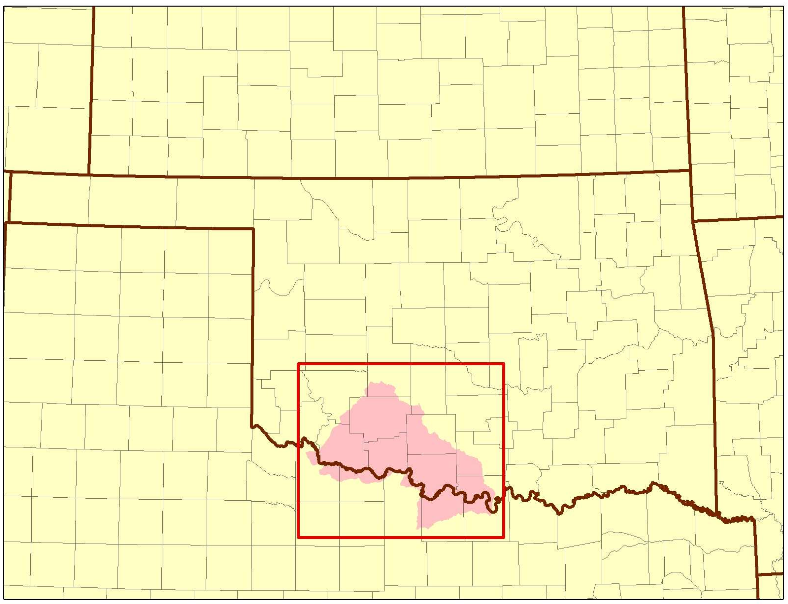
FINAL

BACTERIA TOTAL MAXIMUM DAILY LOADS FOR THE LOWER RED RIVER AREA, OKLAHOMA (OK311100, OK311200, OK 311210, OK311300, OK311310)



Prepared for:

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

Prepared by:

PARSONS

SEPTEMBER 17, 2007

DRAFT

BACTERIA TOTAL MAXIMUM DAILY LOADS FOR THE LOWER RED RIVER AREA, OKLAHOMA (OK311100, OK311200, OK 311210, OK311300, OK311310)

OKWBID

OK311100040010, OK311100040080, OK311200000060, OK311210000140, OK311210000150, OK311300010020, OK311300030070, OK311310010010, OK311310020010, OK311310030050

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SEPTEMBER 17, 2007

Oklahoma Department of Environmental Quality: FY07 106 Grant (CA# I-006400-05) Project 24 – Bacteria TMDL Development

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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
LA	Load allocation
LDC	Load duration curve
mg	Million gallons
mgd	Million gallons per day
mL	Milliliter
MOS	Margin of safety
MS4	Municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
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
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

Response to Comment

<u>Comments from Oklahoma Farm Bureau</u> <u>(received on 09/17/07)</u>

On behalf of the state's largest agriculture organization, with more than 166,000 member families, thank you for the opportunity to comment on this draft TMDL. My comments will address the conclusions from the Oklahoma Department of Environmental Quality's (ODEQ) August 2, Public Notice: "The Washita and Lower Red River watershed are in violation of Oklahoma Water Quality Standards with respect to pathogens. Most of the pathogens come from nonpoint sources though it is not known which sources these are specifically from without additional study."

I do not dispute the ODEQ's conclusion that the rivers and streams are impaired for pathogens/bacteria based on Oklahoma's existing water quality standards. For at least three years I have had concerns about our pathogens/bacteria standard applying to our streams and rivers. It is my understanding that Oklahoma is applying a swimming beach standard for pathogens/bacteria to our rivers and streams. If I don't have confidence the water quality standard has the appropriate criteria, I can't have confidence in the TMDL. (It should be noted I made similar comments in September of 2006 on the Upper Canadian River and Turkey Creek watersheds TMDL.)

Last week when I was in Washinton, D.C., I visited about the pathogens/bacteria issue with Michael Shapiro, Deputy Assistant Adminitstrator, Ofice of Water, Environmental Protection Agency. I expressed concern that TMDLs were being performed needlessly, costing the taxpayers money and the agencies time and money, when there is not confidence in the pathogens/bacteria criteria. Mr. Shapiro said the EPA needed about five years of solid research to determine what the pathogens/bacteria criteria should be. He recommended unofficially that the states should put the stream and river pathogens/bacteria 303(d) listings as a low priority for TMDLs in the interim. Mr. Shapiro acknowledged that he knows Derek Simithee well, as Mr. Smithee has been serving on the national workgroup for this issue.

It seems to me to be a disservice to those residents in the Washita and Lower Red River watersheds to worry them unnecessarily about what may not really be a problem. The state should be focusing its limited resources on real problems.

I agree with Mr. Shapiro's unofficial recommendation. I believed it would be prudent for Oklahoma to place the rivers and streams pathogens bacteria TMDLs as a low priority, until such time as appropriate criteria has been developed.

Response: The Oklahoma Water Resources Board (OWRB) is the state agency in charge of setting water quality standards. This comment will be refered to the OWRB for consideration. Your previous comments regarding pathogen standards had been refered to the OWRB. Before the standards are officially revised, TMDLs must be developed based on the current Oklahoma Water Quality Standards. No changes were made to the report.

Executive Summary

This report documents the data and assessment used to establish Total Maximum Daily Loads (TMDL) for the pathogen indicator bacteria fecal coliform, *Escherichia coli (E. coli),* or Enterococci for certain waterbodies in the Lower Red River Basin. Elevated levels of pathogen indicator bacteria in aquatic environments indicate that a receiving water is contaminated with human or animal feces and that there is a potential health risk for individuals exposed to the water. Data assessment and 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 report is to establish pollutant load allocations for indicator bacteria 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. 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 processes 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 loadings 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

A decision was made to place specific waterbodies in this Study Area, listed in Table ES-1, on the ODEQ 2004 303(d) list because evidence of nonsupport of primary body contact recreation (PBCR) was observed.

Elevated levels of bacteria above the WQS for one or more of the bacterial indicators 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 bacteria loading controls needed to restore the primary body contact recreation use designated for each waterbody.

Table ES-1 Excerpt from the 2004 Integrated Report – Comprehensive Waterbody Assessment Category List

Waterbody ID	Waterbody Name	Stream Miles	Category	TMDL Date	Primary Body Contact Recreation
OK311100040010_00	Mud Creek	66.02	5	2005	N
OK311100040080_00	Lower West Mud Creek	27.73	5	2007	N
OK311200000060_00	Cow Creek	25.73	5	2004	N
OK311210000140_00	Whisky Creek	10.28	5	2007	N
OK311210000150_00	Cottonwood Creek	7.21	5	2007	N
OK311300010020_00	East Cache Creek	26	5	2005	N
OK311300030070_00	Tahoe Creek	16.79	5	2007	N
OK311310010010_00	Red River at US 183	88.02	5	2005	N
OK311310020010_00	West Cache Creek	28.27	5	2005	N
OK311310030050_00	Brush Creek	11.64	5	2007	N

N = Not Supporting; Source: 2004 Integrated Report, ODEQ 2004

For the data collected between 1999 and 2003, evidence of nonsupport of the PBCR use based on fecal coliform concentrations was observed in five waterbodies: Lower West Mud Creek (OK311100040080), Whisky Creek (OK311210000140), Cottonwood Creek (OK311210000150), Tahoe Creek (OK311300030070), and Brush Creek (OK311310030050). Evidence of nonsupport of the PBCR use based on both fecal coliform and Enterococci concentrations were observed in three waterbodies: Mud Creek (OK311100040010), East Cache Creek 9OK311300010020), and Red River at US 183 (OK311310010010). Evidence of nonsupport of the PBCR use based on Enterococci concentrations was observed in one waterbody: Cow Creek (OK311200000060). Evidence of nonsupport of the PBCR use based on all three bacterial indicators, fecal coliform, Enterococci and *E. coli* concentrations were observed in one waterbody: West Cache Creek (OK311310020010). Table ES-2 summarizes the waterbodies requiring TMDLs for not supporting PBCR.

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

WQM Station	Waterbody ID	Waterbody Name	Indicator Bacteria		
			FC	ENT	*E. coli*
OK311100040010-001AT	OK311100040010_00	Mud Creek	X	X	
OK311100040080G	OK311100040080_00	Lower West Mud Creek	X		
USGS_07313600	OK311200000060_00	Cow Creek		X	
OK311210000140D	OK311210000140_00	Whisky Creek	X		
OK311210000150G	OK311210000150_00	Cottonwood Creek	X		
OK311300010020-001AT	OK311300010020_00	East Cache Creek	X	X	
OK311300030070G	OK311300030070_00	Tahoe Creek	X		
OK311310010010-001AT	OK311310010010_00	Red River at US 183	X	X	
OK311310020010-001AT	OK311310020010_00	West Cache Creek	X	X	X
OK311310030050G	OK311310030050_00	Brush Creek	X		

ENT = enterococci; FC = fecal coliform

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 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 2006).

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 water quality monitoring (WQM) stations 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 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 more than 10 percent of 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.

E.2 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 warm-blooded animals; some plant life and sources may be point or nonpoint in nature.

There are no NPDES-permitted facilities of any type in the contributing watersheds of Mud Creek, Lower West Mud Creek, (OK311100040080_00), Cottonwood Creek (OK311210000150_00), Tahoe Creek (OK311300030070_00), West Cache Creek (OK311310020010_00), and Brush Creek (OK311310030050_00). Five of the watersheds in the Study Area, including Mud Creek (OK311100040010_00), Cow Creek (OK311200000060_00), Whisky Creek (OK311210000140_00), East Cache Creek (OK311300010020_00), and Red River at US 183 (OK311310010010_00) have NPDES-permitted facilities. There are six NPDES-permitted no-discharge facilities within the Study Area. For the purposes of these TMDLs, it is assumed that no-discharge facilities do not contribute bacteria loading to the Lower Red River and its tributaries. However, it is possible the wastewater collection systems associated with those wastewater treatment plants could be a source of bacteria loading, or that discharges may occur during large rainfall events that exceed the systems' storage capacities.

While not all sanitary sewer overflows (SSO) are reported, ODEQ has some data on SSOs available. There were 79 SSO occurrences, ranging from 0 gallon to more than 3 million gallons, reported for certain watersheds within the Study Area between February 1990 and March 2007. Given the significant number of occurrences and the size of overflows reported, bacteria from SSOs have been a significant source of bacteria loading in the Cow Creek (OK311200000060_00), East Cache Creek (OK311300010020_00), and Red River at US 183 (OK311310010010_00) watersheds.

There are two concentrated animal feeding operations (CAFO) in the Study Area, one located in Mud Creek (OK311100040010_00) and the other in Red River at US 183 (OK311310010010_00).

There are no NPDES-permitted facilities present in the Lower West Mud Creek (OK311100040080_00), Cottonwood Creek (OK311210000150_00), Tahoe Creek (OK311300030070_00), West Cache Creek (OK311310020010_00), and Brush Creek (OK311310030050_00) watersheds; therefore, nonsupport of the PBCR use is caused entirely by nonpoint sources of bacteria. In watersheds with point and nonpoint sources of bacteria, Cow Creek (OK311200000060_00), Mud Creek (OK311100040010_00), Whisky Creek (OK311210000140_00), East Cache Creek (OK311300010020_00), and Red River at US 183 (OK311310010010_00), the available data suggests that the proportion of bacteria from point sources is minor. There are no permitted MS4s within the study area.

The four major nonpoint source categories contributing to the elevated bacteria in each of the watersheds in the Study Area are livestock, pets, deer, and septic tanks. Livestock are estimated to be the largest 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.

Nonpoint source bacteria loading to the receiving streams of each waterbody emanate from a number of different sources including wildlife, various agricultural activities and domesticated animals, land application fields, urban runoff, failing onsite wastewater disposal systems, and domestic pets. The data analysis and the load duration curves (LDC) demonstrate that exceedances at the WQM stations are the result of a variety of nonpoint source loading.

E.3 Using Load Duration Curves to Develop TMDLs

The TMDL calculations presented in this report are derived from LDCs. LDCs facilitate rapid development of TMDLs and as a TMDL development tool, are effective in identifying whether impairments are associated with point or nonpoint sources.

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 treatment plant effluents would dominate the base flow of the impaired water.

The basic steps to generating an LDC involve:

- obtaining daily flow data for the site of interest from the U.S. Geological Survey ;
- sorting the flow data and calculating flow exceedance percentiles for the time period and season of interest;
- obtaining the water quality data from the primary contact recreation season (May 1 through September 30);
- matching the water quality observations with the flow data from the same date;
- display a curve on a plot that represents the allowable load multiply the actual or estimated flow by the WQS for each respective indicator;
- multiplying the flow by the water quality parameter concentration to calculate daily loads; then
- plotting the flow exceedance percentiles and daily load observations in a load duration plot.

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.

E.4 TMDL Calculations

As indicated above, the bacteria TMDLs for the 303(d)-listed WQM stations 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 uncertainty 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 (See Table ES-3). The difference between existing loading and the water quality target is used to calculate the loading reductions required. Percent reduction goals (PRG) are calculated for each WQM site and bacterial indicator species as the reductions in load required so that no more than 25 percent of the existing instantaneous fecal coliform observations and no more than 10 percent of the existing instantaneous *E. coli* or Enterococci observations would exceed the water quality target.

Table ES-3 presents the percent reductions necessary for each bacterial indicator causing nonsupport of the PBCR use in each waterbody of the Study Area. Attainment of WQS in response to TMDL implementation will be based on results measured at each of these WQM stations. Selection of the appropriate PRG for each waterbody in Table ES-3 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 more than 10 percent of samples exceed the instantaneous criteria.

Based on this table, the TMDL PRGs for West Lower Mud Creek, Whisky Creek, Cottonwood Creek, Tahoe Creek, and Brush Creek will be based on fecal coliform; the TMDL PRGs for Mud Creek, Cow Creek, East Cache Creek, Red River at US 183, and West Cache Creek will be based on Enterococcus. The PRGs range from 23 to 99 percent.

Table ES-3 TMDL Percent Reduction Goals Required to Meet Water Quality Standards for Impaired Waterbodies in the Lower Red River Study Area

Waterbody ID	WQM Station	Waterbody Name	Percent Reduction Required				
			FC	EC		ENT	
			Instant-aneous	Instant-aneous	Geo-mean	Instant-aneous	Geo-mean
OK311100040010_00	OK311100040010-001AT	Mud Creek	23%			88%	**78%**
OK311100040080_00	OK311100040080G	Lower Mud Creek, West	**55%**				
OK311200000060_00	USGS_07313600	Cow Creek				98%	**88%**
OK311210000140_00	OK311210000140D	Whisky Creek	**44%**				
OK311210000150_00	OK311210000150G	Cottonwood Creek	**79%**				
OK311300010020_00	OK311300010020-001AT	East Cache Creek	40%			98%	**94%**
OK311300030070_00	OK311300030070G	Tahoe Creek	**40%**				
OK311310010010_00	OK311310010010-001AT	Red River at US 183	82%			99%	**83%**

Waterbody ID	WQM Station	Waterbody Name	Percent Reduction Required				
			FC	EC		ENT	
			Instant-aneous	Instant-aneous	Geo-mean	Instant-aneous	Geo-mean
OK311310020010_00	OK311310020010-001AT	West Cache Creek	40%	53%	24%	98%	**93%**
OK311310030050_00	OK311310030050G	Brush Creek	**84%**				

The TMDL, WLA, LA, and MOS vary with flow condition, and are calculated at every 5th flow interval percentile. For illustrative purposes, the TMDL, WLA, LA, and MOS are calculated for the median flow at each site in Table ES-4. The WLA component of each TMDL is the sum of all WLAs within the contributing watershed of each WQM station. The sum of the WLAs can be represented as a single line below the LDC. The LDC and the simple equation of:

$$\textit{Average LA} = \textit{average TMDL} - \textit{MOS} - \sum \textit{WLA}$$

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. There are no permitted MS4s in the study area. Where there are no continuous point sources the WLA is zero.

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 uncertainty 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 uncertainty, then the MOS is considered explicit.

For the explicit MOS the water quality target was set at 10 percent lower than the water quality criterion for each pathogen which equates to 360 colony-forming units per 100 milliliter (cfu/100 mL), 365.4 cfu/100 mL, and 97.2/100 mL for fecal coliform, *E. coli*, and Enterococci, respectively. The net effect of the TMDL with MOS is that the assimilative capacity or allowable pollutant loading of each waterbody is slightly reduced. These TMDLs incorporate an explicit MOS by using a curve representing 90 percent of the TMDL as the average MOS. The MOS at any given percent flow exceedance, therefore, can be defined as the difference in loading between the TMDL and the TMDL with MOS. The use of instream bacteria concentrations to estimate existing loading is another conservative element utilized in these TMDLs that can be recognized as an implicit MOS. 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.

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.

Table ES-4 TMDL Summaries Examples

Waterbody ID	WQM Station	Waterbody Name	Indicator Bacteria Species	TMDL† (cfu/day)	WLA† (cfu/day)	LA† (cfu/day)	MOS† (cfu/day)
OK311100040010_00	OK311100040010-001AT	Mud Creek	ENT	1.65E+10	2.75E+08	1.46E+10	1.65E+09
OK311100040080_00	OK311100040080G	Lower West Mud Creek	FC	1.31E+10	0	1.18E+10	1.31E+09
OK311200000060_00	USGS_07313600	Cow Creek	ENT	1.16E+10	0	1.05E+10	1.16E+09
OK311210000140_00	OK311210000140D	Whisky Creek	FC	1.94E+10	0	1.75E+10	1.94E+09
OK311210000150_00	OK311210000150G	Cottonwood Creek	FC	1.66E+10	0	1.49E+10	1.66E+09
OK311300010020_00	OK311300010020-001AT	East Cache Creek	ENT	1.00E+11	3.12E+08	9.01E+10	1.00E+10
OK311300030070_00	OK311300030070G	Tahoe Creek	FC	2.57E+09	0	2.31E+09	2.57E+08
OK311310010010_00	OK311310010010-001AT	Red River at US 183	ENT	1.00E+12	9.49E+08	9.03E+11	1.00E+11
OK311310020010_00	OK311310020010-001AT	West Cache Creek	ENT	3.50E+10	0	3.15E+10	3.50E+09
OK311310030050_00	OK311310030050G	Brush Creek	FC	3.21E+09	0	2.89E+09	3.21E+08

† Derived for illustrative purposes at the median flow value
* WLA calculations for facilities outside of Oklahoma are not enforceable

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 TMDLs for the pathogen indicator bacteria fecal coliform, *Escherichia coli (E. coli)*, or Enterococci for certain waterbodies in the Lower Red River area of the Red River Basin. Elevated levels of pathogen indicator bacteria in aquatic environments indicate that a receiving water is contaminated with human or animal feces and that a potential health risk exists for individuals exposed to the water. Data assessment and TMDL calculations are conducted 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 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 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 that ODEQ placed in Category 5 of the 2004 Integrated Report [303(d) list] for nonsupport of primary body contact recreation (PBCR):

- Mud Creek (OK311100040010_00),
- Lower West Mud Creek (OK311100040080_00),
- Cow Creek (OK311200000060_00),
- Whisky Creek (OK311210000140_00),
- Cottonwood Creek (OK311210000150_00),
- East Cache Creek (OK311300010020_00),
- Tahoe Creek (OK311300030070_00),
- Red River at US 183 (OK311310010010_00),
- West Cache Creek (OK311310020010_00), and
- Brush Creek (OK311310030050_00).

Figure 1-1 is a location map showing these Oklahoma 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.

Elevated levels of bacteria 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 bacteria loading controls needed to restore the contact recreation 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 2004 303(d) Listing Decision

Waterbody Name	Waterbody ID	WQM Station	WQM Station Location Descriptions
Mud Creek	OK311100040010_00	OK311100040010-001AT	Mud Creek, SH 32, Courtney
Lower West Mud Creek	OK311100040080_00	OK311100040080G	Lower West Mud Creek
Cow Creek	OK311200000060_00	USGS_07313600	Cow Creek at SH 5 at Waurika, OK
Whisky Creek	OK311210000140_00	OK311210000140D	Whisky Creek
Cottonwood Creek	OK311210000150_00	OK311210000150G	Cottonwood Creek
East Cache Creek	OK311300010020_00	OK311300010020-001AT	East Cache Creek, SH 53, Walters
Tahoe Creek	OK311300030070_00	OK311300030070G	Tahoe Creek
Red River at US 183	OK311310010010_00	OK311310010010-001AT	Red River, US 183, Davidson
West Cache Creek	OK311310020010_00	OK311310020010-001AT	West Cache Creek, SH 5B, Taylor
Brush Creek	OK311310030050_00	OK311310030050G	Brush Creek

1.2 Watershed Description

General. The Lower Red River Basin is located in the southwestern portion of Oklahoma. The waterbodies addressed in this Study Area are located in Caddo, Comanche, Tillman, Cotton, Stephens, Jefferson, Carter, and Love Counties. The headwaters of the Red River at US 183 (OK311310010010_00) originate in Tillman County, Oklahoma and Cotton County, Oklahoma. 50.3 percent of the Red River at US 183 (OK311310010010_00) watershed falls within Wilbarger and Wichita counties in the State of Texas.

The Oklahoma counties are part of the Central Oklahoma/Texas Plains and Central Great Plains ecoregions. The waterbodies in the Study Area lay within the Wichita Mountain Uplift, Hollis Basin, and Marietta Basin geological provinces. Table 1-2, derived from the 2000 U.S. Census, demonstrates that the counties in which these watersheds are located are variably populated (U.S. Census Bureau 2000).

Table 1-2 County Population and Density

County Name	Population (2000 Census)	Population Density (per square mile)
Caddo	30,150	24
Comanche	114,996	108
Tillman	9,287	11
Wilbarger, TX	14,676	15
Wichita, TX	131,664	210
Cotton	6,614	10
Stephens	43,182	49
Jefferson	6,818	9
Carter	45,621	55
Love	8,831	17

Climate. Table 1-3 summarizes the average annual precipitation for each WQM station. Average annual precipitation values among the WQM stations in this portion of Oklahoma range between 30.1 and 35.3 inches (Oklahoma Climate Survey 2007).

Table 1-3 Average Annual Precipitation by Watershed

Lower Red River Precipitation Summary		
Waterbody Name	Waterbody ID	Average Annual (Inches)
Mud Creek	OK311100040010_00	35.3
Lower West Mud Creek	OK311100040080_00	34.1
Cow Creek	OK311200000060_00	35.1
Whisky Creek	OK311210000140_00	34.2
Cottonwood Creek	OK311210000150_00	34.9
East Cache Creek	OK311300010020_00	33.2
Tahoe Creek	OK311300030070_00	32.8
Red River at US 183	OK311310010010_00	30.0
West Cache Creek	OK311310020010_00	32.6
Brush Creek	OK311310030050_00	31.1

Land Use. Tables 1-4a and 1-4b summarize 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 combination of grasslands/herbaceous and row crops, totaling between 75 and 94 percent, are the primary land use categories in all watersheds in the Study Area. Deciduous forest is the second largest land use category in Mud Creek, the watershed with the lowest percent combination of grasslands/herbaceous and row crops (75%).

There are seven cities located in the Red River at US 183 watershed: Frederick, Davidson, Grandfield, Devol, Randlett, in Oklahoma and Electra and Burkburnett in Texas. All other cities within watersheds in the Study Area are in Oklahoma. Cow Creek watershed has four cities: Empire City, Comanche, Addington, and Waurika. Mud Creek watershed has only two cities: Ringling and Cornish. The only city located in Brush Creek is Chattanooga and the only city located in East Cache Creek is Temple. There are no urban areas within the watersheds of Lower West Mud Creek, Whiskey Creek, Cottonwood Creek, or West Cache Creek. Low, medium, and high intensity developed land account for less than 1 percent of the land use in each watershed.

Table 1-4a Land Use Summaries by Watershed

Land Use Category	WQM Station				
	Mud Creek	Lower West Mud Creek	Cow Creek	Whisky Creek	Cottonwood Creek
Waterbody ID	**OK311100040010_00**	**OK311100040080_00**	**OK311200000060_00**	**OK311210000140_00**	**OK311210000150_00**
Percent of Open Water	0.6	0.5	0.6	0.3	0.5
Percent of Developed, Open Space	2.6	1.6	4.3	4.1	3.6
Percent of Developed, Low Intensity	0.1	0.1	0.7	0.0	0.1
Percent of Developed, Medium Intensity	0.0	0.0	0.2	0.1	0.0
Percent of Developed, High Intensity	0.0	0.0	0.0	0.0	0.0
Percent of Barren Land (Rock/Sand/Clay)	0.0	0.0	0.0	0.0	0.0
Percent of Deciduous Forest	15.1	6.0	11.2	8.5	8.7
Percent of Evergreen Forest	0.0	0.0	0.0	0.0	0.0
Percent of Mixed Forest	0.0	0.0	0.0	0.0	0.0
Percent of Shrub/Scrub	0.0	0.2	0.1	0.0	0.1
Percent of Grassland/Herbaceous	61.9	68.4	66.2	71.8	57.4
Percent of Pasture/Hay	6.7	4.1	0.0	0.0	0.4
Percent of Cultivated Crops	12.9	19.1	16.7	15.1	29.2
Percent of Woody Wetlands	0.0	0.0	0.0	0.0	0.0
Percent of Emergent Herbaceous Wetlands	0.0	0.0	0.0	0.0	0.0
Acres Open Water	1,567	382	494	41	60
Acres Developed, Open Space	7,265	1,287	3,681	589	438
Acres Developed, Low Intensity	399	46	628	7	6
Acres Developed, Medium Intensity	121	2	168	10	0
Acres Developed, High Intensity	9	0	16	0	0
Acres Barren Land (Rock/Sand/Clay)	32	4	11	0	0
Acres Deciduous Forest	43,066	4,732	9,612	1,214	1,066
Acres Evergreen Forest	27	2	2	0	4
Acres Mixed Forest	0	0	0	0	0
Acres Shrub/Scrub	133	181	76	6	9
Acres Grassland/Herbaceous	176,141	54,166	56,985	10,251	6,993
Acres Pasture/Hay	18,970	3,245	27	0	53

Land Use Category	WQM Station				
	Mud Creek	Lower West Mud Creek	Cow Creek	Whisky Creek	Cottonwood Creek
Waterbody ID	**OK311100040010_00**	**OK311100040080_00**	**OK311200000060_00**	**OK311210000140_00**	**OK311210000150_00**
Acres Cultivated Crops	36,648	15,162	14,361	2,159	3,560
Acres Woody Wetlands	0	0	0	0	0
Acres Emergent Herbaceous Wetlands	2	0	0	0	0
Total (Acres)	**284,381**	**79,208**	**86,062**	**14,277**	**12,191**

Table 1-4b Land Use Summaries by Watershed

Land Use Category	WQM Station				
	East Cache Creek	Tahoe Creek	Red River at US 183	West Cache Creek	Brush Creek
Waterbody ID	**OK311300010020_00**	**OK311300030070_00**	**OK311310010010_00**	**OK311310020010_00**	**OK311310030050_00**
Percent of Open Water	0.3	0.2	1.2	0.3	0.2
Percent of Developed, Open Space	4.9	4.1	3.9	4.9	4.2
Percent of Developed, Low Intensity	0.7	0.3	0.7	0.5	0.6
Percent of Developed, Medium Intensity	0.1	0.1	0.2	0.2	0.1
Percent of Developed, High Intensity	0.0	0.0	0.1	0.0	0.0
Percent of Barren Land (Rock/Sand/Clay)	0.0	0.0	2.7	0.0	0.0
Percent of Deciduous Forest	4.7	4.1	1.2	5.3	0.4
Percent of Evergreen Forest	0.0	0.0	0.0	0.0	0.0
Percent of Mixed Forest	0.0	0.0	0.0	0.0	0.0
Percent of Shrub/Scrub	0.6	0.3	3.6	0.7	0.6
Percent of Grassland/Herbaceous	39.0	64.5	29.8	39.2	26.4
Percent of Pasture/Hay	0.1	0.3	0.0	0.1	0.0
Percent of Cultivated Crops	49.6	26.2	56.6	48.8	67.5
Percent of Woody Wetlands	0.0	0.0	0.0	0.0	0.0
Percent of Emergent Herbaceous Wetlands	0.0	0.0	0.0	0.0	0.0
Acres Open Water	140	24	6,004	137	30
Acres Developed, Open Space	2,251	531	20,491	2,376	745
Acres Developed, Low Intensity	314	36	3,586	234	110
Acres Developed, Medium Intensity	45	9	1,040	104	17
Acres Developed, High Intensity	3	5	351	14	7
Acres Barren Land (Rock/Sand/Clay)	15	0	14,170	10	3

Land Use Category	WQM Station				
	East Cache Creek	**Tahoe Creek**	**Red River at US 183**	**West Cache Creek**	**Brush Creek**
Waterbody ID	**OK311300010020_00**	**OK311300030070_00**	**OK311310010010_00**	**OK311310020010_00**	**OK311310030050_00**
Acres Deciduous Forest	2,139	526	6,193	2,573	64
Acres Evergreen Forest	0	4	21	5	0
Acres Mixed Forest	0	4	83	0	0
Acres Shrub/Scrub	261	39	18,708	359	103
Acres Grassland/Herbaceous	17,933	8,338	155,315	19,151	4,680
Acres Pasture/Hay	57	35	170	28	0
Acres Cultivated Crops	22,831	3,386	295,393	23,821	11,978
Acres Woody Wetlands	0	0	199	0	0
Acres Emergent Herbaceous Wetlands	0	0	20	1	0
Total (Acres)	**45,989**	**12,936**	**521,744**	**48,813**	**17,738**

Figure 1-1 Watersheds Not Supporting Primary Body Contact Recreation Use within the Study Area

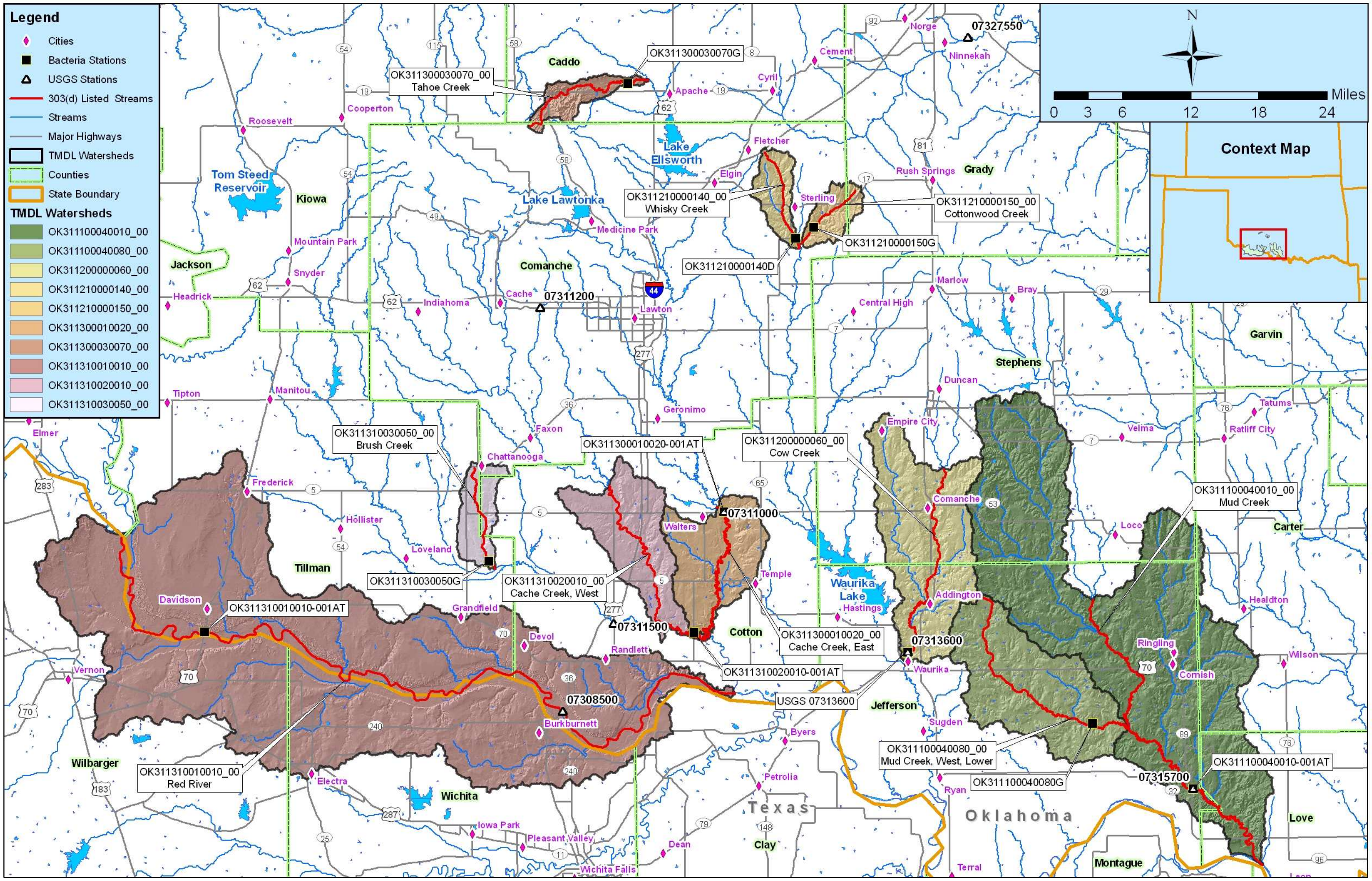
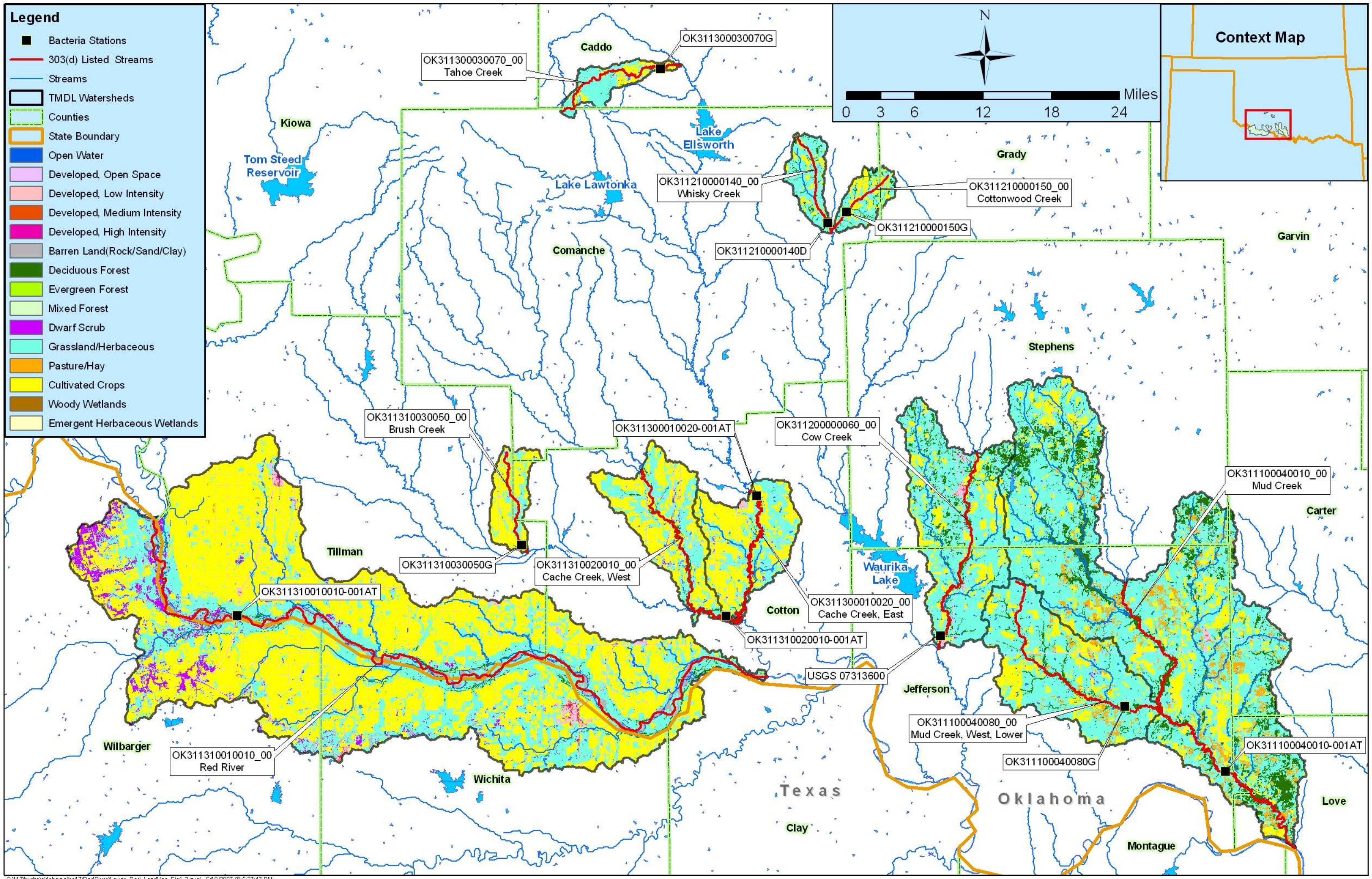


Figure 1-2 Land Use Map by Watershed



SECTION 2
PROBLEM IDENTIFICATION AND WATER QUALITY TARGET

2.1 Oklahoma Water Quality Standards

Title 785 of the Oklahoma Administrative Code authorizes the Oklahoma Water Resources Board (OWRB) to promulgate Oklahoma's water quality standards and implementation procedures (OWRB 2006). The 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 2006). The beneficial uses designated for Mud Creek (OK311100040010), Lower West Mud Creek (OK311100040080), Cow Creek (OK311200000060), Whisky Creek (OK311210000140), Cottonwood Creek (OK311210000150), East Cache Creek (OK311300010020), Tahoe Creek (OK311300030070), Red River at US 183 (OK311310010010), West Cache Creek (OK311310020010), and Brush Creek (OK311310030050) include Primary body contact recreation (PBCR), public/private water supply, warm water aquatic community, industrial and municipal process and cooling water, agricultural water supply, fish consumption, emergency water supply, sensitive water supply and aesthetics. The TMDLs in this report only address the PBCR-designated use.

Table 2-1, an excerpt from Appendix B of the 2004 Integrated Report (ODEQ 2004), summarizes the PBCR use attainment status and the priority for TMDL development established by ODEQ for the impaired waterbodies of the Study Area. The priority for targeting TMDL development and implementation is derived from the chronological order of the dates listed in the TMDL Date column of Table 2-1. The TMDLs established in this report are a necessary step in the process to restore the PBCR use designation for each waterbody.

Table 2-1 Excerpt from the 2004 Integrated Report – Comprehensive Waterbody Assessment Category List

Waterbody ID	Waterbody Name	Stream Miles	Category	TMDL Date	Primary Body Contact Recreation
OK311100040010_00	Mud Creek	66.02	5	2005	N
OK311100040080_00	Lower West Mud Creek	27.73	5	2007	N
OK311200000060_00	Cow Creek	25.73	5	2004	N
OK311210000140_00	Whisky Creek	10.28	5	2007	N
OK311210000150_00	Cottonwood Creek	7.21	5	2007	N
OK311300010020_00	East Cache Creek	26	5	2005	N
OK311300030070_00	Tahoe Creek	16.79	5	2007	N
OK311310010010_00	Red River at US 183	88.02	5	2005	N

Waterbody ID	Waterbody Name	Stream Miles	Category	TMDL Date	Primary Body Contact Recreation
OK311310020010_00	West Cache Creek	28.27	5	2005	N
OK311310030050_00	Brush Creek	11.64	5	2007	N

N = Not Supporting; Source: 2004 Integrated Report, ODEQ 2004

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, 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 2006).

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 WQM stations 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 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.

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, which 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.

2.2 Problem Identification

Table 2-2 summarizes water quality data collected during primary contact recreation season from the WQM stations between 1999 and 2006 for each indicator bacteria. The 1999 to 2003 subset of these data collected during the primary contact recreation season was used to support the decision to place specific waterbodies within the Study Area on the ODEQ 2004 303(d) list (ODEQ 2004). Table 2-2 also summarizes instances where waterbodies or bacterial indicators are recommended for removal from or addition to the 303(d) list based on further data analysis associated with the preparation of this report. Water quality data from the primary and secondary contact recreation seasons are provided in Appendix A. For the data collected between 1999 and 2003, evidence of nonsupport of the PBCR use based on fecal coliform concentrations was observed in five waterbodies: Lower West Mud Creek (OK311100040080), Whisky Creek (OK311210000140), Cottonwood Creek (OK311210000150), Tahoe Creek (OK311300030070), and Brush Creek (OK311310030050). Evidence of nonsupport of the PBCR use based on both fecal coliform and Enterococci concentrations was observed in three waterbodies: Mud Creek (OK311100040010), East Cache Creek (OK311300010020), and Red River at US 183 (OK311310010010). Evidence of nonsupport of the PBCR use based on Enterococci concentrations was observed in one waterbody: Cow Creek (OK311200000060). Evidence of nonsupport of the PBCR use based on all three bacterial indicators, fecal coliform, Enterococci and *E. coli* concentrations, was observed in one waterbody: West Cache Creek (OK311310020010). Table 2-3 summarizes the waterbodies requiring TMDLs for not supporting PBCR.

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 TMDLs in this report, defining the water quality target is somewhat complicated by the use of three different bacterial indicators with three 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 2006). 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 the instantaneous criteria for fecal coliform and both the instantaneous and a long-term geometric mean for both *E. coli* and Enterococci.

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 more than 10 percent of 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 each waterbody 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).

Each water quality target will be used to determine the allowable bacteria load which is derived by using the actual or estimated flow record multiplied by the instream criteria minus a 10 percent MOS. 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.

Table 2-2 Summary of Indicator Bacteria Samples from Primary Body Contact Recreation Season, 1999-2006

Waterbody ID	Waterbody Name	Indicator Bacteria	Single Sample Water Quality Criterion (#/100mL)	Geometric Mean Concentration (count/100mL)	Number of Samples	Number of Samples Exceeding Criterion	% of Samples Exceeding Criterion	Reason for Listing Change
OK311100020010_10	Hickory Creek	EC	406	68	8	1	13%	
		ENT	108	95	8	4	50%	Delist: Low Sample Count
OK311100030010_00	Walnut Bayou	EC	406	80	8	1	13%	
		ENT	108	43	8	2	25%	Delist: Low Sample Count
OK311100040010_00	Mud Creek, SH 32, Courtney	FC	400	198	19	6	32%	
		EC	406	56	19	3	16%	
		ENT	108	137	19	12	63%	
OK311100040080_00	West Mud Creek	FC	400	96	8	4	50%	
		EC	406	79	5	2	40%	Delist: Low Sample Count
		ENT	108	128	6	4	67%	Delist: Low Sample Count
OK311200000060_00	Cow Creek at SH 5 at Waurika, OK	FC	400	206	16	4	25%	
		EC	406	77	17	1	6%	
		ENT	108	258	17	14	82%	
OK311200000080_00	Dry Creek	FC	400	456	6	2	33%	Delist: Low Sample Count
		EC	406	273	4	1	25%	Delist: Low Sample Count
		ENT	108	501	4	3	75%	Delist: Low Sample Count
OK311210000140_00	Whiskey Creek	FC	400	268	9	3	33%	List: >25%
		EC	406	143	5	1	20%	Delist: Low Sample Count
		ENT	108	501	6	6	100%	Delist: Low Sample Count

Waterbody ID	Waterbody Name	Indicator Bacteria	Single Sample Water Quality Criterion (#/100mL)	Geometric Mean Concentration (count/100mL)	Number of Samples	Number of Samples Exceeding Criterion	% of Samples Exceeding Criterion	Reason for Listing Change
OK311210000150_00	Cottonwood Creek	FC	400	1006	7	6	86%	
		EC	406	508	5	4	80%	Delist: Low Sample Count
		ENT	108	1779	5	5	100%	Delist: Low Sample Count
OK311300010020_00	East Cache Creek, SH 53, Walters	FC	400	435	27	11	41%	
		EC	406	124	27	4	15%	Delist: <GeoMean
		ENT	108	510	27	24	89%	
OK311300030070_00	Tahoe Creek	FC	400	146	8	3	38%	List: >25%
		EC	406	64	5	1	20%	Delist: Low Sample Count
		ENT	108	147	6	5	83%	
OK311310010010_00	Red River at US 183	FC	400	228	18	7	39%	
		EC	406	122	18	6	33%	
		ENT	108	174	18	9	50%	
OK311310020010_00	West Cache Creek, SH 5B, Taylor	FC	400	423	22	9	41%	
		EC	406	150	22	3	14%	
		ENT	108	445	21	20	95%	
OK311310020060_00	Blue Beaver Creek	FC	400	147	7	1	14%	
		EC	406	69	6	0	0%	
		ENT	108	245	6	5	83%	Delist: Low Sample Count
OK311310030050_00	Brush Creek	FC	400	400	7	4	57%	
		EC	406	305	5	3	60%	Delist: Low Sample Count
		ENT	108	230	5	3	60%	Delist: Low Sample Count

EC = *E. coli*; ENT = enterococci; FC = fecal coliform
Highlighted bacterial indicators require TMDL

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*
OK311100040010-001AT	OK311100040010_00	Mud Creek	X	X	
OK311100040080G	OK311100040080_00	Lower West Mud Creek	X		
USGS_07313600	OK311200000060_00	Cow Creek		X	
OK311210000140D	OK311210000140_00	Whisky Creek	X		
OK311210000150G	OK311210000150_00	Cottonwood Creek	X		
OK311300010020-001AT	OK311300010020_00	East Cache Creek	X	X	
OK311300030070G	OK311300030070_00	Tahoe Creek	X		
OK311310010010-001AT	OK311310010010_00	Red River at US 183	X	X	
OK311310020010-001AT	OK311310020010_00	West Cache Creek	X	X	X
OK311310030050G	OK311310030050_00	Brush Creek	X		

ENT = enterococci; FC = fecal coliform

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 warm-blooded animals; some plant life and sources may be point or nonpoint in nature.

Point sources are permitted through the NPDES program. NPDES-permitted facilities that discharge treated wastewater are required to monitor for one of the three bacteria indicators (fecal coliform, *E coli*, or Enterococci) in accordance with its 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 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. Where information was available on point and nonpoint sources of bacteria originating in portions of the impaired watersheds located in Texas, data were provided and summarized as part of each category. These data were provided to demonstrate that some of the bacteria loading outside of Oklahoma's jurisdiction may contribute to nonsupport of the PBCR use in Oklahoma. It is recognized that Oklahoma has no enforcement authority over bacteria sources originating beyond the Oklahoma state boundary.

3.1 NPDES-Permitted Facilities

Under 40CFR, §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 loading include:

- NPDES municipal wastewater treatment plant (WWTP);
- NPDES municipal no-discharge WWTP;
- NPDES municipal separate storm sewer discharge (MS4); and
- NPDES Concentrated Animal Feeding Operation (CAFO).

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. 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. Stormwater runoff from MS4 areas, which is now regulated under the USEPA NPDES Program, can also contain high fecal coliform bacteria concentrations. There are no permitted MS4s within the study area. 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.

There are no NPDES-permitted facilities of any type in the contributing watersheds of Lower West Mud Creek (OK311100040080_00), Cottonwood Creek (OK311210000150_00), Tahoe Creek (OK311300030070_00), West Cache Creek (OK311310020010_00) and Brush

Creek (OK311310030050_00). Five of the watersheds in the Study Area, including Mud Creek (OK311100040010_00), Cow Creek (OK311200000060_00), Whisky Creek (OK311210000140_00), East Cache Creek (OK311300010020_00), and Red River at US 183 (OK311310010010_00) have NPDES-permitted facilities. There are no permitted MS4s within the study area.

3.1.1 Continuous Point Source Discharges

The location of the NPDES-permitted facility that discharges wastewater to surface waters addressed in these TMDLs is shown in Figure 3-1 and is listed in Table 3-1. For the purposes of the pollutant sources assessment, only facility types identified in Table 3-1 as Sewerage Systems are assumed to contribute bacteria loads within the watersheds of the impaired waterbodies. For some continuous point source discharge facilities, the permitted design flow was not available and therefore is not provided in Table 3-1.

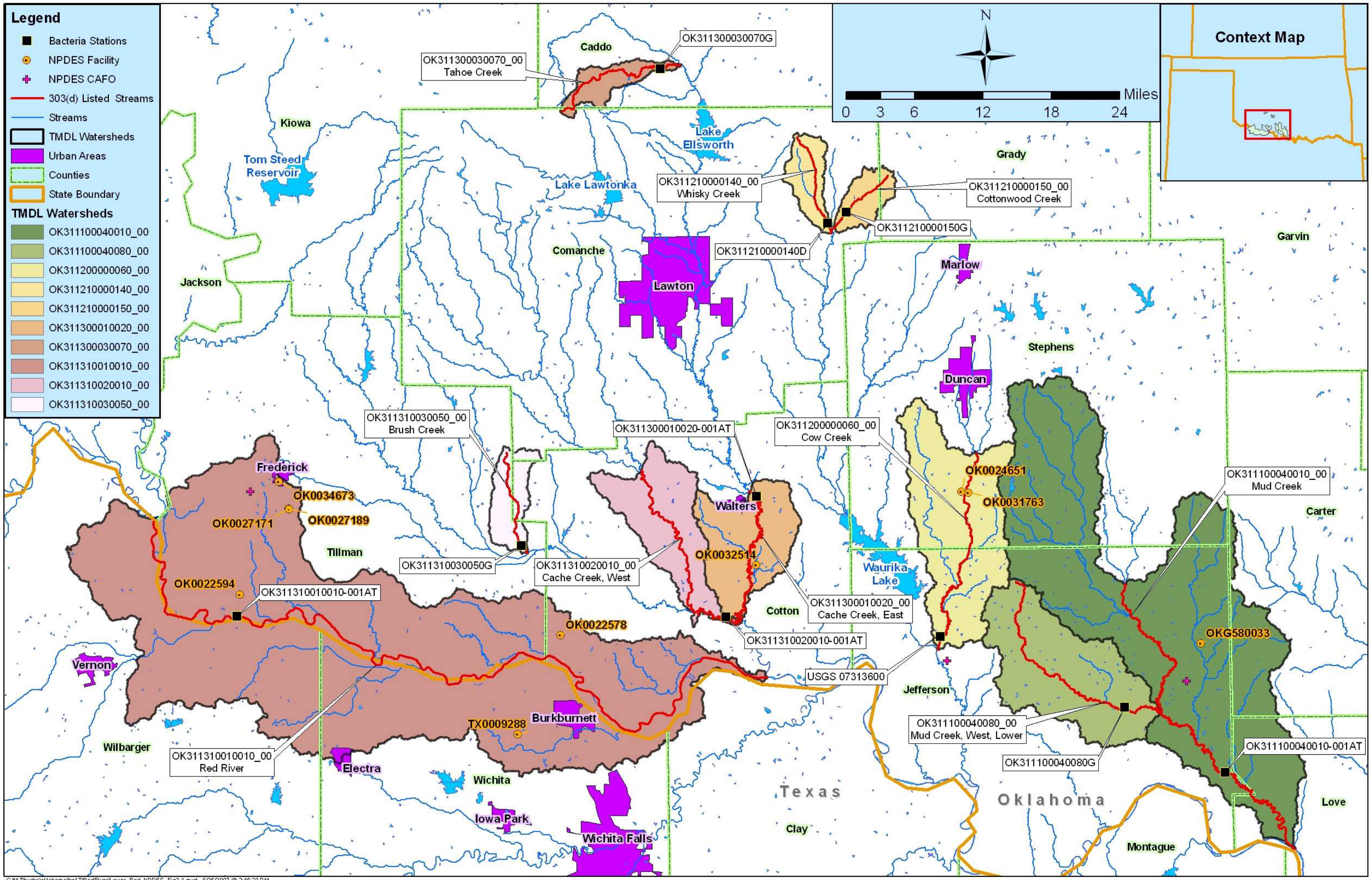
Table 3-1 Point Source Discharges in the Study Area

NPDES Permit No.	Name	Receiving Water	Facility Type	County Name	Design Flow (mgd)	Active/ Inactive	Facility ID
OKG580033	Town of Ringling	OK311100040010_00 Mud Creek	Sewerage Systems	Jefferson	0.22	Active	S11103
OK0032514	Town of Temple	OK311300010020_00 East Cache Creek	Sewerage Systems	Cotton	0.250	Active	S11317
OK0022578	Town of Devol	OK311310010010_00 Red River at US 183	Sewerage Systems	Cotton	0.060	Active	S11403
OK0027189	City of Frederick - Industrial Park	OK311310010010_00 Red River at US 183	Sewerage Systems	Tillman	0.150	Active	S11402
OK0027171	City of Frederick - East WWTP	OK311310010010_00 Red River at US 183	Sewerage Systems	Tillman	0.550	Active	S11309
OK0031763	Comanche Public Works Authority	OK311200000060_00 Cow Creek	Sewerage Systems	Stephens	N/A	Inactive	S11206
OK0024651	Farmers & Ranchers Stockyards	OK311200000060_00 Cow Creek	Prefabricated Metal Buildings	Stephens	N/A	N/A	N/A
OK0022594	Town of Davidson	OK311310010010_00 Red River at US 183	Sewerage Systems	Tillman	N/A	N/A	N/A
OK0034673	Stewart Granite Enterprise	OK311310010010_00 Red River at US 183	Cut Stone And Stone Products	Tillman	N/A	N/A	N/A
TX0009288	Ciba Pipe Systems-Wichita	OK311310010010_00 Red River at US 183	N/A	Wichita	N/A	N/A	N/A

N/A = not available

Discharge Monitoring Reports (DMR) for fecal coliform analyses were not available for the facilities listed in Table 3-1.

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



3.1.2 NPDES No-Discharge Facilities and SSOs

There are six NPDES-permitted no-discharge facilities within the Study Area. The locations of these facilities are listed in Table 3-2. For the purposes of these TMDLs, it is assumed that no-discharge facilities do not contribute bacteria loading to the Lower Red River at US 183 and its tributaries. However, it is possible the wastewater collection systems associated with those WWTPs could be a source of bacteria loading, or that discharges may occur during large rainfall events that exceed the systems' storage capacities.

Table 3-2 NPDES No-Discharge Facilities in the Study Area

Facility	Facility ID	County	Facility Type	Type	Watershed	Active/ Inactive
Edgewood Kwik Mart & Car Wash	WD96-012	Stephens	Total Retention	Industrial	OK311200000060_00 Cow Creek	Active
Shiflett Transport Services Maintenance	WD98-014	Comanche	Total Retention	Industrial	OK311210000140_00 Whisky Creek	Inactive
Indian Chief Mobile Village WWTP	11109	Stephens	Lagoon (Total Retention)	Municipal	OK311100040010_00 Mud Creek	N/A
Cotton Co RWD # 1 (Randlett) WWTP	11321	Cotton	Lagoon (Total Retention)	Municipal	OK311310010010_00 Red River at US 183	N/A
Weaver Doc Detention Center	11382	Tillman	Lagoon (Total Retention)	Municipal	OK311310010010_00 Red River at US 183	N/A
Davidson	11401	Tillman	Land Application	Municipal	OK311310010010_00 Red River at US 183	N/A

N/A = not available

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 79 SSO occurrences, ranging from 0 gallon to more than 3 million gallons, reported for certain watersheds within the Study Area between February 1990 and March 2007 which are summarized in Table 3-3. Additional data on each individual SSO event are provided in Appendix B. No data were summarized for SSOs that may have occurred in portions of the Study Area located in Texas. Given the significant number of occurrences and the size of overflows reported, bacteria from SSOs have been a significant source of bacteria loading in the past in the Cow Creek (OK311200000060_00), East Cache Creek (OK311300010020_00), and Red River at US 183 (OK311310010010_00) watersheds.

Table 3-3 Sanitary Sewer Overflow Summary

Facility Name	NPDES Permit No.	Receiving Water	Facility ID	Number of Occur-rences	Date Range		Amount (Gallons)	
					From	To	Min	Max
Ringling	OKG580033	OK311100040010_00 Mud Creek	S11103	5	4/30/1990	10/18/2006	0	50
Comanche	OK0031763	OK311200000060_00 Cow Creek	S11206	27	2/28/1990	3/30/2007	0	1,995,000
Temple	OK0032514	OK311300010020_00 East Cache Creek	S11317	31	5/4/1992	10/18/2005	0	>3 million
Fredrick	OK0027189	OK311310010010_00 Red River at US 183	S11402	3	2/25/1991	6/11/1995	0	350,000
Devol	OK0022578	OK311310010010_00 Red River at US 183	S11403	13	10/11/1997	3/10/2005	5000	100,000

3.1.3 NPDES Municipal Separate Storm Sewer Discharge (MS4)

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 MS4s

Phase II of the rules developed by the USEPA 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. ODEQ provides information on the current status of the MS4 program on its website, which can be found at: http://www.deq.state.ok.us/WQDnew/stormwater/ms4/

3.1.4 Concentrated Animal Feeding Operations

The Agricultural Environmental Management Services (AEMS) of the Oklahoma Department of Agriculture, Food and Forestry (ODAFF) was created to help develop, coordinate, and oversee environmental policies and programs aimed at protecting the Oklahoma environment from pollutants associated with agricultural animals and their waste. Through regulations established by the Oklahoma Concentrated Animal Feeding Operation Act, AEMS works with producers and concerned citizens to ensure that animal waste does not impact the waters of the state. A CAFO is an animal feeding operation that confines and feeds at least 1,000 animal units for 45 days or more in a 12-month period (ODAFF 2005). The CAFO Act is designed to protect water quality through the use of best management practices (BMP) such as dikes, berms, terraces, ditches, or other similar structures used to isolate animal waste from outside surface drainage, except for a 25-year, 24–hour rainfall event (ODAFF 2005). CAFOs are considered no-discharge facilities.

CAFOs are designated by USEPA as significant sources of pollution, and may have the potential to cause serious impacts to water quality if not managed properly. Potential problems for CAFOs can include animal waste discharges to waters of the state and failure to properly operate wastewater lagoons.

Regulated CAFOs within the watershed operate under NPDES permits issued and overseen by EPA. In order to comply with this TMDL, those CAFO permits in the watershed and their associated management plans must be reviewed. Further actions to reduce bacteria loads and achieve progress toward meeting the specified reduction goals must be implemented. This provision will be forwarded to EPA, as the responsible permitting agency, for follow up.

Figure 3-1 depicts the locations of the 2 CAFOs, one located in Mud Creek (OK311100040010_00) and the other in Red River at US 183 (OK311310010010_00). Table 3-4 lists the CAFOs located in the Study Area. Lower West Mud Creek (OK311100040080_00), Cow Creek (OK311200000060_00), Whisky Creek (OK311210000140_00), Cottonwood Creek (OK311210000150_00), East Cache Creek (OK311300010020_00), Tahoe Creek (OK311300030070_00), West Cache Creek (OK311310020010_00), and Brush Creek (OK311310030050_00) have no CAFOs within their contributing watershed.

Table 3-4 NPDES-Permitted CAFOs in Study Area

ODAFF Owner ID	EPA Facility	ODAFF ID	ODAFF License Number	Maximum Number of Permitted Animals at Facility			Total # of Animal Units at Facility	County	Watershed
				Dairy Heifers	Dairy Cattle	Slaughter Feeder Cattle			
AGN007242	OKG010083	315	98	0	0	1800	1800	Jefferson	OK311100040010_00 Mud Creek
WQ0000325	OKU000455	397	200002	360	2400	0	3720	Tillman	OK311310010010_00 Red River at US 183

3.2 Nonpoint Sources

Nonpoint sources include those sources that cannot be identified as entering the waterbody at a specific location. Bacteria originate from rural, suburban, and urban areas. The following section describes possible major nonpoint sources contributing fecal coliform loading within the Study Area.

These sources include wildlife, various agricultural activities and domesticated animals, land application fields, urban runoff, failing onsite wastewater disposal (OSWD) systems, and domestic pets. As previously stated in Subsection 3.1, there are no NPDES-permitted facilities of any type in the contributing watersheds of Lower West Mud Creek (OK311100040080_00), Cottonwood Creek (OK311210000150_00), Tahoe Creek (OK311300030070_00), West Cache Creek (OK311310020010_00), and Brush Creek (OK311310030050_00); therefore, nonsupport of PBCR use is caused by nonpoint sources of bacteria only.

Bacteria associated with urban runoff can emanate from humans, wildlife, livestock, 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). 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. Best management practices such as buffer strips and proper disposal of domestic animal waste can reduce bacteria loading to waterbodies.

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 and 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 3-5 provides the estimated number of deer for each watershed. No attempt was made to adjust the estimated number of deer using different annual harvesting rates specific to the counties of the Study Area located in Texas.

Table 3-5 Estimated Deer Populations

Waterbody ID	Waterbody Name	Deer	Acre
OK311100040010_00	Mud Creek	1,273	284,371
OK311100040080_00	Lower West Mud Creek	202	79,183
OK311200000060_00	Cow Creek	374	86,071
OK311210000140_00	Whisky Creek	38	14,290
OK311210000150_00	Cottonwood Creek	40	12,193
OK311300010020_00	East Cache Creek	156	45,991
OK311300030070_00	Tahoe Creek	121	12,926
OK311310010010_00	Red River at US 183	793	521,906
OK311310020010_00	West Cache Creek	165	48,811
OK311310030050_00	Brush Creek	54	17,734

According to a livestock 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 3-6 in colony-forming units (cfu)/day provides a relative magnitude of loading in each watershed.

Table 3-6 Estimated Fecal Coliform Production for Deer

Waterbody ID	Waterbody Name	Watershed Area (acres)	Wild Deer Population	Estimated Wild Deer per acre	Fecal Production (x 10^8 cfu/day) of Deer Population
OK311100040010_00	Mud Creek	284,371	1273	0.004	6,364
OK311100040080_00	Lower West Mud Creek	79,183	202	0.003	1,008
OK311200000060_00	Cow Creek	86,071	374	0.004	1,869
OK311210000140_00	Whisky Creek	14,290	38	0.003	190
OK311210000150_00	Cottonwood Creek	12,193	40	0.003	198
OK311300010020_00	East Cache Creek	45,991	156	0.003	779
OK311300030070_00	Tahoe Creek	12,926	121	0.009	604
OK311310010010_00	Red River at US 183	521,906	793	0.002	3,963
OK311310020010_00	West Cache Creek	48,811	165	0.003	827
OK311310030050_00	Brush Creek	17,734	54	0.003	270

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 livestock activities that can contribute to bacteria sources:

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

Table 3-7 provides estimated numbers of selected livestock by watershed based on the 2002 U.S. Department of Agriculture (USDA) county agricultural census data (USDA 2002). The estimated livestock populations in Table 3-7 were derived by using the percentage of the watershed within each county. Because the watersheds are generally much smaller than the counties, and livestock are not evenly distributed across counties or constant with time, these are rough estimates only. Cattle are clearly the most abundant species of livestock in the Study Area and often have direct access to the impaired waterbodies or their tributaries.

Detailed information is not available to describe or quantify the relationship between instream concentrations of bacteria and land application of manure from livestock. The estimated acreage by watershed where manure was applied in 2002 is shown in Table 3-8. These estimates are also based on the county level reports from the 2002 USDA county agricultural census, and thus represent approximations of the livestock populations in each watershed. Despite the lack of specific data, for the purpose of these TMDLs, land application of livestock manure is considered a potential source of bacteria loading to the waterbodies in the Study Area.

According to a livestock study conducted by the ASAE, the daily fecal coliform production rates by livestock 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 livestock populations and the fecal coliform production rates from ASAE, an estimate of fecal coliform production from each group of livestock was calculated in Table 3-8 for each watershed of the Study Area. 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 most likely livestock source of fecal bacteria.

Table 3-7 Livestock and Manure Estimates by Watershed

Waterbody ID	Waterbody Name	Cattle & Calves-all	Dairy Cows	Horses & Ponies	Goats	Sheep & Lambs	Hogs & Pigs	Ducks & Geese	Chickens & Turkeys	Acres of Manure Application
OK311100040010_00	Mud Creek	43,302	52	877	892	163	152	119	642	634
OK311100040080_00	Lower West Mud Creek	14,149	1	144	300	0	23	0	53	0
OK311200000060_00	Cow Creek	13,082	25	281	249	71	53	41	221	50
OK311210000140_00	Whisky Creek	1,499	36	43	9	22	5	4	29	15
OK311210000150_00	Cottonwood Creek	1,484	84	39	11	27	69	4	26	21
OK311300010020_00	East Cache Creek	7,138	1	56	4	29	14	0	27	0
OK311300030070_00	Tahoe Creek	2,074	6	32	3	21	359	2	12	44
OK311310010010_00	Red River at US 183	80,515	1,378	344	182	95	102	13	300	969
OK311310020010_00	West Cache Creek	7,577	1	60	4	30	15	0	29	0
OK311310030050_00	Brush Creek	1,989	85	24	12	5	4	1	13	14

Table 3-8 Fecal Coliform Production Estimates for Selected Livestock (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
OK311100040010_00	Mud Creek	4,503,362	5,244	368	N/A	1,954	1,642	1,366	86	4,514,022
OK311100040080_00	Lower West Mud Creek	1,471,514	110	61	N/A	0	243	0	7	1,471,934
OK311200000060_00	Cow Creek	1,360,511	2,544	118	N/A	852	576	553	30	1,365,184
OK311210000140_00	Whisky Creek	155,923	3,597	18	N/A	262	56	48	4	159,909
OK311210000150_00	Cottonwood Creek	154,328	8,488	16	N/A	326	743	50	3	163,956
OK311300010020_00	East Cache Creek	742,399	141	24	N/A	344	157	0	4	743,068
OK311300030070_00	Tahoe Creek	215,721	617	13	N/A	255	3,875	19	2	220,502
OK311310010010_00	Red River at US 183	8,373,509	139,135	145	N/A	1,138	1,100	624	40	8,515,690
OK311310020010_00	West Cache Creek	788,021	150	25	N/A	365	166	0	4	788,731
OK311310030050_00	Brush Creek	206,824	8,578	10	N/A	62	39	41	2	215,555

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 defines design standards for individual and small public onsite sewage disposal systems (ODEQ 2004). 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 (U.S. Census Bureau 2000). 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 WQM station 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 8 percent of the OSWD systems in the Texas Panhandle (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 3-9 summarizes estimates of sewered and unsewered households for each watershed in the Study Area.

For the purpose of estimating fecal coliform loading in watersheds, an OSWD failure rate of 8 percent was used. Using this 8 percent failure rate, calculations were made to characterize fecal coliform loads in each watershed.

Table 3-9 Estimates of Sewered and Unsewered Households

Waterbody ID	Waterbody Name	Public Sewer	Septic Tank	Other Means	Housing Units	% Sewered
OK311100040010_00	Mud Creek	1,783	1,398	87	3,267	55%
OK311100040080_00	Lower West Mud Creek	397	131	11	539	74%
OK311200000060_00	Cow Creek	764	575	14	1,352	56%
OK311210000140_00	Whisky Creek	196	126	4	325	60%
OK311210000150_00	Cottonwood Creek	140	103	3	246	57%
OK311300010020_00	East Cache Creek	306	93	7	406	75%
OK311300030070_00	Tahoe Creek	103	90	2	195	53%
OK311310010010_00	Red River at US 183	8,440	1,314	48	9,802	86%
OK311310020010_00	West Cache Creek	306	112	11	429	71%
OK311310030050_00	Brush Creek	84	36	2	123	69%

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

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

The average of number of people per household was calculated to be 2.44 for counties in the Study Area (U.S. Census Bureau 2000). Approximately 70 gallons of wastewater were 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 3-10.

Table 3-10 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)
OK311100040010_00	Mud Creek	284,371	1,398	112	723
OK311100040080_00	Lower West Mud Creek	79,183	131	11	68
OK311200000060_00	Cow Creek	86,071	575	46	297
OK311210000140_00	Whisky Creek	14,290	126	10	65
OK311210000150_00	Cottonwood Creek	12,193	103	8	53
OK311300010020_00	East Cache Creek	45,991	93	7	48
OK311300030070_00	Tahoe Creek	12,926	90	7	47
OK311310010010_00	Red River at US 183	521,906	1,314	105	680
OK311310020010_00	West Cache Creek	48,811	112	9	58
OK311310030050_00	Brush Creek	17,734	36	3	19

3.2.4 Domestic Pets

Fecal matter from dogs and cats is transported to streams by runoff from urban and suburban areas and can be a potential source of bacteria loading. On average nationally, there are 0.58 dogs per household and 0.66 cats per household (American Veterinary Medical Association 2004). 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 3-11 summarizes the estimated number of dogs and cats for the watersheds of the Study Area.

Table 3-11 Estimated Numbers of Pets

Waterbody ID	Waterbody Name	Dogs	Cats
OK311100040010_00	Mud Creek	1,830	2,157
OK311100040080_00	Lower West Mud Creek	302	356
OK311200000060_00	Cow Creek	757	893
OK311210000140_00	Whisky Creek	182	215
OK311210000150_00	Cottonwood Creek	138	163
OK311300010020_00	East Cache Creek	227	268
OK311300030070_00	Tahoe Creek	109	129
OK311310010010_00	Red River at US 183	5,489	6,469
OK311310020010_00	West Cache Creek	240	283
OK311310030050_00	Brush Creek	69	81

Table 3-12 provides an estimate of the fecal coliform load from pets. These estimates are based on estimated fecal coliform production rates of $5.4x10^8$ per day for cats and $3.3x10^9$ per day for dogs (Schueler 2000).

Table 3-12 Estimated Fecal Coliform Daily Production by Pets (x 10^9)

Waterbody ID	Waterbody Name	Dogs	Cats	Total
OK311100040010_00	Mud Creek	6,038	1,165	7,203
OK311100040080_00	Lower West Mud Creek	996	192	1,188
OK311200000060_00	Cow Creek	2,499	482	2,981
OK311210000140_00	Whisky Creek	601	116	717
OK311210000150_00	Cottonwood Creek	455	88	543
OK311300010020_00	East Cache Creek	751	145	895
OK311300030070_00	Tahoe Creek	361	70	431
OK311310010010_00	Red River at US 183	18,114	3,493	21,607
OK311310020010_00	West Cache Creek	792	153	945
OK311310030050_00	Brush Creek	227	44	270

3.3 Summary of Bacteria Sources

Table 3-13 summarizes the suspected sources of bacteria loading in each impaired watershed. Since there are no NPDES-permitted facilities present in the Lower West Mud Creek (OK311100040080_00), Cottonwood Creek (OK311210000150_00), Tahoe Creek (OK311300030070_00), West Cache Creek (OK311310020010_00), and Brush Creek (OK311310030050_00) watersheds, nonsupport of the PBCR use is caused entirely by nonpoint sources. In watersheds with point and nonpoint sources of bacteria Mud Creek

(OK311100040010_00), Cow Creek (OK311200000060_00), Whisky Creek (OK311210000140_00), East Cache Creek (OK311300010020_00), and Red River at US 183 (OK311310010010_00), the available data suggests that the proportion of bacteria from point sources is minor. There are no permitted MS4s within in the study area. Overall nonpoint sources are considered to be the major source of bacteria loading in each watershed.

Table 3-13 Estimated Major Source of Bacteria Loading by Watershed

Waterbody ID	Waterbody Name	Point Sources	Nonpoint Sources	Major Source
OK311100040010_00	Mud Creek	Yes	Yes	Nonpoint
OK311100040080_00	Lower West Mud Creek	No	Yes	Nonpoint
OK311200000060_00	Cow Creek	Yes	Yes	Nonpoint
OK311210000140_00	Whisky Creek	Yes	Yes	Nonpoint
OK311210000150_00	Cottonwood Creek	No	Yes	Nonpoint
OK311300010020_00	East Cache Creek	Yes	Yes	Nonpoint
OK311300030070_00	Tahoe Creek	No	Yes	Nonpoint
OK311310010010_00	Red River at US 183	Yes	Yes	Nonpoint
OK311310020010_00	West Cache Creek	No	Yes	Nonpoint
OK311310030050_00	Brush Creek	No	Yes	Nonpoint

Table 3-14 below provides a summary of the estimated fecal coliform loads in cfu/day for the four major nonpoint source categories (livestock, pets, deer, and septic tanks) that are contributing to the elevated bacteria concentrations in each watershed. Livestock 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. Also, the structural properties of some manure, such as cow patties, may limit their wash off into streams by runoff. In contrast, malfunctioning septic tank effluent may be present in pooled water on the surface, or in shallow groundwater, which may enhance its conveyance to streams.

Table 3-14 Summary of Fecal Coliform Load Estimates from Nonpoint Sources to Land Surfaces (x 10^9counts/day)

Waterbody ID	Waterbody Name	All Livestock	Pets	Deer	Estimated Loads from Septic Tanks
OK311100040010_00	Mud Creek	4,514,022	7,203	636	723
OK311100040080_00	Lower West Mud Creek	1,471,934	1,188	101	68
OK311200000060_00	Cow Creek	1,365,184	2,981	187	297
OK311210000140_00	Whisky Creek	159,909	717	19	65
OK311210000150_00	Cottonwood Creek	163,956	543	20	53
OK311300010020_00	East Cache Creek	743,068	895	78	48
OK311300030070_00	Tahoe Creek	220,502	431	60	47
OK311310010010_00	Red River at US 183	8,515,690	21,607	396	680
OK311310020010_00	West Cache Creek	788,731	945	83	58
OK311310030050_00	Brush Creek	215,555	270	27	19

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 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 4.2 through 4.4 below:

- Preparing flow duration curves for gaged and ungaged WQM stations;
- Estimating existing bacteria loading in the receiving water using ambient water quality data;
- Using LDCs to identify the critical condition that will dictate loading reductions necessary to attain WQS; and
- Interpreting LDCs to derive TMDL elements – WLA, LA, MOS, and PRG.

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 WWTP effluents would dominate the base flow of the impaired water.

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.

4.2 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 WQM stations 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 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 WQM stations 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. 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 percentiles for each WQM station 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 (USGS 2007a).

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 4-1 through 4-10 are flow duration curves for each impaired waterbody. The flow duration curve for Mud Creek, segment OK311100040010_00, was based on measured flows at

USGS gage station 07315700 (Mud Creek near Courtney, OK). This gage is co-located with WQM station OK311100040010-001AT. The flow duration curve was based on measured flows from 1961 through 2006.

No flow gage exists on Lower West Mud Creek, segment OK311100040080_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07315700 (Mud Creek near Courtney, OK). The flow duration curve was based on measured flows from 1961 through 2006.

The flow duration curve for Cow Creek, segment OK311200000060_00, was based on measured flows at USGS gage station 07313600 (Cow Creek at SH 5 at Waurika, OK). The flows during water quality sampling were obtained from regression analysis of gage 07313600 with gage 07331000 (Washita River near Dickson, OK). The flow duration curve was based on measured flows from 1966 through 1970.

No flow gage exists on Whisky Creek, segment OK311210000140_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07327550 (Little Washita River east of Ninnekah, OK). The flow duration curve was based on measured flows from 1992 through 2006.

No flow gage exists on Cottonwood Creek, segment OK311210000150_00. Therefore, flows for this waterbody were projected using the watershed area ratio method based on measured flows at USGS gage station 07327550 (Little Washita River east of Ninnekah, OK). The flow duration curve was based on measured flows from 1992 through 2006.

The flow duration curve for East Cache Creek, segment OK311300010020_00, was based on measured flows at USGS gage station 07311000 (East Cache Creek near Walters, OK). The flow duration curve was based on measured flows from 1962 through 2006.

No flow gage exists on Tahoe Creek, segment OK311300030070_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07311200 (Blue Beaver Creek near Cache, OK). The flow duration curve was based on measured flows from 1964 through 2003.

The flow duration curve for Lower Red River, segment OK311310010010_00, was based on measured flows at USGS gage station 07308500 (Red River near Burkburnett, TX). This gage is co-located with WQM station OK311310010010-001AT. The flow duration curve was based on measured flows from 1966 through 2006.

No flow gage exists on West Cache Creek, segment OK311310020010_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07311500 (Deep Red Creek near Randlett, OK). The flow duration curve was based on measured flows from 1975 through 2006.

No flow gage exists on Brush Creek, segment OK311310030050_00. Therefore, flows for this waterbody were projected using the watershed area ratio method based on measured flows at USGS gage station 07311500 (Deep Red Creek near Randlett, OK). The flow duration curve was based on measured flows from 1975 through 2006.

Figure 4-1 Flow Duration Curve for Mud Creek (OK311100040010_00)

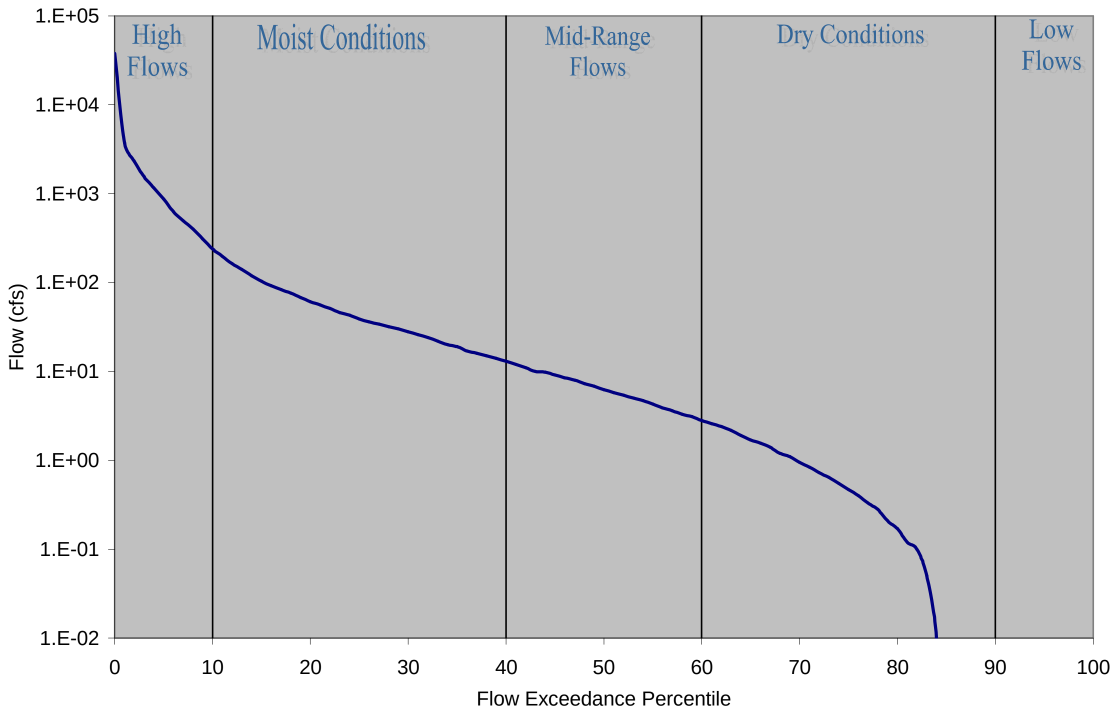


Figure 4-2 Flow Duration Curve for Lower West Mud Creek (OK311100040080_00)

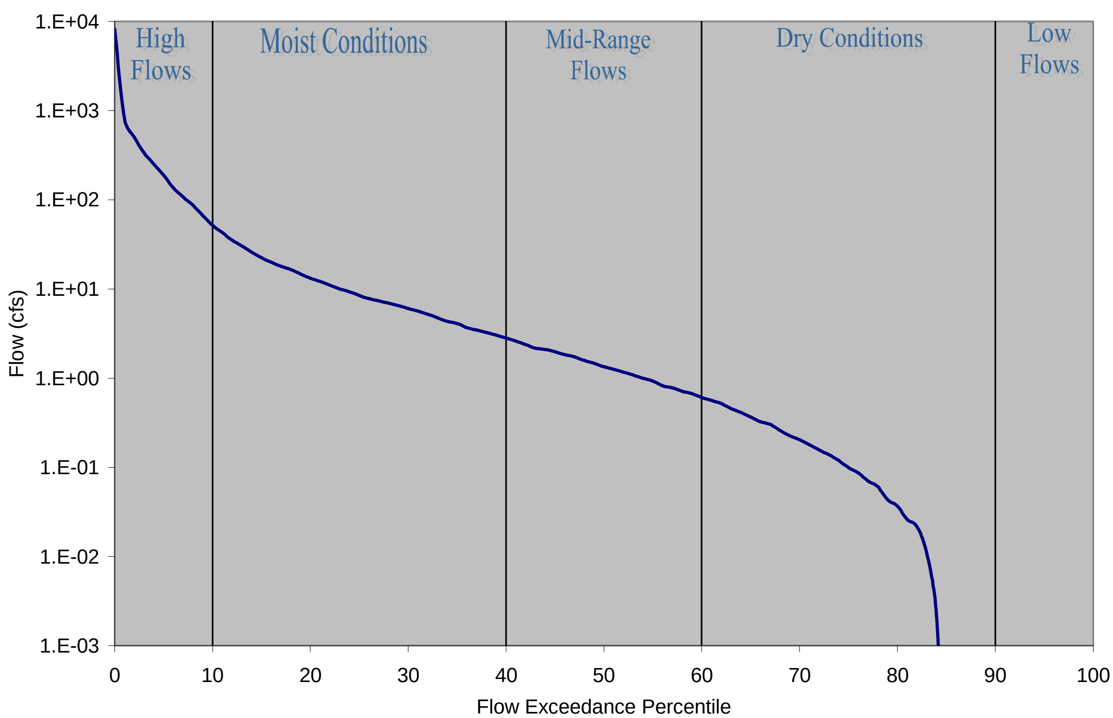


Figure 4-3 Flow Duration Curve for Cow Creek (OK311200000060_00)

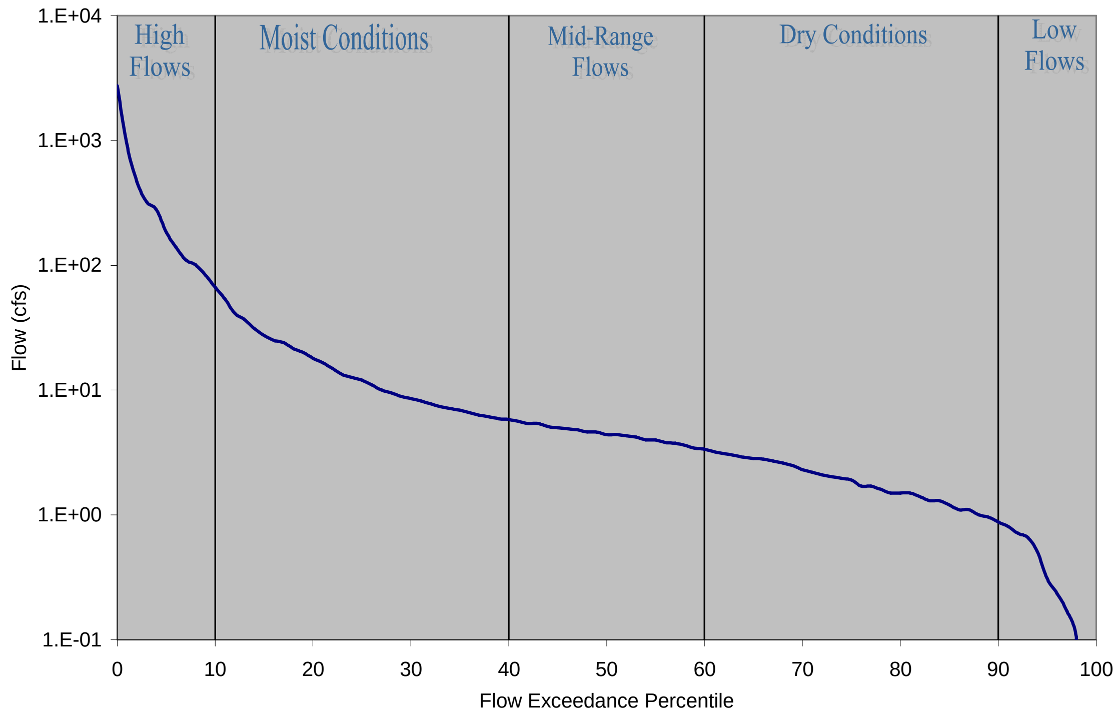


Figure 4-4 Flow Duration Curve for Whisky Creek (OK311210000140_00)

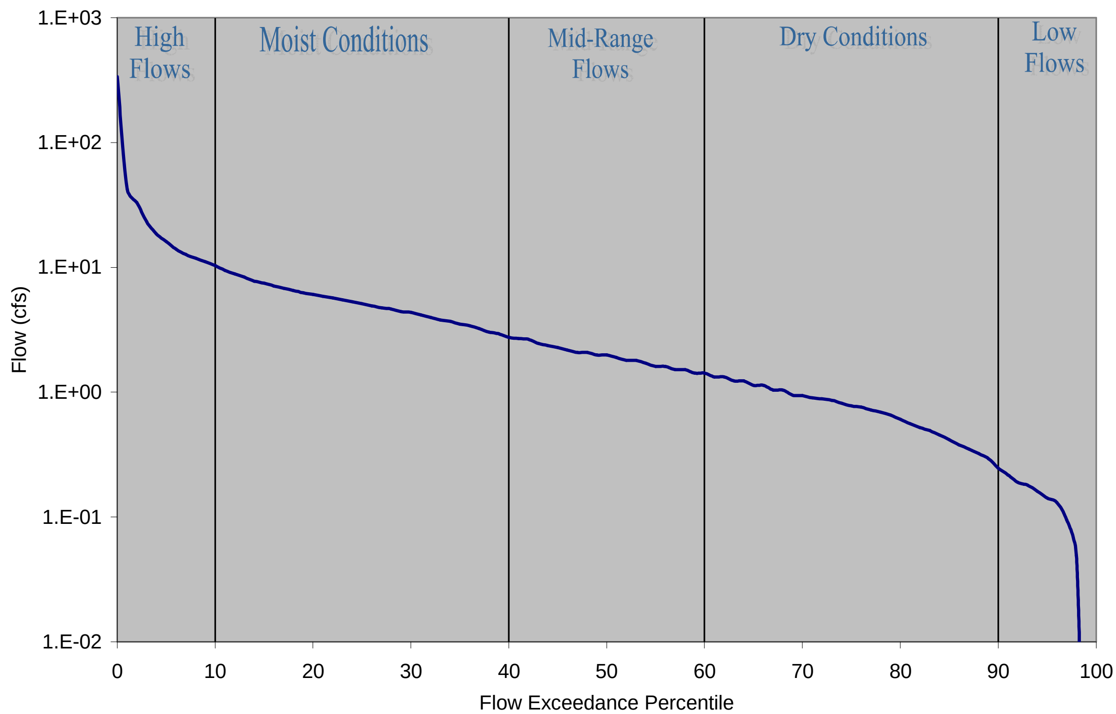


Figure 4-5 Flow Duration Curve for Cottonwood Creek (OK311210000150_00)

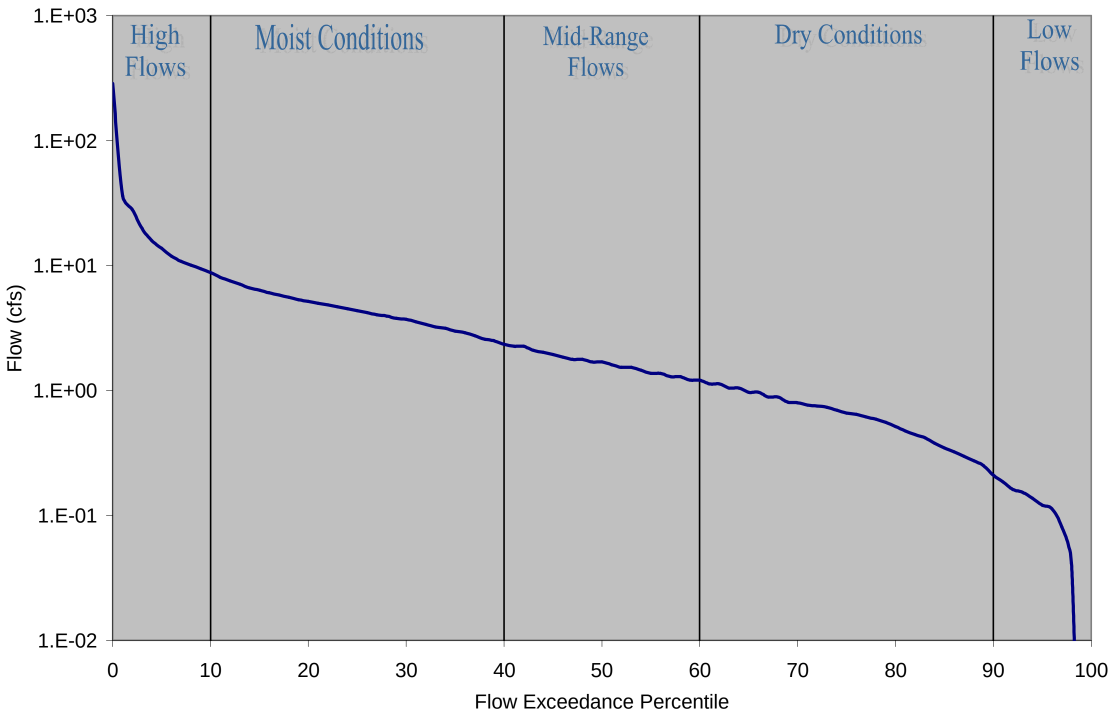


Figure 4-6 Flow Duration Curve for East Cache Creek (OK311300010020_00)

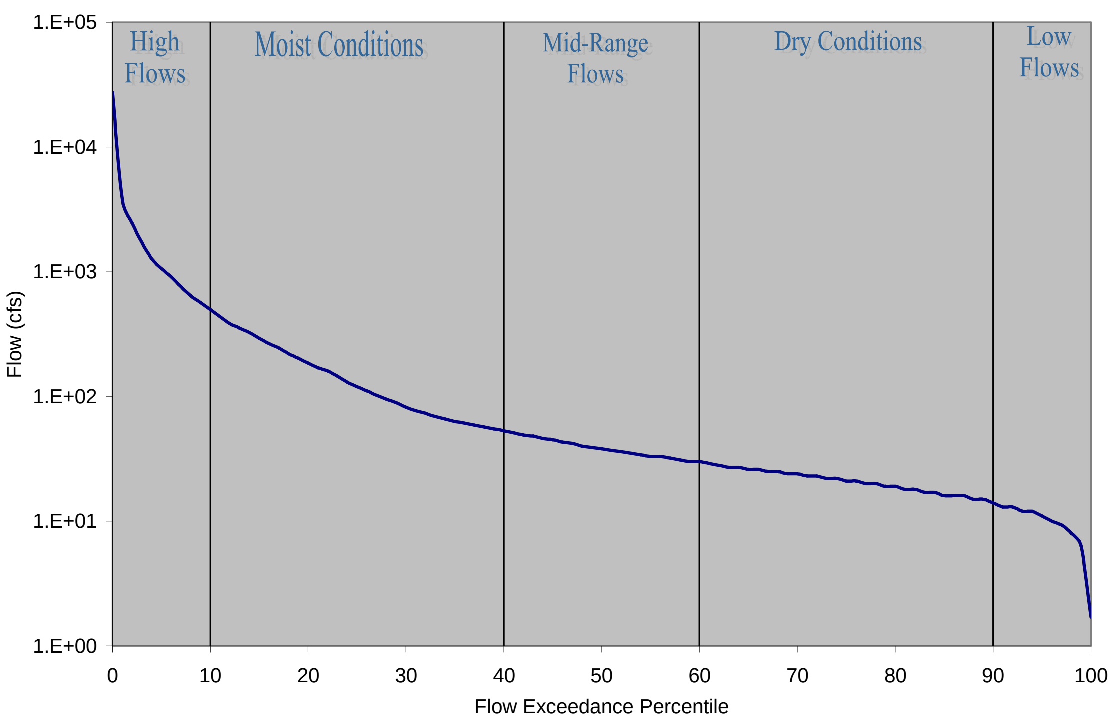


Figure 4-7 Flow Duration Curve for Tahoe Creek (OK311300030070_00)

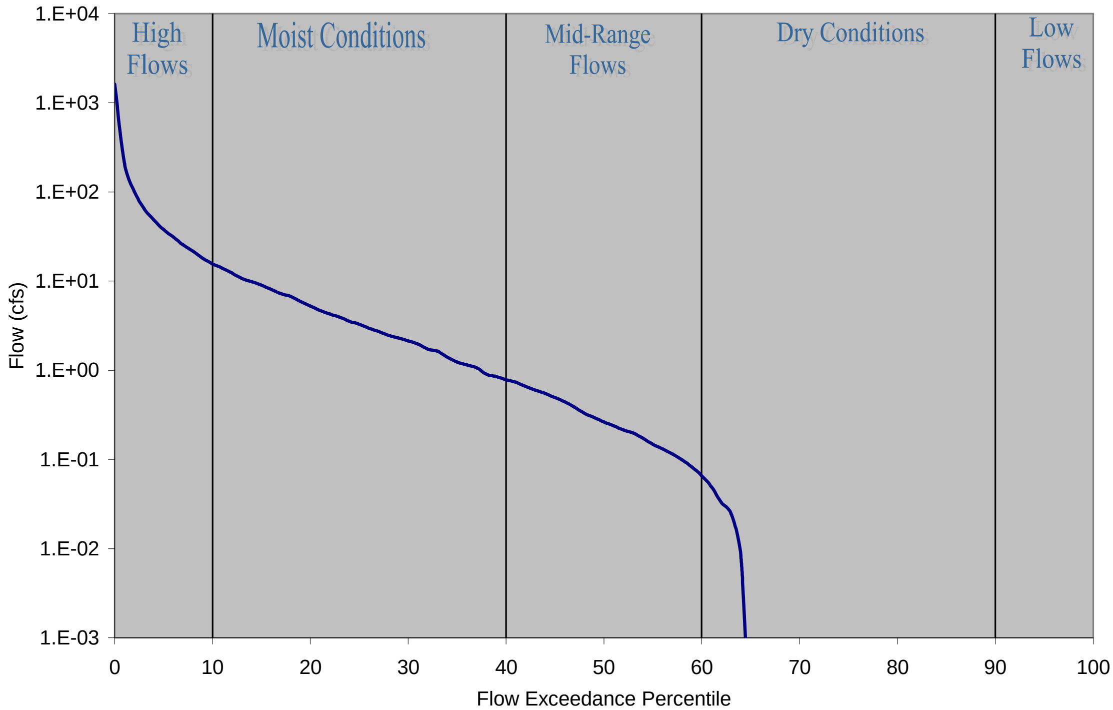


Figure 4-8 Flow Duration Curve for Red River at US 183 (OK311310010010_00)

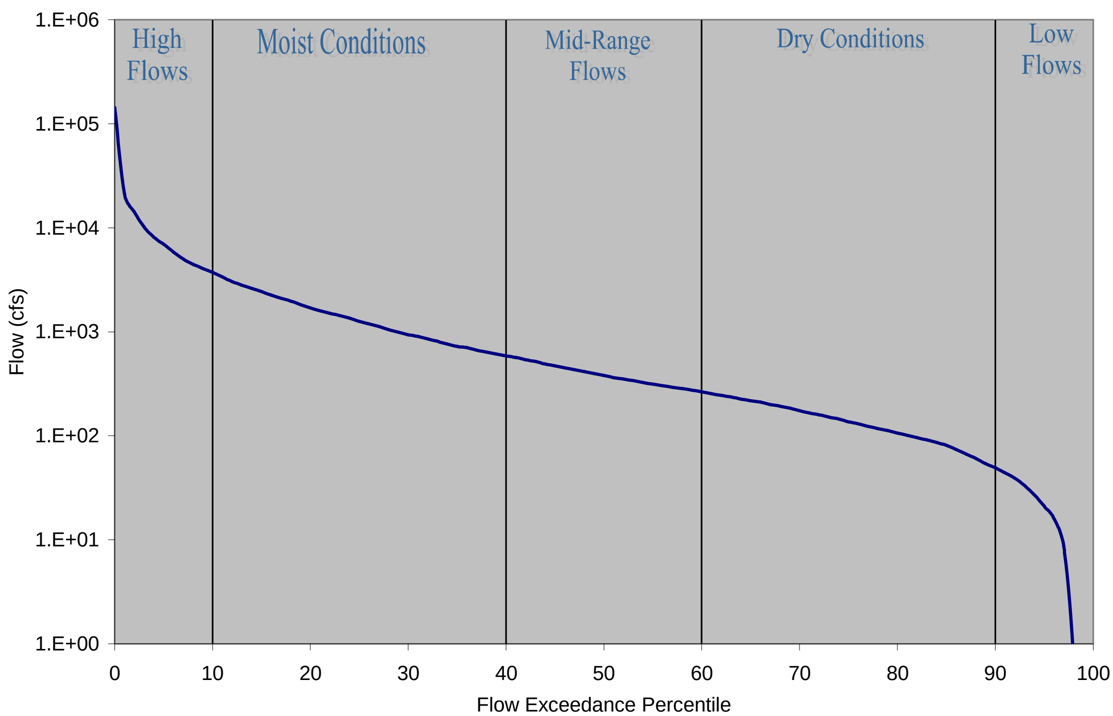


Figure 4-9 Flow Duration Curve for West Cache Creek (OK311310020010_00)

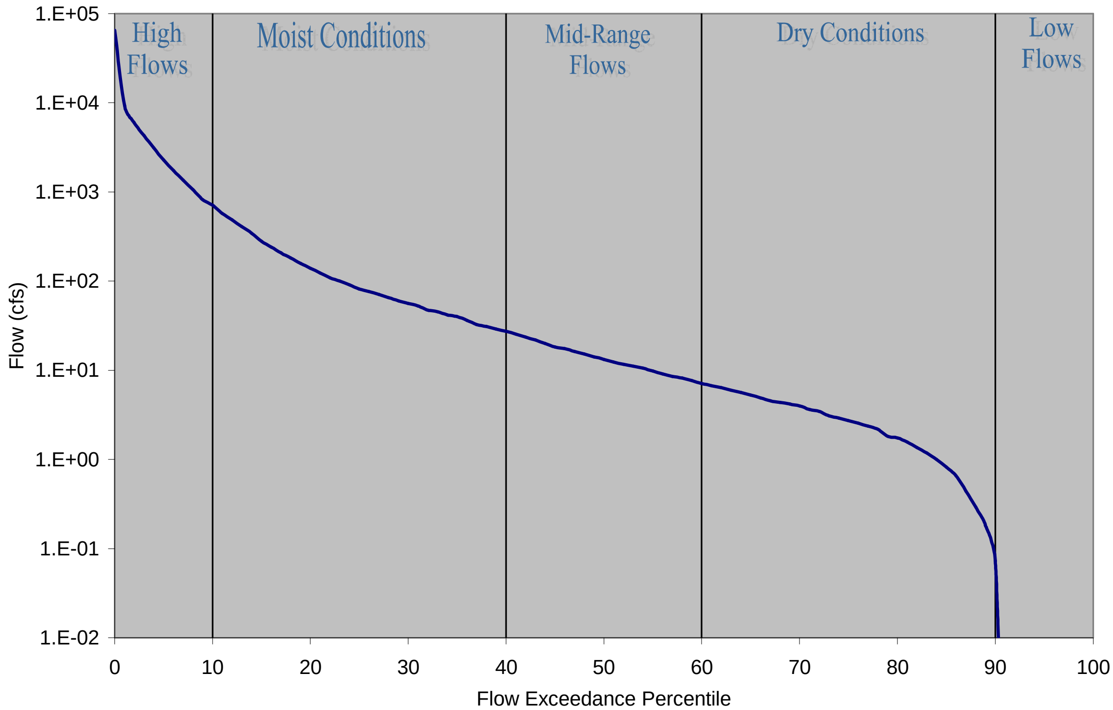
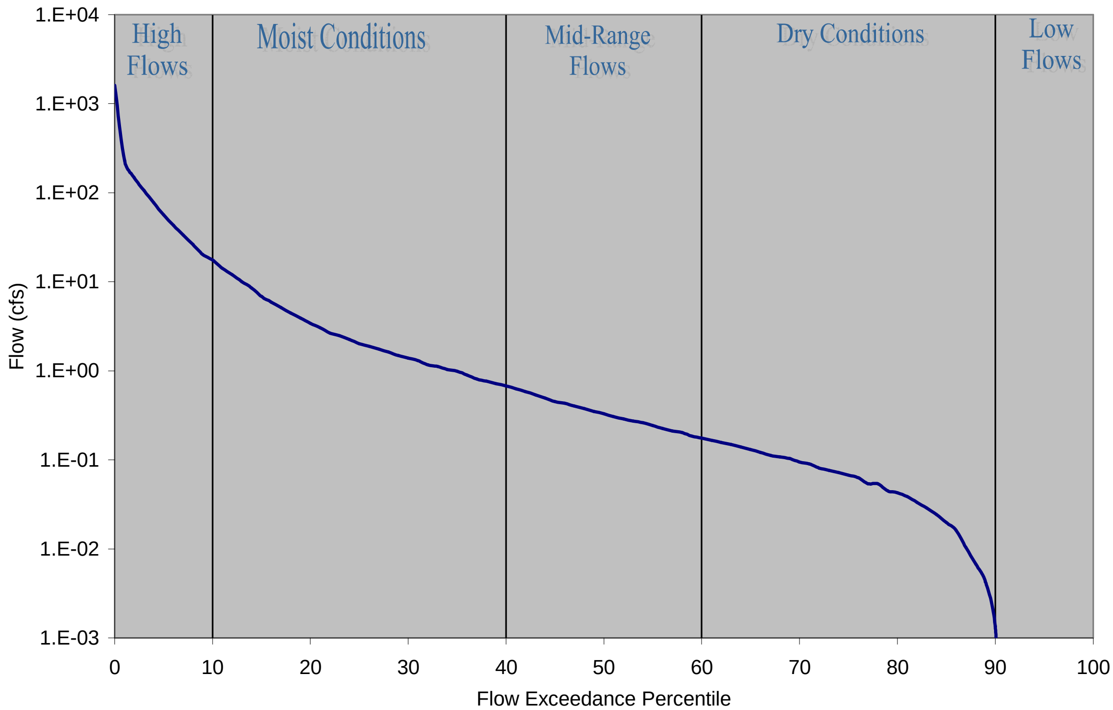


Figure 4-10 Flow Duration Curve for Brush Creek (OK311310030050_00)



Flow duration curves can be subdivided into hydrologic condition classes to facilitate the diagnostic and analytical uses of flow and LDCs. The hydrologic classification scheme utilized in this application is similar to that described by Cleland (2003):

Table 4-1 Hydrologic Classification Scheme

Flow Exceedance Percentile	Hydrologic Condition Class
0-10	High flows
10-40	Moist Conditions
40-60	Mid-Range Conditions
60-90	Dry Conditions
90-100	Low Flows

Flow duration curves are generated using an ODEQ automated application referred to as the bacteria LDC toolbox. A step-by-step procedure on how to generate flow duration curves and flow exceedance percentiles is provided in Appendix C.

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 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.

4.3 Estimating Current Point and Nonpoint Loading

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. Where available, data necessary for this calculation were extracted from each point source's discharge monitoring reports from 1997 through 2006. The 90^{th} 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 (mg)

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.

4.4 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 bacteria loading must be reduced to meet WQSs in the impaired watershed).

Step 1: Generate Bacteria LDCs. LDCs are similar in appearance to flow duration curves; however, the ordinate is expressed in terms of a bacteria load in cfu/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 this 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 percentiles for the time period and season of interest;
- obtaining the water quality data from the primary contact recreation season (May 1 through September 30);
- matching the water quality observations with the flow data from the same date;
- displaying a curve on a plot that represents the allowable load multiply the actual or estimated flow by the WQS for each respective indicator;
- multiplying the flow by the water quality parameter concentration to calculate daily loads; then
- plotting the flow exceedance percentiles and daily load observations in a load duration plot.

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*

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 concentration are paired with flow data and are plotted on the LDC. The fecal coliform load (or the y-value of each point) is calculated by multiplying the fecal coliform concentration (cfu/100 mL) by the instantaneous flow (cubic feet per second [cfs]) 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.

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: Develop LDCs with MOS. An LDC depicting slightly lower estimates than the TMDL is developed to represent the TMDL with MOS. The MOS may be defined explicitly or implicitly. A typical explicit approach would reserve some fraction of the TMDL (*e.g.,* 10%) 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 the TMDLs in this report, an explicit MOS of 10 percent of the TMDL value (10% of the instantaneous water quality criterion) has been selected to slightly reduce assimilative capacity in the watershed. The MOS at any given percent flow exceedance, therefore, is defined as the difference in loading between the TMDL and the TMDL with MOS.

Step 3: Calculate WLA. As previously stated, the pollutant LA for point sources is defined by the WLA. 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.

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. This 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).

WLA for WWTP. WLAs may be set to zero for watersheds with no existing or planned continuous permitted point sources. For watersheds with permitted point sources, WLAs may be derived from NPDES permit limits. A WLA may be calculated for each active NPDES wastewater discharger using a mass balance approach as shown in the equation below. The permitted average flow rate used for each point source discharge and the water quality criterion concentration are used to estimate the WLA for each wastewater facility. All WLA values for each NPDES wastewater discharger are then summed to represent the total WLA for the watershed.

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

Where:

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

Step 4: Calculate LA and WLA for MS4s. 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.

LA = TMDL – MOS - ∑WLA

WLA for MS4s. When there are permitted MS4s in the watershed, WLAs for MS4s will be caluculated based on area prorated LA. This WLA for MS4s may not be the total load allocated for permitted MS4s unless the whole MS4 area is located within the study watershed boundry. However, in most case the study watershed intersects only a portion of the permitted MS4 coverage areas.

Step 5: Estimate WLA Load Reduction. The WLA load reduction 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.

Step 6: Estimate LA Load Reduction. After existing loading estimates are computed for each bacteria 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.

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. Furthermore, TMDLs are derived for all bacteria indicators at any given WQM station placed on the 303(d) list.

To calculate the bacteria load at the WQS, the flow rate at each flow exceedance percentile is multiplied by a unit conversion factor (*24,465,525 ml*s / ft*^{3}**day*) and the criterion specific to each bacteria 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 1st through September 30th) from 1999 to 2003 are paired with the flows measured or estimated in that segment on the same date. Pollutant loads are then calculated by multiplying the measured bacteria concentration by the flow rate and a unit conversion factor of *24,465,525 ml*s / 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 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 for each watershed and bacterial indicator species as the reductions in load required in order that no more than 10 percent of the existing instantaneous water quality observations would exceed the water quality target. This is because for the PBCR use to be supported, criteria for each bacteria indicator must be met in each impaired waterbody.

Table 5-1 presents the percent reductions necessary for each bacteria indicator in each of the impaired waterbodies in the Study Area. Attainment of WQSs in response to TMDL implementation will be based on results measured at each of the WQM stations listed in Table 5-1. Based on this table, the TMDL PRGs for West Lower Mud Creek, Whisky Creek, Cottonwood Creek, Tahoe Creek, and Brush Creek will be based on fecal coliform; the TMDL PRGs for Mud Creek, Cow Creek, East Cache Creek, Red River at US 183, and West Cache Creek will be based on Enterococcus. The PRGs range from 23 to 99 percent.

Table 5-1 TMDL Percent Reductions Required to Meet Water Quality Standards for Impaired Waterbodies in the Lower Red River Watershed

Waterbody ID	WQM Station	Waterbody Name	Percent Reduction Required				
			FC	EC		ENT	
			Instant-aneous	Instant-aneous	Geo-mean	Instant-aneous	Geo-mean
OK311100040010_00	OK311100040010-001AT	Mud Creek	23%			88%	**78%**
OK311100040080_00	OK311100040080G	Lower Mud Creek, West	**55%**				
OK311200000060_00	USGS_07313600	Cow Creek				98%	**88%**
OK311210000140_00	OK311210000140D	Whisky Creek	**44%**				
OK311210000150_00	OK311210000150G	Cottonwood Creek	**79%**				
OK311300010020_00	OK311300010020-001AT	East Cache Creek	40%			98%	**94%**
OK311300030070_00	OK311300030070G	Tahoe Creek	**40%**				
OK311310010010_00	OK311310010010-001AT	Red River at US 183	82%			99%	**83%**
OK311310020010_00	OK311310020010-001AT	West Cache Creek	40%	53%	24%	98%	**93%**
OK311310030050_00	OK311310030050G	Brush Creek	**84%**				

A subset of the LDCs for each impaired waterbody (representing the primary contact recreation season from 1999 through 2003) are shown in Figures 5-1 through 5-10. While some waterbodies may be listed for multiple bacterial indicators, only one LDC for each waterbody is presented in Figures 5-1 through 5-10 – the LDC for the bacterial indicator that is highlighted by bold text in Table 5-1. In other words, Figures 5-1 through 5-10 display a LDC for each waterbody based on the bacterial indicator that represents the most conservative PRG. The LDCs for the other bacterial indicators that require TMDLs are presented in Subsection 5.7 of this report.

The LDC for Mud Creek segment OK311100040010_00 (Figure 5-1) is based on Enterococcus bacteria measurements during primary contact recreation season at WQM station OK311100040010-001AT (Mud Creek near Courtney, OK). The LDC indicates that Enterococcus levels sometimes exceed the instantaneous water quality criteria under dry, moist, and mid-range hydrologic conditions, with the frequency of exceedance increasing with flow, an indication of nonpoint sources or a combination of point and nonpoint sources.

The LDC for West Lower Mud Creek segment OK311100040080_00 (Figure 5-2) is based on fecal coliform bacteria measurements during primary contact recreation season at WQM station OK311100040080G. Fecal coliform measurements collected during secondary contact recreation season (October – April) are also displayed on the figure, although the load at the secondary contact recreation criterion is not shown. The PRG is calculated so the measurements under primary contact recreation season are met; however, this percent reduction is sufficient to ensure that secondary contact recreation criteria are also met. The LDC indicates that fecal coliform levels exceed the instantaneous water quality criteria under mid-range flow and dry hydrologic conditions, possibly indicative of a combination of point and nonpoint sources.

The LDC for Cow Creek segment OK311200000060_00 (Figure 5-3) is based on Enterococcus bacteria measurements during primary contact recreation season at USGS gage 07313600 (Cow Creek at SH 5 at Waurika, OK). The LDC indicates that Enterococcus levels sometimes exceed the instantaneous water quality criteria under moist, dry, and mid-range flow conditions, but the level of exceedance tends to increase with flow, indicating nonpoint sources.

The LDC for Whisky Creek segment OK311210000140_00 (Figure 5-4) is based on fecal coliform bacteria measurements during primary contact recreation season at WQM station OK311210000140D. Fecal coliform measurements collected during secondary contact recreation season (October – April) are also displayed on the figure, although the load at the secondary contact recreation criterion is not shown. The PRG is calculated so the measurements under primary contact recreation season are met; however, this percent reduction is sufficient to ensure that secondary contact recreation criteria are also met. The LDC indicates that fecal coliform levels exceed the instantaneous water quality criteria under moist and dry hydrologic conditions, indicative of nonpoint sources or a combination of point and nonpoint sources.

The LDC for Cottonwood Creek segment OK311210000150_00 (Figure 5-5) is based on fecal coliform bacteria measurements during primary contact recreation season at WQM station OK311210000150G. Fecal coliform measurements collected during secondary contact recreation season (October – April) are also displayed on the figure, although the load at the secondary contact recreation criterion is not shown. The PRG is calculated so the measurements under primary contact recreation season are met; however, this percent reduction is sufficient to ensure that secondary contact recreation criteria are also met. The LDC indicates that fecal coliform levels exceed the instantaneous water quality criteria under low flow, dry, and mid-range hydrologic conditions, indicative of a combination of point and nonpoint sources.

The LDC for East Cache Creek segment OK311300010020_00 (Figure 5-6) is based on Enterococcus bacteria measurements during primary contact recreation season at WQM station OK311300010020-001AT (East Cache Creek near Walters, OK). Fecal coliform measurements collected during secondary contact recreation season (October – April) are also displayed on the figure, although the load at the secondary contact recreation criterion is not shown. The PRG is calculated so the measurements under primary contact recreation season are met; however, this percent reduction is sufficient to ensure that secondary contact recreation criteria are also met. The LDC indicates that Enterococcus levels sometimes exceed the instantaneous water quality criteria under all hydrologic conditions, possibly indicating a combination of point and nonpoint sources.

The LDC for Tahoe Creek segment OK311300030070_00 (Figure 5-7) is based on fecal coliform bacteria measurements during primary contact recreation season at WQM station OK311300030070G. Fecal coliform measurements collected during secondary contact recreation season (October – April) are also displayed on the figure, although the load at the secondary contact recreation criterion is not shown. The PRG is calculated so the measurements under primary contact recreation season are met; however, this percent reduction is sufficient to ensure that secondary contact recreation criteria are also met. The LDC indicates that fecal coliform levels exceed the instantaneous water quality criteria under high flow, mid-range flow, and dry hydrologic conditions, indicative of nonpoint sources.

The LDC for Red River segment OK311310010010_00 (Figure 5-8) is based on Enterococcus bacteria measurements during primary contact recreation season at WQM station OK311310010010-001AT (Red River at US 183, Davidson). The LDC indicates that Enterococcus levels sometimes exceed the instantaneous water quality criteria under all hydrologic conditions, possibly indicating a combination of point and nonpoint sources.

The LDC for West Cache Creek segment OK311310020010_00 (Figure 5-9) is based on Enterococcus bacteria measurements during primary contact recreation season at OK311310020010-001AT (West Cache Creek, SH 5B, Taylor). The LDC indicates that Enterococcus levels sometimes exceed the instantaneous water quality criteria under all hydrologic conditions, indicating nonpoint sources.

The LDC for Brush Creek segment OK311310030050_00 (Figure 5-10) is based on fecal coliform bacteria measurements during primary contact recreation season at WQM station OK311310030050G. Fecal coliform measurements collected during secondary contact recreation season (October – April) are also displayed on the figure, although the load at the secondary contact recreation criterion is not shown. The PRG is calculated so the measurements under primary contact recreation season are met; however, this percent reduction is sufficient to ensure that secondary contact recreation criteria are also met. The LDC indicates that fecal coliform levels exceed the instantaneous water quality criteria under moist and low flow conditions, with the magnitude of exceedance increasing with flow, indicative of nonpoint sources.

Figure 5-1 Load Duration Curve for Enterococci in Mud Creek (OK311100040010_00)

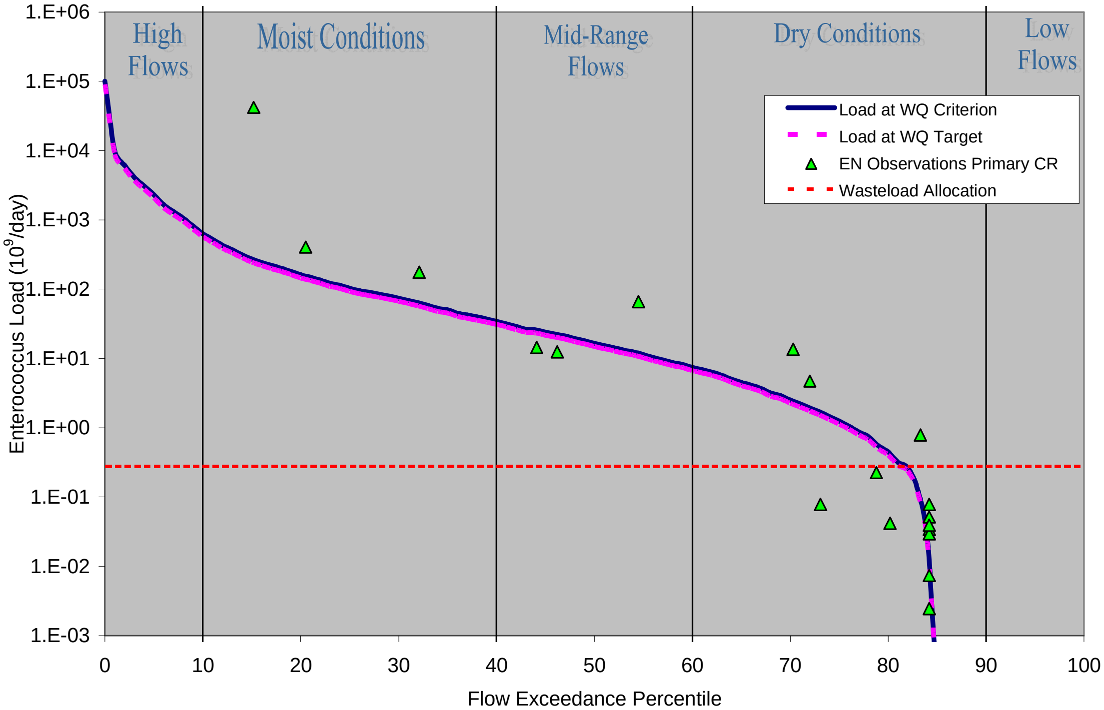
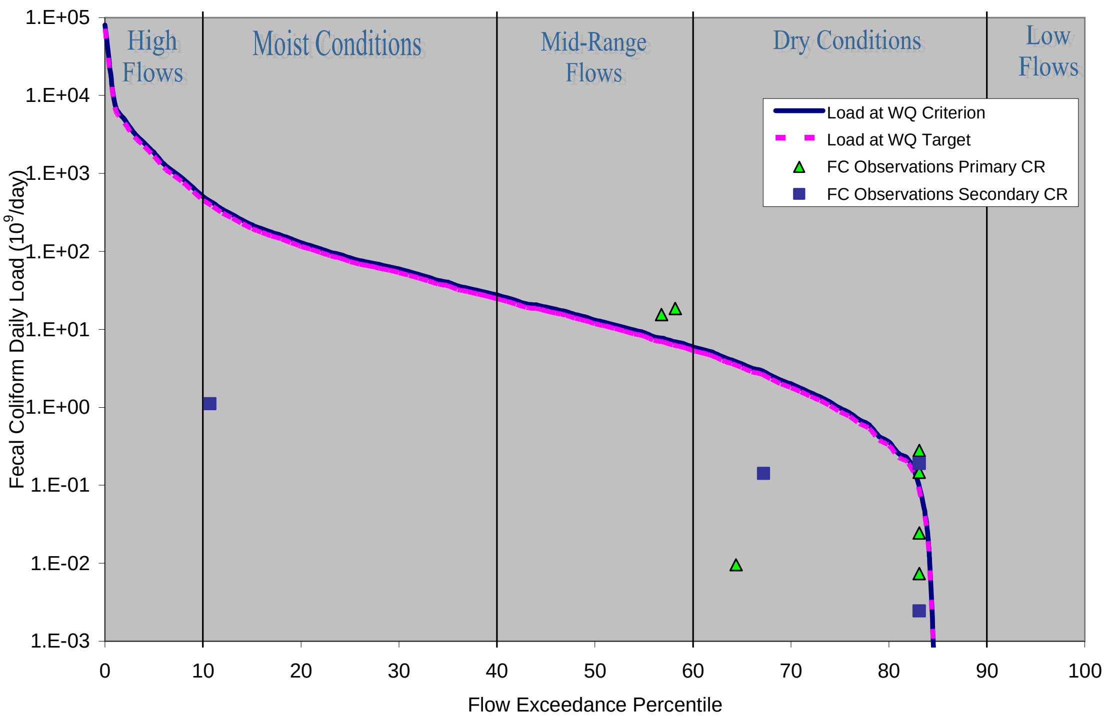
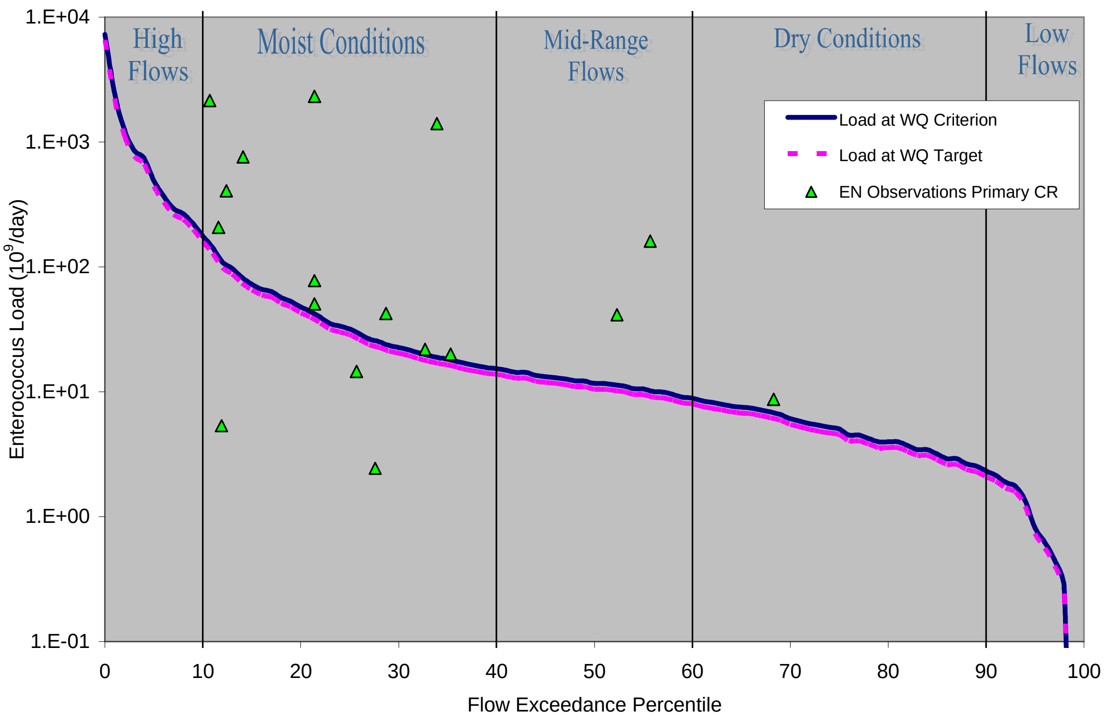


Figure 5-2 Load Duration Curve for Fecal Coliform in Lower West Mud Creek (OK311100040080_00)



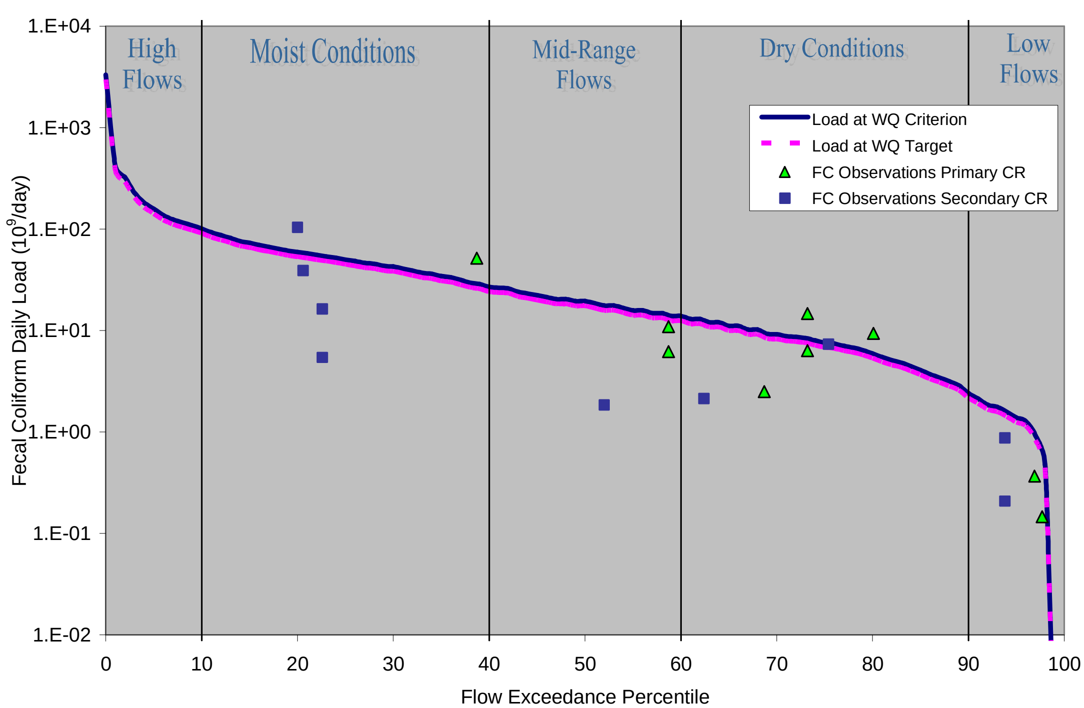
Note: There is no wasteload allocation for this waterbody.

Figure 5-3 Load Duration Curve for Enterococci in Cow Creek (OK311200000060_00)



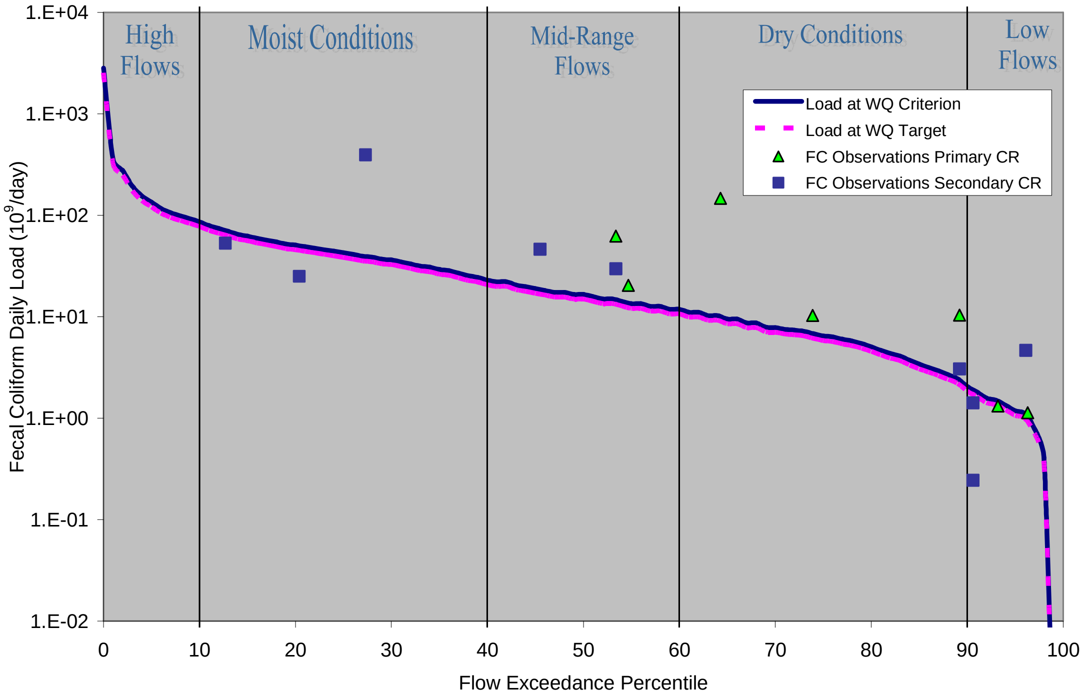
Note: There is no wasteload allocation for this waterbody.

Figure 5-4 Load Duration Curve for Fecal Coliform in Whisky Creek (OK311210000140_00)



Note: There is no wasteload allocation for this waterbody.

Figure 5-5 Load Duration Curve for Fecal Coliform in Cottonwood Creek (OK311210000150_00)



Note: There is no wasteload allocation for this waterbody.

Figure 5-6 Load Duration Curve for Enterococci in East Cache Creek (OK311300010020_00)

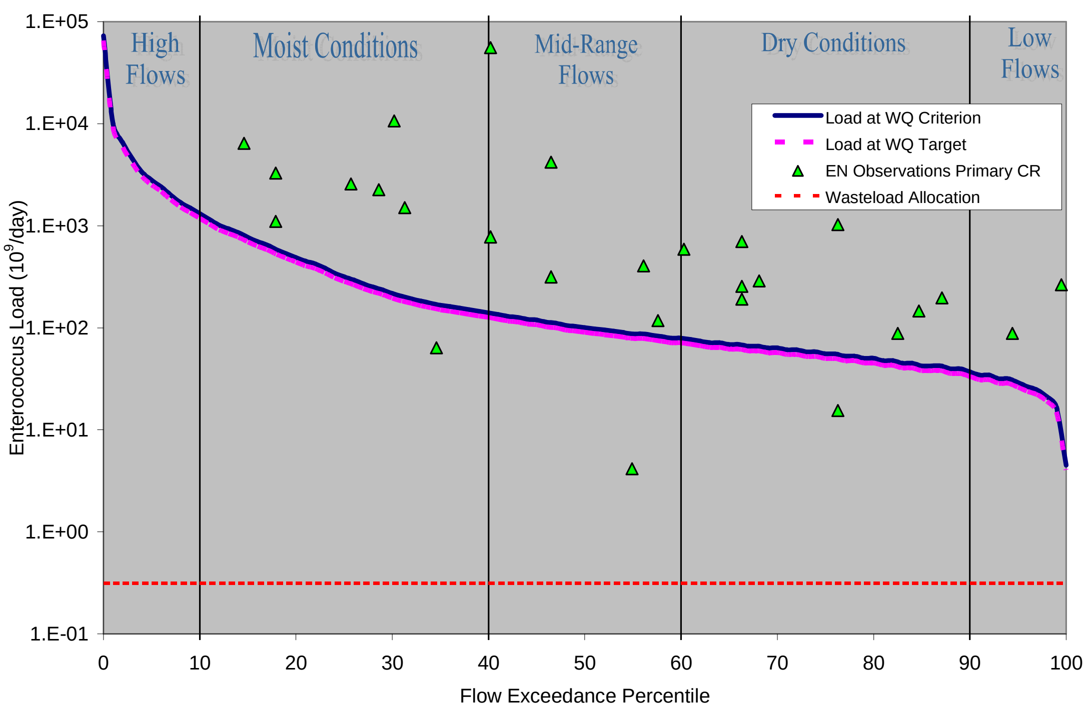
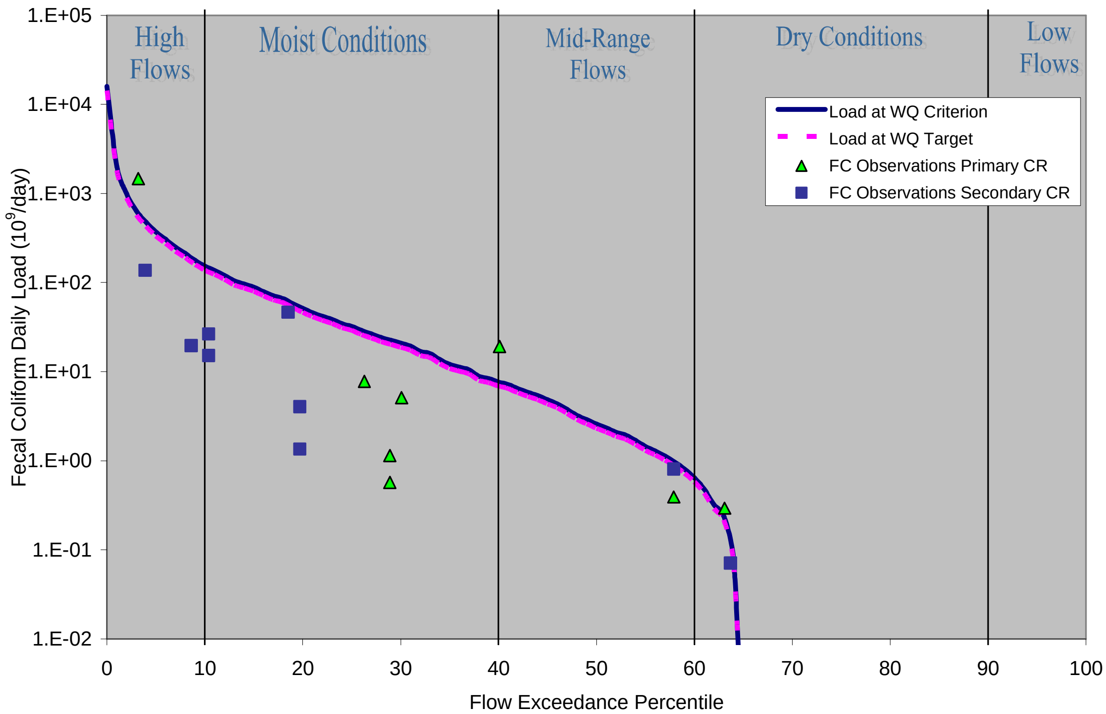


Figure 5-7 Load Duration Curve for Fecal Coliform in Tahoe Creek (OK311300030070_00)



Note: There is no wasteload allocation for this waterbody.

Figure 5-8 Load Duration Curve for Enterococci in Red River at US 183 (OK311310010010_00)

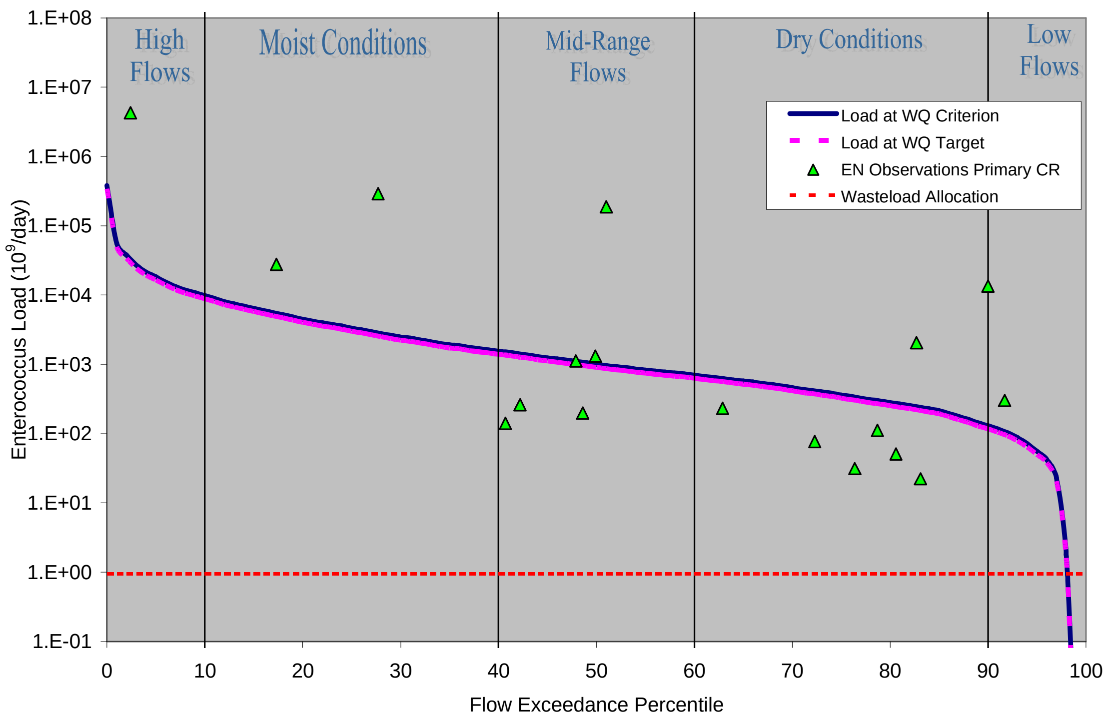
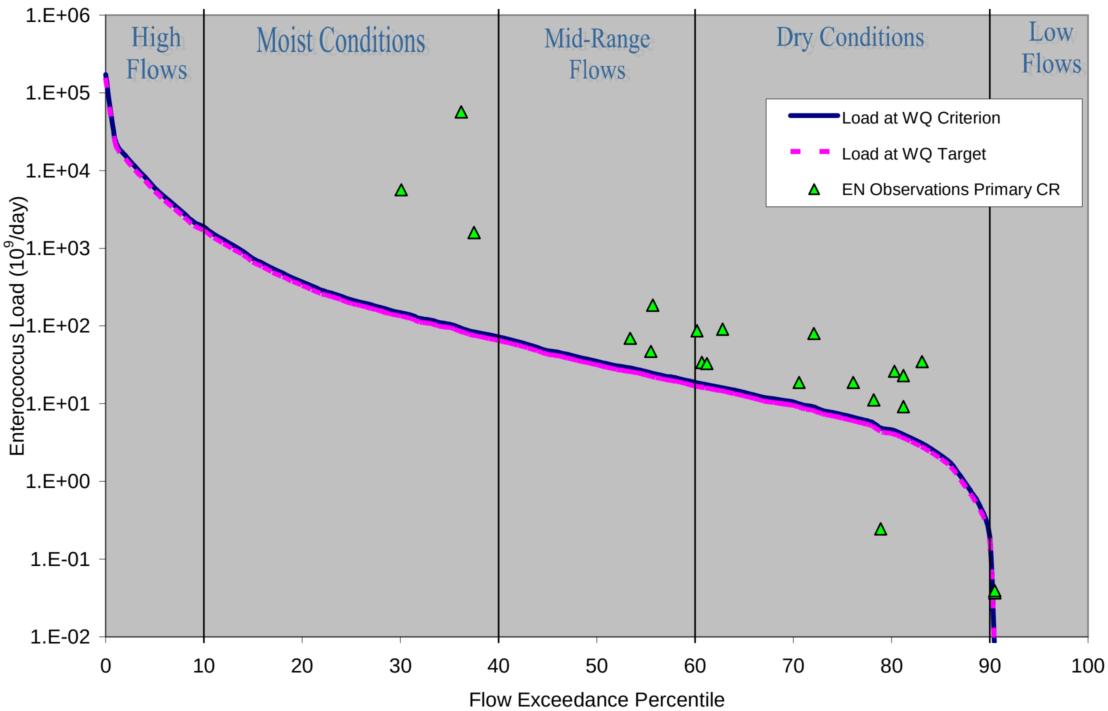
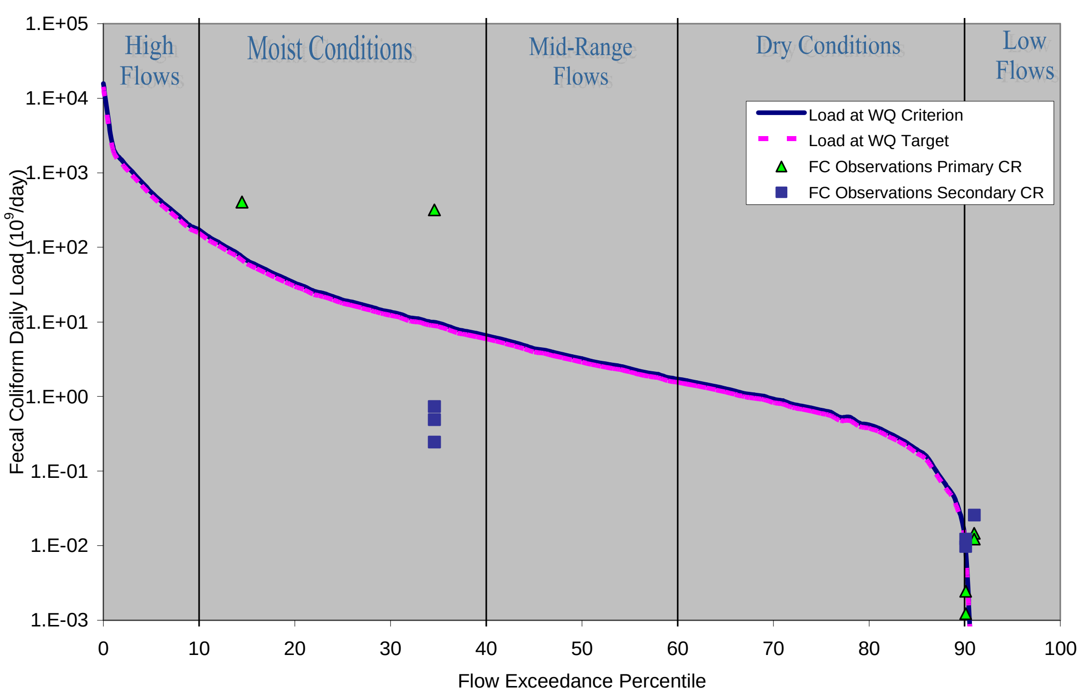


Figure 5-9 Load Duration Curve for Enterococci in West Cache Creek (OK311310020010_00)



Note: There is no wasteload allocation for this waterbody.

Figure 5-10 Load Duration Curve for Fecal Coliform in Brush Creek (OK311310030050_00)



Note: There is no wasteload allocation for this waterbody.

5.2 Wasteload Allocation

NPDES-permitted facilities are allocated a daily wasteload calculated as their permitted daily average discharge flow rate multiplied by the instream single-sample water quality criterion. In other words, the facilities are required to meet instream criteria in their discharge. Table 5-2 summarizes the WLA for the NPDES-permitted facilities within the Lower Red River at US 183 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/100ml 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 5-2 Wasteload Allocations* for NPDES-Permitted Facilities

Waterbody ID	NPDES Permit No.	Name	Design Flow (mgd)	Wasteload Allocation (cfu/day)		
				Fecal Coliform	*E. Coli*	Enterococci
OK311100040010_00 Mud Creek	OKG580033	Town of Ringling	0.22	1.67E+09	1.05E+09	2.75E+08
OK311300010020_00 East Cache Creek	OK0032514	Town of Temple	0.250	1.89E+09	1.19E+09	3.12E+08
OK311310010010_00 Red River at US 183	OK0022578	Town of Devol	0.060	4.54E+08	2.86E+08	7.50E+07
	OK0027189	City of Frederick - Ind Park	0.150	1.14E+09	7.15E+08	1.87E+08
	OK0027171	City of Frederick - East WTF	0.550	4.16E+09	2.62E+09	6.87E+08

* WLA calculations for facilities outside of Oklahoma are not enforceable

Permitted stormwater discharges are considered point sources. There are no permitted MS4s within the study area; therefore, a specific wasteload allocation is not calculated for MS4s.

5.3 Load Allocation

As discussed in Section 3, nonpoint source bacteria loading to the receiving streams of 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 stream segment are calculated as the difference between the TMDL, MOS, and WLA, as follows:

LA = TMDL - ∑WLA - 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 TMDLs established in this report adhere to the seasonal application of the Oklahoma WQS, which limits the PBCR use to the period of May 1^{st} through September 30^{th}. 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 uncertainty 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 uncertainty, then the MOS is considered explicit.

For the explicit MOS the water quality target was set at 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. The net effect of the TMDL with MOS is that the assimilative capacity or allowable pollutant loading of each waterbody is slightly reduced. These TMDLs incorporate an explicit MOS by using a curve representing 90 percent of the TMDL as the average MOS. The MOS at any given percent flow exceedance, therefore, can be defined as the difference in loading between the TMDL and the TMDL with MOS. The use of instream bacteria concentrations to estimate existing loading is another conservative element utilized in these TMDLs that can be recognized as an implicit MOS. 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.

5.6 TMDL Calculations

The bacteria TMDLs for the 303(d)-listed WQM stations 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 uncertainty 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 stream segment the TMDLs presented in this report are expressed as a percent reduction across the full range of flow conditions. The TMDL, WLA, LA, and MOS will vary with flow condition, and are calculated at every 5^{th} flow interval percentile (Tables 5-3 through

5-13). For illustrative purposes, the TMDL, WLA, LA, and MOS are calculated for the median flow at each site in Table 5-3. The WLA component of each TMDL is the sum of all WLAs within the contributing watershed of each WQM station. The sum of the WLAs can be represented as a single line below the LDC. The LDC and the simple equation of:

$$\textbf{\textit{Average LA = average TMDL – MOS -}} \sum \textbf{\textit{WLA}}$$

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. LDCs do not display a specific percentage of the bacteria load assigned to MS4s. The allocation for MS4s will be expressed as a PRG. Where there are no continuous point sources the WLA is zero. The LDCs and TMDL calculations for additional bacterial indicators are provided in Subsection 5.7.

Table 5-3 TMDL Summary Examples

Waterbody ID	WQM Station	Waterbody Name	Indicator Bacteria Species	TMDL† (cfu/day)	WLA† (cfu/day)	LA† (cfu/day)	MOS† (cfu/day)
OK311100040010_00	OK311100040010-001AT	Mud Creek	ENT	1.65E+10	2.75E+08	1.46E+10	1.65E+09
OK311100040080_00	OK311100040080G	Lower West Mud Creek	FC	1.31E+10	0	1.18E+10	1.31E+09
OK311200000060_00	USGS_07313600	Cow Creek	ENT	1.16E+10	0	1.05E+10	1.16E+09
OK311210000140_00	OK311210000140D	Whisky Creek	FC	1.94E+10	0	1.75E+10	1.94E+09
OK311210000150_00	OK311210000150G	Cottonwood Creek	FC	1.66E+10	0	1.49E+10	1.66E+09
OK311300010020_00	OK311300010020-001AT	East Cache Creek	ENT	1.00E+11	3.12E+08	9.01E+10	1.00E+10
OK311300030070_00	OK311300030070G	Tahoe Creek	FC	2.57E+09	0	2.31E+09	2.57E+08
OK311310010010_00	OK311310010010-001AT	Red River at US 183	ENT	1.00E+12	9.49E+08	9.03E+11	1.00E+11
OK311310020010_00	OK311310020010-001AT	West Cache Creek	ENT	3.50E+10	0	3.15E+10	3.50E+09
OK311310030050_00	OK311310030050G	Brush Creek	FC	3.21E+09	0	2.89E+09	3.21E+08

† Derived for illustrative purposes at the median flow value

* WLA calculations for facilities outside of Oklahoma are not enforceable

Table 5-4 Enterococci TMDL Calculations for Mud Creek (OK311100040010_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	37,800	9.99E+13	2.75E+08	8.99E+13	9.99E+12
5	870	2.30E+12	2.75E+08	2.07E+12	2.30E+11
10	239	6.30E+11	2.75E+08	5.67E+11	6.30E+10
15	103	2.72E+11	2.75E+08	2.45E+11	2.72E+10
20	61	1.61E+11	2.75E+08	1.45E+11	1.61E+10
25	39	1.03E+11	2.75E+08	9.25E+10	1.03E+10
30	28	7.40E+10	2.75E+08	6.63E+10	7.40E+09
35	19	5.02E+10	2.75E+08	4.49E+10	5.02E+09
40	13	3.43E+10	2.75E+08	3.06E+10	3.43E+09
45	9.1	2.40E+10	2.75E+08	2.14E+10	2.40E+09
50	6.3	1.65E+10	2.75E+08	1.46E+10	1.65E+09
55	4.3	1.14E+10	2.75E+08	9.95E+09	1.14E+09
60	2.8	7.40E+09	2.75E+08	6.38E+09	7.40E+08
65	1.7	4.49E+09	2.75E+08	3.77E+09	4.49E+08
70	0.95	2.51E+09	2.75E+08	1.98E+09	2.51E+08
75	0.47	1.24E+09	2.75E+08	8.43E+08	1.24E+08
80	0.17	4.49E+08	2.75E+08	1.29E+08	4.49E+07
85	0	3.05E+08	2.75E+08	0	3.05E+07
90	0	3.05E+08	2.75E+08	0	3.05E+07
95	0	3.05E+08	2.75E+08	0	3.05E+07
100	0	3.05E+08	2.75E+08	0	3.05E+07

Table 5-5 Fecal Coliform TMDL Calculations for Lower West Mud Creek (OK311100040080_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	8,176	8.00E+13	0	7.20E+13	8.00E+12
5	188	1.84E+12	0	1.66E+12	1.84E+11
10	52	5.05E+11	0	4.55E+11	5.05E+10
15	22	2.18E+11	0	1.96E+11	2.18E+10
20	13	1.29E+11	0	1.16E+11	1.29E+10
25	8.4	8.26E+10	0	7.43E+10	8.26E+09
30	6.1	5.93E+10	0	5.33E+10	5.93E+09
35	4.1	4.02E+10	0	3.62E+10	4.02E+09
40	2.8	2.75E+10	0	2.48E+10	2.75E+09
45	2.0	1.93E+10	0	1.73E+10	1.93E+09
50	1.3	1.31E+10	0	1.18E+10	1.31E+09
55	0.93	9.10E+09	0	8.19E+09	9.10E+08
60	0.61	5.93E+09	0	5.33E+09	5.93E+08
65	0.37	3.60E+09	0	3.24E+09	3.60E+08
70	0.20	1.99E+09	0	1.79E+09	1.99E+08
75	0.10	9.74E+08	0	8.76E+08	9.74E+07
80	0.04	3.60E+08	0	3.24E+08	3.60E+07
85	0	0	0	0	0
90	0	0	0	0	0
95	0	0	0	0	0
100	0	0	0	0	0

Table 5-6 Enterococci TMDL Calculations for Cow Creek (OK311200000060_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	2,750	7.27E+12	0	6.54E+12	7.27E+11
5	185	4.88E+11	0	4.39E+11	4.88E+10
10	67	1.76E+11	0	1.58E+11	1.76E+10
15	27	7.24E+10	0	6.52E+10	7.24E+09
20	18	4.76E+10	0	4.28E+10	4.76E+09
25	12	3.17E+10	0	2.85E+10	3.17E+09
30	8.6	2.26E+10	0	2.04E+10	2.26E+09
35	6.9	1.82E+10	0	1.64E+10	1.82E+09
40	5.8	1.53E+10	0	1.38E+10	1.53E+09
45	5.0	1.32E+10	0	1.19E+10	1.32E+09
50	4.4	1.16E+10	0	1.05E+10	1.16E+09
55	4.0	1.05E+10	0	9.46E+09	1.05E+09
60	3.4	8.88E+09	0	7.99E+09	8.88E+08
65	2.8	7.50E+09	0	6.75E+09	7.50E+08
70	2.3	6.08E+09	0	5.47E+09	6.08E+08
75	1.9	5.02E+09	0	4.52E+09	5.02E+08
80	1.5	3.96E+09	0	3.57E+09	3.96E+08
85	1.2	3.17E+09	0	2.85E+09	3.17E+08
90	0.88	2.32E+09	0	2.09E+09	2.32E+08
95	0.31	8.14E+08	0	7.32E+08	8.14E+07
100	0	0	0	0	0

Table 5-7 Fecal Coliform TMDL Calculations for Whisky Creek (OK311210000140_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	338	3.31E+12	0	2.98E+12	3.31E+11
5	16	1.58E+11	0	1.42E+11	1.58E+10
10	10	1.01E+11	0	9.08E+10	1.01E+10
15	7.5	7.31E+10	0	6.58E+10	7.31E+09
20	6.1	5.94E+10	0	5.35E+10	5.94E+09
25	5.1	5.00E+10	0	4.50E+10	5.00E+09
30	4.4	4.26E+10	0	3.83E+10	4.26E+09
35	3.5	3.43E+10	0	3.08E+10	3.43E+09
40	2.7	2.69E+10	0	2.42E+10	2.69E+09
45	2.3	2.22E+10	0	2.00E+10	2.22E+09
50	2.0	1.94E+10	0	1.75E+10	1.94E+09
55	1.6	1.57E+10	0	1.42E+10	1.57E+09
60	1.4	1.39E+10	0	1.25E+10	1.39E+09
65	1.1	1.11E+10	0	1.00E+10	1.11E+09
70	0.94	9.17E+09	0	8.25E+09	9.17E+08
75	0.78	7.59E+09	0	6.83E+09	7.59E+08
80	0.61	5.93E+09	0	5.33E+09	5.93E+08
85	0.42	4.07E+09	0	3.67E+09	4.07E+08
90	0.25	2.41E+09	0	2.17E+09	2.41E+08
95	0.14	1.39E+09	0	1.25E+09	1.39E+08
100	0	0	0	0	0

Table 5-8 Fecal Coliform TMDL Calculations for Cottonwood Creek (OK311210000150_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	288	2.82E+12	0	2.54E+12	2.82E+11
5	14	1.35E+11	0	1.21E+11	1.35E+10
10	8.8	8.61E+10	0	7.75E+10	8.61E+09
15	6.4	6.23E+10	0	5.61E+10	6.23E+09
20	5.2	5.07E+10	0	4.56E+10	5.07E+09
25	4.4	4.27E+10	0	3.84E+10	4.27E+09
30	3.7	3.63E+10	0	3.27E+10	3.63E+09
35	3.0	2.92E+10	0	2.63E+10	2.92E+09
40	2.3	2.29E+10	0	2.06E+10	2.29E+09
45	1.9	1.90E+10	0	1.71E+10	1.90E+09
50	1.7	1.66E+10	0	1.49E+10	1.66E+09
55	1.4	1.34E+10	0	1.21E+10	1.34E+09
60	1.2	1.18E+10	0	1.07E+10	1.18E+09
65	0.97	9.48E+09	0	8.53E+09	9.48E+08
70	0.80	7.82E+09	0	7.04E+09	7.82E+08
75	0.66	6.48E+09	0	5.83E+09	6.48E+08
80	0.52	5.06E+09	0	4.55E+09	5.06E+08
85	0.35	3.40E+09	0	3.06E+09	3.40E+08
90	0.21	2.05E+09	0	1.85E+09	2.05E+08
95	0.12	1.18E+09	0	1.07E+09	1.18E+08
100	0	0	0	0	0

Table 5-9 Enterococci TMDL Calculations for East Cache Creek (OK311300010020_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	27,500	7.27E+13	3.12E+08	6.54E+13	7.27E+12
5	1,060	2.80E+12	3.12E+08	2.52E+12	2.80E+11
10	498	1.31E+12	3.12E+08	1.18E+12	1.31E+11
15	292	7.72E+11	3.12E+08	6.94E+11	7.72E+10
20	185	4.88E+11	3.12E+08	4.39E+11	4.88E+10
25	120	3.16E+11	3.12E+08	2.84E+11	3.16E+10
30	82	2.17E+11	3.12E+08	1.95E+11	2.17E+10
35	63	1.66E+11	3.12E+08	1.50E+11	1.66E+10
40	53	1.40E+11	3.12E+08	1.26E+11	1.40E+10
45	45	1.19E+11	3.12E+08	1.07E+11	1.19E+10
50	38	1.00E+11	3.12E+08	9.01E+10	1.00E+10
55	33	8.72E+10	3.12E+08	7.82E+10	8.72E+09
60	30	7.93E+10	3.12E+08	7.10E+10	7.93E+09
65	26	6.87E+10	3.12E+08	6.15E+10	6.87E+09
70	24	6.34E+10	3.12E+08	5.68E+10	6.34E+09
75	21	5.55E+10	3.12E+08	4.96E+10	5.55E+09
80	19	5.02E+10	3.12E+08	4.49E+10	5.02E+09
85	16	4.23E+10	3.12E+08	3.77E+10	4.23E+09
90	14	3.70E+10	3.12E+08	3.30E+10	3.70E+09
95	11	2.91E+10	3.12E+08	2.58E+10	2.91E+09
100	1.7	4.49E+09	3.12E+08	3.73E+09	4.49E+08

Table 5-10 Fecal Coliform TMDL Calculations for Tahoe Creek (OK311300030070_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	1,626	1.59E+13	0	1.43E+13	1.59E+12
5	38	3.70E+11	0	3.33E+11	3.70E+10
10	16	1.53E+11	0	1.37E+11	1.53E+10
15	9.0	8.84E+10	0	7.96E+10	8.84E+09
20	5.3	5.14E+10	0	4.63E+10	5.14E+09
25	3.3	3.21E+10	0	2.89E+10	3.21E+09
30	2.1	2.09E+10	0	1.88E+10	2.09E+09
35	1.2	1.21E+10	0	1.08E+10	1.21E+09
40	0.78	7.63E+09	0	6.87E+09	7.63E+08
45	0.49	4.82E+09	0	4.34E+09	4.82E+08
50	0.26	2.57E+09	0	2.31E+09	2.57E+08
55	0.15	1.45E+09	0	1.30E+09	1.45E+08
60	0.07	6.43E+08	0	5.79E+08	6.43E+07
65	0	0	0	0	0
70	0	0	0	0	0
75	0	0	0	0	0
80	0	0	0	0	0
85	0	0	0	0	0
90	0	0	0	0	0
95	0	0	0	0	0
100	0	0	0	0	0

Table 5-11 Enterococci TMDL Calculations for Red River at US 183 (OK311310010010_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	144,000	3.80E+14	9.49E+08	3.42E+14	3.80E+13
5	6,942	1.83E+13	9.49E+08	1.65E+13	1.83E+12
10	3,720	9.83E+12	9.49E+08	8.85E+12	9.83E+11
15	2,430	6.42E+12	9.49E+08	5.78E+12	6.42E+11
20	1,690	4.47E+12	9.49E+08	4.02E+12	4.47E+11
25	1,260	3.33E+12	9.49E+08	3.00E+12	3.33E+11
30	936	2.47E+12	9.49E+08	2.22E+12	2.47E+11
35	723	1.91E+12	9.49E+08	1.72E+12	1.91E+11
40	585	1.55E+12	9.49E+08	1.39E+12	1.55E+11
45	469	1.24E+12	9.49E+08	1.11E+12	1.24E+11
50	380	1.00E+12	9.49E+08	9.03E+11	1.00E+11
55	314	8.30E+11	9.49E+08	7.46E+11	8.30E+10
60	264	6.98E+11	9.49E+08	6.27E+11	6.98E+10
65	217	5.74E+11	9.49E+08	5.16E+11	5.74E+10
70	174	4.60E+11	9.49E+08	4.13E+11	4.60E+10
75	136	3.59E+11	9.49E+08	3.22E+11	3.59E+10
80	106	2.80E+11	9.49E+08	2.51E+11	2.80E+10
85	81	2.14E+11	9.49E+08	1.92E+11	2.14E+10
90	49	1.30E+11	9.49E+08	1.16E+11	1.30E+10
95	21	5.55E+10	9.49E+08	4.90E+10	5.55E+09
100	0	1.05E+09	9.49E+08	0.00E+00	1.05E+08

Table 5-12 Enterococci TMDL Calculations for West Cache Creek (OK311310020010_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	65,225	1.72E+14	0	1.55E+14	1.72E+13
5	2,276	6.01E+12	0	5.41E+12	6.01E+11
10	711	1.88E+12	0	1.69E+12	1.88E+11
15	279	7.37E+11	0	6.63E+11	7.37E+10
20	140	3.70E+11	0	3.33E+11	3.70E+10
25	82	2.16E+11	0	1.94E+11	2.16E+10
30	56	1.49E+11	0	1.34E+11	1.49E+10
35	40	1.06E+11	0	9.51E+10	1.06E+10
40	27	7.20E+10	0	6.48E+10	7.20E+09
45	18	4.80E+10	0	4.32E+10	4.80E+09
50	13	3.50E+10	0	3.15E+10	3.50E+09
55	9.8	2.59E+10	0	2.33E+10	2.59E+09
60	7.1	1.87E+10	0	1.69E+10	1.87E+09
65	5.3	1.39E+10	0	1.25E+10	1.39E+09
70	4.0	1.06E+10	0	9.51E+09	1.06E+09
75	2.7	7.20E+09	0	6.48E+09	7.20E+08
80	1.7	4.61E+09	0	4.15E+09	4.61E+08
85	0.82	2.16E+09	0	1.94E+09	2.16E+08
90	0.07	1.92E+08	0	1.73E+08	1.92E+07
95	0	0	0	0	0
100	0	0	0	0	0

Table 5-13 Fecal Coliform TMDL Calculations for Brush Creek (OK311310030050_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	1,612	1.58E+13	0	1.42E+13	1.58E+12
5	56	5.50E+11	0	4.95E+11	5.50E+10
10	18	1.72E+11	0	1.55E+11	1.72E+10
15	6.8	6.68E+10	0	6.01E+10	6.68E+09
20	3.4	3.34E+10	0	3.01E+10	3.34E+09
25	2.0	1.98E+10	0	1.78E+10	1.98E+09
30	1.4	1.36E+10	0	1.23E+10	1.36E+09
35	1.0	9.67E+09	0	8.70E+09	9.67E+08
40	0.67	6.59E+09	0	5.93E+09	6.59E+08
45	0.45	4.40E+09	0	3.96E+09	4.40E+08
50	0.33	3.21E+09	0	2.89E+09	3.21E+08
55	0.24	2.37E+09	0	2.14E+09	2.37E+08
60	0.18	1.71E+09	0	1.54E+09	1.71E+08
65	0.13	1.27E+09	0	1.15E+09	1.27E+08
70	0.09	9.23E+08	0	8.31E+08	9.23E+07
75	0.07	6.59E+08	0	5.93E+08	6.59E+07
80	0.04	4.18E+08	0	3.76E+08	4.18E+07
85	0.02	1.93E+08	0	1.74E+08	1.93E+07
90	0.001	1.32E+07	0	1.19E+07	1.32E+06
95	0	0	0	0	0
100	0	0	0	0	0

5.7 LDCs and TMDL Calculations for Additional Bacterial Indicators

As mentioned previously in Subsection 5.1, 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. Furthermore as required, TMDL calculations from LDCs for all bacterial indicators not supporting the PBCR use were prepared. The remaining LDCs and TMDL calculations for additional bacterial indicators are shown in Figures 5-11 through 5-15 and Tables 5-14 through 5-18 respectively.

Figure 5-11 Load Duration Curve for Fecal Coliform in Mud Creek (OK311100040010_00)

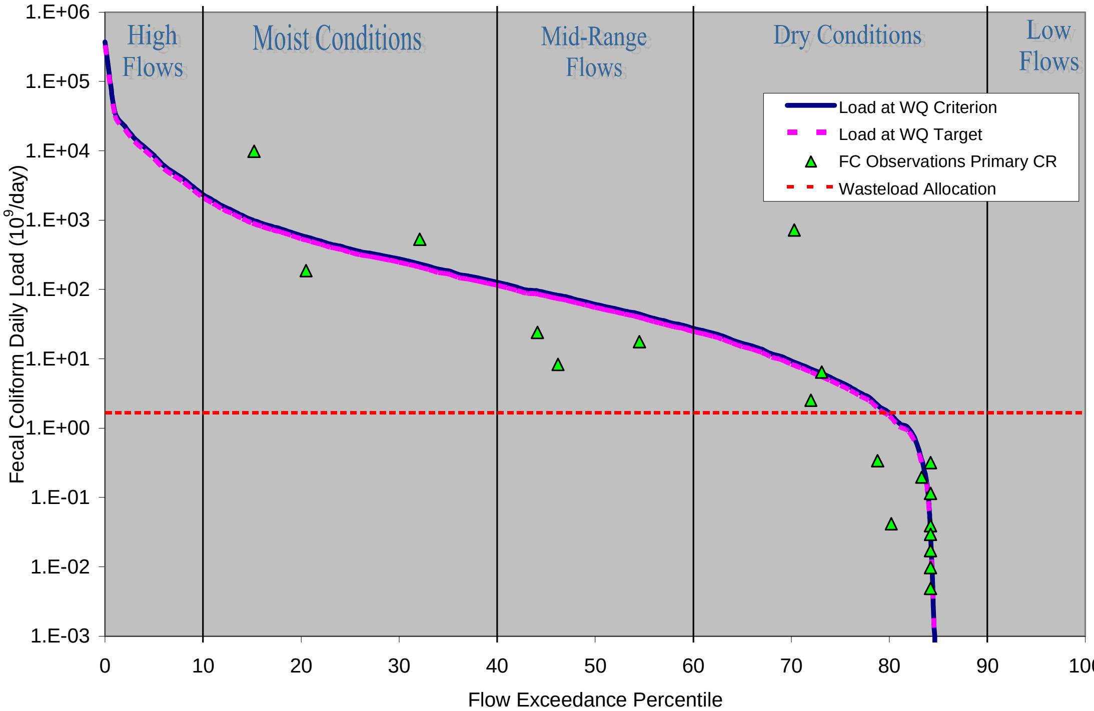


Table 5-14 Fecal Coliform TMDL Calculations for Mud Creek (OK311100040010_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	37,800	3.70E+14	1.67E+09	3.33E+14	3.70E+13
5	870	8.52E+12	1.67E+09	7.66E+12	8.52E+11
10	239	2.33E+12	1.67E+09	2.10E+12	2.33E+11
15	103	1.01E+12	1.67E+09	9.06E+11	1.01E+11
20	61	5.97E+11	1.67E+09	5.36E+11	5.97E+10
25	39	3.82E+11	1.67E+09	3.42E+11	3.82E+10
30	28	2.74E+11	1.67E+09	2.45E+11	2.74E+10
35	19	1.86E+11	1.67E+09	1.66E+11	1.86E+10
40	13	1.27E+11	1.67E+09	1.13E+11	1.27E+10
45	9.1	8.91E+10	1.67E+09	7.85E+10	8.91E+09
50	6.3	6.12E+10	1.67E+09	5.34E+10	6.12E+09
55	4.3	4.21E+10	1.67E+09	3.62E+10	4.21E+09
60	2.8	2.74E+10	1.67E+09	2.30E+10	2.74E+09
65	1.7	1.66E+10	1.67E+09	1.33E+10	1.66E+09
70	1.0	9.30E+09	1.67E+09	6.70E+09	9.30E+08
75	0.47	4.60E+09	1.67E+09	2.47E+09	4.60E+08
80	0.17	1.85E+09	1.67E+09	0.00E+00	1.85E+08
85	0	1.85E+09	1.67E+09	0.00E+00	1.85E+08
90	0	1.85E+09	1.67E+09	0.00E+00	1.85E+08
95	0	1.85E+09	1.67E+09	0.00E+00	1.85E+08
100	0	1.85E+09	1.67E+09	0.00E+00	1.85E+08

Figure 5-12 Load Duration Curve for Fecal Coliform in East Cache Creek (OK311300010020_00)

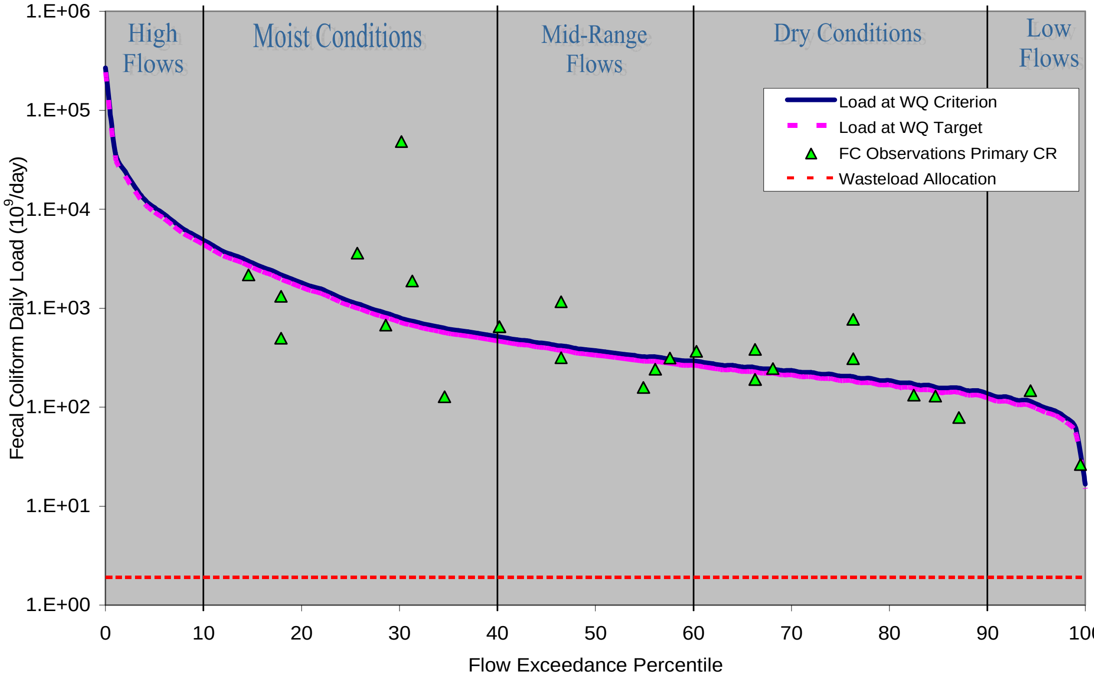


Table 5-15 Fecal Coliform TMDL Calculations for East Cache Creek (OK311300010020_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	27,500	2.69E+14	1.89E+09	2.42E+14	2.69E+13
5	1,060	1.04E+13	1.89E+09	9.33E+12	1.04E+12
10	498	4.87E+12	1.89E+09	4.38E+12	4.87E+11
15	292	2.86E+12	1.89E+09	2.57E+12	2.86E+11
20	185	1.81E+12	1.89E+09	1.63E+12	1.81E+11
25	120	1.17E+12	1.89E+09	1.05E+12	1.17E+11
30	82	8.02E+11	1.89E+09	7.20E+11	8.02E+10
35	63	6.17E+11	1.89E+09	5.53E+11	6.17E+10
40	53	5.19E+11	1.89E+09	4.65E+11	5.19E+10
45	45	4.40E+11	1.89E+09	3.94E+11	4.40E+10
50	38	3.72E+11	1.89E+09	3.33E+11	3.72E+10
55	33	3.23E+11	1.89E+09	2.89E+11	3.23E+10
60	30	2.94E+11	1.89E+09	2.62E+11	2.94E+10
65	26	2.54E+11	1.89E+09	2.27E+11	2.54E+10
70	24	2.35E+11	1.89E+09	2.09E+11	2.35E+10
75	21	2.06E+11	1.89E+09	1.83E+11	2.06E+10
80	19	1.86E+11	1.89E+09	1.65E+11	1.86E+10
85	16	1.57E+11	1.89E+09	1.39E+11	1.57E+10
90	14	1.37E+11	1.89E+09	1.21E+11	1.37E+10
95	11	1.08E+11	1.89E+09	9.50E+10	1.08E+10
100	1.7	1.66E+10	1.89E+09	1.31E+10	1.66E+09

Figure 5-13 Load Duration Curve for Fecal Coliform in Red River at US 183 (OK311310010010_00)

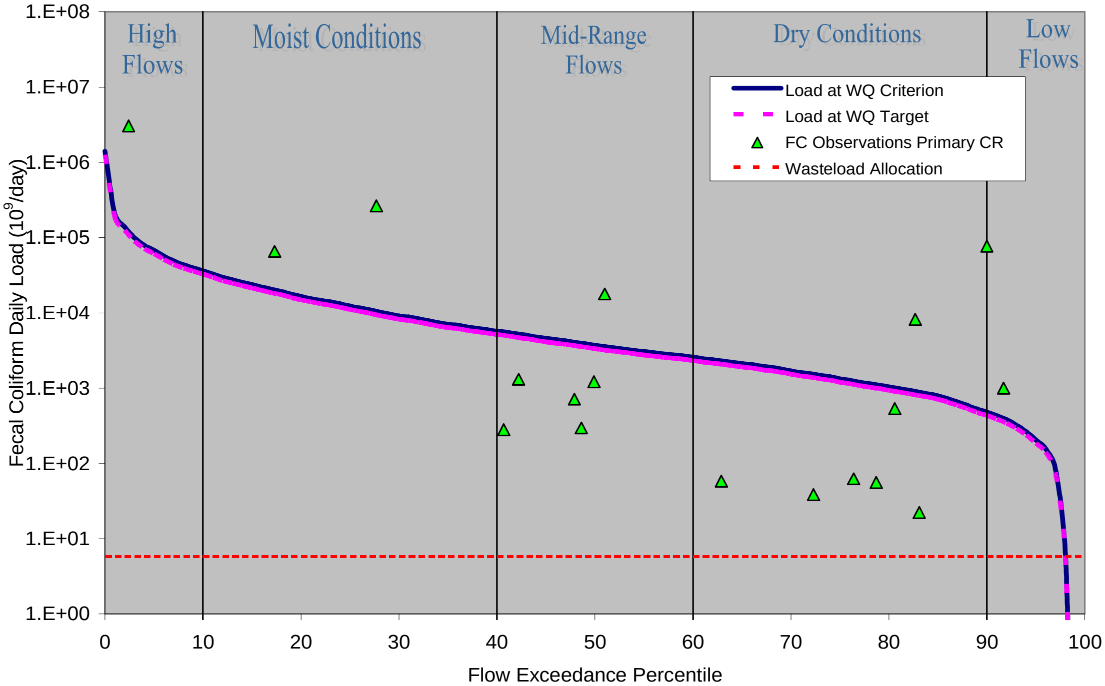
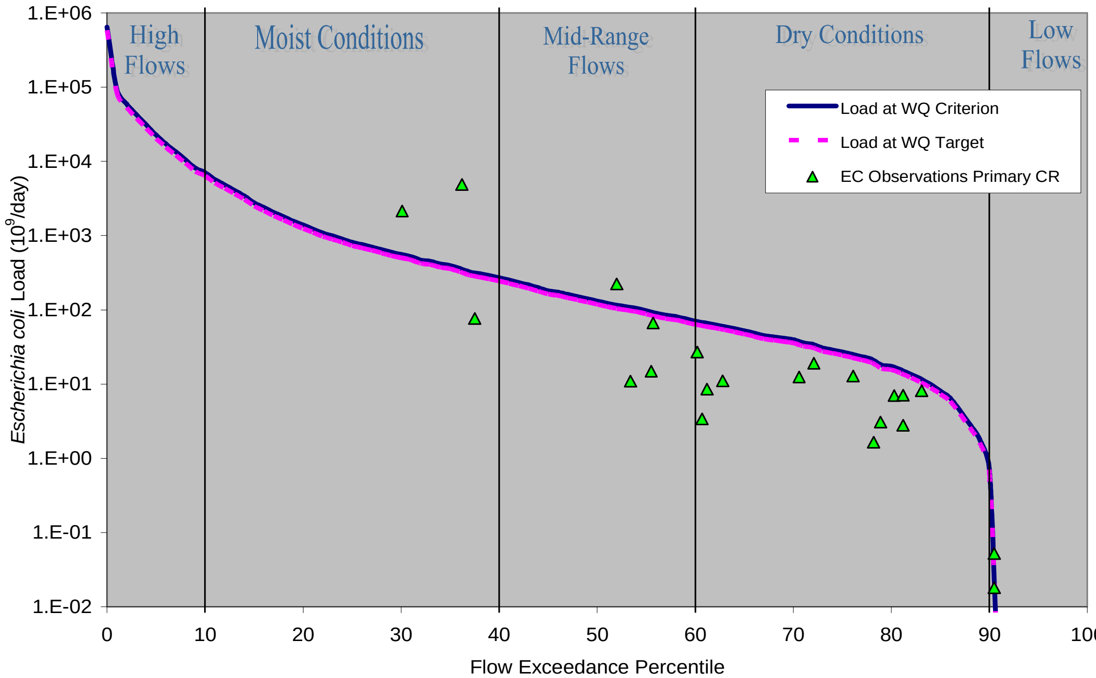


Table 5-16 Fecal Coliform TMDL Calculations for Red River at US 183 (OK311310010010_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	144,000	1.41E+15	5.75E+09	1.27E+15	1.41E+14
5	6,942	6.79E+13	5.75E+09	6.11E+13	6.79E+12
10	3,720	3.64E+13	5.75E+09	3.28E+13	3.64E+12
15	2,430	2.38E+13	5.75E+09	2.14E+13	2.38E+12
20	1,690	1.65E+13	5.75E+09	1.49E+13	1.65E+12
25	1,260	1.23E+13	5.75E+09	1.11E+13	1.23E+12
30	936	9.16E+12	5.75E+09	8.24E+12	9.16E+11
35	723	7.08E+12	5.75E+09	6.36E+12	7.08E+11
40	585	5.73E+12	5.75E+09	5.15E+12	5.73E+11
45	469	4.59E+12	5.75E+09	4.13E+12	4.59E+11
50	380	3.72E+12	5.75E+09	3.34E+12	3.72E+11
55	314	3.07E+12	5.75E+09	2.76E+12	3.07E+11
60	264	2.58E+12	5.75E+09	2.32E+12	2.58E+11
65	217	2.13E+12	5.75E+09	1.91E+12	2.13E+11
70	174	1.70E+12	5.75E+09	1.53E+12	1.70E+11
75	136	1.33E+12	5.75E+09	1.19E+12	1.33E+11
80	106	1.04E+12	5.75E+09	9.28E+11	1.04E+11
85	81	7.93E+11	5.75E+09	7.08E+11	7.93E+10
90	49	4.81E+11	5.75E+09	4.28E+11	4.81E+10
95	21	2.06E+11	5.75E+09	1.79E+11	2.06E+10
100	0	6.39E+09	5.75E+09	0.00E+00	6.39E+08

Figure 5-14 Load Duration Curve for *E. coli* in West Cache Creek (OK311310020010_00)

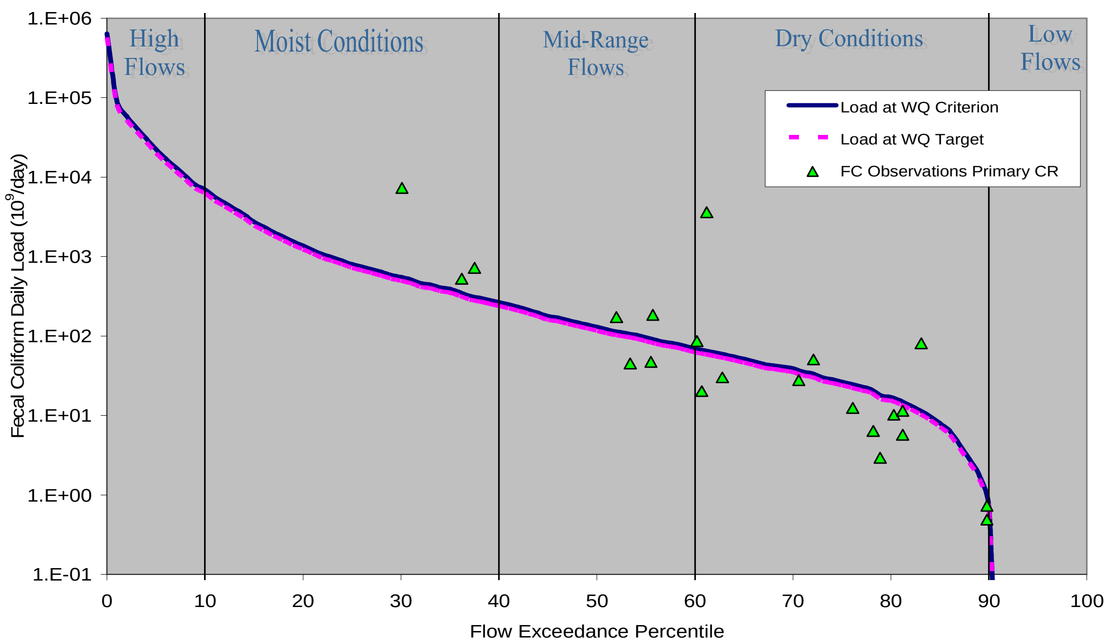


Note: There is no wasteload allocation for this waterbody.

Table 5-17 *E. coli*. TMDL Calculations for West Cache Creek (OK311310020010_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	65,225	6.48E+14	0	5.83E+14	6.48E+13
5	2,276	2.26E+13	0	2.03E+13	2.26E+12
10	711	7.07E+12	0	6.36E+12	7.07E+11
15	279	2.77E+12	0	2.49E+12	2.77E+11
20	140	1.39E+12	0	1.25E+12	1.39E+11
25	82	8.12E+11	0	7.31E+11	8.12E+10
30	56	5.59E+11	0	5.04E+11	5.59E+10
35	40	3.97E+11	0	3.57E+11	3.97E+10
40	27	2.71E+11	0	2.44E+11	2.71E+10
45	18	1.80E+11	0	1.62E+11	1.80E+10
50	13	1.32E+11	0	1.19E+11	1.32E+10
55	9.8	9.75E+10	0	8.77E+10	9.75E+09
60	7.1	7.04E+10	0	6.33E+10	7.04E+09
65	5.3	5.23E+10	0	4.71E+10	5.23E+09
70	4.0	3.97E+10	0	3.57E+10	3.97E+09
75	2.7	2.71E+10	0	2.44E+10	2.71E+09
80	1.7	1.73E+10	0	1.56E+10	1.73E+09
85	0.82	8.12E+09	0	7.31E+09	8.12E+08
90	0.07	7.22E+08	0	6.50E+08	7.22E+07
95	0	0	0	0	0
100	0	0	0	0	0

Figure 5-15 Load Duration Curve for Fecal Coliform in West Cache Creek (OK311310020010_00)



Note: There is no wasteload allocation for this waterbody.

Table 5-18 Fecal Coliform TMDL Calculations for West Cache Creek (OK311310020010_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	65,225	6.38E+14	0	5.74E+14	6.38E+13
5	2,276	2.23E+13	0	2.00E+13	2.23E+12
10	711	6.96E+12	0	6.26E+12	6.96E+11
15	279	2.73E+12	0	2.46E+12	2.73E+11
20	140	1.37E+12	0	1.23E+12	1.37E+11
25	82	8.00E+11	0	7.20E+11	8.00E+10
30	56	5.51E+11	0	4.96E+11	5.51E+10
35	40	3.91E+11	0	3.52E+11	3.91E+10
40	27	2.67E+11	0	2.40E+11	2.67E+10
45	18	1.78E+11	0	1.60E+11	1.78E+10
50	13	1.30E+11	0	1.17E+11	1.30E+10
55	9.8	9.60E+10	0	8.64E+10	9.60E+09
60	7.1	6.93E+10	0	6.24E+10	6.93E+09
65	5.3	5.16E+10	0	4.64E+10	5.16E+09
70	4.0	3.91E+10	0	3.52E+10	3.91E+09
75	2.7	2.67E+10	0	2.40E+10	2.67E+09
80	1.7	1.71E+10	0	1.54E+10	1.71E+09
85	0.82	8.00E+09	0	7.20E+09	8.00E+08
90	0.07	7.11E+08	0	6.40E+08	7.11E+07
95	0	0	0	0	0
100	0	0	0	0	0

5.8 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 a 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 2002). The CPP can be viewed from ODEQ's website at http://www.deq.state.ok.us/WQDnew/pubs/2002_cpp_final.pdf. Table 5-19 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 5-19 Partial List of Oklahoma Water Quality Management Agencies

Agency	Web Link
Oklahoma Conservation Commission	http://www.okcc.state.ok.us/WQ/WQ_home.htm
Oklahoma Department of Wildlife Conservation	http://www.wildlifedepartment.com/watchabl.htm
Oklahoma Department of Agriculture, Food, and Forestry	http://www.oda.state.ok.us/water-home.htm
Oklahoma Water Resources Board	http://www.owrb.state.ok.us/quality/index.php

Nonpoint source pollution is regulated by the Oklahoma Conservation Commission. 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 93 percent. The ODEQ recognizes that achieving such high reductions may not be realistic, especially since unregulated nonpoint sources are a major cause of the impairment. The high reduction rates are not uncommon for pathogen-impaired waters. Similar reduction rates are often found in other pathogen TMDLs around the nation. The suitability of the current criteria for pathogens and the beneficial uses of the receiving stream 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 existing 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 Draft; 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 re-evaluated.

SECTION 6
PUBLIC PARTICIPATION

This TMDL report was sent to other related state agencies and local government agencies for peer review and was also submitted to the EPA for technical review. No comments were received from peer review. The report was technically approved by the EPA on July 19, 2007 with one comment on priority ranking of impaired stream segment. After updating the report according to the EPA's comment, the TMDL report was made available for public from August 2, 2007 through September 17, 2007. A public meeting was held in the auditorium of the Visitor's Center at the Wichita Mountains Wildlife Refuge, Oklahoma on September 6, 2007. Six people attended the public meeting.

At the end of public comment period, one comment was received. The response to the comment was prepared and included as part of this TMDL report. No change was made to the report due to the comment.

SECTION 7
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APPENDIX A
AMBIENT WATER QUALITY BACTERIA DATA – 1999 TO 2006

Appendix A

Ambient Water Quality Bacteria Data – 1999 to 2006

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311100020010M	Hickory Creek: HWY 775	8/30/2004	5	EC	406
OK311100020010M	Hickory Creek: HWY 775	10/4/2004	160	EC	2030
OK311100020010M	Hickory Creek: HWY 775	5/9/2005	20	EC	406
OK311100020010M	Hickory Creek: HWY 775	6/6/2005	1000	EC	406
OK311100020010M	Hickory Creek: HWY 775	7/5/2005	400	EC	406
OK311100020010M	Hickory Creek: HWY 775	8/9/2005	80	EC	406
OK311100020010M	Hickory Creek: HWY 775	9/13/2005	20	EC	406
OK311100020010M	Hickory Creek: HWY 775	4/25/2006	40	EC	2030
OK311100020010M	Hickory Creek: HWY 775	6/6/2006	45	EC	406
OK311100020010M	Hickory Creek: HWY 775	7/11/2006	155	EC	406
OK311100020010M	Hickory Creek: HWY 775	8/30/2004	140	ENT	108
OK311100020010M	Hickory Creek: HWY 775	10/4/2004	140	ENT	540
OK311100020010M	Hickory Creek: HWY 775	5/9/2005	35	ENT	108
OK311100020010M	Hickory Creek: HWY 775	6/6/2005	230	ENT	108
OK311100020010M	Hickory Creek: HWY 775	7/5/2005	510	ENT	108
OK311100020010M	Hickory Creek: HWY 775	8/9/2005	10	ENT	108
OK311100020010M	Hickory Creek: HWY 775	9/13/2005	120	ENT	108
OK311100020010M	Hickory Creek: HWY 775	4/25/2006	240	ENT	540
OK311100020010M	Hickory Creek: HWY 775	6/6/2006	100	ENT	108
OK311100020010M	Hickory Creek: HWY 775	7/11/2006	95	ENT	108
OK311100030010G	Walnut Bayou	8/30/2004	5	EC	406
OK311100030010G	Walnut Bayou	10/4/2004	140	EC	2030
OK311100030010G	Walnut Bayou	5/9/2005	190	EC	406
OK311100030010G	Walnut Bayou	6/6/2005	360	EC	406
OK311100030010G	Walnut Bayou	7/5/2005	580	EC	406
OK311100030010G	Walnut Bayou	8/9/2005	150	EC	406
OK311100030010G	Walnut Bayou	9/13/2005	90	EC	406
OK311100030010G	Walnut Bayou	4/25/2006	10	EC	2030
OK311100030010G	Walnut Bayou	6/6/2006	40	EC	406
OK311100030010G	Walnut Bayou	7/11/2006	15	EC	406
OK311100030010G	Walnut Bayou	8/30/2004	10	ENT	108
OK311100030010G	Walnut Bayou	10/4/2004	430	ENT	540
OK311100030010G	Walnut Bayou	5/9/2005	25	ENT	108
OK311100030010G	Walnut Bayou	6/6/2005	160	ENT	108
OK311100030010G	Walnut Bayou	7/5/2005	490	ENT	108
OK311100030010G	Walnut Bayou	8/9/2005	40	ENT	108
OK311100030010G	Walnut Bayou	9/13/2005	80	ENT	108

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311100030010G	Walnut Bayou	4/25/2006	30	ENT	540
OK311100030010G	Walnut Bayou	6/6/2006	35	ENT	108
OK311100030010G	Walnut Bayou	7/11/2006	5	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	6/30/1999	130	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	7/27/1999	410	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/23/1999	1300	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	9/22/1999	32000	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	5/9/2000	470	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	6/14/2000	140	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	7/19/2000	160	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/16/2000	120	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	9/13/2000	40	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	5/15/2001	900	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	6/12/2001	100	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	7/17/2001	10	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/14/2001	70	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	9/5/2001	200	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	5/29/2002	4000	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	6/26/2002	40	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/6/2002	160	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/19/2002	60	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	9/23/2002	20	FC	400
OK311100040010-001AT	Mud Creek, SH 32, Courtney	6/30/1999	63	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	7/27/1999	185	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/23/1999	187	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	9/22/1999	520	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	5/9/2000	504	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	6/14/2000	116	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	7/19/2000	5	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/16/2000	10	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	9/13/2000	20	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	5/15/2001	201	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	6/12/2001	20	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	7/17/2001	5	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/14/2001	41	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	9/5/2001	63	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	5/29/2002	641	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	6/26/2002	52	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/6/2002	63	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/19/2002	20	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	9/23/2002	10	EC	406
OK311100040010-001AT	Mud Creek, SH 32, Courtney	6/30/1999	280	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	7/27/1999	5	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/23/1999	10	ENT	108

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311100040010-001AT	Mud Creek, SH 32, Courtney	9/22/1999	600	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	5/9/2000	320	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	6/14/2000	260	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	7/19/2000	210	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/16/2000	140	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	9/13/2000	120	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	5/15/2001	300	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	6/12/2001	60	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	7/17/2001	10	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/14/2001	160	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	9/5/2001	800	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	5/29/2002	17000	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	6/26/2002	60	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/6/2002	600	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	8/19/2002	40	ENT	108
OK311100040010-001AT	Mud Creek, SH 32, Courtney	9/23/2002	30	ENT	108
OK311100040080G	West Mud Creek	5/15/2000	100	FC	400
OK311100040080G	West Mud Creek	6/19/2000	800	FC	400
OK311100040080G	West Mud Creek	8/28/2000	600	FC	400
OK311100040080G	West Mud Creek	12/11/2000	20	FC	2000
OK311100040080G	West Mud Creek	2/26/2001	0	FC	2000
OK311100040080G	West Mud Creek	5/7/2001	0	FC	400
OK311100040080G	West Mud Creek	6/11/2001	30	FC	400
OK311100040080G	West Mud Creek	7/16/2001	4	FC	400
OK311100040080G	West Mud Creek	8/20/2001	1140	FC	400
OK311100040080G	West Mud Creek	9/24/2001	1080	FC	400
OK311100040080G	West Mud Creek	10/29/2001	10	FC	2000
OK311100040080G	West Mud Creek	10/29/2001	780	FC	2000
OK311100040080G	West Mud Creek	8/28/2000	437	EC	406
OK311100040080G	West Mud Creek	12/11/2000	73	EC	2030
OK311100040080G	West Mud Creek	6/11/2001	31	EC	406
OK311100040080G	West Mud Creek	7/16/2001	2	EC	406
OK311100040080G	West Mud Creek	8/20/2001	130	EC	406
OK311100040080G	West Mud Creek	9/24/2001	880	EC	406
OK311100040080G	West Mud Creek	10/29/2001	10	EC	2030
OK311100040080G	West Mud Creek	8/28/2000	1000	ENT	108
OK311100040080G	West Mud Creek	12/11/2000	300	ENT	540
OK311100040080G	West Mud Creek	2/26/2001	0	ENT	540
OK311100040080G	West Mud Creek	5/7/2001	0	ENT	108
OK311100040080G	West Mud Creek	6/11/2001	300	ENT	108
OK311100040080G	West Mud Creek	7/16/2001	32	ENT	108
OK311100040080G	West Mud Creek	8/20/2001	830	ENT	108
OK311100040080G	West Mud Creek	9/24/2001	560	ENT	108
OK311100040080G	West Mud Creek	10/29/2001	20	ENT	540

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311100040080G	West Mud Creek	10/29/2001	1560	ENT	540
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	5/15/1999	480	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	6/28/1999	100	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	7/26/1999	30	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	9/21/1999	740	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	5/23/2000	40	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	6/27/2000	1000	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/1/2000	110	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/29/2000	260	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	5/15/2001	100	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	6/12/2001	350	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	7/17/2001	80	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/14/2001	340	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	5/28/2002	1400	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	6/24/2002	180	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/6/2002	300	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/21/2002	120	FC	400
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	5/15/1999	118	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	6/28/1999	41	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	7/26/1999	63	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	9/21/1999	199	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	5/23/2000	30	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	6/27/2000	318	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/1/2000	5	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/29/2000	98	EC	406

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	5/15/2001	131	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	6/12/2001	199	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	7/17/2001	20	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/14/2001	5	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	9/5/2001	197	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	5/28/2002	780	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	6/24/2002	52	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/6/2002	183	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/21/2002	98	EC	406
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	5/15/1999	420	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	6/28/1999	5	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	7/26/1999	10	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	9/21/1999	120	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	5/23/2000	50	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	6/27/2000	1600	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/1/2000	120	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/29/2000	140	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	5/15/2001	1000	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	6/12/2001	180	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	7/17/2001	190	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/14/2001	1700	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	9/5/2001	8000	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	5/28/2002	6000	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	6/24/2002	200	ENT	108
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/6/2002	400	ENT	108

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
USGS_07313600	Cow Creek at SH 5 at Waurika, OK	8/21/2002	130	ENT	108
OK311200000080G	Dry Creek	5/15/2000	100	FC	400
OK311200000080G	Dry Creek	6/19/2000	2100	FC	400
OK311200000080G	Dry Creek	11/6/2000	3000	FC	2000
OK311200000080G	Dry Creek	12/11/2000	160	FC	2000
OK311200000080G	Dry Creek	1/22/2001	40	FC	2000
OK311200000080G	Dry Creek	2/26/2001	180	FC	2000
OK311200000080G	Dry Creek	4/2/2001	800	FC	2000
OK311200000080G	Dry Creek	5/7/2001	3000	FC	400
OK311200000080G	Dry Creek	6/11/2001	220	FC	400
OK311200000080G	Dry Creek	7/16/2001	250	FC	400
OK311200000080G	Dry Creek	8/20/2001	260	FC	400
OK311200000080G	Dry Creek	10/29/2001	780	FC	2000
OK311200000080G	Dry Creek	10/29/2001	110	FC	2000
OK311200000080G	Dry Creek	11/6/2000	1483	EC	2030
OK311200000080G	Dry Creek	12/11/2000	185	EC	2030
OK311200000080G	Dry Creek	1/22/2001	63	EC	2030
OK311200000080G	Dry Creek	2/26/2001	265	EC	2030
OK311200000080G	Dry Creek	4/2/2001	441	EC	2030
OK311200000080G	Dry Creek	5/7/2001	588	EC	406
OK311200000080G	Dry Creek	6/11/2001	160	EC	406
OK311200000080G	Dry Creek	7/16/2001	263	EC	406
OK311200000080G	Dry Creek	8/20/2001	225	EC	406
OK311200000080G	Dry Creek	10/29/2001	740	EC	2030
OK311200000080G	Dry Creek	11/6/2000	16000	ENT	540
OK311200000080G	Dry Creek	12/11/2000	500	ENT	540
OK311200000080G	Dry Creek	1/22/2001	60	ENT	540
OK311200000080G	Dry Creek	2/26/2001	500	ENT	540
OK311200000080G	Dry Creek	4/2/2001	70	ENT	540
OK311200000080G	Dry Creek	5/7/2001	8000	ENT	108
OK311200000080G	Dry Creek	6/11/2001	400	ENT	108
OK311200000080G	Dry Creek	7/16/2001	106	ENT	108
OK311200000080G	Dry Creek	8/20/2001	185	ENT	108
OK311200000080G	Dry Creek	10/29/2001	1560	ENT	540
OK311200000080G	Dry Creek	10/29/2001	60	ENT	540
OK311210000140D	Whiskey Creek	5/23/2000	100	FC	400
OK311210000140D	Whiskey Creek	6/26/2000	300	FC	400
OK311210000140D	Whiskey Creek	6/26/2000	700	FC	400
OK311210000140D	Whiskey Creek	8/1/2000	100	FC	400
OK311210000140D	Whiskey Creek	11/14/2000	70	FC	2000
OK311210000140D	Whiskey Creek	12/19/2000	40	FC	2000
OK311210000140D	Whiskey Creek	1/30/2001	700	FC	2000
OK311210000140D	Whiskey Creek	3/6/2001	270	FC	2000

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311210000140D	Whiskey Creek	4/10/2001	40	FC	2000
OK311210000140D	Whiskey Creek	4/10/2001	120	FC	2000
OK311210000140D	Whiskey Creek	5/15/2001	700	FC	400
OK311210000140D	Whiskey Creek	6/19/2001	300	FC	400
OK311210000140D	Whiskey Creek	6/19/2001	170	FC	400
OK311210000140D	Whiskey Creek	7/24/2001	150	FC	400
OK311210000140D	Whiskey Creek	8/28/2001	640	FC	400
OK311210000140D	Whiskey Creek	10/2/2001	390	FC	2000
OK311210000140D	Whiskey Creek	11/6/2001	50	FC	2000
OK311210000140D	Whiskey Creek	11/6/2001	210	FC	2000
OK311210000140D	Whiskey Creek	8/1/2000	31	EC	406
OK311210000140D	Whiskey Creek	11/14/2000	31	EC	2030
OK311210000140D	Whiskey Creek	12/19/2000	52	EC	2030
OK311210000140D	Whiskey Creek	1/30/2001	1056	EC	2030
OK311210000140D	Whiskey Creek	3/6/2001	199	EC	2030
OK311210000140D	Whiskey Creek	4/10/2001	86	EC	2030
OK311210000140D	Whiskey Creek	5/15/2001	408	EC	406
OK311210000140D	Whiskey Creek	6/19/2001	108	EC	406
OK311210000140D	Whiskey Creek	7/24/2001	160	EC	406
OK311210000140D	Whiskey Creek	8/28/2001	270	EC	406
OK311210000140D	Whiskey Creek	10/2/2001	140	EC	2030
OK311210000140D	Whiskey Creek	11/6/2001	10	EC	2030
OK311210000140D	Whiskey Creek	8/1/2000	470	ENT	108
OK311210000140D	Whiskey Creek	11/14/2000	600	ENT	540
OK311210000140D	Whiskey Creek	12/19/2000	900	ENT	540
OK311210000140D	Whiskey Creek	1/30/2001	52000	ENT	540
OK311210000140D	Whiskey Creek	3/6/2001	100	ENT	540
OK311210000140D	Whiskey Creek	4/10/2001	70	ENT	540
OK311210000140D	Whiskey Creek	4/10/2001	100	ENT	540
OK311210000140D	Whiskey Creek	5/15/2001	2200	ENT	108
OK311210000140D	Whiskey Creek	6/19/2001	200	ENT	108
OK311210000140D	Whiskey Creek	6/19/2001	300	ENT	108
OK311210000140D	Whiskey Creek	7/24/2001	250	ENT	108
OK311210000140D	Whiskey Creek	8/28/2001	1020	ENT	108
OK311210000140D	Whiskey Creek	10/2/2001	170	ENT	540
OK311210000140D	Whiskey Creek	11/6/2001	40	ENT	540
OK311210000140D	Whiskey Creek	11/6/2001	130	ENT	540
OK311210000150G	Cottonwood Creek	5/23/2000	600	FC	400
OK311210000150G	Cottonwood Creek	6/26/2000	1700	FC	400
OK311210000150G	Cottonwood Creek	8/1/2000	360	FC	400
OK311210000150G	Cottonwood Creek	10/10/2000	500	FC	2000
OK311210000150G	Cottonwood Creek	11/14/2000	1000	FC	2000
OK311210000150G	Cottonwood Creek	12/19/2000	800	FC	2000
OK311210000150G	Cottonwood Creek	1/30/2001	300	FC	2000

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311210000150G	Cottonwood Creek	3/6/2001	200	FC	2000
OK311210000150G	Cottonwood Creek	4/10/2001	4000	FC	2000
OK311210000150G	Cottonwood Creek	5/15/2001	6000	FC	400
OK311210000150G	Cottonwood Creek	6/19/2001	1700	FC	400
OK311210000150G	Cottonwood Creek	7/24/2001	465	FC	400
OK311210000150G	Cottonwood Creek	8/28/2001	600	FC	400
OK311210000150G	Cottonwood Creek	10/2/2001	1730	FC	2000
OK311210000150G	Cottonwood Creek	11/6/2001	290	FC	2000
OK311210000150G	Cottonwood Creek	11/6/2001	50	FC	2000
OK311210000150G	Cottonwood Creek	8/1/2000	110	EC	406
OK311210000150G	Cottonwood Creek	10/10/2000	581	EC	2030
OK311210000150G	Cottonwood Creek	11/14/2000	384	EC	2030
OK311210000150G	Cottonwood Creek	12/19/2000	373	EC	2030
OK311210000150G	Cottonwood Creek	1/30/2001	223	EC	2030
OK311210000150G	Cottonwood Creek	3/6/2001	354	EC	2030
OK311210000150G	Cottonwood Creek	4/10/2001	1374	EC	2030
OK311210000150G	Cottonwood Creek	5/15/2001	1223	EC	406
OK311210000150G	Cottonwood Creek	6/19/2001	663	EC	406
OK311210000150G	Cottonwood Creek	7/24/2001	475	EC	406
OK311210000150G	Cottonwood Creek	8/28/2001	800	EC	406
OK311210000150G	Cottonwood Creek	10/2/2001	1540	EC	2030
OK311210000150G	Cottonwood Creek	11/6/2001	100	EC	2030
OK311210000150G	Cottonwood Creek	8/1/2000	150	ENT	108
OK311210000150G	Cottonwood Creek	10/10/2000	4000	ENT	540
OK311210000150G	Cottonwood Creek	11/14/2000	4000	ENT	540
OK311210000150G	Cottonwood Creek	12/19/2000	2600	ENT	540
OK311210000150G	Cottonwood Creek	1/30/2001	65000	ENT	540
OK311210000150G	Cottonwood Creek	3/6/2001	300	ENT	540
OK311210000150G	Cottonwood Creek	4/10/2001	300	ENT	540
OK311210000150G	Cottonwood Creek	5/15/2001	24000	ENT	108
OK311210000150G	Cottonwood Creek	6/19/2001	5000	ENT	108
OK311210000150G	Cottonwood Creek	7/24/2001	745	ENT	108
OK311210000150G	Cottonwood Creek	8/28/2001	1330	ENT	108
OK311210000150G	Cottonwood Creek	10/2/2001	540	ENT	540
OK311210000150G	Cottonwood Creek	11/6/2001	240	ENT	540
OK311210000150G	Cottonwood Creek	11/6/2001	40	ENT	540
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/30/1999	290	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	7/27/1999	190	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/23/1999	1300	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/22/1999	1500	FC	400

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/23/2000	240	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/27/2000	80	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/1/2000	310	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/29/2000	220	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/26/2000	600	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/16/2001	500	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/12/2001	90	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	7/17/2001	200	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/14/2001	500	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/4/2001	1100	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/28/2002	300	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/24/2002	300	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/6/2002	600	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/21/2002	300	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/7/2003	300	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/19/2003	300	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/4/2003	500	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/23/2003	1000	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	7/15/2003	400	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	7/28/2003	300	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/19/2003	500	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/2/2003	24100	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/23/2003	400	FC	400
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/30/1999	109	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	7/27/1999	86	EC	406

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/23/1999	785	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/22/1999	240	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/23/2000	166	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/27/2000	52	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/1/2000	63	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/29/2000	41	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/26/2000	459	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/16/2001	175	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/12/2001	20	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	7/17/2001	10	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/14/2001	31	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/4/2001	195	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/28/2002	85	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/24/2002	109	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/6/2002	109	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/21/2002	132	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/7/2003	175	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/19/2003	238	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/4/2003	171	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/23/2003	620	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	7/15/2003	74	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	7/28/2003	73	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/19/2003	109	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/2/2003	4352	EC	406
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/23/2003	52	EC	406

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/30/1999	860	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	7/27/1999	5	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/23/1999	930	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/22/1999	30	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/23/2000	600	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/27/2000	40	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/1/2000	350	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/29/2000	2200	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/26/2000	2000	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/16/2001	600	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/12/2001	200	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	7/17/2001	500	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/14/2001	300	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/4/2001	4000	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/28/2002	1000	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/24/2002	300	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/6/2002	300	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/21/2002	1100	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/7/2003	400	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	5/19/2003	200	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/4/2003	43000	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	6/23/2003	800	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	7/15/2003	150	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	7/28/2003	500	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	8/19/2003	800	ENT	108

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/2/2003	5300	ENT	108
OK311300010020-001AT	East Cache Creek, SH 53, Walters	9/23/2003	470	ENT	108
OK311300030070G	Tahoe Creek	5/23/2000	100	FC	400
OK311300030070G	Tahoe Creek	6/27/2000	1000	FC	400
OK311300030070G	Tahoe Creek	8/1/2000	1000	FC	400
OK311300030070G	Tahoe Creek	11/14/2000	40	FC	2000
OK311300030070G	Tahoe Creek	12/19/2000	30	FC	2000
OK311300030070G	Tahoe Creek	12/19/2000	10	FC	2000
OK311300030070G	Tahoe Creek	1/30/2001	110	FC	2000
OK311300030070G	Tahoe Creek	3/6/2001	40	FC	2000
OK311300030070G	Tahoe Creek	3/6/2001	70	FC	2000
OK311300030070G	Tahoe Creek	4/10/2001	300	FC	2000
OK311300030070G	Tahoe Creek	5/15/2001	20	FC	400
OK311300030070G	Tahoe Creek	5/15/2001	10	FC	400
OK311300030070G	Tahoe Creek	6/19/2001	110	FC	400
OK311300030070G	Tahoe Creek	7/24/2001	160	FC	400
OK311300030070G	Tahoe Creek	8/28/2001	600	FC	400
OK311300030070G	Tahoe Creek	10/2/2001	330	FC	2000
OK311300030070G	Tahoe Creek	11/6/2001	10	FC	2000
OK311300030070G	Tahoe Creek	11/6/2001	290	FC	2000
OK311300030070G	Tahoe Creek	8/1/2000	30	EC	406
OK311300030070G	Tahoe Creek	11/14/2000	41	EC	2030
OK311300030070G	Tahoe Creek	12/19/2000	63	EC	2030
OK311300030070G	Tahoe Creek	1/30/2001	52	EC	2030
OK311300030070G	Tahoe Creek	3/6/2001	63	EC	2030
OK311300030070G	Tahoe Creek	4/10/2001	228	EC	2030
OK311300030070G	Tahoe Creek	5/15/2001	52	EC	406
OK311300030070G	Tahoe Creek	6/19/2001	52	EC	406
OK311300030070G	Tahoe Creek	7/24/2001	30	EC	406
OK311300030070G	Tahoe Creek	8/28/2001	440	EC	406
OK311300030070G	Tahoe Creek	10/2/2001	340	EC	2030
OK311300030070G	Tahoe Creek	11/6/2001	10	EC	2030
OK311300030070G	Tahoe Creek	8/1/2000	210	ENT	108
OK311300030070G	Tahoe Creek	11/14/2000	160	ENT	540
OK311300030070G	Tahoe Creek	12/19/2000	30	ENT	540
OK311300030070G	Tahoe Creek	12/19/2000	40	ENT	540
OK311300030070G	Tahoe Creek	1/30/2001	5000	ENT	540
OK311300030070G	Tahoe Creek	3/6/2001	50	ENT	540
OK311300030070G	Tahoe Creek	3/6/2001	40	ENT	540
OK311300030070G	Tahoe Creek	4/10/2001	70	ENT	540
OK311300030070G	Tahoe Creek	5/15/2001	120	ENT	108
OK311300030070G	Tahoe Creek	5/15/2001	300	ENT	108
OK311300030070G	Tahoe Creek	6/19/2001	200	ENT	108

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311300030070G	Tahoe Creek	7/24/2001	75	ENT	108
OK311300030070G	Tahoe Creek	8/28/2001	90	ENT	108
OK311300030070G	Tahoe Creek	10/2/2001	190	ENT	540
OK311300030070G	Tahoe Creek	11/6/2001	20	ENT	540
OK311300030070G	Tahoe Creek	11/6/2001	240	ENT	540
OK311310010010-001AT	Red River, US 183, Davidson	6/22/1999	1300	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	7/20/1999	20	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	8/17/1999	30	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	9/21/1999	3600	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	5/23/2000	20	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	6/27/2000	70	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	8/1/2000	10	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	8/29/2000	210	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	9/26/2000	63000	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	5/22/2001	10000	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	6/19/2001	100	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	7/24/2001	10	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	8/21/2001	2000	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	9/18/2001	130	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	5/29/2002	10000	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	6/25/2002	10	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	8/6/2002	20	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	8/20/2002	1000	FC	400
OK311310010010-001AT	Red River, US 183, Davidson	6/22/1999	1860	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	7/20/1999	10	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	8/17/1999	30	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	9/21/1999	1722	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	5/23/2000	98	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	6/27/2000	86	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	8/1/2000	30	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	8/29/2000	52	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	9/26/2000	8164	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	5/22/2001	612	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	6/19/2001	10	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	7/24/2001	5	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	8/21/2001	197	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	9/18/2001	459	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	5/29/2002	761	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	6/25/2002	63	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	8/6/2002	10	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	8/20/2002	281	EC	406
OK311310010010-001AT	Red River, US 183, Davidson	6/22/1999	550	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	7/20/1999	10	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	8/17/1999	20	ENT	108

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311310010010-001AT	Red River, US 183, Davidson	9/21/1999	900	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	5/23/2000	40	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	6/27/2000	110	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	8/1/2000	40	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	8/29/2000	20	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	9/26/2000	11000	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	5/22/2001	14000	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	6/19/2001	20	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	7/24/2001	20	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	8/21/2001	21000	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	9/18/2001	140	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	5/29/2002	11000	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	6/25/2002	10	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	8/6/2002	10	ENT	108
OK311310010010-001AT	Red River, US 183, Davidson	8/20/2002	300	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/30/1999	590	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	7/27/1999	60	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	5/23/2000	250	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/27/2000	600	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/1/2000	150	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	5/16/2001	900	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/12/2001	170	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	7/17/2001	120	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/14/2001	300	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	9/4/2001	2800	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	5/28/2002	800	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/24/2002	200	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/6/2002	120	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/21/2002	22000	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	5/19/2003	200	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/4/2003	200	FC	400

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/23/2003	600	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	7/15/2003	300	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	7/28/2003	300	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/19/2003	500	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	9/2/2003	5300	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	9/23/2003	200	FC	400
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/30/1999	5475	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	7/27/1999	63	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	5/23/2000	171	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/27/2000	226	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/1/2000	73	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	5/16/2001	96	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/12/2001	41	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	7/17/2001	31	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/14/2001	185	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	9/4/2001	281	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	5/28/2002	288	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/24/2002	63	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/6/2002	20	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/21/2002	52	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	5/19/2003	206	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/4/2003	73	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/23/2003	776	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	7/15/2003	134	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	7/28/2003	213	EC	406

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/19/2003	156	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	9/2/2003	1553	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	9/23/2003	74	EC	406
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/30/1999	64000	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	7/27/1999	5	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	5/23/2000	640	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/27/2000	950	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/1/2000	240	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	5/16/2001	2000	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/12/2001	260	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	7/17/2001	210	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/14/2001	600	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	9/4/2001	1200	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	5/28/2002	800	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/24/2002	200	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/6/2002	200	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/21/2002	200	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	5/19/2003	300	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	6/4/2003	600	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	7/15/2003	200	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	7/28/2003	150	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	8/19/2003	500	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	9/2/2003	4100	ENT	108
OK311310020010-001AT	West Cache Creek, SH 5B, Taylor	9/23/2003	160	ENT	108
OK311310020060G	Blue Beaver Creek	5/15/2000	100	FC	400
OK311310020060G	Blue Beaver Creek	6/19/2000	2000	FC	400

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311310020060G	Blue Beaver Creek	8/28/2000	150	FC	400
OK311310020060G	Blue Beaver Creek	10/2/2000	100	FC	2000
OK311310020060G	Blue Beaver Creek	11/7/2000	60	FC	2000
OK311310020060G	Blue Beaver Creek	12/11/2000	30	FC	2000
OK311310020060G	Blue Beaver Creek	1/22/2001	10	FC	2000
OK311310020060G	Blue Beaver Creek	2/26/2001	10	FC	2000
OK311310020060G	Blue Beaver Creek	4/2/2001	100	FC	2000
OK311310020060G	Blue Beaver Creek	5/7/2001	300	FC	400
OK311310020060G	Blue Beaver Creek	6/11/2001	30	FC	400
OK311310020060G	Blue Beaver Creek	7/16/2001	162	FC	400
OK311310020060G	Blue Beaver Creek	9/24/2001	110	FC	400
OK311310020060G	Blue Beaver Creek	10/29/2001	30	FC	2000
OK311310020060G	Blue Beaver Creek	10/29/2001	10	FC	2000
OK311310020060G	Blue Beaver Creek	8/28/2000	10	EC	406
OK311310020060G	Blue Beaver Creek	10/2/2000	1658	EC	2030
OK311310020060G	Blue Beaver Creek	11/7/2000	96	EC	2030
OK311310020060G	Blue Beaver Creek	12/11/2000	10	EC	2030
OK311310020060G	Blue Beaver Creek	1/22/2001	10	EC	2030
OK311310020060G	Blue Beaver Creek	2/26/2001	10	EC	2030
OK311310020060G	Blue Beaver Creek	4/2/2001	262	EC	2030
OK311310020060G	Blue Beaver Creek	5/7/2001	218	EC	406
OK311310020060G	Blue Beaver Creek	6/11/2001	10	EC	406
OK311310020060G	Blue Beaver Creek	7/16/2001	154	EC	406
OK311310020060G	Blue Beaver Creek	8/20/2001	400	EC	406
OK311310020060G	Blue Beaver Creek	9/24/2001	80	EC	406
OK311310020060G	Blue Beaver Creek	10/29/2001	20	EC	2030
OK311310020060G	Blue Beaver Creek	8/28/2000	210	ENT	108
OK311310020060G	Blue Beaver Creek	10/2/2000	11000	ENT	540
OK311310020060G	Blue Beaver Creek	11/7/2000	290	ENT	540
OK311310020060G	Blue Beaver Creek	12/11/2000	10	ENT	540
OK311310020060G	Blue Beaver Creek	1/22/2001	80	ENT	540
OK311310020060G	Blue Beaver Creek	2/26/2001	70	ENT	540
OK311310020060G	Blue Beaver Creek	4/2/2001	140	ENT	540
OK311310020060G	Blue Beaver Creek	5/7/2001	6000	ENT	108
OK311310020060G	Blue Beaver Creek	6/11/2001	120	ENT	108
OK311310020060G	Blue Beaver Creek	7/16/2001	218	ENT	108
OK311310020060G	Blue Beaver Creek	8/20/2001	165	ENT	108
OK311310020060G	Blue Beaver Creek	9/24/2001	40	ENT	108
OK311310020060G	Blue Beaver Creek	10/29/2001	30	ENT	540
OK311310020060G	Blue Beaver Creek	10/29/2001	20	ENT	540
OK311310030050G	Brush Creek	5/15/2000	100	FC	400
OK311310030050G	Brush Creek	6/19/2000	2200	FC	400
OK311310030050G	Brush Creek	11/7/2000	500	FC	2000
OK311310030050G	Brush Creek	12/11/2000	20	FC	2000

WQM Station	Water Body Name	Date	Bacteria Concentration (#/100ml)	Bacteria Indicator	Single Sample Criteria * (#/100)
OK311310030050G	Brush Creek	1/22/2001	10	FC	2000
OK311310030050G	Brush Creek	2/26/2001	400	FC	2000
OK311310030050G	Brush Creek	4/2/2001	30	FC	2000
OK311310030050G	Brush Creek	5/7/2001	13000	FC	400
OK311310030050G	Brush Creek	6/11/2001	50	FC	400
OK311310030050G	Brush Creek	7/16/2001	38	FC	400
OK311310030050G	Brush Creek	8/20/2001	600	FC	400
OK311310030050G	Brush Creek	9/24/2001	500	FC	400
OK311310030050G	Brush Creek	10/29/2001	1050	FC	2000
OK311310030050G	Brush Creek	10/29/2001	30	FC	2000
OK311310030050G	Brush Creek	11/7/2000	358	EC	2030
OK311310030050G	Brush Creek	12/11/2000	52	EC	2030
OK311310030050G	Brush Creek	1/22/2001	20	EC	2030
OK311310030050G	Brush Creek	2/26/2001	246	EC	2030
OK311310030050G	Brush Creek	4/2/2001	30	EC	2030
OK311310030050G	Brush Creek	5/7/2001	11198	EC	406
OK311310030050G	Brush Creek	6/11/2001	30	EC	406
OK311310030050G	Brush Creek	7/16/2001	20	EC	406
OK311310030050G	Brush Creek	8/20/2001	800	EC	406
OK311310030050G	Brush Creek	9/24/2001	490	EC	406
OK311310030050G	Brush Creek	10/29/2001	770	EC	2030
OK311310030050G	Brush Creek	11/7/2000	4000	ENT	540
OK311310030050G	Brush Creek	12/11/2000	70	ENT	540
OK311310030050G	Brush Creek	1/22/2001	80	ENT	540
OK311310030050G	Brush Creek	2/26/2001	200	ENT	540
OK311310030050G	Brush Creek	4/2/2001	200	ENT	540
OK311310030050G	Brush Creek	5/7/2001	42000	ENT	108
OK311310030050G	Brush Creek	6/11/2001	60	ENT	108
OK311310030050G	Brush Creek	7/16/2001	10	ENT	108
OK311310030050G	Brush Creek	8/20/2001	195	ENT	108
OK311310030050G	Brush Creek	9/24/2001	130	ENT	108
OK311310030050G	Brush Creek	10/29/2001	80	ENT	540
OK311310030050G	Brush Creek	10/29/2001	30	ENT	540

EC = E. coli; ENT = enterococci; FC = fecal coliform
* Single sample criterion for secondary contact recreation season is shown for all samples collected between October 1st and April 30th.

APPENDIX B
SANITARY SEWER OVERFLOWS DATA

ODEQ Summary of Available Reports of Sanitary Sewer Overflows

Facility Name	Date	Facility ID	Location	Amount (Gal)	Cause	Type Of Source
COMAMCHE	3/9/1992	S11206	SOUTH 2ND ST		RAIN	
COMAMCHE	3/10/1992	S11206	LIFT STATION		RELASY TO PUMPS FAILED	
COMANCHE	3/30/2007	S11206	S. 2ND/HICKORY AVE & US 81/HILL AVE & 1013 S. 10TH		RAIN	MANHOLE
COMANCHE	2/28/1990	S11206	S 2ND ST.		INFLOW FROM HEAVY RAINS CAUSED MANHOLE TO OVERFLOW	
COMANCHE	6/2/1990	S11206	MANHOLE OVERFLOW S.E. 2ND STREET		BYPASS DUE TO EXCESSIVE RAINFALL	
COMANCHE	4/6/1990	S11206	115 N. 2ND ST.		INFILTRATION/INFLOW FROM HEAVY RAINS	
COMANCHE	1/6/1991	S11206	S 2ND			
COMANCHE	6/5/1991	S11206	MANHOLE ON SOUTH 2ND NEXT TO MAIN LIFT STATION			
COMANCHE	8/30/1991	S11206	2ND BETWEEN HICKORY/ASH,WILLOW AND WALNUT AND S BUNCH		POWER FAILURE DURING STORMS	
COMANCHE	9/3/1991	S11206	S 2ND AND S 10TH		HEAVY RAINFALL	
COMANCHE	9/16/1991	S11206	S 2ND BETWEEN WILLOW AND WALNUT		POWER FAILURE	
COMANCHE	9/18/1991	S11206	S 2ND BETWEEN WILLOW AND WALNUT		RAIN STORM	
COMANCHE	9/20/1991	S11206	S 2ND BETWEEN WILLOW AND WALNUT		RAIN STORM	
COMANCHE	9/27/1991	S11206	S 2ND BETWEEN WILLOW AND WALNUT		RAIN STORM	
COMANCHE	10/28/1991	S11206			HEAVY RAINFALL	
COMANCHE	10/29/1991	S11206	S 2ND BETWEEN WILLOW AND WALNUT		BLOWN FUSE	
COMANCHE	12/2/1991	S11206	SOUTH 2ND		PUMP FROZE UP	
COMANCHE	11/14/1991	S11206	SOUTH 2ND		RAINFALL	
COMANCHE	12/11/1991	S11206			HEAVY RAINFALL AND PUMPS UNDER SIZED TO HANDLE LOAD	
COMANCHE	12/12/1991	S11206			HEAVY RAINFALL PUMPS UNDERSIZED FOR LOAD	
COMANCHE	12/13/1991	S11206			HEAVY RAINFALL PUMPS UNDERSIZED FOR THE LOAD	
COMANCHE	5/29/1992	S11206	S 2ND ST		HYDRUALIC OVERLOAD OF HOLDING BASIN	
COMANCHE	6/8/1992	S11206	LAGOON	296000	PLANT OVERLOAD FROM RAINSTORMS	
COMANCHE	12/14/1992	S11206	WWTP	73500	I/I FROM HEAVY RAINFALL	
COMANCHE	5/9/1993	S11206	LAGOONS	1995000	RAINS	
COMANCHE	4/25/1995	S11206	LAST TWO CELLS OF LAGOON	0	RAIN I/I	
COMANCHE	9/17/1995	S11206	LAGOON CELL #7	50000	RAIN I/I	
DEVOL		S11403				

Facility Name	Date	Facility ID	Location	Amount (Gal)	Cause	Type Of Source
DEVOL	3/10/2005	S11403	PLANT	100,000	LAGOON FULL	LAGOON/BASIN
DEVOL	10/11/1997	S11403	BLOCK 73, TOWN OF DEVOL		COLLAPSED SEWER LINE	
DEVOL	2/17/1998	S11403	SEWER LAGOON	10,000	POWER FAILURE	
DEVOL	11/17/1998	S11403			BROKEN LINE	
DEVOL	1/2/2001	S11403	SEWER LAGOONS #3 CELL	5,000	NO WEIR BOX	
DEVOL	12/25/2000	S11403	L.S.	5,000	LOSS OF POWER	
DEVOL	12/22/2000	S11403	3RD CELL	5,000	NO OUTLET	
DEVOL	11/11/2000	S11403	WW TREATMENT POND	70,000	DIKE OVERFLOWING	
DEVOL	2/16/2001	S11403	3RD LAGOON CELL	6,000	NO WIER BOX	
DEVOL	2/24/2001	S11403	LAGOON	8,000	RAIN	
DEVOL	3/1/2001	S11403	#3 LAGOON CELL	5000	NO WIER BOX	
DEVOL	3/6/2001	S11403	#3 LAGOON CELL	6000	NO WEIR BOX	LAGOON/BASIN
FREDRICK	2/25/1991	S11402				
FREDRICK	6/1/1995	S11402	EAST OF FREDRICK	350000	RAINI/I	
FREDRICK	6/11/1995	S11402	#3 LAGOON	0	RAIN I/I	
FREDRICK	6/11/1995	S11309	#3 LAGOON	0	RAIN I/I	
RINGLING	11/13/2002	S11103	516 E. F	50	NOT ENOUGH GRADE	
RINGLING	10/31/2003	S11103		20	STOPPAGE	PIPE
RINGLING	4/25/2005	S11103	LIFT STATION	35	VANDALISM	LIFT STATION
RINGLING	10/18/2006	S11103	LIFT STATION	40	ELECTRICAL FAILURE	LIFT STATION
RINGLING	4/30/1990	S11103	M.H. OVERFLOWS	0	EXCESSIVE RAINFALL	
TEMPLE	5/21/2003	S11317	1/2 MILE S. OF TOWN	>3 MILL	DISCHARGING LAGOON	LAGOON/BASIN
TEMPLE	11/2/2003	S11317	GREEN DR. - RESIDENT ROBERT HALE	1,100	DEBRIS	
TEMPLE	1/15/2004	S11317	HWY 5, S. ON S. ASH	300	DEBRIS	MANHOLE
TEMPLE	3/30/2004	S11317				
TEMPLE	3/5/2004	S11317	1/2 MILE S.E. OF TOWN ON HWY 5	47,872	CLEANED CLARIFIER	LAGOON/BASIN
TEMPLE	5/5/2004	S11317	632 W. OREGON E. OF SANDS MOTEL	500	MALFUNCTION	LIFT STATION
TEMPLE	12/1/2004	S11317	WWTP		RAIN	LAGOON/BASIN
TEMPLE	7/25/2005	S11317	PLANT		OVERFLOWING	LAGOON/BASIN
TEMPLE	10/18/2005	S11317	WEST OF TOWN	46,750	DRAIN CLARIFIER	LAGOON/BASIN
TEMPLE	6/3/1992	S11317	AT LAGOON	0	EXCESSIVE RAIN	
TEMPLE	5/4/1992	S11317	LAGOON	500	HYDRUALIC OVERLOAD OF HOLDING BASIN	
TEMPLE	1/18/1993	S11317	LAGOONS SOUTH OF TOWN	500	I/I FROM SYSTEM	

Facility Name	Date	Facility ID	Location	Amount (Gal)	Cause	Type Of Source
TEMPLE	5/1/1993	S11317	LAGOONS ON SE SIDE OF TEMPLE	140000	EXCESSIVE RAINS ALL WINTER	
TEMPLE	9/20/1993	S11317	LIFT STATION AT LAGOONS	0	RAINFALL, PUMPS BURNED OUT	
TEMPLE	5/13/1994	S11317	LAGOONS	0	HYDROLIC OVERLOAD FROM I/I	
TEMPLE	4/24/1995	S11317	LAGOONS LAST CELL	0	RAIN I/I	
TEMPLE	5/8/1995	S11317	AT LAGOONM POND	0	RAIN I/I	
TEMPLE	5/31/1995	S11317	#2 CELL AT LAGOON	50000	RAIN I/I	
TEMPLE	4/11/1996	S11317	1/2 MILE S. OF TEMPLE ON HWY. 5		SEEPAGE IN BETWEEN BUIDING BOARDS	
TEMPLE	5/3/1996	S11317	1/2 MILE S.E. OF TEMPLE, OK.	100	LAGOONS FULL	
TEMPLE	9/3/1996	S11317				
TEMPLE	12/1/1996	S11317		160	RAINS	
TEMPLE	10/28/1998	S11317	N. HWY 65 & BOUNDRY	1,000	BLOCKAGE	
TEMPLE	6/24/1999	S11317	LAGOONS			
TEMPLE	7/2/1999	S11317	1/2 MILE S. ON HWY 5	774,864	SEEPAGE	
TEMPLE	10/18/1999	S11317	1/2 MILE S. ON HWY 5		SEEPAGE THROUGH DAM	
TEMPLE	10/22/1999	S11317	1/2 MILE S. OF TEMPLE ON HWY 5	>2 MILLN	DAMAGED LINE TO DAM	
TEMPLE	11/9/2000	S11317	1/2 MILE S. ON HWY 5	75,600	RAINS	
TEMPLE	11/4/2000	S11317	1/2 MILE MS. ON HWY 5	>3 MILLN	RAINS	
TEMPLE	5/8/2001	S11317	217 E. TEXAS /S. CHERRY & E. TEXAS	100	LINE STOPPAGE	
TEMPLE	9/6/2001	S11317	1/2 MILE S. OF CITY & 1/4 MILE EAST AT WHISKEY CREEK	2,000	SEEPAGE	LAGOON/BASIN

APPENDIX C
ESTIMATED FLOW EXCEEDANCE PERCENTILES

Appendix C

Estimated Flow Exceedance Percentiles

WQ Station	OK311100040010-001AT **Mud Creek**	OK311100040080G **Mud Creek, West, Lower**	USGS_07313600 **Cow Creek**	OK311210000140D **Whisky Creek**	OK311210000150G **Cottonwood Creek**	OK311300010020-001AT **Cache Creek, East**	OK311300030070G **Tahoe Creek**	OK311310010010-001AT **Red River**	OK311310020010-001AT **Cache Creek, West**	OK311310030050G **Brush Creek**
WBID Segment	OK311100040010_00	OK311100040080_00	OK311200000060_00	OK311210000140_00	OK311210000150_00	OK311300010020_00	OK311300030070_00	OK311310010010_00	OK311310020010_00	OK311310030050_00
USGS Gage Reference	07315700	07315700	07313600	07327550	07327550	07311000	07311200	07308500	07311500	07311500
Watershed Area (sq. mile)	444.3	123.7	134.5	22.3	19.1	71.9	20.2	815.5	76.3	27.7
NRCS Curve Number	65.6	67.0	66.8	66.0	68.6	73.9	74.1	71.1	75.4	80.7
Average Annual Rainfall (inch)	35.3	34.1	35.1	34.2	34.9	33.2	32.8	30.0	32.6	31.1
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
0	37,800	8,176	2,750	338	288	27,500	1,626	144,000	65,225	1,612
1	3,710	802	914	43	36	3,780	207	20,968	9,335	231
2	2,318	501	469	33	28	2,461	101	14,212	5,961	147
3	1,550	335	322	23	20	1,720	65	10,200	4,272	106
4	1,165	252	279	19	16	1,274	48	8,110	3,125	77
5	870	188	185	16	14	1,060	38	6,942	2,276	56
6	626	135	139	14	12	910	31	5,837	1,738	43
7	497	107	111	13	11	758	25	5,020	1,357	34
8	400	87	101	12	10	640	22	4,460	1,061	26
9	309	67	84	11	9.4	565	18	4,070	820	20
10	239	52	67	10	8.8	498	16	3,720	711	18
11	198	43	54	9.5	8.1	437	14	3,370	573	14
12	163	35	41	8.9	7.6	384	12	3,040	486	12
13	140	30	37	8.3	7.1	353	11	2,816	409	10
14	119	26	31	7.8	6.6	325	9.9	2,610	345	8.5
15	103	22	27	7.5	6.4	292	9.0	2,430	279	6.8
16	92	20	25	7.1	6.1	265	8.0	2,255	241	5.9
17	83	18	24	6.8	5.8	245	7.2	2,100	207	5.1
18	76	16	21	6.5	5.6	220	6.7	1,970	182	4.4
19	68	15	20	6.2	5.3	202	5.9	1,820	158	3.9
20	61	13	18	6.1	5.2	185	5.3	1,690	140	3.4
21	56	12	17	5.9	5.0	170	4.7	1,590	124	3.1
22	51	11	15	5.7	4.8	160	4.3	1,500	109	2.7
23	46	9.9	13	5.5	4.7	145	3.9	1,430	100	2.5
24	43	9.3	13	5.3	4.5	130	3.5	1,347	91	2.2
25	39	8.4	12	5.1	4.4	120	3.3	1,260	82	2.0
26	36	7.8	11	4.9	4.2	111	3.0	1,190	76	1.9
27	34	7.4	10	4.7	4.0	102	2.7	1,120	71	1.8
28	32	6.9	9.5	4.6	4.0	95	2.5	1,050	65	1.6
29	30	6.5	8.9	4.4	3.8	89	2.3	991	60	1.5
30	28	6.1	8.6	4.4	3.7	82	2.1	936	56	1.4
31	26	5.6	8.2	4.2	3.6	77	2.0	902	53	1.3
32	24	5.2	7.8	4.0	3.4	73	1.7	853	47	1.2
33	22	4.8	7.4	3.8	3.2	69	1.6	808	45	1.1
34	20	4.3	7.1	3.7	3.1	66	1.4	759	42	1.0
35	19	4.1	6.9	3.5	3.0	63	1.2	723	40	1.0

WQ Station	OK311100040010-001AT	OK311100040080G	USGS_07313600	OK311210000140D	OK311210000150G	OK311300010020-001AT	OK311300030070G	OK311310010010-001AT	OK311310020010-001AT	OK311310030050G
	Mud Creek	**Mud Creek, West, Lower**	**Cow Creek**	**Whisky Creek**	**Cottonwood Creek**	**Cache Creek, East**	**Tahoe Creek**	**Red River**	**Cache Creek, West**	**Brush Creek**
WBID Segment	OK311100040010_00	OK311100040080_00	OK311200000060_00	OK311210000140_00	OK311210000150_00	OK311300010020_00	OK311300030070_00	OK311310010010_00	OK311310020010_00	OK311310030050_00
USGS Gage Reference	07315700	07315700	07313600	07327550	07327550	07311000	07311200	07308500	07311500	07311500
Watershed Area (sq. mile)	444.3	123.7	134.5	22.3	19.1	71.9	20.2	815.5	76.3	27.7
NRCS Curve Number	65.6	67.0	66.8	66.0	68.6	73.9	74.1	71.1	75.4	80.7
Average Annual Rainfall (inch)	35.3	34.1	35.1	34.2	34.9	33.2	32.8	30.0	32.6	31.1
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
36	17	3.7	6.6	3.4	2.9	61	1.1	702	36	0.90
37	16	3.5	6.3	3.2	2.7	59	1.1	664	33	0.81
38	15	3.2	6.1	3.0	2.6	57	0.90	638	31	0.76
39	14	3.0	5.9	2.9	2.5	55	0.85	611	29	0.72
40	13	2.8	5.8	2.7	2.3	53	0.78	585	27	0.67
41	12	2.6	5.6	2.7	2.3	51	0.73	565	25	0.63
42	11	2.4	5.4	2.6	2.3	49	0.66	537	24	0.58
43	10	2.2	5.4	2.5	2.1	48	0.60	517	22	0.54
44	9.8	2.1	5.1	2.4	2.0	46	0.55	489	20	0.49
45	9.1	2.0	5.0	2.3	1.9	45	0.49	469	18	0.45
46	8.5	1.8	4.9	2.2	1.9	43	0.44	451	17	0.43
47	8.0	1.7	4.8	2.1	1.8	42	0.39	433	16	0.40
48	7.3	1.6	4.6	2.1	1.8	40	0.33	415	15	0.37
49	6.8	1.5	4.6	2.0	1.7	39	0.30	397	14	0.35
50	6.3	1.3	4.4	2.0	1.7	38	0.26	380	13	0.33
51	5.8	1.3	4.4	1.9	1.6	37	0.24	363	12	0.31
52	5.4	1.2	4.3	1.8	1.5	36	0.21	351	12	0.29
53	5.0	1.1	4.2	1.8	1.5	35	0.20	339	11	0.27
54	4.7	1.0	4.0	1.7	1.5	34	0.17	325	11	0.26
55	4.3	0.93	4.0	1.6	1.4	33	0.15	314	9.8	0.24
56	3.9	0.82	3.8	1.6	1.4	33	0.13	303	9.1	0.22
57	3.6	0.78	3.8	1.5	1.3	32	0.11	292	8.5	0.21
58	3.3	0.71	3.6	1.5	1.3	31	0.10	284	8.2	0.20
59	3.1	0.67	3.4	1.4	1.2	30	0.08	275	7.6	0.18
60	2.8	0.61	3.4	1.4	1.2	30	0.07	264	7.1	0.18
61	2.6	0.56	3.2	1.3	1.1	29	0.05	253	6.7	0.17
62	2.4	0.52	3.1	1.3	1.1	28	0.03	244	6.4	0.16
63	2.2	0.45	3.0	1.2	1.0	27	0.02	236	6.0	0.15
64	1.9	0.41	2.9	1.2	1.0	27	0.01	225	5.6	0.14
65	1.7	0.37	2.8	1.1	1.0	26	0	217	5.3	0.13
66	1.6	0.32	2.8	1.1	1.0	26	0	210	4.9	0.12
67	1.4	0.30	2.7	1.0	0.89	25	0	200	4.5	0.11
68	1.2	0.26	2.6	1.0	0.89	25	0	193	4.4	0.11
69	1.1	0.23	2.5	0.95	0.81	24	0	184	4.2	0.10
70	1.0	0.20	2.3	0.94	0.80	24	0	174	4.0	0.09
71	0.84	0.18	2.2	0.90	0.77	23	0	165	3.6	0.09
72	0.73	0.16	2.1	0.88	0.75	23	0	159	3.5	0.08
73	0.64	0.14	2.0	0.86	0.73	22	0	151	3.1	0.08
74	0.55	0.12	2.0	0.81	0.69	22	0	145	2.9	0.07

WQ Station	OK311100040010-001AT	OK311100040080G	USGS_07313600	OK311210000140D	OK311210000150G	OK311300010020-001AT	OK311300030070G	OK311310010010-001AT	OK311310020010-001AT	OK311310030050G
	Mud Creek	**Mud Creek, West, Lower**	**Cow Creek**	**Whisky Creek**	**Cottonwood Creek**	**Cache Creek, East**	**Tahoe Creek**	**Red River**	**Cache Creek, West**	**Brush Creek**
WBID Segment	OK311100040010_00	OK311100040080_00	OK311200000060_00	OK311210000140_00	OK311210000150_00	OK311300010020_00	OK311300030070_00	OK311310010010_00	OK311310020010_00	OK311310030050_00
USGS Gage Reference	07315700	07315700	07313600	07327550	07327550	07311000	07311200	07308500	07311500	07311500
Watershed Area (sq. mile)	444.3	123.7	134.5	22.3	19.1	71.9	20.2	815.5	76.3	27.7
NRCS Curve Number	65.6	67.0	66.8	66.0	68.6	73.9	74.1	71.1	75.4	80.7
Average Annual Rainfall (inch)	35.3	34.1	35.1	34.2	34.9	33.2	32.8	30.0	32.6	31.1
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
75	0.47	0.10	1.9	0.78	0.66	21	0	136	2.7	0.07
76	0.40	0.09	1.7	0.76	0.65	21	0	130	2.5	0.06
77	0.33	0.07	1.7	0.72	0.61	20	0	123	2.4	0.05
78	0.28	0.06	1.6	0.69	0.59	20	0	117	2.2	0.05
79	0.21	0.04	1.5	0.65	0.56	19	0	112	1.8	0.04
80	0.17	0.04	1.5	0.61	0.52	19	0	106	1.7	0.04
81	0.12	0.03	1.5	0.56	0.48	18	0	101	1.6	0.04
82	0.10	0.02	1.4	0.52	0.44	18	0	96	1.4	0.03
83	0.05	0.01	1.3	0.49	0.42	17	0	91	1.2	0.03
84	0.01	0.002	1.3	0.45	0.38	17	0	86	1.0	0.02
85	0	0	1.2	0.42	0.35	16	0	81	0.82	0.02
86	0	0	1.1	0.38	0.32	16	0	74	0.65	0.02
87	0	0	1.1	0.35	0.30	16	0	67	0.44	0.01
88	0	0	1.0	0.32	0.27	15	0	61	0.29	0.01
89	0	0	1.0	0.29	0.25	15	0	54	0.18	0.004
90	0	0	0.88	0.25	0.21	14	0	49	0.07	0.001
91	0	0	0.81	0.22	0.19	13	0	44	0	0
92	0	0	0.71	0.19	0.16	13	0	39	0	0
93	0	0	0.66	0.18	0.15	12	0	33	0	0
94	0	0	0.51	0.16	0.14	12	0	27	0	0
95	0	0	0.31	0.14	0.12	11	0	21	0	0
96	0	0	0.24	0.13	0.11	10	0	16	0	0
97	0	0	0.17	0.09	0.08	9.3	0	8.6	0	0
98	0	0	0.10	0.05	0.04	8.0	0	0.7	0	0
99	0	0	0	0	0	6.3	0	0	0	0
100	0	0	0	0	0	1.7	0	0	0	0

Appendix C
General Methodology for Estimating Flow at WQM Stations

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 WQM stations, along with all USGS flow stations located in the 8-digit HUCs with impaired streams. Parsons will then identify all the USGS gage stations upstream and downstream of the subwatersheds with 303(d) listed WQM stations.

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:

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

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

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

Thus, the runoff curve number equation can be rewritten:

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

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

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

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:

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

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 WQM station and no gages are present upstream or downstream, flows will be estimated for the WQM station 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.