Pathogen TMDLS

For

Planning Segments 4D Reaches

Segments

AR8020301-012, AR8020301-011, and AR8020301-010

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EXECUTIVE SUMMARY

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for impaired waterbodies. A TMDL establishes the amount of a pollutant that a waterbody can assimilate without exceeding its water quality standard for that pollutant. TMDLs provide the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and non-point sources to restore and maintain the quality of the state's water resources (USEPA 1991).

A TMDL for a given pollutant and waterbody is composed of the sum of individual waste-load allocations (WLAs) for point sources, load allocations (LAs) for non-point sources, and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving water-body and may include a future growth (FG) component. The TMDL components are illustrated using the following equation: $TMDL = \Sigma WLAs + \Sigma LAs + MOS + FG$

The study area is part of the Arkansas Department of Environmental Quality (ADEQ) Planning Segment 4D and is located within both the Ozark Highlands and the Mississippi Alluvial plains ecoregion. The study area for this project is limited to three reaches in the Arkansas planning segment 4D (**AR8020301-012, AR8020301-011, and AR8020301-010**). Land use in the study area consists mostly of forest and pastureland. The designated beneficial uses that have been established by ADEQ for Planning Segment 4D include propagation of fish and wildlife, primary and secondary contact recreation; domestic, agricultural and industrial water supply. Two of the planning 4D segments have been designed as extraordinary resource waters, ecologically sensitive waters, and natural and scenic waterways.

The TMDLs in this report were developed using the load duration curve methodology. This method illustrates allowable loading at a wide range of stream flow conditions. The numeric water quality criteria that apply to the impaired reaches in the Cypress Bayou Subbasin can be found in Section 2.6.1 of the TMDL report.

The seasonal fecal coliform bacteria TMDLs were developed on the basis of analyses of the applicable water quality criteria (i.e., calculating allowable loads and percent reductions for both summer and winter).

Table ES-1 Summary of Fecal Coliform TMDLs, (Primary Contact Recreation)

Arkansas Reach ID	Stream Name	Explicit MOS*	WLA*	sWLA*	LA*	TMDL*
08020301-012	Cypress Bayou	6.91E+10	3.79E+09	0.00E+00	6.87E+11	7.60E+11
08020301-011	Cypress Bayou	4.27E+09	2.13E+10	1.40E+10	3.49E+11	3.89E+11
08020301-010	Cypress Bayou	4.07E+10	0	0	3.66E+11	4.07E+11

***Note: cfu/day = colony forming units per day**

Table ES-2 Summary of Fecal Coliform TMDLs, (Secondary Contact Recreation)

Arkansas Reach ID	Stream Name	Explicit MOS*	WLA*	sWLA*	LA*	TMDL*
08020301-012	Cypress Bayou	3.84E+11	9.48E+09	0.00E+00	3.41E+12	3.80E+12
08020301-011	Cypress Bayou	2.14E+11	5.34E+10	8.56E+10	1.80E+12	2.15E+12
08020301-010	Cypress Bayou	2.04E+11	0	0	1.84E+12	2.04E+12

***Note: cfu/day = colony forming units per day**

Table ES-3 Summary of E. Coli TMDLs (Primary Contact Recreation)

Arkansas Reach ID	Stream Name	Explicit MOS*	WLA*	sWLA*	LA*	TMDL*
08020301-012	Cypress Bayou	7.87E+10	3.88E+09	0.00E+00	6.97E+11	7.80E+11
08020301-011	Cypress Bayou	4.38E+10	2.19E+10	1.75E+10	3.40E+11	4.23E+11
08020301-010	Cypress Bayou	4.18E+10	0	0	3.76E+11	4.18E+11

***Note: cfu/day = colony forming units per day**

Table ES-4 Summary of E. Coli TMDLs (Secondary Contact Recreation)

Arkansas Reach ID	Stream Name	Explicit MOS*	WLA*	sWLA*	LA*	TMDL*
08020301-012	Cypress Bayou	3.94E+11	1.942E+10	0.00E+00	3.49E+12	3.90E+12
08020301-011	Cypress Bayou	2.19E+11	1.09E+11	8.76E+10	1.77E+12	2.19E+12
08020301-010	Cypress Bayou	2.09E+11	0	0	1.88E+12	2.09E+12

***Note: cfu/day = colony forming units per day**

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1.0 INTRODUCTION

This report presents total maximum daily loads (TMDLs) for fecal coliform and *Escherichia coli* (E. coli) for 3 stream reaches in the Cypress Bayou watershed in northern Arkansas. These stream reaches were included on the Arkansas Department of Environmental Quality (ADEQ) 2004 Section 305(b) Report (ADEQ 2004a) as not supporting their designated use of primary contact recreation. The suspected sources of contamination and causes of impairment from the 303(d) listing are shown below in Table 1. The TMDLs in this report address the impairments due to pathogens and were developed in accordance with Section 303(d) of the Federal Clean Water Act and the Environmental Protection Agency's (EPA) regulations in 40 CFR 130.7.

The purpose of a TMDL is to determine the pollutant loading that a waterbody can assimilate without exceeding the water quality standard for that pollutant and to establish the load reduction that is necessary to meet the standard in a waterbody. The TMDL is the sum of the wasteload allocation (WLA), the load allocation (LA), and a margin of safety (MOS). The WLA is the load allocated to point sources of the pollutant of concern. The LA is the load allocated to nonpoint sources (NPS), including natural background. The MOS is a percentage of the TMDL that takes into account any lack of knowledge concerning the relationship between pollutant loadings and water quality.

Table 1- Pathogen Impaired 4D reaches

HUC-Reach Number	Waterbody Name	Impaired Use	Pollutant	Suspected Source	Priority Ranking
08020301-012	Cypress Bayou	PCR	Pathogen	Agriculture	Low
08020301-011	Cypress Bayou	PCR	Pathogen	Agriculture	High
08020301-010	Cypress Bayou	PCR	Pathogen	Agriculture	High

PCR = Primary Contact Recreation

2.0 STUDY AREA INFORMATION

2.1 General Description

Cypress Bayou is part of the White River Basin (USGS Hydrologic Unit 08020301) (Appendix A, Figure A-1). The State of Arkansas Department of Environmental Quality (DEQ) has designated the Cypress Bayou as planning segment 4D. The drainage area of Cypress Bayou watershed is 774 square miles (Table 2).

Table 2- Impaired Stream Miles in the Cypress Bayou Subbasin

HUC-Reach Number	Watershed	303(d) Listed Stream Miles (mi.)	Drainage (sq. mi^2)
08020301-012	Cypress Bayou	17.5	98.7
08020301-011	Cypress Bayou	9.5	54.9
08020301-010	Cypress Bayou	5	52.4

Source: EPA, BASINS

The impaired 4D planning segment contains a total of 35 stream miles, all of which are being assessed using monitoring data.

2.2 Soils and Topography

Impaired waters in planning unit 4D are located within both the Arkansas Valley and Mississippi Alluvial Plains ecoregions (i.e. Mississippi Delta). The soils and topography information was obtained from soil surveys for Faulkner, Lonoke, Prairie, Pualski, and White counties (USDA 1984a, USDA 1984b, USDA 1978). The soils in the study area range from deep stony soils to shallow clay and loamy soils. The topography of the study area is characterized by rolling hills, steep valleys, and ridges (Appendix A, Figure A-2).

2.3 Land Use

The Cypress Bayou subbasin is located in the White River Basin in Faulkner, Lonoke, Prairie, Pualski, and White counties. Populated cities and towns in these subbasins are identified in Table 3 (Appendix A, Figure A-3). The largest city in this subbasin is the City of Cabot, with a population of 8,319 people.

Table 3- Populated Cities and Towns in the Cypress Bayou Watershed

HUC-Reach Number	Watershed	Cities / Towns	Population*
08020301-012 08020301-011 08020301-010	Cypress Bayou	Town of Vilonia	1133
		City of Beebe	4455
		City of Ward	1269
		Town of Austin	244
		City of Cabot	8319

Source: EPA, BASIN, 2007

Land use data for the impaired watersheds were obtained from the National Land Use Classification Data (NLCD). These data were based on satellite imagery from 1999. The spatial distribution of these land uses is shown in Appendix A (Figure A-4). Approximate acreage and percentages of these land uses for each watershed is listed in Table 4.

Table 4- Land Use Acres (Percents) in the Cypress Bayou Subbasin (NLCD).

Watersheds	Land Use Categories (Acres / (Percent Area))							
	Barren	Cropland	Forest	Pasture	Transitional	Urban	Water/ Wetlands	Total
Cypress Bayou 08020301-012	0 (0%)	4,127 (7%)	25,658 (41%)	28,919 (46%)	93 (0%)	361 (1%)	3,995 (6%)	63,153 (100%)
Cypress Bayou 08020301-011	0 (0%)	14,303 (41%)	9,330 (27%)	6,830 (19%)	2 (0%)	1,290 (4%)	3,421 (9%)	35,176 (100%)
Cypress Bayou 08020301-010	0 (0%)	13,496 (40%)	12,170 (36%)	6,330 (19%)	93 (0%)	85 (0%)	1,485 (5%)	33,659 (100%)

Source: EPA, BASINS, 2007

For most of the impaired watersheds identified in Table 4, the predominate landuse is pastureland. Forest is the second most prevalent landuse present in the impaired watershed.

2.4 Climatic Characteristic

Precipitation estimates for the Cypress Bayou subbasin are estimated using the North Little Rock, Arkansas weather station. Annual average rainfall ranges from approximately 47 -51 inches per year (Appendix A, Figure A-5). The mean monthly precipitation values are the lowest in January highest during the months May through July.

2.5 Flow Characteristics

The USGS has published stream flow data for waters in the Cypress Bayou subbasin at 3 locations. The locations of the gages are shown in Appendix A (Figure A-6). The only active long-term gage in the study area is the White River at DeValls Bluff (USGS 0707700). Information for these flow gages is summarized below in Table 5.

Table 5- Streamflow Gage Stations

Watershed	Stream Gage Name	Stream Gage ID	Gage Type		Period of Record
			C	P	
Cypress Bayou	Cypress Bayou Near Butlersville, AR	07076850	C	P	1961-1977
Cypress Bayou	Pigeon Roost Creek above Highway 38	07076870		P	1961-2004
White River	White River at DeValls Bluff	07077000	C		1949-Present

Note: C = Continuous gage, P= Peaklfow gage

2.6 Water Quality Standards

2.6.1 Water Quality Standards for Surface Waters of the State of Arkansas

Arkansas standards for pathogenic organisms are found in the Arkansas's Pollution Control and Ecology Commission Regulations Establishing Water Quality Standards for Surface Waters of the State of Arkansas *(*Adopted on April 23, 2004, Amended April 28, 2006).

2.6.2 Designated Uses for Impaired Waters

The use classifications for the impaired waterbodies are shown in Table 6 below.

Table 6- Designated Uses in the Cypress Bayou Subbasin

HUC-Reach Number	Waterbody Name	Impaired Use	Other Designed Uses*						
			ERW	NSW	ESW	PCR	SCR	D,I,A, WS	F
08020301-012	Cypress Bayou	PCR				X	X		
08020301-011	Cypress Bayou	PCR				X	X		
08020301-010	Cypress Bayou	PCR				X	X		

*(ERW) Extraordinary Resource Water, (NWS) Natural and Scenic Waters, (ESW) Ecologically Sensitive Water, (PCR) Primary Contact Recreation, (SCR) Secondary Contact Recreation, (D,I,A, WS) Domestic, Industrial, Agricultural Water Supply, (F) Fisheries

2.6.3 Numeric Criterion for Bacteria

As specified in the State of Arkansas Water Quality Standards, the Arkansas Department of Health has the responsibility of approving or disapproving surface waters for public water supply and of approving or disapproving the suitability of specifically delineated outdoor bathing places for body contact recreation, and it has issued rules and regulations pertaining to such uses.

For the purposes of this regulation, all streams with watersheds less than 10 mi^2 shall not be designated for primary contact unless and until site verification indicates that such use is attainable. No mixing zones are allowed for discharges of bacteria.

> *(A) Primary Contact Waters - Between May 1 and September 30, the fecal coliform content shall not exceed a geometric mean of 200 col/100 ml nor a monthly maximum of 400 col/100 ml. Alternatively, in these waters, Escherichia coli colony counts shall not exceed a geometric mean of more than 126 col/100 ml. or a monthly maximum value of not more than 298 col/100 ml in lakes, reservoirs and Extraordinary Resource Waters or 410 col/100 ml in other rivers and streams. During the remainder of the calendar year, these criteria may be exceeded, but at no time shall these counts exceed the level necessary to support secondary contact recreation (below).*
>
> *(B) Secondary Contact Waters - The fecal coliform content shall not exceed a geometric mean of 1000 col/100 ml, nor a monthly maximum of 2000 col/100 ml. E. coli values shall not exceed the geometric mean of 630 col/100 ml or a monthly maximum of 1490 col/100 ml for lakes, reservoirs and Extraordinary Resource Waters and 2050 col/100 ml for other rivers and streams.*
>
> *(C) For assessment of ambient waters as impaired by bacteria, the above listed applicable values shall not be exceeded in more than 25% of samples in no less than eight (8) samples taken during the primary contact season or during the secondary contact season."*

2.6.4 Antidegradation

As specified in EPA's regulation 40 CFR §130.7(b)(2), applicable water quality standards include antidegradation requirements. Arkansas' antidegradation policy is listed in Section 2.201 through 2.204 of Regulation No. 2. These sections are 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.
- 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.

The numeric criteria above specific one value for primary contact recreation that applies between May 1 and September 30, and a different criterion for the remainder of the year. In this report, we will refer to the primary contact recreation time period from May 1 to September 30 as primary contact recreation-summer (PCR-S). The remainder of the year will be referred to as primary contact recreation-winter (PCR-W). The descriptors PCR-S and PCR-W do not appear in the State of Arkansas water quality standards. They are used to differentiate the numeric criterion that applies during the various seasons.

3.0 CHARACTERIZATION OF EXISTING WATER QUALITY

Three reaches of the Cypress Bayou are included on the 2006 Arkansas Integrated 305(b)/303(d) report as not supporting primary contact recreation designated use due to exceedences of numeric criteria for pathogens. ADEQ historical water quality data were analyzed to look at the magnitude, frequency, and duration of exceedance. This information may be helpful determining if bacterial exceedences occur primarily during wet weather or dry weather events.

3.1 Comparison of Observed Data to Criteria

Fecal coliform and e.coli monitoring data for each listed reach were obtained from ADEQ. Data for most stations were available between 1994 and 2002. All of the available data for each of the stations were evaluated against the instantaneous fecal coliform and e.coli criterion. Based on this evaluation, most of the sampling locations had exceedances of the instantaneous fecal coliform and e.coli criterion (Table 7a and Table 7d).

Table 7a. Summary of Pathogen (E.Coli) Data –Primary Contact Recreation

HUC-Reach Number	Station Name	Sampling Station ID	Criterion (col./100mL)	N	Number of Exceedences (% exceedence)
08020301-012	Cypress Bayou	UWCPB01*	298	3	1/3 (33%)
08020301-011	Cypress Bayou				
08020301-010	Cypress Bayou				

Note: *TMDL Toolbox

Table 7b. Summary of Pathogen (E.Coli) Data –Secondary Contact Recreation

HUC-Reach Number	Station Name	Sampling Station ID	Criterion (col./100mL)	N	Number of Exceedences (% exceedence)
08020301-012	Cypress Bayou	UWCPB01*	1490	3	0/3 (0%)
08020301-011	Cypress Bayou				
08020301-010	Cypress Bayou				

Note: *TMDL Toolbox

Table 7c. Summary of Pathogen (Fecal) Data –Primary Contact Recreation

HUC-Reach Number	Station Name	Sampling Station ID	Criterion (col./100mL)	N	Number of Exceedences (% exceedence)
08020301-012	Cypress Bayou	UWCPB01*	400	8	4/8 (50%)
08020301-011	Cypress Bayou				
08020301-010	Cypress Bayou				

Note: *TMDL Toolbox

Table 7d. Summary of Pathogen (Fecal) Data – Secondary Contact Recreation

HUC-Reach Number	Station Name	Sampling Station ID	Criterion (col./100mL)	N	Number of Exceedences (% exceedence)
08020301-012	Cypress Bayou	UWCPB01*	2000	8	0/8 (0%)
08020301-011	Cypress Bayou				
08020301-010	Cypress Bayou				

Note: *TMDL Toolbox

3.2 Trends and Patterns in Observed Data

The load duration curves for both fecal coliform and e.coli were used to determine the general trend in all of the observed data (Appendix B). For the Cypress Creek watershed, exceedences of the fecal primary contact recreation criterion occurred during dry and low flow conditions. Exceedences of the secondary contact recreation criterion for both fecal coliform and e.coli occurred during dry, mid-range and high flow conditions.

In addition, precipitation and pathogen data (both fecal coliform and e.coli data) were evaluated to determine if a statistical association existed between the two variables. The data showed that some watersheds had a low positive association between bacteria (fecal coliform and e.coli) and rainfall. This low positive association indicates that bacteria sources may be close to the stream and are only delivered in response to rainfall events. Some watersheds showed a low positive association between rainfall and bacteria. In this watershed, most of the exceedence occurred during dry and low flow conditions. Therefore, there may be some indication that the exceedences of the water quality standard may be the result of direct inputs.

Table 7e. Statistical association between Pathogen and Precipitation

Station Name	Sampling Station ID	Pathogenic Indicator	Pearson R	R^2
Cypress Bayou	UWCPB01	Fecal Coliform	-0.185	0.03
		E. Coli	0.145	0.02

4.0 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of potential source categories. Sources are broadly classified as either point or nonpoint sources. A point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Nonpoint sources are diffuse, and generally, but not always, involve accumulation of fecal coliform bacteria on land surfaces that wash off as a result of storm events.

4.1 Point Source Assessment

Title IV of the Clean Water Act establishes the National Pollutant Discharge Elimination System (NPDES) permit program. Basically, there are three categories of NPDES permits: 1)

municipal and industrial wastewater treatment facilities, 2) regulated storm water discharges, and combined animal feeding operations (CAFO). The location of all point sources can be found in Appendix A (Figure A-7).

4.1.1 Wastewater Treatment Facilities

In general, industrial and municipal wastewater treatment facilities have NPDES permits with effluent limits. These permit limits are either based on federal and state effluent guidelines (technology-based limits) or on water quality standards (water quality-based limits).

The EPA has developed technology-based guidelines, which establish a minimum standard of pollution control for municipal and industrial discharges without regard for the quality of the receiving waters. These are based on Best Practical Control Technology Currently Available (BPT), Best Conventional Control Technology (BCT), and Best Available Technology Economically Achievable (BAT). The level of control required by each facility depends on the type of discharge and the pollutant.

Municipal and industrial wastewater treatment facilities' discharges may contribute fecal coliform to receiving waters. There are three NPDES permitted discharges with flows greater than 0.1 MGD identified in the Cypress Bayou watershed that discharge treated municipal wastewater to the impaired stream segments. Table 8 provides the monthly average discharge flows and fecal coliform concentrations for the municipal and industrial treatment facilities, obtained from calendar year 2005 Discharge Monitoring Report (DMR) data. The permitted flow and fecal coliform concentrations for these facilities are also included in this table.

Table 8- Point Source Discharges in Planning Unit 4D

Facility Name / Segment ID	NPDES Permit No.	Permit Expiration Date	Receiving Stream	NPDES Permit Limits		Number of Violations
				Average Design Flow (MGD)	Average Monthly FC (No./ 100mL)	
City of Beebe	AR0022101	09/30/2009	Cypress Bayou/ White River	0.824	25	0
City of Austin 08020301-012	AR0038369	08/31/2013	Fourmile Creek/ Cypress Bayou/ White River	0.084	24	0
City of Vilonia 08020301-012	AR0047121	05/31/2014	Cypress Bayou/ White River	0.25	2	0
City of Ward 08020301-011	AR0047554	06/30/2014	Fourmile Creek/ Cypress Bayou/ White River	0.50	61	4
River City Energy Company 08020301-012	AR0049301	02/28/2011	Ditch/Little Cypress Creek/ Cypress Bayou/ White River	0.0009	311	1

Combined sewer systems convey a mixture of raw sewage and storm water in the same conveyance structure to the wastewater treatment plant. These are considered a component of

municipal wastewater treatment facilities. When the combined sewage exceeds the capacity of the wastewater treatment plant, the excess is diverted to a combined sewage overflow (CSO) discharge point. There are no permitted CSO outfalls in the Cypress Bayou subbasin.

4.1.2 Regulated Storm Water Discharges

Municipal storm water runoff is covered under the NPDES Permit Program. Storm water NPDES permits establish controls "to the maximum extent practicable" (MEP). Regulated storm water discharges that may contain pathogens consist of those small municipal separate storm sewer systems (MS4s) that serve populations of 50,000 or more (USEPA, 1996).

The MS4 Phase II program must include measurable goals. The goals include the following six minimum measures, and evaluation and reporting efforts:

Public education and outreach
Public participation/involvement
Illicit discharge detection and elimination
Construction site runoff control
Post-construction runoff control
Pollution prevention/good housekeeping for municipal operations.

As of February 01, 2004, small MS4s serving urbanized areas are required to obtain a storm water permit under the Phase II storm water regulations. An urbanized area is defined as an entity with a residential population of at least 50,000 people and an overall population density of at least 1,000 people per square mile. There are three (3) Phase II cities/counties in this planning segment Appendix A (Figures A-8). These urban areas represent three percent of the total landuse in this watershed.

Table 9- Small MS4 Dischargers in Planning Unit 4D

Municipal Area	NPDES Permit No.	Permit Expiration Date
City of Cabot	ARR040000	07/31/2014
Lonoke County	ARR040000	07/31/2014
Pulaski County	ARR040000	07/31/2014

4.1.3 Confined Animal Feeding Operations

Confined livestock and confined animal feeding operations (CAFOs) are characterized by high animal densities. This results in large quantities of fecal material being contained in a limited area. Processed agricultural manure from confined hog, dairy cattle, and select poultry operations is generally collected in lagoons. It is then applied to pastureland and cropland as a fertilizer during the growing season, at rates that often vary monthly.

In 1990, the State of Arkansas began registering CAFOs. Many of the CAFOs were issued land application or NPDES permits for treatment of wastewaters generated from their operations. The type of permit issued depends on the operation size (i.e., number of animal units. There are no registered CAFOs in this planning segment.

4.2 Nonpoint Sources

In general, nonpoint sources cannot be identified as entering a waterbody through a discrete conveyance at a single location. Typical nonpoint sources of fecal coliform bacteria include:

- Wildlife
- Agricultural Livestock
  - Animal grazing
  - Animal access to streams
  - Application of manure to pastureland and cropland
- Urban Development
  - Leaking sanitary sewer lines
  - Septic systems
  - Land Application Systems
  - Landfills

4.2.1 Wildlife

The importance of wildlife as a source of fecal coliform bacteria in streams varies considerably, depending on the animal species present in the subwatersheds. Wildlife resource studies show that animals that spend a large portion of their time in or around aquatic habitats are the most important wildlife sources of fecal coliform. Waterfowl, most notably ducks and geese, are considered to potentially be the greatest contributors of fecal coliform. This is because they are typically found on the water surface, often in large numbers, and deposit their feces directly into the water. Other potentially important animals regularly found around aquatic environments include racoons, beavers, muskrats, and to a lesser extent, river otters and minks. Population estimates of these animal species in Arkansas are currently not available.

White-tailed deer have a significant presence throughout the Cypress Bayou watershed. The number of deer camps for hunters provides a relative estimate of area that may have higher deer populations. Based on 1999 Strategic Deer Management Plan, it is estimated that deer population densities in this watershed ranging from 0 to 10 deer per square mile to greater than 101 deer per square mile (Table 10).

Table 10. Estimated Deer Population in the Cypress Bayou Subbasin

County	Deer Density (per square mile)
Faulkner County	11-25
Lonoke County	11-25
Prairie County	51-100
Pulaski County	0-10
White County	>101

Fecal coliform bacteria contributions from deer to water bodies are generally considered

less significant than that of waterfowl, racoons, and beavers. This is because a greater portion of their time is spent in terrestrial habitats. Feces deposited on the land surface can result in the introduction of fecal coliform to streams during runoff events. It should be noted that between storm events, considerable decomposition of the fecal matter might occur, resulting in a decrease in the associated fecal coliform numbers.

3.2.2 Agricultural Livestock

Agricultural livestock are a potential source of fecal coliform to streams in the Cypress Bayou watershed. The animals grazing on pastureland deposit their feces onto land surfaces, where it can be transported during storm events to nearby streams. Animal access to pastureland varies monthly, resulting in varying fecal coliform loading rates throughout the year. Beef cattle spend all of their time in pastures, while dairy cattle and hogs are periodically confined. Agricultural livestock will often have direct access to streams that pass through their pastures, and can thus impact water quality in a more direct manner (USDA, 2002).

Table 11 provides the estimated number of beef cattle, dairy cattle, and swine by category reported by county. These data were provided by the Natural Resources Conservation Service (NRCS) and are based on 2006 data (NRCS, 2006).

Table 11. Estimated Agricultural Livestock Populations in the Cypress Bayou watershed

County	Livestock (head of animals)		
	Beef Cattle	Dairy Cattle	Hog and Pig
Faulkner	23,286	3,842	1,757
Lonoke	7,500	2,896	1,739
Prairie	3,000	917	1,313
Pualski	5,357	636	2,041
White	27,143	2,800	2,535

Source: USDA, National Agricultural Statistics Service, Arkansas Field Office, 2002
(D) Withheld to avoid disclosing data for individual farms.

4.0 TMDL DEVELOPMENT

A TMDL is the total amount of a pollutant that can be assimilated by the receiving waterbody while still achieving water quality standards. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established and thereby provide the basis for establishing water quality-based controls.

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. This TMDL also includes a future growth (FG) component to account for loadings from the continued growth in the TMDL area. The TMDL components are illustrated using the following equation:

$$\boldsymbol{TMDL = \sum WLAs + \sum LAs + MOS + FG}$$

TMDLs, for some pollutants, are expressed as a mass loading (e.g., kilograms per day). TMDLs , for bacteria, can be expressed in terms of organism counts per day, in accordance with 40 CFR 130.2(l). TMDLs in this document are expressed in colony forming unit (cfu) per day.

4.1 TMDL Analytical Approach

The methodology used for the TMDLs in the report is the load duration curve. Because loading capacity varies as a function of the flow present in the stream, these TMDLs represent a continuum of desired loads over all flow conditions, rather than fixed at a single value. The basic elements of this procedure are documented on the Kansas Department of Health and Environment web site (KDHE 2005). This method was used to illustrate allowable loading at a wide range of flows. The steps for how this methodology was applied for the TMDLs in this report can be summarized as follows:

1. Develop a flow duration curve.
2. Convert the flow duration curve to load duration curves for bacteria
3. Plot observed loads with load duration curves.
4. Calculate TMDL, MOS, FG, WLA, and LA (see also Section 4.2).

4.1.1 Flow Duration Curve

For this TMDL, a flow duration curve was developed based on one active USGS gage in the drainage basin (Table 12). Daily streamflow measurements from the USGS gage was sorted in increasing order, and the percentile ranking of each flow was calculated (Appendix C).

Figure 1 below is an example of a flow duration curve. The X-axis shows the percentage of days on which the plotted flow is exceeded. Points at the lower end of the plot (0 through 10 percent) represent high-flow conditions where only 0 through 10 percent of the flow exceeds the plotted point. Conversely, points on the high end of the plot (90 to 100 percent) represent low-flow

conditions.

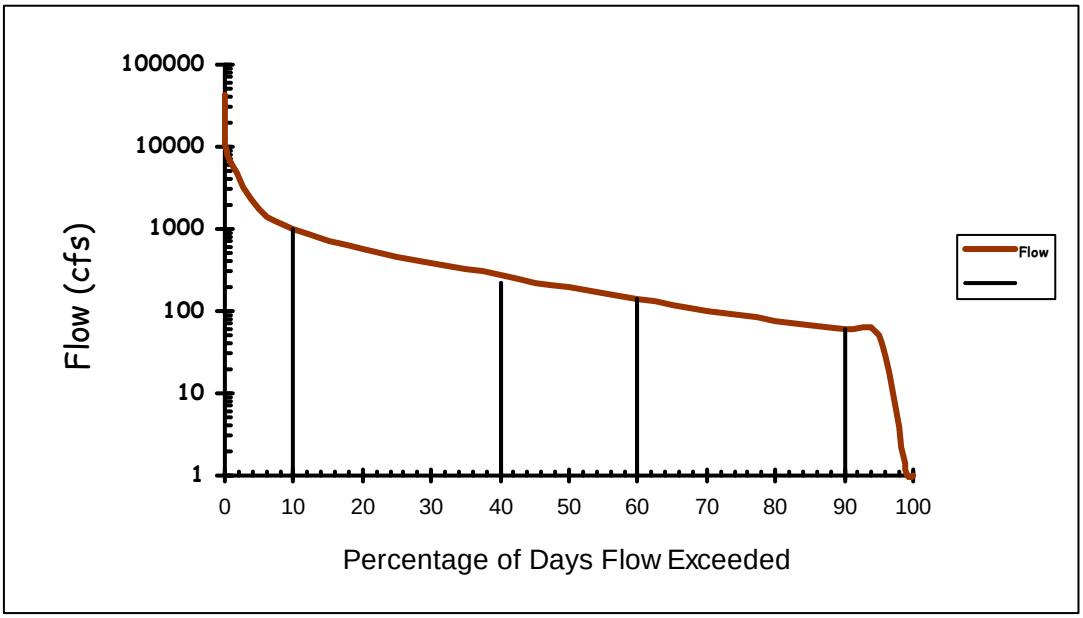

Figure 1. Example of Flow Duration Curve.

Table 12. USGS Streamflow Gage Used for Load Duration Curve

Watershed	Stream Gage Name	Stream Gage Number	Gage Drainage Area	Gage Type		Period of Record
				C	P	
White River	White River at DeValls Bluff, AR	07077000	23,431 sq. mi	C		1949-Present

4.1.2 Load Duration Curve

In developing the load duration curve, the methodology requires that the same flow period be used for both developing the flow duration and calculating load curves from sampling data.

The load duration curve is beneficial when analyzing monitoring data because it presents corresponding flow information and monitoring results plotted as a load. This approach allows the monitoring data to be placed in relation to their place in the flow continuum. Assumptions of the probable source or sources of the impairment can then be made from the plotted data. The load duration curve shows the calculation of the TMDL at any flow rather than at a single critical flow. The official TMDL number is reported as a single number, but the curve is provided to demonstrate the value of the acceptable load at any flow. This will allow analysis of load cases in the future for different flow regimes. Appendix B contains the load duration curve calculations.

4.1.3 Observed Loads

For each sampling station and season, observed loads were calculated by multiplying the

observed bacterial concentration by the flow on the sampling day. These observed loads were then plotted versus the percent flow exceedance of the flow curve on the sampling day and placed on the same plot as the load duration curve. TMDL allocations were set at the 50th percentile water quality criteria to obtain a TMDL for each reach. These plots are shown in Appendix B of this report.

These plots provide visual comparisons between observed and allowable loads under different flow conditions. Observed loads that are plotted above the load duration curve represent conditions where observed water quality concentrations exceed the target concentrations. Observed loads plotted below the load duration curve represent conditions where observed water quality concentrations were less than target concentrations (i.e., not exceeding water quality standards).

4.2 TMDL Development

Each TMDL was calculated as the area under the load duration curve. Because the load duration curves were expressed in mass per unit drainage area, the area under the curve was multiplied by the drainage area for each reach. Tables 13a through 13d present the TMDLs and allocations for the sub-segments in this report.

Table 13a Summary of Fecal Coliform TMDLs, (Primary Contact Recreation-Summer)

Arkansas Reach ID	Stream Name	Explicit MOS*	WLA*	sWLA*	LA*	TMDL*
08020301-012 (UWCPB01)	Cypress Bayou	6.91E+10	3.79E+09	0.00E+00	6.87E+11	7.60E+11
08020301-011 (UWCPB01)	Cypress Bayou	4.27E+09	2.13E+10	1.40E+10	3.49E+11	3.89E+11
08020301-010	Cypress Bayou	4.07E+10	0	0	3.66E+11	4.07E+11

***Note: cfu/day = colony forming units per day**

Table 13b Summary of Fecal Coliform TMDLs, (Primary Contact Recreation-Winter)

Arkansas Reach ID	Stream Name	Explicit MOS*	WLA*	sWLA*	LA*	TMDL*
08020301-012 (UWCPB01)	Cypress Bayou	3.84E+11	9.48E+09	0.00E+00	3.41E+12	3.80E+12
08020301-011 (UWCPB01)	Cypress Bayou	2.14E+11	5.34E+10	8.56E+10	1.80E+12	2.15E+12
08020301-010	Cypress Bayou	2.04E+11	0	0	1.84E+12	2.04E+12

***Note: cfu/day = colony forming units per day**

Table 13c Summary of E. Coli TMDLs (Primary Contact Recreation-Summer)

Arkansas Reach ID	Stream Name	Explicit MOS*	WLA*	sWLA*	LA*	TMDL*
08020301-012 (UWCPB01)	Cypress Bayou	7.87E+10	3.88E+09	0.00E+00	6.97E+11	7.80E+11
08020301-011 (UWCPB01)	Cypress Bayou	4.38E+10	2.19E+10	1.75E+10	3.40E+11	4.23E+11
08020301-010	Cypress Bayou	4.18E+10	0	0	3.76E+11	4.18E+11

***Note: cfu/day = colony forming units per day**

Table 13d Summary of E. Coli TMDLs (Primary Contact Recreation-Winter)

Arkansas Reach ID	Stream Name	Explicit MOS*	WLA*	sWLA*	LA*	TMDL*
08020301-012 (UWCPB01)	Cypress Bayou	3.94E+11	1.942E+10	0.00E+00	3.49E+12	3.90E+12
08020301-011 (UWCPB01)	Cypress Bayou	2.19E+11	1.09E+11	8.76E+10	1.77E+12	2.19E+12
08020301-010	Cypress Bayou	2.09E+11	0	0	1.88E+12	2.09E+12

***Note: cfu/day = colony forming units per day**

4.2.1 Wasteload Allocation

The WLA portion of the TMDL equation is the total loading of a pollutant that is assigned to point sources. There are four permitted continuous discharge facilities discharging sanitary wastewater into Cypress Bayou (Table 14). There are three permitted urbanized areas that discharge into this watershed. These urbanized areas allocations can be found in Table 14. No WLA was provided to the River City Energy Company (AR0049301) because the discharge from this facility is not likely to contribute bacteria. If an individual WLA is needed in the future, the TMDL may be adjusted through the water quality management plan update to reflect the change in the WLA.

Table 14 Summary of WLA for Fecal Coliform and E.coli

Facility Name	NPDES Permit No.	Receiving Stream	Contact Recreation Season	Fecal Coliform WLA (cfu/day)	E.coli WLA (cfu/day)
City of Beebe 08020301-011	AR0022101	Cypress Bayou/ White River	PCR	1.25E+10	1.28E+10
City of Austin 08020301-011	AR0038369	Fourmile Creek/ Cypress Bayou/ White River	PCR	1.27E+09	1.31E+09
City of Vilonia 08020301-012	AR0047121	Cypress Bayou/ White River	PCR	3.79E+09	3.88E+09
City of Ward 08020301-011	AR0047554	Fourmile Creek/ Cypress Bayou/White River	PCR	7.58E+09	7.77E+09
City of Cabot Lonoke County Pulaski County	ARR040000	Fourmile Creek/ Cypress Bayou/White River	PCR	1.40E+10	1.43E+10
City of Beebe 08020301-011	AR0022101	Cypress Bayou/ White River	SCR	3.12E+10	6.40E+10
City of Austin 08020301-011	AR0038369	Fourmile Creek/ Cypress Bayou/ White River	SCR	3.18E+09	6.53E+09
City of Vilonia 08020301-012	AR0047121	Cypress Bayou/ White River	SCR	9.48E+09	1.94E+10
City of Ward 08020301-011	AR0047554	Fourmile Creek/ Cypress Bayou/White River	SCR	1.90E+10	3.88E+10
City of Cabot Lonoke County Pulaski County	ARR040000	Fourmile Creek/ Cypress Bayou/White River	SCR	7.20E+10	7.16E+10

4.2.2 Load Allocation

The load allocation is the portion of the TMDL assigned to natural background loadings as well as nonpoint sources such as septic tank leakage, wildlife, and agricultural practices. For this TMDL, that LA was calculated by subtracting the WLA, MOS, and FG from the total TMDL. LAs were not allocated to separate nonpoint sources; due to the lack of available source characterization data. The LAs are presented in Table 4-2.

Both section 303(d) of the Clean Water Act and the regulations at 40 CFR 130.7 require that TMDLs include an MOS to account for uncertainty in available data or in the actual effect that controls will have on the loading reductions and receiving water quality.

4.2.3 Seasonality and Critical Conditions

The federal regulations at 40 CFR 130.7 require that TMDLs include seasonal variations and take into account critical conditions for streamflow, loading, and water quality parameters. Fecal coliform and e.coli loadings for subsegments with primary contact recreation as the designated use were determined for winter and summer on the basis of seasonal water quality criteria, thus accounting for seasonality. The sampling results for fecal coliform bacteria were plotted over time and reviewed for any seasonal patterns (see Section 3.2).

By accounting for critical conditions, the TMDL makes sure that water quality standards are maintained for infrequent occurrences and not only for average conditions. For fecal coliform bacteria, the water quality criteria include values that must not be exceeded more than 25 percent of the time (primary and secondary contact recreation).

Because of the way the criteria are written (i.e., including critical and noncritical conditions), the TMDL for the pollutant of concern can be developed by reviewing pollutant loads at all flow conditions within applicable periods of the year and evaluating the percentage of values exceeding the criteria. The load duration curve, which determines the allowable loading at a wide range of flows, was chosen as the approach for these TMDLs (see Section 4.1). Therefore, the TMDLs were calculated at all flows rather than at a single critical flow.

4.2.4 Margin of Safety

The margin of safety (MOS) is the portion of the pollutant loading reserved to account for any lack of knowledge concerning the relationship between effluent limitations as stated in 40 CFR §130.7. There are two ways to incorporate the MOS (USEPA 1991). One way is to implicitly incorporate the MOS by using conservative model assumptions to develop allocations. The other way is to explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. The MOS is an explicit 10 percent was set aside for each impaired segment. Using 10 percent of the TMDL load provides an additional level of protection to the designated uses of the waterbodies of concern.

5.0 TMDL IMPLEMENTATION

5.1 Storm water permitting Requirements and Presumptive Best Management practices (BMPs) Approach

5.1.1 Background

The National Pollutant Discharge Elimination System (NPDES) permitting program for stormwater discharges was established under the Clean Water Act as the result of a 1987 amendment. The Act specifies the level of control to be incorporated into the NPDES stormwater permitting program depending on the source (industrial versus municipal stormwater). These programs contain specific requirements for the regulated communities/facilities to establish a comprehensive stormwater management program (SWMP) or storm water pollution prevention plan (SWPPP) to implement any requirements of the total maximum daily load (TMDL) allocation. [See 40 CFR §130.]

Storm water discharges are highly variable both in terms of flow and pollutant concentration, and the relationships between discharges and water quality can be complex. For municipal stormwater discharges in particular, the current use of system-wide permits and a variety of jurisdiction-wide BMPs, including educational and programmatic BMPs, does not easily lend itself to the existing methodologies for deriving numeric water quality-based effluent limitations. These methodologies were designed primarily for process wastewater discharges which occur at predictable rates with predictable pollutant loadings under low flow conditions in receiving waters. EPA has recognized these problems and developed permitting guidance for stormwater permits. [See "Interim Permitting Approach for Water Quality-Based Effluent Limitations in Stormwater Permits" (EPA-833-D-96-00, Date published: 09/01/1996)]

Due to the nature of storm water discharges, and the typical lack of information on which to base numeric water quality-based effluent limitations (expressed as concentration and mass), EPA recommends an interim permitting approach for NPDES storm water permits which is based on BMPs. "The interim permitting approach uses best management practices (BMPs) in first-round storm water permits, and expanded or better-tailored BMPs in subsequent permits, where necessary, to provide for the attainment of water quality standards." (*ibid.*)

A monitoring component is also included in the recommended BMP approach. "Each storm water permit should include a coordinated and cost-effective monitoring program to gather necessary information to determine the extent to which the permit provides for attainment of applicable water quality standards and to determine the appropriate conditions or limitations for subsequent permits." (*ibid.*) This approach was further elaborated in a guidance memo issued in 2002. [See Memorandum from Robert Wayland, Director of OWOW and James Hanlon, Director of OWM to Regional Water Division Directors: "Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit requirements Based on Those WLAs " (Date published: 11/22/2002)] "The policy outlined in this memorandum affirms the appropriateness of an iterative, adaptive management BMP approach, whereby permits include effluent limits (e.g., a combination of structural and nonstructural BMPs) that address storm water discharges, implement mechanisms to evaluate the performance of such

controls, and make adjustments (i.e., more stringent controls or specific BMPs) as necessary to protect water quality. …… If it is determined that a BMP approach (including an iterative BMP approach) is appropriate to meet the storm water component of the TMDL, EPA recommends that the TMDL reflect this." This BMP-based approach to stormwater sources in TMDLs is also recognized and described in the most recent EPA guidance. [See "TMDLs To Stormwater Permits Handbook" (DRAFT), EPA, November 2008]

This TMDL adopts the EPA recommended approach and relies on appropriate BMPs for implementation. No numeric effluent limitations are required or anticipated for municipal stormwater discharge permits.

5.1.2 Specific SWMP/SWPPP Requirements

As discussed in the Arkansas Small MS4 NPDES permit, if a TMDL assigns an individual WLA specifically to a MS4's stormwater discharge, ADEQ's permit specifies that the WLA must be include as a measurable goal for the stormwater management program (SWMP).

Examples of activities that the MS4 may conduct to be consistent with the WLA include:

- Monitoring to evaluate program compliance, the appropriateness of identified best management practices, and progress toward achieving identified measurable goals, and

- Development of a schedule for implementation of additional controls and/or BMPs (if necessary) based on monitoring results, to ensure compliance with applicable TMDLs.

6.0 PUBLIC PARTICIPATION

Federal regulations require EPA to notify the public and seek comment concerning TMDLs that they prepare. The response to public comments are found in Appendix D.

7.0 REFERENCES

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Zar, J.H., 1996. Biostatistical Analysis (3rd ed.). New Jersey: Prentice Hall.

Appendix A

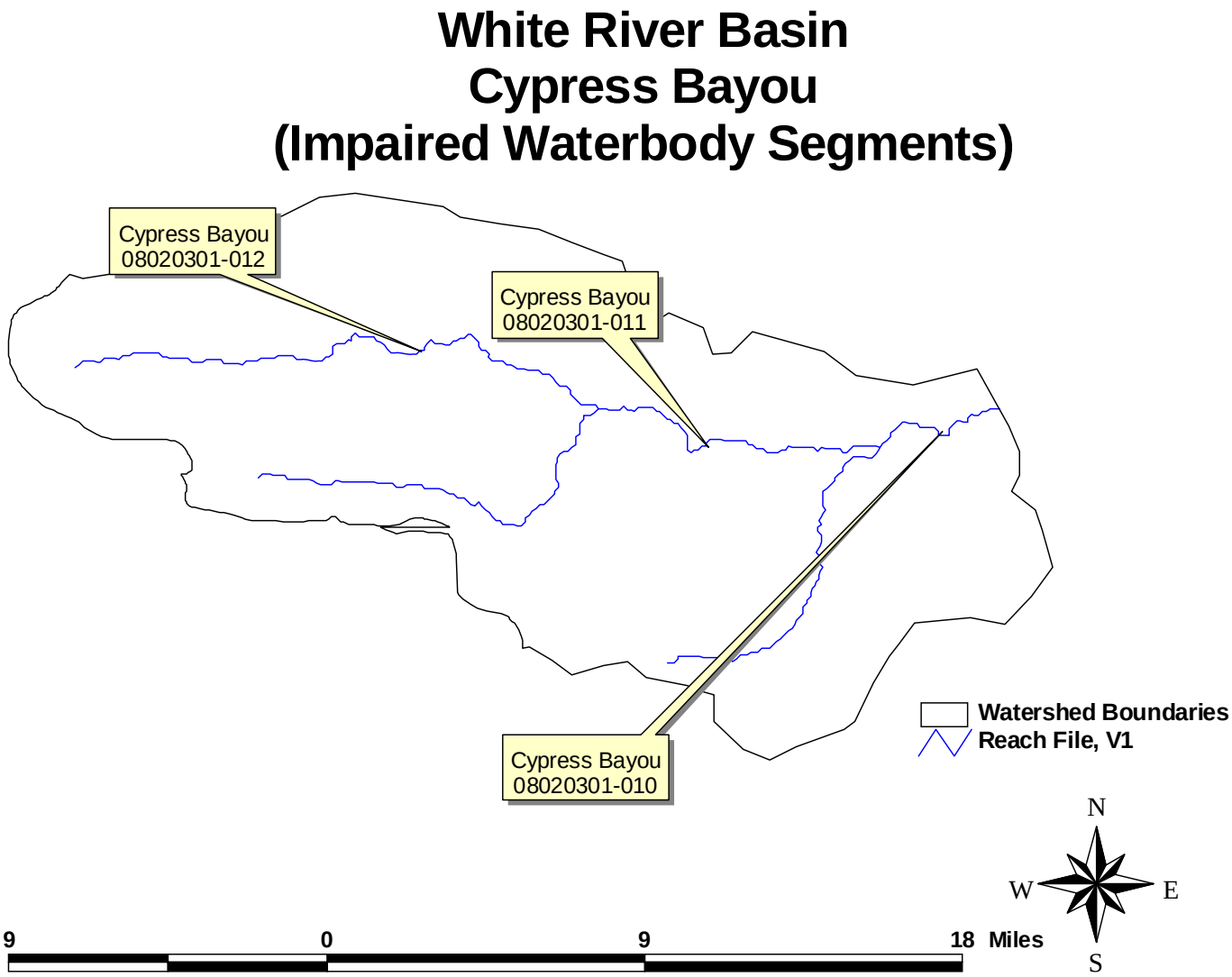


Figure A-1 Study area for Planning Segments in 4D

Cypress Bayou
State Soils

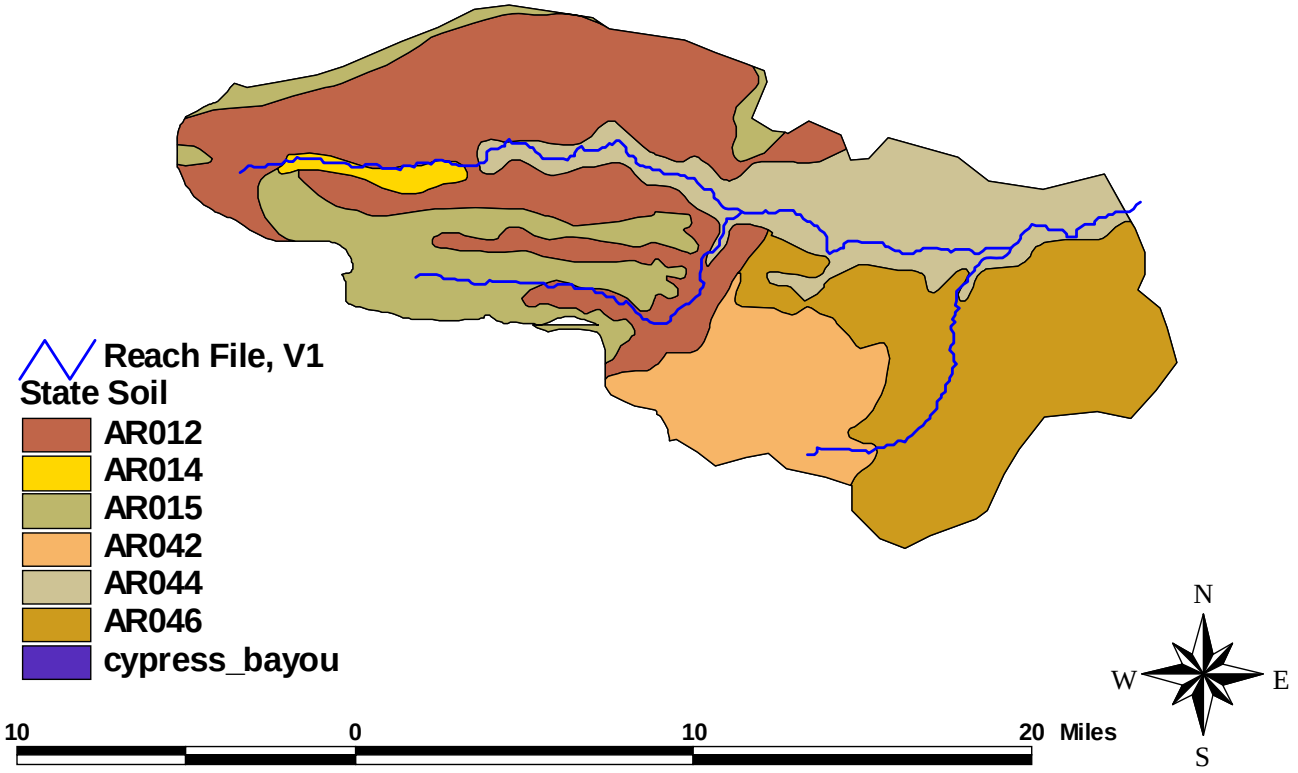


Figure A-2 Soil Types in Planning Segments 4D

Cypress Bayou
(Populated Cities/Towns)

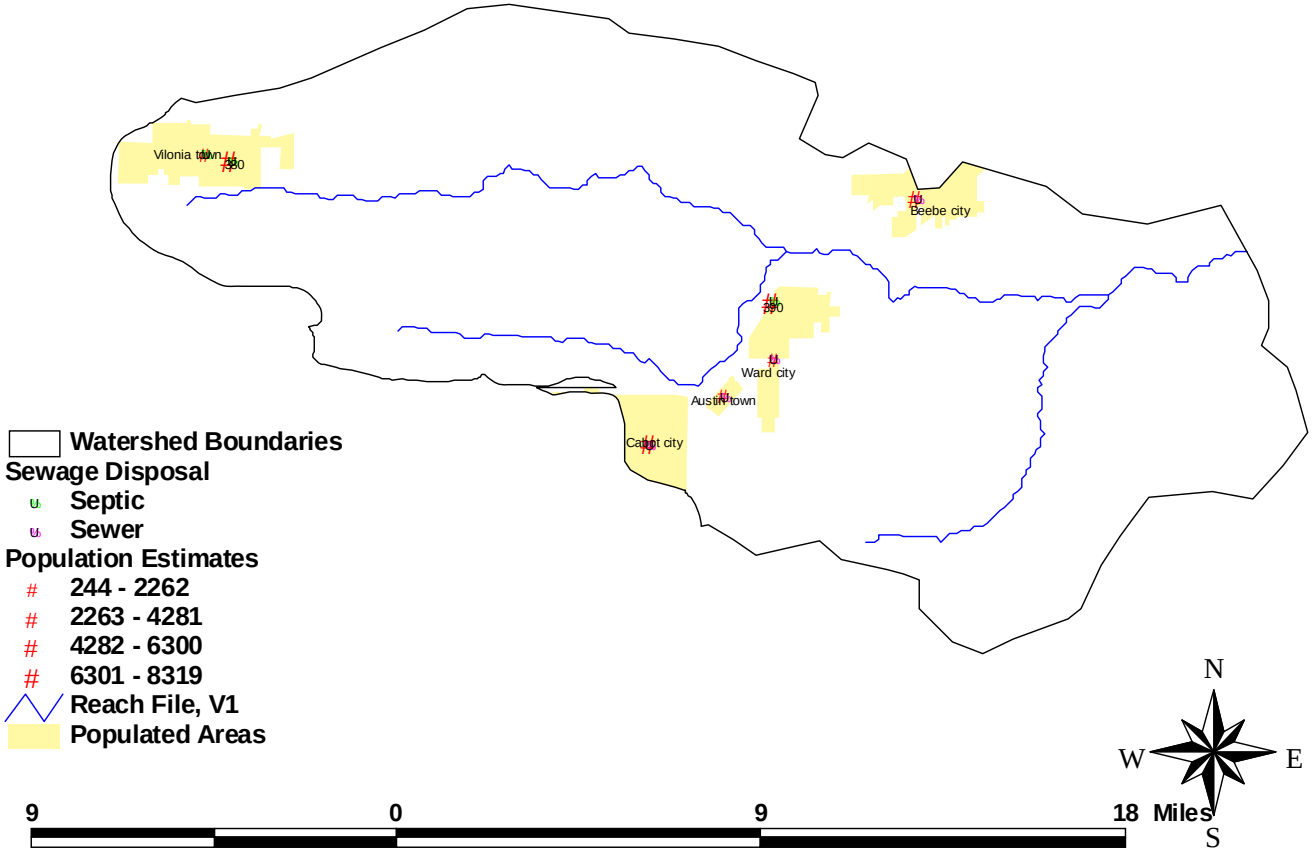


Figure A-3 Populated Cities/Towns in Planning Segments 4D

Cypress Bayou Landuses

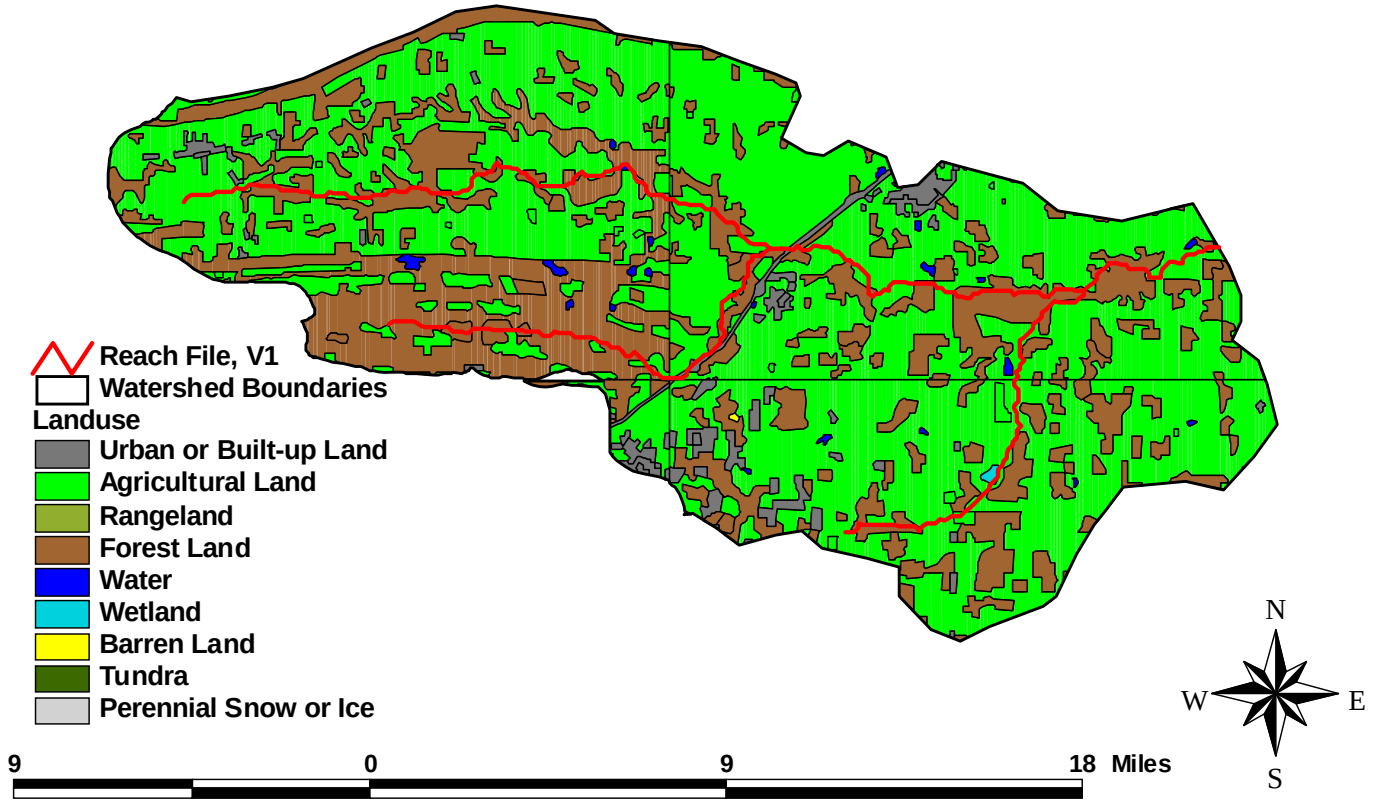


Figure A-4 Landuse in Planning Segments 4D

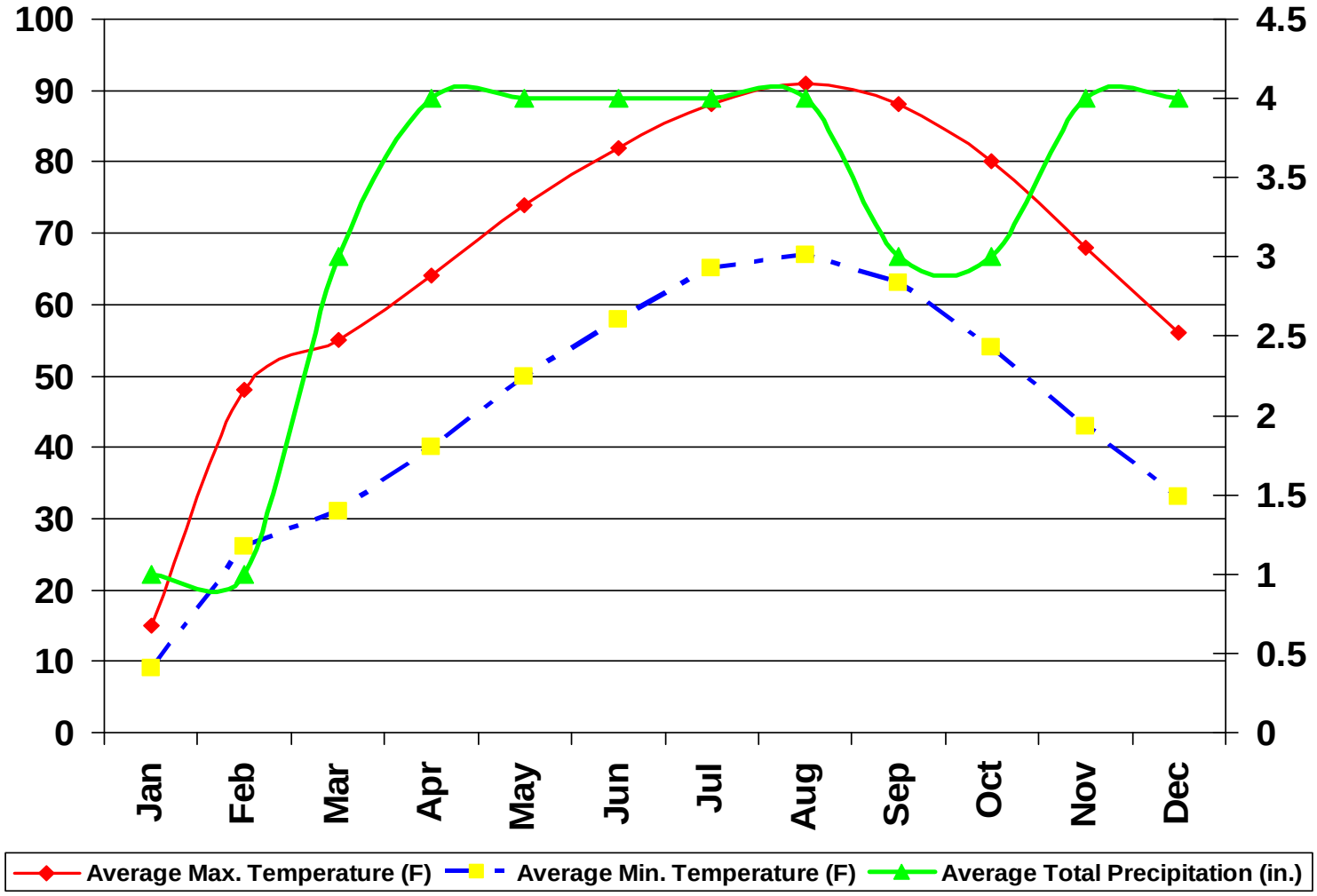


Figure A-5 Climate Conditions in Planning Segments 4D

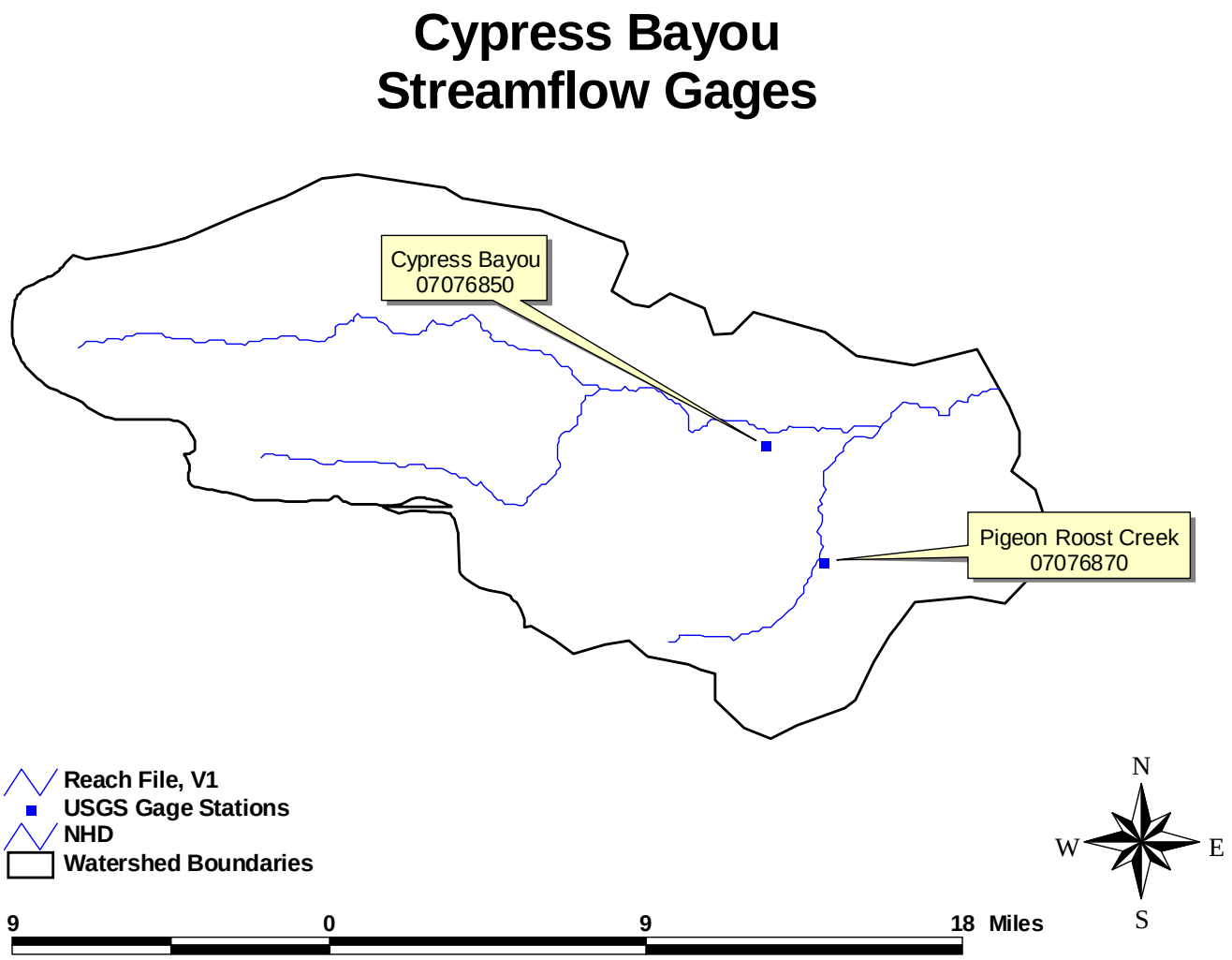


Figure A-6 USGS Streamflow Gages in Planning Segments 4D

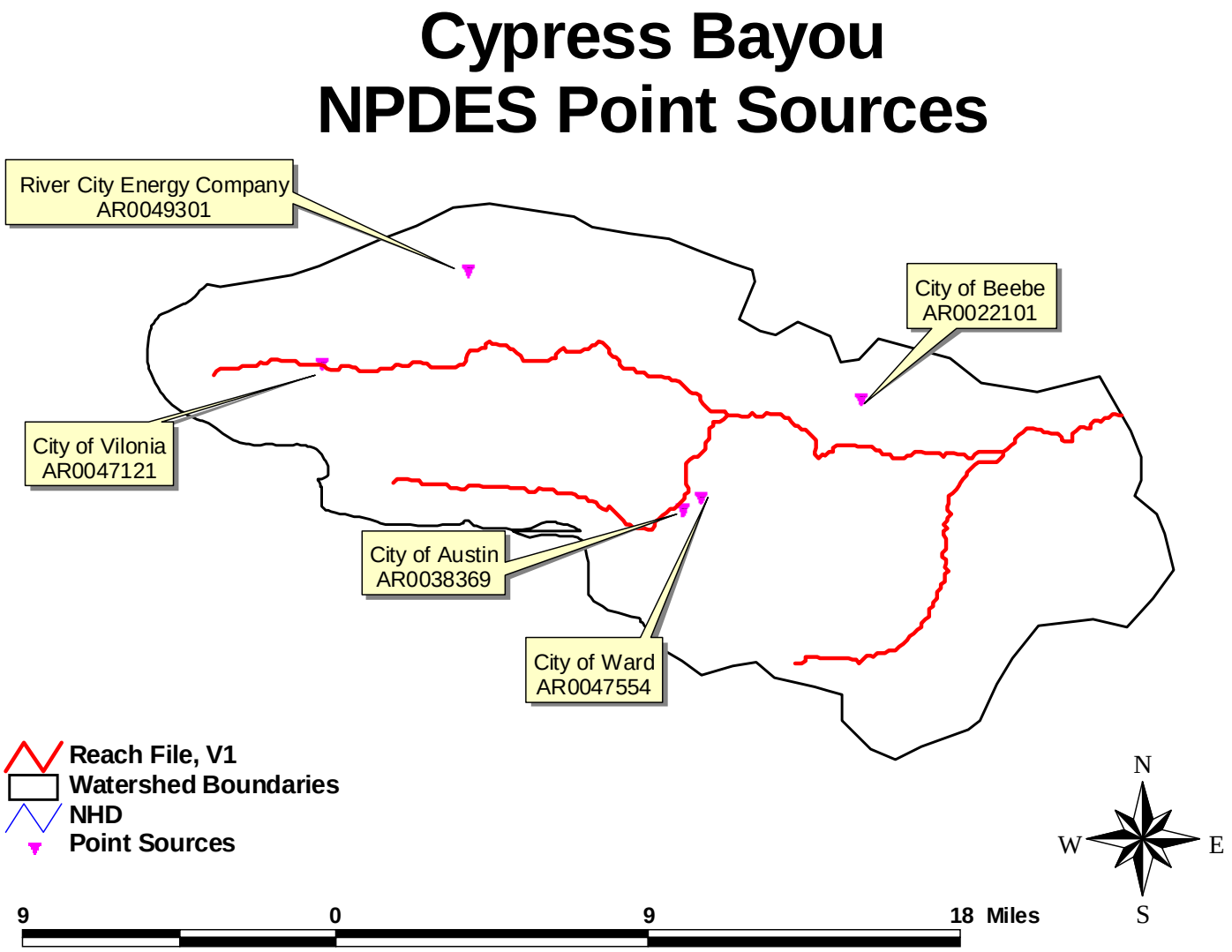


Figure A-7 Point Source Dischargers in Planning Segment 4D

Cypress Bayou
Urbanized Areas

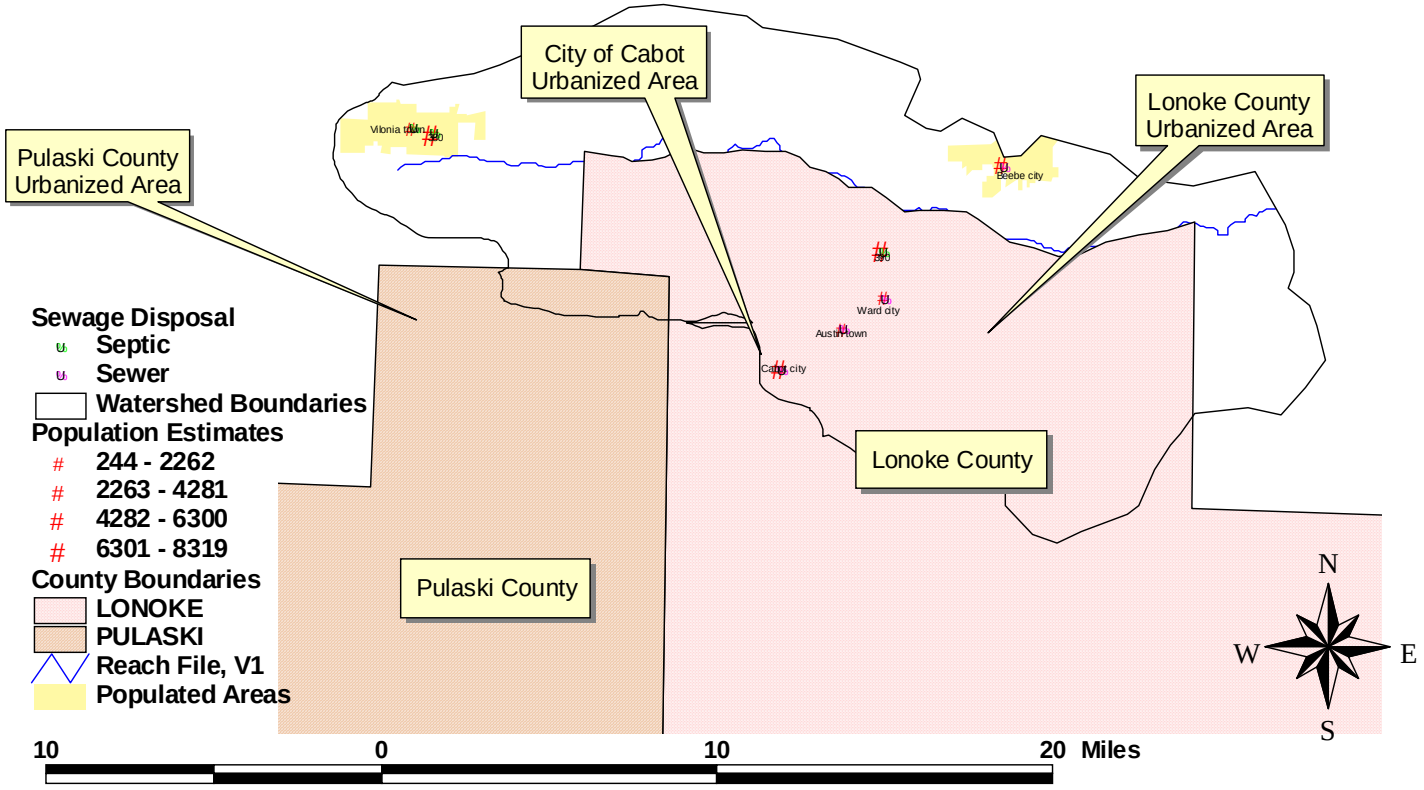


Figure A-8 Urbanized Areas in Planning Segment 4D

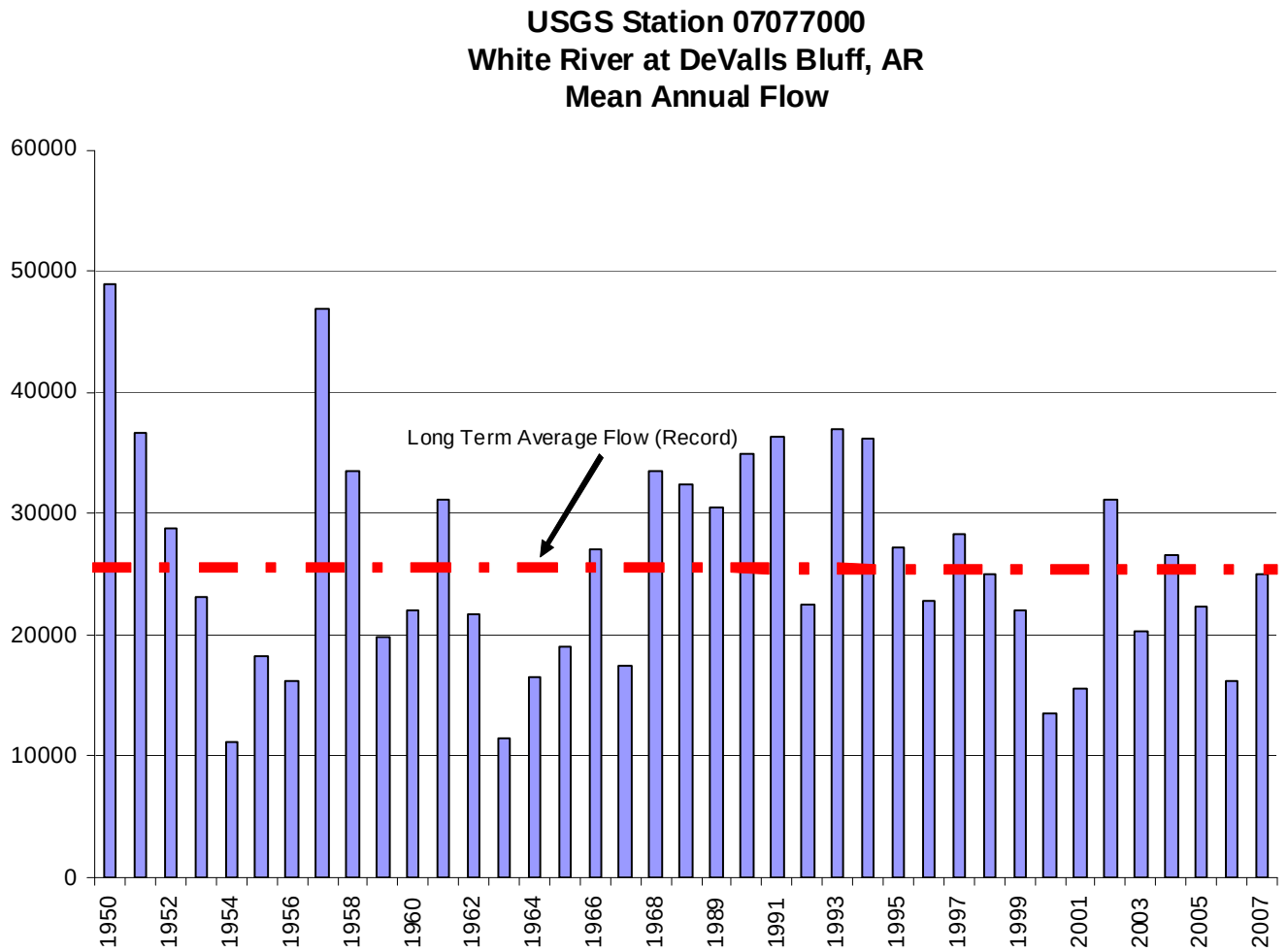


Figure A-9 Streamflow Estimation for White River Basin

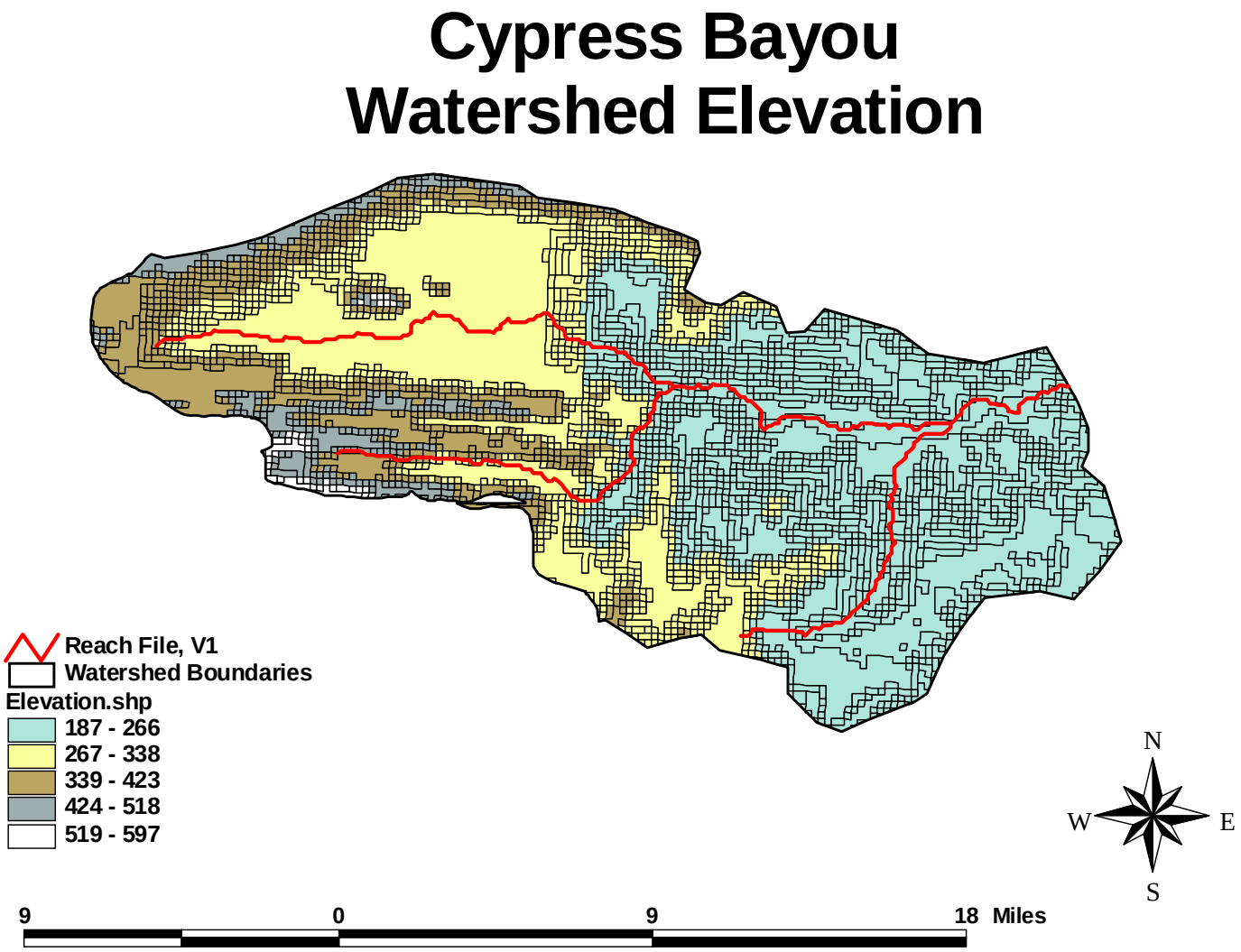


Figure A-10 Cypress Bayou Basin Elevation (ft)

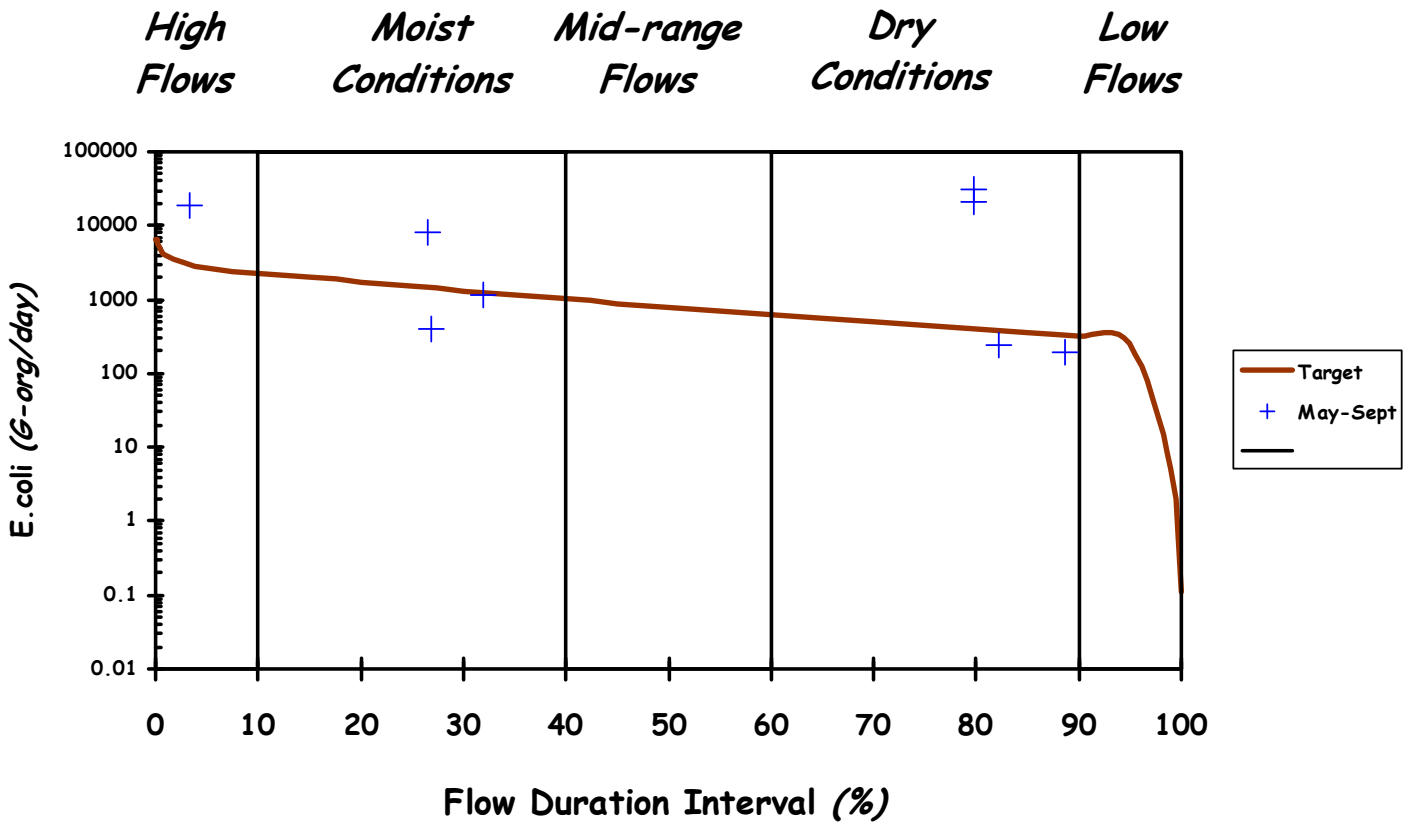
Appendix B

Cypress Bayou, AR

Load Duration Curve

(1994-2002 Fecal Coliform Monitoring Data (Primary Contact Recreation))

Site:UWCPB01



ADEQ Data & USGS Gage Duration Interval

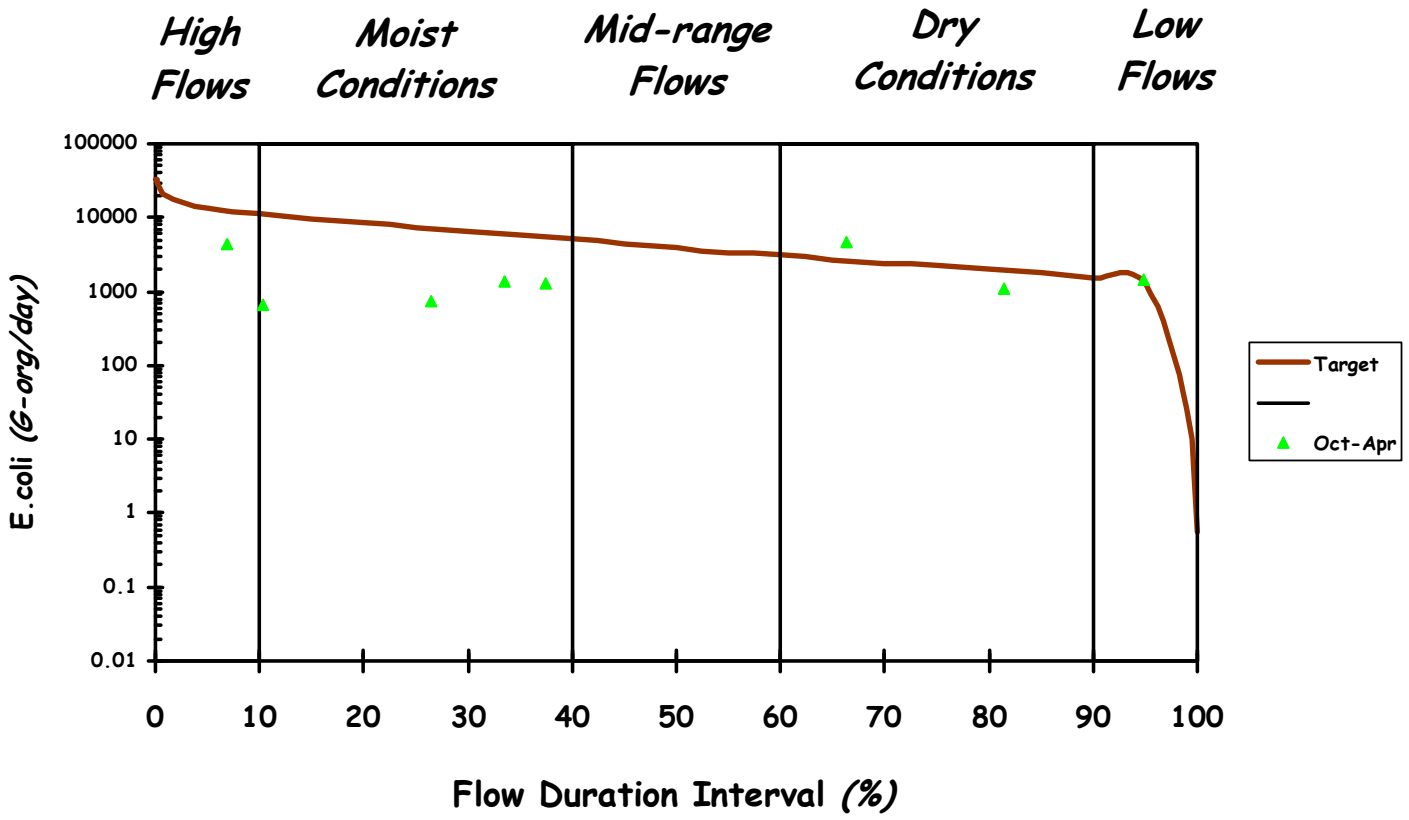
98.7 square miles

Cypress Bayou, AR

Load Duration Curve

(1994 - 2002 Fecal Coliform Monitoring Data (Secondary Contact Recreation)

Site:UWCPB01



ADEQ Data & USGS Gage Duration Interval

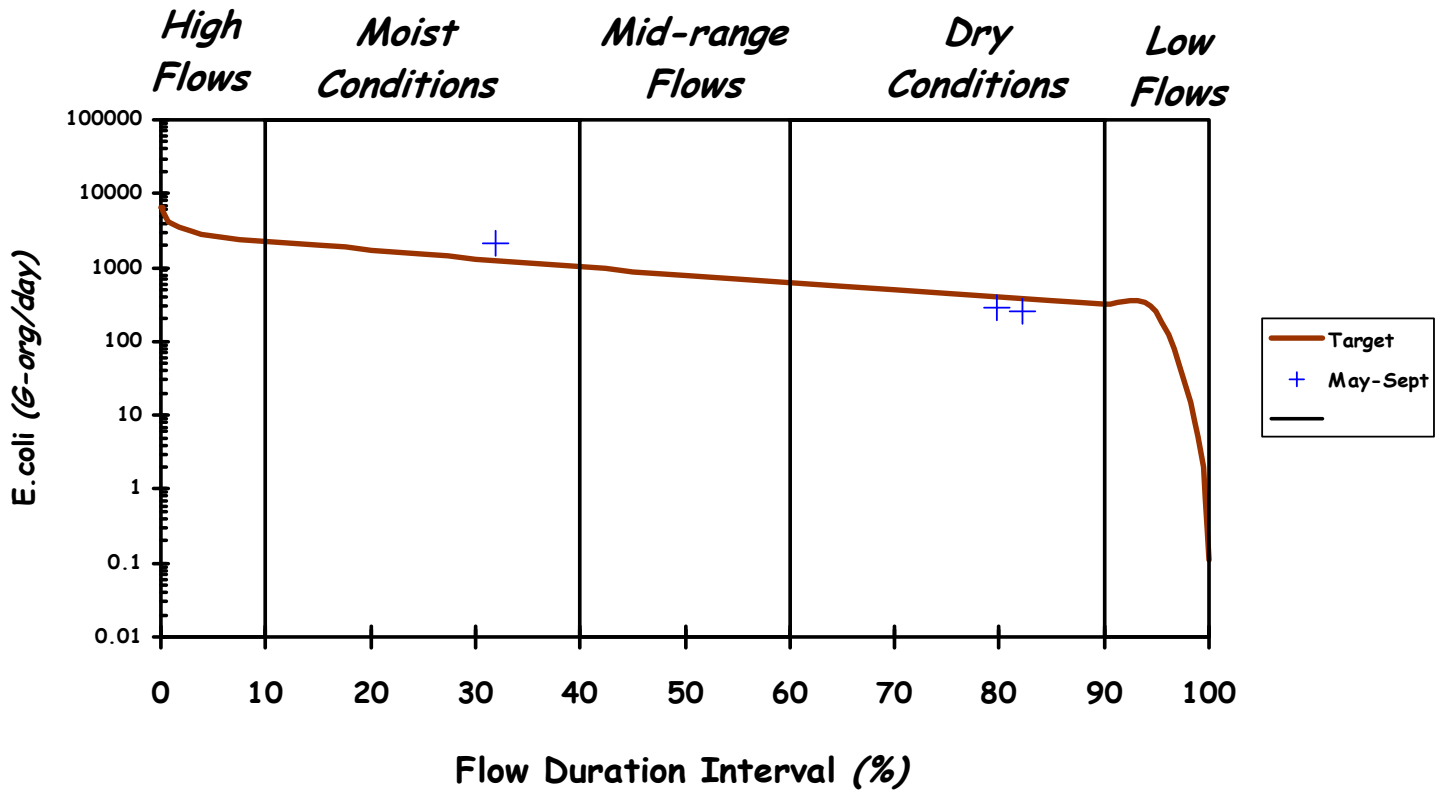
98.7 square miles

Cypress Bayou, AR

Load Duration Curve

(2001 - 2002 E.coli Monitoring Data (Primary Contact Recreation))

Site:UWCPB01



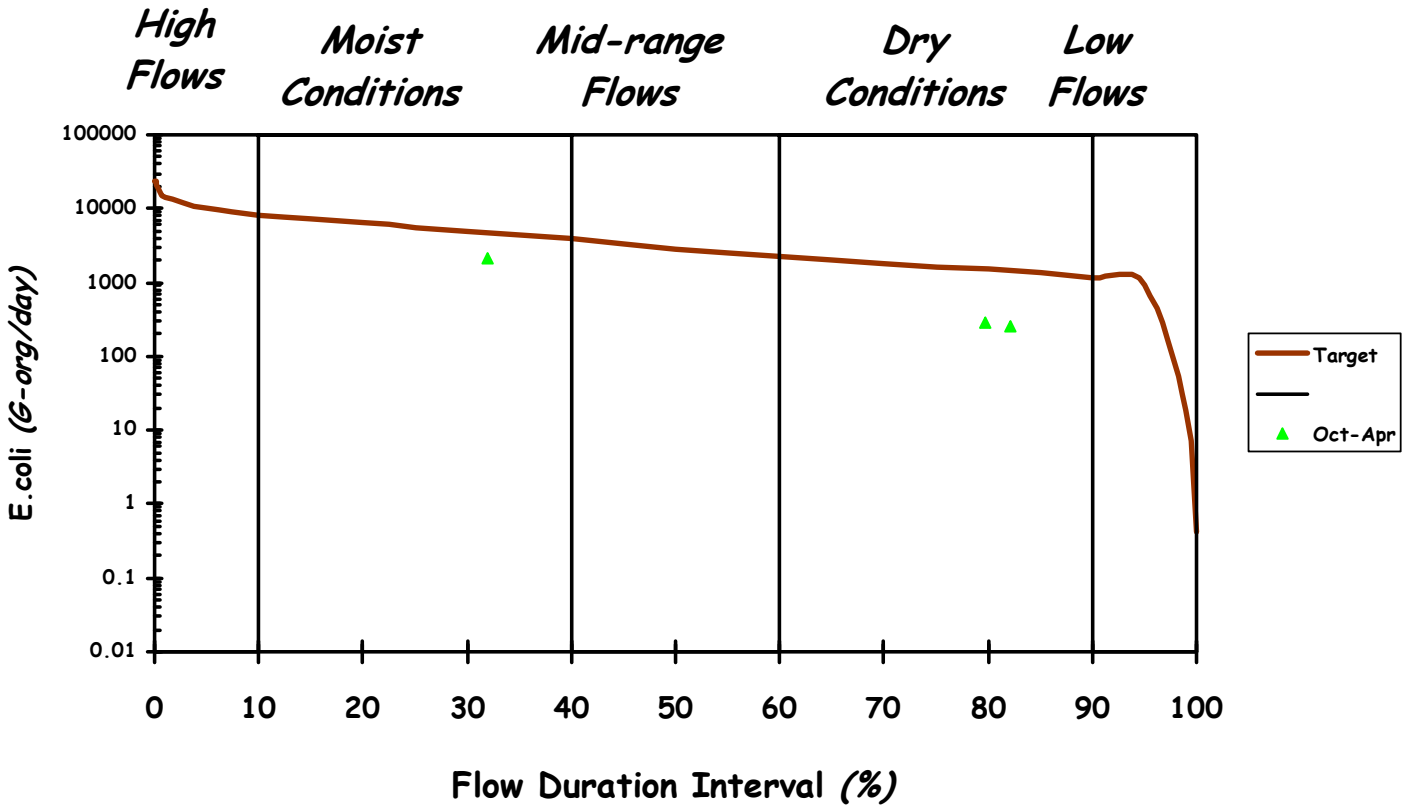
ADEQ Data & USGS Gage Duration Interval

98.7 square miles

Cypress Bayou, AR

Load Duration Curve

(2001 - 2002 E.coli Monitoring Data (Secondary Contact Recreation))



ADEQ Data & USGS Gage Duration Interval

98.7 square miles

Appendix C

Figure 1 –Flow Duration Curve for White River at De Valls Bluff, AR

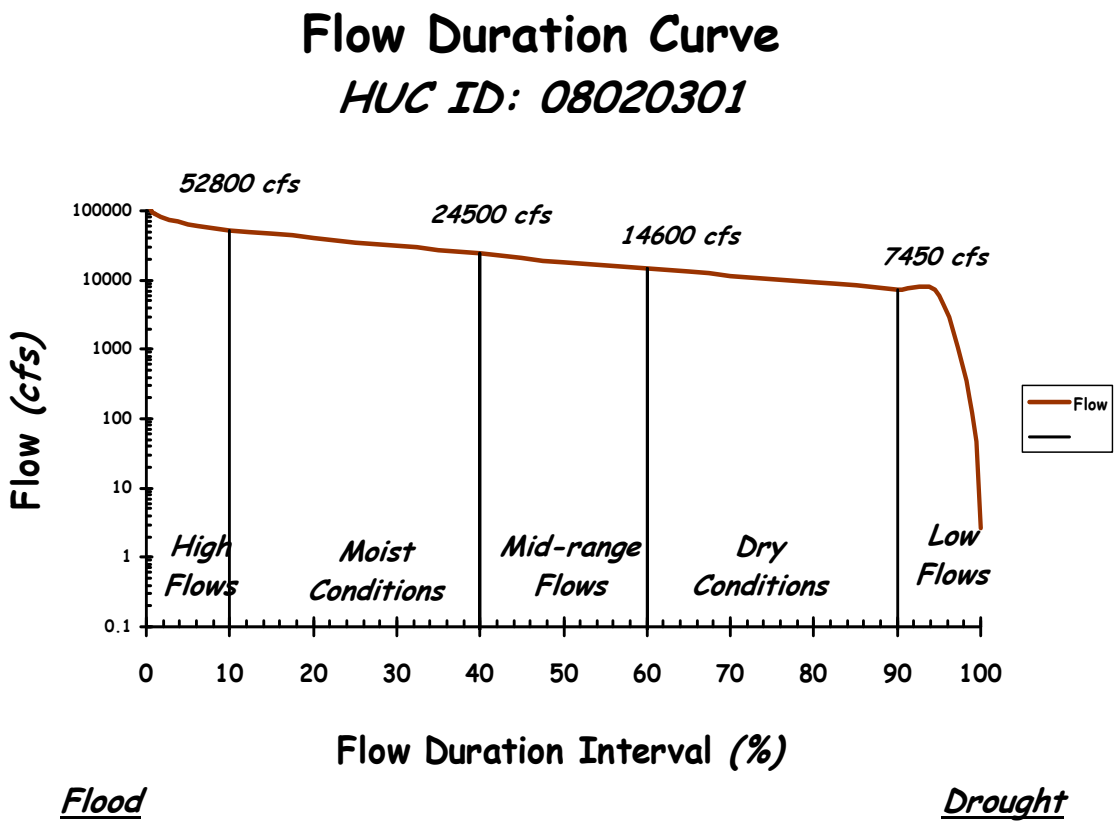


Table 1 –Flow Duration Curve for White River at De Valls Bluff, AR

% > Flow	Flow (cfs)
0.010%	154,000
0.10%	154,000
0.27%	123,000
1%	92,200
5%	63,800
10%	52,800
15%	46,700
20%	41,000
25%	35,500
30%	30,900
35%	27,600
40%	24,500
45%	21,200
50%	18,300
55%	16,300
60%	14,600
65%	13,000
70%	11,600
75%	10,600
80%	9,490
85%	8,530
90%	7,450
95%	6,040
99%	121.8
99.865%	2.7

Figure 2 –Flow Duration Curve for Cypress Bayou

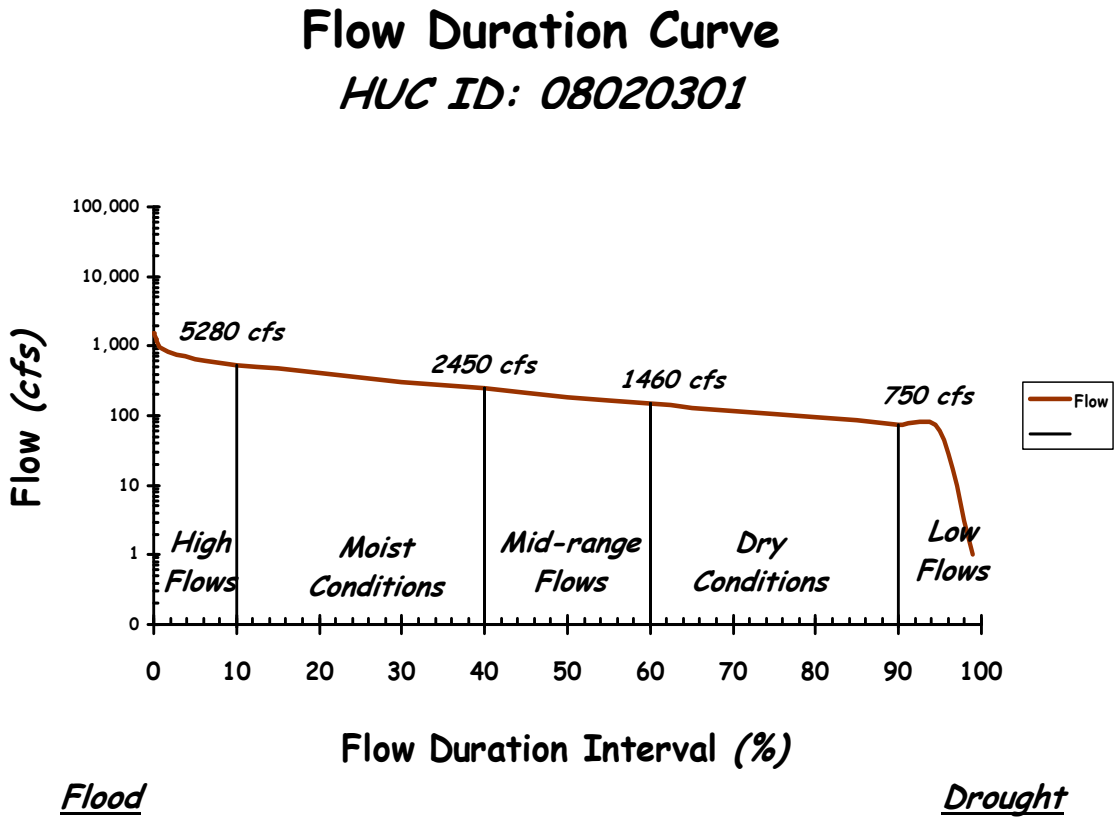


Table 2 –Flow Duration Curve for Cypress Bayou

% > Flow	Flow (cfs)
0.005	1,540
0.01	1,540
0.1	1,230
1	922
5	638
10	528
15	467
20	410
25	355
30	309
35	276
40	245
45	212
50	183
55	163
60	146
65	130
70	116
75	106
80	95
85	85
90	75
95	60
99	1
100	0

Appendix D

Comments from the Arkansas Department of Environmental Quality

Comment #1

These streams segments were added by EPA in 2006. ADEQ assessed these streams as fully attaining designated uses based on E.coli data from the most recent primary contact recreation season using EPA's 1986 Ambient Water Quality Criterion for bacteria.

Response to Comment #1

Based on currently available data, the water was determined to be impaired for primary contact recreation. This data/information, referenced above, was not provided to EPA during the time of TMDL development. EPA will contact the appropriate ADEQ staff to obtain the E.coli information. EPA will assess the data to assess whether the waterbody is still impaired.

Comment #2

Throughout the document, it refers to Primary Contact Recreation-Summer or Winter standard." These are not standards listed in Arkansas's Regulation No. 2. To be consistent with Regulation No. 2, these should be referred to as "Primary Contact Recreation" and "Secondary Contact Recreation".

Response to Comment #2

The TMDL has been updated to specifically refer to Primary Contact Recreation" and "Secondary Contact Recreation" to be consistent with Arkansas's Regulation No.2.

Comment #3

The document refers (pages 2 and 6) to 8 reaches, but only three are listed.

Response to Comment #3

The TMDL has been updated to specifically refer to 3 impaired reaches rather than 8.

Comment #4

On page 8, it is stated that the only active USGS gage station (0707400) in the area is Cypress Bayou near Poughkeepsie. This gage is on the Strawberry River. It is not appropriate to use this station to develop the load duration curves for Cypress Bayou. It also mentions five gages, but there is information for only three.

Response to Comment #4

The TMDL has been updated. The stream gage that was used to develop this TMDL was the White River near DeValls Bluff. This gage was used to develop the load duration curve for Cypress Bayou. In addition, the information has been updated to specifically refer to 3 gages instead of 5 gages.

Comment #5

Several tables in the document refer to UWBLB01 as being Cypress Bayou. This station is actually on Bull Creek.

Response to Comment #5

The TMDL has been updated. The sampling stations there were used is UWCPB01 which is for Cypress Bayou.