FINAL REPORT
January 2007
ID: 107012302

Total Maximum Daily Load

Biological Impairment Due to

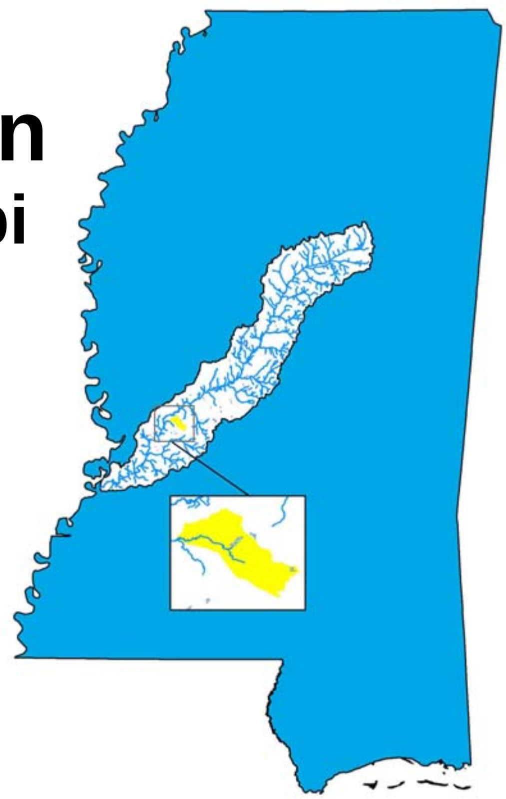
Nutrients and Organic Enrichment/Low Dissolved Oxygen

For

Cox Creek

Big Black River Basin

Hinds 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.

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	:	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

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Table 1. Listing Information

Name	ID	County	HUC	Cause	Stressors
Cox Creek	MS437E	Hinds	08060201	Biological Impairment	Nutrients and Organic Enrichment / Low Dissolved Oxygen
Location: Near Youngton from headwaters to confluence with Porter Creek					

Table 2. Water Quality Standards

Parameter	Beneficial use	Water Quality Criteria
Nutrients	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.
Dissolved Oxygen	Aquatic Life Support	DO 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

Table 3. Total Maximum Daily Load for Nutrients

Stream Name		WLA lbs/day	LA lbs/day	MOS	TMDL lbs/day
Cox Creek	TP	0.0	7.9 – 13.2	Implicit	7.9 – 13.2
Cox Creek	TN	0.0	79.2– 92.5	Implicit	79.2– 92.5
Cox Creek	TBODu	0.0	0.0	Implicit	0.0

EXECUTIVE SUMMARY

This TMDL has been developed for Cox Creek which was placed on the Mississippi 1996 Section 303(d) List of Impaired Water Bodies due to evaluated causes of nutrients and organic enrichment / low dissolved oxygen. MDEQ completed biological monitoring on Cox Creek, which indicated biological impairment. It was determined that the biological impairment is most likely due to nutrients, organic enrichment and low dissolved oxygen and sediment. (MDEQ, 2006) Sediment will be addressed in a separate TMDL report. This TMDL addresses organic enrichment/ low DO and nutrients and will provide an estimate of the total nitrogen (TN) and total phosphorus (TP) in the stream.

Mississippi does not have water quality standards for allowable nutrient concentrations. MDEQ currently has a Nutrient Task Force (NTF) working on the development of criteria for nutrients. An annual concentration range of 0.6 to 0.7 mg/l is an applicable target for TN and 0.06 to 0.10 mg/l for TP for water bodies located in Ecoregion 65. MDEQ is presenting these ranges as preliminary target values for TMDL development which are subject to revision after the development of numeric nutrient criteria by the NTF.

The Cox Creek Watershed is located in northern Mississippi in HUC 08060202. Cox Creek begins in Hinds County near Youngton and flows for approximately 10 miles in a northwestern direction from its headwaters to its confluence with Porter Creek. The stream is shown in Figures 1 and 2.

Because the critical 7Q10 flow of Cox Creek is zero, a predictive model was not needed to determine that this stream is not an appropriate receiving water body for waste water effluent. The TBODu TMDL was set to zero. The limited nutrient data indicates reductions of nutrient loads are needed.

Figure 1. Cox Creek near Vaiden

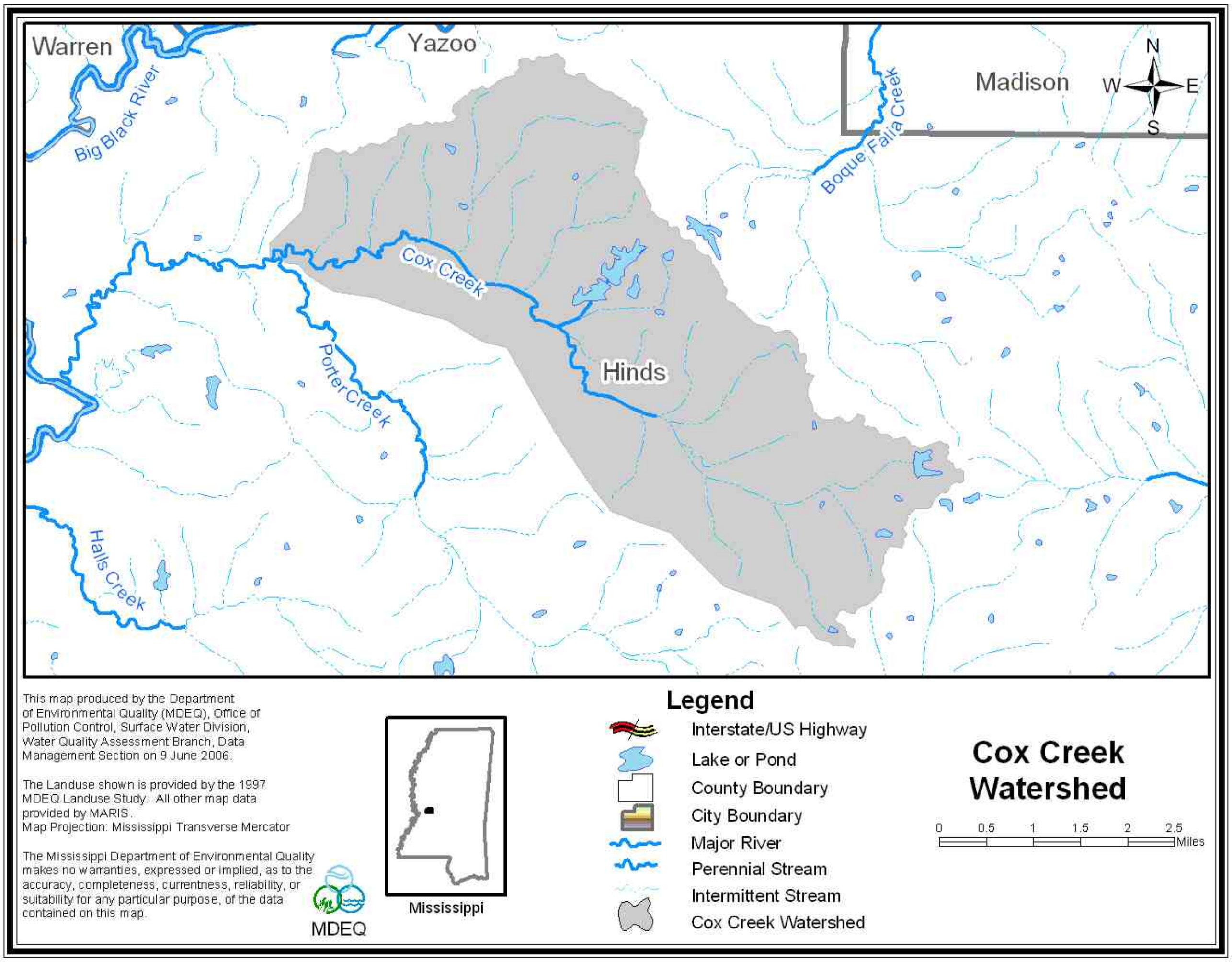

Figure 2. Cox Creek Watershed

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 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 impaired water bodies through the establishment of pollutant specific allowable loads. This TMDL has been developed for the 2004 §303(d) listed segment shown in Figure 3.

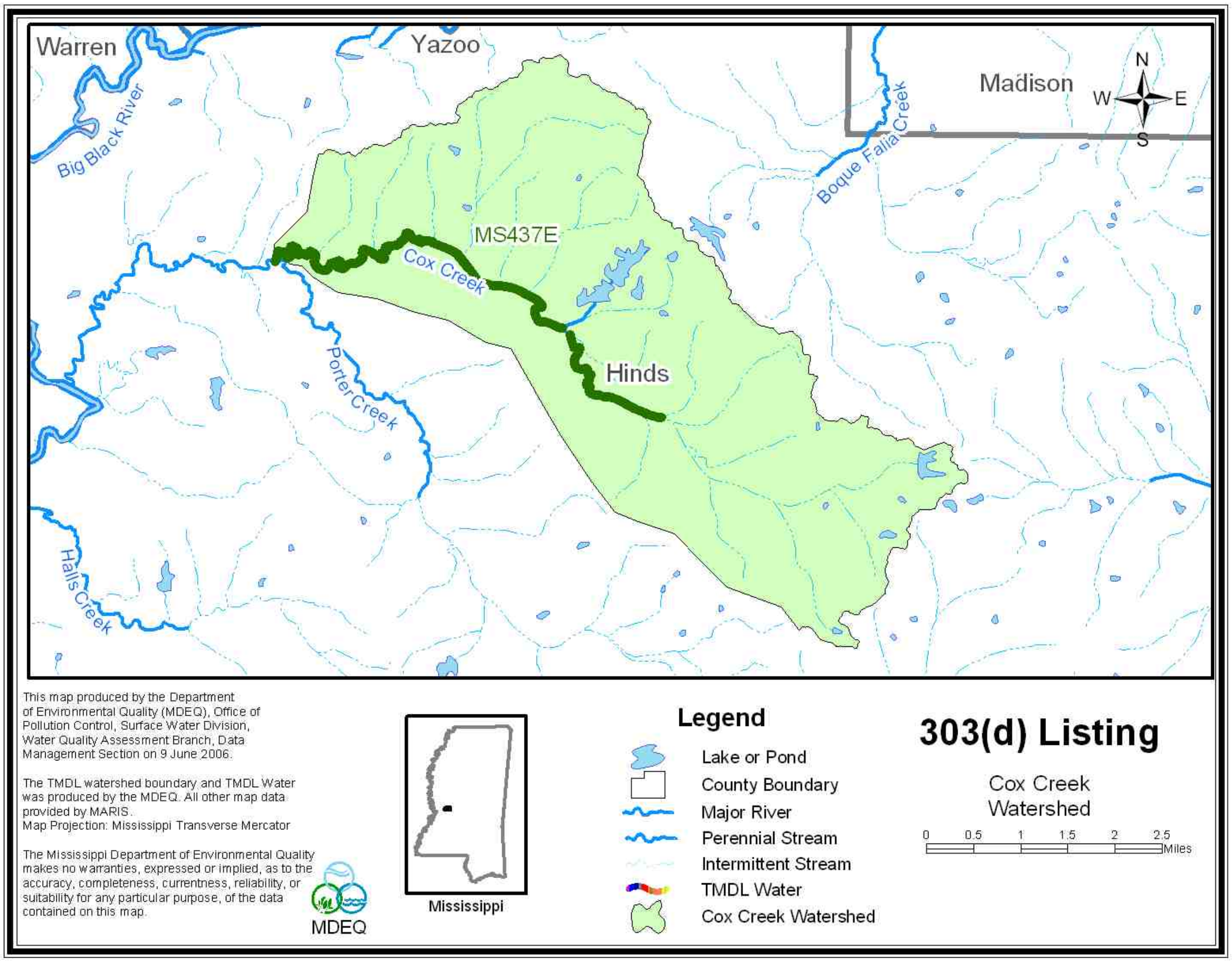

Figure 3. Cox Creek §303(d) Listed Segment

Cox Creek was originally included in the listing for Porter-Cox Creeks – DA (MS437E) on the 1996 List. The listing was split into two separate water bodies on the 2002 List. There were no monitoring data, so the stream remained on the evaluated portion of Mississippi's §303(d) list. MDEQ began a biological monitoring program, the M-BISQ, to monitor this and other evaluated streams to confirm water quality based on the health of the biology in the stream. Cox Creek was confirmed as impaired based on the biology.

1.2 Stressor Identification

The impaired segment was listed due to failure to meet minimum water quality criteria for aquatic use support based on biological sampling (MDEQ, 2003). Because of these results, a detailed assessment of the watershed and potential pollutant sources, called a stressor identification report, was developed for this stream. The purpose of a stressor identification report is to identify the stressors and their sources most likely causing degradation of instream biological conditions. The report indicated that sediment, nutrients, and organic enrichment were the most likely stressors for Cox Creek (MDEQ, 2006).

There are no state criteria in Mississippi for nutrients. These criteria are currently being developed by the Mississippi Nutrient Task Force in coordination with EPA Region 4. MDEQ proposed a work plan for nutrient criteria development that has been approved by EPA and is on schedule according to the approved plan in development of nutrient criteria (MDEQ, 2004). Data were collected for wadeable streams to calculate the nutrient criteria.

For this TMDL, MDEQ is presenting preliminary target ranges for TN and TP. An annual concentration range of 0.6 to 0.7 mg/l is an applicable target for TN and 0.06 to 0.10 mg/l for TP for water bodies located in Ecoregion 65. However, MDEQ is presenting these ranges as 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.

1.3 Applicable Water Body Segment Use

The water use classifications are established by the State of Mississippi in the document *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* (MDEQ, 2003). The designated beneficial use for the listed is fish and wildlife.

1.4 Applicable Water Body Segment Standard

The water quality standard applicable to the use of the water body and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* (MDEQ, 2003).

Mississippi's current standards contain a narrative criteria that can be applied to nutrients which states "*Waters shall be free from materials attributable to municipal, industrial, agricultural, or other discharges producing color, odor, taste, total suspended or dissolved solids, sediment, turbidity, 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 use* (MDEQ, 2002)." In the 1999 Protocol for Developing Nutrient TMDLs, EPA suggests several methods for the development of numeric criteria for nutrients (USEPA, 1999). In accordance with the 1999 Protocol, "The target value for the chosen indicator can be based on: comparison to similar but unimpaired waters; user surveys; empirical data summarized in classification systems; literature values; or professional judgment." MDEQ believes the most economical and scientifically defensible method for use in Mississippi is a comparison between similar but unimpaired waters within the same region. This method is dependent on adequate data which are being collected in accordance with the EPA approved plan. The initial phase of the data collection process for wadeable streams is complete.

1.5 Nutrient Target Development

Nutrient data were collected quarterly at 99 discrete sampling stations state wide where biological data already existed. These stations were identified and used to represent a range of stream reaches according to biological health status, geographic location (selected to account for ecoregion, bioregion, basin and geologic variability) and streams that potentially receive non-point source pollution from urban, agricultural, and silviculture lands as well as point source pollution from NPDES permitted facilities.

Nutrient concentration data were not normally distributed; therefore, data were log transformed for statistical analyses. Data were evaluated for distinct patterns of various data groupings (stratification) according to natural variability. Only stations that were characterized as “least disturbed” through a defined process in the M-BISQ process (M-BISQ 2003) or stations that resulted in a biological impairment rating of “fully attaining” were used to evaluate natural variability of the data set. Each of these two groups was evaluated separately (“least disturbed sites” and “fully attaining sites). Some stations were used in both sets, in other words, they were considered “least disturbed” and “fully attaining”. The number of stations considered “least disturbed” was 30 of 99, and the number of stations considered “fully attaining” was 53 of 99.

Several analysis techniques were used to evaluate nutrient data. Graphical analyses were used as the primary evaluation tool. Specific analyses used included; scatter plots, box plots, Pearson’s correlation, and general descriptive statistics.

In general, natural nutrient variability was not apparent based on box plot analyses according to the 4 stratification scenarios. Bioregions were selected as the stratification scheme to use for TMDLs in the Pascagoula Basin. However, this was not appropriate for some water bodies in smaller bioregions. Therefore, MDEQ now uses ecoregions as a stratification scheme for the water bodies in the remainder of the state.

In order to use the data set to determine possible nutrient thresholds, nutrient concentrations were evaluated as to their correlation with biological metrics. That thorough evaluation was completed prior to the Pascagoula River Basin TMDLs. The methodology and approach were verified. The same methodology was applied to the subsequent bioregions and ecoregions.

For the preliminary target concentration range for each ecoregion, the 75th and 90th percentiles were derived from the mean nutrient value at each site found to be fully supporting of aquatic life support according to the M-BISQ scores. For the estimate of the existing concentrations the 50th percentile (median) was derived from the mean nutrient value at each site of sites that were not attaining and had nutrient concentrations greater than the target.

WATER BODY ASSESSMENT

2.1 Cox Creek Water Quality Data

TN and TP data for the Cox Creek Watershed were gathered and reviewed. Data exist for the §303(d)-listed segment of Cox Creek based on samples collected in the creek at M-BISQ Site # 299. This site, located upstream of U.S. Highway 430, is identified as Cox Creek near Vaiden. The location of the monitoring station is shown in Figure 4. The data for this station are given in Table 4.

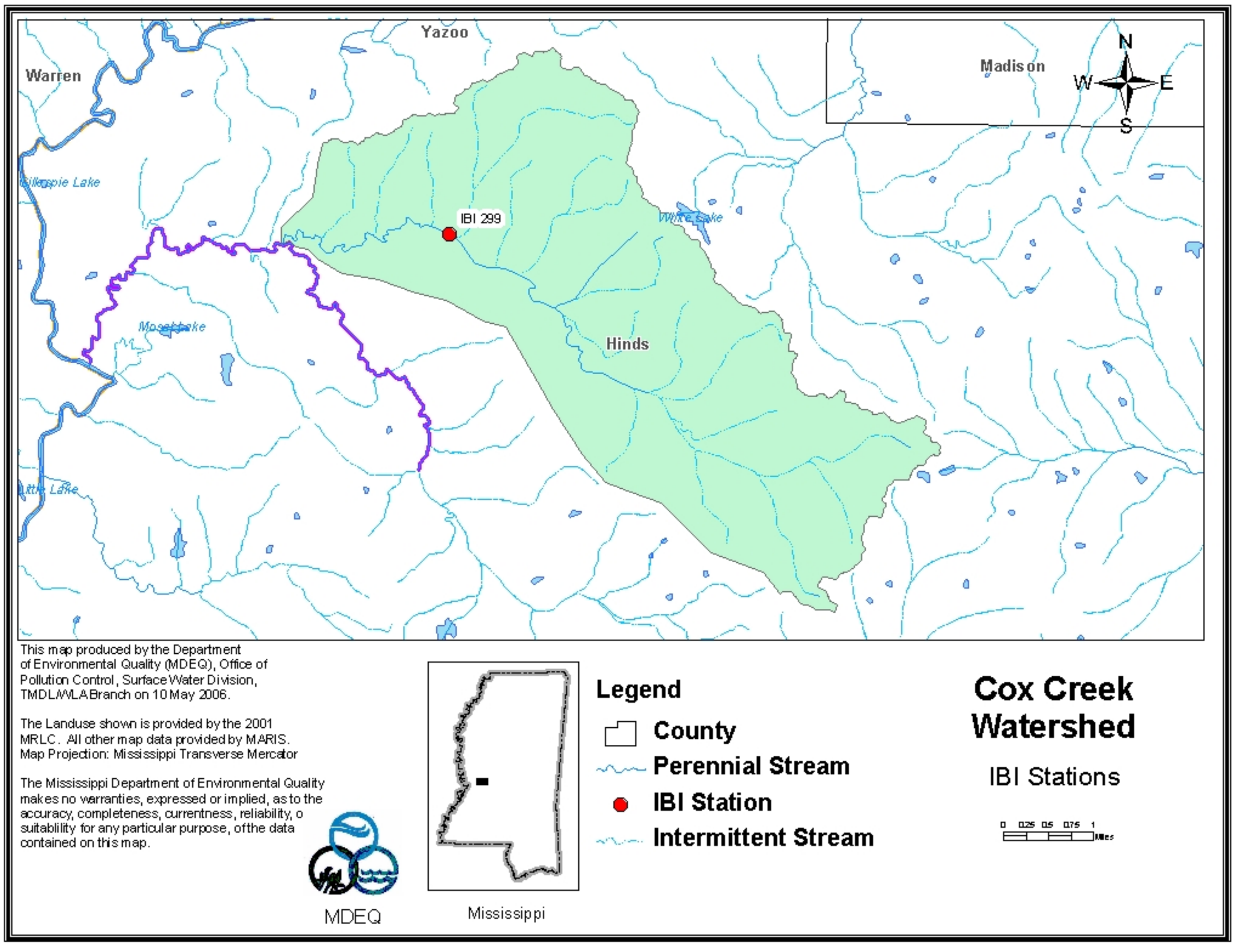

Figure 4. Cox Creek Monitoring Station

Table 4. Cox Creek Water Quality Data

Sample Date	Time	TN (mg/L)	TP (mg/L)
26-Aug-99	16:30	0.86	0.23
15-Jan-01	10:20	1.23	0.46
24-Jan-03	9:20	0.39	0.04

2.2 Assessment of Point Sources

There are no point sources in the watershed.

2.3 Assessment of Non-Point Sources

Non-point loading of nutrients and organic material in a water body results from the transport of the pollutants into receiving waters by overland surface runoff, groundwater infiltration, and atmospheric deposition. The two primary nutrients of concern are nitrogen and phosphorus. Total nitrogen is a combination of many forms of nitrogen found in the environment. Inorganic nitrogen can be transported in particulate and dissolved phases in surface runoff. Dissolved inorganic nitrogen can be transported in groundwater and may enter a stream from groundwater infiltration. Finally, atmospheric gaseous nitrogen may enter a stream from atmospheric deposition.

Unlike nitrogen, phosphorus is primarily transported in surface runoff when it has been sorbed by eroding sediment. Phosphorus may also be associated with fine-grained particulate matter in the atmosphere and can enter streams as a result of dry fallout and rainfall (USEPA, 1999). However, phosphorus is typically not readily available from the atmosphere or the natural water supply (Davis and Cornwell, 1988). As a result, phosphorus is typically the limiting nutrient in most non-point source dominated rivers and streams, with the exception of watersheds which are dominated by agriculture and have high concentrations of phosphorus contained in the surface runoff due to fertilizers and animal excrement or watersheds with naturally occurring soils which are rich in phosphorus (Thomann and Mueller, 1987).

Watersheds with a large number of failing septic tanks may also deliver significant loadings of phosphorus to a stream. All domestic wastewater contains phosphorus which comes from humans and the use of phosphate containing detergents. Table 5 presents typical nutrient loading ranges for various land uses.

Table 5. Nutrient Loadings for Various Land Uses

Landuse	Total Phosphorous [lb/acre-y]			Total Phosphorous [lb/acre-y]		
	Minimum	Maximum	Median	Minimum	Maximum	Median
Roadway	0.53	1.34	0.98	1.2	3.1	2.1
Commercial	0.61	0.81	0.71	1.4	7.8	4.6
Single Family-Low Density	0.41	0.57	0.49	2.9	4.2	3.6
Single Family-High Density	0.48	0.68	0.58	3.6	5.0	5.2
Multifamily Residential	0.53	0.72	0.62	4.2	5.9	5.0
Forest	0.09	0.12	0.10	1.0	2.5	1.8
Grass	0.01	0.22	0.12	1.1	6.3	3.7
Pasture	0.01	0.22	0.12	1.1	6.3	3.7

Source: Horner et al., 1994 in Protocol for Developing Nutrient TMDLs (USEPA 1999)

The drainage area of Cox Creek is approximately 11,449 acres or 17.9 square miles. The watershed contains many different landuse types, including forest, cropland, pasture, scrub/barren, water, and wetlands. The landuse information given below is based on data collected by 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. Pasture is the dominant landuse within this watershed. The landuse distribution for Cox Creek is shown in Table 6 and Figure 5.

Table 6. Landuse Distribution, Cox Creek Watershed

	Forest	Cropland	Pasture	Scrub/Barren	Water	Wetlands
Area (acres)	3538.6	1186.4	4214.8	2028.0	137.6	343.5
Percentage	30.9	10.4	36.8	17.7	1.2	3.0

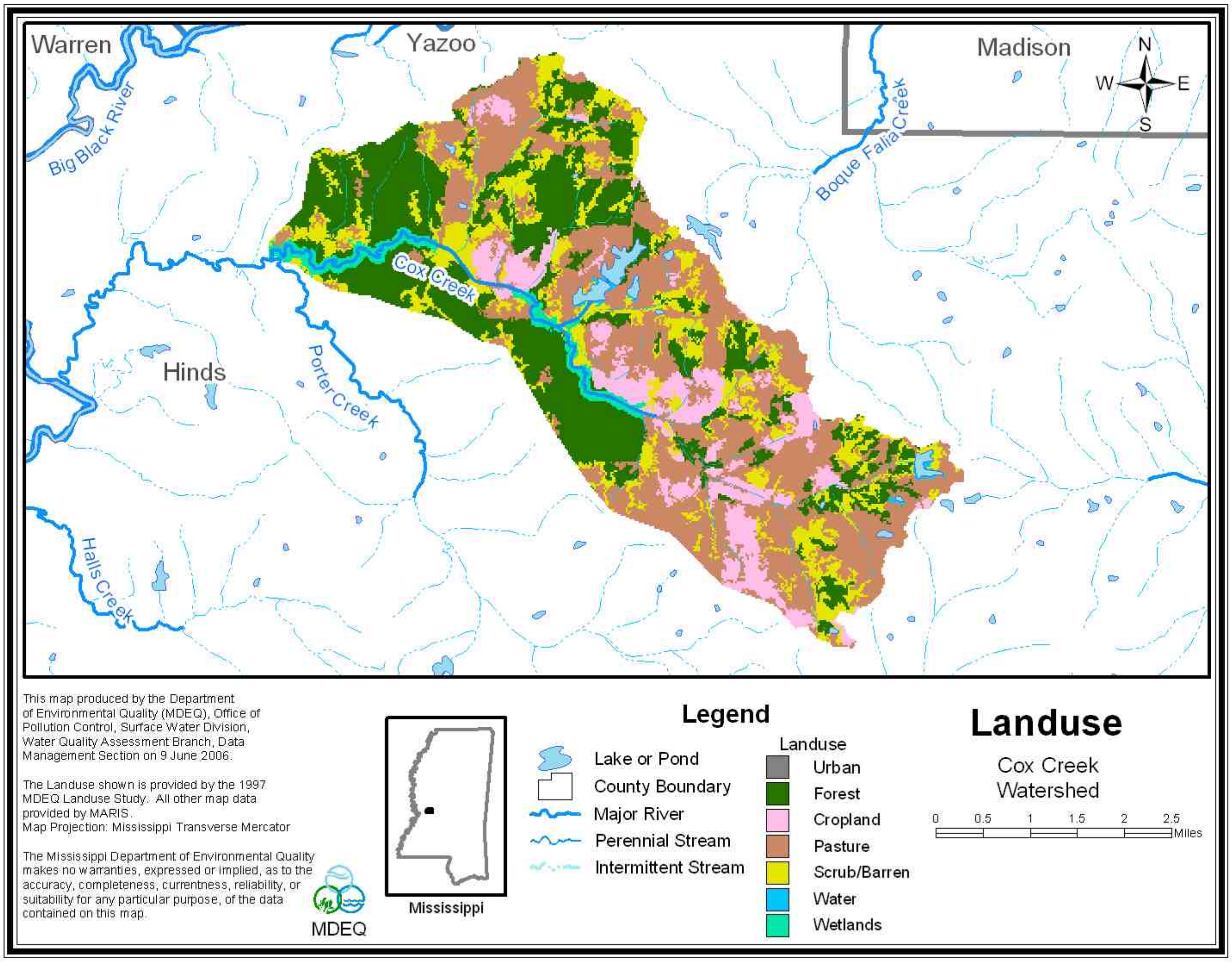

Figure 5. Landuse Distribution for the Cox Creek Watershed

2.4 Channelization of Cox Creek

It is noted that portions of Cox Creek have been considerably altered over the years. The original sinuous channel of Cox Creek was straightened by a local drainage district to prevent flooding. According to field notes taken by MDEQ during a recent stressor identification investigation, there are obvious impacts of channelization and heavy entrenching and ponding along the creek. Several eroded areas were observed with steep banks and unstable Loess soils and trees falling in at most sites. The aerial photograph shown in Figure 6 indicates that there is limited riparian vegetation and few trees along Cox Creek for bank stability and stream cover upstream of the IBI station. MDEQ recommends that Best Management Practices to reduce non-point sources of sediment and nutrients should be installed within the watershed to prevent the further aggradation of the creek and to promote restabilization of the channel.

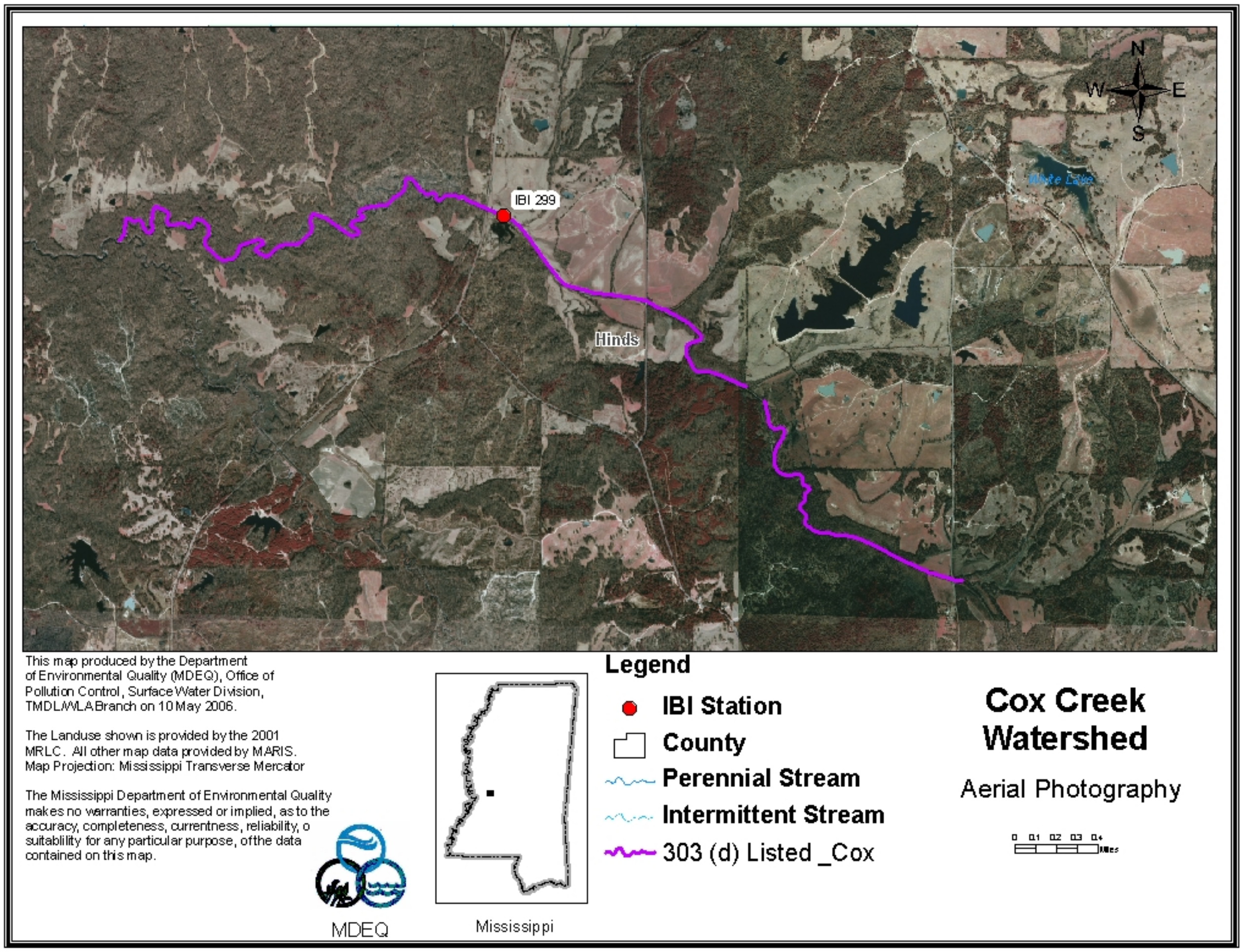

Figure 6. Aerial Photography for the Cox Creek Watershed

2.5 Estimated Existing Load for Total Phosphorous

The estimated existing total phosphorous concentration is based on the median total phosphorous concentrations measured in wadeable streams in Ecoregion 65 with impaired biology and elevated nutrients, which is 0.18 mg/l. The target concentration for TP for Ecoregion 65 is 0.06 to 0.10 mg/l. The average concentration found in this stream is 0.24 mg/L.

To convert the estimated existing total phosphorous concentration to a total phosphorous load, the average annual flow was estimated based on flow data from the USGS gage located on the Big Black River at Bovina, Mississippi (07290000). To estimate the amount of flow in the Cox Creek Drainage Area, a drainage area ratio was calculated (3853 cfs/2812 square miles = 1.37 cfs/square miles). The ratio was then multiplied by the drainage area in square miles of the impaired segment. The existing TP load was then calculated using Equation 1.

TP Load (lb/day) = Flow (cfs) * 5.394 (conversion factor)* TP Concentration (mg/L) (Eq. 1)

Table 7. Estimated Existing Total Phosphorous Load for Cox Creek

Stream	Area (sq miles)	Average Annual Flow (cfs)	TP (mg/l)	TP (lbs/day)
Cox Creek	17.9	24.5	0.18	23.8

2.6 Estimated Existing Load for Total Nitrogen

The estimated existing total nitrogen concentration is based on the median total nitrogen concentrations measured in wadeable streams in Ecoregion 65 with impaired biology and elevated nutrients, which is 1.38 mg/l. The target concentration for TN for Ecoregion 65 is 0.6 to 0.7 mg/l. The average concentration found in this stream is 0.83 mg/L.

To convert the estimated existing total nitrogen concentration to a total nitrogen load, the average annual flow was estimated based on flow data as shown above. The existing TN load was then calculated using Equation 1.

Table 8. Estimated Existing Total Nitrogen Load for Cox Creek

Stream	Area (sq miles)	Average Annual Flow (cfs)	TN (mg/l)	TN (lbs/day)
Cox Creek	17.9	24.5	1.38	182.4

ALLOCATION

The allocation for this TMDL involves a wasteload allocation and a load allocation for non-point sources necessary for attainment of water quality standards in Cox Creek. This TMDL is addressed through initial estimates of the existing and target TP and TN concentrations.

3.1 Wasteload Allocation

There are no point sources in the impaired segments. Therefore the waste load allocation has been set to zero for the TMDLs for TN, TP, and TBODu. Future permits will be considered in accordance with Mississippi's *Wastewater Regulations for National Pollutant Discharge Elimination System (NPDES) Permits, Underground Injection Control (UIC) Permits, State Permits, Water Quality Based Effluent Limitations and Water Quality Certification*.

3.2 Load Allocation

Best management practices (BMPs) should be encouraged in the watersheds to reduce potential nutrient loads from non-point sources. The watershed should be considered a priority for riparian buffer zone restoration and any nutrient reduction BMPs. 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.

3.3 Incorporation of a Margin of Safety

The margin of safety is a required component of a TMDL and accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving water body. The two types of MOS development are to implicitly incorporate the MOS using conservative model assumptions or to explicitly specify a portion of the total TMDL as the MOS. The MOS selected for this model is implicit.

3.4 Calculation of the TMDL

A predictive model was not used to calculate the dissolved oxygen TMDL due to the 7Q10 flow being zero. The TBODu TMDL has been set to zero. Equation 1 was used to calculate the TMDL for TN and TP. The target concentration was used with the average flow for the watershed to determine the TMDL. The TMDL was then compared to the estimated existing load previously calculated and the limited data available.

The total phosphorous estimations indicate needed reductions of 44% to 67%, and the limited data supports these reductions. The TMDL for TP is 7.9 – 13.2 lbs/day. The estimated existing load is 23.8 lbs/day.

The total nitrogen estimations indicate needed reductions of 49% to 56%, and the limited data supports these reductions. The TMDL for TP is 79.2 – 92.5 lbs/day. The estimated existing load is 182.4 lbs/day.

Table 9. TN, TP, and TBODu Total Maximum Daily Load based on Ecoregion Range

Stream	Area (sq miles)	Average Annual Flow (cfs)	Concentration (mg/l)	Load (lbs/day)
Cox TP	17.9	24.5	0.06 – 0.10	7.9 – 13.2
Cox TN	17.9	24.5	0. 6 – 0.7	79.2 – 92.5
Cox TBODu	17.9	24.5	0.0	0.0

3.5 Seasonality and Critical Condition

This TMDL accounts for seasonal variability by requiring allocations that ensure year-round protection of water quality standards, including during critical conditions.

CONCLUSION

Nutrients were addressed through an estimate of a preliminary total phosphorous and totall nitrogen concentration target range. Based on the estimated existing and target total phosphorous concentrations, this TMDL recommends a 44% to 67% reduction of the TP loads entering this stream to meet the preliminary target range of 0.06 to 0.10 mg/l. Based on the estimated existing and target total nitrogen concentrations, this TMDL recommends a 49% to 56% reduction of the TN loads entering this stream to meet the preliminary target range of 0. 60 to 0.70 mg/l. It is recommended that the Cox Creek drainage area be considered as a priority watershed for riparian buffer zone restoration and any nutrient reduction BMPs. The implementation of these BMP activities should reduce the nutrient load entering the creeks. This will provide improved water quality for the support of aquatic life in the water bodies and will result in the attainment of the applicable water quality standards.

4.1 Public Participation

This TMDL will be published for a 30-day public notice. During this time, the public will be notified by publication in the statewide newspaper. The public will be given an opportunity to review the TMDLs 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. Anyone wishing to become a member of the TMDL mailing list should contact Greg Jackson at Greg_Jackson@deq.state.ms.us.

All comments should be directed to Greg Jackson at Greg_Jackson@deq.state.ms.us or Greg Jackson, MDEQ, PO Box 10385, Jackson, MS 39289. All comments received during the public notice period and at any public hearings become a part of the record of this TMDL and will be considered in the submission of this TMDL to EPA Region 4 for final approval.

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