FINAL REPORT
July 2008
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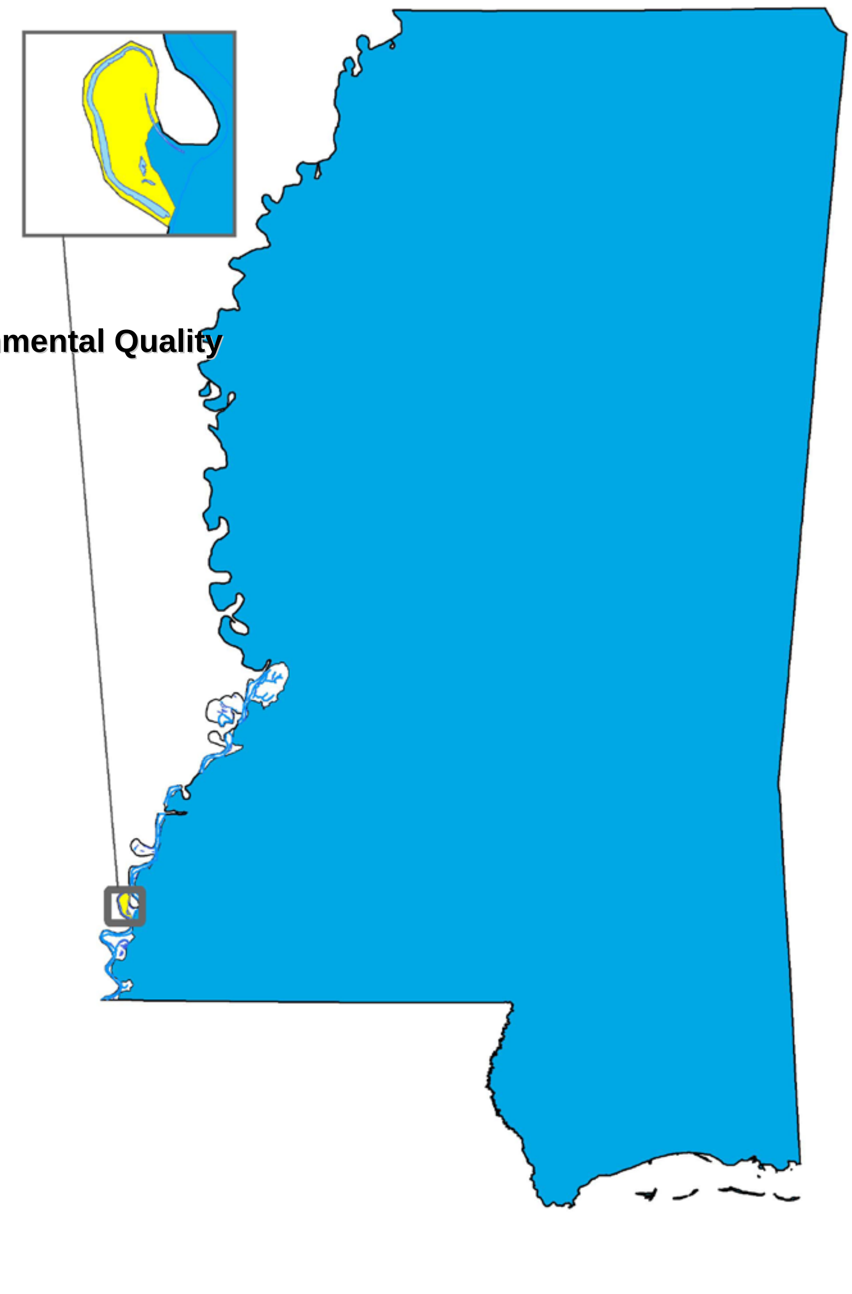
Total Maximum Daily Load
Lower Mississippi River Basin

Designated Oxbow Lakes

for
Sediment



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FOREWORD

This 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 Waterbodies. 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.

Conversion Factors

To convert from	To	Multiply by	To convert from	To	Multiply by
$mile^2$	acre	640	acre	ft^2	43560
km^2	acre	247.1	days	seconds	86400
m^3	ft^3	35.3	meters	feet	3.28
ft^3	gallons	7.48	ft^3	gallons	7.48
ft^3	liters	28.3	hectares	acres	2.47
cfs	gal/min	448.8	miles	meters	1609.3
cfs	MGD	0.646	tonnes	tons	1.1
m^3	gallons	264.2	µg/l * cfs	gm/day	2.45
m^3	liters	1000	µg/l * MGD	gm/day	3.79

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

TMDL INFORMATION

Table 1. Listing Information

Water Body Name	Water Body ID	Location
Old River Lake	MS408E	Near Sibley

Table 2. Water Quality Standard

Parameter	Beneficial use	Narrative Water Quality Criteria
Sediment/Siltation	Aquatic Life Support	Waters shall be free from materials attributable to municipal, industrial, agricultural, or other dischargers producing color, odor, taste, total suspended solids, or other conditions in such degree as to create a nuisance, render the waters injurious to public health, recreation, or to aquatic life and wildlife, or adversely affect the palatability of fish, aesthetic quality, or impair the waters for any designated uses.

Table 3. Total Maximum Daily Load

WLA	LA	MOS	TMDL
0.0004 to 0.0018*	0.0004 to 0.0018*	Implicit	0.0004 to 0.0018*

*tons per acre per day at the effective discharge of each tributary

EXECUTIVE SUMMARY

Each of the water bodies designated in Table 1 within the Lower Mississippi River Basin is on the Mississippi 2006 Section 303(d) List of Impaired Water Bodies for an evaluated sediment listing (MDEQ, 2006). This TMDL addresses this oxbow lake located in the Lower Mississippi River Basin. Oxbow lakes are formed by the continuous processes of sediment erosion and deposition within a meandering stream. Over time, oxbows naturally fill in with sediment delivered by its tributaries. The goal of this TMDL is not to change the natural process of sediment delivery to oxbow lakes; however, the goal is to promote best management practices within these watersheds and tributaries to reduce the sediment load available due to anthropogenic sources.

This TMDL is being completed for clean sediment. The *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* regulation does not include a numerical water quality standard for aquatic life protection due to sediment (MDEQ, 2007a). The narrative standard for the protection of aquatic life is sufficient for justification of TMDL development, but does not provide a quantifiable TMDL target. The target for this TMDL is based on reference sediment yields for stable streams developed by the Channel and Watershed Processes Research Unit (CWPRU) at the National Sedimentation Laboratory (NSL).

The CWPRU developed reference sediment yields, or targets, for each level III ecoregion within Mississippi. These yields were derived from the empirical analysis of historical flow and suspended sediment concentrations for stable streams in each level III ecoregion. These targets were used by MDEQ in the development of the James Creek Sediment TMDL (MDEQ, 2003c) and many subsequent sediment TMDLs throughout the state. The methods used to develop the level III reference yields are described in detail in the reports titled *"Reference" and "Impacted" Rates of Suspended-Sediment Transport for Use in Developing Clean Sediment TMDLs: Mississippi and the Southeastern United States* (Simon, et al., 2002b) and *Actual and Reference Sediment Yields for the James Creek Watershed – Mississippi* (Simon, et al., 2002a).

Recently, the CWPRU updated the level III reference sediment yields within the Lower Mississippi River Basin. The reference yield, or TMDL target, for this TMDL was derived from the empirical analysis of historical flow and suspended sediment concentrations for stable streams in the appropriate level III ecoregion(s) for the Lower Mississippi River Basin. It is appropriate to use the target values developed for streams in this oxbow lake TMDL because the sediment delivered to the oxbow lakes needs to be addressed in the tributaries of the lakes.

According to 40 CFR §130.2 (i), TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure. This TMDL is expressed as the tons of sediment that can be discharged from an acre of a subwatershed during a day (tons/acre/day) at the effective discharge and still attain the applicable water quality standard. This results in a range of acceptable reference yields in tons per acre per day at the effective discharge for each water body that flows into the oxbow lakes.

It is expected that all values within a range of acceptable yields will result in attainment of water quality standards within the stream. The TMDL target is expressed at the effective discharge of the stream. The effective discharge is the channel-forming flow or the flow that moves the most sediment. The effective discharge is obtained by combining flow frequency data with sediment transport relationships. The effective discharge occurs statistically once every one and a half years, not on a daily basis. However, because the effective discharge is the critical condition, compliance with the TMDL target within each tributary to the oxbow lakes at the effective discharge of that tributary will result in the attainment of the water quality standards at all times within both the tributaries and oxbow lakes in which they flow.

For the §303(d) listed oxbow lakes in the Lower Mississippi River Basin sediment data were not available to calibrate a water quality model for prediction of existing sediment loads. Therefore, this TMDL does not provide an existing load specific to each water body. A range of unstable values was assigned to the unstable water bodies based on the level III ecoregion unstable stream values. If the tributaries to the oxbow lakes are assumed to be unstable, the unstable range is representative of the existing loads that would be expected to enter the oxbow lakes. The unstable range is 0.002 to 0.054 tons per acre per day at the effective discharge of the tributary. The unstable yields are larger than the target yields, therefore, a reduction is recommended. Based on the ranges of stable and unstable yield values, a reduction of 77% to 97% is recommended.

Figure 1. Sediment plume entering into oxbow lake

1.0 INTRODUCTION

1.1 Background

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. The pollutant of concern for this TMDL is sediment from landuse runoff and in-channel sediment processes.

Water Body Name	Water Body ID	Location
Old River Lake	MS408E	Near Sibley

The oxbow lake shown in Table 1 (shown in Figure 4) is evaluated, that is no data exist that show impairment. In fact, oxbow lakes naturally fill due to sediment deposition over time. Therefore sedimentation of an oxbow lake is not an impairment of the use of the water body. The goal of this TMDL is not to change the natural process of sediment delivery to oxbow lakes. The goal is to promote best management practices within these watersheds and tributaries to reduce the sediment load available due to anthropogenic sources.

1.2 Lake Description

The continuous processes of erosion and deposition within a meandering stream form oxbow lakes. Meandering streams have a sinuous channel with broadly looping curves and exhibit an unequal distribution of flow velocity. As a consequence of the unequal velocities, the outer bank is eroded and sediment deposition occurs along the opposite, inside bank of the channel. The net effect is that the meander migrates laterally. Over time the channel becomes so sinuous that 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 Wicander, 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. Figure 1-1 demonstrates this process. Over time, oxbow lakes naturally fill with sediment deposits from tributaries.

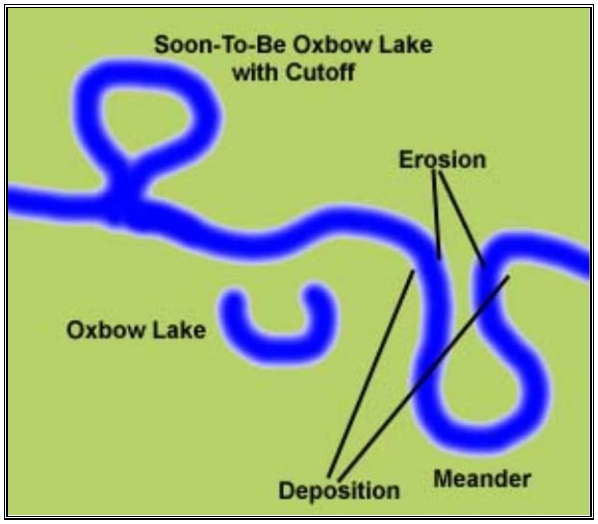


Figure 2. Oxbow Lake Creation Process

1.3 Applicable Water Body Segment Use

Excessive sedimentation from anthropogenic sources is a common problem that can impact water bodies in a number of ways. In the Mississippi Valley suspended sediment and turbid conditions caused by suspended sediment are the primary water quality concerns (MDEQ, 1999). Suspended sediment can affect lake and stream biota in a number of ways. Deposited sediments reduce habitat complexity by filling in pools, riffle areas, and the interstitial spaces used by aquatic invertebrates. Elevated turbidity reduces light penetration necessary for photosynthesis in aquatic plants, reduces feeding efficiency of visual predators and filter feeders, and lowers the respiration capacity in aquatic invertebrates by clogging gill surfaces. In addition, other contaminants such as nutrients and pesticides can be transported to lakes and streams during runoff events while attached to sediment particles. However, this is the natural process for an oxbow lake.

The water use classification for all water bodies included in this TMDL, as established by the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* regulation, is Fish and Wildlife Support (MDEQ, 2007a). Waters with this classification are intended for fishing and propagation of fish, aquatic life, and wildlife. Waters that meet the Fish and Wildlife Support criteria should also be suitable for secondary contact, which is defined as incidental contact with water including wading and occasional swimming.

1.4 Applicable Water Body Segment Standard

The *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* do not include a water quality standard applicable to aquatic life protection due to sediment (MDEQ, 2007a). However, a narrative standard for the protection of aquatic life was interpreted to determine an applicable target for this TMDL. The narrative standard is that waters shall be free from materials attributable to municipal, industrial, agricultural, or other dischargers producing color, odor, taste, total suspended solids, or other conditions in such degree as to create a nuisance, render the waters injurious to public health, recreation, or to aquatic life and wildlife, or adversely affect the palatability of fish, aesthetic quality, or impair the waters for any designated uses.

Figure 3. Slotted Board Riser installed on unnamed tributary to oxbow lake in Mississippi Delta

1.5 Climatic Characteristics

Mississippi is in the humid subtropical climate region, characterized by temperate winters; long, hot summers; and rainfall that occurs more often in the winter and early spring. Late summer and fall are typically the driest times of the year. The state, however, is subject to periods of both drought and flood. Prevailing southerly winds provide moisture for high humidity from May through September. The potential for locally violent and destructive thunderstorms averages about 60 days each year. Many hurricanes have struck Mississippi's coast since 1895, including Hurricane Rita which impacted these lakes in 2005. And tornadoes are a particular danger, especially during the spring season. Normal mean annual temperatures for the Jackson weather station are 18°C. Low temperatures have dropped to 4ºC while the maximum temperatures often reach 29ºC. Mississippi has a climate characterized by absence of severe cold in winter and the presence of extreme heat in summer. The ground rarely freezes and outdoor activities are generally planned year-round. Cold spells are usually of short duration and the growing season is long (Mississippi State Climatologist, 2003).

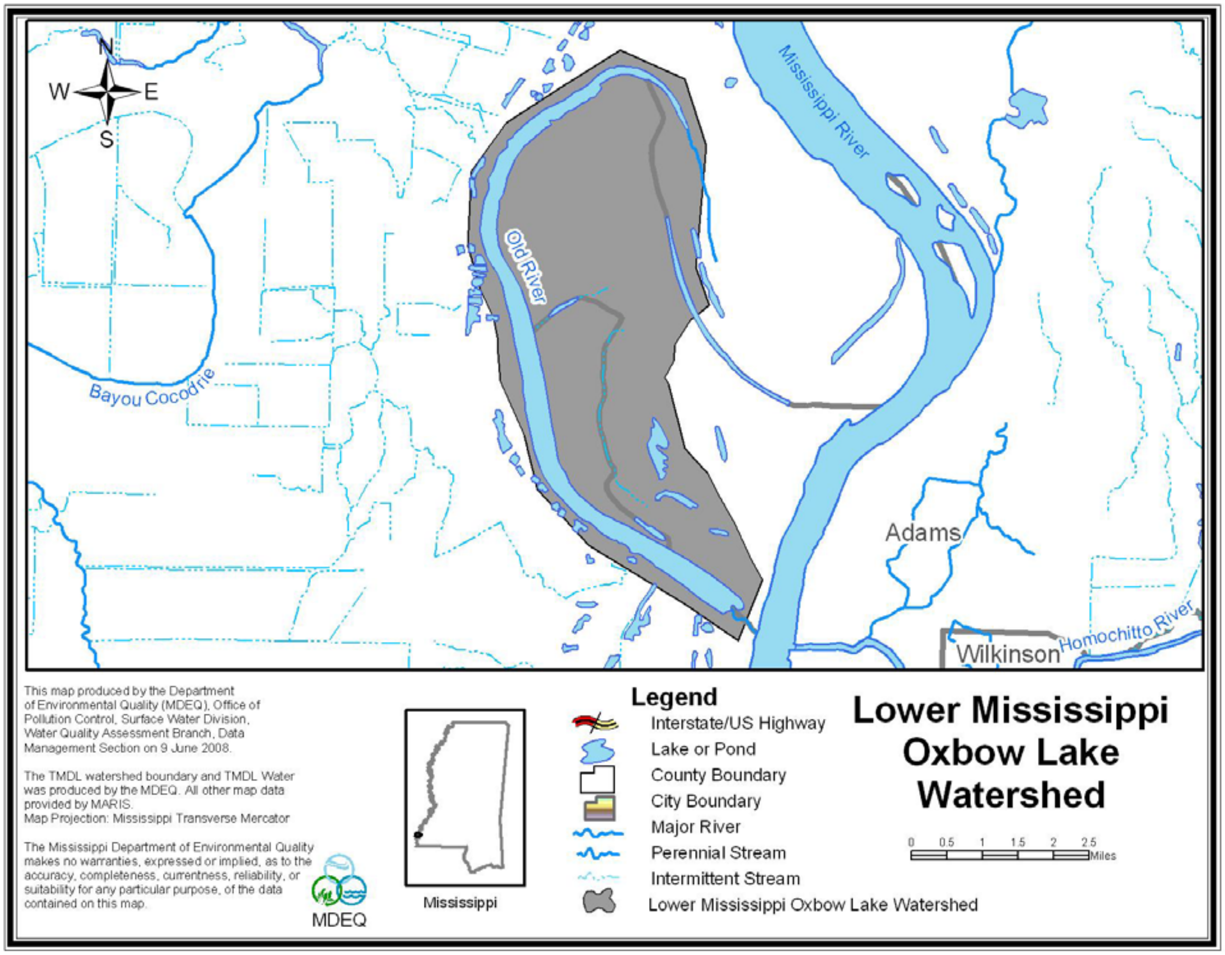


Figure 4. Location of MS408E Watershed

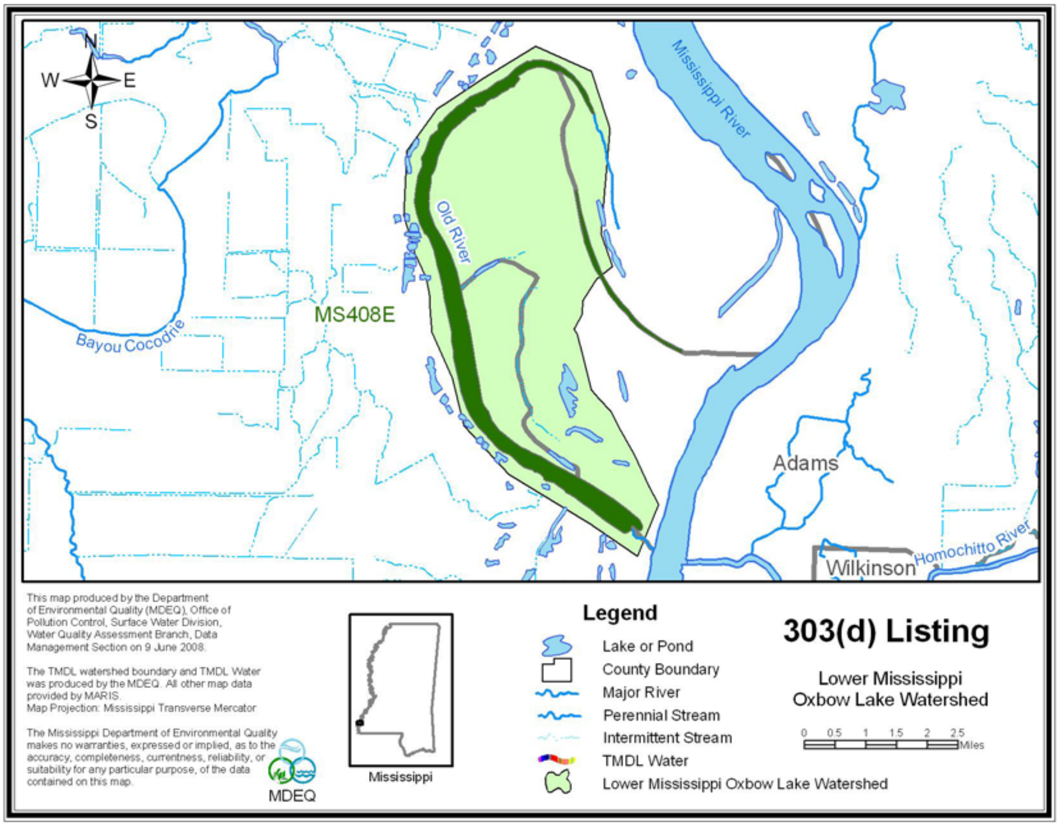


Figure 5. Location of Segment MS408E

2.0 TMDL ENDPOINT AND WATER QUALITY ASSESSMENT

2.1 Selection of a TMDL Endpoint and Critical Condition

One of the major components of a TMDL is the establishment of target endpoints, which are used to evaluate the attainment of acceptable water quality. Target endpoints, therefore, represent the water quality goals that are to be achieved by meeting the load and wasteload allocations specified in the TMDL. The endpoints allow for a comparison between observed conditions and conditions that are expected to restore designated uses.

There is an acceptable range of sediment loadings at the effective discharge of each water body that is a tributary to the oxbow lakes included in this TMDL. The acceptable range was developed from suspended sediment concentration (SSC) data measured at stable streams in the same ecoregion(s). The target range for the tributaries is 0.0004 to 0.0018 tons per acre per day at the effective discharge. The effective discharge is the discharge which moves the most sediment, or is the channel-forming flow. This discharge has been selected as the critical condition for this TMDL (Simon, et al., 2002b). If the sediment target applicable for sediment in the tributaries is maintained during critical conditions, then the health of the stream should improve and the sediment loading to the oxbow lakes will be controlled.

3.0 SOURCE ASSESSMENT and LOAD ESTIMATION

An important part of the TMDL analysis is the identification of individual sources, source categories, or source subcategories of sedimentation in the watershed and the amount of pollutant loading contributed by each of these sources. Under the CWA, sources are broadly classified as either point or nonpoint sources. Under 40 CFR §122.2, a point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The National Pollutant Discharge Elimination System (NPDES) program regulates point source discharges. Point sources can be described by two broad categories: 1) NPDES regulated municipal and industrial wastewater treatment plants (WWTPs) and 2) NPDES regulated industrial activities, which include construction activities and municipal storm water discharges (Municipal Separate Storm Sewer Systems [MS4s]). For the purposes of this TMDL, all sources of sediment loading not regulated by NPDES permits are considered nonpoint sources.

3.1 Assessment of Point Sources

There are no facilities with NPDES permits in this watershed. The TSS component of a NPDES permitted facility is different from the pollutant addressed within this TMDL. The TSS component of the permitted discharges is generally composed more of organic material, and therefore, provides less direct impact on the biologic integrity of a stream (through settling and accumulation) than would stream sedimentation due to soil erosion during wet weather events. The pollutant of concern for this TMDL is sediment from landuse runoff and in-channel processes.

Sediment loadings from NPDES regulated construction activities and MS4s are considered point sources of sediment to surface waters. These discharges occur in response to storm events and are included in the WLA portion of this TMDL. As of March 2003, discharge of storm water from construction activities disturbing more than one acre must obtain an NPDES permit. The purpose of the NPDES permit is to eliminate or minimize the discharge of pollutants (sediment) from construction activities. Since construction activities at a site are of a temporary, relatively short term nature, the number of construction sites covered by the general permit varies. The target for these areas is the same range as the TMDL target for the watershed. The WLAs provided to the NPDES regulated construction activities and MS4s will be implemented as BMPs as specified in Mississippi's General Stormwater Permits for Small Construction, Construction, and Phase I & II MS4 permits. Properly designed and well-maintained BMPs are expected to provide attainment of water quality standards.

There are no MS4 permits within Lower Mississippi River Basin in this oxbow lake watershed.

3.2 Assessment of Nonpoint Sources

Nonpoint loading of sediment in a water body results from the transport of the material into receiving waters by the processes of mass wasting, head cutting, gullying, and sheet and rill erosion. The tributaries receive sediment as a result of these processes and a portion of that sediment is transported to the oxbow lakes.

Sources of sediment include:

- Agriculture
- Aquaculture
- Silviculture
- Construction sites
- Roads
- Urban areas
- Gullies
- Surface mining
- In-channel and instream sources
- Historical landuse activities and channel alterations

The oxbow lake drainage areas all lie within the delta region of the Lower Mississippi River Basin. While the delta region does contain many different landuse types, including forest, cropland, pasture, and urban areas, the dominant landuse within the delta region is agriculture. Table 1 and Figure 8 provide landuse distribution information for the delta region of the Lower Mississippi River Basin.

The landuse information for the region is based on the State of Mississippi's Automated Resource Information System (MARIS), 1997. This data set is based on Landsat Thematic Mapper digital images taken between 1992 and 1993. The MARIS data are classified on a modified Anderson level one and two system with additional level two wetland classifications.

Table 5. Delta Region of the Lower Mississippi River Basin Landuse Distribution (in acres)

Urban	Forest	Cropland	Pasture/Grass	Scrub/Barren	Wetland	Water	Total

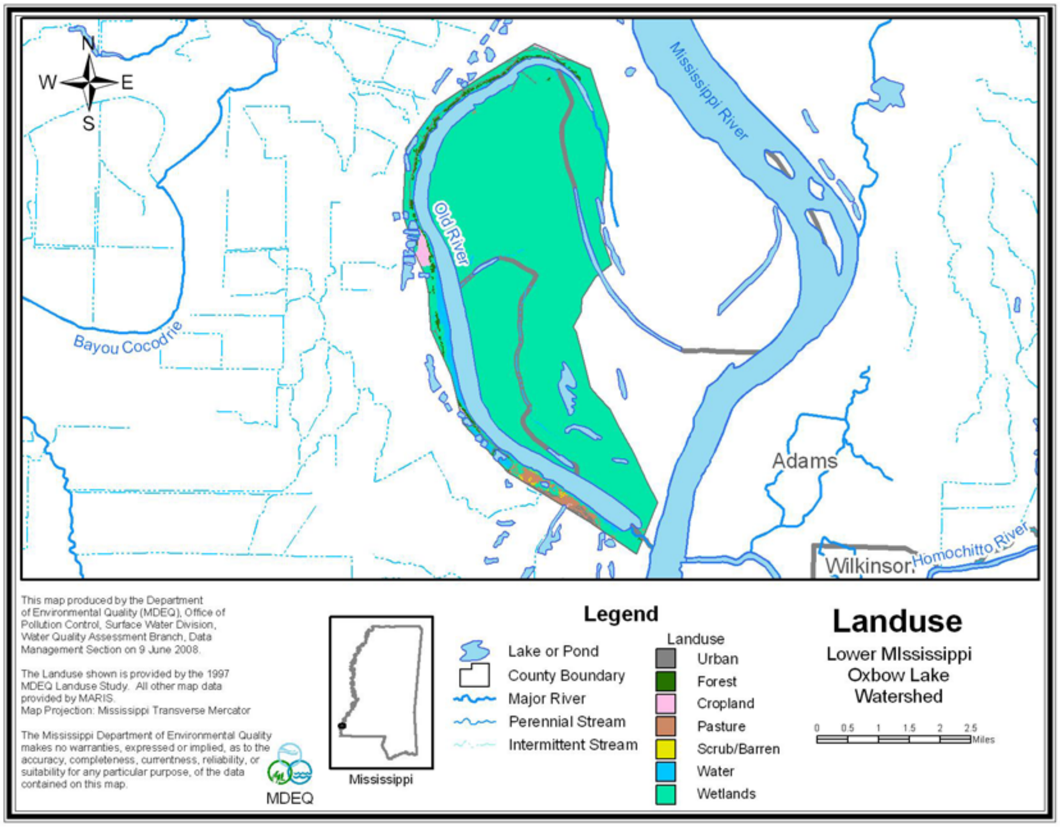


Figure 6. Lower Mississippi River Basin Landuse Distribution

3.3 Existing Load Estimation

Due to lack of data for calibration it was determined that a modeling exercise to quantify the load from each source and estimate the total existing load would be ineffective. Instead an ecoregion approach was utilized to estimate existing load ranges to the tributaries of the oxbow lakes. The CWPRU estimated the typical range for unstable streams within each level III ecoregion in the Lower Mississippi River Basin.

The unstable range for the tributaries within Ecoregion 73 is 0.002 to 0.054 tons per acre per day at the effective discharge.

Table 6. Unstable Stream Sediment Yield Ranges for Level III Ecoregions

Level III Ecoregion	Unstable Streams Sediment Yield Range*
Ecoregion 73	0.002 to 0.054

*tons per acre per day at the effective discharge

4.0 DETERMINING THE TARGET SEDIMENT LOAD

The information and methodologies described in the following sections are based on research efforts conducted by the CWPRU of the National Sedimentation Laboratory in Oxford, Mississippi. The information and methodologies discussed were used to determine the yield ranges for stable streams within each level III ecoregion. If the target yields applicable for sediment in the tributaries is maintained during critical conditions, then the health of the stream should improve and the sediment loading to the oxbow lakes will be controlled.

The primary sources of the information presented in this section are:

- *Actual and Reference Sediment Yields for the James Creek Watershed – Mississippi* (Simon, et al., 2002a)
- *"Reference" and "Impacted" Rates of Suspended-Sediment Transport for Use in Developing Clean Sediment TMDLs: Mississippi and the Southeastern United States* (Simon, et al., 2002b)

4.1 Selecting a Reference Condition (Simon, et al., 2002a)

> Sediment loads (transport rates) in streams vary by orders of magnitude over time and by location. Controls such as geology and channel-boundary materials, land use, channel stability, and the type and timing of precipitation events make prediction of sediment loads difficult and complex. Still, in order to determine the amount of sediment that impairs a given waterbody (TMDL), one must first be able to determine the sediment load that would be expected in an unimpaired stream of a given type and location. However, baseline conditions of flow, sediment concentrations, and transport rates for streams in the wide variety of physiographic provinces and under a wide variety of land uses are poorly understood.
>
> There is no reason to assume that "natural" or background rates of sediment transport will be consistent from one region to another. Within the context of clean sediment TMDLs, it follows that there is no reason to assume that "target" values should be consistent on a nationwide basis. Similarly, there is no reason to assume that channels within a given region will have consistent rates of sediment transport. For example, unstable channel systems or those draining disturbed watersheds will produce and transport more sediment than stable channel systems in the same region. This reflects differences in the magnitude and perhaps type of erosion processes that dominate a subwatershed or stream reach.
>
> To be useful for TMDL practitioners sediment transport relations must be placed within a conceptual and analytic framework such that they can be used to address sediment-related problems at sites where no such data exist. To accomplish this, sediment transport characteristics and relations need to be regionalized according to attributes of channels and drainage basins that are directly related to sediment production, transport, and potential impairment. In a general way, these attributes include among others, physiography, geology, climate and ecology, differentiated collectively as an ecoregion.

In order to identify those sediment transport conditions that represent impacted or impaired conditions, it is essential to first be able to define a non-disturbed, stable, or "reference" condition for the particular stream reach. In some schemes the "reference" condition simply means "representative" of a given category of classified channel forms or morphologies and as such, may not be analogous with a "stable", "undisturbed", or "background" rate of sediment production and transport.

The Rosgen (1985) stream classification system is widely used to describe channel form. In this classification system, stream types D, F, and G are by definition, unstable (Rosgen, 1996). These stream reaches, therefore, would be expected to produce and transport enhanced amounts of sediment and represent "impacted", if not "impaired" conditions. Thus, although it may be possible to define a "representative" reach of stream types D, F, and G, for the purpose of TMDL development, a "reference" condition transporting "natural" or "background" rates of sediment will be difficult to find.

As an alternative scheme for TMDL practitioners, the channel evolution framework set out by Simon and Hupp (1986) is proposed (Figure 3). In most alluvial channels, disruption of the dynamic equilibrium generally results in a certain degree of upstream channel degradation and downstream aggradation. If the predisturbed channel is considered as the initial stage (stage I) of channel evolution and the disrupted channel as an instantaneous condition (stage II), rapid channel degradation can be considered stage III. Degradation flattens channel gradients and consequently reduces the available stream power for given discharges with time. Concurrently, bank heights are increased and bank angles are often steepened by fluvial undercutting and by pore-pressure induced bank failures near the base of the bank. Thus, the degradation stage (stage III) is directly related to destabilization of the channel banks and to channel widening by mass-wasting processes (stage IV) once bank heights and angles exceed the critical conditions of the bank material (as determined by shear-strength characteristics).

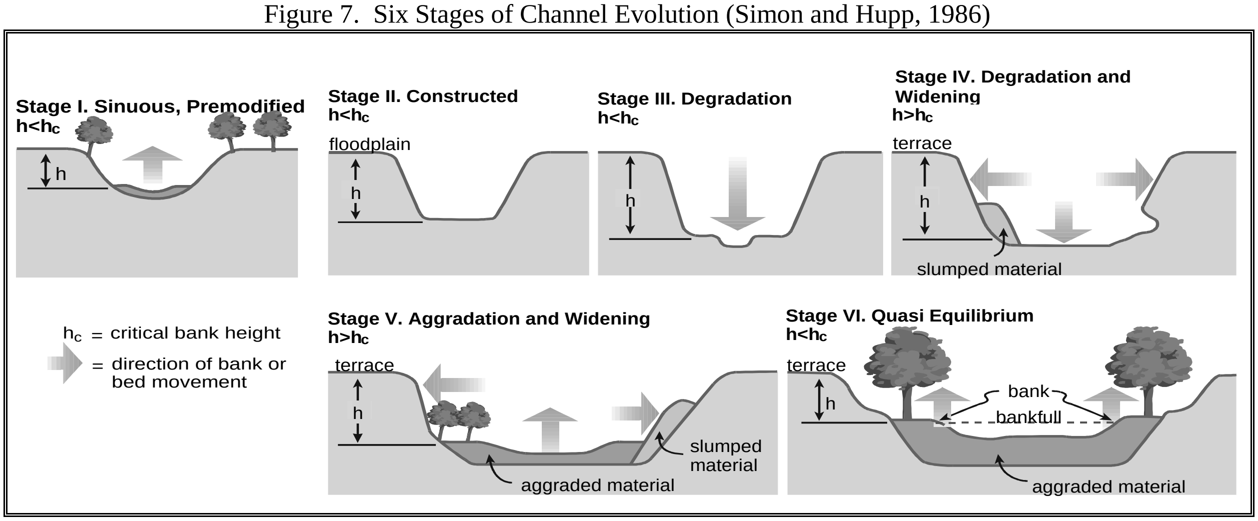
As degradation migrates further upstream, aggradation (stage V) becomes the dominant trend in previously degraded downstream sites because the flatter gradient and lower hydraulic radius at the degraded site cannot transport the heightened sediment loads originating from degrading reaches upstream. This secondary aggradation occurs at rates roughly 60% less than the associated degradation rate (Simon and Hupp, 1992). These reduced aggradation rates indicate that bed-level recovery will not be complete and that attainment of a new dynamic equilibrium will take place through (1) further channel widening, (2) the establishment of riparian vegetation that adds roughness elements and reduces the stream power for given discharges, and (3) further gradient reduction by meander extension and elongation.

The lack of complete bed-level recovery often results in a two-tiered channel configuration with the original floodplain surface becoming a terrace. Flood flows are, therefore, constrained within this enlarged channel below the terrace level.

Without proliferation of riparian vegetation within the channel, this results in a given flow having greater erosive power than if an equivalent flow could dissipate energy by spreading across the floodplain. Where vegetation does re-establish, the additional roughness limits the erosive power of flood events within the incised channel and constrains shear-stress values to near bankfull levels. Aggrading conditions (stage V) are also common in reaches downstream from the area of maximum disturbance immediately after the disturbance is imposed on the stream channel.

With stages of channel evolution tied to discrete channel processes and not strictly to specific channel shapes, they have been successfully used to describe systematic channel-stability processes over time and space in diverse environments subject to various disturbances such as stream response to: channelization in the Southeast US Coastal Plain; volcanic eruptions in the Cascade Mountains; and dams in Tuscany, Italy (Rinaldi and Simon, 1998). Because the stages of channel evolution represent shifts in dominant channel processes, they are systematically related to suspended-sediment and bed-material discharge (Simon, 1989; Kuhnle and Simon, 2000), fish-community structure, rates of channel widening (Simon and Hupp, 1992), and the density and distribution of woody riparian vegetation (Hupp, 1992).

Figure 7. Six Stages of Channel Evolution (Simon and Hupp, 1986)



An advantage of a process-based channel-evolution scheme for use in TMDL development is that Stages I and VI represent two true "reference" conditions. In some cases, channels are unlikely to recover to Stage I, pre-modified conditions. Stage VI, re-stabilized conditions are a more likely target under the present regional landuse and altered hydrologic regimes and can be used as a "reference" condition. However, in pristine areas where disturbances have not occurred or where they are far less severe, Stage I conditions can be used as a "reference" condition.

4.2 Analysis of Available Suspended-Sediment Data (Simon, et al., 2002a)

Analysis of suspended-sediment transport data involves establishing a relation between flow and sediment concentration or load. Instantaneous concentration data combined with either an instantaneous flow value or flow data representing the value obtained from the stage-discharge relation at 15-minute intervals are best. Mean daily values of both flow and sediment loads, which are readily available from the USGS, tend to be biased towards lower flows, particularly in flashy basins. For establishing sediment transport rating relations, instantaneous concentration and 15-minute flow data were used from USGS and ARS gauging station records.

Because the "effective discharge" is that discharge or range of discharges that shape channels and perform the most geomorphic work (transport the most sediment) over the long term, it can serve as a useful indicator of regional suspended-sediment transport conditions for "reference" and impacted sites. The effective discharge is obtained by combining flow frequency data with sediment transport relationships. In many parts of the United States, the effective discharge is approximately equal to the peak flow that occurs about every 1.5 years ($Q_{1.5}$) and may be analogous to the bankfull discharge in stable streams.

The recurrence interval for the effective discharge was calculated for 10 streams in Mississippi. Calculating the effective discharge is a matter of integrating a flow-frequency curve with a sediment transport rating to obtain the discharge (range of discharges) that transports the most sediment. This was accomplished at 10 sites where the complete 15-minute flow record was easily obtainable. For the 10 streams analyzed in Mississippi, the $Q_{1.5}$ is on average, a good approximation. Therefore, the $Q_{1.5}$ was used as a measure of establishing the effective discharge at all sites.

The effective discharge ($Q_{1.5}$) was determined for all sites where the instantaneous sediment concentration data were available. This discharge was then applied to the sediment transport relation to obtain the sediment load at the effective discharge. To normalize the data for differences in basin size, the sediment load was divided by drainage area to obtain sediment yield (in tons/acre/day).

4.3 Target Sediment Yields

Target values for suspended-sediment are based on the concept that stable channel conditions can be represented by channel evolution Stages I and VI. Therefore, the effective discharge sediment yields for Stage I and VI in a given ecoregion represent background or natural transport rates (Simon, et al., 2002b). The targeted sediment yield for an ecoregion is based on the sediment yield values obtained for Stage I and VI sites within that ecoregion. For this ecoregion, the targeted sediment yield range for the oxbow tributaries is 0.0004 to 0.0018 tons per acre per day at the effective discharge.

Table 7. Stable Stream Sediment Yield Ranges for Level III Ecoregions

Level III Ecoregion	Stable Streams Sediment Yield Range*
Ecoregion 73	0.0004 to 0.0018

*tons per acre per day at the effective discharge

5.0 ALLOCATION

The allocation for this TMDL involves a wasteload allocation (WLA) for permitted sources, a load allocation (LA) for unpermitted nonpoint sources, and an implicit margin of safety (MOS), which should result in attainment of water quality standards. According to 40 CFR §130.2 (i), TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure.

This TMDL is expressed as the tons of sediment that can be discharged from an acre of an oxbow lake watershed during a day (tons/acre/day) at the effective discharge of the oxbow tributaries and still attain the applicable water quality standard. It is appropriate to apply the same target yield to permitted (WLA) and unpermitted (LA) watershed areas. For load TMDLs the WLA and LA are summed to calculate the TMDL. Because this TMDL is expressed as a yield, as long as all activities, permitted or unpermitted, meet the same yield, the TMDL yield will be met, regardless of the relative load contribution.

The methods used to develop these values are described in detail in the reports titled, *"Reference" and "Impacted" Rates of Suspended-Sediment Transport for Use in Developing Clean Sediment TMDLs: Mississippi and the Southeastern United States* (Simon, et al., 2002b) and *Actual and Reference Sediment Yields for the James Creek Watershed – Mississippi* (Simon, et al., 2002a). It is important to remember that oxbow lakes fill in with sediment naturally over time. The goal of this TMDL is to promote best management practices to reduce anthropogenic sources of sediment that would accelerate the sediment transport to the oxbow lakes.

5.1 Wasteload Allocations

The TSS contribution from wastewater treatment facilities was considered negligible in the development of this TMDL. The TSS component of any NPDES permitted facility is different from the pollutant addressed within this TMDL. The pollutant of concern for this TMDL is sediment from landuse runoff and in-channel processes, consistent with discharges associated with construction activities and MS4s.

Sediment loadings from NPDES regulated construction activities are considered point sources of sediment to surface waters. These discharges occur in response to storm events and are included in the WLA of this TMDL as the same target yield as the TMDL of 0.0004 to 0.0018 tons per acre per day at the effective discharge for each waterbody.

5.2 Load Allocations

The LA developed for this TMDL is an estimation of the acceptable contribution of all nonpoint sources in the watershed. Channel processes and upland sources both contribute to the sediment loading of the oxbow lakes and their tributaries. Examples of potential nonpoint sources of sediment include agricultural activities, silviculture activities, surface mining activities, gullies, in-channel and instream sources, roads, and construction activities not regulated by NPDES permits.

Mississippi has a voluntary (non-regulated) BMP program for forestry. The program began in 1988 when MDEQ requested that the Mississippi Forestry Commission (MFC) coordinate the development of voluntary BMPs for forestry in Mississippi. The BMP guidelines were approved by MDEQ and EPA Region 4. These guidelines have been published in the handbook, *Mississippi's BMPs: Best Management Practices for Forestry in Mississippi* (MFC, 2000). Forested areas that are subject to silviculture activities may exhibit elevated sediment contributions if voluntary BMPs for forestry in Mississippi are not implemented.

MFC recently conducted the 2003 BMP Implementation Survey in November 2002 through July 2003. A total of 258 sites having recent silviculture activity were randomly selected to evaluate the voluntary implementation of BMPs. These sites were also evaluated for the presence of a significant risk to water quality. The results of the survey indicated that 89% of the BMPs applicable to the survey sites were implemented in accordance with the BMP handbook (MFC, 2004).

BMPs, as outlined in *Mississippi's BMPs: Best Management Practices for Forestry in Mississippi* (MFC, 2000), *Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater* (MDEQ, et. al, 1994), and *Field Office Technical Guide* (NRCS, 2000) would be the most effective means of reducing the load from a majority of potential upland sources.

For the water bodies within the delta region of the Lower Mississippi River Basin to attain the applicable narrative water quality standard for sediment, the allowable range of sediment loads is 0.0004 to 0.0018 tons per acre per day at the effective discharge of the tributaries to the oxbow lakes. If the target yields applicable for sediment in the tributaries is maintained during critical conditions, then the health of the stream should improve and the sediment loading to the oxbow lakes will be controlled.

5.3 Incorporation of a Margin of Safety (MOS)

The two types of MOS development are to implicitly incorporate the MOS using conservative assumptions or to explicitly specify a portion of the total TMDL as the MOS. The MOS selected for this TMDL is implicit. The use of conservative procedures provides a sufficient implicit MOS. These conservative procedures include the use of a stable stream as the target and the use of the effective discharge flow, the flow that produces the most sediment transport.

5.4 Calculation of the TMDL

As stated above, the pollutant of concern for this TMDL is sediment from landuse runoff and in-channel processes. The LA includes the contributions from the channel and surface runoff from the watershed. The MOS for this TMDL is implicit and derived from the conservative assumptions incorporated into this methodology. This TMDL, expressed as an acceptable range of sediment yields, is the same for the WLA, LA, and TMDL. For load TMDLs the WLA and LA are summed to calculate the TMDL. Because this TMDL is expressed as a yield, as long as all activities, permitted or unpermitted, meet the same yield as shown in Table 4, the TMDL yield will be met, regardless of the relative load contribution.

Table 8. TMDL Yields

Parameter	WLA	LA	MOS	TMDL
Sediment	0.0004 to 0.0018*	0.0004 to 0.0018*	Implicit	0.0004 to 0.0018*

*tons per acre per day at the effective discharge

5.5 Seasonality

The use of data collected throughout the year at multiple stations in each ecoregion to set the target addresses seasonal variation. Instantaneous flow and suspended-sediment data were used to develop the TMDL targets for each ecoregion. These data were collected throughout the year and would account for all seasons of the calendar year, changing atmospheric conditions (including rainy and dry seasons and high and low temperatures), and the periods representative of critical conditions.

6.0 CONCLUSION

The acceptable range of sediment yields for stable water bodies within the delta region of the Lower Mississippi River Basin was estimated to be 0.0004 to 0.0018 tons per acre per day at the effective discharge. The estimated existing range for unstable water bodies is 0.002 to 0.054 tons per acre per day at the effective discharge. The estimated existing range is larger than the TMDL range. Therefore, it is recommended that tributaries to these oxbow lakes be considered a priority for streambank and riparian buffer zone restoration and any sediment reduction BMPs, especially for the road crossings, agricultural activities, and construction activities. The implementation of these BMP activities should reduce the sediment load rate to the oxbow lakes. The reduction of the sediment load to water bodies to equal that of a relatively stable stream will allow the oxbow lakes to naturally approach their useable life span with minimumized impact from anthropogenic sources. This will provide improved habitat for the support of aquatic life in the water bodies and will result in the attainment of the applicable water quality standards.

6.1 Future Activities

MDEQ has adopted the Basin Approach to Water Quality Management, a plan that divides Mississippi's major drainage basins into five groups. During each yearlong cycle, MDEQ resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Lower Mississippi River Basin, the water bodies included in this TMDL may receive additional monitoring to identify any changes or improvements in water quality. MDEQ recommends that any monitoring conducted in conjunction with the implementation of BMPs in this watershed be analyzed for SSC to ensure consistency with the TMDL target. For land disturbing activities related to silviculture, construction, and agriculture, it is recommended that practices, as outlined in *Mississippi's BMPs: Best Management Practices for Forestry in Mississippi* (MFC, 2000), *Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater* (MDEQ, et. al, 1994), and *Field Office Technical Guide* (NRCS, 2000) be followed, respectively.

6.2 Public Participation

This TMDL will be published for a 30-day public notice. During this time, the public will be notified by publication in both a statewide and local 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 to those members of the public who have requested to be included on a TMDL mailing list. TMDL mailing list members may request to receive the TMDL reports through either, email or the postal service. Anyone wishing to become a member of the TMDL mailing list should contact Kay Whittington at (601)961-5729 or Kay_Whittington@deq.state.ms.us.

At the end of the 30-day period, MDEQ will determine the level of interest in the TMDL and make a decision on the necessity of holding a public meeting. All comments received during the public notice period and at any public meeting become a part of the record of this TMDL. All comments will be considered in the ultimate completion of this TMDL for submission of this TMDL to EPA Region 4 for final approval.

ABBREVIATIONS

ARS ..... Agricultural Research Service

BMP ..... Best Management Practice

CWA ..... Clean Water Act

CWPRU ..... Channel and Watershed Processes Research Unit

EPA ..... Environmental Protection Agency

HUC ..... Hydrologic Unit Code

LA ..... Load Allocation

MARIS ..... Mississippi Automated Resource Information Service

MDEQ ..... Mississippi Department of Environmental Quality

MFC ..... Mississippi Forestry Commission

MOS ..... Margin of Safety

MS4 ..... Municipal Separate Storm Sewer System

NPDES ..... National Pollution Discharge Elimination System

NRCS ..... Natural Resource Conservation Service

NSL ..... National Sedimentation Laboratory

SSC ..... Suspended Sediment Concentration

TMDL ..... Total Maximum Daily Load

TSS ..... Total Suspended Solids

USGS ..... United States Geological Survey

WLA ..... Wasteload Allocation

WWTP ..... Wastewater Treatment Plant

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