water resources / environmental consultants

BAYOU METO
WATERSHED MANAGEMENT PLAN

JUNE 2, 2022

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Prepared for

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LIST OF ACRONYMS AND ABBREVIATIONS

AGFC	Arkansas Game and Fish Commission
ANHC	Arkansas Natural Heritage Commission
APCEC	Arkansas Pollution Control and Ecology Commission
APHIS	USDA Animal and Plant Health Inspection Service
ARCDC	Arkansas Resource Conservation and Development Council
ATTRA	National Sustainable Agriculture Information Service
BOD	biochemical oxygen demand
°C	degrees Celsius
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
DEQ	Arkansas Department of Energy and Environmental Division of Environmental Quality
DO	dissolved oxygen
EPA	US Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
°F	degrees Fahrenheit
FSA	USDA Farm Services Agency
GIS	Geographic Information System
HUC12	12-digit Hydrologic Unit Code
HUC8	8-digit Hydrologic Unit Code
Mgd	million gallons a day
Mg/L	milligrams per liter
MSA	metropolitan statistical area
MS4	Municipal Separate Storm Sewer System
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NHD	national hydrography dataset

LIST OF ACRONYMS (CONTINUED)

NLCD	national land cover database
NRCS	US Department of Agriculture Natural Resources Conservation Service
NRD	Arkansas Department of Agriculture Natural Resources Division
NTU	Nephelometric Turbidity unit
SARE	Sustainable Agriculture Research and Education program
SU	standard units (of pH)
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
TMDL	total maximum daily load
TSS	total suspended solids
UofA	University of Arkansas
USDA	US Department of Agriculture
USGS	US Geological Survey
USFWS	US Fish and Wildlife Service
WMA	wildlife management area
WRE	Wetland Reserve Easement
WREP	Wetland Reserve Enhancement Partnership
WRICE	Arkansas Waterfowl Rice Incentive Conservation Enhancement program

1.0 INTRODUCTION

This watershed management plan addresses the Bayou Meto watershed located in central Arkansas. The primary focus of this plan is protection and improvement of surface water quality in Bayou Meto and its tributaries through management of unregulated nonpoint sources of pollution.

1.1 Plan Need and Mission

The Arkansas Department of Agriculture Natural Resources Division (NRD) Nonpoint Source Pollution Management program has set itself the goal of preparing watershed management plans for all 57 of the 8-digit Hydrologic Unit Code (HUC8) watersheds located partially or completely in the state of Arkansas. The Bayou Meto HUC8 is not one of the 11 Nonpoint Source priority watersheds designated by NRD (NRD 2018). However, there are stream reaches and reservoirs in the Bayou Meto watershed that are included on the most recent approved (2018) state impaired waters list (303(d) list) due in part to pollution from nonpoint sources. Therefore, the Bayou Meto watershed was selected by NRD for development of a watershed management plan to address these impairments and meet the agency goal for development of plans.

The primary focus of this plan is the **protection** and **improvement** of surface water quality in Bayou Meto and its tributaries through management of unregulated nonpoint sources of pollution. The mission of the watershed management plan for the Bayou Meto watershed is to: Increase awareness of water quality issues, outreach and education, and voluntary implementation of effective water quality management practices. There are agencies and interest groups with active outreach and education programs in the Bayou Meto watershed that are intended to increase public awareness of water quality issues in the watershed and encourage practices that address those issues. This plan supports the efforts of these organizations.

1.2 Watershed Vision

The vision for the Bayou Meto watershed is: The desired and designated uses of Bayou Meto and its tributaries are attained and sustained, resulting in healthy streams that enhance the socioeconomic, agricultural, and natural amenity benefits of the watershed, as visitors, landowners, and local communities work together to protect and improve both water resources and the quality of life throughout the watershed.

Each community, landowner, and producer has their own vision for their part of the watershed. In addition, there are a number of agricultural and natural resources agencies and other organizations that work within the Bayou Meto watershed to manage its natural resources. Some of them have developed plans that document their missions, visions and/or goals for the Bayou Meto watershed (see Appendix A).

1.3 Process

Development of the Bayou Meto watershed management plan followed the steps outlined by US Environmental Protection Agency (EPA) in the Handbook for Developing Watershed Plans (EPA 2008):

1. Building partnerships,
2. Characterizing the watershed,
3. Finalizing management goals and identifying solutions, and
4. Designing an implementation program.

NRD worked with consultants to develop this watershed management plan, utilizing the input of watershed stakeholders. Eight public meetings were held using Zoom as part of the process of developing the Bayou Meto watershed management plan. The purposes of these public meetings were to inform stakeholders of the plan and the process for developing it, and to request and obtain stakeholder input for the plan. Stakeholder input was sought specifically in identifying priority issues in the watershed and selecting management practices for addressing nonpoint source pollution in the watershed. Stakeholders who participated in development of this plan included farmers and ranchers, local residents, sportsmen, representatives of federal and state legislatures, the US Air Force, representatives from county and city governments, US Department of Agriculture Natural Resources Conservation Service (NRCS), US Fish and Wildlife Service (USFWS), Arkansas Department of Energy and Environmental Division of Environmental Quality (DEQ), Arkansas natural resources agencies, University of Arkansas (UofA) Cooperative Extension Service, County Conservation Districts, agricultural interest groups, and recreation and environmental interest groups. Attendance summaries from the meetings are included in Appendix B.

1.4 Document Overview

This document contains elements recommended by EPA and DEQ for watershed management plans. Section 2 describes many of the features of the watershed. Sections 3 and 4 summarize conditions in the watershed, including water quality, hydrology, and ecology. Section 5 provides information on pollutant sources in the Bayou Meto watershed. Section 6 identifies watershed goals and objectives, subwatersheds recommended for initial management of nonpoint pollutant sources, pollutant load reduction targets, and management strategies for controlling nonpoint source pollution in the recommended subwatersheds. Section 7 outlines the overall implementation plan, with schedule, list of management and outreach activities, and identification of indicators and monitoring to track progress and effects. Section 8 discusses costs and benefits of proposed management, and assistance that is available for implementation of nonpoint source pollution management practices. Watershed-based management plans developed to meet the requirements for Clean Water Act Section 319 funding must address nine planning elements required by EPA to manage and protect against nonpoint source pollution. Table 1.1 provides a roadmap for where the required planning elements are addressed in this plan.

Table 1.1. The required nine planning elements to manage and protect against nonpoint source pollution, and the location of the elements within this plan.

Element	Report Section(s)
Element A: Identification of Causes and Sources	
1. Sources identified, described, and mapped	3.4, 4.6
2. Subwatershed sources	4.6
3. Data Sources are accurate and verifiable	all
4. Data gaps	3.5
Element B: Expected Load Reductions	
1. Load reductions achieve environmental goal	4.4, 4.5
2. Load reductions linked to sources	4.8, Appendix I
3. Model complexity appropriate	Appendix I
4. Basis of effectiveness estimates explained	4.8, Appendix I
5. Methods and data cited and verifiable	4.8, Appendix I
Element C: Management Measures Identified	
1. Specific management measures are identified	4.7
2. Priority areas	4.3, 4.9, Appendix G
3. Measure selection rationale documented	4.0
4. Technically sound	4.0
Element D: Technical and Financial Assistance	
1. Estimate of technical assistance	6.3
2.Estimate of financial assistance	6.1, 6.4, Appendix L
Element E: Education/Outreach	
1. Public education/information	5.1
2. All relevant stakeholders are identified in outreach process	1.3, 5.2, Appendix B
3. Stakeholder outreach	5.1, 5.2, 5.3.2
4. Public participation in plan development	Appendix B
5. Emphasis on achieving water quality standards	4.4, 5.6
6. Operation & maintenance of BMPs	Appendix J
Element F: Implementation Schedule	
1. Includes completion dates	5.8
2. Schedule is appropriate	5.8
Element G: Milestones	
1. Milestones are measurable and attainable	5.8
2. Milestones include completion dates	5.8
3. Progress evaluation and course correction	5.5, 5.6, 5.8
4. Milestones linked to schedule	5.8

2.0 WATERSHED DESCRIPTION

2.1 Geography

The Bayou Meto watershed, identified by US Geological Survey (USGS) as HUC8 08020402, covers 992 square miles (634,880 acres) in central to southeastern Arkansas (Figure 2.1). Bayou Meto originates in Faulkner County, and flows southeast across Pulaski, Lonoke, and Arkansas Counties. Bayou Meto, along with its tributary Bayou Two Prairie, forms part of the border between Arkansas and Prairie Counties. Bayou Meto also forms part of the border between Arkansas and Jefferson Counties. A number of towns are located within the watershed. The largest towns are located in the northern watershed and include Sherwood, Jacksonville, and Cabot. Interstate 40 crosses the watershed, as do several US Highways including Highway 63, 67, 70, and 79.

Table 2.1. County areas within the Bayou Meto watershed.

Counties	County area (square miles)	Area within watershed (square miles)	Percent of County within watershed	Percent of watershed within County
Arkansas	1039	339	32.6%	33.9%
Faulkner	803	374	46.6%	37.4%
Pulaski	915	41.2	4.50%	4.12%
Lonoke	664	20.8	3.13%	2.08%
Prairie	675	52.6	7.80%	5.27%
Jefferson	807	172	21.3%	17.2%
Totals	4903	999	115.9%	100.0%

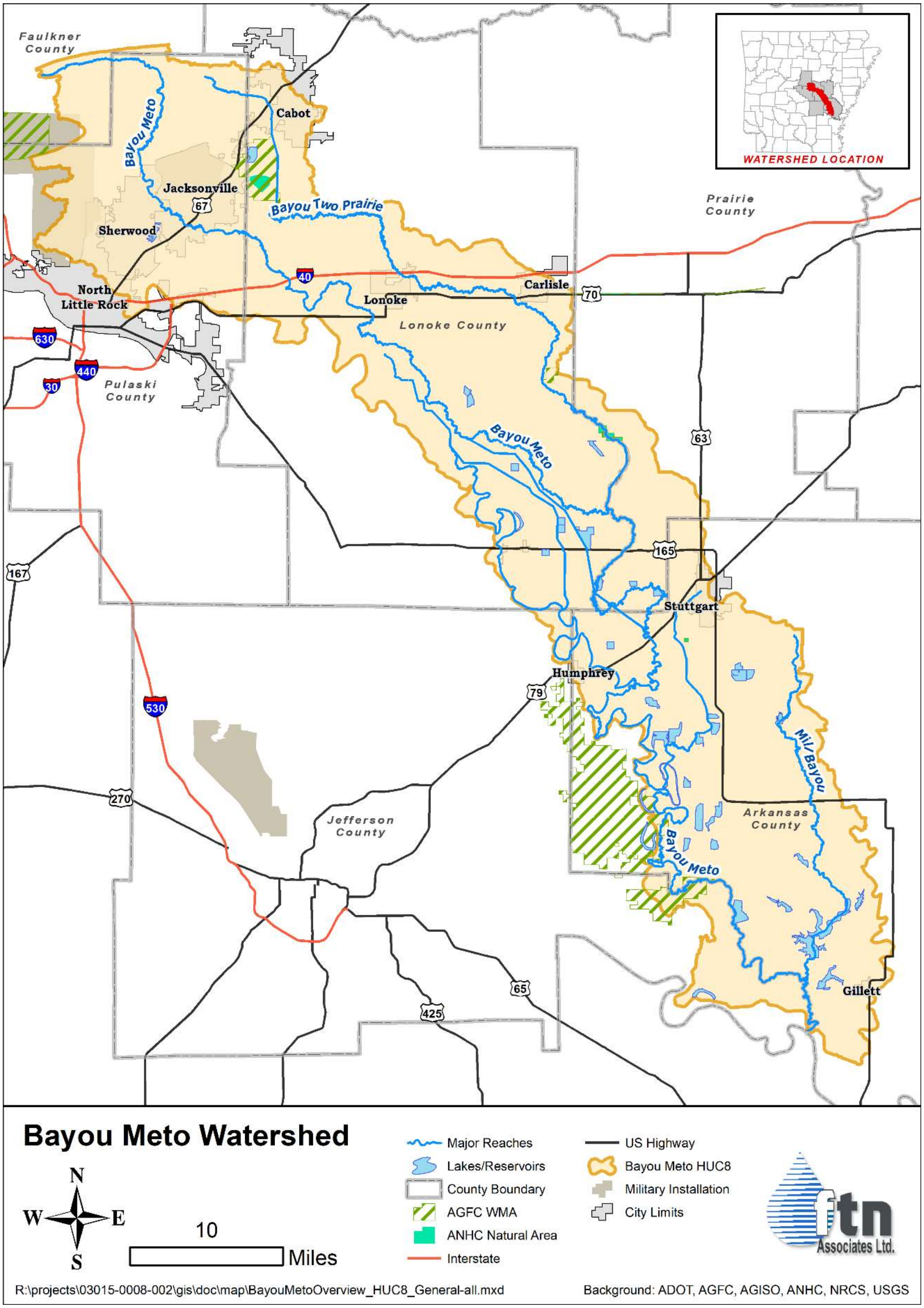


Figure 2.1. Geography of Bayou Meto watershed.

2.2 Socioeconomics

This section summarizes demographic and economic information for the Bayou Meto watershed. Demographic information from the US Census Bureau for the counties of the Bayou Meto watershed is presented.

2.2.1 Population

Numbers of people in the counties of the Bayou Meto watershed are presented in Table 2.2. Three of the counties associated with the Bayou Meto watershed experienced population increases between 2010 and 2019, and three experienced population declines. Population projections for 2030 indicate population increases will continue in Faulkner, Lonoke, and Pulaski Counties, while population is projected to continue to decline in Arkansas, Jefferson, and Prairie Counties.

Table 2.2. Population information for counties associated with Bayou Meto watershed and Arkansas as a whole.

Area	2010[a] Total Population	2010 Population Density (number/ square mile)	2019 Total Population[b]	2019 Population Density (number/ square mile)	2030 Projection[c]
Arkansas County	19,007	18	17,486	17	15,367-18,490
Faulkner County	113,238	141	126,007	190	127,899-154,353
Jefferson County	77,456	96	66,824	73	53,263-59,695
Lonoke County	68,382	103	73,309	91	74,310-94,940
Prairie County	8,716	13	8,062	12	6,317-7,495
Pulaski County	382,749	418	391,911	485	420,837-455,431
State of Arkansas	2,916,031	55	3,017,804	57	3,197,901-3,344,787

a 2010 Census of Population and Housing, Population and Housing Unit Counts, Arkansas (CPH-2-5)
b (US Census Bureau 2019a)
c (Arkansas Economic Development Institute 2013)

The majority of the watershed is classified as rural. The northern watershed includes areas within the Little Rock-North Little Rock-Conway Metropolitan Statistical Area (MSA), which consists of Faulkner, Grant, Lonoke, Perry, Pulaski, and Saline Counties (US Census Bureau 2021). The population within this MSA increased between 2010 and 2020.

Additional demographic information for the counties associated with the Bayou Meto watershed is listed in Table 2.3. This includes percentages of the population for characteristics of commuting, household structure, age, gender, race, median income, poverty, fields of employment, and education level. In the counties associated with the watershed, about two-thirds of households are families, and most of these include two parents. The population of the watershed is older than the state-wide profile. There are lower percentages of persons under age 18, 18 to 34 years, and 35 to 49 years; while there are higher percentages of persons aged 50 to 64 years and 65 and older. The majority of persons in the watershed consider themselves White (non-Hispanic).

The percentages of bachelor's, and graduate degree holders are lower than the state-wide values, except in Faulkner County. However, all but two of the counties have higher percentages of high school graduates than the state as a whole.

2.2.2 Economics

Drivers of the economy in Bayou Meto watershed include agriculture, outdoor recreation, manufacturing, and military installations. The values of sales and receipts reported for selected economic sectors in the counties of the Bayou Meto watershed, in the 2017 economic census, are summarized in Table 2.4. Manufacturing reported the highest revenue in most of the counties. Some of the largest manufacturers in the watershed include Riceland Foods Inc., Remington Arms Co., and Lennox International Inc (Knable and Jones 2013).

Table 2.3. Demographic information for counties associated with Bayou Meto watershed and Arkansas as a whole (US Census Bureau 2019b).

Information	Arkansas County	Faulkner County	Jefferson County	Lonoke County	Prairie County	Pulaski County	State of Arkansas
Gender							
Female	51.8%	51.1%	50.4%	50.6%	50.0%	52.1%	50.9%
Male	48.2%	48.9%	49.6%	49.4%	50.0%	47.9%	49.1%
Age							
Median Age	40.7	32.8	38.7	36.2	47.2	37.2	37.9
Under 18	23.0%	23.5%	22.4%	26.1%	20.4%	23.5%	23.5%
18 to 24 years	6.4%	12.6%	8.4%	6.4%	6.2%	7.0%	7.9%
25 to 44 years	24.7%	29.7%	26.6%	30.2%	22.4%	29.9%	27.3%
45 to 64 years	27.2%	22.4%	26.5%	24.9%	28.9%	25.4%	25.1%
65 and older	18.4%	11.8%	16.3%	12.8%	22.9%	14.5%	16.6%
Race							
White non-Hispanic	73%	82%	40%	89%	85%	57%	77%
Black non-Hispanic	25.8%	11.4%	56.6%	6.1%	13.0%	36.5%	15.3%
Native American	0.1%	0.4%	0.3%	0.6%	0.4%	0.2%	0.7%
Asian	0.0%	1.3%	0.9%	0.7%	0.4%	2.2%	1.5%
Other race	1.6%	4.7%	2.0%	3.6%	0.9%	4.6%	5.8%
Education							
Less than High School Graduate	17%	9%	14%	11%	18%	10%	13%
High School Graduate (or Equivalency)	38%	31%	39%	35%	40%	26%	34%
Some College or Associate's Degree	29%	31%	30%	33%	27%	30%	30%
Bachelor's Degree	11%	19%	11%	14%	11%	21%	15%
Graduate Degree	5%	11%	6%	6%	4%	13%	8%
Household Structure							
Family households	63%	65%	61%	74%	66%	61%	66%
Two parent families	46%	50%	38%	57%	50%	40%	48%
Single parent families	17%	15%	23%	17%	16%	21%	18%
Single person household	30%	27%	34%	23%	32%	34%	29%
Other non-family household	37%	35%	39%	26%	34%	39%	34%

Table 2.4. Value of sales, shipments, receipts, revenue, or business done ($1,000) reported in the 2017 Economic Census of the US (US Census Bureau 2017).

Industry	Arkansas County	Faulkner County	Jefferson County	Lonoke County	Prairie County	Pulaski County	Sum
Manufacturing	$1,655,980	$838,048	$1,581,976	$407,440	$6,506	$5,425,222	$9,915,172
Wholesale trade	$173,596	$554,762	$314,252	$218,513	NR	$9,205,718	$10,466,841
Retail trade	$302,359	$1,880,103	$776,810	$557,155	$51,312	$7,998,111	$11,565,850
Transportation and warehousing*	$180,030	$112,822	$46,033	$53,081	$5,907	$1,317,973	$1,715,846
Real estate and rental and leasing	$16,577	$97,661	$34,477	$22,357	NR	$776,105	$947,177
Professional, scientific, and technical services	$9,886	$116,398	$28,589	$68,976	$3,292	$1,974,607	$2,201,748
Administrative and support and waste management and remediation services	$30,922	$107,961	$88,859	$29,063	NR	$1,030,367	$1,287,172
Educational Services	NR	$8,262	$1,986	NR	NR	$48,896	$59,144
Health care and social assistance	$63,284	$535,520	$398,981	$106,617	$8,054	$6,685,796	$7,798,252
Arts, entertainment, and recreation	$3,053	$26,806	NR	NR	NR	$212,039	$241,898
Accommodation and food services	$20,526	$234,271	NR	$87,411	NR	$1,127,293	$1,469,501
Other services (except public administration)	$5,761	$74,363	$39,535	$22,528	$3,071	$951,331	$1,096,589

*Railroad transportation and US Postal Service excluded.
NR - Not Reported

Agriculture is not an economic sector reported in the economic census. However, agriculture contributes value to manufacturing, real estate, wholesale trade, and transportation and warehousing economic sectors (UofA Divison of Agriculture 2012). Table 2.5 lists the value of sales of agricultural products reported for the six counties of the Bayou Meto watershed in the 2017 census of agriculture. Cattle production is important in the upper Bayou Meto watershed, while row crops dominate in the lower watershed. Soybeans and rice account for the greatest sales in most counties. Bayou Meto watershed includes portions of three counties in the top 10 for grain production in the state. Arkansas county is the top county in the state for grain production. Arkansas is the top rice producing state.

Table 2.5. Sales of agricultural commodities in thousands of dollars (USDA National Agricultural Statistics Service 2017).

Commodity	Arkansas County	Faulkner County	Jefferson County	Lonoke County	Prairie County	Pulaski County	Arkansas
Aquaculture	NR	NR	NR	$20,415	$8,175	NR	$71,121
Cattle (incl. calves)	$725	$12,306	$995	$4,340	$710	$1,756	$737,961
Corn	$31,569	$786	$28,235	$24,300	$10,873	$2,482	$386,041
Cotton	NR	NR	$4,388	$3,999	NR	NR	$342,825
Field Crops (other, incl. hay)	NR	$2,342	$428	$1,459	NR	$386	$110,864
Fruit & Tree Nut	NR	$489	$338	NR	NR	$632	$19,535
Poultry (incl. eggs)	NR	$49	$24,641	$43	NR	NR	$5,112,242
Rice	$71,872	$912	$43,988	$71,781	$52,070	$2,601	$922,214
Soybeans	$107,827	$4,268	$65,528	$49,689	$53,681	$9,729	$1,717,830
Vegetable (incl. seeds/transplants)	$4	NR	$111	$2,193	NR	NR	$45,129
Wheat	$1,588	NR	NR	$746	NR	$92	$29,023

NR - Not Reported

Aquaculture is important in the middle Bayou Meto watershed. Arkansas ranks second among the nation's aquaculture-producing states. Arkansas leads the nation in baitfish production, and the world's largest baitfish farm is located in Lonoke County, within the Bayou Meto watershed. The world's largest goldfish farm and hybrid striped bass hatchery are also located in the watershed. Arkansas leads the nation in hybrid striped bass fry production. (Arkansas Department of Agriculture n.d., Arkansas Farm Bureau n.d., Rice 2018, Beavers 2022, Arkansas Farm Bureau 2020)

Tourism in Arkansas has been increasing in recent years. From 2018 to 2019, total travel expenditures increased 4.2% and 957 travel-generated employees were added to the work force (Arkansas Department of Parks, Heritage, and Tourism 2019). A summary of travel-related revenue for the counties of the Bayou Meto watershed can be seen in Table 2.6. While Pulaski County, housing the state's capital, brought in the most travel-related revenue, Arkansas and

Jefferson County brought in considerable travel revenue given their size. While Pulaski County collected $1.9 million in state taxes for every 10,000 residents, Arkansas County and Jefferson County were on pace with $1.5 million and $1 million per 10,000 residents, respectively. This is primarily due to the location of the 380-acre George H. Dunklin Jr. Bayou Meto Wildlife Management Area (WMA) located in Arkansas County and adjacent to Jefferson County. Duck hunting at this WMA is some of the best in the state with heavy resident and non-resident use. The Arkansas Game and Fish Commission (AGFC) reports that opening day of the season can bring 1,500 to 2,000 hunters into the area each day (AGFC 2020). About 30% of both resident hunters and non-resident hunters in a recent survey responded that they duck hunt most often on Bayou Meto (also known as Long Bell or Scatters), making it one of the most used WMAs in the state (Bennet and Thiedig 2017). Waterfowl hunting in the watershed and in the state as a whole is a booming industry. In the most recent edition of *Economic Impact of Waterfowl Hunting in the United States* by the USFWS (2015), there were more trip and equipment expenditures related to waterfowl hunting in Arkansas than in any other state reported (see Table 2.7). Additionally, Arkansas holds a 20% stake in the nation's $1.3 billion waterfowl hunting industry.

Two military bases are located in the upper Bayou Meto watershed: Little Rock Air Force Base and part of Camp Robinson. The watershed is also not far from the Pine Bluff Arsenal. These installations impact local economies by providing jobs, buying materials, and generating tax revenue. Counties of the Bayou Meto watershed were among the top 20 Arkansas counties in 2015 direct economic inputs from defense (Table 2.8).

Table 2.6. Travel impact data for counties overlapping the Bayou Meto watershed.

Industry	Arkansas County	Faulkner County	Jefferson County	Lonoke County	Prairie County	Pulaski County	Sum
Total County Expenditures (Millions)	$41.62	$146.99	$121.59	$50.4	$6.95	$1,898.25	$2,265.80
Travel-Generated Payroll (Millions)	$6.47	$27.31	$22.5	$8.58	$1.05	$360.05	$425.96
Travel-Generated Employment (Jobs, Thousands)	0.33	1.42	1.17	0.41	0.06	13.77	17.16
Travel-Generated State Tax (Millions)	$2.63	$9.32	$7.01	$3.22	$0.46	$77.23	$99.87
Travel-Generated Local Tax (Millions)	$1.05	$2.84	$2.83	$1.01	$0.18	$37.14	$45.05
2% Tax (Thousands)	$93.65	$411.24	$287.27	$148.58	$13.62	$3,821.69	$4,776.05

Table 2.7. Economic impact of waterfowl hunting in 2011 (USFWS 2015).

State	Trip & Equipment Expenditures	Total Output	Job Income	Jobs	State Tax Revenue	Federal Tax Revenue
United States	**$1,362,542**	**$3,041,425**	**$955,679**	**27,348**	**$202,049**	**$234,131**
Arkansas	$259,960	$384,567	$127,542	5,104	$28,680	$29,422
California	$142,566	$270,616	$99,966	3,151	$19,942	$23,028
Delaware	$4,548	$6,523	$2,139	57	$536	$530
Kansas	$5,559	$8,007	$2,835	70	$533	$626
Louisiana	$86,411	$137,738	$47,773	1,409	$9,952	$9,915
Maryland	$9,203	$14,194	$4,886	168	$1,135	$1,229
South Dakota	$33,893	$46,133	$14,912	453	$3,313	$3,527

Note: States not listed have survey sample sizes too small to report reliably (9 or less). All estimates are based on sample sizes of 10-29. These sample size criteria are consistent with the "2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation."

Table 2.8. 2015 Defense expenditures for selected Bayou Meto counties (Arkansas Economic Development Commission 2016).

	Personnel compensation, millions	Procurement contracts, millions	Transfer payments, millions	Total expenditures, millions
Faulkner County	$11	NR	$102	$113
Jefferson County	$63	$35	$73	$172
Lonoke County	$6	NR	$133	$139
Pulaski County	$470	$92	$571	$1,133

County economic information from the US Census Bureau 2015-2019 American Community Survey 5-Year Estimates (Table DP03) is summarized in Table 2.9. Per-capita incomes in most of the counties associated with the Bayou Meto watershed are above the state level, but in two counties, Arkansas and Jefferson, the per-capita income is lower than for the state. The percentage of families below the poverty level in the counties of the watershed ranges from 15% (Faulkner County) to 34% (Jefferson County), with only two counties having percentages that are higher than the state 23%. The same is true for the percentage of people below the poverty level. The unemployment rates in the counties of the watershed range from 3.6% (Lonoke County) to 9.1% (Jefferson County), with half of the counties having unemployment rates higher than the state overall.

2.3 Ecoregions

Three Level III, and four Level IV ecoregions occur in the Bayou Meto watershed (Figure 2.2). Table 2.10 summarizes the characteristics of these ecoregions. These characteristics are described in greater detail in the following subsections.

2.3.1 Climate

Climate normals are 30-year averages of climate data, calculated at individual recording stations for the United States by the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information. For the Bayou Meto watershed, the 1991-2020 climate normals are estimated using weather stations at Arkansas Post, Cabot, Keo, Pine Bluff, and Stuttgart, Arkansas. The average annual precipitation is approximately 49 inches.

The lowest average monthly precipitation occurs in September, with the highest occurring in April and December. The warmest average monthly temperatures occur in July, while the coldest occur in January. The average monthly precipitation and the average monthly minimum and maximum temperatures are shown on Figure 2.3 (NOAA 2021).

Table 2.9. US Census Bureau economic information for counties of the Bayou Meto watershed (US Census Bureau 2019b).

Information	Arkansas County	Faulkner County	Jefferson County	Lonoke County	Prairie County	Pulaski County	State of Arkansas
Per Capita Income	$26,386	$26,913	$21,472	$27,293	$25,789	$32,692	$26,577
Families below poverty level	13.0%	10.8%	17.4%	8.4%	11.1%	12.3%	12.4%
People below poverty level	17.3%	16.7%	22.2%	12.2%	14.8%	16.8%	17.0%
Employment							
Unemployment rate	5.8%	3.8%	9.1%	3.6%	7.1%	4.7%	5.1%
Mgmt, business, science, arts	29%	38%	30%	36%	33%	41%	34%
Service	15%	17%	21%	15%	16%	16%	17%
Sales, office	21%	23%	19%	24%	20%	23%	22%
Natural resources, construction, maintenance	11%	9%	7%	12%	12%	6%	10%
Production, transportation, material moving	23%	13%	23%	14%	20%	13%	18%
Self-employed	7%	5%	6%	5%	8%	4%	6%

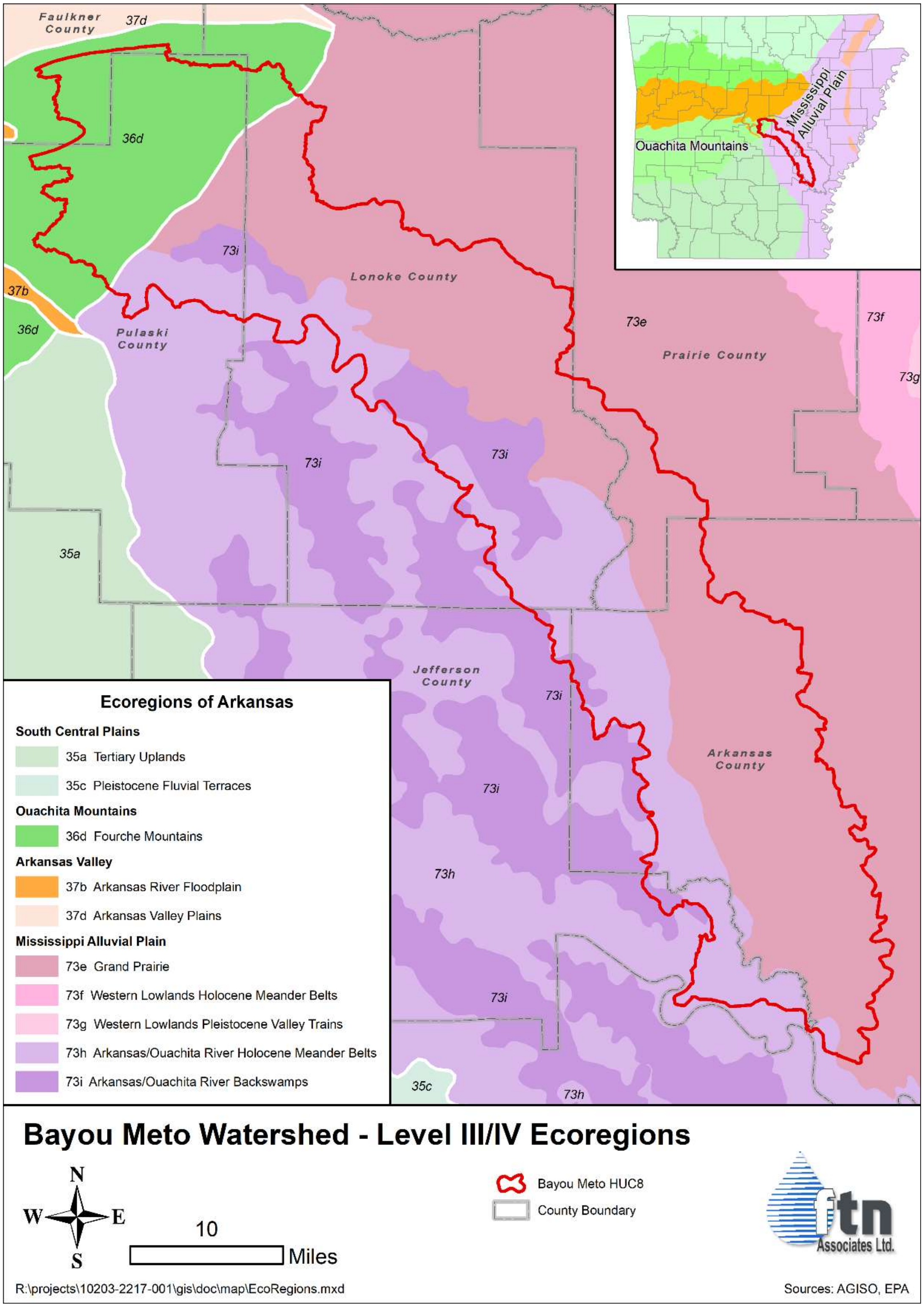


Figure 2.2. Ecoregions of the Bayou Meto watershed.

Table 2.10. Characteristics of Level IV ecoregions of the Bayou Meto watershed (from Woods et al. 2004).

Level III ecoregion code and name	Level IV ecoregion code and name	Topography	Hydrology	Elevation/local relief (feet)	Geology	Common soil series	Mean annual precipitation (inches)	Natural vegetation
36	36d. Fourche Mountains	Rugged, east to west trending, narrow-crested mountain ridges that are separated by narrow valleys and a few wide valleys.	N/A	290-2700; uplands are lowest in the east/ 100-1600	Quaternary colluvium and alluvium. Folded and faulted Pennsylvanian sandstone and shale. Rock outcrops are common.	Carnasaw, Pirum, Octavia, Clebit, Sherless, Caston, Mountainburg, Linker, Leadvale. In broad valleys on floodplains and stream terraces: Spadra, Leadvale, Kenn, Cane, Neff, Avilla, Ceda.	50-62	Potential natural vegetation: oak–hickory–pine forest. Upland native vegetation is mixed shortleaf pine–upland deciduous forest. In wide valleys, native vegetation is woodland or forest. Loblolly pine is native only to wet lowland sites such as riparian areas. Today, pine–oak forest, oak forest, loblolly–shortleaf pine forest, or oak–pine forest occur. On highest ridgetops (including Rich Mountain in Polk County): white oak and post oak forests and woodlands stunted by ice and wind are found; here, the only montane communities in Arkansas occur. North-facing, steep slopes: mesic vegetation including sugar maple and cucumber magnolia. South-facing slopes: drier forests dominated by shortleaf pine. Steep south-facing sites: grassy woodland areas.
73	73h. Arkansas/ Ouachita River Holocene Meander Belts	Flat to nearly flat floodplain containing the meander belts of the present and past courses of the lower Arkansas and Ouachita rivers. Point bars, natural levees, swales, abandoned channels, and meander scars occur.	Oxbow lakes, and low gradient rivers and bayous occur.	Mostly 110-260/ 5-20	Holocene sandy, silty, clayey, and gravelly alluvium.	Perry, Portland, Rilla, Hebert, Crevasse, Bruno, Keo, Norwood, Sharkey	48-55	Potential natural vegetation: southern floodplain forest. Native vegetation is bottomland hardwood forest/woodland containing cottonwood, elm, hackberry, pecan, sycamore, willow, green ash, cherrybark oak, Nuttall oak, swamp chestnut oak, water oak, willow oak, overcup oak, sweetgum, sycamore, and water hickory. In wet channels: bald cypress and water tupelo. Palmetto and Spanish moss occur and are at their northern limit.
73	73i. Arkansas/Ouachita River Backswamps	Low-lying floodplains with poorly-drained flats broken by alternating swales and ridges.	Water often collects into its marshes, swamps, oxbow lakes, ponds, and sloughs. Some low gradient streams with silty substrates occur. Many drainage ditches occur.	100-250/less than 10	Holocene silty, clayey, or loamy fluvial and lacustrine deposits that are locally organic-rich. Natural levee deposits are common.	Sharkey, Desha, Portland, Hebert, Perry, Rilla, Moreland, Yorktown, Alligator	48-55	Potential natural vegetation: southern floodplain forest. Native vegetation is bottomland hardwood forest and woodland dominated by willow oak, Nuttall oak, and water oak along with forested canebrakes containing mixed deciduous trees and giant cane.
73	73e. Grand Prairie	Broad, nearly level terrace with incised streams. A narrow belt of hills occurs in the east.	Perennial and intermittent streams occur.	150-320/ 10-50	Quaternary windblown silt (i.e., loess) veneers Pleistocene terrace deposits (composed of alluvial sand, silt, and clay).	Loring, Crowley, Stuttgart, Calloway, Calhoun, Hillemann, McKamie	48-52	Potential natural vegetation: oak–hickory forest. Native vegetation is mostly tall grass prairie dominated by big bluestem, Indiangrass, and switchgrass. In addition, open woodland and savanna dominated by upland oaks, hickory, elm, maple, and locust.

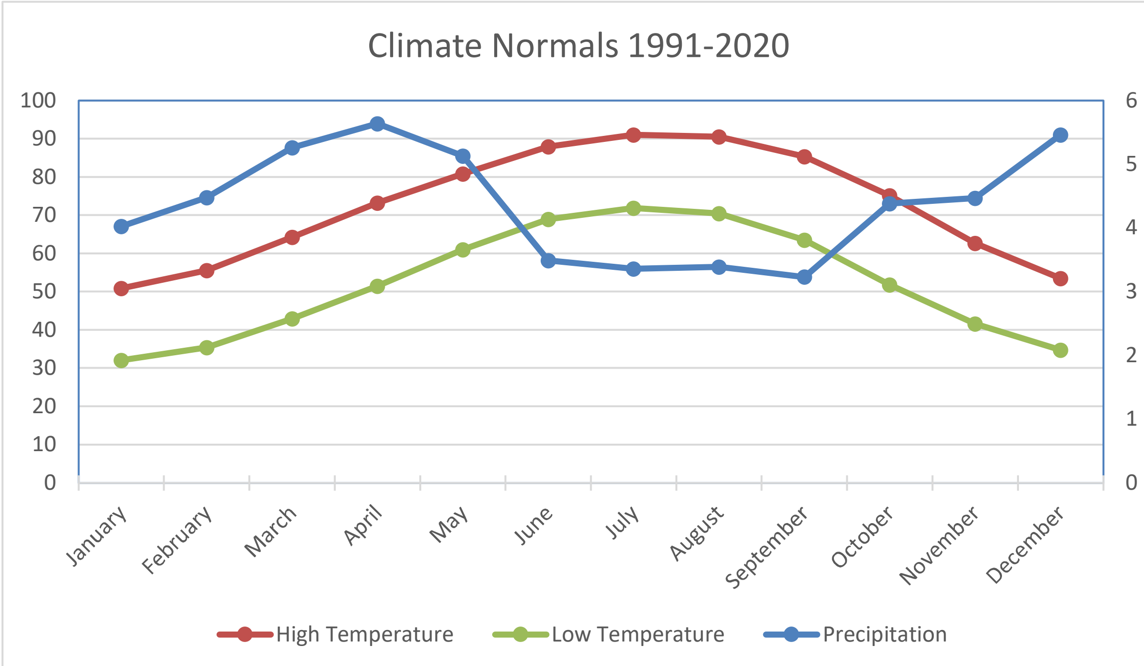


Figure 2.3. 1991-2020 climate normals in the Bayou Meto watershed.

2.3.2 Geology

The majority of the Bayou Meto watershed (87%) is located in the Mississippi Alluvial Plain physiographic region. The upstream end of the watershed originates in the Ouachita Mountains physiographic region (Figure 2.4). The geology of the Ouachita Mountains consists of sedimentary rock deposited in a deep ocean basin that have been uplifted and compressed into east-west trending folds and thrust faults by major mountain building processes. The geology of the Mississippi Alluvial Plain consists of unconsolidated, flat-lying sediments deposited by present day and historic streams, overlying poorly consolidated Tertiary formations (Arkansas Geological Survey 2020). A surface geology map of the Bayou Meto watershed is shown on Figure 2.5.

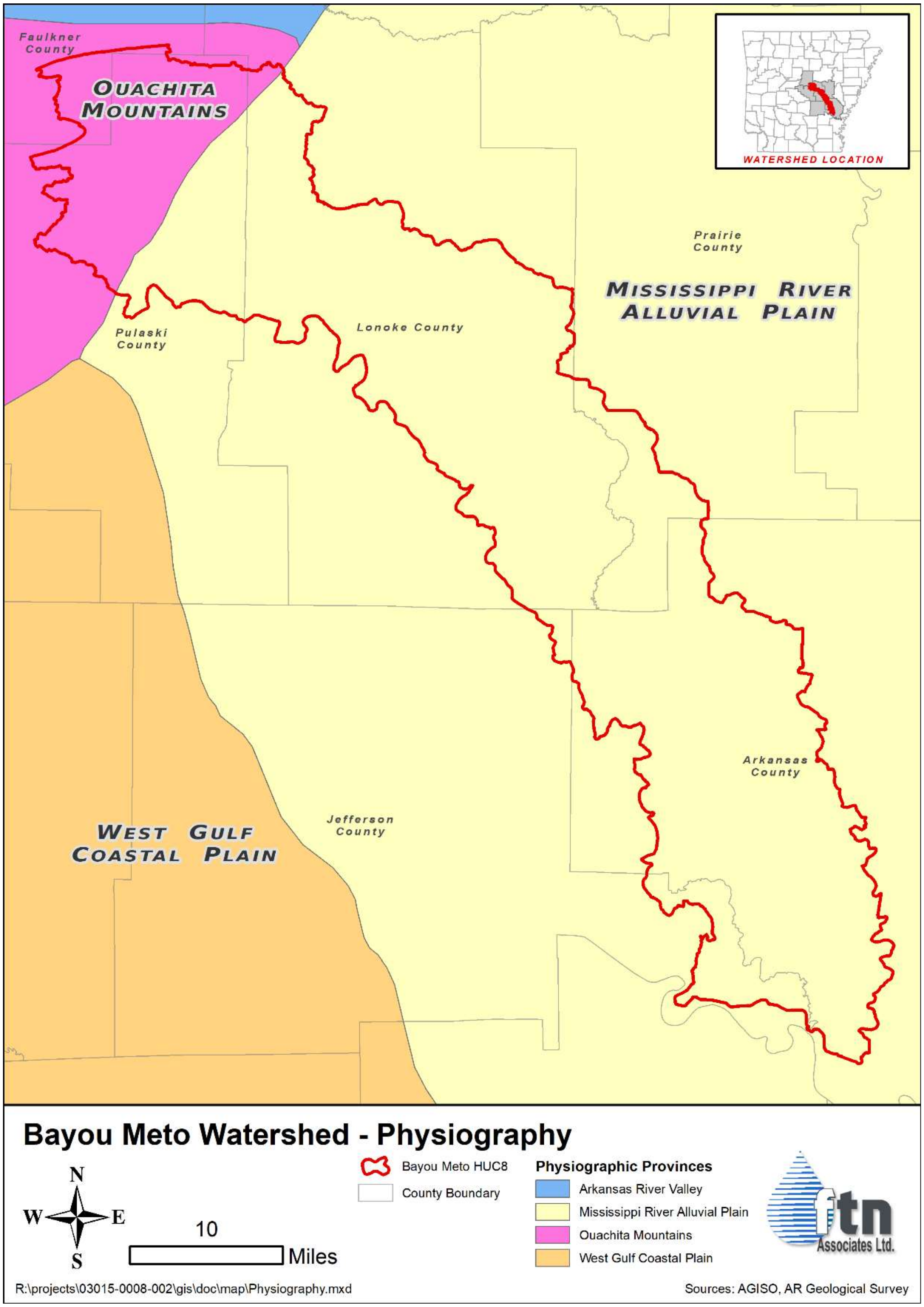


Figure 2.4. Physiographic regions within the Bayou Meto watershed.

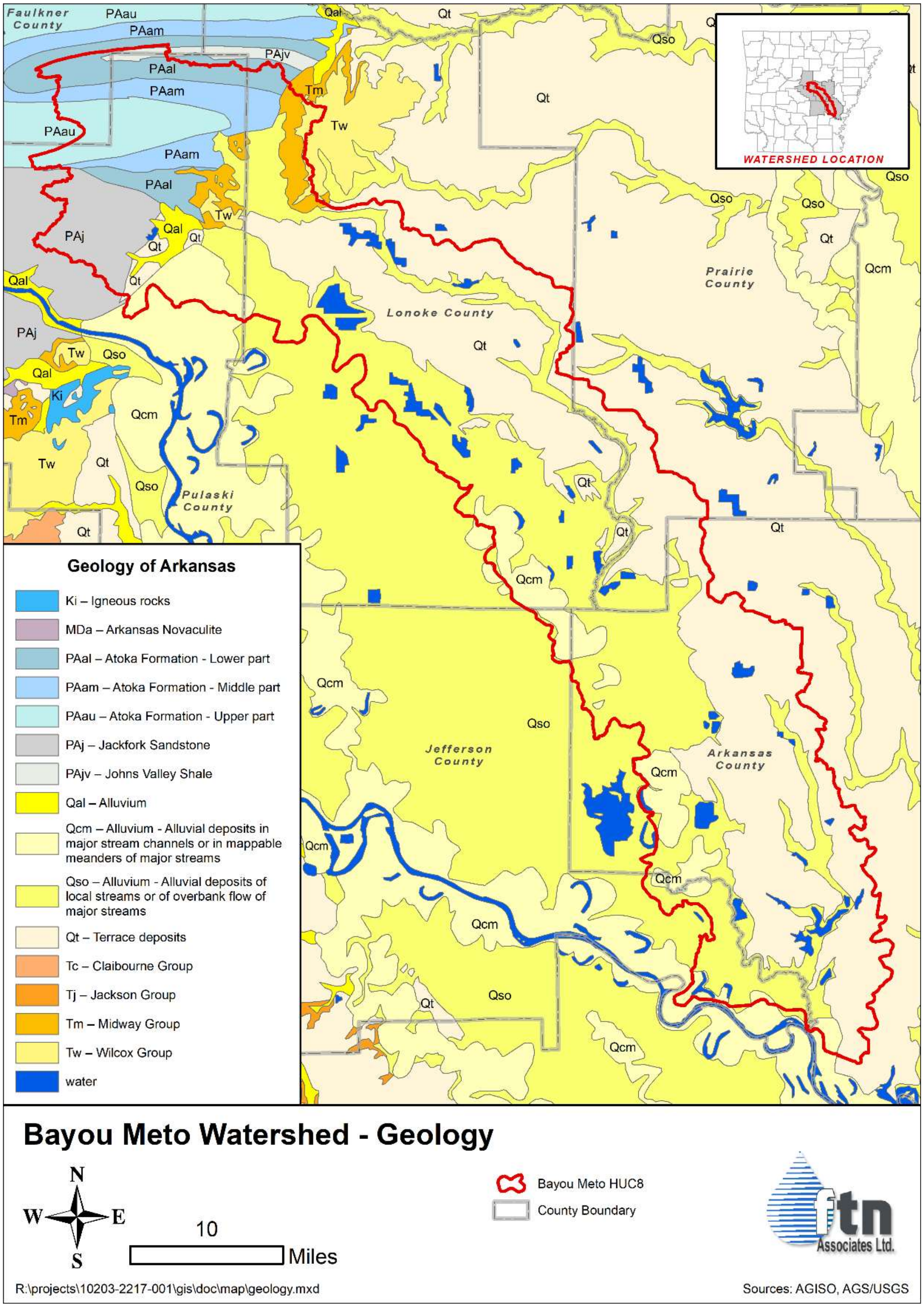


Figure 2.5. Surface geology within the Bayou Meto watershed.

2.3.3 Topography

Elevations within the Bayou Meto watershed range from 751 feet above sea level in the Ouachita Mountains of the upper watershed, to 157 feet above sea level in the lower end of the watershed where Bayou Meto joins the Arkansas River (Center for Advanced Spatial Technologies 2006). The gradient of Bayou Meto from the upstream end of the watershed (630 feet above sea level) to the confluence with the Arkansas River (157 feet above sea level), 183 miles, is approximately 3 feet/mile (DEQ 2013, USGS 2022).

Land slopes in the Bayou Meto watershed range from < 4 degrees in the Mississippi Alluvial Plain, valleys and ridge tops, to > 50 degrees (133%) on cliff faces and hill sides. Slopes of 14% or more are considered steep, while areas with slopes of 7% or less are considered flat lands. Geographic Information System (GIS) analysis indicates that approximately 93% of the watershed has slopes flatter than 7%. Table 2.11 lists the proportion of the Bayou Meto watershed considered flat lands, steep, and in between. Figure 2.6 shows a map of the locations of areas within the three slope ranges. Slopes > 7% are concentrated in the upper watershed.

Table 2.11. Slope areas in the Bayou Meto watershed.

Slope ranges, degrees	**Area within the watershed, acres**	**Percent of watershed**
<7%	597,262	93%
7-14%	29,339	5%
>14%	13,163	2%

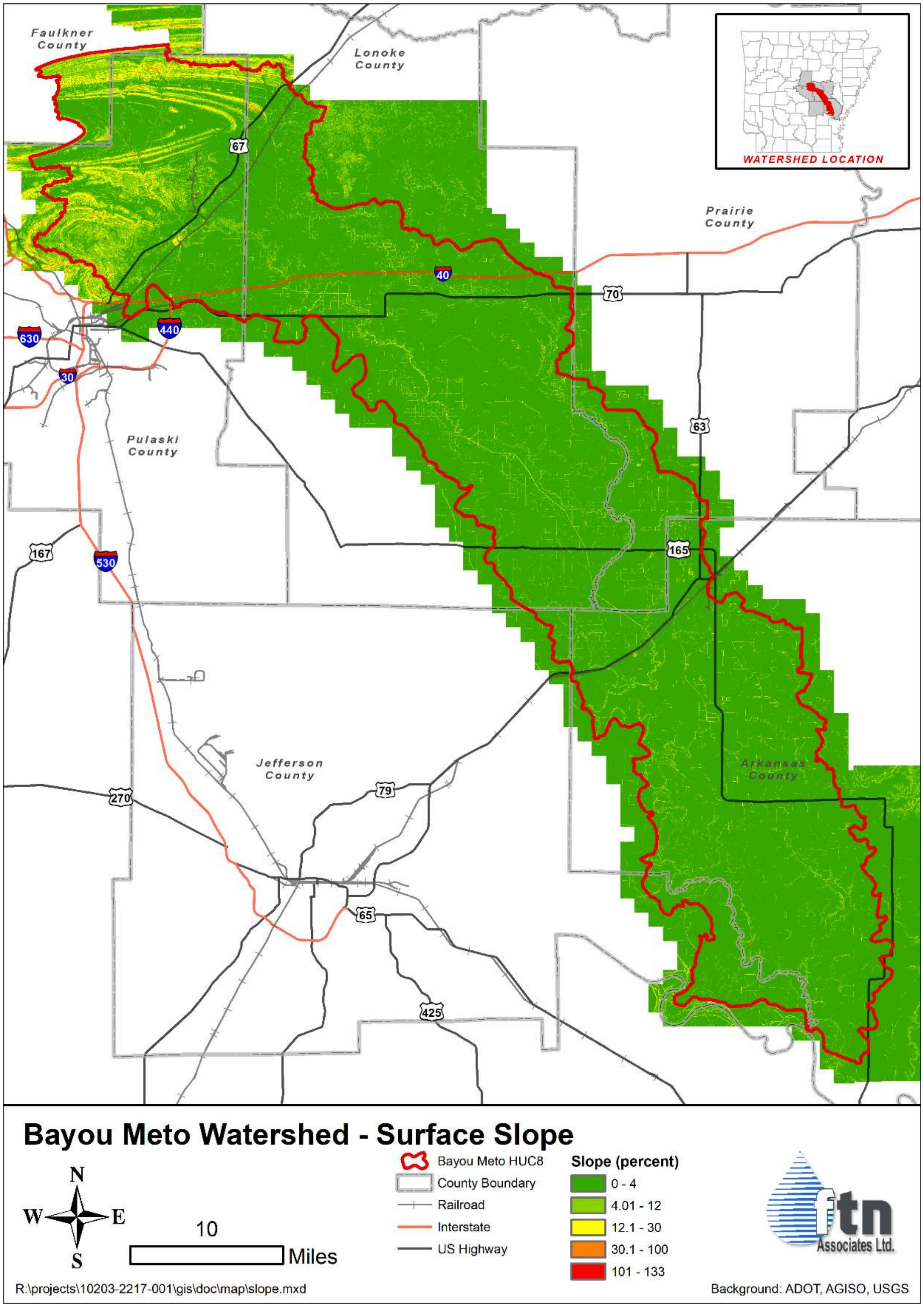


Figure 2.6. Map of slopes in Bayou Meto watershed.

The two physiographic regions in the watershed have very different topography (Figure 2.4). Thirteen percent of the watershed is in the Ouachita Mountains physiographic region, where the characteristic terrain is rugged and relief can be as much as 1,000 feet. Eighty-seven percent of the watershed is in the Mississippi Alluvial Plain physiographic region. This region is characterized by flat to gently rolling plains with little relief. Elevations in this area of the watershed are around 200 feet above sea level.

2.3.4 Soils

Soils in the Ouachita Mountains portion of the Bayou Meto watershed are loamy. Soils on the tops and slopes of ridges are stony, shallow, and well drained. Soils in the valleys are deep and may be poorly drained (Haley, Buckner and Festervand 1975). Soils in the Mississippi Alluvial Plain portion of the Bayou Meto watershed can be gravelly, sandy, silty, or clayey. The most prevalent of these soils are those of the Stuttgart-Crowley association (Figure 2.7). Characteristics of the major soils present in the watershed are summarized in Table 2.12.

Table 2.12. Characteristics of major soil associations of the Bayou Meto watershed (USDA Soil Conservation Service, Arkansas Agricultural Experiment Station 1981, USDA Soil Conservation Service, Arkansas Agricultural Experiment Station 1975).

Soil Association	Drainage	Character	Depth
Henry-Grenada-Calloway-Calhoun	Poorly drained	Silt loam	Deep to moderately deep
Mountainburg-Linker-Enders	Well drained	Fine sandy loam	Moderately deep to shallow
Rilla-Perry-Hebert	Well drained	Silt loam	Deep
Rilla-Portland-Perry	Poorly drained	Clay	Deep
Savannah-Pheba-Amy	Poorly drained	Silt loam	Deep
Sawyer-Savannah-Sacul	Moderately well drained	Fine sandy loam	Deep
Stuttgart-Crowley	Somewhat poorly drained	Silt loam	Deep
Taft-Leadvale	Moderately well drained	Silt loam	Deep

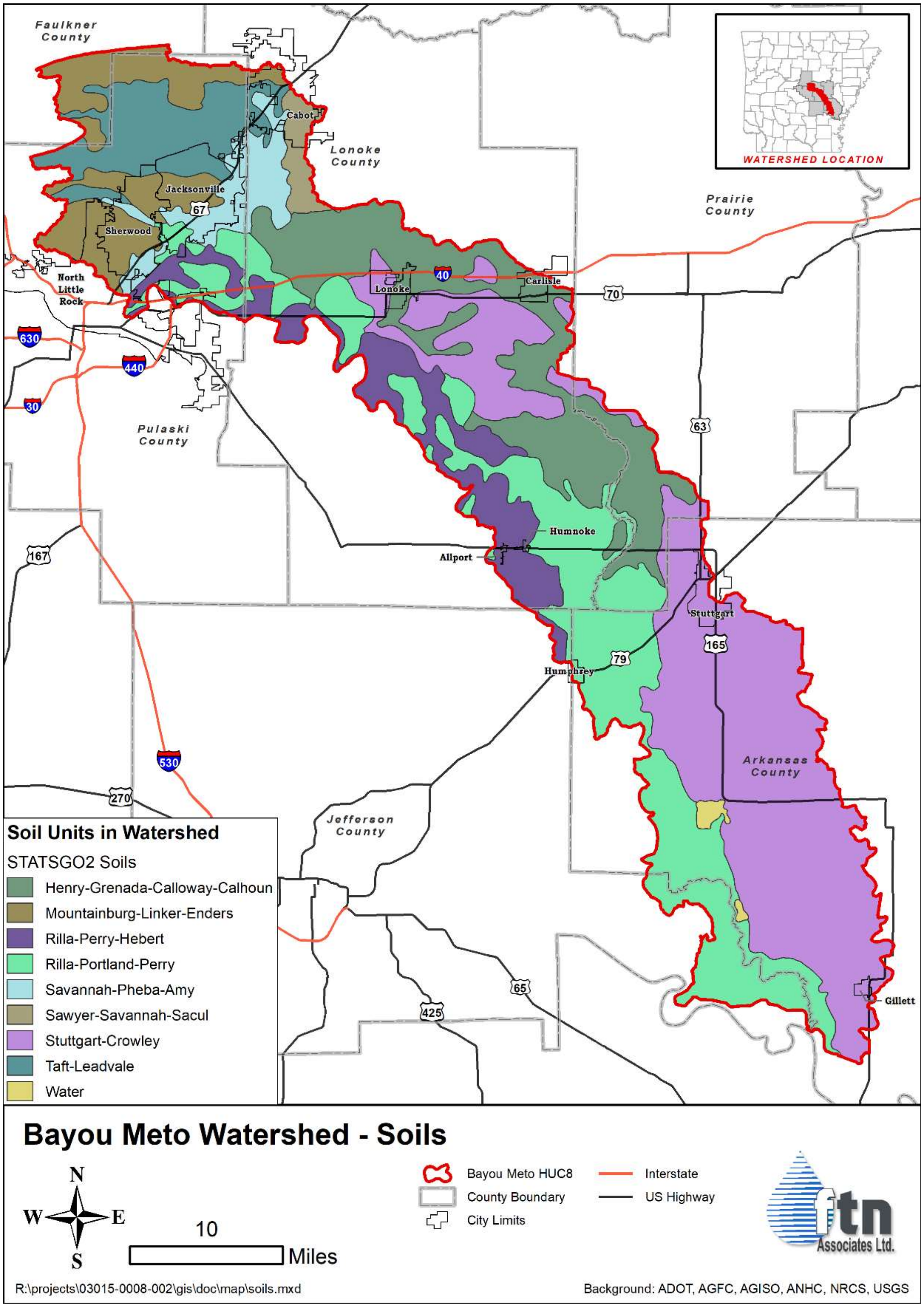


Figure 2.7. Soils map for Bayou Meto watershed.

2.3.5 Land Use/Land Cover

Agriculture is the predominant land use within the Bayou Meto watershed. Cultivated Crops such as rice, corn, cotton, and soybeans cover approximately 52% of the watershed. Croplands are located within the Mississippi Alluvial Plain, alongside wetlands which make up an additional 18% of the total watershed land cover. The remaining land cover/land use is relatively evenly split among forest, development, and pasture lands, all predominately located within the Ouachita Mountain region of the watershed (Figures 2.8 and 2.9). Roughly 2.29 percent of the watershed is covered by impervious structures.

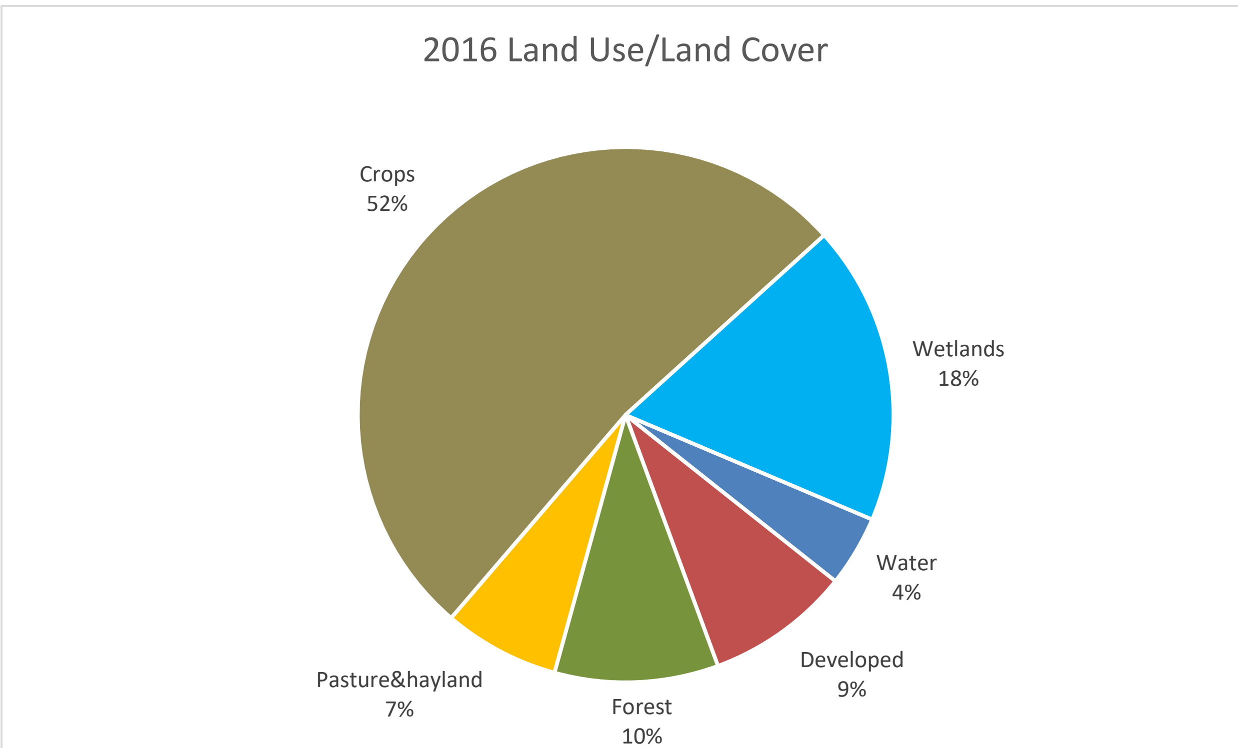


Figure 2.8. Land use/land cover percentages for the Bayou Meto watershed (Wickham, et al. 2021).

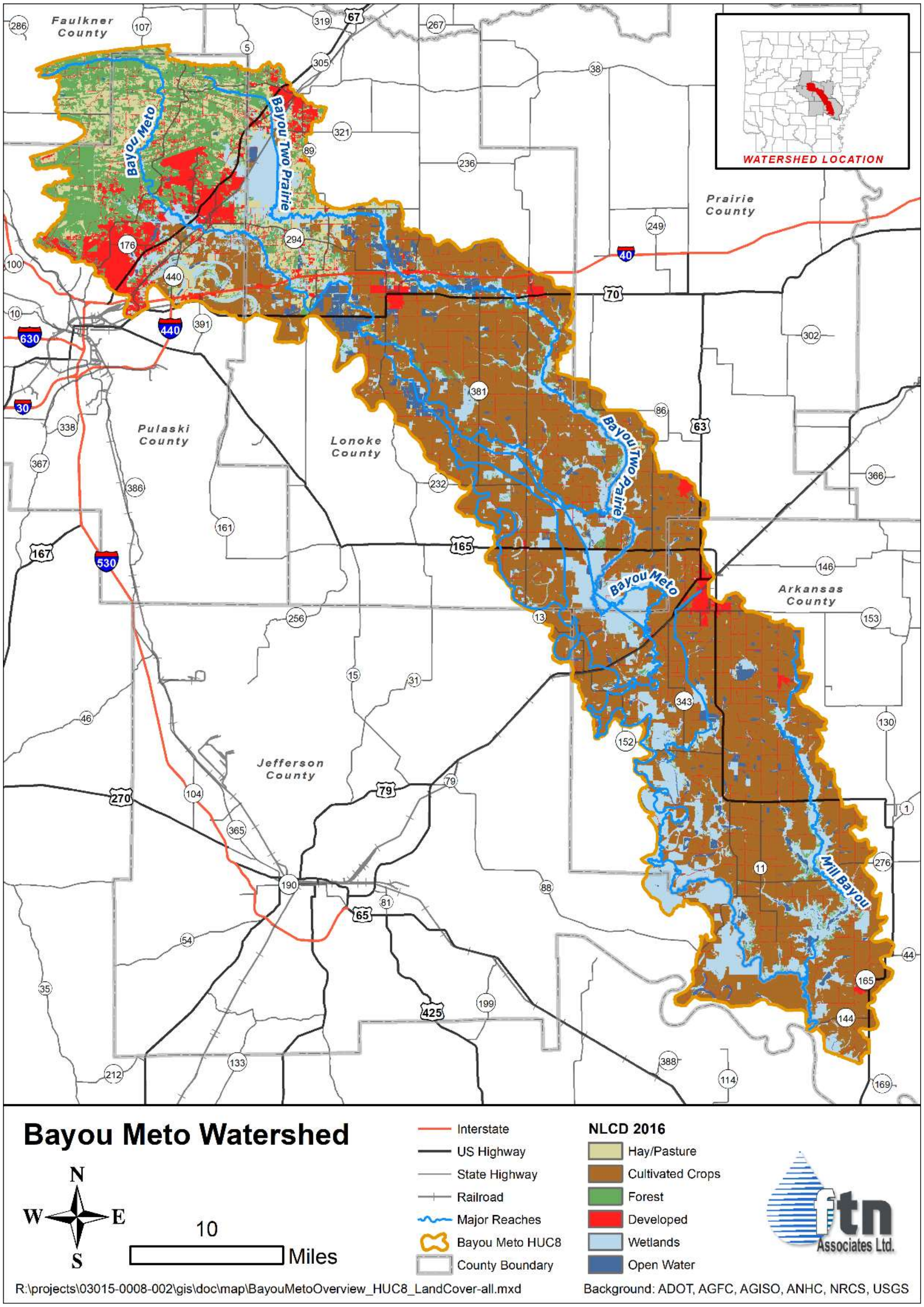


Figure 2.9. Map of 2016 land use in the Bayou Meto watershed (Wickham, et al. 2021).

2.4 Water Resources

Surface water and groundwater resources of the Bayou Meto watershed are described below.

2.4.1 Surface Water

There are over 1,100 miles of streams and over 400 miles of canals and ditches in the Bayou Meto watershed (Center for Advanced Spatial Technologies 2006). Bayou Meto flows for 182 miles from Wilson Hill near Camp Robison into the Arkansas river near Gillett. There is a single active USGS flow gage in the watershed located on Bayou Meto near Lonoke (Figure 2.10). Table 2.13 lists summary statistics for flow measurements from this gage. The largest tributary subbasin in this watershed is Bayou Two Prairie, which accounts for approximately 24% of the watershed. Bayou Two Prairie originates near Cabot Arkansas and flows for 69 miles before entering Bayou Meto near Stuttgart Arkansas. Mill Bayou is the tributary with the next largest subbasin, accounting for 14% of the watershed. Mill Bayou flows for 45 miles from its origins near Stuttgart before connecting with Bayou Meto near its confluence of the Arkansas River (USGS 2020a). Irrigation accounts for the largest use of surface water in the watershed. Surface waters in the Bayou Meto watershed are not used for municipal drinking water.

Table 2.13. Statistics for discharge data from USGS gage active in 2020 (USGS 2021a).

Site Number	Year Established	Drainage Area, (mi²)	Annual Average Discharge, (cfs)	Lowest Mean Monthly Discharge, (cfs)	Highest Mean Monthly Discharge, (cfs)	7Q10 Flow, (cfs)	90% Exceeds Flow, (cfs)	Peak Flow, (cfs)
07264000	1954	207	299.4	56	568	0	27.4	5750

The surface water drainage network in the Mississippi Alluvial Plain portion of the Bayou Meto watershed has been significantly altered with the addition of ditches, levees, and channelizing natural streams. The primary purpose of this work was to improve drainage for row crop production. However, flooding is still a concern of landowners in this part of the watershed (US Army Corps of Engineers Memphis District 2007).

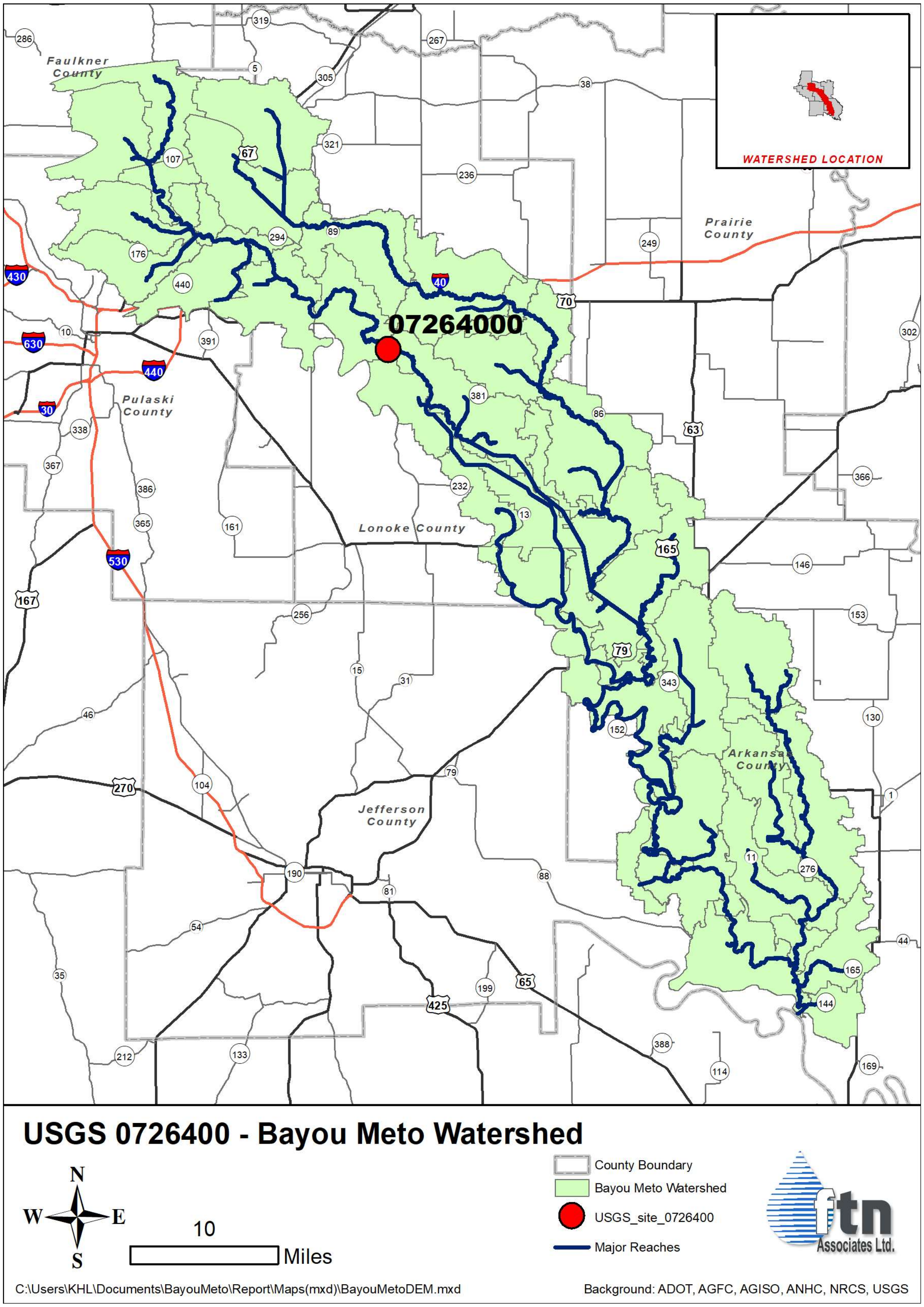


Figure 2.10. Location of active USGS flow gage in Bayou Meto watershed.

2.4.2 Groundwater

There are nine aquifers underlying the Bayou Meto watershed. The Mississippi River Valley Alluvial aquifer, underlain by the Sparta, Cane River, Nacatoch, Wilcox, Cockfield, and Tokio aquifers occur in the Mississippi Alluvial Plain portion of the watershed. The Western Interior Plains Confining System is a series of geologic formations present at the surface in the Ouachita Mountains portion of the watershed that is a locally important water supply source (Kresse, et al. 2014). Table 2.14 shows the geologic formations associated with each of these aquifers, and their relative position with regard to depth. Figure 2.11 shows where these aquifers are unconfined. The two most important aquifers in the Bayou Meto watershed, in terms of water use volume, are the Mississippi River Valley Alluvial aquifer (hereafter referred to as the Alluvial aquifer) and the Sparta aquifer.

Table 2.14. Stratigraphic geology listing with aquifers underlying the Bayou Meto watershed (Kresse, et al. 2014, Broom, Kraemer and Bush 1987, McKee and Hays 2004).

Era	Period	Geologic Unit	Lithology	Aquifer
Quaternary	Pleistocene & Holocene	Alluvial deposits	Unconsolidated sand, gravel, silt, clay	Mississippi River Valley Alluvial aquifer
Tertiary	Eocene	Cockfield formation	Fine to medium grained sand grading upwards to silt, clay, and lignite	Cockfield aquifer
		Cook Mountain formation	Clay, silty clay, fine sand	Middle Claiborne confining unit
		Sparta aquifer	Fine to medium grained sand interspersed with layers of silt, clay, shale, and lignite	Sparta aquifer
		Cane River formation	Clay and shale	Cane River aquifer
		Wilcox group	Unconsolidated sand, shale, and clay	Wilcox aquifer
	Paleocene	Porters Creek clay	Clay	Midway Confining unit

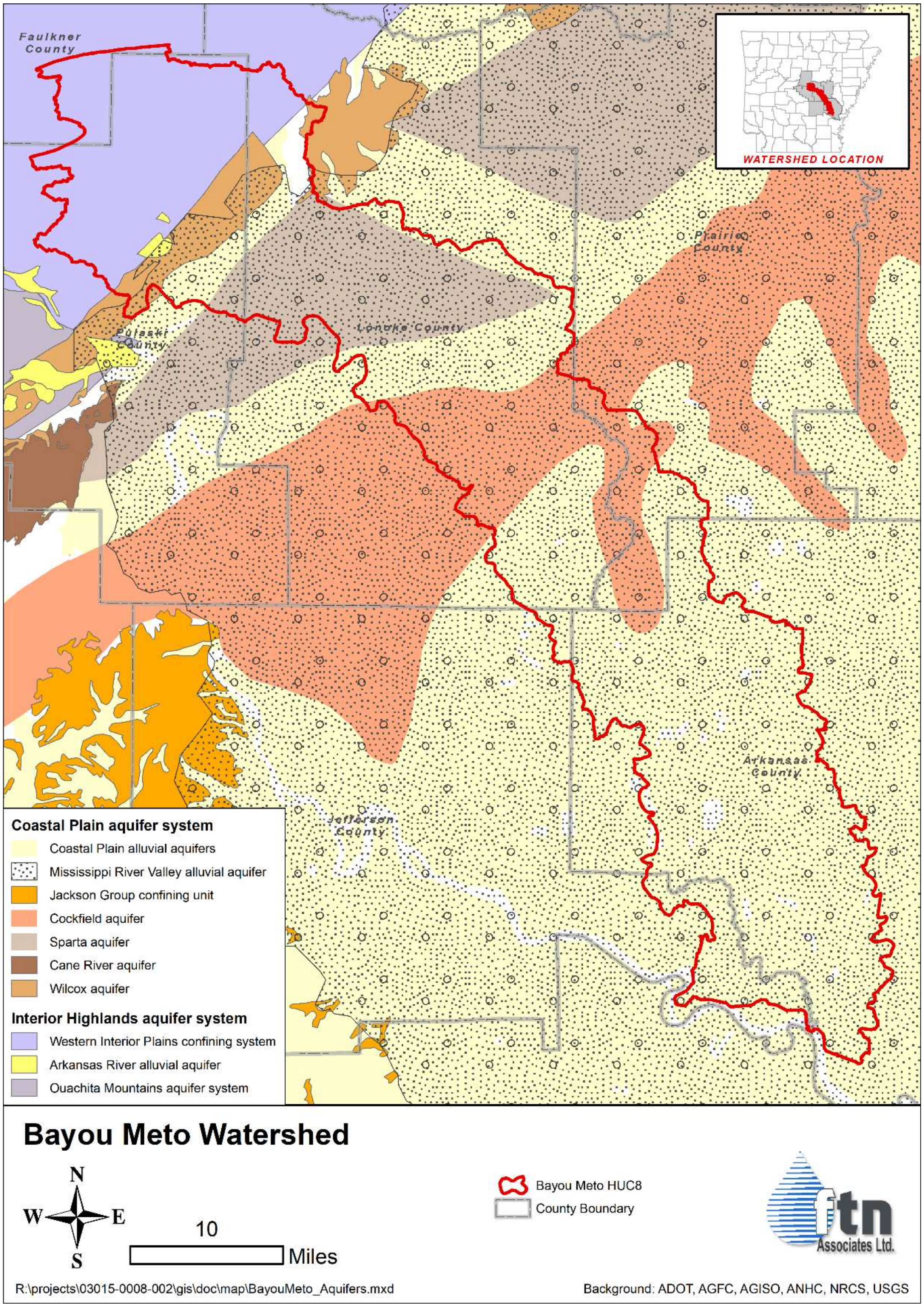


Figure 2.11. Principal aquifers associated with the Bayou Meto watershed.

2.4.2.1 Alluvial Aquifer

The Alluvial aquifer is the most important aquifer in Arkansas in terms of water volume withdrawn and economic importance. This aquifer is the primary irrigation water source for the state, and in the Bayou Meto watershed. The Alluvial aquifer is a primarily unconfined aquifer in unconsolidated coarse sands and gravels of the Mississippi River Alluvial Plain ranging in thickness from 50 to 150 feet. Primary recharge to this aquifer is from precipitation. In some areas, a layer of fine sand, silt, and clay occurs over the coarse sands and gravels and acts as a confining layer, blocking precipitation from the aquifer. Reported yields from this aquifer range from 500 to 5,000 gallons per minute (Kresse, et al. 2014).

The Alluvial aquifer is the main source of irrigation water within the Bayou Meto watershed. Water from this aquifer is also used for drinking water by a few communities. Due to high water usage crops, such as rice, the Grand Prairie region of this aquifer, which includes the Bayou Meto watershed, is listed as a critical groundwater area by NRD (Figure 2.12). In 2012, an estimated 8036.01 million gallons a day (mgd) were pulled from the aquifer. Sustainability estimates suggest 3374.3 mgd is the maximum withdrawal that would maintain the aquifer. Continual withdrawals have lowered water levels in the aquifer within the Bayou Meto watershed by as much as 145 feet beneath the surface. From 2005 to 2015 wells within the Bayou Meto watershed showed water levels drops of up to 7.4 feet. This has resulted in reduction of aquifer storage and decreases in well yields.

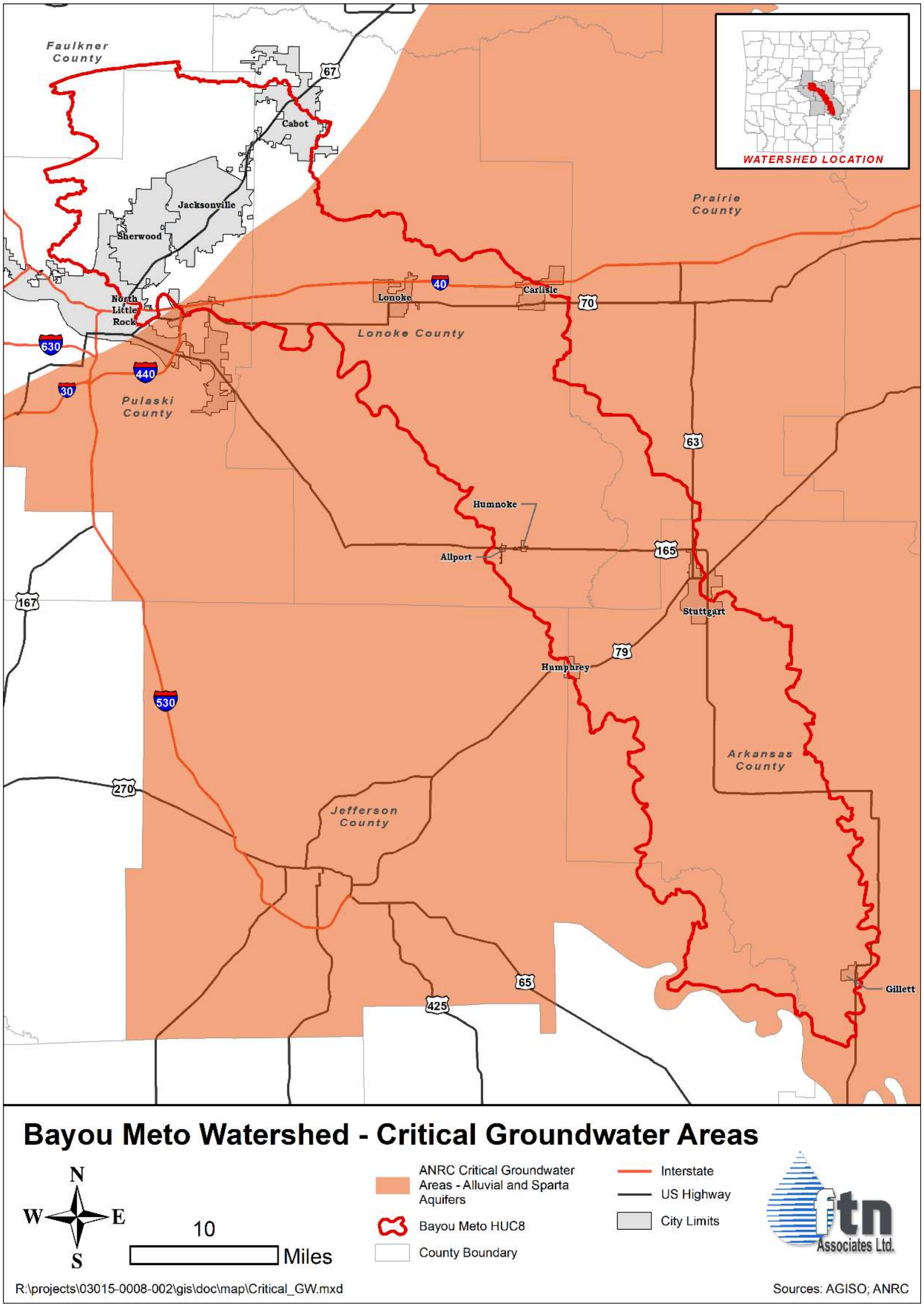


Figure 2.12. Critical Groundwater Areas within the Bayou Meto watershed.

2.4.2.2 Sparta aquifer

Situated below the Alluvial aquifer within the Bayou Meto watershed is the Sparta aquifer. The Sparta aquifer is mostly confined within the watershed, with a small area of outcrop in the upper watershed. It is comprised mainly of sand with silt, clay, shale and lignite and ranges in thickness from 200 to 900 feet. Recharge occurs at the outcrop, and from adjacent aquifers. This aquifer is the primary source of municipal drinking water and industrial water supply in the Bayou Meto watershed. Historically, this aquifer was not used for irrigation, but in recent years that has changed. A significant increase in water use from the Sparta aquifer has been attributed to increased agricultural usage in the Grand Prairie area. Wells within the Bayou Meto watershed have seen decreases in water levels up to 17 feet in the Sparta aquifer between 2010 and 2020 (NRD 2020). Recent estimates suggest 72.45 mgd is the maximum withdrawal required to maintain the aquifer, but estimated daily usage is at 159.45 mgd. The Sparta aquifer under the Bayou Meto watershed has also been designated as a critical groundwater area (Figure 2.12).

2.4.3 Integrated Water Resources Management

As noted in Section 2.4.2, the Bayou Meto watershed includes areas classified as critical groundwater areas for the Alluvial aquifer and the Sparta aquifer. Two irrigation projects are under development that include areas of the Bayou Meto watershed. Both the Grand Prairie Irrigation Project and the Bayou Meto Water Management Project are intended to increase supplies of surface water for irrigation, to decrease the use of groundwater for irrigation in the Grand Prairie critical groundwater area. The Grand Prairie Irrigation Project will transfer water from the White River, while the Bayou Meto Water Management Project will transfer water from the Arkansas River. Figure 2.13 shows the intended service areas for these projects within the Bayou Meto watershed.

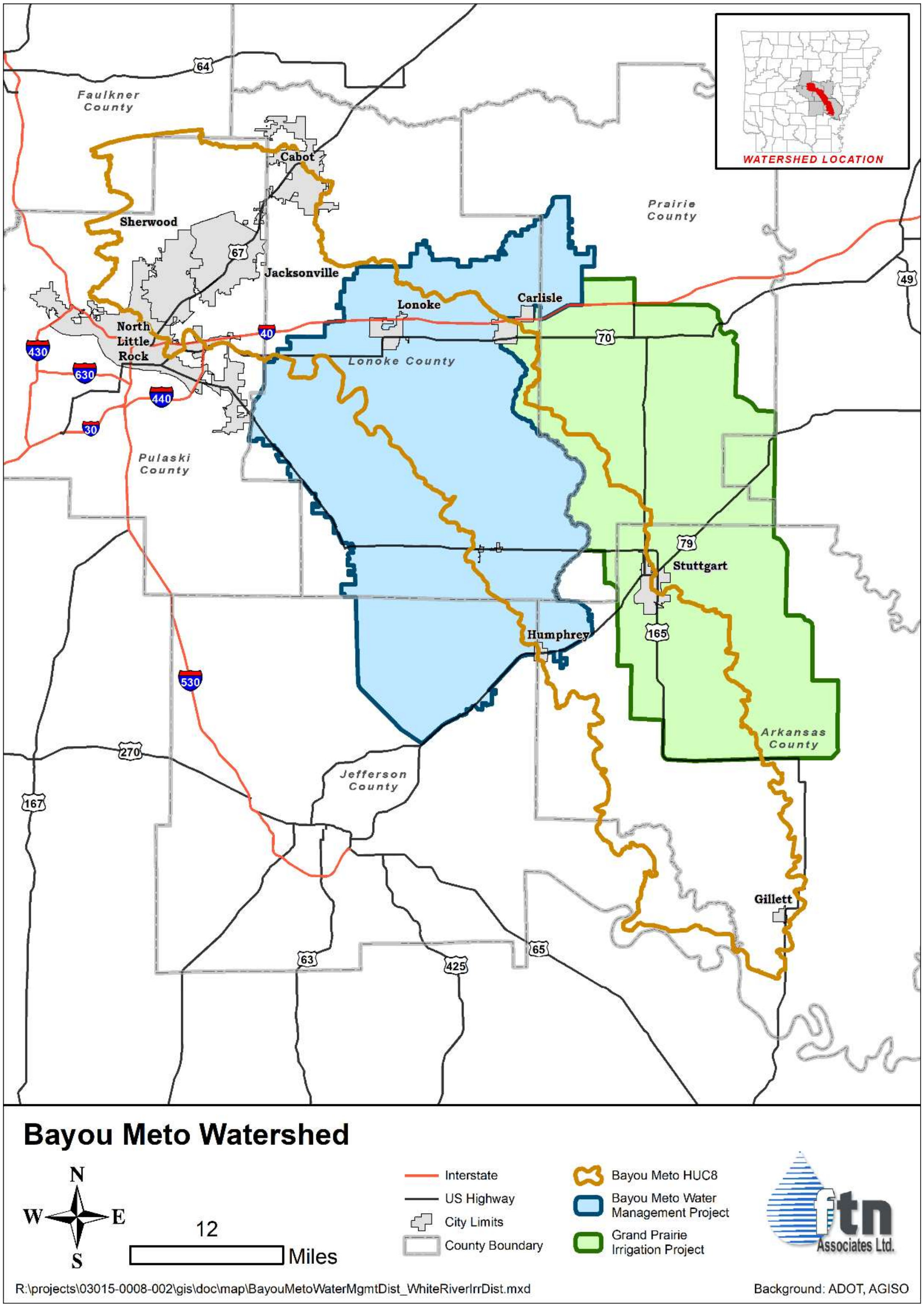


Figure 2.13. Water management and irrigation districts in the Bayou Meto watershed.

2.5 Wildlife Resources

Several species present in the Bayou Meto watershed are found only in Arkansas. A number of native species present in the watershed are listed as threatened or endangered by the state or federal government. There are also a number of native species present that the state has identified as species of greatest conservation need. In addition, there are plants and animals present in the watershed that are not native and that are believed to pose a threat to native species.

2.5.1 Protected Species

There are 18 species that may be found in the Bayou Meto watershed that are listed as threatened or endangered by the state and/ or federal government, with two additional candidate species. Three of the 18 are listed as endangered by the federal government, with four others federally listed as threatened. Of the remaining 11 species, four are listed as endangered by the state of Arkansas with the remaining seven listed as threatened by the state (Table 2.16).

2.5.2 Species of Greatest Conservation Need

There are 377 species of native amphibians, birds, crayfish, fish, insects, invertebrates, mammals, mussels, reptiles, and plants present in Arkansas that are identified as Species of Greatest Conservation Need in the Arkansas Wildlife Action Plan (Fowler and Anderson 2015). Excluding those listed as threatened or endangered by the state and/ or federal government, 61 species of Greatest Conservation Need are found within the Bayou Meto watershed. This includes 38 vascular-plants, 9 insects, 8 birds, 3 isopods, and 2 decapods.

Table 2.16. Protected species that may be present in the Bayou Meto watershed (Arkansas Natural Heritage Commission 2020, USFWS 2021).

Common Name	Scientific name	Category	Federal Status	State Status	Counties
Rattlesnake-master borer moth	Papaipema eryngii	Moth	Candidate	None	Jefferson, Pulaski
Monarch butterfly*	Danaus plexippus	Butterfly	Candidate	None	All
Red-cockaded Woodpecker	Picoides borealis	Bird	Endangered	Endangered	Pulaski
Red knot*	Calidris canutus rufa	Bird	Threatened	None	Lonoke, Prairie
Piping plover*	Charadrius melodus	Bird	Threatened	None	Jefferson, Lonoke, Prairie, Pulaski
Eastern black rail*	Laterallus jamaicensis ssp. jamaicensis	Bird	Threatened	None	Arkansas, Lonoke
Running buffalo clover	Trifolium stoloniferum	Vascular-Plant	Endangered	Historic	Pulaski
Northern long-eared bat	Myotis septentrionalis	Mammal	Threatened	Endangered	Arkansas
Opaque prairie sedge	Carex opaca	Vascular-Plant	None	Endangered	Arkansas, Lonoke, Prairie
Small-head pipewort	Eriocaulon koernickianum	Vascular-Plant	None	Endangered	Pulaski
White-top sedge	Rhynchospora colorata	Vascular-Plant	None	Endangered	Pulaski
White-top sedge	Sabatia campanulata	Vascular-Plant	None	Endangered	Lonoke, Prairie, Pulaski
Prairie evening-primrose	Oenothera pilosella ssp. Sessilis	Vascular-Plant	None	Threatened	Arkansas, Lonoke, Prairie
Pondberry*	Lindera melissifolia	Vascular-Plant	Endangered	None	Prairie
Rein orchid	Platanthera flava	Vascular-Plant	None	Threatened	Arkansas, Pulaski
Purple fringeless orchid	Platanthera peramoena	Vascular-Plant	None	Threatened	Pulaski
Rose pogonia	Pogonia ophioglossoides	Vascular-Plant	None	Threatened	Jefferson
Sand cherry	Prunus pumila var. susquehanae	Vascular-Plant	None	Threatened	Prairie
Pineywoods dropseed	Sporobolus junceus	Vascular-Plant	None	Threatened	Jefferson
Arkansas meadow-rue	Thalictrum arkansanum	Vascular-Plant	None	Threatened	Arkansas, Pulaski

* (USFWS 2021)

2.5.3 Nuisance Species

There are number of non-native species of plants and animals present in the Bayou Meto watershed, in part due to heavy development and land alterations. Three species of non-native fish have been classified as posing a threat to native communities; Common Carp (Cyprinus carpio), Silver Carp (Hypophthalmichthys molitrix) and Bighead Carp (Hypophthalmichthys nobilis) (Heckathorn 1993). These are introduced species from the Eurasian land mass. Common carp eat native vegetation and increase water turbidity by rooting for benthic creatures and aquatic plants. The silver and bighead carp are both classified as Asian Carp. They are planktivors, feeding on microscopic plants and animals within streams and rivers They compete with native filter feeding fishes such as shad (Clupeformes)and paddlefish (Polyodon spathula).

Introduction of non-native ornamental plants near urban areas has led to a spread of invasive plants such as mimosa (*Albiza julibrissin*), Bamboo (*Phyllostachys nigra)*, Wisteria (*Wisteria sp.*), Chinese privet (*Lingustrum sp*.), Japanese honey suckle (*Lonicera japonica*), and Bradford pear throughout the upland areas of the Bayou Meto watershed. These plants provide little benefit to native animal species and often form dense thickets that crowd out native plants (UofA Cooperative Extension 2020a).

Feral hogs are a nuisance species throughout Arkansas, including the Bayou Meto watershed. They compete directly with many native species for food. The rooting and wallowing of feral hogs damage pasture and cropland; destroy sensitive natural areas and habitats; and increase erosion that affects water quality (Arkansas Agriculture Department 2020b).

2.5.4 Sensitive Areas

There is no federally designated critical habitat for threatened or endangered species within the Bayou Meto watershed. There are, however, a number of state designated Natural Areas and WMAs within the watershed (Table 2.17).

Table 2.17. State designated Natural Areas and WMAs within Bayou Meto watershed (AGFC 2021a, Arkansas Natural Heritage Commission [ANHC] 2021).

Name	County	Area	Focus habitat	Owned By
George H. Dunklin Jr. Bayou Meto WMA	Arkansas & Jefferson	33,832 acres (only a small portion of which is within the Bayou Meto watershed)	Stream, lake, bottomland hardwood, wetland	AGFC
Roth Prairie Natural Area WMA	Arkansas	2,483 acres	Grand Prairie	ANHC
Prairie Bayou WMA	Lonoke	453 acres	Grand Prairie	AGFC
Holland Bottoms WMA	Lonoke & Pulaski	6,190 acres	Terrestrial and aquatic	ANHC & AGFC
Holland Bottoms Willow Oak Forest Preserve	Lonoke	632 acres	Bottomland hardwood	ANHC
Railroad Prairie Natural Area WMA	Lonoke & Prairie	251 acres (only a portion of which is within the Bayou Meto watershed)	Prairie and wetland	ANHC
Smoke Hole Natural Area WMA	Lonoke & Prairie	455 acres	Wetland, bottomland hardwoods	ANHC
Konecny Prairie Natural Area	Prairie	71 acres	Grand Prairie	ANHC
Konecny Grove Natural Area	Prairie	22 acres	Prairie slash woodland	ANHC

The AGFC has identified several terrestrial habitats present in the Bayou Meto watershed as important for significant numbers of species of greatest conservation need. Terrestrial habitats present in the Bayou Meto watershed within the top 10 of priority scores (sum of priority scores for species of greatest conservation need) include prairies, forests, and riparian areas in the Ouachita Mountains ecoregion, and the Grand Prairie in the Mississippi River Alluvial Plain ecoregion. Bayou Meto is part of the Mississippi River Valley Alluvial Plain-Arkansas River ecobasin designated by AGFC. This ecobasin does not have a conservation priority score in the top 10 (Fowler and Anderson 2015).

DEQ has designated the section of Bayou Two Prairie between the Prairie Bayou WMA and the Smoke Hole Natural Area as Extraordinary Resource Waters (APCEC 2020).

3.0 WATERSHED ASSESSMENT

This section characterizes the condition of water-related natural resources in the Bayou Meto watershed, and identifies nonpoint sources of pollution present.

3.1 Surface Water Quality

This subsection describes surface water quality in the Bayou Meto watershed in terms of measured concentrations of selected parameters. This includes a summary of the water quality standards that apply in the watershed and the water quality monitoring programs active in the watershed. Recent surface water quality data are summarized and discussed, trends in long-term water quality data are evaluated, and loads of selected pollutants are discussed.

3.1.1 Surface Water Quality Standards

Arkansas state water quality standards consist of designated uses for waterbodies, numeric standards for selected water pollutants or water quality indicators, narrative criteria for pollutants or indicators without numeric standards, and an antidegradation statement. State water quality standards that apply to surface waters in the Bayou Meto watershed are described below.

3.1.1.1 Designated Uses

Designated uses of streams throughout the watershed are primary contact recreation (watersheds >10 square miles); secondary contact recreation; seasonal aquatic life (watersheds < 10 square miles), and perennial aquatic life (watersheds ≥ 10 square miles and streamflow ≥ 1 cubic feet per second). Additionally, all streams have a designated use of domestic, industrial and agricultural water supply except for Rocky Branch Creek (about 4 miles long; located in Jacksonville) and Bayou Meto from Rocky Branch Creek to Bayou Two Prairie (about 55 miles long). All lakes and reservoirs list aquatic life as a designated use. There are no water bodies in this watershed that are designated “Natural and Scenic Waterways” or “Ecologically Sensitive Waterbodies.” The section of Bayou Two Prairie between the Prairie Bayou WMA and the Smoke Hole Natural Area is designated as “Extraordinary Resource Waters” (Arkansas Pollution Control and Ecology Commission [APCEC] 2020).

3.1.1.2 Numeric and Narrative Criteria

Numeric water quality criteria for selected parameters that apply in the Bayou Meto watershed are listed in Table 3.1. Separate turbidity criteria are specified for baseflow conditions. The baseflow criteria should not be exceeded in more than 20% of samples collected June to October. The "all flow" turbidity criteria should not be exceeded in more than 25% of all samples collected over an entire year (APCEC 2020). Numeric water quality criteria for toxic substances and metals can be found in Regulation 2 of the APCEC (APCEC 2020). In addition to numeric water quality criteria, state narrative criteria have been developed for nuisance species; biological integrity; color; taste and odor; solids, floating material, and deposits; toxic substances; oil and grease; and nutrients (no objectionable algal densities or other nuisance aquatic vegetation).

Table 3.1. Numeric water quality criteria for surface waters in the Bayou Meto watershed (APCEC 2020).

Parameter	Season	Applicable Locations	Applicable Conditions	Criteria
Temperature	All	Delta Ecoregion	Least-Altered Streams	30°C (86°F)
			Channel-Altered Streams	32°C (89.6°F)
		Arkansas River Valley Ecoregion	All Streams	31°C (87.8°F)
		Lakes and Reservoirs	1-meter depth	32°C (89.6°F)
Turbidity	Base Flow [a]	Delta Ecoregion	Least-Altered Streams	45 NTU
			Channel-Altered Streams	75 NTU
		Arkansas River Valley Ecoregion	All Streams	21 NTU
		Lakes and Reservoirs	1-meter depth	25 NTU
	All Flows [b]	Delta Ecoregion	Least-Altered Streams	84 NTU
			Channel-Altered Streams	250 NTU
		Arkansas River Valley Ecoregion	All Streams	40 NTU
		Lakes and Reservoirs	1-meter depth	45 NTU
pH	All	All Streams Lakes and Reservoirs	All Streams 1-meter depth	6 - 9 SU

Table 3.1. Numeric water quality criteria for surface waters in the Bayou Meto watershed (continued).

Parameter	Season	Applicable Locations	Applicable Conditions	Criteria
Dissolved Oxygen (DO)	Primary Season [c]	All Streams	All Streams	5 mg/L
	Critical Season [d]	Streams in Delta Ecoregion	<10 square mile watershed	2 mg/L
			10 square miles to 100 square miles	3 mg/L
			>100 square mile watershed	5 mg/L
		Streams in Arkansas River Valley Ecoregion	<10 square mile watershed	2 mg/L
			10 square miles to 150 square miles	3 mg/L
			151 square miles to 400 square miles	4 mg/L
		Lakes and Reservoirs	1-meter depth	5 mg/L
Total Dissolved Solids (TDS)	All	All waterbodies with designated use of domestic water supply	All	500 mg/L [e]
Chloride	All	Bayou Meto (Rocky Branch to Bayou Two Prairie), Rocky Branch Creek	All	64 mg/L
		Bayou Meto (mouth to Bayou Two Prairie), and all tributaries to Bayou Meto along this reach, including Bayou Two Prairie from mouth to Lonoke/Pulaski County line (excluding the Smoke Hole Natural Area)	All	95 mg/L
		All other waterbodies with designated use of domestic water supply	All	250 mg/L [e]
Sulfate	All	Bayou Meto (mouth to Bayou Two Prairie), and all tributaries to Bayou Meto along this reach, including Bayou Two Prairie from mouth to Lonoke/Pulaski County line (excluding the Smoke Hole Natural Area)	All	45 mg/L
		All other waterbodies with designated use of domestic water supply	All	250 mg/L [e]

[a] Baseflow = June - October
[b] All Flows = Entire Year
[c] Primary Season = when water temperature is 22°C or less
[d] Critical Season = when water temperature is > 22°C
[e] 250, 250, 500 are domestic water supply criteria for chloride, sulfate, and TDS in Section 2.511(C) of Regulation No. 2

3.1.1.3 Antidegradation Policy

The antidegradation policy of the Arkansas water quality standards is summarized below:

- Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected;
- Water quality that exceeds standards shall be maintained and protected unless allowing lower water quality is necessary to accommodate important economic or social development, although water quality must still be adequate to fully protect existing uses; and
- For outstanding state or national resource waters, those uses and water quality for which the outstanding waterbody was designated shall be protected.
- For potential water quality impairments associated with a thermal discharge, the antidegradation policy and implementing method shall be consistent with Section 316 of the Clean Water Act (APCEC 2020).

3.1.2 Water Quality Monitoring

DEQ and USGS have collected surface water quality data at 37 locations in the Bayou Meto watershed, beginning in the 1970s. An inventory of historical surface water quality monitoring locations is included in Appendix C. Data collected during 2015-2019 reflect current water quality conditions in the watershed. During 2015-2019, DEQ and USGS conducted water quality sampling at six stream and three reservoir water quality monitoring locations. Information about these monitoring locations is provided in Table 3.2, and their locations are shown on Figure 3.1. Table 3.3 summarizes the water quality parameters that were monitored by DEQ and USGS during 2015-2019. Surface water quality monitoring programs active in the Bayou Meto watershed are described below.

Table 3.2 Surface water quality monitoring stations in the Bayou Meto watershed active during the period 2015-2019 (DEQ 2020a, USGS 2020b, EPA 2019).

Entity	Program	Station ID	Stream	DEQ reach ID	County	Ecoregion[b]	Drainage Area, square miles[c]	Location	Start Year	End Year	Number of sampling dates
DEQ	Special study	ARK0211	Bayou Meto	907	Pulaski	ARV	23	CR70, 1.5 mi. N. of Macon	2017	2018	25
DEQ	Special study	ARK0210	Bridge Cr.	807	Pulaski	ARV	18.9	CR71, 3.5 mi N. of Gibson	2017	2018	28
USGS	Scientific Investigation	07263922	Lil Base Lake	-	Pulaski	-	-	Near Jacksonville	2003	2015	16
USGS	Scientific Investigation	07263924	Big Base Lake West	-	Pulaski	-	-	Near Jacksonville	2003	2015	17
DEQ	Ambient	ARK0060[a]	Bayou Meto	907	Pulaski	ARV	68.2	at West Main Street Bridge in Jacksonville	1983	2020	419
DEQ	Ambient	ARK0050[a]	Bayou Meto	007	Pulaski	DELTA	126	at Hwy. 161 near Jacksonville	1983	2020	435
DEQ	Significant Publicly Owned Lakes	LARK025A	Pickthorne Lake	4010	Lonoke	DELTA	13.2	Along easternmost levee	1994	2020	5 (through 9/20)
DEQ	Ambient	ARK0097[a]	Bayou Two Prairie	206	Lonoke	DELTA	152	at Hwy. 13 south of Carlisle	1993	2020	331
DEQ	Ambient	ARK0023[a]	Bayou Meto	003	Jefferson	DELTA	786	on SR11 1.5 miles S of Bayou Meto	1974	2020	516

[a] Historically, water quality data were collected at this location under different station IDs, and by USGS, as identified in Appendix B. During the period 2015-2019 data were collected by DEQ under this station ID.
[b] DEQ assigned ecoregion, ARV = Arkansas River Valley, DELTA = Mississippi Alluvial Plain
[c] Stream drainage areas determined using StreamStats (USGS 2020a), Pickthorne Lake drainage area from DEQ (2018a)

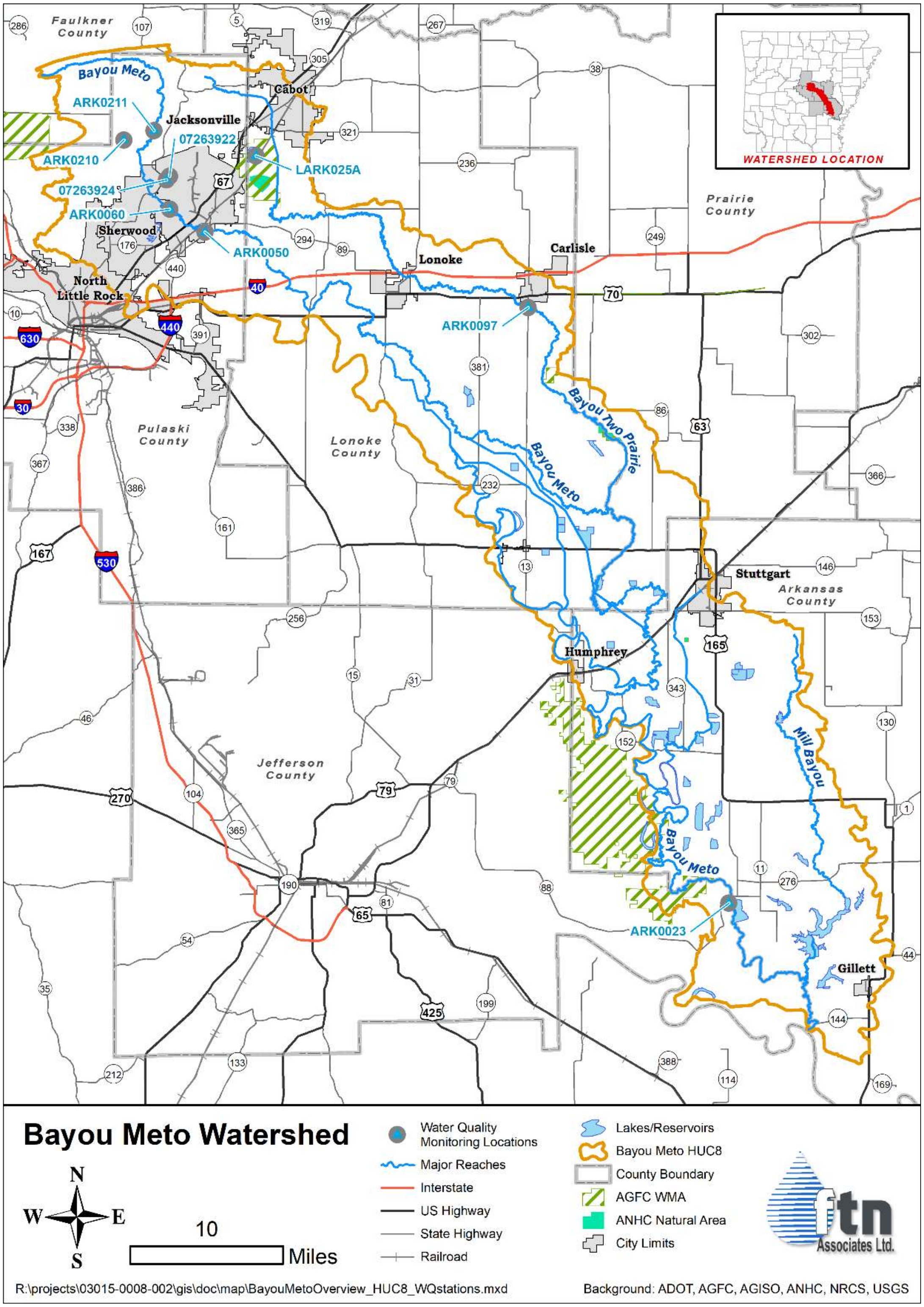


Figure 3.1 Surface water quality monitoring locations active during 2015-2019.

DEQ monitors surface water quality in the Bayou Meto watershed through several programs. There are four DEQ ambient water quality monitoring network sites in the watershed that are sampled monthly. There are also two roving stream water quality monitoring network sites in the watershed. Roving sites throughout the state 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, usually every 6 years (DEQ 2016). The Bayou Meto roving stations were last sampled in 2010. DEQ roving surface water quality sampling is currently on hold while the agency conducts ecoregion studies (J. Martin, DEQ, personal communication 11/24/2021). DEQ has classified Pickthorne Lake, in Lonoke County, as a Significant Publicly-Owned Lake. DEQ occasionally collects water quality data from these lakes. DEQ last collected water quality data from Pickthorne Lake in 2020. Prior to this, the lake was last sampled in 2004. In addition, there are stream and lake sites in the watershed where DEQ has collected, or is collecting, water quality data as part of special studies (DEQ 2018, 2020a).

Since the 1980s, the USGS has collected sediment and water quality data at two lakes on the Little Rock Air Force Base (Justus, Hays and Hart 2015; Justus 2005). The most recent set of water quality data was collected in 2015 (USGS 2020b).

There have been active Stream Teams in the Bayou Meto watershed. Cabot Middle School and High School, and Central Arkansas Master Naturalists Stream Teams have collected water quality data in the upper Bayou Meto watershed within the last five years. These data included measurements of DO, temperature, turbidity, pH, and nutrients (AGFC 2021d).

Monitoring of nutrients, sediment, and water use is being conducted on a farm in the Bayou Meto watershed near Stuttgart through the Arkansas Discovery Farm Program (UofA Cooperative Extension Service 2021).

Table 3.3. Water quality parameters and sampling frequency for monitoring programs active in the Bayou Meto watershed 2015-2019.

Parameter	DEQ Ambient	DEQ Special Study	DEQ Lakes	USGS Investigation
Metals	3-6/yr	M or B	X	
DO	M	M or B	X	X
Turbidity	M	M or B	X	O
Nutrients	M	M or B	X	X
TSS	M	M or B	X	-
Pathogens	H	M or B	-	-
Alkalinity	M	M or B	X	-
TDS	M	M or B	X	-
Other minerals	M	M or B	X	-
Temperature	M	M or B	X	X
Specific conductance	M	M or B	X	X
pH	M	M or B	X	X
Hardness	3-6/yr	M or B	X	-
Total organic carbon	M	M or B	X	-
Organics	-	-	-	O
Biochemical oxygen demand	H	-	H	-

M=monthly; B=twice a month; H=historically, but not in the last five years; X=varies; O=occasionally

3.1.3 Summary of Current Water Quality

Water quality data from 2015-2019 were evaluated to characterize current water quality in the Bayou Meto watershed. During this period, water quality data were collected by DEQ and USGS. Parameters evaluated were DO, biochemical oxygen demand (BOD), TDS, orthophosphate, total phosphorus, inorganic nitrogen, total Kjeldahl nitrogen (TKN), turbidity, and total suspended solids (TSS). Below is a summary of findings from this evaluation. A detailed analysis and discussion of these water quality data is included as Appendix D. Both point sources and nonpoint sources of pollution appear to be affecting water quality in the Bayou Meto watershed.

- Low DO is a widespread condition in the Bayou Meto watershed. However, it is not clear to what extent this is due to natural conditions, or human activity.
- The lowest median DO concentration (3.6 mg/L) occurs at the farthest downstream station (ARK0023). The median DO concentration at this station is statistically significantly lower than median values for the rest of the stations, in general, and during both primary and critical seasons.

- BOD measurements are available from only one station (ARK0050). BOD concentrations at this station ranged from 0.79 mg/L to 3.52 mg/L during 2015-2019, with a median value of 1.83 mg/L.
- TDS concentrations appear to increase in the downstream direction in Bayou Meto. The highest median TDS concentrations occur in Bayou Two Prairie (ARK0097) and in Bayou Meto at ARK0023 (the farthest downstream station).
- The highest median concentrations of total phosphorus and orthophosphate occur in Bayou Two Prairie (ARK0097) and in Bayou Meto at State Road 161 (ARK0050), which is downstream of a municipal point source discharge.
- The highest median inorganic nitrogen concentration (0.856 mg/L) is from the Bayou Meto station at State Road 161 (ARK0050), which is downstream of a municipal point source discharge.
- The highest median TKN concentration (0.839 mg/L) is from the Bayou Two Prairie station (ARK0097).
- The highest median all-flow turbidity levels occur at the Bayou Two Prairie station (ARK0097) and the farthest downstream station in Bayou Meto (ARK0023). The median turbidity levels at these two stations (40 – 43.2 NTU) are statistically significantly higher than the rest of the stations (17 – 27.2 NTU).
- The highest median baseflow turbidity values occur at the Bayou Two Prairie station (ARK0097) and the Bayou Meto station at State Road 161 (ARK0050).
- Median TSS concentrations are lowest in the upper part of the Bayou Meto watershed, while the highest median value occurs at the Bayou Two Prairie station (ARK0097).
- TSS and turbidity appear to be related in the Bayou Meto watershed.
- TSS and turbidity also appear to be related to total phosphorus concentration.
- Water quality at two stations on upper Bayou Meto that are only 4 miles apart (ARK0060 and ARK0050) is statistically different for most of the parameters evaluated. Turbidity, nitrogen, phosphorus, and TDS are higher at the downstream station (ARK0050) and DO is lower. There are several factors that could account for this difference in water quality in such a short distance, including the influence of tributaries joining Bayou Meto between the two stations, point sources discharging to Bayou Meto between the two stations, and the fact that the two stations are located within different ecoregions.

3.1.4 Assessed Water Quality Impairments

At the time of this writing, the most recent list of impaired waters (i.e., 303(d) list) for Arkansas that has been approved by the EPA is the 2018 list. Impaired waters in the Bayou Meto watershed from the final 2018 list are given in Table 3.4 and mapped on Figure 3.2. On the 2018 final 303(d) list, almost 198 miles of streams and almost 890 acres of reservoirs in the watershed are classified as impaired. Two additional impairments are included on the draft 2020 303(d) list; for reach 007 a turbidity impairment (not meeting the baseflow turbidity criterion), and for reach 907 a pH impairment (DEQ 2020b).

There is an active fish consumption advisory that applies to the portion of Bayou Meto reach 007 upstream of Highway 13 (Arkansas Department of Health 2017). Note that the industrial point source of dioxin that is the cause of the fish consumption advisory in reach 007 of Bayou Meto has been eliminated, and the contamination is being addressed through natural attenuation (DEQ 2016).

Table 3.4. Impaired waterbodies in the Bayou Meto watershed identified in the 2018 final 303(d) list (Category 5) (DEQ 2020).

Waterbody Name	Reach numbers	Extent	Monitoring stations [1]	Use not supported	Pollutants	Source(s)
Bayou Meto	001	5.8 miles	e - ARK0023	Aquatic Life	Low DO	Unknown
	003	41.4 miles	ARK0023			
	907	25.8 miles	ARK0060			
Bayou Two Prairie	006	5.2 miles	e - ARK0097	Aquatic Life	Low DO	Unknown
	106	1.9 miles	e - ARK0097			
	206	11.1 miles	ARK0097			
	306	43.3 miles	ARK0021			
	806	6.7 miles	e - ARK0097			
Bayou Meto	007	56.5 miles	ARK0050	Fish Consumption [2]	Priority organics, TDS	Industrial point source, unknown
Pickthorne Lake	4010	325 acres	AGFC	Aquatic Life	Unknown	Unknown
Rodgers Reservoir	4020	562 acres	LARK027A	Aquatic Life	Low DO	Unknown

1. “e” indicates that DEQ evaluated that stream reach based on a station not located within the reach.
2. Fish consumption is not a designated use in Reg. 2, but EPA requires it to be considered for 303(d) lists.

Figure 3.2. 2018 Impaired waterbodies in the Bayou Meto watershed.

3.1.5 Water Quality Trends

While it is important to look at current water quality conditions in the watershed, it is also important to determine if water quality is changing over time. Of particular interest for nonpoint source management are locations where water quality still meets water quality standards, but pollutant concentrations are increasing over time, suggesting that water quality standards may not be met in the future if no action is taken. Pollutant concentrations that are decreasing over time suggest that water quality is improving and that upstream pollutant management practices are providing benefits.

Adequate data for trend analysis were available for four water quality stations in the Bayou Meto watershed (ARK0023, ARK0050, ARK0060, ARK0097). The analyses of these data are described in detail in Appendix E. In the majority of the data sets evaluated, no trend was apparent. The results where trends were indicated are summarized below.

- An increasing trend in turbidity at the Bayou Two Prairie station (ARK0097) suggests there is the potential for exceedance of turbidity criteria in the future.
- Increasing trends in BOD, inorganic nitrogen, and DO saturation at the Bayou Meto station at State Road 161 (ARK0050), suggests declining water quality at this station.
- TKN concentrations exhibited a declining trend at all stations.
- Decreasing trends in DO concentration and DO saturation at the farthest downstream station (ARK0023) suggest declining water quality at this station.
- Decreasing trends in TDS, TSS, TKN, and total phosphorus, along with an increasing trend in DO saturation, at the Bayou Meto station at West Main (ARK0060) suggest improving water quality at this location.
- Both point sources and nonpoint sources of pollution appear to be affecting water quality over the long term in the watershed.

3.1.6 Pollutant Loads

Pollutant loads are the product of concentration and stream flow. As a result, streams with low concentrations can contribute large loads if they have very large flow. Vice versa, a stream with a high concentration but a low flow, may have a relatively small load. Yield is the load for a stream divided by the drainage area of the stream. Flow measurements and water quality data are not collected at the same locations in the Bayou Meto watershed. As a result, it is not a simple matter to calculate or estimate pollutant loads from this watershed using measured data. The loads discussed in this section have been estimated using water quality models. The parameters for which loads are discussed are sediment, total phosphorus, and total nitrogen.

3.1.6.1 USGS SPARROW Model

The USGS recently updated its application of the SPARROW (SPAtially Referenced Regression On Watershed attributes) model to the US. The model now simulates hydrology for 2000-2014, with a "base year" of 2012 for the simulated water quality. Estimated 2012 yields from the Bayou Meto watershed from the updated Midwest SPARROW model are listed in Table 3.5. The simulated yields of phosphorus and sediment for Bayou Meto are in the upper quintile (80th to 100th percentile) for the Midwest model (Robertson and Saad 2019).

Table 3.5. Estimated yields from the Bayou Meto watershed for 2012 using SPARROW model (USGS 2019).

Parameter	Estimated 2012 Bayou Meto yield	Bayou Meto ranking among watersheds in model
Total nitrogen	790 kilograms/square kilometer	Second highest quintile (580-1,070 kilograms/square kilometer)
Total phosphorus	345 kilograms/square kilometer	Highest quintile (>138 kilograms/square kilometer)
Suspended sediment	338 metric tonnes (MT)/square kilometer	Highest quintile (>200 MT/square kilometer)
Streamflow	385 millimeters/year	Second highest quintile (358-471 millimeters/year)

The Midwest SPARROW model covers the entire Mississippi/Atchafalaya River basin (including the Missouri River basin, Ohio River basin, Tennessee River basin, etc.) but provides estimated loads for each HUC8 watershed based on contributions from a variety of sources (Robertson and Saad 2019). Figures 3.3-3.5 illustrate the estimated relative load contributions from sources in the Bayou Meto watershed. The SPARROW model identifies farm fertilizer as the greatest contributor to total phosphorus and total nitrogen loads, and agriculture on fine/silt soils as having the highest sediment yield. This model also identifies atmospheric deposition as contributing significantly to total nitrogen load. This suggests that it would be difficult to achieve a 60% reduction in nitrogen load from this watershed using local land management practices.

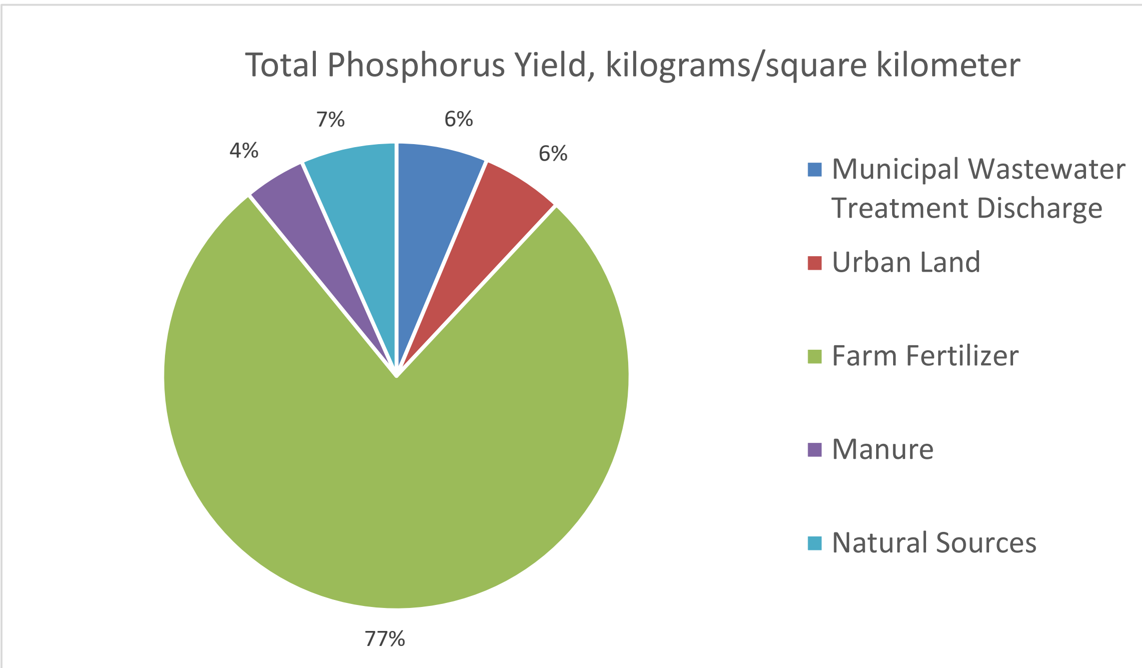


Figure 3.3. SPARROW 2012 total phosphorus yield from sources in Bayou Meto watershed (USGS 2019).

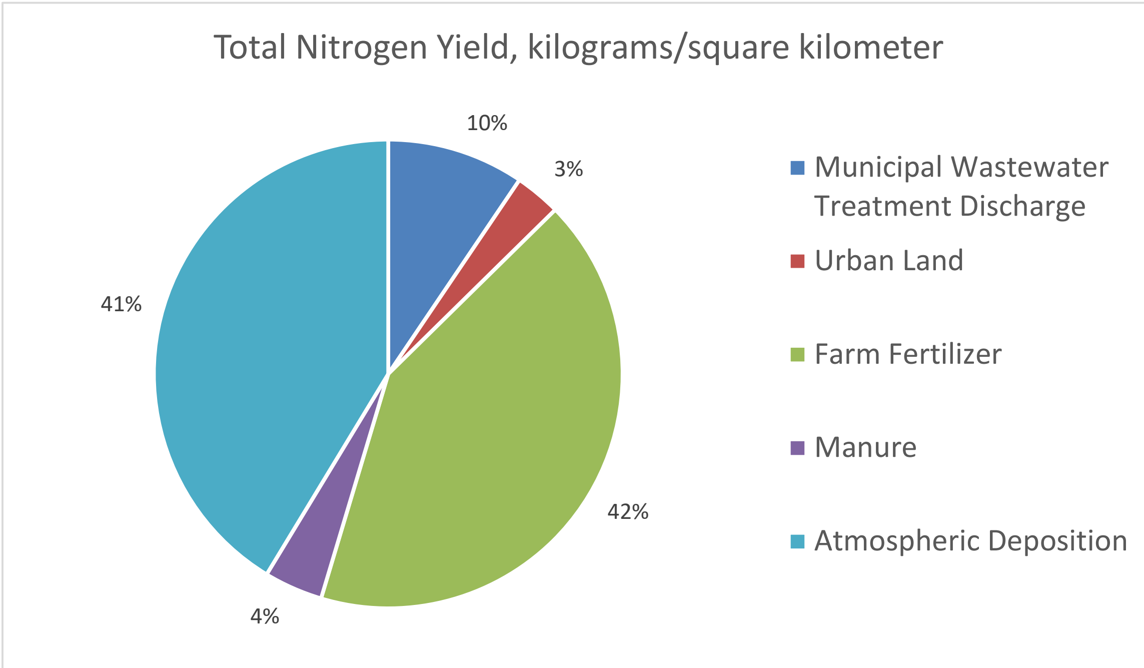


Figure 3.4. SPARROW 2012 total nitrogen yield from sources in Bayou Meto watershed (USGS 2019).

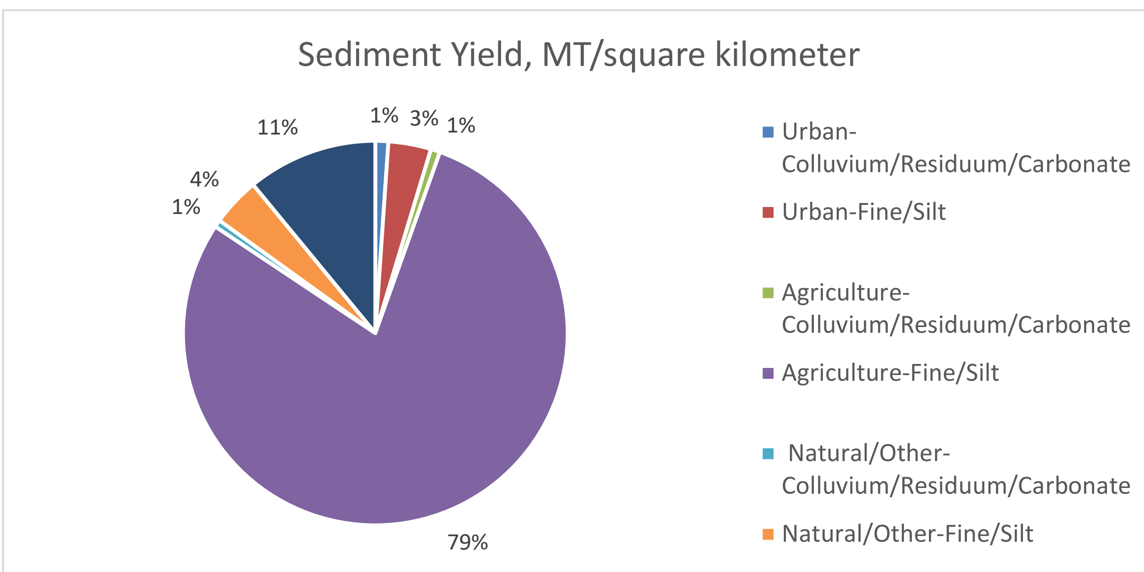


Figure 3.5. SPARROW 2012 sediment yield from sources in Bayou Meto watershed (USGS 2019).

3.1.6.2 SWAT Model

A SWAT (Soil and Water Assessment Tool) model of the Bayou Meto watershed was prepared in 2021 under contract to NRD (FTN Associates, Ltd. 2021). Like the SPARROW model, SWAT also simulates total nitrogen, total phosphorus, and sediment yields, but SWAT simulates physical, chemical, and biological processes in the watershed rather than using regressions. The Bayou Meto SWAT model was applied at a much smaller spatial scale (a single HUC8) than the SPARROW model (the entire Mississippi/Atchafalaya River basin). The Bayou Meto SWAT model was calibrated to observed data within the Bayou Meto watershed, whereas the SPARROW model had many calibration stations throughout the Mississippi/Atchafalaya River basin but none in the Bayou Meto watershed.

Overall average annual loads and yields per unit area from the Bayou Meto SWAT model are listed in Table 3.6. The total nitrogen, total phosphorus, and sediment yields estimated by the SWAT model are approximately 15%, 6%, and 1.5%, respectively, of the loads estimated by the SPARROW model. These differences in model results appear to be due primarily to differences in spatial scale and calibration data.

Table 3.6. SWAT estimated average annual loads from the Bayou Meto watershed.

Parameter	Average annual load	Average annual yield per unit of watershed area
Total Nitrogen	322,175 kilograms	121.7 kilograms/square kilometer
Total Phosphorus	55,499 kilograms	20.9 kilograms/square kilometer
Sediment	13,227 MT	5.00 MT/square kilometer

The purpose of this SWAT modeling effort was to rank Bayou Meto subwatersheds in terms of yields of nutrients and sediment. Figures 3.6-3.8 illustrate the relative rankings of the 12-digit Hydrologic Unit Code (HUC12) subwatersheds based on simulated yields of total nitrogen, total phosphorus, and sediment (FTN Associates, Ltd. 2021). There are several HUC12 subwatersheds that rank in the upper quartile for two of the parameters, but none rank in the top quartile for all three parameters.

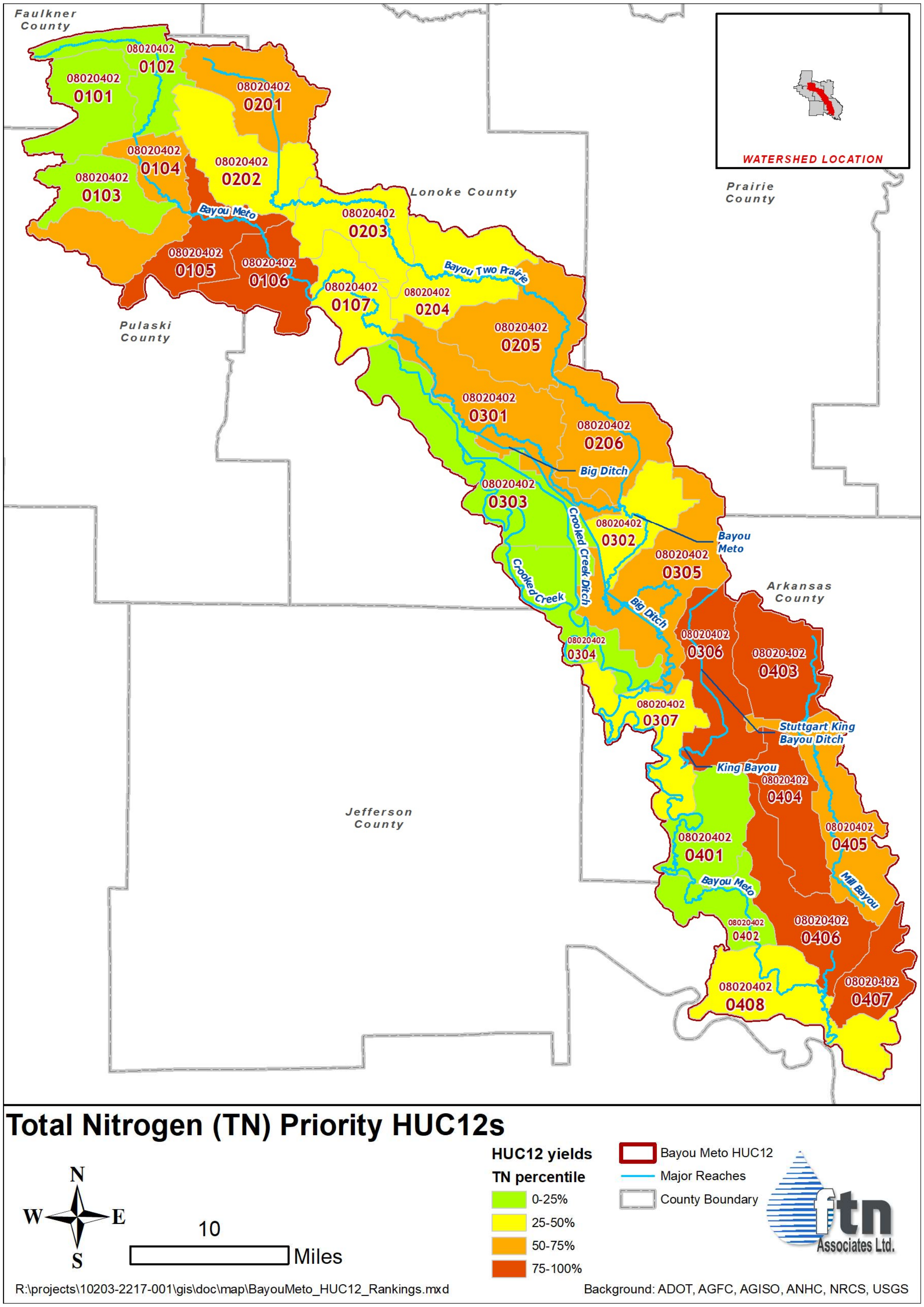


Figure 3.6. Relative ranks of Bayou Meto HUC12s based on modeled total nitrogen yield (from FTN Associates, Ltd. 2021).

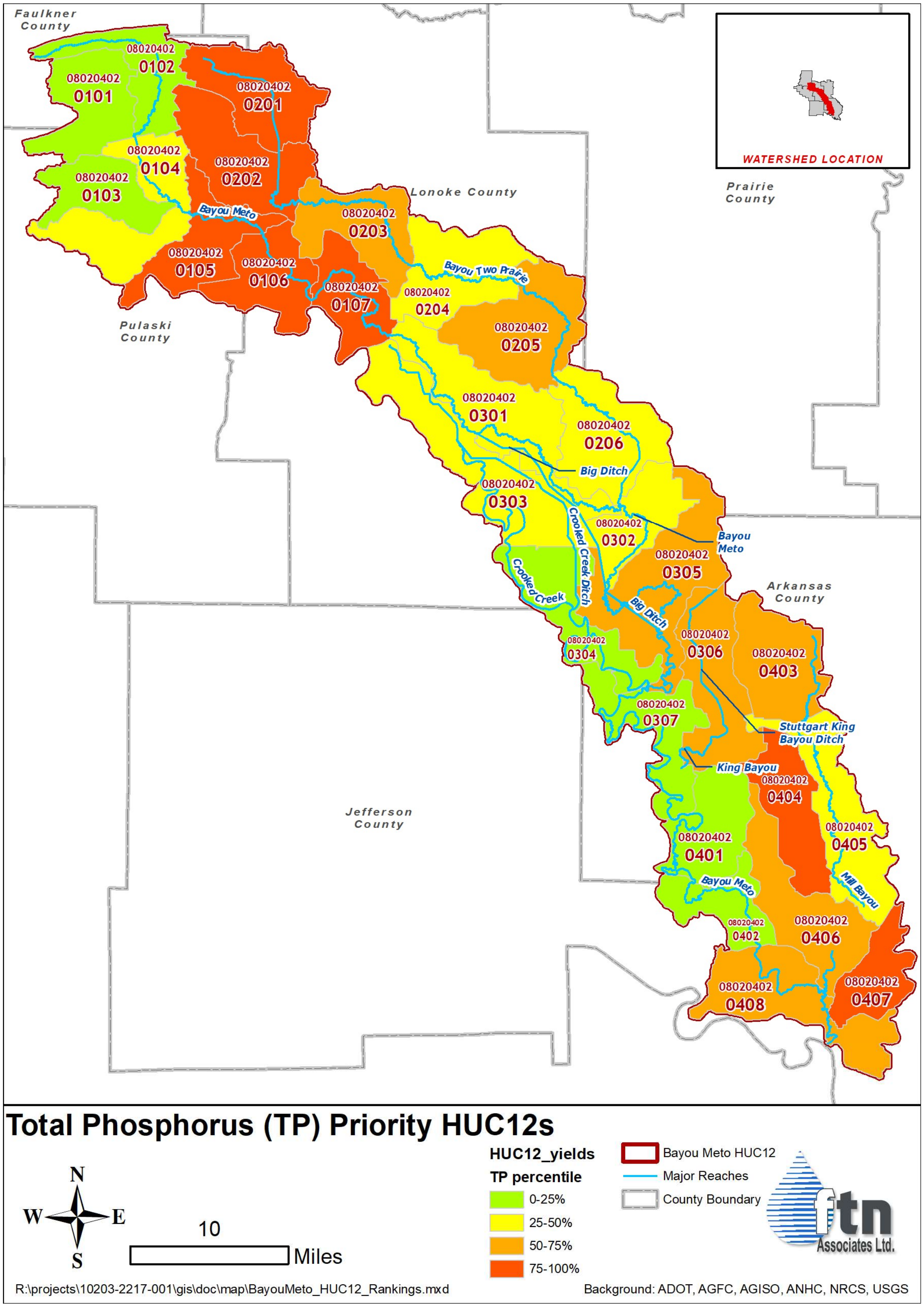


Figure 3.7. Relative ranks of Bayou Meto HUC12s based on modeled total phosphorus yield (from FTN Associates, Ltd. 2021).

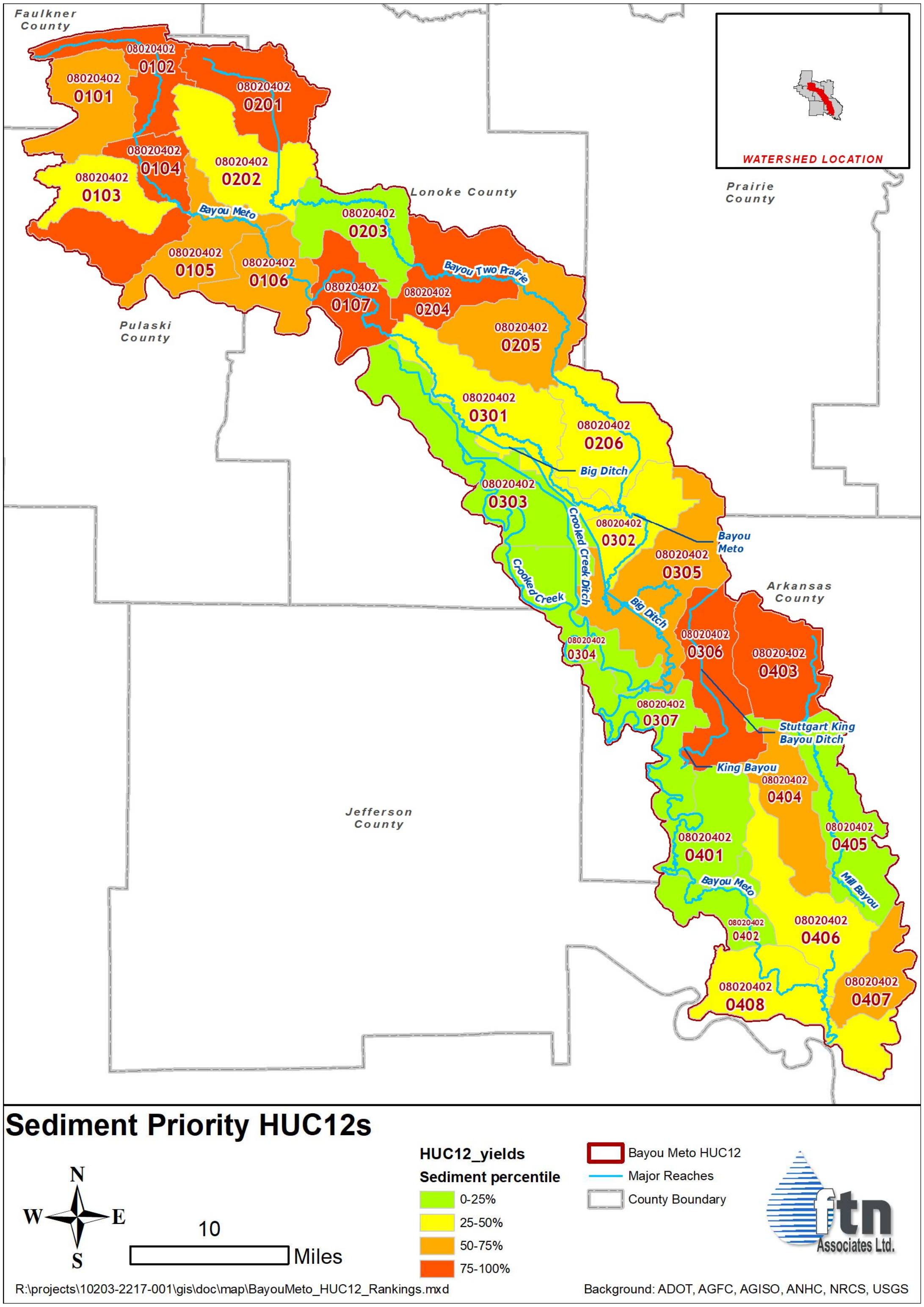


Figure 3.8. Relative ranks of Bayou Meto HUC12s based on modeled sediment yield (from FTN Associates, Ltd. 2021).

3.2 Groundwater Quality

Groundwater is an important resource in the Bayou Meto watershed (see Section 2.4.2). The quality of groundwater affects the uses to which it can be put. In addition, groundwater quality may have the potential to affect surface water quality in this watershed.

3.2.1 Groundwater Quality Standards

There are various environmental regulations in Arkansas that are designed to prevent contamination of groundwater, but Arkansas has not promulgated any numeric water quality criteria that apply to groundwater. However, groundwater that is used for drinking water is evaluated based on national primary drinking water standards. These standards include numeric criteria for organic chemicals (which include a number of pesticides that are, or have been, used in row crop agriculture), metals, microorganisms, radioactive materials, and nitrate and nitrite (EPA 2020).

3.2.2 Groundwater Quality Monitoring

DEQ, NRD, and USGS have collected groundwater quality data in the Bayou Meto watershed. An inventory of groundwater quality monitoring locations is included in Appendix B. Groundwater quality measurements were taken from 36 wells by DEQ, USGS, and NRD during 2015-2019 (Figure 3.9). Active groundwater quality monitoring programs within the Bayou Meto watershed are described in the following paragraphs.

DEQ monitors groundwater quality in the Bayou Meto watershed through its Ambient Groundwater Monitoring Program, initiated in 1986. This program consists of 12 areas sampled approximately every three years. A portion of the Lonoke monitoring area is located within the Bayou Meto watershed. This monitoring area was selected to represent a rural, agricultural area that relies entirely on groundwater for water supply. Contaminants of concern in this area are pesticides (DEQ 2018). Water quality parameters measured in the DEQ groundwater quality monitoring program are identified in Table 3.7.

The USGS, in cooperation with the Arkansas Department of Agriculture Natural Resources Division (NRD), maintains 45 master wells that are sampled for water quality every five years. In addition, five parameters are measured in 150 wells in the Sparta aquifer, and 150 wells in the Alluvial aquifer every other year. Some of the wells shown on Figure 3.9 (and listed in Appendix B) are part of one of these routine groundwater quality monitoring networks. Water quality parameters measured in the USGS and NRD wells are identified in Table 3.7.

The Arkansas Department of Agriculture Pesticides Section (formerly the Arkansas State Plant Board) monitors groundwater for agricultural chemicals through its Arkansas Ground Water Monitoring Program. Through this program, initiated in 2004, the Pesticides Section has sampled 271 wells in 30 counties for pesticides (Arkansas Department of Agriculture 2020). Around 10 of these wells appear to be located within the Bayou Meto watershed (Arkansas State Plant Board pre-2020).

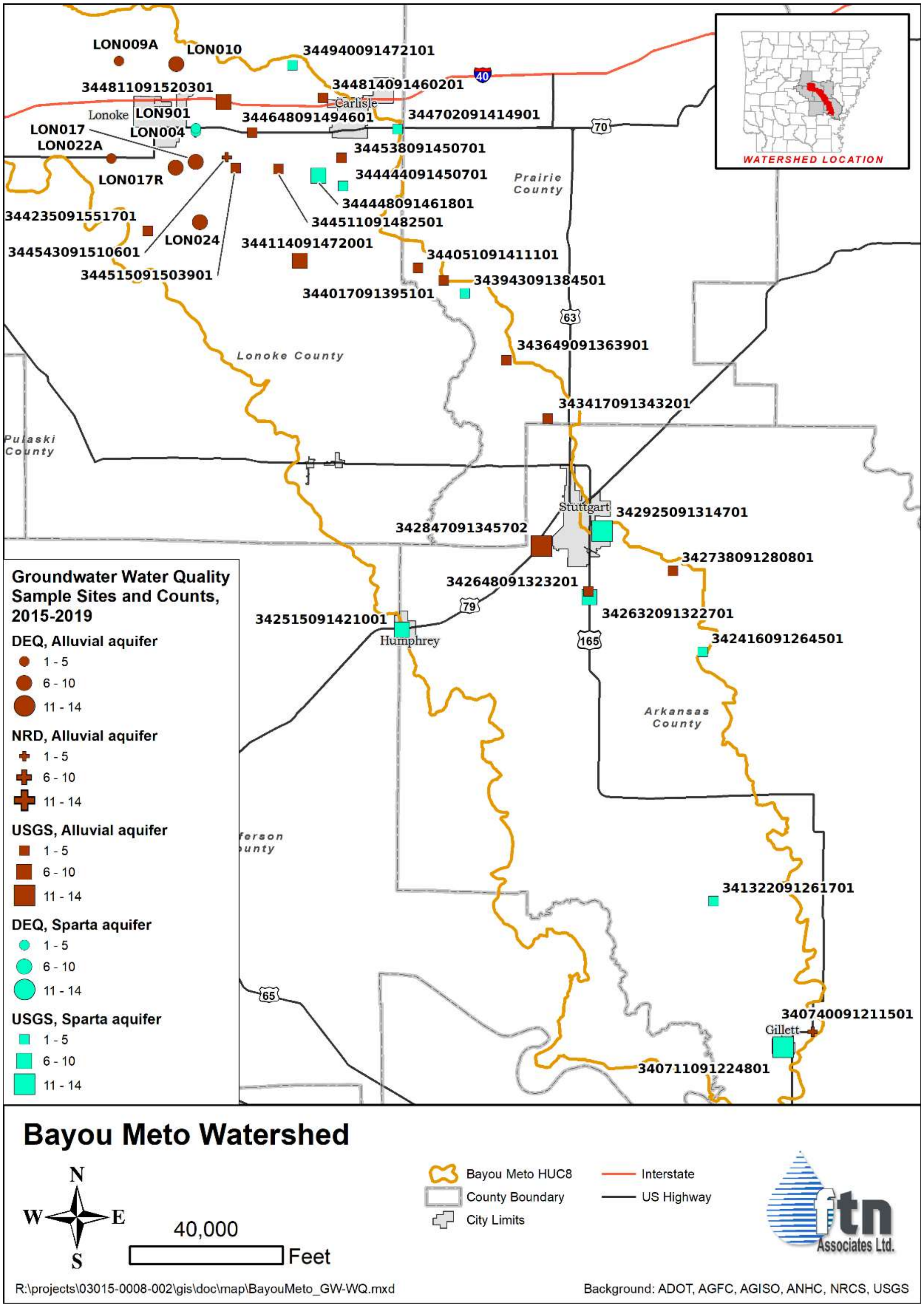


Figure 3.9. Locations of groundwater quality sampling during 2015-2019 (USGS 2021).

Table 3.7. Groundwater quality monitoring stations in the Bayou Meto watershed active during 2015-2019 (DEQ 2020a, USGS 2020b).

Entity	Station ID	Aquifer	Description	County	Depth, ft	Start Year	End Year	Number of dates
USGS	344235091551701	Alluvial Aquifer	01N09W13DAB1	Lonoke	150	2004	2020	5
USGS	344811091520301	Alluvial Aquifer	02N08W16ABC1	Lonoke	170	1995	2020	7
USGS	340711091224801	Sparta aquifer	07S03W06ABC1	Arkansas	720	1963	2019	14
USGS	343943091384501	Sparta aquifer	01N06W34CBB1	Prairie	500	2015	2019	2
DEQ	LON004	-	PWS well 004	Lonoke	-	2013	2018	2
DEQ	LON009A	-	Irrigation Well 009A	Lonoke	-	2004	2018	4
DEQ	LON010	-	Irrigation Well 010	Lonoke	-	1994	2018	7
DEQ	LON017	-	Irrigation Well 017	Lonoke	-	1994	2018	7
DEQ	LON017R	-	Irrigation Well 017R	Lonoke	-	1997	2018	7
DEQ	LON022A	-	Aquaculture Well 022A	Lonoke	-	2010	2018	3
DEQ	LON024	-	Irrigation Well 024	Lonoke	-	1994	2018	7
DEQ	LON901	-	PWS Well 901	Lonoke	-	2004	2018	4
NRD	340740091211501	Alluvial Aquifer	06S03W32ADD1	Arkansas	162	2018	2018	1
USGS	341322091261701	Sparta aquifer	05S04W27SWSW1	Arkansas	828	2018	2018	1
USGS	342925091314701	Sparta aquifer	02S05W34ABC1	Arkansas	758	1966	2018	13
NRD	344543091510601	Alluvial Aquifer	02N08W27DCC1	Lonoke	176	2018	2018	1
USGS	344444091450701	Sparta aquifer	01N07W03BCC1	Lonoke	285	1998	2017	3
USGS	344702091414901	Sparta aquifer	02N07W24DAC1	Lonoke	321	2015	2017	2
USGS	342648091323201	Alluvial Aquifer	03S05W16AA1	Arkansas	110	2014	2016	2
USGS	342738091280801	Alluvial Aquifer	03S04W08BBB1	Arkansas	127	2014	2016	2
USGS	342847091345702	Alluvial Aquifer	03S05W06ABA2	Arkansas	123	1975	2016	10
USGS	343417091343201	Alluvial Aquifer	01S05W31DDA1	Prairie	120	2016	2016	1
USGS	343649091363901	Alluvial Aquifer	01S06W13CCC1	Prairie	-	2010	2016	3
USGS	344017091395101	Alluvial Aquifer	01N06W29DDD1	Prairie	155	2016	2016	1
USGS	344051091411101	Alluvial Aquifer	01N06W30ADC1	Prairie	-	2010	2016	3
USGS	344114091472001	Alluvial Aquifer	01N07W29BBB1	Lonoke	-	1998	2016	9
USGS	344511091482501	Alluvial Aquifer	02N07W31CB1	Lonoke	200	2014	2016	2

Table 3.7. Groundwater quality monitoring stations in the Bayou Meto watershed active during 2015-2019 (DEQ 2020a, USGS 2020) (continued).

Entity	Station ID	Aquifer	Description	County	Depth, ft	Start Year	End Year	Number of dates
USGS	344515091503901	Alluvial Aquifer	02N08W34DA1	Lonoke	192	2014	2016	2
USGS	344538091450701	Alluvial Aquifer	02N07W28DDD1	Lonoke	-	2014	2016	2
USGS	344648091494601	Alluvial Aquifer	02N08W23DCA1	Lonoke	176	2007	2016	3
USGS	344814091460201	Alluvial Aquifer	02N07W16BB1	Lonoke	188	2014	2016	2
USGS	342416091264501	Sparta aquifer	03S04W33BAA1	Arkansas	878	2015	2015	1
USGS	342515091421001	Sparta aquifer	03S06W30BBD1	Arkansas	870	1995	2015	8
USGS	342632091322701	Sparta aquifer	03S05W15CBB1	Arkansas	760	1998	2015	7
USGS	344448091461801	Sparta aquifer	02N07W32DDD1	Lonoke	276	1997	2015	8
USGS	344940091472101	Sparta aquifer	02N07W06ACD1	Lonoke	243	1998	2015	2

3.2.3 Groundwater Quality Summary

With regard to human health, the primary water quality parameters of concern are nitrate, nitrite, and pesticides. Minerals in groundwater are also of interest if there is the potential for surface water impacts from runoff of groundwater used for irrigation or aquaculture. A detailed evaluation of groundwater quality is provided in Appendix F. The findings of this evaluation are summarized below.

- There is no indication that nitrate or nitrite in groundwater is an issue in the Bayou Meto watershed.
- Pesticides in groundwater does not appear to be a widespread issue in the Bayou Meto watershed.
- There may be a localized occurrence of pesticides in the Alluvial aquifer in Lonoke County.
- There is currently no evidence, beyond the mineral concentrations measured in groundwater, to suggest that minerals in groundwater are impacting mineral concentrations in Bayou Meto surface waters.

3.3 Ecological Condition

3.3.1 Stream Hydrology

The USGS analyzed flow data from 1951-2011 for 38 stream gages across the state to identify long term trends. One of the stream gages analyzed was the Bayou Meto gage (07264000). No statistically significant long-term trends were identified in annual, or peak flows at this location. A statistically significant decreasing trend in minimum flows was identified, and a statistically significant increasing trend in autumn flow (Wagner, Krieger, and Merriman 2014). These trends may indicate impacts of agricultural water use on the Bayou Meto flow regime at this location.

Data from current and historical flow gages located in the Bayou Meto watershed were also evaluated recently for evidence of human-caused hydrologic alteration (Hart and Breaker 2019). In this study, random forest regression methods were used to model streamflow conditions without human influence, e.g., from dams and water supply withdrawals. Flow conditions without human influence were referred to as "expected" conditions. The analysis found no significant difference between expected and observed flood events at the flow gages evaluated in the Bayou Meto watershed, two gages on Bayou Meto and one on Crooked Creek. Similarly, at gage 07264000 (the only one with a suitable data set for further analysis), observed duration of high stream flows, frequency of low-pulse periods, and high-flow index values were very close to expected (observed/expected > 0.9). However, there were fewer zero-flow days at this gage than expected (observed/expected = 0.36).

3.3.2 Geomorphology

No geomorphologic studies of the Bayou Meto watershed were identified. However, it is known that the natural geomorphology of the region has been altered significantly by humans. This includes human activities such as digging drainage ditches, channelizing natural streams, building ponds and reservoirs, damming streams, land leveling for crop production, and building field levees for controlling irrigation water.

3.3.3 Aquatic habitat

No DEQ habitat surveys were found for the Bayou Meto watershed (DEQ 2020c). However, aquatic habitats have been evaluated as part of the Environmental Impact investigation for the Bayou Meto Irrigation Project. Kilgore et al. (2005) stated that floodplains and wetlands are important spawning and nursery habitats for fish species in the Bayou Meto watershed. Habitat in most of the waterways in the Bayou Meto watershed is impacted by human activity. Human activities with the greatest impact on fish habitat are withdrawal of water for irrigation and clearing of stream banks (US Army Corps of Engineers Memphis District 2007). Sedimentation also impacts fishery and macroinvertebrate habitat (Kilgore, Hoover, and Murphy 2005; Miller and Payne 2002).

3.3.4 Fisheries

Fish communities in the streams and canals of the Bayou Meto watershed reflect the fact that the watershed and hydrology have been significantly altered by humans. Forty-three species of fish were collected from 19 locations in the Bayou Meto Water Management Project study area (which includes some waterbodies outside of the Bayou Meto HUC8 watershed) in a survey conducted 1999-2000 (Kilgore, Hoover and Murphy 2005). Species tolerant of degraded water quality and habitat accounted for approximately 75% of the fish collected during this survey (US Army Corps of Engineers Memphis District 2007). Sixty-four fish species were identified during a 1991-1992 survey of Bayou Meto (no other streams in the watershed were sampled during this survey). Historically, 79 fish species have been reported from the region (Heckathorn, Fishes of Bayou Meto and Wattensaw Bayou, two lowland streams in East Central Arkansas 1993). Species of wetland obligate fish are present in the watershed, at least one of which is classified by the ANHC as a species of concern (Kilgore, Hoover and Murphy 2005; Arkansas Natural Heritage Commission 2020).

DEQ conducted one fish survey in the watershed; it was conducted in 1986 in King Bayou Ditch about 3 miles downstream of a municipal wastewater discharge. Only three fish species were identified in this survey. Of the 122 fish collected, 115 were Mosquitofish (Gambusia affinis, DEQ 2020c).

The Bayou Meto watershed is home to the largest concentration of the aquaculture industry in Arkansas; 32% of aquaculture operations in the state in 2017 were located in Lonoke County, and 41% of 2017 state aquaculture sales were from Lonoke County. In 2007, baitfish and catfish accounted for the majority of aquaculture production in Lonoke County (USDA National Agricultural Statistics Service 2020). Accidental release of non-native carp species into the Bayou Meto watershed from aquaculture facilities has occurred. As a result, these non-native fish species have become established in the watershed, and pose a threat to native fish communities (Kolar, et al. 2005; USGS 2020c).

3.3.5 Benthics

A 2001 mussel survey that included 15 sites in the Bayou Meto watershed found no live mussels. Sites on Bayou Meto, Bayou Two Prairie, and Crooked Creek Ditch were surveyed. The researchers/surveyors did not think the surveyed sites displayed habitat suitable to support freshwater mussel populations. As of 2001, zebra mussels were not present in the Bayou Meto watershed (Miller and Payne 2002).

DEQ conducted macroinvertebrate surveys at three locations on Bayou Meto during 2018. Between 32 and 43 taxa were identified at each site. The majority of taxa present are classified as tolerant of poorer water quality and habitat. Two or three intolerant taxa were present at each of these sites (DEQ 2020d).

3.3.6 Summary

The geomorphology of the Bayou Meto watershed has been significantly modified to support agriculture. As a result, aquatic habitats and aquatic communities have been significantly impacted. Fish and benthic communities surveyed in the watershed are dominated by species tolerant of poor water quality and habitat. Non-indigenous fish species have been accidently introduced into the watershed. Introduced carp species pose a threat to native fish communities. As of 2001, zebra mussels were not present in the watershed.

3.4 Nonpoint Pollution Sources in Bayou Meto Watershed

Nonpoint source pollution is defined as diffuse pollution, or pollutants coming from many dispersed locations rather than a single location. These pollutants are generally conveyed by precipitation, land runoff, infiltration, drainage, seepage, hydrologic modification, or atmospheric deposition. As water runs off, it picks up and transports pollutants resulting from natural sources and human activity, ultimately depositing the pollutants into rivers, lakes, wetlands, coastal waters, and ground water.

Sources of nonpoint source pollution are primarily land management activities. Nonpoint pollution sources present in the Bayou Meto watershed are described below.

3.4.1 Cropland

Erosion from cultivated agriculture transports sediment and other pollutants that may impair waterbodies. According to the most recent land use study, over 50% of the total land area in the Bayou Meto watershed is cultivated cropland, with the lower region composed of about 70% cultivated cropland (Wickham, et al. 2021). A recent modeling study conducted by the USGS suggests that the Lower Mississippi River watershed contributes the largest amount of TSS in the Mississippi/Atchafalaya River basin with a majority coming from agriculture (Robertson and Saad 2019). Additionally, the Bayou Meto HUC12 subwatershed located in the Mississippi Alluvial Plain ecoregion are all listed at elevated risk of excessive sediment and salts in surface water, and pesticides in surface water and groundwater, according to the 2015 Arkansas State Resource Assessment (NRCS 2016). The majority of fields do not have a crop growing during the winter, leaving soil exposed (USDA National Agricultural Statistics Service 2017). Recently, a coordinated farm field runoff study conducted on fields in the Delta region of northeast Arkansas concluded that runoff, sediment, total phosphorus, and total nitrogen loss from row crop fields were higher in the nongrowing season than in the growing season (Reba et al. 2020).

3.4.2 Livestock

Frequent cattle watering in streams and loitering in shaded riparian areas can cause erosion of streambanks, and the additional manure along streams can increase nutrient loads and bacteria in the stream. Seven percent of the Bayou Meto watershed is classified as hay and pasture lands. The majority of pasture lands are located in the upper watershed, north of Highway 70.

3.4.3 Developed Areas

Several towns are located in the upper portion of the watershed. Runoff from impervious surfaces such as parking lots, rooftops, and roads carry pollutants into storm drains that empty into nearby waterways. Common pollutants from urban development include sediment from erosion on construction projects, lawn products (fertilizer and pesticides), motor oil, nutrients and pathogens from pet waste, and other waste from homes, businesses, and municipalities.

3.4.4 Illegal Dumping

The Arkansas Solid Waste Management Act (§8-6-205) provides rules of proper waste disposal to ensure that wastes do not become a nuisance or a hazard to public health. Illegal dumping of household waste, construction waste, appliances, tires, etc., contributes to water pollution and the burning of this waste contributes to air pollution. DEQ (2021a) maintains an online database of complaints and subsequent inspections of illegal dumps from 2004 through present. Valid records of illegal dumping identified by DEQ in the watershed were primarily located in communities near Little Rock (Table 3.8). However, as these records are inspected and recorded based on complaints, they do not represent all illegal dumping in any area and likely underrepresent dumping in rural communities that may have limited access to solid waste disposal facilities.

Table 3.8 Number of illegal dumping complaints in select communities in the Bayou Meto watershed determined valid by DEQ (DEQ 2021a).

City	Valid Complaints (2004-2019)
Sherwood	19
Cabot	23
Jacksonville	39
Lonoke	7
Carlisle	2
Gillett	1
Total	**91**

3.4.5 Mining

The Arkansas Geological Survey maintains a database of mines within the state (Arkansas Geological Survey 2020). Twenty-eight mines were located in the watershed, with only three located in the Delta ecoregion and were former sand pits. Only three mines are known to be active in the watershed: a shale pit just west of Sherwood and two crushed stone quarries just west of Cabot operated by Freshour. The majority of the 28 mines identified are former sand and gravel pits or stone quarries that have been reclaimed or abandoned. There was one heavy metal mine, an abandoned lead and zinc mine located in Sherwood.

There are three mines in the Bayou Meto watershed with active DEQ mining permits (Table 3.9). One of these mines has a National Pollutant Discharge Elimination System (NPDES) permit to discharge industrial wastewater and stormwater runoff (Table 3.10). The mines in Tables 3.9 and 3.10 appear to be different from the mines identified by Arkansas Geological Survey. Therefore, there are six active mines in the Bayou Meto watershed, three of which appear to be unregulated.

Table 3.9. Mines in the Bayou Meto watershed with active DEQ mine permits (DEQ 2021b).

Mine Name	Operator	County	City	Material	Permit ID
Hoskyn Pit	Hoskyn Enterprises	Arkansas	Stuttgart	Sand & gravel	0648-MN-A2
Hoskyn 79 Mine 2	Hoskyn Enterprises	Arkansas	Stuttgart	Sand & gravel	0002-MN-AG2-009
Shale Pit @ Rockwood & Hwy 89	Jeff Smith	Lonoke	Cabot	Shale	0002-MN-AG2-026

Table 3.10. Mine in the Bayou Meto watershed with active NPDES permit (DEQ 2021b).

Facility Name	County	NPDES Permit No.	Receiving Stream
Shale Pit @ Rockwood & Hwy 89	Lonoke	ARR001721	Bayou Two Prairie

3.4.6 Erosion

The 2015 State Resource Assessment listed only HUC12 watersheds in the upper Bayou Meto watershed has having highest risks of excessive streambank and concentrated flow erosion. Several HUC12 subwatersheds in the Bayou Meto watershed were classified as having moderate, or moderately high risk of sheet, rill, and/or wind erosion (NRCS 2016).

3.4.7 Onsite Wastewater Treatment Systems

Given the rural setting of a majority of the Bayou Meto watershed, it is likely that onsite wastewater treatment systems (e.g., septic systems) are used by a large number of residents. Improper design, installation, and maintenance of these systems has the potential to cause nutrient and bacterial contamination of nearby waterbodies. However, there is currently no indication that onsite wastewater treatment systems are contributing significant water quality issues in the watershed.

3.4.8 Wildlife

The large number of waterfowl that overwinter in the area and utilize the area during migration, could have the potential to impact water quality. During the winter of 2020-2021 AGFC waterfowl surveys reported an average Duck population of over 167,000 in the Bayou Meto-Lower Arkansas survey region (AGFC 2021b). However, there are currently no indications that migrating and overwintering waterfowl are impacting water quality in the Bayou Meto watershed.

Feral hogs may contribute to erosion, sediment, nutrient, or pathogen issues in the rural areas of the Bayou Meto watershed. A high level of feral hog activity has been reported in Arkansas, Jefferson, and Prairie Counties; very little activity has been reported in Pulaski and Lonoke Counties (McPeake, Wallen and Bennet 2019).

3.5 Data Gaps

Several data gaps were identified during inventorying and analyzing data from Bayou Meto watershed. These are discussed in the paragraphs below.

DEQ has collected BOD measurements from only one of their stations in this watershed since 2005, ARK0050. Since low DO is a water quality issue for a number of stream reaches, and at least one reservoir, in this watershed, measuring BOD may be useful. These measurements could be used to help evaluate how much the low DO conditions are influenced by organic matter in the water column (as opposed to organic matter on the bottom of the stream).

Measurements of fecal contamination indicators, i.e., pathogens, have not been collected since 2012 in this watershed. Collecting a more current set of measurements would be useful, particularly in the upper Bayou Meto watershed, where the presence of significant areas of pasture and expanding residential development increase the potential for fecal contamination of surface waters.

Total nitrogen is a useful parameter to monitor, particularly since the Bayou Meto watershed is within the Mississippi River basin, where reduction of nutrient loads is a priority. The current data record of total nitrogen measurements is not long enough to be useful for characterizing current total nitrogen conditions. However, total nitrogen is now part of the DEQ routine water quality analyses for the Bayou Meto watershed. Continuing routine measurement of total nitrogen at the existing DEQ water quality stations will address this data gap.

There are two DEQ roving water quality stations in the Bayou Meto watershed that have not been sampled since 2010. Sampling at these stations in the near future would benefit the biennial assessment of water quality in this watershed, and may be useful for evaluating DO conditions in the watershed, particularly in locations where the permanent monitoring stations are located far apart.

Groundwater quality measurements in the Bayou Meto watershed are not collected frequently at many locations. Pesticide measurements collected by the Arkansas Department of Agriculture Pesticides Section are not currently available to the public online, though they have been in the past.

One of the primary data gaps for calculating sediment and nutrient loads in the Bayou Meto watershed is the lack of daily flow data, particularly at water quality monitoring stations. This increases the uncertainty associated with loads estimated from measured water quality data.

The lack of daily stream flow data in the lower Bayou Meto watershed (i.e., downstream of the USGS gage near Lonoke) is also a data gap for ecological assessment. Stream flow data at multiple locations would be helpful for evaluating the effects of irrigation, including water withdrawals from streams, in-stream berms to pond water for irrigation withdrawal, and groundwater that is used for irrigation and aquaculture eventually entering streams. These activities are likely affecting the hydrology of streams in the watershed, but there are no measurements to characterize the hydrology of streams in the lower portion of the watershed.

Information is available that identifies locations and/or extent of some of the nonpoint sources present in the Bayou Meto watershed, but not all of them. No information was found on locations and extents of eroding pastures and streambanks or failing onsite wastewater treatment systems.

3.6 Conclusions

Conditions in the Bayou Meto watershed have been significantly altered. As a result, aquatic habitat and water quality in some stream reaches have been impacted, and sediment and nutrient loads from this watershed are relatively high. Both point sources and nonpoint sources of pollution are affecting water quality in the watershed and contributing to sediment and nutrient loads in streams.

4.0 MANAGEMENT PLAN

This section identifies management concerns and goals for the Bayou Meto watershed, as well as areas to target management and practices to achieve the watershed goals.

4.1 Management Goals

There are four management goals to achieve the vision of the Bayou Meto watershed:

1. Restore waterbody uses currently not being attained,
2. Sustain those uses that are being attained,
3. Keep pollutants out of surface water and groundwater, and
4. Minimize activities that disturb the stream channel and streambank.

There are several stream reaches and other waterbodies listed by DEQ as currently not meeting water quality standards required to support some of their designated uses (see Section 3.1.4). To achieve the vision for the Bayou Meto watershed, water quality in these streams will need to meet all water quality standards so that all designated uses are supported. In addition, those streams that currently meet water quality standards and attain their designated uses need to continue to do so. The management goals of keeping pollutants out of surface water and groundwater and minimizing activities that disturb the stream bed and its banks contribute to the goals of achieving water quality standards and attaining designated waterbody uses.

Groundwater is an important resource in the Bayou Meto watershed. Groundwater from the shallower Mississippi River Valley Alluvial aquifer (Alluvial aquifer) is used primarily to irrigate crops. Groundwater from the deeper Sparta aquifer is used primarily for community water supplies. Use of the Sparta aquifer for crop irrigation and industry is considered a threat to some community water supplies within the Bayou Meto watershed (Bayou Meto Water Management District undated). A clay layer that overlays the Alluvial aquifer over much of the Delta helps protect it from contaminants from the land surface. In the Bayou Meto watershed, there are no direct recharge areas for the Sparta aquifer (Kresse, et al. 2014). Therefore, groundwater quality protection in this watershed consists of wellhead protection measures.

Hydrology in the Bayou Meto watershed, as in most of the Mississippi Alluvial Plain region of Arkansas, has been significantly altered through land clearing, stream channelization, and ditching to drain land and transport water. Much of the cropland in the watershed has been land-leveled to improve irrigation water management. Clearing wooded streambanks and disturbing the stream channels contributes to bank erosion both upstream and downstream of the disturbed area.

4.2 Management Concerns

In December 2020, stakeholders were contacted to discuss their concerns about the Bayou Meto watershed. The emphasis was on water quality issues, but stakeholders were free to identify other issues. Table 4.1 is a list of the issues identified by stakeholders for this watershed management plan.

Table 4.1. Issues identified by Bayou Meto watershed stakeholders.

Water Quality Issues	Other Issues
Pesticides & herbicides in runoff	Flooding
Fish consumption advisory	Illegal weirs
Low DO	Ditch maintenance and dredging
Disappearing wetlands	Disappearing prairie habitat and quail
TDS in Bayou Meto	Habitat for ducks and other waterfowl
Reducing nutrient loads to Gulf of Mexico	Erosion and loss of land
Siltation in streams and ditches	Pesticide resistance
Quality and quantity of riparian buffers	Loss of pollinators
Quality of stream and reservoir habitat	Groundwater depletion
	Dicamba

Table 4.2 identifies issues and concerns in the recommended subwatersheds. The subwatershed issues are identified based on assessed water quality impairments (fish consumption advisory, low DO, and TDS in Bayou Meto and low DO in Bayou Two Prairie), NRCS Natural Resource Concerns (pesticides and herbicides in runoff, reducing nutrient loads to Gulf of Mexico, siltation in streams and ditches, quality and quantity of riparian buffers, and quality of stream and reservoir habitat), SWAT model results (reducing nutrient loads to Gulf of

Mexico, siltation in streams and ditches), and land cover and professional judgement (disappearing wetlands).

Table 4.2. Water quality issues identified in recommended subwatersheds.

Issue	Headwaters Bayou Meto	Glade Branch	Skinners Branch	Upper Mill Bayou	Hurricane Bayou	Bills Bayou
Stakeholder Water Quality Concerns						
Pesticides & herbicides in runoff			X	X	X	X
Fish consumption advisory						
Low DO	X	X	X			
Disappearing wetlands		X	X	X	X	X
TDS in Bayou Meto						
Reducing nutrient loads to Gulf of Mexico		X	X	X	X	X
Siltation in streams and ditches	X	X		X	X	X
Quality and quantity of riparian buffers	X	X			X	
Quality of stream and reservoir habitat	X		X			
Other Water Quality Concerns						
Presence of protected habitat		X	X			
Excess pathogens in runoff	X	X				

4.3 Subwatersheds Recommended for Management

For this watershed management plan, HUC12 subwatersheds delineated by the USGS are utilized as focus areas for nonpoint source pollution management. There are 28 HUC12 subwatersheds in the Bayou Meto watershed (Figure 4.1). Given that resources for nonpoint source pollution management are limited, we set out to identify a few HUC12s in the Bayou Meto watershed where it appears that nonpoint source pollution management activities would have greater benefits.

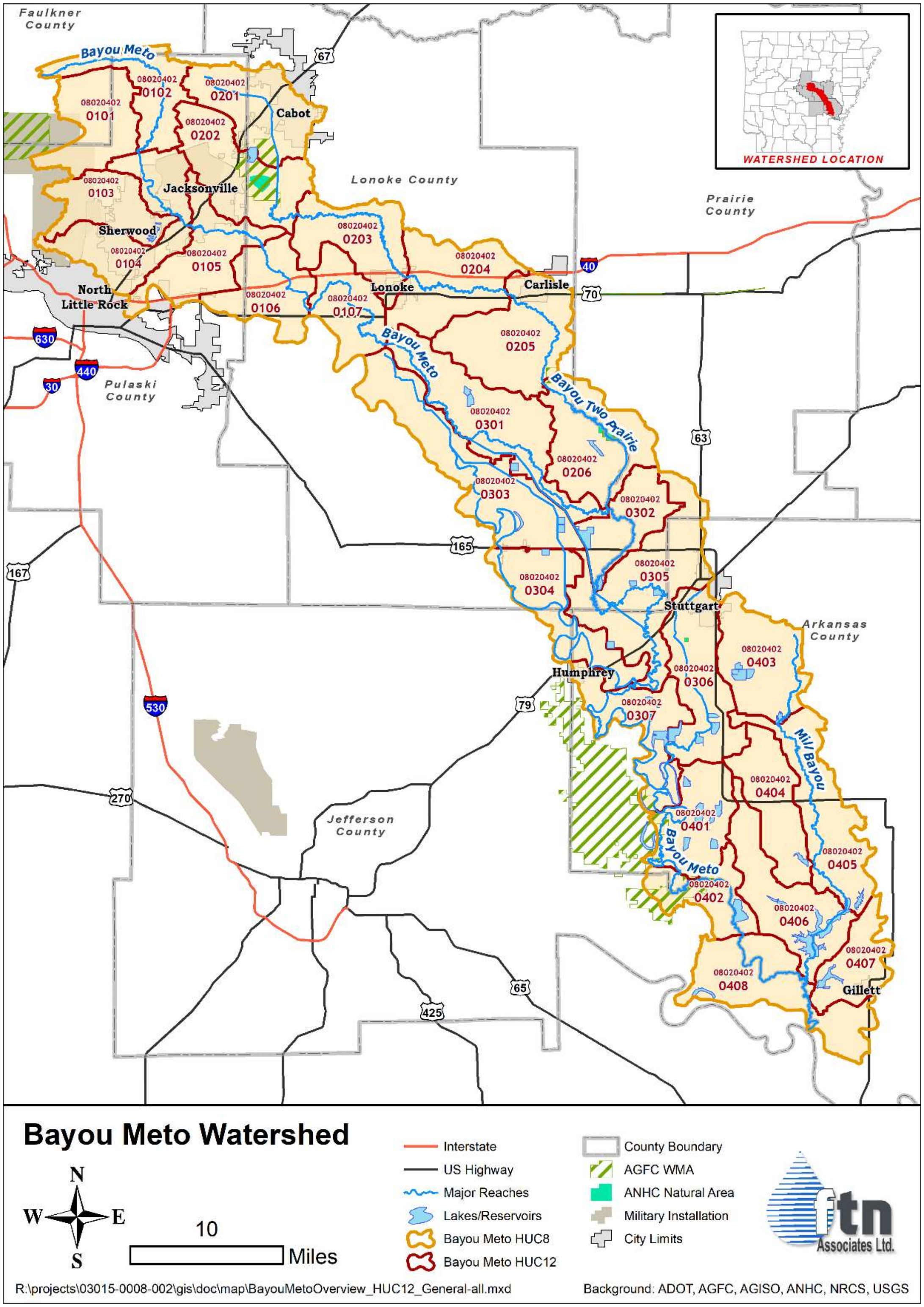


Figure 4.1 Map of HUC12 subwatersheds in the Bayou Meto watershed.

To identify these “recommended” HUC12 subwatersheds, available information was used to rank all of the HUC12 subwatersheds of the Bayou Meto watershed in terms of water quality and habitat concerns. Thirteen water quality-related criteria were assessed and used to rank each of the HUC12 subwatersheds. The following information was used to rank the HUC12 subwatersheds:

- Water quality impairment;
- Water quality data, including loads and natural resource concerns; and
- Aquatic communities and habitat of concern, indicated by the presence of designated habitat of conservation concern, and habitat-related resource concerns.

A detailed description of the data used and ranking approach is included as Appendix G. The six HUC12 subwatersheds with the highest overall ranks were selected as the recommended subwatersheds for additional nonpoint source pollution management through this watershed management plan. The recommended HUC12 subwatersheds are listed in Table 4.3 and mapped on Figure 4.2. These are not the only Bayou Meto HUC12 subwatersheds with existing or potential water quality issues (see Appendix G). This plan is not intended to restrict management activities in areas outside the recommended HUC12 subwatersheds. Water quality management is valuable and is encouraged anywhere in the Bayou Meto watershed.

Table 4.3. Bayou Meto HUC12 subwatersheds recommended for initial management under this watershed management plan.

Subwatershed Name	HUC12 ID	Ranking Score
Headwaters Bayou Meto	080204020102	6
Glade Branch-Bayou Two Prairie	080204020201	7
Skinners Branch Bayou Two Prairie	080204020205	7
Upper Mill Bayou	080204020403	6
Hurricane Bayou	080204020404	6
Bills Bayou	080204020407	6

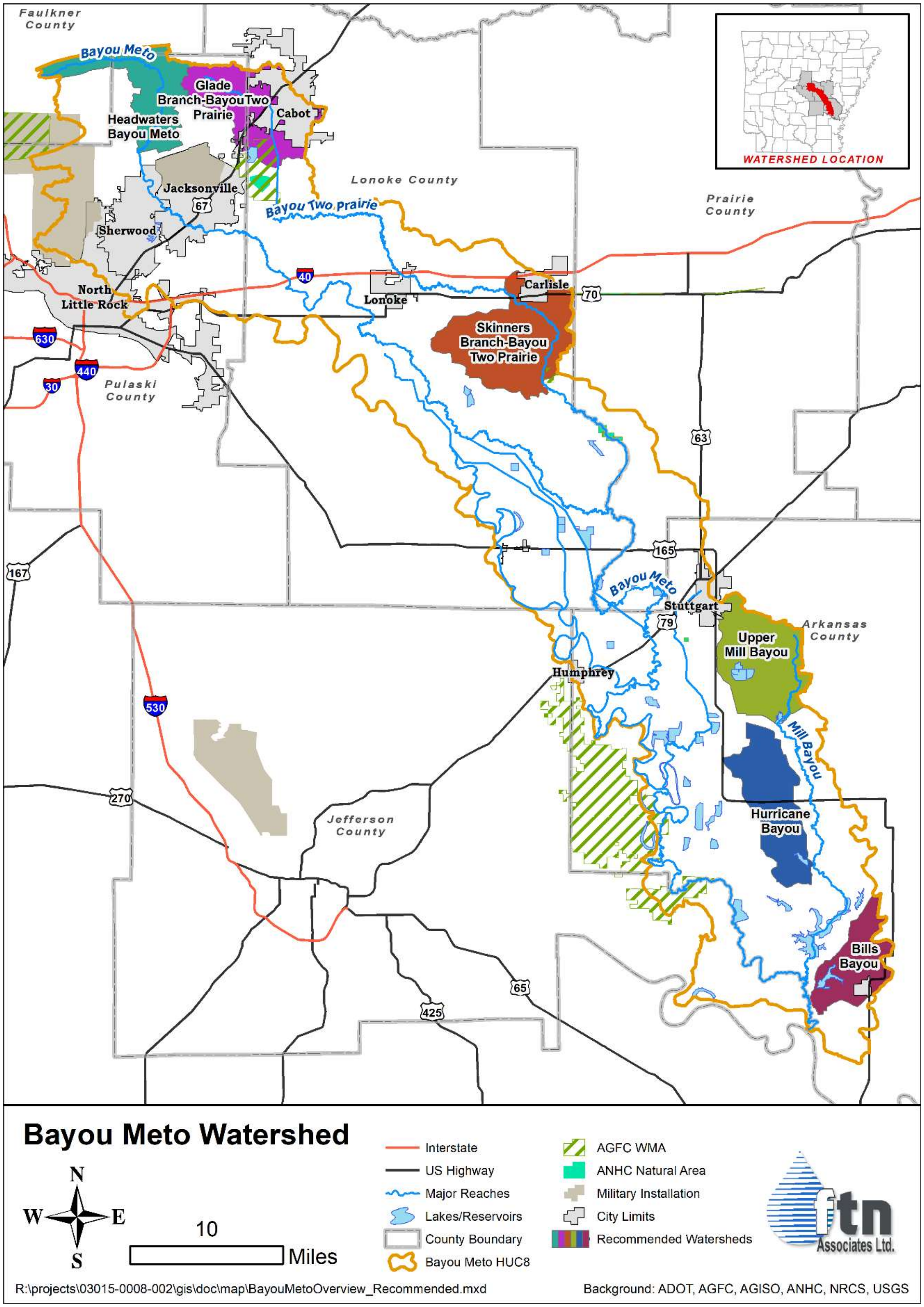


Figure 4.2. Map of recommended focus HUC12 subwatersheds of Bayou Meto.

4.4 Management Targets for Recommended Subwatersheds

Based on the water quality concerns listed in Table 4.2, pollutants of concern in the recommended subwatersheds are pesticides and herbicides, DO, TDS, nutrients, sediment, and pathogens. These parameters are targeted for management under this plan. Management targets for these pollutants are discussed below. Note that management targets for TDS are not discussed because TDS is not impairing Bayou Meto water quality in any of the recommended subwatersheds.

4.4.1 Pesticides and Herbicides Management Targets

Management targets for organic compounds for which DEQ has established water quality criteria, the management targets are the water quality criteria. Table 4.4 lists the surface water numeric criteria promulgated for pesticides and herbicides. Note that the aquatic life criteria listed in Table 4.4 are protective of human health (EPA 2020). To be assessed as achieving the criteria in Table 4.4, DEQ requires that 100% of water measurements must be less than the criteria (DEQ 2022). Until measurements have been collected from the Glade Branch-Bayou Two Prairie, Upper Mill Bayou, Hurricane Bayou, and Bills Bayou subwatersheds, it will not be possible to track achievement of the pesticide and herbicide targets in those subwatersheds.

Table 4.4. Ambient water numeric water quality criteria for pesticides and herbicides (APCEC 2020).

Substance	Aquatic life acute criteria, ug/L	Aquatic life chronic criteria, ug/L
Aldrin	3.0	-
Dieldrin*	2.5	0.0019
DDT & metabolites*	1.1	0.0010
Endrin*	0.18	0.0023
Toxaphene*	0.73	0.0002
Chlordane*	2.4	0.0043
Endosulfan	0.22	0.056
Heptachlor*	0.52	0.0038
Hexachlorocyclohexane	2.0	0.080
Chlorpyrifos	0.083	0.041
Toxaphene	-	-

* Banned pesticide or residue of banned pesticide

4.4.2 Dissolved Oxygen Management Targets

DO management targets for this watershed management plan will be the DO water quality criteria. To be assessed as achieving the DO criterion, DEQ requires that 90% or more of the DO measurements from primary and critical seasons of the assessment period must be equal to or greater than the criterion (DEQ 2022). This target applies to all six recommended subwatersheds. Until DO measurements have been collected from the Glade Branch-Bayou Two Prairie, Upper Mill Bayou, Hurricane Bayou, and Bills Bayou subwatersheds, it will not be possible to track achievement of the DO target in those subwatersheds.

4.4.3 Nutrient Management Targets

There are no numeric criteria for nutrients that apply to the Bayou Meto watershed that could be used as management targets. To address Gulf of Mexico hypoxia, Arkansas has committed to reduce nitrogen loads leaving the state. However, there currently is not a state-specific target nitrogen load for Arkansas, nor are there target nitrogen loads for any of the watersheds in the state (APCEC 2020).

Often, low-DO conditions in Arkansas waterbodies are a result of excessive algal production caused by nutrient inputs. In such situations, management of nutrient inputs will improve DO conditions. Water quality data from monitoring stations used to determine the DO impairment of stream reaches in the recommended subwatersheds were examined for correlations between DO and nutrient concentrations. Simple data graphs and Pearson correlation analysis did not indicate significant correlation between nutrient and DO concentrations overall or seasonally (see Appendix H). Therefore, it was not possible to quantify nutrient loads that would be expected to raise DO concentrations to meet water quality criteria. Factors other than nutrient concentration appear to have a stronger influence on DO concentration, such as water temperature or accumulation of organic matter on stream bottoms. Lack of trees in stream riparian areas reduces shading of the water, which can result in higher water temperatures and reduced capacity of the water to hold DO. Measurements of other factors that can influence DO concentrations, such as flow and biochemical oxygen demand, are not routinely collected at these monitoring stations, so evaluation of their impact was not possible. For the Skinners

Branch-Bayou Two Prairie subwatershed, there was anecdotal evidence that water withdrawals from Bayou Two Prairie in the area of this subwatershed during the critical period (i.e., summer/growing season) could be a factor in the low-DO conditions, causing impairment.

Lacking other guidance for nutrient levels in the recommended subwatersheds, nutrient management targets for this watershed management plan are based on SWAT model areal loads from subwatersheds without water quality impairment and with the fewest water quality concerns in the HUC12 ranking (see Appendix G). There are five HUC12 subwatersheds with no impaired streams and an overall ranking score of 2 or less. These five HUC12 subwatersheds are assumed to represent the best reasonably possible conditions in the Bayou Meto watershed, with regard to the water quality parameters targeted in this plan. These five "best" HUC12s are listed in Table 4.5 along with their SWAT modeled areal total nitrogen and total phosphorus loads. Because land use affects nutrient loading, the reference subwatersheds were divided into two groups based on the most dominant agricultural land use: a cropland-dominant group and a pasture-dominant group (see Table 4.6).

Table 4.5. Modeled areal nutrient loads from reference HUC12s.

HUC12 ID	HUC12 Name	Total Nitrogen Load, kilograms/square kilometer/year (rank)	Total Phosphorus Load, kilograms/square kilometer/year (rank)
080204020103	Kellogg Creek	24.0 (27)	4.1 (22)
080204020302	Buffalo Slough-Bayou Meto	35.0 (19)	4.4 (21)
080204020303	Upper Crooked Creek	28.2 (22)	4.7 (20)
080204020304	Lower Crooked Creek	24.0 (26)	3.0 (27)
080204020305	Fish Slough-Bayou Meto	46.0 (9)	6.5 (12)

Table 4.6. 2016 land use percentages for reference HUC12s (Wickham, et al. 2021).

HUC12 ID	Group	Cropland	Developed	Forested	Pasture	Wetland
080204020103	Pasture	<1%	22%	60%	11%	5%
080204020302	Cropland	62%	3%	1%	<1%	28%
080204020303	Cropland	78%	3%	<1%	<1%	12%
080204020304	Cropland	78%	4%	1%	<1%	15%
080204020305	Cropland	59%	6%	<1%	<1%	30%

4.4.3.1 Nutrient Management Targets for Cropland-dominant Subwatersheds

There are four reference subwatersheds where cropland is the dominant land use. The average of the modeled areal nutrient loads from these four reference subwatersheds (see Table 4.5 for areal nutrient loads) is the watershed management plan nutrient load target for recommended subwatersheds where cropland is the dominant land use. The target areal total nitrogen load for cropland dominant recommended subwatersheds is 33.3 kilograms/square kilometer/year. The target areal total phosphorus load for cropland-dominant recommended subwatersheds is 4.6 kilograms/square kilometer/year.

4.4.3.2 Nutrient Management Targets for Pasture-dominant Subwatersheds

There is one reference subwatershed where pasture is the dominant agricultural land use, Kellogg Creek (HUC12 080204020103). The watershed management plan target nutrient loads for recommended subwatersheds where pasture is the dominant agricultural land use are the modeled areal loads for the Kellogg Creek subwatershed (see Table 4.5).

4.4.4 Sediment Management Targets

None of the stream assessment units in recommended subwatersheds associated with water quality monitoring stations have been identified as exceeding the applicable turbidity numeric water quality criteria. No measurements of turbidity have been collected in Glade Branch-Bayou Two Prairie, Upper Mill Bayou, Hurricane Creek, or Bills Bayou subwatersheds, so it is not possible to determine whether streams in these subwatersheds meet the applicable turbidity numeric water quality criteria. Therefore, sediment management targets for this watershed management plan are based on SWAT model areal loads from the five reference subwatersheds identified in Section 4.2.2 (see Tables 4.5 and 4.6). Table 4.7 lists the modeled areal sediment loads for the five reference HUC12s. The target sediment load for pasture-dominant recommended subwatersheds is 15.6 kilograms/square kilometer/year, the modeled areal sediment load for Kellogg Creek subwatershed (see Table 4.7). The target sediment areal load for cropland-dominant recommended subwatersheds is 24.4 kilograms/square kilometer/year, the average of the modeled sediment loads for the reference cropland-dominant subwatersheds.

Table 4.7. Modeled areal sediment loads from reference HUC12s.

HUC12 ID	HUC12 Name	Sediment Load, kilograms/square kilometer/year (rank)
080204020103	Kellogg Creek	15.4 (18)
080204020302	Buffalo Slough-Bayou Meto	21.0 (15)
080204020303	Upper Crooked Creek	6.1 (26)
080204020304	Lower Crooked Creek	6.6 (25)
080204020305	Fish Slough-Bayou Meto	63.8 (9)

4.4.5 Pathogen Management Targets

Pathogen management targets for this watershed management plan will be the bacteria water quality criteria. To be assessed as achieving the bacteria criteria, DEQ requires that 75% or more of the bacteria measurements from primary and secondary contact seasons of the assessment period must be less than the criterion (DEQ 2022).

4.5 Load Reduction Targets

Given the modeled areal loads of nitrogen, phosphorus, and sediment for the recommended subwatersheds, and the target loads identified in Section 4.4, we can determine the reductions needed to achieve the targets. To determine the load reduction targets, the recommended subwatersheds were first divided into two groups based on the most dominant agricultural land use: a cropland-dominant group and a pasture-dominant group. Table 4.8 shows the land use percentages and associated group assignment for the six recommended subwatersheds.

Table 4.8. 2016 land use percentages for recommended subwatersheds (Wickham, et al. 2021).

HUC12 ID	Group	Cropland	Developed	Forested	Pasture	Wetland
080204020102	Pasture	<1%	7%	58%	34%	<1%
080204020201	Pasture	1%	23%	36%	27%	12%
080204020205	Cropland	78%	5%	2%	1%	11%
080204020403	Cropland	81%	7%	<1%	<1%	5%
080204020404	Cropland	81%	3%	2%	<1%	8%
080204020407	Cropland	78%	5%	<1%	<1%	15%

4.5.1 Load Reduction Targets for Cropland-Dominant Subwatersheds

Tables 4.9 through 4.11 summarize the reductions required in the modeled areal loads for each of the recommended subwatersheds where cropland is the dominant land use, to meet the target nutrient and sediment loads for cropland-dominant subwatersheds. Note that sediment was not previously identified as a water quality concern for the Skinners Branch-Bayou Two Prairie subwatershed, but the modeled sediment load is higher than the target.

Table 4.9. Nitrogen load reductions to meet targets for cropland-dominant subwatersheds.

HUC12 ID	080204020205	080204020403	080204020404	080204020407
Subwatershed name	Skinners Branch-Bayou Two Prairie	Upper Mill Bayou	Hurricane Bayou	Bills Bayou
Modeled nitrogen load, kilograms/square kilometer/year	42.4	50.1	56.3	75.1
Reduction to achieve target nitrogen load of 33.3 kilograms/square kilometer/year	8.9	16.8	23.0	41.8
Percent reduction	21%	34%	41%	56%

Table 4.10. Phosphorus load reductions to meet targets for cropland-dominant subwatersheds.

HUC12 ID	080204020205	080204020403	080204020404	080204020407
Subwatershed name	Skinners Branch-Bayou Two Prairie	Upper Mill Bayou	Hurricane Bayou	Bills Bayou
Modeled phosphorus load, kilograms/square kilometer/year	6.0	7.8	10.7	10.0
Reduction to achieve target phosphorus load of 4.6 kilograms/square kilometer/year	1.4	3.2	6.1	5.4
Percent reduction	23%	41%	57%	54%

Table 4.11. Sediment load reductions to meet targets for cropland-dominant subwatersheds.

HUC12 ID	080204020205	080204020403	080204020404	080204020407
Subwatershed name	Skinners Branch-Bayou Two Prairie	Upper Mill Bayou	Hurricane Bayou	Bills Bayou
Modeled sediment load, kilograms/square kilometer/year	33.2	70.3	25.4	33.4
Reduction to achieve target sediment load of 24.4 kilograms/square kilometer/year	8.8	45.9	1.0	9.0
Percent reduction	26%	65%	4%	27%

4.5.2 Load Reduction Targets for Pasture-Dominant Subwatersheds

Tables 4.12 through 4.14 summarize the reductions required in the modeled areal loads for each of the recommended subwatersheds where pasture is the dominant agricultural land use, to meet the target nutrient and sediment loads for pasture dominant subwatersheds.

Table 4.12. Nitrogen load reductions to meet targets for pasture-dominant subwatersheds.

HUC12 ID	080204020102	080204020201
Subwatershed name	Headwaters Bayou Meto	Glade Branch-Bayou Two Prairie
Modeled nitrogen load, kilograms/square kilometer/year	27.2	45.1
Reduction to achieve target nitrogen load of 24.0 kilograms/square kilometer/year	3.2	21.1
Percent reduction	12%	47%

Table 4.13. Phosphorus load reductions to meet targets for pasture-dominant subwatersheds.

HUC12 ID	080204020102	080204020201
Subwatershed name	Headwaters Bayou Meto	Glade Branch-Bayou Two Prairie
Modeled phosphorus load, kilograms/square kilometer/year	4.0	12.8
Reduction to achieve target phosphorus load of 4.1 kilograms/square kilometer/year	0.0	8.7
Percent reduction	0%	68%

Table 4.14. Sediment load reductions to meet targets for pasture-dominant subwatersheds.

HUC12 ID	080204020102	080204020201
Subwatershed name	Headwaters Bayou Meto	Glade Branch-Bayou Two Prairie
Modeled sediment load, kilograms/square kilometer/year	113.7	244.0
Reduction to achieve target sediment load of 15.4 kilograms/square kilometer/year	98.3	228.6
Percent reduction	86%	94%

The high target reductions for sediment in these subwatersheds are a concern. It can be difficult to achieve large pollutant reductions. It is interesting that there is such a difference in the modeled sediment loads from watersheds with similar land uses. This may be the result of differences in soil types present in the subwatersheds and/or differences in land slopes. Note that all three of these subwatersheds (the reference subwatershed and the two recommended subwatersheds) ranked in the top 25% for the excessive bank erosion from streams, shorelines, or water conveyance channels and concentrated flow erosion resource concerns (the reference subwatershed slightly lower than the two recommended subwatersheds). This suggests that there are similar amounts of streambank erosion and gully erosion in the two recommended subwatersheds to what there is in the reference subwatershed.

4.5.3 Addressing Low DO

Three of the recommended subwatersheds include stream reaches classified as impaired due to low DO. No total maximum daily loads (TMDLs) have been developed for water quality impairments in the Bayou Meto watershed, so load reductions to address the DO impairments in these three recommended subwatersheds have not been determined. Currently, the causes of the low DO conditions in the impaired streams are classified as unknown. It is possible that the load reduction targets specified above could improve DO conditions in some or all of the impaired stream reaches. However, in this plan, low DO conditions in the recommended subwatersheds will be addressed primarily by studying these streams to determine what is causing the low DO conditions. Specific practices to address these causes will be identified in a future update of this plan.

4.5.4 Other Pollutants of Concern

At this time, it is not possible to identify load reduction targets for the recommended subwatersheds for any of the other pollutants of concern for this watershed management plan. There is no data indicating that the water quality criteria for pesticides, herbicides, TDS, or bacteria are being exceeded in the recommended subwatersheds (there are TDS exceedences in the Bayou Meto watershed, but not in the recommended subwatersheds). In this plan, concerns about these pollutants will be addressed through collecting data to assess whether these criteria are being met, and through practices that reduce releases of these pollutants to surface water and groundwater.

4.6 Nonpoint Pollution Sources to be Targeted for Management

Unregulated nonpoint sources of nutrients, sediment, and pathogens in the recommended subwatersheds targeted in this watershed management plan are discussed in detail in the following subsections. They are:

- Eroding streambanks;
- Gullies in pastures and cropland;
- Unpaved roads;
- Runoff from pastures, developed areas, and cropland;
- Fertilizer;
- Livestock;
- Sheet, rill, and wind erosion of cropland; and
- Feral hogs in Arkansas County.

4.6.1 Streambank Erosion

NRCS has identified streambank erosion as a higher-than-average risk in three of the recommended subwatersheds: both pasture-dominant subwatersheds (Headwaters Bayou Meto, Glade Branch-Bayou Two Prairie) and one cropland-dominant subwatershed (Hurricane Bayou). Streambank erosion contributes primarily sediment but can also contribute to nutrient loads.

Streambanks without significant riparian vegetation are more susceptible to erosion. Aerial imagery from 2017 shows that there are stream reaches through pastures with significant forested riparian areas. However, there are also stream reaches through pastures with little or no forested riparian buffer. There are also stream reaches and ditches through croplands with little or no riparian buffer. A simple GIS analysis was performed to estimate miles of channels (stream or canals) with little or no riparian buffer.[1] These estimates are provided in Table 4.15. These are likely locations for streambank erosion and sediment, nitrogen, and pathogen inputs from

[1] For pasture-dominant subwatersheds, the length of National Hydrography Dataset (NHD) streamlines that intersect 2016 National Land Cover Database (NLCD) cells (30 m by 30 m) classified as pasture/hay, or as developed. For cropland-dominant subwatersheds, the length of NHD streamlines that intersect 2016 NLCD cells classified as cropland.

livestock, pasture runoff, and cropland runoff. Livestock loafing in streams and riparian areas can contribute to streambank erosion in pasture streams. Stream reaches in and downstream of developed areas can experience streambank erosion due to reduced vegetation in riparian areas and changes in storm flows due to higher storm runoff from increased impervious area.

Table 4.15. Estimated miles of channels with little or no riparian buffer in recommended subwatersheds.

Subwatershed	Land use	Miles of channel with little or no riparian buffer
Headwaters Bayou Meto	Pasture	23
	Developed	4
Glade Branch-Bayou Two Prairie	Pasture	15
	Developed	15
Skinner Branch-Bayou Two Prairie	Cropland	54
Upper Mill Bayou	Cropland	68
Hurricane Bayou	Cropland	64
Bills Bayou	Cropland	34

4.6.2 Gully Erosion

NRCS has identified concentrated flow erosion as a higher-than-average risk in three of the recommended subwatersheds: both pasture dominant subwatersheds (Headwaters Bayou Meto, Glade Branch-Bayou Two Prairie) and one cropland dominant subwatershed (Bills Bayou). Gully erosion can contribute both sediment and nutrients (carried on soil particles). Nutrients can come from fertilizer applications (most likely in croplands) and animal manure (most likely in pastures). Gully erosion can occur in pastures where the pasture grass is in poor condition or in areas heavily used by livestock. Gully erosion can occur in developed areas where there is inadequate vegetation on soil or where soils are disturbed, such as at construction sites.

4.6.3 Sheet, Rill, and Wind Erosion of Croplands

NRCS has identified sheet, rill, and wind erosion as a higher-than-average risk in three of the cropland-dominant recommended subwatersheds; Skinners Branch-Bayou Two Prairie, Hurricane Bayou, and Bills Bayou. Bills Bayou ranked highest for this risk and Skinners

Branch-Bayou Two Prairie ranked second. Sheet, rill, and wind erosion can contribute sediment and nutrients (carried on soil particles) to surface waters.

4.6.4 Unpaved Roads

Runoff from unpaved roads contributes primarily sediment to surface waters. The extent of GIS-tagged unpaved roads in the recommended subwatersheds ranges from 15 miles to 54 miles (Table 4.16). In the cropland-dominant recommended subwatersheds, there are more unpaved roads and they cross streams and ditches (see Table 4.21). These are the most likely places for sediment from unpaved roads to enter surface waters in these subwatersheds.

Table 4.16. Miles of GIS-tagged unpaved roads in recommended subwatersheds.

Subwatershed	Unpaved road, miles
Headwaters Bayou Meto	16
Glade Branch-Bayou Two Prairie	16
Skinners Branch-Bayou Two Prairie	41
Upper Mill Bayou	54
Hurricane Bayou	35
Bills Bayou	24

4.6.5 Runoff from Developed Areas

Table 4.17 lists percentages of the recommended subwatersheds classified as developed. Output from the SWAT model of Bayou Meto watershed identifies the portion of the modeled loads from developed areas. This information is also shown in Table 4.17. Note that developed areas in Hurricane Bayou and Bills Bayou were small enough that they were not included in the SWAT model. The majority of the developed areas in the recommended subwatersheds is open space or residential (Wickham, et al. 2021). Nonpoint sources of nutrients in runoff from open areas and residences in developed areas include fertilizers (applied to lawns and golf courses) and pet waste. Past and on-going construction projects in and near developed areas are possible sources of current and legacy sediment and nutrient loads.

Table 4.17. Developed areas and modeled load portions in recommended subwatersheds.

Subwatershed	Subwatershed percent developed area (modeled percent area)	SWAT Model Output percent load from developed areas		
		Nitrogen load	Phosphorus load	Sediment load
Headwaters Bayou Meto	7% (7%)	14%	11%	43%
Glade Branch-Bayou Two Prairie	23% (19%)	34%	30%	55%
Skinner Branch-Bayou Two Prairie	5% (1%)	3%	4%	30%
Upper Mill Bayou	7% (5%)	5%	7%	32%
Hurricane Bayou	3% (0)	-	-	-
Bills Bayou	5% (0)	-	-	-

There are several small communities in the Headwaters Bayou Meto subwatershed that may act as bedroom communities for North Little Rock, Jacksonville, the Little Rock Air Force Base, and Cabot. Examination of maps and aerial imagery of developed areas in this subwatershed revealed that runoff from the majority of developed areas enters either a reservoir or wetland upstream of Bayou Meto. Therefore, it is expected that the majority of nutrient and sediment loads from developed areas in this subwatershed may impact local water quality but are not reaching Bayou Meto.

The Glade Branch-Bayou Two Prairie subwatershed includes a significant part of the incorporated area of the town of Cabot (including both commercial and residential development), and a portion of a recent Highway 67/167 construction project (DEQ 2017). The area of Cabot within this subwatershed has experienced recent growth, with new construction. Cabot has a municipal separate storm sewer system (MS4) permit, meaning stormwater runoff from Cabot is regulated through the National Pollutant Discharge Elimination System (NPDES). Regulatory requirements to control nonpoint sources of nutrients and sediment from the Cabot MS4 area will not be addressed in this plan. Since the majority of nonpoint pollution sources associated with developed areas within this subwatershed are regulated, developed areas within this subwatershed will not be targeted in this plan.

Although there is not a large amount of developed land in the Skinner Branch-Bayou Two Prairie subwatershed, almost all of the developed area is located within the city limits of Carlisle. Since the SWAT model results indicate that developed areas do not contribute significantly to nutrient loads from this subwatershed, and since the target nutrient and sediment load reductions for this subwatershed are low, developed areas in this subwatershed will not be a focus for nutrient or sediment load reduction in this plan.

Based on aerial imagery from 2017, a few Stuttgart neighborhoods are located within the upper area of the Upper Mill Bayou subwatershed, along with a golf course. As recently as 2017, construction of new residences was occurring in this area of Stuttgart.

There are no incorporated towns located in the Hurricane Bayou subwatershed. Developed area in this subwatershed consists of roads and scattered residences and businesses.

The town of Gillett is located wholly within the Bills Bayou subwatershed. There is very little impervious area associated with this town. Runoff from Gillett drains to Flag Lake and is not expected to significantly affect water quality in Bills Bayou or Bayou Meto.

4.6.6 Pasture Runoff

Table 4.18 lists percentages of the recommended subwatersheds classified as pasture and hayland (Wickham, et al. 2021). Output from the SWAT model of Bayou Meto watershed identifies the portion of the modeled loads from pasture areas. This information is also shown in Table 4.18. The primary nonpoint nutrient and pathogen source associated with pasture is livestock. Poor vegetation conditions in pasture and/or riparian areas can allow nutrients, sediment, and pathogens to be carried from pasture to streams. Fertilizer applied to pasture and haylands is another potential source of nutrients. Heavily used areas and other pasture areas with poor cover can be more susceptible to erosion, contributing sediment to runoff.

Table 4.18. Pasture areas and modeled load portions in recommended subwatersheds.

Subwatershed	Subwatershed percent pasture area (modeled percent area)	SWAT Model Output percent load from pasture areas		
		Nitrogen load	Phosphorus load	Sediment load
Headwaters Bayou Meto	34% (29%)	64%	70%	56%
Glade Branch-Bayou Two Prairie	27% (25%)	59%	66%	45%
Skinner Branch-Bayou Two Prairie	1% (0)	0	0	0
Mill Bayou	<1% (0)	0	0	0
Hurricane Bayou	<1% (0)	0	0	0
Bills Bayou	<1% (0)	0	0	0

4.6.7 Cropland Runoff

Table 4.19 lists percentages of the recommended subwatersheds classified as cropland (Wickham, et al. 2021). Output from the SWAT model of Bayou Meto watershed identifies the portion of the modeled loads from cropland areas. This information is also shown in Table 4.18.

Table 4.19. Cropland areas and modeled load portions in recommended subwatersheds.

Subwatershed	Subwatershed percent cropland area (modeled percent area)	SWAT Model Output percent load from cropland areas		
		Nitrogen load	Phosphorus load	Sediment load
Headwaters Bayou Meto	0 (0)	0	0	0
Glade Branch-Bayou Two Prairie	1% (0)	0	0	0
Skinner Branch-Bayou Two Prairie	78% (80%)	82%	81%	63%
Upper Mill Bayou	81% (83%)	95%	91%	68%
Hurricane Bayou	81% (90%)	98%	98%	99%
Bills Bayou	78% (85%)	98%	98%	99%

Fertilizers applied to cropland can be carried to surface waters by runoff if they are not all used by the crop or retained in the field. Runoff from croplands can also carry sediment eroded from fields to surface waters. Tilled and bare soil is a source of sediment in cropland runoff.

Results from recent edge-of-field water quality monitoring in northeast Arkansas indicate that higher loads of phosphorus (total phosphorus and orthophosphate), nitrate, and sediment come from furrow-irrigated crops (soybeans and cotton) than from flooded rice. For total nitrogen, though, measured loads (kg/ha) from flooded rice were similar to those from furrow-irrigated row crops. This study also found that nutrient (total phosphorus and total nitrogen) and sediment loads from cultivated fields are statistically higher during the non-growing season than during the growing season (Reba, et al. 2020).

Based on these data, in the cropland-dominant recommended subwatersheds of Bayou Meto, furrow-irrigated crops (e.g., corn and soybeans) are the primary cropland sources of phosphorus and sediment during the growing season, and all crops contribute equally to the total nitrogen load from cropland. During the non-growing season, fields without cover (i.e., not planted or flooded) are the primary source of cropland nutrient and sediment loads.

4.6.8 Fertilizer

Commercial fertilizer applied to lawns in developed areas can be a significant source of nutrients to surface waters (Hobbie, et al. 2017). Fertilizers applied to pastures and croplands have the potential to contribute nutrients to surface waters. Statewide average fertilizer use reported in the Census of Agriculture for crops grown in the recommended subwatersheds are summarized in Table 4.20. Data on fertilizer use for corn in Arkansas was not available.

Table 4.20. Statewide fertilizer application totals for crops grown in the recommended subwatersheds (USDA National Agricultural Statistics Service 2020).

Crop	Reporting Year	Nitrogen Average Application, pounds/acre/year	Phosphate Average Application, pounds/acre/year
Rice	2013*	92	61
Soybeans	2020	(not reported)[+]	69
Soybeans	2018	34	66

* Most recent year for which data were reported. [+] To protect privacy

4.6.9 Livestock

In the pasture-dominant recommended subwatersheds, livestock using pastures are sources of nutrients and pathogens that can enter surface water (Justus, et al. 2010). Cattle wastes deposited in or beside streams can provide nutrients and pathogens to streams (e.g., cows loitering in streams). In addition, livestock use of riparian areas and streams can increase streambank and channel erosion. James et al. (2007) found that pastured cattle deposited significantly more manure in and near streams than in other areas of the pasture. Studies have shown that, unless access to streams is restricted, cattle generally spend much of the day in the riparian area, no matter the season or the availability of other water sources (Zuo and Miller-Goodman 2004; Bagshaw, et al. 2008).

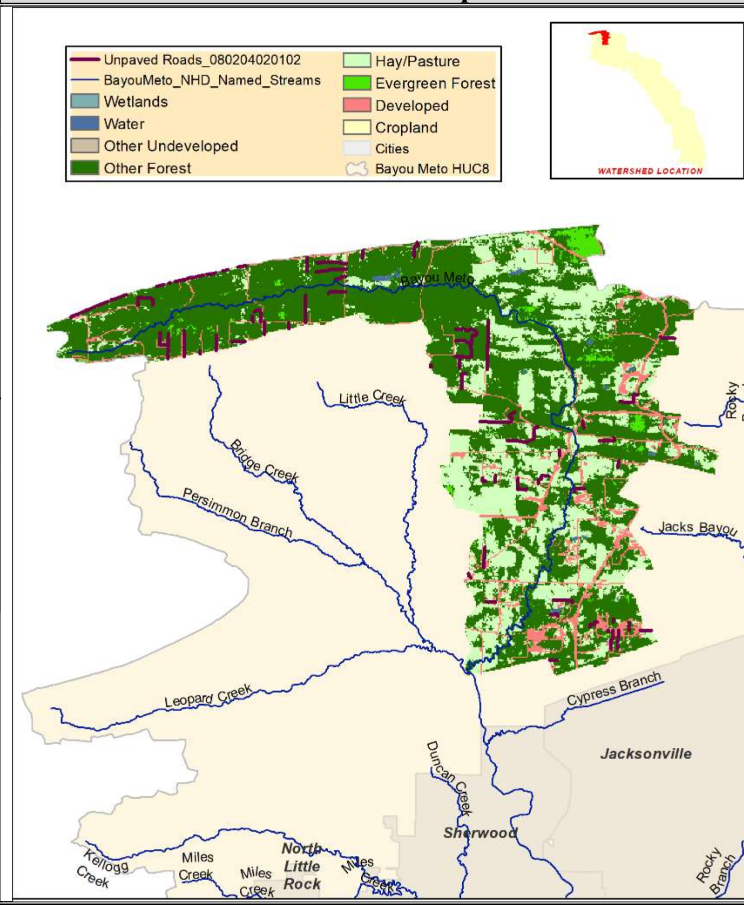
4.6.10 Wildlife

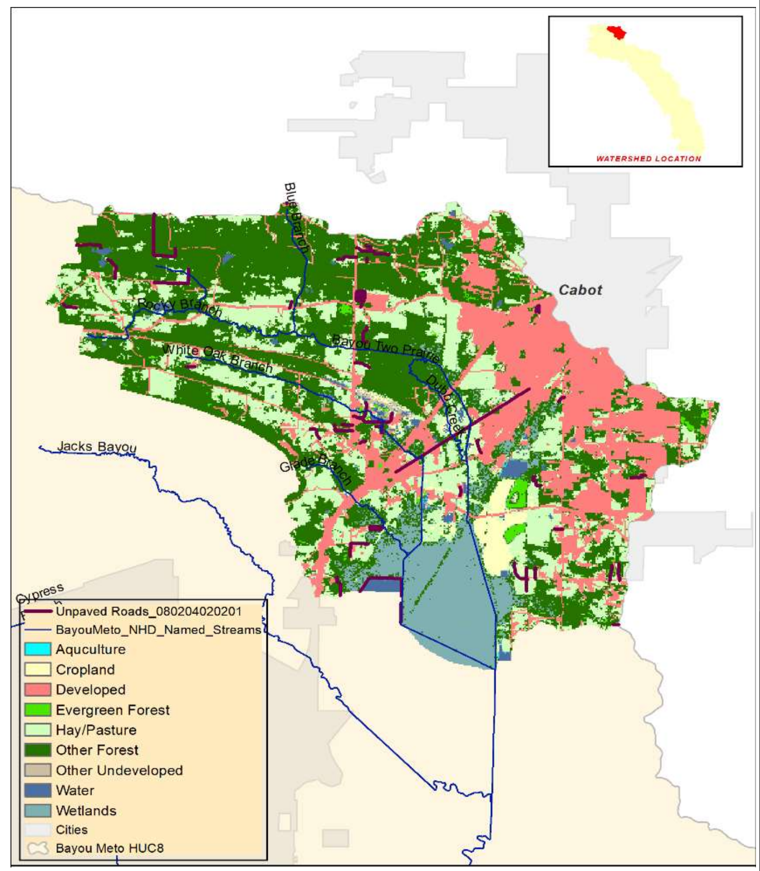
A high level of feral hog activity has been reported in Arkansas County and low activity has been reported in Pulaski and Lonoke Counties (McPeake, Wallen and Bennet 2019). Arkansas County is currently a focus area for feral hog control (NRCS 2019). In 2021 over 600 feral hogs were removed from Arkansas County (Arkansas Feral Hog Eradication Task Force 2022). It was not confirmed if feral hogs have been reported in the recommended subwatersheds.

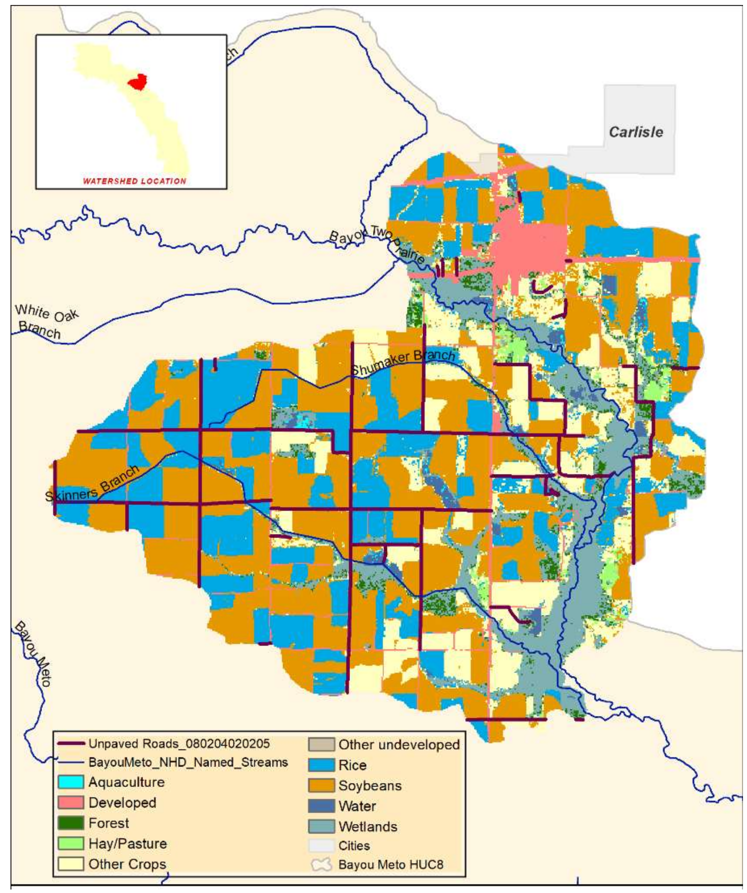
4.6.11 Summary

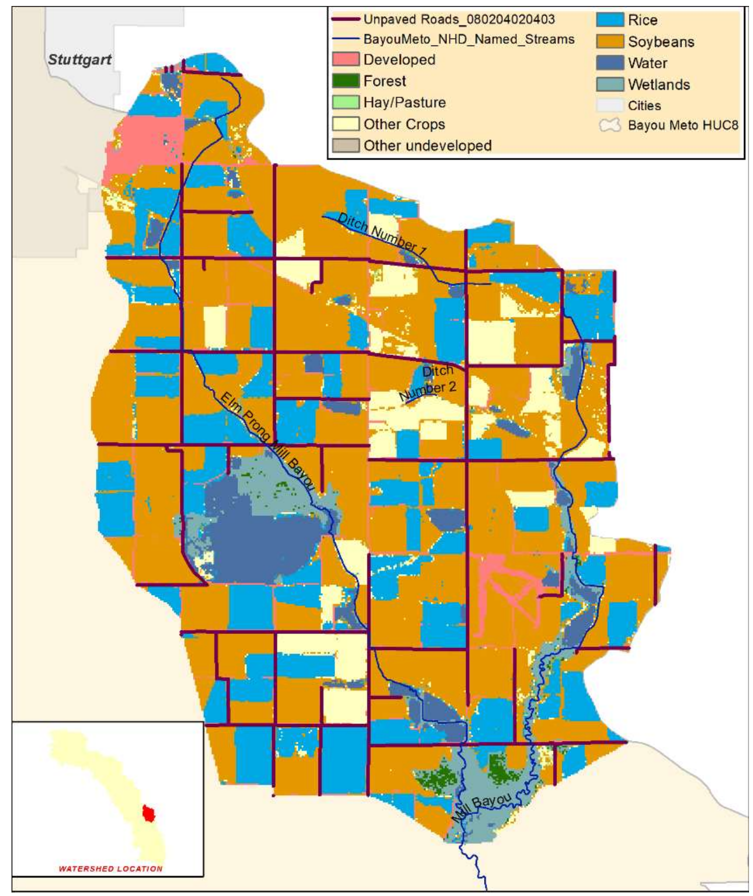
Each of the recommended subwatersheds contains more than one nonpoint source of nutrients and sediment discussed above. Table 4.21 lists the recommended subwatersheds and nonpoint pollution sources of the target pollutants known or expected to be present. Focus areas for management include developed areas, croplands, and pasture and haylands along streams. Of particular interest are areas within 50 feet of streams. Note that this watershed management plan is intended to address only unregulated nonpoint sources. Some nonpoint sources, such as stormwater runoff from developed areas or construction sites may be regulated by DEQ.

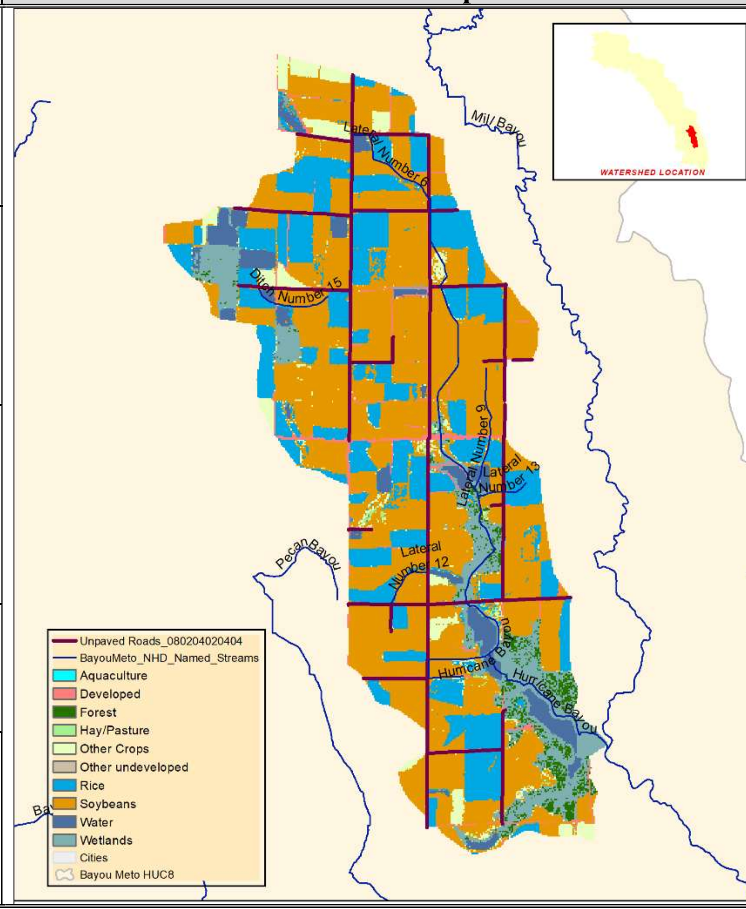
Table 4.21. Summary of pollutants of concern and nonpoint sources in recommended subwatersheds of Bayou Meto.

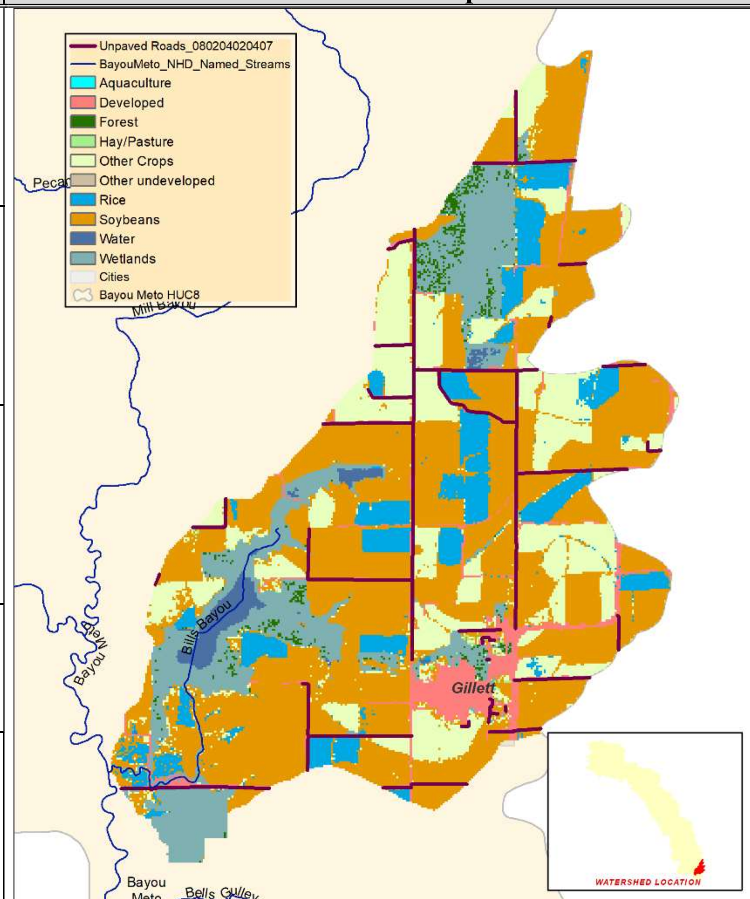
Headwaters Bayou Meto (080204020102) WQ Concerns: Low DO, siltation, quantity & quality of riparian buffers, quality of aquatic habitat, excess pathogens in runoff				
Target Land Use	**% of Area**	**Pollutant of concern**	**Target Nonpoint Pollutant Sources**	**Land Use Map**
Developed	7%	Nitrogen	Fertilizer, stormwater runoff	
		Sediment	Construction, stormwater runoff, streambank erosion, gully erosion	
Pasture & hayland	34%	Nitrogen	Stormwater runoff, livestock, fertilizer	
		Pathogens	Livestock, stormwater runoff	
		Sediment	Stormwater runoff, gully erosion, livestock heavy use areas, streambank erosion	

Glade Branch-Bayou Two Prairie (080204020201) WQ Concerns: Low DO, disappearing wetlands, reducing nutrient loads to Gulf of Mexico, siltation, quantity & quality of riparian buffers, protected habitat, excess pathogens in runoff				
Target Land Use	**% of Area**	**Pollutant of concern**	**Nonpoint Pollutant Sources**	**Land Use Map**
Developed (nonpoint pollutant sources regulated by DEQ)	23%	Nitrogen, phosphorus	Fertilizer, pet waste, stormwater runoff	
		Pathogens	Pet waste, stormwater runoff	
		Sediment	Construction, stormwater runoff, streambank erosion, gully erosion	
Pasture & hayland	27%	Nitrogen, phosphorus	Runoff, livestock, fertilizer	
		Pathogens	Stormwater runoff, livestock	
		Sediment	Runoff, gully erosion, livestock heavy use areas, streambank erosion	

Skinners Branch-Bayou Two Prairie (080204020205) WQ Concerns: Pesticides and herbicides in runoff, low DO, disappearing wetlands, reducing nutrient loads to Gulf of Mexico, quality of aquatic habitat, protected habitat				
Target Land Use	**% of Area**	**Pollutant of concern**	**Nonpoint Pollutant Sources**	**Land Use Map**
Cultivated crops	78%	Nitrogen	Fertilizer, stormwater runoff, fields without cover	
		phosphorus	Fertilizer, stormwater runoff, runoff from furrow irrigation, fields without cover	
		Pesticides and herbicides	Stormwater runoff, irrigation runoff	
		Sediment	Sheet, rill, wind erosion; stormwater runoff; furrow-irrigated crops; fields without cover; unpaved roads	

<table>
<tr><th colspan="5">Upper Mill Bayou (080204020403)
WQ Concerns: Pesticides and herbicides in runoff, disappearing wetlands, reducing nutrient loads to Gulf of Mexico, siltation in streams and ditches</th></tr>
<tr><th>Target Land Use</th><th>% of Area</th><th>Pollutant of concern</th><th>Nonpoint Pollutant Sources</th><th>Land Use Map</th></tr>
<tr><td>Developed</td><td>7%</td><td>Sediment</td><td>Construction, unpaved roads, stormwater runoff</td><td rowspan="5">
</td></tr>
<tr><td rowspan="4">Cultivated crops</td><td rowspan="4">81%</td><td>Nitrogen</td><td>Fertilizer, stormwater runoff, fields without cover, feral hogs</td></tr>
<tr><td>phosphorus</td><td>Fertilizer, stormwater runoff, runoff from furrow irrigation, fields without cover, feral hogs</td></tr>
<tr><td>Pesticides and herbicides</td><td>Stormwater runoff, irrigation runoff</td></tr>
<tr><td>Sediment</td><td>Stormwater runoff; furrow-irrigated crops; fields without cover; feral hogs</td></tr>
</table>

Hurricane Bayou (080204020404) WQ Concerns: Pesticides and herbicides in runoff, disappearing wetlands, reducing nutrient loads to Gulf of Mexico, siltation in streams and ditches, quality and quantity of riparian buffers				
Target Land Use	**% of Area**	**Pollutant of concern**	**Nonpoint Pollutant Sources**	**Land Use Map**
Developed	3%	Sediment	Unpaved roads	
Cultivated crops	81%	Nitrogen	Fertilizer, stormwater runoff, fields without cover, feral hogs	
		phosphorus	Fertilizer, stormwater runoff, runoff from furrow irrigation, fields without cover, feral hogs	
		Pesticides and herbicides	Stormwater runoff, irrigation runoff	
		Sediment	Stormwater runoff; furrow-irrigated crops; fields without cover; streambank erosion; sheet, rill, wind erosion; feral hogs	

Bills Bayou (080204020407) WQ Concerns: Pesticides and herbicides in runoff, disappearing wetlands, reducing nutrient loads to Gulf of Mexico, siltation in streams and ditches				
Target Land Use	**% of Area**	**Pollutant of concern**	**Nonpoint Pollutant Sources**	**Land Use Map**
Developed	5%	Sediment	Unpaved roads	
Cultivated crops	78%	Nitrogen	Fertilizer, stormwater runoff, fields without cover, feral hogs	
		phosphorus	Fertilizer, stormwater runoff, runoff from furrow irrigation, fields without cover, feral hogs	
		Pesticides and herbicides	Stormwater runoff, irrigation runoff	
		Sediment	Stormwater runoff; furrow-irrigated crops; fields without cover; gully erosion; sheet, rill, wind erosion; feral hogs	

4.7 Management Practices

There are two approaches for managing nonpoint source pollution inputs. The first is to reduce the sources of the pollutant that can end up in runoff. Examples of this approach include activities that reduce the use of fertilizer or irrigation water or activities that reduce runoff and erosion. The second approach is to implement measures that remove or capture pollutants in runoff. Examples of this approach include practices that capture or filter runoff.

Prior to the second public meeting for this watershed management plan, selected stakeholders (representatives of natural resource agencies, interest groups, and communities) were asked to identify management practices appropriate for addressing water quality issues in the Bayou Meto watershed. Table 4.22 lists the practices identified by these stakeholders. These practices are applicable primarily for addressing the agricultural nonpoint pollution sources listed in Section 4.6.

Developed, residential, and agricultural land uses are present in the recommended subwatersheds and have potential nonpoint sources of pathogens, nutrients, and sediment associated with them (see Section 4.6). Below, management practices appropriate to the unregulated nonpoint sources of sediment and nutrients associated with these land uses in the recommended subwatersheds are discussed separately.

4.7.1 Residential Areas and Unpaved Roads

In this watershed management plan, nonpoint sources of nutrients and sediment associated with developed and residential areas within the incorporated areas of the City of Cabot in the Glade Branch-Bayou Two Prairie subwatershed are expected to be addressed under the city's NPDES MS4 permit (permit no. ARR040013).

Table 4.23 lists examples of management practices applicable for reducing sediment and nutrient loads from residential areas and unpaved roads within the recommended subwatersheds for this plan. Practices highlighted in yellow were recommended by stakeholders for the Bayou Meto watershed.

Table 4.22. Management practices recommended by stakeholders for Bayou Meto watershed, with targeted sources.

Stakeholder Recommended Practices	Targeted pollutant sources*								Management approach
	Streambank erosion	Gully erosion	Road erosion	Pasture runoff	Urban runoff	Cropland runoff	Sheet, rill, wind erosion cropland	Livestock in streams	
Nutrient mgt plans				X		X			Reduce
Soil testing				X		X			Reduce
Conservation tillage						X	X		Reduce
Dropped pipe/slotted board risers	X	X				X			Reduce
Cover crops		X				X	X		Reduce
Tailwater recovery system	X	X				X			Reduce, capture
Pipe Planner						X	X		Reduce
Surge valves						X	X		Reduce
Prescribed grazing	X	X		X				X	Reduce
Controlled stream access	X							X	Reduce
Grassed riparian areas	X			X	X	X	X		Reduce, capture
Streambank stabilization	X								Reduce
Wetland protection, restoration				X	X	X			Capture
Integrated pest mgt		X					X		Reduce
Land retirement (CRP)	X	X		X		X	X	X	Reduce

Table 4.23. Summary table of management practices for residential areas and management practices in the recommended subwatersheds "(practices highlighted with yellow were recommended by stakeholders for the Bayou Meto watershed).

Practice	Reduce Sources			Remove or Capture		
	Fertilizer Application	Sediment from Unpaved Roads	Runoff	Sediment	Nitrogen	Phosphorus
Fertilize only during growing season	X	--	--	--	--	--
Apply correct amount of fertilizer	X	--	--	--	--	--
Don't apply fertilizer before or immediately after heavy rainfall	X	--	--	--	--	--
Utilize environmentally sensitive road maintenance	--	X	--	--	--	--
Install bioretention basins (rain gardens)	--	--	X	X	X	X
Restoration of natural wetlands	--	--	--	X	X	X
Install riparian buffer	--	--	--	X	X	X

4.7.1.1 Practices to Reduce Nutrient and Sediment Sources

A possible nutrient source associated with residential areas in the recommended subwatersheds that could be reduced is commercial fertilizer. Homeowners and lawn care companies can reduce the amount of fertilizer that gets into runoff from lawns by applying fertilizers only during the growing season, not over-applying fertilizer, and not applying fertilizer immediately before or after heavy rainfall (Patton 2008).

Erosion of unpaved roads is a possible sediment source in some of the recommended subwatersheds. Environmentally sensitive maintenance practices reduce erosion associated with unpaved roads, thus reducing sediment load.

4.7.1.2 Practices to Capture Pollutants in Runoff

Runoff from residential areas can carry a variety of pollutants to surface waters. In addition, the impervious surfaces in residential areas increase the amount of runoff entering stream channels, causing increased streambank and channel erosion. There are stormwater management practices for residential areas that can reduce nutrients and sediment by capturing and/or improving the quality of storm runoff. Bioretention basins (i.e., rain gardens) in residential areas can reduce or delay the amount of storm runoff entering stream channels, as well as reduce nitrogen and sediment loss (Clary, et al. 2020). Natural or restored wetlands can reduce nutrient and sediment concentrations in runoff from residential areas (stakeholders recommended wetland protection and restoration). Riparian buffers (i.e., grassed riparian areas suggested by stakeholders, or forested riparian areas) are also a recommended practice to remove pollutants from urban runoff (Cunningham n.d.). Riparian buffers have been shown to reduce nutrient and sediment inputs to streams (Klapproth and Johnson 2009, Merriman, Gitau and Chaubey 2009).

4.7.2 Pasture

Pasture is a targeted source of nonpoint source pollution in the two pasture-dominant recommended subwatersheds, Headwaters Bayou Meto and Glade Branch – Bayou Two Prairie.

4.7.2.1 Practices to Reduce Pasture Nutrients and Sediment Sources

Possible nutrient and sediment sources associated with pasture in the recommended subwatersheds that could be reduced include fertilizer, livestock in streams, runoff, gully erosion, and streambank erosion. Agricultural land retirement (recommended by stakeholders) can eliminate or reduce all these sources. Soil testing and nutrient management plans (both recommended by stakeholders) can help farmers apply fertilizer so the amount in runoff is minimized. In addition, prescribed grazing (stakeholder-recommended) increases plant vigor and nutrient uptake so nutrients in manure and applied fertilizer are not available to run off (NRCS 2021). Prescribed grazing can also increase water infiltration on pastures, reducing runoff (Sollenberger, et al. 2012).

Eliminating or reducing livestock access to streams associated with pastures can reduce inputs of livestock waste (a source of nutrients and pathogens) directly into the streams and reduce streambank erosion. Practices such as alternative water sources, livestock shelter structures, access control (recommended by stakeholders), and prescribed grazing (recommended by stakeholders) can reduce the time livestock spend in or along streams, the inputs of livestock waste into the streams, and the impacts to streambank stability (NRCS 2021; George, et. al. 2011).

Management practices recommended by stakeholders that can reduce gully and streambank erosion on pastures are prescribed grazing and streambank stabilization. Riparian buffers also stabilize streambanks and reduce bank erosion. Additional pasture management practices NRCS has identified as reducing gully erosion in pastures are critical area planting and heavy-use area planting (NRCS 2021).

4.7.2.2 Practice to Capture Pollutants in Runoff

A management practice that can reduce nutrient and sediment loads from pastures by improving runoff quality is riparian buffers (i.e., grassed riparian areas suggested by stakeholders) (NRCS 2021; George, et al. 2011).

4.7.3 Cropland

Cropland is a targeted source of nonpoint source pollution in the four cropland-dominant recommended subwatersheds.

4.7.3.1 Practices to Reduce Nutrient and Sediment Sources

Possible nutrient and sediment sources associated with croplands in the recommended subwatersheds that could be reduced using management practices include commercial fertilizer, feral hogs, runoff, irrigation tailwater, gully erosion, streambank erosion, and sheet, rill, and wind erosion. Agricultural land retirement (recommended by stakeholders) can reduce all these sources except feral hogs. Soil testing and nutrient management plans (both recommended by stakeholders) can help farmers apply commercial fertilizer such that the amount of fertilizer in runoff is minimized. In addition, cover crops (stakeholder recommendation) can take up fertilizer nutrients not used by the cash crop, so they are not available to run off during the non-growing season (NRCS n.d.).

There are active efforts to control the population of feral hogs in Arkansas, including large-scale eradication efforts in Arkansas County (McPeake, Hoy and Fairhead n.d.; Arkansas

Feral Hog Eradication Task Force 2021). Reducing feral hogs reduces their manure as a nutrient source and reduces their land-disturbance activities that can increase erosion.

Management practices recommended by stakeholders that can reduce gully erosion on cropland are conservation tillage, grade stabilization structures (i.e., dropped pipe or slotted board risers), cover crops, tailwater recovery, and integrated pest management. Additional practices identified by NRCS as reducing gully erosion include grassed waterways and irrigation land-leveling or precision land-forming (NRCS 2021). Management practices recommended by stakeholders that can reduce sheet, rill, and/or wind erosion are cover crops, conservation tillage, irrigation water management (i.e., pipe planner and surge valves), and integrated pest management. Additional practices identified by NRCS as reducing sheet, rill, and/or wind erosion are mulching and irrigation land-leveling (NRCS 2021). Winter flooding of rice fields can also reduce rice field erosion during the non-growing season.

Management practices recommended by stakeholders that can reduce runoff from croplands are conservation tillage, cover crops, irrigation water management (i.e., pipe planner and surge valves), and tailwater recovery systems. Additional practices that can reduce runoff from croplands include winter flooding of rice fields and alternative rice irrigation approaches (e.g., multiple inlet rice irrigation and alternate wetting and drying).

4.7.3.2 Practices to Capture Pollutants in Runoff

Management practices recommended by stakeholders that can reduce nutrient and sediment loads to surface water by improving runoff quality from croplands are riparian buffers (i.e., grassed riparian areas), tailwater recovery systems, and wetlands protection or restoration. Additional practices that can remove sediment and nutrients from cropland runoff include field borders, water and sediment control basins, and two-stage ditches.

4.7.4 Summary

Table 4.24 summarizes nonpoint source pollution management practices suggested for each of the recommended subwatersheds, based on the nonpoint source pollution sources in each that are proposed to be targeted under this plan. Practices highlighted in yellow were recommended by stakeholders for the Bayou Meto watershed.

Table 4.24. Management practices proposed for recommended subwatersheds of Bayou Meto (practices highlighted with yellow were recommended by stakeholders for the Bayou Meto watershed).

Practices*	Headwaters Bayou Meto	Glade Br Bayou Two Prairie	Skinner Br Bayou Two Prairie	Upper Mill Bayou	Hurricane Bayou	Bills Bayou
Residential Area and Unpaved Roads Management Practices						
Fertilizer use management	X	X	-	-	-	-
Environmentally sensitive road maintenance	-	-	-	X	X	X
Bioretention basins (rain gardens)	X	X	-	-	-	-
Pasture and Hayland Management Practices						
Nutrient management plans	X	X	-	-	-	-
Soil testing	X	X	-	-	-	-
Livestock stream access control	X	X	-	-	-	-
Alternative water supply	X	X	-	-	-	-
Heavy use area treatment	X	X	-	-	-	-
Prescribed/rotational grazing	X	X	-	-	-	-
Land retirement	X	X	-	-	-	-
Integrated pest management	X	X	-	-	-	-
Livestock shelter	X	X	-	-	-	-
Cropland Management Practices						
Nutrient management plans	-	-	X	X	X	X
Soil testing	-	-	X	X	X	X
Conservation tillage	-	-	X	X	X	X
Dropped pipe/slotted board riser	-	-	X	X	X	X
Cover crops	-	-	X	X	X	X
Tailwater recovery system	-	-	X	X	X	X
Pipe planner	-	-	X	X	X	X
Surge valves	-	-	X	X	X	X
Integrated pest management	-	-	X	X	X	X
Land retirement	-	-	X	X	X	X

Table 4.24. Management practices proposed for recommended subwatersheds of Bayou Meto (continued).

Practices*	Headwaters Bayou Meto	Glade Br Bayou Two Prairie	Skinner Br Bayou Two Prairie	Upper Mill Bayou	Hurricane Bayou	Bills Bayou
Cropland Management Practices (continued)						
Control of feral hogs	-	-	X	X	X	X
Field borders	-	-	X	X	X	X
Grassed waterways	-	-	X	X	X	X
Two-stage ditches	-	-	X	X	X	X
Water and sediment control basins	-	-	X	X	X	X
Winter flooding rice fields	-	-	X	X	X	X
Land leveling, land forming	-	-	X	X	X	X
Alternative rice irrigation	-	-	X	X	X	X
Management Practices for Multiple Land Uses						
Riparian buffers	X	X	X	X	X	X
Streambank stabilization	X	X	-	-	X	-
Wetland protection/restoration	X	X	X	X	X	X

4.8 Meeting Reduction Goals

This subsection explores whether it is possible to achieve the target interim nutrient and sediment load reductions identified in Section 4.5. Information has been published on the effectiveness of a number of the management practices identified in Section 4.7 for reducing selected pollutants in surface waters. Table 4.25 shows reported reduction percentages for total nitrogen, coliforms, sediment or TSS, and total phosphorus. These data show that, while this plan targets nutrients and sediment, practices that reduce these pollutants also reduce the pathogens that are a concern in the pasture-dominant recommended subwatersheds.

As part of a Gulf of Mexico Hypoxia Task Force project, Arkansas experts identified expected large-scale nutrient reduction efficiencies for selected individual agricultural management practices (FTN Associates, Ltd. 2019). These reduction efficiencies are shown in bold font in Table 4.25. This project also identified nutrient reduction efficiencies for several suites of agricultural management practices often implemented together in Arkansas (Table 4.26).

Table 4.25. Reported reduction efficiencies for selected management practices.

Practice	Target land use	Total nitrogen reduction	Total phosphorus reduction	Sediment reduction	Fecal coliform reduction
Forested riparian buffer	All	47-59%[a], 37-57%[c], 44-70%[g], 68-89%[k], 45%-48%[r], **35% (pasture), 30% (cropland)**[v]	53-63%[a], 45-70%[g], 30-80%[k], 40%-46%[r], **35% (pasture), 45% (cropland)**[v]	76%[b], 94%[o] 55-95%[c], 45-70%[g], 60-90%[k], 53%-57%[r]	30%[o]
Grassed riparian areas	All	68%[d], 31-48%[g], 50-76%[k], 34%-87%[r], **35% (pasture), 20% (cropland)**[v]	67%[d], 50-70%[g], 50-89%[k], 44%-77%[r], **35% (pasture), 45% (cropland)**[v]	23%[d], 50-70%[g], 66-84%[k], 53%-65%[r]	21-100%[k], 70-95%[l]
Nutrient management plans	Agriculture	0-84%[c], **10%**[v]	8-91%[c], **15%**[v]	72-92%[c]	No information found
Soil testing	Agriculture	15%[r]	45%[r]	Not applicable	No information found
Streambank stabilization	Agriculture	15%-75%[r]	22%-75%[r]	Up to 100%[m], 58%-75%[r]	No information
Conservation tillage	Cropland	9%-95%[b], 15%-25%[r], **10%**[v]	9%-91%[b], 36%-69%[r], **20%**[v]	55%-92%[b], 40%-77%[r]	Not applicable
Controlled drainage/Water control/grade stabilization structures (dropped pipe/slotted board risers)	Cropland	No information found	50%[p], 55%[q]	55% - 95%[a]	Not applicable
Cover crops	Cropland	66%[b], **25%**[v]	67%[b], **30%**[v]	70%-76%[b]	Not applicable
Cropland retirement (CRP)	Cropland	90%[r]	81%[r]	95%[r]	Not applicable
Pipe Planner	Cropland	No information found	No information found	No information found	Not applicable
Surge valves	Cropland	No information found	No information found	70%[t]	Not applicable
Tailwater recovery system	Cropland	**25%**[v]	**20%**[v]	77%[b] (value for sediment basin)	Not applicable
Winter flooding of fields	Cropland	No information found	No information found	67%-97%[n]	Not applicable
Bioretention basin	Developed	64-90%[o], 25-80%[s], 75%[w]	55-90%[o], 45-85%[s], 75%[w]	55-98%[s], 90%[w]	90%[w]
Environmentally sensitive road maintenance	Developed	No information found	No information found	80-94%[j] ,31-94%[u]	Not applicable
Controlled stream access	Pasture	32%[b], 60%[e], **10%**[v]	76%[b], 60%[e], **15%**[v]	83%[b], 75%[e], 60%[r]	30% - 95%[f] 44-52%[h]
Heavy use area protection	Pasture	86%[i], **10%**[v]	50%[i], **15%**[v]	98%[i]	92-99%[i]
Prescribed grazing	Pasture	20%[g], **10%**[v]	20%[g], **15%**[v]	60%[b], 20%[g], 33%[r]	90-96%[e]
Watering facility	Pasture	41%[a], 13-77%[c], 30%[e], **10%**[v]	74-97%[c], 30%[e], **15%**[v]	38%[a], 38-96%[c], 30%[e], 19%[r]	57%[b], 51-94%[i]

Ecological Conservation Organization 2009
b Merriman, Gitau and Chaubey 2009
c BMP Tool II
d Garrett 2011
e Peterson, Redmon and McFarland 2011a
f Peterson, Redmon and McFarland 2011b
g EPA 2010
h Stream crossing combined with other practices from Peterson, Redmon and McFarland 2011f
i Peterson, Redmon and McFarland 2011g
j The Nature Conservancy 2017
k Klapproth and Johnson 2009
l Koelsch, Lorimer and Mankin 2006
m Van Epps 2014
n Mississippi State University Forest and Wildlife Research Center 1999
o https://swbmp.vwrrc.vt.edu/
p Feset et al. 2010
q Ross et al. 2016
r STEPL v4.4b
s Simpson & Weammert 2009
t Shock et al. 1993
u Scheetz and Bloser 2008
v FTN Associates, Ltd. 2019
w https://www.mapc.org/resource-library/fact-sheet-bioretention-areas

Table 4.26. Nutrient reduction efficiencies for practice suites of the Arkansas Nutrient Reduction Framework (FTN Associates, Ltd. 2019).

Practice Suite	Total Phosphorus Reduction	Total Nitrogen Reduction
Irrigation Water Management Practices Suite	40%	55%
Tailwater Recovery Practices Suite	35%	50%
Reduced Irrigation Water Use Practices Suite	5%	5%
Row Crop Soil Nutrient Management Practices Suite	25%	15%
Conservation Tillage and Cover Crop Suite	55%	50%
Pasture Management Practices Suite	65%	45%

Information from Tables 4.25 and 4.26 and Section 4.7 was used to estimate potential nutrient and sediment reduction percentages from applying management practices in the recommended subwatersheds. Tables 4.27 through 4.30 summarize these estimates of potential load reductions for the recommended subwatersheds. The values presented in these tables assume that all of the source is treated. Values highlighted in green meet or exceed the load reduction target for the pollutant and subwatershed. The calculations and assumptions used to develop these estimates are provided in Appendix I.

In the pasture-dominant recommended subwatersheds, the estimates of potential load reductions indicate that multiple load sources will need to be treated with multiple practices to achieve the load reduction targets (Table 4.27). Cabot (in the Glade Branch - Bayou Two Prairie subwatershed) is a small MS4 and has a stormwater management plan, and Cabot municipal code includes flood damage-reduction requirements and allows low-impact development.

In cropland-dominant recommended subwatersheds, management practices that reduce irrigation water use will also be useful for reducing nutrient and sediment loads. Many of the proposed management practices reduce nutrient and sediment loads, so producers can choose practices appropriate for their soil type and crops.

Table 4.27. Estimated potential load reductions for pasture-dominant recommended Bayou Meto subwatersheds (values highlighted in green meet or exceed the load reduction target for the pollutant and subwatershed).

Parameter	Total Nitrogen		Total Phosphorus		Sediment	
HUC12	Headwaters Bayou Meto	Glade Br Bayou Two Prairie	Headwaters Bayou Meto	Glade Br Bayou Two Prairie	Headwaters Bayou Meto	Glade Br Bayou Two Prairie
Target reduction	12%	47%	No reduction	68%	86%	94%
Practices						
Prescribed grazing	6%	6%	-	9%	17%	14%
Pasture streambank stabilization with fence	48%	44%	-	9%	42%	34%
Pasture stream access control	6%	6%	-	44%	34%	27%
Pasture forested buffer	22%	21%	-	21%	34%	27%
Pasture grassed buffer	22%	21%	-	21%	34%	27%
Pasture nutrient management plan	6%	6%	-	9%	34%	27%
Pasture management suite	29%	27%	-	38%	36%	29%
Urban bioretention	10%	13%	-	Increase	33%	42%
Urban grass buffer strip	6%	8%	-	Increase	22%	29%

Table 4.28. Estimated potential nitrogen load reductions for cropland-dominant recommended Bayou Meto subwatersheds (values highlighted in green meet or exceed the load reduction target for the pollutant and subwatershed).

HUC12	Skinner Br Bayou Two Prairie	Upper Mill Bayou	Hurricane Bayou	Bills Bayou
Nitrogen reduction target	21%	34%	41%	56%
Practices				
Conservation till	8%	9%	10%	10%
Nutrient management plan	8%	9%	10%	10%
Soil nutrient mgt suite	12%	14%	15%	15%
Irrigation mgt suite	45%	52%	37%	53%
Tailwater recovery suite	41%	47%	37%	49%
Grassed buffer	16%	19%	20%	20%
Winter flooding of rice fields	No data	No data	No data	No data
Conservation till + cover crop	28%	35%	35%	42%
Cover crops	14%	18%	18%	21%

Table 4.29. Estimated potential phosphorus load reductions for cropland-dominant recommended Bayou Meto subwatersheds (values highlighted in green meet or exceed the load reduction target for the pollutant and subwatershed).

HUC12	Skinner Br Bayou Two Prairie	Upper Mill Bayou	Hurricane Bayou	Bills Bayou
Phosphorus reduction target	23%	41%	57%	54%
Practices				
Conservation till	16%	18%	20%	20%
Nutrient management plan	12%	14%	15%	15%
Irrigation management suite	32%	36%	39%	39%
Tailwater recovery suite	28%	32%	34%	34%
Soil nutrient management suite	20%	23%	25%	25%
Grassed buffer	36%	41%	44%	44%
Cover crops	22%	26%	27%	28%
Conservation till + cover crop	41%	47%	50%	52%

Table 4.30. Estimated potential sediment load reductions for cropland-dominant recommended Bayou Meto subwatersheds (values highlighted in green meet or exceed the load reduction target for the pollutant and subwatershed).

HUC12	Skinner Br Bayou Two Prairie	Upper Mill Bayou	Hurricane Bayou	Bills Bayou
Sediment reduction target	26%	65%	4%	27%
Practices				
Conservation till	41%	44%	64%	64%
Nutrient management plan	38%	41%	59%	59%
Irrigation management suite	47%	51%	74%	74%
Tailwater recovery suite	47%	51%	74%	74%
Grassed buffer	38%	41%	59%	59%
Cover crops	38%	44%	62%	69%
Conservation till + cover crop	38%	44%	62%	69%
Winter flooding of rice fields	8%	7%	11%	5%
Environmentally sensitive maintenance of unpaved county roads	-	26%	-	-

4.9 Summary

Nonpoint source pollution concerns and management goals have been identified. Six HUC12 subwatersheds have been recommended in which to focus water quality improvement efforts under this plan. Water quality parameters that will be targeted for reduction are total nitrogen, total phosphorus, and sediment. Load reduction targets for these parameters were set for each recommended subwatershed based on modeled loads. Potential sources of nutrient and sediment loads were identified for each of the recommended subwatersheds, along with management practices to address those sources. Finally, the potential for the identified management practices to achieve nutrient and sediment load reduction targets was evaluated.

5.0 IMPLEMENTATION STRATEGY

The implementation strategy for the Bayou Meto watershed management plan includes several elements and follows the adaptive management process. The strategy elements are described in this section. In addition to implementing practices to manage unregulated nonpoint pollution sources, the implementation strategy includes:

- Information and education activities aimed at watershed stakeholders,
- An implementation lead to coordinate voluntary activities in recommended subwatersheds,
- Water quality and biological monitoring to document any changes resulting from voluntary nonpoint source pollution management activities,
- Milestones for implementation,
- Criteria for evaluation of progress,
- Regular evaluation of progress toward plan goals,
- Update of the plan to accommodate changes in the watershed, and/or in understanding of the watershed, and
- Proposed implementation schedule.

5.1 Information and Education

Watershed management is fundamentally a social activity (Thornton and Laurin 2005). While technical solutions to problems are necessary for effective watershed management, they are not sufficient. Decisions on how to protect and improve water quality, and implement management practices, are ultimately based on the socioeconomic perceptions, beliefs, and values of landowners and stakeholders on how these technical solutions will affect them. The Information and Education objectives of this watershed plan, therefore, include the following:

- Increase local landowner and public awareness of the need for, and the benefits of, watershed restoration and protection practices;
- Increase stakeholder support and participation in watershed management activities for water quality protection and improvement; and

- Improve the understanding of how water quality and environmental improvements contribute to increased economic and social capital in communities.

5.1.1 Existing Outreach and Education in the Bayou Meto Watershed

There are many organizations active in the Bayou Meto watershed that have outreach and education programs in place that could be used as vehicles to accomplish the Information and Education objectives of this watershed management plan. Examples are listed in Table 5.1. Outreach and education activities of some of these organizations are described in Appendix J. Most, but not all, of these organizations are active throughout the Bayou Meto watershed.

Table 5.1. Bayou Meto watershed stakeholder groups and outreach programs.

Stakeholder Groups	Organizations with Information and Education Programs for the Stakeholders
Agriculture producers	NRCS, UofA Division of Agriculture, County Conservation Districts, Arkansas Grazing Lands Coalition, Arkansas Cattlemen's Association, Arkansas Farm Bureau, Rice Stewardship Partnership, Agriculture Council of Arkansas, Arkansas Soil Health Alliance, AGFC, Arkansas Resource Conservation and Development Council (ARCDC), Arkansas Soybean Promotion Board, USA Rice, Arkansas Corn and Grain Sorghum Board, Arkansas Rice Research and Promotion Board
Recreationists	USFWS; AGFC; Audubon Arkansas; The Nature Conservancy; Ducks Unlimited; Arkansas Department of Parks, Heritage, and Tourism
Landowners and residents	Rural Water Associations, NRCS, University of Arkansas Division of Agriculture, County Conservation Districts, AGFC, ANHC, The Nature Conservancy, Arkansas Master Naturalists, ARCDC, City of Cabot MS4 program
Local and county governments	Arkansas Economic Development Commission, NRD, ARCDC, Arkansas Farm Bureau
Concessioners, vendors, hostelers, restaurants	Arkansas Economic Development Commission; Arkansas Department of Parks, Heritage, and Tourism
Teachers	AGFC, DEQ, Arkansas Farm Bureau, Arkansas Soybean Promotion Board

5.1.2 Proposed Information and Education Activities

While there are already a number of organizations with active information and education programs that include the Bayou Meto watershed, two additional activities focused on the Bayou Meto watershed are proposed. These focused activities have the potential to increase awareness in the watershed and increase implementation of practices that reduce nonpoint source pollution and its impacts on water quality.

5.1.2.1 Social Media Platform for the Bayou Meto Watershed

Social media platforms are one of the primary sources of information on almost any topic within any age demographic (Pew Research Center 2021). Median ages of people living in the counties of the Bayou Meto watershed range from 36 to 47 years (US Census Bureau 2019). The majority of producers within these counties are between the ages of 35 and 64 (USDA National Agricultural Statistics Service 2017). The two social media platforms used most extensively by this age group are Facebook and YouTube (Figure 5.1). Using these two social media platforms in the Bayou Meto watershed, then, can be one of the more effective approaches for outreach and education. Most of the organizations active in the Bayou Meto watershed already utilize social media platforms to interact with their constituents. For example, NRD and the UofA Cooperative Extension currently have Facebook pages (https://www.facebook.com/Arkansas-Natural-Resources-Commission-127788010626999/, https://www.facebook.com/uaex.edu/). NRCS Arkansas uses Twitter extensively (https:// twitter.com/arkansasnrcs), and all three agencies host and refer users to YouTube (e.g., https://www.youtube.com/channel/UCWPRIlokkCy1DTROlEoW5OA/featured, https://www.youtube.com/user/ARextension). These three agencies also interact regularly with landowners in the watershed as well as nonprofit organizations such as Arkansas Soil Health Alliance, municipalities, conservation districts, county agencies, and other entities. As importantly, these three agencies also have individuals who routinely monitor traffic and post information on their platforms.

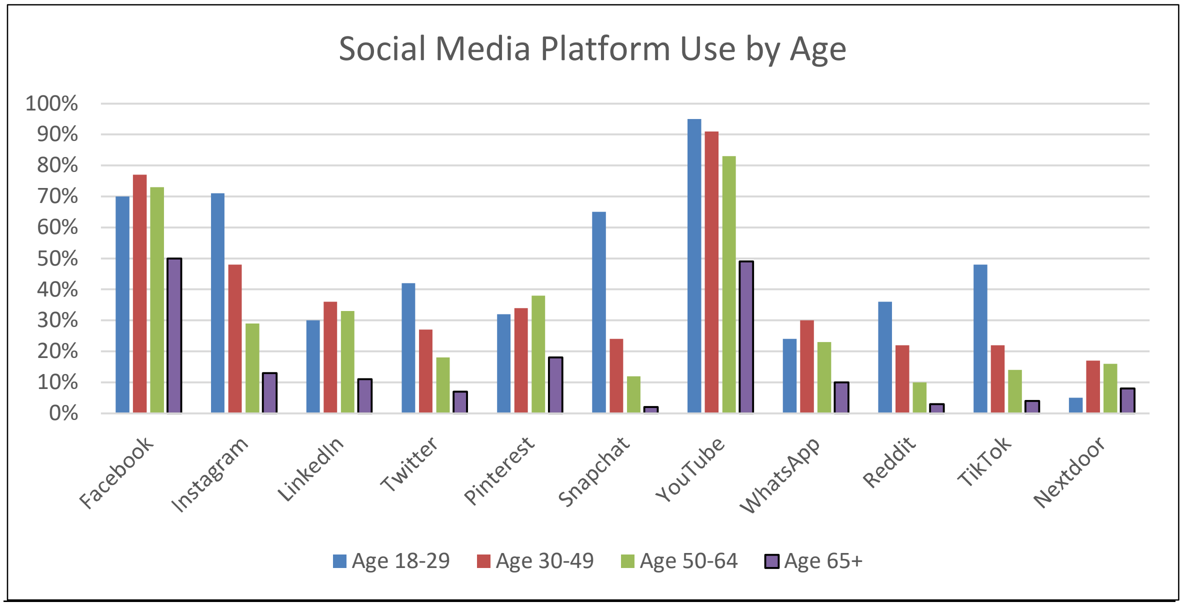


Figure 5.1. Social media platforms use by age group (Pew Research Center 2021).

To enhance the effectiveness of social media in attaining the Bayou Meto watershed management plan goals, several questions, including the following, need to be addressed:

- What are the social media goals?
- What social media platforms are proposed?
- Who is the target audience?
- What are the core demographics?
- What are the core metrics for tracking effectiveness?
- How often will these metrics be assessed?
- What type of content will be hosted?
- What are the best times to post on the platforms?
- Who will monitor and maintain the social media platforms?

A social media marketing checklist is included in Appendix K (York 2018).

The social media goals for the Bayou Meto watershed include the following:

- Provide landowners with technical information, opportunities for cost-share programs, and testimonials of landowners who have cost-effectively implemented management practices;
- Increase community engagement, volunteerism, and educational activities in furthering the goals of this watershed management plan;
- Encourage behavioral actions that protect, sustain, and improve water quality throughout the Bayou Meto watershed; and
- Highlight the economic benefits to landowners from protecting, sustaining, and improving water quality within the watershed.

Facebook and Twitter platforms already exist within NRD, NRCS, and UofA Cooperative Extension as well as county conservation districts and nonprofit interest groups (see information in Appendix J). These platforms not only currently have followers, but followers who are landowners within the watershed and represent the target audience for information. The following core metrics are suggested for these social media platforms:

- Number of clicks or hits,
- Number of likes,
- Number of re-Tweets, and
- Reach (e.g., the number of residents and visitors in the watershed who access social media posts about the watershed).

Several social media platforms have free analytics tools (Facebook, Instagram, Twitter, Pinterest, LinkedIn, and YouTube) that track the metrics listed above, as well as information like days and times of day with the greatest traffic on the site (Thompson 2021). This information can be used to decide when it is most effective to post new information on these social media platforms.

Weekly assessment (e.g., Monday morning) of the platform metrics can be used to determine the effectiveness and reach of the platform in supporting the watershed management goals.

There currently is extensive content on watershed management practices, outreach and education efforts and information, meeting, workshop, and field day announcements, and YouTube and other videos on technical assistance on the NRD, NRCS, and UofA Cooperative Extension platforms, but these sites are not always linked to each other or linked to Bayou Meto watershed activities, or university and nonprofit organizations social media platforms and websites. BMWMD will develop these links and ensure that its platform is linked to any institutions or organizations interested in helping implement this watershed management plan.

5.1.2.2 Quantify Ecosystem Services

Ecosystem services are the benefits people obtain from ecosystems (Millennium Ecosystem Assessment 2005) and the direct and indirect contributions of ecosystems to human well-being (Kumar 2010). As categorized by the Millennium Ecosystem Assessment, these include *provisioning* services such as food, water, timber and fiber; *regulating* services that affect climate, floods, disease, wastes, and water quality; *cultural* services that provide recreational, aesthetic, and spiritual benefits; and *supporting* services such as soil formation, nutrient cycling, and photosynthesis (Millennium Ecosystem Assessment 2005). Typically, only provisioning services have market value, with the monetary benefits determined within the marketplace where goods and services are bought and sold. However, there are many more benefits and values provided by ecosystem services than just provisioning services.

A taxonomy of economic values for ecosystem services has been developed based on whether there is a physical relationship between the ecosystem and human use (National Research Council 2004). Use values can be consumptive, non-consumptive, or indirect use. Consumptive uses, for example, include water withdrawals for drinking or irrigation (i.e., market-based provisioning services). Non-consumptive uses include boating, recreational fishing, or health impacts. Indirect uses include habitat for birds and birdwatching, hunting, or spawning habitat for fish. There are also non-use values, which are not tied directly or indirectly to human use. For example, there are option values, where there currently is no desire to use the ecosystem, but there may be in the future and people value having that future option. Bequest and altruistic values relate to wanting the resource or service available for future generations (bequest) or available for others now (altruistic).

Economists have developed methods for quantifying the value of many of the non-consumptive, indirect, and non-use ecosystem services (Table 5.2). Many of these methods are applicable for estimating the value of services provided by Bayou Meto and its tributaries. Quantifying and presenting the value of services provided by Bayou Meto ecosystems may increase local interest in protecting or improving those ecosystems.

The value of ecosystem services is generally unknown and rarely considered by society because the services are "free". Because most people are risk averse and their fear of incurring loss is significantly greater than their fear of missing out on gain (Kahneman and Tversky 1979, Thaler, et al. 1997), the ecosystem services will be quantified so the differential loss of valued services (e.g., monetary value) can be estimated. For example, manure decomposition (supporting service) makes nutrients available for grass/hay production that offsets the cost of fertilizer application. Soil health, in addition to water quality, represents a category of ecosystem services with significant value to farmers, cattle ranchers and hay producers that can also contribute to improved water quality.

Table 5.2. Monetary valuation methods for ecosystem goods and services.

Market Place Method – value based on ecosystem goods and services bought and sold in commercial markets	**Productivity Method** – value-based products or services that contribute to the production of commercially marketed goods
Hedonic Pricing Method – value based on services that directly affect market price of another good (e.g., streamside vs non-streamside property)	**Travel Cost Method** – value associated with ecosystem used for recreation and willingness of people to pay to travel to the site
Damage Cost Avoided/Replacement Cost Method – value based on cost of avoiding damages from lost services or cost of replacing services (e.g., drinking water treatment costs)	**Contingent Valuation Method –** value based on asking people their willingness to pay (WTP) for specific ecosystem services based on scenario (most widely used method for estimating nonuse values)
Contingent Choice Method – value based on asking people to make trade-offs among choices of services or characteristics. Does not ask for WTP, but infers value from trade-offs	**Benefit Transfer Method –** value based on transferring existing benefit estimates to similar location, issue, or use.

The initial quantification of ecosystem services is proposed for one of the recommended subwatersheds. A DPSIR model framework (Bradley and Yee 2015) is proposed to illustrate the linkages among drivers (D), pressures (P), status (S), impacts (I), and responses (R – DPSIR) and their relationship with ecosystem service changes and well-being in Bayou Meto subwatersheds. The voluntary set of practices and activities proposed in the Task 3 report represent one set of responses to the impacts on these ecosystem services.

Ecosystem services will be quantified following the frameworks proposed by Grizzetti et al. (2016), Ready (2016), and using the tools assessed by Bagstad et al. (2013) and InVEST (www.naturalcapitalproject.org/invest/). InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) is a suite of open-source ecosystem service models developed by the Natural Capital Project. The Natural Capital Project is a joint initiative of the University of Minnesota, The Nature Conservancy, Stanford University, and World Wildlife Fund (www.naturalcapitalproject.org). The set of ecosystem services considered for initial valuation, along with the proposed valuation method, is shown in Table 5.3.

Table 5.3. Freshwater Ecosystem services, type of value and applied valuation methods. The classification of ecosystem services has been developed for fresh and transitional water (Reynaud and Lanzanova 2017).

Ecosystem services	Category[a]	Value type	Valuation method[b]	Examples of economic good provided
1-Water for Drinking	Provisioning	Direct	MP, CV	Water for domestic uses
2-Raw (biotic) materials	Provisioning	Direct	MP, RC	Algae as fertilizers
3-Water for no-drinking purposes	Provisioning	Direct	MP, PF	Water for industrial or agricultural uses
4-Raw materials for energy	Provisioning	Direct	RC	Wood from riparian zones
5-Water purification	Regulation	Indirect	RC, CV	Excess nitrogen removal by microorganisms
6-Erosion prevention	Regulation	Indirect	RC	Vegetation controlling soil erosion
7-Flood protection	Regulation	Indirect	RC, CV	Vegetation acting as barrier for the water flow
8-Maintaining populations and habitats	Regulation	Indirect	RC	Habitats use as a nursery
9-Pest and disease control	Regulation	Indirect	RC, CV	Natural predation of diseases and parasites
10-Soil formation	Regulation	Indirect	RC	Rich soil formation in flood plains
11-Carbon sequestration	Regulation	Indirect	RC, MP	Carbon accumulation in sediments
12-Location climate regulation	Regulation	Indirect	RC, MP	Maintenance of temperature patterns
13-Recreation	Cultural	Direct	CV,TC, DC, HP	Swimming, recreational fishing, sightseeing
14-Recreational fishing	Cultural	Direct	TC, CV	Sportfishing for smallmouth bass
15-Recreational canoeing/swimming	Cultural	Direct	MP, TC, CV	Canoing/kayaking, swimming
16-Intellectual and aesthetic appreciation	Cultural	Non-use	CV, DC	Matter for research, artistic representation
17-Spiritual and symbolic appreciation	Cultural	Non-use	CV, TC, DC	Sense of being
18-Raw abiotic materials	Extra abiotic	Direct	PF, MP	Extraction of sand and gravel
19-Abiotic energy sources	Extra abiotic	Direct	PF, MP	Hydropower generation

5.2 Implementation Lead

The greatest efficacy in implementing watershed management plans, and protecting and improving water quality, is typically achieved through locally-led watershed groups or teams. A recent article provided empirical evidence that nonprofit watershed groups or teams can provide public goods (Grant and Langpap 2018). In economics, a public good is a commodity or service available to all individuals and where one individual cannot reduce the availability to others. Grant and Langpap reviewed information from 2,150 watersheds across the lower US from 1996 to 2008. Watershed groups in these watersheds increased from 500 to 1,500 over this same period. They found the activity of these watershed groups resulted in improved water quality, specifically a decrease in DO deficiency (i.e., increase in DO concentrations in waterbodies), compared to watersheds in which there were no groups. Donations to watershed groups were associated with reduced DO deficiency. Watershed groups can make a significant difference in improved water quality within a watershed through their activities. The Bayou Meto Watershed Management District (BMWMD) has committed to leading implementation of the Bayou Meto Watershed Management Plan. Possible partners in the recommended subwatersheds are listed in Table 5.4.

Table 5.4. Potential stakeholder partners for BMWMD in the Bayou Meto recommended subwatersheds.

Recommended subwatershed	Potential stakeholder partners
Headwaters Bayou Meto	Communities of Tates Mill and Warsaw Pulaski and Faulkner Counties Cattle farmers Foresters
Glade Branch-Bayou Two Prairie	City of Cabot Community of Holland AGFC (Holland Bottoms WMA [quail, waterfowl]) Pulaski and Lonoke Counties AHTD Cattle farmers
Skinners Branch-Bayou Two Prairie	City of Carlisle Lonoke County AGFC (Prairie Bayou WMA [quail, turkey]) Aquaculture farmers Crop farmers Grand Prairie Irrigation District Bayou Meto Water Management District
Upper Mill Bayou	City of Stuttgart Almyra Municipal Airport Ducks Unlimited Arkansas County Crop farmers Grand Prairie Irrigation District
Hurricane Bayou	Community of Eldridge Corner Arkansas County Ducks Unlimited Crop farmers
Bills Bayou	City of Gillett Communities of Hyden and Mayview Arkansas County Ducks Unlimited Crop farmers

5.3 Implement Nonpoint Source Pollution Management Strategies

Section 4.7 identifies nonpoint source pollution management practices appropriate for Bayou Meto watershed and the recommended subwatersheds. Focus areas for management are identified in Section 4.6. Estimates of the number of practices needed to achieve the water quality goals of this plan are provided in Section 4.7. There is no legal requirement that anyone implement any of the practices listed in Sections 4.7 through 4.9. These are practices that are suggested for landowners, operators, and other stakeholders interested in improving or protecting water quality in the Bayou Meto watershed. In addition to protecting water quality, these practices can increase the value and returns on the property where they are implemented. These are not the only practices appropriate for the watershed, but rather those that are generally accepted within the watershed and suggested by stakeholders. There are other practices not listed that could also improve or protect water quality and habitat. Programs that can provide technical and financial assistance to landowners, operators, and other stakeholders for implementing these practices are listed in Section 6.

5.3.1 Existing Implementation of Practices in Watershed

Practices listed in Sections 4.7 through 4.9 are already in use in the Bayou Meto watershed and in the recommended subwatersheds. Figure 5.2 summarizes practices implemented in the Bayou Meto watershed through NRCS EQIP and CSP programs during the period 2008-2020. The 2017 Census of Agriculture reported the area within each county on which selected conservation practices were implemented in 2017. These data for the counties associated with the recommended subwatersheds are listed in Table 5.5. The USDA Farm Services Agency (FSA) reports acres enrolled in the Conservation Reserve Program (CRP) annually by county (FSA 2021a). Acres enrolled during 2019 in the counties associated with the recommended subwatersheds are included in Table 5.5.

An inventory of on-farm irrigation reservoirs in Arkansas, Lonoke, and Prairie Counties was recently completed using 2015 imagery from the National Agricultural Imagery Program (NAIP) (Yeager, et al. 2017). One of the criteria for classifying reservoirs as irrigation reservoirs was the presence of a tailwater recovery ditch, suggesting that this inventory also provides an indication of the number of active tailwater recovery systems in use in these counties. The results of this inventory for Arkansas and Lonoke Counties, where recommended subwatersheds are located, are provided in Table 5.6. Note that some of these tailwater systems may also be accounted for in the treated areas shown in Figure 5.2.

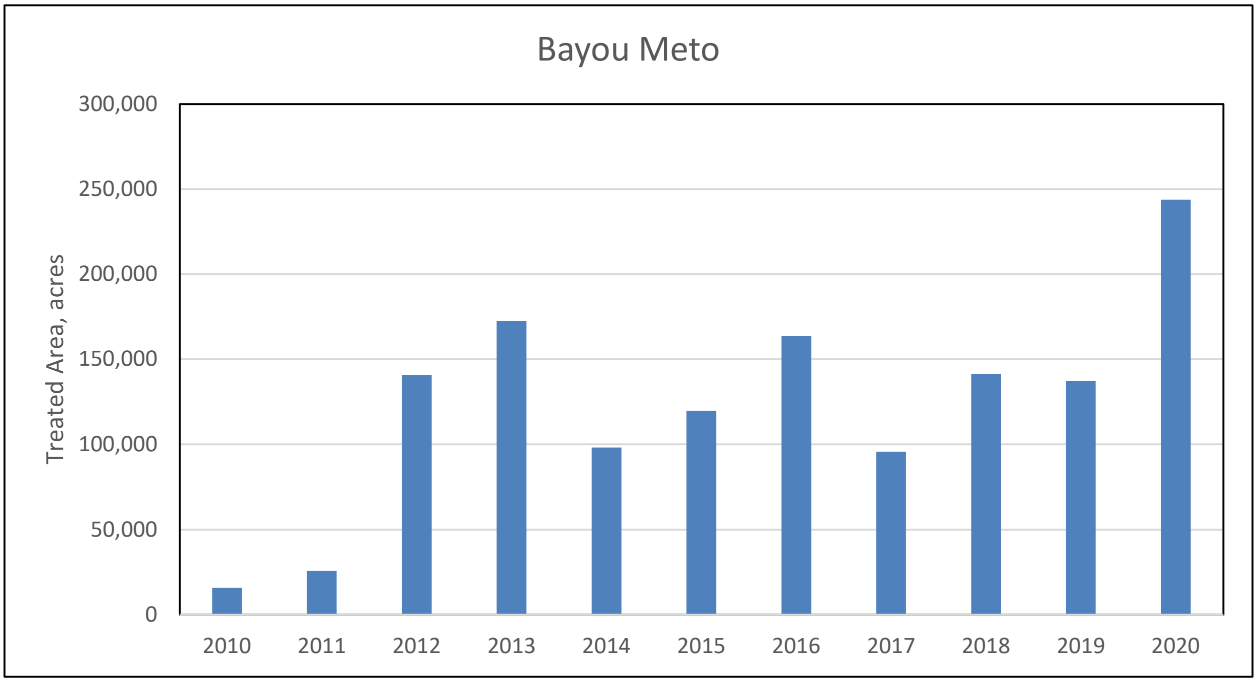


Figure 5.2. Area treated in Bayou Meto watershed by practices that improve water quality implemented through NRCS EQIP and CSP programs over the last 10 years (Christianson 2021).

Table 5.5. Extent of conservation practices by county reported in the 2017 Census of Agriculture (USDA National Agricultural Statistics Service 2017) and by Farm Service Agency (FSA 2021a).

Practices	Reporting year	Extent in:		
		Pulaski County	**Lonoke County**	**Arkansas County**
Prescribed grazing	2017	55 operations	56 operations	Not applicable
Cover crops	2017	Not applicable	3,741 acres	3,441 acres
Conservation tillage	2017	Not applicable	93,145 acres	112,796 acres
No-till	2017	Not applicable	46,833 acres	33,614 acres
Conservation Reserve Program	2019	3,461 acres	12,426 acres	16,232 acres

Table 5.6. Inventory of on-farm irrigation reservoirs present in 2015 (from Yeager et al., 2017).

County	Number of reservoirs	Surface Area, ha		
		Total	Average	Range
Arkansas	282	4,613	16.4	2 to 217
Lonoke	119	1,433	12.0	1 to 48

5.3.2 Influencing Implementation of Management Practices and Activities

Over the past decade, there has been considerable work conducted on ways of leading and implementing change within organizations and communities (Grenny, et al. 2013). In general, there are three important domains, and two important subdomains within each domain, that are critical in influencing change. The domains are personal, social, and structural and the sub-domains are motivation and ability. These three domains and two sub-domains form a six-celled matrix (Table 5.7).

Table 5.7. Domain, sub-domain, and elements that can influence behavioral change in implementing management practices and activities.

Domain	Sub-domain	
	Motivation	Ability
Personal	Links to Values and Personal Benefits	Training, Skill Building
Social	Peer Pressure	Social Support
Structural	Rewards, Accountability	Change the Environment

In many instances, the emphasis has only been on personal motivation and ability, ensuring that individuals have the motivation to change and are provided with the training and ability to make the change. However, the importance of social elements of peer pressure and support groups (e.g., Neighborhood Associations, Grazing Land Coalition, Soil Health Alliance) is also critical in supporting the personal domain. Recent research into adoption of conservation practices in the Arkansas Delta and Lower Mississippi River basin has identified the importance of social networks in increasing adoption of practices (Keerthi and Johnson 2019, Adams 2018). In addition, making changes in the social environment (i.e., structural domain) through cost-share and rewards (i.e., motivation) and improving communication and/or changing the relationship between absent agricultural landowners and producers who rent their land; and changing the physical environment in which individuals interact (e.g., native grass pasture vs. fescue or bermudagrass) are also critical in bringing about changes in how land and water are viewed and managed. The key is to simultaneously address all six cells, not just one or two of the cells. In some cases, it might not be possible to address all six, but the emphasis should be on implementing as many of the six cells as possible to encourage and promote change.

Pasture management and improving soil health represent two recommended approaches for improving water quality within the Bayou Meto watershed. Examples of factors that might influence change for each of the elements in the matrix for these two management efforts (i.e., pasture management, soil health improvement) are shown in Tables 5.8 and 5.9, respectively. The recommendation is that all six elements of the influence matrix be considered during implementation of management practices and activities in the Bayou Meto watershed.

Table 5.8. Elements that might help influence implementation of pasture management practices.

Domain	Motivation	Ability
Personal	• Better pasture/forage quality • Increased rate of gain • Reduced hay feeding • Sustain water supply • Cost-share programs	• Grazing land conference • Field days • YouTube/other videos • Grazing stick • NRCS technical assistance • UofA Cooperative Extension
Social	• Leaders implementing practices • Cattleman of the Year Award	• Grazing land coalition • Field days • Rancher to rancher exchanges • Conferences
Structural	• NRCS EQIP funding • NRCS RCPP funding • 319 funding	• Grow grass, not algae campaign • Grazing stick • Promote 2 strand electric fence • AGFC Acres for Wildlife • 4-5 forage paddocks • Stockpile paddock • Alternative water supply

Table 5.9. Elements that might help influence implementation of soil health improvement practices.

Domain	Motivation	Ability
Personal	• Fewer trips across fields • Fewer irrigation cycles • Increased irrigation infiltration • Increased soil health • Decreased fertilizer cost • Cost-share programs • Increased profit	• Field days • YouTube/ other videos • NRCS technical assistance • Arkansas Cooperative Extension • Arkansas Soil Health Alliance • Conservation Districts
Social	• Leaders implementing practices • Arkansas Farm Family of the Year • Most Crop Per Drop award	• Arkansas Soil Health Alliance • Field days • Farmer to farmer exchange • Conferences
Structural	• NRCS EQIP funding • NRCS RCPP funding • 319 funding	• Water meters • Soil moisture probes • Tailwater recovery systems • Soil testing • Nutrient management plan

5.4 Monitoring

Monitoring is an essential element of adaptive watershed management. The objectives of the ongoing and proposed monitoring programs and special studies in the Bayou Meto watershed include:

- Determine compliance with state water quality standards;
- Characterize current water quality conditions, including patterns;
- Characterize water quality trends and impacts; and
- Identify sources of pollutants.

For all water quality monitoring, existing and proposed, it is recommended that the frequency and timing of sampling result in data that meet DEQ data requirements for the biennial assessment of streams and lakes in Arkansas, e.g., 2022 Assessment Methodology (DEQ 2021c). For example, the requirement for DO data is that at least 10 measurements be collected per season (primary and critical seasons), evenly distributed over at least two years and three quarters per year.

5.4.1 Existing Monitoring Programs

Existing monitoring programs in the Bayou Meto watershed are expected to continue into the future (descriptions provided in Section 3). DEQ will continue to monitor its ambient stream surface water quality stations (Stations ARK0050, ARK0060, and ARK0023 on Bayou Meto, and ARK0097 on Bayou Two Prairie) and the lake water quality station (LARK024A on Pickthorne Lake), as well as the eight groundwater quality monitoring wells in the Bayou Meto watershed. DEQ is also expected to conduct future fish and macroinvertebrate surveys in the watershed. USGS, NRD, and the Arkansas Department of Agriculture Pesticides Section will continue to monitor groundwater quality in the watershed. Surface water quality monitoring at the Bayou Meto Discovery Farm is also expected to continue (M. Daniels, University of Arkansas Department of Agriculture, personal communication 12/8/2021).

5.4.2 Future Special Studies

Special studies are already planned and are proposed to address data gaps. These studies will include data quality assurance planning.

5.4.2.1 DEQ Ecoregion Study

DEQ is in the process of conducting ecoregion studies across the state. In 2017 and 2018 samples were collected in the Bayou Meto watershed as part of an Ouachita Mountains ecoregion study (DEQ 2018a). A Delta ecoregion study is planned for the future (J. Martin, DEQ, personal communication 11/29/2021). This study may involve sampling within the Bayou Meto watershed.

5.4.2.2 Proposed Study – Subwatershed Water Quality Assessments

Currently there are no water quality monitoring data associated with four of the recommended subwatersheds: Glade Branch-Bayou Two Prairie, Upper Mill Bayou, Hurricane Bayou, and Bills Bayou. However, based primarily on land use, these subwatersheds were ranked as having a high potential for water quality issues (see Task 3 report). Therefore, it is recommended that a set of water quality data be collected from each of these subwatersheds, that can be used to assess whether applicable water quality standards are being met in the primary streams; Bayou Two Prairie, Mill Bayou, Hurricane Bayou, and Bills Bayou. A single water quality monitoring location is proposed near the downstream end of each of the subwatersheds. At least five years of sampling is suggested. Sampling frequency and analytical methods will be determined by DEQ data requirements for the biennial statewide assessment of water quality. These studies could be conducted by a university, stream team, or, with funding, by the USGS or a contractor.

DEQ collected water quality data at station ARK0211 during 2017 and 2018 as part of the Ouachita Mountains Wadeable Streams Project (DEQ 2018a). It is recommended that this station be sampled again. The sampling could be conducted by a nearby university, stream team, or, with funding, by the USGS or a contractor. The regional Stream Team Coordinator, Stephen O'Neal, indicates that Bayou Meto stakeholders were interested in the past, and he expects it would not be difficult to generate interest again (personal communication 9/13/2021).

5.4.2.3 Proposed Study - DO Intensive

The cause(s) of low DO conditions in Bayou Meto and Bayou Two Prairie is(are) currently unknown (DEQ 2018a). Therefore, it is recommended that water quality and flow studies be conducted at DO impaired water quality stations to identify the factors causing low DO conditions. Suspected factors include:

- Low flow (i.e., low velocities which result in low reaeration);
- High water temperature (decreases DO saturation levels and causes organic matter to decay faster); and
- External organic loading (i.e., plant material and other organic debris that is washed into streams by runoff), and high primary productivity due to nutrient enrichment (i.e., proliferation of algae, which consume oxygen during the night due to respiration and contribute to organic loading during die-off).

5.4.2.4 Proposed Study – HUC8 Nutrient Load Monitoring

Although the SWAT model was used to simulate sediment and nutrient loads throughout the Bayou Meto watershed, it may be useful to multiple agencies to establish a flow and water quality monitoring station in the lower part of the Bayou Meto watershed for the purpose of estimating loads directly from measured data. Currently, the only location with continuous flow monitoring is Bayou Meto near Lonoke (USGS gage number 07264000), which has an upstream drainage area of 207 square miles (only about 21% of the entire Bayou Meto watershed). Collecting both flow and water quality at the same location will provide data that are needed to calculate loads. The accuracy of the load calculations will be improved if water quality data are collected for a wide range of hydrologic conditions during different seasons of the year. Nutrient loads are of particular interest for the Arkansas Nutrient Reduction Strategy (ANRS). If continuous monitoring isn't feasible, a five-year discrete sampling period conducted every five to 10 years is recommended.

5.5 Evaluation

It is recommended that an evaluation of plan implementation occur approximately every seven years. Therefore, the first evaluation of this plan would occur in 2028. This evaluation will be conducted by the Bayou Meto Water Management District. Performance measures for this evaluation are listed in Section 5.6. If the criteria identified in Section 5.6 are not satisfied, the management approaches, scientific knowledge, and stakeholder knowledge and opinions in the recommended subwatersheds will be re-evaluated by the stakeholders involved in managing water quality and nonpoint sources in the recommended subwatershed(s), and management elements will be adjusted accordingly. This evaluation will need to take into account the fact that it can take more than five years, or even decades, before in-stream water quality improvements resulting from implementation of management measures become apparent (Meals, Dressing and Davenport 2010). The time required to see significant changes in water quality is, in part, a function of how close water quality measurement locations are to where management activities are implemented.

5.6 Performance Measures

The performance measures outlined below consider three major elements of the implementation of a watershed management plan: program inputs, outputs, and outcomes. Performance measures for these elements are identified for information/education, monitoring, and implementation of management practices.

5.6.1 Inputs

The inputs for implementation of this plan are the assistance programs available and stakeholder participation. Indicators that measure this component of the plan implementation are listed in Table 5.10. The stakeholders and organizations that participate in implementation of this plan should provide the implementation lead (see Section 5.2) with annual totals for these input indicators for the period 2021 through 2027 by February 2028.

5.6.2 Outputs

The outputs for implementation of this plan are formation of partnerships, implementation of nonpoint source management practices, information and education, and monitoring and special studies. Indicators that measure this component of the plan implementation are listed in Table 5.11. The stakeholders and organizations that participate in implementation of this plan should provide the implementation lead with annual totals for these indicators for the period 2021 through 2028 by February 2029.

Table 5.10. Indicators of inputs for implementation of this watershed management plan.

Implementation Task	Activity	Indicators
Monitoring	Agency monitoring programs	Resources spent on monitoring in Bayou Meto watershed Hours and number of personnel involved
	Stream Teams	Number of inquiries Number of teams formed Number of participants on teams Hours and number of AGFC personnel involved
	Special studies	Resources spent on special studies Hours and number of personnel involved
Information/Education	Arkansas grazing lands conference (Arkansas Grazing Lands Coalition)	Resources spent on putting on the conference Hours and number of personnel involved
	Events – field days, festivals, river clean-ups	Hours and number of people involved in putting on events Cost
	Community presentations	Hours and number of people involved in putting on presentations Cost
	K-12 education programs	Hours and number of people involved in running education programs Cost
	Interest groups meetings, websites, newsletters	Number of website posts/updates Hours and number of people involved Cost
	Social media	Number of posts, Tweets, etc. Hours and number of people putting content on social media Cost
Implement management practices	Assistance programs in the Bayou Meto watershed	Resources distributed to Bayou Meto watershed Hours and number of people assisting stakeholders in Bayou Meto watershed Number of Bayou Meto watershed stakeholders requesting assistance
	Implementation lead	Number of people/organizations partnering

Table 5.11. Indicators of outputs of implementation of this watershed management plan.

Implementation Task	Activity	Indicators
Monitoring	Agency monitoring programs	Number of active water quality monitoring stations Number of stations sampled Number of water quality parameter measurements collected Number of sampling events Number of biological surveys
	Stream Teams	Number of teams Number of streams monitored Number of active water quality monitoring stations Number of stations sampled Number of water quality parameters measured Number of sampling events Number of invertebrate surveys
	Special studies	Number of studies completed Number of subwatersheds studied Study results reported
Information/Education	Arkansas grazing lands conference (Arkansas Grazing Lands Coalition)	Number of conferences Number of attendees
	Events	Number of events in watershed Number of events outside watershed where watershed information presented Number of attendees
	Community presentation	Number of presentations Number of attendees
	K-12 education programs	Number of programs Number of attendees
	Interest group meetings, websites, newsletters	Number of meetings Number of attendees Number of website visits Number of newsletters distributed
	Bayou Meto social media	Number of likes, re-Tweets, etc. Reach
Implement management practices	Assistance programs in the Bayou Meto watershed	Number/amount of management practices implemented Number of contracts/projects started and finished
	Implementation lead	Number of partnerships formed Number of subwatersheds with implementation projects and/or studies Number of projects and studies organized through lead partnerships Number/amount of management practices implemented through lead partnerships

5.6.1 Outcomes

The intended outcomes for this watershed-based management plan include assessment of water quality in Bayou Meto Headwaters, Glade Creek-Bayou Two Prairie, Upper Mill Bayou, Hurricane Bayou, and Bills Bayou subwatersheds, improvement in water quality and aquatic habitat in Bayou Meto Headwater, Glade Creek-Bayou Two Prairie, and Skinners Branch-Bayou Two Prairie subwatersheds, and increased awareness of, and interest in, water quality and aquatic habitat concerns of the Bayou Meto watershed. The long-term objective of this watershed-based plan is that waterbodies in the Bayou Meto watershed will meet water quality criteria and attain their designated uses, and nutrient loads from this subwatershed will be reduced. The primary indicators suggested for this goal are dissolved oxygen (DO), total dissolved solids (TDS), and turbidity concentrations; pH; and total nitrogen and total phosphorus loads. biochemical oxygen demand (BOD) and total suspended solids (TSS) concentrations are suggested as secondary indicators. These parameters, which are currently being monitored at several locations, are recommended for use in evaluation of the overall effectiveness of nonpoint source pollution management within the Bayou Meto watershed. Within the next four to six years, the goal of this plan is to see incremental progress toward the target DO and TDS levels, reduction in nutrient loads, and document stakeholder activities contributing to good water quality and quality of life in the Bayou Meto watershed.

The monitored waterbodies in the Bayou Meto watershed are assessed by DEQ every two years to develop the Arkansas integrated water quality assessment report, which includes the 303(d) list of impaired waterbodies. This assessment will be used to evaluate achievement of the goals of delisting impaired waterbodies, and no new impaired waterbodies in the watershed.

Implementation of this plan will be considered successful if the following are achieved by 2028:

- At least one implementation project or proposed study has been initiated in a recommended subwatershed;
- Bayou Meto and Bayou Two Prairie are removed from the state impaired waters list;
- Water quality data sufficient for the DEQ biennial assessment have been collected from Upper Mill Bayou, Hurricane Bayou, and Bills Bayou recommended subwatersheds;
- No new water quality impairments resulting from unregulated nonpoint pollution sources are identified in the Bayou Meto watershed.

5.7 Update Watershed Management Plan

Development of the subwatershed implementation plans for the recommended subwatersheds will be part of the update of this watershed management plan. The responsibility for updates to the subwatershed implementation plans will be established in those plans. A comprehensive update of this watershed management plan will be initiated in 2028 by the Bayou Meto Water Management District.

This update will consider and address the following information:

- Results of the evaluation of the implementation of this plan, described in Section 5.5;
- Relevant information about the Bayou Meto system and how it works, nonpoint source management practices, and pollutant sources in the watershed that has been developed since 2021;
- Changes in water quality related issues in the watershed;
- Changes in water quality management assistance programs; and
- Changes in land use, industry, population, and/or economy in the watershed.

A summary of changes in the watershed over the period since completion of the previous watershed management plan, will be prepared. This summary will be presented at one or more public stakeholder meetings. At the meeting(s), stakeholders will provide input on adjustments to management of, and/or goals for, the Bayou Meto watershed. This may include a focus on management in other subwatersheds for water quality improvement or protection.

An update of this watershed management plan, utilizing the information from the implementation evaluation and the public meeting(s), and any other information deemed appropriate, will be prepared. This update will be presented at one or more public stakeholder meetings to elicit feedback. The final update of the watershed management plan will then be prepared, incorporating stakeholder comments.

5.8 Implementation Schedule

A schedule for implementing the elements of this watershed management plan described previously is summarized in Table 5.12. Included in Table 5.12 are milestones, indicators, and long-term goals. This schedule incorporates the adaptive management process, where practices are implemented, monitoring is conducted to document results, the results are evaluated relative to the goals and criteria specified in the plan, and the plan is modified based on the results of the evaluation, accommodating any changes in regulations, available assistance programs, understanding of the watershed, or management priorities.

Table5.12. Proposed implementation schedule for Bayou Meto watershed management plan.

Activity	Action (Lead)	Start	Anticipated Completion	2027 Milestones	Indicator	Long Term Goal
Monitoring	Ambient Surface Water Quality Monitoring Program (DEQ)	1973	Expected to continue indefinitely	Five additional years of water quality data collected at existing stations	Number of sampling events Number of sampling locations	Identify and track changes in water quality Assess water quality relative to water quality standards
	Significant Publicly-owned Lakes Monitoring Program (DEQ)	1994	Expected to continue indefinitely	At least one year of additional water quality data collected	Number of sampling events	Identify and track changes in water quality Assess water quality relative to water quality standards
	Stream Team Water Quality Sampling and Aquatic Invertebrate Surveys	2019	Expected to continue indefinitely	Five additional years of water quality and/or benthic sampling at one or more locations	Number of sampling events Number of sampling locations	Characterize water quality and biology Identify and track changes in water quality
	DEQ Fish Surveys	1986	Expected to continue indefinitely	At least one new fish survey in the Bayou Meto watershed	Number of sampling events Number of sampling locations	Assess fishery condition
	Groundwater Quality Monitoring Program (DEQ, NRD, ADA Pesticides Section, USGS)	1994	Expected to continue indefinitely	At least two additional water quality samples from at least 10 established monitoring locations	Number of sampling events Number of sampling locations	Characterize water quality Identify and track changes in water quality
	Discovery Farm (University of Arkansas Department of Agriculture)	2010	Expected to continue	Additional water quality data collected from edge of field and irrigation reservoirs	Number of sampling events Number of sampling locations	Characterize water quality Identify and track changes in water quality from BMPs
	Delta Ecoregion Study (DEQ)	2025	2027	Data collection completed	Number of sampling events Number of sampling locations	Identify and track changes in water quality Assess water quality relative to water quality standards
Special Studies	Subwatershed Water Quality Assessments (BMWMD, DEQ)	2025	2027	Initiate water quality monitoring in at least one recommended subwatershed	Study plan Study initiated Study completed Study report	Determine if water quality standards are being achieved in four recommended subwatersheds lacking water quality data
	DO Intensive Study (BMWMD, DEQ)	2024	2029	Initiate intensive study at one or more monitoring stations with DO impairment	Study plan Study initiated Study completed Study report	Determine cause(s) of low DO impairment
	HUC8 Nutrient Load Monitoring (BMWMD, NRD)	2024	2029	Initiate monitoring	Number of sampling events Duration of sampling	Characterize nutrient loads from HUC8, and track changes over time
Information and Education	Field demonstrations (NRCS, AGFC, Arkansas Soil Health Alliance)	2021	Expected to continue indefinitely	At least one field demonstration in each of the recommended subwatersheds	Number of demonstrations Number of people attended	Increase use of conservation practices to protect or improve water quality
	Social Media platform for Bayou Meto watershed (BMWMD)	2023	Expected to continue indefinitely	Initiate watershed social media platform and post at least quarterly	Number of views Number of likes Number of retweets Reach	Increase use of conservation practices to protect or improve water quality
	Quantification of ecosystem services in recommended subwatersheds (BMWMD)	2025	2037	Quantification of ecosystems services completed for at least one recommended subwatershed	Study initiated Study report Study completed	Increased understanding of the services and value provided by natural resources in Bayou Meto watershed Increase use of conservation practices to protect or improve water quality
Information and Education	Booths at fairs and festivals (NRCS, AGFC, Arkansas Soil Health Alliance)	2021	Expected to continue indefinitely	At least three booths or presentations within Bayou Meto watershed	Number of events Number of people attending Number of people visit booth	Increase use of conservation practices to protect or improve water quality

Table5.12. Proposed implementation schedule for Bayou Meto watershed management plan (continued).

Activity	Action (Lead)	Start	Anticipated Completion	2027 Milestones	Indicator	Long Term Goal
	Social media posts (NRCS, AGFC, AR Soil Health Alliance, County Conservation Districts)	2020	Expected to continue indefinitely	At least three posts about Bayou Meto watershed	Number of views Number of likes Number of retweets Reach	Increase use of conservation practices to protect or improve water quality
	319 program (NRD, County Conservation Districts, BMWMD)	1990	Expected to continue indefinitely	At least one 319 project in a recommended subwatershed	Number of project proposals submitted Number of projects funded Number of projects completed Number of people participating	All surface waters meet water quality standards Reduce sediment and nutrient loads from Bayou Meto watershed
Implement Management Practices	Arkansas Quail Special Project (AGFC)	2007	Expected to continue	At least one project in Bayou Meto watershed	Number of projects Amount of practices implemented Number of quail	All surface waters meet water quality standards
	Acres for Wildlife (County Conservation Districts, AGFC)	2011	Expected to continue indefinitely	At least one project in Bayou Meto watershed	Number of projects Amount of practices implemented	All surface waters meet water quality standards
	Stream Teams (AGFC)	2000	Expected to continue indefinitely	At least one streambank or aquatic habitat project in Bayou Meto watershed	Number of projects Amount of practices implemented	All surface waters meet water quality standards
	Arkansas Unpaved Roads Program (NRD)	2015	Expected to continue indefinitely	One project proposal submitted by Arkansas County	Number of projects Amount of practices implemented Personnel trained	All surface waters meet water quality standards Reduce road erosion
	Tri-state Mississippi Alluvial Valley WREP (NRCS)	2021	2022	At least one project proposal submitted from Bayou Meto watershed	Number of project proposals submitted Number of project proposals funded Number of projects completed Amount of practices implemented	Enhance wildlife habitat All surface waters meet water quality standards
	Working Lands for Wildlife – Bobwhite Quail (NRCS)	2017	2022	At least one project proposal submitted from Bayou Meto watershed	Number of project proposals submitted Number of project proposals funded Number of projects completed Amount of practices implemented	Enhance wildlife habitat All surface waters meet water quality standards
	Arkansas Southeast Feral Swine Control Pilot Project (NRCS)	2019	2022	At least one project proposal submitted from Bayou Meto watershed	Number of project proposals submitted Number of project proposals funded Number of projects completed Amount of practices implemented	Improved water quality All surface water meet water quality standards

Table5.12. Proposed implementation schedule for Bayou Meto watershed management plan (continued).

Activity	Action (Lead)	Start	Anticipated Completion	2027 Milestones	Indicator	Long Term Goal
Implement Management Practices	EQIP (NRCS)	1996	Expected to continue indefinitely	Increased implementation of practices in recommended subwatersheds	Amount of practices implemented	All surface waters meet water quality standards Reduced sediment and nutrient loads from Bayou Meto watershed
	Midsouth Graduated Water Stewardship Program RCPP Project (NRCS)	2015	2023	Project practices still in place and well maintained	Amount of practices implemented	All surface waters meet water quality standards Reduce groundwater use Reduce sediment and nutrient loads from Bayou Meto watershed
	RCPP Rice Stewardship Partnership (NRCS, DU, USA Rice)	2015	At least 2022	Increased implementation of practices in recommended subwatersheds	Amount of practices implemented	All surface waters meet water quality standards Reduce groundwater use Reduce sediment and nutrient loads from Bayou Meto watershed
	Arkansas Waterfowl Rice Incentive Conservation Enhancement (AGFC)	2019	Unknown	Increased winter flooding of rice fields, particularly in recommended subwatersheds	Acres of rice fields flooded	Reduce sediment and nutrient loads from Bayou Meto watershed
	Partners for Fish and Wildlife Program (USFWS)	1988	Expected to continue indefinitely	Increased implementation of practices in recommended subwatersheds	Amount of practices implemented	All surface waters meet water quality standards Reduce sediment and nutrient loads from Bayou Meto watershed
	State Acres for Wildlife Enhancement Initiative (FSA)	2007	Expected to continue indefinitely	At least one proposal submitted for the Bayou Meto watershed	Number of proposals submitted Number of proposals funded Amount of practices implemented	All surface waters meet water quality standards
	Farmable Wetlands Program (FSA)	2002	Expected to continue indefinitely	At least one proposal submitted for the Bayou Meto watershed	Number of proposals submitted Number of proposals funded Amount of practices implemented	All surface waters meet water quality standards
	Conservation Reserve Program (FSA)	1985	Expected to continue indefinitely	At least one new easement in a recommended subwatershed	Acres of easements Amount of practices implemented on easements	All surface waters meet water quality standards Reduce nutrient and sediment loads from Bayou Meto watershed
	Conservation Stewardship Program (NRCS)	2008	Expected to continue indefinitely	Increased implementation of practices in recommended subwatersheds	Amount of practices implemented	All surface waters meet water quality standards Reduce sediment and nutrient loads from Bayou Meto watershed
	EQIP Arkansas Groundwater Initiative (NRCS)	2019	2022	Increased implementation of practices in recommended subwatersheds	Amount of practices implemented	Reduce groundwater usage and declines All surface waters meet water quality standards Reduce sediment and nutrient loads from Bayou Meto watershed
	Bayou Meto Irrigation Project (BMWMD)	1991	Unknown			Reduce use of groundwater for irrigation All surface waters meet water quality standards Reduce sediment and nutrient loads from Bayou Meto watershed
	Grand Prairie Irrigation Project (WRID)	1996	Unknown			Reduce use of groundwater for irrigation All surface waters meet water quality standards Reduce sediment and nutrient loads from Bayou Meto watershed
	319 program (NRD, County Conservation Districts, BMWMD)	1990	Expected to continue indefinitely	At least one 319 project in a recommended subwatershed	Number of project proposals submitted Number of projects funded Number of projects completed Amount of practices implemented	All surface waters meet water quality standards Reduce sediment and nutrient loads from Bayou Meto watershed
	Technical assistance (NRCS, County Conservation Districts, AGFC, USFWS, AR Soil Health Alliance, DU)	varies	Expected to continue indefinitely	Assistance provided in recommended subwatersheds	Number of contacts Number of plans prepared Amount of practices implemented	All surface waters meet water quality standards Reduce sediment and nutrient loads from Bayou Meto watershed

Table5.12. Proposed implementation schedule for Bayou Meto watershed management plan (continued).

Activity	Action (Lead)	Start	Anticipated Completion	2027 Milestones	Indicator	Long Term Goal
Evaluate	State Biennial Water Quality Assessment (DEQ)	2022	Expected to continue indefinitely	EPA approved final impaired waters lists for 2022 and 2024	Attaining and non-attaining waterbodies in the Bayou Meto watershed	All water quality criteria met in all monitored waterbodies in the Bayou Meto watershed
	Track implementation of management practices in Bayou Meto watershed (BMWMD, NRD, USDA)	2022	Expected to continue indefinitely	Information for 2022 – 2026 compiled	Amount of practices implemented	All water quality criteria met in monitored water bodies Reduce nutrient and sediment loads from Bayou Meto watershed
	Evaluation of watershed management plan (BMWMD)	2028	2028	Data needed for evaluation compiled	Evaluation completed Evaluation made public	All water quality criteria met in monitored water bodies
Update watershed management plan	Public meetings (BMWMD)	2027	2028	Begin planning public meetings	Number of meetings Number of attendees	Stakeholder input to water and water quality management
	Update watershed management plan (BMWMD)	2028	2030	Initiate preparations for update	Updated watershed management plan complete and approved by NRD and EPA Recommended subwatersheds identified Stakeholders involved	Maintain watershed management plan as a living document that reflects stakeholder interest and concerns related to protecting and improving water quality in the Bayou Meto watershed

6.0 IMPLEMENTATION COSTS, BENEFITS, AND AVAILABLE ASSISTANCE

This section characterizes costs and benefits associated with implementation of the Bayou Meto watershed management plan, and identifies potential sources of technical and financial assistance for implementing this plan.

6.1 Implementation Cost Estimates

Estimates of costs for implementing activities identified in this watershed management plan are provided below. Actual costs may differ from these estimates.

6.1.1 Existing Monitoring

The costs of existing routine water quality and biological monitoring in the Bayou Meto watershed are included in agency budgets.

6.1.2 Proposed Special Studies

The cost of sampling new water quality monitoring stations for Mill Bayou, Hurricane Bayou, and Bills Bayou could range up to $40,000-$50,000 per year for the USGS to monitor one site. The cost of sample analysis by a commercial laboratory is estimated to be around $800 per sample. Adding a flow gage to the Bayou Meto watershed and maintaining it is estimated to cost around $15,000 per year.

6.1.3 Information and Education

The costs of existing information and education programs are included in the budgets of the agencies and organizations implementing those programs. Creating and managing social media content on Bayou Meto watershed management could cost as much as $50,000 per year.

6.1.4 Nonpoint Source Pollution Management

The cost of implementing management practices to reduce nonpoint source pollution can be variable, depending on materials markets and site conditions (e.g., slope, soil type). Table 6.1 lists available cost information for selected management practices identified in Section 4.7. While NRCS EQIP reimbursement allocations do not reflect the actual cost of implementing the practice, they provide an idea of relative costs of the shown management practices.

Table 6.1. EQIP reimbursements and reported implementation costs for selected nonpoint source pollution management practices applicable in the Bayou Meto watershed.

Practice	Unit	2021 EQIP (non-HU*) 60% reimbursement per unit	Unit Costs from Other Sources
Fence	Feet	$0.91-$1.77	$2.15-$2.60[a]
Watering facility (<5,000 gallons)	Gallons	$1.05-$2.87	--
Watering facility (fountain)	Each	$714.83	$2,000-$10,000[a]
Livestock pipeline	Feet	$0.86-$2.61	--
Riparian forest buffer plants	Each	$0.81-$1.04	--
Riparian forest buffer forgone pasture income	Acres	$373.72	--
Riparian forest buffer forgone crop income	Acres	$528.08	--
Riparian forest buffer establishment & maintenance	Acres	--	$218- $7,112[a-d]
Riparian herbaceous buffer	Acres	$198.81-$212.48	$168- $400[a]
Prescribed grazing (medium intensity)	Acres	$22.91	$30-$70[e]
Nutrient management plan written (pasture, 101-300 acres, not part of Comprehensive Nutrient Management Plan)	Each	$ 2,408.70	--
Nutrient management plan written (cropland, >300 acres, not part of Comprehensive Nutrient Management Plan)	Each	$3,010.88	--
Nutrient management (basic)	Acres	$4.66-$29.07	--
Nutrient management (adaptive)	Each	$1,412.91	--
Heavy use area protection	Square feet	$0.57 - $2.71	--
Livestock shelter structure	Square feet	$2.47	--
Feral swine management (assessment & evaluation)	Each	$633.52 - $848.10	--

Table 6.1. EQIP reimbursements and reported implementation costs for selected nonpoint source pollution management practices applicable in the Bayou Meto watershed (continued).

Practice	Unit	2021 EQIP (non-HU*) 60% reimbursement per unit	Unit Costs from Other Sources
Bioretention basins (rain gardens)	Square foot	--	\$3-\$15[f]
Cover crops	Acres	\$40.18 - \$80.64	
Delta tailwater pit	Cubic yards	\$0.83	
Tailwater collection structure	Linear foot	\$1.95	
Residue and tillage management (Conservation tillage)	Acres	\$10.52 - \$14.80	
Soil testing	Sample	\$66.55 - \$184.55	

HU = historically underserved producers
[a] (Lynch & Tjaden 2000)
[b] (Butler & Long 2005)
[c] (Whitescarver 2013)
[d] (Washington State University 2006)
e (Undersander, et al. 2002)
[f] http://raingardenalliance.org/what/faqs

Table 6.2 provides examples of potential relative costs for implementation of selected management practices in the pasture-dominant recommended subwatersheds of Bayou Meto. Table 6.3 provides examples of potential relative costs for implementation of selected management practices in the cropland-dominant recommended subwatersheds of Bayou Meto. These costs reflect implementation of practices on 100% of the currently untreated areas in these subwatersheds. A lesser amount of implementation may achieve some of the target load reductions. In several of the recommended subwatersheds, treatment of 100% of one source may not achieve the target sediment load reduction, but would more than achieve the target nutrient load reductions (see Section 4.8). Note that the estimated costs in Tables 6.2 and 6.3 have been rounded to two significant digits. Appendix L provides a detailed description of how these costs were calculated.

Table 6.2. Estimated costs for reducing nonpoint source pollutant loads from pasture-dominant recommended subwatersheds of Bayou Meto.

HUC12	Headwaters Bayou Meto		Glade Branch Bayou Two Prairie	
Practices	**Extent**	**Estimated cost ($1,000)**	**Extent**	**Estimated cost ($1,000)**
Prescribed grazing	4,378 ac	$190	5,073 ac	$200
Pasture streambank stabilization w/ fence	120,384 ft	$2,000	77,088 ft	$1,300
Pasture stream access control (stream fencing)	120,384 ft	$240	77,088 ft	$150
Pasture forested buffer	120,384 ft (83 ac)	$41	77,088 ft (53 ac)	$26
Pasture grassed buffer	120,384 ft	$25	77,088 ft	$16
Pasture nutrient management plan	93 operations	$650	91 operations	$640
Pasture management suite	83 operations	$1,300	83 operations	$1,300
Urban bioretention	16 ac	$11	718 ac	$3,600
Urban grass buffer strip	21,120 ft	$38,000	66,528 ft	$120,000

Table 6.3. Estimated costs for reducing nutrient and sediment loads from crop-dominant recommended subwatersheds of Bayou Meto.

HUC12	Skinner Br Bayou Two Prairie		Upper Mill Bayou		Hurricane Bayou		Bills Bayou	
	Extent	Estimated cost ($1,000)	Extent	Estimated cost ($1,000)	Extent	Estimated cost ($1,000)	Extent	Estimated cost ($1,000)
conservation till	10,045 ac	$200	10,415 ac	$210	8,923 ac	$180	5,947 ac	$120
nutrient management plan	26 operations	$130	21 operations	$100	18 operations	$90	12 operations	$60
soil nutrient mgt suite	26 operations	$650	21 operations	$510	18 operations	$440	12 operations	$290
irrigation mgt suite	153 systems	$130,000	113 systems	$92,000	99 systems	$81,000	66 systems	$54,000
tailwater recovery suite	153 systems	$12,000	113 systems	$8,500	99 systems	$7,500	66 systems	$5,000
grassed buffer	287,232 ft	$69	356,400 ft	$86	335,808 ft	$81	177,408 ft	$43
winter flooding of rice fields	3,661 ac	$150	2,325 ac	$93	2,173 ac	$87	727 ac	$29
conservation till + cover crop	6,737 ac	$610	7,681 ac	$690	6,377 ac	$570	5,061 ac	$460
cover crops	15,667 ac	$1,100	13,476 ac	$940	11,188 ac	$780	8,879 ac	$620

6.2 Benefits of Practices

While there are costs associated with implementing best management practices, as noted in Section 6.1, there are also benefits. These include direct economic benefits to the producers implementing practices, as well as benefits that are more difficult to quantify economically both to the producer implementing practices, as well as to society.

Benefits that humans receive from nature are called ecosystem services. These services have been grouped into four categories: provisioning, regulating, cultural, and supporting (see Section 5.1.2.2). Provisioning services refer to the materials used by humans that are provided by nature, including, food, fiber, wood, and minerals. Regulating services refer to the benefits nature provides by regulating or contributing to air quality, soil fertility, flood control, and pollination. Supporting services refer to providing habitat for plants and animals and maintaining genetic diversity. Cultural services refer to non-material benefits from nature including aesthetic enjoyment, inspiration, emotional well-being, spirituality, and cultural identity.

Management practices recommended for the Bayou Meto watershed are expected to improve the health of ecosystems and their ability to provide services. In some cases, this can result in economic benefits that can be quantified relatively easily. In other cases, the benefits are more difficult to quantify economically. Examples of economic and non-material benefits of recommended management practices are provided below.

6.2.1 Economic Benefits

While not all ecosystem services improved by management practices have directly marketable economic value, there have been assessments of economic benefits of a number of practices. Economic benefits from management practices occur due to improved livestock and crop production; reduced need for inputs such as fertilizer, pesticides, fuel, and labor; and additional opportunities for income-producing activities, such as hunting leases. Table 6.4 summarizes economic benefits associated with the management practices recommended for Bayou Meto watershed. Note that economic benefits have been associated with most, but not all, of the recommended practices. Much of the information in this table is based on the NRCS 2022 Conservation Practice Physical Effects tools (https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/econ/tools/?cid=nrcs143_009740). Other information sources include studies by USGS, NRCS, USDA, and other researchers (Faulkner 2000, Zeckoski, Benham and Lunsford 2012, NRCS 2006, USGS and USDA 2018, USDA 2018a).

One concern with stream exclusion fencing is damage to fences from debris carried by floods, requiring repeated maintenance or replacement. Virtual fencing for cattle is an alternative method of controlling cattle that is generating a lot of interest and shows good potential (Smith Thomas 2021). Use of this technology would eliminate the cost of replacing stream-side fences damaged by flooding.

6.2.2 Other Benefits

Management practices also improve ecosystem services in ways that don't translate well into direct economic benefits. Table 6.5 lists examples of these benefits provided by management practices recommended for the Bayou Meto watershed. Specific best management practices proposed for the Bayou Meto recommended subwatersheds are listed in Table 6.6 along with the non-material environmental benefits that accrue from the implementation of these practices.

Table 6.4. Summary of economic benefits associated with recommended management practices for Bayou Meto watershed.

Practice	Increased cattle production	Decreased fuel use/cost	Decreased fertilizer use/cost	Decreased labor cost	Decreased pesticide use/cost	Increased crop production	Increased honey production	Additional income from hunting lease	Additional income from timber production	Decreased damage *
Wetlands restoration								X		X
Soil testing			X			X				
Nutrient management plans			X							
Prescribed grazing	X									
Access control (stream fencing)	X									
Alternate water supply	X									
Livestock shelter	X									
Streambank stabilization										X
Forested riparian buffer								X	X	X
Herbaceous riparian buffer					X		X	X		X
Critical area planting										X
Heavy use area protection										X
Cover crops		X	X		X	X	X	X		X
Feral hog/swine control										X

Table 6.4. Summary of economic benefits associated with recommended management practices for Bayou Meto watershed (continued).

Practice	Increased cattle production	Decreased fuel use/cost	Decreased fertilizer use/cost	Decreased labor cost	Decreased pesticide use/cost	Increased crop production	Increased honey production	Additional income from hunting lease	Additional income from timber production	Decreased damage *
Conservation tillage		X		X		X		X		
Grade stabilization structure/water control structure										X
Integrated pest management					X					
Tailwater recovery system		X						X		X
Grassed waterway					X	X	X	X		X
Irrigation land leveling		X								X
Irrigation water management (pipe planner + surge valves)		X								
Winter flooding of rice								X		X
Alternate rice irrigation		X								
Field borders					X	X	X	X		
Water and sediment control basins		X						X		X
Two-stage ditches										X

* from flooding, erosion/soil loss, feral swine rooting and wallowing

Table 6.5. Examples of ecosystem service benefits associated with best management practices recommended for Bayou Meto watershed that don't translate well into direct economic benefits.

Ecosystem service benefit	Description of how practice results in benefit
Erosion control	Practice reduces erosion.
Aquatic habitat	Practice provides or improves habitat for aquatic animals, e.g., by reducing water temperature, providing structure or organic matter inputs, or restoring more natural hydrology.
Nutrient cycling	Practice reduces nutrient losses from fields or encourages chemical transformation to non-bioavailable forms.
Carbon storage	Practice increases soil organic matter and vegetation growth that increase removal of greenhouse gases from atmosphere and regulate climate.
Soil health	Practice adds organic matter to soils, increases infiltration, reduces compaction, and improves soil structure and soil health.
Water purification	Practice increases water filtering through soils and vegetative/organic debris, or water contaminants are stored in plant matter.
Waterfowl habitat	Practice increases or improves available waterfowl habitat.
Other Wildlife habitat	Practice increases or improves habitat for pollinators and other beneficial insects, sport birds (other than waterfowl), sport game, and other wildlife.
Aquifer conservation	Practice improves aquifer sustainability by reducing groundwater withdrawals.

Table 6.6. Environmental benefits associated with implementing selected best management practices in the Bayou Meto subwatersheds.

Practice	Erosion control	Aquatic habitat	Nutrient cycling	Carbon sequestration	Soil health	Water purification	Waterfowl habitat	Other wildlife habitat	Aquifer conservation
Wetlands restoration		X	X	X		X	X	X	X
Soil testing			X						
Nutrient management plan			X						
Prescribed grazing	X		X	X	X				
Access control (stream fencing)	X	X	X						
Alternate water supply	X	X							
Livestock shelter									
Streambank stabilization	X	X							
Forested riparian buffer	X	X	X	X	X			X	
Herbaceous riparian buffer	X	X	X	X	X			X	
Critical area planting	X				X				
Heavy use area protection	X				X				
Cover crops	X		X	X	X			X	X
Feral hog/swine control	X								
Conservation tillage	X		X	X	X	X			
Grade stabilization structure/water control structure	X	X				X			
Integrated pest management	X		X		X			X	
Tailwater recovery system			X			X	X		X
Grassed waterways	X		X	X		X		X	
Irrigation land leveling	X								X
Irrigation water management (pipe planner + surge valves)									X
Land out of production	X		X	X	X	X		X	
Winter flooding of rice	X		X				X		
Alternate rice irrigation				X					X
Field borders	X		X	X				X	
Water and sediment control basins	X	X	X			X	X		X
Two-stage ditches	X		X			X			

6.3 Technical Assistance

This section describes programs that can provide technical assistance for implementation of the activities recommended in this plan. The programs described here are examples. This is not intended to be a complete listing of all available programs that can provide technical assistance.

6.3.1 Monitoring

Agencies and universities conducting water quality monitoring generally have their own technical resources. Technical assistance for volunteer water quality monitoring programs is available through the AGFC Stream Team Program.

6.3.2 Information and Education

Information for and assistance with education and outreach activities is available through the DEQ Public Outreach and Assistance Division, Watershed Conservation Resource Center, Clear Choices Clean Water, Arkansas Cooperative Extension Service, and others. Resources are also available from EPA through the Nonpoint Source Outreach Toolbox (http://cfpub.epa.gov/npstbx/index.html).

The DEQ Public Outreach and Assistance Division offers technical assistance and resources to interested citizens and groups. The Watershed Outreach and Education program of this division provides "a variety of tools and services to facilitate and promote awareness, appreciation, knowledge, and stewardship of water resources" (DEQ 2019).

Arkansas Cooperative Extension Service implements stormwater education programs required by municipal storm runoff NPDES permits in Northwest and Southeast Arkansas (UofA Cooperative Extension Service 2018). Information and education sources related to public education about urban stormwater are available on the Arkansas Cooperative Extension Service website, https://www.uaex.uada.edu/environment-nature/water/stormwater/default.aspx.

6.3.3 Implementing Management Practices

There are agencies and organizations that provide technical assistance for management practices identified for the recommended subwatersheds. Examples are summarized in Table 6.7 and discussed below.

6.3.3.1 County Conservation Districts

Conservation Districts for the counties in the Bayou Meto watershed are active in nonpoint source management within the watershed. They work with NRCS to provide technical support to landowners, including information and guidance about management practices for protecting soil and water resources, including benefits, costs, implementation, and maintenance.

Conservation Districts within the Bayou Meto watershed can provide technical support through several special projects including the Feral Swine Initiative, Acres for Wildlife, Quail Special Project, and Arkansas Unpaved Roads Program (Arkansas Association of Conservation Districts 2015). Arkansas County and Prairie County are part of the East Focal Landscape for the Arkansas Quail Special Project (AGFC n.d.).

6.3.3.2 UofA Division of Agriculture

The UofA Cooperative Extension Service provides technical assistance through a range of programs and services including testing of manure, hay, soil, and water; assistance with cropland, pasture, and livestock management; and field days and on-farm demonstrations. Cooperative Extension Service also maintains an extensive library of up-to-date, research-based fact sheets, applied research publications, and best management practice manuals and guidelines that address both agricultural and urban management practices.

The experiment station and Discovery Farm programs of the UofA Division of Agriculture generate, interpret, and distribute information and technology useful to farmers in Arkansas.

Table 6.7. Examples of sources of technical assistance available for implementing management practices in the Bayou Meto watershed.

Practices	NRD	AR Feral Hog Eradication Task Force	AGFC	AR Soil Health Alliance	UofA Cooperative Extension Service	County Conservation Districts	Ducks Unlimited	USDA Farm Services Agency	NRCS	National Sustainable Agriculture Information Service	Quail & Pheasants Forever	Soil Health Institute	Sustainable Agriculture Education Programs	EPA	USFWS	USDA Animal and Plant Health Inspection Service
Alternative livestock water supply						X			X							
Alternative rice irrigation						X			X							
Conservation tillage			X	X		X			X	X		X	X	X		
Controlled stream access			X		X	X			X	X				X	X	
Cover crops			X	X	X	X			X	X		X	X	X		
Critical area planting						X			X							
Dropped pipe/slotted board risers						X			X							
Environmentally Sensitive Road Maintenance	X													X		
Feral hog management		X			X	X			X							X
Field borders			X			X			X		X					
Grassed waterways						X			X							
Heavy use area protection					X	X			X							
Homeowner fertilizer management					X									X		
Integrated pest mgt					X	X			X	X			X	X		
Land leveling						X			X							
Land retirement (CRP)						X	X	X		X	X				X	
Livestock shelters					X	X			X							
Nutrient mgt plans						X			X			X	X	X		
Pipe Planner					X	X			X					X		
Prescribed grazing			X		X	X			X	X			X	X		
Rain gardens					X									X		
Riparian buffers			X		X	X	X	X	X	X	X			X	X	
Soil testing					X	X			X			X		X		
Streambank stabilization			X						X						X	
Surge valves					X	X			X					X		
Tailwater recovery system					X	X			X					X		
Two-stage ditches						X			X							
Water & sediment control basins						X			X							
Wetland protection, restoration			X		X	X	X	X	X					X		
Winter flooding rice fields			X		X	X	X		X							

6.3.3.3 Arkansas Game and Fish Commission

Through the AGFC Private Lands Program and Acres for Wildlife Program, Private Lands Biologists can provide technical assistance to volunteer landowners and tenants with managing their lands to improve both upland and aquatic wildlife habitat, in working pastures and haylands, farm ponds, and in set-aside areas like riparian areas and crop field borders. AGFC is working with the National Bobwhite Conservation Initiative to help restore quail habitat in Arkansas. The majority of the Bayou Meto watershed is classified as having a high quail restoration potential (Jackson, et al. 2015). AGFC biologists can also assist landowners and tenants with controlling invasive and destructive species, such as feral hogs. Management actions that improve wildlife habitat usually also improve water quality and reduce nonpoint source pollution.

Through the Stream Team program, AGFC "provides information to increase understanding and appreciation of Arkansas stream systems" and "training in streambank maintenance and restoration techniques" (AGFC 2015).

6.3.3.4 NRD

NRD houses the Arkansas Unpaved Roads Program. This program provides training in Environmentally Sensitive Road Maintenance and conducts demonstrations of road maintenance techniques that reduce water quality and other environmental impacts of unpaved roads (NRD 2020a).

6.3.3.5 USDA NRCS, Farm Services Agency, and Animal and Plant Health Inspection Service

The NRCS offers several programs to help landowners address natural resources concerns related to cropland, livestock, and pasture management. NRCS conservationists and specialists at county field service centers can work with farmers on resource assessments of pastures and fields, designing practices, developing management plans, and can provide guidance on implementation, and maintenance of implemented practices. Technical assistance is available for a variety of cropland and pasture practices through the NRCS Environmental Quality Incentives Program (EQIP), including feral hog control and capture, and through the

NRCS Conservation Stewardship Program (CSP) (NRCS 2021a, NRCS 2021b). USDA Farm Services Agency (FSA) also provides technical assistance for planning and implementing habitat improvement on Conservation Reserve Program (CRP) lands (FSA 2021b). The USDA Animal and Plant Health Inspection Service (APHIS) can provide technical assistance on feral hog control (NRCS 2020).

6.3.3.6 Sustainable Agriculture Education Programs

The Sustainable Agriculture Research and Education program (SARE) and National Sustainable Agriculture Information Service (ATTRA) (both funded by USDA) support farmers, researchers, and educators exploring practices that improve farm stewardship and profitability, and the vigor of farm communities. These programs emphasize outreach and distribution of the results of program research. This information is available from websites and includes a variety of print and electronic materials appropriate for producers (http://www.southernsare.org/About-Us, www.attra.ncat.org). On-site technical assistance is also available from ATTRA (ATTRA 2018).

6.3.3.7 US Environmental Protection Agency

The EPA website provides access to information on a variety of water quality subjects, including management measures for agriculture, unpaved roads, and developed areas. Specific information sources available through the EPA website include the Watershed Academy (https://www.epa.gov/watershedacademy/online-training-watershed-management), Nonpoint Source Pollution (https://www.epa.gov/nps), Wetlands Protection and Restoration (https://www.epa.gov/wetlands), and Green Infrastructure (https://www.epa.gov/green-infrastructure) webpages.

6.3.3.8 US Fish and Wildlife Service

Through its Partners for Fish and Wildlife program, the US Fish and Wildlife Service provides technical assistance to private landowners on projects to protect, improve, or restore native habitat. Wetlands and prairie habitats are primary habitats of concern for this program in Arkansas, as well as habitat for monarch butterflies. Assistance is available for designing, installing, and maintaining habitat-enhancing projects, including restoration of riparian habitats, wetlands, and native grasslands (https://www.fws.gov/arkansas-es/proj_pfw.html).

6.3.3.9 Non-government Interest Groups

There are a number of non-government organizations that provide technical assistance related to practices that reduce nonpoint sources of pollution. For example, Ducks Unlimited can provide technical assistance to cropland farmers related to managing croplands to support migrating waterfowl, including winter flooding of fields (Ducks Unlimited n.d.). The Arkansas Soil Health Alliance provides technical assistance primarily related to cover crops and conservation tillage. Quail Forever and Pheasants Forever can provide technical assistance related to creating and improving habitat for quail and pheasants on private lands (Pheasants Forever n.d.).

6.4 Financial Assistance

This section describes programs that can provide financial assistance for implementation of the activities recommended in this plan. The programs described here are examples. This is not intended to be a complete listing of all available programs that can provide funding assistance.

6.4.1 Monitoring

DEQ, US Army Corps of Engineers, and USGS have funded water quality monitoring projects in the Bayou Meto watershed. In addition, there is an active University of Arkansas Discovery Farm project in the Bayou Meto watershed, that includes water quality monitoring. Some of the funding for the monitoring programs in the Bayou Meto watershed comes from EPA grants or other agencies. USGS flow and/or water quality monitoring sites could be added in the watershed if a local entity would provide funds. The USGS 104b grant program funds water research projects of the Arkansas Water Resources Center.

SARE grants are available to support agricultural research, which could include water quality and/or biological monitoring. SARE has funded 49 research grants totaling over

$5,000,000 in Arkansas since 1988. In 2021, one Research and Education grant was awarded in Arkansas (Pollock 2021).

The AGFC Stream Team program has supported water quality monitoring in the upper Bayou Meto watershed. The AGFC Stream Team program can also provide funding for volunteer monitoring programs through mini-grants. State Wildlife Grant funding from AGFC can be used for biological surveys. In 2019, federal funds totaling $597,556 were distributed as State Wildlife Grants in Arkansas (https://www.agfc.com/en/wildlife-management/awap/state-wildlife-grants/).

NRD can assist with funding water quality monitoring projects through the 319 Program. In 2019, NRD allocated approximately $1,400,000 in federal funds to monitoring projects (NRD 2021).

6.4.2 Information and Education

AGFC offers Conservation Education Grants. These grants are funded using fines money from convictions for breaking Arkansas game laws (https://www.agfc.com/en/education/classroom/conservation-education-grants/). For the 2021-2022 school year, over $769,000 was available for Conservation Education Grants https://www.agfc.com/en/news/2021/09/01/agfc-aedc-offer-nearly-770000-for-education-grants-from-wildlife-fines/).

Projects funded through the NRD Nonpoint Source Pollution Management Program (Section 319[h] funds) usually include an education and outreach component. In 2020, approximately $100,000 were spent on outreach projects in Arkansas through the 319 Grant Program (NRD 2021).

SARE offers Research and Education grants. Since 1988 SARE has funded 37 Research and Education grants in Arkansas, totaling over $5,000,000. In 2021, one Research and Education grant was awarded in Arkansas (Pollock 2021).

Projects funded through NRCS and Farm Services Agency cost-share and easement programs are often used as demonstrations in NRCS and Conservation District outreach and education programs.

The Arkansas Grazing Lands Coalition sponsors field days.

The EPA provides grants for environmental education (https://www.epa.gov/education/grants).

There are several private foundations that fund education, which may include environmental education. In addition, organizations can often find local businesses or organizations to sponsor information and education activities, such as painting storm drains, festivals, and clean-up days.

6.4.3 Implementing Management Practices

Over the years, funding has been provided for implementation of management practices in the Bayou Meto watershed. There are a number of agencies and programs that offer financial assistance for implementation of nonpoint source pollution management practices recommended for the Bayou Meto watershed. The majority of these are grant programs, many of which require matching funds from the grant recipient. In addition, at least one tax incentive program is active that addresses practices that reduce nonpoint source pollution. Table 6.8 lists management practices for the recommended subwatersheds along with selected funding sources. It is notable that many federal assistance programs are seeing reductions in available funds. However, it is also notable that use of many of these practices can improve the bottom line for producers or communities (see Section 6.2), providing an incentive for implementation even without financial assistance.

6.4.3.1 NRCS

There are NRCS programs active in Arkansas that provide funding assistance for development and installation of nonpoint source pollution management practices that are applicable to the recommended subwatersheds of Bayou Meto. These programs provide funding to individuals rather than groups or organizations. This includes the Conservation Stewardship Program and EQIP. In these programs, a cost-share is usually required to implement practices. During the period 2008-2020 NRCS provided almost $14,000,000 in funding assistance to producers in the Bayou Meto watershed through these programs (Christianson 2021).

Table 6.8. Examples of sources of financial assistance available for management practices in the Bayou Meto watershed.

Funding Organization	**AGFC**			**NRD**		**NRCS**						**FSA**		**Ducks Unlimited, USA Rice, Arkansas Farm Credit Association**	**USFWS**
Program name	Acres for Wildlife	Waterfowl Rice Incentive Conservation Enhancement	Stream Teams	Nonpoint Source Program	Arkansas Unpaved Roads Program	Arkansas Southeast Feral Swine Control Pilot Project	Rice Stewardship Partnership	Partners for Fish and Wildlife	Conservation Stewardship Program	Environmental Quality Incentive Program	Working Lands for Wildlife – Bobwhite Quail	Conservation Reserve Program	Farmable Wetlands	Rice Stewardship Partnership	Partners for Fish and Wildlife
Who can receive funds	Individuals	Individuals	Individuals	Cities, counties, organizations	Counties	Individuals	Individuals	Individuals, organizations	Individuals	Individuals	Individuals	Individuals	Individuals	Individuals	Individuals, organizations
Focus area in Bayou Meto watershed	All	Rice fields	All	All	All	Arkansas County	Rice fields	Wetlands, prairies, habitat for species of concern	All	All	Pulaski and Faulkner Counties	All	All	Rice fields	Wetlands, prairies, habitat for species of concern
Practices															
Alternative livestock water supply				X				X	X	X	X				X
Alternative rice irrigation				X			X		X	X				X	
Conservation tillage				X			X		X	X				X	
Controlled stream access				X				X	X	X	X				X
Cover crops				X			X		X	X	X			X	
Critical area planting	X			X					X	X					
Dropped pipe/slotted board risers				X			X			X				X	
Environmentally Sensitive Road Maintenance					X										
Feral hog management				X		X				X					
Field borders	X			X					X	X	X	X			
Grassed waterways				X					X	X					
Heavy use area protection				X					X	X					

Table 6.8. Examples of sources of financial assistance available for management practices in the Bayou Meto watershed (continued).

Funding Organization	**AGFC**			**NRD**		**NRCS**						**FSA**		**Ducks Unlimited, USA Rice, Arkansas Farm Credit Association**	**USFWS**
Homeowner fertilizer management				X											
Integrated pest mgt				X					X	X					
Land leveling							X		X	X				X	
Land retirement (CRP)								X	X			X			X
Livestock shelters				X						X					
Nutrient mgt plans				X					X	X					
Pipe Planner							X		X	X				X	
Prescribed grazing				X					X	X	X				
Rain gardens				X											
Riparian buffers	X		X	X				X	X	X	X	X			X
Soil testing									X	X					
Streambank stabilization			X	X				X		X					X
Surge valves							X		X	X				X	
Tailwater recovery system							X			X				X	
Two-stage ditches				X						X					
Water & sediment control basins				X			X			X				X	
Wetland protection, restoration								X		X			X		X
Winter flooding rice fields		X					X	X	X	X				X	X

The Wetlands Reserve Easements (WRE) program of the Agricultural Conservation Easement Program provides rental payments for wetlands taken out of production and can provide some financial assistance for wetland restoration or enhancement. A portion of the Bayou Meto watershed is within the focus area for the Tri-state Wetland Reserve Enhancement Partnership (WREP) project (https://www.lmvjv.org/lmvjv-news/2020/12/11/tri-state-conservation-partnership-2021-wrep-proposal). WREP also provides rental payments and financial assistance for wetland restoration and enhancement.

Information about these programs, including application deadlines, cost-share requirements, and funding caps, is available online (https://www.nrcs.usda.gov/wps/portal/nrcs/ar/programs/) or from a local USDA service center, local conservation district, or local cooperative extension agents.

Table 6.9 shows funding provided to individuals in Arkansas through NRCS programs active in the Bayou Meto watershed during the 2020 fiscal year (Arkansas NRCS 2020). Table 6.10 shows the 2022 fiscal year national budget for NRCS conservation programs that can provide funding assistance in the Bayou Meto watershed.

Table 6.9. Funding provided to individuals in Arkansas through NRCS programs during the 2020 fiscal year (NRCS 2020).

Program	Funds distributed, millions of dollars
Agricultural Conservation Easement Program	$27.5
Conservation Stewardship Program	$171.2
Environmental Quality Incentives Program	$45.4
Regional Conservation Partnership Program	$2.9

Table 6.10. 2022 fiscal year national budgets for selected NRCS conservation programs (USDA 2021).

NRCS conservation program	2022 fiscal year budget
Agricultural Conservation Easement Program	$450 million
Conservation Stewardship Program	$800 million
EQIP	$1,850 million
Regional Conservation Partnership Program	$300 million

6.4.3.2 Farm Services Agency

The FSA administers the CRP. Through this land conservation program, landowners receive yearly rental payments for land enrolled in the program. CRP land contracts typically are for 10 to 15 years. Marginal pasture and cropland along streams that can be used for establishment of riparian buffers can be eligible for CRP enrollment. In addition to rental payments, the FSA may pay up to 50% of eligible costs for establishing vegetation on eligible lands, and an additional cost share for Climate-Smart practices that reduce greenhouse gases, or increase carbon sequestration (https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/FactSheets/crp-general-signup-56-enrollment%20period-june-2021.pdf). Additional financial incentives are available in Arkansas through the State Acres for Wildlife Enhancement Initiative and Farmable Wetlands Program of CRP (NRCS 2021c, NRCS 2019b). The fiscal year 2022 national budget for CRP is $2,300 million (USDA 2018b).

6.4.3.3 US Fish and Wildlife Service

The USFWS Partners for Fish and Wildlife program can provide funding assistance to individuals for installing nonpoint source management practices. Funding from this program may require cost-share (USFWS Arkansas Ecological Services Field Office 2012). The 2022 fiscal year national budget for the Partners for Fish and Wildlife program is $65 million (US Department of the Interior 2021). It is unknown how much of these funds will be available for projects in Arkansas, or in the Bayou Meto watershed.

6.4.3.4 NRD

NRD manages the Arkansas Section 319 grant program. This program provides grants to non-profit groups, organizations, communities, and academic institutions for projects related to reduction, control, or abatement of nonpoint source pollution. Eligible projects can include implementation of best management practices on pastures or croplands, as well as stormwater management and low impact development practices in developed areas. Organizations seeking grants must be capable of implementing projects and are typically required to provide a minimum of 43% non-federal matching contributions. In 2019, around $0.4 million in federal funds were spent on implementing management practices in Arkansas through the Clean Water

Act Section 319 grant program (NRD 2021). The 2022 fiscal year national budget for the Section 319 grant program is $180 million (EPA 2021).

6.4.3.5 AGFC

AGFC has programs that can provide financial assistance with implementation of management practices. The Acres for Wildlife program can provide up to $5,000 to landowners to assist with establishment of plantings for wildlife habitat. Stream Team program funds can be used to provide up the $5,000 to private land owners to assist with riparian or streambank stabilization projects (https://www.agfc.com/en/education/onthewater/streamteam/habitat-restoration/). Landowners with fields within 10 miles of waterfowl-focused wildlife management areas or national wildlife refuges can earn up to $150/acre through the Arkansas Waterfowl Rice Incentive Conservation Enhancement (WRICE) program. Landowners with Wetland Reserve Easements are also eligible for this program. Through WRICE, landowners can earn incentive payments for managing their rice fields after harvest to provide waterfowl habitat and allowing waterfowl viewing and hunting (permits required) on their land (https://www.agfc.com/en/wildlife-management/private-lands-program/wrice/).

6.4.3.6 Non-monetary Support of Implementation

Agencies, organizations, and individuals can support implementation of nonpoint source management practices in ways other than providing funds. One way is through offering free or low-cost materials. An example is the AGFC competitive program under their Acres for Wildlife initiative, which provides warm season grass seed to landowners who want to establish native habitat for bobwhite quail (AGFC 2021c). Another example is the provision of low-cost or free tree seedlings by the Arkansas Forestry Commission, Arkansas Urban Forestry Council, and National Arbor Day Foundation.

6.4.3.7 Tax Incentives

Tax incentives are another financial mechanism for encouraging the use of management practices. The Arkansas Private Wetland and Riparian Zone Creation, Restoration, and Conservation Tax Credits Act of 1995 allows the application of a tax credit against Arkansas state taxes by taxpayers involved in conservation or restoration of riparian zones through projects approved by the Private Lands Restoration Committee. Detailed information on this program is available from NRD, who manages the program (http://anrc.ark.org/divisions/water-resources-management/wetlands- riparian-zone-tax-credit/).

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APPENDIX A

Examples of Entities Active in the Bayou Meto Watershed with Vision, Mission, and Goals for the Watershed

A.1 Bayou Meto Water Management District

The Bayou Meto Water Management District is the local entity tasked with implementation and management of the Bayou Meto Water Management Project. The Bayou Meto Water Management District covers portions of the Bayou Meto watershed within Lonoke, Jefferson, and Arkansas Counties. Objectives identified for this project are as follows (Bayou Meto Water Management District undated):

- Protect and conserve the groundwater resources of the Bayou Meto basin.
- Minimize flood damage and improve water management capability within the Bayou Meto basin.
- Protect, restore, and enhance waterfowl management resources within the Bayou Meto basin.

Goals of the selected project plan are as follows (Bayou Meto Water Managment District undated):

- Protect the aquifer without devastating the economy by reducing groundwater use to a sustainable level through use of surface water from the Arkansas River.
- Balance the needs of flood protection and the environment.
- Improve existing waterfowl habitat through improved water management practices and restoration of prairie and prairie wetlands.

A.2 White River Irrigation District

The White River Irrigation District is the local entity tasked with implementation and management of the Grand Prairie Irrigation Project. The Grand Prairie Irrigation Project includes portions of the Bayou Meto watershed within Prairie and Arkansas Counties, east of the Bayou Meto Water Management District. Purposes of this project include the following (USACE 2004):

- Protection and conservation of groundwater resources,
- Support of local agriculture by providing surface water for irrigation to approximately 300,000 acres of cropland, and
- Enhancement of waterfowl management resources.

A.3 Arkansas Game and Fish Commission

All or part of several Wildlife Management Areas (WMAs) owned and managed by the Arkansas Game and Fish Commission (AGFC) are located within the Bayou Meto watershed. The mission of the AGFC is "to conserve and enhance Arkansas's fish and wildlife and their habitats while promoting sustainable use, public understanding and support." The WMAs in the watershed are managed to provide diverse and good quality habitat to support a variety of wildlife, while also providing opportunities for public use of these lands, including hunting and fishing. A master plan has been developed for the Holland Bottoms WMA.

A.4 Ducks Unlimited

Ducks Unlimited Arkansas chapters are active in the Delta region of the state, including the Bayou Meto watershed. The Ducks Unlimited mission is to "conserve, restore, and manage wetlands and associated habitats for North America's waterfowl. These habitats also benefit other wildlife and people." The vision for Ducks Unlimited is "wetlands sufficient to fill the skies with waterfowl today, tomorrow and forever." In the Arkansas Delta, Ducks Unlimited works with AGFC and the Natural Resources Conservation Service (NRCS) to protect, improve, and expand waterfowl habitat.

APPENDIX B

Public Meeting Lists of Attendees

Bayou Meto Public Meeting (via ZOOM)

January 19, 2021 Meeting Attendance Summary

Upper Bayou Meto Meeting Attendance

Organization/ Category	Number of attendees
Agricultural Council of Arkansas	1
Arkansas Association of County Conservation Districts	1
Arkansas Cooperative Extension Service	2
Arkansas Farm Bureau	1
Arkansas Game and Fish Commission	4
Arkansas Natural Heritage Commission	1
Arkansas Rice Federation	1
Arkansas Senate	1
Bayou Meto Water Management District	1
Cabot Chamber of Commerce	1
Central Arkansas Planning and Development District	1
Central Arkansas Water	1
Division of Arkansas Tourism	1
Division of Environmental Quality	1
Ducks Unlimited	1
Hawkins-Weir	1
Natural Resources Division	2
Ozark Society	2
Sherwood Chamber of Commerce	1
US Air Force	2
US Congress	1
US Fish and Wildlife Service	1

Lower Bayou Meto Meeting Attendance

Organization/ Category	Number of attendees
Arkansas Association of County Conservation Districts	1
Arkansas Cooperative Extension Service	1
Arkansas Game and Fish Commission	5
Arkansas Rice Federation	1
Bayou Meto Water Management District	1
Division of Arkansas Tourism	1
Division of Environmental Quality	1
Farmer or rancher	1
Jefferson County Office of Emergency Management	1
Natural Resources Division	2
NRCS	1
Ozark Society	1
USA Rice Federation	1

Bayou Meto Public Meeting (via ZOOM)

April 28, 2021 Meeting Attendance Summary

Upper Bayou Meto Meeting Attendance

Organization/ Category	Number of attendees
Arkansas Cooperative Extension Service	1
Arkansas Department of Agriculture Forestry Division	2
Arkansas Game and Fish Commission	3
Arkansas Natural Heritage Commission	1
Bayou Meto Water Management District	1
Division of Environmental Quality	1
Ducks Unlimited	1
Grand Prairie Farming & Water Co.	1
Natural Resources Division	2
NRCS	1
Ozark Society	1
Pulaski County Public Works	1
Resident	1
US Air Force	1
US Congress	2

Lower Bayou Meto Meeting Attendance

Organization/ Category	Number of attendees
Arkansas Association of County Conservation Districts	1
Arkansas Cooperative Extension Service	1
Arkansas Department of Agriculture Forestry Division	1
Bayou Meto Water Management District	1
Division of Environmental Quality	1
Grand Prairie Farming & Water Co.	1
Jefferson County Office of Emergency Management	2
Natural Resources Division	1
Ozark Society	1
Pulaski County Planning & Development	1
Resident	1
Sportsman	2

Bayou Meto Public Meeting (via ZOOM)

July 22, 2021 Meeting Attendance Summary

Upper Bayou Meto Meeting Attendance

Organization/ Category	Number of attendees
Agricultural Council of Arkansas	1
Arkansas Forestry Division	2
Arkansas Game and Fish Commission	1
Arkansas Natural Heritage Commission	1
Bayou Meto Water Management District	1
City of Sherwood	1
Arkansas Division of Environmental Quality	1
Farmer or rancher	2
Natural Resources Division	1
Ozark Society	1
Pulaski County Public Works	1
Pulaski County	1
City of Sherwood	1

Lower Bayou Meto Meeting Attendance

Organization/ Category	Number of attendees
Agriculture Council of Arkansas	1
Arkansas Game and Fish Commission	1
Bayou Meto Water Management District	1
Ducks Unlimited	1
Farmer or rancher	2
Jefferson County Office of Emergency Management	1
Natural Resources Division	1

Bayou Meto Public Meeting (via ZOOM)

October 26, 2021 Meeting Attendance Summary

Upper Bayou Meto Meeting Attendance

Organization/ Category	Number of attendees
Arkansas Game and Fish Commission	2
Arkansas Natural Heritage Commission	1
Arkansas Legislature	1
Bayou Meto Water Management District	2
Arkansas Department of Agriculture Natural Resources Division	3
Sherwood Office of Emergency Management	1
USDA Natural Resources Conservation Service	1
USDA Agricultural Research Service	1
US Air Force	2
US Congress	1
US Fish and Wildlife Service	1

Lower Bayou Meto Meeting Attendance

Organization/ Category	Number of attendees
Arkansas Department of Agriculture Natural Resources Division	4
Arkansas Department of Agriculture Forestry Division	1
Arkansas Game and Fish Commission	1
Farmer or rancher	1
Sherwood Office of Emergency Management	1
US Air Force	2

APPENDIX C

Inventory of Historical Water Quality Monitoring in Bayou Meto Watershed

Table 1. Active and historical surface water quality monitoring stations in the Bayou Meto watershed (US WQ portal, DEQ online database, Legacy Storet, USGS NWIS).

Entity	Station ID	Stream	County	Location	Start Year	End Year	Number of dates
DEQ	ARK0174A, 60456	Bayou Meto	Lonoke	1.5 mi upstream of Remmington Arms	1973	2012	8
DEQ	ARK0174B, 60457	Bayou Meto	Lonoke	9 mi downstream or Remmington Arms outfall	1973	2012	8
DEQ	60459	Bayou Meto	Arkansas/ Jefferson	at confluence with Arkansas R	1973	1973	3
DEQ	60458	Bayou Meto	Lonoke	At confluence with Bayou Two Prairie	1973	1973	4
DEQ	ARK0174D	Bayou Meto	Lonole	At Hwy 15	2012	2012	4
DEQ, USGS	ARK0050, 07263935	Bayou Meto	Pulaski	at Hwy. 161 near Jacksonville	1983	2020	316+
DEQ	60417	Bayou Meto	Lonoke	At I-40 W of Lonoke	1972	1979	4
DEQ, USGS	ARK0060, 07263920	Bayou Meto	Pulaski	at West Main Street Bridge in Jacksonville	1983	2020	299+
DEQ	ARK0211	Bayou Meto	Pulaski	CR70, 1.5 mi. N. of Macon	2017	2018	14
DEQ, USGS	ARK0023, 50102, 07265099	Bayou Meto	Jefferson	on SR11 1.5 miles S of Bayou Meto	1974	2020	516
USGS	07264000	Bayou Meto	Lonoke	Near Lonoke	1955	1983	169
DEQ	50101, 60807	Bayou Meto	Lonoke	Near Lonoke	1974	1985	143
USGS	07264500	Bayou Meto	Arkansas	near Stuttgart	1949	1974	125
DEQ	50017	Bayou Meto	Arkansas	Near Stuttgart, AR	1968	1985	157
DEQ	ARK0174C	Bayou Meto	Lonoke	Off Blackman Rd.	2012	2012	4
DEQ	UWBMO01	Bayou Meto	Lonoke	on Brumett Rd/CR971 S.E. of Seaton Dump	1994	2010	16
DEQ	UWBMO02	Bayou Meto	Arkansas	on Hwy 63/79 2 mi. S.W. of Stuttgart	1994	2010	14
DEQ	60473	Bayou Two Prairie	Lonoke	1 mi above Cabot STP	1973	1973	2
DEQ	60461	Bayou Two Prairie	Lonoke	1 mi above Lonoke STP	1973	1973	2

Table 1. Active and historical surface water quality monitoring stations in the Bayou Meto watershed (continued).

Entity	Station ID	Stream	County	Location	Start Year	End Year	Number of dates
DEQ	60462	Bayou Two Prairie	Lonoke	6 mi below Lonoke STP	1973	1973	2
DEQ	60460	Bayou Two Prairie	Lonoke	7 mi below Jacksonville STP	1973	1973	2
DEQ	60463	Bayou Two Prairie	Lonoke	9 mi below Carlisle STP	1973	1973	2
USGS	07264200	Bayou Two Prairie	Lonoke	At Carlisle	1961	1961	1
DEQ, USGS	ARK0097, 50284, 07264203	Bayou Two Prairie	Lonoke	at Hwy. 13 south of Carlisle	1993	2020	283+
USGS	07264050	Bayou Two Prairie	Lonoke	Near Furlow, AR	1974	1983	102
DEQ	50100	Bayou Two Prairie	Lonoke	South of Cabot	1974	1985	123
USGS	07263923	Big Base Lake East	Pulaski	Near Jacksonville	2003	2012	16
USGS	07263924	Big Base Lake West	Pulaski	Near Jacksonville	2003	2015	17
DEQ	ARK0210	Bridge Cr.	Pulaski	CR71, 3.5 mi N. of Gibson	2017	2018	15
USGS	07265000	Crooked Cr.	Arkansas	Near Humphrey, AR	1945	1955	19
DEQ	60464	King Bayou Ditch	Arkansas	Above Stuttgart STP	1973	1973	2
DEQ	60465	King Bayou Ditch	Arkansas	Below Stuttgart STP	1973	1973	2
USGS	07263922	Lil Base Lake	Pulaski	Near Jacksonville	2003	2015	16
DEQ	60466	Main Canal 9	Lonoke	3 mi below England STP	1973	1973	2
DEQ	LARK025A	Pickthorne Lake	Lonoke	Along easternmost levee	1994	2020	5 (through 9/20)
DEQ	ARK0175	Rocky Branch Cr.	Pulaski	At S. Redmon Rd. and Municipal Dr.	2014	2014	1
DEQ	LARK027A	Rodgers Reservoir	Arkansas	Near dam	2009	2011	33

Table 2. Active and historical groundwater quality monitoring stations in the Bayou Meto watershed (DEQ online database, USGS NWIS).

Entity	Station ID	Aquifer	Well Name	County	Depth, feet	Start Year	End Year	Number of dates
ADEQ	LON004	NA	PWS well 004	Lonoke	NA	2013	2018	2
ADEQ	LON009A	NA	Irrigation Well 009A	Lonoke	NA	2004	2018	4
ADEQ	LON010	NA	Irrigation Well 010	Lonoke	NA	1994	2018	7
ADEQ	LON017	NA	Irrigation Well 017	Lonoke	NA	1994	2018	8
ADEQ	LON017R	NA	Irrigation Well 017R	Lonoke	NA	1997	2018	7
ADEQ	LON022A	NA	Aquaculture Well 022A	Lonoke	NA	2010	2018	3
ADEQ	LON024	NA	Irrigation Well 024	Lonoke	NA	1994	2018	7
ADEQ	LON901	NA	PWS Well 901	Lonoke	NA	2004	2018	4
USGS	340340091141001	Sparta aquifer	07S02W28ABA1	Arkansas	690	1995	2000	3
USGS	340500091214701	Alluvial aquifer	07S03W17DBB1	Arkansas	NA	1959	1959	1
USGS	340525091221901	Alluvial aquifer	07S03W17BBB1	Arkansas	55	1959	1959	1
USGS	340532091234501	Alluvial aquifer	07S04W12DDC1	Arkansas	NA	1959	1995	2
USGS	340601091225301	Alluvial aquifer	07S03W07BDA1	Arkansas	176	1959	1959	1
USGS	340607091232201	Alluvial aquifer	07S03W07BBC1	Arkansas	128	2008	2010	2
USGS	340622091232401	Alluvial aquifer	07S04W01DDD1	Arkansas	155	1959	2007	7
USGS	340625091243401	Alluvial aquifer	07S04W02DDD1	Arkansas	167	1959	1959	1
USGS	340653091222601	Alluvial aquifer	07S03W06ADD1	Arkansas	100	1959	1959	1
USGS	340711091224801	Sparta aquifer	07S03W06ABC1	Arkansas	720	1963	2019	14
USGS	340736091232801	Alluvial aquifer	06S04W36DAA1	Arkansas	NA	1959	1959	1
AR008	340740091211501	Alluvial aquifer	06S03W32ADD1	Arkansas	135.5	2018	2018	3
USGS	340803091233901	Alluvial aquifer	06S04W36AAB1	Arkansas	NA	1959	1959	1
USGS	340845091213701	Alluvial aquifer	06S03W29ABD1	Arkansas	128	1959	1959	1
USGS	340900091214701	Alluvial aquifer	06S03W20CDD1	Arkansas	NA	1959	1959	1
USGS	340902091243901	Alluvial aquifer	06S04W23DDC1	Arkansas	NA	1959	1959	1
USGS	340921091240501	Alluvial aquifer	06S04W24CAB1	Arkansas	140	1959	1959	1
USGS	340922091222101	Alluvial aquifer	06S03W19ADD1	Arkansas	NA	1959	1959	1
USGS	340935091215701	Alluvial aquifer	06S03W20BAC1	Arkansas	143	1959	1959	1

Table 2. Active and historical groundwater quality monitoring stations in the Bayou Meto watershed (continued).

Entity	Station ID	Aquifer	Well Name	County	Depth, feet	Start Year	End Year	Number of dates
USGS	340938091245801	Alluvial aquifer	06S04W23ABC1	Arkansas	NA	1959	1959	1
USGS	340953091213001	Alluvial aquifer	06S03W17DDC1	Arkansas	NA	1959	1959	1
AR008	341015091300001	Alluvial aquifer	06S05W13DA1	Arkansas	140	1995	1995	1
USGS	341018091232401	Alluvial aquifer	06S04W13ACD1	Arkansas	NA	1959	1959	1
USGS	341054091231201	Alluvial aquifer	06S03W07CBC1	Arkansas	NA	1959	1959	1
USGS	341238091250901	Alluvial aquifer	05S04W35CCA1	Arkansas	NA	1959	1959	1
USGS	341314091294501	Alluvial aquifer	05S05W36AAA1	Arkansas	92	1959	1959	1
USGS	341322091261701	Sparta aquifer	05S04W27SWSW1	Arkansas	828	2018	2018	1
USGS	341329091264501	Alluvial aquifer	05S04W28DCA1	Arkansas	NA	1959	1959	1
USGS	341329091284601	Alluvial aquifer	05S04W30DDB1	Arkansas	NA	1959	1959	1
USGS	341358091243501	Sparta aquifer	05S04W26ACA1	Arkansas	822	1998	1998	1
USGS	341424091282501	Alluvial aquifer	05S04W20CBC1	Arkansas	NA	1959	1959	1
USGS	341500091291802	Alluvial aquifer	05S04W19BAB2	Arkansas	NA	1959	1959	1
USGS	341555091292802	Alluvial aquifer	05S04W18BBB2	Arkansas	NA	2014	2014	1
USGS	341556091293101	Alluvial aquifer	05S04W07CCC1	Arkansas	120	1998	2010	9
USGS	341634091293401	Alluvial aquifer	05S05W12ADA1	Arkansas	NA	2014	2014	1
USGS	341723091364901	Alluvial aquifer	05S06W02DDD1	Arkansas	60	1959	1959	1
USGS	341752091300401	Sparta aquifer	04S05W36DCC1	Arkansas	880	1995	2000	4
USGS	341819091313901	Sparta aquifer	04S05W34DAA1	Arkansas	848	1997	1999	2
USGS	341819091344801	Sparta aquifer	04S05W31DDA1	Arkansas	793	1998	1998	1
USGS	341850091320901	Alluvial aquifer	04S05W34ABB1	Arkansas	NA	1965	1965	1
USGS	342004091251401	Sparta aquifer	04S04W22DAA1	Arkansas	795	1995	1995	1
USGS	342005091292601	Sparta aquifer	04S04W19CBB1	Arkansas	1048	1995	2000	3
USGS	342057091280601	Alluvial aquifer	04S04W17CBA1	Arkansas	NA	1965	1965	1
USGS	342130091400001	Alluvial aquifer	04S06W16BD1	Arkansas	NA	1995	2007	9
USGS	342155091250301	Sparta aquifer	04S04W11BCC1	Arkansas	836	1995	2003	2
AR008	342222091354801	Alluvial aquifer	04S06W12AD1	Arkansas	100	1995	1995	1
AR008	342240091285101	Alluvial aquifer	04S04W06CA1	Arkansas	129	1995	1995	1
USGS	342308091321001	Alluvial aquifer	04S05W03BDB1	Arkansas	NA	2008	2012	2
USGS	342321091295501	Sparta aquifer	04S05W01BAA1	Arkansas	929	1950	1995	2
USGS	342416091264501	Sparta aquifer	03S04W33BAA1	Arkansas	878	2015	2015	1
AR008	342446091410301	Alluvial aquifer	03S06W30DA1	Arkansas	100	1995	1999	2
USGS	342515091421001	Sparta aquifer	03S06W30BBD1	Arkansas	870	1995	2015	8

Table 2. Active and historical groundwater quality monitoring stations in the Bayou Meto watershed (continued).

Entity	Station ID	Aquifer	Well Name	County	Depth, feet	Start Year	End Year	Number of dates
USGS	342632091300501	Sparta Aquifer	03S05W13BDC1	Arkansas	910	1995	1995	1
USGS	342632091322701	Sparta Aquifer	03S05W15CBB1	Arkansas	760	1998	2015	7
USGS	342632091433701	Alluvial aquifer	03S07W14DDB1	Jefferson	NA	2012	2012	1
USGS	342633091352301	Sparta Aquifer	03S05W18CAB1	Arkansas	819	1995	2000	3
USGS	342645091270401	Alluvial aquifer	03S04W16BBB1	Arkansas	140	1954	1954	1
USGS	342647091270501	Sparta Aquifer	03S04W17BBB1	Arkansas	723	1997	1997	1
USGS	342648091323201	Alluvial aquifer	03S05W16AA1	Arkansas	110	2014	2016	2
USGS	342711091270901	Alluvial aquifer	03S04W08DAA1	Arkansas	150	1954	1954	1
USGS	342713091334601	Alluvial aquifer	03S05W08DD1	Arkansas	110	1995	2007	5
USGS	342715091281301	Alluvial aquifer	03S04W07ADD1	Arkansas	NA	1954	1954	1
USGS	342738091280801	Alluvial aquifer	03S04W08BBB1	Arkansas	127	2014	2016	2
AR008	342740091305001	Sparta Aquifer	03S05W12BB1	Arkansas	900	1995	1995	1
USGS	342834091303701	Sparta Aquifer	03S04W02AAB1	Arkansas	806	1997	1997	1
USGS	342839091303201	Sparta Aquifer	03S05W02AAB1	Arkansas	801	1950	2000	5
USGS	342840091323101	Alluvial aquifer	03S05W04AAA1	Arkansas	125	1969	1969	1
USGS	342847091345702	Alluvial aquifer	03S05W06ABA2	Arkansas	123	1975	2016	10
USGS	342925091314701	Sparta Aquifer	02S05W34ABC1	Arkansas	758	1966	2018	13
USGS	343018091325201	Alluvial aquifer	02S05W28ABD1	Arkansas	150	1952	1952	1
USGS	343035092041501	Alluvial aquifer	02S10W27DBD	Pulaski	90	1951	1951	1
AR008	343041091235401	Sparta Aquifer	02S04W23DA2	Arkansas	840	1995	1995	1
AR008	343130091350002	Alluvial aquifer	02S05W19AB1	Arkansas	120	1995	1995	1
USGS	343212091372901	Alluvial aquifer	02S06W14BBB1	Prairie	118	1998	2007	7
USGS	343235091470001	Sparta Aquifer	02S07W08DCC1	Lonoke	552	1999	2009	5
AR008	343238091395301	Alluvial aquifer	02S06W09CB1	Lonoke	140	1995	1995	1
AR008	343317091363501	Alluvial aquifer	02S06W01CC1	Prairie	127	1995	1995	1
USGS	343339091453501	Alluvial aquifer	02S07W04DA1	Lonoke	105	1995	2007	6
USGS	343349091420901	Alluvial aquifer	02S07W01ADD1	Lonoke	NA	1965	1965	1
USGS	343417091343201	Alluvial aquifer	01S05W31DDA1	Prairie	120	2016	2016	1
USGS	343417091364501	Alluvial aquifer	01S06W35DDA1	Prairie	127	2010	2010	1
USGS	343555091400801	Alluvial aquifer	01S06W17DDB1	Lonoke	115	1961	1961	1
AR008	343556091434601	Alluvial aquifer	01S07W23CD1	Lonoke	135	1995	1995	1
AR008	343557091410201	Alluvial aquifer	01S06W19DD1	Lonoke	110	1995	1995	1
AR008	343609091474601	Alluvial aquifer	01S07W19DDB1	Lonoke	151.9	2020	2020	3

Table 2. Active and historical groundwater quality monitoring stations in the Bayou Meto watershed (continued).

Entity	Station ID	Aquifer	Well Name	County	Depth, feet	Start Year	End Year	Number of dates
USGS	343649091363901	Alluvial aquifer	01S06W13CCC1	Prairie	NA	2010	2016	3
USGS	343748091365401	Sparta Aquifer	01S06W11DBD1	Prairie	618	1995	2000	4
USGS	343751091363501	Sparta Aquifer	01S06W12CBC1	Prairie	545	1928	1950	2
USGS	343835091431101	Alluvial aquifer	01S07W12DDD1	Lonoke	NA	1999	1999	1
USGS	343900091451401	Alluvial aquifer	01S07W03CBB1	Lonoke	NA	1961	1961	1
USGS	343943091384501	Sparta Aquifer	01N06W34CBB1	Prairie	500	2015	2019	2
USGS	344017091395101	Alluvial aquifer	01N06W29DDD1	Prairie	155	2016	2016	1
USGS	344051091411101	Alluvial aquifer	01N06W30ADC1	Prairie	NA	2010	2016	3
USGS	344059091462001	Alluvial aquifer	01N07W28BCB1	Lonoke	NA	2001	2001	1
USGS	344104091415401	Alluvial aquifer	01N06W30BBC1	Prairie	NA	2008	2008	1
AR008	344113091442201	Alluvial aquifer	01N07W22DD1	Lonoke	130	1995	1995	1
USGS	344114091472001	Alluvial aquifer	01N07W29BBB1	Lonoke	NA	1998	2016	9
USGS	344214091482501	Alluvial aquifer	01N07W18CCC1	Lonoke	250	1930	1930	1
USGS	344219091590201	Alluvial aquifer	01N09W21BAB1	Lonoke	100	1988	1988	1
USGS	344227091432401	Alluvial aquifer	01N07W14DBA1	Lonoke	148	1961	1961	1
USGS	344235091551701	Alluvial aquifer	01N09W13DAB1	Lonoke	150	2004	2020	5
USGS	344242091551501	Alluvial aquifer	01N09W13DA1	Lonoke	155	1995	2000	3
USGS	344251091560201	Alluvial aquifer	01N09W13BCB1	Lonoke	125	1988	1988	1
AR008	344304091510900	Alluvial aquifer	01N08W15AB1	Lonoke	140	1995	1995	1
USGS	344319091524601	Alluvial aquifer	01N08W09CBC1	Lonoke	150	1988	1988	1
USGS	344333091562401	Alluvial aquifer	01N09W11DBA1	Lonoke	105	1988	1988	1
USGS	344348091474501	Alluvial aquifer	01N07W07ABB1	Lonoke	NA	1961	1961	1
USGS	344444091450701	Sparta Aquifer	01N07W03BCC1	Lonoke	285	1998	2017	3
USGS	344448091461801	Sparta Aquifer	02N07W32DDD1	Lonoke	276.5	1997	2015	8
USGS	344511091482501	Alluvial aquifer	02N07W31CB1	Lonoke	200	2014	2016	2
USGS	344515091503901	Alluvial aquifer	02N08W34DA1	Lonoke	192	2014	2016	2
USGS	344519091534401	Alluvial aquifer	02N08W32BCC1	Lonoke	195	1988	1988	1
USGS	344538091450701	Alluvial aquifer	02N07W28DDD1	Lonoke	NA	2014	2016	2
USGS	344541091570201	Sparta Aquifer	02N09W35BBB2	Lonoke	354	1988	1988	1
AR008	344543091510601	Alluvial aquifer	02N08W27DCC1	Lonoke	176.6	2018	2018	3
USGS	344547091591001	Alluvial aquifer	02N09W28CCC2	Lonoke	136	1988	1988	1
USGS	344605092023201	Alluvial aquifer	02N10W26DDA1	Lonoke	NA	2012	2012	1
USGS	344606091544201	Sparta Aquifer	02N08W30CBA1	Lonoke	255	1995	1995	1

Table 2. Active and historical groundwater quality monitoring stations in the Bayou Meto watershed (continued).

Entity	Station ID	Aquifer	Well Name	County	Depth, feet	Start Year	End Year	Number of dates
USGS	344607092030401	Alluvial aquifer	02N10W26CAD1	Lonoke	90	1951	1951	1
USGS	344648091494601	Alluvial aquifer	02N08W23DCA1	Lonoke	176	2007	2016	3
USGS	344701091535801	Alluvial aquifer	02N08W19DAB1	Lonoke	125	1946	1961	3
USGS	344702091414901	Sparta Aquifer	02N07W24DAC1	Lonoke	321	2015	2017	2
USGS	344705091443701	Alluvial aquifer	02N07W22BDA1	Lonoke	210	1946	1961	3
USGS	344705091535001	Alluvial aquifer	02N08W19ADD1	Lonoke	155	1988	1988	1
USGS	344708091533501	Sparta Aquifer	02N08W20BCD1	Lonoke	NA	1999	2007	4
USGS	344710091533001	Sparta Aquifer	02N08W20BCA1	Lonoke	NA	1999	2007	4
USGS	344717091415301	Alluvial aquifer	02N07W24AAA1	Lonoke	NA	1995	1995	1
USGS	344718091564401	Alluvial aquifer	02N09W23BAC1	Lonoke	150	1988	1988	1
USGS	344725092032101	Alluvial aquifer	02N10W23BCA1	Lonoke	95	1998	2004	3
USGS	344741091444401	Alluvial aquifer	02n07w15cab1	Lonoke	NA	1999	1999	1
USGS	344754092000901	Alluvial aquifer	02n09w17cbb1	Lonoke	NA	1999	1999	1
USGS	344806092033501	Alluvial aquifer	02N10W15AD1	Lonoke	135	1995	2004	3
USGS	344807092051701	Alluvial aquifer	02N10W16BCD1	Pulaski	NA	1951	1951	1
USGS	344809092051101	Alluvial aquifer	02N10W16BDC1	Pulaski	NA	1959	1959	1
USGS	344811091520301	Alluvial aquifer	02N08W16ABC1	Lonoke	170	1995	2020	7
USGS	344814091460201	Alluvial aquifer	02N07W16BB1	Lonoke	188	2014	2016	2
USGS	344815091454001	Alluvial aquifer	02N07W16BAB1	Lonoke	184	2004	2007	2
USGS	344816091453000	Alluvial aquifer	02N07W09CD3	Lonoke	187	2012	2012	1
AR008	344824091565801	Alluvial aquifer	02N09W14BB1	Lonoke	154	1995	1995	1
USGS	344830091545001	Alluvial aquifer	02N08W07CCC1	Lonoke	100	1988	1988	1
USGS	344940091472101	Sparta Aquifer	02N07W06ACD1	Lonoke	243	1998	2015	2
USGS	344944091530201	Alluvial aquifer	02N08W05ACC1	Lonoke	152	1964	1964	1
USGS	344948091534101	Alluvial aquifer	02N08W06ADA1	Lonoke	160	1988	1988	1
USGS	344953092063501	Alluvial aquifer	02N10W05BCC1	Pulaski	97	1951	1951	1
AR008	344955091564201	Alluvial aquifer	02N09W02BDB1	Lonoke	140	1998	1999	2
USGS	344957091565501	Alluvial aquifer	02N09W02BBC1	Lonoke	157	1988	1988	1
USGS	345012091562201	Alluvial aquifer	03N09W35DCC1	Lonoke	NA	1954	1954	1
USGS	345013092062801	Alluvial aquifer	02N10W05BBB1	Pulaski	100	1951	1951	1
USGS	345016092065801	Alluvial aquifer	03N10W31DCD1	Pulaski	90	1956	1956	1
USGS	345025091585301	Alluvial aquifer	03N09W33CBD1	Lonoke	32	1954	1954	1
USGS	345027092011701	Alluvial aquifer	03N09W31CBC1	Lonoke	105	1954	1954	1

Table 2. Active and historical groundwater quality monitoring stations in the Bayou Meto watershed (continued).

Entity	Station ID	Aquifer	Well Name	County	Depth, feet	Start Year	End Year	Number of dates
USGS	345047092040301	Alluvial aquifer	03N10W34BDA1	Lonoke	84	1959	1959	1
USGS	345049091534001	Alluvial aquifer	03N08W31AAD1	Lonoke	159	1955	1955	1
USGS	345050092031801	Alluvial aquifer	03N10W35BCA1	Lonoke	95	1959	1959	1
USGS	345051092030601	Alluvial aquifer	03N10W35BDB1	Lonoke	85	1959	1959	1
USGS	345054092025201	Alluvial aquifer	03N10W35ABC1	Lonoke	100	1959	1959	1
USGS	345054092031401	Alluvial aquifer	03N10W35BBD1	Lonoke	85	1959	1959	1
USGS	345055092135501	Jackfork Sandstone aquifer	03N11W31BCC1	Pulaski	254	1951	1951	1
USGS	345057091530001	Alluvial aquifer	03N08W32ABB3	Lonoke	170	2004	2004	1
USGS	345057092022301	Alluvial aquifer	03N10W36BBC1	Lonoke	95	1959	1959	1
USGS	345058092035601	Alluvial aquifer	03N10W34ABB1	Lonoke	116	1951	2004	3
USGS	345102092042201	Alluvial aquifer	03N10W34BAB1	Lonoke	40.8	1951	1951	1
USGS	345112091585401	Alluvial aquifer	03N09W28CCA1	Lonoke	103.6	1988	1988	1
USGS	345116091533801	Alluvial aquifer	03N08W30DAA1	Lonoke	137	1954	1954	1
USGS	345139091533701	Alluvial aquifer	03N08W30AAD1	Lonoke	135	1988	1988	2
USGS	345140092041201	Alluvial aquifer	03N10W34BDC1	Lonoke	96	1959	1959	1
USGS	345201092115001	Jackfork Sandstone aquifer	03N11W29AAD1	Pulaski	36	1960	1960	1
USGS	345202091584701	Wilcox group aquifer	03N09W21CCD1	Lonoke	28	1954	1954	1
USGS	345204091560701	Alluvial aquifer	03N09W23CCA1	Lonoke	135	1988	1988	1
USGS	345207091590201	Wilcox group aquifer	03N09W20DDA2	Lonoke	NA	1954	1954	1
USGS	345210091590701	Wilcox group aquifer	03N09W20DDA1	Lonoke	397	1954	1954	1
USGS	345252091594601	Wilcox group aquifer	03N09W17CCD1	Lonoke	190	1959	1959	1
USGS	345255092000601	Wilcox group aquifer	03N09W18DDD1	Lonoke	136	1955	1955	1
USGS	345642091562901	Atoka formation aquifer	04N10W26BDC1	Lonoke	67	1955	1955	1
USGS	345645092030101	Atokan series aquifer	04N10W26CAB1	Lonoke	NA	1955	1955	1
USGS	345722092042001	Atokan series aquifer	04N10W22CCC1	Lonoke	39	1969	1969	1

APPENDIX D

Evaluation of Current Water Quality

Measurements of selected parameters of concern collected during 2015-2019 by USGS and DEQ are summarized below. The data used for this summary were downloaded in October 2020 from online databases managed by DEQ and USGS (DEQ 2020, USGS 2020). Parameters examined in this section include those related to current assessed water quality impairments (TDS, DO, nutrients), and sediment parameters (TSS and turbidity). Note that when a measurement is reported as not detected, a value equal to half the detection limit has been used in analyses.

This section includes several box and whisker graphs. Box and whisker graphs show the range and distribution of values. They show the minimum and maximum values as well as the 25th percentile, median or 50th percentile, and 75th percentile. Figure 1 illustrates the elements of the box and whisker graphs in this plan (all figures are located at the end of this appendix). Note that the interquartile range is equal to the 75th percentile value minus the 25th percentile value.

D.1 Dissolved Oxygen

DO in water is used by fish and other aquatic creatures living in waterbodies. Figure 2 shows a box and whisker graph of DO measurements from the Bayou Meto watershed during 2015-2019. The highest median DO concentration occurs at the Bridge Creek station (ARK0210) in the upper watershed. The lowest median DO concentration occurs at the farthest downstream station (ARK0023). The median DO concentration at this station is statistically significantly lower than the median DO concentrations at all the other stations (indicated by the fact that the notch around the median does not overlap the notches in the other boxes). Median DO concentrations at the rest of the water quality stations in the watershed are not statistically significantly different, i.e., the notches in the boxes overlap.

Table 1 lists summary statistics for stream DO measurements from the period 2015-2019. Table 2 lists summary statistics for lake DO measurements from 2015 (the only year measurements were taken during 2015-2019). Numeric DO criteria for lakes apply to measurements taken from depths less than 1 meter. Therefore, the DO summary statistics in Table 2 include statistics for all measurements as well as those at depths less than 3 feet.

Table 1. Summary statistics for DO measurements from streams, 2015-2019.

Station ID*	Number of Values	Minimum, mg/L	25th Percentile, mg/L	Median, mg/L	Mean, mg/L	75th Percentile, mg/L	Maximum, mg/L
ARK0211	25	1.95	4.96	7.54	7.74	9.86	17.2
ARK0210	28	3.20	4.78	7.78	8.10	10.1	18.8
ARK0060	48	2.26	4.60	6.37	7.02	9.62	13.0
ARK0050	50	4.07	5.64	6.46	7.21	9.18	12.2
ARK0097	52	3.37	5.02	6.25	6.87	8.62	12.0
ARK0023	57	1.66	2.49	3.59	4.72	6.83	11.7

* downstream order

Table 2. Summary statistics for DO measurements from lakes, 2015.

Station ID	Sample Depth, feet	Number of Values	Minimum, mg/L	25th Percentile, mg/L	Median, mg/L	Mean, mg/L	75th Percentile, mg/L	Maximum, mg/L
07263924	1-20	62	0.1	0.2	0.55	2.94	5.6	9.5
07263924	$\leq$ 3	14	5.0	5.9	7.9	7.6	9.4	9.5
07263922	1-4	13	4.2	5.0	5.3	5.4	6.0	6.0
07263922	$\leq$ 3	11	4.9	5.1	5.3	5.5	6.0	6.0

Separate numeric criteria are used to evaluate stream DO conditions during the Primary Season, and during the Critical Season (see season definitions with Table 3.1). Seasonal DO conditions are discussed in two subsections below. Note that DEQ classifies waterbodies as DO impaired when over 10% of at least 10 samples do not meet the DO criterion.

D.1.1 Primary Season

The Primary Season for DO is characterized by lower water temperatures and typically higher flows. DO concentrations are usually naturally higher during this season. Figure 3 shows a box and whisker graph of Primary Season DO measurements from streams in the Bayou Meto watershed during 2015-2019. This graph includes a line highlighting the numeric criterion for Primary Season DO, 5 mg/L. Table 3 lists summary statistics for stream DO measurements from the Primary Season, 2015-2019. Included in Table 3 are listings of the number and percentage of Primary Season DO measurements from 2015-2019 that are less than the Primary Season DO criterion for Bayou Meto watershed streams, 5 mg/L.

DO concentrations less than the Primary Season DO criterion have been measured at all of the stream monitoring stations. The lowest median Primary Season DO concentration occurs at the farthest downstream station (ARK0023). This median DO concentration is statistically significantly lower than the median Primary Season DO concentrations at the other water quality stations. Over one-third of the Primary Season DO measurements at the Bayou Meto station at State Road 11 (ARK0023) are less than the seasonal DO numeric criterion, 5 mg/L. There is no statistically significant difference in the median Primary Season DO concentrations for the other water quality stations. There are similar numbers of DO measurements that do not meet the Primary Season DO numeric criterion at these stations (Table 3), however, the percentages of measurements not meeting the criterion are different.

Table 3. Summary statistics for Primary Season DO measurements from streams in the Bayou Meto watershed, 2015-2019.

Station ID*	Number of Values	Minimum Value, mg/L	Median, mg/L	Mean, mg/L	Maximum Value, mg/L	Number of Values < 5.0 mg/L	Percentage of Values < 5.0 mg/L
ARK0211	16	1.95	9.18	9.34	17.2	2	12%
ARK0210	18	3.20	9.36	9.75	18.8	3	17%
ARK0060	33	2.30	8.88	8.09	13.0	4	12%
ARK0050	31	4.15	8.52	8.28	12.2	2	6%
ARK0097	34	4.10	8.24	7.91	12.0	3	9%
ARK0023	32	2.04	5.82	6.10	11.7	12	38%

* downstream order

D.1.2 Critical Season

The Critical Season for DO is characterized by warmer water temperatures and lower flows. As a result, DO concentrations tend to be lower during this season. Figure 4 shows a box and whisker graph of Critical Season DO measurements from streams in the Bayou Meto watershed during 2015-2019. This graph includes lines highlighting the numeric criteria for Critical Season DO that apply in the Bayou Meto watershed, 3 mg/L or 5 mg/L based on the size of the drainage area at the monitoring station (see Table 4). The lowest median Critical Season DO concentration occurs at the farthest downstream station (ARK0023). The median Critical Season DO concentration at this station is statistically significantly lower than the median DO concentrations at all of the other stations. The highest median Critical Season DO concentration occurs at the Bayou Meto station at W. Main St. (ARK0050).

Even though the W. Main St. (ARK0060) and the State Road 161 (ARK0050) stations on Bayou Meto are only about four miles apart, the median Critical Season DO concentrations at these two stations are statistically different, indicating different DO conditions at these two locations. During the Critical Season, this increase in DO over such a short distance is likely due to the discharge of treated wastewater from the City of Jacksonville wastewater treatment plant. The reported effluent DO for this facility has been at least 7.0 mg/L throughout the last ten years of available data (August 2011 – July 2021).

Table 4 lists summary statistics for stream DO measurements from the Critical Season, 2015-2019. Included in Table 4 are listings of the Critical Season numeric DO criteria for each station, along with the number and percentage of Critical Season DO measurements from 2015-2019 that are less than the applicable criterion. At the monitoring stations in the upper watershed (ARK0210, ARK0211, ARK0060), Critical Season DO concentrations were below the applicable criterion less than 12% of the time. All Critical Season DO measurements at the Bayou Meto station at State Road 161 (ARK0050) met the criterion. Over 50% of Critical Season DO measurements were below the applicable criterion at the station farthest downstream on Bayou Meto (ARK0023) and the station on Bayou Two Prairie (ARK0097).

Table 4. Summary statistics for Critical Season DO measurements from the Bayou Meto watershed, 2015-2019.

Station ID*	Number of values	Minimum Value, mg/L	Median, mg/L	Mean, mg/L	Maximum Value, mg/L	Criteria, mg/L	Number of Values < Criteria	Percentage of Values < Criteria
ARK0211	9	2.36	4.96	4.89	7.54	3.0	1	11%
ARK0210	10	3.71	4.86	5.12	7.61	3.0	0	0%
ARK0060	15	2.26	4.29	4.65	7.53	3.0	1	7%
ARK0050	19	4.07	5.66	5.46	7.49	3.0	0	0%
ARK0097	18	3.37	4.84	4.90	7.01	5.0	10	56%
ARK0023	25	1.66	2.52	2.96	8.70	5.0	23	92%

* downstream order

D.2 Biochemical Oxygen Demand

Biochemical Oxygen Demand (BOD) represents the amount of DO needed by aerobic microorganisms to decompose organic matter in a water sample at a specific water temperature.

It is an indicator of the level of organic matter in the water column (not on the bottom of the stream); as organic matter decays, it consumes oxygen and decreases the likelihood of maintaining adequate DO levels. BOD was measured at only one station in the Bayou Meto watershed during 2015-2019, ARK0050 (at State Road 161). Summary statistics for BOD measurements at ARK0050 are listed in Table 5. There is no numeric water quality criterion for BOD in Arkansas. Because DO and decomposition can be affected by temperature, Figure 5 shows a graph of BOD concentrations by day of year.

Table 5. Summary statistics for BOD measurements from ARK0050, 2015-2019.

Statistic	Value
Number of values	47
Minimum Value, mg/L	0.79
25th Percentile, mg/L	1.45
Median, mg/L	1.83
Average, mg/L	1.87
75th Percentile, mg/L	2.24
Maximum Value, mg/L	3.52

D.3 TDS

TDS is an indicator of the amount of minerals dissolved in water. When TDS levels are too high, mineral deposits in equipment and pipes can become a concern. In addition, staining may occur, soaps may not work as well, and the taste of the water may be affected (Safe Drinking Water Foundation 2017). Figure 6 shows a box and whisker graph of TDS measurements from the Bayou Meto watershed during the period 2015-2019. This graph includes horizontal lines at 103 mg/L and 390 mg/L; these values represent “maximum naturally occurring values” in the Arkansas River Valley ecoregion and the Delta ecoregion, respectively, according to Section 2.511(B) of the Arkansas Water Quality Standards (APCEC 2020).

TDS concentrations in Bayou Meto generally appear to increase in the downstream direction. Possible causes for this pattern include changes in geology and soils going from the Arkansas River Valley ecoregion to the Delta ecoregion, as well as increases in anthropogenic inputs (including runoff from fields irrigated with groundwater, some of which has slightly elevated mineral concentrations). The median TDS concentration in Bayou Meto at State Road 161 (ARK0050) is statistically significantly higher than median concentrations at upstream Bayou Meto stations. The median TDS concentration at the farthest downstream Bayou Meto station (ARK0023) is also statistically significantly higher than median concentrations at the upstream Bayou Meto stations. The median TDS concentration at the Bayou Two Prairie station is statistically significantly higher than the median TDS concentrations at stations farther upstream on Bayou Meto and Bridge Creek; however, it is not statistically different from the median concentration at the farthest downstream Bayou Meto station (ARK0023).

Even though the W. Main St. (ARK0060) and the State Road 161 (ARK0050) stations on Bayou Meto are only about four miles apart, the median TDS concentrations at these two stations are statistically significantly different (48 mg/L at ARK0060 and 74 mg/L at ARK0050). Discharges of treated wastewater from the City of Jacksonville wastewater treatment plant (WWTP) likely contribute to this increase. The City of Jacksonville's 2017 National Pollutant Discharge Elimination System (NPDES) permit renewal application reported an average effluent TDS concentration of 145 mg/L based on three samples. Although this average effluent TDS value is higher than the average upstream values in Bayou Meto, it is low compared to most treated municipal wastewater (Park and Snyder 2020; Bolton & Menk, Inc,; Barr Engineering Co. 2017).

Table 6 lists summary statistics for TDS measurements from 2015-2019, including the number and percentage of values that exceed applicable TDS criteria. Only a small percentage of TDS measurements exceed the maximum naturally occurring values, except at the State Road 161 station (ARK0050), which is located on the reach of Bayou Meto that is classified as impaired due to high TDS concentrations (see Table 3.4). It should be noted that the TDS impairment was based on the domestic water supply criterion (500 mg/L); DEQ does not use the maximum naturally occurring values for assessment purposes.

Table 6. Summary statistics for TDS measurements from the Bayou Meto watershed, 2015-2019.

Station ID*	Number of Values	Minimum, mg/L	25th Percentile, mg/L	Median, mg/L	Mean, mg/L	75th Percentile, mg/L	Maximum, mg/L	Max. Naturally Occurring Value, mg/L	No. of Values > Max. Naturally Occurring Value	% of Values > Max. Naturally Occurring Value
ARK0211	22	36	43	49	51	57	78	103	0	0%
ARK0210	26	34	46	64	59	72	83	103	0	0%
ARK0060	49	6	43	48	57	57	255	103	4	8%
ARK0050	51	23	60	74	102	131	300	103	15	29%
ARK0097	54	20	94	124	140	164	347	390	0	0%
ARK0023	56	80	116	148	167	190	370	390	0	0%

* downstream order

D.4 Phosphorus

Phosphorus is a nutrient and is not harmful to humans or animals itself. However, it can stimulate algal growth in surface waters. Excessive algal growth has the potential to create conditions that are a nuisance or harmful to humans, aquatic organisms, or livestock. There are no numeric water quality standards for phosphorus that apply in the Bayou Meto watershed.

D.4.1 Total Phosphorus

Table 7 lists summary statistics for total phosphorus measurements collected in the Bayou Meto watershed during 2015-2019. Figure 7 shows a box and whisker graph of these data. The highest median total phosphorus concentration occurs at the State Road 161 station (ARK0050). Median total phosphorus concentrations at stations downstream of Highway 167 (State Road 161 and down) are statistically significantly higher than median concentrations at stations upstream of the highway.

Table 7. Summary statistics for stream total phosphorus measurements from the Bayou Meto watershed, 2015-2019.

Station ID*	Number of values	Minimum, mg/L	25th Percentile, mg/L	Median, mg/L	Mean, mg/L	75th Percentile, mg/L	Maximum, mg/L
ARK0211	22	<0.020	0.035	0.042	0.054	0.063	0.143
ARK0210	25	0.021	0.043	0.050	0.112	0.086	0.979
ARK0060	50	<1.0	0.032	0.050	0.108	0.070	1.25
ARK0050	52	<1.0	0.115	0.238	0.760	0.826	4.81
ARK0097	55	<1.0	0.181	0.229	0.263	0.302	1.26
ARK0023	60	<1.0	0.110	0.164	0.172	0.218	0.438

* downstream order

Even though the W. Main St. (ARK0060) and the State Road 161 (ARK0050) stations on Bayou Meto are only about four miles apart, the median total phosphorus concentrations at these two stations are statistically different, indicating different phosphorus conditions at these two locations. This appears to be caused by the City of Jacksonville WWTP, which discharges to Bayou Meto between these two stations. Annual graphs of total phosphorus concentrations support this idea, as the highest total phosphorus concentrations at station ARK0050 occur June to October, when runoff is typically low, and a point source discharge can have a greater effect on water quality (Figure 8). At other stations, total phosphorus concentrations do not change much through the year (e.g., ARK0097), or total phosphorus tends to be highest during the spring, when runoff is typically higher (e.g., ARK0023).

The median total phosphorus concentration at the Bayou Two Prairie station (ARK0097) is similar to the median concentration at station ARK0050. Discharges from the City of Cabot WWTP drain into Bayou Two Prairie, but Cabot’s outfall is approximately 30 miles upstream of station ARK0097. Therefore, the higher total phosphorus concentrations at station ARK0097 are likely due primarily to nonpoint source phosphorus inputs. The median total phosphorus concentration at the farthest downstream Bayou Meto station (ARK0023) is statistically significantly lower than the median concentration at the Bayou Two Prairie station. The seasonal pattern of total phosphorus concentrations is also different at these two stations (Figure 8).

Dissolved phosphorus (USGS parameter code 00666) concentrations were measured at the USGS lake stations during the summer of 2015 on three dates. These data are listed in Table 8. Reported sampling depths were less than 1 meter.

Table 8. Summary of dissolved phosphorus (00666) measurements (mg/L) collected by USGS in the Bayou Meto watershed during 2015.

Sample date	07263924 Big Base Lake West	07263922 Lil Base Lake
6/4/2015	0.006	0.014
7/9/2015	0.008	0.017
8/20/2015	0.060	0.084

D.4.2 Orthophosphate

Table 9 lists summary statistics for orthophosphate measurements collected from streams in the Bayou Meto watershed during 2015-2019. Orthophosphate represents phosphorus that is available for uptake by algae or aquatic plants (as compared to total phosphorus, which also includes organic and particulate phosphorus that is not available for uptake). Orthophosphate concentrations from these stations exhibit the same spatial patterns as total phosphorus (see Section D.4.1 and Figure 7). Orthophosphate concentrations were also measured at the USGS lake stations during the summer of 2015 on three dates (Table 10). The majority of these measurements are less than the reporting limit. The comparability of the DEQ and USGS orthophosphate measurements is unclear.

Table 9. Summary statistics for stream orthophosphate measurements from the Bayou Meto watershed, 2015-2019.

Station ID*	Number of Values	Minimum, mg/L	25th Percentile, mg/L	Median, mg/L	Mean, mg/L	75th Percentile, mg/L	Maximum, mg/L
ARK0211	23	<0.020	<0.020	<0.020	<0.020	<0.020	0.069
ARK0210	26	<0.020	<0.020	<0.020	0.057	0.032	0.797
ARK0060	49	<0.020	<0.020	<0.020	0.060	0.012	1.05
ARK0050	51	0.030	0.047	0.196	0.589	0.670	3.14
ARK0097	54	<0.020	0.080	0.107	0.145	0.150	1.04
ARK0023	57	<0.020	0.050	0.070	0.072	0.092	0.146

* downstream order

Table 10. Summary of orthophosphate phosphorus (00671) measurements (mg/L) collected by USGS in the Bayou Meto watershed during 2015.

Sample date	07263924 Big Base Lake West	07263922 Lil Base Lake
6/4/2015	<0.004	0.006
7/9/2015	<0.004	<0.004
8/20/2015	<0.004	<0.004

D.5 Nitrogen

Nitrogen is a nutrient and can stimulate algal growth. Excessive algal growth has the potential to create conditions that are a nuisance or harmful to humans, aquatic organisms, or livestock. The only numeric water quality standards for nitrogen that are specified in the Arkansas Water Quality Standards (APCEC 2020) are the criteria for ammonia nitrogen, which are dependent on temperature and pH. Additionally, DEQ uses the numeric value of 10 mg/L of nitrate nitrogen as a maximum allowable in-stream value for maintaining the designated use of domestic water supply.

In recent years, DEQ has been utilizing a laboratory method that produces a direct measurement of total nitrogen, which is more efficient than the traditional procedure of measuring total Kjeldahl nitrogen (TKN) and nitrate+nitrite nitrogen and summing the results to calculate total nitrogen. However, data from the new method are not available prior to May 2018 for water samples collected in the Bayou Meto watershed. This time period is too short to properly characterize water quality. Therefore, evaluation of nitrogen water quality consists of evaluation of inorganic nitrogen (nitrate+nitrite) and TKN.

D.5.1 Inorganic Nitrogen

Inorganic nitrogen is the sum of nitrate and nitrite nitrogen. Table 11 lists summary statistics for inorganic nitrogen measurements from the Bayou Meto watershed during 2015-2019. Figure 9 shows a box and whisker graph of the stream data. This graph includes a dashed line indicating the maximum allowable value of 10 mg/L nitrate nitrogen for waterbodies with a designated use of domestic water supply.

Table 11. Summary statistics for inorganic nitrogen measurements from the Bayou Meto watershed, 2015-2019.

Station ID	Number of Values	Minimum, mg/L	25th Percentile, mg/L	Median, mg/L	Mean, mg/L	75th Percentile, mg/L	Maximum, mg/L	No. of Values > 10 mg/L
ARK0211	22	<0.050	<0.050	0.059	0.070	0.094	0.242	0
ARK0210	25	<0.050	<0.050	0.077	0.127	0.174	0.897	0
ARK0060	49	<0.050	<0.050	0.081	0.236	0.126	2.96	0
07263922	3	<0.040	-	<0.040	<0.040	-	<0.040	0
07263924	3	<0.040	-	<0.040	<0.040	-	<0.040	0
ARK0050	51	0.098	0.262	0.856	2.00	2.46	12.1	1
ARK0097	54	<0.050	0.170	0.230	0.284	0.379	1.09	0
ARK0023	57	<0.050	<0.050	0.130	0.198	0.270	0.710	0

The highest median inorganic nitrogen concentration is from the Bayou Meto station at State Road 161 (ARK0050). The median inorganic nitrogen concentration at this station is statistically significantly greater than the median concentrations at the other stations. In addition, this is the only station where there is a measurement that exceeds the maximum allowable level of 10 mg/L for drinking water.

The median inorganic nitrogen concentration at the Bayou Two Prairie station is statistically significantly different from the median concentrations at the upstream Bayou Meto and Bridge Creek stations. The median inorganic nitrogen concentration at the farthest downstream station is similar to the median concentrations for the Bayou Meto and Bridge Creek stations upstream of Highway 167.

Even though the W. Main St. (ARK0060) and the State Road 161 (ARK0050) stations on Bayou Meto are only about four miles apart, the median inorganic nitrogen concentrations at these two stations are statistically different, indicating different nitrogen conditions at these two locations. This appears to be caused by effluent from the City of Jacksonville WWTP, which discharges to Bayou Meto between these two stations. Annual graphs of inorganic nitrogen concentrations support this idea, as the highest inorganic nitrogen concentrations at station ARK0050 occur June to October, when runoff is typically low and a point source discharge can have a greater effect on water quality (Figure 10). At other stations, inorganic nitrogen concentrations do not change much through the year (e.g., ARK0097), or inorganic nitrogen tends to be highest during the spring, when runoff is higher (e.g., ARK0023).

D.5.2 Total Kjeldahl Nitrogen

TKN is the sum of organic nitrogen and ammonia nitrogen. Table 12 lists summary statistics for TKN measurements from the Bayou Meto watershed during 2015-2019. Figure 11 shows a box and whisker graph of these data. TKN measurements were not collected at the USGS lake stations (07263922 and 07263924).

TKN concentrations in Bayou Meto exhibit a generally increasing trend in the downstream direction. The W. Main St. (ARK0060) and State Road 161 (ARK0050) stations on Bayou Meto have median TKN concentrations that are statistically different, which is likely due in part to effluent from the City of Jacksonville WWTP. Annual graphs of TKN concentrations support this idea, as the highest TKN concentrations at station ARK0050 occur June to October, when runoff is typically low (Figure 12). At the stations downstream of ARK0050, median TKN concentrations are higher than at ARK0050, which is probably due to nonpoint sources in the Delta ecoregion.

Table 12. Summary statistics for TKN measurements from the Bayou Meto watershed, 2015-2019.

Station ID*	Number of Values	Minimum, mg/L	25th Percentile, mg/L	Median, mg/L	Mean, mg/L	75th Percentile, mg/L	Maximum, mg/L
ARK0211	22	0.187	0.227	0.385	0.415	0.510	0.791
ARK0210	25	0.182	0.334	0.531	0.562	0.734	1.19
ARK0060	49	0.050	0.277	0.395	0.455	0.577	1.24
ARK0050	51	0.357	0.553	0.710	0.914	0.908	6.70
ARK0097	54	0.050	0.730	0.839	0.884	0.993	1.60
ARK0023	57	0.410	0.644	0.749	0.769	0.909	1.13

* downstream order

D.6 Sediment Parameters

DEQ monitors turbidity and total suspended solids (TSS) as indicators of sediment water quality issues. Arkansas water quality standards include numeric criteria for turbidity, but not TSS or suspended sediment concentration. However, turbidity cannot be converted to a load, so DEQ measures TSS concentrations to calculate loads.

D.6.1 Turbidity

Turbidity is an optical property of water related to the light transparency of a water sample. It is measured by how much light can pass through a water sample. A higher turbidity value means less light can pass through the water. Both suspended and dissolved material in water can contribute to turbidity.

Figure 13 shows a box and whisker graph of stream turbidity measurements from the Bayou Meto watershed for the period 2015-2019. The two horizontal lines on the plot represent the numeric water quality standards for turbidity for “All Flow” conditions (as opposed to “Base Flow” conditions) for streams in the Arkansas River Valley ecoregion (40 NTU) and least-altered streams in the Delta ecoregion (84 NTU). The highest median turbidity value occurs at the farthest downstream station (ARK0023), although the median turbidity value at the Bayou Two Prairie station (ARK0097) is similar. The median turbidity values from these two stations are statistically significantly different from the median values from the other stations. The lowest median turbidity values occur at the two farthest upstream Bayou Meto stations (ARK0211 and ARK0060).

Even though the W. Main St. (ARK0060) and the State Road 161 (ARK0050) stations on Bayou Meto are only about four miles apart, the median turbidity values at these two stations are statistically different, indicating different turbidity conditions at these two locations. There are several factors that could account for this difference in water quality in such a short distance, including the influence of tributaries joining Bayou Meto between the two stations, point sources discharging to Bayou Meto between the two stations, the change in watershed size between the two stations, and the fact that the two stations are located within different ecoregions.

Table 13 lists summary statistics for turbidity measurements in Bayou Meto from the period 2015-2019 in Nephelometric Turbidity Units (NTU). Table 14 lists summary statistics for lake turbidity measurements from 2015 (the only year measurements were taken during the period 2015-2019) in Formazin Nephelometric Units (FNU). Included in Table 13 are listings of the applicable All Flow turbidity criteria, and the number and percentage of turbidity measurements that exceed these criteria. Numeric turbidity criteria for lakes apply to measurements taken from depths less than 1 meter. Therefore, summary statistics for measurements taken from depths less than 3 feet are included in Table 14. However, the units for the lake turbidity measurements are not the same as those for the DEQ turbidity measurements and the numeric water quality criteria. Therefore, the lake turbidity measurements cannot be directly compared to the lake turbidity numeric water quality criteria (https://or.water.usgs.gov/grapher/fnu.html).

Separate numeric criteria are used to evaluate stream and lake turbidity levels during Base Flow conditions (see Base Flow definition in the footnotes for Table 3.1). In natural systems, Base Flow conditions are usually characterized by reduced runoff and slower flows, which usually results in lower turbidity levels. Graphs of turbidity by day of the year show that turbidity levels at only one or two of the stations appear to differ much with season (Figure 14). Box plots of the turbidity measurements by season show that, at all but one station, the median turbidity value is lower during the Base Flow season than during the rest of the year, as expected (Figure 15). The fact that the opposite is true of the turbidity measurements from station ARK0050 (Bayou Meto at SR161), suggests that turbidity is decreased by point source discharges, which make up a greater proportion of stream flow at this station during the Base Flow season.

Table 13. Summary statistics for turbidity measurements from streams, 2015-2019.

Station ID*	Number of Values	Minimum, NTU	25th Percentile, NTU	Median, NTU	Mean, NTU	75th Percentile, NTU	Maximum, NTU	All Flows Criteria, NTU	Number of Values > Criteria	Percentage of Values > Criteria
ARK0211	22	11.1	15.4	17.1	29.9	25.6	159	40	3	14%
ARK0210	26	7.61	16.7	21.8	36.9	31.1	196	40	5	19%
ARK0060	48	3.65	12.4	16.9	23.4	24.2	212	40	5	10%
ARK0050	50	11.4	19.8	27.2	30.6	38.7	71.7	84	0	0%
ARK0097	53	4.36	29.5	40.5	48.6	53.6	224	84	4	8%
ARK0023	57	3.0	21.3	43.2	51.4	66.8	252	84	8	14%

* downstream order

Table 14. Summary statistics for turbidity measurements from lakes, 2015.

Station ID	Sample Depth, ft	Number of Values	Minimum, FNU	25th Percentile, FNU	Median, FNU	Mean, FNU	75th Percentile, FNU	Maximum, FNU
07263924	1-20	57	3.6	6.1	8.9	10.0	14.0	17.0
07263924	≤ 3	9	3.6	6.1	14.0	11.3	15.0	15.0
07263922	1-4	9	7.0	8.4	18.0	20.9	20.0	65.0
07263922	≤ 3	7	7.0	8.0	18.0	16.1	20.0	32.0

Table 15 lists summary statistics for Base Flow turbidity measurements from streams in the Bayou Meto watershed during the period 2015-2019. Included in this table is a listing of the applicable Base Flow turbidity numeric water quality criteria, and the number and percentage of measurements that exceed the applicable criteria. All of the lake turbidity measurements were collected during Base Flow conditions, so Table 14 is a summary of the lake Base Flow turbidity measurements. Overall, as expected, medians of Base Flow stream turbidity values are lower than the medians for All Flows in Table 13. There are not significantly more instances of stream turbidity exceeding the Base Flow numeric criteria than the All Flow criteria (Table 13); however, with a smaller number of Base Flow samples overall, the percentage of measurement exceeding the Baseflow criteria ends up being higher.

Table 15. Summary statistics for Base Flow turbidity measurements from Bayou Meto watershed streams, 2015-2019.

Station ID*	Number of measures	Minimum, NTU	25th Percentile, NTU	Median, NTU	Mean, NTU	75th Percentile, NTU	Maximum, NTU	Baseflow Criteria, NTU	Number of Values > Criteria	Percentage of Values > Criteria
ARK0211	7	11.1	11.6	13.7	14.8	16.1	23.7	21	1	14%
ARK0210	9	7.61	12.4	16.3	25.6	38.0	61.5	21	4	44%
ARK0060	18	3.65	6.93	13.6	16.2	22.1	47.1	21	5	28%
ARK0050	20	11.4	18.4	32.2	29.8	36.9	55.3	45	1	5%
ARK0097	22	18.4	25.7	31.7	36.3	43.4	62.1	45	5	23%
ARK0023	24	3.00	17.6	22.4	30.7	38.0	101	45	5	21%

* downstream order

Figure 16 shows a box and whisker graph of Base Flow stream turbidity measurements from the Bayou Meto watershed for the period 2015-2019. The numeric turbidity water quality standards for Base Flow in the Arkansas River Valley (ARV) and Delta Least-altered Streams (DLAS) are also shown on the plot. The highest median Base Flow turbidity values occur at the Bayou Meto station at State Road 161 (ARK0050) and the Bayou Two Prairie station (ARK0097). The lowest median Base Flow turbidity value occurs at the Bayou Meto station at W. Main (ARK0060; the first station downstream of the City of Jacksonville WWTP discharge).

D.6.2 TSS

TSS is a measure of solid material that can be filtered out of a water sample. This solid material can include organic debris as well as inorganic material such as soil particles. Table 16 lists summary statistics for TSS measurements from streams in the Bayou Meto watershed during the period 2015-2019. Figure 17 shows a box and whisker graph of TSS concentrations measured in streams in the Bayou Meto watershed during the period 2015-2019. The highest median TSS concentration occurs at the Bayou Two Prairie station (ARK0097), and the lowest median TSS concentration occurs at the farthest upstream Bayou Meto station (ARK0211). Median TSS concentrations at Bayou Meto stations increase in the downstream direction. The median TSS concentrations for the two upstream Bayou Meto stations (ARK0211 and ARK0060) are statistically significantly lower than the median TSS concentrations for the two downstream Bayou Meto stations (ARK0050 and ARK0023). As with other parameters, median TSS concentrations at the Bayou Meto stations at W. Main (ARK0060) and State Road 161 (ARK0050) are statistically significantly different despite their proximity.

Table 16. Summary statistics for TSS measurements from Bayou Meto watershed streams, 2015-2019.

Station ID*	Number of Values	Minimum, mg/L	25th Percentile, mg/L	Median, mg/L	Mean, mg/L	75th Percentile, mg/L	Maximum, mg/L
ARK0211	22	3.0	4.8	6.0	18.0	11.9	130
ARK0210	26	1.3	4.9	8.8	23.6	15.8	210
ARK0060	49	1.0	3.8	6.3	11.4	11.0	162
ARK0050	51	3.8	9.2	15.2	19.5	26.3	78.5
ARK0097	54	3.5	15.5	24.6	26.9	33.5	131
ARK0023	57	3.3	11.8	17.8	24.5	28.0	96.5

* downstream order

TSS concentrations can also be influenced by seasonal patterns of precipitation, runoff, and stream flow. Figure 18 shows graphs of TSS by day of year. TSS in the Bayou Meto watershed does not appear to exhibit the dramatic seasonal differences seen in turbidity at some of the stations (Figure 14). Box and whisker graphs of TSS comparing concentrations by season support this observation (Figure 19). At several stations (ARK0023, ARK0060, ARK0097), median TSS concentrations during the two seasons are similar. The median TSS concentrations during the two seasons are not statistically significantly different at any of the stations. At two stations (ARK0050 and ARK00210), the median TSS concentration during the Base Flow season is higher than during the high flow season, which is the opposite of the expected pattern for TSS when the suspended particles are primarily inorganic, i.e., sediment. Higher TSS concentrations during Base Flow season may be caused by the presence of organic particles such as algae.

D.6.3 Relationship Between Turbidity and TSS

When measured turbidity is primarily the result of sediment or other solid materials suspended in the water, there can be a strong statistical correlation between TSS and turbidity measurements. Figure 20 shows graphs of turbidity versus TSS data from each of the Bayou Meto stream stations. These graphs appear to indicate that TSS and turbidity are positively, although not strongly, correlated in the Bayou Meto watershed.

D.6.4 Relationship Between Sediment and Total Phosphorus

Because phosphorus sorbs to soil particles, conservation practices that control erosion are expected to reduce phosphorus loads (Lory and Cromley 2006; NRCS 2017). Figure 21 shows graphs of TSS versus total phosphorus, and Figure 22 shows graphs of turbidity versus total phosphorus. Both appear to indicate relationships between the sediment parameters and total phosphorus, at some of the stations. At station ARK0023, total phosphorous appears to be more strongly related to turbidity, i.e., the graphed data have a more linear pattern. At the rest of the stations, total phosphorus appears to be more strongly related to TSS than to turbidity. At Station ARK0050, the lack of positive correlation between phosphorus and either turbidity or TSS is likely due to the influence of effluent from the City of Jacksonville WWTP, especially during low flow periods when turbidity and TSS in the stream tend to be lower.

D.7 References

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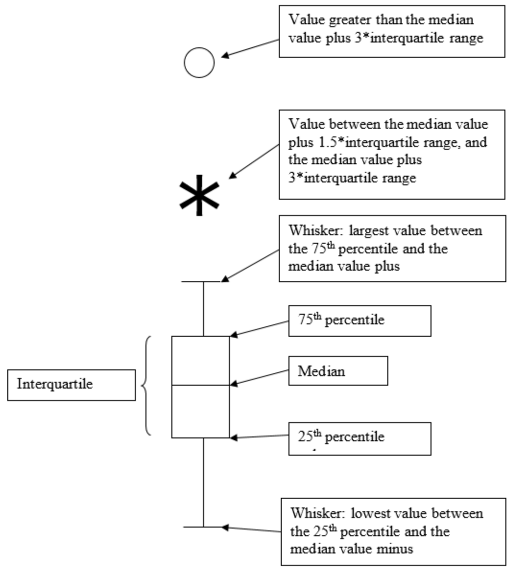


Figure 1. Elements of box and whisker graphs in this report.

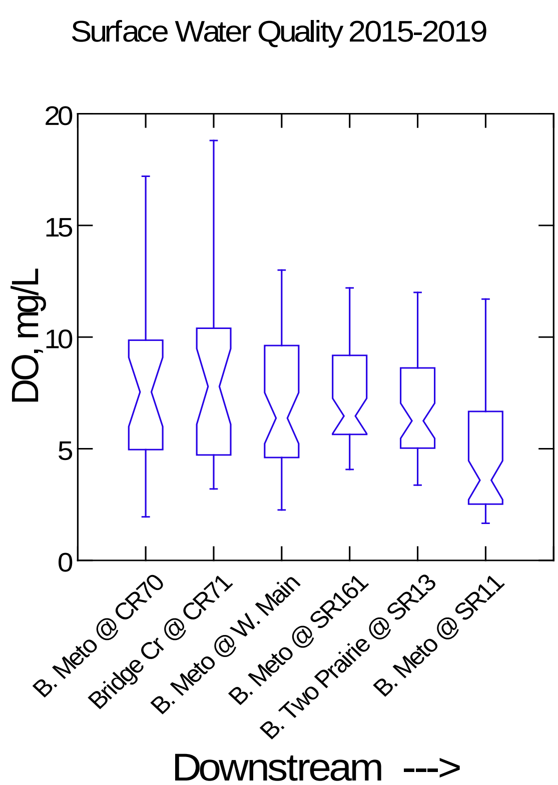


Figure 2. Box and whisker graph of DO measurements from the Bayou Meto watershed during 2015-2019.

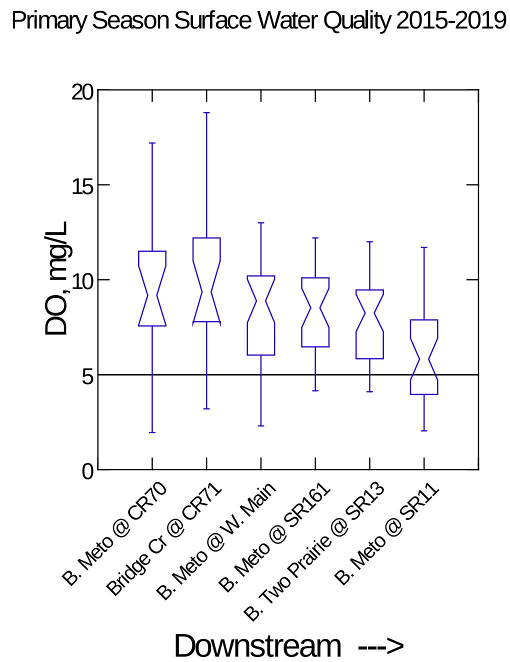


Figure 3. Box and whisker graph of Primary Season DO measurements from the Bayou Meto watershed during 2015-2019, with applicable numeric water quality criterion.

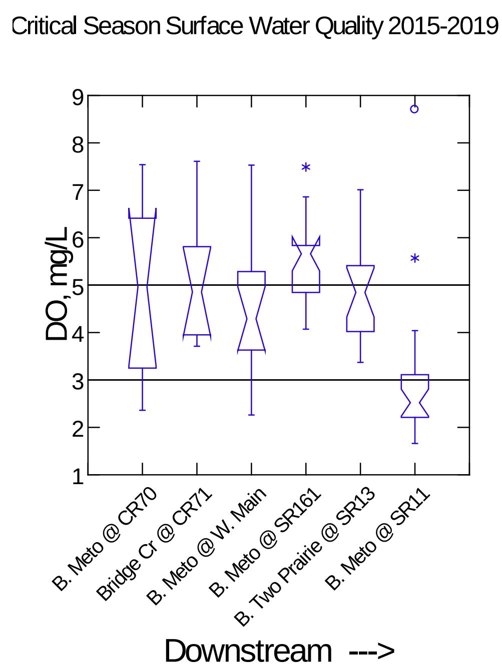


Figure 4. Box and whisker graph of Critical Season DO measurements from the Bayou Meto watershed during 2015-2019, with applicable numeric water quality criterion.

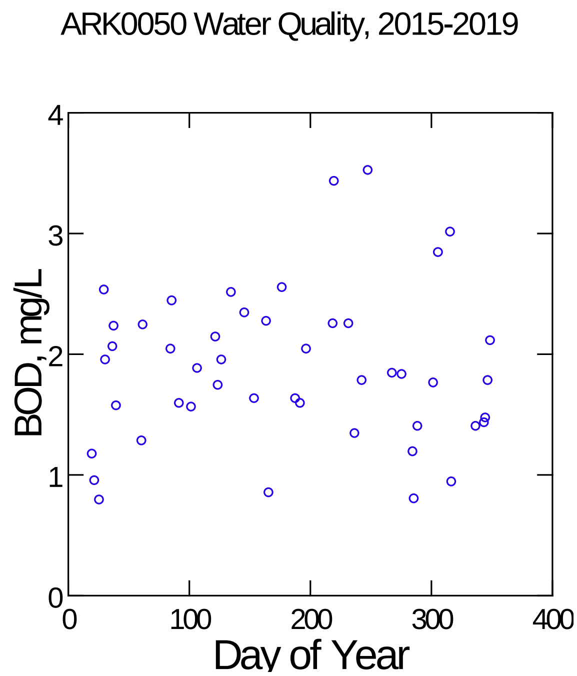


Figure 5. Annual graph of BOD measurements from ARK0050, 2015-2019.

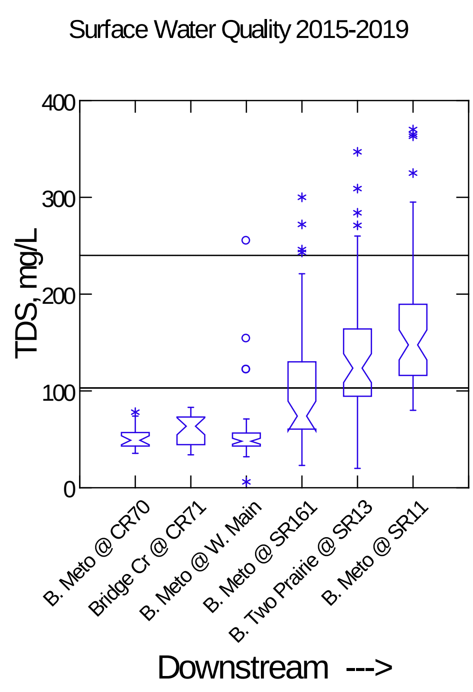


Figure 6. Box and whisker graph of TDS measurements from the Bayou Meto watershed during 2015-2019.

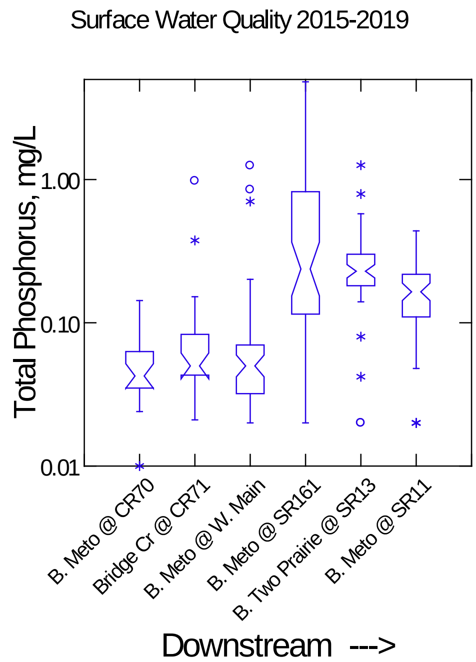


Figure 7. Box and whisker graph of total phosphorus measurements from the Bayou Meto watershed during 2015-2019.

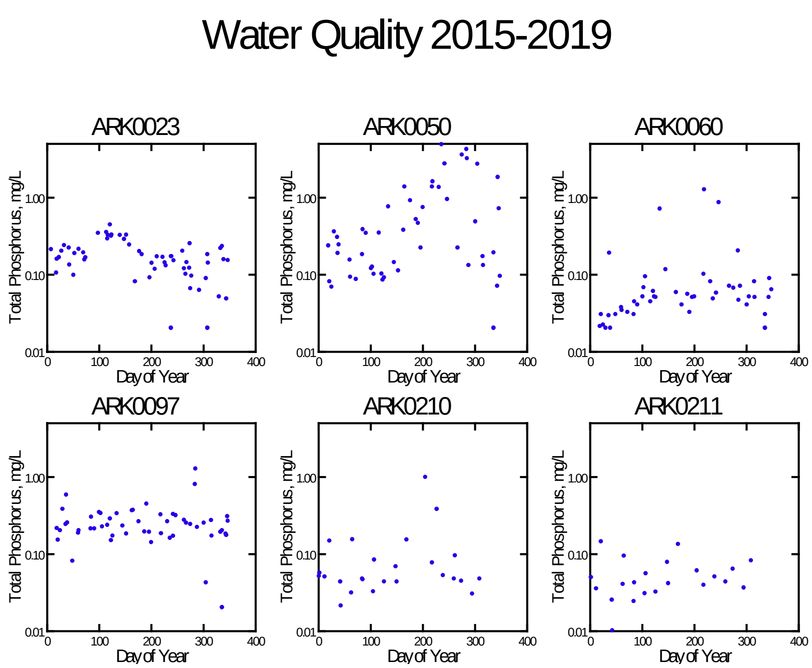


Figure 8. Annual graphs of total phosphorus measurements from the Bayou Meto watershed during 2015-2019. Note June 1 is day 152, and October 31 is day 304.

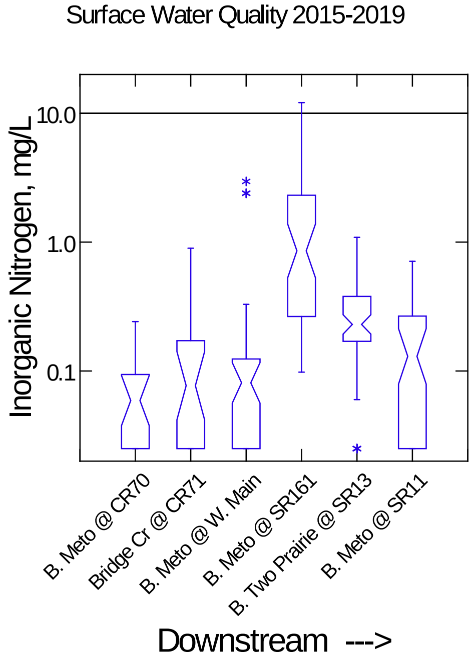


Figure 9. Box and whisker graph of inorganic nitrogen measurements from the Bayou Meto watershed during 2015-2019, with drinking water nitrate criterion.

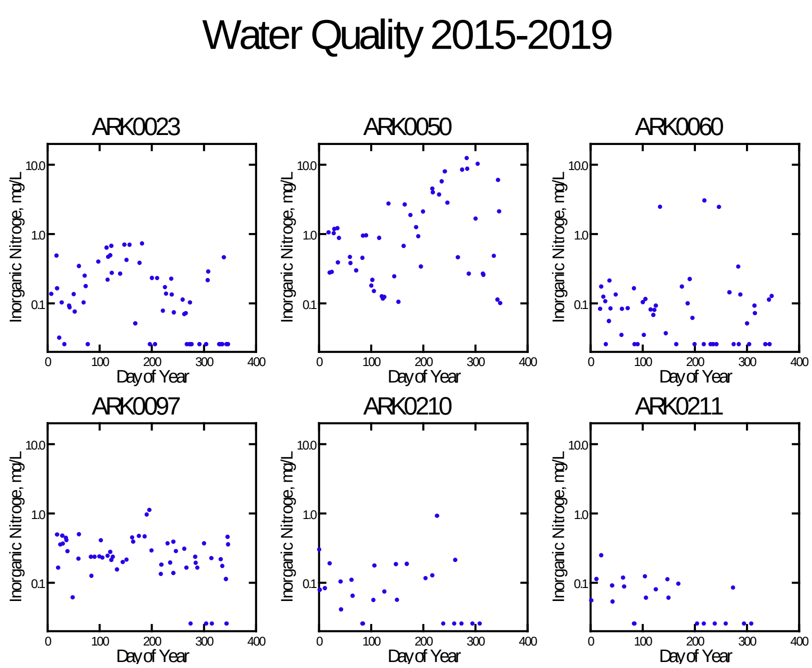


Figure 10. Annual graphs of inorganic nitrogen measurements from the Bayou Meto watershed during 2015-2019. Note June 1 is day 152, and October 31 is day 304.

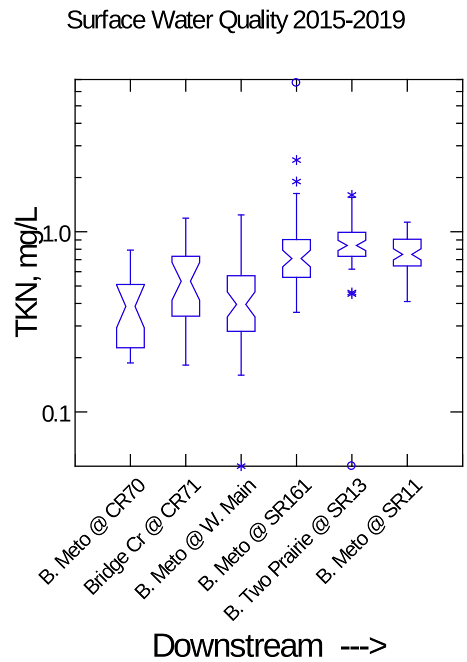


Figure 11. Box and whisker graph of TKN measurements from the Bayou Meto watershed during 2015-2019.

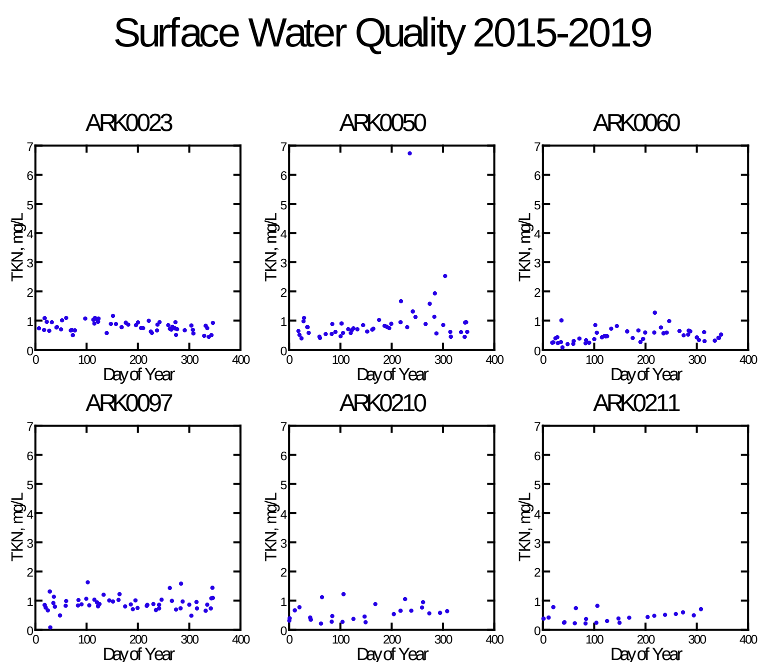


Figure 12. Annual graphs of TKN measurements from the Bayou Meto watershed during 2015-2019. Note June 1 is day 152, and October 31 is day 304.

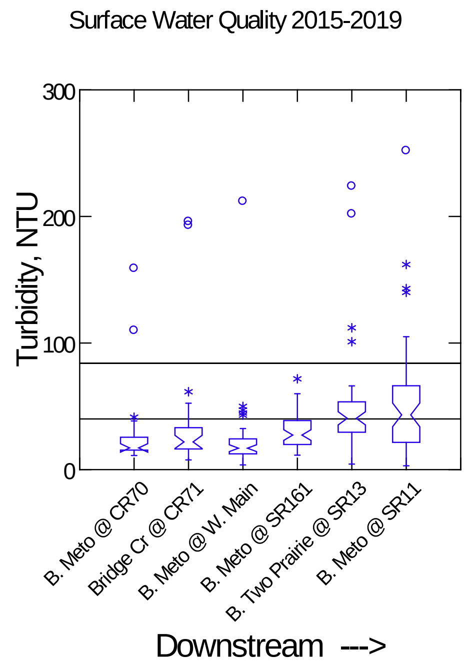


Figure 13. Box and whisker graph of turbidity measurements from the Bayou Meto watershed during 2015-2019, with applicable All Flow numeric water quality criteria.

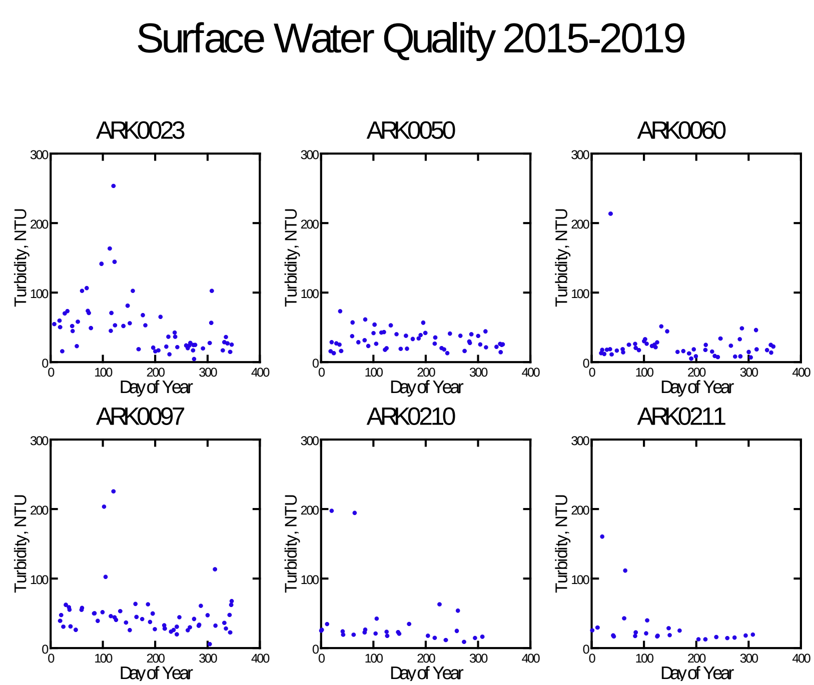


Figure 14. Annual graphs of turbidity measurements from the Bayou Meto watershed during 2015-2019.

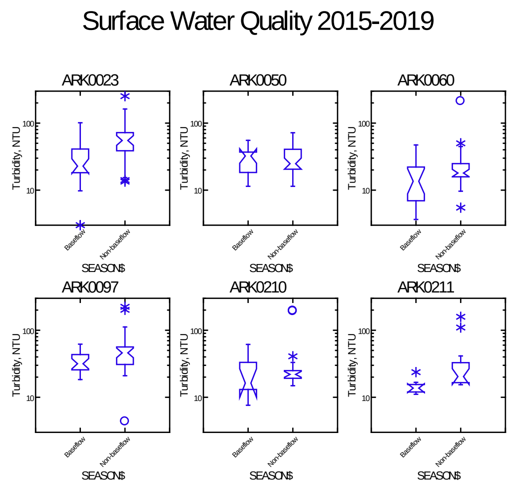


Figure 15. Box and whisker graphs comparing 2015-2019 turbidity measurements by season.

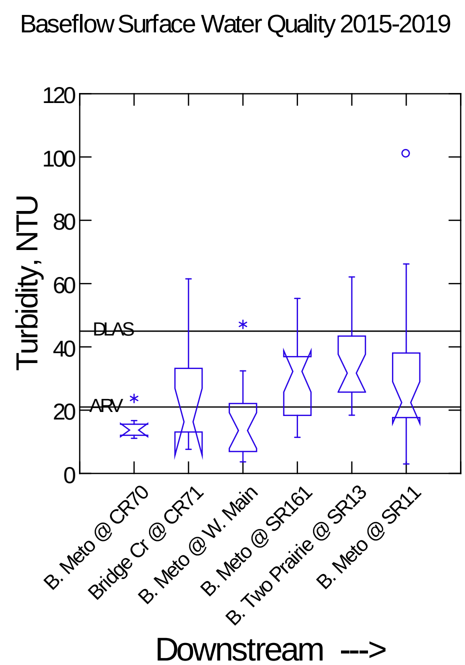


Figure 16. Box and whisker graph of Baseflow turbidity measurements from the Bayou Meto watershed during 2015-2019, with applicable numeric water quality criteria.

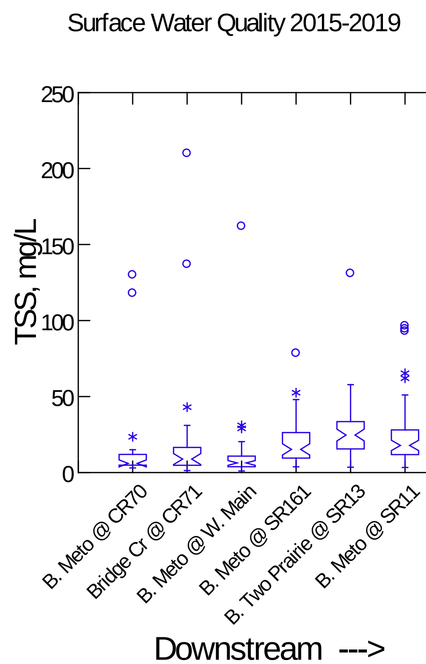


Figure 17. Box and whisker graph of TSS measurements from the Bayou Meto watershed during 2015-2019.

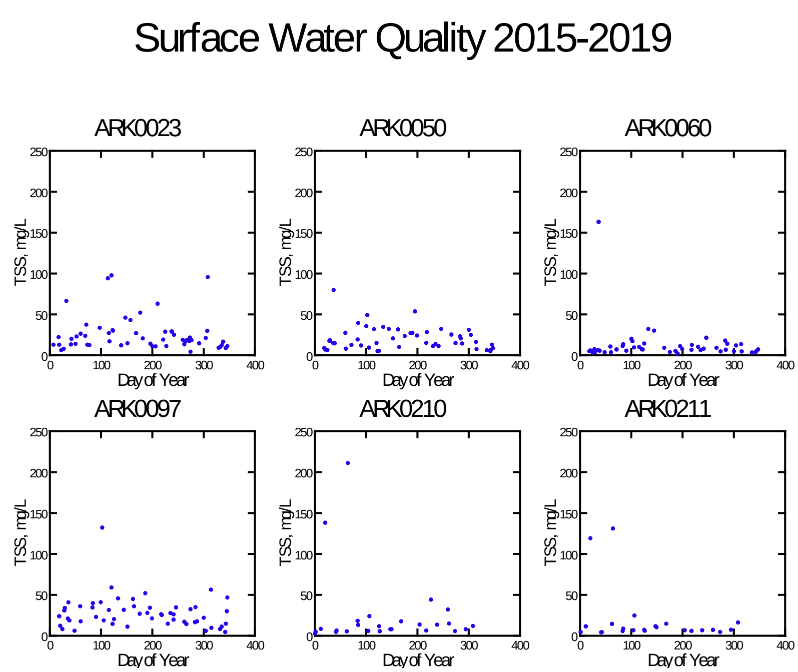


Figure 18. Annual graphs of TSS measurements from the Bayou Meto watershed during 2015-2019.

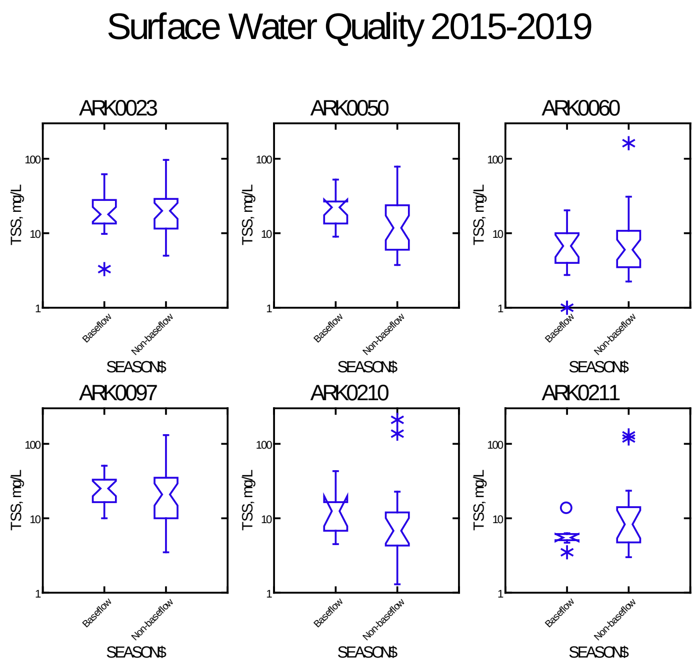


Figure 19. Box and whisker graphs comparing 2015-2019 TSS measurements by season.

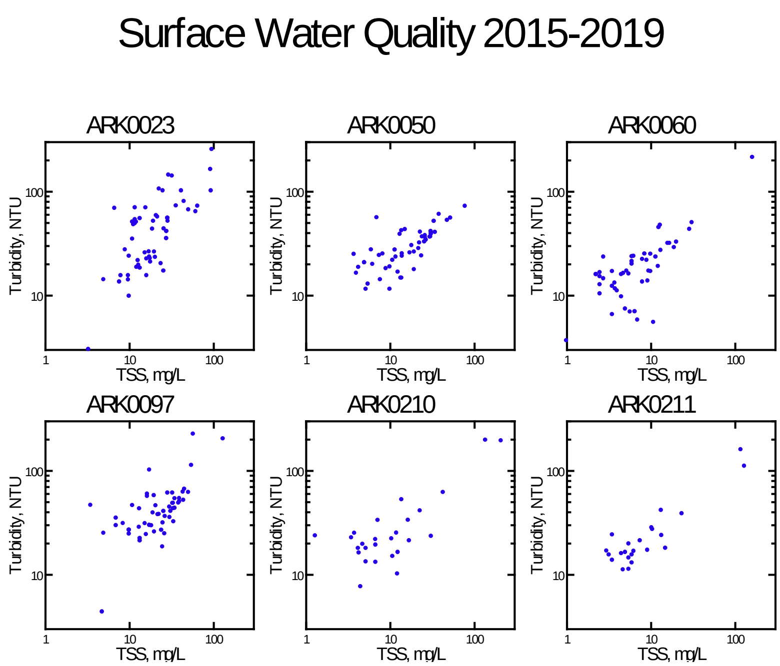


Figure 20. Graphs of 2015-2019 TSS vs turbidity measurements from the Bayou Meto stream stations.

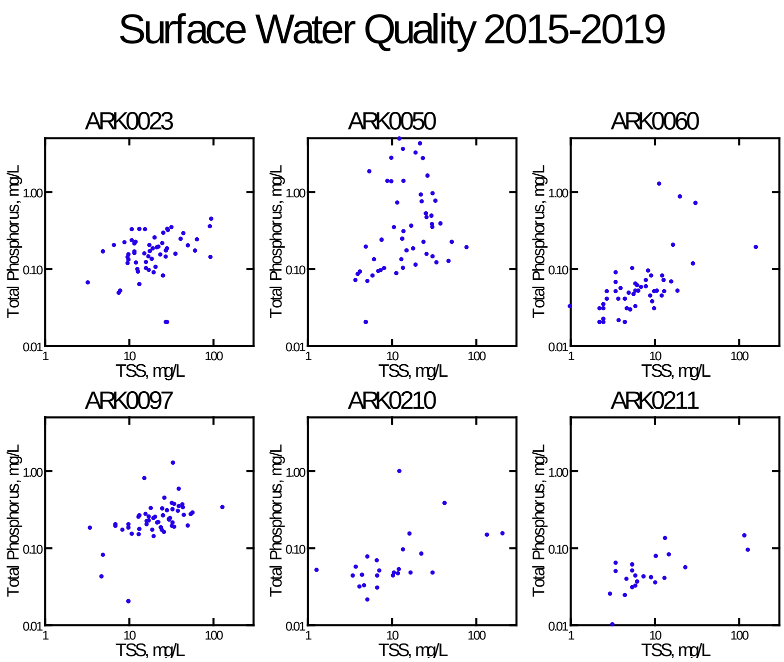


Figure 21. Graphs of 2015-2019 total phosphorus vs TSS measurements from the Bayou Meto stream stations.

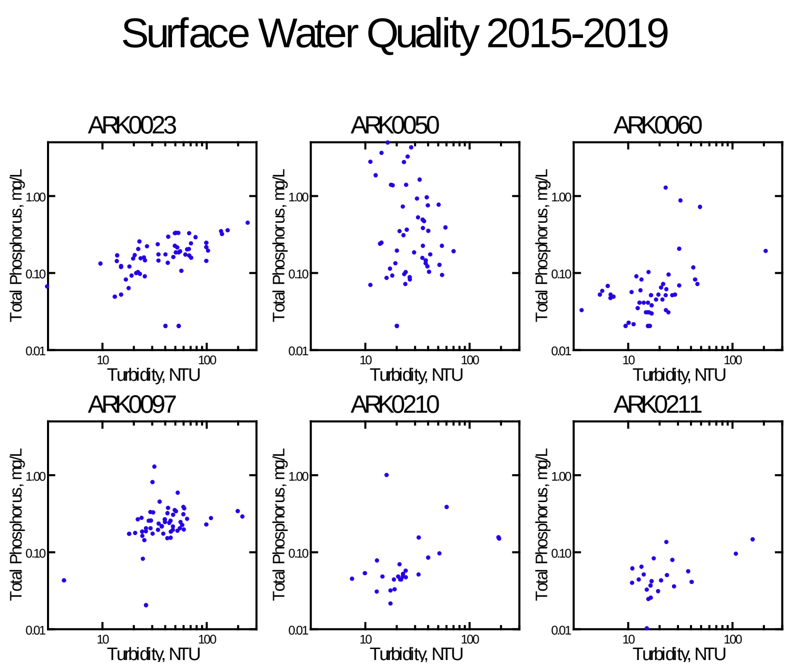


Figure 22. Graphs of 2015-2019 total phosphorus vs turbidity measurements from the Bayou Meto stream stations.

APPENDIX E

Surface Water Quality Trend Analysis

While it is important to look at current water quality conditions in the watershed, it is also important to determine if water quality is changing over time. Of particular interest for nonpoint source management are locations where water quality still meets water quality standards, but pollutant concentrations are increasing over time, suggesting that water quality standards may not be met in the future if no action is taken. Pollutant concentrations that are decreasing over time suggest that water quality is improving and that upstream pollutant management practices are providing benefits.

The parameters DO, and TDS are evaluated for trends because water quality standards for these parameters are not being met in some stream reaches in the Bayou Meto watershed. Because the Bayou Meto watershed is within the Mississippi River Basin, sediment and nutrient parameters are also of interest. Therefore, sediment parameters (TSS and turbidity), nitrogen parameters (dissolved inorganic nitrogen and TKN, which are components of total nitrogen), and total phosphorus are evaluated for long term trends.

E.1 Stations with Long Data Records

There are seven surface water quality monitoring stations in the Bayou Meto watershed with data records of at least 10 years that appear suitable for evaluation to determine if water quality has changed significantly over time. These stations are listed in Table 1. The locations of these stations are shown on Figure 3.1. Five of these stations are located on Bayou Meto, one on Bayou Two Prairie, and one on Lake Pickthorne.

Table 1. Surface water quality monitoring stations with at least 10 years of data.

Station ID	Waterbody	Location	Data record	Type of data record
ARK0023	Bayou Meto	on SR11 1.5 miles S of Bayou Meto	1974-2020	Continuous
ARK0050	Bayou Meto	at Hwy 161 near Jacksonville	1983-2020	Continuous
ARK0060	Bayou Meto	West Main St. Bridge in Jacksonville	1983-2020	Continuous
ARK0097	Bayou Two Prairie	Hwy 13 south of Carlisle	1993-2020	Continuous
LARK025A	Pickthorne Lake	Along easternmost levee	1994-2020	Intermittent
UWBMO01	Bayou Meto	Brumett Rd/CR971 SE of Seaton Dump	1994-2010	Intermittent
UWBMO02	Bayou Meto	Hwy 63/79 2 mi. S.W. of Stuttgart	1990-2010	Intermittent

E.2 Evaluation of Data from Intermittent Stations

Table 2 summarizes the data record for the stations that were sampled intermittently. Monitoring periods and numbers of samples are too dissimilar for statistical comparison over time at intermittent stations UWBMO01 and UWBMO02. At LARK025A, samples are collected on a single day in July, every 5 years. This is not adequate to make a statistical evaluation of water quality over time.

Table 2. Summary of data records for stations UWBMO01, UWBMO02, and LARK025A.

Parameter	Period	Number of Sample Dates		
		UWBMO01	**UWBMO02**	**LARK025A**
TSS	1994-1996	7	5	1
	1999	-	-	1
	2001	5	5	-
	2004	-	-	1
	2009-2010	3	3	-
	2020	-	-	3
Total P	1994-1996	8	6	1
	1999	-	-	1
	2001	5	5	-
	2004	-	-	1
	2009-2010	3	3	-
	2020	-	-	3

E.3 Trend Analysis of Data from Continuous Record Stations

Water quality data collected continuously, or with only short data gaps, can be evaluated mathematically to see if they exhibit trends. Mathematical trend analysis was performed on data from the four stations listed in Table 1 with continuous data records. Only data from January 1993 through September 2020 are analyzed for the following two reasons:

- The station ARK0097 data record starts in January 1993, and
- 2020 data is available only through September at the time of these analyses (November 2020).

Characteristics of the data determine what type of trend analysis is most appropriate. Data characteristics of concern include the presence of seasonal patterns, whether the data are normally distributed, and whether concentrations appear to be related to flow rate. These characteristics are discussed in the following sections.

E.3.1 Dissolved Oxygen

Figure 1 shows plots of DO concentrations from the selected water quality stations for the period 1993 – 2020. For the most part, DO concentrations appear fairly consistent over this time perioE. However, it appears recent DO concentrations at ARK0023 may have tended to be lower than previously. In addition, at ARK0050, DO concentrations appear to have been lower more frequently in the 1990s than they are now. So, DO concentrations at these two stations at least, may have changed over time.

As shown in Figure 2, DO data typically exhibits a seasonal pattern, because DO concentrations, and the processes that affect DO, are affected by water temperature. Therefore, a trend analysis method that accounts for this effect is useE.

The data were tested for normal distribution using the Shaprio-Wilk and Anderson-Darling statistics. The statistics results are given inTable 3. None of the data sets exhibit normal distribution. These statistics yield the same result when natural log of the data are useE. Because the data are not normally distributed, a non-parametric statistical trend test is useE.

Table 3. Normality test results for 1993-2020 DO data from long term stations.

Station	Number of Measures	Shapiro-Wilk Statistic	Shapiro-Wilk p value	Anderson-Darling Statistic	Anderson-Darling p value	Data Distribution
ARK0023	324	0.983	0.001	0.540	>0.15	Unclear
ARK0050	321	0.979	0.000	2.084	<0.1	Not normal
ARK0060	278	0.953	0.000	4.460	<0.1	Not normal
ARK0097	317	0.954	0.000	4.088	<0.1	Not normal

The Seasonal Mann-Kendall non-parametric statistical test was used to evaluate trends in DO concentrations. The USGS program for the Kendall family of tests was used to run the statistical test (Helsel, Mueller, & Slack, 2006). The program was set up with 12 seasons, i.e., each month is considered a separate season. The Mann-Kendall analysis in this program is based on water years. The program input and output are included as Attachment 1. The test results are summarized inTable 4.

Table 4. Results of Seasonal Mann-Kendal test of 1993-2020 DO data, assuming 12 seasons.

Station	Stream	Number of Years	S Statistic	Z Statistic	Adjusted P Value	Statistically Significant Trend?
ARK0023	Bayou Meto	29	-1010	-6.303	0.0007	Yes, decreasing
ARK0050	Bayou Meto	28	419	2.661	0.0636	No
ARK0060	Bayou Meto	28	328	2.212	0.0635	No
ARK0097	Two Prairie Bayou	28	40	0.250	0.8600	No

As suggested in the time series plot, the Seasonal Mann-Kendall test result for station ARK0023 indicates a decreasing trend in DO concentrations. This trend may indicate a decline in water quality in the lower reaches of Bayou Meto in recent years. However, minimum dissolved concentrations appear to be higher at this location during the last two years (Figure 1). This suggests the possibility that water quality may be improving again.

Figure 1. DO time series for selected stations, 1993-2020.

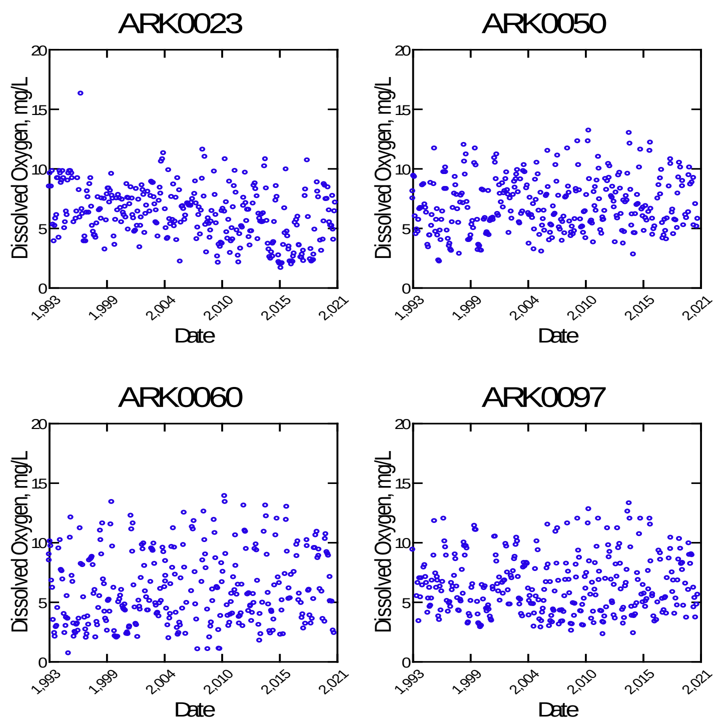
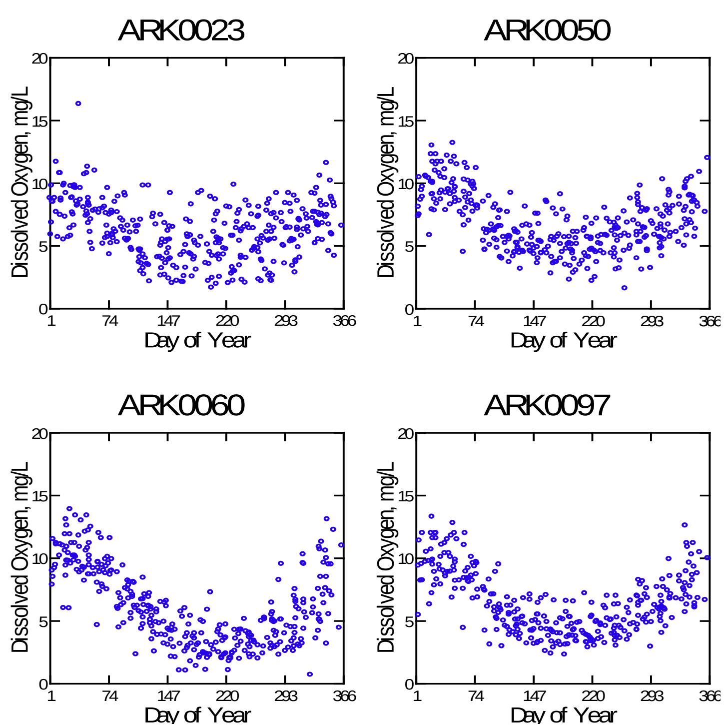


Figure 2. Long term DO data exhibit a seasonal pattern.



E.3.2 DO Saturation

To provide insight into the trends observed in DO concentration, percent DO saturation values were also evaluateE. Algae blooms resulting from nutrient contamination often cause supersaturation of DO in water, i.e., DO saturation values > 100%. DO saturation was not reported for the long term water quality stations. DO saturation was calculated from reported water temperature and DO concentrations. The first step in the calculation is to estimate the DO concentration that represents 100% saturation from the water temperature using the equation:

[exp(7.7117-1.31403*ln(temperature deg C +45.93))]*[(1-(elevation km/44.3))^5.25].

Based on GoogleEarth and topographic maps, elevations at the water quality stations range from 169 feet to 237 feet above mean sea level (Table 5). These elevations result in the elevation factor of the equation, i.e., (1-(elevation km/44.3))^5.25, having a value of 1. Therefore, the equation for the DO concentration representing 100% saturation becomes:

exp(7.7117-1.31403*ln(temperature deg C +45.93)).

Table 5. Elevations of long term water quality stations.

Station	GoogleEarth El., ft	Topo Map El. ft	Elevation used, ft	Estimated El., km	Elevation factor
ARK0050	231	230	230	0.07	1.0
ARK0060	240	235-240	237	0.07	1.0
ARK0097	206	205-210	206	0.06	1.0
ARK0023	169	170	169	0.05	1.0

Percent DO saturation is then calculated by dividing the measured DO concentration by the concentration representing 100% saturation, and multiplying by 100. DO saturation also exhibits seasonal patterns (Figure 3). The seasonal pattern at ARK0060 looks most like what would occur with good water quality over the entire evaluation period (1993-2020). When DO saturation values stay high during the summer and fall, as is seen in the data from stations ARK0023 and ARK0050, and to a lesser degree station ARK0097, that indicates the presence of algal blooms giving off high levels of oxygen. Figure 4 shows that at ARK0023, the highest DO saturation levels occurred prior to 2010. Since then, there are almost no DO saturation levels greater than 100, which suggests improved water quality. High summer DO saturation at stations ARK0050 and ARK0097 appear to occur occasionally throughout the data recorE.

The DO saturation data sets were tested for normal distribution using the Shaprio-Wilk and Anderson-Darling statistics. The statistics results are given inTable 6. Only one of the data sets appears to have a normal distribution. Because most of the data sets are not normally distributed, a non-parametric statistical trend test is useE.

Table 6. Normality test results for 1993-2020 percent DO saturation data from long term stations.

Station	Number of Measures	Shapiro-Wilk Statistic	Shapiro-Wilk p value	Anderson-Darling Statistic	Anderson-Darling p value	Data Distribution
ARK0023		0.988	0.011	0.550	>0.15	Unclear
ARK0050		0.997	0.736	0.218	>0.15	Normal
ARK0060		0.978	0.000	2.241	<0.01	Not normal
ARK0097		0.985	0.003	1.209	<0.01	Not normal

The Seasonal Mann-Kendall non-parametric statistical test was used to evaluate trends in percent DO saturation. The USGS program for the Kendall family of tests was used to run the statistical test (Helsel, Mueller, & Slack, 2006). The program was set up with 12 seasons, i.e., each month is considered a separate season. The program input and output are included as Attachment 2. The test results are summarized inTable 7.

Table 7. Results of Seasonal Mann-Kendal test of 1993-2020 percent DO saturation data, assuming 12 seasons.

Station	Stream	S Statistic	Z Statistic	P Value	Statistically Significant Trend?
ARK0023	Bayou Meto	-968	-6.286	0.0014	Yes, decreasing
ARK0050	Bayou Meto	569	3.723	0.0096	Yes, increasing
ARK0060	Bayou Meto	463	3.201	0.0155	Yes, increasing
ARK0097	Two Prairie Bayou	206	1.345	0.3248	No

Because stations ARK0050 and ARK0060 appear to have increasing DO concentrations (Table 4) and statistically significant increasing trends in DO saturation, it is possible that the increase in DO is the result of increased presence of algal blooms. This would indicate worsening water quality, rather than improving.

Figure 3. Seasonal patterns in DO saturation data.

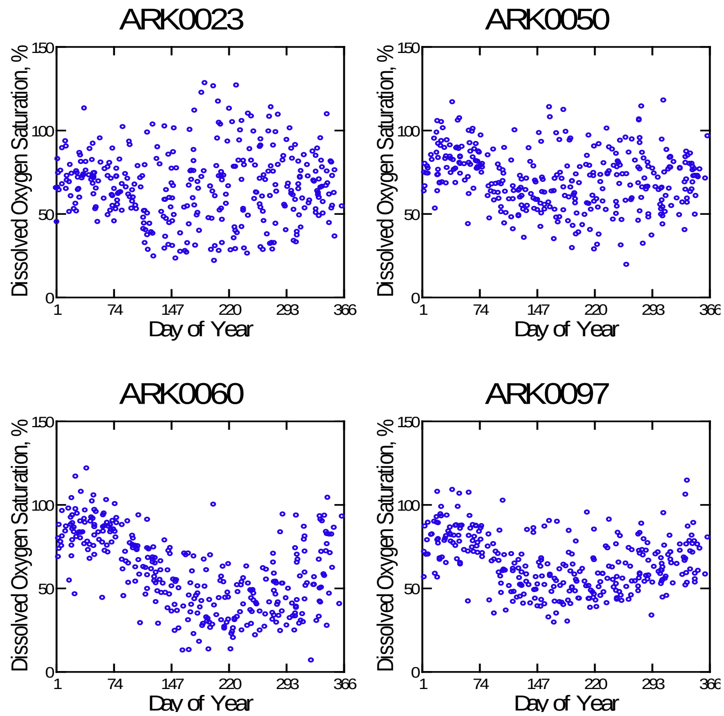
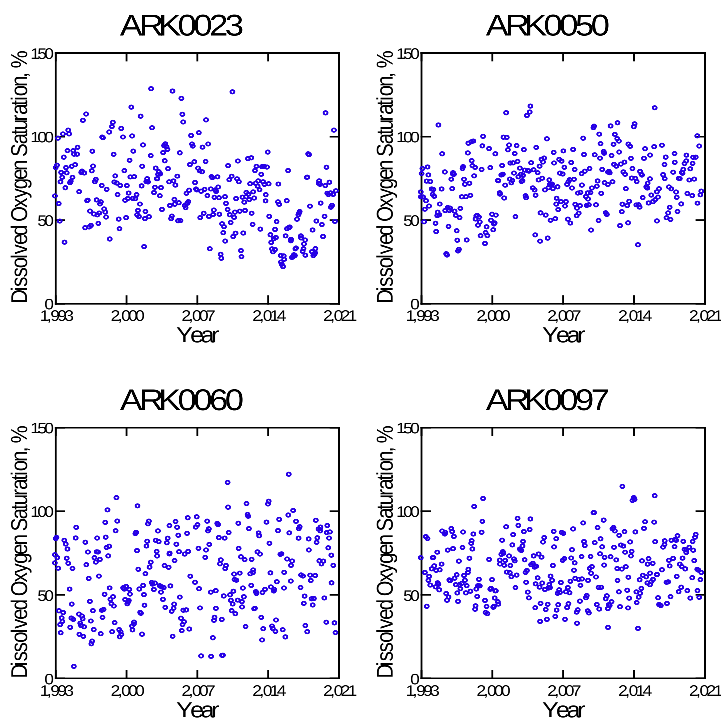


Figure 4. Time series plot of DO saturation data, 1993-2020.



E.3.3 BOD

Figure 5 shows a plot of BOD concentrations from the selected water quality stations for the period 1993 – 2020. The BOD data record from station ARK0050 is the only one adequate for our trend analysis, as it is the only one that extends beyond 2005. BOD concentrations at station ARK0050 appear to have both declined and increased over the period 1993-2020. We are more interested in recent trends. Therefore, we will exclude data prior to 2001 from the trend analysis.

As shown in Figure 6, BOD data often exhibits a seasonal pattern, because BOD loading can be associated with runoff, and the processes that affect organic matter decomposition, are affected by water temperature. Therefore, a trend analysis method that accounts for this effect is useE.

The data were tested for normal distribution using the Shaprio-Wilk and Anderson-Darling statistics. The statistics results are given in Table 8. None of the data sets exhibit normal distribution. These statistics yield the same result when natural log of the data are useE. Because the data are not normally distributed, a non-parametric statistical trend test is useE.

Table 8. Normality test results for 2001-2020 BOD data from long term station ARK0050.

Station	Number of Measures	Shapiro-Wilk Statistic	Shapiro-Wilk p value	Anderson-Darling Statistic	Anderson-Darling p value	Data Distribution
ARK0050	213	0.730	0.000	9.899	<0.01	Not normal

The Seasonal Mann-Kendall non-parametric statistical test was used to evaluate BOD concentrations from Station ARK0050 for trends. The USGS program for the Kendall family of tests was used to run the statistical test (Helsel, Mueller, & Slack, 2006). The program was set up with 12 seasons, i.e., each month is considered a separate season. The Mann-Kendall analysis in this program is based on water years. The program input and output are included as Attachment 3. The test results are summarized in Table 9.

Table 9. Results of Seasonal Mann-Kendal test of 1993-2020 DO data, assuming 12 seasons.

Station	Stream	Number of Years	S Statistic	Z Statistic	Adjusted P Value	Statistically Significant Trend?
ARK0050	Bayou Meto	20	262	2.854	0.016	Yes, increasing

As suggested in the time series plot, the Seasonal Mann-Kendall test result for station ARK0050 indicates an increasing trend in BOD concentrations. This trend may indicate a decline in water quality.

Figure 5. Time series plots of BOD measurements from selected water quality stations, 1993-2020.

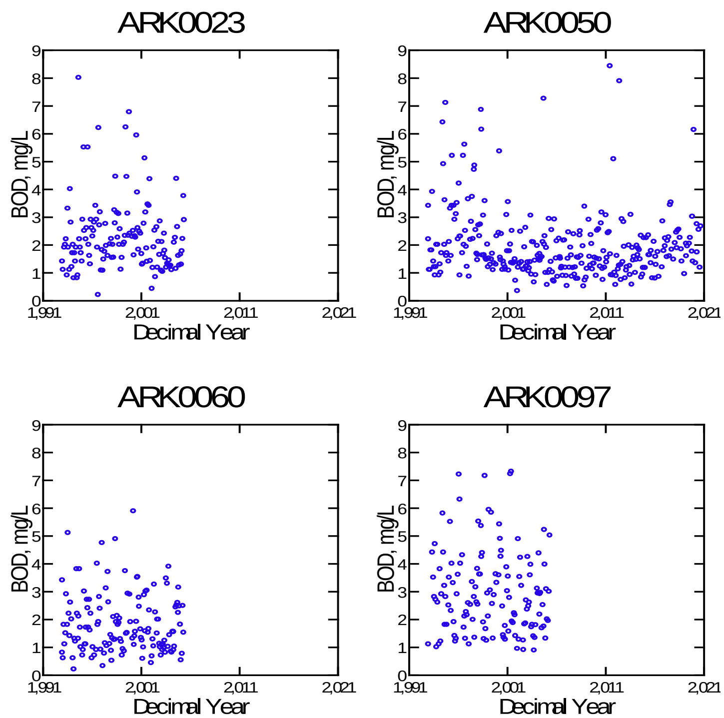
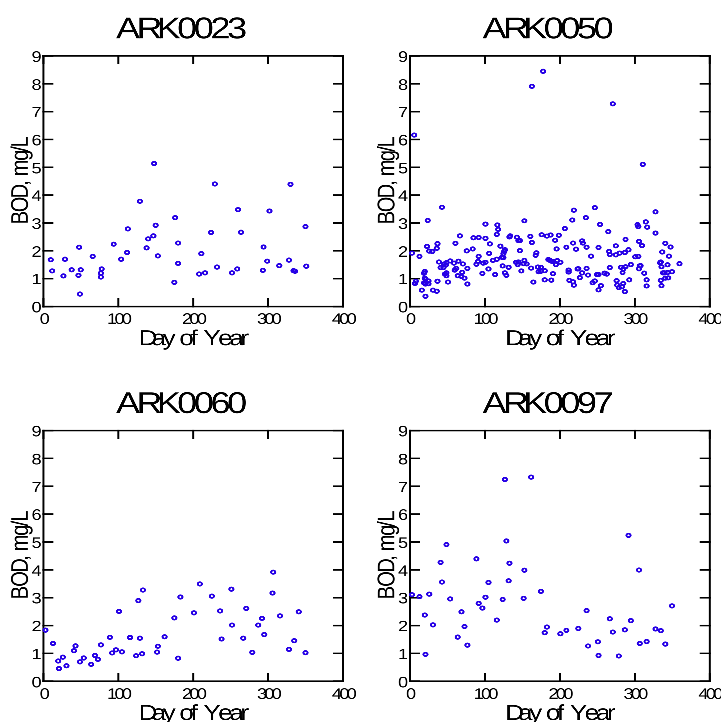


Figure 6. Long term BOD data exhibit a seasonal pattern.



E.3.4 TDS

Figure 7 shows plots of TDS concentrations from the selected water quality stations for the period 1993 – 2020. It appears that TDS concentrations may be declining slightly over time at some of the stations. TDS concentrations were also plotted against the day of the year to see if there is a seasonal pattern in the data. As shown in Figure 8, there does appear to be a seasonal pattern to these data that will need to be considered in the trend analysis.

The TDS data were tested for normal distribution using the Shaprio-Wilk and Anderson-Darling statistics. The statistics results are given in Table 10. None of the data sets exhibit normal distribution. These statistics yield the same result when natural log of the data are useE. Because the data are not normally distributed, a non-parametric statistical trend test is useE.

Table 10. Normality test results for 1993-2020 TDS data from long term stations.

Station	Number of Measures	Shapiro-Wilk Statistic	Shapiro-Wilk p value	Anderson-Darling Statistic	Anderson-Darling p value	Normal Data Distribution?
ARK0023	329	0.872	0.000	15.288	<0.01	No
ARK0050	320	0.873	0.000	15.240	<0.01	No
ARK0060	276	0.473	0.000	35.069	<0.01	No
ARK0097	319	0.923	0.000	4.776	<0.01	No

The Seasonal Mann-Kendall non-parametric statistical test was used to evaluate trends in TDS. The USGS program for the Kendall family of tests was used to run the statistical test (Helsel, Mueller, & Slack, 2006). The program was set up with 12 seasons, i.e., each month is considered a separate season. The program input and output are included as Attachment 4. The test results are summarized in Table 11.

Table 11. Results of Seasonal Mann-Kendal test of 1993-2020 TDS data, assuming 12 seasons.

Station	Stream	Number of years	S Statistic	Z Statistic	Adjusted P Value	Statistically Significant Trend?
ARK0023	Bayou Meto	29	-409	-2.473	0.125	No
ARK0050	Bayou Meto	28	54	0.338	0.804	No
ARK0060	Bayou Meto	28	-482	-3.276	0.016	Yes, decreasing

ARK0097	Two Prairie Bayou	28	-268	-1.688	0.251	No

The only station with a declining trend in TDS is ARK0060, the farthest upstream station. This suggests that water quality in this section of Bayou Meto may be improving slightly. There is no statistically significant change in TDS concentrations from the other stations during the period from 1993 to 2020.

Figure 7. Time series plots of TDS measurements from selected water quality stations, 1993-2020.

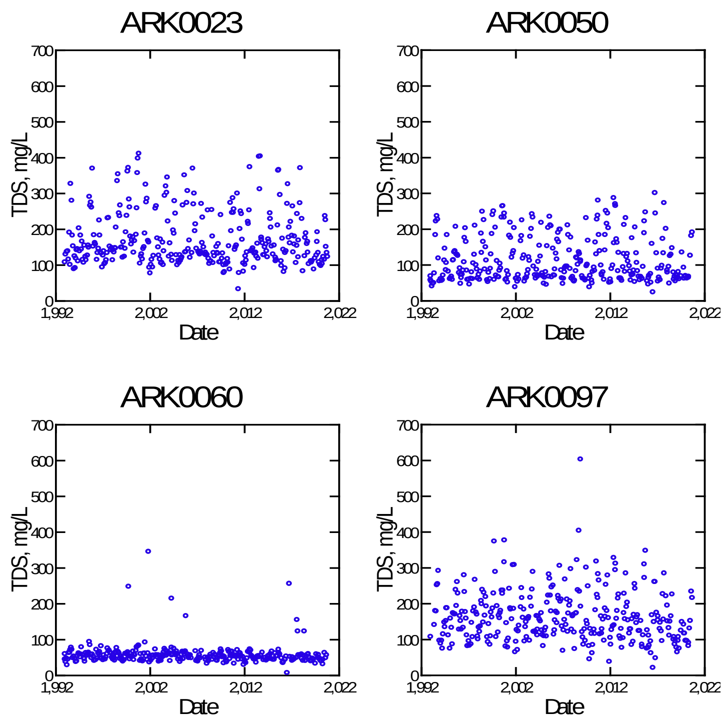
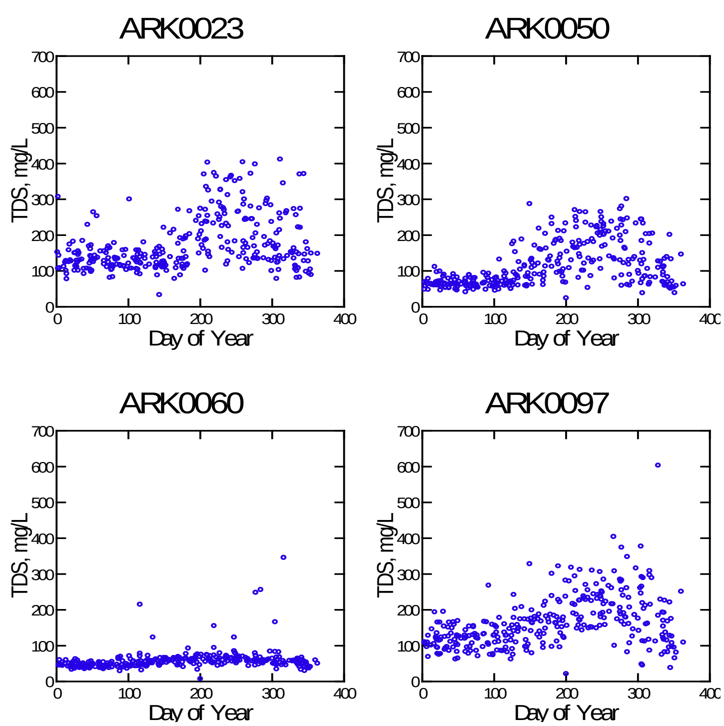


Figure 8. Long term TDS data exhibit a seasonal pattern.



E.3.5 TSS

Figure 9 shows plots of TSS concentrations from the selected water quality stations for the period 1993 – 2020. A log 10 scale is used to better display the data. It appears that there may have been slight changes in TSS concentrations over time. TSS concentrations are also plotted by day of the year to see if there is a seasonal pattern to the data. As shown in Figure 10, there does appear to be a slight seasonal pattern to the TSS concentrations that will need to be considered in trend analysis.

The TSS data were tested for normal distribution using the Shaprio-Wilk and Anderson-Darling statistics. The statistics results are given in Table 12. None of the data sets exhibit normal distribution. These statistics yield the same result when natural log of the data are useE. Because the data are not normally distributed, a non-parametric statistical trend test is useE.

Table 112. Normality test results for 1993-2020 TSS data from long term stations.

Station	Number of Measures	Shapiro-Wilk Statistic	Shapiro-Wilk p value	Anderson-Darling Statistic	Anderson-Darling p value	Normal Data Distribution?
ARK0023	328	0.495	0.000	35.288	<0.01	No
ARK0050	321	0.482	0.000	40.448	<0.01	No
ARK0060	277	0.342	0.000	49.186	<0.01	No
ARK0097	320	0.498	0.000	37.567	<0.01	No

The Seasonal Mann-Kendall non-parametric statistical test was used to evaluate trends in TSS. The USGS program for the Kendall family of tests was used to run the statistical test (Helsel, Mueller, & Slack, 2006). The program was set up with 12 seasons, i.e., each month is considered a separate season. The program input and output are included as Attachment 5. The test results are summarized in Table 13.

Table 13. Results of Seasonal Mann-Kendal test of 1993-2020 TSS data, assuming 12 seasons.

Station	Stream	Number of years	S Statistic	Z Statistic	Adjusted P Value	Statistically Significant Trend?
ARK0023	Bayou Meto	29	-187	-1.134	0.393	No
ARK0050	Bayou Meto	28	-243	-1.543	0.217	No
ARK0060	Bayou Meto	28	-524	-3.562	0.013	Yes, decreasing
ARK0097	Two Prairie Bayou	28	238	1.499	0.219	No

A statistically significant trend was identified only at station ARK0060, the farthest upstream station. This decreasing trend also suggests an improvement in water quality at this station over time. Looking at Figure 9, it appears TSS concentrations at station ARK0060 may have decreased starting sometime around 2007.

Figure 9. Time series plots of TSS measurement from selected water quality stations, 1993-2020.

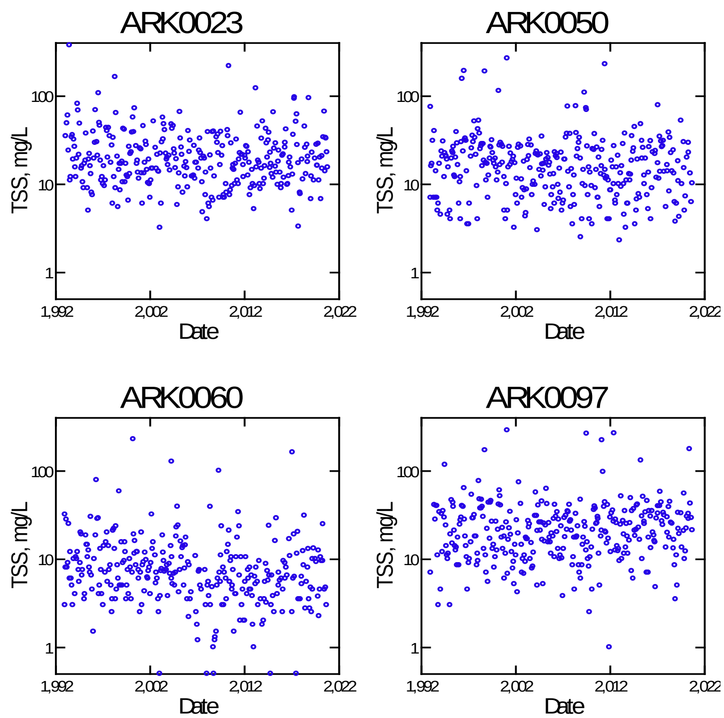
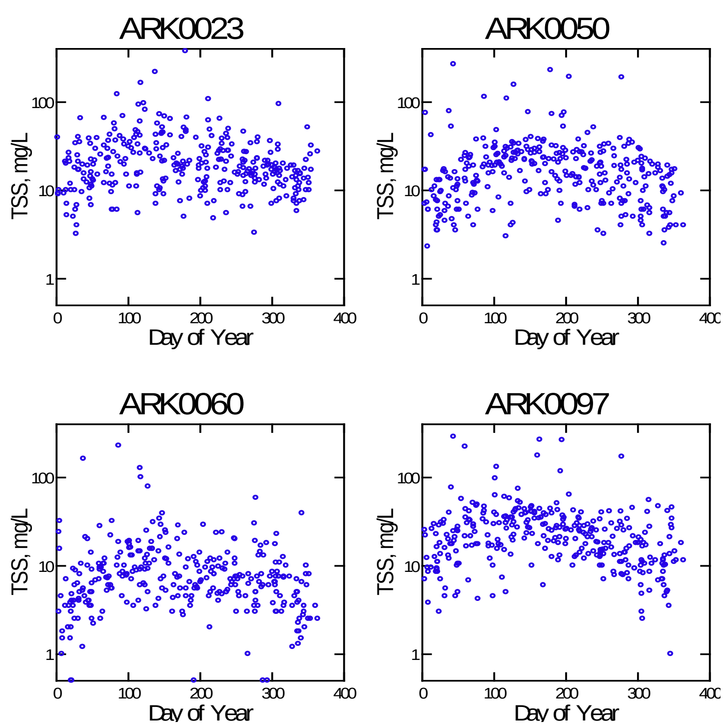


Figure 10. Long term TSS data exhibit a seasonal pattern.



E.3.6 Turbidity

Figure 11 shows plots of turbidity from the selected water quality stations for the period 1993 – 2020. A log 10 scale is used to better display the data. There does appear to have been changes in turbidity over time at these stations, but it is not clear if there is a long term trenE. Turbidity data are also plotted to determine if there is a seasonal pattern to the data. As shown in Figure 12, the turbidity data from these stations do appear to exhibit a seasonal pattern that will need to be considered in trend analysis.

The turbidity data were tested for normal distribution using the Shaprio-Wilk and Anderson-Darling statistics. The statistics results are given in Table 14. None of the data sets exhibit normal distribution. These statistics yield the same result when natural log of the data are useE. Because the data are not normally distributed, a non-parametric statistical trend test is useE.

Table 14. Normality test results for 1993-2020 turbidity data from long term stations.

Station	Number of Measures	Shapiro-Wilk Statistic	Shapiro-Wilk p value	Anderson-Darling Statistic	Anderson-Darling p value	Normal Data Distribution?
ARK0023	329	0.799	0.000	13.188	<0.01	No
ARK0050	319	0.519	0.000	37.194	<0.01	No
ARK0060	275	0.505	0.000	28.205	<0.01	No
ARK0097	318	0.590	0.000	35.024	<0.01	No

The Seasonal Mann-Kendall non-parametric statistical test was used to evaluate trends in turbidity. The USGS program for the Kendall family of tests was used to run the statistical test (Helsel, Mueller, & Slack, 2006). The program was set up with 12 seasons, i.e., each month is considered a separate season. The program input and output are included as Attachment 6. The test results are summarized in Table 15.

Table 15. Results of Seasonal Mann-Kendal test of 1993-2020 turbidity data, assuming 12 seasons.

Station	Stream	Number of years	S Statistic	Z Statistic	Adjusted P Value	Statistically Significant Trend?
ARK0023	Bayou Meto	29	178	1.074	0.496	No

ARK0050	Bayou Meto	28	343	2.200	0.092	No
ARK0060	Bayou Meto	28	-231	-1.582	0.238	No
ARK0097	Two Prairie Bayou	28	833	5.310	0.000	Yes, increasing

It is interesting to note that trend analysis results for TSS and turbidity are not the same. The increasing trend at the Bayou Two Prairie station (ARK0097) suggests water quality could be declining at that location. Looking at Figure 11, it appears that turbidity has had periods of increase and decline over the years at all of the stations. The most recent period of increasing turbidity at station ARK0097 appears to have started sometime around 2012. A similar pattern appears at station ARK0050.

Figure 11. Time series plots of turbidity measurements from selected water quality stations, 1993-2020.

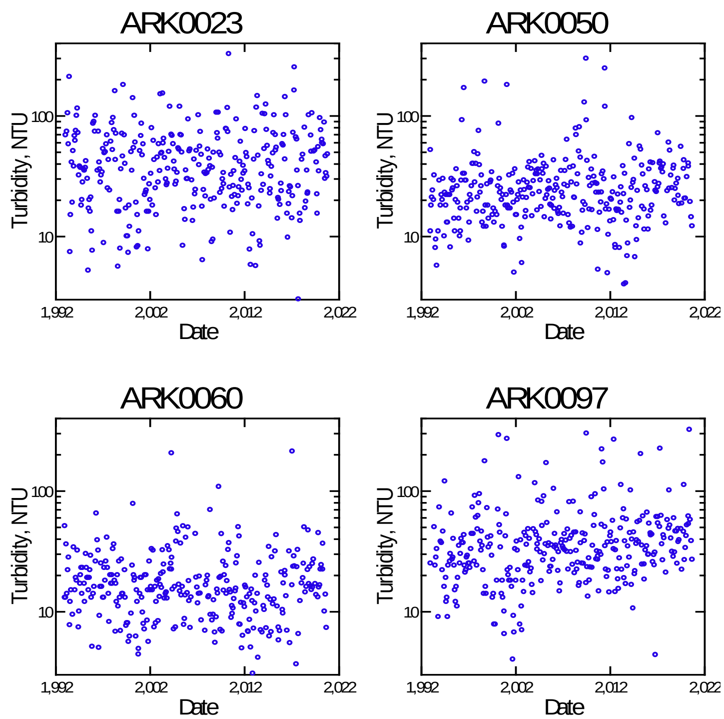
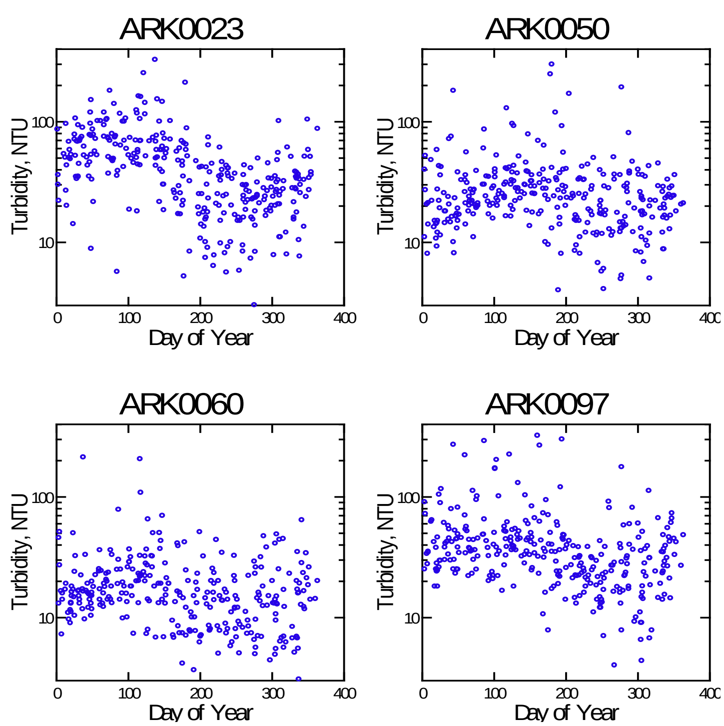


Figure 12. Long term turbidity data exhibit a seasonal pattern.



E.3.7 Inorganic Nitrogen

Figure 13 shows plots of inorganic nitrogen from the selected water quality stations for the period 1993 – 2020. A log 10 scale is used to better display the data. A large number of measurements from stations ARK0023 and ARK0060 were reported as less than detection, 49 of 330 for station ARK0023, and 57 of 307 for station ARK0060. In addition, the inorganic nitrogen detection limits used by DEQ have changed over time. As a result, the inorganic nitrogen data from these stations is judged not suitable for evaluation of trends.

The data from station ARK0050 appears to exhibit a possible increasing trenE. No trend is apparent in the data from station ARK0097. Inorganic nitrogen data from stations ARK0050 and ARK0097 are also plotted to determine if there is a seasonal pattern to the data. As shown in Figure 14, the inorganic nitrogen data from these stations do appear to exhibit a seasonal pattern that will need to be considered in trend analysis.

The inorganic nitrogen data were tested for normal distribution using the Shaprio-Wilk and Anderson-Darling statistics. The statistics results are given in Table 16. Neither of the data sets exhibit normal distribution. These statistics yield the same result when natural log of the data are useE. Because the data are not normally distributed, a non-parametric statistical trend test is useE.

Table 16. Normality test results for 1993-2020 inorganic nitrogen data from long term stations.

Station	Number of Measures	Shapiro-Wilk Statistic	Shapiro-Wilk p value	Anderson-Darling Statistic	Anderson-Darling p value	Normal Data Distribution?
ARK0050	322	0.685	0.000	36.395	<0.01	No
ARK0097	321	0.563	0.000	17.754	<0.01	No

The Seasonal Mann-Kendall non-parametric statistical test was used to evaluate trends in inorganic nitrogen. The USGS program for the Kendall family of tests was used to run the statistical test (Helsel, Mueller, & Slack, 2006). The program was set up with 12 seasons, i.e., each month is considered a separate season. The program input and output are included as Attachment 6. The test results are summarized in Table 17.

Table 17. Results of Seasonal Mann-Kendal test of 1993-2020 inorganic nitrogen data, assuming 12 seasons.

Station	Stream	Number of years	S Statistic	Z Statistic	Adjusted P Value	Statistically Significant Trend?
ARK0050	Bayou Meto	28	685	4.334	0.006	Yes, increasing
ARK0097	Two Prairie Bayou	28	-326	-2.046	0.056	No

As suggested by the time series graph, a statistically significant increasing trend is apparent in the inorganic nitrogen data from station ARK0050.

Figure 13. Time series plots of inorganic nitrogen measurements from selected water quality stations, 1993-2020.

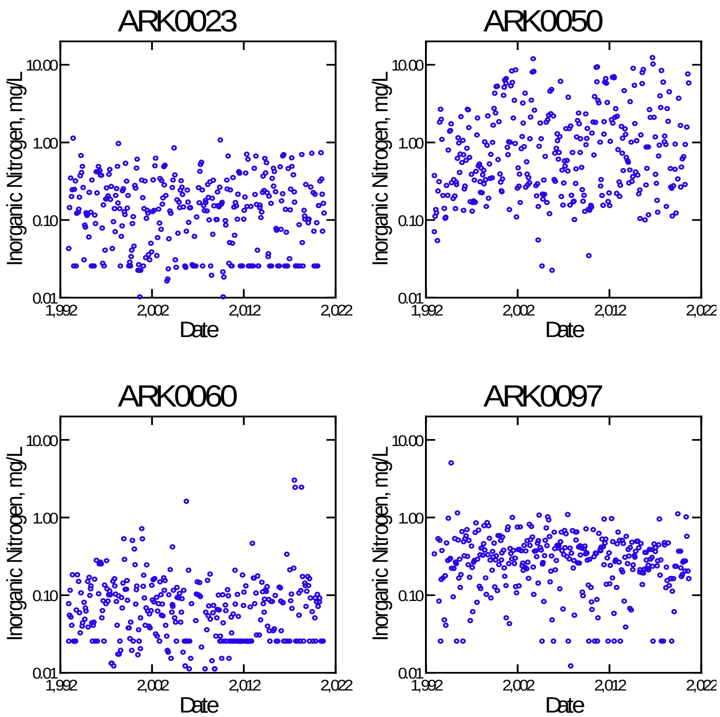
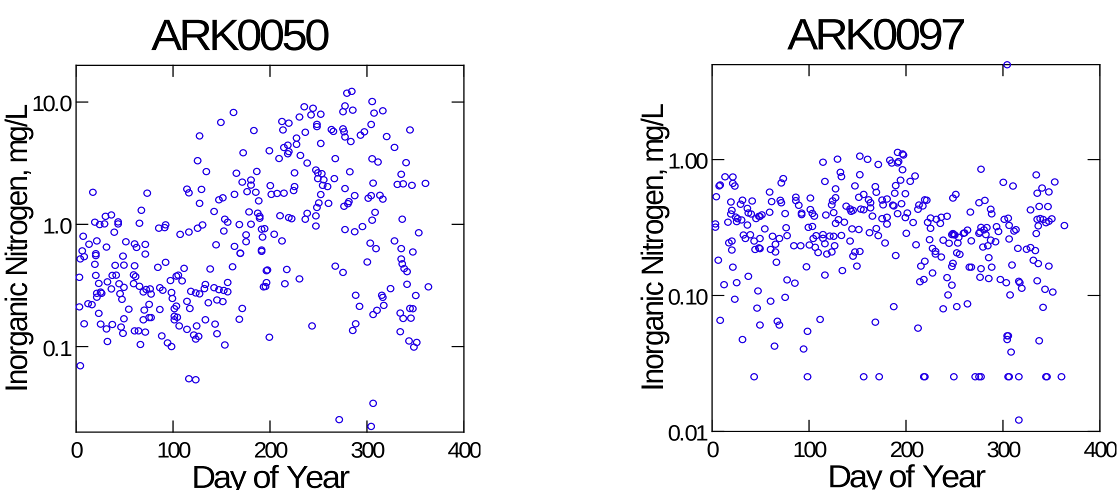


Figure 14. Long term inorganic nitrogen data exhibit a seasonal pattern.



E.3.8 TKN

Figure 15 shows plots of TKN from the selected water quality stations for the period 1998 – 2020. A log 10 scale is used to better display the data. TKN measurements were not collected at stations ARK0023 or ARK0007 until late 1997. Therefore, the analysis period for TKN is set to 1998-2020. There appear to have been declines in TKN at all four stations over time.

In Figure 16 TKN data are plotted against day of the year to determine if there is a seasonal pattern to the data. TKN data from these stations do appear to exhibit a seasonal pattern that will need to be considered in trend analysis.

The TKN data were tested for normal distribution using the Shaprio-Wilk and Anderson-Darling statistics. The statistics results are given in Table 18. None of the data sets exhibit normal distribution. These statistics yield the same result when natural log of the data are useE. Because the data are not normally distributed, a non-parametric statistical trend test is useE.

Table 18. Normality test results for 1998-2020 TKN data from long term stations.

Station	Number of Measures	Shapiro-Wilk Statistic	Shapiro-Wilk p value	Anderson-Darling Statistic	Anderson-Darling p value	Normal Data Distribution?
ARK0023	257	0.956	0.000	2.041	<0.01	No
ARK0050	245	0.562	0.000	18.575	<0.01	No
ARK0060	233	0.937	0.000	2.772	<0.01	No
ARK0097	251	0.900	0.000	5.970	<0.01	No

The Seasonal Mann-Kendall non-parametric statistical test was used to evaluate trends in TKN. The USGS program for the Kendall family of tests was used to run the statistical test (Helsel, Mueller, & Slack, 2006). The program was set up with 12 seasons, i.e., each month is considered a separate season. The program input and output are included as Attachment 7. The test results are summarized in Table 19.

Table 19. Results of Seasonal Mann-Kendal test of 1998-2020 TKN data, assuming 12 seasons.

Station	**Stream**	**Number of years**	**S Statistic**	**Z Statistic**	**Adjusted P Value**	**Statistically Significant Trend?**
ARK0023	Bayou Meto	24	-940	-7.572	0.000	Yes, decreasing
ARK0050	Bayou Meto	23	-420	-3.565	0.030	Yes, decreasing
ARK0060	Bayou Meto	23	-681	-6.186	0.000	Yes, decreasing
ARK0097	Two Prairie Bayou	23	-975	-8.077	0.000	Yes, decreasing

As suggested by the time series graphs, statistically significant decreasing trends are present in TKN measurements at all four stations. Decreasing TKN concentrations suggests improving water quality, at least in terms of nitrogen levels.

Figure 15. Time series plots of TKN measurements from selected water quality stations, 1998-2020.

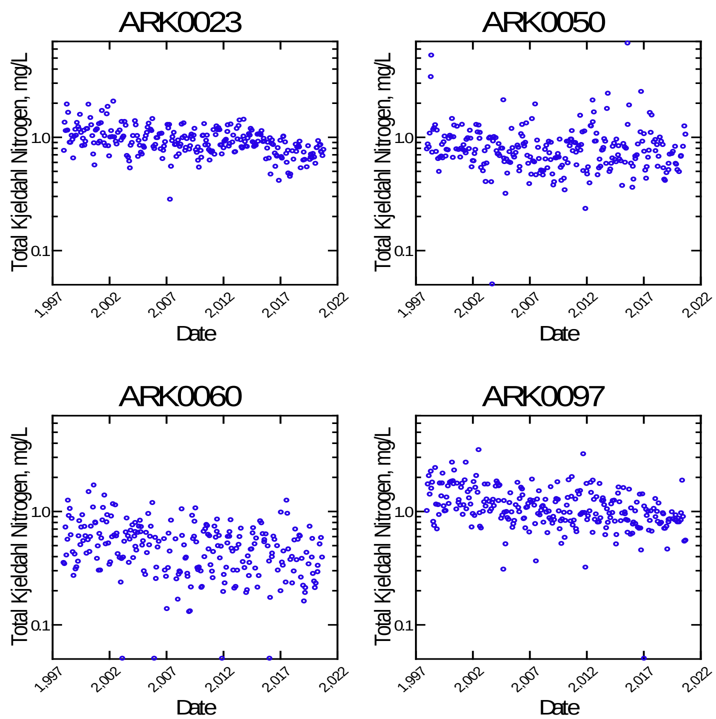
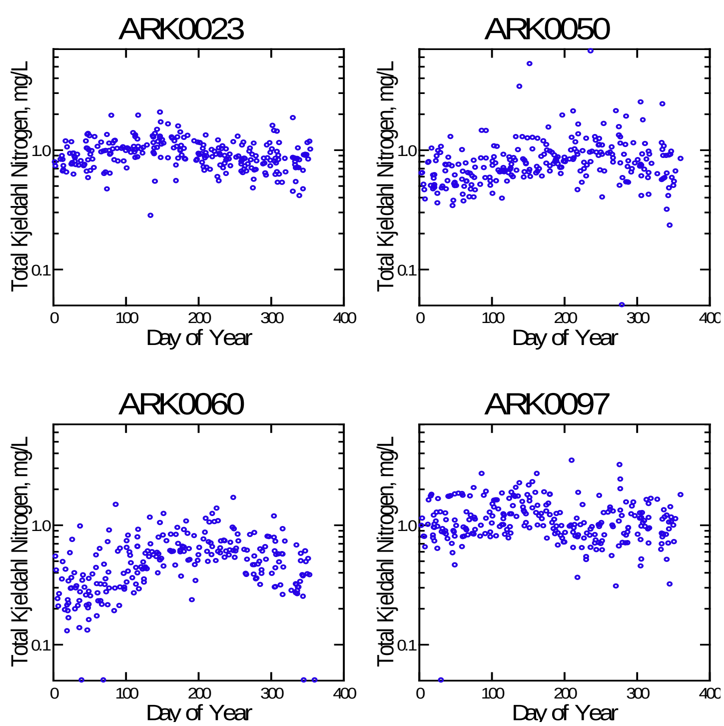


Figure 16. Long term TKN data exhibit a seasonal pattern.



E.3.9 Total Phosphorus

Figure 17 shows plots of total phosphorus from the selected water quality stations for the period 1993 – 2020. A log 10 scale is used to better display the data. Total phosphorus concentrations appear to have stayed fairly consistent over time at stations ARK0023 and ARK0050. However, at stations ARK0060 and ARK0097, it appears that total phosphorus concentrations may be declining over time.

Figure 18 shows the total phosphorus data plotted by day of the year. The plots in this figure appear to show seasonal patterns in the data that will need to be considered in the trend analysis. Note that the seasonal pattern at station ARK0050, where total phosphorus concentrations are higher during what is normally the drier time of year, suggests the influence of one or more point sources of nutrients.

The total phosphorus data were tested for normal distribution using the Shaprio-Wilk and Anderson-Darling statistics. The statistics results are given in Table 20. None of the data sets exhibit normal distribution. These statistics yield the same result when natural log of the data are useE. Because the data are not normally distributed, a non-parametric statistical trend test is useE.

Table 20. Normality test results for 1993-2020 total phosphorus data from long term stations.

Station	Number of Measures	Shapiro-Wilk Statistic	Shapiro-Wilk p value	Anderson-Darling Statistic	Anderson-Darling p value	Normal Data Distribution?
ARK0023	339	0.907	0.000	7.599	<0.01	No
ARK0050	323	0.762	0.000	26.618	<0.01	No
ARK0060	281	0.409	0.000	57.229	<0.01	No
ARK0097	324	0.415	0.000	57.504	<0.01	No

The Seasonal Mann-Kendall non-parametric statistical test was used to evaluate trends in total phosphorus. The USGS program for the Kendall family of tests was used to run the statistical test (Helsel, Mueller, & Slack, 2006). The program was set up with 12 seasons, i.e., each month is considered a separate season. The program input and output are included as Attachment 8. The test results are summarized in Table 21.

Table 21. Results of Seasonal Mann-Kendal test of 1993-2020 total phosphorus data, assuming 12 seasons.

Station	Stream	Number of years	S Statistic	Z Statistic	Adjusted P Value	Statistically Significant Trend?
ARK0023	Bayou Meto	29	95	0.574	0.643	No
ARK0050	Bayou Meto	28	33	0.206	0.867	No
ARK0060	Bayou Meto	28	-839	-5.736	0.000	Yes, decreasing
ARK0097	Two Prairie Bayou	28	-698	-4.461	0.001	Yes, decreasing

Figure 17. Time series plots of total phosphorus measurements from selected water quality stations, 1993-2020.

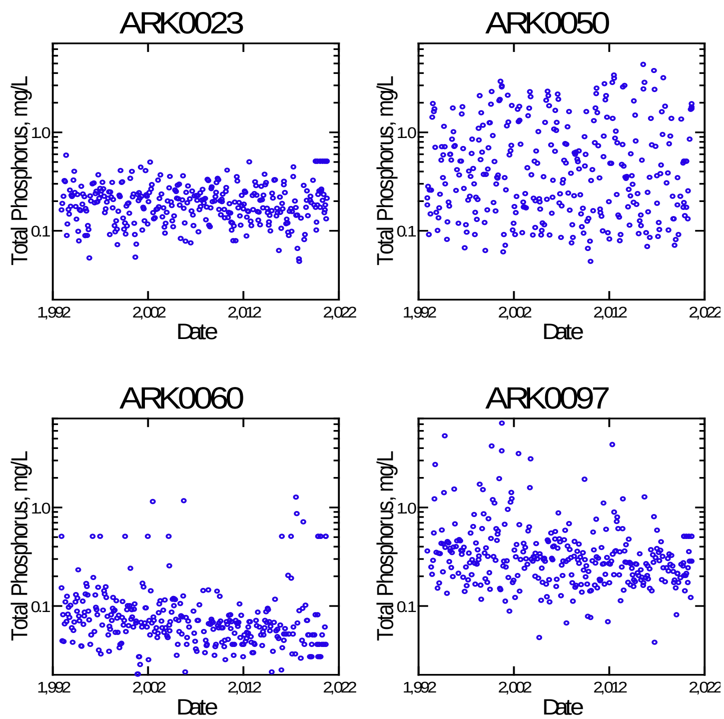
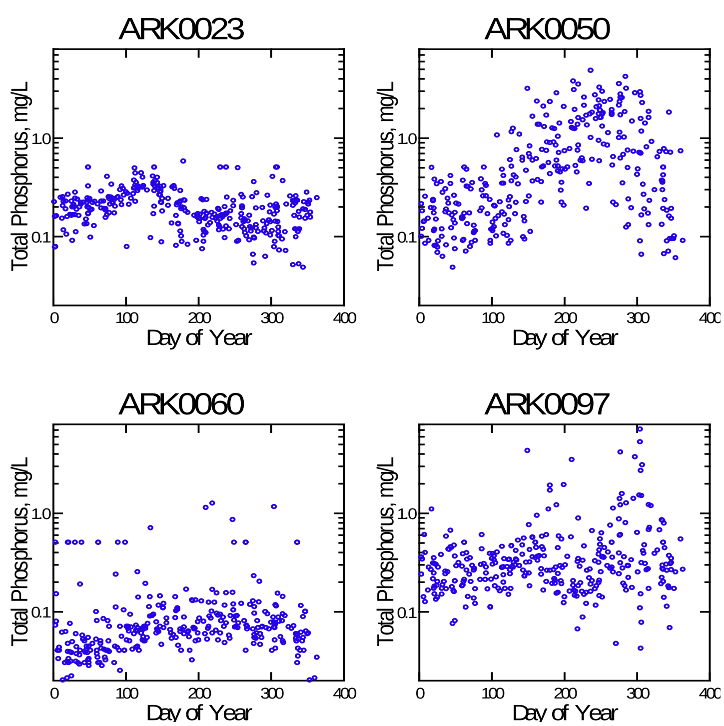


Figure 18. Long term total phosphorus data exhibit a seasonal pattern.



E.4 Summary

Water quality data collected continuously, or with only short data gaps, can be evaluated mathematically to see if they exhibit trends. Data for parameters of interest from the four long term data stations with continuous data records were analyzed for trends. Because of the characteristics of these data sets, non-parametric trend analysis was useE. In the majority of the data sets evaluated, no trend was apparent. The stations where parameters of interest did exhibit trends identified by the analyses are listed in Table 22.

Table 22. Water quality stations where parameters of interest exhibit trends.

Station ID	Stream	Parameter	Trend Direction
ARK0023	Bayou Meto	DO	Decreasing
		Percent DO Saturation	Decreasing
		TKN	Decreasing
ARK0050	Bayou Meto	Percent DO Saturation	Increasing
		BOD	Increasing
		Inorganic Nitrogen	Increasing
		TKN	Decreasing
ARK0060	Bayou Meto	Percent DO Saturation	Increasing
		TDS	Decreasing
		TSS	Decreasing
		TKN	Decreasing
		Total P	Decreasing
ARK0097	Bayou Two Prairie	Turbidity	Increasing
		TKN	Decreasing
		Total P	Decreasing

There were too many values below the reporting limit in the inorganic nitrogen data at stations ARK0023 and ARK0060 to evaluate trends over time. Changing reporting levels over time contributed to the difficulty of using these data for trend analysis.

The fact that both DO concentration and percent DO saturation values are declining at Station ARK0023 suggests that water quality conditions are getting worse over time. This could also indicate that low DO conditions at this station are being affected by human activities in the watersheE.

Decreasing trends in TDS, TSS, and two nutrient parameters, along with an increasing trend in percent DO saturation, suggest that water quality conditions are generally improving at station ARK0060.

The increasing trend in turbidity at station ARK0097 suggests that there is the potential for exceedance of numeric water quality criteria for turbidity in the future. Actions to control turbidity levels in the upper Bayou Two Prairie watershed may need to be a priority.

At station ARK0050, the trends in BOD (increasing) and inorganic nitrogen (increasing) suggest declining water quality, but the trends in percent DO saturation (increasing) and TKN (decreasing) suggest improving water quality. In other words, the trend analyses are inconclusive at this station.

It is interesting that TKN exhibits a declining trend at all four stations. It is unclear whether TKN is actually declining or if there have been changes over time in analytical methods or other aspects of the sampling program.

E.5 References

References

Helsel, E. R., Mueller, E. K., & Slack, J. R. (2006). *Computer Program for the Mann-Kendall Family of Trend Tests.* Reston, VA: US Geological Survey.

Attachment 1 DO Trend Analysis Program Inputs and Output
Station ARK0023 Input File

```
2 0       DO ARK0023 1993-2019
1993 1  8.50
1993 2  9.60
1993 3  8.50
1993 4  9.80
1993 5  5.30
1993 6  3.90
1993 7  5.20
1993 8  5.80
1993 9  6.10
1993 10 9.20
1993 11 9.20
1993 12 4.20
1994 1  9.80
1994 2  9.60
1994 3  8.80
1994 4  9.00
1994 5  9.80
1994 5  9.20
1994 7  5.00
1994 8  5.50
1994 9  6.40
1994 10 6.10
1994 11 9.00
1994 11 9.60
1995 1  9.80
1995 1  9.80
1995 3  9.60
1995 4  9.20
1995 5  5.50
1995 8  5.80
1995 9  6.40
1995 10 9.20
1995 12 8.20
1996 1  5.90
1996 2  16.30
1996 3  6.60
1996 4  6.20
1996 5  3.90
1996 6  4.30
1996 7  3.90
1996 8  6.30
1996 9  8.10
1996 10 7.60
1996 11 6.30
1996 12 8.70
1997 1  9.20
1997 2  6.80
1997 3  5.20
1997 4  4.70
1997 5  4.40
1997 6  4.40
```

1997	7	4.20
1997	8	5.40
1997	9	7.50
1997	10	7.60
1997	11	6.50
1997	12	6.60
1998	1	5.80
1998	2	7.50
1998	5	7.47
1998	6	3.22
1998	7	5.66
1998	8	7.84
1998	9	8.34
1998	10	8.34
1998	11	7.16
1998	12	8.14
1999	1	9.56
1999	2	7.73
1999	3	7.48
1999	4	4.30
1999	5	3.60
1999	6	5.70
1999	7	7.50
1999	8	6.50
1999	9	7.80
1999	11	7.50
1999	12	6.70
2000	1	5.50
2000	2	7.40
2000	3	6.30
2000	4	6.10
2000	5	6.80
2000	6	5.90
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2000	8	7.55
2000	9	4.89
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2001	1	7.49
2001	2	6.10
2001	3	5.83
2001	4	4.70
2001	5	4.80
2001	6	8.30
2001	7	5.20
2001	8	6.40
2001	9	7.40
2001	10	3.40
2001	11	5.20
2001	12	5.90
2002	1	8.60
2002	2	8.20
2002	3	7.80

2002	4	4.60
2002	5	6.20
2002	6	6.90
2002	7	9.36
2002	8	8.06
2002	10	6.40
2002	11	7.70
2002	12	8.90
2003	1	8.80
2003	2	8.80
2003	3	7.60
2003	4	7.00
2003	5	5.50
2003	6	6.50
2003	6	5.40
2003	8	4.30
2003	9	7.30
2003	10	8.40
2003	11	7.90
2003	12	10.60
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2004	2	11.30
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2004	4	6.59
2004	5	5.00
2004	6	4.10
2004	7	4.18
2004	8	9.87
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2004	11	5.81
2004	11	7.62
2005	1	5.69
2005	2	8.67
2005	3	5.17
2005	4	5.55
2005	5	7.55
2005	5	4.00
2005	7	9.20
2005	8	8.12
2005	9	8.18
2005	10	2.20
2005	11	5.47
2005	12	6.80
2006	1	6.85
2006	1	6.61
2006	3	5.70
2006	4	6.06
2006	5	7.27
2006	6	7.09
2006	7	7.00
2006	8	6.89
2006	10	6.88
2006	11	7.13

2006	12	7.45
2007	1	7.69
2007	2	7.88
2007	3	8.93
2007	4	7.08
2007	5	4.08
2007	6	5.05
2007	7	6.10
2007	8	6.75
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2008	2	11.00
2008	3	5.28
2008	4	2.97
2008	5	5.48
2008	6	5.83
2008	7	5.37
2008	8	4.20
2008	9	4.81
2008	10	5.55
2008	11	6.44
2008	12	7.29
2009	1	9.76
2009	2	7.79
2009	3	6.11
2009	4	5.41
2009	5	2.63
2009	6	2.10
2009	7	3.62
2009	8	3.44
2009	9	3.79
2009	10	6.44
2009	11	3.71
2009	12	6.63
2010	1	6.39
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2010	7	8.91
2010	8	2.92
2010	9	3.90
2010	10	5.00
2010	11	4.06
2010	11	6.76
2011	1	8.53
2011	2	9.82
2011	3	7.98
2011	4	4.82
2011	5	2.69

2011	6	2.13
2011	7	4.50
2011	8	3.29
2011	9	5.18
2011	10	5.05
2011	11	6.88
2011	12	7.55
2012	1	9.66
2012	2	7.11
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2012	4	6.55
2012	5	6.55
2012	6	4.25
2012	7	3.55
2012	8	4.74
2012	9	4.75
2012	10	7.18
2012	11	7.07
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2013	6	5.81
2013	7	5.55
2013	8	6.15
2013	9	5.50
2013	10	5.53
2013	11	6.25
2013	12	10.20
2014	1	10.80
2014	2	8.34
2014	3	5.61
2014	4	3.69
2014	5	3.21
2014	6	2.58
2014	7	2.44
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2014	10	3.71
2014	11	3.83
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2015	2	8.53
2015	3	7.63
2015	4	2.72
2015	5	2.16
2015	6	2.04
2015	7	1.66
2015	8	2.02
2015	9	2.06
2015	10	3.59
2015	11	6.67

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2016	2	4.72
2016	3	4.32
2016	4	3.22
2016	5	3.46
2016	6	2.21
2016	7	1.97
2016	8	2.22
2016	9	2.18
2016	10	2.62
2016	11	2.88
2016	12	5.46
2017	1	5.69
2017	2	5.23
2017	3	5.96
2017	4	3.59
2017	5	3.55
2017	6	2.55
2017	7	2.52
2017	8	2.78
2017	9	3.11
2017	10	2.25
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2017	12	8.25
2018	1	11.70
2018	2	10.70
2018	3	5.94
2018	5	2.40
2018	6	3.25
2018	7	2.20
2018	8	2.29
2018	9	2.33
2018	10	2.78
2018	11	4.88
2019	1	8.85
2019	2	8.07
2019	3	7.60
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2019	12	7.44
2020	1	7.46
2020	2	8.43
2020	3	6.50
2020	4	5.49
2020	5	5.22
2020	6	5.20
2020	7	7.71
2020	8	4.89

```
2020 9 4.03
2020 10 6.42
```

Station ARK0023 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  DO ARK0023 1993-2019

 The record is 29 complete water years with  12 seasons per year
    beginning in water year 1993.

 The tau correlation coefficient is -0.253
     S =  -1010.
     z =  -6.303
     p =  0.0000
     p =  0.0007 adjusted for correlation among seasons
                 (such as serial dependence)
 The adjusted p-value should be used only for data with
    more than 10 annual values per season.

 The estimated trend may be described by the equation:

    Y =   7.484     +  -0.9200E-01 * Time

    where Time = Year (as a decimal) - 1992.75
                                      (beginning of first water year)
```

Station ARK0050 Input File

```
2 0       DO ARK0050 1993-2019
1993 1  8.10
1993 1  7.50
1993 2  9.40
1993 3  9.30
1993 3  6.00
1993 5  4.50
1993 6  4.90
1993 7  4.70
1993 8  5.70
1993 9  6.60
1993 10 6.70
1993 11 6.70
1993 12 8.60
1994 2  8.70
1994 3  7.00
1994 4  6.70
1994 5  6.30
1994 6  3.60
1994 7  3.40
1994 8  4.40
1994 9  4.40
1994 10 8.80
1994 11 5.20
1994 11 6.10
1995 1  8.70
1995 2  11.70
1995 3  4.70
1995 4  5.70
1995 5  6.60
1995 6  4.40
1995 7  2.30
1995 8  2.20
1995 9  4.80
1995 10 4.00
1995 10 5.70
1995 11 6.40
1996 1  9.70
1996 2  8.30
1996 3  10.10
1996 3  9.70
1996 4  8.30
1996 5  4.80
1996 6  4.10
1996 7  3.50
1996 8  3.70
1996 9  3.20
1996 10 3.10
1996 11 5.50
1996 12 6.70
1997 1  7.90
1997 2  9.30
1997 3  8.60
```

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1997	5	6.59
1997	6	5.45
1997	7	2.85
1997	8	7.15
1997	9	7.74
1997	10	7.90
1997	12	7.10
1997	12	12.00
1998	1	10.60
1998	2	9.50
1998	3	11.20
1998	4	7.20
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1998	6	4.00
1998	8	4.10
1998	9	4.40
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1999	10	8.24
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1999	12	5.71
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2000	2	4.51
2000	3	4.66
2000	4	4.53
2000	5	8.12
2000	6	4.42
2000	7	5.60
2000	8	5.73
2000	9	5.82
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2000	10	5.69
2000	12	10.89
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2001	2	9.12
2001	3	11.20
2001	4	6.20
2001	5	6.04
2001	6	8.60
2001	7	7.89
2001	8	7.17
2001	9	8.77

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2001	12	8.11
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2002	2	9.69
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2002	4	7.82
2002	5	4.60
2002	6	7.50
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2003	2	9.50
2003	3	9.89
2003	4	8.02
2003	5	5.50
2003	6	5.40
2003	6	9.10
2003	7	6.20
2003	9	6.40
2003	10	9.80
2003	11	10.30
2003	12	9.70
2004	1	8.35
2004	2	8.59
2004	3	6.27
2004	4	3.70
2004	5	6.10
2004	6	7.55
2004	7	6.10
2004	8	5.86
2004	9	7.02
2004	10	3.23
2004	11	4.90
2004	12	9.07
2005	1	7.37
2005	2	10.50
2005	3	9.52
2005	4	6.47
2005	5	4.43
2005	6	7.97
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2005	9	5.76
2005	10	6.47
2005	11	4.79
2005	12	7.70
2006	1	7.82
2006	2	11.50
2006	3	8.45
2006	4	3.99

2006	5	4.62
2006	6	5.31
2006	7	5.23
2006	8	4.16
2006	9	6.83
2006	10	6.10
2006	11	6.21
2006	12	10.30
2007	1	8.90
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2007	3	7.72
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2007	5	4.88
2007	6	5.70
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2007	12	7.67
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2008	7	5.13
2008	8	4.49
2008	9	4.76
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2008	12	8.09
2009	1	12.30
2009	2	10.30
2009	3	8.18
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2009	5	5.06
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2009	7	5.13
2009	8	4.61
2009	9	6.35
2009	10	6.42
2009	11	4.16
2009	12	7.78
2010	1	12.30
2010	2	13.20
2010	3	9.12
2010	4	5.50
2010	5	5.64
2010	6	5.39
2010	7	3.81
2010	8	8.03
2010	9	6.85
2010	10	8.45

2010	11	6.46
2010	12	9.00
2011	1	11.00
2011	2	10.00
2011	3	7.43
2011	4	4.84
2011	5	4.54
2011	6	5.91
2011	7	5.68
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2012	6	8.48
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2012	10	7.99
2012	11	6.02
2012	12	5.82
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2013	11	7.33
2013	12	9.57
2014	1	13.00
2014	2	12.10
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2014	4	5.22
2014	5	6.16
2014	6	2.80
2014	7	4.59
2014	8	4.58
2014	9	6.18
2014	10	6.95
2014	11	7.79
2014	12	7.03
2015	1	10.10
2015	3	11.60
2015	4	6.57
2015	5	6.01

```
2015 6  6.73
2015 7  4.77
2015 8  5.85
2015 8  6.86
2015 10 5.64
2015 12 6.36
2016 1  11.50
2016 2  12.20
2016 3  6.63
2016 4  5.80
2016 5  4.45
2016 6  4.92
2016 7  5.15
2016 11 7.49
2016 12 8.61
2017 1  9.18
2017 2  7.84
2017 3  9.90
2017 4  5.43
2017 5  4.15
2017 6  4.40
2017 7  5.72
2017 8  4.77
2017 9  4.07
2017 10 5.82
2017 12 8.51
2018 1  10.80
2018 2  10.40
2018 3  6.31
2018 4  6.57
2018 5  4.50
2018 6  5.72
2018 8  5.66
2018 9  5.02
2018 10 7.91
2018 11 9.26
2018 12 10.50
2019 1  10.10
2019 3  8.52
2019 4  8.96
2019 5  5.25
2019 7  6.11
2019 8  5.85
2019 10 6.34
2019 11 9.45
2019 12 10.10
2020 1 8.67
2020 3 8.84
2020 4 9.22
2020 5 5.25
2020 7 7.02
2020 8 5.14
2020 9 5.79
```

Station ARK0050 Output File

```
    Seasonal Kendall Test for Trend
      US Geological Survey, 2009

Data set:  DO ARK0050 1993-2019

The record is 28 complete water years with  12 seasons per year
   beginning in water year 1993.

The tau correlation coefficient is  0.108
    S =    419.
    z =   2.661
    p =  0.0078
    p =  0.0636 adjusted for correlation among seasons
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =   6.160     +   0.3143E-01 * Time

   where Time = Year (as a decimal) - 1992.75
                                     (beginning of first water year)
```

Station ARK0060 Input File

```
2 0       DO ARK0060 1993-2019
1993 1  9.00
1993 1  8.50
1993 2  10.10
1993 3  9.70
1993 3  6.80
1993 5  6.20
1993 6  3.50
1993 7  2.40
1993 8  2.10
1993 9  2.90
1993 10 3.00
1993 11 4.50
1993 12 9.50
1994 2  10.20
1994 3  7.70
1994 4  7.60
1994 5  6.90
1994 6  4.00
1994 7  2.40
1994 8  3.00
1994 9  3.70
1994 10 5.50
1994 11 3.60
1994 11 0.70
1995 1  10.40
1995 2  12.10
1995 3  7.20
1995 4  6.70
1995 5  3.20
1995 6  2.10
1995 7  2.50
1995 8  2.40
1995 9  3.10
1995 10 3.20
1995 10 2.60
1995 11 3.60
1996 1  11.20
1996 2  8.20
1996 4  8.10
1996 5  5.40
1996 6  3.70
1996 7  2.70
1996 8  2.00
1996 9  2.30
1996 10 3.80
1996 11 3.10
1996 12 8.50
1997 1  8.60
1997 2  8.70
1997 3  8.80
1997 4  8.10
1997 5  5.68
```

1997	6	6.01
1997	7	2.04
1997	8	3.33
1997	9	3.05
1997	10	4.50
1997	12	5.50
1997	12	11.00
1998	1	10.20
1998	2	9.00
1998	3	11.60
1998	4	6.90
1998	5	6.50
1998	6	4.20
1998	6	3.60
1998	8	3.40
1998	9	2.60
1998	10	5.10
1998	11	5.20
1998	12	4.20
1999	1	11.52
1999	2	13.40
1999	3	9.66
1999	4	6.20
1999	5	2.56
1999	6	2.14
1999	7	2.07
1999	8	2.02
1999	9	2.09
1999	10	4.99
1999	11	5.23
1999	12	5.53
2000	1	6.02
2000	2	4.66
2000	3	4.47
2000	4	4.37
2000	5	4.80
2000	6	4.29
2000	7	2.33
2000	8	2.46
2000	9	2.32
2000	10	2.86
2000	10	2.96
2000	12	12.25
2001	1	11.10
2001	2	9.23
2001	3	11.60
2001	4	6.40
2001	5	4.55
2001	6	3.17
2001	7	3.07
2001	8	2.07
2001	9	5.12
2001	10	4.61
2001	11	4.37

2001	12	7.02
2002	1	9.80
2002	2	9.43
2002	3	9.92
2002	4	8.03
2002	5	5.90
2002	6	5.40
2002	7	4.30
2002	8	4.30
2002	10	5.10
2002	11	6.70
2002	12	9.50
2003	1	9.40
2003	2	9.30
2003	3	9.91
2003	4	8.21
2003	5	4.90
2003	6	4.70
2003	6	4.00
2003	7	4.10
2003	9	3.80
2003	10	4.90
2003	11	6.10
2003	12	5.10
2004	1	9.56
2004	2	9.20
2004	3	6.25
2004	4	6.73
2004	4	8.44
2004	5	7.20
2004	6	4.45
2004	7	3.05
2004	8	1.97
2004	9	3.63
2004	10	4.00
2004	11	6.50
2004	12	9.63
2005	1	7.88
2005	2	11.20
2005	3	9.57
2005	4	7.30
2005	5	4.10
2005	6	2.83
2005	7	2.26
2005	8	2.40
2005	9	3.27
2005	10	3.04
2005	11	6.99
2005	12	4.45
2006	1	9.79
2006	2	12.50
2006	3	7.89
2006	4	2.33
2006	5	4.93

```
2006 11 5.92
2006 12 11.30
2007 1  11.10
2007 2  11.80
2007 3  7.51
2007 4  4.81
2007 5  3.53
2007 6  1.04
2007 11 6.69
2007 12 8.50
2008 1  12.60
2008 2  10.20
2008 3  9.00
2008 4  7.84
2008 5  4.37
2008 6  1.05
2008 8  2.04
2008 9  2.95
2008 10 3.29
2008 11 6.06
2008 12 5.08
2009 1  11.90
2009 2  10.80
2009 3  8.68
2009 4  6.26
2009 5  6.16
2009 6  2.65
2009 7  1.09
2009 8  1.07
2009 9  3.83
2009 10 8.26
2009 11 6.67
2009 12 7.54
2010 1  13.90
2010 2  13.40
2010 3  9.03
2010 4  4.73
2010 5  3.85
2010 6  3.00
2010 7  3.26
2010 8  3.94
2010 9  5.00
2010 10 5.70
2010 11 4.03
2010 12 7.08
2011 1  6.00
2011 2  10.60
2011 3  8.04
2011 4  5.62
2011 5  6.46
2011 6  3.75
2011 7  3.20
2011 8  3.83
2011 9  4.06
```

2011	10	6.46
2011	11	2.98
2011	12	13.10
2012	1	11.00
2012	2	10.90
2012	3	9.46
2012	4	5.65
2012	5	4.25
2012	6	5.74
2012	7	4.64
2012	8	4.71
2012	9	3.41
2012	10	4.09
2012	11	5.67
2012	12	4.92
2013	1	9.46
2013	2	9.84
2013	3	9.34
2013	4	6.78
2013	5	3.09
2013	6	1.77
2013	7	4.00
2013	8	2.31
2013	10	4.95
2013	12	10.90
2014	1	13.10
2014	2	12.20
2014	3	8.97
2014	4	5.77
2014	5	4.80
2014	6	2.56
2014	7	2.37
2014	8	4.28
2014	9	4.16
2014	10	2.60
2014	11	3.53
2014	12	6.40
2015	1	10.60
2015	3	12.00
2015	4	7.07
2015	5	6.59
2015	7	2.26
2015	8	4.29
2015	8	5.15
2015	10	2.30
2015	12	7.35
2016	1	11.90
2016	2	13.00
2016	3	9.23
2016	4	5.27
2016	5	6.15
2016	6	5.32
2016	7	7.28
2016	11	7.53

```
2017 1  9.81
2017 2  8.86
2017 3  10.10
2017 4  5.16
2017 5  5.71
2017 7  4.92
2017 8  3.67
2017 9  3.97
2017 10 2.78
2017 12 3.18
2018 1  10.20
2018 2  9.70
2018 3  5.95
2018 4  6.03
2018 5  3.88
2018 6  3.20
2018 8  3.59
2018 9  5.25
2018 10 9.54
2018 11 9.54
2018 12 10.60
2019 1  10.90
2019 2  8.70
2019 3  8.88
2019 4  9.41
2019 5  6.09
2019 7  5.88
2019 8  3.58
2019 10 3.36
2019 11 10.30
2019 12 10.70
2020 1 9.20
2020 2 9.06
2020 3 8.89
2020 4 7.11
2020 5 5.08
2020 7 5.04
2020 8 2.61
2020 9 2.40
```

Station ARK0060 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  DO ARK0060 1993-2019

 The record is 28 complete water years with  12 seasons per year
    beginning in water year 1993.

 The tau correlation coefficient is  0.092
     S =    328.
     z =   2.212
     p =  0.0269
     p =  0.0635 adjusted for correlation among seasons
```

```
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =   5.231     +   0.2778E-01 * Time

   where Time = Year (as a decimal) - 1992.75
                                     (beginning of first water year)
```

Station ARK0097 Input File

```
2 0       DO ARK0097 1993-2019
1993 1  9.40
1993 6  5.50
1993 7  6.60
1993 8  3.40
1993 9  7.00
1993 10 5.40
1993 11 7.00
1993 12 6.40
1994 2  7.90
1994 3  8.10
1994 4  7.10
1994 5  6.60
1994 6  4.10
1994 7  5.30
1994 8  6.20
1994 9  4.60
1994 10 4.70
1994 11 5.30
1994 11 6.80
1995 1  8.90
1995 2  11.80
1995 3  7.40
1995 4  6.20
1995 5  7.10
1995 6  6.80
1995 7  3.80
1995 8  3.50
1995 9  6.30
1995 10 4.30
1995 10 5.90
1995 11 6.70
1996 1  12.00
1996 2  10.10
1996 3  9.60
1996 4  8.90
1996 5  5.10
1996 6  4.20
1996 7  4.90
1996 8  5.00
1996 9  4.60
1996 10 6.60
1996 11 6.00
1996 12 6.30
1997 1  7.20
1997 2  9.00
1997 3  8.60
1997 4  6.30
1997 5  5.33
1997 6  4.30
1997 7  4.25
1997 8  5.20
1997 9  5.05
```

1997	10	7.70
1997	12	5.70
1997	12	10.00
1998	1	9.70
1998	2	8.90
1998	3	9.70
1998	4	9.50
1998	5	3.20
1998	6	3.30
1998	6	4.00
1998	8	3.80
1998	9	5.10
1998	10	6.20
1998	11	6.50
1999	1	11.40
1999	2	11.07
1999	3	11.05
1999	4	5.02
1999	5	3.96
1999	6	3.22
1999	7	3.11
1999	8	2.89
1999	9	3.02
1999	10	6.43
1999	11	5.22
1999	12	6.17
2000	1	6.32
2000	2	4.44
2000	3	4.22
2000	4	4.51
2000	5	4.72
2000	6	4.37
2000	7	3.78
2000	8	3.55
2000	9	3.44
2000	10	6.27
2000	10	6.06
2000	12	10.48
2001	1	10.50
2001	2	8.92
2001	3	8.40
2001	4	6.50
2001	5	5.90
2001	6	7.06
2001	7	5.12
2001	9	6.62
2001	10	5.71
2001	11	6.77
2001	12	6.82
2002	1	9.88
2002	2	9.66
2002	3	7.48
2002	4	5.99
2002	5	4.80

2002	6	4.80
2002	7	7.20
2002	8	7.00
2002	10	7.60
2002	11	8.60
2002	12	8.80
2003	1	9.80
2003	2	10.40
2003	3	10.10
2003	4	7.11
2003	5	5.30
2003	6	4.80
2003	6	5.20
2003	7	4.00
2003	9	3.80
2003	10	7.90
2003	11	8.30
2003	12	8.00
2004	1	8.30
2004	2	8.22
2004	3	6.14
2004	4	3.88
2004	5	5.10
2004	6	5.51
2004	7	4.84
2004	8	6.00
2004	9	4.83
2004	10	2.94
2004	11	4.04
2004	12	7.77
2005	1	5.47
2005	2	10.10
2005	3	9.35
2005	4	5.15
2005	5	3.55
2005	6	2.88
2005	7	3.40
2005	8	4.12
2005	9	4.44
2005	10	5.10
2005	11	6.02
2005	12	6.67
2006	1	7.83
2006	2	11.50
2006	3	8.15
2006	4	2.98
2006	5	6.68
2006	6	3.40
2006	7	3.84
2006	8	3.30
2006	9	4.38
2006	10	4.27
2006	11	5.89
2006	12	10.90

2007	1	8.23
2007	2	11.20
2007	3	6.78
2007	4	3.12
2007	5	4.29
2007	6	3.36
2007	7	4.32
2007	8	3.38
2007	9	4.17
2007	10	5.49
2007	11	6.86
2007	12	8.23
2008	1	11.60
2008	2	7.55
2008	3	6.87
2008	4	5.74
2008	5	3.17
2008	6	2.60
2008	7	3.14
2008	8	4.91
2008	9	3.85
2008	10	4.86
2008	11	8.14
2008	12	7.06
2009	1	12.00
2009	2	9.32
2009	3	8.72
2009	4	4.24
2009	5	4.21
2009	6	3.07
2009	7	4.76
2009	8	3.03
2009	9	5.28
2009	10	7.11
2009	11	6.13
2009	12	7.44
2010	1	11.60
2010	2	12.80
2010	3	8.42
2010	4	5.62
2010	5	3.60
2010	6	6.63
2010	7	4.20
2010	8	3.23
2010	9	6.04
2010	10	8.27
2010	11	5.56
2010	12	9.64
2011	1	12.00
2011	2	6.85
2011	3	7.55
2011	4	4.27
2011	5	4.23
2011	6	3.33

2011	7	2.31
2011	8	3.28
2011	9	3.79
2011	10	6.95
2011	11	4.56
2011	12	11.20
2012	1	9.77
2012	2	8.76
2012	3	9.21
2012	4	6.88
2012	5	5.06
2012	6	4.91
2012	7	3.89
2012	8	6.44
2012	9	3.63
2012	10	8.16
2012	11	7.13
2012	12	11.20
2013	1	9.53
2013	2	9.88
2013	3	8.22
2013	4	6.07
2013	5	4.34
2013	6	3.19
2013	7	4.52
2013	8	3.66
2013	9	6.33
2013	10	6.60
2013	11	7.70
2013	12	12.60
2014	1	13.30
2014	2	12.00
2014	3	9.59
2014	4	4.61
2014	5	3.85
2014	6	2.39
2014	7	3.82
2014	8	4.66
2014	9	3.97
2014	10	4.90
2014	11	7.43
2014	12	6.85
2015	1	10.70
2015	3	12.00
2015	4	5.63
2015	5	4.98
2015	6	6.43
2015	7	5.71
2015	8	4.60
2015	8	5.07
2015	10	5.25
2015	11	7.61
2015	12	6.07
2016	1	12.00

```
2016 2  11.50
2016 3  8.42
2016 4  5.49
2016 5  5.67
2016 6  3.80
2016 7  3.37
2016 9  3.49
2016 11 4.97
2016 12 9.32
2017 1  9.10
2017 2  8.55
2017 4  5.27
2017 5  4.10
2017 6  4.32
2017 7  5.32
2017 8  5.41
2017 9  4.03
2017 10 7.01
2017 12 8.66
2018 1  9.46
2018 2  10.40
2018 3  7.49
2018 4  5.84
2018 5  6.81
2018 6  4.02
2018 8  5.30
2018 9  4.72
2018 10 6.82
2018 11 8.57
2018 12 10.30
2019 1  9.48
2019 2  8.20
2019 3  7.69
2019 4  8.29
2019 5  4.69
2019 7  6.55
2019 8  3.69
2019 10 6.02
2019 11 9.93
2019 12 8.96
2020 1 8.21
2020 2 9.01
2020 3 8.93
2020 4 6.21
2020 5 4.56
2020 6 5.34
2020 7 3.71
2020 8 4.79
2020 9 5.62
```

Station ARK0097 Output File

```
     Seasonal Kendall Test for Trend
```

```
      US Geological Survey, 2009

Data set:  DO ARK0097 1993-2019

The record is 28 complete water years with  12 seasons per year
   beginning in water year 1993.

The tau correlation coefficient is  0.010
    S =     40.
    z =   0.250
    p =  0.8026
    p =  0.8600 adjusted for correlation among seasons
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =   6.104     +   0.2222E-02 * Time

   where Time = Year (as a decimal) - 1992.75
                                     (beginning of first water year)
```

Attachment 2 DO Saturation Trend Analysis Program Inputs and Output
Station ARK0023 Input File

```
2 0       DO saturation ARK0023 1993-2020
1993 1  64.0
1993 2  81.1
1993 3  82.4
1993 4  98.6
1993 5  59.4
1993 6  49.0
1993 7  72.4
1993 8  78.1
1993 9  75.2
1993 10 101.2
1993 11 87.3
1993 12 36.3
1994 1  68.9
1994 2  81.1
1994 3  77.9
1994 4  91.1
1994 5  101.2
1994 5  103.5
1994 7  72.0
1994 8  72.8
1994 9  81.8
1994 10 75.2
1994 11 91.1
1994 11 89.0
1995 1  82.7
1995 3  89.0
1995 4  93.2
1995 5  66.6
1995 8  78.1
1995 9  78.9
1995 10 109.3
1995 12 77.8
1996 1  45.0
1996 2  113.0
1996 3  61.2
1996 4  61.5
1996 5  45.5
1996 6  55.0
1996 7  46.3
1996 8  79.1
1996 9  90.8
1996 10 81.9
1996 11 53.2
1996 12 72.6
1997 1  73.9
1997 2  61.6
1997 3  52.7
1997 4  47.6
1997 5  53.7
1997 6  59.3
1997 7  60.5
```

1997	8	70.2
1997	9	99.3
1997	10	98.9
1997	11	56.2
1997	12	54.4
1998	1	51.4
1998	2	68.0
1998	5	102.3
1998	6	38.3
1998	8	105.6
1998	9	108.1
1998	10	89.0
1998	11	72.4
1998	12	76.0
1999	2	71.7
1999	3	64.9
1999	4	50.1
1999	5	44.4
1999	6	70.3
1999	7	104.5
1999	9	99.3
1999	11	79.2
1999	12	61.4
2000	1	51.0
2000	2	70.2
2000	3	62.4
2000	4	65.7
2000	5	85.4
2000	6	75.4
2000	7	117.2
2000	8	99.9
2000	9	62.5
2000	10	90.9
2000	11	75.5
2000	12	62.4
2001	1	64.8
2001	2	52.8
2001	3	55.3
2001	4	51.7
2001	5	59.2
2001	6	111.8
2001	7	70.0
2001	8	81.8
2001	9	94.6
2001	10	33.7
2001	11	50.4
2001	12	54.7
2002	1	72.6
2002	2	74.3
2002	3	72.4
2002	4	51.6
2002	6	88.2
2002	7	128.2
2002	8	104.8

2002	10	66.1
2002	11	69.2
2002	12	80.7
2003	1	74.3
2003	2	74.3
2003	3	77.0
2003	4	78.5
2003	5	64.1
2003	6	77.2
2003	6	69.0
2003	8	55.9
2003	9	90.0
2003	10	94.2
2003	11	85.1
2003	12	95.2
2004	1	93.4
2004	2	91.9
2004	3	80.4
2004	4	72.5
2004	5	58.3
2004	6	50.5
2004	7	51.9
2004	8	126.8
2004	9	73.0
2004	10	61.9
2004	11	70.5
2004	11	59.1
2005	2	75.9
2005	3	49.2
2005	4	59.9
2005	5	89.9
2005	5	49.2
2005	7	122.4
2005	8	112.9
2005	9	108.3
2005	11	58.2
2005	12	57.0
2006	1	65.6
2006	1	59.7
2006	3	60.6
2006	4	67.4
2006	5	82.8
2006	6	100.2
2006	7	95.1
2006	8	93.9
2006	10	84.5
2006	11	72.0
2006	12	68.2
2007	1	67.6
2007	2	80.6
2007	3	101.9
2007	4	79.1
2007	5	51.0
2007	6	66.8

2007	7	78.5
2007	8	93.2
2007	9	53.6
2007	10	68.0
2007	11	84.7
2007	12	109.6
2008	1	64.2
2008	2	95.1
2008	3	51.8
2008	4	32.4
2008	5	68.2
2008	6	75.6
2008	7	74.9
2008	8	52.9
2008	9	55.5
2008	10	63.2
2008	11	67.6
2008	12	66.7
2009	1	75.5
2009	2	69.3
2009	3	62.9
2009	4	53.0
2009	5	29.1
2009	6	26.7
2009	7	47.3
2009	8	42.0
2009	9	45.6
2009	10	63.6
2009	11	37.0
2009	12	59.6
2010	1	55.9
2010	2	82.2
2010	3	73.8
2010	4	52.8
2010	5	48.1
2010	6	75.8
2010	7	126.4
2010	8	39.7
2010	9	51.2
2010	10	54.3
2010	11	62.4
2010	11	41.7
2011	1	74.3
2011	2	84.9
2011	3	72.5
2011	4	54.9
2011	5	31.3
2011	6	27.7
2011	7	63.3
2011	8	41.8
2011	9	60.3
2011	10	55.3
2011	11	63.5
2011	12	66.1

2012	1	86.4
2012	2	65.1
2012	3	61.8
2012	4	71.3
2012	5	86.8
2012	6	53.6
2012	7	47.0
2012	8	66.5
2012	9	62.8
2012	10	79.3
2012	11	71.6
2012	12	81.8
2013	1	69.8
2013	2	73.0
2013	3	67.7
2013	4	44.1
2013	5	77.0
2013	6	81.6
2013	7	72.4
2013	8	81.7
2013	9	70.9
2013	10	61.0
2013	11	64.8
2013	12	81.3
2014	1	90.3
2014	2	71.3
2014	3	51.8
2014	4	40.8
2014	5	36.2
2014	6	32.3
2014	7	30.6
2014	8	38.4
2014	9	31.9
2014	10	44.0
2014	11	39.1
2014	12	48.7
2015	1	60.5
2015	2	71.1
2015	3	59.0
2015	4	28.4
2015	5	24.4
2015	6	23.2
2015	7	21.7
2015	8	28.1
2015	9	26.1
2015	10	40.1
2015	11	61.2
2015	12	44.4
2016	1	79.3
2016	2	45.1
2016	3	45.4
2016	4	37.2
2016	5	38.0
2016	6	27.2

```
2016 7  27.7
2016 8  28.8
2016 9  28.4
2016 10 32.4
2016 11 32.9
2016 12 50.1
2017 1  52.8
2017 2  53.9
2017 3  54.7
2017 4  40.1
2017 5  38.9
2017 6  30.9
2017 7  32.4
2017 8  35.3
2017 9  37.6
2017 10 28.6
2017 11 75.2
2017 12 75.3
2018 1  89.3
2018 2  88.8
2018 3  57.9
2018 5  30.7
2018 6  43.6
2018 7  28.4
2018 8  29.2
2018 9  29.9
2018 10 32.5
2018 11 49.0
2019 1  71.6
2019 2  73.0
2019 3  71.0
2019 4  59.7
2019 5  46.9
2019 7  39.8
2019 8  51.8
2019 9  70.2
2019 10 113.8
2019 11 81.2
2019 12 65.6
2020 1  64.8
2020 2  72.2
2020 3  65.8
2020 4  57.3
2020 5  58.3
2020 6  64.9
2020 7  103.5
2020 9  48.8
```

Station ARK0023 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  DO saturation ARK0023 1993-2020
```

```
The record is 28 complete water years with  12 seasons per year
   beginning in water year 1993.

The tau correlation coefficient is -0.256
    S =   -968.
    z =  -6.286
    p =  0.0000
    p =  0.0014 adjusted for correlation among seasons
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =   79.64     +  -0.9889     * Time

   where Time = Year (as a decimal) - 1992.75
                                     (beginning of first water year)
```

Station ARK0050 Input File

```
2 0       DO saturation ARK0050 1993-2020
1993 1  63.4
1993 1  66.4
1993 2  77.4
1993 3  80.4
1993 3  63.4
1993 5  48.5
1993 6  56.0
1993 7  61.1
1993 8  72.8
1993 9  81.4
1993 10 76.6
1993 11 58.0
1993 12 72.6
1994 2  68.1
1994 3  64.9
1994 4  67.8
1994 5  63.8
1994 6  47.7
1994 7  42.7
1994 8  52.3
1994 9  54.2
1994 10 106.5
1994 11 52.7
1994 11 59.2
1995 1  68.1
1995 2  89.3
1995 5  78.4
1995 6  55.2
1995 7  29.4
1995 8  28.6
1995 9  57.0
1995 10 45.7
1995 10 55.3
1995 11 56.7
1996 1  74.0
1996 2  68.4
1996 3  77.1
1996 3  77.9
1996 4  77.0
1996 5  54.9
1996 6  52.4
1996 7  43.1
1996 8  37.5
1996 9  31.0
1996 10 32.1
1996 11 51.0
1996 12 56.6
1997 1  63.5
1997 2  80.4
1997 3  81.6
1997 4  74.0
1997 5  71.0
```

1997	6	63.5
1997	7	37.7
1997	8	89.8
1997	9	95.6
1997	10	71.6
1997	12	64.4
1997	12	96.4
1998	1	85.2
1998	2	82.2
1998	3	96.9
1998	4	76.0
1998	5	81.1
1998	6	50.2
1998	6	52.0
1998	8	52.4
1998	9	46.5
1998	10	51.4
1998	11	48.4
1998	12	40.2
1999	1	79.9
1999	2	94.0
1999	3	99.7
1999	5	35.5
1999	6	42.1
1999	7	45.5
1999	8	40.3
1999	10	92.4
1999	11	81.0
1999	12	49.4
2000	1	53.0
2000	2	43.7
2000	3	47.2
2000	4	47.8
2000	5	89.3
2000	6	52.5
2000	8	73.2
2000	9	73.1
2000	10	65.9
2000	10	65.1
2000	12	76.6
2001	1	82.2
2001	2	77.0
2001	3	99.2
2001	4	62.8
2001	5	70.4
2001	6	113.8
2001	7	99.0
2001	8	91.6
2001	9	94.5
2001	10	74.1
2001	11	83.7
2001	12	71.8
2002	1	73.3
2002	2	83.8

2002	3	77.7
2002	4	89.4
2002	5	51.6
2002	6	94.2
2002	7	84.7
2002	8	75.4
2002	10	80.7
2002	11	77.0
2002	12	72.7
2003	1	73.1
2003	2	76.3
2003	3	91.7
2003	4	79.5
2003	5	64.1
2003	6	62.9
2003	6	112.2
2003	7	79.2
2003	9	78.9
2003	10	114.2
2003	11	117.8
2003	12	83.9
2004	1	68.8
2004	2	79.7
2004	3	67.6
2004	4	40.7
2004	5	64.4
2004	6	93.1
2004	7	78.0
2004	8	73.6
2004	9	81.8
2004	10	36.9
2004	11	53.9
2004	12	86.0
2005	1	74.6
2005	2	84.4
2005	3	86.7
2005	4	67.6
2005	5	52.5
2005	6	98.3
2005	7	38.8
2005	8	69.0
2005	9	73.6
2005	10	71.1
2005	11	49.4
2005	12	71.1
2006	1	68.5
2006	2	90.1
2006	3	83.8
2006	4	50.4
2006	5	59.1
2006	6	62.6
2006	7	69.5
2006	8	55.8
2006	9	85.9

```
2006 10 77.7
2006 11 60.6
2006 12 84.9
2007 1  77.2
2007 2  91.0
2007 3  81.2
2007 4  58.0
2007 5  60.6
2007 6  70.9
2007 7  50.1
2007 8  72.6
2007 9  73.7
2007 10 47.8
2007 11 84.1
2007 12 68.7
2008 1  91.9
2008 2  74.0
2008 3  79.9
2008 4  58.9
2008 5  52.1
2008 6  56.7
2008 7  65.7
2008 8  53.6
2008 9  58.1
2008 10 66.1
2008 11 77.4
2008 12 70.5
2009 1  98.6
2009 2  88.9
2009 3  78.8
2009 4  63.6
2009 5  58.3
2009 6  65.8
2009 7  62.2
2009 8  58.7
2009 9  80.4
2009 10 66.0
2009 11 43.6
2009 12 68.7
2010 1  104.9
2010 2  105.8
2010 3  88.6
2010 4  58.7
2010 5  69.8
2010 6  73.0
2010 7  49.3
2010 8  101.0
2010 9  86.6
2010 10 95.3
2010 11 65.6
2010 12 79.9
2011 1  90.6
2011 2  89.6
2011 3  71.9
```

2011	4	54.0
2011	5	52.9
2011	6	70.9
2011	7	78.3
2011	8	78.7
2011	9	77.9
2011	10	105.9
2011	11	88.2
2011	12	72.5
2012	1	94.9
2012	2	82.9
2012	3	100.9
2012	4	81.9
2012	5	98.3
2012	6	107.8
2012	7	96.9
2012	8	90.3
2012	9	46.2
2012	10	83.2
2012	11	54.6
2012	12	59.1
2013	1	78.5
2013	2	84.3
2013	3	77.0
2013	4	68.3
2013	5	58.3
2013	6	47.9
2013	7	95.0
2013	8	60.8
2013	9	93.7
2013	10	86.5
2013	11	74.7
2013	12	80.4
2014	1	105.5
2014	2	107.2
2014	3	74.5
2014	4	58.7
2014	5	72.6
2014	6	34.8
2014	7	58.7
2014	8	57.3
2014	9	78.7
2014	10	77.0
2014	11	76.6
2014	12	63.0
2015	1	86.5
2015	3	92.3
2015	4	69.5
2015	5	68.7
2015	6	71.6
2015	7	59.8
2015	8	74.2
2015	8	88.5
2015	10	64.5

```
2015 12 60.6
2016 1  93.6
2016 2  116.8
2016 3  61.8
2016 4  66.5
2016 5  49.0
2016 6  63.3
2016 7  68.3
2016 11 94.4
2016 12 76.8
2017 1  82.8
2017 2  74.4
2017 3  87.3
2017 4  50.9
2017 6  53.8
2017 7  69.4
2017 8  57.2
2017 9  49.9
2017 10 68.2
2017 12 78.2
2018 1  89.4
2018 2  84.2
2018 3  66.4
2018 4  63.2
2018 5  54.7
2018 6  74.5
2018 8  74.4
2018 9  59.2
2018 10 78.1
2018 11 77.6
2018 12 79.9
2019 1  83.4
2019 3  85.0
2019 4  88.4
2019 5  65.4
2019 7  73.5
2019 8  80.3
2019 10 64.2
2019 11 83.5
2019 12 87.2
2020 1  74.1
2020 3  87.2
2020 4  100.0
2020 5  59.7
2020 7  93.9
2020 8  64.6
2020 9  66.8
```

Station ARK0050 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  DO saturation ARK0050 1993-2020
```

```
The record is 28 complete water years with  12 seasons per year
   beginning in water year 1993.

The tau correlation coefficient is  0.152
    S =    569.
    z =   3.723
    p =  0.0002
    p =  0.0096 adjusted for correlation among seasons
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =   66.87     +   0.4382     * Time

   where Time = Year (as a decimal) - 1992.75
                                     (beginning of first water year)
```

Station ARK0060 Input File

```
2 0       DO saturation ARK0060 1993-2020
1993 1  68.7
1993 1  73.5
1993 2  83.2
1993 3  83.9
1993 3  71.8
1993 5  65.5
1993 6  40.0
1993 7  31.8
1993 8  26.8
1993 9  35.8
1993 10 33.6
1993 11 38.9
1993 12 82.2
1994 2  79.9
1994 3  71.4
1994 4  77.0
1994 5  68.4
1994 6  52.9
1994 7  30.1
1994 8  35.6
1994 9  44.0
1994 10 65.3
1994 11 34.9
1994 11 6.8
1995 1  83.6
1995 2  89.9
1995 5  38.0
1995 6  25.9
1995 7  32.5
1995 8  31.2
1995 9  36.8
1995 10 35.2
1995 10 24.7
1995 11 30.4
1996 1  81.0
1996 2  67.6
1996 4  75.1
1996 5  59.4
1996 6  45.6
1996 7  33.9
1996 8  20.3
1996 9  21.8
1996 10 40.1
1996 11 28.8
1996 12 71.8
1997 1  69.1
1997 2  75.3
1997 3  83.5
1997 4  75.1
1997 5  60.7
1997 6  70.7
1997 7  26.3
```

1997	8	40.3
1997	9	36.0
1997	10	40.8
1997	12	49.9
1997	12	92.9
1998	1	84.0
1998	2	77.8
1998	3	100.3
1998	4	72.9
1998	5	78.7
1998	6	53.7
1998	6	46.8
1998	8	44.2
1998	9	27.5
1998	10	48.4
1998	11	42.8
1998	12	32.9
1999	1	87.9
1999	2	107.7
1999	3	93.7
1999	5	28.7
1999	6	24.5
1999	7	27.4
1999	8	25.8
1999	10	53.8
1999	11	53.0
1999	12	46.7
2000	1	54.6
2000	2	44.2
2000	3	45.3
2000	4	46.1
2000	5	52.8
2000	6	50.0
2000	8	30.9
2000	9	28.6
2000	10	32.1
2000	10	33.2
2000	12	86.2
2001	1	86.9
2001	2	76.0
2001	3	102.7
2001	4	64.8
2001	5	53.0
2001	6	39.1
2001	7	38.5
2001	8	26.0
2001	9	55.2
2001	10	49.7
2001	11	43.3
2001	12	62.2
2002	1	78.7
2002	2	81.6
2002	3	92.0
2002	4	93.6

2002	5	66.2
2002	6	69.0
2002	7	56.9
2002	8	55.9
2002	10	52.7
2002	11	56.6
2002	12	82.2
2003	1	75.5
2003	2	72.8
2003	3	87.8
2003	4	81.4
2003	5	55.0
2003	6	54.8
2003	6	51.1
2003	7	54.3
2003	9	46.8
2003	10	53.9
2003	11	67.1
2003	12	42.0
2004	1	80.7
2004	2	83.4
2004	3	66.0
2004	4	74.0
2004	4	90.9
2004	5	74.5
2004	6	54.9
2004	7	39.7
2004	8	24.7
2004	9	41.5
2004	10	44.0
2004	11	70.0
2004	12	93.4
2005	1	79.8
2005	2	90.0
2005	3	85.2
2005	4	75.3
2005	5	48.2
2005	6	35.5
2005	7	28.2
2005	8	31.8
2005	9	40.3
2005	10	33.4
2005	11	74.0
2005	12	40.5
2006	1	86.3
2006	2	95.6
2006	3	75.5
2006	4	29.1
2006	5	60.7
2006	11	57.0
2006	12	90.1
2007	1	96.2
2007	2	91.5
2007	3	77.3

2007	4	53.2
2007	5	41.7
2007	6	13.0
2007	11	71.9
2007	12	76.4
2008	1	93.6
2008	2	87.8
2008	3	89.0
2008	4	79.7
2008	5	51.1
2008	6	12.7
2008	8	23.9
2008	9	34.3
2008	10	36.1
2008	11	52.0
2008	12	41.4
2009	1	92.2
2009	2	91.6
2009	3	83.8
2009	4	68.1
2009	5	70.4
2009	6	34.8
2009	7	13.3
2009	8	13.4
2009	9	48.9
2009	10	83.5
2009	11	65.3
2009	12	67.1
2010	1	116.8
2010	2	102.0
2010	3	86.8
2010	4	49.5
2010	5	46.3
2010	6	40.1
2010	7	44.0
2010	8	51.7
2010	9	62.0
2010	10	58.7
2010	11	38.2
2010	12	58.3
2011	1	46.4
2011	2	92.3
2011	3	77.3
2011	4	62.5
2011	5	72.3
2011	6	45.5
2011	7	42.3
2011	8	53.6
2011	9	48.4
2011	10	70.6
2011	11	30.6
2011	12	104.2
2012	1	97.7
2012	2	96.5

2012	3	89.1
2012	4	62.1
2012	5	55.2
2012	6	70.8
2012	7	62.9
2012	8	64.4
2012	9	41.2
2012	10	41.5
2012	11	51.4
2012	12	50.4
2013	1	75.2
2013	2	86.5
2013	3	84.9
2013	4	73.9
2013	5	36.0
2013	6	22.5
2013	7	50.9
2013	8	29.3
2013	10	52.8
2013	12	93.0
2014	1	103.9
2014	2	105.5
2014	3	80.4
2014	4	62.7
2014	5	54.3
2014	6	30.8
2014	7	29.4
2014	8	51.8
2014	9	52.8
2014	10	27.7
2014	11	34.5
2014	12	57.4
2015	1	88.0
2015	3	94.7
2015	4	73.7
2015	5	74.0
2015	7	28.7
2015	8	53.7
2015	8	63.0
2015	10	24.4
2015	12	71.0
2016	1	97.3
2016	2	121.7
2016	3	86.6
2016	4	57.8
2016	5	67.2
2016	6	69.8
2016	7	100.0
2016	11	93.5
2017	1	83.4
2017	2	89.2
2017	3	90.3
2017	4	53.9
2017	5	61.4

```
2017 7  60.8
2017 8  44.4
2017 9  48.8
2017 10 31.2
2017 12 27.5
2018 1  83.0
2018 2  76.4
2018 3  61.3
2018 4  58.1
2018 5  47.1
2018 6  43.5
2018 8  47.4
2018 9  61.1
2018 10 94.2
2018 11 80.9
2018 12 83.7
2019 1  88.9
2019 2  69.9
2019 3  87.8
2019 4  90.1
2019 5  68.0
2019 7  69.7
2019 8  47.6
2019 10 33.2
2019 11 86.8
2019 12 91.0
2020 1  77.7
2020 2  83.5
2020 3  87.2
2020 4  73.2
2020 5  56.7
2020 7  67.2
2020 8  32.8
2020 9  26.9
```

Station ARK0060 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  DO saturation ARK0060 1993-2020

 The record is 28 complete water years with  12 seasons per year
    beginning in water year 1993.

 The tau correlation coefficient is  0.135
     S =    463.
     z =   3.201
     p =  0.0014
     p =  0.0155 adjusted for correlation among seasons
                 (such as serial dependence)
 The adjusted p-value should be used only for data with
    more than 10 annual values per season.

 The estimated trend may be described by the equation:
```

Y =   54.68   +   0.3833   * Time

where Time = Year (as a decimal) - 1992.75
(beginning of first water year)

Station ARK0097 Input File

```
2 0       DO saturation ARK0097 1993-2020
1993 1  71.7
1993 6  62.9
1993 7  84.3
1993 8  42.7
1993 9  83.2
1993 10 58.2
1993 11 60.5
1993 12 55.4
1994 2  65.1
1994 3  71.7
1994 4  71.9
1994 5  66.8
1994 6  54.3
1994 7  64.1
1994 8  75.0
1994 9  56.7
1994 10 55.8
1994 11 52.5
1994 11 64.5
1995 1  67.9
1995 2  87.7
1995 5  85.9
1995 6  86.9
1995 7  50.3
1995 8  46.3
1995 9  76.2
1995 10 48.2
1995 10 58.5
1995 11 58.0
1996 1  89.2
1996 2  87.4
1996 3  77.1
1996 4  84.4
1996 5  59.4
1996 6  55.6
1996 7  61.5
1996 8  50.6
1996 9  45.6
1996 10 69.7
1996 11 55.7
1996 12 53.2
1997 1  56.4
1997 2  77.8
1997 3  87.1
1997 4  61.1
1997 5  58.3
1997 6  50.7
1997 7  55.0
1997 8  62.9
1997 9  64.8
1997 10 71.4
1997 12 51.7
```

1997	12	80.3
1998	1	81.9
1998	2	77.0
1998	3	85.9
1998	4	102.4
1998	5	40.9
1998	6	42.9
1998	6	52.9
1998	8	48.6
1998	9	55.0
1998	10	58.8
1998	11	54.9
1999	1	87.0
1999	2	93.5
1999	3	107.2
1999	5	46.2
1999	6	39.0
1999	7	42.6
1999	8	38.3
1999	10	70.7
1999	11	52.9
1999	12	53.4
2000	1	58.6
2000	2	42.1
2000	3	42.7
2000	4	47.6
2000	5	51.9
2000	6	51.9
2000	8	45.4
2000	9	44.0
2000	10	70.3
2000	10	68.0
2000	12	73.7
2001	1	82.2
2001	2	75.3
2001	3	74.4
2001	4	67.2
2001	5	70.1
2001	6	90.2
2001	7	63.1
2001	9	72.8
2001	10	62.8
2001	11	67.1
2001	12	60.4
2002	1	79.4
2002	2	85.6
2002	3	71.0
2002	4	69.8
2002	5	53.8
2002	6	61.3
2002	7	95.3
2002	8	91.1
2002	10	77.0
2002	11	76.2

2002	12	76.1
2003	1	78.7
2003	2	81.5
2003	3	87.4
2003	4	70.5
2003	5	63.0
2003	6	57.0
2003	6	64.1
2003	7	51.1
2003	9	47.7
2003	10	88.6
2003	11	94.9
2003	12	67.5
2004	1	68.4
2004	2	72.8
2004	3	66.2
2004	4	41.8
2004	5	56.1
2004	6	66.7
2004	7	59.7
2004	8	74.0
2004	9	54.2
2004	10	33.6
2004	11	44.4
2004	12	72.1
2005	1	56.6
2005	2	81.1
2005	3	83.8
2005	4	52.7
2005	5	40.8
2005	6	34.9
2005	7	43.8
2005	8	53.6
2005	9	55.7
2005	10	53.8
2005	11	60.7
2005	12	58.2
2006	1	67.1
2006	2	87.5
2006	3	78.2
2006	4	36.6
2006	5	83.1
2006	6	40.4
2006	7	50.5
2006	8	43.6
2006	9	52.5
2006	10	51.0
2006	11	56.9
2006	12	86.9
2007	1	70.2
2007	2	86.4
2007	3	71.1
2007	4	34.9
2007	5	51.3

```
2007 6  42.0
2007 7  53.8
2007 8  44.2
2007 9  50.8
2007 10 57.6
2007 11 71.5
2007 12 76.5
2008 1  89.0
2008 2  64.2
2008 3  68.7
2008 4  59.4
2008 5  39.2
2008 6  32.5
2008 7  40.6
2008 8  58.8
2008 9  45.7
2008 10 55.3
2008 11 72.4
2008 12 59.0
2009 1  92.5
2009 2  81.4
2009 3  79.1
2009 4  47.8
2009 5  49.1
2009 6  39.9
2009 7  58.1
2009 8  38.7
2009 9  65.3
2009 10 72.5
2009 11 62.5
2009 12 66.4
2010 1  98.7
2010 2  98.7
2010 3  80.8
2010 4  60.2
2010 5  43.7
2010 6  89.7
2010 7  54.0
2010 8  41.0
2010 9  74.1
2010 10 83.0
2010 11 54.0
2010 12 78.2
2011 1  94.2
2011 2  67.3
2011 3  71.9
2011 4  47.1
2011 5  48.9
2011 6  41.3
2011 7  30.0
2011 8  43.6
2011 9  43.2
2011 10 72.3
2011 11 45.4
```

2011	12	89.1
2012	1	89.8
2012	2	78.0
2012	3	87.8
2012	4	70.4
2012	5	65.2
2012	6	58.1
2012	7	51.3
2012	8	85.1
2012	9	42.4
2012	10	79.3
2012	11	64.9
2012	12	114.4
2013	1	78.7
2013	2	87.3
2013	3	75.0
2013	4	66.3
2013	5	52.2
2013	6	41.7
2013	7	60.0
2013	8	47.5
2013	9	81.2
2013	10	72.9
2013	11	75.5
2013	12	106.0
2014	1	107.7
2014	2	106.5
2014	3	87.1
2014	4	51.3
2014	5	44.9
2014	6	29.4
2014	7	48.1
2014	8	58.5
2014	9	50.5
2014	10	53.3
2014	11	69.9
2014	12	61.2
2015	1	89.2
2015	3	93.3
2015	4	60.3
2015	5	56.6
2015	6	67.9
2015	7	71.2
2015	8	55.6
2015	8	62.5
2015	10	57.4
2015	11	68.4
2015	12	58.7
2016	1	93.0
2016	2	108.9
2016	3	81.3
2016	4	61.6
2016	5	61.7
2016	6	47.8

```
2016 7  43.8
2016 9  43.1
2016 11 64.5
2016 12 78.1
2017 1  79.7
2017 2  81.8
2017 4  57.0
2017 5  44.4
2017 6  57.3
2017 7  70.2
2017 8  66.8
2017 9  48.4
2017 10 82.2
2017 12 71.3
2018 1  78.3
2018 2  82.5
2018 3  82.2
2018 4  60.5
2018 5  84.9
2018 6  51.4
2018 8  67.9
2018 9  54.1
2018 10 66.4
2018 11 71.5
2018 12 81.5
2019 1  76.7
2019 2  65.1
2019 3  74.9
2019 4  76.4
2019 5  52.1
2019 7  78.0
2019 8  47.6
2019 10 59.8
2019 11 81.4
2019 12 76.2
2020 1  70.0
2020 2  84.0
2020 3  85.7
2020 4  64.8
2020 5  52.0
2020 6  64.3
2020 7  48.0
2020 8  58.6
2020 9  62.9
```

Station ARK0097 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  DO saturation ARK0097 1993-2020

 The record is 28 complete water years with  12 seasons per year
    beginning in water year 1993.
```

```
The tau correlation coefficient is  0.055
    S =    206.
    z =   1.345
    p =  0.1785
    p =  0.3248 adjusted for correlation among seasons
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =   62.43     +   0.1333     * Time

   where Time = Year (as a decimal) - 1992.75
                                     (beginning of first water year)
```

Attachment 3 BOD Trend Analysis Program Input and Output
Station ARK0050 Input File

```
2 0       BOD ARK0050 2001-2020
2001 1  1.77
2001 2  3.535
2001 3  1.08
2001 4  1.77
2001 5  2.01
2001 6  1.35
2001 7  2.5
2001 8  1.33
2001 9  1.37
2001 10 1.48
2001 11 0.71
2001 12 1.66
2002 1  0.34
2002 2  1.18
2002 3  1.34
2002 4  1.32
2002 5  2.47
2002 6  1.38
2002 8  1.1
2002 9  1.12
2002 10 1.91
2002 11 2.61
2002 12 1.22
2003 1  1.23
2003 2  1.37
2003 3  1.05
2003 4  1.16
2003 5  1.38
2003 6  3.05
2003 6  0.93
2003 7  2.10
2003 9  2.09
2003 10 0.65
2003 11 1.43
2003 12 0.91
2004 1  1.96
2004 2  1.61
2004 3  1.49
2004 4  1.67
2004 5  1.43
2004 6  1.51
2004 7  1.56
2004 8  2.10
2004 9  7.25
2004 10 2.01
2004 11 2.31
2004 12 0.99
2005 1  1.89
2005 2  0.56
2005 3  0.99
2005 4  2.93
```

2005	5	1.09
2005	6	1.39
2005	7	2.53
2005	8	1.01
2005	9	0.72
2005	10	0.68
2005	11	2.91
2005	12	1.51
2006	1	2.13
2006	2	0.85
2006	4	2.22
2006	5	1.56
2006	6	1.50
2006	7	1.15
2006	8	1.21
2006	9	0.89
2006	10	2.15
2006	11	2.16
2006	12	1.18
2007	1	0.88
2007	2	0.52
2007	3	1.50
2007	4	2.45
2007	5	1.18
2007	6	1.90
2007	7	1.62
2007	8	0.86
2007	9	1.17
2007	10	2.38
2007	11	0.93
2007	12	1.19
2008	1	0.78
2008	2	1.55
2008	3	0.78
2008	4	1.53
2008	5	2.34
2008	6	2.49
2008	7	1.60
2008	8	1.32
2008	9	1.95
2008	10	0.51
2008	11	3.37
2008	12	0.72
2009	1	0.82
2009	2	1.14
2009	4	2.90
2009	5	1.57
2009	6	1.26
2009	7	2.35
2009	8	2.03
2009	9	1.12
2009	10	1.32
2009	11	1.33
2009	12	1.54

2010	1	0.89
2010	2	1.50
2010	3	2.51
2010	4	2.56
2010	5	1.48
2010	6	1.22
2010	7	2.77
2010	8	3.16
2010	9	1.14
2010	10	0.74
2010	11	1.77
2010	12	1.18
2011	1	3.06
2011	2	1.37
2011	3	1.53
2011	4	2.42
2011	5	2.46
2011	6	8.42
2011	7	1.66
2011	8	0.91
2011	10	0.9
2011	11	5.08
2011	12	1.00
2012	1	0.56
2012	2	0.88
2012	3	1.6
2012	4	1.12
2012	5	1.25
2012	6	7.88
2012	7	1.28
2012	8	0.74
2012	9	2.92
2012	10	1.38
2012	11	2.82
2012	12	1.93
2013	1	0.8
2013	2	1.08
2013	3	1.2
2013	5	1.98
2013	6	1.24
2013	7	0.92
2013	8	3.08
2013	9	0.57
2013	10	1.89
2013	11	1.44
2013	12	1.57
2014	1	0.99
2014	2	1.46
2014	3	1.97
2014	4	1.63
2014	5	1.87
2014	6	1.81
2014	7	1.48
2014	8	2.33

2014	9	0.83
2014	10	0.93
2014	11	1.17
2014	12	2.24
2015	1	1.17
2015	3	2.24
2015	5	2.34
2015	6	1.63
2015	7	1.63
2015	8	1.34
2015	8	1.78
2015	10	0.8
2015	12	2.11
2016	1	0.79
2016	2	1.57
2016	3	1.28
2016	5	1.74
2016	6	0.85
2016	10	1.19
2016	11	2.84
2016	12	1.78
2017	1	1.95
2017	2	2.23
2017	4	1.56
2017	5	2.14
2017	6	2.27
2017	7	1.59
2017	8	3.43
2017	9	3.52
2017	10	1.83
2017	12	1.47
2018	1	2.53
2018	2	2.06
2018	3	2.44
2018	4	1.88
2018	5	2.51
2018	6	2.55
2018	8	2.25
2018	9	1.84
2018	10	1.40
2018	11	0.94
2018	12	1.43
2019	1	0.95
2019	3	2.04
2019	4	1.59
2019	5	1.95
2019	7	2.04
2019	8	2.25
2019	10	1.76
2019	11	3.01
2019	12	1.40
2020	1	6.13
2020	3	1.34
2020	4	2.74

```
2020 5  1.73
2020 7  2.54
2020 8  1.18
2020 9  2.66
```

Station ARK0050 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  BOD ARK0050 2001-2020

 The record is 20 complete water years with  12 seasons per year
    beginning in water year 2001.

 The tau correlation coefficient is  0.143
     S =    262.
     z =   2.854
     p =  0.0043
     p =  0.0163 adjusted for correlation among seasons
                 (such as serial dependence)
 The adjusted p-value should be used only for data with
    more than 10 annual values per season.

 The estimated trend may be described by the equation:

    Y =   1.316     +   0.2343E-01 * Time

    where Time = Year (as a decimal) - 2000.75
                                       (beginning of first water year)
```

Attachment 4 TDS Trend Analysis Program Inputs and Output

Station ARK0023 Input File

```
2 0       TDS ARK0023 1993-2020
1993 1  107
1993 2  129
1993 3  136
1993 4  138
1993 5  115
1993 6  190
1993 7  100
1993 8  326
1993 9  279
1993 10 182
1993 11 152
1993 12 88
1994 1  124
1994 2  91
1994 3  118
1994 4  141
1994 5  144
1994 5  110
1994 7  202
1994 8  138
1994 9  182
1994 10 143
1994 11 165
1994 11 114
1995 1  106
1995 1  154
1995 3  123
1995 4  113
1995 5  126
1995 6  154
1995 7  148
1995 8  290
1995 9  265
1995 10 274
1995 11 260
1995 12 369
1996 1  151
1996 2  183
1996 3  161
1996 4  157
1996 5  114
1996 6  133
1996 7  145
1996 8  224
1996 9  182
1996 10 135
1996 11 132
1996 12 93
1997 1  126
1997 2  138
1997 3  102
```

1997	4	105
1997	5	113
1997	6	133
1997	7	230
1997	8	231
1997	9	255
1997	10	151
1997	11	141
1997	12	147
1998	1	113
1998	2	141
1998	3	135
1998	4	147
1998	5	146
1998	6	204
1998	7	334
1998	8	353
1998	9	244
1998	10	236
1998	11	266
1998	12	148
1999	1	149
1999	2	120.5
1999	3	163
1999	4	123
1999	5	145
1999	6	191
1999	7	237
1999	8	361
1999	9	371
1999	10	282.5
1999	11	260.5
1999	12	179
2000	1	157
2000	2	168
2000	3	177
2000	4	134
2000	5	166.5
2000	7	184
2000	8	258
2000	9	356.5
2000	10	397
2000	11	410.5
2000	12	103.5
2001	1	123
2001	2	129.5
2001	3	115.5
2001	4	144.5
2001	5	149.5
2001	6	187.5
2001	7	324
2001	8	274.5
2001	9	284.5
2001	10	167

2001	11	162.5
2001	12	92
2002	1	76.5
2002	2	100
2002	3	114
2002	4	93
2002	5	125
2002	7	159
2002	8	257
2002	9	264
2002	10	174
2002	11	149
2002	12	126
2003	1	115
2003	2	171
2003	3	104
2003	4	106
2003	5	162
2003	6	99.5
2003	6	138
2003	8	293
2003	9	319
2003	10	301
2003	11	344
2003	12	221
2004	1	123
2004	2	160
2004	3	153
2004	4	128
2004	5	111
2004	6	196
2004	7	187
2004	8	278
2004	9	243
2004	10	127
2004	11	113
2004	11	99
2005	1	111
2005	2	105
2005	3	127
2005	4	111
2005	5	117
2005	5	121
2005	7	266
2005	8	271
2005	9	350
2005	10	135
2005	11	136
2005	12	273
2006	1	306
2006	1	144
2006	3	168
2006	4	120
2006	5	103

2006	6	133
2006	7	369
2006	8	269
2006	9	299
2006	10	194
2006	11	213
2006	12	145
2007	1	114
2007	2	136
2007	3	133
2007	4	129
2007	5	137
2007	6	270
2007	7	161
2007	8	232
2007	9	149
2007	10	130
2007	11	134
2007	12	127
2008	1	128
2008	2	252
2008	3	117
2008	4	103
2008	5	109
2008	6	110
2008	7	253
2008	8	179
2008	9	105
2008	10	133
2008	11	124
2008	12	174
2009	1	150
2009	2	133
2009	3	131
2009	4	158
2009	5	107
2009	6	107
2009	7	239
2009	8	117
2009	9	132
2009	10	99
2009	11	77
2009	12	80
2010	1	100
2010	2	104
2010	3	116
2010	4	106
2010	5	152
2010	6	87
2010	7	273
2010	8	194
2010	9	245
2010	10	286
2010	11	245

2010	11	255
2011	1	142
2011	2	149
2011	3	154
2011	4	299
2011	5	32
2011	6	77
2011	7	200
2011	8	249
2011	9	242
2011	10	170
2011	11	104
2011	12	81
2012	1	100
2012	2	124
2012	3	112
2012	4	135
2012	5	220
2012	6	214
2012	7	252
2012	8	373
2012	9	138
2012	10	155
2012	11	141
2012	12	146
2013	1	91
2013	2	131
2013	3	134
2013	4	123
2013	5	159
2013	6	117
2013	7	402
2013	8	311
2013	9	403
2013	10	176
2013	11	170
2013	12	160
2014	1	127
2014	2	127
2014	3	149
2014	4	157
2014	5	138
2014	6	121
2014	7	171
2014	8	164
2014	9	244
2014	10	228
2014	11	204
2014	12	151
2015	1	129
2015	3	154
2015	4	120
2015	5	110
2015	6	114

2015	7	210
2015	8	363
2015	9	365
2015	10	295
2015	11	110
2015	12	97
2016	1	173
2016	2	142
2016	3	80
2016	4	90
2016	5	133
2016	6	138
2016	7	270
2016	8	325
2016	9	176
2016	10	204
2016	11	160
2016	12	220
2017	1	181
2017	2	263
2017	3	135
2017	4	157
2017	5	179
2017	6	105
2017	7	153
2017	8	242
2017	9	121
2017	10	168
2017	11	272
2017	12	370
2018	1	119
2018	2	228
2018	3	82
2018	5	124
2018	6	175
2018	7	188
2018	8	158
2018	9	164
2018	10	134
2018	11	102
2019	1	110
2019	2	106
2019	3	110
2019	4	128
2019	5	87
2019	7	118
2019	8	126
2019	9	164
2019	10	191
2019	11	133
2019	12	107
2020	1	99.5
2020	2	96.5
2020	3	113

```
2020 4  102
2020 5  122
2020 6  114
2020 7  236
2020 8  225
2020 9  150
2020 10 133
2020 11 122
```

Station ARK0023 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  TDS ARK0023 1993-2020

 The record is 29 complete water years with  12 seasons per year
    beginning in water year 1993.

 The tau correlation coefficient is -0.098
     S =    -409.
     z =  -2.473
     p =  0.0134
     p =  0.1249 adjusted for correlation among seasons
                 (such as serial dependence)
 The adjusted p-value should be used only for data with
    more than 10 annual values per season.

 The estimated trend may be described by the equation:

    Y =   156.0     +  -0.6193     * Time

    where Time = Year (as a decimal) - 1992.75
                                  (beginning of first water year)
```

Station ARK0050 Input File

```
2 0       TDS ARK0050 1993-2020
1993 1  68
1993 1  57
1993 2  53
1993 3  40
1993 3  47
1993 5  49
1993 6  76
1993 7  183
1993 8  221
1993 9  236
1993 10 226
1993 11 118
1993 12 54
1994 2  60
1994 3  55
1994 4  57
1994 5  70
1994 6  112
1994 7  145
1994 8  85
1994 9  105
1994 10 183
1994 11 81
1995 1  60
1995 2  62
1995 3  67
1995 4  58
1995 5  112
1995 6  113
1995 7  135
1995 8  138
1995 9  206
1995 10 129
1995 10 128
1995 11 125
1996 1  77
1996 2  90
1996 3  47
1996 3  72
1996 4  63
1996 5  72
1996 6  84
1996 7  107
1996 8  175
1996 9  202
1996 10 164
1996 11 84
1996 12 58
1997 1  59
1997 2  45
1997 4  61
1997 5  79
```

1997	6	60
1997	7	104
1997	8	128
1997	9	209
1997	10	99
1997	12	87
1997	12	62
1998	1	63
1998	2	72
1998	3	58
1998	4	81
1998	5	187
1998	6	133
1998	6	248
1998	8	164
1998	9	225
1998	10	87
1998	11	149
1998	12	112
1999	1	57
1999	2	52
1999	3	77.5
1999	4	60
1999	5	89
1999	6	129
1999	7	186
1999	8	239
1999	9	249
1999	10	58
1999	11	203.5
1999	12	70
2000	1	110.5
2000	2	66
2000	3	65
2000	4	83.5
2000	5	103
2000	6	90
2000	7	232
2000	8	263
2000	9	264
2000	10	232
2000	10	243
2000	12	57.5
2001	1	60
2001	2	82
2001	3	50.5
2001	4	71
2001	5	181
2001	6	217.5
2001	7	175
2001	8	120
2001	9	131
2001	10	138
2001	11	202.5

2001	12	37.5
2002	1	61
2002	2	62
2002	3	52.5
2002	4	71.5
2002	5	59
2002	7	166
2002	8	180
2002	9	224
2002	10	117
2002	11	126
2002	12	53
2003	1	61.5
2003	2	62.5
2003	3	64.5
2003	4	73.5
2003	5	85
2003	6	121
2003	6	111
2003	7	178
2003	9	200
2003	10	241
2003	11	232
2003	12	95
2004	1	71
2004	2	61.5
2004	3	86
2004	4	71
2004	5	66.5
2004	6	108
2004	7	153
2004	8	123
2004	9	217
2004	10	69.5
2004	11	76
2004	12	67.5
2005	1	47.5
2005	2	64
2005	3	79.5
2005	4	44
2005	5	152
2005	6	203
2005	7	67
2005	8	234
2005	9	210
2005	10	208
2005	11	65
2005	12	145
2006	1	70.5
2006	2	69.5
2006	3	87
2006	4	131
2006	5	115
2006	6	170

2006	7	189
2006	8	163
2006	9	198
2006	10	198
2006	11	84.5
2006	12	62.5
2007	1	46.5
2007	2	61
2007	3	79
2007	4	91.5
2007	5	95
2007	6	95
2007	7	210
2007	8	183
2007	9	140
2007	10	88.5
2007	11	176
2007	12	61.5
2008	1	66
2008	2	56
2008	3	53
2008	4	56
2008	5	82
2008	6	120
2008	7	118
2008	8	100
2008	9	135
2008	10	130
2008	11	108
2008	12	112
2009	1	68
2009	2	61.5
2009	3	61
2009	4	60
2009	5	56
2009	6	230
2009	7	96
2009	8	100
2009	9	167
2009	10	60.5
2009	11	37
2009	12	69
2010	1	56
2010	2	48
2010	3	80
2010	4	92
2010	5	83
2010	6	162
2010	7	129
2010	8	226
2010	9	237
2010	10	279
2010	11	183
2010	12	138

2011	1	98
2011	2	74
2011	3	70
2011	4	79
2011	5	58
2011	6	140
2011	7	183
2011	8	250
2011	9	214
2011	10	243
2011	11	202
2011	12	50
2012	1	59
2012	2	51
2012	3	88
2012	4	98
2012	5	286
2012	6	160
2012	7	269
2012	8	264
2012	9	171
2012	10	161
2012	11	82
2012	12	133
2013	1	62
2013	2	62
2013	3	60
2013	4	55
2013	5	93
2013	6	130
2013	7	211
2013	8	80
2013	9	230
2013	10	121
2013	11	130
2013	12	109
2014	1	96
2014	2	81
2014	3	56
2014	4	70
2014	5	174
2014	6	72
2014	7	84
2014	8	52
2014	9	204
2014	10	132
2014	11	105
2014	12	82
2015	1	67
2015	3	57
2015	4	66
2015	5	60
2015	6	61
2015	7	94

2015	8	188
2015	8	221
2015	10	246
2015	12	54
2016	1	45
2016	2	63
2016	3	69
2016	4	74
2016	5	50
2016	6	158
2016	7	23
2016	10	300
2016	11	243
2016	12	132
2017	1	89
2017	2	53
2017	3	64
2017	4	58
2017	5	57
2017	6	89
2017	7	97
2017	8	172
2017	9	132
2017	10	272
2017	12	200
2018	1	84
2018	2	78
2018	3	94
2018	4	47.5
2018	5	124
2018	6	128
2018	8	146
2018	9	78.5
2018	10	58.5
2018	11	66
2018	12	53.5
2019	1	69.5
2019	3	64
2019	4	79.5
2019	5	59.5
2019	7	68
2019	8	134
2019	10	91.5
2019	11	61
2019	12	66.5
2020	1	68.5
2020	3	61.5
2020	4	63.5
2020	5	66.5
2020	7	125
2020	8	180
2020	9	190

Station ARK0050 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

Data set:  TDS ARK0050 1993-2020

The record is 28 complete water years with  12 seasons per year
   beginning in water year 1993.

The tau correlation coefficient is  0.014
    S =     54.
    z =   0.338
    p =  0.7356
    p =  0.8041 adjusted for correlation among seasons
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =   87.72     +   0.5556E-01 * Time

   where Time = Year (as a decimal) - 1992.75
                                     (beginning of first water year)
```

Station ARK0060 Input File

```
2 0       TDS ARK0060 1993-2020
1993 1  44
1993 1  59
1993 2  37
1993 3  47
1993 3  28
1993 5  44
1993 6  62
1993 7  63
1993 8  70
1993 9  77
1993 10 71
1993 11 48
1993 12 52
1994 2  45
1994 3  37
1994 4  39
1994 5  54
1994 6  61
1994 7  58
1994 8  50
1994 9  58
1994 10 78
1994 11 57
1995 1  45
1995 2  38
1995 3  62
1995 4  54
1995 5  56
1995 6  60
1995 7  63
1995 8  93
1995 9  84
1995 10 58
1995 10 48
1995 11 58
1996 1  52
1996 2  40
1996 4  42
1996 5  71
1996 6  47
1996 7  61
1996 8  60
1996 9  65
1996 10 47
1996 11 81
1996 12 47
1997 1  42
1997 2  56
1997 4  44
1997 5  50
1997 6  59
1997 7  75
```

1997	8	67
1997	9	69
1997	10	63
1997	12	61
1997	12	49
1998	1	49
1998	2	44
1998	3	49
1998	4	41
1998	5	61
1998	6	65
1998	6	76
1998	8	53
1998	9	65
1998	10	61
1998	11	46
1998	12	53
1999	1	48
1999	2	41
1999	3	38.5
1999	4	42
1999	5	51
1999	6	60
1999	7	59
1999	8	60
1999	9	64
1999	10	247
1999	11	44.5
1999	12	52.5
2000	1	50
2000	2	53.5
2000	3	66
2000	4	42.5
2000	5	58
2000	6	56
2000	7	68
2000	8	78
2000	9	79
2000	10	83
2000	10	82
2000	12	40
2001	1	59
2001	2	44.5
2001	3	40.5
2001	4	39
2001	5	60
2001	6	60.5
2001	7	91.5
2001	8	52.5
2001	9	42.5
2001	10	61
2001	11	344.5
2001	12	36
2002	1	50

2002	2	41
2002	3	54
2002	4	46.5
2002	5	55
2002	7	72
2002	8	56
2002	9	56
2002	10	50
2002	11	56
2002	12	38
2003	1	41
2003	2	46
2003	3	40
2003	4	48
2003	5	56.5
2003	6	51.5
2003	6	63.5
2003	7	73.5
2003	9	69
2003	10	54.5
2003	11	59.5
2003	12	58.5
2004	1	61.5
2004	2	39.5
2004	3	68.5
2004	4	77
2004	4	214
2004	5	55.5
2004	6	59
2004	7	74
2004	8	62
2004	9	56
2004	10	56.5
2004	11	66.5
2004	12	59.5
2005	1	44
2005	2	50.5
2005	3	37
2005	4	43.5
2005	5	56.5
2005	6	65.5
2005	7	45
2005	8	64
2005	9	57.5
2005	10	66.5
2005	11	165
2005	12	58.5
2006	1	53
2006	2	48
2006	3	53
2006	4	56
2006	5	47.5
2006	11	67
2006	12	39.5

2007	1	43
2007	2	38.5
2007	3	50
2007	4	56
2007	5	47
2007	6	68
2007	11	49.5
2007	12	42.5
2008	1	32
2008	2	49
2008	3	39
2008	4	43
2008	5	51
2008	6	57
2008	8	43
2008	9	62
2008	10	50
2008	11	57
2008	12	56
2009	1	41.5
2009	2	40
2009	3	47
2009	4	56.5
2009	5	52
2009	6	63
2009	7	72
2009	8	66.5
2009	9	50
2009	10	53
2009	11	33.5
2009	12	51
2010	1	40
2010	2	36
2010	3	39
2010	4	70
2010	5	65
2010	6	45
2010	7	54
2010	8	66
2010	9	65.5
2010	10	55
2010	11	52
2010	12	32
2011	1	55
2011	2	53
2011	3	51
2011	4	70
2011	5	43
2011	6	62
2011	7	56
2011	8	61
2011	9	54
2011	10	44
2011	11	51

2011	12	29
2012	1	41
2012	2	37
2012	3	34
2012	4	47
2012	5	65
2012	6	65
2012	7	63
2012	8	72
2012	9	69
2012	10	54
2012	11	51
2012	12	49
2013	1	44
2013	2	46
2013	3	44
2013	4	35
2013	5	52
2013	6	53
2013	8	50
2013	10	55
2013	12	63
2014	1	42
2014	2	48
2014	3	48
2014	4	42
2014	5	41
2014	6	44
2014	7	53
2014	8	46
2014	9	55
2014	10	59
2014	11	45
2014	12	66
2015	1	43
2015	3	43
2015	4	61
2015	5	53
2015	7	53
2015	8	71
2015	8	62
2015	10	58
2015	12	47
2016	1	35
2016	2	34
2016	3	37
2016	4	44
2016	5	43
2016	6	52
2016	7	6
2016	10	255
2016	11	51
2017	1	40
2017	2	50

```
2017 3  42
2017 4  44
2017 5  45
2017 7  48
2017 8  154
2017 9  122
2017 10 56
2017 12 56
2018 1  58
2018 2  46
2018 3  40
2018 4  54.5
2018 5  122
2018 6  39.5
2018 8  52.5
2018 9  57.5
2018 10 59
2018 11 50
2018 12 48
2019 1  39
2019 2  40.5
2019 3  46
2019 4  45
2019 5  44
2019 7  32
2019 8  58.5
2019 10 49
2019 11 56.5
2019 12 46
2020 1  46
2020 2  40
2020 3  38.5
2020 4  30.5
2020 5  43
2020 7  62
2020 8  47.5
2020 9  56
```

Station ARK0060 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  TDS ARK0060 1993-2020

 The record is 28 complete water years with  12 seasons per year
    beginning in water year 1993.

 The tau correlation coefficient is -0.136
     S =   -482.
     z =  -3.276
     p =  0.0011
     p =  0.0159 adjusted for correlation among seasons
                 (such as serial dependence)
 The adjusted p-value should be used only for data with
```

more than 10 annual values per season.

The estimated trend may be described by the equation:

Y = 56.25 + -0.2500 * Time

where Time = Year (as a decimal) - 1992.75
(beginning of first water year)

Station ARK0097 Input File

```
2 0       TDS ARK0097 1993-2020
1993 1  107
1993 6  140
1993 7  179
1993 8  178
1993 9  251
1993 10 254
1993 11 291
1993 12 96
1994 2  88
1994 3  96
1994 4  74
1994 5  114
1994 6  147
1994 7  134
1994 8  151
1994 9  187
1994 10 187
1994 11 111
1995 1  74
1995 2  158
1995 3  132
1995 4  86
1995 5  173
1995 6  172
1995 7  170
1995 8  170
1995 9  238
1995 10 193
1995 10 260
1995 11 228
1996 1  127
1996 2  165
1996 3  151
1996 4  127
1996 5  177
1996 6  132
1996 7  279
1996 8  232
1996 9  176
1996 10 158
1996 11 111
1996 12 81
1997 1  95
1997 2  82
1997 4  86
1997 5  146
1997 6  106
1997 7  178
1997 8  189
1997 9  266
1997 10 175
1997 12 169
```

1997	12	108
1998	1	100
1998	2	133
1998	3	121
1998	4	136
1998	5	207
1998	6	198
1998	6	238
1998	8	147
1998	9	230
1998	10	166
1998	11	218
1998	12	192
1999	1	106
1999	2	92
1999	3	142.5
1999	4	85
1999	5	108.5
1999	6	175
1999	7	161
1999	8	186
1999	9	228
1999	10	373
1999	11	288
1999	12	106.5
2000	1	192.5
2000	2	119
2000	3	166
2000	4	159
2000	5	173
2000	6	179.5
2000	7	236
2000	8	227
2000	9	236
2000	10	315
2000	10	376
2000	12	80
2001	1	145
2001	2	94.5
2001	3	77
2001	4	102
2001	5	241
2001	6	186.5
2001	7	183
2001	8	156
2001	9	307
2001	10	185
2001	11	307.5
2001	12	64
2002	1	93
2002	2	126
2002	3	70
2002	4	122
2002	5	138

2002	7	189.5
2002	8	243
2002	9	215
2002	10	160
2002	11	183
2002	12	94
2003	1	134
2003	2	148
2003	3	106
2003	4	158
2003	5	157
2003	6	162
2003	6	96
2003	7	216
2003	9	191
2003	10	239
2003	11	288
2003	12	121
2004	1	122
2004	2	119
2004	3	165
2004	4	111
2004	5	127
2004	6	164
2004	7	155
2004	8	150
2004	9	173
2004	10	125
2004	11	112
2004	12	81
2005	1	109
2005	2	124
2005	3	132
2005	4	108
2005	5	202
2005	6	222
2005	7	281
2005	8	269
2005	9	222
2005	10	178
2005	11	245
2005	12	250
2006	1	113
2006	2	125
2006	3	153
2006	4	177
2006	5	145
2006	6	173
2006	7	221
2006	8	213
2006	9	305
2006	10	205
2006	11	211
2006	12	136

2007	1	68
2007	2	125
2007	3	154
2007	4	267
2007	5	140
2007	6	211
2007	7	121
2007	8	172
2007	9	194
2007	10	206
2007	11	296
2007	12	127
2008	1	164
2008	2	168
2008	3	119
2008	4	73
2008	5	172
2008	6	173
2008	7	321
2008	8	237
2008	9	403
2008	10	233
2008	11	602
2008	12	191
2009	1	120
2009	2	105
2009	3	85
2009	4	128
2009	5	95.5
2009	6	300
2009	7	151
2009	8	142
2009	9	248
2009	10	81
2009	11	44
2009	12	129
2010	1	115
2010	2	61
2010	3	84
2010	4	127
2010	5	115
2010	6	181
2010	7	317
2010	8	224
2010	9	215
2010	10	282
2010	11	264
2010	12	114
2011	1	164
2011	2	116
2011	3	128
2011	4	155
2011	5	96
2011	6	186

2011	7	163
2011	8	252
2011	9	179
2011	10	278
2011	11	159
2011	12	37
2012	1	104
2012	2	85
2012	3	126
2012	4	136
2012	5	327
2012	6	139
2012	7	293
2012	8	311
2012	9	157
2012	10	179
2012	11	214
2012	12	225
2013	1	108
2013	2	101
2013	3	129
2013	4	76
2013	5	103
2013	6	173
2013	7	227
2013	8	156
2013	9	284
2013	10	190
2013	11	202
2013	12	153
2014	1	116
2014	2	128
2014	3	128
2014	4	84
2014	5	156
2014	6	93
2014	7	168
2014	8	254
2014	9	241
2014	10	145
2014	11	161
2014	12	167
2015	1	123
2015	3	123
2015	4	151
2015	5	85
2015	6	78
2015	7	111
2015	8	309
2015	8	271
2015	10	347
2015	11	74
2015	12	125
2016	1	76

2016	2	110
2016	3	82
2016	4	94
2016	5	61
2016	6	167
2016	7	20
2016	8	148
2016	9	260
2016	10	260
2016	11	47
2016	12	174
2017	1	153
2017	2	164
2017	4	129
2017	5	146
2017	6	122
2017	7	95
2017	8	226
2017	9	155
2017	10	284
2017	12	220
2018	1	194
2018	2	150
2018	3	131
2018	4	110
2018	5	149
2018	6	164
2018	8	225
2018	9	99
2018	10	106
2018	11	85.5
2018	12	94.5
2019	1	76.5
2019	2	63.5
2019	3	95.5
2019	4	106
2019	5	74
2019	7	124
2019	8	148
2019	10	141
2019	11	116
2019	12	116
2020	1	95.5
2020	2	95.5
2020	3	95
2020	4	81
2020	5	90
2020	6	130
2020	7	151
2020	8	233
2020	9	215

Station ARK0097 Output File

```
    Seasonal Kendall Test for Trend
      US Geological Survey, 2009

Data set:  TDS ARK0097 1993-2020

The record is 28 complete water years with  12 seasons per year
   beginning in water year 1993.

The tau correlation coefficient is -0.068
    S =   -268.
    z =  -1.688
    p =  0.0913
    p =  0.2511 adjusted for correlation among seasons
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =   158.5     +  -0.5385     * Time

   where Time = Year (as a decimal) - 1992.75
                                     (beginning of first water year)
```

Attachment 5 TSS Trend Analysis Program Inputs and Output
Station ARK0023 Input File

```
2 0       TSS ARK0023 1993-2020
1993 2  35
1993 3  49
1993 4  60
1993 5  24
1993 6  375
1993 7  11
1993 8  12
1993 9  34
1993 10 36
1993 11 19
1993 12 32
1994 1  26.5
1994 2  15.5
1994 3  12
1994 4  19.5
1994 5  81.5
1994 5  68.5
1994 7  21.5
1994 8  48.5
1994 10 15
1994 11 16
1994 11 10.5
1995 1  9
1995 1  17
1995 3  18.5
1995 4  37.5
1995 5  9
1995 6  5
1995 7  19
1995 8  22
1995 9  16
1995 10 13
1995 11 8
1995 12 7.5
1996 1  39.5
1996 2  19.5
1996 3  29.5
1996 4  69
1996 5  30
1996 6  21
1996 7  107.5
1996 8  49.5
1996 9  46
1996 10 18.5
1996 11 11
1996 12 12
1997 1  10
1997 2  16
1997 3  9.5
1997 4  11
1997 5  43.5
```

1997	6	40
1997	7	20
1997	8	43.5
1997	9	17.5
1997	10	35
1997	11	17.5
1997	12	27.5
1998	1	6
1998	2	33.5
1998	3	12
1998	4	164
1998	5	9
1998	6	64
1998	7	20.5
1998	8	5.5
1998	9	14.5
1998	10	17
1998	11	8.5
1998	12	17
1999	1	18
1999	2	10.5
1999	3	42.5
1999	4	41.5
1999	5	10.5
1999	6	17
1999	7	12.5
1999	8	12
1999	9	6.5
1999	10	26.5
1999	11	13
1999	12	22
2000	1	23
2000	2	38.5
2000	3	57
2000	4	39
2000	5	72.5
2000	7	27
2000	8	17
2000	9	18.5
2000	10	13.5
2000	11	11.5
2000	12	25.5
2001	1	24.8
2001	2	13.3
2001	3	6
2001	4	45.5
2001	5	13.25
2001	6	17.5
2001	7	30.3
2001	8	27.8
2001	9	14.5
2001	10	10.3
2001	11	19
2001	12	10

2002	1	7
2002	2	11
2002	3	15
2002	4	15
2002	5	51.5
2002	7	11.3
2002	8	25.8
2002	9	15
2002	10	21.5
2002	11	14
2002	12	13.8
2003	1	3.2
2003	2	22.3
2003	3	6
2003	4	29.8
2003	5	56.8
2003	6	32.2
2003	6	48
2003	8	41
2003	9	22.2
2003	10	19
2003	11	20
2003	12	16.5
2004	1	21
2004	2	14.3
2004	3	8.2
2004	4	47.7
2004	5	42.5
2004	6	45.8
2004	7	24.8
2004	8	22.2
2004	9	15.2
2004	10	19.2
2004	11	13.8
2004	11	5.8
2005	1	9.2
2005	2	13.2
2005	3	65.8
2005	4	33
2005	5	26
2005	5	21.5
2005	7	8
2005	8	13.5
2005	9	15.8
2005	10	12.2
2005	11	17.8
2005	12	15.2
2006	1	9.2
2006	1	40
2006	3	23.2
2006	4	31.2
2006	5	23.7
2006	6	12.2
2006	7	12.2

2006	8	12.5
2006	9	27.2
2006	10	11.5
2006	11	17.5
2006	12	17.5
2007	1	9.5
2007	2	15
2007	3	24
2007	4	33
2007	5	22.5
2007	6	19.5
2007	7	10.5
2007	8	4.8
2007	9	20.5
2007	10	19.5
2007	11	7.5
2007	12	13.5
2008	1	4
2008	2	39
2008	3	6
2008	4	5.5
2008	5	21.2
2008	6	15
2008	7	7
2008	8	39
2008	9	6.5
2008	10	39.5
2008	11	12.2
2008	12	50
2009	1	34
2009	2	29.5
2009	3	36.5
2009	4	22.5
2009	5	7
2009	6	16.5
2009	7	39.2
2009	8	21
2009	9	27
2009	10	7
2009	11	7.5
2009	12	7
2010	1	10
2010	2	8
2010	3	41
2010	4	35
2010	5	218
2010	6	7.5
2010	7	8.5
2010	8	29
2010	9	9.5
2010	10	15
2010	11	16.5
2010	11	14.5
2011	1	10

2011	2	17
2011	3	32
2011	4	11
2011	5	10
2011	6	19
2011	7	22.5
2011	8	64.5
2011	9	21.5
2011	10	21.5
2011	11	16.5
2011	12	12
2012	1	21
2012	2	19.5
2012	3	27
2012	4	26.5
2012	5	12.5
2012	6	23
2012	7	17.5
2012	8	7.5
2012	9	9
2012	10	13.3
2012	11	14.5
2012	12	10
2013	1	5.2
2013	2	9.5
2013	3	122
2013	4	15.5
2013	5	45
2013	6	18.5
2013	7	17.5
2013	8	10
2013	9	8.8
2013	10	15
2013	11	32.8
2013	12	51.5
2014	1	10
2014	2	11.5
2014	3	16
2014	4	42.5
2014	5	29
2014	6	20
2014	7	31.3
2014	8	38.3
2014	9	15.3
2014	10	22.8
2014	11	17
2014	12	13
2015	1	11.8
2015	2	65.3
2015	3	25.3
2015	4	15.8
2015	5	29
2015	6	13.5
2015	7	9.8

2015	8	18
2015	9	24
2015	10	13.5
2015	11	9
2015	12	10
2016	1	21
2016	2	21.8
2016	3	11.8
2016	4	26
2016	5	29.5
2016	6	41.8
2016	7	9.8
2016	8	10
2016	9	12.3
2016	10	17.5
2016	11	20
2016	12	15.5
2017	1	5
2017	2	12.8
2017	3	36.3
2017	4	93
2017	5	96.5
2017	6	51
2017	7	62
2017	8	27.8
2017	9	17.3
2017	10	3.3
2017	11	8
2017	12	7.7
2018	1	11.8
2018	2	19
2018	3	11.3
2018	5	45
2018	6	25.8
2018	7	13
2018	8	28
2018	9	17.8
2018	10	20.5
2018	11	94.5
2019	1	6.75
2019	2	12.2
2019	3	22.8
2019	4	32.5
2019	5	11
2019	7	19.5
2019	8	28
2019	9	16.2
2019	10	16.2
2019	11	28.8
2019	12	11
2020	1	20
2020	2	6.75
2020	3	20.8
2020	4	15

```
2020 5  34
2020 6  66.5
2020 7  14
2020 8  33.5
2020 9  33
2020 10 23
2020 11 15.5
```

Station ARK0023 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  TSS ARK0023 1993-2020

 The record is 29 complete water years with  12 seasons per year
    beginning in water year 1993.

 The tau correlation coefficient is -0.045
     S =   -187.
     z =  -1.134
     p =  0.2567
     p =  0.3932 adjusted for correlation among seasons
                 (such as serial dependence)
 The adjusted p-value should be used only for data with
    more than 10 annual values per season.

 The estimated trend may be described by the equation:

    Y =   19.09     +  -0.7500E-01 * Time

    where Time = Year (as a decimal) - 1992.75
                                   (beginning of first water year)
```

Station ARK0050 Input File

```
2 0       TSS ARK0050 1993-2020
1993 1  7
1993 1  75
1993 2  16
1993 3  17
1993 3  31
1993 5  7
1993 6  40
1993 7  7
1993 8  14
1993 9  7
1993 10 5
1993 11 6
1993 12 17
1994 2  4.5
1994 3  23.5
1994 4  20.5
1994 5  30.5
1994 6  12
1994 7  22.5
1994 8  21
1994 9  20.5
1994 10 19
1994 11 4.5
1994 11 15.5
1995 1  5
1995 2  4
1995 3  19.5
1995 4  23.5
1995 5  22.5
1995 6  26.5
1995 7  12.5
1995 8  12
1995 9  20
1995 10 39
1995 10 29
1995 11 16.5
1996 1  6
1996 2  10.5
1996 3  4
1996 3  12
1996 4  30
1996 5  156.5
1996 6  23.5
1996 7  192
1996 8  31.5
1996 9  33
1996 10 31
1996 11 14
1996 12 3.5
1997 1  3.5
1997 2  6
1997 4  20.5
```

1997	5	25.5
1997	6	35.5
1997	7	30
1997	8	51.5
1997	9	33.5
1997	10	21.5
1997	12	9.5
1997	12	4
1998	1	42
1998	2	52.5
1998	3	37.5
1998	4	25
1998	5	27
1998	6	28.5
1998	6	16
1998	8	28.5
1998	9	18.5
1998	10	189.5
1998	11	17.5
1998	12	11
1999	1	17
1999	2	7
1999	3	12.5
1999	4	19.5
1999	5	26.5
1999	6	26
1999	7	31.5
1999	8	22.5
1999	9	18.5
1999	10	17
1999	11	19.5
1999	12	15.5
2000	1	11
2000	2	13.5
2000	3	114
2000	4	27.5
2000	5	16.5
2000	6	29.5
2000	7	28
2000	8	17.5
2000	9	26.5
2000	10	12
2000	10	5
2000	12	4
2001	1	10
2001	2	266.8
2001	3	5
2001	4	15.5
2001	5	26.5
2001	6	16.5
2001	7	22.3
2001	8	17.75
2001	9	18.8
2001	10	20.5

2001	11	3.2
2001	12	17.3
2002	1	7.5
2002	2	11.5
2002	3	6
2002	4	25.8
2002	5	28
2002	7	26.8
2002	8	11.3
2002	9	7
2002	10	9
2002	11	18
2002	12	8.5
2003	1	4.3
2003	2	4.7
2003	3	8.7
2003	4	18.8
2003	5	27.8
2003	6	20.8
2003	6	32
2003	7	15.2
2003	9	27.5
2003	10	7.5
2003	11	9.8
2003	12	10.7
2004	1	9.8
2004	2	22
2004	3	23.5
2004	4	3
2004	5	21.5
2004	6	21.2
2004	7	14.5
2004	8	21.8
2004	9	12.2
2004	10	34.7
2004	11	16.8
2004	12	14.2
2005	1	17
2005	2	5.8
2005	3	9.2
2005	4	19
2005	5	22.5
2005	6	19.8
2005	7	16.2
2005	8	17.5
2005	9	12.8
2005	10	5.2
2005	11	7.5
2005	12	9.2
2006	1	13
2006	2	6
2006	3	23
2006	4	20.7
2006	5	22

2006	6	19.8
2006	7	9.8
2006	8	6.8
2006	9	15
2006	10	8
2006	11	22.8
2006	12	5
2007	1	6
2007	2	6.5
2007	3	19
2007	4	19
2007	5	33.8
2007	6	37.3
2007	7	75.8
2007	8	13.8
2007	9	9.2
2007	10	37.2
2007	11	5.5
2007	12	14.8
2008	1	3.5
2008	2	7.5
2008	3	12.5
2008	4	5.8
2008	5	76.5
2008	6	38
2008	7	20.5
2008	8	25
2008	9	29.5
2008	10	33.5
2008	11	19.5
2008	12	2.5
2009	1	4
2009	2	10
2009	3	14.5
2009	4	109
2009	5	9.5
2009	6	73
2009	7	69.5
2009	8	26.8
2009	9	7.5
2009	10	15.5
2009	11	4
2009	12	13.5
2010	1	9.5
2010	2	3.5
2010	3	25
2010	4	24.5
2010	5	37
2010	6	9
2010	7	14.5
2010	8	26
2010	9	7
2010	10	7
2010	11	20

2010	12	5.5
2011	1	13
2011	2	16
2011	3	24.5
2011	4	31
2011	5	12.5
2011	6	229
2011	7	14.5
2011	8	11.5
2011	9	12
2011	10	4
2011	11	11
2011	12	4
2012	1	8.5
2012	2	8.5
2012	3	18.5
2012	4	15.5
2012	5	10
2012	6	27
2012	7	6.5
2012	8	6
2012	9	15.5
2012	10	7.5
2012	11	21
2012	12	10
2013	1	2.3
2013	2	13.3
2013	3	9.3
2013	4	16
2013	5	28.5
2013	6	10
2013	7	4.5
2013	8	37.5
2013	9	3.2
2013	10	11
2013	11	6
2013	12	6
2014	1	13
2014	2	11
2014	3	12.8
2014	4	18.5
2014	5	35
2014	6	23.3
2014	7	25.5
2014	8	44.5
2014	9	3.5
2014	10	5
2014	11	6.7
2014	12	19
2015	1	7.7
2015	3	7
2015	4	48
2015	5	31
2015	6	19.5

2015	7	25.8
2015	8	12.5
2015	8	10
2015	10	19.5
2015	12	7.5
2016	1	5.2
2016	2	13.5
2016	3	26.3
2016	4	30.8
2016	5	4
2016	6	9
2016	7	23
2016	10	22
2016	11	23.8
2016	12	11.8
2017	1	17.3
2017	2	78.5
2017	3	11.5
2017	4	34.5
2017	5	13.8
2017	6	30.5
2017	7	26.3
2017	8	27
2017	9	31
2017	10	13.8
2017	12	5.5
2018	1	16.5
2018	2	14
2018	3	38.5
2018	4	8.25
2018	5	33.5
2018	6	22.5
2018	8	14
2018	9	24.2
2018	10	13.2
2018	11	6.25
2018	12	3.75
2019	1	6
2019	3	18.2
2019	4	10.8
2019	5	4.25
2019	7	52.5
2019	8	10
2019	10	30
2019	11	15.2
2019	12	5
2020	1	7.25
2020	3	20
2020	4	29.5
2020	5	22.8
2020	7	13.2
2020	8	6.25
2020	9	10.2

Station ARK0050 Output File

```
    Seasonal Kendall Test for Trend
      US Geological Survey, 2009

Data set:  TSS ARK0050 1993-2020

The record is 28 complete water years with  12 seasons per year
   beginning in water year 1993.

The tau correlation coefficient is -0.063
    S =   -243.
    z =  -1.543
    p =  0.1229
    p =  0.2168 adjusted for correlation among seasons
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =   17.72     +  -0.1083     * Time

   where Time = Year (as a decimal) - 1992.75
                                     (beginning of first water year)
```

Station ARK0060 Input File

```
2 0       TSS ARK0060 1993-2020
1993 1  3
1993 1  32
1993 2  8
1993 3  28
1993 3  8
1993 5  9
1993 6  25
1993 7  6
1993 8  12
1993 9  6
1993 10 5
1993 11 3
1993 12 10
1994 2  4
1994 3  10.5
1994 4  10
1994 5  12
1994 6  7.5
1994 7  5.5
1994 8  9
1994 9  20
1994 10 19
1994 11 6.5
1994 11 7.5
1995 1  3.5
1995 2  4
1995 3  18.5
1995 4  14.5
1995 5  14.5
1995 6  10.5
1995 7  12.5
1995 8  8
1995 9  7
1995 10 30
1995 10 6.5
1995 11 4.5
1996 1  1.5
1996 2  10
1996 4  18.5
1996 5  78.5
1996 6  28.5
1996 7  29
1996 8  4
1996 9  5
1996 10 13
1996 11 7.5
1996 12 4
1997 1  3
1997 2  14
1997 4  7
1997 5  15.5
1997 6  20
```

1997	7	5.5
1997	8	14
1997	9	7.5
1997	10	8.5
1997	12	5
1997	12	2.5
1998	1	3.5
1998	2	21
1998	3	22
1998	4	13
1998	5	3.5
1998	6	23.5
1998	6	4.5
1998	8	8.5
1998	9	6
1998	10	58.5
1998	11	5
1998	12	5
1999	1	15.5
1999	2	5
1999	3	9
1999	4	9.5
1999	5	15.5
1999	6	12
1999	7	3.5
1999	8	5
1999	9	7.5
1999	10	4
1999	11	10
1999	12	8
2000	1	3.5
2000	2	7
2000	3	228
2000	4	19
2000	5	11.5
2000	6	16
2000	7	8.5
2000	8	12
2000	9	12
2000	10	7.5
2000	10	6
2000	12	2.5
2001	1	7
2001	2	20
2001	3	3
2001	4	8.5
2001	5	9.2
2001	6	4.3
2001	7	11.8
2001	8	9.75
2001	9	6.2
2001	10	6
2001	11	7.3
2001	12	8

2002	1	4
2002	2	9
2002	3	32
2002	4	13
2002	5	15.5
2002	7	11
2002	8	5.3
2002	9	7
2002	10	6
2002	11	3.5
2002	12	2.5
2003	1	0.5
2003	2	3.8
2003	3	7.3
2003	4	7.7
2003	5	18.5
2003	6	11.8
2003	6	9.5
2003	7	7.2
2003	9	7.5
2003	10	7.5
2003	11	8.5
2003	12	3.8
2004	1	8.8
2004	2	6.8
2004	3	14
2004	4	6
2004	4	127
2004	5	10.5
2004	6	5.2
2004	7	6.8
2004	8	5
2004	9	7
2004	10	18
2004	11	22.8
2004	12	39.2
2005	1	24
2005	2	4.2
2005	3	7.5
2005	4	15.8
2005	5	10.5
2005	6	13.3
2005	7	14
2005	8	5
2005	9	7.8
2005	10	14.3
2005	11	17.5
2005	12	3.5
2006	1	9.2
2006	2	2.2
2006	3	8.5
2006	4	3.5
2006	5	4.2
2006	11	10.8

2006	12	2.5
2007	1	1.8
2007	2	1.2
2007	3	7.2
2007	4	7.5
2007	5	5
2007	6	4.5
2007	11	7.5
2007	12	3
2008	1	0.5
2008	2	5
2008	3	5.5
2008	4	3.8
2008	5	39
2008	6	3
2008	8	4.8
2008	9	1
2008	10	0.5
2008	11	1.2
2008	12	1.3
2009	1	1.5
2009	2	5
2009	3	6
2009	4	100
2009	5	7
2009	6	5.5
2009	7	11
2009	8	23.5
2009	9	3
2009	10	8
2009	11	3
2009	12	7
2010	1	6
2010	2	3.5
2010	3	12
2010	4	14.5
2010	5	21
2010	6	5.5
2010	7	9.5
2010	8	10.5
2010	9	4.5
2010	10	5
2010	11	7.5
2010	12	1.5
2011	1	4
2011	2	4
2011	3	10.5
2011	4	17.5
2011	5	34
2011	6	23.5
2011	7	6.5
2011	8	2
2011	9	10.5
2011	10	3

2011	11	4.5
2011	12	2
2012	1	2
2012	2	5.5
2012	3	10.5
2012	4	4
2012	5	7.5
2012	6	6
2012	7	4.5
2012	8	8
2012	9	4.5
2012	10	6.5
2012	11	3.8
2012	12	1.8
2013	1	1
2013	2	6.3
2013	3	5.2
2013	4	8
2013	5	5.5
2013	6	3
2013	8	9.5
2013	10	3.5
2013	12	1.8
2014	1	2
2014	2	3.5
2014	3	5.5
2014	4	8.8
2014	5	3.2
2014	6	7.3
2014	7	5.7
2014	8	23.8
2014	9	6.5
2014	10	0.5
2014	11	3
2014	12	6.5
2015	1	3.8
2015	3	2.5
2015	4	16
2015	5	29
2015	7	4
2015	8	5
2015	8	7
2015	10	5.7
2015	12	6
2016	1	2.5
2016	2	4.5
2016	3	9.5
2016	4	9
2016	5	6
2016	6	8
2016	7	6.5
2016	10	16.8
2016	11	10.8
2017	1	2.5

```
2017 2  162
2017 3  6
2017 4  19
2017 5  6.3
2017 7  0.5
2017 8  11.5
2017 9  20.3
2017 10 3.5
2017 12 3.5
2018 1  6.3
2018 2  5.2
2018 3  12.3
2018 4  8.5
2018 5  31
2018 6  2.75
2018 8  5.5
2018 9  8
2018 10 13
2018 11 3.5
2018 12 2.75
2019 1  4.75
2019 2  2.5
2019 3  10
2019 4  4.5
2019 5  13.2
2019 7  10
2019 8  9.25
2019 10 3.75
2019 11 12.5
2019 12 2.25
2020 1  4.5
2020 2  10.5
2020 3  9.5
2020 4  9.5
2020 5  24.8
2020 7  4.5
2020 8  4.75
2020 9  3
```

Station ARK0060 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  TSS ARK0060 1993-2020

 The record is 28 complete water years with  12 seasons per year
    beginning in water year 1993.

 The tau correlation coefficient is -0.148
     S =    -524.
     z =  -3.562
     p =  0.0004
     p =  0.0127 adjusted for correlation among seasons
```

```
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =   8.690     +  -0.1207     * Time

   where Time = Year (as a decimal) - 1992.75
                                     (beginning of first water year)
```

Station ARK0097 Input File

```
2 0       TSS ARK0097 1993-2020
1993 1  7
1993 6  41
1993 7  28
1993 8  40
1993 9  40
1993 10 11
1993 11 3
1993 12 34
1994 2  4.5
1994 3  32.5
1994 4  12
1994 5  35
1994 6  29.5
1994 7  117
1994 8  24
1994 9  14
1994 10 11
1994 11 10
1994 11 11.5
1995 1  3
1995 2  19
1995 3  46.5
1995 4  15
1995 5  43.5
1995 6  39
1995 7  21
1995 8  14
1995 9  12.5
1995 10 13.5
1995 10 8.5
1995 11 17.5
1996 1  8.5
1996 2  24.5
1996 3  27.5
1996 4  29.5
1996 5  40
1996 6  39
1996 7  63.5
1996 8  28
1996 9  18
1996 10 14
1996 11 10.5
1996 12 4.5
1997 1  9
1997 2  10
1997 4  15.5
1997 5  53.5
1997 6  29
1997 7  29
1997 8  31.5
1997 9  18
1997 10 18
```

1997	12	8.5
1997	12	11.5
1998	1	9.5
1998	2	76.5
1998	3	47.5
1998	4	37.5
1998	5	37.5
1998	6	47
1998	6	39
1998	8	30
1998	9	13
1998	10	171
1998	11	11
1998	12	7
1999	1	22
1999	2	5.5
1999	3	43.5
1999	4	17
1999	5	43.5
1999	6	45.5
1999	7	26.5
1999	8	13
1999	9	14.5
1999	10	8
1999	11	10.5
1999	12	26.5
2000	1	12.5
2000	2	21.5
2000	3	41.5
2000	4	60
2000	5	51.5
2000	6	40.5
2000	7	17.5
2000	8	22.5
2000	9	13
2000	10	18
2000	10	6
2000	12	11.5
2001	1	26
2001	2	287.6
2001	3	6.8
2001	4	16.5
2001	5	22.3
2001	6	34.3
2001	7	18.8
2001	8	12
2001	9	7.8
2001	10	9.3
2001	11	5.2
2001	12	14.5
2002	1	11
2002	2	27.5
2002	3	4.2
2002	4	19.5

2002	5	74
2002	7	42.2
2002	8	14.5
2002	9	7
2002	10	10
2002	11	6.8
2002	12	11
2003	1	9.3
2003	2	17.5
2003	3	16.8
2003	4	16.8
2003	5	27
2003	6	22.8
2003	6	24.8
2003	7	10
2003	9	15.2
2003	10	7.8
2003	11	8.2
2003	12	11.8
2004	1	30.8
2004	2	56.8
2004	3	30.8
2004	4	5
2004	5	20.8
2004	6	40.5
2004	7	26
2004	8	21
2004	9	26
2004	10	45
2004	11	16.5
2004	12	5.2
2005	1	25.3
2005	2	15.8
2005	3	24
2005	4	62.5
2005	5	42
2005	6	15.5
2005	7	25.5
2005	8	17.5
2005	9	15.5
2005	10	11.5
2005	11	19.5
2005	12	18
2006	1	28.5
2006	2	10.5
2006	3	41.2
2006	4	30.2
2006	5	20.2
2006	6	34
2006	7	13
2006	8	28
2006	9	10
2006	10	11
2006	11	23.5

2006	12	10.2
2007	1	3.8
2007	2	13
2007	3	29.2
2007	4	17.7
2007	5	31
2007	6	21.5
2007	7	34.8
2007	8	34
2007	9	41.2
2007	10	26.5
2007	11	27.5
2007	12	21
2008	1	8.5
2008	2	10.5
2008	3	17.5
2008	4	4.5
2008	5	32.5
2008	6	17.5
2008	7	18
2008	8	23.5
2008	9	8.5
2008	10	7
2008	11	47
2008	12	6
2009	1	8.5
2009	2	14.5
2009	3	17.5
2009	4	26.2
2009	5	23.2
2009	6	12.5
2009	7	264
2009	8	15.5
2009	9	10
2009	10	8.2
2009	11	2.5
2009	12	10.5
2010	1	13.5
2010	2	4.5
2010	3	21.5
2010	4	36
2010	5	39.5
2010	6	37.4
2010	7	25
2010	8	25.5
2010	9	30
2010	10	28.5
2010	11	11.5
2010	12	5
2011	1	18
2011	2	21
2011	3	222
2011	4	97.3
2011	5	39

2011	6	44
2011	7	20.5
2011	8	20
2011	9	15
2011	10	41
2011	11	17
2011	12	1
2012	1	29.5
2012	2	12
2012	3	33
2012	4	35.5
2012	5	26.5
2012	6	266
2012	7	12.5
2012	8	28
2012	9	25.5
2012	10	14
2012	11	12.3
2012	12	13
2013	1	9.5
2013	2	24.5
2013	3	51.3
2013	4	10
2013	5	27
2013	6	19
2013	7	11.5
2013	8	35
2013	9	13.5
2013	10	25
2013	11	18
2013	12	11.5
2014	1	16.2
2014	2	25.5
2014	3	49
2014	4	7.3
2014	5	35
2014	6	6
2014	7	36.8
2014	8	21
2014	9	18.3
2014	10	21.5
2014	11	40.5
2014	12	41.5
2015	1	22.7
2015	3	16.5
2015	4	131
2015	5	30.5
2015	6	10
2015	7	50.8
2015	8	26.5
2015	8	25
2015	10	33.8
2015	11	7
2015	12	45.5

```
2016 1  7
2016 2  17.5
2016 3  35
2016 4  30.3
2016 5  13.3
2016 6  35
2016 7  20
2016 8  18.5
2016 9  16
2016 10 15.5
2016 11 4.8
2016 12 28.8
2017 1  32.8
2017 2  39.7
2017 4  39.8
2017 5  57.8
2017 6  43.8
2017 7  26.8
2017 8  24.3
2017 9  33.5
2017 10 31.3
2017 12 13.5
2018 1  29.8
2018 2  19.8
2018 3  38.8
2018 4  17.5
2018 5  44.5
2018 6  25.8
2018 8  25.2
2018 9  13.2
2018 10 16.5
2018 11 8.5
2018 12 3.5
2019 1  11
2019 2  5
2019 3  33.5
2019 4  22
2019 5  19.2
2019 7  33
2019 8  13.5
2019 10 20.8
2019 11 55.2
2019 12 10
2020 1  12.2
2020 2  22.2
2020 3  30.2
2020 4  32.5
2020 5  28.5
2020 6  176
2020 7  42.5
2020 8  29.2
2020 9  21.2
```

Station ARK0097 Output File

```
    Seasonal Kendall Test for Trend
      US Geological Survey, 2009

Data set:  TSS ARK0097 1993-2020

The record is 28 complete water years with  12 seasons per year
   beginning in water year 1993.

The tau correlation coefficient is  0.061
    S =    238.
    z =   1.499
    p =  0.1338
    p =  0.2188 adjusted for correlation among seasons
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =   19.52     +   0.1059     * Time

   where Time = Year (as a decimal) - 1992.75
                                     (beginning of first water year)
```

Attachment 6 Inorganic Nitrogen Trend Analysis Program Inputs and Output
Station ARK0050 Input File

```
2 0       NOx ARK0050 1993-2020
1993 1  0.365
1993 1  0.069
1993 2  0.109
1993 3  0.133
1993 3  0.121
1993 5  0.053
1993 6  0.231
1993 7  0.305
1993 8  1.78
1993 9  2.61
1993 10 1.94
1993 11 1.07
1993 12 0.202
1994 2  0.138
1994 3  0.103
1994 4  0.106
1994 5  0.272
1994 6  0.203
1994 7  0.779
1994 9  1.36
1994 10 1.39
1994 11 1.7
1994 11 0.295
1995 1  0.185
1995 2  0.323
1995 3  0.199
1995 4  0.137
1995 5  0.3
1995 6  0.278
1995 7  0.61
1995 8  1.123
1995 9  0.959
1995 10 0.4
1995 10 0.694
1995 11 2.099
1996 1  0.538
1996 2  1.037
1996 3  0.13
1996 3  0.678
1996 4  0.245
1996 5  0.267
1996 6  0.576
1996 7  0.821
1996 8  2.611
1996 9  2.569
1996 10 1.518
1996 11 0.626
1996 12 0.168
1997 1  0.378
1997 2  0.127
1997 3  0.164
```

1997	4	0.172
1997	5	0.319
1997	6	0.166
1997	7	0.413
1997	8	1.219
1997	9	2.015
1997	10	0.487
1997	12	0.515
1997	12	0.305
1998	1	0.222
1998	2	0.457
1998	3	0.219
1998	4	0.373
1998	5	0.427
1998	6	0.285
1998	6	0.992
1998	8	0.323
1998	9	0.146
1998	10	0.897
1998	11	2.15
1998	12	0.186
1999	1	0.516
1999	2	0.335
1999	3	0.685
1999	4	0.341
1999	5	0.979
1999	6	1.63
1999	7	2.68
1999	8	4.2
1999	9	2.34
1999	10	5.13
1999	11	5.168
1999	12	0.588
2000	1	1.81
2000	2	0.382
2000	3	0.3
2000	4	0.232
2000	5	0.226
2000	6	0.331
2000	7	3.955
2000	8	5.025
2000	9	6.232
2000	10	5.65
2000	10	6.49
2000	12	0.844
2001	1	0.68
2001	2	0.997
2001	3	0.133
2001	4	0.98
2001	5	5.23
2001	6	8.136
2001	7	5.79
2001	8	2.014
2001	9	3.41

2001	10	0.949
2001	11	8.395
2001	12	0.107
2002	1	0.251
2002	2	0.459
2002	3	0.266
2002	4	0.38
2002	5	0.164
2002	6	0.812
2002	7	1.163
2002	8	3.138
2002	9	1.734
2002	10	0.861
2002	11	4.21
2002	12	0.259
2003	1	0.55
2003	2	0.38
2003	3	0.277
2003	4	0.343
2003	5	0.295
2003	6	1.09
2003	6	2.07
2003	7	3.42
2003	9	7.88
2003	10	11.7
2003	11	8.04
2003	12	2.54
2004	1	0.27
2004	2	0.2
2004	3	0.286
2004	4	0.054
2004	5	0.146
2004	6	0.872
2004	7	1.74
2004	8	1.09
2004	9	0.025
2004	10	0.211
2004	11	0.181
2004	12	0.32
2005	1	0.209
2005	2	0.645
2005	3	1.78
2005	4	0.164
2005	5	1.91
2005	6	2.19
2005	7	0.118
2005	8	4.46
2005	9	2.29
2005	10	4.71
2005	11	0.022
2005	12	2.14
2006	1	0.325
2006	2	0.712
2006	3	0.308

2006	4	0.819
2006	5	1.26
2006	6	1.03
2006	7	0.595
2006	8	0.724
2006	9	1.16
2006	10	5.98
2006	11	0.196
2006	12	0.43
2007	1	0.152
2007	2	0.293
2007	3	0.565
2007	4	0.484
2007	5	1.47
2007	6	0.572
2007	7	0.419
2007	8	3.74
2007	9	1.47
2007	10	0.152
2007	11	1.59
2007	12	0.203
2008	1	0.724
2008	2	0.167
2008	3	0.171
2008	4	0.099
2008	5	0.289
2008	6	0.445
2008	7	1.15
2008	8	1.87
2008	9	2.34
2008	10	1.7
2008	11	0.724
2008	12	1.09
2009	1	0.466
2009	2	0.241
2009	3	0.171
2009	4	0.203
2009	5	0.126
2009	6	2.28
2009	7	0.912
2009	8	1.1
2009	9	1.48
2009	10	0.134
2009	11	0.034
2009	12	0.131
2010	1	0.151
2010	2	0.143
2010	3	1.29
2010	4	1.79
2010	5	0.673
2010	6	3.81
2010	7	1.77
2010	8	9.05
2010	9	5.9

2010	10	9.2
2010	11	3.4
2010	12	3.16
2011	1	0.985
2011	2	0.268
2011	3	0.324
2011	4	0.202
2011	5	0.151
2011	6	1.25
2011	7	1.81
2011	8	5.85
2011	9	6.5
2011	10	5.65
2011	11	3.2
2011	12	0.169
2012	1	0.218
2012	2	0.15
2012	3	1.01
2012	4	1.92
2012	5	6.75
2012	6	1.74
2012	7	6.86
2012	8	6.65
2012	9	2.06
2012	10	2.66
2012	11	0.215
2012	12	2.12
2013	1	0.79
2013	2	0.302
2013	3	0.197
2013	4	0.274
2013	5	1.57
2013	6	0.713
2013	7	1.11
2013	8	0.423
2013	9	4.54
2013	10	1.46
2013	11	1.24
2013	12	0.626
2014	1	0.569
2014	2	0.544
2014	3	0.293
2014	4	0.432
2014	5	3.28
2014	6	0.985
2014	7	0.307
2014	8	0.354
2014	9	8.8
2014	10	5.31
2014	11	1.71
2014	12	0.406
2015	1	1.03
2015	3	0.37
2015	4	0.212

2015	5	0.238
2015	6	0.102
2015	7	1.22
2015	8	5.6
2015	8	7.77
2015	10	8.5
2015	12	0.098
2016	1	0.276
2016	2	0.853
2016	3	0.453
2016	4	0.856
2016	5	0.114
2016	6	2.59
2016	7	2.05
2016	10	12.1
2016	11	10
2016	12	2.06
2017	1	1.15
2017	2	0.378
2017	3	0.29
2017	4	0.175
2017	5	0.123
2017	6	0.653
2017	7	0.902
2017	8	3.89
2017	9	2.75
2017	10	8.25
2017	12	5.85
2018	1	0.998
2018	2	1.18
2018	3	0.921
2018	4	0.146
2018	5	2.67
2018	6	1.83
2018	8	4.39
2018	9	0.45
2018	10	0.26
2018	11	0.25
2018	12	0.11
2019	1	0.27
2019	3	0.44
2019	4	0.93
2019	5	0.12
2019	7	0.33
2019	8	3.62
2019	10	1.62
2019	11	0.26
2019	12	0.47
2020	1	0.6
2020	3	0.64
2020	4	0.28
2020	5	0.92
2020	7	1.54
2020	8	7.46

2020 9 5.7

Station ARK0050 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  NOx ARK0050 1993-2020

 The record is 28 complete water years with  12 seasons per year
    beginning in water year 1993.

 The tau correlation coefficient is  0.175
     S =    685.
     z =   4.334
     p =  0.0000
     p =  0.0058 adjusted for correlation among seasons
                 (such as serial dependence)
 The adjusted p-value should be used only for data with
    more than 10 annual values per season.

 The estimated trend may be described by the equation:

    Y =  0.4740     +   0.1350E-01 * Time

    where Time = Year (as a decimal) - 1992.75
                                       (beginning of first water year)
```

Station ARK0097 Input File

```
2 0       NOx ARK0097 1993-2020
1993 1  0.333
1993 6  0.523
1993 7  0.082
1993 8  0.498
1993 9  0.025
1993 10 0.156
1993 11 0.367
1993 12 0.163
1994 2  0.047
1994 3  0.174
1994 4  0.04
1994 5  0.46
1994 6  0.273
1994 7  0.958
1994 9  0.283
1994 10 0.291
1994 11 4.94
1994 11 0.217
1995 1  0.093
1995 2  0.216
1995 3  0.524
1995 4  0.261
1995 5  0.249
1995 6  0.025
1995 7  1.12
1995 8  0.501
1995 9  0.162
1995 10 0.284
1995 10 0.123
1995 11 0.18
1996 1  0.644
1996 2  0.025
1996 3  0.477
1996 4  0.314
1996 5  0.519
1996 6  0.569
1996 7  0.685
1996 8  0.309
1996 9  0.241
1996 10 0.496
1996 11 0.166
1996 12 0.046
1997 1  0.419
1997 2  0.222
1997 3  0.06
1997 4  0.26
1997 5  0.274
1997 6  0.626
1997 7  0.834
1997 8  0.079
1997 9  0.284
1997 10 0.674
```

1997	12	0.127
1997	12	0.324
1998	1	0.119
1998	2	0.394
1998	3	0.397
1998	4	0.319
1998	5	0.45
1998	6	0.767
1998	6	0.373
1998	8	0.163
1998	9	0.1
1998	10	0.841
1998	11	0.325
1998	12	0.764
1999	1	0.528
1999	2	0.276
1999	3	0.09
1999	4	0.205
1999	5	0.358
1999	6	0.303
1999	7	0.458
1999	8	0.125
1999	9	0.278
1999	10	0.314
1999	11	0.112
1999	12	0.573
2000	1	0.242
2000	2	0.571
2000	3	0.494
2000	4	0.278
2000	5	0.343
2000	6	0.549
2000	7	0.371
2000	8	0.22
2000	9	0.171
2000	10	0.13
2000	10	0.05
2000	12	0.678
2001	1	0.74
2001	2	0.249
2001	3	0.042
2001	4	0.39
2001	5	0.336
2001	6	0.287
2001	7	0.98
2001	8	0.368
2001	9	0.25
2001	10	0.293
2001	11	0.126
2001	12	0.105
2002	1	0.738
2002	2	0.378
2002	3	0.129
2002	4	0.38

2002	5	0.742
2002	6	0.364
2002	7	0.234
2002	8	0.253
2002	9	0.204
2002	10	0.427
2002	11	0.223
2002	12	0.363
2003	1	0.214
2003	2	0.491
2003	3	0.26
2003	4	0.161
2003	5	0.799
2003	6	0.428
2003	6	0.508
2003	7	0.75
2003	9	0.549
2003	10	0.225
2003	11	0.1
2003	12	0.36
2004	1	0.364
2004	2	0.306
2004	3	0.457
2004	4	0.14
2004	5	0.492
2004	6	1.05
2004	7	0.401
2004	8	0.373
2004	9	0.025
2004	10	0.246
2004	11	0.258
2004	12	0.081
2005	1	0.315
2005	2	0.498
2005	3	0.718
2005	4	0.425
2005	5	0.998
2005	6	0.912
2005	7	0.556
2005	8	0.145
2005	9	0.199
2005	10	0.313
2005	11	0.047
2005	12	0.025
2006	1	0.633
2006	2	0.388
2006	3	0.207
2006	4	0.273
2006	5	0.429
2006	6	0.423
2006	7	0.396
2006	8	0.427
2006	9	0.118
2006	10	0.477

2006	11	0.633
2006	12	0.365
2007	1	0.065
2007	2	0.327
2007	3	0.667
2007	4	0.4
2007	5	0.603
2007	6	0.308
2007	7	1.07
2007	8	0.025
2007	9	0.286
2007	10	0.395
2007	11	0.012
2007	12	0.34
2008	1	0.662
2008	2	0.219
2008	3	0.273
2008	4	0.054
2008	5	0.634
2008	6	0.501
2008	7	0.638
2008	8	0.255
2008	9	0.407
2008	10	0.253
2008	11	0.422
2008	12	0.322
2009	1	0.394
2009	2	0.107
2009	3	0.096
2009	4	0.387
2009	5	0.419
2009	6	0.332
2009	7	0.699
2009	8	0.342
2009	9	0.276
2009	10	0.132
2009	11	0.025
2009	12	0.283
2010	1	0.123
2010	2	0.08
2010	3	0.064
2010	4	0.684
2010	5	0.306
2010	6	0.025
2010	7	0.341
2010	8	0.336
2010	9	0.086
2010	10	0.025
2010	11	0.05
2010	12	0.612
2011	1	0.374
2011	2	0.365
2011	3	0.406
2011	4	0.516

2011	5	0.412
2011	6	0.241
2011	7	0.934
2011	8	0.459
2011	9	0.516
2011	10	0.135
2011	11	0.295
2011	12	0.025
2012	1	0.343
2012	2	0.137
2012	3	0.236
2012	4	0.947
2012	5	0.163
2012	6	0.477
2012	7	0.057
2012	8	0.025
2012	9	0.265
2012	10	0.278
2012	11	0.123
2012	12	0.448
2013	1	0.634
2013	2	0.26
2013	3	0.497
2013	4	0.025
2013	5	0.207
2013	6	0.499
2013	7	0.195
2013	8	0.452
2013	9	0.082
2013	10	0.301
2013	11	0.038
2013	12	0.56
2014	1	0.249
2014	2	0.379
2014	3	0.312
2014	4	0.066
2014	5	0.403
2014	6	0.063
2014	7	0.469
2014	8	0.209
2014	9	0.24
2014	10	0.318
2014	11	0.302
2014	12	0.359
2015	1	0.483
2015	3	0.486
2015	4	0.398
2015	5	0.193
2015	6	0.209
2015	7	0.452
2015	8	0.19
2015	8	0.134
2015	10	0.188
2015	11	0.212

```
2015 12 0.348
2016 1  0.346
2016 2  0.277
2016 3  0.216
2016 4  0.238
2016 5  0.207
2016 6  0.38
2016 7  0.284
2016 8  0.379
2016 9  0.3
2016 10 0.23
2016 11 0.025
2016 12 0.447
2017 1  0.356
2017 2  0.401
2017 4  0.233
2017 5  0.271
2017 6  0.437
2017 7  0.936
2017 8  0.177
2017 9  0.278
2017 10 0.025
2017 12 0.025
2018 1  0.465
2018 2  0.433
2018 3  0.122
2018 4  0.224
2018 5  0.151
2018 6  0.46
2018 8  0.13
2018 9  0.16
2018 10 0.16
2018 11 0.025
2018 12 0.11
2019 1  0.16
2019 2  0.06
2019 3  0.23
2019 4  0.23
2019 5  0.23
2019 7  1.09
2019 8  0.36
2019 10 0.36
2019 11 0.22
2019 12 0.17
2020 1  0.18
2020 2  0.26
2020 3  0.27
2020 4  0.2
2020 5  0.27
2020 6  0.995
2020 7  0.56
2020 8  0.2
2020 9  0.16
```
Station ARK0097 Output File

```
    Seasonal Kendall Test for Trend
      US Geological Survey, 2009

Data set:  NOx ARK0097 1993-2020

The record is 28 complete water years with  12 seasons per year
   beginning in water year 1993.

The tau correlation coefficient is -0.082
    S =    -326.
    z =  -2.046
    p =  0.0408
    p =  0.0558 adjusted for correlation among seasons
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =  0.3361     +  -0.2760E-02 * Time

   where Time = Year (as a decimal) - 1992.75
                                     (beginning of first water year)
```

Attachment 7 TKN Trend Analysis Program Inputs and Output
Station ARK0023 Input File

```
2 0       TKN ARK0023 1998-2020
1998 1  0.755
1998 2  1.339
1998 3  1.13
1998 4  1.934
1998 5  1.14
1998 6  1.635
1998 7  0.891
1998 8  0.889
1998 9  1.025
1998 10 0.943
1998 11 0.648
1998 12 1.005
1999 1  1.159
1999 2  1.028
1999 3  1.332
1999 4  1.221
1999 5  1.168
1999 6  1.57
1999 7  1.09
1999 8  0.832
1999 9  0.967
1999 10 1.137
1999 11 0.842
1999 12 0.909
2000 1  1.176
2000 2  1.176
2000 3  1.929
2000 5  1.471
2000 6  1.272
2000 7  1.019
2000 8  0.701
2000 9  0.88
2000 10 0.561
2000 11 1.141
2000 12 1.17
2001 1  0.877
2001 2  1.3
2001 3  0.91
2001 4  1.325
2001 5  1.699
2001 6  1.08
2001 7  0.88
2001 8  1.018
2001 9  0.834
2001 10 1.591
2001 11 1.844
2001 12 0.83
2002 1  0.676
2002 2  0.992
2002 3  1.13
2002 4  1.0
```

```
2002 5  2.055
2002 6  0.995
2002 7  0.987
2002 8  0.91
2002 9  0.861
2002 10 1.09
2002 12 1.14
2003 1  0.929
2003 2  1.36
2003 3  0.98
2003 4  1.01
2003 5  1.36
2003 6  1.26
2003 8  0.681
2003 9  0.658
2003 10 0.608
2003 11 0.529
2003 12 0.839
2004 1  0.886
2004 2  1.02
2004 3  1.02
2004 4  1.38
2004 5  1.27
2004 6  1.02
2004 7  0.669
2004 8  0.926
2004 9  0.838
2004 10 0.728
2004 11 1.0
2004 11 0.702
2005 1  0.828
2005 2  0.804
2005 3  0.954
2005 4  1.02
2005 5  1.09
2005 5  1.21
2005 7  1.31
2005 8  1.12
2005 9  1.16
2005 10 1.13
2005 11 1.44
2005 12 0.819
2006 1  0.786
2006 1  0.852
2006 3  0.98
2006 4  0.979
2006 5  0.882
2006 6  1.06
2006 7  0.78
2006 8  1.07
2006 9  0.641
2006 10 0.756
2006 11 0.823
2006 12 0.903
```

2007	1	0.748
2007	2	1.28
2007	3	1.19
2007	4	1.28
2007	5	0.28
2007	6	0.547
2007	7	0.922
2007	8	0.998
2007	9	1.09
2007	10	0.85
2007	11	0.856
2007	12	0.668
2008	1	0.932
2008	2	0.705
2008	3	0.819
2008	4	0.857
2008	5	1.29
2008	6	0.981
2008	7	1.32
2008	8	1.01
2008	9	0.755
2008	10	0.802
2008	11	0.961
2008	12	0.882
2009	1	0.775
2009	2	0.83
2009	3	1.01
2009	4	1.05
2009	5	0.945
2009	6	1.03
2009	7	1.18
2009	8	0.765
2009	9	0.726
2009	10	0.811
2009	11	0.618
2009	12	0.537
2010	1	0.754
2010	2	0.656
2010	3	1.02
2010	4	1.03
2010	5	1.3
2010	6	0.845
2010	7	0.927
2010	8	1.03
2010	9	0.845
2010	10	0.767
2010	11	0.62
2010	11	0.746
2011	1	0.727
2011	2	0.748
2011	3	1.15
2011	4	0.699
2011	5	1.04
2011	6	1.24

2011	7	1.15
2011	8	1.2
2011	9	1.15
2011	10	0.845
2011	11	0.848
2011	12	0.703
2012	1	0.796
2012	2	0.91
2012	3	0.927
2012	4	0.947
2012	5	1.11
2012	6	1.27
2012	7	0.826
2012	8	0.869
2012	9	1.29
2012	10	1.02
2012	11	0.894
2012	12	1.03
2013	1	0.732
2013	2	0.737
2013	3	1.18
2013	4	0.952
2013	5	1.25
2013	6	1.4
2013	7	0.938
2013	8	0.815
2013	9	0.793
2013	10	1.01
2013	11	1.42
2013	12	0.905
2014	1	0.825
2014	2	0.818
2014	3	0.971
2014	4	1.06
2014	5	1.03
2014	6	1.18
2014	7	1.14
2014	8	0.901
2014	9	0.818
2014	10	0.883
2014	11	0.842
2014	12	0.839
2015	1	1.05
2015	2	0.909
2015	3	1.06
2015	4	1.06
2015	5	1.04
2015	6	1.13
2015	7	0.904
2015	8	0.964
2015	9	0.913
2015	10	0.636
2015	11	0.791
2015	12	0.892

2016	1	0.646
2016	2	0.976
2016	3	0.466
2016	4	0.867
2016	5	0.934
2016	6	0.85
2016	7	0.715
2016	8	0.546
2016	9	0.687
2016	10	0.673
2016	11	0.798
2016	12	0.41
2017	1	0.927
2017	2	0.666
2017	3	0.646
2017	4	1.0
2017	5	1.01
2017	6	0.897
2017	7	0.711
2017	8	0.592
2017	9	0.757
2017	10	0.476
2017	11	0.446
2017	12	0.467
2018	1	0.701
2018	2	0.749
2018	3	0.632
2018	5	0.858
2018	6	0.74
2018	7	0.81
2018	8	0.83
2018	9	0.81
2018	10	0.91
2018	11	0.53
2019	1	0.62
2019	2	0.73
2019	3	0.63
2019	4	1.04
2019	5	0.54
2019	7	0.83
2019	8	0.63
2019	9	0.66
2019	10	0.7
2019	11	0.65
2019	12	0.71
2020	1	0.66
2020	2	0.58
2020	3	0.8
2020	4	0.8
2020	5	0.92
2020	6	0.84
2020	7	0.85
2020	8	0.74
2020	9	0.73

```
2020 10 0.68
2020 11 0.77
```

Station ARK0023 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  TKN ARK0023 1998-2020

 The record is 24 complete water years with  12 seasons per year
    beginning in water year 1998.

 The tau correlation coefficient is -0.335
     S =   -940.
     z =  -7.572
     p =  0.0000
     p =  0.0001 adjusted for correlation among seasons
                (such as serial dependence)
 The adjusted p-value should be used only for data with
    more than 10 annual values per season.

 The estimated trend may be described by the equation:

    Y =   1.076     +  -0.1437E-01 * Time

    where Time = Year (as a decimal) - 1997.75
                                      (beginning of first water year)
```

Station ARK0050 Input File

```
2 0       TKN ARK0050 1998-2020
1998 1  0.779
1998 2  0.86
1998 3  0.812
1998 4  1.073
1998 5  3.38
1998 6  5.23
1998 6  0.729
1998 8  1.156
1998 9  1.194
1998 10 1.274
1998 11 0.739
1998 12 1.14
1999 1  0.64
1999 2  0.492
1999 3  0.656
1999 4  0.673
1999 5  0.854
1999 6  0.651
1999 7  0.898
1999 8  1.01
1999 9  0.674
1999 10 0.772
1999 11 0.764
1999 12 0.966
2000 1  1.026
2000 2  0.996
2000 3  1.444
2000 4  0.655
2000 5  0.997
2000 6  1.262
2000 8  0.779
2000 9  1.234
2000 10 0.769
2000 12 0.66
2001 1  0.79
2001 2  1.281
2001 3  0.77
2001 4  0.847
2001 5  0.752
2001 6  0.72
2001 7  0.944
2001 8  0.976
2001 9  0.784
2001 10 1.137
2001 11 0.968
2001 12 0.54
2002 1  0.614
2002 2  0.611
2002 3  0.71
2002 4  0.77
2002 5  1.28
2002 6  1.099
```

2002	7	1.263
2002	8	0.966
2002	9	1.09
2002	10	0.533
2002	12	0.499
2003	1	0.573
2003	2	0.75
2003	3	0.401
2003	4	0.584
2003	5	0.815
2003	6	0.97
2003	7	0.989
2003	9	0.399
2003	10	0.05
2003	11	0.917
2003	12	1.0
2004	1	0.979
2004	2	0.75
2004	3	0.704
2004	4	0.705
2004	5	0.866
2004	6	0.679
2004	7	0.79
2004	8	0.79
2004	9	2.11
2004	10	0.647
2004	11	0.6
2004	12	0.315
2005	1	0.635
2005	2	0.475
2005	3	0.6
2005	4	0.736
2005	5	0.59
2005	6	1.18
2005	7	0.798
2005	8	0.69
2005	9	0.66
2005	11	0.724
2005	12	0.84
2006	1	0.805
2006	2	0.498
2006	3	0.544
2006	4	1.06
2006	5	1.28
2006	6	1.01
2006	7	0.865
2006	8	0.826
2006	9	0.89
2006	10	1.32
2006	11	0.683
2006	12	0.58
2007	1	0.384
2007	2	0.663
2007	3	0.465

2007	4	1.44
2007	5	0.61
2007	6	0.598
2007	7	1.94
2007	8	0.46
2007	9	0.93
2007	10	0.803
2007	11	0.64
2007	12	0.476
2008	1	0.506
2008	2	0.497
2008	3	0.458
2008	4	0.5
2008	5	0.771
2008	6	0.635
2008	7	0.84
2008	8	0.53
2008	9	0.91
2008	10	0.72
2008	11	0.626
2008	12	0.89
2009	1	0.467
2009	2	0.374
2009	3	0.399
2009	4	0.651
2009	5	0.651
2009	6	0.66
2009	7	0.708
2009	8	0.66
2009	9	0.95
2009	10	0.534
2009	11	0.41
2009	12	0.558
2010	1	0.428
2010	2	0.339
2010	3	0.64
2010	4	0.91
2010	5	0.587
2010	6	0.91
2010	7	0.83
2010	8	0.95
2010	9	0.95
2010	10	1.13
2010	11	0.75
2010	12	0.89
2011	1	0.885
2011	2	0.729
2011	3	0.562
2011	4	0.798
2011	5	0.834
2011	6	1.54
2011	7	0.76
2011	8	0.85
2011	9	1.1

2011	10	0.5
2011	11	1.12
2011	12	0.232
2012	1	0.499
2012	2	0.467
2012	3	0.54
2012	4	0.39
2012	5	1.25
2012	6	1.24
2012	7	2.1
2012	8	1.35
2012	9	1.65
2012	10	0.91
2012	11	0.915
2012	12	1.07
2013	1	0.46
2013	2	0.529
2013	3	0.632
2013	4	0.546
2013	5	0.76
2013	6	0.767
2013	7	0.8
2013	8	0.957
2013	9	0.91
2013	10	0.58
2013	11	1.77
2013	12	2.41
2014	1	0.491
2014	2	0.516
2014	3	0.581
2014	4	0.648
2014	5	0.82
2014	6	0.875
2014	7	0.629
2014	8	0.599
2014	9	0.95
2014	10	0.69
2014	11	0.83
2014	12	0.634
2015	1	0.61
2015	3	0.37
2015	4	0.868
2015	5	0.812
2015	6	0.593
2015	7	0.79
2015	8	6.7
2015	8	1.28
2015	10	1.9
2015	12	0.582
2016	1	0.357
2016	2	0.547
2016	3	0.421
2016	4	0.674
2016	5	0.639

```
2016 6  0.69
2016 7  0.86
2016 10 1.1
2016 11 2.5
2016 12 0.91
2017 1  1.06
2017 2  0.742
2017 3  0.505
2017 4  0.428
2017 5  0.542
2017 6  0.657
2017 7  0.758
2017 8  1.63
2017 9  1.09
2017 10 1.55
2017 12 0.9
2018 1  0.942
2018 2  0.75
2018 3  0.849
2018 4  0.546
2018 5  0.67
2018 6  0.99
2018 8  0.91
2018 9  0.85
2018 10 0.53
2018 11 0.42
2018 12 0.41
2019 1  0.48
2019 3  0.51
2019 4  0.58
2019 5  0.7
2019 7  0.71
2019 8  0.74
2019 10 0.82
2019 11 0.58
2019 12 0.57
2020 1  0.51
2020 3  0.49
2020 4  0.67
2020 5  0.68
2020 7  0.82
2020 8  1.24
2020 9  1.05
```

Station ARK0050 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  TKN ARK0050 1998-2020

 The record is 23 complete water years with  12 seasons per year
    beginning in water year 1998.
```

```
The tau correlation coefficient is -0.162
    S =   -420.
    z =  -3.565
    p =  0.0004
    p =  0.0299 adjusted for correlation among seasons
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =  0.8377     +  -0.7455E-02 * Time

   where Time = Year (as a decimal) - 1997.75
                                     (beginning of first water year)
```

Station ARK0060 Input File

```
2 0       TKN ARK0060 1998-2020
1998 1  0.35
1998 2  0.342
1998 3  0.719
1998 4  0.407
1998 5  0.56
1998 6  1.24
1998 6  0.909
1998 8  1.049
1998 9  0.614
1998 10 0.857
1998 11 0.435
1998 12 0.269
1999 1  0.416
1999 2  0.307
1999 3  0.32
1999 4  0.359
1999 5  0.601
1999 6  0.817
1999 7  0.503
1999 8  0.718
1999 9  0.922
1999 10 0.545
1999 11 0.728
1999 12 0.602
2000 1  0.423
2000 2  0.557
2000 3  1.475
2000 4  0.437
2000 5  0.592
2000 6  0.732
2000 8  1.078
2000 9  1.687
2000 10 0.794
2000 10 0.782
2000 12 0.38
2001 1  0.49
2001 2  0.299
2001 3  0.63
2001 4  0.3
2001 5  0.575
2001 6  0.83
2001 7  1.071
2001 8  1.375
2001 9  0.512
2001 10 0.798
2001 11 0.923
2001 12 0.52
2002 1  0.337
2002 2  0.354
2002 3  0.9
2002 4  0.59
2002 5  1.153
```

2002	6	0.611
2002	7	1.128
2002	8	0.6
2002	9	0.635
2002	10	0.418
2002	12	0.387
2003	1	0.235
2003	2	0.379
2003	3	0.05
2003	4	0.39
2003	5	0.539
2003	6	0.65
2003	7	0.863
2003	9	0.602
2003	10	0.351
2003	11	0.562
2003	12	0.674
2004	1	0.751
2004	2	0.386
2004	3	0.598
2004	4	0.656
2004	4	0.788
2004	5	0.486
2004	6	0.45
2004	7	0.644
2004	8	0.732
2004	9	0.825
2004	10	0.653
2004	11	0.725
2004	12	0.498
2005	1	0.544
2005	2	0.295
2005	3	0.274
2005	4	0.644
2005	5	0.427
2005	6	0.946
2005	7	0.501
2005	8	0.596
2005	9	0.73
2005	11	1.18
2005	12	0.05
2006	1	0.582
2006	2	0.253
2006	3	0.318
2006	4	0.479
2006	5	0.539
2006	11	0.568
2006	12	0.3
2007	1	0.264
2007	2	0.137
2007	3	0.315
2007	4	0.634
2007	5	0.441
2007	6	0.827

2007	11	0.566
2007	12	0.251
2008	1	0.166
2008	2	0.276
2008	3	0.294
2008	4	0.288
2008	5	1.04
2008	6	0.606
2008	8	0.5
2008	9	0.382
2008	10	0.39
2008	11	0.281
2008	12	0.264
2009	1	0.129
2009	2	0.131
2009	3	0.213
2009	4	0.912
2009	5	0.568
2009	6	0.596
2009	7	0.808
2009	8	1.06
2009	9	0.531
2009	10	0.315
2009	11	0.302
2009	12	0.319
2010	1	0.295
2010	2	0.211
2010	3	0.215
2010	4	0.659
2010	5	0.394
2010	6	0.694
2010	7	0.757
2010	8	0.74
2010	9	0.619
2010	10	0.461
2010	11	0.602
2010	12	0.334
2011	1	0.293
2011	2	0.257
2011	3	0.437
2011	4	0.732
2011	5	0.585
2011	6	0.658
2011	7	0.844
2011	8	0.492
2011	9	0.606
2011	10	0.384
2011	11	0.487
2011	12	0.05
2012	1	0.194
2012	2	0.274
2012	3	0.231
2012	4	0.317
2012	5	0.521

2012	6	0.594
2012	7	0.596
2012	8	0.654
2012	9	0.833
2012	10	0.467
2012	11	0.441
2012	12	0.3
2013	1	0.208
2013	2	0.215
2013	3	0.466
2013	4	0.299
2013	5	0.505
2013	6	0.592
2013	8	0.702
2013	10	0.356
2013	12	0.315
2014	1	0.19
2014	2	0.201
2014	3	0.4
2014	4	0.268
2014	5	0.35
2014	6	0.458
2014	7	0.462
2014	8	0.638
2014	9	0.71
2014	10	0.512
2014	11	0.312
2014	12	0.574
2015	1	0.212
2015	3	0.268
2015	4	0.815
2015	5	0.784
2015	7	0.629
2015	8	0.533
2015	8	0.557
2015	10	0.625
2015	12	0.49
2016	1	0.36
2016	2	0.05
2016	3	0.172
2016	4	0.394
2016	5	0.424
2016	6	0.598
2016	7	0.559
2016	10	0.492
2016	11	0.3
2017	1	0.197
2017	2	0.973
2017	3	0.352
2017	4	0.331
2017	5	0.442
2017	7	0.235
2017	8	1.24
2017	9	0.95

```
2017 10 0.461
2017 12 0.372
2018 1  0.395
2018 2  0.231
2018 3  0.294
2018 4  0.553
2018 5  0.69
2018 6  0.37
2018 8  0.56
2018 9  0.61
2018 10 0.6
2018 11 0.26
2018 12 0.38
2019 1  0.22
2019 2  0.16
2019 3  0.19
2019 4  0.21
2019 5  0.43
2019 7  0.34
2019 8  0.73
2019 10 0.39
2019 11 0.57
2019 12 0.28
2020 1  0.24
2020 2  0.21
2020 3  0.23
2020 4  0.29
2020 5  0.33
2020 7  0.51
2020 8  0.58
2020 9  0.39
```

Station ARK0060 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  TKN ARK0060 1998-2020

 The record is 23 complete water years with  12 seasons per year
    beginning in water year 1998.

 The tau correlation coefficient is -0.291
     S =   -681.
     z =  -6.186
     p =  0.0000
     p =  0.0005 adjusted for correlation among seasons
                 (such as serial dependence)
 The adjusted p-value should be used only for data with
    more than 10 annual values per season.

 The estimated trend may be described by the equation:

    Y =  0.5943     +  -0.9333E-02 * Time
```

where Time = Year (as a decimal) - 1997.75
(beginning of first water year)

Station ARK0097 Input File

```
2 0       TKN ARK0097 1998-2020
1998 1  1.004
1998 2  1.725
1998 3  2.041
1998 4  1.403
1998 5  2.24
1998 6  1.58
1998 6  1.789
1998 8  0.805
1998 9  0.743
1998 10 2.404
1998 11 1.145
1998 12 0.692
1999 1  1.132
1999 2  0.926
1999 3  1.758
1999 4  1.352
1999 5  1.76
1999 6  2.147
1999 7  1.106
1999 8  1.0
1999 9  1.005
1999 10 1.32
1999 11 1.658
1999 12 1.158
2000 1  1.791
2000 2  1.82
2000 3  2.683
2000 4  1.84
2000 5  1.733
2000 6  2.286
2000 8  1.036
2000 9  1.753
2000 10 1.186
2000 10 1.254
2000 12 1.12
2001 1  1.61
2001 2  1.748
2001 3  0.93
2001 4  1.129
2001 5  1.871
2001 6  2.68
2001 7  1.041
2001 8  1.472
2001 9  1.3
2001 10 1.544
2001 11 1.147
2001 12 0.72
2002 1  0.945
2002 2  1.808
2002 3  0.91
2002 4  1.61
2002 5  2.048
```

2002	6	1.458
2002	7	3.46
2002	8	0.96
2002	9	0.731
2002	10	0.705
2002	12	0.99
2003	1	1.2
2003	2	1.72
2003	3	1.1
2003	4	1.27
2003	5	1.72
2003	6	1.21
2003	7	0.99
2003	9	1.04
2003	10	1.19
2003	11	1.26
2003	12	1.11
2004	1	1.65
2004	2	1.83
2004	3	1.76
2004	4	1.23
2004	5	1.66
2004	6	1.69
2004	7	0.859
2004	8	0.917
2004	9	0.306
2004	10	1.23
2004	11	0.972
2004	12	0.511
2005	1	0.985
2005	2	0.872
2005	3	0.842
2005	4	1.18
2005	5	1.44
2005	6	0.978
2005	7	0.714
2005	8	0.77
2005	9	0.821
2005	11	1.13
2005	12	1.78
2006	1	1.07
2006	2	0.982
2006	3	1.28
2006	4	1.61
2006	5	1.56
2006	6	1.38
2006	7	0.854
2006	8	0.863
2006	9	0.707
2006	10	1.07
2006	11	1.08
2006	12	1.16
2007	1	0.651
2007	2	1.25

2007	3	1.2
2007	4	1.9
2007	5	1.23
2007	6	1.12
2007	7	0.77
2007	8	0.361
2007	9	1.27
2007	10	0.945
2007	11	1.5
2007	12	0.92
2008	1	1.01
2008	2	1.09
2008	3	1.11
2008	4	0.792
2008	5	1.04
2008	6	1.26
2008	7	0.972
2008	8	0.641
2008	9	0.993
2008	10	0.867
2008	11	1.63
2008	12	0.838
2009	1	0.776
2009	2	0.891
2009	3	0.834
2009	4	1.2
2009	5	1.28
2009	6	1.8
2009	7	1.26
2009	8	0.998
2009	9	0.694
2009	10	0.816
2009	11	0.515
2009	12	0.847
2010	1	0.967
2010	2	0.582
2010	3	0.821
2010	4	1.12
2010	5	1.31
2010	6	1.88
2010	7	0.969
2010	8	0.814
2010	9	1.34
2010	10	2.0
2010	11	0.749
2010	12	0.828
2011	1	1.27
2011	2	0.695
2011	3	0.654
2011	4	1.49
2011	5	1.4
2011	6	1.51
2011	7	0.926
2011	8	0.941

2011	9	0.964
2011	10	3.18
2011	11	0.965
2011	12	0.318
2012	1	1.74
2012	2	0.835
2012	3	0.904
2012	4	1.0
2012	5	1.78
2012	6	1.45
2012	7	0.644
2012	8	1.86
2012	9	1.26
2012	10	0.842
2012	11	0.937
2012	12	1.33
2013	1	0.796
2013	2	0.8
2013	3	1.74
2013	4	0.867
2013	5	1.23
2013	6	1.3
2013	7	1.24
2013	8	1.13
2013	9	0.615
2013	10	0.709
2013	11	1.04
2013	12	0.79
2014	1	0.951
2014	2	0.871
2014	3	1.15
2014	4	0.964
2014	5	1.23
2014	6	1.24
2014	7	0.811
2014	8	0.51
2014	9	0.617
2014	10	1.43
2014	11	1.62
2014	12	1.2
2015	1	0.817
2015	3	0.954
2015	4	1.6
2015	5	0.977
2015	6	0.941
2015	7	0.838
2015	8	0.646
2015	8	0.825
2015	10	1.55
2015	11	0.62
2015	12	1.06
2016	1	0.633
2016	2	0.763
2016	3	0.794

```
2016 4  1.0
2016 5  0.773
2016 6  1.19
2016 7  0.716
2016 8  0.701
2016 9  1.4
2016 10 0.704
2016 11 0.451
2016 12 1.41
2017 1  0.05
2017 2  1.1
2017 4  1.03
2017 5  0.909
2017 6  0.993
2017 7  0.674
2017 8  0.821
2017 9  1.0
2017 10 0.662
2017 12 1.05
2018 1  1.28
2018 2  0.887
2018 3  0.988
2018 4  0.806
2018 5  1.17
2018 6  0.77
2018 8  0.79
2018 9  0.96
2018 10 0.94
2018 11 0.7
2018 12 0.7
2019 1  0.73
2019 2  0.46
2019 3  0.8
2019 4  0.84
2019 5  0.85
2019 7  0.98
2019 8  0.85
2019 10 0.83
2019 11 0.92
2019 12 0.83
2020 1  0.8
2020 2  0.86
2020 3  0.8
2020 4  0.83
2020 5  0.96
2020 6  1.86
2020 7  0.89
2020 8  0.54
2020 9  0.55
```

Station ARK0097 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

Data set:  TKN ARK0097 1998-2020

The record is 23 complete water years with  12 seasons per year
   beginning in water year 1998.

The tau correlation coefficient is -0.362
    S =   -975.
    z =  -8.077
    p =  0.0000
    p =  0.0000 adjusted for correlation among seasons
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =   1.292     +  -0.2538E-01 * Time

   where Time = Year (as a decimal) - 1997.75
                                     (beginning of first water year)
```

Attachment 8 Total Phosphorus Trend Analysis Program Inputs and Output
Station ARK0023 Input File

```
2 0       TP ARK0023 1993-2020
1993 1  0.16
1993 2  0.186
1993 3  0.22
1993 4  0.317
1993 5  0.31
1993 6  0.576
1993 7  0.088
1993 8  0.115
1993 9  0.162
1993 10 0.145
1993 11 0.254
1993 12 0.174
1994 1  0.226
1994 2  0.219
1994 3  0.225
1994 4  0.321
1994 5  0.395
1994 5  0.24
1994 7  0.173
1994 8  0.129
1994 9  0.229
1994 10 0.096
1994 11 0.077
1994 11 0.161
1995 1  0.158
1995 1  0.278
1995 3  0.183
1995 4  0.232
1995 5  0.218
1995 6  0.087
1995 7  0.165
1995 8  0.156
1995 9  0.088
1995 10 0.111
1995 11 0.101
1995 12 0.052
1996 1  0.222
1996 2  0.197
1996 4  0.295
1996 5  0.3
1996 6  0.189
1996 7  0.234
1996 8  0.247
1996 9  0.192
1996 10 0.194
1996 11 0.364
1996 12 0.21
1997 1  0.264
1997 2  0.231
1997 3  0.25
1997 4  0.305
```

1997	5	0.262
1997	6	0.22
1997	7	0.15
1997	8	0.164
1997	9	0.12
1997	10	0.192
1997	11	0.21
1997	12	0.244
1998	1	0.09
1998	2	0.243
1998	3	0.216
1998	4	0.304
1998	5	0.168
1998	6	0.204
1998	7	0.111
1998	8	0.096
1998	9	0.124
1998	10	0.102
1998	11	0.071
1998	12	0.155
1999	1	0.226
1999	2	0.218
1999	3	0.402
1999	4	0.304
1999	5	0.309
1999	6	0.132
1999	7	0.102
1999	8	0.118
1999	9	0.091
1999	10	0.175
1999	11	0.11
1999	12	0.185
2000	1	0.188
2000	2	0.148
2000	3	0.335
2000	5	0.394
2000	6	0.217
2000	7	0.232
2000	8	0.117
2000	9	0.09
2000	10	0.053
2000	11	0.072
2000	12	0.23
2001	1	0.199
2001	2	0.239
2001	3	0.21
2001	4	0.435
2001	5	0.22
2001	6	0.1
2001	7	0.17
2001	8	0.164
2001	9	0.124
2001	10	0.401
2001	11	0.228

2001	12	0.22
2002	1	0.115
2002	2	0.194
2002	3	0.24
2002	4	0.49
2002	5	0.261
2002	6	0.289
2002	7	0.103
2002	8	0.15
2002	9	0.13
2002	10	0.133
2002	12	0.162
2003	1	0.164
2003	2	0.321
2003	3	0.172
2003	4	0.209
2003	5	0.363
2003	6	0.232
2003	8	0.136
2003	9	0.168
2003	10	0.107
2003	11	0.093
2003	12	0.117
2004	1	0.151
2004	2	0.197
2004	3	0.253
2004	4	0.268
2004	5	0.35
2004	6	0.193
2004	7	0.177
2004	8	0.124
2004	9	0.108
2004	10	0.139
2004	11	0.271
2004	11	0.255
2005	1	0.246
2005	2	0.21
2005	3	0.285
2005	4	0.208
2005	5	0.292
2005	5	0.179
2005	7	0.082
2005	8	0.127
2005	9	0.202
2005	10	0.355
2005	11	0.166
2005	12	0.118
2006	1	0.077
2006	1	0.241
2006	3	0.189
2006	4	0.28
2006	5	0.249
2006	6	0.207
2006	7	0.074

2006	8	0.156
2006	9	0.248
2006	10	0.142
2006	11	0.111
2006	12	0.222
2007	1	0.221
2007	2	0.224
2007	3	0.2
2007	4	0.224
2007	5	0.096
2007	6	0.161
2007	7	0.238
2007	8	0.173
2007	9	0.201
2007	10	0.258
2007	11	0.204
2007	12	0.188
2008	1	0.209
2008	2	0.127
2008	3	0.171
2008	4	0.327
2008	5	0.318
2008	6	0.112
2008	7	0.108
2008	8	0.168
2008	9	0.263
2008	10	0.274
2008	11	0.194
2008	12	0.214
2009	1	0.197
2009	2	0.218
2009	3	0.241
2009	4	0.303
2009	5	0.334
2009	6	0.323
2009	7	0.162
2009	8	0.198
2009	9	0.143
2009	10	0.205
2009	11	0.194
2009	12	0.231
2010	1	0.162
2010	2	0.133
2010	3	0.246
2010	4	0.27
2010	5	0.406
2010	6	0.134
2010	7	0.151
2010	8	0.185
2010	9	0.149
2010	10	0.12
2010	11	0.1
2010	11	0.118
2011	1	0.078

2011	2	0.11
2011	3	0.192
2011	4	0.078
2011	5	0.348
2011	6	0.315
2011	7	0.168
2011	8	0.19
2011	9	0.139
2011	10	0.112
2011	11	0.225
2011	12	0.177
2012	1	0.164
2012	2	0.183
2012	3	0.248
2012	4	0.241
2012	5	0.087
2012	6	0.135
2012	7	0.156
2012	8	0.154
2012	9	0.493
2012	10	0.176
2012	11	0.123
2012	12	0.111
2013	1	0.224
2013	2	0.161
2013	3	0.234
2013	4	0.309
2013	5	0.282
2013	6	0.226
2013	7	0.154
2013	8	0.126
2013	9	0.152
2013	10	0.113
2013	11	0.2
2013	12	0.278
2014	1	0.203
2014	2	0.168
2014	3	0.226
2014	4	0.368
2014	5	0.288
2014	6	0.303
2014	7	0.166
2014	8	0.15
2014	9	0.112
2014	10	0.121
2014	11	0.141
2014	12	0.098
2015	1	0.157
2015	2	0.236
2015	3	0.211
2015	4	0.32
2015	5	0.324
2015	6	0.323
2015	7	0.139

2015	8	0.166
2015	9	0.15
2015	10	0.062
2015	11	0.216
2015	12	0.151
2016	1	0.104
2016	2	0.186
2016	3	0.164
2016	4	0.288
2016	5	0.312
2016	6	0.24
2016	7	0.116
2016	8	0.129
2016	9	0.118
2016	10	0.095
2016	11	0.088
2016	12	0.155
2017	1	0.165
2017	2	0.097
2017	3	0.154
2017	4	0.349
2017	5	0.438
2017	6	0.197
2017	7	0.169
2017	8	0.141
2017	9	0.142
2017	10	0.065
2017	11	0.051
2017	12	0.048
2018	1	0.209
2018	2	0.132
2018	5	0.284
2018	6	0.08
2018	7	0.09
2018	8	0.17
2018	9	0.2
2018	10	0.25
2018	11	0.14
2019	1	0.2
2019	2	0.22
2019	3	0.19
2019	4	0.34
2019	5	0.32
2019	7	0.18
2019	8	0.5
2019	8	0.17
2019	8	0.5
2019	9	0.1
2019	10	0.12
2019	11	0.5
2019	11	0.5
2019	11	0.18
2019	12	0.23
2020	1	0.25

```
2020 2  0.5
2020 2  0.5
2020 2  0.17
2020 3  0.25
2020 4  0.26
2020 5  0.5
2020 5  0.5
2020 5  0.2
2020 6  0.23
2020 7  0.15
2020 8  0.5
2020 8  0.16
2020 8  0.5
2020 9  0.18
2020 10 0.13
2020 11 0.5
2020 11 0.21
2020 11 0.5
```

Station ARK0023 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  TP ARK0023 1993-2020

 The record is 29 complete water years with  12 seasons per year
    beginning in water year 1993.

 The tau correlation coefficient is  0.023
     S =     95.
     z =   0.574
     p =  0.5661
     p =  0.6425 adjusted for correlation among seasons
                 (such as serial dependence)
 The adjusted p-value should be used only for data with
    more than 10 annual values per season.

 The estimated trend may be described by the equation:

    Y =  0.1880     +   0.2042E-03 * Time

    where Time = Year (as a decimal) - 1992.75
                                       (beginning of first water year)
```

Station ARK0050 Input File

```
2 0       TP ARK0050 1993-2019
1993 1  0.212
1993 1  0.18
1993 2  0.277
1993 3  0.090
1993 3  0.255
1993 5  0.146
1993 6  0.254
1993 7  1.4
1993 8  1.93
1993 9  1.6
1993 10 1.7
1993 11 0.693
1993 12 0.151
1994 2  0.099
1994 3  0.133
1994 4  0.168
1994 5  0.231
1994 6  0.513
1994 7  0.703
1994 8  0.34
1994 9  0.58
1994 10 1.13
1994 11 0.702
1994 11 0.294
1995 1  0.080
1995 2  0.121
1995 3  0.192
1995 4  0.175
1995 5  0.587
1995 6  0.589
1995 7  0.514
1995 8  0.838
1995 9  1.74
1995 10 0.997
1995 10 0.706
1995 11 0.72
1996 1  0.252
1996 2  0.41
1996 4  0.117
1996 5  0.362
1996 6  0.502
1996 7  0.501
1996 8  1.51
1996 9  1.788
1996 10 0.672
1996 11 0.264
1996 12 0.066
1997 1  0.113
1997 2  0.095
1997 4  0.201
1997 5  0.397
1997 6  0.22
```

1997	7	0.35
1997	8	0.6
1997	9	0.838
1997	10	0.422
1997	12	0.294
1997	12	0.09
1998	1	0.151
1998	2	0.215
1998	3	0.128
1998	4	0.204
1998	5	1.08
1998	6	0.822
1998	6	2.317
1998	8	0.52
1998	9	1.553
1998	10	0.618
1998	11	1.16
1998	12	0.367
1999	1	0.119
1999	2	0.062
1999	3	0.367
1999	4	0.16
1999	5	0.416
1999	6	0.685
1999	7	1.23
1999	8	1.23
1999	9	1.896
1999	10	2.55
1999	11	0.913
1999	12	0.19
2000	1	0.497
2000	2	0.156
2000	3	0.293
2000	4	0.343
2000	5	0.337
2000	6	0.361
2000	7	2.063
2000	8	2.122
2000	9	3.239
2000	10	2.843
2000	10	2.907
2000	12	0.06
2001	1	0.09
2001	2	0.34
2001	3	0.07
2001	4	0.256
2001	5	1.145
2001	6	2.34
2001	7	1.25
2001	8	0.58
2001	9	0.641
2001	10	0.726
2001	11	1.839
2001	12	0.1

2002	1	0.117
2002	2	0.173
2002	3	0.09
2002	4	0.15
2002	5	0.219
2002	6	1.686
2002	7	1.263
2002	8	1.801
2002	9	1.302
2002	10	0.744
2002	12	0.094
2003	1	0.192
2003	2	0.171
2003	3	0.171
2003	4	0.234
2003	5	0.168
2003	6	0.43
2003	7	1.45
2003	9	1.73
2003	10	2.54
2003	11	2.26
2003	12	0.364
2004	1	0.089
2004	2	0.21
2004	3	0.5
2004	4	0.106
2004	5	0.198
2004	6	0.635
2004	7	0.478
2004	8	1
2004	9	0.208
2004	10	0.193
2004	11	0.163
2004	12	0.089
2005	1	0.099
2005	2	0.118
2005	3	0.348
2005	4	0.113
2005	5	1.24
2005	6	2.08
2005	7	0.205
2005	8	2.57
2005	9	2.32
2005	10	1.83
2005	11	0.089
2005	12	0.732
2006	1	0.148
2006	2	0.215
2006	3	0.32
2006	4	1.06
2006	5	0.631
2006	6	1.64
2006	7	1.03
2006	8	1.24

2006	9	2.4
2006	10	2.13
2006	11	0.188
2006	12	0.233
2007	1	0.084
2007	2	0.176
2007	3	0.3
2007	4	0.325
2007	5	0.511
2007	6	0.757
2007	7	0.48
2007	8	0.743
2007	9	1.12
2007	10	0.237
2007	11	1.6
2007	12	0.159
2008	1	0.377
2008	2	0.074
2008	3	0.113
2008	4	0.084
2008	5	0.223
2008	6	0.61
2008	7	0.589
2008	8	0.62
2008	9	0.525
2008	10	0.495
2008	11	0.637
2008	12	0.417
2009	1	0.228
2009	2	0.146
2009	3	0.108
2009	4	0.166
2009	5	0.093
2009	6	0.887
2009	7	0.447
2009	8	0.587
2009	9	1.6
2009	10	0.123
2009	11	0.065
2009	12	0.131
2010	1	0.077
2010	2	0.048
2010	3	0.318
2010	4	0.411
2010	5	0.157
2010	6	1.29
2010	7	0.773
2010	8	1.74
2010	9	2.43
2010	10	2.76
2010	11	1.56
2010	12	0.718
2011	1	0.338
2011	2	0.163

2011	3	0.15
2011	4	0.138
2011	5	0.098
2011	6	0.556
2011	7	0.899
2011	8	3.06
2011	9	2.1
2011	10	2.32
2011	11	1.4
2011	12	0.094
2012	1	0.194
2012	2	0.081
2012	3	0.477
2012	4	0.476
2012	5	3.15
2012	6	1.36
2012	7	3.75
2012	8	3.48
2012	9	0.858
2012	10	1.01
2012	11	0.229
2012	12	0.77
2013	1	0.142
2013	2	0.135
2013	3	0.078
2013	4	0.09
2013	5	0.464
2013	6	0.74
2013	7	2.84
2013	8	0.446
2013	9	2.94
2013	10	0.345
2013	11	0.335
2013	12	0.35
2014	1	0.172
2014	2	0.258
2014	3	0.112
2014	4	0.222
2014	5	0.595
2014	6	0.356
2014	7	0.291
2014	8	0.191
2014	9	2.05
2014	10	1.47
2014	11	0.804
2014	12	0.182
2015	1	0.234
2015	3	0.092
2015	4	0.124
2015	5	0.142
2015	6	0.111
2015	7	0.513
2015	8	4.81
2015	8	2.71

2015	10	3.16
2015	12	0.094
2016	1	0.068
2016	2	0.241
2016	3	0.153
2016	4	0.343
2016	5	0.084
2016	6	1.36
2016	7	0.734
2016	10	4.17
2016	11	2.68
2016	12	0.709
2017	1	0.356
2017	2	0.187
2017	3	0.086
2017	4	0.119
2017	5	0.101
2017	6	0.373
2017	7	0.458
2017	8	1.59
2017	9	0.935
2017	10	3.53
2017	12	1.81
2018	2	0.301
2018	3	0.38
2018	4	0.1
2018	5	0.753
2018	6	0.9
2018	8	1.36
2018	9	0.22
2018	10	0.13
2018	11	0.13
2018	12	0.07
2019	1	0.08
2019	3	0.18
2019	4	0.34
2019	5	0.09
2019	7	0.22
2019	8	1.34
2019	10	0.48
2019	11	0.17
2019	12	0.5
2019	12	0.5
2019	12	0.19
2020	1	0.14
2020	3	0.17
2020	3	0.5
2020	3	0.5
2020	4	0.13
2020	5	0.25
2020	7	0.84
2020	8	1.68
2020	9	1.78
2020	9	1.71

```
2020 9  1.92
```

Station ARK0050 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  TP ARK0050 1993-2019

 The record is 28 complete water years with  12 seasons per year
    beginning in water year 1993.

 The tau correlation coefficient is  0.009
     S =     33.
     z =   0.206
     p =  0.8370
     p =  0.8667 adjusted for correlation among seasons
                 (such as serial dependence)
 The adjusted p-value should be used only for data with
    more than 10 annual values per season.

 The estimated trend may be described by the equation:

    Y =  0.3600     +   0.5000E-03 * Time

    where Time = Year (as a decimal) - 1992.75
                                       (beginning of first water year)
```

Station ARK0060 Input File

```
2 0       TP ARK0060 1993-2020
1993 1  0.5
1993 1  0.15
1993 2  0.0435
1993 3  0.0801
1993 3  0.0428
1993 5  0.0646
1993 6  0.108
1993 7  0.0683
1993 8  0.123
1993 9  0.0811
1993 10 0.0955
1993 11 0.0751
1993 12 0.0997
1994 2  0.059
1994 3  0.042
1994 4  0.0556
1994 5  0.0674
1994 6  0.108
1994 7  0.128
1994 8  0.0868
1994 9  0.118
1994 10 0.229
1994 11 0.0776
1994 11 0.0695
1995 1  0.0386
1995 2  0.0383
1995 3  0.11
1995 4  0.064
1995 5  0.0777
1995 6  0.085
1995 7  0.13
1995 8  0.166
1995 9  0.155
1995 10 0.127
1995 10 0.087
1995 11 0.071
1996 1  0.04
1996 2  0.05
1996 4  0.5
1996 5  0.191
1996 6  0.054
1996 7  0.127
1996 8  0.095
1996 9  0.09
1996 10 0.08
1996 11 0.152
1996 12 0.035
1997 1  0.5
1997 2  0.032
1997 4  0.063
1997 5  0.089
1997 6  0.14
```

1997	7	0.13
1997	8	0.154
1997	9	0.12
1997	10	0.077
1997	12	0.05
1997	12	0.034
1998	1	0.061
1998	2	0.057
1998	3	0.08
1998	4	0.07
1998	5	0.093
1998	6	0.12
1998	6	0.087
1998	8	0.089
1998	9	0.053
1998	10	0.111
1998	11	0.074
1998	12	0.053
1999	1	0.079
1999	2	0.037
1999	3	0.04
1999	4	0.041
1999	5	0.075
1999	6	0.109
1999	7	0.063
1999	8	0.07
1999	9	0.5
1999	10	0.054
1999	11	0.09
1999	12	0.099
2000	1	0.062
2000	2	0.099
2000	3	0.237
2000	4	0.072
2000	5	0.09
2000	6	0.076
2000	7	0.06
2000	8	0.091
2000	9	0.103
2000	10	0.066
2000	10	0.069
2000	12	0.02
2001	1	0.02
2001	2	0.03
2001	3	0.03
2001	4	0.025
2001	5	0.067
2001	6	0.06
2001	7	0.167
2001	8	0.153
2001	9	0.066
2001	10	0.094
2001	11	0.094
2001	12	0.06

2002	1	0.5
2002	2	0.028
2002	3	0.07
2002	4	0.05
2002	5	0.14
2002	6	0.066
2002	7	1.128
2002	8	0.076
2002	9	0.07
2002	10	0.054
2002	12	0.059
2003	1	0.047
2003	2	0.052
2003	3	0.084
2003	4	0.103
2003	5	0.111
2003	6	0.069
2003	7	0.059
2003	9	0.089
2003	10	0.053
2003	11	0.113
2003	12	0.059
2004	1	0.049
2004	2	0.047
2004	3	0.5
2004	4	0.063
2004	4	0.251
2004	5	0.055
2004	6	0.068
2004	7	0.085
2004	8	0.115
2004	9	0.117
2004	10	0.099
2004	11	0.116
2004	12	0.114
2005	1	0.072
2005	2	0.031
2005	3	0.04
2005	4	0.07
2005	5	0.054
2005	6	0.104
2005	7	0.078
2005	8	0.051
2005	9	0.076
2005	10	0.124
2005	11	1.15
2005	12	0.021
2006	1	0.075
2006	2	0.04
2006	3	0.047
2006	4	0.069
2006	5	0.06
2006	11	0.087
2006	12	0.052

2007	1	0.043
2007	2	0.036
2007	3	0.034
2007	4	0.07
2007	5	0.07
2007	6	0.101
2007	11	0.141
2007	12	0.054
2008	1	0.033
2008	2	0.044
2008	3	0.039
2008	4	0.04
2008	5	0.143
2008	6	0.065
2008	8	0.064
2008	9	0.072
2008	10	0.069
2008	11	0.067
2008	12	0.057
2009	1	0.031
2009	2	0.038
2009	3	0.04
2009	4	0.139
2009	5	0.062
2009	6	0.059
2009	7	0.066
2009	8	0.123
2009	9	0.069
2009	10	0.059
2009	11	0.042
2009	12	0.059
2010	1	0.038
2010	2	0.044
2010	3	0.028
2010	4	0.068
2010	5	0.064
2010	6	0.045
2010	7	0.079
2010	8	0.07
2010	9	0.08
2010	10	0.058
2010	11	0.068
2010	12	0.04
2011	1	0.031
2011	2	0.04
2011	3	0.052
2011	4	0.07
2011	5	0.066
2011	6	0.065
2011	7	0.061
2011	8	0.067
2011	9	0.103
2011	10	0.047
2011	11	0.079

2011	12	0.04
2012	1	0.03
2012	2	0.04
2012	3	0.05
2012	4	0.043
2012	5	0.046
2012	6	0.053
2012	7	0.052
2012	8	0.06
2012	9	0.068
2012	10	0.068
2012	11	0.048
2012	12	0.042
2013	1	0.033
2013	2	0.033
2013	3	0.041
2013	4	0.04
2013	5	0.07
2013	6	0.062
2013	8	0.085
2013	10	0.06
2013	12	0.05
2014	1	0.039
2014	2	0.054
2014	3	0.05
2014	4	0.059
2014	5	0.07
2014	6	0.086
2014	7	0.067
2014	8	0.093
2014	9	0.09
2014	10	0.068
2014	11	0.055
2014	12	0.061
2015	1	0.021
2015	3	0.034
2015	4	0.067
2015	5	0.115
2015	7	0.055
2015	8	0.048
2015	8	0.057
2015	10	0.046
2015	12	0.063
2016	1	0.022
2016	2	0.5
2016	3	0.037
2016	4	0.044
2016	5	0.051
2016	6	0.058
2016	7	0.051
2016	10	0.201
2016	11	0.051
2017	1	0.5
2017	2	0.188

2017	3	0.032
2017	4	0.051
2017	5	0.06
2017	7	0.032
2017	8	1.25
2017	9	0.851
2017	10	0.066
2017	12	0.088
2018	2	0.029
2018	3	0.044
2018	4	0.0928
2018	5	0.703
2018	6	0.04
2018	8	0.1
2018	9	0.07
2018	10	0.07
2018	11	0.05
2018	12	0.05
2019	1	0.03
2019	2	0.03
2019	3	0.03
2019	4	0.04
2019	5	0.05
2019	7	0.05
2019	8	0.08
2019	10	0.04
2019	11	0.08
2019	12	0.5
2019	12	0.5
2019	12	0.03
2020	1	0.04
2020	2	0.03
2020	3	0.5
2020	3	0.5
2020	3	0.03
2020	4	0.04
2020	5	0.05
2020	7	0.04
2020	8	0.06
2020	9	0.5
2020	9	0.04
2020	9	0.5

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

Data set:  TP ARK0060 1993-2020

The record is 28 complete water years with  12 seasons per year
   beginning in water year 1993.

The tau correlation coefficient is -0.239
    S =   -839.
    z =  -5.736
    p =  0.0000
    p =  0.0003 adjusted for correlation among seasons
                (such as serial dependence)
The adjusted p-value should be used only for data with
   more than 10 annual values per season.

The estimated trend may be described by the equation:

   Y =  0.7922E-01 +  -0.9444E-03 * Time

   where Time = Year (as a decimal) - 1992.75
                                     (beginning of first water year)
```

Station ARK0097 Input File

```
2 0       TP ARK0097 1993-2019
1993 1  0.355
1993 6  0.244
1993 7  0.206
1993 8  0.285
1993 9  0.541
1993 10 1.2
1993 11 2.68
1993 12 0.344
1994 2  0.149
1994 3  0.337
1994 4  0.168
1994 5  0.334
1994 6  0.424
1994 7  0.58
1994 8  0.218
1994 9  0.419
1994 10 1.39
1994 11 5.24
1994 11 0.386
1995 1  0.132
1995 2  0.442
1995 3  0.429
1995 4  0.277
1995 5  0.377
1995 6  0.356
1995 7  0.241
1995 8  0.342
1995 9  0.195
1995 10 0.389
1995 10 1.51
1995 11 0.669
1996 1  0.394
1996 2  0.45
1996 4  0.211
1996 5  0.463
1996 6  0.45
1996 7  0.36
1996 8  0.328
1996 9  0.358
1996 10 0.192
1996 11 0.387
1996 12 0.138
1997 1  0.244
1997 2  0.158
1997 4  0.181
1997 5  0.338
1997 6  0.27
1997 7  0.54
1997 8  0.204
1997 9  0.29
1997 10 0.629
1997 12 0.833
```

1997	12	0.266
1998	1	0.164
1998	2	0.428
1998	3	0.261
1998	4	0.365
1998	5	0.29
1998	6	0.316
1998	6	1.69
1998	8	0.16
1998	9	0.115
1998	10	0.599
1998	11	1.49
1998	12	0.847
1999	1	0.339
1999	2	0.186
1999	3	0.382
1999	4	0.171
1999	5	0.313
1999	6	0.755
1999	7	0.214
1999	8	0.145
1999	9	0.476
1999	10	4.13
1999	11	1.179
1999	12	0.312
2000	1	1.09
2000	2	0.286
2000	3	0.598
2000	4	0.455
2000	5	0.526
2000	6	0.567
2000	7	1.927
2000	8	0.148
2000	9	0.144
2000	10	3.692
2000	10	7.058
2000	12	0.25
2001	1	0.28
2001	2	0.662
2001	3	0.11
2001	4	0.244
2001	5	0.282
2001	6	0.94
2001	7	0.191
2001	8	0.087
2001	9	1.113
2001	10	1.398
2001	11	1.209
2001	12	0.17
2002	1	0.179
2002	2	0.362
2002	3	0.12
2002	4	0.31
2002	5	0.413

2002	6	0.2
2002	7	3.46
2002	8	0.657
2002	9	0.139
2002	10	0.291
2003	1	0.348
2003	2	0.424
2003	3	0.237
2003	4	0.386
2003	5	0.296
2003	6	0.26
2003	7	0.567
2003	9	0.624
2003	10	1.56
2003	11	3.06
2003	12	0.293
2004	1	0.28
2004	2	0.311
2004	3	0.304
2004	4	0.197
2004	5	0.337
2004	6	0.422
2004	7	0.295
2004	8	0.188
2004	9	0.047
2004	10	0.333
2004	11	0.311
2004	12	0.112
2005	1	0.238
2005	2	0.171
2005	3	0.291
2005	4	0.3
2005	5	0.279
2005	6	0.164
2005	7	0.122
2005	8	0.459
2005	9	0.442
2005	10	0.182
2005	11	0.108
2005	12	0.54
2006	1	0.299
2006	2	0.289
2006	3	0.393
2006	4	0.399
2006	5	0.47
2006	6	0.56
2006	7	0.155
2006	8	0.183
2006	9	0.379
2006	10	0.866
2006	11	0.472
2006	12	0.44
2007	1	0.125
2007	2	0.255

2007	3	0.2
2007	4	0.281
2007	5	0.461
2007	6	0.576
2007	7	0.278
2007	8	0.066
2007	9	0.399
2007	10	0.29
2007	11	0.675
2007	12	0.368
2008	1	0.304
2008	2	0.203
2008	3	0.169
2008	4	0.11
2008	5	0.314
2008	6	0.444
2008	7	0.152
2008	8	0.159
2008	9	0.353
2008	10	0.289
2008	11	0.418
2008	12	0.266
2009	1	0.308
2009	2	0.162
2009	3	0.136
2009	4	0.341
2009	5	0.227
2009	6	1.9
2009	7	0.29
2009	8	0.194
2009	9	0.251
2009	10	0.164
2009	11	0.077
2009	12	0.22
2010	1	0.139
2010	2	0.075
2010	3	0.141
2010	4	0.282
2010	5	0.552
2010	6	0.364
2010	7	0.16
2010	8	0.268
2010	9	0.747
2010	10	0.31
2010	11	0.15
2010	12	0.3
2011	1	0.183
2011	2	0.177
2011	3	0.181
2011	4	0.385
2011	5	0.261
2011	6	1.09
2011	7	0.264
2011	8	0.164

```
2011 9  0.206
2011 10 0.589
2011 11 0.305
2011 12 0.068
2012 1  0.265
2012 2  0.169
2012 3  0.261
2012 4  0.28
2012 5  4.28
2012 6  0.329
2012 7  0.204
2012 8  0.882
2012 9  0.352
2012 10 0.357
2012 11 0.708
2012 12 0.784
2013 1  0.599
2013 2  0.203
2013 3  0.348
2013 4  0.111
2013 5  0.244
2013 6  0.598
2013 7  1.2
2013 8  0.142
2013 9  0.355
2013 10 0.274
2013 11 0.411
2013 12 0.271
2014 1  0.171
2014 2  0.468
2014 3  0.272
2014 4  0.161
2014 5  0.264
2014 6  0.237
2014 7  0.203
2014 8  0.155
2014 9  0.181
2014 10 0.174
2014 11 0.263
2014 12 0.26
2015 1  0.213
2015 3  0.2
2015 4  0.333
2015 5  0.229
2015 6  0.181
2015 7  0.192
2015 8  0.159
2015 8  0.169
2015 10 1.26
2015 11 0.19
2015 12 0.264
2016 1  0.2
2016 2  0.251
2016 3  0.185
```

2016	4	0.234
2016	5	0.148
2016	6	0.366
2016	7	0.14
2016	8	0.325
2016	9	0.272
2016	10	0.792
2016	11	0.042
2016	12	0.304
2017	1	0.377
2017	2	0.577
2017	4	0.343
2017	5	0.283
2017	6	0.361
2017	7	0.441
2017	8	0.182
2017	9	0.313
2017	10	0.24
2017	12	0.173
2018	2	0.24
2018	3	0.298
2018	4	0.223
2018	5	0.331
2018	6	0.26
2018	8	0.32
2018	9	0.25
2018	10	0.22
2018	11	0.17
2018	12	0.18
2019	1	0.15
2019	2	0.08
2019	3	0.21
2019	4	0.21
2019	5	0.17
2019	7	0.19
2019	8	0.26
2019	10	0.25
2019	11	0.27
2019	12	0.2
2019	12	0.5
2019	12	0.5
2020	1	0.14
2020	2	0.2
2020	3	0.21
2020	3	0.5
2020	3	0.5
2020	4	0.17
2020	5	0.24
2020	6	0.5
2020	6	0.5
2020	6	0.35
2020	7	0.28
2020	8	0.12
2020	9	0.5

```
2020 9  0.28
2020 9  0.5
```

Station ARK0097 Output File

```
     Seasonal Kendall Test for Trend
       US Geological Survey, 2009

 Data set:  TP ARK0097 1993-2019

 The record is 28 complete water years with  12 seasons per year
    beginning in water year 1993.

 The tau correlation coefficient is -0.181
     S =    -698.
     z =  -4.461
     p =  0.0000
     p =  0.0006 adjusted for correlation among seasons
                 (such as serial dependence)
 The adjusted p-value should be used only for data with
    more than 10 annual values per season.

 The estimated trend may be described by the equation:

    Y =  0.3495     +  -0.4569E-02 * Time

    where Time = Year (as a decimal) - 1992.75
                                      (beginning of first water year)
```

APPENDIX F

Evaluation of Current Groundwater Quality

Measurements of selected parameters of concern collected during 2015-2019 by USGS and DEQ are summarized below. The data used for this summary were downloaded in February 2021 from online databases managed by DEQ and USGS (DEQ 2020a, USGS 2020). With regard to human health, the primary water quality parameters of concern are nitrate, nitrite, and pesticides. Minerals in groundwater are also of interest if there is the potential for surface water impacts from runoff of groundwater used for irrigation or aquaculturF.

F.1 Nitrate and Nitrite in Groundwater

Nitrite was not measured at any of the monitoring wells during 2015-2019. Nitrate + nitrite nitrogen was measured once in the DEQ monitoring wells during 2015-2019, in 2018. All nitrate + nitrite nitrogen measurement results from this DEQ sampling event were reported as less than detection. Nitrate nitrogen was measured at only two of the USGS monitoring wells, 342847091345702 (Alluvial aquifer) and 342925091314701 (Sparta aquifer), but not during 2015-2019. All nitrate nitrogen measurements from these wells collected since 2000 were reported as less than the detection limit. Data reported in Kresse et al. (2014) also show nitrate concentrations as being less than 1.5 mg/L in both the Alluvial aquifer and the Sparta aquifer under the Bayou Meto watershed. As a result, there is no indication that nitrate or nitrite in groundwater is an issue in the Bayou Meto watershed.

F.2 Pesticides in Groundwater

DEQ measured concentrations of 58 organic compounds, including pesticides, in seven of their nine water quality monitoring wells (the two wells where pesticides were not measured were LON004 and LON022A). A list of the organic compounds DEQ measured is provided in Table 1. However, DEQ did not measure organics in their monitoring wells during 2015-2019. The most recent measurements were collected in 2010. All of the measurements from this sampling event were reported as less than the detection limit.

Table 1. Organic compounds measured by DEQ and USGS in groundwater from wells in the Bayou Meto watershed.

Name of Organic Compound	Measured by DEQ	Measured by USGS
.alpha.-Endosulfan	X	X
.beta.-Endosulfan	X	
.beta.-Hexachlorocyclohexane	X	
.delta.-Hexachlorocyclohexane	X	
Alachlor	X	X
Aldrin	X	X
Ametryn	X	
Atraton	X	
Atrazine	X	X
Chloroneb	X	
Chlorothalonil	X	
Chlorpyrifos	X	X
cis-Chlordane	X	X
Clomazone	X	
Cyanazine	X	X
Cyclohexane	X	
Diazinon	X	X
Dieldrin	X	X
Endosulfan sulfate	X	
Endrin	X	X
Endrin aldehyde	X	
Endrin ketone	X	
Ethylan	X	
Fluchloralin	X	
Fonofos	X	X
Heptachlor	X	X
Heptachlor epoxide	X	X
Hexachlorobenzene	X	
Hexazinone	X	
Lindane	X	X
Malathion	X	X
Methoxychlor	X	
Methyl parathion	X	X
Metolachlor	X	X
Metribuzin	X	X
Mirex	X	X
Molinate	X	X
p,p'-DDE	X	X
PCB 1221	X	
PCB 1232	X	
PCB 1242	X	
PCB 1248	X	
PCB 1254	X	
PCB 1260	X	

Table 3.4. Organic compounds measured by DEQ and USGS in groundwater from wells in the Bayou Meto watershed (continued).

Name of Organic Compound	Measured by DEQ	Measured by USGS
PCBs	X	X
Parathion	X	X
Pendimethalin	X	X
Permethrin	X	(cis-Permethrin)
Prometon	X	X
Prometryn	X	
Propachlor	X	X
Propazine	X	
Secbumeton	X	
Simazine	X	X
Terbuthylazine	X	
Terbutryn	X	
trans-Chlordane	X	
trans-Nonachlor	X	
Triazines mixture, unspecified	X	
Trifluralin	X	X

USGS measured concentrations of organic compounds, including pesticides, in two wells, but those measurements were not during 2015-2019. The most recent organics measurements were collected in 2004 from well 342847091345702 (Alluvial aquifer), and in 2008 from well 342925091314701 (Sparta aquifer). All of the measurements from 2004 and 2008 were reported as less than the detection limit. Table 1 shows which organic compounds were measured by USGS.

A map of wells sampled by the Arkansas Department of Agriculture Pesticides Section shows one well in Lonoke County where pesticides were detected that appears to be located within the Bayou Meto watershed (https://www.agriculturF.arkansas.gov/wp-content/uploads/2020/05/Ground-Water-Monitoring-Program-Doc-1.pdf). At this time, more detailed information is not available from the Arkansas Department of Agriculture website, regarding when this well was sampled, what pesticide(s) was detected, or what concentration of the detected pesticide(s) was measured.

Based on the data described above, pesticides in groundwater does not appear to be a widespread issue in the Bayou Meto watershed. There may be a localized occurrence of pesticides in the Alluvial aquifer in Lonoke County.

F.3 Minerals

Arkansas has numeric water quality criteria for chloride, sulfate, and TDS in surface water. These minerals can also be a concern for crop irrigation, and guidelines for concentrations of these and other minerals have been published (Bauder, et al. 2014; McFarland, Lemon and Stichler 2002; Hardke 2018). Table 2 shows a comparison of recommended concentrations of these minerals in irrigation water to the numeric surface water quality standards that apply in the agricultural area of the Bayou Meto watershed. Note that while we did not find irrigation guidelines for sulfate, sulfate compounds contribute to salinity in groundwater, for which there are guidelines. Concentrations of chloride and TDS allowed in irrigation water are greater than the numeric surface water quality criteria. Given this fact and the amount of groundwater put on the land and potentially entering surface waters in the Bayou Meto watershed, it could be useful to compare groundwater mineral concentrations to numeric surface water mineral criteria.

Table 2 includes the range of concentrations of chloride, sulfate, and TDS measured in selected wells sampled by DEQ and USGS during the period 2015-2019. DEQ identifies the wells they sample that are used for irrigation or aquaculturF. Therefore, only the measurements from these six wells (five irrigation wells and one aquaculture well) are summarized in Table 2. USGS identifies the aquifer from which the wells they sample draw groundwater. Since the majority of groundwater used for agricultural purposes in the watershed is withdrawn from the Alluvial aquifer, only measurements from wells pulling from this aquifer are summarized in Table 2.

Table 2. Evaluation of minerals in irrigation water.

Parameter	Guidelines for maximum concentration for irrigation use, mg/L[a]	Surface water numeric criterion for cropland area of Bayou Meto watershed, mg/L	2015-2019 concentrations in irrigation wells and aquaculture well sampled by DEQ	2015-2019 concentrations in Alluvial aquifer wells sampled by USGS
Chloride	70 - 710	95	6.18 - 36.4	7.07 - 127
Sulfate	None	45	1.5 - 65.8	29.2 - 185
TDS	704 - 3264	240	211 - 456	388 - 698

[a] Bauder et al. 2014, McFarland et al. 2002, Hardke 2018, crops vary in their sensitivity, so a range of values are published.

Chloride was measured by DEQ and USGS in all of the wells they sampled during 2015-2019. All but one of these wells was sampled only once during this period. Well 342847091345702 was sampled twice during this period, and chloride was measured both times. All but one of the measured chloride concentrations during 2015-2019 (from well 340740091211501) was less than the applicable surface water numeric criterion. Therefore, chloride from groundwater does not appear to have much potential for causing a chloride impairment of surface waters in the Bayou Meto watershed.

Sulfate was measured by DEQ in all of the wells they sampled during 2015-2019. The USGS measured sulfate in only three Alluvial aquifer wells during this period. Overall, measured sulfate concentrations from four of the nine wells sampled during 2015-2019 exceeded the sulfate numeric criterion for surface water. This suggests that sulfate in groundwater has the potential to contribute to sulfate impairment of surface waters in the Bayou Meto watershed.

TDS was measured by DEQ in all of the wells they sampled during 2015-2019. The USGS measured TDS in only three Alluvial aquifer wells during this period. Overall, measured TDS concentrations from eight of the nine wells sampled during 2015-2019 exceeded the TDS numeric criterion for surface water. This suggests that TDS in groundwater has the potential to contribute to TDS impairment of surface waters in the Bayou Meto watershed.

It is worth noting that there is currently no evidence, beyond the mineral concentrations measured in groundwater, to suggest that minerals in groundwater are impacting mineral concentrations in Bayou Meto surface waters. Despite the fact that groundwater has been used for aquaculture and crop irrigation in this watershed for decades, the only minerals-related surface water impairment identified in the Bayou Meto watershed is for a location upstream of the agricultural area of the watershed. In addition, no increasing trend in TDS concentration was identified at any of the long-term water quality monitoring stations in the watershed.

F.4 Summary

Groundwater is an important water resource in the Bayou Meto watershed, particularly in the agricultural area of the watershed. Groundwater quality was measured by DEQ, NRD, and USGS at over 35 wells in the Bayou Meto watershed during 2015-2019. The most frequently measured parameters were temperature and specific conductancF. Based on the information available from 2015-2019, groundwater quality in the Bayou Meto watershed appears to meet drinking water standards. Mineral concentrations in groundwater from the Alluvial aquifer (which is used for irrigation and aquaculture) do exceed surface water criteria for sulfate and TDS. However, there is no indication in the surface water quality data that use of this groundwater has significantly increased sulfate or TDS concentrations in the surface waters of this watershed. Groundwater that is used for irrigation is typically diluted by surface runoff before it reaches a stream.

F.5 REFERENCES

Bauder, TA, RM Waskom, PL Sutherland, and JG Davis. 2014. *Irrigation Water Quality Criteria.* Fact Sheet No. 0.506, Fort Collins: Colorado State University Extension.

Hardke, Jarrod T, ed. 2018. *Rice Production Handbook.* Little Rock, AR: University of Arkansas Division of Agriculture Cooperative Extension ServicF.

Kresse, TM, PD Hays, KR Merriman, JA Gillip, DT Fugitt, JT Spellman, AM Nottmeier, DA Westerman, JM Blackstock, and JL Battreal. 2014. *Aquifers of Arkansas - Protection, Managment, and Hydraulic and Geochemical Characteristics of Groundwater Resources in Arkansas.* Scientific Investigations Report 2014-5149, USGS.

McFarland, Mark, Robert Lemon, and Charles Stichler. 2002. *Irrigation Water Quality*. Fact Sheet L-5417, College Station: Texas A&M AgriLife Extension.

Safe Drinking Water Foundation. 2017. "TDS and pH Fact Sheet." *Safe Drinking Water Foundation.* January 23. Accessed December 23, 2020. https://www.safewater.org/fact-sheets-1/2017/1/23/tds-and-ph.

APPENDIX G

Bayou Meto HUC12 Ranking

To identify HUC12 subwatersheds to recommend for additional management of nonpoint source pollution under this plan, available information was used to rank all of the HUC12 subwatersheds of the Bayou Meto watershed in terms of water quality and habitat concerns. Thirteen water quality-related criteria were assessed and used to rank each of the HUC12 subwatersheds. The following information was used to rank the HUC12 subwatersheds:

- Water quality impairment;
- Water quality data, including loads and natural resource concerns; and
- Aquatic communities and habitat, including the presence of designated habitat of conservation concern, and habitat-related resource concerns.

G.1 Water Quality Impairment

Almost 198 miles of streams and almost 890 acres of reservoirs in the Bayou Meto watershed were classified as impaired on the 2018 Arkansas 303(d) list (DEQ 2020). For ranking, HUC12 subwatersheds containing stream reaches or reservoirs classified as impaired by low dissolved oxygen (DO) or total dissolved solids (TDS) were assigned a value of one. In addition, all HUC12 subwatersheds upstream of a HUC12 with an impaired stream reach were assigned a value of one, because pollutants from upstream subwatersheds may contribute to stream impairment. All other HUC12 subwatersheds were assigned a value of zero. Figure 1 shows the locations of impaired stream reaches and the associated HUC12 subwatersheds. Figure 2 summarizes the water quality impairment ranking of the Bayou Meto HUC12 subwatersheds.

G.2 Water Quality Data

Measurements of water quality were available from only 10 HUC12 subwatersheds. Recent water quality data (from 2015 – 2019) were available from eight HUC12 subwatersheds, most of them in the upper watershed (Figure 3). Overall, the available water quality measurements were not considered appropriate for identifying recommended HUC12 subwatersheds. Modeled areal loads (SWAT model) and NRCS water quality degradation resource concerns information were available for all the HUC12 subwatersheds, so this information was used to rank the HUC12 subwatersheds.

A recent SWAT modeling project of the Bayou Meto watershed estimated areal loads (loads per unit of watershed area) of total nitrogen, total phosphorus, and sediment from each of the HUC12 subwatersheds (FTN Associates, Ltd. 2021). The modeled loads for the HUC12s were ranked from highest loads to lowest. Separate ranking values were assigned to the HUC12 subwatersheds for nitrogen, phosphorus, and sediment loads. For each parameter, the seven HUC12 subwatersheds with the highest modeled load (representing the upper quartile) were assigned a value of one. All other HUC12 subwatersheds were assigned a value of zero for that parameter load. Figure 4 summarizes the load rankings of the Bayou Meto HUC12 subwatersheds. There are several subwatersheds where more than one constituent load was in the top quartile. There are no subwatersheds where all three loads were in the top quartile.

Figure 1. Impaired stream reaches in Bayou Meto HUC12 subwatersheds.

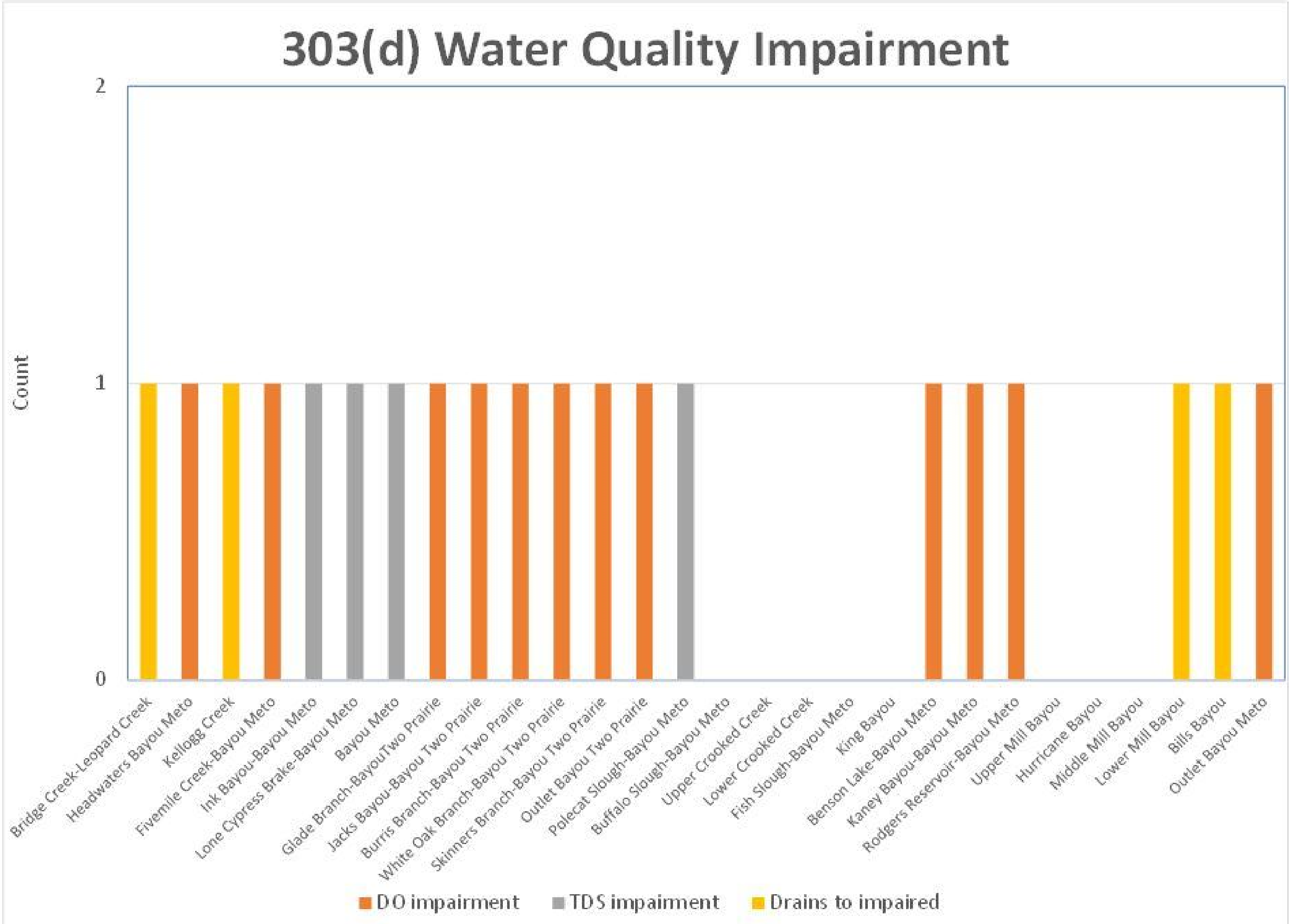

Figure 2. Summary of water quality impairment ranking of Bayou Meto HUC12 subwatersheds.

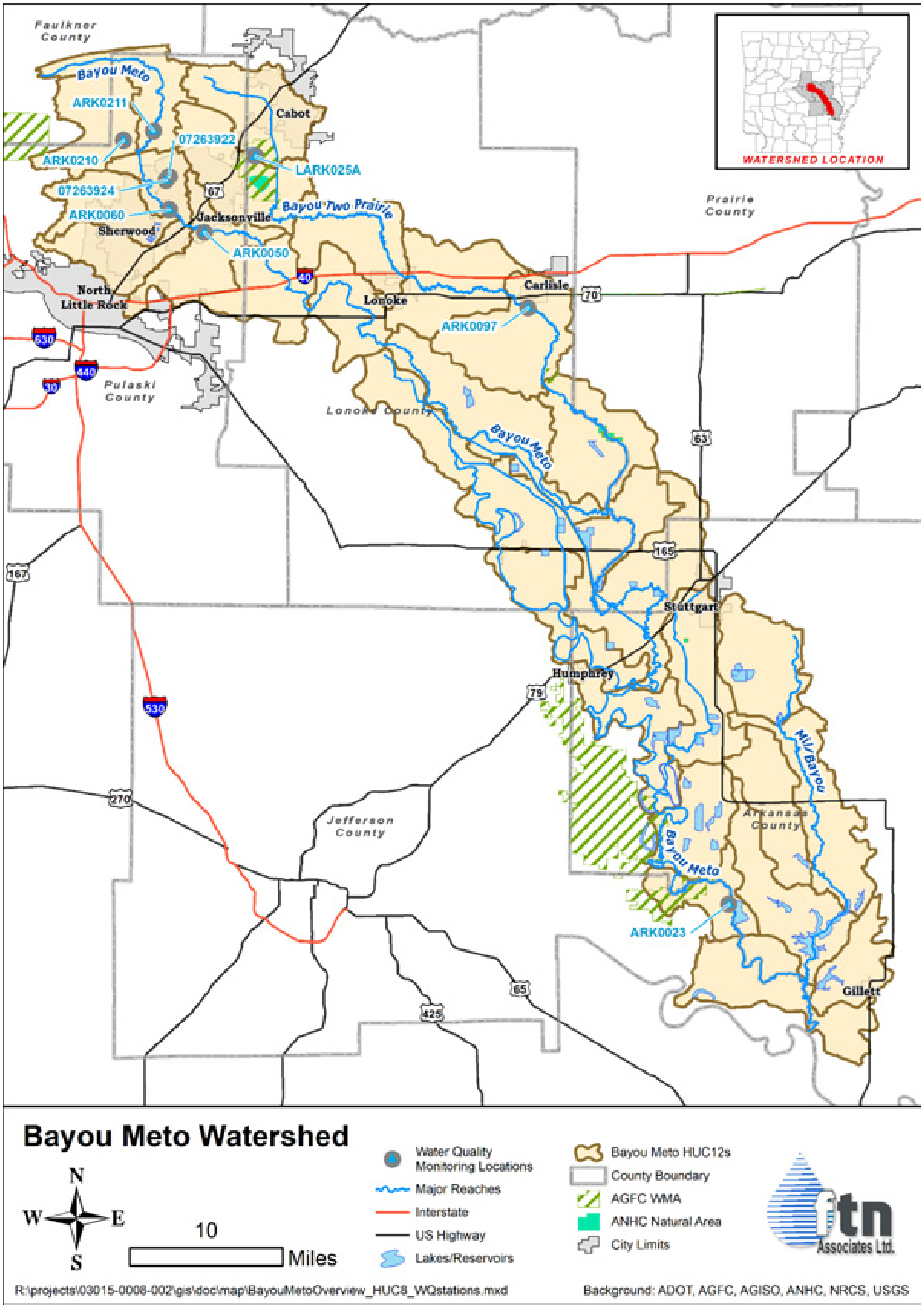

Figure 3. Water quality monitoring locations in the Bayou Meto HUC12 subwatersheds.

Figure 4. Summary of Bayou Meto HUC12 subwatershed ranks based on SWAT modeled nutrient and sediment loads.

Area-weighted risks assigned to HUC12 subwatersheds for water quality degradation resource concerns in the NRCS 2015 Arkansas State Resource Assessment were also ranked from highest to lowest. Separate ranking values (one or zero) were assigned to the HUC12 subwatersheds for each of the following water quality degradation natural resource concerns:

- Excess nutrients in surface water and groundwater;
- Excess sediment in surface water;
- Petroleum, heavy metals, and other pollutants transported to receiving water sources;
- Pesticides and herbicides transported to surface water and groundwater; and
- Excess pathogens and chemicals from manure, biosolids, or compost applications.

For each resource concern, the seven HUC12 subwatersheds (representing the upper quartile) with the highest area-weighted risks were assigned a value of one. All other HUC12 subwatersheds were assigned a value of zero for that resource concern. Figure 5 summarizes the water resource concern rankings of the Bayou Meto HUC12 subwatersheds. Several subwatersheds were in the upper quartile of area-weighted risk for multiple resource concerns. The subwatershed with the highest number of resource concerns had four rankings in the upper quartile.

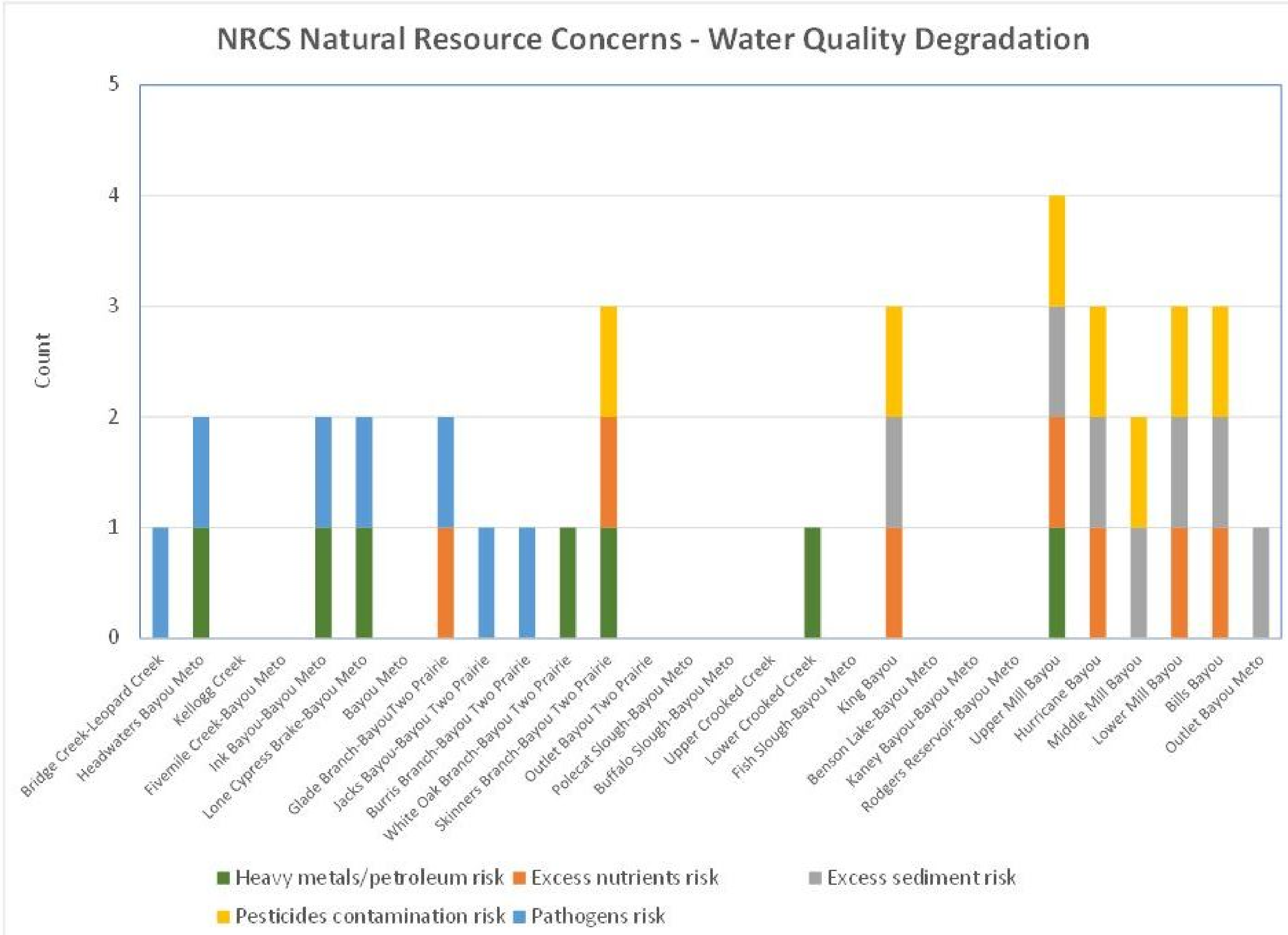

Figure 5. Summary of Bayou Meto HUC12 subwatershed ranks based on NRCS water quality resource concerns risk.

G.3 Aquatic Communities and Habitat

The quality of aquatic habitat in the Bayou Meto watershed has been altered significantly over time. Recent surveys have characterized aquatic communities throughout the watershed as primarily composed of species tolerant of poor-quality habitat (see Section). As a result, criteria derived from characteristics of aquatic communities were not useful for identifying recommended subwatersheds.

Aquatic habitat concerns, however, were incorporated into the HUC12 subwatershed ranking by considering the presence of state-designated Extraordinary Resource Waters, Wildlife Management Areas, and Natural Areas. The locations of waterbodies with these designations are shown in Figure 6. All HUC12 subwatersheds containing waterbodies with one or more of these designations were assigned a value of one. In addition, all HUC12 subwatersheds that drain to a HUC12 containing waterbodies with these designations were assigned a value of one, because pollutants from upstream subwatersheds may impact conditions in the designated waterbodies. All other HUC12 subwatersheds were assigned a value of zero.

Two NRCS resource concerns were used to rank aquatic habitat concerns in the HUC12 subwatersheds: degradation of wildlife habitat and excessive bank erosion from streams, shorelines, or water conveyance channels. Streambank erosion was used as an indicator of the condition of riparian areas. Area-weighted mean risks assigned to HUC12 subwatersheds for these two resource concerns were ranked from highest to lowest. Separate ranking values were assigned for each resource concern. For each resource concern, the seven HUC12 subwatersheds with the highest area-weighted mean risks were assigned a value of one. All other HUC12 subwatersheds were assigned a value of zero. Figure 7 provides a summary of the aquatic habitat ranking of the Bayou Meto subwatersheds. There are several HUC12 subwatersheds where more than one habitat criterion was ranked in the top quartile.

G.4 Overall Ranking

The overall ranking for each Bayou Meto HUC12 subwatersheds, was determined by summing the assigned values of one and zero for each criterion, as shown in Figure 8. HUC12 subwatersheds with higher totals were considered to have a greater number of water quality concerns and to be most likely to benefit from implementation of additional nonpoint source pollution management practices. The highest total value from the ranking was seven, which occurred for two HUC12s. Four HUC12 subwatersheds had total values equal to six. These six HUC12 subwatersheds are recommended for management under this watershed management plan.

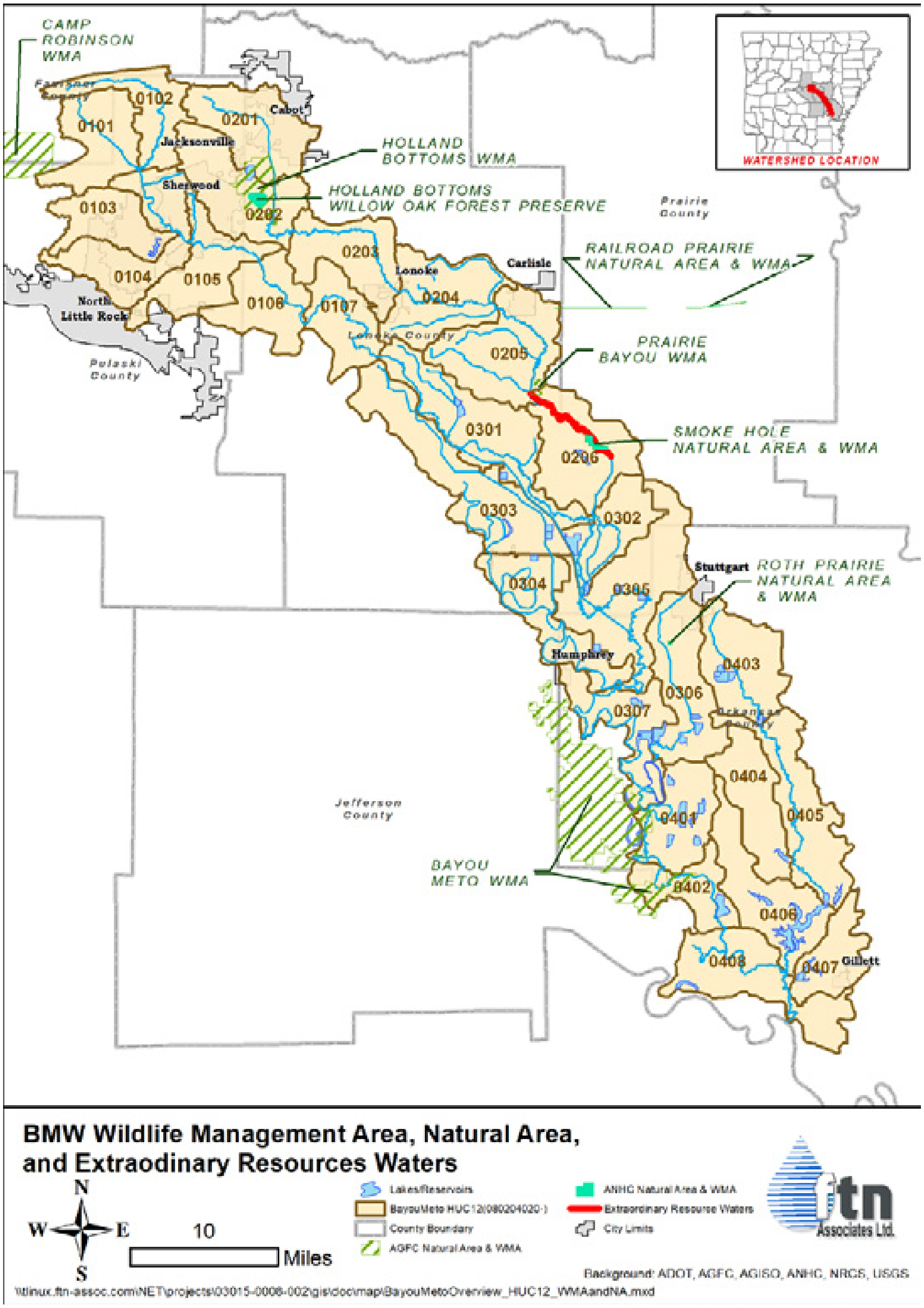

Figure 6. Extraordinary Resource Waters, Wildlife Management Areas, and Natural Areas within the Bayou Meto watershed.

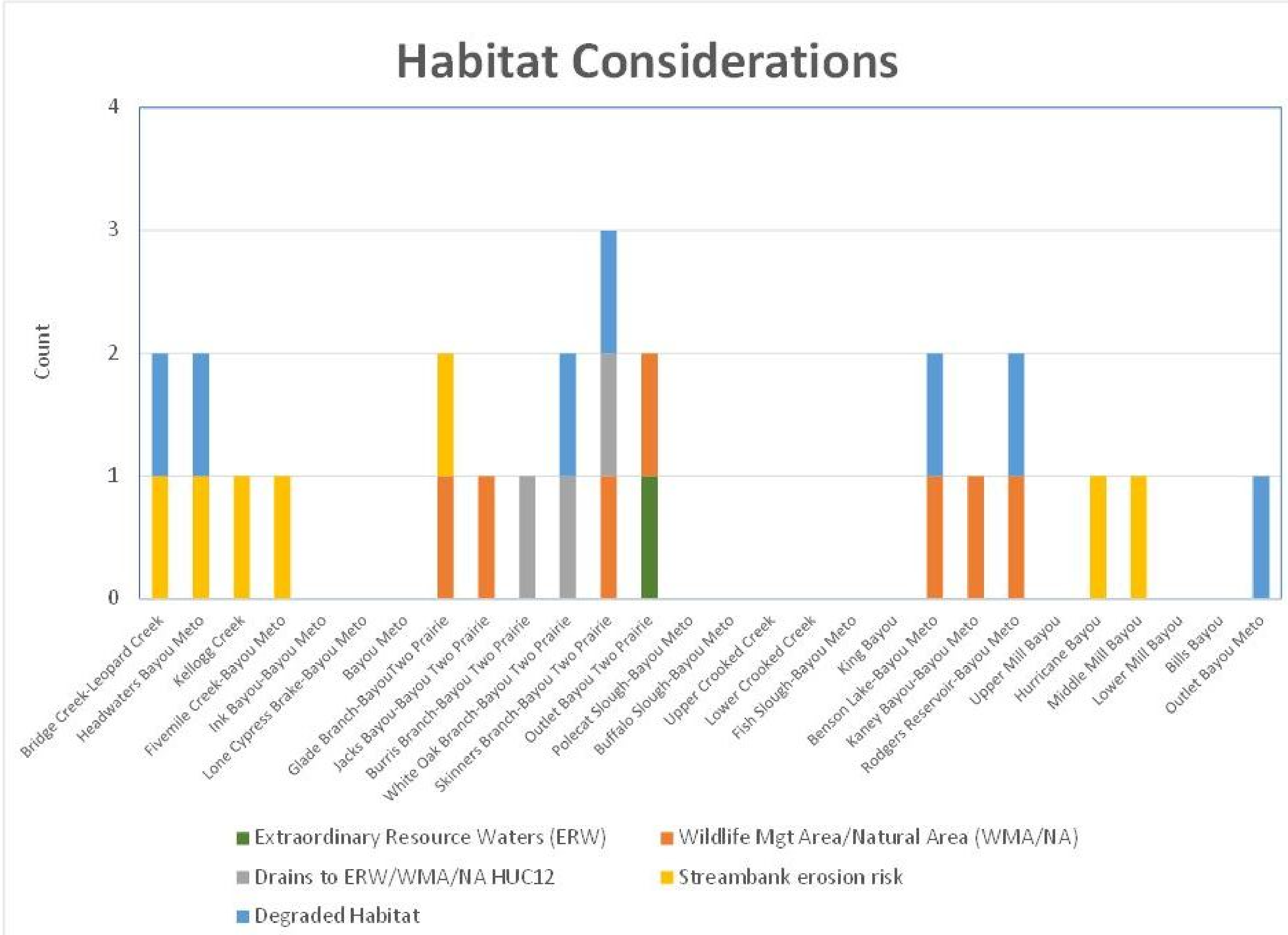

Figure 7. Summary of Bayou Meto HUC12 subwatershed ranks based on aquatic habitat indicators.

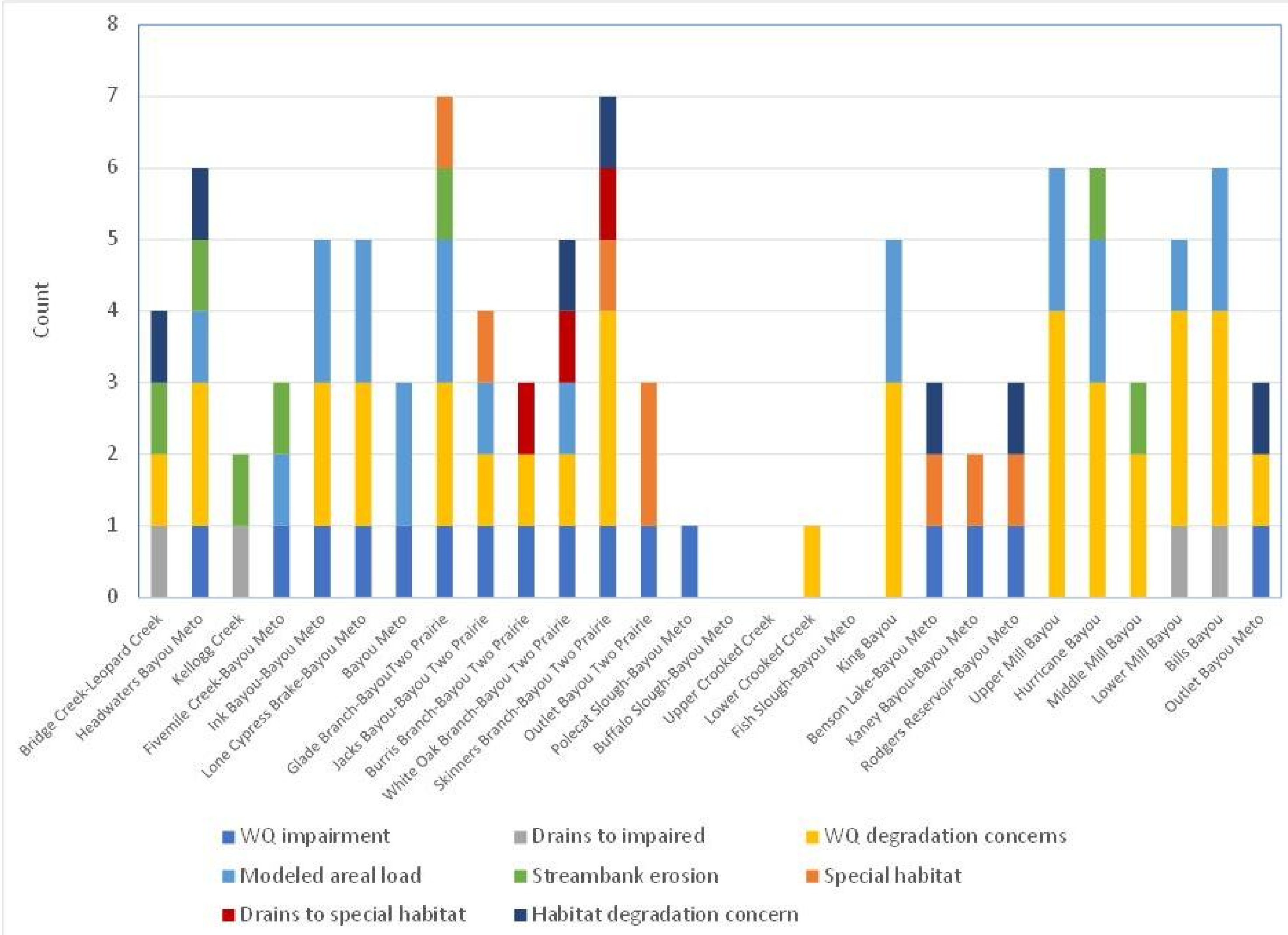

Figure 8. Summary of ranking totals for the Bayou Meto HUC12 subwatersheds.

G.5 References

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APPENDIX H

Analysis of Relationships Between DO and Other Parameters

Often, low dissolved oxygen (DO) conditions in Arkansas waterbodies are a result of excessive algal production caused by nutrient inputs. In such situations, management of nutrient inputs will improve DO conditions. Water quality data from monitoring stations used to determine the DO impairment of stream reaches in the recommended subwatersheds were examined for correlations between DO and nutrient concentrations. Simple data graphs and Pearson Correlation analysis (shown in Figures 1 through 12) did not indicate significant linear correlation between nutrient and DO concentrations, neither overall, nor seasonally.
Figures 1 – 4 show graphs of DO concentrations versus temperature and nutrient concentrations, with Pearson Correlation coefficients, for all of the measurements collected from 2000 through 2020. Figures 5 – 8 show graphs of DO concentrations versus temperature and nutrient concentrations, with Pearson Correlation coefficients, using measurements collected 2000-2020 during the Primary Season for DO, i.e., when water temperature is 22°C or less, usually September – May. Figures 9 –12 show graphs of DO concentrations versus temperature and nutrient concentrations, with Pearson Correlation coefficients, using measurements collected 2000-2020 during the Critical Season for DO, i.e., when water temperature is greater than 22°C, usually May-September.

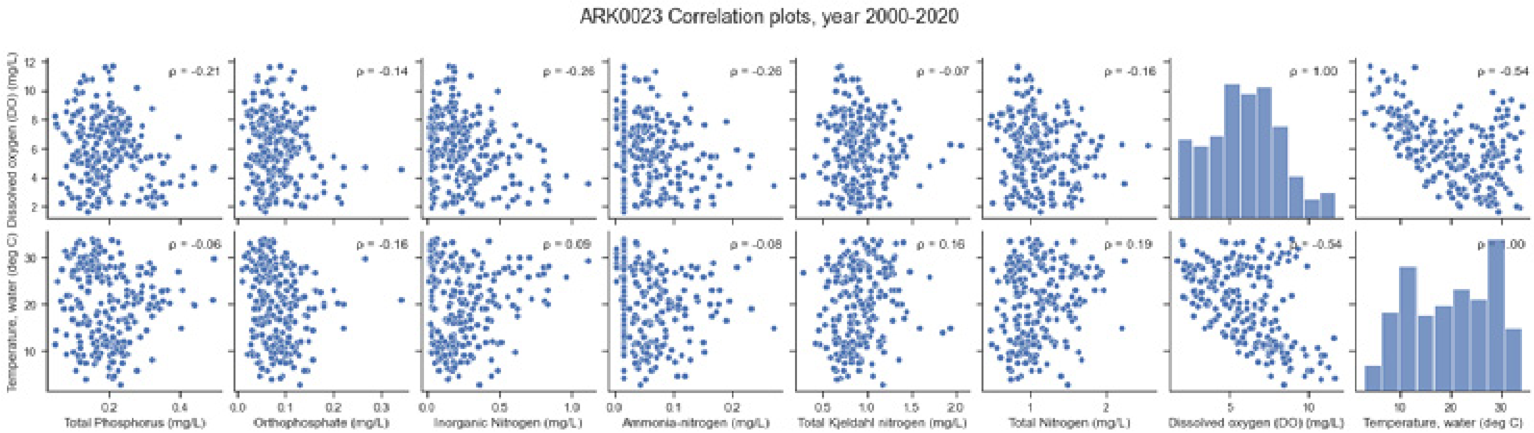

Figure 1. Correlation between DO, temperature, and nutrient measurements from 2000 through 2020 at DEQ station AR0023, Bayou Meto at SR11.

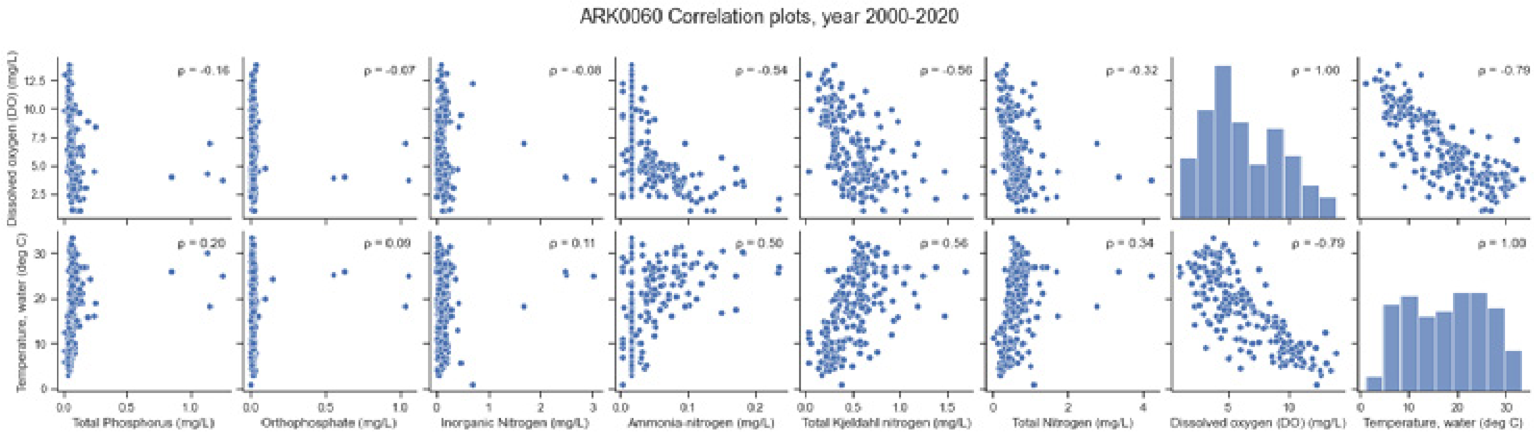

Figure 2. Correlation between DO, temperature, and nutrient measurements from 2000 through 2020 at DEQ station AR0060, Bayou Meto Main Street in Jacksonville.

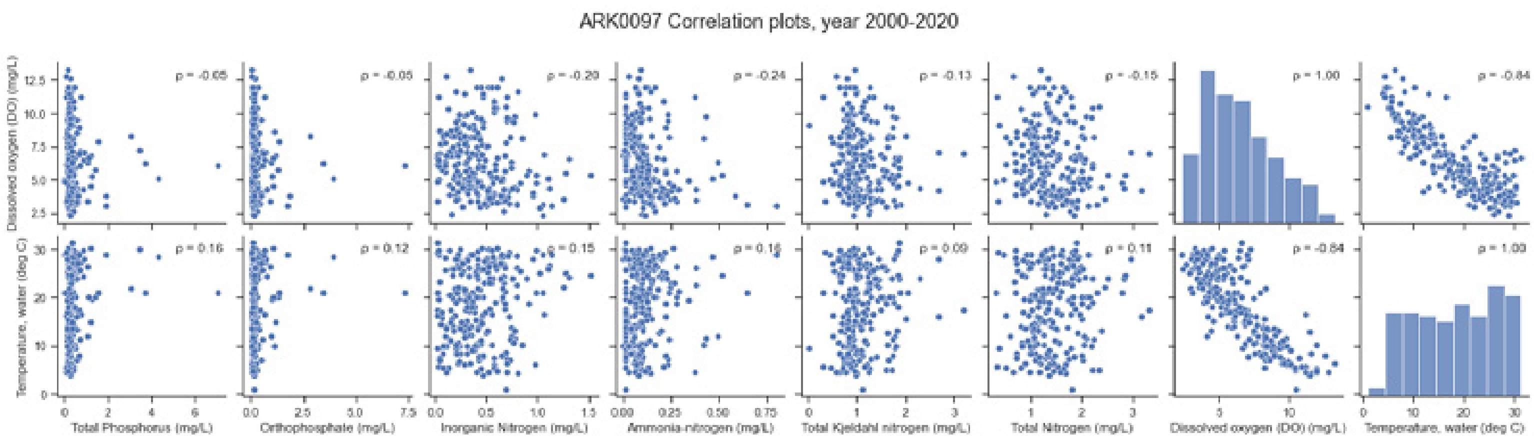

Figure 3. Correlation between DO, temperature, and nutrient measurements from 2000 through 2020 at DEQ station AR0097, Bayou Two Prairie at Highway 13.

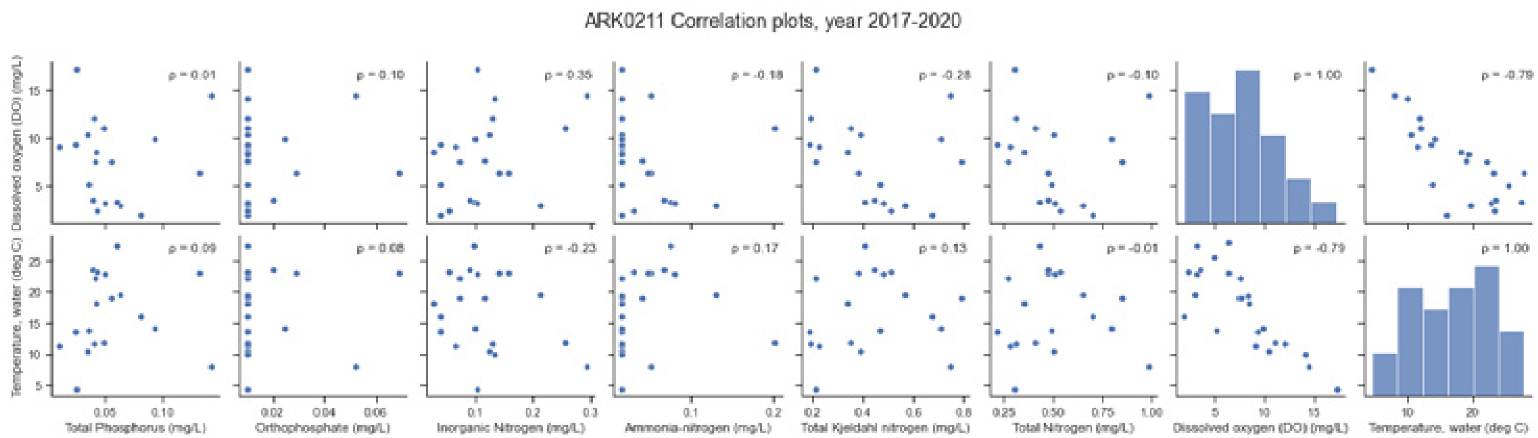

Figure 4. Correlation between DO, temperature, and nutrient measurements from 2000 through 2020 at DEQ station AR0211, Bayou Meto at CR70.

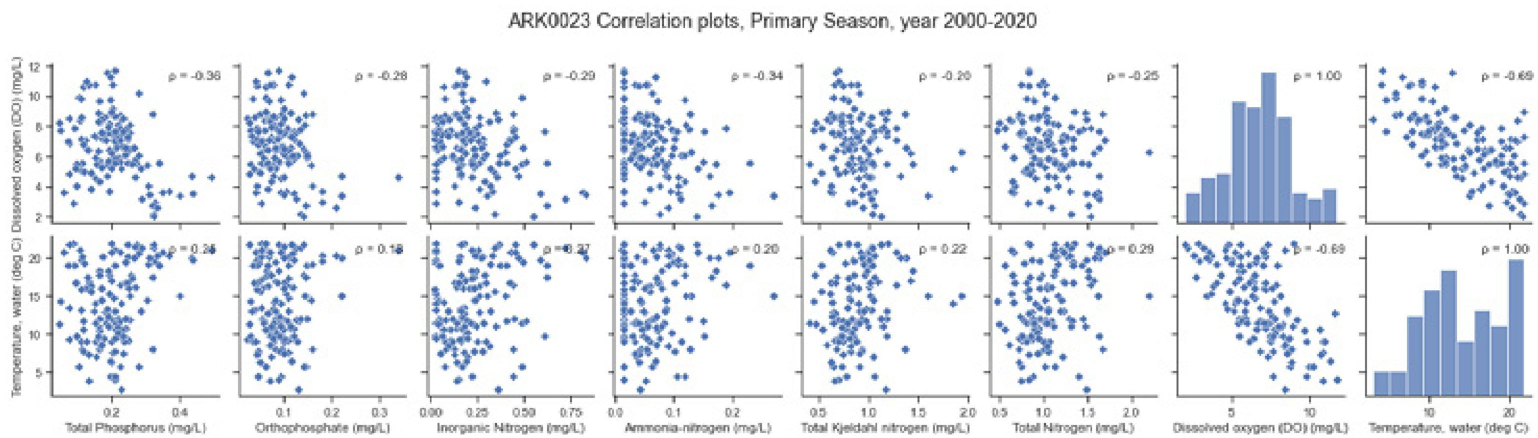

Figure 5. Correlation between DO, temperature, and nutrient measurements from Primary Season at DEQ station AR0023, Bayou Meto at SR11.

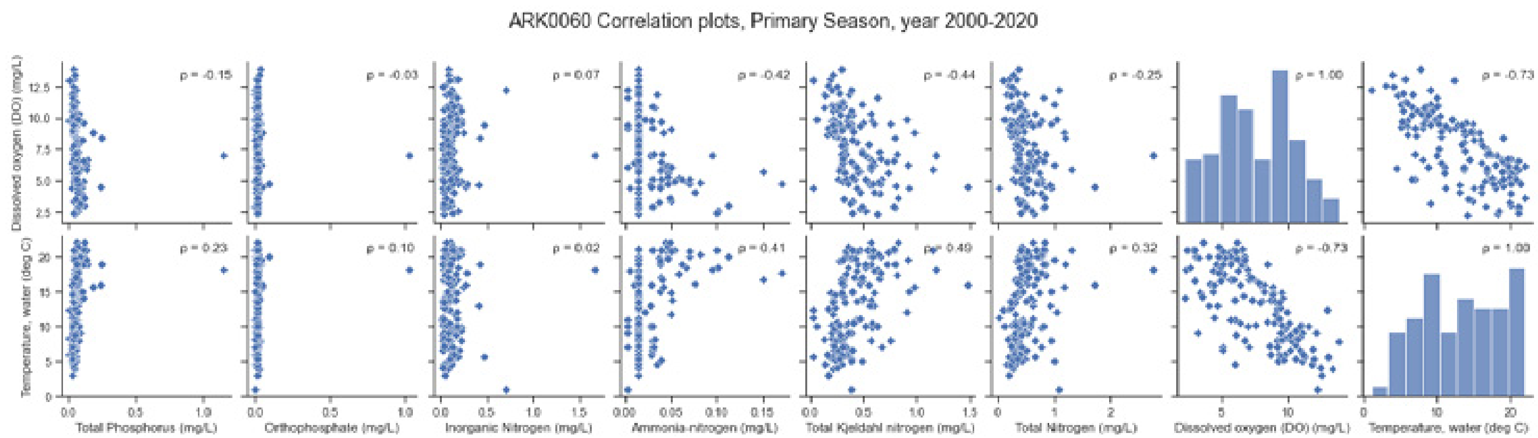

Figure 6. Correlation between DO, temperature, and nutrient measurements from Primary Season at DEQ station AR0060, Bayou Meto Main Street in Jacksonville.

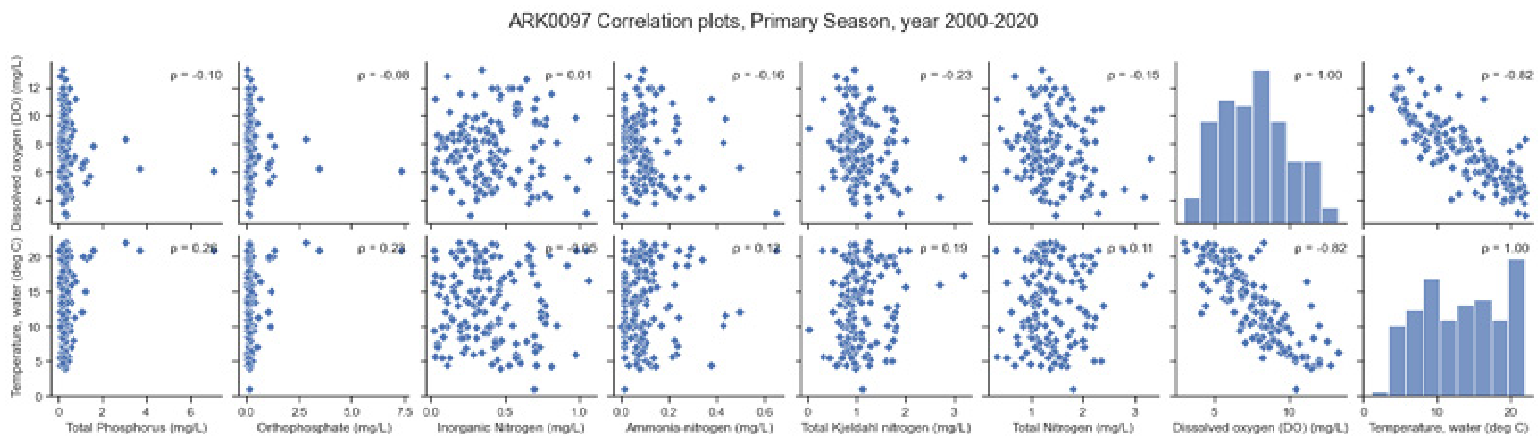

Figure 7. Correlation between DO, temperature, and nutrient measurements from Primary Season at DEQ station AR0097, Bayou Two Prairie at Highway 13.

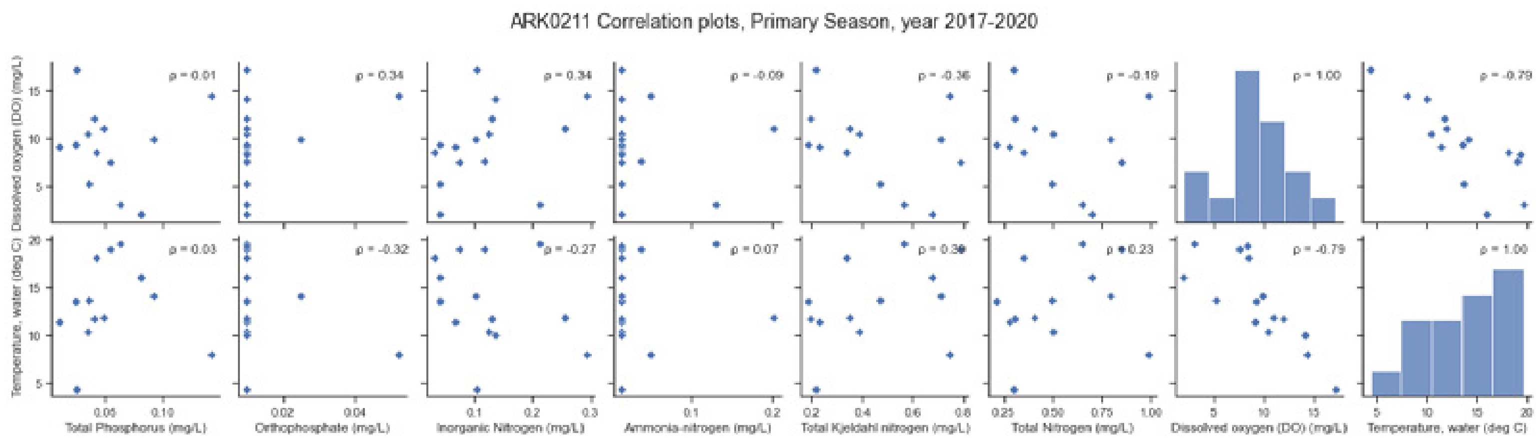

Figure 8. Correlation between DO, temperature, and nutrient measurements from Primary Season at DEQ station AR0211, Bayou Meto at CR70.

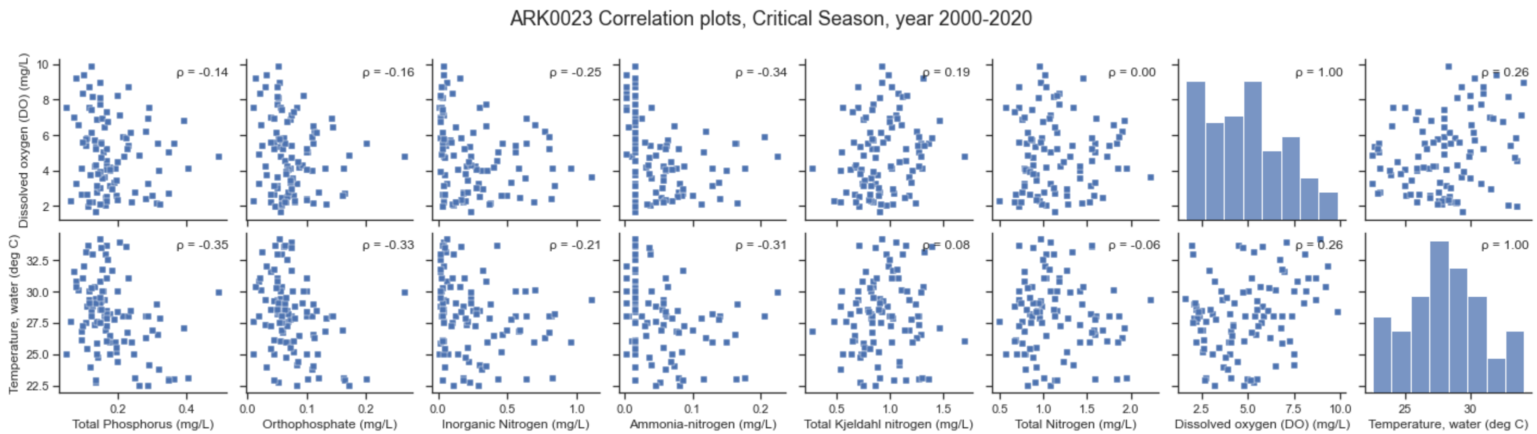

Figure 9. Correlation between DO, temperature, and nutrient measurements from Critical Season at DEQ station AR0023, Bayou Meto at SR11.

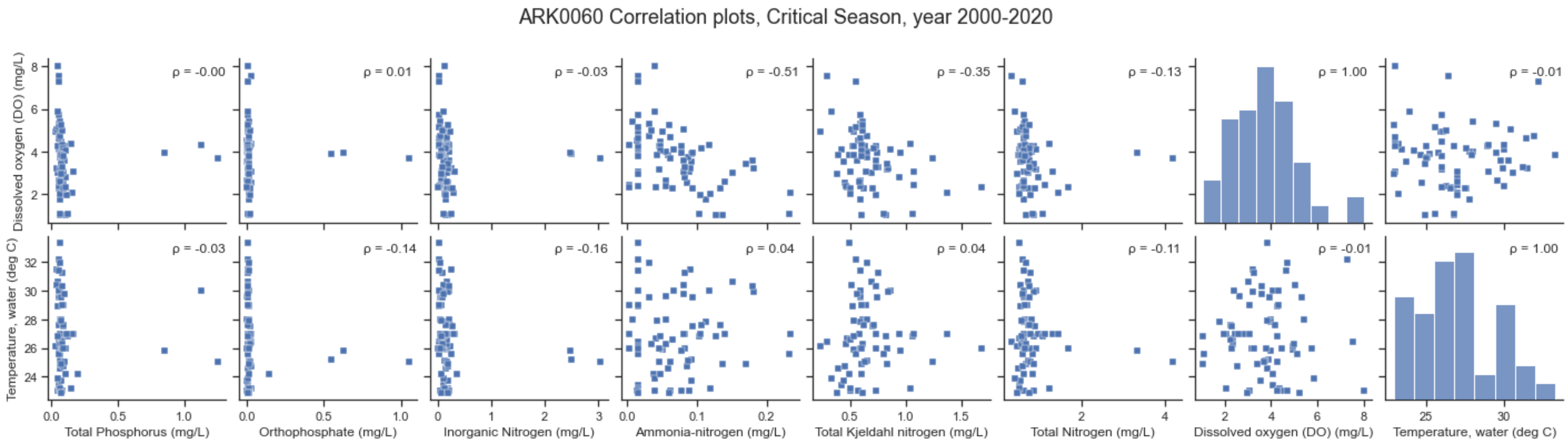

Figure 10. Correlation between DO, temperature, and nutrient measurements from Critical Season at DEQ station AR0060, Bayou Meto Main Street in Jacksonville.

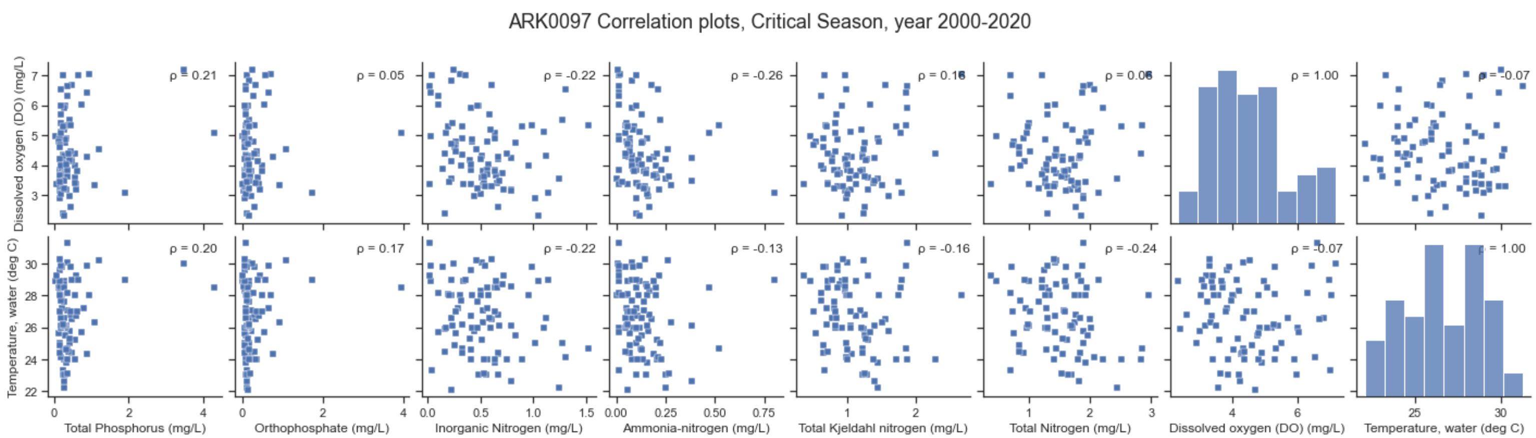

Figure 11. Correlation between DO, temperature, and nutrient measurements from Critical Season at DEQ station AR0097, Bayou Two Prairie at Highway 13.

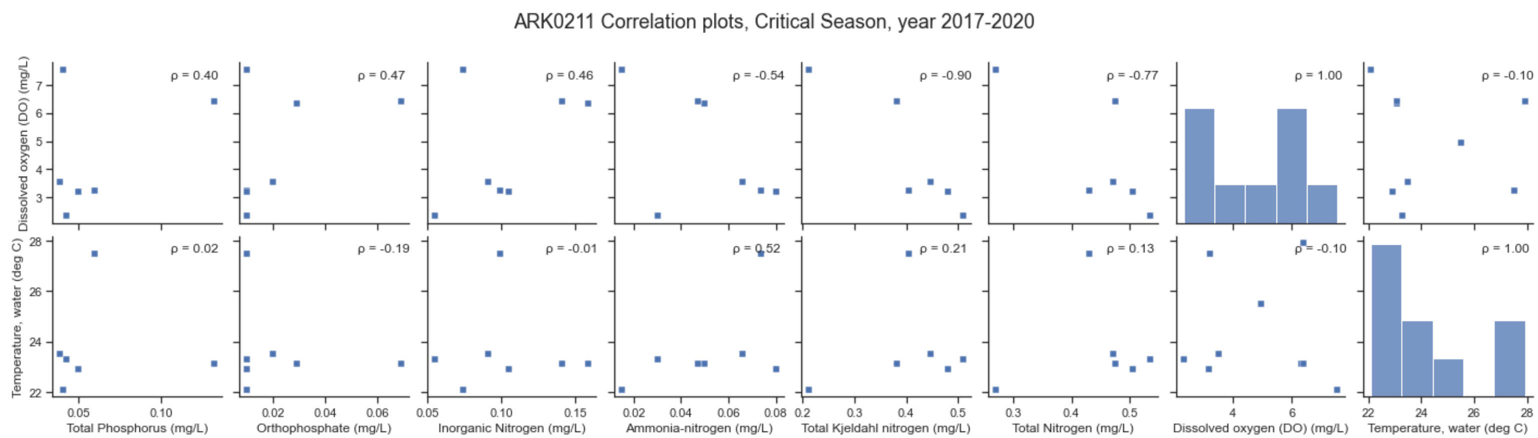

Figure 12. Correlation between DO, temperature, and nutrient measurements from Critical Season at DEQ station AR0211, Bayou Meto at CR70.

APPENDIX I

Estimation of Potential Pollutant Load Reduction Through Use of BMPs

I.1 Assumptions

Some assumptions are made for any estimate of future conditions. Assumptions made in calculating these estimates are discussed below.

I.1.1 Effectiveness of Practices

Table 1 lists the load reductions assumed to result from use of selected practices. These are the values used in the calculations to estimate the potential load reductions from implementing management practices. The majority of the nutrient reductions for agricultural conservation practices are taken from the Arkansas Nutrient Reduction Framework (FTN Associates, Ltd., 2019). Sediment reductions for agricultural conservation practices are based on values from a number of sources, including an Arkansas BMP Tool developed in 2008 (Merriman, Gitau, & Chaubey, 2009). The majority of nutrient and sediment reduction efficiencies for urban conservation practices are based on the 2020 summary statistics for the International Stormwater BMP Database (Clary, Jones, Leisenring, Hobson, & Strecker, 2020). These reductions are calculated from the median inflow and outflow concentrations of total nitrogen, total phosphorus, or TSS in the database.

Table 1. Load reduction values used to calculate potential load reductions from implementing management practices.

Land use	Practice	TN reduction[a]	TP reduction[a]	Sediment reduction[a]
pasture	bank stabilization w/ fence	0.75	0.75	0.75
pasture	access control	0.1	0.15	0.6
pasture	prescribed grazing	0.1	0.15	0.3
pasture	alternate water source	0.1	0.15	0.3
pasture	forested buffer	0.35	0.35	0.6
pasture	grassed buffer	0.35	0.35	0.6
pasture	pasture management suite	0.45	0.65	0.6 [b]
developed	grass buffer strip	0.14	increase	0.52
developed	bioretention	0.24	increase	0.77
unpaved road	Environmentally Sensitive Management	no data	no data	0.80
crop	conservation till	0.1	0.2	0.65
crop	cover crops	0.25	0.3	0.75
crop	nutrient mgt plan	0.1	0.15	0.6
crop	forested buffer	0.3	0.45	0.6
crop	grassed buffer	0.2	0.45	0.6
crop	irrigation mgt suite	0.55	0.4	0.75

Table 1. Load reduction values used to calculate extent of source treatment (continued).

Land use	Practice	TN reduction[a]	TP reduction[a]	Sediment reduction[a]
crop	tailwater recovery suite	0.5	0.35	0.75
crop	conservation till + cover crop	0.5	0.55	0.75[b]
crop	soil nutrient mgt suite	0.15	0.25	0.6
crop	winter flooding of rice fields	no data found	no data found	0.7

a Purple = based on default values used in STEPL version 4.4b
Blue = values from 2019 Arkansas Nutrient Reduction Framework (FTN Associates, Ltd., 2019)
Orange = based on values from multiple sources
Green = based on values from International Stormwater BMP Database (Clary, Jones, Leisenring, Hobson, & Strecker, 2020)
b set to highest value from the practices that make up this suite

I.1.2 Proportion of Load from Land Use Categories

SWAT model output was used to estimate the percentage of HUC12 nutrient and sediment loads originating from target land uses. SWAT can output loads from each of the land covers within a model subbasin. In the Bayou Meto SWAT model, subbasins correspond to HUC12s (FTN Associates, Ltd., 2021). Mean loads from the output were used to calculate percentages of the modeled load from each of the land covers in a subbasin. The output from the model subbasins that correspond to the recommended Bayou Meto subwatersheds are listed in Table 2. Also listed in Table 2 are modeled loads from point sources in the subbasins. Total load from each model subbasin is the sum of the land use and point source loads. The load percentages calculated from the model loads are also shown in Table 2. Load percentages from Table 2 were used in the calculations to estimate potential reduction of nutrient and sediment loads from the recommended subwatersheds.

The proportion of loads generated by different crops is of interest because some of the management practices being evaluated are assumed to be crop specific. We assume that the winter flooding practice will be applied only to rice fields. We also assume winter cover crops will not be grown on rice fields, because they will be flooded, and because it can be more difficult to establish winter cover crops on soils where rice is grown (M. Isbell, personal communication, July 22, 2021).

Table 2. SWAT output loads for recommended subwatersheds by source.

HUC12 ID	Load source	Total N load, kg	Total N load, %	Total P load, kg	Total P load, %	Sediment load, tons	Sediment load, %
080204020102 Bayou Meto Headwaters	Developed	889	14%	58.8	11%	13,097	43%
	Forest	343	6%	103	19%	164	1%
	Pasture	3,946	64%	379	70%	16,995	56%
	Point sources	1,021	16%	0.77	0.1%	0	-
	Total	**6,199**		**541**		**30,255**	
080204020201 Glade Branch – Bayou Two Prairie	Developed	3,643	33%	1,030	29%	49,366	54%
	Forest	472	4%	107	3%	408	0.4%
	Pasture	6,478	59%	2,311	66%	41,070	45%
	Suburban	134	1%	26.6	1%	558	1%
	Wetlands	207	2%	36.3	1%	235	0.3%
	Point sources	0	-	0	-	0	-
	Total	**10,935**		**3,510**		**91,636**	
080204020205 Skinners Branch – Bayou Two Prairie	Corn	1,273	10%	291	13%	429	2%
	Developed	394	3%	98.3	4%	6,156	30%
	Other crops	142	1%	36.1	2%	103	0.5%
	Rice	448	3%	95.3	4%	252	1%
	Soybeans	8,819	68%	1,411	63%	12,148	59%
	Wetlands	1,576	12%	242	11%	1,458	7%
	Point sources[a]	358	3%	77.2	3%	1.48	0.0072%
	Total	**13,010**		**2,251**		**20,547**	
080204020403 Upper Mill Bayou	Corn	1,193	6%	275	6%	844	1.5%
	Developed	987	5%	313	7%	18,395	32%
	Rice	571	3%	70.7	2%	749	1.3%
	Soybeans	18,384	86%	3,546	83%	37,743	65%
	Wetlands	49.0	0.2%	12.2	0.3%	47.7	0.1%
	Point sources[b]	189	0.9%	38.9	0.9%	0.11	0.0002%
	Total	**21,372**		**4,255**		**57,778**	
080204020404 Hurricane Bayou	Rice	1,099	5%	410	10%	789	2%
	Soybeans	18,862	93%	3,433	88%	34,922	97%
	Wetlands	155	0.8%	34.6	0.9%	198	0.6%
	Point sources[c]	223	1.1%	45.9	1.2%	0.13	0.0004%
	Total	**20,340**		**3,923**		**35,910**	
080204020407 Bills Bayou	Corn	1,410	11%	307	13%	466	2%
	Rice	57.5	0.5%	20.1	0.9%	24.3	0.1%
	Soybeans	11,040	87%	1,927	83%	18,273	97%
	Wetlands	184	1.4%	41.7	2%	162	1%
	Point sources[b]	62.8	0.5%	12.9	0.6%	0.038	0.0002%
	Total	**12,755**		**2,309**		**18,925**	

a – discharges from municipal wastewater treatment, aquaculture ponds and flooded rice fields
b – discharges from municipal wastewater treatment and flooded rice fields
c – discharges from flooded rice fields

As a check, the proportions of modeled loads from different crops were compared to sampling data from Reba et al. (2020). The sampling data (Table 3) indicate that measured areal total nitrogen and sediment loads from rice are more similar to those from other row crops than the model results suggest (Table 2). Therefore, load percentages for rice and other row crops were calculated using modeled areas, assumed representative areal loads based on the values from Reba et al. (2020), and the modeled load proportions for cropland. The numbers used and resulting load proportions used to calculate the load reductions are listed in Table 4. The assumed loads represent the relative loads exhibited in the measured data. For example, in the measured data, median areal phosphorus load from rice is equivalent to approximately 20% of the loads from cotton and soybeans. Thus, the assumed total phosphorus load for rice is 0.2 kg/ha and the assumed load for other row crops is 1 kg/ha. As expected, the calculated load proportions for total nitrogen and sediment from rice in Table 4 are quite different from those in Table 2.

Table 3. Measured loads of total nitrogen, total phosphorus, and sediment measured 2014-2017 (Reba et al., 2020).

Crop	Median load, kg/ha		
	Total N	**Total P**	**Sediment**
Cotton	0.045	0.040	43.40
Rice	0.061	0.007	26.43
Soybeans	0.062	0.037	56.56

Table 4. Calculated load proportions for rice and other row crops.

<table>
<tr><th rowspan="2">HUC ID</th><th rowspan="2">Information</th><th colspan="2">Total N</th><th colspan="2">Total P</th><th colspan="2">Sediment</th></tr>
<tr><th>Rice</th><th>Other crops</th><th>Rice</th><th>Other crops</th><th>Rice</th><th>Other crops</th></tr>
<tr><td>All</td><td>Assumed load, kg/ha</td><td>1</td><td>1</td><td>0.2</td><td>1</td><td>1</td><td>2</td></tr>
<tr><td rowspan="3">080204020205 Skinners Branch – Bayou Two Prairie</td><td>Modeled area, ha</td><td>2,646</td><td>57,601</td><td>2,646</td><td>57,601</td><td>2,646</td><td>57,601</td></tr>
<tr><td>Modeled load from cropland</td><td>82%</td><td></td><td>81%</td><td></td><td>63%</td><td></td></tr>
<tr><td>Calculated load proportion</td><td>26%</td><td>56%</td><td>7%</td><td>74%</td><td>12%</td><td>51%</td></tr>
<tr><td rowspan="3">080204020403 Upper Mill Bayou</td><td>Modeled area, ha</td><td>1,761</td><td>5,173</td><td>1,761</td><td>5,173</td><td>1,761</td><td>5,173</td></tr>
<tr><td>Modeled load from cropland</td><td>94%</td><td></td><td>91%</td><td></td><td>68%</td><td></td></tr>
<tr><td>Calculated load proportion</td><td>24%</td><td>70%</td><td>6%</td><td>85%</td><td>10%</td><td>58%</td></tr>
<tr><td rowspan="3">080204020404 Hurricane Bayou</td><td>Modeled area, ha</td><td>1,809</td><td>4,721</td><td>1,809</td><td>4,721</td><td>1,809</td><td>4,721</td></tr>
<tr><td>Modeled load from cropland</td><td>98%</td><td></td><td>98%</td><td></td><td>99%</td><td></td></tr>
<tr><td>Calculated load proportion</td><td>27%</td><td>71%</td><td>7%</td><td>91%</td><td>16%</td><td>83%</td></tr>
<tr><td rowspan="3">080204020407 Bills Bayou</td><td>Modeled area, ha</td><td>573</td><td>3,546</td><td>573</td><td>3,546</td><td>573</td><td>3,546</td></tr>
<tr><td>Modeled load from cropland</td><td>98%</td><td></td><td>98%</td><td></td><td>99%</td><td></td></tr>
<tr><td>Calculated load proportion</td><td>14%</td><td>84%</td><td>3%</td><td>95%</td><td>7%</td><td>92%</td></tr>
</table>

I.2 Potential Load Reductions

The estimated load reduction resulting from application of a practice to a specific source was calculated as follows:

% load reduction from treatment = % load reduction from practice * % of load from this source.

This calculation assumes that all the pollutant source is treated, and all the pollutant load attributed to a specific land use is coming from the treated source. Thus, the reported values represent the maximum potential load reduction resulting from use of a practice. These calculations and their results are summarized for each of the recommended subwatersheds in the subsections below.

I.2.1 Bayou Meto Headwaters

There is no load reduction target for phosphorus for this subwatershed. Estimated nitrogen and sediment load reductions from implementing selected practices are presented in Tables 5 and 6. Estimated load reductions that meet or exceed the targets are highlighted in green. The calculations in Table 5 indicate that it may be possible to achieve the target nitrogen load reduction by treating pasture sources using one or more management practices, or by treating a combination of pasture and developed area sources using one or more management practices. Note that a small point source discharging in this subwatershed contributes approximately 16% of the nitrogen load (based on SWAT model results shown in Table 2).

The calculations in Table 6 indicate that it is not possible to achieve the target sediment load reduction by treating a single source, since model results indicate that both pasture and developed areas individually account for less than 86% of the sediment load. Model results indicate that combined these two sources account for 99% of the sediment load. It will be necessary to reduce sediment loads from both pasture and developed areas to achieve the reduction target. It may be difficult to achieve large reductions in sediment loads. Careful consideration of soil types and land slopes in choosing and designing management practices may result in sediment load reductions greater than those assumed for these calculations. As noted in Table 6.10 of the report, sediment reductions of 70% to over 90% have been reported in some instances for some management practices.

Table 5. Estimated potential nitrogen load reduction in Bayou Meto Headwaters subwatershed.

Land use	% of nitrogen load assumed from this source	Practice	Nitrogen target load reduction = 12%	
			Practice nitrogen reduction efficiency	Practice nitrogen load % reduction
Pasture	64%	Prescribed grazing	10%	6%
Pasture	64%	Nutrient mgt plan	10%	6%
Pasture stream	64%	Bank stabilization w/ fence	75%	48%
Pasture stream	64%	Access control	10%	6%
Pasture stream	64%	Forested buffer	35%	22%
Pasture stream	64%	Grassed buffer	35%	22%
Pasture & stream bank	64%	Pasture management suite	45%	29%
Developed	14%	Bioretention	24%	3%
Urban stream	14%	Urban grass buffer strip	14%	2%

Table 6. Estimated potential sediment load reduction in Bayou Meto Headwaters subwatershed.

Land use (source)	% of sediment load assumed from this source	Practice	Sediment target load reduction = 86%	
			Practice sediment reduction efficiency	Practice sediment load % reduction
Pasture	56%	Prescribed grazing	30%	17%
Pasture	56%	Nutrient mgt plan	60%	34%
Pasture stream	56%	Bank stabilization w/ fence	75%	42%
Pasture stream	56%	Access control	60%	34%
Pasture stream	56%	Forested buffer	60%	34%
Pasture stream	56%	Grassed buffer	60%	34%
Pasture & stream bank	56%	Pasture management suite	60%	34%
Developed	43%	Bioretention	77%	33%
Urban stream	43%	Urban grass buffer strip	52%	22%

I.2.2 Glade Branch Bayou Two Prairie

Estimated nutrient and sediment load reductions from implementing selected practices in this subwatershed are presented in Tables 7 – 9. The calculations in these tables indicate that it would not be possible to achieve the target load reductions by treating a single source with a single practice. It will be necessary to reduce loads from both developed areas and pastures to achieve the reduction targets. It may be possible to achieve the target nitrogen load reductions by treating multiple sources. However, careful design and site selection for management practices may result in load reductions greater than those assumed for the calculations in Tables 7 – 9.

Table 7. Estimated potential nitrogen load reduction in Glade Branch-Bayou Two Prairie subwatershed.

Land use	% of nitrogen load assumed from this source	Practice	Nitrogen load target reduction = 47%	
			Practice nitrogen reduction efficiency	Practice nitrogen load % reduction
Pasture	59%	Prescribed grazing	10%	6%
Pasture	59%	Nutrient mgt plan	10%	6%
Pasture stream	59%	Bank stabilization w/ fence	75%	44%
Pasture stream	59%	Access control	10%	6%
Pasture stream	59%	Forested buffer	35%	21%
Pasture stream	59%	Grassed buffer	35%	21%
Pasture & stream bank	59%	Pasture management suite	45%	27%
Developed	34%	Bioretention	24%	8%
Urban stream	34%	Urban grass buffer strip	14%	5%

Table 8. Estimated potential phosphorus load reduction in Glade Branch-Bayou Two Prairie subwatershed.

Land use	% of phosphorus load assumed from this source	Practice	Phosphorus load target reduction = 68%	
			Practice phosphorus reduction efficiency	practice phosphorus load % reduction
Pasture	66%	Prescribed grazing	15%	10%
Pasture	66%	Nutrient mgt plan	15%	10%
Pasture stream	66%	Access control	15%	10%
Pasture stream	66%	Bank stabilization w/ fence	75%	50%
Pasture stream	66%	Forested buffer	35%	23%
Pasture stream	66%	Grassed buffer	35%	23%
Pasture & stream bank	66%	Pasture management suite	65%	43%
Developed	30%	Bioretention	Increase	-
Urban stream	30%	Urban grass buffer strip	Increase	-

Table 9. Estimated potential sediment load reduction in Glade Branch Bayou-Two Prairie subwatershed.

Land use	% of sediment load assumed from this source	Practice	Sediment target reduction = 94%	
			Practice sediment reduction efficiency	Practice sediment load reduction
Pasture	45%	Prescribed grazing	30%	14%
Pasture	45%	Nutrient mgt plan	60%	27%
Pasture stream	45%	Bank stabilization w/ fence	75%	34%
Pasture stream	45%	Access control	60%	27%
Pasture stream	45%	Forested buffer	60%	27%
Pasture stream	45%	Grassed buffer	60%	27%
Pasture & stream bank	45%	Pasture management suite	60%	27%
Developed	55%	Bioretention	77%	42%
Urban stream	55%	Urban grass buffer strip	52%	29%

I.2.3 Skinners Branch Bayou Two Prairie

Estimated nutrient and sediment load reductions from implementation of selected practices in this subwatershed are presented in Tables 10 – 12. The calculations in these tables indicate that it would be possible to achieve the target load reductions by implementing additional conservation practices on cropland. Note that reducing loads from developed areas is not a focus for this watershed management plan (see Section 4.7.5).

Table 10. Estimated potential nitrogen load reduction in Skinners Branch-Bayou Two Prairie subwatershed.

Land use	% of nitrogen load assumed from this source	Practice	Nitrogen load target reduction = 21%	
			Practice nitrogen reduction efficiency	Practice nitrogen load reduction
Crop	82%	Conservation till	10%	8%
Crop	82%	Nutrient mgt plan	10%	8%
Crop	82%	Soil nutrient mgt suite	15%	12%
Crop	82%	Irrigation mgt suite	55%	45%
Crop	82%	Tailwater recovery suite	50%	41%
Crop streams	82%	Grassed buffer	20%	16%
Rice	26%	Winter flooding of rice fields	No data found	-
Non-rice crop	56%	Conservation till + cover crop	50%	28%
Non-rice crop	56%	Cover crops	25%	14%

Table 11. Estimated potential phosphorus load reduction in Skinners Branch-Bayou Two Prairie subwatershed.

land use	% of phosphorus load assumed from this source	practice	Phosphorus load target reduction = 23%	
			practice phosphorus reduction efficiency	practice phosphorus load reduction
Crop	81%	Conservation till	20%	16%
Crop	81%	Nutrient mgt plan	15%	12%
Crop	81%	Irrigation mgt suite	40%	32%
Crop	81%	Tailwater recovery suite	35%	28%
Crop	81%	Soil nutrient mgt suite	25%	20%
Crop streams	81%	Grassed buffer	45%	36%
Non-rice crop	74%	Conservation till + cover crop	55%	41%
Non-rice crop	74%	Cover crops	30%	22%
Rice	7%	Winter flooding of rice fields	No data found	-

Table 12. Estimated potential sediment load reduction in Skinners Branch-Bayou Two Prairie subwatershed.

Land use	% of sediment load assumed from this source	Practice	Sediment target reduction = 26%	
			Practice sediment reduction efficiency	Practice sediment load reduction
Crop	63%	Conservation till	65%	41%
Crop	63%	Nutrient mgt plan	60%	38%
Crop	63%	Soil nutrient mgt suite	60%	38%
Crop	63%	Irrigation mgt suite	75%	47%
Crop	63%	Tailwater recovery suite	75%	47%
Crop streams	63%	Grassed buffer	60%	38%
Non-rice crop	51%	Cover crops	75%	38%
Non-rice crop	51%	Conservation till + cover crop	75%	38%
Rice	12%	Winter flooding of rice fields	70%	8%

I.2.4 Upper Mill Bayou

Estimated nutrient and sediment load reductions from implementation of selected practices in this subwatershed are presented in Tables 13 – 15. The calculations in these tables indicate that it may be possible to achieve target nutrient load reductions by implementing suites of practices on croplands. However, it will not be possible to achieve the target sediment load reduction by implementing practices only on croplands. Sediment loads from unpaved roads and developed areas may also need to be addressed.

Table 13. Estimated potential nitrogen load reduction in Upper Mill Bayou subwatershed.

Land use	% of nitrogen load assumed from this source	Practice	Nitrogen load target reduction =34%	
			Practice nitrogen reduction efficiency	Practice nitrogen load reduction
Crop	94%	Conservation till	10%	9%
Crop	94%	Nutrient mgt plan	10%	9%
Crop	94%	Irrigation mgt suite	55%	52%
Crop	94%	Tailwater recovery suite	50%	47%
Crop	94%	Soil nutrient mgt suite	15%	14%
Crop streams	94%	Grassed buffer	20%	19%
Non-rice crop	70%	Cover crops	25%	18%
Non-rice crop	70%	Conservation till + cover crop	50%	35%
Rice	24%	Winter flooding of rice fields	No data found	-

Table 14. Estimated potential phosphorus load reduction in Upper Mill Bayou subwatershed.

land use	% of phosphorus load assumed from this source	practice	Phosphorus load target reduction = 41%	
			practice phosphorus reduction efficiency	practice phosphorus load reduction
Crop	91%	Conservation till	20%	18%
Crop	91%	Nutrient mgt plan	15%	14%
Crop	91%	Irrigation mgt suite	40%	36%
Crop	91%	Tailwater recovery suite	35%	32%
Crop	91%	Soil nutrient mgt suite	25%	23%
Crop streams	91%	Grassed buffer	45%	41%
Non-rice crop	85%	Cover crops	30%	26%
Non-rice crop	85%	Conservation till + cover crop	55%	47%
Rice	6%	Winter flooding of rice fields	No data found	-

Table 15. Estimated potential sediment load reduction in Upper Mill Bayou subwatershed.

Land use	% of sediment load assumed from this source	Practice	Sediment target reduction =65%	
			Practice sediment reduction efficiency	Practice sediment load reduction
Crop	68%	Conservation till	65%	44%
Crop	68%	Nutrient mgt plan	60%	41%
Crop	68%	Irrigation mgt suite	75%	51%
Crop	68%	Tailwater recovery suite	75%	51%
Crop	68%	Soil nutrient mgt suite	60%	41%
Crop streams	68%	Grassed buffer	60%	41%
Non-rice crops	58%	Cover crops	75%	44%
Non-rice crops	58%	Conservation till + cover crop	75%	44%
Rice	10%	Winter flooding of rice fields	70%	7%
Unpaved roads	32%	Environmentally sensitive management	80%	26%

I.2.5 Hurricane Bayou

Estimated nutrient and sediment load reductions from implementation of selected practices in this subwatershed are presented in Tables 16 – 18. Note that because the SWAT model did not estimate loads from developed areas for this subwatershed, it is not possible to estimate sediment reductions from treating unpaved roads. The calculations in these tables indicate that it would be possible to achieve target sediment load reductions by implementing additional conservation practices. It may also be possible to achieve target nitrogen load reduction by implementing suites of practices on croplands. However, it may be difficult to achieve the target phosphorus load reduction using a single practice/approach.

Table 16. Estimated potential nitrogen load reduction in Hurricane Bayou subwatershed.

Land use	% of nitrogen load assumed from this source	Practice	Nitrogen load target reduction = 41%	
			Practice nitrogen reduction efficiency	Practice nitrogen load reduction
Crop	98%	Conservation till	10%	10%
Crop	98%	Nutrient mgt plan	10%	10%
Crop	98%	Irrigation mgt suite	55%	54%
Crop	98%	Tailwater recovery suite	50%	49%
Crop	98%	Soil nutrient mgt suite	15%	15%
Crop streams	98%	Grassed buffer	20%	20%
Non-rice crop	71%	Cover crops	25%	18%
Non-rice crop	71%	Conservation till + cover crop	50%	35%
Rice	27%	Winter flooding of rice fields	No data found	-

Table 17. Estimated potential phosphorus load reduction in Hurricane Bayou subwatershed.

Land use	% of phosphorus load assumed from this source	Practice	Phosphorus load target reduction = 57%	
			Practice phosphorus reduction efficiency	Practice phosphorus load reduction
Crop	98%	Conservation till	20%	20%
Crop	98%	Nutrient mgt plan	15%	15%
Crop	98%	Irrigation mgt suite	40%	39%
Crop	98%	Tailwater recovery suite	35%	34%
Crop	98%	Soil nutrient mgt suite	25%	25%
Crop streams	98%	Grassed buffer	45%	44%
Non-rice crop	91%	Cover crops	30%	27%
Non-rice crop	91%	Conservation till + cover crop	55%	50%
Rice	7%	Winter flooding of rice fields	No data found	-

Table 18. Estimated potential sediment load reduction in Hurricane Bayou subwatershed.

Land use	% of sediment load assumed from this source	Practice	Sediment target reduction = 4%	
			Practice sediment reduction efficiency	Practice sediment load reduction
Crop	99%	Conservation till	65%	64%
Crop	99%	Nutrient mgt plan	60%	59%
Crop	99%	Irrigation mgt suite	75%	74%
Crop	99%	Tailwater recovery suite	75%	74%
Crop	99%	Soil nutrient mgt suite	60%	59%
Crop streams	99%	Grassed buffer	60%	59%
Non-rice crop	83%	Cover crops	75%	62%
Non-rice crop	83%	Conservation till + cover crop	75%	62%
Rice	16%	Winter flooding of rice fields	70%	11%
Unpaved roads	Unknown	Environmentally sensitive management	80%	Unknown

I.2.6 Bills Bayou

Estimated nutrient and sediment load reductions from implementation of selected practices in this subwatershed are presented in Tables 19 – 21. Note that because the SWAT model did not estimate loads from developed areas for this subwatershed, it is not possible to estimate sediment reductions from treating unpaved roads. The calculation results shown in these tables indicate that it may be difficult to achieve the large nutrient load reduction targets using a single practice or practice suite. Implementing practices to reduce nutrient loads in this subwatershed is likely to result in achieving the sediment load reduction target.

Table 19. Estimated potential nitrogen load reduction in Bills Bayou subwatershed.

Land use	% of nitrogen load assumed from this source	Practice	Nitrogen load target reduction = 56%	
			Practice nitrogen reduction efficiency	Practice nitrogen load reduction
Crop	98%	Conservation till	10%	10%
Crop	98%	Nutrient mgt plan	10%	10%
Crop	98%	Irrigation mgt suite	55%	54%
Crop	98%	Tailwater recovery suite	50%	49%
Crop	98%	Soil nutrient mgt suite	15%	15%
Crop streams	98%	Grassed buffer	20%	20%
Non-rice crop	84%	Cover crops	25%	21%
Non-rice crop	84%	Conservation till + cover crop	50%	42%
Rice	14%	Winter flooding of rice fields	No data found	-

Table 20. Estimated potential phosphorus load reduction in Bills Bayou subwatershed.

Land use	% of phosphorus load assumed from this source	Practice	Phosphorus load target reduction = 54%	
			Practice phosphorus reduction efficiency	Practice phosphorus load reduction
Crop	98%	Conservation till	20%	20%
Crop	98%	Nutrient mgt plan	15%	15%
Crop	98%	Irrigation mgt suite	40%	39%
Crop	98%	Tailwater recovery suite	35%	34%
Crop	98%	Soil nutrient mgt suite	25%	25%
Crop streams	98%	Grassed buffer	45%	44%
Non-rice crop	95%	Cover crops	30%	28%
Non-rice crop	95%	Conservation till + cover crop	55%	52%
Rice	3%	Winter flooding of rice fields	No data found	-

Table 21. Estimated potential sediment load reduction in Bills Bayou subwatershed.

Land use	% of sediment load assumed from this source	Practice	Sediment target reduction = 27%	
			Practice sediment reduction efficiency	Practice sediment load reduction
Crop	99%	Conservation till	65%	64%
Crop	99%	Nutrient mgt plan	60%	59%
Crop	99%	Irrigation mgt suite	75%	74%
Crop	99%	Tailwater recovery suite	75%	74%
Crop	99%	Soil nutrient mgt suite	60%	59%
Crop streams	99%	Grassed buffer	60%	59%
Non-rice crop	92%	Cover crops	75%	69%
Non-rice crop	92%	Conservation till + cover crop	75%	69%
Rice	7%	Winter flooding of rice fields	70%	5%
Unpaved roads	Unknown	Environmentally sensitive management	80%	Unknown

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APPENDIX J

Existing Information and Education Activities

J.1 Natural Resources Conservation Service

Information and education activities of the NRCS include participation in field days and farm demonstrations, soil and water stewardship materials, and informational and training programs at county offices, in addition to information posted on their website (https://www.nrcs.usda.gov/wps/portal/nrcs/ar/home/), Twitter (https://twitter.com/arkansasnrcs), and YouTube (https://www.youtube.com/channel/UCWPRIlokkCy1DTROlEoW5OA/featured). Through these activities, NRCS provides information and education on a wide range of topics related to agriculture in the state, including benefits, implementation, and maintenance of agricultural practices to protect or improve water quality so water quality standards are met.

J.2 University of Arkansas Division of Agriculture

The UofA Division of Agriculture is a research and information support agency for the agricultural sector in Arkansas. The Division of Agriculture provides information and education through the Cooperative Extension Service. Information and education activities of the Cooperative Extension Service include the Arkansas Watershed Steward program, displays and presentations at fairs and festivals, participation in field days and farm demonstrations, informational and training programs at county offices, newsletters, publications on a variety of topics including feral hog management, and short and long-term agricultural methods that protect water quality so water quality standards are met. A website (https://www.uaex.edu/), and Facebook (https://www.facebook.com/uaex.edu/), Twitter (https://twitter.com/UAEX_edu), Instagram (https://www.instagram.com/uaex_edu/), and YouTube (https://www.youtube.com/user/ARextension) accounts provide access to information about programs and resources, and copies of informational publications and videos. The Division of Agriculture also sponsors the annual Most Crop per Drop Irrigation contest.

The Arkansas Cooperative Extension Service also provides information on protecting water quality for non-agricultural landowners and residents in developed areas, through their website and social media. In addition, they are working with communities in Northwest and Southeast Arkansas to provide public urban stormwater education and participation programs to fulfill requirements of NPDES municipal stormwater permits. These programs include printed materials; videos; commercials; storm drain markers; demonstrations and presentations to children, adults, and local companies; stream and lake clean-up events; and social media that include slogans or catch phrases like “slow it down, spread it out and soak it in”, “Know the Flow **–** storms on streets drain to creeks”, “If it rains, it drains”, and an animated spokesperson Wayne the raindrop. This information could be useful to municipalities in the Bayou Meto watershed even if they are not regulated by an NPDES municipal stormwater permit. Information on this topic is available to the public on the Cooperative Extension Service website, https://www.uaex.edu/environment-nature/water/stormwater/default.aspx**.**

J.3 County Conservation Districts

Information and education activities of the County Conservation Districts include displays and presentations at fairs and festivals, participation in field days and farm demonstrations, soil and water stewardship materials, informational and training programs at county offices, and support of Arkansas Envirothon, in addition to social media like Facebook (e.g., https://www.facebook.com/prairie.county/) and Twitter (e.g., https://twitter.com/countyprairie?lang=en). Through these activities, County Conservation Districts provide information and education on a wide range of topics related to agriculture and rural life, including benefits, implementation, and maintenance of agricultural practices and feral hog control to protect water quality so water quality standards are met.

J.4 Arkansas Natural Resource Agencies

Arkansas natural resource agencies, including AGFC, Arkansas Natural Heritage Commission, Arkansas Department of Energy and the Environment Division of Environmental Quality (DEQ) and the NRD, all have information and education programs aimed at increasing public interest, understanding, and stewardship of the natural resources of our state, including protecting water quality to achieve water quality standards. Examples of agency programs relevant to the target nonpoint pollution sources in the recommended subwatersheds include the NRD Unpaved Roads Program and nonpoint source pollution program, AGFC Stream Teams, and DEQ Watershed Outreach and Education Program. Arkansas natural resources agencies use a variety of methods to reach Arkansans, including websites (https://www.agfc.com/en/**,** https://www.arkansasheritage.com/arkansas-natural-heritage/anhc-home, https://www.agriculture.arkansas.gov/natural-resources/, https://www.adeq.state.ar.us/poa/watershed/); social media (e.g., https://www.youtube.com/c/ArkansasGameandFishCommission, https://www.facebook.com/arnaturalheritage/, https://twitter.com/ARDeptofAgricul); newsletters; presentations and displays at meetings, fairs, and festivals; news media stories; and hosting volunteer and training events.

J.5 Arkansas Soil Health Alliance

The Arkansas Soil Health Alliance is a nonprofit organization of farmers for the purpose of educating farmers about soil health and practices that improve soil health, such as cover crops and reduced tillage. Information and education activities of this organization include participation in conferences and field days, and a Facebook page (https://www.facebook.com/Arsoilhealth/).

J.6 Other Nonprofit Interest Groups

There are several other nonprofit groups with interests in the Bayou Meto watershed. These include the Arkansas Cattlemen's Association, Arkansas Farm Bureau, Audubon Arkansas, and Ducks Unlimited. These organizations provide information and education to their members and the public through a variety of methods including, websites; social media; newsletters; presentations and displays at schools, meetings, conferences, fairs, and festivals; teacher resources; and news media stories. Many of these organizations already provide information and education about how to protect and improve water quality so that state water quality standards are met. Some of these organizations, e.g., Arkansas Cattlemen's Association and Ducks Unlimited, focus their efforts only in select areas of the Bayou Meto watershed.

J.7 City of Cabot

As part of the requirements for the City of Cabot NPDES stormwater permit, the city conducts outreach and education activities related to improving the water quality of stormwater runoff. These outreach and education activities are outlined in the city stormwater management plan (https://www.cabotar.gov/DocumentCenter/View/50/Stormwater-Management-Plan-PDF).

APPENDIX K

Social Marketing Checklist

7 Steps in Creating a Winning Social Media Marketing Strategy in 2018

Alex York

Just a few years ago, you could get away with building a social media marketing strategy on the fly. As long as you were present, you were doing more than your competitors–right?

Well it's 2018 and not much of the same logic applies today. With 30% of millennials saying they engage with a brand on social at least once a month (https://sproutsocial.com/insights/data/q1-2017/), your strategy can't be only about existence. Brands must be fully invested in their social media marketing strategies and focus on engagement. Otherwise, you'll lose out on real customers, which means serious effects on your bottom line.

We're not here to scare your brand into the world of social media. Instead, we want to provide your marketing team with the right steps to take toward a successful social strategy so your brand isn't left in the dust.

Here are the seven steps to create a winning social media marketing strategy in 2018 (https://sproutsocial.com/insights/social-media-marketing-strategy/#infographic):

1. Create Social Media Marketing Goals That Solve Your Biggest Challenges

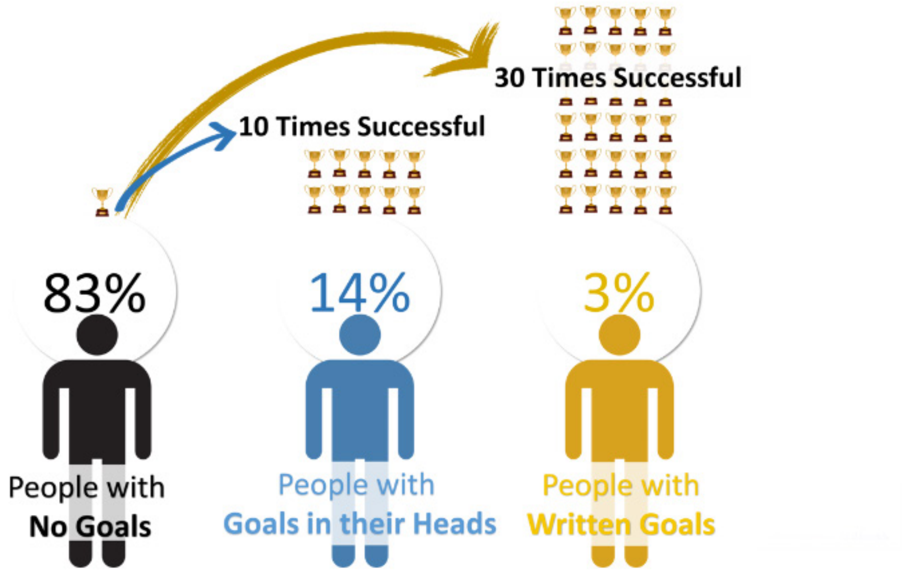
The first step to any strategy is to understand what you want out of your efforts. Social media marketing isn't about flipping a switch and calling it a day. Instead, social media planning should be looked at like cooking your favorite dish.

Once you have your ingredients, you follow a recipe and presto! But that's not always the case. What if you have guests and need to feed more people? What if someone is allergic to one of the ingredients? Suddenly, your goal goes from making a meal to ensuring it will feed enough people and be edible by all.

That's why creating goals is so critical to the first part of your social media strategy. At the same time, it's best to set goals that you know are attainable. Asking for 1 million new Instagram followers in 2018 is unrealistic. With achievable goals, you're more likely to stick to the original plan and continue to take on new hurdles as you complete old ones.

This is the same reason why brands should never take on every social media channel possible in their current marketing strategy. Try to choose the channels that have the most importance based on your brand's goals. Avoid over complicating a strategy with too many targets and objectives. Simplicity can take you a long way.

And also, don't forget to document your social media goals. Not only is it important to help you benchmark where you are, but it also improves your chances of achieving them. According to some statistics, people who write their goals down are 30 times more successful.



Social Media Goals to Consider in 2018

Goal setting is a staple of all marketing and business strategies. Social media is no exception. Of course, with a range of social capabilities, it can be difficult to determine exactly what your objectives should be. For guidance, here are some common social media goals to consider:

- **Increase brand awareness:** To create authentic and lasting brand awareness, avoid a slew of promotional messages. Instead, focus on meaningful content and a strong brand personality through your social channels.
- **Higher quality of sales:** Digging through your social channels is nearly impossible without monitoring or listening to specific keywords, phrases or hashtags. Through more efficient social media targeting, you reach your core audience much faster.
- **Drive in-person sales:** Some retailers rely on social media marketing efforts to drive in-store sales. Is your brand promoting enough on social to reward those who come to you? What about alerting customers to what's going on in your stores?
- **Improve ROI:** There's not a brand on social media that doesn't want to increase its return on investment (ROI). But on social media, this goal is specific to performing a thorough audit of your channels and ensuring cost of labor, advertisements and design stay on track.
- **Create a loyal fanbase:** Does your brand promote user-generated content? Do your followers react positively without any initiation? Getting to this point takes time and effort with creating a positive brand persona on social.
- **Better pulse on the industry:** What are your competitors doing that seems to be working? What strategies are they using to drive engagement or sales? Having a pulse on

the industry could simply help you improve your efforts and take some tips from those doing well.

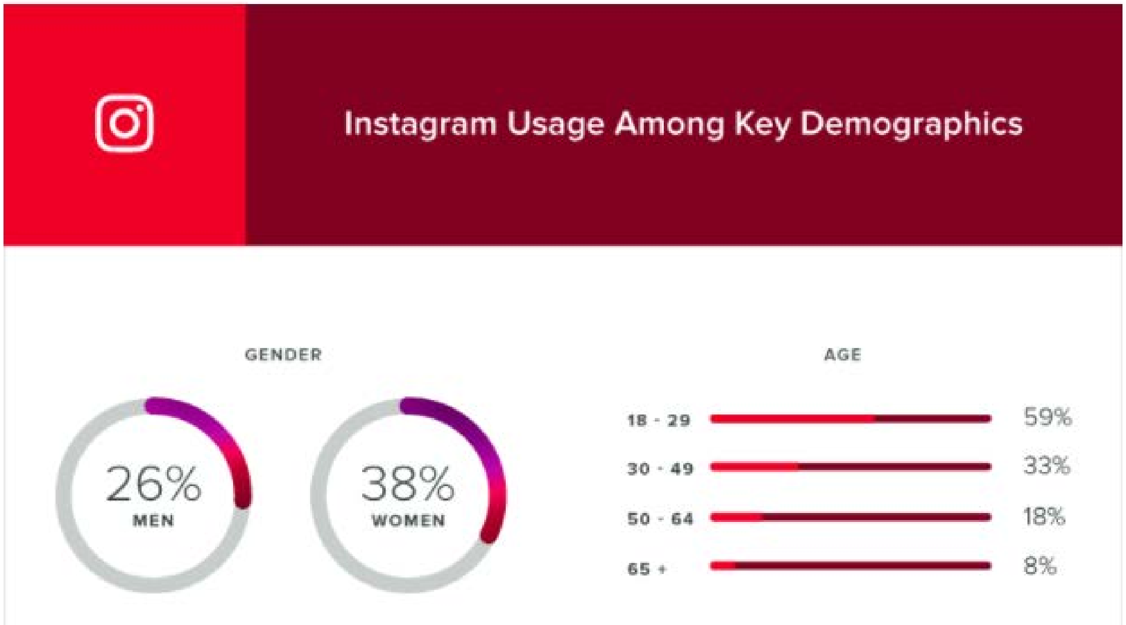
2. Research Your Social Media Audience

Approximately 79% of adults use Facebook–but are your customers actively engaging with your brand there? Understanding your audience is necessary to learn things like who buys your products, what age group is the toughest to sell and what income level makes up the most of your returning customers? As for social media, it's just as critical to know your audience.

First, your brand should look into the demographics of your most valuable social channels. Like we mentioned before, you should have a goal in mind for your social media marketing strategy. This is why you need to research the channels that correlate the most with your goals.

To help you find your focus channels: let's take a quick look at the essential demographics data for each major network:

- **Facebook's most popular demographics include:**
  - Women users (89%)
  - 18-29 year olds (88%)
  - Urban- and rural-located users (81% each)
  - Those earning less than $30,000 (84%)
  - Users with some college experience (82%)
- **Instagram's most popular demographics include:**
  - Women users (38%)
  - 18-29 year olds (59%),
  - Urban-located users (39%)
  - Those earning less than $30,000 (38%)
  - Users with some college experience (37%)



- **Twitter's most popular demographics include:**
  - Women users (25%)
  - 18-29 year olds (36%)
  - Urban-located users (26%)
  - Those earning $50,000-$74,999 (28%)
  - Users with college experience or more (29%)
- **LinkedIn's most popular demographics include:**
  - Men users (31%)
  - 18-29 year olds (34%)
  - Urban-located users (34%)
  - Those earning $75,000 or more (45%)
  - Users with college experience or more (50%)
- **Snapchat and other auto-delete app's most popular demographics include:**
  - Men users (24%)
  - 18-29 year olds (56%)
  - Those earning less than $50,000 (27%)
  - Users with some college experience (27%)

See even more demographics data on our in-depth guide! (https://sproutsocial.com/insights/new-social-media-demographics/)

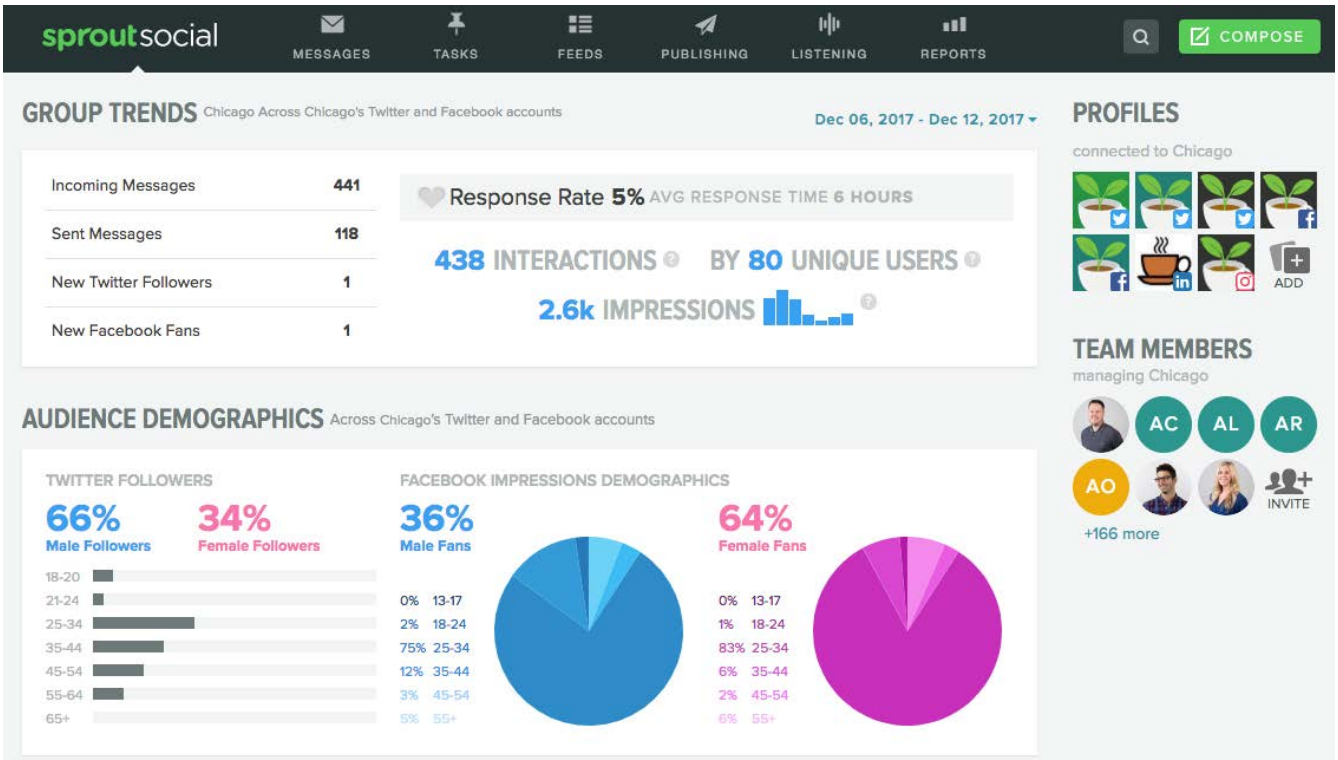
The best marketers you'll come across don't sleep until they have a better idea on their audience and segmentation strategy.

Identifying Customer Demographics

While the demographics data above give you insight into each channel, what about your own customers? Further analysis has to be completed before you can truly know your customer demographics on social media.

That’s why many brands use a social media dashboard (Figure) that can provide an overview of who’s following you and how they interact with you on each channel. Most brands today are using at least some sort of dashboard. However, does your dashboard address your specific goals?

Whether you’re an agency providing insights for your clients or an enterprise company discovering your own demographics, an all-in-one dashboard solution is critical.



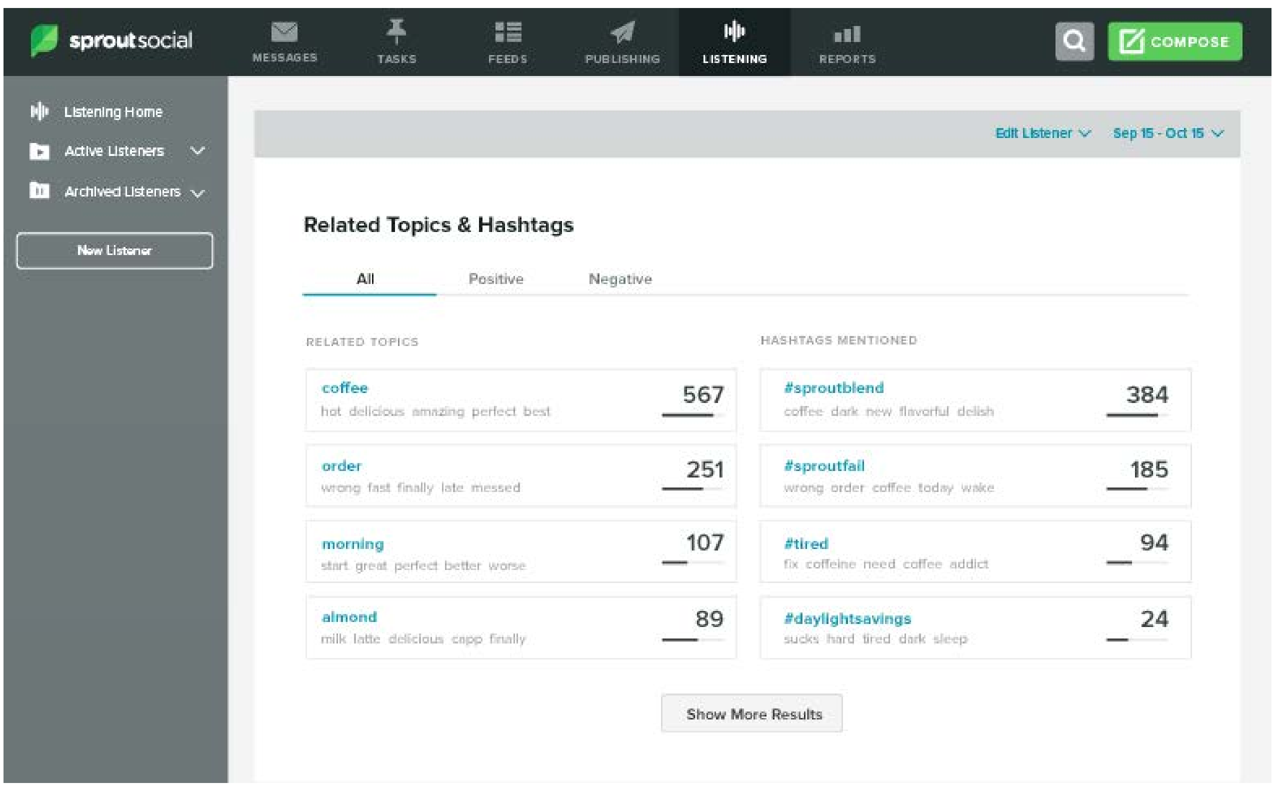
3. Establish Your Most Important Metrics

While your targeted social media metrics might be the most important step of a strategy, it’s often the spot most veer off the path. Vanity metrics like follower count and likes are always good to measure, but does it tell you the **whole story of your brand** on social media?

We often get wrapped up in viewing followers and likes as the truth to a campaign, but it’s smart to take a step back and evaluate the social metrics associated with your overall goals.

Engagement metrics sometimes paint a better picture, because as we’ve mentioned many times here, building lasting relationships works on social. Large audiences and likable content is absolutely great, but here are some other metrics you might want to pursue in 2018:

- **Reach:** Post reach is the number of unique users who saw your post. How far is your content spreading across social? Is it actually reaching user’s feeds?
- **Clicks:** This is the amount of clicks on your content, company name or logo. Link clicks are critical toward understanding how users move through your marketing funnel. Tracking clicks per campaign is essential to understand what drives curiosity or encourages people to buy.
- **Engagement:** The total number of social interactions divided by number of impressions. For engagement, it’s about seeing who interacted and if it was a good ratio out of your total reach. This sheds light on how well your audience perceives you and their willingness to interact.
- **Hashtag performance:** What were your most used hashtags on your own side? Which hashtags were most associated with your brand? Or what hashtags created the most engagement?



- **Sentiment:** This is the measurement of how users reacted to your content, brand or hashtag. Did customers find your recent campaign offensive? What type of sentiment are people associating with your campaign hashtag? It’s always better to dig deeper and find what people are saying.
- **Organic and paid likes:** More than just standard Likes, these likes are defined from paid or organic content. For channels like Facebook, organic engagement is much harder to

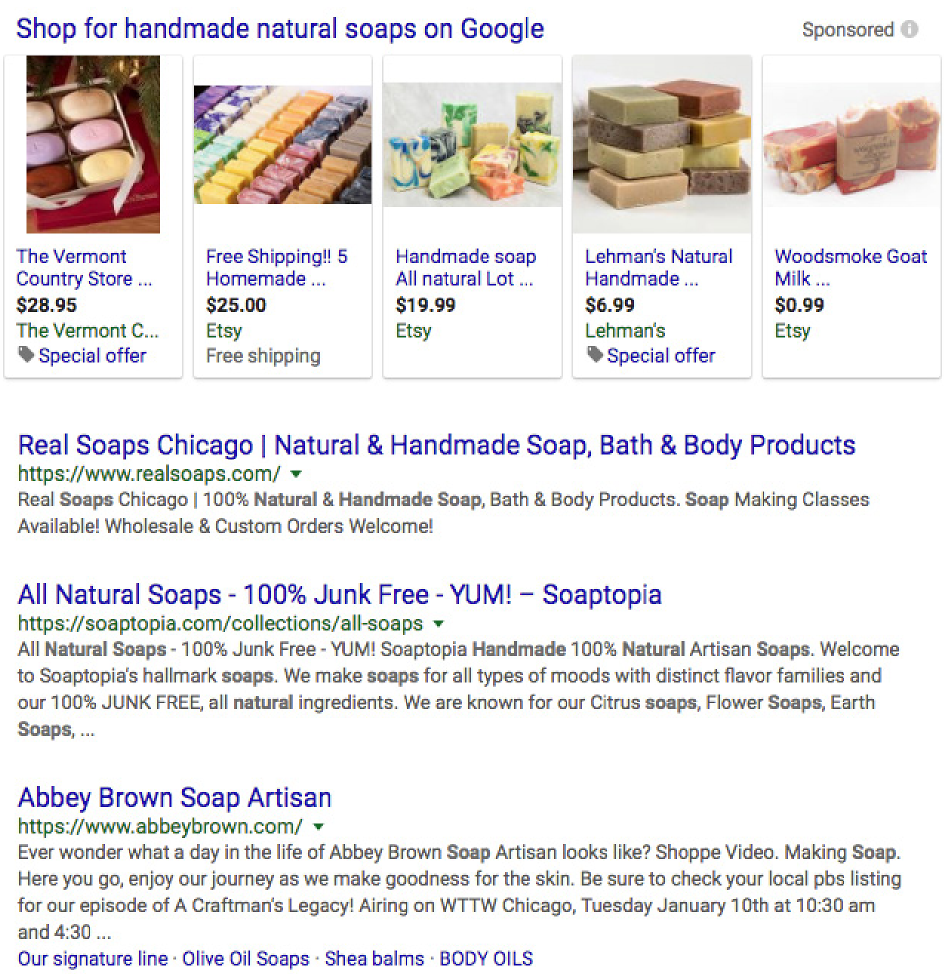
gain traction, which is why many brands turn to Facebook Ads. However, earning organic likes on Instagram isn't quite as difficult.

4. Research Your Social Competitive Landscape

Before you start creating content (we promise we're almost there!), it's really smart to investigate your competitors. We put this before the content creation process because you often find new ways to look at content by analyzing what's making your competitors successful.

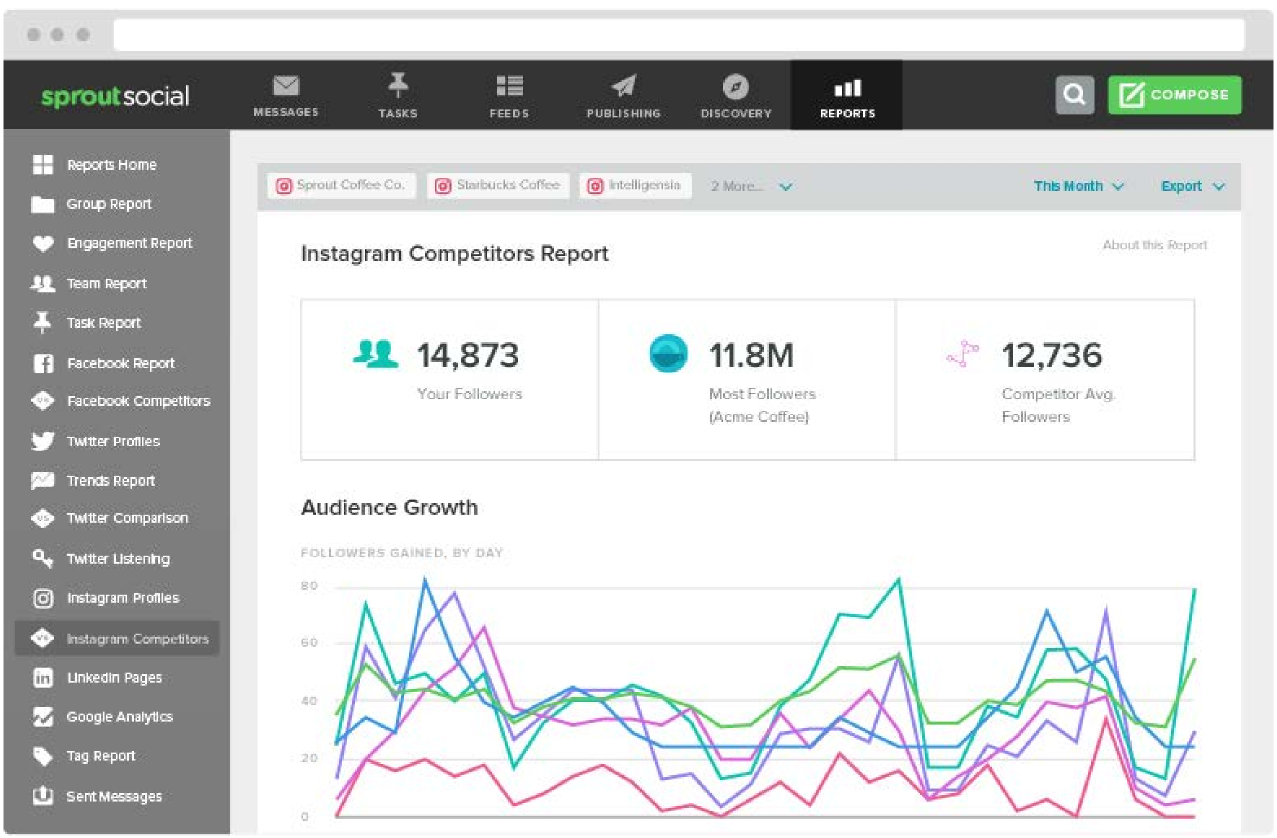
Again, we'll always believe you shouldn't steal your competitors' ideas, but instead learn and grow from their success and failures. So how do you find that information? The first step is to find out who's your competition in the first place.

The simplest way to find competitors is through a simple Google search. Look up your most valuable keywords, phrases and industry terms to see who shows up. For example, if you sold various soaps, "handmade natural soaps" would be a great keyword to investigate:



You can exclude the major retailers like Amazon and Bath & Body Works. Search for those who show up who are in your specific industry. Next you want to see who is active on social.

As you can see, Wild Soap has an active social presence, which means they're a great candidate to track. After gathering a handful of industry competitors, it's smart to use a social media competitive analysis tool like Sprout Social to track Facebook and Instagram content.



Here you can see post break downs of text, images and video to see what your competitors are doing to drive the most engagement. Once you dig through the competitive analysis, you'll have a better idea of what your potential customers want.

5. Build & Curate Engaging Social Media Content

Did someone say content? It's no lie–social media content is extremely important to your marketing strategy. However, it's best to follow the previous steps before planning out content (we caught you, blog skippers!) so you can start building more effective themes.

For starters, we recommend creating content that fits to your brand's identity. This means you should avoid things like reaching out to your unpopular demographics without a complete strategy in place.

It's necessary to find the perfect balance between target content and being overly promotional as well. In fact, 46% of users say they'll unfollow a brand if there's too many promotional messages. Additionally, 41% of users say they'd unfollow a brand that shared too much irrelevant content (https://sproutsocial.com/insights/data/q3-2016/).

Video Content or Bust

How important is video to your social media marketing strategy? Extremely–approximately 90% of online shoppers believe product videos help them make a purchasing decision (https://www.forbes.com/sites/forbesagencycouncil/2017/02/03/video-marketing-the-future-of-content-marketing/#744d94af6b53). Additionally, the average online video is completely watched end to end by 37% of viewers (https://blog.hubspot.com/marketing/video-marketing-statistics#sm.0000f7ujhkwrse8sqa62aq63w23fi).

These types of statistics should only enforce your reasoning to invest in social media video content. Brands can reach users through Instagram Stories, Facebook Live and other in-the-moment media.

Build Content Themes

One of the toughest challenges to visual content is creating it on a day-to-day basis. A Venngage infographic showed 36.7% of marketers said their No.1 struggle with creating visual content was doing so consistently (https://www.impactbnd.com/blog/visual-content-marketing-statistics-2017).

This truly shows how important highly-visual content is to marketers and the people they want to reach. That's why building content themes is a great approach to sectioning out your content. Instagram is one your premier channels to work off visual themes.

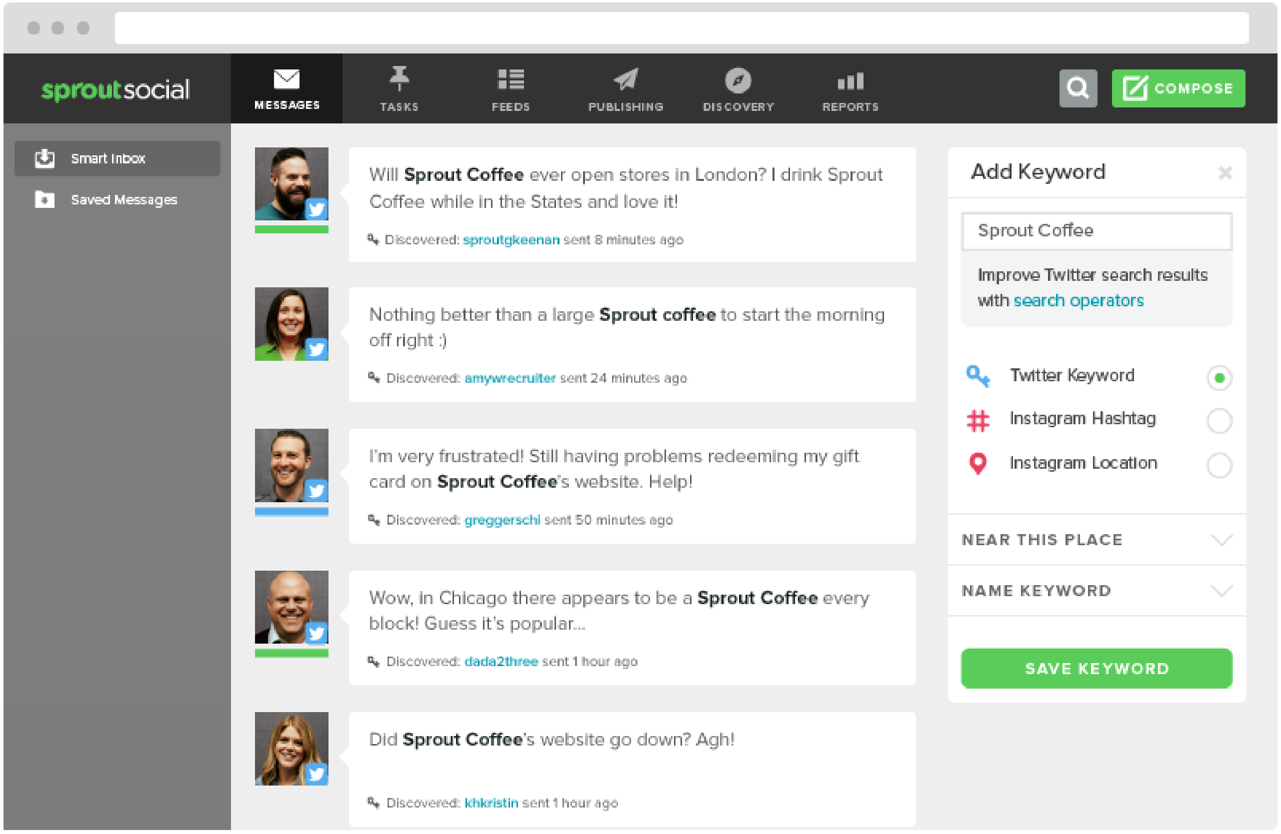
Anthropologie does an amazing job at keeping their Instagram feed consistent, colorful and eye-popping. Work in content themes to ensure you have a consistent schedule of excellent content to publish.

6. Engage With Your Audience & Don't Ignore

Social media channels are built as networks. This means their main purpose is to be a space to converse, discuss topics and share content. Your brand can't forget these core elements of "networking" and it takes effort to ensure conversations or engagement opportunities aren't left unattended.

Through social media, you gain respect as a brand by just being present and talking to your audience. That's why social customer care is so important to brands wanting to increase audience awareness. It's all about engagement.

For example, Seamless (https://twitter.com/Seamless) does a wonderful job of not only responding, but showing customer care is priority. Through the right social media monitoring tools, you can find instances across all your channels to interact, respond and gauge customer service inquiries.



Designating teams to specific tasks can help your staff run like a well-oiled social media team, whether you're a group of one or 100.

Post at the Best Times to Engage

When is your brand available to engage and interact with customers? You might see some recommending times to post late in the evening. But if your brand isn't there to communicate, what's the point of posting at the preferred time?

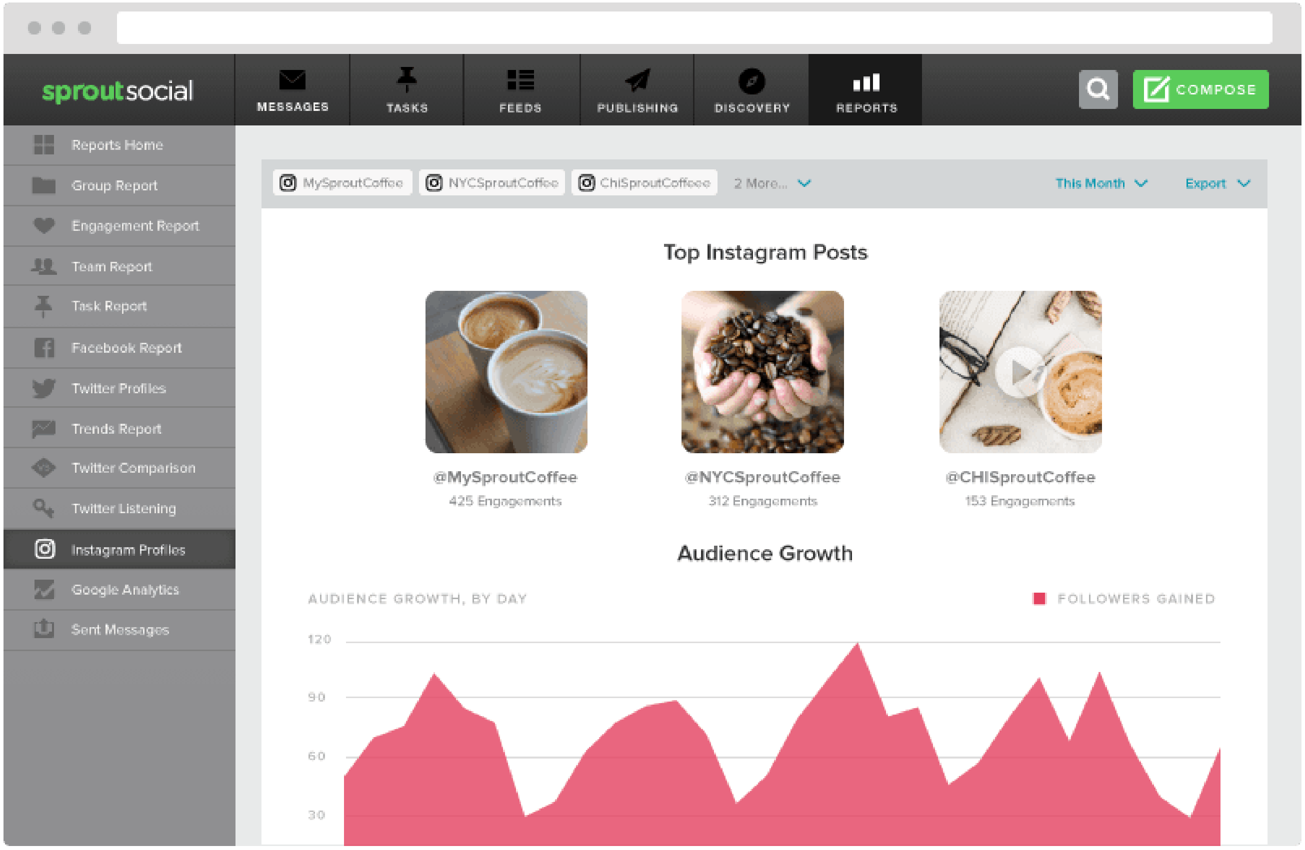
Instead, try to ensure your social media or community managers are available and ready to answer any product questions or concerns when you tweet or post. It's smart to learn the best times to post on social media, but it's just as critical to engage after posting.

According to our Index, a brand's average response time is around 10 hours. But did you know that most users believe brands should respond to social media messages within four hours?

With all the updated algorithms, organic content has a tough time reaching the majority of your audience. The last thing you want to do is ignore those who engage and lose out on sending more down your marketing funnel.

7. Track Your Efforts & Always Improve

So, how well did you do on your social media marketing strategy? Without continuously analyzing your efforts, you'll never know how one campaign did over another. Having a bird's-eye-view of your social media activity helps put things into perspective.



You've got down your most important goals, network preferences and metrics–now it's time to make sure you made the right decisions. Knowing you've made the right choices is still a difficult task in social media.

In fact, 46% of B2B marketers are unsure if their social strategy actually created revenue for their brand (https://www.business2community.com/social-media/47-superb-social-media-marketing-stats-facts-01431126#HT07K2mwjfUGsG2Z.99). But marketers are always trying and looking for the perfect connection. That's why the most commonly used metric (80%) for marketers is engagement.

If you work at building lasting relationships, there's a lot less room for failure with your social media marketing strategy.

Use a Tool to Track Success

Sprout Social was created with social media marketing in mind. Our social media tools offer a full suite of analytics and reporting features to help you pinpoint exactly which posts, messages and hashtags perform the best.

It's easy to connect other critical tools to our dashboard like Google Analytics, which helps you see which posts drove the most traffic, conversions and overall revenue.

Social Media Marketing Strategy Checklist

We wanted to give our readers a few resources to use moving forward. That's why we put together this 7-step social media marketing strategy checklist to help all of our readers creating and auditing their own strategies.

We encourage you to share it with colleagues or use the embed code to put it on your own site!

Social Media Checklist

What are your social media goals?

- □ Increase brand awareness
- □ Community engagement and education
- □ Increase volunteerism/public recruitment
- □ Fundraising
- □ Others?

Where will you reach your social media audience?

- □ Facebook
- □ Instagram
- □ Twitter
- □ Linked In
- □ Snapchat
- □ YouTube
- □ Google

What are your core demographics?

- □ Age (18-29; 30-49; 50-65; 65+
- □ Gender (M, F)
- □ Location (urban, suburban, rural)
- □ Income ($30K-49.9K: 50K-75K; 75K+)
- □ Education (High School or less; some college; college+)

What are your core metrics?

- □ No. of clicks
- □ Reach (how broadly discussed)
- □ Hashtag performance
- □ Engagement (total no of clicks or reviews/demographic core goals)
- □ Shares
- □ Retweets

What type of content will you produce?

- ◻ Videos (YouTube)
- ◻ Webinars
- ◻ Blogs
- ◻ Photos
- ◻ Case studies
- ◻ Gated guides
- ◻ Post other nonprofits that promote your effort

What are your best times to post on media?

- ◻ Facebook (Day, Time of day)
- ◻ Instagram (Day, Time of day)
- ◻ Twitter (Day, Time of day)
- ◻ Linked In (Day, Time of day)
- ◻ Snapchat (Day, Time of day)

How often will you assess your metrics?

- ◻ Daily
- ◻ Weekly
- ◻ Monthly
- ◻ Annually

Who is going to monitor and maintain the social media platform?

- ◻ ANRC
- ◻ Nonprofit partner
- ◻ Contract
- ◻ Other

APPENDIX L

Cost Estimates for Implementation of BMPs

L.1 Estimation Approach

Potential relative costs for implementation of management practices were estimated by multiplying the cost of a practice (see Sections L.2 and L.3) by the extent over which the practice could be implemented (see Section L.4). The extents could be expressed in a variety of units, but for our examples were expressed in acres, feet, operation (i.e., farm), or residential lot. The extents used in estimating the costs reported in Tables 6.2 and 6.3 were estimates of the currently untreated areas in the recommended subwatersheds.

L.2 Estimated Costs of Agricultural Practices

Practice costs used to estimate cost for implementing agricultural management practices in the recommended subwatersheds are listed in Table 1. The Cost for Estimation values in Table 1 were primarily derived from unit costs identified for the Arkansas Environmental Quality Incentives Program (EQIP) for 2021 60% allowance for non-historically underserved (HU) producers (NRCS, 2020). The cost used for estimation was derived by dividing the EQIP unit cost by 0.6, i.e., assuming the EQIP allowance is 60% of the actual cost for implementation. The result of this calculation was then rounded to one or two significant digits.

For some of the practices the units for the EQIP allowance would be difficult to characterize for estimating implementation costs, for example, for ponds and ditches the EQIP allowance was based on cubic yards of dirt moving. Where possible, the Cost for Estimation for these practices was derived from the average of reported EQIP funds distributed for the practice in Arkansas during the period 2008-2020 (Christianson, 2021). As with the EQIP allowance, the reported funds distributed were assumed to represent 60% of the cost of implementation. The values given in Table 1 were calculated by dividing the average of the reported funding by 0.6 and then rounding up to one or two significant digits.

Table 1. Costs used to estimate costs of implementing agricultural management practices in recommended HUC12 subwatersheds.

Practice[a]	Cost for Estimation	Units	2021 EQIP practice	2021 EQIP 60% allowance (non-HU)[b]	Average EQIP & CSP funding 2008-2020[c]	Assumptions
Wetland restoration	$500.00	Acre	657 Riverine channel and floodplain restoration	$285/ac	$9.73/ac (wetland restoration, enhancement, management)	
Soil testing	$8.00	Acre	590 Basic nutrient mgt, non-organic	$4.66/ac	$8.00/acre nutrient management	
Nutrient management plan (pasture)*	$7,000.00	Operation	102 Comprehensive NMP livestock operation < 300 AU without land application	$2,255.10 - $6,250.68/operation		
Nutrient management plan (cropland)*	$5,100.00	Operation	104 Nutrient management CAP >300 ac not part of CNMP	$3,010.88/plan/operation		
Prescribed grazing*	$40.00	Acre	528 Medium intensity prescribed grazing	$22.91/ac	$89/acre	
Access control (stream fencing)*	$2.00	Foot	382 Fence	$0.91 – $1.77/ft	$2.30/ft (fence) $951/ac access control	
Alternate water supply	$600.00	Facility	614 Watering facility	$0.40 - $3.00/gal	$588/each	Based on average of reported EQIP funding for practice in Pulaski and Lonoke Counties
Livestock shelter	$3,000.00	structure	576 Portable shade structure	$2.66/sq ft	$1,237/each (shade shelter)	Based on average of reported EQIP funding for practice in Arkansas
Streambank stabilization*	$15.00	Foot	580 Vegetative streambank/shoreline protection	$8.22 - $11.91/ft	$162/ft	
Forested riparian buffer*	$500.00	Acre	391 Hardwood with pasture forgone income	$306.65/ac	$763/ac pasture	
	$770.00	acre	391 Hardwood with cropland forgone income	$461.01/ac	$716/ac cropland	
Herbaceous riparian buffer*	$300.00	1,452 feet	390 Riparian herbaceous cover	$159.05 - $169.90/ac	$343/ac	Buffer width of 30 ft
Critical area planting	$300.00	Acre	342 Normal tillage	$169.49/ac	$371/ac	
Heavy use area protection	$1.60	Square foot	561 Rock/gravel no geotextile	$0.94/sq ft	$11,996/ac or $0.28/sq ft	
Pasture management suite*	$16,200.00	Operation	Nutrient mgt plan Soil testing AR P index 4R nutrient mgt Access control Watering facility Heavy use area protection Prescribed grazing	-	-	50 acres pasture/ operation managed 0.1 acre heavy use area protection/ operation 1 watering facility/ operation 100 ft of stream fencing $20/acre for nutrient mgt (P index, 4R)
Cover crops*	$70.00	Acre	340 Basic cover crop	$40.18/ac	$39/ac	
Feral hog/swine control	$10.00	Acre	297 Assessment	$506.82/number	$9.12/ac	Based on average of reported EQIP funding for practice in Bayou Meto watershed
			297 Evaluation	$678.48/number		
Conservation tillage*	$20.00	Acre	345 Residue and tillage management, reduced till	$10.52/ac	$26/ac	
Grade stabilization structure/water control structure	$9.00	structure	410 Drop pipe	$1.63/ft dia steel $0.89 - $1.16/ft dia plastic	$581/each	1.5 ft pipe
			587 Flashboard riser	$2.37/ft diameter		
Integrated pest management	$5,000.00	Number (plan)	114 IPM Plan >250 ac	$3,010.88/number	$255/plan	
Tailwater recovery system	$25,000.00	system	447 Delta tailwater pit	$0.83/cu yd	$15,654/each	Based on average of reported

Table 1. Costs used to estimate costs of implementing agricultural management practices in recommended HUC12 subwatersheds (continued).

Practice[a]	Cost for Estimation	Units	2021 EQIP practice	2021 EQIP 60% allowance (non-HU)[b]	Average EQIP & CSP funding 2008-2020[c]	Assumptions
			447 Tailwater collection structure	$1.95/linear ft		EQIP funding for practice in Bayou Meto watershed
Grassed waterways	$2,000.00	Acre	412 Base waterway	$1,186.32/ac	$874/ac	
Irrigation land leveling	$360.00	Acre	464 Irrigation land leveling with stockpiling	$1.27/cu yd	$213/ac	Based on average of reported EQIP funding for practice in Bayou Meto watershed
Irrigation water management (pipe planner + surge valves)	$700.00	Acre	443 Surge valve & controller	$153.82/in	$401/ac	Based on average of reported EQIP funding for practice 443 in Bayou Meto watershed
			443 poly irrigation tubing	$0.31/ft		
Winter flooding of rice*	$40.00	Acre	646 Shallow water development, close risers	$11.56/ac	$17/acre	
			646 shallow water management – low level	$12.39/ac		
Alternate rice irrigation	$50.00	Acre	449 Rice intermittent flood	$27.85/ac	$20/ac	
Field borders	$500.00	Acre	386 Field border with forgone income	$288.10 - $543.37/ac	$225ac	
Two-stage ditches	$4.00	Foot	608 Two-stage ditch	$1.38/cu yd	$2.39/ft	Based on average of reported EQIP funding for practice 608 in Bayou Meto watershed
Soil nutrient management suite*	$25,000.00	Operation	Nutrient mgt plan Soil testing N-ST*R for rice 4R nutrient mgt	-	-	700 acres managed $20/acre for nutrient management (4R, N-ST*R)
Irrigation management suite*	$820,000.00	Operation	Land leveling Pipe planner Irrigation scheduling Surge valve Tailwater system Irrigation reservoir	-	-	700 acres managed
Tailwater recovery suite*	$75,000.00	Operation	Tailwater system Irrigation reservoir		$38,125/ irrigation reservoir	$50,000 for irrigation reservoir

a - yellow indicates practice recommended by stakeholders, * indicates practice for which reductions were reported in Section 4.8
b - (NRCS, 2020)
c - (Christianson, 2021)

For the practice suites, the acres managed were based on the average acres per operation for appropriate counties, estimated from data reported in the 2017 Arkansas Census of Agriculture. The average acres per operation calculations are summarized in Table 2. Because it is unlikely that 100% of cropland or pasture acres in an operation would be managed, for a variety of reasons, areas less than the acres per operation were assumed when estimating costs. Overall cost for implementing the suite was estimated by summing the costs for the individual practices included in the suite.

Table 2. Calculations used as the basis for assuming acres of pasture and cropland in an operation (farm) within the recommended HUC12 subwatersheds.

County	Pulaski	Lonoke	Lonoke	Arkansas
Land use	Pasture	Pasture	Cropland	Cropland
Acres	15,848	23,850	284,946	358,999
Operation type	Livestock	Livestock	Crop	Crop
Number of operations	277	364	478	400
Acres per operation	57	66	596	897

L.3 Estimated Costs of Urban Management Practices

One estimated cost of installing a bioretention basin on a residential lot is around $1,000 (https://www.lid-stormwater.net/bio_costs.htm). Estimated cost of seeding grass in a riparian buffer is $30/square foot (https://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Filtering%20Practice/Grassed%20Filter%20Strip.htm). If we assume a 30-foot buffer width, this comes out to $900 per linear foot of streambank, or $1,800 per linear foot of stream, assuming both banks are seeded.

L.4 Estimating Currently Untreated Areas in Recommended HUC12s

Land areas for treatment to reduce nonpoint source pollution were based on 2016 land cover data (Wickham, Stehman, Sorensen, Gass, & Dewitz, 2021). We know that the management practices recommended for Bayou Meto watershed are already in use within the watershed. Therefore, we assumed that some of the land in the recommended subwatersheds is already being treated using the recommended management practices. Areas already being treated, i.e., where conservation practices are already in use, were estimated using information from the 2017 Arkansas Census of Agriculture, as described in the following subsections.

L.4.1 Pasture Area Not Being Treated Using Prescribed Grazing

The 2017 Arkansas Census of Agriculture reports number of grazing operations and number of operations using prescribed grazing by county. These numbers were used to calculate percentage of operations using prescribed grazing in Pulaski and Lonoke Counties (Table 3). This percentage was then multiplied by the acres of pasture within the pasture-dominant recommended subwatershed to estimate the acres of pasture with prescribed grazing. The Pulaski County percentage was used for the Bayou Meto Headwaters subwatershed, and the average of the Pulaski County and Lonoke County percentages was used for the Glade Branch Bayou Two Prairie subwatershed. This estimation method assumes that all grazing operations have the same number of acres, and that prescribed grazing is used on all pasture within an operation. To estimate the pasture area not being treated with prescribed grazing, the estimated pasture area with prescribed grazing was subtracted from the total subwatershed pasture area. Estimated pasture areas in the recommended subwatersheds not already treated using prescribed grazing are listed in Table 4.

Table 3. 2017 prescribed grazing information for Pulaski and Lonoke Counties (USDA National Agricultural Statistics Service, 2017).

Information	Lonoke County	Pulaski County
Number of grazing operations	364	277
Number of operations using prescribed grazing	56	55
Percentage of operations using prescribed grazing	15%	20%

Table 4. Estimated pasture area in recommended subwatersheds not being treated using prescribed grazing.

Information	Bayou Meto Headwaters (HUC12 080204020102)	Glade Branch Bayou Two Prairie (HUC12 080204020201)
Pasture, acres	5,912	6,158
Assumed percentage with prescribed grazing	20%	18%
Estimated pasture with prescribed grazing, acres	1,174	1,085
Estimated pasture without prescribed grazing, acres	4,738	5,073

L4.2 Row Crops Where Cover Crops Can Be Added

The 2017 Arkansas Census of Agriculture reports acres of cover crops and acres of row crops by county. These numbers were used to calculate percentage of row crop acres with cover crops for Arkansas and Lonoke Counties (Table 5). It was assumed that cover crops were grown after any crop but rice. Data from the 2018 NASS Cropland Data Layer, clipped to the subwatershed boundaries, was used to calculate the percentage of cropland within the cropland dominant recommended subwatersheds planted in rice. This percentage was multiplied by the 2016 NLCD cropland area for the subwatersheds to estimate the 2016 area in rice. This area was then subtracted from the 2016 NLCD cropland area for the subwatersheds to estimate the acres of non-rice crops. The area of non-rice crops was then multiplied by the appropriate county cover crop percentage to estimate the acres in the subwatershed using cover crops. This value was subtracted from the total acres of non-rice crops in the subwatersheds to determine the row crop acres where cover crops could be added. Results from these calculations are provided in Table 6.

Table 5. 2017 cover crop information for Arkansas and Lonoke Counties (USDA National Agricultural Statistics Service, 2017).

Information	Arkansas County	Lonoke County
Acres of cropland	358,999	284,946
Acres of cover crop	3,741	3,441
Acres of rice	81,070	84,573
Acres of non-rice crop	277,929	200,373
Percentage of non-rice cropland with cover crop	1.3%	1.7%

Table 6. Estimated acres of row crops in recommended subwatersheds where cover crops could be added.

Information	Skinners Branch Bayou Two Prairie (080204020205)	Upper Mill Bayou (080204020403)	Hurricane Bayou (080204020404)	Bills Bayou (080204020407)
2018 cropland acres	20,774	17,135	16,136	10,180
2018 rice acres	6,538	4,352	4,352	1,416
2018 rice percentage	31%	25%	27%	14%
2016 cropland acres	23,262	18,310	15,686	10,455
Estimated 2016 rice acres	7,321	4,650	4,230	1,455
Estimated 2016 acres non-rice cropland	15,941	13,660	11,456	9,000
Assumed percentage of non-rice cropland with cover crop	1.7%	1.3%	1.3%	1.3%
Estimated 2016 acres with cover crop (non-rice)	274	184	154	121
Estimated 2016 cropland acres available for cover crop (non-rice)	15,667	13,476	11,302	8,879

L4.3 Row Crops Where Conventional Tillage Is Used

The 2017 Arkansas Census of Agriculture reported acreages for conventional tillage, conservation tillage, and no-till by county. These data were used to calculate the percentage of cropland on which conventional tillage practices were used. Because the sum of the acreages for conventional tillage, conservation tillage, and no-till was less than the total county cropland acreage, the percentage of conventional tillage was calculated by dividing the acres for conventional tillage by the sum of the acreages reported for conventional tillage, conservation tillage, and no-till. These calculations are summarized in Table 7. The acres of cropland in the recommended subwatersheds under conventional tillage were estimated by multiplying the total cropland acreage by the appropriate county percentage (Table 8).

Table 7. 2017 tillage information for Arkansas and Lonoke Counties (USDA National Agricultural Statistics Service, 2017).

Information	Arkansas County	Lonoke County
Acres conventional tillage	193,155	106,390
Acres conservation tillage	112,796	93,145
Acres no-till	33,614	46,833
Sum of acres with reported tillage	339,565	246,368
Percentage of conventional tillage	57%	43%

Table 8. Estimated acres of cropland in the recommended subwatersheds under conventional tillage.

Information	Skinners Branch Bayou Two Prairie (080204020205)	Upper Mill Bayou (080204020403)	Hurricane Bayou (080204020404)	Bills Bayou (080204020407)
2016 cropland acres	23,262	18,310	15,686	10,455
Assumed percentage under conventional tillage	43%	57%	57%	57%
Estimated acres under conventional tillage	10,045	10,415	8,923	5,947

L4.4 Rice Not Flooded in Winter

County conservationists estimate that, on average, 60% of rice fields in Lonoke County are flooded in the winter for waterfowl, and 50% in Arkansas County (K. Perkins, Lonoke County Extension Office, personal communication 7/1/2020; P. Horton, Arkansas County Extension Office, personal communication 7/17/2020). It was assumed that 50% of the rice acres in the recommended subwatersheds are flooded in the winter. Estimated 2016 rice acreages were multiplied by 50% to estimate the acres of rice fields in each of the recommended subwatershed where winter flooding could be added (Table 9).

Table 9. Estimated acres of rice in the recommended subwatersheds where winter flooding could be added.

Information	Skinners Branch Bayou Two Prairie (080204020205)	Upper Mill Bayou (080204020403)	Hurricane Bayou (080204020404)	Bills Bayou (080204020407)
Estimated 2016 rice acres*	7,321	4,650	4,230	1,455
Estimated acres of rice where winter flooding could be added.	3,661	2,325	2,115	727

* from Table 6

L4.5 Cropland Not Treated Using Tailwater Recovery

An inventory of on-farm irrigation reservoirs in Arkansas, Lonoke, and Prairie Counties was recently completed using 2015 imagery from the National Agricultural Imagery Program (NAIP) (Yeager, Reba, Hassey, & Adviento-Borbe, 2017). One of the criteria for classifying reservoirs as on-farm irrigation reservoirs was the presence of a tailwater recovery ditch, suggesting that this inventory also provides an indication of the number of active tailwater recovery systems in use in these counties. The number of on-farm irrigation reservoirs was reported by county (Table 10). To get an estimate of the number of tailwater systems in the recommended subwatersheds, the number of on-farm irrigation reservoir per acre was calculated for Arkansas and Lonoke Counties (Table 10). These values were multiplied by the acres of cropland in each recommended subwatershed to estimate a number of existing tailwater systems (Table 11). The cropland area treated by these systems was estimated by multiplying the number of systems by 105 acres (reference). As a check for this estimate, the number of tailwater systems funded through EQIP during the period 2008-2020 in each of the recommended subwatersheds, was retrieved from Christianson (2021) along with the total treated area for these systems (Table 11). The largest of the two areas treated by tailwater systems was subtracted from the 2016 cropland acres to estimate the cropland area not currently treated with tailwater systems. The number of tailwater systems needed to treat the currently untreated area was estimated by dividing the untreated area by 105 acres. The results of these calculations are summarized in Table 11.

Table 10. On-farm irrigation reservoir numbers reported in Yeager et al. (2017).

County	Number of on-farm irrigation reservoirs in 2015	Acres of cropland 2016	Tailwater systems/acre cropland
Arkansas	282	358,999	0.0008
Lonoke	119	284,946	0.0004

Table 11. Estimated acres of cropland in the recommended subwatersheds where tailwater recovery could be added.

Information	Skinners Branch Bayou Two Prairie (080204020205)	Upper Mill Bayou (080204020403)	Hurricane Bayou (080204020404)	Bills Bayou (080204020407)
2016 cropland acres	23,262	18,310	15,686	10,455
Tailwater systems/acres cropland	.0004	.0008	.0008	.0008
Estimated number of systems	10	15	12	8
Estimated acres cropland treated with tailwater recovery	1,050	1,575	1,260	840
Systems installed 2008-2020	2	19	3	0
Treated area 2008-2020, acres	200	1,896	300	0
Estimated acres of cropland where tailwater recovery could be added	22,212	16,414	14,426	9,615
Estimated number of systems to treat untreated area	153	113	99	66

L4.6 Croplands Without Nutrient Management Plans

Acres in Arkansas County with nutrient management funded for the years 2016 – 2020 were retrieved from Christiansen (2021) (see Table 12). Nutrient management plans (practice numbers 102 or 104) were not reported in this database, so nutrient management (practice number 590) was used as a surrogate. The average of the acres with funded nutrient management (5,516) was divided by the 2017 acres of cropland reported for Arkansas County in the Census of agriculture (358,999) to calculate a percentage of cropland with nutrient management (10.5%).

Based on these calculations, we assumed that 90% of the cropland in the recommended subwatersheds had no nutrient management plan. To estimate the number of operations without nutrient management plans, the estimated acreage without treatment was divided by 800, an assumed number of acres per operation based on the data in Table 2. These calculations are summarized in Table 13.

Table 12. Acres of nutrient management funded through EQIP in Arkansas County by year.

Year	Acres nutrient management funded in Arkansas County
2020	5530
2019	2457
2018	8171
2017	6378
2016	5045
Average	5516

Table 13. Estimated acres of cropland and crop operations without nutrient management plans in recommended subwatersheds.

Information	Skinners Branch Bayou Two Prairie (080204020205)	Upper Mill Bayou (080204020403)	Hurricane Bayou (080204020404)	Bills Bayou (080204020407)
2016 cropland acres	23,262	18,310	15,686	10,455
90% of 2016 cropland acres	20,936	16,479	14,117	9,410
Number of operations	26	21	18	12

L4.7 Stream Miles Without Riparian Buffer

As described in Section 4.6.1, simple GIS analysis was used to estimate stream miles without riparian buffers. In this analysis NHD stream lines that intersected NLCD cells (30 m by 30 m) classified as pasture, developed, or cropland were clipped and then their lengths summed. Note that the NHD stream lines include both natural channels, channelized streams, and drainage ditches in the Delta region of Arkansas, including the Bayou Meto watershed.

Table 14. Estimated extent of streams without wooded buffer in recommended subwatersheds.

Subwatershed	Land use	Miles of stream without buffer
Bayou Meto Headwaters (HUC12 080204020102)	Pasture	22.8
	Developed	4.0
Glade Branch Bayou Two Prairie (HUC12 080204020201)	Pasture	14.6
	Developed	12.6
Skinners Branch Bayou Two Prairie (080204020205)	Cropland	54.0
Upper Mill Bayou (080204020403)	Cropland	67.5
Hurricane Bayou (080204020404	Cropland	64.0
Bills Bayou (080204020407)	Cropland	33.6

L4.8 Residential Lots Without Bioretention

In Cabot, within the Glade Creek recommended subwatershed, based on a few measurements from online aerial photos, it appears that the average residential lot is approximately 0.2 acres. To estimate the number of residential lots in the subwatershed, the acres of medium intensity development in the subwatershed was divided by 0.2 acres. In the Bayou Meto Headwaters recommended subwatershed, based on a few measurements from online aerial photos, it appears that residential lots range from 1 to 3 acres. For this subwatershed, the number of residential lots was estimated by dividing the acres of medium intensity development by 1.5 acres per residential lot. The assumption for the cost estimate was that bioretention basins were installed on every residential lot. These calculations are summarized in Table 15.

Table 15. Estimates of residential area without bioretention basins in two recommended subwatersheds.

Information	Bayou Meto Headwaters (HUC12 080204020102)	Glade Branch Bayou Two Prairie (HUC12 080204020201)
Medium density development, acres	16.0	717.9
Assumed average lot size, acres	1.5	0.2
Estimated number of residential lots	11	3,590

L.5 References

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