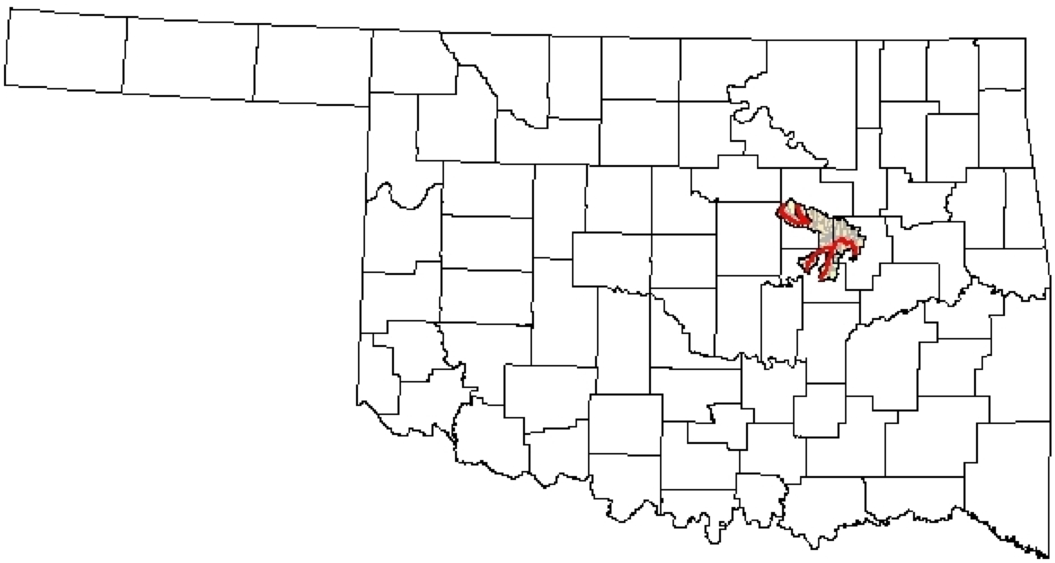
FINAL

BACTERIA AND TURBIDITY TOTAL MAXIMUM DAILY LOADS FOR THE LOWER DEEP FORK OF CANADIAN RIVER AREA, OKLAHOMA (OK520700)



OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

SEPTEMBER 2011

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OKWBID

OK520700020010_10
OK520700020200_00
OK520700030020_00
OK520700060130_10
OK520700060140_00

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

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ACRONYMS AND ABBREVIATIONS

AEMS	Agricultural Environmental Management Service
ASAE	American Society of Agricultural Engineers
BMP	best management practice
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
cfs	Cubic feet per second
cfu	Colony-forming unit
CPP	Continuing planning process
CWA	Clean Water Act
DMR	Discharge monitoring report
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
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRMSE	Normalized root mean square error
NTU	Nephelometric turbidity unit
OLS	Ordinary least square
O.S.	Oklahoma statutes
ODAFF	Oklahoma Department of Agriculture, Food and Forestry
ODEQ	Oklahoma Department of Environmental Quality
OPDES	Oklahoma Pollutant Discharge Elimination System
OSWD	Onsite wastewater disposal
OWRB	Oklahoma Water Resources Board
PBCR	Primary body contact recreation
PRG	Percent reduction goal
RMSE	Root mean square error
SH	State Highway

SSO	Sanitary sewer overflow
TMDL	Total maximum daily load
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WLA	Wasteload allocation
WQM	Water quality monitoring
WQS	Water quality standard
WWTP	Wastewater treatment plant

Executive Summary

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

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

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

E.1 Problem Identification and Water Quality Target

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

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

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

Waterbody ID	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*E. coli*	FC	Designated Use Primary Body Contact Recreation	Turbidity	Designated Use Warm Water Aquatic Life
OK520700020010_10	Canadian River, Deep Fork	39.074	2019	4	X		X	N	X	N
OK520700020200_00	Nuyaka Creek	21.72	2019	4				X	X	N
OK520700030020_00	Walnut Creek	14.71	2016	3				X	X	N
OK520700060130_10	Little Deep Fork Creek	24.39	2016	3	X	X	X	N	X	N
OK520700060140_00	Catfish Creek	9.94	2016	3				X	X	N

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

Table ES-2 summarizes water quality data collected during primary contact recreation season (May 1 through September 30) from the water quality monitoring (WQM) stations 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 ODEQ 2008 303(d) list (ODEQ 2008). It also includes the new date collected after the data cutoff date for the 2008 303(d) list.

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

Waterbody ID	Stream Segments	Bacteria Indicator	Standards	GeoMean	# of Violations	# of Samples	% violations	2008 303(d)	Comments
OK520700020010_10	Canadian River, Deep Fork	FC	400	126.9	10	28	36%	X	TMDL required
		EC	406	60.7	4	26	15%		Meet standard
		ENT	108	127.5	13	26	50%	X	TMDL required
OK520700060130_10	Little Deep Fork Creek	FC	400	848.0	4	8	50%	X	TMDL required
		EC	406	540.5	2	2	100%	X	not Impaired: insufficient data
		ENT	108	787.0	1	1	100%	X	not Impaired: insufficient data

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

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

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

(b) Screening levels:

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

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

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

(c) Fecal coliform:

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

(d) Escherichia coli (E. coli):

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

(e) Enterococci:

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

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

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

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

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

Table ES-3 Summary of Turbidity and TSS Samples Collected Under Base Flow Condition

Waterbody ID	Waterbody Name	Number of turbidity samples	Number of TSS samples	Number of Turbidity samples greater than 50 NTU	% turbidity samples exceeding criterion	2008 303(d)	Comments
OK520700020010_10	Canadian River, Deep Fork	30	0	21	70%	X	TMDL required
OK520700020200_00	Nuyaka Creek	12	1	1	8%	X	Not impaired: meet standard
OK520700030020_00	Walnut Creek	14	0	0	0%	X	Not impaired: meet standard
OK520700060130_10	Little Deep Fork Creek	17	3	3	18%	X	TMDL required
OK520700060140_00	Catfish Creek	20	3	3	15%	X	TMDL required

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

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

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

2. Lakes: 25 NTU; and

3. Other surface waters: 50 NTUs.

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

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

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

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

Assessment of Fish and Wildlife Propagation support

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

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

785:46-15-4. Default protocols

(b) Short term average numerical parameters.

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

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

TMDLs for turbidity in streams designated as WWAC must take into account that no more than 10 percent of the samples may exceed the numeric criterion of 50 nephelometric turbidity units (NTU). However, as described above, because turbidity cannot be expressed as a mass load, TSS is used as a surrogate in this TMDL. Since there is no numeric criterion in the Oklahoma WQS for TSS, a regression method to convert the turbidity criterion to TSS based on a relationship between turbidity and TSS was used to establish TSS goals as surrogates. Table ES-4 provides the results of the waterbody specific regression analysis.

Table ES-4 Regression Statistics and TSS Goals

Waterbody ID	Waterbody Name	R-square	NRMSE	TSS Goals (mg/L)
OK520700020010_10	Deep Fork Creek	0.93	6.3%	34.5
OK520700060130_10	Little Deep Fork Creek	0.57	18.5%	35.3
OK520700060140_00	Catfish Creek	0.72	13.8%	19.9

After re-evaluating bacteria and turbidity/TSS data for the streams listed in Table ES-1, Table ES-5 shows the bacteria and turbidity TMDLs that will be developed in this report:

E.2 Pollutant Source Assessment

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

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

Table ES-5 Stream Segments and Pollutants for TMDL Development

Waterbody ID	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*Fecal Coliform*	Turbidity
OK520700020010_10	Canadian River, Deep Fork	39.074	2019	4	X	X	X
OK520700060130_10	Little Deep Fork Creek	24.39	2016	3		X	X
OK520700060140_00	Catfish Creek	9.94	2016	3			X

Table ES-6 Summary of Potential Pollutant Sources by Category

Waterbody ID	Waterbody Name	Municipal NPDES Facility	Industrial NPDES Facility	MS4	NPDES No Discharge Facility	CAFO	Mines	Construction Stormwater Permit	Nonpoint Source
OK520700020010_10	Canadian River, Deep Fork	Bacteria	Bacteria						Bacteria/TSS
OK520700060130_10	Little Deep Fork Creek	Bacteria							Bacteria/TSS
OK520700060140_00	Catfish Creek								Bacteria/TSS

No facility present in watershed.

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

E.3 Using Load Duration Curves to Develop TMDLs

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

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

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

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

The basic steps to generating an LDC involve:

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

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

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

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

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

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

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

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

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

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

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

E.4 TMDL Calculations

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

This definition can be expressed by the following equation:

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

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

Table ES-7 presents the percent reductions necessary for each bacterial indicator causing nonsupport of the PBCR use in each waterbody of the Study Area. Selection of the appropriate PRG for each waterbody in Table ES-7 is denoted by bold text. The TMDL PRG will be the lesser of that required to meet the geometric mean or instantaneous criteria for *E. coli* and Enterococci because WQSs are considered to be met if, 1) either the geometric mean of all data is less than the geometric mean criteria, or 2) no samples exceed the instantaneous criteria. The PRGs range from 46 to 78 percent.

Table ES-7 TMDL Percent Reductions Required to Meet Water Quality Standards for Indicator Bacteria

Waterbody ID	Waterbody Name	Required Reduction Rate				
		FC	EC		ENT	
		Instant-aneous	Instant-aneous	Geo-mean	Instant-aneous	Geo-mean
OK520700020010_10	Canadian River, Deep Fork	**46.3%**			94.9%	**78.4%**
OK520700060130_10	Little Deep Fork Creek	**76.1%**				

Similarly, percent reduction goals for TSS are calculated as the required overall reduction so that no more than 10 percent of the samples exceed the water quality target for TSS. The PRGs for the four waterbodies included in this TMDL report are summarized in Table ES-8 and range from 35 to 81 percent.

Table ES-8 TMDL Percent Reductions Required to Meet Water Quality Targets for Total Suspended Solids

Waterbody ID	Waterbody Name	Required Reduction Rate
OK520700020010_10	Canadian River, Deep Fork	81.3%
OK520700060130_10	Little Deep Fork Creek	64.9%
OK520700060140_00	Catfish Creek	34.9%

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

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

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

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

For bacteria TMDLs, an explicit MOS was set at 10 percent.

For turbidity, the TMDLs are calculated for TSS instead of turbidity. Thus, the quality of the regression has a direct impact on confidence of the TMDL calculations. The better the regression is, the more confidence there is in the TMDL targets. As a result, it leads to a smaller margin of safety. The selection of MOS is based on the normalized root mean square error (NRMSE) for each waterbody. The explicit MOS ranges from 10% to 20% in this report.

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

E.5 Reasonable Assurance

As authorized by Section 402 of the CWA, ODEQ has delegation of the NPDES in Oklahoma, except for certain jurisdictional areas related to agriculture and the oil and gas industry retained by the Oklahoma Department of Agriculture and Oklahoma Corporation Commission, for which the USEPA has retained permitting authority. The NPDES program in Oklahoma is implemented via Title 252, Chapter 606 of the Oklahoma Pollution Discharge Elimination System (OPDES) Act, and in accordance with the agreement between ODEQ and USEPA relating to administration and enforcement of the delegated NPDES program. Implementation of WLAs for point sources is done through permits issued under the OPDES program. The reduction rates called for in this TMDL report are as high as 81 percent. The ODEQ recognizes that achieving such high reductions will be a challenge, especially since unregulated nonpoint sources are a major cause of both bacteria and TSS loading. The high reduction rates are not uncommon for pathogen- or TSS-impaired waters. Similar reduction rates are often found in other pathogen and TSS TMDLs around the nation.

SECTION 1
INTRODUCTION

1.1 TMDL Program Background

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

This report documents the data and assessment used to establish TMDLs for the pathogen indicator bacteria [fecal coliform and Enterococci] and turbidity for selected waterbodies in the Lower Deep Fork of Canadian River basin just above Lake Eufaula. (All future references to bacteria in this document imply these two classes of fecal pathogen indicator bacteria unless specifically stated otherwise.) Elevated levels of pathogen indicator bacteria in aquatic environments indicate that a waterbody is contaminated with human or animal feces and that a potential health risk exists for individuals exposed to the water. Elevated turbidity levels caused by excessive sediment loading and stream bank erosion impact aquatic biological communities. Data assessment and TMDL calculations are conducted in accordance with requirements of Section 303(d) of the CWA, Water Quality Planning and Management Regulations (40 CFR Part 130), USEPA guidance, and Oklahoma Department of Environmental Quality (ODEQ) guidance and procedures. ODEQ is required to submit all TMDLs to USEPA for review and approval. Once the USEPA approves a TMDL, then the waterbody may be moved to Category 4a of a state's Integrated Water Quality Monitoring and Assessment Report, where it remains until compliance with water quality standards (WQS) is achieved (USEPA 2003).

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

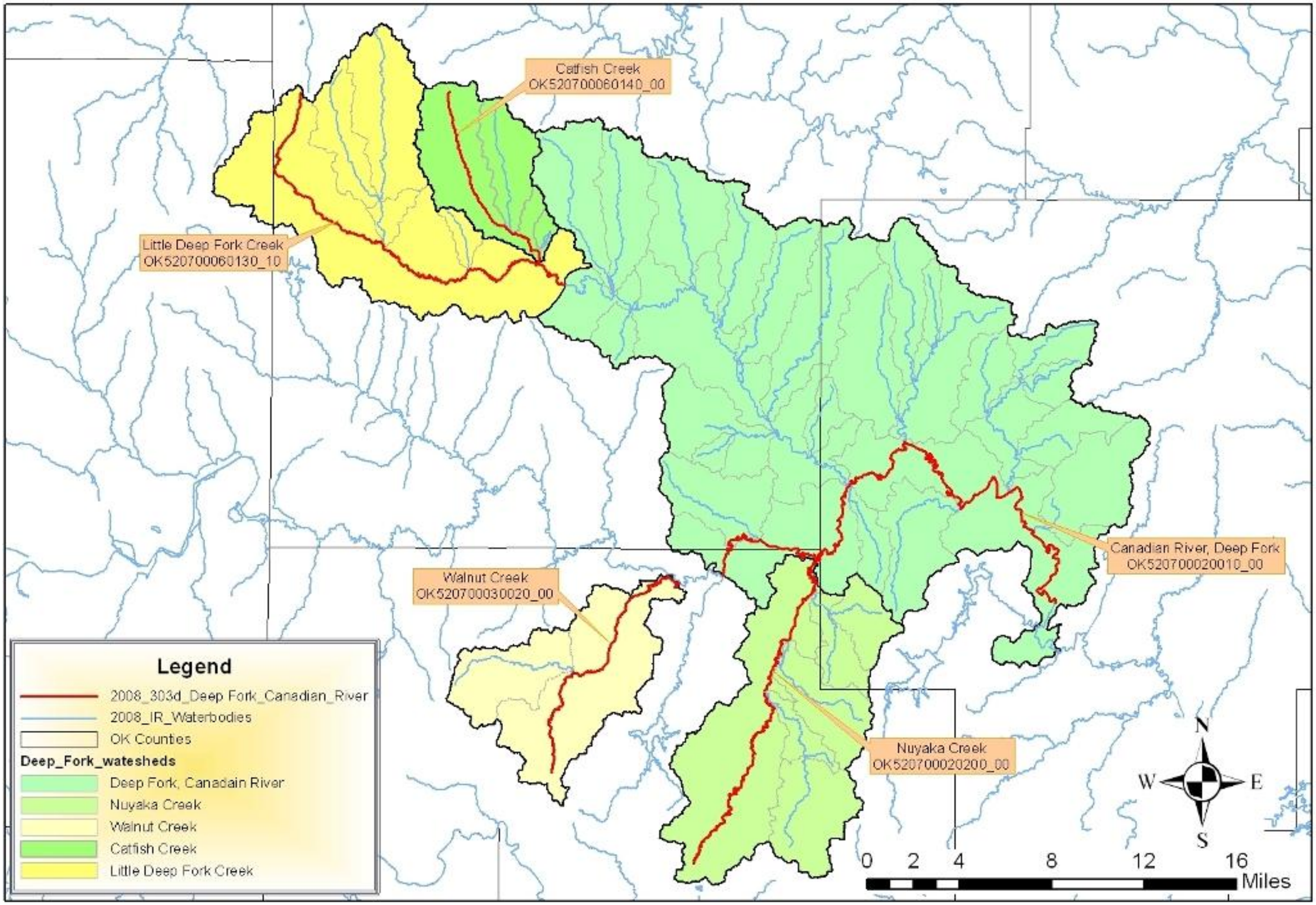
This report does not stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce bacteria or turbidity within each watershed. Watershed-specific control actions and management measures will be identified, selected, and implemented under a separate process 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 ODEQ placed in Category 5 [303(d) list] of the *Water Quality in Oklahoma, 2008 Integrated Report* (2008 Integrated Report) for nonsupport of primary body contact recreation (PBCR) or warm water aquatic community (WWAC) designated uses. The waterbodies addressed in this report, which are presented upstream to downstream, include:

- Canadian River, Deep Fork OK520700020010_10
- Nuyaka Creek OK520700020200_00
- Walnut Creek OK520700030020_00
- Little Deep Fork Creek OK520700060130_10
- Catfish Creek OK520700060140_00

Figure 1-1 is location maps showing these Oklahoma waterbodies and their contributing watersheds. These maps also display 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.

Figure 1-1 Lower Deep Fork of Canadian River Watersheds Not Supporting Primary Body Contact Recreation or Fish and Wildlife Propagation



Elevated levels of pathogen indicator bacteria or turbidity above the WQS result in the requirement that a TMDL be developed. The TMDLs established in this report are a necessary step in the process to develop the pollutant loading controls needed to restore the primary body contact recreation or fish and wildlife propagation use designated for each waterbody. Table 1-1 provides a description of the locations of WQM stations on the 303(d)-listed waterbodies.

Table 1-1 Water Quality Monitoring Stations Used in This Report

WBID	Name	monitoring sites	Lat	Long	Agency
OK520700060140_00	Catfish Creek	OK520700-06-0140G	35.8282	-96.4190	OCC
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	35.8279	-96.5341	OCC
OK520700030020_00	Walnut Creek	WALNUT CREEK near Mason	35.5953	-96.3494	ODEQ
OK520700020200_00	Nuyaka Creek	NUYAKA CREEK near Okfuskee	35.5950	-96.2117	ODEQ
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	35.6742	-96.0688	OWRB

1.2 Watershed Description

General. The Lower Deep Fork of Canadian River basin is located in the east central portion of Oklahoma. The waterbodies addressed in this report are located in Okmulgee, Okfuskee, Creek and Lincoln counties. Table 1-2, derived from the 2010 U.S. Census, demonstrates that the counties in which these watersheds are located are sparsely populated (U.S. Census Bureau 2010). Table 1-3 lists the towns and cities located in each watershed.

Table 1-2 County Population and Density

County Name	Population (2000 Census)	Area (square mile)	Population Density (per square mile)
Okmulgee	40,069	702.0	57
Okfuskee	12,191	628.6	19
Creek	69,967	969.7	72
Lincoln	34,273	965.3	36

Table 1-3 Towns and Cities by Watershed

Towns and Cities	Stream Name	Waterbody ID
Shamrock	Little Deep Fork Crk	OK520700060130_10
Bristow	Little Deep Fork Crk	OK520700060130_10
Pulaski	Little Deep Fork Crk	OK520700060130_10
Depew	Little Deep Fork Crk	OK520700060130_10
Bellvue	Canadian River, Deep Fork	OK520700020010_10
Tabor	Canadian River, Deep Fork	OK520700020010_10
Slick	Canadian River, Deep Fork	OK520700020010_10
Beggs	Canadian River, Deep Fork	OK520700020010_10
Dentonville	Canadian River, Deep Fork	OK520700020010_10
Preston	Canadian River, Deep Fork	OK520700020010_10
Edna	Canadian River, Deep Fork	OK520700020010_10
Tuskegee	Canadian River, Deep Fork	OK520700020010_10
Nuyaka	Canadian River, Deep Fork	OK520700020010_10
Park Wheeler Corner	Canadian River, Deep Fork	OK520700020010_10
Okfuskee	Nuyaka Creek	OK520700020200_00
Last Chance	Nuyaka Creek	OK520700020200_00
Oriental	Nuyaka Creek	OK520700020200_00
Woodard Corner	Nuyaka Creek	OK520700020200_00
Mason	Walnut Creek	OK520700030020_00
Chilesville	Walnut Creek	OK520700030020_00
IXL	Walnut Creek	OK520700030020_00

Climate. Table 1-4 summarizes the average annual precipitation for each Oklahoma waterbody based on the approximate midpoint of each watershed. Average annual precipitation values among the watersheds in this portion of Oklahoma range between 40.1 and 42.2 inches (Oklahoma Climate Survey 2007).

Table 1-4 Average Annual Precipitation by Watershed

Precipitation Summary		
Waterbody Name	Waterbody ID	Average Annual Precipitation (Inches)
Canadian River, Deep Fork	OK520700020010_10	41.7
Nuyaka Creek	OK520700020200_00	42.2
Walnut Creek	OK520700030020_00	41.7
Little Deep Fork Creek	OK520700060130_10	40.1
Catfish Creek	OK520700060140_00	40.4

Land Use. Tables1-5 summarize 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) 2001 National Land Cover Dataset (USGS 2007). The land use categories are displayed in Figure 1-2. The three most dominant land use categories throughout the study area are deciduous forest, grasslands/herbaceous and pasture/hay. Ninety to ninety-five percent of sub-watershed areas consist of these three land covers.

Figure 1-2 Land Use Map

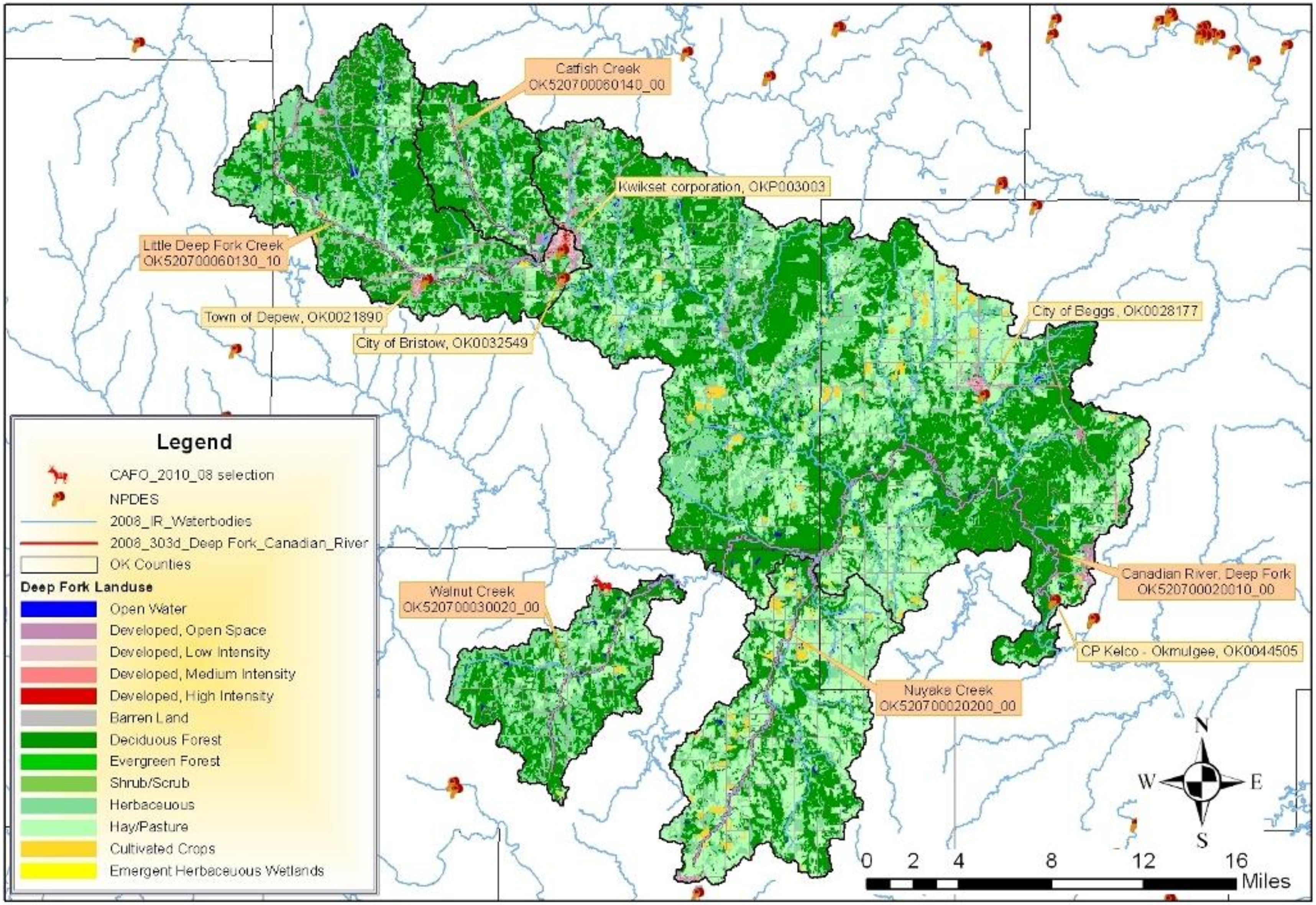


Table 1-5 Land Use Summaries by Watershed

Landuse Category	Canadian River, Deep Fork	Nuyaka Creek	Walnut Creek	Little Deep Fork Creek	Catfish Creek
Waterbody ID	OK520700020010_00	OK520700020200_00	OK520700030020_00	OK520700060130_10	OK520700060140_00
Open Water	1588.8	340.4	305.4	729.7	217.6
Medium Intensity Residential	810.6	85.8	5.8	553.6	66.1
High Intensity Residential	81.0	3.3	0.0	83.4	3.1
Bare Rock/Sand/Clay	0.0	0.0	0.0	0.0	0.0
Deciduous Forest	93852.6	16090.1	12655.2	30015.2	9641.9
Evergreen Forest	69.4	4.0	5.3	6.0	0.0
Grasslands/Herbaceous	53239.2	11619.0	11011.2	19782.2	5629.1
Pasture/Hay	42198.2	21983.9	4148.6	6086.8	2201.3
Row Crops	2419.0	1608.9	153.5	335.8	0.0
Urban/Recreational Grasses	9589.8	2140.6	1015.9	4122.8	1067.3
Woody Wetlands	24.0	0.0	0.0	0.0	0.0
Emergent Herbaceous Wetlands	121.0	8.9	12.0	0.0	0.0
Total (Acres):	203994	53885	29313	61715	18826
Open Water	0.78%	0.63%	1.04%	1.18%	1.16%
Medium Intensity Residential	0.40%	0.16%	0.02%	0.90%	0.35%
High Intensity Residential	0.04%	0.01%	0.00%	0.14%	0.02%
Bare Rock/Sand/Clay	0.00%	0.00%	0.00%	0.00%	0.00%
Deciduous Forest	46.01%	29.86%	43.17%	48.63%	51.21%
Evergreen Forest	0.03%	0.01%	0.02%	0.01%	0.00%
Grasslands/Herbaceous	26.10%	21.56%	37.56%	32.05%	29.90%
Pasture/Hay	20.69%	40.80%	14.15%	9.86%	11.69%
Row Crops	1.19%	2.99%	0.52%	0.54%	0.00%
Urban/Recreational Grasses	4.70%	3.97%	3.47%	6.68%	5.67%
Woody Wetlands	0.01%	0.00%	0.00%	0.00%	0.00%
Emergent Herbaceous Wetlands	0.06%	0.02%	0.04%	0.00%	0.00%
Total (percentage):	100.0%	100.0%	100.0%	100.0%	100.0%

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. At various WQM stations additional flow measurements are available which were collected at the same time bacteria, total suspended solids (TSS) and turbidity water quality samples were collected. Not all of the waterbodies in this Study Area have historical flow data available. However, the flow data from the surrounding USGS gage stations and the instantaneous flow measurement data along with water quality samples have been used to estimate flows for ungaged streams. Flow data collected at the time of water quality sampling are included in Appendix A along with corresponding water chemistry 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's water quality standards and implementation procedures (OWRB 2008). The Oklahoma Water Resources Board (OWRB) has statutory authority and responsibility concerning establishment of state water quality standards, as provided under 82 Oklahoma Statute [O.S.], §1085.30. This statute authorizes the OWRB to promulgate rules …*which establish classifications of uses of waters of the state, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters.* [O.S. 82:1085:30(A)]. Beneficial uses are designated for all waters of the state. Such uses are protected through restrictions imposed by the antidegradation policy statement, narrative water quality criteria, and numerical criteria (OWRB 2008). An excerpt of the Oklahoma WQS (Title 785) summarizing the State of Oklahoma Antidegradation Policy is provided in Appendix D. Table 2-2, an excerpt from the 2008 Integrated Report (ODEQ 2008), lists beneficial uses designated for each bacteria and/or turbidity impaired stream segment in the Study Area. The beneficial uses include:

- AES – Aesthetics
- AG – Agriculture Water Supply
- 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 summarizes the PBCR and WWAC use attainment status and the bacteria & turbidity impairment status for streams in the Study Area. The TMDL priority shown in Table 2-1 is directly related to the TMDL target date. The TMDLs established in this report, which are a necessary step in the process of restoring water quality, only address bacteria and/or turbidity impairments that affect the PBCR and Fish and Wildlife Propagation uses.

The definition of PBCR is summarized by the following excerpt from the Oklahoma Water Quality Standards (785-:45-5-16):

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

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

Table 2-1 Excerpt from the 2008 Integrated Report – Oklahoma 303(d) List of Impaired Waters (Category 5)

Waterbody ID	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*E. coli*	FC	Turbidity
OK520700020010_10	Canadian River, Deep Fork	39.074	2019	4	X		X	X
OK520700020200_00	Nuyaka Creek	21.72	2019	4				X
OK520700030020_00	Walnut Creek	14.71	2016	3				X
OK520700060130_10	Little Deep Fork Creek	24.39	2016	3	X	X	X	X
OK520700060140_00	Catfish Creek	9.94	2016	3				X

* TMDL completed in Sans Bios Bacteria TMDL report
ENT = enterococci; FC = fecal coliform
X = Criterion exceeded
Source: 2008 Integrated Report, ODEQ 2008.

Table 2-2 Designated Beneficial Uses for the Listed Stream Segments in the Study Area

Waterbody ID	Waterbody Name	AES	AG	WWAC	*FISH*	PBCR	PPWS
OK520700020010_10	Canadian River, Deep Fork	I	F	N	F	N	I
OK520700020200_00	Nuyaka Creek	I	I	N	X	X	X
OK520700030020_00	Walnut Creek	I	F	N	X	X	
OK520700060130_10	Little Deep Fork Creek	F	F	N	X	N	I
OK520700060140_00	Catfish Creek	I	N	N	X	X	

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

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

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

(b) Screening levels.

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

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

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

(c) Fecal coliform:

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

(2) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to fecal coliform if the geometric mean of 400 colonies per 100 ml is not met, or greater than 25% of the sample concentrations from that waterbody exceed the screening level prescribed in (b) of this Section, or both such conditions exist.

(d) Escherichia coli (E. coli):

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

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

(e) Enterococci:

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

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

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

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

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

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

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

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

ii. Lakes: 25 NTU; and

iii. Other surface waters: 50 NTUs.

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

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

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

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

Assessment of Fish and Wildlife Propagation support

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

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

785:46-15-4. Default protocols

(b) Short term average numerical parameters.

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

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

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

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

2.2 Problem Identification

In this subsection water quality data summarizing waterbody impairments caused by elevated levels of bacteria are summarized first followed by the data summarizing impairments caused by elevated levels of turbidity.

2.2.1 Bacteria Data Summary

Table 2-3 summarizes water quality data collected during primary contact recreation season from the WQM stations between 1999 and 2006 for each indicator bacteria. The data summary in Table 2-3 provides a general understanding of the amount of water quality data available and the severity of exceedances of the water quality criteria. This data collected during the primary contact recreation season was used to support the decision to place specific waterbodies within the Study Area on the ODEQ 2008 303(d) list (ODEQ 2008). Water quality data from the primary contact recreation seasons are provided in Appendix A. For the data collected between 1999 and 2006, evidence of nonsupport of the PBCR use based on elevated fecal coliform and Enterococci concentrations was observed in Canadian River, Deep Fork (OK520700020010_10). Evidence of nonsupport of the PBCR use based on fecal coliform exceedances was observed in Little Deep Fork Creek (OK520700060130_10). There were no enough E. coli and Enterococci data in Little Deep Fork Creek for impairment assessment.

2.2.2 Turbidity Data Summary

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

Table 2-4 summarizes turbidity and TSS data collected from the WQM stations between 1997 and 2010. However, as stipulated in Title *785:45-5-12 (f) (7) (C)*, numeric criteria for turbidity only apply under base flow conditions. While the base flow condition is not specifically defined in the Oklahoma Water Quality Standards, ODEQ considers base flow conditions to be all flows less than the 25^{th} flow exceedance percentile (i.e., the lower 75 percent of flows) which is consistent with the USGS Streamflow Conditions Index (USGS 2007a). Therefore, Water quality samples collected under flow conditions greater than the 25^{th} flow exceedance percentile (highest flows) were therefore excluded from the data set used for TMDL analysis. Table 2-5 was prepared to represent the subset of these data for samples collected during base flow conditions. For the data collected between 1997 and 2010, evidence of nonsupport of the Fish and Wildlife Propagations was observed in Canadian River, Deep Fork (OK520700020010_10), Little Deep Fork Creek (OK520700060130_10), and Catfish Creek (OK520700060140_00). Fish and Wildlife Propagations beneficial use was fully supported with regard to turbidity in Nuyahka Creek and Walnut Creek. Assessment for Nuyahka Creek and Walnut Creek was based on the most recent data collected in 2009 and 2010. Water quality data for turbidity and TSS are provided in Appendix A.

Table 2-3 Summary of Indicator Bacteria Samples from Primary Body Contact Recreation Season

Waterbody ID	Stream Segments	Bacteria Indicator	Standards	GeoMean	# of Violations	# of Samples	% violations	2008 303(d)	Comments
OK520700020010_10	Canadian River, Deep Fork	FC	400	126.9	10	28	36%	X	TMDL required
		EC	406	60.7	4	26	15%		Meet standard
		ENT	108	127.5	13	26	50%	X	TMDL required
OK520700060130_10	Little Deep Fork Creek	FC	400	848.0	4	8	50%	X	TMDL required
		EC	406	540.5	2	2	100%	X	Delist: no enough data
		ENT	108	787.0	1	1	100%	X	Delist: no enough data

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

Table 2-4 Summary of All Turbidity and TSS Samples

Waterbody ID	Waterbody Name	Number of turbidity samples	Number of TSS samples	Number of turbidity samples greater than 50 NTU	% turbidity samples exceeding criterion	Sampling period
OK520700020010_10	Canadian River, Deep Fork	39	0	30	77%	2006-2010
OK520700020200_00	Nuyaka Creek	12	1	1	8%	2009-2010
OK520700030020_00	Walnut Creek	14	0	0	0	2009-2010
OK520700060130_10	Little Deep Fork Creek	21	20	7	33%	1999-2001
OK520700060140_00	Catfish Creek	20	27	3	15%	1997-1999

Table 2-5 Summary of Turbidity and TSS Samples Excluding High Flow Samples

Waterbody ID	Waterbody Name	Number of turbidity samples	Number of TSS samples	Number of Turbidity samples greater than 50 NTU	% turbidity samples exceeding criterion	2008 303(d)	Comments
OK520700020010_10	Canadian River, Deep Fork	30	0	21	70%	X	TMDL required
OK520700020200_00	Nuyaka Creek	12	1	1	8%	X	Delist: meet standard
OK520700030020_00	Walnut Creek	14	0	0	0%	X	Delist: meet standard
OK520700060130_10	Little Deep Fork Creek	17	3	3	18%	X	TMDL required
OK520700060140_00	Catfish Creek	20	3	3	15%	X	TMDL required

After re-evaluating both bacteria and turbidity data following Oklahoma's assessment protocol, TMDLs will be developed only for the streams and pollutants listed in Table 2-6. A total of 6 bacteria/turbidity TMDLs will be developed in this report.

Table 2-6 Stream Segments and Pollutants for TMDL Development

Waterbody ID	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*Fecal Coliform*	Turbidity
OK520700020010_10	Canadian River, Deep Fork	39.074	2019	4	X	X	X
OK520700060130_10	Little Deep Fork Creek	24.39	2016	3		X	X
OK520700060140_00	Catfish Creek	9.94	2016	3			X

2.3 Water Quality Target

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

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

If fecal coliform is utilized to establish the TMDL, then the water quality target is the instantaneous water quality criteria (400/100 mL). If *E. coli* is utilized to establish the TMDL, then the water quality target is the instantaneous water quality criterion value (406/100 mL), and the geometric mean water quality target is the geometric mean criterion value (126/100 mL). If Enterococci are utilized to establish the TMDL, then the water quality target is the instantaneous water quality criterion value (108/100 mL) and the geometric mean water quality target is the geometric mean criterion value (33/100 mL).

The TMDL for bacteria will incorporate an explicit 10 percent margin of safety. The allowable bacteria load is derived by using the actual or estimated flow record multiplied by the water quality target. The line drawn through the allowable load data points is the water quality target which represents the maximum load for any given flow that still satisfies the WQS.

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

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

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

SECTION 3
POLLUTANT SOURCE ASSESSMENT

A 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; some plant life and sources may be point or nonpoint in nature. Turbidity may originate from NPDES-permitted facilities, fields, construction sites, quarries, stormwater runoff and eroding stream banks.

Point sources are permitted through the NPDES program. NPDES-permitted facilities that discharge treated wastewater are required to monitor for one of the three bacterial pathogen indicators (fecal coliform, or Enterococci) and TSS in accordance with their permits. Nonpoint sources are diffuse sources that typically cannot be identified as entering a waterbody through a discrete conveyance at a single location. Nonpoint sources may emanate from land activities that contribute bacteria or TSS to surface water as a result of rainfall runoff. For the TMDLs in this report, all sources of pollutant loading not regulated by NPDES are considered nonpoint sources.

The 2008 Integrated Water Quality Assessment Report (ODEQ 2008) listed potential sources of turbidity as clean sediment, grazing in riparian corridors of streams and creeks, highway/road/bridge runoff (non-construction related), non-irrigated crop production, petroleum/natural gas activities, rangeland grazing, as well as other unknown sources. The following discussion describes what is known regarding point and nonpoint sources of bacteria in the impaired watersheds. Where information was available on point and nonpoint sources of indicator bacteria or TSS, data were provided and summarized as part of each category. .

3.1 NPDES-Permitted Facilities

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

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

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

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

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

There is at least one NPDES-permitted facility in each sub-watershed.

3.1.1 Continuous Point Source Dischargers

The locations of the NPDES-permitted facilities that discharge wastewater to surface waters addressed in these TMDLs are listed in Table 3-1 and displayed in Figures 3-1 and 3-2. For some continuous point source discharge facilities the permitted design flow was not available and therefore is not provided in Table 3-1. There are 4 active continuous point source discharging facilities within the Study Area but they are not all sources of concern for bacteria or TSS loading. All of these facilities are discharging to a waterbody that requires a TMDL for bacteria. All of the facilities in Table 3-1 discharge TSS and have specific permit limits for TSS which are provided in Table 3-1. However, the municipal WWTPs designated with a Standard Industrial Code number 4952 in Table 3-1 discharge organic TSS and therefore are not considered a potential source of turbidity within their respective watershed. There is one active NPDES-permitted industrial facility (SIC Code: 2099, Food Preparations) operating in the Study Area. This facility also discharges organic TSS and therefore is not considered a potential source of turbidity.

3.1.2 NPDES No-Discharge Facilities and Sanitary Sewer Overflows

For the purposes of these TMDLs, it is assumed that no-discharge facilities do not contribute indicator bacteria or TSS loading. However, it is possible the wastewater collection systems associated with these no-discharge facilities could be a source of indicator bacteria loading, or that discharges from the wastewater plant may occur during large rainfall events that exceed the systems' storage capacities. There are no no-discharge facilities in the study area.

Sanitary sewer overflows (SSO) from wastewater collection systems, although infrequent, can be a major source of indicator bacteria loading to streams. SSOs have existed since the introduction of separate sanitary sewers, and most are caused by blockage of sewer pipes by grease, tree roots, and other debris that clog sewer lines, by sewer line breaks and leaks, cross connections with storm sewers, and inflow and infiltration of groundwater into sanitary sewers. SSOs are permit violations that must be addressed by the responsible NPDES permittee. The reporting of SSOs has been strongly encouraged by USEPA, primarily through enforcement and fines. While not all sewer overflows are reported, ODEQ has data on reported SSOs. 44 overflows were reported since 2000 ranging from 10 to 10,000 gallons. Table 3-2 summarizes the SSO occurrences by NPDES facility. SSO data are provided in Appendix D.

Table 3-1 Point Source Discharges in the Study Area

Waterbody name	Waterbody ID	FACILITY	NPID	STATE_ID	SIC code	Design Flow (MGD)	Fecal Coliform Ave/Max. cfu /100mL	Max./Avg TSS mg/L	Expiration Date	Notes
Little Deep Fork Creek	OK520700060130_10	DEPEW, TOWN OF	OK0021890	S20716	4952	0.05	200/400	90/135	05/31/11	Active
		BRISTOW, CITY OF	OK0032549	S20717	4952	0.945	200/400	30/45	09/30/14	Active
		KWIKSET CORPORATION	OKP003003	19001400		NA	NA	NA	NA	Closed on 8/15/06
Canadian River, Deep Fork	OK520700020010_10	CP KELCO US, INC.-OKMULGEE	OK0044504	56000630	2099	Report	200/400	30/45	08/31/15	Active
		BEGGS, CITY OF	OK0028177	S20718	4952	0.175	200/400	15/22.5	05/31/16	Active

NA = not available.

Table 3-2 Sanitary Sewer Overflow (SSO) Summary

Facility Name	Facility ID	Receiving Stream	Receiving Water	Number of Occurrences	Date Range		Amount (Gallons)	
					From	To	Min	Max
Town of Depew	S20718	Little Deep Fork Creek	OK520700060130_10	17	2001	2010	10	500
City of Bristow	S20717	Little Deep Fork Creek	OK520700060130_10	21	2000	2007	100	10,000
City of Beggs	S20716	Canadian River, Deep Fork	OK520700020010_10	6	2000	2001	800	2000

4

Figure 3-1 Locations of NPDES-Permitted Facilities for Discharges and Constructions in the Study Area

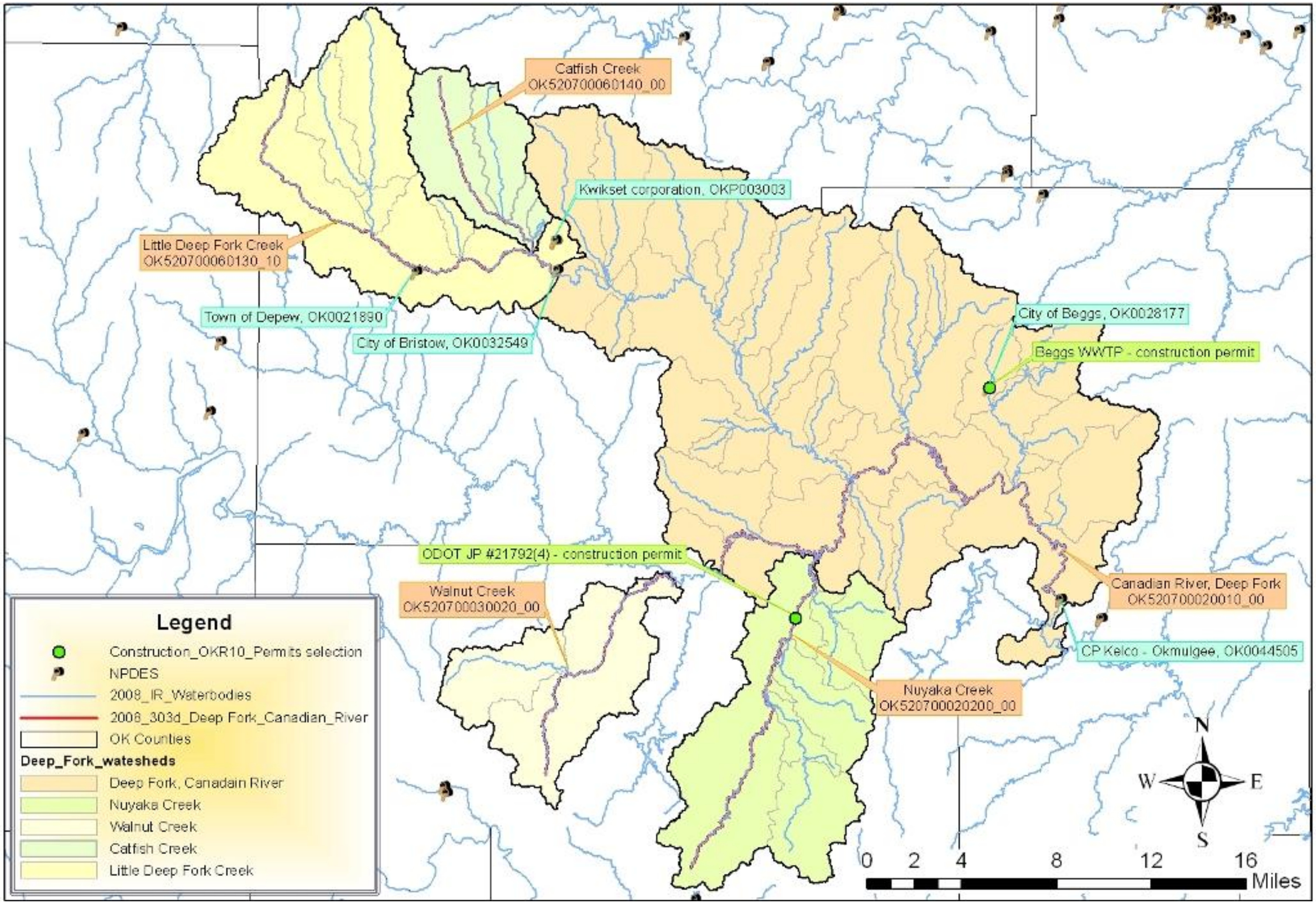
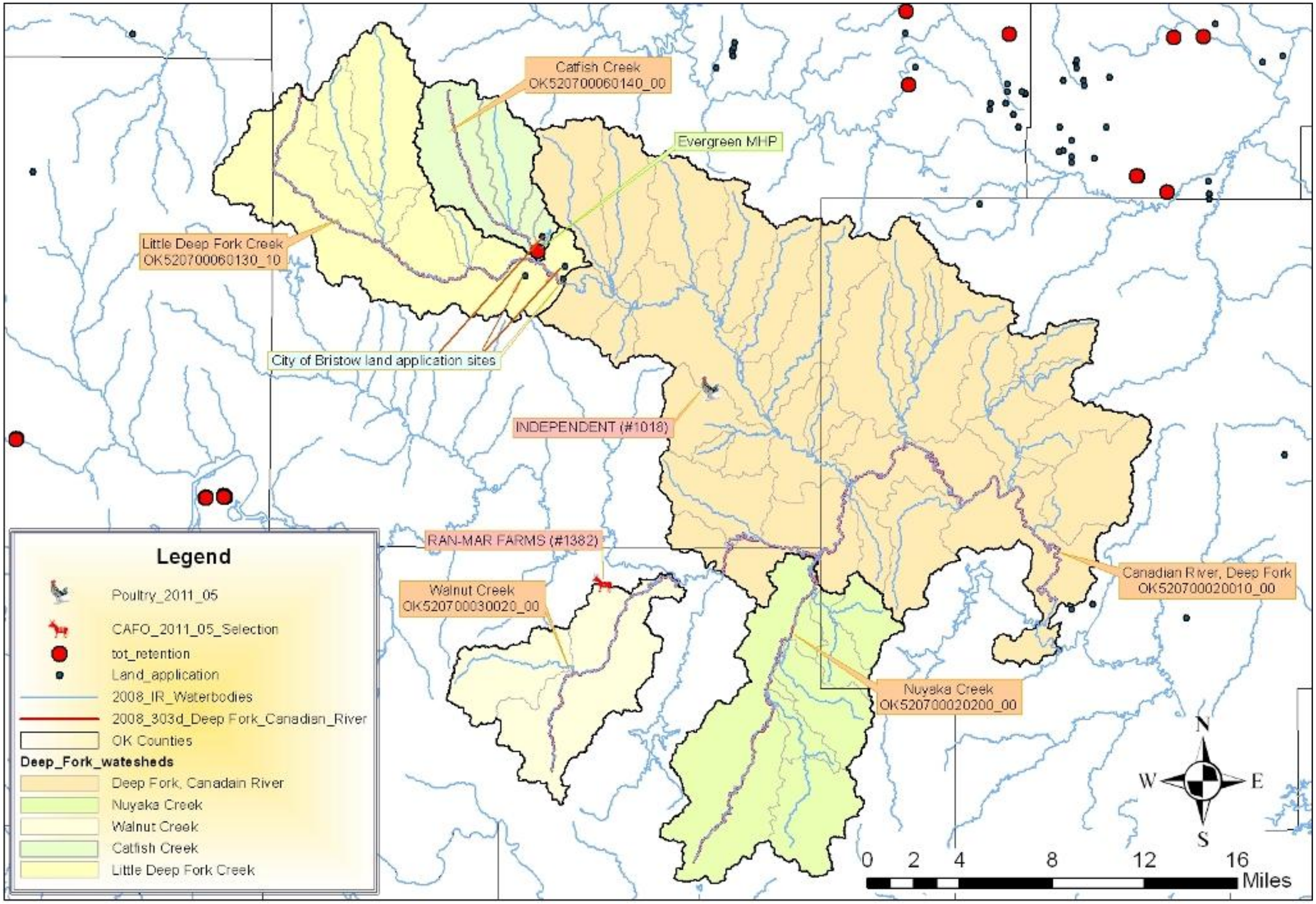


Figure 3-2 Locations of CAFOs, Poultry, Total Retention Facilities and Land Application Sites in the Study Area



3.1.3 NPDES Municipal Separate Storm Sewer Discharge

Phase I MS4

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

Phase II MS4

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

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

The small MS4 General Permit for communities in Oklahoma became effective on February 8, 2005. ODEQ provides information on the current status of the MS4 program on its website, which can be found at: http://www.deq.state.ok.us/WQDnew/stormwater/ms4/.

There is no permitted MS4s in the study area.

3.1.4 Concentrated Animal Feeding Operations and Poultry Feeding Operations

The Agricultural Environmental Management Services (AEMS) of the Oklahoma Department of Agriculture, Food and Forestry (ODAFF) was created to help develop, coordinate, and oversee environmental policies and programs aimed at protecting the Oklahoma environment from pollutants associated with agricultural animals and their waste. Through regulations established by the Oklahoma Concentrated Animal Feeding Operation (CAFO) Act and Poultry Feeding Operation (PFO) Registration Act, AEMS works with producers and concerned citizens to ensure that animal waste does not impact the waters of the state.

(1) CAFOs

A CAFO is an animal feeding operation that confines and feeds at least 1,000 animal units for 45 days or more in a 12-month period (ODAFF 2005). The CAFO Act and SFO Act are designed to protect water quality through the use of best management practices (BMP) such as dikes, berms, terraces, ditches, or other similar structures used to isolate animal waste from outside surface drainage, except for a 25-year, 24–hour rainfall event (ODAFF 2005). CAFOs are considered no-discharge facilities.

CAFOs are designated by USEPA as significant sources of pollution, and may have the potential to cause serious impacts to water quality if not managed properly. Potential problems from CAFOs can include unauthorized discharges of bacteria or nutrient loads to waters of the state and failure to properly operate wastewater lagoons. CAFOs are not considered a source of TSS loading. The location of each CAFO is shown in Figure 3-2 and is listed in Table 3-3. CAFO data used in this report were provided by ODAFF in May of 2011.

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

Table 3-3 NPDES-Permitted CAFOs in Study Area

ODAFF Location ID	EPA Facility	License #	Company	Max # of Swine >55 lbs units at facility	Max # of Swine <55 lbs units at facility	Total # of Animal Units at Facility	County	Waterbody ID and Waterbody Name
AGN031723		1382	RAN-MAR FARMS	1500	0	1500	Okfuskee	OK520700030020_00

(2). PFOs

A registered PFO is an animal feeding operation which raises chicken and generates more than 10 tons of poultry waste (litter) per year. PFO is required to develop an Animal Waste Management Plan (AWMP) or an equivalent document such as Nutrient Management Plan (NMP) to store and apply litter properly in order to protect water quality of streams and lakes located in the watershed. Applicable BMPs shall be included in the Plan.

Per data provided by ODAFF in May 2011, there is only one PFO located in the watershed as shown on Table 3-4. It generates dry litter and does not have any significant impact on the watershed.

Table 3-4 Registered PFOs in Study Area

Waterbody ID	Waterbody Name	Company Name	Poultry ID	County	Type	Total Birds
OK520700020010_10	Canadian River, Deep Fork	Fisher Ag. Enterprises, Inc	1018	Okmulgee	Layer	30,000

3.1.5 Stormwater Permits Construction Activities

A general stormwater permit (OKR10) is required by the ODEQ for any stormwater discharges associated with construction activities that result in land disturbance of equal to or greater than one (1) acre, or less than one (1) acre if they are part of a larger common plan of development or sale that totals at least one (1) acre. The permit also authorizes any stormwater discharges from support activities (e.g. concrete or asphalt batch plants, equipment staging yards, material storage areas, excavated material disposal areas, and borrow areas) that are directly related to a construction site that is required to have permit coverage, and is not a commercial operation serving unrelated different sites (ODEQ 2007). Stormwater discharges occur only during or immediately following periods of rainfall and elevated flow conditions when the turbidity criteria do not apply and are not considered potential contributors to turbidity impairment. The construction permits are summarized in Table 3-5.

3.1.6 Rock, Sand and Gravel Quarries

Operators of rock, sand and gravel quarries in Oklahoma are regulated with a general permit (OKG950000) issued by the ODEQ. The general permit does not allow discharge of wastewater to waterbodies included in Oklahoma's 303(d) List of impaired water bodies listed for turbidity for which a TMDL has not been performed or the result of the TMDL indicates that discharge limits more stringent than 45 mg/l for TSS are required (ODEQ 2009). If the TMDL shows that a TSS limit more stringent than 45 mg/L is required, an individual discharge permit with the TMDL required TSS limit will be issued to the facility. According to the data from the Oklahoma Department of Mines, there are no rock, sand and gravel quarries located within the Study Area.

3.1.7 Section 404 permits

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

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

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

Table 3-5 Construction Permits Summary

Company Name	County	Permit ID	Date Issued	Waterbody ID	Receiving Water (Permit)	Estimated Acres
ODOT JP #21792(04)	OKFUSKEE	8462	10/30/2007	OK520700030020_00	Nuyaka Creek	6
BEGGS WASTEWATER TREATMENT P	OKMULGEE	9210		OK520700020010_10	Unnamed trib to Adams Creek, to Deep Fork of Canadian River	2

3.2 Nonpoint Sources

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

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

3.2.1 Wildlife

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

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

According to a study conducted by the American Society of Agricultural Engineers (ASAE), deer release approximately $5x10^8$ fecal coliform units per animal per day (ASAE 1999). Although only a fraction of the total fecal coliform loading produced by the deer population may actually enter a waterbody, the estimated fecal coliform production based on the estimated deer population provided in Table 3-6 in cfu/day provides a relative magnitude of loading in each watershed.

Table 3-6 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
OK520700020010_10	Canadian River, Deep Fork	203994	3005	0.0147	1502
OK520700060130_10	Little Deep Fork Creek	61715	764	0.0124	382
OK520700060140_00	Catfish Creek	18826	237	0.0126	118

3.2.2 Non-Permitted Agricultural Activities and Domesticated Animals

There are a number of non-permitted agricultural activities that can also be sources of bacteria or TSS 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 bacteria sources include:

Processed commercially raised farm animal manure is often applied to fields as fertilizer, and can contribute to fecal bacteria loading to waterbodies if washed into streams by runoff.

Animal grazing in pastures deposit manure containing fecal bacteria onto land surfaces. These bacteria may be washed into waterbodies by runoff.

Animal often have direct access to waterbodies and can provide a concentrated source of fecal bacteria loading directly into streams or can cause unstable stream banks which can contribute TSS.

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

Detailed information is not available to describe or quantify the relationship between instream concentrations of bacteria and land application of manure from commercially raised farm animal. Nor is sufficient information available to describe or quantify the contributions of sediment loading caused by commercially raised farm animal responsible for destabilizing stream banks or erosion in pasture fields. The estimated acreage by watershed where manure was applied in 2002 is shown in Table 3-7. These estimates are also based on the county level reports from the 2002 USDA county agricultural census, and thus, represent approximations of the commercially raised farm animal populations in each watershed. 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 bacteria loading to the watersheds in the Study Area.

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

Beef cattle release approximately 1.04E+11 fecal coliform counts per animal per day;

Dairy cattle release approximately 1.01E+11 per animal per day

Swine release approximately 1.08E+10 per animal per day

Chickens release approximately 1.36E+08 per animal per day

Sheep release approximately 1.20E+10 per animal per day

Horses release approximately 4.20E+08 per animal per day;

Turkey release approximately 9.30E+07 per animal per day

Ducks release approximately 2.43E+09 per animal per day

Geese release approximately 4.90E+10 per animal per day

Using the estimated animal populations and the fecal coliform production rates from ASAE, an estimate of fecal coliform production from each group of commercially raised farm animal was calculated in each watershed of the Study Area in Table 3-8. Note that only a small fraction of these fecal coliform are expected to represent loading into waterbodies, either washed into streams by runoff or by direct deposition from wading animals. Cattle again appear to represent the most likely commercially raised farm animal source of fecal bacteria.

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

Waterbody ID	Waterbody Name	Cattle & Calves-all	Dairy Cows	Horses & Ponies	Goats	Sheep & Lambs	Hogs & Pigs	Ducks & Geese	Chicken & Turkeys	Acres of Manure Application
OK520700020010_10	Canadian River, Deep Fork	17,277	94	1,315	2	306	725	244	5,956	744
OK520700060130_10	Little Deep Fork Creek	4,375	46	405	2	115	128	123	3,332	248
OK520700060140_00	Catfish Creek	1,267	11	124	0	33	40	40	1,101	59

Table 3-8 Fecal Coliform Production Estimates for Commercially Raised Farm Animals ($x10^9$ number/day)

Waterbody ID	Waterbody Name	Cattle & Calves-all	Dairy Cows	Horses & Ponies	Goats	Sheep & Lambs	Hogs & Pigs	Ducks & Geese	Chickens & Turkeys	Total
OK520700020010_10	Canadian River, Deep Fork	1,796,790	9,449	552	20	3,671	7,834	592	810	1,819,718
OK520700060130_10	Little Deep Fork Creek	454,969	4,690	170	21	1,378	1,382	299	453	463,362
OK520700060140_00	Catfish Creek	131,809	1,065	52	4	391	429	97	150	133,996

3.2.3 Failing Onsite Wastewater Disposal Systems and Illicit Discharges

ODEQ is responsible for implementing the regulations of Title 252, Chapter 641 of the Oklahoma Administrative Code, which defines design standards for individual and small public onsite sewage disposal systems (ODEQ 2004). OSWD systems and illicit discharges can be a source of bacteria loading to streams and rivers. Bacteria loading from failing OSWD systems can be transported to streams in a variety of ways, including runoff from surface ponding or through groundwater. Fecal coliform-contaminated groundwater discharges to creeks through springs and seeps.

To estimate the potential magnitude of OSWDs fecal bacteria loading, the number of OSWD systems was estimated for each watershed. The estimate of OSWD systems was derived by using data from the 1990 U.S. Census (U.S. Census Bureau 2000). The density of OSWD systems within each watershed was estimated by dividing the number of OSWD systems in each census block by the number of acres in each census block. This density was then applied to the number of acres of each census block within a WQM station watershed. Census blocks crossing a watershed boundary required additional calculation to estimate the number of OSWD systems based on the proportion of the census tracking falling within each watershed. This step involved adding all OSWD systems for each whole or partial census block.

Over time, most OSWD systems operating at full capacity will fail. OSWD system failures are proportional to the adequacy of a state's minimum design criteria (Hall 2002). The 1995 American Housing Survey conducted by the U.S. Census Bureau estimates that, nationwide, 10 percent of occupied homes with OSWD systems experience malfunctions during the year (U.S. Census Bureau 1995). A study conducted by Reed, Stowe & Yanke, LLC (2001) reported that approximately 12 percent of the OSWD systems in east Texas and 8 percent 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 3-9 summarizes estimates of sewered and unsewered households for each watershed in the Study Area.

Table 3-9 Estimates of Sewered and Unsewered Households

Waterbody ID	Waterbody Name	Public Sewer	Septic Tank	Other Means	Housing Units	% Sewered
OK520700020010_10	Canadian River, Deep Fork	3,392	2,398	57	5,847	58.0%
OK520700060130_10	Little Deep Fork Creek	560	586	18	1,164	48.1%
OK520700060140_00	Catfish Creek	346	278	8	632	54.7%

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

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

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

The average of number of people per household was calculated to be 2.44 for counties in the Study Area (U.S. Census Bureau 2000). Approximately 70 gallons of wastewater were estimated to be produced on average per person per day (Metcalf and Eddy 1991). The fecal coliform concentration in septic tank effluent was estimated to be 10^6 per 100 mL of effluent based on reported concentrations from a number of publications (Metcalf and Eddy 1991; Canter and Knox 1985; Cogger and Carlile 1984). Using this information, the estimated load from failing septic systems within the watersheds was summarized below in Table 3-10.

Table 3-10 Estimated Fecal Coliform Load from OSWD Systems

Waterbody ID	Waterbody Name	Acres	Septic Tank	# of Failing Septic Tanks	Estimated Loads from Septic Tanks (x 10^9 counts/day)
OK520700020010_10	Canadian River, Deep Fork	203,994	2398	240	1639
OK520700060130_10	Little Deep Fork Creek	61,715	586	59	401
OK520700060140_00	Catfish Creek	18,826	278	28	190

3.2.4 Domestic Pets

Fecal matter from dogs and cats, which is transported to streams by runoff from urban and suburban areas, can be a potential source of bacteria loading. On average 37.2 percent of the nation's households own dogs and 32.4 percent own cats and in these households the average number of dogs is 1.7 and 2.2 cats per household (American Veterinary Medical Association 2007). Using the U.S. Census data at the block level (U.S. Census Bureau 2010), dog and cat populations can be estimated for each watershed. Table 3-11 summarizes the estimated number of dogs and cats for the watersheds of the Study Area.

Table 3-11 Estimated Numbers of Pets

Waterbody ID	Waterbody Name	Dogs	Cats
OK520700020010_10	Canadian River, Deep Fork	3,678	4,116
OK520700060130_10	Little Deep Fork Creek	732	819
OK520700060140_00	Catfish Creek	398	445

Table 3-12 provides an estimate of the fecal coliform load from pets. These estimates are based on estimated fecal coliform production rates of 5.4×10^8 per day for cats and 3.3×10^9 per day for dogs (Schueler 2000).

Table 3-12 Estimated Fecal Coliform Daily Production by Pets ($\times 10^9$ counts/day)

Waterbody ID	Waterbody Name	Dogs	Cats	Total
OK520700020010_10	Canadian River, Deep Fork	12,137	2,223	14,359
OK520700060130_10	Little Deep Fork Creek	2,416	443	2,859
OK520700060140_00	Catfish Creek	1,312	240	1,552

3.3 Summary of Bacteria Sources

The Deep Fork of Canadian River and Little Deep Fork Creek watersheds have continuous point source discharge. There is no CAFO in the Deep Fork of Canadian River and Little Deep Fork Creek watershed which require bacterian TMDLs. The various nonpoint sources are considered to be the major source of bacteria loading in each watershed that requires a TMDL for bacteria.

Table 3-13 below provides a summary of the estimated fecal coliform loads in cfu/day for the four major nonpoint source categories (commercially raised farm animals, pets, deer, and septic tanks) that contribute to the elevated bacteria concentrations in each watershed. Livestock are estimated to be the largest contributors of fecal coliform loading to land surfaces. It must be noted that while no data are available to estimate populations and fecal loading of wildlife other than deer, a number of bacteria source tracking studies around the nation demonstrate that wild birds and mammals represent a major source of the fecal bacteria found in streams.

Table 3-13 Summary of Fecal Coliform Load Estimates from Nonpoint Sources to Land Surfaces

Waterbody ID	Waterbody Name	Commercially Raised Farm Animals	Pets	Deer	Estimated Loads from Septic Tanks
OK520700020010_10	Canadian River, Deep Fork	99.05%	0.78%	0.08%	0.09%
OK520700060130_10	Little Deep Fork Creek	99.22%	0.61%	0.08%	0.09%
OK520700060140_00	Catfish Creek	98.63%	1.14%	0.09%	0.14%

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.

Of the 3 watersheds in the Study Area that require turbidity TMDLs, None of them have industrial permitted sources of TSS that will necessitate a WLA. Therefore, nonsupport of WWAC use in the all watersheds is caused primarily by nonpoint sources of TSS. Sediment loading of streams can originate from natural erosion processes, including the weathering of soil, rocks, and uncultivated land; geological abrasion; and other natural phenomena. There is insufficient data available to quantify contributions of TSS from these natural processes. TSS or sediment loading can also occur under non-runoff conditions as a result of anthropogenic activities in riparian corridors which cause erosive conditions. Given the lack of data to establish the background conditions for TSS/turbidity, separating background loading from nonpoint sources whether it is from natural or anthropogenic processes is not feasible in this TMDL development.

SECTION 4
TECHNICAL APPROACH AND METHODS

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

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

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

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

4.1 Determining a Surrogate Target for Turbidity

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

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

- Replace TSS samples of "<10" with 9.99;
- Remove data collected under high flow conditions exceeding the base-flow criterion. This means that measurements corresponding to flow exceedance percentiles lower than 25^{th} were not used in the regression;
- Check rainfall data on the day when samples were collected and on the previous two days. If there was a significant rainfall event (>= 1.0 inch) in any of these days, the sample will be excluded from regression analysis with one exception. If the significant rainfall happened on the sampling day and the turbidity reading was less than 25 NTUs (half of turbidity standard for streams), the sample will not be excluded from analysis because most likely the rainfall occurred after the sample was taken, and

- Log-transform both turbidity and TSS data to minimize effects of their non-linear data distributions.

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

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

LOC minimizes fitted residuals in both the X and Y directions;

It provides a unique best-fit line regardless of which parameter is used as the independent variable; and

Regression-fitted values have the same variance as the original data.

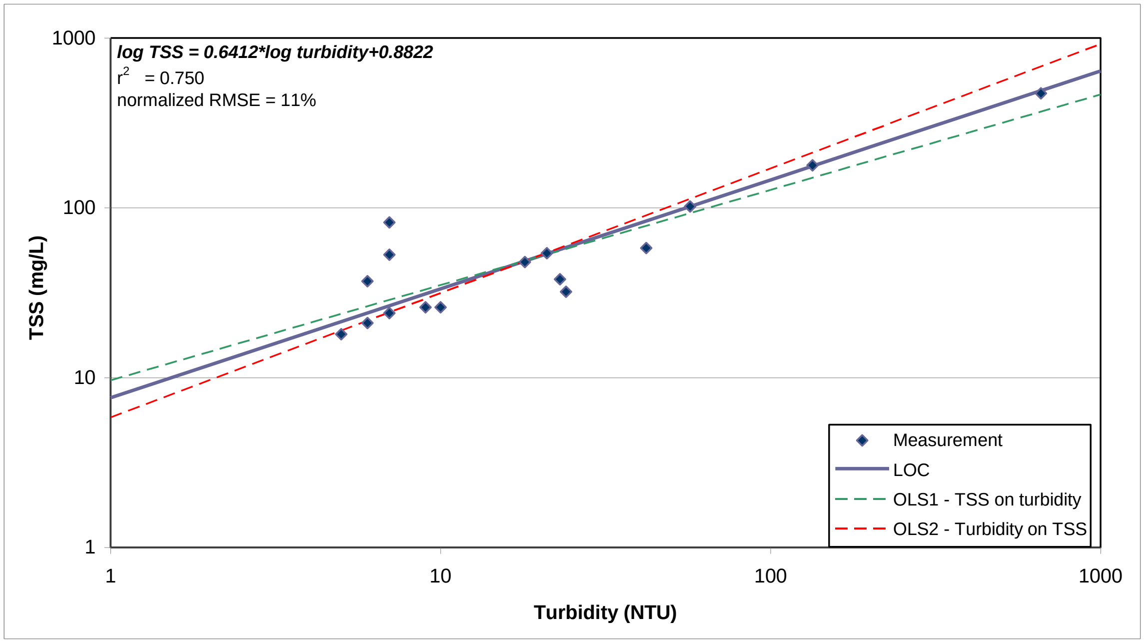
The LOC minimizes the areas of the right triangles formed by horizontal and vertical lines drawn from observations to the fitted line. The slope of the LOC line equals the geometric mean of the Y on X (TSS on turbidity) and X on Y (turbidity on TSS) OLS slopes, and is calculated as:

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

where $m1$ is the slope of the LOC line, m is the TSS on turbidity OLS slope, m' is the turbidity on TSS OLS slope, r is the TSS-turbidity correlation coefficient, s_y is the standard deviation of the TSS measurements, and s_x is the standard deviation of the turbidity measurements.

The intercept of the LOC ($b1$) is subsequently found by fitting the line with the LOC slope through the point (mean turbidity, mean TSS). Figures 4-1 shows an example of the correlation between TSS and turbidity, along with the LOC and the OLS lines.

Figure 4-1 Linear Regression for TSS-Turbidity for the Red River, North Fork, Headrick (OK311500010020_10)



The NRMSE and R-square (r^2) were used as the primary measures of goodness-of-fit. As shown in Figure 4-1, the LOC yields a NRMSE value of 11% which means the root mean square error (RMSE) is 11% of the average of the measured TSS values. The R-square (r^2) value indicates the fraction of the total variance in TSS or turbidity observations that is explained by the LOC. The regression equation can be used to convert turbidity standard of 50 NTUs to TSS goals.

It was noted that there may be a few outliers that exerted undue influence on the regression relationship. These outliers were identified by applying the Tukey's Boxplot method (Tukey 1977) to the dataset of the distances from observed points to the regression line. The Tukey Method is based on the interquartile range (IQR), the difference between the 75th percentile (Q_3) and 25th percentile (Q_1) of distances between observed points and the LOC. Using the Tukey method, any point with an error greater than $Q_3 + 1.5*$ IQR or less than $Q_1 - 1.5*$IQR was identified as an outlier and removed from the regression dataset. The above regressions were calculated using the dataset with outliers removed.

The Tukey Method is equivalent to using three times the standard deviation to identify outliers if the residuals (observed - predicted) follow a normal distribution. The probability of sampling results being within three standard deviations of the mean is 99.73% while the probability for the Tukey Method is 99.65%. If three times the standard deviation is used to identify outliers, it is necessary to first confirm that the residuals are indeed normally distributed. This is difficult to do because of the size limitations of the existing turbidity &

TSS dataset. Tukey's method does not rely on any assumption about the distribution of the residuals. It can be used regardless of the shape of distribution.

Outliers were removed from the dataset only for calculating the turbidity-TSS relationship, not from the dataset used to develop the TMDL.

The regression between TSS and turbidity and its statistics for each turbidity impaired stream segments will be shown in Section 5.1.

4.2 Using Load Duration Curves to Develop TMDLs

The TMDL calculations presented in this report are derived from load duration curves (LDC). LDCs facilitate rapid development of TMDLs, and as a TMDL development tool are effective at identifying whether impairments are associated with point or nonpoint sources. The technical approach for using LDCs for TMDL development includes the following steps that are described in Subsections 4.3 through 4.5 below:

Preparing flow duration curves for gaged and ungaged WQM stations;

Estimating existing loading in the waterbody using ambient bacteria water quality data; and estimating loading in the waterbody using measured TSS water quality data and turbidity-converted data; and

Using LDCs to identify the critical condition that will dictate loading reductions and the overall percent reduction goal (PRG) necessary to attain WQS.

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

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.

4.3 Development of Flow Duration Curves

Flow duration curves serve as the foundation of LDCs and are graphical representations of the flow characteristics of a stream at a given site. Flow duration curves utilize the historical hydrologic record from stream gages to forecast future recurrence frequencies. Many WQM stations throughout Oklahoma do not have long-term flow data and therefore, flow frequencies must be estimated. Seventeen of the twenty-four waterbodies in the Study Area do not have USGS gage stations. The default approach used to develop flow frequencies necessary to establish flow duration curves considers watershed differences in rainfall, land use, and the hydrologic properties of soil that govern runoff and retention. A detailed explanation of the methods for estimating flow for ungaged streams is provided in Appendix B. The most basic method to estimate flows at an ungaged site involves 1) identifying an upstream or downstream flow gage; 2) calculating the contributing drainage areas of the ungaged sites and the flow gage; and 3) calculating daily flows at the ungaged site by using the flow at the gaged site multiplied by the drainage area ratio.

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

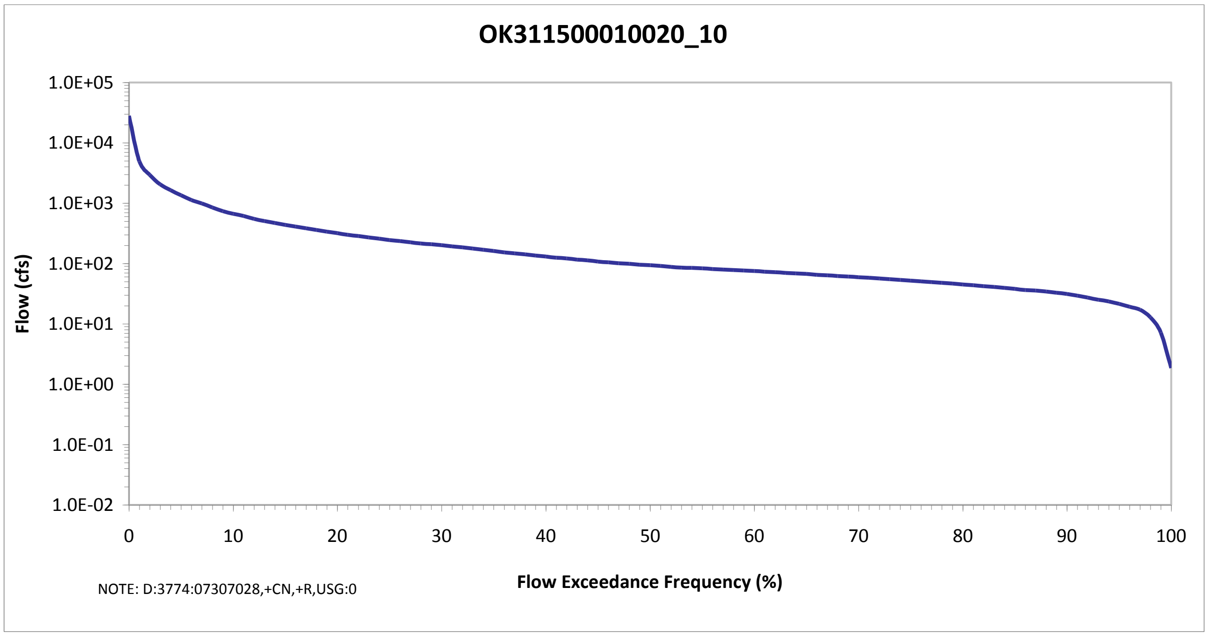
While the number of observations required to develop a flow duration curve is not rigorously specified, a flow duration curve is usually based on more than 1 year of observations, and encompasses inter-annual and seasonal variation. Ideally, the drought of record and flood of record are included in the observations. For this purpose, the long-term flow gaging stations operated by the USGS are utilized (USGS 2007a) 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. These were not combined with the daily average flows or used in calculating flow percentiles, but were matched to bacteria, turbidity, or TSS grab measurements collected at the same site and time. 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 percent and downward at a frequency near 100 percent, often with a relatively constant slope in between. For sites that on occasion exhibit no flow, the curve will intersect the abscissa at a frequency less than 100 percent. As the number of observations at a site increases, the line of the LDC tends to appear smoother. However, at extreme low and high flow values, flow duration curves may exhibit a “stair step” effect due to the USGS flow data rounding conventions near the limits of quantitation. An example of a typical flow duration curve was shown in Figure 4-2.

Figure 4-2 Flow Duration Curve for the Red River, North Fork, Headrick (OK311500010020_10)



Flow duration curve for each stream segment in this study will be developed in Section 5.2.

4.4 Estimating Existing Loading

A key step in the use of LDCs for TMDL development is the estimation of existing instream loads. This is accomplished by:

- matching the water quality observations with the flow data from the same date;
- converting measured concentration values to loads by multiplying the flow at the time the sample was collected by the water quality parameter concentration (for sampling events with both TSS and turbidity data, the measured TSS value is used; if only turbidity was measured, the value was converted to TSS using the regression equations described); or multiplying the flow by the bacteria indicator concentration to calculate daily loads.

4.5 Development of TMDLs Using Load Duration Curves

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

Step 1: Generate Bacteria LDCs. LDCs are similar in appearance to flow duration curves; however, for bacteria the ordinate is expressed in terms of a bacteria load in cfu/day, and for TSS the ordinate is expressed in terms of a load in lbs/day. The curve represents the single sample water quality criterion for fecal coliform (400 cfu/100 mL), *E. coli* (406 cfu/100 mL), or Enterococci (108 cfu/100 mL) expressed in terms of a load through multiplication by the continuum of flows historically observed at the site. For turbidity, the curve represents the water quality target for TSS from Table 5-1 expressed in terms of a load obtained through multiplication of the TSS goal by the continuum of flows historically observed at the site. The basic steps to generating an LDC involve:

- obtaining daily flow data for the site of interest from the USGS;
- sorting the flow data and calculating flow exceedance percentiles for the time period and season of interest;
- obtaining the water quality data from the primary contact recreation season (May 1 through September 30); or obtaining available turbidity and TSS water quality data;
- displaying a curve on a plot that represents the allowable load determined by multiplying the actual or estimated flow by the WQS for each respective bacteria indicator; or displaying a curve on a plot that represents the allowable load determined by multiplying the actual or estimated flow by the WQ_{goal} for TSS;
- matching the water quality observations with the flow data from the same date and determining the corresponding exceedance percentile;
- plotting the flow exceedance percentiles and daily load observations in a load duration plot (See Section 5).

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

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

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

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

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

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

where: WQ_{goal} = waterbody specific TSS concentration derived from regression analysis results presented in Table 5-1

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

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

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

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

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

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

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

WLA for bacteria:

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

Where:

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

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

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

WLA for TSS:

WLA = WQ goal * flow * unit conversion factor (lb/day)

Where:

WQ goal is provided in Table 5-1;

flow (10^6 gal/day) = permitted flow or average monthly flow

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

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

LAs can be calculated under different flow conditions as the water quality target load minus the WLA. The LA is represented by the area under the LDC but above the WLA. The LA at any particular flow exceedance is calculated as shown in the equation below.

LA = TMDL - WLA_WWTP - WLA_MS4 - MOS

WLA for MS4s. For bacteria TMDLs, if there are no permitted MS4s in the study area, WLA_MS4 is set to zero. When there are permitted MS4s in the watershed, we can first calculate the sum of LA + WLA_MS4 using the above formula, then separate WLA for MS4s from the sum based on the percentage of a watershed that is under a MS4 jurisdiction. This WLA for MS4s may not be the total load allocated for permitted MS4s unless the whole MS4 area is located within the study watershed boundary. However, in most case the study watershed intersects only a portion of the permitted MS4 coverage areas.

For turbidity TMDLs, WLAs for permitted stormwater such as MS4s, construction, and multi-sector general permits are not calculated since these discharges occur under high flow conditions when the turbidity criteria do not apply.

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

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

If permitted TSS limit is less than TSS goal for the receiving stream, there will be no reductions;

If permitted TSS limit is greater than TSS goal for the receiving stream, the permit limit will be set at the TSS goal.

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

SECTION 5
TMDL CALCULATIONS

5.1 Surrogate TMDL Target for Turbidity

Using the LOC method described in Section 4.1, the correlation between TSS and turbidity were developed for Deep Fork of Canadian River, Little Deep Fork Creek and Catfish Creek (Figure 5-1 through 5-3). The statistics of the regressions and the resultant TSS goals were shown in Table 5-1.

Figure 5-1 Linear Regression for TSS-Turbidity for Deep Fork of Canadian River (OK520700020010_10)

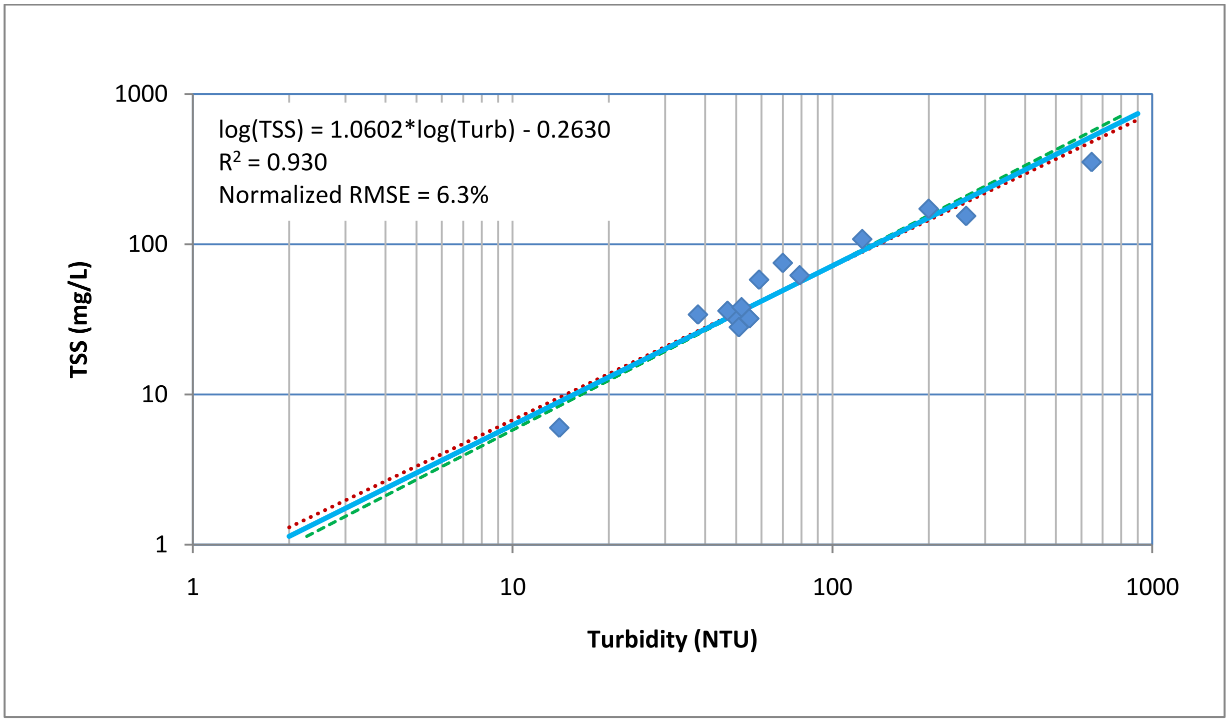


Figure 5-2 Linear Regression for TSS-Turbidity for Little Deep Fork Creek (OK520700060130_10)

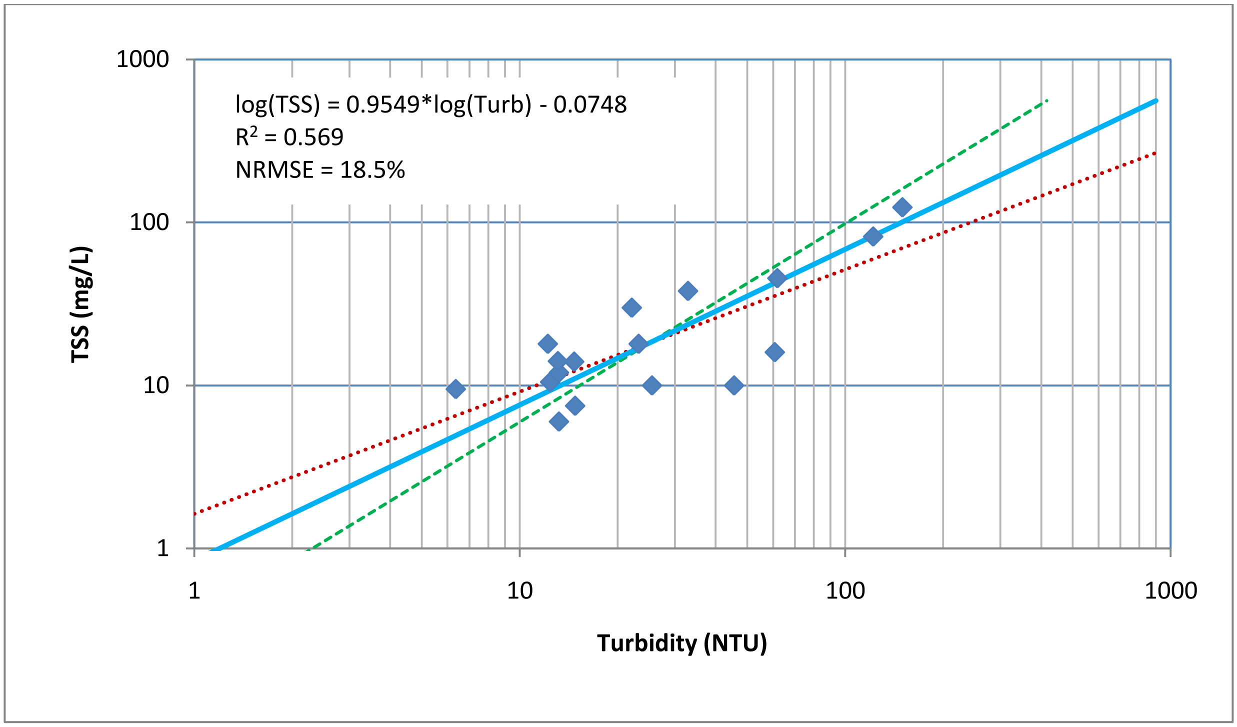


Figure 5-3 Linear Regression for TSS-Turbidity for Catfish Creek (OK520700060140_00)

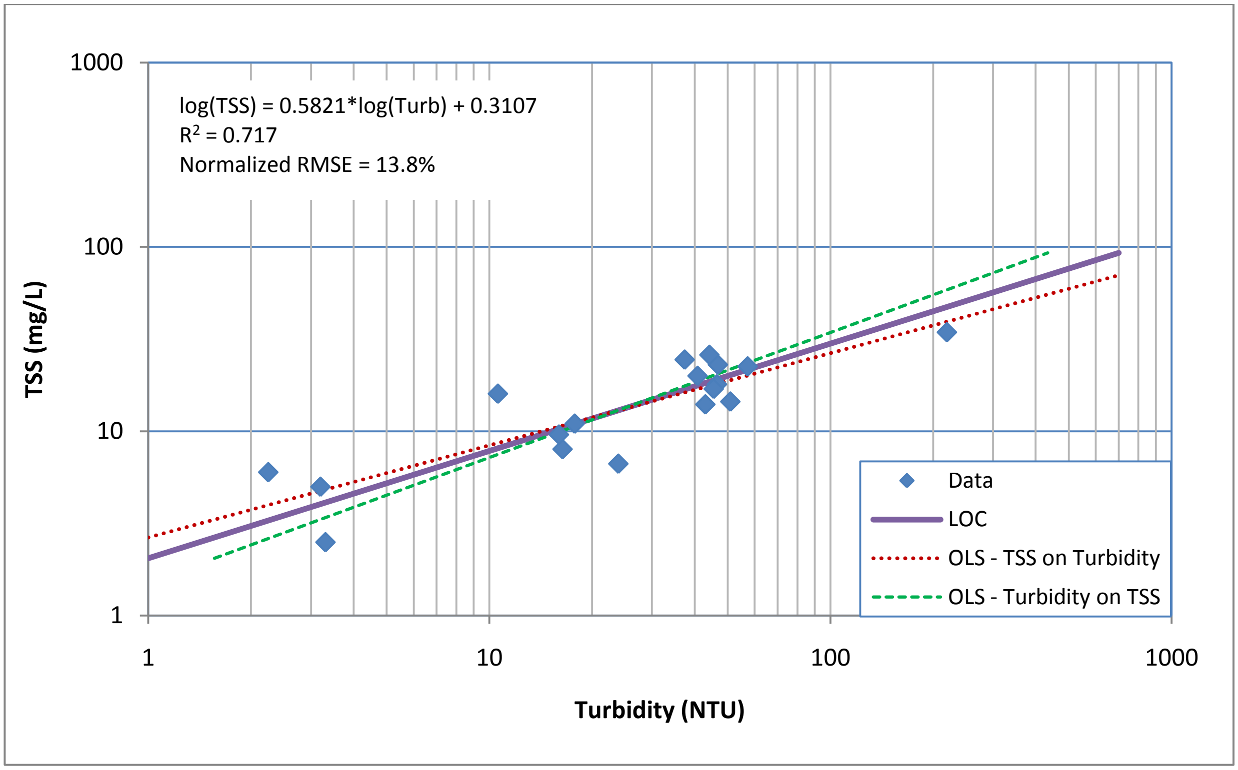


Table 5-1 Regression Statistics and TSS Goals

Waterbody ID	Waterbody Name	R-square	NRMSE	TSS Goal (mg/L)[a]	MOS[b]
OK520700020010_10	Deep Fork Creek	0.93	6.3%	34.5	10%
OK520700060130_10	Little Deep Fork Creek	0.57	18.5%	35.3	20%
OK520700060140_00	Catfish Creek	0.72	13.8%	19.9	15%

[a] Calculated using the regression equation and the turbidity standard (50 NTU)
[b] Based on the goodness-of-fit of the turbidity-TSS regression (NRMSE)

5.2 Flow Duration Curve

Following the same procedures described in Section 4.3, flow duration curve for each stream segment in this study was developed and shown in Figure 5-4 through Figure 5-6.

Figure 5-4 Flow Duration Curve for Deep Fork of Canadian River (OK520700020010_10)

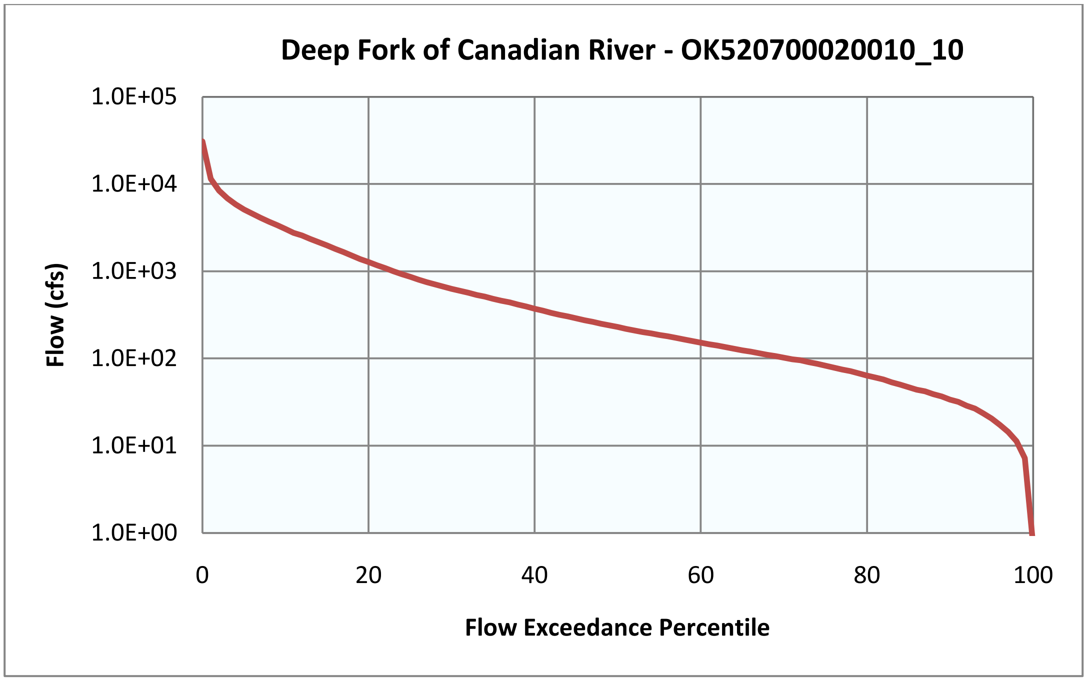


Figure 5-5 Flow Duration Curve for Little Deep Fork Creek (OK520700060130_10)

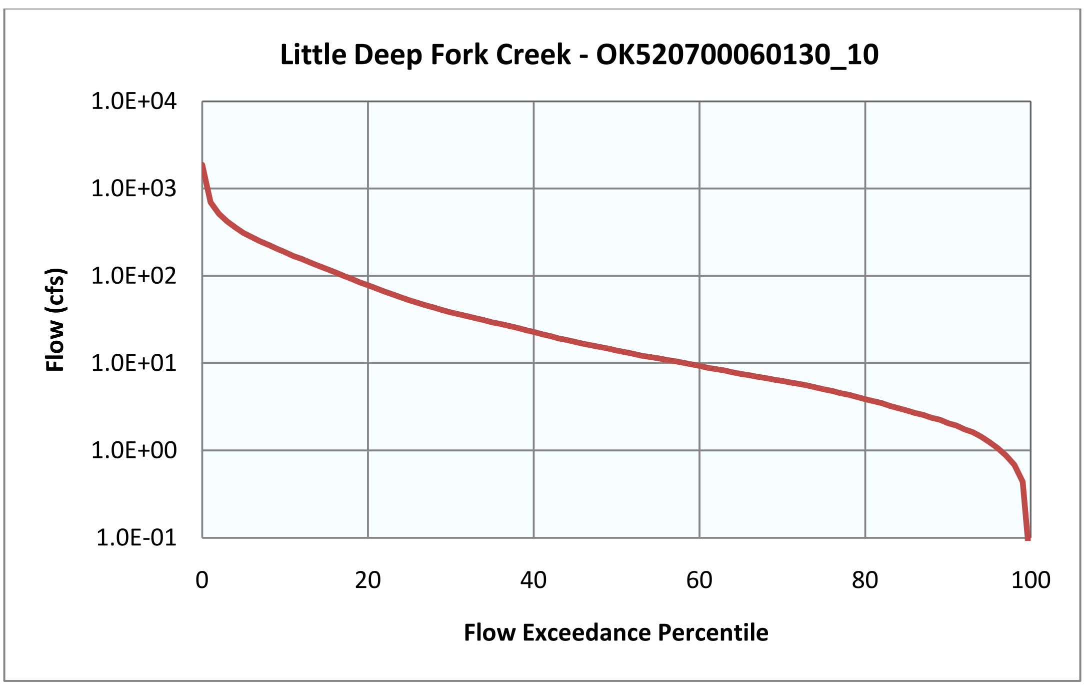
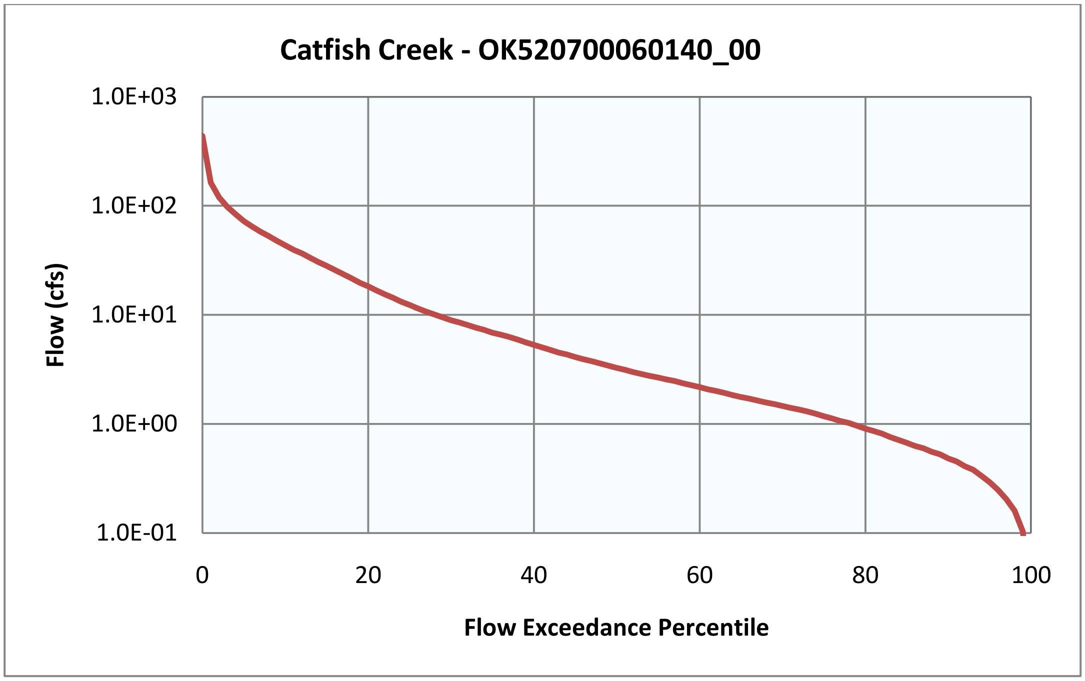


Figure 5-6 Flow Duration Curve for Catfish Creek (OK520700060140_00)



5.3 Estimated Loading and Critical Conditions

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

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

To estimate existing loading, bacteria observations for the primary contact recreation season (May 1st through September 30th) from 2002 to 2009 are paired with the flows measured or estimated in that waterbody on the same date. Pollutant loads are then calculated by multiplying the measured bacteria concentration by the flow rate and the unit conversion factor of *24,465,756 mLs /* ft^3 *day*. The associated flow exceedance percentile is then matched with the measured flow from the tables provided in Appendix B. The observed bacteria loads are then added to the LDC plot as points. These points represent individual ambient water quality samples of bacteria. Points above the LDC indicate the bacteria instantaneous standard was exceeded at the time of sampling. Conversely, points under the LDC indicate the sample met the WQS.

The bacteria LDCs developed for each impaired waterbody (representing the primary contact recreation season from 1999through 2006) are shown in Figures 5-7 through 5-9. Waterbodies may have more than one LDC because for the PBCR use to be supported, criteria for each bacterial indicator must be met in each impaired waterbody.

The LDCs for Deep Fork of Canadian River (Figures 5-7 & 8) are based on fecal coliform and Enterococci bacteria measurements collected during primary contact recreation season at WQM station 520700020010-001AT. The LDCs indicate that levels of fecal coliform and Enterococci exceed the instantaneous water quality criteria under all flow conditions.

Figure 5-7 Load Duration Curve for *Fecal Coliform in Deep Fork of* Canadian River (OK520700020010_10)

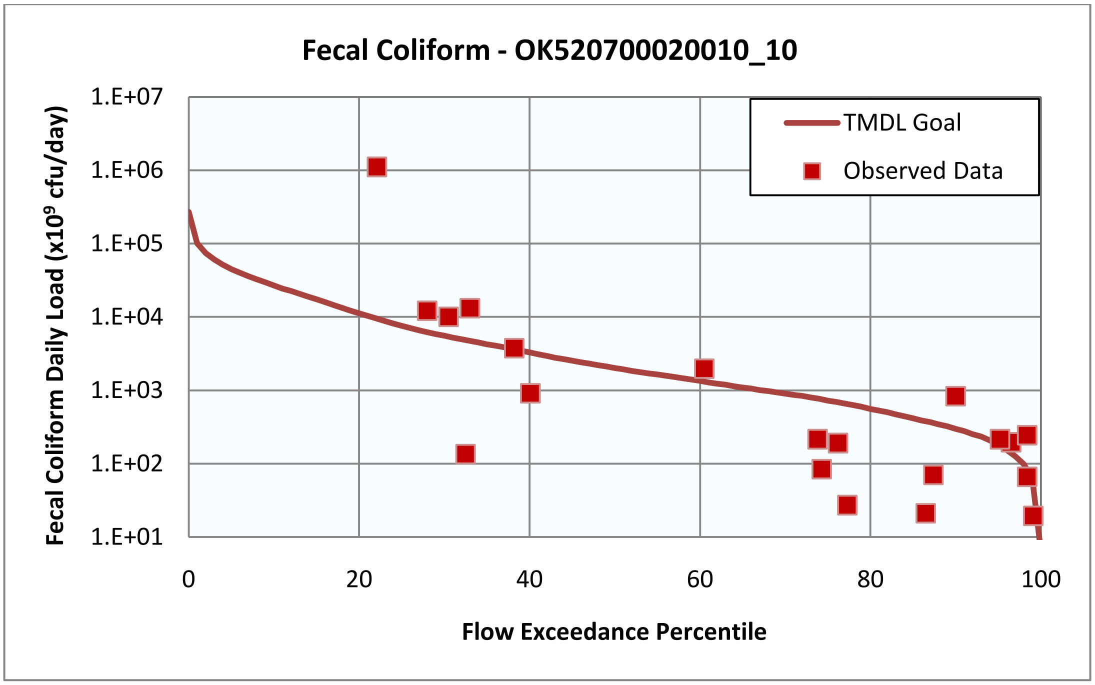
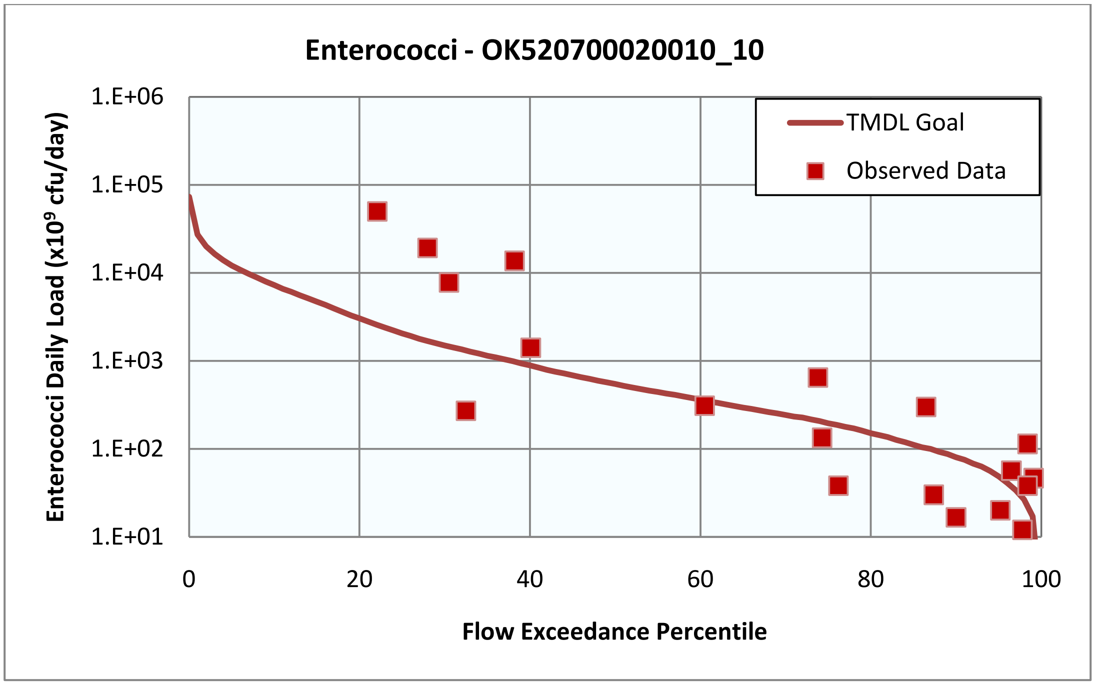
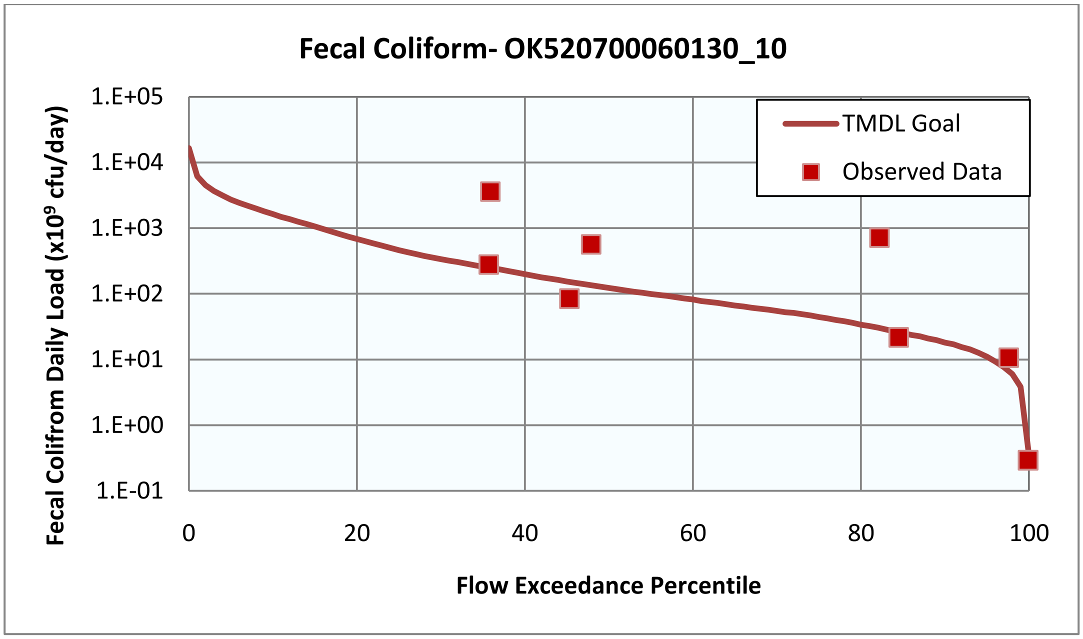


Figure 5-8 Load Duration Curve for *Enterococci in Deep Fork of* Canadian River (OK520700020010_10)



The LDCs for Little Deep Fork Creek (Figure 5-9) are based on *fecal coliform* bacteria measurements collected during primary contact recreation season at WQM station OK520700-06-0130T. The LDCs indicate that levels of *fecal coliform* exceed the instantaneous water quality criteria under all sampled flow conditions.

Figure 5-9 Load Duration Curve for *Fecal Coliform* in Little Deep Fork Creek (OK520700060130_10)



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

To estimate existing loading, TSS and turbidity observations from 1997 to 2010 are paired with the flows measured or projected on the same date for the waterbody. For sampling events with both TSS and turbidity data, the measured TSS value is used. Pollutant loads are then calculated by multiplying the TSS concentration by the flow rate and the unit conversion factor. The associated flow exceedance percentile is then matched with the flow from the tables provided in Appendix B. The observed TSS or converted turbidity loads are then added to the LDC plot as points. These points represent individual ambient water quality samples of TSS. Points above the LDC indicate the TSS goal was exceeded at the time of sampling. Conversely, points under the LDC indicate the sample did not exceed the TSS goal. For sampling events with only turbidity data, the turbidity data were converted to TSS with the corresponding regression relation developed in Section 5.1.

Figures 5-10 through Figure 5-13 show the TSS LDCs developed for the three turbidity impaired waterbodies addressed in this TMDL report. Data in the figures indicate that TSS levels exceed the water quality target during all flow conditions, indicating water quality impairments due to nonpoint sources or a combination of point and nonpoint sources. Wet weather influenced samples found during low flow conditions can be caused by an isolated rainfall event during dry weather conditions. It is noted that the LDC plots include data under all flow conditions to show the overall condition of the waterbody. However, the turbidity standard only applies for base-flow conditions. Thus, when interpreting the LDC to derive TMDLs for TSS, only the portion of the graph corresponding to flows above the 25th flow exceedance percentile should be used. WLAs for point sources discharges (continuous) of inorganic TSS are shown on a LDC as a horizontal line which represents the sum of all WLAs for TSS in a given watershed.

Figure 5-10 Load Duration Curve for Total Suspended Solids in Deep Fork of Canadian River (OK520700020010_10)

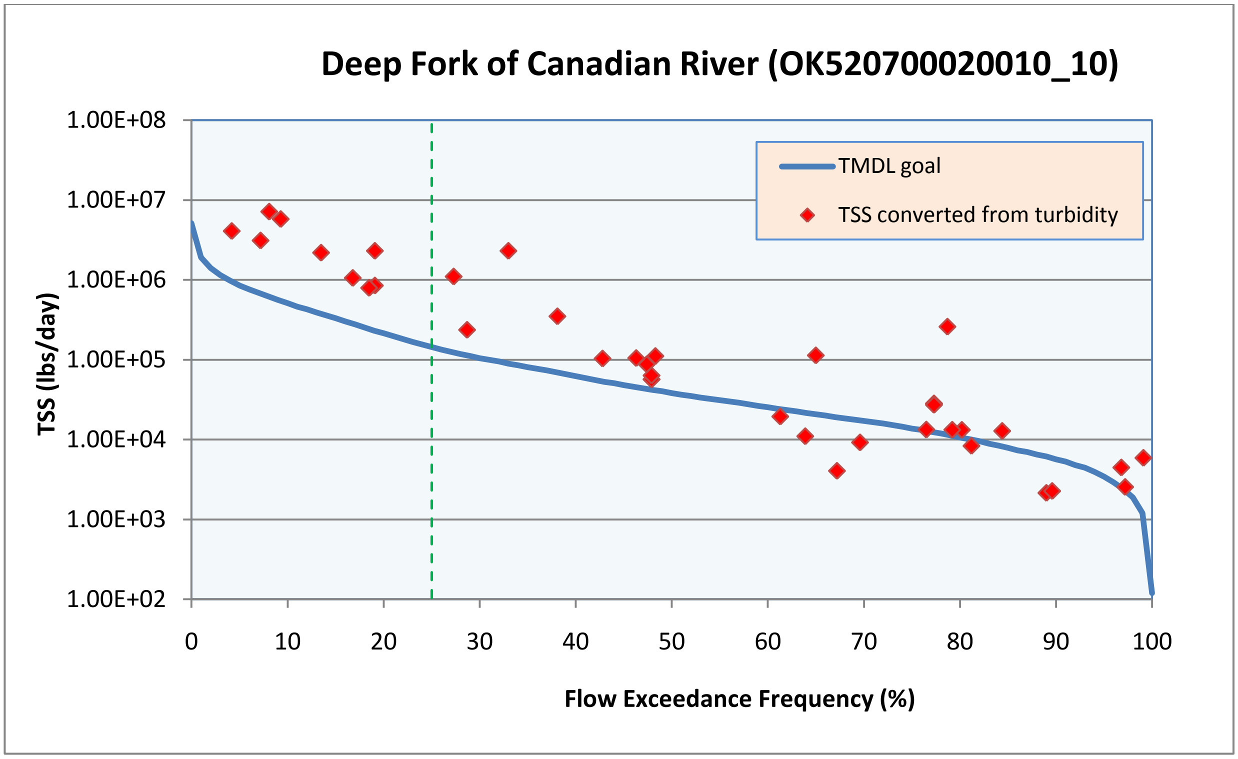


Figure 5-11 Load Duration Curve for Total Suspended Solids in Little Deep Fork Creek (OK520700060130_10)

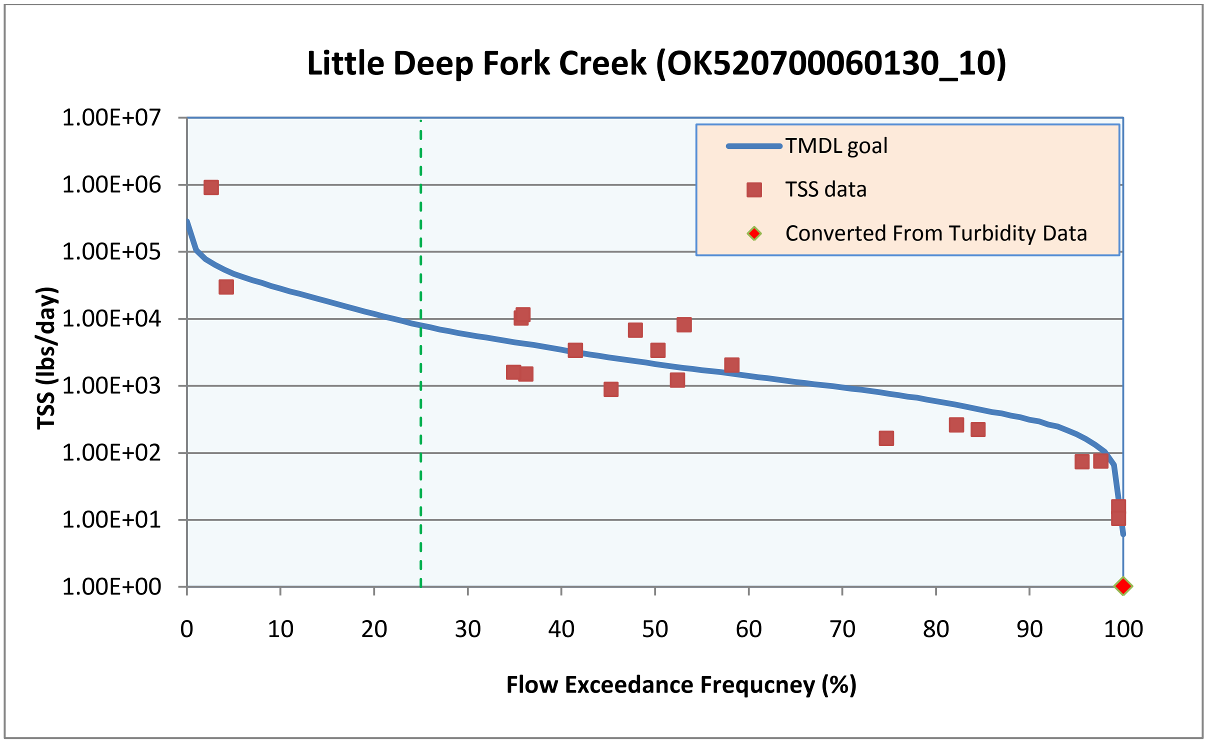
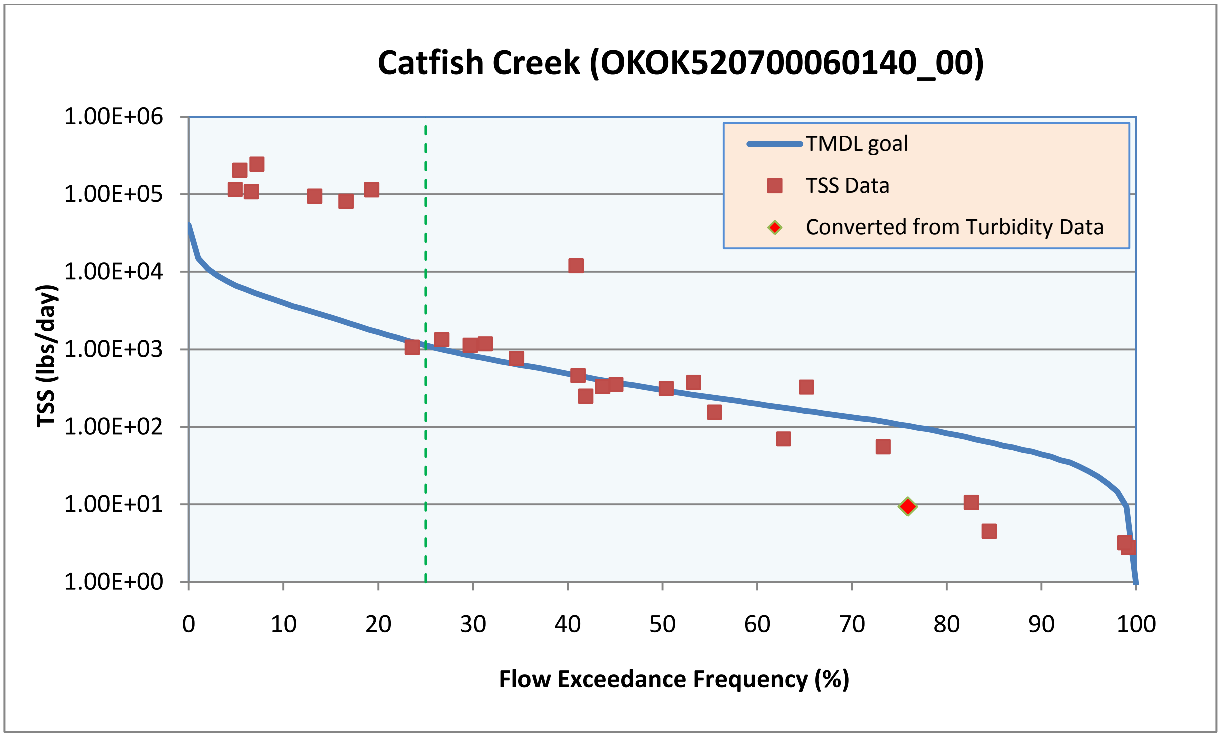


Figure 5-12 Load Duration Curve for Total Suspended Solids in Catfish Creek (OK520700060140_00)



Establishing Percent Reduction Goals: The LDC approach recognizes that the assimilative capacity of a waterbody depends on the flow, and that maximum allowable loading varies with flow condition. Existing loading and load reductions required to meet the TMDL water quality target can also be calculated under different flow conditions. The difference between existing loading and the water quality target is used to calculate the loading reductions required. Percent reduction goals are calculated through an iterative process of taking a series of percent reduction values applying each value uniformly between the concentrations of samples and verifying that no more than a fixed percent of the samples exceed the water quality target concentration. PRG are calculated for each watershed and bacterial indicator species as the reductions in load required so no existing instantaneous water quality observations would exceed the water quality targets for *E. coli* and Enterococci and no more than 25 percent of the samples exceed the water quality target for fecal coliform. This is because for the PBCR use to be supported, criteria for each bacterial indicator must be met in each impaired waterbody. Table 5-2 presents 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 46 to 78 percent.

Table 5-2 TMDL Percent Reductions Required to Meet Water Quality Standards for Indicator Bacteria

Waterbody ID	Waterbody Name	Required Reduction Rate				
		FC	EC		ENT	
		Instant-aneous	Instant-aneous	Geo-mean	Instant-aneous	Geo-mean
OK520700020010_10	Canadian River, Deep Fork Crk	**46.3%**			94.9%	**78.4%**
OK520700060130_10	Little Deep Fork Creek	**76.1%**				

Similarly, percent reduction goals for TSS are calculated as the required overall reduction so that no more than 10 percent of the samples exceed the water quality target for TSS. The PRGs for the three waterbodies included in this TMDL report are summarized in Table 5-3 and range from 35to 81 percent.

Table 5-3 TMDL Percent Reductions Required to Meet Water Quality Targets for Total Suspended Solids

Waterbody ID	Waterbody Name	Required Reduction Rate
OK520700020010_10	Canadian River, Deep Fork	81.3%
OK520700060130_10	Little Deep Fork Creek	64.9%
OK520700060140_00	Catfish Creek	34.9%

5.4 Wasteload Allocation

5.4.1 Indicator Bacteria

For bacteria TMDLs, NPDES-permitted facilities are allocated a daily wasteload calculated as their permitted flow rate multiplied by the instream geometric mean water quality criterion. In other words, the facilities are required to meet instream criteria in their discharge. Table 5-4 summarizes the WLA for the NPDES-permitted facilities within the study area. The WLA for each facility discharging to a bacteria-impaired reach is derived from the following equation:

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

Where:

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

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

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

When multiple NPDES facilities occur within a watershed, individual WLAs are summed and the total WLA for continuous point sources is included in the TMDL calculation for the corresponding waterbody. When there are no NPDES WWTPs discharging into the contributing watershed of a WQM station, then the WLA is zero. Compliance with the WLA will be achieved by adhering to the fecal coliform limits and disinfection requirements of NPDES permits. Table 5-4 indicates which point source dischargers within Oklahoma currently have a disinfection requirement in their permit. Certain facilities that utilize lagoons for treatment have not been required to provide disinfection since storage time and exposure to ultraviolet radiation from sunlight should reduce bacteria levels. In the future, all point source dischargers which are assigned a wasteload allocation but do not currently have a bacteria limit in their permit will receive a permit limit consistent with the wasteload allocation as their permits are reissued. Regardless of the magnitude of the WLA calculated in these TMDLs, future new discharges of bacteria or increased bacteria load from existing discharges will be considered consistent with the TMDL provided that the NPDES permit requires instream criteria to be met. Table 5-4a shows the wasteload allocations for each permitted facilities.

Table 5-4 Permit Information for NPDES-Permitted Facilities

Waterbody ID	Facility Name	NPDES Permit No.	Dis-infection	Design Flow (MGD)	FC Limits (cfu/100mL)	Expiration Date
OK520700060130_10	DEPEW, TOWN OF	OK0021890	No	0.15	no limits	05/31/11
	BRISTOW, CITY OF	OK0032549	Yes	1.75	200/400	09/30/14
OK520700020010_10	CP KELCO US, INC.-OKMULGEE	OK0044504	Yes	0.946	200/400	08/31/15
	BEGGS, CITY OF	OK0028177	Yes	0.175	200/400	05/31/16

Table 5-4a Wasteload Allocations for NPDES-Permitted Facilities

Waterbody ID	Stream Name	Facility Name	NPDES Permit No.	Pollutant	WLA (cfu/day)
OK520700060130_10	Little Deep Fork Creek	DEPEW, TOWN OF	OK0021890	FC	1.14E+09
		BRISTOW, CITY OF	OK0032549	FC	1.33E+10
OK520700020010_10	Canadian River, Deep Fork	CP KELCO US, INC.-OKMULGEE	OK0044504	FC	7.17E+09
		BEGGS, CITY OF	OK0028177	FC	1.33E+09
OK520700020010_10	Canadian River, Deep Fork	CP KELCO US, INC.-OKMULGEE	OK0044504	ENT	1.18E+09
		BEGGS, CITY OF	OK0028177	ENT	2.19E+08

Permitted stormwater discharges are considered point sources; however, there are no areas designated as MS4s within the watersheds of the waterbodies impaired for contact recreation, so the WLA for MS4 is zero.

5.4.2 Total Suspended Solids

NPDES-permitted facilities discharging inorganic TSS are allocated a daily wasteload calculated by using the average of self-reported monthly flow multiplied by the water quality target. In other words, the facilities are required to meet instream criteria in their discharge. If the current monthly TSS limits of a facility are greater than instream TSS criteria, the new limits equal to instream criteria will be applied to the facility as their permit is renewed. The WLA for each facility is derived as follows:

WLA_WWTP = WQ goal * flow * unit conversion factor (lb/day)

Where:

WQ goal = waterbody-specific water quality goal as summarized in Table 4-1

flow (10^6 gal/day) = average monthly flow

unit conversion factor = 8.3445 L*lb/(10^6 gal * mg)

There are no NPDES permitted facilities discharge inorganic TSS in the study area.

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

5.4.3 Section 404 permits

No TSS wasteload allocations were set aside for Section 404 permits. The state will use its Section 401 certification authority to ensure Section 404 permits protect Oklahoma water quality standards and comply with the turbidity TMDLs in this report. For any project requiring a Section 404 permit that is located on a waterbody with a turbidity TMDL established in this report, the Section 401 water quality certification will be conditioned to include one of the following two conditions:

- Include TSS limits consistent with this TMDL in the certification and establish a monitoring requirement to ensure compliance with the turbidity standards and TSS TMDLs.

or

- Submit to ODEQ a BMP-based turbidity reduction plan which should include all practicable turbidity control techniques. The turbidity reduction plan must be approved by ODEQ before a Section 401 water quality certification will be issued. The certification will include a condition requiring compliance with the approved plan.

Compliance with the Section 401 certification condition will be considered compliance with this TMDL.

5.5 Load Allocation

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

LA = TMDL – WLA_WWTP– MOS

This equation is used to calculate the LA for TSS however the LA is further reduced by allocating 1 percent of the TMDL as part of the WLA:

LA = TMDL – WLA_WWTP – WLA_growth – MOS

5.6 Seasonal Variability

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

5.7 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.

For bacteria TMDLs, an explicit MOS was set at 10 percent.

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

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

Waterbody ID	Waterbody Name	NRMSE	Margin of Safety
OK520700020010_10	Deep Fork Creek	6.3%	10%
OK520700060130_10	Little Deep Fork Creek	18.5%	20%
OK520700060140_00	Catfish Creek	13.8%	15%

5.8 TMDL Calculations

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

This definition can be expressed by the following equation:

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

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

The TMDL, WLA, LA, and MOS will vary with flow condition, and are calculated at every 5th flow interval percentile. Table 6 & 7 summarize the TMDL, WLA, LA and MOS loadings at the 50% flow percentile. Tables 5-8 through 5-13 summarize the allocations for indicator bacteria and Tables 5-14 to 5-17 present the allocations for total suspended solids.

Table 5-6 Summaries of Bacteria TMDLs

Waterbody ID	Stream Name	Pollutant	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)	TMDL (cfu/day)
OK520700020010_10	Canadian River, Deep Fork	FC	8.49E+09	2.01E+12	2.24E+11	2.24E+12
OK520700020010_10	Canadian River, Deep Fork	ENT	1.40E+09	5.44E+11	6.05E+10	6.05E+11
OK520700060130_10	Little Deep Fork Creek	FC	1.44E+10	1.14E+11	1.37E+10	1.37E+11

Table 5-7 Summaries of TSS TMDLs

Waterbody ID	Stream Name	Pollutant	WLA * (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
OK520700020010_10	Canadian River, Deep Fork	TSS	426.3	37938.1	4262.7	42627.1
OK520700060130_10	Little Deep Fork Creek	TSS	26.5	2097.4	531.0	2654.9
OK520700060140_00	Catfish Creek	TSS	3.5	294.7	52.6	350.9

* WLA reserved for growth

Table 5-8 *Fecal Coliform* TMDL Calculations for Deep Fork of Canadian River (OK520700020010_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	30774.74	3.01E+14	8.49E+09	0	2.71E+14	3.01E+13
5	5084.28	4.98E+13	8.49E+09	0	4.48E+13	4.98E+12
10	3048.52	2.98E+13	8.49E+09	0	2.68E+13	2.98E+12
15	1974.38	1.93E+13	8.49E+09	0	1.74E+13	1.93E+12
20	1278.74	1.25E+13	8.49E+09	0	1.13E+13	1.25E+12
25	864.43	8.46E+12	8.49E+09	0	7.61E+12	8.46E+11
30	627.09	6.14E+12	8.49E+09	0	5.51E+12	6.14E+11
35	481.83	4.72E+12	8.49E+09	0	4.24E+12	4.72E+11
40	372.37	3.64E+12	8.49E+09	0	3.27E+12	3.64E+11
45	287.46	2.81E+12	8.49E+09	0	2.52E+12	2.81E+11
50	229.15	2.24E+12	8.49E+09	0	2.01E+12	2.24E+11
55	186.18	1.82E+12	8.49E+09	0	1.63E+12	1.82E+11
60	152.43	1.49E+12	8.49E+09	0	1.33E+12	1.49E+11
65	123.78	1.21E+12	8.49E+09	0	1.08E+12	1.21E+11
70	102.30	1.00E+12	8.49E+09	0	8.93E+11	1.00E+11
75	82.35	8.06E+11	8.49E+09	0	7.17E+11	8.06E+10
80	63.43	6.21E+11	8.49E+09	0	5.50E+11	6.21E+10
85	47.06	4.61E+11	8.49E+09	0	4.06E+11	4.61E+10
90	33.76	3.30E+11	8.49E+09	0	2.89E+11	3.30E+10
95	20.46	2.00E+11	8.49E+09	0	1.72E+11	2.00E+10
100	0.72	8.49E+09	8.49E+09	0	0.00E+00	0.00E+00

Table 5-9 Enterococci TMDL Calculations for Deep Fork of Canadian River (OK520700020010_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	30774.74	8.13E+13	1.40E+09	0	7.32E+13	8.13E+12
5	5084.28	1.34E+13	1.40E+09	0	1.21E+13	1.34E+12
10	3048.52	8.06E+12	1.40E+09	0	7.25E+12	8.06E+11
15	1974.38	5.22E+12	1.40E+09	0	4.69E+12	5.22E+11
20	1278.74	3.38E+12	1.40E+09	0	3.04E+12	3.38E+11
25	864.43	2.28E+12	1.40E+09	0	2.05E+12	2.28E+11
30	627.09	1.66E+12	1.40E+09	0	1.49E+12	1.66E+11
35	481.83	1.27E+12	1.40E+09	0	1.14E+12	1.27E+11
40	372.37	9.84E+11	1.40E+09	0	8.84E+11	9.84E+10
45	287.46	7.60E+11	1.40E+09	0	6.82E+11	7.60E+10
50	229.15	6.05E+11	1.40E+09	0	5.44E+11	6.05E+10
55	186.18	4.92E+11	1.40E+09	0	4.41E+11	4.92E+10
60	152.43	4.03E+11	1.40E+09	0	3.61E+11	4.03E+10
65	123.78	3.27E+11	1.40E+09	0	2.93E+11	3.27E+10
70	102.30	2.70E+11	1.40E+09	0	2.42E+11	2.70E+10
75	82.35	2.18E+11	1.40E+09	0	1.94E+11	2.18E+10
80	63.43	1.68E+11	1.40E+09	0	1.49E+11	1.68E+10
85	47.06	1.24E+11	1.40E+09	0	1.11E+11	1.24E+10
90	33.76	8.92E+10	1.40E+09	0	7.89E+10	8.92E+09
95	20.46	5.41E+10	1.40E+09	0	4.73E+10	5.41E+09
100	0.72	1.89E+09	1.40E+09	0	3.02E+08	1.89E+08

Table 5-10 Fecal Coliform TMDL Calculations for Little Deep Fork Creek (OK520700060130_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	1876.09	1.84E+13	1.44E+10	0	1.65E+13	1.84E+12
5	309.95	3.03E+12	1.44E+10	0	2.72E+12	3.03E+11
10	185.84	1.82E+12	1.44E+10	0	1.62E+12	1.82E+11
15	120.36	1.18E+12	1.44E+10	0	1.05E+12	1.18E+11
20	77.95	7.63E+11	1.44E+10	0	6.72E+11	7.63E+10
25	52.70	5.16E+11	1.44E+10	0	4.50E+11	5.16E+10
30	38.23	3.74E+11	1.44E+10	0	3.22E+11	3.74E+10
35	29.37	2.87E+11	1.44E+10	0	2.44E+11	2.87E+10
40	22.70	2.22E+11	1.44E+10	0	1.86E+11	2.22E+10
45	17.52	1.71E+11	1.44E+10	0	1.40E+11	1.71E+10
50	13.97	1.37E+11	1.44E+10	0	1.09E+11	1.37E+10
55	11.35	1.11E+11	1.44E+10	0	8.56E+10	1.11E+10
60	9.29	9.09E+10	1.44E+10	0	6.75E+10	9.09E+09
65	7.55	7.38E+10	1.44E+10	0	5.21E+10	7.38E+09
70	6.24	6.10E+10	1.44E+10	0	4.05E+10	6.10E+09
75	5.02	4.91E+10	1.44E+10	0	2.98E+10	4.91E+09
80	3.87	3.78E+10	1.44E+10	0	1.97E+10	3.78E+09
85	2.87	2.81E+10	1.44E+10	0	1.09E+10	2.81E+09
90	2.06	2.01E+10	1.44E+10	0	3.73E+09	2.01E+09
95	1.25	1.44E+10	1.44E+10	0	0.00E+00	0.00E+00
100	0.04	1.44E+10	1.44E+10	0	0.00E+00	0.00E+00

Table 5-11 Total Suspended Solids TMDL Calculations for Deep Fork of Canadian River (OK520700020010_10)

Flow Exceedance Frequency	Flow (cfs)	TMDL (lbs/day)	WWTP (lbs/day)	MS4 (lbs/day)	Growth (lbs/day)	LA (lbs/day)	MOS (lbs/day)
0	30774.7	N/A	0	0	N/A	N/A	N/A
5	5084.28	N/A	0	0	N/A	N/A	N/A
10	3048.52	N/A	0	0	N/A	N/A	N/A
15	1974.38	N/A	0	0	N/A	N/A	N/A
20	1278.74	N/A	0	0	N/A	N/A	N/A
25	864.429	160803.1	0	0	1608.0	143114.8	16080.3
30	627.095	116653.6	0	0	1166.5	103821.7	11665.4
35	481.83	89631.1	0	0	896.3	79771.7	8963.1
40	372.369	69269.0	0	0	692.7	61649.4	6926.9
45	287.461	53474.2	0	0	534.7	47592.0	5347.4
50	229.15	42627.1	0	0	426.3	37938.1	4262.7
55	186.185	34634.5	0	0	346.3	30824.7	3463.5
60	152.426	28354.6	0	0	283.5	25235.6	2835.5
65	123.782	23026.2	0	0	230.3	20493.4	2302.6
70	102.299	19030.0	0	0	190.3	16936.7	1903.0
75	82.3509	15319.1	0	0	153.2	13634.0	1531.9
80	63.4256	11798.6	0	0	118.0	10500.7	1179.9
85	47.0577	8753.8	0	0	87.5	7790.9	875.4
90	33.7588	6279.9	0	0	62.8	5589.1	628.0
95	20.4599	3806.0	0	0	38.1	3387.3	380.6
100	0.7161	133.2	0	0	1.3	118.6	13.3

Table 5-12 Total Suspended Solids TMDL Calculations for Little Deep Fork Creek (OK520700060130_10)

Flow Exceedance Frequency	Flow (cfs)	TMDL (lbs/day)	WWTP (lbs/day)	MS4 (lbs/day)	Growth (lbs/day)	LA (lbs/day)	MOS (lbs/day)
0	1876.1	N/A	0	0	N/A	N/A	N/A
5	309.95	N/A	0	0	N/A	N/A	N/A
10	185.84	N/A	0	0	N/A	N/A	N/A
15	120.36	N/A	0	0	N/A	N/A	N/A
20	77.955	N/A	0	0	N/A	N/A	N/A
25	52.697	10015.3	0	0	100.2	7912.1	2003.1
30	38.229	7265.5	0	0	72.7	5739.8	1453.1
35	29.373	5582.5	0	0	55.8	4410.2	1116.5
40	22.7	4314.3	0	0	43.1	3408.3	862.9
45	17.524	3330.5	0	0	33.3	2631.1	666.1
50	13.969	2654.9	0	0	26.5	2097.4	531.0
55	11.35	2157.1	0	0	21.6	1704.1	431.4
60	9.2922	1766.0	0	0	17.7	1395.2	353.2
65	7.546	1434.1	0	0	14.3	1133.0	286.8
70	6.2364	1185.2	0	0	11.9	936.3	237.0
75	5.0203	954.1	0	0	9.5	753.8	190.8
80	3.8666	734.9	0	0	7.3	580.5	147.0
85	2.8687	545.2	0	0	5.5	430.7	109.0
90	2.058	391.1	0	0	3.9	309.0	78.2
95	1.2473	237.0	0	0	2.4	187.3	47.4
100	0.04	7.6	0	0	0.1	6.8	0.8

Table 5-13 Total Suspended Solids TMDL Calculations for Catfish Creek (OK520700060140_00)

Flow Exceedance Frequency	Flow (cfs)	TMDL (lbs/day)	WWTP (lbs/day)	MS4 (lbs/day)	Growth (lbs/day)	LA (lbs/day)	MOS (lbs/day)
0	438.57	N/A	0	0	N/A	N/A	N/A
5	72.457	N/A	0	0	N/A	N/A	N/A
10	43.445	N/A	0	0	N/A	N/A	N/A
15	28.137	N/A	0	0	N/A	N/A	N/A
20	18.223	N/A	0	0	N/A	N/A	N/A
25	12.319	1323.6	0	0	13.2	1111.8	198.5
30	8.9368	960.2	0	0	9.6	806.5	144.0
35	6.8666	737.8	0	0	7.4	619.7	110.7
40	5.3067	570.2	0	0	5.7	478.9	85.5
45	4.0966	440.1	0	0	4.4	369.7	66.0
50	3.2656	350.9	0	0	3.5	294.7	52.6
55	2.6533	285.1	0	0	2.9	239.5	42.8
60	2.1722	233.4	0	0	2.3	196.0	35.0
65	1.764	189.5	0	0	1.9	159.2	28.4
70	1.4579	156.6	0	0	1.6	131.6	23.5
75	1.1736	126.1	0	0	1.3	105.9	18.9
80	0.9039	97.1	0	0	1.0	81.6	14.6
85	0.6706	72.1	0	0	0.7	60.5	10.8
90	0.4811	51.7	0	0	0.5	43.4	7.8
95	0.2916	31.3	0	0	0.3	26.3	4.7
100	0.0102	1.1	0	0	0.0	1.0	0.1

5.9 Reasonable Assurances

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

Table 5-14 provides a partial list of the state partner agencies ODEQ will collaborate with to address point and nonpoint source reduction goals established by TMDLs.

Table 5-14 Partial List of Oklahoma Water Quality Management Agencies

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

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

As authorized by Section 402 of the CWA, the ODEQ has delegation of the NPDES Program in Oklahoma, except for certain jurisdictional areas related to agriculture and the oil and gas industry retained by State Department of Agriculture and Oklahoma Corporation Commission, for which the USEPA has retained permitting authority. The NPDES Program in Oklahoma is implemented via Title 252, Chapter 606 of the Oklahoma Pollution Discharge

Elimination System (OPDES) Act and in accordance with the agreement between ODEQ and USEPA relating to administration and enforcement of the delegated NPDES Program. Implementation of point source WLAs is done through permits issued under the OPDES program.

The reduction rates called for in this TMDL report are as high as 81 percent. The ODEQ recognizes that achieving such high reductions will be a challenge, especially since unregulated nonpoint sources are a major cause of both bacteria and TSS loading. The high reduction rates are not uncommon for pathogen- or TSS-impaired waters. Similar reduction rates are often found in other pathogen and TSS TMDLs around the nation. The suitability of the current criteria for pathogens and the beneficial uses of a waterbody should be reviewed. For example, the Kansas Department of Environmental Quality has proposed to exclude certain high flow conditions during which pathogen standards will not apply, although that exclusion was not approved by the USEPA. Additionally, USEPA has been conducting new epidemiology studies and may develop new recommendations for pathogen criteria in the near future.

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

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

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

SECTION 6
PUBLIC PARTICIPATION

The Lower Deep Fork of the Canadian River Bacteria and Turbidity TMDL Report was sent to other related governmental agencies for peer review and then submitted to EPA to be Preliminarily Reviewed on July 5, 2011. EPA completed their review on July 14, 2011. On July 28, 2011 a public notice about the Lower Deep Fork of the Canadian River Bacterial and Turbidity TMDL Report was posted on the DEQ webpage at http://www.deq.state.ok.us/wqdnew/index.htm and was sent to persons on the DEQ contact list either who have requested all notices or who live in the watershed of interest. In addition, the public notice was sent to local newspapers and/or other publications in the watershed area affected by this TMDL.

The public was given a 45-day opportunity to review the Lower Deep Fork of the Canadian River Bacterial and Turbidity TMDL Report, submit comments to DEQ, and/or request a public meeting. DEQ did not receive any public comments or requests for a public meeting by the time the public comment period ended on September 12, 2011.

SECTION 7
REFERENCES

American Veterinary Medical Association 2007. U.S. Pet Ownership and Demographics Sourcebook (2007 Edition). Schaumberg, IL.

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

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

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

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

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

Helsel, D.R. and R.M. Hirsch 2002. Statistical Methods in Water Resources. U.S. Department of the Interior, U.S. Geological Survey, September 2002.

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

ODAFF 2005. http://www.ok.gov/~okag/aems.

ODEQ 2006. The State of Oklahoma 2006 Continuing Planning Process. 2006 Edition.

ODEQ 2007. Reissuance of General Permit OKR10 for Storm Water Discharges from Construction Activities within the State of Oklahoma. Fact Sheet. July 24, 2007.

ODEQ 2008. *Water Quality in Oklahoma, 2008 Integrated Report*. 2008.

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

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

OWRB 2008. Oklahoma Water Resources Board. *2008 Water Quality Standards*.

OWRB 2008a. Oklahoma Water Resources Board. Implementation of Oklahoma's Water Quality Standards (Chapter 46). May 27, 2008.

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

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

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

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

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

U.S. Census Bureau 2010. http://2010.census.gov/2010census/data/.

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

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

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

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

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

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

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

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

Woods, A.J., Omernik, J.M., Butler, D.R., Ford, J.G., Henley, J.E., Hoagland, B.W., Arndt, D.S., and Moran, B.C., 2005. Ecoregions of Oklahoma (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,250,000).

APPENDIX A

AMBIENT WATER QUALITY DATA

BACTERIA DATA — 1999 - 2006

TURBIDITY AND TOTAL SUSPENDED SOLIDS DATA — 1998 TO 2010

Ambient Water Quality Bacteria Data, 1999-2006

Waterbody ID	Streams	WQM Station	Date[1]	FC[2]	EC[2]	ENT[2]
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	07/11/01	10	10	20
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	08/08/01	10	10	10
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	10/03/01	10		
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	11/07/01	6000		
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	03/11/02	20		
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	05/13/02	42000	11970	92000
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	06/04/02	100	108.5	155
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	07/24/02	15	25.5	165
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	05/03/04	1000	609	5000
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	05/19/04	540	57.5	85
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	06/07/04	100	41	300
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	06/14/04	370	217.5	1350
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	07/12/04	700	213	1100
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	07/19/04	100	10	20
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	07/27/04	20	15	285
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	08/16/04	670	146	520
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	08/30/04	40	52	63.5
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	09/20/04	10	20	10
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	05/23/06	70	52	30
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	06/12/06	120	909	288
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	06/26/06	10	10	20
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	07/05/06	500	102	145
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	07/24/06	30	10	41
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	08/07/06	50	10	10
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	08/21/06	1000	620	465
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	08/22/06	440	10	41
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	09/05/06	1000	20	20
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	09/18/06	270	135	156
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	09/20/06	150	171	86
OK520700020010_10	Canadian River, Deep Fork	520700020010-001AT	10/02/06	20	20	80
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	04/26/99	2000		
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	10/04/99	300		
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	11/09/99	500		
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	12/14/99	600		
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	01/19/00	200		
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	02/23/00	4200		
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	03/28/00	200		

Waterbody ID	Streams	WQM Station	Date[1]	FC[2]	EC[2]	ENT[2]
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	10/30/00	300	364	6000
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	12/04/00	600	637	550
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	01/16/01	40	85	300
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	02/21/01	100	121	200
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	03/26/01	400	335	400
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	05/24/99	400		
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	06/21/99	1500		
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	07/20/99	300		
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	08/24/99	200		
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	05/09/00	5200		
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	06/13/00	8500		
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	07/17/00			
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	08/21/00	560	24192	
OK520700060130_10	Little Deep Fork	OK520700-06-0130T	09/25/00	300	697	3000

FC = fecal coliform (STORET Code: 31610); EC = *E. coli* (STORET Code: 31609); ENT = enterococci (STORET Code: 31649)

[1] Samples collected during secondary contact recreation season (October 1st and April 30th) are included in Appendix A but were not used in TMDL calculations.

[2] Units = counts/100 mL

Ambient Water Quality Turbidity and TSS Data, 1997 - 2010

Station ID	Stream Name	Date	Turbidity (NTU)	TSS (mg/L)	Flow (cfs)	Flow Condition	Data Sources
520700020010-001AT	Canadian River, Deep Fork	11/18/98	79	62			OWRB
520700020010-001AT	Canadian River, Deep Fork	12/16/98	51	28			OWRB
520700020010-001AT	Canadian River, Deep Fork	01/27/99	14	6			OWRB
520700020010-001AT	Canadian River, Deep Fork	02/17/99	123	92			OWRB
520700020010-001AT	Canadian River, Deep Fork	03/16/99	363	220			OWRB
520700020010-001AT	Canadian River, Deep Fork	04/28/99	270	24			OWRB
520700020010-001AT	Canadian River, Deep Fork	05/25/99	220	176			OWRB
520700020010-001AT	Canadian River, Deep Fork	06/30/99	216	103			OWRB
520700020010-001AT	Canadian River, Deep Fork	06/30/99	216	103			OWRB
520700020010-001AT	Canadian River, Deep Fork	07/27/99	70	75			OWRB
520700020010-001AT	Canadian River, Deep Fork	07/27/99	70	75			OWRB
520700020010-001AT	Canadian River, Deep Fork	09/01/99	50	32			OWRB
520700020010-001AT	Canadian River, Deep Fork	09/01/99	50	32			OWRB
520700020010-001AT	Canadian River, Deep Fork	09/28/99	262	154			OWRB
520700020010-001AT	Canadian River, Deep Fork	09/28/99	262	154			OWRB
520700020010-001AT	Canadian River, Deep Fork	10/28/99	38	34			OWRB
520700020010-001AT	Canadian River, Deep Fork	11/22/99	47	36			OWRB
520700020010-001AT	Canadian River, Deep Fork	12/21/99	52	38			OWRB
520700020010-001AT	Canadian River, Deep Fork	03/01/00	200	172			OWRB
520700020010-001AT	Canadian River, Deep Fork	03/29/00	343				OWRB
520700020010-001AT	Canadian River, Deep Fork	04/26/00	123	106			OWRB
520700020010-001AT	Canadian River, Deep Fork	06/26/00	650	1970			OWRB
520700020010-001AT	Canadian River, Deep Fork	08/02/00	124	108			OWRB
520700020010-001AT	Canadian River, Deep Fork	08/22/00	35	64			OWRB
520700020010-001AT	Canadian River, Deep Fork	09/25/00	59	58			OWRB
520700020010-001AT	Canadian River, Deep Fork	10/23/00	647	352			OWRB
520700020010-001AT	Canadian River, Deep Fork	12/05/00	55	32			OWRB
520700020010-001AT	Canadian River, Deep Fork	01/23/06	16				OWRB
520700020010-001AT	Canadian River, Deep Fork	02/28/06	37				OWRB
520700020010-001AT	Canadian River, Deep Fork	04/03/06	68				OWRB
520700020010-001AT	Canadian River, Deep Fork	05/08/06	1000				OWRB
520700020010-001AT	Canadian River, Deep Fork	06/12/06	48				OWRB
520700020010-001AT	Canadian River, Deep Fork	07/17/06	226				OWRB
520700020010-001AT	Canadian River, Deep Fork	08/22/06	77				OWRB
520700020010-001AT	Canadian River, Deep Fork	09/20/06	212				OWRB
520700020010-001AT	Canadian River, Deep Fork	10/18/06	879				OWRB
520700020010-001AT	Canadian River, Deep Fork	01/30/07	83				OWRB

Station ID	Stream Name	Date	Turbidity (NTU)	TSS (mg/L)	Flow (cfs)	Flow Condition	Data Sources
520700020010-001AT	Canadian River, Deep Fork	03/13/07	55				OWRB
520700020010-001AT	Canadian River, Deep Fork	04/11/07	361				OWRB
520700020010-001AT	Canadian River, Deep Fork	05/07/07	192				OWRB
520700020010-001AT	Canadian River, Deep Fork	06/19/07	177				OWRB
520700020010-001AT	Canadian River, Deep Fork	08/15/07	99				OWRB
520700020010-001AT	Canadian River, Deep Fork	10/02/07	87				OWRB
520700020010-001AT	Canadian River, Deep Fork	11/06/07	36				OWRB
520700020010-001AT	Canadian River, Deep Fork	12/19/07	138				OWRB
520700020010-001AT	Canadian River, Deep Fork	02/20/08	464				OWRB
520700020010-001AT	Canadian River, Deep Fork	03/18/08	423				OWRB
520700020010-001AT	Canadian River, Deep Fork	04/29/08	156				OWRB
520700020010-001AT	Canadian River, Deep Fork	05/27/08	404				OWRB
520700020010-001AT	Canadian River, Deep Fork	07/08/08	114				OWRB
520700020010-001AT	Canadian River, Deep Fork	09/09/08	52				OWRB
520700020010-001AT	Canadian River, Deep Fork	10/27/08	24				OWRB
520700020010-001AT	Canadian River, Deep Fork	01/05/09	10				OWRB
520700020010-001AT	Canadian River, Deep Fork	03/04/09	23				OWRB
520700020010-001AT	Canadian River, Deep Fork	04/01/09	239				OWRB
520700020010-001AT	Canadian River, Deep Fork	05/11/09	154.5				OWRB
520700020010-001AT	Canadian River, Deep Fork	06/23/09	45.75				OWRB
520700020010-001AT	Canadian River, Deep Fork	08/18/09	209				OWRB
520700020010-001AT	Canadian River, Deep Fork	10/28/09	89.5				OWRB
520700020010-001AT	Canadian River, Deep Fork	05/04/10	58.7				OWRB
520700020010-001AT	Canadian River, Deep Fork	05/04/10	58.7				OWRB
520700020010-001AT	Canadian River, Deep Fork	05/04/10	65.3				OWRB
520700020010-001AT	Canadian River, Deep Fork	09/20/10	97.3				OWRB
520700020010-001AT	Canadian River, Deep Fork	09/20/10	98				OWRB
520700020010-001AT	Canadian River, Deep Fork	09/20/10	94.3				OWRB
520700020010-001AT	Canadian River, Deep Fork	10/19/10	17.8				OWRB
NUYAKA CREEK near Okfuskee	Nuyaka Creek	07/13/09	9.12	<10	0.156		ODEQ
NUYAKA CREEK near Okfuskee	Nuyaka Creek	08/04/09	53.3	71	0.028		ODEQ
NUYAKA CREEK near Okfuskee	Nuyaka Creek	09/29/09	36.3	23	0.417		ODEQ
NUYAKA CREEK near Okfuskee	Nuyaka Creek	11/09/09	12.8	<10	7.209		ODEQ
NUYAKA CREEK near Okfuskee	Nuyaka Creek	12/07/09	14.9	<10	5.687		ODEQ

Station ID	Stream Name	Date	Turbidity (NTU)	TSS (mg/L)	Flow (cfs)	Flow Condition	Data Sources
NUYAKA CREEK near Okfuskee	Nuyaka Creek	01/20/10	24.4	<10	15.21		ODEQ
NUYAKA CREEK near Okfuskee	Nuyaka Creek	03/03/10	36.6	13	23		ODEQ
NUYAKA CREEK near Okfuskee	Nuyaka Creek	03/29/10	23.9	14	18.9		ODEQ
NUYAKA CREEK near Okfuskee	Nuyaka Creek	04/12/10	16.5	22	8.104		ODEQ
NUYAKA CREEK near Okfuskee	Nuyaka Creek	04/29/10	22.6	22	4.531		ODEQ
NUYAKA CREEK near Okfuskee	Nuyaka Creek	05/26/10	26.6	20	7.073		ODEQ
NUYAKA CREEK near Okfuskee	Nuyaka Creek	06/24/10	15.7	12	3.398		ODEQ
WALNUT CREEK near Mason	Walnut Creek	07/13/09	13.6	<10	0.273		ODEQ
WALNUT CREEK near Mason	Walnut Creek	08/04/09	9.82	<10	<0.005		ODEQ
WALNUT CREEK near Mason	Walnut Creek	09/29/09	11.7	14	<0.005		ODEQ
WALNUT CREEK near Mason	Walnut Creek	11/09/09	19.7	<10	8.034		ODEQ
WALNUT CREEK near Mason	Walnut Creek	12/07/09	12	<10	2.728		ODEQ
WALNUT CREEK near Mason	Walnut Creek	01/20/10	24.1	<10	11.191		ODEQ
WALNUT CREEK near Mason	Walnut Creek	03/03/10	36.6	15	20.494		ODEQ
WALNUT CREEK near Mason	Walnut Creek	03/29/10	25.3	<10	20.11		ODEQ
WALNUT CREEK near Mason	Walnut Creek	04/12/10	18.2	18	13.683		ODEQ
WALNUT CREEK near Mason	Walnut Creek	04/29/10	10.7	<10	7.714		ODEQ
WALNUT CREEK near Mason	Walnut Creek	05/26/10	17.4	<10	10.057		ODEQ
WALNUT CREEK near Mason	Walnut Creek	06/24/10	10.7	12	7.197		ODEQ
WALNUT CREEK near Mason	Walnut Creek	08/09/10	6.44	<10	0.772		ODEQ
WALNUT CREEK near Mason	Walnut Creek	09/07/10	7.58	<10	0.008		ODEQ
OK520700-06-0130T	Little Deep Fork	04/26/99	390	372		High flow	OCC

Station ID	Stream Name	Date	Turbidity (NTU)	TSS (mg/L)	Flow (cfs)	Flow Condition	Data Sources
OK520700-06-0130T	Little Deep Fork	10/04/99	12.4	10.5	0.277		OCC
OK520700-06-0130T	Little Deep Fork	11/09/99	14.8	7.5	0.261		OCC
OK520700-06-0130T	Little Deep Fork	12/14/99	61.9	45.5	13.817		OCC
OK520700-06-0130T	Little Deep Fork	01/19/00	13.2	12	1.141		OCC
OK520700-06-0130T	Little Deep Fork	02/23/00	150	124	12.214		OCC
OK520700-06-0130T	Little Deep Fork	03/28/00	23.2	18	12.592		OCC
OK520700-06-0130T	Little Deep Fork	10/30/00	60.8	16			OCC
OK520700-06-0130T	Little Deep Fork	12/04/00	32.9	38	10.018		OCC
OK520700-06-0130T	Little Deep Fork	01/16/01	25.5	10	27.834		OCC
OK520700-06-0130T	Little Deep Fork	02/21/01	45.6	10	29.71		OCC
OK520700-06-0130T	Little Deep Fork	03/26/01	22.1	30	20.974		OCC
OK520700-06-0130T	Little Deep Fork	05/24/99	106	67	28.585	High flow	OCC
OK520700-06-0130T	Little Deep Fork	06/21/99	122	82	15.357		OCC
OK520700-06-0130T	Little Deep Fork	07/20/99	14.7	14	2.964		OCC
OK520700-06-0130T	Little Deep Fork	08/24/99	6.36	9.5			OCC
OK520700-06-0130T	Little Deep Fork	05/09/00	124	76	28.263	Elevated	OCC
OK520700-06-0130T	Little Deep Fork	06/13/00	13.1	14.1	3.45		OCC
OK520700-06-0130T	Little Deep Fork	07/17/00	13.2	6	5.118		OCC
OK520700-06-0130T	Little Deep Fork	08/21/00	12.2	18	0.779		OCC
OK520700-06-0130T	Little Deep Fork	09/25/00	6.83		0.037		OCC
OK520700-06-0140G	Catfish Creek	03/16/98		795		High Flow	OCC
OK520700-06-0140G	Catfish Creek	04/27/98		537		High Flow	OCC
OK520700-06-0140G	Catfish Creek	04/28/98		291		High Flow	OCC
OK520700-06-0140G	Catfish Creek	06/11/98		440		High Flow	OCC
OK520700-06-0140G	Catfish Creek	10/05/98		543		High Flow	OCC
OK520700-06-0140G	Catfish Creek	11/01/98		615		High Flow	OCC
OK520700-06-0140G	Catfish Creek	01/30/99		1098		High Flow	OCC
OK520700-06-0140G	Catfish Creek	03/13/99		328		High Flow	OCC
OK520700-06-0140G	Catfish Creek	09/04/97	7	1.2	0.696		OCC
OK520700-06-0140G	Catfish Creek	09/16/97	3.06				OCC
OK520700-06-0140G	Catfish Creek	10/23/97	16.4	8	1.283		OCC
OK520700-06-0140G	Catfish Creek	11/17/97	46.5	18	3.219		OCC
OK520700-06-0140G	Catfish Creek	12/18/97	37.4	24.5	2.831		OCC
OK520700-06-0140G	Catfish Creek	01/29/98	57.2	22.5	10.968		OCC
OK520700-06-0140G	Catfish Creek	02/18/98	40.8	20	7.054		OCC
OK520700-06-0140G	Catfish Creek	03/04/98	10.6	16	4.081		OCC
OK520700-06-0140G	Catfish Creek	04/09/98	46.8	23	9.109		OCC
OK520700-06-0140G	Catfish Creek	05/19/98	44.2	26	8.396		OCC

Station ID	Stream Name	Date	Turbidity (NTU)	TSS (mg/L)	Flow (cfs)	Flow Condition	Data Sources
OK520700-06-0140G	Catfish Creek	06/23/98	3.31	2.5	0.785		OCC
OK520700-06-0140G	Catfish Creek	07/08/98	219.5	34.5	1.755		OCC
OK520700-06-0140G	Catfish Creek	08/18/98	2.25	6	0.086		OCC
OK520700-06-0140G	Catfish Creek	09/16/98	3.2	5	0.119		OCC
OK520700-06-0140G	Catfish Creek	10/27/98	23.9	6.67	1.944		OCC
OK520700-06-0140G	Catfish Creek	11/29/98	16	9.6	4.802		OCC
OK520700-06-0140G	Catfish Creek	12/16/98	45.5	17	5.007		OCC
OK520700-06-0140G	Catfish Creek	01/20/99	17.8	11	2.605		OCC
OK520700-06-0140G	Catfish Creek	02/17/99	43	14	4.383		OCC
OK520700-06-0140G	Catfish Creek	03/25/99	50.9	14.5	13.66		OCC

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

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

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

b. If flow measurements at the coincident gage are missing for some dates on which water quality samples were collected, the gaps in the flow record will be filled, or the record will be extended, by estimating flow based on measured streamflows at a nearby gages. All gages within 150 km radius are identified. For each of the identified gage with a minimum of 99 flow measurements on matching dates, four different regressions are calculated including linear, log linear, logarithmic and exponential regressions. The regression with the lowest root mean square error (RMSE) is chosen for each gage. The potential filling gages are ranked by RMSE from lowest to highest. The record is filled from the first gage (lowest RMSE) for those dates that exist in both records. If dates remain unfilled in the desired timespan of the timeseries, the filling process is repeated with the next gage with the next lowest RMSE and proceeds in this fashion until all missing values in the desired timespan are filled.

c. The flow frequency for the flow duration curves will be based on measured flows only. The filled timeseries described above is used to match flows to sampling dates to calculate loads.

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

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

a. Watershed delineations are performed using ESRI Arc Hydro with a 30 m resolution National Elevation Dataset digital elevation model, and National

Hydrography Dataset (NHD) streams. The area of each watershed will be calculated following watershed delineation.

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

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

Runoff Curve Numbers for Various Land Use Categories

and Hydrologic Soil Groups

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

d. 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 in Kansas 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-percentduration streamflow to mean streamflow;
- the percentage duration of appreciable (0.10 ft /s) streamflow; and
- 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 (TCEQ), 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):

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

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

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

Thus, the runoff curve number equation can be rewritten:

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

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

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

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, Pgaged. 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:

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

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

<u>Generalized Flow Projection Methodology</u>

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 above 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 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, and 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.

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

References

Furness, L.W., 1959, *Kansas Streamflow Characteristics- Part 1, Flow Duration*: Kansas Water Resources Board Technical Report No. 1.

Wurbs, R.A., and E.D. Sisson, *Evaluation of Methods for Distributing Naturalized Streamflows from Gaged Watersheds to Ungaged Subwatersheds*, Technical Report 179, Texas Water Resources Institute and Texas Natural Resource Conservation Commission, August 1999.

Wurbs, R.A . 2006. *Methods for Developing Naturalized Monthly Flows at Gaged and Ungaged Sites*. Journal of Hydrologic Engineering, January/February 2006, ASCE

Estimated Flow Exceedance Percentiles

WQ Station			
Stream Name	OK520700020010_00	OK520700060130_10	OK520700060140_00
WBID Segment	Canadian River, Deep Fork	Little Deep Fork Creek	Catfish Creek
USGS Gage Reference	OK520700020010_10	OK520700020010_10	OK520700020010_10
Drainage Area (sq. mile)	575	96	29
NRCS Curve Number	64.6	62.4	61.9
Average Annual Rainfall (inch)	41.7	40.1	40.4
Exceedance Frequency	Q (cfs)	Q (cfs)	Q (cfs)
0	30774.74	1876.09	438.57
1	11457.52	698.47	163.28
2	8407.78	512.55	119.82
3	6864.28	418.46	97.82
4	5851.52	356.72	83.39
5	5084.28	309.95	72.46
6	4548.64	277.29	64.82
7	4081.74	248.83	58.17
8	3708.55	226.08	52.85
9	3355.42	204.55	47.82
10	3048.52	185.84	43.44
11	2762.08	168.38	39.36
12	2567.71	156.53	36.59
13	2342.65	142.81	33.39
14	2148.29	130.96	30.62
15	1974.38	120.36	28.14
16	1810.70	110.38	25.80
17	1657.25	101.03	23.62
18	1514.03	92.30	21.58

19	1381.04	84.19	19.68
20	1278.74	77.95	18.22
21	1176.44	71.72	16.77
22	1084.37	66.11	15.45
23	1002.53	61.12	14.29
24	926.83	56.50	13.21
25	864.43	52.70	12.32
26	804.07	49.02	11.46
27	750.88	45.77	10.70
28	706.89	43.09	10.07
29	663.92	40.47	9.46
30	627.09	38.23	8.94
31	595.38	36.30	8.48
32	566.74	34.55	8.08
33	535.03	32.62	7.62
34	510.47	31.12	7.27
35	481.83	29.37	6.87
36	460.35	28.06	6.56
37	439.89	26.82	6.27
38	416.36	25.38	5.93
39	393.85	24.01	5.61
40	372.37	22.70	5.31
41	351.91	21.45	5.02
42	333.50	20.33	4.75
43	316.10	19.27	4.50
44	302.81	18.46	4.32
45	287.46	17.52	4.10
46	274.16	16.71	3.91
47	262.91	16.03	3.75

48	250.63	15.28	3.57
49	240.40	14.66	3.43
50	229.15	13.97	3.27
51	218.92	13.35	3.12
52	209.71	12.78	2.99
53	200.51	12.22	2.86
54	193.35	11.79	2.76
55	186.18	11.35	2.65
56	179.02	10.91	2.55
57	172.89	10.54	2.46
58	165.72	10.10	2.36
59	158.56	9.67	2.26
60	152.43	9.29	2.17
61	145.27	8.86	2.07
62	140.15	8.54	2.00
63	135.04	8.23	1.92
64	129.06	7.87	1.84
65	123.78	7.55	1.76
66	119.69	7.30	1.71
67	114.58	6.98	1.63
68	110.48	6.74	1.57
69	106.39	6.49	1.52
70	102.30	6.24	1.46
71	98.21	5.99	1.40
72	95.14	5.80	1.36
73	91.05	5.55	1.30
74	86.95	5.30	1.24
75	82.35	5.02	1.17
76	78.77	4.80	1.12

77	74.68	4.55	1.06
78	71.61	4.37	1.02
79	67.52	4.12	0.96
80	63.43	3.87	0.90
81	60.36	3.68	0.86
82	57.29	3.49	0.82
83	53.20	3.24	0.76
84	50.13	3.06	0.71
85	47.06	2.87	0.67
86	43.99	2.68	0.63
87	41.94	2.56	0.60
88	38.87	2.37	0.55
89	36.83	2.25	0.52
90	33.76	2.06	0.48
91	31.71	1.93	0.45
92	28.64	1.75	0.41
93	26.60	1.62	0.38
94	23.53	1.43	0.34
95	20.46	1.25	0.29
96	17.39	1.06	0.25
97	14.32	0.87	0.20
98	11.25	0.69	0.16
99	7.17	0.44	0.10
100	0.72	0.04	0.01

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

SANITARY SEWER OVERFLOWS DATA

Sanitary Sewer Overflows (SSO) Data since 2000

Facility Name	Bypass Date	Facility ID	Amount (Gallons)	Cause	Cleanup	Preventive	Type of Source
BEGGS	05/29/01	S20718		EXCESSIVE RAINFALL		NONE	MANHOLE
BEGGS	05/29/01	S20718		EXCESSIVE RAINFALL		NONE	MANHOLE
BEGGS	05/29/01	S20718		EXCESSIVE RAINFALL		NONE	MANHOLE
BEGGS	05/30/01	S20718		FLOODING			MANHOLE
BEGGS	01/30/02	S20718	10	STOPPED LINE	CLEANED	RODDED	MANHOLE
BEGGS	07/08/03	S20718	60	GREASE	LIMED	FLUSHED	PIPE
BEGGS	10/09/03	S20718	200	RAIN	LIMED	NONE	MANHOLE
BEGGS	03/04/04	S20718	500	RAINS			PIPE
BEGGS	03/04/04	S20718	500	RAINS			PIPE
BEGGS	06/20/07	S20718	400	RAIN	LIME	NONE	MANHOLE
BEGGS	10/09/08	S20718	75	POWER FAILURE	C & S		PIPE
BEGGS	11/27/08	S20718	300	BLOCKAGE	C & S	PUT CAP ON CLEANOUT	PIPE
BEGGS	02/26/10	S20718	500	BROKEN SEWER MAIN	CLEANED	REPLACED	PIPE
BEGGS	03/17/10	S20718	200	PUMP FAILURE		REPAIR	PIPE
BEGGS	04/20/10	S20718	150	PUMP FAILURE	CLEANED	REPAIRED	PIPE
BEGGS	05/26/10	S20718	500	PUMP FAILURE		REPAIR	
BEGGS	06/14/10	S20718	250	BLOCKAGE	LIME	CLEARED	MANHOLE
BRISTOW	03/22/00	S20717	1,000	RAIN			
BRISTOW	10/23/00	S20717	100	GREASE	C & D	RODDED	
BRISTOW	02/01/01	S20717	5,000	LINE BLOCKAGE	LIMED	RODDED	
BRISTOW	05/01/01	S20717	500	LINE BLOCKAGE	C & L	RODDED	MANHOLE
BRISTOW	06/12/01	S20717	10,000	BROKEN MAIN	LIMED	REPLACE	PIPE
BRISTOW	12/13/01	S20717	150	GREASE	CLEANED	RODDED	MANHOLE
BRISTOW	06/03/02	S20717	2,400	CLOGGED	LIMED	RODDED	MANHOLE
BRISTOW	06/08/02	S20717	500	LEAK IN END PLATE		REPAIRED	DRYING BEDS
BRISTOW	01/08/03	S20717	700	BLOCKAGE	FLUSHED	RODDED	MANHOLE
BRISTOW	04/12/03	S20717	200	MALFUNCTION		REPAIR	DIGESTER
BRISTOW	05/28/03	S20717	1,000	ROOTS & GREASE	LIMED	REMOVED	MANHOLE
BRISTOW	09/05/03	S20717	7,500	PUMP FAILURE	LIMED	REPAIR	LIFT STATION
BRISTOW	10/04/03	S20717	1,500	GREASE	LIMED	CLEARED	MANHOLE
BRISTOW	11/07/03	S20717	175	BROKE CABLE	LIMED	REPAIR	DIGESTER
BRISTOW	05/03/04	S20717	700	DOG DUG OUT DIRT FROM DAM	LIMED	REPACKED DAM	DRYING BEDS
BRISTOW	09/06/05	S20717	175	CONSTRUCTION ERROR	LIMED	REPLACE JOINT OF PIPE	PIPE
BRISTOW	10/30/05	S20717	600	BROKEN LINE	LIMED	REPAIR	PIPE
BRISTOW	11/01/05	S20717	1,500	DEBRIS	LIMED	WASHED	MANHOLE

Facility Name	Bypass Date	Facility ID	Amount (Gallons)	Cause	Cleanup	Preventive	Type of Source
BRISTOW	01/17/06	S20717	600	BROKEN LINE	LIMED	REPAIR LINES	MANHOLE
BRISTOW	01/17/06	S20717	175	ROOTS	WASHED	ROOT CUT	MANHOLE
BRISTOW	11/18/07	S20717	7,500	BLOCKAGE	LIMED	REMOVED	MANHOLE
DEPEW	05/31/00	S20716	2,000	LINE STOPPAGE	WASHED , LIMED	CLEANED	
DEPEW	10/31/00	S20716	2,000	BLOCKAGE	RODDED		
DEPEW	07/14/03	S20716	1,500	BAD PIPES	LIMED	REPLACED	PIPE
DEPEW	01/26/04	S20716		BAD PIPE	C & S	REPLACED	PIPE
DEPEW	01/26/04	S20716	800	BROKEN PIPE	LIMED	REPLACE PIPE	PIPE
DEPEW	04/05/04	S20716	2,000	PIPE CLOGGED	LIMED	RELAY PIPE	PIPE