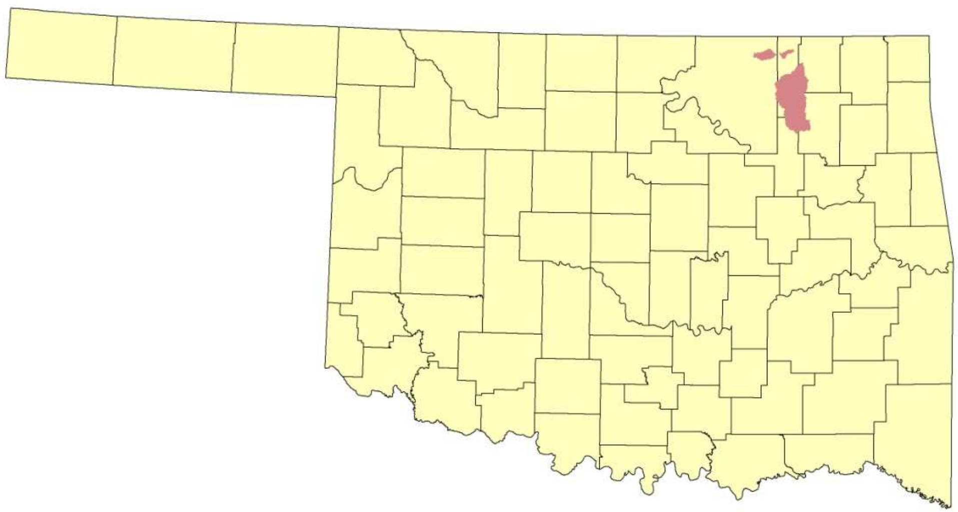
FINAL

BACTERIA AND TURBIDITY TOTAL MAXIMUM DAILY LOADS FOR STREAMS IN THE CANEY RIVER WATERSHED, OKLAHOMA



Prepared By:

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

SEPTEMBER 2010

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BACTERIA TOTAL MAXIMUM DAILY LOADS FOR STREAMS IN THE CANEY RIVER WATERSHED, OKLAHOMA

OKWBID

OK121400010010_00 - Caney River

OK121400010010_10 - Caney River

OK121400010300_00 - Hogshooter Creek

OK121400010270_00 - Curl Creek

OK121400020190_00 - Mission Creek

OK121400020140_00 - Little Caney River

OK121400010090_00 - Rabb Creek

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ACRONYMS AND ABBREVIATIONS

AEMS	Agricultural Environmental Management Service
ASAE	American Society of Agricultural Engineers
BMP	best management practice
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
cfs	Cubic feet per second
cfu	Colony-forming unit
CPP	Continuing planning process
CWA	Clean Water Act
DMR	Discharge monitoring report
IQR	interquartile range
LA	Load allocation
LDC	Load duration curve
LOC	line of organic correlation
mg	Million gallons
mgd	Million gallons per day
mg/L	microgram per liter
mL	Milliliter
MOS	Margin of safety
MS4	Municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
NTU	nephelometric turbidity unit
OLS	ordinary least square regression
O.S.	Oklahoma statutes
ODAFF	Oklahoma Department of Agriculture, Food and Forestry
ODEQ	Oklahoma Department of Environmental Quality
OPDES	Oklahoma Pollutant Discharge Elimination System
OSWD	Onsite wastewater disposal
OWRB	Oklahoma Water Resources Board
PBCR	Primary body contact recreation
PRG	Percent reduction goal
SSO	Sanitary sewer overflow
TMDL	Total maximum daily load
TSS	Total suspended solids
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WLA	Wasteload allocation
WQM	Water quality monitoring
WQS	Water quality standard
WWTP	Wastewater treatment plant

Executive Summary

This report documents the data and assessment used to establish TMDLs for the pathogen indicator bacteria [fecal coliform, *Escherichia coli (E. coli)*, Enterococci] and turbidity for certain waterbodies in the Caney River basin. Elevated levels of pathogen indicator bacteria in aquatic environments indicate that a waterbody is contaminated with human or animal feces and that a potential health risk exists for individuals exposed to the water. Elevated turbidity levels caused by excessive sediment loading and stream bank erosion impact aquatic communities. Data assessment and total maximum daily load (TMDL) calculations are conducted in accordance with requirements of Section 303(d) of the Clean Water Act (CWA, Water Quality Planning and Management Regulations (40 CFR Part 130), U.S. Environmental Protection Agency (USEPA) guidance, and Oklahoma Department of Environmental Quality (ODEQ) guidance and procedures. ODEQ is required to submit all TMDLs to USEPA for review and approval. Once the USEPA approves a TMDL, then the waterbody may be moved to Category 4a of a state's Integrated Water Quality Monitoring and Assessment Report, where it remains until compliance with water quality standards (WQS) is achieved (USEPA 2003).

The purpose of this TMDL report is to establish pollutant load allocations for indicator bacteria and turbidity in impaired waterbodies, which is the first step toward restoring water quality and protecting public health. TMDLs determine the pollutant loading a waterbody can assimilate without exceeding the WQS for that pollutant. TMDLs also establish the pollutant load allocation necessary to meet the WQS established for a waterbody based on the relationship between pollutant sources and instream water quality conditions. A TMDL consists of a wasteload allocation (WLA), load allocation (LA), and a margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources, and includes stormwater discharges regulated under the National Pollutant Discharge Elimination System (NPDES) as point sources. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. The MOS is a percentage of the TMDL set aside to account for the lack of knowledge associated with natural process in aquatic systems, model assumptions, and data limitations.

This report does not stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce bacteria or turbidity within each watershed. Watershed-specific control actions and management measures will be identified, selected, and implemented under a separate process.

E.1 Problem Identification and Water Quality Target

This TMDL report focuses on waterbodies in the Caney River Basin, identified in Table ES-1, that ODEQ placed in Category 5 [303(d) list] of the *Water Quality in Oklahoma, 2008 Integrated Report* (2008 Integrated Report) for nonsupport of primary body contact recreation (PBCR) or warm water aquatic community (WWAC).

Elevated levels of bacteria or turbidity above the WQS result in the requirement that a TMDL be developed. The TMDLs established in this report are a necessary step in the process to develop the pollutant loading controls needed to restore the primary body contact recreation or fish and wildlife propagation use designated for each waterbody.

Table ES- 1 Excerpt from the 2008 Integrated Report – Oklahoma 303(d) List of Impaired Waters (Category 5)

Waterbody ID	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*E. coli*	FC	Designated Use Primary Body Contact Recreation	Turbidity	Designated Use Warm Water Aquatic Life
OK121400010010_00	Caney River	18	2013	2	**X**			**N**	**X**	**N**
OK121400010010_10	Caney River	47	2013	2	**X**			**N**	**X**	**N**
OK121400010300_00	Hogshooter Creek	20	2016	3	**X**	**X**	**X**	**N**	**X**	**N**
OK121400010270_00	Curl Creek	17	2013	2	**X**			**N**	**X**	**N**
OK121400020190_00	Mission Creek	18	2019	3	**X**			**N**		
OK121400020140_00	Little Caney River	6	2019	4					**X**	**N**
OK121400010090_00	Rabb Creek	6	2013	2			**X**	**N**		

ENT = enterococci; FC = fecal coliform; N = Not attaining; X = Criterion Exceeded, TMDL Required Source: 2008 Integrated Report, ODEQ 2008.

Table ES- 2 Summary of Indicator Bacteria Samples from Primary Body Contact Recreation Season, 1999-2008

Waterbody ID	Waterbody Name	Indicator Bacteria	Geo-Mean Concentration (count/100ml)	Number of Samples	Number of Samples Exceeding Single Sample Criterion	% of Samples Exceeding Single Sample Criterion	2008 303(d) Listing	Reason for Listing Change
OK121400010010_00	Caney River	FC						
		ENT					X	Delist: No data available
		EC						
OK121400010010_10	Caney River	FC						
		ENT	69	25	15	60.0%	X	TMDL required
		EC						
OK121400010300_00	Hogshooter Creek	FC	220	10	3	30.0%	X	TMDL required
		ENT	256	17	16	94.0%	X	TMDL required
		EC	230	17	12	70.6%	X	TMDL required
OK121400010270_00	Curl Creek	FC						
		ENT	250	16	15	93.8%	X	TMDL required
		EC						
OK121400020190_00	Mission Creek	FC						
		ENT	131	15	9	60. 0%	X	TMDL required
		EC	139	15	7	46.7%		List: Does not meet standards
OK121400020140_00	Little Caney River	FC						
		ENT	92	16	11	68.8%		List: Does not meet standards
		EC						
OK121400010090_00	Rabb Creek	FC	215	10	2	20.0%	X	Delist: Meets standards
		ENT						
		EC						

Fecal coliform (FC) water quality criterion = Geometric Mean of 400 counts/100 mL
E. coli (EC) water quality criterion = Geometric Mean of 126 counts/100 mL
Enterococci (ENT) water quality criterion = Geometric Mean of 33 counts/100 mL

For the data collected between 1999 and 2008, when there is enough data to make an assessment, evidence of nonsupport of primary body contact recreation beneficial uses was observed for all three bacteria indicators in Hogshooter Creek. Caney River segment OK121400010010_00 was delisted due to insufficient data and Rabb Creek segment was found to meet standards for Fecal Coliform. Nonsupport of PBCR was observed for Enterococci in Caney River segment OK121400010010_10, Curl Creek and Little Caney River (Caney Creek). There was enough data in Little Caney River (Caney Creek) and Mission Creek to assess the PBCR uses for Enterococci and *E. coli* respectively, in addition to the impairments indicated on the Oklahoma 303(d) list. Table ES-3 summarizes the waterbodies requiring TMDLs for not supporting PBCR

The definition of PBCR is summarized by the following excerpt from Chapter 45 of the Oklahoma WQSs.

(a) Primary Body Contact Recreation involves direct body contact with the water where a possibility of ingestion exists. In these cases the water shall not contain chemical, physical or biological substances in concentrations that are irritating to skin or sense organs or are toxic or cause illness upon ingestion by human beings.

(b) In waters designated for Primary Body Contact Recreation...limits...shall apply only during the recreation period of May 1 to September 30. The criteria for Secondary Body Contact Recreation will apply during the remainder of the year.

To implement Oklahoma's WQS for PBCR, the Oklahoma Water Resources Board (OWRB) promulgated Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2008a). The abbreviated excerpt below from Chapter 46: 785:46-15-6, stipulates how water quality data will be assessed to determine support of the PBCR use as well as how the water quality target for TMDLs will be defined for each bacterial indicator.

(a) Scope. The provisions of this Section shall be used to determine whether the subcategory of Primary Body Contact of the beneficial use of Recreation designated in OAC 785:45 for a waterbody is supported during the recreation season from May 1 through September 30 each year. Where data exist for multiple bacterial indicators on the same waterbody or waterbody segment, the determination of use support shall be based upon the use and application of all applicable tests and data.

(b) Screening levels:

(1) The screening level for fecal coliform shall be a density of 400 colonies per 100 ml.

(2) The screening level for Escherichia coli shall be a density of 235 colonies per 100 ml in streams designated in OAC 785:45 as Scenic Rivers and in lakes, and 406 colonies per 100 ml in all other waters of the state designated as Primary Body Contact Recreation.

(3) The screening level for enterococci shall be a density of 61 colonies per 100 ml in streams designated in OAC 785:45 as Scenic Rivers and in lakes, and 108 colonies per 100 ml in all other waters of the state designated as Primary Body Contact Recreation.

(c) Fecal coliform:

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to fecal coliform if the geometric mean of 400 colonies per 100 ml is met and no greater than 25% of the sample concentrations from that waterbody exceed the screening level prescribed in (b) of this Section.

(d) Escherichia coli (E. coli):

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is met, or the sample concentrations from that waterbody taken during the recreation season do not exceed the screening level prescribed in (b) of this Section, or both such conditions exist.

(e) Enterococci:

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to enterococci if the geometric mean of 33 colonies per 100 ml is met, or the sample concentrations from that waterbody taken during the recreation season do not exceed the screening level prescribed in (b) of this Section, or both such conditions exist.

Where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, each indicator group must demonstrate compliance with the numeric criteria prescribed (OWRB 2008). Waterbodies placed on the 303(d) list for not supporting the PBCR are the result of individual samples exceeding the instantaneous criteria or the long-term geometric mean of individual samples exceeding the geometric mean criteria for each respective bacterial indicator. Targeting the instantaneous criterion established for the primary contact recreation season (May 1st to September 30th) as the water quality goal for TMDLs corresponds to the basis for 303(d) listing and may be protective of the geometric mean criterion as well as the criteria for the secondary contact recreation season. However, both the instantaneous and geometric mean criteria for *E. coli* and Enterococci will be evaluated as water quality targets to ensure the most protective goal is established for each waterbody.

All TMDLs for fecal coliform must take into account that no more than 25 percent of the samples may exceed the instantaneous numeric criteria. For *E. coli* and Enterococci, no samples may exceed instantaneous criteria. Since the attainability of stream beneficial uses for *E. coli* and Enterococci is based on the compliance of either the instantaneous or a long-term geometric mean criterion, percent reductions goals will be calculated for both criteria. TMDLs will be based on the percent reduction required to meet either the instantaneous or the long-term geometric mean criterion, whichever is less.

Turbidity is a measure of water clarity and is caused by suspended particles in the water column. Because turbidity cannot be expressed as a mass load, total suspended solids (TSS) are used as a surrogate for the TMDLs in this report. Therefore, both turbidity and TSS data are presented.

Table ES-3 summarizes a subset of water quality data collected from the WQM stations between 1999 and 2008 for turbidity under base flow conditions, which ODEQ considers to be all flows less than the 25th flow exceedance percentile (i.e., the lower 75 percent of flows) Water quality samples collected under flow conditions greater than the 25th flow exceedance percentile (highest flows) were therefore excluded from the data set used for TMDL analysis. Table ES-4 presents a subset of data for TSS samples collected during base flow conditions.

Table ES- 3 Summary of Turbidity Samples Collected During Base Flow Conditions, 1998-2009

WQM Station	Waterbody Name	Number of Turbidity Samples	Number of Samples Exceeding 50 (NTU)	Percentage of Samples Exceeding Criterion	Average Turbidity (NTU)
OK121400010010-001AT	Caney River	17	7	41.2%	63.3
OK121400-01-0300D	Hogshooter Creek	48	1	2.1%	19.9
OK121400-01-0300D OK121400-01-0300J	Curl Creek	27	6	22.2%	33.9
OK121400-01-0270C OK121400-01-0270G	Mission Creek	35	5	14.3%	53.4
OK121400-02-0140H	Little Caney River	34	23	67.6%	73.7
OK121400-01-0090D	Rabb Creek	15	3	20.0%	38.0

Table ES- 4 Summary of TSS Samples During Base Flow Conditions, 1998-2009

WQM Station	Waterbody Name	Number of TSS Samples	Average TSS (mg/L)
OK121400010010-001AT	Caney River	17	53.1
OK121400-01-0300D	Hogshooter Creek	48	13.1
OK121400-01-0300D OK121400-01-0300J	Curl Creek	26	26.5
OK121400-01-0270C OK121400-01-0270G	Mission Creek	33	40.4
OK121400-02-0140H	Little Caney River	32	42.6
OK121400-01-0090D	Rabb Creek	13	30.4

The beneficial use of WWAC is one of several subcategories of the Fish and Wildlife Propagation use established to manage the variety of communities of fish and shellfish throughout the state (OWRB 2008). The numeric criteria for turbidity to maintain and protect the use of "Fish and Wildlife Propagation" from Title 785:45-5-12 (f) (7) is as follows:

(A) Turbidity from other than natural sources shall be restricted to not exceed the following numerical limits:

1. Cool Water Aquatic Community/Trout Fisheries: 10 NTUs;

2. Lakes: 25 NTU; and

3. Other surface waters: 50 NTUs.

(B) In waters where background turbidity exceeds these values, turbidity from point sources will be restricted to not exceed ambient levels.

(C) Numerical criteria listed in (A) of this paragraph apply only to seasonal base flow conditions.

(D) Elevated turbidity levels may be expected during, and for several days after, a runoff event.

The abbreviated excerpt below from Chapter 46: 785:46-15-5, stipulates how water quality data will be assessed to determine support of fish and wildlife propagation as well as how the water quality target for TMDLs will be defined for turbidity.

Assessment of Fish and Wildlife Propagation support

(a) Scope. The provisions of this Section shall be used to determine whether the beneficial use of Fish and Wildlife Propagation or any subcategory thereof designated in OAC 785:45 for a waterbody is supported.

(e) Turbidity. The criteria for turbidity stated in 785:45-5-12(f) (7) shall constitute the screening levels for turbidity. The tests for use support shall follow the default protocol in 785:46-15-4(b).

785:46-15-4. Default protocols

(b) Short term average numerical parameters.

(1) Short term average numerical parameters are based upon exposure periods of less than seven days. Short term average parameters to which this Section applies include, but are not limited to, sample standards and turbidity.

(2) A beneficial use shall be deemed to be fully supported for a given parameter whose criterion is based upon a short term average if 10% or less of the samples for that parameter exceed the applicable screening level prescribed in this Subchapter.

TMDLs for turbidity in streams designated as WWAC must take into account that no more than 10 percent of the samples may exceed the numeric criterion of 50 nephelometric turbidity units (NTU). However, as described above, because turbidity cannot be expressed as a mass load, TSS is used as a surrogate in this TMDL. Since there is no numeric criterion in the Oklahoma WQS for TSS, a regression method to convert the turbidity criterion to TSS based on a relationship between turbidity and TSS was used to establish TSS targets as surrogates. Table ES-5 provides the results of the waterbody specific regression analysis.

Table ES- 5 Regression Statistics and TSS Targets

Waterbody ID	Waterbody Name	R-square	NRMSE	TSS Target (mg/L)
OK121400010010_10	Caney River	0.93	6.0%	44
OK121400010270_00	Curl Creek	0.65	11.4%	37
OK121400020190_00	Mission Creek	0.77	15.2%	38
OK121400020140_00	Little Caney River	0.51	11.4%	30
OK121400010090_00	Rabb Creek	0.78	12.1%	36

After re-evaluating bacteria and turbidity/TSS data for the streams listed in Table ES-1, bacteria and turbidity impairments on Caney River (OK121400010010_00) are recommended for delisting. Turbidity and bacteria impairments on Hogshooter Creek and Rabb Creek are also recommended for delisting respectively. Table ES-6 shows the bacteria and turbidity TMDLs that will be developed in this report:

Table ES- 6 Stream Segments and Pollutants for TMDL Development

WQM Station	Waterbody ID	Waterbody Name	Indicator Bacteria			Turbidity
			FC	ENT	EC	
OK121400010010-001AT	OK121400010010_10	Caney River		X		X
OK121400-01-0300D OK121400-01-0300J	OK121400010300_00	Hogshooter Creek	X	X	X	
OK121400-01-0270C OK121400-01-0270G	OK121400010270_00	Curl Creek		X		X
OK121400-02-0190B	OK121400020190_00	Mission Creek		X	X	X
OK121400-02-0140H	OK121400020140_00	Little Caney River		X		X
OK121400-01-0090D	OK121400010090_00	Rabb Creek				X

E.2 Pollutant Source Assessment

A pollutant source assessment characterizes known and suspected sources of pollutant loading to impaired waterbodies. Sources within a watershed are categorized and quantified to the extent that information is available. Bacteria originate from warm-blooded animals; some plant life and sources may be point or nonpoint in nature. Turbidity may originate from NPDES-permitted facilities, fields, construction sites, quarries, stormwater runoff and eroding stream banks.

Point sources are permitted through the NPDES program. NPDES-permitted facilities that discharge treated wastewater are required to monitor for one of the three bacterial indicators (fecal coliform, *E coli*, or Enterococci) and TSS in accordance with their permits. Nonpoint sources are diffuse sources that typically cannot be identified as entering a waterbody through a discrete conveyance at a single location. Nonpoint sources may emanate from land activities that contribute bacteria or TSS to surface water as a result of rainfall runoff. For the TMDLs in this report, all sources of pollutant loading not regulated by NPDES are considered nonpoint sources. Sediment loading of streams can originate from natural erosion processes, including the weathering of soil, rocks, and uncultivated land; geological abrasion; and other natural phenomena. There is insufficient data available to quantify contributions of TSS from these natural processes. TSS or sediment loading can also occur under non-runoff conditions as a result of anthropogenic activities in riparian corridors which cause erosive conditions. Given the lack of data to establish the background conditions for TSS/turbidity, separating background loading from nonpoint sources whether it is from natural or anthropogenic processes is not feasible in this TMDL development. Table ES-6 summarizes the point and nonpoint sources that contribute bacteria or TSS to each respective waterbody.

Table ES- 7 Summary of Potential Pollutant Sources by Category

Waterbody ID	Waterbody Name	Municipal NPDES Facility	Industrial NPDES Facility	MS4	NPDES No Discharge Facility	CAFO	Mines	Construction Stormwater Permit	Nonpoint Source
OK121400010010_10	Caney River	Bacteria/TSS							Bacteria, TSS
OK121400010300_00	Hogshooter Creek								Bacteria
OK121400010270_00	Curl Creek								Bacteria, TSS
OK121400020190_00	Mission Creek								Bacteria, TSS
OK121400020140_00	Little Caney River								Bacteria, TSS
OK121400010090_00	Rabb Creek								TSS

No facility present in watershed.

E.3 Using Load Duration Curves to Develop TMDLs

The TMDL calculations presented in this report are derived from load duration curves (LDC). LDCs facilitate rapid development of TMDLs, and as a TMDL development tool are effective at identifying whether impairments are associated with point or nonpoint sources. The technical approach for using LDCs for TMDL development includes the following steps:

- Preparing flow duration curves for gaged and ungaged WQM stations;
- Estimating existing loading in the waterbody using ambient bacteria water quality data; and estimating loading in the waterbody using measured TSS water quality data and turbidity-converted data; and
- Using LDCs to identify the critical condition that will dictate loading reductions and the overall percent reduction goal (PRG) necessary to attain WQS.

Use of the LDC obviates the need to determine a design storm or selected flow recurrence interval with which to characterize the appropriate flow level for the assessment of critical conditions. For waterbodies impacted by both point and nonpoint sources, the "nonpoint source critical condition" would typically occur during high flows, when rainfall runoff would contribute the bulk of the pollutant load, while the "point source critical condition" would typically occur during low flows, when wastewater treatment plant (WWTP) effluents would dominate the base flow of the impaired water. However, flow range is only a general indicator of the relative proportion of point/nonpoint contributions. Violations have been noted under low flow conditions in some watersheds that contain no point sources.

LDCs display the maximum allowable load over the complete range of flow conditions by a line using the calculation of flow multiplied by a water quality criterion. The TMDL can be expressed as a continuous function of flow, equal to the line, or as a discrete value derived from a specific flow condition.

The basic steps to generating an LDC involve:

- obtaining daily flow data for the site of interest from the U.S. Geological Survey (USGS);
- sorting the flow data and calculating flow exceedance frequencies for the time period and season of interest;
- obtaining the water quality data from the primary contact recreation season (May 1 through September 30); or obtaining available turbidity and TSS water quality data;
- matching the water quality observations with the flow data from the same date;
- displaying a curve on a plot that represents the allowable load determined by multiplying the actual or estimated flow by the WQS for each respective bacteria indicator; or displaying a curve on a plot that represents the allowable load determined by multiplying the actual or estimated flow by the WQ_{target} for TSS;
- converting measured concentration values to loads by multiplying the flow at the time the sample was collected by the water quality parameter concentration (for sampling events with both TSS and turbidity data, the measured TSS value is used; if only turbidity was measured, the value was converted to TSS using the regression equation in Figure 4-1 through Figure 4-5); or multiplying the flow by the bacteria indicator concentration to calculate daily loads; then

- plotting the flow exceedance frequencies and daily load observations in a load duration plot.

For bacteria TMDLs the culmination of these steps is expressed in the following formula, which is displayed on the LDC as the TMDL curve:

TMDL (cfu/day) = WQS * flow (cfs) * unit conversion factor

Where: WQS = 400 cfu /100 mL (Fecal coliform); 406 cfu/100 mL (E. coli); or 108 cfu/100 mL (Enterococci)

unit conversion factor = 24,465,525 mL*s / ft3*day

For turbidity (TSS) TMDLs the culmination of these steps is expressed in the following formula, which is displayed on the LDC as the TMDL curve:

TMDL (lb/day) = WQ_{target} **** flow (cfs) * unit conversion factor***

where: WQ_{target} ***= waterbody specific TSS concentration derived from regression analysis results presented in Table 4-1***

unit conversion factor = 5.39377 L*s*lb /(ft^3****day*mg)***

Historical observations of bacteria, TSS and/or turbidity concentrations are paired with flow data and are plotted as separate LDCs. The fecal coliform load (or the y-value of each point) is calculated by multiplying the fecal coliform concentration (colonies/100 mL) by the instantaneous flow (cubic feet per second) at the same site and time, with appropriate volumetric and time unit conversions. Fecal coliform/*E. coli*/Enterococci loads representing exceedance of water quality criteria fall above the water quality criterion line. Likewise, the TSS load (or the y-value of each point) is calculated by multiplying the TSS concentration (measured or converted from turbidity) (mg/L) by the instantaneous flow (cfs) at the same site and time, with appropriate volumetric and time unit conversions. TSS loads representing exceedance of water quality criteria fall above the TMDL line.

E.4 TMDL Calculations

A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for the lack of knowledge concerning the relationship between effluent limitations and water quality.

This definition can be expressed by the following equation:

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

For each waterbody the TMDLs presented in this report are expressed as a percent reduction across the full range of flow conditions. The difference between existing loading and the water quality target is used to calculate the loading reductions required. PRG are calculated for each waterbody and bacterial indicator species as the reductions in load required so no instantaneous observations would exceed the water quality target for *E. coli* and Enterococci and no more than 25 percent of the samples exceed the water quality target for fecal coliform.

Table ES-7 presents the percent reductions necessary for each bacterial indicator causing nonsupport of the PBCR use in each waterbody of the Study Area. Selection of the appropriate PRG for each waterbody in Table ES-7 is denoted by bold text. The TMDL PRG will be the lesser of that required to meet the geometric mean or instantaneous criteria for *E. coli* and Enterococci because WQSs are considered to be met if, 1) either the geometric mean of all data is less than the geometric mean criteria, or 2) no samples exceed the instantaneous criteria. The PRGs range from 19 to 88 percent.

Table ES- 8 TMDL Percent Reductions Required to Meet Water Quality Standards for Indicator Bacteria

Waterbody ID	Waterbody Name	Required Reduction Rate				
		FC	EC		ENT	
		Instant-aneous	Instant-aneous	Geo-mean	Instant-aneous	Geo-mean
OK121400010010_10	Caney River				99.9%	**57%**
OK121400010300_00	Hogshooter Creek	**40%**	81%	**51%**	95%	**88%**
OK121400010270_00	Curl Creek				99%	**88%**
OK121400020190_00	Mission Creek		82%	**19%**	95%	**77%**
OK121400020140_00	Little Caney River				96%	**68%**

Similarly, percent reduction goals for TSS are calculated as the required overall reduction so that no more than 10 percent of the samples exceed the water quality target for TSS. The PRGs for the fourteen waterbodies included in this TMDL report are summarized in Table ES-8 and range from 31 to 76 percent.

Table ES- 9 TMDL Percent Reductions Required to Meet Water Quality Targets for Total Suspended Solids

Waterbody ID	Waterbody Name	Required Reduction Rate
OK121400010010_10	Caney River	**76%**
OK121400010270_00	Curl Creek	**36%**
OK121400020190_00	Mission Creek	**31%**
OK121400020140_00	Little Caney River	**69%**
OK121400010090_00	Rabb Creek	**36%**

The TMDL, WLA, LA, and MOS vary with flow condition, and are calculated at every 5th flow interval percentile. The WLA component of each TMDL is the sum of all WLAs within each contributing watershed. The sum of the WLAs can be represented as a single line below the LDC. The LDC and the simple equation of:

Average LA = average TMDL – MOS - ∑WLA

can provide an individual value for the LA in counts per day, which represents the area under the TMDL target line and above the WLA line.

Federal regulations (40 CFR §130.7(c) (1)) require that TMDLs include an MOS and account for seasonal variability. The MOS, which can be implicit or explicit, is a conservative measure incorporated into the TMDL equation that accounts for the lack of knowledge associated with calculating the allowable pollutant loading to ensure WQSs are attained.

For bacteria TMDLs, an explicit MOS was set at 10 percent, thus, allowable loads were calculated using targets that are 10 percent lower than the water quality criterion for each pathogen, which equates to 360 cfu/100 mL, 365.4 cfu/100 mL, and 97.2/100 mL for fecal coliform, *E. coli*, and Enterococci, respectively. This conservative approach to establishing the

MOS will ensure that both the 30-day geometric mean and instantaneous bacteria standards can be achieved and maintained.

For turbidity, the TMDLs are calculated for TSS instead of turbidity. Thus, the quality of the regression has a direct impact on confidence of the TMDL calculations. The better the regression is, the more confidence there is in the TMDL targets. As a result, it leads to a smaller margin of safety. The selection of MOS is based on the normalized root mean square error (NRMSE) for each waterbody. The explicit MOS ranges from 10 percent to 25 percent. Table 5-5 shows the MOS for each waterbody.

The bacteria TMDLs established in this report adhere to the seasonal application of the Oklahoma WQS which limits the PBCR use to the period of May 1st through September 30th. Similarly, the TSS TMDLs established in this report adhere to the seasonal application of the Oklahoma WQS for turbidity, which applies to seasonal base flow conditions only. Seasonal variation was also accounted for in these TMDLs by using more than 5 years of water quality data and by using the longest period of USGS flow records when estimating flows to develop flow exceedance percentiles.

E.5 Reasonable Assurance

As authorized by Section 402 of the CWA, ODEQ has delegation of the NPDES in Oklahoma, except for certain jurisdictional areas related to agriculture and the oil and gas industry retained by the Oklahoma Department of Agriculture and Oklahoma Corporation Commission, for which the USEPA has retained permitting authority. The NPDES program in Oklahoma is implemented via Title 252, Chapter 606 of the Oklahoma Pollution Discharge Elimination System (OPDES) Act, and in accordance with the agreement between ODEQ and USEPA relating to administration and enforcement of the delegated NPDES program. Implementation of WLAs for point sources is done through permits issued under the OPDES program. The reduction rates called for in this TMDL report are as high as 88 percent for bacteria and 76 percent for turbidity. The ODEQ recognizes that achieving such high reductions will be a challenge, especially since unregulated nonpoint sources are a major cause of both bacteria and TSS loading. The high reduction rates are not uncommon for pathogen- or TSS-impaired waters. Similar reduction rates are often found in other pathogen and TSS TMDLs around the nation.

SECTION 1
INTRODUCTION

1.1 TMDL Program Background

Section 303(d) of the Clean Water Act (CWA) and U.S. Environmental Protection Agency (USEPA) Water Quality Planning and Management Regulations (40 Code of Federal Regulations [CFR] Part 130) require states to develop total maximum daily loads (TMDL) for waterbodies not meeting designated uses where technology-based controls are in place. TMDLs establish the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so states can implement water quality-based controls to reduce pollution from point and nonpoint sources and restore and maintain water quality (USEPA 1991).

This report documents the data and assessment used to establish bacteria and turbidity TMDLs for certain waterbodies in the Caney River Area. The 2008 Integrated Water Quality Assessment Report (Oklahoma Department of Environmental Quality [ODEQ] 2008) identified these seven streams are impaired for either bacteria and/or turbidity. Data assessment and TMDL calculations are conducted in accordance with requirements of Section 303(d) of the CWA, Water Quality Planning and Management Regulations (40 CFR Part 130), USEPA guidance, and Oklahoma Department of Environmental Quality (ODEQ) guidance and procedures. ODEQ is required to submit all TMDLs to USEPA for review and approval. Once the USEPA approves a TMDL, then the waterbody may be moved to Category 4a of a state's Integrated Water Quality Monitoring and Assessment Report, where it remains until compliance with water quality standards (WQS) is achieved (USEPA 2003).

The purpose of this TMDL report is to establish pollutant load allocations for indicator bacteria and turbidity in impaired waterbodies, which is the first step toward restoring water quality and protecting public health. TMDLs determine the pollutant loading a waterbody can assimilate without exceeding the WQS for that pollutant. TMDLs also establish the pollutant load allocation necessary to meet the WQS established for a waterbody based on the relationship between pollutant sources and in-stream water quality conditions. A TMDL consists of a wasteload allocation (WLA), load allocation (LA), and a margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources, and includes stormwater discharges regulated under the National Pollutant Discharge Elimination System (NPDES) as point sources. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. The MOS is a percentage of the TMDL set aside to account for the uncertainty associated with natural process in aquatic systems, model assumptions, and data limitations.

This report does not stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce bacteria and /or turbidity loadings within each watershed. Watershed-specific control actions and management measures will be identified, selected, and implemented under a separate process involving stakeholders who live and work in the watersheds, tribes, and local, state, and federal government agencies.

This TMDL report focuses on waterbodies listed below that ODEQ placed in Category 5 of the 2008 Integrated Report [303(d) list] for nonsupport of primary body contact recreation (PBCR) or beneficial use category Fish and Wildlife Propagation:

- Caney River (OK121400010010_00)
- Caney River (OK121400010010_10)
- Hogshooter Creek (OK121400010300_00)
- Curl Creek (OK121400010270_00)
- Mission Creek (OK121400020190_00)
- Little Caney River (OK121400020140_00)
- Rabb Creek (OK121400010090_00)

Figure 1-1 is a location map showing the impaired segments of these waterbodies and their contributing watersheds. This map also displays the locations of the water quality monitoring (WQM) stations used as the basis for placement of these waterbodies on the Oklahoma 303(d) list. These waterbodies and their surrounding watersheds are hereinafter referred to as the Study Area.

The TMDLs established in this report are a necessary step in the process to develop the bacteria and turbidity loading controls needed to restore the contact recreation and the Fish and Wildlife Propagation use designated for each waterbody. Table 1-1 provides a description of the locations of the WQM stations on the 303(d)-listed waterbodies.

Table 1-1 Water Quality Monitoring Stations used for 2008 303(d) Listing Decision

Waterbody Name	Waterbody ID	WQM Station	WQM Station Locations Descriptions
Caney River	OK121400010010_00	None	None
Caney River	OK121400010010_10	OK121400010010-001AT	NE¼ NW¼ Section 5-23N-14E
Hogshooter Creek	OK121400010300_00	OK121400-01-0300D OK121400-01-0300J	SW¼ Section 19-25N-14E Sections 6/7 25N-14E
Curl Creek	OK121400010270_00	OK121400-01-0270C OK121400-01-0270G	S.B. Section 31-25N-14E NW¼ SW¼ Section 29-25N-14E
Mission Creek	OK121400020190_00	OK121400-02-0190B	SE¼ SW¼ SE¼ Section 28-28N-12E
Little Caney River	OK121400020140_00	OK121400-02-0140H	N.B. Section 6-27N-13E
Rabb Creek	OK121400010090_00	OK121400-01-0090D	Sections 22/27 23N-14E

1.2 Watershed Description

General. The watersheds in the Caney River Study Area in this TMDL are located in Northern Oklahoma. The vast majority of the drainage area for the waterbodies included in this report is located in Washington County. Small portions of the drainage areas are located in Nowata County, Osage County, Tulsa County and Rogers County.

Table 1-2, derived from the 2000 U.S. Census, demonstrates that the counties in which these watersheds are located are sparsely populated (U.S. Census Bureau 2000) with the exception of Tulsa County which is densely populated.

Table 1-2 County Population and Density

County Name	Population (2000 Census)	Area (square miles)	Population Density (per square mile)
Nowata	10,569	581	18
Osage	44,437	2,304	19
Rogers	70,641	711	99
Tulsa	563,299	587	960
Washington	48,996	424	116

Climate. Table 1-3 summarizes the average annual precipitation for each stream segment. Average annual precipitation values among the stream segments in this portion of Oklahoma range between 38.2 and 41.6 inches (Oklahoma Climatological Survey 2005).

Table 1-3 Average Annual Precipitation by Stream Segment

Waterbody Name	Waterbody ID	Average Annual (Inches)
Caney River	OK121400010010_00	40.66
Caney River	OK121400010010_10	40.66
Hogshooter Creek	OK121400010300_00	40.76
Curl Creek	OK121400010270_00	41.02
Mission Creek	OK121400020190_00	38.17
Little Caney River	OK121400020140_00	39.46
Rabb Creek	OK121400010090_00	41.58

Land Use. Table 1-4 summarizes the acreages and the corresponding percentages of the land use categories for the contributing watershed associated with each respective Oklahoma waterbody. The land use/land cover data were derived from the U.S. Geological Survey (USGS) 2001 National Land Cover Dataset (USGS 2007). The land use categories are displayed in Figure 1-2.

The dominant land use throughout all of the Study Area is pasture/hay. The second most prevalent land use in all sub-watersheds is the combination of Deciduous Forest and grassland/herbaceous.

Table 1-4 Land Use Summaries by Watershed

Land Use Category	Stream Segments						
	Caney River	Caney River	Hogshooter Creek	Curl Creek	Mission Creek	Little Caney River	Rabb Creek
Waterbody ID	OK121400010010_00	OK121400010010_10	OK121400010300_00	OK121400010270_00	OK121400020190_00	OK121400020140_00	OK121400010090_00
Herbaceous Wetland	0.09%	0.09%	0.00%	0.00%	0.00%	0.45%	0.00%
Woody Wetland	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Cultivated	2.63%	3.64%	0.16%	0.11%	0.48%	3.85%	3.71%
Pasture Hay	40.98%	31.57%	49.80%	41.89%	32.43%	49.57%	60.74%
Grassland	25.67%	40.10%	28.89%	40.82%	35.74%	16.39%	20.25%
Shrub	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Mixed Forest	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Evergreen Forest	0.06%	0.03%	0.07%	0.00%	0.05%	0.83%	0.00%
Deciduous Forest	17.94%	17.47%	14.20%	12.73%	26.70%	16.39%	6.27%
Barren	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Developed High Intensity	0.18%	0.05%	0.02%	0.00%	0.00%	0.05%	0.13%
Developed Medium Intensity	3.51%	1.07%	0.11%	0.10%	0.07%	2.02%	1.71%
Developed Low Intensity	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Developed Open Space	7.95%	4.96%	6.36%	4.08%	4.28%	9.42%	5.91%
Water	1.00%	0.77%	0.78%	0.32%	0.26%	0.84%	0.41%
Total Percentage:	100%	100%	100%	100%	100%	100%	100%
Herbaceous Wetland (Acres)	41	123	0	0	0	47	0
Woody Wetland (Acres)	0	0	0	0	0	0	0
Cultivated (Acres)	1,257	5,077	47	34	130	397	214
Pasture Hay (Acres)	19,607	44,605	14,167	12,894	8,701	5,104	3,498
Grassland (Acres)	12,281	55,977	8,217	12,563	9,588	1,688	1,166
Shrub (Acres)	0	0	0	0	0	0	0
Mixed Forest	0	0	0	0	0	0	0
Evergreen Forest (Acres)	27	40	19	0	12	86	0
Deciduous Forest (Acres)	8,581	24,392	3987	3,917	7,162	1,688	361
Barren (Acres)	0	2	0	0	0	0	0
Developed High Intensity (Acres)	86	73	7	0	0	6	8
Developed Medium Intensity (Acres)	1,679	1,487	31	30	18	208	99
Developed Low Intensity (Acres)	0	0	0	0	0	0	0
Developed Open Space (Acres)	3,802	6,918	1,808	1,256	1,148	970	341
Water (Acres)	478	1,081	221	99	70	87	24
Total (Acres)	47,841	139,599	28,446	30,778	26,827	10,296	5,760

Figure 1-1 Watersheds Not Supporting Primary Body Contact Recreation and/ or Fish and Wildlife Propagation Use within the Study Area

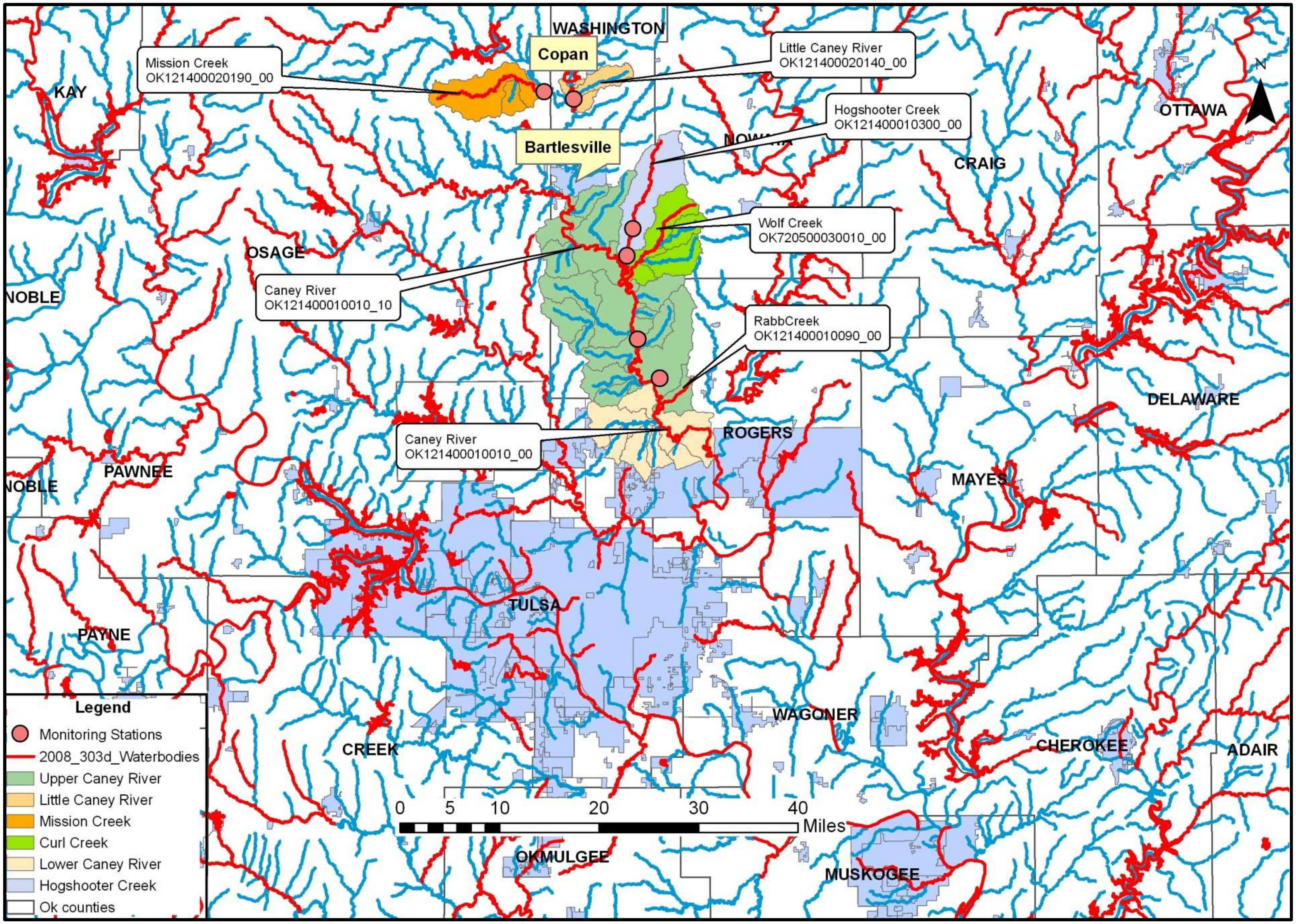
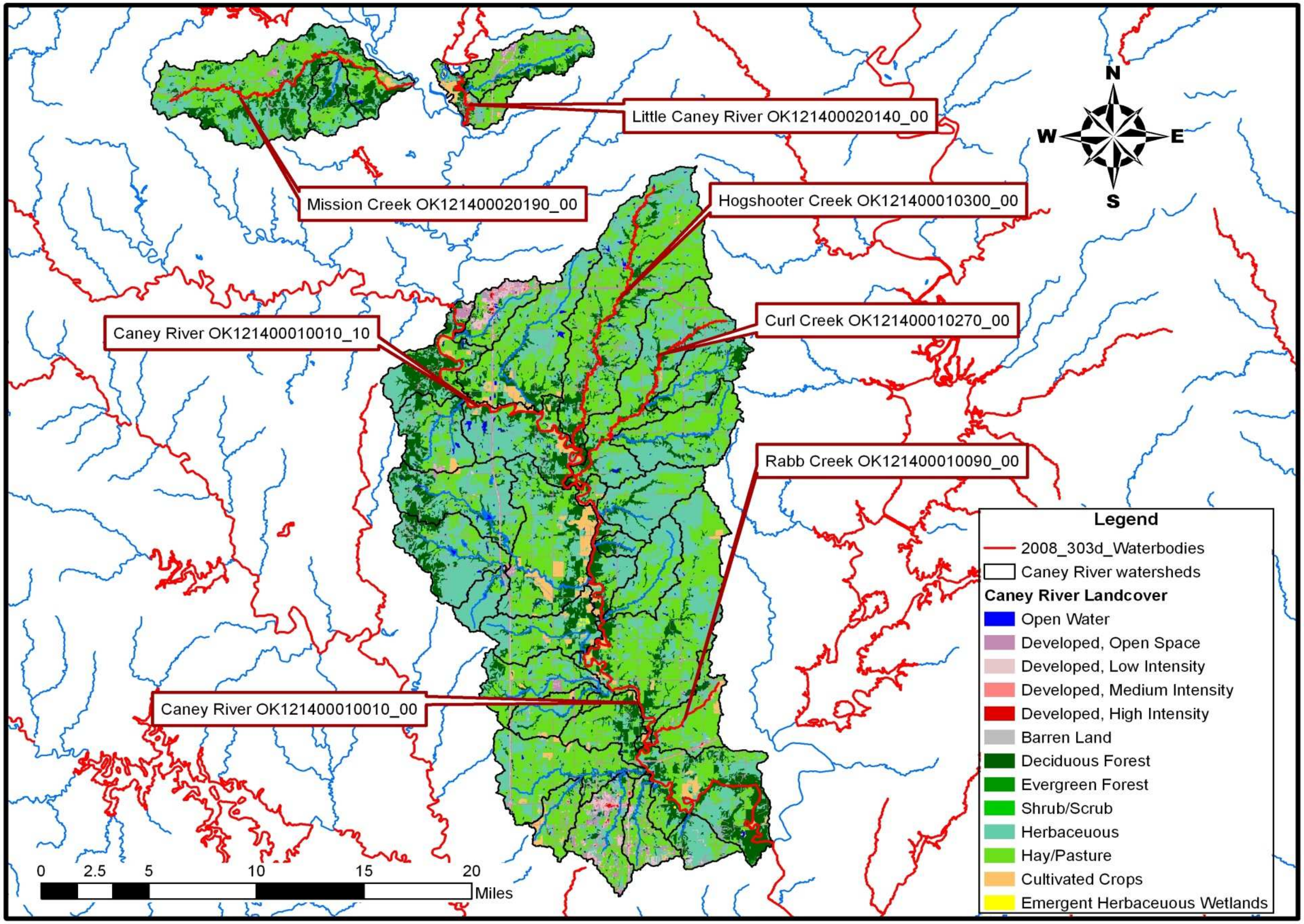


Figure 1-2 Land Use Map by Watershed



SECTION 2
PROBLEM IDENTIFICATION AND WATER QUALITY TARGET

2.1 Oklahoma Water Quality Standards

Title 785 of the Oklahoma Administrative Code contains Oklahoma's water quality standards and implementation procedures (OWRB 2008). The Oklahoma Water Resources Board (OWRB) has statutory authority and responsibility concerning establishment of state water quality standards, as provided under 82 Oklahoma Statute [O.S.], §1085.30. This statute authorizes the OWRB to promulgate rules …*which establish classifications of uses of waters of the state, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters.* [O.S. 82:1085:30(A)]. Beneficial uses are designated for all waters of the state. Such uses are protected through restrictions imposed by the antidegradation policy statement, narrative water quality criteria, and numerical criteria (OWRB 2008). An excerpt of the Oklahoma WQS (Title 785) summarizing the State of Oklahoma Antidegredation Policy is provided in Appendix D. Table 2-1a, an excerpt from the 2008 Integrated Report (ODEQ 2008), lists beneficial uses designated for each bacteria and/or turbidity impaired stream segment in the Study Area. The beneficial uses include:

- AES – Aesthetics
- AG – Agriculture Water Supply
- HLAC – Habitat Limited Aquatic Community
- WWAC – Warm Water Aquatic Community
- FISH – Fishery and Wildlife Propagation
- PBCR – Primary Body Contact Recreation
- SBCR – Secondary Body Contact Recreation
- PPWS – Public & Private Water Supply
- EWS – Emergency Water Supply
- SWS – Sensitive Water Supply

Table 2-1 summarizes the PBCR and WWAC use attainment status and bacteria & turbidity impairment status for streams in the Study Area. The TMDL priority shown in Table 2-1 is directly related to the TMDL target date. The TMDLs established in this report, which are a necessary step in the process of restoring water quality, only address bacteria and turbidity pollutants that affect the PBCR and WWAC designated uses.

Table 2-1 Excerpt from the Oklahoma 2008 303(d) List

Waterbody ID	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*E. coli*	FC	Designated Use Primary Body Contact Recreation	Turbidity	Designated Use Warm Water Aquatic Life
OK121400010010_00	Caney River	18	2013	2	**X**			**N**	**X**	**N**
OK121400010010_10	Caney River	47	2013	2	**X**			**N**	**X**	**N**
OK121400010300_00	Hogshooter Creek	20	2016	3	**X**	**X**	**X**	**N**	**X**	**N**
OK121400010270_00	Curl Creek	17	2013	2	**X**			**N**	**X**	**N**
OK121400020190_00	Mission Creek	18	2019	3	**X**			**N**		
OK121400020140_00	Little Caney River	6	2019	4					**X**	**N**
OK121400010090_00	Rabb Creek	6	2013	2			**X**	**N**		

Table 2-1a Designated Beneficial Uses for Each Impaired Waterbody in the Study Area

Waterbody ID	Waterbody Name	AES	AG	WWAC	*FISH*	PBCR	SBCR	PPWS	Limitation
OK121400010010_10	Caney River	I	F	N	F	N		I	
OK121400010300_00	Hogshooter Creek	F		N	X	N			
OK121400010270_00	Curl Creek	F	F	N	X	N			
OK121400020190_00	Mission Creek	F	F	N	X	N			
OK121400020140_00	Little Caney River	F	F	N	X	F		I	
OK121400010090_00	Rabb Creek	I	F	F	X	N		X	

F – Fully supporting; N – Not supporting; I – Insufficient information; X – Not assessed

Bacteria Standards

The definition of PBCR is summarized by the following excerpt from Chapter 45 of the Oklahoma WQS.

(a) Primary Body Contact Recreation involves direct body contact with the water where a possibility of ingestion exists. In these cases the water shall not contain chemical, physical or biological substances in concentrations that are irritating to skin or sense organs or are toxic or cause illness upon ingestion by human beings.

(b) In waters designated for Primary Body Contact Recreation...limits...shall apply only during the recreation period of May 1 to September 30. The criteria for Secondary Body Contact Recreation will apply during the remainder of the year.

To implement Oklahoma's WQS for PBCR, OWRB promulgated Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2007). The excerpt below from Chapter 46: 785:46-15-6, stipulates how water quality data will be assessed to determine support of the PBCR use as well as how the water quality target for TMDLs will be defined for each bacterial indicator.

(a) Scope. The provisions of this Section shall be used to determine whether the subcategory of Primary Body Contact of the beneficial use of Recreation designated in OAC 785:45 for a waterbody is supported during the recreation season from May 1 through September 30 each year. Where data exist for multiple bacterial indicators on the same waterbody or waterbody segment, the determination of use support shall be based upon the use and application of all applicable tests and data.

(b) Screening levels.

(1) The screening level for fecal coliform shall be a density of 400 colonies per 100ml.

(2) The screening level for Escherichia coli shall be a density of 235 colonies per 100 ml in streams designated in OAC 785:45 as Scenic Rivers and in lakes, and 406 colonies per 100 ml in all other waters of the state designated as Primary Body Contact Recreation.

(3) The screening level for enterococci shall be a density of 61 colonies per 100 ml in streams designated in OAC 785:45 as Scenic Rivers and in lakes, and 108 colonies per 100 ml in all other waters of the state designated as Primary Body Contact Recreation.

(c) Fecal coliform:

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to fecal coliform if the geometric mean of 400 colonies per 100 ml is met and no greater than 25% of the sample concentrations from that waterbody exceed the screening level prescribed in (b) of this Section.

(2) The parameter of fecal coliform is not susceptible to an assessment that Primary Body Contact Recreation is partially supported.

(3) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to fecal coliform if the geometric mean of 400 colonies per 100 ml is not met, or greater than 25% of the sample concentrations from that

waterbody exceed the screening level prescribed in (b) of this Section, or both such conditions exist.(d) Escherichia coli (E. coli):

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is met, or the sample concentrations from that waterbody taken during the recreation season do not exceed the screening level prescribed in (b) of this Section, or both such conditions exist.

(2) The parameter of E. coli is not susceptible to an assessment that Primary Body Contact Recreation is partially supported.

(3) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is not met and any of the sample concentrations from that waterbody taken during the recreation season exceed a screening level prescribed in (b) of this Section.

(e) Enterococci:

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to enterococci if the geometric mean of 33 colonies per 100 ml is met, or the sample concentrations from that waterbody taken during the recreation season do not exceed the screening level prescribed in (b) of this Section, or both such conditions exist.

(2) The parameter of enterococci is not susceptible to an assessment that Primary Body Contact Recreation is partially supported.

(3) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to enterococci if the geometric mean of 33 colonies per 100 ml is not met and any of the sample concentrations from that waterbody taken during the recreation season exceed a screening level prescribed in (b) of this Section.

Compliance with the Oklahoma WQS is based on meeting requirements for all three bacterial indicators. Where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, each indicator group must demonstrate compliance with the numeric criteria prescribed (OWRB 2008).

As stipulated in the WQS, utilization of the geometric mean to determine compliance for any of the three indicator bacteria depends on the collection of five samples within a 30-day period. For most stream segments in Oklahoma there are insufficient data available to calculate the 30-day geometric mean since most water quality samples are collected once a month. As a result, waterbodies placed on the 303(d) list for not supporting the PBCR are the result of individual samples exceeding the instantaneous criteria or the long-term geometric mean of individual samples exceeding the geometric mean criteria for each respective bacterial indicator. Targeting the instantaneous criterion established for the primary body contact recreation season (May 1^{st} to September 30^{th}) as the water quality goal for TMDLs corresponds to the basis for 303(d) listing and may be protective of the geometric mean criterion as well as the criteria for the secondary contact recreation season. However, both the instantaneous and geometric mean criteria for *E. coli* and Enterococci will be evaluated as water quality targets to ensure the most protective goal is established for each waterbody.

The specific data assessment method for listing indicator bacteria based on instantaneous or single sample criterion is detailed in Oklahoma's 2004 Integrated Report. As stated in the report, a minimum of 10 samples collected between May 1st and September 30th (during the primary recreation season) is required to list a segment for *E. coli* and Enterococci.

A sample quantity exception exists for fecal coliform that allows waterbodies to be listed for nonsupport of PBCR if there are less than 10 samples. The assessment method states that if there are less than 10 samples and the existing sample set already assures a nonsupport determination, then the waterbody should be listed for TMDL development. This condition is true in any case where the small sample set demonstrates that at least three out of six samples exceed the single sample fecal coliform criterion. In this case if four more samples were available to meet minimum of 10 samples, this would still translate to >25 percent exceedance or nonsupport of PBCR (*i.e.,* three out of 10 samples = 33 percent exceedance). For *E. coli* and Enterococci, the 10-sample minimum was used, without exception, in attainment determination.

Turbidity Standards

The TMDL established in this report is a necessary step in the process to restore the fish and wildlife propagation designation for these waterbodies.

The numeric criteria for turbidity to maintain and protect the use of "Fish and Wildlife Propagation" from Title 785:45-5-12 (f) (7) is as follows:

(a) Turbidity from other than natural sources shall be restricted to not exceed the following numerical limits:

4. Cool Water Aquatic Community/Trout Fisheries: 10 NTUs;

5. Lakes: 25 NTU; and

6. Other surface waters: 50 NTUs.

(b) In waters where background turbidity exceeds these values, turbidity from point sources will be restricted to not exceed ambient levels.

(c) Numerical criteria listed in (A) of this paragraph apply only to seasonal base flow conditions.

(d) Elevated turbidity levels may be expected during, and for several days after, a runoff event.

To implement Oklahoma's WQS for Fish and Wildlife Propagation, OWRB promulgated Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2008). The excerpt below from Chapter 46: 785:46-15-5, stipulates how water quality data will be assessed to determine support of fish and wildlife propagation as well as how the water quality target for TMDLs will be defined for turbidity.

Assessment of Fish and Wildlife Propagation support

(a) Scope. The provisions of this Section shall be used to determine whether the beneficial use of Fish and Wildlife Propagation or any subcategory thereof designated in OAC 785:45 for a waterbody is supported.

(e) Turbidity. The criteria for turbidity stated in 785:45-5-12(f)(7) shall constitute the screening levels for turbidity. The tests for use support shall follow the default protocol in 785:46-15-4(b).

785:46-15-4. Default protocols

(b) Short term average numerical parameters.

(1) Short term average numerical parameters are based upon exposure periods of less than seven days. Short term average parameters to which this Section applies include, but are not limited to, sample standards and turbidity.

(2) A beneficial use shall be deemed to be fully supported for a given parameter whose criterion is based upon a short term average if 10% or less of the samples for that parameter exceed the applicable screening level prescribed in this Subchapter.

(3) A beneficial use shall be deemed to be fully supported but threatened if the use is supported currently but the appropriate state environmental agency determines that available data indicate that during the next five years the use may become not supported due to anticipated sources or adverse trends of pollution not prevented or controlled. If data from the preceding two year period indicate a trend away from impairment, the appropriate agency shall remove the threatened status.

(4) A beneficial use shall be deemed to be not supported for a given parameter whose criterion is based upon a short term average if at least 10% of the samples for that parameter exceed the applicable screening level prescribed in this Subchapter.

2.2 Problem Identification

Bacteria

Table 2-2 summarizes water quality data collected during primary body contact recreation season from the stream segments between 1999 and 2008 for each indicator bacteria. All the data within this time frame were used to support the decision to place specific waterbodies within the Study Area on the ODEQ 2008 303(d) list (ODEQ 2008). Water quality data from the primary and secondary contact recreation seasons are provided in Appendix A.

For the data collected between 1999 and 2008, when there is enough data to make an assessment, evidence of nonsupport of primary body contact recreation beneficial uses was observed for all three bacteria indicators in Hogshooter Creek . Nonsupport of PBCR was observed for Enterococci in Caney River (OK121400010010_10) and Curl Creek. There is not enough data in Caney River (OK121400010010_00) and Rabb Creek to assess the PBCR uses for Enterococci and Fecal Coliform respectively. Mission Creek was found supporting PBCR beneficial uses for Enterococci and E. coli although it is only listed for Enterococci. Little Caney River was also found supporting PBRC beneficial uses for Enterococci though it is only listed for turbidity. Table 2-3 summarizes the waterbodies requiring TMDLs for not supporting PBCR.

Table 2-2 Summary of Indicator Bacteria Samples from Primary Body Contact Recreation Season, 1999-2008

Waterbody ID	Waterbody Name	Indicator Bacteria	Geo-Mean Concentration (count/100ml)	Number of Samples	Number of Samples Exceeding Single Sample Criterion	% of Samples Exceeding Single Sample Criterion	2008 303(d) Listing	Reason for Listing Change
OK121400010010_00	Caney River	FC						
		ENT					X	Delist: No data available
		EC						
OK121400010010_10	Caney River	FC						
		ENT	69	25	15	60.0%	X	TMDL required
		EC						
OK121400010300_00	Hogshooter Creek	FC	220	10	3	30.0%	X	TMDL required
		ENT	256	17	16	94.0%	X	TMDL required
		EC	230	17	12	70.6%	X	TMDL required
OK121400010270_00	Curl Creek	FC						
		ENT	250	16	15	93.8%	X	TMDL required
		EC						
OK121400020190_00	Mission Creek	FC						
		ENT	131	15	9	60. 0%	X	TMDL required
		EC	139	15	7	46.7%		List: Does not meet standards
OK121400020140_00	Little Caney River	FC						
		ENT	92	16	11	68.8%		List: Does not meet standards
		EC						
OK121400010090_00	Rabb Creek	FC	215	10	2	20.0%	X	Delist: Single sample criterion exceedance < 25%
		ENT						
		EC						

Table 2-3 Waterbodies Requiring TMDLs for Not Supporting Primary Body Contact Recreation Use

WQM Station	Waterbody ID	Waterbody Name	Indicator Bacteria		
			FC	ENT	*E. coli*
OK121400010010-001AT	OK121400010010_10	Caney River		X	
OK121400-01-0300D OK121400-01-0300J	OK121400010300_00	Hogshooter Creek	X	X	X
OK121400-01-0270C OK121400-01-0270G	OK121400010270_00	Curl Creek		X	
OK121400-02-0190B	OK121400020190_00	Mission Creek		X	X
OK121400-02-0140H	OK121400020140_00	Little Caney River		X	

ENT = enterococci; FC = fecal Coliform

Turbidity

Turbidity is a measure of water clarity and is caused by suspended particles in the water column. Because turbidity cannot be expressed as a mass load, total suspended solids (TSS) are used as a surrogate in this TMDL. Therefore, both turbidity and TSS data are presented in this section.

Table 2-4 summarizes water quality data collected from the WQM stations between 1998 and 2008 for turbidity. However, as stipulated in Title *785:45-5-12 (f) (7) (C)*, numeric criteria for turbidity only apply under base flow conditions. While the base flow condition is not specifically defined in the Oklahoma Water Quality Standards, DEQ considers base flow conditions to be all flows less than the 25th flow exceedance percentile (i.e., the lower 75 percent of flows) which is consistent with the USGS Streamflow Conditions Index (USGS 2009). Therefore, Table 2-5 was prepared to represent the subset of these data for samples collected during base flow conditions. Water quality samples collected under flow conditions greater than the 25th flow exceedance percentile were therefore excluded from the data set used for TMDL analysis. The data in Table 2-5 were used to support the decision to place Caney River, Curl Creek, Mission Creek and Little Caney River on the ODEQ 2008 303(d) list (ODEQ 2008) for nonsupport of the Fish and Wildlife Propagation use based on turbidity levels observed in the waterbody. Although Rabb Creek is not listed for turbidity, it was found to not support the Fish and Wildlife Propagation use based on its turbidity levels. There were no turbidity data available for Caney River segment OK121400010010_00 and the percentage of samples exceeding the turbidity criteria of 50 NTU for Hogshooter Creek was found to be less than ten percent which implies that Hogshooter Creek should be delisted for turbidity

Table 2-4 Summaries of All Turbidity Samples 1999 - 2008

WQM Station	Waterbody Name	Number of Turbidity Samples	Number of Samples Exceed 50 (NTU)	Percentage of Samples Exceeding Criterion	Average Turbidity (NTU)
OK121400010010-001AT	Caney River	26	16	61.5%	146.3
OK121400-01-0300D OK121400-01-0300J	Hogshooter Creek	61	3	4.9%	19.5
OK121400-01-0300D OK121400-01-0300J	Curl Creek	30	8	26.7%	36.5
OK121400-01-0270C OK121400-01-0270G	Mission Creek	42	9	21.4%	52.2
OK121400-02-0140H	Little Caney River	42	27	64.3%	86.0
OK121400-01-0090D	Rabb Creek	22	7	31.8%	51.6

Table 2-5 Summary of Turbidity Samples Collected During Base Flow Conditions 1999 - 2008

WQM Station	Waterbody Name	Number of Turbidity Samples	Number of Samples Exceed 50 (NTU)	Percentage of Samples Exceeding Criterion	Average Turbidity (NTU)
OK121400010010-001AT	Caney River	17	7	41.2%	63.3
OK121400-01-0300D	Hogshooter Creek	48	1	2.1%	19.9
OK121400-01-0300D OK121400-01-0300J	Curl Creek	27	6	22.2%	33.9
OK121400-01-0270C OK121400-01-0270G	Mission Creek	35	5	14.3%	53.4
OK121400-02-0140H	Little Caney River	18	6	33.3%	54.9
OK121400-01-0090D	Rabb Creek	15	3	20.0%	38.0

Table 2-6 summarizes water quality data collected from the WQM stations between 1998 and 2008 for TSS. Table 2-7 presents a subset of these data for samples collected during base flow conditions. Water quality data for turbidity and TSS are provided in Appendix A.

Table 2-6 Summary of All TSS Samples 1999 - 2008

WQM Station	Waterbody Name	Number of TSS Samples	Average TSS (mg/L)
OK121400010010-001AT	Caney River	24	98.1
OK121400-01-0300D	Hogshooter Creek	58	12.6
OK121400-01-0300D OK121400-01-0300J	Curl Creek	29	27.1
OK121400-01-0270C OK121400-01-0270G	Mission Creek	40	36.9
OK121400-02-0140H	Little Caney River	40	52.2
OK121400-01-0090D	Rabb Creek	20	40.7

Table 2-7 Summary of TSS Samples Excluding High Flow Samples

WQM Station	Waterbody Name	Number of TSS Samples	Average TSS (mg/L)
OK121400010010-001AT	Caney River	17	53.1
OK121400-01-0300D	Hogshooter Creek	48	13.1
OK121400-01-0300D OK121400-01-0300J	Curl Creek	26	26.5
OK121400-01-0270C OK121400-01-0270G	Mission Creek	33	40.4
OK121400-02-0140H	Little Caney River	18	33.8
OK121400-01-0090D	Rabb Creek	13	30.4

2.3 Water Quality Target

The Code of Federal Regulations (40 CFR §130.7(c)(1)) states that, "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards." For the WQM stations requiring bacteria TMDLs in this report, defining the water quality target is somewhat complicated by the use of three different bacterial indicators each with different numeric criterion for determining attainment of PBCR use as defined in the Oklahoma WQSs. An individual water quality target is established for each bacterial indicator since each indicator group must demonstrate compliance with the numeric criteria prescribed in the Oklahoma WQS (OWRB 2008). As previously stated, because available bacteria data were collected on an approximate monthly basis (see Appendix A) instead of at least five samples over a 30–day period, data for these TMDLs are analyzed and presented in relation to both the instantaneous and a long-term geometric mean for each bacterial indicator.

All TMDLs for fecal coliform must take into account that no more than 25 percent of the samples may exceed the instantaneous numeric criteria. For *E. coli* and Enterococci, no samples may exceed instantaneous criteria. Since the attainability of stream beneficial uses for *E. coli* and Enterococci is based on the compliance of either the instantaneous or a long-term geometric mean criterion, percent reductions goals will be calculated for both criteria. TMDLs will be based on the percent reduction required to meet either the instantaneous or long-term geometric mean criterion, whichever is less.

The water quality target for bacteria will also incorporate an explicit 10 percent MOS. For example, if fecal coliform is utilized to establish the TMDL, then the water quality target is 360 organisms per 100 milliliters (mL), 10 percent lower than the instantaneous water quality criteria (400/100 mL). For *E. coli* the instantaneous water quality target is 365 organisms/100 mL, which is 10 percent lower than the criterion value (406/100 mL), and the geometric mean water quality target is 113 organisms/100 mL, which is 10 percent lower than the criterion value (126/100 mL). For Enterococci the instantaneous water quality target is 97/100 mL, which is 10 percent lower than the criterion value (108/100 mL) and the geometric mean water quality target is 30 organisms/100 mL, which is 10 percent lower than the criterion value (33/100 mL).

The allowable bacteria load is derived by using the actual or estimated flow record multiplied by the water quality target. The line drawn through the allowable load data points is the water quality target which represents the maximum load for any given flow that still satisfies the WQS.

An individual water quality target established for turbidity must demonstrate compliance with the numeric criteria prescribed in the Oklahoma WQS (OWRB 2008). According to the Oklahoma WQS [785:45-5-12(f)(7)], the turbidity criterion for streams with WWAC beneficial use is 50 NTUs (OWRB 2008). The turbidity of 50 NTUs applies only to seasonal base flow conditions. Turbidity levels are expected to be elevated during, and for several days after, a storm event.

TMDLs for turbidity in streams designated as WWAC must take into account that no more than 10 percent of the samples may exceed the numeric criterion of 50 NTU. However, as described above, because turbidity cannot be expressed as a mass load, TSS is used as a surrogate for TMDL development. Since there is no numeric criterion in the Oklahoma WQS for TSS, a specific method must be developed to convert the turbidity criterion to TSS based on a relationship between turbidity and TSS. The method for deriving the relationship between turbidity and TSS and for calculating a water body specific water quality target using TSS is summarized in Section 4 of this report.

The MOS for the TSS TMDLs varies by waterbody and is related to the goodness-of-fit metrics of the turbidity-TSS regressions. The method for defining MOS percentages is described in Section 5 of this report.

SECTION 3
POLLUTANT SOURCE ASSESSMENT

A source assessment characterizes known and suspected sources of pollutant loading to impaired waterbodies. Sources within a watershed are categorized and quantified to the extent that information is available. Bacteria originate from humans and warm-blooded animals; and sources may be point or nonpoint in nature. Turbidity may originate from NPDES-permitted facilities, fields, construction sites, quarries, stormwater runoff and eroding stream banks

Point sources are permitted through the NPDES program. NPDES-permitted facilities that discharge treated wastewater are required to monitor for one of the three bacterial indicators (fecal coliform, *E coli*, or Enterococci) and turbidity in accordance with their permit. Nonpoint sources are diffuse sources that typically cannot be identified as entering a waterbody through a discrete conveyance at a single location. These sources may involve land activities that contribute bacteria and /or TSS to surface water as a result of rainfall runoff. For the TMDLs in this report, all sources of pollutant loading not regulated by NPDES are considered nonpoint sources. The following discussion describes what is known regarding point and nonpoint sources of bacteria in the impaired watersheds.

3.1 NPDES-Permitted Facilities

Under 40 CFR, §122.2, a point source is described as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Certain NPDES-permitted municipal plants are classified as no-discharge facilities. NPDES-permitted facilities classified as point sources that may contribute bacteria or TSS loadings include:

- NPDES municipal wastewater treatment plant (WWTP);
- NPDES Industrial WWTP Discharges;
- NPDES municipal no-discharge WWTP;
- NPDES Concentrated Animal Feeding Operation (CAFO);
- NPDES municipal separate storm sewer system (MS4) discharges;
- NPDES multi-sector general permits; and
- NPDES construction stormwater discharges.

Continuous point source discharges such as WWTPs, could result in discharge of elevated concentrations of fecal coliform bacteria if the disinfection unit is not properly maintained, is of poor design, or if flow rates are above the disinfection capacity. It is possible that continuous point source discharges from municipal and industrial WWTPs, could result in discharge of elevated concentrations of TSS if a facility is not properly maintained, is of poor design, or flow rates exceed capacity. However, in most cases suspended solids discharged by WWTPs consist primarily of organic solids rather than inorganic suspended solids (i.e., soil and sediment particles from erosion or sediment resuspension). Discharges of organic suspended solids from WWTPs are addressed by ODEQ through its permitting of point sources to maintain WQS for dissolved oxygen and are not considered a potential source of turbidity in this TMDL. Discharges of TSS will be considered to be organic suspended solids if the discharge permit includes a limit for BOD or CBOD. Only WWTP discharges of inorganic suspended solids will be considered and will receive wasteload allocations.

While the no-discharge facilities do not discharge wastewater directly to a waterbody, it is possible that the collection systems associated with each facility may be a source of bacteria loading to surface waters. CAFOs are recognized by USEPA as significant sources of pollution, and may have the potential to cause serious impacts to water quality if not properly managed.

Stormwater runoff from MS4 areas, which is now regulated under the USEPA NPDES Program, can also contain high fecal coliform bacteria concentrations. Stormwater runoff from MS4 areas, facilities under multi-sector general permits, and NPDES construction stormwater discharges, which are regulated under the USEPA NPDES Program, can contain TSS concentrations. 40 C.F.R. § 130.2(h) requires that NPDES-regulated stormwater discharges must be addressed by the wasteload allocation component of a TMDL. However, any stormwater discharge by definition occurs during or immediately following periods of rainfall and elevated flow conditions when where Oklahoma Water Quality Standard for turbidity does not apply. Oklahoma Water Quality Standards specify that the criteria for turbidity "apply only to seasonal base flow conditions" and go on to say "Elevated turbidity levels may be expected during, and for several days after, a runoff event" [OAC 785:45-5-12(f)(7)]. In other words, the turbidity impairment status is limited to base flow conditions and stormwater discharges from MS4 areas or construction sites do not contribute to the violation of Oklahoma's turbidity standard. Therefore, WLAs for NPDES-regulated stormwater discharges is essentially considered unnecessary in this TMDL report and will not be included in the TMDL calculations.

There are two NPDES permitted facilities in the contributing watershed of Caney River (OK121400010010_10). Of the two discharging facilities, the Town of Ramona's WWT is considered a seasonal discharger and the Town of Ochelata's WWT would be a continuous discharger.

3.1.1 Continuous Point Source Discharges

The location of the two NPDES permitted facilities which are tributaries to Caney River (OK121400010010_10) addressed in these TMDLs are shown in Figure 3-1 and is listed in Table 3-1. For the purposes of the TMDLs calculated in Chapter 5, only facility types identified in Table 3-1 as Sewerage Systems are assumed to contribute bacteria loads within the watersheds of the impaired waterbodies.

Table 3-1 Point Source Discharges in the Study Area

NPDES Permit No.	Name	Receiving Water	Facility Type	County Name	Design Flow (mgd)	Active/ Inactive	Facility ID
OK0028339	Ramona PWA	Caney River OK121400010010	Sewage	Washington	0.06	Active	S21407
OK0034517	Ochelata UA	Caney River OK121400010010	Sewage	Washington	0.07	Active	S21410

Discharge Monitoring Reports (DMR) on bacteria was not available for either of the above facilities. Bacteria monitoring was not required in their NPDES permit.

The facilities in Table 3-1 discharge organic TSS and are not considered potential sources of turbidity for this TMDL. The locations of the dischargers are shown in Figure 3-1. The Monthly Discharge Monitoring Reports (DMR) for TSS available for the facilities listed in Table 3-1 showed permit violations which have been highlighted in Table 3-2 for the Town of Ochelata. The permit issued to the Ochelata Utility Authority allows for a 15 mg/l TSS for the spring and summer seasons. The Town of Ramona showed no permit violation from their DMR. Additional Monthly Discharge Monitoring Reports (DMR) for TSS available for the facilities listed below is provided in Appendix B.

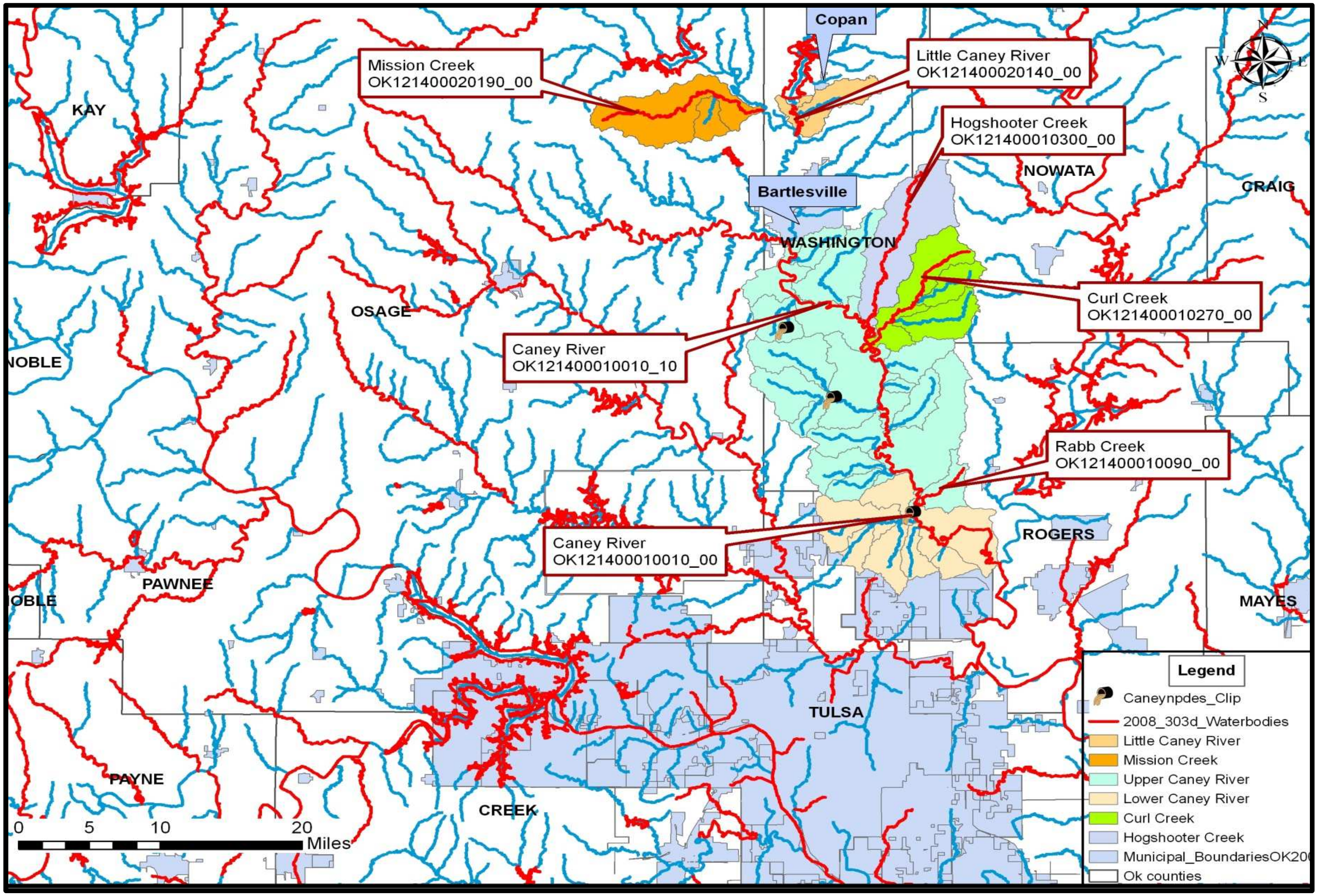
Table 3-2 Discharge Monitoring Data for Facilities in the Study Area

NPDES	Name of Facility	Time	Max Flow (mgd)	Ave Flow (mgd)	Max TSS (mg/L)	Ave TSS (mg/L)
OK0034517	Ochelata UA	5/31/2009	0.07	0.07	5	5
OK0034517	Ochelata UA	4/30/2009	0.07	0.07	5	5
OK0034517	Ochelata UA	3/31/2009	0.07	0.07	57	57
OK0034517	Ochelata UA	2/28/2009	0.07	0.07	22	22
OK0034517	Ochelata UA	1/31/2009	0.07	0.07	20	20
OK0034517	Ochelata UA	12/31/2008	0.07	0.07	40	40
OK0034517	Ochelata UA	11/30/2008	0.07	0.07	5	5
OK0034517	Ochelata UA	10/31/2008	0.07	0.07	5	5
OK0034517	Ochelata UA	9/30/2008	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	8/31/2008	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	7/31/2008	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	6/30/2008	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	5/31/2008	0.07	0.07	36	36
OK0034517	Ochelata UA	4/30/2008	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	3/31/2008	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	2/29/2008	0.07	0.07	5	5
OK0034517	Ochelata UA	1/31/2008	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	12/31/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	11/30/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	10/31/2007	0.07	0.07	22	22
OK0034517	Ochelata UA	9/30/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	8/31/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	7/31/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	6/30/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	5/31/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	4/30/2007	0.07	0.07	25	25
OK0034517	Ochelata UA	3/31/2007	NODI	NODI	NODI	NODI

NPDES	Name of Facility	Time	Max Flow (mgd)	Ave Flow (mgd)	Max TSS (mg/L)	Ave TSS (mg/L)
OK0034517	Ochelata UA	2/28/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	1/31/2007	NODI	NODI	NODI	NODI
OK0028339	Ramona PWA	5/31/2009	0.070	0.030	44	44
OK0028339	Ramona PWA	4/30/2009	0.058	0.045	7	7
OK0028339	Ramona PWA	3/31/2009	0.040	0.030	5	5
OK0028339	Ramona PWA	2/28/2009	0.030	0.030	7	7
OK0028339	Ramona PWA	1/31/2009	0.040	0.020	5	5
OK0028339	Ramona PWA	12/31/2008	0.030	0.015	6	6
OK0028339	Ramona PWA	11/30/2008	0.040	0.025	90	90
OK0028339	Ramona PWA	10/31/2008	0.040	0.025	59	59
OK0028339	Ramona PWA	9/30/2008	NODI	NODI	NODI	NODI
OK0028339	Ramona PWA	8/31/2008	NODI	NODI	NODI	NODI
OK0028339	Ramona PWA	7/31/2008	0.120	0.036	6	6
OK0028339	Ramona PWA	6/30/2008	0.050	0.045	5	5
OK0028339	Ramona PWA	5/31/2008	0.050	0.040	63	63
OK0028339	Ramona PWA	4/30/2008	0.226	0.183	17	17
OK0028339	Ramona PWA	3/31/2008	0.103	0.062	6	6
OK0028339	Ramona PWA	2/29/2008	0.030	0.030	19	19
OK0028339	Ramona PWA	1/31/2008	0.040	0.033	31	31
OK0028339	Ramona PWA	12/31/2007	0.080	0.048	44	44
OK0028339	Ramona PWA	11/30/2007	0.040	0.035	58	58
OK0028339	Ramona PWA	10/31/2007	0.030	0.030	79	79
OK0028339	Ramona PWA	9/30/2007	NDR	NDR	NDR	NDR
OK0028339	Ramona PWA	8/31/2007	0.040	0.038	17	17
OK0028339	Ramona PWA	7/31/2007	0.120	0.056	32	32
OK0028339	Ramona PWA	6/30/2007	0.040	0.021	27	27
OK0028339	Ramona PWA	5/31/2007	0.030	0.023	38	38
OK0028339	Ramona PWA	4/30/2007	0.030	0.017	55	55
OK0028339	Ramona PWA	3/31/2007	0.030	0.015	65	65
OK0028339	Ramona PWA	2/28/2007	0.030	0.019	42	42
OK0028339	Ramona PWA	1/31/2007	0.030	0.020	25	25

NODI= No discharge; NDR = No Data Received

Figure 3-1 Locations of NPDES-Permitted Facilities in the Study Area



3.1.2 NPDES No-Discharge Facilities and SSOs

There is no NPDES no-discharge facility in any of the sub-watersheds in the study area.

Sanitary sewer overflows (SSO) from wastewater collection systems, although infrequent, can be a major source of fecal coliform loading to streams. SSOs have existed since the introduction of separate sanitary sewers, and most are caused by blockage of sewer pipes by grease, tree roots, and other debris that clog sewer lines, by sewer line breaks and leaks, cross connections with storm sewers, and inflow and infiltration of groundwater into sanitary sewers. SSOs are permit violations that must be addressed by the responsible NPDES permittee. The reporting of SSOs has been strongly encouraged by USEPA, primarily through enforcement and fines. While not all sewer overflows are reported, ODEQ has some data on SSOs available. There were 50 combined SSO occurrences in the Caney River Study Area on record which goes back to as early as 1990. The first occurrence was in May 1990 and the last in November 2009. A summary of the reported SSOs in the Caney River Study Area are provided in Table 3-3. Additional data on each individual SSO event and the facility are provided in Appendix B.

Table 3-3 Sanitary Sewer Overflow Summary

Facility Name	NPDES Permit No.	Receiving Water	Facility ID	Number of Occurrences	Date Range	
					From	To
Ramona PWA	OK0028339	Caney River OK121400010010	S21407	38	5/28/1990	11/28/2009
Ochelata UA	OK0034517	Caney River OK121400010010	S21410	12	01/06/1998	11/13/2008

SSOs are a common result of the aging wastewater infrastructure around the state. DEQ has been ahead of other states and, in some cases EPA itself, in its handling of SSOs. Due to the widespread nature of the SSO problem, DEQ has focused its limited resources to first target SSOs that result in definitive environmental harm, such as fish kills, or lead to citizen complaints. All SSOs falling in these two categories are addressed through DEQ's formal enforcement process. A Notice of Violation (NOV) is first issued to the owner of the collection system and a Consent Order (CO) is negotiated between the owner and DEQ to establish a schedule for necessary collection system upgrades to eliminate future SSOs.

Another target area for DEQ is chronic SSOs from OPDES major facilities, those with a total design flow in excess of 1 MGD. DEQ periodically reviews the bypass reports submitted by these major facilities and identifies problem areas and chronic SSOs. When these problems are attributable to wet weather, DEQ endeavors to enter into a CO with the owner of the collection system to establish a schedule for necessary repairs. When the problems seem to be dry weather-related, DEQ will encourage the owner of the collection system to implement the proposed Capacity, Management, Operation, and Maintenance (CMOM) guidelines aimed at minimizing or eliminating dry weather SSOs. This is often accomplished through entering into a Consent Order to establish a schedule for implementation and annual auditing of the CMOM program.

All SSOs are considered unpermitted discharges under State statute and DEQ regulations. The smaller towns have a smaller reserve, are more likely to use utility revenue for general purposes, and/or tend to budget less for ongoing and/or preventive maintenance. If and when DEQ becomes aware of chronic SSOs (more than one from a single location in a year) or receives a complaint about an SSO in a smaller community, DEQ will pursue enforcement action. Enforcement almost always begins with the issuance of an NOV and, if the problem is not corrected by a long-term solution, DEQ will enter into a CO with the facility for a long-term solution. Long-term solutions usually begin with sanitary sewer evaluation surveys (SSESs). Based on the result of the SSES, the facilities can prioritize and take corrective action.

3.1.3 NPDES Municipal Separate Storm Sewer Discharge

Bacteria

Phase I MS4

In 1990 the USEPA developed rules establishing Phase I of the NPDES Stormwater Program, designed to prevent harmful pollutants from being washed by stormwater runoff into MS4s (or from being dumped directly into the MS4) and then discharged into local water bodies (USEPA 2005). Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or greater) to implement a stormwater management program as a means to control polluted discharges. Approved stormwater management programs for medium and large MS4s are required to address a variety of water quality-related issues, including roadway runoff management, municipal-owned operations, and hazardous waste treatment. There are no Phase I MS4 permits in the Study Area.

Phase II MS4

Phase II of the rule extends coverage of the NPDES Stormwater Program to certain small MS4s. Small MS4s are defined as any MS4 that is not a medium or large MS4 covered by Phase I of the NPDES Stormwater Program. Phase II requires operators of regulated small MS4s to obtain NPDES permits and develop a stormwater management program. Programs are designed to reduce discharges of pollutants to the “maximum extent practicable,” protect water quality, and satisfy appropriate water quality requirements of the CWA. Small MS4 stormwater programs must address the following minimum control measures:

- Public Education and Outreach;
- Public Participation/Involvement;
- Illicit Discharge Detection and Elimination;
- Construction Site Runoff Control;
- Post- Construction Runoff Control; and
- Pollution Prevention/Good Housekeeping.

The small MS4 General Permit for communities in Oklahoma became effective on February 8, 2005. There are no permitted MS4s within the study area.

Turbidity

There are no urbanized areas designated as MS4s within this Study Area. A general stormwater permit is required for construction activities. Permittees are authorized to discharge pollutants in stormwater runoff associated with construction activities for construction sites. Stormwater discharges occur only during or immediately following periods of rainfall and elevated flow conditions when the turbidity criteria do not apply and are not considered potential contributors to turbidity impairment. ODEQ provides information on the current status of its MS4 program on its website, found at:

http://www.deq.state.ok.us/WQDnew/stormwater/ms4/

3.1.4 Concentrated Animal Feeding Operations

There are no NPDES-permitted CAFO facilities within the Study Area.

3.1.5 Section 404 Permits

Section 404 of the Clean Water Act (CWA) establishes programs to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. Activities in waters of the United States regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports) and mining projects. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g. certain farming and forestry activities).

Section 404 permits are administrated by the U.S. Army Corps of Engineers. EPA reviews and provides comments on each permit application to make sure it adequately protects water quality and complies with applicable guidelines. Both USACE and EPA can take enforcement actions for violations of Section 404.

Discharge of dredged or fill material in waters can be a significant source of turbidity/TSS. The federal Clean Water Act requires that a permit be issued for activities which discharge dredged or fill materials into the waters of the United States, including wetlands. The state of Oklahoma will use its Section 401 certification authority to ensure Section 404 permits protect Oklahoma water quality standards.

3.2 Nonpoint Sources

Nonpoint sources include those sources that cannot be identified as entering the waterbody at a specific location. The relatively homogeneous land use/land cover categories throughout the Study Area associated with rural agricultural, forest and range management activities has an influence on the origin and pathways of pollutant sources to surface water. Bacteria originate from warm-blooded animals in rural, suburban, and urban areas. These sources include wildlife, various agricultural activities and domesticated animals, land application fields, urban runoff, failing onsite wastewater disposal (OSWD) systems and domestic pets. Water quality data collected from streams draining urban communities often show existing concentrations of fecal coliform bacteria at levels greater than a state's instantaneous standards. A study under USEPA's National Urban Runoff Project indicated that the average fecal coliform concentration from 14 watersheds in different areas within the United States was approximately 15,000/100 mL in stormwater runoff (USEPA 1983). Runoff from urban areas not permitted under the MS4 program can be a significant source of fecal coliform bacteria. Water quality data collected from streams draining many of the nonpermitted communities show existing loads of fecal coliform bacteria at levels greater than the State's instantaneous standards.

Various potential nonpoint sources of TSS as indicated in the 2008 Integrated Report include sediments originating from grazing in riparian corridors of streams and creeks, highway/road/bridge runoff, non-irrigated crop production, rangeland grazing and other sources of sediment loading (ODEQ 2008). Elevated turbidity measurements can be caused by stream bank erosion processes, stormwater runoff events and other channel disturbances. The following section provides general information on nonpoint sources contributing bacteria or TSS loading within the Study Area.

3.2.1 Wildlife

Fecal coliform bacteria are produced by all warm-blooded animals, including wildlife such as mammals and birds. In developing bacteria TMDLs it is important to identify the potential for bacteria contributions from wildlife by watershed. Wildlife is naturally attracted to riparian corridors of streams and rivers. With direct access to the stream channel, wildlife can be a concentrated source of bacteria loading to a waterbody. Fecal coliform bacteria from wildlife are also deposited onto land surfaces, where it may be washed into nearby streams by rainfall runoff. Currently there are insufficient data available to estimate populations and spatial distribution of wildlife and avian species by watershed. Consequently it is difficult to assess the magnitude of bacteria contributions from wildlife species as a general category.

However, adequate data are available by county to estimate the number of deer by watershed. This report assumes that deer habitat includes forests, croplands, and pastures. Using Oklahoma Department of Wildlife Conservation county data, the population of deer can be roughly estimated from the actual number of deer harvested and harvest rate estimates. Because harvest success varies from year to year based on weather and other factors, the average harvest from 1999 to 2003 was combined with an estimated annual harvest rate of 20 percent to predict deer population by county. Using the estimated deer population by county and the percentage of the watershed area within each county, a wild deer population can be calculated for each watershed. Table 3-3 provides the estimated number of deer for each watershed.

Table 3-3 Estimated Deer Populations

Waterbody ID	Waterbody Name	Deer	Acre
OK121400010010_10	Caney River	2,085	139,599
OK121400010300_00	Hogshooter Creek	498	28,446
OK121400010270_00	Curl Creek	590	30,778
OK121400020190_00	Mission Creek	34	26,827
OK121400020140_00	Little Caney River	160	10,296

According to a study conducted by ASAE (the American Society of Agricultural Engineers), deer release approximately $5x10^8$ fecal coliform units per animal per day

(ASAE 1999). Although only a fraction of the total fecal coliform loading produced by the deer population may actually enter a waterbody, the estimated fecal coliform production for deer provided in Table 3-4 in cfu/day provides a relative magnitude of loading in each watershed.

Table 3-4 Estimated Fecal Coliform Production for Deer

Waterbody ID	Waterbody Name	Watershed Area (acres)	Wild Deer Population	Estimated Wild Deer per acre	Fecal Production (x 10^9 cfu/day) of Deer Population
OK121400010010_10	Caney River	139,599	2,085	0.0149	1,042
OK121400010300_00	Hogshooter Creek	28,446	498	0.0175	249
OK121400010270_00	Curl Creek	30,778	590	0.0192	295
OK121400020190_00	Mission Creek	26,827	34	0.0013	18
OK121400020140_00	Little Caney River	10,296	160	0.0156	81

3.2.2 Non-Permitted Agricultural Activities and Domesticated Animals

There are a number of non-permitted agricultural activities that can also be sources of fecal bacteria loading. Agricultural activities of greatest concern are typically those associated with livestock operations (Drapcho and Hubbs 2002). The following are examples of commercially raised farm animal activities that can contribute to bacteria sources:

- Processed commercially raised farm animal manure is often applied to fields as fertilizer, and can contribute to fecal bacteria loading to waterbodies if washed into streams by runoff.
- Animals grazing in pastures deposit manure containing fecal bacteria onto land surfaces. These bacteria may be washed into waterbodies by runoff.
- Animals often have direct access to waterbodies and can provide a concentrated source of fecal bacteria loading directly into streams.

Table 3-5 provides estimated numbers of commercially raised farm animals by watershed based on the 2002 U.S. Department of Agriculture (USDA) county agricultural census data (USDA 2002). The estimated animal populations in Table 3-5 were derived by using the percentage of the watershed within each county. Because the watersheds are generally much smaller than the counties, and commercially raised farm animals are not evenly distributed across counties or constant with time, these are rough estimates only. Cattle generate the largest amount of fecal coliform and often have direct access to the impaired waterbodies.

Detailed information is not available to describe or quantify the relationship between instream concentrations of bacteria and land application of manure. The estimated acreage by watershed where manure was applied in 2002 is shown in Table 3-5. These estimates are also based on the county level reports from the 2002 USDA county agricultural census, and thus represent approximations of the land application area in each watershed. Because of the lack of specific data, for the purpose of these TMDLs, land application of animal manure is not quantified in Table 3-6 but is considered a potential source of bacteria loading to the waterbodies in the Study Area. Most poultry feeding operations are regulated by ODAFF, and are required to land apply chicken waste in accordance with their Animal Waste Management Plans or Comprehensive Nutrient Management Plans. While these plans are not designed to control bacteria loading, best management practices and conservation measures, if properly implemented, could greatly reduce the contribution of bacteria from this group of animals to the watershed.

According to a study conducted by the ASAE, the daily fecal coliform production rates by species were estimated as follows (ASAE 1999):

- Beef cattle release approximately 1.04E+11 fecal coliform counts per animal per day;
- Dairy cattle release approximately 1.01E+11 per animal per day
- Swine release approximately 1.08E+10 per animal per day
- Chickens release approximately 1.36E+08 per animal per day
- Sheep release approximately 1.20E+10 per animal per day
- Horses release approximately 4.20E+08 per animal per day;
- Turkey release approximately 9.30E+07 per animal per day
- Ducks release approximately 2.43E+09 per animal per day
- Geese release approximately 4.90E+10 per animal per day

Using the estimated animal populations and the fecal coliform production rates from ASAE, an estimate of fecal coliform production from each group of commercially raised farm animals was calculated in each watershed of the Study Area in Table 3-6. Note that only a small fraction of these fecal coliform are expected to represent loading into waterbodies, either washed into streams by runoff or by direct deposition from wading animals. Cattle appear to represent the largest source of fecal bacteria.

According to data provided by Oklahoma Department of Agriculture, Food, and Forestry (ODAFF), there are no CAFOs or poultry operations in the study area (Figure 3-1).

Table 3-5 Commercially Raised Farm Animals and Manure Application Area Estimates by Watershed

Waterbody ID	Waterbody Name	Cattle & Calves-all	Dairy Cows	Horses & Ponies	Goats	Sheep & Lambs	Hogs & Pigs	Ducks & Geese	Chicken & Turkeys	Acres of Manure Application
OK121400010010_10	Caney River	17,922	85	1,360	3	408	36	92	959	1255
OK121400010300_00	Hogshooter Creek	4,328	16	225	0	70	10	6	144	150
OK121400010270_00	Curl Creek	5,224	26	187	0	47	20	6	127	58
OK121400020190_00	Mission Creek	3,155	3	86	0	22	10	4	63	15
OK121400020140_00	Little Caney River	1,250	2	64	0	23	0	2	64	97

Table 3-6 Fecal Coliform Production Estimates for Commercially Raised Farm Animals ($x10^9$ number/day)

Waterbody ID	Waterbody Name	Cattle & Calves-all	Dairy Cows	Horses & Ponies	Goats	Sheep & Lambs	Hogs & Pigs	Ducks & Geese	Chickens & Turkeys	Total
OK121400010010_10	Caney River	1,863,888	8,585	571	N/A	4,896	389	118	13	1,878,460
OK121400010300_00	Hogshooter Creek	450,112	1,616	95	N/A	840	108	8	2	452,781
OK121400010270_00	Curl Creek	543,296	2,626	79	N/A	564	216	8	2	546,791
OK121400020190_00	Mission Creek	328,120	303	36	N/A	264	108	5	1	328,837
OK121400020140_00	Little Caney River	130,000	202	27	N/A	276	0	3	1	130,509

3.2.3 Failing Onsite Wastewater Disposal Systems and Illicit Discharges

ODEQ is responsible for implementing the regulations of Title 252, Chapter 641 of the Oklahoma Administrative Code, which define design standards for individual and small public onsite sewage disposal systems (ODEQ 2008a). OSWD systems and illicit discharges can be a source of bacteria loading to streams and rivers. Bacteria loading from failing OSWD systems can be transported to streams in a variety of ways, including runoff from surface ponding or through groundwater. Fecal coliform-contaminated groundwater discharges to creeks through springs and seeps.

To estimate the potential magnitude of OSWDs fecal bacteria loading, the number of OSWD systems was estimated for each watershed. The estimate of OSWD systems was derived by using data from the 1990 U.S. Census because this data was not available in the 2000 U.S. Census. The estimate was then prorated based on the population data from both the 1990 and 2000 U.S. Census. The density of OSWD systems within each watershed was estimated by dividing the number of OSWD systems in each census block by the number of acres in each census block. This density was then applied to the number of acres of each census block within a waterbody watershed. Census blocks crossing a watershed boundary required additional calculation to estimate the number of OSWD systems based on the proportion of the census tracking falling within each watershed. This step involved adding all OSWD systems for each whole or partial census block.

Over time, most OSWD systems operating at full capacity will fail. OSWD system failures are proportional to the adequacy of a state's minimum design criteria (Hall 2002). The 1995 American Housing Survey conducted by the U.S. Census Bureau estimates that, nationwide, 10 percent of occupied homes with OSWD systems experience malfunctions during the year (U.S. Census Bureau 1995). A study conducted by Reed, Stowe & Yanke, LLC (2001) reported that approximately 12 percent of the OSWD systems in northeast Texas (adjacent to the study area) were chronically malfunctioning. Most studies estimate that the minimum lot size necessary to ensure against contamination is roughly one-half to one acre (Hall 2002). Some studies, however, found that lot sizes in this range or even larger could still cause contamination of ground or surface water (University of Florida 1987). It is estimated that areas with more than 40 OSWD systems per square mile (6.25 septic systems per 100 acres) can be considered to have potential contamination problems (Canter and Knox 1986). Table 3-7 summarizes estimates of sewered and unsewered households for each watershed in the study area.

Table 3-7 Estimates of Sewered and Unsewered Households

Waterbody ID	Waterbody Name	Public Sewer	Septic Tank	Other Means	Housing Units	% Sewered
OK121400010010_10	Caney River	3,930	1,587	24	5,541	71%
OK121400010300_00	Hogshooter Creek	78	294	4	376	21%
OK121400010270_00	Curl Creek	46	183	3	232	20%
OK121400020190_00	Mission Creek	2	110	4	116	2%
OK121400020140_00	Little Caney River	111	100	2	213	52%

For the purpose of estimating fecal coliform loading in watersheds, an OSWD failure rate of 12 percent was used. Using this 12 percent failure rate, calculations were made to characterize fecal coliform loads in each watershed.

Fecal coliform loads were estimated using the following equation (USEPA 2001):

$$\#\frac{counts}{day} = (\#\,Failing\_systems)\times\left(\frac{10^6\,counts}{100ml}\right)\times\left(\frac{70\,gal}{personday}\right)\times\left(\#\frac{person}{household}\right)\times\left(3785.2\frac{ml}{gal}\right)$$

The average of number of people per household was calculated to be 2.48 for counties in the Study Area (U.S. Census Bureau 2000). Approximately 70 gallons of wastewater was estimated to be produced on average per person per day (Metcalf and Eddy 1991). The fecal coliform concentration in septic tank effluent was estimated to be 10^6 per 100 mL of effluent based on reported concentrations from a number of published reports (Metcalf and Eddy 1991, Canter and Knox 1985; Cogger and Carlile 1984). Using this information, the estimated load from failing septic systems within the watersheds was summarized below in Table 3-8.

Table 3-8 Estimated Fecal Coliform Load from OSWD Systems

Waterbody ID	Waterbody Name	Acres	Septic Tank	# of Failing Septic Tanks	Estimated Loads from Septic Tanks (x 10^9 counts/day)
OK121400010010_10	Caney River	139,599	1,587	190	1,249
OK121400010300_00	Hogshooter Creek	28,446	294	35	230
OK121400010270_00	Curl Creek	30,778	183	22	145
OK121400020190_00	Mission Creek	26,827	110	13	85
OK121400020140_00	Little Caney River	10,296	100	12	79

3.2.4 Domestic Pets

Fecal matter from dogs and cats, which is transported to streams by runoff from urban and suburban areas can be a potential source of bacteria loading. On average 37.2 percent of the nation's households own dogs and 32.4 percent own cats and in these households the average number of dogs is 1.7 and 2.2 cats per household (American Veterinary Medical Association 2007).. Using the U.S. census data at the block level (U.S. Census Bureau 2000), dog and cat populations can be estimated for each watershed. Table 3-9 summarizes the estimated number of dogs and cats for the watersheds of the Study Area.

Table 3-9 Estimated Numbers of Pets

Waterbody ID	Waterbody Name	Housing Units	Dogs	Cats
OK121400010010_10	Caney River	5,541	9,420	12,190
OK121400010300_00	Hogshooter Creek	376	639	827
OK121400010270_00	Curl Creek	232	394	510
OK121400020190_00	Mission Creek	116	197	255
OK121400020140_00	Little Caney River	213	362	469

Table 3-10 provides an estimate of the fecal coliform load from pets. These estimates are based on estimated fecal coliform production rates of 5.4×10^8 per day for cats and 3.3×10^9 per day for dogs (Schueler 2000).

Table 3-10 Estimated Fecal Coliform Daily Production by Pets (x 10^9)

Waterbody ID	Waterbody Name	Dogs	Cats	Total
OK121400010010_10	Caney River	31,085	6,583	37,668
OK121400010300_00	Hogshooter Creek	2,109	447	2,556
OK121400010270_00	Curl Creek	1,302	276	1,577
OK121400020190_00	Mission Creek	651	138	789
OK121400020140_00	Little Caney River	1,195	253	1,448

3.3 Summary of Bacteria Sources

NPDES-permitted facilities operate in a few of the watersheds in the Study Area but most of the point sources are relatively minor and for the most part tend to meet instream water quality criteria in their effluent. Thus, nonpoint sources are considered to be the major source of bacteria loading in each watershed. Table 3-11 summarizes the suspected sources of bacteria loading in each impaired watershed.

Table 3-11 Estimated Major Source of Bacteria Loading by Watershed

Waterbody ID	Waterbody Name	Point Sources	Nonpoint Sources	Major Source
OK121400010010_10	Caney River	Yes	Yes	Nonpoint
OK121400010300_00	Hogshooter Creek	No	Yes	Nonpoint
OK121400010270_00	Curl Creek	No	Yes	Nonpoint
OK121400020190_00	Mission Creek	No	Yes	Nonpoint
OK121400020140_00	Little Caney River	No	Yes	Nonpoint

Table 3-12 below provides a summary of the estimated fecal coliform loads in percentage for the four major nonpoint source categories (commercially raised farm animals, pets, deer and septic tanks) that are contributing to the elevated bacteria concentrations in each watershed. Commercially raised farm animals are estimated to be the primary contributors of fecal coliform loading to land surfaces. It must be noted that while no data are available to estimate populations and fecal loading of wildlife other than deer, a number of bacteria source tracking studies demonstrate that wild birds and mammals represent a major source of the fecal bacteria found in streams.

The magnitude of loading to a stream may not reflect the magnitude of loading to land surfaces. While no studies quantify these effects, bacteria may die off or survive at different rates depending on the manure characteristics and a number of other environmental conditions. Manure handling practices, use of BMPs, and relative location to streams can also affect stream loading. Also, the structural properties of some manures, such as cow patties, may limit their washoff into streams by runoff. Because litter is applied in a pulverized form, it could be a larger source during storm runoff events. The Shoal Creek report showed that poultry litter was about 71% of the high flow load and cow pats contributed only about 28% of it (Missouri Department of Natural Resources, 2003). The Shoal Creek report also showed that poultry litter was insignificant under low flow conditions up to 50% frequency. In contrast, malfunctioning septic tank effluent may be present in pools on the surface, or in shallow groundwater, which may enhance its conveyance to streams.

Table 3-12 Summary of Daily Fecal Coliform Load Estimates from Nonpoint Sources to Land Surfaces

Waterbody ID	Waterbody Name	Commercially Raised Farm Animals	Pets	Deer	Septic Tanks
OK121400010010_10	Caney River	97.92%	1.96%	0.05%	0.07%
OK121400010300_00	Hogshooter Creek	99.33%	0.56%	0.05%	0.05%
OK121400010270_00	Curl Creek	99.63%	0.29%	0.05%	0.03%
OK121400020190_00	Mission Creek	99.73%	0.24%	0.01%	0.03%
OK121400020140_00	Little Caney River	98.78%	1.10%	0.06%	0.06%

SECTION 4
TECHNICAL APPROACH AND METHODS

The objective of a TMDL is to estimate allowable pollutant loads and to allocate these loads to the known pollutant sources in the watershed so appropriate control measures can be implemented and the WQS achieved. A TMDL is expressed as the sum of three elements as described in the following mathematical equation:

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

The WLA is the portion of the TMDL allocated to existing and future point sources. The LA is the portion of the TMDL allocated to nonpoint sources, including natural background sources. The MOS is intended to ensure that WQSs will be met. Thus, the allowable pollutant load that can be allocated to point and nonpoint sources can then be defined as the TMDL minus the MOS.

40 CFR, §130.2(1), states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For fecal coliform, *E. coli*, or Enterococci bacteria, TMDLs are expressed as colony-forming units per day, where possible, or as a percent reduction goal (PRG), and represent the maximum one-day load the stream can assimilate while still attaining the WQS.

4.1 Determining a Surrogate Target for Turbidity

Turbidity is a commonly measured indicator of the suspended solids load in streams. However, turbidity is an optical property of water, and measures scattering of light by suspended solids and colloidal matter. To develop TMDLs, a gravimetric (mass-based) measure of solids loading is required to express loads. There is often a strong relationship between the total suspended solids concentration and turbidity. Therefore, the TSS load, which is expressed as mass per time, is used as a surrogate for turbidity and represents the maximum one-day load the stream can assimilate while still attaining the WQS.

To determine the relationship between turbidity and TSS, a linear regression between TSS and turbidity was developed using data collected from 1998 to 2008 at one station within the Study Area. Prior to developing the regression the following steps were taken to refine the dataset:

- Replace TSS samples of “<10” with 9.99;
- Remove data collected under high flow conditions exceeding the base-flow criterion. This means that measurements corresponding to flow exceedance frequencieslower than 25^{th} were not used in the regression;
- Check rainfall data on the day samples were collected and on the previous two days for the samples with high turbidity and/or TSS readings. If there was a significant rainfall event (greater than 1.0 inch) in any of the three days, the sample will be excluded from regression analysis, and
- Log-transform both turbidity and TSS data to minimize effects of their non-linear data distributions.

When ordinary least squares regression (OLS) is applied to ascertain the best relationship between two variables (i.e., X and Y), one variable (Y) is considered “dependent” on the other variable (X), but X must be considered "independent" of the other, and known without measurement error. OLS minimizes the squares of differences, or residuals, between measured Y values and Y values predicted based on the X variable.

For current purposes, a relationship is necessary to predict TSS concentrations from measured turbidity values, but also to translate the TSS-based TMDL back to in-stream turbidity values. For this purpose, an alternate regression fitting procedure known as the line of organic correlation (LOC) was applied. The LOC has three advantages over OLS (Helsel and Hirsch 2002):

- LOC minimizes fitted residuals in both the X and Y directions;
- It provides a unique best-fit line regardless of which parameter is used as the independent variable; and
- Regression-fitted values have the same variance as the original data.

The LOC minimizes the areas of the right triangles formed by horizontal and vertical lines drawn from observations to the fitted line. The slope of the LOC line equals the geometric mean of the Y on X (TSS on turbidity) and X on Y (turbidity on TSS) OLS slopes, and is calculated as:

$$m1 = \sqrt{m \cdot m'} = sign[r] \cdot \frac{s_y}{s_x}$$

where *m*1 is the slope of the LOC line, *m* is the TSS on turbidity OLS slope, *m'* is the turbidity on TSS OLS slope, *r* is the TSS-turbidity correlation coefficient, s_y is the standard deviation of the TSS measurements, and s_x is the standard deviation of the turbidity measurements.

The intercept of the LOC (*b*1) is subsequently found by fitting the line with the LOC slope through the point (mean turbidity, mean TSS). The correlation between TSS and turbidity, along with the LOC and the OLS lines are shown in Figure 4-1 through Figure 4-5.

Figure 4-1 Linear Regression for TSS-Turbidity for Caney River (OK121400010010_10)

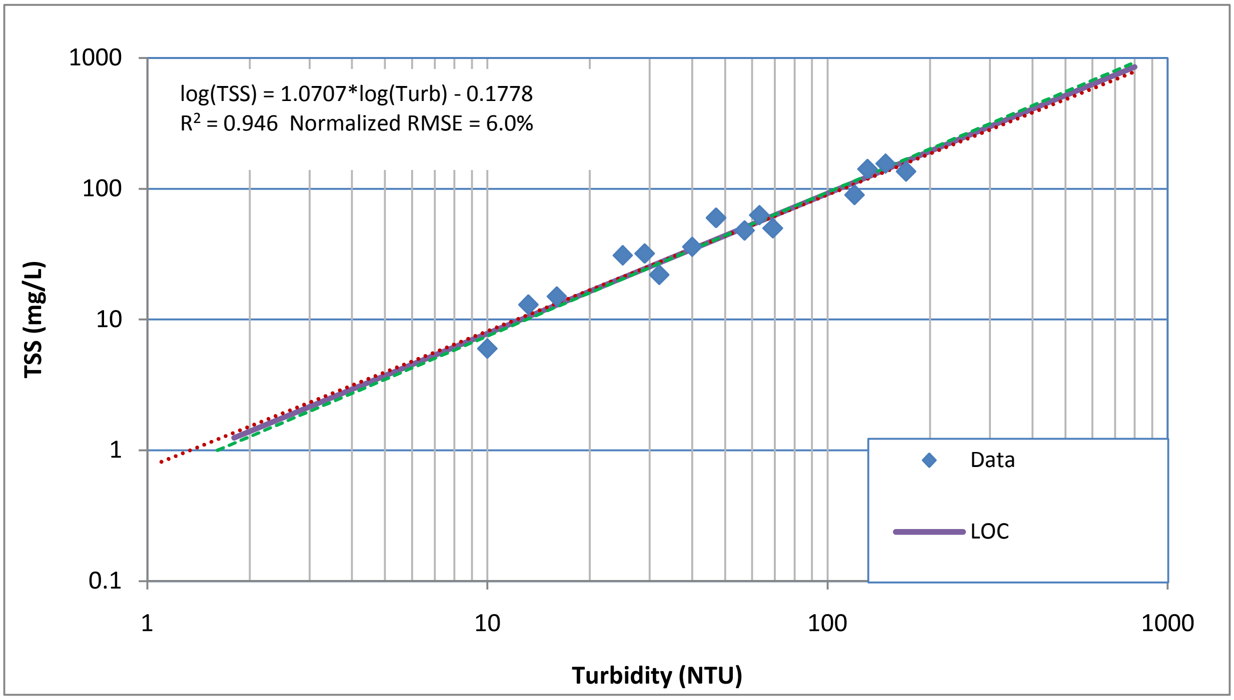


Figure 4-2 Linear Regression for TSS-Turbidity for Curl Creek (OK121400010270_00)

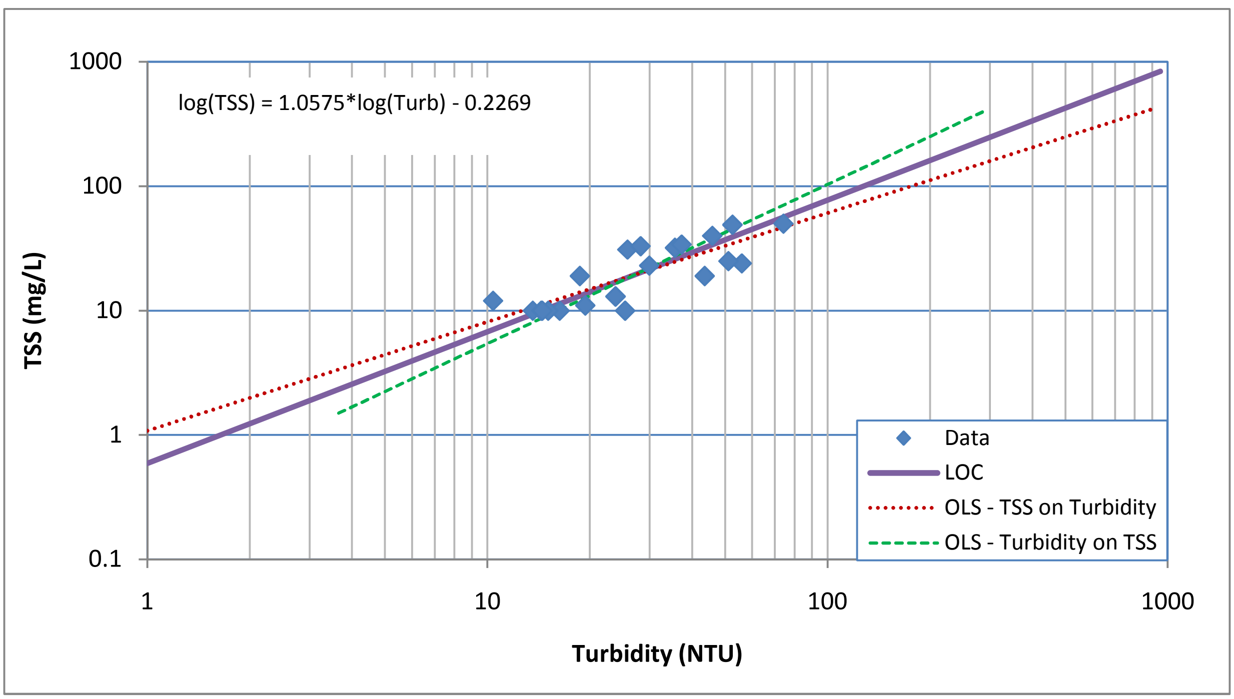


Figure 4-3 Linear Regression for TSS-Turbidity for Mission Creek (OK121400020190_00)

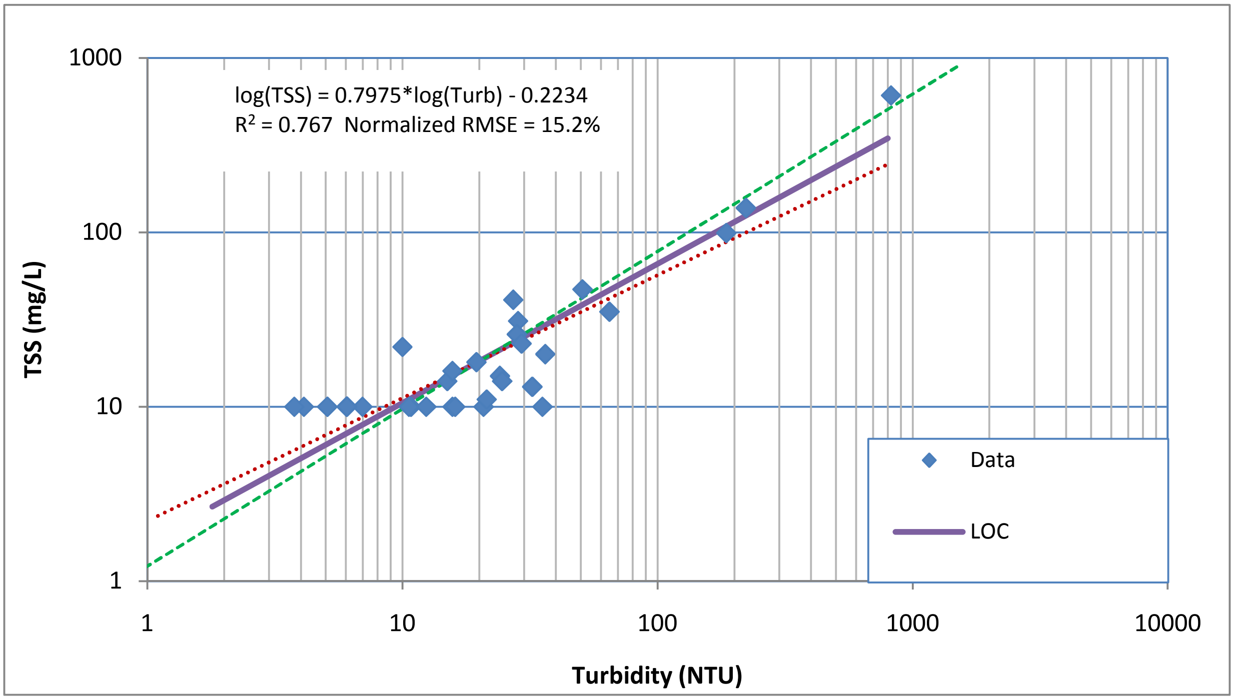


Figure 4-4 Linear Regression for TSS-Turbidity for Little Caney River (OK121400020140_00)

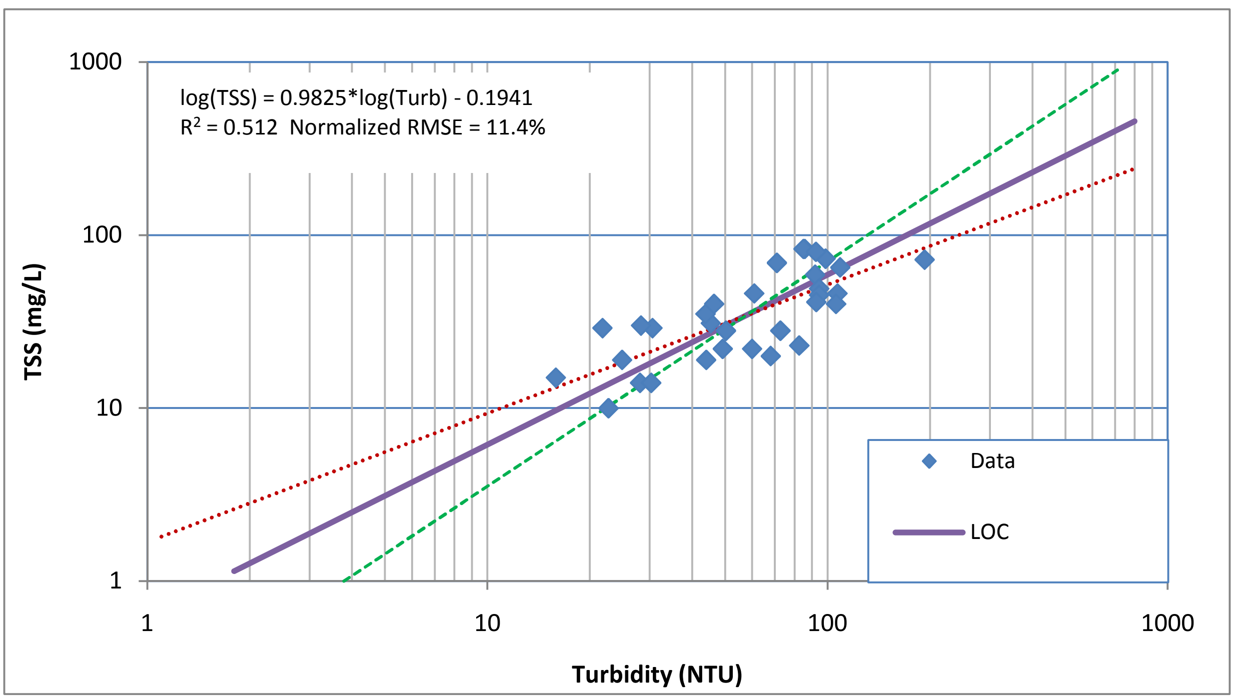
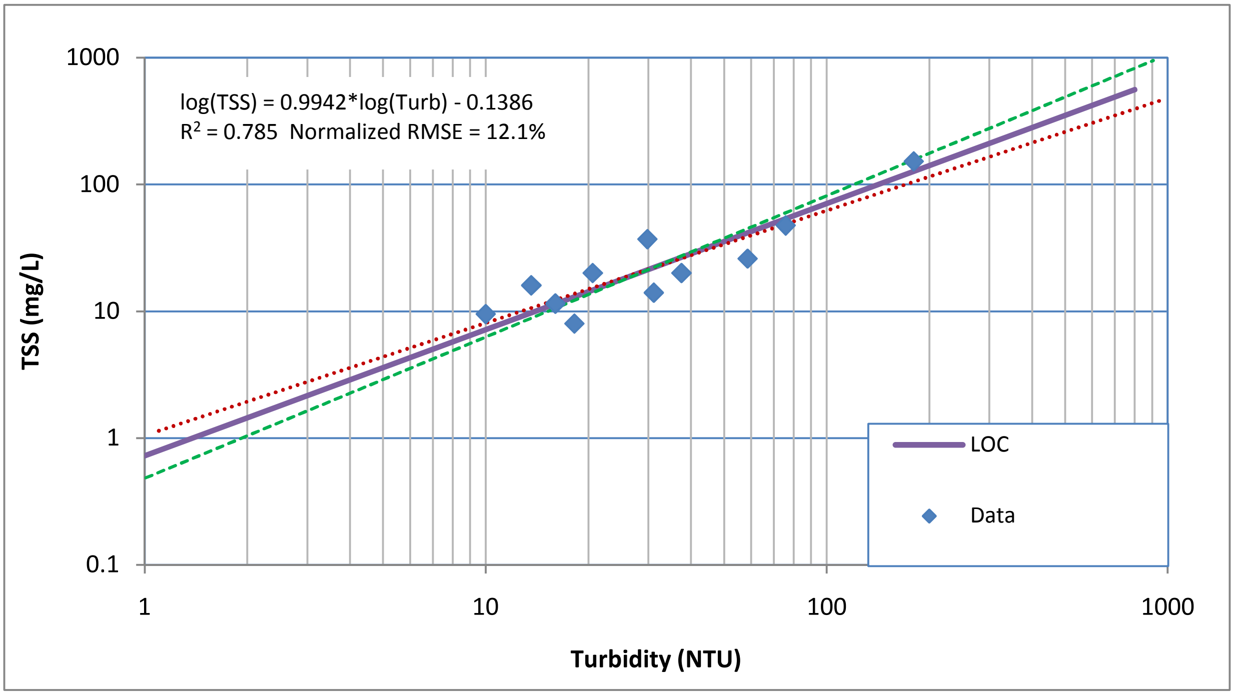


Figure 4-5 Linear Regression for TSS-Turbidity for Rabb Creek (OK121400010090_00)



The normalized root mean square error (NRMSE) and R-square (R^2) were used as the primary measure of goodness-of-fit. For example, as shown in Figure 4-1, the LOC yields a NRMSE value of 6.0% which means the root mean square error (RMSE) is 6.0% of the average of the measured TSS values. The R-square (R^2) value, which indicates the fraction of the total variance in TSS or turbidity observations that is explained by the LOC. Table 4-1 shows the statistics of the regressions and TSS targets.

Table 4-1 Regression Statistics and TSS Targets

Waterbody ID	Waterbody Name	R-square	NRMSE	Turbidity Criterion (NTU)	TSS Target (mg/L)
OK121400010010_10	Caney River	0.93	6.0%	50	44
OK121400010270_00	Curl Creek	0.65	11.4%	50	37
OK121400020190_00	Mission Creek	0.77	15.2%	50	38
OK121400020140_00	Little Caney River	0.51	11.4%	50	30
OK121400010090_00	Rabb Creek	0.78	12.1%	50	36

It was noted that there were a few outliers that exerted undue influence on the regression relationship. These outliers were identified by applying the Tukey's Boxplot method (Tukey 1977) to the dataset of the distances from observed points to the regression line. The Tukey Method is based on the interquartile range (IQR), the difference between the 75th and 25th percentiles of distances between observed points and the LOC. Using the Tukey method, any point with an error greater than the 75th percentile + 1.5 times the IQR or smaller than the

25th percentile - 1.5 times the IQR was identified as an outlier and removed from the regression dataset. The above regressions were recalculated using the dataset with outliers removed.

It is worth to note that the Tukey Method is equivalent to using three times standard deviation to identify outliers if the residuals (observed - predicted) follow a normal distribution. The probability of three times standard deviation is 99.73% while the probability for the Tukey Method is 99.65%. If we use three times standard deviation to identify outliers, we have to first confirm that the residuals are indeed normally distributed. This is difficult to do because most of the time we don't have a large turbidity & TSS dataset. The Tukey's method, however, does not have the assumption of distribution. Therefore, it can be used regardless of the shape of distribution.

It is also worth to note that outliers were removed only from the turbidity-TSS relationship, not from the dataset used to develop the TMDL.

4.2 Using Load Duration Curves to Develop TMDLs

The TMDL calculations presented in this report are derived from load duration curves (LDC). LDCs facilitate rapid development of TMDLs, and as a TMDL development tool are effective at identifying whether impairments are associated with point or nonpoint sources. The technical approach for using LDCs for TMDL development includes the four following steps that are described in Subsections 4.3 through 4.4 below:

- Preparing flow duration curves for gaged and ungaged WQM stations;
- Estimating existing loading in the waterbody using ambient bacteria water quality data; and estimating loading in the waterbody using measured TSS water quality data and turbidity-converted data; and
- Using LDCs to identify the critical condition that will dictate loading reductions and the overall percent reduction goal (PRG) necessary to attain WQS.

Historically, in developing WLAs for pollutants from point sources, it was customary to designate a critical low flow condition (*e.g.*, 7Q2) at which the maximum permissible loading was calculated. As water quality management efforts expanded in scope to quantitatively address nonpoint sources of pollution and types of pollutants, it became clear that this single critical low flow condition was inadequate to ensure adequate water quality across a range of flow conditions. Use of the LDC obviates the need to determine a design storm or selected flow recurrence interval with which to characterize the appropriate flow level for the assessment of critical conditions. For waterbodies impacted by both point and nonpoint sources, the "nonpoint source critical condition" would typically occur during high flows, when rainfall runoff would contribute the bulk of the pollutant load, while the "point source critical condition" would typically occur during low flows, when point source discharges would dominate the base flow of the impaired water. However, flow range is only a general indicator of the relative proportion of point/nonpoint contributions. It is not used in this report to quantify point source or nonpoint source contributions. Violations that occur during low flows may not be caused exclusively by point sources. Violations have been noted in some watersheds that contain no point sources. Research has shown that bacteria loading in streams during low flow conditions may be due to direct deposit of cattle manure into streams and faulty septic tank/lateral field systems.

LDCs display the maximum allowable load over the complete range of flow conditions by a line using the calculation of flow multiplied by the water quality criterion. The TMDL can be expressed as a continuous function of flow, equal to the line, or as a discrete value derived from a specific flow condition.

4.3 Development of Flow Duration Curves

Flow duration curves serve as the foundation of LDCs and are graphical representations of the flow characteristics of a stream at a given site. Flow duration curves utilize the historical hydrologic record from stream gages to forecast future recurrence frequencies. Many streams throughout Oklahoma do not have long term flow data and therefore, flow frequencies must be estimated. The most basic method to estimate flows at an ungaged site involves 1) identifying an upstream or downstream flow gage; 2) calculating the contributing drainage areas of the ungaged sites and the flow gage; and 3) calculating daily flows at the ungaged site by using the flow at the gaged site multiplied by the drainage area ratio. The more complex approach used here in this TMDL report, also considers watershed differences in rainfall, land use, and the hydrologic properties of soil that govern runoff and retention. More than one upstream flow gage may also be considered. A more detailed explanation of the methods for estimating flow at ungaged streams is provided in Appendix C.

Flow duration curves are a type of cumulative distribution function. The flow duration curve represents the fraction of flow observations that exceed a given flow at the site of interest. The observed flow values are first ranked from highest to lowest then, for each observation, the percentage of observations exceeding that flow is calculated. The flow value is read from the ordinate (y-axis), which is typically on a logarithmic scale since the high flows would otherwise overwhelm the low flows. The flow exceedance frequency is read from the abscissa, which is numbered from 0 to 100 percent, and may or may not be logarithmic. Flow exceedance frequency can be defined as “percent of time a given flow was equaled or exceeded based on daily flow values. The lowest measured flow occurs at an exceedance frequency of 100 percent, indicating that flow has equaled or exceeded this value 100 percent of the time, while the highest measured flow is found at an exceedance frequency of 0 percent. The median flow occurs at a flow exceedance frequency of 50 percent. The flow exceedance frequencies for each stream segment addressed in this report are provided in Appendix C.

While the number of observations required to develop a flow duration curve is not rigorously specified, a flow duration curve is usually based on more than 1 year of observations, and encompasses inter-annual and seasonal variation. Ideally, the drought of record and flood of record are included in the observations. For this purpose, the long-term flow gaging stations operated by the USGS are utilized (2009).

A typical semi-log flow duration curve exhibits a sigmoidal shape, bending upward near a flow exceedance frequency value of 0 percent and downward at a frequency near 100 percent, often with a relatively constant slope in between. For sites that on occasion exhibit no flow, the curve will intersect the abscissa at a frequency less than 100 percent. As the number of observations at a site increases, the line of the LDC tends to appear smoother. However, at extreme low and high flow values, flow duration curves may exhibit a “stair step” effect due to the USGS flow data rounding conventions near the limits of quantitation.

Figures 4-6 through 4-11 are flow duration curves for each impaired waterbody developed for both bacteria and turbidity. The flow duration curve for Caney River was based on measured flows at USGS gage station 07175500 (Caney River at Ramona, OK). The flow period used for this station was 1945 through 2009.

No flow gages exist on Hogshooter Creek, Curl Creek, Mission Creek, Little Caney River and Rabb Creek. The flow duration curves for these streams were estimated using the watershed area ratio method based on measured flows at USGS gage station 07191000(Big Cabin Creek at Big Cabin, OK) because estimated flow from Caney River at Ramona was not realistic of the above mentioned streams. The flow period used for this station was 1947 through 2009.

Figure 4-6 Flow Duration Curve for Caney River

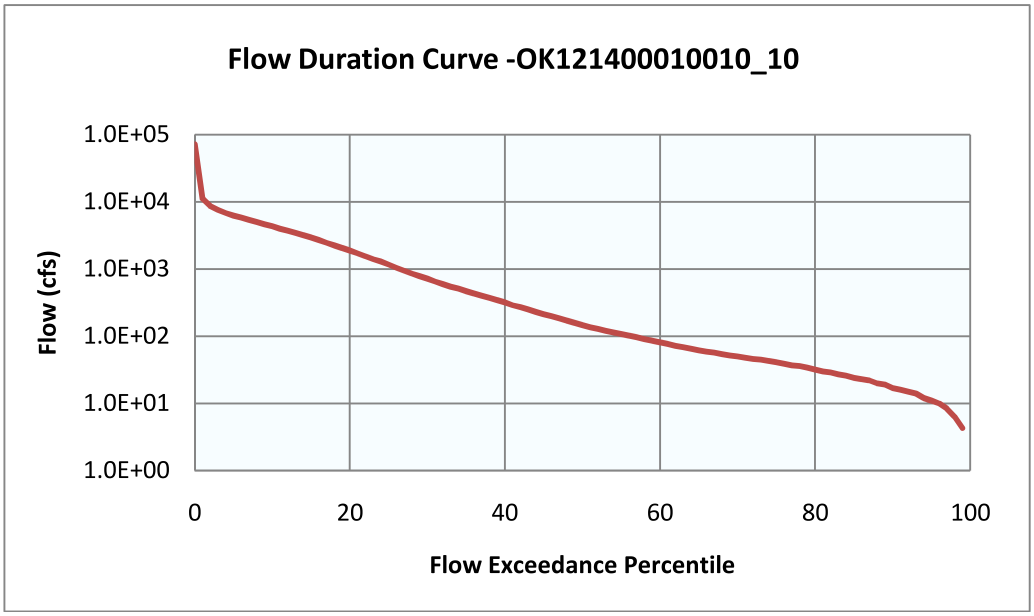


Figure 4-7 Flow Duration Curve for Hogshooter Creek

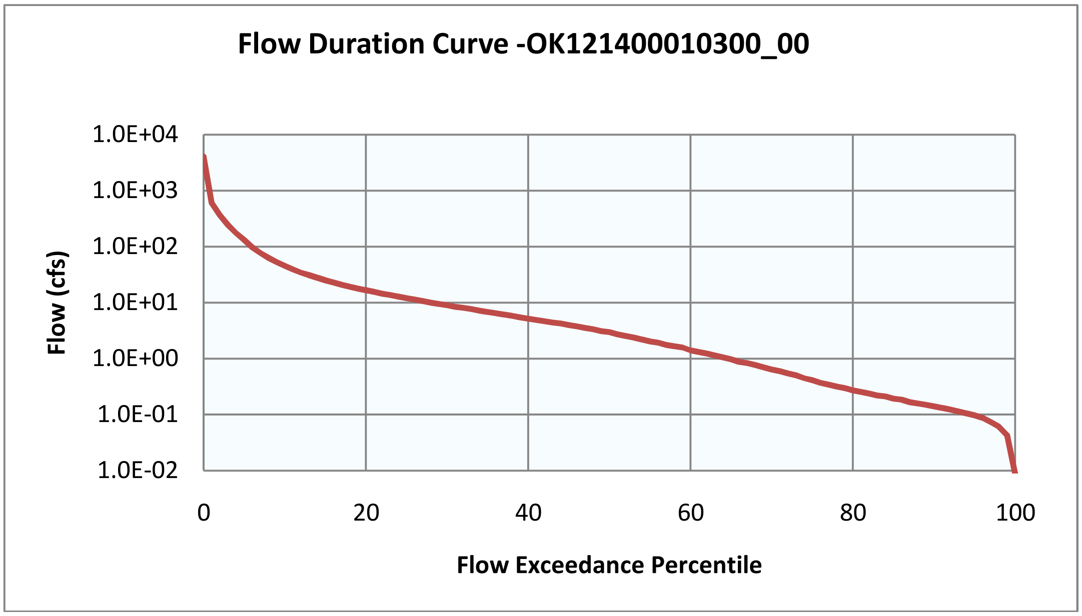


Figure 4-8 Flow Duration Curve for Curl Creek

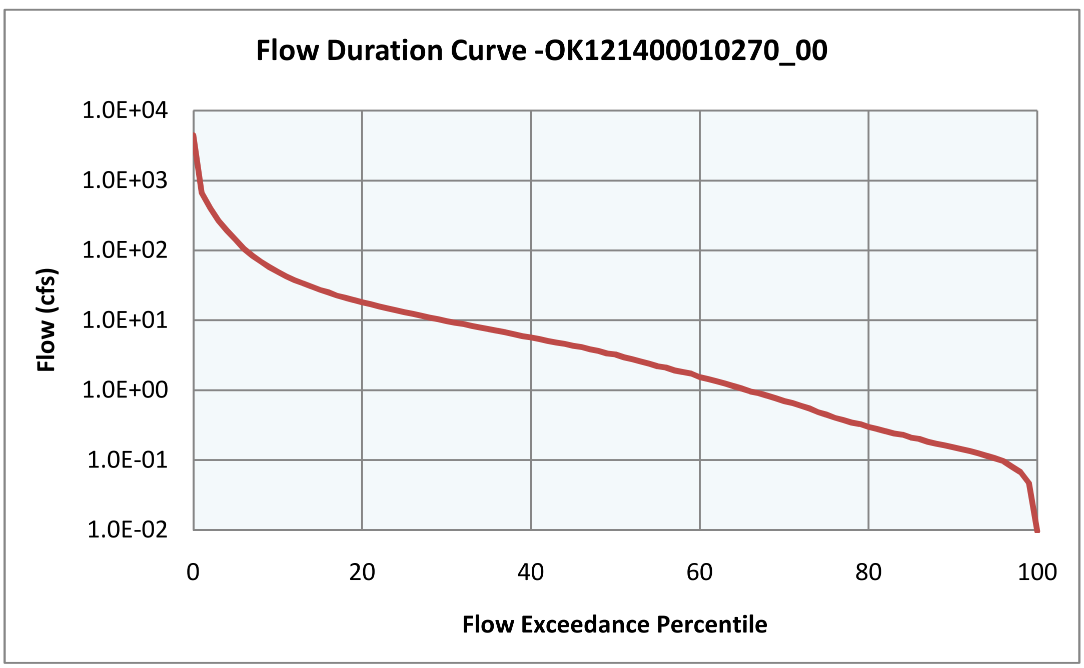


Figure 4-9 Flow Duration Curve for Mission Creek

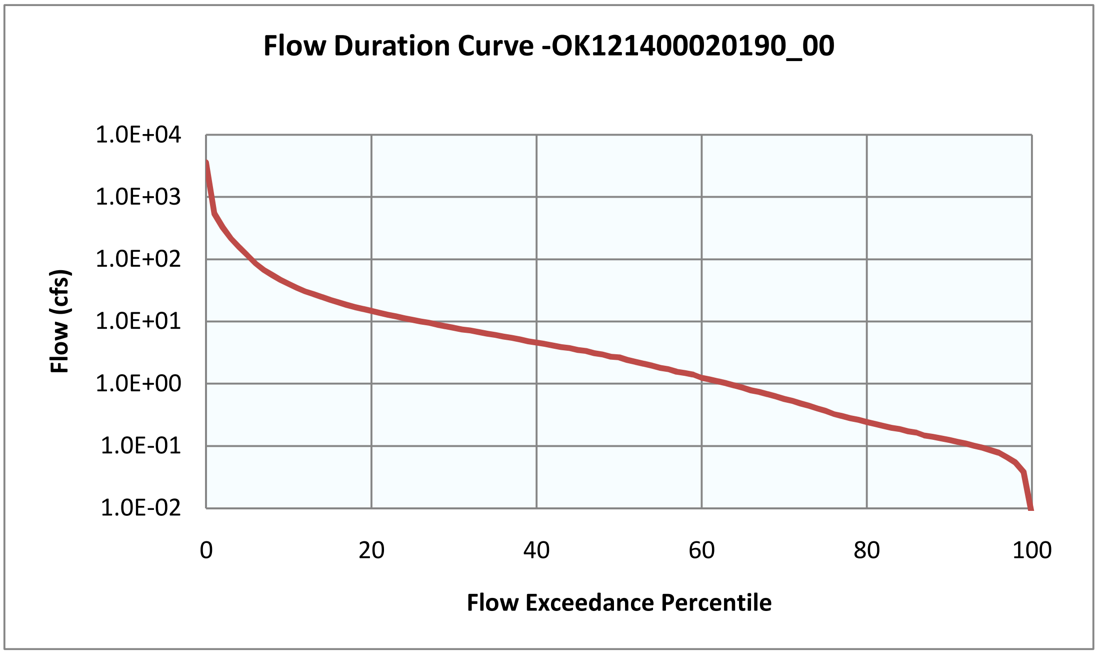


Figure 4-10 Flow Duration Curve for Little Caney River

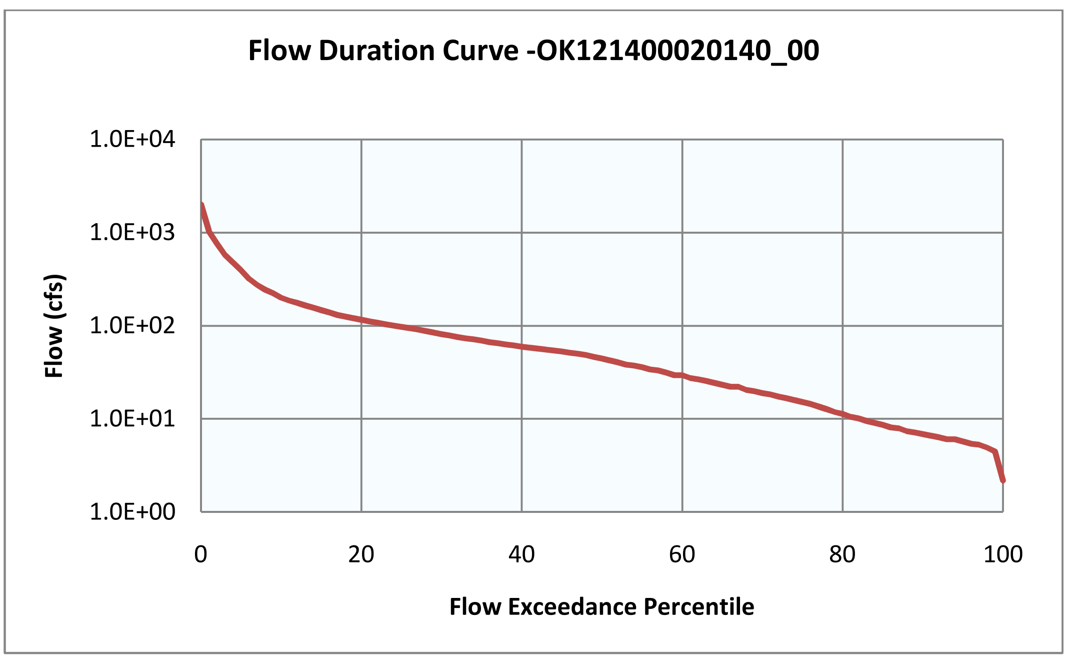
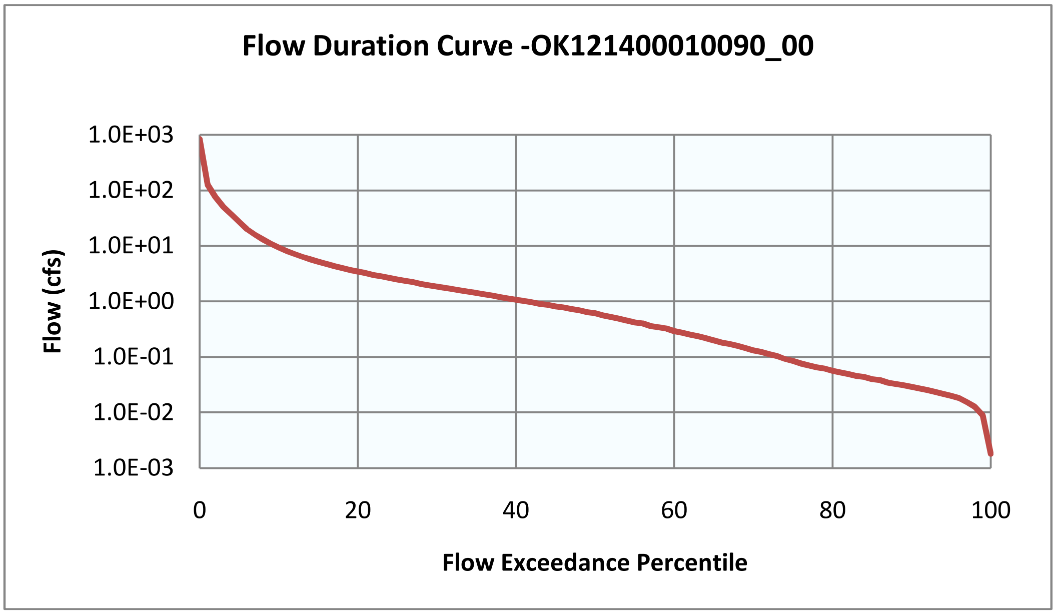


Figure 4-11 Flow Duration Curve for Rabb Creek



The USGS National Water Information System serves as the primary source of flow measurements for the application. All available daily average flow values for all gages in Oklahoma, as well as the nearest upstream and downstream gages in adjacent states, were retrieved for use in the application. The application includes a data update module that automatically downloads the most recent USGS data and appends it to the existing flow database.

Some instantaneous flow measurements were available from various agencies. These were not combined with the daily average flows or used in calculating flow percentiles, but were matched to bacteria/turbidity grab measurements collected at the same site and time. When available, these instantaneous flow measurements were used in lieu of the daily average flow to calculate instantaneous bacteria loads.

4.4 Estimating Current Point and Nonpoint Loading for Bacteria

Another key step in the use of LDCs for TMDL development is the estimation of existing bacteria loading from point and nonpoint sources and the display of this loading in relation to the TMDL. In Oklahoma, WWTPs that discharge treated sanitary wastewater must meet the state WQSs for fecal bacteria at the point of discharge. However, for TMDL analysis it is necessary to understand the relative contribution of WWTPs to the overall pollutant loading and its general compliance with required effluent limits. The monthly bacteria load for continuous point source dischargers is estimated by multiplying the monthly average flow rates by the monthly geometric mean using a conversion factor. . The 90th percentile value of the monthly loads was used to express the estimated existing point source load in counts/day. The current pollutant loading from each permitted point source discharge is calculated using the equation below.

Point Source Loading = monthly average flow rates (mgd) * geometric mean of corresponding fecal coliform concentration * unit conversion factor

Where: unit conversion factor = 37,854,120 100-ml/million gallons

It is difficult to estimate current nonpoint loading due to lack of specific water quality and flow information that would assist in estimating the relative proportion of non-specific sources within the watershed. Therefore, existing instream loads were used as a conservative surrogate for nonpoint loading. Existing instream loads were calculated as the 90^{th} percentile of measured bacteria concentrations multiplied by the flow rate under various flow conditions

4.5 Development of TMDLs Using Load Duration Curves

The final step in the TMDL calculation process involves a group of additional computations derived from the preparation of LDCs. These computations are necessary to derive a PRG (which is one method of presenting how much pollutant loads must be reduced to meet WQSs in the impaired watershed).

Step 1: Generate LDCs. LDCs are similar in appearance to flow duration curves; however, for bacteria the ordinate is expressed in terms of a bacteria load in cfu/day, and for TSS the ordinate is expressed in terms of a load in lbs/day. The curve represents the single sample water quality criterion for fecal coliform (400 cfu/100 mL), *E. coli* (406 cfu/100 mL), or Enterococci (108 cfu/100 mL) expressed in terms of a load through multiplication by the continuum of flows historically observed at the site. For turbidity, the curve represents the water quality target for TSS from Table 4-1 expressed in terms of a load obtained through multiplication of the TSS target by the continuum of flows historically observed at the site. The basic steps to generating an LDC involve:

- obtaining daily flow data for the site of interest from the USGS;
- sorting the flow data and calculating flow exceedance frequencies for the time period and season of interest;
- obtaining the water quality data from the primary contact recreation season (May 1 through September 30); or obtaining available turbidity and TSS water quality data;
- matching the water quality observations with the flow data from the same date;
- displaying a curve on a plot that represents the allowable load determined by multiplying the actual or estimated flow by the WQS for each respective bacteria indicator; or displaying a curve on a plot that represents the allowable load determined by multiplying the actual or estimated flow by the WQ_{target} for TSS;
- converting measured concentration values to loads by multiplying the flow at the time the sample was collected by the water quality parameter concentration (for sampling events with both TSS and turbidity data, the measured TSS value is used; if only turbidity was measured, the value was converted to TSS using the regression equation in Figure 4-1 through Figure 4-3); or multiplying the flow by the bacteria indicator concentration to calculate daily loads; then
- plotting the flow exceedance frequencies and daily load observations in a load duration plot (See Section 5).

For bacteria TMDLs the culmination of these steps is expressed in the following formula, which is displayed on the LDC as the TMDL curve:

TMDL (cfu/day) = WQS * flow (cfs) * unit conversion factor

Where: WQS = 400 cfu /100 mL (Fecal coliform); 126 cfu/100 mL (E. coli); or 33 cfu/100 mL (Enterococci)

unit conversion factor = 24,465,525 mL*s / ft3*day

For turbidity (TSS) TMDLs the culmination of these steps is expressed in the following formula, which is displayed on the LDC as the TMDL curve:

$$TMDL\ (lb/day) = WQ_{target} * flow\ (cfs) * unit\ conversion\ factor$$

where: WQ_{target} ***= waterbody specific TSS concentration derived from regression analysis results presented in Table 4-1***

unit conversion factor = $5.39377\ L*s*lb/(ft^3*day*mg)$

The flow exceedance frequency (x-value of each point) is obtained by looking up the historical exceedance frequency of the measured or estimated flow, in other words, the percent of historical observations that equal or exceed the measured or estimated flow. Historical observations of bacteria, TSS and/or turbidity concentrations are paired with flow data and are plotted as separate LDCs. The fecal coliform load (or the y-value of each point) is calculated by multiplying the fecal coliform concentration (colonies/100 mL) by the instantaneous flow (cubic feet per second) at the same site and time, with appropriate volumetric and time unit conversions. Fecal coliform/*E. coli*/Enterococci loads representing exceedance of water quality criteria fall above the water quality criterion line. Likewise, the TSS load (or the y-value of each point) is calculated by multiplying the TSS concentration (measured or converted from turbidity) (mg/L) by the instantaneous flow (cfs) at the same site and time, with appropriate volumetric and time unit conversions. TSS loads representing exceedance of water quality criteria fall above the TMDL line. Regarding bacteria data, it is noted that only those flows and water quality samples observed in the months comprising the primary contact recreation season are used to generate the LDCs. It is inappropriate to compare single sample bacteria observations and instantaneous or daily flow durations to a 30-day geometric mean water quality criterion in the LDC.

As noted earlier, runoff has a strong influence on loading of nonpoint pollution. Yet flows do not always correspond directly to runoff; high flows may occur in dry weather and runoff influence may be observed with low or moderate flows.

Step 2: Define MOS. The MOS may be defined explicitly or implicitly. A typical explicit approach would reserve some specific fraction of the TMDL as the MOS. In an implicit approach, conservative assumptions used in developing the TMDL are relied upon to provide an MOS to assure that WQSs are attained. For bacteria TMDLs in this report, an explicit MOS of 10 percent was selected. The 10% MOS has been used in other approved bacteria TMDLs. For turbidity (TSS) TMDLs an explicit MOS is derived from the NRMSE established by the turbidity/TSS regression analysis conducted for each waterbody. This approach for setting an explicit MOS has been used in other approved turbidity TMDLs.

Step 3: Calculate WLA. As previously stated, the pollutant load allocation for point sources is defined by the WLA. For bacteria TMDLs a point source can be either a wastewater (continuous) or stormwater (MS4) discharge. Stormwater point sources are typically associated with urban and industrialized areas, and recent USEPA guidance includes NPDES-permitted stormwater discharges as point source discharges and, therefore, part of the WLA. For TMDL development purposes when addressing turbidity or TSS, a WLA will be established for wastewater (continuous) discharges in impaired watersheds that do not have a BOD or CBOD permit limit but do have a TSS limit. These point source discharges of inorganic suspended solids will be assigned a TSS WLA as part of turbidity TMDLs to ensure WQS can be maintained. As discussed in Section 3.1 a WLA for TSS is not necessary for MS4s.

The LDC approach recognizes that the assimilative capacity of a waterbody depends on the flow, and that maximum allowable loading will vary with flow condition. TMDLs can be expressed in terms of maximum allowable concentrations, or as different maximum loads allowable under different flow conditions, rather than single maximum load values. For bacteria TMDLs a concentration-based approach meets the requirements of 40 CFR, 130.2(i) for expressing TMDLs “in terms of mass per time, toxicity, or other appropriate measures” and is consistent with USEPA’s Protocol for Developing Pathogen TMDLs (USEPA 2001). For turbidity (TSS) TMDLs a load-based approach also meets the requirements of 40 CFR, 130.2(i) for expressing TMDLs “in terms of mass per time, toxicity, or other appropriate measures.”

WLA for WWTP. WLAs may be set to zero in cases of watersheds with no existing or planned continuous permitted point sources. For watersheds with permitted point sources, NPDES permit limits are used to derive WLAs. The permitted flow rate used for each point source discharge and the water quality concentration defined in a permit are used to estimate the WLA for each wastewater facility. In cases where a permitted flow rate is not available for a WWTP, then the maximum monthly average flow rate derived from DMRs can be used. WLA values for each NPDES wastewater discharger are then summed to represent the total WLA for a given watershed. Using this information, bacteria and TSS WLAs can be calculated using a mass balance approach as shown in the equations below. Since there are no permitted inorganic TSS dischargers in the study area, WLAs for these watersheds are zero.

WLA for bacteria:

WLA = WQS * flow * unit conversion factor (#/day)

Where:

WQS = 200 cfu /100 mL (Fecal coliform); 126 cfu/100 mL (E. coli); or 33 cfu/100 mL (Enterococci)

flow (10^6 gal/day) = permitted flow

unit conversion factor = 37,854,120-10^6gal/day

WLA for TSS:

WLA = WQ_{target} * flow * unit conversion factor (lb/day)

Where:

WQ_{target} is provided in Table 4-1;

flow (10^6 gal/day) = permitted flow

unit conversion factor = 8.3445 L*lb/(gal*mg)

WLA for Permitted Stormwater (MS4s). For bacteria TMDLs no specific portion of the WLA has been allocated for MS4s because there are no MS4 jurisdictions fall within the watersheds requiring TMDLs. In addition, the LDCs do not display a specific percentage of the bacteria load assigned to MS4s. For turbidity TMDLs, WLAs for permitted stormwater such as MS4s, construction, and multi-sector general permits are not calculated since these discharges occur under high flow conditions when the turbidity criteria do not apply.

Step 4: Calculate LA. Given the lack of data and the variability of storm events, it is difficult to quantify discharges that accurately represent projected loadings from nonpoint sources. However, LAs can be calculated under different flow conditions as the water quality target load minus the WLA. The LA is represented by the area under the LDC but above the WLA. The LA at any particular flow exceedance is calculated as shown in the equation below.

$$\mathbf{LA = TMDL - MOS - \sum WLA}$$

Step 5: Estimate WLA Load Reduction. The WLA load reduction for bacteria was not calculated as it was assumed that continuous dischargers (NPDES-permitted WWTPs) are adequately regulated under existing permits to achieve water quality standards at the end-of-pipe and, therefore, no WLA reduction would be required. If there are no MS4s located within the Study Area requiring a TMDL then there is no need to establish a PRG for permitted stormwater.

The WLA load reduction for TSS for dischargers without BOD/CBOD limits can be determined as follows:

- If permitted TSS limit is less than TSS target for the receiving stream, there will be no reductions;
- If permitted TSS limit is greater than TSS target for the receiving stream, the permit limit will be set at the TSS target.

Step 6: Estimate LA Load Reduction. After existing loading estimates are computed for each bacterial indicator, nonpoint load reduction estimates for each WQM station are calculated by using the difference between estimated existing loading and the allowable load expressed by the LDC (TMDL-MOS). This difference is expressed as the overall PRG for the impaired waterbody. For fecal coliform the PRG which ensures that no more than 25 percent of the samples exceed the TMDL based on the instantaneous criteria allocates the loads in manner that is also protective of the geometric mean criterion. For *E. coli* and Enterococci, because WQSs are considered to be met if 1) either the geometric mean of all data is less than the geometric mean criteria, or 2) no sample exceeds the instantaneous criteria, the TMDL PRG will be the lesser of that required to meet the geometric mean or instantaneous criteria. For turbidity, the PRG is the load reduction that ensures that no more than 10 percent of the samples under flow-base conditions exceed the TMDL.

SECTION 5
TMDL CALCULATIONS

5.1 Estimated Loading and Critical Conditions

USEPA regulations at 40 CFR 130.7(c) (1) require TMDLs to take into account critical conditions for stream flow, loading, and all applicable water quality standards. To accomplish this, available instream WQM data were evaluated with respect to flows and magnitude of water quality criteria exceedance using LDCs.

Bacteria LDC: To calculate the bacteria load, the flow rate at each flow exceedance percentile is multiplied by a unit conversion factor (*24,465,525 mLs / ft^3 day*) and the criterion specific to each bacterial indicator. This calculation produces the maximum bacteria load in the stream without exceeding the instantaneous standard over the range of flow conditions. The allowable bacteria (fecal coliform, *E. coli*, or Enterococci) loads at the WQS establish the TMDL and are plotted versus flow exceedance percentile as a LDC. The x-axis indicates the flow exceedance percentile, while the y-axis is expressed in terms of a bacteria load.

To estimate existing loading, bacteria observations for the primary contact recreation season (May 1^{st} through September 30^{th}) from 1999 to 2008 are paired with the flows measured or estimated in that waterbody on the same date. Pollutant loads are then calculated by multiplying the measured bacteria concentration by the flow rate and the unit conversion factor of *24,465,756 mLs / ft^3 day*. The associated flow exceedance percentile is then matched with the measured flow from the tables provided in Appendix C. The observed bacteria loads are then added to the LDC plot as points. These points represent individual ambient water quality samples of bacteria. Points above the LDC indicate the bacteria instantaneous standard was exceeded at the time of sampling. Conversely, points under the LDC indicate the sample met the WQS.

The bacteria LDCs developed for each impaired waterbody (representing the primary contact recreation season from 1999 through 2008) and for each bacteria indicator are shown in Figures 5-1 through 5-8.

The LDC for Caney River, segment OK121400010010_10 (Figure 5-1) shows Enterococci bacteria measurements at WQM station OK121400010010-001AT. The LDC indicates that Enterococci levels exceed the instantaneous water quality criteria under both high and low flow conditions. This indicates that nonpoint sources are a major cause of impairment and point source discharge may also contribute to the impairment. The exceedance under low flow may be caused by point sources, but also could be caused by failing onsite systems, or direct deposition of animal manure.

The LDCs for Hogshooter Creek, segment OK121400010300_00 (Figure 5-2 through 5-4) shows measurements for each bacteria indicator at WQM station OK121400-01-0300D. The LDCs indicate that bacteria levels exceed the instantaneous water quality criteria under various flow conditions, indicating a combination nonpoint and point sources as causes for impairment. However, since there is no point source in the watershed, non-point sources are left to be the cause of the impairment.

The LDC for Curl Creek, segment OK121400010270_00 (Figure 5-5) shows Enterococci bacteria measurements at WQM stations OK121400-01-0300D and OK121400-01-0300J. The LDC indicates that Enterococci levels exceed the instantaneous water quality criteria under both high and low flow conditions. This indicates that nonpoint sources are a major cause of impairment and point source discharge may also contribute to the impairment. The exceedance under low flow may be caused by point sources, but also could be caused by failing onsite systems, or direct deposition of animal manure. However, since there is no point source in the watershed, non-point sources are left to be the cause of the impairment.

The LDCs for Mission Creek, segment OK121400020190_00 (Figure 5-6 through 5-7) shows E. coli and Enterococci bacteria measurements at WQM stations OK121400-01-0270C and OK121400-01-0270G. The LDC indicates that Enterococci levels exceed the instantaneous water quality criteria under both high and low flow conditions. This indicates that nonpoint sources are a major cause of impairment and point source discharge may also contribute to the impairment. The exceedance under low flow may be caused by point sources, but also could be caused by failing onsite systems, or direct deposition of animal manure.

The LDC for Little Caney River, segment OK121400020140_00 (Figure 5-8) shows Enterococci bacteria measurements at WQM stations OK121400-02-0140H. The LDC indicates that Enterococci levels exceed the instantaneous water quality criteria under both high and low flow conditions. This indicates that nonpoint sources are a major cause of impairment and point source discharge may also contribute to the impairment. The exceedance under low flow may be caused by point sources, but also could be caused by failing onsite systems, or direct deposition of animal manure.

Figure 5-1 Load Duration Curve for Enterococci in Caney River

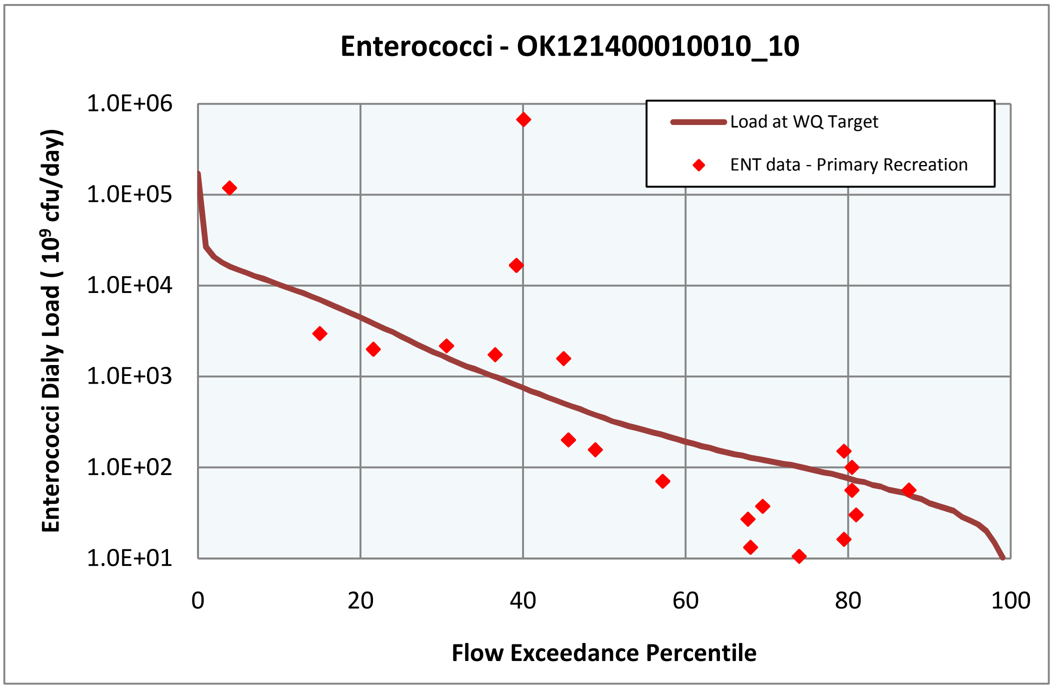


Figure 5-2 Load Duration Curve for E. Coli in Hogshooter Creek

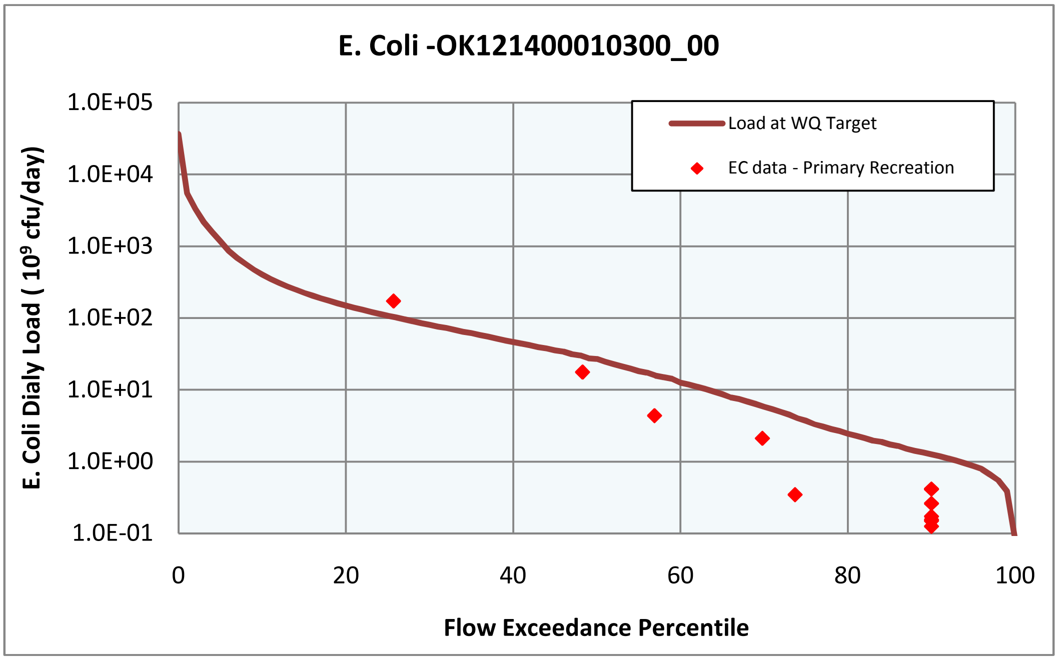


Figure 5-3 Load Duration Curve for Enterococci in Hogshooter Creek

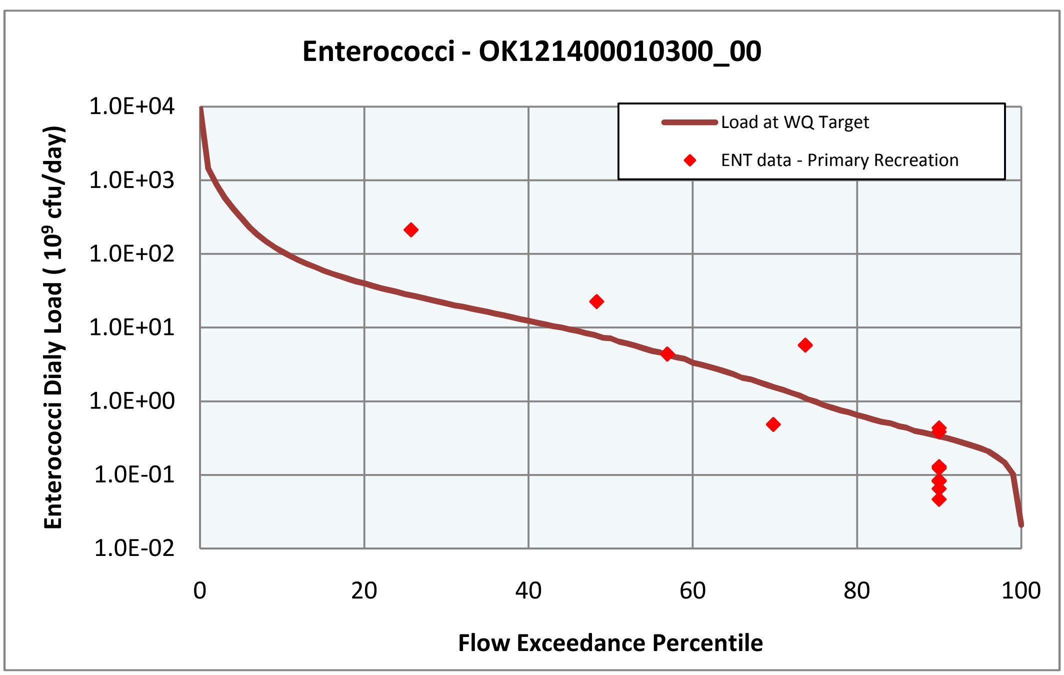


Figure 5-4 Load Duration Curve for fecal Coliform in Hogshooter Creek

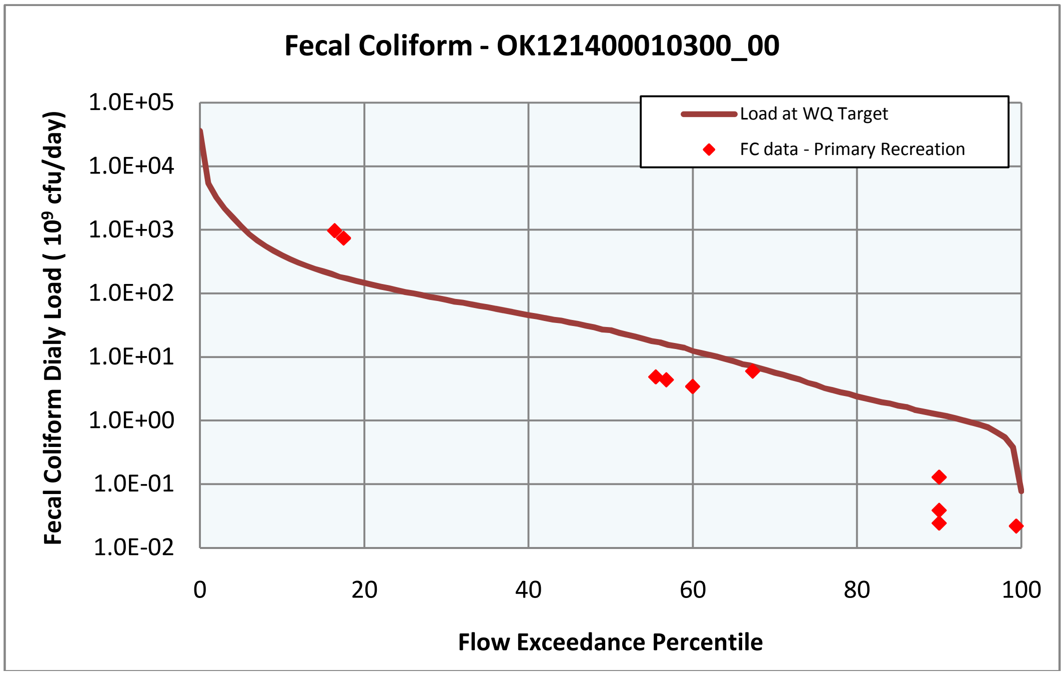


Figure 5-5 Load Duration Curve for Enterococci in Curl Creek

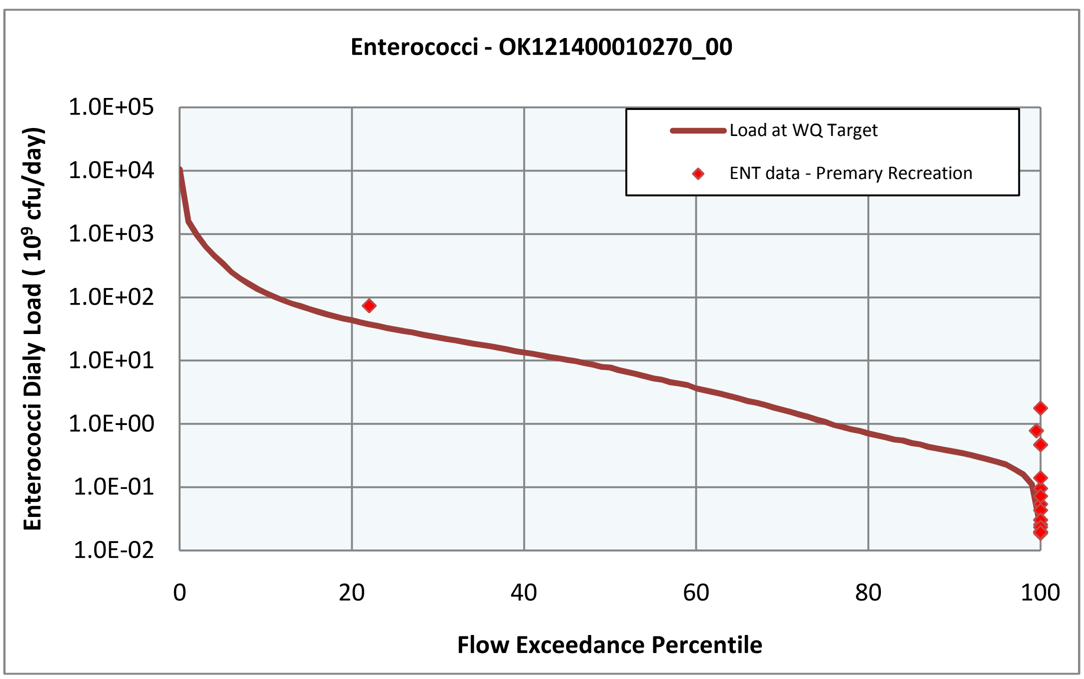


Figure 5-6 Load Duration Curve for E. Coli in Mission Creek

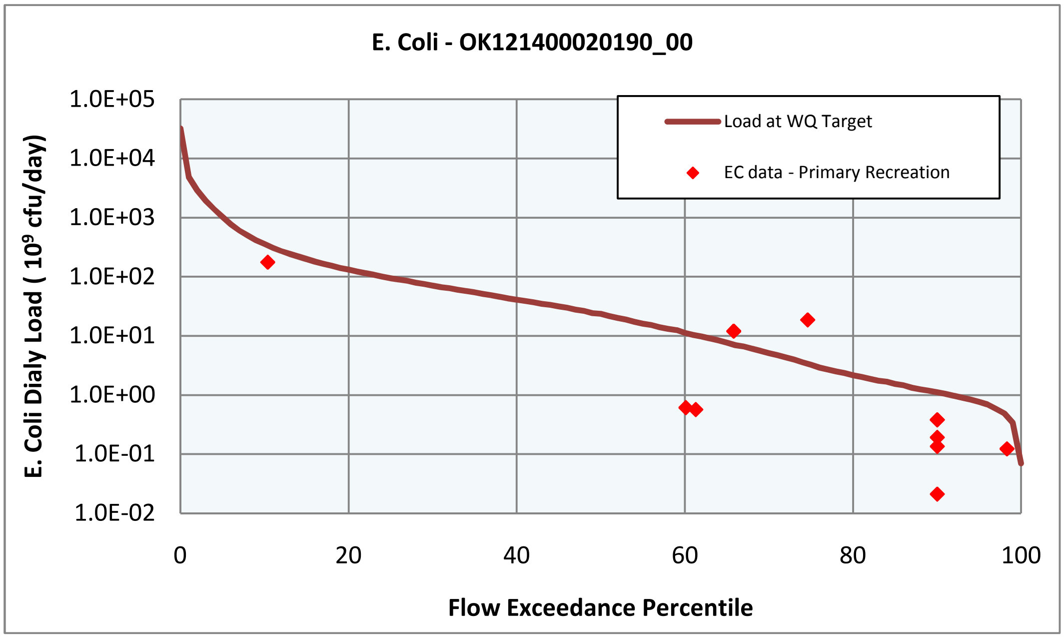


Figure 5-7 Load Duration Curve for Enterococci in Mission Creek

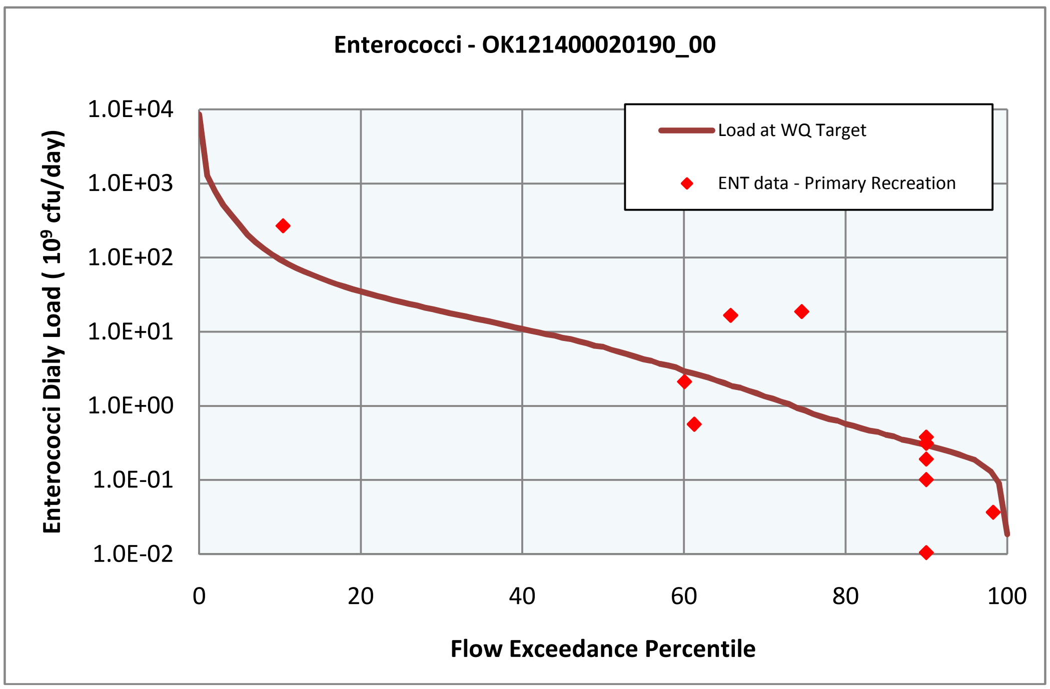
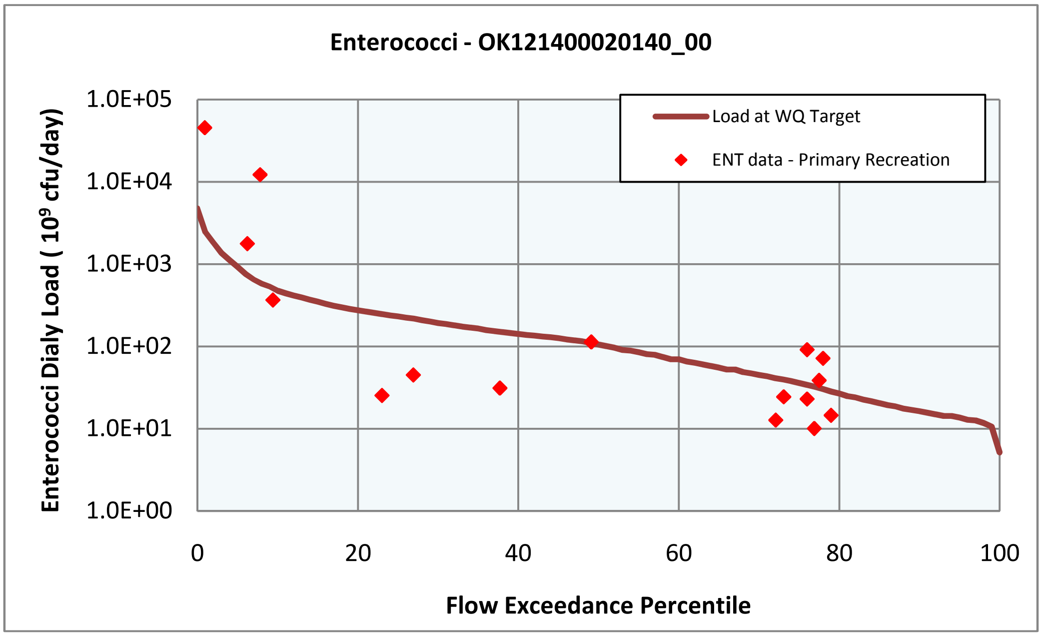


Figure 5-8 Load Duration Curve for Enterococci in Little Caney River



TSS LDC: To calculate the TSS load at the WQ_{target}, the flow rate at each flow exceedance percentile is multiplied by a unit conversion factor (*5.39377 L*s*lb /ft^3/day/mg*) and the TSS goal (TSS target minus margin of safety) for each waterbody. This calculation produces the maximum TSS load in the waterbody that will result in attainment of the 50 NTU target for turbidity. The allowable TSS loads at the WQS establish the TMDL and are plotted versus flow exceedance percentile as a LDC. The x-axis indicates the flow exceedance percentile, while the y-axis is expressed in terms of a TSS load in pounds per day.

To estimate existing loading, TSS and turbidity observations from 1999 to 2008 are paired with the flows measured on the same date or projected for the waterbody. For sampling events with both TSS and turbidity data, the measured TSS value is used; if only turbidity was measured, the value was converted to TSS using the regression equation in Figure 4-1 through Figure 4-5. Pollutant loads are then calculated by multiplying the TSS concentration by the flow rate and the unit conversion factor. The associated flow exceedance percentile is then matched with the flow from the tables provided in Appendix C. The observed TSS or converted turbidity loads are then added to the LDC plot as points. These points represent individual ambient water quality samples of TSS. Points above the LDC indicate the TSS target was exceeded at the time of sampling. Conversely, points under the LDC indicate the sample did not exceed the TSS target.

Figures 5-9 through Figure 5-13 show the TSS LDCs developed for Caney River, Curl Creek, Mission Creek, Little Caney River and Rabb Creek. Data in the figures indicate that for most waterbodies, TSS levels exceed the water quality target during all flow conditions, indicating water quality impairments due to nonpoint sources or a combination of point and nonpoint sources. It is noted that the LDC plots include data under all flow conditions to show the overall condition of the waterbody. However, the turbidity standard only applies for base-flow conditions. Thus, when interpreting the LDC to derive TMDLs for TSS, only the portion of the graph corresponding to flows above the 25^{th} flow exceedance percentile should be used. WLAs for point sources discharges (continuous) of inorganic TSS are shown on a LDC as a horizontal line which represents the sum of all WLAs for TSS in a given watershed.

Figure 5-9 Load Duration Curve for Total Suspended Solids in Caney River

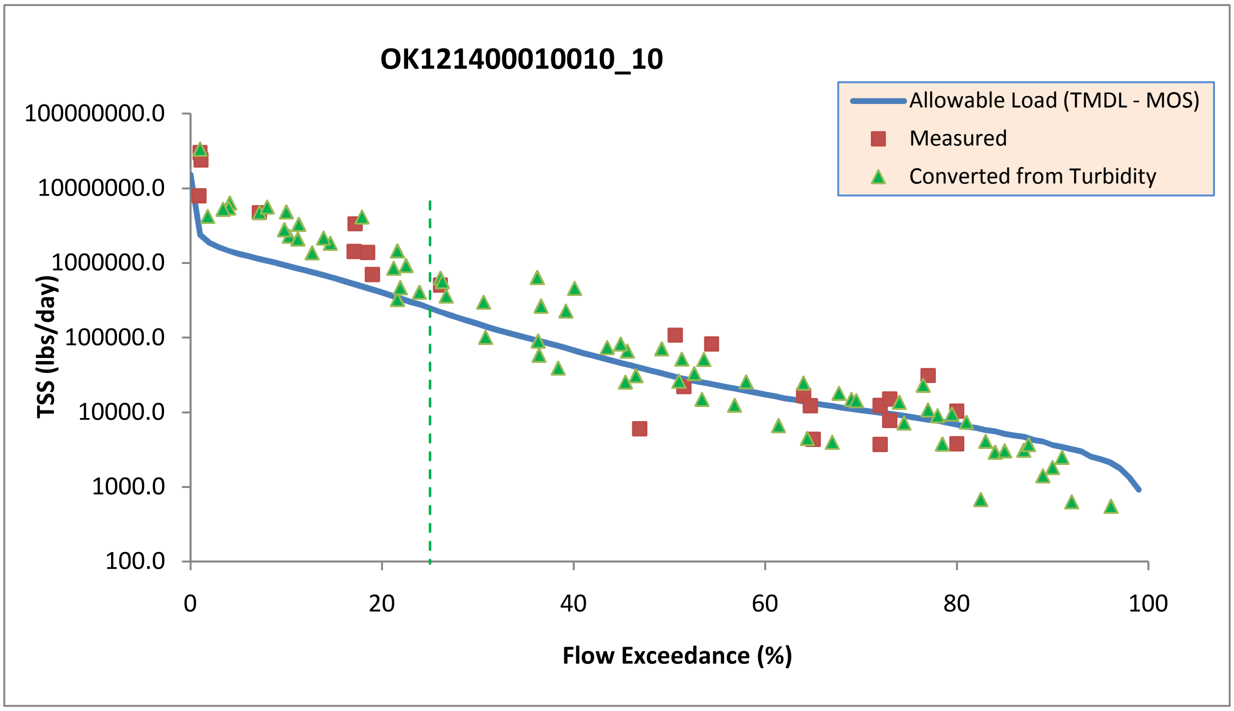


Figure 5-10 Load Duration Curve for Total Suspended Solids in Curl Creek

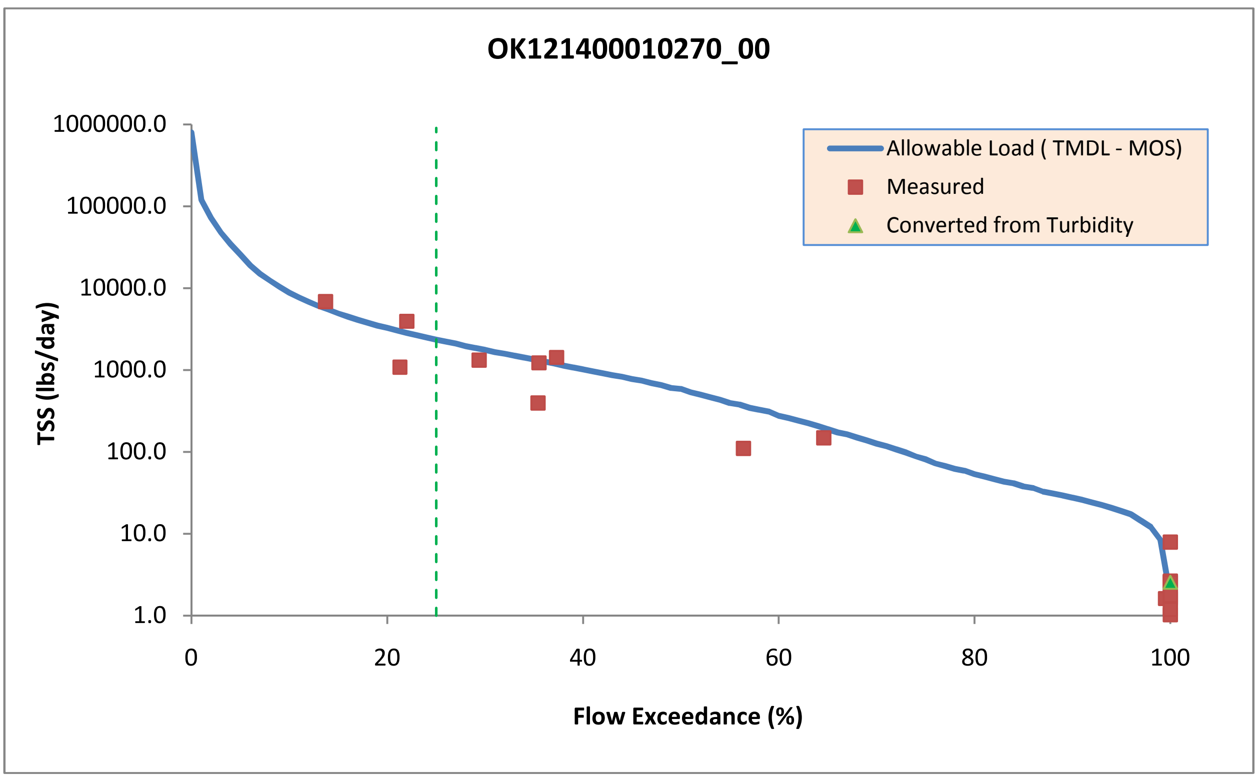


Figure 5-11 Load Duration Curve for Total Suspended Solids in Mission Creek

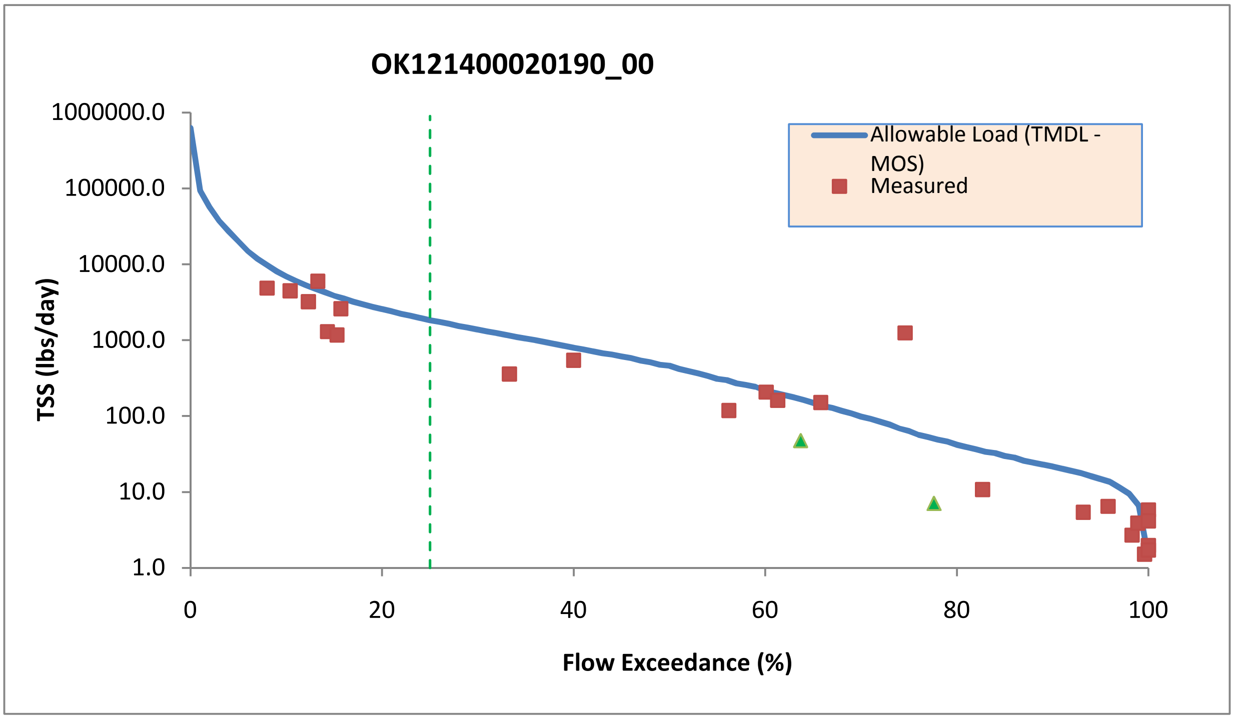


Figure 5-12 Load Duration Curve for Total Suspended Solids in Little Caney River

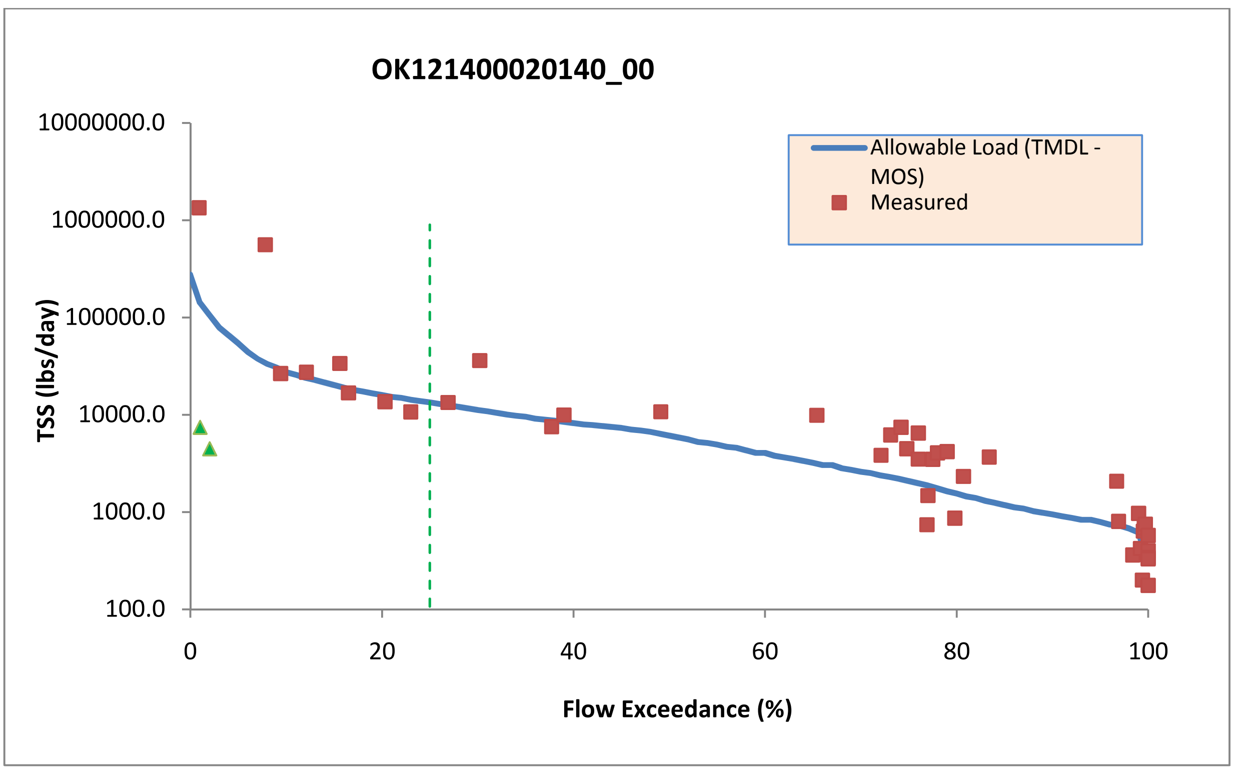
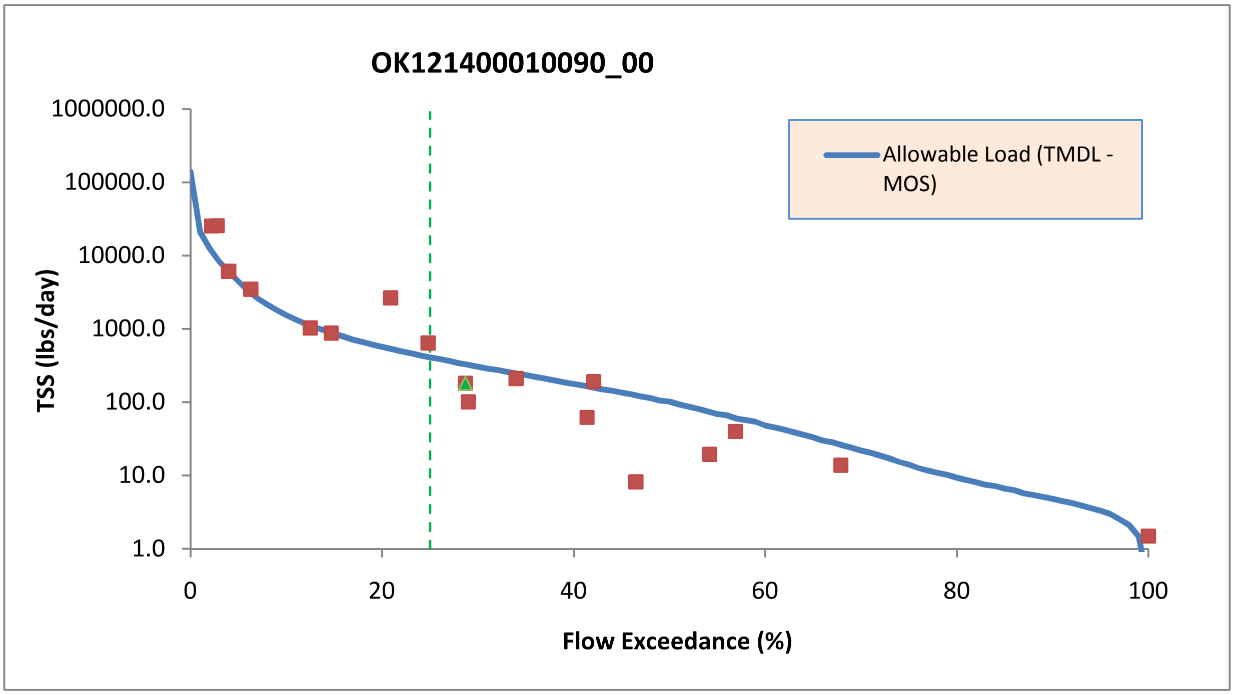


Figure 5-13 Load Duration Curve for Total Suspended Solids in Rabb Creek



Establishing Percent Reduction Goals: The LDC approach recognizes that the assimilative capacity of a waterbody depends on the flow, and that maximum allowable loading varies with flow condition. Existing loading and load reductions required to meet the TMDL water quality target can also be calculated under different flow conditions. The difference between existing loading and the water quality target is used to calculate the loading reductions required. Percent reduction goals are calculated through an iterative process of taking a series of percent reduction values applying each value uniformly between the concentrations of samples and verifying that no more than a fixed percent of the samples exceed the water quality target concentration. PRG are calculated for each watershed and bacterial indicator species as the reductions in load required so no instantaneous water quality observations would exceed the water quality target for *E. coli* and Enterococci and no more than 25 percent of the samples exceed the water quality target for fecal coliform. This is because for the PBCR use to be supported, criteria for each bacterial indicator must be met in each impaired waterbody. Table 5-1 presents the percent reductions necessary for each bacterial indicator in each of the impaired waterbodies in the Study Area. The PRGs range from 40 to 99.9 percent.

Table 5-1 TMDL Percent Reductions Required to Meet Water Quality Standards for Indicator Bacteria

Waterbody ID	Waterbody Name	Required Reduction Rate				
		FC	EC		ENT	
		Instantaneous	Instantaneous	Geomean	Instantaneous	Geomean
OK121400010010_10	Caney River				99.9%	**57%**
OK121400010300_00	Hogshooter Creek	**40%**	81%	**51%**	95%	**88%**
OK121400010270_00	Curl Creek				99%	**88%**
OK121400020190_00	Mission Creek		82%	**19%**	95%	**77%**
OK121400020140_00	Little Caney River				82%	**68%**

Similarly, percent reduction goals for TSS are calculated as the required overall reduction so that no more than 10 percent of the samples exceed the water quality target for TSS. The PRGs for the fourteen waterbodies included in this TMDL report are summarized in Table 5-2 and range from 31 to 76 percent.

Table 5-2 TMDL Percent Reductions Required to Meet Water Quality Targets for Total Suspended Solids

Waterbody ID	Waterbody Name	Required Reduction Rate
OK121400010010_10	Caney River	**76%**
OK121400010270_00	Curl Creek	**36%**
OK121400020190_00	Mission Creek	**31%**
OK121400020140_00	Little Caney River	**69%**
OK121400010090_00	Rabb Creek	**36%**

5.2 Wasteload Allocation

5.2.1 Indicator Bacteria

For bacteria TMDLs, NPDES-permitted facilities are allocated a daily wasteload calculated as their permitted flow rate multiplied by the instream geometric mean water quality criterion. In other words, the facilities are required to meet instream criteria in their discharge. Table 5-3 summarizes the WLA for the NPDES-permitted facilities within the Caney River Study Area. The WLA for each facility is derived from the following equation:

WLA = WQS * flow * unit conversion factor (#/day)

Where:

WQS = 33, 200, and 126 cfu/100 mL for Enterococci, fecal coliform, and E. coli respectively

flow (10^6 gal/day) = permitted flow

unit conversion factor = 37,854,120-10^6gal/day

When multiple NPDES facilities occur within a watershed, individual WLAs are summed and the total WLA for continuous point sources is included in the TMDL calculation for the corresponding waterbody. When there are no NPDES WWTPs discharging into the contributing watershed of a WQM station, then the WLA is zero. Compliance with the WLA will be achieved by adhering to the fecal coliform limits and disinfection requirements of NPDES permits. Table 5-3 indicates which point source dischargers within Oklahoma currently have a disinfection requirement in their permit. Certain facilities that utilize lagoons for treatment have not been required to provide disinfection since storage time and exposure to ultraviolet radiation from sunlight should reduce bacteria levels. In the future, all point source dischargers which are assigned a wasteload allocation but do not currently have a bacteria limit in their permit will receive a permit limit consistent with the wasteload allocation as their permits are reissued. Regardless of the magnitude of the WLA calculated in these TMDLs, future new discharges of bacteria or increased bacteria load from existing discharges will be considered consistent with the TMDL provided that the NPDES permit requires instream criteria to be met.

Table 5-3 Wasteload Allocations for NPDES-Permitted Facilities

Waterbody ID	NPDES Permit No.	Name	Design Flow (mgd)	Dis-infection	Wasteload Allocation (cfu/day)		
					FC	ENT	E Coli
OK121400010010_10	OK0028339	Caney River	0.06	No		1.62E+08	
	OK0034517		0.07	No		1.62E+08	

Permitted stormwater discharges are considered point sources; however, there are no areas designated as MS4s within this Study Area, so the WLA for MS4 is zero.

5.2.2 Total Suspended Solids

The WLA for the Study Area is zero.

No wasteload allocations are needed for stormwater dischargers in the Study Area. By definition, any stormwater discharge occurs during periods of rainfall and elevated flow conditions. Oklahoma's Water Quality Standards specify that the criteria for turbidity "apply only to seasonal base flow conditions" and go on to say "Elevated turbidity levels may be expected during, and for several days after, a runoff event" [OAC 785:45-5-12(f)(7)]. To accommodate the potential for future growth in those watersheds with no WLA for TSS, 1% of TSS loading is reserved as part of the WLA.

5.2.3 Section 404 Permits

No TSS wasteload allocations were set aside for Section 404 permits. The state will use its Section 401 certification authority to ensure Section 404 permits protect Oklahoma water quality standards and comply with TSS TMDLs in this report. Section 404 permits will be conditioned to meet one of the following two conditions to be certified by the state:

- Include TSS limits in the permit and establish a monitoring requirement to ensure compliance with turbidity standard and TSS TMDLs.
- Submit to the ODEQ a BMP turbidity reduction plan which should include all practicable turbidity control techniques. The turbidity reduction plan must be approved first before a Section 404 permit can be issued.

5.3 Load Allocation

As discussed in Section 3, nonpoint source bacteria loading to each waterbody emanate from a number of different sources. The data analysis and the LDCs demonstrate that exceedances at the WQM stations are the result of a variety of nonpoint source loading. The LAs for each waterbody are calculated as the difference between the TMDL, MOS, and WLA, as follows:

LA = TMDL – WLA_WWTP – WLA_growth - MOS

5.4 Seasonal Variability

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs account for seasonal variation in watershed conditions and pollutant loading. The bacteria TMDLs established in this report adhere to the seasonal application of the Oklahoma WQS which limits the PBCR use to the period of May 1st through September 30th. Similarly, the TSS TMDLs established in this report adhere to the seasonal application of the Oklahoma WQS for turbidity, which applies to seasonal base flow conditions only. Seasonal variation was also accounted for in these TMDLs by using more than 5 years of water quality data and by using the longest period of USGS flow records when estimating flows to develop flow exceedance percentiles.

5.5 Margin of Safety

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs include an MOS. The MOS is a conservative measure incorporated into the TMDL equation that accounts for the lack of knowledge associated with calculating the allowable pollutant loading to ensure WQSs are attained. USEPA guidance allows for use of implicit or explicit expressions of the MOS, or both. When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a specific percentage of the TMDL is set aside to account for the lack of knowledge, then the MOS is considered explicit.

For bacteria TMDLs, an explicit MOS of 10 percent was selected. The 10 percent MOS was applied by setting the water quality targets for calculating reduction goals at the 90% of the water quality criteria for each pathogen. Therefore, the water quality targets for load reduction goals are 360 cfu/100 mL, 365.4 cfu/100 mL, and 97.2/100 mL for fecal coliform, *E. coli*, and Enterococci, respectively.

For turbidity, the TMDLs are calculated for TSS instead of turbidity. Thus, the quality of the regression has a direct impact on confidence of the TMDL calculations. The better the regression is, the more confidence there is in the TMDL targets. As a result, it leads to a smaller margin of safety. The selection of MOS is based on the NRMSE for each waterbody. The explicit MOS ranges from 10 percent to 25 percent. Table 5-4 shows the MOS for each waterbody.

Table 5-4 Explicit Margin of Safety for Total Suspended Solids TMDLs

Waterbody ID	Waterbody Name	NRMSE	Margin of Safety
OK121400010010_10	Caney River	6.0%	10%
OK121400010270_00	Curl Creek	11.4%	15%

Waterbody ID	Waterbody Name	NRMSE	Margin of Safety
OK121400020190_00	Mission Creek	15.2%	15%
OK121400020140_00	Little Caney River	11.4%	15%
OK121400010090_00	Rabb Creek	12.1%	15%

The explicit MOS is applied by reducing the water quality target of TSS by the percentage of the MOS. For example, the water quality target of TSS for Caney River is 44 mg/L and the MOS is 10%. The resulting water quality target will be 39.6 mg/L (44x (1 - 0.1) = 39.6). This target will be used to calculate the reduction rate for TSS.

5.6 TMDL Calculations

The TMDLs for the 303(d)-listed waterbodies covered in this report were derived using LDCs. A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for the lack of knowledge concerning the relationship between effluent limitations and water quality.

This definition can be expressed by the following equation:

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

The TMDL represents a continuum of desired load over all flow conditions, rather than fixed at a single value, because loading capacity varies as a function of the flow present in the stream. The higher the flow is, the more wasteload the stream can handle without violating water quality standards. Regardless of the magnitude of the WLA calculated in these TMDLs, future new discharges or increased load from existing discharges will be considered consistent with the TMDL provided the NPDES permit requires instream criteria to be met.

The TMDL, WLA, LA, and MOS will vary with flow condition, and are calculated at every 5th flow interval percentile. Tables 5-5 through 5-12 summarize the allocations for indicator bacteria and Tables 5-13 to 5-17 present the allocations for total suspended solids.

Table 5-5 Enterococci TMDL Calculations for Caney River (OK121400010010_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	71700	1.89E+14	1.62E+08	1.71E+14	1.89E+13
5	6266	1.66E+13	1.62E+08	1.49E+13	1.66E+12
10	4330	1.14E+13	1.62E+08	1.03E+13	1.14E+12
15	2950	7.79E+12	1.62E+08	7.02E+12	7.79E+11
20	1890	4.99E+12	1.62E+08	4.49E+12	4.99E+11
25	1160	3.07E+12	1.62E+08	2.76E+12	3.07E+11
30	718	1.90E+12	1.62E+08	1.71E+12	1.90E+11
35	471	1.24E+12	1.62E+08	1.12E+12	1.24E+11
40	318	8.40E+11	1.62E+08	7.56E+11	8.40E+10
45	214	5.65E+11	1.62E+08	5.09E+11	5.65E+10
50	147	3.88E+11	1.62E+08	3.49E+11	3.88E+10
55	108	2.85E+11	1.62E+08	2.57E+11	2.85E+10
60	81	2.14E+11	1.62E+08	1.92E+11	2.14E+10
65	62	1.64E+11	1.62E+08	1.47E+11	1.64E+10
70	50	1.32E+11	1.62E+08	1.19E+11	1.32E+10
75	41	1.08E+11	1.62E+08	9.73E+10	1.08E+10
80	32	8.46E+10	1.62E+08	7.59E+10	8.46E+09
85	24	6.34E+10	1.62E+08	0	6.34E+09
90	17	4.49E+10	1.62E+08	0	4.49E+09
95	11	2.91E+10	1.62E+08	0	2.91E+09
100	0	0	1.62E+08	0	0

Table 5-6 *E. coli* TMDL Calculations for Hogshooter Creek (OK121400010300_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	4078	4.05E+13	0	3.65E+13	4.05E+12
5	131	1.30E+12	0	1.17E+12	1.30E+11
10	45	4.49E+11	0	4.04E+11	4.49E+10
15	25	2.50E+11	0	2.25E+11	2.50E+10
20	17	1.66E+11	0	1.50E+11	1.66E+10
25	12	1.19E+11	0	1.07E+11	1.19E+10
30	9	8.92E+10	0	8.03E+10	8.92E+09
35	7	6.82E+10	0	6.14E+10	6.82E+09
40	5	5.16E+10	0	4.65E+10	5.16E+09
45	4	3.94E+10	0	3.54E+10	3.94E+09
50	3	2.97E+10	0	2.68E+10	2.97E+09
55	2	2.01E+10	0	1.81E+10	2.01E+09
60	1.4	1.40E+10	0	1.26E+10	1.40E+09
65	1.0	9.62E+09	0	8.66E+09	9.62E+08
70	0.6	6.39E+09	0	5.75E+09	6.39E+08
75	0.4	4.11E+09	0	3.70E+09	4.11E+08
80	0.3	2.71E+09	0	2.44E+09	2.71E+08
85	0.2	1.92E+09	0	1.73E+09	1.92E+08
90	0.1	1.40E+09	0	1.26E+09	1.40E+08
95	0.1	9.62E+08	0	8.66E+08	9.62E+07
100	0	0	0	0	0

Table 5-7 Enterococci TMDL Calculations for Hogshooter Creek (OK121400010300_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	4078	1.08E+13	0	9.70E+12	1.08E+12
5	131	3.47E+11	0	3.12E+11	3.47E+10
10	45	1.19E+11	0	1.07E+11	1.19E+10
15	25	6.66E+10	0	5.99E+10	6.66E+09
20	17	4.42E+10	0	3.98E+10	4.42E+09
25	12	3.17E+10	0	2.85E+10	3.17E+09
30	9	2.37E+10	0	2.14E+10	2.37E+09
35	7	1.82E+10	0	1.63E+10	1.82E+09
40	5	1.37E+10	0	1.24E+10	1.37E+09
45	4	1.05E+10	0	9.43E+09	1.05E+09
50	3	7.91E+09	0	7.12E+09	7.91E+08
55	2	5.35E+09	0	4.82E+09	5.35E+08
60	1.4	3.72E+09	0	3.35E+09	3.72E+08
65	1.0	2.56E+09	0	2.30E+09	2.56E+08
70	0.6	1.70E+09	0	1.53E+09	1.70E+08
75	0.4	1.09E+09	0	9.85E+08	1.09E+08
80	0.3	7.22E+08	0	6.49E+08	7.22E+07
85	0.2	5.12E+08	0	4.61E+08	51205327
90	0.1	3.72E+08	0	3.35E+08	37240238
95	0.1	2.56E+08	0	2.30E+08	25602664
100	0	0	0	0	0

Table 5-8 Fecal Coliform TMDL Calculations for Hogshooter Creek (OK121400010300_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	4078	3.99E+13	0	3.59E+13	3.99E+12
5	131	1.28E+12	0	1.16E+12	1.28E+11
10	45	4.42E+11	0	3.98E+11	4.42E+10
15	25	2.47E+11	0	2.22E+11	2.47E+10
20	17	1.64E+11	0	1.47E+11	1.64E+10
25	12	1.17E+11	0	1.06E+11	1.17E+10
30	9	8.79E+10	0	7.91E+10	8.79E+09
35	7	6.72E+10	0	6.05E+10	6.72E+09
40	5	5.09E+10	0	4.58E+10	5.09E+09
45	4	3.88E+10	0	3.49E+10	3.88E+09
50	3	2.93E+10	0	2.64E+10	2.93E+09
55	2	1.98E+10	0	1.78E+10	1.98E+09
60	1.4	1.38E+10	0	1.24E+10	1.38E+09
65	1.0	9.48E+09	0	8.53E+09	9.48E+08
70	0.6	6.29E+09	0	5.66E+09	6.29E+08
75	0.4	4.05E+09	0	3.65E+09	4.05E+08
80	0.3	2.67E+09	0	2.41E+09	2.67E+08
85	0.2	1.90E+09	0	1.71E+09	1.90E+08
90	0.1	1.38E+09	0	1.24E+09	1.38E+08
95	0.1	9.48E+08	0	8.53E+08	9.48E+07
100	0	0	0	0	0

Table 5-9 Enterococci TMDL Calculations for Curl Creek (OK121400010270_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	4441	1.17E+13	0	1.06E+13	1.17E+12
5	143	3.78E+11	0	3.40E+11	3.78E+10
10	49	1.30E+11	0	1.17E+11	1.30E+10
15	27	7.25E+10	0	6.52E+10	7.25E+09
20	18	4.82E+10	0	4.33E+10	4.82E+09
25	13	3.45E+10	0	3.10E+10	3.45E+09
30	10	2.58E+10	0	2.33E+10	2.58E+09
35	7	1.98E+10	0	1.78E+10	1.98E+09
40	6	1.50E+10	0	1.35E+10	1.50E+09
45	4	1.14E+10	0	1.03E+10	1.14E+09
50	3	8.62E+09	0	7.75E+09	8.62E+08
55	2	5.83E+09	0	5.25E+09	5.83E+08
60	1.5	4.05E+09	0	3.65E+09	4.05E+08
65	1.1	2.79E+09	0	2.51E+09	2.79E+08
70	0.7	1.85E+09	0	1.67E+09	1.85E+08
75	0.5	1.19E+09	0	1.07E+09	1.19E+08
80	0.3	7.86E+08	0	7.07E+08	7.86E+07
85	0.2	5.58E+08	0	5.02E+08	5.58E+07
90	0.2	4.05E+08	0	3.65E+08	4.05E+07
95	0.1	2.79E+08	0	2.51E+08	2.79E+07
100	0	0	0	0	0

Table 5-10 E. coli TMDL Calculations for Mission Creek (OK121400020190_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	3600	3.58E+13	0	3.22E+13	3.58E+12
5	116	1.15E+12	0	1.04E+12	1.15E+11
10	40	3.96E+11	0	3.57E+11	3.96E+10
15	22	2.21E+11	0	1.99E+11	2.21E+10
20	15	1.47E+11	0	1.32E+11	1.47E+10
25	11	1.05E+11	0	9.45E+10	1.05E+10
30	8	7.88E+10	0	7.09E+10	7.88E+09
35	6	6.02E+10	0	5.42E+10	6.02E+09
40	5	4.56E+10	0	4.10E+10	4.56E+09
45	3	3.48E+10	0	3.13E+10	3.48E+09
50	3	2.63E+10	0	2.36E+10	2.63E+09
55	2	1.78E+10	0	1.60E+10	1.78E+09
60	1.2	1.24E+10	0	1.11E+10	1.24E+09
65	0.9	8.50E+09	0	7.65E+09	8.50E+08
70	0.6	5.64E+09	0	5.07E+09	5.64E+08
75	0.4	3.63E+09	0	3.27E+09	3.63E+08
80	0.2	2.39E+09	0	2.15E+09	2.39E+08
85	0.2	1.70E+09	0	1.53E+09	1.70E+08
90	0.1	1.24E+09	0	1.11E+09	1.24E+08
95	0.1	8.50E+08	0	7.65E+08	8.50E+07
100	0	0	0	0	0

Table 5-11 Enterococci TMDL Calculations for Mission Creek (OK121400020190_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	3600	9.51E+12	0	8.56E+12	9.51E+11
5	116	3.06E+11	0	2.76E+11	3.06E+10
10	40	1.05E+11	0	9.49E+10	1.05E+10
15	22	5.88E+10	0	5.29E+10	5.88E+09
20	15	3.90E+10	0	3.51E+10	3.90E+09
25	11	2.79E+10	0	2.51E+10	2.79E+09
30	8	2.10E+10	0	1.89E+10	2.10E+09
35	6	1.60E+10	0	1.44E+10	1.60E+09
40	5	1.21E+10	0	1.09E+10	1.21E+09
45	3	9.25E+09	0	8.32E+09	9.25E+08
50	3	6.99E+09	0	6.29E+09	6.99E+08
55	2	4.73E+09	0	4.25E+09	4.73E+08
60	1.2	3.29E+09	0	2.96E+09	3.29E+08
65	0.9	2.26E+09	0	2.03E+09	2.26E+08
70	0.6	1.50E+09	0	1.35E+09	1.50E+08
75	0.4	9.66E+08	0	8.69E+08	9.66E+07
80	0.2	6.37E+08	0	5.73E+08	6.37E+07
85	0.2	4.52E+08	0	4.07E+08	4.52E+07
90	0.1	3.29E+08	0	2.96E+08	3.29E+07
95	0.1	2.26E+08	0	2.03E+08	2.26E+07
100	0	0	0	0	0

Table 5-12 Enterococci TMDL Calculations for Little Caney River (OK121400020140_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	1998	5.28E+12	0	4.75E+12	5.28E+11
5	393	1.04E+12	0	9.34E+11	1.04E+11
10	199	5.26E+11	0	4.74E+11	5.26E+10
15	147	3.88E+11	0	3.49E+11	3.88E+10
20	116	3.06E+11	0	2.76E+11	3.06E+10
25	97	2.58E+11	0	2.32E+11	2.58E+10
30	81	2.14E+11	0	1.93E+11	2.14E+10
35	69	1.83E+11	0	1.64E+11	1.83E+10
40	60	1.58E+11	0	1.42E+11	1.58E+10
45	53	1.40E+11	0	1.26E+11	1.40E+10
50	44	1.17E+11	0	1.05E+11	1.17E+10
55	35.8	9.45E+10	0	8.51E+10	9.45E+09
60	29.5	7.80E+10	0	7.02E+10	7.80E+09
65	23.3	6.15E+10	0	5.53E+10	6.15E+09
70	18.9	4.99E+10	0	4.49E+10	4.99E+09
75	15.2	4.01E+10	0	3.61E+10	4.01E+09
80	11.3	2.98E+10	0	2.69E+10	2.98E+09
85	8.6	2.27E+10	0	2.05E+10	2.27E+09
90	6.9	1.82E+10	0	1.63E+10	1.82E+09
95	5.7	1.51E+10	0	1.36E+10	1.51E+09
100	2.2	5.74E+09	0	5.16E+09	5.74E+08

Table 5-13 Total Suspended Solids TMDL Calculations for Caney River (OK121400010010_10)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)		LA (lb/day)	MOS (lb/day)
			WWTP	Future Growth		
0	71700	N/A	0	N/A	N/A	N/A
5	6266	N/A	0	N/A	N/A	N/A
10	4330	N/A	0	N/A	N/A	N/A
15	2950	N/A	0	N/A	N/A	N/A
20	1890	N/A	0	N/A	N/A	N/A
25	1160	274985	0	2750	244689	27499
30	718	170206	0	1702	151484	17021
35	471	111653	0	1117	99372	11165
40	318	75384	0	754	67092	7538
45	214	50730	0	507	45150	5073
50	147	34847	0	348	31014	3485
55	108	25602	0	256	22786	2560
60	81	19202	0	192	17089	1920
65	62	14697	0	147	13081	1470
70	50	11853	0	119	10549	1185
75	41	9719	0	97	8650	972
80	32	7586	0	76	6751	759
85	24	5689	0	57	5064	569
90	17	4030	0	40	3587	403
95	11	2608	0	26	2321	261
100	0	0	0	0	0	0

NA = Not applicable

Table 5-14 Total Suspended Solids TMDL Calculations for Curl Creek (OK121400010270_10)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)		LA (lb/day)	MOS (lb/day)
			WWTP	Future Growth		
0	4441	N/A	0	N/A	N/A	N/A
5	143	N/A	0	N/A	N/A	N/A
10	49	N/A	0	N/A	N/A	N/A
15	27	N/A	0	N/A	N/A	N/A
20	18	N/A	0	N/A	N/A	N/A
25	13	2600	0	26	2184	390
30	10	1950	0	20	1638	293
35	7	1491	0	15	1253	224
40	6	1128	0	11	948	169
45	4	860	0	9	723	129
50	3	650	0	7	546	98
55	2	440	0	4	369	66
60	1.5	306	0	3	257	46
65	1.1	210	0	2	177	32
70	0.7	140	0	1	117	21
75	0.5	90	0	1	75	13
80	0.3	59	0	1	50	9
85	0.2	42	0	0	35	6
90	0.2	31	0	0	26	5
95	0.1	21	0	0	18	3
100	0.0	2	0	0	2	0

NA = Not applicable

Table 5-15 Total Suspended Solids TMDL Calculations for Mission Creek (OK121400020190_10)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)		LA (lb/day)	MOS (lb/day)
			WWTP	Future Growth		
0	3600	N/A	0	N/A	N/A	N/A
5	116	N/A	0	N/A	N/A	N/A
10	40	N/A	0	N/A	N/A	N/A
15	22	N/A	0	N/A	N/A	N/A
20	15	N/A	0	N/A	N/A	N/A
25	11	2165	0	22	1819	325
30	8	1624	0	16	1364	244
35	6	1242	0	12	1043	186
40	5	939	0	9	789	141
45	3	716	0	7	602	107
50	3	541	0	5	455	81
55	2	366	0	4	308	55
60	1.2	255	0	3	214	38
65	0.9	175	0	2	147	26
70	0.6	116	0	1	98	17
75	0.4	75	0	1	63	11
80	0.2	49	0	0	41	7
85	0.2	35	0	0	29	5
90	0.1	25	0	0	21	4
95	0.1	18	0	0	15	3
100	0.0	2	0	0	1	0

NA = Not applicable

Table 5-16 Total Suspended Solids TMDL Calculations for Little Caney River (OK121400020140_00)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)		LA (lb/day)	MOS (lb/day)
			WWTP	Future Growth		
0	2332	N/A	0	0	N/A	N/A
5	75	N/A	0	0	N/A	N/A
10	26	N/A	0	0	N/A	N/A
15	14	N/A	0	0	N/A	N/A
20	10	N/A	0	0	N/A	N/A
25	7	1107	0	11	930	166
30	5	830	0	8	698	125
35	4	635	0	6	533	95
40	3	480	0	5	403	72
45	2	366	0	4	308	55
50	2	277	0	3	233	42
55	1	187	0	2	157	28
60	0.8	130	0	1	109	20
65	0.6	90	0	1	75	13
70	0.4	59	0	1	50	9
75	0.2	38	0	0	32	6
80	0.2	25	0	0	21	4
85	0.1	18	0	0	15	3
90	0.1	13	0	0	11	2
95	0.0	0	0	0	0	0
100	0.0	0	0	0	0	0

NA = Not applicable

Table 5-17 Total Suspended Solids TMDL Calculations for Rabb Creek (OK121400010090_00)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)		LA (lb/day)	MOS (lb/day)
			WWTP	Future Growth		
0	842	N/A	0	N/A	N/A	N/A
5	27	N/A	0	N/A	N/A	N/A
10	9	N/A	0	N/A	N/A	N/A
15	5	N/A	0	N/A	N/A	N/A
20	3	N/A	0	N/A	N/A	N/A
25	2	480	0	5	403	72
30	2	360	0	4	302	54
35	1.4	275	0	3	231	41
40	1.1	208	0	2	175	31
45	0.8	159	0	2	133	24
50	0.6	120	0	1	101	18
55	0.4	81	0	1	68	12
60	0.3	56	0	1	47	8
65	0.2	39	0	0	33	6
70	0.1	26	0	0	22	4
75	0.1	17	0	0	14	2
80	0.1	11	0	0	9	2
85	0.0	8	0	0	7	1
90	0.0	6	0	0	5	1
95	0.0	0	0	0	0	0
100	0.0	0	0	0	0	0

NA = Not applicable

5.7 Reasonable Assurances

ODEQ will collaborate with a host of other state agencies and local governments working within the boundaries of state and local regulations to target available funding and technical assistance to support implementation of pollution controls and management measures. Various water quality management programs and funding sources provide reasonable assurance that the pollutant reductions as required by these TMDLs can be achieved and water quality can be restored to maintain designated uses. ODEQ's Continuing Planning Process (CPP), required by the CWA §303(e) (3) and 40 CFR 130.5, summarizes Oklahoma's commitments and programs aimed at restoring and protecting water quality throughout the State (ODEQ 2006). The CPP can be viewed from ODEQ's website at http://www.deq.state.ok.us/WQDnew/pubs.html Table 5-18 provides a partial list of the state partner agencies ODEQ will collaborate with to address point and nonpoint source reduction goals established by TMDLs.

Table 5-18 Partial List of Oklahoma Water Quality Management Agencies

Agency	Web Link
Oklahoma Conservation Commission	http://www.ok.gov/conservation/Agency_Divisions/Water_Quality_Division
Oklahoma Department of Wildlife Conservation	http://www.wildlifedepartment.com/watchabl.htm
Oklahoma Department of Agriculture, Food, and Forestry	http://www.ok.gov/~okag/aems
Oklahoma Water Resources Board	http://www.owrb.state.ok.us/quality/index.php

Nonpoint source pollution in Oklahoma is managed by the Oklahoma Conservation Commission (OCC). The OCC works with state partners such as Oklahoma Department of Agriculture, Food, and Forestry (ODAFF) and federal partners such USEPA and the National Resources Conservation Service (NRCS), to address water quality problems similar to those seen in the Study Area. The primary mechanisms used for management of nonpoint source pollution are incentive-based programs that support the installation of BMPs and public education and outreach. Other programs include regulations and permits for CAFOs. The CAFO Act, as administered by the ODAFF, provides CAFO operators the necessary tools and information to deal with the manure and wastewater animals produce so streams, lakes, ponds, and groundwater sources are not polluted.

As authorized by Section 402 of the CWA, the ODEQ has delegation of the NPDES Program in Oklahoma, except for certain jurisdictional areas related to agriculture and the oil and gas industry retained by State Department of Agriculture and Oklahoma Corporation Commission, for which the USEPA has retained permitting authority. The NPDES Program in Oklahoma is implemented via Title 252, Chapter 606 of the Oklahoma Pollution Discharge Elimination System (OPDES) Act and in accordance with the agreement between ODEQ and USEPA relating to administration and enforcement of the delegated NPDES Program. Implementation of point source WLAs is done through permits issued under the OPDES program.

The reduction rates called for in this TMDL report are as high as 96 percent. The ODEQ recognizes that achieving such high reductions will be a challenge, especially since unregulated nonpoint sources are a major cause of both bacteria and TSS loading. The high reduction rates are not uncommon for pathogen- or TSS-impaired waters. Similar reduction rates are often found in other pathogen and TSS TMDLs around the nation. The suitability of the current criteria for pathogens and the beneficial uses of a waterbody should be reviewed. For example, the Kansas Department of Environmental Quality has proposed to exclude certain high flow conditions during which pathogen standards will not apply, although that exclusion was not approved by the USEPA. Additionally, USEPA has been conducting new epidemiology studies and may develop new recommendations for pathogen criteria in the near future.

Revisions to the current pathogen provisions of Oklahoma's WQSs should be considered. There are three basic approaches to such revisions that may apply.

- Removing the PBCR use: This revision would require documentation in a Use Attainability Analysis that the use is not an existing use and cannot be attained. It is unlikely that this approach would be successful since there is evidence that people do swim in this segment of the river, thus constituting an existing use. Existing uses cannot be removed.
- Modifying application of the existing criteria: This approach would include considerations such as an exemption under certain high flow conditions, an allowance for wildlife or "natural conditions," a sub-category of the use or other special provision for urban areas, or other special provisions for storm flows. Since large bacteria violations occur over all flow ranges, it is likely that large reductions would still be necessary. However, this approach may have merit and should be considered.
- Revising the existing numeric criteria: Oklahoma's current pathogen criteria are based on USEPA guidelines (See Implementation Guidance for Ambient Water Quality Criteria for Bacteria, May 2002 FINAL; and Ambient Water Quality Criteria for Bacteria-1986, January 1986). However, those guidelines have received much criticism and USEPA studies that could result in revisions to their recommendations are ongoing. The use of the three indicators specified in Oklahoma's standards should be evaluated. The numeric criteria values should also be evaluated using a risk-based method such as that found in USEPA guidance.

Unless or until the WQSs are revised and approved by USEPA, federal rules require that the TMDLs in this report must be based on attainment of the current standards. If revisions to the pathogen standards are approved in the future, reductions specified in these TMDLs will be

SECTION 6
PUBLIC PARTICIPATION

This report is submitted to EPA for technical review. After the technical approval, a public notice will be circulated to the local newspapers and/or other publications in the area affected by this TMDL. The public will have opportunities to review the TMDL report and make written comments. The public comment period lasts 45 days. Depending on the interest and responses from the public, a public meeting may be held within the watershed affected by this TMDL. If a public meeting is held, the public will also have opportunities to ask questions and make formal oral comments at the meeting and/or to submit written comments at the public meeting.

All written comments received during the public notice period become a part of the record of this TMDL. All comments will be considered and the TMDL report will be revised according to the comments if necessary in the ultimate completion of this TMDL for submission to EPA for final approval.

After EPA's final approval, each TMDL will be adopted into the Water Quality Management Plan (WQMP). These TMDLs provide a mathematical solution to meet ambient water quality criterion with a given set of facts. The adoption of these TMDLs into the WQMP provides a mechanism to recalculate acceptable loads when information changes in the future. Updates to the WQMP demonstrate compliance with the water quality criterion. The updates to the WQMP are also useful when the water quality criterion changes and the loading scenario is reviewed to ensure that the instream criterion is predicted to be met.

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APPENDIX A
AMBIENT WATER QUALITY DATA – 1999 TO 2008

FOR BACTERIA AND TURBIDITY

Appendix A

Ambient Water Quality Bacteria Data – 1999 to 2008

WQM Station	Waterbody Name	Date	Bacteria Concentration (#/100ml)	Bacterial Indicator
OK121400010010-001AT	Caney River	9/18/2006	110	Enterococci
OK121400010010-001AT	Caney River	9/5/2006	10	Enterococci
OK121400010010-001AT	Caney River	8/22/2006	41	Enterococci
OK121400010010-001AT	Caney River	8/21/2006	132	Enterococci
OK121400010010-001AT	Caney River	8/7/2006	74	Enterococci
OK121400010010-001AT	Caney River	7/24/2006	20	Enterococci
OK121400010010-001AT	Caney River	7/5/2006	10	Enterococci
OK121400010010-001AT	Caney River	6/26/2006	10	Enterococci
OK121400010010-001AT	Caney River	6/12/2006	187	Enterococci
OK121400010010-001AT	Caney River	5/23/2006	41	Enterococci
OK121400010010-001AT	Caney River	9/15/2003	40	Enterococci
OK121400010010-001AT	Caney River	8/11/2003	10	Enterococci
OK121400010010-001AT	Caney River	7/29/2003	30	Enterococci
OK121400010010-001AT	Caney River	7/7/2003	300	Enterococci
OK121400010010-001AT	Caney River	6/18/2003	50	Enterococci
OK121400010010-001AT	Caney River	6/2/2003	700	Enterococci
OK121400010010-001AT	Caney River	9/4/2002	30	Enterococci
OK121400010010-001AT	Caney River	7/9/2002	170	Enterococci
OK121400010010-001AT	Caney River	6/4/2002	40	Enterococci
OK121400010010-001AT	Caney River	5/8/2002	2000	Enterococci
OK121400010010-001AT	Caney River	9/26/2001	10	Enterococci
OK121400010010-001AT	Caney River	8/6/2001	10	Enterococci
OK121400010010-001AT	Caney River	7/9/2001	20	Enterococci
OK121400010010-001AT	Caney River	6/4/2001	130	Enterococci
OK121400010010-001AT	Caney River	5/7/2001	87000	Enterococci
OK121400-01-0300J	Hogshooter Creek	8/21/2007	30	E. Coli
OK121400-01-0300D	Hogshooter Creek	7/17/2007	220	E. Coli
OK121400-01-0300D	Hogshooter Creek	7/10/2007	580	E. Coli
OK121400-01-0300D	Hogshooter Creek	6/12/2007	1920	E. Coli
OK121400-01-0300D	Hogshooter Creek	5/8/2007	1920	E. Coli
OK121400-01-0300D	Hogshooter Creek	9/12/2006	720	E. Coli
OK121400-01-0300D	Hogshooter Creek	8/8/2006	30	E. Coli
OK121400-01-0300D	Hogshooter Creek	6/13/2006	690	E. Coli
OK121400-01-0300D	Hogshooter Creek	6/16/2003	220	E. Coli
OK121400-01-0300D	Hogshooter Creek	5/12/2003	100	E. Coli

WQM Station	Waterbody Name	Date	Bacteria Concentration (#/100ml)	Bacterial Indicator
OK121400-01-0300D	Hogshooter Creek	9/9/2002	60	E. Coli
OK121400-01-0300D	Hogshooter Creek	8/5/2002	1210	E. Coli
OK121400-01-0300D	Hogshooter Creek	7/8/2002	130	E. Coli
OK121400-01-0300D	Hogshooter Creek	5/28/2002	610	E. Coli
OK121400-01-0300D	Hogshooter Creek	9/17/2001	>800	E. Coli
OK121400-01-0300D	Hogshooter Creek	8/13/2001	130	E. Coli
OK121400-01-0300D	Hogshooter Creek	9/19/2000	121	E. Coli
OK121400-01-0300J	Hogshooter Creek	8/15/2000	10	E. Coli
OK121400-01-0300D	Hogshooter Creek	8/21/2007	500	Enterococci
OK121400-01-0300D	Hogshooter Creek	7/17/2007	380	Enterococci
OK121400-01-0300D	Hogshooter Creek	7/10/2007	570	Enterococci
OK121400-01-0300D	Hogshooter Creek	6/12/2007	1780	Enterococci
OK121400-01-0300D	Hogshooter Creek	5/8/2007	>2000	Enterococci
OK121400-01-0300D	Hogshooter Creek	9/12/2006	380	Enterococci
OK121400-01-0300D	Hogshooter Creek	8/8/2006	40	Enterococci
OK121400-01-0300D	Hogshooter Creek	6/13/2006	390	Enterococci
OK121400-01-0300D	Hogshooter Creek	6/16/2003	280	Enterococci
OK121400-01-0300D	Hogshooter Creek	5/12/2003	100	Enterococci
OK121400-01-0300D	Hogshooter Creek	9/9/2002	40	Enterococci
OK121400-01-0300D	Hogshooter Creek	8/5/2002	300	Enterococci
OK121400-01-0300D	Hogshooter Creek	7/8/2002	30	Enterococci
OK121400-01-0300D	Hogshooter Creek	5/28/2002	750	Enterococci
OK121400-01-0300D	Hogshooter Creek	9/17/2001	>600	Enterococci
OK121400-01-0300D	Hogshooter Creek	8/13/2001	215	Enterococci
OK121400-01-0300J	Hogshooter Creek	9/17/2001	>600	Fecal Coliform
OK121400-01-0300D	Hogshooter Creek	9/19/2000	40	Fecal Coliform
OK121400-01-0300J	Hogshooter Creek	9/19/2000	180	Fecal Coliform
OK121400-01-0300J	Hogshooter Creek	8/15/2000	30	Fecal Coliform
OK121400-01-0300J	Hogshooter Creek	7/11/2000	100	Fecal Coliform
OK121400-01-0300J	Hogshooter Creek	6/6/2000	<100	Fecal Coliform
OK121400-01-0300J	Hogshooter Creek	5/2/2000	1500	Fecal Coliform
OK121400-01-0300J	Hogshooter Creek	9/28/1999	300	Fecal Coliform
OK121400-01-0300J	Hogshooter Creek	8/17/1999	<100	Fecal Coliform
OK121400-01-0300J	Hogshooter Creek	6/15/1999	<100	Fecal Coliform
OK121400-01-0300J	Hogshooter Creek	5/18/1999	1800	Fecal Coliform
OK121400-01-0270C	Curl Creek	8/21/2007	30	Enterococci
OK121400-01-0270C	Curl Creek	7/17/2007	110	Enterococci
OK121400-01-0270C	Curl Creek	7/10/2007	410	Enterococci

WQM Station	Waterbody Name	Date	Bacteria Concentration (#/100ml)	Bacterial Indicator
OK121400-01-0270C	Curl Creek	6/12/2007	>2000	Enterococci
OK121400-01-0270C	Curl Creek	5/8/2007	7600	Enterococci
OK121400-01-0270C	Curl Creek	9/12/2006	85	Enterococci
OK121400-01-0270C	Curl Creek	8/8/2006	185	Enterococci
OK121400-01-0270C	Curl Creek	6/13/2006	230	Enterococci
OK121400-01-0270G	Curl Creek	6/16/2003	310	Enterococci
OK121400-01-0270G	Curl Creek	5/12/2003	80	Enterococci
OK121400-01-0270G	Curl Creek	9/9/2002	100	Enterococci
OK121400-01-0270G	Curl Creek	8/5/2002	130	Enterococci
OK121400-01-0270G	Curl Creek	7/8/2002	1065	Enterococci
OK121400-01-0270G	Curl Creek	5/28/2002	190	Enterococci
OK121400-01-0270G	Curl Creek	9/17/2001	>600	Enterococci
OK121400-01-0270G	Curl Creek	8/13/2001	80	Enterococci
OK121400-02-0190B	Mission Creek	7/17/2007	110	E. Coli
OK121400-02-0190B	Mission Creek	7/10/2007	>1000	E. Coli
OK121400-02-0190B	Mission Creek	6/12/2007	>2000	E. Coli
OK121400-02-0190B	Mission Creek	5/8/2007	>2000	E. Coli
OK121400-02-0190B	Mission Creek	9/11/2006	10	E. Coli
OK121400-02-0190B	Mission Creek	8/7/2006	50	E. Coli
OK121400-02-0190B	Mission Creek	6/12/2006	710	E. Coli
OK121400-02-0190B	Mission Creek	6/17/2003	<20	E. Coli
OK121400-02-0190B	Mission Creek	5/13/2003	>2000	E. Coli
OK121400-02-0190B	Mission Creek	9/10/2002	<10	E. Coli
OK121400-02-0190B	Mission Creek	8/6/2002	100	E. Coli
OK121400-02-0190B	Mission Creek	7/9/2002	<10	E. Coli
OK121400-02-0190B	Mission Creek	5/28/2002	190	E. Coli
OK121400-02-0190B	Mission Creek	9/18/2001	610	E. Coli
OK121400-02-0190B	Mission Creek	8/14/2001	20	E. Coli
OK121400-02-0190B	Mission Creek	7/17/2007	30	Enterococci
OK121400-02-0190B	Mission Creek	7/10/2007	>1000	Enterococci
OK121400-02-0190B	Mission Creek	6/12/2007	1640	Enterococci
OK121400-02-0190B	Mission Creek	5/8/2007	>2000	Enterococci
OK121400-02-0190B	Mission Creek	9/11/2006	5	Enterococci
OK121400-02-0190B	Mission Creek	8/7/2006	55	Enterococci
OK121400-02-0190B	Mission Creek	6/12/2006	530	Enterococci
OK121400-02-0190B	Mission Creek	6/17/2003	20	Enterococci
OK121400-02-0190B	Mission Creek	5/13/2003	>2000	Enterococci
OK121400-02-0190B	Mission Creek	9/10/2002	20	Enterococci

WQM Station	Waterbody Name	Date	Bacteria Concentration (#/100ml)	Bacterial Indicator
OK121400-02-0190B	Mission Creek	8/6/2002	30	Enterococci
OK121400-02-0190B	Mission Creek	7/9/2002	<10	Enterococci
OK121400-02-0190B	Mission Creek	5/28/2002	290	Enterococci
OK121400-02-0190B	Mission Creek	9/18/2001	850	Enterococci
OK121400-02-0190B	Mission Creek	8/14/2001	70	Enterococci
OK121400-02-0140H	Little Caney River	8/21/2007	120	Enterococci
OK121400-02-0140H	Little Caney River	7/17/2007	<10	Enterococci
OK121400-02-0140H	Little Caney River	7/10/2007	230	Enterococci
OK121400-02-0140H	Little Caney River	6/12/2007	1620	Enterococci
OK121400-02-0140H	Little Caney River	5/8/2007	>2000	Enterococci
OK121400-02-0140H	Little Caney River	9/12/2006	230	Enterococci
OK121400-02-0140H	Little Caney River	8/8/2006	65	Enterococci
OK121400-02-0140H	Little Caney River	6/13/2006	260	Enterococci
OK121400-02-0140H	Little Caney River	6/16/2003	<20	Enterococci
OK121400-02-0140H	Little Caney River	5/12/2003	100	Enterococci
OK121400-02-0140H	Little Caney River	9/9/2002	60	Enterococci
OK121400-02-0140H	Little Caney River	8/5/2002	30	Enterococci
OK121400-02-0140H	Little Caney River	7/8/2002	20	Enterococci
OK121400-02-0140H	Little Caney River	5/29/2002	70	Enterococci
OK121400-02-0140H	Little Caney River	9/17/2001	50	Enterococci
OK121400-02-0140H	Little Caney River	8/13/2001	30	Enterococci
OK121400-01-0090D	Rabb Creek	9/19/2000	50	Fecal Coliform
OK121400-01-0090D	Rabb Creek	8/15/2000	90	Fecal Coliform
OK121400-01-0090D	Rabb Creek	7/11/2000	40	Fecal Coliform
OK121400-01-0090D	Rabb Creek	6/6/2000	100	Fecal Coliform
OK121400-01-0090D	Rabb Creek	5/2/2000	6000	Fecal Coliform
OK121400-01-0090D	Rabb Creek	9/28/1999	<100	Fecal Coliform
OK121400-01-0090D	Rabb Creek	8/17/1999	<100	Fecal Coliform
OK121400-01-0090D	Rabb Creek	7/13/1999	200	Fecal Coliform
OK121400-01-0090D	Rabb Creek	6/15/1999	200	Fecal Coliform
OK121400-01-0090D	Rabb Creek	5/18/1999	5000	Fecal Coliform

Appendix A

Ambient Water Quality Turbidity and TSS Data – 1999 to 2008

WQM Station	Waterbody Name	Date	Turbidity (NTU)	Total Suspended Solids (mg/L)	Flow (cfs)	Flow Condition
OK121400010010-001AT	Caney River	11/29/2000	16	15	46	
OK121400010010-001AT	Caney River	10/24/2000	40	36	63	
OK121400010010-001AT	Caney River	9/27/2000	49	0	37	
OK121400010010-001AT	Caney River	8/30/2000	47	60	32	
OK121400010010-001AT	Caney River	8/1/2000	170	136	112	
OK121400010010-001AT	Caney River	6/28/2000	223	256	2430	High flow
OK121400010010-001AT	Caney River	5/10/2000	681	436	12800	High flow
OK121400010010-001AT	Caney River	3/27/2000	172		5350	High flow
OK121400010010-001AT	Caney River	2/22/2000	25	31	132	
OK121400010010-001AT	Caney River	1/19/2000	13.2	13	62	
OK121400010010-001AT	Caney River	12/14/1999	118	108	2450	High flow
OK121400010010-001AT	Caney River	11/17/1999	29	32	45	
OK121400010010-001AT	Caney River	10/28/1999	32	22	32	
OK121400010010-001AT	Caney River	9/28/1999	131	142	141	
OK121400010010-001AT	Caney River	8/24/1999	57	48	65	
OK121400010010-001AT	Caney River	7/27/1999	224	119	2160	High flow
OK121400010010-001AT	Caney River	6/22/1999	148	156	37	
OK121400010010-001AT	Caney River	5/24/1999	1100	400	11100	High flow
OK121400010010-001AT	Caney River	4/27/1999	73	70	21000	High flow
OK121400010010-001AT	Caney River	4/27/1999	73		21000	High flow
OK121400010010-001AT	Caney River	3/30/1999	63	63	2060	High flow
OK121400010010-001AT	Caney River	3/30/1999			43	
OK121400010010-001AT	Caney River	2/24/1999	0	62	45	
OK121400010010-001AT	Caney River	2/23/1999	69	50	46	
OK121400010010-001AT	Caney River	1/27/1999	10	6	186	
OK121400010010-001AT	Caney River	1/26/1999		3	245	
OK121400010010-001AT	Caney River	12/2/1998	120	90	1040	
OK121400010010-001AT	Caney River	12/2/1998	120		1040	
OK121400-01-0270C	Curl Creek	12/11/2007	78.5	40	31.67	High flow
OK121400-01-0270C	Curl Creek	04/29/2008	23.8	13	0.00	
OK121400-01-0270C	Curl Creek	03/25/2008	25.4	9.99	7.33	
OK121400-01-0270C	Curl Creek	02/20/2008	64.9	12	16.72	High flow
OK121400-01-0270C	Curl Creek	01/16/2008	16.3	9.99	2.05	

WQM Station	Waterbody Name	Date	Turbidity (NTU)	Total Suspended Solids (mg/L)	Flow (cfs)	Flow Condition
OK121400-01-0270C	Curl Creek	10/30/2007	14.4	9.99	0	
OK121400-01-0270C	Curl Creek	09/25/2007	15.1	9.99	0	
OK121400-01-0270C	Curl Creek	08/21/2007	18.7	19	0.01	
OK121400-01-0270C	Curl Creek	07/17/2007	14.5	9.99	0	
OK121400-01-0270C	Curl Creek	06/16/2003	74.1	50	0	
OK121400-01-0270C	Curl Creek	05/12/2003	52.5	49	0.01	
OK121400-01-0270C	Curl Creek	04/07/2003	25.8	31	7.30	
OK121400-01-0270C	Curl Creek	03/03/2003	45.8	40	6.61	
OK121400-01-0270C	Curl Creek	01/27/2003	17.8	153	0	
OK121400-01-0270C	Curl Creek	12/16/2002	34.5	9.99	0	
OK121400-01-0270C	Curl Creek	11/18/2002	28.2	33	0	
OK121400-01-0270C	Curl Creek	10/14/2002	35.6	32	0	
OK121400-01-0270C	Curl Creek	09/09/2002	19.4	11	0	
OK121400-01-0270C	Curl Creek	08/05/2002	72.9	9.99	0	
OK121400-01-0270C	Curl Creek	07/08/2002	43.3	9.99	0.03	
OK121400-01-0270C	Curl Creek	05/28/2002	45	46	15.85	High flow
OK121400-01-0270C	Curl Creek	04/22/2002	55.9	24	10.17	
OK121400-01-0270C	Curl Creek	03/18/2002	13.6	9.99	0.03	
OK121400-01-0270C	Curl Creek	02/11/2002	51.1	25	1.10	
OK121400-01-0270C	Curl Creek	01/07/2002	22.5	31	0	
OK121400-01-0270C	Curl Creek	12/03/2001	10.4	12	0	
OK121400-01-0270C	Curl Creek	10/22/2001	29.9	23	0	
OK121400-01-0270C	Curl Creek	09/17/2001	43.5	19	0	
OK121400-01-0270C	Curl Creek	08/30/2001	62.9		0	
OK121400-01-0270C	Curl Creek	08/13/2001	37.2	34	0	
OK121400-02-0190B	Mission Creek	4/28/2008	00	9.99	21.72	High flow
OK121400-02-0190B	Mission Creek	3/24/2008	51.1	9.99	24.12	High flow
OK121400-02-0190B	Mission Creek	2/19/2008	75.3	20	29.81	High flow
OK121400-02-0190B	Mission Creek	1/15/2008	35.4	9.99	6.65	
OK121400-02-0190B	Mission Creek	12/11/2007	10	22	4.6	
OK121400-02-0190B	Mission Creek	10/29/2007	32.3	13	1.69	
OK121400-02-0190B	Mission Creek	9/25/2007	24.1	15	0.08	
OK121400-02-0190B	Mission Creek	8/21/2007	19.5	18	0.04	
OK121400-02-0190B	Mission Creek	7/17/2007	29.3	23	0	
OK121400-02-0190B	Mission Creek	6/12/2007	222	138	0	
OK121400-02-0190B	Mission Creek	5/8/2007	186	99	0	

WQM Station	Waterbody Name	Date	Turbidity (NTU)	Total Suspended Solids (mg/L)	Flow (cfs)	Flow Condition
OK121400-02-0190B	Mission Creek	4/3/2007	19.8	16	56.31	High flow
OK121400-02-0190B	Mission Creek	2/26/2007	12.4	9.99	0.1	
OK121400-02-0190B	Mission Creek	1/22/2007	15.7	9.99	0.05	
OK121400-02-0190B	Mission Creek	12/19/2006	36.3	20	0	
OK121400-02-0190B	Mission Creek	11/13/2006	4.11	9.99	0	
OK121400-02-0190B	Mission Creek	10/16/2006	10.6	9.99	0	
OK121400-02-0190B	Mission Creek	9/11/2006	9.39	0	0	
OK121400-02-0190B	Mission Creek	8/7/2006	6.04	9.99	0	
OK121400-02-0190B	Mission Creek	6/12/2006	50.8	47	0	
OK121400-02-0190B	Mission Creek	6/2/2006	12.7		0.29	
OK121400-02-0190B	Mission Creek	6/17/2003	28.1	26	1.15	
OK121400-02-0190B	Mission Creek	5/13/2003	822	609	0.38	
OK121400-02-0190B	Mission Creek	4/8/2003	64.9	42	26.51	High flow
OK121400-02-0190B	Mission Creek	3/4/2003	33.5	23	20.91	High flow
OK121400-02-0190B	Mission Creek	1/28/2003	24.6	14	0	
OK121400-02-0190B	Mission Creek	12/17/2002	21.4	11	0.01	
OK121400-02-0190B	Mission Creek	11/19/2002	5.07	9.99	0	
OK121400-02-0190B	Mission Creek	10/15/2002	15.7	16	0	
OK121400-02-0190B	Mission Creek	9/10/2002	27.2	41	0	
OK121400-02-0190B	Mission Creek	8/6/2002	5.09	9.99	0.05	
OK121400-02-0190B	Mission Creek	7/9/2002	6.97	9.99	0	
OK121400-02-0190B	Mission Creek	5/28/2002	50.8	22	37.82	High flow
OK121400-02-0190B	Mission Creek	4/23/2002	15	14	0.02	
OK121400-02-0190B	Mission Creek	3/19/2002	10.8	9.99	0.2	
OK121400-02-0190B	Mission Creek	2/12/2002	20.8	9.99	0.05	
OK121400-02-0190B	Mission Creek	1/8/2002	6.06	10	0	
OK121400-02-0190B	Mission Creek	12/4/2001	3.77	9.99	0	
OK121400-02-0190B	Mission Creek	10/23/2001	16.1	9.99	0	
OK121400-02-0190B	Mission Creek	9/18/2001	64.8	35	0.8	
OK121400-02-0190B	Mission Creek	9/5/2001	30.7		0.96	
OK121400-02-0190B	Mission Creek	8/14/2001	28.4	31	1.24	
OK121400-02-0140H	Little Caney	4/29/2008	82.6	23		High flow
OK121400-02-0140H	Little Caney	3/25/2008	49.2	22		High flow
OK121400-02-0140H	Little Caney	2/20/2008	21.8	29		High flow
OK121400-02-0140H	Little Caney	1/16/2008	28.3	30		High flow
OK121400-02-0140H	Little Caney	12/11/2007	68.1	20	13.66	High flow
OK121400-02-0140H	Little Caney R	10/29/2007	50.3	28	0.00	

WQM Station	Waterbody Name	Date	Turbidity (NTU)	Total Suspended Solids	Flow (cfs)	Flow Condition
OK121400-02-0140H	Little Caney	9/25/2007	92.5	80	22.9	High flow
OK121400-02-0140H	Little Caney	8/21/2007	94.5	49	13.17	High flow
OK121400-02-0140H	Little Caney	7/17/2007	24.9	19		High flow
OK121400-02-0140H	Little Caney	6/12/2007	145	217		High flow
OK121400-02-0140H	Little Caney	5/8/2007	620	415	250	High flow
OK121400-02-0140H	Little Caney	4/3/2007	85.8	83		High flow
OK121400-02-0140H	Little Caney	2/27/2007	45.4	31	2.39	
OK121400-02-0140H	Little Caney	1/23/2007	22.7	9.99	3.7	
OK121400-02-0140H	Little Caney	12/20/2006	106	40	10.78	High flow
OK121400-02-0140H	Little Caney	11/14/2006	44	19	4.12	
OK121400-02-0140H	Little Caney	10/17/2006	72.7	28	5.31	
OK121400-02-0140H	Little Caney	9/12/2006	92	59	12.77	High flow
OK121400-02-0140H	Little Caney	8/8/2006	85	83	14.46	High flow
OK121400-02-0140H	Little Caney	7/10/2006	91.3		15.38	High flow
OK121400-02-0140H	Little Caney	6/13/2006	94.5	45	14.42	High flow
OK121400-02-0140H	Little Caney	6/16/2003	60	22		High flow
OK121400-02-0140H	Little Caney	5/12/2003	89.4	43	46.23	High flow
OK121400-02-0140H	Little Caney	4/7/2003	46.6	44	142.1	High flow
OK121400-02-0140H	Little Caney	3/3/2003	107	46	2.32	
OK121400-02-0140H	Little Caney	1/28/2003	23.1	41	3.11	
OK121400-02-0140H	Little Caney	12/16/2002	30.3	14	11.42	High flow
OK121400-02-0140H	Little Caney	11/18/2002	28.1	14	4.78	
OK121400-02-0140H	Little Caney	10/14/2002	46.4	40	4.48	
OK121400-02-0140H	Little Caney	9/9/2002	71	69	16.64	High flow
OK121400-02-0140H	Little Caney	8/5/2002	92.7	41	17.32	High flow
OK121400-02-0140H	Little Caney	7/8/2002	99.8	27	91.92	High flow
OK121400-02-0140H	Little Caney	5/29/2002	117	23		High flow
OK121400-02-0140H	Little Caney	4/22/2002	193	72	5.34	
OK121400-02-0140H	Little Caney	3/18/2002	43.8	35	3.37	
OK121400-02-0140H	Little Caney	2/11/2002	30.6	29	1.7	
OK121400-02-0140H	Little Caney	1/7/2002	15.9	15	0.83	
OK121400-02-0140H	Little Caney	12/3/2001	60.9	46	3.03	
OK121400-02-0140H	Little Caney	10/22/2001	98.7	73	9.33	High flow
OK121400-02-0140H	Little Caney	9/17/2001	109	65	11.92	High flow
OK121400-02-0140H	Little Caney	8/31/2001	148		15.86	High flow
OK121400-02-0140H	Little Caney	8/13/2001	83.6	9.99	13.74	High flow
OK121400-01-0090D	Rabb Creek	3/20/2001	21.2	28	6.83	High flow

WQM Station	Waterbody Name	Date	Turbidity (NTU)	Total Suspended Solids	Flow (cfs)	Flow Condition
OK121400-01-0090D	Rabb Creek	2/13/2001	79.1	82	57.77	High flow
OK121400-01-0090D	Rabb Creek	1/9/2001	39.6	30	37.71	High flow
OK121400-01-0090D	Rabb Creek	11/28/2000	37.5	20	0.37	
OK121400-01-0090D	Rabb Creek	10/24/2000	180	152	0	
OK121400-01-0090D	Rabb Creek	9/19/2000	30.7		0	
OK121400-01-0090D	Rabb Creek	8/15/2000	31.1	14	0	
OK121400-01-0090D	Rabb Creek	7/11/2000	13.8	2	0.76	
OK121400-01-0090D	Rabb Creek	6/6/2000	29.8	37	0.96	
OK121400-01-0090D	Rabb Creek	5/2/2000	69.5	34	19.02	High flow
OK121400-01-0090D	Rabb Creek	3/21/2000	48.4	30	5.42	High flow
OK121400-01-0090D	Rabb Creek	2/15/2000	18.2	8	0.45	
OK121400-01-0090D	Rabb Creek	1/11/2000	13.6	16	0.16	
OK121400-01-0090D	Rabb Creek	12/7/1999	75.8	47.5	2.51	High flow
OK121400-01-0090D	Rabb Creek	11/2/1999	11.3	31.5	0	
OK121400-01-0090D	Rabb Creek	9/28/1999	239	151	3.25	High flow
OK121400-01-0090D	Rabb Creek	8/17/1999	20.6	20	0	
OK121400-01-0090D	Rabb Creek	7/29/1999	23.5		2	
OK121400-01-0090D	Rabb Creek	7/13/1999	16	11.5	1	
OK121400-01-0090D	Rabb Creek	6/15/1999	58.6	26	1.5	
OK121400-01-0090D	Rabb Creek	5/18/1999	67.5	64	73.38	High flow
OK121400-01-0090D	Rabb Creek	4/20/1999	10	9.5	1.97	

APPENDIX B
NPDES PERMIT DISCHARGE MONITORING REPORT DATA AND SANSITARY SEWER OVERFLOW DATA

Appendix B

Summary of Discharge Monitoring Report Data for facilities in the Study

NPDES	Name of Facility	Time	Max Flow (mgd)	Ave Flow (mgd)	Max TSS (mg/L)	Ave TSS (mg/L)
OK0034517	Ochelata UA	5/31/2009	0.07	0.07	5	5
OK0034517	Ochelata UA	4/30/2009	0.07	0.07	5	5
OK0034517	Ochelata UA	3/31/2009	0.07	0.07	57	57
OK0034517	Ochelata UA	2/28/2009	0.07	0.07	22	22
OK0034517	Ochelata UA	1/31/2009	0.07	0.07	20	20
OK0034517	Ochelata UA	12/31/2008	0.07	0.07	40	40
OK0034517	Ochelata UA	11/30/2008	0.07	0.07	5	5
OK0034517	Ochelata UA	10/31/2008	0.07	0.07	5	5
OK0034517	Ochelata UA	9/30/2008	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	8/31/2008	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	7/31/2008	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	6/30/2008	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	5/31/2008	0.07	0.07	36	36
OK0034517	Ochelata UA	4/30/2008	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	3/31/2008	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	2/29/2008	0.07	0.07	5	5
OK0034517	Ochelata UA	1/31/2008	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	12/31/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	11/30/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	10/31/2007	0.07	0.07	22	22
OK0034517	Ochelata UA	9/30/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	8/31/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	7/31/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	6/30/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	5/31/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	4/30/2007	0.07	0.07	25	25
OK0034517	Ochelata UA	3/31/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	2/28/2007	NODI	NODI	NODI	NODI
OK0034517	Ochelata UA	1/31/2007	NODI	NODI	NODI	NODI
OK0028339	Ramona PWA	5/31/2009	0.070	0.030	44	44
OK0028339	Ramona PWA	4/30/2009	0.058	0.045	7	7
OK0028339	Ramona PWA	3/31/2009	0.040	0.030	5	5
OK0028339	Ramona PWA	2/28/2009	0.030	0.030	7	7
OK0028339	Ramona PWA	1/31/2009	0.040	0.020	5	5
OK0028339	Ramona PWA	12/31/2008	0.030	0.015	6	6

NPDES	Name of Facility	Time	Max Flow (mgd)	Ave Flow (mgd)	Max TSS (mg/L)	Ave TSS (mg/L)
OK0028339	Ramona PWA	11/30/2008	0.040	0.025	90	90
OK0028339	Ramona PWA	10/31/2008	0.040	0.025	59	59
OK0028339	Ramona PWA	9/30/2008	NODI	NODI	NODI	NODI
OK0028339	Ramona PWA	8/31/2008	NODI	NODI	NODI	NODI
OK0028339	Ramona PWA	7/31/2008	0.120	0.036	6	6
OK0028339	Ramona PWA	6/30/2008	0.050	0.045	5	5
OK0028339	Ramona PWA	5/31/2008	0.050	0.040	63	63
OK0028339	Ramona PWA	4/30/2008	0.226	0.183	17	17
OK0028339	Ramona PWA	3/31/2008	0.103	0.062	6	6
OK0028339	Ramona PWA	2/29/2008	0.030	0.030	19	19
OK0028339	Ramona PWA	1/31/2008	0.040	0.033	31	31
OK0028339	Ramona PWA	12/31/2007	0.080	0.048	44	44
OK0028339	Ramona PWA	11/30/2007	0.040	0.035	58	58
OK0028339	Ramona PWA	10/31/2007	0.030	0.030	79	79
OK0028339	Ramona PWA	9/30/2007	NDR	NDR	NDR	NDR
OK0028339	Ramona PWA	8/31/2007	0.040	0.038	17	17
OK0028339	Ramona PWA	7/31/2007	0.120	0.056	32	32
OK0028339	Ramona PWA	6/30/2007	0.040	0.021	27	27
OK0028339	Ramona PWA	5/31/2007	0.030	0.023	38	38
OK0028339	Ramona PWA	4/30/2007	0.030	0.017	55	55
OK0028339	Ramona PWA	3/31/2007	0.030	0.015	65	65
OK0028339	Ramona PWA	2/28/2007	0.030	0.019	42	42
OK0028339	Ramona PWA	1/31/2007	0.030	0.020	25	25

NODI= No discharge; NDR = No Data Received

ODEQ Summary of Available Reports of Sanitary Sewer Overflows

Facility Name	Date	Facility ID	Location	Amount (gal)	Cause	Type of Source
OCHELATA	11/13/2008	S21410		500,000	RAIN	
OCHELATA	11/6/2008	S21410	BEHIND LAGOON	288,000	RAIN	
OCHELATA	11/3/2008	S21410	S. SIDE OF LAGOON	20,000	KEEP DYKES FROM OVERFLOW	
OCHELATA	10/1/2008	S21410	E. SIDE OF S.E. LAGOON		OVERFLOW	
OCHELATA	6/6/2008	S21410	PLANT		NOT SURE	MANHOLE
OCHELATA	3/30/2008	S21410	S.E. LAGOON		RAIN	LAGOON/BASIN
OCHELATA	5/4/2004	S21410	S.E. LAGOON		RAIN	
OCHELATA	3/2/2004	S21410	S.E. LAGOON		OVERFLOW - RAIN	
OCHELATA	1/28/2004	S21410	S.E. LAGOON S. BANK		RAIN	LAGOON/BASIN
OCHELATA	6/26/2000	S21410	PLANT N. OF SOUTH CELL	240,000	RAIN	
OCHELATA	7/8/1999	S21410	N. OF S. CELL		RAIN	
OCHELATA	1/6/1998	S21410	EAST END OF #3 CELL	500,000	LARGE ANOUNTS OF RAIN	
RAMONA	11/28/2009	S21407	CLARK ALLEY	2	POWER FAILURE	LIFT STATION
RAMONA	11/25/2009	S21407	CLARK ALLEY		POWER FAILURE	LIFT STATION
RAMONA	11/12/2009	S21407	SHAWNEE & 7TH	2,200	L.S. DOWN	LIFT STATION
RAMONA	11/1/2009	S21407	VETERANS & RAMONA AVE.	11,000	BROKEN MAIN	PIPE
RAMONA	10/29/2009	S21407	3RD & SHAWNEE	700	RAIN	MANHOLE
RAMONA	10/29/2009	S21407	4TH & 5TH @ CHEROKEE & DELAWARE	750	RAIN	
RAMONA	8/25/2009	S21407	W 3960 & N3010	1,000	PUMP FAILURE	LIFT STATION
RAMONA	7/30/2009	S21407	PLANT		RAIN	LIFT STATION
RAMONA	6/16/2009	S21407	CLARK ALLEY	600	RAIN	LIFT STATION
RAMONA	6/11/2009	S21407	CLARK ALLEY	1,800	RAIN	LIFT STATION
RAMONA	5/1/2009	S21407	CLARK ALLEY	80,000	RAIN	LIFT STATION
RAMONA	4/16/2009	S21407	RD 3960 & 3010	7,000	MOTOR SHUT DOWN	LIFT STATION
RAMONA	4/8/2009	S21407	ROAD 2900 & 3960 - STONE RIDGE TRAILER PARK	2,000	L.S. PUMP DOWN	LIFT STATION
RAMONA	3/31/2009	S21407	OFF HWY 75 ON WYANDOTTE	100	PUMP FAILURE	LIFT STATION

Facility Name	Date	Facility ID	Location	Amount (gal)	Cause	Type of Source
RAMONA	1/8/2009	S21407	MOUND VIEW TP		PUMP FAILURE	LAGOON/BASIN
RAMONA	1/6/2009	S21407	WWTP	100	FROZEN	LAGOON/BASIN
RAMONA	12/9/2008	S21407	LIFT STATION @ 2900 & 3000 ON 3964	700	POWER FAILURE	LIFT STATION
RAMONA	11/13/2008	S21407	RD. N.S. 3968 & W. 3010	30	ROOTS	PIPE
RAMONA	8/11/2008	S21407	CLARK ALLEY	1,800	RAIN	LIFT STATION
RAMONA	6/9/2008	S21407	CLARK ALLEY & MAPLE	10,000	RAIN	MANHOLE
RAMONA	4/21/2008	S21407	3960 & 3010 RD	25,000	UNKNOWN	LIFT STATION
RAMONA	3/31/2008	S21407	CLARK ALLEY L.S.	10,000	RAIN	MANHOLE
RAMONA	12/11/2007	S21407	PLANT		POWER OUTAGE	
RAMONA	5/8/2007	S21407	US 75 & WYANDOTTE	25,000	ROOTS & RAIN	PIPE
RAMONA	5/7/2007	S21407	281 KEELER		ROOTS & RAIN	
RAMONA	5/7/2007	S21407	1 BLK S. OF WYANDOTTE & KEELER	25,000	FLOODING	MANHOLE
RAMONA	5/7/2007	S21407	MAPLE & CLARK ALLEY	75,000	GROUND WATER IN SEWER	MANHOLE
RAMONA	4/26/2007	S21407	WYANDOTTE RD. 1/4 MILE EAST OF HWY 75	500	FLOODING BUILDINGS	LIFT STATION
RAMONA	6/16/2005	S21407	E. END OF MAPLE ST.	35,000	POWER OUTAGE	MANHOLE
RAMONA	1/29/1997	S21407	WYANDOTTE - IN ALLEY BEHIND GENE KINNEY & FAY BENNETT	100	LEAK IN SEWER	
RAMONA	6/5/1995	S21407	EAST LIFT STATION	1,000	POWER FAILURE	
RAMONA	5/19/1995	S21407	EAST LIFT STATION	100,000	POWER LINE DOWN	
RAMONA	5/7/1995	S21407	EASTSIDE LIFT STATION	1,000,000	PLASTIC JUG	
RAMONA	5/7/1995	S21407	WYANDOTTE & HIWAY 75N		HYDROLIC OVERLOAD	
RAMONA	7/21/1994	S21407	LIFT SATATIO ON EASTSIDE		RAINSTORM	
RAMONA	5/18/1993	S21407	LAGOON	150,000	HEAVY RAINS	
RAMONA	5/8/1993	S21407	LIFT STATION	2,250	HEAVY RAIN - LIFT STATION WENT DOWN NOT PUMPING	
RAMONA	5/28/1990	S21407	LAGOON	532,000	SOMEONE REMOVED A WEIR OUT OF THE LAGOON	

APPENDIX C
ESTIMATED FLOW EXCEEDANCE PERCENTILES

Appendix C

Estimated Flow exceedance frequencies

	Caney River	Big Cabin Creek***	Hogshooter Creek	Curl Creek	Mission Creek	Little Caney River	Rabb Creek
WBID Segment	OK121400010010_10	OK121600060060_00	OK121400010300_00	OK121400010270_00	OK121400020190_00	OK121400020140_00	OK121400010090_00
USGS Gage Reference	7175500	7191000	7191000	7191000	7191000	7191000	7191000
Drainage Area (sq. mile)	319.66	466.80	44.45	48.09	41.92	26.09	9.00
NRCS Curve Number	70.11	70.33	70.90	69.85	67.2	71.07	69.08
Average Annual Rainfall (inch)	40.66	44.07	40.77	41.02	38.15	39.71	41.58
Flow Exceedance Frequency	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
0	71700.0	46300.0	4078.4	4440.8	3599.9	1998.39	842.3
1	11193.0	6942.3	611.5	665.9	539.8	1028.89	126.3
2	8700.0	4199.2	369.9	402.8	326.5	763.41	76.4
3	7567.9	2770.0	244.0	265.7	215.4	574.80	50.4
4	6810.0	2010.0	177.1	192.8	156.3	474.07	36.6
5	6266.5	1490.0	131.2	142.9	115.9	392.79	27.1
6	5820.0	1100.0	96.9	105.5	85.5	319.93	20.0
7	5390.0	872.0	76.8	83.6	67.8	273.35	15.9
8	5020.0	718.0	63.2	68.9	55.8	242.77	13.1
9	4663.7	600.1	52.9	57.6	46.7	223.60	10.9
10	4330.0	513.0	45.2	49.2	39.9	199.22	9.3
11	4000.0	445.0	39.2	42.7	34.6	186.71	8.1
12	3720.0	393.0	34.6	37.7	30.6	175.52	7.1
13	3460.0	351.0	30.9	33.7	27.3	165.29	6.4
14	3190.0	317.0	27.9	30.4	24.6	156.19	5.8
15	2950.0	286.0	25.2	27.4	22.2	146.91	5.2
16	2700.0	261.0	23.0	25.0	20.3	138.59	4.7
17	2470.0	237.0	20.9	22.7	18.4	130.69	4.3
18	2250.0	220.0	19.4	21.1	17.1	125.80	4.0
19	2060.0	203.0	17.9	19.5	15.8	120.32	3.7

	Caney River	Big Cabin Creek***	Hogshooter Creek	Curl Creek	Mission Creek	Little Caney River	Rabb Creek
WBID Segment	OK121400010010_10	OK121600060060_00	OK121400010300_00	OK121400010270_00	OK121400020190_00	OK121400020140_00	OK121400010090_00
USGS Gage Reference	7175500	7191000	7191000	7191000	7191000	7191000	7191000
Drainage Area (sq. mile)	319.66	466.80	44.45	48.09	41.92	26.09	9.00
NRCS Curve Number	70.11	70.33	70.90	69.85	67.2	71.07	69.08
Average Annual Rainfall (inch)	40.66	44.07	40.77	41.02	38.15	39.71	41.58
Flow Exceedance Frequency	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
20	1890.0	190.0	16.7	18.2	14.8	115.99	3.5
21	1720.0	177.0	15.6	17.0	13.8	111.17	3.2
22	1550.0	165.0	14.5	15.8	12.8	108.11	3.0
23	1410.0	155.0	13.7	14.9	12.1	103.86	2.8
24	1300.0	145.0	12.8	13.9	11.3	100.24	2.6
25	1160.0	136.0	12.0	13.0	10.6	97.47	2.5
26	1050.0	129.0	11.4	12.4	10.0	94.02	2.3
27	947.0	122.0	10.7	11.7	9.5	91.45	2.2
28	859.0	114.0	10.0	10.9	8.9	87.50	2.1
29	783.0	108.0	9.5	10.4	8.4	84.62	2.0
30	718.0	102.0	9.0	9.8	7.9	81.09	1.9
31	653.0	96.0	8.5	9.2	7.5	78.71	1.7
32	598.0	92.0	8.1	8.8	7.2	75.79	1.7
33	548.7	87.0	7.7	8.3	6.8	73.29	1.6
34	510.6	82.0	7.2	7.9	6.4	71.25	1.5
35	471.0	78.0	6.9	7.5	6.1	69.16	1.4
36	436.0	74.0	6.5	7.1	5.8	66.49	1.3
37	404.0	70.0	6.2	6.7	5.4	64.86	1.3
38	374.0	66.0	5.8	6.3	5.1	63.19	1.2
39	345.0	62.0	5.5	5.9	4.8	61.49	1.1
40	318.0	59.0	5.2	5.7	4.6	59.75	1.1
41	290.1	56.0	4.9	5.4	4.4	57.98	1.0
42	271.0	53.0	4.7	5.1	4.1	56.78	1.0

	Caney River	Big Cabin Creek***	Hogshooter Creek	Curl Creek	Mission Creek	Little Caney River	Rabb Creek
WBID Segment	OK121400010010_10	OK121600060060_00	OK121400010300_00	OK121400010270_00	OK121400020190_00	OK121400020140_00	OK121400010090_00
USGS Gage Reference	7175500	7191000	7191000	7191000	7191000	7191000	7191000
Drainage Area (sq. mile)	319.66	466.80	44.45	48.09	41.92	26.09	9.00
NRCS Curve Number	70.11	70.33	70.90	69.85	67.2	71.07	69.08
Average Annual Rainfall (inch)	40.66	44.07	40.77	41.02	38.15	39.71	41.58
Flow Exceedance Frequency	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
43	250.0	50.0	4.4	4.8	3.9	55.56	0.9
44	231.0	48.0	4.2	4.6	3.7	54.32	0.9
45	214.0	45.0	4.0	4.3	3.5	53.07	0.8
46	199.0	43.0	3.8	4.1	3.3	51.14	0.8
47	184.0	40.0	3.5	3.8	3.1	49.97	0.7
48	170.6	38.0	3.3	3.6	3.0	48.48	0.7
49	158.0	35.0	3.1	3.4	2.7	46.42	0.6
50	147.0	34.0	3.0	3.3	2.6	44.29	0.6
51	136.0	31.0	2.7	3.0	2.4	42.53	0.6
52	128.0	29.0	2.6	2.8	2.3	40.57	0.5
53	120.3	27.0	2.4	2.6	2.1	38.22	0.5
54	114.0	25.0	2.2	2.4	1.9	37.42	0.5
55	108.0	23.0	2.0	2.2	1.8	35.77	0.4
56	102.0	22.0	1.9	2.1	1.7	34.06	0.4
57	97.0	20.0	1.8	1.9	1.6	33.18	0.4
58	91.0	19.0	1.7	1.8	1.5	31.38	0.3
59	86.0	18.0	1.6	1.7	1.4	29.50	0.3
60	81.0	16.0	1.4	1.5	1.2	29.50	0.3
61	77.0	15.0	1.3	1.4	1.2	27.53	0.3
62	72.0	14.0	1.2	1.3	1.1	26.51	0.3
63	69.0	13.0	1.1	1.2	1.0	25.46	0.2
64	65.0	12.0	1.1	1.2	0.9	24.38	0.2
65	62.0	11.0	1.0	1.1	0.9	23.26	0.2

	Caney River	Big Cabin Creek***	Hogshooter Creek	Curl Creek	Mission Creek	Little Caney River	Rabb Creek
WBID Segment	OK121400010010_10	OK121600060060_00	OK121400010300_00	OK121400010270_00	OK121400020190_00	OK121400020140_00	OK121400010090_00
USGS Gage Reference	7175500	7191000	7191000	7191000	7191000	7191000	7191000
Drainage Area (sq. mile)	319.66	466.80	44.45	48.09	41.92	26.09	9.00
NRCS Curve Number	70.11	70.33	70.90	69.85	67.2	71.07	69.08
Average Annual Rainfall (inch)	40.66	44.07	40.77	41.02	38.15	39.71	41.58
Flow Exceedance Frequency	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
66	59.0	10.0	0.9	1.0	0.8	22.10	0.2
67	57.0	9.5	0.8	0.9	0.7	22.10	0.2
68	54.0	8.7	0.8	0.8	0.7	20.53	0.2
69	52.0	8.0	0.7	0.8	0.6	19.78	0.1
70	50.0	7.3	0.6	0.7	0.6	18.87	0.1
71	48.0	6.8	0.6	0.7	0.5	18.34	0.1
72	46.0	6.2	0.5	0.6	0.5	17.38	0.1
73	45.0	5.7	0.5	0.5	0.4	16.67	0.1
74	43.0	5.1	0.4	0.5	0.4	15.94	0.1
75	41.0	4.7	0.4	0.5	0.4	15.19	0.1
76	39.0	4.2	0.4	0.4	0.3	14.41	0.1
77	37.0	3.9	0.3	0.4	0.3	13.59	0.1
78	36.0	3.6	0.3	0.3	0.3	12.74	0.1
79	34.0	3.4	0.3	0.3	0.3	11.87	0.1
80	32.0	3.1	0.3	0.3	0.2	11.30	0.1
81	30.0	2.9	0.3	0.3	0.2	10.52	0.1
82	29.0	2.7	0.2	0.3	0.2	10.12	0.0
83	27.0	2.5	0.2	0.2	0.2	9.49	0.0
84	26.0	2.4	0.2	0.2	0.2	9.05	0.0
85	24.0	2.2	0.2	0.2	0.2	8.60	0.0
86	23.0	2.1	0.2	0.2	0.2	8.14	0.0
87	22.0	1.9	0.2	0.2	0.1	7.90	0.0
88	20.0	1.8	0.2	0.2	0.1	7.40	0.0

	Caney River	Big Cabin Creek***	Hogshooter Creek	Curl Creek	Mission Creek	Little Caney River	Rabb Creek
WBID Segment	OK121400010010_10	OK121600060060_00	OK121400010300_00	OK121400010270_00	OK121400020190_00	OK121400020140_00	OK121400010090_00
USGS Gage Reference	7175500	7191000	7191000	7191000	7191000	7191000	7191000
Drainage Area (sq. mile)	319.66	466.80	44.45	48.09	41.92	26.09	9.00
NRCS Curve Number	70.11	70.33	70.90	69.85	67.2	71.07	69.08
Average Annual Rainfall (inch)	40.66	44.07	40.77	41.02	38.15	39.71	41.58
Flow Exceedance Frequency	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
89	19.0	1.7	0.1	0.2	0.1	7.14	0.0
90	17.0	1.6	0.1	0.2	0.1	6.87	0.0
91	16.0	1.5	0.1	0.1	0.1	6.60	0.0
92	15.0	1.4	0.1	0.1	0.1	6.32	0.0
93	14.0	1.3	0.1	0.1	0.1	6.03	0.0
94	12.0	1.2	0.1	0.1	0.1	6.03	0.0
95	11.0	1.1	0.1	0.1	0.1	5.73	0.0
96	10.0	1.0	0.1	0.1	0.1	5.42	0.0
97	8.4	0.8	0.1	0.1	0.1	5.29	0.0
98	6.3	0.7	0.1	0.1	0.1	4.93	0.0
99	4.3	0.5	0.0	0.0	0.0	4.47	0.0
100	0.0	0.1	0.0	0.0	0.0	2.17	0.0

*** flows from Hogshooter ,Curl, Mission and Rabb Creeks were estimated from this USGS reference gage † incremental watershed area below other gages

Appendix C
General Methodology for Estimating Stream Flow

Flows duration curve will be developed using existing USGS measured flow where the data exist from a gage on the stream segment of interest, or by estimating flow for stream segments with no corresponding flow record. Flow data to support flow duration curves and load duration curves will be derived for each Oklahoma stream segment in the following priority:

i) In cases where a USGS flow gage occurs on, or within one-half mile upstream or downstream of the Oklahoma stream segment.

a. If simultaneously-collected flow data matching the water quality sample collection date are available, these flow measurements will be used.

b. If flow measurements at the coincident gage are missing for some dates on which water quality samples were collected, the gaps in the flow record will be filled, or the record will be extended, by estimating flow based on measured streamflows at a nearby gage. First, the most appropriate nearby stream gage is identified. All flow data are first log-transformed to linearize the data because flow data are highly skewed. Linear regressions are then developed between 1) daily streamflow at the gage to be filled/extended, and 2) streamflow at all gages within 95 miles that have at least 300 daily flow measurements on matching dates. The station with the best flow relationship, as indicated by the highest r-squared value, is selected as the index gage. R-squared indicates the fraction of the variance in flow explained by the regression. The regression is then used to estimate flow at the gage to be filled/extended from flow at the index station. Flows will not be estimated based on regressions with r-squared values less than 0.25, even if that is the best regression. In some cases, it will be necessary to fill/extend flow records from two or more index gages. The flow record will be filled/extended to the extent possible based on the best index gage (highest r-squared value), and remaining gaps will be filled from the next best index gage (second highest r-squared value), and so forth.

c. Flow duration curves will be based on measured flows only, not on the filled or extended flow time series calculated from other gages using regression.

d. On a stream impounded by dams to form reservoirs of sufficient size to impact stream flow, only flows measured after the date of the most recent impoundment will be used to develop the flow duration curve. This also applies to reservoirs on major tributaries to the stream.

ii) In the case no coincident flow data are available for a stream segment, but flow gage(s) are present upstream and/or downstream without a major reservoir between, flows will be estimated for the stream segment from an upstream or downstream gage using a watershed area ratio method derived by delineating subwatersheds, and relying on the National Resources Conservation Service (NRCS) runoff curve numbers and antecedent rainfall condition. Drainage subbasins will first be delineated for all impaired 303(d)-listed stream segments, along with all USGS flow stations located in the 8-digit HUCs with impaired streams. Then all the USGS gage stations upstream and downstream of the subwatersheds with 303(d) listed stream segments will be identified.

a. Watershed delineations are performed using ESRI Arc Hydro with a 30 m resolution National Elevation Dataset (NED) digital elevation model, and National Hydrography Dataset (NHD) streams. The area of each watershed will be calculated following watershed delineation.

b. The watershed average curve number is calculated from soil properties and land cover as described in the U.S. Department of Agriculture (USDA) Publication *TR-55: Urban Hydrology for Small Watersheds*. The soil hydrologic group is extracted from NRCS STATSGO soil data, and land use category from the 2001 National Land Cover Dataset (NLCD). Based on land use and the hydrologic soil group, SCS curve numbers are estimated at the 30-meter resolution of the NLCD grid as shown in Table 7. The average curve number is then calculated from all the grid cells within the delineated watershed.

c. The average rainfall is calculated for each watershed from gridded average annual precipitation datasets for the period 1971-2000 (Spatial Climate Analysis Service, Oregon State University, http://www.ocs.oregonstate.edu/prism/, created 20 Feb 2004).

Table C-1 Runoff Curve Numbers for Various Land Use Categories and Hydrologic Soil Groups

NLCD Land Use Category	Curve number for hydrologic soil group			
	A	B	C	D
0 in case of zero	100	100	100	100
11 Open Water	100	100	100	100
12 Perennial Ice/Snow	100	100	100	100
21 Developed, Open Space	39	61	74	80
22 Developed, Low Intensity	57	72	81	86
23 Developed, Medium Intensity	77	85	90	92
24 Developed, High Intensity	89	92	94	95
31 Barren Land (Rock/Sand/Clay)	77	86	91	94
32 Unconsolidated Shore	77	86	91	94
41 Deciduous Forest	37	48	57	63
42 Evergreen Forest	45	58	73	80
43 Mixed Forest	43	65	76	82
51 Dwarf Scrub	40	51	63	70
52 Shrub/Scrub	40	51	63	70
71 Grasslands/Herbaceous	40	51	63	70
72 Sedge/Herbaceous	40	51	63	70
73 Lichens	40	51	63	70
74 Moss	40	51	63	70
81 Pasture/Hay	35	56	70	77
82 Cultivated Crops	64	75	82	85
90-99 Wetlands	100	100	100	100

d. Flow at the ungaged site is calculated from the gaged site. The NRCS runoff curve number equation is:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \quad (1)$$

where:

Q = runoff (inches)

P = rainfall (inches)

S = potential maximum retention after runoff begins (inches)

I_a = initial abstraction (inches)

If P < 0.2, Q = 0. Initial abstraction has been found to be empirically related to S by the equation

$$I_a = 0.2 * S \quad (2)$$

Thus, the runoff curve number equation can be rewritten:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \quad (3)$$

S is related to the curve number (CN) by:

$$S = \frac{1000}{CN} - 10 \quad (4)$$

e. First, S is calculated from the average curve number for the gaged watershed. Next, the daily historic flows at the gage are converted to depth basis (as used in equations 1 and 3) by dividing by its drainage area, then converted to inches. Equation 3 is then solved for daily precipitation depth of the gaged site, P_{gaged}. The daily precipitation depth for the ungaged site is then calculated as the precipitation depth of the gaged site multiplied by the ratio of the long-term average precipitation in the watersheds of the ungaged and gaged sites:

$$P_{ungaged} = P_{gaged} \left(\frac{M_{ungaged}}{M_{gaged}} \right) \quad (5)$$

where M is the mean annual precipitation of the watershed in inches. The daily precipitation depth for the ungaged watershed, along with the average curve number of the ungaged watershed, are then used to calculate the depth equivalent daily flow Q of the ungaged site. Finally, the volumetric flow rate at the ungaged site is calculated by multiplying by the area of the watershed of the ungaged site and converted to cubic ft.

f. If any flow measurements are available on the stream segment of interest, the projected flows will be compared to the measured flows on each date. If there is poor agreement, projections will be repeated with a simpler approach, using only the watershed area ratio and the gaged site (thereby eliminating the influence of differences in curve number and precipitation between the gaged and ungaged stream watersheds). If this simpler approach provides better agreement with existing data, the projected flows based on the simpler approach will be used.

iii) In the rare case where no coincident flow data are available for a stream segment and no gages are present upstream or downstream, flows will be estimated for the stream segment from a gage on an adjacent watershed of similar size and properties, via the same procedure described above for upstream or downstream gages.

APPENDIX D
STATE OF OKLAHOMA ANTIDEGRADATION POLICY

Appendix D
State of Oklahoma Antidegradation Policy

785:45-3-1. Purpose; Antidegradation policy statement

(a) Waters of the state constitute a valuable resource and shall be protected, maintained and improved for the benefit of all the citizens.

(b) It is the policy of the State of Oklahoma to protect all waters of the state from degradation of water quality, as provided in OAC 785:45-3-2 and Subchapter 13 of OAC 785:46.

785:45-3-2. Applications of antidegradation policy

(a) Application to outstanding resource waters (ORW). Certain waters of the state constitute an outstanding resource or have exceptional recreational and/or ecological significance. These waters include streams designated "Scenic River" or "ORW" in Appendix A of this Chapter, and waters of the State located within watersheds of Scenic Rivers. Additionally, these may include waters located within National and State parks, forests, wilderness areas, wildlife management areas, and wildlife refuges, and waters which contain species listed pursuant to the federal Endangered Species Act as described in 785:45-5-25(c)(2)(A) and 785:46-13-6(c). No degradation of water quality shall be allowed in these waters.

(b) Application to high quality waters (HQW). It is recognized that certain waters of the state possess existing water quality which exceeds those levels necessary to support propagation of fishes, shellfishes, wildlife, and recreation in and on the water. These high quality waters shall be maintained and protected.

(c) Application to beneficial uses. No water quality degradation which will interfere with the attainment or maintenance of an existing or designated beneficial use shall be allowed.

(d) Application to improved waters. As the quality of any waters of the state improve, no degradation of such improved waters shall be allowed.

785:46-13-1. Applicability and scope

(a) The rules in this Subchapter provide a framework for implementing the antidegradation policy stated in OAC 785:45-3-2 for all waters of the state. This policy and framework includes three tiers, or levels, of protection.

(b) The three tiers of protection are as follows:

(1) Tier 1. Attainment or maintenance of an existing or designated beneficial use.

(2) Tier 2. Maintenance or protection of High Quality Waters and Sensitive Public and Private Water Supply waters.

(3) Tier 3. No degradation of water quality allowed in Outstanding Resource Waters.

(c) In addition to the three tiers of protection, this Subchapter provides rules to implement the protection of waters in areas listed in Appendix B of OAC 785:45. Although Appendix B areas are not mentioned in OAC 785:45-3-2, the framework for protection of Appendix B areas is similar to the implementation framework for the antidegradation policy.

(d) In circumstances where more than one beneficial use limitation exists for a waterbody, the most protective limitation shall apply. For example, all antidegradation policy implementation rules applicable to Tier 1 waterbodies shall be applicable also to Tier 2 and Tier 3 waterbodies or areas, and implementation rules applicable to Tier 2 waterbodies shall be applicable also to Tier 3 waterbodies.

(e) Publicly owned treatment works may use design flow, mass loadings or concentration, as appropriate, to calculate compliance with the increased loading requirements of this section if those flows, loadings or concentrations were approved by the Oklahoma Department of Environmental Quality as a portion of Oklahoma's Water Quality Management Plan prior to the application of the ORW, HQW or SWS limitation.

785:46-13-2. Definitions

The following words and terms, when used in this Subchapter, shall have the following meaning, unless the context clearly indicates otherwise:

"Specified pollutants" means

(A) Oxygen demanding substances, measured as Carbonaceous Biochemical Oxygen Demand (CBOD) and/or Biochemical Oxygen Demand (BOD);

(B) Ammonia Nitrogen and/or Total Organic Nitrogen;

(C) Phosphorus;

(D) Total Suspended Solids (TSS); and

(E) Such other substances as may be determined by the Oklahoma Water Resources Board or the permitting authority.

785:46-13-3. Tier 1 protection; attainment or maintenance of an existing or designated beneficial use

(a) General.

(1) Beneficial uses which are existing or designated shall be maintained and protected.

(2) The process of issuing permits for discharges to waters of the state is one of several means employed by governmental agencies and affected persons which are designed to attain or maintain beneficial uses which have been designated for those waters. For example, Subchapters 3, 5, 7, 9 and 11 of this Chapter are rules for the permitting process. As such, the latter Subchapters not only implement numerical and narrative criteria, but also implement Tier 1 of the antidegradation policy.

(b) Thermal pollution. Thermal pollution shall be prohibited in all waters of the state. Temperatures greater than 52 degrees Centigrade shall constitute thermal pollution and shall be prohibited in all waters of the state.

(c) Prohibition against degradation of improved waters. As the quality of any waters of the state improves, no degradation of such improved waters shall be allowed.

785:46-13-4. Tier 2 protection; maintenance and protection of High Quality Waters and Sensitive Water Supplies

(a) General rules for High Quality Waters. New point source discharges of any pollutant after June 11, 1989, and increased load or concentration of any specified pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of OAC 785:45 with the limitation "HQW". Any discharge of any pollutant to a waterbody designated "HQW" which would, if it occurred, lower existing water quality shall be prohibited. Provided however, new point source discharges or increased load or concentration of any specified pollutant from a discharge existing as of June 11, 1989, may be approved by the permitting authority in circumstances where the discharger demonstrates to the satisfaction of the permitting authority that such new discharge or increased load or concentration would result in maintaining or improving the level of water quality which exceeds that necessary to support recreation and propagation of fishes, shellfishes, and wildlife in the receiving water.

(b) General rules for Sensitive Public and Private Water Supplies. New point source discharges of any pollutant after June 11, 1989, and increased load of any specified pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of OAC 785:45 with the limitation "SWS". Any discharge of any pollutant to a waterbody designated "SWS" which would, if it occurred, lower existing water quality shall be prohibited. Provided however, new point source discharges or increased load of any specified pollutant from a discharge existing as of June 11, 1989, may be approved by the permitting authority in circumstances where the discharger demonstrates to the satisfaction of the permitting authority that such new discharge or increased load will result in maintaining or improving the water quality in both the direct receiving water, if designated SWS, and any downstream waterbodies designated SWS.

(c) Stormwater discharges. Regardless of subsections (a) and (b) of this Section, point source discharges of stormwater to waterbodies and watersheds designated "HQW" and "SWS" may be approved by the permitting authority.

(d) Nonpoint source discharges or runoff. Best management practices for control of nonpoint source discharges or runoff should be implemented in watersheds of waterbodies designated "HQW" or "SWS" in Appendix A of OAC 785:45.

785:46-13-5. Tier 3 protection; prohibition against degradation of water quality in outstanding resource waters

(a) General. New point source discharges of any pollutant after June 11, 1989, and increased load of any pollutant from any point source discharge existing as of June 11, 1989, shall be prohibited in any waterbody or watershed designated in Appendix A of OAC 785:45 with the limitation "ORW" and/or "Scenic River", and in any waterbody located within the watershed of any waterbody designated with the limitation "Scenic River". Any discharge of any pollutant to a waterbody designated "ORW" or "Scenic River" which would, if it occurred, lower existing water quality shall be prohibited.

(b) Stormwater discharges. Regardless of 785:46-13-5(a), point source discharges of stormwater from temporary construction activities to waterbodies and watersheds designated "ORW" and/or "Scenic River" may be permitted by the permitting authority. Regardless of 785:46-13-5(a), discharges of stormwater to waterbodies and watersheds designated "ORW" and/or "Scenic River" from point sources existing as of June 25, 1992, whether or not such stormwater discharges were permitted as point sources prior to June 25, 1992, may be permitted by the permitting authority; provided, however, increased load of any pollutant from such stormwater discharge shall be prohibited.

(c) Nonpoint source discharges or runoff. Best management practices for control of nonpoint source discharges or runoff should be implemented in watersheds of waterbodies designated "ORW" in Appendix A of OAC 785:45, provided, however, that development of conservation plans shall be required in sub-watersheds where discharges or runoff from nonpoint sources are identified as causing or significantly contributing to degradation in a waterbody designated "ORW".

(d) LMFO's. No licensed managed feeding operation (LMFO) established after June 10, 1998 which applies for a new or expanding license from the State Department of Agriculture after March 9, 1998 shall be located...[w]ithin three (3) miles of any designated scenic river area as specified by the Scenic Rivers Act in 82 O.S. Section 1451 and following, or [w]ithin one (1) mile of a waterbody [2:9-210.3(D)] designated in Appendix A of OAC 785:45 as "ORW".

785:46-13-6. Protection for Appendix B areas

(a) General. Appendix B of OAC 785:45 identifies areas in Oklahoma with waters of recreational and/or ecological significance. These areas are divided into Table 1, which includes national and state parks, national forests, wildlife areas, wildlife management areas and wildlife refuges; and Table 2, which includes areas which contain threatened or endangered species listed as such by the federal government pursuant to the federal Endangered Species Act as amended.

(b) Protection for Table 1 areas. New discharges of pollutants after June 11, 1989, or increased loading of pollutants from discharges existing as of June 11, 1989, to waters within the boundaries of areas listed in Table 1 of Appendix B of OAC 785:45 may be approved by the permitting authority under such conditions as ensure that the recreational and ecological significance of these waters will be maintained.

(c) Protection for Table 2 areas. Discharges or other activities associated with those waters within the boundaries listed in Table 2 of Appendix B of OAC 785:45 may be restricted through agreements between appropriate regulatory agencies and the United States Fish and Wildlife Service. Discharges or other activities in such areas shall not substantially disrupt the threatened or endangered species inhabiting the receiving water.

(d) Nonpoint source discharges or runoff. Best management practices for control of nonpoint source discharges or runoff should be implemented in watersheds located within areas listed in Appendix B of OAC 785:45.

APPENDIX E

RESPONSE TO COMMENTS

Comments from Oklahoma Farm Bureau were received on September 7, 2010:

Comment #1: We appreciate the opportunity to provide comments on these FINAL TMDLs. As we have on their FINAL TMDLs, we continue to comment that sewer overflows and bypasses should be included into the point source allocation as a contributor to bacteria impairment.

Response #1: *Sewer overflows and bypasses are not permitted and therefore cannot be added to the point source allocations. All SSOs are considered unpermitted discharges under State statute and DEQ regulations and will be dealt through enforcement actions as described in the last paragraph of Section 3.1.2. No changes were made.*

Comment #2: With regard to these bacteria TMDLs, we concur three approaches to revising the pathogen provisions of Oklahoma's water quality standards -- removing the primary body contact recreation use, modifying application of the existing criteria, and revising the existing numeric criteria – should be considered.

Response #2*: Thank you for the comments*.