DRAFT

2015 BACTERIAL
TOTAL MAXIMUM DAILY LOADS FOR OKLAHOMA STREAMS IN THE CANADIAN RIVER AREA (OK520810)

Oklahoma Waterbody Identification Numbers

Little River	OK520810000080_00
Rock Creek	OK520810000090_00
Elm Creek, West	OK520810000140_00

Prepared by:

Oklahoma 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
cfu	colony-forming unit
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	Enterococcus
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
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 (DEQ, 2013) (http://www.deq.state.ok.us/rules/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)*, Enterococcus] for selected waterbodies in the Canadian River 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. An 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 Canadian River Study Area, identified in **Table ES-1**, that DEQ placed in Category 5 [303(d) list] of the *Water Quality in Oklahoma, 2012 Integrated Report* for nonsupport of primary body contact recreation (PBCR) beneficial uses.

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 uses designated for each waterbody.

Table ES-2 summarizes water quality data collected during primary contact recreation season from the water quality monitoring (WQM) stations in 2008 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. This data collected during the primary contact recreation season includes the data used to support the decision to place specific waterbodies within the Study Area on the DEQ 2012 303(d) list (DEQ 2013).

ES-2.1 Chapter 45: Criteria for Bacteria

The definition of PBCR and the bacterial WQSs for PBCR are summarized by the following excerpt from Title 785, Chapter 45-5-16 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 785:45-5-16 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) Enterococcus: The Enterococcus geometric mean criterion is 33/100 ml. For swimming advisory and permitting purposes, Enterococcus 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 46: Implementation of OWQS for Bacteria

To implement Oklahoma's WQS for PBCR, OWRB promulgated Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2013a). The excerpt below from Chapter 46: 785:46-15-6, stipulates how water quality data will be assessed to determine support of the PBCR use as well as how the water quality target for TMDLs will be defined for each bacterial indicator.

(a). ***Scope.***

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

(b). ***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 785:46-15-3(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 785:46-15-3(c).

(c). ***Enterococcus.***

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to Enterococcus 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 785:46-15-3(c).

(2) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to Enterococcus 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 785:46-15-3(c).

Where concurrent data exist for multiple bacterial indicators on the same waterbody, each indicator group must demonstrate compliance with the numeric criteria prescribed (OWRB 2013).

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 Enterococcus bacterial indicators.

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

Table ES-1 Excerpt from the 2012 Integrated Report – Oklahoma 303(d) List of Impaired Waters (Category 5)

Waterbody ID	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*E. coli*	Designated Use Primary Body Contact Recreation
OK520810000080_00	Little River	14.96	2014	1	X	X	N
OK520810000090_00	Rock Creek	5.99	2014	1	X	X	N
OK520810000140_00	Elm Creek, West	8.00	2014	1	X	X	N

ENT = Enterococcus; N = Not attaining; X = Criterion exceeded
Source: 2012 Integrated Report, DEQ 2013

Table ES-2 Summary of Indicator Bacterial Samples from Primary Body Contact Recreation Subcategory Season May 1 to September 30, 2008

Waterbody ID	Waterbody Name	Indicator	Number of samples	Geometric Mean Conc (cfu/100 ml)	Assessment Results
OK520810000080_00	Little River	EC	21	320	TMDL Required
		ENT	21	462	TMDL Required
OK520810000090_0	Rock Creek	EC	21	356	TMDL Required
		ENT	21	597	TMDL Required
OK520810000140_00	Elm Creek, West	EC	21	356	TMDL Required
		ENT	21	633	TMDL Required

Enterococcus (ENT) water quality criterion = Geometric Mean of 33 counts/100 mL
E. coli (EC) water quality criterion = Geometric Mean of 126 counts/100 mL
TMDLs will be developed for waterbodies highlighted in green

Table ES-3 shows the bacterial TMDLs that will be developed in this report.

Table ES-3 Stream and Pollutants for TMDL Development

Waterbody ID	HUC 8 Codes	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*E. coli*
OK520810000080_00	11090203	Little River	14.96	2014	1	X	X
OK520810000090_00	11090203	Rock Creek	5.99	2014	1	X	X
OK520810000140_00	11090203	Elm Creek, West	8.00	2014	1	X	X

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 fecal coliform under the current permits and will be required to monitor *E. coli* when their permits come to renew. These facilities are also required to monitor TSS in accordance with their permits. There are no active permitted municipal or industrial point source facilities within 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-4 summarizes the point and nonpoint sources that contribute bacteria to each respective waterbody.

Table ES-4 Summary of Potential Pollutant Sources by Category

Waterbody ID	Waterbody Name	Municipal OPDES Facility	Industrial OPDES Facility	MS4	OPDES No Discharge Facility	PFO	Mines	Construction Stormwater Permit	Multi-Sector General Permit	Nonpoint Source
OK520810000080_00	**Little River**									Bacteria
OK520810000090_00	**Rock Creek**									Bacteria
OK520810000140_00	**Elm Creek, West**									Bacteria

Facility present in watershed and potential as contributing pollutant source

Facility present in watershed, but not recognized as pollutant source

No facility present in watershed

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.

For bacterial TMDLs, obtain the water quality data from 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 for each respective bacterial indicator.

5. 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.

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

Where: WQS = 126 cfu/100 mL (E. coli); or 33 cfu/100 mL (Enterococcus)

unit conversion factor = 24,465,525

ES-4.2 LDC 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. This definition can be expressed by the following equation:

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

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 colony forming units (cfu) per day across the full range of flow conditions. For information purposes, 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 cfu/100 ml for *E. coli* and 33 cfu/100 ml for Enterococcus) with 10% of MOS.

Table ES-5 presents the percent reductions necessary for each bacterial indicator causing nonsupport of the PBCR use in each waterbody of the Study Area.

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

Waterbody ID	Waterbody Name	Required Reduction Rate	
		ENT	*E. coli*
OK520810000080_00	Little River	93%	61%
OK520810000090_00	Rock Creek	95%	65%
OK520810000140_00	Elm Creek, West	95%	65%

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 §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 §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 rules 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 WLA based on an assumption that nonpoint source load reductions will occur. In such a case, "reasonable assurances" that nonpoint (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 standard numerical criteria. This ensures that the impairments of the waterbodies in this report will not be caused by point sources. Since the point source WLAs in this TMDL report are not dependent on NPS load reduction, reasonable assurance does not apply.

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: www.deq.state.ok.us/wqdnew/index.htm. 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 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 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 (DEQ, 2013) (http://www.deq.state.ok.us/rules/606.pdf)].

Section 303(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 Enterococcus][1] for selected waterbodies in the Canadian River 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, 2012 Integrated Report* for nonsupport of primary body contact recreation (PBCR) beneficial uses. The waterbodies considered for TMDL development in this report are listed in **Table 1-1**:

Table 1-1 TMDL Waterbodies

Little River	OK520810000080_00
Rock Creek	OK520810000090_00
Elm Creek, West	OK520810000140_00

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 designated for each waterbody. **Table 1-2** provides a description of the locations of WQM stations on the 303(d)-listed waterbodies.

Figure 1-1 Canadian River Watershed Not Supporting Primary Body Contact Recreation Beneficial Uses

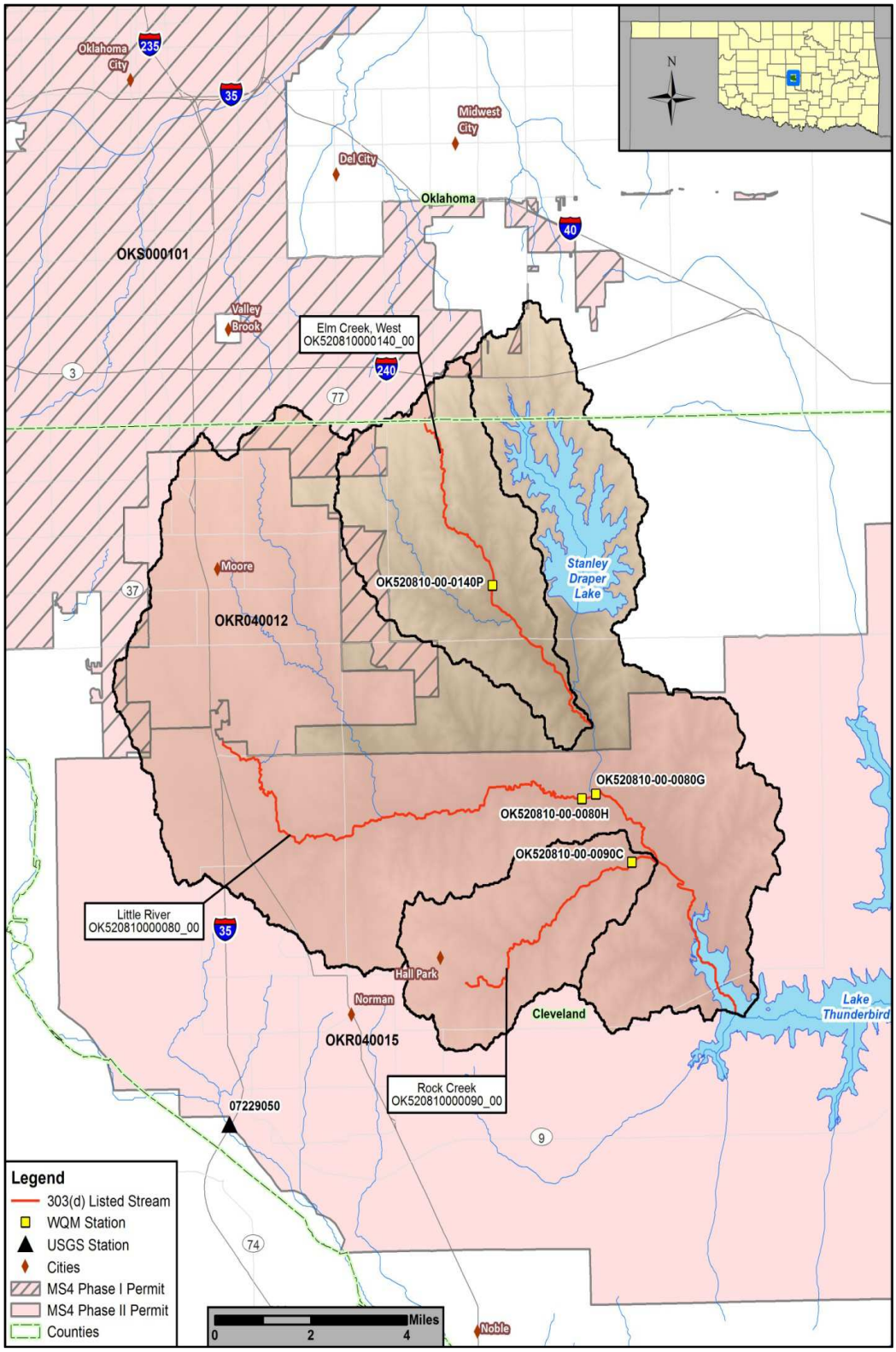


Table 1-2 Water Quality Monitoring Stations used for Assessment of Streams

WQM Station	Waterbody Name	Station Location	Waterbody ID
OK520810-00-0080G	Little River	Little River near Franklin Road	OK520810000080_00
OK520810-00-0080H	Little River	Little River near 60th Street	OK520810000080_00
OK520810-00-0090C	Rock Creek	Rock Creek near 72nd Avenue	OK520810000090_00
OK520810-00-0140P	Elm Creek, West	West Elm Creek near 134th Street	OK520810000140_00

1.2 WATERSHED DESCRIPTION

1.2.1 General

The Canadian River study area is located in central Oklahoma. The waterbodies and their watersheds addressed in this report are in Cleveland county. This county is part of the Central Great Plains and Cross Timbers ecoregions (Woods, A.J, et al 2005). A small portion of the West Elm Creek watershed is located on Oklahoma County. The watersheds in the Study Area are located in the Anadarko Basin geological provinces. **Table 1-3**, derived from the 2010 U.S. Census, demonstrates that the counties in which these watersheds are located are densly populated (U.S. Census Bureau 2010). **Table 1-4** lists major towns and cities located in each watershed.

Table 1-3 County Population and Density

County Name	Population (2010 Census)	Population Density (per square mile)
Cleveland	255,755	460
Oklahoma	718,633	1,000

Table 1-4 Major Municipalities by Watershed

Waterbody Name	Waterbody ID	Municipalities
Little River	OK520810000080_00	Moore, Norman & Oklahoma City
Rock Creek	OK520810000090_00	Hall Park, Norman & Oklahoma City
Elm Creek, West	OK520810000140_00	Oklahoma City

1.2.2 Climate

Table 1-5 summarizes the average annual precipitation for each Oklahoma waterbody derived from a geospatial layer developed to display annual precipitation using data collected from Oklahoma weather stations between 1981 through 2010. Average annual precipitation values among the watersheds in this portion of Oklahoma range between 37.0 and 37.6 inches (PRISM Climate Group; 2014).

Table 1-5 Average Annual Precipitation by Watershed

Waterbody Name	Waterbody ID	Average Annual Precipitation (inches)
Little River	OK520810000080_00	37.3
Rock Creek	OK520810000090_00	37.6
Elm Creek, West	OK520810000140_00	37.0

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 U.S. Geological Survey (USGS) 2011 National Land Cover Dataset (MRLC 2011). 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 two most dominant land use categories throughout the Canadian River Study Area are deciduous forest and grassland/herbaceous. The watersheds targeted for TMDL development in this Study Area range in size from 7,521 acres (Rock Creek, OK520810000090_00) to 56,688 acres (Little River, OK520810000080_00).

Figure 1-2 Land Use Map

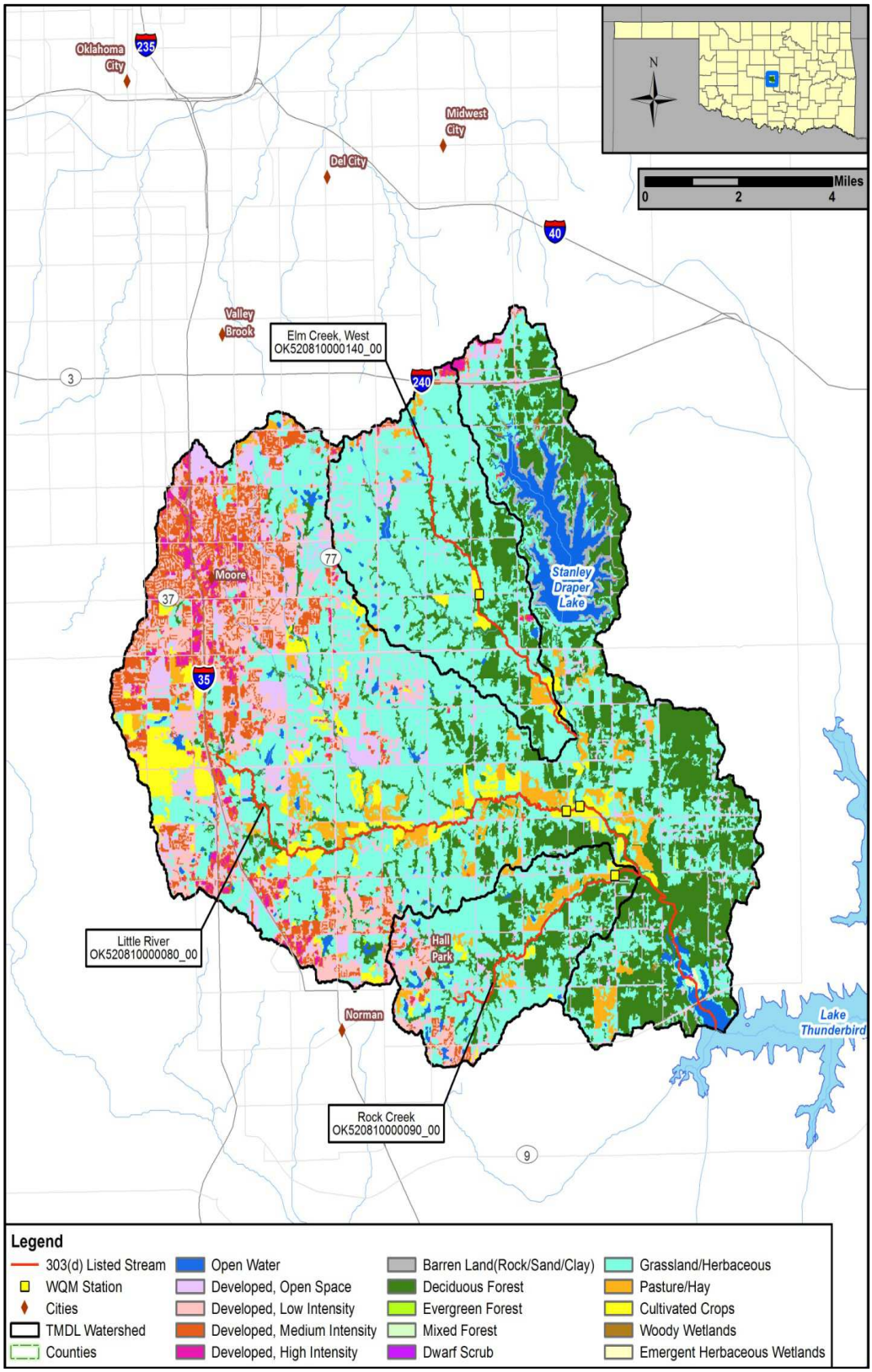


Table 1-6 Land Use Summaries by Watershed

Landuse Category	Watershed		
	Little River	Rock Creek	Elm Creek, West
Waterbody ID	**OK520810000080_00**	**OK520810000090_00**	**OK520810000140_00**
Open Water	4.4	2.0	1.3
Developed, Open Space	9.5	7.7	6.2
Developed, Low Intensity	10.9	7.7	2.2
Developed, Medium Intensity	8.4	2.8	0.8
Developed, High Intensity	1.7	0.1	0.4
Bare Rock/Sand/Clay	1.2	0.1	0.1
Deciduous Forest	20.0	24.2	18.9
Evergreen Forest	0	0	0
Mixed Forest	0	0	0
Shrub/Scrub	0	0	0
Grasslands/Herbaceous	35.3	49.2	67.0
Pasture/Hay	3.7	4.4	1.6
Cultivated Crops	4.6	1.8	1.4
Woody Wetlands	0.1	0	0
Emergent Herbaceous Wetlands	0.1	0	0
Total (%)	**100.0**	**100.0**	**100.0**
Open Water	2,521	154	153
Developed, Open Space	5,395	582	704
Developed, Low Intensity	6,152	582	254
Developed, Medium Intensity	4,747	209	95
Developed, High Intensity	959	7	43
Bare Rock/Sand/Clay	695	7	15
Deciduous Forest	11,341	1,820	2,148
Evergreen Forest	5	0	2
Mixed Forest	0	0	0
Shrub/Scrub	4	0	0
Grasslands/Herbaceous	20,003	3,698	7,601
Pasture/Hay	2,111	329	183
Cultivated Crops	2,626	133	155
Woody Wetlands	77	0	0
Emergent Herbaceous Wetlands	48	0	0
Total (Acres):	**56,688**	**7,521**	**11,354**

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. None of the waterbodies in this Study Area have historical quantitative flow data available. Flow data from USGS gage stations on a nearby, similar watershed have been used to estimate flows for these ungaged streams. Qualitative stream stage conditions recorded during the time of water quality sampling are included in **Appendix A** along with corresponding bacteriological data results. 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**.

SECTION 2 PROBLEM IDENTIFICATION AND WATER QUALITY TARGET

2.1 OKLAHOMA WATER QUALITY STANDARDS

Title 785 of the Oklahoma Administrative Code contains Oklahoma Water Quality Standards (OWQS) and implementation procedures (OWRB 2013). The Oklahoma Water Resources Board (OWRB) has statutory authority and responsibility concerning establishment of State WQS, as provided under 82 Oklahoma Statute [O.S.], §1085.30. This statute authorizes the OWRB to promulgate rules *…which establish classifications of uses of waters of the state, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters.* [O.S. 82:1085:30(A)]. Beneficial uses are designated for all waters of the State. Such uses are protected through restrictions imposed by the antidegradation policy statement, narrative water quality criteria, and numerical criteria (OWRB 2013). An excerpt of the Oklahoma WQS (Title 785) summarizing the State of Oklahoma Antidegradation Policy is provided in **Appendix C**. **Table 2-1**, an excerpt from the 2012 Integrated Report (DEQ 2013), 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 ID	Waterbody Name	AES	AG	WWAC	FISH	PBCR	PPWS
OK520810000080_00	**Little River**	X	F	N	X	N	X
OK520810000090_00	**Rock Creek**	X	F	I	X	N	X
OK520810000140_00	**Elm Creek, West**	X	F	F	X	N	X
F – Fully supporting information	**N** – Not supporting	**I** – Insufficient		**X** – Not assessed		Source: **DEQ 2012 Integrated Report**	

2.1.1 Chapter 45: Definition of PBCR and Bacterial WQSs

The definition of PBCR and the bacterial WQSs for PBCR are summarized by the following excerpt from Title 785, Chapter 45-5-16 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 785:45-5-16 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) Enterococcus: The Enterococcus geometric mean criterion is 33/100 ml. For swimming advisory and permitting purposes, Enterococcus 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 46: Implementation of OWQS for PBCR

To implement Oklahoma's WQS for PBCR, OWRB promulgated Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2013a). The following excerpt from Chapter 46: 785:46-15-6, stipulates how water quality data will be assessed to determine support of the PBCR use as well as how the water quality target for TMDLs will be defined for each bacterial indicator.

(a). ***Scope.***

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

(b). ***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 785:46-15-3(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 785:46-15-3(c).

(c). ***Enterococcus.***

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to Enterococcus 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 785:46-15-3(c).

(2) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to Enterococcus 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 785:46-15-3(c).*

Compliance with the Oklahoma WQS is based on meeting requirements for both *E. coli* and Enterococcus 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 (OWRB 2013).

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 Enterococcus.

2.1.3 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 uses.

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:[1]

Priority 1 watersheds - above the 90th percentile (32 watersheds)

Priority 2 watersheds - 70th to 90th percentile (64 watersheds)

Priority 3 watersheds - 40th to 70th percentile (81 watersheds)

Priority 4 watersheds - below the 40th percentile (141 watersheds)

Each waterbody on the 2012 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.

[1] Appendix C, 2012 Integrated Report

Table 2-2 Excerpt from the 2012 Integrated Report – Oklahoma 303(d) List of Impaired Waters (Category 5)

Waterbody ID	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*E. coli*	Designated Use Primary Body Contact Recreation
OK520810000080_00	Little River	14.96	2014	1	X	X	N
OK520810000090_00	Rock Creek	5.99	2014	1	X	X	N
OK520810000140_00	Elm Creek, West	8.00	2014	1	X	X	N

ENT = Enterococcus; N = Not attaining; X = Criterion exceeded
Source: 2012 Integrated Report, DEQ 2013

2.2 PROBLEM IDENTIFICATION

Table 2-3 summarizes water quality data collected during primary contact recreation season from the WQM stations in 2008 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. These data collected during the primary contact recreation season were used to support the decision to place specific waterbodies within the Study Area on the DEQ 2012 303(d) list (DEQ 2013). Water quality data from the primary contact recreation season are provided in **Appendix A**. For the data collected in 2008, evidence of nonsupport of the PBCR use based on Enterococcus and *E. coli* exceedances was observed in all three study area waterbodies. Rows highlighted in green in **Table 2-3** required TMDLs.

2.3 WATER QUALITY TARGETS

The Code of Federal Regulations (40 CFR §130.7(c)(1)) states that, "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards." The water quality targets for *E. coli* and Enterococcus are geometric mean standards of 126 cfu/100ml and 33 cfu/100ml, respectively. The TMDL for bacteria will incorporate an explicit 10% margin of safety.

Table 2-3 Summary of Assessment of Indicator Bacterial Samples from Primary Body Contact Recreation Subcategory Season May 1 to September 30, 2008

Waterbody ID	Waterbody Name	Indicator	Number of samples	Geometric Mean Conc (cfu/100 ml)	Assessment Results
OK520810000080_00	Little River	EC	21	320	TMDL Required
		ENT	21	462	TMDL Required
OK520810000090_0	Rock Creek	EC	21	356	TMDL Required
		ENT	21	597	TMDL Required
OK520810000140_00	Elm Creek, West	EC	21	356	TMDL Required
		ENT	21	633	TMDL Required

Enterococcus (ENT) water quality criterion = Geometric Mean of 33 counts/100 mL
E. coli (EC) water quality criterion – Geometric Mean of 126 counts/100mL
TMDLs will be developed for waterbodies that are highlighted

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 fecal coliform in accordance with their permits. Dischargers with bacterial limits will be required to monitor for *E. coli* when their permits come up for renewal. 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. 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 impaired 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, §122.2, a point source is described as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface

waters. 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)
  - OPDES Industrial WWTF Discharges
- OPDES-regulated stormwater discharges
  - Municipal separate storm sewer system (MS4) discharges
    - Phase 1 MS4
    - Phase 2 MS4 – OKR04
  - Multi-sector general permits (OKR05)
    - Regulated Sector J Discharges
    - Rock, Sand and Gravel Quarries
  - Construction stormwater discharges (OKR10)
- 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)

There are no OPDES-permitted facilities within the contributing watershed. 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.

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.

There are no OPDES-permitted facilities that discharge wastewater to surface waters addressed in these TMDLs.

3.2.1.1 Municipal OPDES WWTFs

There are no active permitted municipal point source facilities within the Study Area.

3.2.1.2 Industrial OPDES WWTFs

There are no OPDES industrial point source dischargers in this 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. 2008). Based on data summarized in the NSQD median concentration in stormwater ranged from 570 to 9,000 cfu/100mL for *E. coli* (Pitt et. al. 2008).

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.

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 two Phase I MS4 facilities in the Study Area, one in Little River (OK520810000080_00) and one in Elm Creek, West (OK520810000140_00) watersheds (See **Table 3-1** and **Figure 3-1**).

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: www.deq.state.ok.us/WQDnew/stormwater/ms4/. There are three Phase II MS4 facilities in the Study Area, two in Little River (OK520810000080_00) and one in Rock Creek (OK520810000090_00) watersheds (See **Table 3-1** and **Figure 3-1**). Since the entire watershed of Rock Creek lies within an MS4 area, no load aalocation was given to nonpoint sources.

The specific requiresments for bacterial control in a MS4 permit can be found in **Appendix E**. Information on a list of BMPs and their effectiveness are also included in **Appendix E**. Best management practices (BMP) such as buffer strips, repair of leaking sewage collection systems, elimination of illicit discharges, and proper disposal of domestic animal waste can reduce bacterial loading to waterbodies.

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 three municipal no-discharge facilities in the Study Area (see **Table 3-2**). Two facilities are located in the Little River (OK520810000080_00) watershed and one is located in the Rock Creek (OK520810000090_00) watershed. In addition, there are four industrial no-discharge facilities in the Study Area, all in the Little River (OK520810000080_00) watershed (See **Table 3-2** and **Figure 3-1**). These no-discharge facilities could be contributing to the elevated levels of in-stream indicator bacterial loading.

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 1989 and 2014. During that period 29 overflows were reported ranging from a minimal quantity to over 0.5 million gallons. **Table 3-3** summarizes the SSO occurrences by NPDES facilities. Historical data of reported SSOs are provided in **Appendix D**.

Table 3-1 MS4 Facilities in the Study Area

Waterbody Name	Waterbody ID	MS4 Jurisdiction	Permit No.	Type
Little River	OK520810000080_00	City of Norman	OKR040015	Phase II
Little River	OK520810000080_00	City of Moore	OKR040012	Phase II
Little River	OK520810000080_00	Oklahoma City	OKS000101	Phase I
Rock Creek	OK520810000090_00	City of Norman	OKR040015	Phase II
Elm Creek, West	OK520810000140_00	Oklahoma City	OKS000101	Phase I

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

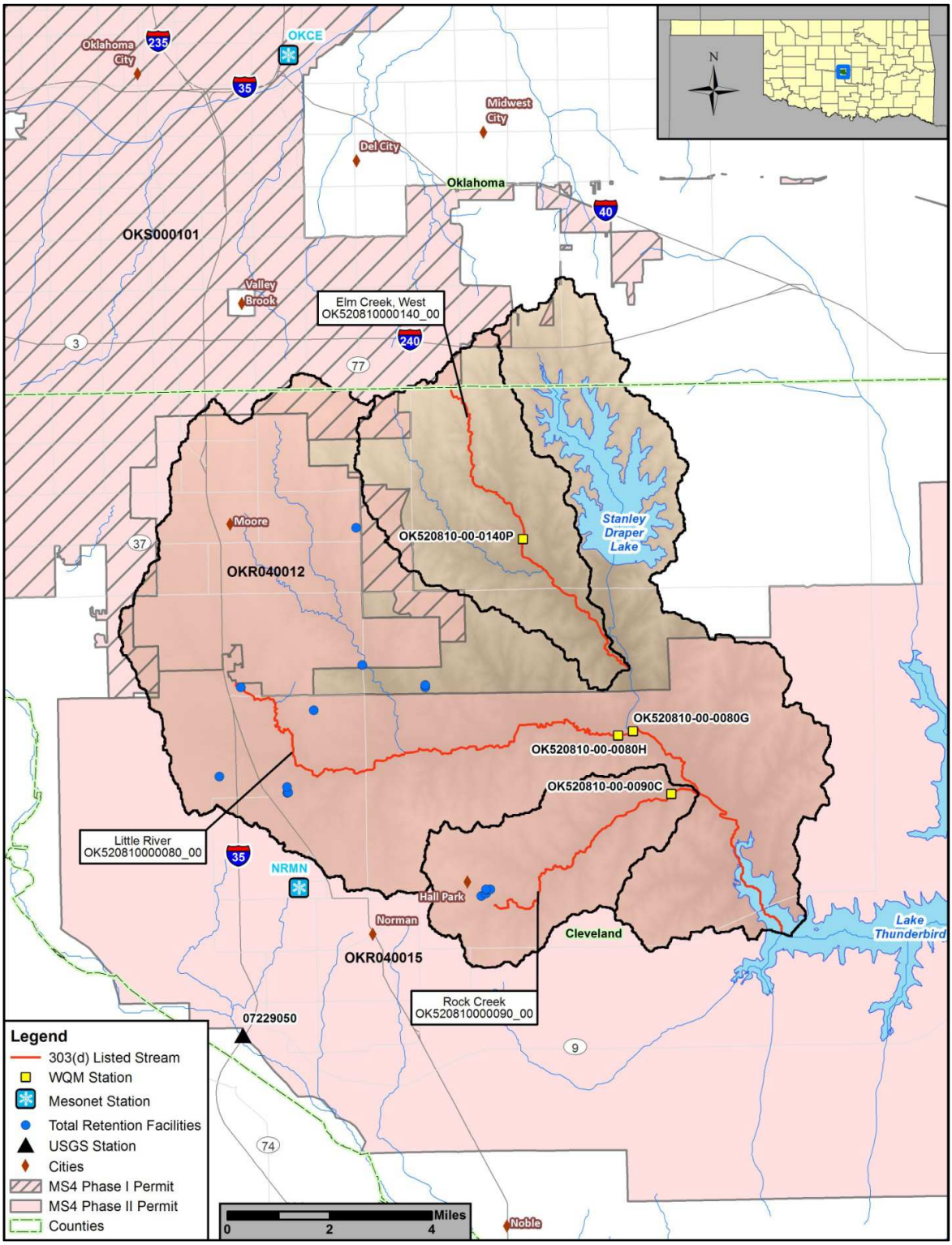
Facility	Facility ID	County	Facility Type	Type	Waterbody ID	Waterbody Name
All Saints Catholic School Lagoon	20687	Cleveland	Lagoon (Total Retention)	Municipal	OK520810000080_00	Little River
Control Flow	14000380	Cleveland	Total Retention	Industrial	OK520810000080_00	Little River
Lucky Food Mart	14000470	Cleveland	Total Retention	Industrial	OK520810000080_00	Little River
Norman Concrete Inc	14000390	Cleveland	Total Retention	Industrial	OK520810000080_00	Little River
Ranch Estates Mhp	20812	Cleveland	Lagoon (Total Retention)	Municipal	OK520810000080_00	Little River
Schwarz Ready Mix - Norman Pla	14000600	Cleveland	Total Retention	Industrial	OK520810000080_00	Little River
Hall Park	20806	Cleveland	Lagoon (Total Retention)	Municipal	OK520810000090_00	Rock Creek

Table 3-3 Sanitary Sewer Overflow Summary (1989-2014)

Facility Name	OPDES Permit No.	Receiving Water	Facility ID	Number of Occurrences	Date Range		Amount (Gallons)	
					From	To	Min	Max
Hall Park	NA	OK520810000090_00	20806	29	5/3/1990	7/1/2002	2	500,000

NA = not available

Figure 3-1 Location of OPDES-Permitted Facilities 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 per the Agriculture Pollutant Discharge Elimination System (AgPDES) Act (Title 2, Chapter 1, Article 2A-1 to Article 2A-29). Through Statutes and 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), The Swine Feeding Operation (SFO) Act (Title 2, Chapter 1, Article 20 – 1 to Article 20 – 29 of the State Statutes), and the Poultry Feeding Operation (PFO) Registration Act (Title 2, Chapter 10-9.1 to 10-9.25 of the State Statutes), AEMS works with producers and concerned citizens to ensure that animal waste does not impact the waters of the State.

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' Code 590 to base the Plan from. NRCS (2010) has developed Animal Waste Management software to assist in plan preparation. There are no AFOs in the Study Area.

3.2.5.1 CAFO

A CAFO as defined by State Statutes is an animal feeding operation that confines and feeds at least 1,000 animal units for 90 days or more in a 12-month period (ODAFF 2014). Animal Waste Management Plans (AWMP) (Section 35:17-4-12), as specified in Oklahoma's CAFO Rules are designed to protect water quality through the use of Best Management Practices (BMPs) and structures such as dikes, berms, terraces, and ditches, to isolate animal waste from outside surface drainage, except for a 25-year, 24–hour rainfall event.[1] The Plans may include, but are not limited to, a Comprehensive Nutrient Management Plan per NRCS guidance or Nutrient Management Plan.

CAFOs are considered no-discharge facilities for the purpose of the TMDL calculations in this report, they are not considered a source of TSS loading, and runoff of animal waste into surface waterbodies or groundwater is prohibited. CAFOs are designated by EPA as potentially significant sources of pollution and may 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.

[1] 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.

Oklahoma CAFO Rules require CAFOs to submit a *Documentation of No Hydrologic Connection* (OAC 35:17-4-10[2]) for all retention structures in order to prevent any leakage of wastewater into waterbodies. Thus, the potential for pollutant loading from CAFOs to a receiving stream is almost minimal.

There are no CAFOs located in this Study Area.

3.2.5.2 SFO

The purpose of the SFO Act is to provide for environmentally responsible construction and operation/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.[3] According to the SFO Act, a "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.

Licensed SFOs are required to develop a Swine Waste Management Plan[4], to prevent swine waste from being discharged into surface or groundwaters. This Plan includes the BMPs being used to prevent runoff & 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). 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 evaporative (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(e)(6)]. Oklahoma Rules requires SFOs to submit a *Documentation of No Hydrologic Connection* (OAC 35:17-3-12) for all retention structures in order to prevent any leaking of wastewater to waterbodies. Thus, the potential for loading from SFOs to the receiving stream is minimal.

There are no SFOs in this Study Area.

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2 USDA NRCS 2009 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.

3 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)

4 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.

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. PFOs are required to develop an AWMP or a comprehensive nutrient management plan (CNMP). 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. The plans must be acceptable to ODAFF. A PFO AWMP or CNMP must address the impact of both nitrogen and phosphorus on the watershed. 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 such as grassed strips at the edge of the field are used to minimize and prevent runoff from carrying eroded soil and poultry waste into adjacent 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 that is classified as having excessive erosion.[5]

PFOs located in nutrient limited watersheds should have a nutrient sample analysis from that year to make available.[6] PFOs in non-nutrient limited watersheds need to have available the most recent nutrient sample analysis.

There are no PFOs located in this Study Area.

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 has an influence on the origin and pathways of pollutant sources to surface water. Bacteria originate from warm-blooded animals in rural, suburban, and urban areas. These sources include wildlife, various agricultural activities and domesticated animals, land application fields, urban runoff, failing 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

[5] 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.

[6] Nutrient limited watersheds are defined in the Oklahoma Water Quality Standards (Title 785, Chapter 45). Nutrient limited watersheds can be found in Appendix A of the OWQS. They are the ones designated "NLW" in the "Remarks" column.

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 Study Area.

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 2007 to 2011 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 3-4** in cfu/day provides a relative magnitude of loading in each of the TMDL watersheds impaired for bacteria.

Table 3-4 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 cfu/day) of Deer Population
OK520810000080_00	Little River	56,689	685	0.012	343
OK520810000090_00	Rock Creek	7,521	93	0.012	46
OK520810000140_00	Elm Creek, West	11,352	136	0.012	68

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 loading. 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.

Table 3-5 provides estimated numbers of commercially raised farm animals and estimated acreage where manure was applied by watershed. This was calculated using the 2012 U.S. Department of Agriculture (USDA) county agricultural census data (USDA 2012) 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 3-5**, 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.

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 3-6** gives the daily fecal coliform production rates by animal species:

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

Waterbody ID	Waterbody Name	Cattle	Dairy Cows	Horses	Sheep	Hogs & Pigs	Ducks	Turkeys	Chickens	Acres of Manure Application
OK520810000080_00	Little River	2,403	5	423	170	291	7	9	733	618
OK520810000090_00	Rock Creek	322	1	56	23	40	1	1	99	85
OK520810000140_00	Elm Creek, West	479	1	85	34	58	1	2	146	122

Table 3-6 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
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*	5.00E+08
Dogs**	3.30E+09
Cats**	5.40E+08

* According to a livestock study conducted by the ASAE (1999)

** Schueler 2000

Using the estimated animal populations and the fecal coliform production rates from **Table 3-6**, 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 3-7**. 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 again appear to represent the most likely commercially raised farm animal source of fecal bacteria.

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 37.2% of the nation's households own dogs and 32.4% own cats. In 2007, the average number of pets per household was 1.7 dogs and 2.2 cats (American Veterinary Medical Association 2012). Using the U.S. Census data at the block level (U.S. Census Bureau 2010), dog and cat populations can be estimated for each watershed. **Table 3-8** summarizes the estimated number of dogs and cats for the watersheds of the Study Area.

Table 3-7 Fecal Coliform Production Estimates for Commercially Raised Farm Animals ($x10^9$ number/day)

Waterbody ID	Waterbody Name	Cattle	Dairy Cows	Horses	Sheep	Hogs & Pigs	Ducks	Turkeys	Chickens	Total
OK520810000080_00	Little River	249,957	515	178	2,042	3,139	17	1	100	255,948
OK520810000090_00	Rock Creek	33,538	64	24	275	431	2	0	14	34,347
OK520810000140_00	Elm Creek, West	49,859	106	36	407	621	3	0	20	51,052

Table 3-8 Estimated Numbers of Pets

Waterbody ID	Waterbody Name	Dogs	Cats
OK520810000080_00	Little River	11,383	12,842
OK520810000090_00	Rock Creek	1,105	1,246
OK520810000140_00	Elm Creek, West	661	745

Table 3-9 provides an estimate of the fecal coliform production from pets. These estimates are based on estimated fecal coliform production rates from **Table 3-6.**

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

Waterbody ID	Waterbody Name	Dogs	Cats	Total
OK520810000080_00	Little River	37,564	6,935	44,498
OK520810000090_00	Rock Creek	3,646	673	4,319
OK520810000140_00	Elm Creek, West	2,180	402	2,583

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 2012). OSWD systems and illicit discharges can be a source 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, Stowe & Yanke, LLC (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 3-10** 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):

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

Table 3-10 Estimates of Sewered and Unsewered Households

Waterbody ID	Waterbody Name	Public Sewer	Septic Tank	Other Means	Housing Units	# of Septic Tanks / Mile^2
OK520810000080_00	Little River	14,237	1,923	26	18,011	21.7
OK520810000090_00	Rock Creek	1,108	201	0	1,748	17.1
OK520810000140_00	Elm Creek, West	821	355	6	1,045	20.0

The average of number of people per household was calculated to be 2.6 for counties in the Study Area (U.S. Census Bureau 2010). 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 in **Table 3-11**.

Table 3-11 Estimated Fecal Coliform Load from OSWD Systems

Waterbody ID	Waterbody Name	Acres	Septic Tank	# of Failing Septic Tanks	Estimated Loads from Septic Tanks (x 10^9 counts/day)
OK520810000080_00	Little River	56,688	1,923	154	1,060
OK520810000090_00	Rock Creek	7,521	201	16	111
OK520810000140_00	Elm Creek, West	11,352	355	28	196

3.4 SUMMARY OF SOURCES OF IMPAIRMENT

3.4.1 Bacteria

There are no continuous, permitted point sources of bacteria in the study area watersheds which require bacterial TMDLs. Therefore, the conclusion is that nonsupport of PBCR use in these watersheds is caused by nonpoint sources of bacteria. There are no CAFOs, SFOs, or PFOs in the Study Area. Therefore the various nonpoint sources are considered to be the major source of bacterial loading in each watershed that requires a TMDL.

All the stream segments in **Table 3-12** require bacterial TMDLs. That table provides a summary of the estimated percentage of fecal coliform loads in cfu/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. Because of their numbers and animal unit production of bacteria, livestock are estimated to be the largest contributors of fecal coliform loading to land surfaces. It must be noted that while no data are available to estimate populations and fecal loading of wildlife other than deer, a number of bacterial source tracking studies around the nation demonstrate that wild birds and mammals represent a major source of the fecal bacteria found in streams.

Table 3-12 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
OK520810000080_00	Little River	84.79	14.74	0.11	0.35
OK520810000090_00	Rock Creek	88.47	11.13	0.12	0.29
OK520810000140_00	Elm Creek, West	94.72	4.79	0.13	0.36

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.

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 as described in the following mathematical equation:

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

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 Enterococcus 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 to 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 identifying 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. None of the three waterbodies in the Study Area 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, downstream, or adjacent 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 B**.

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

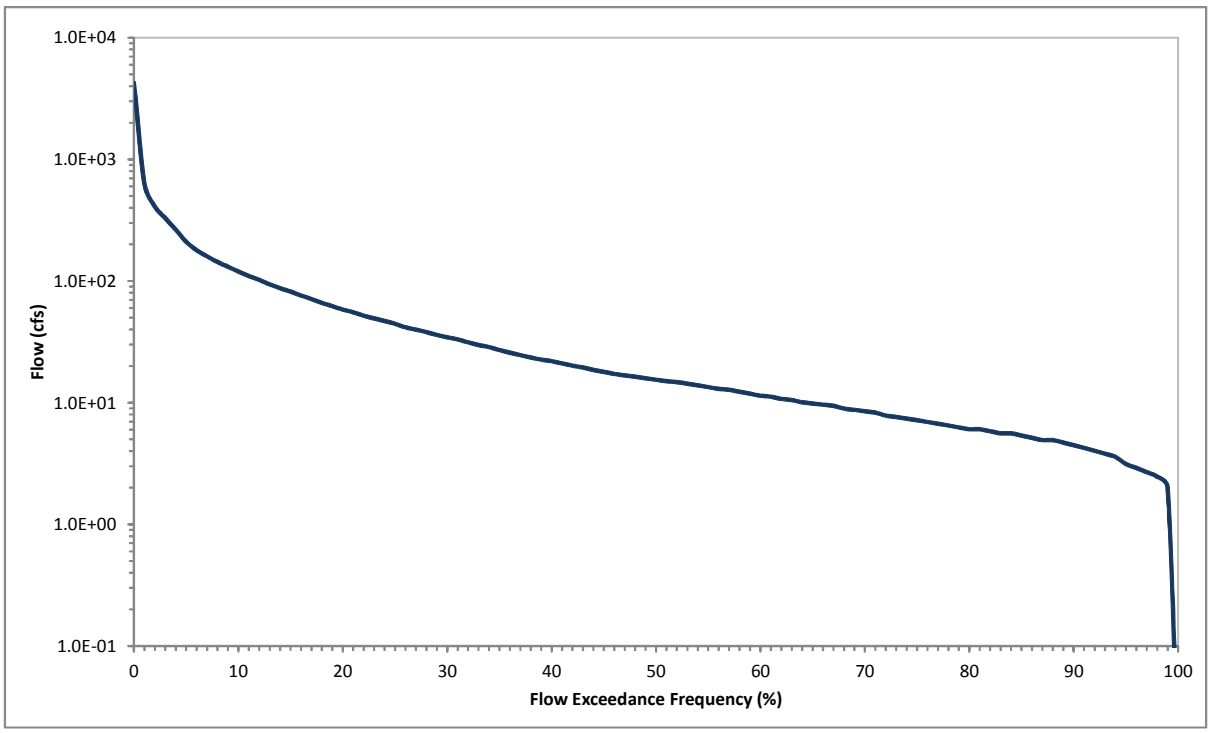
The USGS National Water Information System serves as the primary source of flow measurements for the Oklahoma TMDL Toolbox. All available daily average flow values for all gages in Oklahoma, as well as the nearest upstream and downstream gages in adjacent states, were retrieved for use in the Oklahoma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

Some instantaneous flow measurements were available from various agencies. 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 5.2.

Figure 4-1 Flow Duration Curve for the Little River (OK520810000080_00)



4.2.2 Using Flow Duration Curves to Calculate Load Duration Curves

4.2.2.1 Bacteria

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 cfu/day. The bacterial curve represents the geometric mean water quality criterion for *E. coli* or Enterococcus 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 4.3.3.1.1 calculates a load in the units of cfu per day. The cfu is 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 cfu 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).

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

Where:

WQS = 126 cfu/100 mL (E. coli); or 33 cfu/100 mL (Enterococcus)

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 (cfu/day)

Where:

WQS = 126 cfu/100 mL (E. coli); or 33 cfu/100 mL (Enterococcus)

Flow (mgd) = permitted flow unit conversion factor = 37,854,120

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.

LA = TMDL - WLA_WWTF - WLA_MS4 – MOS

4.2.3.4.1 Bacterial WLAs for MS4s

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_MS4 using the above formula, then separate WLA for MS4s from the sum based on the percentage of a watershed that is under a MS4 jurisdiction. This WLA for MS4s may not be the total load allocated for permitted MS4s unless the whole MS4 area is located within the study watershed 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:

1. If the geometric mean of the reduced values of all samples is less than the geometric mean standards (for bacteria).

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 Enterococcus: Because WQSs are considered to be met if the geometric mean of all future data is maintained below the geometric mean criteria (TMDL), the PRG is the reduction that ensures that the geometric mean of all data is less than the geometric mean criterion.

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 5-3.**

No flow gages exist on the Little River (OK520810000080_00), Rock Creek (OK520810000090_00), or West Elm Creek (OK520810000140_00). Flow gages do exist on the Little River downstream of Lake Thunderbird, but the flows at these gages are strongly influenced by storage in, and releases from, Lake Thunderbird. Therefore, flows for these waterbodies were estimated using the watershed area ratio method based on measured flows for the nearby Deep Fork at Warwick, Oklahoma (OK520700050010_00) at USGS gage station 07242380. The flow duration curves were based on measured flows from 1983 to 2014.

Figure 5-1 Flow Duration Curve for the Little River (OK520810000080_00)

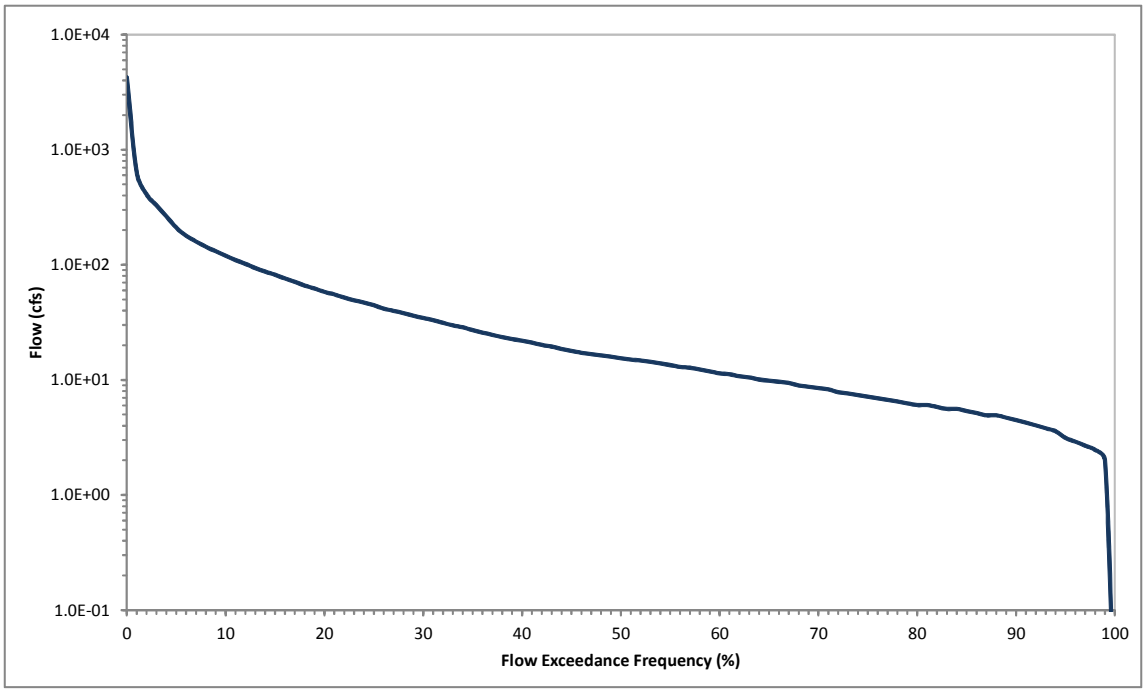


Figure 5-2 Flow Duration Curve for Rock Creek (OK520810000090_00)

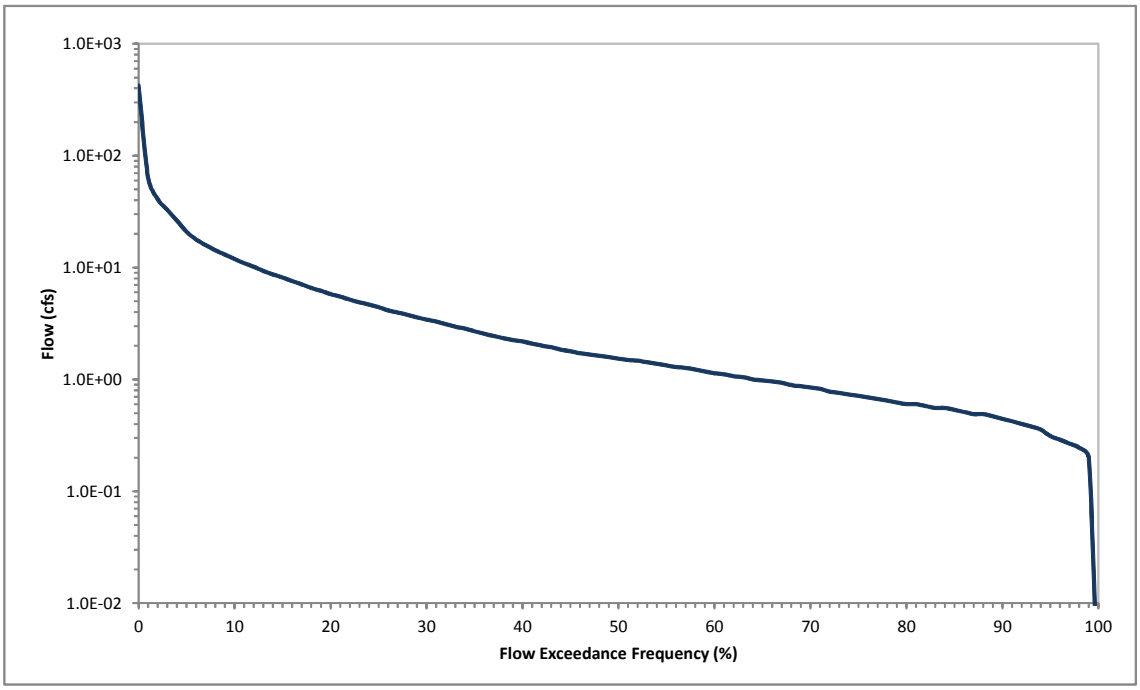
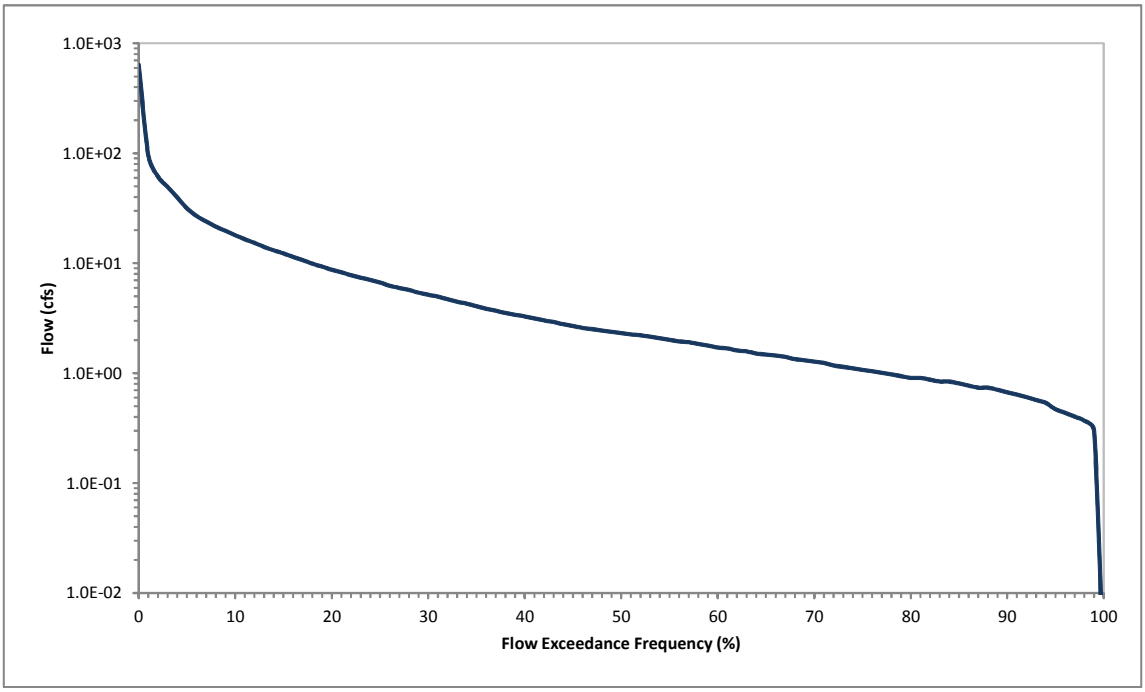


Figure 5-3 Flow Duration Curve for Elm Creek, West (OK52010000140_00)



5.2 ESTIMATED LOADING AND CRITICAL CONDITIONS

EPA regulations [40 CFR 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 Enterococcus) 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) in 2008 are paired with the flows measured or 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 **Figures 5-4 through 5-9**. Each waterbody has a LDC for Enterococcus and *E. coli*.

The LDCs for Little River (**Figure 5-4 and Figure 5-5**) are based on Enterococcus and *E. coli* bacterial measurements collected during primary contact recreation season at WQM stations OK520810-00-0080G and OK520810-00-0080H.

Figure 5-4 Load Duration Curve for Enterococcus in Little River (OK520810000080_00)

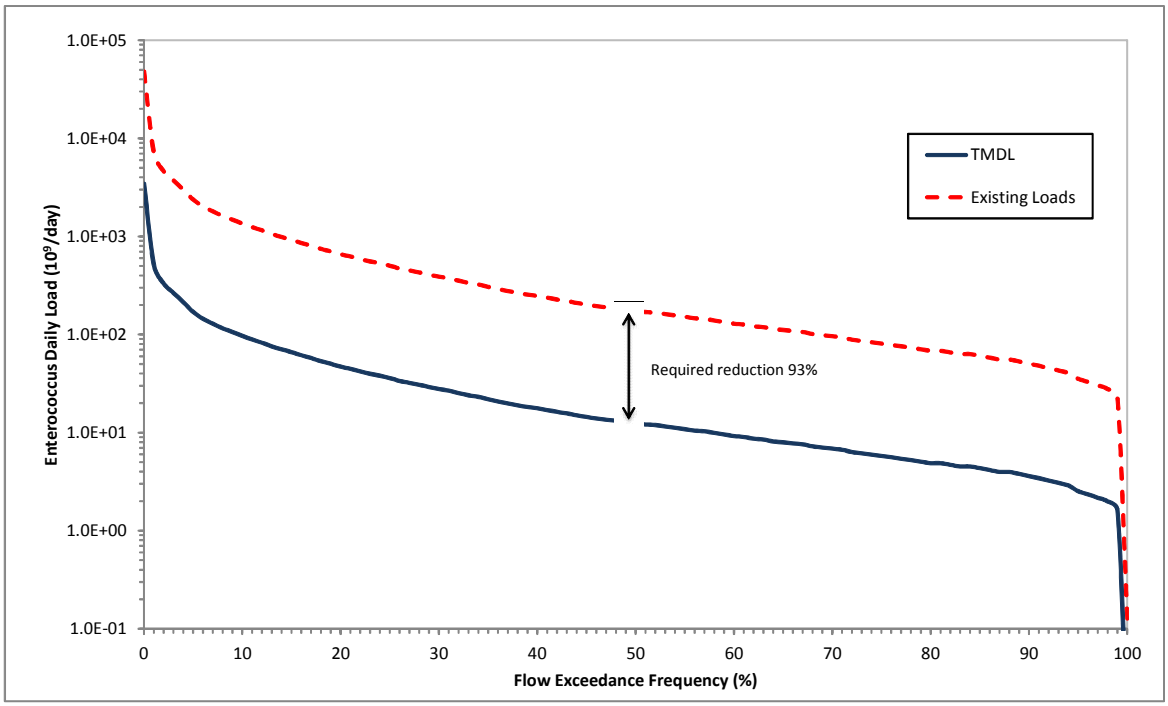
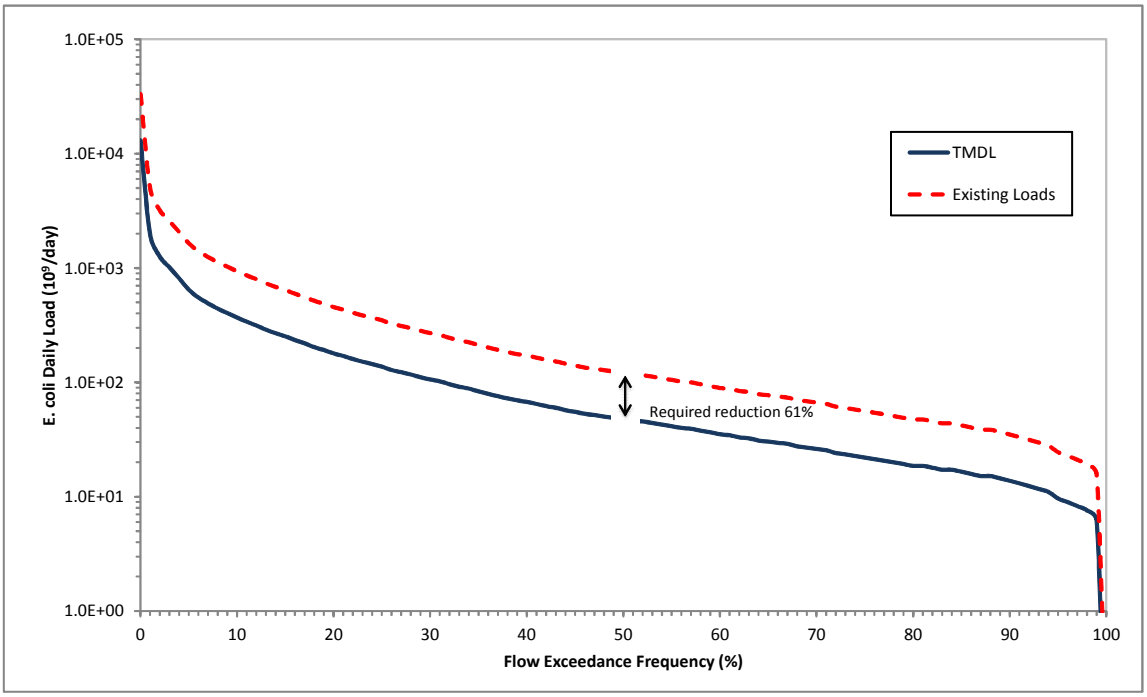


Figure 5-5 Load Duration Curve for *E. coli* in Little River (OK520810000080_00)



The LDCs for Rock Creek (**Figure 5-6 and Figure 5-7**) are based on Enterococcus and *E. coli* bacterial measurements collected during primary contact recreation season at WQM station OK520810-00-0090C.

Figure 5-6 Load Duration Curve for Enterococcus in Rock Creek (OK520810000090_00)

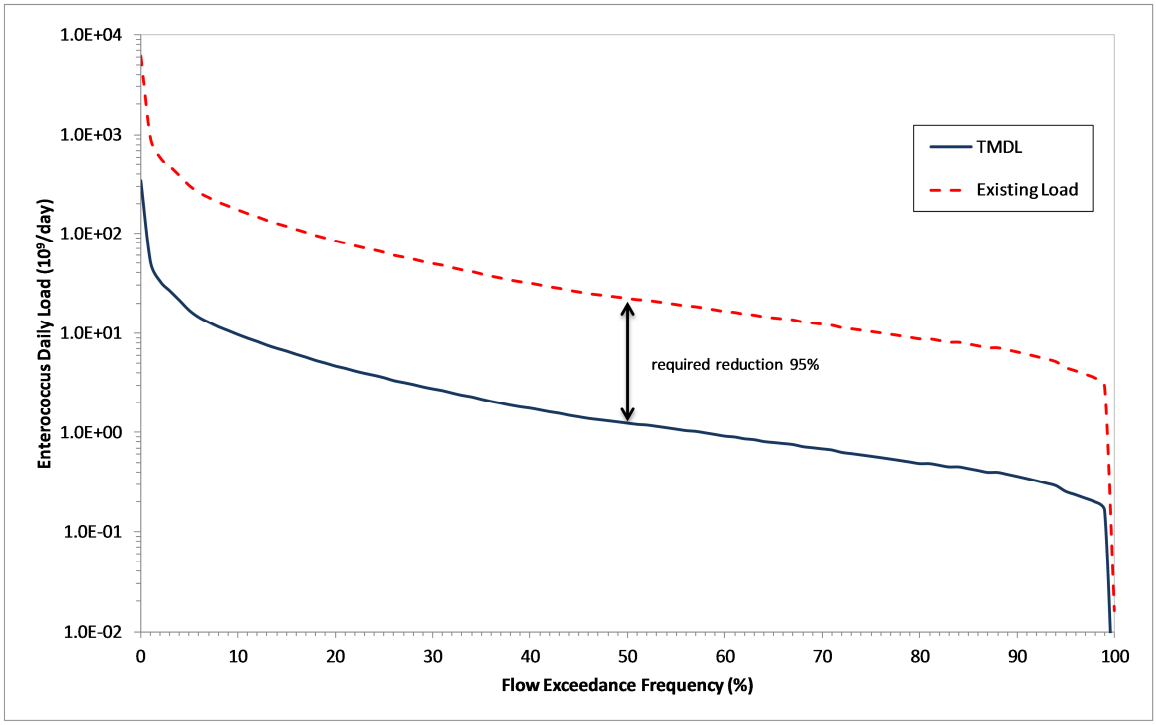
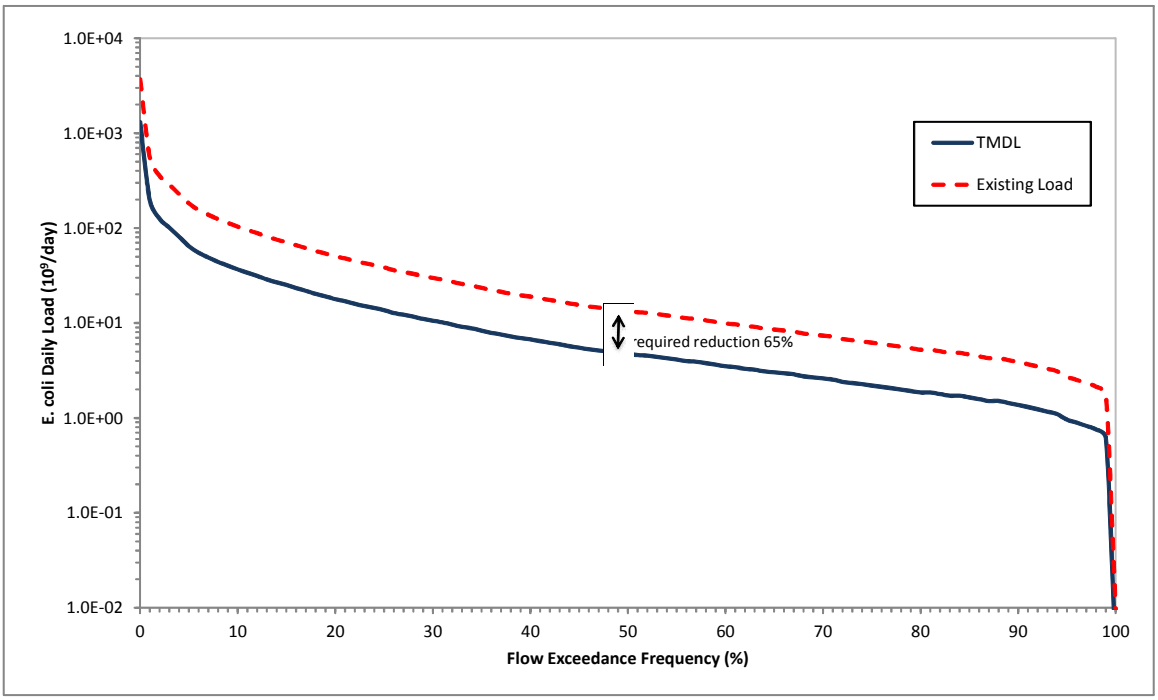


Figure 5-7 Load Duration Curve for *E. coli* in Rock Creek (OK520810000090_00)



The LDCs for Elm Creek, West (**Figure 5-8 and Figure 5-9**) are based on Enterococcus and *E. coli* measurements during primary contact recreation season at WQM station OK520810-00-0140P.

Figure 5-8 Load Duration Curve for Enterococcus in Elm Creek, West (OK520810000140_00)

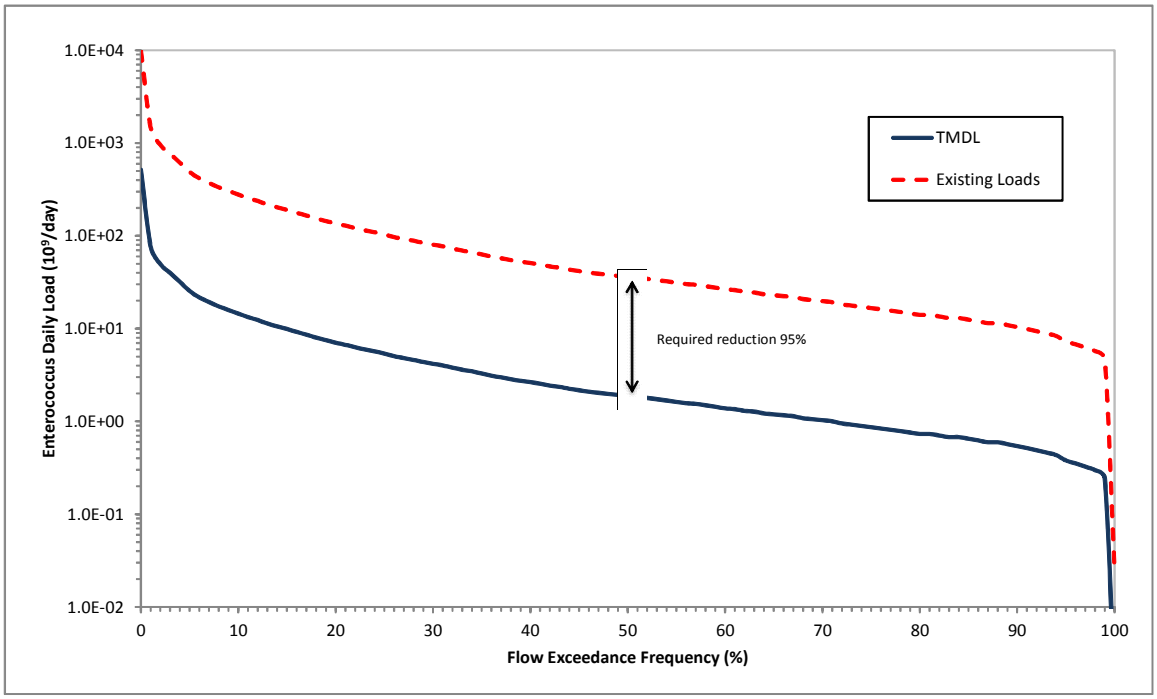
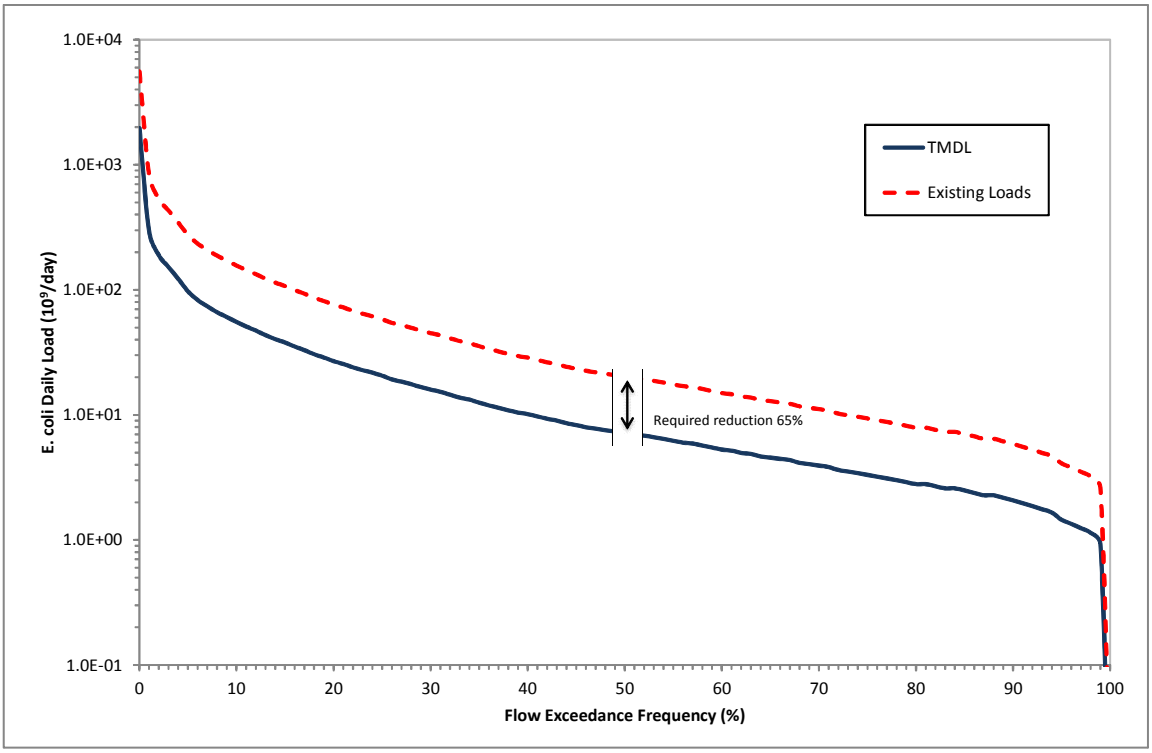


Figure 5-9 Load Duration Curve for E. coli in Elm Creek, West (OK520810000140_00)



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.

5.2.2.1 Bacterial PRGs

PRGs for bacteria are calculated through an iterative process of taking a series of percent reduction values, applying each value uniformly to the concentrations of samples and verifying 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 range from 61% to 95%.

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

Waterbody ID	Waterbody Name	Required Reduction Rate	
		Enterococcus	E. coli
OK520810000080_00	Little River	93%	61%
OK520810000090_00	Rock Creek	95%	65%
OK520810000140_00	Elm Creek, West	95%	65%

5.3 WASTELOAD ALLOCATION

5.3.1 Bacterial WLA

For bacterial TMDLs, OPDES-permitted wastewater treatment 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. There are currently no OPDES-permitted facilities within the Study Area. Therefore the WLA_{WWTF} is set to zero for each waterbody. Regardless of the magnitude of the WLA calculated in these TMDLs, future new discharges of bacteria will be considered consistent with the TMDL provided that the OPDES permit requires in-stream criteria to be met.

Permitted stormwater discharges are considered point sources. Bacteria WLAs for OPDES-permitted stormwater will be necessary for three MS4 permits as specified in **Table 5-2**. The WLA_{MS4} was derived from the percentage of the watershed of each waterbody within the area covered by the MS4 permit.

Table 5-2 Summary of Bacterial Wasteload Allocations at Median Flow for MS4s

Waterbody ID & Name	Permit No.	MS4 Jurisdiction	Type	Acreage and Percentage of Subwatershed	*E. coli* WLA (cfu/day)	Enterococcus WLA (cfu/day)
OK520810000080_00 Little River	OKR040015	City of Norman	Phase II	27,434 (48.39%)	2.07E+10	5.43E+09
	OKR040012	City of Moore	Phase II	13,084 (23.08%)	9.89E+09	2.59E+09
	OKS000101	Oklahoma City	Phase I	3,049 (5.38%)	2.30E+09	6.04E+08
OK520810000090_00 Rock Creek	OKR040015	City of Norman	Phase II	7,521 (100%)	4.27E+09	1.12E+09
OK520810000140_00 Elm Creek, West	OKS000101	Oklahoma City	Phase I	1,241 (10.93%)	7.04E+08	1.84E+08

5.4 Load Allocation

As discussed in Section 3, nonpoint source loading to each waterbody emanates from a number of different sources. The data analysis and the LDCs indicate that exceedances 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:

$$\mathbf{LA = TMDL - WLA_WWTF - WLA_MS4 - MOS}$$

5.5 Seasonal Variability

Federal regulations (40 CFR §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 the longest period of USGS flow records when estimating flows to develop flow exceedance percentiles.

5.6 Margin of Safety

Federal regulations [40 CFR §130.7(c)(1)] require that TMDLs include an MOS. The MOS is a conservative measure incorporated into the TMDL equation that accounts for the lack of knowledge associated with calculating the allowable pollutant loading to ensure WQSs are attained. 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:

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

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 5-3** summarizes the TMDL, WLA, LA and MOS loadings at the 50% flow percentile. **Tables 5-4 through 5-9** summarize the allocations for indicator bacteria. The bacterial TMDLs calculated in these tables apply to the recreation season (May 1 through September 30) only.

Table 5-3 Summaries of Bacterial TMDLs at Median Flow

Stream Name	Waterbody ID	Pollutant[1]	TMDL (cfu/day)	WLA_{WWTF} (cfu/day)	$WLA_{_MS4}$ (cfu/day)	LA (cfu/day)	MOS (cfu/day)
Little River	OK520810000080_00	EN	1.25E+10	0	8.62E+09	2.60E+09	1.25E+09
		EC	4.76E+10	0	3.29E+10	9.92E+09	4.76E+09
Rock Creek	OK520810000090_00	EN	1.24E+09	0	1.12E+09	0	1.24E+08
		EC	4.74E+09	0	4.27E+09	0	4.74E+08
Elm Creek, West	OK520810000140_00	EN	1.87E+09	0	1.84E+08	1.50E+09	1.87E+08
		EC	7.15E+09	0	7.04E+08	5.73E+09	7.15E+08

[1] EC = E. coli; EN = Enterococcus

Table 5-4 Enterococcus TMDL Calculations for Little River (OK520810000080_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4_1} (cfu/day)	WLA_{MS4_2} (cfu/day)	WLA_{MS4_3} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	4,253	3.43E+12	0.00E+00	1.50E+12	7.13E+11	1.66E+11	7.15E+11	3.43E+11
5	210	1.70E+11	0.00E+00	7.40E+10	3.53E+10	8.22E+09	3.54E+10	1.70E+10
10	120	9.67E+10	0.00E+00	4.21E+10	2.01E+10	4.68E+09	2.01E+10	9.67E+09
15	81.9	6.61E+10	0.00E+00	2.88E+10	1.37E+10	3.20E+09	1.38E+10	6.61E+09
20	58.2	4.70E+10	0.00E+00	2.05E+10	9.76E+09	2.27E+09	9.79E+09	4.70E+09
25	44.5	3.60E+10	0.00E+00	1.57E+10	7.47E+09	1.74E+09	7.49E+09	3.60E+09
30	34.5	2.78E+10	0.00E+00	1.21E+10	5.78E+09	1.35E+09	5.80E+09	2.78E+09
35	27.1	2.19E+10	0.00E+00	9.52E+09	4.54E+09	1.06E+09	4.56E+09	2.19E+09
40	21.9	1.77E+10	0.00E+00	7.71E+09	3.68E+09	8.57E+08	3.69E+09	1.77E+09
45	17.9	1.45E+10	0.00E+00	6.30E+09	3.00E+09	7.00E+08	3.01E+09	1.45E+09
50	15.4	1.25E+10	0.00E+00	5.43E+09	2.59E+09	6.04E+08	2.60E+09	1.25E+09
55	13.4	1.08E+10	0.00E+00	4.72E+09	2.25E+09	5.25E+08	2.26E+09	1.08E+09
60	11.4	9.22E+09	0.00E+00	4.01E+09	1.91E+09	4.46E+08	1.92E+09	9.22E+08
65	9.8	7.95E+09	0.00E+00	3.46E+09	1.65E+09	3.85E+08	1.66E+09	7.95E+08
70	8.5	6.87E+09	0.00E+00	2.99E+09	1.43E+09	3.32E+08	1.43E+09	6.87E+08
75	7.2	5.78E+09	0.00E+00	2.52E+09	1.20E+09	2.80E+08	1.20E+09	5.78E+08
80	6.0	4.88E+09	0.00E+00	2.13E+09	1.01E+09	2.36E+08	1.02E+09	4.88E+08
85	5.4	4.34E+09	0.00E+00	1.89E+09	9.01E+08	2.10E+08	9.04E+08	4.34E+08
90	4.5	3.61E+09	0.00E+00	1.57E+09	7.51E+08	1.75E+08	7.53E+08	3.61E+08
95	3.1	2.53E+09	0.00E+00	1.10E+09	5.26E+08	1.22E+08	5.27E+08	2.53E+08
100	0.01	9.04E+06	0.00E+00	3.94E+06	1.88E+06	4.37E+05	1.88E+06	9.04E+05

MS4_1 = City of Norman (OKR040015)
MS4_2 = City of Moore (OKR040012)
MS4_3 = City of Oklahoma City (OKS000101)

Table 5-5 *E. coli* TMDL Calculations for Little River (OK520810000080_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4_1} (cfu/day)	WLA_{MS4_2} (cfu/day)	WLA_{MS4_3} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	4,253	1.31E+13	0.00E+00	5.71E+12	2.72E+12	6.35E+11	2.73E+12	1.31E+12
5	210	6.49E+11	0.00E+00	2.82E+11	1.35E+11	3.14E+10	1.35E+11	6.49E+10
10	120	3.69E+11	0.00E+00	1.61E+11	7.67E+10	1.79E+10	7.69E+10	3.69E+10
15	81.9	2.53E+11	0.00E+00	1.10E+11	5.25E+10	1.22E+10	5.26E+10	2.53E+10
20	58.2	1.79E+11	0.00E+00	7.81E+10	3.73E+10	8.68E+09	3.74E+10	1.79E+10
25	44.5	1.37E+11	0.00E+00	5.98E+10	2.85E+10	6.65E+09	2.86E+10	1.37E+10
30	34.5	1.06E+11	0.00E+00	4.63E+10	2.21E+10	5.14E+09	2.21E+10	1.06E+10
35	27.1	8.35E+10	0.00E+00	3.64E+10	1.73E+10	4.04E+09	1.74E+10	8.35E+09
40	21.9	6.76E+10	0.00E+00	2.95E+10	1.40E+10	3.27E+09	1.41E+10	6.76E+09
45	17.9	5.52E+10	0.00E+00	2.40E+10	1.15E+10	2.67E+09	1.15E+10	5.52E+09
50	15.4	4.76E+10	0.00E+00	2.07E+10	9.89E+09	2.30E+09	9.92E+09	4.76E+09
55	13.4	4.14E+10	0.00E+00	1.80E+10	8.60E+09	2.00E+09	8.62E+09	4.14E+09
60	11.4	3.52E+10	0.00E+00	1.53E+10	7.31E+09	1.70E+09	7.33E+09	3.52E+09
65	9.8	3.04E+10	0.00E+00	1.32E+10	6.31E+09	1.47E+09	6.32E+09	3.04E+09
70	8.5	2.62E+10	0.00E+00	1.14E+10	5.45E+09	1.27E+09	5.46E+09	2.62E+09
75	7.2	2.21E+10	0.00E+00	9.62E+09	4.59E+09	1.07E+09	4.60E+09	2.21E+09
80	6.0	1.86E+10	0.00E+00	8.11E+09	3.87E+09	9.02E+08	3.88E+09	1.86E+09
85	5.4	1.66E+10	0.00E+00	7.21E+09	3.44E+09	8.02E+08	3.45E+09	1.66E+09
90	4.5	1.38E+10	0.00E+00	6.01E+09	2.87E+09	6.68E+08	2.87E+09	1.38E+09
95	3.1	9.66E+09	0.00E+00	4.21E+09	2.01E+09	4.68E+08	2.01E+09	9.66E+08
100	0.01	3.45E+07	0.00E+00	1.50E+07	7.17E+06	1.67E+06	7.19E+06	3.45E+06

MS4_1 = City of Norman (OKR040015)
MS4_2 = City of Moore (OKR040012)
MS4_3 = City of Oklahoma City (OKS000101)

Table 5-6 Enterococcus TMDL Calculations for Rock Creek (OK520810000090_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	423	3.42E+11	0.00E+00	3.08E+11	0.00E+00	3.42E+10
5	20.9	1.69E+10	0.00E+00	1.52E+10	0.00E+00	1.69E+09
10	11.9	9.63E+09	0.00E+00	8.66E+09	0.00E+00	9.63E+08
15	8.16	6.58E+09	0.00E+00	5.93E+09	0.00E+00	6.58E+08
20	5.79	4.68E+09	0.00E+00	4.21E+09	0.00E+00	4.68E+08
25	4.43	3.58E+09	0.00E+00	3.22E+09	0.00E+00	3.58E+08
30	3.43	2.77E+09	0.00E+00	2.49E+09	0.00E+00	2.77E+08
35	2.70	2.18E+09	0.00E+00	1.96E+09	0.00E+00	2.18E+08
40	2.18	1.76E+09	0.00E+00	1.59E+09	0.00E+00	1.76E+08
45	1.78	1.44E+09	0.00E+00	1.30E+09	0.00E+00	1.44E+08
50	1.54	1.24E+09	0.00E+00	1.12E+09	0.00E+00	1.24E+08
55	1.34	1.08E+09	0.00E+00	9.71E+08	0.00E+00	1.08E+08
60	1.14	9.18E+08	0.00E+00	8.26E+08	0.00E+00	9.18E+07
65	0.98	7.92E+08	0.00E+00	7.12E+08	0.00E+00	7.92E+07
70	0.85	6.84E+08	0.00E+00	6.15E+08	0.00E+00	6.84E+07
75	0.71	5.76E+08	0.00E+00	5.18E+08	0.00E+00	5.76E+07
80	0.60	4.86E+08	0.00E+00	4.37E+08	0.00E+00	4.86E+07
85	0.53	4.32E+08	0.00E+00	3.89E+08	0.00E+00	4.32E+07
90	0.45	3.60E+08	0.00E+00	3.24E+08	0.00E+00	3.60E+07
95	0.31	2.52E+08	0.00E+00	2.27E+08	0.00E+00	2.52E+07
100	0.001	9.00E+05	0.00E+00	8.10E+05	0.00E+00	9.00E+04

Table 5-7 *E. coli* TMDL Calculations for Rock Creek (OK520810000090_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	423	1.31E+12	0.00E+00	1.17E+12	0.00E+00	1.31E+11
5	20.9	6.46E+10	0.00E+00	5.81E+10	0.00E+00	6.46E+09
10	11.9	3.68E+10	0.00E+00	3.31E+10	0.00E+00	3.68E+09
15	8.16	2.51E+10	0.00E+00	2.26E+10	0.00E+00	2.51E+09
20	5.79	1.79E+10	0.00E+00	1.61E+10	0.00E+00	1.79E+09
25	4.43	1.37E+10	0.00E+00	1.23E+10	0.00E+00	1.37E+09
30	3.43	1.06E+10	0.00E+00	9.52E+09	0.00E+00	1.06E+09
35	2.70	8.31E+09	0.00E+00	7.48E+09	0.00E+00	8.31E+08
40	2.18	6.73E+09	0.00E+00	6.06E+09	0.00E+00	6.73E+08
45	1.78	5.50E+09	0.00E+00	4.95E+09	0.00E+00	5.50E+08
50	1.54	4.74E+09	0.00E+00	4.27E+09	0.00E+00	4.74E+08
55	1.34	4.12E+09	0.00E+00	3.71E+09	0.00E+00	4.12E+08
60	1.14	3.50E+09	0.00E+00	3.15E+09	0.00E+00	3.50E+08
65	0.98	3.02E+09	0.00E+00	2.72E+09	0.00E+00	3.02E+08
70	0.85	2.61E+09	0.00E+00	2.35E+09	0.00E+00	2.61E+08
75	0.71	2.20E+09	0.00E+00	1.98E+09	0.00E+00	2.20E+08
80	0.60	1.85E+09	0.00E+00	1.67E+09	0.00E+00	1.85E+08
85	0.53	1.65E+09	0.00E+00	1.48E+09	0.00E+00	1.65E+08
90	0.45	1.37E+09	0.00E+00	1.24E+09	0.00E+00	1.37E+08
95	0.31	9.62E+08	0.00E+00	8.66E+08	0.00E+00	9.62E+07
100	0.001	3.43E+06	0.00E+00	3.09E+06	0.00E+00	3.43E+05

Table 5-8 Enterococcus TMDL Calculations for Elm Creek, West (OK520810000140_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	639	5.16E+11	0.00E+00	5.07E+10	4.13E+11	5.16E+10
5	31.6	2.55E+10	0.00E+00	2.51E+09	2.05E+10	2.55E+09
10	18.0	1.45E+10	0.00E+00	1.43E+09	1.16E+10	1.45E+09
15	12.3	9.94E+09	0.00E+00	9.77E+08	7.96E+09	9.94E+08
20	8.74	7.06E+09	0.00E+00	6.94E+08	5.66E+09	7.06E+08
25	6.69	5.40E+09	0.00E+00	5.31E+08	4.33E+09	5.40E+08
30	5.18	4.18E+09	0.00E+00	4.11E+08	3.35E+09	4.18E+08
35	4.07	3.28E+09	0.00E+00	3.23E+08	2.63E+09	3.28E+08
40	3.30	2.66E+09	0.00E+00	2.62E+08	2.13E+09	2.66E+08
45	2.69	2.17E+09	0.00E+00	2.14E+08	1.74E+09	2.17E+08
50	2.32	1.87E+09	0.00E+00	1.84E+08	1.50E+09	1.87E+08
55	2.02	1.63E+09	0.00E+00	1.60E+08	1.31E+09	1.63E+08
60	1.71	1.38E+09	0.00E+00	1.36E+08	1.11E+09	1.38E+08
65	1.48	1.19E+09	0.00E+00	1.17E+08	9.57E+08	1.19E+08
70	1.28	1.03E+09	0.00E+00	1.01E+08	8.27E+08	1.03E+08
75	1.08	8.69E+08	0.00E+00	8.55E+07	6.96E+08	8.69E+07
80	0.91	7.33E+08	0.00E+00	7.21E+07	5.88E+08	7.33E+07
85	0.81	6.51E+08	0.00E+00	6.41E+07	5.22E+08	6.51E+07
90	0.67	5.43E+08	0.00E+00	5.34E+07	4.35E+08	5.43E+07
95	0.47	3.80E+08	0.00E+00	3.74E+07	3.05E+08	3.80E+07
100	0.002	1.36E+06	0.00E+00	1.34E+05	1.09E+06	1.36E+05

Table 5-9 *E. coli* TMDL Calculations for Elm Creek, West (OK520810000140_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	639	1.97E+12	0.00E+00	1.94E+11	1.58E+12	1.97E+11
5	31.6	9.74E+10	0.00E+00	9.58E+09	7.81E+10	9.74E+09
10	18.0	5.55E+10	0.00E+00	5.45E+09	4.45E+10	5.55E+09
15	12.3	3.79E+10	0.00E+00	3.73E+09	3.04E+10	3.79E+09
20	8.74	2.69E+10	0.00E+00	2.65E+09	2.16E+10	2.69E+09
25	6.69	2.06E+10	0.00E+00	2.03E+09	1.65E+10	2.06E+09
30	5.18	1.60E+10	0.00E+00	1.57E+09	1.28E+10	1.60E+09
35	4.07	1.25E+10	0.00E+00	1.23E+09	1.01E+10	1.25E+09
40	3.30	1.02E+10	0.00E+00	9.99E+08	8.14E+09	1.02E+09
45	2.69	8.29E+09	0.00E+00	8.16E+08	6.65E+09	8.29E+08
50	2.32	7.15E+09	0.00E+00	7.04E+08	5.73E+09	7.15E+08
55	2.02	6.22E+09	0.00E+00	6.12E+08	4.99E+09	6.22E+08
60	1.71	5.29E+09	0.00E+00	5.20E+08	4.24E+09	5.29E+08
65	1.48	4.56E+09	0.00E+00	4.49E+08	3.66E+09	4.56E+08
70	1.28	3.94E+09	0.00E+00	3.87E+08	3.16E+09	3.94E+08
75	1.08	3.32E+09	0.00E+00	3.26E+08	2.66E+09	3.32E+08
80	0.91	2.80E+09	0.00E+00	2.75E+08	2.24E+09	2.80E+08
85	0.81	2.49E+09	0.00E+00	2.45E+08	1.99E+09	2.49E+08
90	0.67	2.07E+09	0.00E+00	2.04E+08	1.66E+09	2.07E+08
95	0.47	1.45E+09	0.00E+00	1.43E+08	1.16E+09	1.45E+08
100	0.002	5.18E+06	0.00E+00	5.10E+05	4.15E+06	5.18E+05

5.8 TMDL IMPLEMENTATION

DEQ will collaborate with a host of other state agencies and local governments working within the boundaries of state and local regulations to target available funding and technical assistance to support implementation of pollution controls and management measures. Various water quality management programs and funding sources 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 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: www.deq.state.ok.us/wqdnew/305b_303d/Final%20CPP.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	www.ok.gov/conservation/Agency_Divisions/Water_Quality_Division
Oklahoma Department of Wildlife Conservation	www.wildlifedepartment.com/wildlifemgmt/endangeredspecies.htm
Oklahoma Department of Agriculture, Food, and Forestry	http://www.ok.gov/~okag/aems/
Oklahoma Water Resources Board	http://www.owrb.ok.gov/quality/index.php

5.8.1 Point Sources

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

5.8.2 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 95%. 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 and TSS TMDLs around the nation. The suitability of the current criteria for pathogens and the beneficial uses of a waterbody should be reviewed. For example, the Kansas Department of 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 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.

5.9 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, 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). The wasteload allocations for MS4s will be implemented through the OPDES MS4 permits. MS4 permits contain specific requirements for the regulated communities/facilities to establish a comprehensive stormwater management program (SWMP) or stormwater pollution prevention plan (SWP3) to implement best management practices (BMPs), public education and outreach, and illicit discharge elimination.

Reasonable assurance that nonpoint sources will meet their allocated amount in the TMDL is dependent upon the availability and implementation of nonpoint source pollutant reduction plans, controls or BMPs within the watershed. The OCC is responsible for the state's NPS program as defined in Section 319 of CWA. DEQ will work in conjunction with OCC and other federal, state, and local partners within the respective watersheds 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: http://www.deq.state.ok.us/wqdnew/index.htm.

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

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APPENDIX A: AMBIENT WATER QUALITY DATA

Table Appendix A-1 Bacterial Data: 2008

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Little River	OK520810-00-0080G	5/6/2008	160	540
Little River	OK520810-00-0080G	5/14/2008	140	200
Little River	OK520810-00-0080G	5/20/2008	110	80
Little River	OK520810-00-0080G	5/28/2008	340	150
Little River	OK520810-00-0080G	6/3/2008	>1000	>1000
Little River	OK520810-00-0080H	6/10/2008	6500	8000
Little River	OK520810-00-0080H	6/18/2008	8300	9800
Little River	OK520810-00-0080H	6/23/2008	160	780
Little River	OK520810-00-0080H	6/30/2008	120	200
Little River	OK520810-00-0080H	7/7/2008	120	120
Little River	OK520810-00-0080H	7/14/2008	250	300
Little River	OK520810-00-0080H	7/23/2008	190	110
Little River	OK520810-00-0080H	7/28/2008	75	155
Little River	OK520810-00-0080H	8/4/2008	60	90
Little River	OK520810-00-0080H	8/12/2008	7100	6300
Little River	OK520810-00-0080H	8/18/2008	280	1960
Little River	OK520810-00-0080H	8/27/2008	100	470
Little River	OK520810-00-0080H	9/2/2008	670	1900
Little River	OK520810-00-0080H	9/9/2008	>1000	>1000
Little River	OK520810-00-0080H	9/15/2008	280	230
Little River	OK520810-00-0080H	9/22/2008	50	40
Rock Creek	OK520810-00-0090C	5/6/2008	>2000	>2000
Rock Creek	OK520810-00-0090C	5/14/2008	280	740
Rock Creek	OK520810-00-0090C	5/20/2008	200	220
Rock Creek	OK520810-00-0090C	5/28/2008	140	390
Rock Creek	OK520810-00-0090C	6/3/2008	170	230
Rock Creek	OK520810-00-0090C	6/10/2008	2700	8400
Rock Creek	OK520810-00-0090C	6/18/2008	1200	5000
Rock Creek	OK520810-00-0090C	6/23/2008	580	640
Rock Creek	OK520810-00-0090C	6/30/2008	80	120
Rock Creek	OK520810-00-0090C	7/7/2008	180	380
Rock Creek	OK520810-00-0090C	7/14/2008	240	240
Rock Creek	OK520810-00-0090C	7/23/2008	920	410
Rock Creek	OK520810-00-0090C	7/28/2008	>500	415
Rock Creek	OK520810-00-0090C	8/4/2008	175	145
Rock Creek	OK520810-00-0090C	8/12/2008	2800	6400
Rock Creek	OK520810-00-0090C	8/18/2008	340	1160
Rock Creek	OK520810-00-0090C	8/27/2008	140	460
Rock Creek	OK520810-00-0090C	9/2/2008	120	290

Waterbody Name	WQM Station	Date	EC[1]	ENT[1]
Rock Creek	OK520810-00-0090C	9/9/2008	400	1000
Rock Creek	OK520810-00-0090C	9/15/2008	280	360
Rock Creek	OK520810-00-0090C	9/22/2008	150	260
Elm Creek, West	OK520810-00-0140P	5/6/2008	>2000	>2000
Elm Creek, West	OK520810-00-0140P	5/14/2008	360	460
Elm Creek, West	OK520810-00-0140P	5/20/2008	710	640
Elm Creek, West	OK520810-00-0140P	5/28/2008	560	660
Elm Creek, West	OK520810-00-0140P	6/3/2008	930	660
Elm Creek, West	OK520810-00-0140P	6/10/2008	1280	2000
Elm Creek, West	OK520810-00-0140P	6/18/2008	1000	4500
Elm Creek, West	OK520810-00-0140P	6/23/2008	560	700
Elm Creek, West	OK520810-00-0140P	6/30/2008	560	620
Elm Creek, West	OK520810-00-0140P	7/7/2008	110	190
Elm Creek, West	OK520810-00-0140P	7/14/2008	310	380
Elm Creek, West	OK520810-00-0140P	7/23/2008	150	460
Elm Creek, West	OK520810-00-0140P	7/28/2008	85	260
Elm Creek, West	OK520810-00-0140P	8/4/2008	70	310
Elm Creek, West	OK520810-00-0140P	8/12/2008	1720	2000
Elm Creek, West	OK520810-00-0140P	8/18/2008	140	460
Elm Creek, West	OK520810-00-0140P	8/27/2008	160	280
Elm Creek, West	OK520810-00-0140P	9/2/2008	340	650
Elm Creek, West	OK520810-00-0140P	9/9/2008	260	720
Elm Creek, West	OK520810-00-0140P	9/15/2008	180	640
Elm Creek, West	OK520810-00-0140P	9/22/2008	190	330

[1] EC = *E. coli*; ENT = Enterococcus; units = counts/100 mL.

APPENDIX B: GENERAL METHOD FOR ESTIMATING FLOW FOR UNGAGED STREAMS AND ESTIMATED FLOW EXCEEDANCE PERCENTILES

Appendix B

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 streamflows at a nearby gages. All gages within 150 km radius were identified. For each of the identified gage with a minimum of 99 flow measurements on matching dates, four different regressions were calculated including linear, log linear, logarithmic and exponential regressions. The regression with the lowest root mean square error (RMSE) was chosen for each gage. The potential filling gages were ranked by RMSE from lowest to highest. The record was filled from the first gage (lowest RMSE) for those dates that existed in both records. If dates remained unfilled in the desired timespan of the timeseries, the filling process was repeated with the next gage with the next lowest RMSE and proceeded in this fashion until all missing values in the desired timespan were filled.

   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, and relying on the Natural Resources Conservation Service (NRCS) runoff curve numbers and antecedent rainfall condition. Drainage subbasins were first delineated for all impaired 303(d)-listed streams, along with all USGS flow stations located in the 8-digit HUCs with impaired streams. Then all the USGS gage stations were identified upstream and downstream of the subwatersheds with 303(d) listed streams.

1. Watershed delineations are performed using ESRI Arc Hydro with a 30-meter resolution National Elevation Dataset digital elevation model (DEM) and National Hydrography Dataset (NHD) streams (USGS 2013). The area of each watershed was calculated following watershed delineation.

2. The watershed average curve number was calculated from soil properties and land cover as described in the U.S. Department of Agriculture (USDA) Publication *TR-55: Urban Hydrology for Small Watersheds* (USDA-NRCS 1986). The soil hydrologic group was extracted from NRCS soil data, and land use category from the National Land Cover Dataset (NLCD). Based on land use and the hydrologic soil group, SCS curve numbers were estimated at the 30-meter resolution of the NLCD grid as shown in **Table Appendix B-1**. The average curve number was then calculated from all the grid cells within the delineated watershed.

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

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

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

4. The method used to project flow from a gaged location to an ungaged location was adapted by combining aspects of two other flow projection methodologies developed by Furness (Furness 1959) and Wurbs (Wurbs 1999).

Furness Method

The Furness method has been employed by both the USGS and Kansas Department of Health and Environment to estimate flow-duration curves. The method typically uses maps, graphs, and computations to identify six unique factors of flow duration for ungaged sites. These factors include:

- The mean streamflow and percentage duration of mean streamflow
- The ratio of 1-percent-duration streamflow to mean streamflow
- The ratio of 0.1-percent-duration streamflow to 1-percent-duration streamflow
- The ratio of 50-percent-duration streamflow to mean streamflow
- The percentage duration of appreciable (0.10 ft /s) streamflow
- Average slope of the flow-duration curve

Furness defined appreciable flow as 0.10 ft/s. This value of streamflow was important because, for many years, this was the smallest non-zero streamflow value reported in most Kansas streamflow records. The average slope of the duration curve is a graphical approximation of the variability index, which is the standard deviation of the logarithms of the streamflows (Furness 1959, p. 202-204, figs. 147 and 148). On a duration curve that fits the log-normal distribution exactly, the variability index is equal to the ratio of the streamflow at the 15.87-percent-duration point to the streamflow at the 50-percent-duration point. Because duration curves usually do not exactly fit the log-normal distribution, the average-slope line is drawn through an arbitrary point, and the slope is transferred to a position approximately defined by the previously estimated points.

The method provides a means of both describing shape of the flow duration curve and scaling the magnitude of the curve to another location, basically generating a new flow duration curve with a very similar shape but different magnitude at the ungaged location.

Wurbs Modified NRCS Method

As a part of the Texas water availability modeling (WAM) system developed by Texas Natural Resources Conservation Commission (now known as the Texas Commission on Environmental Quality) and partner agencies, various contractors developed models of all Texas rivers. As a part of developing the model code to be used, Dr. Ralph Wurbs of Texas A&M University researched methods to distribute flows from gaged locations to ungaged

locations (Wurbs 2006). His results included the development of a modified NRCS curve-number (CN) method for distributing flows from gaged locations to ungaged locations.

This modified NRCS method is based on the following relationship between rainfall depth, P in inches, and runoff depth, Q in inches (NRCS 1985; McCuen 2005):

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

Where:

Q = runoff depth (inches)

P = rainfall (inches)

S = potential maximum retention after runoff begins (inches)

I_a = initial abstraction (inches)

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

$$I_a = 0.2*S \quad \textbf{(2)}$$

Thus, the runoff curve number equation can be rewritten:

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

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

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

P and Q in inches must be multiplied by the watershed area to obtain volumes. The potential maximum retention, S in inches, represents an upper limit on the amount of water that can be abstracted by the watershed through surface storage, infiltration, and other hydrologic abstractions. For convenience, S is expressed in terms of a curve number CN, which is a dimensionless watershed parameter ranging from 0 to 100. A CN of 100 represents a limiting condition of a perfectly impervious watershed with zero retention and thus all the rainfall becoming runoff. A CN of zero conceptually represents the other extreme with the watershed abstracting all rainfall with no runoff regardless of the rainfall amount.

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

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

Where:

M = the mean annual precipitation of the watershed in inches.

The daily precipitation depth for the ungaged watershed, along with the average curve number of the ungaged watershed, was then used to calculate the depth equivalent daily flow (Q) of the ungaged site. Finally, the volumetric flow rate at the ungaged site was calculated by multiplying by the area of the watershed of the ungaged site and converted to cubic feet.

In a subsequent study (Wurbs 2006), Wurbs evaluated the predictive ability of various flow distribution methods including:

- Distribution of flows in proportion to drainage area
- Flow distribution equation with ratios for various watershed parameters
- Modified NRCS curve-number method
- Regression equations relating flows to watershed characteristics
- Use of recorded data at gaging stations to develop precipitation-runoff relationships
- Use of watershed (precipitation-runoff) computer models such as SWAT

As a part of the analysis, the methods were used to predict flows at one gaged station to another gage station so that fit statistics could be calculated to evaluate the efficacy of each of the methods. Based upon similar analyses performed for many gaged sites which reinforced the tests performed as part of the study, Wurbs observed that temporal variations in flows are dramatic, ranging from zero flows to major floods. Mean flows are reproduced reasonably well with the all flow distribution methods and the NRCS CN method reproduces the mean the closest. Accuracy in predicting mean flows is much better than the accuracy of predicting the flow-frequency relationship.

Performance in reproducing flow-frequency relationships is better than for reproducing flows for individual flows.

Wurbs concluded that the NRCS CN method, the drainage area ratio method, and drainage area – CN – mean annual precipitation depth (MP) ratio methods all yield similar levels of accuracy. If the CN and MP are the same for the gaged and ungaged watersheds, the three alternative methods yield identical results. Drainage area is the most important watershed parameter. However, the NRCS method adaptation is preferable in those situations in which differences in CN (land use and soil type) and long-term MP are significantly different between the gaged and ungaged watersheds. The CN and MP are usually similar but not identical.

Generalized Flow Projection Methodology

In the first several versions of the Oklahoma TMDL toolbox, all flows at ungaged sites that required projection from a gaged site were performed with the Modified NRCS CN method. This led a number of problems with flow projections in the early versions. As described previously, the NRCS method, in common with all others, reproduces the mean or central tendency best but the accuracy of the fit degrades towards the extremes of the frequency spectrum. Part of the degradation in accuracy is due to the quite non-linear nature of the NRCS equations. On the low flow end of the frequency spectrum, **Equation 2** constitutes a low flow limit below which the NRCS equations are not applicable at all. Given the flashy nature of most streams in locations for which the TMDL Toolbox was developed, high and low flows are relatively more common and spurious results from the limits of the equations abounded.

In an effort to increase the flow prediction efficacy and remedy the failure of the NRCS CN method at the extremes of the flow spectrum, a hybrid of the NRCS CN method and the Furness method was developed. Noting the facts that all tested projection methods, particularly the NRCS CN method, perform best near the central tendency or mean and that none of the methods predict the entire flow frequency spectrum well, an assumption that is implicit in the Furness method is applied. The Furness method implicitly assumes that the shape of the flow frequency curve at an upstream site is related to and similar to the shape of the flow frequency curve at a site downstream. As described previously, the Furness method employs several relationships derived between the mean flows and flows at differing frequencies to replicate the shape of the flow frequency curve at the projected site, while utilizing other regressed relationships to scale the magnitude of the curve. Since, as part of the Toolbox calculations, the entire flow frequency curve at a 1% interval is calculated for every USGS gage utilizing very long periods of record, this vector in association with the mean flow was used to project the flow frequency curve.

In the ideal situation flows are projected from an ungaged location from a downstream gaged location. The Toolbox also has the capability to project

flows from and upstream gaged location if there is no useable downstream gage.

C. In the rare case where no coincident flow data was available for a WQM station and no gages were 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.

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Table Appendix B-2 Estimated Flow Exceedance Percentiles

Stream Name	Little River	Rock Creek	Elm Creek, West
WBID Segment	OK520810000080_00	OK520810000090_00	OK520810000140_00
USGS Gage Reference	07242380	07242380	07242380
Drainage Area (mi^2)	88.58	11.75	17.74
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
0	4,253	423	639
1	636	63.3	95.5
2	410	40.8	61.5
3	329	32.8	49.4
4	264	26.3	39.7
5	210	20.9	31.6
6	179	17.8	26.9
7	160	15.9	24.0
8	143	14.3	21.5
9	131	13.1	19.7
10	120	11.9	18.0
11	110	11.0	16.5
12	102	10.2	15.3
13	93.8	9.34	14.1
14	87.3	8.69	13.1
15	81.9	8.16	12.3
16	76.1	7.58	11.4
17	71.2	7.09	10.7
18	66.0	6.57	9.92
19	62.2	6.19	9.35
20	58.2	5.79	8.74
21	55.3	5.50	8.30
22	51.9	5.17	7.80
23	49.2	4.90	7.40

Stream Name	Little River	Rock Creek	Elm Creek, West
WBID Segment	OK520810000080_00	OK520810000090_00	OK520810000140_00
USGS Gage Reference	07242380	07242380	07242380
Drainage Area (mi^2)	88.58	11.75	17.74
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
24	47.0	4.68	7.06
25	44.5	4.43	6.69
26	41.6	4.14	6.25
27	39.8	3.97	5.98
28	38.1	3.79	5.72
29	36.0	3.59	5.41
30	34.5	3.43	5.18
31	33.1	3.30	4.98
32	31.3	3.12	4.71
33	29.8	2.96	4.47
34	28.7	2.85	4.30
35	27.1	2.70	4.07
36	25.7	2.56	3.87
37	24.6	2.45	3.70
38	23.5	2.34	3.53
39	22.6	2.25	3.40
40	21.9	2.18	3.30
41	21.0	2.09	3.16
42	20.1	2.01	3.03
43	19.5	1.94	2.93
44	18.6	1.85	2.79
45	17.9	1.78	2.69
46	17.2	1.72	2.59
47	16.8	1.67	2.52
48	16.3	1.63	2.45
49	15.9	1.58	2.39

Stream Name	Little River	Rock Creek	Elm Creek, West
WBID Segment	OK520810000080_00	OK520810000090_00	OK520810000140_00
USGS Gage Reference	07242380	07242380	07242380
Drainage Area (mi^2)	88.58	11.75	17.74
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
50	15.4	1.54	2.32
51	15.0	1.49	2.25
52	14.8	1.47	2.22
53	14.3	1.43	2.15
54	13.9	1.38	2.08
55	13.4	1.34	2.02
56	13.0	1.29	1.95
57	12.8	1.27	1.92
58	12.3	1.23	1.85
59	11.9	1.18	1.78
60	11.4	1.14	1.71
61	11.2	1.11	1.68
62	10.7	1.07	1.61
63	10.5	1.05	1.58
64	10.1	1.00	1.51
65	9.8	0.98	1.48
66	9.6	0.96	1.45
67	9.4	0.94	1.41
68	9.0	0.89	1.34
69	8.7	0.87	1.31
70	8.5	0.85	1.28
71	8.3	0.82	1.24
72	7.8	0.78	1.18
73	7.6	0.76	1.14
74	7.4	0.74	1.11
75	7.2	0.71	1.08

Stream Name	Little River	Rock Creek	Elm Creek, West
WBID Segment	OK520810000080_00	OK520810000090_00	OK520810000140_00
USGS Gage Reference	07242380	07242380	07242380
Drainage Area (mi^2)	88.58	11.75	17.74
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
76	6.9	0.69	1.04
77	6.7	0.67	1.01
78	6.5	0.65	0.98
79	6.3	0.62	0.94
80	6.0	0.60	0.91
81	6.0	0.60	0.91
82	5.8	0.58	0.87
83	5.6	0.56	0.84
84	5.6	0.56	0.84
85	5.4	0.53	0.81
86	5.1	0.51	0.77
87	4.9	0.49	0.74
88	4.9	0.49	0.74
89	4.7	0.47	0.71
90	4.5	0.45	0.67
91	4.3	0.42	0.64
92	4.0	0.40	0.61
93	3.8	0.38	0.57
94	3.6	0.36	0.54
95	3.1	0.31	0.47
96	2.9	0.29	0.44
97	2.7	0.27	0.40
98	2.5	0.25	0.37
99	2.0	0.20	0.30
100	0.01	0.001	0.002

* US Army Corp of Engineers gage station

APPENDIX C: STATE OF OKLAHOMA ANTIDEGRADATION POLICY

Appendix C

State of Oklahoma Antidegradation Policy

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

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

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

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

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

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

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

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

785:46-13-1. Applicability and scope

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

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

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

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

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

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

of Appendix B areas is similar to the implementation framework for the antidegradation policy.

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

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

785:46-13-2. Definitions

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

"Specified pollutants" means

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

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

(C) Phosphorus;

(D) Total Suspended Solids (TSS); and

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

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

(a) General.

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

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

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

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

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

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

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

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

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

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

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

(b) Stormwater discharges. Regardless of 785:46-13-5(a), point source discharges of stormwater from temporary construction activities to waterbodies and watersheds designated "ORW" and/or "Scenic River" may be permitted by the permitting authority.

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

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

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

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

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

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

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

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

APPENDIX D: DEQ SANITARY SEWER OVERFLOW DATA (1989-2014)

Table Appendix D-1 DEQ Sanitary Sewer Overflow Data (1989-2014)

Facility Name	Date	Facility ID	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
Hall Park	1/5/1998	S20806		Hall Park Lagoons				Heavy Rainfall Over The Weekend
Hall Park	3/23/1995	S20806	0.0	Unk	0	X		Unk
Hall Park	11/23/1992	S20806	5.0	2400 E Robinson	2		X	Heavy Rains
Hall Park	8/13/2001	S20806		Doubletree MH's On South Side Of Walking Loop	5	X		Clogged Sewer
Hall Park	12/27/1990	S20806		Plant	75			Froze Line
Hall Park	7/1/2002	S20806	4.0	Wheaton & Auburn Ct.	80	X		Rain
Hall Park	12/14/1992	S20806		WWTP	1000	X		
Hall Park	5/4/1993	S20806	24.0	Lagoons	2400	X		Rainstorm
Hall Park	3/15/1993	S20806	24.0	Lagoons	4800	X		Rainstorm
Hall Park	2/17/1993	S20806	24.0	Lagoons	12000	X		Rainstorm
Hall Park	5/11/1993	S20806	24.0	Lagoons	12000	X		Rainstorm
Hall Park	1/14/1993	S20806	96.0	Final Stage Lagoon No. 1	19200		X	Rain Over Load
Hall Park	2/16/1993	S20806	24.0	Lagoons	24000	X		Rainstorm
Hall Park	3/8/1993	S20806	48.0	Lagoons	24000	X		Rainstorm
Hall Park	5/10/1993	S20806	24.0	Lagoons	24000	X		Rainstorm
Hall Park	5/12/1993	S20806	120.0	Lagoons	24000	X		Rainstorm
Hall Park	2/18/1993	S20806	144.0	Lagoons	28800	X		Rainstorm
Hall Park	3/31/1993	S20806	192.0	Lagoons	38400	X		Rainstorm

Facility Name	Date	Facility ID	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
Hall Park	4/19/1995	S20806	72.0	Lagoons	43200	X		Rain I/I
Hall Park	12/26/1992	S20806	240.0	Final Stage Lagoon No. 1	48000		X	Rain Over Load
Hall Park	3/20/1995	S20806	48.0	Lagoon	57600	X		Hydrolic Overload From I/I
Hall Park	2/26/1993	S20806	144.0	Lagoons	144000	X		Rainstorm
Hall Park	1/18/1993	S20806	168.0	Final Stage Lagoon No. 1	168000		X	Rain Overload
Hall Park	6/9/1992	S20806	168.0	Lagoon	500000	X		System Overload From I/I
Hall Park	5/3/1990	S20806		Overflow On The Backside Of The Old Lagoon				
Hall Park	9/27/1996	S20806		Lagoon				
Hall Park	11/1/1996	S20806		N. Side Of Lagoon #1				Rain
Hall Park	2/21/1997	S20806		Lagoons At E. Robinson				Broken Main
Hall Park	3/18/1998	S20806						
Hall Park	3/2/2001	S20806	18.0	200 Yds S. Of 3000 E. Robinson			X	Pipe Separated
Hall Park	4/2/2001	S20806		N.E. & S. Side Of 80 Acre Site			X	Sprinkler System Malfunction
Hall Park	4/5/2001	S20806		Lagoon			X	Overflow

APPENDIX E: STORMWATER PERMITTING REQUIREMENTS AND PRESUMPTIVE BEST MANAGEMENT PRACTICES (BMP) APPROACH

Stormwater Permitting Requirements and Presumptive Best Management practices (BMPs) Approach

A. Background

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

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

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

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

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

necessary to protect water quality. …… If it is determined that a BMP approach (including an iterative BMP approach) is appropriate to meet the stormwater component of the TMDL, EPA recommends that the TMDL reflect this." This BMP-based approach to stormwater sources in TMDLs is also recognized and described in the most recent EPA guidance. [See "TMDLs to Stormwater Permits Handbook" (DRAFT), EPA, November 2008[1]]

B. This TMDL adopts the EPA recommended approach and relies on appropriate BMPs for implementation. No numeric effluent limitations are required or anticipated for municipal stormwater discharge permits. All three categories of stormwater permits are covered in this Appendix: Municipal Separate Storm Sewer System (MS4) Discharges (Permit number OKR04), Storm Water Discharges from Construction Activities (Permit number OKR10), and Storm Water Discharges from Industrial Facilities under the Multi-Sector Industrial General Permit (Permit number OKR05).**Specific SWMP/SWPPP Requirements**

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

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

Table Appendix E-1 MS4 Permits Affected by this TMDL Report

Entity	Permit No.	MS4 Phase	Date Issued
City of Norman	OKR040015	Phase II	February 8, 2005
City of Moore	OKR040012	Phase II	February 8, 2005
City of Oklahoma City[1]	OKS000101	Phase I	March 15, 2013

[1] Co-permittee with Oklahoma Department of Transportation and Oklahoma Turnpike Authority

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

[1] http://www.epa.gov/owow/tmdl/pdf/tmdl-sw_permits11172008.pdf (as of November 28, 2012).

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

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

As noted above, when a BMP approach is selected a coordinated monitoring program is necessary to establish the effectiveness of the selected BMPs and demonstrate progress toward attaining water quality standards. The monitoring results should be used to refine bacterial controls in the future. With nine permitted entities in the watershed, it is likely that a cooperative monitoring program would be more cost effective than nine individual programs. Individual permittees are not required to participate in a coordinated program and are free to develop their own program if desired.

After EPA approval of the final TMDL, existing MS4 permittees will be notified of the TMDL provisions and schedule. Industrial stormwater permittees are not expected to be a significant source of bacteria. But if any are identified, similar actions will be required.

Compliance with the following provisions will constitute compliance with the requirements of this TMDL.

1. Develop a TMDL Compliance Plan

The permittee shall adopt its WLAs specified in the TMDL as measurable goals within its permit. The permittees shall submit an approvable TMDL compliance Plan to the DEQ within 24 months of EPA approval of this TMDL. Unless disapproved by the Director within 60 days of submission, the plan shall be approved and then implemented by the permittee. This plan shall, at a minimum, include the following:

A. An evaluation to identify potential significant sources of bacteria entering your MS4. Such an evaluation should include an enhanced plan for illicit discharge screening and remediation. Following the evaluation and using guidelines outlined below, the permittee shall develop (or modify an existing program as necessary) and implement a program to reduce the discharge of bacteria in municipal stormwater contributed by all significant sources identified in the evaluation.

B. Selecting a General Strategy for the plan: An MS4 should demonstrate, in the TMDL Compliance Plan that it understands the TMDL requirements and that it has a strategy for meeting the WLAs. There are several ways for an MS4 to meet a TMDL waste load allocation (WLA) using BMPs and other approaches, including but not limited to:

a. Retrofitting developed areas and other suitable sites with structural stormwater BMPs (e.g. infiltration BMPs in built out areas).

b. Implementing BMPs that prevent additional stormwater bacterial pollution associated with new development and re-development; (e.g. promoting wet and dry detention pond development and biofiltration practices, developing wetland treatment systems, and installing hydrodynamic and manufactured devices).

c. Implementing non-structural BMPs designed for source control (e.g. manure management, source controls, and riparian buffer protection requirements) by considering ordinances or other regulatory mechanisms to require bacterial pollution control, as well as enforcement procedures for noncompliance.

d. Implementing non-structural BMPs designed to treat existing loads (e.g. livestock riparian access control).

e. Developing and implementing water quality trading: water quality trading among the MS4 permittees may be considered as a tool to achieve the overall WLA of the TMDLs. As the authorization and enforcement agency of Oklahoma's MS4 permits, the DEQ reserves the authority for the final approval of any trades or trading programs that may be considered in the study watershed.

C. Determining a schedule for achieving the WLA: This schedule can be general in nature, discussing groups of activities to be implemented within permit cycles or based on funding cycles. Specific activities need not be included in this section of the TMDL Compliance Plan. For example:

"MS4 X" will achieve necessary pollutant reductions within four permit cycles. During the first permit cycle, "MS4 X" will evaluate its existing stormwater program in relation to the TMDL compliance plan, determine if the program requires modification, outline a process for develop the TMDL compliance plan, and implement BMPs if opportunities arise. In the second permit cycle, "MS4 X" will modify its stormwater program as necessary, implement non-structural BMPs, develop a system to evaluate the effectiveness of these BMPs and implement structural BMPs if opportunities arise. In the third permit cycle, "MS4 X" will evaluate the effectiveness of non-structural BMPs, determine if structural BMPs (through retrofits) are needed, identify where and which structural BMPs will achieve the needed pollutant load reductions, and implement structural BMPs if opportunities arise. In the fourth permit cycle, "MS4 X" will implement structural BMPs as needed.

D. Implementing and Tracking BMPs

BMP Summary Sheets should be prepared for both structural and non-structural BMPs. For BMPs for which pollutant reductions can be calculated or modeled, BMP sheets should include any information used to make the calculations, BMP efficiencies, and maintenance information for the BMP (e.g. to ensure the efficiency used in the calculation is valid into the future or determine if it needs to be adjusted). Include references to support the calculations or modeling.

BMP Sheets can be prepared for ordinances, resources, or other tools needed for implementation of BMPs. Load reductions may be difficult to quantify with these BMPs, but these tools may be needed to implement BMPs that reduce loading.

E. Educational programs directed at reducing bacterial pollution. Implement a public education program to reduce the discharge of bacteria in municipal stormwater contributed (if applicable) by pets, recreational and exhibition livestock, and zoos.

2. Develop or Participate In a Pollutant Monitoring and Tracking Program

As noted above, when a BMP approach is selected a coordinated monitoring program is necessary to establish the effectiveness of the selected BMPs and demonstrate progress toward achieving the reduction goals of the TMDL and eventually attaining water quality standards in the study watershed. The monitoring results should also be used to refine bacterial controls in the future. The permittee may participate in a coordinated regional monitoring program or develop its own individual program. Specific requirements for an effective monitoring and tracking program are as follows.

A. Within 24 months of EPA approval of this TMDL, the permittee shall prepare and submit to the DEQ either a TMDL monitoring plan or a commitment to participate in a coordinated regional monitoring program. Unless disapproved by the Director within 60 days of submission, the plan shall be approved and then implemented by the permittee. The plan or program shall include:

a. Evaluation of any existing stormwater monitoring program in relation to TMDL reduction goals.

b. A detailed description of the goals, monitoring, and sampling and analytical methods.

c. A map that identifies discharge points, stormwater drainage areas contributing to discharge points, and within each such drainage area, mapping the conveyance system.

d. A list and map of the selected TMDL monitoring sites, which may include sites on receiving waterbodies.

e. Consideration of methods for evaluating pollutant loading in stormwater discharges from residential and agricultural areas, such as monitoring requirement for on-site wastewater treatment facilities and animal feeding operations.

f. The frequency of sample collection to occur at each station or site: at a minimum, sample collection shall include at least one representative sample of a stormwater discharge from at least 50% of the major discharge points discharging directly to surface waters of the state within the portion of the TMDL watershed in the MS4 area. A major discharge point is a pipe or open conveyance measuring 36 inches or more at its widest cross section.

g. The parameters to be measured, as appropriate for and relevant to the TMDL: at a minimum, the samples shall be analyzed for subjected bacteria

in WLA. In this TMDL, the samples shall be analyzed for both *E. coli* and Enterococci.

B. The monitoring program shall be fully implemented within three years of EPA approval of this TMDL.

C. With the obtained monitoring and tracking data, periodically evaluate the effectiveness of individual BMPs if possible and the effectiveness of the overall TMDL compliance plan to ensure progress toward attainment of the WLA. If progress cannot be shown, the MS4 permittee must revise its TMDL compliance plan to further its load reduction efforts

3. Annual Reporting

The permittee shall include a TMDL implementation report as part of their annual report. The TMDL implementation report shall include the status and actions taken by the permittee to implement TMDL Compliance plan and monitoring program. The TMDL implementation report shall document relevant actions taken by the permittee that affect MS4 stormwater discharges to the waterbody segments that are the subject of the TMDL. This TMDL implementation report also shall identify the status of any applicable TMDL implementation schedule milestones.

Table Appendix E-2 Some BMPs Applicable to Bacteria

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
Animal waste management: A planned system designed to manage liquid and solid waste from livestock and poultry. It improves water quality by storing and spreading waste at the proper time, rate and location.	X		75%[1]	
Artificial wetland/rock reed microbial filter: A long shallow hydroponic plant/rock filter system that treats polluted waste and wastewater. It combines horizontal and vertical flow of water through the filter, which is filled with aquatic and semi-aquatic plants and microorganisms and provides a high surface area of support media, such as rocks or crushed stone.	X	X		
Compost facility: Treating organic agricultural wastes in order to reduce the pollution potential to surface and ground water. The composting facility must be constructed, operated and maintained without polluting air and/or water resources.	X	X		Permit may be needed
Conservation landscaping: The placement of vegetation in and around stormwater management BMPs. Its purpose is to help stabilize disturbed areas, enhance the pollutant removal capabilities of stormwater BMP, and improve the overall aesthetics of a stormwater BMP.		X		
Diversions: Establishing a channel with a supporting ridge on the lower side constructed along the general land slope which improves water quality by directing nutrient and sediment laden water to sites where it can be used or disposed of safely.	X	X		

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
Drain Inlet Inserts: A proprietary BMP that is generally easily installed in a drain inlet or catch basin to treat stormwater runoff. Three basic types of inlet insert are available, the tray type, bag type and basket type. The tray type allows flow to pass through filter media residing in a tray located around the perimeter of the inlet.	X	X	5%[2]	
Dry detention pond/basin: Detention ponds/basins that have been designed to temporarily detain stormwater runoff. These ponds fill with stormwater and release it over a period of a few days. They can also be used to provide flood control by including additional flood detention storage.	X	X	40%[2] 51%[3] 88% [4]	
Earthen embankments: A raised impounding structure made from compacted soil. It is appropriate for use with infiltration, detention, extended-detention or retention facilities.	X	X		
Drip irrigation: An irrigation method that supplies a slow, even application of low-pressure water through polyethylene tubing running from supply line directly to a plant's base. Water soaks into the soil gradually, reducing runoff and evaporation (i.e., salinity). Transmission of nutrients and pathogens spread by splashing water and wet foliage created by overhead sprinkler irrigation is greatly reduced. Weed growth is minimized, thereby reducing herbicide applications. Vegetable farming and virtually every type of landscape situation can benefit from the use of drip irrigation.	X	X		
Fencing: A constructed barrier to livestock, wildlife or people. Standard or conventional (barbed or smooth wire), suspension, woven wire, or electric fences consist of acceptable fencing designs to control the animal(s) or people of concern and meet the intended life of the practice.	X		75%[1]	
Filtration (e.g., sand filters): Intermittent sand filters capture, pre-treat to remove sediments, store while awaiting treatment, and treat to remove pollutants (by percolation through sand media) the most polluted stormwater from a site. Intermittent sand filter BMPs may be constructed in underground vaults, in paved trenches within or at the perimeter of impervious surfaces, or in either earthen or concrete open basins.	X	X	30%[1] 55%[2] 37%[4]	
Infiltration Basin: A vegetated open impoundment where incoming stormwater runoff is stored until it gradually infiltrates into the soil strata. While flooding and channel erosion control may be achieved within an infiltration basin, they are primarily used for water quality enhancement.		X	50%[1]	
Infiltration Trench: A shallow, excavated trench backfilled with a coarse stone aggregate to create an underground reservoir. Stormwater runoff diverted into the trench gradually infiltrates into the surrounding soils from the bottom and sides of the trench. The trench can be either an open surface trench or an underground facility.		X	50%[1]	
Irrigation water management: The process of determining and controlling the volume, frequency, and application rate of irrigation water in a planned, efficient manner. An irrigation system adapted for site conditions (soil, slope, crop grown, climate, water quantity and quality, etc.) must be available and capable of applying water to meet the intended purpose(s).	X	X		

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
Lagoon pump out: A waste treatment impoundment made by constructing an embankment and/or excavating a pit or dugout in order to biologically treat waste (such as manure and wastewater) and thereby reduce pollution potential by serving as a treatment component of a waste management system.	X	X		
Land-use conversion: BMPs that involve a change in land use in order to retire land contributing detrimentally to the environment. Some examples of BMPs with associated land use changes are: Conservation Reserve Program (CRP) - cropland to pasture; Forest conservation - pervious urban to forest; Forest/grass buffers - cropland to forest/pasture; Tree planting - cropland/pasture to forest; and Conservation tillage – conventional tillage to conservation tillage.	X	X		
Limit livestock access: Excluding livestock from areas where grazing or trampling will cause erosion of stream banks and lowering of water quality by livestock activity in or adjacent to the water. Limitation is generally accomplished by permanent or temporary fencing. In addition, installation of an alternative water source away from the stream has been shown to reduce livestock access.	X			
Litter control: Litter includes larger items and particulates deposited on street surfaces, such as paper, vegetation residues, animal feces, bottles and broken glass, plastics and fallen leaves. Litter-control programs can reduce the amount of deposition of pollutants by as much as 50%, and may be an effective measure of controlling pollution by storm runoff.		X		
Livestock water crossing facility: Providing a controlled crossing for livestock and/or farm machinery in order to prevent streambed erosion and reduce sediment.	X		100%[1]	
Manufactured BMP systems: Structural measures which are specifically designed and sized by the manufacturer to intercept stormwater runoff and prevent the transfer of pollutants downstream. They are used solely for water quality enhancement in urban and ultra-urban areas where surface BMPs are not feasible.	X	X		
Onsite treatment system installation: Conventional onsite wastewater treatment and disposal system (onsite system) consists of three major components: a septic tank, a distribution box, and a subsurface soil absorption field (consisting of individual trenches). This system relies on gravity to carry household waste to the septic tank, move effluent from the septic tank to the distribution box, and distribute effluent from the distribution box throughout the subsurface soil absorption field. All of these components are essential for a conventional onsite system to function in an acceptable manner.		X		
Porous pavement: An alternative to conventional pavement, it is made from asphalt (in which fine filler fractions are missing) or modular or poured-in concrete pavements. Its use allows rainfall to percolate through it to the sub-base, providing storage and enhancing soil infiltration that can be used to reduce runoff and combined sewer overflows. The water stored in the sub-base then gradually infiltrates the subsoil.		X	50%[1]	

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
Proper site selection for animal feeding facility: Establishing or relocating confined feeding facilities away from environmentally vulnerable areas such as sinkholes, streams, and rivers in order to reduce or eliminate the amount of pollutant runoff reaching these areas.	X			
Raingarden/bio-retention basin: Rain gardens are landscaped gardens of trees, shrubs, and plants located in commercial or residential areas in order to treat stormwater runoff through temporary collection of the water before infiltration. They are slightly depressed areas into which stormwater runoff is channeled by pipes, curb openings, or gravity.		X	40%[1]	
Range and pasture management: Systems of practices to protect the vegetative cover on improved pasture and native rangelands. It includes practices such as seeding or reseeding, brush management (mechanical, chemical, physical, or biological), proper stocking rates and proper grazing use, and deferred rotational systems.	X		50%[1]	
Wet retention ponds/basins: A stormwater facility that includes a permanent pool of water and, therefore, is normally wet even during non-rainfall periods. Inflows from stormwater runoff may be temporarily stored above this permanent pool.	X	X	32%[1] 70%[4]	
Riparian buffer zones: A protection method used along streams to reduce erosion, sedimentation, and the pollution of water from agricultural non-point sources.	X	X	43–57%[1]	Forested buffer w/o incentive payment
Septic system pump-out: A typical septic system consists of a tank that receives waste from a residence or business, and a drain field or subsurface absorption system consisting of a series of percolation lines for the disposal of the liquid effluent. Solids (sludge) that remain after decomposition by bacteria in the tank must be pumped out periodically.		X	5%[1]	
Sewer line maintenance (e.g., sewer flushing): Sewer flushing during dry weather is designed to periodically remove solids that have deposited on the bottom of the sewer and the biological slime that grows on the walls of combined sewers during periods of low-flow. Flushing is especially necessary in sewer systems that have low grades which has resulted in velocities during low-flow periods that fall below those needed for self-cleaning.		X		
Stream bank protection and stabilization (e.g., riprap, gabions): Stabilizing shoreline areas that are being eroded by landscaping, constructing bulkheads, riprap revetments, gabion systems, or establishing vegetation.	X	X	40-75%[1]	40 % w/o fencing; 75 % w/fencing
Street sweeping: The practice of passing over an impervious surface, usually a street or a parking lot, with a vacuum or a rotating brush for the purpose of collecting and disposing of accumulated debris, litter, sand and sediments. In areas with defined wet and dry seasons, sweeping prior to the wet season is likely to be beneficial; following snowmelt and heavy leaf fall are also opportune times.		X		

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
Terrace: An earth embankment, or a combination ridge and channel, constructed across the field slope. Terraces can be used when there is a need to conserve water, excessive runoff is a problem, and the soils and topography are such that terraces can be constructed and farmed with reasonable effort.	X	X		
Vegetated filter strip: A densely vegetated strip of land engineered to accept runoff from upstream development as overland sheet flow. It may adopt any naturally vegetated form, from grassy meadow to small forest. The purpose of a vegetated filter strip is to enhance the quality of stormwater runoff through filtration, sediment deposition, infiltration and absorption.	X	X	<30% [3]	
Waste system/storage (e.g., lagoons, litter shed): Waste treatment lagoons biologically treat liquid waste to reduce the nutrient and BOD content. Lagoons must be emptied and their contents disposed of properly.	X	X	80–100%[1]	
Water treatment (e.g., disinfection, flocculation, carbon filter system): Physical, chemical and/or biological processes used to treat concentrated discharges. Physical-chemical processes that have been demonstrated to effectively treat discharge include sedimentation, vortex separation, screening (e.g., fine-mesh screening), and sand-peat filters. Chemical additives used to enhance separation of particles from liquid include chemical coagulants such as lime, alum, ferric chloride, and various polyelectrolytes. Biological processes that have been demonstrated to effectively treat discharges include contact stabilization, biodiscs, oxidation ponds, aerated lagoons, and facultative lagoons.	X	X		
Wetland development/enhancement: The construction of a wetland for the treatment of animal waste runoff or stormwater runoff. Wetlands improve water quality by removing nutrients from animal waste or sediments and nutrients from stormwater runoff.	X	X	30%[1] 78%[4]	Including creation and restora-tion

4. Evaluating Progress

Compliance with this TMDL and progress toward achieving the wasteload allocations and load reduction goals will be evaluated at each renewal of the MS4 permit for the entity, generally every 5 years. Consideration will be given to:

- Water quality data and results from the pollutant monitoring and tracking program
- The status of achieving milestones and accomplishing items in the current compliance plan
- Any revisions that have been made to or proposed for the compliance plan
- Any proposed enhancements to the compliance plan for the next permit term

If sufficient progress is not demonstrated, an updated compliance plan and implementation schedule will be required to be submitted within 6 months. Noncompliance may subject the permittee to enforcement action.

Sources

[1] BMP Efficiencies Chesapeake Bay Watershed Model (PhaseIV) August 1999; Draft FC and Nitrate TMDL IP for Dry River (2001); EPA (1998); EPA (1999b); Novotny (1994); Storm Water Best Management Practice Categories and Pollutant Removal Efficiencies (2003); USDA (2003); DCR (1999); DEQ/DCR (2001).

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

[3] The Expected Pollutant Removal (Percent) Data Adapted from US EPA, 1993C.

[4] National Pollutant Removal Performance Database, Version 3, September, 2007

APPENDIX F: RESPONSE TO PUBLIC COMMENTS