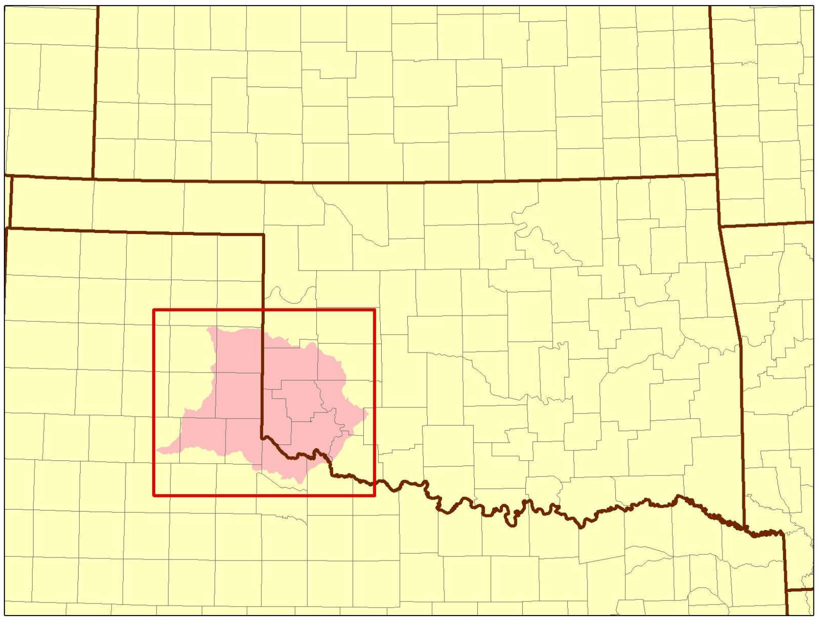
# FINAL

# BACTERIA TOTAL MAXIMUM DAILY LOADS FOR THE UPPER RED RIVER AREA, OKLAHOMA (OK311500, OK311510, OK311600, OK311800)



*Prepared for:*

**OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY**

*Prepared by:*

PARSONS

**JUNE 2008**

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## BACTERIA TOTAL MAXIMUM DAILY LOADS FOR THE UPPER RED RIVER AREA, OKLAHOMA (OK311500, OK311510, OK311600, OK311800)

### OKWBID

OK311500010020, OK311500010050, OK311500010110, OK311500020040, OK311500030010, OK311500030040, OK311510010010, OK311510020060, OK311600010040, OK311600020010, OK311600020010, OK311600020110, OK311600020140, OK311800000010, OK311800000070, OK311800000130

*Prepared for:*

**OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY**

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**JUNE 2008**


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 |
| PS | Point source |
| SBCR | Secondary body contact recreation |
| 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 |

# 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 Upper 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 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) or secondary body contact recreation (SBCR) were 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 or secondary 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 | Secondary Body Contact Recreation |
|---|---|---|---|---|---|---|
| OK311500010020_10 | Red River-North Fork at US 62 | 62.04 | 5 | 2005 | N | NA |
| OK311500010050_00 | Stinking Creek | 17.44 | 5 | 2007 | N | NA |
| OK311500010110_00 | Tepee Creek | 19.51 | 5 | 2007 | N | NA |
| OK311500020040_00 | West Otter Creek | 8.27 | 5 | 2007 | N | NA |
| OK311500030010_00 | Elk Creek | 15.70 | 5 | 2005 | N | NA |
| OK311500030040_00 | Little Elk Creek | 16.20 | 5 | 2007 | N | NA |
| OK311510010010_00 | Red River-North Fork at US 34 | 58.68 | 5 | 2005 | N | NA |
| OK311510020060_00 | Turkey Creek | 19.42 | 5 | 2007 | N | NA |
| OK311600010040_00 | Sandy Creek (Lebos) | 39.65 | 5 | 2005 | NA | N |
| OK311600020010_00 | Red River-Salt Fork at US 283 | 13.67 | 5 | 2005 | N | NA |
| OK311600020010_10 | Red River-Salt Fork at SH 34 | 69.63 | 5 | 2005 | N | NA |
| OK311600020110_00 | Bitter Creek | 5.27 | 5 | 2007 | NA | N |
| OK311600020140_00 | Cave Creek | 13.69 | 5 | 2007 | N | NA |
| OK311800000010_00 | Red River-Elm Fork | 62.93 | 5 | 2005 | N | NA |
| OK311800000070_00 | Deer Creek | 22.57 | 5 | 2007 | N | NA |
| OK311800000130_00 | Fish Creek | 17.79 | 5 | 2007 | N | NA |

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

For data collected between 1999 and 2003, evidence of nonsupport of the PBCR use based on fecal coliform concentrations was observed in seven waterbodies: Stinking Creek (OK311500010050), Tepee Creek (OK311500010110), West Otter Creek (OK311500020040), Little Elk Creek (OK311500030040), Turkey Creek (OK311510020060), Deer Creek (OK311800000070), and Fish Creek (OK311800000130). Evidence of nonsupport of the PBCR use based on Enterococci concentrations was observed in three waterbodies: Elk Creek (OK311500030010), Red River-North Fork at US 62 (OK311500010020), and Red River-North Fork at SH 34 (OK311510010010). Evidence of nonsupport of the PBCR use based on both fecal coliform and Enterococci concentrations were observed in two waterbodies: Red River-Salt Fork at SH 34 (OK311600020010_10), and Cave Creek (OK311600020140). Evidence of nonsupport of the PBCR use based on all three bacterial indicators, fecal coliform, Enterococci and *E. coli* concentrations were observed in two waterbodies: Red River-Salt Fork at US 283 (OK311600020010_00) and Red River-Elm Fork (OK311800000010). For data collected between 1999 and 2001, evidence of nonsupport of the SBCR use based on Enterococci concentrations was observed in two waterbodies: Sandy Creek (OK311600010040) and Bitter Creek (OK311600020110). In Appendix C of the ODEQ 2004 Integrated Report total fecal coliform is also identified as a pollutant of concern for some 303(d) listed waterbodies. This indicator is typically associated with evaluating use impairment for waterbodies with drinking water as a designated use. However, because there are no drinking water intakes within 5 miles of the WQM stations associated with total fecal coliform samples collected, the listing of this bacterial indicator in Category 5 of the 2004 Integrated Report does not require the development of a TMDL. Table ES-2 summarizes the waterbodies requiring TMDLs for not supporting PBCR and Table ES-3 summarizes waterbodies requiring TMDLs for not supporting SBCR.

**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* |
| OK311500010020-001AT | OK311500010020_10 | Red River-North Fork at US 62 | | X | |
| OK311500010050G | OK311500010050_00 | Stinking Creek | X | | |
| OK311500010110G | OK311500010110_00 | Tepee Creek | X | | |
| OK311500020040G | OK311500020040_00 | West Otter Creek | X | | |
| OK311500030010-001AT | OK311500030010_00 | Elk Creek | | X | |
| OK311500030040-001AT | OK311500030040_00 | Little Elk Creek | X | | |
| OK311510010010-001AT | OK311510010010_00 | Red River-North Fork at SH 34 | | X | |
| OK311510020060G | OK311510020060_00 | Turkey Creek | X | | |
| OK311600020010-002AT | OK311600020010_00 | Red River-Salt Fork at US 283 | X | X | X |
| OK311600020010-001AT | OK311600020010_10 | Red River-Salt Fork at SH 34 | X | X | |
| OK311600020140G | OK311600020140_00 | Cave Creek | X | X | |
| OK311800000010-001AT | OK311800000010_00 | Red River-Elm Fork | X | X | X |
| OK311800000070C | OK311800000070_00 | Deer Creek | X | | |
| OK311800000130G | OK311800000130_00 | Fish Creek | X | | |

ENT = enterococci; FC = fecal coliform

**Table ES-3 Waterbodies Requiring TMDLs for Not Supporting Secondary Body Contact Recreation Use**

| WQM Station | Waterbody ID | Waterbody Name | Indicator Bacteria | | |
|---|---|---|---|---|---|
| | | | FC | ENT | *E. coli* |
| OK311600010040-001AT | OK311600010040_00 | Sandy Creek (Lebos) | | X | |
| OK311600020110G | OK311600020110_00 | Bitter 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.*

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

*(a) The water quality requirements for Secondary Body Contact Recreation are usually not as stringent as for Primary Body Contact Recreation.*

*(b) The Secondary Body Contact Recreation beneficial use is designated where ingestion of water is not anticipated.*

*(c) Associated activities may include boating, fishing or wading.*

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 1$^{st}$ to September 30$^{th}$) as the water quality goal for TMDLs corresponds to the basis for 303(d) listing and may be protective of the geometric mean criterion as well as the criteria for the secondary contact recreation season. However, both the instantaneous and geometric mean criteria for *E. coli* and Enterococci will be evaluated as water quality targets to ensure the most protective goal is established for each waterbody.

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.

The two creeks in the Upper Red River Study Area, Sandy Creek (OK311600010040) and Bitter Creek (OK311600020110), which are designated in Chapter 45 of the Oklahoma WQS for secondary body contact recreation (SBCR) use. The data assessment method used for SBCR streams is the same as with the PBCR, although the criteria are five times those of the PBCR streams. The single sample criterion for SBCR for fecal coliform, *E. coli*, and Enterococci are 2,000, 2,030, and 540 colonies per 100 mL, respectively; and the geometric mean criterion for fecal coliform, E. coli, and Enterococci are 2000, 630, and 165 colonies per 100 mL, respectively.

## 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 humans, warm-blooded animals, and 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 Elk Creek (OK311500030010_00), Bitter Creek (OK311600020110_00), Cave Creek (OK311600020140_00), Deer Creek (OK311800000070_00), and Fish Creek (OK311800000130_00). Eleven of the watersheds in the Study Area, including Red River-North Fork at US 62 (OK311500010020_10), Stinking Creek (OK311500010050_00), Tepee Creek (OK311500010110_00), West Otter Creek (OK311500020040_00), Little Elk Creek (OK311500030040_00), Red River-North Fork at SH 34 (OK311510010010_00 ), Turkey Creek (OK311510020060_00), Sandy Creek (Lebos) (OK311600010040_00), Red River-Salt Fork at SH 34 (OK311600020010_10), Red River-Salt Fork at US 283 (OK311600020010_00), and Red River-Elm Fork (OK311800000010_00) have NPDES-permitted facilities.

There are 12 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 Upper Red River 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.

While not all sewer overflows are reported, ODEQ has some data on SSOs available. There were 34 SSO occurrences, ranging from 0 gallon to 11,433,700 gallons, reported for certain watersheds within the Study Area between December 1991 and August 1999. Given the significant number of occurrences and the size of overflows reported, SSOs have been a significant source of bacteria loading in the past in the Stinking Creek (OK311500010050_00) and Red River- Salt Fork at SH 34 (OK311600020010_10) watersheds.

The Municipal separate storm sewer system (MS4) permit for small communities in Oklahoma became effective on February 8, 2005. The City of Altus (Permit #: OKR040043) located in the Stinking Creek (OK311500010050_00) watershed, falls under requirements designated by USEPA for inclusion in the Phase II NPDES Stormwater Program. This municipality was designated because their municipal boundaries intersected a U.S. Census-defined Urbanized Area. There are two different CAFOs located in the Study Area, one in Red River-Salt Fork at US 283 (OK311600020010_00) and one in Stinking Creek (OK311500010050_00).

There are no NPDES-permitted facilities of any type in the contributing watershed of Elk Creek (OK311500030010_00), Bitter Creek (OK311600020110_00), Cave Creek (OK311600020140_00), Deer Creek (OK311800000070_00), and Fish Creek (OK311800000130_00).; therefore, nonsupport of PBCR use is caused by nonpoint sources of bacteria only. In watersheds with both point and nonpoint sources of bacteria, the available data suggests that the proportion of bacteria from point sources ranges from minor to moderate. Those waterbodies in which point sources are a minor contributor of bacteria include Red River-North Fork at US 62 (OK311500010020_10), Tepee Creek (OK311500010110_00), West Otter Creek (OK311500020040_00), Little Elk Creek (OK311500030040_00), Red River-North Fork at SH 34 (OK311510010010_00), Turkey Creek (OK311510020060_00), Sandy Creek (Lebos) (OK311600010040_00), Red River-Salt Fork at US 283 (OK311600020010_00), and Red River-Elm Fork (OK311800000010_00). In the remaining two watersheds, Stinking Creek (OK311500010050_00) and Red River-Salt Fork at SH 34 (OK311600020010_10), point sources such as WWTP, SSOs, and CAFOs, contribute moderate bacteria loads in proportion to nonpoint sources. The urban area designated as Phase II MS4s in the City of Altus further increases the proportion of bacteria loading from point sources in Stinking Creek (OK311500010050_00). However, overall nonpoint sources are considered to be the major source of bacteria loading in each watershed.

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 occurring during a range of flow conditions. Low flow exceednaces are likely due to a combination of non-point sources, uncontrolled point sources and permit noncompliance.

## 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. However, Flow range is only a general indicator of the relative proportion of point/nonpoint contributions. It is not used in this report to quantify point source or nonpoint source contributions. Violations that occur during low flows may not be caused exclusively by point sources. Violations have been noted in some watersheds that contain no point sources. Research has show that bacteria loading in streams during low flow conditions may be due to direct deposit of cattle manure into streams and faulty septic tank/lateral field systems.

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) for waterbodies not supporting the PBCR use;
- obtaining water quality data from the entire calendar year for waterbodies not supporting the SBCR use;
- 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-4). 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-4 presents the percent reductions necessary for each bacterial indicator causing nonsupport of the PBCR or SBCR 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-4 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 North Fork Red River at US 62, Elk Creek, North Fork Red River at SH 34, Sandy Creek, Salt Fork Red River at US 283, Salt Fork Red River at SH 34, Bitter Creek, Cave Creek, and Elm Fork Red River will be based on Enterococci. The TMDL PRGs for Stinking Creek, Tepee Creek, West Otter Creek, Little Elk Creek, Turkey Creek, Deer Creek and Fish Creek will be based on fecal coliform. The PRGs range from 14 to 99 percent.

**Table ES-4 TMDL Percent Reduction Goals Required to Meet Water Quality Standards for Impaired Waterbodies in the Upper 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 |
| OK311500010020_10 | OK311500010020-001AT | Red River-North Fork at US 62 | | | | 88% | **81%** |
| OK311500010050_00 | OK311500010050G | Stinking Creek | **97%** | | | | |
| OK311500010110_00 | OK311500010110G | Tepee Creek | **28%** | | | | |
| OK311500020040_00 | OK311500020040G | West Otter Creek | **66%** | | | | |
| OK311500030010_00 | OK311500030010-001AT | Elk Creek | | | | 94% | **85%** |
| OK311500030040_00 | OK311500030040G | Little Elk Creek | **67%** | | | | |
| OK311510010010_00 | OK311510010010-001AT | Red River-North Fork at SH 34 | | | | 96% | **70%** |
| OK311510020060_00 | OK311510020060G | Turkey Creek | **60%** | | | | |
| OK311600010040_00 | OK311600010040-001AT | Sandy Creek (Lebos) | | | | 99% | **83%** |
| OK311600020010_00 | OK311600020010-002AT | Red River-Salt Fork at US 283 | 76% | 89% | 14% | 99% | **94%** |
| OK311600020010_10 | OK311600020010-001AT | Red River-Salt Fork at SH 34 | 64% | | | 99% | **96%** |
| OK311600020110_00 | OK311600020110G | Bitter Creek | | | | 96% | **76%** |

| Waterbody ID | WQM Station | Waterbody Name | Percent Reduction Required | | | | |
|---|---|---|---|---|---|---|---|
| | | | FC | EC | | ENT | |
| | | | Instant-aneous | Instant-aneous | Geo-mean | Instant-aneous | Geo-mean |
| OK311600020140_00 | OK311600020140G | Cave Creek | 72% | | | 95% | **92%** |
| OK311800000010_00 | OK311800000010-001AT | Red River-Elm Fork | 28% | 87% | 79% | 98% | **87%** |
| OK311800000070_00 | OK311800000070C | Deer Creek | **72%** | | | | |
| OK311800000130_00 | OK311800000130G | Fish Creek | **28%** | | | | |

The TMDL, WLA, LA, and MOS vary with flow condition, and are calculated at every 5$^{th}$ flow interval percentile. For illustrative purposes, the TMDL, WLA, LA, and MOS calculated for the median flow at each site are presented in Table ES-5. The WLA component of each TMDL is the sum of WLAs for all WWTPs within the contributing watershed of each WQM station. The sum of the WLAs for WWTPs can be represented as a single line below the LDC. The WLA for MS4s is estimated based on the percentage of study watershed which is under the MS4 coverage. The LDC and the simple equation of:

***Average LA = average TMDL – MOS - WLA_WWTF - WLA_MS4***

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. For MS4s the load reduction will be the same as the PRG established for the LA (nonpoint sources). 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. For PBCR this 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. For SBCR, this equates to 1,800 colony-forming units per 100 milliliter (cfu/100 mL), 1,827 cfu/100 mL, and 486/100 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-5 TMDL Summaries Examples

| Waterbody ID | WQM Station | Waterbody Name | Indicator Bacteria Species | TMDL† (cfu/day) | WLA_WWTP† (cfu/day) | WLA_MS4† (cfu/day) | LA† (cfu/day) | MOS† (cfu/day) |
|---|---|---|---|---|---|---|---|---|
| OK311500010020_10 | OK311500010020-001AT | Red River-North Fork at US 62 | ENT | 1.98171E+11 | 0 | 0 | 1.78354E+11 | 19817074894 |
| OK311500010050_00 | OK311500010050G | Stinking Creek | FC | 4.70E+10 | 1.51E+10 | 1.84E+09 | 25329065970 | 4700774205 |
| OK311500010110_00 | OK311500010110G | Tepee Creek | ENT | 843301322.4 | 0 | 0 | 758971190.2 | 84330132.24 |
| OK311500020040_00 | OK311500020040G | West Otter Creek | ENT | 1665939887 | 0 | 0 | 1499345898 | 166593988.7 |
| OK311500030010_00 | OK311500030010-001AT | Elk Creek | ENT | 44918703092 | 0 | 0 | 40426832783 | 4491870309 |
| OK311500030040_00 | OK311500030040G | Little Elk Creek | ENT | 656168743.3 | 0 | 0 | 590551868.9 | 65616874.33 |
| OK311510010010_00 | OK311510010010-001AT | Red River-North Fork at SH 34 | ENT | 1.13618E+11 | 0 | 0 | 1.02256E+11 | 11361789606 |
| OK311510020060_00 | OK311510020060G | Turkey Creek | FC | 14520288826 | 0 | 0 | 13068259944 | 1452028883 |
| OK311600010040_00 | OK311600010040-001AT | Sandy Creek (Lebos) | ENT | 6.87E+10 | 0 | 0 | 61829273668 | 6869919296 |
| OK311600020010_00 | OK311600020010-002AT | Red River-Salt Fork at US 283 | ENT | 2.19309E+11 | 0 | 0 | 1.97378E+11 | 21930896216 |
| OK311600020010_10 | OK311600020010-001AT | Red River-Salt Fork at SH 34 | ENT | 1.80E+10 | 3.75E+08 | 0 | 15795980557 | 1.80E+09 |
| OK311600020110_00 | OK311600020110G | Bitter Creek | ENT | 5.06E+10 | 0 | 0 | 4.55E+10 | 5.06E+09 |
| OK311600020140_00 | OK311600020140G | Cave Creek | ENT | 281100440.8 | 0 | 0 | 252990396.7 | 28110044.08 |
| OK311800000010_00 | OK311800000010-001AT | Red River-Elm Fork | ENT | 63414639660 | 0 | 0 | 57073175694 | 6341463966 |
| OK311800000070_00 | OK311800000070C | Deer Creek | ENT | 3166992912 | 0 | 0 | 2850293621 | 316699291.2 |
| OK311800000130_00 | OK311800000130G | Fish Creek | FC | 8.23E+09 | 0 | 0 | 7.41E+09 | 8.23E+08 |

† Derived for illustrative purposes at the median flow value

# 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 Upper 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 or secondary body contact recreation:

- Red River-North Fork at US 62 (OK311500010020_00),
- Stinking Creek (OK311500010050_00),
- Tepee Creek (OK311500010110_00),
- West Otter Creek (OK311500020040_00),
- Elk Creek (OK311500030010_00),
- Little Elk Creek (OK311500030040_00),
- Red River-North Fork at SH 34 (OK311510010010_00)
- Turkey Creek (OK311510020060_00),
- Sandy Creek (OK311600010040_00),
- Red River-Salt Fork at US 283 (OK311600020010_00),
- Red River-Salt Fork at US 34 (OK311600020010_10),
- Bitter Creek (OK311600020110_00),
- Cave Creek (OK311600020140_00),
- Red River-Elm Fork (OK311800000010_00),
- Deer Creek (OK311800000070_00), and
- Fish Creek (OK311800000130_00).

Figure 1-1 is a location map showing the impaired segments of 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 |
|---|---|---|---|
| Red River-North Fork at US 62 | OK311500010020_10 | OK311500010020-001AT | Red River-North Fork |
| Stinking Creek | OK311500010050_00 | OK311500010050G | Stinking Creek |
| Tepee Creek | OK311500010110_00 | OK311500010110G | Tepee Creek |
| West Otter Creek | OK311500020040_00 | OK311500020040G | West Otter Creek |
| Elk Creek | OK311500030010_00 | OK311500030010-001AT | Elk Creek |
| Little Elk Creek | OK311500030040_00 | OK311500030040-001AT | Little Elk Creek |
| Red River-North Fork at SH 34 | OK311510010010_00 | OK311510010010-001AT | Red River-North Fork |
| Turkey Creek | OK311510020060_00 | OK311510020060G | Turkey Creek |
| Sandy Creek (Lebos) | OK311600010040_00 | OK311600010040-001AT | Sandy Creek (Lebos) |
| Red River-Salt Fork at US 283 | OK311600020010_00 | OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer |

| Waterbody Name | Waterbody ID | WQM Station | WQM Station Location Descriptions |
|---|---|---|---|
| Red River-Salt Fork at US 34 | OK311600020010_10 | OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum |
| Bitter Creek | OK311600020110_00 | OK311600020110G | Bitter Creek |
| Cave Creek | OK311600020140_00 | OK311600020140G | Cave Creek |
| Red River-Elm Fork | OK311800000010_00 | OK311800000010-001AT | Red River-Elm Fork |
| Deer Creek | OK311800000070_00 | OK311800000070C | Deer Creek |
| Fish Creek | OK311800000130_00 | OK311800000130G | Fish Creek |

## 1.2 Watershed Description

**General.** The Red River Basin is located in the southwestern portion of Oklahoma. The majority of the waterbodies addressed in this report are located in Beckman, Washita, Kiowa, Jackson, Harmon and Greer Counties. The headwaters of Red River-Salt Fork (OK311600020010_10) originate in Collingsworth County, Texas, although the majority of its contributing watershed is located in the State of Oklahoma (95 percent).

These counties are part of the Central Great Plains ecoregion. The waterbodies in the Study Area lay within the Anadarko Basin, Wichita Mountain Uplift and Hollis Basin geological provinces. The northern portion of the West Otter Creek (OK311500020040) watershed is part of the Wichita Mountains Wildlife Refuge.

Table 1-2, derived from the 2000 U.S. Census, demonstrates that the counties in which these watersheds are located are sparsely populated (U.S. Census Bureau 2000).

**Table 1-2 County Population and Density**

| County Name | Population (2000 Census) | Population Density (per square mile) |
|---|---|---|
| Beckham | 19,799 | 22 |
| Washita | 11,508 | 12 |
| Kiowa | 10,227 | 10 |
| Jackson | 28,439 | 35 |
| Harmon | 3,283 | 6 |
| Greer | 6,061 | 10 |
| Collingsworth, TX | 3,206 | 4 |

**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 26.3 and 30.3 inches (Oklahoma Climate Survey 2007).

**Table 1-3 Average Annual Precipitation by Watershed**

| Upper Red River Precipitation Summary | | |
|---|---|---|
| **Waterbody Name** | **Waterbody ID** | **Average Annual (Inches)** |
| Red River-North Fork at US 62 | OK311500010020_10 | 29.8 |
| Stinking Creek | OK311500010050_00 | 29.3 |
| Tepee Creek | OK311500010110_00 | 29.1 |
| West Otter Creek | OK311500020040_00 | 30.3 |
| Elk Creek | OK311500030010_00 | 29.4 |
| Little Elk Creek | OK311500030040_00 | 29.2 |
| Red River-North Fork at SH 34 | OK311510010010_00 | 28.1 |
| Turkey Creek | OK311510020060_00 | 26.3 |
| Sandy Creek (Lebos) | OK311600010040_00 | 26.7 |
| Red River-Salt Fork at US 283 | OK311600020010_00 | 27.7 |
| Red River-Salt Fork at SH 34 | OK311600020010_10 | 27.4 |
| Bitter Creek | OK311600020110_00 | 29.2 |
| Cave Creek | OK311600020140_00 | 26.7 |
| Red River-Elm Fork | OK311800000010_00 | 28.0 |
| Deer Creek | OK311800000070_00 | 27.2 |
| Fish Creek | OK311800000130_00 | 26.3 |

**Land Use.** Tables 1-4a, 1-4b and 1-4c 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 shrub/scrub and row crops, totaling between 69 and 92 percent, are the primary land use categories in all watersheds in the Study Area, except for Turkey Creek, Cave Creek, Deer Creek and Fish Creek. The watersheds for these creeks are primarily shrub/scrub at 36.6, 72.3, 65.6, and 66.3 percent, respectively. The second most common land use for Turkey Creek, Cave Creek, Deer Creek and Fish Creek is grasslands/herbaceous at 35.9, 13.3, 21.6, and 32.8 percent respectively. There are three cities within the Red River-Elm Fork watershed: Greer, Granite and Mangum. The Red River-Salt Fork at US 283 watershed has three cities: East Duke, Olustee, and Elmer. There are also three cities in the Red River-North Fork at US 62 watershed: Headrick, Snyder, and Mountain Park. The Cities of Eldorado and Gould are within the Sandy Creek watershed. Red River-North Fork at SH 34 also has two cities: Willow and Carter. The only city located in Turkey Creek watershed is Erick, the only city located in the Stinking Creek watershed is Altus, the only city within Tepee Creek is Lone Wolf, and the only city in the Little Elk Creek watershed is Rocky. There are no urban areas within Fish Creek, Deer Creek, Red River-Salt Fork at SH 34, Bitter Creek, Otter Creek, Elm Creek or Cave Creek watersheds. Low, medium, and high intensity developed land account for less than 1 percent of the land use in each watershed, with the exception of the Stinking Creek watershed, where developed land accounts for 4.1 percent of the land use.

**Table 1-4a Land Use Summaries by Watershed**

| Landuse Category | WQM Station | | | | | |
|---|---|---|---|---|---|---|
| | Red River-North Fork at US 62 | Stinking Creek | Tepee Creek | West Otter Creek | Elk Creek | Little Elk Creek |
| **Waterbody ID** | OK311500010020_10 | OK311500010050_00 | OK311500010110_00 | OK311500020040_00 | OK311500030010_00 | OK311500030040_00 |
| Percent of Open Water | 1.1 | 0.2 | 0.3 | 0.2 | 0.2 | 0.7 |
| Percent of Developed, Open Space | 3.5 | 6.6 | 3.9 | 3.9 | 3.9 | 4.5 |
| Percent of Developed, Low Intensity | 0.4 | 2.7 | 0.2 | 0.1 | 0.0 | 0.7 |
| Percent of Developed, Medium Intensity | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent of Developed, High Intensity | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent of Barren Land (Rock/Sand/Clay) | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent of Deciduous Forest | 1.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 |
| Percent of Evergreen Forest | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent of Mixed Forest | 4.0 | 2.6 | 3.7 | 1.8 | 1.7 | 2.6 |
| Percent of Shrub/Scrub | 22.2 | 20.8 | 22.4 | 42.7 | 25.0 | 20.6 |
| Percent of Grassland/Herbaceous | 20.6 | 4.9 | 1.8 | 7.8 | 6.7 | 4.5 |
| Percent of Pasture/Hay | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent of Cultivated Crops | 46.8 | 60.5 | 67.5 | 42.5 | 62.4 | 66.2 |
| Percent of Woody Wetlands | 0.0 | 0.1 | 0.1 | 0.4 | 0.1 | 0.1 |
| Percent of Emergent Herbaceous Wetlands | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | |
| Acres Open Water | 2,260 | 165 | 126 | 40 | 68 | 259 |
| Acres Developed, Open Space | 6,948 | 5,227 | 1,841 | 948 | 1,554 | 1,642 |
| Acres Developed, Low Intensity | 733 | 2,125 | 89 | 26 | 11 | 273 |
| Acres Developed, | 66 | 607 | 14 | 0 | 2 | 6 |

| Landuse Category | WQM Station | | | | | |
|---|---|---|---|---|---|---|
| | **Red River-North Fork at US 62** | **Stinking Creek** | **Tepee Creek** | **West Otter Creek** | **Elk Creek** | **Little Elk Creek** |
| **Waterbody ID** | **OK311500010020_10** | **OK311500010050_00** | **OK311500010110_00** | **OK311500020040_00** | **OK311500030010_00** | **OK311500030040_00** |
| Medium Intensity | | | | | | |
| Acres Developed, High Intensity | 39 | 500 | 2 | 2 | 0 | 0 |
| Acres Barren Land (Rock/Sand/Clay) | 443 | 40 | 0 | 0 | 0 | 0 |
| Acres Deciduous Forest | 1,965 | 32 | 15 | 142 | 1 | 2 |
| Acres Evergreen Forest | 221 | 13 | 3 | 2 | 1 | 0 |
| Acres Mixed Forest | 8,045 | 2,085 | 1,738 | 450 | 662 | 949 |
| Acres Shrub/Scrub | 44,322 | 16,429 | 10,555 | 10,459 | 10,020 | 7,532 |
| Acres Grassland/Herbaceous | 41,183 | 3,864 | 865 | 1,911 | 2,694 | 1,651 |
| Acres Pasture/Hay | 52 | 0 | 0 | 0 | 0 | 0 |
| Acres Cultivated Crops | 93,450 | 47,772 | 31,764 | 10,416 | 24,979 | 24,243 |
| Acres Woody Wetlands | 40 | 80 | 31 | 103 | 28 | 48 |
| Acres Emergent Herbaceous Wetlands | 4 | 0 | 0 | 0 | 0 | 0 |
| **Total (Acres)** | **199,771** | **78,938** | **47,043** | **24,499** | **40,020** | **36,606** |

**Table 1-4b Land Use Summaries by Watershed**

| Landuse Category | WQM Station | | | | |
|---|---|---|---|---|---|
| | Red River-North Fork at SH 34 | Turkey Creek | Sandy Creek (Lebos) | Red River-Salt Fork at US 283 | Red River-Salt Fork at SH 34 |
| **Waterbody ID** | OK311510010010_00 | OK311510020060_00 | OK311600010040_00 | OK311600020010_00 | OK311600020010_10 |
| Percent of Open Water | 0.2 | 0.1 | 0.0 | 0.2 | 0.2 |
| Percent of Developed, Open Space | 3.0 | 3.1 | 4.6 | 3.4 | 1.7 |
| Percent of Developed, Low Intensity | 0.1 | 0.6 | 0.2 | 0.1 | 0.2 |
| Percent of Developed, Medium Intensity | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Percent of Developed, High Intensity | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent of Barren Land (Rock/Sand/Clay) | 0.3 | 0.4 | 0.0 | 0.2 | 0.4 |
| Percent of Deciduous Forest | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| Percent of Evergreen Forest | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent of Mixed Forest | 5.6 | 3.7 | 0.9 | 1.0 | 3.6 |
| Percent of Shrub/Scrub | 39.9 | 36.6 | 39.5 | 42.7 | 59.6 |
| Percent of Grassland/Herbaceous | 17.3 | 35.9 | 2.1 | 4.1 | 13.9 |
| Percent of Pasture/Hay | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent of Cultivated Crops | 32.5 | 19.5 | 52.5 | 48.0 | 18.0 |
| Percent of Woody Wetlands | 1.2 | 0.0 | 0.0 | 0.3 | 2.3 |
| Percent of Emergent Herbaceous Wetlands | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | |
| Acres Open Water | 276 | 21 | 51 | 458 | 209 |
| Acres Developed, Open Space | 5,121 | 947 | 5,394 | 7,743 | 2,291 |
| Acres Developed, Low Intensity | 111 | 195 | 189 | 304 | 322 |
| Acres Developed, Medium Intensity | 14 | 23 | 15 | 10 | 35 |
| Acres Developed, High Intensity | 1 | 6 | 0 | 2 | 16 |
| Acres Barren Land (Rock/Sand/Clay) | 596 | 114 | 5 | 345 | 587 |
| Acres Deciduous Forest | 4 | 0 | 60 | 73 | 16 |
| Acres Evergreen Forest | 2 | 0 | 48 | 77 | 4 |

| Landuse Category | WQM Station | | | | |
|---|---|---|---|---|---|
| | **Red River-North Fork at SH 34** | **Turkey Creek** | **Sandy Creek (Lebos)** | **Red River-Salt Fork at US 283** | **Red River-Salt Fork at SH 34** |
| **Waterbody ID** | **OK311510010010_00** | **OK311510020060_00** | **OK311600010040_00** | **OK311600020010_00** | **OK311600020010_10** |
| Acres Mixed Forest | 9,679 | 1,111 | 1,078 | 2,341 | 4,985 |
| Acres Shrub/Scrub | 68,969 | 11,109 | 46,709 | 97,852 | 82,352 |
| Acres Grassland/Herbaceous | 29,849 | 10,907 | 2,521 | 9,319 | 19,252 |
| Acres Pasture/Hay | 0 | 0 | 0 | 0 | 0 |
| Acres Cultivated Crops | 56,231 | 5,926 | 62,034 | 110,079 | 24,834 |
| Acres Woody Wetlands | 2,039 | 4 | 52 | 728 | 3,186 |
| Acres Emergent Herbaceous Wetlands | 0 | 0 | 0 | 0 | 0 |
| **Total (Acres)** | **172,892** | **30,364** | **118,158** | **229,332** | **138,090** |

**Table 1-4c Land Use Summaries by Watershed**

| Landuse Category | WQM Station | | | | |
|---|---|---|---|---|---|
| | Bitter Creek | Cave Creek | Red River-Elm Fork | Deer Creek | Fish Creek |
| **Waterbody ID** | OK311600020110_00 | OK311600020140_00 | OK311800000010_00 | OK311800000070_00 | OK311800000130_00 |
| Percent of Open Water | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| Percent of Developed, Open Space | 4.2 | 2.1 | 2.3 | 0.7 | 0.2 |
| Percent of Developed, Low Intensity | 0.1 | 0.0 | 0.2 | 0.0 | 0.0 |
| Percent of Developed, Medium Intensity | 0.0 | 0.0 | 0.0 | 0.0 | 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 | 0.1 | 0.5 | 0.1 | 0.0 |
| Percent of Deciduous Forest | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent of Evergreen Forest | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent of Mixed Forest | 0.6 | 1.1 | 1.2 | 0.5 | 0.5 |
| Percent of Shrub/Scrub | 10.1 | 72.3 | 59.2 | 65.6 | 66.3 |
| Percent of Grassland/Herbaceous | 2.6 | 13.3 | 14.2 | 21.6 | 32.8 |
| Percent of Pasture/Hay | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Percent of Cultivated Crops | 82.0 | 11.1 | 21.9 | 11.4 | 0.3 |
| Percent of Woody Wetlands | 0.1 | 0.0 | 0.4 | 0.0 | 0.0 |
| Percent of Emergent Herbaceous Wetlands | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | |
| Acres Open Water | 0 | 1 | 338 | 14 | 0 |
| Acres Developed, Open Space | 138 | 337 | 6,004 | 204 | 33 |
| Acres Developed, Low Intensity | 4 | 4 | 517 | 0 | 0 |
| Acres Developed, Medium Intensity | 0 | 0 | 41 | 0 | 0 |
| Acres Developed, High Intensity | 0 | 0 | 21 | 0 | 0 |
| Acres Barren Land (Rock/Sand/Clay) | 0 | 11 | 1,205 | 35 | 5 |
| Acres Deciduous Forest | 7 | 0 | 14 | 0 | 0 |

| Landuse Category | WQM Station | | | | |
|---|---|---|---|---|---|
| | **Bitter Creek** | **Cave Creek** | **Red River-Elm Fork** | **Deer Creek** | **Fish Creek** |
| **Waterbody ID** | **OK311600020110_00** | **OK311600020140_00** | **OK311800000010_00** | **OK311800000070_00** | **OK311800000130_00** |
| Acres Evergreen Forest | 3 | 0 | 11 | 0 | 0 |
| Acres Mixed Forest | 19 | 168 | 3,081 | 157 | 97 |
| Acres Shrub/Scrub | 331 | 11,335 | 153,339 | 19,388 | 13,756 |
| Acres Grassland/Herbaceous | 85 | 2,083 | 36,795 | 6,394 | 6,807 |
| Acres Pasture/Hay | 0 | 0 | 0 | 0 | 0 |
| Acres Cultivated Crops | 2,694 | 1,734 | 56,571 | 3,361 | 54 |
| Acres Woody Wetlands | 4 | 6 | 908 | 12 | 3 |
| Acres Emergent Herbaceous Wetlands | 0 | 0 | 0 | 0 | 0 |
| **Total (Acres)** | **3,285** | **15,678** | **258,847** | **29,567** | **20,756** |

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

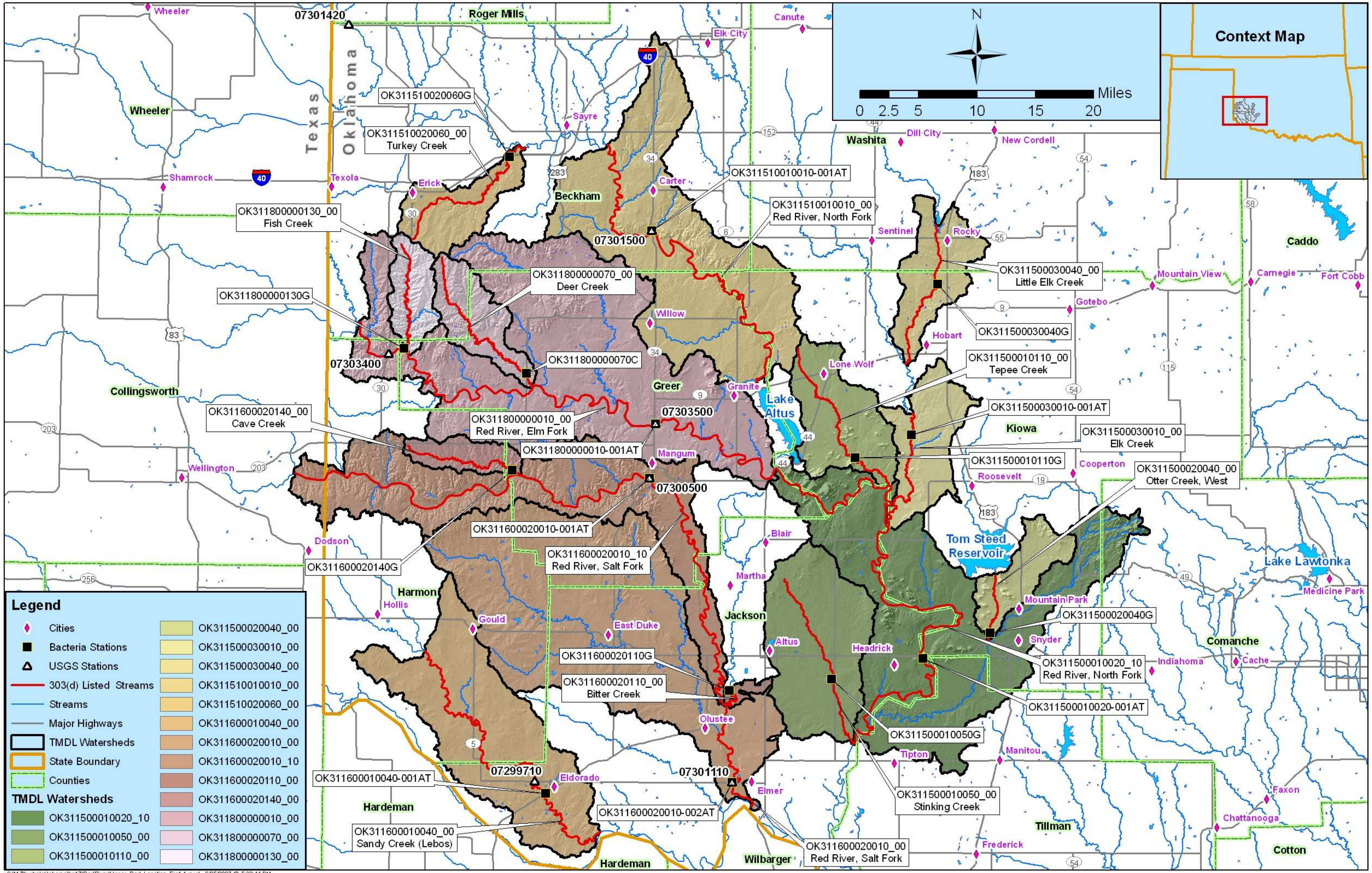
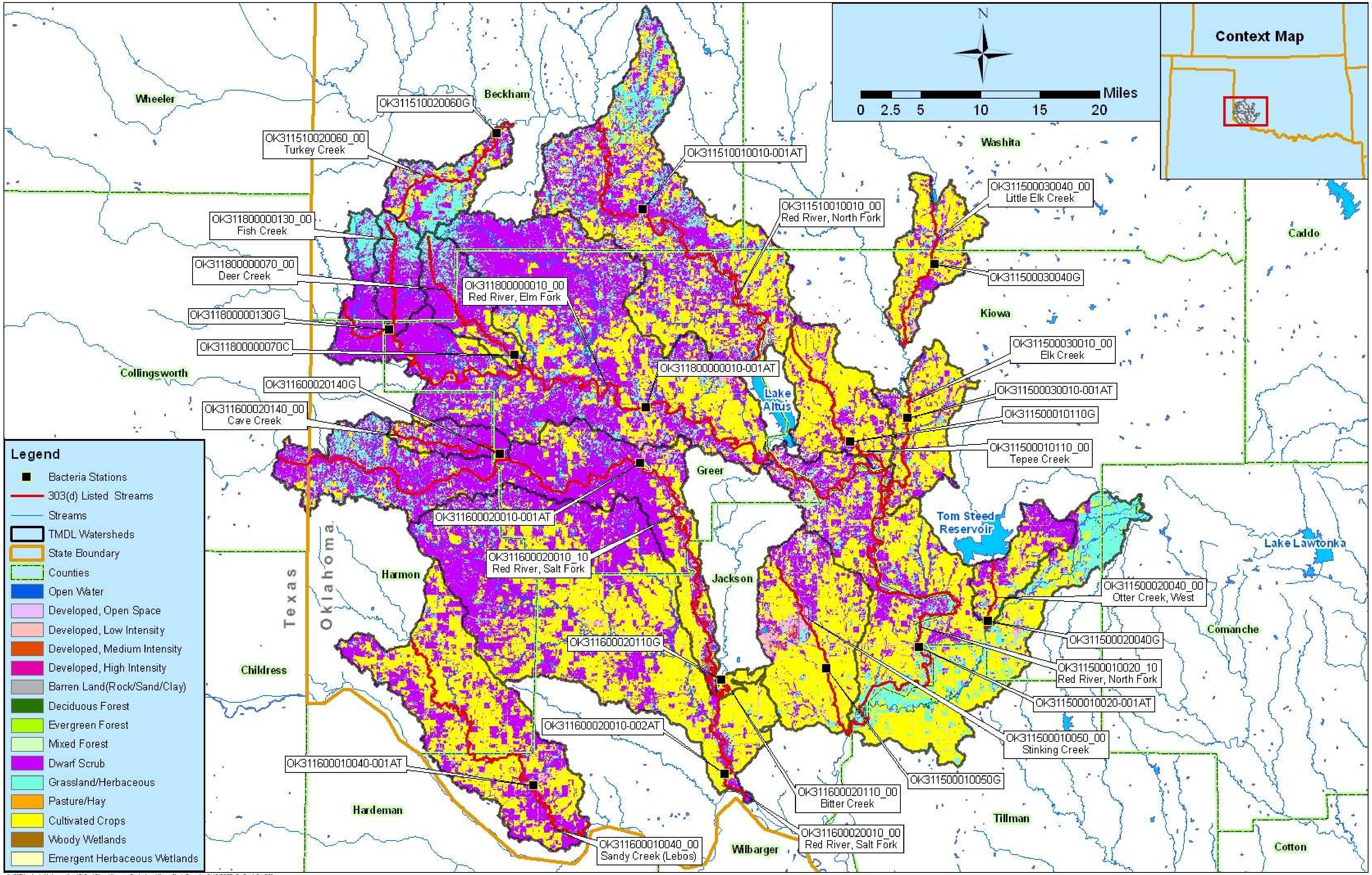


Figure 1-2 Land Use Map by Watershed



# 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 the Red River-North Fork at US 62 (OK311500010020), Red River-North Fork at SH 34 (OK311510010010), Stinking Creek (OK311500010050), Tepee Creek (OK311500010110), West Otter Creek (OK311500020040), Elk Creek (OK311500030010), Little Elk Creek (OK311500030040), Turkey Creek (OK311510020060), Sandy Creek (OK311600010040), Red River-Salt Fork at US 283 (OK311600020010_00), Red-River-Salt Fork at SH 34 (OK311600020010_10), Bitter Creek (OK311600020110), Cave Creek (OK311600020140), Red River-Elm Fork (OK311800000010), Deer Creek (OK311800000070), and Fish Creek (OK311800000130) include PBCR, public/private water supply, warm water aquatic community, industrial and municipal process and cooling water, agricultural water supply, fish consumption, sensitive water supply, habitat limited aquatic community, secondary body contact recreation (SBCR) and aesthetics. The TMDLs in this report address the SBCR use for Sandy Creek (OK311600010040) and Bitter Creek (OK311600020110) and the PBCR use for all of the remaining waterbodies. Table 2-1, an excerpt from Appendix B of the 2004 Integrated Report (ODEQ 2004), summarizes the PBCR or SBCR 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 or SBCR use designation for each waterbody.

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.*

**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 | Secondary Body Contact Recreation |
|---|---|---|---|---|---|---|
| OK311500010020_10 | Red River-North Fork at US 62 | 62.04 | 5 | 2005 | N | NA |
| OK311500010050_00 | Stinking Creek | 17.44 | 5 | 2007 | N | NA |
| OK311500010110_00 | Tepee Creek | 19.51 | 5 | 2007 | N | NA |
| OK311500020040_00 | West Otter Creek | 8.27 | 5 | 2007 | N | NA |
| OK311500030010_00 | Elk Creek | 15.70 | 5 | 2005 | N | NA |
| OK311500030040_00 | Little Elk Creek | 16.20 | 5 | 2007 | N | NA |
| OK311510010010_00 | Red River-North Fork at US 34 | 58.68 | 5 | 2005 | N | NA |
| OK311510020060_00 | Turkey Creek | 19.42 | 5 | 2007 | N | NA |
| OK311600010040_00 | Sandy Creek (Lebos) | 39.65 | 5 | 2005 | NA | N |
| OK311600020010_00 | Red River-Salt Fork at US 283 | 13.67 | 5 | 2005 | N | NA |
| OK311600020010_10 | Red River-Salt Fork at SH 34 | 69.63 | 5 | 2005 | N | NA |
| OK311600020110_00 | Bitter Creek | 5.27 | 5 | 2007 | NA | N |
| OK311600020140_00 | Cave Creek | 13.69 | 5 | 2007 | N | NA |
| OK311800000010_00 | Red River-Elm Fork | 62.93 | 5 | 2005 | N | NA |
| OK311800000070_00 | Deer Creek | 22.57 | 5 | 2007 | N | NA |
| OK311800000130_00 | Fish Creek | 17.79 | 5 | 2007 | N | NA |

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

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

*(a) The water quality requirements for Secondary Body Contact Recreation are usually not as stringent as for Primary Body Contact Recreation.*

*(b) The Secondary Body Contact Recreation beneficial use is designated where ingestion of water is not anticipated.*

*(c) Associated activities may include boating, fishing or wading.*

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 1$^{st}$ to September 30$^{th}$) as the water quality goal for TMDLs corresponds to the basis for 303(d) listing and may be protective of the geometric mean criterion as well as the criteria for the secondary contact recreation season. However, both the instantaneous and geometric mean criteria for *E. coli* and Enterococci will be evaluated as water quality targets to ensure the most protective goal is established for each waterbody.

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

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

There are two creeks, Sandy Creek (OK311600010040) and Bitter Creek (OK311600020110), in the Upper Red River Study Area that are designated as Secondary Body Contact Recreation (SBCR) beneficial use. The data assessment method used for SBCR streams is the same as with the PBCR, although the criteria are five times those of the PBCR streams. The single sample criterion for SBCR for fecal coliform, *E. coli,* and Enterococci are 2,000, 2,030, and 540 colonies per 100 mL, respectively; and the geometric mean criterion for fecal coliform, E. coli, and Enterococci are 2000, 630, and 165 colonies per 100 mL, respectively.

## 2.2 Problem Identification

Table 2-2 summarizes water quality data collected during primary contact recreation season from the WQM stations between 1999 and 2003 for each indicator bacteria. Table 2-3 summarizes water quality data collected during secondary contact recreation season from the WQM stations between 1999 and 2001 for each indicator bacteria. All the data collected during the primary or secondary 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 and Table 2-3 also summarize 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 seven waterbodies: Stinking Creek (OK311500010050), Tepee Creek (OK311500010110), West Otter Creek (OK311500020040), Little Elk Creek (OK311500030040), Turkey Creek (OK311510020060), Deer Creek (OK311800000070), and Fish Creek (OK311800000130). Evidence of nonsupport of the PBCR use based on Enterococci concentrations was observed in three waterbodies: Elk Creek (OK311500030010), Red River-North Fork at US 62 (OK311500010020), and Red River-North Fork at SH 34 (OK311510010010). Evidence of nonsupport of the PBCR use based on both fecal coliform and Enterococci concentrations were observed in two waterbodies: Red River-Salt Fork at SH 34 (OK311600020010_10), and Cave Creek (OK311600020140). Evidence of nonsupport of the PBCR use based on all three bacterial indicators, fecal coliform, Enterococci and *E. coli* concentrations were observed in two waterbodies: Red River-Salt Fork at US 283 (OK311600020010_00) and Red River-Elm Fork (OK311800000010). Evidence of nonsupport of the SBCR use based on Enterococci concentrations was observed in two waterbodies: Sandy Creek (OK311600010040) and Bitter Creek (OK311600020110). In Appendix C of the ODEQ 2004 Integrated Report total fecal coliform is also identified as a pollutant of concern for some 303(d) listed waterbodies. This indicator is typically associated with evaluating use impairment for waterbodies with drinking water as a designated use. However, because there are no drinking water intakes within 5 miles of the WQM stations associated with total fecal coliform samples collected, the listing of this bacterial indicator in Category 5 of the 2004 Integrated Report does not require the development of a TMDL. Tables 2-4 and 2-5 summarize the waterbodies requiring TMDLs for not supporting PBCR and SBCR use, respectively.

## 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, for PBCR, 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).

For SBCR, the water quality target for fecal coliform is 1,800 organisms per 100 mL, 10 percent lower than the instantaneous water quality criteria (2,000/100 mL). For *E. coli* the instantaneous water quality target is 1,827 organisms/100 mL, which is 10 percent lower than the criterion value (2,030/100 mL), and the geometric mean water quality target is 567 organisms/100 mL, which is 10 percent lower than the criterion value (630/100 mL). For Enterococci the instantaneous water quality target is 486/100 mL, which is 10 percent lower than the criterion value (540/100 mL) and the geometric mean water quality target is 149 organisms/100 mL, which is 10 percent lower than the criterion value (165/100 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, 1999-2003**

| 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 |
|---|---|---|---|---|---|---|---|---|
| OK311500010020_10 | North Fork of Red River at US 62 | FC | 400 | 167 | 17 | 4 | 24% | |
| | | EC | 406 | 90 | 18 | 2 | 11% | |
| | | ENT | 108 | 156 | 16 | 9 | 56% | |
| OK311500010050_00 | Stinking Creek | FC | 400 | 2947 | 7 | 6 | 86% | |
| | | EC | 406 | 338 | 5 | 2 | 40% | Delist: Low Sample Count |
| | | ENT | 108 | 518 | 6 | 4 | 67% | Delist: Low Sample Count |
| OK311500010110_00 | Tepee Creek | FC | 400 | 240 | 9 | 3 | 33% | |
| | | EC | 406 | 250 | 6 | 2 | 33% | Delist: Low Sample Count |
| | | ENT | 108 | 697 | 6 | 5 | 83% | Delist: Low Sample Count |
| OK311500020040_00 | West Otter Creek | FC | 400 | 584 | 8 | 6 | 75% | |
| | | EC | 406 | 227 | 7 | 1 | 14% | Delist: Low Sample Count |
| | | ENT | 108 | 1184 | 6 | 5 | 83% | Delist: Low Sample Count |
| OK311500030010_00 | Elk Creek, off US 183, Hobart | FC | 400 | 165 | 26 | 5 | 19% | |
| | | EC | 406 | 49 | 26 | 1 | 4% | |
| | | ENT | 108 | 204 | 26 | 16 | 62% | |
| OK311500030040_00 | Little Elk Creek | FC | 400 | 348 | 8 | 3 | 38% | |
| | | EC | 406 | 161 | 6 | 1 | 17% | Delist: Low Sample Count |
| | | ENT | 108 | 1027 | 6 | 5 | 83% | Delist: Low Sample Count |
| OK311510010010_00 | North Fork of the Red River at SH 34 | FC | 400 | 109 | 20 | 4 | 20% | |
| | | EC | 406 | 45 | 20 | 1 | 5% | |
| | | ENT | 108 | 99 | 20 | 8 | 40% | |
| OK311510020060_00 | Turkey Creek | FC | 400 | 447 | 8 | 3 | 38% | |
| | | EC | 406 | 97 | 6 | 0 | 0% | |
| | | ENT | 108 | 554 | 6 | 5 | 83% | Delist: Low Sample Count |
| OK311600020010_00 | Salt Fork of the Red River at US 283 | FC | 400 | 794 | 18 | 11 | 61% | |
| | | EC | 406 | 132 | 18 | 3 | 17% | List: >GeoMean+Daily Max |
| | | ENT | 108 | 496 | 18 | 12 | 67% | |

| 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 |
|---|---|---|---|---|---|---|---|---|
| OK311600020010_10 | Salt Fork of the Red River at SH 34 | FC | 400 | 252 | 11 | 4 | 36% | List: >25% |
| | | EC | 406 | 55 | 11 | 0 | 0% | |
| | | ENT | 108 | 683 | 11 | 9 | 82% | |
| OK311600020010_10 | Salt Fork of Red River | FC | 400 | 153 | 5 | 1 | 20% | |
| | | EC | 406 | 32 | 3 | 0 | 0% | |
| | | ENT | 108 | 122 | 3 | 1 | 33% | Delist: Low Sample Count |
| OK311600020140_00 | Cave Creek | FC | 400 | 540 | 11 | 6 | 55% | List: >25% |
| | | EC | 406 | 242 | 6 | 2 | 33% | Delist: Low Sample Count |
| | | ENT | 108 | 372 | 10 | 9 | 90% | |
| OK311800000010_00 | Elm Fork River, SH 9, Mangum | FC | 400 | 154 | 27 | 7 | 26% | |
| | | EC | 406 | 538 | 27 | 17 | 63% | |
| | | ENT | 108 | 233 | 27 | 17 | 63% | |
| OK311800000070_00 | Deer Creek: Greer Co. | FC | 400 | 518 | 7 | 6 | 86% | |
| | | EC | 406 | 174 | 6 | 2 | 33% | Delist: Low Sample Count |
| | | ENT | 108 | 239 | 6 | 4 | 67% | Delist: Low Sample Count |
| OK311800000130_00 | Fish Creek | FC | 400 | 300 | 8 | 4 | 50% | |
| | | EC | 406 | 54 | 6 | 0 | 0% | |
| | | ENT | 108 | 155 | 6 | 3 | 50% | Delist: Low Sample Count |

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

**Table 2-3 Summary of Indicator Bacteria Samples from Secondary Body Contact Recreation Season, 1999-2001**

| 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 |
|---|---|---|---|---|---|---|---|---|
| OK311600010040_00 | Sandy Creek (Lebos) | FC | 2000 | 634 | 14 | 3 | 21% | Delist: <GeoMean |
| | | EC | 2030 | 230 | 14 | 1 | 7% | Delist: <GeoMean |
| | | ENT | 540 | 884 | 14 | 7 | 50% | |
| OK311600020110_00 | Bitter Creek | FC | 2000 | 238 | 13 | 2 | 15% | |
| | | EC | 2030 | 73 | 11 | 0 | 0% | |
| | | ENT | 540 | 620 | 13 | 5 | 38% | |

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

**Table 2-4 Waterbodies Requiring TMDLs for Not Supporting Primary Body Contact Recreation Use**

| WQM Station | Waterbody ID | Waterbody Name | Indicator Bacteria | | |
|---|---|---|---|---|---|
| | | | FC | ENT | *E. coli* |
| OK311500010020-001AT | OK311500010020_10 | Red River-North Fork at US 62 | | X | |
| OK311500010050G | OK311500010050_00 | Stinking Creek | X | | |
| OK311500010110G | OK311500010110_00 | Tepee Creek | X | | |
| OK311500020040G | OK311500020040_00 | West Otter Creek | X | | |
| OK311500030010-001AT | OK311500030010_00 | Elk Creek | | X | |
| OK311500030040-001AT | OK311500030040_00 | Little Elk Creek | X | | |
| OK311510010010-001AT | OK311510010010_00 | Red River-North Fork at SH 34 | | X | |
| OK311510020060G | OK311510020060_00 | Turkey Creek | X | | |
| OK311600020010-002AT | OK311600020010_00 | Red River-Salt Fork at US 283 | X | X | X |
| OK311600020010-001AT | OK311600020010_10 | Red River-Salt Fork at SH 34 | X | X | |
| OK311600020140G | OK311600020140_00 | Cave Creek | X | X | |
| OK311800000010-001AT | OK311800000010_00 | Red River-Elm Fork | X | X | X |
| OK311800000070C | OK311800000070_00 | Deer Creek | X | | |
| OK311800000130G | OK311800000130_00 | Fish Creek | X | | |

ENT = enterococci; FC = fecal coliform

**Table 2-5 Waterbodies Requiring TMDLs for Not Supporting Secondary Body Contact Recreation Use**

| WQM Station | Waterbody ID | Waterbody Name | Indicator Bacteria | | |
|---|---|---|---|---|---|
| | | | FC | ENT | *E. coli* |
| OK311600010040-001AT | OK311600010040_00 | Sandy Creek (Lebos) | | X | |
| OK311600020110G | OK311600020110_00 | Bitter 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 humans, warm-blooded animals, and 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 two urbanized areas designated as MS4s within this 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 Elk Creek (OK311500030010_00), Bitter Creek (OK311600020110_00), Cave Creek (OK311600020140_00), Deer Creek (OK311800000070_00), and Fish Creek

(OK311800000130_00). Eleven of the watersheds in the Study Area, including Red River-North Fork at US 62 (OK311500010020_10), Stinking Creek (OK311500010050_00), Tepee Creek (OK311500010110_00), West Otter Creek (OK311500020040_00), Little Elk Creek (OK311500030040_00), Red River-North Fork at SH 34 (OK311510010010_00 ), Turkey Creek (OK311510020060_00), Sandy Creek (Lebos) (OK311600010040_00), Red River-Salt Fork at SH 34 (OK311600020010_10), Red River-Salt Fork at US 283 (OK311600020010_00), and Red River-Elm Fork (OK311800000010_00) have NPDES-permitted facilities. There is one urbanized area designated as an MS4 within this Study Area.

### 3.1.1 Continuous Point Source Discharges

The locations of the NPDES-permitted facilities which discharge wastewater to surface waters addressed in these TMDLs are listed in Table 3-1 and displayed in Figure 3-1. For the purposes of the pollutant source 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 |
|---|---|---|---|---|---|---|---|
| OKG950015 | Meridian Aggregates Co.-Snyder | OK311500010020_10 Red River-North Fork at US 62 | Crushed And Broken Granite | Kiowa | N/A | Active | N/A |
| OK0028037 | City of Altus WWTF | OK311500010050_00 Stinking Creek | Sewerage Systems | Jackson | 2.0 | Active | S11514 |
| OK0043290 | Republic Gypsum Co. Quarry | OK311600020010_00 Red River-Salt Fork at US 283 | Crushed And Broken Limestone | Jackson | N/A | Active | N/A |
| OK0043362 | American Gypsum Co.-Wall Board | OK311600020010_00 Red River-Salt Fork at US 283 | Gypsum Products | Jackson | N/A | Active | N/A |
| OK0028827 | City of Mangum | OK311600020010_10 Red River, Salt Fork at SH 34 | Sewerage Systems | Greer | 0.30 | Active | S11607 |
| OK0041530 | Snyder Processing Plant | OK311500010020_10 Red River-North Fork at US 62 | Crushed And Broken Granite | Kiowa | N/A | Inactive | N/A |
| OK0042137 | Snyder Quarry And Processing | OK311500010020_10 Red River-North Fork at US 62 | Crushed And Broken Granite | Kiowa | N/A | Inactive | N/A |
| OK0020745 | City of Erick | OK311510020060_00 Turkey Creek | Sewerage Systems | Beckham | N/A | Inactive | S11501 |
| OK0032492 | Town of Snyder | OK311500010020_10 Red River-North Fork at US 62 | Sewerage Systems | Kiowa | N/A | N/A | N/A |

| NPDES Permit No. | Name | Receiving Water | Facility Type | County Name | Design Flow (mgd) | Active/ Inactive | Facility ID |
|---|---|---|---|---|---|---|---|
| OK0034690 | Roosevelt Granite Co-Kiowa Cou | OK311500020040_00 Otter Creek, West | Cut Stone And Stone Products | Kiowa | N/A | N/A | N/A |
| OK0027481 | Town of Arnett | OK311600020010_00 Red River-Salt Fork at US 283 | Sewerage Systems | Harmon | N/A | N/A | N/A |
| OK0020044 | Town of Olustee | OK311600020010_00 Red River-Salt Fork at US 283 | Sewerage Systems | Jackson | N/A | N/A | N/A |
| OK0033448 | Oklahoma Sta Reformatory-Grani | OK311800000010_00 Red River-Elm Fork | Sewerage Systems | Greer | N/A | N/A | N/A |
| OK0042706 | N/A | OK311800000010_00 Red River-Elm Fork | N/A | Greer | N/A | N/A | N/A |

N/A = not available

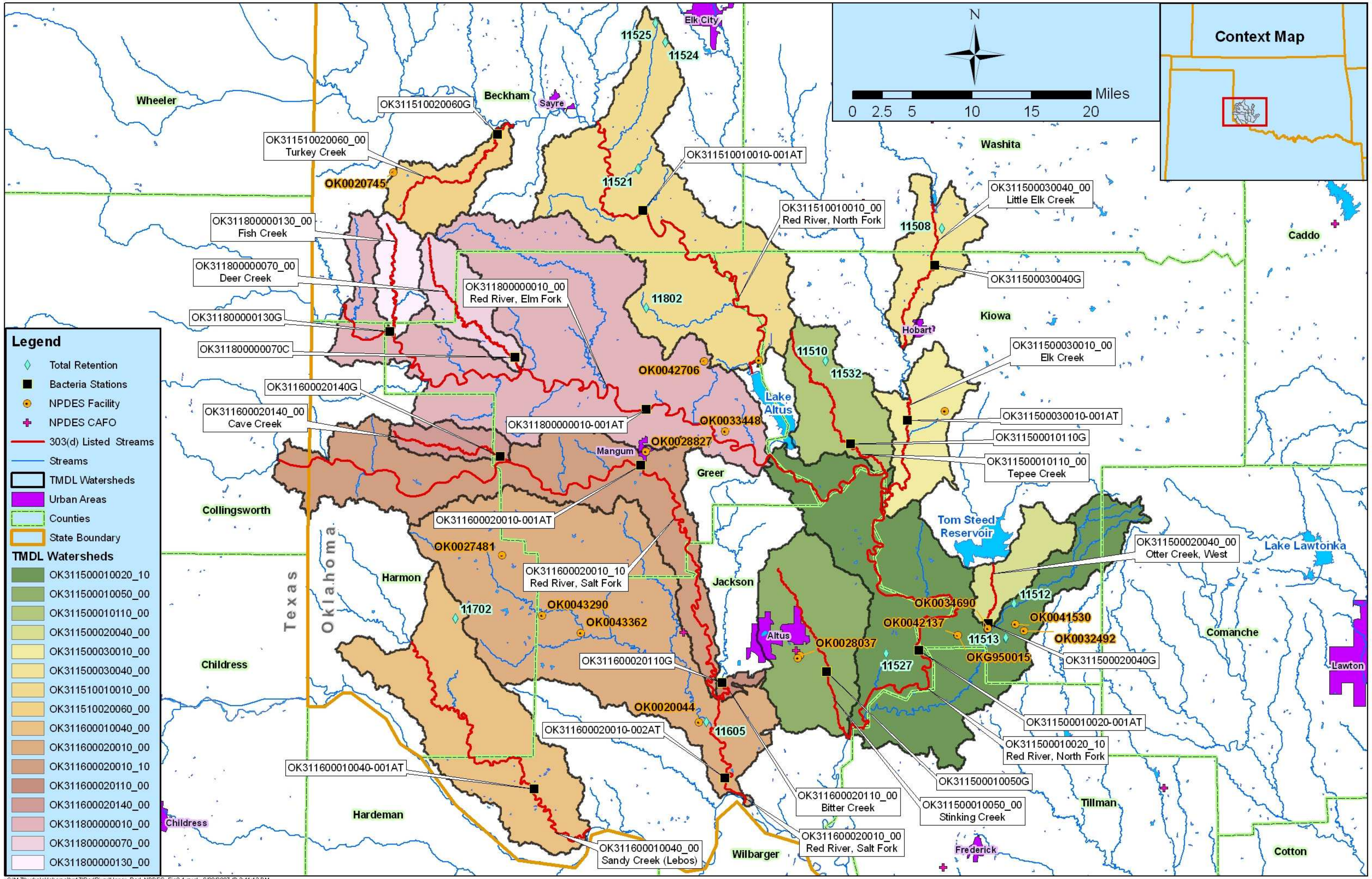
Discharge Monitoring Reports (DMR) for fecal coliform analyses were not available for the facilities listed in Table 3-1. Given the lack of DMR data on bacteria concentrations from point source discharges in the Study Area, it is not possible to provide an adequate evaluation of the performance of WWTPs in the impaired watersheds with respect to their compliance with fecal coliform permit limits over time.

### 3.1.2 NPDES No-Discharge Facilities and SSOs

There are 12 NPDES no-discharge facilities within the Study Area. The locations of these facilities are listed in Table 3-2 and displayed in Figure 3-1. For the purposes of these TMDLs, it is assumed that no-discharge facilities do not contribute bacteria loading to the Upper Red River 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.

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 34 SSO occurrences, ranging from 0 gallon to 11,433,700 gallons, reported for certain watersheds within the Study Area between December 1991 and August 1999 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

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



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 Stinking Creek (OK311500010050_00) and Red River- Salt Fork at SH 34 (OK311600020010_10) watersheds.

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

| Facility | Facility ID | County | Facility Type | Type | Watershed | Active/ Inactive |
|---|---|---|---|---|---|---|
| Mountain Park WWTP | 11512 | Kiowa | Lagoon (Total Retention) | Municipal | OK311500010020_10 Red River-North Fork at US 62 | N/A |
| Snyder WWTP | 11513 | Kiowa | Land Application | Municipal | OK311500010020_10 Red River-North Fork at US 62 | N/A |
| Headrick WWTP | 11527 | Jackson | Lagoon (Total Retention) | Municipal | OK311500010020_10 Red River-North Fork at US 62 | N/A |
| Lone Wolf WWTP | 11510 | Kiowa | Land Application | Municipal | OK311500010110_00 Tepee Creek | N/A |
| Kiowa Co Rws And SWMD #1 WWTP | 11532 | Kiowa | Lagoon (Total Retention) | Municipal | OK311500010110_00 Tepee Creek | N/A |
| Rocky WWTP | 11508 | Washita | Lagoon (Total Retention) | Municipal | OK311500030040_00 Little Elk Creek | N/A |
| Carter WWTP | 11521 | Beckham | Lagoon (Total Retention) | Municipal | OK311510010010_00 Red River-North Fork at SH 34 | N/A |
| Merritt Mobile Home & RV Park | 11524 | Beckham | Lagoon (Total Retention) | Municipal | OK311510010010_00 Red River-North Fork at SH 34 | N/A |
| Potter's Trailer Park WWTP | 11525 | Beckham | Lagoon (Total Retention) | Municipal | OK311510010010_00 Red River-North Fork at SH 34 | N/A |
| Willow WWTP | 11802 | Greer | Lagoon (Total Retention) | Municipal | OK311510010010_00 Red River-North Fork at SH 34 | N/A |
| Gould WWTP | 11702 | Harmon | Lagoon (Total Retention) | Municipal | OK311600010040_00 Sandy Creek (Lebos) | N/A |
| Olustee WWTP | 11605 | Jackson | Lagoon (Total Retention) | Municipal | OK311600020010_00 Red River-Salt Fork at US 283 | N/A |

N/A = not available

**Table 3-3 Sanitary Sewer Overflows Summary**

| Facility Name | NPDES Permit No. | Receiving Water | Facility ID | Number of Occur-rences | Date Range | | Amount (Gallons) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | From | To | Min | Max |
| City of Altus | OK0028037 | OK311500010050_00 Stinking Creek | S11514 | 26 | 11/29/1993 | 8/1/1999 | 0 | 8,000,000 |
| City of Mangum | OK0028827 | OK311600020010_10 Red River-Salt Fork at SH 34 | S11607 | 8 | 12/20/1991 | 8/28/1996 | 0 | 11,433,700 |

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

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

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

### 3.1.3 NPDES Municipal Separate Storm Sewer Discharge (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. Because stormwater discharges cannot be centrally collected, monitored, and treated, they are not subject to the same types of effluent limitations as wastewater facilities. Instead, stormwater discharges are required to meet a performance standard of providing treatment to the "maximum extent practical" through the implementation of best management practices (BMPs).

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. The City of Altus, located in the Stinking Creek (OK311500010050_00) watershed falls under requirements designated by USEPA for inclusion in the Phase II NPDES Stormwater Program. The municipality was designated because its municipal boundaries intersected a U.S. Census-defined Urbanized Area. In an effort to quantify the relative contribution of bacteria loads from the MS4 area of the City of Altus the percentage of the Stinking Creek watershed under MS4 jurisdiction was calculated. The area of the City of Altus MS4 (Permit #: OKR040043) is estimated to be 6,869 acres or 6.8% of the watershed. While this is a relatively small portion of the total watershed the bacterial loads from the City of Altus urban area maybe of concern given that some of the riparian corridor of Stinking Creek travels through the MS4 area. There are no Phase II MS4s in the following watersheds: Red River-North Fork at US 62 (OK311500010020_10), Tepee Creek (OK311500010110_00), Otter

Creek, West (OK311500020040_00), Elk Creek (OK311500030010_00), Little Elk Creek (OK311500030040_00), Turkey Creek (OK311510020060_00), Sandy Creek (Lebos) (OK311600010040_00), Red River-Salt Fork at US 283 (OK311600020010_00), Bitter Creek (OK311600020110_00), Cave Creek (OK311600020140_00), Deer Creek (OK311800000070_00), Red River-Salt Fork at SH 34 (OK311600020010_10), Red River-Elm Fork (OK311800000010_00, and Fish Creek (OK311800000130_00).

ODEQ provides information on the current status of the MS4 program on its website, which can be found at:

**Oklahoma Department of Environmental Quality**

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.

Figure 3-1 depicts the locations of the two different CAFOs located in the Study Area, one in Red River-Salt Fork at US 283 (OK311600020010_00) and one in Stinking Creek (OK311500010050_00). Table 3-4 lists the CAFOs located in the Study Area. Red River-North Fork at US 62 (OK311500010020_10), Tepee Creek (OK311500010110_00), Otter Creek, West (OK311500020040_00), Elk Creek (OK311500030010_00), Little Elk Creek (OK311500030040_00), Red River-North Fork at SH 34 (OK311510010010_00), Turkey Creek (OK311510020060_00), Sandy Creek (Lebos) (OK311600010040_00), Red River-Salt Fork at SH 34 (OK311600020010_10), Bitter Creek (OK311600020110_00), Cave Creek (OK311600020140_00), Red River-Elm Fork (OK311800000010_00), Deer Creek (OK311800000070_00), and Fish Creek (OK311800000130_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 Slaughter Feeder Cattle at Facility | Total # of Animal Units at Facility | County | Watershed |
|---|---|---|---|---|---|---|---|
| WQ0000056 | OKG010055 | 146 | 49 | 4000 | 4000 | Jackson | OK311600020010_00 Red River-Salt Fork at US 283 |
| WQ0000070 | OKG010063 | 174 | 62 | 3000 | 3000 | Jackson | OK311500010050_00 Stinking Creek |

## 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 Elk Creek (OK311500030010_00), Bitter Creek (OK311600020110_00), Cave Creek (OK311600020140_00), Deer Creek (OK311800000070_00), and Fish Creek (OK311800000130_00).; therefore, nonsupport of PBCR use is caused by nonpoint sources of bacteria only.

Bacteria associated with urban runoff can emanate from humans, wildlife, commercially Raised farm animals, and domestic pets. Water quality data collected from streams draining urban communities often show existing concentrations of fecal coliform bacteria at levels greater than a state's instantaneous standards. A study under USEPA's National Urban Runoff Project indicated that the average fecal coliform concentration from 14 watersheds in different areas within the United States was approximately 15,000 /100 mL in stormwater runoff (USEPA 1983). Runoff from urban areas not permitted under the MS4 program can be a significant source of fecal coliform bacteria. Water quality data collected from streams draining many of the nonpermitted communities show existing loads of fecal coliform bacteria at levels greater than the State's instantaneous standards. The specific requirements for bacteria control in a MS4 permit can be found in Appendix E. Appendix E also includes information on a list of BMPs and its effectiveness. Best management practices (BMP) such as buffer strips, repair of leaking sewage collection systems, elimination of illicit discharges, 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 |
|---|---|---|---|
| OK311500010020_10 | Red River-North Fork at US 62 | 657 | 199,852 |
| OK311500010050_00 | Stinking Creek | 346 | 78,932 |
| OK311500010110_00 | Tepee Creek | 122 | 47,040 |
| OK311500020040_00 | West Otter Creek | 64 | 24,502 |
| OK311500030010_00 | Elk Creek | 104 | 40,009 |
| OK311500030040_00 | Little Elk Creek | 120 | 36,599 |
| OK311510010010_00 | Red River-North Fork at SH 34 | 781 | 172,895 |
| OK311510020060_00 | Turkey Creek | 138 | 30,386 |
| OK311600010040_00 | Sandy Creek (Lebos) | 528 | 118,173 |
| OK311600020010_00 | Red River-Salt Fork at US 283 | 1,065 | 229,293 |
| OK311600020010_10 | Red River-Salt Fork at SH 34 | 651 | 138,108 |
| OK311600020110_00 | Bitter Creek | 14 | 3,280 |
| OK311600020140_00 | Cave Creek | 72 | 15,678 |
| OK311800000010_00 | Red River-Elm Fork | 1,354 | 258,868 |
| OK311800000070_00 | Deer Creek | 150 | 29,565 |
| OK311800000130_00 | Fish Creek | 95 | 20,749 |

According to a livestock study conducted by ASAE (the American Society of Agricultural Engineers), deer release approximately $5 \times 10^8$ 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 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 |
|---|---|---|---|---|---|
| OK311500010020_10 | Red River-North Fork at US 62 | 199,852 | 657 | 0.003 | 3,283 |
| OK311500010050_00 | Stinking Creek | 78,932 | 346 | 0.004 | 1,731 |
| OK311500010110_00 | Tepee Creek | 47,040 | 122 | 0.003 | 611 |
| OK311500020040_00 | West Otter Creek | 24,502 | 64 | 0.003 | 318 |
| OK311500030010_00 | Elk Creek | 40,009 | 104 | 0.003 | 521 |
| OK311500030040_00 | Little Elk Creek | 36,599 | 120 | 0.003 | 599 |
| OK311510010010_00 | Red River-North Fork at SH 34 | 172,895 | 781 | 0.005 | 3,906 |
| OK311510020060_00 | Turkey Creek | 30,386 | 138 | 0.005 | 688 |
| OK311600010040_00 | Sandy Creek (Lebos) | 118,173 | 528 | 0.004 | 2,641 |
| OK311600020010_00 | Red River-Salt Fork at US 283 | 229,293 | 1065 | 0.005 | 5,327 |
| OK311600020010_10 | Red River-Salt Fork at SH 34 | 138,108 | 651 | 0.005 | 3,254 |
| OK311600020110_00 | Bitter Creek | 3,280 | 14 | 0.004 | 72 |
| OK311600020140_00 | Cave Creek | 15,678 | 72 | 0.005 | 362 |
| OK311800000010_00 | Red River-Elm Fork | 258,868 | 1354 | 0.005 | 6,769 |
| OK311800000070_00 | Deer Creek | 29,565 | 150 | 0.005 | 749 |
| OK311800000130_00 | Fish Creek | 20,749 | 95 | 0.005 | 474 |

### 3.2.2 Non-Permitted Agricultural Activities and Domesticated Animals

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

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

Table 3-7 provides estimated numbers of selected commercially raised farm animal by watershed based on the 2002 U.S. Department of Agriculture (USDA) county agricultural census data (USDA 2002). The estimated animal populations in Table 3-7 were derived by using the percentage of the watershed within each county. Because the watersheds are generally much smaller than the counties, and commercially raised farm animal 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 3-7. These estimates are also based on the county level reports from the 2002 USDA county agricultural census, and thus represent approximations of the land application area in each watershed. Because of the lack of specific data, land application of animal manure is not quantified in the Table 3-8 but is considered a potential source of bacteria loading to the waterbodies in the Study Area. Most poultry feeding operations are regulated by ODAFF, and are required to land apply chicken waste in accordance with their Animal Waste Management Plans or Comprehensive Nutrient Management Plans. While these plans are not designed to controlled bacteria loading, best management practices and conservation measures, if properly implemented, could greatly reduce the contribution of bacteria from this group of animals to the watershed.

According to a 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 animal populations and the fecal coliform production rates from ASAE, an estimate of fecal coliform production from each group of commercially raised farm animals was calculated in 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 largest source of fecal bacteria.

**Table 3-7 Commercially Raised Farm Animals and Manure Application Area Estimates by Watershed**

| Waterbody ID | Waterbody Name | Cattle & Calves-all | Dairy Cows | Horses & Ponies | Goats | Sheep & Lambs | Hogs & Pigs | Ducks & Geese | Chickens & Turkeys | Acres of Manure Application |
|---|---|---|---|---|---|---|---|---|---|---|
| OK311500010020_10 | Red River-North Fork at US 62 | 19,618 | 321 | 266 | 112 | 396 | 97 | 12 | 91 | 623 |
| OK311500010050_00 | Stinking Creek | 7,002 | 0 | 135 | 61 | 112 | 45 | 8 | 47 | 229 |
| OK311500010110_00 | Tepee Creek | 5,046 | 4 | 47 | 9 | 164 | 28 | 0 | 5 | 220 |
| OK311500020040_00 | West Otter Creek | 2,628 | 2 | 24 | 5 | 86 | 15 | 0 | 3 | 115 |
| OK311500030010_00 | Elk Creek | 4,291 | 3 | 40 | 8 | 140 | 24 | 0 | 4 | 187 |
| OK311500030040_00 | Little Elk Creek | 4,909 | 11 | 36 | 50 | 81 | 11 | 0 | 11 | 142 |
| OK311510010010_00 | Red River-North Fork at SH 34 | 17,163 | 77 | 266 | 225 | 213 | 96 | 6 | 72 | 263 |
| OK311510020060_00 | Turkey Creek | 3,298 | 21 | 60 | 47 | 32 | 18 | 0 | 16 | 45 |
| OK311600010040_00 | Sandy Creek (Lebos) | 10,726 | 0 | 109 | 34 | 63 | 293 | 4 | 26 | 543 |
| OK311600020010_00 | Red River-Salt Fork at US 283 | 19,772 | 6 | 275 | 151 | 192 | 324 | 18 | 86 | 700 |
| OK311600020010_10 | Red River-Salt Fork at SH 34 | 11,170 | 7 | 112 | 93 | 56 | 230 | 10 | 33 | 398 |
| OK311600020110_00 | Bitter Creek | 289 | 0 | 6 | 3 | 5 | 0 | 0 | 2 | 9 |
| OK311600020140_00 | Cave Creek | 1,403 | 0 | 8 | 2 | 1 | 51 | 0 | 1 | 77 |
| OK311800000010_00 | Red River-Elm Fork | 20,555 | 49 | 276 | 311 | 148 | 200 | 25 | 90 | 175 |
| OK311800000070_00 | Deer Creek | 2,582 | 10 | 40 | 41 | 22 | 16 | 2 | 12 | 18 |
| OK311800000130_00 | Fish Creek | 2,214 | 14 | 40 | 31 | 22 | 12 | 0 | 10 | 29 |

**Table 3-8 Fecal Coliform Production Estimates for Commercially Raised Farm Animals (x109 number/day)**

| Waterbody ID | Waterbody Name | Cattle & Calves-all | Dairy Cows | Horses & Ponies | Goats | Sheep & Lambs | Hogs & Pigs | Ducks & Geese | Chickens & Turkeys | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| OK311500010020_10 | Red River-North Fork at US 62 | 2,040,258 | 32,378 | 112 | N/A | 4,757 | 1,042 | 203 | 12 | 2,078,763 |
| OK311500010050_00 | Stinking Creek | 728,224 | 0 | 57 | N/A | 1,348 | 484 | 19 | 6 | 730,138 |
| OK311500010110_00 | Tepee Creek | 524,755 | 414 | 20 | N/A | 1,973 | 307 | 0 | 1 | 527,469 |
| OK311500020040_00 | West Otter Creek | 273,274 | 216 | 10 | N/A | 1,028 | 160 | 0 | 0 | 274,688 |
| OK311500030010_00 | Elk Creek | 446,269 | 351 | 17 | N/A | 1,676 | 261 | 0 | 1 | 448,574 |
| OK311500030040_00 | Little Elk Creek | 510,520 | 1,091 | 15 | N/A | 970 | 120 | 0 | 2 | 512,718 |
| OK311510010010_00 | Red River-North Fork at SH 34 | 1,784,918 | 7,743 | 112 | N/A | 2,550 | 1,037 | 281 | 10 | 1,796,652 |
| OK311510020060_00 | Turkey Creek | 343,028 | 2,086 | 25 | N/A | 387 | 191 | 0 | 2 | 345,720 |
| OK311600010040_00 | Sandy Creek (Lebos) | 1,115,549 | 0 | 46 | N/A | 754 | 3,160 | 11 | 4 | 1,119,523 |
| OK311600020010_00 | Red River-Salt Fork at US 283 | 2,056,265 | 559 | 115 | N/A | 2,304 | 3,499 | 311 | 12 | 2,063,065 |
| OK311600020010_10 | Red River-Salt Fork at SH 34 | 1,161,645 | 741 | 47 | N/A | 677 | 2,488 | 380 | 5 | 1,165,982 |
| OK311600020110_00 | Bitter Creek | 30,100 | 0 | 2 | N/A | 56 | 0 | 1 | 0 | 30,159 |
| OK311600020140_00 | Cave Creek | 145,873 | 22 | 3 | N/A | 12 | 548 | 11 | 0 | 146,469 |
| OK311800000010_00 | Red River-Elm Fork | 2,137,747 | 4,967 | 116 | N/A | 1,780 | 2,163 | 1,171 | 12 | 2,147,955 |
| OK311800000070_00 | Deer Creek | 268,483 | 1,038 | 17 | N/A | 268 | 173 | 102 | 2 | 270,082 |
| OK311800000130_00 | Fish Creek | 230,295 | 1,366 | 17 | N/A | 258 | 130 | 6 | 1 | 232,073 |

### 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.

**Table 3-9 Estimates of Sewered and Unsewered Households**

| Waterbody ID | Waterbody Name | Public Sewer | Septic Tank | Other Means | Housing Units | % Sewered |
|---|---|---|---|---|---|---|
| OK311500010020_10 | Red River-North Fork at US 62 | 1,003 | 558 | 13 | 1,574 | 64% |
| OK311500010050_00 | Stinking Creek | 4,978 | 372 | 12 | 5,361 | 93% |
| OK311500010110_00 | Tepee Creek | 113 | 124 | 0 | 237 | 48% |
| OK311500020040_00 | West Otter Creek | 166 | 39 | 1 | 207 | 80% |
| OK311500030010_00 | Elk Creek | 368 | 75 | 5 | 448 | 82% |
| OK311500030040_00 | Little Elk Creek | 478 | 81 | 8 | 567 | 84% |
| OK311510010010_00 | Red River-North Fork at SH 34 | 1,070 | 512 | 6 | 1,588 | 67% |
| OK311510020060_00 | Turkey Creek | 116 | 62 | 3 | 181 | 64% |
| OK311600010040_00 | Sandy Creek (Lebos) | 223 | 137 | 1 | 361 | 62% |

| Waterbody ID | Waterbody Name | Public Sewer | Septic Tank | Other Means | Housing Units | % Sewered |
|---|---|---|---|---|---|---|
| OK311600020010_00 | Red River-Salt Fork at US 283 | 780 | 351 | 6 | 1,137 | 69% |
| OK311600020010_10 | Red River-Salt Fork at SH 34 | 1,021 | 225 | 5 | 1,251 | 82% |
| OK311600020110_00 | Bitter Creek | 28 | 15 | 0 | 44 | 64% |
| OK311600020140_00 | Cave Creek | 116 | 23 | 0 | 140 | 83% |
| OK311800000010_00 | Red River-Elm Fork | 1,324 | 419 | 14 | 1,758 | 75% |
| OK311800000070_00 | Deer Creek | 88 | 45 | 2 | 135 | 65% |
| OK311800000130_00 | Fish Creek | 57 | 34 | 2 | 93 | 61% |

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.

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) |
|---|---|---|---|---|---|
| OK311500010020_10 | Red River-North Fork at US 62 | 199,852 | 558 | 45 | 289 |
| OK311500010050_00 | Stinking Creek | 78,932 | 372 | 30 | 192 |
| OK311500010110_00 | Tepee Creek | 47,040 | 124 | 10 | 64 |
| OK311500020040_00 | West Otter Creek | 24,502 | 39 | 3 | 20 |
| OK311500030010_00 | Elk Creek | 40,009 | 75 | 6 | 39 |
| OK311500030040_00 | Little Elk Creek | 36,599 | 81 | 6 | 42 |
| OK311510010010_00 | Red River-North Fork at SH 34 | 172,895 | 512 | 41 | 265 |
| OK311510020060_00 | Turkey Creek | 30,386 | 62 | 5 | 32 |
| OK311600010040_00 | Sandy Creek (Lebos) | 118,173 | 137 | 11 | 71 |
| OK311600020010_00 | Red River-Salt Fork at US 283 | 229,293 | 351 | 28 | 182 |
| OK311600020010_10 | Red River-Salt Fork at SH 34 | 138,108 | 225 | 18 | 116 |
| OK311600020110_00 | Bitter Creek | 3,280 | 15 | 1 | 8 |
| OK311600020140_00 | Cave Creek | 15,678 | 23 | 2 | 12 |
| OK311800000010_00 | Red River-Elm Fork | 258,868 | 419 | 34 | 217 |
| OK311800000070_00 | Deer Creek | 29,565 | 45 | 4 | 23 |
| OK311800000130_00 | Fish Creek | 20,749 | 34 | 3 | 18 |

### 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 |
|---|---|---|---|
| OK311500010020_10 | Red River-North Fork at US 62 | 881 | 1,039 |
| OK311500010050_00 | Stinking Creek | 3,002 | 3,539 |
| OK311500010110_00 | Tepee Creek | 133 | 156 |
| OK311500020040_00 | West Otter Creek | 116 | 137 |
| OK311500030010_00 | Elk Creek | 251 | 296 |
| OK311500030040_00 | Little Elk Creek | 318 | 374 |
| OK311510010010_00 | Red River-North Fork at SH 34 | 889 | 1,048 |
| OK311510020060_00 | Turkey Creek | 101 | 119 |
| OK311600010040_00 | Sandy Creek (Lebos) | 202 | 238 |
| OK311600020010_00 | Red River-Salt Fork at US 283 | 637 | 751 |
| OK311600020010_10 | Red River-Salt Fork at SH 34 | 701 | 826 |
| OK311600020110_00 | Bitter Creek | 25 | 29 |
| OK311600020140_00 | Cave Creek | 78 | 92 |
| OK311800000010_00 | Red River-Elm Fork | 984 | 1,160 |
| OK311800000070_00 | Deer Creek | 76 | 89 |
| OK311800000130_00 | Fish Creek | 52 | 61 |

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 |
|---|---|---|---|---|
| OK311500010020_10 | Red River-North Fork at US 62 | 2,909 | 561 | 3,470 |
| OK311500010050_00 | Stinking Creek | 9,908 | 1,911 | 11,819 |
| OK311500010110_00 | Tepee Creek | 438 | 84 | 522 |
| OK311500020040_00 | West Otter Creek | 382 | 74 | 456 |
| OK311500030010_00 | Elk Creek | 828 | 160 | 987 |
| OK311500030040_00 | Little Elk Creek | 1,048 | 202 | 1,250 |
| OK311510010010_00 | Red River-North Fork at SH 34 | 2,934 | 566 | 3,500 |
| OK311510020060_00 | Turkey Creek | 334 | 64 | 399 |
| OK311600010040_00 | Sandy Creek (Lebos) | 668 | 129 | 796 |
| OK311600020010_00 | Red River-Salt Fork at US 283 | 2,101 | 405 | 2,507 |
| OK311600020010_10 | Red River-Salt Fork at SH 34 | 2,313 | 446 | 2,759 |
| OK311600020110_00 | Bitter Creek | 81 | 16 | 97 |
| OK311600020140_00 | Cave Creek | 258 | 50 | 308 |
| OK311800000010_00 | Red River-Elm Fork | 3,248 | 626 | 3,875 |
| OK311800000070_00 | Deer Creek | 250 | 48 | 298 |
| OK311800000130_00 | Fish Creek | 172 | 33 | 205 |

## 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 Elk Creek (OK311500030010_00), Bitter Creek (OK311600020110_00), Cave Creek (OK311600020140_00), Deer Creek (OK311800000070_00), and Fish Creek (OK311800000130_00) watersheds, nonsupport of the PBCR use is caused entirely by nonpoint sources. In watersheds with both point and nonpoint sources of bacteria, the available data suggests that the proportion of bacteria from point sources ranges from minor to moderate. Those waterbodies in which point sources are a minor contributor of bacteria include Red River-North Fork at US 62 (OK311500010020_10), Tepee Creek (OK311500010110_00), West Otter Creek (OK311500020040_00), Little Elk Creek (OK311500030040_00), Red River-North Fork at SH 34 (OK311510010010_00), Turkey Creek (OK311510020060_00), Sandy Creek (Lebos) (OK311600010040_00), Red River-Salt Fork at US 283 (OK311600020010_00), and Red River-Elm Fork (OK311800000010_00). In the remaining two watersheds, Stinking Creek (OK311500010050_00) and Red River-Salt Fork at SH 34 (OK311600020010_10), point sources such as WWTP, SSOs, and CAFOs, contribute moderate bacteria loads in proportion to nonpoint sources. The urban area designated as Phase II MS4s in the City of Altus further increase the proportion of bacteria loading from point sources in Stinking Creek (OK311500010050_00). However, 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 |
|---|---|---|---|---|
| OK311500010020_10 | Red River-North Fork at US 62 | Yes | Yes | Nonpoint |
| OK311500010050_00 | Stinking Creek | Yes | Yes | Nonpoint |
| OK311500010110_00 | Tepee Creek | Yes | Yes | Nonpoint |
| OK311500020040_00 | West Otter Creek | Yes | Yes | Nonpoint |
| OK311500030010_00 | Elk Creek | No | Yes | Nonpoint |
| OK311500030040_00 | Little Elk Creek | Yes | Yes | Nonpoint |
| OK311510010010_00 | Red River-North Fork at SH 34 | Yes | Yes | Nonpoint |
| OK311510020060_00 | Turkey Creek | Yes | Yes | Nonpoint |
| OK311600010040_00 | Sandy Creek (Lebos) | Yes | Yes | Nonpoint |
| OK311600020010_00 | Red River-Salt Fork at US 283 | Yes | Yes | Nonpoint |
| OK311600020010_10 | Red River-Salt Fork at SH 34 | Yes | Yes | Nonpoint |
| OK311600020110_00 | Bitter Creek | No | Yes | Nonpoint |
| OK311600020140_00 | Cave Creek | No | Yes | Nonpoint |
| OK311800000010_00 | Red River-Elm Fork | Yes | Yes | Nonpoint |
| OK311800000070_00 | Deer Creek | No | Yes | Nonpoint |
| OK311800000130_00 | Fish Creek | No | Yes | Nonpoint |

Table 3-14 below provides a summary of the estimated fecal coliform loads in percentage for the four major nonpoint source categories (commercially raised farm animals, pets, deer, and septic tanks) that are contributing to the elevated bacteria concentrations in each watershed. Commercially raised farm animals are estimated to be the primary contributors of fecal coliform loading to land surfaces. however, its contribution of bacteria to streams may be greatly reduced if BMPs are properly implemented 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 may represent a major source of the fecal bacteria found in streams.

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

| Waterbody ID | Waterbody Name | Commercially Raised Farm Animals | Pets | Deer | Estimated Loads from Septic Tanks |
|---|---|---|---|---|---|
| OK311500010020_10 | Red River-North Fork at US 62 | 99.80% | 0.17% | 0.02% | 0.01% |
| OK311500010050_00 | Stinking Creek | 98.36% | 1.59% | 0.02% | 0.03% |
| OK311500010110_00 | Tepee Creek | 99.88% | 0.10% | 0.01% | 0.01% |
| OK311500020040_00 | West Otter Creek | 99.82% | 0.17% | 0.01% | 0.01% |
| OK311500030010_00 | Elk Creek | 99.76% | 0.22% | 0.01% | 0.01% |
| OK311500030040_00 | Little Elk Creek | 99.74% | 0.24% | 0.01% | 0.01% |
| OK311510010010_00 | Red River-North Fork at SH 34 | 99.77% | 0.19% | 0.02% | 0.01% |
| OK311510020060_00 | Turkey Creek | 99.86% | 0.12% | 0.02% | 0.01% |
| OK311600010040_00 | Sandy Creek (Lebos) | 99.90% | 0.07% | 0.02% | 0.01% |
| OK311600020010_00 | Red River-Salt Fork at US 283 | 99.84% | 0.12% | 0.03% | 0.01% |
| OK311600020010_10 | Red River-Salt Fork at SH 34 | 99.73% | 0.24% | 0.03% | 0.01% |
| OK311600020110_00 | Bitter Creek | 99.63% | 0.32% | 0.02% | 0.03% |
| OK311600020140_00 | Cave Creek | 99.76% | 0.21% | 0.02% | 0.01% |
| OK311800000010_00 | Red River-Elm Fork | 99.78% | 0.18% | 0.03% | 0.01% |
| OK311800000070_00 | Deer Creek | 99.85% | 0.11% | 0.03% | 0.01% |
| OK311800000130_00 | Fish Creek | 99.88% | 0.09% | 0.02% | 0.01% |

# 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:

$$\text{TMDL} = \Sigma\ \text{WLA} + \Sigma\ \text{LA} + \text{MOS}$$

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. However, Flow range is only a general indicator of the relative proportion of point/nonpoint contributions. It is not used in this report to quantify point source or nonpoint source contributions. Violations that occur during low flows may not be caused exclusively by point sources. Violations have been noted in some watersheds that contain no point sources. Research has show that bacteria loading in streams during low flow conditions may be due to direct deposit of cattle manure into streams and faulty septic tank/lateral field systems.

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

## 4.2 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 4-16 are flow duration curves for each impaired waterbody. The flow duration curve for North Fork Red River, segment OK311510010010_00 was based on measured flows at USGS gage station 07301500 (North Fork Red River at SH 34 near Carter, OK). The flow at this station was restricted by a dam in 1987, thus the flow duration curve was based on measured flows from 1988 through 2006.

No flow gage exists on Stinking Creek, segment OK311500010050_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07299670 (Groesbeck Creek at SH 6 near Quanah, TX). The flow duration curve was based on measured flows from 1962 through 2006.

No flow gage exists on Tepee Creek, segment OK311500010110_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07300500 (Salt Fork Red River at Mangum, OK). The flow duration curve was based on measured flows from 1938 through 2006.

USGS flow gage 07305500 (West Otter Creek at Snyder Lake) measures flow releases into West Otter Creek, segment OK311500020040_00, from Snyder Lake (Tom Steed Reservoir). Additional inflow to segment OK311500020040_00 is derived from watershed runoff. Total flows in segment OK311500020040_00 were estimated as the sum of flow at USGS gage 07305500 and watershed runoff inflows, calculated by incremental watershed area ratio from a downstream USGS gage 07307010 (Otter Creek near Snyder, OK). The flow duration curve was based on measured flows from 1984 through 2003.

The flow duration curve for Elk Creek, segment OK311500030010_00, was based on measured flows at USGS gage station 07304500 (Elk Creek off US 183 near Hobart, OK). The flows during water quality sampling events were obtained from regression analysis of flows at gage 07304500 with USGS gage 07305000 (Salt Fork Red River at Mangum, OK). The flow duration curve was based on measured flows from 1905 through 1993.

No flow gage exists on Little Elk Creek, segment OK311500030040_00. Therefore, flows for this waterbody were projected using the watershed area ratio method based on measured flows at USGS gage station 07300500 (Salt Fork Red River at Mangum, OK). The flow duration curve was based on measured flows from 1937 through 2006.

The flow duration curve for North Fork Red River, segment OK311510010010_00 was based on measured flows at USGS gage station 07301500 (North Fork Red River at SH 34 near Carter, OK). The flow at this station was restricted by dam active from 10/1/1987. The flow duration curve was based on measured flows from 1988 through 2006.

No flow gage exists on Turkey Creek, segment OK311510020060_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07303400 (Elm Fork North Fork Red River near Carl, OK). The flow duration curve was based on measured flows from 1959 through 2006.

The flow duration curve for Sandy Creek, segment OK311600010040_00, was based on measured flows at USGS gage station 07299710 (Sandy Creek near Eldorado, OK). The flows during water quality sampling were estimated from regression analysis of gage 07299710 with gage 07299670 (Groesbeck Creek at SH 6 near Quanah, TX). The flow duration curve was based on measured flows from 1960 through 1963.

The flow duration curve for Salt Fork of the Red River, segment OK311600020010_00, was based on measured flows at USGS gage station 07301110 (Salt Fork Red River off US 283 near Elmer, OK). The flow duration curve was based on measured flows from 1980 through 2006.

The flow duration curve for Salt Fork of the Red River, SH 34, Mangum, segment OK311600020010_10 was based on measured flows at USGS gage station 07300500 (Salt Fork Red River at SH 34 at Mangum, OK). The flow duration curve was based on measured flows from 1938 through 2006.

No flow gage exists on Bitter Creek, segment OK311600020110_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method from flows measured at a downstream USGS gage station 073011100 (Salt Fork Red River near Elmer, OK), after subtracting flows (and contributing watershed area) from a USGS gage station 07300500 (Salt Fork Red River near Mangum, OK) above Bitter Creek's confluence with the Salt Fork Red River. The flow duration curve was based on measured flows from 1980 through 2006.

No flow gage exists on Cave Creek, segment OK311600020140_00. Therefore, flows for this waterbody were projected using the watershed area ratio method based on measured flows at USGS gage station 07300500 (Salt Fork Red River at Mangum, OK). The flow duration curve was based on measured flows from 1937 through 2006.

The flow duration curve for Elm Fork Red River, segment OK311800000010_00 was based on measured flows at USGS gage station 07303500 (Elm Fork North Fork Red River at SH 9 near Mangum, OK). The flows during water quality sampling were obtained from regression analysis of gage 07303500 with USGS gage 07303400 (Elm Fork North Fork Red River near Carl, OK). The flow duration curve was based on measured flows from 1905 through 1976.

No flow gage exists on Deer Creek, segment OK311800000070_00. Therefore, flows for this waterbody were projected using the watershed area ratio method based on measured flows at USGS gage station 07301420 (Sweetwater Creek near Sweetwater, OK). The flow duration curve was based on measured flows from 1986 through 2006.

No flow gage exists on Fish Creek, segment OK311800000130_00. Therefore, flows for this waterbody were projected using the watershed area ratio method based on measured flows at USGS gage station 07301420 (Sweetwater Creek near Sweetwater, OK). The flow duration curve was based on measured flows from 1986 through 2006.

**Figure 4-1 Flow Duration Curve for North Fork Red River at US 62 (OK311500010020_10)**

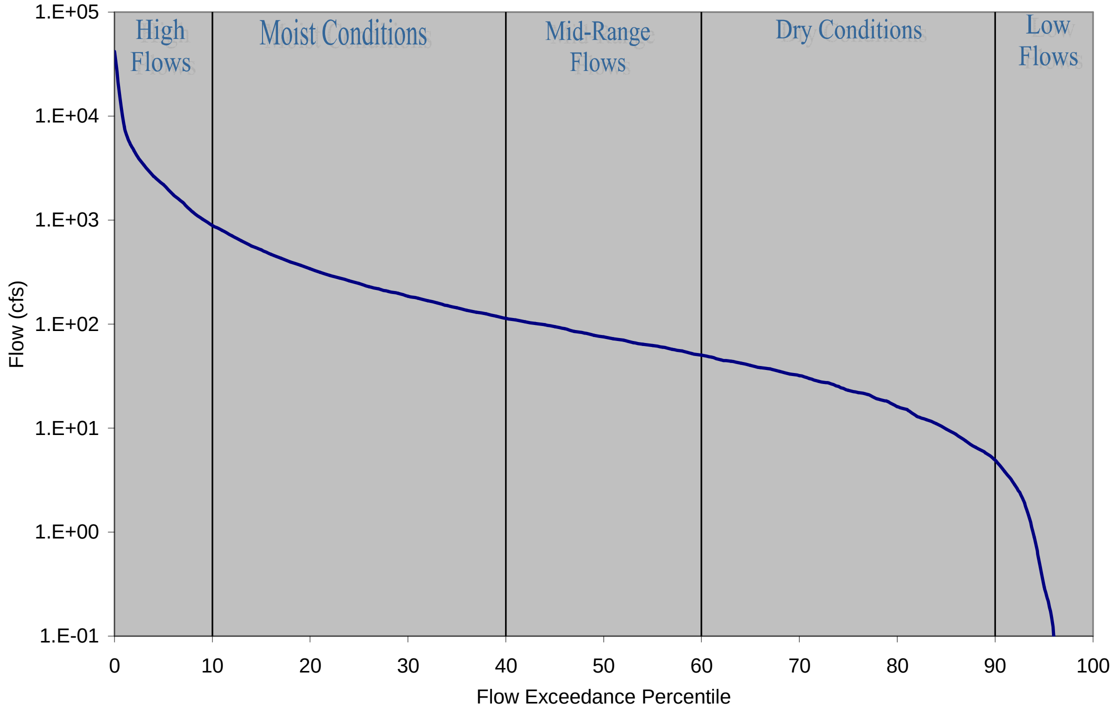



**Figure 4-2 Flow Duration Curve for Stinking Creek (OK311500010050_00)**

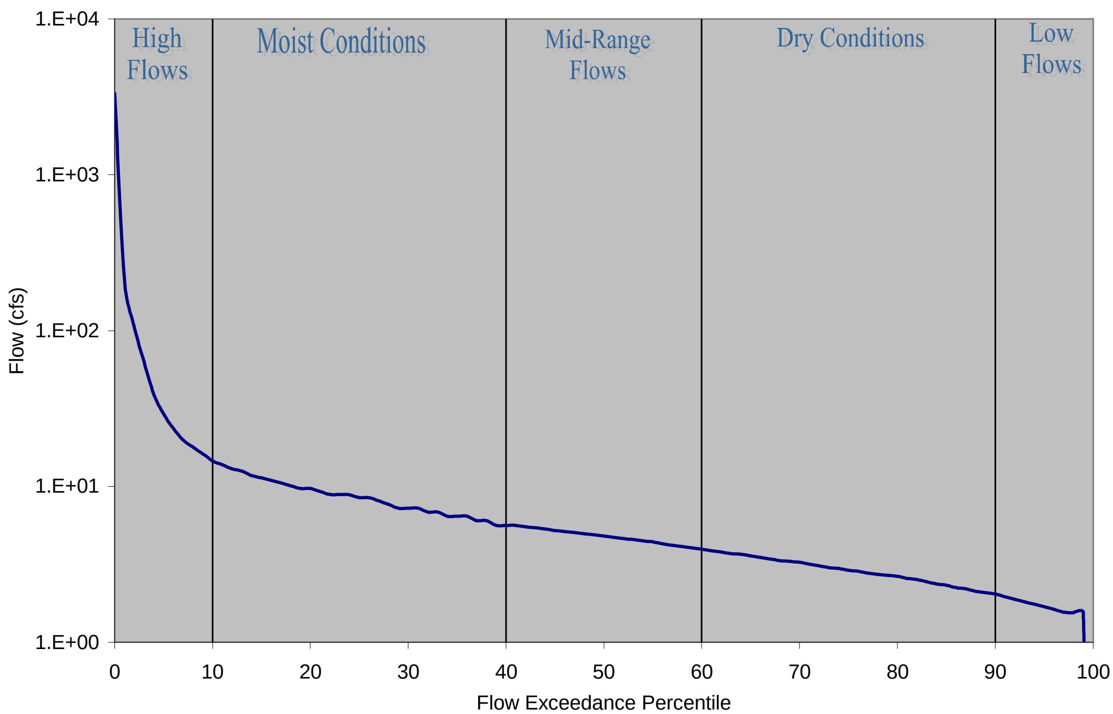


**Figure 4-3 Flow Duration Curve for Tepee Creek (OK311500010110_00)**

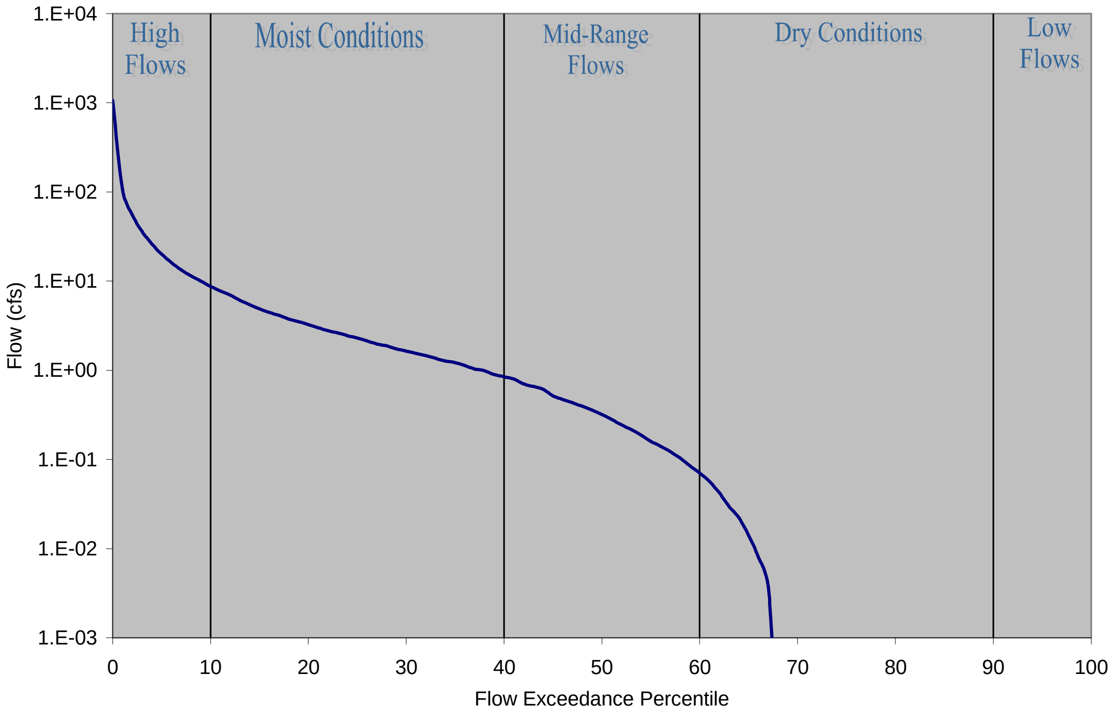



**Figure 4-4 Flow Duration Curve for West Otter Creek (OK311500020040_00)**

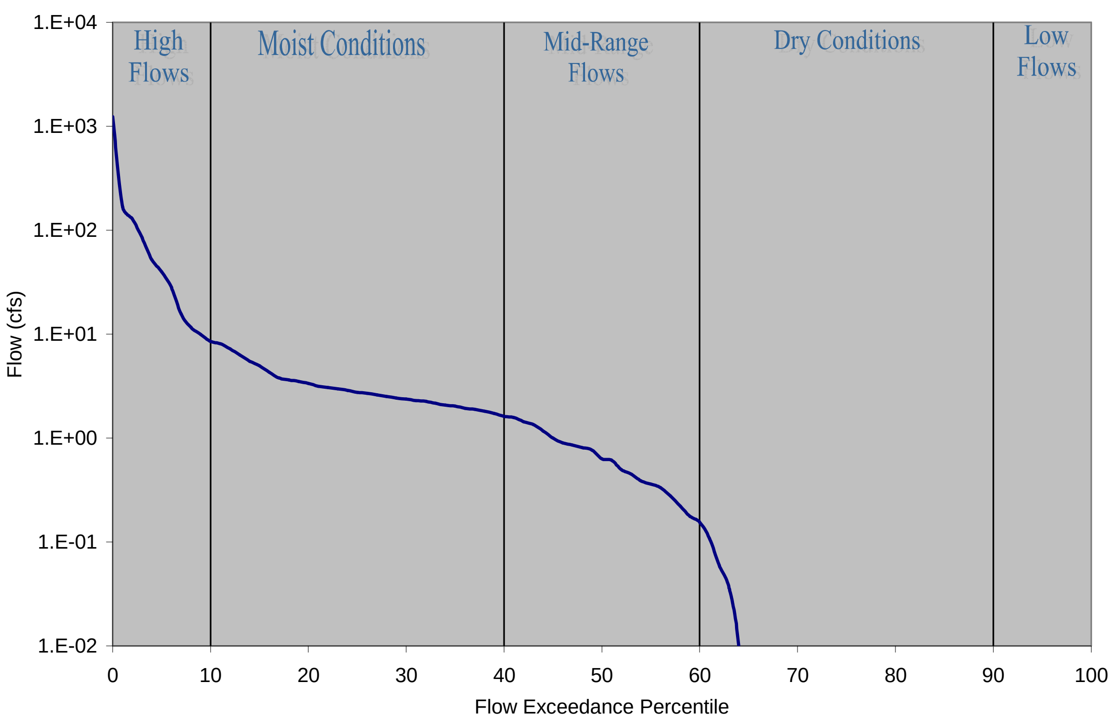


**Figure 4-5 Flow Duration Curve for Elk Creek at US 183 (OK311500030010_00)**

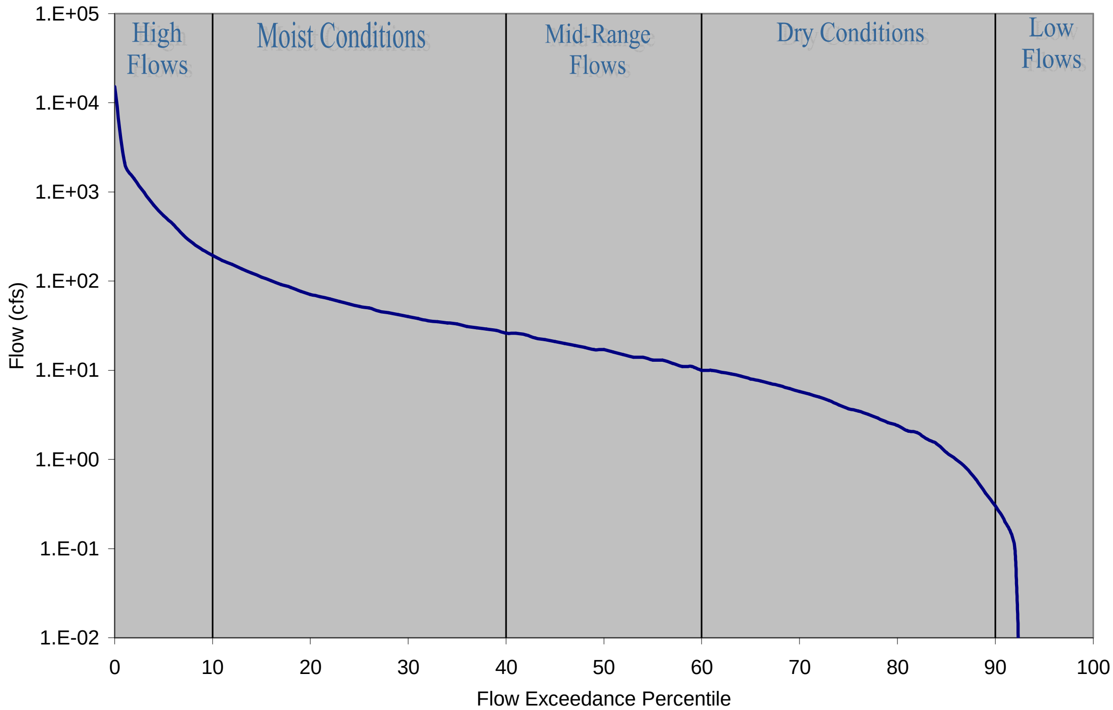



**Figure 4-6 Flow Duration Curve for Little Elk Creek (OK311500030040_00)**

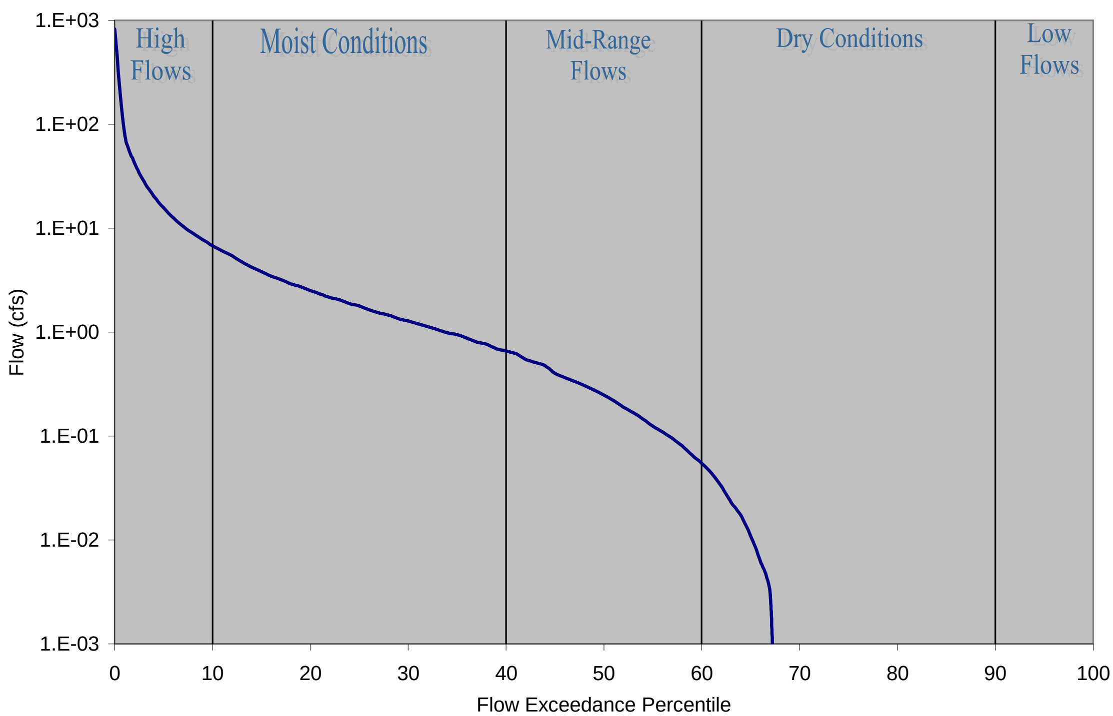


**Figure 4-7 Flow Duration Curve for North Fork Red River at SH 34 (OK311510010010_00)**

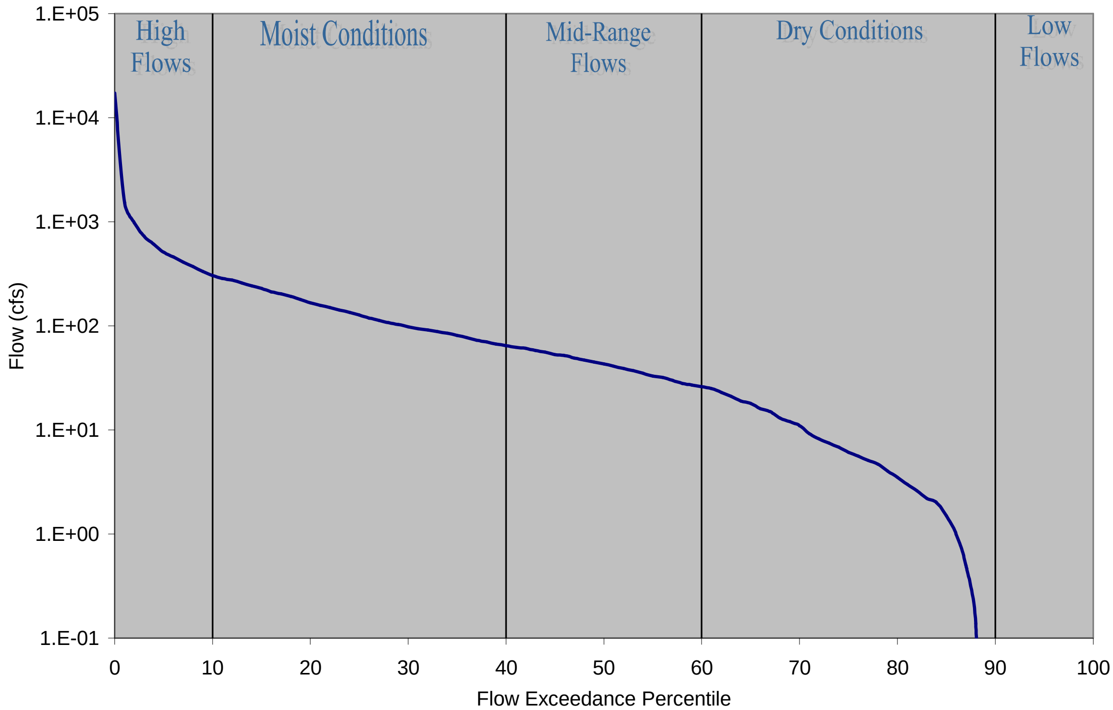



**Figure 4-8 Flow Duration Curve for Turkey Creek (OK311510020060_00)**

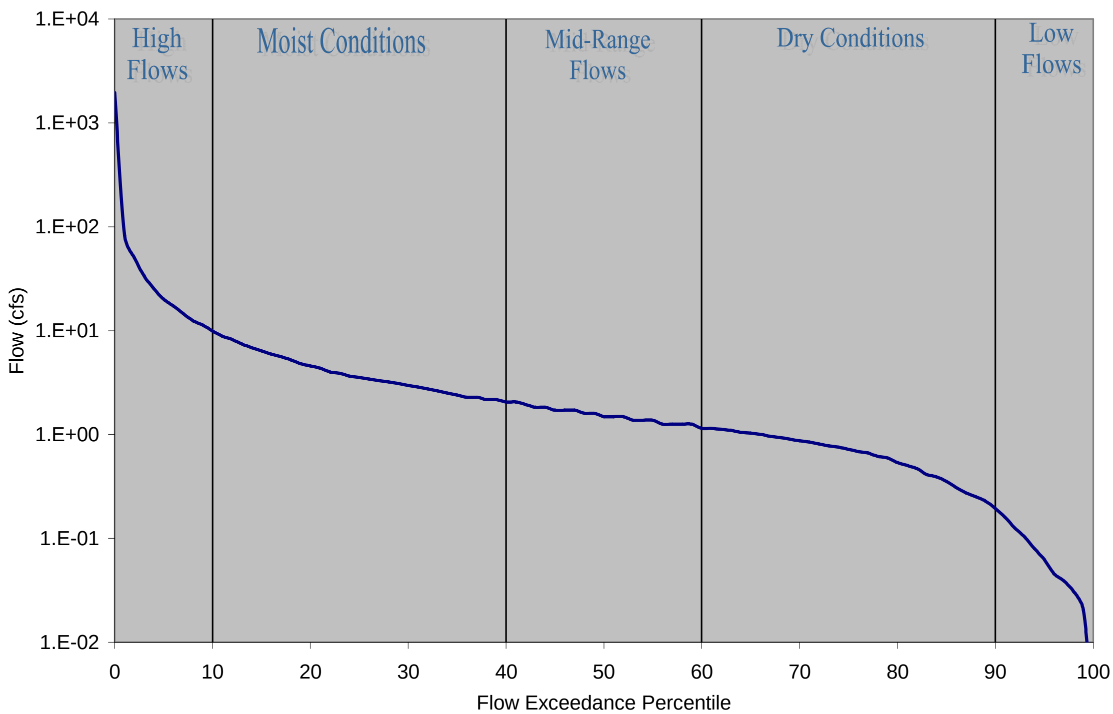


**Figure 4-9 Flow Duration Curve for Sandy Creek (OK311600010040_00)**

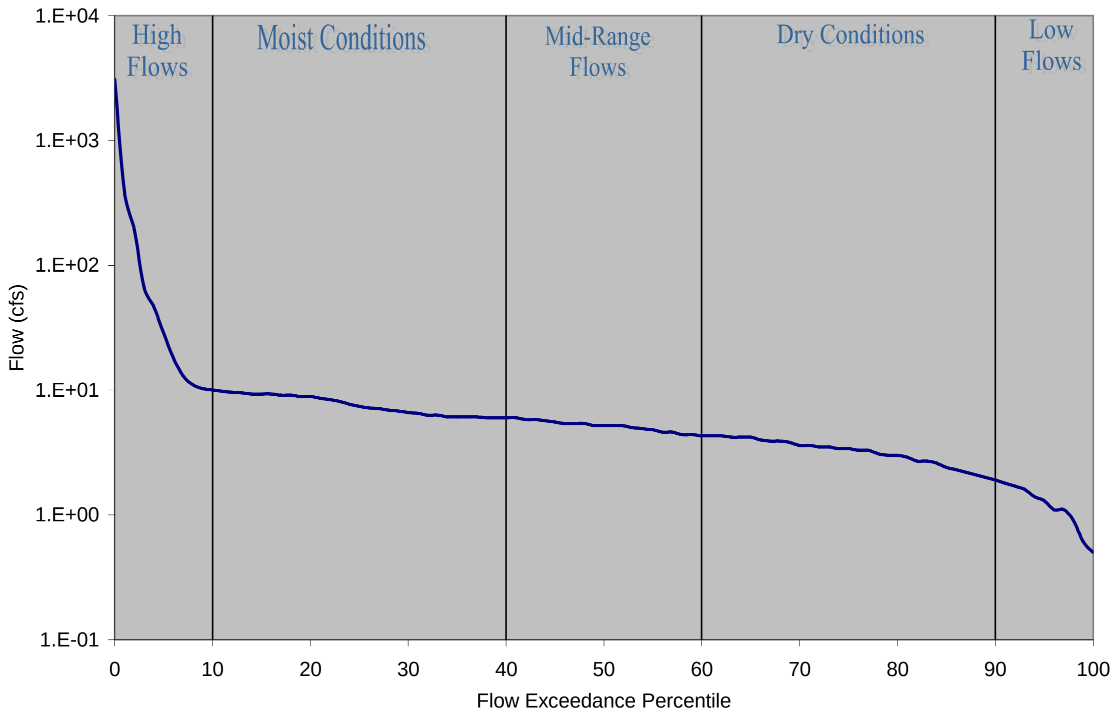



**Figure 4-10 Flow Duration Curve for Salt Fork Red River at US 283 (OK311600020010_00)**

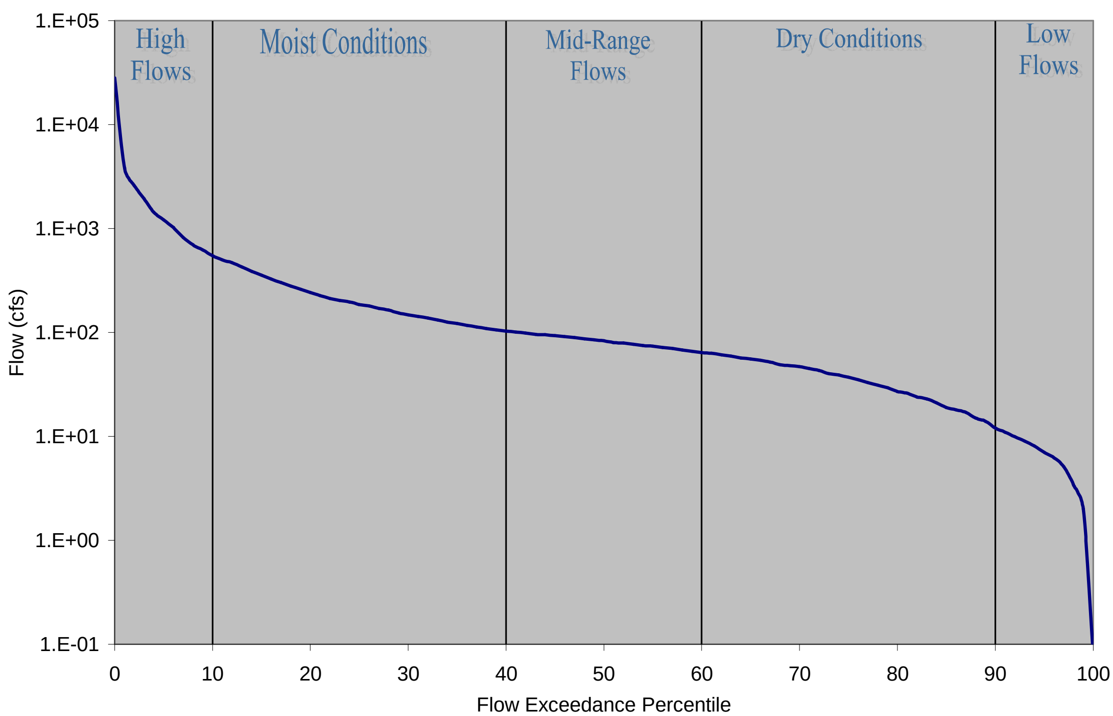


**Figure 4-11 Flow Duration Curve for Salt Fork Red River at SH 34 (OK311600020010_10)**

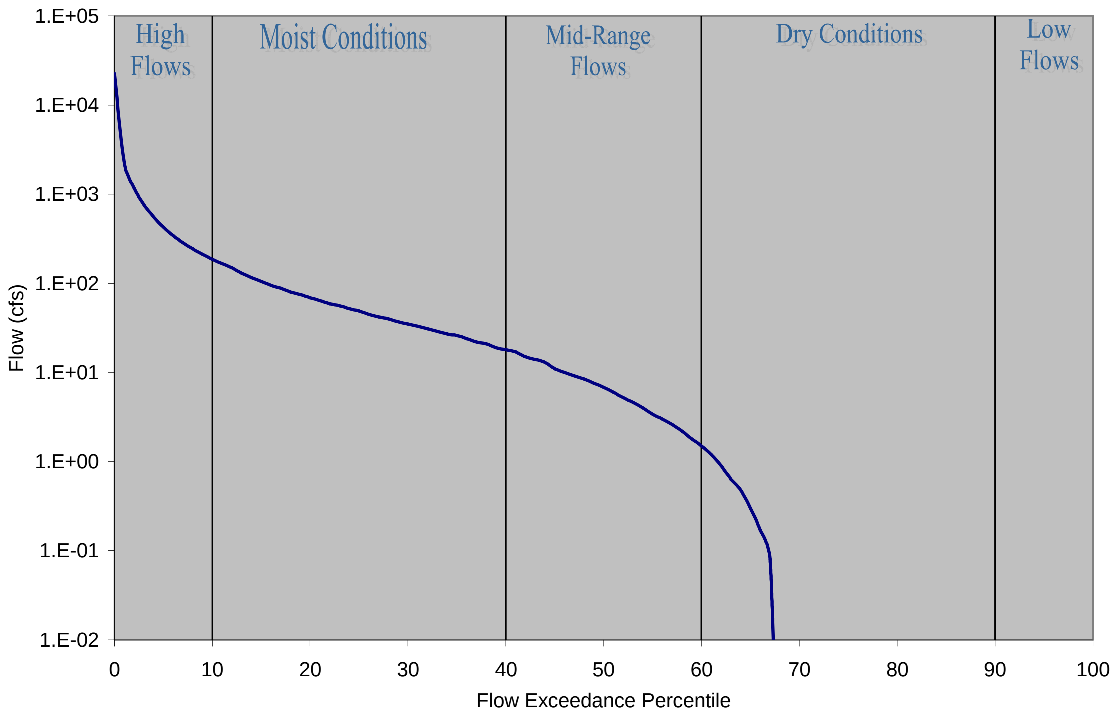



**Figure 4-12 Flow Duration Curve for Bitter Creek (OK311600020110_00)**

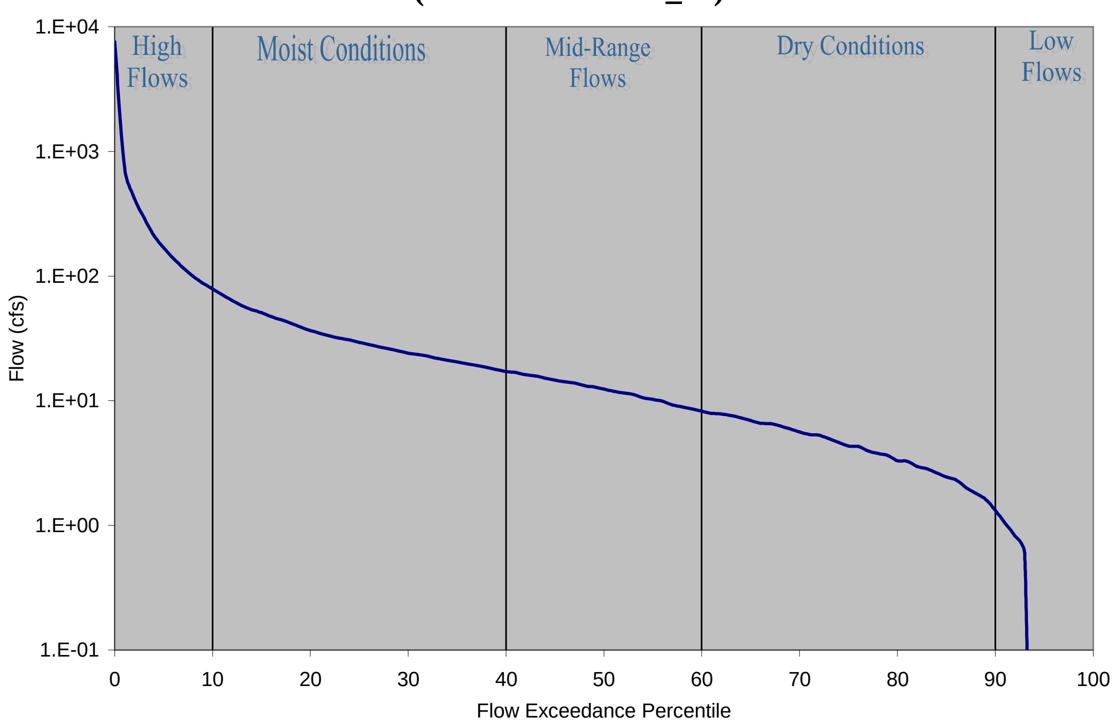


**Figure 4-13 Flow Duration Curve for Cave Creek (OK311600020140_00)**

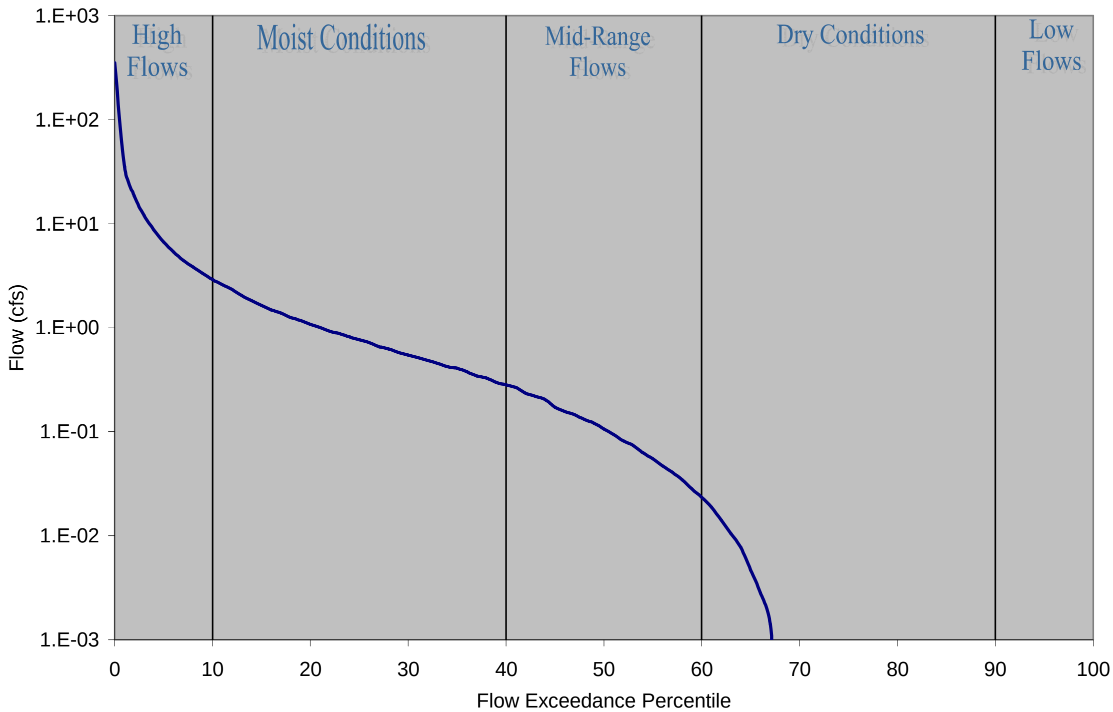



**Figure 4-14 Flow Duration Curve for Elm Fork River (OK311800000010_00)**

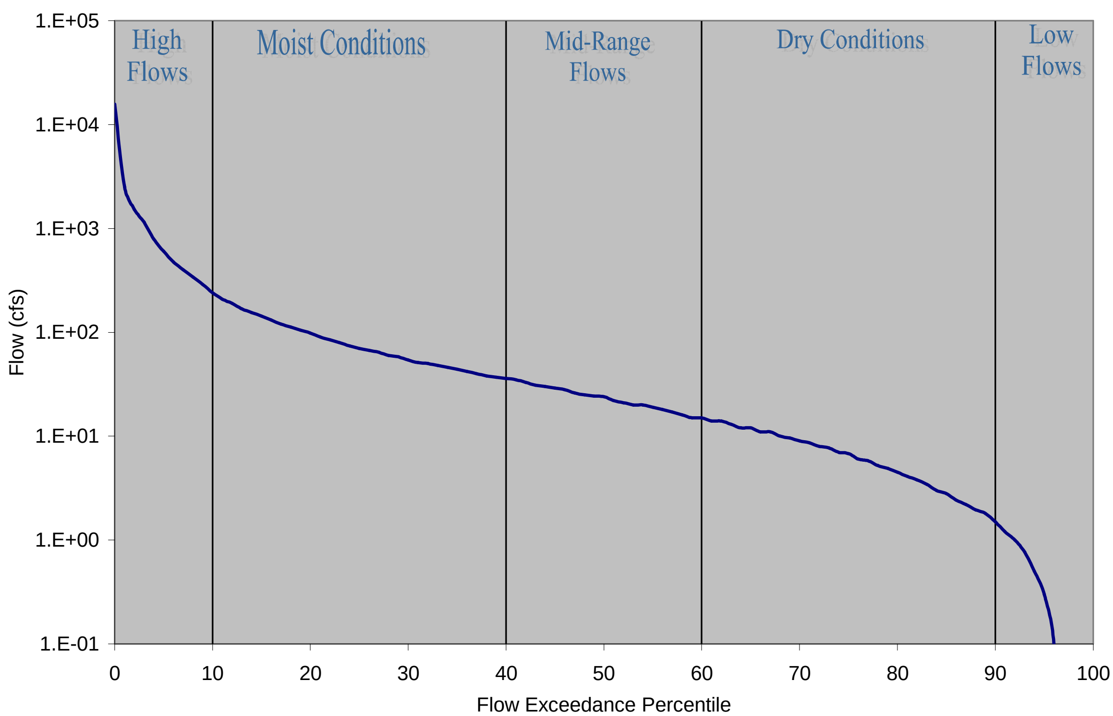


**Figure 4-15 Flow Duration Curve for Deer Creek (OK311800000070_00)**

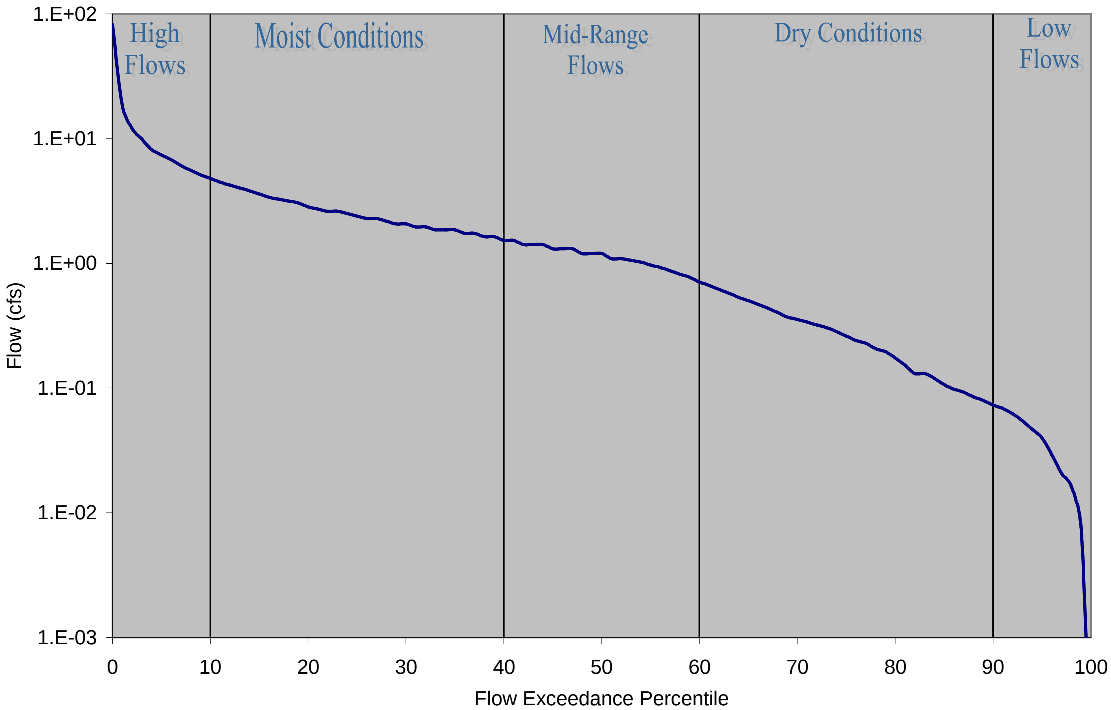
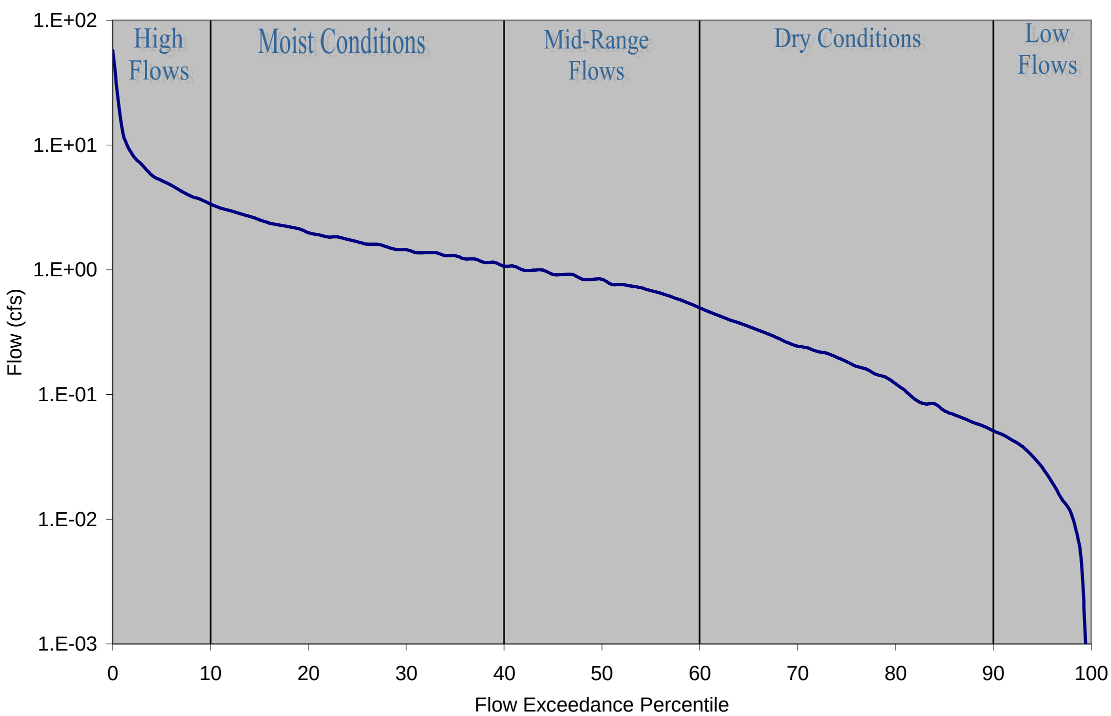



**Figure 4-16 Flow Duration Curve for Fish Creek (OK311800000130_00)**



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. 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 minus the point source loads were used as an estimate for nonpoint loading.

## 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) for waterbodies not supporting the PBCR use;
- obtaining water quality data from the entire calendar year for waterbodies not supporting the SBCR use;
- 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.

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: PBCR WQS = 400 cfu /100 ml (Fecal coliform); 406 cfu/100 ml (E. coli); or 108 cfu/100 ml (Enterococci), or*

*SBCR WQS = 2000 cfu /100 ml (Fecal coliform); 2030 cfu/100 ml (E. coli); or 540 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.

Flows and water quality samples observed in the months comprising the primary contact recreation season are used to generate the LDCs for waterbodies not supporting PBCR use. Flows and water quality samples observed over the entire calendar year are used to generate the LDCs for waterbodies not support SBCR use. 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 local 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 load allocation 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-$10^6$gal/day*

**Step 4: Calculate LA and WLA for MS4s.** Given the lack of data and the variability of storm events and discharges from storm sewer system discharges, it is difficult to establish numeric limits on stormwater discharges that accurately address projected loadings. As a result, EPA regulations and guidance recommend expressing NPDES permit limits for MS4s as BMPs.

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 - WLA_WWTP - WLA_MS4 - MOS**

**WLA for MS4s.** If there are no permitted MS4s in the study area, WLA_MS4 is set to zero. When there are permitted MS4s in the watershed, we can first calculate the sum of LA + WLA_MS4 using the above formula, then separate WLA for MS4s from the sum based on the percentage of a watershed that is under a MS4 jurisdiction. 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. All SSOs are considered unpermitted discharges under State statute and DEQ regulations. For any MS4s that are located within a watershed requiring a TMDL the load reduction will be equal to the PRG established for the overall watershed.

**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 WQ standards 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 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 or SBCR 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 North Fork Red River at US 62, Elk Creek, North Fork Red River at SH 34, Sandy Creek, Salt Fork Red River at US 283, Salt Fork Red River at SH 34, Bitter Creek, Cave Creek, and Elm Fork Red River will be based on Enterococci; the TMDL PRGs for Stinking Creek, Tepee Creek, West Otter Creek, Little Elk Creek, Turkey Creek, Deer Creek and Fish Creek will be based on fecal coliform. The PRGs range from 14 to 99 percent.

**Table 5-1 TMDL Percent Reductions Required to Meet Water Quality Standards for Impaired Waterbodies in the Upper 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 |
| OK311500010020_10 | OK311500010020-001AT | Red River-North Fork at US 62 | | | | 88% | **81%** |
| OK311500010050_00 | OK311500010050G | Stinking Creek | **97%** | | | | |
| OK311500010110_00 | OK311500010110G | Tepee Creek | **28%** | | | | |
| OK311500020040_00 | OK311500020040G | West Otter Creek | **66%** | | | | |
| OK311500030010_00 | OK311500030010-001AT | Elk Creek | | | | 94% | **85%** |
| OK311500030040_00 | OK311500030040G | Little Elk Creek | **67%** | | | | |
| OK311510010010_00 | OK311510010010-001AT | Red River-North Fork at SH 34 | | | | 96% | **70%** |
| OK311510020060_00 | OK311510020060G | Turkey Creek | **60%** | | | | |
| OK311600010040_00 | OK311600010040-001AT | Sandy Creek (Lebos) | | | | 99% | **83%** |
| OK311600020010_00 | OK311600020010-002AT | Red River-Salt Fork at US 283 | 76% | 89% | 14% | 99% | **94%** |
| OK311600020010_10 | OK311600020010-001AT | Red River-Salt Fork at SH 34 | 64% | | | 99% | **96%** |
| OK311600020110_00 | OK311600020110G | Bitter Creek | | | | 96% | **76%** |
| OK311600020140_00 | OK311600020140G | Cave Creek | 72% | | | 95% | **92%** |
| OK311800000010_00 | OK311800000010-001AT | Red River-Elm Fork | 28% | 87% | 79% | 98% | **87%** |
| OK311800000070_00 | OK311800000070C | Deer Creek | **72%** | | | | |
| OK311800000130_00 | OK311800000130G | Fish Creek | **28%** | | | | |

A subset of the LDCs for each impaired waterbody is shown in Figures 5-1 through 5-16. While some waterbodies may be listed for multiple bacterial indicators, only one LDC for each waterbody is presented in Figures 5-1 through 5-16 – the LDC for the bacterial indicator that is highlighted by bold text in Table 5-1. In other words, Figures 5-1 through 5-16 display an 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 North Fork Red River segment OK311500010020_10 (Figure 5-1) is based on Enterococcus bacteria measurements during primary contact recreation season at WQM station OK311500010020-001AT (North Fork Red River near Headrick, OK). The PRG is calculated so the measurements under primary contact recreation season are met. The LDC indicates that Enterococcus levels sometimes exceed the instantaneous water quality criteria during all flow conditions, possibly indicating water quality impairments due to nonpoint sources or a combination of point and nonpoint sources. Exceedances occurred during high flow conditions indicate that the majority of the pollution is due to non-point sources. The exceedances found during dry weather conditions indicate some level of pollution may be due to point sources, failing onsite systems, or direct deposition of animal manure.

The LDC for Stinking Creek segment OK311500010050_00 (Figure 5-2) is based on fecal coliform bacteria measurements during primary contact recreation season at WQM station OK311500010050G. 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, moist, and mid-range flow conditions, indicative of nonpoint sources.

The LDC for Tepee Creek segment OK311500010110_00 (Figure 5-3) is based on fecal coliform bacteria measurements during primary contact recreation season at WQM station OK311500010110G. 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 occasionally exceed the instantaneous water quality criteria under dry and moist hydrologic conditions. However, since there is no point source discharge in the watershed, the bacteria loading must come from nonpoint sources.

The LDC for West Otter Creek segment OK311500020040_00 (Figure 5-4) is based on fecal coliform bacteria measurements during primary contact recreation season at WQM station OK311500020040G. 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 during high flow, moist, and mid-range flow conditions, indicative of nonpoint sources.

The LDC for Elk Creek segment OK311500030010_00 (Figure 5-5) is based on Enterococcus bacteria measurements during primary contact recreation season at WQM station OK311500030010-001AT (Elk Creek off US 183 near Hobart, OK). The LDC indicates that Enterococcus levels sometimes exceed the instantaneous water quality criteria under moist conditions, mid-range flows, and dry hydrologic conditions. However, since there is no point source discharge in the watershed, the bacteria loading must come from nonpoint sources.

The LDC for Little Elk Creek segment OK311500030040_00 (Figure 5-6) is based on fecal coliform bacteria measurements during primary contact recreation season at WQM station OK311500030040G. 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. However, since there is no point source discharge in the watershed, the bacteria loading must come from nonpoint sources.

The LDC for North Fork Red River segment OK311510010010_00 (Figure 5-7) is based on Enterococcus bacteria measurements during primary contact recreation season at WQM station OK311510010010-001AT (North Fork Red River near Carter, OK). The LDC indicates that Enterococcus levels sometimes exceed the instantaneous water quality criteria under all hydrologic conditions. However, since there is no point source discharge in the watershed, the bacteria loading must come from nonpoint sources.

The LDC for Turkey Creek segment OK311510020060_00 (Figure 5-8) is based on fecal coliform bacteria measurements during primary contact recreation season at WQM station OK311510020060G. 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 during most flow conditions. Since there is no point source discharge in the watershed, the bacteria loading must come from nonpoint sources.

The LDC for Sandy Creek segment OK311600010040_00 (Figure 5-9) is based on Enterococci bacteria measurements and flows during all seasons at WQM station OK311600010040-001AT (Sandy Creek, SH 6, Eldorado). The PRG is calculated so the measurements under secondary contact recreation season are met, as primary contact recreation is not a designated use for this segment. The LDC indicates that Enterococci levels exceeded the instantaneous secondary contact recreation water quality criteria during high flow and moist conditions (all samples were collected under these conditions), indicative of nonpoint sources.

The LDC for Salt Fork Red River segment OK311600020010_00 (Figure 5-10) is based on fecal coliform bacteria measurements during primary contact recreation season at WQM station OK311600020010-002AT (Salt Fork Red River near Elmer, OK). The LDC indicates that fecal coliform levels exceed the instantaneous water quality criteria during most flow conditions, indicative of a combination of point and nonpoint sources.

The LDC for Salt Fork Red River segment OK311600020010_10 (Figure 5-11) is based on fecal coliform bacteria measurements during primary contact recreation season at WQM station OK311600020010-001AT (Salt Fork Red River at SH 34 at Mangum, OK). The LDC indicates that fecal coliform levels have exceeded the instantaneous water quality criteria during high flow, mid-range flow, and dry hydrologic conditions, possibly indicating a combination of nonpoint and point sources. The LDC for this waterbody presents some atypical characteristics – zero flow above the 68$^{th}$ flow percentile based on a long-term USGS gage station on the river and a WWTP that provides continuous flow above the 68$^{th}$ percentile. In cases such as this stream flow above the 65$^{th}$ percentile is considered effluent dominated and it is assumed that the WWTP is compliant with permit requirements and therefore its discharge will not result in WQS exceedances.

The LDC for Bitter Creek segment OK311600020110_00 (Figure 5-12) is based on Enterococcus bacteria measurements and flows during all seasons at WQM station OK311600020110G. The PRG is calculated so the measurements under secondary contact recreation season are met, as primary contact recreation is not a designated use for this segment. The LDC indicates that Enterococcus levels sometimes exceed the instantaneous secondary contact recreation water quality criteria under all hydrologic conditions, indicating nonpoint sources.

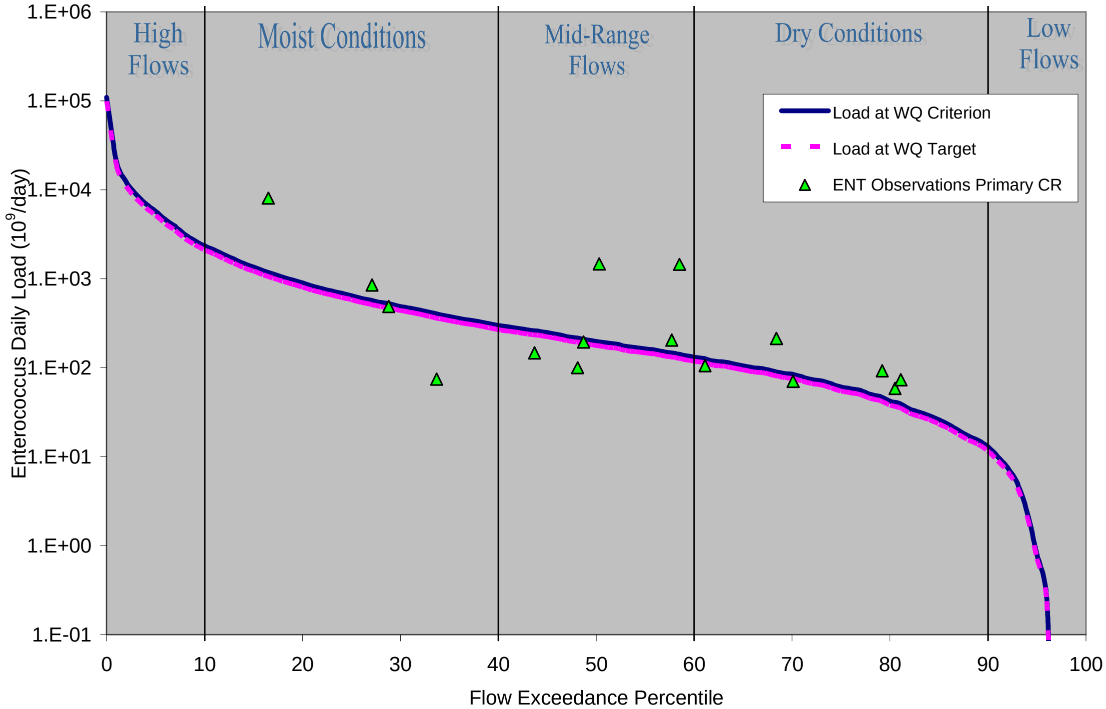
The LDC for Cave Creek segment OK311600020140_00 (Figure 5-13) is based on Enterococci bacteria measurements during primary contact recreation season at WQM station OK311600020140G. Enterococci measurements collected during secondary contact recreation season (October – April) are also displayed on the 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 Enterococci levels exceed the instantaneous water quality criteria during moist and mid-range flow conditions, indicative of nonpoint sources.

The LDC for Elm Fork Red River segment OK311800000010_00 (Figure 5-14) is based on Enterococci bacteria measurements during primary contact recreation season at WQM station OK311800000010-001AT (Elm Fork Red River near Mangum, OK). The LDC indicates that fecal coliform levels exceed the instantaneous water quality criteria under all hydrologic conditions. However, since there is no point source discharge in the watershed, the bacteria loading must come from nonpoint sources.

The LDC for Deer Creek segment OK311800000070_00 (Figure 5-15) is based on fecal coliform bacteria measurements during primary contact recreation season at WQM station OK311800000070C. 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 mid-range flow conditions, indicative of nonpoint sources.

The LDC for Fish Creek segment OK311800000130_00 (Figure 5-16) is based on fecal coliform bacteria measurements during primary contact recreation season at WQM station OK311800000130G (Fish Creek). 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, low flow, and mid-range conditions. However, since there is no point source discharge in the watershed, the bacteria loading must come from nonpoint sources

**Figure 5-1 Load Duration Curve for Enterococci in North Fork Red River at US 62 (OK311500010020_10)**




Note: There is no wasteload allocation for this waterbody.

**Figure 5-2 Load Duration Curve for Fecal Coliform in Stinking Creek (OK311500010050_00)**

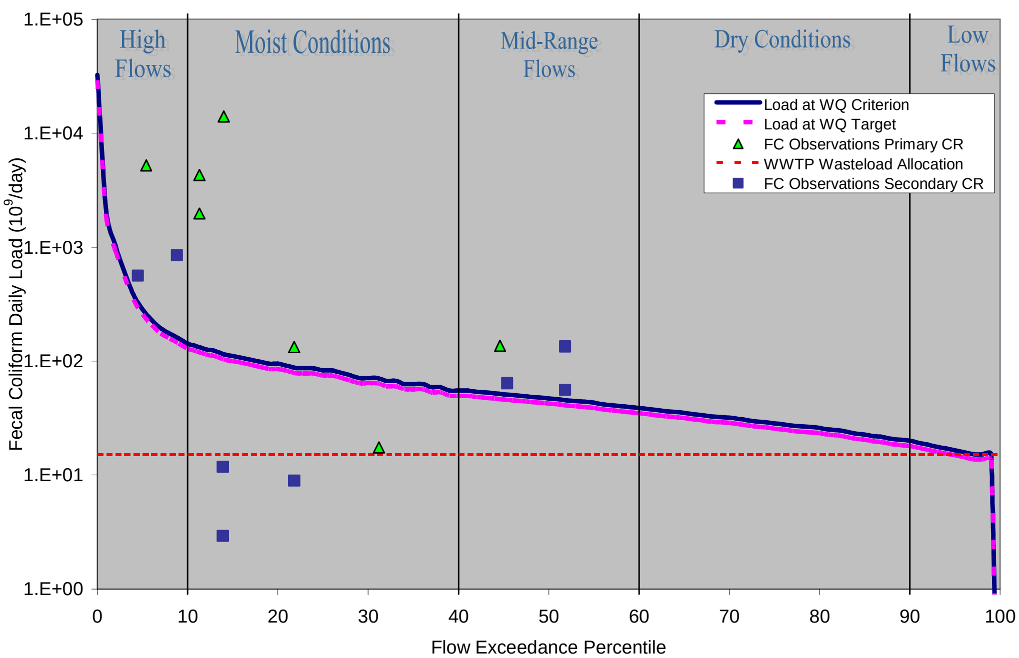
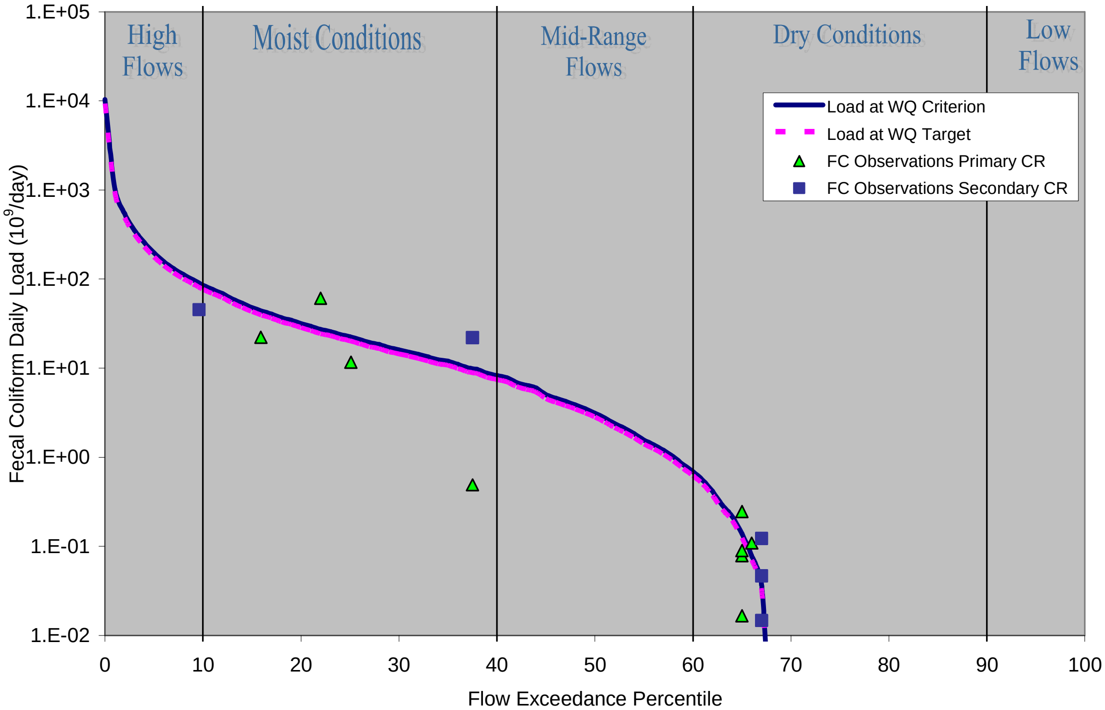
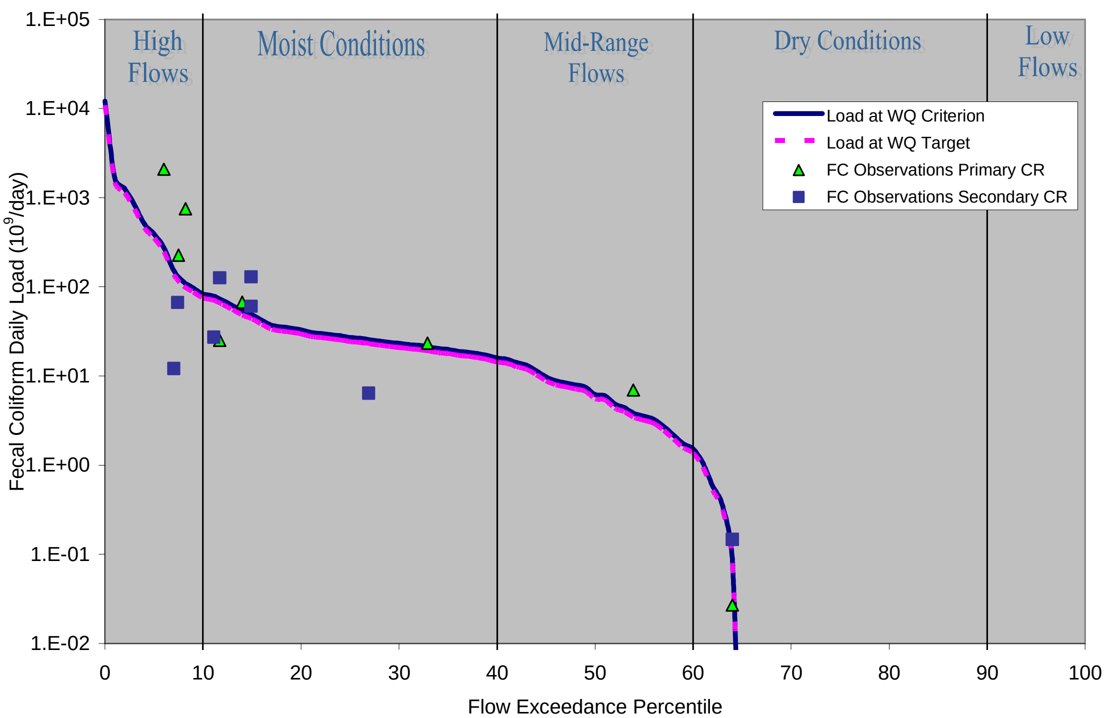


**Figure 5-3 Load Duration Curve for Fecal Coliform in Tepee Creek (OK311500010110_00)**



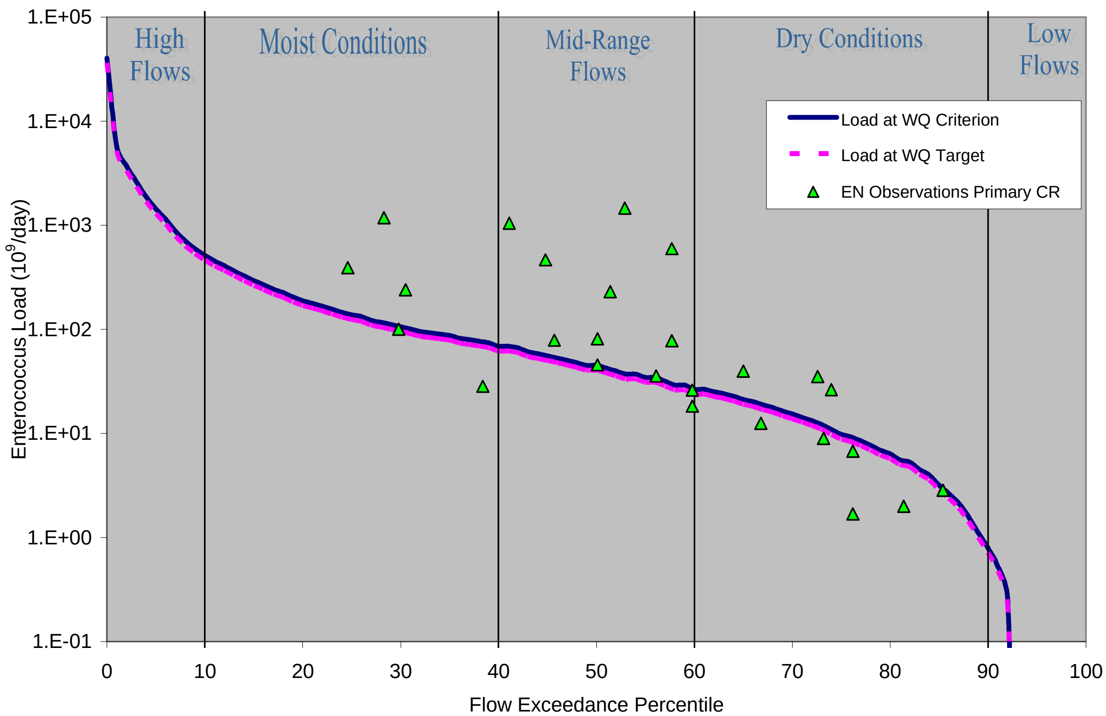

Note: There is no wasteload allocation for this waterbody.

**Figure 5-4 Load Duration Curve for Fecal Coliform in West Otter Creek (OK311500020040_00)**



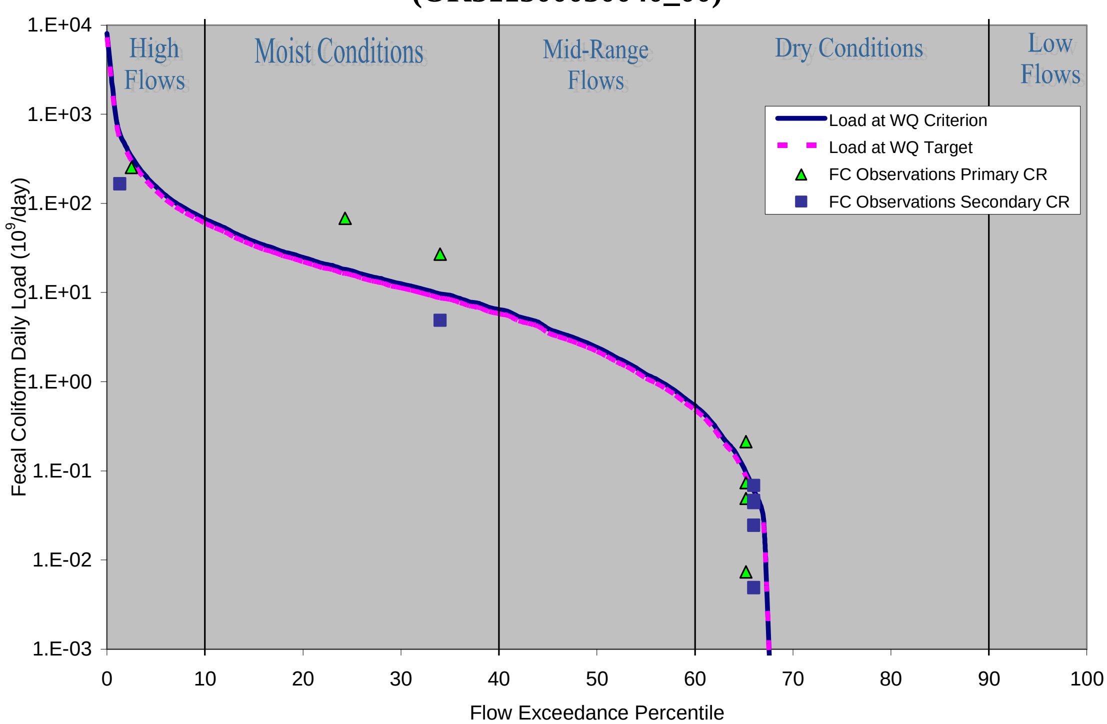

Note: There is no wasteload allocation for this waterbody.

**Figure 5-5 Load Duration Curve for Enterococci in Elk Creek (OK311500030010_00)**



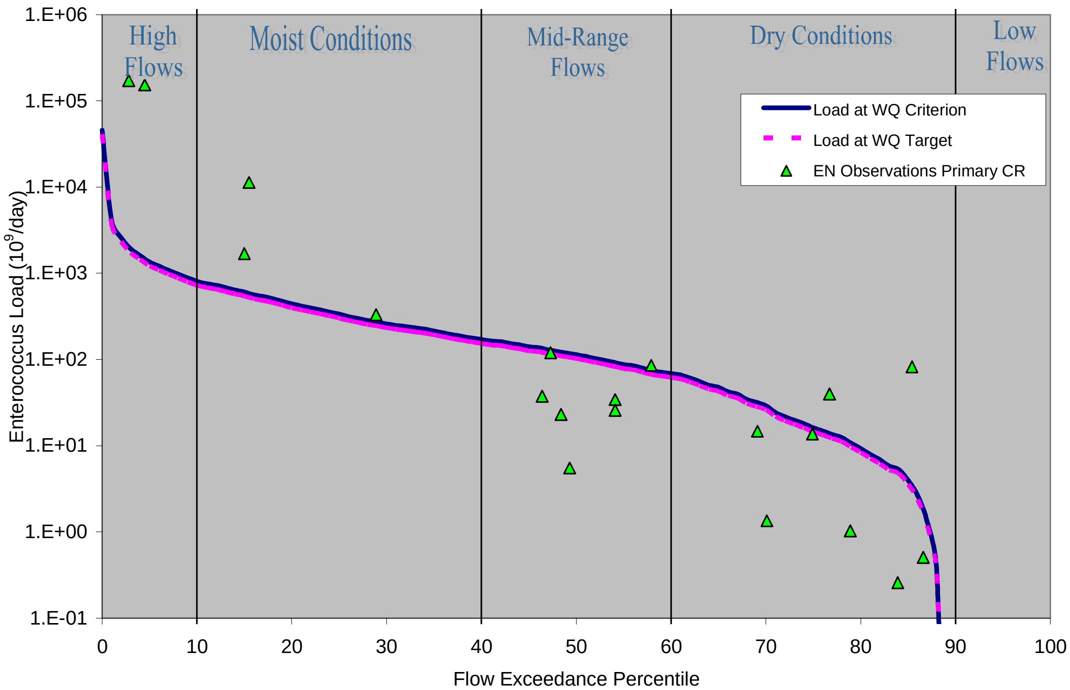

Note: There is no wasteload allocation for this waterbody.

**Figure 5-6 Load Duration Curve for Fecal Coliform in Little Elk Creek (OK311500030040_00)**



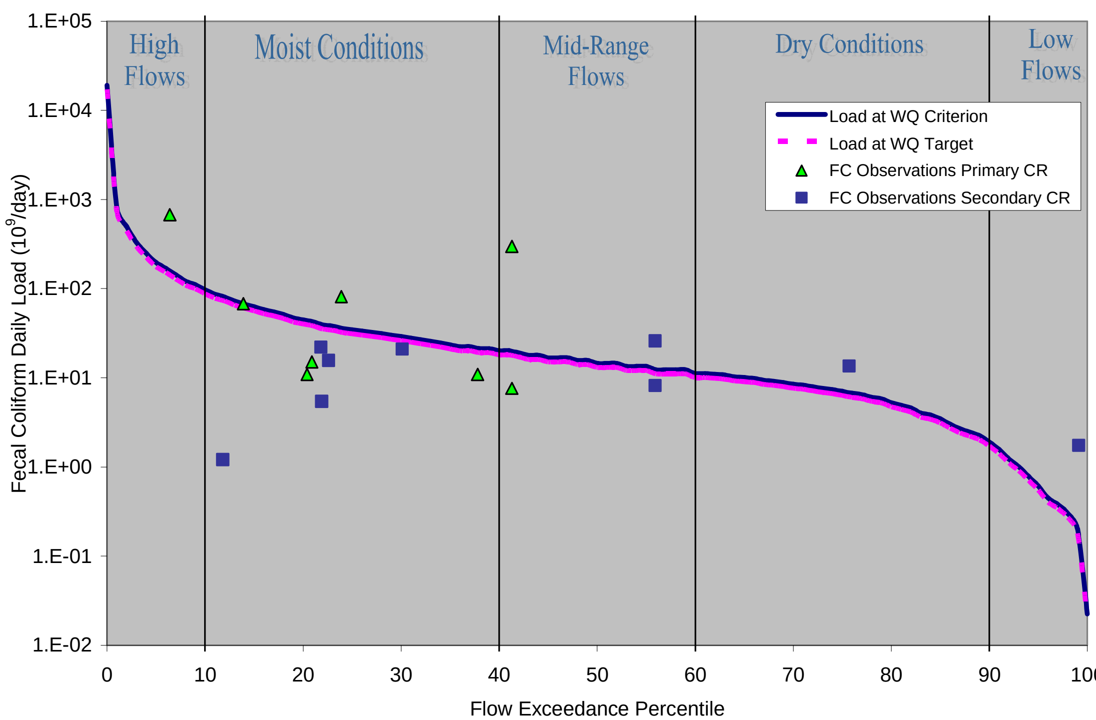

Note: There is no wasteload allocation for this waterbody.

**Figure 5-7 Load Duration Curve for Enterococci in North Fork Red River at SH 34 (OK311510010010_00)**



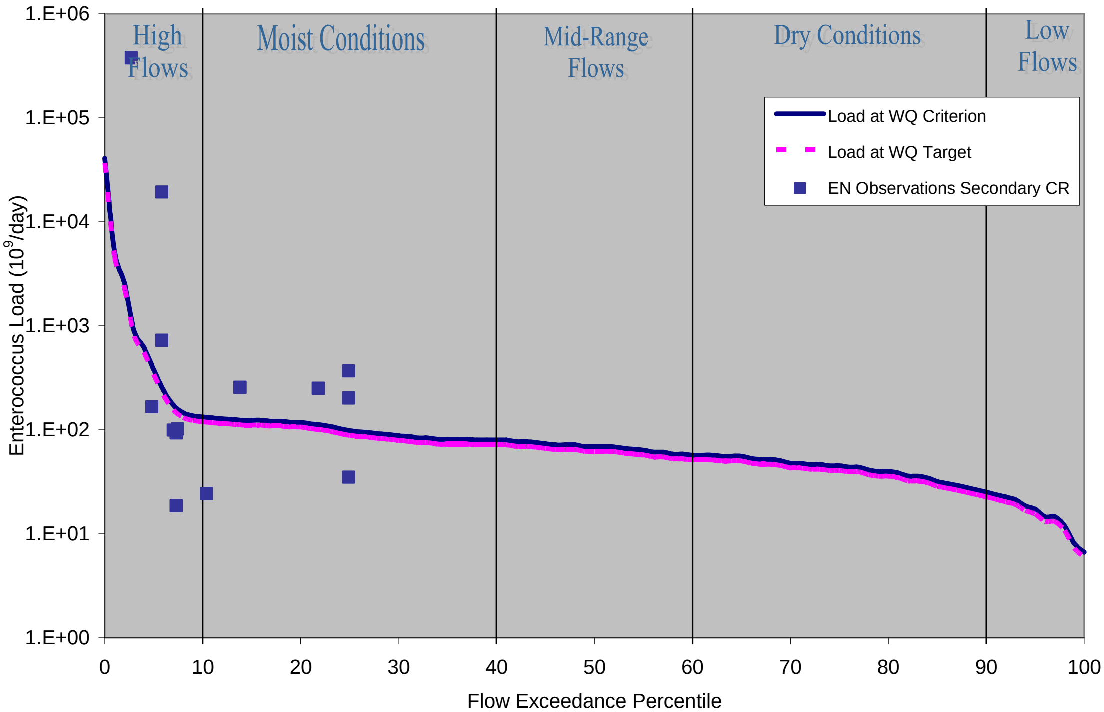

Note: There is no wasteload allocation for this waterbody.

**Figure 5-8 Load Duration Curve for Fecal Coliform in Turkey Creek (OK311510020060_00)**



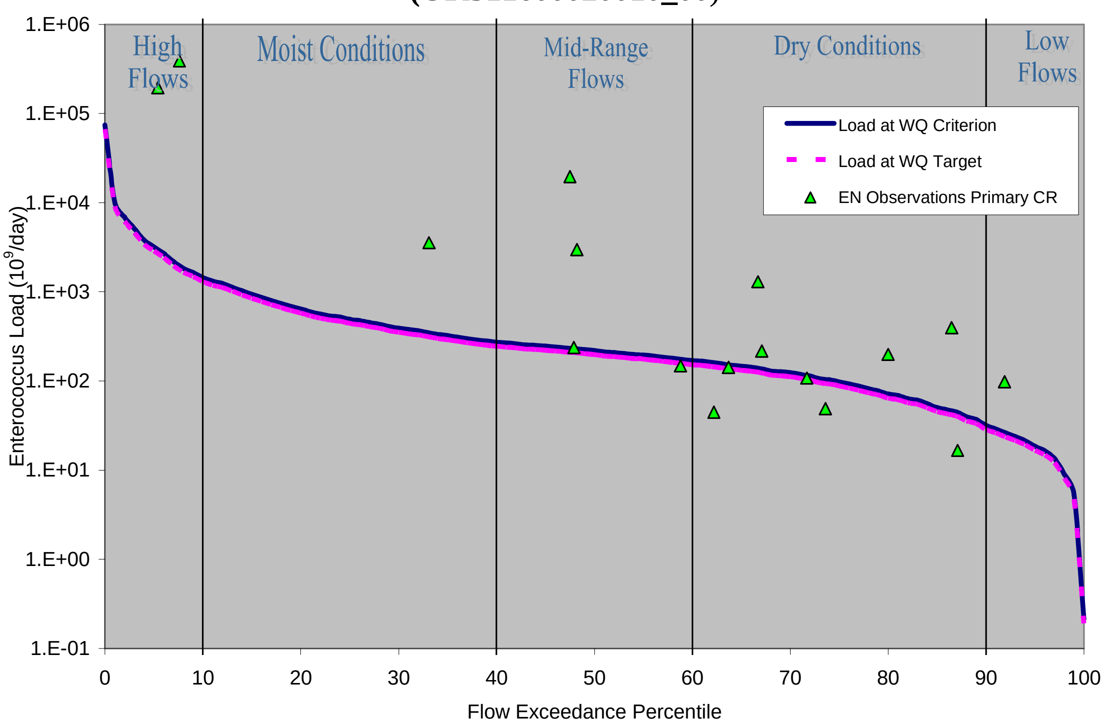

Note: There is no wasteload allocation for this waterbody.

**Figure 5-9 Load Duration Curve for Enterococci in Sandy Creek (OK311600010040_00)**




Note: There is no wasteload allocation for this waterbody.

**Figure 5-10 Load Duration Curve for Enterococci in Salt Fork Red River at US 283 (OK311600020010_00)**




Note: There is no wasteload allocation for this waterbody.

**Figure 5-11 Load Duration Curve for Enterococci in Salt Fork Red River at SH 34 (OK311600020010_10)**

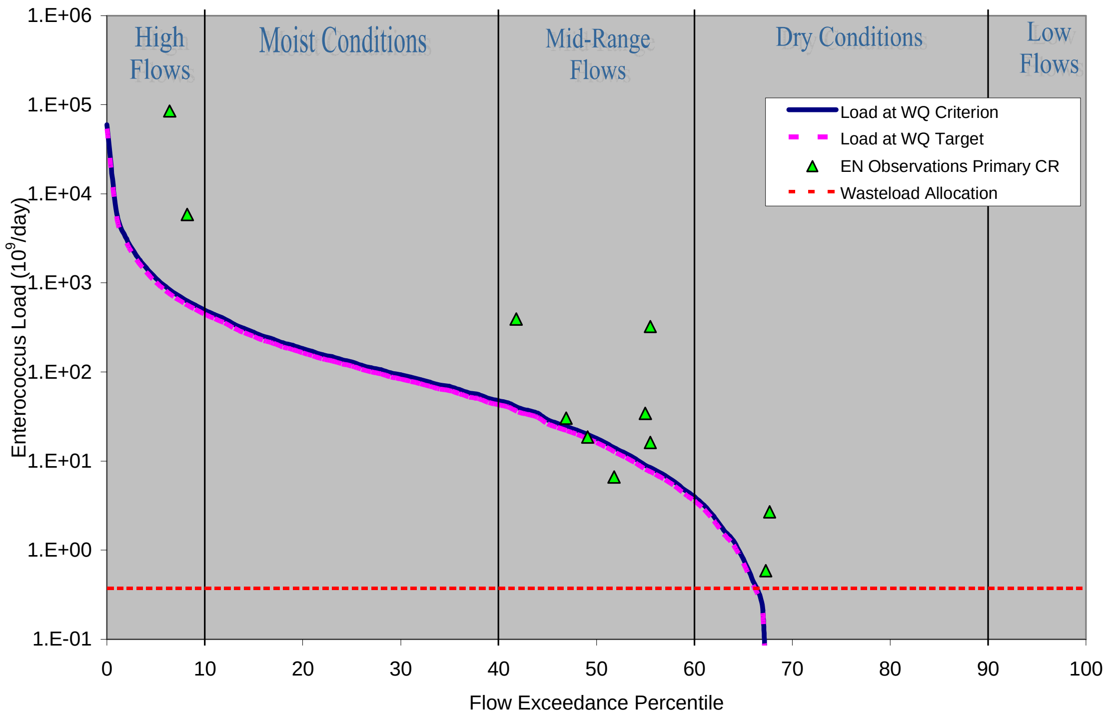
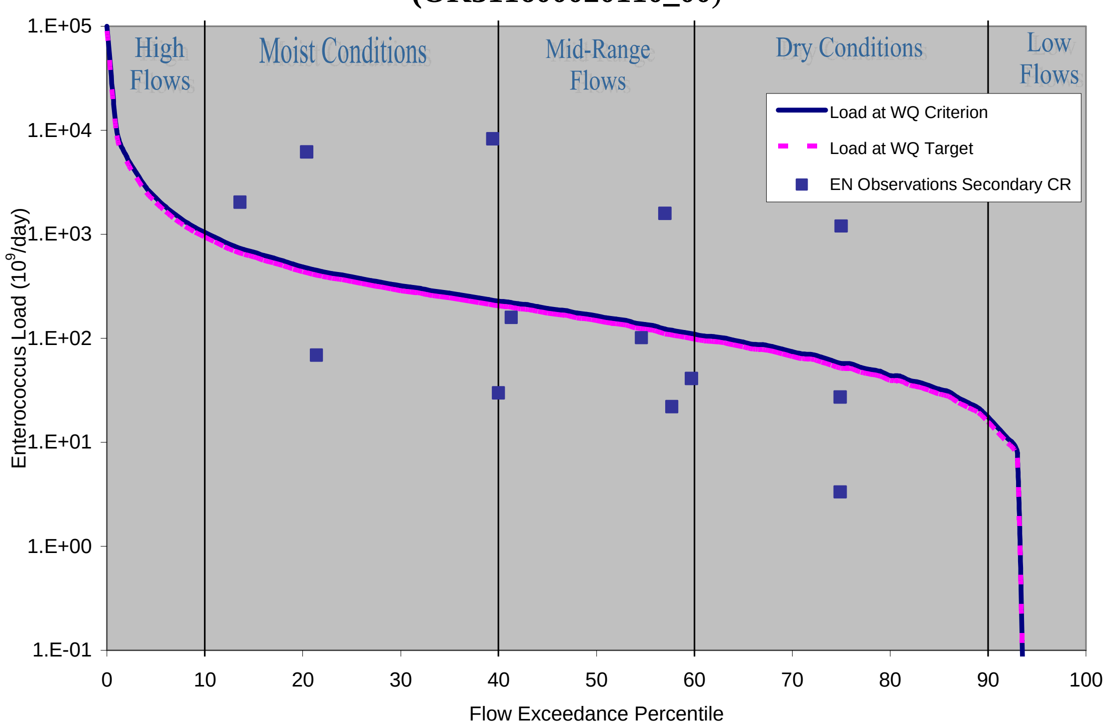
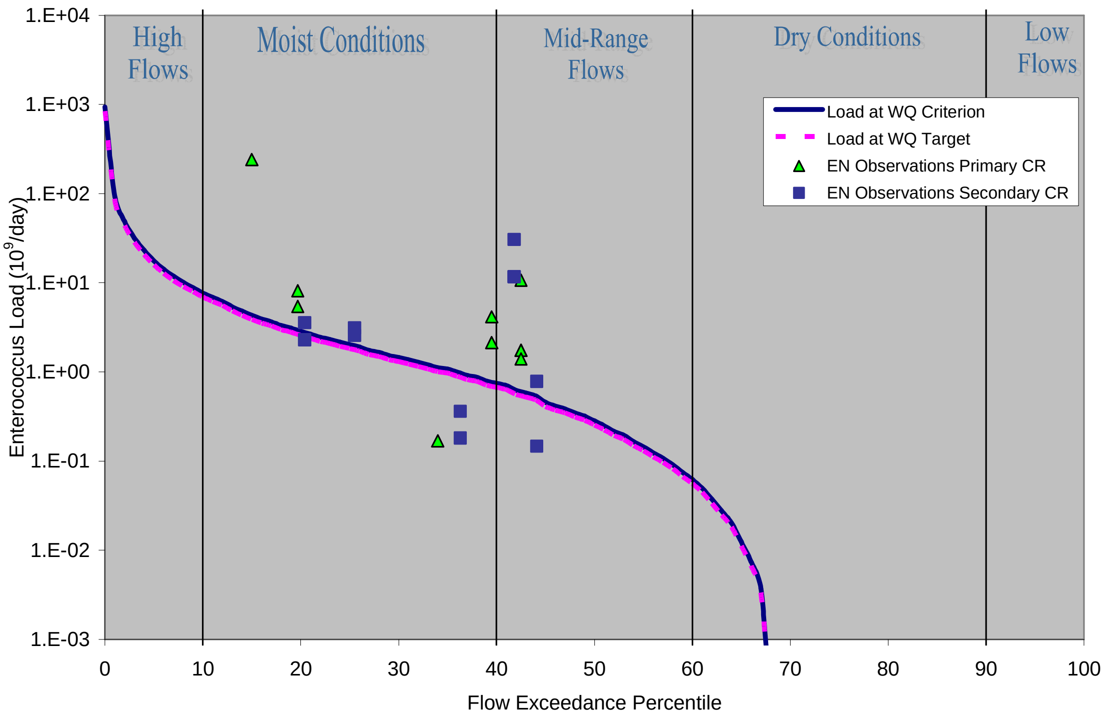



**Figure 5-12 Load Duration Curve for Enterococci in Bitter Creek (OK311600020110_00)**



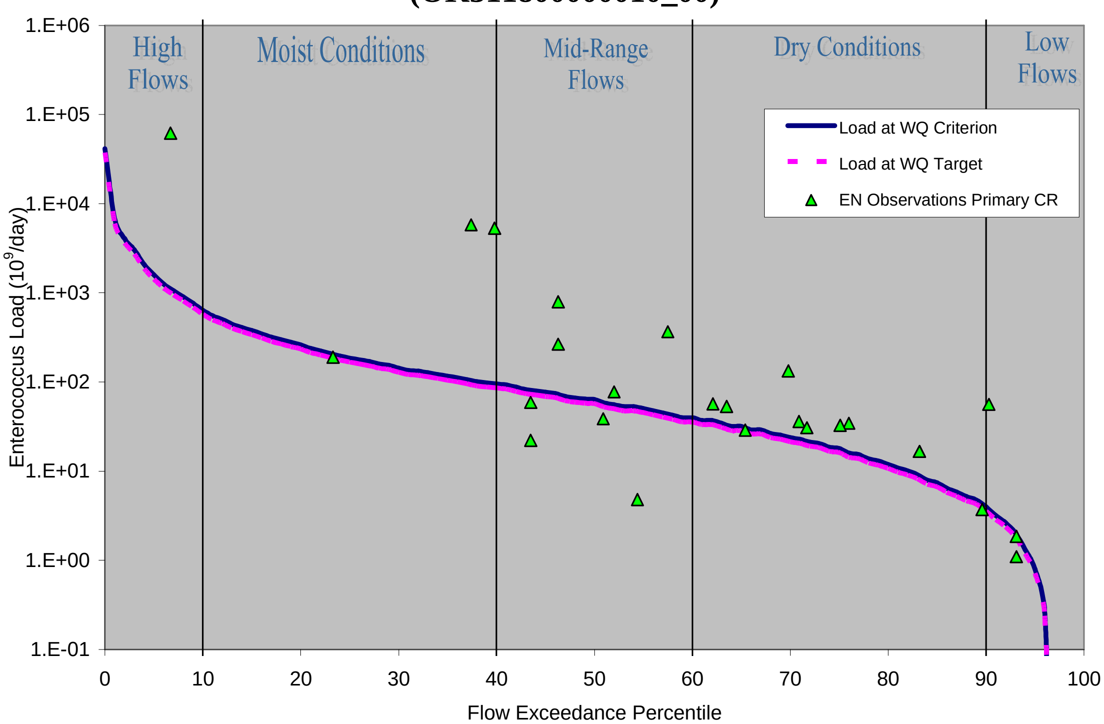

Note: There is no wasteload allocation for this waterbody.

**Figure 5-13 Load Duration Curve for Enterococci in Cave Creek (OK311600020140_00)**



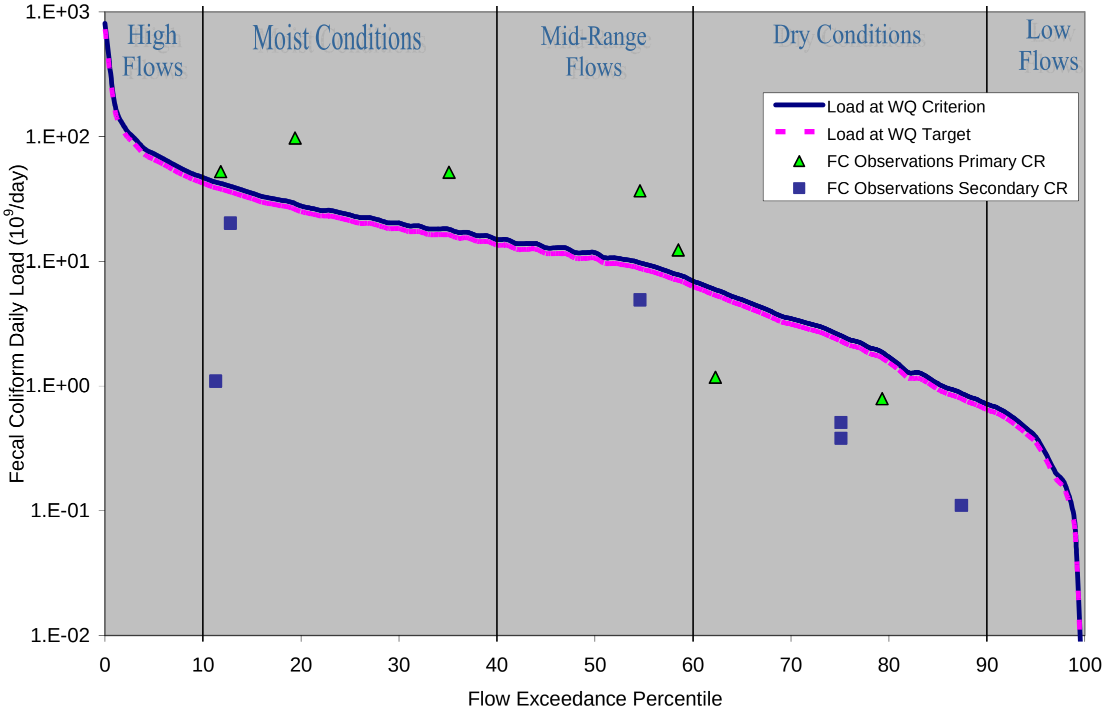

Note: There is no wasteload allocation for this waterbody.

**Figure 5-14 Load Duration Curve for Enterococci in Elm Fork Red River (OK311800000010_00)**



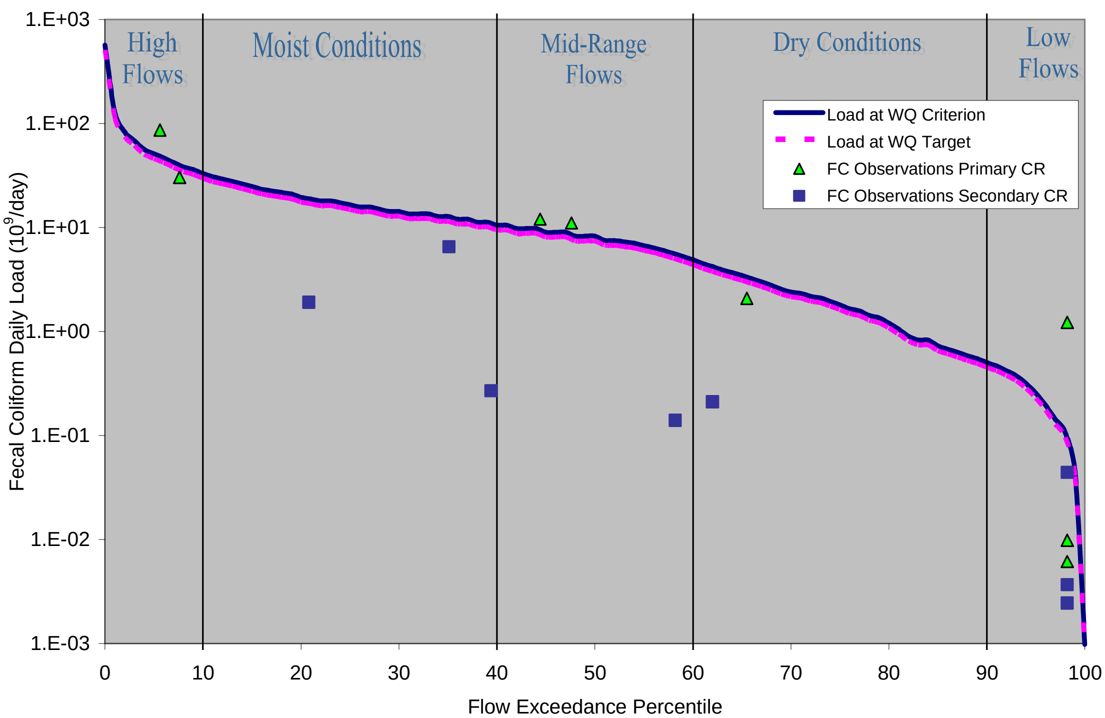

Note: There is no wasteload allocation for this waterbody.

**Figure 5-15 Load Duration Curve for Fecal Coliform in Deer Creek (OK311800000070_00)**




Note: There is no wasteload allocation for this waterbody.

**Figure 5-16 Load Duration Curve for Fecal Coliform in Fish Creek (OK311800000130_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 Upper Red River Study Area. The WLA for each facility is derived from the following equation:

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

***Where:***

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

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

***unit conversion factor = 37,854,120-$10^6$gal/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 indicates which point source dischargers within Oklahoma currently have a disinfection requirement in their permit. Certain facilities that utilize lagoons for treatment have not been required to provide disinfection since storage time and exposure to ultraviolet radiation from sunlight should reduce bacteria levels. In the future, all point source dischargers which are assigned a wasteload allocation but do not currently have a bacteria limit in their permit will receive a permit limit consistent with the wasteload allocation as their permits are reissued.

**Table 5-2 Wasteload Allocations* for NPDES-Permitted Facilities**

| Waterbody ID | NPDES Permit No. | Name | Design Flow (mgd) | Disinfection | Wasteload Allocation (cfu/day) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Fecal Coliform | *E. Coli* | Enterococci |
| OK311500010050_00 Stinking Creek | OK0028037 | City of Altus WWTP | 2.000 | Yes | 1.51E+10 | 9.54E+09 | 2.50E+09 |
| OK311600020010_10 Red River, Salt Fork | OK0028827 | City of Magnum WWTP | 0.300 | NO | 2.27E+09 | 1.43E+09 | 3.75E+08 |

Permitted stormwater discharges are considered point sources. The WLA calculations for MS4s must be expressed as different maximum loads allowable under different flow conditions. Therefore the percentage of a watershed that is under a MS4 jurisdictional is used to estimate the amount of the overall LA that should be dedicated as the MS4 contribution. The only urbanized area designated as an MS4 within this Study Area is the City of Altus (Permit #: OKR040043) located in the Stinking Creek (OK311500010050_00) watershed. The flow dependent calculations for the WLA established for the City of Altus MS4 are provided in Tables 5-3 and 5-5.

## 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 for WWTP and MS4s as follows:

LA = TMDL – WLA_WWTP – WLA_MS4 - 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. For PBCR, this equates to 360 cfu/100 mL, 365.4 cfu/100 mL, and 97.2/100 mL for fecal coliform, *E. coli*, and Enterococci, respectively. For secondary body contact recreation this equates to 1,800 organisms/100 mL, 1,827 organisms/100 mL, and 486/100 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:

$$\boldsymbol{TMDL = \Sigma\ WLA + \Sigma\ LA + MOS}$$

Where the Σ WLA component can be further divided into WLA for WWTPs and WLA for MS4s:

$$\Sigma\ \text{WLA} = \text{WLA\_WWTP} + \text{WLA\_MS4}$$

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 5-4 through 5-19). For illustrative purposes, the TMDL, WLA, LA, and MOS calculated for the median flow at each site are presented in Table 5-3.

The LDC and the equation of:

$$\boldsymbol{Average\ LA = average\ TMDL - MOS - WLA\_WWTP - WLA\_MS4}$$

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. For MS4s the load reduction will be the same as the PRG established for the LA (nonpoint sources). 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_WWTP† (cfu/day) | WLA_MS4† (cfu/day) | LA† (cfu/day) | MOS† (cfu/day) |
|---|---|---|---|---|---|---|---|---|
| OK311500010020_10 | OK311500010020-001AT | Red River-North Fork at US 62 | ENT | 1.98E+11 | 0 | 0 | 1.78E+11 | 1.98E+10 |
| OK311500010050_00 | OK311500010050G | Stinking Creek | FC | 4.70E+10 | 1.51E+10 | 1.84E+09 | 2.53E+10 | 4.70E+09 |
| OK311500010110_00 | OK311500010110G | Tepee Creek | FC | 8.43E+08 | 0 | 0 | 7.59E+08 | 8.43E+07 |
| OK311500020040_00 | OK311500020040G | West Otter Creek | FC | 1.67E+09 | 0 | 0 | 1.50E+09 | 1.67E+08 |
| OK311500030010_00 | OK311500030010-001AT | Elk Creek | ENT | 4.49E+10 | 0 | 0 | 4.04E+10 | 449E+09 |
| OK311500030040_00 | OK311500030040G | Little Elk Creek | FC | 6.56E+08 | 0 | 0 | 5.91E+08 | 6.56E+07 |
| OK311510010010_00 | OK311510010010-001AT | Red River-North Fork at SH 34 | ENT | 1.14E+11 | 0 | 0 | 1.02E+11 | 1.14E+10 |
| OK311510020060_00 | OK311510020060G | Turkey Creek | FC | 1.45E+10 | 0 | 0 | 1.31E+10 | 1.45E+09 |
| OK311600010040_00 | OK311600010040-001AT | Sandy Creek (Lebos) | ENT | 6.87E+10 | 0 | 0 | 6.18E+00 | 6.87E+09 |
| OK311600020010_00 | OK311600020010-002AT | Red River-Salt Fork at US 283 | ENT | 2.19E+11 | 0 | 0 | 1.97E+11 | 2.19E+10 |
| OK311600020010_10 | OK311600020010-001AT | Red River-Salt Fork at SH 34 | ENT | 1.80E+10 | 3.75E+08 | 0 | 1.58E+10 | 1.80E+09 |
| OK311600020110_00 | OK311600020110G | Bitter Creek | ENT | 1.64E+11 | 0 | 0 | 1.47E+11 | 1.64E+10 |
| OK311600020140_00 | OK311600020140G | Cave Creek | ENT | 2.81E+08 | 0 | 0 | 2.53E+08 | 2.81E+07 |
| OK311800000010_00 | OK311800000010-001AT | Red River-Elm Fork | ENT | 6.34E+10 | 0 | 0 | 5.71E+10 | 6.34E+09 |
| OK311800000070_00 | OK311800000070C | Deer Creek | FC | 3.17E+09 | 0 | 0 | 2.85E+09 | 3.17E+08 |
| OK311800000130_00 | OK311800000130G | Fish Creek | FC | 8.23E+09 | 0 | 0 | 7.41E+09 | 8.23E+08 |

† Derived for illustrative purposes at the median flow value

**Table 5-4 Enterococci TMDL Calculations for North Fork Red River at US 62 (OK311500010020_10)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 41,600 | 1.10E+14 | 0 | 9.89E+13 | 1.10E+13 |
| 5 | 2,180 | 5.76E+12 | 0 | 5.18E+12 | 5.76E+11 |
| 10 | 887 | 2.34E+12 | 0 | 2.11E+12 | 2.34E+11 |
| 15 | 514 | 1.36E+12 | 0 | 1.22E+12 | 1.36E+11 |
| 20 | 340 | 8.98E+11 | 0 | 8.09E+11 | 8.98E+10 |
| 25 | 245 | 6.47E+11 | 0 | 5.83E+11 | 6.47E+10 |
| 30 | 185 | 4.89E+11 | 0 | 4.40E+11 | 4.89E+10 |
| 35 | 143 | 3.78E+11 | 0 | 3.40E+11 | 3.78E+10 |
| 40 | 113 | 2.99E+11 | 0 | 2.69E+11 | 2.99E+10 |
| 45 | 94 | 2.48E+11 | 0 | 2.24E+11 | 2.48E+10 |
| 50 | 75 | 1.98E+11 | 0 | 1.78E+11 | 1.98E+10 |
| 55 | 62 | 1.64E+11 | 0 | 1.47E+11 | 1.64E+10 |
| 60 | 50 | 1.32E+11 | 0 | 1.19E+11 | 1.32E+10 |
| 65 | 40 | 1.06E+11 | 0 | 9.51E+10 | 1.06E+10 |
| 70 | 32 | 8.46E+10 | 0 | 7.61E+10 | 8.46E+09 |
| 75 | 23 | 6.08E+10 | 0 | 5.47E+10 | 6.08E+09 |
| 80 | 16 | 4.23E+10 | 0 | 3.80E+10 | 4.23E+09 |
| 85 | 9.8 | 2.59E+10 | 0 | 2.33E+10 | 2.59E+09 |
| 90 | 4.9 | 1.29E+10 | 0 | 1.17E+10 | 1.29E+09 |
| 95 | 0.30 | 7.93E+08 | 0 | 7.13E+08 | 7.93E+07 |
| 100 | 0 | 0 | 0 | 0 | 0 |

**Table 5-5 Fecal Coliform TMDL Calculations for Stinking Creek (OK311500010050_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA_WWTP (cfu/day) | WLA_MS4 (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|---|
| 0 | 3,319 | 3.25E+13 | 1.51E+10 | 1.97E+12 | 2.72E+13 | 3.25E+12 |
| 5 | 29 | 2.85E+11 | 1.51E+10 | 1.63E+10 | 2.25E+11 | 2.85E+10 |
| 10 | 15 | 1.43E+11 | 1.51E+10 | 7.65E+09 | 1.06E+11 | 1.43E+10 |
| 15 | 11 | 1.11E+11 | 1.51E+10 | 5.71E+09 | 7.88E+10 | 1.11E+10 |
| 20 | 9.7 | 9.48E+10 | 1.51E+10 | 4.74E+09 | 6.54E+10 | 9.48E+09 |
| 25 | 8.5 | 8.29E+10 | 1.51E+10 | 4.02E+09 | 5.54E+10 | 8.29E+09 |
| 30 | 7.2 | 7.09E+10 | 1.51E+10 | 3.29E+09 | 4.54E+10 | 7.09E+09 |
| 35 | 6.4 | 6.29E+10 | 1.51E+10 | 2.81E+09 | 3.87E+10 | 6.29E+09 |
| 40 | 5.6 | 5.50E+10 | 1.51E+10 | 2.32E+09 | 3.20E+10 | 5.50E+09 |
| 45 | 5.2 | 5.10E+10 | 1.51E+10 | 2.08E+09 | 2.87E+10 | 5.10E+09 |
| 50 | 4.8 | 4.70E+10 | 1.51E+10 | 1.84E+09 | 2.53E+10 | 4.70E+09 |
| 55 | 4.4 | 4.30E+10 | 1.51E+10 | 1.59E+09 | 2.20E+10 | 4.30E+09 |
| 60 | 3.9 | 3.86E+10 | 1.51E+10 | 1.33E+09 | 1.83E+10 | 3.86E+09 |
| 65 | 3.6 | 3.51E+10 | 1.51E+10 | 1.11E+09 | 1.53E+10 | 3.51E+09 |
| 70 | 3.3 | 3.19E+10 | 1.51E+10 | 9.15E+08 | 1.26E+10 | 3.19E+09 |
| 75 | 2.9 | 2.83E+10 | 1.51E+10 | 6.97E+08 | 9.62E+09 | 2.83E+09 |
| 80 | 2.6 | 2.59E+10 | 1.51E+10 | 5.52E+08 | 7.61E+09 | 2.59E+09 |
| 85 | 2.3 | 2.27E+10 | 1.51E+10 | 3.58E+08 | 4.94E+09 | 2.27E+09 |
| 90 | 2.0 | 1.99E+10 | 1.51E+10 | 1.88E+08 | 2.60E+09 | 1.99E+09 |
| 95 | 1.7 | 1.68E+10 | 1.51E+10 | 0 | 0 | 1.68E+09 |
| 100 | 0 | 1.68E+10 | 1.51E+10 | 0 | 0 | 1.68E+09 |

**Table 5-6 Fecal Coliform TMDL Calculations for Tepee Creek (OK311500010110_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 1,061 | 1.04E+13 | 0 | 9.34E+12 | 1.04E+12 |
| 5 | 20 | 1.96E+11 | 0 | 1.76E+11 | 1.96E+10 |
| 10 | 8.7 | 8.52E+10 | 0 | 7.66E+10 | 8.52E+09 |
| 15 | 4.9 | 4.78E+10 | 0 | 4.30E+10 | 4.78E+09 |
| 20 | 3.2 | 3.17E+10 | 0 | 2.85E+10 | 3.17E+09 |
| 25 | 2.3 | 2.25E+10 | 0 | 2.03E+10 | 2.25E+09 |
| 30 | 1.6 | 1.61E+10 | 0 | 1.45E+10 | 1.61E+09 |
| 35 | 1.2 | 1.19E+10 | 0 | 1.07E+10 | 1.19E+09 |
| 40 | 0.8 | 8.27E+09 | 0 | 7.44E+09 | 8.27E+08 |
| 45 | 0.5 | 5.05E+09 | 0 | 4.55E+09 | 5.05E+08 |
| 50 | 0.32 | 3.12E+09 | 0 | 2.81E+09 | 3.12E+08 |
| 55 | 0.16 | 1.56E+09 | 0 | 1.41E+09 | 1.56E+08 |
| 60 | 0.07 | 6.89E+08 | 0 | 6.20E+08 | 6.89E+07 |
| 65 | 0.01 | 1.38E+08 | 0 | 1.24E+08 | 1.38E+07 |
| 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 5-7 Fecal Coliform TMDL Calculations for West Otter Creek (OK311500020040_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 1238 | 1.21E+13 | 0 | 1.09E+13 | 1.21E+12 |
| 5 | 40 | 3.91E+11 | 0 | 3.52E+11 | 3.91E+10 |
| 10 | 8.5 | 8.33E+10 | 0 | 7.50E+10 | 8.33E+09 |
| 15 | 5.0 | 4.85E+10 | 0 | 4.36E+10 | 4.85E+09 |
| 20 | 3.4 | 3.30E+10 | 0 | 2.97E+10 | 3.30E+09 |
| 25 | 2.8 | 2.70E+10 | 0 | 2.43E+10 | 2.70E+09 |
| 30 | 2.4 | 2.32E+10 | 0 | 2.09E+10 | 2.32E+09 |
| 35 | 2.0 | 1.98E+10 | 0 | 1.78E+10 | 1.98E+09 |
| 40 | 1.6 | 1.59E+10 | 0 | 1.43E+10 | 1.59E+09 |
| 45 | 1.0 | 9.76E+09 | 0 | 8.79E+09 | 9.76E+08 |
| 50 | 0.63 | 6.17E+09 | 0 | 5.55E+09 | 6.17E+08 |
| 55 | 0.36 | 3.52E+09 | 0 | 3.17E+09 | 3.52E+08 |
| 60 | 0.15 | 1.52E+09 | 0 | 1.36E+09 | 1.52E+08 |
| 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 5-8 Enterococci TMDL Calculations for Elk Creek (OK311500030010_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 15,200 | 4.02E+13 | 0 | 3.61E+13 | 4.02E+12 |
| 5 | 543 | 1.43E+12 | 0 | 1.29E+12 | 1.43E+11 |
| 10 | 194 | 5.13E+11 | 0 | 4.61E+11 | 5.13E+10 |
| 15 | 111 | 2.93E+11 | 0 | 2.64E+11 | 2.93E+10 |
| 20 | 71 | 1.88E+11 | 0 | 1.69E+11 | 1.88E+10 |
| 25 | 52 | 1.37E+11 | 0 | 1.24E+11 | 1.37E+10 |
| 30 | 40 | 1.06E+11 | 0 | 9.51E+10 | 1.06E+10 |
| 35 | 33 | 8.72E+10 | 0 | 7.85E+10 | 8.72E+09 |
| 40 | 26 | 6.87E+10 | 0 | 6.18E+10 | 6.87E+09 |
| 45 | 21 | 5.55E+10 | 0 | 4.99E+10 | 5.55E+09 |
| 50 | 17 | 4.49E+10 | 0 | 4.04E+10 | 4.49E+09 |
| 55 | 13 | 3.43E+10 | 0 | 3.09E+10 | 3.43E+09 |
| 60 | 10 | 2.64E+10 | 0 | 2.38E+10 | 2.64E+09 |
| 65 | 8.0 | 2.11E+10 | 0 | 1.90E+10 | 2.11E+09 |
| 70 | 5.8 | 1.53E+10 | 0 | 1.38E+10 | 1.53E+09 |
| 75 | 3.7 | 9.78E+09 | 0 | 8.80E+09 | 9.78E+08 |
| 80 | 2.4 | 6.34E+09 | 0 | 5.71E+09 | 6.34E+08 |
| 85 | 1.2 | 3.17E+09 | 0 | 2.85E+09 | 3.17E+08 |
| 90 | 0.30 | 7.93E+08 | 0 | 7.13E+08 | 7.93E+07 |
| 95 | 0 | 0 | 0 | 0 | 0 |
| 100 | 0 | 0 | 0 | 0 | 0 |

**Table 5-9 Fecal Coliform TMDL Calculations for Little Elk Creek (OK311500030040_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 825 | 8.08E+12 | 0 | 7.27E+12 | 8.08E+11 |
| 5 | 16 | 1.54E+11 | 0 | 1.38E+11 | 1.54E+10 |
| 10 | 6.8 | 6.65E+10 | 0 | 5.98E+10 | 6.65E+09 |
| 15 | 3.8 | 3.74E+10 | 0 | 3.36E+10 | 3.74E+09 |
| 20 | 2.5 | 2.47E+10 | 0 | 2.22E+10 | 2.47E+09 |
| 25 | 1.8 | 1.75E+10 | 0 | 1.58E+10 | 1.75E+09 |
| 30 | 1.3 | 1.25E+10 | 0 | 1.13E+10 | 1.25E+09 |
| 35 | 0.95 | 9.29E+09 | 0 | 8.36E+09 | 9.29E+08 |
| 40 | 0.66 | 6.43E+09 | 0 | 5.79E+09 | 6.43E+08 |
| 45 | 0.40 | 3.93E+09 | 0 | 3.54E+09 | 3.93E+08 |
| 50 | 0.25 | 2.43E+09 | 0 | 2.19E+09 | 2.43E+08 |
| 55 | 0.12 | 1.22E+09 | 0 | 1.09E+09 | 1.22E+08 |
| 60 | 0.05 | 5.36E+08 | 0 | 4.82E+08 | 5.36E+07 |
| 65 | 0.01 | 1.07E+08 | 0 | 9.65E+07 | 1.07E+07 |
| 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 5-10 Enterococci TMDL Calculations for North Fork Red River at SH 34 (OK311510010010_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 17,300 | 4.57E+13 | 0 | 4.11E+13 | 4.57E+12 |
| 5 | 510 | 1.35E+12 | 0 | 1.21E+12 | 1.35E+11 |
| 10 | 305 | 8.06E+11 | 0 | 7.25E+11 | 8.06E+10 |
| 15 | 229 | 6.05E+11 | 0 | 5.45E+11 | 6.05E+10 |
| 20 | 167 | 4.41E+11 | 0 | 3.97E+11 | 4.41E+10 |
| 25 | 127 | 3.36E+11 | 0 | 3.02E+11 | 3.36E+10 |
| 30 | 98 | 2.59E+11 | 0 | 2.33E+11 | 2.59E+10 |
| 35 | 81 | 2.14E+11 | 0 | 1.93E+11 | 2.14E+10 |
| 40 | 65 | 1.71E+11 | 0 | 1.54E+11 | 1.71E+10 |
| 45 | 53 | 1.40E+11 | 0 | 1.26E+11 | 1.40E+10 |
| 50 | 43 | 1.14E+11 | 0 | 1.02E+11 | 1.14E+10 |
| 55 | 33 | 8.72E+10 | 0 | 7.85E+10 | 8.72E+09 |
| 60 | 26 | 6.87E+10 | 0 | 6.18E+10 | 6.87E+09 |
| 65 | 18 | 4.76E+10 | 0 | 4.28E+10 | 4.76E+09 |
| 70 | 11 | 2.91E+10 | 0 | 2.62E+10 | 2.91E+09 |
| 75 | 6.1 | 1.61E+10 | 0 | 1.45E+10 | 1.61E+09 |
| 80 | 3.5 | 9.25E+09 | 0 | 8.32E+09 | 9.25E+08 |
| 85 | 1.5 | 3.96E+09 | 0 | 3.57E+09 | 3.96E+08 |
| 90 | 0 | 0 | 0 | 0 | 0 |
| 95 | 0 | 0 | 0 | 0 | 0 |
| 100 | 0 | 0 | 0 | 0 | 0 |

**Table 5-11 Fecal Coliform TMDL Calculations for Turkey Creek (OK311510020060_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 1,952 | 1.91E+13 | 0 | 1.72E+13 | 1.91E+12 |
| 5 | 20 | 1.96E+11 | 0 | 1.76E+11 | 1.96E+10 |
| 10 | 9.9 | 9.72E+10 | 0 | 8.75E+10 | 9.72E+09 |
| 15 | 6.4 | 6.25E+10 | 0 | 5.63E+10 | 6.25E+09 |
| 20 | 4.6 | 4.47E+10 | 0 | 4.02E+10 | 4.47E+09 |
| 25 | 3.5 | 3.46E+10 | 0 | 3.12E+10 | 3.46E+09 |
| 30 | 3.0 | 2.90E+10 | 0 | 2.61E+10 | 2.90E+09 |
| 35 | 2.4 | 2.35E+10 | 0 | 2.11E+10 | 2.35E+09 |
| 40 | 2.1 | 2.01E+10 | 0 | 1.81E+10 | 2.01E+09 |
| 45 | 1.7 | 1.68E+10 | 0 | 1.51E+10 | 1.68E+09 |
| 50 | 1.5 | 1.45E+10 | 0 | 1.31E+10 | 1.45E+09 |
| 55 | 1.4 | 1.34E+10 | 0 | 1.21E+10 | 1.34E+09 |
| 60 | 1.1 | 1.12E+10 | 0 | 1.01E+10 | 1.12E+09 |
| 65 | 1.0 | 1.01E+10 | 0 | 9.05E+09 | 1.01E+09 |
| 70 | 0.87 | 8.49E+09 | 0 | 7.64E+09 | 8.49E+08 |
| 75 | 0.72 | 7.04E+09 | 0 | 6.33E+09 | 7.04E+08 |
| 80 | 0.54 | 5.25E+09 | 0 | 4.72E+09 | 5.25E+08 |
| 85 | 0.35 | 3.46E+09 | 0 | 3.12E+09 | 3.46E+08 |
| 90 | 0.19 | 1.90E+09 | 0 | 1.71E+09 | 1.90E+08 |
| 95 | 0.06 | 6.12E+08 | 0 | 5.50E+08 | 6.12E+07 |
| 100 | 0.002 | 2.23E+07 | 0 | 2.01E+07 | 2.23E+06 |

**Table 5-12 Enterococci TMDL Calculations for Sandy Creek (OK311600010040_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 3,080 | 4.07E+13 | 0 | 3.66E+13 | 4.07E+12 |
| 5 | 29 | 3.78E+11 | 0 | 3.40E+11 | 3.78E+10 |
| 10 | 10 | 1.32E+11 | 0 | 1.19E+11 | 1.32E+10 |
| 15 | 9.3 | 1.23E+11 | 0 | 1.11E+11 | 1.23E+10 |
| 20 | 8.9 | 1.18E+11 | 0 | 1.06E+11 | 1.18E+10 |
| 25 | 7.4 | 9.78E+10 | 0 | 8.80E+10 | 9.78E+09 |
| 30 | 6.6 | 8.72E+10 | 0 | 7.85E+10 | 8.72E+09 |
| 35 | 6.1 | 8.06E+10 | 0 | 7.25E+10 | 8.06E+09 |
| 40 | 6.0 | 7.93E+10 | 0 | 7.13E+10 | 7.93E+09 |
| 45 | 5.5 | 7.32E+10 | 0 | 6.59E+10 | 7.32E+09 |
| 50 | 5.2 | 6.87E+10 | 0 | 6.18E+10 | 6.87E+09 |
| 55 | 4.8 | 6.34E+10 | 0 | 5.71E+10 | 6.34E+09 |
| 60 | 4.3 | 5.68E+10 | 0 | 5.11E+10 | 5.68E+09 |
| 65 | 4.2 | 5.55E+10 | 0 | 4.99E+10 | 5.55E+09 |
| 70 | 3.6 | 4.76E+10 | 0 | 4.28E+10 | 4.76E+09 |
| 75 | 3.4 | 4.49E+10 | 0 | 4.04E+10 | 4.49E+09 |
| 80 | 3.0 | 3.96E+10 | 0 | 3.57E+10 | 3.96E+09 |
| 85 | 2.4 | 3.17E+10 | 0 | 2.85E+10 | 3.17E+09 |
| 90 | 1.9 | 2.51E+10 | 0 | 2.26E+10 | 2.51E+09 |
| 95 | 1.3 | 1.72E+10 | 0 | 1.55E+10 | 1.72E+09 |
| 100 | 0.5 | 6.61E+09 | 0 | 5.95E+09 | 6.61E+08 |

**Table 5-13 Enterococci TMDL Calculations for Salt Fork Red River at US 283 Creek (OK311600020010_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 28,200 | 7.45E+13 | 0 | 6.71E+13 | 7.45E+12 |
| 5 | 1,210 | 3.20E+12 | 0 | 2.88E+12 | 3.20E+11 |
| 10 | 547 | 1.45E+12 | 0 | 1.30E+12 | 1.45E+11 |
| 15 | 356 | 9.41E+11 | 0 | 8.47E+11 | 9.41E+10 |
| 20 | 243 | 6.42E+11 | 0 | 5.78E+11 | 6.42E+10 |
| 25 | 186 | 4.91E+11 | 0 | 4.42E+11 | 4.91E+10 |
| 30 | 148 | 3.91E+11 | 0 | 3.52E+11 | 3.91E+10 |
| 35 | 122 | 3.22E+11 | 0 | 2.90E+11 | 3.22E+10 |
| 40 | 103 | 2.72E+11 | 0 | 2.45E+11 | 2.72E+10 |
| 45 | 93 | 2.46E+11 | 0 | 2.21E+11 | 2.46E+10 |
| 50 | 83 | 2.19E+11 | 0 | 1.97E+11 | 2.19E+10 |
| 55 | 74 | 1.96E+11 | 0 | 1.76E+11 | 1.96E+10 |
| 60 | 64 | 1.69E+11 | 0 | 1.52E+11 | 1.69E+10 |
| 65 | 55 | 1.47E+11 | 0 | 1.32E+11 | 1.47E+10 |
| 70 | 47 | 1.24E+11 | 0 | 1.12E+11 | 1.24E+10 |
| 75 | 37 | 9.78E+10 | 0 | 8.80E+10 | 9.78E+09 |
| 80 | 27 | 7.13E+10 | 0 | 6.42E+10 | 7.13E+09 |
| 85 | 19 | 5.02E+10 | 0 | 4.52E+10 | 5.02E+09 |
| 90 | 12 | 3.17E+10 | 0 | 2.85E+10 | 3.17E+09 |
| 95 | 7.0 | 1.85E+10 | 0 | 1.66E+10 | 1.85E+09 |
| 100 | 0.08 | 2.11E+08 | 0 | 1.90E+08 | 2.11E+07 |

**Table 5-14 Enterococci TMDL Calculations for Salt Fork Red River at SH 34 (OK311600020010_10)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 22,600 | 5.97E+13 | 3.75E+08 | 5.37E+13 | 5.97E+12 |
| 5 | 427 | 1.13E+12 | 3.75E+08 | 1.01E+12 | 1.13E+11 |
| 10 | 186 | 4.91E+11 | 3.75E+08 | 4.42E+11 | 4.91E+10 |
| 15 | 105 | 2.77E+11 | 3.75E+08 | 2.49E+11 | 2.77E+10 |
| 20 | 69 | 1.82E+11 | 3.75E+08 | 1.64E+11 | 1.82E+10 |
| 25 | 49 | 1.29E+11 | 3.75E+08 | 1.16E+11 | 1.29E+10 |
| 30 | 35 | 9.25E+10 | 3.75E+08 | 8.29E+10 | 9.25E+09 |
| 35 | 26 | 6.87E+10 | 3.75E+08 | 6.15E+10 | 6.87E+09 |
| 40 | 18 | 4.76E+10 | 3.75E+08 | 4.24E+10 | 4.76E+09 |
| 45 | 11 | 2.91E+10 | 3.75E+08 | 2.58E+10 | 2.91E+09 |
| 50 | 6.8 | 1.80E+10 | 3.75E+08 | 1.58E+10 | 1.80E+09 |
| 55 | 3.4 | 8.98E+09 | 3.75E+08 | 7.71E+09 | 8.98E+08 |
| 60 | 1.5 | 3.96E+09 | 3.75E+08 | 3.19E+09 | 3.96E+08 |
| 65 | 0.30 | 7.93E+08 | 3.75E+08 | 3.39E+08 | 7.93E+07 |
| 70 | 0 | 4.16E+08 | 3.75E+08 | 0.00E+00 | 4.16E+07 |
| 75 | 0 | 4.16E+08 | 3.75E+08 | 0.00E+00 | 4.16E+07 |
| 80 | 0 | 4.16E+08 | 3.75E+08 | 0.00E+00 | 4.16E+07 |
| 85 | 0 | 4.16E+08 | 3.75E+08 | 0.00E+00 | 4.16E+07 |
| 90 | 0 | 4.16E+08 | 3.75E+08 | 0.00E+00 | 4.16E+07 |
| 95 | 0 | 4.16E+08 | 3.75E+08 | 0.00E+00 | 4.16E+07 |
| 100 | 0 | 4.16E+08 | 3.75E+08 | 0.00E+00 | 4.16E+07 |

**Table 5-15 Enterococci TMDL Calculations for Bitter Creek (OK311600020110_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 7,570 | 1.00E+14 | 0 | 9.00E+13 | 1.00E+13 |
| 5 | 169 | 2.23E+12 | 0 | 2.01E+12 | 2.23E+11 |
| 10 | 79 | 1.04E+12 | 0 | 9.34E+11 | 1.04E+11 |
| 15 | 51 | 6.72E+11 | 0 | 6.04E+11 | 6.72E+10 |
| 20 | 37 | 4.84E+11 | 0 | 4.36E+11 | 4.84E+10 |
| 25 | 29 | 3.88E+11 | 0 | 3.49E+11 | 3.88E+10 |
| 30 | 24 | 3.18E+11 | 0 | 2.87E+11 | 3.18E+10 |
| 35 | 20 | 2.70E+11 | 0 | 2.43E+11 | 2.70E+10 |
| 40 | 17 | 2.27E+11 | 0 | 2.04E+11 | 2.27E+10 |
| 45 | 15 | 1.93E+11 | 0 | 1.74E+11 | 1.93E+10 |
| 50 | 12 | 1.64E+11 | 0 | 1.47E+11 | 1.64E+10 |
| 55 | 10 | 1.35E+11 | 0 | 1.22E+11 | 1.35E+10 |
| 60 | 8.3 | 1.09E+11 | 0 | 9.81E+10 | 1.09E+10 |
| 65 | 6.9 | 9.16E+10 | 0 | 8.24E+10 | 9.16E+09 |
| 70 | 5.6 | 7.41E+10 | 0 | 6.67E+10 | 7.41E+09 |
| 75 | 4.3 | 5.71E+10 | 0 | 5.14E+10 | 5.71E+09 |
| 80 | 3.3 | 4.36E+10 | 0 | 3.93E+10 | 4.36E+09 |
| 85 | 2.4 | 3.23E+10 | 0 | 2.90E+10 | 3.23E+09 |
| 90 | 1.3 | 1.74E+10 | 0 | 1.57E+10 | 1.74E+09 |
| 95 | 0 | 0 | 0 | 0 | 0 |
| 100 | 0 | 0 | 0 | 0 | 0 |

**Table 5-16 Enterococci TMDL Calculations for Cave Creek (OK311600020140_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 354 | 9.34E+11 | 0 | 8.41E+11 | 9.34E+10 |
| 5 | 6.7 | 1.76E+10 | 0 | 1.59E+10 | 1.76E+09 |
| 10 | 2.9 | 7.66E+09 | 0 | 6.90E+09 | 7.66E+08 |
| 15 | 1.6 | 4.32E+09 | 0 | 3.89E+09 | 4.32E+08 |
| 20 | 1.1 | 2.85E+09 | 0 | 2.57E+09 | 2.85E+08 |
| 25 | 0.77 | 2.03E+09 | 0 | 1.82E+09 | 2.03E+08 |
| 30 | 0.55 | 1.45E+09 | 0 | 1.30E+09 | 1.45E+08 |
| 35 | 0.41 | 1.07E+09 | 0 | 9.67E+08 | 1.07E+08 |
| 40 | 0.28 | 7.44E+08 | 0 | 6.70E+08 | 7.44E+07 |
| 45 | 0.17 | 4.55E+08 | 0 | 4.09E+08 | 4.55E+07 |
| 50 | 0.11 | 2.81E+08 | 0 | 2.53E+08 | 2.81E+07 |
| 55 | 0.05 | 1.45E+08 | 0 | 1.30E+08 | 1.45E+07 |
| 60 | 0.02 | 6.20E+07 | 0 | 5.58E+07 | 6.20E+06 |
| 65 | 0.005 | 1.24E+07 | 0 | 1.12E+07 | 1.24E+06 |
| 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 5-17 Enterococci TMDL Calculations for Elm Fork Red River (OK311800000010_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 15,700 | 4.15E+13 | 0 | 3.73E+13 | 4.15E+12 |
| 5 | 601 | 1.59E+12 | 0 | 1.43E+12 | 1.59E+11 |
| 10 | 240 | 6.35E+11 | 0 | 5.72E+11 | 6.35E+10 |
| 15 | 143 | 3.78E+11 | 0 | 3.40E+11 | 3.78E+10 |
| 20 | 98 | 2.60E+11 | 0 | 2.34E+11 | 2.60E+10 |
| 25 | 70 | 1.85E+11 | 0 | 1.66E+11 | 1.85E+10 |
| 30 | 54 | 1.43E+11 | 0 | 1.28E+11 | 1.43E+10 |
| 35 | 44 | 1.16E+11 | 0 | 1.05E+11 | 1.16E+10 |
| 40 | 36 | 9.51E+10 | 0 | 8.56E+10 | 9.51E+09 |
| 45 | 29 | 7.66E+10 | 0 | 6.90E+10 | 7.66E+09 |
| 50 | 24 | 6.34E+10 | 0 | 5.71E+10 | 6.34E+09 |
| 55 | 19 | 5.02E+10 | 0 | 4.52E+10 | 5.02E+09 |
| 60 | 15 | 3.96E+10 | 0 | 3.57E+10 | 3.96E+09 |
| 65 | 12 | 3.17E+10 | 0 | 2.85E+10 | 3.17E+09 |
| 70 | 9.0 | 2.38E+10 | 0 | 2.14E+10 | 2.38E+09 |
| 75 | 6.8 | 1.80E+10 | 0 | 1.62E+10 | 1.80E+09 |
| 80 | 4.5 | 1.19E+10 | 0 | 1.07E+10 | 1.19E+09 |
| 85 | 2.8 | 7.40E+09 | 0 | 6.66E+09 | 7.40E+08 |
| 90 | 1.5 | 3.96E+09 | 0 | 3.57E+09 | 3.96E+08 |
| 95 | 0.30 | 7.93E+08 | 0 | 7.13E+08 | 7.93E+07 |
| 100 | 0 | 0 | 0 | 0 | 0 |

**Table 5-18 Fecal Coliform TMDL Calculations for Deer Creek (OK311800000070_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 82 | 8.05E+11 | 0 | 7.25E+11 | 8.05E+10 |
| 5 | 7.4 | 7.25E+10 | 0 | 6.53E+10 | 7.25E+09 |
| 10 | 4.8 | 4.69E+10 | 0 | 4.22E+10 | 4.69E+09 |
| 15 | 3.6 | 3.52E+10 | 0 | 3.17E+10 | 3.52E+09 |
| 20 | 2.8 | 2.77E+10 | 0 | 2.50E+10 | 2.77E+09 |
| 25 | 2.4 | 2.35E+10 | 0 | 2.11E+10 | 2.35E+09 |
| 30 | 2.1 | 2.03E+10 | 0 | 1.82E+10 | 2.03E+09 |
| 35 | 1.9 | 1.81E+10 | 0 | 1.63E+10 | 1.81E+09 |
| 40 | 1.5 | 1.49E+10 | 0 | 1.34E+10 | 1.49E+09 |
| 45 | 1.3 | 1.28E+10 | 0 | 1.15E+10 | 1.28E+09 |
| 50 | 1.2 | 1.17E+10 | 0 | 1.06E+10 | 1.17E+09 |
| 55 | 1.0 | 9.49E+09 | 0 | 8.54E+09 | 9.49E+08 |
| 60 | 0.7 | 6.93E+09 | 0 | 6.24E+09 | 6.93E+08 |
| 65 | 0.5 | 4.91E+09 | 0 | 4.41E+09 | 4.91E+08 |
| 70 | 0.4 | 3.48E+09 | 0 | 3.13E+09 | 3.48E+08 |
| 75 | 0.26 | 2.56E+09 | 0 | 2.30E+09 | 2.56E+08 |
| 80 | 0.17 | 1.71E+09 | 0 | 1.54E+09 | 1.71E+08 |
| 85 | 0.11 | 1.04E+09 | 0 | 9.39E+08 | 1.04E+08 |
| 90 | 0.07 | 7.14E+08 | 0 | 6.43E+08 | 7.14E+07 |
| 95 | 0.04 | 3.90E+08 | 0 | 3.51E+08 | 3.90E+07 |
| 100 | 0 | 0 | 0 | 0 | 0 |

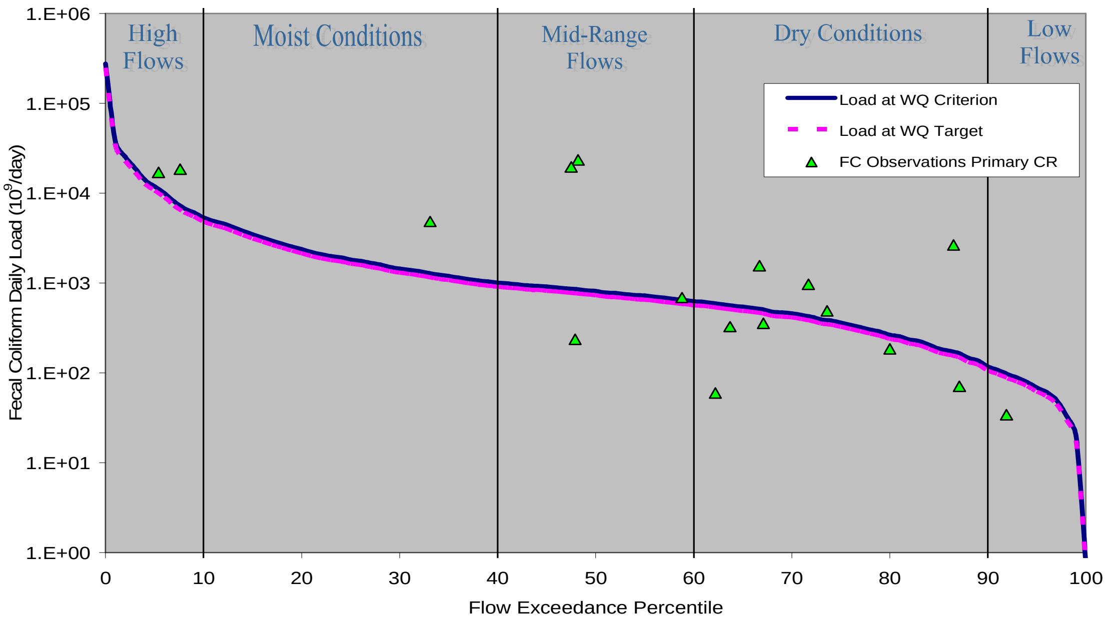
**Table 5-19 Fecal Coliform TMDL Calculations for Fish Creek (OK311800000130_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 58 | 5.65E+11 | 0 | 5.08E+11 | 5.65E+10 |
| 5 | 5.2 | 5.09E+10 | 0 | 4.58E+10 | 5.09E+09 |
| 10 | 3.4 | 3.29E+10 | 0 | 2.96E+10 | 3.29E+09 |
| 15 | 2.5 | 2.47E+10 | 0 | 2.22E+10 | 2.47E+09 |
| 20 | 2.0 | 1.95E+10 | 0 | 1.75E+10 | 1.95E+09 |
| 25 | 1.7 | 1.65E+10 | 0 | 1.48E+10 | 1.65E+09 |
| 30 | 1.5 | 1.42E+10 | 0 | 1.28E+10 | 1.42E+09 |
| 35 | 1.3 | 1.27E+10 | 0 | 1.14E+10 | 1.27E+09 |
| 40 | 1.1 | 1.05E+10 | 0 | 9.43E+09 | 1.05E+09 |
| 45 | 0.9 | 8.98E+09 | 0 | 8.08E+09 | 8.98E+08 |
| 50 | 0.8 | 8.23E+09 | 0 | 7.41E+09 | 8.23E+08 |
| 55 | 0.7 | 6.66E+09 | 0 | 5.99E+09 | 6.66E+08 |
| 60 | 0.5 | 4.86E+09 | 0 | 4.38E+09 | 4.86E+08 |
| 65 | 0.35 | 3.44E+09 | 0 | 3.10E+09 | 3.44E+08 |
| 70 | 0.24 | 2.39E+09 | 0 | 2.16E+09 | 2.39E+08 |
| 75 | 0.18 | 1.80E+09 | 0 | 1.62E+09 | 1.80E+08 |
| 80 | 0.12 | 1.20E+09 | 0 | 1.08E+09 | 1.20E+08 |
| 85 | 0.07 | 7.26E+08 | 0 | 6.53E+08 | 7.26E+07 |
| 90 | 0.05 | 5.01E+08 | 0 | 4.51E+08 | 5.01E+07 |
| 95 | 0.03 | 2.54E+08 | 0 | 2.29E+08 | 2.54E+07 |
| 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 5-17 through 5-22 and Tables 5-20 through 5-25, respectively.

**Figure 5-17 Load Duration Curve for Fecal Coliform in Salk Fork Red River at US 283 (OK311600020010_00)**

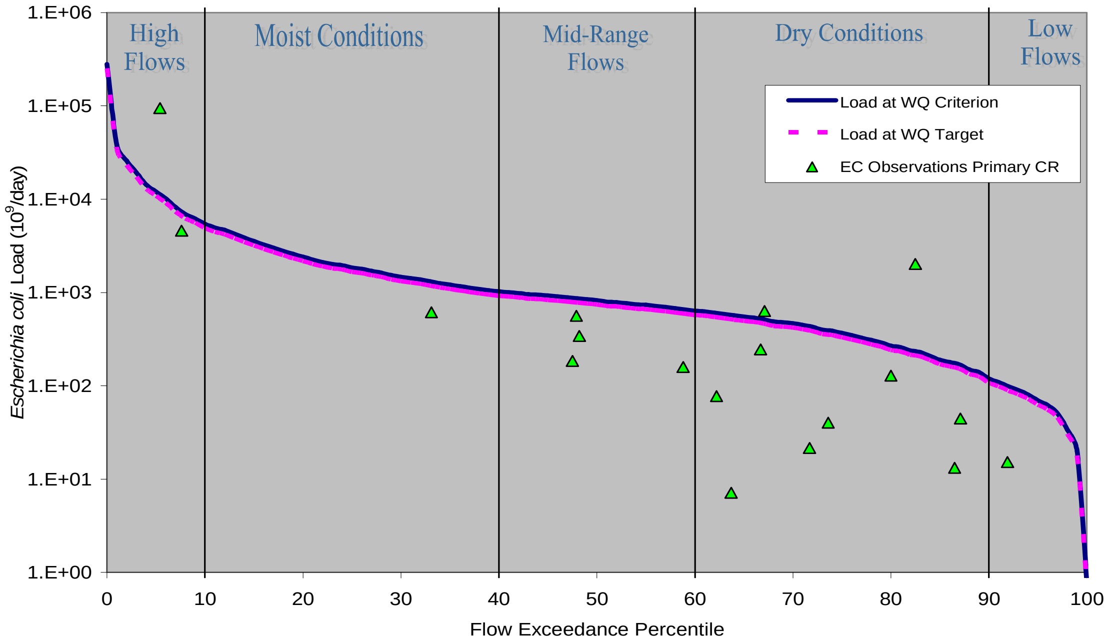



Note: There is no wasteload allocation for this waterbody.

**Table 5-20 Fecal Coliform TMDL Calculations for Salk Fork Red River at US 283 (OK311600020010_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 28,200 | 2.76E+14 | 0 | 2.48E+14 | 2.76E+13 |
| 5 | 1,210 | 1.18E+13 | 0 | 1.07E+13 | 1.18E+12 |
| 10 | 547 | 5.35E+12 | 0 | 4.82E+12 | 5.35E+11 |
| 15 | 356 | 3.48E+12 | 0 | 3.14E+12 | 3.48E+11 |
| 20 | 243 | 2.38E+12 | 0 | 2.14E+12 | 2.38E+11 |
| 25 | 186 | 1.82E+12 | 0 | 1.64E+12 | 1.82E+11 |
| 30 | 148 | 1.45E+12 | 0 | 1.30E+12 | 1.45E+11 |
| 35 | 122 | 1.19E+12 | 0 | 1.07E+12 | 1.19E+11 |
| 40 | 103 | 1.01E+12 | 0 | 9.07E+11 | 1.01E+11 |
| 45 | 93 | 9.10E+11 | 0 | 8.19E+11 | 9.10E+10 |
| 50 | 83 | 8.12E+11 | 0 | 7.31E+11 | 8.12E+10 |
| 55 | 74 | 7.24E+11 | 0 | 6.52E+11 | 7.24E+10 |
| 60 | 64 | 6.26E+11 | 0 | 5.64E+11 | 6.26E+10 |
| 65 | 55 | 5.43E+11 | 0 | 4.89E+11 | 5.43E+10 |
| 70 | 47 | 4.60E+11 | 0 | 4.14E+11 | 4.60E+10 |
| 75 | 37 | 3.62E+11 | 0 | 3.26E+11 | 3.62E+10 |
| 80 | 27 | 2.64E+11 | 0 | 2.38E+11 | 2.64E+10 |
| 85 | 19 | 1.86E+11 | 0 | 1.67E+11 | 1.86E+10 |
| 90 | 12 | 1.17E+11 | 0 | 1.06E+11 | 1.17E+10 |
| 95 | 7.0 | 6.85E+10 | 0 | 6.17E+10 | 6.85E+09 |
| 100 | 0.08 | 7.83E+08 | 0 | 7.05E+08 | 7.83E+07 |

**Figure 5-18 Load Duration Curve for *E. Coli* in Salt Fork Red River at US 283 (OK311600020010_00)**




Note: There is no wasteload allocation for this waterbody.

**Table 5-21 *E. Coli* TMDL Calculations for Salt Fork Red River at US 283 (OK311600020010_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 28,200 | 2.80E+14 | 0 | 2.52E+14 | 2.80E+13 |
| 5 | 1,210 | 1.20E+13 | 0 | 1.08E+13 | 1.20E+12 |
| 10 | 547 | 5.43E+12 | 0 | 4.89E+12 | 5.43E+11 |
| 15 | 356 | 3.54E+12 | 0 | 3.18E+12 | 3.54E+11 |
| 20 | 243 | 2.41E+12 | 0 | 2.17E+12 | 2.41E+11 |
| 25 | 186 | 1.85E+12 | 0 | 1.66E+12 | 1.85E+11 |
| 30 | 148 | 1.47E+12 | 0 | 1.32E+12 | 1.47E+11 |
| 35 | 122 | 1.21E+12 | 0 | 1.09E+12 | 1.21E+11 |
| 40 | 103 | 1.02E+12 | 0 | 9.21E+11 | 1.02E+11 |
| 45 | 93 | 9.24E+11 | 0 | 8.31E+11 | 9.24E+10 |
| 50 | 83 | 8.24E+11 | 0 | 7.42E+11 | 8.24E+10 |
| 55 | 74 | 7.35E+11 | 0 | 6.62E+11 | 7.35E+10 |
| 60 | 64 | 6.36E+11 | 0 | 5.72E+11 | 6.36E+10 |
| 65 | 55 | 5.51E+11 | 0 | 4.96E+11 | 5.51E+10 |
| 70 | 47 | 4.67E+11 | 0 | 4.20E+11 | 4.67E+10 |
| 75 | 37 | 3.68E+11 | 0 | 3.31E+11 | 3.68E+10 |
| 80 | 27 | 2.68E+11 | 0 | 2.41E+11 | 2.68E+10 |
| 85 | 19 | 1.89E+11 | 0 | 1.70E+11 | 1.89E+10 |
| 90 | 12 | 1.19E+11 | 0 | 1.07E+11 | 1.19E+10 |
| 95 | 7.0 | 6.95E+10 | 0 | 6.26E+10 | 6.95E+09 |
| 100 | 0.08 | 7.95E+08 | 0 | 7.15E+08 | 7.95E+07 |

**Figure 5-19 Load Duration Curve for Fecal Coliform in Salt Fork Red River at SH 34 (OK311600020010_10)**

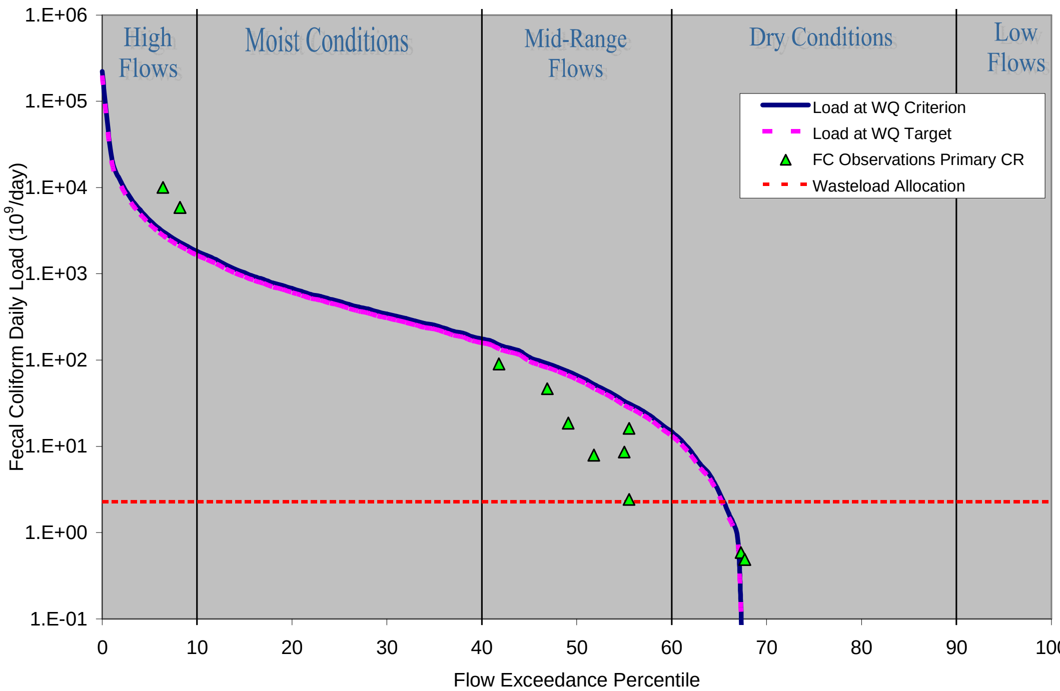
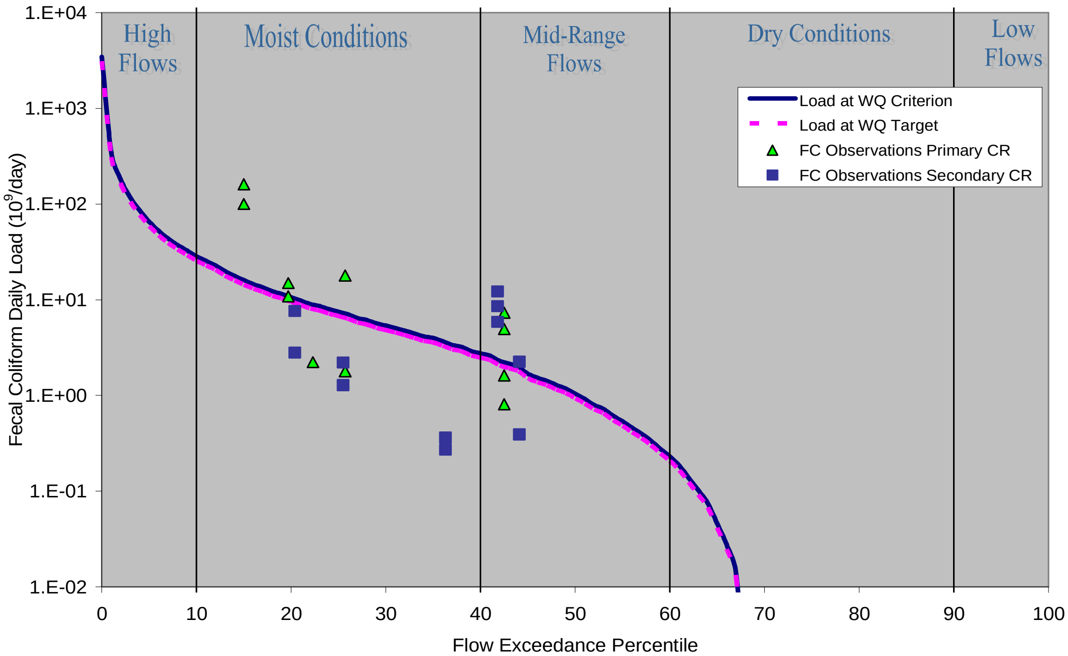



**Table 5-22 Fecal Coliform TMDL Calculations for Salt Fork Red River at SH 34 (OK311600020010_10)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 22,600 | 2.21E+14 | 2.27E+09 | 1.99E+14 | 2.21E+13 |
| 5 | 427 | 4.18E+12 | 2.27E+09 | 3.76E+12 | 4.18E+11 |
| 10 | 186 | 1.82E+12 | 2.27E+09 | 1.64E+12 | 1.82E+11 |
| 15 | 105 | 1.03E+12 | 2.27E+09 | 9.23E+11 | 1.03E+11 |
| 20 | 69 | 6.75E+11 | 2.27E+09 | 6.05E+11 | 6.75E+10 |
| 25 | 49 | 4.80E+11 | 2.27E+09 | 4.29E+11 | 4.80E+10 |
| 30 | 35 | 3.43E+11 | 2.27E+09 | 3.06E+11 | 3.43E+10 |
| 35 | 26 | 2.54E+11 | 2.27E+09 | 2.27E+11 | 2.54E+10 |
| 40 | 18 | 1.76E+11 | 2.27E+09 | 1.56E+11 | 1.76E+10 |
| 45 | 11 | 1.08E+11 | 2.27E+09 | 9.46E+10 | 1.08E+10 |
| 50 | 6.8 | 6.65E+10 | 2.27E+09 | 5.76E+10 | 6.65E+09 |
| 55 | 3.4 | 3.33E+10 | 2.27E+09 | 2.77E+10 | 3.33E+09 |
| 60 | 1.5 | 1.47E+10 | 2.27E+09 | 1.09E+10 | 1.47E+09 |
| 65 | 0.30 | 2.94E+09 | 2.27E+09 | 3.71E+08 | 2.94E+08 |
| 70 | 0 | 2.52E+09 | 2.27E+09 | 0 | 2.52E+08 |
| 75 | 0 | 2.52E+09 | 2.27E+09 | 0 | 2.52E+08 |
| 80 | 0 | 2.52E+09 | 2.27E+09 | 0 | 2.52E+08 |
| 85 | 0 | 2.52E+09 | 2.27E+09 | 0 | 2.52E+08 |
| 90 | 0 | 2.52E+09 | 2.27E+09 | 0 | 2.52E+08 |
| 95 | 0 | 2.52E+09 | 2.27E+09 | 0 | 2.52E+08 |
| 100 | 0 | 2.52E+09 | 2.27E+09 | 0 | 2.52E+08 |

**Figure 5-20 Load Duration Curve for Fecal Coliform in Cave Creek (OK311600020140_00)**

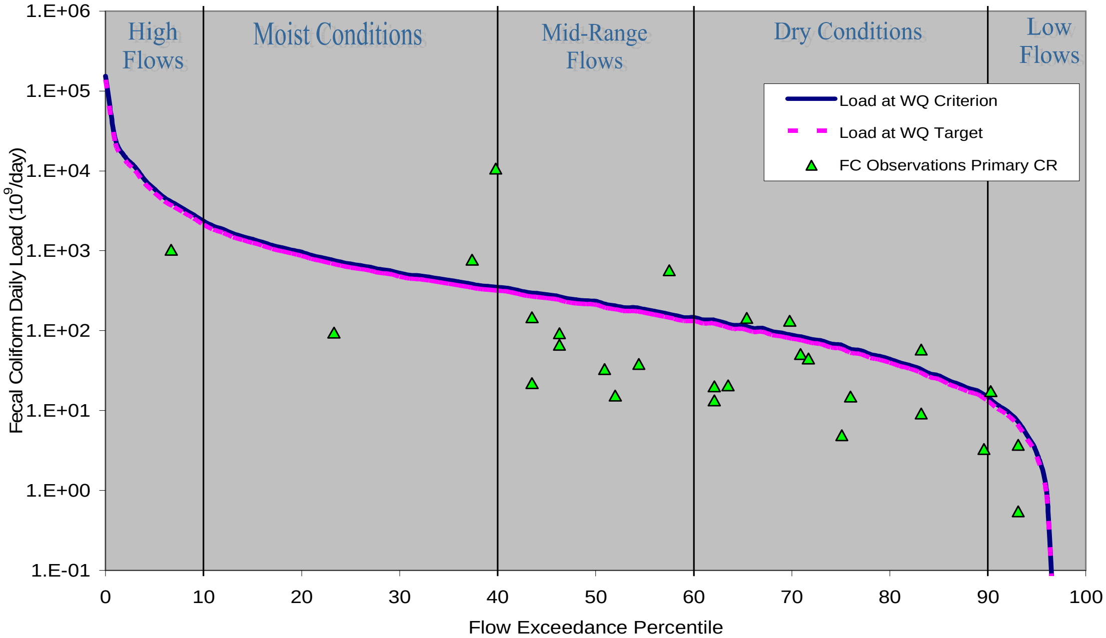



Note: There is no wasteload allocation for this waterbody.

**Table 5-23 Fecal Coliform TMDL Calculations for Cave Creek (OK311600020140_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 354 | 3.46E+12 | 0 | 3.11E+12 | 3.46E+11 |
| 5 | 6.7 | 6.53E+10 | 0 | 5.88E+10 | 6.53E+09 |
| 10 | 2.9 | 2.84E+10 | 0 | 2.55E+10 | 2.84E+09 |
| 15 | 1.6 | 1.60E+10 | 0 | 1.44E+10 | 1.60E+09 |
| 20 | 1.1 | 1.06E+10 | 0 | 9.51E+09 | 1.06E+09 |
| 25 | 0.77 | 7.50E+09 | 0 | 6.75E+09 | 7.50E+08 |
| 30 | 0.55 | 5.36E+09 | 0 | 4.82E+09 | 5.36E+08 |
| 35 | 0.41 | 3.98E+09 | 0 | 3.58E+09 | 3.98E+08 |
| 40 | 0.28 | 2.76E+09 | 0 | 2.48E+09 | 2.76E+08 |
| 45 | 0.17 | 1.68E+09 | 0 | 1.52E+09 | 1.68E+08 |
| 50 | 0.11 | 1.04E+09 | 0 | 9.37E+08 | 1.04E+08 |
| 55 | 0.05 | 5.36E+08 | 0 | 4.82E+08 | 5.36E+07 |
| 60 | 0.02 | 2.30E+08 | 0 | 2.07E+08 | 2.30E+07 |
| 65 | 0.005 | 4.59E+07 | 0 | 4.13E+07 | 4.59E+06 |
| 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 |

**Figure 5-21 Load Duration Curve for Fecal Coliform in Red River-Elm Fork (OK311800000010_00)**

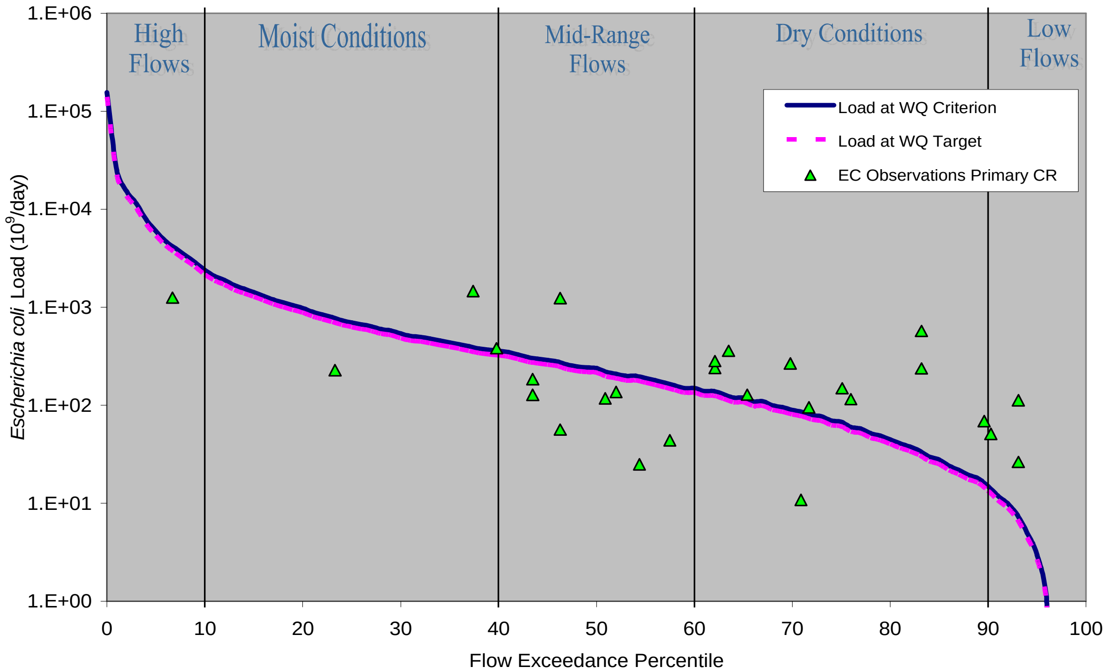



Note: There is no wasteload allocation for this waterbody.

**Table 5-24 Fecal Coliform TMDL Calculations for Red River-Elm Fork (OK311800000010_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 15,700 | 1.54E+14 | 0 | 1.38E+14 | 1.54E+13 |
| 5 | 601 | 5.88E+12 | 0 | 5.29E+12 | 5.88E+11 |
| 10 | 240 | 2.35E+12 | 0 | 2.12E+12 | 2.35E+11 |
| 15 | 143 | 1.40E+12 | 0 | 1.26E+12 | 1.40E+11 |
| 20 | 98 | 9.63E+11 | 0 | 8.67E+11 | 9.63E+10 |
| 25 | 70 | 6.85E+11 | 0 | 6.17E+11 | 6.85E+10 |
| 30 | 54 | 5.28E+11 | 0 | 4.76E+11 | 5.28E+10 |
| 35 | 44 | 4.31E+11 | 0 | 3.88E+11 | 4.31E+10 |
| 40 | 36 | 3.52E+11 | 0 | 3.17E+11 | 3.52E+10 |
| 45 | 29 | 2.84E+11 | 0 | 2.55E+11 | 2.84E+10 |
| 50 | 24 | 2.35E+11 | 0 | 2.11E+11 | 2.35E+10 |
| 55 | 19 | 1.86E+11 | 0 | 1.67E+11 | 1.86E+10 |
| 60 | 15 | 1.47E+11 | 0 | 1.32E+11 | 1.47E+10 |
| 65 | 12 | 1.17E+11 | 0 | 1.06E+11 | 1.17E+10 |
| 70 | 9.0 | 8.81E+10 | 0 | 7.93E+10 | 8.81E+09 |
| 75 | 6.8 | 6.65E+10 | 0 | 5.99E+10 | 6.65E+09 |
| 80 | 4.5 | 4.40E+10 | 0 | 3.96E+10 | 4.40E+09 |
| 85 | 2.8 | 2.74E+10 | 0 | 2.47E+10 | 2.74E+09 |
| 90 | 1.5 | 1.47E+10 | 0 | 1.32E+10 | 1.47E+09 |
| 95 | 0.30 | 2.94E+09 | 0 | 2.64E+09 | 2.94E+08 |
| 100 | 0 | 0 | 0 | 0 | 0 |

**Figure 5-22 Load Duration Curve for *E. Coli* in Red River-Elm Fork (OK311800000010_00)**




Note: There is no wasteload allocation for this waterbody.

**Table 5-25 *E. Coli* TMDL Calculations for Red River-Elm Fork (OK311800000010_00)**

| Percentile | Flow (cfs) | TMDL (cfu/day) | WLA (cfu/day) | LA (cfu/day) | MOS (cfu/day) |
|---|---|---|---|---|---|
| 0 | 15,700 | 1.56E+14 | 0 | 1.40E+14 | 1.56E+13 |
| 5 | 601 | 5.97E+12 | 0 | 5.37E+12 | 5.97E+11 |
| 10 | 240 | 2.39E+12 | 0 | 2.15E+12 | 2.39E+11 |
| 15 | 143 | 1.42E+12 | 0 | 1.28E+12 | 1.42E+11 |
| 20 | 98 | 9.77E+11 | 0 | 8.80E+11 | 9.77E+10 |
| 25 | 70 | 6.95E+11 | 0 | 6.26E+11 | 6.95E+10 |
| 30 | 54 | 5.36E+11 | 0 | 4.83E+11 | 5.36E+10 |
| 35 | 44 | 4.37E+11 | 0 | 3.93E+11 | 4.37E+10 |
| 40 | 36 | 3.58E+11 | 0 | 3.22E+11 | 3.58E+10 |
| 45 | 29 | 2.88E+11 | 0 | 2.59E+11 | 2.88E+10 |
| 50 | 24 | 2.38E+11 | 0 | 2.15E+11 | 2.38E+10 |
| 55 | 19 | 1.89E+11 | 0 | 1.70E+11 | 1.89E+10 |
| 60 | 15 | 1.49E+11 | 0 | 1.34E+11 | 1.49E+10 |
| 65 | 12 | 1.19E+11 | 0 | 1.07E+11 | 1.19E+10 |
| 70 | 9.0 | 8.94E+10 | 0 | 8.05E+10 | 8.94E+09 |
| 75 | 6.8 | 6.75E+10 | 0 | 6.08E+10 | 6.75E+09 |
| 80 | 4.5 | 4.47E+10 | 0 | 4.02E+10 | 4.47E+09 |
| 85 | 2.8 | 2.78E+10 | 0 | 2.50E+10 | 2.78E+09 |
| 90 | 1.5 | 1.49E+10 | 0 | 1.34E+10 | 1.49E+09 |
| 95 | 0.30 | 2.98E+09 | 0 | 2.68E+09 | 2.98E+08 |
| 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 5-26 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 5-26 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 managed by the Oklahoma Conservation Commission. The OCC works with state partners such as ODAFF and federal partners such EPA and NRCS, to address water quality problems similart to those seen in the Red River watershed. 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.

When a watershed extends into an adjacent state, the same reduction goal that applies to the watershed within Oklahoma should also be considered to apply to the watershed in the adjacent state. These goals could be achieved by reductions in some combination of nonpoint sources and uncontrolled point sources. Since Oklahoma has no authority over potential bacteria sources in adjacent states, these reductions can only be facilitated through cooperation between Oklahoma agencies, the adjacent state and EPA.

The reduction rates called for in this TMDL report are as high as 97 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 these waterbodies, 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. Then the report was submitted to the EPA for technical review and approval. The report was technically approved by the EPA on January 7, 2008. A public was published on January 24, 2008 and the report was made available for public review and comments. The public comment period started on January 24, 2008 and ended on March 10, 2008. Only one written comment was received.

All comments were responded and the report was updated accordingly. The response to comments was included in Appendix F of this report.

# SECTION 7
# REFERENCES

American Veterinary Medical Association 2002. U.S. Pet Ownership and Demographics Sourcebook (2002 Edition). Schaumberg, IL.

ASAE (American Society of Agricultural Engineers) 1999. ASAE standards, 46th edition: standards, engineering practices, data. St. Joseph, MI.

Canter, LW and RC Knox. 1985. Septic tank system effects on ground water quality. Lewis Publishers, Boca Raton, FL.

Cleland 2003. Cleland, B. TMDL Development from the "Bottom Up" – Part III: Duration Curves and Wet-Weather Assessments. Water Environment Federation National TMDL Science and Policy Conference 2003. Chicago, IL.

Cogger, CG and BL Carlile 1984. Field performance of conventional and alternative septic systems in wet soils. *J. Environ. Qual*. 13 (1).

Drapcho, C.M. and A.K.B. Hubbs 2002. Fecal Coliform Concentration in Runoff from Fields with Applied Dairy Manure. http://www.lwrri.lsu.edu/downloads/drapcho Annual%20report01.02.pdf

Hall, S. 2002. Washington State Department of Health, Wastewater Management Program Rule Development Committee, Issue Research Report - Failing Systems, June 2002.

Metcalf and Eddy 1991. Wastewater Engineering: Treatment, Disposal, Reuse: 2nd Edition.

ODAFF 2005. http://www.state.ok.us/~okag/water-home.htm

ODEQ 2002. The State of Oklahoma 2002 Continuing Planning Process. 2002.

ODEQ 2004. *The State of Oklahoma 2004 Water Quality Assessment Integrated Report*. 2004.

Oklahoma Climate Survey. 2005. Viewed August 29, 2005 in

http://climate.ocs.ou.edu/county_climate/Products/County_Climatologies/

OWRB 2006. Oklahoma Water Resources Board. *2006 Water Quality Standards*.

OWRB 2007. Oklahoma Water Resources Board. Viewed June 1, 2007. Implementation of Oklahoma's Water Quality Standards (Chapter 46).

Reed, Stowe &Yanke, LLC 2001. *Study to Determine the Magnitude of, and Reasons for, Chronically Malfunctioning On-Site Sewage Facility Systems in Texas*. September 2001.

Schueler, TR. 2000. Microbes and Urban Watersheds: Concentrations, Sources, and Pathways. In *The Practice of Watershed Protection*, TR Schueler and HK Holland, eds. Center for Watershed Protection, Ellicott City, MD.

University of Florida 1987. Institute of Food and Agricultural Sciences, University Of Florida, Florida Cooperative Extension Service, No. 31, December, 1987.

U.S. Census Bureau 1995. http://www.census.gov/.

U.S. Census Bureau 2000. http://www.census.gov/main/www/cen2000.html

USDA 2002. Census of Agriculture, National Agricultural Statistics Service, United States Department of Agriculture. http://www.nass.usda.gov/Census/Create_Census_US_CNTY.jsp

USEPA 1983. Final Report of the Nationwide Urban Runoff Program. U.S. Environmental Protection Agency, Water Planning Division.

USEPA 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. Office of Water, USEPA 440/4-91-001.

USEPA 2001. Protocol for Developing Pathogen TMDLs. First Edition. Office of Water, USEPA 841-R-00-002.

USEPA 2003. Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the Clean Water Act, TMDL -01-03 - Diane Regas-- July 21, 2003.

USEPA 2005. U.S. Environmental Protection Agency, Office of Water. Stormwater Phase II Final Rule. EPA833-F-00-002 Fact Sheet 2.0. December 2005.

USGS 2007. Multi-Resolution Land Characteristics Consortium. http://www.mrlc.gov/index.asp

USGS 2007a. USGS Daily Streamflow Data. http://waterdata.usgs.gov/nwis/sw

# APPENDIX A
# AMBIENT WATER QUALITY BACTERIA DATA – 1999 TO 2003

# Appendix A

## Ambient Water Quality Bacteria Data – 1999 to 2003

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 6/22/1999 | 750 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 7/20/1999 | 10 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/17/1999 | 30 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 9/21/1999 | 30 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 5/23/2000 | 3120 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 6/27/2000 | 80 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/1/2000 | 30 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/29/2000 | 1500 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 9/26/2000 | 150 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 5/22/2001 | 1500 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 6/19/2001 | 200 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 7/24/2001 | 240 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/21/2001 | 200 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 5/29/2002 | 300 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 6/24/2002 | 60 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/6/2002 | 200 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/20/2002 | 100 | FC | 400 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 6/22/1999 | 6970 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 7/20/1999 | 20 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/17/1999 | 20 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 9/21/1999 | 10 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 5/23/2000 | 84 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 6/27/2000 | 10 | EC | 406 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/1/2000 | 20 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/29/2000 | 1200 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 9/26/2000 | 74 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 5/22/2001 | 314 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 6/19/2001 | 31 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 7/24/2001 | 181 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/21/2001 | 97 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 9/19/2001 | 73 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 5/29/2002 | 95 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 6/24/2002 | 275 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/6/2002 | 85 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/20/2002 | 143 | EC | 406 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 6/22/1999 | 730 | ENT | 108 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 7/20/1999 | 20 | ENT | 108 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/17/1999 | 50 | ENT | 108 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 9/21/1999 | 90 | ENT | 108 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 5/23/2000 | 60 | ENT | 108 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 6/27/2000 | 100 | ENT | 108 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/1/2000 | 150 | ENT | 108 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/29/2000 | 210 | ENT | 108 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 9/26/2000 | 150 | ENT | 108 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 6/19/2001 | 160 | ENT | 108 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 7/24/2001 | 1100 | ENT | 108 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/21/2001 | 100 | ENT | 108 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 5/29/2002 | 800 | ENT | 108 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 6/24/2002 | 90 | ENT | 108 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/6/2002 | 250 | ENT | 108 |
| OK311500010020-001AT | North Fork of Red River, US 62, Headrick | 8/20/2002 | 200 | ENT | 108 |
| OK311500010050G | Stinking Creek | 5/15/2000 | 100 | FC | 400 |
| OK311500010050G | Stinking Creek | 6/19/2000 | 6000 | FC | 400 |
| OK311500010050G | Stinking Creek | 7/24/2000 | 8000 | FC | 400 |
| OK311500010050G | Stinking Creek | 8/28/2000 | 48700 | FC | 400 |
| OK311500010050G | Stinking Creek | 10/2/2000 | 500 | FC | 2000 |
| OK311500010050G | Stinking Creek | 11/7/2000 | 2100 | FC | 2000 |
| OK311500010050G | Stinking Creek | 12/11/2000 | 40 | FC | 2000 |
| OK311500010050G | Stinking Creek | 1/22/2001 | 10 | FC | 2000 |
| OK311500010050G | Stinking Creek | 2/26/2001 | 700 | FC | 2000 |
| OK311500010050G | Stinking Creek | 4/2/2001 | 40 | FC | 2000 |
| OK311500010050G | Stinking Creek | 5/7/2001 | 13000 | FC | 400 |
| OK311500010050G | Stinking Creek | 6/11/2001 | 600 | FC | 400 |
| OK311500010050G | Stinking Creek | 9/24/2001 | 1060 | FC | 400 |
| OK311500010050G | Stinking Creek | 10/29/2001 | 1175 | FC | 2000 |
| OK311500010050G | Stinking Creek | 10/29/2001 | 490 | FC | 2000 |
| OK311500010050G | Stinking Creek | 8/28/2000 | 4190 | EC | 406 |
| OK311500010050G | Stinking Creek | 10/2/2000 | 120 | EC | 2030 |
| OK311500010050G | Stinking Creek | 11/7/2000 | 4611 | EC | 2030 |
| OK311500010050G | Stinking Creek | 12/11/2000 | 134 | EC | 2030 |
| OK311500010050G | Stinking Creek | 1/22/2001 | 20 | EC | 2030 |
| OK311500010050G | Stinking Creek | 2/26/2001 | 364 | EC | 2030 |
| OK311500010050G | Stinking Creek | 4/2/2001 | 108 | EC | 2030 |
| OK311500010050G | Stinking Creek | 5/7/2001 | 1551 | EC | 406 |
| OK311500010050G | Stinking Creek | 6/11/2001 | 85 | EC | 406 |
| OK311500010050G | Stinking Creek | 8/20/2001 | 400 | EC | 406 |
| OK311500010050G | Stinking Creek | 9/24/2001 | 20 | EC | 406 |
| OK311500010050G | Stinking Creek | 10/29/2001 | 315 | EC | 2030 |
| OK311500010050G | Stinking Creek | 8/28/2000 | 3500 | ENT | 108 |
| OK311500010050G | Stinking Creek | 10/2/2000 | 700 | ENT | 540 |
| OK311500010050G | Stinking Creek | 11/7/2000 | 900 | ENT | 540 |
| OK311500010050G | Stinking Creek | 12/11/2000 | 60 | ENT | 540 |
| OK311500010050G | Stinking Creek | 1/22/2001 | 30 | ENT | 540 |
| OK311500010050G | Stinking Creek | 2/26/2001 | 1500 | ENT | 540 |
| OK311500010050G | Stinking Creek | 4/2/2001 | 10 | ENT | 540 |
| OK311500010050G | Stinking Creek | 5/7/2001 | 7000 | ENT | 108 |
| OK311500010050G | Stinking Creek | 6/11/2001 | 1400 | ENT | 108 |
| OK311500010050G | Stinking Creek | 7/16/2001 | 52 | ENT | 108 |
| OK311500010050G | Stinking Creek | 8/20/2001 | 120 | ENT | 108 |
| OK311500010050G | Stinking Creek | 9/24/2001 | 90 | ENT | 108 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311500010050G | Stinking Creek | 10/29/2001 | 245 | ENT | 540 |
| OK311500010050G | Stinking Creek | 10/29/2001 | 120 | ENT | 540 |
| OK311500010110G | Tepee Creek | 5/16/2000 | 900 | FC | 400 |
| OK311500010110G | Tepee Creek | 6/20/2000 | 200 | FC | 400 |
| OK311500010110G | Tepee Creek | 7/25/2000 | 210 | FC | 400 |
| OK311500010110G | Tepee Creek | 8/29/2000 | 320 | FC | 400 |
| OK311500010110G | Tepee Creek | 10/3/2000 | 500 | FC | 2000 |
| OK311500010110G | Tepee Creek | 1/23/2001 | 60 | FC | 2000 |
| OK311500010110G | Tepee Creek | 2/27/2001 | 200 | FC | 2000 |
| OK311500010110G | Tepee Creek | 4/3/2001 | 900 | FC | 2000 |
| OK311500010110G | Tepee Creek | 5/8/2001 | 20 | FC | 400 |
| OK311500010110G | Tepee Creek | 6/12/2001 | 1000 | FC | 400 |
| OK311500010110G | Tepee Creek | 7/17/2001 | 68 | FC | 400 |
| OK311500010110G | Tepee Creek | 8/21/2001 | 445 | FC | 400 |
| OK311500010110G | Tepee Creek | 9/25/2001 | 365 | FC | 400 |
| OK311500010110G | Tepee Creek | 10/30/2001 | 190 | FC | 2000 |
| OK311500010110G | Tepee Creek | 10/30/2001 | 60 | FC | 2000 |
| OK311500010110G | Tepee Creek | 8/29/2000 | 181 | EC | 406 |
| OK311500010110G | Tepee Creek | 10/3/2000 | 256 | EC | 2030 |
| OK311500010110G | Tepee Creek | 1/23/2001 | 218 | EC | 2030 |
| OK311500010110G | Tepee Creek | 2/27/2001 | 1054 | EC | 2030 |
| OK311500010110G | Tepee Creek | 4/3/2001 | 836 | EC | 2030 |
| OK311500010110G | Tepee Creek | 5/8/2001 | 657 | EC | 406 |
| OK311500010110G | Tepee Creek | 6/12/2001 | 285 | EC | 406 |
| OK311500010110G | Tepee Creek | 7/17/2001 | 50 | EC | 406 |
| OK311500010110G | Tepee Creek | 8/21/2001 | 350 | EC | 406 |
| OK311500010110G | Tepee Creek | 9/25/2001 | 410 | EC | 406 |
| OK311500010110G | Tepee Creek | 10/30/2001 | 190 | EC | 2030 |
| OK311500010110G | Tepee Creek | 8/29/2000 | 470 | ENT | 108 |
| OK311500010110G | Tepee Creek | 10/3/2000 | 1300 | ENT | 540 |
| OK311500010110G | Tepee Creek | 1/23/2001 | 200 | ENT | 540 |
| OK311500010110G | Tepee Creek | 2/27/2001 | 8000 | ENT | 540 |
| OK311500010110G | Tepee Creek | 4/3/2001 | 700 | ENT | 540 |
| OK311500010110G | Tepee Creek | 5/8/2001 | 32000 | ENT | 108 |
| OK311500010110G | Tepee Creek | 6/12/2001 | 1100 | ENT | 108 |
| OK311500010110G | Tepee Creek | 7/17/2001 | 46 | ENT | 108 |
| OK311500010110G | Tepee Creek | 8/21/2001 | 195 | ENT | 108 |
| OK311500010110G | Tepee Creek | 9/25/2001 | 640 | ENT | 108 |
| OK311500010110G | Tepee Creek | 10/30/2001 | 920 | ENT | 540 |
| OK311500010110G | Tepee Creek | 10/30/2001 | 770 | ENT | 540 |
| OK311500020040G | West Otter Creek | 6/19/2000 | 2700 | FC | 400 |
| OK311500020040G | West Otter Creek | 8/28/2000 | 110 | FC | 400 |
| OK311500020040G | West Otter Creek | 10/2/2000 | 600 | FC | 2000 |
| OK311500020040G | West Otter Creek | 11/7/2000 | 700 | FC | 2000 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311500020040G | West Otter Creek | 12/11/2000 | 140 | FC | 2000 |
| OK311500020040G | West Otter Creek | 1/22/2001 | 30 | FC | 2000 |
| OK311500020040G | West Otter Creek | 2/26/2001 | 200 | FC | 2000 |
| OK311500020040G | West Otter Creek | 4/2/2001 | 100 | FC | 2000 |
| OK311500020040G | West Otter Creek | 5/7/2001 | 3000 | FC | 400 |
| OK311500020040G | West Otter Creek | 6/11/2001 | 700 | FC | 400 |
| OK311500020040G | West Otter Creek | 7/16/2001 | 138 | FC | 400 |
| OK311500020040G | West Otter Creek | 8/20/2001 | 440 | FC | 400 |
| OK311500020040G | West Otter Creek | 9/24/2001 | 710 | FC | 400 |
| OK311500020040G | West Otter Creek | 10/29/2001 | 490 | FC | 2000 |
| OK311500020040G | West Otter Creek | 10/29/2001 | 1050 | FC | 2000 |
| OK311500020040G | West Otter Creek | 5/15/2000 | 500 | FC | 400 |
| OK311500020040G | West Otter Creek | 8/28/2000 | 20 | EC | 406 |
| OK311500020040G | West Otter Creek | 10/2/2000 | 238 | EC | 2030 |
| OK311500020040G | West Otter Creek | 11/7/2000 | 402 | EC | 2030 |
| OK311500020040G | West Otter Creek | 12/11/2000 | 134 | EC | 2030 |
| OK311500020040G | West Otter Creek | 1/22/2001 | 52 | EC | 2030 |
| OK311500020040G | West Otter Creek | 2/26/2001 | 583 | EC | 2030 |
| OK311500020040G | West Otter Creek | 4/2/2001 | 379 | EC | 2030 |
| OK311500020040G | West Otter Creek | 5/7/2001 | 3348 | EC | 406 |
| OK311500020040G | West Otter Creek | 6/11/2001 | 166 | EC | 406 |
| OK311500020040G | West Otter Creek | 7/16/2001 | 96 | EC | 406 |
| OK311500020040G | West Otter Creek | 8/20/2001 | 195 | EC | 406 |
| OK311500020040G | West Otter Creek | 9/24/2001 | 300 | EC | 406 |
| OK311500020040G | West Otter Creek | 10/29/2001 | 280 | EC | 2030 |
| OK311500020040G | West Otter Creek | 8/28/2000 | 51000 | ENT | 108 |
| OK311500020040G | West Otter Creek | 10/2/2000 | 6000 | ENT | 540 |
| OK311500020040G | West Otter Creek | 11/7/2000 | 13000 | ENT | 540 |
| OK311500020040G | West Otter Creek | 12/11/2000 | 200 | ENT | 540 |
| OK311500020040G | West Otter Creek | 1/22/2001 | 60 | ENT | 540 |
| OK311500020040G | West Otter Creek | 2/26/2001 | 1700 | ENT | 540 |
| OK311500020040G | West Otter Creek | 4/2/2001 | 200 | ENT | 540 |
| OK311500020040G | West Otter Creek | 5/7/2001 | 16000 | ENT | 108 |
| OK311500020040G | West Otter Creek | 6/11/2001 | 1500 | ENT | 108 |
| OK311500020040G | West Otter Creek | 7/16/2001 | 96 | ENT | 108 |
| OK311500020040G | West Otter Creek | 8/20/2001 | 130 | ENT | 108 |
| OK311500020040G | West Otter Creek | 9/24/2001 | 180 | ENT | 108 |
| OK311500020040G | West Otter Creek | 10/29/2001 | 120 | ENT | 540 |
| OK311500020040G | West Otter Creek | 10/29/2001 | 80 | ENT | 540 |
| OK311500030040G | Little Elk Creek | 5/16/2000 | 1500 | FC | 400 |
| OK311500030040G | Little Elk Creek | 6/20/2000 | 300 | FC | 400 |
| OK311500030040G | Little Elk Creek | 8/29/2000 | 30 | FC | 400 |
| OK311500030040G | Little Elk Creek | 10/3/2000 | 100 | FC | 2000 |
| OK311500030040G | Little Elk Creek | 1/23/2001 | 20 | FC | 2000 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311500030040G | Little Elk Creek | 2/27/2001 | 100 | FC | 2000 |
| OK311500030040G | Little Elk Creek | 4/3/2001 | 200 | FC | 2000 |
| OK311500030040G | Little Elk Creek | 5/8/2001 | 1100 | FC | 400 |
| OK311500030040G | Little Elk Creek | 6/12/2001 | 200 | FC | 400 |
| OK311500030040G | Little Elk Creek | 7/17/2001 | 300 | FC | 400 |
| OK311500030040G | Little Elk Creek | 9/25/2001 | 870 | FC | 400 |
| OK311500030040G | Little Elk Creek | 10/30/2001 | 280 | FC | 2000 |
| OK311500030040G | Little Elk Creek | 10/30/2001 | 180 | FC | 2000 |
| OK311500030040G | Little Elk Creek | 10/30/2001 | 190 | FC | 2000 |
| OK311500030040G | Little Elk Creek | 8/29/2000 | 63 | EC | 406 |
| OK311500030040G | Little Elk Creek | 10/3/2000 | 213 | EC | 2030 |
| OK311500030040G | Little Elk Creek | 1/23/2001 | 31 | EC | 2030 |
| OK311500030040G | Little Elk Creek | 2/27/2001 | 471 | EC | 2030 |
| OK311500030040G | Little Elk Creek | 4/3/2001 | 504 | EC | 2030 |
| OK311500030040G | Little Elk Creek | 5/8/2001 | 131 | EC | 406 |
| OK311500030040G | Little Elk Creek | 6/12/2001 | 109 | EC | 406 |
| OK311500030040G | Little Elk Creek | 7/17/2001 | 56 | EC | 406 |
| OK311500030040G | Little Elk Creek | 8/21/2001 | 400 | EC | 406 |
| OK311500030040G | Little Elk Creek | 9/25/2001 | 880 | EC | 406 |
| OK311500030040G | Little Elk Creek | 10/30/2001 | 200 | EC | 2030 |
| OK311500030040G | Little Elk Creek | 8/29/2000 | 17000 | ENT | 108 |
| OK311500030040G | Little Elk Creek | 10/3/2000 | 38000 | ENT | 540 |
| OK311500030040G | Little Elk Creek | 1/23/2001 | 8000 | ENT | 540 |
| OK311500030040G | Little Elk Creek | 2/27/2001 | 15000 | ENT | 540 |
| OK311500030040G | Little Elk Creek | 4/3/2001 | 500 | ENT | 540 |
| OK311500030040G | Little Elk Creek | 5/8/2001 | 8000 | ENT | 108 |
| OK311500030040G | Little Elk Creek | 6/12/2001 | 400 | ENT | 108 |
| OK311500030040G | Little Elk Creek | 7/17/2001 | 42 | ENT | 108 |
| OK311500030040G | Little Elk Creek | 8/21/2001 | 525 | ENT | 108 |
| OK311500030040G | Little Elk Creek | 9/25/2001 | 980 | ENT | 108 |
| OK311500030040G | Little Elk Creek | 10/30/2001 | 20 | ENT | 540 |
| OK311500030040G | Little Elk Creek | 10/30/2001 | 920 | ENT | 540 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/20/1999 | 70 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/17/1999 | 150 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/21/1999 | 150 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 5/23/2000 | 130 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/10/2000 | 200 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/1/2000 | 180 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/29/2000 | 400 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/26/2000 | 130 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 6/19/2001 | 400 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/24/2001 | 90 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/21/2001 | 1300 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/19/2001 | 1100 | FC | 400 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 5/29/2002 | 200 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 6/25/2002 | 220 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/6/2002 | 40 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/21/2002 | 10 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/25/2002 | 90 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 5/7/2003 | 100 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 5/19/2003 | 4000 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 6/3/2003 | 10 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 6/23/2003 | 70 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/15/2003 | 10 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/28/2003 | 40 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/20/2003 | 2300 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/2/2003 | 3100 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/24/2003 | 170 | FC | 400 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/20/1999 | 122 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/17/1999 | 20 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/21/1999 | 73 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 5/23/2000 | 108 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/10/2000 | 73 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/1/2000 | 31 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/29/2000 | 31 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/26/2000 | 41 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 6/19/2001 | 41 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/24/2001 | 84 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/21/2001 | 84 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/19/2001 | 84 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 5/29/2002 | 86 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 6/25/2002 | 185 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/6/2002 | 20 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/21/2002 | 10 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/25/2002 | 20 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 5/7/2003 | 20 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 5/19/2003 | 798 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 6/3/2003 | 20 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 6/23/2003 | 331 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/15/2003 | 10 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/28/2003 | 10 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/20/2003 | 31 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/2/2003 | 259 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/24/2003 | 10 | EC | 406 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/20/1999 | 40 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/17/1999 | 110 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/21/1999 | 70 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 5/23/2000 | 160 | ENT | 108 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/10/2000 | 300 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/1/2000 | 120 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/29/2000 | 80 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/26/2000 | 260 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 6/19/2001 | 250 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/24/2001 | 270 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/21/2001 | 200 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/19/2001 | 1700 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 5/29/2002 | 600 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 6/25/2002 | 70 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/6/2002 | 200 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/21/2002 | 80 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/25/2002 | 300 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 5/7/2003 | 100 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 5/19/2003 | 900 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 6/3/2003 | 100 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 6/23/2003 | 1100 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/15/2003 | 20 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 7/28/2003 | 40 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 8/20/2003 | 100 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/2/2003 | 2100 | ENT | 108 |
| OK311500030010-001AT | Elk Creek, off US 183, Hobart | 9/24/2003 | 4200 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 7/20/1999 | 10 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/17/1999 | 5 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/23/2000 | 10 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/27/2000 | 4000 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/1/2000 | 60 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/29/2000 | 350 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/22/2001 | 1600 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/19/2001 | 100 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 7/24/2001 | 90 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/21/2001 | 170 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 9/19/2001 | 70 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/29/2002 | 20 | FC | 400 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/24/2002 | 80 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/7/2002 | 60 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/7/2003 | 100 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/19/2003 | 4000 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/3/2003 | 110 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/23/2003 | 600 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 7/15/2003 | 30 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 9/24/2003 | 100 | FC | 400 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 7/20/1999 | 51 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/17/1999 | 86 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/23/2000 | 41 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/27/2000 | 534 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/1/2000 | 10 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/29/2000 | 31 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/22/2001 | 332 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/19/2001 | 30 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 7/24/2001 | 20 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/21/2001 | 31 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 9/19/2001 | 10 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/29/2002 | 20 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/24/2002 | 63 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/7/2002 | 10 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/7/2003 | 41 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/19/2003 | 318 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/3/2003 | 96 | EC | 406 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/23/2003 | 160 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 7/15/2003 | 20 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 9/24/2003 | 10 | EC | 406 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 7/20/1999 | 20 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/17/1999 | 5 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/23/2000 | 5 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/27/2000 | 11000 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/1/2000 | 40 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/29/2000 | 2400 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/22/2001 | 9000 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/19/2001 | 130 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 7/24/2001 | 90 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/21/2001 | 300 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 9/19/2001 | 5 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/29/2002 | 30 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/24/2002 | 50 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 8/7/2002 | 30 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/7/2003 | 100 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 5/19/2003 | 2100 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/3/2003 | 120 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 6/23/2003 | 300 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 7/15/2003 | 10 | ENT | 108 |
| OK311510010010-001AT | North Fork of the Red River, SH 34, Carter | 9/24/2003 | 30 | ENT | 108 |
| OK311510020060G | Turkey Creek | 5/23/2000 | 100 | FC | 400 |
| OK311510020060G | Turkey Creek | 6/27/2000 | 1700 | FC | 400 |
| OK311510020060G | Turkey Creek | 8/1/2000 | 900 | FC | 400 |
| OK311510020060G | Turkey Creek | 9/6/2000 | 6000 | FC | 400 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311510020060G | Turkey Creek | 10/10/2000 | 400 | FC | 2000 |
| OK311510020060G | Turkey Creek | 11/14/2000 | 300 | FC | 2000 |
| OK311510020060G | Turkey Creek | 12/19/2000 | 180 | FC | 2000 |
| OK311510020060G | Turkey Creek | 1/30/2001 | 60 | FC | 2000 |
| OK311510020060G | Turkey Creek | 3/6/2001 | 10 | FC | 2000 |
| OK311510020060G | Turkey Creek | 4/10/2001 | 240 | FC | 2000 |
| OK311510020060G | Turkey Creek | 5/14/2001 | 400 | FC | 400 |
| OK311510020060G | Turkey Creek | 6/18/2001 | 140 | FC | 400 |
| OK311510020060G | Turkey Creek | 7/23/2001 | 155 | FC | 400 |
| OK311510020060G | Turkey Creek | 8/28/2001 | 200 | FC | 400 |
| OK311510020060G | Turkey Creek | 10/2/2001 | 170 | FC | 2000 |
| OK311510020060G | Turkey Creek | 11/6/2001 | 180 | FC | 2000 |
| OK311510020060G | Turkey Creek | 11/6/2001 | 570 | FC | 2000 |
| OK311510020060G | Turkey Creek | 8/1/2000 | 243 | EC | 406 |
| OK311510020060G | Turkey Creek | 9/6/2000 | 228 | EC | 406 |
| OK311510020060G | Turkey Creek | 10/10/2000 | 529 | EC | 2030 |
| OK311510020060G | Turkey Creek | 11/14/2000 | 146 | EC | 2030 |
| OK311510020060G | Turkey Creek | 12/19/2000 | 185 | EC | 2030 |
| OK311510020060G | Turkey Creek | 1/30/2001 | 86 | EC | 2030 |
| OK311510020060G | Turkey Creek | 3/6/2001 | 74 | EC | 2030 |
| OK311510020060G | Turkey Creek | 4/10/2001 | 441 | EC | 2030 |
| OK311510020060G | Turkey Creek | 5/14/2001 | 153 | EC | 406 |
| OK311510020060G | Turkey Creek | 6/18/2001 | 20 | EC | 406 |
| OK311510020060G | Turkey Creek | 7/23/2001 | 20 | EC | 406 |
| OK311510020060G | Turkey Creek | 8/28/2001 | 240 | EC | 406 |
| OK311510020060G | Turkey Creek | 10/2/2001 | 60 | EC | 2030 |
| OK311510020060G | Turkey Creek | 11/6/2001 | 80 | EC | 2030 |
| OK311510020060G | Turkey Creek | 8/1/2000 | 1400 | ENT | 108 |
| OK311510020060G | Turkey Creek | 9/6/2000 | 2400 | ENT | 108 |
| OK311510020060G | Turkey Creek | 10/10/2000 | 6000 | ENT | 540 |
| OK311510020060G | Turkey Creek | 11/14/2000 | 1000 | ENT | 540 |
| OK311510020060G | Turkey Creek | 12/19/2000 | 700 | ENT | 540 |
| OK311510020060G | Turkey Creek | 1/30/2001 | 29000 | ENT | 540 |
| OK311510020060G | Turkey Creek | 3/6/2001 | 30 | ENT | 540 |
| OK311510020060G | Turkey Creek | 3/6/2001 | 100 | ENT | 540 |
| OK311510020060G | Turkey Creek | 4/10/2001 | 500 | ENT | 540 |
| OK311510020060G | Turkey Creek | 5/14/2001 | 3000 | ENT | 108 |
| OK311510020060G | Turkey Creek | 6/18/2001 | 200 | ENT | 108 |
| OK311510020060G | Turkey Creek | 7/23/2001 | 90 | ENT | 108 |
| OK311510020060G | Turkey Creek | 8/28/2001 | 160 | ENT | 108 |
| OK311510020060G | Turkey Creek | 10/2/2001 | 10 | ENT | 540 |
| OK311510020060G | Turkey Creek | 11/6/2001 | 80 | ENT | 540 |
| OK311510020060G | Turkey Creek | 11/6/2001 | 100 | ENT | 540 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 6/21/1999 | 150 | FC | 400 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 7/19/1999 | 100 | FC | 400 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 8/16/1999 | 800 | FC | 400 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 9/20/1999 | 370 | FC | 400 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 5/23/2000 | 420 | FC | 400 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 6/27/2000 | 13000 | FC | 400 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 8/1/2000 | 400 | FC | 400 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 8/29/2000 | 120 | FC | 400 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 9/26/2000 | 110 | FC | 400 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 5/22/2001 | 15000 | FC | 400 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 6/19/2001 | 700 | FC | 400 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 7/24/2001 | 300 | FC | 400 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 8/21/2001 | 6000 | FC | 400 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 9/18/2001 | 700 | FC | 400 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 6/21/1999 | 1870 | EC | 406 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 7/19/1999 | 299 | EC | 406 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 8/16/1999 | 31 | EC | 406 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 9/20/1999 | 238 | EC | 406 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 5/23/2000 | 148 | EC | 406 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 6/27/2000 | 618 | EC | 406 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 8/1/2000 | 95 | EC | 406 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 8/29/2000 | 1789 | EC | 406 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 9/26/2000 | 201 | EC | 406 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 5/22/2001 | 2909 | EC | 406 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 6/19/2001 | 195 | EC | 406 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 7/24/2001 | 131 | EC | 406 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 8/21/2001 | 119 | EC | 406 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 9/18/2001 | 10 | EC | 406 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 6/21/1999 | 210 | ENT | 108 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 7/19/1999 | 100 | ENT | 108 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 8/16/1999 | 340 | ENT | 108 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 9/20/1999 | 190 | ENT | 108 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 5/23/2000 | 60 | ENT | 108 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 6/27/2000 | 150000 | ENT | 108 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 8/1/2000 | 300 | ENT | 108 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 8/29/2000 | 1100 | ENT | 108 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 9/26/2000 | 2000 | ENT | 108 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 5/22/2001 | 37000 | ENT | 108 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 6/19/2001 | 1100 | ENT | 108 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 7/24/2001 | 1200 | ENT | 108 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 8/21/2001 | 1500 | ENT | 108 |
| OK311600010040-001AT | Sandy Creek, SH 6, Eldorado | 9/18/2001 | 300 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 6/22/1999 | 620 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 7/20/1999 | 420 | FC | 400 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/17/1999 | 1500 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 9/21/1999 | 270 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 5/23/2000 | 500 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 6/27/2000 | 40 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/1/2000 | 11000 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/29/2000 | 280 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 9/26/2000 | 69000 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 5/22/2001 | 1000 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 6/19/2001 | 230 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 7/24/2001 | 9000 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/21/2001 | 900 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 9/18/2001 | 110 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 5/29/2002 | 1200 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 6/25/2002 | 140 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/6/2002 | 6000 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/20/2002 | 170 | FC | 400 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 6/22/1999 | 3448 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 7/20/1999 | 97 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/17/1999 | 189 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 9/21/1999 | 187 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 5/23/2000 | 41 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 6/27/2000 | 52 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/1/2000 | 160 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/29/2000 | 496 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 9/26/2000 | 3436 | EC | 406 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 5/22/2001 | 247 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 6/19/2001 | 5 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 7/24/2001 | 85 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/21/2001 | 20 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 9/18/2001 | 262 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 5/29/2002 | 189 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 6/25/2002 | 62 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/6/2002 | 30 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/20/2002 | 107 | EC | 406 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 6/22/1999 | 7100 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 7/20/1999 | 90 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/17/1999 | 1100 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 9/21/1999 | 290 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 5/23/2000 | 50 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 6/27/2000 | 30 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/1/2000 | 1400 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/29/2000 | 170 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 9/26/2000 | 15000 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 5/22/2001 | 21000 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 6/19/2001 | 100 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 7/24/2001 | 9000 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/21/2001 | 100 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 9/18/2001 | 110 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 5/29/2002 | 1000 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 6/25/2002 | 400 | ENT | 108 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/6/2002 | 900 | ENT | 108 |
| OK311600020010-002AT | Salt Fork of the Red River, off US 283, Elmer | 8/20/2002 | 40 | ENT | 108 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 5/22/2001 | 1000 | FC | 400 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 6/19/2001 | 60 | FC | 400 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 9/18/2001 | 100 | FC | 400 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 5/28/2002 | 200 | FC | 400 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 6/24/2002 | 30 | FC | 400 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 8/6/2002 | 600 | FC | 400 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 5/7/2003 | 100 | FC | 400 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 5/19/2003 | 200 | FC | 400 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 6/23/2003 | 1300 | FC | 400 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 7/15/2003 | 2000 | FC | 400 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 9/24/2003 | 230 | FC | 400 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 5/22/2001 | 132 | EC | 406 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 6/19/2001 | 5 | EC | 406 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 9/18/2001 | 5 | EC | 406 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 5/28/2002 | 10 | EC | 406 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 6/24/2002 | 52 | EC | 406 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 8/6/2002 | 298 | EC | 406 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 5/7/2003 | 52 | EC | 406 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 5/19/2003 | 85 | EC | 406 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 6/23/2003 | 368 | EC | 406 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 7/15/2003 | 189 | EC | 406 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 9/24/2003 | 86 | EC | 406 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 5/22/2001 | 1000 | ENT | 108 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 6/19/2001 | 50 | ENT | 108 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 9/18/2001 | 400 | ENT | 108 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 5/28/2002 | 130 | ENT | 108 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 6/24/2002 | 4000 | ENT | 108 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 8/6/2002 | 600 | ENT | 108 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 5/7/2003 | 100 | ENT | 108 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 5/19/2003 | 200 | ENT | 108 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 6/23/2003 | 11000 | ENT | 108 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 7/15/2003 | 11000 | ENT | 108 |
| OK311600020010-001AT | Salt Fork of the Red River, SH 34, Mangum | 9/24/2003 | 1000 | ENT | 108 |
| OK311600020010G | Salt Fork of Red River | 5/16/2000 | 200 | FC | 400 |
| OK311600020010G | Salt Fork of Red River | 6/20/2000 | 1400 | FC | 400 |
| OK311600020010G | Salt Fork of Red River | 8/29/2000 | 100 | FC | 400 |
| OK311600020010G | Salt Fork of Red River | 11/7/2000 | 200 | FC | 2000 |
| OK311600020010G | Salt Fork of Red River | 12/12/2000 | 10 | FC | 2000 |
| OK311600020010G | Salt Fork of Red River | 1/23/2001 | 80 | FC | 2000 |
| OK311600020010G | Salt Fork of Red River | 2/27/2001 | 200 | FC | 2000 |
| OK311600020010G | Salt Fork of Red River | 4/3/2001 | 90 | FC | 2000 |
| OK311600020010G | Salt Fork of Red River | 5/8/2001 | 300 | FC | 400 |
| OK311600020010G | Salt Fork of Red River | 6/12/2001 | 10 | FC | 400 |
| OK311600020010G | Salt Fork of Red River | 8/29/2000 | 20 | EC | 406 |
| OK311600020010G | Salt Fork of Red River | 11/7/2000 | 145 | EC | 2030 |
| OK311600020010G | Salt Fork of Red River | 12/12/2000 | 51 | EC | 2030 |
| OK311600020010G | Salt Fork of Red River | 1/23/2001 | 173 | EC | 2030 |
| OK311600020010G | Salt Fork of Red River | 2/27/2001 | 471 | EC | 2030 |
| OK311600020010G | Salt Fork of Red River | 4/3/2001 | 31 | EC | 2030 |
| OK311600020010G | Salt Fork of Red River | 5/8/2001 | 169 | EC | 406 |
| OK311600020010G | Salt Fork of Red River | 6/12/2001 | 10 | EC | 406 |
| OK311600020010G | Salt Fork of Red River | 8/29/2000 | 50 | ENT | 108 |
| OK311600020010G | Salt Fork of Red River | 11/7/2000 | 1100 | ENT | 540 |
| OK311600020010G | Salt Fork of Red River | 12/12/2000 | 100 | ENT | 540 |
| OK311600020010G | Salt Fork of Red River | 1/23/2001 | 200 | ENT | 540 |
| OK311600020010G | Salt Fork of Red River | 2/27/2001 | 10000 | ENT | 540 |
| OK311600020010G | Salt Fork of Red River | 4/3/2001 | 20 | ENT | 540 |
| OK311600020010G | Salt Fork of Red River | 5/8/2001 | 1800 | ENT | 108 |
| OK311600020010G | Salt Fork of Red River | 6/12/2001 | 20 | ENT | 108 |
| OK311600020110G | Bitter Creek | 5/16/2000 | 100 | FC | 400 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311600020110G | Bitter Creek | 6/20/2000 | 1200 | FC | 400 |
| OK311600020110G | Bitter Creek | 8/29/2000 | 3100 | FC | 400 |
| OK311600020110G | Bitter Creek | 10/3/2000 | 610 | FC | 2000 |
| OK311600020110G | Bitter Creek | 12/12/2000 | 10 | FC | 2000 |
| OK311600020110G | Bitter Creek | 1/22/2001 | 10 | FC | 2000 |
| OK311600020110G | Bitter Creek | 2/26/2001 | 100 | FC | 2000 |
| OK311600020110G | Bitter Creek | 4/2/2001 | 70 | FC | 2000 |
| OK311600020110G | Bitter Creek | 5/7/2001 | 10000 | FC | 400 |
| OK311600020110G | Bitter Creek | 6/11/2001 | 90 | FC | 400 |
| OK311600020110G | Bitter Creek | 9/24/2001 | 100 | FC | 400 |
| OK311600020110G | Bitter Creek | 10/29/2001 | 460 | FC | 2000 |
| OK311600020110G | Bitter Creek | 10/29/2001 | 1175 | FC | 2000 |
| OK311600020110G | Bitter Creek | 8/29/2000 | 168 | EC | 406 |
| OK311600020110G | Bitter Creek | 10/3/2000 | 85 | EC | 2030 |
| OK311600020110G | Bitter Creek | 12/12/2000 | 31 | EC | 2030 |
| OK311600020110G | Bitter Creek | 1/22/2001 | 10 | EC | 2030 |
| OK311600020110G | Bitter Creek | 2/26/2001 | 185 | EC | 2030 |
| OK311600020110G | Bitter Creek | 4/2/2001 | 52 | EC | 2030 |
| OK311600020110G | Bitter Creek | 5/7/2001 | 527 | EC | 406 |
| OK311600020110G | Bitter Creek | 6/11/2001 | 52 | EC | 406 |
| OK311600020110G | Bitter Creek | 8/20/2001 | 400 | EC | 406 |
| OK311600020110G | Bitter Creek | 9/24/2001 | 10 | EC | 406 |
| OK311600020110G | Bitter Creek | 10/29/2001 | 70 | EC | 2030 |
| OK311600020110G | Bitter Creek | 8/29/2000 | 7000 | ENT | 108 |
| OK311600020110G | Bitter Creek | 10/3/2000 | 11000 | ENT | 540 |
| OK311600020110G | Bitter Creek | 12/12/2000 | 7000 | ENT | 540 |
| OK311600020110G | Bitter Creek | 1/22/2001 | 400 | ENT | 540 |
| OK311600020110G | Bitter Creek | 2/26/2001 | 1500 | ENT | 540 |
| OK311600020110G | Bitter Creek | 4/2/2001 | 70 | ENT | 540 |
| OK311600020110G | Bitter Creek | 5/7/2001 | 19000 | ENT | 108 |
| OK311600020110G | Bitter Creek | 6/11/2001 | 200 | ENT | 108 |
| OK311600020110G | Bitter Creek | 7/16/2001 | 82 | ENT | 108 |
| OK311600020110G | Bitter Creek | 8/20/2001 | 385 | ENT | 108 |
| OK311600020110G | Bitter Creek | 9/24/2001 | 100 | ENT | 108 |
| OK311600020110G | Bitter Creek | 10/29/2001 | 30 | ENT | 540 |
| OK311600020110G | Bitter Creek | 10/29/2001 | 245 | ENT | 540 |
| OK311600020140G | Cave Creek | 5/16/2000 | 100 | FC | 400 |
| OK311600020140G | Cave Creek | 6/20/2000 | 100 | FC | 400 |
| OK311600020140G | Cave Creek | 6/20/2000 | 1000 | FC | 400 |
| OK311600020140G | Cave Creek | 8/29/2000 | 880 | FC | 400 |
| OK311600020140G | Cave Creek | 8/29/2000 | 1300 | FC | 400 |
| OK311600020140G | Cave Creek | 10/3/2000 | 1400 | FC | 2000 |
| OK311600020140G | Cave Creek | 10/3/2000 | 2000 | FC | 2000 |
| OK311600020140G | Cave Creek | 12/12/2000 | 1000 | FC | 2000 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311600020140G | Cave Creek | 1/23/2001 | 40 | FC | 2000 |
| OK311600020140G | Cave Creek | 1/23/2001 | 30 | FC | 2000 |
| OK311600020140G | Cave Creek | 2/27/2001 | 300 | FC | 2000 |
| OK311600020140G | Cave Creek | 2/27/2001 | 110 | FC | 2000 |
| OK311600020140G | Cave Creek | 4/3/2001 | 70 | FC | 2000 |
| OK311600020140G | Cave Creek | 4/3/2001 | 120 | FC | 2000 |
| OK311600020140G | Cave Creek | 5/8/2001 | 4000 | FC | 400 |
| OK311600020140G | Cave Creek | 5/8/2001 | 2500 | FC | 400 |
| OK311600020140G | Cave Creek | 6/12/2001 | 400 | FC | 400 |
| OK311600020140G | Cave Creek | 6/12/2001 | 550 | FC | 400 |
| OK311600020140G | Cave Creek | 9/25/2001 | 300 | FC | 400 |
| OK311600020140G | Cave Creek | 9/25/2001 | 150 | FC | 400 |
| OK311600020140G | Cave Creek | 10/30/2001 | 80 | FC | 2000 |
| OK311600020140G | Cave Creek | 10/30/2001 | 460 | FC | 2000 |
| OK311600020140G | Cave Creek | 8/29/2000 | 211 | EC | 406 |
| OK311600020140G | Cave Creek | 10/3/2000 | 933 | EC | 2030 |
| OK311600020140G | Cave Creek | 12/12/2000 | 1515 | EC | 2030 |
| OK311600020140G | Cave Creek | 1/23/2001 | 63 | EC | 2030 |
| OK311600020140G | Cave Creek | 2/27/2001 | 216 | EC | 2030 |
| OK311600020140G | Cave Creek | 4/3/2001 | 216 | EC | 2030 |
| OK311600020140G | Cave Creek | 5/8/2001 | 985 | EC | 406 |
| OK311600020140G | Cave Creek | 6/12/2001 | 179 | EC | 406 |
| OK311600020140G | Cave Creek | 7/17/2001 | 160 | EC | 406 |
| OK311600020140G | Cave Creek | 8/21/2001 | 400 | EC | 406 |
| OK311600020140G | Cave Creek | 9/25/2001 | 85 | EC | 406 |
| OK311600020140G | Cave Creek | 10/30/2001 | 60 | EC | 2030 |
| OK311600020140G | Cave Creek | 8/29/2000 | 310 | ENT | 108 |
| OK311600020140G | Cave Creek | 8/29/2000 | 1900 | ENT | 108 |
| OK311600020140G | Cave Creek | 10/3/2000 | 1900 | ENT | 540 |
| OK311600020140G | Cave Creek | 10/3/2000 | 5000 | ENT | 540 |
| OK311600020140G | Cave Creek | 12/12/2000 | 2000 | ENT | 540 |
| OK311600020140G | Cave Creek | 1/23/2001 | 40 | ENT | 540 |
| OK311600020140G | Cave Creek | 1/23/2001 | 20 | ENT | 540 |
| OK311600020140G | Cave Creek | 2/27/2001 | 90 | ENT | 540 |
| OK311600020140G | Cave Creek | 2/27/2001 | 140 | ENT | 540 |
| OK311600020140G | Cave Creek | 4/3/2001 | 170 | ENT | 540 |
| OK311600020140G | Cave Creek | 4/3/2001 | 140 | ENT | 540 |
| OK311600020140G | Cave Creek | 5/8/2001 | 6000 | ENT | 108 |
| OK311600020140G | Cave Creek | 6/12/2001 | 200 | ENT | 108 |
| OK311600020140G | Cave Creek | 6/12/2001 | 300 | ENT | 108 |
| OK311600020140G | Cave Creek | 7/17/2001 | 16 | ENT | 108 |
| OK311600020140G | Cave Creek | 8/21/2001 | 300 | ENT | 108 |
| OK311600020140G | Cave Creek | 8/21/2001 | 585 | ENT | 108 |
| OK311600020140G | Cave Creek | 9/25/2001 | 325 | ENT | 108 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311600020140G | Cave Creek | 9/25/2001 | 260 | ENT | 108 |
| OK311600020140G | Cave Creek | 10/30/2001 | 160 | ENT | 540 |
| OK311600020140G | Cave Creek | 10/30/2001 | 30 | ENT | 540 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 7/20/1999 | 80 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/17/1999 | 200 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/21/1999 | 30 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/23/2000 | 60 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/27/2000 | 12000 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/1/2000 | 30 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/29/2000 | 240 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/26/2000 | 70 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/22/2001 | 100 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/19/2001 | 50 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 7/24/2001 | 60 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/21/2001 | 220 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/18/2001 | 1400 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/29/2002 | 140 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/24/2002 | 100 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/7/2002 | 110 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/21/2002 | 700 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/25/2002 | 100 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/7/2003 | 500 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/19/2003 | 600 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/3/2003 | 30 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/23/2003 | 800 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 7/15/2003 | 80 | FC | 400 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 7/28/2003 | 30 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/20/2003 | 200 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/2/2003 | 500 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/24/2003 | 40 | FC | 400 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 7/20/1999 | 52 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/17/1999 | 250 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/21/1999 | 173 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/23/2000 | 213 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/27/2000 | 430 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/1/2000 | 265 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/29/2000 | 51 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/26/2000 | 1211 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/22/2001 | 121 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/19/2001 | 120 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 7/24/2001 | 717 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/21/2001 | 465 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/18/2001 | 108 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/29/2002 | 85 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/24/2002 | 1860 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/7/2002 | 6867 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/21/2002 | 2851 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/25/2002 | 768 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/7/2003 | 443 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/19/2003 | 1201 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/3/2003 | 909 | EC | 406 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/23/2003 | 1515 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 7/15/2003 | 1669 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 7/28/2003 | 6131 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/20/2003 | 1421 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/2/2003 | 1450 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/24/2003 | 842 | EC | 406 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 7/20/1999 | 10 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/17/1999 | 80 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/21/1999 | 30 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/23/2000 | 70 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/27/2000 | 6000 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/1/2000 | 150 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/29/2000 | 170 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/26/2000 | 180 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/22/2001 | 6000 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/19/2001 | 100 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 7/24/2001 | 170 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/21/2001 | 150 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/18/2001 | 900 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/29/2002 | 400 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/24/2002 | 1200 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/7/2002 | 200 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/21/2002 | 200 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/25/2002 | 230 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/7/2003 | 100 | ENT | 108 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 5/19/2003 | 600 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/3/2003 | 200 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 6/23/2003 | 6000 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 7/15/2003 | 90 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 7/28/2003 | 60 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 8/20/2003 | 100 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/2/2003 | 1600 | ENT | 108 |
| OK311800000010-001AT | Elm Fork River, SH 9, Mangum | 9/24/2003 | 50 | ENT | 108 |
| OK311800000070C | Deer Creek: Greer Co. | 5/16/2000 | 1200 | FC | 400 |
| OK311800000070C | Deer Creek: Greer Co. | 6/20/2000 | 500 | FC | 400 |
| OK311800000070C | Deer Creek: Greer Co. | 8/29/2000 | 170 | FC | 400 |
| OK311800000070C | Deer Creek: Greer Co. | 10/3/2000 | 50 | FC | 2000 |
| OK311800000070C | Deer Creek: Greer Co. | 1/23/2001 | 10 | FC | 2000 |
| OK311800000070C | Deer Creek: Greer Co. | 2/27/2001 | 200 | FC | 2000 |
| OK311800000070C | Deer Creek: Greer Co. | 4/3/2001 | 200 | FC | 2000 |
| OK311800000070C | Deer Creek: Greer Co. | 5/8/2001 | 1500 | FC | 400 |
| OK311800000070C | Deer Creek: Greer Co. | 6/12/2001 | 1300 | FC | 400 |
| OK311800000070C | Deer Creek: Greer Co. | 8/21/2001 | 630 | FC | 400 |
| OK311800000070C | Deer Creek: Greer Co. | 9/25/2001 | 80 | FC | 400 |
| OK311800000070C | Deer Creek: Greer Co. | 10/30/2001 | 60 | FC | 2000 |
| OK311800000070C | Deer Creek: Greer Co. | 10/30/2001 | 80 | FC | 2000 |
| OK311800000070C | Deer Creek: Greer Co. | 8/29/2000 | 20 | EC | 406 |
| OK311800000070C | Deer Creek: Greer Co. | 10/3/2000 | 20 | EC | 2030 |
| OK311800000070C | Deer Creek: Greer Co. | 1/23/2001 | 10 | EC | 2030 |
| OK311800000070C | Deer Creek: Greer Co. | 2/27/2001 | 218 | EC | 2030 |
| OK311800000070C | Deer Creek: Greer Co. | 4/3/2001 | 305 | EC | 2030 |
| OK311800000070C | Deer Creek: Greer Co. | 5/8/2001 | 520 | EC | 406 |
| OK311800000070C | Deer Creek: Greer Co. | 6/12/2001 | 262 | EC | 406 |
| OK311800000070C | Deer Creek: Greer Co. | 7/17/2001 | 160 | EC | 406 |
| OK311800000070C | Deer Creek: Greer Co. | 8/21/2001 | 460 | EC | 406 |
| OK311800000070C | Deer Creek: Greer Co. | 9/25/2001 | 140 | EC | 406 |
| OK311800000070C | Deer Creek: Greer Co. | 10/30/2001 | 80 | EC | 2030 |
| OK311800000070C | Deer Creek: Greer Co. | 8/29/2000 | 170 | ENT | 108 |
| OK311800000070C | Deer Creek: Greer Co. | 10/3/2000 | 180 | ENT | 540 |
| OK311800000070C | Deer Creek: Greer Co. | 1/23/2001 | 20 | ENT | 540 |
| OK311800000070C | Deer Creek: Greer Co. | 2/27/2001 | 700 | ENT | 540 |
| OK311800000070C | Deer Creek: Greer Co. | 4/3/2001 | 200 | ENT | 540 |
| OK311800000070C | Deer Creek: Greer Co. | 5/8/2001 | 3000 | ENT | 108 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311800000070C | Deer Creek: Greer Co. | 6/12/2001 | 700 | ENT | 108 |
| OK311800000070C | Deer Creek: Greer Co. | 7/17/2001 | 42 | ENT | 108 |
| OK311800000070C | Deer Creek: Greer Co. | 8/21/2001 | 205 | ENT | 108 |
| OK311800000070C | Deer Creek: Greer Co. | 9/25/2001 | 60 | ENT | 108 |
| OK311800000070C | Deer Creek: Greer Co. | 10/30/2001 | 770 | ENT | 540 |
| OK311800000070C | Deer Creek: Greer Co. | 10/30/2001 | 160 | ENT | 540 |
| OK311800000130G | Fish Creek | 5/23/2000 | 500 | FC | 400 |
| OK311800000130G | Fish Creek | 6/27/2000 | 300 | FC | 400 |
| OK311800000130G | Fish Creek | 8/1/2000 | 250 | FC | 400 |
| OK311800000130G | Fish Creek | 9/6/2000 | 5000 | FC | 400 |
| OK311800000130G | Fish Creek | 10/10/2000 | 10 | FC | 2000 |
| OK311800000130G | Fish Creek | 11/14/2000 | 20 | FC | 2000 |
| OK311800000130G | Fish Creek | 12/19/2000 | 10 | FC | 2000 |
| OK311800000130G | Fish Creek | 1/30/2001 | 10 | FC | 2000 |
| OK311800000130G | Fish Creek | 3/6/2001 | 40 | FC | 2000 |
| OK311800000130G | Fish Creek | 4/10/2001 | 210 | FC | 2000 |
| OK311800000130G | Fish Creek | 5/14/2001 | 700 | FC | 400 |
| OK311800000130G | Fish Creek | 6/18/2001 | 500 | FC | 400 |
| OK311800000130G | Fish Creek | 7/23/2001 | 25 | FC | 400 |
| OK311800000130G | Fish Creek | 8/28/2001 | 40 | FC | 400 |
| OK311800000130G | Fish Creek | 11/6/2001 | 15 | FC | 2000 |
| OK311800000130G | Fish Creek | 11/6/2001 | 180 | FC | 2000 |
| OK311800000130G | Fish Creek | 8/1/2000 | 95 | EC | 406 |
| OK311800000130G | Fish Creek | 9/6/2000 | 110 | EC | 406 |
| OK311800000130G | Fish Creek | 10/10/2000 | 10 | EC | 2030 |
| OK311800000130G | Fish Creek | 11/14/2000 | 20 | EC | 2030 |
| OK311800000130G | Fish Creek | 12/19/2000 | 20 | EC | 2030 |
| OK311800000130G | Fish Creek | 1/30/2001 | 10 | EC | 2030 |
| OK311800000130G | Fish Creek | 3/6/2001 | 20 | EC | 2030 |
| OK311800000130G | Fish Creek | 4/10/2001 | 242 | EC | 2030 |
| OK311800000130G | Fish Creek | 5/14/2001 | 242 | EC | 406 |
| OK311800000130G | Fish Creek | 6/18/2001 | 63 | EC | 406 |
| OK311800000130G | Fish Creek | 7/23/2001 | 15 | EC | 406 |
| OK311800000130G | Fish Creek | 8/28/2001 | 10 | EC | 406 |
| OK311800000130G | Fish Creek | 11/6/2001 | 15 | EC | 2030 |
| OK311800000130G | Fish Creek | 8/1/2000 | 140 | ENT | 108 |
| OK311800000130G | Fish Creek | 9/6/2000 | 7000 | ENT | 108 |
| OK311800000130G | Fish Creek | 10/10/2000 | 10 | ENT | 540 |
| OK311800000130G | Fish Creek | 11/14/2000 | 3000 | ENT | 540 |
| OK311800000130G | Fish Creek | 12/19/2000 | 90 | ENT | 540 |
| OK311800000130G | Fish Creek | 1/30/2001 | 100 | ENT | 540 |
| OK311800000130G | Fish Creek | 3/6/2001 | 40 | ENT | 540 |
| OK311800000130G | Fish Creek | 4/10/2001 | 60 | ENT | 540 |
| OK311800000130G | Fish Creek | 5/14/2001 | 700 | ENT | 108 |

| WQM Station | Water Body Name | Date | Bacteria Concentration (#/100ml) | Bacteria Indicator | Single Sample Criteria* (#/100) |
|---|---|---|---|---|---|
| OK311800000130G | Fish Creek | 6/18/2001 | 20 | ENT | 108 |
| OK311800000130G | Fish Creek | 7/23/2001 | 25 | ENT | 108 |
| OK311800000130G | Fish Creek | 8/28/2001 | 40 | ENT | 108 |
| OK311800000130G | Fish Creek | 11/6/2001 | 80 | 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 |
|---|---|---|---|---|---|---|
| ALTUS | 11/29/1993 | S11514 | LINE STOPPAGE AT THE PLANT | 500 | STOPPAGE | |
| ALTUS | 8/7/1994 | S11514 | LIFT STATION | 500 | OVERLOAD DUE TO HOLE IN IRRIGATION PIPE | |
| ALTUS | 10/31/1994 | S11514 | AT RECARB BASIN AT PLANT | 15 | WASTE PUMP AT RECYCLE POINT QUIT | |
| ALTUS | 12/13/1994 | S11514 | PUMP STATION AT WEST LAGOON | 500000 | 8 VALVE BROKE | |
| ALTUS | 1/9/1995 | S11514 | SECONDARY CLARIFIER | 500 | SCRAPER BROKE/PUMPED OUT TO REPAIR(STAYED BY PLANT) | |
| ALTUS | 3/23/1995 | S11514 | AT PLANT BY RAILROAD | 9000 | CONTRACTOR WAS INSTALLING A SPLITTER BOX AND EMPTIED WET WELL | |
| ALTUS | 6/3/1995 | S11514 | TREATMENT PLANT | 2600000 | RAIN I/I | |
| ALTUS | 6/15/1995 | S11514 | HOLDING POND | 8000000 | RAIN I/I COULDN'T IRRIGATE | |
| ALTUS | 8/2/1995 | S11514 | CITY WIDE | 0 | RAIN I/I | |
| ALTUS | 10/1/1995 | S11514 | 1604 URANUS | 800 | RAIN I/I | |
| ALTUS | 10/9/1995 | S11514 | LAGOONS | 0 | PLANT DOWN | |
| ALTUS | 10/10/1995 | S11514 | 305 EAST A STREET | 100 | STOPPAGE | |
| ALTUS | 2/21/1996 | S11514 | 1300 N JACKSON | 50 | STOPPAGE | |
| ALTUS | 5/30/1996 | S11514 | 920 EAST SUTERLAND | 150 | LINE STOPPAGE | |
| ALTUS | 10/4/1996 | S11514 | OLD LINE THAT WENT TO THE AIRBASIN (EAST SIDE) | | BACKHOE HIT LINE | |
| ALTUS | 2/27/1997 | S11514 | SPLITTER BOX; S.E. WWTP | 1 | FOAM | |
| ALTUS | 5/14/1997 | S11514 | 602 KATIE DR. | 100 | | |
| ALTUS | 6/2/1997 | S11514 | 600 KATY DR. | 100 | | |
| ALTUS | 11/14/1997 | S11514 | S.E. WWTP | | DESIGN FLAW | |
| ALTUS | 11/18/1997 | S11514 | AIREATOR BASINS EAST | | OVERFLOW | |
| ALTUS | 9/28/1998 | S11514 | WWTP | 75 | | |
| ALTUS | 3/29/1999 | S11514 | CELL #5 | | FULL LAGOONS | |
| ALTUS | 8/1/1999 | S11514 | LINE AT S. PLANT | 94,947 | PUMP FAILURE & LINE BREAK | |
| ALTUS EAST | 10/24/1995 | S11514 | 200 NORTH KELWOOD | 4000 | GREASE BLOCKAGE | |
| ALTUS SW | 5/3/1995 | S11514 | #7 CELL OF LAGOONS | 3000000 | RAIN I/I | |
| ALTUS WEST | 10/31/1995 | S11514 | LAGOON #5 | 1500000 | HYDROLIC OVERLOAD (OPERATION ERROR) | |
| MANGUM | 12/20/1991 | S11607 | OVERFLOW FROM IRRIGATION LAGOON | 5224897 | EXCESSIVE RAINFALL | |
| MANGUM | 1/21/1993 | S11607 | LAGOONS | 11433700 | EXTENDED WET WEATHER | |
| MANGUM | 2/22/1993 | S11607 | FINAL IRRIGATION LAGOON | | RAIN OVERLOAD | |
| MANGUM | 5/9/1993 | S11607 | LAGOONS | 1 | HYDROLIC OVERLOAD FROM I/I | |

| Facility Name | Date | Facility ID | Location | Amount (Gal) | Cause | Type Of Source |
|---|---|---|---|---|---|---|
| MANGUM | 3/8/1994 | S11607 | FINAL LAGOON | 2000000 | HYDROLICC OVERLOAD FROM EXCESSIVE RAINFALL | |
| MANGUM | 6/10/1994 | S11607 | #6 LAGOON | 1 | FAILURE TO USE AS IRRIGATION WATER | |
| MANGUM | 11/28/1995 | S11607 | #5 LAGOON;THROUGH FARMERS FIELD TO DITCHES, THEN TO RIVER | 0 | PUMP LEFT ON ALL NIGHT | |
| MANGUM | 8/28/1996 | S11607 | #6 LAGOON THROUGH FARMER'S FIELD LAND IRRIGATION | 1 | LARGE AMOUNT OF RAIN | |

# APPENDIX C
# ESTIMATED FLOW EXCEEDANCE PERCENTILES

# Appendix C

## Estimated Flow Exceedance Percentiles

| WQ Station | OK311500010020-001AT Red River-North Fork at US 62 | OK311500010050G Stinking Creek | OK311500010110G Tepee Creek | OK311500020040G West Otter Creek† | OK311500030010-001AT Elk Creek | OK311500030040-001AT Little Elk Creek | OK311510010010-001AT Red River-North Fork at SH 34 | OK311510020060G Turkey Creek | OK311600010040-001AT Sandy Creek (Lebos) | OK311600020010-001AT Red River-Salt Fork at SH 34 | OK311600020010-002AT Red River-Salt Fork at US 283 | OK311600020110G Bitter Creek† | OK311600020140G Cave Creek | OK311800000010-001AT Red River-Elm Fork | OK311800000070C Deer Creek | OK311800000130G Fish Creek |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WBID Segment** | OK311500010020_10 | OK311500010050_00 | OK311500010110_00 | OK311500020040_00 | OK311500030010_00 | OK311500030040_00 | OK311510010010_00 | OK311510020060_00 | OK311600010040_00 | OK311600020010_10 | OK311600020010_00 | OK311600020110_00 | OK311600020140_00 | OK311800000010_00 | OK311800000070_00 | OK311800000130_00 |
| **USGS Gage Reference** | 07301500 | 07299670 | 07300500 | 7305500 & 07307010 | 07304500 | 07300500 | 07301500 | 07303400 | 07299710 | 07300500 | 07301110 | 73011100 | 07300500 | 07303500 | 07301420 | 07301420 |
| **Watershed Area (sq. mile)** | 312.3 | 123.3 | 73.5 | 38.3 | 62.5 | 57.2 | 270.1 | 47.5 | 184.6 | 215.8 | 358.3 | 5.1 | 24.5 | 404.5 | 46.2 | 32.4 |
| **NRCS Curve Number** | 70.8 | 73.4 | 79.5 | 77.1 | 76.4 | 76.8 | 65.8 | 64.1 | 72.2 | 66.8 | 73.5 | 78.7 | 69.2 | 69.5 | 71.0 | 69.8 |
| **Average Annual Rainfall (inch)** | 29.8 | 29.3 | 29.1 | 30.3 | 29.4 | 29.2 | 28.1 | 26.3 | 26.7 | 27.4 | 27.7 | 29.2 | 26.7 | 28.0 | 27.2 | 26.3 |
| **Percentile** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** |
| **0** | 41600 | 3319 | 1061 | 1238 | 15200 | 825 | 17300 | 1952 | 3080 | 22600 | 28200 | 7570 | 354 | 15,700 | 82 | 58 |
| **1** | 7848 | 209 | 106 | 169 | 2146 | 82 | 1529 | 82 | 384.68 | 2249 | 3824 | 746 | 35 | 2,512 | 18 | 13 |
| **2** | 4634 | 105 | 55 | 129 | 1400 | 43 | 982 | 51 | 193.84 | 1180 | 2594 | 423 | 18 | 1,530 | 12 | 8.5 |
| **3** | 3380 | 63 | 36 | 85 | 988 | 28 | 727 | 34 | 66.56 | 767 | 1940 | 293 | 12 | 1,146 | 9.9 | 7.0 |
| **4** | 2640 | 39 | 26 | 52 | 709 | 20 | 609 | 25 | 46.68 | 559 | 1438 | 213 | 8.7 | 788 | 8.2 | 5.7 |
| **5** | 2180 | 29 | 20 | 40 | 543 | 16 | 510 | 20 | 28.6 | 427 | 1210 | 169 | 6.7 | 601 | 7.4 | 5.2 |
| **6** | 1751 | 24 | 16 | 28 | 431 | 13 | 458 | 17 | 18 | 343 | 1022 | 138 | 5.4 | 475 | 6.8 | 4.8 |
| **7** | 1470 | 20 | 13 | 16 | 330 | 10 | 410 | 15 | 13 | 285 | 824 | 117 | 4.5 | 400 | 6.1 | 4.3 |
| **8** | 1190 | 18 | 11 | 12 | 266 | 8.9 | 371 | 12 | 11 | 244 | 696 | 100 | 3.8 | 340 | 5.6 | 3.9 |
| **9** | 1020 | 16 | 10 | 9.9 | 224 | 7.8 | 334 | 11 | 10 | 213 | 623 | 88 | 3.3 | 289 | 5.1 | 3.7 |
| **10** | 887 | 15 | 8.7 | 8.5 | 194 | 6.8 | 305 | 9.9 | 10 | 186 | 547 | 79 | 2.9 | 240 | 4.8 | 3.4 |
| **11** | 798 | 14 | 7.8 | 8.1 | 171 | 6.1 | 287 | 8.9 | 9.8 | 167 | 500 | 71 | 2.6 | 209 | 4.5 | 3.1 |
| **12** | 705 | 13 | 7.0 | 7.2 | 154 | 5.4 | 275 | 8.2 | 9.6 | 149 | 469 | 64 | 2.3 | 190 | 4.2 | 3.0 |
| **13** | 632 | 13 | 6.1 | 6.3 | 137 | 4.7 | 258 | 7.4 | 9.5 | 130 | 427 | 58 | 2.0 | 168 | 4.0 | 2.8 |
| **14** | 562 | 12 | 5.4 | 5.5 | 123 | 4.2 | 242 | 6.8 | 9.3 | 116 | 389 | 54 | 1.8 | 155 | 3.8 | 2.7 |
| **15** | 514 | 11 | 4.9 | 5.0 | 111 | 3.8 | 229 | 6.4 | 9.3 | 105 | 356 | 51 | 1.6 | 143 | 3.6 | 2.5 |
| **16** | 467 | 11 | 4.5 | 4.3 | 101 | 3.5 | 213 | 5.9 | 9.3 | 95 | 327 | 47 | 1.5 | 131 | 3.4 | 2.4 |
| **17** | 428 | 11 | 4.1 | 3.8 | 92 | 3.2 | 203 | 5.6 | 9.1 | 88 | 302 | 45 | 1.4 | 120 | 3.3 | 2.3 |
| **18** | 394 | 10 | 3.8 | 3.6 | 85 | 2.9 | 192 | 5.2 | 9.1 | 80 | 280 | 42 | 1.3 | 112 | 3.2 | 2.2 |
| **19** | 367 | 9.7 | 3.5 | 3.5 | 77 | 2.7 | 179 | 4.8 | 8.9 | 75 | 260 | 39 | 1.2 | 105 | 3.1 | 2.1 |
| **20** | 340 | 9.7 | 3.2 | 3.4 | 71 | 2.5 | 167 | 4.6 | 8.9 | 69 | 243 | 37 | 1.1 | 98 | 2.8 | 2.0 |
| **21** | 314 | 9.3 | 3.0 | 3.2 | 67 | 2.3 | 158 | 4.3 | 8.6 | 64 | 226 | 35 | 1.0 | 90 | 2.7 | 1.9 |
| **22** | 293 | 8.9 | 2.8 | 3.1 | 63 | 2.2 | 150 | 4.0 | 8.4 | 59 | 213 | 33 | 0.92 | 85 | 2.6 | 1.8 |
| **23** | 277 | 8.9 | 2.6 | 3.0 | 59 | 2.0 | 142 | 3.9 | 8.1 | 56 | 203 | 32 | 0.88 | 79 | 2.6 | 1.8 |
| **24** | 260 | 8.8 | 2.4 | 2.9 | 55 | 1.9 | 135 | 3.7 | 7.7 | 52 | 197 | 31 | 0.81 | 74 | 2.5 | 1.8 |
| **25** | 245 | 8.5 | 2.3 | 2.8 | 52 | 1.8 | 127 | 3.5 | 7.4 | 49 | 186 | 29 | 0.77 | 70 | 2.4 | 1.7 |
| **26** | 229 | 8.5 | 2.1 | 2.7 | 50 | 1.6 | 119 | 3.4 | 7.2 | 45 | 180 | 28 | 0.72 | 67 | 2.3 | 1.6 |
| **27** | 217 | 8.1 | 2.0 | 2.6 | 46 | 1.5 | 113 | 3.3 | 7.1 | 42 | 171 | 27 | 0.66 | 64 | 2.3 | 1.6 |
| **28** | 205 | 7.7 | 1.9 | 2.5 | 44 | 1.5 | 107 | 3.2 | 6.9 | 40 | 164 | 26 | 0.63 | 60 | 2.2 | 1.5 |
| **29** | 197 | 7.2 | 1.7 | 2.4 | 42 | 1.4 | 103 | 3.1 | 6.8 | 37 | 154 | 25 | 0.58 | 58 | 2.1 | 1.5 |
| **30** | 185 | 7.2 | 1.6 | 2.4 | 40 | 1.3 | 98 | 3.0 | 6.6 | 35 | 148 | 24 | 0.55 | 54 | 2.1 | 1.5 |
| **31** | 177 | 7.2 | 1.5 | 2.3 | 38 | 1.2 | 94 | 2.9 | 6.5 | 33 | 143 | 23 | 0.52 | 51 | 2.0 | 1.4 |
| **32** | 168 | 6.8 | 1.5 | 2.3 | 36 | 1.1 | 91 | 2.7 | 6.3 | 31 | 138 | 23 | 0.48 | 50 | 2.0 | 1.4 |

| WQ Station | OK311500010020-001AT Red River-North Fork at US 62 | OK311500010050G Stinking Creek | OK311500010110G Tepee Creek | OK311500020040G West Otter Creek† | OK311500030010-001AT Elk Creek | OK311500030040-001AT Little Elk Creek | OK311510010010-001AT Red River-North Fork at SH 34 | OK311510020060G Turkey Creek | OK311600010040-001AT Sandy Creek (Lebos) | OK311600020010-001AT Red River-Salt Fork at SH 34 | OK311600020010-002AT Red River-Salt Fork at US 283 | OK311600020110G Bitter Creek† | OK311600020140G Cave Creek | OK311800000010-001AT Red River-Elm Fork | OK311800000070C Deer Creek | OK311800000130G Fish Creek |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WBID Segment** | OK311500010020_10 | OK311500010050_00 | OK311500010110_00 | OK311500020040_00 | OK311500030010_00 | OK311500030040_00 | OK311510010010_00 | OK311510020060_00 | OK311600010040_00 | OK311600020010_10 | OK311600020010_00 | OK311600020110_00 | OK311600020140_00 | OK311800000010_00 | OK311800000070_00 | OK311800000130_00 |
| **USGS Gage Reference** | 07301500 | 07299670 | 07300500 | 7305500 & 07307010 | 07304500 | 07300500 | 07301500 | 07303400 | 07299710 | 07300500 | 07301110 | 73011100 | 07300500 | 07303500 | 07301420 | 07301420 |
| **Watershed Area (sq. mile)** | 312.3 | 123.3 | 73.5 | 38.3 | 62.5 | 57.2 | 270.1 | 47.5 | 184.6 | 215.8 | 358.3 | 5.1 | 24.5 | 404.5 | 46.2 | 32.4 |
| **NRCS Curve Number** | 70.8 | 73.4 | 79.5 | 77.1 | 76.4 | 76.8 | 65.8 | 64.1 | 72.2 | 66.8 | 73.5 | 78.7 | 69.2 | 69.5 | 71.0 | 69.8 |
| **Average Annual Rainfall (inch)** | 29.8 | 29.3 | 29.1 | 30.3 | 29.4 | 29.2 | 28.1 | 26.3 | 26.7 | 27.4 | 27.7 | 29.2 | 26.7 | 28.0 | 27.2 | 26.3 |
| **Percentile** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** |
| **33** | 159 | 6.8 | 1.4 | 2.2 | 35 | 1.1 | 88 | 2.6 | 6.3 | 29 | 132 | 22 | 0.45 | 48 | 1.9 | 1.4 |
| **34** | 150 | 6.4 | 1.3 | 2.1 | 34 | 1.0 | 85 | 2.5 | 6.1 | 27 | 126 | 21 | 0.42 | 46 | 1.9 | 1.3 |
| **35** | 143 | 6.4 | 1.2 | 2.0 | 33 | 0.95 | 81 | 2.4 | 6.1 | 26 | 122 | 20 | 0.41 | 44 | 1.9 | 1.3 |
| **36** | 135 | 6.4 | 1.1 | 1.9 | 31 | 0.88 | 77 | 2.3 | 6.1 | 24 | 117 | 20 | 0.38 | 42 | 1.7 | 1.2 |
| **37** | 130 | 6.0 | 1.0 | 1.9 | 30 | 0.80 | 73 | 2.3 | 6.1 | 22 | 113 | 19 | 0.34 | 40 | 1.7 | 1.2 |
| **38** | 125 | 6.0 | 1.0 | 1.8 | 29 | 0.77 | 70 | 2.2 | 6.0 | 21 | 109 | 18 | 0.33 | 38 | 1.6 | 1.1 |
| **39** | 119 | 5.6 | 0.89 | 1.7 | 28 | 0.69 | 67 | 2.2 | 6.0 | 19 | 106 | 18 | 0.30 | 37 | 1.6 | 1.1 |
| **40** | 113 | 5.6 | 0.84 | 1.6 | 26 | 0.66 | 65 | 2.1 | 6.0 | 18 | 103 | 17 | 0.28 | 36 | 1.5 | 1.1 |
| **41** | 109 | 5.6 | 0.80 | 1.6 | 26 | 0.62 | 62 | 2.1 | 6.0 | 17 | 101 | 17 | 0.27 | 35 | 1.5 | 1.1 |
| **42** | 105 | 5.5 | 0.70 | 1.4 | 25 | 0.55 | 61 | 1.9 | 5.8 | 15 | 99 | 16 | 0.23 | 33 | 1.4 | 0.99 |
| **43** | 101 | 5.4 | 0.66 | 1.4 | 23 | 0.51 | 58 | 1.8 | 5.8 | 14 | 96 | 16 | 0.22 | 31 | 1.4 | 0.99 |
| **44** | 98 | 5.3 | 0.61 | 1.2 | 22 | 0.47 | 56 | 1.8 | 5.7 | 13 | 95 | 15 | 0.20 | 30 | 1.4 | 0.99 |
| **45** | 94 | 5.2 | 0.52 | 1.0 | 21 | 0.40 | 53 | 1.7 | 5.5 | 11 | 93 | 15 | 0.17 | 29 | 1.3 | 0.92 |
| **46** | 90 | 5.1 | 0.47 | 0.90 | 20 | 0.37 | 52 | 1.7 | 5.4 | 10 | 91 | 14 | 0.16 | 28 | 1.3 | 0.92 |
| **47** | 85 | 5.0 | 0.43 | 0.86 | 19 | 0.34 | 49 | 1.7 | 5.4 | 9.2 | 89 | 14 | 0.15 | 26 | 1.3 | 0.92 |
| **48** | 82 | 5.0 | 0.39 | 0.81 | 18 | 0.31 | 47 | 1.6 | 5.4 | 8.4 | 87 | 13 | 0.13 | 25 | 1.2 | 0.84 |
| **49** | 78 | 4.9 | 0.36 | 0.77 | 17 | 0.28 | 45 | 1.6 | 5.2 | 7.6 | 85 | 13 | 0.12 | 24 | 1.2 | 0.84 |
| **50** | 75 | 4.8 | 0.32 | 0.63 | 17 | 0.25 | 43 | 1.5 | 5.2 | 6.8 | 83 | 12 | 0.11 | 24 | 1.2 | 0.84 |
| **51** | 72 | 4.7 | 0.28 | 0.61 | 16 | 0.22 | 41 | 1.5 | 5.2 | 6.0 | 80 | 12 | 0.09 | 22 | 1.1 | 0.76 |
| **52** | 70 | 4.6 | 0.24 | 0.50 | 15 | 0.19 | 39 | 1.5 | 5.2 | 5.2 | 79 | 12 | 0.08 | 21 | 1.1 | 0.76 |
| **53** | 66 | 4.6 | 0.22 | 0.45 | 14 | 0.17 | 37 | 1.4 | 5.0 | 4.6 | 77 | 11 | 0.07 | 20 | 1.1 | 0.74 |
| **54** | 64 | 4.5 | 0.19 | 0.39 | 14 | 0.15 | 35 | 1.4 | 4.9 | 4.0 | 75 | 11 | 0.06 | 20 | 1.0 | 0.72 |
| **55** | 62 | 4.4 | 0.16 | 0.36 | 13 | 0.12 | 33 | 1.4 | 4.8 | 3.4 | 74 | 10 | 0.05 | 19 | 0.97 | 0.68 |
| **56** | 60 | 4.3 | 0.14 | 0.33 | 13 | 0.11 | 32 | 1.3 | 4.6 | 3.0 | 72 | 9.9 | 0.05 | 18 | 0.93 | 0.65 |
| **57** | 57 | 4.2 | 0.12 | 0.28 | 12 | 0.09 | 30 | 1.3 | 4.6 | 2.6 | 70 | 9.2 | 0.04 | 17 | 0.87 | 0.61 |
| **58** | 55 | 4.1 | 0.10 | 0.22 | 11 | 0.08 | 28 | 1.3 | 4.4 | 2.2 | 68 | 8.9 | 0.03 | 16 | 0.82 | 0.57 |
| **59** | 52 | 4.0 | 0.08 | 0.18 | 11 | 0.07 | 27 | 1.3 | 4.4 | 1.8 | 66 | 8.6 | 0.03 | 15 | 0.77 | 0.54 |
| **60** | 50 | 3.9 | 0.07 | 0.15 | 10 | 0.05 | 26 | 1.1 | 4.3 | 1.5 | 64 | 8.3 | 0.02 | 15 | 0.71 | 0.50 |
| **61** | 48 | 3.9 | 0.06 | 0.11 | 10 | 0.04 | 25 | 1.1 | 4.3 | 1.2 | 63 | 7.9 | 0.02 | 14 | 0.66 | 0.46 |
| **62** | 45 | 3.8 | 0.04 | 0.06 | 9.5 | 0.03 | 23 | 1.1 | 4.3 | 0.90 | 61 | 7.8 | 0.01 | 14 | 0.62 | 0.43 |
| **63** | 44 | 3.7 | 0.03 | 0.04 | 9.1 | 0.02 | 21 | 1.1 | 4.2 | 0.64 | 59 | 7.6 | 0.01 | 13 | 0.58 | 0.40 |
| **64** | 42 | 3.7 | 0.02 | 0.01 | 8.6 | 0.02 | 19 | 1.1 | 4.2 | 0.48 | 57 | 7.3 | 0.01 | 12 | 0.53 | 0.37 |
| **65** | 40 | 3.6 | 0.01 | 0 | 8.0 | 0.01 | 18 | 1.0 | 4.2 | 0.30 | 55 | 6.9 | 0.005 | 12 | 0.50 | 0.35 |
| **66** | 38 | 3.5 | 0.01 | 0 | 7.6 | 0.01 | 16 | 1.0 | 4.0 | 0.17 | 54 | 6.6 | 0.003 | 11 | 0.47 | 0.33 |
| **67** | 37 | 3.4 | 0.004 | 0 | 7.1 | 0.003 | 15 | 0.96 | 3.9 | 0.08 | 52 | 6.5 | 0.001 | 11 | 0.44 | 0.31 |
| **68** | 35 | 3.3 | 0 | 0 | 6.7 | 0 | 13 | 0.94 | 3.9 | 0 | 49 | 6.3 | 0 | 10 | 0.40 | 0.28 |

| WQ Station | OK311500010020-001AT<br>**Red River-North Fork at US 62** | OK311500010050G<br>**Stinking Creek** | OK311500010110G<br>**Tepee Creek** | OK311500020040G<br>**West Otter Creek†** | OK311500030010-001AT<br>**Elk Creek** | OK311500030040-001AT<br>**Little Elk Creek** | OK311510010010-001AT<br>**Red River-North Fork at SH 34** | OK311510020060G<br>**Turkey Creek** | OK311600010040-001AT<br>**Sandy Creek (Lebos)** | OK311600020010-001AT<br>**Red River-Salt Fork at SH 34** | OK311600020010-002AT<br>**Red River-Salt Fork at US 283** | OK311600020110G<br>**Bitter Creek†** | OK311600020140G<br>**Cave Creek** | OK311800000010-001AT<br>**Red River-Elm Fork** | OK311800000070C<br>**Deer Creek** | OK311800000130G<br>**Fish Creek** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WBID Segment** | OK311500010020_10 | OK311500010050_00 | OK311500010110_00 | OK311500020040_00 | OK311500030010_00 | OK311500030040_00 | OK311510010010_00 | OK311510020060_00 | OK311600010040_00 | OK311600020010_10 | OK311600020010_00 | OK311600020110_00 | OK311600020140_00 | OK311800000010_00 | OK311800000070_00 | OK311800000130_00 |
| **USGS Gage Reference** | 07301500 | 07299670 | 07300500 | 7305500 & 07307010 | 07304500 | 07300500 | 07301500 | 07303400 | 07299710 | 07300500 | 07301110 | 73011100 | 07300500 | 07303500 | 07301420 | 07301420 |
| **Watershed Area (sq. mile)** | 312.3 | 123.3 | 73.5 | 38.3 | 62.5 | 57.2 | 270.1 | 47.5 | 184.6 | 215.8 | 358.3 | 5.1 | 24.5 | 404.5 | 46.2 | 32.4 |
| **NRCS Curve Number** | 70.8 | 73.4 | 79.5 | 77.1 | 76.4 | 76.8 | 65.8 | 64.1 | 72.2 | 66.8 | 73.5 | 78.7 | 69.2 | 69.5 | 71.0 | 69.8 |
| **Average Annual Rainfall (inch)** | 29.8 | 29.3 | 29.1 | 30.3 | 29.4 | 29.2 | 28.1 | 26.3 | 26.7 | 27.4 | 27.7 | 29.2 | 26.7 | 28.0 | 27.2 | 26.3 |
| **Percentile** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** | **Q (cfs)** |
| **69** | 33 | 3.3 | 0 | 0 | 6.2 | 0 | 12 | 0.90 | 3.8 | 0 | 48 | 5.9 | 0 | 10 | 0.37 | 0.26 |
| **70** | 32 | 3.3 | 0 | 0 | 5.8 | 0 | 11 | 0.87 | 3.6 | 0 | 47 | 5.6 | 0 | 9.0 | 0.36 | 0.24 |
| **71** | 30 | 3.2 | 0 | 0 | 5.4 | 0 | 9.2 | 0.84 | 3.6 | 0 | 45 | 5.4 | 0 | 8.6 | 0.34 | 0.24 |
| **72** | 28 | 3.1 | 0 | 0 | 5.0 | 0 | 8.2 | 0.81 | 3.5 | 0 | 43 | 5.3 | 0 | 8.0 | 0.32 | 0.22 |
| **73** | 27 | 3.0 | 0 | 0 | 4.6 | 0 | 7.5 | 0.78 | 3.5 | 0 | 40 | 5.0 | 0 | 7.7 | 0.31 | 0.21 |
| **74** | 25 | 3.0 | 0 | 0 | 4.1 | 0 | 6.8 | 0.75 | 3.4 | 0 | 39 | 4.6 | 0 | 7.0 | 0.28 | 0.20 |
| **75** | 23 | 2.9 | 0 | 0 | 3.7 | 0 | 6.1 | 0.72 | 3.4 | 0 | 37 | 4.3 | 0 | 6.8 | 0.26 | 0.18 |
| **76** | 22 | 2.8 | 0 | 0 | 3.5 | 0 | 5.6 | 0.68 | 3.3 | 0 | 35 | 4.3 | 0 | 6.0 | 0.24 | 0.17 |
| **77** | 21 | 2.8 | 0 | 0 | 3.2 | 0 | 5.1 | 0.66 | 3.3 | 0 | 33 | 4.0 | 0 | 5.8 | 0.23 | 0.16 |
| **78** | 19 | 2.7 | 0 | 0 | 2.9 | 0 | 4.7 | 0.62 | 3.1 | 0 | 31 | 3.8 | 0 | 5.2 | 0.21 | 0.15 |
| **79** | 18 | 2.7 | 0 | 0 | 2.6 | 0 | 4.0 | 0.59 | 3.0 | 0 | 29 | 3.6 | 0 | 4.9 | 0.20 | 0.14 |
| **80** | 16 | 2.6 | 0 | 0 | 2.4 | 0 | 3.5 | 0.54 | 3.0 | 0 | 27 | 3.3 | 0 | 4.5 | 0.17 | 0.12 |
| **81** | 15 | 2.6 | 0 | 0 | 2.1 | 0 | 3.0 | 0.50 | 2.9 | 0 | 26 | 3.3 | 0 | 4.1 | 0.15 | 0.11 |
| **82** | 13 | 2.5 | 0 | 0 | 2.0 | 0 | 2.6 | 0.47 | 2.7 | 0 | 24 | 3.0 | 0 | 3.8 | 0.13 | 0.09 |
| **83** | 12 | 2.4 | 0 | 0 | 1.7 | 0 | 2.2 | 0.41 | 2.7 | 0 | 23 | 2.8 | 0 | 3.4 | 0.13 | 0.08 |
| **84** | 11 | 2.4 | 0 | 0 | 1.5 | 0 | 2.0 | 0.39 | 2.6 | 0 | 21 | 2.6 | 0 | 3.0 | 0.12 | 0.08 |
| **85** | 9.8 | 2.3 | 0 | 0 | 1.2 | 0 | 1.5 | 0.35 | 2.4 | 0 | 19 | 2.4 | 0 | 2.8 | 0.11 | 0.07 |
| **86** | 8.7 | 2.2 | 0 | 0 | 1.0 | 0 | 1.0 | 0.31 | 2.3 | 0 | 18 | 2.3 | 0 | 2.4 | 0.10 | 0.07 |
| **87** | 7.5 | 2.2 | 0 | 0 | 0.81 | 0 | 0.50 | 0.27 | 2.2 | 0 | 17 | 2.0 | 0 | 2.2 | 0.09 | 0.06 |
| **88** | 6.5 | 2.1 | 0 | 0 | 0.60 | 0 | 0.14 | 0.25 | 2.1 | 0 | 15 | 1.8 | 0 | 2.0 | 0.08 | 0.06 |
| **89** | 5.8 | 2.1 | 0 | 0 | 0.42 | 0 | 0 | 0.23 | 2.0 | 0 | 14 | 1.6 | 0 | 1.8 | 0.08 | 0.06 |
| **90** | 4.9 | 2.0 | 0 | 0 | 0.30 | 0 | 0 | 0.19 | 1.9 | 0 | 12 | 1.3 | 0 | 1.5 | 0.07 | 0.05 |
| **91** | 3.8 | 2.0 | 0 | 0 | 0.20 | 0 | 0 | 0.16 | 1.8 | 0 | 11 | 1.0 | 0 | 1.2 | 0.07 | 0.05 |
| **92** | 2.9 | 1.9 | 0 | 0 | 0.10 | 0 | 0 | 0.13 | 1.7 | 0 | 9.9 | 0.82 | 0 | 1.0 | 0.06 | 0.04 |
| **93** | 1.9 | 1.8 | 0 | 0 | 0 | 0 | 0 | 0.10 | 1.6 | 0 | 9.0 | 0.59 | 0 | 0.76 | 0.05 | 0.04 |
| **94** | 0.90 | 1.8 | 0 | 0 | 0 | 0 | 0 | 0.08 | 1.4 | 0 | 8.1 | 0 | 0 | 0.50 | 0.05 | 0.03 |
| **95** | 0.30 | 1.7 | 0 | 0 | 0 | 0 | 0 | 0.06 | 1.3 | 0 | 7.0 | 0 | 0 | 0.30 | 0.04 | 0.03 |
| **96** | 0.10 | 1.6 | 0 | 0 | 0 | 0 | 0 | 0.05 | 1.1 | 0 | 6.2 | 0 | 0 | 0.10 | 0.03 | 0.02 |
| **97** | 0 | 1.6 | 0 | 0 | 0 | 0 | 0 | 0.04 | 1.1 | 0 | 5.1 | 0 | 0 | 0 | 0.02 | 0.01 |
| **98** | 0 | 1.5 | 0 | 0 | 0 | 0 | 0 | 0.03 | 0.90 | 0 | 3.4 | 0 | 0 | 0 | 0.02 | 0.01 |
| **99** | 0 | 1.5 | 0 | 0 | 0 | 0 | 0 | 0.02 | 0.61 | 0 | 2.0 | 0 | 0 | 0 | 0.01 | 0.005 |
| **100** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.002 | 0.50 | 0 | 0.08 | 0 | 0 | 0 | 0 | 0 |

† incremental watershed area below other gages

# 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.

# APPENDIX E
# STORM WATER PERMITTING REQUIREMENTS AND PRESUMPTIVE BEST MANAGEMENT PRACTICES (BMPS) APPROACH

# Appendix E

## Storm water permitting Requirements and Presumptive Best Management practices (BMP) Approach

## A. BACKGROUND

The National Pollutant Discharge Elimination System (NPDES) permitting program for stormwater discharges was established under the Clean Water Act as the result of a 1987 amendment. The Act specifies the level of control to be incorporated into the NPDES stormwater permitting program depending on the source (industrial versus municipal stormwater). These programs contain specific requirements for the regulated communities/facilities to establish a comprehensive stormwater management program (SWMP) or storm water pollution prevention plan (SWPPP) to implement any requirements of the total maximum daily load (TMDL) allocation. [See 40 CFR §130.]

Storm water discharges are highly variable both in terms of flow and pollutant concentration, and the relationships between discharges and water quality can be complex. For municipal stormwater discharges in particular, the current use of system-wide permits and a variety of jurisdiction-wide BMPs, including educational and programmatic BMPs, does not easily lend itself to the existing methodologies for deriving numeric water quality-based effluent limitations. These methodologies were designed primarily for process wastewater discharges which occur at predictable rates with predictable pollutant loadings under low flow conditions in receiving waters.

EPA has recognized these problems and developed permitting guidance for stormwater permits. [See "Interim Permitting Approach for Water Quality-Based Effluent Limitations in Stormwater Permits" (EPA-833-D-96-00, Date published: 09/01/1996)] Due to the nature of storm water discharges, and the typical lack of information on which to base numeric water quality-based effluent limitations (expressed as concentration and mass), EPA recommends an interim permitting approach for NPDES storm water permits which is based on BMPs. "The interim permitting approach uses best management practices (BMPs) in first-round storm water permits, and expanded or better-tailored BMPs in subsequent permits, where necessary, to provide for the attainment of water quality standards." (*ibid.*)

A monitoring component is also included in the recommended BMP approach. "Each storm water permit should include a coordinated and cost-effective monitoring program to gather necessary information to determine the extent to which the permit provides for attainment of applicable water quality standards and to determine the appropriate conditions or limitations for subsequent permits." (*ibid.*)

This approach was further elaborated in a guidance memo issued in 2002. [See Memorandum from Robert Wayland, Director of OWOW and James Hanlon, Director of OWM to Regional Water Division Directors: "Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit requirements Based on Those WLAs " (Date published: 11/22/2002)] "The policy outlined in this memorandum affirms the appropriateness of an iterative, adaptive management BMP approach, whereby permits include effluent limits (e.g., a combination of structural and non-structural BMPs) that address storm water discharges, implement mechanisms to evaluate the performance of such controls, and make adjustments (i.e., more stringent controls or specific

BMPs) as necessary to protect water quality. …… If it is determined that a BMP approach (including an iterative BMP approach) is appropriate to meet the storm water component of the TMDL, EPA recommends that the TMDL reflect this.” This TMDL adopts the EPA recommended approach and relies on appropriate BMPs for implementation. No numeric effluent limitations are required or anticipated for municipal stormwater discharge permits.

## B. SPECIFIC SWMP/SWPPP REQUIREMENTS

As noted in Section 3 of this report, Oklahoma Pollutant Discharge Elimination System (OPDES)-permitted facilities and non-point sources (e.g., wildlife, agricultural activities and domesticated animals, land application fields, urban runoff, failing onsite wastewater disposal system, and domestic pets) could contribute to exceedances of the water quality criteria. In particular, stormwater runoff from the Phase 1 and 2 municipal separate storm sewer systems (MS4s) is likely to contain elevated bacteria concentrations. Permits for these discharges must comply with the provisions of this TMDL. Table E-1 provides a list of Phase 1 and 2 MS4s that are affected by this bacteria TMDL report.

Agricultural activities and other nonpoint sources of bacteria are unregulated. Voluntary measures and incentives should be used and encouraged wherever possible and such sources should strive to attain the reduction goals established in this TMDL.

The provisions of this appendix apply only to OPDES/NPDES regulated stormwater discharges. 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.

**Table E-1. MS4 Permits affected by this bacteria TMDL Report**

| ENTITIES | PHASE 1 OR PHASE 2 MS4 | DATE ISSUED | NOTES |
|---|---|---|---|
| Altus, City of | Phase 2 MS4 | 08/19/05 | |

To ensure compliance with the TMDL requirements under the permit, stormwater permittees must develop strategies designed to achieve progress toward meeting the reduction goals established in the TMDL. Relying primarily upon a Best Management Practices (BMP) approach, permittees should take advantage of existing information on BMP performance and select a suite of BMPs appropriate to the local community that are expected to result in progress toward meeting the reduction goals established in the TMDL. The permittee should provide guidance on BMP installation and maintenance, as well as a monitoring and/or inspection schedule.

Table E–2 provides a summary description of some BMPs with reported effectiveness in reducing bacteria. Permittees may choose different BMPs to meet the permit requirements, as long as the permittees demonstrate that these practices will result in progress toward attaining water quality standards.

As noted above, when a BMP approach is selected a coordinated monitoring program is necessary to establish the effectiveness of the selected BMPs and demonstrate progress toward attaining water quality standards. The monitoring results should be used to refine bacteria controls in the future. Individual permittees could participate in a coordinated program if there is one in the area or they could develop their own program.

After EPA approval of the final TMDL, existing small MS4 permittees will be notified of the TMDL provisions and schedule. The re-issued permit will contain general provisions addressing this TMDL. Industrial stormwater permittees are not expected to be a significant source of bacteria but if any are identified, similar actions will be required. Compliance with the following provisions will constitute compliance with the requirements of this TMDL.

**1. Develop A Bacteria Reduction Plan**

Permittees shall submit an approvable Bacteria Reduction Plan to the DEQ within 12 months of notification. Unless disapproved by the Director within 60 days of submission, the plan shall be approved then implemented by the permittee. This plan shall, at a minimum, include the following:

a. Consideration of ordinances or other regulatory mechanisms to require bacteria pollution control, as well enforcement procedures for noncompliance;
b. Evaluation of the existing SWMP in relation to TMDL reduction goals;
c. Educational programs directed at reducing bacterial pollution;
d. Investigation and implementation of BMPs that prevent additional storm water bacteria pollution associated with new development and re-development;
e. Implementation of BMPs applicable to bacteria. Table E-2 below presents summary information on some BMPs that should be considered. Permittees are not limited to BMPs on this list and should select BMPs appropriate to the local community that are expected to meet all or part of the reduction goals established in the TMDL.
f. Modifications to the dry weather field screening and illicit discharge detection and elimination provisions of the SWMP to consider storm water sampling and other measures intended to specifically identify bacterial pollution sources and high priority areas for bacteria reductions.
g. Periodic evaluation of the effectiveness of the bacteria reduction plan to ensure progress toward attainment of water quality standards.
h. An implementation schedule leading to modification of the SWMP and full implementation of the plan within 3 years of notification.

**2. Develop Or Participate In A Bacteria Monitoring Program**

Permittees may participate in a coordinated regional bacteria monitoring program or develop their own individual program. The monitoring program should be designed to establish the effectiveness of the selected BMPs and demonstrate progress toward the reduction goals of the TMDL and eventual attainment of water quality standards.

a. Within 18 months of notification, the permittee shall prepare and submit to the DEQ either a TMDL monitoring schedule or a commitment to participate in a coordinated regional monitoring program. The schedule or program shall include:

   (1) A detailed description of the goals, monitoring, and sampling and analytical methods;

   (2) A list and map of the selected TMDL monitoring sites;

   (3) The frequency of data collection to occur at each station or site;

   (4) The parameters to be measured, as appropriate for and relevant to the TMDL;

   (5) A Quality Assurance Project Plan that complies with EPA requirements [EPA Requirements for QA Project Plans (QA/R-5)]

b. The monitoring program shall be fully implemented within 3 years of notification.

**3. Annual Reporting**

The permittee shall include a TMDL implementation report as part of their annual report. The TMDL report shall include the status and actions taken by the permittee to implement the TMDL. The TMDL report shall document relevant actions taken by the permittee that affect MS4 storm water discharges to the waterbody segment that is the subject of the TMDL. This TMDL report also shall identify the status of any applicable TMDL implementation schedule milestones.

## Table F–2. Some BMPs Applicable to Bacteria

| BEST MANAGEMENT PRACTICE | IMPAIRMENT SOURCE | | REPORTED EFFICIENCY | NOTE |
|---|---|---|---|---|
| | AGRICULTURE | URBAN | | |
| **Animal waste management**: A planned system designed to manage liquid and solid waste from livestock and poultry. It improves water quality by storing and spreading waste at the proper time, rate and location. | X | | 75 %[1] | |
| **Artificial wetland/rock reed microbial filter**: Long shallow hydroponic plant/rock filter system that treats polluted waste and wastewater. It combines horizontal and vertical flow of water through the filter ( filled with aquatic and semi-aquatic plants and microorganisms) and provides a high surface area of support media, such as rocks or crushed stone. | X | X | | |
| **Compost facility**: Treating organic agricultural wastes in order to reduce the pollution potential to surface and ground water. The composting facility must be constructed, operated and maintained without polluting air and/or water resources. | X | X | | DEQ permit needed |
| **Conservation landscaping**: The placement of vegetation in and around stormwater management BMPs. Its purpose is to help stabilize disturbed areas, enhance the pollutant removal capabilities of storm water BMP, and improve the overall aesthetics of a storm water BMP. | | X | | |
| **Detention pond/basin**: Detention ponds/basins maintain a permanent pool of water in addition to temporarily detaining storm water. The permanent pool of water enhances the removal of many pollutants. These ponds fill with stormwater and release most of it over a period of a few days, slowly returning to its normal depth of water. | X | X | 25 %[1], 40%[2], 51%[3] | |
| **Diversions/earthen embankments**: 1). Diversions -Establishing a channel with a supporting ridge on the lower side constructed along the general land slope which improves water quality by directing nutrient and sediment laden water to sites where it can be used or disposed of safely. 2). Earthen embankment- A raised impounding structure made from compacted soil. It is appropriate for use with infiltration, detention, | X | X | | |

| BEST MANAGEMENT PRACTICE | IMPAIRMENT SOURCE | | REPORTED EFFICIENCY | NOTE |
|---|---|---|---|---|
| | AGRICULTURE | URBAN | | |
| extended-detention or retention facilities. | | | | |
| **Drain Inlet Inserts**: A proprietary BMP that is generally easily installed in a drain inlet or catch basin to treat storm water runoff. Three basic types of inlet insert are available, the tray type, bag type and basket type. The tray type allows flow to pass through filter media residing in a tray located around the perimeter of the inlet. | | X | 5%[2] | |
| **Drip irrigation**: An irrigation method that supplies a slow, even application of low-pressure water through polyethylene tubing running from supply line directly to a plant's base. Water soaks into the soil gradually, reducing runoff and evaporation (i.e., salinity). Transmission of nutrients and pathogens spread by splashing water and wet foliage created by overhead sprinkler irrigation is greatly reduced. Weed growth is minimized, thereby reducing herbicide applications. Vegetable farming and virtually every type of landscape situation can benefit from the use of drip irrigation. | X | X | | |
| **Fencing**: A constructed barrier to livestock, wildlife or people. Standard or conventional (barbed or smooth wire), suspension, woven wire, or electric fences shall consist of acceptable fencing designs to control the animal(s) or people of concern and meet the intended life of the practice. | X | | 75 %[1] | |
| **Filtration (e.g., sand filters)**: Intermittent sand filters capture, pre-treat to remove sediments, store while awaiting treatment, and treat to remove pollutants (by percolation through sand media) the most polluted stormwater from a site. Intermittent sand filter BMPs may be constructed in underground vaults, in paved trenches within or at the perimeter of impervious surfaces, or in either earthen or concrete open basins. | X | X | 30 %[1], 55%[2], 51%[3] | |
| **Infiltration Basin**: A vegetated open impoundment where incoming stormwater runoff is stored until it gradually infiltrates into the soil strata. While flooding and channel erosion control may be achieved within an infiltration basin, they are primarily used for water quality enhancement. | | X | 50 %[1] | |
| **Infiltration Trench**: A shallow, excavated trench backfilled with a coarse stone aggregate to | | X | 50 %[1] | |

| BEST MANAGEMENT PRACTICE | IMPAIRMENT SOURCE | | REPORTED EFFICIENCY | NOTE |
|---|---|---|---|---|
| | AGRICULTURE | URBAN | | |
| create an underground reservoir. Stormwater runoff diverted into the trench gradually infiltrates into the surrounding soils from the bottom and sides of the trench. The trench can be either an open surface trench or an underground facility. | | | | |
| **Irrigation water management**: The process of determining and controlling the volume, frequency, and application rate of irrigation water in a planned, efficient manner. An irrigation system adapted for site conditions (soil, slope, crop grown, climate, water quantity and quality, etc.) must be available and capable of applying water to meet the intended purpose(s). | X | X | | |
| **Lagoon pump out**: A waste treatment impoundment made by constructing an embankment and/or excavating a pit or dugout in order to biologically treat waste (such as manure and wastewater) and thereby reduce pollution potential by serving as a treatment component of a waste management system. | X | X | | |
| **Land-use conversion**: BMPs that involve a change in land use in order to retire land contributing detrimentally to the environment. Some examples of BMPs with associated land use changes are: Conservation Reserve Program (CRP) - cropland to pasture; Forest conservation - pervious urban to forest; Forest/grass buffers - cropland to forest/pasture; Tree planting - cropland/pasture to forest; and Conservation tillage – conventional tillage to conservation tillage. | X | X | | |
| **Limit livestock access**: Excluding livestock from areas where grazing or trampling will cause erosion of stream banks and lowering of water quality by livestock activity in or adjacent to the water. Limitation is generally accomplished by permanent or temporary fencing. In addition, installation of an alternative water source away from the stream has been shown to reduce livestock access. | X | | | |
| **Litter control**: Litter includes larger items and articulates deposited on street surfaces, such as paper, vegetation residues, animal feces, bottles and broken glass, plastics and fallen leaves. Litter-control programs can reduce the amount of | | X | | |

| BEST MANAGEMENT PRACTICE | IMPAIRMENT SOURCE | | REPORTED EFFICIENCY | NOTE |
|---|---|---|---|---|
| | AGRICULTURE | URBAN | | |
| deposition of pollutants by as much as 50%, and may be an effective measure of controlling pollution by storm runoff. | | | | |
| **Livestock water crossing facility**: Providing a controlled crossing for livestock and/or farm machinery in order to prevent streambed erosion and reduce sediment. | X | | 100 %[1] | |
| **Manufactured BMP systems**: Structural measures which are specifically designed and sized by the manufacturer to intercept storm water runoff and prevent the transfer of pollutants downstream. They are used solely for water quality enhancement in urban and ultra-urban areas where surface BMPs are not feasible. | X | X | | |
| **Onsite treatment system installation**: Conventional onsite wastewater treatment and disposal system (onsite system) consists of three major components: a septic tank, a distribution box, and a subsurface soil absorption field (consisting of individual trenches). This system relies on gravity to carry household waste to the septic tank, move effluent from the septic tank to the distribution box, and distribute effluent from the distribution box throughout the subsurface soil absorption field. All of these components are essential for a conventional onsite system to function in an acceptable manner. | | X | | |
| **Porous pavement**: An alternative to conventional pavement, it is made from asphalt (in which fine filler fractions are missing) or modular or poured-in concrete pavements. Its use allows rainfall to percolate through it to the sub-base, providing storage and enhancing soil infiltration that can be used to reduce runoff and combined sewer overflows. The water stored in the sub-base then gradually infiltrates the subsoil. | | X | 50 %[1] | |
| **Proper site selection for animal feeding facility**: Establishing or relocating confined feeding facilities away from environmentally vulnerable areas such as sinkholes, streams, and rivers in order to reduce or eliminate the amount of pollutant runoff reaching these areas. | X | | | |
| **Rain garden /bio-retention basin:** Rain gardens are landscaped gardens of trees, shrubs, and | | X | 40 %[1] | |

| BEST MANAGEMENT PRACTICE | IMPAIRMENT SOURCE | | REPORTED EFFICIENCY | NOTE |
|---|---|---|---|---|
| | AGRICULTURE | URBAN | | |
| plants located in commercial or residential areas in order to treat storm water runoff through temporary collection of the water before infiltration. They are slightly depressed areas into which storm water runoff is channeled by pipes, curb openings, or gravity. | | | | |
| **Range and pasture management**: Systems of practices to protect the vegetative cover on improved pasture and native rangelands. It includes practices such as seeding or reseeding, brush management (mechanical, chemical, physical, or biological), proper stocking rates and proper grazing use, and deferred rotational systems. | X | | 50 %[1] | |
| **Retention ponds/basins Retention basin**: A storm water facility that includes a permanent pool of water and, therefore, is normally wet even during non-rainfall periods. Inflows from storm water runoff may be temporarily stored above this permanent pool. | X | X | 32 %[1] | |
| **Riparian Buffer Zone**: A protection method used along streams to reduce erosion, sedimentation, and the pollution of water from agricultural non-point sources. | X | X | 43 – 57 %[1] | Forested buffer w/o incentive payment |
| **Septic system pump-out**: A typical septic system consists of a tank that receives waste from a residence or business, and a drain field or subsurface absorption system consisting of a series of percolation lines for the disposal of the liquid effluent. Solids (sludge) that remain after decomposition by bacteria in the tank must be pumped out periodically. | | X | 5 %[1] | |
| **Sewer line maintenance/sewer flushing**: Sewer flushing during dry weather is designed to periodically remove solids that have deposited on the bottom of the sewer and the biological slime that grows on the walls of combined sewers during periods of low-flow. Flushing is especially necessary in sewer systems that have low grades which has resulted in velocities during low-flow periods that fall below those needed for self-cleaning. | | X | | |
| **Stream bank protection and stabilization (e.g., riprap, gabions)**: Stabilizing shoreline areas | X | X | 40 - 75 %[1] | 40 % w/o fencing; |

| BEST MANAGEMENT PRACTICE | IMPAIRMENT SOURCE | | REPORTED EFFICIENCY | NOTE |
|---|---|---|---|---|
| | AGRICULTURE | URBAN | | |
| that are being eroded by landscaping, constructing bulkheads, riprap revetments, gabion systems, or establishing vegetation. | | | | 75 % w/ fencing |
| **Terrace**: An earth embankment, or a combination ridge and channel, constructed across the field slope. Terraces can be used when there is a need to conserve water, excessive runoff is a problem, and the soils and topography are such that terraces can be constructed and farmed with reasonable effort. | X | X | | |
| **Vegetated filter strip**: A densely vegetated strip of land engineered to accept runoff from upstream development as overland sheet flow. It may adopt any naturally vegetated form, from grassy meadow to small forest. The purpose of a vegetated filter strip is to enhance the quality of stormwater runoff through filtration, sediment deposition, infiltration and absorption. | X | X | | |
| **Waste system/storage (e.g., lagoons, litter shed)**: Waste treatment lagoons biologically treat liquid waste to reduce the nutrient and BOD content. Lagoons must be emptied and their contents disposed of properly. | X | X | 80 – 100 %[1] | |
| **Water treatment (e.g., disinfection, flocculation, carbon filter system) Water treatment**: Physical, chemical and/or biological processes used to treat concentrated discharges. Physical-chemical processes that have been demonstrated to effectively treat discharge include sedimentation, vortex separation, screening (e.g., fine-mesh screening), and sand-peat filters. Chemical additives used to enhance separation of particles from liquid include chemical coagulants such as lime, alum, ferric chloride, and various polyelectrolytes. Biological processes that have been demonstrated to effectively treat discharges include contact stabilization, biodiscs, oxidation ponds, aerated lagoons, and facultative lagoons. | X | X | | |
| **Wetland development/enhancement**: The construction of a wetland for the treatment of animal waste runoff or storm water runoff. Wetlands improve water quality by removing nutrients from animal waste or sediments and nutrients from storm water runoff. | X | X | 30 %[1] | Including creation and restora-tion |

[1] Sources: BMP Efficiencies Chesapeake Bay Watershed Model (Phase IV) August 1999; Draft FC and Nitrate TMDL IP for Dry River (2001); EPA (1998); EPA (1999b); Novotny (1994); Storm Water Best

Management Practice Categories and Pollutant Removal Efficiencies (2003); USDA (2003); DCR (1999); DEQ/DCR (2001).

[2] Barrett, M.E., Complying with the Edwards Aquifer Rules: Technical Guidance on Best Management Practices, Texas Natural Resource Conservation Commission Report RG-348, June, (1999).

[3] Watershed Protection Techniques. *Vol 3. No. 1*, 1999

# APPENDIX F
# RESPONSE TO COMMENTS

# Appendix F

## Response to Comments

## A. Comments from Oklahoma Department of Agriculture, Food, and Forestry

A1. Page ES-7, last paragraph before section E3. the final sentence should read: "The data analysis and the load duration curves (LDC) demonstrate that exceedances at the WQM stations are the results of a variety of nonpoint source loading occurring during high flow conditions although because of the number of low flow exceedances, point sources cannot be ruled out as an additional source."

- *Response #A1: The report text was changed as follows. "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 occurring during a range of flow conditions. Low flow exceedances are likely due to a combination of nonpoint sources, uncontrolled point sources, and permit noncompliance."*

A2. Page ES-7, second paragraph under Section E.3, second sentence. Although we don't argue with the assumptions behind the LDC method, research has shown significant NPS contribution to bacteria loading can also occur at low flows. Because the data show exceedances on streams with and without dischargers during a variety of flow conditions, there may need to be some clarification as to why baseflow exceedances are considered indicative of point sources in one stream and indicative of NPS loading in another.

- *Response #A2: Agree. Conclusions have be change where appropriate.*

A3. Page 3-3, first paragraph after table. The report states that DMRs are not available to determine whether or not the facilities are in compliance regarding bacteria concentrations. One recommended practice to help meet bacterial load reductions would be to insure that those DMRs were available and did not indicate compliance problems.

- *Response #A3: Agree.*

A4. Page 3-8, Last paragraph, last sentence: Should also mention, although not necessarily here, other practices that reduce bacteria loading including elimination of illicit discharges and rehabilitation of dilapidated sewer systems, if needed.

- *Response #A4: Suggested changes were made.*

A5. Page 3-11, last sentence of first paragraph. The reference to land application seems to be a holdover from TMDL reports from poultry producing areas or those with a significant number of CAFOs. In these watersheds, the only manure being applied would be from the two CAFOs, and those are operating within their permits, and suing the same logic applied to WWTP operating within permits, so their contribution would be negligible. If, however, you mean deposition of manure in pastureland by livestock, you should clarify this.

- *Response #A5: Land application of manure is considered as a source of bacteria loading although it may not be a significant source in this report. No change was maded.*

A6. Page 3-11, Daily Fecal coliform Production Rates by Livestock Species:

The report used the Beef Cattle release approximately 1.04E+11, and Dairy Cattle release 1.01 E+11. They are 3-5 times as high as the rates used by Gen Yagow, et al., Virginia Tech University in research paper: "TMDL Modeling of Fecal Coliform Bacteria with HSPF", 2001, presented at ASAE Annual Internatinal meeting 2001, of 2.07E+10 and 3.11 E+10 respectively.

- *Response #A6: The bacteria production rates in the report were taken from the American Society of Agricultural Engineers standards. Many other production rates could be found in the literature. The chosen rates are valid and not significantly different from the proposed reference. No changes were made as a result of this comment.*

A7. Page 3-11, Last paragraph, last sentence. Would recommend replacing "most likely" with "largest".

- *Response #A7: The sentence was changed to "Cattle appear to represent the largest totential source of fecal bacteria".*

A8. Page 3-12, Table 3-7 "Livestock and Manure Estimates by Watershed":

  - The title should be: "Livestock and Manure Application Area Estimates by Watershed", as no manure amount is included in the table;
  - Number of cattle and calves should be divided in two groups: one as free roaming and the other in feedlots, as the amount of manure produced by each group is quite different.

- *Response #A8: the title of Table 3-6 was changed to "Commercially Raised Farm Animals and Manure Application Area Estimates by Watershed".*

  *The information was not available to divid cattle and valves into two groups. No changes were made as a result of this comment.*

A9. Page 3-13, Table 3-8 Fecal Coliform Production Estimates for Selected Livestock: Since the Coliform Production Rates are over-estimated and number of Livestock is somewhat misrepresented, as number of cattle and calves are not divided in two groups, the numbers of Coliform Production presented in the table are about 5 times as high as they should be.

- *Response #A9: See response #A6*

A10. Pages 3-10 to 3-13, sub- section 3.2.2: Non-Permitted Agricultural Activities and Domesticated Animals; pages 3-17 to 3-18, section 3.3: Summary of Bacteria Sources, and Executive Summary:

  - 1st bullet of 1std paragraph of sub-section 3.2.2: "poultry waste" should be added after "Processed livestock manure".
  - For Bacteria Contribution to the Watersheds by Livestock (beef and dairies cattle): As the survival rates of coliform depends on how the manure is stored, when and how it is spread on land, setbacks distances and BMPs conducted by farmers/ranchers, and relative locations of the farms to the streams, numbers of coliform reaching water-bodies from this source should be minimal compared to the amount of bacteria produced on land.

- *Response #A10: References to "livestock" were changed to "commercially raised farm animals" throughout the report.*

  *The following clarification was added in Section 3.3: "Manure handling practices, use of BMPs, and relative location to streams can also affect stream loading."*

A11. Page 3-17: under section 3.3 Should be clarified that these are suspected or potential sources, perhaps in the title of the Section. Along those lines, the justification for considering point sources to be minor or moderate contributors when there is no data to show that these facilities are in compliance should be clarified. Why are they assumed to be minor? If it is because of the mass balance, the disinfection process or for whatever other reason, this should be clarified.

- *Response #A11: the following language was added in section 5.2: "Table 5-2 indicates which point source dischargers within Oklahoma currently have a disinfection requirement in their permit. Certain facilities that utilize lagoons for treatment have not been required to provide disinfection since storage time and exposure to ultraviolet radiation from sunlight should reduce bacteria levels. In the future, all point source dischargers which are assigned a wasteload allocation but do not currently have a bacteria limit in their permit will receive a permit limit consistent with the wasteload allocation as their permits are reissued."*

A12. Page 3-18- the second sentence of the first paragraph, suggest adding to the end of that sentence "; however, its contribution of coliforms to the streams in the watershed may not be significant if BMPs are properly implemented".

- *Response #A12: the following language was added; "however, its contribution of bacteria to streams may be greatly reduced if BMPs are properly implemented".*

A13. Page 3-18- the last sentence of the first paragraph might be better read as "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 may represent a major source of bacteria found in some streams."

- *Response #A13: Suggested change was made.*

A14. Page 4-14, first full paragraph: shouldn't the NPS load be estimated by subtracting the point source load from instream loading? Otherwise, you're assuming the point sources contribute 10% of the loading, aren't you? There doesn't seem to be anything to base this assumption off of.

- *Response #A14: The comment is correct. However, some language in this section was inadvertently left in the document from a previous calculation method. The obsolete language was deleted and remaining language was clarified as suggested. The correct calculation of current loading is found in Section 5.1.*

A15. Page 4-15, third full paragraph states that "high flows may occur in dry weather." I'm not sure how this could happen without a lagoon breach or some other kind of illegal discharge or a dam rupture.

- *Response #A15: A clarification was added. High flows could occur in the absence of local runoff due, for example, to precipitation upstream in the watershed or releases from upstream dams.*

A16. Page 4-16, Step 5- is this assumption justified given that there is no compliance data and there were a significant number of SSOs in certain watersheds? If so, the reasons supporting it should be better explained.

Page 5-3, "LDC for Stinking Creek at high, moist, and mid-range indicates nonpoint source pollution"; we suggest wording saying that "due to the preponderance of exceedances during high flow conditions the majority of the pollution is thought to be due to NP sources but that the exceedances found during dry weather conditions indicate that some level of pollution may be due to point sources. We would suggest adding this type of language to any stream with point source discharges that had exceedances during lower flow conditions. Throughout this section, the language needs to consider, the conundrum presented by the fact that exceedences at low flow sometimes mean point source and other times mean NPS. The fact exists that direct application of manure in a stream at low flow conditions by wading cattle causes impairment at low flow conditions yet is still nps. Likewise, direct pipelines of septage to streams and gullies can also contribute to base flow impairment as can transport of septage from lateral fields down to groundwater. One solution might be to say that pollution at low flow conditions indicates both point and non-point sources are possible while pollution found at high flow conditions indicates nps in the absence of a bypass or overflow at a WWTP.

- *Response #A16: Language regarding to SSO was added in section 3.1.2.*

  *The LDC for Stinking Creek does not show any exceedances under low flow condition, therefore, it does not suggest point source as a major potential source. No change was made for Sticking Creek. However, we agree with the general concept that point source should be included as a potential source when exceedances occurred at low flow conditions. Changes were made throughout the section to make the assessment for each stream segment more consistent.*

A17. page 5-40 first paragraph after the table. The OCC is not a regulatory agency. A more correct statement is "The Oklahoma Conservation Commission (OCC) is the lead State agency for Nonpoint Source Pollution. The OCC works with State partners such as ODAFF and federal partners such as EPA and NRCS, to address water quality problems similar to those seen in the Red River Watershed."

- *Response #A17: Suggested change was made.*

## B. Staff Identified Changes

B1. Appendix E: Storm water permitting Requirements and Presumptive Best Management practices (BMP) Approach was added to the report. And a reference to Appendix E was added in section 3.2.