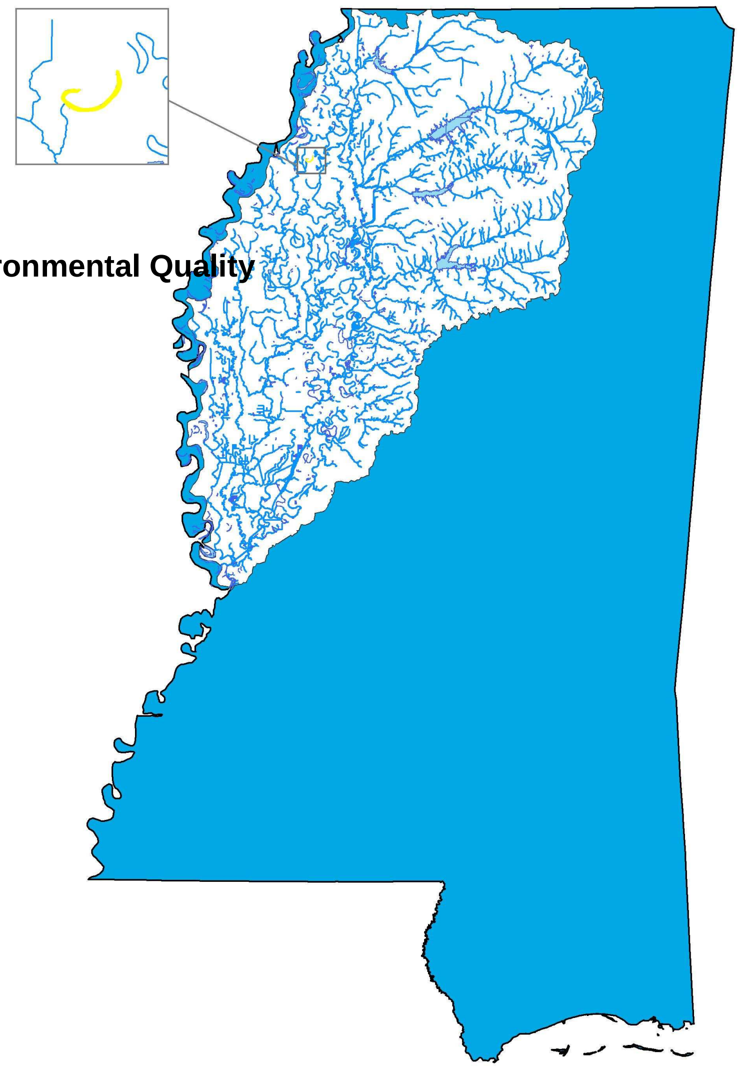
FINAL REPORT
June 2008
ID: 908063053

Total Maximum Daily Load

For Nutrients and Organic Enrichment / Low Dissolved Oxygen In Stovall Lake

Yazoo River Basin

Coahoma County, Mississippi



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Foreword

This report has been prepared in accordance with the schedule contained within the federal consent decree dated December 22, 1998. The report contains one or more Total Maximum Daily Loads (TMDLs) for water body segments found on Mississippi's 1996 Section 303(d) List of Impaired Water Bodies. Because of the accelerated schedule required by the consent decree, many of these TMDLs have been prepared out of sequence with the State's rotating basin approach. The implementation of the TMDLs contained herein will be prioritized within Mississippi's rotating basin approach.

The amount and quality of the data on which this report is based are limited. As additional information becomes available, the TMDLs may be updated. Such additional information may include water quality and quantity data, changes in pollutant loadings, or changes in landuse within the watershed. In some cases, additional water quality data may indicate that no impairment exists.

Prefixes for fractions and multiples of SI units

Fraction	Prefix	Symbol	Multiple	Prefix	Symbol
10-1	deci	d	10	deka	da
10-2	centi	c	102	hecto	h
10-3	milli	m	103	kilo	k
10-6	micro		106	mega	M
10-9	nano	n	109	giga	G
10-12	pico	p	1012	tera	T
10-15	femto	f	1015	peta	P
10-18	atto	a	1018	exa	E

Conversion Factors

To convert from	To	Multiply by	To Convert from	To	Multiply by
Acres	Sq. miles	0.00156	Days	Seconds	86400
Cubic feet	Cu. Meter	0.02832	Feet	Meters	0.3048
Cubic feet	Gallons	7.48052	Gallons	Cu feet	0.1337
Cubic feet	Liters	28.31685	Hectares	Acres	2.4711
cfs	Gal/min	448.83117	Miles	Meters	1609.344
cfs	MGD	0.64632	Mg/l	ppm	1.0
Cubic meters	Gallons	264.17205	g/l * cfs	Gm/day	2.4500

Section 1
Goals and Objectives for the Stovall Lake Watershed

1.1 Total Maximum Daily Load (TMDL) Overview

The identification of water bodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those water bodies are required by Section 303(d) of the Clean Water Act (CWA) and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130). The TMDL process is designed to restore and maintain the quality of those water bodies through the establishment of pollutant specific allowable loads.

A TMDL, is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards. To meet this requirement, the Mississippi Department of Environmental Quality (MDEQ) must identify water bodies not meeting water quality standards and then establish TMDLs for restoration of water quality. MDEQ lists water bodies not meeting water quality standards every two years. This list is called the Mississippi Section 303(d) List of Impaired Waters, and water bodies on the list are then targeted for TMDL development.

In general, a TMDL is a quantitative assessment of water quality problems, contributing sources, and pollution reductions needed to attain water quality standards. The TMDL specifies the amount of a pollutant that needs to be reduced to meet water quality standards, allocates pollutant controls or management responsibilities among sources in a watershed, and provides a scientific and policy basis for taking actions needed to restore a water body.

1.2 TMDL Goals and Objectives for the Stovall Lake Watershed

The TMDL goals and objectives for the Stovall Lake watershed are to develop TMDLs for impaired water bodies within the watershed, describe all of the necessary elements of the TMDL, and gain public acceptance of the process. Following is the impaired water body segment in the Stovall Lake watershed for which a TMDL will be developed:

- Stovall Lake

This impaired water body segment is shown on Figure 1-1. Table 1-1 lists the water body segment, water body size, and causes of impairment for the water body for which TMDLs will be developed.

Table 1-1 Impaired Water Bodies in the Stovall Lake Watershed

Water Body ID	Water Body Name	Size	Impaired Use	*Causes of Impairment*
MS371SLE	Stovall Lake	426 acres	Aquatic Life	Nutrients Organic Enrichment/Low Dissolved Oxygen

The TMDLs for the water body listed above will specify the following elements:

- Loading Capacity (LC) or the maximum amount of pollutant loading a water body can receive without violating water quality standards
- Waste Load Allocation (WLA) or the portion of the TMDL allocated to existing or future point sources
- Load Allocation (LA) or the portion of the TMDL allocated to existing or future nonpoint sources and natural background
- Margin of Safety (MOS) or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality

These elements are combined into the following equation:

$$TMDL = LC = \Sigma WLA + \Sigma LA + MOS$$

The TMDLs take into account the seasonal variability of pollutant loads so that water quality standards are met during all seasons of the year. Also, reasonable assurance that the TMDL will be achieved is described in the final report.

1.3 Report Overview

The remaining sections of this report contain:

- **Section 2 Stovall lake Watershed Characteristics** provides a description of the water body, the watershed's location, topography, geology, land use, soils, population, and hydrology.
- **Section 3 Stovall Lake Water Quality Standards** defines the water quality standards for the impaired water body.
- **Section 4 Stovall Lake Watershed Characterization** presents the available water quality data and also describes the point and non-point sources with potential to contribute to the watershed load.
- **Section 5 Methodologies to Complete TMDLs for the Stovall Lake Watershed** discusses the models and analyses needed for TMDL development.
- **Section 6 Model Development** provides an explanation of model development for Stovall Lake.
- **Section 7 Total Maximum Daily Load for the Stovall Lake Watershed** discusses the allowable loadings to water bodies to meet water quality standards and the reduction in existing loadings needed to meet allowable loads.

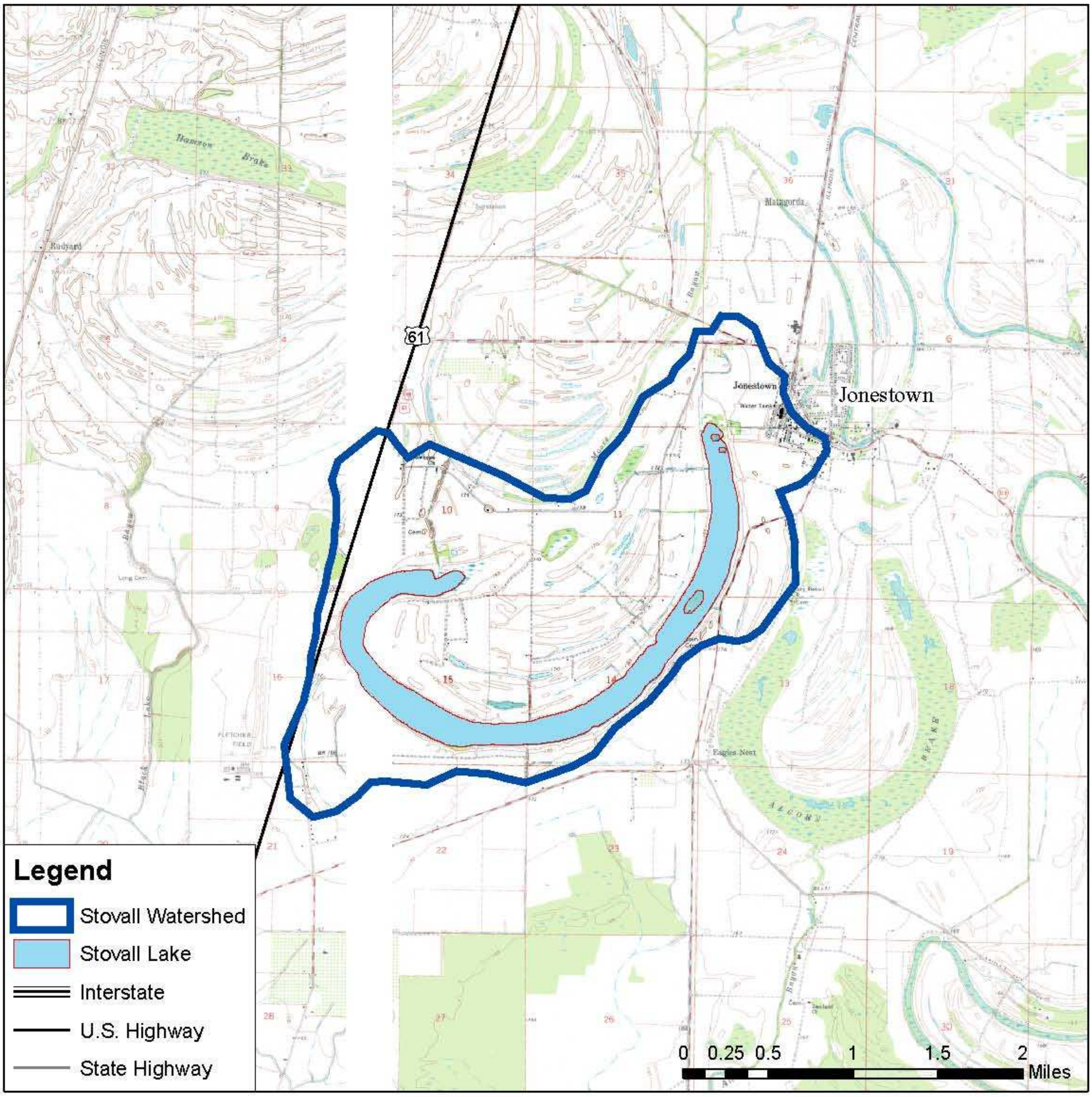


Figure 1.1:
Stovall Lake Watershed

Section 2
Stovall Watershed Description

2.1 Watershed Overview

The Stovall Lake watershed (Figure 1-1) is located in northwestern Mississippi in the Yazoo River Basin. Stovall Lake is a 426-acre lake in the Yazoo River watershed in the eastern part of Coahoma County, Mississippi. Its watershed encompasses an area of 3,293 acres. Stovall Lake is also referred to as Swan Lake.

Stovall Lake is an oxbow lake which is formed by a long process involving erosion within a meandering stream. Meandering streams possess a winding channel with broad curves that create an unequal distribution of flow velocity. Due to the unequal velocities, the outer bank is eroded and sediment deposition occurs along the opposite side of the channel. The net effect is that the meander migrates laterally. Over time the land separating the adjacent meanders becomes very narrow. During a flood, the stream will abandon its channel, cutting through the narrow strip of land, and flow the shorter distance (Monroe and Wincander, 1992). Sediment transported by the stream is deposited along the new stream bank at the site of the abandoned meander. Once the abandoned meander is completely isolated from the main channel, it becomes an oxbow lake.

2.2 Topography

Topography is an important factor in watershed management because stream types, precipitation, and soil types can vary dramatically by elevation. Digital Elevation Model (DEM) coverages containing 10-meter grid resolution elevation data are available from the Mississippi Automated Resource Information System (MARIS) for each county in Mississippi. Elevation data for the Stovall Lake watershed were obtained by overlaying the grid onto the geographic information system (GIS)-delineated watershed. Figure 2-1 shows the elevations found within the watershed. Elevation in the Stovall Lake watershed ranges from 163 feet above sea level to 176 feet.

2.3 Land Use

Land use data for the Stovall Lake watershed were extracted from the National Agricultural Statistics Service (NASS) Cropland Data Layer (CDL) Program. CDL provides NASS with internal proprietary county and state level acreage indications of major crop commodities, and secondarily provides the public with "statewide" (where available) raster, geo-referenced, categorized land cover data products after the public release of county estimates. The actual Cropland Data Layer images, which are a collection of scenes from the satellites Landsat5, Landsat7, or RESOURCESAT-1, corresponding to an entire state or a major portion of a state, and are categorized based on ground truth information collected from producers by USDA enumerators.

The land use of the Stovall Lake watershed was determined by overlaying the NASS Cropland Data Layer onto the GIS-delineated watershed. Figure 2-2 illustrates the land uses in to the Stovall Lake watershed, based on the CDL land use categories and also includes the area of each land cover category and percentage of the watershed area. illustrates the land uses of the watershed.

The land cover data reveal that all 3,293 acres of Stovall Lake Watershed are >75% cultivated.

2.4 Soils

Detailed soils data and spatial coverages were gathered from the Soil Survey Geographic (SSURGO) database for a limited number of counties. For SSURGO data, field mapping methods using national standards are used to construct the soil maps. Mapping scales generally range from 1:12,000 to 1:63,360 making SSURGO the most detailed level of soil mapping done by the NRCS.

Figure 2-3 displays the SSURGO soil series in the Stovall Lake watershed. Attributes of the spatial coverage can be linked to the SSURGO database, which provides information on various chemical and physical soil characteristics for each map unit and soil series. Of particular interest for TMDL development are the hydrologic soil groups as well as the K-factor of the Universal Soil Loss Equation. The following sections describe and summarize the specified soil characteristics for the Stovall Lake watershed.

2.4.1 Stovall Lake Watershed Soil Characteristics

The predominant soil type in the watershed is a Dundee-Forestdale-Dubbs.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils are assigned to one of four groups. They are grouped according to the infiltration of water when the soils are thoroughly wet and receive precipitation from long-duration storms. The Dundee-Forestdale-Dubbs soil is categorized as a D soil. D soils are defined as "soils having a high runoff potential due to very slow infiltration rates." D soils “consist primarily of clays with high swelling potential, soils with permanently high water tables, soils with claypan or clay layer at or near the surface and shallow soils over nearly impervious parent material" (NRCS 2005).

A commonly used soil attribute is the K-factor. The K-factor:

> *Indicates the susceptibility of a soil to sheet and rill erosion by water.* (The K-factor) *is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion. Losses are expressed in tons per acre per year. These estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.02 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by water (NRCS 2005).*

The distribution of K-factor values in the Stovall Lake watershed range from 0.32 to 0.43.

2.5 Population

Population data from the US Census were reviewed for Coahoma County. Coahoma County is a moderately populated area covering 583 square miles and having 49 persons per square mile (US DOC, Census, 2006). Comparatively, Mississippi has 60 persons per square mile and the United States has 83 persons per square mile. The largest source of jobs in the area is in the service sector at 41.0 percent of total employment. The services industry includes establishments primarily engaged in providing a wide variety of services, such as hotels and other lodging places; establishments providing personal, business, repair, and amusement services; health, legal, engineering, and other professional services; educational institutions; membership organizations; and other miscellaneous services (OSHA, 2001). The second largest source of jobs in the area is the government sector (which includes federal, state, and local government), accounting for 19.6 percent of total employment. The retail trade sector is the third largest employer, providing 7.5 percent of the total number of jobs, followed by manufacturing at 6.7 percent and finally the agricultural sector, which accounted for 4.6 percent.

Stovall Lake is approximately 8.5 miles northeast of Clarksdale, Mississippi, which is the largest city in Coahoma County. Jonestown is less than one mile to the east of Stovall Lake. The area surrounding Stovall Lake is mostly agricultural, with the exception of Jonestown.

2.6 Climate and Stream Flow

2.6.1 Climate

Northwest Mississippi has a humid subtropic climate with long hot, humid summers and short temperate winters. There is a weather station in Clarksdale, which has recorded monthly precipitation and temperature data between 1930 and 2006 (Station ID 1707). The Clarksdale, Mississippi station was chosen to be representative of meteorological conditions throughout Coahoma County.

Table 2-2 contains the average monthly precipitation along with average high and low temperatures for the period of record. The average annual precipitation is approximately 51 inches.

Table 2-2 Average Monthly Climate Data for the Stoval Lake Watershed

Month	Total Precipitation (inches)	Maximum Temperature (degrees F)	Minimum Temperature (degrees F)
January	5.2	61.9	21.0
February	4.8	67.8	24.6
March	5.2	75.2	32.7
April	4.8	81.9	46.4
May	4.8	88.9	53.8
June	4.0	100.8	64.0
July	3.9	99.2	68.3
August	2.5	101.1	63.8
September	3.0	94.4	63.8
October	2.8	86.5	44.2
November	4.9	70.2	33.8
December	5.1	63.7	23.5
Total	**50.9**		

2.6.2 Stream Flow

Analysis of the Stovall Lake watershed requires an understanding of flow throughout the drainage area. Stovall Lake is approximately 8.5 miles northeast of Clarksdale, Mississippi, which is the largest city in Coahoma County. Jonestown is less than one mile to the east of Stovall Lake.

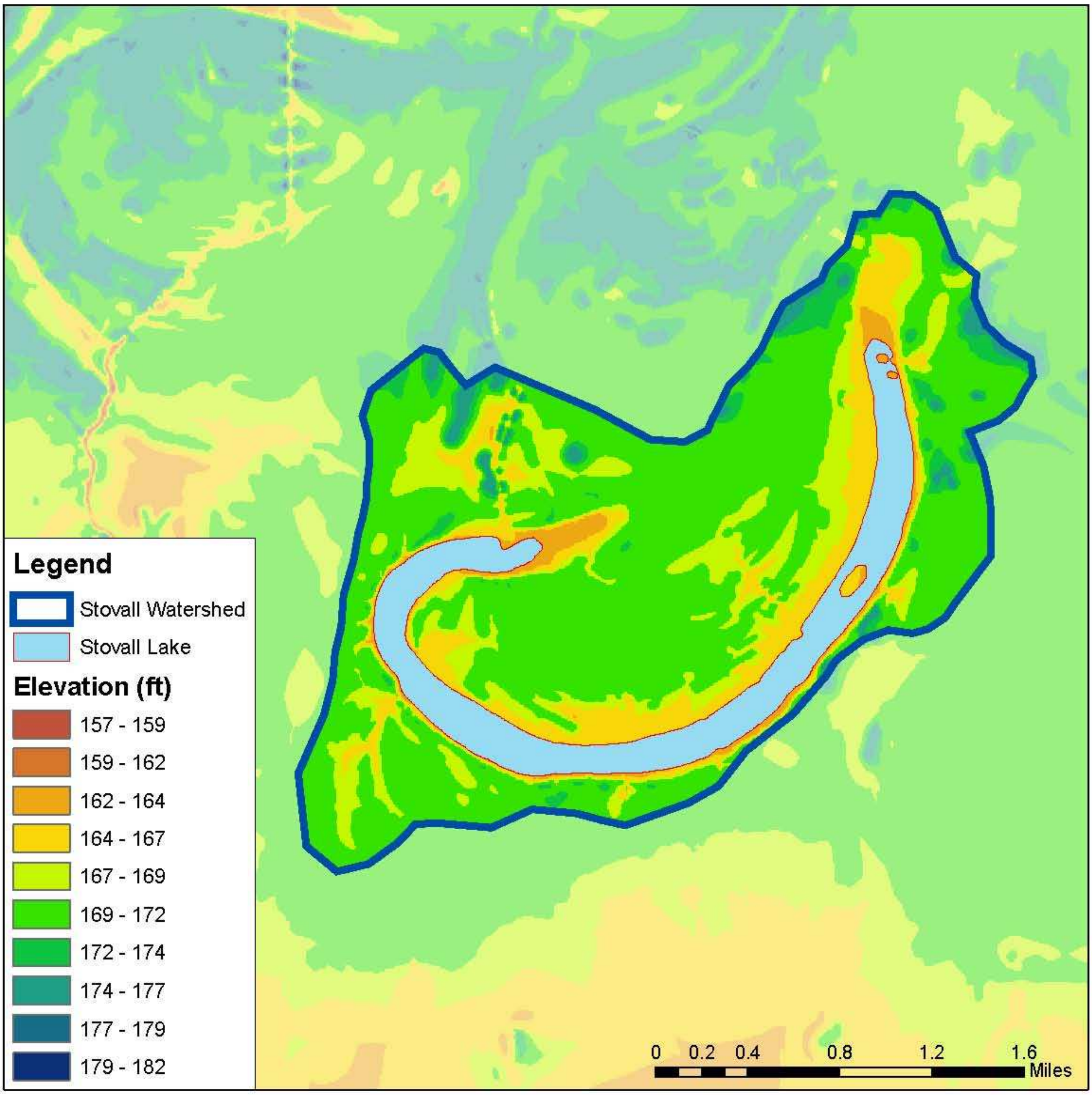


Figure 2.1: Topography Stovall Lake Watershed

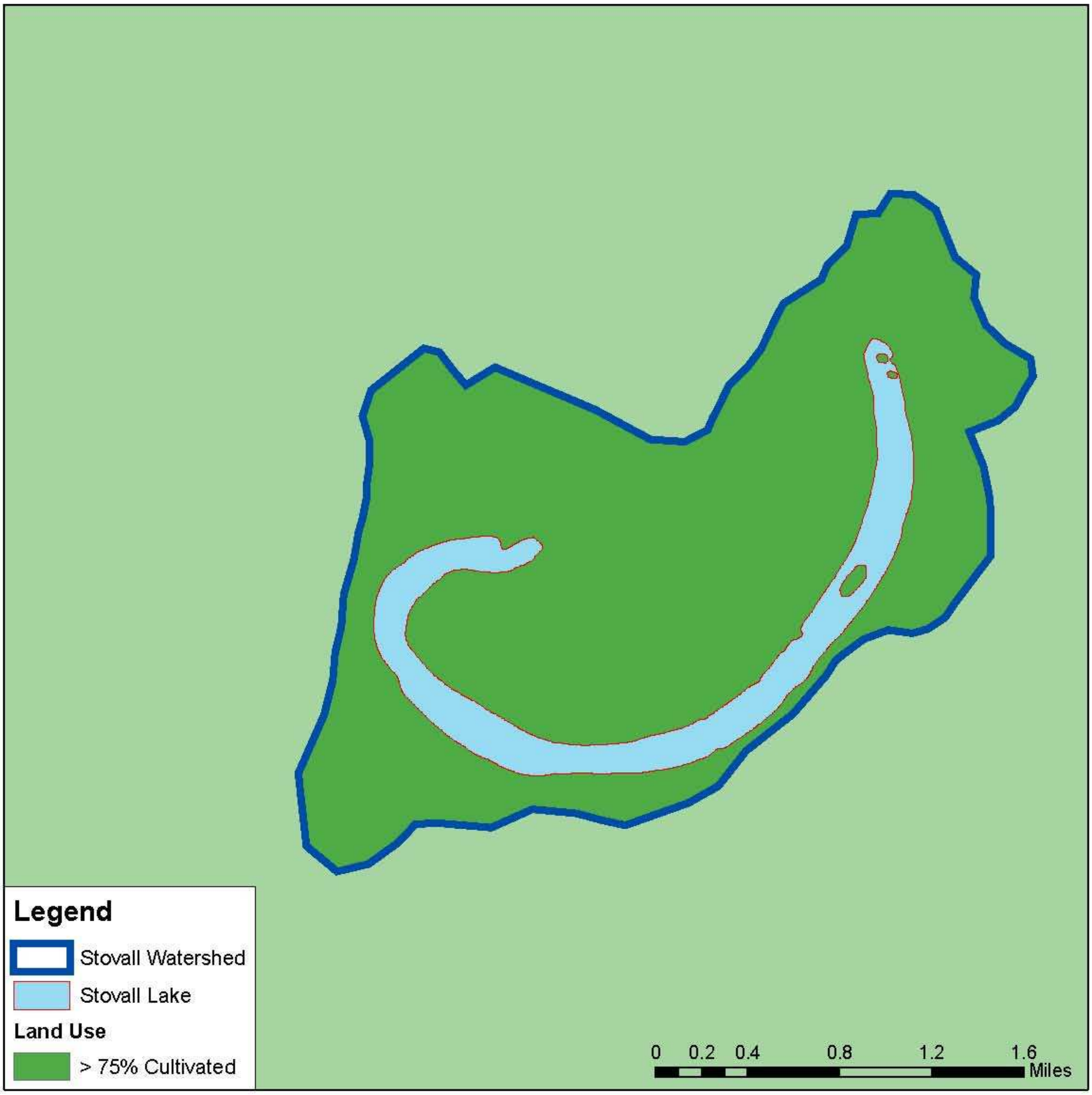


Figure 2.2:
Land Use
Stovall Lake Watershed

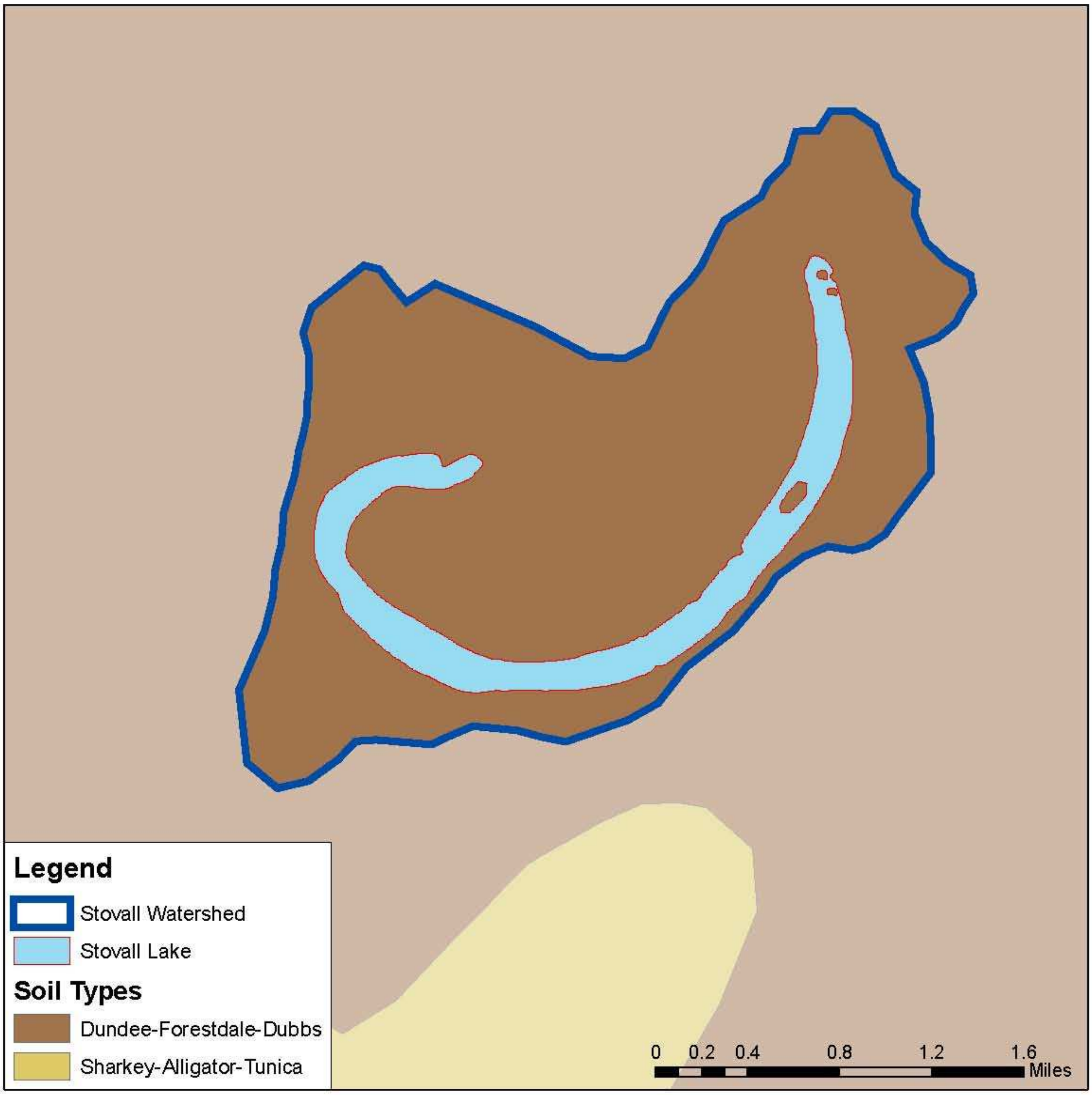


Figure 2.3: Soil Types Stovall Lake Watershed

Section 3
Stovall Lake Watershed Water Quality Standards

3.1 Mississippi Water Quality Standards

Water quality standards are developed and enforced by the state to protect the "designated uses" of the state's waterways. Mississippi state law mandates in Section 49-17-19 the protection of public health and welfare and the present use of waters for public water supplies, propagation of fish and aquatic life and wildlife, recreational purposes, and agricultural, industrial, and other legitimate uses. Mississippi's water quality standards can be found in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* adopted on August 23, 2007.

3.2 Designated Uses

Designated uses are those uses specified in water quality standards for each water body or segment whether or not they are being attained. They take into consideration the use and value of water for public water supplies, protection and propagation of aquatic life, recreation in and on the water (such as swimming and boating), and protection of consumers of fish and shellfish. Mississippi waters are classified into the following uses:

- Public Water Supply
- Shellfish Harvesting
- Recreation
- Fish and Wildlife
- Ephemeral

Attainment of these uses is based on specific numeric and narrative criteria which are also specified in the water quality standards. Stovall Lake is designated for the Fish and Wildlife Use.

3.3 Stovall Lake Water Quality Standards

Stovall Lake is listed on the 2006 §303(d) list for the impairment of the aquatic life use support. Parameters thought to be causing the impairment of this use were evaluated as organic enrichment/low DO and nutrients. These are evaluated listings and as such, no data have been collected to confirm the impairment status of the water body.

3.3.1 Organic Enrichment/Low DO

Section II.7 of the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* states that "dissolved oxygen concentrations shall be maintained at a daily average of not less than 5.0 mg/L with an instantaneous minimum of not less than 4.0 mg/L. When possible, samples should be taken from ambient sites according to the following guidelines:

- For waters that are not thermally stratified, such as unstratified lakes, lakes during turnover, streams, and rivers, samples should be collected at mid-depth if the total water column depth is ten (10) feet or less and at five (5) feet from the water surface if the total water column depth is greater than 10 feet.

- For waters that are thermally stratified such as lakes, estuaries, and impounded streams, samples should be collected at mid-depth of the epilimnion if the epilimnion depth is 10 feet or less or at 5 feet from the water surface if the epilimnion depth is greater than 10 feet.

3.3.2 Nutrients

The *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* does not currently contain nutrient specific numeric water quality criteria. These criteria are currently being developed by the Mississippi Nutrient Task Force in coordination with EPA Region 4. The state is in the process of developing numeric criteria for nutrients and has drafted "Nutrient Assessments Supporting Development of Nutrient Criteria for Mississippi Lakes and Reservoirs" (2007).

The original document included criteria for lakes and reservoirs greater than 500 acres while the amendment for small lakes and reservoirs included criteria for all lakes and reservoirs greater than 100 acres. MDEQ proposed a Nutrient Criteria Development Plan that has been mutually agreed to by EPA and is on schedule (MDEQ, 2004). MDEQ is presenting these preliminary target values for TMDL development which is subject to revision after the development of nutrient criteria, when the work of the NTF is complete. Table 3-1 contains the preliminary target values for nutrients for lakes greater than 100 acres.

Table 3-1: Draft Recommended Nutrient Criteria for Lakes and Reservoirs Greater than 100 acres

Total Phophorus (ug/L)	Total Nitrogen (ug/L)	Chlorophyll-a (ug/L)	Secchi Depth (m)
90	1020	20.3	0.45

Section 4
Stovall Lake Watershed Characterization

Data were collected and reviewed from many sources in order to further characterize the Stovall Lake watershed. Data have been collected for water quality as well as both point and nonpoint sources. This information is presented and discussed in further detail in the remainder of this section.

4.1 Available Water Quality Data

The historic water quality data for the Stovall Lake Watershed is extremely limited and only includes a few parameters measured in July of 1994. The samples were collected at one location. Figure 4-1 shows sampling location SWLK-01 while Table 4-1 presents the summary of historical data.

Table 4-1: Swan Lake Water Quality Summary – Location SWLK-01 (July 1994)

Parameter	Units	Average	Minimum	Maximum	Number of Samples
Water Temperature	℃	29	27	31	2
Sample Depth	Ft	2.14	1	3.28	2
Specific Conductance	umhos/cm @25C	58	58	58	1
Dissolved Oxygen*	mg/l	8.35	3.6	13.1	2
Field pH	SU	7.8	7.8	7.8	1
Total Alkalinity	mg/l	25	25	25	1
Nitrogen, Ammonia	mg/l	0.11	0.11	0.11	1
Nitrogen, TKN	mg/l	1.62	1.62	1.62	1
Nitrogen, NO_2+NO_3	mg/l	0.04	0.04	0.04	1
Phosphorus, Total	mg/l	0.29	0.29	0.29	1
TOC	mg/l	5	5	5	1
Total Hardness	mg/l	20	20	20	1

* DO samples were collected at 1 and 3.3 feet

One of the two samples taken for DO violated the minimum concentration standard of 4.0 mg/L, however, it was the sample taken near the bottom which is more than the mid-depth sampling requirement included in the water quality standard. In addition, both phosphorus and nitrogen samples exceeded the draft nutrient criteria for each parameter.

Additional monitoring was collected and is shown in Table 4-2.

Table 4-2: Swan Lake Recent Water Quality Data – Location SWLK-01 (January 2008)

Parameter	Units	Value
Water Temperature	℃	6.87
Specific Conductance	umhos/cm @25C	149
Dissolved Oxygen*	mg/l	11.75
Field pH	SU	7.38
Nitrogen, Ammonia	mg/l	<MQL
Nitrogen, TKN	mg/l	2.40
Nitrogen, NO_2+NO_3	mg/l	0.12
Phosphorus, Total	mg/l	0.47

4.2 Point and Non-point Sources

Potential sources of pollutant loading to Stovall Lake were reviewed for this TMDL. Potential pollutant sources include those associated with point sources (those sources required to obtain a National Pollution Discharge Elimination System (NPDES) permit), as well as non-point sources associated with overland runoff.

4.2.1 Point Sources

GIS data for NPDES permitted facilities were downloaded from MARIS and plotted against the watershed boundary delineated from elevation data. The Jonestown Publicly Owned Treatment Works (POTW) (Permit no. MS0021075) is permitted to discharge to Stovall Lake through a conventional lagoon treatment system. Table 4-2 contains permit information available through the USEPA's Permit Compliance System (PCS).

Table 4-2: Jonestown POTW Permit Information (USEPA PCS 2007)

Parameter	Units	Permit Limit
Discharge Rate	MGD	0.166
Average BOD5 Concentration	mg/L	45
Average TSS Concentration	mg/l	90

4.2.2 Nonpoint Sources

Nonpoint sources represent contributions from diffuse, nonpermitted sources. Nonpoint sources include both precipitation driven and non-precipitation driven events, such as contributions from groundwater; septic systems; direct deposition of pollutants from wildlife, livestock, or atmospheric fallout. In addition, aquaculture is a potential nonpoint source within the Mississippi Valley.

4.2.2.1 Agriculture Information

As discussed in Section 2, all of the land within the watershed is >75% cultivated. Drainage from delta cropland flows into the lake leaving deposits of sediments that can potentially contain high nutrients.

4.2.2.2 Aquaculture

The production of catfish is the largest aquaculture enterprise in the United States. Catfish ponds located in the Mississippi Valley account for approximately 78% of the total land area devoted to catfish production (USEPA, 2002). Again, GIS data for catfish ponds were downloaded from MARIS and plotted on a watershed map. No catfish ponds are located near Stovall Lake.

4.2.2.3 Animal Operations

Watershed specific animal numbers were not available for the Stovall Lake Watershed. The estimated numbers for Coahoma County from the 2002 Census of Agriculture are provided below for countywide reference. The population of animals within the county is relatively low and is not likely a major contributor to pollutant loads within the lake.

Table 4-3 Coahoma County Animal Population (2002 Census of Agriculture)

Category	2002
Cattle and Calves	796
Hogs and Pigs	231
Poultry	0
Sheep and Lambs	0
Horses and Ponies	151

4.2.2.4 Septic Systems

Failing septic systems represent a source that may contribute oxygen-consuming constituents to receiving water bodies through surface or subsurface failures. Many households in rural areas are not connected to municipal sewers and use onsite sewage disposal systems, or septic systems. There are many types of septic systems, but the most common septic system is composed of a septic tank draining to a septic field, where nutrient removal occurs. The degree of nutrient removal is limited by soils and system upkeep and maintenance.

Jonestown contains a small number of residences which are located within the lake watershed. Jonestown has a sewage system that is treated at the Jonestown POTW which discharges to Stovall Lake. Because residences within the watershed are served by a sewer system, septic systems were omitted from the analysis.

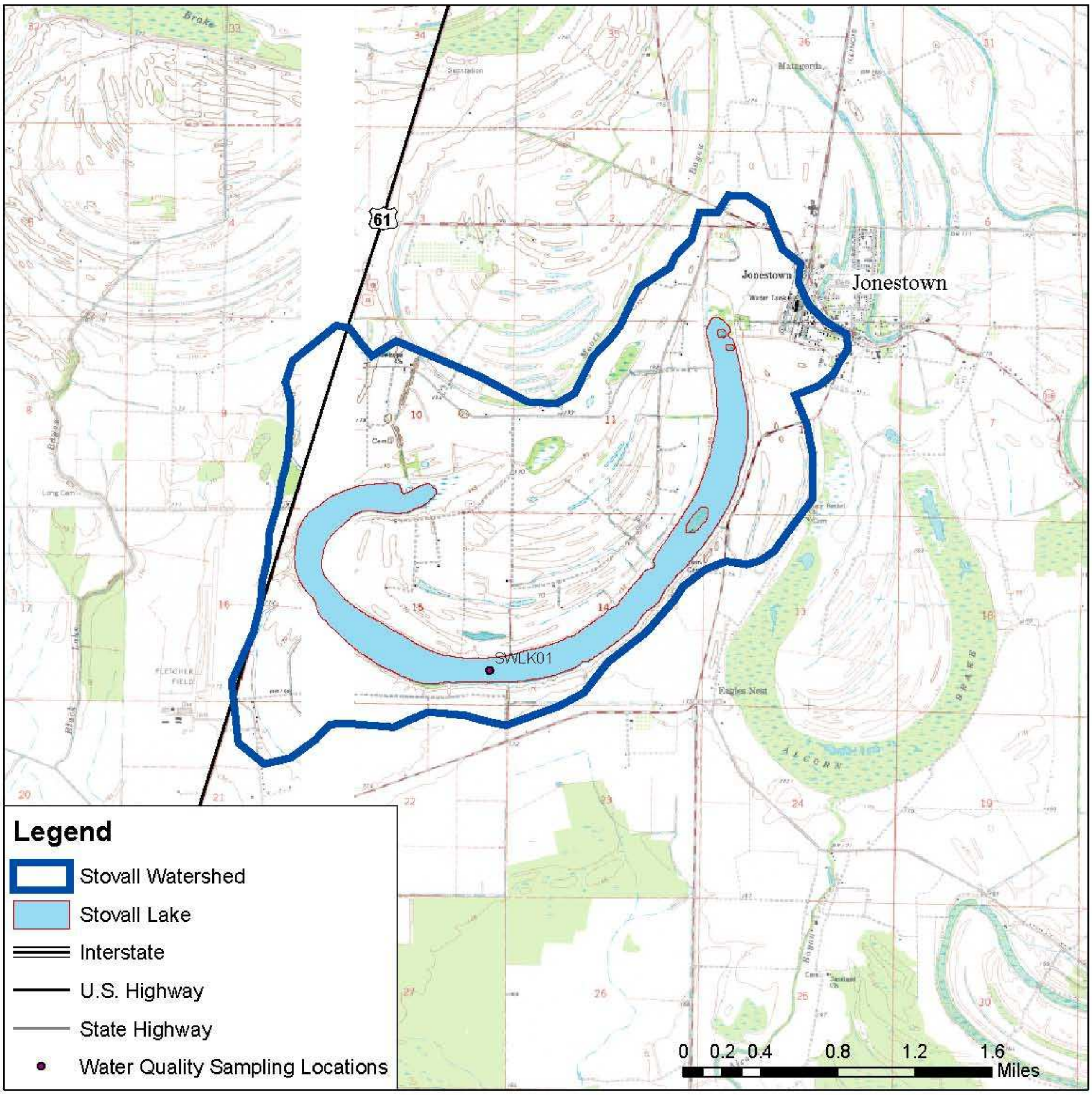


Figure 4.1:
Water Quality Sampling Locations

Section 5
Methodologies and Models to Complete TMDLs for Stovall Lake

5.1 Set Endpoints for TMDLs

TMDLs are used to define the total amount of pollutants that may be discharged into a particular water body within any given day based on a particular use of that water body. Defining a TMDL for any particular water body must take into account not only the science related to physical, chemical, and biological processes that may impact water quality, but must also be responsive to temporal changes in the watershed and likely influences of potential solutions to water quality impairments on entities that reside in the watershed.

5.2 Methodologies and Models to Assess TMDL Endpoints

Methodologies and models were utilized to assess TMDL endpoints for the Stovall Lake Watershed. Model development is more data intensive than using simpler methodologies or mathematical relationships for the basis of TMDL development. In situations where only limited or qualitative data exist to characterize impairments, methodologies were used to develop TMDLs as appropriate.

In addition to methodologies, watershed and receiving water computer models are available for TMDL development. Most models have similar overall capabilities but operate at different time and spatial scales and were developed for varying conditions. The available models range between empirical and physically based. However, all existing watershed and receiving water computer models simplify processes and often include obviously empirical components that omit the general physical laws. They are, in reality, a representation of data.

Each model has its own set of limitations on its use, applicability, and predictive capabilities. For example, watershed models may be designed to project loads within annual, seasonal, monthly, or storm event time scales with spatial scales ranging from large watersheds to small subbasins to individual parcels such as construction sites. With regard to time, receiving water models can be steady state, quasi dynamic, or fully dynamic. As the level of temporal and spatial detail increases, the data requirements and level of modeling effort increase.

5.2.1 Watershed Models

Watershed or loading models can be divided into categories based on complexity, operation, time step, and simulation technique. USEPA has grouped existing watershed-scale models for TMDL development into three categories based on the number of processes they incorporate and the level of detail they provide (USEPA 1997):

- Simple models
- Mid-range models
- Detailed models

Simple models primarily implement empirical relationships between physiographic characteristics of the watershed and pollutant runoff. Simple models may be used to support an assessment of the relative significance of different nonpoint sources, guide decisions for management plans, and focus continuing monitoring efforts. Generally, simple models aggregate watershed physiographic data spatially at a large-scale and provide pollutant loading estimates on large time-scales. Although they can easily be adopted to estimate storm event loading, their accuracy decreases since they cannot capture the large fluctuations of pollutant concentrations observed over smaller time-scales.

Mid-range models attempt a compromise between the empiricism of the simple models and complexity of detailed mechanistic models. Mid-range models are designed to estimate the importance of pollutant contributions from multiple land uses and many individual source areas in a watershed. Therefore, they require less aggregation of the watershed physiographic characteristics than the simple models. Mid-range models may be used to define large areas for pollution migration programs on a watershed basis and make qualitative evaluations of BMP alternatives.

Detailed models use storm event or continuous simulation to predict flow and pollutant concentrations for a range of flow conditions. These models explicitly simulate the physical processes of infiltration, runoff, pollutant accumulation, instream effects, and groundwater/surface water interaction. These models are complex and were not designed with emphasis on their potential use by the typical state or local planner. Many of these models were developed for research into the fundamental land surface and instream processes that influence runoff and pollutant generation rather than to communicate information to decision-makers faced with planning watershed management (USEPA 1997). Although detailed or complex models provide a comparatively high degree of realism in form and function, complexity does not come without a price of data requirements for model construction, calibration, verification, and operation. If the necessary data are not available, and many inputs must be based upon professional judgment or taken from literature, the resulting uncertainty in predicted values undermine the potential benefits from greater realism. Based on the available data for the Stovall Lake Watershed, a detailed or even mid-range model could not be constructed, calibrated, and verified with certainty and the watershed model selection should focus on the simple models.

5.2.1.1 Watershed Model Recommendation

The watershed model recommendation for the Stovall Lake watershed is the rational method. A more complex watershed model is not appropriate for this watershed because there is little to no data available from the surrounding watershed area. The rational method calculates a drainage area discharge based on the area, precipitation data, and a weighted runoff coefficient based on the imperviousness of the subbasin land uses. In addition, event mean concentration (EMC) data were used in conjunction with land use data to estimate nutrient concentrations contributed to the lake from the surrounding area.

5.2.2 Receiving Water Quality Models

Receiving water quality models differ in many ways, but some important dimensions of discrimination include conceptual basis, input conditions, process characteristics, and output. Table 5-1 presents extremes of simplicity and complexity for each condition as a point of reference. Most receiving water quality models have some mix of simple and complex characteristics that reflect tradeoffs made in optimizing performance for a particular task.

Table 5-1 General Receiving Water Quality Model Characteristics

Model Characteristic	Simple Models	Complex Models
Conceptual Basis	Empirical	Mechanistic
Input Conditions	Steady State	Dynamic
Process	Conservative	Nonconservative
Output Conditions	Deterministic	Stochastic

The concept behind a receiving water quality model may reflect an effort to represent major processes individually and realistically in a formal mathematical manner (mechanistic), or it may simply be a "black-box" system (empirical) wherein the output is determined by a single equation, perhaps incorporating several input variables, but without attempting to portray constituent processes mechanistically.

In any natural system, important inputs such as flow in the river change over time. Most receiving water quality models assume that the change occurs sufficiently slowly so that the parameter (for example, flow) can be treated as a constant (steady state). A dynamic receiving water quality model, which can handle unsteady flow conditions, provides a more realistic representation of hydraulics, especially those conditions associated with short duration storm flows, than a steady-state model. However, the price of greater realism is an increase in model complexity that may be neither justified nor supportable.

The manner in which input data are processed varies greatly according to the purpose of the receiving water quality model. The simplest conditions involve conservative substances where the model need only calculate a new flow-weighted concentration when a new flow is added (conservation of mass). Such an approach is unsatisfactory for constituents such as DO or labile nutrients, such as nitrogen and phosphorus, which will change in concentration due to biological processes occurring in the stream.

Whereas the watershed nonpoint model's focus is the generation of flows and pollutant loads from the watershed, the receiving water models simulate the fate and transport of the pollutant in the water body. Table 5-2 presents the steady-state (constant flow and loads) models applicable for this watershed. The steady-state models are less complex than the dynamic models. Also, as discussed above, the dynamic models require significantly more data to develop and calibrate an accurate simulation of a water body.

Table 5-2 Descriptive List of Model Components - Steady-State Water Quality Models

Model	Water Body Type	Parameters Simulated	Process Simulated	
			Physical	**Chemical/Biological**
USEPA Screening Methods	River, lake/ reservoir, estuary, coastal	Water body nitrogen, phosphorus, chlorophyll "a," or chemical concentrations	Dilution, advection, dispersion	First order decay - empirical relationships between nutrient loading and eutrophication indices
EUTROMOD	Lake/reservoir	DO, nitrogen, phosphorus, chlorophyll "a"	Dilution	Empirical relationships between nutrient loading and eutrophication indices
BATHTUB	Lake/reservoir	DO, nitrogen, phosphorus, chlorophyll "a"	Dilution	Empirical relationships between nutrient loading and eutrophication indices
SYMPTOX3	River/reservoir	Conservative and nonconservative substances	Dilution, advection, dispersion	First order decay, sediment exchange

5.2.2.1 Receiving Water Model Recommendation

The receiving water model recommended for Stovall Lake is BATHTUB. BATHUB will be used to investigate nutrient concentrations in the lake. Because there are only two data points for dissolved oxygen and the average of the data is above the standard while the minimum is just below the standard, it is assumed that reductions in nutrient loading will improve dissolved oxygen levels within the lake to concentrations that meet the water quality standard.

BATHUB applies a series of empirical eutrophication models to reservoirs and lakes. The program performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network that accounts for advective and diffusive transport, and nutrient sedimentation. Eutrophication-related water quality conditions are predicted using empirical relationships (USEPA 1997).

Section 6
Methodology Development for the Stovall Lake Watershed

6.1 Methodology Overview

Table 6-1 contains information on the methodologies selected and used to develop TMDLs for Stovall Lake.

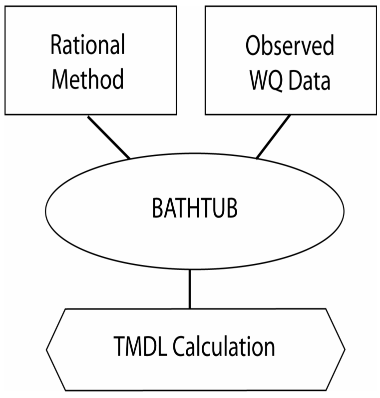
Table 6-1 Methodologies Used to Develop TMDLs for Stovall Lake

Segment Name	Cause of Impairment	Methodology
Stovall Lake	Low DO/Organic Enrichment	BATHTUB
	Nutrients	BATHTUB

6.1.1 BATHTUB Overview

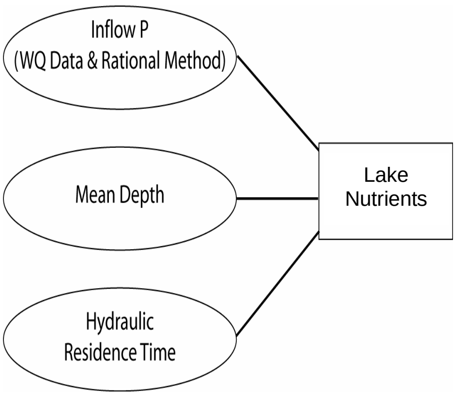
The approach taken for nutrient TMDL analysis for Stovall Lake included using observed data coupled with the rational method as inputs to the BATHTUB model. This method required inputs from several sources including online databases and GIS-compatible data.

Schematic 1 shows the data inputs for the BATHTUB model that were used to calculate the TMDL. Flow and concentration data were unavailable for the lake watershed. Therefore, the rational method was used to estimate runoff and concentrations from the subbasins adjacent to the impaired lake. The rational method calculates a subbasin discharge based on the subbasin area, precipitation data, and a weighted runoff coefficient based on the imperviousness of the subbasin land uses. In addition, event mean concentration (EMC) data were used in conjunction with land use data to estimate total phosphorus and total nitrogen concentrations from the subbasin areas.



Schematic 1

Once the subbasin flow and concentrations were estimated, they were used as input for the BATHTUB model. The BATHTUB model uses empirical relationships between mean lake depth, total nutrients input to the lake, and the hydraulic residence time to determine in-lake concentrations (see Schematic 2).



Schematic 2

6.2 Methodology Development

The following sections further discuss and describe the methodologies utilized to examine total nutrient levels in Stovall Lake.

6.2.1 BATHTUB Model Development and Input

BATHTUB has three primary input interfaces: global, reservoir segment(s), and watershed inputs. The individual inputs for each of these interfaces are described in the following sections.

6.2.1.1 Global Inputs

Global inputs represent atmospheric contributions of precipitation, evaporation, and atmospheric deposition of phosphorus and nitrogen. The model for Stovall Lake was developed using the annual precipitation for 1994 which corresponds to in-lake data available for the lake. TMDL calculations were also performed using 1994 data as it was an above average year. The precipitation value used to represent 1994 was 52.41 inches while the average historic annual precipitation (1930-2006) was 50.9 inches. The average annual evaporation input to the model was 53.4 inches. Pan evaporation data were available through Mississippi State University Extension Service from a station in Stoneville, MS. Data from 1994 were unavailable, and average annual data from 1996 through 2000 were used for both model setup and TMDL development. The default atmospheric phosphorus and nitrogen deposition rates suggested in the BATHTUB model were used in absence of site-specific data. The default phosphorus rate is 30 mg/m^2-yr and the default nitrogen rate is 1,000 mg/m^2-yr.

6.2.1.2 Reservoir Segment Inputs

Reservoir segment inputs in BATHTUB are used for physical characterization of the reservoir. Due to the very limited data available for Stovall Lake, the lake was modeled as one segment in BATHTUB. The data collected in 1994 from site SWLK01 were used to characterize the lake segment.

Segment inputs to the model include average depth, surface area and segment length. The lake depth was represented by the depth data associated with the water quality sampling performed on the lake in 1994. Surface area and segment length were determined using GIS. Reservoir segment input data are provided in Table 6-2.

Table 6-2 Stovall Lake Segment Input for BATHTUB

Segment Name	Surface Area (km2)	Segment Length (km)	Average Depth (m)
SWLK01	1.72	7.21	1

6.2.1.3 Tributary Inputs

Tributary inputs to BATHTUB include drainage area, flow, and total phosphorus and nitrogen concentrations. The drainage area of each tributary is equivalent to the basin or subbasin it represents, which was determined with GIS analyses. Again, due to the lack of in-lake data and the relatively small watershed area around Stovall Lake, the model was built with one tributary area. In addition, the point source input from the Jonestown POTW was included as a tributary. Tributary information is contained in Table 6-3.

Table 6-3 Stovall lake Tributary Subbasin Information

Tributary Name	Lake Segment Receiving Drainage	Subbasin Area (km2)	Estimated Subbasin flow (million m3/yr)
Direct Runoff : Stovall watershed	SWLK01	13.3	7.1
Point Source: MS0021075 Jonestown POTW	SWLK01	-	0.23*

* Flow determined by converting 0.166 MGD to million m^3/year

Through the rational method, the total mean daily flow into Stovall Lake associated with overland runoff from the surround watershed was determined to be 7.1 million cubic meters per year. EMCs associated with open areas were used to estimate nutrient concentrations being contributed to the lake from the surrounding watershed. Table 6-4 contains this analysis.

Table 6-4 Estimated Watershed Nutrient Concentrations

	Open
Area (acres)	3,293
Percent of Watershed (%)	100
	EMC
Total Phosphorus (ug/L)	121
Total Nitrogen (ug/L)	1508

In addition, nutrient concentrations were estimated to account for point source contributions from the lake. The Jonestown POTW is not required by its permit to sample for nutrients. In order to estimate total phosphorus and total nitrogen concentrations, EPA guidance was reviewed and average effluent concentrations of total nitrogen and total phosphorus from facilities using stabilization ponds were used for model development. A total nitrogen concentration of 11.5 mg/L and a total phosphorus concentration of 5.2 mg/L were used as estimates of effluent concentrations from the Jonestown POTW.

6.2.1.4 BATHTUB Confirmatory Analysis

In-lake data were used to help confirm model calculations. The following setup was used in the BATHTUB Model:

- Conservative Substance Balance: Not computed
- Phosphorus Balance: 2nd Order, Available Phosphorus
- Nitrogen Balance: 2nd Order, Available Nitrogen
- Chlorophyll-*a*: Phosphorus, Light, Turbidity
- Secchi Depth: Chlorophyll-a and Turbidity
- Longitudinal Dispersion: Fischer-Numeric
- Error Analysis: Not computed
- Phosphorus Calibration: Decay Rates
- Nitrogen Calibration: Decay Rates
- Application of Nutrient Availability Factors: Ignore
- Calculation of Mass Balances: Use estimated concentration

The loadings described above were entered into the BATHTUB model and compared with available water quality data for the lake. When using these loadings, the BATHTUB model under-predicted the concentration of phosphorus and closely predicted the concentration of nitrogen when compared to actual water quality data. To achieve a better match with actual total phosphorus water quality data, internal loading rates were adjusted. Internal loading rates reflect nutrient recycling from bottom sediments. Table 6-5 shows the results of this analysis.

Table 6-5 Summary of Model Confirmatory Analysis: Lake Total Nutrients (µg/L)

Parameter	**Predicted Concentration**	**Observed Concentration**	**Internal Loading Rate (mg/m^2-day)**
Total Phosphorus	291	290	7
Total Nitrogen	1593	1640	

Section 7
TMDL Development

7.1 TMDL Calculations

The TMDL endpoints for total phosphorus and total nitrogen are summarized in Table 7-1. The total phosphorus endpoint is a maximum concentration of 90 ug/L while the total nitrogen endpoint is a maximum concentration of 1,020 ug/L. These endpoints are based on protection of aquatic life in Stovall Lake.

For DO, concentrations must be greater than 5.0 mg/L averaged over any 24-hour period and must never be below 4.0 mg/L. Only two DO samples were available for Stovall Lake. Surface and bottom samples were collected and had concentrations of 13.1 mg/L and 3.6 mg/L respectively. Because there is limited DO data and limited data available on oxygen-demanding materials other than nutrients to the lake, it is assumed that controlling nutrient loads through the suggested TMDL reductions will also control and improve hypolimnetic DO concentrations.

Table 7-1 TMDL Endpoints and Average Observed Concentrations for Impaired segments in the Stovall Lake Watershed

Segment	Parameter	TMDL Endpoint	Observed Value
Stovall Lake	DO	5.0 mg/L (average of any 24-hour period), 4.0 mg/L minimum	3.6 mg/L (minimum) 8.35 mg/L (average)
	Total Phosphorus	90 ug/L	290 ug/L
	Total Nitrogen	1,020 ug/L	1640 ug/L

7.2 Pollutant Sources and Linkages

Pollutant sources and their linkages to Stovall Lake were established through the BATHTUB modeling and loading calculations discussed in Section 6. Modeling indicated that loads of total phosphorus originate from internal and external sources. Potential sources of nutrients in the watershed include nonpoint sources such as runoff from the surrounding cultivated land, atmospheric deposition, internal loading from nutrient rich sediments and the Jonestown POTW. The TMDLs explained throughout the remainder of this section will examine how much the loads need to be reduced in order to meet the total phosphorus and total nitrogen TMDL targets in Stovall Lake.

7.3 TMDL Allocations for Stovall Lake

As explained in Section 1, the TMDL for Stovall Lake addresses the following equation:

$$\mathbf{TMDL = LC = \Sigma WLA + \Sigma LA + MOS}$$

where LC = Maximum amount of pollutant loading a water body can receive without violating water quality standards

WLA = The portion of the TMDL allocated to existing or future point sources

LA = Portion of the TMDL allocated to existing or future nonpoint sources and natural background

MOS = An accounting of uncertainty about the relationship between pollutant loads and receiving water quality

Each of these elements will be discussed in this section as well as consideration of seasonal variation in the TMDL calculation.

7.3.1 Loading Capacity

The LC of Stovall Lake is the pounds of total phosphorus and total nitrogen that can be allowed as input to the lake per day and still meet the TMDL targets for each parameter. The allowable nutrient loads that can be generated in the watershed and still meet the target were determined with the model that was set up and confirmed as discussed in Section 6. To accomplish this, the point and nonpoint source loads were reduced by a percentage and entered into the BATHTUB model until the targets were met in Stovall Lake. Table 7-2 contains the allowable daily loads determined for both total phosphorus and total nitrogen. This analysis is included as Appendix A.

Table 7-2 Allowable Nutrient Loads to Stovall Lake

Parameter	Load (lbs/day)
Total Nitrogen	49.6
Total Phosphorus	5.8

7.3.2 Seasonal Variation

A season is represented by changes in weather; for example, a season can be classified as warm or cold as well as wet or dry. Seasonal variation is represented in the Stovall Lake TMDL as conditions were modeled on an annual basis. Modeling on an annual basis takes into account the seasonal effects the lake will undergo during a given year. Since the pollutant source can be expected to contribute loadings in different quantities during different time periods (e.g., various portions of the agricultural season resulting in different runoff characteristics), the loadings for this TMDL will focus on average annual loadings converted to daily loads rather than specifying different loadings by season. The Stovall Lake Watershed would most likely experience critical conditions annually based on the growing season. Because an average annual basis was used for TMDL development, it is assumed that the critical condition is accounted for within the analysis.

7.3.3 Margin of Safety

The MOS can be implicit (incorporated into the TMDL analysis through conservative assumptions) or explicit (expressed in the TMDL as a portion of the loadings) or a combination of both. The MOS for the Stovall Lake TMDL is implicit. The analysis completed for Stovall Lake is conservative because of the following:

- Conservative estimates were used for point source effluent estimates.
- 1994 precipitation data were used for the model which represented a wet year. Watershed loads from a wet year would likely be higher than average and TMDL reductions are based on this higher loading scenario.
- Default values were used in the BATHTUB model, which in absence of site-specific information are assumed conservative. Default model values, such as the phosphorus assimilation rate, are based on scientific data accumulated from a large survey of lakes. Because no site-specific data are available, default model rates are used which are based on

error analysis calculations. The model used for this analysis uses estimates of second-order sedimentation coefficients which are generally accurate to within a factor of 2 for phosphorus and a factor of 3 for nitrogen. This provides a conservation range of where the predictions could fall and provides confidence in the predicted values.

- Because site-specific data were not available on internal cycling rates, conservative estimates were used based on available in-lake concentration data and predicted concentrations in the absence of internal loading. The model is set up to allow conservative estimates of internal loading which result in the model achieving a close estimate of in-lake concentration data for the average-loading conditions modeled in this scenario.

7.3.4 Waste Load Allocation

There is one point source located within the Stovall Lake watershed. The Jonestown POTW (Permit MS0021075) is not required to collect phosphorus or nitrogen data. Phosphorus and nitrogen concentrations were estimated for these constituents and similar treatment processes. Table 7-3 contains the WLA determined through TMDL development for the Jonestown POTW.

Table 7-3: WLA for Stovall Lake Nutrient TMDLs

Facility	Average Discharge (mgd)	Parameter	Concentration (ug/L)	WLA (lbs/day)
Jonestown POTW MS0021075	0.166	Total Phosphorus	1,000	1.4
		Total Nitrogen	5,000	6.9

7.3.5 Load Allocation and TMDL Summary

Table 7-4 shows a summary of the total phosphorus and total nitrogen TMDLs for Stovall Lake. On average, a total reduction of 86% of total phosphorus loads to Stovall Lake would result in compliance with the water quality standard of 90 ug/L total phosphorus and a total reduction of 44% of total nitrogen loads to the lake would result in compliance with the TMDL target of 1020 ug/L. The percent reductions would need to come from the sources discussed above.

Table 7-4 TMDL Summary for Stovall Lake

Parameter	LC (lb/day)	WLA (lb/day)	LA (lb/day)	MOS (lb/day)	Current Estimated Load (lb/day)	Reduction Needed (lb/day)	Reduction Needed (percent)
Total Phosphorus	5.8	1.4	4.4	Implicit	40	34.2	86%
Total Nitrogen	49.6	6.9	42.7	implicit	88.9	39.3	44%

7.3.6 Reasonable Assurance

Reasonable assurance means that a demonstration is given that nonpoint source reductions in this watershed will be implemented. It should be noted that all programs available to reduce nonpoint source contributions are voluntary and some may be in practice to some degree within the watershed. Information on conservation practices and subsidies for implementation can be found in the US Farm Bill (www.fsa.usda.gov). In addition, local NRCS offices may provide nonpoint source control information and/or assistance to interested parties.

7.3.7 Next Steps

MDEQ's Basin Management Approach and Nonpoint Source Program emphasize restoration of impaired waters with developed TMDLs. During the watershed prioritization process to be conducted by the Yazoo River Basin Team, this TMDL will be considered as a basis for implementing possible restoration projects. The basin team is made up of state and federal resource agencies and stakeholder organizations and provides the opportunity for these entities to work with local stakeholders to achieve quantifiable improvements in water quality. Together, basin team members work to understand water quality conditions, determine causes and sources of problems, prioritize watersheds for potential water quality restoration and protection activities, and identify collaboration and leveraging opportunities. The Basin Management Approach and the Nonpoint Source Program work together to facilitate and support these activities.

The Nonpoint Source Program provides financial incentives to eligible parties to implement appropriate restoration and protection projects through the Clean Water Act's Section 319 Nonpoint Source (NPS) Grant Program. This program makes available around $1.6M each grant year for restoration and protections efforts by providing a 60% cost share for eligible projects.

Mississippi Soil and Water Conservation Commission (MSWCC) is the lead agency responsible for abatement of agricultural NPS pollution through training, promotion, and installation of BMPs on agricultural lands. USDA Natural Resource Conservation Service (NRCS) provides technical assistance to MSWCC through its conservation districts located in each county. NRCS assists animal producers in developing nutrient management plans and grazing management plans. MDEQ, MSWCC, NRCS, and other governmental and nongovernmental organizations work closely together to reduce agricultural runoff through the Section 319 NPS Program.

Mississippi Forestry Commission (MFC), in cooperation with the Mississippi Forestry Association (MFA) and Mississippi State University (MSU), have taken a leadership role in the development and promotion of the forestry industry Best Management Practices (BMPs) in Mississippi. MDEQ is designated as the lead agency for implementing an urban polluted runoff control program through its Stormwater Program. Through this program, MDEQ regulates most construction activities. Mississippi Department of Transportation (MDOT) is responsible for implementation of erosion and sediment control practices on highway construction.

Due to this TMDL, projects within this watershed will receive a higher score and ranking for funding through the basin team process and Nonpoint Source Program described above.

7.3.8 Public Participation

This TMDL will be published for a 30-day public notice period. During this time, the public will be notified by publication in the statewide newspaper. The public will be given an opportunity to review the TMDL and submit comments. MDEQ also distributes all TMDLs at the beginning of the public notice period to those members of the public who have requested to be included on a TMDL mailing list. TMDL mailing list members may ask to receive the TMDL reports through either email or mail. Anyone wishing to be included on the TMDL mailing list should contact Kay Whittington at (601) 961-5729 or Kay_Whittington@deq.state.ms.us

All comments received during the public notice period and at any public hearings become a part of the record of this TMDL. All comments will be considered in the submission of this TMDL to EPA Region 4 for final approval.

Section 8
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