FINAL

Nutrient
Total Maximum Daily Loads (TMDLs)
for the
Cahaba River Watershed

Cahaba River AL/Cahaba R_01
Cahaba River AL/Cahaba R_02
Cahaba River AL/Cahaba R_03
Cahaba River AL/Cahaba R_04

Alabama Department of Environmental Management
Water Quality Branch
Water Division
September 2006

Table of Contents

List of Tables

List of Figures

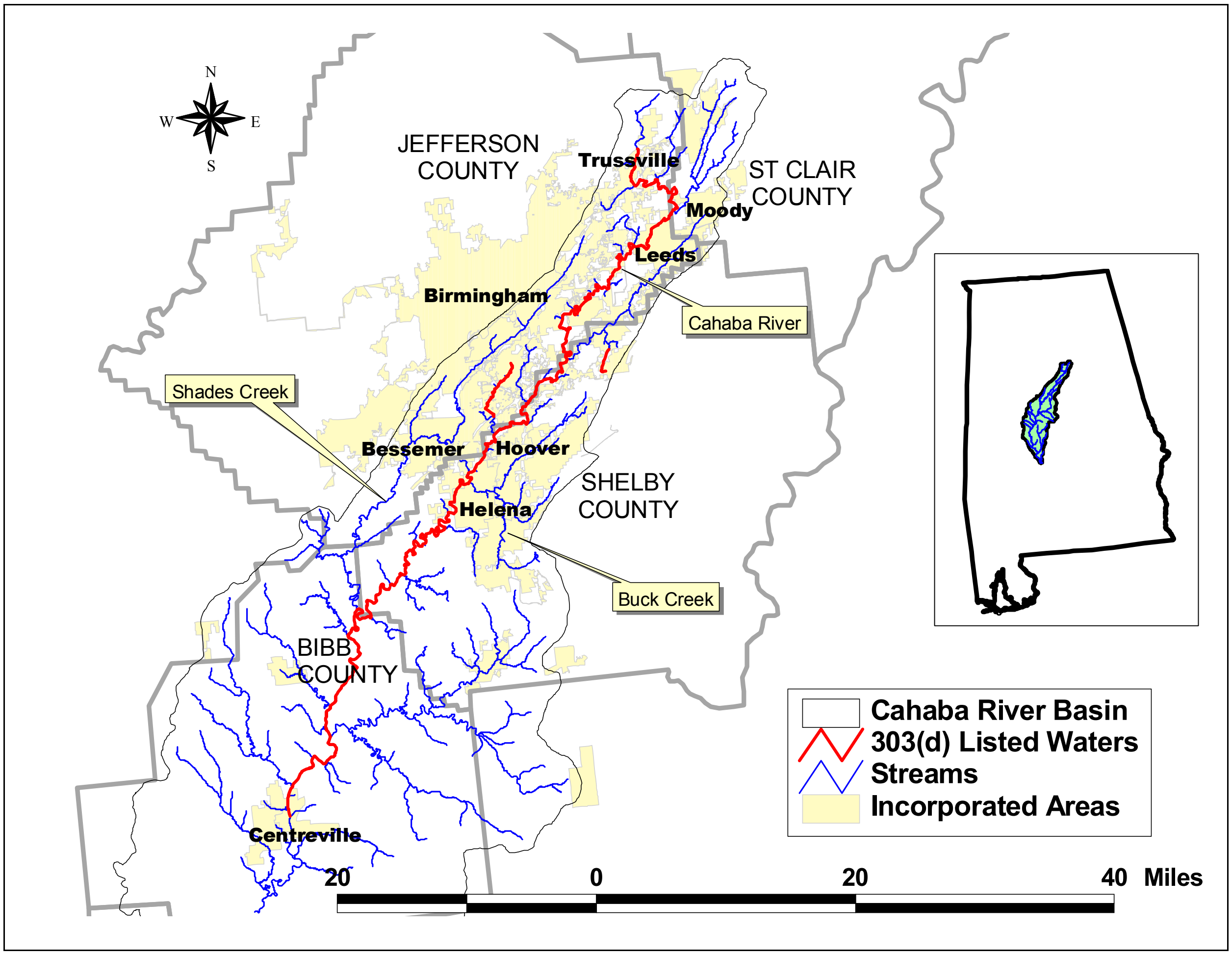


Figure I **Upper Cahaba River Basin (HUC 03150202)**

1.0 Executive Summary

This report presents the Total Maximum Daily Load (TMDL) developed by the Alabama Department of Environmental Management (ADEM) and the U.S. Environmental Protection Agency Region 4 (EPA Region 4) to address nutrient impacts within the Cahaba River watershed. This nutrient TMDL has been developed for the portion of the Cahaba River Basin from AL Hwy 82 to its source. All nutrient impaired segments contained on Alabama's Section §303(d) List of Impaired waterbodies within the Cahaba River watershed are being addressed by this TMDL. The original listing (Segment 03) by the Alabama Department of Environmental Management (ADEM) in 1996 was for nutrients. In 1999, EPA added the other segments (01, 02, and 04) to the Alabama's 1998 §303(d) list. Table 1-1 presents the listed segment names, assessment units, lengths, designated uses, causes of impairment, pollutant sources, the listing year, and the segment location descriptions. The four listed segments encompass approximately 1,027 square miles of drainage area and includes the City of Birmingham in the upper third of the watershed.

Table 1-1 §303(d) Listed Segments of the Cahaba River

Assessment Unit ID	Waterbody Name	Miles	Designated Uses	Causes of Impairment	Sources	§303(d) List	Segment Location (Downstream to Upstream)
AL03150202-0101-102	Cahaba River (Segment 02)*	3.13	OAW and F&W	**Nutrients**, Siltation, and Other Habitat Alteration	Municipal, Urban runoff/storm sewers, and Land development	1998; 2006 (Nutrients only)	US Highway 11 to I-59
AL03150202-0104-102		21.11	F&W				Grant's Mill Road to US Highway 11
AL03150202-0201-102		13.45	OAW and PWS				Dam near US Highway 280 to Grant's Mill Road
AL03150202-0201-101	Cahaba River (Segment 01)	17.46	F&W	**Nutrients** and Siltation	Municipal and Urban runoff/storm sewers	1998	Buck Creek to Dam near US Highway 280
AL03150202-0203-102	Cahaba River (Segment 03)	3.62	OAW and F&W	**Nutrients**, Siltation, Pathogens and Other Habitat Alteration	Municipal, Urban runoff/storm sewers, and Land development	1996 (Nutrients Only); 1998 (All other causes added)	Shelby County Road 52 to Buck Creek
AL03150202-0203-101		23.61	OAW and F&W				Shades Creek to Shelby County Road 52
AL03150202-0405-100	Cahaba River (Segment 04)	13.51	OAW and F&W	**Nutrients,** Siltation, and Other Habitat Alteration	Municipal, Urban runoff/storm sewers, and Land development	1998 (Nutrients and Other Habitat Alteration only); 2002 (Siltation added)	Lower Little Cahaba River to Shades Creek
AL03150202-0503-102		10.58	OAW and S				Alabama Highway 82 to Lower Little Cahaba River

* Segment 02 has been included on ADEM's Draft 2006 §303(d) List for nutrients and is currently pending EPA's approval.
OAW = Outstanding Alabama Water; F&W = Fish and Wildlife; PWS = Public Water Supply; S = Swimming

Figure 1-1 presents a map of the Cahaba River watershed with the listed segments of the mainstem identified. Of the four listed mainstem segments in the Cahaba River, all are listed as impaired for siltation and nutrients, and one for pathogens. The siltation, other habitat alteration, and pathogen TMDLs were public noticed on October 31, 2003 in a separate TMDL document.

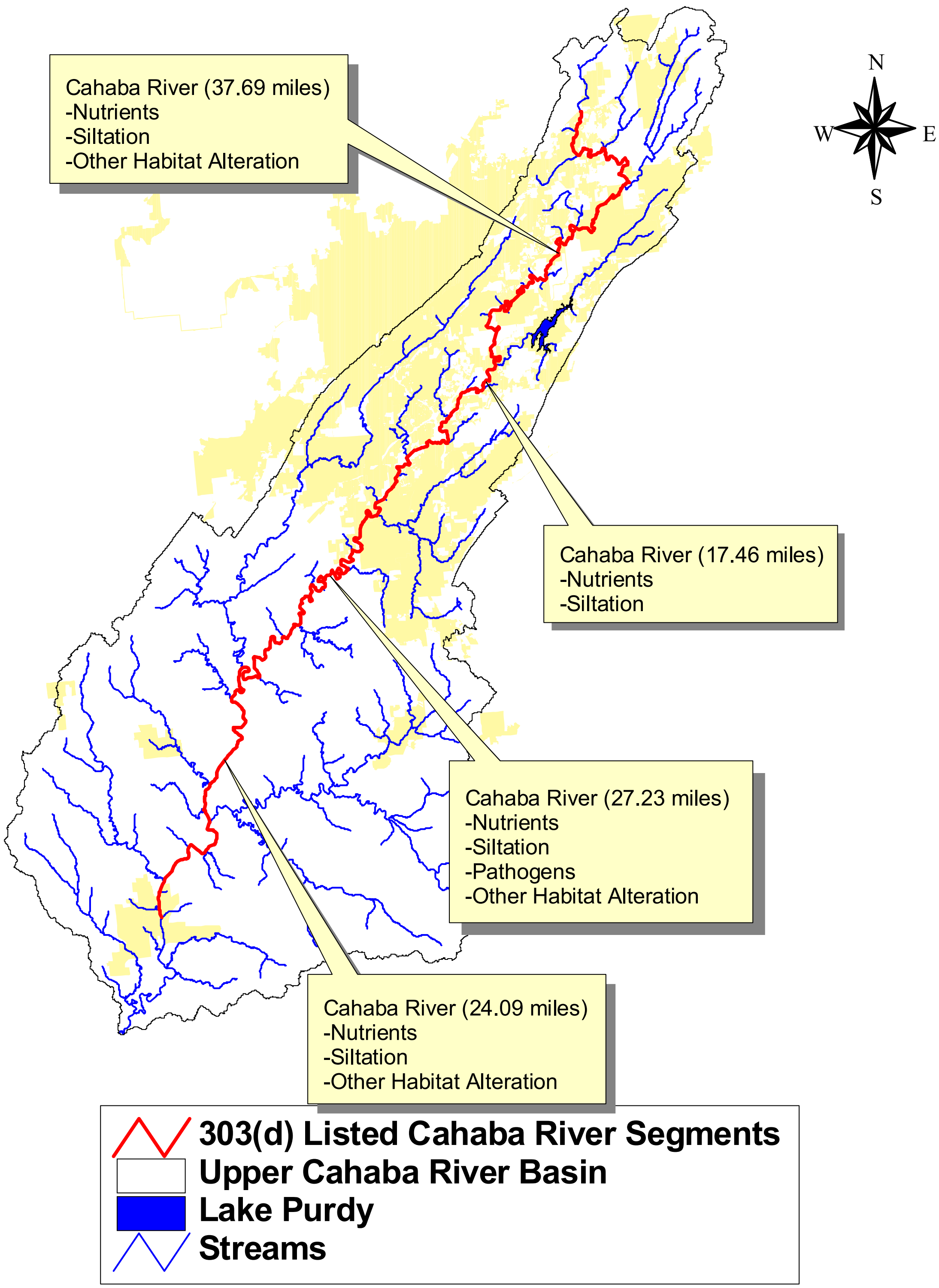


Figure 1-1 §303(d) Listed Reaches of the Cahaba River

Many water quality studies have been conducted within the upper Cahaba River watershed that verify the Cahaba River continues to exhibit numerous impairments of its designated uses. For instance, the findings of EPA and GSA are that biological data indicate that the health of the system within the listed segments ranges from fair to poor based on species diversity, benthic community structure, and biological condition. The causes are attributed primarily to two mechanisms: siltation from urbanized land areas, and eutrophication (attached filamentous algae growth, also known as periphyton) due to nutrient loading from municipal wastewater sources and nonpoint sources (O'Neil 2002, USEPA Region 4, 2003). Overall, the wealth of chemical, physical and biological data collected over the years by the many different agencies collectively demonstrates that the Cahaba River is impaired due to nutrient over-enrichment and siltation in all four segments.

For nutrients, siltation, and other habitat alteration, the water quality criteria are narrative as stated in ADEM's Administrative Code, Rule 335-6-10-.06 and do not change depending upon the designated use of the waterbody. The listed segments on the Cahaba River include four designated uses: Fish and Wildlife (F&W), Public Water Supply (PWS), Swimming and Other Whole Body Water-Contact Sports (S) and Outstanding Alabama Water (OAW). Designated uses within the Cahaba River watershed are shown in Figure 1-2 and listed in Table 1-2.

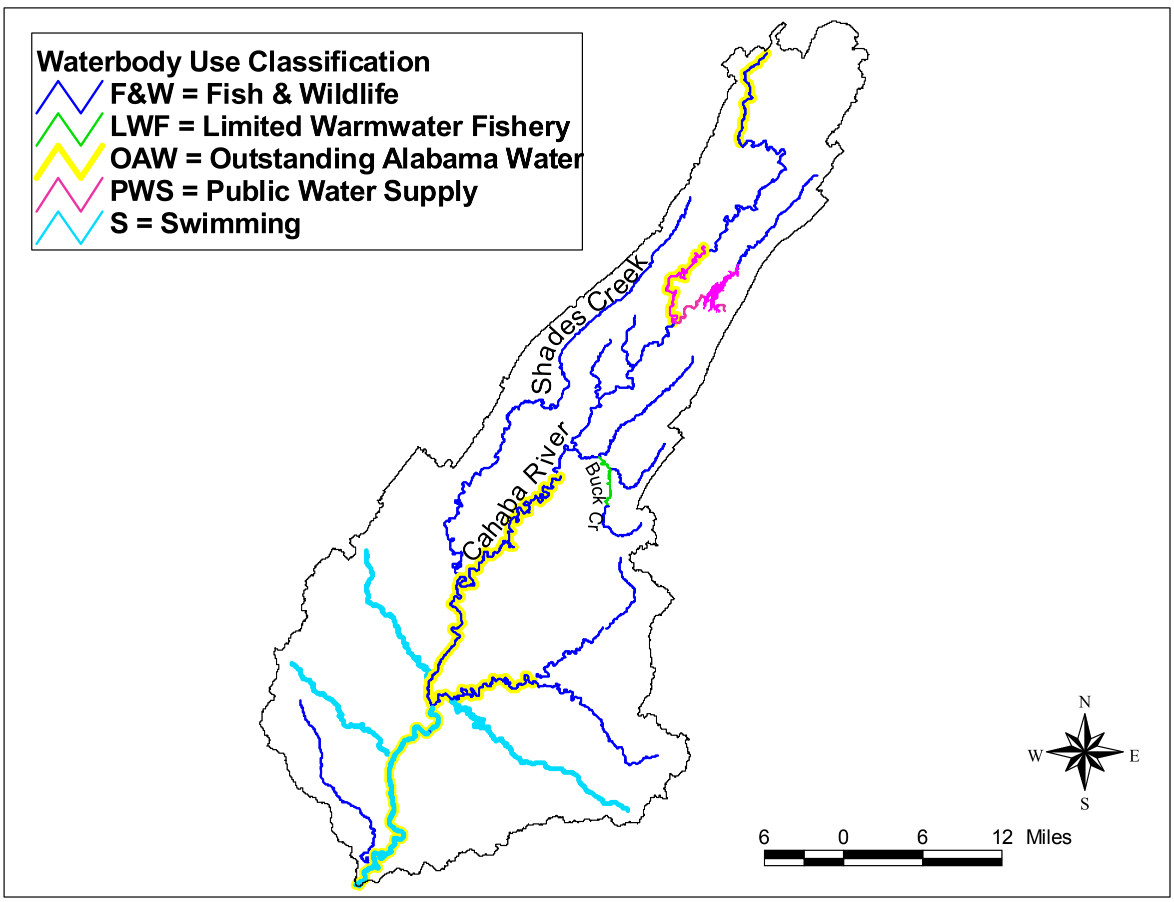


Figure 1-2 Designated Uses in the Cahaba River Watershed

Table 1-2 Designated Uses in the Cahaba River Watershed

Stream	From	To	Classification
Cahaba River	Alabama River	Junction of Lower Little Cahaba River	OAW/S
Cahaba River	Junction of Lower Little Cahaba River	Shelby County Highway 52	OAW/F&W
Cahaba River	Shelby County Highway 52	Dam near US Highway 280	F&W
Cahaba River	Dam near US Highway 280	Grant's Mill Road	OAW/PWS
Cahaba River	Grant's Mill Road	US Highway 11	F&W
Cahaba River	US Highway 11	Its source	OAW/F&W
Haysop Creek	Cahaba River	Its source	F&W
Schultz Creek	Cahaba River	Its source	S
Little Cahaba River (Bibb County)	Cahaba River	Its source	OAW/F&W
Sixmile Creek	Little Cahaba River	Its source	S
Mahan Creek	Little Cahaba River	Its source	F&W
Shoal Creek	Little Cahaba River	Its source	F&W
Caffee Creek	Cahaba River	Its source	F&W
Shades Creek	Cahaba River	Its source	F&W
Buck Creek	Cahaba River	Cahaba Valley Creek	F&W
Buck Creek	Cahaba Valley Creek	Shelby County Road 44	LWF
Buck Creek	Shelby County Road 44	Its source	F&W
Cahaba Valley Creek	Buck Creek	Its source	F&W
Peavine Creek	Buck Creek	Its source	F&W
Patton Creek	Cahaba River	Its source	F&W
Little Shades Creek	Cahaba River	Its source	F&W
Little Cahaba River (Jefferson-Shelby County)	Cahaba River	Head of Lake Purdy	PWS
Little Cahaba River (Jefferson County)	Head of Lake Purdy	Its source	F&W

The Cahaba River Total Maximum Daily Loads (TMDLs) are established at levels necessary to attain applicable water quality standards. In doing so, the designated uses of the river are restored and protected, nuisance algal blooms are prevented, and healthy habitat suitable for the indigenous aquatic species is preserved, including threatened and endangered (T&E) species. Excessive sedimentation and excessive growth of filamentous algae have been two of the primary factors in habitat degradation within the Cahaba River. (USEPA Region 4, 2003; O'Neil, 2002, Hartfield 2002, USFWS 2000, Shepard et al. 1994).

The Cahaba River Nutrient TMDL is based on an instream total phosphorus (TP) target of 35 µg/L established at three critical locations along the Cahaba River and is applied during the April through October growing season. Although the 35 ug/L target is only applicable during the growing season, it is still considered protective of designated uses throughout the entire year, to include the non-growing season (winter months). The three critical locations identified for TMDL development were as follows:

- Roper Road downstream of Trussville (river mile 175.4)
- Old Montgomery Highway (Bain's Bridge, river mile 136.8)
- Shelby County Highway 52 (river mile 127.4)

For reference, river mile 0.0 is the mouth of the Cahaba River located at its confluence with the Alabama River. These three locations were chosen because of historically high instream nutrient levels that have caused periphyton growth in areas downstream of these locations. These sites are shown in Figure 1-3.

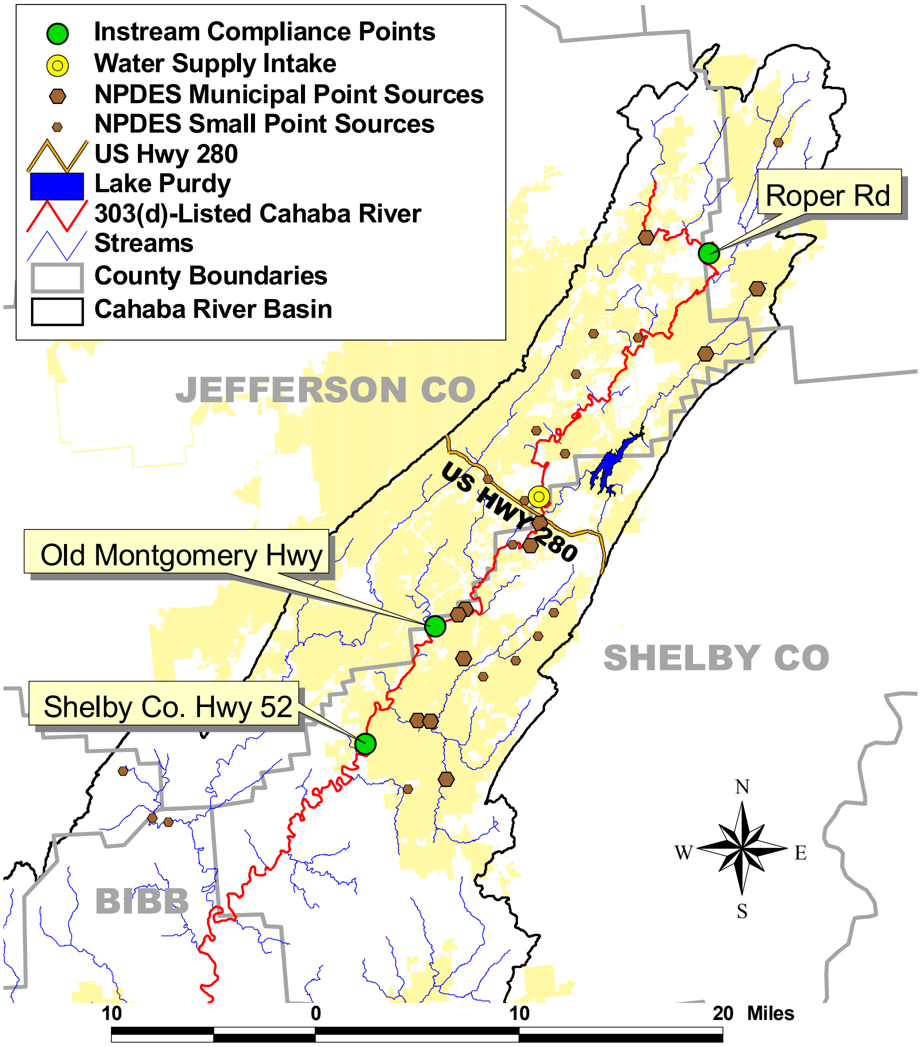


Figure 1-3 Cahaba River Nutrient TMDL Compliance Points

ADEM developed the nutrient target to support this TMDL as discussed in a document titled "Nutrient Target Development in Support of Nutrient TMDLs for the Cahaba River Watershed" (ADEM, 2004) that is provided as Attachment B to this report. The nutrient target development consisted of using a "reference condition" approach based upon EPA recommended procedures outlined in the *Nutrient Criteria Technical Guidance Manual*: *Rivers and Streams* (USEPA, 2000b). As a result of the analysis using this approach, a total phosphorus concentration of 35 µg/L applied over a growing season is the appropriate target upon which to base the Cahaba River Nutrient TMDL. ADEM and EPA believe this TP level will decrease the growth of both suspended and attached algae sufficiently to protect designated uses of the Cahaba River on a year round basis to include the non-growing season. Based on available literature, including EPA guidance summarizing evidence that phosphorus often limits stream algae (EPA 2000b), control of total phosphorus rather than total nitrogen should be effective as an initial strategy to manage algal productivity. In addition, the Department believes this control strategy will also be protective of downstream uses given that waters downstream of the impaired segments of the Cahaba River are currently fully supporting their designated uses.

Further data analysis included the gathering of Cahaba River basin data from many agencies such as ADEM, EPA Region 4, Jefferson County Environmental Services Division (ESD), United States Geological Survey (USGS), Geological Survey of Alabama (GSA), Stormwater Management Authority (SWMA), Clean Water Partnership Cahaba River Basin Project Steering Committee, Birmingham Water Works and Sewer Board (BWWSB), and the Cahaba River Society. All of the hydrologic, hydraulic, meteorological, and water quality data were entered into the Water Resources Database (WRDB) for archival and analysis purposes.

The model development included the following:

- Watershed Flow Modeling,
- Nonpoint Source Assessment,
- Spreadsheet Mass Balance Model,
- EPDRIV1 Hydrodynamic River Model,
- EPDRIV1 Water Quality Model, and
- WASP Periphyton Model.

All of these models were linked together to create a management tool for the Cahaba River for future wasteload allocations, TMDLs, and nutrient target review. The result of the calibration and validation of the models for 1999 through 2001 is a management tool to examine how the nutrients, specifically TP, will respond to key physical parameters in the river. The models were run for three critical years and the TMDLs were developed to achieve the nutrient target of 35 µg/L applied as a growing season median (April-October) at three specific locations along the river.

Table 1-3 summarizes the Nutrient TMDL for the Cahaba River based on the instream TP target of 35 ug/L. The TMDL is defined as the required waste load allocation (WLA) expressed as the TP concentration from continuous point sources (WWTPs) and NPDES-regulated municipal separate storm sewer systems (MS4s), and the load allocation (LA) from urban areas not located within designated MS4 boundaries. Implementation of the subject TMDL will be determined for each point source discharge and MS4 permittee on a case by case basis by ADEM's NPDES permitting program.

Table 1-3 Nutrient (Total Phosphorus) TMDL Summary for the Cahaba River Watershed

WLA(1) (Continuous Sources) Total Phosphorus (TP) (µg/L)	WLA(2) (Stormwater Sources) Total Phosphorus (µg/L)	LA (Stormwater Sources) Total Phosphorus (ug/L)	WLA (Continuous Sources) % Reduction from 1999-2001 loads	LA and MS4 WLA % Reduction from 1999-2001 loads
43 - Major WWTPs (≥1.0 MGD design) / 300 - Minor WWTPs (<1.0 MGD design)**	100 urban/ MS4 25 forest 60 other	100 urban 25 forest 60 other	81%	65% urban / MS4 0% forest 0% other

(1) The TP concentration is applied as a monthly average NPDES limit during the months of April-October.
(2) Based on the 2001 MRLC land cover data set, this is not considered a numeric permit limitation for TP.
* Margaret WWTP (0.5 MGD), due to its headwaters location, is required to meet 150 µg/L TP

MS4 and urban nonpoint source loads were determined by a modeling approach described in Sections 3.3 and 4.4. Urban loads were derived from empirical data and the USGS MRLC land use classifications designated as "urban" types (high intensity residential, low intensity residential, and high intensity commercial/industrial/transportation). MS4 loads included in the Waste Load Allocation (WLA) are defined as urban area loads within designated NPDES MS4 boundaries, while urban area loads outside of MS4 areas are defined as part of the Load Allocation (LA), in order to be consistent with EPA guidelines. No reductions are required from forested areas or "other" land use classifications.

Table 1-4 shows existing and predicted instream growing season (Apr-Oct) median total phosphorus concentrations at the three critical compliance points on the Cahaba River.

Table 1-4 Existing and Predicted Instream Growing Season Median TP in the Cahaba River

Segment	Existing Condition 1999-2000 Instream Growing Season Median Conditions* (µg/L TP)	TMDL Condition Predicted Instream Growing Season Median Conditions* (µg/L TP)
Cahaba River at Roper Rd.	1140**	31
Cahaba River at Old Montgomery Hwy	895	35
Cahaba River at Shelby Co. Hwy 52	560	26

*Instream conditions are evaluated as the median value of growing season data collected April-October
**Downstream of Trussville site existing conditions are shown due to lack of data at Roper Rd.

Throughout this TMDL process the Department plans to use adaptive management as a means to advance mitigation efforts to address known water quality impacts, while continuing to address uncertainties that are encountered along the way, such as those associated with the nutrient target. An effective water quality monitoring program is a key component of a TMDL process that incorporates adaptive management, for it provides vital information concerning the effectiveness of control measures being implemented as well as provides the necessary data to address known data gaps and uncertainties.

2.0 Basis for §303(d) Listing

2.1 Introduction

Section 303(d) of the Clean Water Act (CWA) as amended by the Water Quality Act of 1987 and EPA's Water Quality Planning and Management Regulations [(Title 40 of the Code of Federal Regulations (CFR), Part 130)] require states to identify waterbodies which are not meeting water quality standards applicable to their designated use classifications. The identified waters are prioritized based on severity of pollution with respect to designated use classifications. Total maximum daily loads (TMDLs) for all pollutants causing violation of applicable water quality standards are required to be determined for each identified segment. Such loads are established at levels necessary to implement the applicable water quality standards with seasonal variations and margins of safety. The TMDL process establishes the allowable loading of pollutants, or other quantifiable parameters for a waterbody, based on the relationship between pollution sources and instream water quality conditions, so that states can establish water-quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources.

In 1996, the Alabama Department of Environmental Management (ADEM) identified one segment of the Cahaba River (Shades Creek to Buck Creek) on the 1996-§303(d) list as impaired by nutrients. In 1999, after consultation with the U.S. Fish and Wildlife Service (USFWS) and in consideration of impacts to threatened and endangered species of mussels, snails, and fishes as required by the Endangered Species Act, the U.S. Environmental Protection Agency (USEPA) listed four segments of the mainstem Cahaba River as impaired for siltation and two additional segments as impaired for nutrients. In addition, ADEM added pathogens as a cause of impairment in the segment from Buck Creek to Shades Creek as impaired for pathogens. In 2006, ADEM identified another segment of the Cahaba River (Dam near Highway 280 to I-59) on the 2006-§303(d) list as impaired by nutrients. Table 1-1 presents the listed segments along with the causes of impairment for each listed segment. Table 2-1 shows the threatened and endangered species cited by USFWS as being impacted in the upper Cahaba River watershed.

Table 2-1 List of Existing or Extirpated Threatened and Endangered Species in the Cahaba River Watershed (USFR, 1998; Hartfield, 2002)

Listed Species	Common Name	Type	ESA Status	Found in Cahaba Basin?
Lampsilis altilis	Fine-Lined Pocketbook	Mussel	Threatened	Yes
Ptychobranchus greeni	Triangular Kidneyshell	Mussel	Endangered	Yes
Lioplax cyclostomaformis	Cylindrical Lioplax	Snail	Endangered	Yes
Lepyrium showalteri	Flat Pebblesnail	Snail	Endangered	Yes
Leptoxis ampla	Round Rocksnail	Snail	Threatened	Yes
Medionidus acutissimus	Alabama Moccasinshell	Mussel	Threatened	No, Extirpated since 1973
Pleurobema decisum	Southern Clubshell	Mussel	Endangered	No, Extirpated since 1973
Epioblasma metatstiata	Upland Combshell	Mussel	Endangered	No, Extirpated since 1973
Notropis cahabae	Cahaba Shiner	Fish	Endangered	Yes
Percina aurolineata	Goldline Darter	Fish	Threatened	Yes
Lampsilis perovalis	Orange-nacre Mucket	Mussel	Threatened	Yes

In addition, on July 1, 2004, USFWS finalized the designation of critical habitat (USFR, 2004) in the Cahaba River upstream of U.S. Hwy 82 in Centreville and downstream of Grant's Mill Road, and the lower Little Cahaba River for the species of mussels listed in the table above.

The TMDLs developed for the Cahaba River watershed illustrate the steps that can be taken to address a waterbody impaired by nutrients. In the case of the Cahaba River, the reasons for habitat alteration and degradation are due to the cumulative impacts of excessive nutrient loading and siltation.

Throughout this TMDL process the Department plans to use adaptive management as a means to move forward mitigation efforts to address such impacts, while continuing to address uncertainties that are encountered along the way, such as those associated with the nutrient target. An effective water quality monitoring program is a key component of a TMDL process that incorporates adaptive management, for it provides vital information concerning the effectiveness of control measures being implemented as well as provides the necessary data to address known data gaps and uncertainties.

These TMDLs are consistent with an adaptive management approach: allowable loads have been identified using the best available data and information; load reduction goals have been established and will be implemented on a case by case basis for each permittee; future water quality will be monitored for plan effectiveness and need for future revisions. Flexibility is built into the plan so that load reduction targets and control actions can be reviewed and updated when future monitoring indicates continuing water quality problems or improvement.

2.2 Problem Definition

The Cahaba River watershed is located within the Alabama River Basin in the Ridge and Valley geomorphic province with its headwaters north and east of the City of Birmingham. The Cahaba River watershed covers a total of 1,824 square miles. The drainage area contributing to the §303(d)-listed segments in the upper Cahaba watershed consists of a total of approximately 1,027 square miles in parts of St. Clair, Jefferson, Shelby and Bibb Counties, with small fractions in Tuscaloosa and Chilton Counties. Most of the surface waters within the Cahaba River watershed are designated Fish and Wildlife (F&W) use classification, however, a 12.7 mile segment of the upper Cahaba River is also classified Public Water Supply (PWS), and three segments comprising approximately over 64 miles of the listed segments of the Cahaba River are classified Outstanding Alabama Water (OAW).

The Cahaba River is an important natural resource within the state of Alabama, and especially to the many users within the metropolitan area of Birmingham and surrounding municipalities. The Cahaba River supports many different uses including, but not limited to the following:

- a diversity of aquatic flora and fauna,
- various types of recreation, such as fishing, swimming, canoeing, kayaking, and nature observing,
- public drinking water supply,
- assimilation of effluents from wastewater treatments facilities and industries, and
- assimilation of stormwater run-off from a rapidly growing area.

Table 2-2 presents descriptions of a few of the many recent biological studies in the upper Cahaba River watershed. The findings of EPA and GSA are that biological data indicate that the health of the system within the listed segments ranges from fair to poor based on species diversity, benthic community structure, and biological condition. The causes are attributed primarily to two mechanisms: siltation from urbanized land areas, and eutrophication (attached filamentous algae growth, also known as periphyton) due to nutrient loading from municipal wastewater sources and nonpoint sources (O'Neil 2002, USEPA Region 4, 2003).

Table 2-2 Biological Studies in the Upper Cahaba River Watershed

Author	Year	Study Name	Data Years
Geological Survey of Alabama	1994	Biomonitoring and Water Quality Studies in the Upper Cahaba River Drainage of Alabama, 1989-1994	1989-1994
Geological Survey of Alabama	1997	Water-Quality Assessment of the Lower Cahaba River Watershed, Alabama	1996
Geological Survey of Alabama	2002	A Biological Assessment of Selected Sites in the Cahaba River System, Alabama	2002
Geological Survey of Alabama	2005	Hatchet Creek Regional Reference Watershed Study	2004
Howell, W.M. and L.J. Davenport, Samford University	2001	Report on Fishes and Macroinvertebrates of the Upper Cahaba River and Three Additional Sites	2001
Jefferson County ESD	1999-2002	Cahaba River Water Quality Assessment Project + MOA Data	1999-2002
Onorato, D.P., R.A. Angus, and K.R. Marion, University of Alabama at Birmingham	1998	Comparison of a Small-Mesh Seine and a Backpack Electroshocker for Evaluating Fish Populations in a North-Central Alabama Stream	1995-1996
Onorato, D.P., R.A. Angus, and K.R. Marion, University of Alabama at Birmingham	2000	Historical Changes in the Ichthyofaunal Assemblages of the Upper Cahaba River in Alabama Associated with Extensive Urban Development in the Watershed	1995-1997
Onorato, D.P., R.A. Angus, and K.R. Marion, University of Alabama at Birmingham	1998	Longitudinal Variations in the Ichthyofaunal Assemblages of the Upper Cahaba River: Possible Effects of Urbanization in a Watershed	1995-1997
USEPA Region 4 SESD	2001	Cahaba and Little Cahaba Rivers: Biological and Water Quality Studies, Birmingham, AL	August 27-31, 2001
USEPA Region 4 SESD	2002	Cahaba River: Biological and Water Quality Studies, Birmingham, AL	March/April, July and September, 2002

In addition to the biological studies listed in Table 2-2, ADEM has more recently performed biological studies on the Cahaba River in 2004, 2005, and in 2006. Some of the data is currently being processed and should be available in the near future. Based on the compilation of both historical and recently available chemical, physical, biological data collected by numerous stakeholders (i.e., ADEM, Jefferson County, GSA, Samford University, UAB, USEPA, etc.), ADEM is satisfied that the upper Cahaba River is indeed impaired for nutrients.

Hydrologic conditions that affect surface water quality include high variability in streamflow, characterized by extremely low flows in the late summer-early autumn seasons, magnified peak flows due to high impervious land cover in urbanized areas, decreased groundwater infiltration and retention, and the occasional dewatering effects of the major municipal water supply withdrawal above U.S. Hwy 280. Summer and autumn low-flow periods result in reduced stream velocities, increased retention time, and reduced dilution of point source effluents, conditions which are particularly conducive to excessive algal growth when nutrients are in abundance.

Based on available data and information, historical wastewater impacts may have been a contributing reason for the reduction in range of the T&E species. The river has experienced dissolved oxygen (DO) sags in the 1970s and early 1980s due to wastewater discharges from the

Patton Creek Wastewater Treatment Plant, which was inactivated in the late 1980's (Howell and others, 1981). Water quality in the Cahaba River has improved significantly since this time due to improvements in wastewater treatment (Blancher, 2002). The current biological status/trends of the river may partially be due to a slow recovery from these impacts.

Stiles (1999) cited the upstream limit of the Cahaba shiner as the "New Slab"—otherwise called the "Marvel Slab"—a concrete slab bridge about 3.5 miles downstream of the confluence with Savage Creek. This bridge has been recently removed to allow organisms to repopulate upstream areas. This is expected not only to expand the range of T&E fish such as the Cahaba shiner and goldline darter, but also to benefit T&E mussels whose eggs are transported by fish. A recent Birmingham News article on November 15, 2004 indicated that biologist, scientist, and environmentalist from Alabama, Mississippi, Tennesee, and Georgia had participated in the removal of more than 10,000 snails and mussels, including five endangered species found within 10 feet of the bridge.

The purpose of the Cahaba River Nutrient TMDL is to establish the acceptable loading of nutrients from all sources, such that the established water quality targets outlined in Section 3.1 are attained and habitat suitable for all indigenous aquatic life to include threatened and endangered species is restored and preserved according to the designated uses of the Cahaba River.

2.2.1 Nutrient Impacts

Historically, impacts of nutrient over-enrichment (eutrophication) in the Cahaba River were documented by Shepard et al. (1994), noting that especially in the downstream segment, "biological integrity from [Shelby Co. Hwy 52] to Centreville was controlled primarily by eutrophication and associated effects which degraded the quality of habitat by promoting excessive algal growth on substrates and perhaps through chronic exposure to TRC [total residual chlorine], ammonia, and other aquatic toxics." Furthermore, Shepard et al. concluded based on their exhaustive study of water quality, habitat, and biological integrity: "Further regulation of phosphorus and nitrogen is needed to improve water quality and biological conditions in the upper Cahaba River drainage."

The present-day nutrient impacts on the Cahaba River have been confirmed through recent biological studies on the Cahaba River. In the EPA preliminary field studies conducted during August 2001, it was found that filamentous forms of green (Cladophora) and blue-green (Schizothrix) algae dominated the periphyton communities at many sites in the Cahaba River. Substrate chlorophyll *a* surficial densities up to 230 mg/m^2 were measured (USEPA Region 4 2001, USEPA Region 4 2003). The primary regulatory impetus for a nutrient TMDL is the observation by the U.S. Fish and Wildlife Service that historical communities of threatened and endangered species of fishes, mussels and snails, in addition to the overall aquatic community in the Cahaba River, are currently being impacted by the effects of nutrient over-enrichment on habitat. The species of concern are noted to be either extirpated from the basin or present but non-viable due to nutrient and siltation impacts.

Overall, the habitat impacts of excessive periphyton growth are summarized as follows:

- Inhibits mussel survival and reproduction,
- Inhibits fish reproduction for certain species, and
- Changes in biological community structure.

Hartfield (2002) describes how the life cycle of the threatened and endangered mussels requires a host fish for mussel glochidia (larva) to parasitize prior to the juvenile phase. Thus, in addition to being smothered by benthic periphyton, mussel decline in the Cahaba River basin is linked to the survival of fish species, though the species that may serve as a host is unknown.

A review performed by EPA and Dr. Jan Stevenson (2003) confirms impairment of aquatic life use in the Cahaba River. The impairment has been to the overall biological community, not just threatened and endangered species. As discussed above, the observed habitat degradation is due to nutrient over-enrichment and compounded by concurrent effects of excess sedimentation and extremes in prevailing hydrologic patterns. The dissolved oxygen diurnal (Δ DO) signal demonstrated signs of over-enrichment due to excessive swings (i.e, over 12 mg/L on days documented to have elevated levels of periphyton). Dr. Stevenson's report was summarized to show indications of key algal response at levels of total phosphorus in the range of 20 to 40 µg/L and total nitrogen in the range of 500 to 600 µg/L.

An example of diurnal dissolved oxygen fluctuations at Piper Bridge (river mile 94.5) is shown in Figure 2-1. There is a high degree of diurnal fluctuation indicated in the data measured at Piper Bridge compared to the data measured 30 miles upstream at Shelby Co. Hwy 52. The difference shows the effects of major periphyton biomass accumulation in this Cahaba River segment.

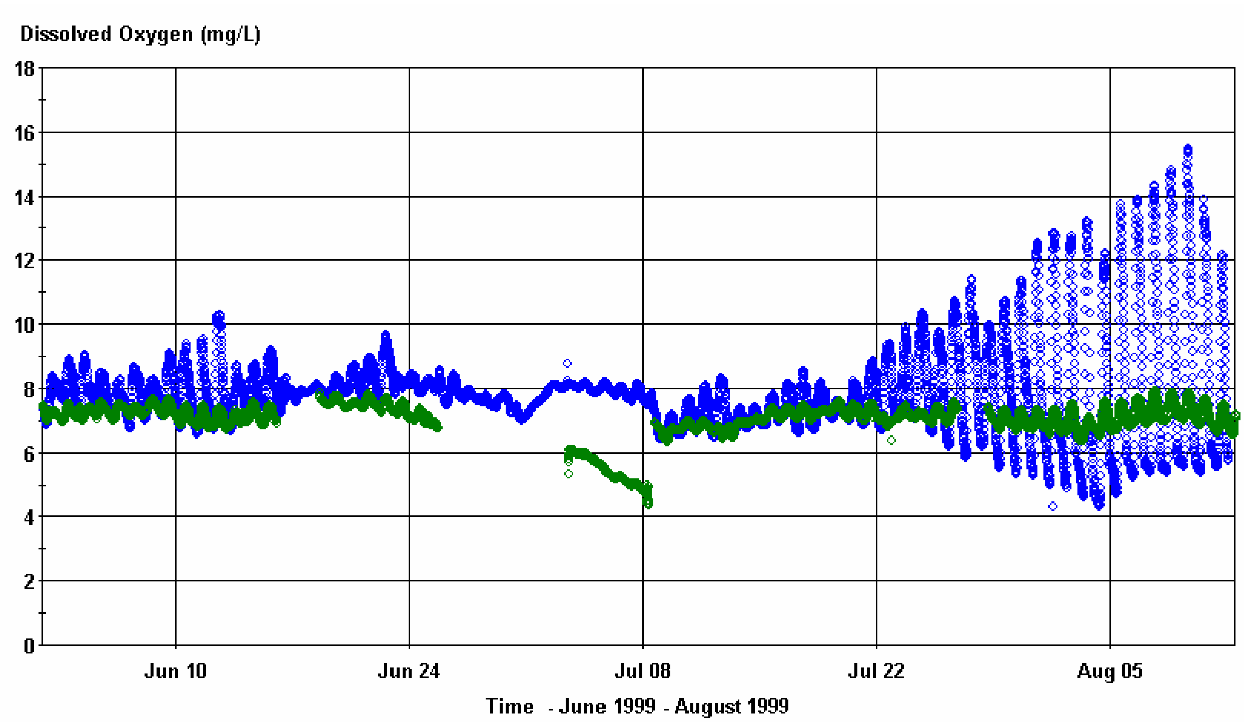


Figure 2-1 Diurnal Fluctuation of Dissolved Oxygen Concentrations at Piper Bridge (blue) and Shelby County Highway 52 (green)

2.3 TMDL Nutrient Target

Typically, development of a water quality criterion for a given pollutant involves extensive research using information from many areas of aquatic toxicology. For example, development of numeric criteria for toxic pollutants, such as mercury, involves numerous toxicological studies such as dose/response relationships, bioaccumulation studies, fate and transport studies, and an understanding of both the acute and chronic effects to aquatic life. As part of the toxicological evaluations, EPA performs uncertainty analysis to help guide selection of the recommended water quality criterion for a given pollutant. For toxic pollutants, the more uncertainty revealed during the evaluation, the more conservative (i.e. the lower the value) the recommended criterion becomes.

Nutrients such as phosphorus and nitrogen are essential elements to aquatic life, but can be undesirable when present at sufficient concentrations to stimulate excessive plant growth. Even though these pollutants are generally considered nontoxic (the exception being un-ionized ammonia toxicity to aquatic life), they can impact aquatic life due to their indirect effects on water quality, either when in overabundance or when availability is limited.

ADEM's water quality standards applying to nutrients are narrative as stated in ADEM's Administrative Code, Rule 335-6-10-.06, therefore a numerical translator is needed to define the TMDL target. Based on the historical data available for the Cahaba River, there is sufficient evidence that designated uses are impaired as a result of nutrient over-enrichment, but some uncertainty remains in the exact quantification of the nutrient target due to the inherent complexity regarding the relationship between nutrient loading and its associated effects on the environment. This is a very common dilemma in nutrient water quality management, and often warrants an alternate approach. EPA recommends, in the absence of sufficient "effects-based" information, an ecoregional reference condition approach be used for determining protective nutrient criteria. With this approach, a numerical value can be empirically developed that can be assumed to inherently protect designated uses of the Cahaba because these nutrient levels are supporting designated uses in the reference waters. This approach can provide an initial target while continuing studies will allow further evaluation of the cause and effect relationships that might result in refinement of the initial target. Also see Attachment B for more information regarding target development for this TMDL.

ADEM's Narrative Criteria, are shown in ADEM's Administrative Code 335-6-10-.06 and are stated as follows:

335-6-10-.06 <u>Minimum Conditions Applicable to All State Waters</u>. *The following minimum conditions are applicable to all State waters, at all places and at all times, regardless of their uses:*

(a) State waters shall be free from substances attributable to sewage, industrial wastes or other wastes that settle in forming bottom deposits which are unsightly, putrescent or interfere directly or indirectly with any classified water use.
(b) State waters shall be free from floating debris, oil, scum, and other floating materials attributable to sewage, industrial wastes or other wastes in amounts sufficient to be unsightly, or which interfere directly or indirectly with any classified water use.
(c) State waters shall be free from substances attributable to sewage, industrial wastes or other wastes in concentrations or combinations, which are toxic or harmful to human, animal, or aquatic life to the extent commensurate with the designated usage of such waters.

According to procedures outlined in *EPA's Ambient Water Quality Criteria Recommendations, December 2000 (USEPA, 2000a),* EPA's recommended ecoregional nutrient criteria are empirically derived using data sets from Legacy STORET, NASQAN, and NAWQA for the period 1990 through 1998. The values derived by EPA are intended to address eutrophication and represent conditions of surface waters that are minimally impacted by human activities and protective of aquatic life and recreational uses. More importantly, EPA intended these values to be recommendations to States as they begin to develop and adopt water quality criteria into their water quality standards program. EPA recognizes that States require flexibility in adopting numeric nutrient criteria and, thus, have recommended the following options in order of preference:

A) Wherever possible, develop nutrient criteria that fully reflect localized conditions and protect specific designated uses using the process described in EPA's *Nutrient Criteria Technical Guidance Manual* (USEPA, 2000b). Such criteria may be expressed either as numeric criteria or as procedures to translate a State's narrative criterion into a quantified endpoint.

B) Adopt EPA's Section 304(a) water quality criteria for nutrients, either as numeric criteria or as procedures to translate a State's narrative nutrient criterion into a quantified endpoint.

C) Develop nutrient criteria protective of designated uses using other scientifically defensible methods and appropriate water quality data.

EPA's Ambient Water Quality Criteria Recommendations (USEPA, 2000a) for rivers and streams suggests establishing nutrient targets based on the 75th percentile of reference stream conditions. If reference streams are not available and/or currently unidentified, the 25th percentile of all streams, including those impaired, can be used as surrogate for an actual reference population when establishing nutrient targets. According to EPA guidance, data analyses to date indicated that the 25th percentile from an entire population roughly approximates the 75th percentile for a reference population. Table 2-3 summarizes the EPA recommended values for the ecoregions in and near the Cahaba River watershed, with the upper watershed falling into Ecoregion 67.

Table 2-3 EPA Recommended Values of TN and TP for Ecoregions within Alabama (USEPA 2000a).

Aggregate Nutrient Ecoregion	Level III Ecoregion	TP (µg/L)	TN (µg/L)
IX	45	30	615
	65	22.5	618
	71	30	800
XI	67	10	214
	68	6	300
XII	75	40	900

In developing a nutrient target for the Cahaba River Nutrient TMDL, ADEM has chosen to use a "reference condition" approach for determining the appropriate levels of nutrients necessary to support designated uses. This approach is based on using ambient water quality data from candidate references streams that are located in characteristically similar regions of Alabama known as ecoregions. An ecoregion is defined as a relatively homogeneous area defined by similar climate, landform, soil, potential natural vegetation, hydrology and other ecologically relevant variables (USEPA, 2000b). "Reference streams" are defined as a waterbodies that have been relatively undisturbed or minimally-impacted that can serve as examples of the natural biological integrity of a particular ecoregion. These "reference streams" can be monitored over time to establish a baseline to which other waters can be compared. Reference streams are not necessarily pristine or undisturbed by humans, however they do represent waters within Alabama that are healthy and fully support their designated uses, to include protection of aquatic life. Ideally, when using a reference condition approach to develop a nutrient target, one would find streams with similar chemical, physical and biological characteristics as the Cahaba River, that are fully supporting their designated uses. Since the Cahaba River was and continues to be §303(d)-listed for its inability to support certain aquatic species due to excessive algal growth and sediment deposition, it seems most sensible to find systems that are supporting balanced populations of indigenous aquatic species and use their nutrient and sediment dynamics as a basis for developing targets. Rivers exhibiting the identical characteristics, such as size, stream order, drainage area, gradient, and substrate, as the Cahaba River and supporting viable populations of balanced populations of indigenous aquatic species have not been identified at this time. Consequently, the best, least impacted, similar streams in the same ecoregion were selected as reference waters. ADEM and EPA believe that the "reference condition" approach used to determine appropriate nutrient targets for the Cahaba River, is reasonable, scientifically defensible, protective of designated uses, and consistent with USEPA guidance.

ADEM evaluated both TN and TP to gain an understanding of the current condition of the Cahaba River and the selected reference streams. As expected, a wide range of values for both TN and TP were encountered. Various calculations were made to determine the most appropriate way to represent TP and TN in the system. In keeping with ADEM's application of EPA guidance, data sets for each of the streams were compiled for each of the 6 reference streams used in the analysis. The range of values calculated for both TP and TN of the reference streams located within Ecoregion 67 is shown in Table 2-4. The 75th percentile and the 90th percentile values for TP were calculated to be 35 μg/L and 47 μg/L, respectively, and for TN were calculated to be 351 μg/L and 534 μg/L, respectively.

Table 2-4 Summary Statistics of Total Phosphorus and Total Nitrogen from April-October within Ecoregion 67 of Alabama.

	Range of All Data From All Sites	75th % of All Data From All Sites	90th % of All Data From All Sites	Range of Site Median Values	75th% of Median Values	90th% of Median Values
TP (μg/L)	**<4 - 77**	**35**	**47**	**19 – 32**	**28**	**31**
TN (μg/L)	**77 – 1,258**	**351**	**534**	**167- 307**	**278**	**301**

Although the 75th percentile statistic used to determine the numeric nutrient target is a single value, it represents the range of values measured over multiple-year growing seasons at the designated reference sites. Therefore, application and interpretation of the target for the Cahaba River should consider that ambient TP concentrations may exceed the target at times while still maintaining conditions similar to those in streams that fully support the designated use of aquatic life, as long as the desired range and growing season median concentrations are maintained. The range of TP concentrations measured at the six reference sites are shown in Figure 3-5.

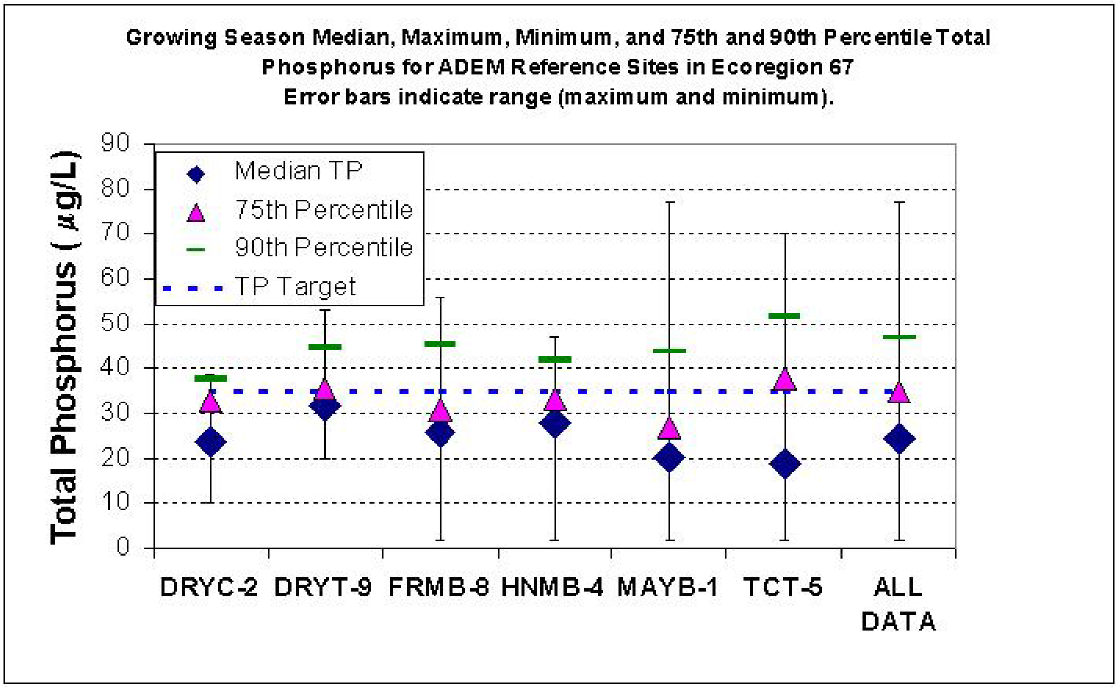


Figure 2-2 Range of TP Concentrations Measured at the Six Ecoregion 67 Reference Sites

At some locations in the Cahaba River, conditions exist where both nitrogen and phosphorus are available in abundance (USEPA Region 4, 2003), and algal growth is limited by canopy shading and other physical factors, such as instream velocities and suspended solids (TAI, 2002). However, it is evident that when conditions are suitable, such as low flow periods in the absence of rain events, the combination of high nitrogen and phosphorus levels coupled with available sunlight in unshaded areas, excessive growth of attached filamentous algae occurs (Shepard et al., 1996; CRS 2002; EPA Region 4 2003). Moreover, persistence of the filamentous algae at other times is also thought to impact habitat for endangered, threatened, and other native aquatic species (USFWS 2002; EPA Region 4, 2003), and the threshold for this impact is presently unknown.

Phosphorus has commonly been considered the primary limiting nutrient governing algal growth in most freshwater stream systems in North America, particularly in freshwater lakes, in contrast with nitrogen-limited estuarine ecosystems (e.g., Correll, 1998). Case studies cited in EPA guidance demonstrated that control of nutrient concentrations can limit the growth of filamentous algae (USEPA, 2000b; Sosiak, 2002). Recent evidence suggests that nutrient limitation by nitrogen or phosphorus may be seasonal and that nitrogen limitation has been observed in some streams (Dodds et al., 2002). This is corroborated by algal growth potential tests conducted by EPA indicating that either phosphorus or nitrogen can be the limiting nutrient at different locations and times in the Cahaba River (USEPA Region 4, 2001; USEPA Region 4, 2003). In addition EPA Region 4 found that "nitrogen in nitrogen-limited waters is usually the limiting plant growth nutrient because of an excess of phosphorus in the system" (USEPA Region 4, 2003). Based on the aforementioned, the ADEM and EPA believe an appropriate initial strategy to controlling algal growth in the Cahaba River, is to effectively control phosphorus loadings in the system. Therefore, controlling nitrogen in the system should be unnecessary because phosphorus will be managed to prevent TN from being a limiting factor. In addition, ADEM currently has no indication of water quality problems directly attributable to nitrogen from the upper Cahaba River.

Unfortunately, definitive cause and effect relationships between nutrient inputs (TP and TN) and algal responses (periphyton) are not currently available for rivers and streams within the Southeast, much less the Cahaba River. Secondly, appropriate habitat conditions for T&E species have not been clearly established. Based on the results of our analysis, ADEM and EPA believe using a TP target of 35 µg/L applied over a growing season is protective of designated uses within the Cahaba River year round and provides adequate flexibility in managing a very complex system. Fine tuning such relationships can and will come in the future as we continue to monitor and evaluate the effects of nutrient inputs to surface waters of the State, to include the Cahaba River.

3.0 Source Assessment

3.1 Existing Conditions

Existing nutrient conditions in the Cahaba River show a wide range of total phosphorus concentrations as might be expected due to seasonal variations in flow, rainfall, temperature, light availability, assimilation, location of nutrient sources, and other factors that affect fate and transport of phosphorus. As shown in Figure 3-1 below, total phosphorus concentrations in the Cahaba River in the proximity of the Birmingham metropolitan area are much higher than concentrations exhibited in the reference streams located within the same region of Alabama.

The Jefferson County Environmental Services Division (JCESD) has implemented a long-term sampling program for the last several years, and some of the data have been reported as part of a Memorandum of Agreement (MOA) signed with ADEM in 2000.

A few sampling stations from the MOA data collection effort within the listed segments of the Cahaba were selected for comparison with ADEM's TP target. These sites are U.S. Highway 280, Caldwell Mill Road, upstream of the JCESD Cahaba River WWTP, and at Shelby County Highway 52, downstream of the confluence with Buck Creek. Medians of the 2000-2001 data are shown in Figure 3-1 (JCESD, 2002) along with ADEM's target concentration for total phosphorus.

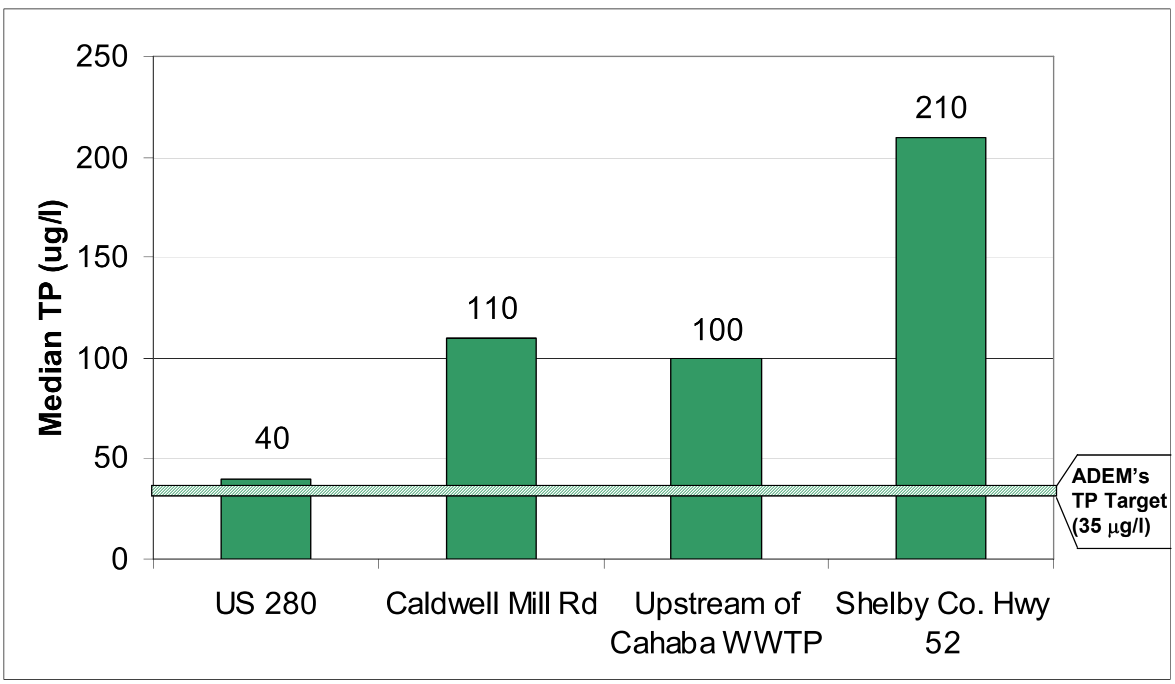


Figure 3-1 Median Total Phosphorus Concentrations in the Cahaba River, 2000-2001 (data from JCESD, 2002).

3.2 Point Sources

EPA identifies point sources as those sources regulated by the National Pollutant Discharge Elimination System (NPDES) program. Urban areas designated as part of the Municipal Separate Storm Sewer System (MS4) program are regulated by NPDES, and as such, are considered to be point sources. EPA (2003) states that "Excessive nutrient inputs (nitrogen and phosphorus) to the Cahaba system from both point and non-point sources have allowed the excessive and widespread growths of filamentous algae." In the majority of the mainstem Cahaba River upstream of Centreville, during normal or low flow conditions, effluent discharges from NPDES-permitted point sources dominate and control ambient instream nutrient concentrations. For example, in the severe drought of 2000, the streamflow of the Cahaba River at USGS Station #02423555 near Helena (Shelby Co. Hwy 52) averaged 31.8 cfs for the month of October. The sum of the discharge from the eight major WWTPs in the middle basin that would have been hydrologically connected at that time was an average of 21.8 cfs, comprising approximately 68 percent of the total streamflow. Effluent total phosphorus concentrations from the same plants averaged approximately 2.3 mg/L based on interpretation of available data from 1999-2001.

Data analysis of the years 1999-2001 indicates that major NPDES-permitted point sources accounted for nearly 70 percent of the total phosphorus loading to the Cahaba River, according to an analysis with the Cahaba Spreadsheet Model, described in Section 4.4. Locations of municipal NPDES facilities are shown in Figure 3-2 and Table 3-1, and semipublic/private NPDES facilities are shown in Figure 3-3 and Table 3-2.

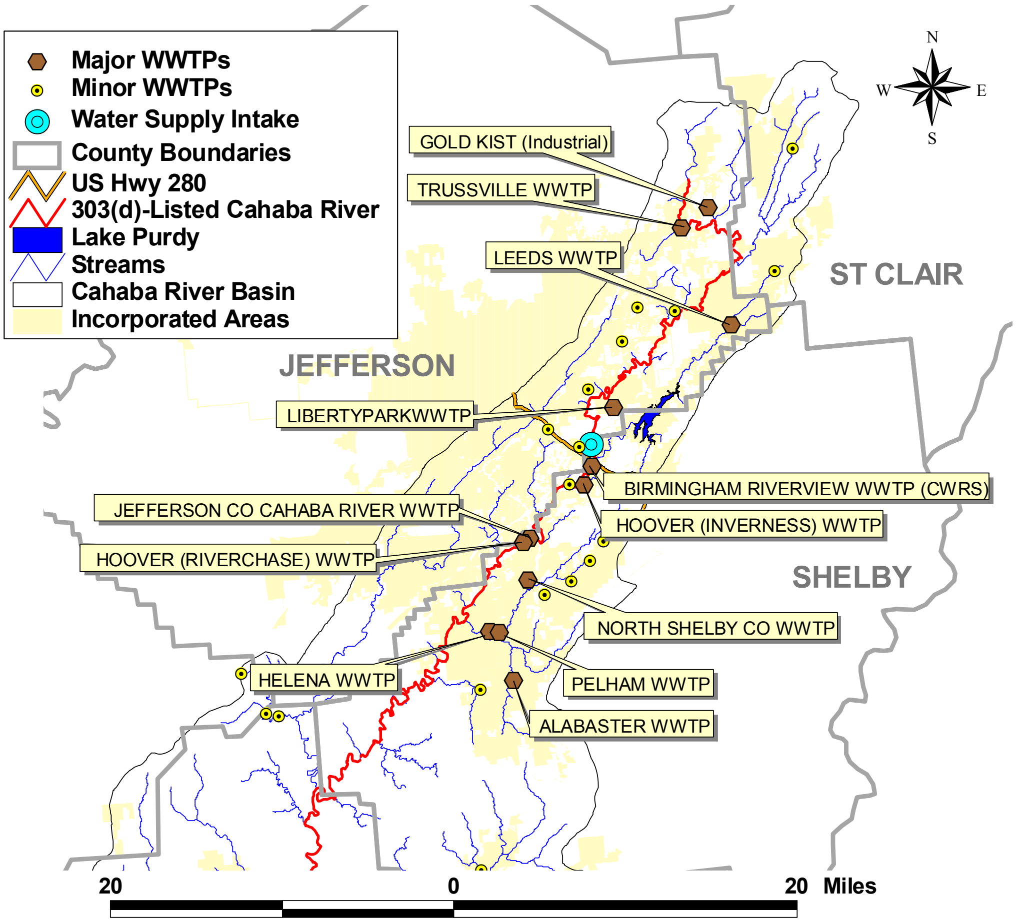


Figure 3-2 Locations of Major (≥1.0 MGD) NPDES-Permitted Point Source Discharges in the Upper Cahaba River Watershed

Table 3-1 Descriptions of Major (≥1.0 MGD) NPDES-Permitted Point Source Discharges in the Upper Cahaba River Watershed

Municipal or Industrial NPDES Discharge	NPDES	Latitude	Longitude	Design Flow (MGD)
Gold Kist (Industrial— Inactive as of November 2003)	AL0003395	33.63500	-86.56111	INACTIVE
Jefferson County Trussville WWTP	AL0022934	33.62034	-86.60135	4.00
Jefferson County Cahaba River WWTP	AL0023027	33.37200	-86.78630	12.00
Helena WWTP	AL0023116	33.29721	-86.83574	4.95
Alabaster WWTP	AL0025828	33.25403	-86.81649	7.60
Hoover (Inverness) WWTP*	AL0025852	33.41228	-86.72570	1.2 (HCR)*
Hoover (Riverchase) WWTP	AL0041653	33.36893	-86.79265	1.50
Birmingham Riverview WWTP (CWRS)	AL0045969	33.42734	-86.71572	1.50
Pelham WWTP	AL0054666	33.29604	-86.82541	4.00
Pelham Hunters Glen WWTP	AL0055182	33.28744	-86.79081	INACTIVE
North Shelby County WWTP	AL0056251	33.33750	-86.79167	6.00
Jefferson County Leeds WWTP	AL0067067	33.53489	-86.56060	2.00
Liberty Park WWTP**	AL0067814	33.47481	-86.6885	1.5-3.0 (HCR)

*Hoover Inverness WWTP has a summer hydraulically-controlled release permit that stipulates no discharge when flow in the Cahaba River is less than 100 CFS, up to 3 MGD when Cahaba River streamflow is 100<Q<300 and up to 10 MGD when Cahaba River streamflow is greater than 300 CFS.
**Liberty Park has two wet weather outfalls: 002 and 003. No discharge is permitted when the Cahaba River is <50 cfs and if storage is at least half full. If the Cahaba is flowing >50 cfs: Q=0.6 MGD; 75 cfs: Q=1.5 MGD; 100 cfs: Q=2.2 MGD and 150 cfs: Q=3.0 MGD.

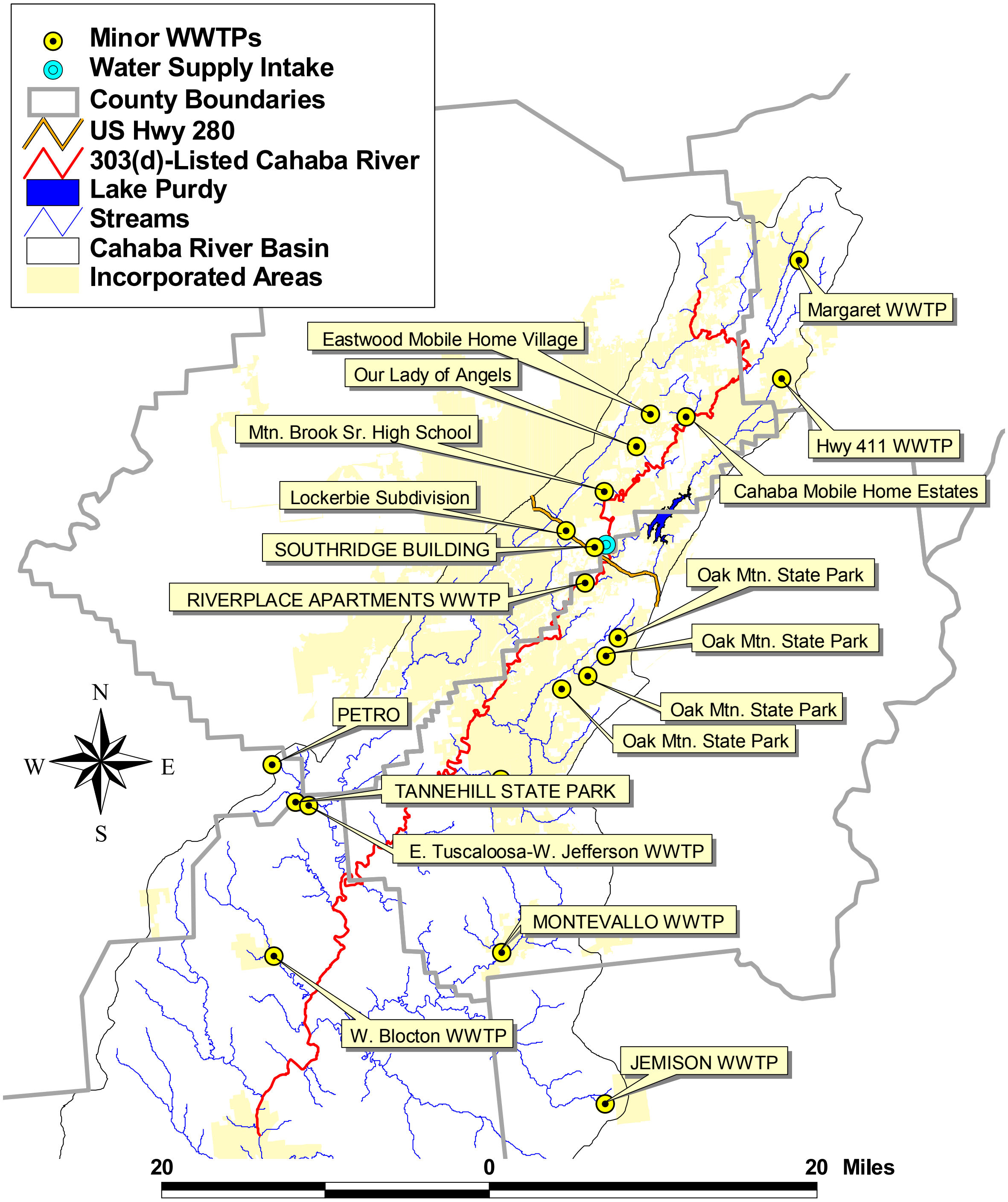


Figure 3-3 **Locations of Minor (<1.0 MGD) NPDES Permitted Point Source Discharges in the Upper Cahaba River Watershed**

Table 3-2 Descriptions of Minor (<1.0 MGD) NPDES-Permitted Point Source Discharges in the Upper Cahaba River Watershed

Semi-public/Private NPDES Discharge	NPDES	Latitude	Longitude	Flow(MGD)
Cahaba Mobile Home Estates	AL0057487	33.55121	-86.6163	0.039
Eastwood Mobile Home Village	AL0056685	33.55702	-86.6541	0.07
Fox Valley Apartments	AL0054330	33.24976	-86.8501	0.026
Hewitt-Trussville High School	AL0047970	33.65643	-86.5908	INACTIVE
Lockerbie Subdivision	AL0047571	33.46234	-86.7558	0.03
Mountain Brook Senior High School	AL0050971	33.49279	-86.7112	0.05
Oak Mountain State Park	AL0050831_1	33.32399	-86.7763	0.009
Oak Mountain State Park	AL0050831_2	33.33288	-86.7473	0.0584
Oak Mountain State Park	AL0050831_3	33.36396	-86.7112	0.013
Oak Mountain State Park	AL0050831_4	33.34901	-86.7266	0.01375
Our Lady of Angels Monastery	AL0057681	33.52996	-86.6723	0.02
Petro Stopping Center	AL0057142	33.28184	-87.0902	0.20
Riverplace Apartments (Caldwell Mill WRF)	AL0063088	33.41488	-86.7403	0.09
Emmett R. Johnson Building WWTP	AL0045225	33.44482	-86.7267	INACTIVE
Tannehill State Park	AL0056359	33.24681	-87.0687	0.08
East Tuscaloosa-West Jefferson WWTP	AL0068420	33.2432	-87.05578	0.80
Montevallo WWTP	AL0023299	33.09829	-86.86671	0.85
Birmingham HWY 411 WWTP	AL0055255	33.57676	-86.51121	0.50
Wilton WWTP	AL0064416	33.08121	-86.88331	INACTIVE
Jemison WWTP	AL0059331	32.95704	-86.77335	0.15
West Blocton WWTP	AL0074195	33.11483	-86.1062	0.49
Margaret WWTP	AL0074837	33.67917	-86.4797	0.50

3.3 Nonpoint Sources

EPA identifies nonpoint sources as those sources not regulated by the National Pollutant Discharge Elimination System (NPDES) program. Urban areas designated as part of the Municipal Separate Storm Sewer System (MS4) program are regulated by NPDES, and as such, are considered to be point sources by EPA. Since pollutant loads from MS4's are associated with stormwater runoff, the technical analysis in this TMDL considers MS4 loads to behave as a nonpoint source.

Nonpoint sources of nutrients in the Cahaba River watershed are primarily due to anthropogenic activity strongly correlated to land use. Urban (residential, commercial, industrial, and transportation) land uses exhibit high total phosphorus concentrations in runoff compared to reference conditions. Specific anthropogenic sources can include land disturbance, fertilizer application, use of phosphate-containing detergents, and subsurface flow derived from approximately 40,000 onsite septic systems in the basin.

In order to assess the impact of nonpoint source nutrient loading in the Cahaba River watershed, certain sub-watershed areas were examined where no major point sources were present, and where water quality data had been collected. Data from eight sampling sites on Shades Creek, Patton Creek, Little Shades Creek, and the upper Cahaba River, collected by Jefferson County ESD (Jefferson County ESD, 2003) and SWMA (SWMA 2002), were analyzed to determine the typical instream nutrient concentrations where no continuous point sources (i.e. WWTPs) are present. The locations of these sites are shown in Table 3-3 and illustrated in Figure 3-4.

Table 3-3 Locations of Water Quality Sampling Locations Used to Assess Water Quality in Subwatersheds Primarily Unaffected by Point Source Effluent

Station ID	Agency	Location	Latitude	Longitude
CR1IS	SWMA	Cahaba River at Hwy 11 Civitan Park - Trussville	33.6228	-86.5994
SC1IS	SWMA	Shades Cr at Elder St near Eastwood Mall in Birmingham	33.5211	-86.7164
SC2IS	SWMA	Shades Cr at Columbiana Rd - Lakeshore Drive Junction	33.4506	-86.8111
SC3IS	SWMA	Shades Cr at Hwy 150 Galleria area - Hoover	33.3550	-86.8767
SC4IS	SWMA	Shades Cr at Dickey Springs Rd (02423630) nr Greenwood	33.3261	-86.9497
ST2	JCESD	Little Shades Creek above Cahaba River	33.3253	-86.7528
ST3	JCESD	Patton Creek above Cahaba River	33.1462	-86.8033
ST4	JCESD	Patton Creek at Patton Chapel Rd.	33.3889	-86.8272

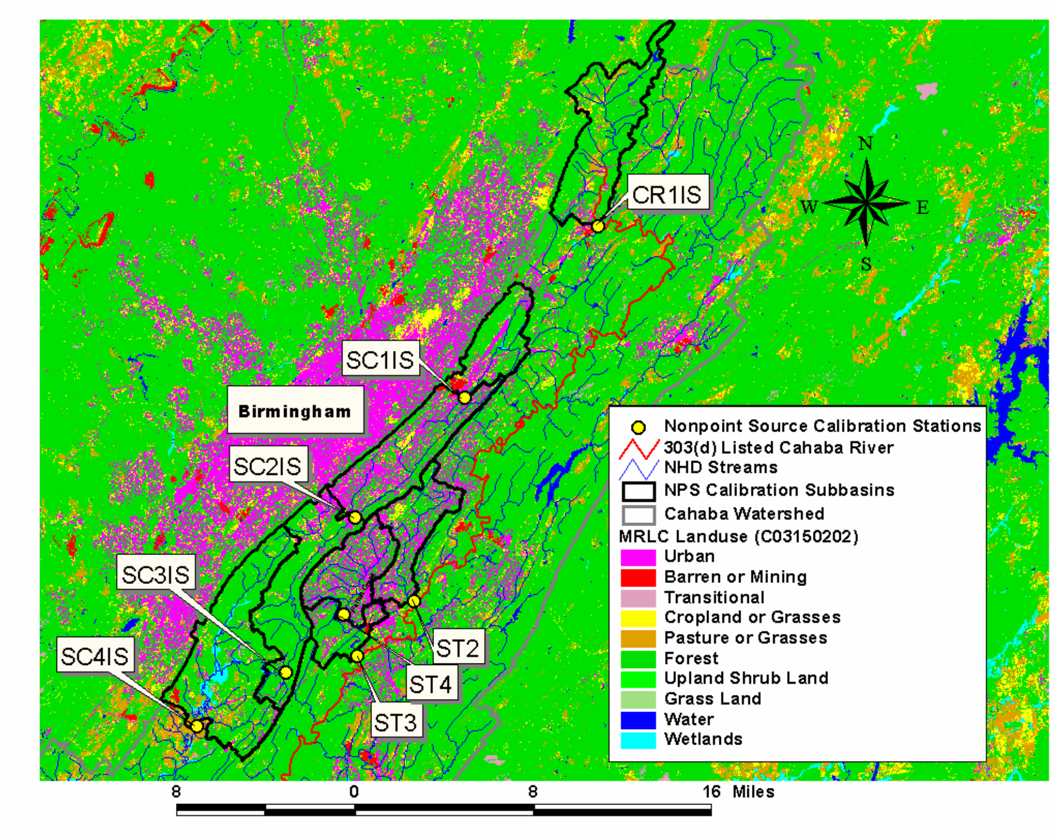


Figure 3-4 Water Quality Sampling Stations Used to Assess Nonpoint-Source Concentrations of Total Phosphorus and Other Nutrients

The chosen sampling locations were assessed using delineated watershed boundaries and the 1992 USGS MRLC Landuse classification. (Note: It is known that certain local agencies have developed more recent GIS landuse data and additional water quality data at these sites, but these were not made publicly available for this analysis. The most recent USGS MRLC provides a sufficiently accurate characterization of the relative degrees of urban and rural land use in the region). Acres of each land use are shown in Table 3-4, in addition to the percent urban area according to that classification.

Table 3-4 1992 MRLC Land Use Distribution for the Nonpoint Source Assessment Sites

Station ID	Water (Acres)	Urban (Acres)	Transitional (Acres)	Forest (Acres)	Grasses (Acres)	Wetlands (Acres)	Total (Acres)	Percent Urban
CR1IS	107	465	8	10347	1704	0	12631	**3.7%**
SC1IS	13	1311	214	4093	417	39	6088	**21.5%**
SC2IS	34	5613	280	9776	1307	39	17051	**32.9%**
SC3IS	80	6920	304	18919	1995	65	28284	**24.5%**
SC4IS	111	7651	503	32746	3971	1096	46077	**16.6%**
ST2	20	2373	0	3875	613	3	6885	**34.5%**
ST3	52	3874	80	6042	876	4	10928	**35.5%**
ST4	13	3161	0	3383	577	0	7133	**44.3%**

Trends of landuse in the characterized subwatersheds ranged from approximately 3.7 percent to over 44 percent urban classification, including residential, commercial, industrial and transportation categories. Total phosphorus data from these sites were analyzed to derive the median values, as are shown in Table 3-5.

Table 3-5 Median Total Phosphorus Concentrations from Assessed Nonpoint Source Watersheds.

Station ID	Location	Percent Forest	Percent Other	Percent Urban	Median TP (µg/L)
CR1IS	Cahaba River at Hwy 11 Civitan Park - Trussville	82%	14%	**3.7%**	**50**
SC1IS	Shades Cr at Elder St near Eastwood Mall in Birmingham	67%	11%	**21.5%**	**70**
SC2IS	Shades Cr at Columbiana Rd - Lakeshore Drive Junction	57%	10%	**32.9%**	**70**
SC3IS	Shades Cr at Hwy 150 Galleria area - Hoover	67%	9%	**24.5%**	**66**
SC4IS	Shades Cr at Dickey Springs Rd (02423630) nr Greenwood	71%	12%	**16.6%**	**75**
ST2	Little Shades Creek above Cahaba River	56%	9%	**34.5%**	**160**
ST3	Patton Creek above Cahaba River	55%	9%	**35.5%**	**130**
ST4	Patton Creek at Patton Chapel Rd.	47%	8%	**44.3%**	**145**

General trends of total phosphorus indicate greater values downstream of the more highly-developed urban areas of the greater Birmingham metropolitan area. A linear regression of the percent urban area shows a significant correlation as shown in Figure 3-5.

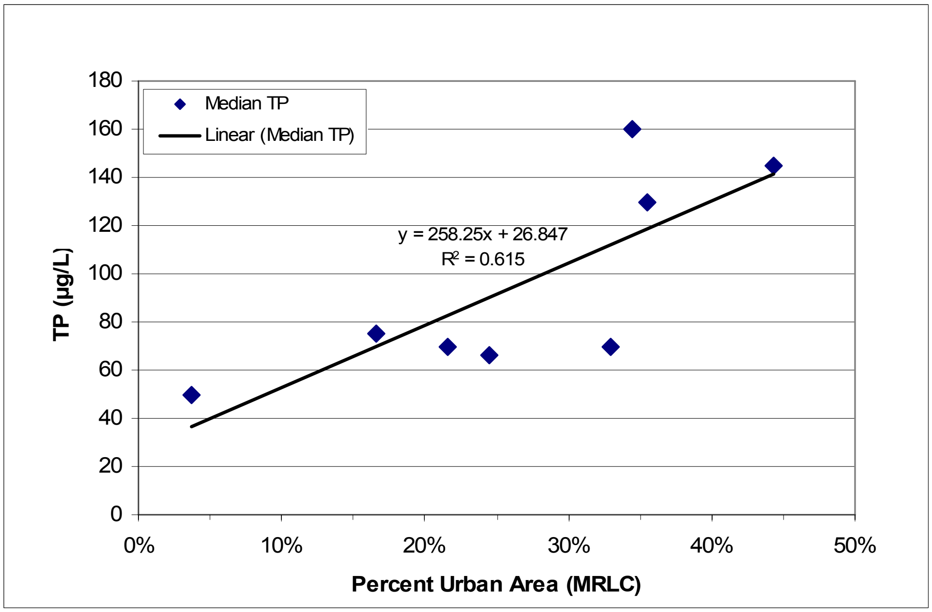


Figure 3-5 Nonpoint Source Total Phosphorus as a Function of Percent Urban Area

The correlation of median instream total phosphorus concentrations to percent urban area in the assessed subwatersheds confirms that the background concentrations of TP are in agreement with the proposed 35 µg/L TMDL nutrient target developed using a "reference condition" approach. According to the regression equation, areas with zero percent urban area would be expected to have median TP concentration of approximately 27 µg/L, and one hundred percent urban areas should have on the order of 285 µg/L. These results are also in close agreement with the median value for least-impacted reference streams (25 µg/L) and the National Stormwater Quality Database for urban MS4 catchments (270 µg/L) (Pitt et al., 2004).

Furthermore, the derived trends were used to develop the general three-category characterization of 25 µg/L total phosphorus for MRLC forested lands, 285 µg/L for urban lands, and 60 µg/L for all other land use/cover categories combined. This characterization is in very close agreement with the two-category correlation shown in Figure 3-5. The three-category characterization has also been used in the Cahaba Spreadsheet Model described in Section 4.4.

4.0 Technical Approach for TMDL Development

The technical approach for deriving TMDLs for the Cahaba River system incorporates a system of linked modeling components which work together to create a comprehensive picture of watershed hydrology and nutrient loading and transport mechanisms that must be quantified in order to develop TMDLs. These components, each of which consists of a separate computer program linked with the others by either input or output, and their applications are described briefly as follows:

- LSPC Watershed Model — Generates calibrated predictions of watershed hydrology and runoff based on geomorphic characteristics and weather data.
- EPD-RIV1 Hydrodynamic Model — Predicts dynamic unsteady-state flow hydraulic transport and water quality kinetic transformations.
- Cahaba Spreadsheet Model — Combines river geometry, monthly-median streamflow predictions and time of travel, and mass balance of water quality inputs from nonpoint source landuse predictions with monthly point source records to predict instream total phosphorus concentrations on a monthly basis.
- WASP Water Quality Model — Utilizes output from the EPDRIV1 model to make predictions of periphyton biomass and corresponding diurnal dissolved oxygen fluctuations

The time period for this study was 1999-2001 which includes the critical, low-flow, drought year of 2000. The following sections outline the procedures used to configure and apply each of these components to help estimate existing conditions in the Cahaba River and also to determine what reductions in nutrient loading would be necessary for conditions in the Cahaba River to comply with the TMDL target.

4.1 Hydrology and Hydrodynamic Modeling

LSPC, an evolution of the well-known Hydrologic Simulation Program Fortran (HSPF) software, was developed by Tetra Tech, Inc. for EPA Regions 3 and 4 to support TMDL development. LSPC provides a linkage between land-based sources of pollutant runoff, stream pollutant concentrations during routing of flows, and delivery of loads to the mainstem river model.

The LSPC model is designed to predict surface hydrology based on geomorphology, land use characterization, precipitation and climactic records. Daily or hourly outputs of LSPC correspond to Cahaba River tributaries and catchments adjacent to the mainstem. In addition to hydrology, LSPC can predict water quality constituent runoff from the land surface, and resulting instream concentrations based on dilution from groundwater flows. Transport is predicted by time-of-travel within a representative reach length, calculated by Manning's equation. For the Cahaba River model, the water quality module of LSPC was investigated initially, but was not used in favor of a more empirical, runoff-concentration approach for determining nonpoint source loads within the Cahaba Spreadsheet Model.

In the Cahaba River linked modeling system, LSPC net flows from tributaries and catchments adjacent to the mainstem become the input boundary conditions for the EPDRIV1 hydrodynamic and water quality model.

4.2 Watershed Model Configuration – The LSPC Model

For the upper Cahaba River watershed, LSPC has been configured to simulate a series of hydrologically-connected subwatersheds, each with defined slope, length, area, and landuse distribution. Each subbasin area contributes runoff and pollutant loads to its respective reach and the cumulative flow and loads are routed downstream. Ultimately, watershed flows become input for the EPDRIV1 instream model.

Geographic and hydrographic data were processed using Arcview GIS along with the Watershed Characterization System (WCS), a system developed by Tetra Tech, Inc. for EPA Region 4 to store and analyze environmental GIS data similar to EPA-BASINS. Delineation of subbasins was performed to separate the upper Cahaba River basin system into contiguous land areas, each of which was analyzed for stream slope, length, and area of each land use classification. This was done at a scale small enough to capture the reach/slope and landform characteristics of each tributary reach segment, resulting in 304 subbasins. This is near the maximum desirable number of subbasins to complete one model run in 1-2 hours runtime on a Pentium 4 computer. The ridge-and-valley terrain in the basin necessitated the large number of subbasins in order to capture the flow accumulation patterns of the complex tributary system.

Subbasins were delineated using the National Elevation Dataset (NED) 30-meter resolution digital elevation model (DEM) and the National Hydrography Dataset (NHD) stream reach GIS files. These datasets are depicted in Figures 4-1 and 4-2, below.

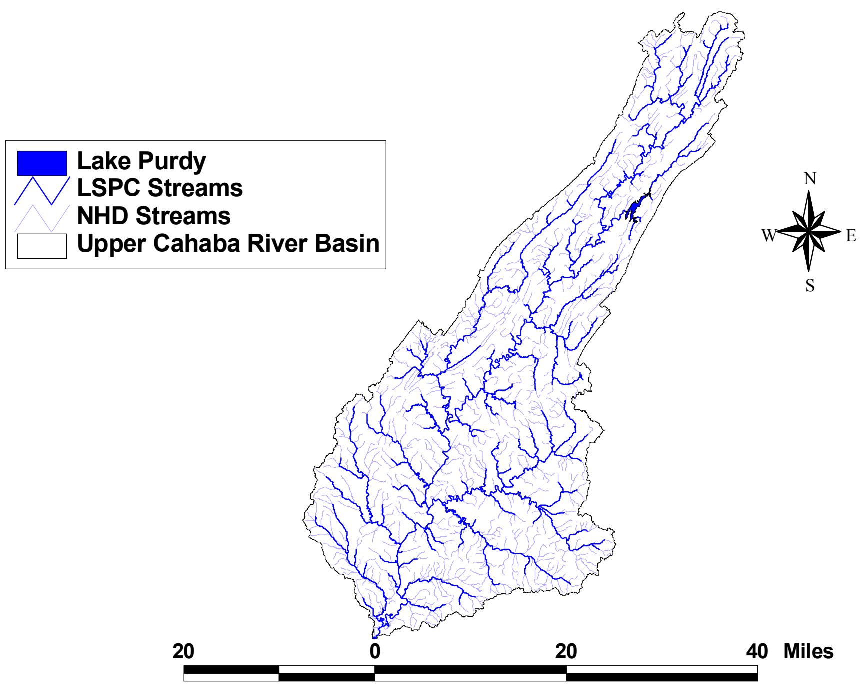


Figure 4-1 NHD Streams and the LSPC Stream Reach Network

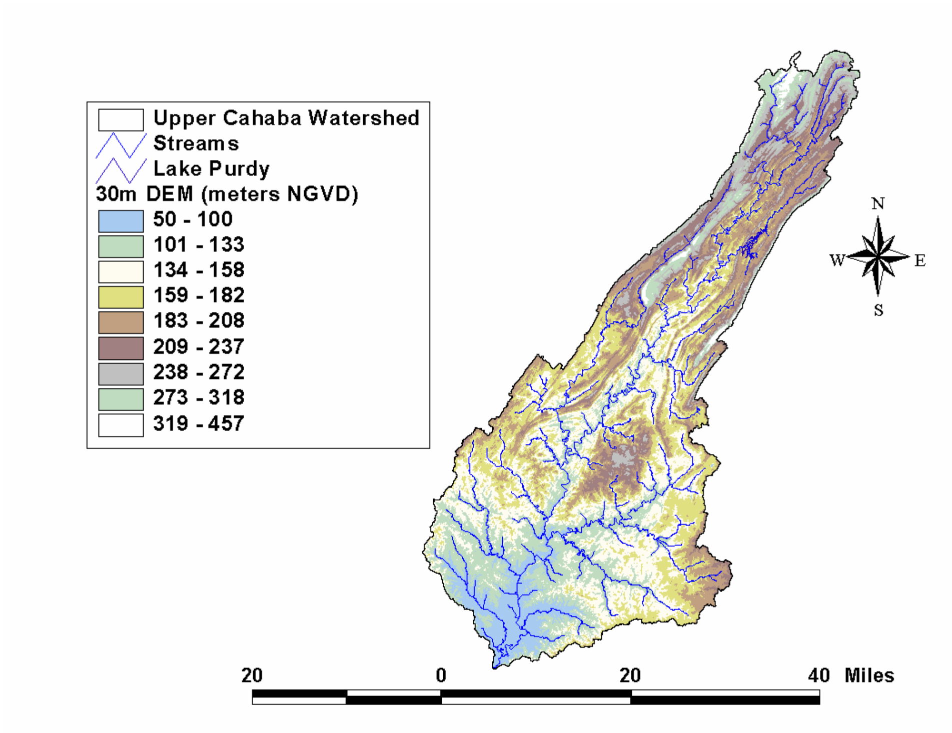


Figure 4-2 The National Elevation Dataset (NED) 30-meter Digital Elevation Model (DEM)

In each delineated subbasin, the LSPC model uses a separate set of hydrologic parameters for infiltration rate, groundwater outflows, and contaminant runoff for each category of land use and soil type. For the Cahaba River LSPC model, there are two general soil types ("B" and "C") and ten land use groups, as shown in Figure 4-3:

- Urban
- Open Water
- Barren/Mining
- Transitional
- Cropland/Grasses
- Pasture/Other Grass
- Forest
- Upland Shrub Land
- Wetlands
- Grass Land

4.2.1 Urban Pervious Surface and Urban Impervious Surface

Each land use group has different runoff, infiltration, and evapotranspiration characteristics. The model predicts the fate of precipitation in each hour of the weather file for each subbasin, i.e. the quantity of rain that becomes direct runoff to the stream, retained in soils, groundwater inflow, or is trapped by vegetation on the land surface. The aggregated total streamflow is the sum of the predicted quantity for each land use category within a subbasin, and is routed in the stream reach for a time-of-travel depending on reach slope and geometry and the amount of flow.

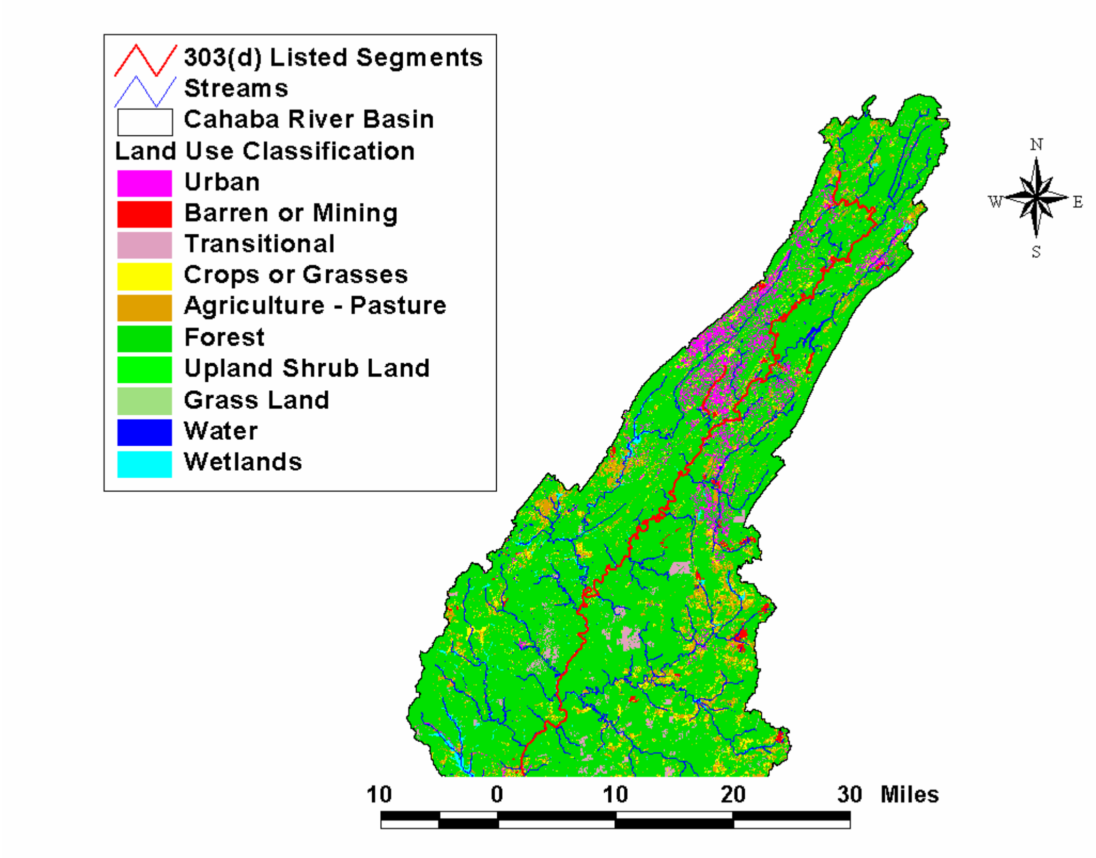


Figure 4-3 Multi-Resolution Landuse Classification (MRLC) Land Use Distribution (USGS)

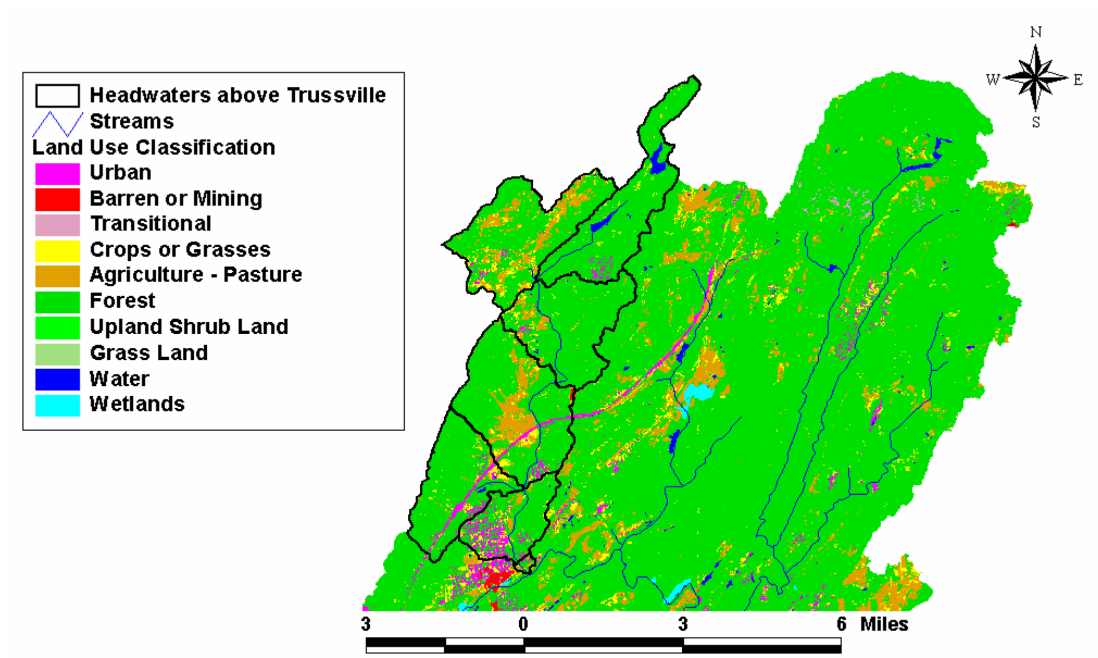


Figure 4-4 MRLC Landuse Aggregation Calculated by LSPC Subbasin Delineation

An example of the land use distribution within a few subbasins is shown in Figure 4-4, which depicts the Cahaba headwaters area and the City of Trussville. The GIS shapefiles created by subbasin delineation can be viewed in the LSPC interface (Figure 4-5), which shows the subbasins selected for a model run. Physical data describing the stream reach network and land use distributions for each subbasin are stored in a Microsoft Access database and queried for each model run.

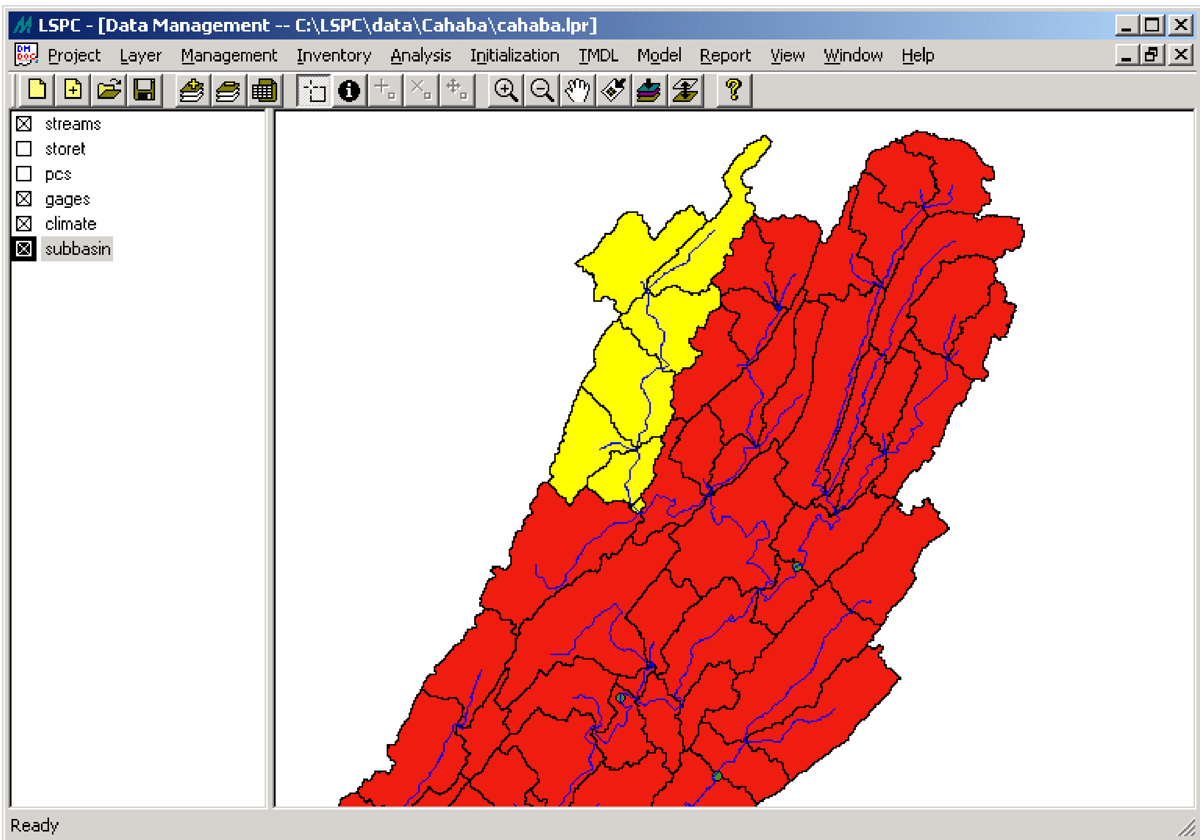


Figure 4-5 LSPC Interface Displaying Subbasins Selected for Model Run

Figure 4-6 shows the 304 upper watershed model subbasin delineations incorporating the entire Cahaba River basin upstream of Centreville.

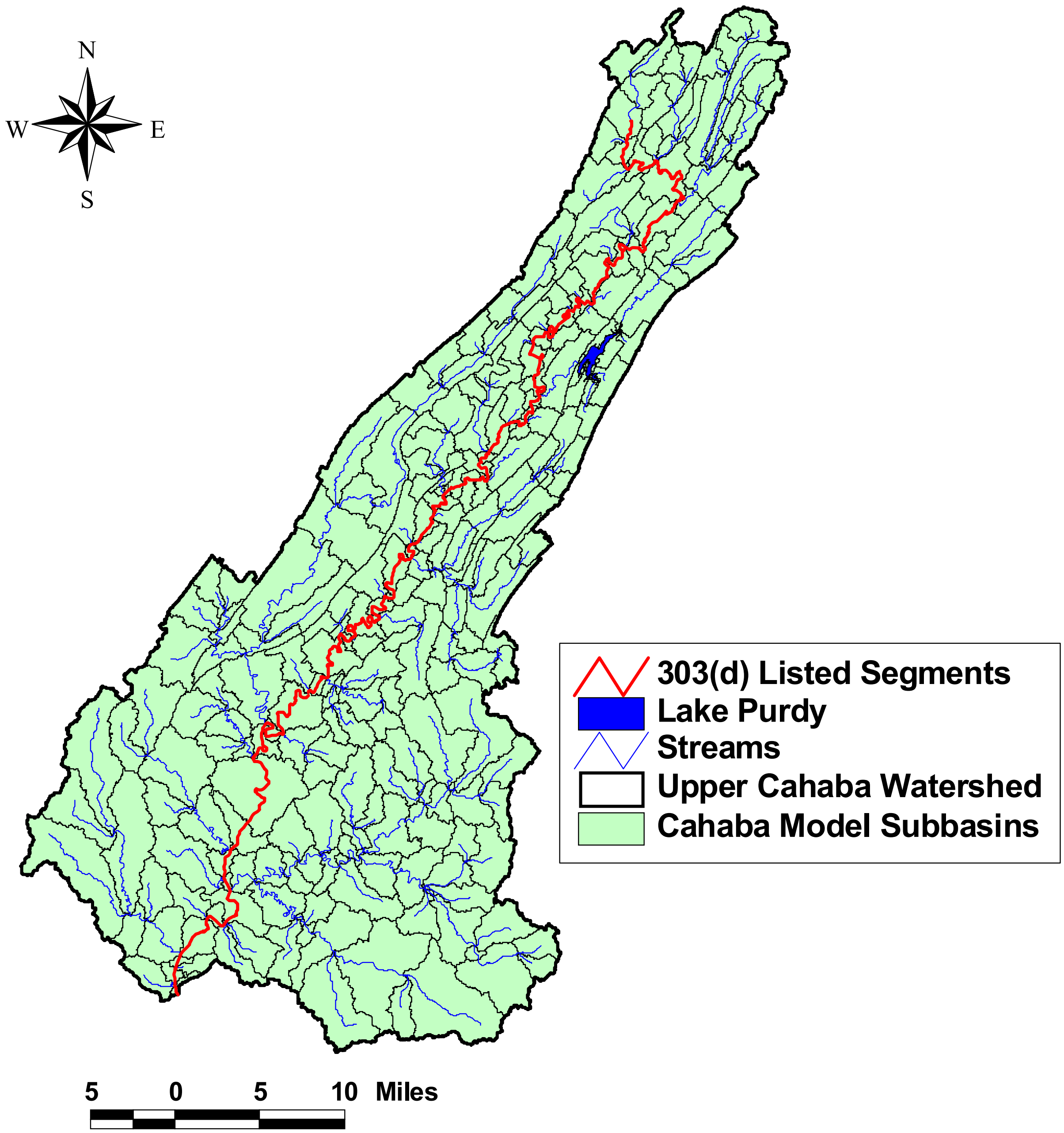


Figure 4-6 Subbasin delineation for LSPC watershed model

4.2.2 Precipitation Inputs

Precipitation inputs are the most critical input for successful watershed hydrology calibration. A major part of the data gathering effort was compiling and formatting enough weather station data to provide good coverage of the watershed. JCESD provided local data for 5 stations in the central watershed. Other station data, including hourly summaries from the Birmingham and Shelby Co. (Alabaster) Airports, were extracted from the National Climactic Data Center (NCDC) website. The stations used for LSPC hydrologic simulation are listed in Table 4-1 and shown in Figure 4-7.

Table 4-1 Precipitation Stations Used in LSPC Watershed Model

Weather Station	Source
Alabaster/Shelby Co. Airport	hourly NCDC
Bessemer 3 WSW	daily disaggregated NCDC
Cahaba Heights Pump Station	from 5-min. Jefferson County ESD
Birmingham Airport	hourly NCDC
Centreville WSMO	daily disaggregated NCDC
Helena	daily disaggregated. NCDC, patched with Shelby
Leeds	daily disaggregated NCDC
Montevallo	daily disaggregated NCDC
Palmerdale	daily disaggregated NCDC
Patton Creek Facility	from 5-min. Jefferson County ESD
Pinson	daily disaggregated NCDC
West Blocton	daily disaggregated NCDC

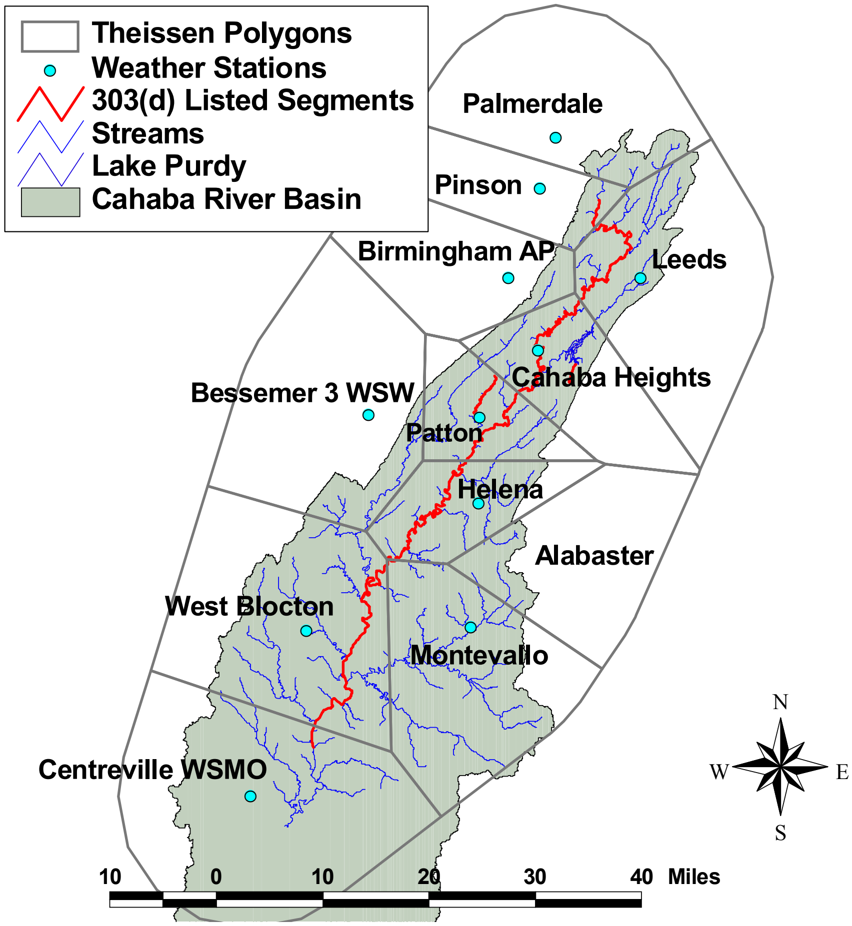


Figure 4-7 Precipitation Stations Used in LSPC Watershed Model

The JCESD stations were provided in 5-minute format but were easily converted to the hourly format required by the LSPC model. It was more difficult to utilize many of the NCDC stations that are in daily format. To disaggregate daily total into hourly (rainfall intensity) format, the rainfall daily fraction in each hour was assumed to be the same as the nearest hourly station. If the hourly station did not experience rainfall on a particular day, the daily station total was distributed according to the assumption of fractional intensities of a SCS 6-hour design storm. Although precipitation varies widely over the Cahaba River basin, the temperature, cloud cover (sunlight intensity), and potential evaporation (based on relative humidity, dew point and temperature) from the Birmingham Airport are assumed to be uniform and valid throughout the watershed.

4.2.3 Hydrologic Model Calibration

The LSPC model was used to predict watershed flows, including tributary streamflows and adjacent catchment runoff entering the Cahaba River at 88 points. Calibration of the LSPC hydrology was accomplished through comparison of simulated flows at several locations in the model domain, USGS station 02423130 near the headwaters of the Cahaba, and USGS station 02423630 on Shades Creek. Streamflow calibrations for the Cahaba River at Mountain Brook, at Caldwell Mill, near Acton, and near Helena are in the domain of the EPD-RIV1 instream model discussed in the following section.

The results show the model accurately predicting the flow balance over the full duration of the simulations as well as the time variation in hydrology over a three-year period. Some errors in prediction are caused by spatial variation in precipitation in the watershed deviating from that measured at the precipitation gages used.

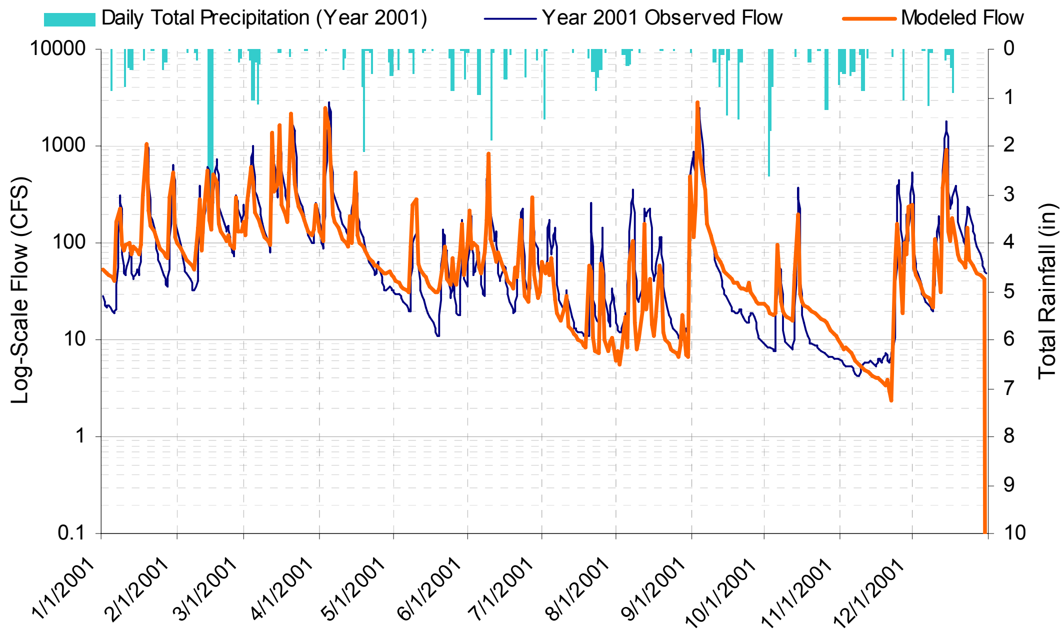


Figure 4-8 Example of Hydrologic Model Calibration: Model and Observed Streamflow

4.3 EPDRIV1 Hydrodynamic Instream Model Configuration

The EPDRIV1 model has been used to perform instream hydraulic and water quality simulations for the mainstem Cahaba River from Trussville to Centreville. These simulations have two main functions in the linked system of models used to evaluate the Cahaba TMDLs. The first is that the output of the hydraulic simulations is used to calculate median monthly time-of-travel for the Cahaba Spreadsheet Model. The second is to evaluate the results of dynamic water quality simulations for existing conditions (1999-2001) and projected scenarios.

4.3.1 Geometry data

A set of the Cahaba River cross-section data for the segment between US HWY-280 and river mile 95.8 was obtained from JCESD and XCG Consultants LTD. This set of cross-section data is used in the lower Cahaba River model. Cross-section data for the upstream segment of the river were obtained from FEMA HEC-2 flood-forecast studies.

Where cross-section data are not available, in the downstream segment below Bibb Co. 24 (Piper Bridge), cross-sections are interpolated and estimated. Specifically, the cross-section data at river mile 95.8 is used for the cross-section at USGS Station 02424000 while the elevations are adjusted according to the average slope of the river between US HWY-280 and river mile 95.8. The cross-section data between river mile 95.8 and USGS Station 02424000 are then interpolated using the interpolation function in HEC-RAS.

The roughness coefficients, i.e., the Manning coefficients, for each cross-section are set to 0.05 for the upper part and 0.06 for lower reaches of the Cahaba River model.

4.3.2 Boundary Condition data and the LSPCRIV1 program

For the EPDRiv1 model, the simulation time begins at 01/02/99 and ends at 12/10/01. Many of the data gathering efforts have focused on this period of interest.

In general, any flow and contaminant into or out of the model domain is considered a boundary condition. Therefore, the BWWSB withdrawal and all lateral flows, which includes point and nonpoint source flows, are discussed herein as boundary conditions.

Because both the river models have only one mainstem branch, flows feeding into the Cahaba River from other tributaries are treated as lateral flows in the EPDRiv1 model. Point sources, such as wastewater treatment plants, and nonpoint source runoff are treated as lateral flows as well. A FORTRAN program called LSPCRIV1 was developed to reformat lateral flow input files for EPDRiv1 using nonpoint source runoff simulated by LSPC and Discharge Monitoring Reports (DMRs) for point sources DMRs as input.

The LSPCRIV1 program has the capability of distributing overland runoff from a sub-basin into river cross-sections uniformly if two or more cross-sections are located in the river segment that is in the sub-basin. If runoff from a sub-basin feeds into a river as an in-stream flow, then the LSPCRIV1 feeds the runoff into only one cross-section. Similarly, the LSPCRIV1 feeds each point source flow into only one cross-section. In the case that overland runoff flows and point source flows or in-stream runoff flows and point source flows feed into the same cross-section, the total flows are combined.

Daily overland and instream runoff flows and nutrient data between 01/02/99 and 12/31/2001 are simulated by the LSPC watershed model. Major point sources for the upper portion of the Cahaba River model (above US280), namely Trussville and Gold Kist wastewater treatment plants (WWTPs) and discharge from Lake Purdy, are included in the model. Monthly DMR flow and nutrient data for the wastewater treatment plants are available for the period 1999-2001. For months without data, the average value is used for the month. Daily discharge data from Lake Purdy are available from the Birmingham Water Works and Sewer Board while water quality constituent data is available from historical USGS records.

Major point sources directly input into the model below US Hwy 280 are Birmingham Riverview, Hoover Inverness, Jefferson County Cahaba River, and Hoover Riverchase. In the Buck Creek basin, Helena, Pelham, Alabaster, and North Shelby County WWTPs are included as the total Buck Creek lateral inflow to EPDRIV1, with an attenuation factor to account for instream losses of TP in Buck Creek and Cahaba Valley Creek. Again, some of the monthly flow and nutrient data for these WWTPs are available for the period 1999-2001. For months with no water quality data, the average from available data or from the ADEM municipal nutrient database is used for that month.

Average daily flow data at the USGS station 02423130 at U.S. Hwy 11 in Trussville were used for the upstream flow boundary condition. Estimated nutrient, DO, and water temperature data are used for the upstream water quality boundaries.

Several HEC-RAS simulations with different flow rates have been conducted to obtain the downstream rating table for both models. In the water quality simulations, no downstream boundary conditions are needed. Daily water withdrawal data at the Cahaba Pump Station for the period of 1999 and 2000 were used to calculate net flows and releases from Lake Purdy.

4.3.3 Initial Condition Data and Other Auxiliary Data

The initial flow condition, that is, the flow depth at each cross-section for each model is obtained from a HEC-RAS steady-state flow simulation. The initial DO and water temperature are estimated based on the correlations between the ambient air temperature (dry bulb temperature) and DO and water temperature, respectively.

For water quality simulations, hourly meteorological data, such as cloud cover, wind speed, dry bulb temperature, dew point temperature, and atmospheric pressure at Birmingham International Airport, are used in the EPDRIV1 model.

4.4 Cahaba Spreadsheet Model

In order to combine the dynamic elements of watershed hydrology, urban nonpoint source and background phosphorus loading, and predict instream dilution of major point source inputs, Tetra Tech created a mass-balance spreadsheet model that utilizes and combines information from USGS streamflow gages, LSPC model-predicted hydrology, land use classification, river geometry, EPDRIV1 dynamically-predicted stream velocity, and historical WWTP data from NPDES discharge monitoring reports (DMRs). The Cahaba Spreadsheet Model estimates the monthly median TP at 160 points along the Cahaba River, from Trussville to Centreville, for each month in the study period 1999-2001 based on historical and projected point source loads, historical flows, and estimated nonpoint source loads.

The main processes controlling nutrient dynamics in the upper Cahaba River are transport and dilution. An accurate, comprehensive picture of instream total phosphorus concentrations in the Cahaba River can be constructed by simply combining known streamflows with the known WWTP loads and estimated nonpoint source loadings. Since WWTP effluent flows and nutrient discharge concentrations are recorded by ADEM on a monthly average basis, it makes sense to examine conditions in the Cahaba River on a monthly basis as well.

Data inputs for the Cahaba Spreadsheet Model include the following:

- River geometry (segment length) from EPDRIV1 cross-section input
- Predicted median monthly instream velocities from EPDRIV1 simulation output
- USGS monthly median streamflow at Trussville (upstream boundary) and Caldwell Mill (below US 280 dam)
- Predicted monthly median streamflow at 88 tributary points from LSPC watershed model
- Estimated nonpoint source nutrient concentrations based on percent urban landuse (1992 USGS MLRC) for all 88 tributary subwatersheds
- Reported and estimated monthly WWTP effluent discharge rate and nutrient concentrations from DMR reports as available

A schematic of the basic process of combining these data is shown in Figure 4-9.

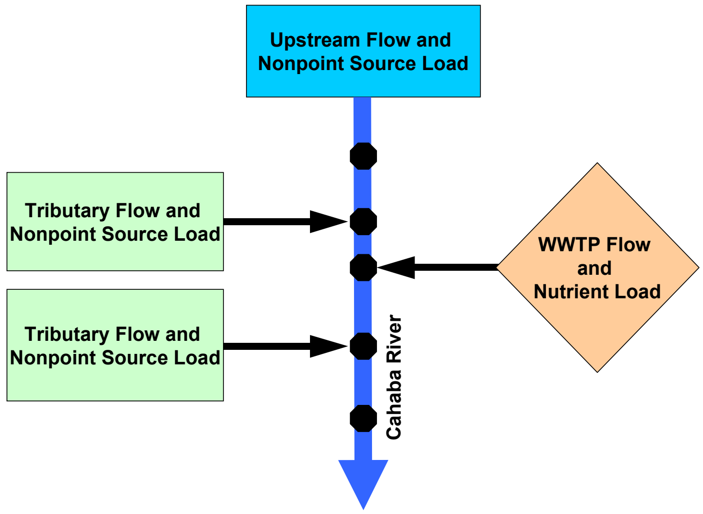


Figure 4-9 Schematic of the functional relationship of data inputs in the Cahaba Spreadsheet Model

Nonpoint source nutrient concentrations in each of the tributary watersheds were estimated from the characteristic concentrations from the Urban, Forest, and Other categories as described in Section 3.3, *Nonpoint Sources*. These concentrations are 285 µg/L, 25 µg/L, and 60 µg/L total phosphorus, respectively. Each of the 88 tributary watersheds has a percent landuse of each of these three categories, and has an expected nonpoint source nutrient concentration based on the combination of the fraction of each landuse category and the nonpoint source concentration for each.

Output of the LSPC watershed model includes daily average streamflow for each of the 88 tributary watersheds. These data were summarized into monthly median values for each of the 36 months in the period 1999-2001. In addition, monthly medians of the USGS streamflow data were used for the upstream boundary at Trussville and at Caldwell Mill Rd. below the US 280 dam. Figure 4-10 shows the watershed boundaries for the 88 watershed inputs utilized in the Cahaba Spreadsheet Model.

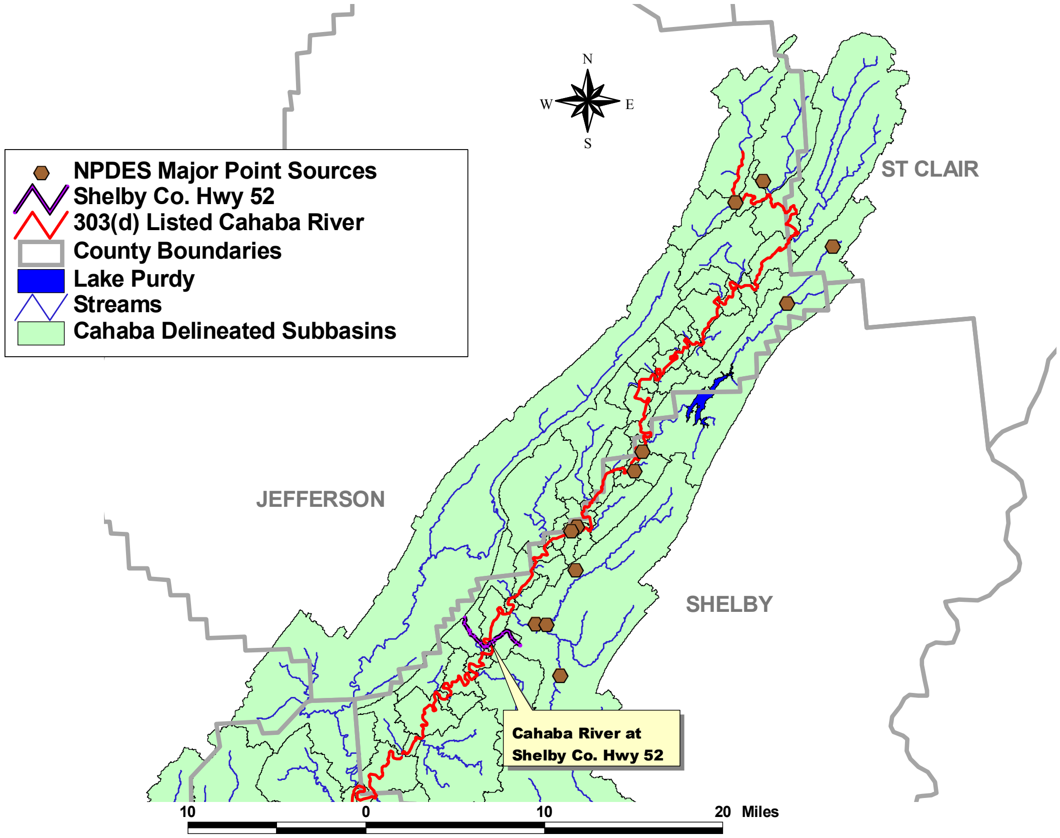


Figure 4-10 Tributary watersheds (88) considered in the Cahaba Spreadsheet Model

Instream flows and instream TP concentrations in the Cahaba River are estimated at 160 nodes corresponding to points where cross-section data is available. These are the same cross-sections utilized in the EPDRIV1 model. The tributary inflows enter the Cahaba River at 88 of these nodes. Inflows and nutrient concentrations for the six major WWTPs on the mainstem are also considered, in addition to the combined effluent from the major WWTPs located in the Buck Creek drainage basin. WWTP effluent loads and TP concentrations used in the model consist of historical data from NPDES discharge monitoring reports (DMRs) and estimates for each point source when TP is not reported.

At each node, the total streamflow and total phosphorus concentrations are calculated from the mass balance of the combined inputs at that point. Instream loss of total phosphorus is estimated by a first-order decay coefficient based on time of travel (see Smith et al., 1997), which is a sufficient approximation to account for reductions in instream total phosphorus by uptake and settling.

4.4.1 Point Source Input and Assessment

Municipal wastewater treatment plants (WWTPs) have historically contributed the majority of nutrient loading to the Cahaba River. Major NPDES-permitted WWTPs in the Cahaba basin discharge to the mainstem of the river, at Trussville and in the Hoover vicinity, Buck Creek and tributaries, and the Little Cahaba River (above Lake Purdy). The major WWTPs considered in this model are shown in Figure 4-11. NPDES permit limits for these plants are shown in Table 4-2, on the following page.

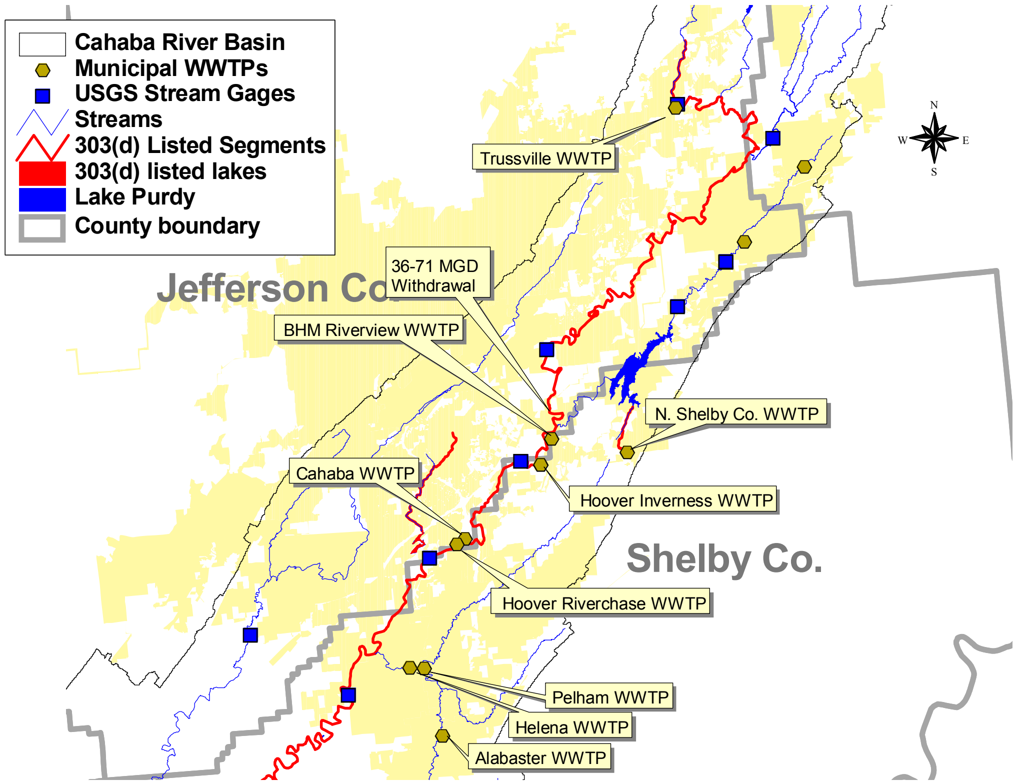


Figure 4-11 Locations of Major WWTPs in the Upper Cahaba River Basin

For the major NPDES point sources in the Cahaba River, DMR records were analyzed to determine total phosphorus concentrations for the historical period 1999-2001. Since many point sources were not required to report total phosphorus, ADEM collected some voluntary nutrient sample data for the years 1997-1999. As a part of recent permits issued in 2000-2002, most NPDES permittees now report effluent total phosphorus. When available, monthly average values were used for all months in the study period. When specific data were not available, an average of the available data was used to represent most-probable discharge concentrations for months in the study period. For a graphical description of best estimates of nutrient effluent discharges for 1999-2001, please refer to "Attachment A: Discharge Monitoring Report (DMR) Data and Estimates." Table 4-2 shows current permit limits and reporting requirements for the major WWTPs discharging to the upper Cahaba River watershed.

Table 4-2 Current Permit Limits for Major (design flow greater than or equal to 1.0 MGD) WWTPs Discharging to the Upper Cahaba River Watershed

WWTP Name	NPDES	Season	Flow (MGD)	$CBOD_5$ (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	TP (mg/L)	OP (mg/L)	NO_x (mg/L)
Cahaba WWTP	**AL0023027**	winter	12.00	10	30	2.0	4.0	r	r	r
		summer	12.00	4	30	1.0	2.0	r	r	r
Trussville	**AL0022934**	winter	4.00	10	30	1.0	3.0			
		summer	4.00	3	30	1.0	2.0			
North Shelby	**AL0056251**	winter	6.00	8	30	0.7	1.7	2.2	r	2.4
		summer	6.00	3	30	0.5	1.5	2.2	r	2.4
Hoover Riverchase	**AL0041653**	winter	1.50	10	30	2.0	4	r	r	r
		summer	1.50	4	30	1.0	2	r	r	r
Hoover-Inverness	**AL0025852**	**winter**	1.20	4	30	1.0	r		r	r
		to pond	r	15	30	3.0	10.0	1.0	r	10.0
		HCR	HCR(3-10)	15	30	3.0	8.0	r	r	r
Birmingham Riverview	**AL0045969**	winter	1.50	10	30	2.0	4	r	r	r
		summer	1.50	4	30	1.0	2	r	r	r
Pelham	**AL0054666**	winter	4.00	8	30	0.7	1.7	2.2	r	2.4
		summer	4.00	3	30	0.5	1.5	2.2	r	2.4
Alabaster WWTP	**AL0025828**	winter	7.60	8	30	0.7	1.7	2.2	r	2.4
		summer	7.60	3	30	0.5	1.5	2.2	r	2.4
Helena WWTP	**AL0023116**	winter	4.95	8	30	0.7	1.7	2.2	r	2.4
		summer	4.95	3	30	0.5	1.5	2.2	r	2.4
Liberty Park WWTP	**AL0067814**	yr-round	HCR (1.5-3.0)	5	30	1.0		1.0		
Leeds WWTP	**AL0067067**	winter	2.0	10	30	3.0	8.0	r		
		summer	2.0	4	30	2.0	4.0	r		

r = Reporting required

4.4.2 Cahaba Spreadsheet Model Results

The Cahaba Spreadsheet Model is configured so that the user can quickly view the overall total phosphorus conditions in the Cahaba River based on mixing/dilution, transport, and first order decay. Outputs are in the form of estimated monthly median total phosphorus concentrations for each month. The calculations are performed steady-state, i.e. the steady-state TP concentrations in the Cahaba River based on the median conditions for each month in the period 1999-2001, for each node in the model. A graphical example of the estimated longitudinal total phosphorus concentrations for September 1999 is shown in Figure 4-12. The monthly median TP concentration at each node is shown in green, while the maximum and minimum estimated TP concentrations based on minimum and maximum flows, respectively, are shown in grey.

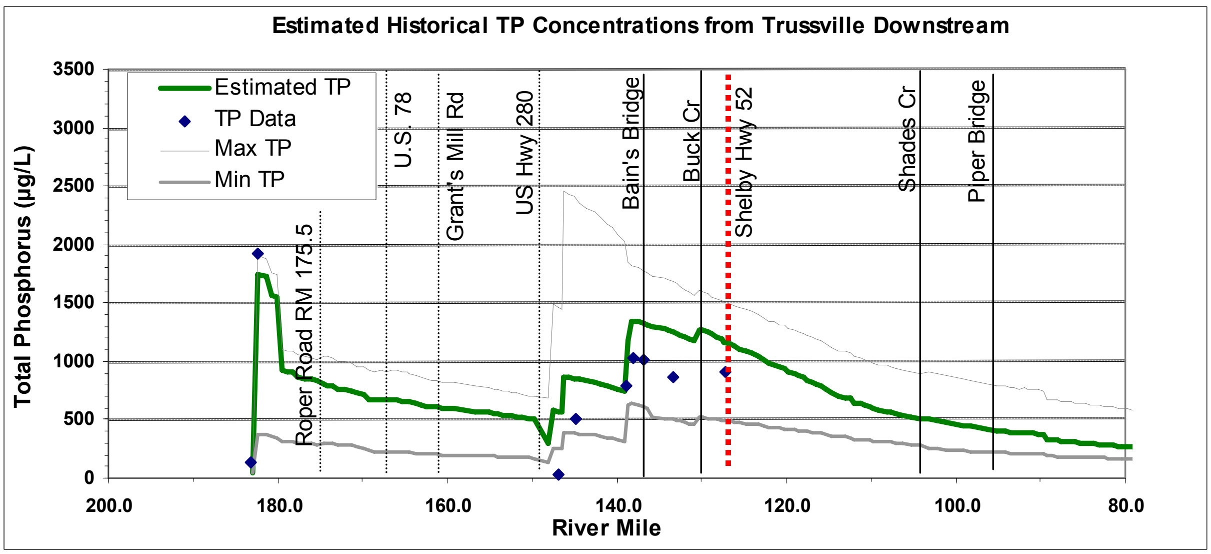


Figure 4-12 Estimated Monthly-Median Total Phosphorus Concentrations in the Cahaba River in September 1999, from Trussville to Centreville

In addition, monthly median, maximum, and minimum predicted streamflow can be compared to USGS data to illustrate model performance relating to total streamflow and mixing, as illustrated in Figure 4-13.

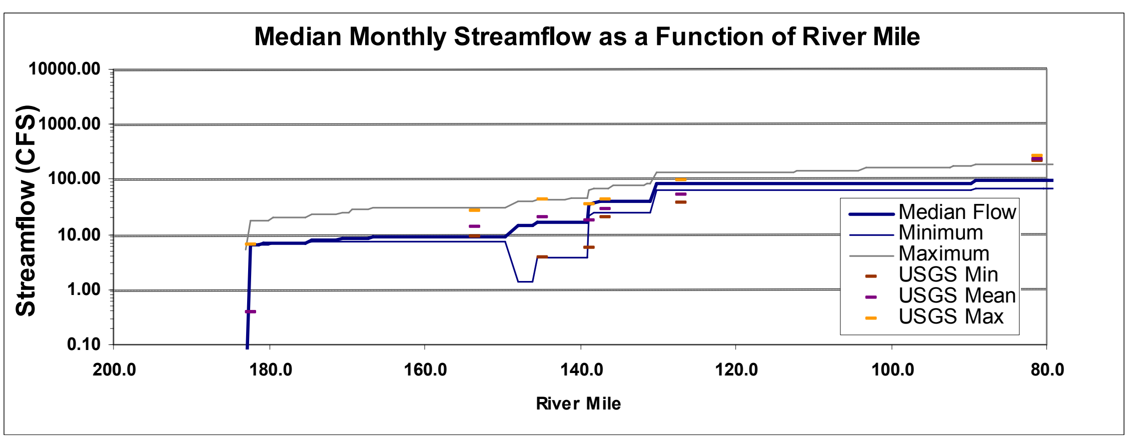


Figure 4-13 Median, Maximum, and Mean Monthly Streamflow as Predicted in the Spreadsheet Model for September 1999, Compared to Mean, Maximum and Minimum USGS Data

Since the Cahaba Spreadsheet Model incorporates all of the point and nonpoint source inputs in a tabular format, it is a simple matter to calculate the total loads from each category as desired. Total nonpoint and point source loads for August 2000, a critical low flow month, are listed in Table 4-3.

Table 4-3 Total Nonpoint and Point Source Loads for August 2000 Spreadsheet Output

Category	Flow (MGD)	TP (lb/day)
All Point Sources	**17.2**	**339**
Nonpoint Source	**13.7**	**5**
Percent Point Source	**56%**	**98%**

Especially during the low-flow months, point sources contribute the vast majority of total phosphorus loads to the Cahaba River.

4.4.3 Projected Scenarios in the Cahaba Spreadsheet Model

The Cahaba Spreadsheet Model was also designed to compare projected scenarios for the same study period 1999-2001, but with alternate point source permit limits based on hypothetical NPDES permit requirements. This allows the model to be used as a management tool to assess alternative combinations of waste load and load allocations that would most fairly, efficiently, and effectively establish TMDLs for the Cahaba River. An example of spreadsheet model output representing longitudinal instream TP concentrations based on a scenario for point and nonpoint source reductions is shown in Figure 4-14.

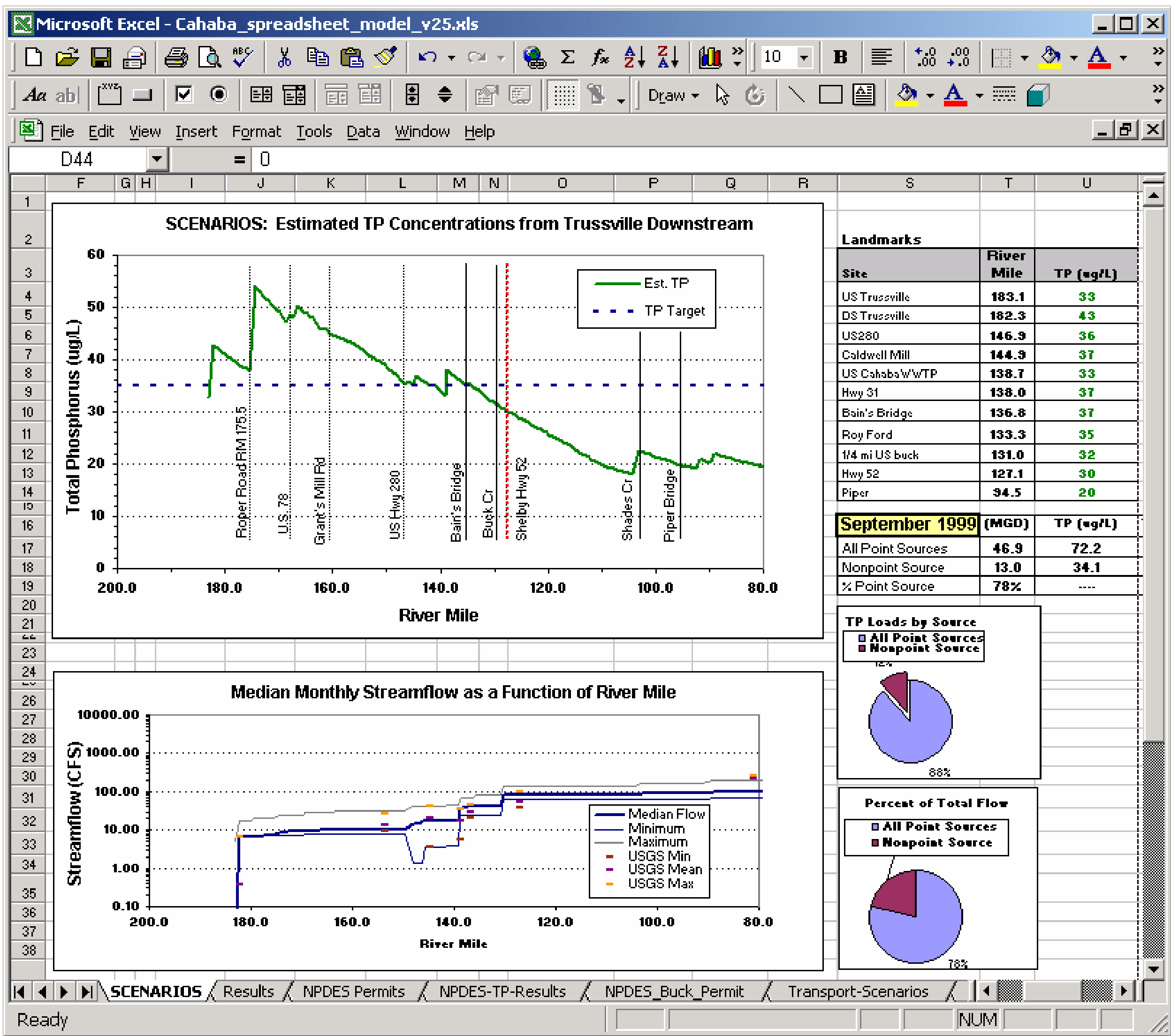


Figure 4-14 Example of Spreadsheet Model Scenario Output Worksheet

The Cahaba Spreadsheet Model has been constructed to graphically illustrate the relative total phosphorus contributions from nonpoint and point source loading as shown in Figure 4-15. The figure shows the relative contributions/loadings from both nonpoint and point sources based on a scenario of point sources at maximum permit flow and NPDES effluent TP limits of 0.4 mg/L April-October (growing season) and 0.5 mg/L November-March (non-growing season).

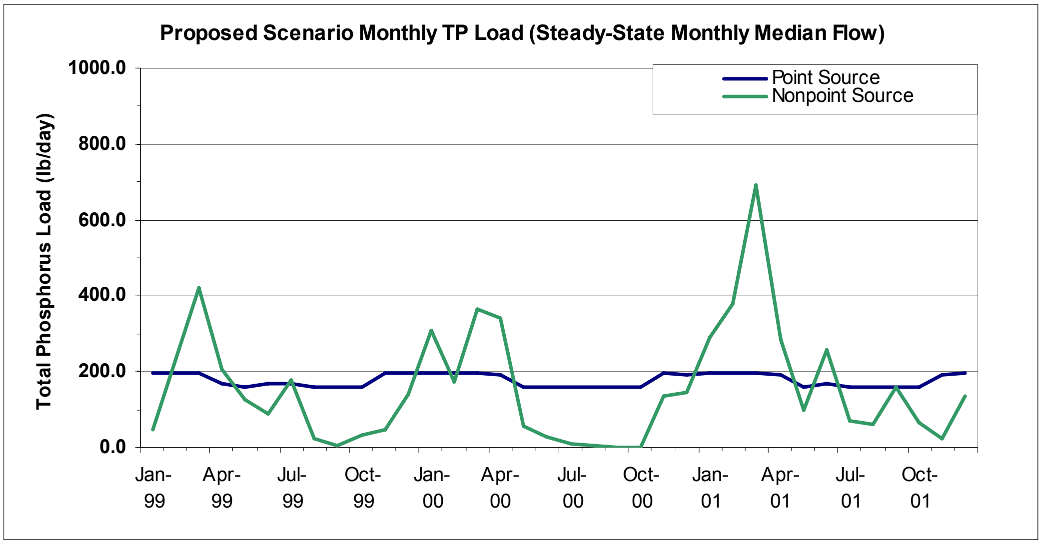


Figure 4-15 Monthly Total Phosphorus Loading from All Combined Point Sources and Nonpoint Source Loading at Permit Limits of 0.4 mg/L Summer and 0.5 mg/L Winter.

As shown in the figure, point source discharges of total phosphorus remain relatively steady throughout the year, while total nonpoint source loads (including loads from MS4 areas) are generally greatest in the winter and spring months (non-growing season).

To simplify assessment of scenarios, and to ensure protection of the segments of the Cahaba River most affected by periphyton blooms, three compliance points were chosen as focus points at which to compare growing season average TP concentrations. These points are as follows:

- Cahaba River at Roper Road (downstream of Trussville)
- Bain's Bridge (Old Montgomery Highway), and
- Shelby County Hwy 52

These locations were chosen at points downstream of major WWTPs including those in the Buck Creek drainage, as illustrated in Figure 4-16.

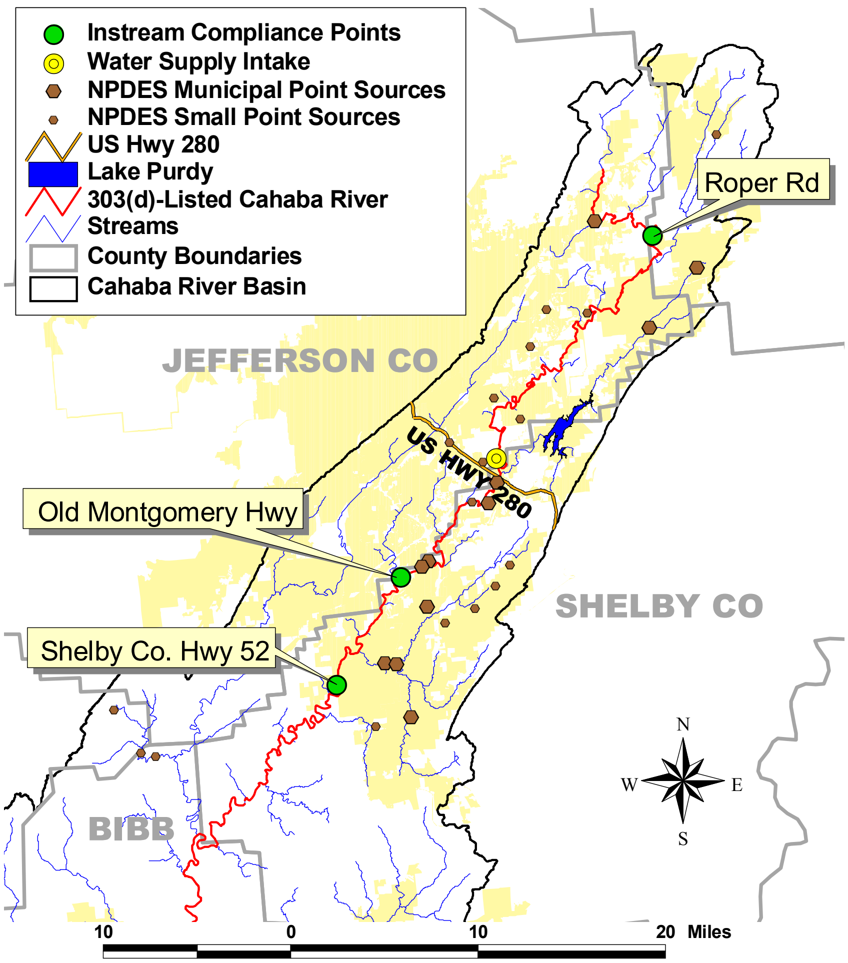


Figure 4-16 Compliance Points for Measuring TP Concentrations in the Cahaba River

The designated compliance points are ideally suited for monitoring ambient instream total phosphorus. In this situation, phosphorus is being monitored as the causal variable, where periphyton growth is the response variable. In many cases, periphyton growth is negatively correlated with ambient total phosphorus at the same location due to uptake and assimilation making the growth possible. Therefore, it is necessary to measure TP concentrations within the Cahaba River at locations that are downstream of TP sources, such as WWTPs and urban areas, but upstream of wide, shallow areas with direct sun exposure where abundant periphyton growth most frequently occurs and phosphorus uptake can be at its highest.

Even at year-round NPDES point source effluent limits of 100 µg/L TP, and all nonpoint source runoff at background levels of 25 ug/L, the reference target of 35 µg/L cannot be achieved for most months in the study period, as shown in Figure 4-17.

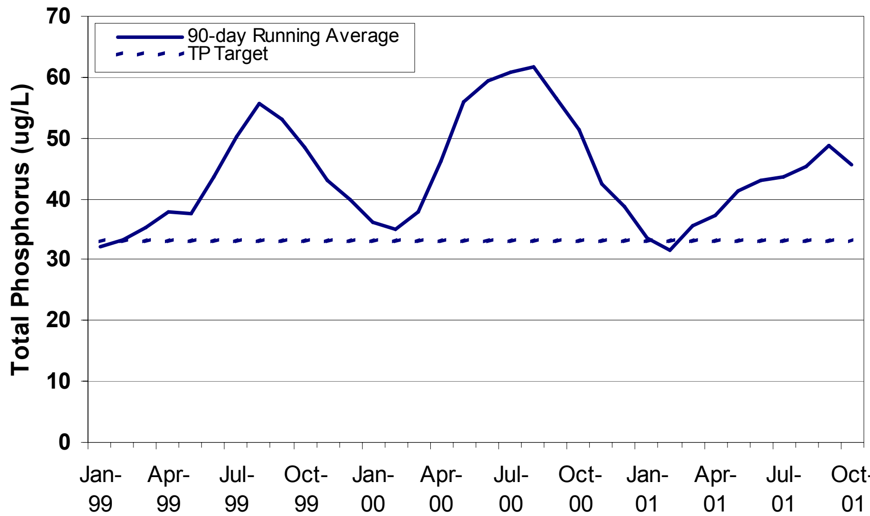


Figure 4-17 Average Total Phosphorus Concentrations at Shelby Co. Hwy 52 at Permit Limits of 100 µg/L Summer and Winter and Nonpoint Source Inflows at 25 µg/L

In order to compare the predicted instream results of various approaches to reducing point source permits for total phosphorus within achievable values, a series of scenarios were examined using the Cahaba Spreadsheet Model to compare the predicted instream results of various approaches to reducing point source phosphorus limits. These were created using a combination of summer (April-October) and winter (November-March) TP permit limits, and most scenarios considered the urban component of nonpoint source runoff to have a TP concentration of 285 µg/L. The results were assessed at the three compliance points downstream of major point sources and upstream of segments known to have significant periphyton densities. The results are shown in Figure 4-18 and Table 4-4.

Figure 4-18 Growing Season Median TP at Bain's Bridge (Old Montgomery Hwy) at various TP Permit Limits and Urban TP Runoff

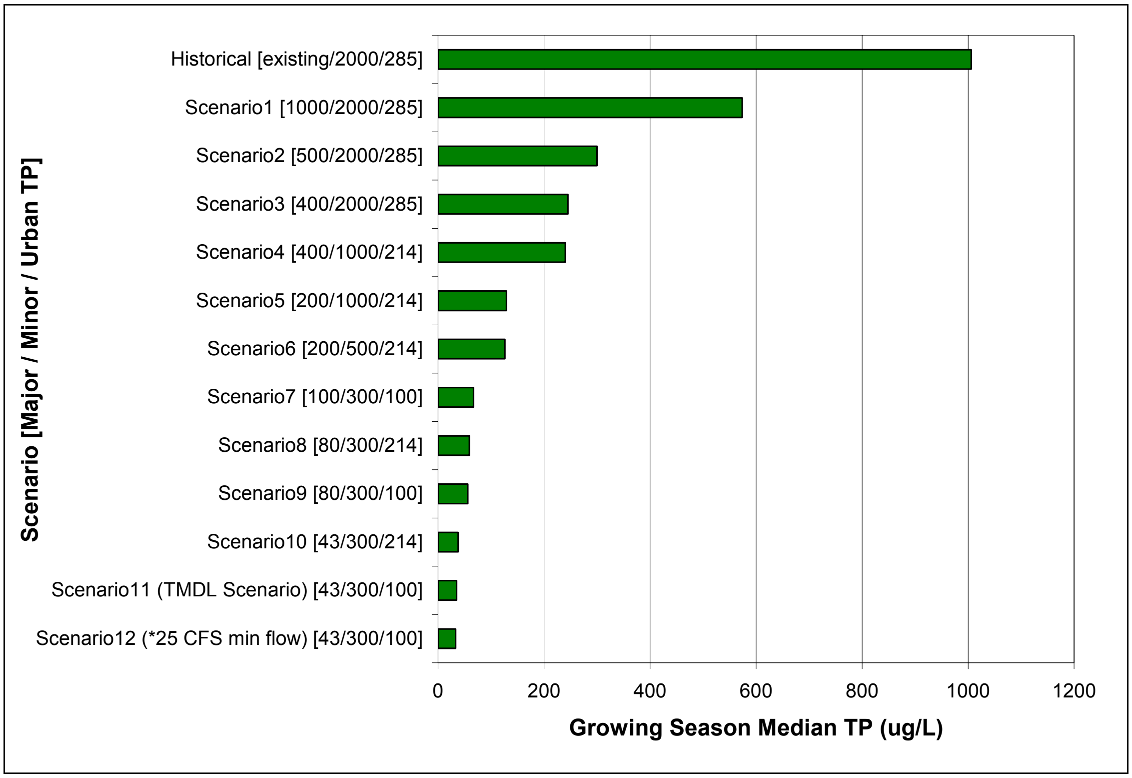


Table 4-4 Results of Cahaba Spreadsheet Model Scenarios: Growing Season Median TP at Bain's Bridge (Old Montgomery Hwy) at Various Permit Limit Alternatives for Total Phosphorus

SCENARIO	Major permit (µg/L)	Minor permit (µg/L)	Urban Nonpoint Source (µg/L)	Forest Background Nonpoint Source (µg/L)	Other Nonpoint Source (µg/L)	Growing Season Median TP 1999 (µg/L)	Growing Season Median TP 2000 (µg/L)	Growing Season Median TP 2001 (µg/L)	Overall Growing Season Median TP (µg/L)
Historical	existing	2000	285	25	60	886	1461	671	**1006**
Scenario1	1000	2000	285	25	60	507	823	392	**574**
Scenario2	500	2000	285	25	60	268	418	213	**300**
Scenario3	400	2000	285	25	60	221	337	176	**245**
Scenario4	400	1000	214	25	60	216	332	171	**240**
Scenario5	200	1000	214	25	60	118	170	99	**129**
Scenario6	200	500	214	25	60	116	168	95	**126**
Scenario7	100	300	100	25	60	62	85	53	**67**
Scenario8	80	300	214	25	60	56	70	51	**59**
Scenario9	80	300	100	25	60	53	69	46	**56**
Scenario10	43	300	214	25	60	37	40	37	**38**
Scenario11 (TMDL Scenario)	43	300	100	25	60	34	39	33	**35**
Scenario12 *25 CFS min flow	43	300	100	25	60	33	35	33	**33**

Based on these scenarios, it is apparent that point source discharges would have to be reduced well below 0.10 mg/L TP in order to approach the desired nutrient target of 0.035 mg/L (35 µg/L) that has been established as the Cahaba River TMDL nutrient target. Summer limits on the order of 0.2 mg/L TP, will be required to reduce instream growing season average TP concentrations below 0.1 mg/L (100 µg/L). This would result in an 85 percent reduction from 1999-2001 growing season average total phosphorus.

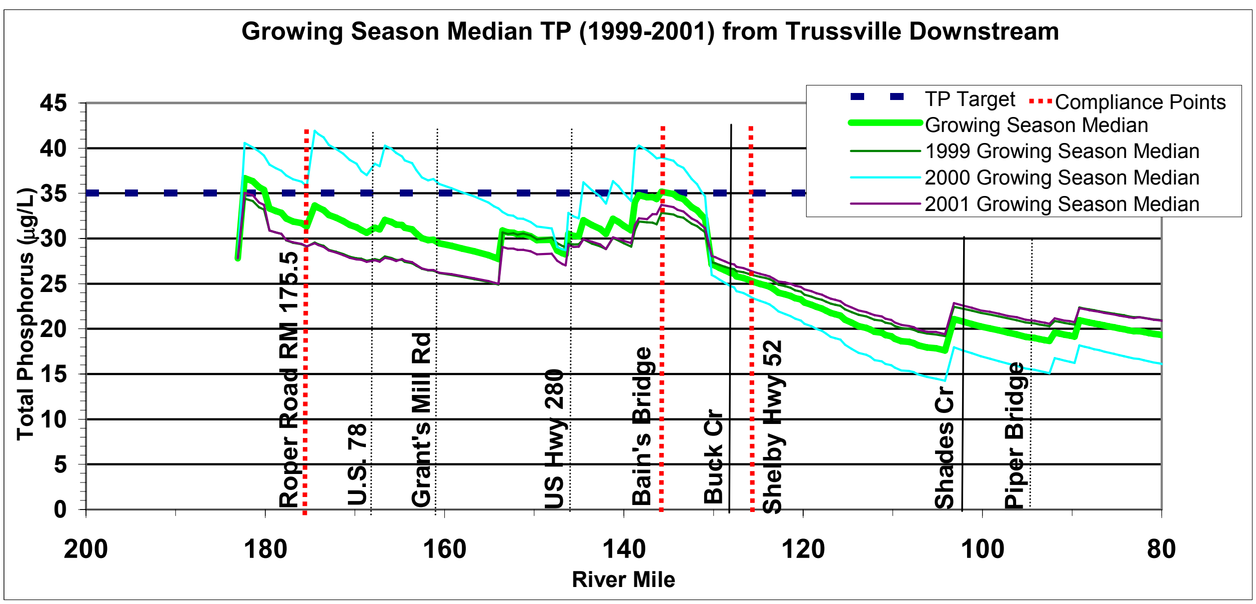
The spreadsheet tool can be used to predict instream dilution and mixing based on user-specified WWTP permit limits for total phosphorus, in addition to monthly median flows and daily flows from 1999-2001. It can be useful for visualizing longitudinal trends in total phosphorus and as a screening tool to predict overall effects of reductions in NPDES permit limits and anthropogenic nonpoint-source loading. For a more dynamic analysis the EPDRIV1 model would be necessary in conjunction with the WASP model, however, since mass-balance and dilution are the dominant processes in the point-source dominated portion of the upper and middle Cahaba River during low flow periods, the spreadsheet model has been shown to give results that are suitable for establishing management alternatives.

4.4.4 TMDL Scenario

In order to meet instream growing season average total phosphorus levels of 35 ug/L in each of the four 303(d)-listed segments, the Cahaba Spreadsheet Model was used to determine NPDES permit limits that meet the requirements of a TMDL. "Urban" landuse components were reduced by 65 percent, and the "other" and "forest" categories were set at 60 µg/L and 25 µg/L, respectively. NPDES permit limits were reduced such that the growing season median total phosphorus concentrations at three designated compliance points do not exceed 35 µg/L. Instream losses of TP are assumed to occur at the same rate of first order decay as used in all of the historical and proposed scenarios.

Compliance points were established at three locations corresponding to sampling locations where high nutrient concentrations have been observed both historically and presently. These are Roper Road near Trussville, Bain's Bridge (Old Montgomery Highway) near Hoover, and Shelby County Hwy 52. These were selected because they are at points in the Cahaba River which are downstream of major point sources, and also upstream of the critical areas where periphyton growth has historically been most evident. Longitudinal predicted annual average and growing season median TP concentrations based on the TMDL scenario are shown in Figure 4-19.

Figure 4-19 TMDL Scenario in which Growing Season Average TP does not Exceed 35 µg/L at Designated Compliance Points



The necessary NPDES permit limits to reach these instream concentrations are summer limits of 0.043 mg/L for major WWTPs and 0.300 mg/L for minor WWTPs, except for Margaret WWTP which has unique limits due to its headwaters location. These permit limitations required to meet the TMDL are shown in Table 4-5.

Table 4-5 Required Summer Monthly (April-October) NPDES Permit Limits for WWTPs Necessary to Meet Instream Growing Season Median TP Concentrations of 35 µg/L

WWTP Facility Name	NPDES	Classification	Design Flow (MGD)	WLA (mg/L)
Gold Kist (Industrial-inactive Nov. 2003)	AL0003395	**Inactive**	INACTIVE	N/A
Jefferson County Trussville WWTP	AL0022934	**Major**	4.0	0.043
Jefferson County Cahaba River WWTP	AL0023027	**Major**	12.0	0.043
Helena WWTP	AL0023116	**Major**	4.95	0.043
Montevallo WWTP	AL0023299	**Minor**	0.85	0.3
Alabaster WWTP	AL0025828	**Major**	7.6	0.043
Hoover (Inverness) WWTP*	AL0025852	**Major-HCR**	1.2-10.0 (HCR)*	0.043
Hoover (Riverchase) WWTP	AL0041653	**Major**	1.5	0.043
Birmingham Riverview WWTP (CWRS)	AL0045969	**Major**	1.5	0.043
Pelham WWTP	AL0054666	**Major**	4.0	0.043
Pelham Hunters Glen WWTP	AL0055182	**Inactive**	INACTIVE	N/A
Birmingham HWY 411 WWTP	AL0055255	**Not in TMDL**	0.08	N/A
North Shelby County WWTP	AL0056251	**Major**	6.0	0.043
Jemison WWTP	AL0059331	**Minor**	0.15	0.3
Wilton WWTP	AL0064416	**Inactive**	INACTIVE	N/A
Jefferson County Leeds WWTP	AL0067067	**Not in TMDL**	2.0	N/A
West Blocton WWTP	AL0074195	**Minor**	0.49	0.3
Margaret WWTP	AL0074837	**Unique**	0.5	0.15
Cahaba Mobile Home Estates	AL0057487	**Minor**	0.039	0.3
Eastwood Mobile Home Village	AL0056685	**Minor**	0.07	0.3
Fox Valley Apartments	AL0054330	**Minor**	0.026	0.3
Hewitt-Trussville High School	AL0047970	**Inactive**	INACTIVE	N/A
Liberty Park WWTP	AL0067814	**Major-HCR**	1.5-3.0 (HCR)	0.043
Lockerbie Subdivision	AL0047571	**Minor**	0.03	0.3
Mountain Brook Senior High School	AL0050971	**Minor**	0.05	0.3
Oak Mountain State Park	AL0050831_1	**Minor**	0.009	0.3
Oak Mountain State Park	AL0050831_2	**Minor**	0.0584	0.3
Oak Mountain State Park	AL0050831_3	**Minor**	0.013	0.3
Oak Mountain State Park	AL0050831_4	**Minor**	0.01375	0.3
Our Lady of Angels Monastery	AL0057681	**Minor**	0.02	0.3
Petro Stopping Center	AL0057142	**Minor**	0.2	0.3
Riverplace Apartments (Caldwell Mill WRF)	AL0063088	**Minor**	0.09	0.3
Emmett R. Johnson Building WWTP	AL0045225	**Inactive**	INACTIVE	N/A
Tannehill State Park	AL0056359	**Minor**	0.08	0.3
East Tuscaloosa-West Jefferson WWTP	AL0068420	**Minor**	0.8	0.3

5.0 TMDL Development for the Cahaba River

This section presents the TMDLs developed for nutrients for the Cahaba River watershed. A TMDL is the total amount of a pollutant load that can be assimilated by the receiving water while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are comprised of the sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

In order to develop the TMDL, the following steps were taken:

- Numeric Targets,
- Critical Conditions,
- Waste Load Allocations, and
- Load Allocations,
- Margin of Safety (MOS),
- Seasonal Variation,

Based on the best available science pertinent to the protection of designated uses caused by nutrient enrichment, extensive assessment of all available data for the Cahaba River, and a detailed modeling analysis, significant reductions in nutrient loading specifically total phosphorus to the Cahaba River will be necessary to meet the numeric target established for the river. Implementation of these TMDLs will be determined for each point source discharger and MS4 permittee on a case by case basis by ADEM's NPDES permitting program. In consideration of the required planning and capital investment in order to achieve major reductions in nonpoint source and WWTP effluent total phosphorus, the NPDES permit limits required by this TMDL will be determined on a case by case basis by ADEM's NPDES permitting program.

5.0.1 Limitations of WWTP Treatment Technology

At the present time, WWTP discharges of total phosphorus within the Cahaba River watershed are on the order of and often exceed 1.0 mg/L TP (1000 µg/L). The impact of these discharges is that point source loads comprised approximately 75 percent of the total phosphorus load in the Cahaba River in the years 1999-2001, and up to 99 percent of the TP load in critical low-flow periods such as October 2000.

Modern treatment technologies for TP removal from municipal wastewater currently allow effluent TP concentrations between 0.050 and 0.200 mg/L (50-200 ug/L) depending on the treatment process implemented. The processes available are combinations of conventional treatment, biological treatment, and chemical treatment. It is acknowledged that treatment costs increase dramatically in order to reduce effluent TP from 0.200 to 0.050 mg/L. Furthermore, the required process alterations and improvements will vary among each WWTP facility based on existing processes, and already-planned upgrades. These reductions will occur in time as determined by ADEM's NPDES permitting program.

5.1 Numeric Targets

The TMDL endpoint to address the nutrient impairments in the Cahaba River is a growing season median total phosphorus concentration of 35 µg/L, based on a growing season median (April – October), as described in Section 2.3.

5.2 Critical Conditions

The critical conditions for impairment of designated uses in the Cahaba River by nutrient enrichment are the low-flow summer months. This period consists of the growing season from April through October.

5.3 Waste Load Allocations-Continuous Sources

Growing season (April-October) waste load allocations from NPDES-permitted point sources shall be incorporated into permits as a monthly average total phosphorus (TP) limit and will be determined for each point WWTP facility on a case by case basis by ADEM's NPDES permitting program. The required waste load allocation (WLA) for total phosphorus for major and minor NPDES regulated point sources necessary to meet the TMDL shall be incorporated into permits as follows:

- **Major WWTPs (≥1.0 MGD): monthly avg. limit not to exceed TP = 0.043 mg/L**
- **Minor WWTPs(<1.0 MGD): monthly avg. limit not to exceed TP = 0.300 mg/L**
- **Margaret WWTP (AL0074837): monthly avg. limit not to exceed TP = 0.150 mg/L**

The implementation schedule for all permittees will be determined on a case by case basis by ADEM's NPDES permitting program. The Department recognizes that the required process alterations and improvements will vary based on existing processes, and already planned upgrades. And, in some cases long-term compliance schedules (e.g. beyond the first or second five-year permit cycle) may be necessary due to the availability of advanced wastewater treatment technology capable of consistently achieving the required WLAs.

Note that Leeds WWTP (AL0067067) and Hwy 411 WWTP (AL0055255) are not considered in the TMDL because of the buffering effect of Lake Purdy (discharges are equivalent to background levels of TP). However, these dischargers will be considered in a separate upcoming analysis. Inactive NPDES permits do not receive a WLA under this TMDL (Gold Kist AL0003395; Pelham Hunter's Glen WWTP AL0055182; Wilton WWTP AL0064416; Hewitt-Trussville High School AL0047970; and Emmett R. Johnson Building WWTP AL0045225).

Future requests for new or expanded NPDES permits which would discharge within the Cahaba River watershed upstream of Centerville will be evaluated consistent with the Department's permitting strategy for impaired waters.

5.3.1 Waste Load Allocations-Stormwater Sources

Urban areas designated as part of the Municipal Separate Storm Sewer System (MS4) program are regulated by NPDES, and as such, are considered to be point sources by EPA and receive Waste Load Allocations (WLAs) under these TMDLs. The municipal separate stormwater sewer system (MS4) addressed in the TMDL process includes areas within the boundary of urban areas as designated by ADEM as shown in Figure 5-1. These include the NPDES permits ALS000001 issued to the Stormwater Management Authority (SWMA) of Jefferson County, and ALS000003 issued to the Shelby County Commission.

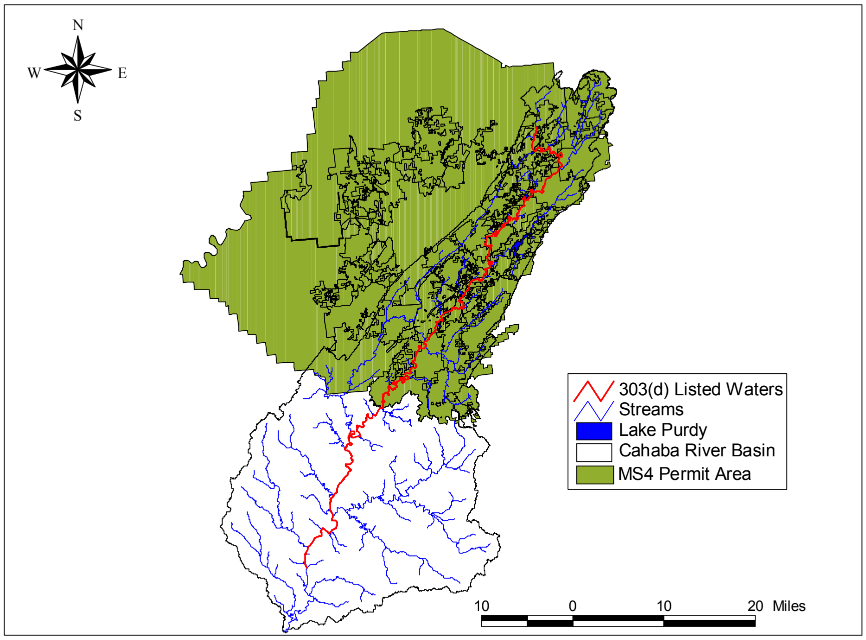


Figure 5-1 MS4 Boundaries Pertinent to the Cahaba River Watershed TMDL Development

Since virtually the entire upper Cahaba River watershed has been defined as an MS4 area, all runoff of nutrients conveyed by a municipal separate storm sewer system shall be subject to a Waste Load Allocation (WLA) for total phosphorus.

The critical conditions for nutrient impairment have been defined as the low-flow summer months April-October. Although the majority of nutrient loading from MS4 areas occurs in high-flow months and storm events, reductions in nutrient loading are still necessary to meet the TMDL target for the critical period. Furthermore, MS4 nutrient reductions are required to make fair and equitable allocations to all stakeholders and to reduce nutrient loading for the Cahaba watershed as a whole. In addition to achieving the goals of the Cahaba River Nutrient TMDL, nutrient reductions within the MS4 area will reduce the impact of nutrient enrichment further downstream at the confluence with the Alabama River. MS4 areas in the urban MRLC landuse classification with runoff conveyed by a municipal separate storm sewer system receive waste load allocations of 100 µg/L TP which corresponds to 65% reduction from the baseline existing condition concentrations evaluated from 1999-2001.

5.4 Load Allocations

Areas in the urban landuse classification outside of the permitted MS4 area receive a load allocation. These areas receive a load allocation of 100 µg/L TP which corresponds to 65% reduction from the baseline existing condition concentrations evaluated from 1999-2001.

5.5 Margin of Safety

The Margin of Safety (MOS) for the Cahaba River Nutrient TMDL is implicit. There are three aspects of conservative assumptions in the implicit margin of safety. First, by using least-impacted reference streams within Ecoregion 67, the target TP concentration range is known to support good habitat and biology with minimal algal growth, rather than just borderline. This approach is conservative and recommended by EPA guidance and was used in the development of the Cahaba River TMDL Nutrient Target, resulting in a TP target of the 75^{th} percentile of all data from these least-impacted reference streams. Second, using a steady-state model with monthly median flows is conservative because no transient pulses flush effluent from the system. Third, requiring TP concentrations to meet the growing-season target at the critical compliance points means that downstream of these points, TP concentrations would be expected to attenuate.

5.6 Critical Conditions and Seasonal Variation

Seasonal variation is considered in the TMDLs for the Cahaba River by using a growing season median TP target to represent the critical conditions for impairment caused by nutrient enrichment.

5.7 TMDLs for the Cahaba River

TMDLs are based on the waste load allocation (WLA) and load allocation (LA) and margin of safety (MOS) required to meet the numeric target of 35 µg/L growing season median total phosphorus. These TMDLs incorporate load allocations and waste load allocations that will be achieved for each point source discharger and MS4 permittee on a case by case basis as determined by ADEM's NPDES permitting program. Some permittees will meet the ultimate NPDES permit limit or required reductions sooner than others as each discharger or MS4 permittee are at different levels of treatment technologies.

Table 5-1 summarizes the Nutrient TMDL for the Cahaba River based on the instream TP target of 35 ug/L. The TMDL is defined as the required waste load allocation (WLA) expressed as the TP concentration from continuous point sources (WWTPs) and NPDES-regulated municipal separate storm sewer systems (MS4s), and the load allocation (LA) from urban areas not located within designated MS4 boundaries. Implementation of the subject TMDL will be determined for each point source discharge and MS4 permittee on a case by case basis by ADEM's NPDES permitting program.

Table 5-1 Nutrient (Total Phosphorus) TMDL Summary for the Cahaba River Watershed

WLA[1] (Continuous Sources) Total Phosphorus (TP) (µg/L)	WLA[2] (Stormwater Sources) Total Phosphorus (µg/L)	LA (Stormwater Sources) Total Phosphorus (ug/L)	WLA (Continuous Sources) % Reduction from 1999-2001 loads	LA and MS4 WLA % Reduction from 1999-2001 loads
43 - Major WWTPs (≥1.0 MGD design) / 300 - Minor WWTPs (<1.0 MGD design)**	100 urban/ MS4 25 forest 60 other	100 urban 25 forest 60 other	81%	65% urban / MS4 0% forest 0% other

(1) The TP concentration is applied as a monthly average NPDES limit during the months of April-October.
(2) Based on the 2001 MRLC land cover data set, this is not considered a numeric permit limitation for TP.
* Margaret WWTP (0.5 MGD), due to its headwaters location, is required to meet 150 µg/L TP

MS4 and urban nonpoint source loads were determined by a modeling approach described in Sections 3.3 and 4.4. Urban loads were derived from empirical data and the USGS MRLC land use classifications designated as "urban" types (high intensity residential, low intensity residential, and high intensity commercial/industrial/transportation). MS4 loads included in the Waste Load Allocation (WLA) are defined as urban area loads within designated NPDES MS4 boundaries, while urban area loads outside of MS4 areas are defined as part of the Load Allocation (LA), in order to be consistent with EPA guidelines. No reductions are required from forested areas or "other" land use classifications.

Table 5-2 shows existing and predicted instream growing season (Apr-Oct) median total phosphorus concentrations at the three critical compliance points on the Cahaba River.

Table 5-2 Existing and Predicted Instream Growing Season Median TP in the Cahaba River

Segment	Existing Condition 1999-2000 Instream Growing Season Median Conditions* (µg/L TP)	TMDL Condition Predicted Instream Growing Season Median Conditions* (µg/L TP)
Cahaba River at Roper Rd.	1140**	31
Cahaba River at Old Montgomery Hwy	895	35
Cahaba River at Shelby Co. Hwy 52	560	26

*Instream conditions are evaluated as the median value of growing season data collected April-October
**Downstream of Trussville site existing conditions are shown due to lack of data at Roper Rd.

6.0 TMDL Implementation

Relative to impairment by nutrient enrichment, the Cahaba River watershed is impacted by both NPDES-permitted point source discharges including urban areas regulated by MS4 permits and urban nonpoint sources that are not regulated by MS4 permits. Necessary reductions will be sought during TMDL implementation which will be determined for each point source discharger and MS4 permittee on a case by case basis by ADEM's NPDES permitting program.

It should be noted that timelines for implementation are not a component of the WLA or LA, and therefore, are not a component of the TMDL submitted for EPA's review and approval. Clean Water Act (CWA) Section 303(d) does not establish any new implementation authorities beyond those that exist elsewhere in state, local, or federal law; therefore, TMDL implementation is not subject to EPA's review and approval/disapproval authorities under CWA Section 303(d). Implementation of the TMDL will be consistent with CWA Section 402 and its implementing regulations, as well as the Alabama's Water Pollution Control Act and its implementing regulations. To the extent that there are any applicable Endangered Species Act (ESA) requirements associated with TMDL implementation, we expect that EPA will consult with Fish & Wildlife Service (FWS) as appropriate.

It has been noted that nutrient enrichment in the Cahaba River downstream of US Highway 280 is exacerbated by the fact that the existing water supply withdrawal reduces streamflow in that reach to nearly zero. Analysis of instream dilution processes indicates that maintaining a minimum flow of 25 CFS measured at Caldwell Mill Rd. (USGS 02423425) would preserve assimilative capacity in the middle Cahaba River resulting in a 35 percent reduction in peak total phosphorus concentrations at Old Montgomery Highway in certain critical months. Therefore, stakeholders should consider possible alternatives to maintaining natural or minimum flows in the Cahaba River downstream of US Hwy 280.

6.1 Implementation of Point Source Reductions

Implementation of phosphorus reductions will be achieved through the issuance of NPDES permits that require WWTP effluent total phosphorus concentrations to meet stringent requirements. NPDES permits requiring reductions in effluent TP will be issued by ADEM's NPDES permitting program and determined on a case by case basis.

Implementation of required phosphorus reductions from MS4 sources will begin with the design and implementation of a watershed nutrient monitoring program and using appropriate best management practices.

6.2 Implementation of Nonpoint Source Reductions

Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the Cahaba River. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. Therefore, TMDL implementation activities for nonpoint sources will be coordinated through interaction with local entities in conjunction with Clean Water Partnership efforts.

6.3 Adaptive Management

It is possible during the implementation of this TMDL that further evaluation of instream conditions in the Cahaba River, including biological and chemical monitoring, will reveal trends of improvement in water quality and biological conditions. If so, any required implementation in the future may be revised according to the best available science at that time.

ADEM has a program to systematically collect additional nutrient data at the ecoregional reference sites used to develop the Cahaba TMDL nutrient target, in addition to other reference sites and candidate reference sites throughout Alabama. Adaptive management, in conjunction with the implementation schedule as determined by ADEM's NPDES permitting program, will allow the TMDL target to be validated or adjusted as necessary based on additional data that becomes available in the future.

7.0 Follow Up Monitoring

Follow up monitoring will help further characterize water quality conditions resulting from the implementation of best management practices in the watershed. A coordinated monitoring plan for the Cahaba River watershed will be developed with stakeholder involvement to ensure that limited monitoring resources are used effectively. The purpose of the monitoring plan will be to track and document changes in water quality conditions related to nutrient enrichment as total phosphorus reductions occur in the watershed.

In 2004 and 2005, the Department's program for monitoring sites within the Cahaba River included nutrient sampling, habitat and macroinvertebrate assessments, 72-hour diurnal dissolved oxygen, flow, fecal coliform bacteria, and periphyton at multiple locations. For 2004, 13 locations were selected for intensive follow-up monitoring and for 2005, 14 locations were selected for intensive follow-up monitoring which are shown in Figure 7-1. For 2006, the number of locations selected for intensive follow-up monitoring were reduced due to laboratory constraints and limited resources. However, it is anticipated that the 2007 follow-up monitoring locations selected will be the same as those selected in 2005 provided that there are no laboratory constraints and that resources are available.

As identified in ADEM's Cahaba River Nutrient TMDL Target Development Report (ADEM, 2004), further reference stream sampling will help to verify the existing nutrient target (35 µg/L instream TP) that was established for the purpose of developing the Cahaba River Nutrient TMDL. Continued monitoring and research efforts will also help to better understand the cause and effect relationships between nutrient loadings and instream responses such as periphyton and dissolved oxygen. The primary goals are to gather additional data and information that can be used to refine, if necessary, the existing nutrient target and to continue the difficult process of evaluating/establishing the cause and effect relationships between nutrient inputs and associated chemical, physical and biological responses so that more definitive targets (both causal & response parameters) can be established in the future.

In addition to the above stated goals, the data and information gathered as part of our ongoing monitoring efforts will be utilized in many other ways such as the following:

- Provide additional supporting data and information to ADEM as we continue our ongoing efforts to develop numeric nutrient criteria for rivers/streams throughout Alabama.
- Assist in better refining and calibrating the various models, such as RIV1, LSPC, and other empirical models that have been developed for the Cahaba River system.
- Data can be used to revise/update the Siltation, Nutrient and Pathogen TMDLs that have developed for the Cahaba River and its associated tributaries.
- Ongoing long-term trend analysis of various parameters for assessment and listing purposes required under Section §303(d) and §305(b) of the Clean Water Act.

Based upon the Department's initial review of available chemical, physical and biological data collected to thus far, Hatchet Creek has shown to be a good candidate reference waterbody that will be used in our ongoing efforts to meet the previously mentioned goals.

The 14 sites on the Cahaba River and the 8 stations on Hatchet Creek that were sampled for the 2005 sampling period are presented in Tables 7-1 and 7-2.

Table 7-1 ADEM's 2005 Cahaba River Sampling Locations

Station ID	Stream	Latitude	Longitude	Station Description
CABJ-8	Cahaba River	33.6223	-86.5996	Cahaba River @ US Highway 11
C1	Cahaba River	33.6051	-86.5493	Cahaba River @ St. Clair County Road 10 (Roper Road)
CABJ-7	Cahaba River	33.5459	-86.6128	Cahaba River @ US Highway 78
CABJ-6	Cahaba River	33.5113	-86.6527	Cahaba River @ Grants Mill Road
CARJ-5	Cahaba River	33.4314	-86.7163	Cahaba River below dam @ US Highway 280
C2	Cahaba River	33.4153	-86.7400	Cahaba River @ Caldwell Mill Road (County Road 29)
CAHS-1	Cahaba River	33.3633	-86.8136	Cahaba River @Bains Bridge (Old Montgomery Highway)
PA-1A	Patton Creek	33.3668	-86.8218	Patton Creek @ US Highway 150
CARJ-6	Cahaba River	33.3407	-86.8350	Cahaba River behind Hoover High School
B-1	Buck Creek	33.2969	-86.8426	Buck Ceek below dam in Helena off Highway 261 (RM2.4)
C3	Cahaba River	33.2845	-86.8826	Cahaba River @ Shelby County Highway 52
SH-1A	Shades Creek	33.3567	-86.8781	Shades Creek @ Alabama Highway 150
CABB-3	Cahaba River	33.1656	-87.0297	Cahaba River @ Old Coal Road (Concrete Slab)
CABB-2a	Cahaba River	33.0836	-87.0646	Cahaba River ~1 mile d/s of Bibb County Road 24 (Piper Bridge)

Table 7-2 ADEM's 2005 Hatchet Creek Sampling Locations

Station ID	Stream	Latitude	Longitude	Station Description
HAT-3	Hatchet Creek	33.1305	-86.0550	Hatchet Creek @ East Creek
HATC-2	Hatchet Creek	33.0364	-86.1232	Hatchet Creek @ US Highway 280
HAT-2	Hatchet Creek	32.9998	-86.1425	Hatchet Creek @ Dunham Property
SOCC-1	Socapatoy Creek	32.9656	-86.1496	Socapatoy Creek @ Coosa County Road 69
HATC-4	Hatchet Creek	32.9442	-86.2361	Hatchet Creek @ McConnell Property
HATC-1	Hatchet Creek	32.9168	-86.2703	Hatchet Creek @ Coosa County Road 18 (USGS 02408540)
HATC-3	Hatchet Creek	32.9134	-86.2848	Hatchet Creek @ Tyler Ford (Billy Woodfin's property)
HATC-1a	Hatchet Creek	32.8612	-86.3388	Hatchet Creek @ Coosa County Road 29

The sampling stations presented above are listed from upstream to downstream. The Cahaba River sampling stations are depicted in Figure 7-1.

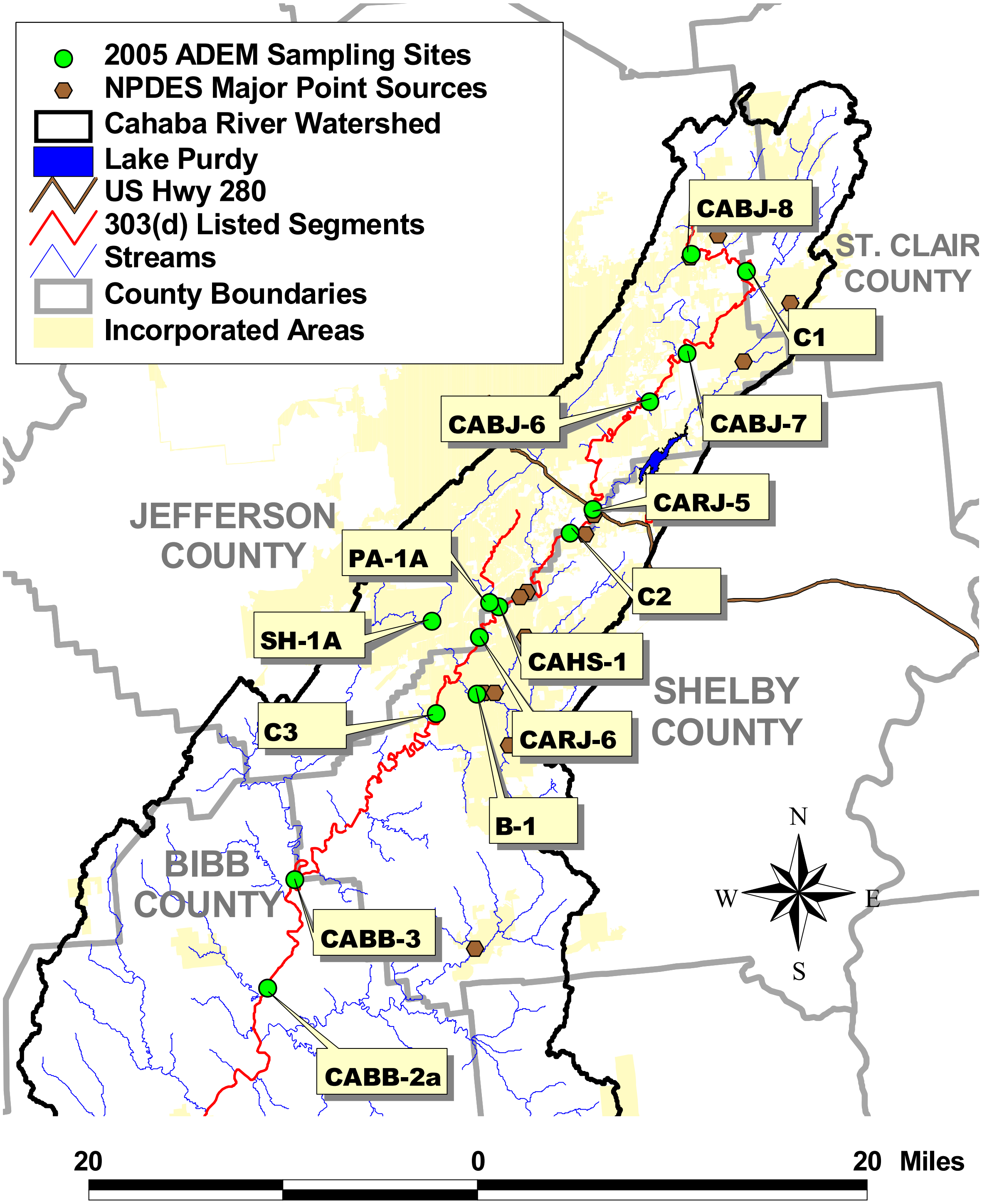


Figure 7-1 ADEM 2005 Cahaba River Monitoring Stations

8.0 Public Participation

As part of the public participation process, this TMDL was placed on public notice and made available for review and comment. The public notice was prepared and published in the four major daily newspapers in Montgomery, Huntsville, Birmingham, and Mobile, as well as submitted to persons who have requested to be on ADEM's postal and electronic mailing distributions. In addition, the public notice and subject TMDL was made available on ADEM's Website: www.adem.state.al.us. The public can also request paper or electronic copies of the TMDL by contacting Mr. Chris Johnson at 334-271-7827 or clj@adem.state.al.us. The public was given an opportunity to review the TMDL and submit comments to the Department in writing. At the end of the public review period, all written comments received during the public notice period became part of the administrative record. ADEM considered all comments received by the public prior to finalization of this TMDL and subsequent submission to EPA Region 4 for final review and approval.

6.0 References

ADEM, 1996. "1996 305(b) Water Quality Report to Congress."

ADEM, 1998. 1998 Section §303(d) List for Alabama.

ADEM, 2000. Chapter 335-6-10 Water Quality Criteria. Alabama Department of Environmental Management Water Division - Water Quality Program.

ADEM, 2004. "Nutrient Target Development in Support of Nutrient TMDLs for the Cahaba River Watershed." See Attachment B to this report.

Erman, D.C. and N.A. Erman, 1984. "The response of stream macroinvertebrates to substrate size and heterogeneity." *Hydrobiologia* 108:75-82.

Hartfield, Paul, 2002. "Mussels of the Cahaba River: Species Assessment and Sources of Information." Presented to EPA, ADEM and JCESD May 23, 2002. U.S. Fish and Wildlife Service, Jackson MS.

Lalor, Melinda M., C. David, H. Griffin, Shirly Clark, Shaun Crawford and Nikki Beckom, 1997. "Stormwater Nutrient Contributions in Urbanizing Watersheds." Final Project Report, Department of Civil and Environmental Engineering, University of Alabama at Birmingham.

Pitt, Robert A., A. Maestre, R. Morquecho. "The National Stormwater Quality Database (NSQD, version 1.1)" Dept. of Civil and Environmental Engineering, University of Alabama, Tuscaloosa, AL. http://unix.eng.ua.edu/~rpitt/Research/ms4/Paper/Mainms4paper.html

Shepard, Thomas E., Patrick E. O'Neil, Stuart W. McGregor, Maurice F. Mettee, and Steven C. Harris, 1994. "Biomonitoring and Water Quality Studies in the Upper Cahaba River Drainage of Alabama, 1989-1994." Geological Survey of Alabama. Bulletin 165. Montgomery, Alabama.

Simon, A., 1992. Energy, time, and channel evolution in catastrophically-disturbed fluvial systems. In: Phillips, J.D., Renwick, W.H. (Eds.), *Geomorphic Systems: Geomorphology* vol. 5 pp. 345-372.

Simon, A., 2003. "Suspended-Sediment Transport and Bed-Material Characteristics of Shades Creek, Alabama and Ecoregion 67: Developing Water-Quality Criteria for Sediment", U.S Department of Agriculture-Agricultural Research Service, National Sedimentation Laboratory, Channel and Watershed Processes Research Unit, September 2003.

Smith, R.A., G.E. Schwarz, and R.B. Alexander, 1997, Regional interpretation of water-quality monitoring data, Water Resources Research, v. 33, no. 12, pp. 2781-2798.

Stevenson, 2003. "A Review of Reports and Selected Literature for Development of Nutrient TMDL Targets for the Cahaba River." Prepared for Tetra Tech and the United States Environmental Protection Agency, Region 4. Department of Zoology, Michigan State University, East Lansing MI.

Tetra Tech, 2002. "Data Summary Report for the Cahaba River Watershed," Prepared for ADEM, November 2002. Atlanta, GA.

U.S. Census Bureau, 1990. Census 1990 Summary File. http://factfinder.census.gov

USEPA Region 4, 2003, “Cahaba River: Biological and Water Quality Studies, Birmingham, Alabama, March/April, July and September, 2002,” USEPA Region 4, Science and Ecological Support Division, Athens, GA.

USFWS, 2000. “Recovery Plan for the Mobile River Basin.” U.S. Fish and Wildlife Service, Jackson MS.

USGS, 1992. Multi-Resolution Land Use Classification. Available for download at http://landcover.usgs.gov.

USFR, 1998. Endangered and Threatened Wildlife and Plants; Endangered Status for Three Aquatic Snails, and Threatened Status for Three Aquatic Snails in the Mobile River Basin of Alabama. U. S. Federal Register Vol. 63, No. 208: 57610-57620.

USFR, 2004. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin; Final Rule. U. S. Federal Register Vol. 69, No. 126: 40084-40171.

Attachment A

Discharge Monitoring Report (DMR) and Estimated Data

Table A-1 Reported Discharge and TP Concentrations 1999-2001 (*Average TP data) for Gold Kist AL0003395

DATE	FLOWMGD	TP* mg/l	TP lb/day
01/01/99	1.06	0.47*	4.15
02/01/99	1.24	0.47*	4.85
03/01/99	1.31	0.47*	5.13
04/01/99	1.03	0.47*	4.03
05/01/99	1.07	0.47*	4.19
06/01/99	1.23	0.47*	4.81
07/01/99	1.29	0.47*	5.05
08/01/99	1.19	0.47*	4.66
09/01/99	1.04	0.47*	4.07
10/01/99	1.08	0.47*	4.23
11/01/99	1.03	0.47*	4.03
12/01/99	0.97	0.47*	3.80
01/01/00	1.01	0.47*	3.95
02/01/00	1.28	0.47*	5.01
03/01/00	1.33	0.47*	5.21
04/01/00	1.23	0.47*	4.81
05/01/00	1.17	0.47*	4.58
06/01/00	1.18	0.47*	4.62
07/01/00	0.87	0.47*	3.40
08/01/00	1.13	0.47*	4.43
09/01/00	0.85	0.47*	3.33
10/01/00	1.02	0.47*	3.99
11/01/00	0.94	0.47*	3.68
12/01/00	1.00	0.47*	3.91
01/01/01	1.24	0.47*	4.85
02/01/01	1.21	0.47*	4.74
03/01/01	1.21	0.47*	4.74
04/01/01	1.07	0.47*	4.19
05/01/01	1.23	0.47*	4.81
06/01/01	1.25	0.47*	4.89
07/01/01	1.12	0.47*	4.38
08/01/01	1.25	0.47*	4.89
09/01/01	1.19	0.47*	4.66
10/01/01	1.25	0.47*	4.89
11/01/01	1.26	0.47*	4.93
12/01/01	1.12	0.47*	4.38

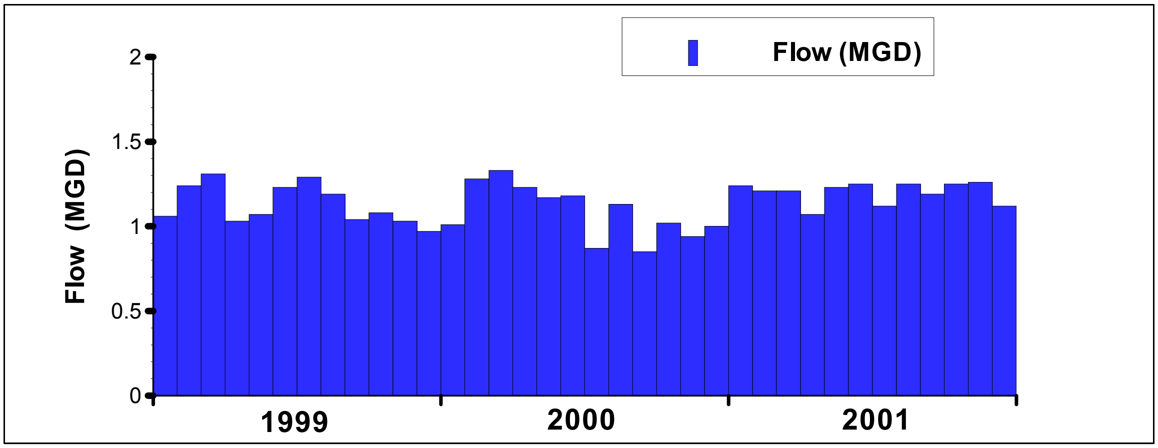


Figure A-1 Monthly Average Flow, AL0003395 Gold Kist

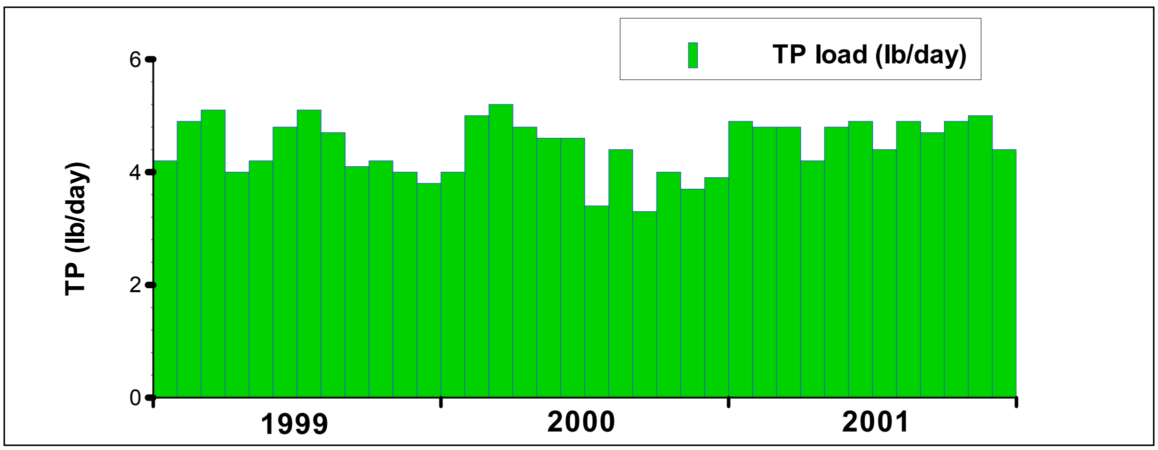


Figure A-2 Monthly Average TP load, AL0003395 Gold Kist

Table A-2 Reported Discharge and TP Concentrations 1999-2001 (*Average TP data) for Trussville WWTP AL0022934

DATE	FLOWMGD	TP mg/l	TP lb/day
01/01/99	2.49	0.85	17.62
02/01/99	2.76	0.65	14.94
03/01/99	2.93	1.40	34.16
04/01/99	2.15	0.75	13.43
05/01/99	1.82	1.60	24.25
06/01/99	2.23	1.70	31.57
07/01/99	2.39	1.40	27.86
08/01/99	1.73	1.90	27.37
09/01/99	1.35	2.10	23.61
10/01/99	1.58	1.37*	18.02
11/01/99	1.57	1.37*	17.91
12/01/99	1.60	1.37*	18.25
01/01/00	2.20	1.37*	25.10
02/01/00	2.00	1.37*	22.82
03/01/00	2.80	1.37*	31.94
04/01/00	3.20	1.37*	36.51
05/01/00	1.80	1.37*	20.53
06/01/00	1.66	1.37*	18.94
07/01/00	1.46	1.37*	16.66
08/01/00	1.70	1.37*	19.39
09/01/00	1.47	1.37*	16.77
10/01/00	1.42	1.37*	16.20
11/01/00	1.81	1.37*	20.65
12/01/00	1.85	1.37*	21.10
01/01/01	2.25	1.37*	25.67
02/01/01	2.52	1.37*	28.75
03/01/01	3.30	1.37*	37.65
04/01/01	3.00	1.37*	34.22
05/01/01	1.70	1.37*	19.39
06/01/01	2.10	1.37*	23.96
07/01/01	2.00	1.37*	22.82
08/01/01	1.70	1.37*	19.39
09/01/01	2.50	1.37*	28.52
10/01/01	1.40	1.37*	15.97
11/01/01	1.30	1.37*	14.83
12/01/01	2.10	1.37*	23.96

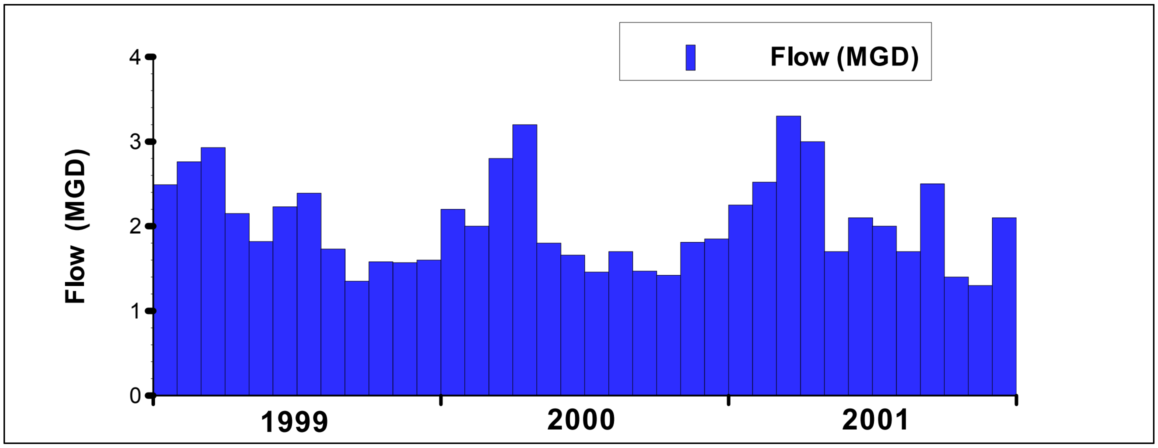


Figure A-3 Monthly Average Flow, AL0022934 Trussville WWTP

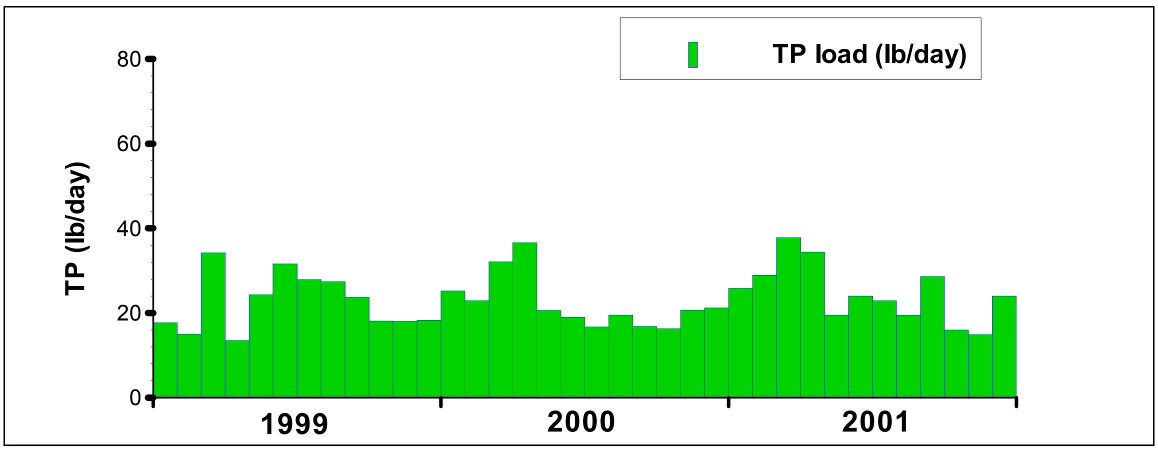


Figure A-4 Monthly Average TP load, AL0022934 Trussville WWTP

Table A-3 Reported Discharge and TP Concentrations 1999-2001 (*Average TP data) for Cahaba WWTP AL0023027

DATE	FLOWMGD	TP mg/l	TP lb/day
01/01/99	8.10	1.20	80.94
02/01/99	8.70	0.34	24.63
03/01/99	9.50	1.80	142.39
04/01/99	10.10	1.40	117.74
05/01/99	8.50	1.60	113.25
06/01/99	10.30	1.70	145.81
07/01/99	8.90	1.74*	128.95
08/01/99	8.00	1.74*	115.91
09/01/99	7.90	1.80	118.41
10/01/99	8.80	1.74*	127.50
11/01/99	8.50	1.74*	123.16
12/01/99	9.90	1.74*	143.44
01/01/00	10.20	1.74*	147.79
02/01/00	9.80	1.74*	141.99
03/01/00	11.00	1.74*	159.38
04/01/00	12.50	1.74*	181.11
05/01/00	8.60	1.74*	124.61
06/01/00	8.10	1.74*	117.36
07/01/00	7.60	1.74*	110.12
08/01/00	8.00	1.74*	115.91
09/01/00	7.20	1.74*	104.32
10/01/00	6.70	1.74*	97.08
11/01/00	9.00	2.25	168.62
12/01/00	8.40	1.88	131.15
01/01/01	10.60	1.88	165.50
02/01/01	9.90	1.38	113.35
03/01/01	11.20	0.63	58.29
04/01/01	11.90	0.88	86.70
05/01/01	9.00	1.75	131.15
06/01/01	10.60	1.88	165.50
07/01/01	9.20	2.25	172.37
08/01/01	9.80	0.25	20.40
09/01/01	10.40	1.88	162.38
10/01/01	7.90	1.75	115.12
11/01/01	7.70	2.50	160.29
12/01/01	10.20	1.13	95.55

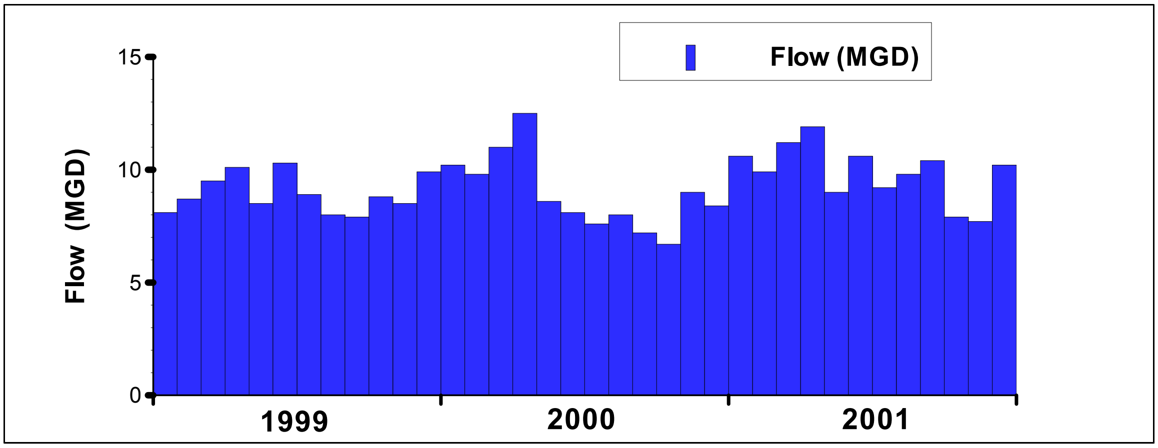


Figure A-5 Monthly Average Flow, AL0023027 Cahaba River WWTP

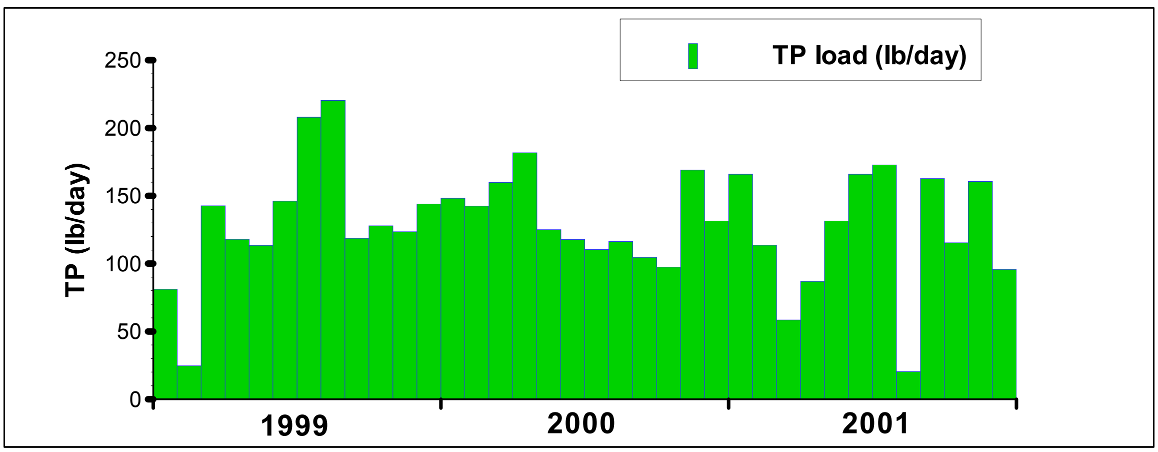


Figure A-6 Monthly Average TP load, AL0023027 Cahaba River WWTP

Table A-4 Reported Discharge and TP Concentrations 1999-2001 (*Average TP data) for Helena WWTP AL0023116

DATE	FLOWMGD	TP mg/l	TP lb/day
01/01/99	1.78	2.40*	35.57
02/01/99	1.79	2.10	31.34
03/01/99	2.00	1.90	31.69
04/01/99	1.51	3.10	39.00
05/01/99	1.31	6.10	66.39
06/01/99	1.30	3.20	34.67
07/01/99	1.28	2.40*	25.66
08/01/99	0.83	2.40*	16.51
09/01/99	0.76	2.40*	15.09
10/01/99	1.01	2.40*	20.08
11/01/99	1.04	2.40*	20.82
12/01/99	1.29	2.40*	25.78
01/01/00	1.77	2.40*	35.27
02/01/00	1.47	2.40*	29.46
03/01/00	1.88	2.40*	37.63
04/01/00	1.86	2.40*	37.11
05/01/00	0.83	2.40*	16.53
06/01/00	0.87	2.40*	17.37
07/01/00	0.74	2.40*	14.81
08/01/00	0.77	2.40*	15.29
09/01/00	0.72	2.40*	14.31
10/01/00	0.78	2.40*	15.63
11/01/00	1.20	2.40*	23.92
12/01/00	1.24	2.40*	24.82
01/01/01	1.73	2.40*	34.61
02/01/01	1.72	2.40*	34.41
03/01/01	2.19	2.40*	43.77
04/01/01	1.77	2.40*	35.43
05/01/01	1.22	2.40*	24.38
06/01/01	1.65	2.40*	32.97
07/01/01	1.27	1.97	20.83
08/01/01	1.51	2.42	30.43
09/01/01	1.65	2.64	36.27
10/01/01	1.15	1.85	17.72
11/01/01	1.08	1.77	15.92
12/01/01	1.94	1.74	28.11

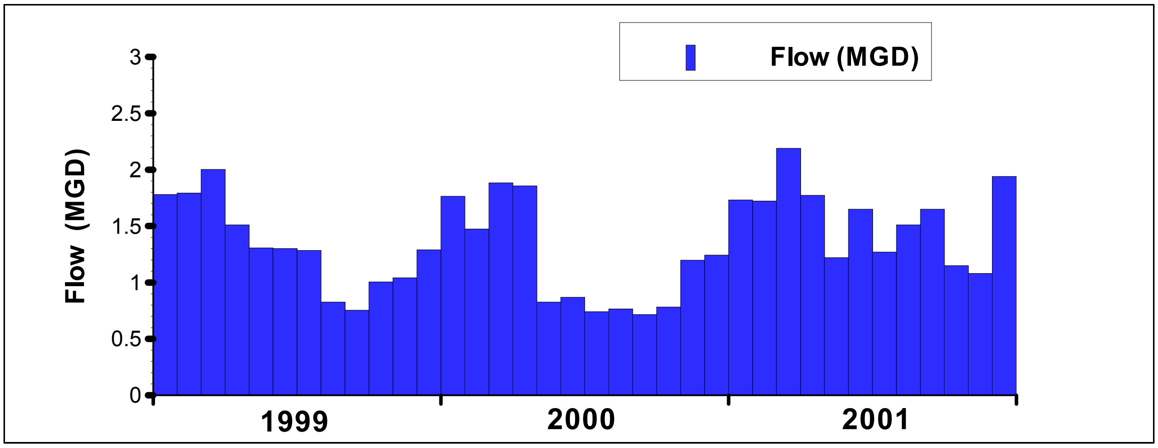


Figure A-7 Monthly Average Flow, AL0023116 Helena WWTP

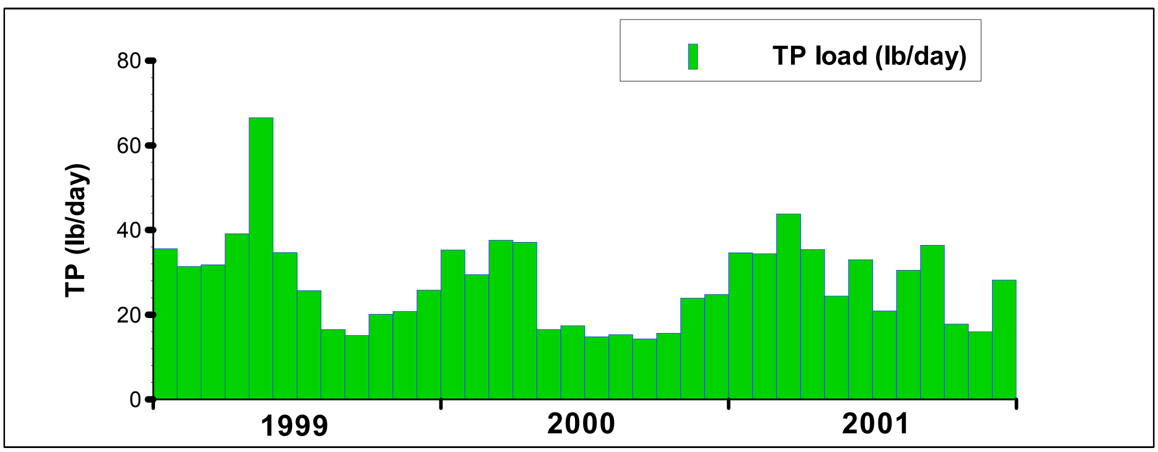


Figure A-8 Monthly Average TP load, AL0023116 Helena WWTP

Table A-5 Reported Discharge and TP Concentrations 1999-2001 (*Average TP data) for Montevallo WWTP AL0023299

DATE	FLOWMGD	TP mg/l	TP lb/day
01/01/99	0.56	5.41*	25.05
02/01/99	0.61	5.41*	27.48
03/01/99	0.59	5.41*	26.76
04/01/99	0.52	5.41*	23.29
05/01/99	0.43	5.40	19.52
06/01/99	0.48	5.20	20.61
07/01/99	0.52	12.40	53.49
08/01/99	0.42	4.20	14.65
09/01/99	0.45	5.41*	20.27
10/01/99	0.46	5.41*	20.86
11/01/99	0.42	5.41*	18.83
12/01/99	0.41	5.41*	18.65
01/01/00	0.50	5.41*	22.30
02/01/00	0.48	5.41*	21.58
03/01/00	0.57	5.41*	25.68
04/01/00	0.65	5.41*	29.06
05/01/00	0.42	5.41*	18.70
06/01/00	0.45	5.41*	20.18
07/01/00	0.43	5.41*	19.46
08/01/00	0.41	5.41*	18.43
09/01/00	0.42	5.41*	18.88
10/01/00	0.39	5.41*	17.57
11/01/00	0.41	5.41*	18.52
12/01/00	0.38	5.41*	17.03
01/01/01	0.43	5.41*	19.15
02/01/01	0.47	5.41*	21.17
03/01/01	0.71	5.41*	31.89
04/01/01	0.59	5.41*	26.53
05/01/01	0.38	5.41*	16.94
06/01/01	0.50	5.41*	22.66
07/01/01	0.41	5.41*	18.38
08/01/01	0.45	5.41*	20.23
09/01/01	0.50	5.41*	22.70
10/01/01	0.45	5.41*	20.27
11/01/01	0.43	5.41*	19.19
12/01/01	0.49	5.41*	22.03

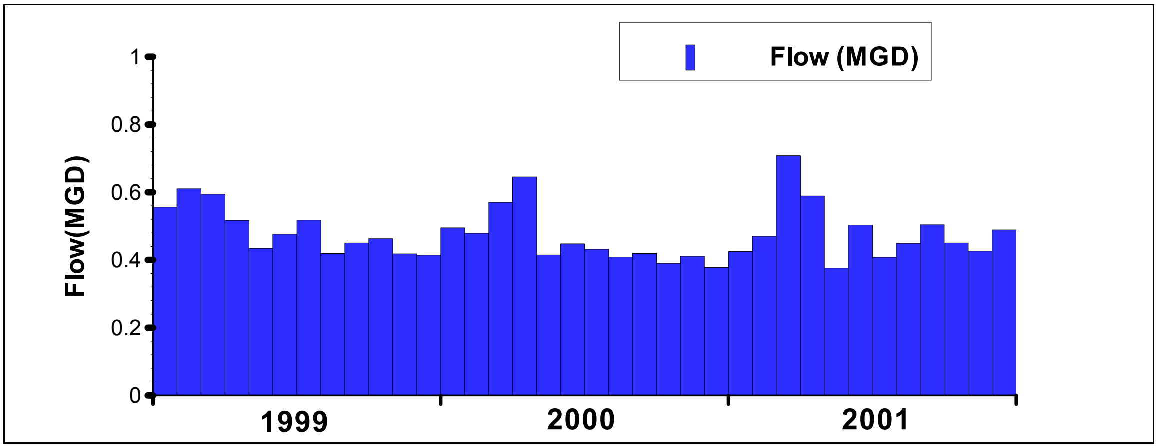


Figure A-9 **Monthly Average Flow, AL0023299 Montevallo**

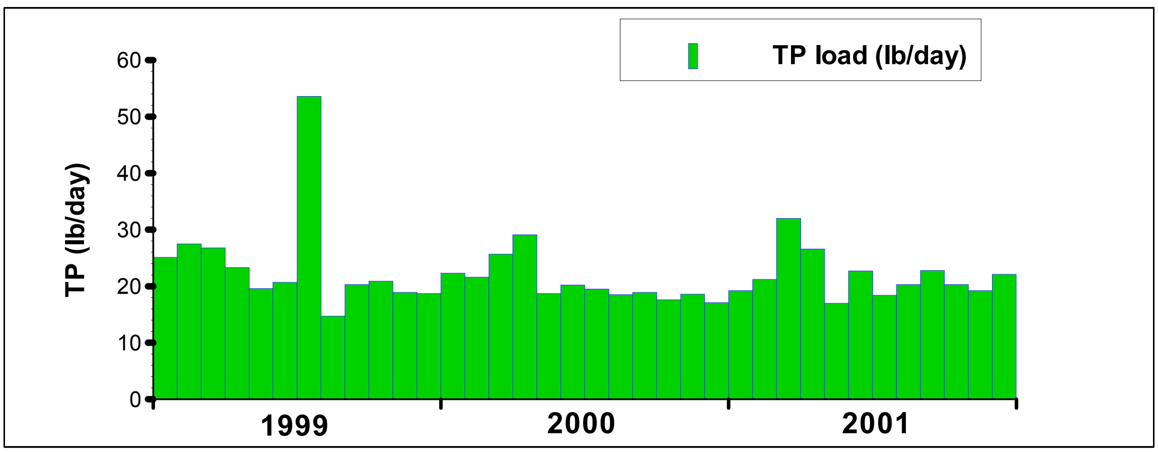


Figure A-10 **Monthly Average TP load, AL0023299 Montevallo**

Table A-6 Reported Discharge and TP Concentrations 1999-2001 (*Average TP data) for Alabaster WWTP AL0025828

DATE	FLOWMGD	TP mg/l	TP lb/day
01/01/99	2.35	3.16*	61.81
02/01/99	2.52	3.16*	66.34
03/01/99	2.61	3.16*	68.65
04/01/99	1.91	3.16*	50.15
05/01/99	1.71	3.16*	44.92
06/01/99	1.89	3.16*	49.81
07/01/99	1.67	3.16*	44.00
08/01/99	1.38	3.16*	36.29
09/01/99	1.36	3.16*	35.84
10/01/99	1.56	3.16*	40.97
11/01/99	1.54	3.16*	40.42
12/01/99	1.69	3.16*	44.42
01/01/00	1.99	3.16*	52.31
02/01/00	1.64	3.16*	43.18
03/01/00	2.34	3.16*	61.44
04/01/00	2.38	3.16*	62.57
05/01/00	1.47	3.16*	38.63
06/01/00	1.49	3.16*	39.29
07/01/00	1.31	3.16*	34.42
08/01/00	1.35	3.16*	35.44
09/01/00	1.34	3.16*	35.37
10/01/00	1.33	3.16*	35.02
11/01/00	1.96	3.16*	51.50
12/01/00	1.79	3.16*	47.13
01/01/01	2.36	3.16*	62.07
02/01/01	2.62	3.16*	68.89
03/01/01	4.08	3.16*	107.46
04/01/01	2.76	3.16*	72.52
05/01/01	2.00	3.16*	52.65
06/01/01	2.34	3.16*	61.47
07/01/01	1.57	2.93	38.23
08/01/01	2.10	3.98	69.60
09/01/01	2.31	3.20	61.61
10/01/01	1.74	3.34	48.39
11/01/01	1.80	2.82	42.27
12/01/01	3.34	2.70	74.98

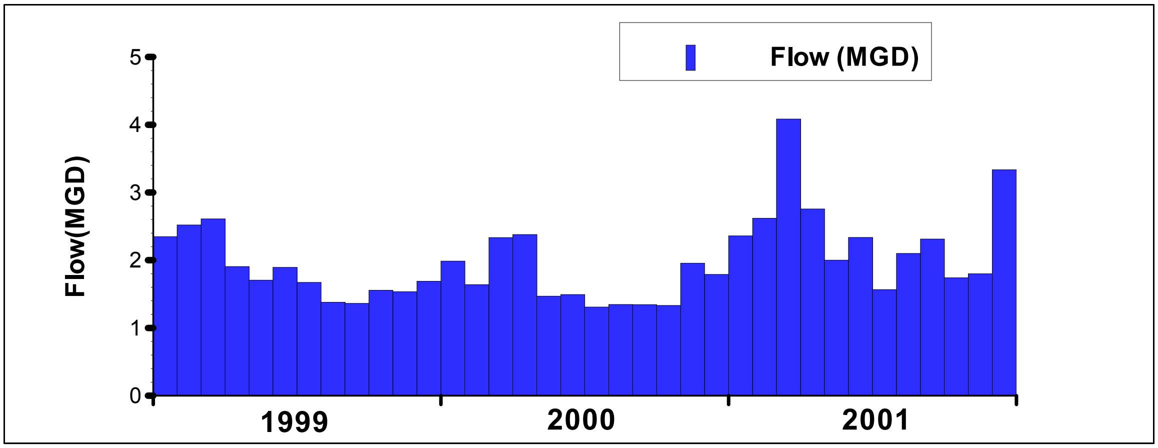


Figure A-11 Monthly Average Flow, AL0025828 Alabaster

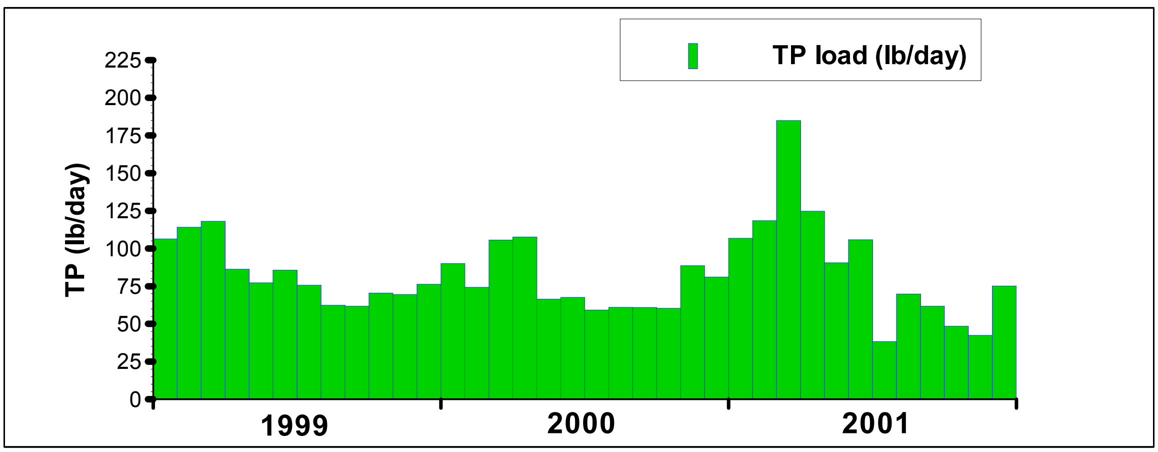


Figure A-12 Monthly Average TP load, AL0025828 Alabaster

Table A-7 Reported Discharge and TP Concentrations 1999-2001 (*Average TP data) for Hoover Inverness AL0025852

DATE	FLOWMGD	TP mg/l	TP lb/day
01/01/99	2.20	4.90	89.77
02/01/99	1.43	4.90	58.39
03/01/99	0.00	0.00	0.00
04/01/99	0.00	0.00	0.00
05/01/99	0.00	0.00	0.00
06/01/99	2.43	0.02	0.40
07/01/99	2.05	0.02	0.34
08/01/99	0.00	0.00	0.00
09/01/99	0.00	0.00	0.00
10/01/99	0.00	0.00	0.00
11/01/99	0.00	0.00	0.00
12/01/99	2.05	0.92	15.64
01/01/00	3.66	0.57	17.51
02/01/00	1.09	1.52	13.85
03/01/00	0.95	2.68	21.14
04/01/00	1.87	0.80	12.48
05/01/00	0.00	0.00	0.00
06/01/00	0.00	0.00	0.00
07/01/00	0.00	0.00	0.00
08/01/00	0.00	0.00	0.00
09/01/00	0.00	0.00	0.00
10/01/00	0.00	0.00	0.00
11/01/00	0.00	0.00	0.00
12/01/00	0.00	0.00	0.00
01/01/01	0.00	0.00	0.00
02/01/01	0.00	0.00	0.00
03/01/01	0.00	0.00	0.00
04/01/01	6.05	1.10	55.39
05/01/01	0.00	0.00	0.00
06/01/01	1.28	0.07	0.75
07/01/01	0.42	0.46	1.61
08/01/01	0.00	0.00	0.00
09/01/01	0.00	0.00	0.00
10/01/01	0.00	0.00	0.00
11/01/01	0.00	0.00	0.00
12/01/01	0.00	0.00	0.00

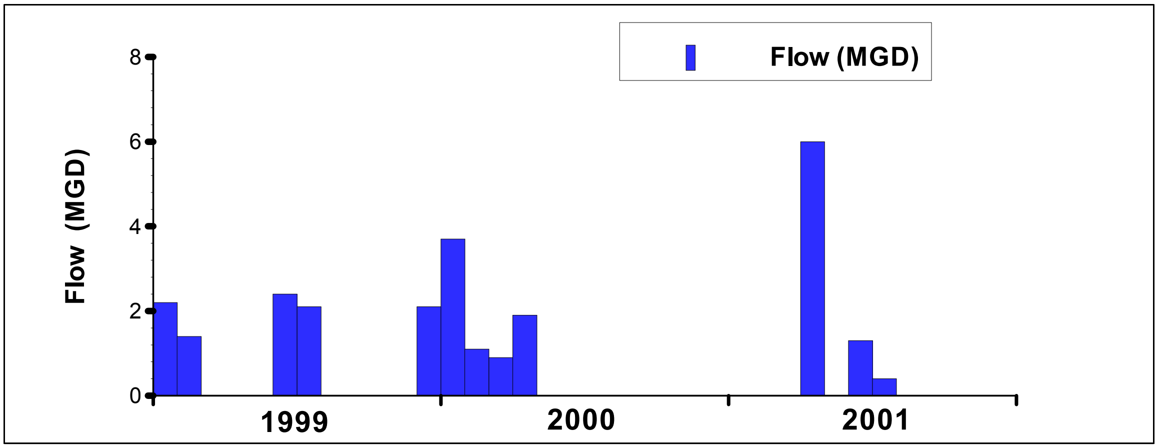


Figure A-13 Monthly Average Flow, AL0025852 Hoover Inverness

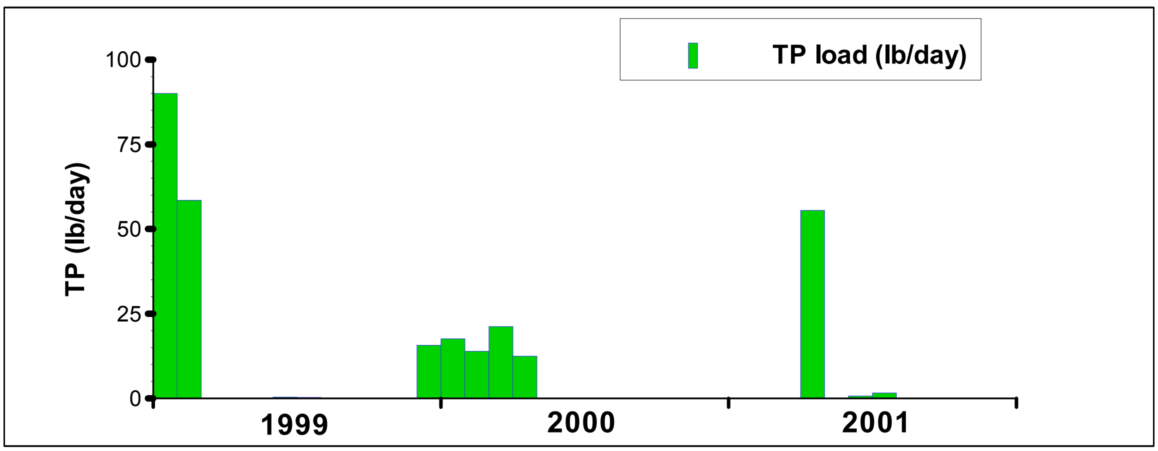


Figure A-14 Monthly Average TP load, AL0025852 Hoover Inverness

Table A-8 Reported Discharge and TP Concentrations 1999-2001 (*Average TP data) for Hoover Riverchase AL0041653

DATE	FLOWMGD	TP mg/l	TP lb/day
01/01/99	1.31	2.04*	22.25
02/01/99	1.42	2.04*	24.14
03/01/99	1.69	2.04*	28.64
04/01/99	1.29	2.04*	21.91
05/01/99	1.06	2.04*	17.99
06/01/99	1.13	2.04*	19.16
07/01/99	1.17	2.04*	19.87
08/01/99	0.99	2.04*	16.87
09/01/99	0.90	2.04*	15.27
10/01/99	0.98	2.04*	16.56
11/01/99	1.04	2.04*	17.72
12/01/99	1.07	2.04*	18.16
01/01/00	1.27	2.04*	21.52
02/01/00	1.10	2.04*	18.65
03/01/00	1.50	2.04*	25.41
04/01/00	1.65	2.04*	28.10
05/01/00	1.23	2.04*	20.86
06/01/00	1.15	2.04*	19.50
07/01/00	1.38	2.04*	23.39
08/01/00	1.42	2.04*	24.04
09/01/00	1.25	2.04*	21.20
10/01/00	1.28	2.04*	21.68
11/01/00	1.78	4.48	66.14
12/01/00	1.37	0.13	1.43
01/01/01	1.79	0.14	2.05
02/01/01	1.89	0.03	0.39
03/01/01	2.05	0.11	1.92
04/01/01	1.97	0.13	2.05
05/01/01	1.60	0.01	0.17
06/01/01	2.03	0.13	2.12
07/01/01	1.63	0.28	3.74
08/01/01	1.69	0.00	0.00
09/01/01	1.79	0.28	4.11
10/01/01	1.30	0.51	5.53
11/01/01	1.17	0.64	6.22
12/01/01	1.69	0.39	5.46

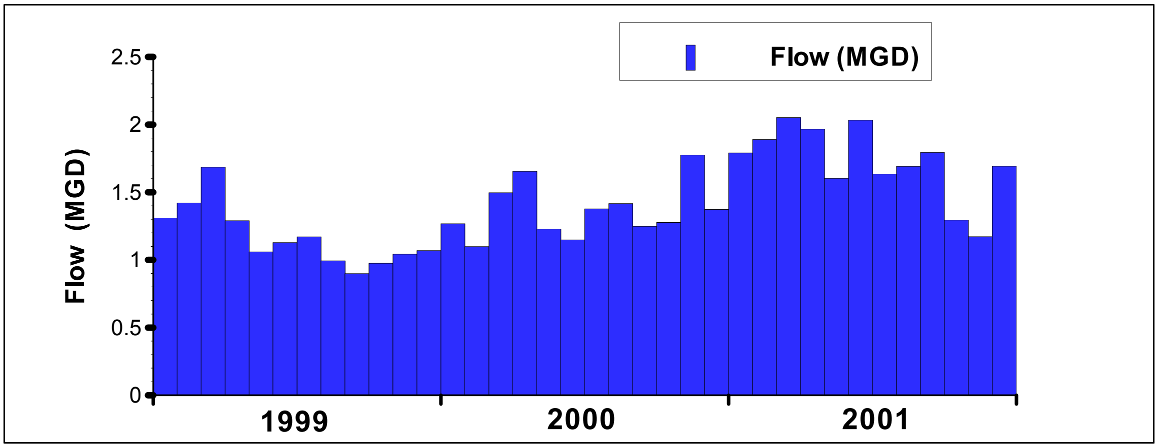


Figure A-15 Monthly Average Flow, AL0041653 Hoover Riverchase

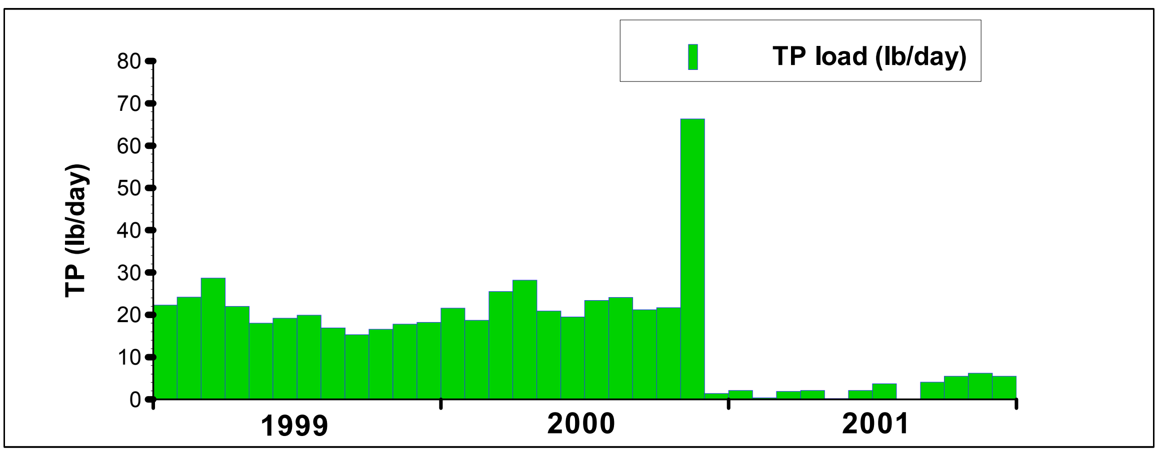


Figure A-16 Monthly Average TP load, AL0041653 Hoover Riverchase

Table A-9 Reported Discharge and TP Concentrations 1999-2001 (*Average TP data) for Birmingham Riverview AL0045969

DATE	FLOWMGD	TP mg/l	TP lb/day
01/01/99	1.32	2.32	25.50
02/01/99	1.24	2.70	27.88
03/01/99	1.11	2.30	21.26
04/01/99	1.16	3.33	32.17
05/01/99	1.23	3.74	38.31
06/01/99	1.38	3.83	44.01
07/01/99	1.25	4.14	43.09
08/01/99	1.17	3.63	35.37
09/01/99	1.13	3.60	33.87
10/01/99	1.11	3.39	31.33
11/01/99	1.05	3.52	30.78
12/01/99	1.10	2.72	24.91
01/01/00	1.18	3.35	32.92
02/01/00	1.06	3.59	31.69
03/01/00	1.12	2.48	23.13
04/01/00	1.22	3.65	37.08
05/01/00	1.19	4.19	41.52
06/01/00	1.19	3.23	32.01
07/01/00	1.16	6.26	60.47
08/01/00	1.23	4.33	44.35
09/01/00	1.15	2.99	28.63
10/01/00	1.00	4.82	40.14
11/01/00	1.02	4.73	40.17
12/01/00	1.00	3.80	31.64
01/01/01	1.16	2.75	26.56
02/01/01	1.16	3.08	29.75
03/01/01	1.31	3.00	32.73
04/01/01	1.23	0.33	3.38
05/01/01	1.14	5.70	54.11
06/01/01	1.39	5.30	61.35
07/01/01	1.30	4.10	44.38
08/01/01	1.38	2.20	25.28
09/01/01	1.48	3.50	43.13
10/01/01	1.30	3.30	35.72
11/01/01	1.19	2.80	27.75
12/01/01	1.29	3.30	35.45

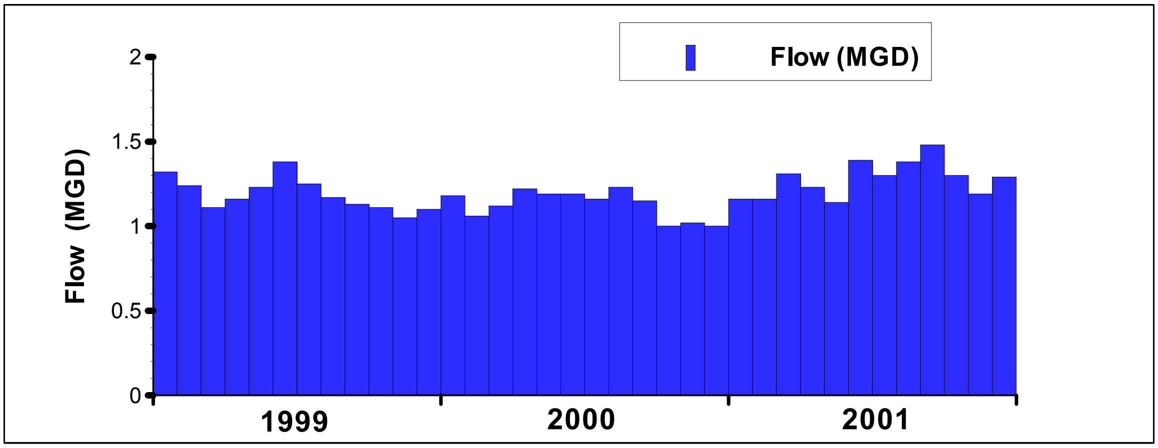


Figure A-17 Monthly Average Flow, AL0045969 BHM Riverview

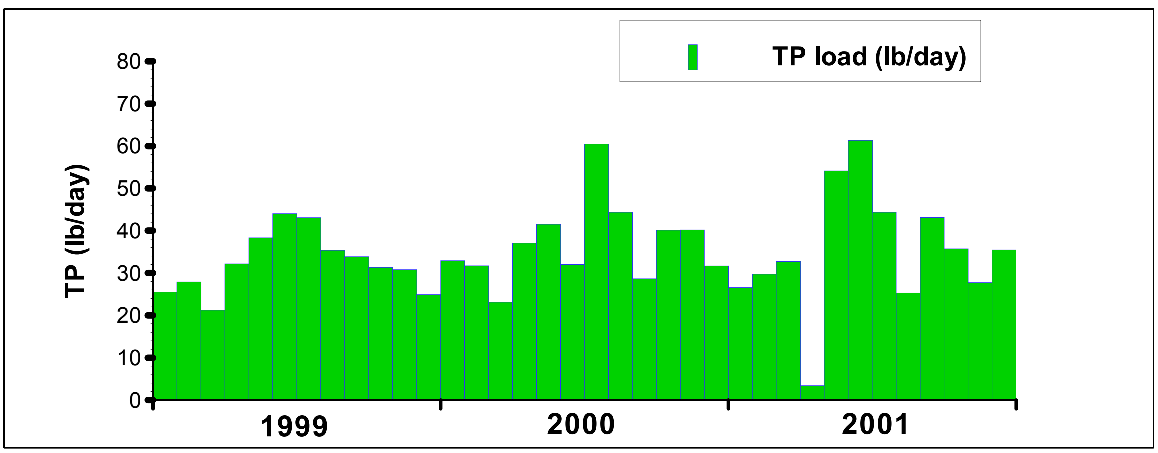


Figure A-18 Monthly Average TP load, AL0045969 BHM Riverview

Table A-10 Reported Discharge and TP Concentrations 1999-2001 (*Average TP data) for Pelham WWTP AL0054666

DATE	FLOWMGD	TP mg/l	TP lb/day
01/01/99	2.14	1.68*	29.94
02/01/99	2.19	1.68*	30.65
03/01/99	2.33	1.68*	32.61
04/01/99	1.91	1.68*	26.73
05/01/99	1.79	1.68*	25.10
06/01/99	1.75	1.68*	24.48
07/01/99	1.85	1.68*	25.85
08/01/99	1.69	1.68*	23.59
09/01/99	1.51	1.68*	21.17
10/01/99	1.44	1.68*	20.07
11/01/99	1.64	1.68*	22.98
12/01/99	1.75	1.68*	24.50
01/01/00	1.92	1.68*	26.86
02/01/00	1.89	1.68*	26.44
03/01/00	2.28	1.68*	31.90
04/01/00	2.71	1.68*	37.91
05/01/00	1.65	1.68*	23.05
06/01/00	1.59	1.68*	22.19
07/01/00	1.60	1.68*	22.35
08/01/00	1.64	1.68*	22.91
09/01/00	1.53	1.68*	21.42
10/01/00	1.48	1.68*	20.72
11/01/00	1.67	1.68*	23.29
12/01/00	1.55	1.68*	21.64
01/01/01	1.93	1.64	26.29
02/01/01	2.14	1.40	24.94
03/01/01	3.03	1.60	40.30
04/01/01	2.62	0.82	17.88
05/01/01	1.82	1.60	24.25
06/01/01	2.11	2.00	35.11
07/01/01	2.16	1.55	27.88
08/01/01	2.59	1.60	34.51
09/01/01	2.83	1.62	38.16
10/01/01	2.07	2.70	46.54
11/01/01	1.91	1.98	31.49
12/01/01	2.78	1.91	44.21

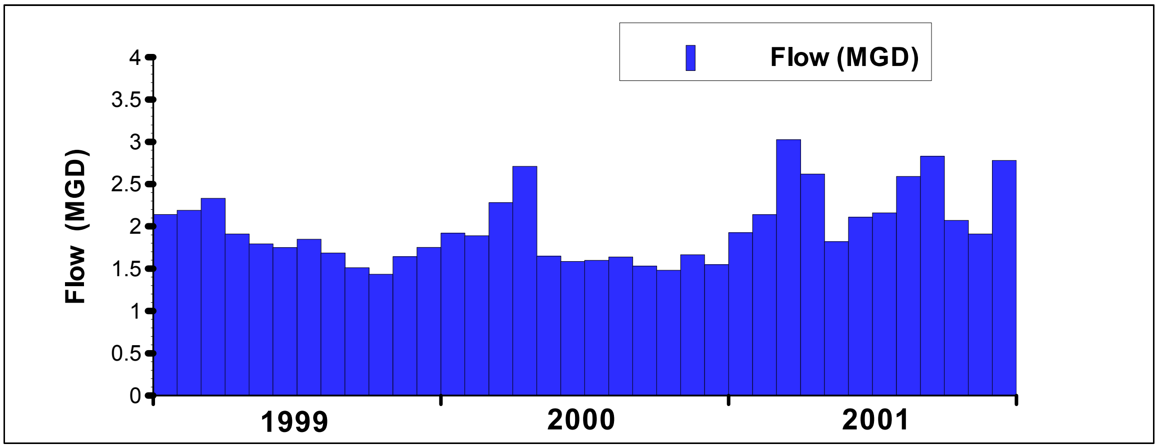


Figure A-19 Monthly Average Flow, AL0054666 Pelham WWTP

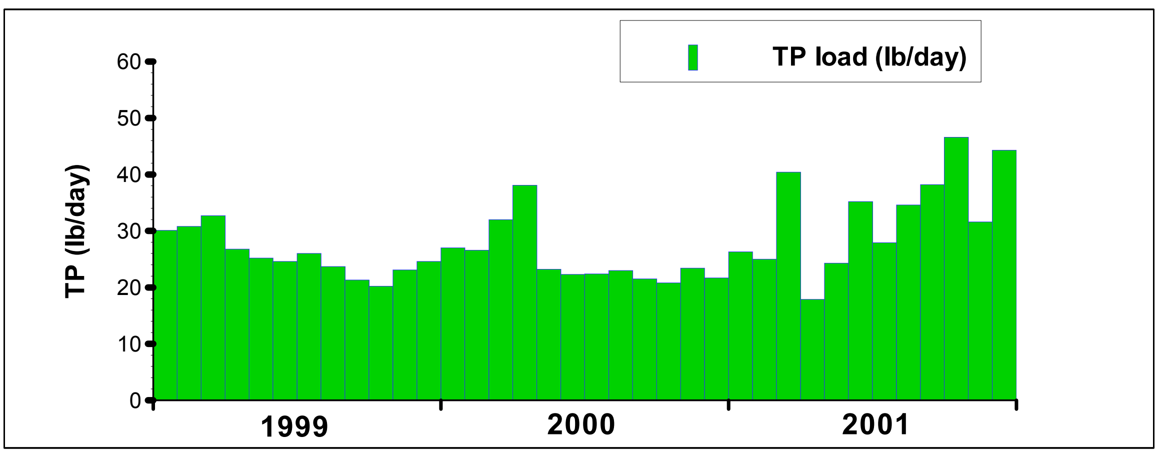


Figure A-20 Monthly Average TP load, AL0054666 Pelham WWTP

Table A-11 Reported Discharge and TP Concentrations 1999-2001 (*Average TP data) for Pelham Hunter's Glen WWTP AL0055182

DATE	FLOWMGD	TP mg/l	TP lb/day
01/01/99	0.06	2.43*	1.21
02/01/99	0.06	2.43*	1.11
03/01/99	0.06	2.43*	1.15
04/01/99	0.04	2.43*	0.73
05/01/99	0.03	2.43*	0.61
06/01/99	0.03	2.43*	0.67
07/01/99	0.03	2.43*	0.55
08/01/99	0.02	2.43*	0.42
09/01/99	0.02	2.43*	0.40
10/01/99	0.02	2.43*	0.49
11/01/99	0.03	2.43*	0.51
12/01/99	0.03	2.43*	0.57
01/01/00	0.04	2.43*	0.89
02/01/00	0.04	2.43*	0.75
03/01/00	0.05	2.43*	1.07
04/01/00	0.06	2.43*	1.11
05/01/00	0.03	2.43*	0.61
06/01/00	0.02	2.43*	0.47
07/01/00	0	0.00	0.00
08/01/00	0	0.00	0.00
09/01/00	0	0.00	0.00
10/01/00	0	0.00	0.00
11/01/00	0	0.00	0.00
12/01/00	0	0.00	0.00
01/01/01	0	0.00	0.00
02/01/01	0	0.00	0.00
03/01/01	0	0.00	0.00
04/01/01	0	0.00	0.00
05/01/01	0	0.00	0.00
06/01/01	0	0.00	0.00
07/01/01	0	0.00	0.00
08/01/01	0	0.00	0.00
09/01/01	0	0.00	0.00
10/01/01	0	0.00	0.00
11/01/01	0	0.00	0.00
12/01/01	0	0.00	0.00

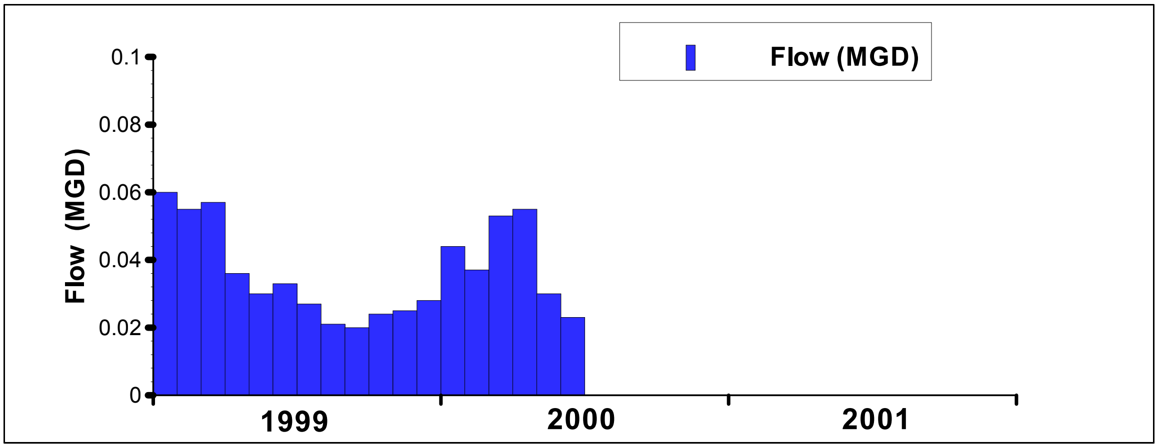


Figure A-21 Monthly Average Flow, AL0055182 Pelham Hunters Glen

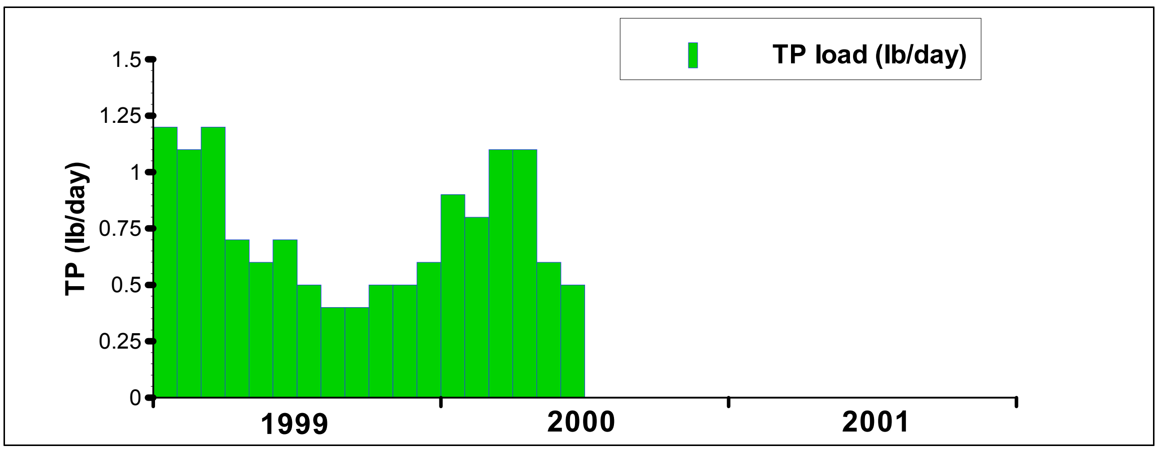


Figure A-22 Monthly Average TP load, AL0055182 Pelham Hunters Glen

Table A-12 Reported Discharge and TP Concentrations 1999-2001 (*Average TP data) for North Shelby WWTP AL0056251

DATE	FLOWMGD	TP mg/l	TP lb/day
01/01/99	1.33	2.32*	25.64
02/01/99	1.37	2.32*	26.45
03/01/99	1.53	2.32*	29.62
04/01/99	1.35	2.32*	26.04
05/01/99	1.33	2.32*	25.77
06/01/99	1.44	2.32*	27.74
07/01/99	1.40	2.32*	27.01
08/01/99	1.29	2.32*	24.90
09/01/99	1.27	2.32*	24.52
10/01/99	1.38	2.32*	26.64
11/01/99	1.48	2.32*	28.67
12/01/99	1.46	2.32*	28.19
01/01/00	1.56	2.32*	30.10
02/01/00	1.27	2.32*	24.52
03/01/00	1.67	2.32*	32.34
04/01/00	1.82	2.32*	35.08
05/01/00	1.31	2.32*	25.27
06/01/00	1.39	2.32*	26.83
07/01/00	1.35	2.32*	26.14
08/01/00	1.36	2.32*	26.25
09/01/00	1.33	2.32*	25.75
10/01/00	1.55	2.32*	29.91
11/01/00	1.70	2.32*	32.75
12/01/00	1.44	2.32*	27.90
01/01/01	1.92	2.32*	37.01
02/01/01	1.69	2.32*	32.65
03/01/01	1.89	2.32*	36.45
04/01/01	1.63	2.32*	31.43
05/01/01	1.60	2.32*	30.87
06/01/01	1.53	2.32*	29.60
07/01/01	1.36	0.98	11.08
08/01/01	1.46	1.42	17.29
09/01/01	1.83	0.83	12.63
10/01/01	1.44	0.94	11.29
11/01/01	1.44	0.67	8.04
12/01/01	1.80	1.30	19.45

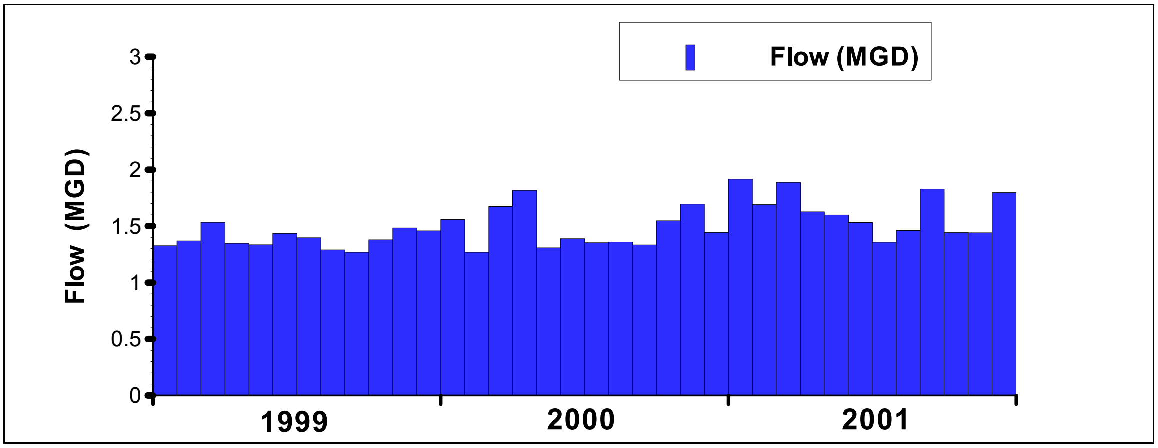


Figure A-23 Monthly Average Flow, AL0056251 N. Shelby WWTP

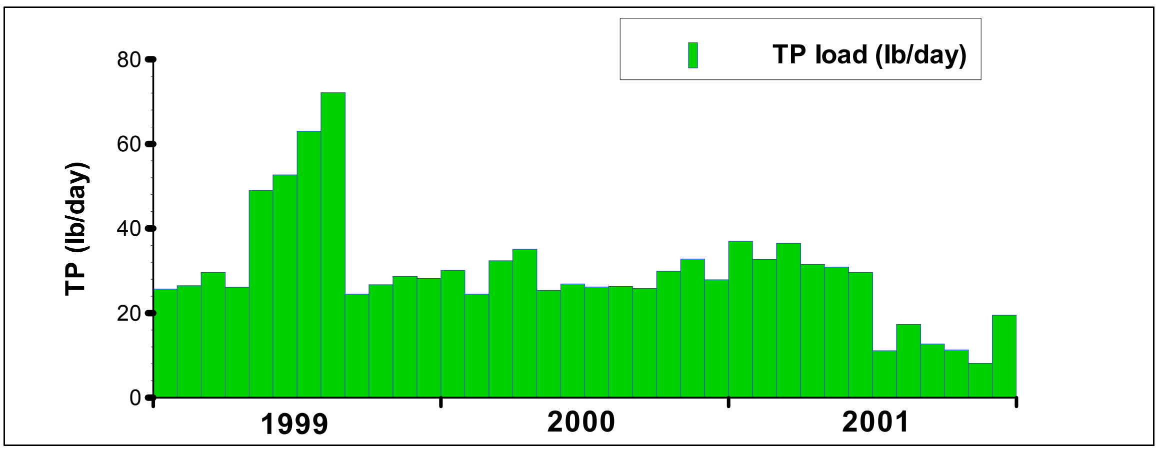


Figure A-24 Monthly Average TP load, AL0056251 N. Shelby WWTP

Attachment B

Nutrient Target Development for the Cahaba River TMDL