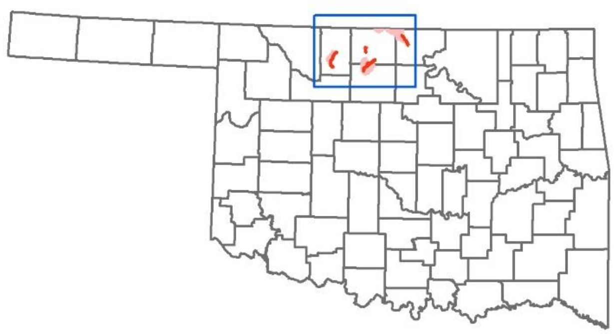
DRAFT

2024 BACTERIAL TOTAL MAXIMUM DAILY LOADS FOR OKLAHOMA STREAMS IN ARKANSAS - KEYSTONE BASIN AREA

Oklahoma Waterbody Identification Numbers

Wild Horse Creek	OK621000020040_00
Spring Creek	OK621000020130_00
Clay Creek, West	OK621010010130_00
Chikaskia River	OK621100000010_20



Prepared by:

Oklahoma Department of Environmental Quality

O K L A H O M A
DEPARTMENT OF ENVIRONMENTAL QUALITY

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ACRONYMS AND ABBREVIATIONS

AEMS	Agricultural Environmental Management Service
AFO	Animal Feeding Operation
AgPDES	Agriculture Pollutant Discharge Elimination System
ASAE	American Society of Agricultural Engineers
AVMA	American Veterinary Medical Association
BMP	Best management practices
BOD	Biochemical Oxygen Demand
BUMP	Beneficial Use Monitoring Program
CAFO	Concentrated Animal Feeding Operation
CBOD	Carbonaceous Biochemical Oxygen Demand
CFR	Code of Federal Regulations
cfs	cubic feet per second
CN	Curve number
CPP	Continuing Planning Process
CWA	Clean Water Act
CWAC	Cool water aquatic community
DEM	Digital Elevation Model
DEQ	Oklahoma Department of Environmental Quality
DMR	Discharge monitoring report
E. coli	*Escherichia coli*
ENT	Enterococci
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System
HUC	Hydrologic unit code
IQR	Interquartile range
LA	Load allocation
LDC	Load duration curve
LOC	Line of organic correlation
mg	Million gallons
mgd	Million gallons per day
mg/L	Milligram per liter
mL	Milliliter
MOS	Margin of Safety
MS4	Municipal separate storm sewer system
MSGP	Multi-Sector General Permit
NASS	USDA's National Agricultural Statistics Service
NED	National Elevation Dataset
NHD	National Hydrography Dataset
NLCD	National Land Cover Dataset
NPDES	National Pollutant Discharge Elimination System

NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
NRMSE	Normalized Root Mean Square Error
NTU	Nephelometric Turbidity Unit
NWIS	National Water Information System
OAC	Oklahoma Administrative Code
OCC	Oklahoma Conservation Commission
OLS	Ordinary Least Square
O.S.	Oklahoma Statute
ODAFF	Oklahoma Department of Agriculture, Food and Forestry
OKWBID	Oklahoma Waterbody Identification Number
OPDES	Oklahoma Pollutant Discharge Elimination System
OSWD	Onsite Wastewater Disposal
OWQS	Oklahoma Water Quality Standards
OWRB	Oklahoma Water Resources Board
PBCR	Primary Body Contact Recreation
PRG	Percent Reduction Goal
r^2	Correlation coefficient
RMSE	Root mean square error
SH	State Highway
SSO	Sanitary Sewer Overflow
STORET	EPA Storage and Retrieval System
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
USACE	United States Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WWAC	Warm water aquatic community
WLA	Wasteload allocation
WQ	Water quality
WQM	Water quality monitoring
WQMP	Water Quality Management Plan
WQS	Water quality standard
WWTF	Wastewater treatment facility

EXECUTIVE SUMMARY

ES - 1 Overview

As promulgated by Section 402 of the Clean Water Act (CWA), the U.S. Environmental Protection Agency (EPA) has delegated authority to the Oklahoma Department of Environmental Quality (DEQ) to partially oversee the National Pollutant Discharge Elimination System (NPDES) Program in the State of Oklahoma. Exceptions are agriculture [retained by the Oklahoma Department of Agriculture, Food, and Forestry (ODAFF)], and the oil & gas industry (retained by the Oklahoma Corporation Commission) for which EPA has retained permitting authority. The NPDES Program in Oklahoma, in accordance with an agreement between DEQ and EPA, is implemented via the Oklahoma Pollutant Discharge Elimination System (OPDES) Act [Title 252, Chapter 606 (https://www.deq.ok.gov/wp-content/uploads/deqmainresources/606.pdf)].

This total maximum daily load (TMDL) report documents the data and assessment used to establish TMDLs for the pathogen indicator bacteria [*Escherichia coli (E. coli)* and Enterococci] for selected waterbodies in the Arkansas-Keystone Basin Study Area in Oklahoma. Elevated levels of pathogen indicator bacteria in aquatic environments indicate that a waterbody is contaminated with human or animal feces and that a potential health risk exists for individuals exposed to the water.

Data assessment and TMDL calculations are conducted in accordance with requirements of Section 303(d) of the CWA, Water Quality Planning and Management Regulations (40 CFR § Part 130), EPA guidance, and DEQ guidance and procedures. DEQ is required to develop TMDLs for all impaired waterbodies which are on the 303(d) list. The draft TMDL went to EPA for review before it was submitted for public comment. After the public comment period, the TMDL was submitted to EPA for final approval. Once EPA approves the final TMDL, then the waterbody is moved to Category 4a of the Integrated Report, where it remains until it reaches compliance with Oklahoma's water quality standards (WQS).

These TMDLs provide a load reduction to meet ambient water quality criterion with a given set of facts. The adoption of these TMDLs into the Water Quality Management Plan (WQMP) provides a mechanism to recalculate acceptable pollutant loads when information changes in the future. Updates to the WQMP demonstrate compliance with the water quality criterion. The updates to the WQMP are also useful when the water quality criterion changes and loading scenarios are reviewed to ensure that the predicted in-stream criterion will be met.

The purpose of this TMDL study was 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 wasteload allocations (WLA), load allocations (LA), and a margin of safety (MOS). A WLA is the fraction of the total pollutant load apportioned to point sources, and includes stormwater discharges regulated under OPDES as point sources. A LA is the fraction of the total pollutant load apportioned to nonpoint sources. MOS can be implicit and/or explicit. The implicit MOS is achieved by using conservative assumptions in the TMDL calculations. An explicit MOS is a percentage of the TMDL set aside to account for the lack of knowledge associated with natural process in aquatic systems, model assumptions, and data limitations.

This report does not stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce bacteria 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, along with native tribes, and local, state, and federal government agencies.

ES - 2 Problem Identification and Water Quality Target

This TMDL study focused on waterbodies in the Arkansas-Keystone Basin Study Area, identified in **Table ES - 1**, which DEQ placed in Category 5 [303(d) list] of the *Water Quality in Oklahoma, 2022 Integrated Report* for nonsupport of Primary Body Contact Recreation (PBCR) beneficial use.

Elevated levels of bacteria above the WQS necessitate the development of a TMDL. The TMDLs established in this report are a necessary step in the process to develop the pollutant loading controls needed to restore the PBCR beneficial use designated for each waterbody.

Table ES - 2 summarizes water quality data collected during primary contact recreation season from the water quality monitoring (WQM) stations between **2000** and **2018** for each bacterial indicator. The data summary in **Table ES – 2** provides a general understanding of the amount of water quality data available and the severity of exceedances of the water quality criteria. The data collected during the primary contact recreation season was used to support the decision to place specific waterbodies within the Study Area on the DEQ 2022 303(d) list (DEQ 2022).

ES-2.1 Chapter 730: Criteria for Bacteria

The definitions of PBCR and the bacterial WQSs for PBCR are summarized by the following excerpt from Title 252, Chapter 730-5-16 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 the following limits for bacteria set forth in (c) of this section 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.

(c). Compliance with 252:730-5-16 shall be based upon meeting the requirements of one of the options specified in (1) or (2) of this subsection (c) for bacteria. Upon selection of one (1) group or test method, said method shall be used exclusively over the time period prescribed therefor. Provided, where concurrent data exist for multiple bacterial indicators on the same waterbody

or waterbody segment, no criteria exceedances shall be allowed for any indicator group.

(1) Escherichia coli (E. coli): The E. coli geometric mean criterion is 126/100 ml. For swimming advisory and permitting purposes, E. coli shall not exceed a monthly geometric mean of 126/100 ml based upon a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. For swimming advisory and permitting purposes, no sample shall exceed a 75% one-sided confidence level of 235/100 ml in lakes and high use waterbodies and the 90% one-sided confidence level of 406/100 ml in all other Primary Body Contact Recreation beneficial use areas. These values are based upon all samples collected over the recreation period. For purposes of sections 303(d) and 305(b) of the federal Clean Water Act as amended, beneficial use support status shall be assessed using only the geometric mean criterion of 126/100 milliliters compared to the geometric mean of all samples collected over the recreation period.

(2) Enterococci: The Enterococci geometric mean criterion is 33/100 ml. For swimming advisory and permitting purposes, Enterococci shall not exceed a monthly geometric mean of 33/100 ml based upon a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. For swimming advisory and permitting purposes, no sample shall exceed a 75% one-sided confidence level of 61/100 ml in lakes and high use waterbodies and the 90% one-sided confidence level of 108/100 ml in all other Primary Body Contact Recreation beneficial use areas. These values are based upon all samples collected over the recreation period. For purposes of sections 303(d) and 305(b) of the federal Clean Water Act as amended, beneficial use support status shall be assessed using only the geometric mean criterion of 33/100 milliliters compared to the geometric mean of all samples collected over the recreation period.

ES-2.2 Chapter 740: Implementation of Oklahoma's WQS for Bacteria

To implement Oklahoma's WQS for PBCR, Oklahoma DEQ promulgated Chapter 740, *Implementation of Oklahoma's Water Quality Standards* (DEQ 2022). The excerpt below from Chapter 740: 252:740-15-6, 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 252:730 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). ***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. These values are based upon all samples collected over the recreation period in accordance with OAC 252:740-15-3(c).

(2) 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. These values are based upon all samples collected over the recreation period in accordance with OAC 252:740-15-3(c).

(c). ***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. These values are based upon all samples collected over the recreation period in accordance with OAC 252:740-15-3(c).

(2) 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. These values are based upon all samples collected over the recreation period in accordance with OAC 252:740-15-3(c).

Where concurrent data exist for multiple bacterial indicators on the same waterbody, each indicator group must demonstrate compliance with the numeric criteria prescribed (DEQ 2022).

As stipulated in the WQS, only the geometric mean of all samples collected over the recreation period shall be used to assess the impairment status of a stream. Therefore, only the geometric mean criteria are used to develop TMDLs for *E. coli* and Enterococci bacterial indicators.

It is worth noting that the Oklahoma Water Quality Standards (WQS) prior to July 1, 2011 contained three bacterial indicators (fecal coliform, *E. coli*, and Enterococci). Since July 1, 2011, the WQS address only *E. coli* and Enterococci bacteria. Therefore, bacterial TMDLs are developed only for *E. coli* and/or Enterococci impaired streams.

Table ES - 1 Excerpt from the 2022 Integrated Report – Oklahoma 303(d) List of Impaired Waters

Waterbody ID	Waterbody Name	Stream Miles	Priority	ENT	*EC*	Designated Use Primary Body Contact Recreation	Turbidity	Designated Use Warm Water Aquatic Life
OK621000020040_00	Wild Horse Creek	24.66	3		X	N		N*
OK621000020130_00	Spring Creek	6.14	3	X	X	N		F
OK621010010130_00	Clay Creek, West	22.92	1	X	X	N		N*
OK621100000010_20	Chikaskia River	12.81	4	X		N		F

Note: ENT = Enterococci; ***EC***= *Escherichia coli;* **N** = Not attaining; **X** = Criterion exceeded; **F** = Fully supporting,
* Impaired for Macroinvertebrate Bio-assessments, Fish Bio-assessments, DO, or TDS,
Source: 2022 Integrated Report, DEQ 2022

Table ES - 2 Summary of Indicator Bacterial Samples from Primary Body Contact Recreation Subcategory Season May 1 to September 30, 2000-2018

Waterbody ID	Waterbody Name	Indicator	Sample Period	Number of Samples	Geometric Mean Conc. (colonies/100 ml)	Assessment Results/ Recommended Action
OK621000020040_00	Wild Horse Creek	ENT	2002 - 2004	8	172	Impaired & List in 303(d)/ TMDL
		EC	2017 - 2018	10	205	Impaired / TMDL
OK621000020130_00	Spring Creek	ENT	2000 - 2001	6	146	Impaired / TMDL
		EC	2000 - 2001	6	165	Impaired / TMDL
OK621010010130_00	West Clay Creek	ENT	2004 - 2008	10	157	Impaired / TMDL
		EC	2017 - 2018	10	322	Impaired / TMDL
OK621100000010_20	Chikaskia River	ENT	2004 - 2008	10	85	Impaired / TMDL
		EC	2004 - 2008	10	94	Meet WQS / No TMDL

Note: ENT = Enterococci; water quality criterion = Geometric Mean of 33 colonies/100 mL
EC= *Escherichia coli,* water quality criterion = Geometric Mean of 126 colonies/100 mL
TMDLs will be developed for waterbodies highlighted in green

ES-2.3 Chapter 740: Minimum number of Samples

Chapter 740, *Implementation of Oklahoma's Water Quality Standards* (DEQ 2022). The excerpt below from Chapter 740 (OAC 252:740-15-3(d)), stipulates the minimum number of samples to assess beneficial use.

252:740-15-3. Data requirements

(d). Minimum number of samples.

(1) Except when (f) of this Section applies, or unless otherwise noted in subchapter 252:740-15 for a particular parameter, a minimum number of samples shall be required to assess beneficial use support.

(A) For streams and rivers, a minimum of 10 samples shall be required.

(B) For lakes greater than 250 surface acres, a minimum of 20 samples shall be required.

(C) For lakes 250 surface acres or smaller, a minimum of 10 samples shall be required.

(D) For toxicants for the protection of the Fish and Wildlife Propagation and Public and Private Water beneficial uses, a minimum of 5 samples shall be required.

ES - 3 Pollutant Source Assessment

A pollutant source assessment characterizes known and suspected sources of pollutant loading to impaired waterbodies. Sources within a watershed are categorized and quantified to the extent that information is available. Bacteria originate from warm-blooded animals and sources may be point or nonpoint in nature.

Point sources are permitted through the OPDES program. OPDES-permitted facilities that discharge treated sanitary wastewater are required to monitor *E. coli* under the current permits. There are no active point source facilities within the Study Area.

For the purposes of these TMDLs, no-discharge facilities do not contribute bacteria loading to the listed waterbodies and their tributaries. However, it is possible the wastewater collection systems associated with WWTPs could be a source of bacteria loading. While not all sewer overflows are reported, DEQ has some data on sanitary sewer overflows (SSO) available. There were 14 SSO occurrences, ranging from 100 to over 21 million gallons, reported for certain watersheds within the Study Area between 1992 and 2000. Given the insignificant number of occurrences and the size of overflows reported (APPENDIX D:, the SSOs were not considered to be a significant source of bacteria loading to streams in the Study Area. There are neither the permitted animal feeding operations (AFOs) nor the municipal separate storm sewer system (MS4) facilities in the Study Area.

Nonpoint sources include those sources that cannot be identified as entering a waterbody at a specific location. Nonpoint sources may emanate from 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 OPDES permits are considered nonpoint sources.

Table ES - 3 summarizes the point and nonpoint sources that contribute bacteria to each respective waterbody.

ES - 4 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 can provide some information for identifying whether impairments are associated with point or nonpoint sources. The LDC is a simple and efficient method to show the relationship between flow and pollutant load. LDCs graphically display the changing water quality over changing flows that may not be apparent when visualizing raw data. The LDC has additional valuable uses in the post-TMDL implementation phase of the restoration of the water quality for a waterbody. Plotting future monitoring information on the LDC can show trends of improvement to sources that will identify areas for revision to the watershed restoration plan. The low cost of the LDC method allows accelerated development of TMDL plans on more waterbodies and the evaluation of the implementation of WLAs and BMPs. The technical approach for using LDCs for TMDL development includes the following steps:

1. Prepare flow duration curves for gaged and ungaged WQM stations.
2. Estimate existing loading in the waterbody using ambient bacterial water quality data.
3. Use LDCs to identify the critical condition that will dictate loading reductions and the overall percent reduction goal (PRG) necessary to attain WQS.

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

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

The following are the basic steps in developing a LDC:

1. Obtain daily flow data for the site of interest from the U.S. Geological Survey (USGS), or if unavailable, obtain projected flow from a nearby USGS site.
2. Sort the flow data and calculate the flow exceedance percentiles.
3. Obtain the water quality data.
4. For bacterial TMDLs, obtain the water quality data from the primary contact recreation season (May 1 through September 30).

5. Match the water quality observations with the flow data from the same date
6. Display a curve on a plot that represents the allowable load determined by multiplying the actual or estimated flow by the WQS for each respective bacterial indicator.
7. For bacterial TMDLs, display and differentiate another curve derived by plotting the geometric mean of all existing bacterial samples continuously along the full spectrum of flow exceedance percentiles which represents the observed load in the stream.

Table ES - 3 Summary of Potential Pollutant Sources by Category

Waterbody ID	Waterbody Name	Municipal NPDES Facility	Industrial NPDES Facility	MS4	NPDES No Discharge Facility	AFO	Nonpoint Source
OK621000020040_00	Wild Horse Creek				Ø		Bacteria
OK621000020130_00	Spring Creek						Bacteria
OK621010010130_00	Clay Creek, West						Bacteria
OK621100000010_20	Chikaskia River						Bacteria

O Facility present in watershed and potential as contributing pollutant source.

Ø Facility present in watershed, but not recognized as pollutant source.

No facility present in watershed.

ES-4.1 Bacterial LDC

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

TMDL (colonies/day) = WQS * flow (cfs) * Unit conversion factor

Where:

WQS = 126 colonies/100 mL (E. coli); or 33 colonies/100 mL (Enterococci)

Unit conversion factor = 24,465,525

ES-4.2 Summary

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.

Historical observations of bacteria were plotted as a separate LDC based on the geometric mean of all samples. It is noted that the LDCs for bacteria were based on the geometric mean standards or geometric mean of all samples. It is inappropriate to compare single sample bacterial observations to a geometric mean water quality criterion in the LDC; therefore individual bacterial samples are not plotted on the LDCs.

ES - 5 TMDL Calculations

A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for the lack of knowledge concerning the relationship between pollutant loading and water quality. A TMDL is expressed as the sum of three elements (WLA, LA, and MOS) as described in the following mathematical equation:

$$TMDL = WLA_{WWTF} + WLA_{MS4} + WLA_{Growth} + LA + MOS$$

The WLA is the portion of the TMDL allocated to existing and future point sources. The LA is the portion of the TMDL allocated to nonpoint sources, including natural background sources. The MOS is intended to ensure that WQSs will be met.

ES-5.1 Bacterial PRG

For each waterbody the TMDLs presented in this report are expressed as colonies per day across the full range of flow conditions. For information purpose, percent reductions are also provided. The difference between existing loading and the water quality target is used to calculate the loading reductions required. For bacteria, the PRG is calculated by reducing all samples by the same percentage until the geometric mean of the reduced sample values meets the corresponding bacterial geometric mean standard (126 colonies/100 ml for *E. coli* and 33 colonies/100 ml for Enterococci) with 10% of MOS.

Table ES-4 presents the percent reductions necessary for each bacterial indicator causing nonsupport of the PBCR use in each waterbody of the Study Area. The PRGs ranged from **44.7%** to **96.6%.**

Table ES - 4 Bacterial Percent Reductions Required to Meet Water Quality Standards

Waterbody ID	Waterbody Name	Required Reduction Rate (%)	
		Enterococci	*E. coli*
OK621000020040_00	Wild Horse Creek	91.5%	44.7%
OK621000020130_00	Spring Creek	96.6%	89.3%
OK621010010130_00	Clay Creek, West	81.0%	64.7%
OK621100000010_20	Chikaskia River	65.1%	-

ES-5.2 Seasonal Variation

The TMDL, WLA, LA, and MOS vary with flow condition, and are calculated at every 5th flow interval percentile. The WLA component of each TMDL is the sum of all WLAs within each contributing watershed. The LA can then be calculated as follows:

$$LA = TMDL – MOS - \sum WLA$$

Federal regulations (40 CFR § Part 130.7(c)(1)) require that TMDLs account for seasonal variation in watershed conditions and pollutant loading.

The bacterial TMDLs established in this report adhere to the seasonal application of the Oklahoma WQS which limits the PBCR use to the period of May 1st through September 30th.

ES-5.3 MOS

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

For bacterial TMDLs, an explicit MOS was set at 10%.

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

ES - 6 Reasonable Assurance

Reasonable assurance is required by the EPA guidance for a TMDL to be approvable only when a waterbody is impaired by both point and nonpoint sources and where a point source is given a less stringent wasteload allocation based on an assumption that nonpoint source load reductions will occur. In such a case, "reasonable assurance" that the NPS load reductions will actually occur must be demonstrated. In this report, all point source discharges either already have or will be given discharge limitations less than or equal to the water quality standards numerical criteria. Therefore, reasonable assurance is derived from Oklahoma Pollutant Discharge Elimination System (OPDES).

Reasonable assurance of nonpoint sources will meet their allocated amount in the TMDL which dependent upon the availability and implementation of nonpoint source pollutant reduction plans, controls or BMPs within the watershed. The OCC has responsibilities for the state's NPS program defined in Section 319 of CWA. DEQ will work in conjunction with OCC and other federal, state, and local partners to meet the load reduction goals for NPS. All waterbodies are prioritized as part of the Unified Watershed Assessment (UWA) and that ranking will determine the likelihood of an implementation project in a watershed.

ES - 7 Public Participation

A public notice about the draft TMDL report will be sent to local newspapers, government agencies, stakeholders in the Study Area affected by these draft TMDLs, and stakeholders who have requested copies of all TMDL public notices. The public notice (which includes the draft 208 TMDL factsheet) and draft TMDL report will be posted at the following DEQ website: https://www.deq.ok.gov/water-quality-division/watershed-planning/tmdl/. The public will have an opportunity to review the draft TMDL report and make written comments.

The public comment period lasts 45 days. Depending on the interest and responses from the public, a public meeting may be held within the watershed affected by the TMDLs in this report. If a public meeting is held, the public will also have opportunities to ask questions and make formal oral comments at the meeting and/or submit written comments at the public meeting.

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

SECTION 1 INTRODUCTION

1.1 TMDL Program Background

As promulgated by Section 402 (aka Section 1342) of the Clean Water Act (CWA) and 40 CFR § Part 123, the U.S. Environmental Protection Agency (EPA) has delegated authority to the Oklahoma Department of Environmental Quality (DEQ) to partially oversee the National Pollutant Discharge Elimination System (NPDES) Program in the State of Oklahoma. Exceptions are agriculture (retained by State Department of Agriculture, Food, and Forestry), and the oil & gas industry (retained by the Oklahoma Corporation Commission) for which EPA has retained permitting authority. The NPDES Program in Oklahoma, in accordance with an agreement between DEQ and EPA, is implemented via the Oklahoma Pollutant Discharge Elimination System (OPDES) Act [Title 252, Chapter 606 (https://www.deq.ok.gov/wp-content/uploads/deqmainresources/606.pdf)].

Section 303(d) [aka Section 1313(d)] of the CWA and EPA Water Quality Planning and Management Regulations [40 Code of Federal Regulations (CFR) § Part 130] require states to develop total maximum daily loads (TMDL) for all waterbodies and pollutants identified by the Regional Administrator as suitable for TMDL calculation. Waterbodies and pollutants identified on the approved 303(d) list as not meeting designated uses where technology-based controls are in place will be given a higher priority for development of TMDLs. 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 (EPA 1991).

This report documents the data and assessment used to establish TMDLs for the pathogen indicator bacteria [*Escherichia coli (E. coli)* and Enterococci][1] for selected waterbodies in the Arkansas-Keystone Basin Area in Oklahoma. Elevated levels of pathogen indicator bacteria in aquatic environments indicate that a waterbody is contaminated with human or animal feces and that a potential health risk exists for individuals exposed to the water.

Data assessment and TMDL calculations are conducted in accordance with requirements of Section 303(d) of the CWA, Water Quality Planning and Management Regulations (40 CFR § Part 130), EPA guidance, and Oklahoma Department of Environmental Quality (DEQ) guidance and procedures. DEQ is required to submit all TMDLs to EPA for review. Approved 303(d) listed waterbody-pollutant pairs or surrogates TMDLs will receive notification of the approval or disapproval action. Once the EPA 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 (EPA 2003).

[1] All future references to bacteria in this document imply these two fecal pathogen indicator bacterial groups unless specifically stated otherwise

These TMDLs provide a load reduction to meet ambient water quality criterion with a given set of facts. The adoption of these TMDLs into the Water Quality Management Plan (WQMP) provides a mechanism to recalculate acceptable pollutant loads when information changes in the future. Updates to the WQMP demonstrate compliance with the water quality criterion. The updates to the WQMP are also useful when the water quality criterion changes and loading scenarios are reviewed to ensure that the predicted in-stream criterion will be met.

The purpose of this TMDL study was 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 OPDES. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. MOS can be implicit and/or explicit. An implicit MOS is achieved by using conservative assumptions in the TMDL calculations. An explicit MOS is a percentage of the TMDL set aside to account for the lack of knowledge associated with natural process in aquatic systems, model assumptions, and data limitations.

This report does not stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce bacteria 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, along with tribes, and local, state, and federal government agencies.

This TMDL report focuses on waterbodies that DEQ placed in Category 5 [303(d) list] of the *Water Quality in Oklahoma, 2022 Integrated Report* for nonsupport of primary body contact recreation (PBCR) beneficial use. The waterbodies considered for TMDL development in this report are listed in **Table 1-1**:

Table 1-1 TMDL Waterbodies

Waterbody Name	Waterbody ID
Wild Horse Creek	OK621000020040_00
Spring Creek	OK621000020130_00
Clay Creek, West	OK621010010130_00
Chikaskia River	OK621100000010_20

Figure 1-1 shows these Oklahoma waterbodies and their contributing watersheds. This map also displays locations of the water quality monitoring (WQM) stations used as the

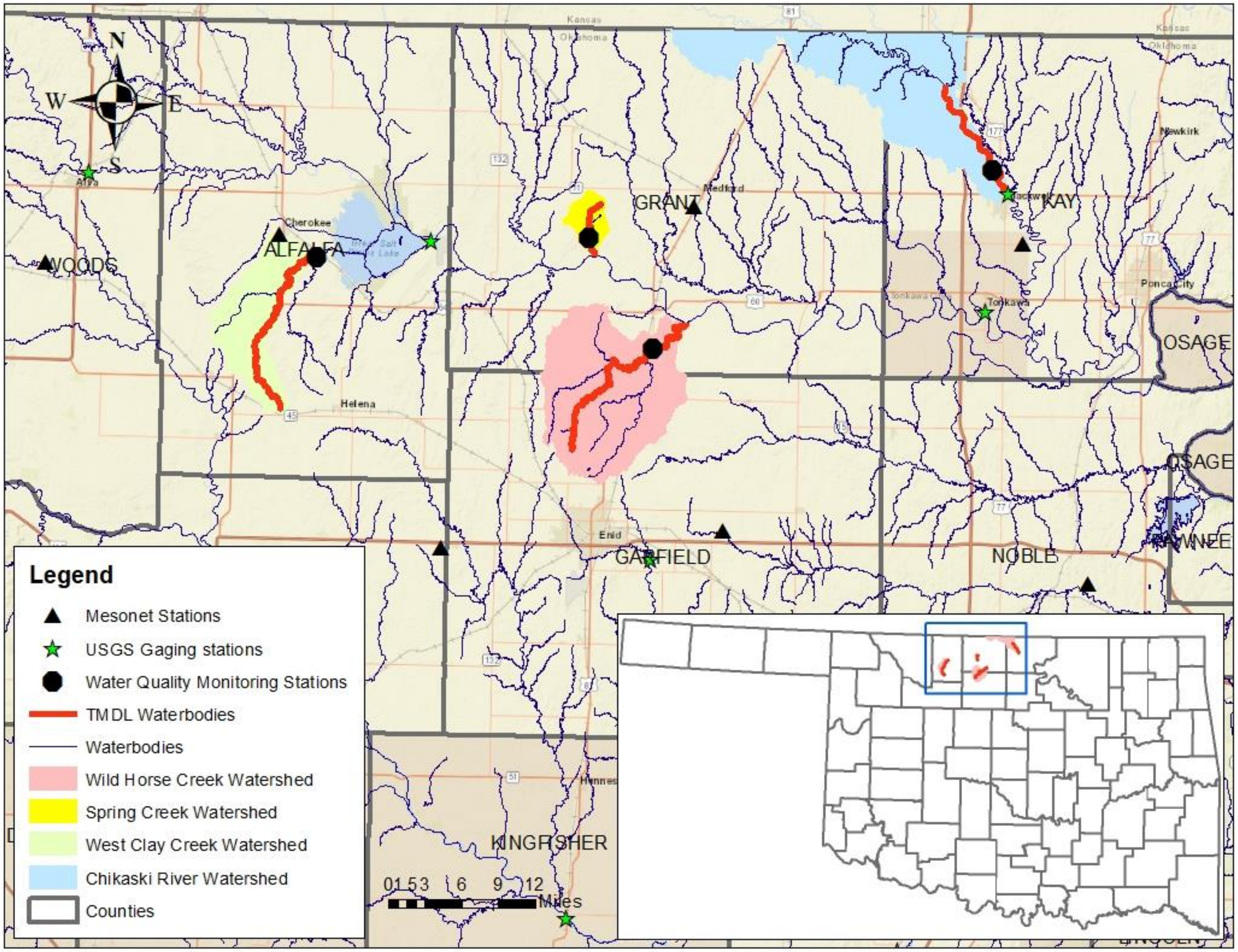
basis for placement of these waterbodies on the Oklahoma 303(d) list. These waterbodies and their surrounding watersheds are hereinafter referred to as the Study Area.

TMDLs are required to be developed whenever elevated levels of pathogen indicator bacteria are above the WQS numeric criterion. The TMDLs established in this report are a necessary step in the process to develop the pollutant loading controls needed to restore the PBCR use for each waterbody. **Table 1-2** provides a description of the locations of WQM stations on the selected waterbodies.

Table 1-2 Water Quality Monitoring Stations Used for Assessment of Streams

Waterbody Name	Waterbody ID	WQM Station	Station Location
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	Lat.: 36.624, Long.: -97.803
Spring Creek	OK621000020130_00	OK621000-02-0130G	Lat.: 36.753, Long.: -97.902
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	Lat.: 36.723, Long.: -98.307
Chikaskia River	OK621100000010_20	OK621100-00-0010M	Lat.: 36.840, Long.: -97.302

Figure 1-1 Arkansas-Keystone Basin Watersheds Not Supporting Primary Body Contact Recreation Beneficial Use



1.2 Watershed Description

1.2.1 General

The Arkansas-Keystone Basin Study Area is located in the northcentral portion of Oklahoma. The waterbodies and their watersheds addressed in this report are scattered over Alfalfa, Garfield, Grant, and Kay Counties. These counties are part of the Central Great Plains Level III ecoregion (Woods, A.J, et al 2005). **Table 1-3** derived from the 2020 U.S. Census, demonstrates that the counties in which these watersheds are located are mostly sparsely populated (U.S. Census Bureau 2020). **Table 1-4** lists major towns and cities located in each watershed.

Table 1-3 County Population and Density

County Name	Population (2020 Census)	Population Density (per square mile)
Alfalfa	5,699	6.5
Garfield	62,846	59.3
Grant	4,169	4.2
Kay	43,700	46.2

Table 1-4 Major Municipalities by Watershed

Waterbody Name	Waterbody ID	Municipalities
Wild Horse Creek	OK621000020040_00	Kremlin, Enid
Spring Creek	OK621000020130_00	
Clay Creek, West	OK621010010130_00	Cherokee, Lambert
Chikaskia River	OK621100000010_20	Braman, Blackwell

1.2.2 Climate

Table 1-5 summarizes the average annual precipitation at Mesonet Station near each Oklahoma waterbody derived from current and past 15 years daily data. Average annual precipitation values among the watersheds in this portion of Oklahoma range between 28.4 and 34.2 inches (Oklahoma Climatological Survey 2023).

Table 1-5 Average Annual Precipitation by Watershed

Waterbody Name	Waterbody ID	Mesonet Station	Average Annual Precipitation (inches)
Wild Horse Creek	OK621000020040_00	Breckinridge	31.8
Spring Creek	OK621000020130_00	Medford	32.0
Clay Creek, West	OK621010010130_00	Cherokee	28.4
Chikaskia River	OK621100000010_20	Blackwell	34.2

1.2.3 Land Use

Table 1-6 summarizes the percentages and acreages of the land use categories for the contributing watershed associated with each respective Oklahoma waterbody addressed in the Study Area. The land use/land cover data were derived from the 2021 U.S. Geological Survey (USGS) National Land Cover Dataset (USGS 2023). The percentages provided in **Table 1-6** are rounded so in some cases may not total exactly 100%. The land use categories are displayed in **Figure 1-2**.

The most dominant land use categories throughout the Arkansas-Keystone Basin Study Area are grassland/herbaceous and cultivated crops. The aggregated total of open space, low, medium, and high intensity developed land use percentage ranges from approximately 4% in the Spring Creek watershed (OK621000020130_00) to 5% in the West Clay Creek watershed (OK621010010130_00). The watersheds targeted for TMDL development in this Study Area range in size from 7,645 acres (Spring Creek, OK621000020130_00) to 86,314 acres (Chikaskia River, OK621100000010_20).

1.3 Stream Flow Conditions

Stream flow characteristics and data are key information when conducting water quality assessments such as TMDLs. The USGS operates flow gages throughout Oklahoma, from which long-term stream flow records can be obtained. Not all of the waterbodies in this Study Area have historical flow data available. At various WQM stations additional flow measurements are available which were collected at the same time bacteria water quality samples were collected. Flow data from the surrounding USGS gage stations and the instantaneous flow measurement data taken with water quality samples have been used to estimate flows for ungaged streams. A summary of the method used to project flows for ungaged streams and flow exceedance percentiles from projected flow data are provided in **Appendix B**.

Figure 1-2 Arkansas-Keystone Basin Land Use Map

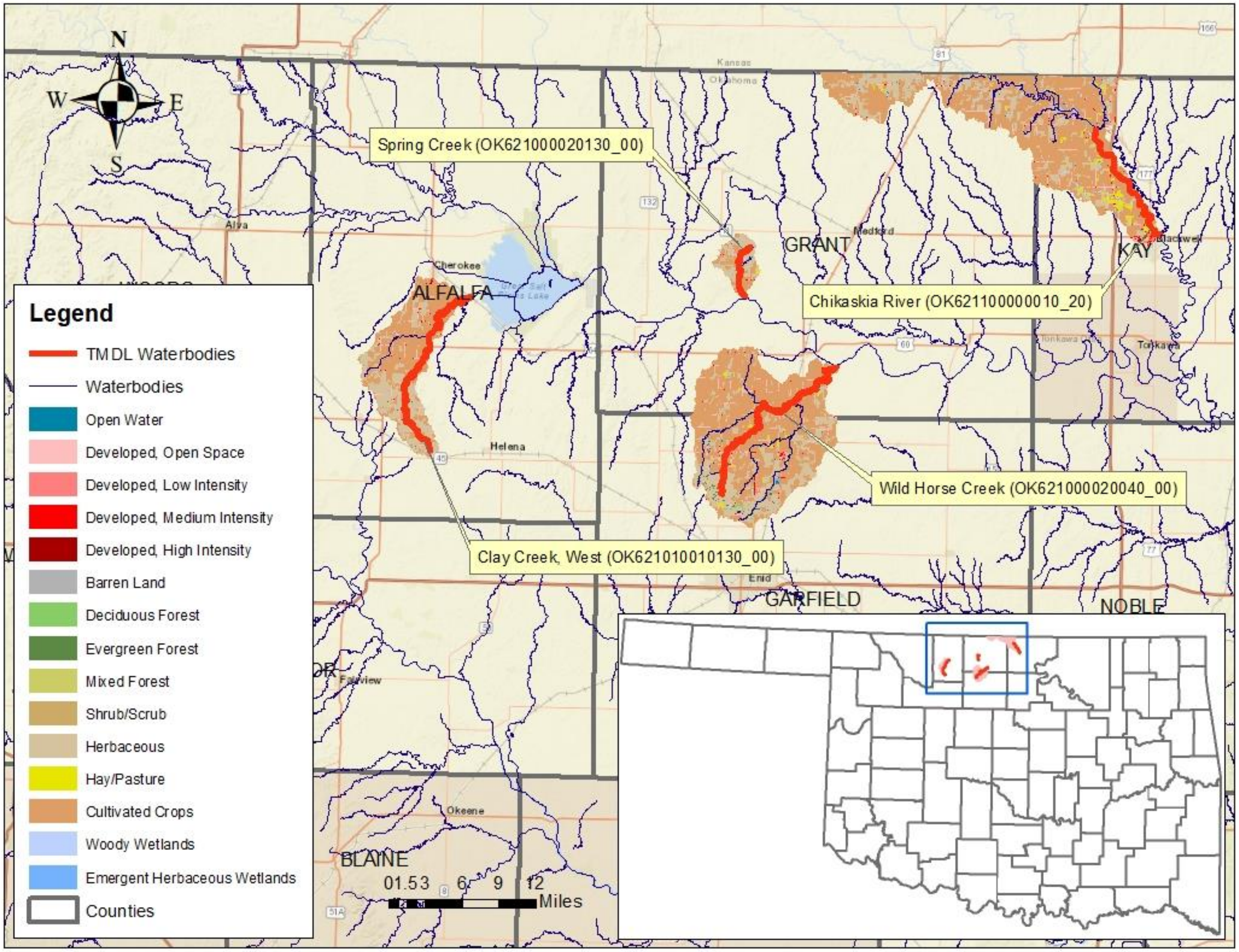


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Table 1-6 Land Use Summaries by Watershed

Landuse Category	Watershed			
	Wild Horse Creek	Spring Creek	Clay Creek, West	Chikaskia River
Waterbody ID	OK621000020040_00	OK621000020130_00	OK621010010130_00	OK621100000010_20
Open Water (Acres)	299.5	56.8	65.1	740.2
Developed, Open Space (Acres)	2,189.9	204.1	1,149.3	2,708.9
Developed, Low Intensity (Acres)	872.5	59.4	424.6	912.5
Developed, Medium Intensity (Acres)	507.6	21.1	291.9	486.6
Developed, High Intensity (Acres)	71.5	2.2	38.6	113.9
Bare Rock/Sand/Clay (Acres)	10.6	25.9	15.0	26.7
Deciduous Forest (Acres)	467.1	3.5	165.5	195.6
Evergreen Forest (Acres)	331.8		11.7	
Mixed Forest (Acres)	1.6		0.5	18.2
Shrub/Scrub (Acres)	1.7	8.1	5.0	9.1
Grasslands/Herbaceous (Acres)	22,424.2	4,424.6	14,525.8	19,612.1
Pasture/Hay (Acres)	632.5	39.9	50.6	2,547.2
Cultivated Crops (Acres)	52,426.5	2,696.1	20,603.2	56,318.2
Woody Wetlands (Acres)	156.8	27.2	2.7	2,278.0
Emergent Herbaceous Wetlands (Acres)	133.3	76.3	5.1	347.2
Total (Acres)	80,527	7,645	37,355	86,314
Open Water (%)	0.4%	0.7%	0.2%	0.9%
Developed, Open Space (%)	2.7%	2.7%	3.1%	3.1%
Developed, Low Intensity (%)	1.1%	0.8%	1.1%	1.1%
Developed, Medium Intensity (%)	0.6%	0.3%	0.8%	0.6%
Developed, High Intensity (%)	0.1%	0.03%	0.1%	0.1%
Bare Rock/Sand/Clay (%)	0.01%	0.3%	0.04%	0.03%
Deciduous Forest (%)	0.6%	0.05%	0.4%	0.2%
Evergreen Forest (%)	0.4%		0.03%	
Mixed Forest (%)	0.002%		0.001%	0.02%
Shrub/Scrub (%)	0.002%	0.1%	0.01%	0.01%
Grasslands/Herbaceous (%)	27.8%	57.9%	38.9%	22.7%
Pasture/Hay (%)	0.8%	0.5%	0.1%	3.0%
Cultivated Crops (%)	65.1%	35.3%	55.2%	65.2%
Woody Wetlands (%)	0.2%	0.4%	0.01%	2.6%
Emergent Herbaceous Wetlands (%)	0.2%	1.0%	0.01%	0.4%
Total (%):	**100%**	**100%**	**100%**	**100%**

SECTION 2 PROBLEM IDENTIFICATION AND WATER QUALITY TARGET

2.1 Oklahoma Water Quality Standards

Title 252 of the Oklahoma Administrative Code contains Oklahoma Water Quality Standards (WQS) and implementation procedures (DEQ 2022). The Oklahoma Department of Environmental Quality (DEQ) has statutory authority and responsibility concerning establishment of State WQS, as provided under 82 Oklahoma Statute [O.S.], §1085.30. This statute authorizes the DEQ to promulgate rules …w*hich 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 (DEQ 2022). An excerpt of the Oklahoma WQS (Title 252) summarizing the State of Oklahoma Antidegradation Policy is provided in **Appendix C**. **Table 2-1,** an excerpt from the 2022 Integrated Report (DEQ 2022), lists beneficial uses designated for each impaired stream segment in the Study Area. The beneficial uses include:

- AES – Aesthetics
- AG – Agriculture Water Supply
- Fish and Wildlife Propagation
  - WWAC – Warm Water Aquatic Community
- FISH – Fish Consumption
- PBCR – Primary Body Contact Recreation
- PPWS – Public & Private Water Supply

Table 2-1 Designated Beneficial Uses for Each Stream Segment in the Study Area

Waterbody Name	Waterbody ID	AES	AG	WWAC	FISH	PBCR	PPWS
Wild Horse Creek	OK621000020040_00	F	F	N	X	N	
Spring Creek	OK621000020130_00	F	F	F	X	N	
Clay Creek, West	OK621010010130_00	F	N	N	X	N	I
Chikaskia River	OK621100000010_20	I	F	F	X	N	F
F – Fully supporting	N – Not supporting	I-Insufficient data	X–Not assessed	**Source:** DEQ 2022 Integrated Report			

2.1.1 Chapter 730: Definition of PBCR and Bacterial WQSs

The definition of PBCR and the bacterial WQSs for PBCR are summarized by the following excerpt from Title 252, Chapter 730-5-16 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.*

(c). *Compliance with 252:730-5-16 shall be based upon meeting the requirements of one of the options specified in (1) or (2) of this subsection (c) for bacteria. Upon selection of one (1) group or test method, said method shall be used exclusively over the time period prescribed therefore. Provided, where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, no criteria exceedances shall be allowed for any indicator group.*

(1) Escherichia coli (E. coli): The E. coli geometric mean criterion is 126/100 ml. For swimming advisory and permitting purposes, E. coli shall not exceed a monthly geometric mean of 126/100 ml based upon a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. For swimming advisory and permitting purposes, no sample shall exceed a 75% one-sided confidence level of 235/100 ml in lakes and high use waterbodies and the 90% one-sided confidence level of 406/100 ml in all other Primary Body Contact Recreation beneficial use areas. These values are based upon all samples collected over the recreation period. For purposes of sections 303(d) and 305(b) of the federal Clean Water Act as amended,

beneficial use support status shall be assessed using only the geometric mean criterion of 126/100 milliliters compared to the geometric mean of all samples collected over the recreation period.

(2) Enterococci: The Enterococci geometric mean criterion is 33/100 ml. For swimming advisory and permitting purposes, Enterococci shall not exceed a monthly geometric mean of 33/100 ml based upon a minimum of not less than five (5) samples collected over a period of not more than thirty (30) days. For swimming advisory and permitting purposes, no sample shall exceed a 75% one-sided confidence level of 61/100 ml in lakes and high use waterbodies and the 90% one-sided confidence level of 108/100 ml in all other Primary Body Contact Recreation beneficial use areas. These values are based upon all samples collected over the recreation period. For purposes of sections 303(d) and 305(b) of the federal Clean Water Act as amended, beneficial use support status shall be assessed using only the geometric mean criterion of 33/100 milliliters compared to the geometric mean of all samples collected over the recreation period.

2.1.2 Chapter 740: Implementation of Oklahoma's WQS for PBCR

To implement Oklahoma's WQS for PBCR, DEQ promulgated *Chapter 740, Implementation of Oklahoma's Water Quality Standards* (DEQ 2022). The following excerpt from Chapter 740 (OAC 252:740-15-6), 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 252:730 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). ***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. These values are based upon all samples collected over the recreation period in accordance with OAC 252:740-15-3(c).

(2) 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. These values are based upon all samples collected over the recreation period in accordance with OAC 252:740-15-3(c).

(c). ***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. These values are based upon all samples collected over the recreation period in accordance with OAC 252:740-15-3(c).

(2) 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. These values are based upon all samples collected over the recreation period in accordance with OAC 252:740-15-3(c).

Compliance with the Oklahoma WQS is based on meeting requirements for both *E. coli* and Enterococci bacterial indicators in addition to the minimum sample requirements for assessment. 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 (DEQ 2022).

As stipulated in the WQS, only the geometric mean of all samples collected over the primary recreation period shall be used to assess the impairment status of a stream segment. Therefore, only the geometric mean criteria will be used to develop TMDLs for *E. coli* and Enterococci.

2.1.3 Chapter 740: Minimum Number of Samples

The excerpt below from Chapter 740 (OAC 252:740-15-3(d)), stipulates the minimum number of samples to assess beneficial use.

252:740-15-3. Data requirements

(d) ***Minimum number of samples.***

(1) Except when (f) of this Section applies, or unless otherwise noted in subchapter OAC 252:740-15 for a particular parameter, a minimum number of samples shall be required to assess beneficial use support.

(A) For streams and rivers, a minimum of 10 samples shall be required.

(B) For lakes greater than 250 surface acres, a minimum of 20 samples shall be required.

(C) For lakes 250 surface acres or smaller, a minimum of 10 samples shall be required.

(D) For toxicants for the protection of the Fish and Wildlife Propagation and Public and Private Water beneficial uses, a minimum of 5 samples shall be required.

(2) In order to satisfy the minimum sample requirements of this sub-section, samples may be aggregated consistent with the spatial and temporal requirements prescribed in (b), (c), and (d) of this Section.

(3) The prescribed minimum samples shall not be necessary if the available samples already assure exceedance of the applicable percentage for beneficial use assessment.

(4) If a mathematical calculation including, but not limited to, a mean, median, or quartile, is required for assessment, a minimum of ten samples shall be required, regardless of the parameter type.

(5) Additional samples for the calculation of temperature, pH and hardness dependent acute and chronic criteria shall be collected as required by OAC 252:740-5-4.

2.1.4 Prioritization of TMDL Development

Table 2-2 summarizes the PBCR use attainment status and the bacterial impairment status for streams in the Study Area. The TMDL priority shown in **Table 2-2** is directly related to the TMDL target date. The TMDLs established in this report, which are a necessary step in the process of restoring water quality, only address bacterial impairments that affect the PBCR beneficial use.

After the 303(d) list is compiled, DEQ assigns a four-level rank to each of the Category 5a waterbodies. This rank helps in determining the priority for TMDL development. The rank is based on criteria developed using the procedure outlined in the 2012 Continuing Planning Process (pp. 139-140). The TMDL prioritization point totals calculated for each watershed were broken down into the following four priority levels:[2]

Priority 1 watersheds - above the 90th percentile

Priority 2 watersheds - 70th to 90th percentile

Priority 3 watersheds - 40th to 70th percentile

Priority 4 watersheds - below the 40th percentile

Each waterbody on the 2022 303(d) list has been assigned a potential date of TMDL development based on the priority level for the corresponding HUC 11 watershed.

Priority 1 watersheds are targeted for TMDL development within the next two years. Other priority watersheds are established for TMDL development within the next five years for Priority 2, eight years for Priority 3, and eleven years for Priority 4.

[2] Appendix C, 2022 Integrated Report

Table 2-2 Excerpt from the 2022 Integrated Report – Oklahoma 303(d) List of Impaired Waters

Waterbody ID	Waterbody Name	Stream Miles	Priority	ENT	*EC*	Designated Use Primary Body Contact Recreation	Turbidity	Designated Use Warm Water Aquatic Life
OK621000020040_00	Wild Horse Creek	24.66	3		X	N		N*
OK621000020130_00	Spring Creek	6.14	3	X	X	N		F
OK621010010130_00	Clay Creek, West	22.92	1	X	X	N		N*
OK621100000010_20	Chikaskia River	12.81	4	X		N		F

Note: ENT = Enterococci; ***EC***= *Escherichia coli;* **N** = Not attaining; **X** = Criterion exceeded; F = Fully supporting,
* Impaired for Macroinvertebrate Bio-assessments,
Source: 2022 Integrated Report, DEQ 2022

2.2 Bacterial Data Summary

Table 2-3 summarizes water quality data collected during primary contact recreation season from the WQM stations between **2000** and **20189** for each indicator bacteria. The data summary in **Table 2-3** provides a general understanding of the amount of water quality data available and the severity of exceedances of the water quality criteria. This data collected during the PBCR season was used to support the decision to place specific waterbodies within the Study Area on the DEQ 2022 303(d) list (DEQ 2022). Water quality data from the PBCR season are provided in **APPENDIX A:** For the data collected between **2000** and **2018,** evidence of nonsupport of the PBCR use based on Enterococci or *E. coli* exceedances was observed in all waterbodies.

Seven bacterial TMDLs are needed for the waterbodies in the Study Area. Rows highlighted in green in **Table 2-3** required TMDLs.

2.3 Water Quality Targets

The Code of Federal Regulations (40 CFR § Part 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." The water quality targets for *E. coli* and Enterococci are geometric mean standards of 126 colonies/100 ml and 33 colonies/100 ml, respectively. The TMDL for bacteria will incorporate an explicit 10% margin of safety as well as 10% future growth.

Table 2-3 Summary of Assessment of Indicator Bacterial Samples from Primary Body Contact Recreation Subcategory Season May 1 to September 30, 2000-2018

Waterbody ID	Waterbody Name	Indicator	Sample Period	Number of Samples	Geometric Mean Conc. (colonies/100 ml)	Assessment Results/ Recommended Action
OK621000020040_00	Wild Horse Creek	ENT	2002 - 2004	8	172	Impaired & List in 303(d)/ TMDL
		EC	2017 - 2018	10	205	Impaired / TMDL
OK621000020130_00	Spring Creek	ENT	2000 - 2001	6	146	Impaired / TMDL
		EC	2000 - 2001	6	165	Impaired / TMDL
OK621010010130_00	West Clay Creek	ENT	2004 - 2008	10	157	Impaired / TMDL
		EC	2017 - 2018	10	322	Impaired / TMDL
OK621100000010_20	Chikaskia River	ENT	2004 - 2008	10	85	Impaired / TMDL
		EC	2004 - 2008	10	94	Meet WQS / No TMDL

Note: ENT = Enterococci; water quality criterion = Geometric Mean of 33 colonies/100 mL
EC= *Escherichia coli,* water quality criterion = Geometric Mean of 126 colonies/100 mL
TMDLs will be developed for waterbodies highlighted in green

SECTION 3 POLLUTANT SOURCE ASSESSMENT

3.1 Overview

A pollutant source assessment characterizes known and suspected sources of pollutant loading to impaired waterbodies. Sources within a watershed are categorized and quantified to the extent that information is available. Pathogen indicator bacteria originate from the digestive tract of warm-blooded animals, and sources may be point or nonpoint in nature.

Point source dischargers are permitted through the OPDES program. OPDES-permitted facilities that discharge treated wastewater are currently required to monitor for *E. coli* in accordance with their permits. Nonpoint sources are diffuse sources that typically cannot be identified as entering a waterbody through a discrete conveyance at a single location. Nonpoint sources may emanate from natural sources or 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 OPDES permits are considered nonpoint sources.

The potential nonpoint sources for bacteria were compared based on the fecal coliform load produced in each subwatershed. Although fecal coliform is no longer used as a bacterial indicator in the Oklahoma WQS, it is still valid to use fecal coliform concentration or loading estimates to compare the potential contributions of different nonpoint sources because *E. coli* is a subset of fecal coliform. Currently there is insufficient data available in the scientific arena to quantify counts of *E. coli* in feces from warm-blooded animals discussed in Section 3.

The following nonpoint sources of bacteria were considered in this report:

- Wildlife (deer)
- Non-Permitted Agricultural Activities and Domesticated Animals
- Pets (dogs and cats)
- Failing Onsite Wastewater Disposal (OSWD) Systems and Illicit Discharges

The following discussion describes what is known regarding point and nonpoint sources of bacteria in the TMDL watersheds. Where information was available on point and nonpoint sources of indicator bacteria data were provided and summarized as part of each category.

3.2 OPDES-Permitted Facilities

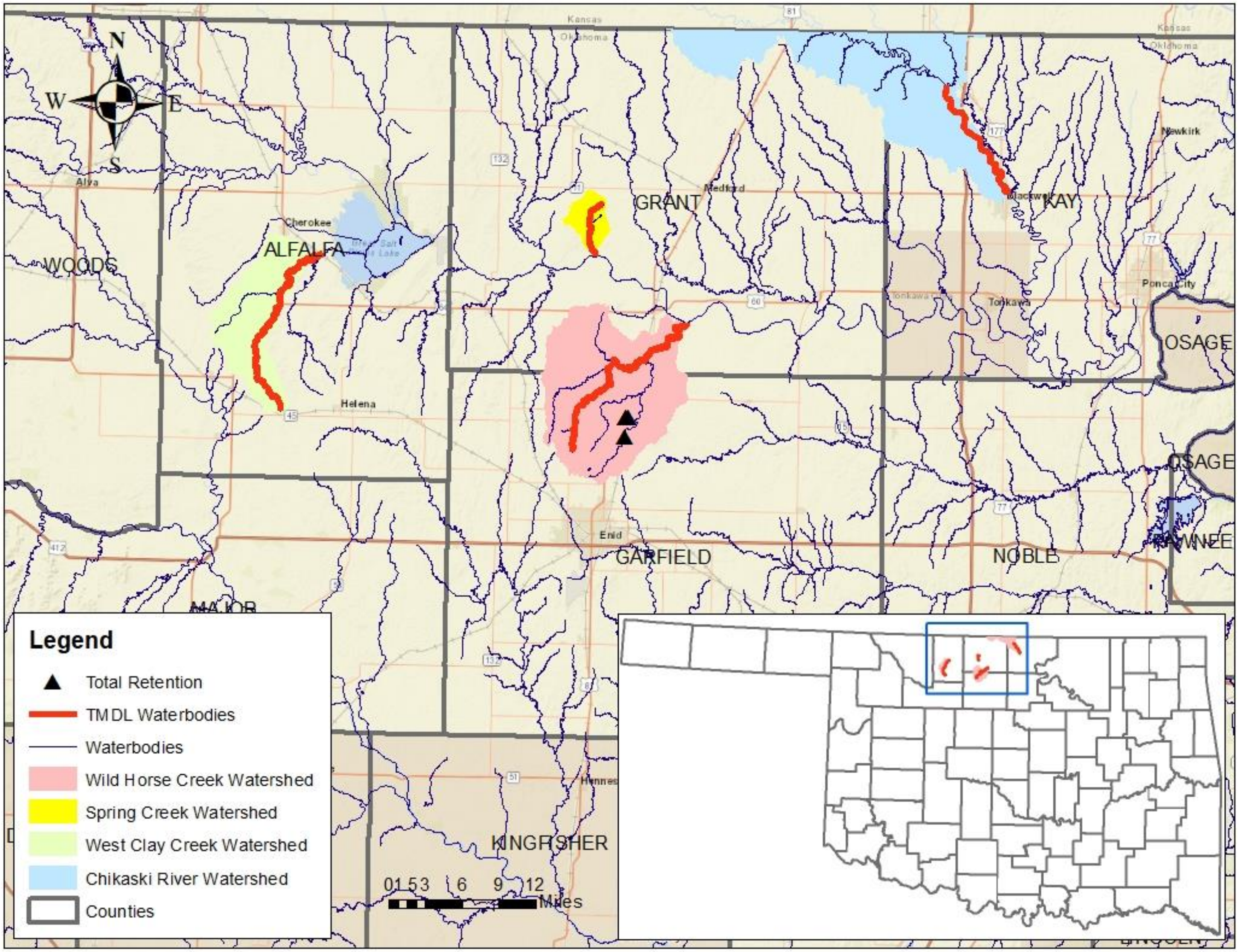
Under 40 CFR § Part 122.2, a point source is described as a discernible, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters.

OPDES-permitted facilities classified as point sources that may contribute bacterial loading into the watersheds include:

- Continuous Point Source Dischargers
  - OPDES municipal wastewater treatment facilities (WWTF) discharges
  - OPDES industrial WWTF discharges
- OPDES-regulated stormwater discharges
  - Municipal separate storm sewer system (MS4) discharges
    - Phase 1 MS4
    - Phase 2 MS4 – OKR04
- No-discharge WWTF
- Sanitary sewer overflow (SSO)
- NPDES Animal Feeding Operations (AFO)
  - Concentrated Animal Feeding Operations (CAFO)
  - Swine Feeding Operation (SFO)
  - Poultry Feeding Operation (PFO)

No waterbodies in the Study Area have OPDES-permitted facilities within their contributing watersheds. 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 bacterial loading to surface waters. CAFOs are recognized by EPA as potential significant sources of pollution, and may have the potential to cause serious impacts to water quality if not properly managed.

Figure 3-1 Location of Total Retention Facilities in the Study Area



3.2.1 Continuous Point Source Dischargers

Continuous point source discharges, such as WWTFs, could result in discharge of elevated concentrations of indicator bacteria if the disinfection unit is not properly maintained, is of poor design, or if flow rates are above the disinfection capacity.

3.2.1.1 Municipal OPDES WWTFs

There are no permitted municipal point source facilities within the Study Area. Municipal WWTFs are designated with a Standard Industrial Code (SIC) number 4952. The effluent from these facilities is considered a source of bacteria.

3.2.1.2 Industrial OPDES WWTFs

There are no industrial WWTFs within the Study Area.

3.2.2 Stormwater Permits

Stormwater runoff from OPDES-permitted facilities (MS4s, facilities with multi-sector general permits, and construction sites) can contain impairments. The National Stormwater Quality Database (NSQD) summarizes concentrations for a number of pollutants of concern in stormwater runoff from around the country (Pitt et. al. 2004). Based on data summarized in the NSQD, median concentration in stormwater ranged from 570 to 9,000 colonies/100 ml for *E. coli*.

EPA regulations [40 C.F.R. §130.2(h)] require that NPDES-regulated stormwater discharges must be addressed by the WLA component of a TMDL. Stormwater runoff from permitted areas can contain high fecal coliform concentrations. Therefore, MS4 areas will receive WLAs for each bacterial indicator exceeding WQS.

3.2.2.1 Municipal Separate Storm Sewer System Permit

3.2.2.1.1 Phase I MS4

In 1990, EPA developed Phase I of the NPDES Stormwater Program. This program was designed to prevent harmful pollutants in MS4s from being washed by stormwater runoff into local waterbodies (EPA 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 facilities in the Study Area.

3.2.2.1.2 Phase II MS4 (OKR04)

In 1999, Phase II began requiring certain small MS4s to comply with the NPDES stormwater program. 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," to protect water quality, and to satisfy appropriate water quality requirements of the CWA. Phase II MS4 stormwater programs must address the following six minimum control measures:

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

In Oklahoma, Phase II General Permit (OKR04) for small MS4 communities has been in effect since 2005. Information about DEQ's MS4 program can be found on-line at the following DEQ website: https://www.deq.ok.gov/water-quality-division/wastewater-stormwater/stormwater-permitting/okr04-municipal-stormwater/.

There are no Phase II MS4 communities in the Study Area.

3.2.3 No-Discharge Facilities

Some facilities are classified as no-discharge. These facilities are required to sign an affidavit of no discharge. For the purposes of these TMDLs, it is assumed that no-discharge facilities do not contribute indicator bacterial loading. While 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 bacterial loading to surface waters. For example, discharges from the wastewater facility may occur during large rainfall events that exceed the systems' storage capacities. There are two no-discharge facilities in the Wild Horse Creek watershed (**Figure 3-1**).

3.2.4 Sanitary Sewer Overflows

Sanitary sewer overflow (SSO) from wastewater collection systems, although infrequent, can be a major source of indicator bacterial 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 EPA, primarily through enforcement and fines. While not all sewer overflows are reported, DEQ has some data on SSOs reported between **1992** and **2000**. During that period overflows were reported ranging from 100 to over 21 million gallons. **Table 3-1** summarizes the SSO occurrences by total retention facility. Given the insignificant number of occurrences and the size of overflows reported over their duration (APPENDIX D:, the SSOs were not considered to be a significant source of bacteria loading to streams in the Study Area.

3.2.5 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. ODAFF is the NPDES-permitting authority for animal feeding operations in Oklahoma under what ODAFF calls the Agriculture Pollutant Discharge Elimination System (AgPDES). Through regulations (rules) established by the Oklahoma Concentrated Animal Feeding Operation (CAFO) Act (Title 2, Chapter 1, Article 20 – 40 to Article 20 – 64 of the State Statutes), Swine Feeding Operation (SFO) Act (Title 2, Chapter 1, Article 20 – 1 to Article 20 – 29 of the State Statutes), and Poultry Feeding Operation (PFO) Registration Act (Title 2, Chapter 10-9.1 to 10-9.12 of the State Statutes), AEMS works with producers and concerned citizens to ensure that animal waste does not impact the waters of the State.

All of these animal feeding operations (AFO) require an Animal Waste Management Plan (AWMP) to prevent animal waste from entering any Oklahoma waterbody. These plans outline how the animal feeding operator will prevent direct discharges of animal waste into waterbodies as well as any runoff of waste into waterbodies. The rules for all of these AFOs recommend using the USDA NRCS' Agricultural Waste Management Field Handbook to develop their Plan. NRCS has developed Animal Waste Management software to develop this Plan.

3.2.5.1 CAFO

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 2014). AWMP (Section 35:17-4-12), as specified in Oklahoma's CAFO regulations are designed to protect water quality through the use of structures such as dikes, berms, terraces, ditches, to isolate animal waste from outside surface drainage, except for a 25-year, 24–hour rainfall event.[3] AWMPs may include, but are not limited to, a NRCS Geospatial Nutrient Tool or Nutrient Management Plan per EPA guidance.

CAFOs are considered no-discharge facilities for the purpose of the TMDL calculations in this report, they are not considered a source of animal waste

[3] CAFO Animal Waste Management Plan Requirements [Title 35 (ODAFF), Chapter 17 (Water Quality), Subchapter 4 (Concentrated Animal Feeding Operations)] can be found in 35:17-4-12.

into surface waterbodies or groundwater is prohibited. CAFOs are designated by EPA 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.

Oklahoma CAFO Rules require CAFOs to submit a *Documentation of No Hydrologic Connection* (OAC 35:17-4-10[4]) for all retention structures designed to prevent any leakage of wastewater into waterbodies. Thus, the potential for pollutant loading from CAFOs to a receiving stream is almost non-existent. There are no CAFOs in the Study Area.

3.2.5.2 SFO

The purpose of the SFO Act is to provide for environmentally responsible construction and expansion of swine feeding operations and to protect the safety, welfare and quality of life of persons who live in the vicinity of a swine feeding operation.[5] According to the SFO Act, a "Concentrated swine feeding operation" is a lot or facility where swine kept for at least ninety (90) consecutive days or more in any twelve-month period and where crops, vegetation, forage growth or post-harvest residues are not grown during the normal growing season on any part of the lot.

SFOs are required to develop a Swine Waste Management Plan[6], to prevent swine waste from being discharged into surface or groundwater. This Plan includes the BMPs being used to prevent runoff and erosion. The Swine Waste Management Plan may include, but is not limited to, a Comprehensive Nutrient Management Plan (CNMP) per NRCS guidance or Nutrient Management Plan (NMP) per EPA guidance. SFOs are required to store wastewater in Waste Retention Structures (WRS) and either to land apply wastewater or make the WRS large enough to be total retention lagoons. SFOs are not allowed to discharge to State waterbodies.

For large SFOs with more than 1,000 animal units, monitoring wells or a leakage detection system for waste retention structures must be installed in order to monitor and control seepage/leakage [OAC 35:17-3-11(i)(6)].

There are no SFOs in the Study Area**.**

4 USDA NRCS design specifications in the USDA NRCS Agricultural Waste Management Field Handbook Chapter 10 shall satisfy documentation of no hydrologic connection so long as the facility is designed by USDA NRCS and does not exceed one thousand (1,000) animal units.

5 A concentrated swine feeding operation has at least 750 swine that each weighs over 25 kilograms (about 55 pounds), 3,000 weaned swine weighing under 25 kilograms, or 300 swine animal units. A swine animal unit is a unit of measurement for any swine feeding operation calculated by adding the following numbers: The number of swine weighing over twenty-five (25) kilograms, multiplied by four-tenths (0.4), plus the number of weaned swine weighing under twenty-five (25) kilograms multiplied by one-tenth (0.1)

6 Swine Animal Waste Management Plan Requirements [Title 35 (ODAFF), Chapter 17 (Water Quality), Subchapter 3 (Swine Feeding Operations)] can be found in 35:17-3-14.

Table 3-1 Sanitary Sewer Overflow Summary (1992-2000)

Facility Name	NPDES Permit No.	Receiving Water	Facility ID	Number of Occurrences	Date Range		Amount (Gallons)	
					From	To	Min	Max
Kremlin WWT	TRL000246	Sand Creek (OK621000020050_00) to Wild Horse Creek (OK621000020040_00)	S21008	14	9/3/92	1/3/00	100	21,396,092

3.2.5.3 PFO

Poultry feeding operations not licensed under the Oklahoma Concentrated Animal Feeding Operation Act must register with the State Board of Agriculture. A registered PFO is an animal feeding operation which raises poultry and generates more than 10 tons of poultry waste (litter) per year. According to PFO regulations, PFOs are required to develop an AWMP or an equivalent nutrient management plan (NMP) such as the ODAFF Nutrient Management Plan or EPA Nutrient Management Plan. These plans describe how litter will be stored and applied properly in order to protect water quality of streams and lakes located in the watershed. A PFO AWMP must address both nitrogen and phosphorus. In order to comply with this TMDL, the registered PFOs in the watershed and their associated management plans must be reviewed. Further actions to reduce bacterial loads and achieve progress toward meeting the specified reduction goals must be implemented.

According to the PFO rules, runoff of poultry waste from the application site is prohibited. BMPs and practices must be used to minimize movement of poultry waste to waterbodies. Grassed strips at the edge of the field must be used to prevent runoff from carrying poultry waste into the waterbodies. Poultry waste is not allowed to be applied to land when the ground is saturated or while it is raining; and poultry waste application is prohibited on land with excessive erosion.[7]

PFOs located in nutrient limited watersheds should have a nutrient sample analysis from that year to make available.[8] PFOs in non-nutrient limited watersheds perform nutrient sample analysis at least once every three years and must have available the most recent record of the analysis.

There are no PFOs in this Study Area.

3.2.6 Section 404 Permits

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

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7 PFO Animal Waste Management Plan Requirements [Title 35 (ODAFF), Chapter 17 (Water Quality), Subchapter 5 (Registered Poultry Feeding Operations)] can be found in 35:17-5-5.

8 Nutrient limited watersheds are defined in the Oklahoma Water Quality Standards (Title 252, Chapter 730). Nutrient limited watersheds can be found in Appendix A of the Oklahoma WQS. They are the ones designated “NLW” in the “Remarks” column.

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

Discharge of dredged or fill material in waters can be a significant source of turbidity/TSS. The federal CWA requires that a permit be issued for activities which discharge dredged or fill materials into the waters of the United States, including wetlands. The State of Oklahoma will use its Section 401 Certification authority to ensure Section 404 Permits protect Oklahoma WQS.

3.3 Nonpoint Sources

Nonpoint sources include those sources that cannot be identified as entering the waterbody at a specific location. The relatively homogeneous land use/land cover categories throughout the Study Area associated with rural agricultural, forest and range management activities have an influence on the origin and pathways of pollutant sources to surface water. Bacteria originate from warm-blooded animals in rural, suburban, and urban areas. These sources include wildlife, various agricultural activities and domesticated animals, land application fields, urban runoff, failing OSWD systems and domestic pets. Water quality data collected from streams draining urban communities often show existing concentrations of fecal coliform bacteria at levels greater than a state’s water quality standards. A study under EPA’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 (EPA 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 non-permitted communities show a high level of fecal coliform bacteria.

The following sections provide general information on nonpoint sources contributing bacterial loading within the TMDL watersheds.

3.3.1 Wildlife

Fecal coliform bacteria are produced by all warm-blooded animals, including wildlife such as mammals and birds. In developing bacterial TMDLs it is important to identify the potential for bacterial contributions from wildlife by watershed. Wildlife is naturally attracted to riparian corridors of streams and rivers due to habitat and resource availability. With direct access to the stream channel, wildlife can be a concentrated source of bacterial 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 of wildlife and avian species by watershed. Consequently, it is difficult to assess the magnitude of bacterial 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 (ODWC) 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 2017 to 2021 was combined with an estimated annual harvest rate of 20% 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.

According to a study conducted by the American Society of Agricultural Engineers (ASAE), deer release approximately 5×10^8 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 based on the estimated deer population provided in **Table 3-2** in counts/day provides a relative magnitude of loading in each of the TMDL watersheds impaired for bacteria.

Table 3-2 Estimated Population and Fecal Coliform Production for Deer

Waterbody ID	Waterbody Name	Watershed Area (acres)	Wild Deer Population	Estimated Wild Deer per Acre	Fecal Production (x 10^9 colonies/day) of Deer Population
OK621000020040_00	Wild Horse Creek	80,527	754	0.01	377
OK621000020130_00	Spring Creek	7,645	85	0.01	43
OK621010010130_00	Clay Creek, West	37,355	381	0.01	191
OK621100000010_20	Chikaskia River	86,314	868	0.01	434

3.3.2 Non-Permitted Agricultural Activities and Domesticated Animals

There are a number of non-permitted agricultural activities that can also be sources of bacterial. Agricultural activities of greatest concern are typically those associated with livestock operations (Drapcho and Hubbs 2002). Examples of commercially raised farm animal activities that can contribute to stream pollutants include:

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

Detailed information is not available to describe or quantify the relationship between in-stream concentrations of bacteria and land application or direct deposition of manure from commercially raised farm animals. Despite the lack of specific data, for the purpose of these TMDLs, land application of commercially raised farm animal manure is considered a potential source of bacterial loading to the watersheds in the Study Area. **Table 3-3** gives the daily fecal coliform production rates by animal species:

Table 3-3 Daily Fecal Coliform Production Rates by Animal Species

Animal	Daily fecal coliform production rate counts per animal per day
Beef cattle*	1.04E+11
Dairy cattle*	1.01E+11
Horses*	4.20E+08
Goats	1.20E+10
Sheep*	1.20E+10
Swine*	1.08E+10
Ducks*	2.43E+09
Geese*	4.90E+10
Chickens*	1.36E+08
Turkey*	9.30E+07
Deer*	$5x10^8$
Dogs🐈	$3.3x10^9$
Cats🐈	$5.4x10^8$
* According to a livestock study conducted by the ASAE (1999)	
🐈 Schueler, TR 1999	

The estimated acreage by watershed where manure was applied in 2022 is shown in **Table 3-4**. This was calculated using the 2022 U.S. Department of Agriculture (USDA) county agricultural census data (USDA 2022) and the percentage of the watershed within each county. Because the watersheds are generally much smaller than the counties, and commercially raised farm animals are not evenly distributed across counties or constant with time, these are rough estimates only. According to **Table 3-4,** cattle are clearly the most abundant species of commercially raised farm animals in the Study Area and often have direct access to the waterbodies and their tributaries.

Using the estimated animal populations and the fecal coliform production rates from **Table 3-3**, an estimate of fecal coliform production from each group of commercially raised farm animal was calculated in each watershed of the Study Area. These estimates are presented in **Table 3-5**. 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. Because of their numbers, cattle appear to represent the most likely commercially raised farm animal source of fecal bacteria loading.

Table 3-4 Commercially Raised Farm Animals and Manure Application Area Estimated by Watershed

Waterbody ID	Waterbody Name	Cattle	Dairy Cows	Horses	Sheep	Hogs & Pigs	Ducks	Acres of Manure Application
OK621000020040_00	Wild Horse Creek	6,305	32	66	74	12	6	227
OK621000020130_00	Spring Creek	517	0	4	2	2	0	20
OK621010010130_00	Clay Creek, West	3,576	6	22	12	2	2	232
OK621100000010_20	Chikaskia River	5,346	15	69	168	21	13	322

Table 3-5 Fecal Coliform Production Estimated for Commercially Raised Farm Animals (x 10^9 counts/day)

Waterbody ID	Waterbody Name	Cattle	Dairy Cows	Horses	Sheep	Hogs & Pigs	Ducks	Total
OK621000020040_00	Wild Horse Creek	655,714	3,244	28	892	135	15	660,828
OK621000020130_00	Spring Creek	53,783	0	2	23	17	0	53,838
OK621010010130_00	Clay Creek, West	371,924	636	9	148	16	4	372,907
OK621100000010_20	Chikaskia River	559,114	1,496	29	2,021	224	32	563,143

3.3.3 Domestic Pets

Fecal matter from dogs and cats, which can be transported to streams by runoff from urban and suburban areas, is a potential source of bacterial loading. On average 45% of the nation's households own dogs and 26% own cats. In 2020, the average number of pets per household was 1.5 dogs and 1.8 cats (American Veterinary Medical Association 2022). Using the U.S. Census data at the block level (U.S. Census Bureau 2020), dog and cat populations can be estimated for each watershed. **Table 3-6** summarizes the estimated number of dogs and cats for the watersheds of the Study Area. **Table 3-7** provides an estimate of the fecal coliform production from pets. These estimates are based on estimated fecal coliform production rates from **Table 3-3.**

Table 3-6 Estimated Numbers of Pets

Waterbody ID	Waterbody Name	Dogs	Cats
OK621000020040_00	Wild Horse Creek	942	653
OK621000020130_00	Spring Creek	17	12
OK621010010130_00	Clay Creek, West	111	77
OK621100000010_20	Chikaskia River	1,222	847

Table 3-7 Estimated Fecal Coliform Daily Production by Pets (x10^9 counts/day)

Waterbody ID	Waterbody Name	Dogs	Cats	Total
OK621000020040_00	Wild Horse Creek	3,108	353	3,461
OK621000020130_00	Spring Creek	57	6	63
OK621010010130_00	Clay Creek, West	366	41	407
OK621100000010_20	Chikaskia River	4,033	458	4,491

3.3.4 Failing Onsite Wastewater Disposal Systems and Illicit Discharges

DEQ 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 (DEQ 2021). OSWD systems and illicit discharges can be sources of bacterial loading to streams and rivers. Bacterial 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 may discharge to creeks through springs and seeps.

To estimate the potential magnitude of OSWDs fecal bacterial 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 which was the last year in which there were Census questions about plumbing facilities (U.S. Department of Commerce, Bureau of the Census 1990). 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 block 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 1990 American Housing Survey for Oklahoma conducted by the U.S. Census Bureau estimates that, nationwide, 10% of occupied homes with OSWD systems experience malfunctions during the year (U.S. Department of Commerce, Bureau of the Census 1990). A study conducted by Reed et al. (2001) reported that approximately 12% of the OSWD systems in east Texas and 8% in the Texas Panhandle 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 3-8** summarizes estimates of sewered and unsewered households and the average number of septic tanks per square mile for each watershed in the Study Area.

For the purpose of estimating fecal coliform loading in watersheds, an OSWD failure rate of 12% was used in the calculations made to characterize fecal coliform loads in each watershed. Fecal coliform loads were estimated using the following equation (EPA 2001):

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

Table 3-8 Estimated of Sewered and Unsewered Households

Waterbody ID	Waterbody Name	Public Sewer	Septic Tank	Other Means	Housing Units	# of Septic Tanks/Mile^2
OK621000020040_00	Wild Horse Creek	1,179	214	6	1,399	1.7
OK621000020130_00	Spring Creek	23	11	0	34	1.0
OK621010010130_00	Clay Creek, West	142	77	4	223	1.3
OK621100000010_20	Chikaskia River	1,652	312	14	1,978	2.3

The average of number of people per household was calculated to be from 1.9 to 2.3 for counties in the TMDL watersheds (U.S. Census Bureau 2020). 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 publications (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 3-9.**

Table 3-9 Estimated Fecal Coliform Load from OSWD Systems

Waterbody ID	Waterbody Name	Watershed Area (Acres)	Septic Tank	# of Failing Septic Tanks	Estimated Loads from Septic Tanks (x 10^9 counts/day
OK621000020040_00	Wild Horse Creek	80,527	214	26	139
OK621000020130_00	Spring Creek	7,645	11	1	7
OK621010010130_00	Clay Creek, West	37,355	77	9	57
OK621100000010_20	Chikaskia River	86,314	312	37	200

3.4 Summary of Sources of Impairment

There are no continuous, permitted point sources of bacteria in the Study Area. Therefore, the conclusion is that nonsupport of PBCR use in these watersheds is caused by nonpoint sources of bacteria.

Table 3-10 provides a summary of the estimated percentage of fecal coliform loads in counts/day from the four major nonpoint source categories (commercially raised farm animals, pets, deer, and septic tanks) that contribute to the elevated bacterial concentrations in each watershed. The percentage of fecal coliform loads from commercially raised farm animal ranged from 99.4% to 99.8%. Because of their numbers and animal unit production of bacteria, commercially raised farm animals 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 bacterial source tracking studies around the nation demonstrate that wild birds and mammals represent a major source of the fecal bacteria found in streams. The magnitude of loading to a stream may not reflect the magnitude of loading to land surfaces. While no studies have quantified these effects, bacteria may die off or survive at different rates depending on the manure characteristics and a number of other environmental conditions. Also, the structural properties of some manure, such as cow patties, may limit their washoff into streams by runoff. In contrast, malfunctioning septic tank effluent may be present in standing water on the surface, or in shallow groundwater, which may enhance its conveyance to streams.

Table 3-10 Percentage Contribution 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
OK621000020040_00	Wild Horse Creek	99.4%	0.5%	0.1%	0.02%
OK621000020130_00	Spring Creek	99.8%	0.1%	0.1%	0.01%
OK621010010130_00	Clay Creek, West	99.8%	0.1%	0.1%	0.02%
OK621100000010_20	Chikaskia River	99.2%	0.8%	0.1%	0.04%

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SECTION 4 TECHNICAL APPROACH AND METHODS

4.1 Pollutant Loads and TMDLs

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 (WLA, LA, and MOS) as described in the following mathematical equation:

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

The WLA is the portion of the TMDL allocated to existing and future point sources. The LA is the portion of the TMDL allocated to nonpoint sources, including natural background sources. The MOS is intended to ensure that WQSs will be met.

For *E. coli* or Enterococci bacteria, TMDLs are expressed as colony-forming units per day and represent the maximum one day load the stream can assimilate while still attaining the WQS. Percent reduction goals are also calculated to aid in characterizing the possible magnitude of the effort to restore the segment to meeting water quality criterion.

4.2 Steps to Calculating 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 can help identify whether impairments are associated with point or nonpoint sources. The technical approach for using LDCs for TMDL development includes the following steps that are described in **Subsections 4.2.1** through **4.2.3**:

1. Prepare flow duration curves for gaged and ungaged WQM stations.
2. Estimate existing loading in the waterbody using ambient bacterial water quality data.
3. Use LDCs to identify if there is a critical condition.

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 WWTF 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 during low flows have been noted in some watersheds that contain no point sources.

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

4.2.1 Development of Flow Duration Curves

Flow duration curves (FDC) 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. Most of waterbodies in the Study Area do not have USGS gage stations. The default approach used to develop flow frequencies necessary to establish flow duration curves considers watershed differences in rainfall, land use, and the hydrologic properties of soil that govern runoff and retention. A detailed explanation of the methods for estimating flow for ungaged streams is provided in **Appendix B**.

To estimate flows at an ungaged site:

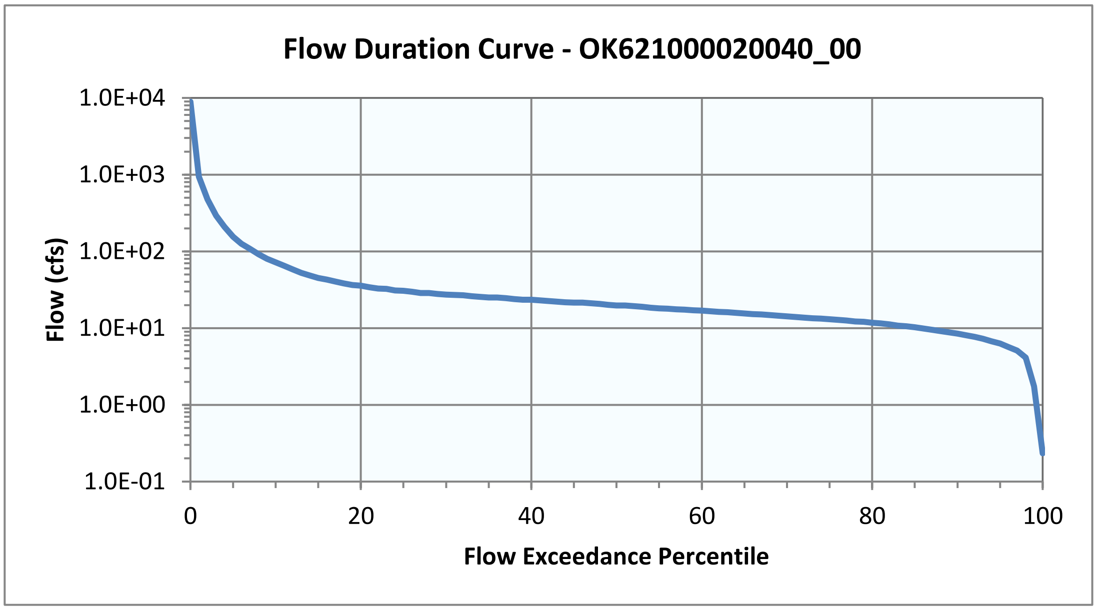
- Identify an upstream or downstream flow gage.
- Calculate the contributing drainage areas of the ungaged sites and the flow gage.
- Calculate daily flows at the ungaged site by using the flow at the gaged site multiplied by the drainage area ratio.

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 (x-axis), which is numbered from 0% to 100%, and may or may not be logarithmic. The lowest measured flow occurs at an exceedance frequency of 100% indicating that flow has equaled or exceeded this value 100% of the time, while the highest measured flow is found at an exceedance frequency of 0%. The median flow occurs at a flow exceedance frequency of 50%. The flow exceedance percentiles for each waterbody addressed in this report are provided in **Appendix Table B-1**.

Some instantaneous flow measurements were available from various agencies. When available, these instantaneous flow measurements were used in lieu of projected flows to calculate pollutant loads.

A typical semi-log flow duration curve exhibits a sigmoidal shape, bending upward near a flow exceedance frequency value of 0% and downward at a frequency near 100%, 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%. 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 quantization. An example of a typical flow duration curve is shown in **Figure 4-1**. Flow duration curves for each impaired waterbody in the Study Area are provided in **Section 5.1**.

Figure 4-1 Flow Duration Curve for Wild Horse Creek (OK621000020040_00)



4.2.2 Using Flow Duration Curves to Calculate Load Duration Curves

Existing in-stream loads can be calculated using FDCs. For bacteria:

- Calculate the geometric mean of all water quality observations from the period of record selected for the waterbody.
- Convert the geometric mean concentration value to loads by multiplying the flow duration curve by the geometric mean of the ambient water quality data for each bacterial indicator.

4.2.3 Using Load Duration Curves to Develop TMDLs

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

4.2.3.1 Step 1 - Generate LDCs

LDCs are similar in appearance to flow duration curves.

For bacteria, the ordinate is expressed in terms of a bacterial load in colonies/day. The bacterial curve represents the geometric mean water quality criterion for *E. coli* or Enterococci bacteria expressed in terms of a load through multiplication by the continuum of flows historically observed at the site. Bacterial TMDLs are not easily expressed in mass per day. The equation in **Section 4.2.3.1.1** calculates a load in the units of colonies per day. The colonies are a total for the day at a specific flow for bacteria, which is the best equivalent to a mass per day of a pollutant such as sulfate. Expressing bacterial TMDLs as colonies per day is consistent with EPA's *Protocol for Developing Pathogen TMDLs* (EPA 2001).

The following are the basic steps in developing an LDC:

1. Obtain daily flow data for the site of interest from the USGS.

2. Sort the flow data and calculate flow exceedance percentiles.

3. For bacteria, obtain water quality data for the primary contact recreation season (May 1 through September 30).

4. Display a curve on a plot that represents the allowable load determined by multiplying the actual or estimated flow by the WQS numerical criterion for each parameter (geometric mean standard for bacteria).

5. For bacterial TMDLs, display another curve derived by plotting the geometric mean of all existing bacterial samples continuously along the full spectrum of flow exceedance percentiles which represents the LDC (See **Section 5**).

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 are equal to or exceed the measured or estimated flow.

As noted earlier, runoff has a strong influence on loading of nonpoint pollution. Flows do not always correspond directly to runoff. High flows may occur in dry weather (e.g., lake release to provide water downstream) and runoff influence may be observed with low or moderate flows (e.g., persistent high turbidity due to previous storm).

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

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

Where:

WQS = 126 colonies/100 ml (E. coli); or 33 colonies/100 ml (Enterococci)

Unit conversion factor = 24,465,525

Historical observations of bacteria were plotted as a separate LDC based on the geometric mean of all samples. It is noted that the LDCs for bacteria were based on the geometric mean standards or geometric mean of all samples. It is inappropriate to compare single sample bacterial observations to a geometric mean water quality criterion in the LDC; therefore individual bacterial samples are not plotted on the LDCs.

4.2.3.2 Step 2 - Define MOS

The MOS may be defined explicitly or implicitly. A typical explicit approach would reserve some specific fraction of the TMDL as the MOS. In an implicit approach, conservative assumptions used in developing the TMDL are relied upon to provide an MOS to assure that WQSs are attained. For bacterial TMDLs in this report, an explicit MOS of 10% was selected. The 10% MOS has been used in other approved bacterial TMDLs.

4.2.3.3 Step 3 - Calculate WLA

As previously stated, the pollutant load allocation for point sources is defined by the WLA. For bacterial TMDLs a point source can be either a wastewater (continuous) or stormwater (MS4) discharge. Stormwater point sources are typically associated with urban and industrialized areas. Recent EPA guidance includes OPDES-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. WLAs can be expressed in terms of a single load, or as different loads allowable under different flows. WLAs may be set to zero in cases of watersheds with no existing or planned continuous permitted point sources.

WLA for WWTF

For watersheds with permitted point sources discharging the pollutant of concern, OPDES permit limits are used to derive WLAs for evaluation as appropriate for use in the TMDL. The permitted flow rate used for each point source discharge and the water quality concentration defined in a permit are used to estimate the WLA for each wastewater facility. In cases where a permitted flow rate is not available for a WWTF, then the average of monthly flow rates derived from DMRs can be used. WLA values for each OPDES wastewater discharger are then summed to represent the total WLA for a given segment. Using this information, WLAs can be calculated using the approach as shown in the equations below.

4.2.3.3.1 WLA for Bacteria

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

Where:

WQS = 126 colonies/100 ml (E. coli); or 33 colonies/100 ml (Enterococci)

Flow (mgd) = permitted flow

Unit conversion factor = 37,854,120

4.2.3.3.2 WLA for Future Growth

Future growth allowances in TMDLs account for increased pollutant loadings and can be included as an allocation of pollutant loads from new sources expected in the future. For bacterial TMDLs, 10% of TMDL was reserved for future sources.

4.2.3.4 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 OPDES permit limits for MS4s as BMPs.

LAs can be calculated under different flow conditions. The LA at any particular flow exceedance is calculated as shown in the equation below.

$$\mathbf{LA = TMDL - WLA\_{WWTF} - WLA\_{MS4} - WLA\_{Growth} - MOS}$$

For bacterial TMDLs, if there are no permitted MS4s in the Study Area, WLA_{MS4} is set to zero. When there are permitted MS4s in a watershed, first calculate the sum of LA + WLA_{MS4s} 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 boundary. However, in most case the study watershed intersects only a portion of the permitted MS4 coverage areas.

4.2.3.5 Step 5 - Estimate Percent Load Reduction

Percent load reductions are not required items and are provided for informational purposes when making inferences about individual TMDLs or between TMDLs usually in regard to implementation of the TMDL.

The LDC approach recognizes that the assimilative capacity of a waterbody depends on stream flow and that the maximum allowable loading varies with flow condition. Existing loading and load reductions required to meet the TMDL can also be calculated under different flow conditions. The difference between existing loading and the TMDL is used to calculate the loading reductions required. Percent reduction goals (PRG) are calculated through an iterative process of taking a series of percent reduction values applying each value uniformly to the measured concentrations of samples and verifying if the geometric mean of the reduced values of all samples is less than the geometric mean standards.

4.2.3.5.1 WLA Load Reduction

The WLA load reduction for bacteria was not calculated as it was assumed that continuous dischargers (OPDES-permitted WWTFs) are adequately regulated under existing permits to achieve WQS at the end-of-pipe and, therefore, no WLA reduction would be required. Currently, bacterial limits are not required for lagoon systems. Lagoon systems located within a sub-watershed of bacterially-impaired stream segment will be required to meet *E. coli* standards at the discharge when the permits are renewed.

MS4s are classified as point sources, but they are nonpoint sources in nature. Therefore, the percent reduction goal calculated for LA will also apply to the MS4 area within the bacterially-impaired sub-watershed. If there are no MS4s located within the Study Area requiring a TMDL, then there is no need to establish a PRG for permitted stormwater.

4.2.3.5.2 LA Load Reduction

After existing loading estimates are computed for each pollutant, nonpoint load reduction estimates for each segment are calculated by using the difference between the estimate of existing loading and the allowable loading (TMDL) under all flow conditions. This difference is expressed as the overall PRG for the impaired waterbody. The PRG serves as a guide for the amount of pollutant reduction necessary to meet the TMDL.

E. coli and Enterococci: WQSs are considered to be met if the geometric mean of all future data is maintained below the geometric mean criteria (TMDL).

SECTION 5 TMDL CALCULATIONS

5.1 Flow Duration Curve

Following the same procedures described in **Section 4.2.1**, a flow duration curve for each stream segment requiring a TMDL in the Study Area was developed. These are shown in **Figure 5-1** through **Figure 5-4.**

Most of the Study Area waterbodies do not have USGS flow gages. Therefore, flows for these waterbodies were estimated using the watershed area ratio method based on measured flows at existing adjacent USGS gage stations.

Flows for the waterbodies listed below were projected using USGS gage station 07160350 located in an adjacent watershed (Skeleton Creek at Enid, OK). The flow duration curve was based on measured flows from 1996 to 2024.

- Wild Horse Creek (OK621000020040_00)
- Spring Creek (OK621000020130_00)
- Clay Creek, West (OK621010010130_00)

The flow duration curve for the Chikaskia River (OK621100000010_20) was developed based on the flow data from 2005 to 2023 at USGS gage station 07152000 (Chikaskia River near Blackwell, OK).

Figure 5-1 Flow Duration Curve for Wild Horse Creek (OK621000020040_00)

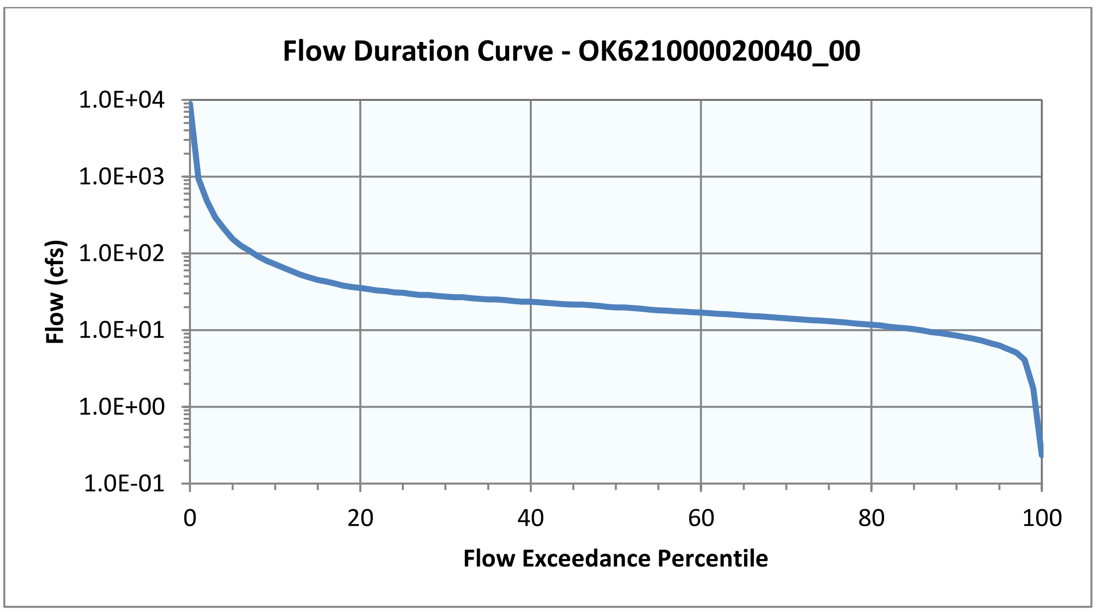


Figure 5-2 Flow Duration Curve for Spring Creek (OK621000020130_00)

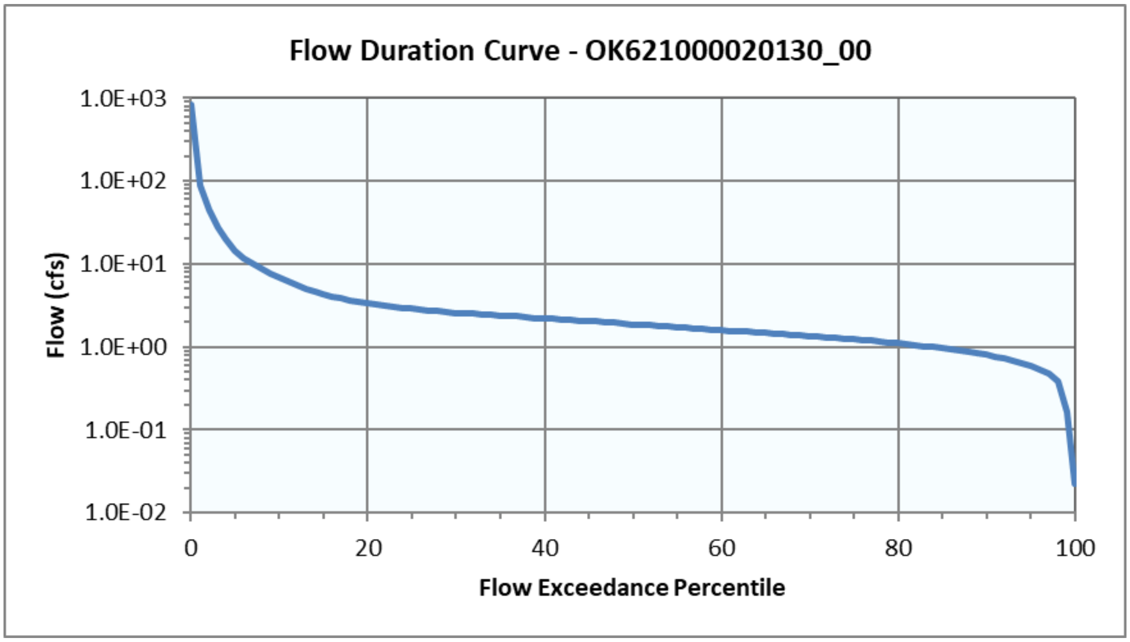


Figure 5-3 Flow Duration Curve for Clay Creek, West (OK621010010130_00)

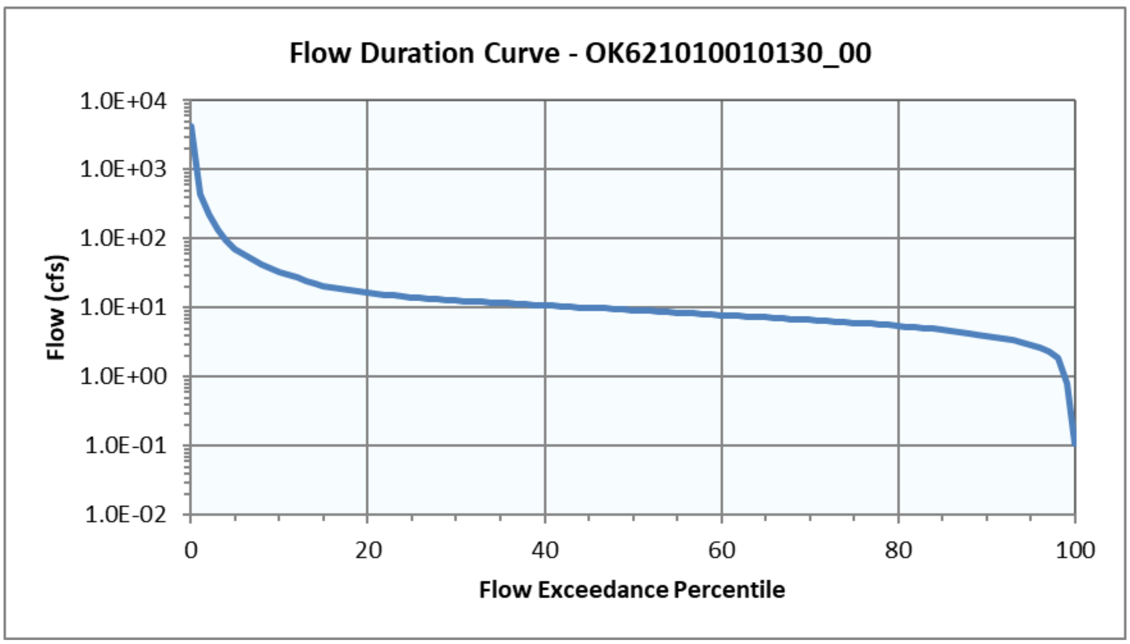
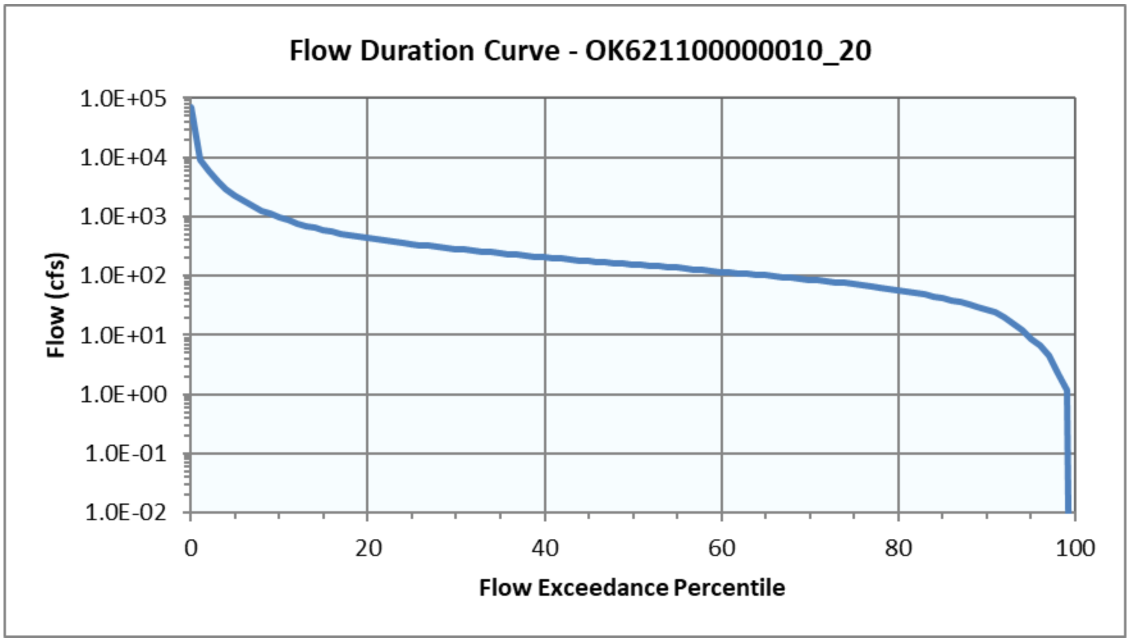


Figure 5-4 Flow Duration Curve for the Chikaskia River (OK621100000010_20)



5.2 Estimated Loading and Critical Conditions

EPA regulations [40 CFR § Part 130.7(c)(1)] require TMDLs to take into account critical conditions for stream flow, loading, and all applicable WQS. To accomplish this, available in-stream WQM data were evaluated with respect to flows and magnitude of water quality criteria exceedance using LDCs.

5.2.1 Bacterial LDCs

To calculate the allowable bacterial load, the flow rate at each flow exceedance percentile is multiplied by a unit conversion factor (*24,465,525*) and the geometric mean water quality criterion for each bacterial indicator. This calculation produces the maximum bacterial load in the stream over the range of flow conditions. The allowable bacterial (*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 bacterial load.

To estimate existing loading, the geometric mean of all bacterial observations (concentrations) for the primary contact recreation season (May 1st through September 30th) from **2000** to **2019** are estimated in that waterbody. Pollutant loads are then calculated by multiplying the measured bacterial concentration by the flow rate and the unit conversion factor of *24,465,525*. The bacterial LDCs developed for each impaired waterbody are shown in **Figure 5-5** through **Figure 5-11**.

The LDCs for **Wild Horse Creek** (**Figure 5-5** and **Figure 5-6**) are based on *E. coli* and Enterococci measurements collected during primary contact recreation season at WQM station OK621000-02-0040F.

Figure 5-5 Load Duration Curve for *E. coli* in Wild Horse Creek (OK621000020040_00)

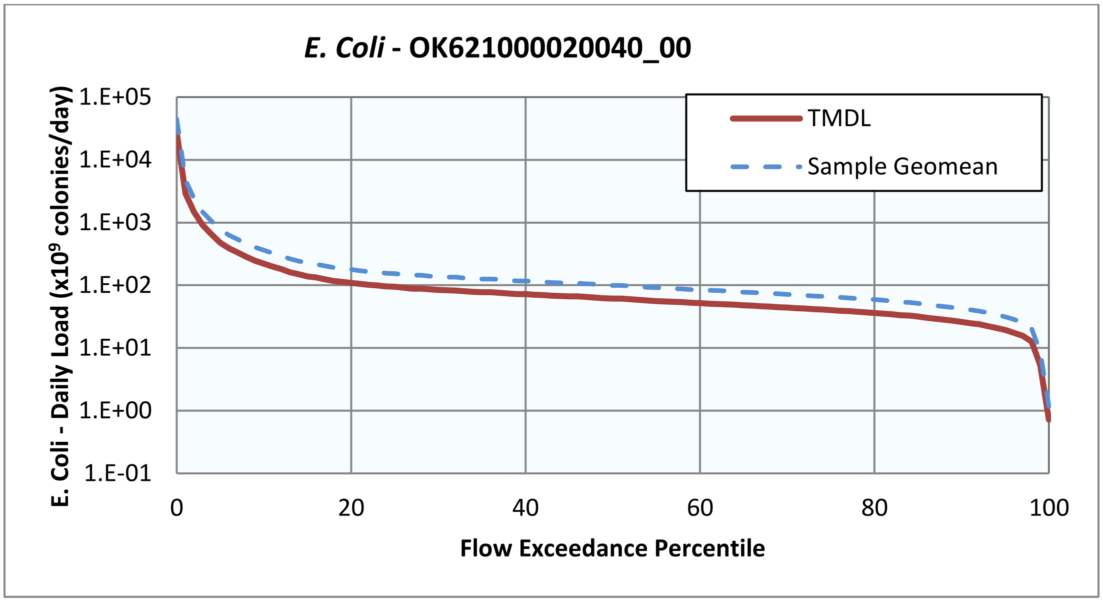
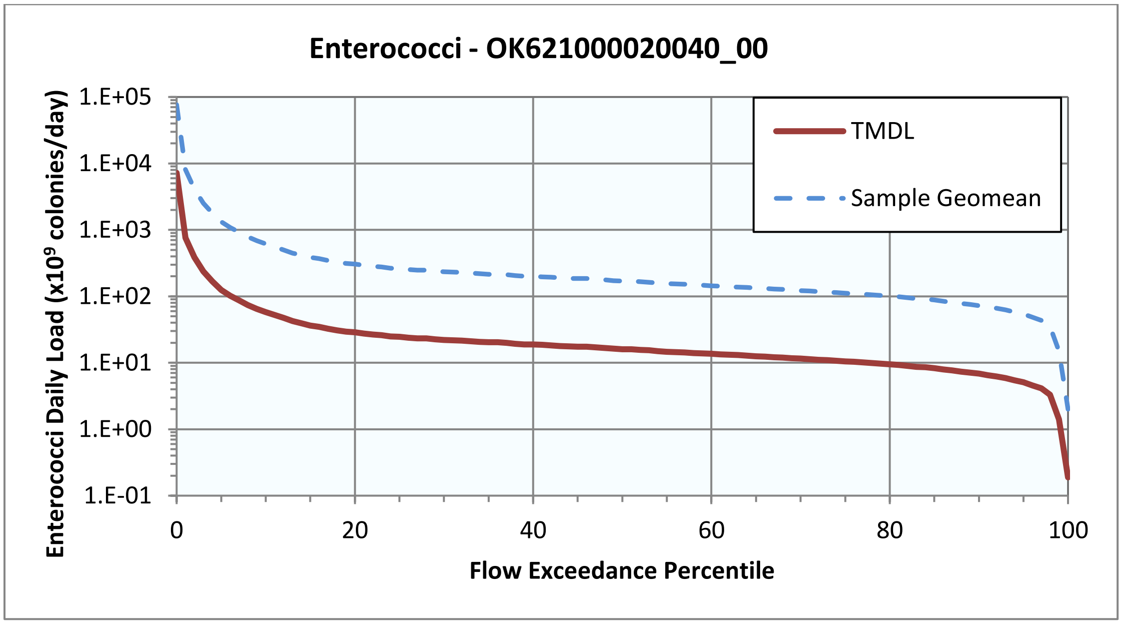


Figure 5-6 Load Duration Curve for Enterococci in Wild Horse Creek (OK621000020040_00)



The LDCs for **Spring Creek** (**Figure 5-7** and **Figure 5-8**) is based on *E. coli* and Enterococci measurements during primary contact recreation season at WQM station OK621000-02-0130G.

Figure 5-7 Load Duration Curve for E. coli in Spring Creek (OK621000020130_00)

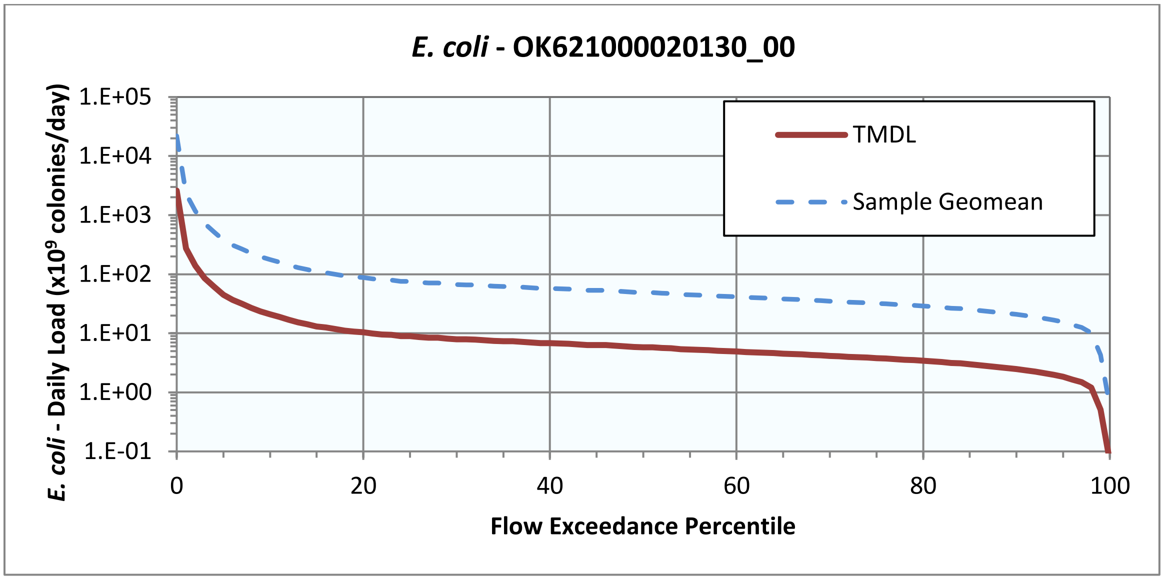
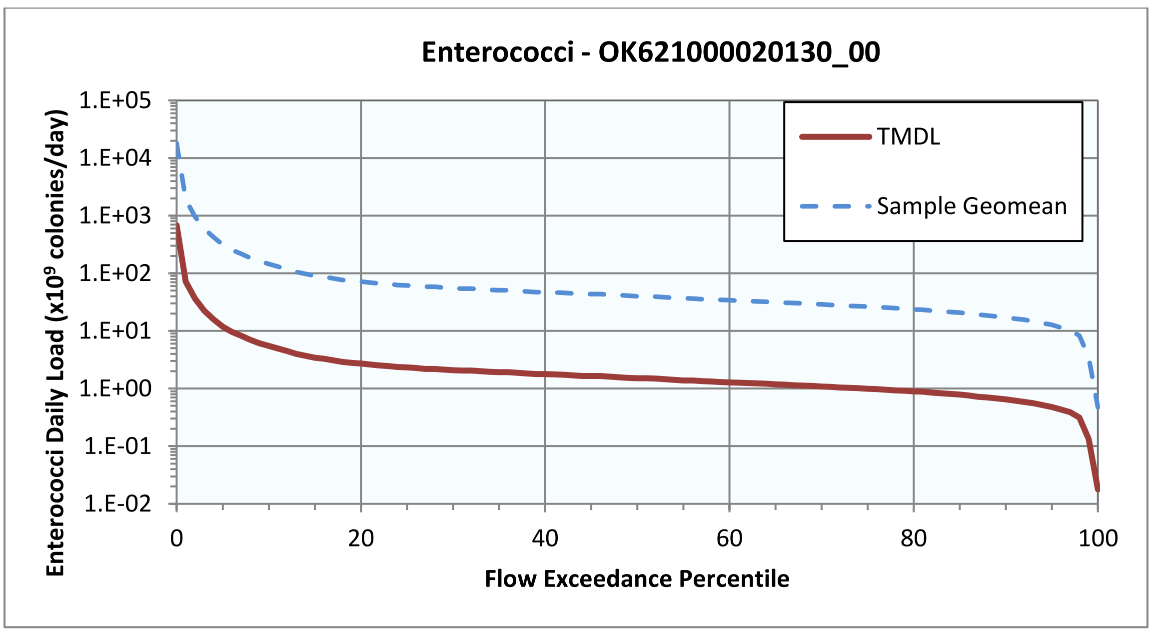


Figure 5-8 Load Duration Curve for Enterococci in Spring Creek (OK621000020130_00)



The LDCs for **West Clay Creek** (**Figure 5-9** and **Figure 5-10**) is based on *E. coli* and Enterococci measurements during primary contact recreation season at WQM station OK621010-01-0130R.

Figure 5-9 Load Duration Curve for *E. coli* in West Clay Creek (OK621010010130_00)

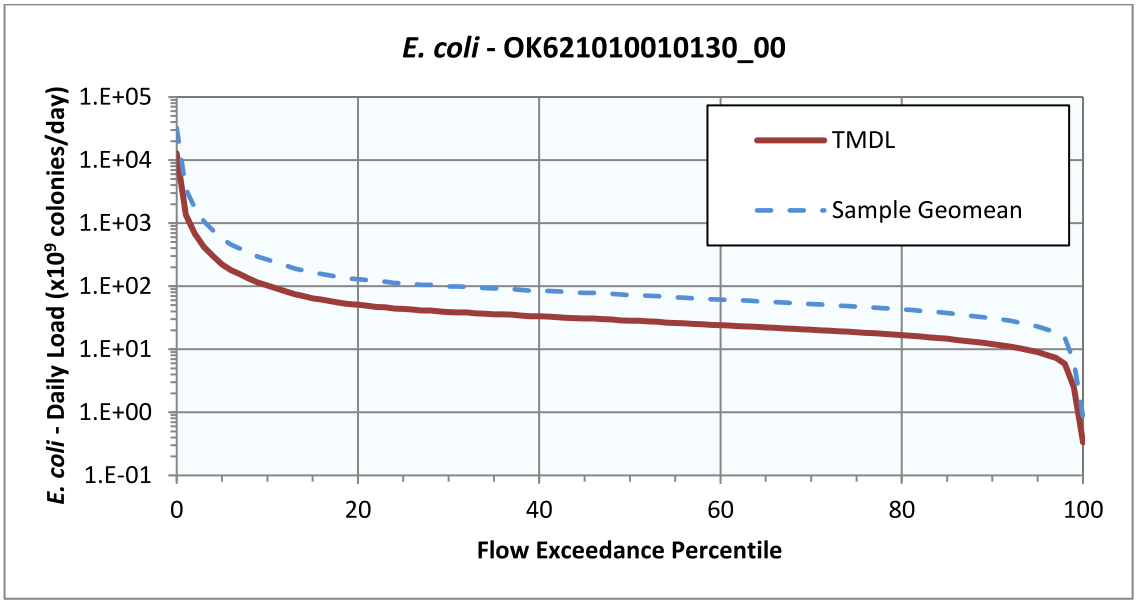
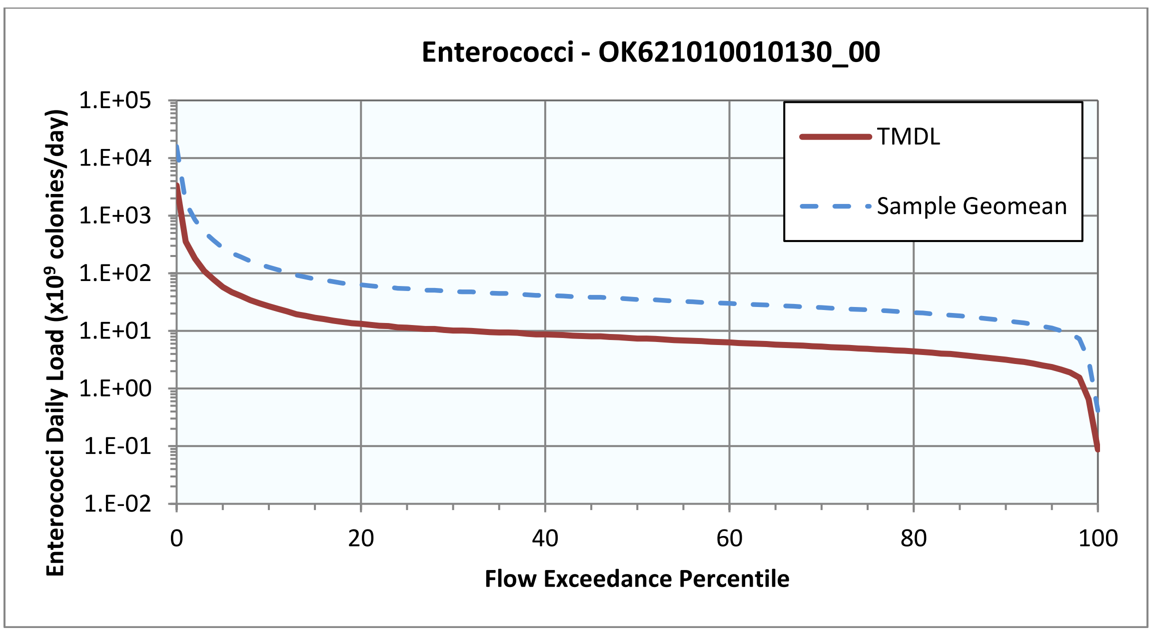
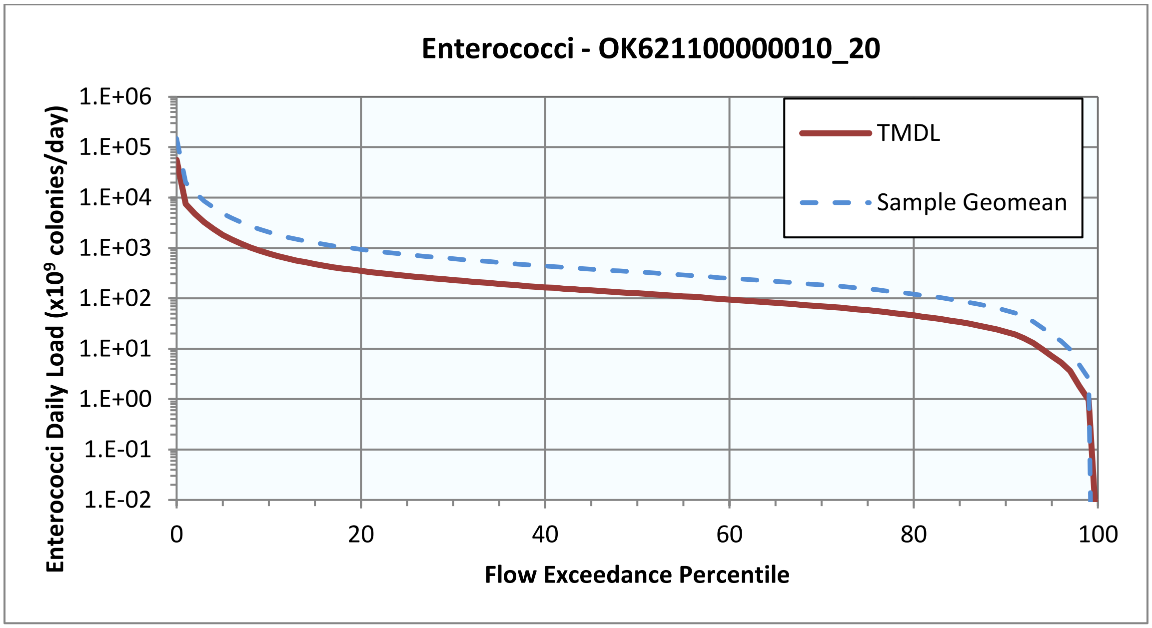


Figure 5-10 Load Duration Curve for Enterococci in West Clay Creek (OK621010010130_00)



The LDC for the **Chikaskia River** (**Figure 5-11**) is based on Enterococci measurements during primary contact recreation season at WQM station OK621100-00-0010M.

Figure 5-11 Load Duration Curve for Enterococci in the Chikaskia River Creek (OK621100000010_20)



5.2.2 Establish Percent Reduction Goals

The LDC approach recognizes that the assimilative capacity of a waterbody depends on the flow, and that maximum allowable loading varies with flow condition. Existing loading and load reductions required to meet the TMDL can also be calculated under different flow conditions. The difference between existing loading and the TMDL is used to calculate the loading reductions required.

PRGs for bacteria are calculated to verify if the geometric mean of the reduced values of all samples is less than the WQS geometric mean. **Table 5-1** represents the percent reductions necessary to meet the TMDL water quality target for each bacterial indicator in each of the impaired waterbodies in the Study Area. The PRGs ranged from **44.7%** to **96.6%.**

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

Waterbody ID	Waterbody Name	Required Reduction Rate (%)	
		Enterococci	*E. coli*
OK621000020040_00	Wild Horse Creek	91.5%	44.7%
OK621000020130_00	Spring Creek	96.6%	89.3%
OK621010010130_00	Clay Creek, West	81.0%	64.7%
OK621100000010_20	Chikaskia River	65.1%	-

5.3 Wasteload Allocation

5.3.1 Bacterial WLA

For bacterial TMDLs, OPDES-permitted facilities are allocated a daily wasteload calculated as their permitted flow rate multiplied by the in-stream geometric mean water quality criterion. In other words, the facilities are required to meet in-stream criteria in their discharge. Error! Reference source not found. summarizes the WLA for the OPDES-permitted facilities within the Study Area. The WLA for each facility discharging to a waterbody is derived from the following equation:

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

Where:

WQS = 33 and 126 colonies/100 ml for Enterococci and E. coli respectively

Flow (mgd) = permitted flow

Unit conversion factor = 37,854,120

When multiple OPDES 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 OPDES WWTFs discharging into the contributing watershed of a stream segment, then the WLA is zero. Compliance with the WLA will be achieved by adhering to the *E. coli* limits and disinfection requirements of OPDES permits. Currently, these discharges or any other discharges with a bacterial WLA will be required to monitor for *E. coli* as their permits. There are no facilities given a WLA.

Permitted stormwater discharges are considered point sources. However, there are no designated MS4s within the watersheds of the Study Area impaired for contact recreation, so there are no WLAs for MS4s.

Future growth allowances account for increased pollutant loadings and can be included as an allocation of pollutant loads from new sources expected in the future. In this report, 10% of bacterial loading was reserved for future growth.

5.3.2 Permit Implications

Regardless of the magnitude of the WLA calculated in these TMDLs, future new discharges of bacteria or increased bacterial load from existing discharges will be considered consistent with the TMDL provided that the OPDES permit requires in-stream criteria to be met.

5.4 Load Allocation

As discussed in **Section 3.3**, nonpoint source loading to each waterbody emanates from a number of different sources. The data analysis and the LDCs indicate that exceedance for each waterbody are the result of a variety of nonpoint source loading. The LAs for each bacterial indicator in waterbodies not supporting the PBCR use are calculated as the difference between the TMDL, MOS, and WLA, as follows:

$$\mathbf{LA = TMDL - WLA_{WWTF} - WLA_{MS4} - WLA_{Growth} - MOS}$$

5.5 Seasonal Variability

Federal regulations (40 CFR § Part 130.7(c)(1)) require that TMDLs account for seasonal variation in watershed conditions and pollutant loading. The bacterial TMDLs established in this report adhere to the seasonal application of the Oklahoma WQS which limits the PBCR use to the period of May 1st through September 30th. Seasonal variation was also accounted for in these TMDLs by using five years of water quality data and by using all available USGS flow records when estimating flows to develop flow exceedance percentiles.

5.6 Margin of Safety

Federal regulations (40 CFR § Part 130.7(c)(1)) require that TMDLs include an MOS. The MOS is a conservative measure incorporated into the TMDL equation that accounts for the lack of knowledge associated with calculating the allowable pollutant loading to ensure WQSs are attained. EPA guidance allows for use of implicit or explicit expressions of the MOS, or both. For bacterial TMDLs, an explicit MOS was set at 10%.

5.7 TMDL Calculations

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

This definition can be expressed by the following equation:

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

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

The TMDL, WLA, LA, and MOS will vary with flow condition, and are calculated at every 5th flow interval percentile. **Table 5-2** summarizes the TMDL, WLA, LA and MOS loadings at the 50% flow percentile. **Table 5-3** through **Table 5-9** summarized the allocations for indicator bacteria. The bacterial TMDLs calculated in these tables apply to the recreation season (May 1 through September 30) only.

Table 5-2 Summaries of Bacterial TMDLs

Stream Name	Waterbody ID	Pollutant	TMDL (colonies /day)	WLA_{WWTF} (colonies /day)	WLA_{MS4} (colonies /day)	WLA_{Growth} (colonies /day)	LA (colonies /day)	MOS (colonies /day)
Wild Horse Creek	OK621000020040_00	ENT	1.60E+10	0	0	1.60E+09	1.28E+10	1.60E+09
		EC	6.09E+10	0	0	6.09E+09	4.88E+10	6.09E+09
Spring Creek	OK621000020130_00	ENT	1.51E+09	0	0	1.51E+08	1.36E+09	1.51E+08
		EC	5.76E+09	0	0	5.76E+08	4.61E+09	5.76E+08
Clay Creek, West	OK621010010130_00	ENT	7.41E+09	0	0	7.41E+08	6.67E+09	7.41E+08
		EC	2.83E+10	0	0	2.83E+09	2.26E+10	2.83E+09
Chikaskia River	OK621100000010_20	ENT	1.26E+11	0	0	1.26E+10	1.13E+11	1.26E+10

Table 5-3 TMDL Calculations for *E. coli* in Wild Horse Creek (OK621000020040_00)

Percentile	Flow (cfs)	TMDL (colonies /day)	WLA_{WWTF} (colonies /day)	WLA_{MS4} (colonies /day)	WLA_{Growth} (colonies /day)	LA (colonies /day)	MOS (colonies /day)
0	8,931.8	2.75E+13	0	0	2.75E+12	2.20E+13	2.75E+12
5	154.6	4.76E+11	0	0	4.76E+10	3.81E+11	4.76E+10
10	71.9	2.22E+11	0	0	2.22E+10	1.77E+11	2.22E+10
15	44.9	1.38E+11	0	0	1.38E+10	1.11E+11	1.38E+10
20	35.6	1.10E+11	0	0	1.10E+10	8.78E+10	1.10E+10
25	30.6	9.42E+10	0	0	9.42E+09	7.53E+10	9.42E+09
30	27.2	8.40E+10	0	0	8.40E+09	6.72E+10	8.40E+09
35	25.2	7.76E+10	0	0	7.76E+09	6.20E+10	7.76E+09
40	23.4	7.20E+10	0	0	7.20E+09	5.76E+10	7.20E+09
45	21.6	6.65E+10	0	0	6.65E+09	5.32E+10	6.65E+09
50	19.8	6.09E+10	0	0	6.09E+09	4.88E+10	6.09E+09
55	18.2	5.60E+10	0	0	5.60E+09	4.48E+10	5.60E+09
60	16.9	5.20E+10	0	0	5.20E+09	4.16E+10	5.20E+09
65	15.5	4.79E+10	0	0	4.79E+09	3.83E+10	4.79E+09
70	14.3	4.40E+10	0	0	4.40E+09	3.52E+10	4.40E+09
75	13.0	4.02E+10	0	0	4.02E+09	3.21E+10	4.02E+09
80	11.7	3.62E+10	0	0	3.62E+09	2.89E+10	3.62E+09
85	10.2	3.16E+10	0	0	3.16E+09	2.53E+10	3.16E+09
90	8.5	2.61E+10	0	0	2.61E+09	2.09E+10	2.61E+09
95	6.3	1.94E+10	0	0	1.94E+09	1.55E+10	1.94E+09
100	0.2	7.20E+08	0	0	6.48E+08	0.00E+00	7.20E+07

Table 5-4 TMDL Calculations for Enterococci in Wild Horse Creek (OK621000020040_00)

Percentile	Flow (cfs)	TMDL (colonies /day)	WLA_{WWTF} (colonies /day)	WLA_{MS4} (colonies /day)	WLA_{growth} colonies /day)	LA (colonies /day)	MOS (colonies /day)
0	8,931.8	7.21E+12	0	0	7.21E+11	5.77E+12	7.21E+11
5	154.6	1.25E+11	0	0	1.25E+10	9.98E+10	1.25E+10
10	71.9	5.80E+10	0	0	5.80E+09	4.64E+10	5.80E+09
15	44.9	3.63E+10	0	0	3.63E+09	2.90E+10	3.63E+09
20	35.6	2.87E+10	0	0	2.87E+09	2.30E+10	2.87E+09
25	30.6	2.47E+10	0	0	2.47E+09	1.97E+10	2.47E+09
30	27.2	2.20E+10	0	0	2.20E+09	1.76E+10	2.20E+09
35	25.2	2.03E+10	0	0	2.03E+09	1.63E+10	2.03E+09
40	23.4	1.89E+10	0	0	1.89E+09	1.51E+10	1.89E+09
45	21.6	1.74E+10	0	0	1.74E+09	1.39E+10	1.74E+09
50	19.8	1.60E+10	0	0	1.60E+09	1.28E+10	1.60E+09
55	18.2	1.47E+10	0	0	1.47E+09	1.17E+10	1.47E+09
60	16.9	1.36E+10	0	0	1.36E+09	1.09E+10	1.36E+09
65	15.5	1.25E+10	0	0	1.25E+09	1.00E+10	1.25E+09
70	14.3	1.15E+10	0	0	1.15E+09	9.21E+09	1.15E+09
75	13.0	1.05E+10	0	0	1.05E+09	8.42E+09	1.05E+09
80	11.7	9.47E+09	0	0	9.47E+08	7.58E+09	9.47E+08
85	10.2	8.27E+09	0	0	8.27E+08	6.62E+09	8.27E+08
90	8.5	6.83E+09	0	0	6.83E+08	5.47E+09	6.83E+08
95	6.3	5.08E+09	0	0	5.08E+08	4.06E+09	5.08E+08
100	0.2	1.89E+08	0	0	1.70E+08	0.00E+00	1.89E+07

Table 5-5 TMDL Calculations for *E. coli* in Spring Creek (OK621000020130_00)

Percentile	Flow (cfs)	TMDL (colonies /day)	WLA_{WWTF} (colonies /day)	WLA_{MS4} (colonies /day)	WLA_{growth} (colonies /day)	LA (colonies /day)	MOS (colonies /day)
0	844.9	2.60E+12	0	0	2.60E+11	2.08E+12	2.60E+11
5	14.6	4.51E+10	0	0	4.51E+09	3.61E+10	4.51E+09
10	6.8	2.10E+10	0	0	2.10E+09	1.68E+10	2.10E+09
15	4.3	1.31E+10	0	0	1.31E+09	1.05E+10	1.31E+09
20	3.4	1.04E+10	0	0	1.04E+09	8.30E+09	1.04E+09
25	2.9	8.91E+09	0	0	8.91E+08	7.13E+09	8.91E+08
30	2.6	7.94E+09	0	0	7.94E+08	6.36E+09	7.94E+08
35	2.4	7.34E+09	0	0	7.34E+08	5.87E+09	7.34E+08
40	2.2	6.81E+09	0	0	6.81E+08	5.45E+09	6.81E+08
45	2.0	6.29E+09	0	0	6.29E+08	5.03E+09	6.29E+08
50	1.9	5.76E+09	0	0	5.76E+08	4.61E+09	5.76E+08
55	1.7	5.29E+09	0	0	5.29E+08	4.23E+09	5.29E+08
60	1.6	4.92E+09	0	0	4.92E+08	3.93E+09	4.92E+08
65	1.5	4.53E+09	0	0	4.53E+08	3.62E+09	4.53E+08
70	1.3	4.16E+09	0	0	4.16E+08	3.33E+09	4.16E+08
75	1.2	3.80E+09	0	0	3.80E+08	3.04E+09	3.80E+08
80	1.1	3.42E+09	0	0	3.42E+08	2.74E+09	3.42E+08
85	1.0	2.99E+09	0	0	2.99E+08	2.39E+09	2.99E+08
90	0.8	2.47E+09	0	0	2.47E+08	1.97E+09	2.47E+08
95	0.6	1.83E+09	0	0	1.83E+08	1.47E+09	1.83E+08
100	0.0	6.81E+07	0	0	6.81E+06	5.45E+07	6.81E+06

Table 5-6 TMDL Calculations for Enterococci in Spring Creek (OK621000020130_00)

Percentile	Flow (cfs)	TMDL (colonies /day)	WLA_{WWTF} (colonies /day)	WLA_{MS4} (colonies /day)	WLA_{growth} (colonies /day)	LA (colonies /day)	MOS (colonies /day)
0	844.9	6.82E+11	0	0	6.82E+10	6.14E+11	6.82E+10
5	14.6	1.18E+10	0	0	1.18E+09	1.06E+10	1.18E+09
10	6.8	5.49E+09	0	0	5.49E+08	4.94E+09	5.49E+08
15	4.3	3.43E+09	0	0	3.43E+08	3.09E+09	3.43E+08
20	3.4	2.72E+09	0	0	2.72E+08	2.45E+09	2.72E+08
25	2.9	2.33E+09	0	0	2.33E+08	2.10E+09	2.33E+08
30	2.6	2.08E+09	0	0	2.08E+08	1.87E+09	2.08E+08
35	2.4	1.92E+09	0	0	1.92E+08	1.73E+09	1.92E+08
40	2.2	1.78E+09	0	0	1.78E+08	1.61E+09	1.78E+08
45	2.0	1.65E+09	0	0	1.65E+08	1.48E+09	1.65E+08
50	1.9	1.51E+09	0	0	1.51E+08	1.36E+09	1.51E+08
55	1.7	1.39E+09	0	0	1.39E+08	1.25E+09	1.39E+08
60	1.6	1.29E+09	0	0	1.29E+08	1.16E+09	1.29E+08
65	1.5	1.19E+09	0	0	1.19E+08	1.07E+09	1.19E+08
70	1.3	1.09E+09	0	0	1.09E+08	9.80E+08	1.09E+08
75	1.2	9.95E+08	0	0	9.95E+07	8.96E+08	9.95E+07
80	1.1	8.96E+08	0	0	8.96E+07	8.07E+08	8.96E+07
85	1.0	7.82E+08	0	0	7.82E+07	7.04E+08	7.82E+07
90	0.8	6.46E+08	0	0	6.46E+07	5.82E+08	6.46E+07
95	0.6	4.80E+08	0	0	4.80E+07	4.32E+08	4.80E+07
100	0.0	1.78E+07	0	0	1.78E+06	1.61E+07	1.78E+06

Table 5-7 TMDL Calculations for *E. coli* in West Clay Creek (OK621010010130_00)

Percentile	Flow (cfs)	TMDL (colonies /day)	WLA_{WWTF} (colonies /day)	WLA_{MS4} (colonies /day)	WLA_{growth} (colonies /day)	LA (colonies /day)	MOS (colonies /day)
0	4,146.4	1.28E+13	0	0	1.28E+12	1.02E+13	1.28E+12
5	71.7	2.21E+11	0	0	2.21E+10	1.77E+11	2.21E+10
10	33.4	1.03E+11	0	0	1.03E+10	8.23E+10	1.03E+10
15	20.9	6.43E+10	0	0	6.43E+09	5.14E+10	6.43E+09
20	16.5	5.09E+10	0	0	5.09E+09	4.07E+10	5.09E+09
25	14.2	4.37E+10	0	0	4.37E+09	3.50E+10	4.37E+09
30	12.6	3.90E+10	0	0	3.90E+09	3.12E+10	3.90E+09
35	11.7	3.60E+10	0	0	3.60E+09	2.88E+10	3.60E+09
40	10.8	3.34E+10	0	0	3.34E+09	2.67E+10	3.34E+09
45	10.0	3.09E+10	0	0	3.09E+09	2.47E+10	3.09E+09
50	9.2	2.83E+10	0	0	2.83E+09	2.26E+10	2.83E+09
55	8.4	2.60E+10	0	0	2.60E+09	2.08E+10	2.60E+09
60	7.8	2.41E+10	0	0	2.41E+09	1.93E+10	2.41E+09
65	7.2	2.22E+10	0	0	2.22E+09	1.78E+10	2.22E+09
70	6.6	2.04E+10	0	0	2.04E+09	1.63E+10	2.04E+09
75	6.0	1.86E+10	0	0	1.86E+09	1.49E+10	1.86E+09
80	5.4	1.68E+10	0	0	1.68E+09	1.34E+10	1.68E+09
85	4.8	1.47E+10	0	0	1.47E+09	1.17E+10	1.47E+09
90	3.9	1.21E+10	0	0	1.21E+09	9.69E+09	1.21E+09
95	2.9	9.00E+09	0	0	9.00E+08	7.20E+09	9.00E+08
100	0.1	3.34E+08	0	0	3.34E+07	2.67E+08	3.34E+07

Table 5-8 TMDL Calculations for Enterococci in West Clay Creek (OK621010010130_00)

Percentile	Flow (cfs)	TMDL (colonies /day)	WLA_{WWTF} (colonies /day)	WLA_{MS4} (colonies /day)	WLA_{growth} (colonies /day)	LA (colonies /day)	MOS (colonies /day)
0	4,146.4	3.35E+12	0	0	3.35E+11	3.01E+12	3.35E+11
5	71.7	5.79E+10	0	0	5.79E+09	5.21E+10	5.79E+09
10	33.4	2.69E+10	0	0	2.69E+09	2.42E+10	2.69E+09
15	20.9	1.68E+10	0	0	1.68E+09	1.52E+10	1.68E+09
20	16.5	1.33E+10	0	0	1.33E+09	1.20E+10	1.33E+09
25	14.2	1.15E+10	0	0	1.15E+09	1.03E+10	1.15E+09
30	12.6	1.02E+10	0	0	1.02E+09	9.19E+09	1.02E+09
35	11.7	9.43E+09	0	0	9.43E+08	8.49E+09	9.43E+08
40	10.8	8.76E+09	0	0	8.76E+08	7.88E+09	8.76E+08
45	10.0	8.08E+09	0	0	8.08E+08	7.27E+09	8.08E+08
50	9.2	7.41E+09	0	0	7.41E+08	6.67E+09	7.41E+08
55	8.4	6.80E+09	0	0	6.80E+08	6.12E+09	6.80E+08
60	7.8	6.32E+09	0	0	6.32E+08	5.69E+09	6.32E+08
65	7.2	5.82E+09	0	0	5.82E+08	5.24E+09	5.82E+08
70	6.6	5.34E+09	0	0	5.34E+08	4.81E+09	5.34E+08
75	6.0	4.88E+09	0	0	4.88E+08	4.40E+09	4.88E+08
80	5.4	4.40E+09	0	0	4.40E+08	3.96E+09	4.40E+08
85	4.8	3.84E+09	0	0	3.84E+08	3.46E+09	3.84E+08
90	3.9	3.17E+09	0	0	3.17E+08	2.86E+09	3.17E+08
95	2.9	2.36E+09	0	0	2.36E+08	2.12E+09	2.36E+08
100	0.1	8.76E+07	0	0	8.76E+06	7.88E+07	8.76E+06

Table 5-9 TMDL Calculations for Enterococci in the Chikaskia River (OK621100000010_20)

Percentile	Flow (cfs)	TMDL (colonies /day)	WLA_{WWTF} (colonies /day)	WLA_{MS4} (colonies /day)	WLA_{growth} (colonies /day)	LA (colonies /day)	MOS (colonies /day)
0	69,500	5.61E+13	0	0	5.61E+12	5.05E+13	5.61E+12
5	2,260	1.82E+12	0	0	1.82E+11	1.64E+12	1.82E+11
10	968	7.82E+11	0	0	7.82E+10	7.03E+11	7.82E+10
15	595	4.80E+11	0	0	4.80E+10	4.32E+11	4.80E+10
20	437	3.53E+11	0	0	3.53E+10	3.18E+11	3.53E+10
25	346	2.79E+11	0	0	2.79E+10	2.51E+11	2.79E+10
30	285	2.30E+11	0	0	2.30E+10	2.07E+11	2.30E+10
35	241	1.95E+11	0	0	1.95E+10	1.75E+11	1.95E+10
40	205	1.66E+11	0	0	1.66E+10	1.49E+11	1.66E+10
45	178	1.44E+11	0	0	1.44E+10	1.29E+11	1.44E+10
50	156	1.26E+11	0	0	1.26E+10	1.13E+11	1.26E+10
55	136	1.10E+11	0	0	1.10E+10	9.88E+10	1.10E+10
60	117	9.45E+10	0	0	9.45E+09	8.50E+10	9.45E+09
65	101	8.15E+10	0	0	8.15E+09	7.34E+10	8.15E+09
70	86	6.94E+10	0	0	6.94E+09	6.25E+10	6.94E+09
75	72	5.81E+10	0	0	5.81E+09	5.23E+10	5.81E+09
80	57	4.60E+10	0	0	4.60E+09	4.14E+10	4.60E+09
85	42	3.39E+10	0	0	3.39E+09	3.05E+10	3.39E+09
90	27	2.18E+10	0	0	2.18E+09	1.96E+10	2.18E+09
95	8.8	7.10E+09	0	0	7.10E+08	6.39E+09	7.10E+08
100	0.0	8.07E-04	0	0	8.07E-05	7.27E-04	8.07E-05

5.8 Strength and Weakness

Strength: The LDC is a simple and efficient method to show the relationship between flow and pollutant load. Therefore, it facilitates rapid development of TMDLs and provides some information for identifying whether impairments are associated with point or nonpoint sources. The low cost of the LDC method allows accelerated development of TMDL plans on more waterbodies and the evaluation of the implementation of WLAs and BMPs.

Weakness: LDCs graphically display the changing water quality over changing flows that may not be apparent when visualizing raw data. Flow range is only a general indicator of the relative proportion of point/nonpoint contributions. LDCs cannot identify nonpoint sources as entering a waterbody at a specific location. Therefore, the specific control actions cannot be stipulated.

5.9 TMDL Implementation

DEQ will collaborate with 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 will be utilized so that the pollutant reductions as required by these TMDLs can be achieved and water quality can be restored to maintain designated uses. DEQ's Continuing Planning Process (CPP), required by the CWA §303(e)(3) and 40 CFR § Part 130.5, summarizes Oklahoma's commitments and programs aimed at restoring and protecting water quality throughout the State (DEQ 2012). The CPP can be viewed at DEQ's website: https://www.deq.ok.gov/wp-content/uploads/water-division/2012-OK-CPP.pdf. **Table 5-10** provides a partial list of the state partner agencies DEQ will collaborate with to address point and nonpoint source reduction goals established by TMDLs.

Table 5-10 Partial List of Oklahoma Water Quality Management Agencies

Agency	Web Link
Oklahoma Conservation Commission	https://conservation.ok.gov/water-quality-division/
Oklahoma Department of Wildlife Conservation	https://www.wildlifedepartment.com/hunting/research
Oklahoma Department of Agriculture, Food, and Forestry	https://ag.ok.gov/divisions/agricultural-environmental-management/
Oklahoma Water Resources Board	https://oklahoma.gov/owrb/data-and-maps/monitoring-data.html

5.9.1 Point Sources

Point source WLAs are outlined in the Oklahoma Water Quality Management Plan (aka the 208 Plan) under the OPDES program.

5.9.2 Nonpoint Sources

Nonpoint source pollution in Oklahoma is managed by the Oklahoma Conservation Commission. The Oklahoma Conservation Commission works with other agencies that collect water monitoring information and/or address water quality problems associated with nonpoint source pollution. These agencies at the State level are DEQ, OWRB, Corporation Commission (for oil & gas activities), and ODAFF [they are the NPDES-permitting authority for CAFOs and SFOs in Oklahoma under what ODAFF calls the Agriculture Pollutant Discharge Elimination System (AgPDES)]. The agencies at the Federal level are EPA, USGS, U.S. Army Corps of Engineers (USACE) & the National Resources Conservation Service (NRCS) of the U.S. Department of Agriculture (USDA). 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.

The reduction rates called for in this TMDL report are as high as 96.6% for bacteria. DEQ recognizes that achieving such high reductions will be a challenge, especially since unregulated nonpoint sources are a major cause of bacterial loading. 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 a waterbody should be reviewed. For example, the Kansas Department of Health and Environment proposed to exclude certain high flow conditions during which pathogen standards will not apply though that exclusion was not approved by the EPA. Additionally, EPA has been conducting new epidemiology studies and may develop new recommendations for pathogen criteria in the future.

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

- **Remove the PBCR use**: This revision would require documentation in a Use Attainability Analysis that the use is not an existing use and cannot be attained. It is unlikely that this approach would be successful since there is evidence that people swim in bacterially-impaired waterbodies, thus constituting an existing use. Existing uses cannot be removed.

- **Modify 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 bacterial violations occur over all flow ranges, it is likely that large reductions would still be necessary. However, this approach may have a merit and should be considered.

- **Revise the existing numeric criteria**: Oklahoma's current pathogen criteria, revised in 2011, are based on EPA guidelines (See the *2012 Draft Recreational Water Quality Criteria*, December 2011; 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 EPA studies that could result in revisions to their recommendations are ongoing. The numeric criteria values should also be evaluated using a risk-based method such as that found in EPA guidance.

Unless or until the WQSs are revised and approved by EPA, 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.

5.10 Reasonable Assurances

Reasonable assurance is required by the EPA guidance for a TMDL to be approvable only when a waterbody is impaired by both point and nonpoint sources and where a point source is given a less stringent wasteload allocation based on an assumption that nonpoint source load reductions will occur. In such a case, "reasonable assurance" that the NPS load reductions will actually occur must be demonstrated. In this report, no point sources were given a WLA and nonpoint source were considered as a main contributor for impairment.

Reasonable assurance of nonpoint sources will meet their allocated amount in the TMDL which dependent upon the availability and implementation of nonpoint source pollutant reduction plans, controls or BMPs within the watershed. The OCC has responsibilities for the state's NPS program defined in Section 319 of CWA. DEQ will work in conjunction with OCC and other federal, state, and local partners to meet the load reduction goals for NPS. All waterbodies are prioritized as part of the Unified Watershed Assessment (UWA) and that ranking will determine the likelihood of an implementation project in a watershed.

SECTION 6 PUBLIC PARTICIPATION

This TMDL report has been preliminary reviewed by EPA. After EPA reviewed this draft TMDL report, DEQ was given approval to submit this report for public notice. A public notice will be sent to local newspapers, to stakeholders in the Study Area affected by these draft TMDLs, and to stakeholders who have requested all copies of TMDL public notices. The public notice will also be posted at the DEQ website: https://www.deq.ok.gov/water-quality-division/watershed-planning/tmdl/.

The public comment period lasts 45 days. During that time, the public has the opportunity to review the TMDL report and make written comments. Depending on the interest and responses from the public, a public meeting may be held within the watershed affected by the TMDLs in this report. If a public meeting is held, the public will also have opportunities to ask questions and make formal oral comments at the meeting and/or to submit written comments at the public meeting.

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

After EPA's final approval, the TMDLs and 208 Factsheet will be adopted into the Water Quality Management Plan (WQMP).

SECTION 7 REFERENCES

American Veterinary Medical Association (2022). *AVMA 3033. Pet Ownership and Demographics Sourcebook*. Schaumberg, IL. Available from https://ebusiness.avma.org/ProductCatalog/product.aspx?ID=2050.

ASAE (American Society of Agricultural Engineers) (1999). ASAE standards, 46th edition: Standards, Engineering Practices, Data. St. Joseph, MI.

Brown, R.B. and Bicki, T.J. (1987). On-site sewage disposal - influence of system densities on water quality. Notes in Soil Science No. 31. Soil Science Department, G-159 McCarty Hall, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida.

Canter, L.W. and Knox, R.C. (1984). *Evaluation of septic tank system effects on ground water quality*. (EPA Publication No. 600/S2-84-107). Available from https://nepis.epa.gov/Exe/ZyPDF.cgi/9101LYBI.PDF?Dockey=9101LYBI.PDF.

Cogger, C.G. and Carlile, B.L. (1984, January). Field performance of conventional and alternative septic systems in wet soils. *J. Environ. Qual*. 13 (1), 137-142.

DEQ (2012). *The State of Oklahoma 2012 Continuing Planning Process*. Retrieved from https://www.deq.ok.gov/wp-content/uploads/water-division/2012-OK-CPP.pdf.

DEQ (2021). *Individual and small public on-site sewage treatment systems (Chapter 641).* September 15, 2021. Retrieved from www.deq.ok.gov/wp-content/uploads/deqmainresources/641.pdf.

DEQ (2022). *Water Quality in Oklahoma, 2022 Integrated Report*. Retrieved from https://www.deq.ok.gov/wp-content/uploads/water-division/OK_2022-Integrated-Report_report-only-Final.pdf.

DEQ (2022). *General Permit OKR10 for Stormwater Discharges from Construction Activities within the State of Oklahoma*. September 16, 2022. Retrieved from https://www.deq.ok.gov/wp-content/uploads/water-division/OKR10-2022-Final-permit-1.pdf.

DEQ (2022). Oklahoma 303(d) list of impaired waters. Found in Appendix C of the *2022 Integrated Report*. Retrieved from https://www.deq.ok.gov/wp-content/uploads/water-division/OK_2022-Appendix-C-Final.pdf.

DEQ (2022). *OPDES Multi-Sector General Permit OKR05 for Stormwater Discharges from Industrial Activity within the State of Oklahoma*. July 5, 2022. Available from www.deq.ok.gov/wp-content/uploads/water-division/2022-OKR05-General-Permit.pdf.

DEQ (2022). *Oklahoma Pollutant Discharge Elimination System (OPDES) Standards (Chapter 606).* October 25, 2022. https://www.deq.ok.gov/wp-content/uploads/deqmainresources/606.pdf.

DEQ (2022). *Title 252, Chapter 730 (Oklahoma's Water Quality Standards)*. https://www.deq.ok.gov/wp-content/uploads/deqmainresources/730.pdf .

DEQ (2022). *Title 252, Chapter 740 (Implementation of Oklahoma's Water Quality Standards)*. https://www.deq.ok.gov/wp-content/uploads/deqmainresources/740.pdf.

Drapcho, C.M. and Hubbs, A.K.B. (2002). *Fecal Coliform concentration in runoff from fields with applied dairy manure.* Retrieved from http://water.usgs.gov/wrri/AnnualReports/2001/FY2001_LA_Annual_Report.pdf

EPA (1983). *Results of the Nationwide Urban Runoff Program, Volume 1 - Final Report*, (EPA Publication No. WH-554). Retrieved from www.epa.gov/npdes/pubs/sw_nurp_vol_1_finalreport.pdf.

EPA (1986). *Ambient water quality criteria for bacteria – 1986*. Office of Water, EPA 440/5-84-002. Retrieved from https://www.epa.gov/sites/default/files/2019-03/documents/ambient-wqc-bacteria-1986.pdf.

EPA (1991). *Guidance for water quality-based decisions: The TMDL process*. (EPA Publication No. 440/4-91-001). Retrieved from https://nepis.epa.gov/Exe/ZyPDF.cgi/00001KIO.PDF?Dockey=00001KIO.PDF.

EPA (1991). *Technical support document for water quality-based toxics control*. Office of Water (EPA Publication No. 505/2-90-001. Retrieved from http://nepis.epa.gov/Adobe/PDF/100002CU.PDF.

EPA (1997). *Compendium of tools for watershed assessment and TMDL development* (EPA Publication 841-B-97-006). Retrieved from http://nepis.epa.gov/Exe/ZyPDF.cgi/20004NX4.PDF?Dockey=20004NX4.PDF .

EPA (1999). *Guidance for water quality-based decisions: The TMDL process (Second edition)*. (EPA Publication No. 841-D-99-001). Retrieved from http://nepis.epa.gov/Exe/ZyPDF.cgi/P1007N47.PDF?Dockey=P1007N47.PDF.

EPA (2001). *Protocol for developing pathogen TMDLs: First edition* (EPA Publication No. 841-R-00-0002). Retrieved from http://nepis.epa.gov/Exe/ZyPDF.cgi/20004QSZ.PDF?Dockey=20004QSZ.PDF.

EPA (2003). *Watershed-based National Pollutant Discharge Elimination System (NPDES) permitting implementation guidance* (EPA Publication No. 833-B-03-004). Retrieved from www.epa.gov/sites/production/files/2015-09/documents/watershedpermitting_finalguidance.pdf.

EPA (2005). *Guidance for 2006 assessment, listing and reporting requirements pursuant to Sections 303(d), 305(b), and 314 of the Clean Water Act*. , Office of Wetlands, Oceans, and Watersheds, From Diane Regas-- July 29, 2005.

EPA (2005). *Stormwater Phase II final rule*; *Small MS4 stormwater program overview* (EPA Publication No. 833-F-00-002, Fact Sheet 2.0). Retrieved from https://www.epa.gov/system/files/documents/2023-09/EPA-Stormwater-Phase-II-Final-Rule-Factsheet-2.0-Small-MS4-Overview.pdf.

EPA (2007). *An approach for using load duration curves in the development of TMDLs* (EPA Publication 841-B-07-006). Retrieved from http://www.epa.gov/sites/production/files/2015-07/documents/2007_08_23_tmdl_duration_curve_guide_aug2007.pdf.

EPA (2008). *TMDLs to stormwater permits draft handbook* (Draft, November, 2008). Retrieved from http://www.epa.gov/sites/production/files/2015-07/documents/tmdl-sw_permits11172008.pdf.

EPA (2008). *Handbook for developing watershed TMDLs* (Draft, December 15, 2008). Retrieved from www.epa.gov/sites/production/files/2015-10/documents/2009_01_09_tmdl_draft_handbook.pdf

EPA (2012). *Recreational water quality criteria*. Retrieved from https://www.epa.gov/sites/default/files/2015-10/documents/rwqc2012.pdf.

EPA (2014). *Protection of downstream waters in Water Quality Standards: Frequently asked questions*. Office of Water (EPA-Publication No. 820-F-14-001).

EPA Administered Permit Programs: The National Pollutant Discharge Elimination System, 40 CFR § 122 (2015). Retrieved from https://www.gpo.gov/fdsys/pkg/CFR-2015-title40-vol22/pdf/CFR-2015-title40-vol22-part122.pdf.

EPA State Program Requirements, 40 CFR § 123 (2015). Retrieved from https://www.gpo.gov/fdsys/pkg/CFR-2015-title40-vol22/pdf/CFR-2015-title40-vol22-part123.pdf.

EPA Water Quality Planning and Management, 40 CFR § 130 (2015). Retrieved from https://www.gpo.gov/fdsys/pkg/CFR-2015-title40-vol22/pdf/CFR-2015-title40-vol22-part130.pdf.

EPA Total Maximum Daily Loads (TMDL) and Individual Water Quality-Based Effluent Limitations, 40 CFR § 130.7 (2015). Retrieved from https://www.gpo.gov/fdsys/pkg/CFR-2015-title40-vol22/pdf/CFR-2015-title40-vol22-sec130-7.pdf.

Hall, S. (2002). *Failing systems* [PDF document). Washington State Department of Health, Wastewater Management Program, Rule Development Committee, Issue Research Report. Retrieved from http://www.doh.wa.gov/portals/1/Documents/Pubs/337-098.pdf.

National Atmospheric Deposition Program (2016). NADP Maps and Data. https://nadp.slh.wisc.edu/.

NOAA (2016). NOAA National Climatic Data Center. Available from www.ncdc.noaa.gov/cdo-web/#t=secondTabLink

ODAFF (2021). *Title 35, Chapter 17 (Water Quality)*, Retrieved from https://rules.ok.gov/code..

ODAFF (2021). Agricultural Environmental Management Services. Available from https://ag.ok.gov/divisions/agricultural-environmental-management/.

Oklahoma Climatological Survey (2021). Mesonet Long-Term Averages - Graphs. Available from https://www.mesonet.org/index.php/past_data/mesonet_averages_graphs#series%5B%5D=nrmn%3Atair_av%3Acurrent%3AN%3A0%3A%23000000%3AN%3A1&series%5B%5D=nrmn%3Atair_mx%3Aaverage%3AN%3A5%3A%23990000%3AN%3A1&series%5B%5D=nrmn%3Atair_av%3Aaverage%3AN%3A5%3A%23006600%3AN%3A1&series%5B%5D=nrmn%3Atair_mn%3Aaverage%3AN%3A5%3A%23000066%3AN%3A1.

Oklahoma Conservation Commission (2015). *Statewide Rotating Basin Monitoring Program*. Available from https://conservation.ok.gov/wq-statewide-rotating-basin-monitoring-program/

Oklahoma Department of Commerce (2023). Oklahoma State and county population projections through 2070. Policy, Research, and Economic Analysis Division. Available from https://www.okcommerce.gov/wp-content/uploads/Oklahoma-State-and-County-Population-Projections-Through-2070.pdf.

Oklahoma Department of Wildlife Conservation (ODWC) (2023). Deer harvest totals. Available from https://www.wildlifedepartment.com/hunting/species/big-game-reports.

Oklahoma Mesonet (2024). *Mesonet Meteorological Data*. Available from www.mesonet.org/

Pitt, R.; Maestre, A.; and Morquecho, R. (2004). The National Stormwater Quality Database, version 1.1. Available from http://unix.eng.ua.edu/~rpitt/Research/ms4/Paper/Mainms4paper.html.

Reed, K., Stowe, J.E. & Yanke, D. (2001). *Study to determine the magnitude of, and reasons for, chronically malfunctioning on-site sewage facility systems in Texas*, Report to the Texas On-Site Wastewater Treatment Research Council. Retrieved from www.tceq.texas.gov/assets/public/compliance/compliance_support/regulatory/ossf/StudyToDetermine.pdf.

Schueler, T.R. (1999). Microbes and urban watersheds: Concentrations, sources, and pathways. *Watershed Protection Techniques, 3* (1). Retrieved from https://owl.cwp.org/mdocs-posts/elc_pwp17/.

Tukey, J.W.; 1977. Exploratory Data Analysis. Addison-Wesely.

U.S. Bureau of Reclamation; 2012. U.S. Bureau of Reclamation Oklahoma Lakes and Reservoir Operations. http://www.usbr.gov/gp/lakes_reservoirs/oklahoma_lakes.htm.

U.S. Census Bureau; 1990. *1990 Census of Housing, Detailed Housing Characteristics Oklahoma*. https://www.govinfo.gov/content/pkg/GOVPUB-C3-PURL-LPS9261/pdf/GOVPUB-C3-PURL-LPS9261.pdf.

USACE; 2012. U.S. Army Corps of Engineers Water Control Data System (Tulsa District). http://www.swt-wc.usace.army.mil/stations.htm.

USDA (U.S. Department of Agriculture)-NASS (National Agricultural Statistics Service) (2019). *Census of Agriculture*. Available from https://www.nass.usda.gov/Publications/AgCensus/2017/index.php#full_report.

USDA-NRCS (2009). Agricultural Waste Management Field Handbook, Part 651. Available from http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/ecoscience/mnm/?&cid=stelprdb1045935

USDA-NRCS; 2009. Comprehensive Nutrient Management Plans (NCMP). Available from http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/plantsanimals/livestock/afo/

USDA-NRCS (2016). Manure Management Planner (MMP). Available from http://www.purdue.edu/agsoftware/mmp/

USDA-NRCS, National Cooperative Soil Survey (2015). *National Cooperative Soil Characterization Database*. Available from ncsslabdatamart.sc.egov.usda.gov/.

USDA-NRCS (2016). Geospatial Data Gateway: https://www.usgs.gov/tools/us-department-agriculture-usda-geospatial-data-gateway.

U.S. Department of Commerce, U.S. Census Bureau (2020). Available from https://www.census.gov/programs-surveys/decennial-census/decade/2020/2020-census-results.html.

USGS (2016). USGS Daily Streamflow Data. Retrieved from http://waterdata.usgs.gov/ok/nwis/rt.

USGS (2016). *USGS National Water Information System; USGS Water Data for Oklahoma*. Available from waterdata.usgs.gov/ok/nwis/nwis.

Woods, A.J., Omernik, J.M., Butler, D.R., Ford, J.G., Henley, J.E., Hoagland, B.W., Moran, B.C. (2005). Ecoregions of Oklahoma (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,250,000). Downloads - including shapefiles, metadata, and PDF documents - are available from https://gaftp.epa.gov/EPADataCommons/ORD/Ecoregions/ok/ok_eco_lg.pdf.

APPENDIX A: Ambient Water Quality Data

Appendix Table A-1 Bacterial Data: 2006 to 2021

Waterbody Name	OKWBID	WQM Station (s)	Date	ENT[1]	EC[2]
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	07/29/02	3167	
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	09/03/02	20	
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	05/06/03	140	
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	06/09/03	1560	
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	07/14/03	530	
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	08/18/03	360	
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	09/22/03	450	
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	06/07/04	190	
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	05/31/17		200
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	06/12/17		560
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	7/24/2017		1000
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	8/28/2017		60
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	5/14/2018		90
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	6/11/2018		120
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	7/9/2018		20
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	8/14/2018		520
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	8/21/2018		960
Wild Horse Creek	OK621000020040_00	OK621000-02-0040F	9/24/2018		180
Spring Creek	OK621000020130_00	OK621000-02-0130G	8/29/2000	14,000	736
Spring Creek	OK621000020130_00	OK621000-02-0130G	5/8/2001	3,000	2,142
Spring Creek	OK621000020130_00	OK621000-02-0130G	6/12/2001	2,000	3654
Spring Creek	OK621000020130_00	OK621000-02-0130G	7/23/2001	185	610
Spring Creek	OK621000020130_00	OK621000-02-0130G	8/20/2001	110	400
Spring Creek	OK621000020130_00	OK621000-02-0130G	9/24/2001	260	1030
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	6/8/2004	100	
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	6/5/2007	900	
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	7/9/2007	180	
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	7/23/2007	90	
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	8/7/2007	160	
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	9/17/2007	90	
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	5/20/2008	170	

Waterbody Name	OKWBID	WQM Station (s)	Date	ENT[1]	EC[2]
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	6/24/2008	540	
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	7/29/2008	460	
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	9/2/2008	10	
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	5/31/2017		240
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	6/12/2017		120
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	7/25/2017		280
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	8/29/2017		120
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	5/14/2018		160
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	6/12/2018		240
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	7/9/2018		320
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	8/13/2018		5,000
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	8/21/2018		1,660
Clay Creek, West	OK621010010130_00	OK621010-01-0130R	9/24/2018		120
Chikaskia River	OK621100000010_20	OK621100-00-0010M	6/2/2004	10	10
Chikaskia River	OK621100000010_20	OK621100-00-0010M	5/29/2007	2,000	1,200
Chikaskia River	OK621100000010_20	OK621100-00-0010M	6/25/2007	300	100
Chikaskia River	OK621100000010_20	OK621100-00-0010M	7/3/2007	460	540
Chikaskia River	OK621100000010_20	OK621100-00-0010M	7/30/2007	40	30
Chikaskia River	OK621100000010_20	OK621100-00-0010M	9/10/2007	40	20
Chikaskia River	OK621100000010_20	OK621100-00-0010M	5/12/2008	40	540
Chikaskia River	OK621100000010_20	OK621100-00-0010M	6/24/2008	40	40
Chikaskia River	OK621100000010_20	OK621100-00-0010M	7/29/2008	280	320
Chikaskia River	OK621100000010_20	OK621100-00-0010M	8/25/2008	10	20

Note : [1] ENT = Enterococci; units = counts/100 mL.
[2] EC = *E. coli*; units = counts/100 mL.

APPENDIX B: General Method for Estimating Flow for Ungaged Streams and Estimated Flow Exceedance Percentiles

General Method for Estimating Flow for Ungaged Streams

Flows duration curve were developed using existing USGS measured flow where the data existed 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 were derived for each Oklahoma stream segment in the following priority:

A. In cases where a USGS flow gage occurred on, or within one-half mile upstream or downstream of the Oklahoma stream segment:

   1. If simultaneously collected flow data matching the water quality sample collection date were available, those flow measurements were used.

   2. If flow measurements at the coincident gage were missing for some dates on which water quality samples were collected, the gaps in the flow record were filled, or the record was extended by estimating flow based on measured stream flows at a nearby gages. Based on Land Use and watershed size, an adjacent flow gage was identified and missing flow was estimated by the drainage area ratio.

   3. The flow frequency for the flow duration curves were based on measured flows only. The filled timeseries described above was used to match flows to sampling dates to calculate loads.

   4. On streams impounded by dams to form reservoirs of sufficient size to impact stream flow, only flows measured after the date of the most recent impoundment were used to develop the flow duration curve. This also applied to reservoirs on major tributaries to the streams.

B. In case no coincident flow data was available for a stream segment, but flow gage(s) were present upstream and/or downstream without a major reservoir between, flows were estimated for the stream segment from an upstream or downstream gage using a watershed area ratio method derived by delineating subwatersheds.

   1. Watershed delineations are performed with predetermined watershed shapefile using ESRI Arc Hydro with a 30-meter resolution National Elevation Dataset digital elevation model and National Hydrography Dataset (NHD) streams. The area of each watershed was calculated following watershed delineation.

   2. Drainage area of the ungagged site was calculated based on watershed delineation. To calculate the contributing drainage area for the ungagged sites, the areas of delineated subwatersheds between the ungagged site and the USGS gaging station were subtracted from or added to the available drainage area of the USGS gaging station.

   3. The average flow was calculated by using using the flow at the gaged site multiplied by the drainage area ratio.

C. In the rare case where no coincident flow data was available for a WQM station and no gage was present upstream or downstream, flows were estimated for the WQM station from a gage on an adjacent watershed of similar size and properties, via the same procedure described previously for upstream or downstream gages.

Appendix Table B-1 Estimated Flow Exceedance Percentiles

Stream Name	Wild Horse Creek	Spring Creek	Clay Creek, West	Chikaskia River
WBID Segment	OK621000020040_00	OK621000020130_00	OK621010010130_00	OK621100000010_20
Reference Gage	**07160350**	**07160350**	**07160350**	**07152000**
USGS Gage Drainage Area (mi^2)	70	70	70	1,876
Drainage Area (mi^2)	126	11.9	58.4	1,876
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
0	8,931.8	844.9	4,146.4	69,500.0
1	943.2	89.2	437.8	9,303.8
2	478.0	45.2	221.9	5,910.0
3	292.9	27.7	136.0	4,000.0
4	209.0	19.8	97.0	2,970.0
5	154.6	14.6	71.7	2,260.0
6	125.8	11.9	58.4	1,820.0
7	107.8	10.2	50.1	1,520.0
8	91.7	8.7	42.5	1,265.2
9	80.0	7.6	37.2	1,100.0
10	71.9	6.8	33.4	968.0
11	64.7	6.1	30.0	857.0
12	58.4	5.5	27.1	768.0
13	52.3	4.9	24.3	698.0
14	48.5	4.6	22.5	644.7
15	44.9	4.3	20.9	595.0
16	43.0	4.1	19.9	550.0
17	40.4	3.8	18.8	516.0
18	38.1	3.6	17.7	486.0
19	36.5	3.5	16.9	461.0
20	35.6	3.4	16.5	437.0

Stream Name	Wild Horse Creek	Spring Creek	Clay Creek, West	Chikaskia River
WBID Segment	OK621000020040_00	OK621000020130_00	OK621010010130_00	OK621100000010_20
Reference Gage	**07160350**	**07160350**	**07160350**	**07152000**
USGS Gage Drainage Area (mi^2)	70	70	70	1,876
Drainage Area (mi^2)	126	11.9	58.4	1,876
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
21	34.1	3.2	15.9	415.0
22	32.9	3.1	15.3	395.0
23	32.3	3.1	15.0	377.0
24	30.9	2.9	14.3	360.0
25	30.6	2.9	14.2	346.0
26	29.7	2.8	13.8	331.0
27	28.8	2.7	13.3	319.1
28	28.8	2.7	13.3	308.0
29	27.9	2.6	12.9	297.5
30	27.2	2.6	12.6	285.0
31	27.0	2.6	12.5	276.0
32	26.8	2.5	12.4	267.0
33	26.1	2.5	12.1	258.0
34	25.5	2.4	11.8	250.0
35	25.2	2.4	11.7	241.0
36	25.2	2.4	11.7	233.0
37	24.6	2.3	11.4	225.0
38	23.9	2.3	11.1	218.0
39	23.4	2.2	10.8	211.0
40	23.4	2.2	10.8	205.0
41	23.0	2.2	10.7	200.0
42	22.6	2.1	10.5	193.0
43	22.1	2.1	10.3	189.0

Stream Name	Wild Horse Creek	Spring Creek	Clay Creek, West	Chikaskia River
WBID Segment	OK621000020040_00	OK621000020130_00	OK621010010130_00	OK621100000010_20
Reference Gage	**07160350**	**07160350**	**07160350**	**07152000**
USGS Gage Drainage Area (mi^2)	70	70	70	1,876
Drainage Area (mi^2)	126	11.9	58.4	1,876
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
44	21.7	2.1	10.1	183.0
45	21.6	2.0	10.0	178.0
46	21.6	2.0	10.0	173.0
47	21.0	2.0	9.8	168.0
48	20.7	2.0	9.6	164.0
49	20.1	1.9	9.3	160.0
50	19.8	1.9	9.2	156.0
51	19.8	1.9	9.2	152.0
52	19.4	1.8	9.0	148.0
53	19.0	1.8	8.8	143.0
54	18.5	1.8	8.6	140.0
55	18.2	1.7	8.4	136.0
56	18.0	1.7	8.3	133.0
57	17.6	1.7	8.2	129.0
58	17.4	1.6	8.1	125.0
59	17.1	1.6	7.9	120.0
60	16.9	1.6	7.8	117.0
61	16.6	1.6	7.7	114.0
62	16.3	1.5	7.6	111.0
63	16.1	1.5	7.5	107.0
64	15.8	1.5	7.3	104.0
65	15.5	1.5	7.2	101.0
66	15.3	1.4	7.1	98.0

Stream Name	Wild Horse Creek	Spring Creek	Clay Creek, West	Chikaskia River
WBID Segment	OK621000020040_00	OK621000020130_00	OK621010010130_00	OK621100000010_20
Reference Gage	**07160350**	**07160350**	**07160350**	**07152000**
USGS Gage Drainage Area (mi²)	70	70	70	1,876
Drainage Area (mi²)	126	11.9	58.4	1,876
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
67	15.0	1.4	7.0	95.2
68	14.8	1.4	6.9	92.0
69	14.5	1.4	6.7	89.0
70	14.3	1.3	6.6	86.0
71	14.0	1.3	6.5	84.0
72	13.7	1.3	6.4	81.0
73	13.5	1.3	6.3	78.0
74	13.3	1.3	6.2	75.0
75	13.0	1.2	6.0	72.0
76	12.8	1.2	5.9	69.0
77	12.5	1.2	5.8	66.0
78	12.2	1.2	5.7	63.0
79	12.0	1.1	5.6	59.9
80	11.7	1.1	5.4	57.0
81	11.5	1.1	5.3	53.6
82	11.1	1.1	5.2	51.0
83	10.8	1.0	5.0	48.0
84	10.6	1.0	4.9	44.6
85	10.2	1.0	4.8	42.0
86	9.9	0.9	4.6	39.0
87	9.5	0.9	4.4	36.0
88	9.1	0.9	4.2	33.0
89	8.8	0.8	4.1	30.0

Stream Name	Wild Horse Creek	Spring Creek	Clay Creek, West	Chikaskia River
WBID Segment	OK621000020040_00	OK621000020130_00	OK621010010130_00	OK621100000010_20
Reference Gage	**07160350**	**07160350**	**07160350**	**07152000**
USGS Gage Drainage Area (mi^2)	70	70	70	1,876
Drainage Area (mi^2)	126	11.9	58.4	1,876
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
90	8.5	0.8	3.9	27.0
91	8.1	0.8	3.8	24.0
92	7.7	0.7	3.6	20.0
93	7.3	0.7	3.4	16.0
94	6.8	0.6	3.1	12.0
95	6.3	0.6	2.9	8.8
96	5.7	0.5	2.6	6.6
97	5.1	0.5	2.4	4.5
98	4.1	0.4	1.9	2.3
99	1.7	0.2	0.8	1.2
100	0.2	0.02	0.1	0.0

APPENDIX C: State of Oklahoma Antidegradation Policy

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State of Oklahoma Antidegradation Policy

252:730-3-1. 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 252:730-3-2 and Subchapter 13 of OAC 252:740.

252:730-3-2. 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 252:730-5-25(c)(2)(A) and 252:740-13-6(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.

252:740-13-1. Applicability and scope

(a) The rules in this Subchapter provide a framework for implementing the antidegradation policy stated in OAC 252:730-3-2 and OAC 252:730-5-25 for all waters of the state. This policy and framework includes four tiers, or levels, of protection.

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

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

(2) Tier 2. Maintenance and protection Sensitive Water Supply-Reuse waterbodies.

(3) Tier 2.5 Maintenance and protection of High Quality Waters, Sensitive Public and Private Water Supply waters.

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

(c) In addition to the four tiers of protection, this Subchapter provides rules to implement the protection of waters in areas listed in Appendix B of OAC 252:730. Although Appendix B areas are not mentioned in OAC 252:730-3-2, 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, Tier 2.5 and Tier 3 waterbodies or areas, and implementation rules applicable to Tier 2 waterbodies shall be applicable also to Tier 2.5 and 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, SWS, or SWS-R limitation.

252:740-13-2. 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 DEQ or the permitting authority.

252:740-13-3. 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.

252:740-13-4. Tier 2 protection; maintenance and protection of sensitive water supply-reuse and other tier 2 waterbodies

(a) General rules for Sensitive Water Supply – Reuse (SWS-R) Waters.

(1) Classification of SWS-R Waters. DEQ may consider classification of a waterbody as an SWS-R waterbody based upon required documentation submitted by any interested party. The interested party shall submit documentation presenting background information and justification to support the classification of a waterbody as SWS-R including, but not limited to, the following:

(A) Determination of the waterbody's assimilative capacity pursuant to 252:740-13-8, including all supporting information and calculations.

(B) Documentation demonstrating that municipal wastewater discharge for the purpose of water supply augmentation has been considered as part of a local water supply plan or other local planning document.

(C) Any additional information or documentation necessary for DEQ's consideration of a request for the classification of a waterbody as SWS-R.

(D) Prior to consideration by DEQ, any interested party seeking the classification of a waterbody as SWS-R shall submit documentation to DEQ staff demonstrating that local stakeholders, including those that use the waterbody for any designated or existing beneficial uses, have been afforded notice and an opportunity for an informal public meeting, if requested, regarding the proposed classification of the waterbody as SWS-R at least one hundred eighty (180) days prior to DEQ consideration. In addition, all information or documentation submitted pursuant to this subsection shall be available for public review.

(2) The drought of record waterbody level shall be considered the receiving water critical condition for SWS-R waterbodies.

(A) All beneficial uses shall be maintained and protected during drought of record conditions.

(B) Drought of record shall be determined with the permitting authority approved monthly time step model using hydrologic data with a minimum period of record from 1950 to the present. If empirical data are not available over the minimum period of record, modeled data shall be included in the analysis, if available.

(3) In accordance with OAC 252:730-5-25(c)(8)(D), SWS-R waterbodies with a permitted discharge shall be monitored and water quality technically evaluated to ensure that beneficial uses are protected and maintained and use of assimilative capacity does not exceed that prescribed by permit. Prior to any monitoring and/or technical analysis, the permittee shall submit a Receiving Water Monitoring and Evaluation Plan to the permitting authority for review and approval.

(A) The Receiving Water Monitoring and Evaluation Plan shall include, at a minimum, 17 the following sections:

(i) Monitoring section that meets the required spatial, temporal, and parametric coverage of this subchapter, OAC 252:740-15, and OAC 252:628-11.

(ii) Analysis and reporting section that meets the requirements of this subchapter, OAC 252:740-15, and OAC 252:628-11.

(iii) Quality Assurance Project Plan that meets the most recent requirements for United States Environmental Protection Agency Quality Assurance Project Plans.

(B) The monitoring section of the Receiving Water Monitoring and Evaluation Plan, at a minimum shall:

(i) Include parametric, temporal (including frequency of sampling events), and spatial sampling design adequate to characterize water quality related to limnological, hydrologic, seasonal, and diurnal influences and variation.

(ii) Include nutrient monitoring adequate to characterize both external and internal loading and nutrient cycling.

(iii) Include algal biomass monitoring consistent with this sub-paragraph (B) and phytoplankton monitoring sufficient to evaluate general shifts and/or trends in phytoplankton community dynamics over time.

(iv) Include in-situ monitoring of dissolved oxygen, temperature, and pH adequate to characterize diurnal changes and fluctuations during periods of thermal stratification and complete mix.

(v) Include monitoring of pollutants with a permit effluent limit and/or permit monitoring requirements.

(C) The Receiving Water Monitoring and Evaluation Plan may include special studies, as necessary.

(D) At least biennially and prior to permit renewal, the permittee shall submit a Receiving Water Monitoring and Evaluation Report to the permitting authority that includes, at a minimum:

(i) Summarized review of monitoring objectives and approach.

(ii) Presentation and evaluation of monitoring results, including an analysis of both short-term and long-term trends.

(iii) An assessment of beneficial use attainment that is at a minimum in accordance with OAC 252:740-15.

(iv) Summarized assessment of data quality objectives, including an explanation of any data quality issues.

(v) All monitoring data shall be submitted electronically.

(E) If the report documents nonattainment of a beneficial use(s) resulting from the discharge, the permitting authority shall consider actions including, but not limited to, additional permit requirements, cessation of the discharge, and/or a recommendation to DEQ to revoke the SWS-R waterbody classification.

(b) General rules for other Tier 2 Waterbodies.

(1) General rules for other Tier 2 waterbodies shall be developed as waters are identified.

(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 252:730.

252:740-13-5. Tier 2.5 protection; maintenance and protection of high quality waters, sensitive water supplies, and other tier 2.5 waterbodies

(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 252:730 with the limitation "HQW". Any 18 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 252:730 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", "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 252:730.

252:740-13-6. 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 252:730

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 252:740-13-6(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 252:740-13-6(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 252:730, 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 19 "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 252:730 as "ORW".

252:740-13-7. Protection for Appendix B areas

(a) General. Appendix B of OAC 252:730 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 252:730 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 252:730 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 252:730.

252:740-13-8. Antidegradation review in surface waters

(a) General. The antidegradation review process below presents the framework to be used when making decisions regarding the intentional lowering of water quality, where water quality is better than the minimum necessary to protect beneficial uses. OWRB technical guidance TRWQ2017-01 provides additional information.

(b) Determination of Assimilative Capacity in Tier 2, Tier 2.5, and Tier 3 Waters.

(1) All water quality monitoring and technical analyses necessary to determine receiving waterbody assimilative capacity for all applicable numeric and narrative criteria and associated parameters protective of waterbody beneficial uses shall be conducted by the interested party.

(2) Prior to initiating any monitoring or technical analysis to support determination of waterbody assimilative capacity, the interested party shall submit a workplan consistent with the requirements of OWRB technical guidance TRWQ2017-01 for review and approval by DEQ staff.

(3) As part of an approved workplan, the interested party shall characterize existing water quality of the receiving waterbody for each applicable criteria and associated parameters and evaluate if there is available assimilative capacity. Consistent with OWRB technical guidance TRWQ2017-01, characterization of existing water quality shall address, at a minimum:

(A) Measurement of load and or concentration for all applicable criteria and associated parameter(s) in the receiving water; and

(B) The measurement of both existing and proposed point and nonpoint source discharge concentrations and or loadings, including the measurement of external and internal nutrient loading, where required by OWRB technical guidance TRWQ2017-01; and

(C) The critical low flow or critical lake level of the receiving waterbody, including drought of record in waterbodies receiving IPR discharges; and

(D) The limnological, hydrologic, seasonal, spatial and temporal variability and critical conditions of the waterbody; and

(E) Volumetric determination of anoxic dissolved oxygen condition consistent with OAC 252:730 and 252:740; and

(F) The bioaccumulative nature of a pollutant shall be considered when determining assimilative capacity; and

(G) The 303(d) list as contained in the most recently approved Integrated Water Quality Assessment Report shall be reviewed and any difference between the water quality assessment information and the characterization of existing water quality shall be reconciled.

(4) Assimilative capacity shall be determined by comparing existing water quality, as determined consistent with subsection (a)(3) above to the applicable narrative and numeric criteria. In Tier 2 waters, assimilative capacity shall be determined and used with a margin(s) of safety (252:740-13-8(d)(1)(D)), which takes into account any uncertainty between existing or proposed discharges and impacts on receiving water quality.

(5) When existing water quality does not meet the criterion or associated parameter necessary to support beneficial use(s) or is identified as impaired on Oklahoma's

303(d) list as contained in the most recently approved Integrated Water Quality Assessment Report, no assimilative capacity shall exist for the given criterion.

(c) Use of Assimilative Capacity in Tier 1 Waters. Available assimilative capacity may be used in Tier 1 waters such that, water quality is maintained to fully protect all designated and existing beneficial uses.

(d) Use of Assimilative Capacity in Tier 2 Waters.

(1) If it is determined that assimilative capacity is available, the consumption of assimilative capacity may be allowed in a manner consistent with the requirements in 40 CFR 131.12(a)(2) and this subchapter. In allowing the use of assimilative capacity, the state shall assure that:

(A) Water quality shall be maintained to fully protect designated and existing beneficial uses.

(B) Assimilative capacity shall be reserved such that all applicable narrative criteria in OAC 252:730 are attained and beneficial uses are protected.

(C) Fifty percent (50%) of assimilative capacity shall be reserved for all applicable water quality criteria listed in OAC 252:730, Appendix G, Table 2.

(D) In order to preserve a margin of safety; in no case shall any activity be authorized without the application of margin(s) of safety specified below:

(i) A twenty percent (20%) margin of safety shall be applied to an applicable numeric criterion for chlorophyll-a, total phosphorus, and total nitrogen. If numeric criteria are not available, the narrative nutrient criterion (252:730-5-9(d)) shall be applied and a twenty percent (20%) margin of safety shall be applied to the parameters listed in the criterion.

(ii) No more than forty-five percent (45%) of the lake volume shall be less than the dissolved oxygen criterion magnitude in OAC 252:730-5-12(f)(1)(C)(ii).

(iii) If the existing value of a criterion is within the margin of safety, no assimilative capacity is available and existing water quality shall be maintained or improved.

(E) When existing water quality does not satisfy the applicable criterion and support beneficial use(s) or has been designated as impaired in Oklahoma's 303(d) list as contained in the most recently approved Integrated Water Quality Assessment Report, the applicable criterion shall be met at the point of discharge. If a TMDL has been approved for the impairment, loading capacity for the parameter may be available if TMDL load allocations include the proposed load from the discharge.

(2) An analysis of alternatives shall evaluate a range of practicable alternatives that would prevent or lessen the water quality degradation associated with the proposed activity. When the analysis of alternatives identifies one or more practicable alternatives, the State shall only find that a lowering is necessary if one such alternative is selected for implementation.

(3) After an analysis of alternatives and an option that utilizes any or all of the assimilative capacity is selected, the discharger must demonstrate that the lowering of water quality is necessary to accommodate important economic or social development in the area in which the waters are located.

(e) Use of Assimilative Capacity in Tier 2.5 or 3.0 Waters. Consistent with 252:730-3-2(a) - (c), 252:730-5-25(a), 252:730-5-25(b), and 252:730-5-25(c)(1) – (c)(6) all available assimilative capacity shall be reserved in waterbodies classified as Tier 2.5 or 3.0 waters.

(f) Public Participation. Agencies implementing subsection 8(d), shall conduct all activities with intergovernmental coordination and according to each agency's public participation procedures, including those specified in Oklahoma's continuing planning process.

APPENDIX D: DEQ Sanitary Sewer Overflow Data (1992-2000)

Table Appendix D-1 DEQ Sanitary Sewer Overflow Data (1992-2000)

Facility Name	Date	Facility ID	Duration (hours)	Location	Amount (gallons)	Cause
Kremlin WWT	9/3/1992	S21008	20	LIFT STATION S PART OF TOWN	100	EXCESSIVE RAINS PUMPS FAILED
Kremlin WWT	2/5/1993	S21008	24	LIFT STATION FAILED	15,000	LIFT STATION FAILED
Kremlin WWT	3/5/1993	S21008	499	L AGOONS FROM CELLS 3 & 5	898,200	EXCESSIVE RAINFALL HAS OVERLOADED LAGOONS
Kremlin WWT	6/6/1995	S21008	90	5TH CELL OF LAGOON		RAIN I/I
Kremlin WWT	7/29/1997	S21008		S.W. OF TOWN		RAIN
Kremlin WWT	10/29/1997	S21008		LAGOONS		
Kremlin WWT	3/18/1998	S21008	240	E. LIFT STATION		4" RAININ 4HRS, GROUND WATER INFILTRATION
Kremlin WWT	3/18/1998	S21008	384	LAGOONS	21,396,092	EXCESSIVE RAINFALL, GROUND WATER INFILTRATION, RUNOFF
Kremlin WWT	5/1/1998	S21008	408	WEST LAGOONS	20,000,000	FLOW AND INFILTRATION
Kremlin WWT	6/17/1998	S21008		WEST LAGOONS	4,000,000	TO PROTECT INTEGRITY OF DIKES
Kremlin WWT	3/16/1999	S21008		WEST LAGOONS		SNOW & RAIN
Kremlin WWT	5/4/1999	S21008		WEST LAGOON	2,000,000	OVERFLOW
Kremlin WWT	6/25/1999	S21008		WEST LAGOONS		
Kremlin WWT	1/3/2000	S21008		LAGOONS	4,000,000	OVERFLOW LAGOONS