues primarily occur in shallow aquifers (ADEQ 2009a). For the most part, groundwater quality issues have not changed significantly since the 1990 AWP update (ADEQ 2009a, Bryant, Ludwig and Morris 1985).

5.6.3.1 Mississippi River Valley alluvial aquifer

In general the groundwater quality of the MRV alluvial aquifer throughout the EAWRPR is good when compared to EPA primary drinking water standards. Certain basic water-quality characteristics limit the use of this aquifer for domestic, industrial, and municipal supply purposes, which include elevated concentrations of hardness, iron, and manganese.

Groundwater in this aquifer has naturally high levels of iron, manganese, and hardness, which can cause problems in industrial and domestic applications such as staining, scaling, and unpleasant taste (Renken 1998). As a result, groundwater from this aquifer is mostly used for irrigation (ADEQ 2009a). Additionally, some areas contain elevated concentrations of chloride that can affect crop production, deteriorate soil structure, and reduce soil infiltration rates.

Kresse and Clark (2008) performed a comprehensive study to determine the occurrence, distribution, and sources of elevated chloride in the alluvial aquifer. Their study defined two distinct areas of elevated chloride concentrations (greater than 100 mg/L) with two different sources: Area I included most of Jefferson, Lincoln, and Desha Counties; and Area II included most of Chicot County. In Area I, elevated chloride concentrations were contributed to evapotranspiration in low-permeability, clay-dominated backswamps, which tended to concentrate chloride. In Area II, elevated chloride concentrations were contributed to upwelling of brine water from the Smackover Formation. Outside of these areas, elevated chloride concentrations are observed in areas north of the Arkansas River and along the transition between the Interior Highlands and the Coastal Plain (commonly referred to as the fall line) from

Pulaski to Clay Counties, especially near Bald Knob in White County where it is not uncommon for chloride concentrations to exceed 1000 mg/L. Although no definitive sources have been identified to explain the occurrence of elevated chloride concentrations north of the Arkansas River, elevated chloride concentrations along the fall line are believed to be related to upwelling from deeper aquifers of poorer water quality along this boundary (Kresse, et al. 2013).

In the deeper parts of the aquifer, naturally-occurring arsenic can exceed federal primary drinking water standards. Studies have attributed the arsenic to the dissolution of iron minerals (iron oxyhydroxides) under reducing conditions, which releases trace amounts of arsenic (Sharif, Davis, et al. 2008a, 2008b, 2011). However, since wells used as drinking sources are completed in the shallower portion of the aquifer, arsenic contamination does not pose a problem to domestic supply (Kresse, et al. 2013).

Because row-crop agriculture is the dominant land use in eastern Arkansas, pesticides and fertilizer use pose the most common and widespread threat from human activity to groundwater quality in the shallow alluvial aquifer. Steele and others (1994) observed elevated nitrate concentrations (median value of 2.94 mg/L as nitrogen) in shallow alluvial wells (less than 50 feet) that were attributed to fertilizer application. Pesticide monitoring in Arkansas became routine in the early 1990s when Federal mandates required each state to develop a State Management Plan for pesticide use. Based on results of annual pesticide monitoring and findings from studies, pesticide occurrence in groundwater is related to the physical and chemical properties of the pesticide rather than the amount of pesticide applied, where highly water soluble chemicals are more likely to be present in groundwater. Transport of pesticides to groundwater is primarily the result of vertical infiltration through normal application practices. Review of pesticide monitoring since the early 1990s reveals an average 14% detection rate; however, concentrations are typically low and far below maximum contaminant levels and health advisory standards (Kresse, et al. 2013).

5.6.3.2 Sparta-Memphis aquifer

The Sparta aquifer in eastern Arkansas generally provides water of excellent quality. Only a few areas of the state have problems with use of groundwater from the Sparta-Memphis

aquifer, which are primarily related to elevated salinity. Chloride values exceeding levels that can effect crop production are observed in portions of Chicot, Prairie, Monroe and Lee Counties. In addition, isolated areas where the Sparta-Memphis aquifer underlies the MRV alluvial aquifer are noted for elevated levels of iron, which may stain or impart an unpleasant taste to water without treatment (Kresse, et al. 2013).

5.6.3.3 Minor aquifers

The Cockfield aquifer contains groundwater that is typically of high quality and is used throughout southeastern Arkansas. Isolated areas of the aquifer contain elevated sulfate and chloride concentrations as a result of mixing with water of poor quality in underlying formations. The Wilcox aquifer produces water of generally excellent quality. In general, water quality is better in the eastern extent of the aquifer in northeastern Arkansas. Numerous samples from wells contained iron concentrations that exceed EPA secondary drinking water standards, which could cause problems for various commercial, industrial, and public uses. In south-central to southern Arkansas high salinity and elevated dissolved solids prevent the use of this aquifer. In the EAWRPR, the Nacatoch aquifer is a viable and important source of water for the extreme northeastern part of the state. High salinity in this aquifer prevents its use outside of the extreme northeastern portion of the planning region (Kresse, et al. 2013).

5.6.4 Fish Consumption Advisories

There are active fish consumption advisories due to mercury and dioxins for several waterbodies in the EAWRPR. Details of these advisories are given in Table 5.4. A mercury-related fish consumption advisory for Lake Monticello was lifted in 2011 (ADH 2011a). The locations of these water bodies are shown on Figure 5.7.

Table 5.4. Fish consumption advisories in EAWRPR (ADH, AGFC, ADEQ 2011, ADEQ 2009a).

Waterbody	Miles Affected	Pollutant of Concern	Restrictions for high risk groups[1]	Restrictions for general public
Cut-off Creek from Highway 35 to Bayou Bartholomew	16.8	Mercury	Should not eat any fish.	Should not eat drum, buffalo, redhorse, or suckers. No more than 2 meals a month of largemouth bass, catfish, crappie, gar, pickerel, or bowfin.
Bayou Bartholomew from the Drew-Ashley county line to the Arkansas-Louisiana state line	48	Mercury	Should not eat flathead catfish, gar, bowfin, pickerel, or blue catfish that are 20 inches or longer; nor largemouth bass longer than 12 inches; nor buffalo 18 inches or longer.	No more than 2 meals a month of flathead catfish, gar, pickerel, blue catfish 20 inches or longer, largemouth bass 12 inches or longer, or buffalo 18 inches or longer
Bayou Meto	48	Dioxin	Should not eat any fish	Should not eat any fish

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

5.6.5 Nonpoint Source Pollution

Nonpoint source pollution was identified as a water resources issue in the 1990 AWP (ASWCC 1990). Nonpoint source pollution still contributes significantly to surface water and groundwater quality issues in the EAWRPR. As discussed in Sections 5.6.2, in this planning region, row crop agriculture is the primary source of nonpoint source pollution. Loss of wetlands, ditching and channelization of streams for drainage, and maintenance dredging of ditches and streams associated with agricultural activities in this region contribute to nonpoint source pollution issues. Hazardous waste sites in the planning region also contribute nonpoint source pollution.

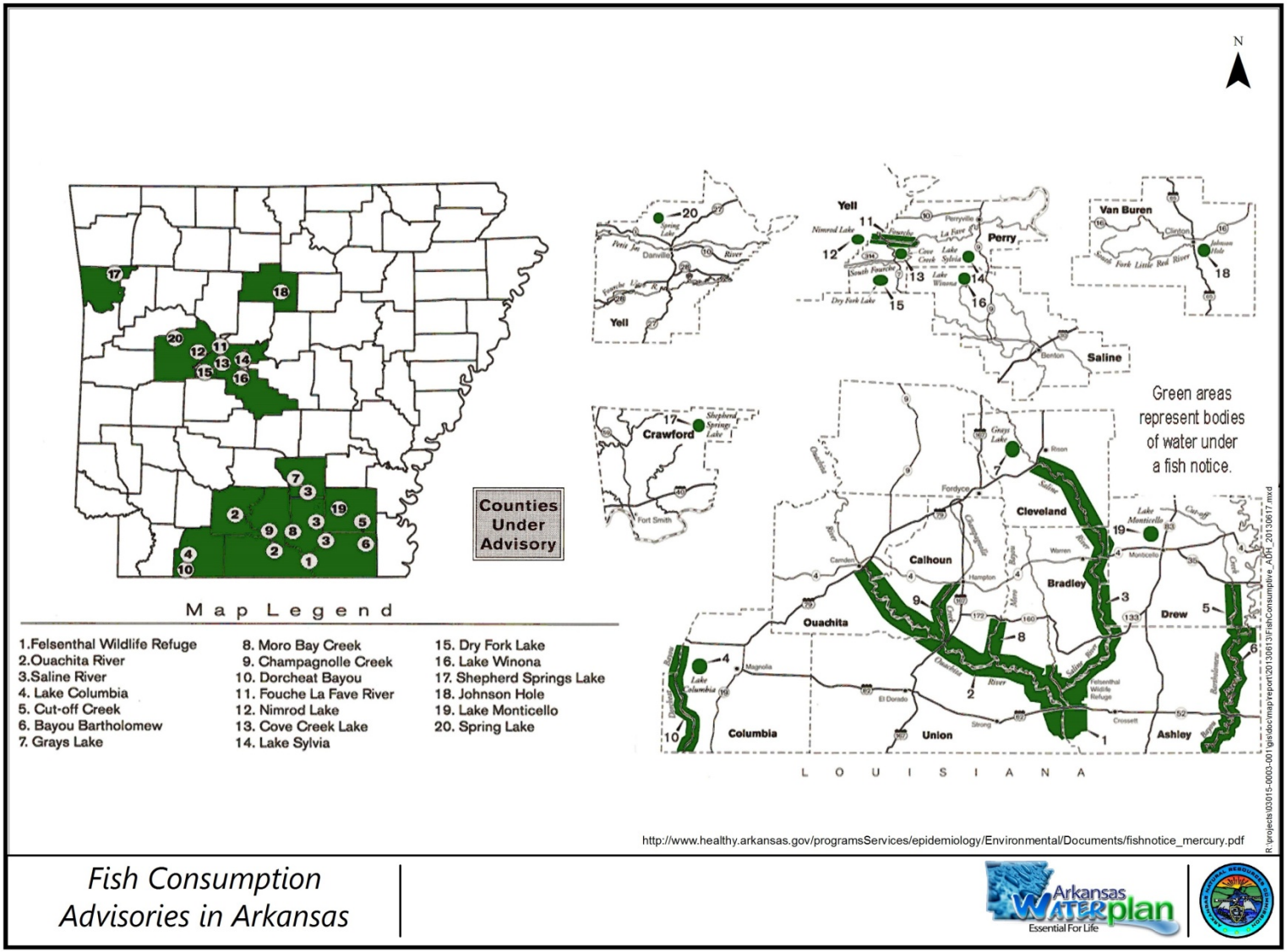

Figure 5.7. Waterbodies in the EAWRPR for which fish consumption advisories have been issued (ADH, AGFC, ADEQ 2011)

5.6.5.1 ANRC Priority Watersheds

In the 2011 – 2016 Nonpoint Source Pollution Management Plan, three watersheds within the EAWRPR have been identified as priority watersheds for nonpoint source pollution issues; Bayou Bartholomew, Cache River, and L'Anguille River (Figure 5.8). The pollutants of concern identified in the management plan for these watersheds are listed in Table 5.5. In these priority watersheds, the targeted source of nutrients is row crop agriculture (ANRC 2012d).

Table 5.5 Pollutants of concern in nonpoint source pollution priority watersheds (ANRC 2012d).

Watershed	Pollutants of Concern
Bayou Bartholomew	Siltation/turbidity, pathogens, TDS, chlorides, low dissolved oxygen
Cache River	Nutrients, sediment
L'Anguille River	Siltation/turbidity, nutrients, low dissolved oxygen, minerals

5.6.5.2 Hazardous Waste Remedial Action Priority Sites

There are eight sites in the EAWRPR identified as federal priority for hazardous waste cleanup (i.e., Superfund sites) due to contamination of water resources. All of these sites have had, or have, groundwater contamination issues. Surface water contamination has been an issue at four of these sites. Table 5.6 summarizes the information about these sites. Six of these sites were active at the time of the 1990 AWP update. The South 8th Street Landfill site was added to the national priority list (NPL) in 1992 and the Cedar Chemical Company site in 2012. Groundwater remediation has been implemented at seven of these sites, and several have been removed from the NPL (EPA 2013b).

There is one site in the planning region that was identified as a state priority for hazardous waste cleanup due to contamination of groundwater. Soil and shallow groundwater at the abandoned Starr Starrette facility in Dumas, Arkansas in Desha County, were determined to be contaminated with benzene, trichloroethylene and its degradation products, and metals, primarily arsenic, chromium, and cadmium. The site was added to the state priority list in 2010. Additional evaluation of the site contamination resulted in the conclusion that no remediation was necessary beyond monitoring of the chemical plume (ADEQ 2013f).

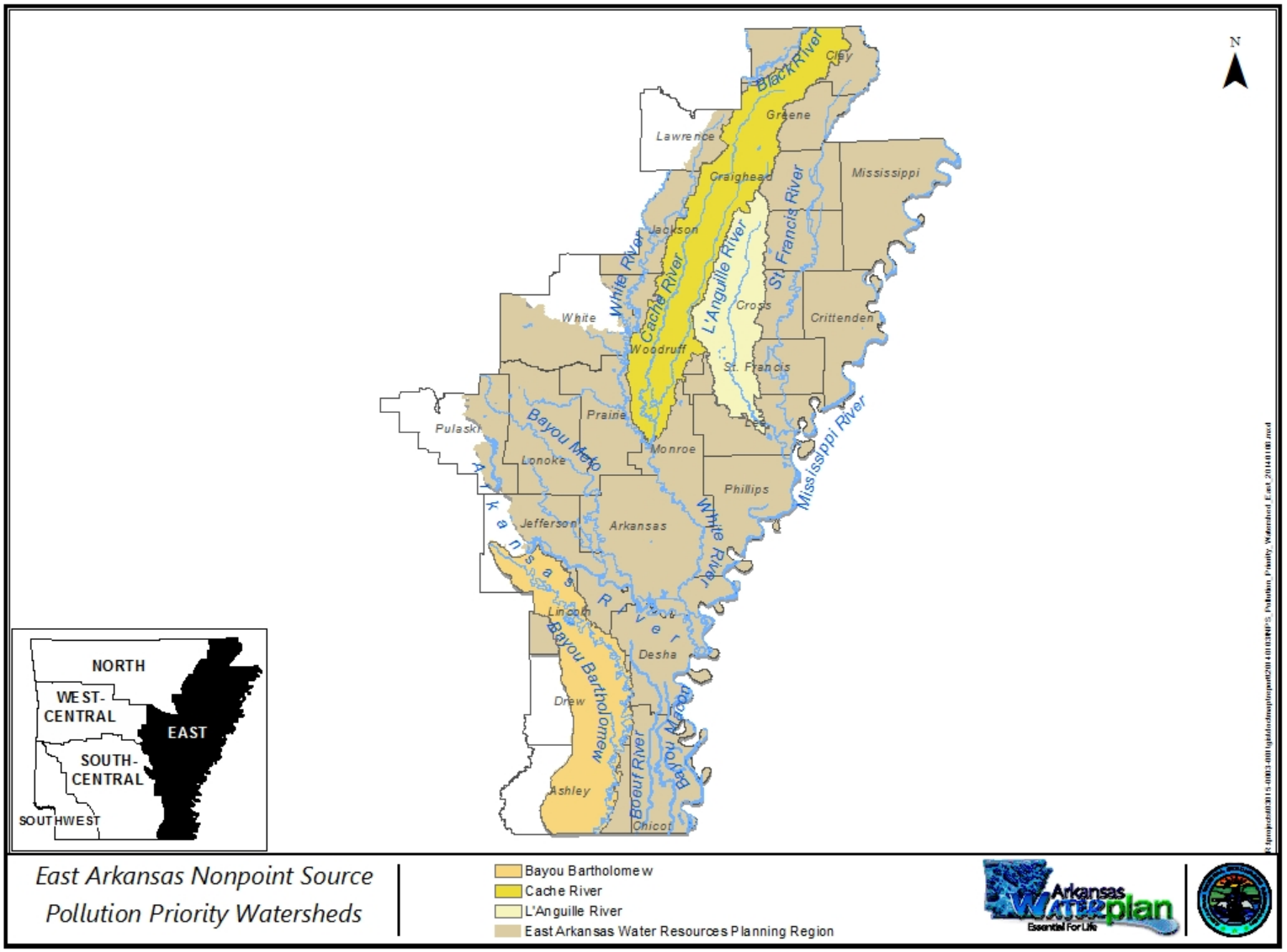

Figure 5.8. Nonpoint source pollution priority watersheds in the EAWRPR (ANRC 2012d).

Table 5.6. Status of Superfund sites in the EAWRPR with surface water quality issues. (Region 6 EPA 2013).

Site name	EPA ID	Site Location	Pollutants of concern	Contaminated water resources	Remediation status	Removed from NPL
Cedar Chemical Co.	ARD990660649	Phillips County	Dieldrin; 1,2-dichloroethane; aldrin; dinoseb; chloroform; methylene chloride; toxaphene; methoxychlor; heptachlor; pentachloro-phenol	Surface water and groundwater	Ongoing	NA
Gurley Pit	ARD035662469	Crittenden County	Lead, barium, zinc, PCB	Groundwater and Fifteen Mile Bayou	Threat controlled with de-watering of pits and treatment of surface runoff, Runoff management system completed in 1994	2003
Jacksonville Municipal Landfill	ARD980809941	Pulaski County	Dioxin; 2-4D; 2-4-5 T; 2-4-5 TP	Groundwater	Threat controlled through removal of hazardous substances in 1994, groundwater monitoring	2000
Monroe Auto Equipment Co. (Paragould Pit)	ARD980864110	Greene County	1-1dicholoroethane; 1-2 dicholoroethane; Xylenes, metals	Groundwater	Removal of contaminated soil in 1999, groundwater monitoring of natural attenuation in 1988	NA
Rogers Road Municipal Landfill	ARD981055809	Pulaski County	2-4 D; 2-4-5 T; 2-4-5 TP; dieldrin; 2-3-7-8 TCDD	Groundwater	Groundwater monitoring	2010
South 8th Street Landfill	ARD980496723	Crittenden County	Low pH; lead, PCB, PAHs	Groundwater	Groundwater monitoring	2004
Vertac	ARD000023440	Pulaski County	dioxin	Groundwater and Rocky Branch Creek	French drain in 1986, groundwater recovery and treatment in 1998; on-going groundwater monitoring, Removal of contaminated soil and hazardous materials in 1997	NA
Frit Industries	0600106	Lawrence County	Zinc sulfate, cadmium, chromium, lead	Cook Creek	Surface water collection and treatment system completed in 1985	1997

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

5.6.6 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.

5.7 Loss of Aquatic Biodiversity

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. These species of greatest conservation need include 107 species associated with aquatic and semi-aquatic habitats that occur in the EAWRPR (see Section 3.4). Figures 5.9 through 5.12 show the number of aquatic species of greatest conservation need present in watersheds within the EAWRPR. The greater the numbers of aquatic species of greatest conservation need present in a watershed, the more important it is to protect and restore water resources and their habitats (e.g., water levels, flow volumes, seasonal variablility in water levels and flows) in the watershed. The highest numbers of species of greatest conservation need are present in the St. Francis River and its tributaries. Other important streams for species of greatest conservation need in the planning region include Village Creek, the lower White River, and Bayou Bartholomew (Figure 5.12). Eight aquatic and semi-aquatic species present in the planning region are on the federal list of threatened and endangered species (Table 5.7).

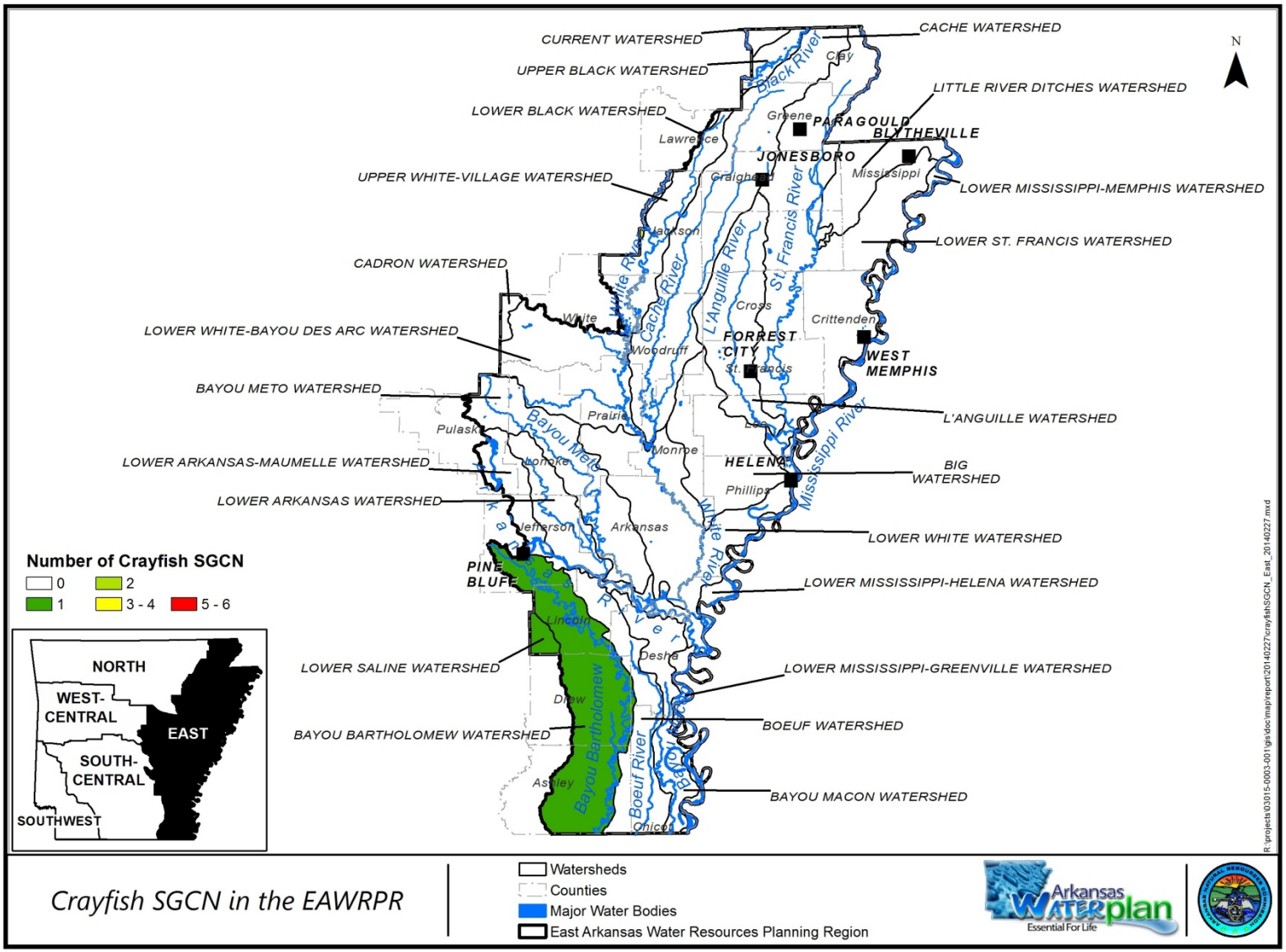

Figure 5.9. Numbers of crayfish Species of Greatest Conservation Need (SGCN) in watersheds of the EAWRPR.

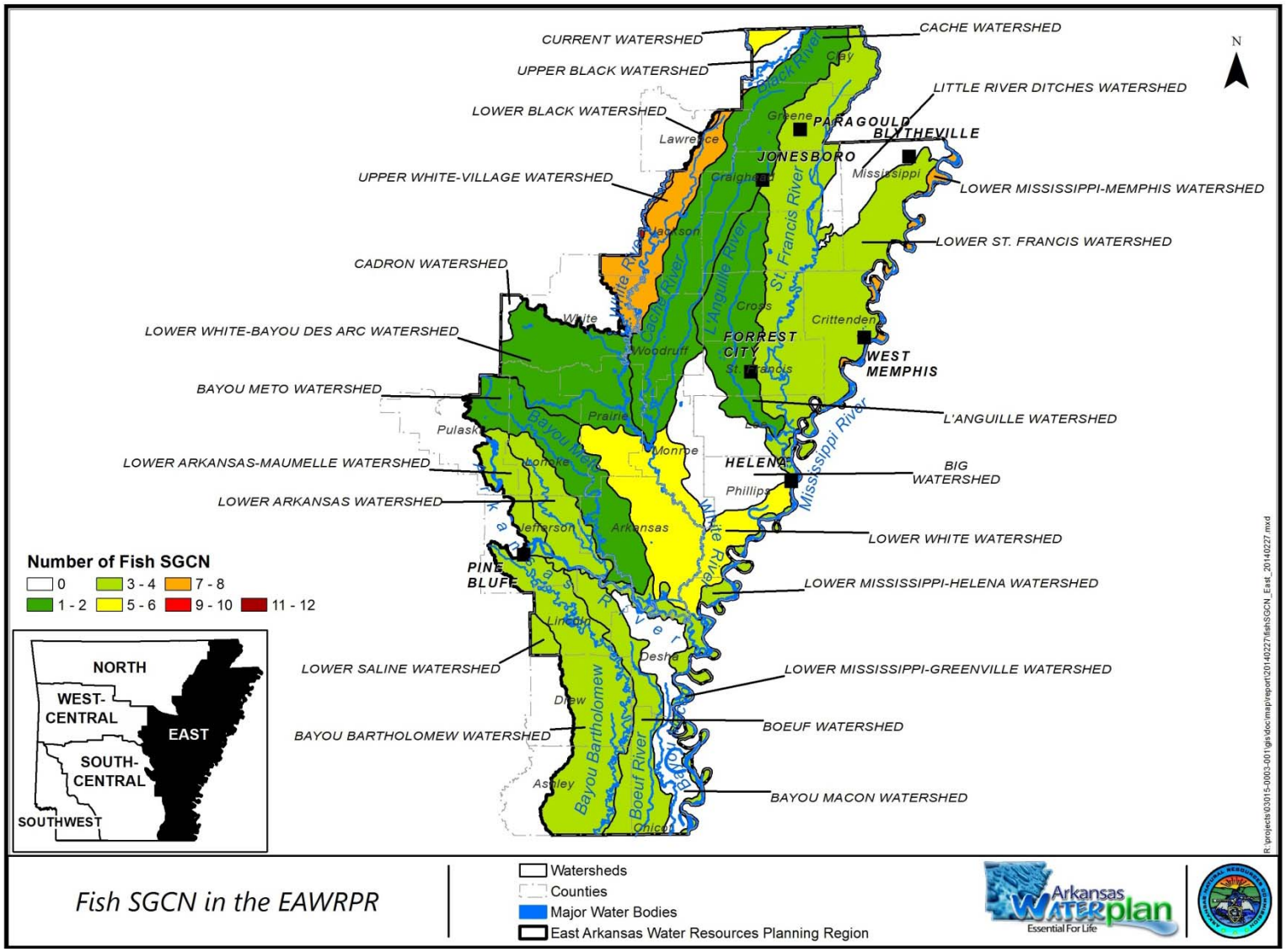

Figure 5.10. Numbers of fish SGCN in watersheds of the EAWRPR.

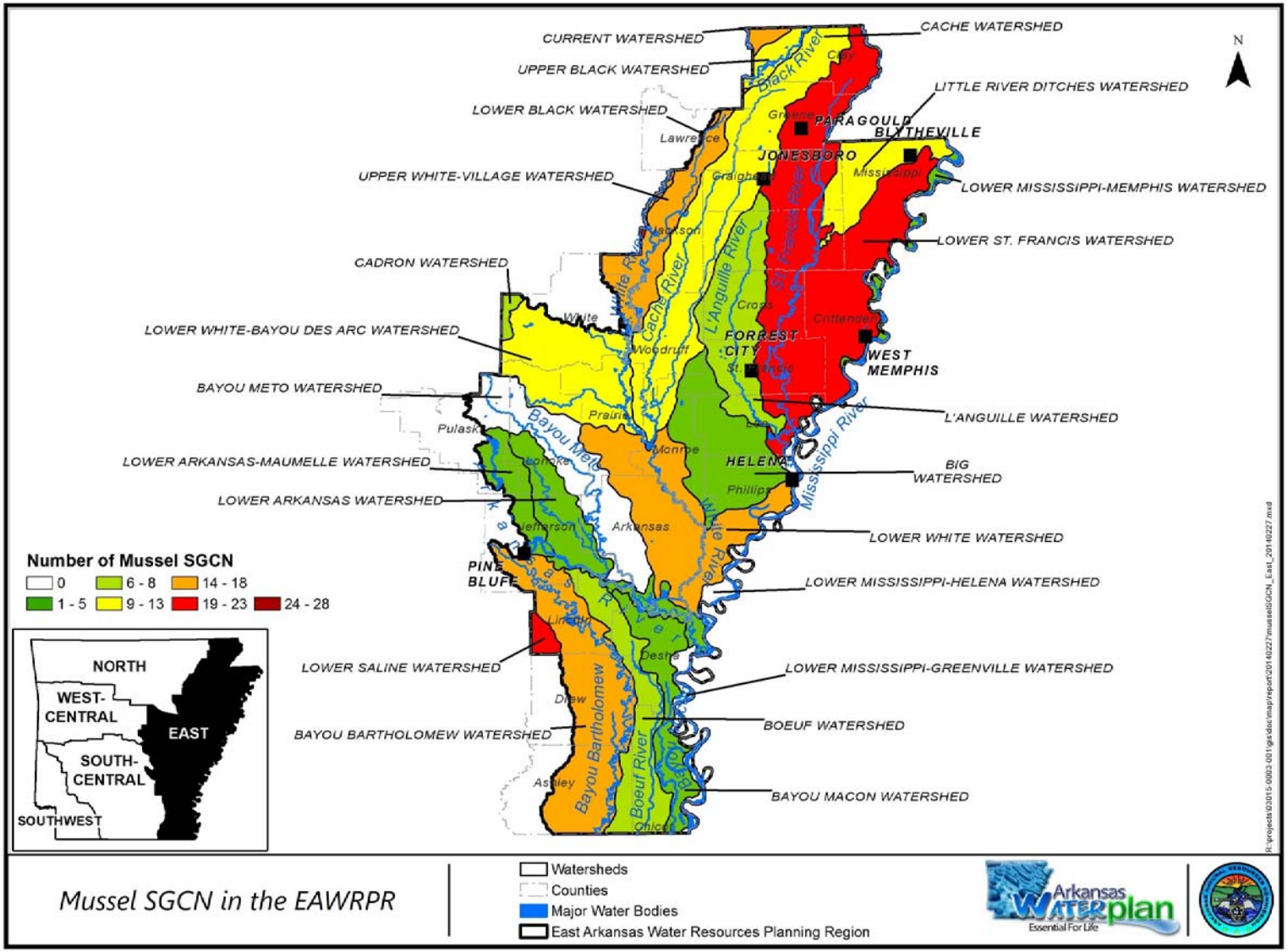

Figure 5.11 Numbers of mussel SGCN in the watersheds of the EAWRPR.

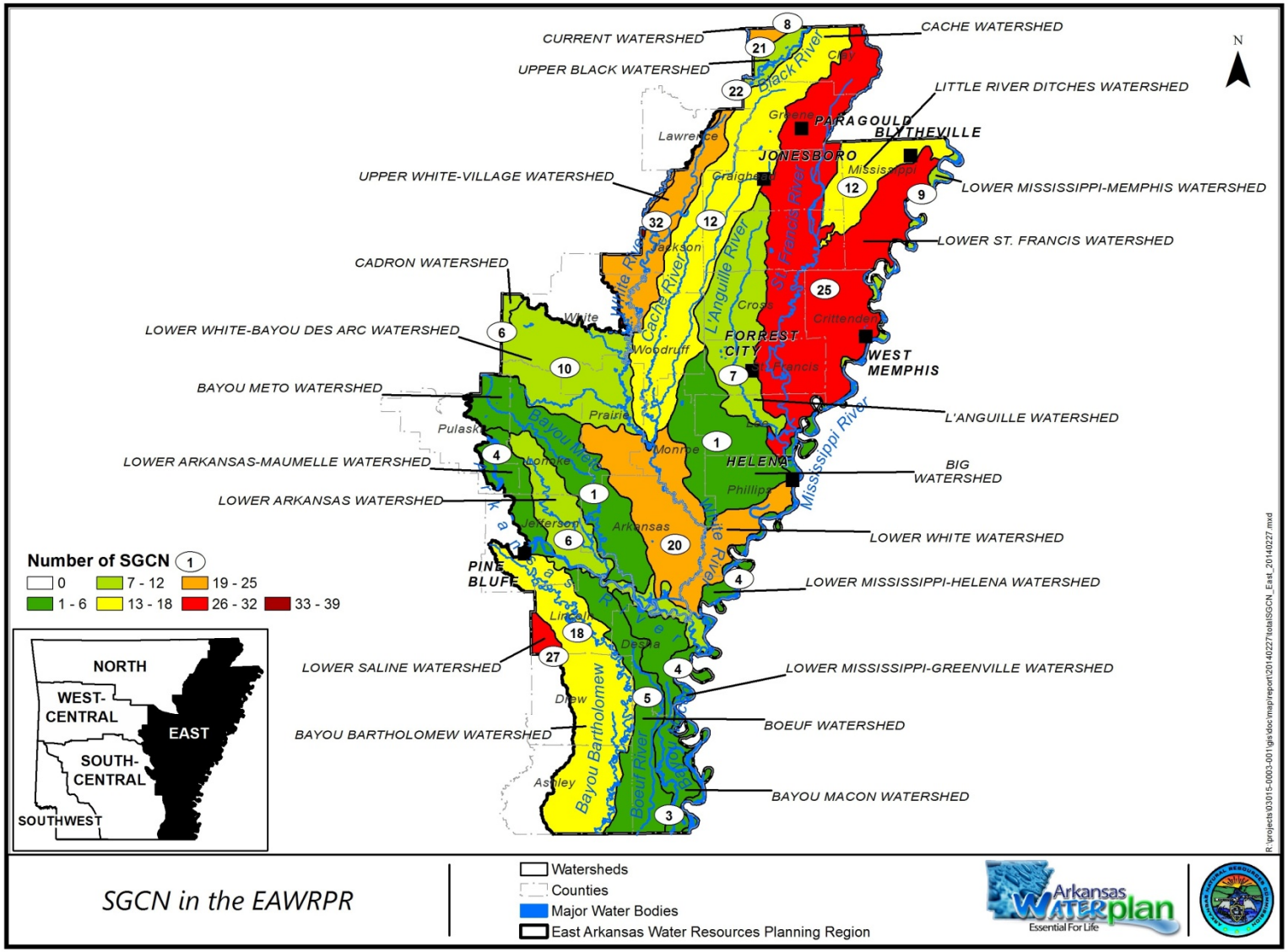

Figure 5.12. Total numbers of crayfish, fish, and mussel SGCN in the watersheds of the EAWRPR.

Table 5.7. Threatened and endangered species occurring in aquatic and semi-aquatic habitats in EAWRPR (ANHC 2013, Anderson 2006).

Common Name	Species Name	Status	EAWRPR habitat
Pallid Sturgeon	Scaphirhynchus albus	Endangered	Large pools of Mississippi River, White River, St. Francis River, Arkansas River
Scaleshell	Leptodea leptodon	Endangered	St. Francis River headwater glides, riffles, runs, gravel/cobble substrate
Fat Pocketbook	Potamilus capax	Endangered	St. Francis River, White River, headwater runs, headwater pools, sand/clay substrate
Pink Mucket	Lampsilis abrupta	Endangered	White River runs, pools, shoals, sand/gravel substrate
Ivory-billed Woodpecker	Campephilus principalis	Endangered	Mississippi alluvial plain bottomland depression, lower Mississippi River high bottomland forest, lower Mississippi River low bottomland forest
Interior Least Tern	Sterna antillarum athalassos	Endangered	Mud flats, ponds, lakes
Piping Plover	Charadrius melodus	Threatened	Mud flats
Pondberry	Lindera melissifolia	Endangered	Mississippi alluvial plain bottomland depression, lower Mississippi River high bottomland forest, lower Mississippi River low bottomland forest

In addition to the animal species of greatest conservation need, the Arkansas Natural Heritage Commission has identified 71 species of rare aquatic and semi-aquatic plants in the EAWRPR. There is one aquatic plant present in the planning region that is classified as endangered by the federal government (Table 5.7). Eleven semi-aquatic plant species present in the planning region are on the state threatened and endangered plant species list (Table 5.8). These plant species are affected by water quality, water levels, flow rates, and/or seasonal changes in water or levels or flow.

Table 5.8. State threatened and endangered species occurring in aquatic and semi-aquatic habitats in the EAWRPR counties (Arkansas Natural Heritage Commission 2013).

Common Name	Species Name	Status
Sedge	Carex opaca	Endangered
Snowy orchid	Platanthera nivea	Endangered
Southern tubercled orchid	Platanthera flava	Threatened
Winterberry	Ilex verticillata	Threatened
Pondberry	Lindera melissifolia	Endangered
Texas sunnybell	Schoenolirion wrightii	Threatened
Purple fringeless orchid	Platanthera peramoena	Threatened
Rose turtlehead	Chelone obliqua var. speciosa	Endangered
Slender rose-gentian	Sabatia campanulata	Endangered
Small-headed pipewort	Eriocaulon koernikianum	Endangered
White-top sedge	Rhynchospora colorata	Endangered

In some cases, the presence of non-native aquatic species is believed to affect aquatic biodiversity. There are 26 non-native aquatic animal species known to occur in the EAWRPR (Table 5.9). The majority of the non-native fish species present in the region are sportfish species that have been introduced purposely and are regularly stocked. Some of the non-native fish species are believed to have escaped from aquaculture ponds. 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 sportfish and exotic clams, are suspected to affect native species by competing with them for food and/or habitat (USGS 2013d). There are also seven species of invasive aquatic plants known to occur in the planning region Table 5.9.

5.8 Water Infrastructure

Communities throughout the state struggle to maintain drinking water and wastewater infrastructure, including treatment plants and distribution lines. A few communities in the EAWRPR are experiencing growth that is requiring expansion of water supply and wastewater capacity (see Section 4.1). In other areas within the planning region, maintaining aging infrastructure with limited financial resources is more likely an issue.

Table 5.9. Non-native aquatic species identified in the EAWRPR (University of Georgia - Center for Invasive Species and Ecosystem Health 2013, USGS 2013d).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
Waterflea	*Daphnia lumholtzi*	Asia	Lake Poinsett, Horn Lake, Spring Lake, Lake Pine Bluff, Merrisach Lake, Lake Chicot	1995	accidental	Competition with natives
	Eurytemora affinis	Atlantic & Gulf Coasts	Merrisach Lake	1967	Accidental	unknown
Inland silverside	Menidia beryllina	Mississippi & Red Rivers	White River, lower Arkansas River	1987	Stocking	Competition with natives
Redbreast sunfish	Lepomis auritus	Atlantic drainage	White River	2007	Stocking	Competition & hybridization with natives
Northern snakehead	Channa argus	China, Russia, Korea	Piney Creek & Little Piney Creek	2008, 2009	unauthorized stocking	Competition with natives
Blue tilapia	Oreochromis aureus	Africa, Middle East	Lower Arkansas River	1998	Stocking or accidental	Competition with natives, mussel decline
Goldfish	Carassius auratus	Asia	L'Anguille River	1988	Accidental	Unknown
Grass Carp	Ctenopharyngodon idella	Eastern Asia	Throughout the region	1988, 1970,	stocking	Habitat modification
Common carp	Cyprinus carpio	Eurasia	Throughout the region	1988, 1986, 1985, 2005, 1950	Stocking	Habitat modification
Silver carp	Hypophthalmichthys molitrix	Asia	Little River drainage, Lost Creek, lower White River drainage, Bayou Meto drainage, Arkansas River	1988, 1981, 1975	Accidental	Competition with natives
Bighead carp	Hypophthalmichthys nobilis	China	Lower St. Francis drainage, lower White River drainage, Bayou Meto drainage, Arkansas River	1988, 2003	Accidental	Unknown
Black carp	Mylopharyngodon piceus	Asia	White River	2005	Accidental	Reduction of mussel populations
Fathead minnow	Pimephales promelas	US	Piedmont Bayou, lower St. Francis River, Bayou Macon drainage, Overflow Creek, Bayou Bartholomew	1988, 1980	Accidental	Unknown
Rudd	Scardinius erythrophthalmus	Western Europe	Horseshoe Lake	1991	Accidental	Unknown

Table 5.9. Non-native aquatic species identified in the EAWRPR (University of Georgia - Center for Invasive Species and Ecosystem Health 2013, USGS 2013d) (continued).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
White catfish	Ameiurus catus	Atlantic drainage	East Bayou, Bayou Des Arc, Big Cypress Creek, Big Creek drainage	1988	Stocked	Competition with natives
Brown bullhead	Ameiurus nebulosus	Northern US, Atlantic drainage	Otter Bayou, Bayou Bartholomew, Arkansas River	1988	Stocked	Competition with natives
Blue catfish	Ictalurus furcatus	Mississippi River basin, Gulf coast drainage	Lake Des Arc	1997	Stocked	None
Wiper	Morone chrysops x M. saxatilis	None, artificial hybrid	Storm Creek, Arkansas River	1988, 1984	Stocked	Hybridize with native bass
Striped bass	Morone saxatilis	Atlantic & Gulf drainages	St. Francis River, Arkansas River, White River	1988	Stocked	Can impact populations of small fishes
Cutthroat trout	Oncorhynchus clarkia	Pacific coast drainage	White River	1982, 1983	Stocked	None
Rainbow trout	Oncorhynchus mykiss	Pacific drainage	White River	1988	Stocked	Unknown
Brook trout	Salvelinus fontinalis	Northeastern & Great Lakes drainage	White River	1988	Stocked	Unknown
Nutria	Myocastor coypus	South America	Throughout region	1978, 2005, 1958,	Accidental	Over-grazing of wetlands
Asian clam	Corbicula fluminea	Asia	St. Francis River, Little River ditch, L'Anguille River, White River, La Grue Bayou, Arkansas River, Coon Bayou, Lake Chicot, Boeuf River	1968, 1976, 1969, 1978, 1973, 1966, 1977, 1964, 1980, 2005, 1974, 1975	Accidental	Competition with natives, biofouling
Zebra mussel	Dreissena polymorpha	Black, Caspian, & Azov Seas	Arkansas River, Plum Bayou, White River	1993, 1994, 1998	Accidental	Competition with natives, habitat modification, biofouling
Yellow anaconda	Eunectes notaeus	South America	Wapanocca Wildlife Refuge	2004, 2005	Released	Unknown
Alligator weed	*Alternanthera philoxeroides*	South America	Arkansas, Ashley, Chicot, Desha, Drew, Jefferson, and Lincoln Counties	1988, 2009	Accidental	Habitat modification
Sessile joyweed	*Alternanthera sessilis*	Asia	Arkansas and Prairie Counties	2001	Introduced	nuisance

Table 5.9. Non-native aquatic species identified in the EAWRPR (University of Georgia - Center for Invasive Species and Ecosystem Health 2013, USGS 2013d). (continued).

Species Common Name	Species Scientific Name	Origin	Locations	Dates Identified	Method of introduction	Impact
Water hyacinth	*Eichhornia crassipes*	South America	Jefferson County, Chicot County	1999, 2001	Accidental	Habitat modification
Hydrilla	*Hydrilla verticillata*	Asia	Ashley County	2005	accidental	Competition with natives
Purple loosestrife	*Lythrum salicaria*	Europe & Asia	Craighead County	1985	Introduced	Displacement of natives
Parrotfeather	*Myriophyllum aquaticum*	South America	Arkansas, Ashley, Greene, Cross, Crittenden, Prairie, and Jefferson Counties	1988, 1970	Introduced	Competition with natives
Eurasian water milfoil	*Myriophyllum spicatum*	Europe, Asia, Africa	Chicot County	2011	Accidental	Habitat modification, displacement of natives
Brittleleaf niad	***Najas minor***	Europe	Lonoke County	2010		
Watercress	***Nasturtium officinale***	Europe, Africa, Asia	Lawrence and Phillips County	1988		
Water fern	***Salvinia minima***	Mexico, South America	Arkansas, Chicot, Desha, Jefferson, Lee, Lincoln, Lonoke, Monroe, Phillips, Prairie, and Pulaski County	1998, 1999		

Of particular concern, is the recent increased focus on nutrients in wastewater discharges. Historically, permitted point source discharges in Arkansas were not limited with regard to the amount of nutrients that can 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 (Arkansas Regulations 2.509). While there are no phosphorus impaired waterbodies in the EAWRPR, several municipalities in the planning region have wastewater treatment plants that are currently required to monitor nutrient levels in their wastewater discharge (ADEQ 2009b, 2013a). Substantial upgrades to existing wastewater facilities may be required to meet discharge nutrient limits.

6.0 INSTITUTIONAL AND REGULATORY SETTING

This section provides a description of the regulatory and institutional framework for water resources management in EAWRPR. 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 EAWRPR 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 2011). The discussion below identifies and summarizes the laws and regulations and associated programs that guide water management in EAWRPR, 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 influence water resources management in the EAWRPR 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 EAWRPR 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 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 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 EAWRPR 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.

Table 6.1. Federal laws and regulatory programs that address EAWRPR 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	USFS
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.

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 EAWRPR were completed in 2001. 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 2001, 17 TMDLs have been completed for waterbodies in the EAWRPR (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 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 335 public water utilities in the EAWRPR 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. Some of the legislation and programs that address water quality also address other aspects of water resources management. For example, preservation of forest lands protects water quality and hydrology. As a result, there is some duplication in Tables 6.1 and 6.2. Federally appropriated water, such as the water required to maintain navigation on the 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 Arkansas 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	EPA	Protects human health
	Operator certification	EPA	Informs the public
Endangered Species Act	Freshwater species protection	US Fish and Wildlife Service (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	USDA	Water resources protection/improvement
	Natural Resources Inventory	USDA	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		

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

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
Arkansas Wilderness Act	National forests	USFS	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
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
National Flood Insurance Act	National Flood Insurance Program	FEMA	Insurance against flood losses
	Floodplain management	FEMA	Reduction of flood damage
	Flood hazard mapping	FEMA	Identification of flood hazard areas
None	Climate monitoring	NOAA	Tracking precipitation and evaporation – water availability
	Climate prediction	NOAA	Future water availability
	Drought status	NOAA	Enactment of water shortage specific management
Wild and Scenic Rivers Act	National Wild and Scenic Rivers	USFS	Preservation of unregulated rivers and streams for recreation

Note: Highlighted programs were initiated after the 1990 AWP update

An important federal program for conservation of water resources in the EAWRPR is the dredge and fill permitting program of the CWA (Section 404). In 1990, 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). There are four sites within the EAWRPR that have been designated as commercial mitigation banks for CWA dredge and fill permitting (Table 6.3). The program is a mechanism for implementing the federal policy of no-net-loss of wetlands (EPA 2013d). Revised regulations governing this mitigation program were issued in 2008.

Table 6.3. Commercial mitigation banks within and serving areas within the EAWRPR (USACE 2013).

Name of site	Location	Year Established	Area (acres)	Primary service area	Secondary service area	Sponsor	Credits
Camp Nine	Chicot County		320	Beouf River watershed in Chicot, Ashley, Desha, Drew, and Lincoln Counties	None	ANRC	355.13408 wetland
Lower Cutoff	Drew County		473.48	Bayou Bartholomew watershed in Ashley, Drew, Lincoln, and Jefferson Counties	None	Natural Resources Investment Group	493.4 wetlands, 236,814 stream
Davis Creek	Searcy County	2010	319	None in EAWRPR	Small areas of White and Jackson Counties in the EAWRPR	Mitigation Solutions LLC	93,778.7 stream
Little Creek	White County			Cadron Creek watershed, which includes a small area of White County in the EAWRPR	None in EAWRPR	Keathley Farms	5.85 wetland, 25619 stream

The Endangered Species Act provides for protection and recovery of imperiled terrestrial, freshwater, and marine plant and animal species (except pest insects) (USFWS 2013b). The EAWRPR contains aquatic and semi-aquatic habitat important for a number of endangered species (Table 5.5).

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 (EPA 2013e).

Under the National Flood Insurance Act, flood hazard maps have been completed for the entire EAWRPR, and most of the mapping has been, or is in the process of being, modernized, within the last 8 years, with the exception of Lee, Prairie, Monroe, and Woodruff Counties (Figure 6.1). Flood hazard maps for these counties are more than 25-years old. Flood hazard mapping for St. Francis County was updated in 2005. 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, the flood hazard maps identify the regulatory SFHA whereby the community floodplain administrator applies the locally adopted and enforced floodplain management ordinance. Participation the National Flood Insurance Program is voluntary, however non-participation results in federal flood insurance not being available to residents and limits post-disaster financial assistance. All of the counties included in the EAWRPR are participating in the program, as well as a large percentage of the communities.

Surface waters in the EAWRPR that are under some degree of federal management include the Arkansas River (MKARNS); Mississippi River (navigation); White River (USACE reservoirs upstream of the alluvial plain, MKARNS, White River navigation to Newport, White River National Wildlife Refuge); St. Francis River (flood control project); and L'Anguille River (St. Francis National Forest). Federally authorized uses for the portions of the Arkansas River and White River in this planning region include navigation and flood control. The Arkansas River is also authorized for hydropower.

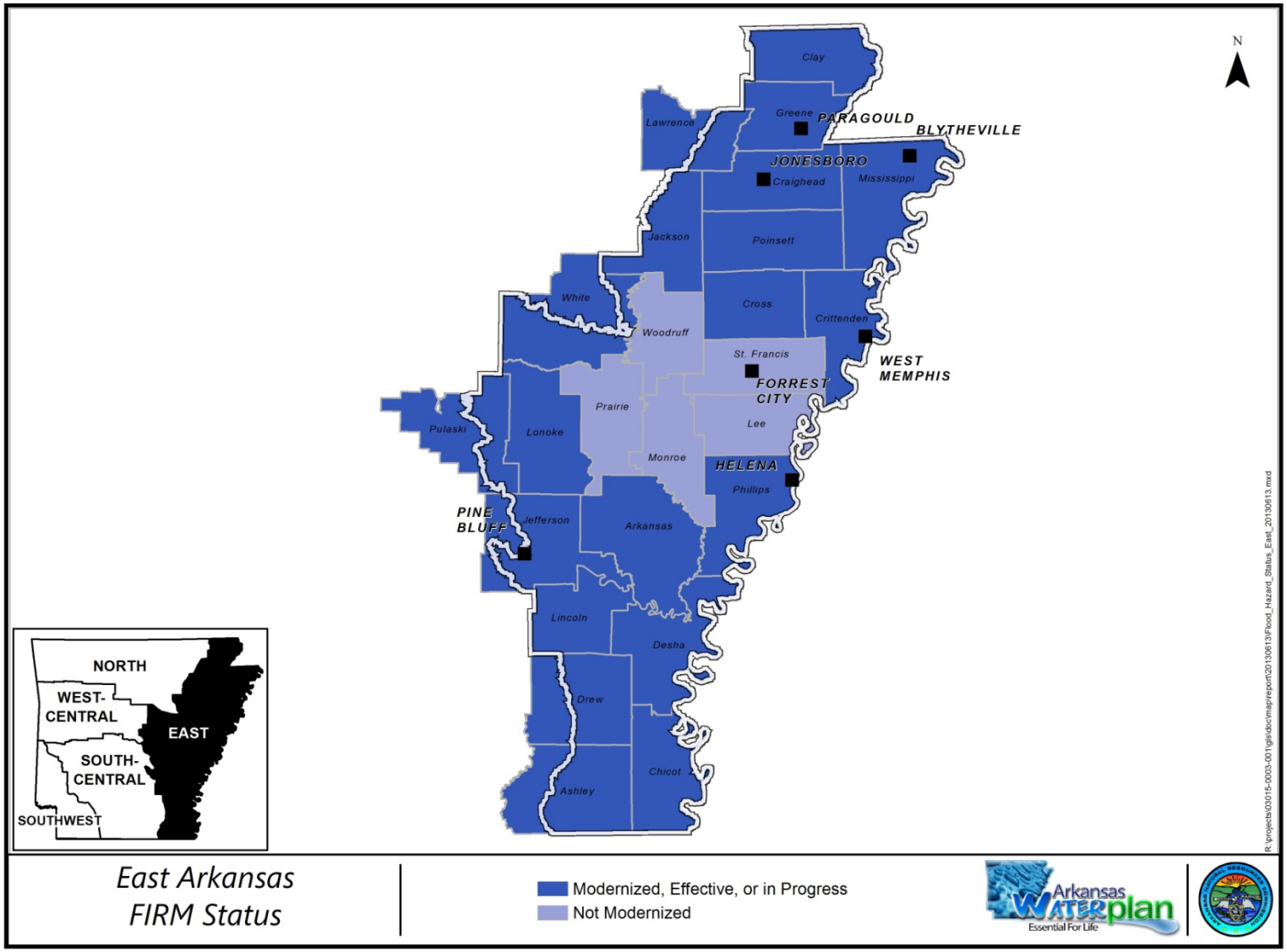

Figure 6.1. Status of flood hazard mapping in the EAWRPR.

Federally appropriated water, such as the water required to maintain navigation on the MKARNS, is not available for other uses. Federal water requirements preempt other beneficial water uses, such as irrigation. The Arkansas River minimum flow at Little Rock (Murray Lock and Dam 7) required for navigation is 3,000 cfs. On the White River, water elevation is more important for maintaining a passable navigation channel. White River stages necessary to maintain commercial navigation are listed in Table 6.4.

Table 6.4. Spring 2014 estimated minimum White River stages for commercial navigation (Paul Hamm, USACE Memphis District, personal communication, 3/20/13).

Location	Elevation/Stage	Gage Zero Elevation (feet above sea level)	Discharge (cfs)
RM 15	Elevation 121feet above sea level	NA	NA
Clarendon gage	18 feet	139.91	21,200[2]
DeValls Bluff gage	14 feet	152.96	26,800[1]
Georgetown gage	11 feet	170.08	24,600[1]
Augusta gage	23 feet	169.85	22,200[1]
Newport gage	11 feet	194.09	22,500[1]

[1] USGS Ratings Depot [2] USACE, Memphis Rating

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 6.5 summarizes current federal assistance programs available in the EAWRPR and the associated federal laws. The majority of the federal assistance programs listed in Table 6.5 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 (see Table 6.5). In 2012, over 423,000 acres in the counties of the EAWRPR were enrolled in Farm Bill programs, and over $27 million in funding provided to those counties for water quality practices (Table 6.6) (NRCS 2012).

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.

There are additional federal laws that authorize programs that provide assistance for community waste treatment and management to protect water quality. HUD grants for construction and upgrading of wastewater infrastructure were also authorized by the Housing and Community Development Act. Several programs to provide financial assistance for wastewater systems and solid waste programs in rural areas were authorized by the Consolidated Farm and Rural Development Act.

Table 6.5. Federal laws and assistance programs that affect the EAWRPR water quality.

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	USFS
	Forest Legacy Program	
	Urban and Community Forestry Program	
Housing and Community Development Act	Community Development Block Grant program	US Department Housing and Urban Development (HUD)
Farm Bill	Agricultural Water Enhancement Program	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	
	Wetlands Reserve Program	
	Wildlife Habitat Incentives Program	
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	
American Recovery and Reinvestment Act	Clean Water State Revolving Fund	Recovery Accountability and Transparency Board
	Clean-up of leaking underground storage tanks	
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.

Table 6.6. NRCS conservation programs summary for 2012 (NRCS 2012).

County	CRP			EQIP			National water quality initiative			Mississippi River Basin Healthy Watersheds		
	Contracts	Acres	Money obligated	Contracts	Acres	Money obligated	Contracts	Acres	Money obligated	Contracts	Acres	Money obligated
Arkansas	66	61,110.8	$2,766,311	30	19,420.4	$1,293,331	NA			0	0	0
Ashley	3	1,740.0	$45,314	9	8,415.5	$121,642	NA			1	220.5	$61,344
Chicot	4	5,505.9	$153,288	52	21,956.3	$2,240,770	NA			37	16142	$1,993,065
Clay	5	5,634.5	$158,920	23	21,414.7	$88,899	NA			0	0	0
Craighead	19	15,412.6	$490,221	33	10,621.3	$772,415	NA			7	1,054.7	$245,156
Crittenden	3	2,757.2	$61,080	76	25,102.2	$1,380,785	NA			55	7,238.3	$1,251,288
Cross	58	86,959.0	$2,261,088	36	12,535.6	$1,361,510	NA			36	11,204.42	$1,262,326
Desha	36	44,768.3	$1,968,904	84	42,664.9	$3,688,879	NA			67	10,767.2	$3,598,056
Drew	3	4,870.4	$160,949	22	14,158.2	$404,132	NA			0	0	0
Greene	1	673.0	$8,002	20	37,352.3	$61,921	NA			0	0	0
Jackson	81	77,367.4	$2,254,550	35	11,080.0	$814,772	NA			10	1,697.31	$297,507
Jefferson	34	36,081.1	$1,251,011	43	15,082.2	$2,258,878	14	4,949.8	$758,983	1	152.2	$97,643
Lawrence	68	52,330.3	$2,326,961	8	6,559.0	$149,718	NA			0	0	0
Lee	14	10,941.4	$289,841	28	3,768.2	$827,155	NA			9	1,513.40	$133,158
Lincoln	54	66,598.9	$2,237,067	53	10,899.0	$1,117,499	25	5,400.7	$925,436	0	0	0
Lonoke	7	5,139.0	$166,913	16	5,884.3	$1,212,522	NA			7	3,027.9	$915,220
Mississippi	5	9,872.9	$132,994	35	8,840.1	$1,223,175	NA			30	3,759.3	$1,159,683
Monroe	3	3,482.8	$56,917	7	737.2	$292,416	NA			2	203	$79,772
Phillips	8	10,265.7	$307,938	38	4,545.5	$1,244,393	NA			10	889.8	$537,740
Poinsett	10	9,937.2	$323,366	37	9,141.0	$919,041	NA			34	7,789.8	$690,246
Prairie	10	9,078.7	$222,826	16	7,198.7	$1,854,269	NA			8	4023	$1,147,226
Pulaski	0			4	12.7	$33,604	NA			0	0	0
St. Francis	26	34,920.8	$916,195	34	4,663.3	$859,632	NA			10	916.7	$308,525
White	2	1,964.3	$50,600	4	298.5	$82,932	NA			0	0	0
Woodruff	2	3,058.0	$89,403	11	3,119.4	$443,413	NA			9	2,426	$373,041
Totals		**39,943.1**	**$1,056,198**		**305,470.5**	**$24,747,703**		**5,400.7**	**$925,436.00**		**73,025.53**	**$14,150,996.00**

The American Recovery and Reinvestment Act 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 systems and clean up of leaking underground storage tanks and hazardous waste sites (EPA 2013f). Recovery money was awarded to the Arkansas State Clean Water Revolving Loan Fund, and the ADEQ Leaking Underground Storage Tank Program. Through these programs, recovery money was awarded to three leaking underground storage tank remediation projects and one clean water project in the planning region (EPA n.d.).

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). Money from this program was used to install fixed pumpout facilities at an Arkansas River marina near Pine Bluff (ADH 2011b).

Forestry assistance programs are included in Table 6.5 because forest land 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 6.7. 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 6.6 and 6.7.

Table 6.7 Federal assistance programs for aspects of EAWRPR 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
	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	USFS	Trees in communities reduce stormwater runoff, improving hydrology
	Forest Stewardship Program	USFS	Well-managed forestlands improve and protect water resources
	Forest Legacy Program		
Flood Control Act/Water Resources Development Act	Habitat restoration	USACE	Water storage, water supply, flood reduction, flow management, restoration of physical aquatic habitat
	Irrigation projects		
	Basin studies		
Housing and Community Development Act	Community Development Block Grant program	HUD	Protects/improves public water supply

Table 6.7 Federal assistance programs for aspects of EAWRPR water resources other than water quality (continued).

Federal Law	Federal Program	Responsible Federal Agency	Water Plan Relevance
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 grants 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 Safe Drinking Water Act established the Drinking Water State Revolving Fund to assist drinking water utilities in financing infrastructure improvements and pollution control activities. Using this fund, states can offer utilities low-cost loans and other types of assistance. Funds available through the American Recovery and Reinvestment Act were awarded to the Arkansas Drinking Water State Revolving Fund and used for three projects in the EAWRPR (EPA n.d.).

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Farm Bill amendments and associated assistance programs, as well as the Conservation Effects Assessment Program, the assistance programs associated with the Consolidated Farm and Rural Development Act, and the HUD Community Block Development Grant Program were discussed in Section 6.1.2.1. Farm Bill programs address water conservation (e.g., Groundwater Decline Initiative), flood control (e.g., Watershed protection and Flood prevention), and conservation and restoration of aquatic habitat (e.g., Wetlands Reserve Program, Wildlife Habitat Incentives Program). In 2012, over 11,600 acres of land in EAWRPR counties were enrolled in these programs, and $12 million in funding was allocated to these counties (Table 6.6) (NRCS 2012).

Several water resources projects have been authorized in Arkansas since 1990 under the Water Resources Development Act (WRDA). Projects located in the EAWRPR that have been authorized and funded through WRDA are described in Table 6.8.

Table 6.8. WRDA projects in EAWRPR initiated after 1990 (USACE Memphis District 2012, 2013, NRCS 2011, Bayou Meto Water Management District 2013, Dickard 2013).

Project Name	Location	Description	Authority	Status
Lower Cache Restoration	Monroe County	Increase fish and wildlife habitat by restoring flow to three old meanders	WRDA 1986	2012 federal funding for implementation allocated
White River Basin Comprehensive Study	White River basin to the Arkansas River	Identify water resources needs and opportunities for water supply, flood control, navigation, recreation, power generation, wastewater management, and environment	WRDA 1986, 2000, 2007	
White River Backwater	Phillips and Desha Counties	Maintenance of levees and pump station for flood control	Flood Control Act 1952	On-going
Bayou Meto Basin	Lonoke, Pulaski, Prairie, Jefferson, Arkansas Counties	Diversion from Arkansas River for irrigation, channel improvements and pumping station for flood control, waterfowl conservation and management, environmental restoration	WRDA 1996	First diversion pump station 89% complete, Flood control pump station under construction
St. Francis Basin	Clay, Green, Mississippi, Craighead, Poinsett, Crittenden, St. Francis, and Lee Counties	Levees and pump stations for flood protection	WRDA 2007	Mitigation underway
St. Francis River and Tributaries	Clay, Green, Mississippi, Craighead, Poinsett, Crittenden, St. Francis, and Lee Counties	Maintenance and repair of existing levees, pump stations, and drainage ditches for flood control	Flood Control Act 1968	On-going
Helena Harbor maintenance	Phillips County, Mississippi River mile 652	Dredging to maintain channel, berthing and fleeting areas, and turning basin	WRDA 1986	Dredged 2012
Oceola Harbor maintenance	Mississippi County, Mississippi River mile 785	Dredging to maintain navigation channel	WRDA 2007	Dredged 2012
Beouf-Tensas flood control project	Chicot, Ashley, and Drew Counties	Maintenance and report of existing levees, pump station, and drainage ditches	WRDA 1986	On-going

Table 6.8. WRDA projects in EAWRPR initiated after 1990 (continued).

Project Name	Location	Description	Authority	Status
Grand Prairie Area Demonstration Project	Arkansas and Prairie Counties, small areas in Lonoke and Marion Counties	Diversion from White River for irrigation, tailwater recovery systems, surface water storage reservoir for irrigation	WRDA 1996	Pump station under construction
Lower Mississippi River Resource Assessment	Mississippi River and floodplain, which includes lower Arkansas River and White River	Identify information needs for river management, natural resource habitat needs, needs for river access and related recreation for preparation of a comprehensive watershed management plan	WRDA 2000	Assessment 1 scheduled for January 2014 completion

6.1.3 State Laws and Regulatory Programs

Arkansas has primary authority for regulation of water usage within the state. Many of the state laws and agency regulations related to water quality implement federal laws. The federal government has delegated authority to the state for a number of the regulatory administrative activities of both the Clean Water Act and the Safe Drinking Water Act.

6.1.3.1 Water Use 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 2011).

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 6.9 summarizes selected Arkansas water use regulations that apply in the EAWRPR.

Table 6.9. State regulations related to water use.

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	Arkansas Code §17-50-201 et seq.
	Construction requirements	
	Well reporting requirements	
Affiliate Transaction Rules[3]	Requirements for utility rates	Arkansas Code §23-2-101 et seq.
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

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) and the main stem of the White River (2009).

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. In the White River Basin, Arkansas Code §15-22-304(e) further limits excess to an amount not to "exceed on a monthly basis an amount which is 50% of the monthly average of each individual month of excess surface water."

Minimum streamflow is often mistakenly equated with fish and wildlife flow requirements. Fish and wildlife flows are one of the 5 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.

In 1991, the Arkansas Ground Water Protection and Management Act (Arkansas Code §15-22-901 et seq.) was signed into law, providing ANRC with authority to designate critical groundwater areas. As of 2013, two critical groundwater areas have been designated in the EAWRPR (Figure 4.8). 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.

Legislation passed in 2001 requires the use of water meters on all non-domestic wells withdrawing water from sustaining aquifers, beginning in 2006 (Arkansas Code §15-22-915). Designated sustaining aquifers in the EAWRPR include the Nacatoch, Wilcox, Sparta/Memphis, and Cockfield aquifers (Figure 3.14).

6.1.3.2 Water Quality Regulations

Water quality regulations are promulgated by the General Assembly, APCEC, the State Board of Health, and ANRC. Table 6.10 identifies state regulations and laws, along with associated federal laws, that address water quality.

Table 6.10 illustrates that there are myriad state regulations, covering a range of activities, which address water quality. The most basic of these are the regulations that set criteria for the quality of state surface waters and groundwater. These regulations identify the uses that state waterbodies should support, and specify narrative and numeric criteria for water quality to ensure 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 the designated uses assigned to surface waterbodies in the EAWRPR under Regulation 2 is provided in Table 6.11. Delta ecoregion numeric surface water quality criteria apply in the EAWRPR. Delta ecoregion numeric water quality criteria also apply to surface waters on Crowley's Ridge as there are no ecoregion-specific water quality criteria for that ecoregion. Numeric surface water quality criteria for the water bodies in the planning region are listed in Tables 6.12 through 6.14. Figure 6.2 shows the ADEQ Water Quality Planning Segments that are located in the planning region.

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 (see section 3.12).

Table 6.10. State regulations that protect water quality.

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.)	CWA
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.)	CWA
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.)	CWA
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.)	CWA
Regulation 5: Liquid Animal Waste Systems[1]	State wastewater permit	Arkansas Water and Air Pollution Control Act (Arkansas Code § 8-4-201 et seq.)	CWA
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.)	CWA
Regulation 12: Storage Tank Regulations[1]	Petroleum storage tank trust fund	Petroleum Storage Tank Trust Fund Act (Arkansas Code § 8-7-901 et seq.)	CWA, Underground Storage Tank Regulations, including Energy Policy Act of 2005
Regulation 15: Open-Cut Mining and Land Reclamation Code[1]	Environmental protection during non-coal mining activities	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
	Restoration of non-coal mining sites		
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.)	SDWA
Regulation 22: Solid Waste Management Rules[1]	Landfill construction specifications	Arkansas Solid Waste Management Act	RCRA, Pollution Prevention Act

Table 6.10. State regulations that protect water quality (continued).

Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
	Acceptable materials for landfill disposal	(Arkansas Code § 8-6-201 et seq.), Arkansas Pollution Prevention Act (Arkansas Code § 8-10-201 et seq.)	
	Regional solid waste management districts		
	Pollution prevention		
Regulation 23: Hazardous Waste Management[1]	Hazardous waste management	Arkansas Hazardous Waste Act (Arkansas Code § 8-7-201 et seq.), Arkansas Hazardous Materials Transportation Act (Arkansas Code § 27-2-101 et seq.)	RCRA, Pollution Prevention Act
	Pollution prevention	Arkansas Pollution Prevention Act (Arkansas Code § 8-10-201 et seq.)	
Regulation 27: Licensing of Landfill Operators and Illegal Dumps Control Officers[1]	Licensing of landfill operators	Arkansas Code § 8-6-901 et seq.,	RCRA
	Licensing of illegal dumps control officers	Illegal Dump Eradication and Corrective Action Program Act (Arkansas Code § 8-6-501 et seq.)	
Regulation 29: Brownfields Redevelopment[1]	Clean-up and redevelopment of contaminated sites	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 (CERCLA)
	Clean-up funding		
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.)	CERCLA
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.)	CWA

Table 6.10. State regulations that protect water quality (continued).

Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Title 4: Rules for the Protection and Management of Groundwater[2]	Groundwater Protection Program	Arkansas Groundwater Protection and Management Act (Arkansas Code § 15-22-901 et seq.)	None
Rules and regulations pertaining to general sanitation[3]	Groundwater pollution	Arkansas Sewage Disposal Systems Act (Arkansas Code § 14-236-101 et seq.)	CWA
	Surface water pollution		
	Sewage treatment		
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.	SDWA
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.	SDWA
Rules and regulations pertaining to water operator licensing[3]	Licensing for drinking water treatment systems	Arkansas Code § 17-51-101 et seq.	SDWA
Rules and regulations pertaining to onsite wastewater systems, designated representative, and installers[3]	Permitting of onsite wastewater treatment systems (septic systems)	Arkansas Sewage Disposal Systems Act (Arkansas Code § 14-236-101 et seq.)	CWA
	Licensing of designated representatives for onsite wastewater treatment systems		
	Licensing of installers of onsite wastewater treatment systems		
Rules and regulations pertaining to mobile home and recreational vehicle parks[3]	Water supply	Arkansas Code § 20-7-101 et seq.	CWA, SDWA, RCRA
	Wastewater disposal		
	Solid waste management		
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

Table 6.10. State regulations that protect water quality (continued).

Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Arkansas Water Well Construction Commission Rules and Regulations[2]	Specifications for construction of water wells to provide safe drinking water	Water Well Construction Act (Arkansas Code § 17-50-101 et seq.)	SDWA
Rules and regulations pertaining to outdoor bathing places[3]	Swim beach water quality	Arkansas Code § 20-7-101 et seq.	CWA
Marine sanitation[3]	Marine sanitation	Arkansas Code § 27-101-401 et seq.	CWA

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

Table 6.11. State designated uses for surface waters in the EAWRPR (APCEC 2011).

Designated Use	Waterbodies
Extraordinary Resource Waters	Second Creek Cache River above Cache Bayou and adjacent to natural areas Arkansas River below Dam 2 Strawberry River Two Prairie Bayou adjacent to natural areas
Ecologically Sensitive Waterbodies	Lower St. Francis River Lower 10 miles of Straight Slough Right Hand Chute at confluence with St. Francis River Departee Creek Black River at mouth of Spring River
Channel-altered Delta Ecoregion Streams	Streams characterized by substantial alteration of the morphology of the main-stem and tributary channels, including the following: • Cache River, • Bayou DeView, • Village Creek, and • Blackfish Bayou.
Primary Contact Recreation	All lakes and reservoirs, and streams with watersheds greater than 10 square miles, except Little Lake Bayou
Secondary Contact Recreation	All waters
Domestic, Industrial, and Agricultural Water Supply	All waters, except no domestic water supply use for: • Coon Creek, • Unnamed tributary to Coon Creek from Frit Industries, • Rocky Branch Creek, • Bayou Meto from Rocky Branch Creek to Bayou Two Prairie, • Ditch No. 27, and • Ditch No. 6
Fishery	All lakes and reservoirs
Seasonal Fishery	All streams with watersheds smaller than 10 square miles, and Little Lake Bayou
Perennial Fishery	All streams with watersheds of 10 square miles or larger, All streams where discharge is 1 cfs or more, and Unnamed ditch to Little Lagrue Bayou

Table 6.12. Temperature and turbidity numeric criteria that apply in the EAWRPR.

Water body	Temperature (degrees Fahrenheit)	Turbidity – base flow (NTU)	Turbidity – all flows (NTU)
Delta Least altered streams	86.0	45	84
Delta Channel altered streams	89.6	75	250
White River	89.6	75	250
St. Francis River	89.6	75	100
Mississippi River	89.6	50	75
Arkansas River	89.6	50	52
Lakes and reservoirs	89.6	25	45
Ditch No. 27	95.0	75	250
Bayou Bartholomew from headwaters to Able's Cr, and tributaries	86.0	21	32
Seven Devils Swamp	89.6	25	45

Table 6.13. Dissolved oxygen numeric water quality criteria that apply in the EAWRPR.

Water body	Dissolved Oxygen Primary (mg/L)	Dissolved Oxygen Critical (mg/L)
Streams with watershed < 10 square miles	5	2
Streams with watershed 10 – 100 square miles	5	3
Streams with watershed > 100 square miles	5	5
Lakes and reservoirs	5	NA

Table 6.14. Numeric water quality criteria for minerals that apply in the EAWRPR.

Water body	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
Bayou Bartholomew Chemin-A-Haut Creek	50	20	500
Bayou DeView from Arkansas Hwy 14 to Whistle Ditch	48	38	411.3
Bayou DeView from mouth to Arkansas Hwy 14	48	37.3	411.3
Big Creek from Whistle Ditch to mouth of unnamed tributary	58	49	500
Big Creek Cache River Lost Creek Ditch Black River	20	30	270
Delta reference streams	48	37.3	411.3
Delta streams	63.84	49.61	500
Ditch No. 27	63.84	480	1200
Ditch No. 6 from Ditch No. 27 to mouth	63.84	210	630
L'Anguille River	20	30	235
Little River	20	30	365
Mississippi River from Arkansas River to Missouri state line	60	175	450
Mississippi River from Louisiana state line to Arkansas River	60	150	425
Overflow Creek	20	30	170
Pemiscot Bayou	20	30	380
Rocky Branch Creek Bayou Meto from Rocky Branch Creek to Bayou Two Prairie	64	49.61	500
St. Francis River 36 N Latitude to 36d 30s N Latitude	10	20	180
St. Francis River mouth to 36 N Latitude	10	30	330
Tyronza River from Ditch No. 6 to mouth	20	60	500
Tyronza River from headwaters to Ditch No. 6	20	30	350
Unnamed tributary to Big Creek	71	60	453
Unnamed Tributary to Coon Creek from Frit Industries	63.84	48	500
White River from mouth to Dam 3	20	60	430
Bakers Bayou Bayou Meto from mouth to Bayou Two Prairie Bayou Two Prairie from mouth to Rickey Branch Bear Bayou Big Ditch Blue Point Ditch Boggy Slough Bradley Slough Brownsville Branch Brushy Slough Bubbling Slough Buffalo Slough Caney Creek Castor Bayou Caney Creek Ditch Crooked Creek Ditch Cross Bayou Dennis Slough Eagle Branch Fish Trap Slough Five Forks Bayou Flat Bayou Flynn Slough Government Cypress Slough Hurricane Slough Indian Bayou Indian Bayou Ditch Little Bayou Meto Long Pond Slough Main Ditch Newton Bayou Plum Bayou Ricky Branch Salt Bayou Salt Bayou Ditch Shumaker Branch Skinner Branch Snow Bayou Tipton Ditch Tupelo Bayou Wabbaseka Bayou West Bayou White Oak Branch	95	45	500

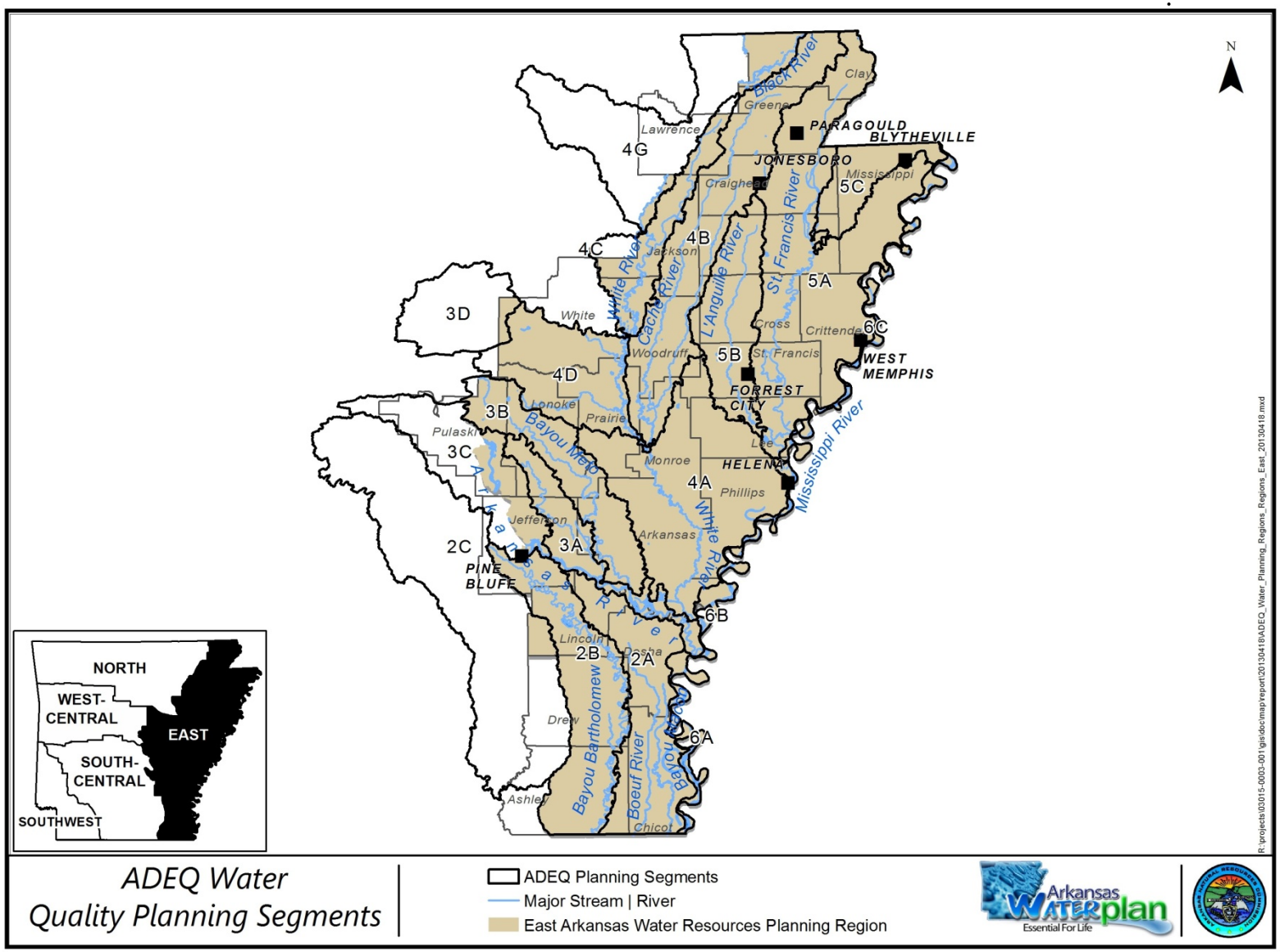

Figure 6.2. ADEQ water quality planning segments included in the EAWRPR

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 just over 335 active public water supply utilities in the EAWRPR. Almost 230 of these utilities use groundwater from their own wells, and are subject to the state wellhead protection program. Only one utility uses surface water and is subject to the state source water protection program. The remainder of the water utilities in the Planning Region purchase groundwater and/or surface water to supply to their customers (ADH n.d.).

6.1.3.3 Floodplain Management Regulations

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, 104).

Arkansas statute also requires each county, city, or town that is participating in the National Flood Insurance Program 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." The designated floodplain administrator must also be accredited by ANRC under the commission's authority regarding flood control. State accreditation of flood plain 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 6.15 summarizes these regulations, and the associated federal legislation.

Table 6.15 State regulations related to water management.

State Water Resources Regulation	Subjects/Programs	Related State Legislation	Related Federal Legislation
Title 6: Water Plan Compliance Review Procedures[1]	Arkansas Water Plan	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	Rivers and Harbors Act, Clean Water Act
Arkansas Wildlife Resources Regulations[2]	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 Enforcement by ANRC
2 Enforcement by Arkansas Game and Fish Commission
Note: Highlighted legislation was promulgated after 1990 AWP update

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, non-profit, 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 USACE 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 USACE can approve the purchase of "credits" from the state mitigation bank to satisfy all regulatory mitigation requirements. The Camp 9 Mitigation Bank was created in 1998, in Chicot County, through the Arkansas Mitigation Bank program (USACE Vicksburg District 2013).

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 such as those authorized by 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 6.16). There are also state-funded programs that provide financial assistance for drinking water and wastewater systems (Table 6.17). Programs shown in both Table 6.16 and 6.17 use both federal and state funding sources.

Table 6.16. Federal water supply assistance programs managed 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 fund program
		Construction assistance revolving loan fund

Table 6.17. State programs for public water and wastewater system assistance (administered by ANRC).

State Water Use Regulations	State Financial Assistance Programs	Related State Legislation
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 program	Arkansas Water, Waste Disposal, and Pollution Abatement Facilities Financing Act of 2007 (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 §15-5-901 et seq., Arkansas Code §15-22-1101 et seq.
	Construction assistance revolving loan fund	
Title 16: Rules governing the Arkansas Clean Water Revolving Loan Fund Program	Clean water state 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 wastewater	Arkansas Code §15-5-901 et seq.

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

ADEQ and ANRC administer a number of incentive and assistance programs related to water resources management (Table 6.18). 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 6.18 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 6.18. State incentive and assistance programs that protect water quality and promote water resources management.

State Regulation	State Incentive and 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 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
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 Waste disposal and pollution abatement facilities general obligation bond program	Arkansas Code § 14-230-101 et seq., § 15-22-601 et seq., § 15-22-701 et seq.	None
Title 10: Rules governing the Arkansas water resource agricultural cost-share program[2]	Arkansas water resources agricultural cost-share program	Arkansas Groundwater Protection and Management Act (Arkansas Code §15-22-913 through 914) Arkansas Code §15-22-507	None
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

Table 6.18. State incentive and assistance programs that protect water quality and promote water resources management (continued).

State Regulation	State Incentive and Assistance Programs	Related State Legislation	Related Federal Legislation
Title 14: Rules for implementing the Water Resources Conservation and Development Incentives Act[2]	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
None	Nonpoint source pollution grant program[2]	None	Clean Water Act (Section 319)

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

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 154 species of greatest conservation need identified for Arkansas in this plan that are found in the EAWRPR. The most highly recommended conservation activity for this planning region is habitat restoration and improvement (Anderson 2006).

6.1.5.2 Arkansas State Wetland Strategy

A state wetland strategy was ed in 1995 by a team of Arkansas agencies. This strategy consisted of 10 elements that addressed 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. The primary focus of this wetland strategy is the EAWRPR (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

Several agencies and organizations have developed management or restoration programs for areas within the EAWRPR. The purpose of some of these programs is to implement a state or federal regulation or policy, such as ambient water quality standards, no net loss of wetlands, or conservation of wildlife. These programs constitute a framework that provides opportunities for leveraging resources (personnel and funding) to accomplish water resources management goals.

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). There are two watersheds in the planning region for which nine-element watershed management plans have been approved by EPA. Both the L'Anguille River Nine-Element Plan and the Bayou Bartholomew Watershed Plan Update were completed in 2009. Both of these plans address reduction of siltation and turbidity (Arkansas Water 2013).

6.1.7.2 Wetland Planning Areas

The Arkansas Wetland Strategy designated eight watersheds in the EAWRPR as Wetland Planning Areas. Wetland Planning Area reports have been completed for three of these watersheds; Bayou Bartholomew, St. Francis River, and Bayou Meto (Layher BioLogics RTEC, Inc. n.d., 2003, FTN Associates, Ltd. n.d.). These reports are part of implementation of the Arkansas Wetlands Strategy. They include information on the current physical, biological, demographic, socioeconomic characteristics of the watershed, an overview of the history of land and water resources management in the watershed, characteristics of the current wetland ecosystems in the watershed, and the potential for loss of wetlands in the watershed (Arkansas Multi-agency Wetlands Planning Team 1995).

6.1.7.3 Lower Mississippi River Conservation Initiatives

The Lower Mississippi River Conservation Committee is a coalition of natural resources and environmental quality agencies from the six states that border the lower Mississippi River, supported by the USFWS. In 2000, this committee completed and approved the Aquatic Resources Management Plan for the Lower Mississippi River. The goals of this plan included restoration of aquatic habitats and species, and improving water quality. The Mississippi River Conservation Initiative is the implementation phase of this plan. Over 60 potential conservation and restoration projects were identified in Arkansas under this initiative. Three of these projects were completed in 2008 (Lower Mississippi River Conservation Committee 2013).

6.1.7.4 Fayetteville Shale Best Management Practices

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

6.1.7.5 Nonprofit Organizations

There are several nonprofit organizations that have active programs within the EAWRPR. These include The Nature Conservancy, Ducks Unlimited, the Lower Mississippi River Conservation Committee, and the Walton Family Foundation.

The Nature Conservancy has designated the Big Woods in Arkansas as a priority area for their activities. The Big Woods is the area of bottomland hardwoods that exists along the White River, Arkansas River, Cache River, and Bayou DeView. Activities in the Big Woods include reforestation, reconnecting creeks to their floodplains, purchasing bottomland hardwood wetlands, and assisting with enrolling bottomland hardwood wetlands in reserve programs, such as the NRCS Wetlands Reserve Program (The Nature Conservancy 2013).

Ducks Unlimited has identified the Mississippi Alluvial Valley from Illinois and Missouri to the Gulf of Mexico as a Level 1 conservation priority area. They have identified this area as the most significant winter habitat area for mallards in North America. The EAWRPR is part of this conservation priority area. Ducks Unlimited has participated in hundreds of wetland

conservation and restoration projects on private lands and in Wildlife Management Areas (Ducks Unlimited n.d.).

The Walton Family Foundation has partnered with the Lower Mississippi Valley Joint Venture to fund restoration and enhancement of habitat for waterfowl within the Mississippi Delta in Arkansas, Louisiana, and Mississippi. The first grants were funded through this partnership in 2010 (Lower Mississippi River Joint Venture 2013).

6.1.8 Interstate Compacts

Arkansas is part of the Red River Compact, an interstate compact agreement among the states of Arkansas, Oklahoma, Texas, and Louisiana. One purpose of the compact is to promote the equitable apportionment and development of the water in the river basin among the participating states. According to Article II, Section 2.01 of the Red River Compact, each member state may use the water allocated to it by the compact in any manner deemed beneficial by that state. Each state may freely administer water rights and uses in accordance with the laws of that state, but such uses shall be subject to availability of water in accordance with the apportionments made by the compact.

There are five defined reaches in the Red River Basin covered by the compact (Figure 6.3). Bayou Bartholomew, Boeuf River, and Bayou Macon in the EAWRPR are included in Reach IV of the Red River. Guaranteed minimum flows are not set for these streams in the compact. However, flow criteria for these streams are defined (Table 6.19). When these flows are reached, diversions from these streams must be managed to ensure an equitable portion of flow passes into Louisiana (Red River Compact Commission 1978).

Table 6.19. Red River Compact flow criteria for Reach IV streams in Arkansas.

Stream	Flow criterion, cfs
Bayou Bartholomew	80
Boeuf River	40
Bayou Macon	40

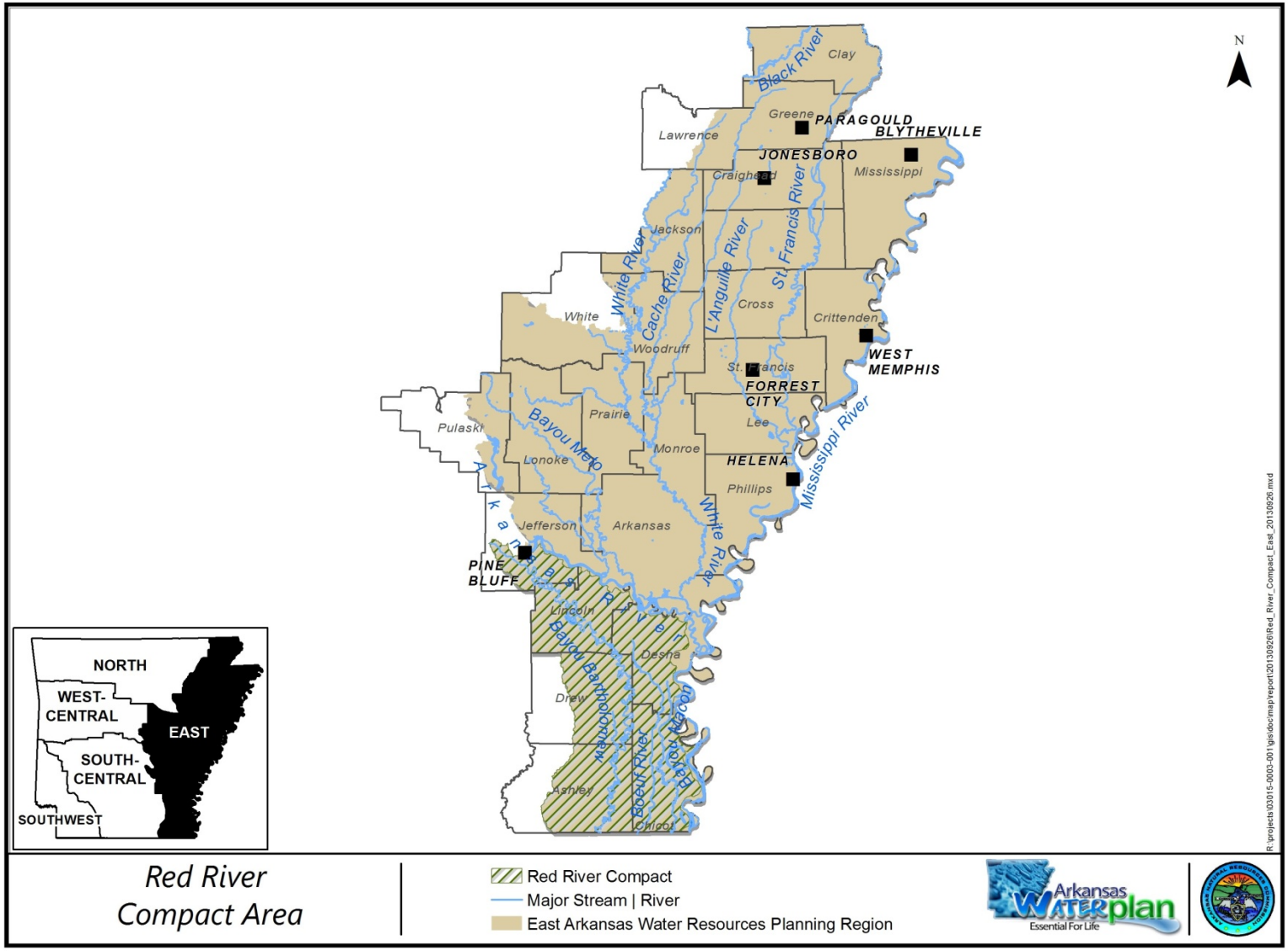

Figure 6.3. Boundaries of Reaches II through V of the Red River Compact (Oklahoma Water Resources Board n.d.).

6.2 Institutional Framework

Governmental responsibility for water resources management in the EAWRPR is split among many agencies on three levels (federal, state, and local). As a result, management of water resources in the EAWRPR 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 16 federal agencies involved in water resources management in the EAWRPR. These federal agencies are listed in Table 6.20, along with their respective activities in this planning region.

Table 6.20. Federal agencies with water resources-related responsibilities in the EAWRPR.

Federal Agency	Responsibility in Arkansas
EPA	• Oversees state agencies in implementation of management and funding programs under o Clean Water Act, o Safe Drinking Water Act, o RCRA, 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 state • Implements programs under the Toxic Substances Control Act
Federal Energy Regulatory Commission	Oversees environmental matters related to natural gas and hydropower projects in the planning region
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 planning region

Table 6.20. Federal agencies with water resources-related responsibilities in the EAWRPR (continued).

Federal Agency	Responsibility in Arkansas

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

Southwestern Power Administration	Markets and delivers hydroelectric power produced at USACE hydropower projects in the planning region
US Department of Defense	Manages land and surface water resources within the boundaries of the Little Rock Air Force Base
USACE	• Manages federal water, navigation, flood control, and hydropower projects in the planning region • 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 planning region
USFS	• Manages the Ozark-St. Francis National Forest and associated surface waters • Forest management incentive programs • Participates in forest inventory • Manages Urban and Community Forestry Program
NRCS	• Implements over 20 Farm Bill erosion control and habitat restoration funding and technical assistance programs in the planning region • 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
USDA Rural Development	• Implements USDA rural utilities financial assistance programs
USDI National Park Service	• Manages one national park and associated water resources within the planning region • Provides funds for land and water conservation projects

Table 6.20. Federal agencies with water resources-related responsibilities in the EAWRPR (continued).

Federal Agency	Responsibility in Arkansas

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 Big Lake, White River, and overflow National Wildlife Refuges
	• Implements the Partners For Wildlife Program for restoration of bottomland hardwood forests
	• Conducts the National Wetland Inventory
	• Oversees state wildlife planning through the State Wildlife Grant Program

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 EAWRPR. These state agencies are listed in Table 6.21, along with a description of their water resources management responsibilities within the planning region.

Table 6.21. Arkansas agencies and entities with responsibilities related to water resources in the EAWRPR (continued).

Table 6.21. Arkansas agencies and entities with responsibilities related to water resources in the EAWRPR.

State Agency	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 19 state parks and associated water resources in the planning region • Prepares comprehensive outdoor recreation plan • Manages outdoor recreation grant program

Table 6.21. Arkansas agencies and entities with responsibilities related to water resources in the EAWRPR (continued).

State Agency	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
AGFC	• Manages protection, conservation and preservation of fish and wildlife in the planning region 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 programs • Manages over 5,000 acres of public waters 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
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 o oil, o natural gas, and o brine • Issues permits for drilling and operation of o oil, natural gas, and brine 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 6.21. Arkansas agencies and entities with responsibilities related to water resources in the EAWRPR (continued).

State Agency	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 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
Military Department of Arkansas Arkansas National Guard	Manages land and surface water resources within the boundaries of Camp Robinson

6.2.3 Federal-State Organizations

There are at least six federal-state organizations involved in water resources management in the EAWRPR:

- Red River Compact Commission,
- Delta Regional Authority,
- Lower Mississippi River Conservation Committee,
- Lower Mississippi River Joint Venture,
- Arkansas Conservation Partnership,
- Arkansas Watershed Advisory Group

The Red River Compact Commission administers the Red River Compact, which applies to Bayou Bartholomew, Beouf River and Bayou Macon (see Section 6.1.6). The commission is made up of one representative from the water agency of each of the member states (ANRC in Arkansas), a resident from each state chosen by the governor, and a federal representative appointed by the US president (Oklahoma Water Resources Board n.d.).

The Delta Regional Authority was established in 2000 to enhance economic development and improve quality of life in the Mississippi River delta region of eight states, including the EAWRPR. These goals are accomplished through improvements to infrastructure, funded by grants from the Delta Regional Authority, to support job creation and retention. Infrastructure improvements include improvement of water supply and wastewater infrastructure. This organization is managed by a board made up the governors from each of the eight states, and a federal representative appointed by the US president and confirmed by the US Senate (Delta Regional Authority 2013b).

The Lower Mississippi River Conservation Committee is a coalition of natural resources and environmental quality agencies from the six states that border the lower Mississippi River, supported by the US Fish and Wildlife Service. This committee provides a regional forum for conservation of the natural resources of the Mississippi River floodplain. The committee addresses long-term conservation and restoration planning and implementation, and nature-based economic development in the Mississippi River floodplain (Lower Mississippi River Conservation Committee 2013).

The Lower Mississippi River Joint Venture is a non-regulatory partnership of non-government, state, and federal conservation organizations focused on implementing the National Waterfowl Management Plan (see Section 5.3.1.5). The management board for this joint venture project includes wildlife agencies from eight states, Ducks Unlimited, The Nature Conservancy, The Conservation Fund, NRCS, USFWS, USGS, and USFS (Lower Mississippi River Joint Venture 2013).

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 the NRCS, other federal agencies, ANRC, 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 2012d, 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 2012d).

6.2.4 Regional and Local Entities

There are numerous regional and local entities in the EAWRPR 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 6.22, along with descriptions of their activities related to water resources management.

Table 6.22. Some of the regional and local government entities involved in water resources management in the EAWRPR.

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
Drainage Districts	Usually created by circuit court order to plan, construct, and maintain a system to drain lands
Improvement Districts	Created by circuit court order to implement federal projects for improvement of any river, tributary, or stream bordering the state
Irrigation Districts	Created by circuit court order to distribute water resources
Levee Districts	Provide for the construction and maintenance of levees for flood protection
Red River Compact Commission	Administers the Red River Compact
Regional Planning and Economic Development Districts	• Water supply and wastewater infrastructure improvements • Assist Regional Solid Waste Management Districts
Regional Solid Waste Management Districts	Manage collection, disposal, and recycling of solid waste
Regional Water Distribution Districts	Public nonprofit organizations for distribution of water from federal water projects
Southeast Arkansas Regional Planning Commission	Stormwater management education and outreach
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 EAWRPR that are related to water resources management. These organizations are listed in Table 6.23 with a description of their water resources related activities in the planning region.

Table 6.23. Examples of nonprofit groups involved in water resources management in the EAWRPR.

Nonprofit	Water Resources Involvement
Arkansas Environmental Federation	Advocate for industry
Arkansas Farm Bureau	Advocate for agriculture
Arkansas Rural Water Association	Support of rural water and wastewater utilities
Arkansas Water Works and Water Environment Association	Support of water and wastewater utilities
Arkansas Waterways Association	Promotes and protects Arkansas inland transportation waterways
Arkansas Wildlife Federation	Conservation of aquatic habitat for fish and wildlife
Audubon Arkansas	Ten Important Bird Areas in the planning region include wildlife management areas, Stuttgart airport, and Lake Chicot
Ducks Unlimited	Conservation and restoration of aquatic habitat for waterfowl
ECO	Water quality monitoring on Bayou Bartholomew and L'Anguille River
Stream teams	Water quality monitoring, stream bank rehab, restoration of fish habitat
The Nature Conservancy	Big Woods priority area Cache River priority area Benson Creek preserve Burke Crowley's Ridge Preserve Conservation forestry at Pine City
Watershed organizations (at least 5)	Water resources planning, Sponsor for water quality and quantity projects

6.2.6 Institutional Interactions in Water Resources Management

As noted at the beginning of this section, water resources management in the EAWRPR involves numerous entities at multiple scales. Examples of the interactions among federal, state, and local entities that occur in water resources management in the EAWRPR are presented in Table 6.24.

Table 6.24. Examples of interactions of federal, state, and local entities in water resources management within the EAWRPR.

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, irrigation districts (water withdrawers)
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
Interstate water compacts	NRCS, USGS, USACE	ANRC (state representative)	Red River Compact Commission
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 (certification)	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
Clean Water Act funding program (including nonpoint source and clean water revolving loan fund)	EPA (funding)	ANRC (program lead)	Watershed organizations, sewer districts, municipalities

Table 6.24. Interactions of federal, state, and local entities in water resources management (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
Groundwater protection and management – critical groundwater areas	USGS, USACE (water projects)	ANRC (program lead), Water Well Construction Commission	Counties, Irrigation Districts (water projects)
Wetland and riparian zone tax credit program	None	ANRC (state mitigation banks)	Watershed organizations
Wetland and stream mitigation	USACE (lead)	ANRC (state mitigation banks), 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 (wetlands nutrient standards)	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

Table 6.24. Interactions of federal, state, and local entities in water resources management (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	**State Entities**	**Regional or Local Entities**
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
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 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	USFS	Arkansas Forestry Commission, Arkansas Urban Forestry Council	Municipalities

Table 6.24. Interactions of federal, state, and local entities in water resources management (continued).

State Water Resources Responsibility/Program	Involves:		
	Federal Entities	State Entities	Regional or Local Entities
Forest stewardship	USFS, 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	USFS (funding), Land Trust Alliance	Arkansas Forestry Commission	Landowners
State parks	USACE, National Park Service (funding)	Arkansas Department of Parks and Tourism	Northeast chapter Arkansas Master Naturalists
Stream teams	None	AGFC	Northeast chapter Arkansas Master Naturalists
Wildlife management areas, refuges	USFWS	AGFC	Nonprofit organizations
Fishing and boating programs	USACE, USFWS	AGFC, Arkansas Department of Parks and Tourism	None
Pollution prevention program	EPA	ADEQ	Municipalities
Commercial navigation	USACE Memphis and Little Rock Districts	Arkansas Waterways Commission	None
Federal irrigation projects	USACE Memphis and Vicksburg Districts, USDA Natural Resources Conservation Service	ANRC	Irrigation Districts, Regional Water Distribution Districts

7.0 REFERENCES

Adamski, J. C., J. C. Petersen, D. A. Freiwald, and J. V. Davis. 1995. *Environmental and hydrologic setting of the Ozarks Plateaus study unit, Arkansas, Kansas, Missouri, and Oklahoma.* U.S. Geological Survey Water-Resources Investigations Report 94-4022, USGS.

ADEQ. 2009a. *2008 Integrated Water Quality Monitoring and Assessment Report.* Water Division, Little Rock, AR: Arkansas Department of Environmental Quality, 350.

ADEQ. 2009b. *2008 List of Impaired Waterbodies (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. 2012a. *Arkansas Hazardous Waste Generators Facility Summary.* http://www.adeq.state.ar.us/hazwaste/rcra2/facil_sum.asp (accessed May 14, 2013).

ADEQ. 2012b. *Arkansas TMDLs.* http://www.adeq.state.ar.us/water/tmdls/default.asp#Display (accessed April 12, 2013).

ADEQ. 2012c. *State of Arkansas Nutrient Criteria Development Plan.* 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. 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 July 10, 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 July 2, 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 July 2, 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 July 24, 2013).

ADEQ. 2013f. *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).

ADH. 2011a. *Environmental Epidemiology.* http://www.healthy.arkansas.gov/programsServices/epidemiology/Environmental/Pages/default.aspx (accessed June 19, 2013).

ADH. 2011b. "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. n.d. *Drinking Water Information for Arkansans.* http://www.healthy.arkansas.gov/eng/autoupdates/pwslist0.htm (accessed March 20, 2013).

ADH, AGFC, ADEQ. 2011. *Fish Consumption Notice - Mercury in Fish.* Little Rock: Arkansas 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).

AGFC.2011. *Wildlife Management Areas.* http://www.agfc.com/hunting/pages/wmalist.aspx (accessed March 22, 2013).

AGFC. 2013a. *General Fishing Regulations.* http://www.agfc.com/fishing/pages/fishingregulations.aspx (accessed September 18, 2013).

AGFC. 2013b. *The Great Outdoors, A $1.8 Billion Business in Arkansas.* brochure, Little Rock: Arkansas Game and Fish Commission.

AHTD. 2006. *Public Land Boundary (polygon).* GeoStor. http://www.geostor.arkansas.gov/G6/Home.html?q=public+land+boundary (accessed April 25, 2013).

Albin, D. R., M. S. Hines, and J. W. Stephens. 1967. *Water resources of Jackson and Independence Counties, Arkansas.* US Geological Survey Water Supply Paper 1839-G, USGS.

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

ANHC. 2010. *Natural Areas.* http://www.naturalheritage.com/natural-area/default.aspx (accessed March 22, 2013).

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

ANRC. 2008. *Arkansas ground water protection and management report for 2008, a supplement to the Arkansas Water Plan.* Little Rock, AR: Arkansas Natural Resources Commission.

ANRC. 2010. "Facts About Critical Groundwater Designation." *Arkansas Natural Resources Commission Water Resources Management Division.* http://www.anrc.arkansas.gov/groundwater/gw_designation_graphic.pdf (accessed May 16, 2013).

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

ANRC. 2012a. *Arkansas Ground-Water Protection and Management Report for 2011.* Little Rock: Arkansas Natural Resources Commission.

ANRC. 2012b. *Arkansas Groundwater Protection and Management Report for 2011*. Little Rock: Arkansas Natural Resources Commission.

ANRC. 2012c.*Status Report to Legislative Council on Grand Prairie and Bayou Meto Projects.* Little Rock: Arkansas Natural Resources Commission.

ANRC. 2012d. "2011-2016 Nonpoint Source Pollution Management Plan." 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 Emergency Management. 2010. *All Hazard Mitigation Plan, State of Arkansas.* Little Rock: Arkansas Department of Emergency Management.

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. 2005a. *Lower White River Museum State Park.* park information brochure, Ltitle Rock: Arkansas Department of Parks and Tourism.

Arkansas Department of Parks and Tourism. 2005b. *Delta Heritage State Park.* Park information brochure, Little Rock: 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 Electric Cooperative Corporation. *LIHI Certificate #51 --- Arkasnas River Dam No. 2 Hydroelectric Project (FERC No. 3033) Arkansas River, Arkansas.* Low Impact Hydropower Institute Certified Facilities. http://www.lowimpacthydro.org/lihi-certificate-51-arkansas-river-dam-no.2-hydroelectric-project-ferc-no.-3033-arkansas-river-arkansas.html (accessed November 19, 2013).

Arkansas Farm Bureau. 2012. *Arkansas Agricultural Profile.* Little Rock: Farm Bureau.

Arkansas Farm Bureau. 2013. *Farm Bureau Arkansas, Arkansas Ag Data.* http://www.arfb.com/ag-markets- Arkansas Farm Bureau statistics/arkansas-ag-data/default.aspx (accessed April 22, 2013).

Arkansas Oil and Gas Commission. 2013. *Google Earth Maps.* Arkansas Oil and Gas Commission. October 24, 2013. http://www.aogc.state.ar.us/Maps_GoogleEarth.htm (accessed October 24, 2013).

Arkansas Geological Survey. 2012. *Mississippi River Alluvial Plain, Geology.* http://www.geology.ar.gov/education/geo_mississippi_plain.htm (accessed March 2013).

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

Arkansas Multi-agency Wetland Planning Team. 2001. *Wetlands in Arkansas.* http://www.mawpt.org/wetlands/loss_gain.asp (accessed March 18, 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).

Arkansas Water. 2013. *ArkansasWater.org.* http://arkansaswater.org/index.php?option=com_content&view=article&id=29&Itemid=2 (accessed June 25, 2013).

Arkansas Waterways Association. 2011. *Ark-White Cutoff.* http://arkansaswaterways.com/navigablewaterways/ouachitaredwhiterivers.html (accessed November 21, 2013).

Arkansas Waterways Commission. 2013. *2011-2012 Biennial.* Biennial report, Little Rock: Arkansas Waterways Commission.

Arkansas Waterways Commission. 2012a. *Arkansas Waterways Commission, Rivers.* http://waterways.arkansas.gov/rivers/Pages/default.aspx (accessed March 18, 2013).

Arkansas Waterways Commission. 2012b. *White River.* http://waterways.arkansas.gov/rivers/Pages/whiteRiver.aspx (accessed April 11, 2013).

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

ASWCC. 1984. *Arkansas State Water Plan Boeuf-Tensas basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

ASWCC. 1987.*Arkansas State Water Plan Lower 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.

ASWCC. 1990. *Arkansas Water Plan Executive Summary.* Little Rock: Arkansas Soil and Water Conservation Commission,

Balogh, George W. 2012. *Encyclopedia of Arkansas History and Culture - Timber Industry.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2143&type=Category&item=Industries&parent=Business+and+Economics&grandparent= (accessed March 18, 2013).

Bayou Meto Water Management District. 2013. *Bayou Meto Water Management Project.* http://www.bayoumetowatermanagementproject.com/ProjectStatus.html (accessed June 25, 2013).

Bedinger, M.S., and H.G. Jeffrey. 1964. *Groundwater in the Lower Arkansas River Valley.* Water Supply Paper 19669-v, Little Rock: US Geological Survey.

Bolton, S. Charles. 1995. *25 Years Later A History of the McClellan-Kerr Arkansas River Navigation System in Arkansas.* Little Rock: USACE Little Rock District.

Bolton, S. Charles. 2012. *Louisiana Purchase through Early Statehood, 1803 through 1860.* http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Broom, Matthew E., and Forest P. Lyford. 1981. *Alluvial Aquifer of the Cache and St. Francis River Basins, Northeastern Arkansas.* Open-file Report 81-476, Little Rock: US Geological Survey.

Bryant, C.T., A.H. Ludwig, and E.E. Morris. 1985. *Ground-water Problems in Arkansas.* Water Resources Investigations Report 85-4010, Little Rock: US Geological Survey.

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).

Cavaneau, Jerry. 2012. *Encyclopedia of Arkansas History and Culture - Black River.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryid=4120 (accessed March 18, 2013).

Central Arkansas RSWMD. 2011. *Combined Regional Solid Waste Management Needs Assessment & Plan.* Lonoke: Central Arkansas Regiona Solid Waste Management District.

Clark, B. R., R. M. Hart, and J. J. Gurdak. 2011. *Groundwater availability of the Mississippi embayment.* US Geological Survey Professional Paper 1785, USGS.

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

Craighead County RSWMD. 2011. *Regional Solid Waste Management Plan for Craighead County Regional Solid Waste Management District.* Jonesboro: Craighead County Regional Solid Waste Management District.

Czarnecki, John B., Phillip D. Hays, and Paul W. McKee. 2002. *The Mississippi River Valley Alluvial Aquifer in Arkansas: A sustainable water resource?* Fact Sheet FS-041-02, Little Rock: US Geological Survey.

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

DeBlack, Thomas A. 2012. *Civil War through Reconstruction, 1861 through 1874.* http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Delta Regional Authority. 2013a. *Economic Development, Distressed Counties and Parishes.* http://www.dra.gov/econom-devel/project-info/default.aspx (accessed March 2013).

Delta Regional Authority. 2013b. *About DRA.* http://www.dra.gov/about-us/default.aspx (accessed June 26, 2013).

Dickard, Jason. 2013. *Lower Mississippi River Resource Assessment*. Memphis District US Army Corps of Engineers Memphis District Projects. http://www.mvm.usace.army.mil/Portals/51/docs/missions/projects/LMRRA/LMRRA.pdf (accessed June 25, 2013).

Ducks Unlimited. n.d. *Conservation, Mississippi Alluvial Valley.* http://www.ducks.org/conservation/where-we-work/mississippi-alluvial-valley (accessed April 26, 2013).

Early, Anne M. 2011. *Pre-European Exploration, Prehistory through 1540.* http://www.encyclopediaofarkansas.net/ (accessed February 13, 2013).

East Arkansas RSWMD. 2011. *Regional Solid Waste Management Plan for East Arkansas Regional Solid Waste Management District.* Jonesboro: East Arkansas Regional Solid Waste Management District.

Engle, Carole R. 2012. *Aquaculture*. Arkansas Encyclopedia of History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=3640 (accessed September 5, 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. *What Are Water Quality Standards?* http://water.epa.gov/scitech/swguidance/standards/about_index.cfm (accessed July 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/scitech/swguidance/standards/about_index.cfm (accessed June 11, 2013).

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

EPA. 2013b. *National Priorities List.* http://www.epa.gov/superfund/sites/npl/ (accessed July 26, 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. *Consumer Confidence Reports.* http://water.epa.gov/lawsregs/rulesregs/sdwa/ccr/index.cfm (accessed June 11, 2013).

EPA. 2013f. *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).

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.

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

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.

FTN Associates, Ltd. n.d. *Bayou Meto Wetland Planning Area Report*. http://anrc.cast.uark.edu/assets/wetland_rep/bayo_meto.pdf (accessed April 17, 2013).

Fulmer, Robert F, and George L Harp. 1977. *The fishes of Crowley's Ridge in Arkansas.* Arkansas Academy of Sciences Proceedings 31: 42-45.

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 Globla Warning Final Report.* Little Rock: Arkansas Governor's Commission on Global Warming.

Gonthier, Gerard J., and Barbara A. Kleiss. 1996. *Ground-water Flow Patterns and Water Budget of a Bottomland Forested Wetland, Black Swamp, Eastern Arkansas.* Water Resources Investigation Report 95-4192, Little Rock: US Geological Survey.

Goss, Kay C. 2012. *Encyclopedia of Arkansas History and Culture - McClellan-Kerr Arkansas River Navigation System.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-

detail.aspx?entryID=2309&type=Category&item=Water&parent=Transportation&grandparent= (accessed March 18, 2013).

Green, Brooks. 1986. *Irrigation expansion in Arkansas: A preliminary investigation*. Arkansas Historical Quarterly: 261-268.

Hawkins, Van. 2011. *Cotton Industry*. http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Holland, Terrence W. 2007. *Water Use in Arkansas, 2005.* Scientific Investigations Report 2007-5241, Reston: US Geological Survey.

Jackson, Donna Brewer. 2011. *Levees and Drainage Districts*. Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=1165 (accessed September 5, 2013).

Key, Joseph Patrick. 2012. *European Exploration and Settlement, 1951 through 1802*. http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

Kleiss, B.A., R.H. Coupe, G.J. Gonthier, and B.J. Justus. 2000. *Water Quality in the Mississippi Embayment, Mississippi, Louisiana, Arkansas, Missouri, Tennessee, and Kentucky, 1995-98.* Circular 1208, USGS.

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

Kresse, Timothy M., and Brian R. Clark. 2008. *Occurrence, Distribution, Sources, and Trends of Elevated Chloride Concentrations in the Mississippi River Valley Alluvial Aquifer in Southeast Arkansas.* Scientific Investigations Report 2008-5193, Resont, VA: US Geological Survey.

Lake, Amy. 2010. *A slice of the pie in the Arkansas Delta with Beth Wiedower*. Center for Rural Entrepreneurship. http://www.energizingentrepreneurs.org/site/images/research/es/se/se29.pdf (accessed June 19, 2013).

Lancaster, Guy. 2011. *Red River*. Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2650 (accessed July 16, 2013).

Layher BioLogics RTEC, Inc. n.d. *Bayou bartholomew Wetland Planning Area Report.* http://anrc.cast.uark.edu/assets/wetland_rep/BB_Cover_ToC.pdf (accessed April 17, 2013).

Layher Biologics RTEC, Inc. 2003. *St. Francis River Wetland Planning Area Report.* http://anrc.cast.uark.edu/assets/wetland_rep/StF_Cover_TOC.pdf (accessed April 17, 2013).

Lochmann, Steve. 2013. *Fish*. Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2097 (accessed September 18, 2013).

Lower Mississippi River Conservation Committee. 2013. *Lower Mississippi River Conservation Committee.* http://www.lmrcc.org/who_we_are.htm (accessed March 22, 2013).

Lower Mississippi River Joint Venture. 2013. *Lower Mississippi Joint Venture.* http://www.lmvjv.org/ (accessed June 28, 2013).

Ludwig, A.H. 1992. *Flow Duration and Low-flow Characteristics of Selected Arkansas Streams.* Water Resources Investigations Report 92-4026, Little Rock: US Geological Survey.

Manger, W. L., D. L. Zachry, and M. L. Garrigan. 1988. *An introduction to the geology of northwestern Arkansas.* The Compass: 242-257.

Mayfield, Walter. 2001. *Arkansas Mineral Resources (map)*. Little Rock: Arkansas Geological Commission.

McFarland, J. D. 2004. *Stratigraphic summary of Arkansas*. Arkansas Geological Commission Information Circular: 36-38.

McGraw, Shirley. 2013. *Lonoke County*. Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=787 (accessed July 8, 2013).

Mississippi County RSWMD. 2011. *Regional Solid Waste Management Plan for Mississippi County Regional Solid Waste Management District.* Blytheville: Mississippi County Regional Solid Waste Management District.

Mississippi River Commission. 2008. *The Mississippi River & Tributaries Project: Backwater Areas*. Mississippi Valley Division US Army Corps of Engineers. http://www.mvd.usace.army.mil/Portals/52/docs/Backwater_Areas_info_paper.pdf (accessed September 5, 2013).

Mississippi River Commission. 2007. *The Mississippi River & Tributaries Project: History of the Lower Mississippi River Levee System*. Mississippi Valley Division US Army Corps of Engineers. http://www.mvd.usace.army.mil/Portals/52/docs/Levees%20info%20paper.pdf (accessed September 5, 2013).

Morrow, Lynn A. n.d. *Duck and Goose Shambles: Sportsmen and market hunters at Big Lake, Arkansas*. Big Muddy. http://www6.semo.edu/universitypress/bigmuddy/NF/A_Duck_and_Goose_Shambles.htm (accessed September 16, 2013).

Nachtmann, Heather. 2002. *Economic Evaluation of the Impact of Waterways on the State of Arkansas.* Fayetteville: University of Arkansas.

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

National Weather Service Weather Forecast Office Little Rock AR. 2013. *Climate Data.* http://www.srh.noaa.gov/lzk/?n=wxcntl3.htm (accessed June 12, 2013).

NatureServe. 2002. *Number of Extince Species in Each State.* http://www.natureserve.org/consIssues/ivoryBilled_table1.htm (accessed December 19, 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 NCDC. 2013a. *Climate Data Online: Text and Map Search.* http://www.ncdc.noaa.gov/cdo-web/#t=secondTabLink (accessed May 2013).

NOAA NCDC. 2013b. *Historical Palmer Drought Indices.* September 4, http://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers.php (accessed May 15, 2013).

NOAA NCDC. 2013c. *Plot Time Series.* http://www.ncdc.noaa.gov/temp-and-precip/time-series/index.php (accessed June 2013).

NOAA NCDC.n.d. *Climate of Arkansas*. National Climatic Data Center. http://hurricane.ncdc.noaa.gov/climatenormals/clim60/states/Clim_AR_01.pdf (accessed May 15, 2013).

Northeast Arkansas RSWMD. 2011.*January 1, 2011 Annual Update of the Year 2004 Solid waste Management Plan.* Paragould: Northeast Arkansas Regional Solid Waste Management District.

NRCS. 2011. *Active Irrigation Projects.* http://www.ar.nrcs.usda.gov/programs/watersheds_irrigation_active.html (accessed June 18, 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. 2013a. *Arkansas NRCS Conservation Programs.* http://www.nrcs.usda.gov/wps/portal/nrcs/main/ar/programs/ (accessed September 17, 2013).

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

Oklahoma Water Resources Board. n.d. *Red River Compact Commission.* http://www.owrb.ok.gov/rrccommission/graphics/reach_2_5.jpg (accessed June 14, 2013).

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.

Ramsar Convention. 2013. *Ramsar Sites Information Service.* http://ramsar.wetlands.org/Database/SearchforRamsarsites/tabid/765/Default.aspx (accessed June 28, 2013).

Red River Compact Commission. 1978. *Red River Compact.* Red River Compact Commission,

Region 6 EPA. *Arkansas Site Status Summaries.* 2013. http://www.epa.gov/region6/6sf/6sf-ar.htm (accessed June 15, 2013).

Renken, R. A. 1998. *Arkansas, Louisiana, Mississippi HA 730-F*. Groundwater Atlas of the United States, HA 730, by US Geological Survey. Reston, VA: US Geological Survey.

Robison, Henry W., and Thomas M. Buchanan. 1988. *Fishes of Arkansas.* Fayetteville: University of Arkansas Press.

Rogers, Aaron W. 2013. *Encyclopedia of Arkansas History and Culture - White River.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=2310&type=Category&item=Water&parent=Transportation&grandparent= (accessed March 18, 2013).

Rural Heritage Development Initiative. 2008. *Arkansas Delta Soil and Soul.* http://arkansasdelta.org/ (accessed June 19, 2013).

Saucier, R. T. 1994. *Geomorphology and Quaternary geologic history of the Lower Mississippi Valley, Volume I.* Vicksburg, MS: U.S. Army Corps of Engineers, Waterways Experiment Station.

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.

Sharif, S. U., et al. 2008a. *Distribution and variability of redox zones controlloing spatial variability of arsenic in the Mississippi River Valley alluvial aquifer, southeastern Arkansas.* Journal of Contaminant Hydrology: 49-67.

Sharif, S. U., R. K. Davis, K. F. Steele, K. Burmshik, T. M. Kresse, and J. A. Fazio. 2008b. *Inverse geochemical modeling of groundwater evolution with emphasis on arsenic in the Mississippi River Valley alluvial aquifer, Arkansas, USA.* Journal of Hydrology: 41-55.

Sharif, S. U., et al. 2011. *Surface complexation modeling for predicting solid phase arsenic concentrations in the sediments of the Mississippi River alluvial aquifer, Arkansas, USA.* Applied Geochemistry: 496-504.

Shoults, Lenore. 2011. *Encyclopedia of Arkansas History and Culture - Pearl Rush.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=6576 (accessed March 18, 2013).

Shrum, Bill. 2012. *Stuttgart (Arkansas County).* Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=820 (accessed September 17, 2013).

Southeast Arkansas RSWMD. 2011. *Regional Solid Waste Management Plan Update for Southeast Arkansas Regional Solid Waste Management District.* Pine Bluff: Southeast Arkasnas Regional Solid Waste Management District.

Steele, K. F., S. S. Hill, T. W. Nichols, H. D. Scott, P. Vendrell, and H. S. Lin. 1994. *Completion Report - ground water monitoring project for Arkasnas phase III.* MSC-197, Fayetteville, AR: Arkansas Water Resources Center.

Stewart-Abernathy, Leslie C. 2011a. *Cherokee.* http://www.encyclopediaofarkansas.net (accessed February 13, 2013).

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

Stone, Nathan, Larry Dorman, and Hugh Thomforde. 2010. *Baitfish Industry*. Arkansas Encyclopedia of History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=3641 (accessed September 5, 2013).

Stroud, Hubert B. 2011. *Encyclopedia of Arkansas History and Culture: Crowley's Ridge*. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=12&type=Category&item=Six+Natural+Divisions&parent=Geography&grandparent=Land+and+Resources (accessed March 15, 2013).

Stroud, Hubert B. 2012. *Encyclopedia of Arkansas History and Culture: Mississippi Alluvial Plain.* http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=444&type=Category&item=Six+Natural+Divisions&parent=Geography&grandparent=Land+and+Resources (accessed March 15, 2013).

Terry, J. E., C. T. Bryant, A. H. Ludwig, and J. E. Reed. 1986. *Water-Resources Appraisal of the South-Arkasnas Lignite Area.* Arkansas Geological Commission Information Circular 28-D, Arkansas Geological Commission.

The Nature Conservancy. 2013. *Arkansas Places We Protect.* http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/arkansas/placesweprotect/index.htm (accessed March 22, 2013).

Turner, Ellen E. 2001. *Crowley's Ridge: An Upland in the Lowlands.* Little Rock: Butler Center.

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 Arkansas Divison of Agriculture. 2012. *Economic Contribution of Arkansas Agriculture.* Little Rock: University of Arkansas Division of Agriculture.

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. 1993. *1992 Economic Census Area Profile, Arkansas.* Economic Census. http://www.census.gov/epcd/www/92profiles/AR_92PRF.TXT (accessed May 29, 2013).

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): 53033-53043.

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. www.census.gov.* http://www.census.gov/compendia/statab/2012/tables/12s0020.pdf (accessed March 12, 2013).

US Census Bureau. n.d.a. *DP05 ACS Demographic and Housing Estimates 2007-2011 American Community Survey 5-year Estimates.* American FactFinder. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_11_5YR_DP05&prodType=table (accessed March 2013).

US Census Bureau. n.d.b. *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. 1996. *1992 Census of Transportation, Communitcations, and Utilities - 1993 Commodity Flow Survey Arkansas.* TC92-CF-4, Washington DC: US Department of Commerce.

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 Department of Commerce. 1994. *1992 Census of Agriculture, Volume 2 Subject Series, Part 3 Ranking of States and Counties.* Washington, DC: US Department of Commerce.

US Department of Commerce Bureau of the Census. 1977. *1974 Census of Agriculture Volume 1 Part 4 Arkansas State and County Data.* Washington DC: US Department of Commerce.

US Department of Commerce Bureau of the Census. 1984. *1982 Census of Agriculture Volume 1 Geographic Area Services Part 4 Arkansas State and County Data.* Washington DC: US Department of Commerce.

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

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

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 Institute for Water Resources. 2011. *Waterborne Commerce of the United States, Calendar Year 2011, Part 2-Waterways and Harbors Gulf Coast, Mississippi River System and Antilles.* Alexandria, VA: USACE.

USACE Institute for Water Resources. n.d. *Locks by Waterway Lock Commodity CY 1993 - 2012*. Waterborne Commerce Statistics Center. http://www.navigationdatacenter.us/lpms/cy2012comweb.htm (accessed November 19, 2013).

USACE Little Rock District. 1987. *Arkansas State Water Plan Upper White River Basin.* Little Rock: Arkansas Soil and Water Conservation Commission.

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

USACE Little Rock District. 2012. *Three Rivers, AR.* US Army Corps of Engineers Southwestern Division. http://www.swd.usace.army.mil/Portals/42/docs/FY13%20Three%20Rivers%20Study,%20AR.pdf (accessed November 19, 2013).

USACE Memphis District. 2012. *Arkansas Projects.* http://www.mvm.usace.army.mil/Portals/51/docs/missions/projects/Projects%20By%20State/AR_Projects.pdf (accessed March 20, 2013).

USACE Memphis District. 2013. *Arkansas projects*. Memphis District Projects. http://www.mvm.usace.army.mil/Portals/51/docs/missions/projects/Projects%20By%20State/WEB%20Pages%20ARKANSAS.pdf (accessed November 19, 2013).

USACE Vicksburg District. 1984. *Arkansas State Water Plan Special Report in the Grand Prairie Agricultural Water Supply*. Little Rock: Arkansas Soil and Water Conservation Commission.

USACE Vicksburg District. 2013. *Vicksburg District Mitigation Banks.* US Army Corps of Engineers Vicksburg District. http://www.mvk.usace.army.mil/Portals/58/docs/regulatory/District_%20Mitigation_%20Banks.pdf (accessed July 2013).

USDA National Agricultural Statistical Service. 2006.*Census of Aquaculture (2005) .* Washington DC: USDA National Agricultural Statistical Service.

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

USDA National Agricultural Statistics Service. 2007. *2007 Census of Agriculture State Profile, Arkansas.* Washington, DC: 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. 2007. *Best Management Practices for Fayetteville Shale Natural Gas Activities.* Conway: US Fish and Wildlife Service.

USFWS. 2013a. *National Wildlife Refuge System.* http://www.fws.gov/southeast/refuges/refuges-by-state.html#arkansas (accessed September 16, 2013).

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

USFWS; US Department of Commerce Bureau of the Census. 1993. *1991 National Survey of Fishing, Hunting, and Wildlife-associated Recreation, Arkansas.* Washington, DC: US Government Printing Office.

USFWS; US Department of Commerce Census Bureau. 2013. *2011 National Survey of Hunting, Fishing, and Wildlife-associated Recreation - Arkansas.* Washington, DC: US Fish and Wildlife Service.

USGS. 2005. *Water Use Data for Arkansas.* http://waterdata.usgs.gov/ar/nwis/water_use?wu_year=ALL&wu_area=County&wu_county=ALL&wu_category=AQ&submitted_form=introduction (accessed September 9, 2013).

USGS. 2009. *USGS Water Use Data for Arkansas.* http://waterdata.usgs.gov/ar/nwis/wu (accessed July 8, 2013).

USGS. 2012. *2008 Minerals Yearbook, Arkansas.* USGS.

USGS. 2013a. USGS. ftp://nhdftp.usgs.gov/DataSets/Staged/States/FileGDB/HighResolution/NHDH_AR_931v210.zip (accessed October 19, 2013).

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

USGS. 2013c. *USGS Water Quality Data for Arkansas.* http://waterdata.usgs.gov/ar/nwis/qw (accessed July 25, 2013).

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

Westerfield, P. W. 1994. *Potentiometric-surface maps of the Cockfield and lower Wilcox Aquifers in Arkansas, 1991.* US Geological Survey Water-Resources Investigation Report 93-4137, USGS.

Westerman, D.A, K.R. Merriman, J.L. De Lanois, and Charles Berenbrock. 2013. *Analysis and Inundation Mapping of the April-May 2011 Flood at Selected Locations in Northern and Eastern Arkansas and Southern Missouri.* Scientific Investigations Report 2013-5148, Reston: US Geological Survey.

White River RSWMD. 2011. *2011 Regional Solid Waste Management Plan, Regional Needs Assessment, Annual Waste Tire Report, Annual Recycling Program Report.* Batesville: White River Regional Solid Waste Management District.

White, Mel.2011. *Birds*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=4510 (accessed November 2013).

White, Mel. 2010. *Mississippi Flyway*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?search=1&entryID=5926 (accessed November 2013).

Williams, C. Fred. 2012. *Agriculture*. Arkansas Encyclopedia of History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=385 (accessed September 5, 2013).

Woods, Alan J, T Foti, S. Chapmen, J. Omnerick, J. Wise, E. Murray, W. Prior, J. Pagan Jr., J. Comstock, M Radford. 2004. *Ecoregions of Arkansas (color poster with map, descriptive text, summary tables, and photographs).* Reston, VA: US Geological Survey.

Zbinden, Van. 2011. *St. Louis Southwestern Railway*. The Encyclopedia of Arkansas History and Culture. http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=5104 (accessed August 20, 2013).

APPENDIX A

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

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
2A – Boeuf River & tributaries	464.2	464.2	Aquatic life	67.8	Chloride	67.8	Agriculture
					Sediment/siltation	67.8	Agriculture
					Sulfate	49.4	Agriculture
					TDS	18.3	Agriculture
2B – Bayou Bartholomew & tributaries	489.3	489.3	Fish consumption	101.9	Mercury	101.9	Unknown
			Aquatic life	404	DO	314.8	Unknown
					Chloride	144.4	Unknown
					copper	6.6	Urban area
					Lead	154.7	Agriculture, urban area, unknown
					Sediment/siltation	354.2	Unknown, Agriculture
					TDS	116.6	Agriculture
					Zinc	64.7	Agriculture, urban area
			Primary contact	126.4	Pathogens	126.4	Unknown, agriculture, urban area
			Secondary contact	7	Pathogens	7	Unknown, urban area
			Agriculture & industrial water supply	134.5	Chloride	100.6	Agriculture
					TDS	116.6	Agriculture
			Total	444			
3A – Lower Arkansas River	186.6	186.6	Aquatic life	101.7	DO	101.7	Unknown
3B – Bayou Meto & tributaries (all but reach 907)	233.7	187.4	Aquatic life	133.6	DO	88.8	Unknown
					Copper	44.8	Industrial point source
3C – Arkansas River & tributaries: lock & dam 4 to 7	108.6	108.6	None				
4A – Lower White River & tributaries	466.1	403.9	Aquatic life	31.1	DO	31.1	Unknown

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
			Agriculture & industrial water supply	34.3	Chloride	34.3	Agriculture
					TDS	34.3	Agriculture
			Total	65.4			
4B – Bayou DeView and Cache River	599.1	253	Aquatic life	224.3	Lead	204	Agriculture
					Aluminum	20.3	Municipal WWTP
					Sediment/siltation	28.5	Agriculture
			Primary contact	5.9	Pathogens	5.9	Unknown
			Agriculture & industrial water supply	56.7	Chloride	28.2	Industrial point source, municipal WWTP
					TDS	48.8	Agriculture
			Total	232.2			
4C – Village Creek & tributaries	285	208.5	Aquatic life	115.6	DO	39.4	Unknown
					Zinc	76.2	Agriculture
			Primary contact recreation	37.5	Pathogens	37.5	Unknown
			Total	123			
4D – White River, Wattensaw Bayou, and Bayou Des Arc	257.7	230.7	Aquatic life	136.4	DO	48.2	Unknown
					Lead	5	Agriculture
					Zinc	83.2	Agriculture
			Primary contact recreation	61	Pathogens	61	Unknown
			Total	163.4			
4G - Black River (11010008, 11010007, 11010009-001)	150	150	Aquatic life	82.7	DO	82.7	unknown
					Sediment/siltation	35.6	erosion

ADEQ Planning Segment	Total miles	Stream miles assessed	Designated uses impaired	Stream miles impaired	Pollutant	Stream miles	Source
5A – St. Francis River Basin	572	368.8	Aquatic life	62.9	DO	40.1	Unknown
			Drinking water supply	22.8	Chloride	22.8	Unknown
			Agriculture & industrial water supply	95.8	Chloride	95.8	Agriculture, unknown
			Total	113.1			
5B – St. Francis River Basin	208.1	165.1	Aquatic life	114.8	DO	114.8	Unknown
					Sediment/siltation	98.4	agriculture
			Primary contact	60.1	Pathogens	60.1	agriculture
			Drinking water supply	12.8	Chloride, TDS, sulfate	12.8	agriculture
			Agriculture & industrial water supply	107.4	Chloride	98.4	agriculture
					TDS	107.4	agriculture, WWTP
					Sulfate	44.1	agriculture
			total	136.6			
5C – St. Francis River Basin	153	153	None				
6A thru 6C – Mississippi River Basin	437	0	None				
total	4610.4	3369.1		1663.5			