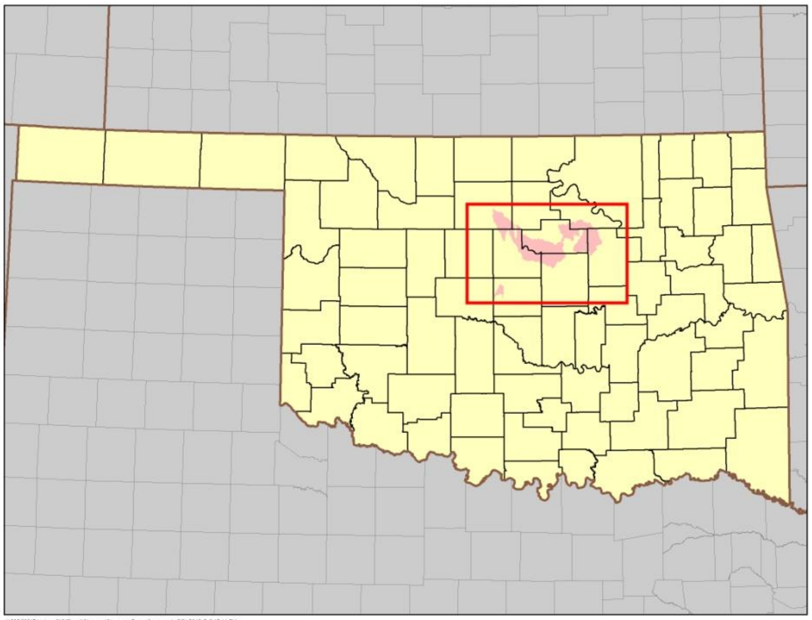
FINAL

2012 BACTERIA AND TURBIDITY TOTAL MAXIMUM DAILY LOADS FOR THE CIMARRON RIVER STUDY AREA OKLAHOMA (OK620900, OK620910)



Prepared for:

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

Prepared by:

PARSONS

SEPTEMBER 2012

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BACTERIA AND TURBIDITY
TOTAL MAXIMUM DAILY LOADS
FOR THE CIMARRON RIVER STUDY AREA, OKLAHOMA
(OK620900, OK620910)

OKWBID

OK620900010180_00, OK620900010170_10, OK620900010290_00,
OK620900010310_00, OK620900020020_00, OK620900020050_00,
OK620900040040_00, OK620900030080_00, OK620900030010_00,
OK620910040140_00, OK620900030230_00, OK620900030260_00,
OK620910030040_00

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SEPTEMBER 2012

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ACRONYMS AND ABBREVIATIONS

AEMS	Agricultural Environmental Management Service
ASAE	American Society of Agricultural Engineers
BMP	Best management practices
BOD	Biochemical Oxygen Demand
CAFO	Concentrated Animal Feeding Operation
CBOD	Carbonaceous Biochemical Oxygen Demand
CFR	Code of Federal Regulations
cfs	cubic feet per second
cfu	colony-forming unit
CPP	Continuing Planning Process
CWA	Clean Water Act
DEQ	Oklahoma Department of Environmental Quality
DMR	Discharge monitoring report
E. coli	Escherichia coli
ENT	Enterococci
EPA	U.S. Environmental Protection Agency
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
NPS	Non-point source
NRCS	Natural Resources Conservation Service
NRMSE	Normalized root mean square error
NTU	Nephelometric turbidity unit
OAC	Oklahoma Administrative Code

OLS	Ordinary least square
O.S.	Oklahoma statute
ODAFF	Oklahoma Department of Agriculture, Food and Forestry
OKWBID	Oklahoma Waterbody Identification Number
OPDES	Oklahoma Pollutant Discharge Elimination System
OSWD	Onsite wastewater disposal
OWQS	Oklahoma Water Quality Standards
OWRB	Oklahoma Water Resources Board
PBCR	Primary Body Contact Recreation
PRG	Percent reduction goal
RMSE	Root mean square error
SH	State Highway
SSO	Sanitary sewer overflow
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WWAC	warm water aquatic community
WLA	wasteload allocation
WQM	Water quality monitoring
WQMP	Water Quality Management Plan
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 [*Escherichia coli (E. coli),* Enterococci] and turbidity for certain waterbodies in the Cimarron 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 (EPA) guidance, and Oklahoma Department of Environmental Quality (DEQ) guidance and procedures. DEQ is required to submit all TMDLs to EPA for review. Approved 303(d) listed waterbody-pollutant pairs or surrogates TMDLs will receive notification of the approval or disapproval action. Once the EPA approves a TMDL, then the waterbody may be moved to Category 4a of a state's Integrated Water Quality Monitoring and Assessment Report, where it remains until compliance with water quality standards (WQS) is achieved (EPA 2003).

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. MOS can be implicit and/or explicit. The implicit MOS is achieved by using conservative assumptions in the TMDL calculations. An explicit MOS is a percentage of the TMDL set aside to account for the lack of knowledge associated with natural process in aquatic systems, model assumptions, and data limitations.

This report does not stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce bacteria 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 Cimarron River Basin, identified in Table ES-1, that DEQ 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 necessitates the development of a TMDL. The TMDLs established in this report are a necessary step in the process to develop the pollutant loading controls needed to restore the PBCR or fish and wildlife propagation beneficial uses 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*	Designated Use Primary Body Contact Recreation	Turbidity	Designated Use Warm Water Aquatic Life
Otter Creek	OK620910030040_00	30.15	2019	4	X		N	X	N
Beaver Creek, West	OK620900030260_00	13.21	2019	4	X	X	N	X	N
Beaver Creek	OK620900030230_00	12.65	2019	4				X	N
Bluff Creek	OK620910040140_00	9.32	2010	1	X	X	N		
Cimarron River	OK620900030010_00	42.09	2016	3	X		N	X	N
Dugout Creek	OK620900030080_00	13.58	2016	3	X	X	N	X	N
Stillwater Creek	OK620900040040_00	3.53	2016	3	X	X	N		
Council Creek	OK620900020050_00	21.94	2016	3	X		N		
Salt Creek	OK620900020020_00	14.71	2016	3	X	X	N		
Cottonwood Creek	OK620900010310_00	6.26	2019	4	X	X	N		
Euchee Creek	OK620900010290_00	9.56	2019	4	X		N	X	N
Cimarron River	OK620900010170_10	26.58	2013	2	X		N	X	N
Lagoon Creek	OK620900010180_00	18.55	2016	3	X	X	N		

ENT = Enterococci; N = Not attaining; X = Criterion exceeded
Source: 2008 Integrated Report, DEQ 2008.

Table ES-2 summarizes water quality data collected during primary contact recreation season from the water quality monitoring (WQM) stations between 2000 and 2008 for each bacterial indicator. The data summary in Table ES-2 provides a general understanding of the amount of water quality data available and the severity of exceedances of the water quality criteria. This data collected during the primary contact recreation season includes the data used to support the decision to place specific waterbodies within the Study Area on the DEQ 2008 303(d) list (DEQ 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, 2000-2008

Waterbody ID	Waterbody Name	Indicator	Number of samples	Geometric Mean Concentration (count/100 ml)	Notes
OK620910030040_00	Otter Creek	EC	14	139	Not listed, but geomean is exceeded
		ENT	14	208	
OK620900030260_00	Beaver Creek, West	EC	5	76	Insufficient number of samples, de-list
		ENT	5	212	Insufficient number of samples, de-list
OK620900030230_00	Beaver Creek	EC	14	133	Not listed, but geomean is exceeded
		ENT	14	148	Not listed, but geomean is exceeded
OK620910040140_00	Bluff Creek	EC	13	101	Not impaired, de-list
		ENT	13	437	
OK620900030010_00	Cimarron River	ENT	38	71	
OK620900030080_00	Dugout Creek	EC	14	371	
		ENT	14	416	
OK620900040040_00	Stillwater Creek	EC	24	169	
		ENT	24	205	
OK620900020050_00	Council Creek	EC	16	230	Not listed, but geomean is exceeded
		ENT	16	420	
OK620900020020_00	Salt Creek	EC	16	186	
		ENT	16	215	
OK620900010310_00	Cottonwood Creek	EC	15	276	
		ENT	15	580	
OK620900010290_00	Euchee Creek	EC	16	244	Not listed, but geomean is exceeded
		ENT	16	233	
OK620900010170_10	Cimarron River	ENT	28	119	
OK620900010180_00	Lagoon Creek	EC	16	151	
		ENT	16	221	

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

The definition of PBCR and the bacteria WQSs for PBCR are summarized by the following excerpt from Chapter 45 of the Oklahoma WQSs.

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

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

(c) Compliance with 785:45-5-16 shall be based upon meeting the requirements of one of the options specified in (1) or (2) of this subsection (c) for bacteria. Upon selection of one (1) group or test method, said method shall be used exclusively over the time period prescribed therefore. Provided, where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, no criteria exceedances shall be allowed for any indicator group.

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

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

To implement Oklahoma's WQS for PBCR, the Oklahoma Water Resources Board (OWRB) promulgated Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2011). 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) Escherichia coli (E. coli):

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

(2) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is not met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

(c) ***Enterococci.***

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to Enterococci if the geometric mean of 33 colonies per 100 ml is met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

(2) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to Enterococci if the geometric mean of 33 colonies per 100 ml is not met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

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 2011). As stipulated in the WQS, only the geometric mean of all samples collected over the recreation period shall be used to assess the impairment status of a stream segment. Therefore, only the geometric mean criteria will be used to develop TMDLs for *E. coli* and Enterococci bacteria indicators.

It is worth noting that the Oklahoma Water Quality Standards (OWQS) prior to July 1, 2011 contains three bacteria indicators (fecal coliform, *E. coli* and Enterococci) and the new OWQS effective on July 1, 2011 contains only *E. coli* and Enterococci. Because the new OWQS no longer have a standard for fecal coliform, fecal coliform TMDLs will not be developed for any stream segment in this report even though the stream segments were listed for fecal coliform impairment in the 2008 303(d) list. Bacteria TMDLs will be developed only for *E. coli* and/or Enterococci impaired streams.

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 2011). 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.

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 water quality data collected for turbidity and TSS under base flow conditions, which DEQ considers to be all flows less than the 25^{th} flow exceedance percentile (i.e., the lower 75% 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.

TMDLs for turbidity in streams designated as WWAC must take into account that no more than 10% 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-3 Summary of Turbidity and TSS Samples Collected During Base Flow Conditions, 1998-2011

Waterbody ID	Waterbody Name	WQM Stations	Number of turbidity samples	Number of samples greater than 50 NTU	% samples exceeding criterion	Average Turbidity (NTU)	Assessment Results
OK620910030040_00	Otter Creek	OK620910-03-0040C	13	0	0%	16	Not impaired, de-list
OK620900030260_00	Beaver Creek, West	OK620900-03-0260G	16	2	13%	37	
OK620900030230_00	Beaver Creek	OK620900-03-0230C	13	2	15%	27	
OK620900030010_00	Cimarron River	620900030010-001AT	13	4	31%	43	
OK620900030080_00	Dugout Creek	OK620900-03-0080C	17	1	6%	15	Not impaired, de-list
OK620900040040_00	Stillwater Creek	OK620900-04-0040C	29	3	10%	45	Not listed, but impaired
OK620900020050_00	Council Creek	OK620900-02-0050H	18	2	11%	13	Not listed, but impaired
OK620900020020_00	Salt Creek	OK620900-02-0020D	14	0	0%	11	
OK620900010290_00	Euchee Creek	OK620900-01-0290D	17	3	18%	27	
OK620900010170_10	Cimarron River	620900010170-001AT	38	18	47%	216	
OK620900010180_00	Lagoon Creek	OK620900-01-0180J	16	1	6%	14	

TMDLs will be developed for waterbodies highlighted in green.

Table ES-4 Regression Statistics and TSS Goals

Waterbody ID	Waterbody Name	R-square	NRMSE	TSS Goal (mg/L)[a]	MOS[b]
OK620900030260_00	West Beaver Creek	0.637	20.1%	25	25%
OK620900030230_00	Beaver Creek	0.343	15.9%	26	20%
OK620900030010_00	Cimarron River	0.673	13.6%	35	15%
OK620900040040_00	Stillwater Creek	0.753	8.7%	37	10%
OK620900020050_00	Council Creek	0.565	1.3%	11	5%
OK620900010290_00	Euchee Creek	0.842	8.1%	39	10%
OK620900010170_10	Cimarron River	0.673	13.6%	35	15%

After re-evaluating bacteria and turbidity/TSS data for the streams listed in Table ES-1, bacteria impairments for *E. coli* on Bluff Creek are recommended for delisting and bacteria TMDLs are not required for Bluff Creek. Turbidity/TSS impairments on Otter Creek and Dugout Creek are recommended for delisting and Turbidity/TSS TMDLs are not required for Otter Creek or Dugout Creek. Table ES-5 shows the bacteria and turbidity TMDLs that will be developed in this report.

Table ES-5 Stream Segments and Pollutants for TMDL Development

Waterbody ID	Waterbody Name	Stream Miles	TMDL Date	Priority	ENT	*E. coli*	Turbidity
Otter Creek	OK620910030040_00	30.15	2019	4	X	X	
Beaver Creek, West	OK620900030260_00	13.21	2019	4			X
Beaver Creek	OK620900030230_00	12.65	2019	4	X	X	X
Bluff Creek	OK620910040140_00	9.32	2010	1	X		
Cimarron River	OK620900030010_00	42.09	2016	3	X		X
Dugout Creek	OK620900030080_00	13.58	2016	3	X	X	
Stillwater Creek	OK620900040040_00	3.53	2016	3	X	X	X
Council Creek	OK620900020050_00	21.94	2016	3	X	X	X
Salt Creek	OK620900020020_00	14.71	2016	3	X	X	
Cottonwood Creek	OK620900010310_00	6.26	2019	4	X	X	
Euchee Creek	OK620900010290_00	9.56	2019	4	X	X	X
Cimarron River	OK620900010170_10	26.58	2013	2	X		X
Lagoon Creek	OK620900010180_00	18.55	2016	3	X	X	

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 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 sanitary wastewater are required to monitor fecal coliform under the current permits and will be required to monitor *E. coli* when their permits come to renew. These facilities are also required to monitor TSS in accordance with their permits. 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 permits 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-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	Multi-Sector General Permit	Nonpoint Source
Otter Creek	OK620910030040_00									Bacteria
Beaver Creek, West	OK620900030260_00									Turbidity
Beaver Creek	OK620900030230_00									Bacteria/Turbidity
Bluff Creek	OK620910040140_00									Bacteria
Cimarron River	OK620900030010_00									Bacteria/Turbidity
Dugout Creek	OK620900030080_00									Bacteria
Stillwater Creek	OK620900040040_00									Bacteria/Turbidity
Council Creek	OK620900020050_00									Bacteria/Turbidity
Salt Creek	OK620900020020_00									Bacteria
Cottonwood Creek	OK620900010310_00									Bacteria
Euchee Creek	OK620900010290_00									Bacteria/Turbidity
Cimarron River	OK620900010170_10									Bacteria/Turbidity
Lagoon Creek	OK620900010180_00									Bacteria

Facility present in watershed and potential as contributing pollutant source.

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

No facility present in watershed.

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 can provide some information for identifying whether impairments are associated with point or nonpoint sources. The efficiency and simplicity of the LDC method should not be considered as bad descriptors of this powerful tool for displaying the changing water quality over changing flows that provides information as to the sources of the pollutant that is not apparent in the raw data. The LDC has additional valuable uses in the post-TMDL implementation phase of the restoration of the water quality for a segment. Plotting future monitoring information on the LDC will show trends of improvement to sources that will identify areas for revision to the segment restoration plan. The low cost of the LDC method allows the development of TMDL plans on more segments and the evaluation of the implementation of WLAs and BMPs on more segments. 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), or if unavailable, projected from a nearby USGS site;
- Sorting the flow data and calculating flow exceedance percentiles;
- 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;
- For bacteria TMDLs, displaying and differentiating another curve derived by plotting the geometric mean of all existing bacteria samples continuously along the full spectrum of flow exceedance percentiles which represents the observed load in the stream; or
- For turbidity TMDLs, 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 = 126 cfu/100 mL (E. coli); or 33 cfu/100 mL (Enterococci)

unit conversion factor = 24,465,525

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) = $\boldsymbol{WQ_{goal}}$ **** flow (cfs) * unit conversion factor***

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

unit conversion factor = 5.39377

Historical observations of bacteria were plotted as a separate LDC based on the geometric mean of all samples. Historical observations of TSS and/or turbidity concentrations are paired with flow data and are plotted on the LDC for a stream. It is noted that the LDCs for bacteria were based on the geometric mean standards or geometric mean of all samples. It is inappropriate to compare single sample bacteria observations to a geometric mean water quality criterion in the LDC; therefore individual bacteria samples are not plotted on the LDCs.

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 pollutant loading and water quality.

This definition can be expressed by the following equation:

$$TMDL = WLA\_{WWTP} + WLA\_{MS4} + LA + MOS$$

For each waterbody the TMDLs presented in this report are expressed as colony forming units per day across the full range of flow conditions. For information purpose, percent reductions are also provided. The difference between existing loading and the water quality target is used to calculate the loading reductions required. For bacteria, the PRG is calculated by reducing all samples by the same percentage until the geomean of the reduced sample values meets the corresponding bacteria geomean standard (126 cfu/100 ml for *E. coli* and 33 cfu/100 ml for Enterococci) with 10% of MOS. For turbidity, the PRG is the load reduction that ensures that no more than 10% of the samples under flow-base conditions exceed the TMDL.

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.

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

Waterbody ID	Waterbody Name	Required Reduction Rate	
		EC	ENT
OK620910030040_00	Otter Creek	18%	86%
OK620900030230_00	Beaver Creek	15%	80%
OK620910040140_00	Bluff Creek		93%
OK620900030010_00	Cimarron River		58%
OK620900030080_00	Dugout Creek	69%	93%
OK620900040040_00	Stillwater Creek	33%	85%
OK620900020050_00	Council Creek	51%	93%
OK620900020020_00	Salt Creek	39%	86%
OK620900010310_00	Cottonwood Creek	59%	95%
OK620900010290_00	Euchee Creek	53%	87%
OK620900010170_10	Cimarron River		75%
OK620900010180_00	Lagoon Creek	25%	87%

Similarly, PRGs for TSS are calculated as the required overall reduction so that no more than 10% of the samples exceed the water quality target for TSS. The PRGs for the waterbodies requiring turbidity TMDLs in this report are summarized in Table ES-8 and range from 10% to 92%.

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

Waterbody ID	Waterbody Name	Required Reduction Rate
OK620900030260_00	West Beaver Creek	71%
OK620900030230_00	Beaver Creek	29%
OK620900030010_00	Cimarron River	44%
OK620900040040_00	Stillwater Creek	20%
OK620900020050_00	Council Creek	10%

Waterbody ID	Waterbody Name	Required Reduction Rate
OK620900010290_00	Euchee Creek	17%
OK620900010170_10	Cimarron River	92%

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

LA = TMDL – MOS - ∑WLA

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%.

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 MOS. The selection of MOS is based on the normalized root mean square error (NRMSE) for each waterbody (Table ES-4).

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 five 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

Reasonable assurance is required by the EPA rules for a TMDL to be approvable only when a waterbody is impaired by both point and nonpoint sources and where a point source is given a less stringent WLA based on an assumption that nonpoint source load reductions will occur. In such a case, "reasonable assurance" that the non-point source (NPS) load reductions will actually occur must be demonstrated. In this report, all point source discharges either already have or will be given discharge limitations less than or equal to the water quality standard numerical criteria. This ensures that the impairments of the waterbodies in this report will not be caused by point sources. Since the point source WLAs in this TMDL report are not dependent on NPS load reduction, reasonable assurance does not apply.

SECTION 1
INTRODUCTION

1.1 TMDL Program Background

Section 303(d) of the Clean Water Act (CWA) and U.S. Environmental Protection Agency(EPA) Water Quality Planning and Management Regulations (40 Code of Federal Regulations [CFR] Part 130) require states to develop total maximum daily loads (TMDL) for all segments and pollutants identified by the Regional Administrator as suitable for TMDL calculation. Segments and pollutants identified on the approved 303(d) list as not meeting designated uses where technology-based controls are in place will be given a higher priority for development of TMDLs. TMDLs establish the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and 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 (EPA 1991).

This report documents the data and assessment used to establish TMDLs for the pathogen indicator bacteria [*Escherichia coli (E. coli),* Enterococci] and turbidity for selected waterbodies in the Cimarron River basin. (All future references to bacteria in this document imply these two fecal pathogen indicator bacteria groups 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), EPA guidance, and Oklahoma Department of Environmental Quality (DEQ) guidance and procedures. DEQ is required to submit all TMDLs to EPA for review. Approved 303(d) listed waterbody-pollutant pairs or surrogates TMDLs will received notification of the approval or disapproval action. Once the EPA approves a TMDL, then the waterbody may be moved to Category 4a of a state's Integrated Water Quality Monitoring and Assessment Report, where it remains until compliance with water quality standards (WQS) is achieved (EPA 2003).

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. MOS can be implicit and/or explicit. An implicit MOS is achieved by using conservative assumptions in the TMDL calculations. An explicit MOS is a percentage of the TMDL set aside to account for the lack of knowledge associated with natural process in aquatic systems, model assumptions, and data limitations.

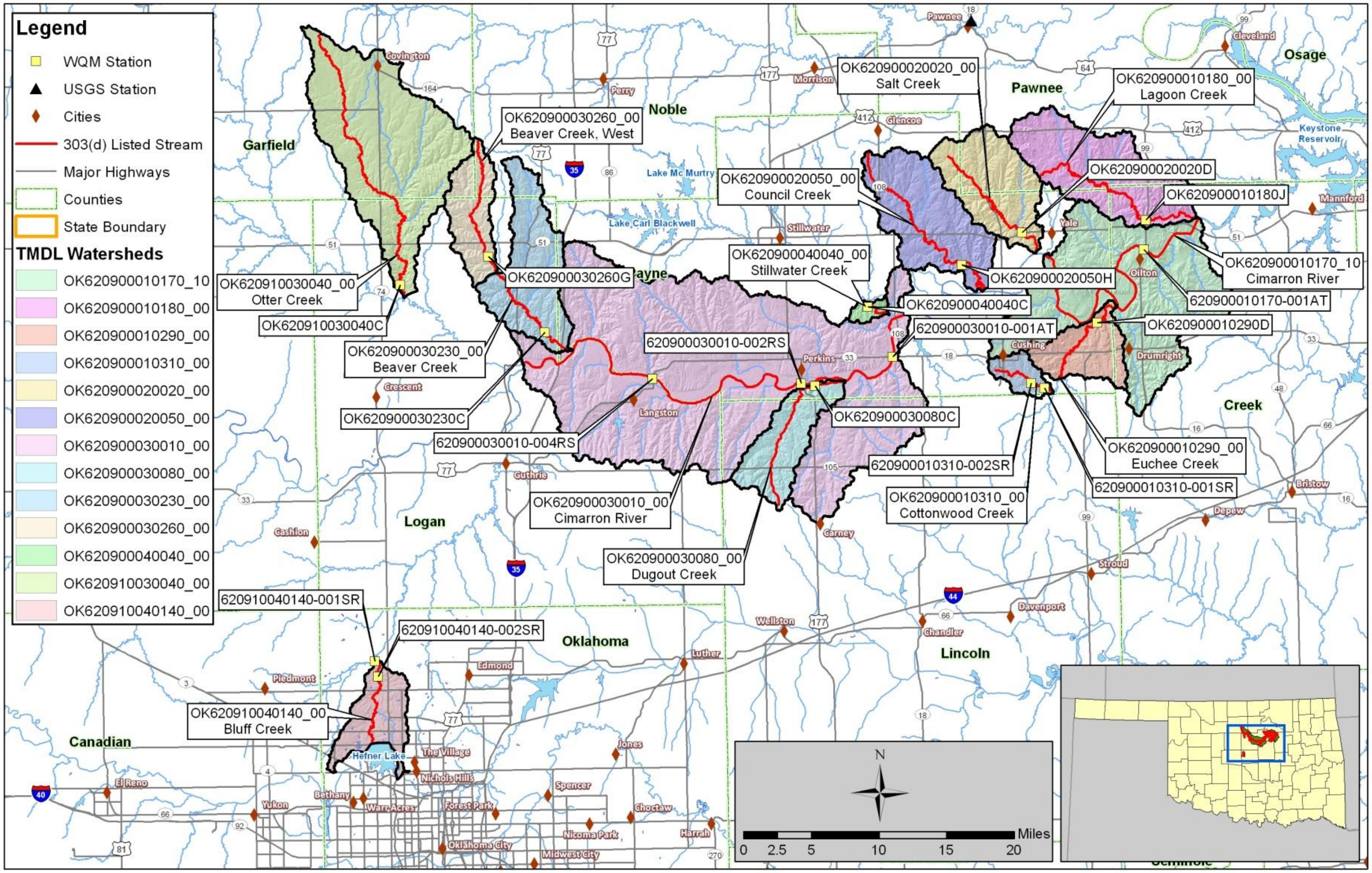
This report does not stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce bacteria or turbidity within each watershed. Watershed-specific control actions and management measures will be identified, selected, and implemented 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 DEQ 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 Fish and Wildlife Propagation beneficial uses. The waterbodies considered for TMDL development in this report, which are presented upstream to downstream, include:

- Otter Creek OK620910030040_00
- Beaver Creek, West OK620900030260_00
- Beaver Creek OK620900030230_00
- Bluff Creek OK620910040140_00
- Cimarron River OK620900030010_00
- Dugout Creek OK620900030080_00
- Stillwater Creek OK620900040040_00
- Council Creek OK620900020050_00
- Salt Creek OK620900020020_00
- Cottonwood Creek OK620900010310_00
- Euchee Creek OK620900010290_00
- Cimarron River OK620900010170_10
- Lagoon Creek OK620900010180_00

Figure 1-1 shows 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 Cimarron River Watersheds Not Supporting Primary Body Contact Recreation or Fish and Wildlife Propagation Use



Elevated levels of pathogen indicator bacteria or turbidity above the WQS numeric criterion 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 PBCR 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 for Assessment of Streams

Station ID	Waterbody Name	WBID
OK620910-03-0040C	Otter Creek, off CR 65	OK620910030040_00
OK620900-03-0260G	West Beaver Creek, off CR 63	OK620900030260_00
OK620900-03-0230C	Beaver Creek, off N. Douglas Blvd.	OK620900030230_00
620910040140-001SR	Bluff Creek, off US 74, Bethany	OK620910040140_00
620910040140-002SR	Bluff Creek, off US 74, Bethany	OK620910040140_00
620900030010-001AT	Cimarron River, SH 33, Ripley	OK620900030010_00
620900030010-002RS	Cimarron River, US 177, near Perkins	OK620900030010_00
620900030010-004RS	Cimarron River, SH 33, near Coyle	OK620900030010_00
OK620900-03-0080C	Dugout Creek, off 140th Street	OK620900030080_00
OK620900-04-0040C	Stillwater Creek, off N3400 Rd.	OK620900040040_00
OK620900-02-0050H	Council Creek, off Mt. Vernon Rd.	OK620900020050_00
OK620900-02-0020D	Salt Creek, off 6th St., near Yale	OK620900020020_00
620900010310-001SR	Cottonwood Creek, Off SH 33, Cushing	OK620900010310_00
620900010310-002SR	Cottonwood Creek, off SH 33, Cushing	OK620900010310_00
OK620900-01-0290D	Euchee Creek, off N3570 Rd.	OK620900010290_00
620900010170-001AT	Cimarron River, off SH 99, Oilton	OK620900010170_10
OK620900-01-0180J	Lagoon Creek, off SH 99	OK620900010180_00

1.2 Watershed Description

1.2.1 General

The Cimarron River basin is located in the central portion of Oklahoma. The majority of the waterbodies addressed in this report are located in Garfield, Logan, Lincoln, Creek, Pawnee and Payne Counties. Bluff Creek (OK620910040140_00) is located in Oklahoma County and the northern portion of West Beaver Creek (OK620900030260_00) is located in Noble County. These counties are part of the Central Great Plains and Cross Timbers Level III ecoregions (Woods, A.J, Omerik, J.M., et al 2005). The watersheds in the Study Area are located in the Cherokee Platform geological province. Table 1-2, derived from the 2010 U.S. Census, demonstrates that the counties in which these watersheds are located are mostly sparsely populated, except for Oklahoma County, which is densely 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 (2010 Census)	Population Density (per square mile)
Creek	69,967	72
Garfield	60,580	57
Lincoln	34,273	35
Logan	41,848	56
Noble	11,561	16
Oklahoma	718,633	1,000
Pawnee	16,577	28
Payne	77,350	111

Table 1-3 Towns and Cities by Watershed

Waterbody Name	Waterbody ID	Municipalities
Otter Creek	OK620910030040_00	Covington, Douglas
Beaver Creek	OK620900030230_00	Mulhall, Orlando
Bluff Creek	OK620910040140_00	Oklahoma City, The Village
Cimarron River	OK620900030010_00	Coyle, Langston, Perkins, Ripley, Tryon
Cimarron River	OK620900010170_10	Cushing, Drumright, Oilton
Lagoon Creek	OK620900010180_00	Jennings

1.2.2 Climate

Table 1-4 summarizes the average annual precipitation for each Oklahoma waterbody derived from a geospatial layer developed to display annual precipitation using data collected from Oklahoma weather stations between 1971 through 2000. Average annual precipitation values among the watersheds in this portion of Oklahoma range between 34 and 39 inches (Oklahoma Climatological Survey 2005).

Table 1-4 Average Annual Precipitation by Watershed

Waterbody Name	Waterbody ID	Average Annual Precipitation (inches)
Otter Creek	OK620910030040_00	34
Beaver Creek, West	OK620900030260_00	36
Beaver Creek	OK620900030230_00	36
Bluff Creek	OK620910040140_00	36
Cimarron River	OK620900030010_00	37

Waterbody Name	Waterbody ID	Average Annual Precipitation (inches)
Dugout Creek	OK620900030080_00	37
Stillwater Creek	OK620900040040_00	37
Council Creek	OK620900020050_00	38
Salt Creek	OK620900020020_00	38
Cottonwood Creek	OK620900010310_00	38
Euchee Creek	OK620900010290_00	38
Cimarron River	OK620900010170_10	39
Lagoon Creek	OK620900010180_00	39

1.2.3 Land Use

Tables 1-5a and 1-5b 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 percentages provided in Tables 1-5a and 1-5b are rounded so in some cases may not total exactly 100%. The land use categories are displayed in Figure 1-2. The most dominant land use category throughout the Cimarron River Study Area is grasslands/herbaceous. Three watersheds in the Study Area have a significant percentage of land use classified as cultivated crops including Otter Creek (OK620910030040_00), West Beaver Creek (OK620900030260_00), and Beaver Creek (OK620900030230_00). Seven of the 13 watersheds have sizeable areas covered in deciduous forest land ranging from 20% to 36% of the respective watersheds. The aggregated total of low, medium, and high intensity developed land accounts for approximately 41% of the the land use in Bluff Creek (OK620910040140_00) and 21% of the land use in Cottonwood Creek (OK620900010310_00). In the remaining 11 watersheds of the Study Area low, medium, and high intensity developed land accounts for less than 2% of the land use. The watersheds targeted for TMDL development in this Study Area range in size from 2,353 acres (Stillwater Creek, OK60900040040_00) to 219,548 acres (Cimarron River, OK620900030010_00).

Table 1-5a Land Use Summaries by Watershed

Landuse Category	Watershed						
	Otter Creek	Beaver Creek, West	Beaver Creek	Bluff Creek	Cimarron River	Dugout Creek	Stillwater Creek
Waterbody ID	OK620910030040_00	OK620900030260_00	OK620900030230_00	OK620910040140_00	OK620900030010_00	OK620900030080_00	OK620900040040_00
Percent of Open Water	0.31	0.86	0.69	1.15	1.60	0.56	0.50
Percent of Developed, Open Space	3.96	3.75	6.22	15.86	5.03	4.51	5.29
Percent of Developed, Low Intensity	0.20	0.00	0.34	18.93	0.41	0.07	0.11
Percent of Developed, Medium Intensity	0.05	0.00	0.11	17.11	0.09	0.00	0.00
Percent of Developed, High Intensity	0.01	0.00	0.01	4.5	0.02	0.00	0.00
Percent of Barren Land (Rock/Sand/Clay)	0.00	0.00	0.00	0.10	0.06	0.00	0.00
Percent of Deciduous Forest	6.72	10.65	8.40	4.12	21.76	18.30	25.09
Percent of Evergreen Forest	1.75	3.55	1.14	0.01	2.86	1.83	8.56
Percent of Mixed Forest	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent of Shrub/Scrub	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent of Grassland/Herbaceous	39.49	64.79	65.52	26.71	50.60	60.42	42.72
Percent of Pasture/Hay	0.17	0.00	0.00	0.49	5.20	5.65	3.28
Percent of Cultivated Crops	47.34	16.40	17.58	11.03	12.36	8.67	14.43
Percent of Woody Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent of Emergent Herbaceous Wetlands	0.00	0.00	0.00	0.00	0.02	0.00	0.00
Acres Open Water	237	151	229	191	3,502	117	12
Acres Developed, Open Space	2,993	661	2,064	2,632	11,047	952	125
Acres Developed, Low Intensity	154	0	111	3,140	891	15	3
Acres Developed, Medium Intensity	36	0	37	2,839	199	0	0
Acres Developed, High Intensity	6	0	3	747	52	0	0
Acres Barren Land (Rock/Sand/Clay)	0	0	0	16	132	0	0
Acres Deciduous Forest	5,079	1,873	2,787	683	47,764	3,860	590
Acres Evergreen Forest	1,322	624	378	2	6,280	385	201
Acres Mixed Forest	0	0	0	0	0	0	0

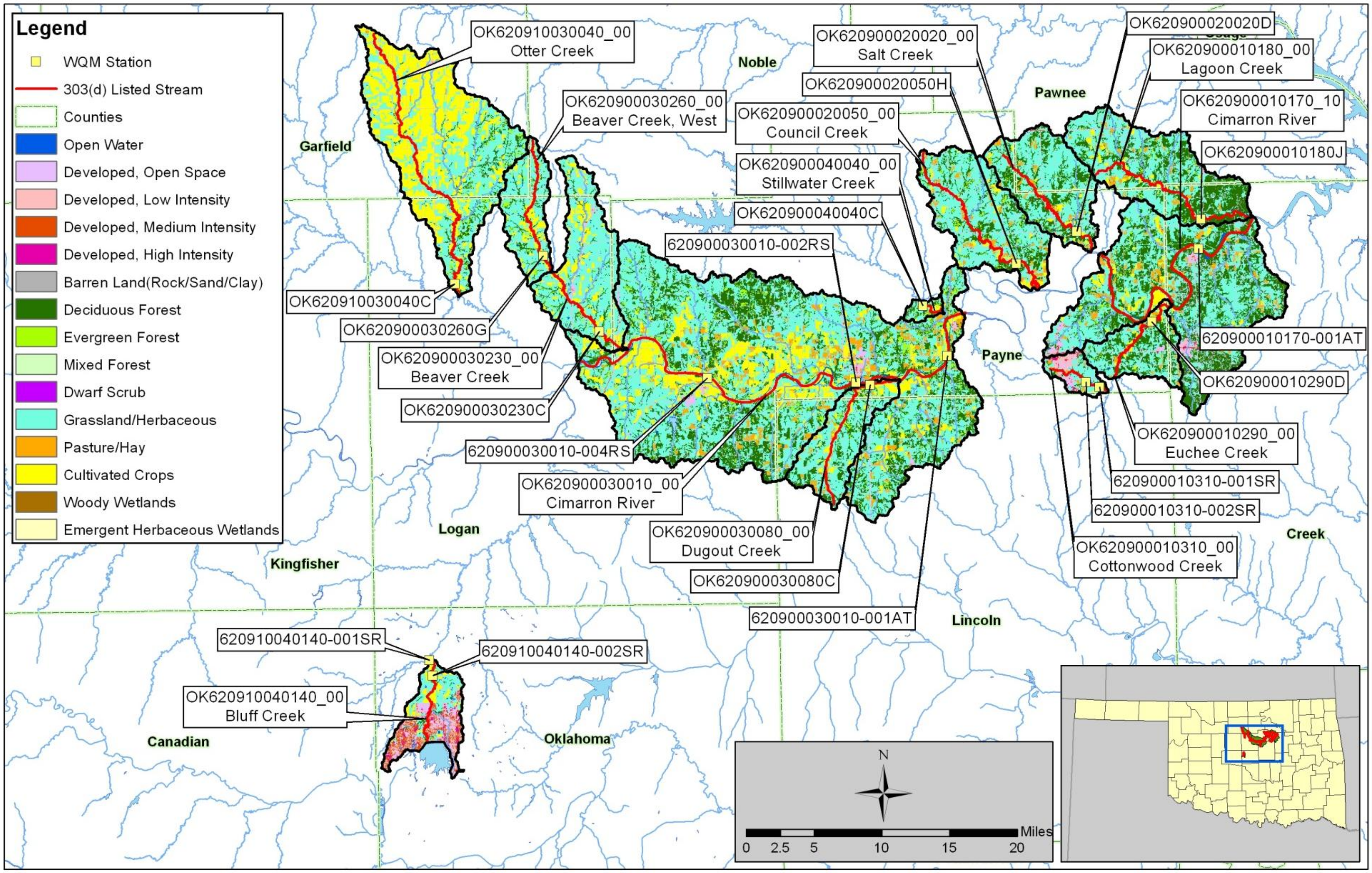
Landuse Category	Watershed						
	Otter Creek	Beaver Creek, West	Beaver Creek	Bluff Creek	Cimarron River	Dugout Creek	Stillwater Creek
Waterbody ID	**OK620910030040_00**	**OK620900030260_00**	**OK620900030230_00**	**OK620910040140_00**	**OK620900030010_00**	**OK620900030080_00**	**OK620900040040_00**
Acres Shrub/Scrub	0	0	0	0	0	0	0
Acres Grassland/Herbaceous	29,847	11,397	21,751	4,432	111,091	12,743	1,005
Acres Pasture/Hay	128	0	0	81	11,427	1,191	77
Acres Cultivated Crops	35,783	2,885	5,836	1,830	27,128	1,828	340
Acres Woody Wetlands	0	0	0	0	0	0	0
Acres Emergent Herbaceous Wetlands	0	0	0	0	33	0	0
Total (Acres)	**75,587**	**17,591**	**33,197**	**16,593**	**219,548**	**21,092**	**2,353**

Table 1-5b Land Use Summaries by Watershed

Landuse Category	Watershed					
	Council Creek	Salt Creek	Cottonwood Creek	Euchee Creek	Cimarron River	Lagoon Creek
Waterbody ID	OK620900020050_00	OK620900020020_00	OK620900010310_00	OK620900010290_00	OK620900010170_10	OK620900010180_00
Percent of Open Water	0.37	0.23	0.70	0.47	1.95	0.33
Percent of Developed, Open Space	4.76	4.62	16.16	5.92	7.14	4.96
Percent of Developed, Low Intensity	0.26	0.42	14.63	0.92	1.25	0.37
Percent of Developed, Medium Intensity	0.01	0.14	3.53	0.35	0.38	0.11
Percent of Developed, High Intensity	0.00	0.01	2.46	0.18	0.18	0.00
Percent of Barren Land (Rock/Sand/Clay)	0.00	0.00	0.00	0.00	0.03	0.00
Percent of Deciduous Forest	19.50	27.96	8.31	31.61	35.62	35.85
Percent of Evergreen Forest	2.65	1.19	0.60	0.89	0.97	1.15
Percent of Mixed Forest	0.00	0.00	0.00	0.00	0.00	0.00
Percent of Shrub/Scrub	0.00	0.00	0.00	0.00	0.00	0.00
Percent of Grassland/Herbaceous	61.83	57.76	47.89	50.82	44.74	50.95
Percent of Pasture/Hay	5.45	3.77	4.64	4.33	4.36	3.36
Percent of Cultivated Crops	5.15	3.89	1.08	4.51	3.36	2.92
Percent of Woody Wetlands	0.00	0.00	0.00	0.00	0.00	0.00
Percent of Emergent Herbaceous Wetlands	0.02	0.00	0.00	0.00	0.00	0.00
Acres Open Water	139	68	43	79	1,656	136
Acres Developed, Open Space	1,768	1,370	987	996	6,048	2,042
Acres Developed, Low Intensity	97	125	893	155	1,055	151
Acres Developed, Medium Intensity	2	42	215	59	323	44
Acres Developed, High Intensity	1	4	150	31	149	2
Acres Barren Land (Rock/Sand/Clay)	0	0	0	0	28	0
Acres Deciduous Forest	7,248	8,289	507	5,319	30,176	14,758
Acres Evergreen Forest	984	353	36	150	826	475
Acres Mixed Forest	0	0	0	0	0	0
Acres Shrub/Scrub	0	0	0	0	0	0
Acres Grassland/Herbaceous	22,987	17,122	2,923	8,552	37,899	20,971

Landuse Category	Watershed					
	Council Creek	Salt Creek	Cottonwood Creek	Euchee Creek	Cimarron River	Lagoon Creek
Waterbody ID	**OK620900020050_00**	**OK620900020020_00**	**OK620900010310_00**	**OK620900010290_00**	**OK620900010170_10**	**OK620900010180_00**
Acres Pasture/Hay	2,028	1,117	284	729	3,695	1,384
Acres Cultivated Crops	1,916	1,152	66	760	2,849	1,201
Acres Woody Wetlands	0	0	0	0	0	0
Acres Emergent Herbaceous Wetlands	6	0	0	0	2	0
Total (Acres)	**37,177**	**29,642**	**6,105**	**16,828**	**84,705**	**41,163**

Figure 1-2 Land Use Map



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. Flow data from the surrounding USGS gage stations and the instantaneous flow measurement data taken with water quality samples have been used to estimate flows for ungaged streams. 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 Water Quality Standards (OWQS) and implementation procedures (OWRB 2011). The Oklahoma Water Resources Board (OWRB) has statutory authority and responsibility concerning establishment of state WQS, as provided under 82 Oklahoma Statute [O.S.], §1085.30. This statute authorizes the OWRB to promulgate rules …*which establish classifications of uses of waters of the state, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters.* [O.S. 82:1085:30(A)]. Beneficial uses are designated for all waters of the state. Such uses are protected through restrictions imposed by the antidegradation policy statement, narrative water quality criteria, and numerical criteria (OWRB 2011). An excerpt of the Oklahoma WQS (Title 785) summarizing the State of Oklahoma Antidegradation Policy is provided in Appendix C. Table 2-1, an excerpt from the 2008 Integrated Report (DEQ 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 Propogation
  - WWAC – Warm Water Aquatic Community
- HLAC – Habitat Limited Aquatic Community
- FISH – Fish Consumption
- PBCR – Primary Body Contact Recreation
- PPWS – Public & Private Water Supply
- EWS – Emergency Water Supply

Table 2-1 Designated Beneficial Uses for Each Stream Segment in This Report

Waterbody ID	Waterbody Name	AES	AG	WWAC	FISH	PBCR	PPWS	EWS
Otter Creek	OK620910030040_00	F	F	N	X	N	I	
Beaver Creek, West	OK620900030260_00	I	F	N	X	N	I	
Beaver Creek	OK620900030230_00	I	N	N	X	F	I	
Bluff Creek	OK620910040140_00	I	X	I	X	N	I	
Cimarron River	OK620900030010_00	I	N	N	N	N		F
Dugout Creek	OK620900030080_00	F	F	N	X	N	I	
Stillwater Creek	OK620900040040_00	I	N	F	X	N	N	
Council Creek	OK620900020050_00	F	F	F	X	N	I	
Salt Creek	OK620900020020_00	F	F	F	X	N	I	
Cottonwood Creek	OK620900010310_00	I	X	N	X	N		F
Euchee Creek	OK620900010290_00	I	F	N	X	N		F
Cimarron River	OK620900010170_10	I	N	N	N	N		F
Lagoon Creek	OK620900010180_00	F	F	F	X	N		

F – Fully supporting; N – Not supporting; I – Insufficient information; X – Not assessed
Source: 2008 Integrated Report, DEQ 2008

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

The definition of PBCR and the bacteria WQSs for PBCR are summarized by the following excerpt from Chapter 45 of the Oklahoma WQSs.

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

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

(c) Compliance with 785:45-5-16 shall be based upon meeting the requirements of one of the options specified in (1) or (2) of this subsection (c) for bacteria. Upon selection of one (1) group or test method, said method shall be used exclusively over the time period prescribed therefore. Provided, where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, no criteria exceedances shall be allowed for any indicator group.

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

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

To implement Oklahoma's WQS for PBCR, OWRB promulgated Chapter 46, *Implementation of Oklahoma's Water Quality Standards* (OWRB 2011a). The excerpt below from Chapter 46: 785:46-15-6, stipulates how water quality data will be assessed to determine support of the PBCR use as well as how the water quality target for TMDLs will be defined for each bacterial indicator.

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

(b) ***Escherichia coli (E. coli).***

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

(2) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to E. coli if the geometric mean of 126 colonies per 100 ml is not met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

(c) ***Enterococci.***

(1) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be fully supported with respect to Enterococci if the geometric mean of 33 colonies per 100 ml is met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

(2) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to Enterococci if the geometric mean of 33 colonies per 100 ml is not met. These values are based upon all samples collected over the recreation period in accordance with OAC 785:46-15-3(c).

Table 2-2 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*	Designated Use Primary Body Contact Recreation	Turbidity	Designated Use Warm Water Aquatic Life
Otter Creek	OK620910030040_00	30.15	2019	4	X		N	X	N
Beaver Creek, West	OK620900030260_00	13.21	2019	4	X	X	N	X	N
Beaver Creek	OK620900030230_00	12.65	2019	4				X	N
Bluff Creek	OK620910040140_00	9.32	2010	1	X	X	N		
Cimarron River	OK620900030010_00	42.09	2016	3	X		N	X	N
Dugout Creek	OK620900030080_00	13.58	2016	3	X	X	N	X	N
Stillwater Creek	OK620900040040_00	3.53	2016	3	X	X	N		
Council Creek	OK620900020050_00	21.94	2016	3	X		N		
Salt Creek	OK620900020020_00	14.71	2016	3	X	X	N		
Cottonwood Creek	OK620900010310_00	6.26	2019	4	X	X	N		
Euchee Creek	OK620900010290_00	9.56	2019	4	X		N	X	N
Cimarron River	OK620900010170_10	26.58	2013	2	X		N	X	N
Lagoon Creek	OK620900010180_00	18.55	2016	3	X	X	N		

ENT = Enterococci; N = Not attaining; X = Criterion exceeded
Source: 2008 Integrated Report, DEQ 2008

Compliance with the Oklahoma WQS is based on meeting requirements for both *E. coli* and Enterococci bacterial indicators in addition to the minimum sample requirements for assessment. Where concurrent data exist for multiple bacterial indicators on the same waterbody or waterbody segment, each indicator group must demonstrate compliance with the numeric criteria prescribed (OWRB 2011).

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

It is worth noting that the Oklahoma WQS prior to July 1, 2011 contains three bacteria indicators (fecal coliform, *E. coli* and Enterococci) and the new Oklahoma WQS effective on July 1, 2011 contains only *E. coli* and Enterococci. Because the new Oklahoma WQS no longer have a standard for fecal coliform, fecal coliform TMDLs will not be developed for any stream segment in this report even though some stream segments were listed for fecal coliform impairment in the 2008 303(d) list. Bacteria TMDLs will be developed only for *E. coli* and/or Enterococci impaired streams.

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 2011). 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 2011a). 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 exceeds 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 2000 and 2008 for each indicator bacteria. The data summary in Table 2-3 provides a general understanding of the amount of water quality data available and the severity of exceedances of the water quality criteria. 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 DEQ 2008 303(d) list (DEQ 2008). Water quality data from the primary contact recreation season are provided in Appendix A. For the data collected between 2000 and 2008, evidence of nonsupport of the PBCR use based on elevated *E. coli* and Enterococci concentrations was observed in all, except four waterbodies: Beaver Creek, West (OK620900030260_00), Bluff Creek (OK620910040140_00), Cimarron River (OK620900030010_00), and Cimarron River (OK620900010170_10). Evidence of nonsupport of the PBCR use based on Enterococci concentrations was observed in three waterbodies: Bluff Creek (OK620910040140_00), Cimarron River (OK620900030010_00), and Cimarron River (OK620900010170_10). Bluff Creek (OK620910040140_00) was listed on the DEQ 2008 303(d) list (DEQ 2008) as nonsupport for both *E. coli*. and Enterococci, although review of the data indicates this segment is not impaired for *E. coli*. Detailed review of the data collected between 2000 and 2008 for Beaver Creek, West (OK620900030260_00) indicated an insufficient number of samples were available, therefore no TMDLs are required and delisting is recommended. Rows highlighted in green and yellow in Table 2-3 require TMDLs. Beaver Creek (OK620900030230_00) was not identified in the 2008 303(d) list as nonsupporting for PBCR use, however, upon detailed review of available data it was determined that the geometric mean criteria for both *E. coli* and Enterococci were exceeded. Twelve of the 13 water bodies for which water quality data was assessed will have TMDLs developed for bacteria resulting in a total of 21 bacterial TMDLs for waterbody/pollutant combinations.

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.

For the 11 waterbodies assessed in this report for turbidity, Table 2-4 summarizes water quality data collected from the WQM stations between 1998 and 2011. 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 WQS, DEQ considers base flow conditions to be all flows less than the 25^{th} flow exceedance percentile (i.e., the lower 75% of flows) which is consistent with the USGS Streamflow Conditions Index (USGS 2009). Therefore, Table 2-5 was prepared to represent the subset of these data for samples collected during base flow conditions. 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. Using this qualified data set seven of the 11 waterbodies identified in Table 2-4 indicate nonsupport of the Fish and Wildlife Propagation use based on turbidity levels observed in the waterbody which will be targeted for TMDL development. Table 2-6 summarizes water quality data collected from the WQM stations between 1998 and 2011 for TSS. Table 2-7 presents a subset of these data for samples collected during base flow conditions. In using TSS as a surrogate to support TMDL development at least 10 TSS samples are required to conduct the regression analysis between turbidity and TSS. Water quality data for turbidity and TSS are provided in Appendix A.

Table 2-3 Summary of Assessment of Indicator Bacteria Samples from Primary Body Contact Recreation Subcategory Season May 1 to September 30, 2000-2008

Waterbody ID	Waterbody Name	Indicator	Number of samples	Geometric Mean Concentration (count/100 ml)	Notes
OK620910030040_00	Otter Creek	EC	14	139	Not listed, but geomean is exceeded
		ENT	14	208	
OK620900030260_00	Beaver Creek, West	EC	5	76	Insufficient number of samples, de-list
		ENT	5	212	Insufficient number of samples, de-list
OK620900030230_00	Beaver Creek	EC	14	133	Not listed, but geomean is exceeded
		ENT	14	148	Not listed, but geomean is exceeded
OK620910040140_00	Bluff Creek	EC	13	101	Not impaired, de-list
		ENT	13	437	
OK620900030010_00	Cimarron River	ENT	38	71	
OK620900030080_00	Dugout Creek	EC	14	371	
		ENT	14	416	
OK620900040040_00	Stillwater Creek	EC	24	169	
		ENT	24	205	
OK620900020050_00	Council Creek	EC	16	230	Not listed, but geomean is exceeded
		ENT	16	420	
OK620900020020_00	Salt Creek	EC	16	186	
		ENT	16	215	
OK620900010310_00	Cottonwood Creek	EC	15	276	
		ENT	15	580	
OK620900010290_00	Euchee Creek	EC	16	244	Not listed, but geomean is exceeded
		ENT	16	233	
OK620900010170_10	Cimarron River	ENT	28	119	
OK620900010180_00	Lagoon Creek	EC	16	151	
		ENT	16	221	

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 Samples, 1998-2011

Waterbody ID	Waterbody Name	WQM Stations	Number of turbidity samples	Number of samples greater than 50 NTU	% samples exceeding criterion	Average Turbidity (NTU)
OK620910030040_00	Otter Creek	OK620910-03-0040C	20	3	15%	96
OK620900030260_00	Beaver Creek, West	OK620900-03-0260G	22	6	27%	105
OK620900030230_00	Beaver Creek	OK620900-03-0230C	19	6	32%	118
OK620900030010_00	Cimarron River	620900030010-001AT	94	35	37%	195
OK620900030080_00	Dugout Creek	OK620900-03-0080C	26	7	27%	66
OK620900040040_00	Stillwater Creek	OK620900-04-0040C	47	15	32%	105
OK620900020050_00	Council Creek	OK620900-02-0050H	27	7	26%	74
OK620900020020_00	Salt Creek	OK620900-02-0020D	25	3	12%	43
OK620900010290_00	Euchee Creek	OK620900-01-0290D	27	8	30%	66
OK620900010170_10	Cimarron River	620900010170-001AT	42	22	52%	257
OK620900010180_00	Lagoon Creek	OK620900-01-0180J	26	6	23%	59

Table 2-5 Summary of Turbidity Samples Collected During Base Flow Conditions, 1998-2011

Waterbody ID	Waterbody Name	WQM Stations	Number of turbidity samples	Number of samples greater than 50 NTU	% samples exceeding criterion	Average Turbidity (NTU)	Assessment Results
OK620910030040_00	Otter Creek	OK620910-03-0040C	13	0	0%	16	Not impaired, de-list
OK620900030260_00	Beaver Creek, West	OK620900-03-0260G	16	2	13%	37	
OK620900030230_00	Beaver Creek	OK620900-03-0230C	13	2	15%	27	
OK620900030010_00	Cimarron River	620900030010-001AT	13	4	31%	43	
OK620900030080_00	Dugout Creek	OK620900-03-0080C	17	1	6%	15	Not impaired, de-list
OK620900040040_00	Stillwater Creek	OK620900-04-0040C	29	3	10%	45	Not listed, but impaired
OK620900020050_00	Council Creek	OK620900-02-0050H	18	2	11%	13	Not listed, but impaired
OK620900020020_00	Salt Creek	OK620900-02-0020D	14	0	0%	11	
OK620900010290_00	Euchee Creek	OK620900-01-0290D	17	3	18%	27	
OK620900010170_10	Cimarron River	620900010170-001AT	38	18	47%	216	
OK620900010180_00	Lagoon Creek	OK620900-01-0180J	16	1	6%	14	

TMDLs will be developed for waterbodies highlighted in green.

Table 2-6 Summary of All TSS Samples, 1998-2011

Waterbody ID	Waterbody Name	WQM Stations	Number of TSS samples	Average TSS (mg/L)
OK620910030040_00	Otter Creek	OK620910-03-0040C	20	715
OK620900030260_00	Beaver Creek, West	OK620900-03-0260G	20	119
OK620900030230_00	Beaver Creek	OK620900-03-0230C	20	457
OK620900030010_00	Cimarron River	620900030010-001AT	-	-
OK620900030080_00	Dugout Creek	OK620900-03-0080C	25	56
OK620900040040_00	Stillwater Creek	OK620900-04-0040C	47	119
OK620900020050_00	Council Creek	OK620900-02-0050H	25	83
OK620900020020_00	Salt Creek	OK620900-02-0020D	25	48
OK620900010290_00	Euchee Creek	OK620900-01-0290D	25	59
OK620900010170_10	Cimarron River	620900010170-001AT	-	-
OK620900010180_00	Lagoon Creek	OK620900-01-0180J	25	43

Table 2-7 Summary of TSS Samples During Base Flow Conditions 1998-2011

Waterbody ID	Waterbody Name	WQM Stations	Number of TSS samples	Average TSS (mg/L)
OK620910030040_00	Otter Creek	OK620910-03-0040C	12	14
OK620900030260_00	Beaver Creek, West	OK620900-03-0260G	14	19
OK620900030230_00	Beaver Creek	OK620900-03-0230C	13	16
OK620900030010_00	Cimarron River	620900030010-001AT	-	-
OK620900030080_00	Dugout Creek	OK620900-03-0080C	17	14
OK620900040040_00	Stillwater Creek	OK620900-04-0040C	29	23
OK620900020050_00	Council Creek	OK620900-02-0050H	16	11
OK620900020020_00	Salt Creek	OK620900-02-0020D	13	11
OK620900010290_00	Euchee Creek	OK620900-01-0290D	15	20
OK620900010170_10	Cimarron River	620900010170-001AT	-	-
OK620900010180_00	Lagoon Creek	OK620900-01-0180J	15	14

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." The water quality targets for *E. coli* and Enterococci are geometric mean standards of 126 cfu/100ml and 33 cfu/100ml, respectively.

The TMDL for bacteria will incorporate an explicit 10% margin of safety.

An individual water quality target established for turbidity must demonstrate compliance with the numeric criteria prescribed in the Oklahoma WQS (OWRB 2011). According to the

Oklahoma WQS [785:45-5-12(f)(7)], the turbidity criterion for streams with WWAC beneficial use is 50 NTUs (OWRB 2011). 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% 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, 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 currently required to monitor for fecal coliform and TSS in accordance with their permits. The discharges with bacteria limits will be required to monitor for *E. coli* when their permits come to renew. 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 permits are considered nonpoint sources.

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

The following nonpoint sources of *E. coli* were considered in this report:

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

The 2008 Integrated Water Quality Assessment Report (DEQ 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.

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 municipal plants are classified as no-discharge facilities. These facilities are required to sign an affidavit of no discharge. NPDES-permitted facilities classified as point sources that may contribute bacteria or TSS loading includes:

- NPDES municipal wastewater treatment plant (WWTP);
- NPDES Industrial WWTP Discharges;
- 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 indicator bacteria if the disinfection unit is not properly maintained, is of poor design, or if flow rates are above the disinfection capacity. While the no-discharge facilities do not discharge wastewater directly to a waterbody, it is possible that 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 DEQ 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 Biochemical Oxygen Demand (BOD) or Carbonaceous Biochemical Oxygen Demand (CBOD). Only WWTP discharges of inorganic suspended solids will be considered and will receive WLAs.

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 EPA as potential 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 EPA 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 EPA NPDES Program, can contain TSS. 40 C.F.R. § 130.2(h) requires that NPDES-regulated stormwater discharges must be addressed by the WLA 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. OWQS 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, TSS WLAs for NPDES-regulated stormwater discharges is essentially considered unnecessary in this TMDL report and will not be included in the TMDL calculations. However, bacteria WLAs for NPDES-regulated stormwater will be necessary for the two NPDES MS4 permits, The Village and Oklahoma City, in the Bluff Creek (OK620910040140_00) watershed.

Five watersheds in the Study Area (Beaver Creek West, Stillwater Creek, Council Creek, Salt Creek, and Lagoon Creek) have no NPDES permitted facilities within their contributing watershed. There are at least two NPDES-permitted facilities in each of the remaining eight watersheds in the Study Area.

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 Figure 3-1. There are 11 continuous point source facilities discharging within the Study Area but they are not considered significant sources of concern for bacteria or TSS loading. All these facilities discharge TSS and have specific permit limits for TSS which are provided in Table 3-1. Three of the NPDES-permitted facilities will require a WLA for TSS. The other eight 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. These eight facilities will require a WLA for bacteria. Two facilities, OK0028801 and OK0022501, reported a high number of both average and maximum bacteria concentrations from 2010 through 2011 and 2006 through 2009, respectively. One facility, OK0026701 reported high numbers of exceedances for maximum bacteria concentrations from 2009 through 2010. Available discharge monitoring report (DMR) data for bacteria and TSS are provided in Appendix D.

3.1.2 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 four municipal no-discharge facilities and three industrial no-discharge facility in the Study Area which are listed in Table 3-2. The no-discharge facilities located in Otter Creek (OK620910030040_00), Beaver Creek (OK620900030230_00), Bluff Creek (OK620910040140_00), Brush Creek (OK620900030030_00), and Cimarron River (OK620900030010_00 and OK620900010170_10) watersheds could be contributing to the elevated levels of instream indicator bacteria loading.

Sanitary sewer overflow (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 EPA, primarily through enforcement and fines. While not all sewer overflows are reported, DEQ has some data on SSOs available. Between 1989 and 2007, 879 SSO overflows were reported ranging from 1 gallon to over 55 million gallons. Table 3-3 summarizes the SSO occurrences by NPDES facility. Historical data of reported SSOs are provided in Appendix E.

Table 3-1 Point Source Discharges in the Study Area

OPDES Permit No.	Name	Receiving Water	Receiving Waterbody Name	Facility Type	SIC Code	County	Design Flow (mgd)	Facility ID	Expiration Date	Avg./Max. FC cfu/100mL	Avg./Max. TSS mg/L	Outfall
OK0044598	Greenfield Environmental Multistate Trust LLC - Skull Creek	OK620900010360_00	Skull Creek	Sanitary Services	4959	Payne	Report	60000690	1/31/15	NA	NA/45	001A
OK0022713	Covington Utilities Authority	OK620910030290_00	Covington Creek	Sewerage System	4952	Garfield	0.075	S20936	1/31/12	NA	90/135	001A
OK0026077	Bethany/Warr Acres PWA – Bluff WWTP	OK620910040140_00	Bluff Creek	Sewerage System	4952	Oklahoma	5	S20925	10/31/12	200/400	15/22.5	001A
OK0027511	Langston Public Works Auth. WWTP	OK620900030150_00	Fitzgerald Creek	Sewerage System	4952	Logan	0.4	S20967	11/30/14	200/400	30/45	001A
OK0028801	City of Perkins WWTP	OK620900030100_00	Perkins Creek	Sewerage System	4952	Payne	0.29	S20941	1/31/12	200/400	90/135	001A
OKG580029	Tryon Utility Authority WWTP	OK620900030040_00	Sand Creek	Sewerage System	4952	Lincoln	0.061	S20942	6/30/16	NA	90/135	001A
OK0026701	City of Cushing (WWTP south)	OK620900010310_00	Cottonwood Creek	Sewerage System	4952	Payne	1.6	S20951	7/31/14	200/400	20/30	001A
OK0022501	Drumright Utilities Trust	OK620900010250_00	Tiger Creek	Sewerage System	4952	Creek	0.68	S20952	4/30/16	200/400	30/45	001A
OK0035599	Oilton Public Works Authority WWTP	OK620900010170_10	Cimarron River	Sewerage System	4952	Creek	0.123	S20953	6/30/11	200/400	30/45	001A
OK0038318	City of Drumright	OK620900010250_00	Tiger Creek	Water Supply	4941	Creek	Report	W20904	5/31/12	NA	20/30	001A
OK0043320	Greenfield Environmental Multistate Trust LLC - Cushing	OK620900010360_00	Skull Creek	Petroleum Refining	2911	Payne	Report	60000470	3/31/16	NA	30/45	1,7,8

NA = not available.

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

Facility	Facility ID	County	Facility Type	Type	Waterbody ID	Waterbody Name
Covington WWT	20936	Garfield	Lagoon (total retention)	Municipal	OK620910030040_00	Otter Creek
Mulhall WWT	20938	Logan	Lagoon (total retention)	Municipal	OK620900030230_00	Beaver Creek
Coyle PWA WWT	20940	Logan	Lagoon (total retention)	Municipal	OK620900030010_00	Cimarron River
Kerns Ready Mixed Concrete Inc	OKG11T028	Payne	Total retention	Industrial	OK620900030010_00	Cimarron River
Ripley WWT	20948	Payne	Lagoon (total retention)	Municipal	OK620900030010_00	Cimarron River
Okmulgee Ready Mix Concrete Co	OKG11T203	Okmulgee	Total retention	Industrial	OK620900030030_00	Brush Creek
Quapaw Co Badger Quarry	OKGC3T027	Creek	Total retention	Industrial	OK620900010170_10	Cimarron River

Table 3-3 Sanitary Sewer Overflow Summary

Facility Name	NPDES Permit No.	Receiving Water	Facility ID	Number of Occurrences	Date Range		Amount (Gallons)	
					From	To	Min	Max
Town of Covington/WWT	OK0022713	OK620910030290_00	S20936	18	5/9/1995	3/21/2003	115	4,000,000
Bethany/Warr Acres PWA - Bluff	OK0026077	OK620910040140_00	S20925	165	12/27/1989	3/30/2007	8	2,000,000
Langston Public Works Auth.	OK0027511	OK620900030150_00	S20967	1	11/29/2005	11/29/2005	NA	NA
City of Perkins	OK0028801	OK620900030100_00	S20941	7	1/10/1994	7/11/2003	500	1,700
Tryon Utility Authority	OKG580029	OK620900030040_00	S20942	4	9/27/2001	6/28/2004	25	<300
City of Cushing (south STP)	OK0026701	OK620900010310_00	S20951	586	2/28/1990	3/3/2007	1	1,000,000
Drumright Utilities Trust	OK0022501	OK620900010250_00	S20952	76	1/7/1998	2/26/2007	5	5,000
Oilton Public Works Authority	OK0035599	OK620900010170_10	S20953	19	5/9/1990	7/8/2003	<50	>55,000,000
Mulhall WWT		OK620900030230_00	S20938	3	3/31/1999	3/4/2004	NA	NA

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

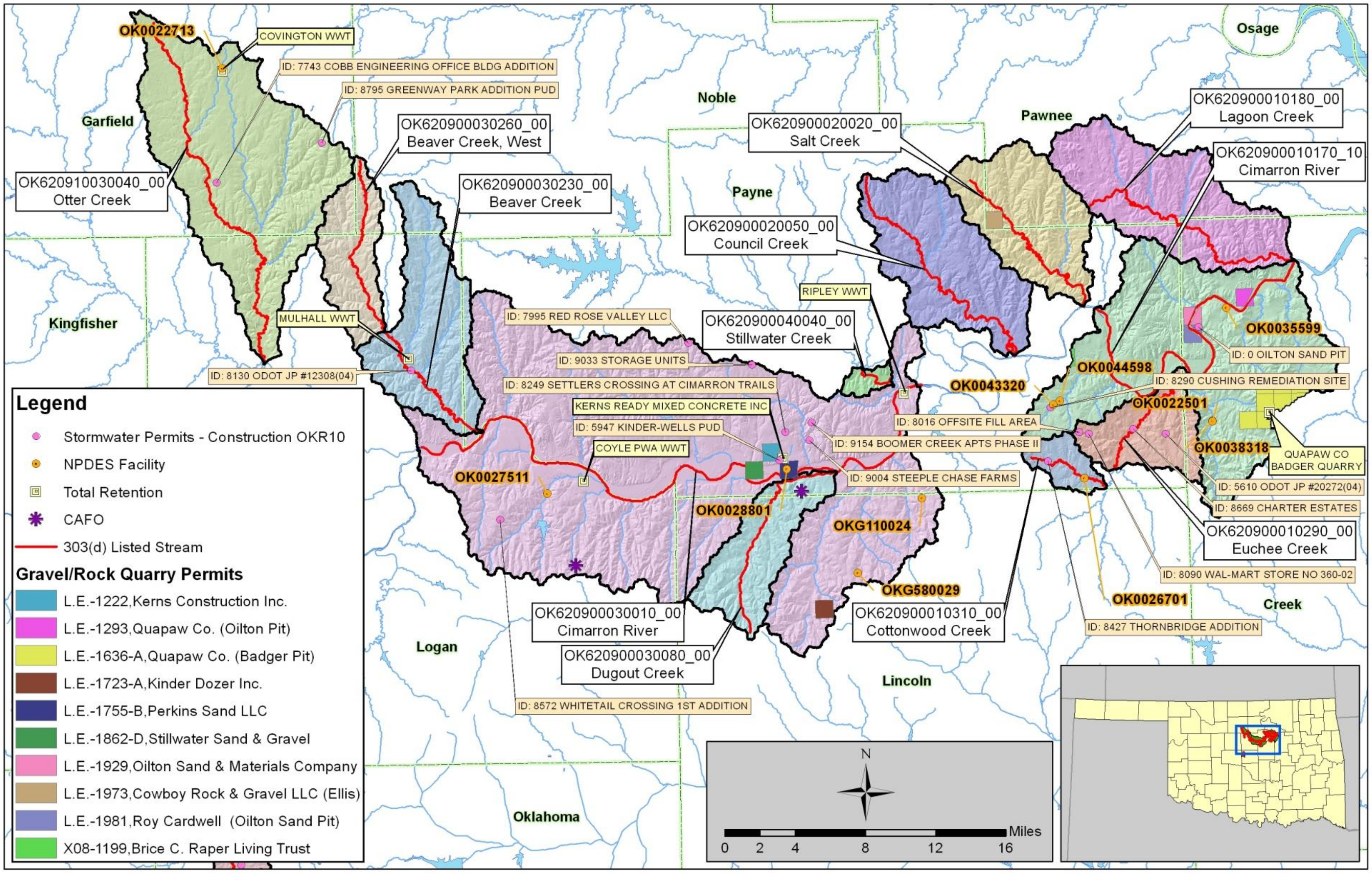
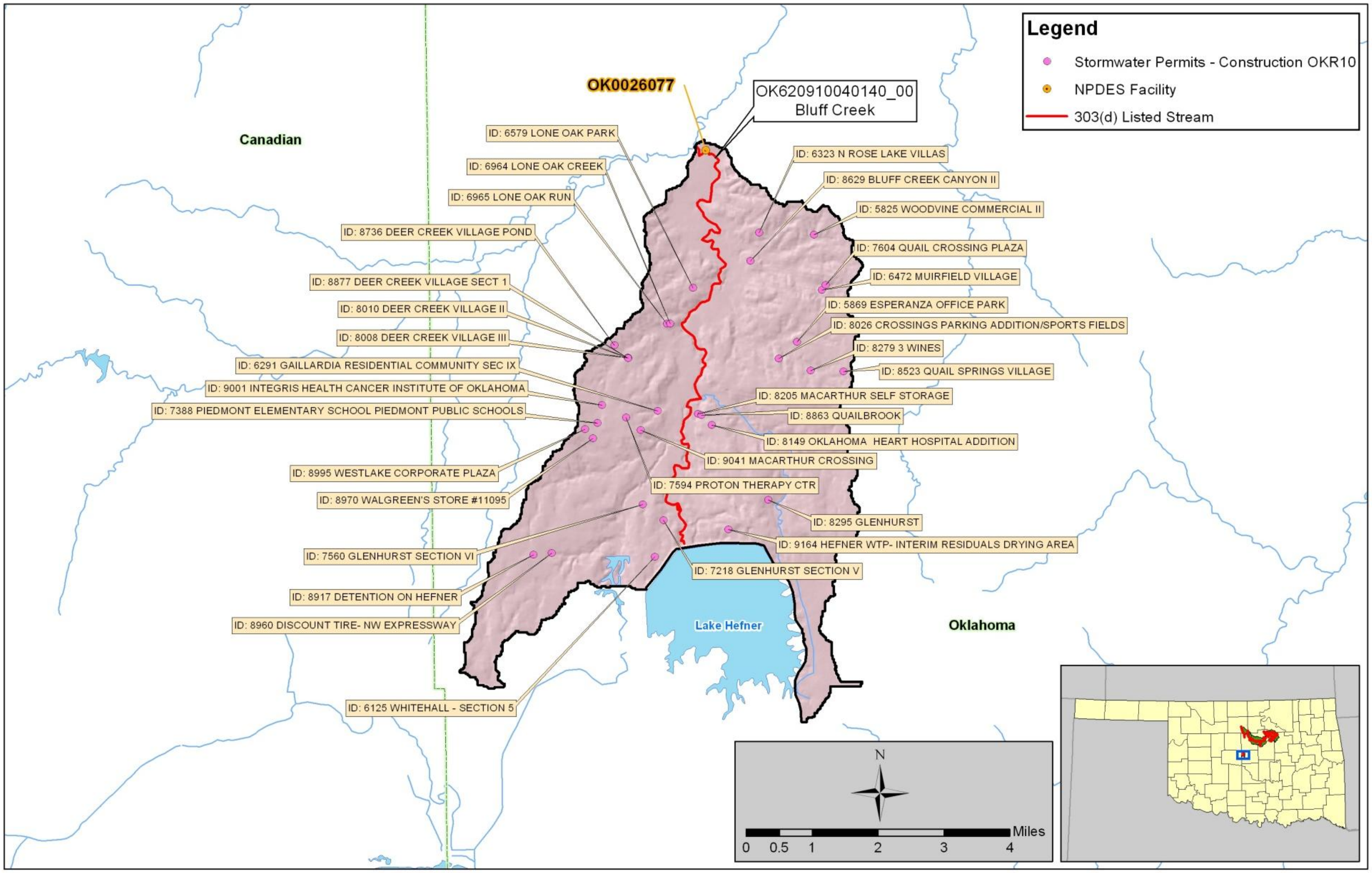


Figure 3-2 Locations of NPDES-Permitted Facilities in the Lower Study Area



3.1.3 NPDES Municipal Separate Storm Sewer System

Phase I MS4

In 1990 the EPA 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 (EPA 2005). Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or greater) to implement a stormwater management program as a means to control polluted discharges. Approved stormwater management programs for medium and large MS4s are required to address a variety of water quality-related issues, including roadway runoff management, municipal-owned operations, and hazardous waste treatment. Oklahoma City (with Oklahoma Department of Transportation as a co-permittee) is the only Phase I MS4 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. DEQ 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/. The Village is the only Phase II MS4 within this Study Area [Bluff Creek (OK620910040140_00)].

3.1.4 Concentrated Animal Feeding Operations

The Agricultural Environmental Management Services (AEMS) of the Oklahoma Department of Agriculture, Food and Forestry (ODAFF) was created to help develop, coordinate, and oversee environmental policies and programs aimed at protecting the Oklahoma environment from pollutants associated with agricultural animals and their waste. Through regulations established by the Oklahoma Concentrated Animal Feeding Operation (CAFO) Act, Swine Feeding Operation (SFO) 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.

CAFO

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

CAFOs are designated by EPA as significant sources of pollution (ODAFF 2009), and may have the potential to cause serious impacts to water quality if not managed properly. Potential problems for CAFOs can include animal waste discharges to waters of the state and failure to properly operate wastewater lagoons. CAFOs are not considered a source of TSS loading. The locations of both of the CAFOs are shown in Figure 3-1 and are listed in Table 3-4. Figure 3-1 shows two CAFO facilities. However, one of them (Barta Dairy, OKG010097) is no longer in existence and therefore is not included in Table 3-4.

Regulated CAFOs within the Study Area 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 and evaluated. 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 3-4 NPDES-Permitted CAFO in Study Area

ODAFF Owner ID	EPA Facility	ODAFF ID	ODAFF License Number	Max # of Slaughter Feeder Cattle units at Facility	Total # of Animal Units at Facility	County	Waterbody ID and Waterbody Name
AGN007215	OKG010068	15	69	7000	7000	Logan	OK620900030010_00, Cimarron River

PFO

Poultry feeding operations not licensed under the Oklahoma Concentrated Animal Feeding Operation Act must register with the State Board of Agriculture. A registered PFO is an animal feeding operation which raises poultry and generates more than 10 tons of poultry waste (litter) per year. PFOs are required to develop an Animal Waste Management Plan (AWMP) or an equivalent document such as a Nutrient Management Plan (NMP). These plans describe how litter will be stored and applied properly in order to protect water quality of streams and lakes located in the watershed. Applicable BMPs must be included in the Plan.

In order to comply with this TMDL, any registered PFOs in this Study Area 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. Currently there are no PFOs in this Study Area.

3.1.5 Stormwater Permits

Construction Activities

A general stormwater permit (OKR10) is required by the DEQ 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 (DEQ 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 permits for construction projects that were active during the time period that samples were taken are summarized in Table 3-5.

Multi-Sector General Permits

A multi-sector industrial general permit (OKR05) is also required by the DEQ for stormwater discharges from industrial facilities (DEQ 2011). Stormwater discharges from all industrial facilities, except mine dewatering discharges at crushed stone, construction sand and gravel, or industrial sand mining facilities, occur only during or immediately following periods of rainfall and elevated flow conditions when the turbidity criteria do not apply and therefore are not considered potential contributors of turbidity impairment. Mine dewatering discharges can happen at any time and have the following specific number effluent limitations for TSS:

- Daily Maximum: 45 mg/L
- Monthly Average: 25 mg/L

If the TMDL shows that a TSS limit more stringent than 45 mg/L is required, additional TSS limitations and monitoring requirements will be required. These additional requirements will be implemented under the multi-sector general permit. There are currently no facilities within the Study Area with a multi-sector general permit.

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 DEQ. 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 (DEQ 2009). Table 3-6 summarizes data from the Oklahoma Department of Mines and provides the permitted mining acres for each of the quarries located within the Study Area. The locations of these quarries are shown in Figure 3-1.

Table 3-5 Permits Summary

Company Name	County	Permit ID	Date Issued	Waterbody ID	Receiving Water (Permit)	Estimated Acres
Construction General Permits (OKR10)						
Greenway Park Addition Pud	Cleveland	OKR108795	2/20/2008	OK620910030040_00	Merkle Creek	7
Cobb Engineering Office Bldg Addition	Oklahoma	OKR107743	12/18/2007	OK620910030040_00	Unnamed Tributary To Belle Isle Creek	1
ODOT JP #12308(04)	Logan	OKR108130	10/2/2007	OK620900030230_00	Beaver Creek	7
Detention On Hefner	Oklahoma	OKR108917	3/31/2008	OK620910040140_00	Unnamed Tributary Of Bluff Creek	1
Discount Tire- NW Expressway	Oklahoma	OKR108960	4/18/2008	OK620910040140_00	Unnamed Tributary Of Bluff Creek	1
Westlake Corporate Plaza	Oklahoma	OKR108995	5/8/2008	OK620910040140_00	Bluff Creek	18
Walgreen's Store #11095	Oklahoma	OKR108970	5/8/2008	OK620910040140_00	Unnamed Tributary Of Deer Creek	2
Piedmont Elementary Public Schools	Oklahoma	OKR107388	2/20/2008	OK620910040140_00	Unnamed Tributary Of Bluff Creek	10
Integris Health Cancer Institute of Oklahoma	Oklahoma	OKR109001	5/8/2008	OK620910040140_00	Deer Creek	20
Deer Creek Village Pond	Oklahoma	OKR108736	1/19/2008	OK620910040140_00	Unnamed Tributary Of Bluff Creek	4
Proton Therapy Ctr	Oklahoma	OKR107594	12/27/2007	OK620910040140_00	Unnamed Tributary To Bluff Creek	5.986
Deer Creek Village II	Oklahoma	OKR108010	1/19/2008	OK620910040140_00	Unnamed Tributary To Bluff Creek	25
Deer Creek Village III	Oklahoma	OKR108008	1/19/2008	OK620910040140_00	Unnamed Tributary To Bluff Creek	20
Deer Creek Village Sect 1	Oklahoma	OKR108877	3/31/2008	OK620910040140_00	Unnamed Tributary To Bluff Creek	30
MacArthur Crossing	Oklahoma	OKR109041	5/23/2008	OK620910040140_00	Bluff Creek	37
Glenhurst Section VI	Oklahoma	OKR107560	3/5/2008	OK620910040140_00	Unnamed Tributary To Bluff Creek	18.01
Whitehall - Section 5	Oklahoma	OKR106125		OK620910040140_00	Unnamed Tributary To Bluff Creek	14
Gaillardia Residential Community Sec IX	Oklahoma	OKR106291		OK620910040140_00	Unnamed Tributary Of Bluff Creek	26
Glenhurst Section V	Oklahoma	OKR107218	3/5/2008	OK620910040140_00	Unnamed Tributary To Spring Creek	13.86+/-
Lone Oak Run	Oklahoma	OKR106965	1/10/2008	OK620910040140_00	Unnamed Tributary Of Bluff Creek	30
Lone Oak Creek	Oklahoma	OKR106964	12/26/2007	OK620910040140_00	Unnamed Tributary Of Bluff Creek	30
Lone Oak Park	Oklahoma	OKR106579	10/20/2007	OK620910040140_00	Bluff Creek	15
Hefner WTP- Interim Residuals Drying Area	Oklahoma	OKR109164	6/11/2008	OK620910040140_00	Unnamed Tributary Of Bluff Creek	2
Bluff Creek Canyon II	Oklahoma	OKR108629	12/17/2007	OK620910040140_00	Unnamed Tributary Of Bluff Creek	10.61
N Rose Lake Villas	Oklahoma	OKR106323	12/27/2007	OK620910040140_00	Bluff Creek	30

Company Name	County	Permit ID	Date Issued	Waterbody ID	Receiving Water (Permit)	Estimated Acres
Crossings Parking Addition/Sports Fields	Oklahoma	OKR108026	1/10/2008	OK620910040140_00	Unnamed Tributary To Bluff Creek	7.46
Esperanza Office Park	Oklahoma	OKR105869	10/1/2007	OK620910040140_00	Bluff Creek	
3 Wines	Oklahoma	OKR108279	10/30/2007	OK620910040140_00	Unnamed Tributary Of Bluff Creek	2
Woodvine Commercial II	Oklahoma	OKR105825	3/5/2008	OK620910040140_00	Unnamed Tributary To Bluff Creek	3
Muirfield Village	Oklahoma	OKR106472	10/8/2007	OK620910040140_00	Bluff Creek	
Quail Crossing Plaza	Oklahoma	OKR107604	10/20/2007	OK620910040140_00	Deer Creek Basin/Unnamed Tributary To Bluff Creek	3.41
Quail Springs Village	Oklahoma	OKR108523	11/20/2007	OK620910040140_00	An Unnamed Tributary Of Chisholm Creek	110
MacArthur Self Storage	Oklahoma	OKR108205	10/1/2007	OK620910040140_00	Deer Creek	1
Quailbrook	Oklahoma	OKR108863	3/24/2008	OK620910040140_00	Bluff Creek	3
Oklahoma Heart Hospital Addition	Oklahoma	OKR108149	1/18/2008	OK620910040140_00	Bluff Creek	2
Glenhurst	Oklahoma	OKR108295		OK620910040140_00	Bluff Creek	160
Whitetail Crossing 1St Addition	Logan	OKR108572	12/4/2007	OK620900030010_00	Tributary Of Fitzgerald Creek	39.44
Kinder-Wells Pud	Payne	OKR105947		OK620900030010_00	Cimmarron River	100
Settlers Crossing At Cimarron Trails	Payne	OKR108249	10/3/2007	OK620900030010_00	Lost Creek	37
Storage Units	Payne	OKR109033	5/23/2008	OK620900030010_00	Unnamed Tributary Of Lost Creek	13
Steeple Chase Farms	Payne	OKR109004	5/8/2008	OK620900030010_00	Lost Creek	8
Boomer Creek Apts Phase II	Payne	OKR109154	6/16/2008	OK620900030010_00	Unnamed Tributary Of Stillwater Creek	6.9
Red Rose Valley LLC	Payne	OKR107995	10/20/2007	OK620900030010_00	Unnamed Tributary To Wild Horse Creek	10
Thornbridge Addition	Payne	OKR108427	10/24/2007	OK620900010310_00	Cottonwood Creek	7
Offsite Fill Area	Payne	OKR108016	3/31/2008	OK620900010290_00	Unnamed Tributary To Euchee Creek	14
Wal-Mart Store No 360-02	Payne	OKR108090	12/18/2007	OK620900010290_00	Tributary Of Euchee Creek	26
Charter Estates	Marshall	OKR108669	3/31/2008	OK620900010290_00	Lake Texoma	4
ODOT JP #20272(04)	Payne	OKR105610	3/24/2008	OK620900010290_00	Unnamed Tributary To Euchee Creek	111
Cushing Remediation Site	Payne	OKR108290	3/31/2008	OK620900010170_10	Skull Creek	30

Table 3-6 Rock, Sand and Gravel Quarries

Company Name	County	Permit ID	Product	Permitted Acres	Permit Issue Date	Permit Renewal Date	Mining Expiration Date	Waterbody ID
Stillwater Sand & Gravel	Payne	L.E.-1862-D	Sand & Gravel	41.5	6/1/2001	5/31/2009	5-31-2021	OK620900030010_00
Kerns Construction, Inc.	Payne	L.E.-1222	Sand & Gravel	76	10/1/1998	9/30/2008	9-30-2018	OK620900030010_00
Kinder Dozer Inc.	Lincoln	L.E.-1723-A	Clay & Shale	80	8/1/1998	7/31/2008	7-31-...(Life of Mine)	OK620900030010_00
Perkins Sand, LLC	Payne	L.E.-1755-B	Sand	74	4/11/2007	7/31/2008	7-31-2024	OK620900030010_00
Perkins Sand, LLC	Payne	L.E.-1755-B	Sand	74	4/11/2007	7/31/2008	7-31-2024	OK620900030080_00
Cowboy Rock & Gravel, LLC (Ellis)	Pawnee	L.E.-1973	Limestone	160	5/1/2007	4/30/2009	4-30-2027	OK620900020020_00
Brice C. Raper Trustee of the Brice C. Raper Living Trust	Payne	X08-1199	Sand	5	12/1/2007	NA	11-30-08	OK620900010170_10
Quapaw Co. (Badger Pit)	Creek	L.E.-1636-A	Limestone	3234.3	5/1/1998	4/30/2009	4-30-2048	OK620900010170_10
Quapaw Co. (Badger Pit)	Creek	L.E.-1636-A	Limestone	3234.3	5/1/1998	4/30/2009	4-30-2048	OK620900010170_10
Quapaw Co. (Badger Pit)	Creek	L.E.-1636-A	Limestone	3234.3	5/1/1998	4/30/2009	4-30-2048	OK620900010170_10
Quapaw Co. (Badger Pit)	Creek	L.E.-1636-A	Limestone	3234.3	5/1/1998	4/30/2009	4-30-2048	OK620900010170_10
Quapaw Co. (Badger Pit)	Creek	L.E.-1636-A	Limestone	3234.3	5/1/1998	4/30/2009	4-30-2048	OK620900010170_10
Quapaw Co. (Oilton Pit)	Creek	L.E.-1293	Sand & Gravel	21	4/1/1994	3/31/2008	3-31-2019	OK620900010170_10
Quapaw Co. (Badger Pit)	Creek	L.E.-1636-A	Limestone	3234.3	5/1/1998	4/30/2009	4-30-2048	OK620900010170_10
Kelly Ward DBA Oilton Sand & Materials Company	Creek	L.E.-1929	Sand & Gravel	40	5/1/2002	4/30/2009	4-30-2017	OK620900010170_10
Quapaw Co. (Badger Pit)	Creek	L.E.-1636-A	Limestone	3234.3	5/1/1998	4/30/2009	4-30-2048	OK620900010170_10
Quapaw Co. (Badger Pit)	Creek	L.E.-1636-A	Limestone	3234.3	5/1/1998	4/30/2009	4-30-2048	OK620900010170_10
Quapaw Co. (Badger Pit)	Creek	L.E.-1636-A	Limestone	3234.3	5/1/1998	4/30/2009	4-30-2048	OK620900010170_10
Roy Cardwell (Oilton Sand Pit)	Creek	L.E.-1981	Sand, Topsoil	10	12/1/2004	11/30/2007	11-30-2054	OK620900010170_10

3.1.7 Section 404 permits

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

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

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

3.2 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. Bacteria originate from warm-blooded animals in rural, suburban, and urban areas. These sources include wildlife, various agricultural activities and domesticated animals, land application fields, urban runoff, failing OSWD systems and domestic pets. Water quality data collected from streams draining urban communities often show existing concentrations of fecal coliform bacteria at levels greater than a state's water quality standards. A study under EPA's National Urban Runoff Project indicated that the average fecal coliform concentration from 14 watersheds in different areas within the United States was approximately 15,000/100 mL in stormwater runoff (EPA 1983). Runoff from urban areas not permitted under the MS4 program can be a significant source of fecal coliform bacteria. Water quality data collected from streams draining many of the non-permitted communities show a high level of fecal coliform bacteria. The specific requirements for bacteria control in a MS4 permit can be found in Appendix F. Appendix F also includes information on a list of BMPs and their effectiveness. Best management practices (BMP) such as buffer strips, repair of leaking sewage collection systems, elimination of illicit discharges, and proper disposal of domestic animal waste can reduce bacteria loading to waterbodies. 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 (DEQ 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 due to habitat and resource availability. 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 2005 to 2009 was combined with an estimated annual harvest rate of 20% to predict deer population by county. Using the estimated deer population by county and the percentage of the watershed area within each county, a wild deer population can be calculated for each watershed.

According to a study conducted by the American Society of Agricultural Engineers (ASAE), deer release approximately 5×10^8 fecal coliform units per animal per day (ASAE 1999). Although only a fraction of the total fecal coliform loading produced by the deer population may actually enter a waterbody, the estimated fecal coliform production based on the estimated deer population provided in Table 3-7 in cfu/day provides a relative magnitude of loading in each watershed.

Table 3-7 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
OK620910030040_00	Otter Creek	75,304	618	0.008	309
OK620900030260_00	Beaver Creek, West	17,568	208	0.012	104
OK620900030230_00	Beaver Creek	33,099	434	0.013	217
OK620910040140_00	Bluff Creek	16,593	113	0.007	56
OK620900030010_00	Cimarron River	218,953	3,043	0.014	1,521
OK620900030080_00	Dugout Creek	21,040	289	0.014	145
OK620900040040_00	Stillwater Creek	2,345	34	0.014	17
OK620900020050_00	Council Creek	37,104	535	0.014	267
OK620900020020_00	Salt Creek	29,580	458	0.015	229
OK620900010310_00	Cottonwood Creek	6,095	88	0.014	44
OK620900010290_00	Euchee Creek	16,800	254	0.015	127
OK620900010170_10	Cimarron River	84,605	1,466	0.017	733
OK620900010180_00	Lagoon Creek	41,090	709	0.017	355

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.
- Animals grazing in pastures deposit manure containing fecal bacteria onto land surfaces. These bacteria may be washed into waterbodies by runoff.
- Animals often have direct access to waterbodies and can provide a concentrated source of fecal bacteria loading directly into streams or can cause unstable stream banks which can contribute TSS.

Table 3-8 provides estimated numbers of selected livestock by watershed based on the 2007 U.S. Department of Agriculture (USDA) county agricultural census data (USDA 2007). The estimated commercially raised farm animal populations in Table 3-8 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 waterbodies and their tributaries.

Detailed information is not available to describe or quantify the relationship between instream concentrations of bacteria and land application or direct deposition 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 2007 is shown in Table 3-8. These estimates are also based on the county level reports from the 2007 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. These estimates are presented in Table 3-9. Note that only a small fraction of these fecal coliform are expected to represent loading into waterbodies, either washed into streams by runoff or by direct deposition from wading animals. Because of their numbers, cattle again appear to represent the most likely commercially raised farm animal source of fecal bacteria.

Table 3-8 Commercially Raised Farm Animals and Manure Application Area Estimates by Watershed

Waterbody ID	Waterbody Name	Cattle & Calves	Dairy Cows	Hogs & Pigs	Chickens	Sheep & Lambs	Horses & Ponies	Turkeys	Ducks	Geese	Acres of Manure Application
OK620910030040_00	Otter Creek	10,232	71	37	253	222	402	2	10	2	274
OK620900030260_00	Beaver Creek, West	2,042	9	10	93	53	81	1	3	2	76
OK620900030230_00	Beaver Creek	3,562	22	30	233	115	155	3	8	4	181
OK620910040140_00	Bluff Creek	746	0	26	160	56	119	3	13	5	64
OK620900030010_00	Cimarron River	24,841	524	576	1,960	789	1,319	22	74	28	1,800
OK620900030080_00	Dugout Creek	2,396	74	35	169	52	122	1	10	2	270
OK620900040040_00	Stillwater Creek	278	7	10	24	9	16	0	1	0	17
OK620900020050_00	Council Creek	4,403	107	151	375	150	256	5	12	5	274
OK620900020020_00	Salt Creek	3,445	48	70	203	98	226	2	8	3	160
OK620900010310_00	Cottonwood Creek	723	18	25	61	24	42	1	2	1	46
OK620900010290_00	Euchee Creek	1,869	42	62	254	63	103	2	11	2	113
OK620900010170_10	Cimarron River	7,423	105	211	2,617	235	312	10	139	13	404
OK620900010180_00	Lagoon Creek	4,175	13	38	610	99	268	2	34	4	139

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

Waterbody ID	Waterbody Name	Cattle & Calves	Dairy Cows	Hogs & Pigs	Chickens	Sheep & Lambs	Horses & Ponies	Turkeys	Ducks	Geese	Total
OK620910030040_00	Otter Creek	1,064,120	7,158	402	34	2,660	169	0	25	99	1,074,667
OK620900030260_00	Beaver Creek, West	212,352	906	103	13	638	34	0	8	83	214,138
OK620900030230_00	Beaver Creek	370,486	2,174	329	32	1,374	65	0	20	209	374,688
OK620910040140_00	Bluff Creek	77,596	0	281	22	672	50	0	32	223	78,876
OK620900030010_00	Cimarron River	2,583,443	52,895	6,219	267	9,471	554	2	181	1,388	2,654,420
OK620900030080_00	Dugout Creek	249,166	7,502	376	23	623	51	0	24	111	257,876
OK620900040040_00	Stillwater Creek	28,946	685	103	3	114	7	0	2	15	29,875
OK620900020050_00	Council Creek	457,899	10,837	1,636	51	1,799	108	0	30	245	472,604
OK620900020020_00	Salt Creek	358,242	4,830	754	28	1,171	95	0	20	141	365,282
OK620900010310_00	Cottonwood Creek	75,147	1,790	265	8	293	18	0	5	40	77,565
OK620900010290_00	Euchee Creek	194,368	4,233	672	35	754	43	0	26	115	200,245
OK620900010170_10	Cimarron River	771,999	10,564	2,284	356	2,825	131	1	337	645	789,141
OK620900010180_00	Lagoon Creek	434,150	1,360	405	83	1,192	113	0	84	184	437,570

3.2.3 Failing Onsite Wastewater Disposal Systems and Illicit Discharges

DEQ is responsible for implementing the regulations of Title 252, Chapter 641 of the Oklahoma Administrative Code, which defines design standards for individual and small public onsite sewage disposal systems (DEQ 2011a). 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 may discharge 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 which was the last year in which there were Census questions about plumbing facilities (U.S. Department of Commerce, Bureau of the Census 1990). The density of OSWD systems within each watershed was estimated by dividing the number of OSWD systems in each census block by the number of acres in each census block. This density was then applied to the number of acres of each census block within a WQM station watershed. Census blocks crossing a watershed boundary required additional calculation to estimate the number of OSWD systems based on the proportion of the census block falling within each watershed. This step involved adding all OSWD systems for each whole or partial census block.

Over time, most OSWD systems operating at full capacity will fail. OSWD system failures are proportional to the adequacy of a state's minimum design criteria (Hall 2002). The 1990 American Housing Survey for Oklahoma conducted by the U.S. Census Bureau estimates that, nationwide, 10% of occupied homes with OSWD systems experience malfunctions during the year (U.S. Department of Commerce, Bureau of the Census 1990). A study conducted by Reed, Stowe & Yanke, LLC (2001) reported that approximately 12% of the OSWD systems in east Texas and 8% in the Texas Panhandle were chronically malfunctioning. Most studies estimate that the minimum lot size necessary to ensure against contamination is roughly one-half to one acre (Hall 2002). Some studies, however, found that lot sizes in this range or even larger could still cause contamination of ground or surface water (University of Florida 1987). It is estimated that areas with more than 40 OSWD systems per square mile (6.25 septic systems per 100 acres) can be considered to have potential contamination problems (Canter and Knox 1986). Table 3-10 summarizes estimates of sewered and unsewered households and the average number of septic tanks per square mile for each watershed in the Study Area.

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

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

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

Table 3-10 Estimates of Sewered and Unsewered Households

Waterbody ID	Waterbody Name	Public Sewer	Septic Tank	Other Means	Housing Units	# of Septic Tanks / Mile^2
OK620910030040_00	Otter Creek	353	158	9	521	1.34
OK620900030260_00	Beaver Creek, West	17	40	3	60	1.46
OK620900030230_00	Beaver Creek	140	77	6	222	1.49
OK620910040140_00	Bluff Creek	17,309	151	8	17,469	5.82
OK620900030010_00	Cimarron River	1,502	1,816	8	3,326	5.31
OK620900030080_00	Dugout Creek	238	152	1	391	4.62
OK620900040040_00	Stillwater Creek	1	38	0	39	10.37
OK620900020050_00	Council Creek	5	353	7	365	6.09
OK620900020020_00	Salt Creek	16	175	5	197	3.79
OK620900010310_00	Cottonwood Creek	2,569	108	1	2,678	11.34
OK620900010290_00	Euchee Creek	382	289	6	678	11.01
OK620900010170_10	Cimarron River	2,181	1,004	17	3,201	7.59
OK620900010180_00	Lagoon Creek	246	340	4	590	5.30

The average of number of people per household was calculated to be 2.08 for counties in the Study Area (U.S. Census Bureau 2010). Approximately 70 gallons of wastewater were estimated to be produced on average per person per day (Metcalf and Eddy 1991). The fecal coliform concentration in septic tank effluent was estimated to be 10^6 per 100 mL of effluent based on reported concentrations from a number of publications (Metcalf and Eddy 1991; Canter and Knox 1985; Cogger and Carlile 1984). Using this information, the estimated load from failing septic systems within the watersheds was summarized below in Table 3-11.

Table 3-11 Estimated Fecal Coliform Load from OSWD Systems

Waterbody ID	Waterbody Name	Acres	Septic Tank	# of Failing Septic Tanks	Estimated Loads from Septic Tanks (x 10^9 counts/day)
OK620910030040_00	Otter Creek	75,304	158	19	107
OK620900030260_00	Beaver Creek, West	17,568	40	5	27
OK620900030230_00	Beaver Creek	33,099	77	9	52
OK620910040140_00	Bluff Creek	16,593	151	18	102
OK620900030010_00	Cimarron River	218,953	1,816	218	1,224
OK620900030080_00	Dugout Creek	21,040	152	18	103
OK620900040040_00	Stillwater Creek	2,345	38	5	26
OK620900020050_00	Council Creek	37,104	353	42	238
OK620900020020_00	Salt Creek	29,580	175	21	118
OK620900010310_00	Cottonwood Creek	6,095	108	13	73

Waterbody ID	Waterbody Name	Acres	Septic Tank	# of Failing Septic Tanks	Estimated Loads from Septic Tanks (x 10^9 counts/day)
OK620900010290_00	Euchee Creek	16,800	289	35	195
OK620900010170_10	Cimarron River	84,605	1,004	120	677
OK620900010180_00	Lagoon Creek	41,090	340	41	229

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% of the nation's households own dogs and 32.4% 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 3-12 summarizes the estimated number of dogs and cats for the watersheds of the Study Area.

Table 3-12 Estimated Numbers of Pets

Waterbody ID	Waterbody Name	Dogs	Cats
OK620910030040_00	Otter Creek	210	237
OK620900030260_00	Beaver Creek, West	16	18
OK620900030230_00	Beaver Creek	160	181
OK620910040140_00	Bluff Creek	16,887	19,051
OK620900030010_00	Cimarron River	3,008	3,394
OK620900030080_00	Dugout Creek	86	97
OK620900040040_00	Stillwater Creek	27	30
OK620900020050_00	Council Creek	318	359
OK620900020020_00	Salt Creek	114	128
OK620900010310_00	Cottonwood Creek	1,559	1,759
OK620900010290_00	Euchee Creek	407	459
OK620900010170_10	Cimarron River	1,683	1,899
OK620900010180_00	Lagoon Creek	261	295

Table 3-13 provides an estimate of the fecal coliform production 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 3-13 Estimated Fecal Coliform Daily Production by Pets (x10^9 counts/day)

Waterbody ID	Waterbody Name	Dogs	Cats	Total
OK620910030040_00	Otter Creek	694	128	822
OK620900030260_00	Beaver Creek, West	52	10	61
OK620900030230_00	Beaver Creek	530	98	627
OK620910040140_00	Bluff Creek	55,727	10,288	66,015
OK620900030010_00	Cimarron River	9,928	1,833	11,760
OK620900030080_00	Dugout Creek	283	52	335
OK620900040040_00	Stillwater Creek	89	16	105
OK620900020050_00	Council Creek	1,051	194	1,245
OK620900020020_00	Salt Creek	375	69	444
OK620900010310_00	Cottonwood Creek	5,146	950	6,096
OK620900010290_00	Euchee Creek	1,344	248	1,592
OK620900010170_10	Cimarron River	5,555	1,025	6,580
OK620900010180_00	Lagoon Creek	862	159	1,021

3.3 Summary of Sources of Impairments

3.3.1 Bacteria

There are no continuous, permitted point sources of bacteria in the Beaver Creek, West Beaver Creek, Dugout Creek, Stillwater Creek, Council Creek, Salt Creek, Euchee Creek or Lagoon Creek watersheds which require bacteria TMDLs; therefore, the conclusion is that nonsupport of PBCR use in these watersheds is caused by nonpoint sources of bacteria. Otter Creek (OK620910030040_00), Cimarron River (OK620900030010_00 and OK620900010170_10), and Cottonwood Creek (OK620900010310_00) each have one or more continuous point source dischargers which contribute bacteria, but the available data suggests that the proportion of bacteria from point sources is minor. The CAFO may be contributing bacteria loading to the Cimarron River (OK620900030010_00) watershed. Therefore the various nonpoint sources are considered to be the major source of bacteria loading in each watershed that requires a TMDL.

Table 3-14 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. Because of their numbers and animal unit production of bacteria, livestock are estimated to be the largest contributors of fecal coliform loading to land surfaces. It must be noted that while no data are available to estimate populations and fecal loading of wildlife other than deer, a number of 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 3-14 Percentage Contribution of Fecal Coliform Load Estimates from Nonpoint Sources to Land Surfaces

Waterbody ID	Waterbody Name	All Livestock	Pets	Deer	Estimated Loads from Septic Tanks
OK620910030040_00	Otter Creek	1,074,667	822	309	107
OK620900030260_00	Beaver Creek, West	214,138	61	104	27
OK620900030230_00	Beaver Creek	374,688	627	217	52
OK620910040140_00	Bluff Creek	78,876	66,015	56	102
OK620900030010_00	Cimarron River	2,654,420	11,760	1,521	1224
OK620900030080_00	Dugout Creek	257,876	335	145	103
OK620900040040_00	Stillwater Creek	29,875	105	17	26
OK620900020050_00	Council Creek	472,604	1,245	267	238
OK620900020020_00	Salt Creek	365,282	444	229	118
OK620900010310_00	Cottonwood Creek	77,565	6,096	44	73
OK620900010290_00	Euchee Creek	200,245	1,592	127	195
OK620900010170_10	Cimarron River	789,141	6,580	733	677
OK620900010180_00	Lagoon Creek	437,570	1,021	355	229

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.

3.3.2 Turbidity

Of the seven watersheds in the Study Area that require turbidity TMDLs, one of them, Cimarron River (OK620900010170_10) has industrial permitted sources of TSS that will necessitate a WLA. The other watersheds have other permitted activities such as construction and/or mining that contribute some TSS loading. Therefore nonsupport of WWAC use, in all but one watershed, 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:

$$\boldsymbol{TMDL = WLA\_{_{WWTP}} + WLA\_{_{MS4}} + LA + MOS}$$

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

For *E. coli* or Enterococci bacteria, TMDLs are expressed as colony-forming units per day, and represent the maximum one-day load the stream can assimilate while still attaining the WQS. Percent reduction goals are also calculated to aid to characterizing the possible magnitude of the effort to restore the segment to meeting water quality criterion. 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 from 1998 to 2011 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 25th 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 (OLS) regression 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:

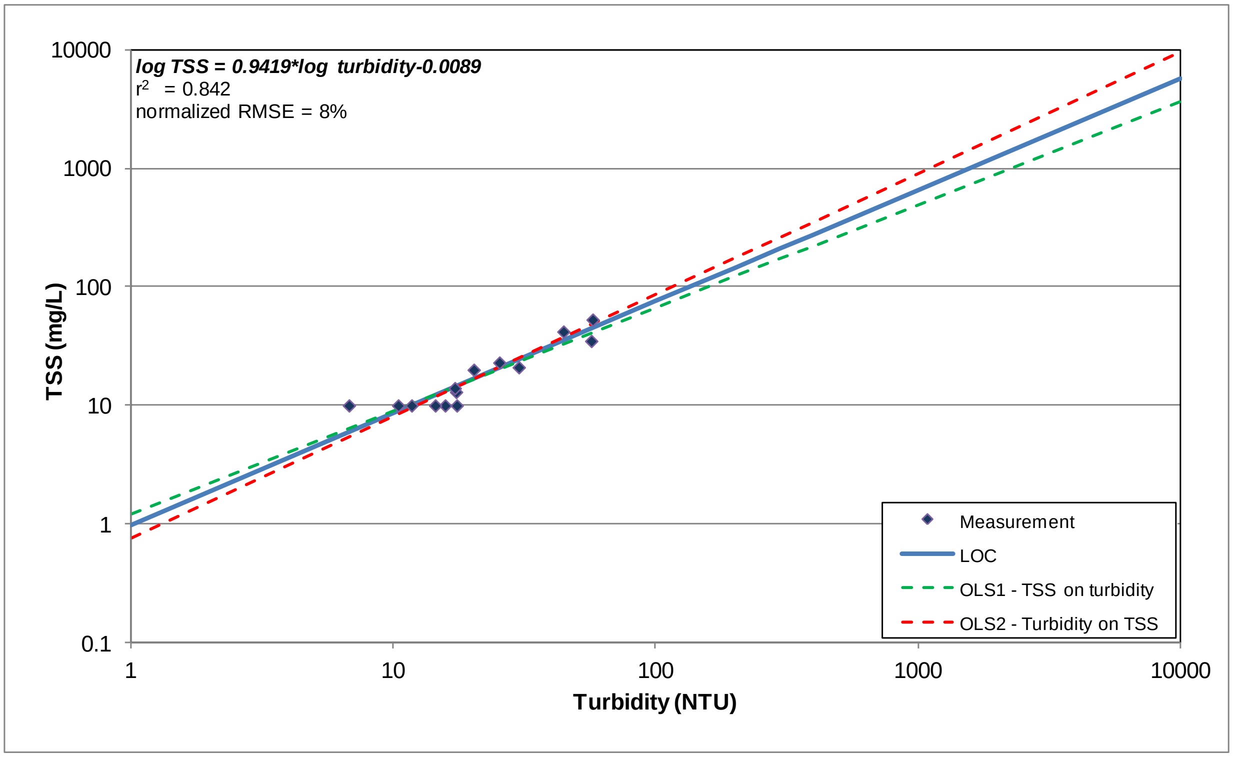
$$m1 = \sqrt{m \cdot m'} = sign[r] \cdot \frac{s_y}{s_x}$$

where *m*1 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 (*b*1) is subsequently found by fitting the line with the LOC slope through the point (mean turbidity, mean TSS). Figure 4-1 shows an example of the correlation between TSS and turbidity, along with the LOC and the OLS lines.

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 8 which means the root mean square error (RMSE) is 8% 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 the turbidity standard of 50 NTUs to TSS goals.

Figure 4-1 Linear Regression for TSS-Turbidity for Euchee Creek (OK620900010290_00)



It was noted that there were 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 regressions presented in Section 5 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 segment is provided 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 can help identifying whether impairments are associated with point or nonpoint sources. The technical approach for using LDCs for TMDL development includes the three 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 if there is a critical condition.

Historically, in developing WLAs for pollutants from point sources, it was customary to designate a critical low flow condition (*e.g.*, 7Q2) at which the maximum permissible loading was calculated. As water quality management efforts expanded in scope to quantitatively address nonpoint sources of pollution and types of pollutants, it became clear that this single critical low flow condition was inadequate to ensure adequate water quality across a range of flow conditions. Use of the LDC obviates the need to determine a design storm or selected flow recurrence interval with which to characterize the appropriate flow level for the assessment of critical conditions. For waterbodies impacted by both point and nonpoint sources, the “nonpoint source critical condition” would typically occur during high flows, when rainfall runoff would contribute the bulk of the pollutant load, while the “point source critical condition” would typically occur during low flows, when 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 during low flows have been noted in some watersheds that contain no point sources.

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

4.3 Development of Flow Duration Curves

Flow duration curves (FDC) serve as the foundation of LDCs and are graphical representations of the flow characteristics of a stream at a given site. Flow duration curves utilize the historical hydrologic record from stream gages to forecast future recurrence frequencies. Many WQM stations throughout Oklahoma do not have long-term flow data and therefore, flow frequencies must be estimated. Nine of the eleven 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 (x-axis), which is numbered from 0% to 100%, and may or may not be logarithmic. The lowest measured flow occurs at an exceedance frequency of 100% indicating that flow has equaled or exceeded this value 100% of the time, while the highest measured flow is found at an exceedance frequency of 0%. The median flow occurs at a flow exceedance frequency of 50%. The flow exceedance percentiles for each waterbody addressed in this report are provided in Appendix B.

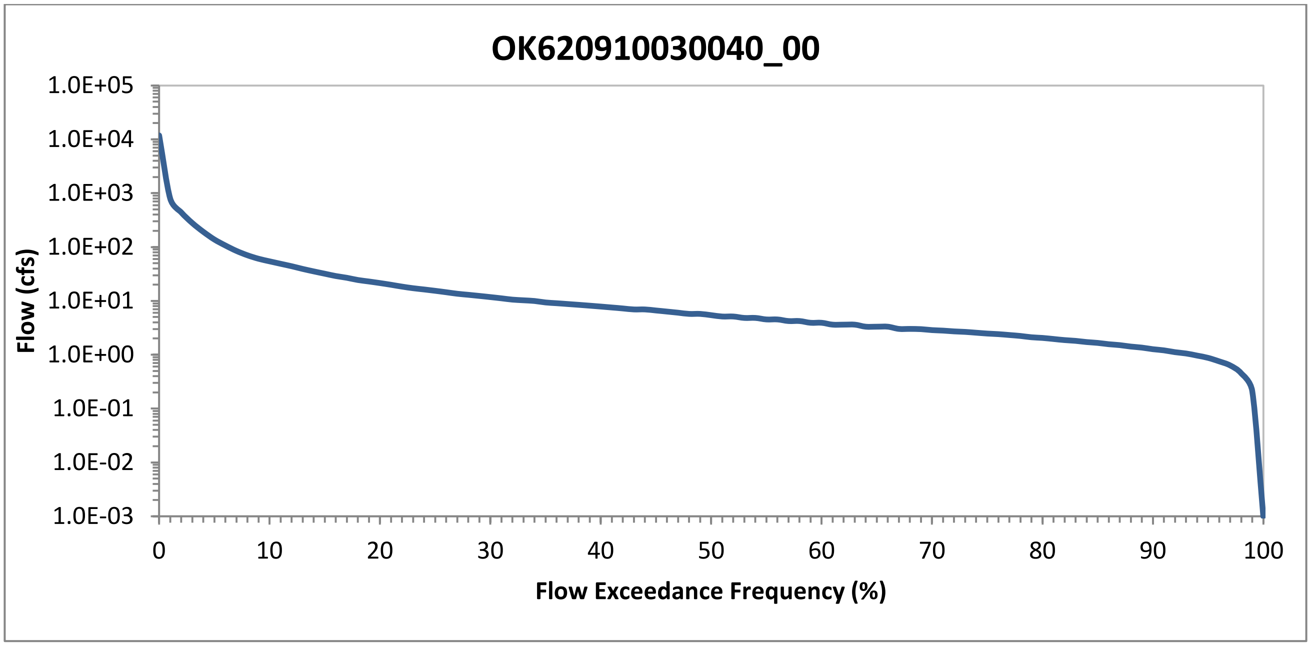
While the number of observations required to develop a flow duration curve is not rigorously specified, a flow duration curve is usually based on more than one year of observations, and encompasses inter-annual and seasonal variation. Ideally, the drought of record and flood of record are included in the observations. For this purpose, the long-term flow gaging stations operated by the USGS are utilized (USGS 2009) 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 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% and downward at a frequency near 100%, often with a relatively constant slope in between. For sites that on occasion exhibit no flow, the curve will intersect the abscissa at a frequency less than 100%. As the number of observations at a site increases, the line of the LDC tends to appear smoother. However, at extreme low and high flow values, flow duration curves may exhibit a “stair step” effect due to the USGS flow data rounding conventions near the limits of quantization. An example of a typical flow duration curve is shown in Figure 4-2.

Figure 4-2 Flow Duration Curve for Otter Creek (OK31620910030040_00)



Flow duration curves for each impaired waterbody in the Study Area are provided in Section 5.2.

4.4 Estimating Existing Loading

Existing instream loads can be estimated using FDCs. For bacteria, this is accomplished by:

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

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

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;
- 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 numerical criterion for each parameter (geometric mean standard for bacteria and TSS goal for turbidity); and
- For bacteria TMDLs, displaying another curve derived by plotting the geometric mean of all existing bacteria samples continuously along the full spectrum of flow exceedance percentiles which represents LDC (See Section 5); or
- For turbidity TMDLs, matching the water quality observations with the flow data from the same date and determining the corresponding exceedance percentile (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 = 126 cfu/100 mL (E. coli); or 33 cfu/100 mL (Enterococci)

unit conversion factor = 24,465,525

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

The flow exceedance frequency (x-value of each point) is obtained by looking up the historical exceedance frequency of the measured or estimated flow, in other words, the percent of historical observations that are equal to or exceed the measured or estimated flow. Historical observations of bacteria were plotted as a separate LDC based on the geometric mean of all samples. Historical observations of TSS and/or turbidity concentrations are paired with flow data and are plotted on the LDC for a stream. TSS loads representing exceedance of water quality criteria fall above the TMDL line. It is noted that the LDCs for bacteria were based on the geometric mean standards or geometric mean of all samples. It is inappropriate to compare single sample bacteria observations to a geometric mean water quality criterion in the LDC; therefore individual bacteria samples are not plotted on the LDCs.

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 (e.g., lake release to provide water downstream) and runoff influence may be observed with low or moderate flows (e.g., persistent high turbidity due to previous storm).

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% was selected. The 10% 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 EPA 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. WLAs can be expressed in terms of a single load, or as different loads allowable under different flows. WLAs may be set to zero in cases of watersheds with no existing or planned continuous permitted point sources. 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. For watersheds with permitted point sources discharging the pollutant of concern, NPDES permit limits are used to derive WLAs for evaluation as appropriate for use in the TMDL. The permitted flow rate used for each point source discharge and the water quality concentration defined in a permit are used to estimate the WLA for each wastewater facility. In cases where a permitted flow rate is not available for a 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 segment. Using this information bacteria and TSS WLAs can be calculated using the approach as shown in the equations below.

WLA for bacteria:

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

Where:

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

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

WLA for TSS:

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

Where:

WQ goal =Waterbody specific water quality goal provided in Table 5-1, or monthlyTSS limit in the current permit, whichever is smaller

flow (mgd) = permitted flow or average monthly flow unit conversion factor = 8.3445

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. The LA at any particular flow exceedance is calculated as shown in the equation below.

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

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 a watershed, first calculate the sum of LA + WLA_MS4 using the above formula, then separate WLA for MS4s from the sum based on the percentage of a watershed that is under a MS4 jurisdiction. This WLA for MS4s may not be the total load allocated for permitted MS4s unless the whole MS4 area is located within the study watershed boundary. However, in most case the study watershed intersects only a portion of the permitted MS4 coverage areas.

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

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

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 WQS at the end-of-pipe and, therefore, no WLA reduction would be required. Currently, bacteria limits are not required for lagoon systems. Lagoon systems located within a sub-watershed of bacteria impaired stream segment will be required to meet *E. coli* standards at the discharge when the permits are renewed.

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

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.

LA Load Reduction. After existing loading estimates are computed for each pollutant, nonpoint load reduction estimates for each segment are calculated by using the difference between the estimate of existing loading and the allowable loading (TMDL) under all flow conditions. This difference is expressed as the overall PRG for the impaired waterbody. The PRG serves as a guide for the amount of pollutant reduction necessary to meet the TMDL. For *E. coli* and Enterococci, because WQSs are considered to be met if the geometric mean of all future data is maintained below the geometric mean criteria (TMDL). For turbidity, the PRG is the load reduction that ensures that no more than 10% 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, correlations between TSS and turbidity were developed for establishing the statistics of the regressions and the resulting TSS goals were provided in Table 5-1. The regression analysis for each impaired waterbody in the Study Area using the LOC method is displayed in Figures 5-1 through 5-7. No concurrent turbidity and TSS data were available for Cimarron River (OK620900030010_00) and Cimarron River (OK620900010170_10). Therefore, the regression statistics for these two water bodies were derived from the data within the 8-digit hydrologic unit code (HUC) (11050003).

Table 5-1 Regression Statistics and TSS Goals

Waterbody ID	Waterbody Name	R-square	NRMSE	TSS Goal (mg/L)[a]	MOS[b]
OK620900030260_00	West Beaver Creek	0.637	20.1%	25	25%
OK620900030230_00	Beaver Creek	0.343	15.9%	26	20%
OK620900030010_00	Cimarron River	0.673	13.6%	35	15%
OK620900040040_00	Stillwater Creek	0.753	8.7%	37	10%
OK620900020050_00	Council Creek	0.565	1.3%	11	5%
OK620900010290_00	Euchee Creek	0.842	8.1%	39	10%
OK620900010170_10	Cimarron River	0.673	13.6%	35	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)

Figure 5-1 Linear Regression for TSS-Turbidity for West Beaver Creek (OK620900030260_00)

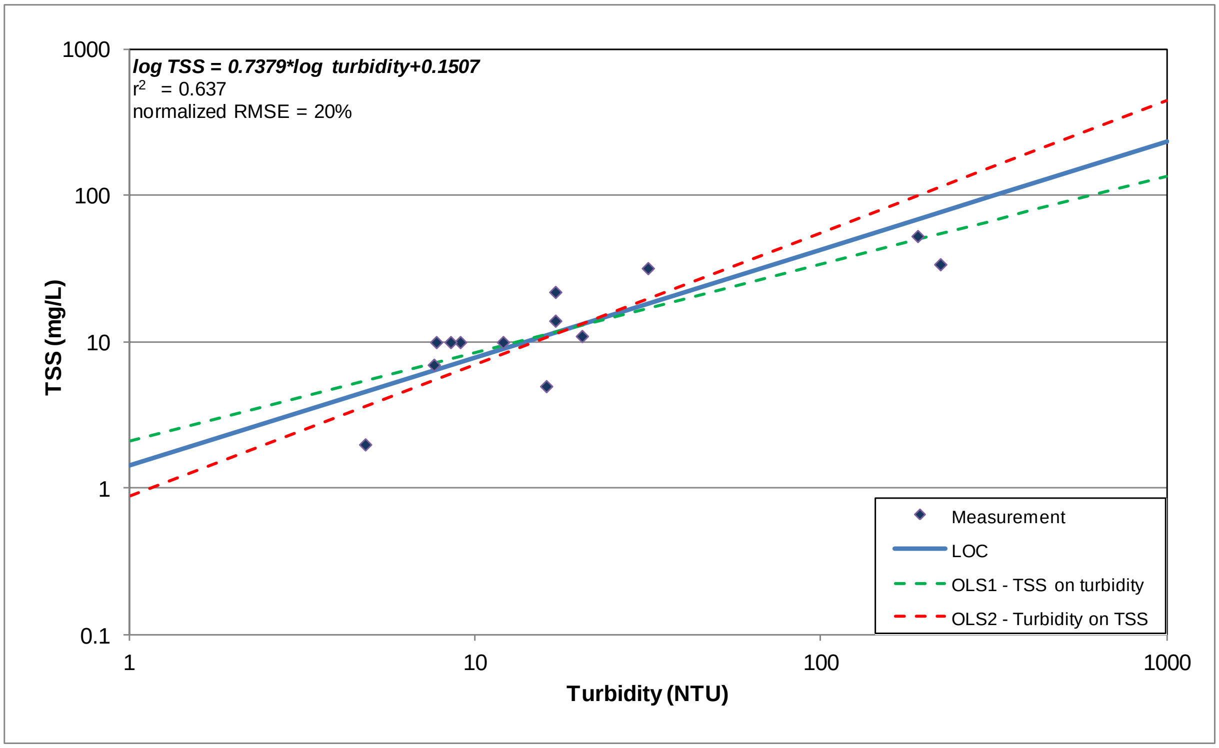


Figure 5-2 Linear Regression for TSS-Turbidity for Beaver Creek (OK620900030230_00)

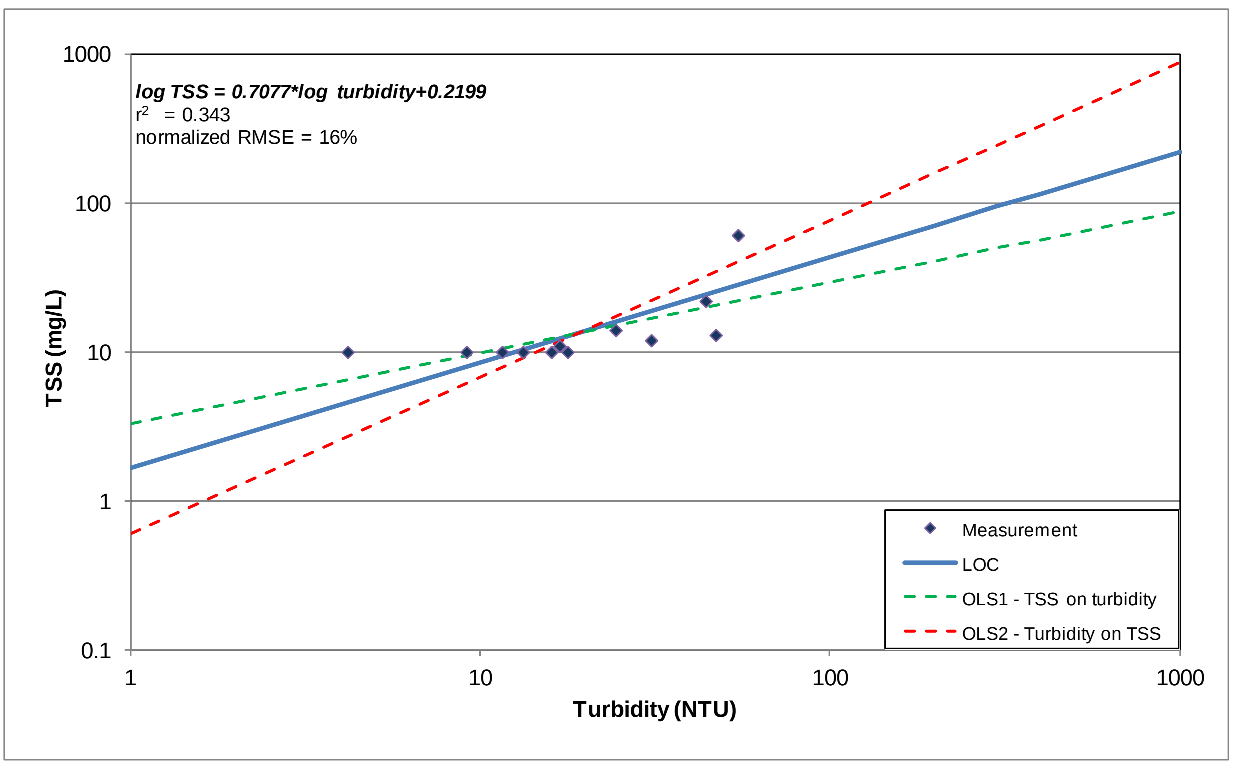
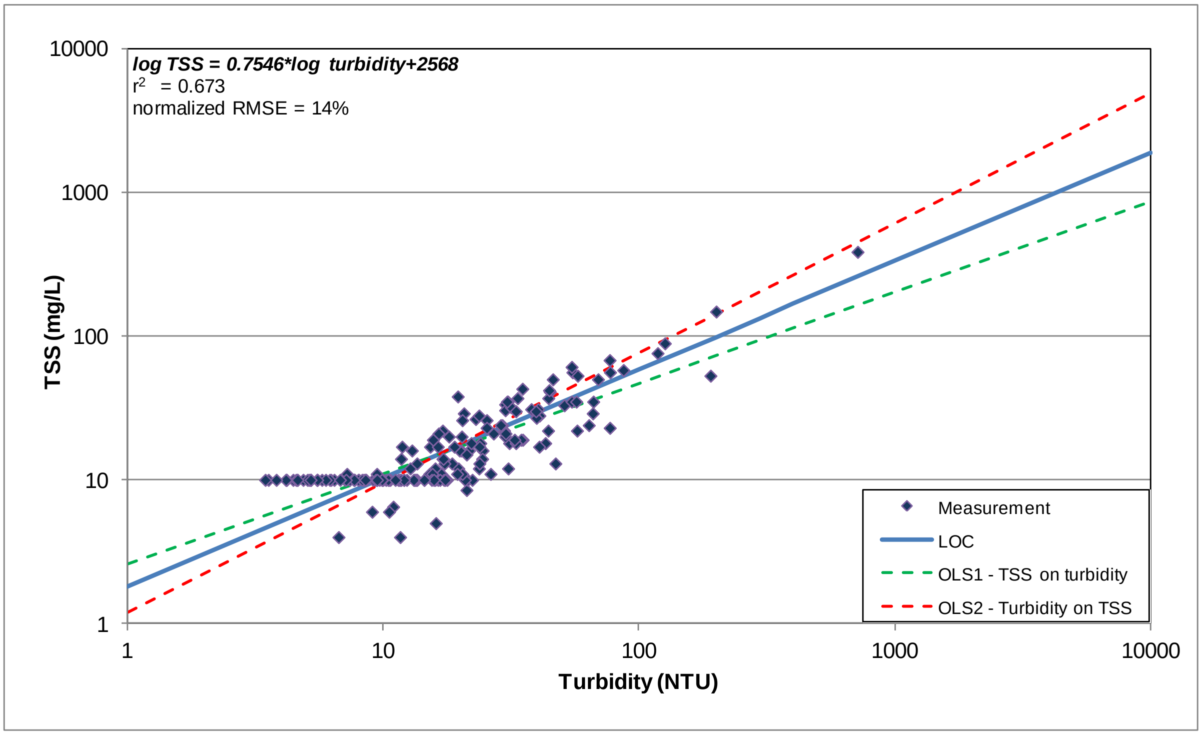


Figure 5-3 Linear Regression for TSS-Turbidity for Cimarron River (OK620900030010_00 and OK620900010170_10)



Note: The regression for WBIDs OK620900030010_00 and OK620900010170_10 was developed using data for the 8-digit HUC (11050003) due to the lack of WBID-specific TSS-turbidity paired data.

Figure 5-4 Linear Regression for TSS-Turbidity for Stillwater Creek (OK620900040040_00)

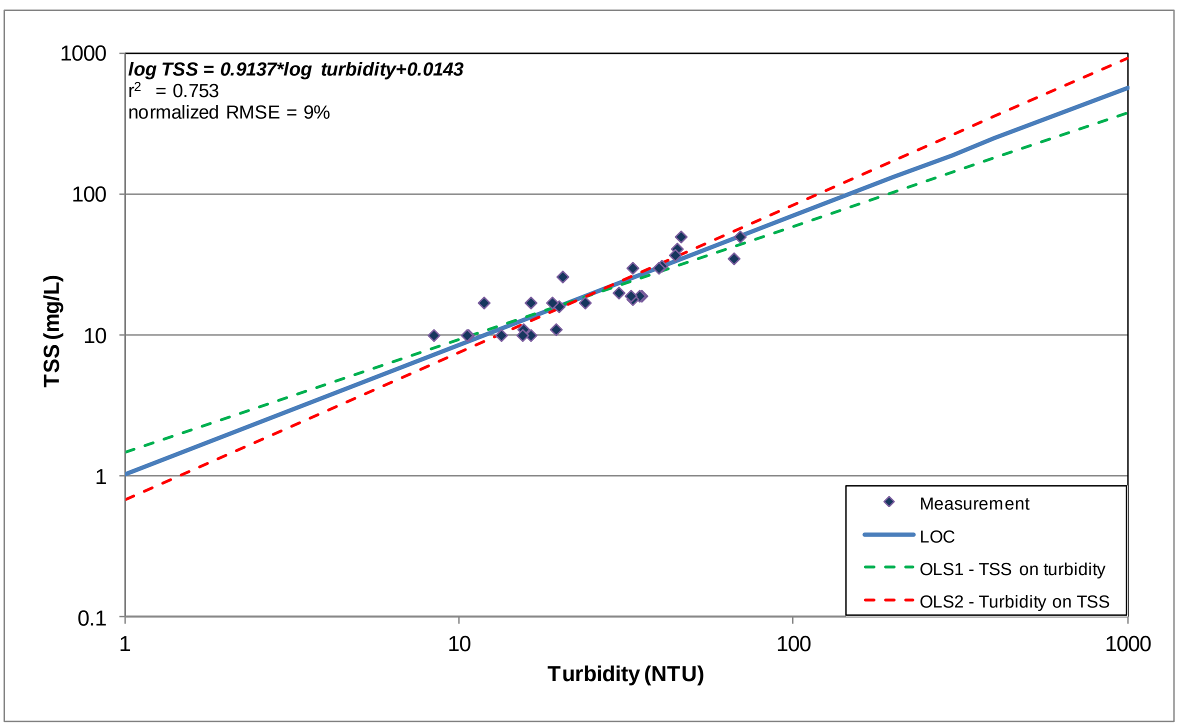


Figure 5-5 Linear Regression for TSS-Turbidity for Council Creek (OK620900020050_00)

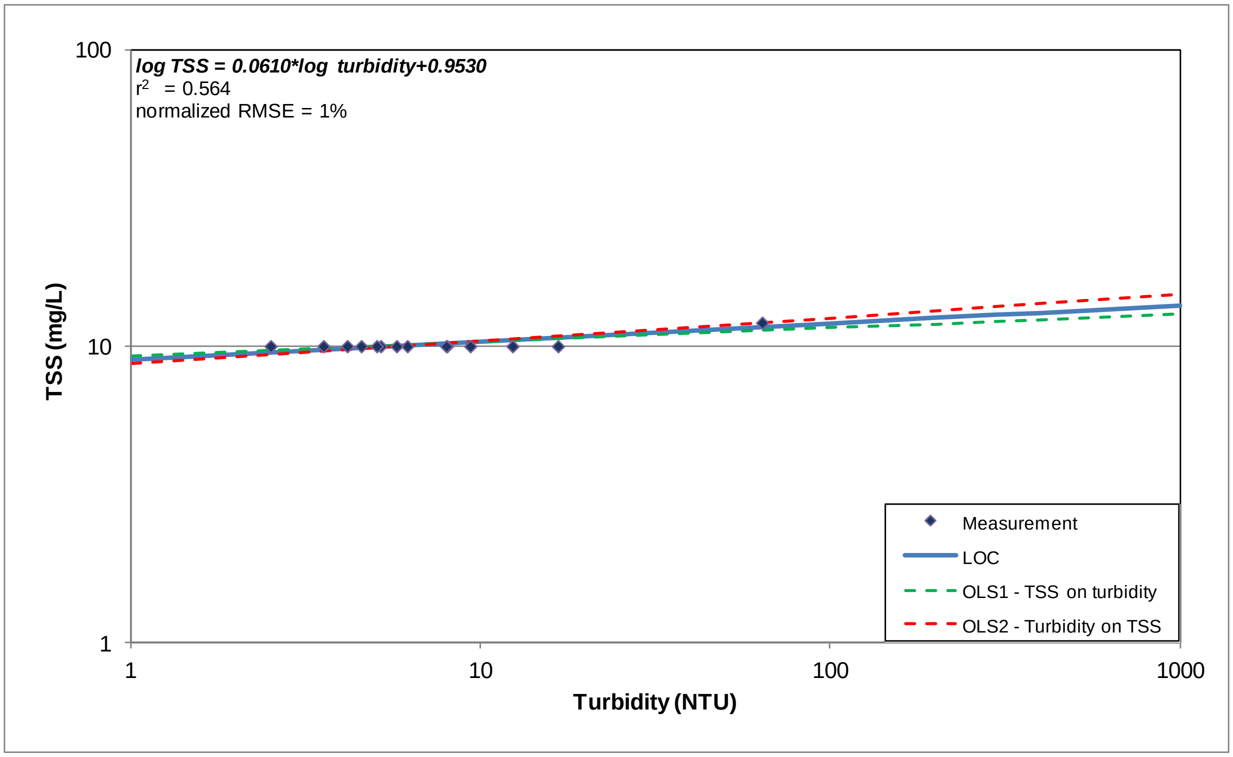
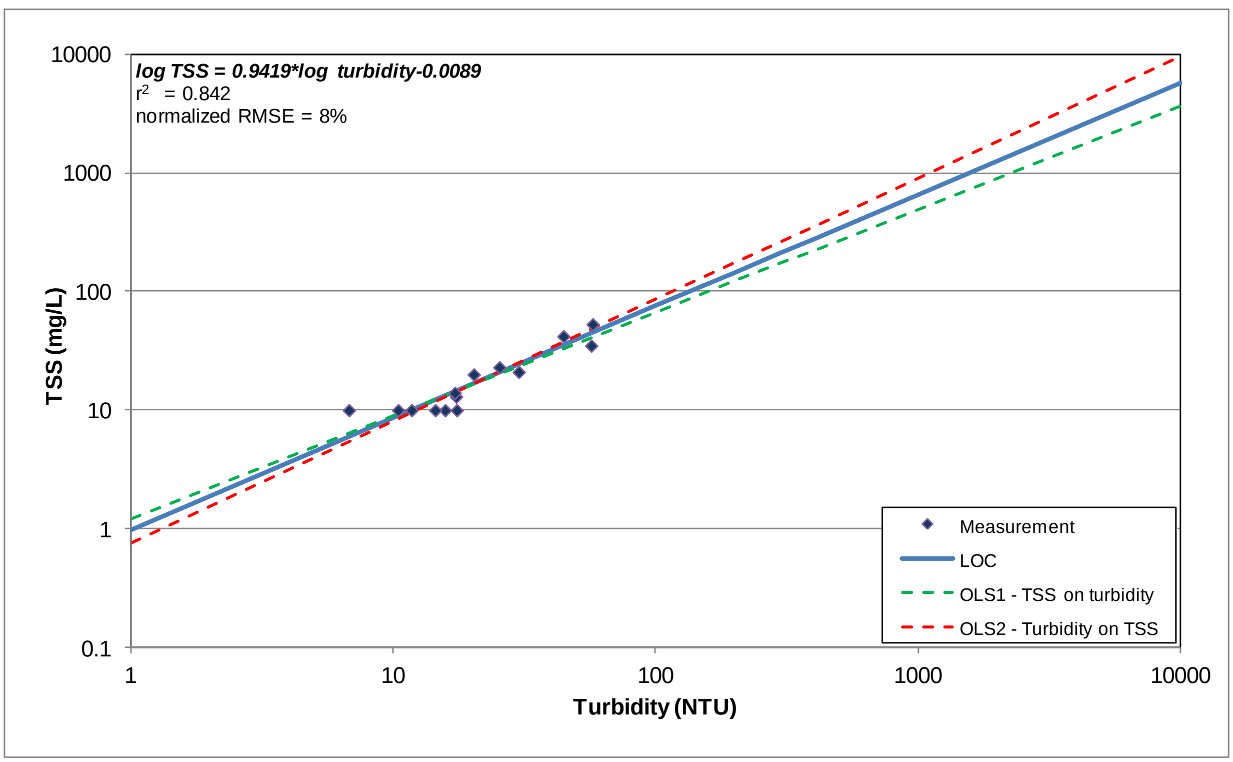


Figure 5-6 Linear Regression for TSS-Turbidity for Euchee Creek (OK620900010290_00)

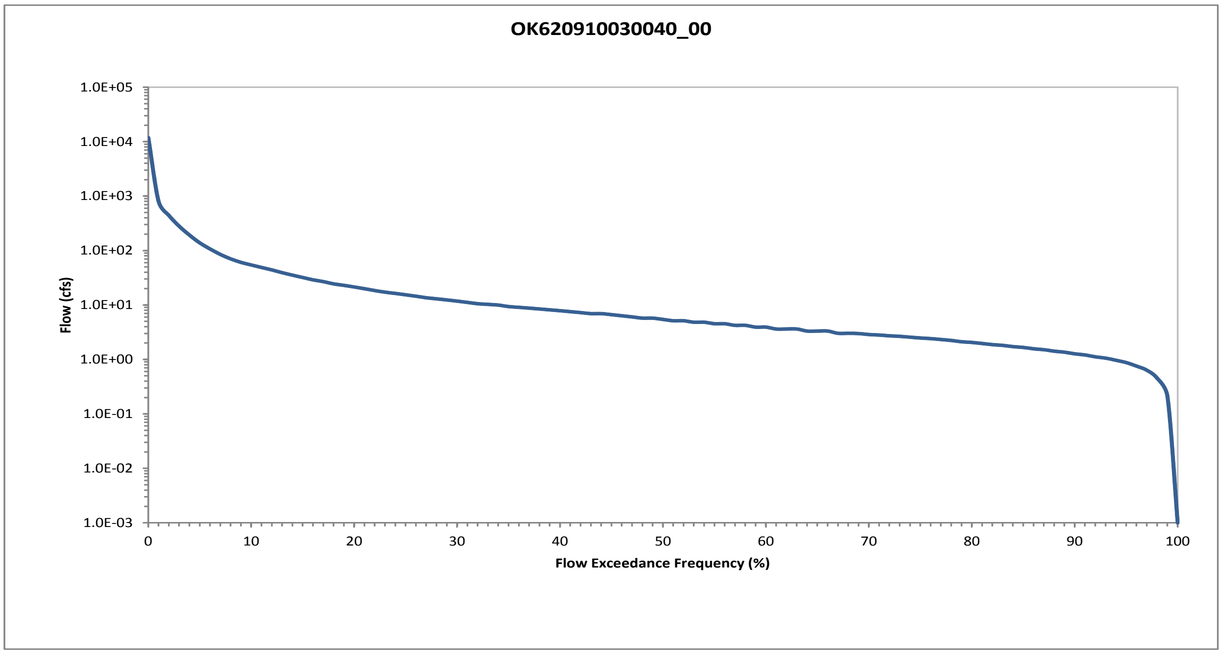


5.2 Flow Duration Curve

Following the same procedures described in Section 4.3, a flow duration curve for each stream segment in this study was developed. These are shown in Figures 5-7 through Figure 5-19.

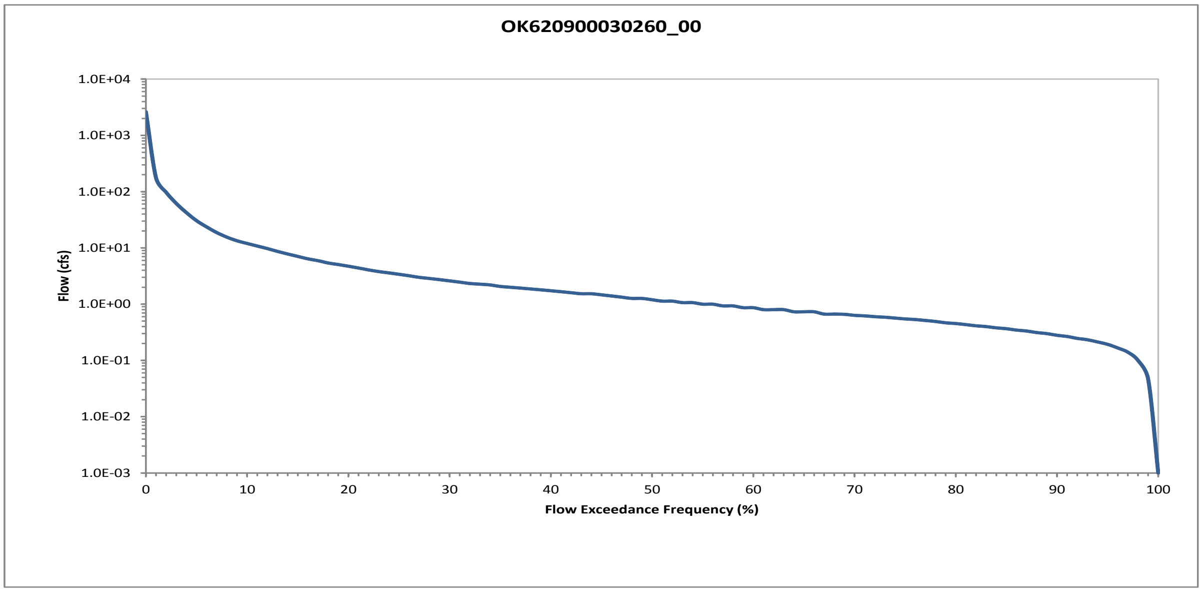
No flow gage exists on Otter Creek, segment OK620910030040_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 0760500 located in an adjacent watershed (Skeleton Creek, near Lovell, OK). The flow duration curve was based on measured flows from 1949 to 2011.

Figure 5-7 Flow Duration Curve for Otter Creek (OK620910030040_00)



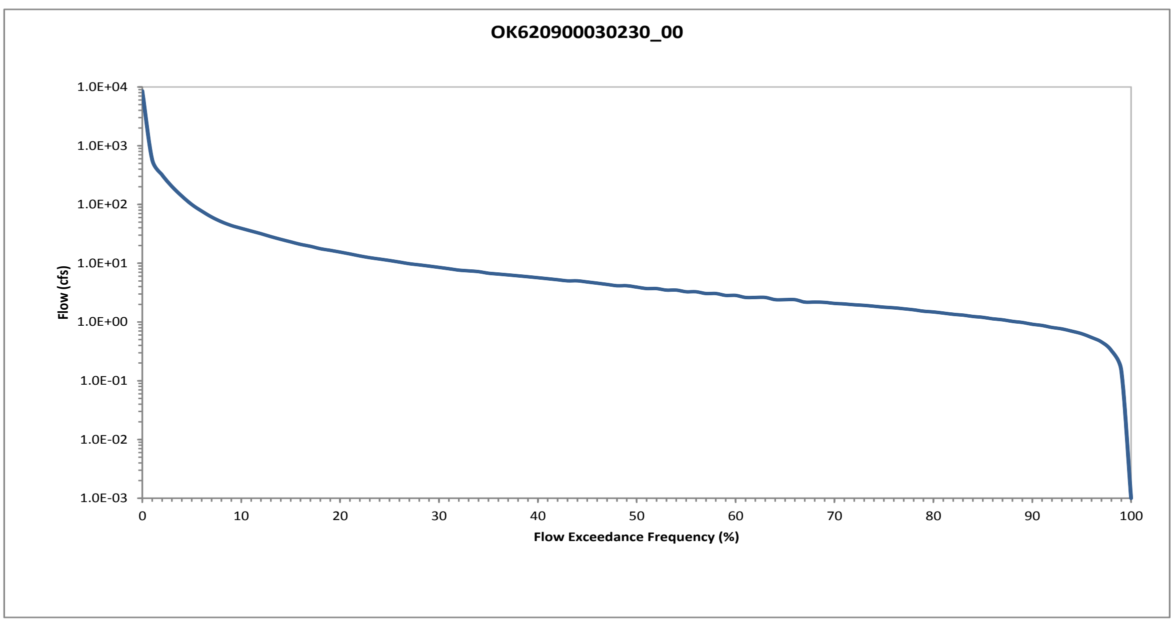
No flow gage exists on West Beaver Creek, segment OK620900030260_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 0760500 located located in an adjacent watershed (Skeleton Creek, near Lovell, OK). The flow duration curve was based on measured flows from 1949 to 2011.

Figure 5-8 Flow Duration Curve for West Beaver Creek (OK620900030260_00)



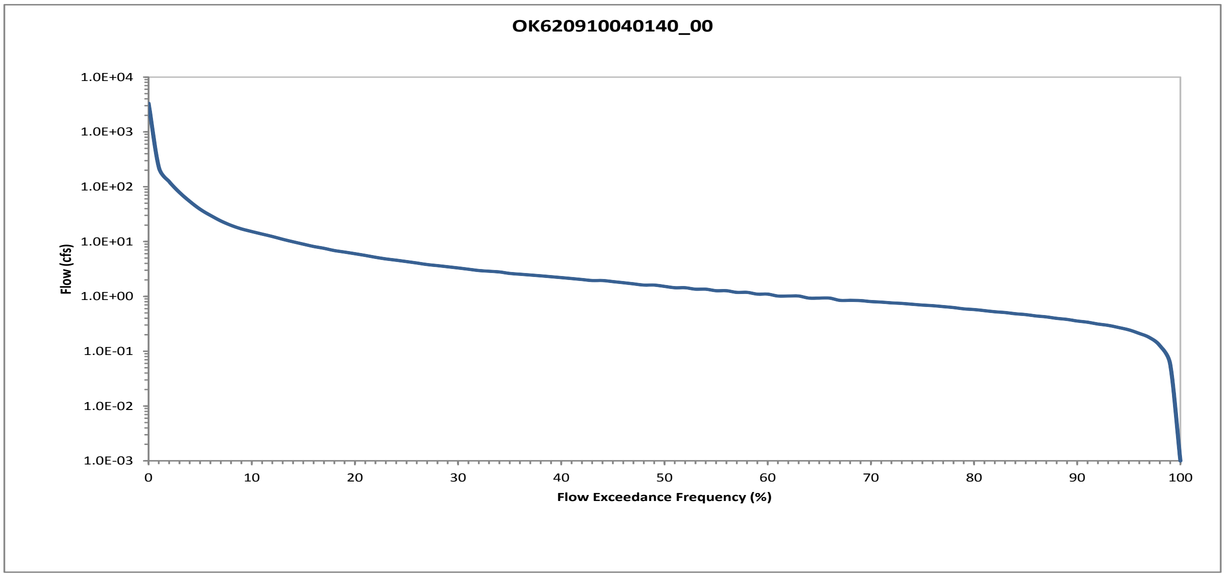
No flow gage exists on Beaver Creek, segment OK620900030230_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 0760500 located in an adjacent watershed (Skeleton Creek, near Lovell, OK). The flow duration curve was based on measured flows from 1949 to 2011.

Figure 5-9 Flow Duration Curve for Beaver Creek (OK620900030230_00)



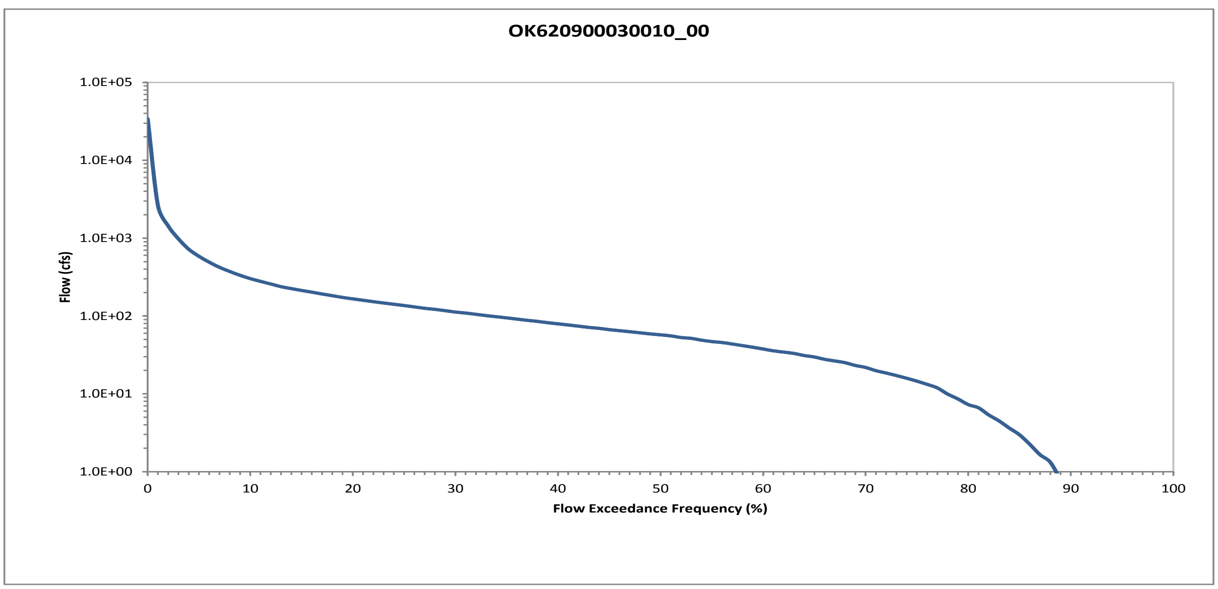
No flow gage exists on Bluff Creek, segment OK620910040140_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 0760500 located in an adjacent watershed (Skeleton Creek, near Lovell, OK). The flow duration curve was based on measured flows from 1949 to 2011. Given the small size of the

Figure 5-10 Flow Duration Curve for Bluff Creek (OK620910040140_00)



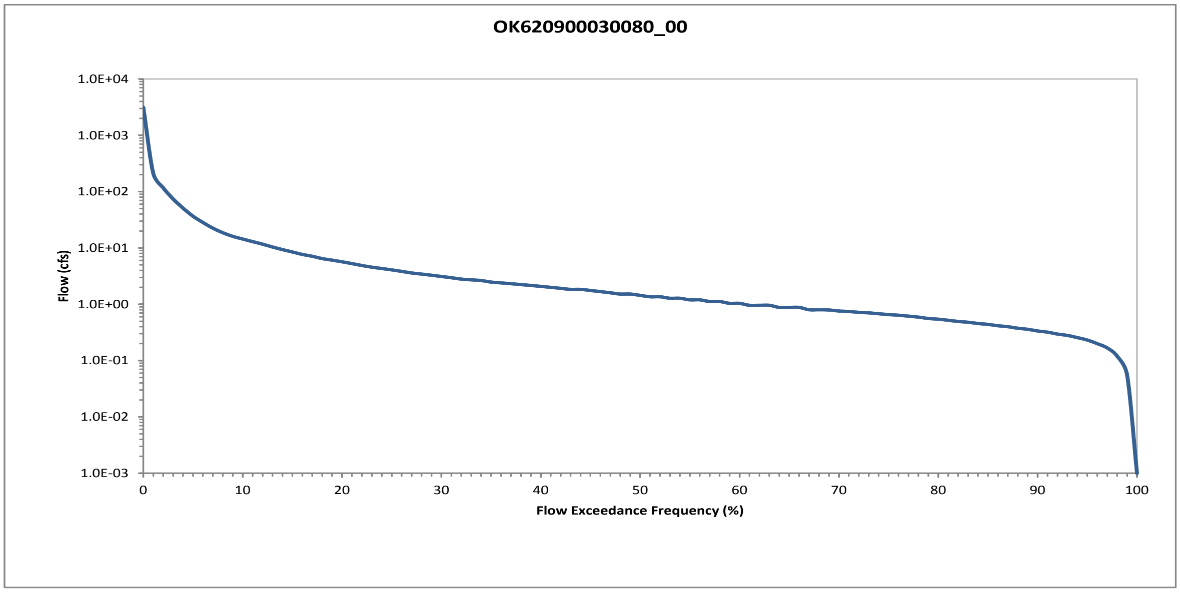
No flow gage exists on Cimarron River, segment OK620900030010_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07158000 (Cimarron River, near Waynoka, OK). The flow duration curve was based on measured flows from 1937 to 2011.

Figure 5-11 Flow Duration Curve for Cimarron River (OK620900030010_00)



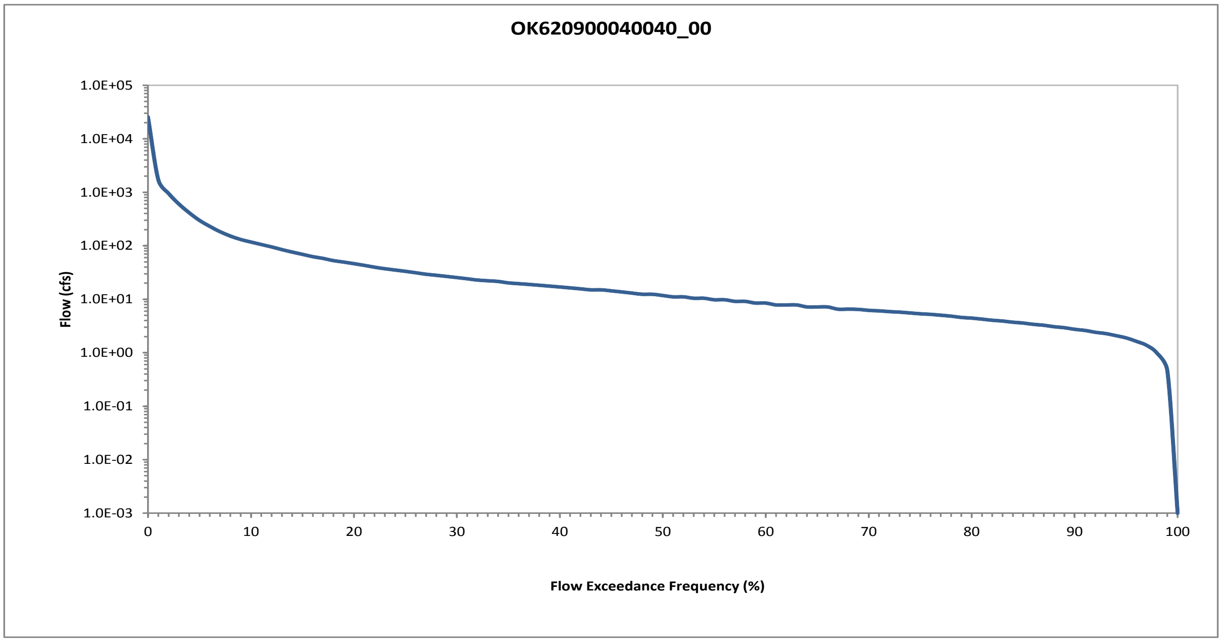
No flow gage exists on Dugout Creek, segment OK620900030080_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 0760500 located in an adjacent watershed (Skeleton Creek, near Lovell, OK). The flow duration curve was based on measured flows from 1949 to 2011.

Figure 5-12 Flow Duration Curve for Dugout Creek (OK620900030080_00)



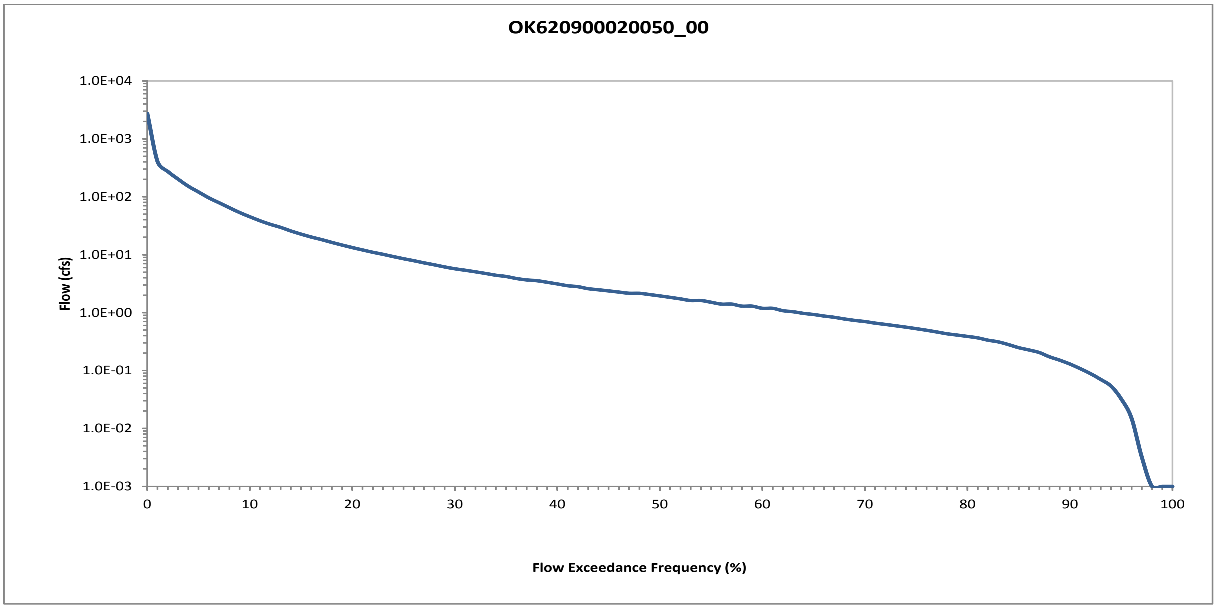
No flow gage exists on Stillwater Creek, segment OK620900040040_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 0760500 located in an adjacent watershed (Skeleton Creek, near Lovell, OK). The flow duration curve was based on measured flows from 1949 to 2011.

Figure 5-13 Flow Duration Curve for Stillwater Creek (OK620900040040_00)



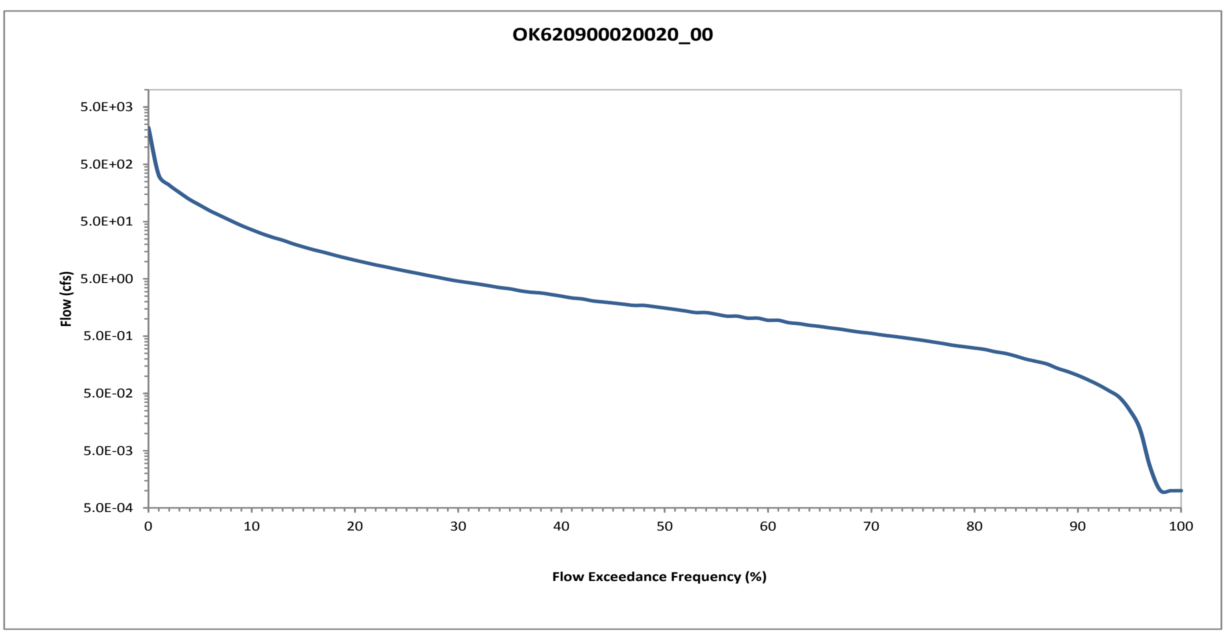
No flow gage exists on Council Creek, segment OK620900020050_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 0715300 located in an adjacent watershed (Black Bear Creek, near Pawnee, OK). The flow duration curve was based on measured flows from 1941 to 2011.

Figure 5-14 Flow Duration Curve for Council Creek (OK620900020050_00)



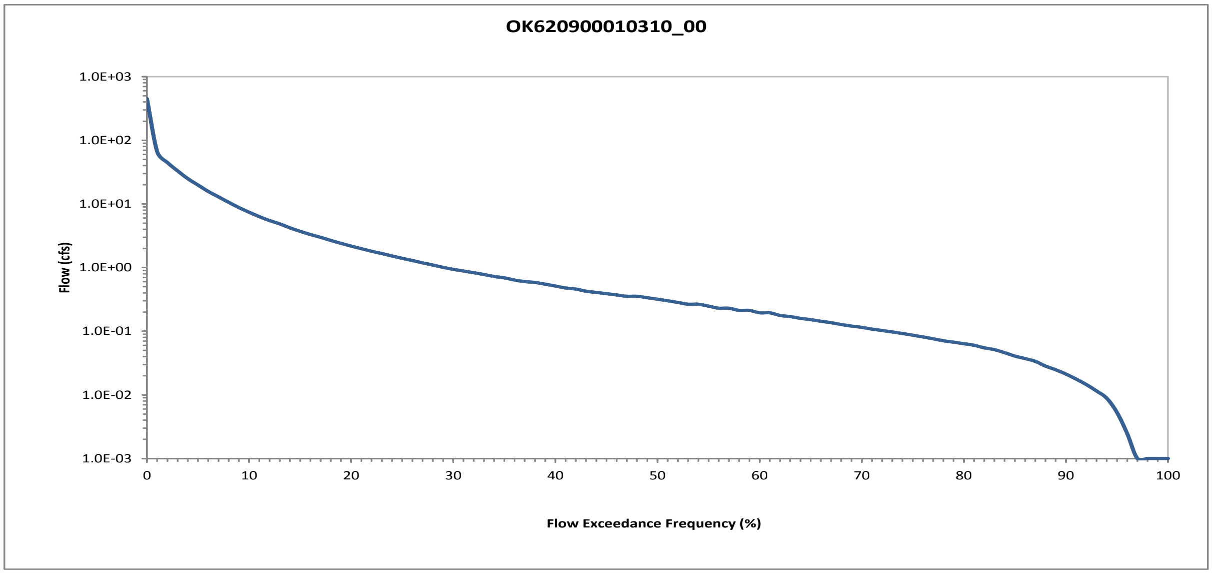
No flow gage exists on Salt Creek, segment OK620900020020_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 0715300 located in an adjacent watershed (Black Bear Creek, near Pawnee, OK). The flow duration curve was based on measured flows from 1941 to 2011.

Figure 5-15 Flow Duration Curve for Salt Creek (OK620900020020_00)



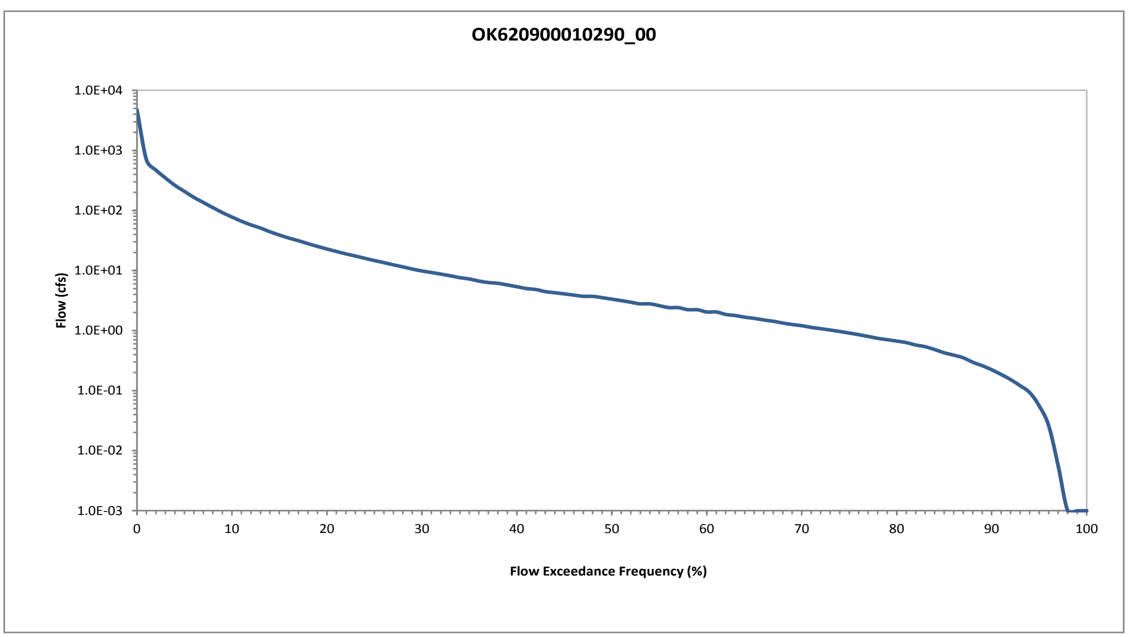
No flow gage exists on Cottonwood Creek, segment OK620900010310_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 0715300 located in an adjacent watershed (Black Bear Creek, near Pawnee, OK). The flow duration curve was based on measured flows from 1941 to 2011.

Figure 5-16 Flow Duration Curve for Cottonwood Creek (OK620900010310_00)



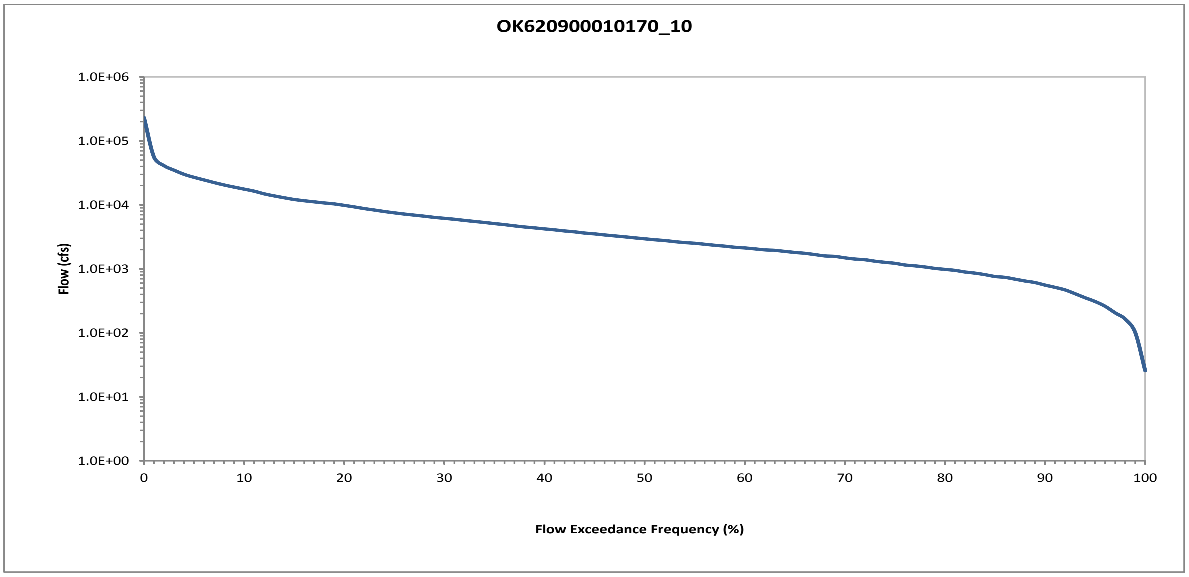
No flow gage exists on Euchee Creek, segment OK620900010290_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 0715300 located in an adjacent watershed (Black Bear Creek, near Pawnee, OK). The flow duration curve was based on measured flows from 1941 to 2011.

Figure 5-17 Flow Duration Curve for Euchee Creek (OK620900010290_00)



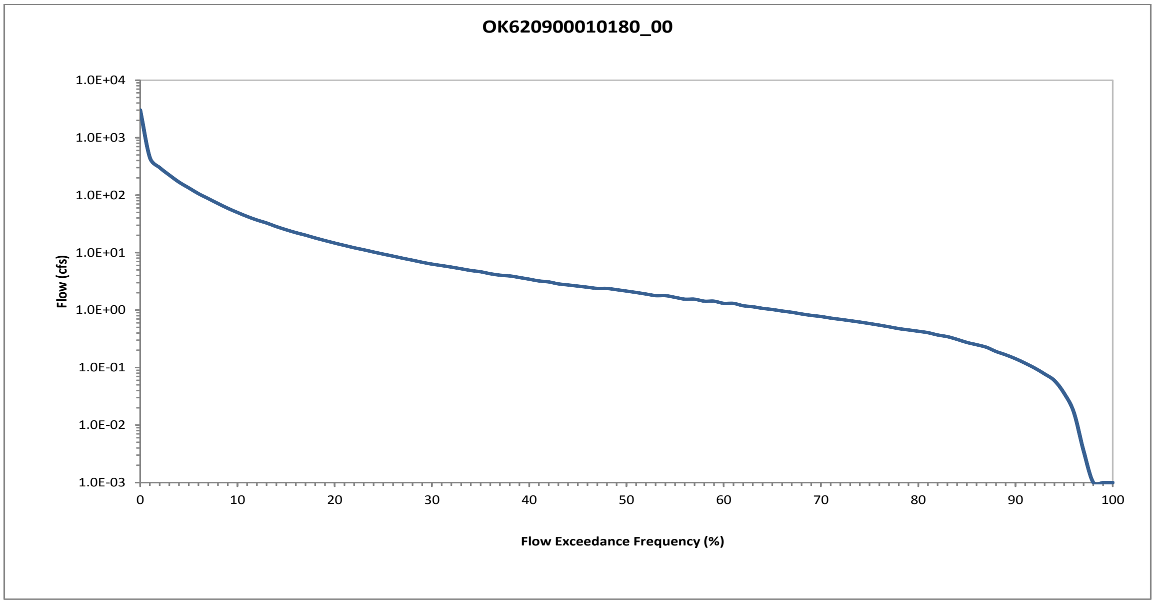
No flow gage exists on Cimarron River, segment OK620900010170_10. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 07464500 (Arkansas River, at Tulsa, OK). The flow duration curve was based on measured flows from 1925 to 2010.

Figure 5-18 Flow Duration Curve for Cimarron River (OK620900010170_10)



No flow gage exists on Lagoon Creek, segment OK620900010180_00. Therefore, flows for this waterbody were estimated using the watershed area ratio method based on measured flows at USGS gage station 0715300 located in an adjacent watershed (Black Bear Creek, near Pawnee, OK). The flow duration curve was based on measured flows from 1941 to 2011.

Figure 5-19 Flow Duration Curve for Lagoon Creek (OK620900010180_00)



5.3 Estimated Loading and Critical Conditions

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

5.3.1 Bacteria LDC

To calculate the allowable bacteria load, the flow rate at each flow exceedance percentile is multiplied by a unit conversion factor (*24,465,525*) and the geometric mean water quality criterion for each bacterial indicator. This calculation produces the maximum bacteria load in the stream over the range of flow conditions. The allowable bacteria (*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, the geometric mean of all bacteria observations (concentrations) for the primary contact recreation season (May 1st through September 30th) from 2000 to 2008 are paired with the flows measured or estimated in that waterbody. Pollutant loads are then calculated by multiplying the measured bacteria concentration by the flow rate and the unit conversion factor of *24,465,756*.

The bacteria LDCs developed for each impaired waterbody (representing the primary contact recreation season from 2000 through 2008) are shown in Figures 5-21 through 5-41. Each waterbody had an LDC for either *E. coli*, Enterococci or both. This is because for the PBCR use to be supported, criteria for each bacterial indicator must be met in each impaired waterbody.

The LDCs for Otter Creek (Figures 5-20 and 5-21) are based on *E. coli* and Enterococci bacteria measurements collected during primary contact recreation season at WQM stations OK620910-03-0040C.

Figure 5-20 Load Duration Curve for *E. coli* in Otter Creek (OK620910030040_00)

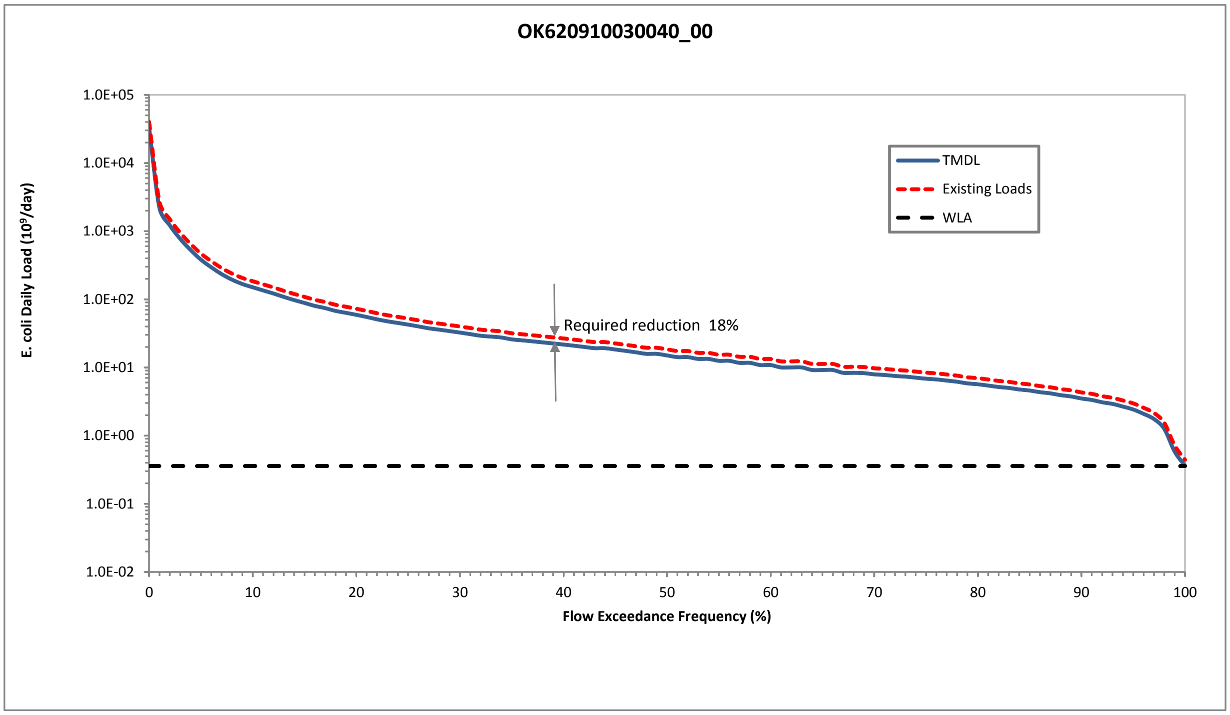
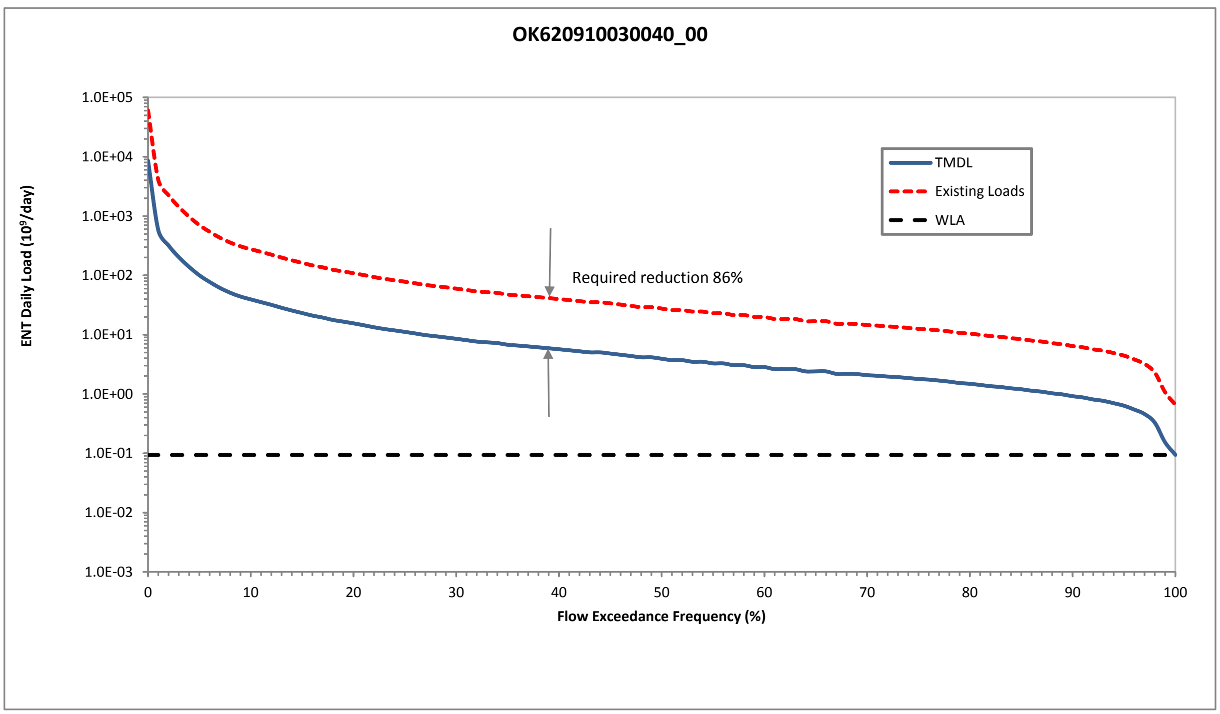


Figure 5-21 Load Duration Curve for Enterococci in Otter Creek (OK620910030040_00)



The LDC for Beaver Creek (Figures 5-22 and 5-23) is based on *E. coli* and Enterococci measurements during primary contact recreation season at WQM stations OK620900-03-0230C.

Figure 5-22 Load Duration Curve for *E. coli* in Beaver Creek (OK620900030230_00)

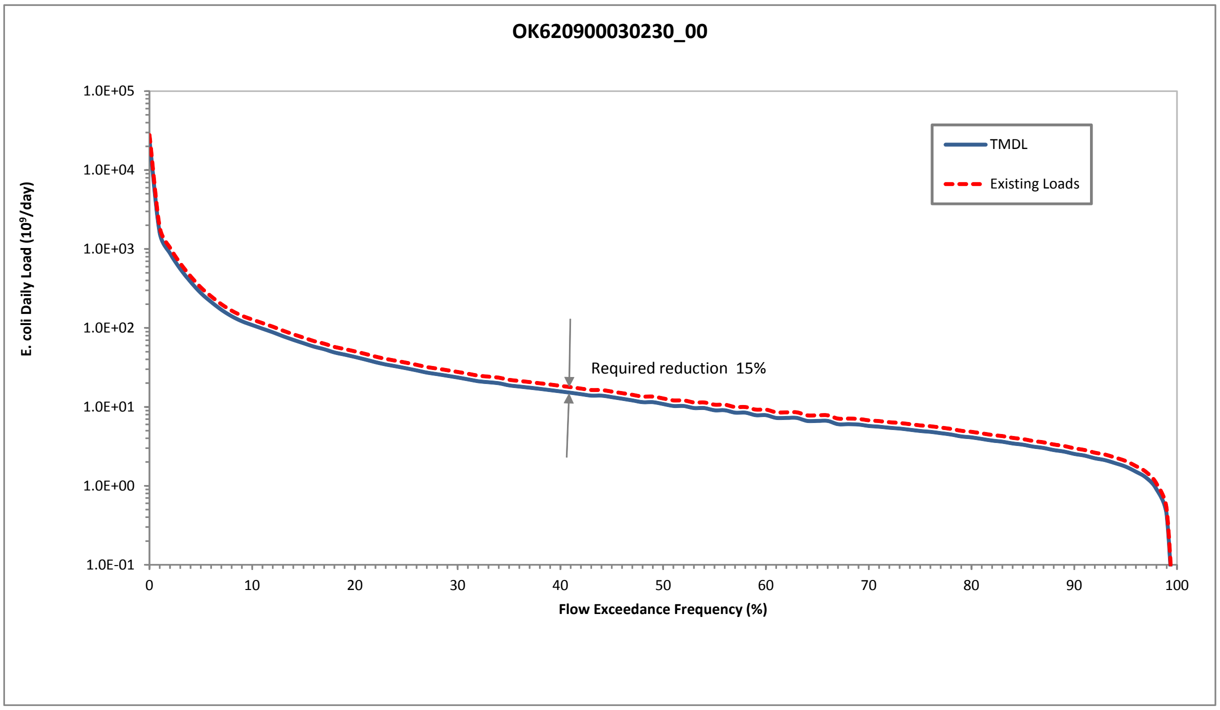
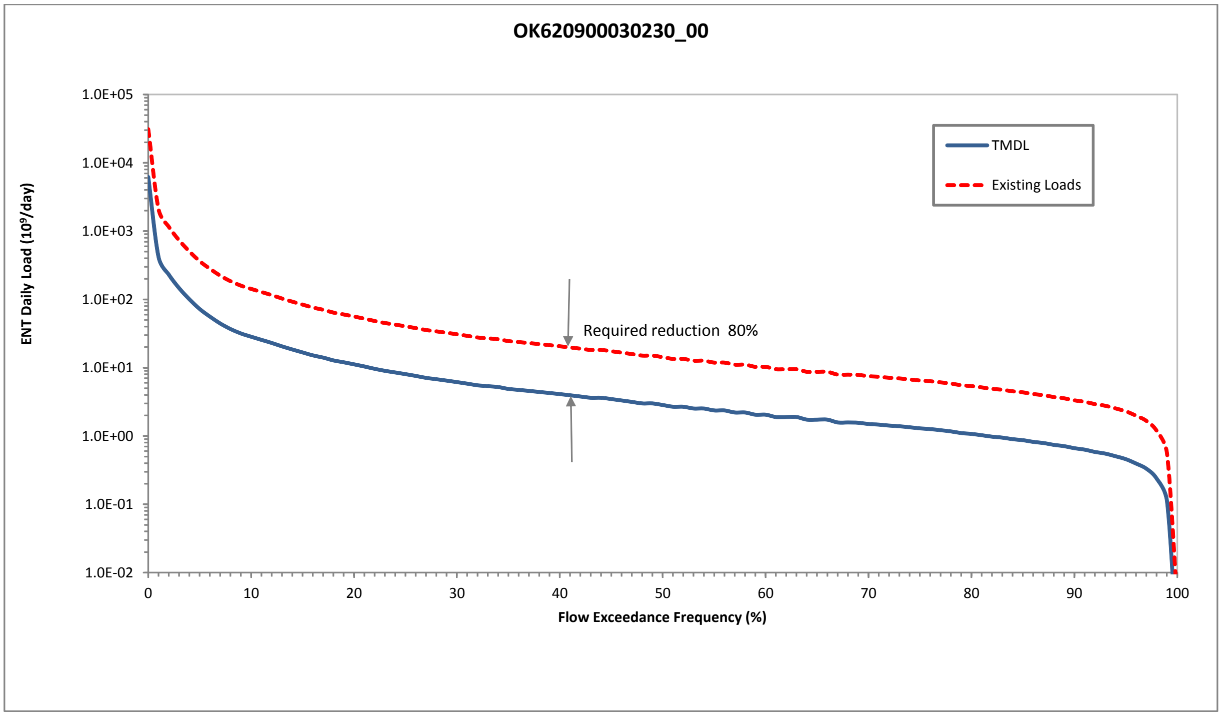
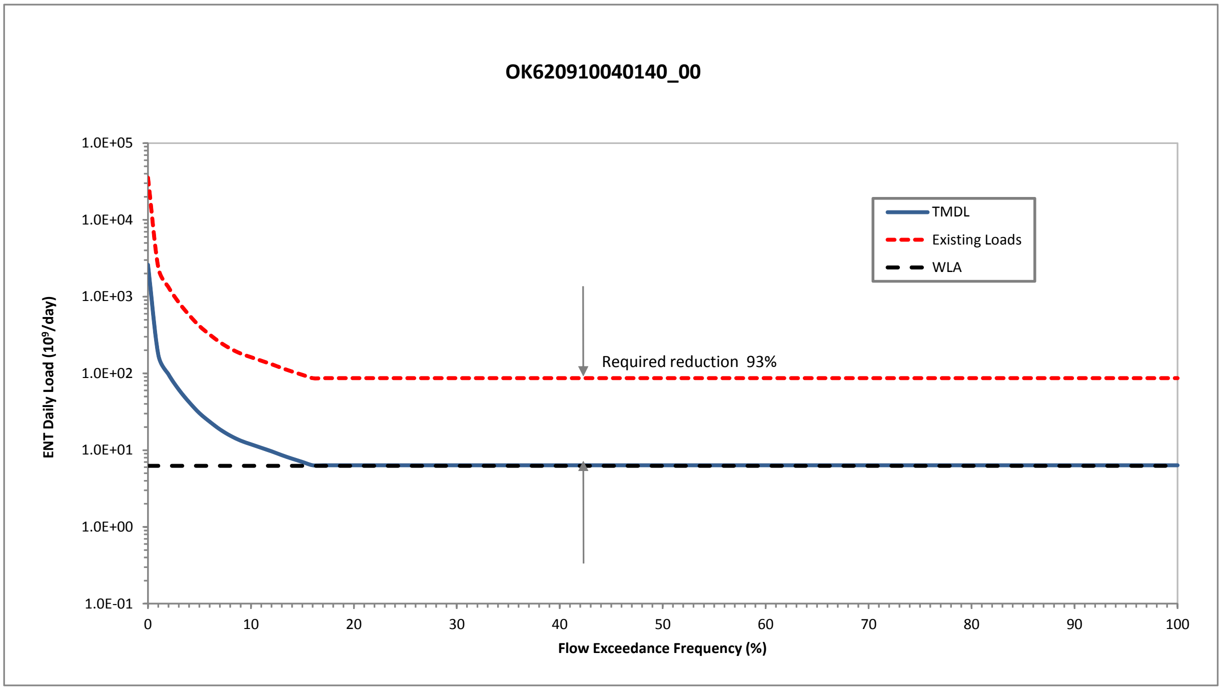


Figure 5-23 Load Duration Curve for Enterococci in Beaver Creek (OK620900030230_00)



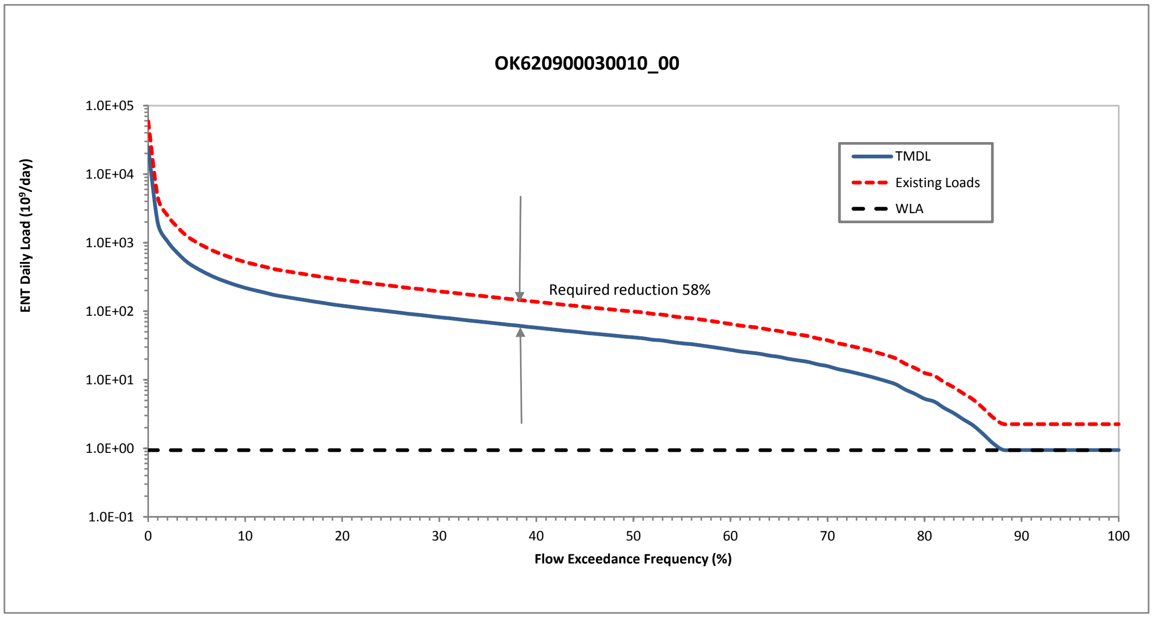
The LDCs for Bluff Creek (Figures 5-24) are based on Enterococci bacteria measurements collected during primary contact recreation season at WQM station 620910040140-001SR and 620910040140-002SR. The atypical configuration of the LDC for Bluff Creek is the result of several different characteristics. The small size of the watershed results in very low historical naturalized flow in Bluff Creek. Coupling the intermittent naturalized flow of the creek with the discharge of a large WWTP results in Bluff Creek being an effluent dominated stream. The horizontal LDC reflects the influence of the continuous discharge using the permitted design flow (5 mgd) of the Bethany/Warr Acres Public Works Authority WWTP.

Figure 5-24 Load Duration Curve for Enterococci in Bluff Creek (OK620910040140_00)



The LDC for the Cimarron River (Figure 5-25) is based on Enterococci measurements during primary contact recreation season at WQM stations 620900030010-001AT, 620900030010-002RS, and 620900030010-004RS. The last part of the curve, where the total allowable load is lower than the wasteload from WWTFs, is assumed equal to the WLA_{WWTP}. This explains the difference of shape between the LDC and FDC at very low flows.

Figure 5-25 Load Duration Curve for Enterococci in Cimarron River (OK620900030010_00)



The LDCs for Dugout Creek (Figures 5-26 and 5-27) are based on *E. coli* and Enterococci bacteria measurements collected during primary contact recreation season at WQM stations OK620900-03-008C.

Figure 5-26 Load Duration Curve for *E. coli* in Dugout Creek (OK620900030080_00)

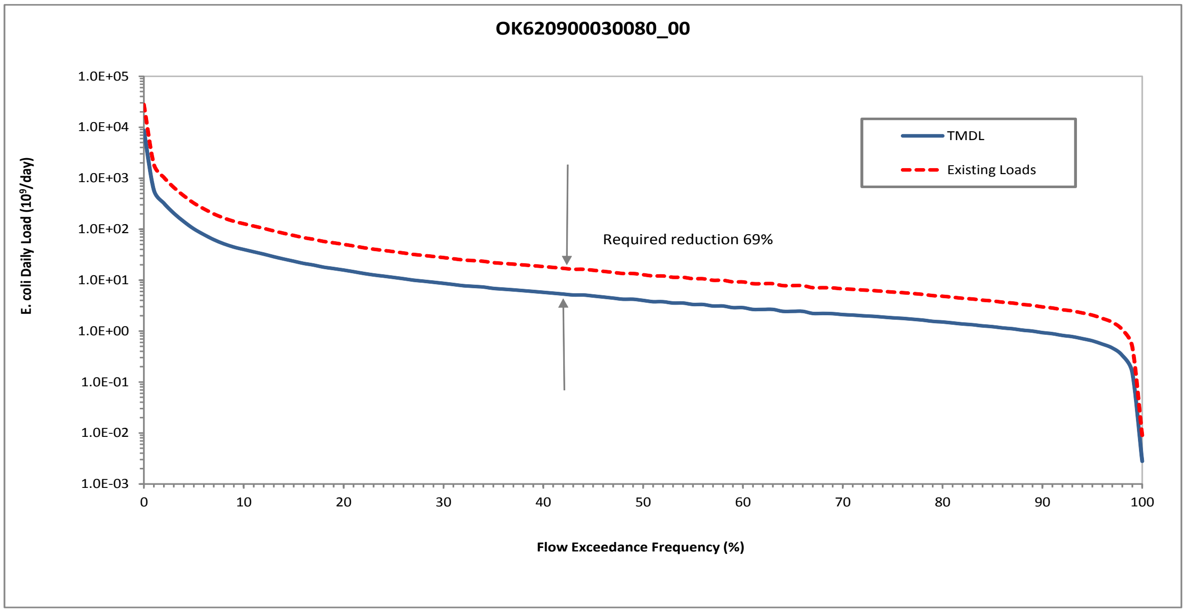
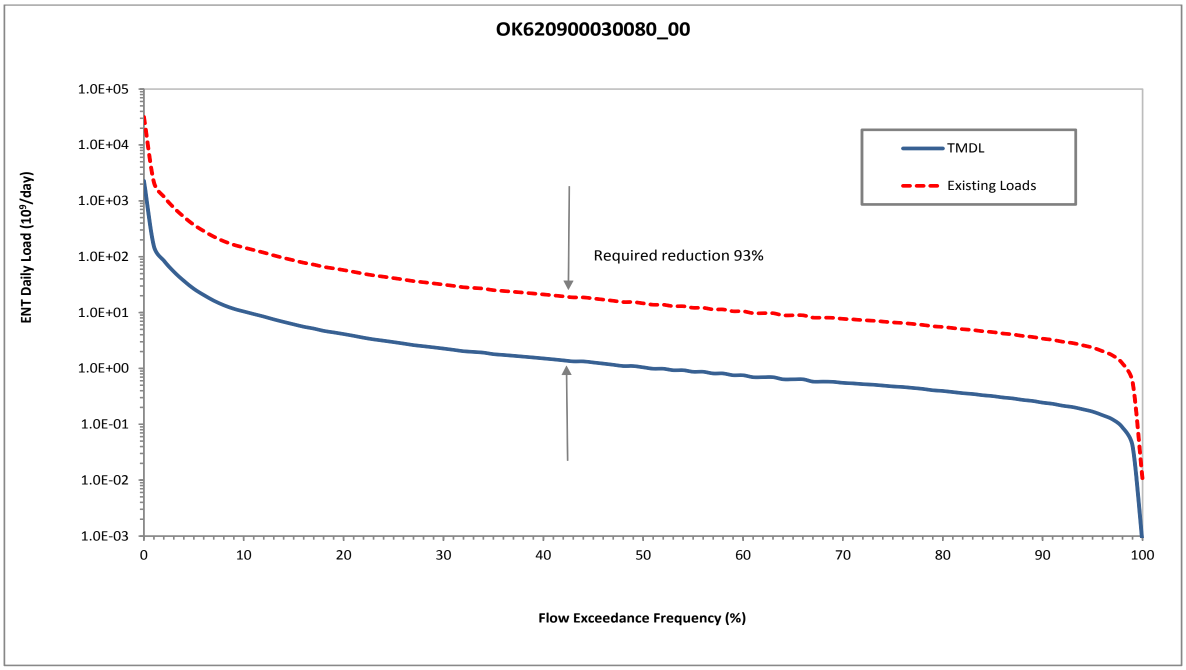


Figure 5-27 Load Duration Curve for Enterococci in Dugout Creek (OK620900030080_00)



The LDCs for Stillwater Creek (Figures 5-28 and 5-29) are based on *E. coli* and Enterococci measurements during primary contact recreation season at WQM station OK620900-04-0040C.

Figure 5-28 Load Duration Curve for *E. coli* in Stillwater Creek (OK620900040040_00)

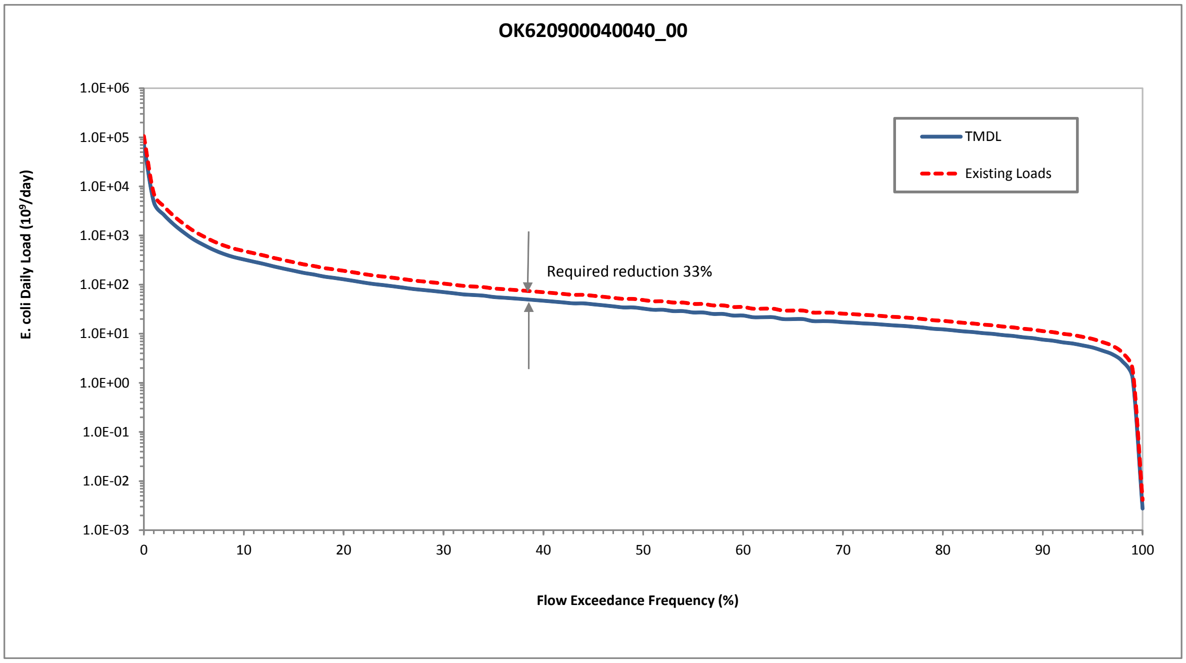
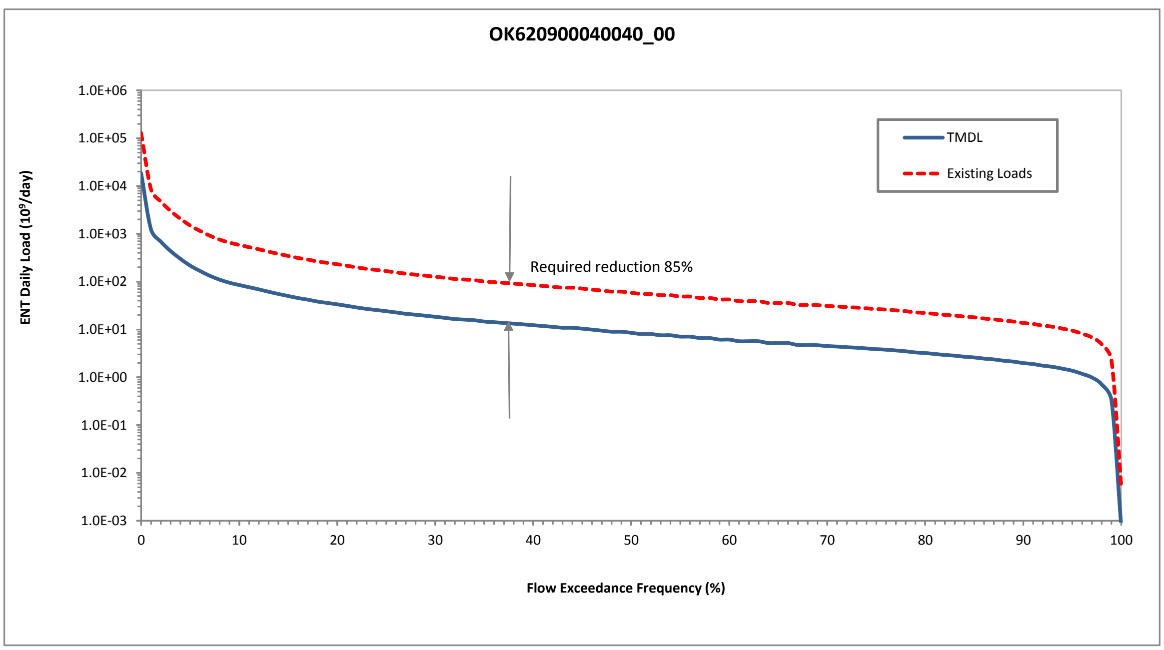


Figure 5-29 Load Duration Curve for Enterococci in Stillwater Creek (OK620900040040_00)



The LDC for Council Creek (Figure 5-30 and Figure 5-31) is based on *E. coli* and Enterococci measurements during primary contact recreation season at WQM station OK620900-02-0050H.

Figure 5-30 Load Duration Curve for *E. coli* in Council Creek (OK620900020050_00)

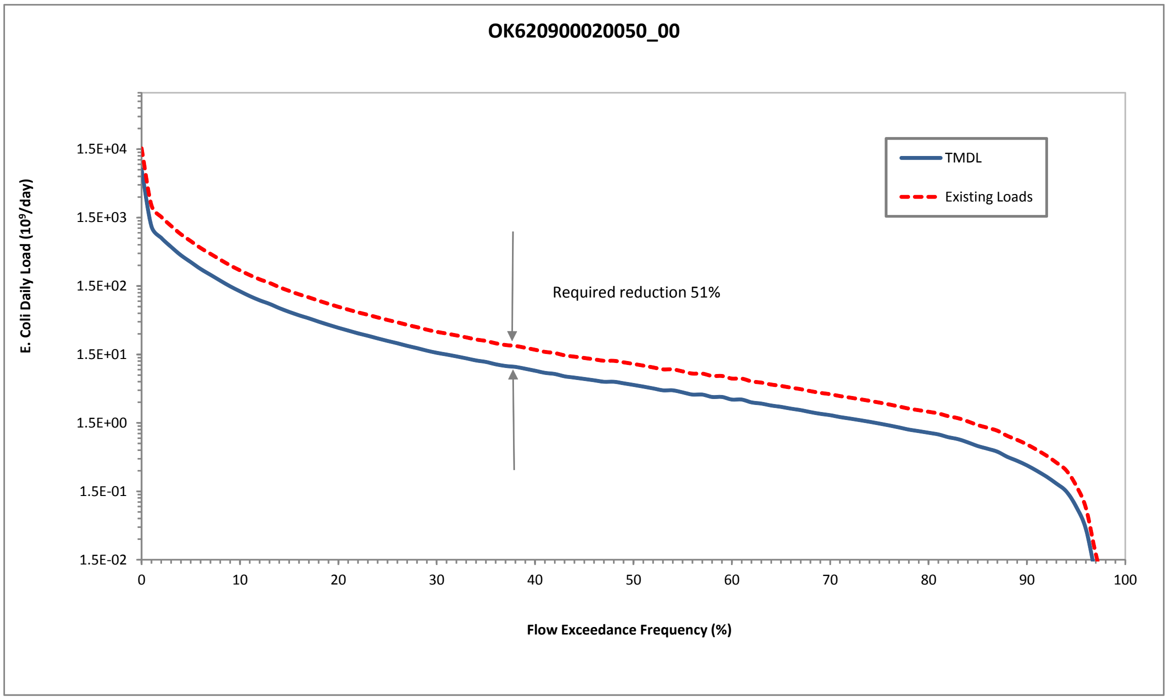
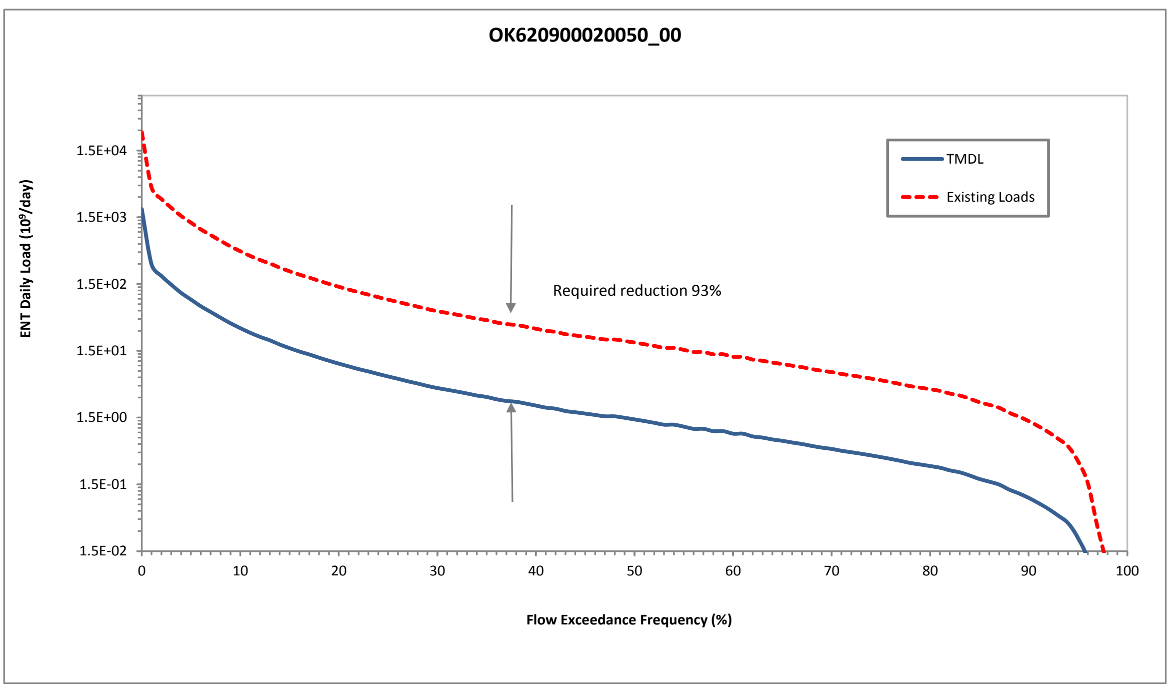


Figure 5-31 Load Duration Curve for Enterococci in Council Creek (OK620900020050_00)



The LDCs for Salt Creek (Figure 5-32 and Figure 5-33) for *E. coli* and Enterococci measurements during primary contact recreation season at WQM station OK620900-02-0020D.

Figure 5-32 Load Duration Curve for *E. coli* in Salt Creek (OK620900020020_00)

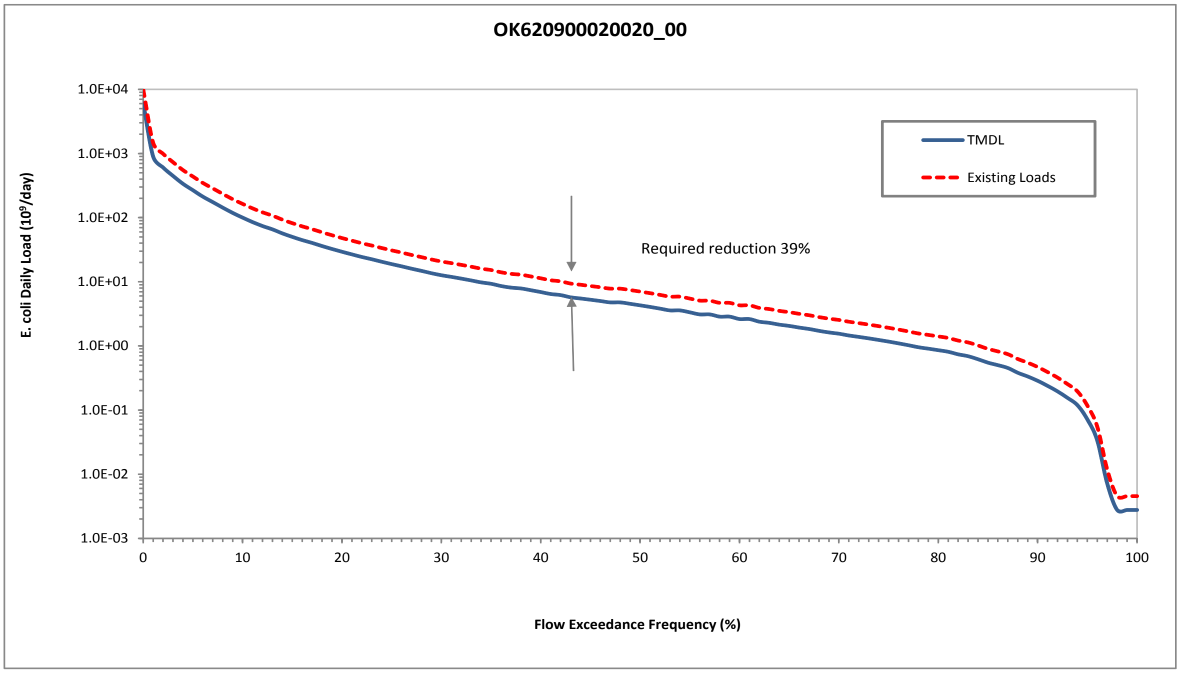
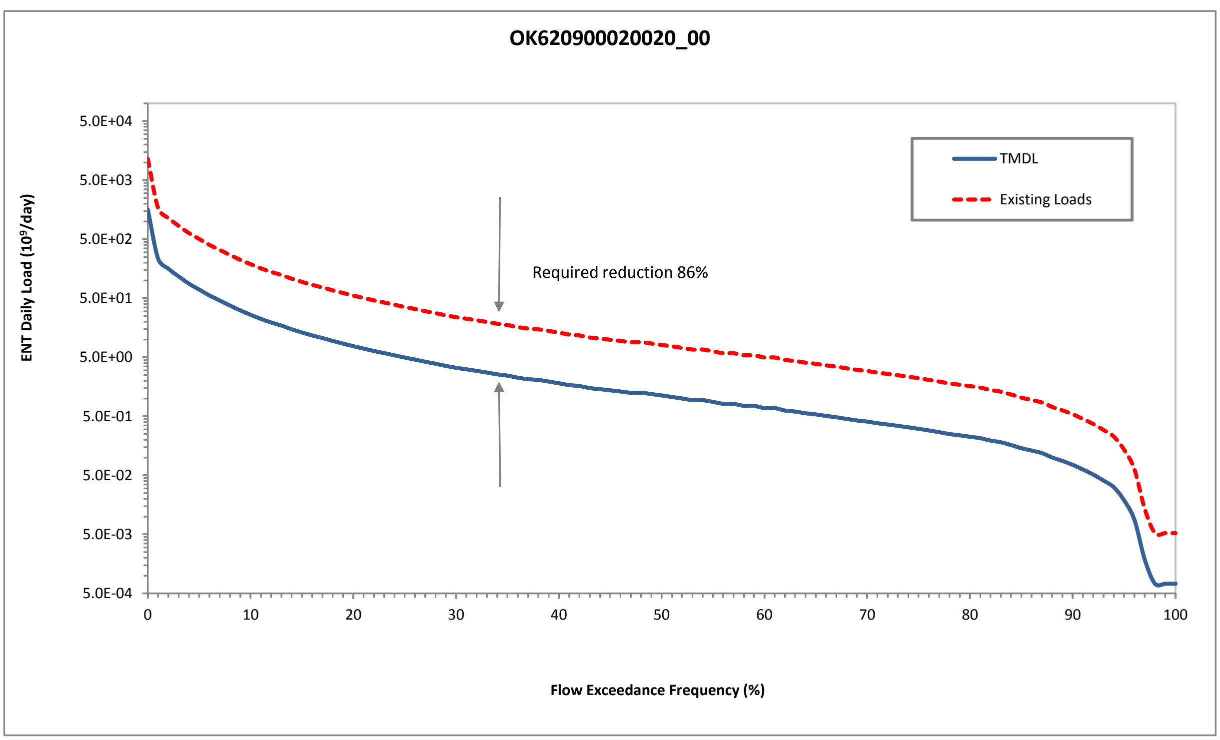


Figure 5-33 Load Duration Curve for Enterococci in Salt Creek (OK620900020020_00)



The LDCs for Cottonwood Creek (Figure 5-34 and Figure 5-35) for *E. coli* and Enterococci measurements during primary contact recreation season at WQM station 620900010310-001SR and 620900010310-002SR. The atypical configuration of the LDC for Cottonwood Creek is the result of several different characteristics. The small size of the watershed results in very low historical naturalized flow in Cottonwood Creek. Coupling the intermittent naturalized flow of the creek with the discharge of a large WWTP results in Cottonwood Creek being an effluent dominated stream. The horizontal LDC reflects the influence of the continuous discharge using the permitted design flow (1.6 mgd) of the City of Cushing WWTP.

Figure 5-34 Load Duration Curve for *E. coli* in Cottonwood Creek (OK620900010310_00)

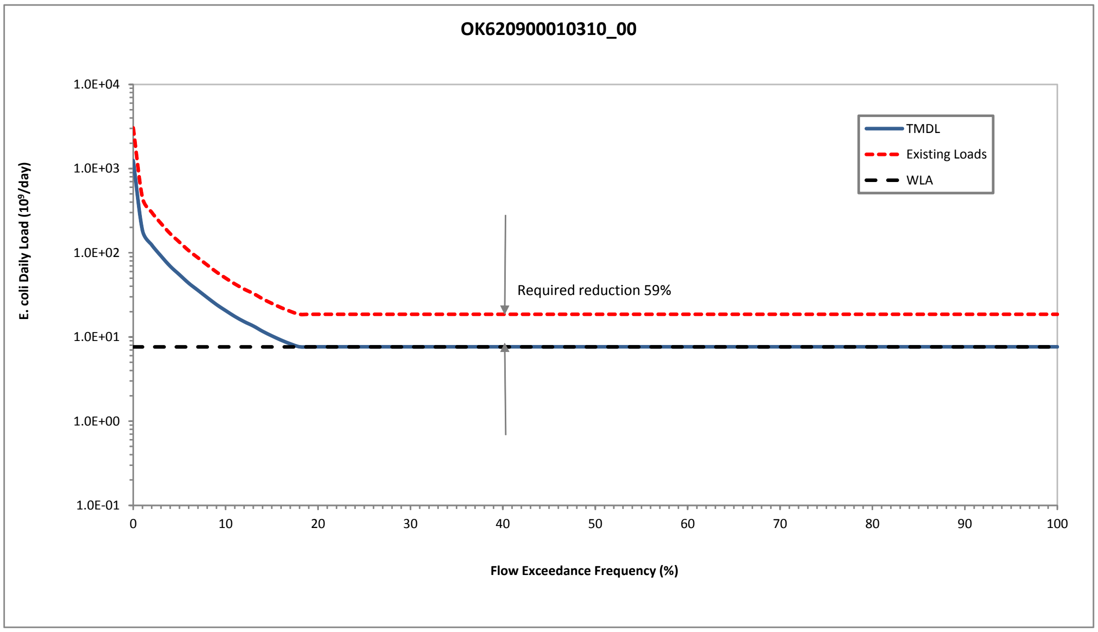
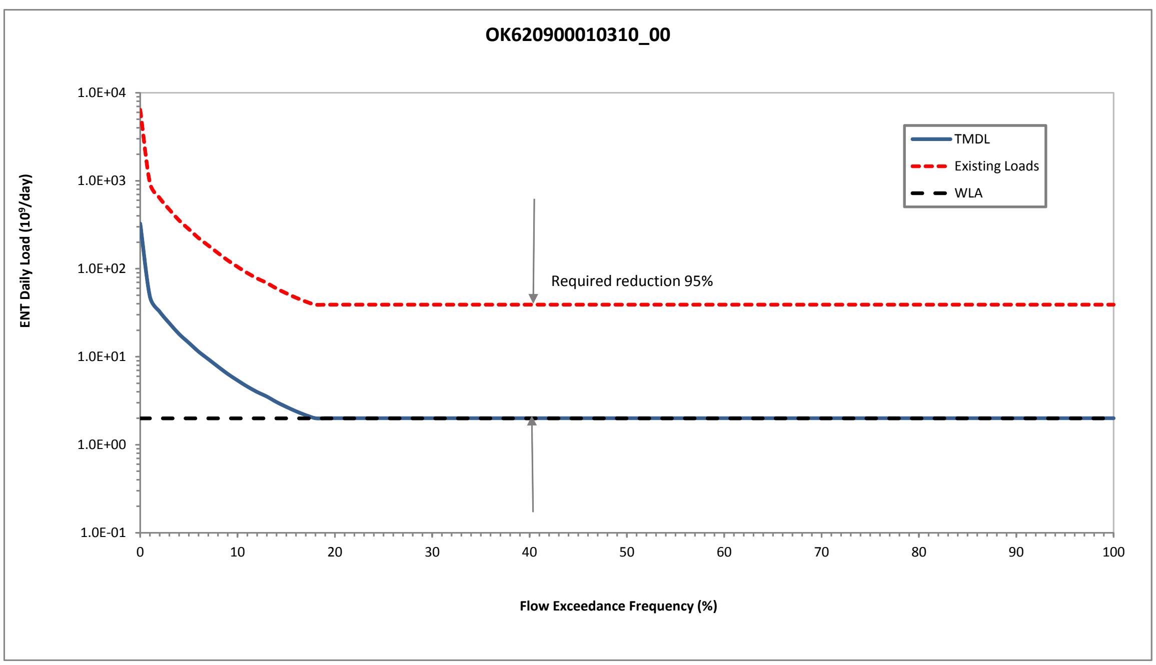


Figure 5-35 Load Duration Curve for Enterococci in Cottonwood Creek (OK620900010310_00)



The LDCs for Euchee Creek (Figure 5-36 and Figure 5-37) for *E. coli* and Enterococci measurements during primary contact recreation season at WQM station OK620900-01-0290D.

Figure 5-36 Load Duration Curve for *E. coli* in Euchee Creek (OK620900010290_00)

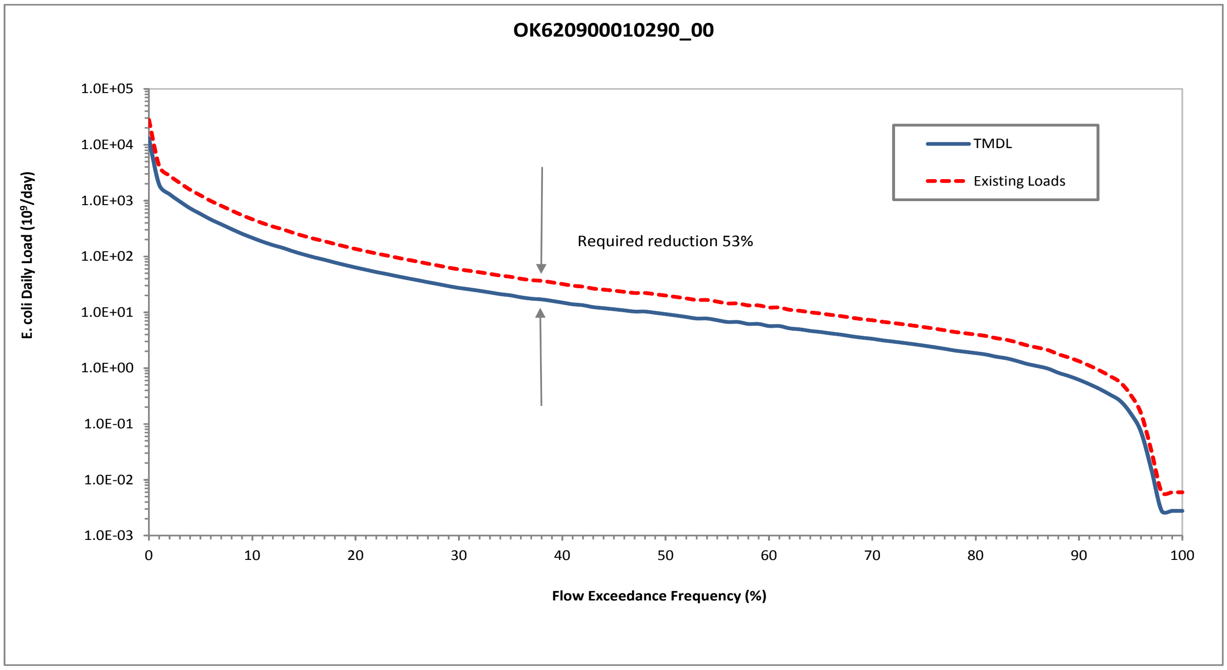
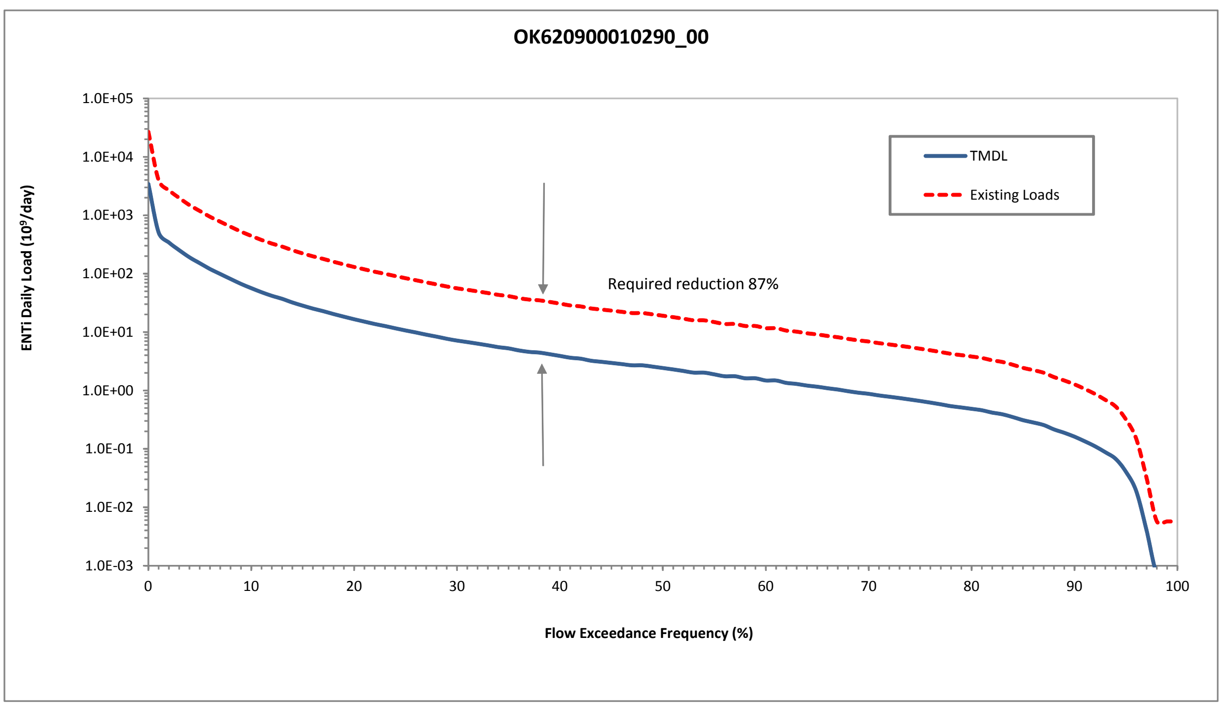
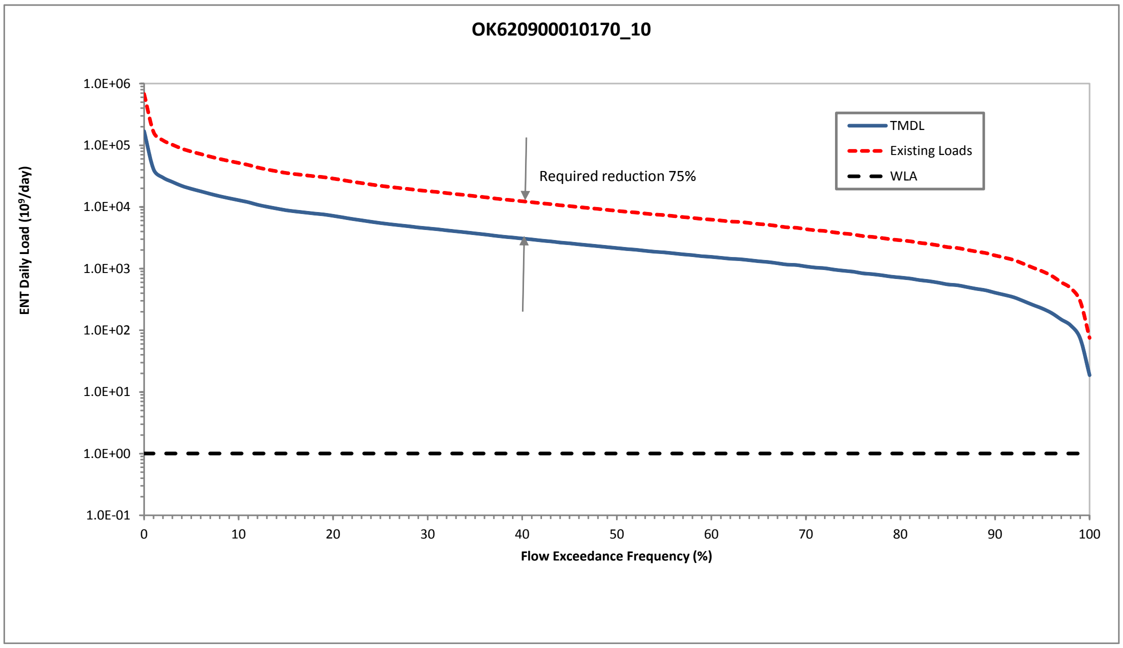


Figure 5-37 Load Duration Curve for Enterococci in Euchee Creek (OK620900010290_00)



The LDCs for Cimarron River (Figure 5-38) for Enterococci measurements during primary contact recreation season at WQM station 620900010170-001AT.

Figure 5-38 Load Duration Curve for Enterococci in Cimarron River (OK620900010170_10)



The LDCs for Lagoon Creek (Figure 5-39 and Figure 5-40) for *E. coli* and Enterococci measurements during primary contact recreation season at WQM station OK620900-01-0180J.

Figure 5-39 Load Duration Curve for *E. coli* in Lagoon Creek (OK620900010180_00)

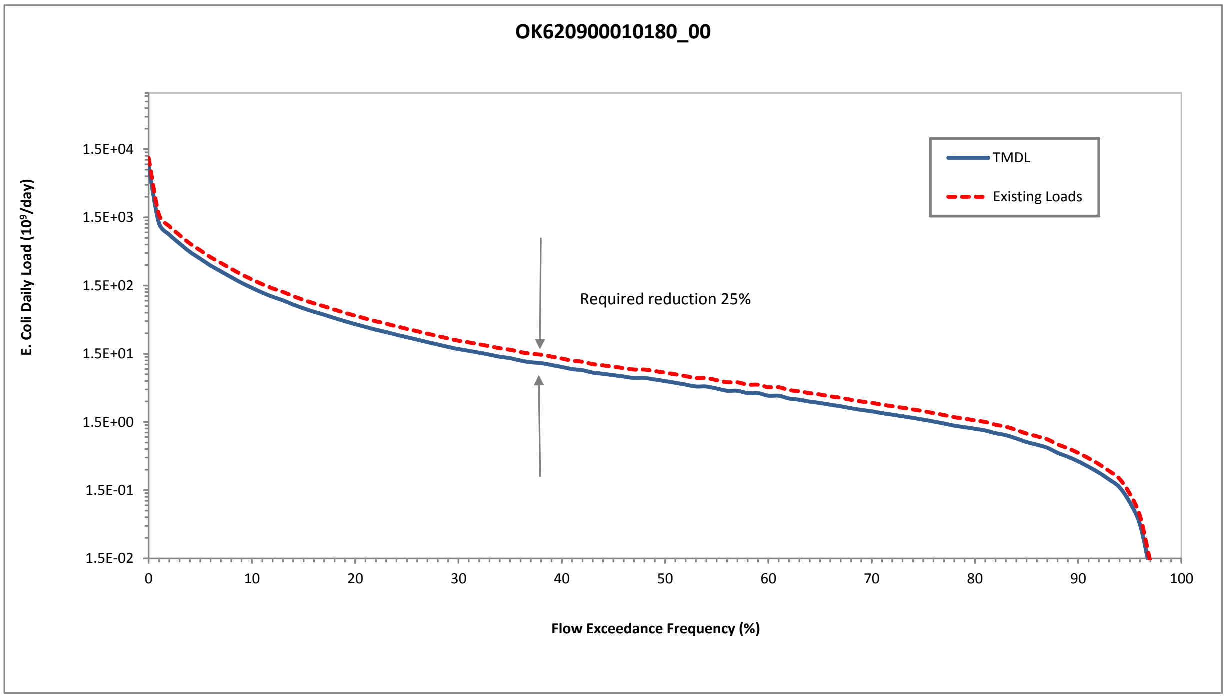
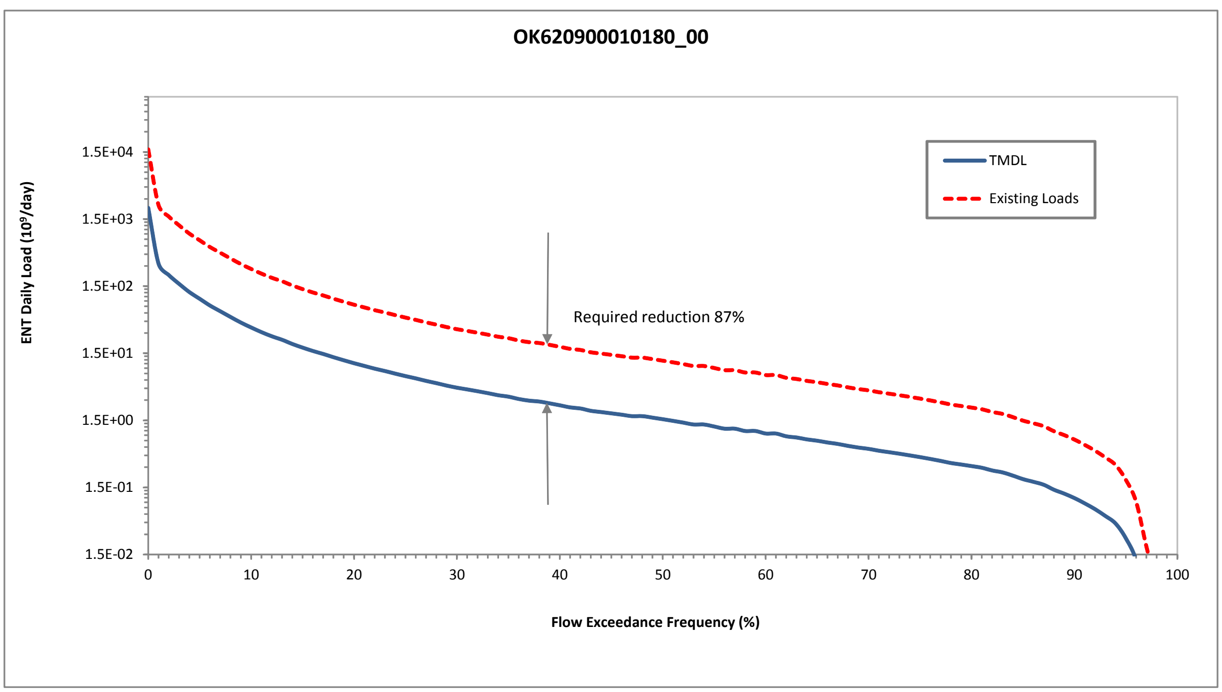


Figure 5-40 Load Duration Curve for Enterococci in Lagoon Creek (OK620900010180_00)



5.3.2 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*) 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 1998 to 2011 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.

Figures 5-41 through Figure 5-47 show the TSS LDCs developed for the waterbodies addressed in this TMDL report. Data in the figures indicate that for most waterbodies, 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 5-41 Load Duration Curve for Total Suspended Solids in West Beaver Creek (OK620900030260_00)

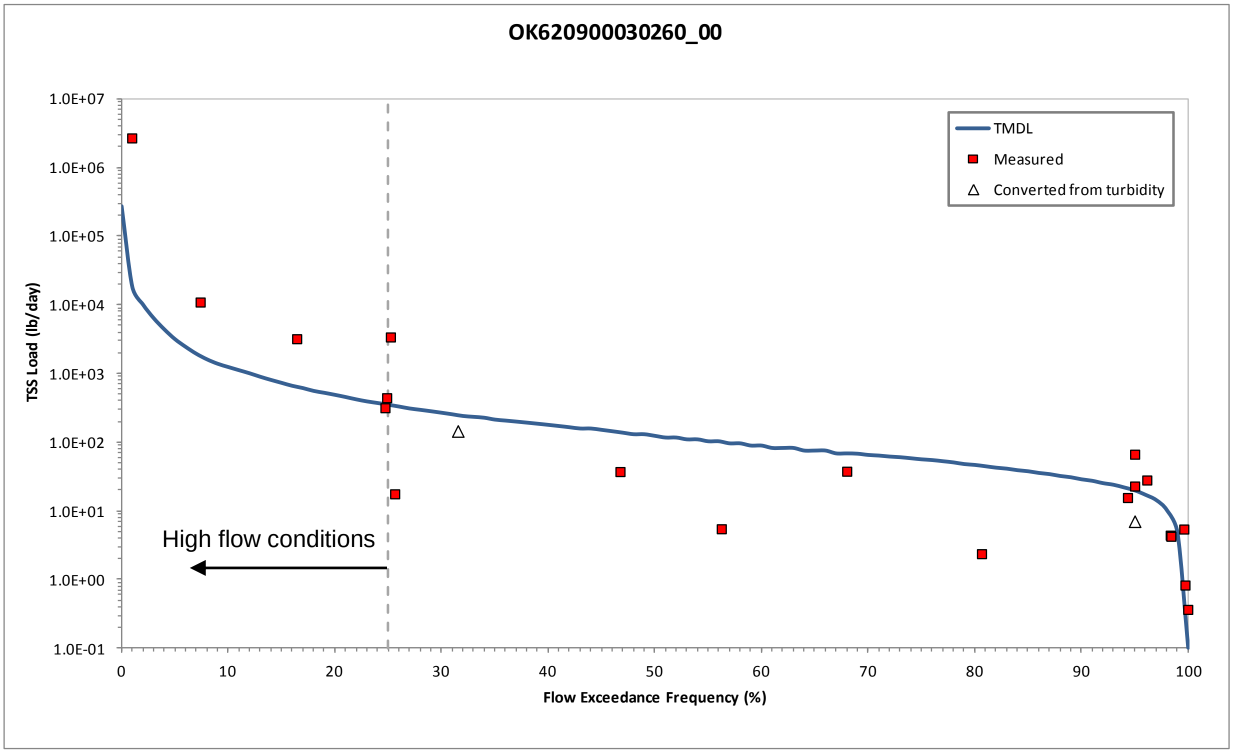


Figure 5-42 Load Duration Curve for Total Suspended Solids in Beaver Creek (OK620900030230_00)

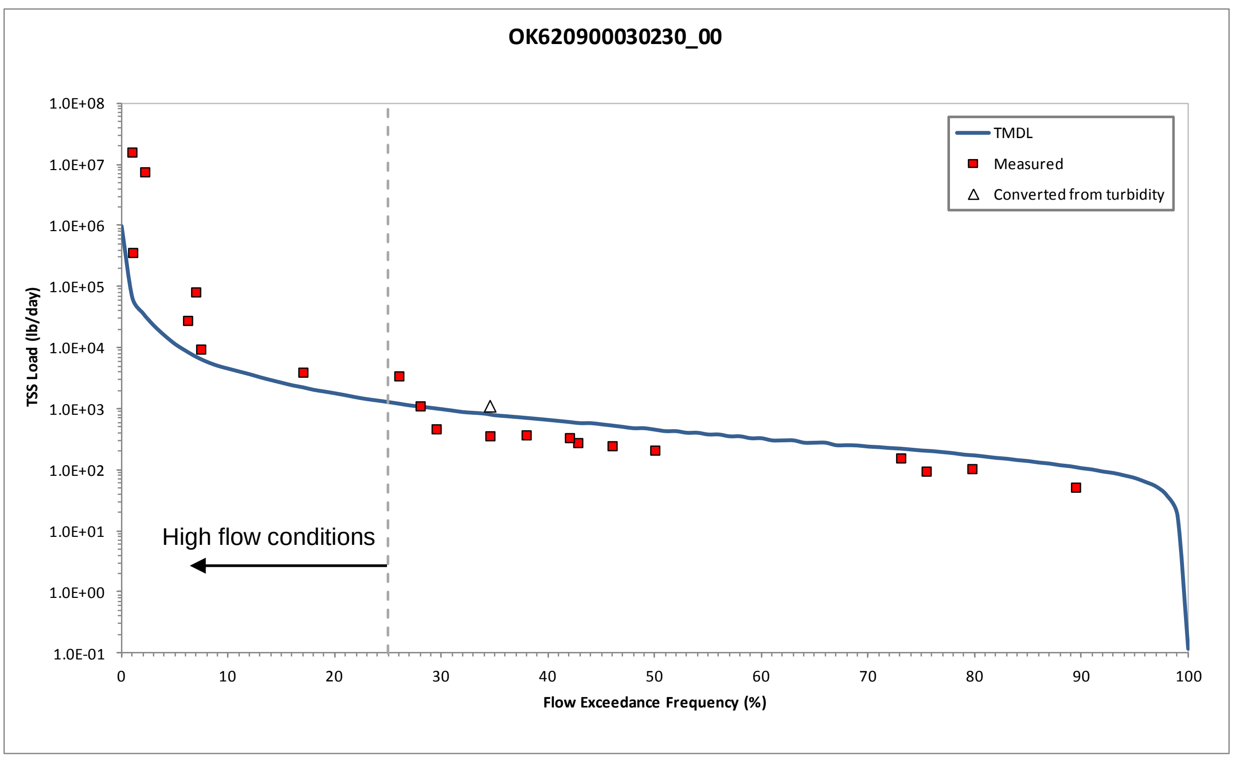


Figure 5-43 Load Duration Curve for Total Suspended Solids in Cimarron River (OK620900030010_00)

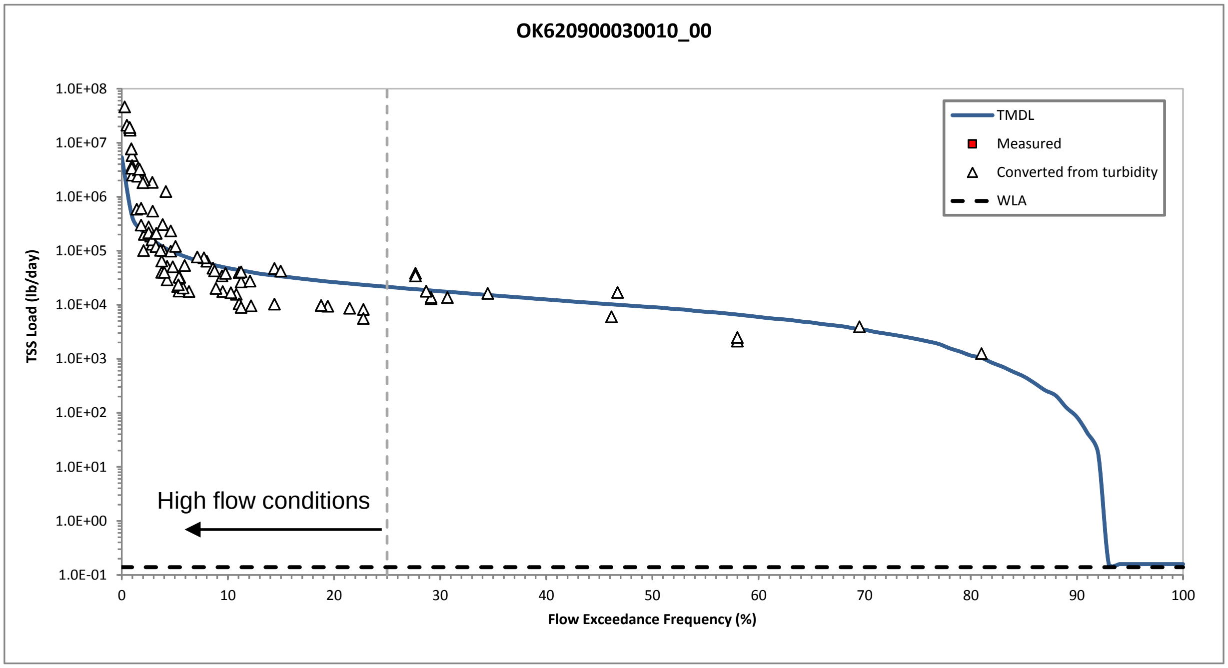


Figure 5-44 Load Duration Curve for Total Suspended Solids in Stillwater Creek (OK620900040040_00)

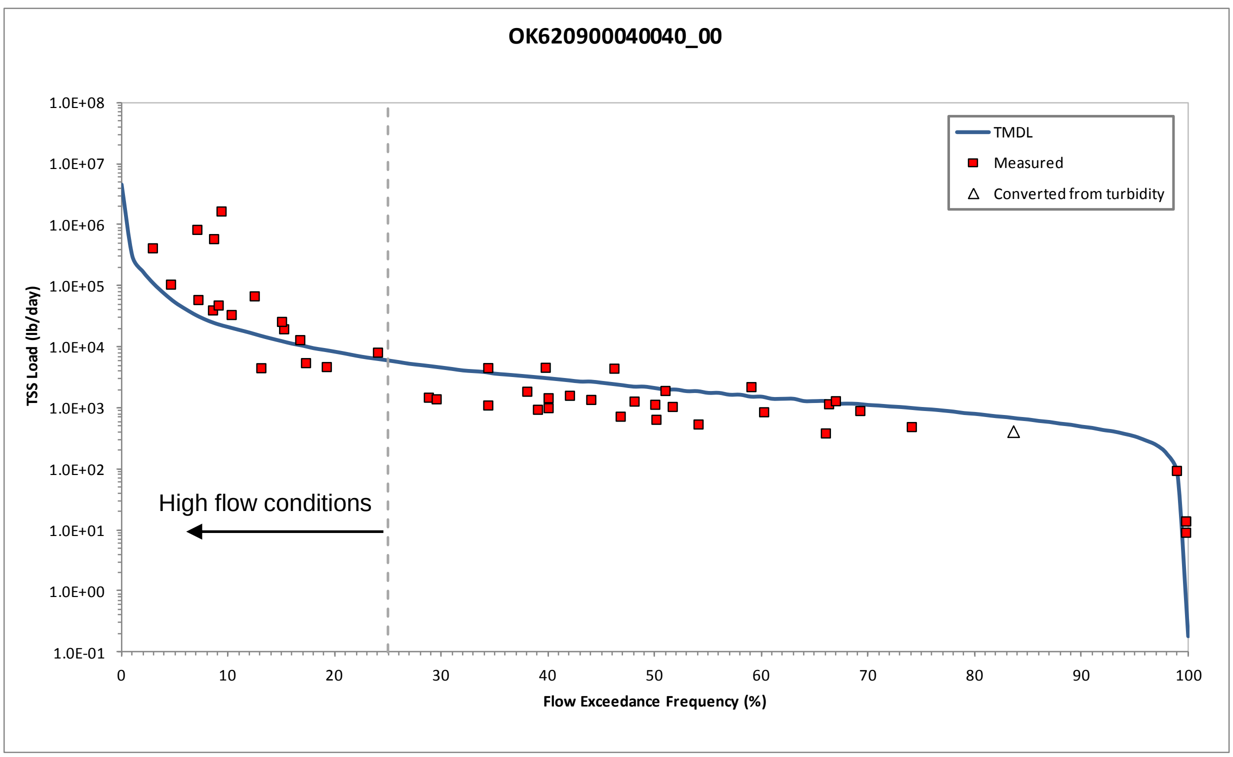


Figure 5-45 Load Duration Curve for Total Suspended Solids in Council Creek (OK620900020050_00)

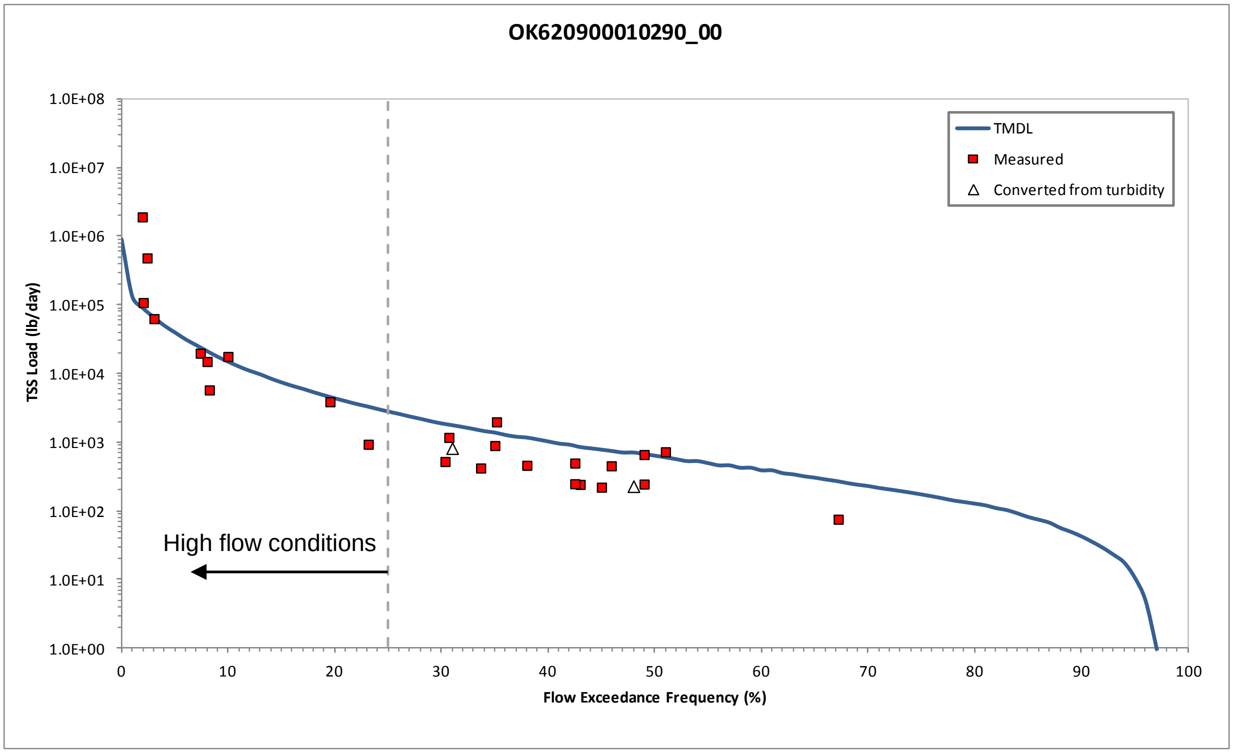


Figure 5-46 Load Duration Curve for Total Suspended Solids in Euchee Creek (OK620900010290_00)

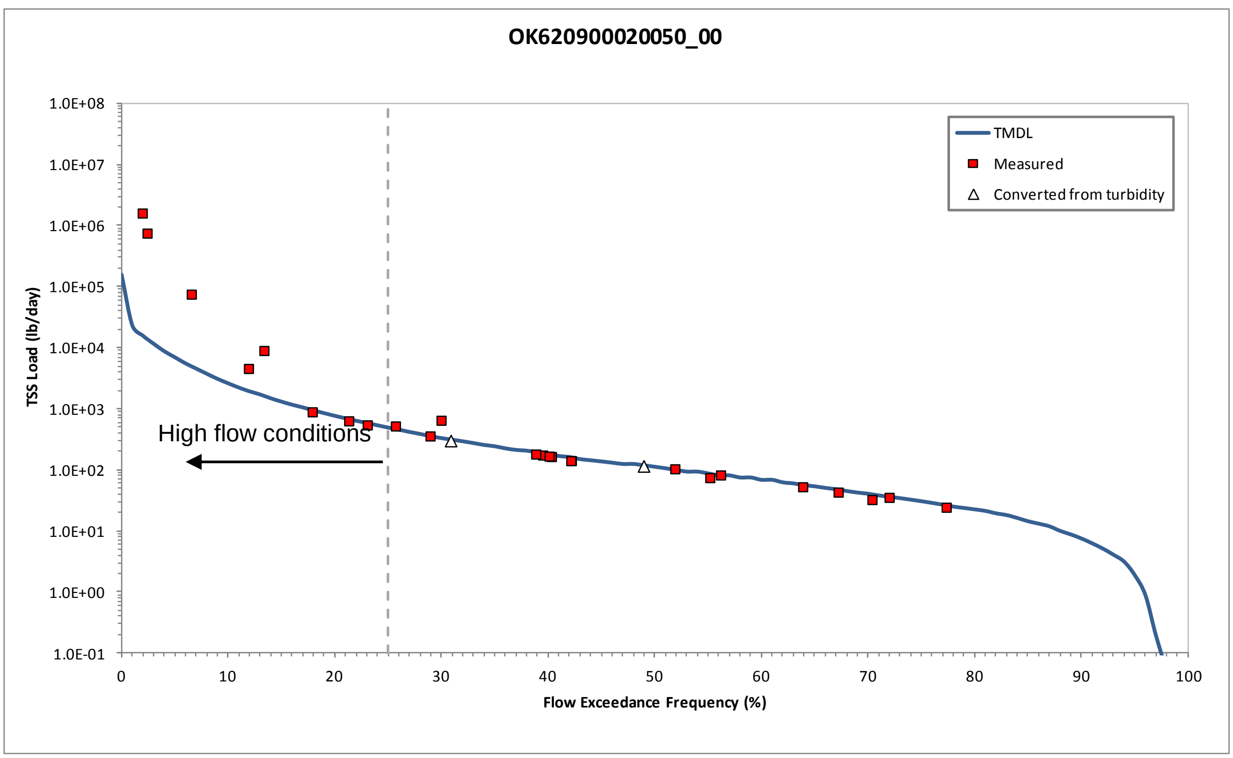
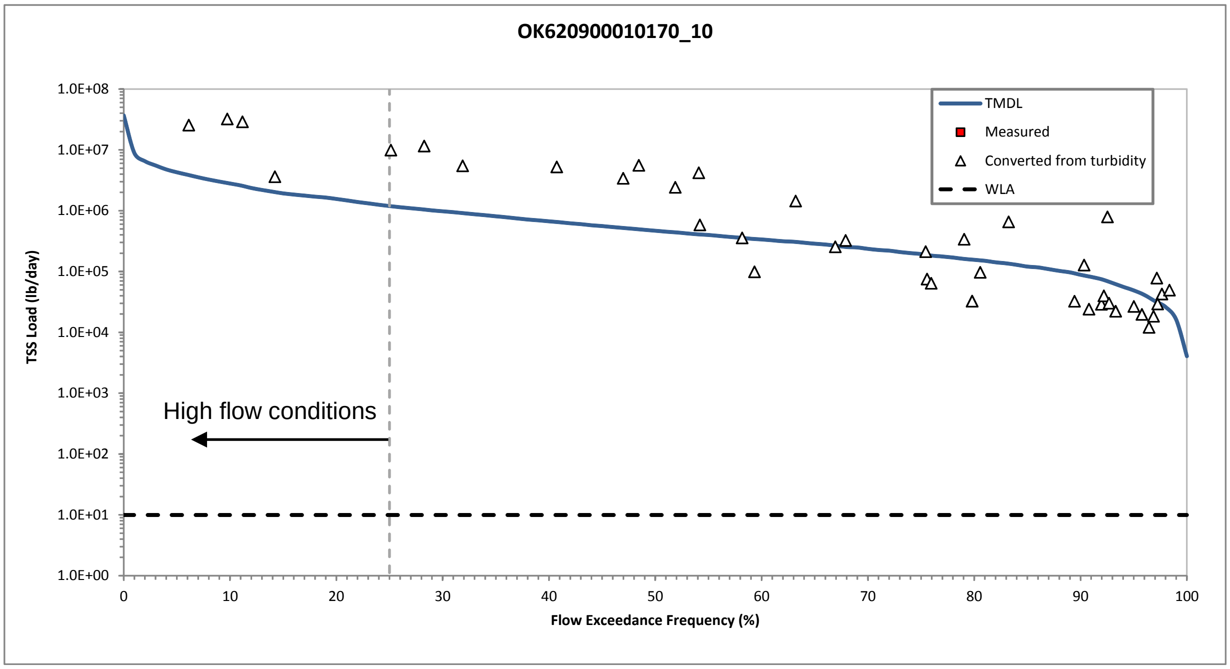


Figure 5-47 Load Duration Curve for Total Suspended Solids in Cimarron River (OK620900010170_10)



5.3.3 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 can also be calculated under different flow conditions. The difference between existing loading and the TMDL is used to calculate the loading reductions required. PRGs are calculated through an iterative process of taking a series of percent reduction values, applying each value uniformly to the concentrations of samples and verifying if the geometric mean of the reduced values of all samples is less than the WQS geometric mean. Table 5-2 represents the percent reductions necessary to meet the TMDL water quality target for each bacterial indicator in each of the impaired waterbodies in the Study Area. The PRGs range from 15% to 95%.

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

Waterbody ID	Waterbody Name	Required Reduction Rate	
		EC	ENT
OK620910030040_00	Otter Creek	18%	86%
OK620900030230_00	Beaver Creek	15%	80%
OK620910040140_00	Bluff Creek		93%
OK620900030010_00	Cimarron River		58%
OK620900030080_00	Dugout Creek	69%	93%
OK620900040040_00	Stillwater Creek	33%	85%
OK620900020050_00	Council Creek	51%	93%
OK620900020020_00	Salt Creek	39%	86%
OK620900010310_00	Cottonwood Creek	59%	95%
OK620900010290_00	Euchee Creek	53%	87%
OK620900010170_10	Cimarron River		75%
OK620900010180_00	Lagoon Creek	25%	87%

PRGs for TSS are calculated as the required overall reduction so that no more than 10% of the samples exceed the water quality target for TSS. The PRGs for the seven waterbodies included in this TMDL report are summarized in Table 5-3 and range from 10% to 92%.

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

Waterbody ID	Waterbody Name	Required Reduction Rate
OK620900030260_00	West Beaver Creek	71%
OK620900030230_00	Beaver Creek	29%
OK620900030010_00	Cimarron River	44%

Waterbody ID	Waterbody Name	Required Reduction Rate
OK620900040040_00	Stillwater Creek	20%
OK620900020050_00	Council Creek	10%
OK620900010290_00	Euchee Creek	17%
OK620900010170_10	Cimarron River	92%

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 Cimarron River Study Area. The WLA for each facility discharging to a bacteria-impaired waterbody is derived from the following equation:

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

<u>Where:</u>

WQS = 33 and 126 cfu/100 mL for Enterococci and E. coli respectively

flow (mgd) = permitted flow

unit conversion factor = 37,854,120

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 stream segment, then the WLA is zero. Compliance with the WLA will be achieved by adhering to the fecal coliform or *E. coli* limits and disinfection requirements of NPDES permits. Currently, facilities that discharge treated wastewater are required to monitor for fecal coliform. These discharges or any other discharges with a bacterial WLA will be required to monitor for *E. coli* as their permits are renewed.

Table 5-4 indicates which point source dischargers within the Study Area 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 5-4 Bacteria Wasteload Allocations for NPDES-Permitted Facilities

Waterbody ID & Waterbody Name	NPDES Permit No.	Name	Disin-fection?	Design Flow (mg/d)	EC Wasteload Allocation (cfu/day)	ENT Wasteload Allocation (cfu/day)
OK620910030040_00 Otter Creek	OK0022713	Covington Utilities Authority	No	0.075	3.58E+08	9.37E+07
OK620910040140_00 Bluff Creek	OK0026077	Bethany/Warr Acres PWA – Bluff WWTP	Yes	5	-	6.25E+09
OK620900030010_00 Cimarron River	OK0027511	Langston PWA WWTP	Yes	0.4	-	5.00E+08
	OK0028801	City of Perkins WWTP	Yes	0.29	-	3.62E+08
	OKG580029	Tryon Utility Authority WWTP	No	0.061	-	7.62E+07
OK620900010310_00 Cottonwood Creek	OK0026701	City of Cushing WWTP	Yes	1.6	7.63E+09	2.00E+09
OK620900010170_10 Cimarron River	OK0022501	Drumright Utilities Trust	Yes	0.68	-	8.49E+08
	OK0035599	Oilton Public Works Authority	Yes	0.123	-	1.54E+08

[a] Average self-reported flow

Permitted stormwater discharges are considered point sources. Bacteria WLAs for NPDES-regulated stormwater will be necessary for the two NPDES MS4 permits, The Village and Oklahoma City, in the Bluff Creek (OK620910040140_00) watershed.

WLA_{MS4}= (TMDL-MOS-WLA)*% watershed covered by MS4

<u>Where:</u> TMDL = total maximum daily load at a given flow, as calculated using LDCs

MOS = explicit margin of safety (10% for this study)

WLA = waste load allocation for permitted WWTPs as defined previously

The WLA_{MS4} for The Village and Oklahoma City was therefore derived from the percentage of Bluff Creek watershed covered by the MS4 permits. There are no MS4 permits in the other 12 watersheds within the Study Area, so the WLA_{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.

Table 5-5 summarizes the WLA for the NPDES-permitted facilities within the Cimarron River Study Area. The WLA for each facility is derived as follows:

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

<u>Where:</u>

WQ goal = waterbody-specific water quality goal as summarized in Table5-1, or monthlyTSS limit in the current permit, whichever is smaller

flow (mgd) = average monthly flow

unit conversion factor = 8.3445

Table 5-5 Total Suspended Solids Wasteload Allocations for NPDES-Permitted Facilities

Waterbody ID & Waterbody Name	NPDES Permit No.	Name	Average Monthly Flow (mgd)	Effluent TSS Target (mg/L)[a]	Wasteload Allocation (lb/day)
OK620900030010_00 Cimarron River	OKG11T203	Okmulgee Ready Mix Concrete Co	0.00048[b]	34.6	0.1
OK620900010170_10 Cimarron River	OKR051039[c]	Oilton Sand Pit	0.01[d]	34.6	2.9
	OK0044598	Greenfield Environmental Multistate Trust LLC	0.01[d]	34.6	2.9
	OK0038318	City of Drumright	0.01[d]	20	1.7
	OK0043320	Greenfield Environmental Multistate	0.01[d]	30	2.5

[a] Lower of instream TSS criteria and effluent limit for TSS (if any).
[b] Average of self-reported flows (when discharging). Facility changed to total retention.
[c] Multi-sector General Permit completed May 2012 with the filing of a Notice of Termination.
[d] Flow was assumed equal to 0.01 MGD for allocation purposes.

No TSS WLAs are needed for MS4s 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% of TSS loading is reserved as part of the WLA.

5.4.3 Section 404 permits

No TSS WLAs were set aside for Section 404 permits. The state will use its Section 401 Certification authority to ensure Section 404 Permits protect Oklahoma WQS and comply with

TSS TMDLs in this report. Section 401 Certification will be conditioned to meet one of the following two conditions to be certified by the State:

- Include TSS limits in the permit and establish a monitoring requirement to ensure compliance with turbidity standards and TSS TMDLs; or
- Submit to the DEQ a BMP turbidity reduction plan which should include all practicable turbidity control techniques. The turbidity reduction plan must be approved first before a Section 401 Certification can be issued.

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:

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

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

$$\mathbf{LA = TMDL - WLA_{WWTP} - WLA_{MS4} - WLA_{growth} - MOS}$$

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 adheres 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 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. EPA guidance allows for use of implicit or explicit expressions of the MOS, or both. When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a specific percentage of the TMDL is set aside to account for the lack of knowledge, then the MOS is considered explicit.

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

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 MOS. The selection of MOS is based on the NRMSE for each waterbody. The explicit MOS ranges from 10% to 15%. Table 5-6 shows the MOS for each waterbody.

Table 5-6 Explicit Margin of Safety for Total Suspended Solids TMDLs

Waterbody ID	Waterbody Name	NRMSE	Margin of Safety
OK620900030260_00	West Beaver Creek	20.1%	25%
OK620900030230_00	Beaver Creek	15.9%	20%
OK620900030010_00	Cimarron River	13.6%	15%
OK620900040040_00	Stillwater Creek	8.7%	10%
OK620900020050_00	Council Creek	1.3%	5%
OK620900010290_00	Euchee Creek	8.1%	10%
OK620900010170_10	Cimarron River	13.6%	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 pollutant loading and water quality.

This definition can be expressed by the following equation:

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

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

The TMDL, WLA, LA, and MOS will vary with flow condition, and are calculated at every 5^{th} flow interval percentile. Tables 5-7 through 5-27 summarize the allocations for indicator bacteria. The bacteria TMDLs calculated in these tables apply to the recreation season (May 1 through September 30) only. Tables 5-28 to 5-34 present the allocations for total suspended solids.

Table 5-7 *E. coli* TMDL Calculations for Otter Creek (OK620910030040_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	11,821	3.64E+13	3.58E+08	0	3.28E+13	3.64E+12
5	138	4.26E+11	3.58E+08	0	3.83E+11	4.26E+10
10	54.3	1.67E+11	3.58E+08	0	1.50E+11	1.67E+10
15	32.0	9.85E+10	3.58E+08	0	8.83E+10	9.85E+09
20	21.4	6.60E+10	3.58E+08	0	5.90E+10	6.60E+09
25	15.4	4.74E+10	3.58E+08	0	4.23E+10	4.74E+09
30	11.8	3.63E+10	3.58E+08	0	3.23E+10	3.63E+09
35	9.3	2.88E+10	3.58E+08	0	2.56E+10	2.88E+09
40	7.8	2.42E+10	3.58E+08	0	2.14E+10	2.42E+09
45	6.6	2.05E+10	3.58E+08	0	1.80E+10	2.05E+09
50	5.4	1.67E+10	3.58E+08	0	1.47E+10	1.67E+09
55	4.5	1.39E+10	3.58E+08	0	1.22E+10	1.39E+09
60	3.9	1.21E+10	3.58E+08	0	1.05E+10	1.21E+09
65	3.3	1.02E+10	3.58E+08	0	8.85E+09	1.02E+09
70	2.9	8.83E+09	3.58E+08	0	7.59E+09	8.83E+08
75	2.5	7.62E+09	3.58E+08	0	6.50E+09	7.62E+08
80	2.1	6.32E+09	3.58E+08	0	5.33E+09	6.32E+08
85	1.7	5.11E+09	3.58E+08	0	4.24E+09	5.11E+08
90	1.3	3.90E+09	3.58E+08	0	3.16E+09	3.90E+08
95	0.9	2.70E+09	3.58E+08	0	2.07E+09	2.70E+08
100	0.1	4.01E+08	3.58E+08	0	2.99E+06	4.01E+07

Table 5-8 Enterococci TMDL Calculations for Otter Creek (OK620910030040_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	11,821	9.54E+12	9.37E+07	0	8.59E+12	9.54E+11
5	138	1.12E+11	9.37E+07	0	1.00E+11	1.12E+10
10	54.3	4.38E+10	9.37E+07	0	3.93E+10	4.38E+09
15	32.0	2.58E+10	9.37E+07	0	2.31E+10	2.58E+09
20	21.4	1.73E+10	9.37E+07	0	1.55E+10	1.73E+09
25	15.4	1.24E+10	9.37E+07	0	1.11E+10	1.24E+09
30	11.8	9.50E+09	9.37E+07	0	8.45E+09	9.50E+08
35	9.3	7.55E+09	9.37E+07	0	6.70E+09	7.55E+08
40	7.8	6.33E+09	9.37E+07	0	5.60E+09	6.33E+08
45	6.6	5.36E+09	9.37E+07	0	4.73E+09	5.36E+08
50	5.4	4.38E+09	9.37E+07	0	3.85E+09	4.38E+08
55	4.5	3.65E+09	9.37E+07	0	3.19E+09	3.65E+08
60	3.9	3.17E+09	9.37E+07	0	2.76E+09	3.17E+08
65	3.3	2.68E+09	9.37E+07	0	2.32E+09	2.68E+08
70	2.9	2.31E+09	9.37E+07	0	1.99E+09	2.31E+08
75	2.5	2.00E+09	9.37E+07	0	1.70E+09	2.00E+08
80	2.1	1.66E+09	9.37E+07	0	1.40E+09	1.66E+08
85	1.7	1.34E+09	9.37E+07	0	1.11E+09	1.34E+08
90	1.3	1.02E+09	9.37E+07	0	8.27E+08	1.02E+08
95	0.9	7.06E+08	9.37E+07	0	5.42E+08	7.06E+07
100	0.1	1.05E+08	9.37E+07	0	7.84E+05	1.05E+07

Table 5-9 *E. coli* TMDL Calculations for Beaver Creek (OK620900030230_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	8,536	2.63E+13	0	0	2.37E+13	2.63E+12
5	100	3.07E+11	0	0	2.77E+11	3.07E+10
10	39.2	1.21E+11	0	0	1.09E+11	1.21E+10
15	23.1	7.12E+10	0	0	6.40E+10	7.12E+09
20	15.5	4.77E+10	0	0	4.29E+10	4.77E+09
25	11.1	3.42E+10	0	0	3.08E+10	3.42E+09
30	8.5	2.62E+10	0	0	2.36E+10	2.62E+09
35	6.8	2.08E+10	0	0	1.87E+10	2.08E+09
40	5.7	1.75E+10	0	0	1.57E+10	1.75E+09
45	4.8	1.48E+10	0	0	1.33E+10	1.48E+09
50	3.9	1.21E+10	0	0	1.09E+10	1.21E+09
55	3.3	1.01E+10	0	0	9.06E+09	1.01E+09
60	2.8	8.73E+09	0	0	7.85E+09	8.73E+08
65	2.4	7.38E+09	0	0	6.65E+09	7.38E+08
70	2.1	6.38E+09	0	0	5.74E+09	6.38E+08
75	1.8	5.50E+09	0	0	4.95E+09	5.50E+08
80	1.5	4.56E+09	0	0	4.11E+09	4.56E+08
85	1.2	3.69E+09	0	0	3.32E+09	3.69E+08
90	0.9	2.82E+09	0	0	2.54E+09	2.82E+08
95	0.6	1.95E+09	0	0	1.75E+09	1.95E+08
100	0.0	3.08E+06	0	0	2.77E+06	3.08E+05

Table 5-10 Enterococci TMDL Calculations for Beaver Creek (OK620900030230_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	8,536	6.89E+12	0	0	6.20E+12	6.89E+11
5	100	8.05E+10	0	0	7.25E+10	8.05E+09
10	39.2	3.16E+10	0	0	2.85E+10	3.16E+09
15	23.1	1.86E+10	0	0	1.68E+10	1.86E+09
20	15.5	1.25E+10	0	0	1.12E+10	1.25E+09
25	11.1	8.97E+09	0	0	8.07E+09	8.97E+08
30	8.5	6.86E+09	0	0	6.17E+09	6.86E+08
35	6.8	5.45E+09	0	0	4.90E+09	5.45E+08
40	5.7	4.57E+09	0	0	4.11E+09	4.57E+08
45	4.8	3.87E+09	0	0	3.48E+09	3.87E+08
50	3.9	3.16E+09	0	0	2.85E+09	3.16E+08
55	3.3	2.64E+09	0	0	2.37E+09	2.64E+08
60	2.8	2.29E+09	0	0	2.06E+09	2.29E+08
65	2.4	1.93E+09	0	0	1.74E+09	1.93E+08
70	2.1	1.67E+09	0	0	1.50E+09	1.67E+08
75	1.8	1.44E+09	0	0	1.30E+09	1.44E+08
80	1.5	1.20E+09	0	0	1.08E+09	1.20E+08
85	1.2	9.67E+08	0	0	8.70E+08	9.67E+07
90	0.9	7.38E+08	0	0	6.65E+08	7.38E+07
95	0.6	5.10E+08	0	0	4.59E+08	5.10E+07
100	0.0	8.07E+05	0	0	7.27E+05	8.07E+04

Table 5-11 Enterococci TMDL Calculations for Bluff Creek (OK620910040140_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	3,317	2.68E+12	6.25E+09	7.77E+11	1.81E+12	8.03E+10
5	39	3.13E+10	6.25E+09	7.23E+09	1.69E+10	9.39E+08
10	15	1.23E+10	6.25E+09	1.70E+09	3.98E+09	3.69E+08
15	9	7.24E+09	6.25E+09	2.34E+08	5.45E+08	2.17E+08
20	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
25	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
30	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
35	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
40	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
45	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
50	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
55	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
60	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
65	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
70	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
75	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
80	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
85	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
90	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
95	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08
100	8.1	6.56E+09	6.25E+09	3.48E+07	8.11E+07	1.97E+08

Table 5-12 Enterococci TMDL Calculations for Cimarron River (OK620900030010_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	34,071	2.75E+13	9.38E+08	0	2.48E+13	2.75E+12
5	584	4.71E+11	9.38E+08	0	4.23E+11	4.71E+10
10	302	2.44E+11	9.38E+08	0	2.18E+11	2.44E+10
15	213	1.72E+11	9.38E+08	0	1.54E+11	1.72E+10
20	166	1.34E+11	9.38E+08	0	1.19E+11	1.34E+10
25	136	1.10E+11	9.38E+08	0	9.79E+10	1.10E+10
30	112	9.06E+10	9.38E+08	0	8.06E+10	9.06E+09
35	94	7.62E+10	9.38E+08	0	6.77E+10	7.62E+09
40	79	6.40E+10	9.38E+08	0	5.66E+10	6.40E+09
45	67	5.38E+10	9.38E+08	0	4.75E+10	5.38E+09
50	57	4.62E+10	9.38E+08	0	4.06E+10	4.62E+09
55	47	3.79E+10	9.38E+08	0	3.31E+10	3.79E+09
60	38	3.04E+10	9.38E+08	0	2.64E+10	3.04E+09
65	30	2.40E+10	9.38E+08	0	2.07E+10	2.40E+09
70	22	1.76E+10	9.38E+08	0	1.49E+10	1.76E+09
75	15	1.17E+10	9.38E+08	0	9.62E+09	1.17E+09
80	7	5.86E+09	9.38E+08	0	4.34E+09	5.86E+08
85	3	2.40E+09	9.38E+08	0	1.22E+09	2.40E+08
90	1	1.05E+09	9.38E+08	0	6.59E+06	1.05E+08
95	1	1.05E+09	9.38E+08	0	6.59E+06	1.05E+08
100	1	1.05E+09	9.38E+08	0	6.59E+06	1.05E+08

Table 5-13 *E. coli* TMDL Calculations for Dugout Creek (OK620900030080_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	3,131	9.65E+12	0	0	8.69E+12	9.65E+11
5	37	1.13E+11	0	0	1.01E+11	1.13E+10
10	14.4	4.43E+10	0	0	3.99E+10	4.43E+09
15	8.5	2.61E+10	0	0	2.35E+10	2.61E+09
20	5.7	1.75E+10	0	0	1.57E+10	1.75E+09
25	4.1	1.26E+10	0	0	1.13E+10	1.26E+09
30	3.1	9.60E+09	0	0	8.64E+09	9.60E+08
35	2.5	7.63E+09	0	0	6.87E+09	7.63E+08
40	2.1	6.40E+09	0	0	5.76E+09	6.40E+08
45	1.8	5.42E+09	0	0	4.87E+09	5.42E+08
50	1.4	4.43E+09	0	0	3.99E+09	4.43E+08
55	1.2	3.69E+09	0	0	3.32E+09	3.69E+08
60	1.0	3.20E+09	0	0	2.88E+09	3.20E+08
65	0.9	2.71E+09	0	0	2.44E+09	2.71E+08
70	0.8	2.34E+09	0	0	2.10E+09	2.34E+08
75	0.7	2.02E+09	0	0	1.82E+09	2.02E+08
80	0.5	1.67E+09	0	0	1.51E+09	1.67E+08
85	0.4	1.35E+09	0	0	1.22E+09	1.35E+08
90	0.3	1.03E+09	0	0	9.31E+08	1.03E+08
95	0.2	7.14E+08	0	0	6.43E+08	7.14E+07
100	0.0	3.08E+06	0	0	2.77E+06	3.08E+05

Table 5-14 Enterococci TMDL Calculations for Dugout Creek (OK620900030080_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	3,131	2.53E+12	0	0	2.27E+12	2.53E+11
5	37	2.95E+10	0	0	2.66E+10	2.95E+09
10	14.4	1.16E+10	0	0	1.04E+10	1.16E+09
15	8.5	6.83E+09	0	0	6.15E+09	6.83E+08
20	5.7	4.58E+09	0	0	4.12E+09	4.58E+08
25	4.1	3.29E+09	0	0	2.96E+09	3.29E+08
30	3.1	2.51E+09	0	0	2.26E+09	2.51E+08
35	2.5	2.00E+09	0	0	1.80E+09	2.00E+08
40	2.1	1.68E+09	0	0	1.51E+09	1.68E+08
45	1.8	1.42E+09	0	0	1.28E+09	1.42E+08
50	1.4	1.16E+09	0	0	1.04E+09	1.16E+08
55	1.2	9.67E+08	0	0	8.70E+08	9.67E+07
60	1.0	8.38E+08	0	0	7.54E+08	8.38E+07
65	0.9	7.09E+08	0	0	6.38E+08	7.09E+07
70	0.8	6.13E+08	0	0	5.51E+08	6.13E+07
75	0.7	5.29E+08	0	0	4.76E+08	5.29E+07
80	0.5	4.38E+08	0	0	3.95E+08	4.38E+07
85	0.4	3.55E+08	0	0	3.19E+08	3.55E+07
90	0.3	2.71E+08	0	0	2.44E+08	2.71E+07
95	0.2	1.87E+08	0	0	1.68E+08	1.87E+07
100	0.0	8.07E+05	0	0	7.27E+05	8.07E+04

Table 5-15 *E. coli* TMDL Calculations for Stillwater Creek (OK620900040040_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	25,591	7.89E+13	0	0	7.10E+13	7.89E+12
5	299	9.22E+11	0	0	8.30E+11	9.22E+10
10	117.5	3.62E+11	0	0	3.26E+11	3.62E+10
15	69.2	2.13E+11	0	0	1.92E+11	2.13E+10
20	46.4	1.43E+11	0	0	1.29E+11	1.43E+10
25	33.3	1.03E+11	0	0	9.24E+10	1.03E+10
30	25.5	7.85E+10	0	0	7.06E+10	7.85E+09
35	20.2	6.24E+10	0	0	5.61E+10	6.24E+09
40	17.0	5.23E+10	0	0	4.71E+10	5.23E+09
45	14.4	4.43E+10	0	0	3.98E+10	4.43E+09
50	11.8	3.62E+10	0	0	3.26E+10	3.62E+09
55	9.8	3.02E+10	0	0	2.72E+10	3.02E+09
60	8.5	2.62E+10	0	0	2.35E+10	2.62E+09
65	7.2	2.21E+10	0	0	1.99E+10	2.21E+09
70	6.2	1.91E+10	0	0	1.72E+10	1.91E+09
75	5.4	1.65E+10	0	0	1.49E+10	1.65E+09
80	4.4	1.37E+10	0	0	1.23E+10	1.37E+09
85	3.6	1.11E+10	0	0	9.96E+09	1.11E+09
90	2.7	8.45E+09	0	0	7.61E+09	8.45E+08
95	1.9	5.84E+09	0	0	5.25E+09	5.84E+08
100	0.0	3.08E+06	0	0	2.77E+06	3.08E+05

Table 5-16 Enterococci TMDL Calculations for Stillwater Creek (OK620900040040_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	25,591	2.07E+13	0	0	1.86E+13	2.07E+12
5	299	2.41E+11	0	0	2.17E+11	2.41E+10
10	117.5	9.49E+10	0	0	8.54E+10	9.49E+09
15	69.2	5.59E+10	0	0	5.03E+10	5.59E+09
20	46.4	3.74E+10	0	0	3.37E+10	3.74E+09
25	33.3	2.69E+10	0	0	2.42E+10	2.69E+09
30	25.5	2.06E+10	0	0	1.85E+10	2.06E+09
35	20.2	1.63E+10	0	0	1.47E+10	1.63E+09
40	17.0	1.37E+10	0	0	1.23E+10	1.37E+09
45	14.4	1.16E+10	0	0	1.04E+10	1.16E+09
50	11.8	9.49E+09	0	0	8.54E+09	9.49E+08
55	9.8	7.91E+09	0	0	7.12E+09	7.91E+08
60	8.5	6.85E+09	0	0	6.17E+09	6.85E+08
65	7.2	5.80E+09	0	0	5.22E+09	5.80E+08
70	6.2	5.01E+09	0	0	4.51E+09	5.01E+08
75	5.4	4.32E+09	0	0	3.89E+09	4.32E+08
80	4.4	3.58E+09	0	0	3.23E+09	3.58E+08
85	3.6	2.90E+09	0	0	2.61E+09	2.90E+08
90	2.7	2.21E+09	0	0	1.99E+09	2.21E+08
95	1.9	1.53E+09	0	0	1.38E+09	1.53E+08
100	0.0	8.07E+05	0	0	7.27E+05	8.07E+04

Table 5-17 *E. coli* TMDL Calculations for Council Creek (OK620900020050_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	2,739	8.44E+12	0	0	7.60E+12	8.44E+11
5	121	3.72E+11	0	0	3.35E+11	3.72E+10
10	45.2	1.39E+11	0	0	1.25E+11	1.39E+10
15	22.6	6.98E+10	0	0	6.28E+10	6.98E+09
20	13.3	4.09E+10	0	0	3.68E+10	4.09E+09
25	8.5	2.63E+10	0	0	2.36E+10	2.63E+09
30	5.7	1.76E+10	0	0	1.59E+10	1.76E+09
35	4.2	1.30E+10	0	0	1.17E+10	1.30E+09
40	3.1	9.64E+09	0	0	8.68E+09	9.64E+08
45	2.4	7.31E+09	0	0	6.58E+09	7.31E+08
50	1.9	5.98E+09	0	0	5.39E+09	5.98E+08
55	1.5	4.65E+09	0	0	4.19E+09	4.65E+08
60	1.2	3.66E+09	0	0	3.29E+09	3.66E+08
65	0.9	2.86E+09	0	0	2.57E+09	2.86E+08
70	0.7	2.16E+09	0	0	1.94E+09	2.16E+08
75	0.5	1.63E+09	0	0	1.47E+09	1.63E+08
80	0.4	1.20E+09	0	0	1.08E+09	1.20E+08
85	0.2	7.65E+08	0	0	6.88E+08	7.65E+07
90	0.1	3.99E+08	0	0	3.59E+08	3.99E+07
95	0.0	9.97E+07	0	0	8.98E+07	9.97E+06
100	0.0	3.08E+06	0	0	2.77E+06	3.08E+05

Table 5-18 Enterococci TMDL Calculations for Council Creek (OK620900020050_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	2,739	2.21E+12	0	0	1.99E+12	2.21E+11
5	121	9.75E+10	0	0	8.78E+10	9.75E+09
10	45.2	3.65E+10	0	0	3.28E+10	3.65E+09
15	22.6	1.83E+10	0	0	1.65E+10	1.83E+09
20	13.3	1.07E+10	0	0	9.64E+09	1.07E+09
25	8.5	6.88E+09	0	0	6.19E+09	6.88E+08
30	5.7	4.61E+09	0	0	4.15E+09	4.61E+08
35	4.2	3.40E+09	0	0	3.06E+09	3.40E+08
40	3.1	2.52E+09	0	0	2.27E+09	2.52E+08
45	2.4	1.92E+09	0	0	1.72E+09	1.92E+08
50	1.9	1.57E+09	0	0	1.41E+09	1.57E+08
55	1.5	1.22E+09	0	0	1.10E+09	1.22E+08
60	1.2	9.58E+08	0	0	8.62E+08	9.58E+07
65	0.9	7.49E+08	0	0	6.74E+08	7.49E+07
70	0.7	5.66E+08	0	0	5.09E+08	5.66E+07
75	0.5	4.27E+08	0	0	3.84E+08	4.27E+07
80	0.4	3.13E+08	0	0	2.82E+08	3.13E+07
85	0.2	2.00E+08	0	0	1.80E+08	2.00E+07
90	0.1	1.04E+08	0	0	9.40E+07	1.04E+07
95	0.0	2.61E+07	0	0	2.35E+07	2.61E+06
100	0.0	8.07E+05	0	0	7.27E+05	8.07E+04

Table 5-19 *E. coli* TMDL Calculations for Salt Creek (OK620900020020_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	2,183	6.73E+12	0	0	6.06E+12	6.73E+11
5	96	2.97E+11	0	0	2.67E+11	2.97E+10
10	36.0	1.11E+11	0	0	9.99E+10	1.11E+10
15	18.1	5.56E+10	0	0	5.01E+10	5.56E+09
20	10.6	3.26E+10	0	0	2.93E+10	3.26E+09
25	6.8	2.09E+10	0	0	1.88E+10	2.09E+09
30	4.6	1.40E+10	0	0	1.26E+10	1.40E+09
35	3.4	1.03E+10	0	0	9.30E+09	1.03E+09
40	2.5	7.68E+09	0	0	6.92E+09	7.68E+08
45	1.9	5.83E+09	0	0	5.25E+09	5.83E+08
50	1.5	4.77E+09	0	0	4.29E+09	4.77E+08
55	1.2	3.71E+09	0	0	3.34E+09	3.71E+08
60	0.9	2.91E+09	0	0	2.62E+09	2.91E+08
65	0.7	2.28E+09	0	0	2.05E+09	2.28E+08
70	0.6	1.72E+09	0	0	1.55E+09	1.72E+08
75	0.4	1.30E+09	0	0	1.17E+09	1.30E+08
80	0.3	9.54E+08	0	0	8.58E+08	9.54E+07
85	0.2	6.09E+08	0	0	5.48E+08	6.09E+07
90	0.1	3.18E+08	0	0	2.86E+08	3.18E+07
95	0.0	7.95E+07	0	0	7.15E+07	7.95E+06
100	0.0	3.08E+06	0	0	2.77E+06	3.08E+05

Table 5-20 Enterococci TMDL Calculations for Salt Creek (OK620900020020_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	2,183	1.76E+12	0	0	1.59E+12	1.76E+11
5	96	7.77E+10	0	0	7.00E+10	7.77E+09
10	36.0	2.91E+10	0	0	2.62E+10	2.91E+09
15	18.1	1.46E+10	0	0	1.31E+10	1.46E+09
20	10.6	8.54E+09	0	0	7.68E+09	8.54E+08
25	6.8	5.48E+09	0	0	4.93E+09	5.48E+08
30	4.6	3.68E+09	0	0	3.31E+09	3.68E+08
35	3.4	2.71E+09	0	0	2.44E+09	2.71E+08
40	2.5	2.01E+09	0	0	1.81E+09	2.01E+08
45	1.9	1.53E+09	0	0	1.37E+09	1.53E+08
50	1.5	1.25E+09	0	0	1.12E+09	1.25E+08
55	1.2	9.72E+08	0	0	8.74E+08	9.72E+07
60	0.9	7.63E+08	0	0	6.87E+08	7.63E+07
65	0.7	5.97E+08	0	0	5.37E+08	5.97E+07
70	0.6	4.51E+08	0	0	4.06E+08	4.51E+07
75	0.4	3.40E+08	0	0	3.06E+08	3.40E+07
80	0.3	2.50E+08	0	0	2.25E+08	2.50E+07
85	0.2	1.60E+08	0	0	1.44E+08	1.60E+07
90	0.1	8.33E+07	0	0	7.49E+07	8.33E+06
95	0.0	2.08E+07	0	0	1.87E+07	2.08E+06
100	0.0	8.07E+05	0	0	7.27E+05	8.07E+04

Table 5-21 *E. coli* TMDL Calculations for Cottonwood Creek (OK620900010310_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	450	1.39E+12	7.63E+09	0	1.24E+12	1.39E+11
5	20	6.11E+10	7.63E+09	0	4.74E+10	6.11E+09
10	7.4	2.29E+10	7.63E+09	0	1.30E+10	2.29E+09
15	3.7	1.15E+10	7.63E+09	0	2.69E+09	1.15E+09
20	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
25	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
30	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
35	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
40	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
45	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
50	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
55	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
60	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
65	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
70	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
75	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
80	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
85	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
90	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
95	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08
100	2.8	8.51E+09	7.63E+09	0	2.68E+07	8.51E+08

Table 5-22 Enterococci TMDL Calculations for Cottonwood Creek (OK620900010310_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	450	3.63E+11	2.00E+09	0	3.25E+11	3.63E+10
5	20	1.60E+10	2.00E+09	0	1.24E+10	1.60E+09
10	7.4	5.99E+09	2.00E+09	0	3.39E+09	5.99E+08
15	3.7	3.00E+09	2.00E+09	0	7.04E+08	3.00E+08
20	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
25	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
30	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
35	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
40	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
45	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
50	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
55	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
60	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
65	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
70	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
75	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
80	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
85	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
90	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
95	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08
100	2.8	2.23E+09	2.00E+09	0	7.03E+06	2.23E+08

Table 5-23 *E. coli* TMDL Calculations for Euchee Creek (OK620900010290_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	4,717	1.45E+13	0	0	1.31E+13	1.45E+12
5	208	6.41E+11	0	0	5.77E+11	6.41E+10
10	78	2.40E+11	0	0	2.16E+11	2.40E+10
15	39	1.20E+11	0	0	1.08E+11	1.20E+10
20	23	7.04E+10	0	0	6.34E+10	7.04E+09
25	15	4.52E+10	0	0	4.07E+10	4.52E+09
30	10	3.03E+10	0	0	2.73E+10	3.03E+09
35	7	2.23E+10	0	0	2.01E+10	2.23E+09
40	5	1.66E+10	0	0	1.49E+10	1.66E+09
45	4	1.26E+10	0	0	1.13E+10	1.26E+09
50	3	1.03E+10	0	0	9.27E+09	1.03E+09
55	3	8.01E+09	0	0	7.21E+09	8.01E+08
60	2	6.30E+09	0	0	5.67E+09	6.30E+08
65	2	4.92E+09	0	0	4.43E+09	4.92E+08
70	1	3.72E+09	0	0	3.35E+09	3.72E+08
75	1	2.81E+09	0	0	2.52E+09	2.81E+08
80	1	2.06E+09	0	0	1.85E+09	2.06E+08
85	0	1.32E+09	0	0	1.19E+09	1.32E+08
90	0	6.87E+08	0	0	6.18E+08	6.87E+07
95	0	1.72E+08	0	0	1.55E+08	1.72E+07
100	0	0	0	0	0	0

Table 5-24 Enterococci TMDL Calculations for Euchee Creek (OK620900010290_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	4,717	3.81E+12	0	0	3.43E+12	3.81E+11
5	208	1.68E+11	0	0	1.51E+11	1.68E+10
10	78	6.28E+10	0	0	5.65E+10	6.28E+09
15	39	3.15E+10	0	0	2.83E+10	3.15E+09
20	23	1.84E+10	0	0	1.66E+10	1.84E+09
25	15	1.18E+10	0	0	1.07E+10	1.18E+09
30	10	7.95E+09	0	0	7.15E+09	7.95E+08
35	7	5.85E+09	0	0	5.26E+09	5.85E+08
40	5	4.35E+09	0	0	3.91E+09	4.35E+08
45	4	3.30E+09	0	0	2.97E+09	3.30E+08
50	3	2.70E+09	0	0	2.43E+09	2.70E+08
55	3	2.10E+09	0	0	1.89E+09	2.10E+08
60	2	1.65E+09	0	0	1.48E+09	1.65E+08
65	2	1.29E+09	0	0	1.16E+09	1.29E+08
70	1	9.75E+08	0	0	8.77E+08	9.75E+07
75	1	7.35E+08	0	0	6.61E+08	7.35E+07
80	1	5.40E+08	0	0	4.86E+08	5.40E+07
85	0	3.45E+08	0	0	3.10E+08	3.45E+07
90	0	1.80E+08	0	0	1.62E+08	1.80E+07
95	0	4.50E+07	0	0	4.05E+07	4.50E+06
100	0	0	0	0	0	0

Table 5-25 Enterococci TMDL Calculations for Cimarron Creek (OK620900010170_10)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	231,573	1.87E+14	1.00E+09	0	1.68E+14	1.87E+13
5	26,972	2.18E+13	1.00E+09	0	1.96E+13	2.18E+12
10	17,656	1.43E+13	1.00E+09	0	1.28E+13	1.43E+12
15	12,155	9.81E+12	1.00E+09	0	8.83E+12	9.81E+11
20	9,848	7.95E+12	1.00E+09	0	7.16E+12	7.95E+11
25	7,524	6.07E+12	1.00E+09	0	5.47E+12	6.07E+11
30	6,175	4.99E+12	1.00E+09	0	4.49E+12	4.99E+11
35	5,111	4.13E+12	1.00E+09	0	3.71E+12	4.13E+11
40	4,223	3.41E+12	1.00E+09	0	3.07E+12	3.41E+11
45	3,531	2.85E+12	1.00E+09	0	2.56E+12	2.85E+11
50	2,959	2.39E+12	1.00E+09	0	2.15E+12	2.39E+11
55	2,520	2.03E+12	1.00E+09	0	1.83E+12	2.03E+11
60	2,129	1.72E+12	1.00E+09	0	1.55E+12	1.72E+11
65	1,810	1.46E+12	1.00E+09	0	1.31E+12	1.46E+11
70	1,491	1.20E+12	1.00E+09	0	1.08E+12	1.20E+11
75	1,224	9.89E+11	1.00E+09	0	8.89E+11	9.89E+10
80	985	7.95E+11	1.00E+09	0	7.15E+11	7.95E+10
85	762	6.15E+11	1.00E+09	0	5.53E+11	6.15E+10
90	559	4.51E+11	1.00E+09	0	4.05E+11	4.51E+10
95	310	2.50E+11	1.00E+09	0	2.24E+11	2.50E+10
100	26	2.08E+10	1.00E+09	0	1.77E+10	2.08E+09

Table 5-26 *E. coli* TMDL Calculations for Lagoon Creek (OK620900010180_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	3,032	9.35E+12	0	0	8.41E+12	9.35E+11
5	134	4.12E+11	0	0	3.71E+11	4.12E+10
10	50.0	1.54E+11	0	0	1.39E+11	1.54E+10
15	25.1	7.73E+10	0	0	6.95E+10	7.73E+09
20	14.7	4.53E+10	0	0	4.07E+10	4.53E+09
25	9.4	2.91E+10	0	0	2.62E+10	2.91E+09
30	6.3	1.95E+10	0	0	1.76E+10	1.95E+09
35	4.7	1.43E+10	0	0	1.29E+10	1.43E+09
40	3.5	1.07E+10	0	0	9.60E+09	1.07E+09
45	2.6	8.09E+09	0	0	7.29E+09	8.09E+08
50	2.1	6.62E+09	0	0	5.96E+09	6.62E+08
55	1.7	5.15E+09	0	0	4.64E+09	5.15E+08
60	1.3	4.05E+09	0	0	3.64E+09	4.05E+08
65	1.0	3.16E+09	0	0	2.85E+09	3.16E+08
70	0.8	2.39E+09	0	0	2.15E+09	2.39E+08
75	0.6	1.80E+09	0	0	1.62E+09	1.80E+08
80	0.4	1.32E+09	0	0	1.19E+09	1.32E+08
85	0.3	8.46E+08	0	0	7.62E+08	8.46E+07
90	0.1	4.42E+08	0	0	3.97E+08	4.42E+07
95	0.0	1.10E+08	0	0	9.93E+07	1.10E+07
100	0.0	3.08E+06	0	0	2.77E+06	3.08E+05

Table 5-27 Enterococci TMDL Calculations for Lagoon Creek (OK620900010180_00)

Percentile	Flow (cfs)	TMDL (cfu/day)	WLA_{WWTP} (cfu/day)	WLA_{MS4} (cfu/day)	LA (cfu/day)	MOS (cfu/day)
0	3,032	2.45E+12	0	0	2.20E+12	2.45E+11
5	134	1.08E+11	0	0	9.71E+10	1.08E+10
10	50.0	4.04E+10	0	0	3.63E+10	4.04E+09
15	25.1	2.02E+10	0	0	1.82E+10	2.02E+09
20	14.7	1.19E+10	0	0	1.07E+10	1.19E+09
25	9.4	7.61E+09	0	0	6.85E+09	7.61E+08
30	6.3	5.11E+09	0	0	4.60E+09	5.11E+08
35	4.7	3.76E+09	0	0	3.38E+09	3.76E+08
40	3.5	2.79E+09	0	0	2.52E+09	2.79E+08
45	2.6	2.12E+09	0	0	1.91E+09	2.12E+08
50	2.1	1.73E+09	0	0	1.56E+09	1.73E+08
55	1.7	1.35E+09	0	0	1.21E+09	1.35E+08
60	1.3	1.06E+09	0	0	9.54E+08	1.06E+08
65	1.0	8.29E+08	0	0	7.46E+08	8.29E+07
70	0.8	6.26E+08	0	0	5.64E+08	6.26E+07
75	0.6	4.72E+08	0	0	4.25E+08	4.72E+07
80	0.4	3.47E+08	0	0	3.12E+08	3.47E+07
85	0.3	2.22E+08	0	0	1.99E+08	2.22E+07
90	0.1	1.16E+08	0	0	1.04E+08	1.16E+07
95	0.0	2.89E+07	0	0	2.60E+07	2.89E+06
100	0.0	8.07E+05	0	0	7.27E+05	8.07E+04

Table 5-28 Total Suspended Solids TMDL Calculations for West Beaver Creek (OK620900030260_00)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)		LA (lb/day)	MOS (lb/day)
			WWTP	Future growth		
0	2,616	NA	NA	NA	NA	NA
5	31	NA	NA	NA	NA	NA
10	12	NA	NA	NA	NA	NA
15	7.1	NA	NA	NA	NA	NA
20	4.7	NA	NA	NA	NA	NA
25	3.4	466	0	5	345	116
30	2.6	356	0	4	264	89
35	2.1	283	0	3	210	71
40	1.7	238	0	2	176	59
45	1.5	201	0	2	149	50
50	1.2	164	0	2	122	41
55	1.0	137	0	1	101	34
60	0.9	119	0	1	88	30
65	0.7	100	0	1	74	25
70	0.6	87	0	1	64	22
75	0.5	75	0	1	55	19
80	0.5	62	0	1	46	16
85	0.4	50	0	1	37	13
90	0.3	38	0	0	28	10
95	0.2	26	0	0	20	7
100	0	0	0	0	0	0

Table 5-29 Total Suspended Solids TMDL Calculations for Beaver Creek (OK620900030230_00)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)		LA (lb/day)	MOS (lb/day)
			WWTP	Future growth		
0	8,536	NA	NA	NA	NA	NA
5	100	NA	NA	NA	NA	NA
10	39	NA	NA	NA	NA	NA
15	23	NA	NA	NA	NA	NA
20	15	NA	NA	NA	NA	NA
25	11	1,584	0	16	1,251	317
30	8	1,211	0	12	957	242
35	7	963	0	10	761	193
40	6	808	0	8	638	162
45	4.8	683	0	7	540	137
50	3.9	559	0	6	442	112
55	3.3	466	0	5	368	93
60	2.8	404	0	4	319	81
65	2.4	342	0	3	270	68
70	2.1	295	0	3	233	59
75	1.8	255	0	3	201	51
80	1.5	211	0	2	167	42
85	1.2	171	0	2	135	34
90	0.9	130	0	1	103	26
95	0.6	90	0	1	71	18
100	0	0	0	0	0	0

Table 5-30 Total Suspended Solids TMDL Calculations for Cimarron River (OK620900030010_00)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)		LA (lb/day)	MOS (lb/day)
			WWTP	Future growth		
0	34,071	NA	NA	NA	NA	NA
5	584	NA	NA	NA	NA	NA
10	302	NA	NA	NA	NA	NA
15	213	NA	NA	NA	NA	NA
20	166	NA	NA	NA	NA	NA
25	136	25,375	0.1	254	21,315	3,806
30	112	20,940	0.1	209	17,590	3,141
35	94	17,614	0.1	176	14,796	2,642
40	79	14,781	0.1	148	12,416	2,217
45	67	12,441	0.1	124	10,450	1,866
50	57	10,671	0.1	107	8,963	1,601
55	47	8,746	0.1	87	7,346	1,312
60	38	7,021	0.1	70	5,898	1,053
65	30	5,543	0.1	55	4,656	831
70	22	4,065	0.1	41	3,414	610
75	15	2,710	0.1	27	2,276	406
80	7.3	1,355	0.1	14	1,138	203
85	3.0	554	0.1	6	465	83
90	0.5	99	0.1	1	83	15
95	0.001	0.2	0.1	0	0	0.03
100	0.001	0.2	0.1	0	0	0.03

Table 5-31 Total Suspended Solids TMDL Calculations for Stillwater Creek (OK620900040040_00)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)		LA (lb/day)	MOS (lb/day)
			WWTP	Future growth		
0	25,591	NA	NA	NA	NA	NA
5	299	NA	NA	NA	NA	NA
10	118	NA	NA	NA	NA	NA
15	69	NA	NA	NA	NA	NA
20	46	NA	NA	NA	NA	NA
25	33	6,621	0	66	5,893	662
30	25	5,063	0	51	4,506	506
35	20	4,025	0	40	3,582	402
40	17	3,375	0	34	3,004	338
45	14	2,856	0	29	2,542	286
50	12	2,337	0	23	2,080	234
55	10	1,947	0	19	1,733	195
60	8	1,688	0	17	1,502	169
65	7	1,428	0	14	1,271	143
70	6	1,233	0	12	1,098	123
75	5	1,065	0	11	947	106
80	4	883	0	9	786	88
85	3.6	714	0	7	635	71
90	2.7	545	0	5	485	55
95	1.9	376	0	4	335	38
100	0	0	0	0	0	0

Table 5-32 Total Suspended Solids TMDL Calculations for Council Creek (OK620900020050_00)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)		LA (lb/day)	MOS (lb/day)
			WWTP	Future growth		
0	2,739	NA	NA	NA	NA	NA
5	121	NA	NA	NA	NA	NA
10	45	NA	NA	NA	NA	NA
15	23	NA	NA	NA	NA	NA
20	13	NA	NA	NA	NA	NA
25	9	524	0	5	492	26
30	6	351	0	4	330	18
35	4	259	0	3	243	13
40	3	192	0	2	181	10
45	2.4	146	0	1	137	7
50	1.9	119	0	1	112	6
55	1.5	93	0	1	87	5
60	1.2	73	0	1	69	4
65	0.9	57	0	1	54	3
70	0.7	43	0	0	41	2
75	0.5	32	0	0	31	2
80	0.4	24	0	0	22	1
85	0.2	15	0	0	14	1
90	0.1	8	0	0	7	0
95	0.03	2	0	0	2	0
100	0	0	0	0	0	0

Table 5-33 Total Suspended Solids TMDL Calculations for Euchee Creek (OK620900010290_00)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)		LA (lb/day)	MOS (lb/day)
			WWTP	Future growth		
0	4,717	NA	NA	NA	NA	NA
5	208	NA	NA	NA	NA	NA
10	78	NA	NA	NA	NA	NA
15	39	NA	NA	NA	NA	NA
20	23	NA	NA	NA	NA	NA
25	15	3,088	0	31	2,749	309
30	10	2,072	0	21	1,844	207
35	7	1,525	0	15	1,357	152
40	5	1,134	0	11	1,009	113
45	4	860	0	9	765	86
50	3.3	704	0	7	626	70
55	2.6	547	0	5	487	55
60	2.0	430	0	4	383	43
65	1.6	336	0	3	299	34
70	1.2	254	0	3	226	25
75	0.9	192	0	2	170	19
80	0.7	141	0	1	125	14
85	0.4	90	0	1	80	9
90	0.2	47	0	0	42	5
95	0.1	12	0	0	10	1
100	0	0	0	0	0	0

Table 5-34 Total Suspended Solids TMDL Calculations for Cimarron River (OK620900010170_10)

Percentile	Flow (cfs)	TMDL (lb/day)	WLA (lb/day)		LA (lb/day)	MOS (lb/day)
			WWTP	Future growth		
0	231,573	NA	NA	NA	NA	NA
5	26,972	NA	NA	NA	NA	NA
10	17,656	NA	NA	NA	NA	NA
15	12,155	NA	NA	NA	NA	NA
20	9,848	NA	NA	NA	NA	NA
25	7,524	1,403,594	10	14,036	1,179,009	210,539
30	6,175	1,152,007	10	11,520	967,676	172,801
35	5,111	953,385	10	9,534	800,833	143,008
40	4,223	787,867	10	7,879	661,798	118,180
45	3,531	658,762	10	6,588	553,350	98,814
50	2,959	552,006	10	5,520	463,675	82,801
55	2,520	470,072	10	4,701	394,850	70,511
60	2,129	397,244	10	3,972	333,675	59,587
65	1,810	337,657	10	3,377	283,622	50,649
70	1,491	278,071	10	2,781	233,569	41,711
75	1,224	228,415	10	2,284	191,859	34,262
80	985	183,725	10	1,837	154,319	27,559
85	762	142,180	10	1,422	119,421	21,327
90	559	104,276	10	1,043	87,582	15,641
95	310	57,766	10	578	48,513	8,665
100	26	4,800	10	48	4,022	720

5.9 TMDL Implementation

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

Table 5-35 provides a partial list of the State partner agencies DEQ will collaborate with to address point and nonpoint source reduction goals established by TMDLs.

Table 5-35 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/wildlifemgmt/endangeredspecies.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

5.9.1 Point Sources

As authorized by Section 402 of the CWA, the DEQ has delegation of the NPDES Program in Oklahoma, except for certain jurisdictional areas related to agriculture (retained by State Department of Agriculture, Food, and Forestry), and the oil & gas industry (retained by the Oklahoma Corporation Commission) for which the EPA has retained permitting authority. The NPDES Program in Oklahoma, in accordance with an agreement between DEQ and EPA relating to administration and enforcement of the delegated NPDES Program, is implemented via the Oklahoma Pollutant Discharge Elimination System (OPDES) Act [Title 252, Chapter 606 (http://www.deq.state.ok.us/rules/611.pdf)]. Point source WLAs are outlined in the Oklahoma Water Quality Management Plan (aka the 208 Plan) under the OPDES program.

5.9.2 Nonpoint Sources

Nonpoint source pollution in Oklahoma is managed by the Oklahoma Conservation Commission. The Oklahoma Conservation Commission works with State partners such as ODAFF and federal partners such as the EPA and the National Resources Conservation Service of the USDA, 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.

The reduction rates called for in this TMDL report are as high as 95%. The DEQ 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 EPA. Additionally, EPA 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, revised in 2011, are based on EPA guidelines (See the *2012 Draft Recreational Water Quality Criteria*, December 2011; *Implementation Guidance for Ambient Water Quality Criteria for Bacteria*, May 2002 Draft; and *Ambient Water Quality Criteria for Bacteria-1986*, January 1986). However, those guidelines have received much criticism and EPA studies that could result in revisions to their recommendations are ongoing. The numeric criteria values should also be evaluated using a risk-based method such as that found in EPA guidance.

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

5.10 Reasonable Assurances

Reasonable assurance is required by the EPA guidance for a TMDL to be approvable only when a waterbody is impaired by both point and nonpoint sources and where a point source is given a less stringent wasteload allocation based on an assumption that nonpoint source load reductions will occur. In such a case, "reasonable assurance" that the NPS load reductions will actually occur must be demonstrated. In this report, all point source discharges either already have or will be given discharging discharge limitations less than or equal to the water quality standards numerical criteria. This ensures that the impairments to the waterbodies in this report will not be caused by point sources. Since the point source WLAs in this TMDL report are not dependent on NPS load reduction, reasonable assurance does not apply.

SECTION 6
PUBLIC PARTICIPATION

This report was preliminarily reviewed by EPA prior to the public notice. The public notice was then sent to local newspapers, to stakeholders in the area affected by the TMDLs in this Study Area, and to stakeholders who have requested all copies of TMDL public notices. The public notice was also posted at the DEQ website:
http://www.deq.state.ok.us/wqdnew/index.htm.

The public comment period lasted 45 days. During that time, the public had the opportunity to review the TMDL report and make written comments. No written comments were received during the public notice period and there were no requests for a public meeting.

After EPA's final approval, each TMDL will be adopted into the Water Quality Management Plan (WQMP). These TMDLs provide a mathematical solution to meet ambient water quality criteria with a given set of facts. The adoption of these TMDLs into the WQMP provides a mechanism to recalculate acceptable loads when information changes in the future. Updates to the WQMP demonstrate compliance with the water quality criteria. The updates to the WQMP are also useful when the water quality criteria change and the loading scenario is reviewed to ensure that the instream criterion is predicted to be met.

SECTION 7
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APPENDIX A

AMBIENT WATER QUALITY DATA

Table A-1 Bacteria Data-2000 to 2008

Waterbody ID	WQM Station	Date	EC[1]	ENT[1]
OK620910030040_00	OK620910-03-0040C	06/02/03	50	210
OK620910030040_00	OK620910-03-0040C	07/08/03	10	220
OK620910030040_00	OK620910-03-0040C	08/12/03	20	20
OK620910030040_00	OK620910-03-0040C	09/16/03	200	230
OK620910030040_00	OK620910-03-0040C	06/02/04	20	20
OK620910030040_00	OK620910-03-0040C	05/30/07	8100	4200
OK620910030040_00	OK620910-03-0040C	06/26/07	120	460
OK620910030040_00	OK620910-03-0040C	07/31/07	30	100
OK620910030040_00	OK620910-03-0040C	09/11/07	3000	900
OK620910030040_00	OK620910-03-0040C	05/13/08	240	300
OK620910030040_00	OK620910-03-0040C	06/17/08	8800	7300
OK620910030040_00	OK620910-03-0040C	07/22/08	30	20
OK620910030040_00	OK620910-03-0040C	08/25/08	110	30
OK620910030040_00	OK620910-03-0040C	09/29/08	40	290
OK620900030260_00	OK620900-03-0260G	08/28/00	10	60
OK620900030260_00	OK620900-03-0260G	06/11/01	51	400
OK620900030260_00	OK620900-03-0260G	07/16/01	120	188
OK620900030260_00	OK620900-03-0260G	08/20/01	90	140
OK620900030260_00	OK620900-03-0260G	09/24/01	450	680
OK620900030230_00	OK620900-03-0230C	06/02/03	60	65
OK620900030230_00	OK620900-03-0230C	07/08/03	10	70
OK620900030230_00	OK620900-03-0230C	08/12/03	20	20
OK620900030230_00	OK620900-03-0230C	09/16/03	220	280
OK620900030230_00	OK620900-03-0230C	06/02/04	10	20
OK620900030230_00	OK620900-03-0230C	05/30/07	6200	4300
OK620900030230_00	OK620900-03-0230C	06/26/07	650	1700
OK620900030230_00	OK620900-03-0230C	07/31/07	120	550
OK620900030230_00	OK620900-03-0230C	09/11/07	550	950
OK620900030230_00	OK620900-03-0230C	05/13/08	400	120
OK620900030230_00	OK620900-03-0230C	06/17/08	500	600
OK620900030230_00	OK620900-03-0230C	07/22/08	1000	30
OK620900030230_00	OK620900-03-0230C	08/25/08	40	60
OK620900030230_00	OK620900-03-0230C	09/29/08	10	10.0
OK620910040140_00	620910040140-001SR	06/13/01	74	300
OK620910040140_00	620910040140-002SR	06/13/01	10	1100
OK620910040140_00	620910040140-001SR	07/16/01	85	500
OK620910040140_00	620910040140-002SR	07/16/01	122	300
OK620910040140_00	620910040140-001SR	08/13/01	85	1800
OK620910040140_00	620910040140-002SR	08/13/01	131	1700
OK620910040140_00	620910040140-002SR	09/04/01	309	6000

Waterbody ID	WQM Station	Date	EC[1]	ENT[1]
OK620910040140_00	620910040140-001SR	05/20/02	226	60
OK620910040140_00	620910040140-002SR	05/20/02	262	20
OK620910040140_00	620910040140-001SR	08/21/02	63	100
OK620910040140_00	620910040140-002SR	08/21/02	63	200
OK620910040140_00	620910040140-001SR	09/18/02	183	1200
OK620910040140_00	620910040140-002SR	09/18/02	98	800
OK620900030010_00	620900030010-001AT	05/06/03	10	10
OK620900030010_00	620900030010-002RS	05/06/03	10	10
OK620900030010_00	620900030010-004RS	05/06/03	10	10
OK620900030010_00	620900030010-001AT	05/28/03	97	400
OK620900030010_00	620900030010-002RS	05/28/03	84	40
OK620900030010_00	620900030010-004RS	05/28/03	74	200
OK620900030010_00	620900030010-001AT	06/09/03	717	4000
OK620900030010_00	620900030010-002RS	06/09/03	2247	10000
OK620900030010_00	620900030010-004RS	06/09/03	3654	18000
OK620900030010_00	620900030010-001AT	07/01/03	10	50
OK620900030010_00	620900030010-002RS	07/01/03	63	100
OK620900030010_00	620900030010-004RS	07/01/03	262	60
OK620900030010_00	620900030010-001AT	07/07/03	10	10
OK620900030010_00	620900030010-002RS	07/07/03	20	10
OK620900030010_00	620900030010-004RS	07/07/03	84	10
OK620900030010_00	620900030010-001AT	08/05/03	20	10
OK620900030010_00	620900030010-002RS	08/05/03	20	10
OK620900030010_00	620900030010-004RS	08/05/03	10	10
OK620900030010_00	620900030010-001AT	08/11/03	73	50
OK620900030010_00	620900030010-002RS	08/11/03	10	400
OK620900030010_00	620900030010-004RS	08/11/03	142	700
OK620900030010_00	620900030010-001AT	09/09/03	20	130
OK620900030010_00	620900030010-002RS	09/09/03	10	60
OK620900030010_00	620900030010-004RS	09/09/03	10	30
OK620900030010_00	620900030010-001AT	09/15/03	31	10
OK620900030010_00	620900030010-002RS	09/15/03	31	10
OK620900030010_00	620900030010-004RS	09/15/03	195	110
OK620900030010_00	620900030010-002RS	09/30/03	61	70
OK620900030010_00	620900030010-001AT	05/22/06	10	10
OK620900030010_00	620900030010-001AT	06/05/06	41	109
OK620900030010_00	620900030010-001AT	06/19/06	464	743
OK620900030010_00	620900030010-001AT	07/18/06	31	155
OK620900030010_00	620900030010-001AT	07/26/06	10	20
OK620900030010_00	620900030010-001AT	07/31/06	10	41
OK620900030010_00	620900030010-001AT	08/16/06	63	145

Waterbody ID	WQM Station	Date	EC[1]	ENT[1]
OK620900030010_00	620900030010-001AT	08/21/06	10	30
OK620900030010_00	620900030010-001AT	09/27/06	368	31
OK620900030010_00	620900030010-001AT	06/02/08	3654	798
OK620900030080_00	OK620900-03-0080C	06/02/03	440	625
OK620900030080_00	OK620900-03-0080C	07/07/03	445	500
OK620900030080_00	OK620900-03-0080C	08/11/03	40	80
OK620900030080_00	OK620900-03-0080C	09/15/03	360	570
OK620900030080_00	OK620900-03-0080C	06/07/04	500	160
OK620900030080_00	OK620900-03-0080C	05/29/07	1500	2050
OK620900030080_00	OK620900-03-0080C	06/25/07	440	780
OK620900030080_00	OK620900-03-0080C	07/31/07	2600	3750
OK620900030080_00	OK620900-03-0080C	09/11/07	220	740
OK620900030080_00	OK620900-03-0080C	05/13/08	540	680
OK620900030080_00	OK620900-03-0080C	06/17/08	1700	8900
OK620900030080_00	OK620900-03-0080C	07/22/08	120	50
OK620900030080_00	OK620900-03-0080C	08/26/08	90	50
OK620900030080_00	OK620900-03-0080C	09/29/08	180	30
OK620900040040_00	OK620900-04-0040C	06/03/03	200	380
OK620900040040_00	OK620900-04-0040C	07/08/03	100	380
OK620900040040_00	OK620900-04-0040C	08/12/03	180	40
OK620900040040_00	OK620900-04-0040C	09/16/03	520	380
OK620900040040_00	OK620900-04-0040C	06/08/04	500	175
OK620900040040_00	OK620900-04-0040C	08/03/04	230	60
OK620900040040_00	OK620900-04-0040C	08/31/04	40	120
OK620900040040_00	OK620900-04-0040C	09/21/04	70	130
OK620900040040_00	OK620900-04-0040C	05/25/05	685	230
OK620900040040_00	OK620900-04-0040C	06/28/05	150	180
OK620900040040_00	OK620900-04-0040C	07/26/05	80	130
OK620900040040_00	OK620900-04-0040C	09/07/05	130	210
OK620900040040_00	OK620900-04-0040C	05/16/06	60	40
OK620900040040_00	OK620900-04-0040C	06/19/06	660	620
OK620900040040_00	OK620900-04-0040C	07/24/06	15	250
OK620900040040_00	OK620900-04-0040C	08/29/06	190	280
OK620900040040_00	OK620900-04-0040C	05/29/07	950	1100
OK620900040040_00	OK620900-04-0040C	06/25/07	340	660
OK620900040040_00	OK620900-04-0040C	07/30/07	110	220
OK620900040040_00	OK620900-04-0040C	09/10/07	600	1350
OK620900040040_00	OK620900-04-0040C	05/12/08	320	740
OK620900040040_00	OK620900-04-0040C	07/21/08	100	20
OK620900040040_00	OK620900-04-0040C	08/26/08	70	120
OK620900040040_00	OK620900-04-0040C	09/30/08	80	110

Waterbody ID	WQM Station	Date	EC[1]	ENT[1]
OK620900020050_00	OK620900-02-0050H	06/02/03	190	510
OK620900020050_00	OK620900-02-0050H	07/07/03	30	320
OK620900020050_00	OK620900-02-0050H	08/11/03	200	100
OK620900020050_00	OK620900-02-0050H	09/15/03	380	530
OK620900020050_00	OK620900-02-0050H	06/07/04	140	500
OK620900020050_00	OK620900-02-0050H	05/19/07	2750	2700
OK620900020050_00	OK620900-02-0050H	06/25/07	180	360
OK620900020050_00	OK620900-02-0050H	07/03/07	860	1080
OK620900020050_00	OK620900-02-0050H	08/07/07	160	470
OK620900020050_00	OK620900-02-0050H	09/10/07	600	500
OK620900020050_00	OK620900-02-0050H	05/12/08	100	40
OK620900020050_00	OK620900-02-0050H	06/17/08	6800	10000
OK620900020050_00	OK620900-02-0050H	06/24/08	140	180
OK620900020050_00	OK620900-02-0050H	07/22/08	50	170
OK620900020050_00	OK620900-02-0050H	08/26/08	130	150
OK620900020050_00	OK620900-02-0050H	09/30/08	40	480
OK620900020020_00	OK620900-02-0020D	06/02/03	90	200
OK620900020020_00	OK620900-02-0020D	07/08/03	20	90
OK620900020020_00	OK620900-02-0020D	08/11/03	180	20
OK620900020020_00	OK620900-02-0020D	09/15/03	740	470
OK620900020020_00	OK620900-02-0020D	06/07/04	400	185
OK620900020020_00	OK620900-02-0020D	05/29/07	980	860
OK620900020020_00	OK620900-02-0020D	06/25/07	340	620
OK620900020020_00	OK620900-02-0020D	07/03/07	1100	800
OK620900020020_00	OK620900-02-0020D	08/07/07	40	110
OK620900020020_00	OK620900-02-0020D	09/10/07	200	440
OK620900020020_00	OK620900-02-0020D	05/12/08	100	60
OK620900020020_00	OK620900-02-0020D	06/17/08	8200	10000
OK620900020020_00	OK620900-02-0020D	06/24/08	280	120
OK620900020020_00	OK620900-02-0020D	07/22/08	40	20
OK620900020020_00	OK620900-02-0020D	08/26/08	20	70
OK620900020020_00	OK620900-02-0020D	09/30/08	40	310
OK620900010310_00	620900010310-001SR	06/26/01	160	200
OK620900010310_00	620900010310-002SR	06/26/01	3448	600
OK620900010310_00	620900010310-001SR	07/17/01	24192	6000
OK620900010310_00	620900010310-002SR	07/17/01	2481	2000
OK620900010310_00	620900010310-001SR	08/14/01	63	160
OK620900010310_00	620900010310-002SR	08/14/01	10	90
OK620900010310_00	620900010310-001SR	09/05/01	199	90
OK620900010310_00	620900010310-002SR	09/05/01	148	200
OK620900010310_00	620900010310-002SR	05/22/02	6131	4000

Waterbody ID	WQM Station	Date	EC[1]	ENT[1]
OK620900010310_00	620900010310-001SR	07/24/02	158	9000
OK620900010310_00	620900010310-002SR	07/24/02	10	130
OK620900010310_00	620900010310-001SR	08/26/02	382	3000
OK620900010310_00	620900010310-002SR	08/26/02	246	5000
OK620900010310_00	620900010310-001SR	09/25/02	86	120
OK620900010310_00	620900010310-002SR	09/25/02	85	90
OK620900010290_00	OK620900-01-0290D	06/02/03	280	180
OK620900010290_00	OK620900-01-0290D	07/07/03	60	40
OK620900010290_00	OK620900-01-0290D	08/11/03	280	60
OK620900010290_00	OK620900-01-0290D	09/15/03	580	420
OK620900010290_00	OK620900-01-0290D	06/07/04	380	360
OK620900010290_00	OK620900-01-0290D	05/29/07	640	680
OK620900010290_00	OK620900-01-0290D	06/25/07	140	240
OK620900010290_00	OK620900-01-0290D	07/03/07	560	780
OK620900010290_00	OK620900-01-0290D	08/07/07	300	120
OK620900010290_00	OK620900-01-0290D	09/10/07	380	340
OK620900010290_00	OK620900-01-0290D	05/12/08	80	60
OK620900010290_00	OK620900-01-0290D	06/17/08	5300	10000
OK620900010290_00	OK620900-01-0290D	06/24/08	180	160
OK620900010290_00	OK620900-01-0290D	07/22/08	50	70
OK620900010290_00	OK620900-01-0290D	08/26/08	40	130
OK620900010290_00	OK620900-01-0290D	09/30/08	170	260
OK620900010170_10	620900010170-001AT	06/04/01	95	3000
OK620900010170_10	620900010170-001AT	07/09/01	10	10
OK620900010170_10	620900010170-001AT	08/06/01	10	10
OK620900010170_10	620900010170-001AT	09/10/01	10	50
OK620900010170_10	620900010170-001AT	05/22/02	2014	100
OK620900010170_10	620900010170-001AT	06/04/02	10	20
OK620900010170_10	620900010170-001AT	07/24/02	10	10
OK620900010170_10	620900010170-001AT	08/26/02	161	500
OK620900010170_10	620900010170-001AT	09/23/02	1071	6000
OK620900010170_10	620900010170-001AT	05/03/04	31	150
OK620900010170_10	620900010170-001AT	06/02/04	323	1100
OK620900010170_10	620900010170-001AT	06/16/04	20	30
OK620900010170_10	620900010170-001AT	06/22/04	288	3700
OK620900010170_10	620900010170-001AT	07/07/04	73	1700
OK620900010170_10	620900010170-001AT	07/19/04	10	60
OK620900010170_10	620900010170-001AT	08/10/04	10	60
OK620900010170_10	620900010170-001AT	08/23/04	10	52
OK620900010170_10	620900010170-001AT	09/15/04	20	20
OK620900010170_10	620900010170-001AT	09/28/04	63	10

Waterbody ID	WQM Station	Date	EC[1]	ENT[1]
OK620900010170_10	620900010170-001AT	05/22/06	10	71
OK620900010170_10	620900010170-001AT	06/05/06	108	134
OK620900010170_10	620900010170-001AT	06/19/06	20	31
OK620900010170_10	620900010170-001AT	07/18/06	10	183
OK620900010170_10	620900010170-001AT	07/26/06	10	41
OK620900010170_10	620900010170-001AT	07/31/06	10	108
OK620900010170_10	620900010170-001AT	08/16/06	97	158
OK620900010170_10	620900010170-001AT	08/21/06	10	3255
OK620900010170_10	620900010170-001AT	09/27/06	31	110
OK620900010180_00	OK620900-01-0180J	06/03/03	980	830
OK620900010180_00	OK620900-01-0180J	07/08/03	1070	1810
OK620900010180_00	OK620900-01-0180J	08/12/03	80	40
OK620900010180_00	OK620900-01-0180J	09/15/03	605	670
OK620900010180_00	OK620900-01-0180J	06/08/04	95	85
OK620900010180_00	OK620900-01-0180J	05/29/07	640	380
OK620900010180_00	OK620900-01-0180J	06/25/07	200	220
OK620900010180_00	OK620900-01-0180J	07/03/07	800	980
OK620900010180_00	OK620900-01-0180J	08/07/07	10	20
OK620900010180_00	OK620900-01-0180J	09/10/07	580	720
OK620900010180_00	OK620900-01-0180J	05/12/08	60	60
OK620900010180_00	OK620900-01-0180J	06/17/08	3100	10000
OK620900010180_00	OK620900-01-0180J	06/24/08	20	160
OK620900010180_00	OK620900-01-0180J	07/22/08	10	60
OK620900010180_00	OK620900-01-0180J	08/26/08	10	20
OK620900010180_00	OK620900-01-0180J	09/30/08	70	70
OK620910030040_00	OK620910-03-0040G	08/28/00	41	180
OK620910030040_00	OK620910-03-0040G	05/07/01	119	200
OK620910030040_00	OK620910-03-0040G	06/11/01	20	50
OK620910030040_00	OK620910-03-0040G	07/16/01	126	6
OK620910030040_00	OK620910-03-0040G	08/20/01	40	60
OK620910030040_00	OK620910-03-0040G	09/24/01	110	100
OK620910030040_00	OK620910-03-0040C	08/06/02	80	130
OK620910030040_00	OK620910-03-0040C	09/04/02	20	80
OK620900030230_00	OK620900-03-0230C	08/06/02	70	50
OK620900030230_00	OK620900-03-0230C	09/04/02	20	20
OK620900030010_00	620900030010-001AT	06/04/01	120	3000
OK620900030010_00	620900030010-001AT	07/09/01	10	30
OK620900030010_00	620900030010-001AT	08/06/01	10	10
OK620900030010_00	620900030010-001AT	09/10/01	10	200
OK620900030010_00	620900030010-001AT	05/13/02	10	10
OK620900030010_00	620900030010-001AT	06/04/02	20	20

Waterbody ID	WQM Station	Date	EC[1]	ENT[1]
OK620900030010_00	620900030010-001AT	07/24/02	10	200
OK620900030010_00	620900030010-001AT	08/26/02	195	600
OK620900030010_00	620900030010-001AT	09/23/02	933	3000
OK620900030080_00	OK620900-03-0080C	07/22/02	315	90
OK620900030080_00	OK620900-03-0080C	08/26/02	1020	300
OK620900030080_00	OK620900-03-0080C	09/30/02	70	230
OK620900040040_00	OK620900-04-0040C	07/23/02	260	140
OK620900040040_00	OK620900-04-0040C	08/27/02	2567	766
OK620900020050_00	OK620900-02-0050H	08/21/00	20	
OK620900020050_00	OK620900-02-0050H	09/25/00	20	30
OK620900020050_00	OK620900-02-0050H	07/23/02	50	100
OK620900020050_00	OK620900-02-0050H	08/27/02	740	280
OK620900020050_00	OK620900-02-0050H	09/30/02	20	20
OK620900020020_00	OK620900-02-0020D	07/23/02	500	40
OK620900020020_00	OK620900-02-0020D	08/27/02	440	160
OK620900020020_00	OK620900-02-0020D	09/30/02	1600	1200
OK620900010290_00	OK620900-01-0290R	08/21/00	10	
OK620900010290_00	OK620900-01-0290R	09/25/00	85	500
OK620900010290_00	OK620900-01-0290D	07/22/02	80	230
OK620900010290_00	OK620900-01-0290D	08/26/02	80	20
OK620900010290_00	OK620900-01-0290D	09/30/02	40	20
OK620900010180_00	OK620900-01-0180J	07/23/02	800	1590
OK620900010180_00	OK620900-01-0180J	08/27/02	1267	380

EC = *E. coli* (STORET Code: 31609); ENT = Enterococci (STORET Code: 31649)
> 1000 reported as 1000.001 in data analysis
[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

Table A-2 Turbidity and Total Suspended Solids Data – 1998-2011

Waterbody ID	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
OK620910030040_00	OK620910-03-0040C	05/30/07		7600	high
OK620910030040_00	OK620910-03-0040C	06/26/07	26.2	28	high
OK620910030040_00	OK620910-03-0040C	07/31/07	7.77	15	low
OK620910030040_00	OK620910-03-0040C	08/29/07	14.4		low
OK620910030040_00	OK620910-03-0040C	09/11/07	489	305	high
OK620910030040_00	OK620910-03-0040C	10/15/07	42.1	42	low
OK620910030040_00	OK620910-03-0040C	11/14/07	9.48	10	low
OK620910030040_00	OK620910-03-0040C	12/18/07	10.6	10	high
OK620910030040_00	OK620910-03-0040C	01/23/08	10.1	10	low
OK620910030040_00	OK620910-03-0040C	03/04/08	126	53	high
OK620910030040_00	OK620910-03-0040C	04/07/08	19.8	14	high
OK620910030040_00	OK620910-03-0040C	05/13/08	34.1	29	high
OK620910030040_00	OK620910-03-0040C	06/17/08	>1000	6082	high
OK620910030040_00	OK620910-03-0040C	07/22/08	13.8	10	low
OK620910030040_00	OK620910-03-0040C	08/25/08	27.1	19	low
OK620910030040_00	OK620910-03-0040C	09/29/08	17.1	10	low
OK620910030040_00	OK620910-03-0040C	11/03/08	17.5	11	low
OK620910030040_00	OK620910-03-0040C	12/16/08	4.97	10	low
OK620910030040_00	OK620910-03-0040C	02/03/09	4.58	10	low
OK620910030040_00	OK620910-03-0040C	03/02/09	14.6	10	low
OK620910030040_00	OK620910-03-0040C	04/07/09	23.3	12	low
OK620900030260_00	OK620900-03-0260G	07/31/98	8.33		low
OK620900030260_00	OK620900-03-0260G	05/15/00	11.2	17	high
OK620900030260_00	OK620900-03-0260G	06/15/00	16.6		low
OK620900030260_00	OK620900-03-0260G	06/19/00	160	96	high
OK620900030260_00	OK620900-03-0260G	07/24/00	328	188	high
OK620900030260_00	OK620900-03-0260G	08/28/00	17	22	low
OK620900030260_00	OK620900-03-0260G	10/02/00	10.9	64	low
OK620900030260_00	OK620900-03-0260G	11/06/00	>1000	1670	high
OK620900030260_00	OK620900-03-0260G	12/11/00	9.02	1	low
OK620900030260_00	OK620900-03-0260G	01/22/01	4.79	1	low
OK620900030260_00	OK620900-03-0260G	02/27/01	185	116	high
OK620900030260_00	OK620900-03-0260G	04/02/01	7.57	1	low
OK620900030260_00	OK620900-03-0260G	05/07/01	19.3	24	high
OK620900030260_00	OK620900-03-0260G	06/11/01	16	5	low
OK620900030260_00	OK620900-03-0260G	07/16/01	20.3	11	low
OK620900030260_00	OK620900-03-0260G	08/20/01	221	34	low
OK620900030260_00	OK620900-03-0260G	09/24/01	190	53	low

Waterbody ID	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
OK620900030260_00	OK620900-03-0260G	10/30/01	12	10	low
OK620900030260_00	OK620900-03-0260G	12/10/01	8.46	10	low
OK620900030260_00	OK620900-03-0260G	01/14/02	7.69	10	low
OK620900030260_00	OK620900-03-0260G	02/20/02	31.5	31.99	low
OK620900030260_00	OK620900-03-0260G	03/26/02	17	14	low
OK620900030230_00	OK620900-03-0230C	05/30/07		4722	high
OK620900030230_00	OK620900-03-0230C	06/26/07	54.4	61	low
OK620900030230_00	OK620900-03-0230C	07/31/07	26.2	31	high
OK620900030230_00	OK620900-03-0230C	09/11/07	166	70	high
OK620900030230_00	OK620900-03-0230C	10/15/07	44	22	low
OK620900030230_00	OK620900-03-0230C	11/14/07	9.09	10	low
OK620900030230_00	OK620900-03-0230C	12/18/07	13.2	10	low
OK620900030230_00	OK620900-03-0230C	01/23/08	4.16	10	low
OK620900030230_00	OK620900-03-0230C	03/04/08	498	245	high
OK620900030230_00	OK620900-03-0230C	04/08/08	>1000	3706	high
OK620900030230_00	OK620900-03-0230C	05/13/08	47.4	38	high
OK620900030230_00	OK620900-03-0230C	06/17/08	152	119	high
OK620900030230_00	OK620900-03-0230C	07/09/08	59.1		low
OK620900030230_00	OK620900-03-0230C	07/22/08	16.8	11	low
OK620900030230_00	OK620900-03-0230C	08/25/08	24.3	14	low
OK620900030230_00	OK620900-03-0230C	09/29/08	15.9	10	low
OK620900030230_00	OK620900-03-0230C	11/03/08	17.7	10	low
OK620900030230_00	OK620900-03-0230C	12/16/08		10	low
OK620900030230_00	OK620900-03-0230C	02/03/09	11.5	10	low
OK620900030230_00	OK620900-03-0230C	03/02/09	30.7	12	low
OK620900030230_00	OK620900-03-0230C	04/07/09	47	13	low
OK620900030010_00	620900030010-001AT	01/21/03	15		high
OK620900030010_00	620900030010-001AT	03/05/03	17		high
OK620900030010_00	620900030010-001AT	04/01/03	44		high
OK620900030010_00	620900030010-002RS	04/01/03	25		low
OK620900030010_00	620900030010-004RS	04/01/03	27		low
OK620900030010_00	620900030010-001AT	05/06/03	33		high
OK620900030010_00	620900030010-004RS	05/06/03			low
OK620900030010_00	620900030010-001AT	06/11/03	84		high
OK620900030010_00	620900030010-002RS	06/11/03	99		low
OK620900030010_00	620900030010-004RS	06/11/03	85		low
OK620900030010_00	620900030010-002RS	07/07/03	46		low
OK620900030010_00	620900030010-004RS	07/07/03	45		high
OK620900030010_00	620900030010-001AT	07/08/03	24		high

Waterbody ID	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
OK620900030010_00	620900030010-001AT	08/11/03	35		high
OK620900030010_00	620900030010-002RS	08/11/03	10		high
OK620900030010_00	620900030010-004RS	08/11/03	29		low
OK620900030010_00	620900030010-001AT	09/15/03	60		high
OK620900030010_00	620900030010-002RS	09/15/03	51		low
OK620900030010_00	620900030010-004RS	09/15/03	54		high
OK620900030010_00	620900030010-001AT	10/27/03	10		high
OK620900030010_00	620900030010-002RS	10/27/03	10		high
OK620900030010_00	620900030010-002RS	10/27/03	10		high
OK620900030010_00	620900030010-004RS	10/27/03	10		high
OK620900030010_00	620900030010-001AT	12/15/03	9		high
OK620900030010_00	620900030010-002RS	12/15/03	9		low
OK620900030010_00	620900030010-004RS	12/15/03	11		low
OK620900030010_00	620900030010-001AT	01/12/04	7		high
OK620900030010_00	620900030010-002RS	01/12/04	6		high
OK620900030010_00	620900030010-004RS	01/12/04	8		high
OK620900030010_00	620900030010-001AT	03/10/04	687		high
OK620900030010_00	620900030010-002RS	03/10/04	788		high
OK620900030010_00	620900030010-004RS	03/10/04	490		high
OK620900030010_00	620900030010-001AT	05/03/04	124		high
OK620900030010_00	620900030010-001AT	06/22/04	1000		high
OK620900030010_00	620900030010-002RS	06/22/04	1000		high
OK620900030010_00	620900030010-004RS	06/22/04	1000		high
OK620900030010_00	620900030010-001AT	07/19/04	39		high
OK620900030010_00	620900030010-001AT	08/23/04	139		high
OK620900030010_00	620900030010-001AT	09/28/04	21		high
OK620900030010_00	620900030010-001AT	10/26/04	33		high
OK620900030010_00	620900030010-002RS	10/27/04	37		high
OK620900030010_00	620900030010-004RS	10/27/04	24		high
OK620900030010_00	620900030010-001AT	11/29/04	422		high
OK620900030010_00	620900030010-001AT	01/31/05	36		high
OK620900030010_00	620900030010-001AT	04/19/05	24		high
OK620900030010_00	620900030010-001AT	06/06/05	52		high
OK620900030010_00	620900030010-001AT	07/18/05	67		high
OK620900030010_00	620900030010-001AT	08/15/05	783		high
OK620900030010_00	620900030010-001AT	09/19/05	859		high
OK620900030010_00	620900030010-001AT	10/24/05	17		high
OK620900030010_00	620900030010-001AT	12/05/05	6		high
OK620900030010_00	620900030010-001AT	01/31/06	10		high

Waterbody ID	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
OK620900030010_00	620900030010-001AT	02/27/06	14		high
OK620900030010_00	620900030010-001AT	04/04/06	11		high
OK620900030010_00	620900030010-001AT	05/08/06	58		high
OK620900030010_00	620900030010-001AT	06/13/06	6		high
OK620900030010_00	620900030010-001AT	07/26/06	44		low
OK620900030010_00	620900030010-001AT	08/21/06	37		low
OK620900030010_00	620900030010-001AT	10/02/06	78		low
OK620900030010_00	620900030010-001AT	11/06/06	20.5		low
OK620900030010_00	620900030010-001AT	12/12/06	10		high
OK620900030010_00	620900030010-001AT	01/29/07	11		high
OK620900030010_00	620900030010-001AT	03/05/07	6		high
OK620900030010_00	620900030010-001AT	04/02/07	1001		high
OK620900030010_00	620900030010-001AT	04/30/07	48		high
OK620900030010_00	620900030010-001AT	06/04/07	689		high
OK620900030010_00	620900030010-001AT	07/16/07	535		high
OK620900030010_00	620900030010-001AT	08/13/07	48		high
OK620900030010_00	620900030010-001AT	09/24/07	30		high
OK620900030010_00	620900030010-001AT	10/22/07	971		high
OK620900030010_00	620900030010-001AT	11/26/07	10		high
OK620900030010_00	620900030010-001AT	01/28/08	11		high
OK620900030010_00	620900030010-001AT	03/03/08	580		high
OK620900030010_00	620900030010-001AT	04/15/08	306		high
OK620900030010_00	620900030010-001AT	05/27/08	1001		high
OK620900030010_00	620900030010-001AT	07/21/08	38		high
OK620900030010_00	620900030010-001AT	09/15/08	1000		high
OK620900030010_00	620900030010-001AT	11/10/08	122		high
OK620900030010_00	620900030010-001AT	01/20/09	5		high
OK620900030010_00	620900030010-001AT	01/20/09	6.3		high
OK620900030010_00	620900030010-001AT	01/20/09	6.3		high
OK620900030010_00	620900030010-001AT	03/16/09	6.5		high
OK620900030010_00	620900030010-001AT	04/13/09	200		high
OK620900030010_00	620900030010-001AT	05/26/09	31		high
OK620900030010_00	620900030010-001AT	07/06/09	29		high
OK620900030010_00	620900030010-001AT	08/24/09	1000		high
OK620900030010_00	620900030010-001AT	11/02/09	1000		high
OK620900030010_00	620900030010-001AT	01/04/10	7		high
OK620900030010_00	620900030010-001AT	03/15/10	29.7		high
OK620900030010_00	620900030010-001AT	05/17/10	632		high
OK620900030010_00	620900030010-001AT	07/19/10	66		high

Waterbody ID	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
OK620900030010_00	620900030010-001AT	09/13/10	49.3		high
OK620900030010_00	620900030010-001AT	11/29/10	29		high
OK620900030010_00	620900030010-001AT	01/03/11	5		high
OK620900030010_00	620900030010-001AT	03/15/11	10.3		high
OK620900030080_00	OK620900-03-0080C	01/05/04	5.19	10	low
OK620900030080_00	OK620900-03-0080C	02/09/04	63.5	24	low
OK620900030080_00	OK620900-03-0080C	03/15/04	9.4	11	low
OK620900030080_00	OK620900-03-0080C	04/19/04	26.2	11	low
OK620900030080_00	OK620900-03-0080C	06/07/04	39.6	27	low
OK620900030080_00	OK620900-03-0080C	05/22/07	4.25		high
OK620900030080_00	OK620900-03-0080C	05/29/07	143	79	high
OK620900030080_00	OK620900-03-0080C	06/25/07	48.9	26	high
OK620900030080_00	OK620900-03-0080C	07/31/07	143	109	high
OK620900030080_00	OK620900-03-0080C	09/11/07	30.4	35	low
OK620900030080_00	OK620900-03-0080C	10/15/07	57.3	33	high
OK620900030080_00	OK620900-03-0080C	11/14/07	4.84	10	low
OK620900030080_00	OK620900-03-0080C	12/18/07	17.2	10	low
OK620900030080_00	OK620900-03-0080C	01/23/08	7.18	11	low
OK620900030080_00	OK620900-03-0080C	03/04/08	201	79	high
OK620900030080_00	OK620900-03-0080C	04/08/08	754	752	high
OK620900030080_00	OK620900-03-0080C	05/13/08	20.1	22	high
OK620900030080_00	OK620900-03-0080C	06/17/08	95.7	60	high
OK620900030080_00	OK620900-03-0080C	07/22/08	7.36	10	low
OK620900030080_00	OK620900-03-0080C	08/26/08	13.5	10	low
OK620900030080_00	OK620900-03-0080C	09/29/08	4.42	10	low
OK620900030080_00	OK620900-03-0080C	11/03/08	5	27	low
OK620900030080_00	OK620900-03-0080C	12/16/08	5.49	10	low
OK620900030080_00	OK620900-03-0080C	02/03/09	4.17	10	low
OK620900030080_00	OK620900-03-0080C	03/02/09	5.48	10	low
OK620900030080_00	OK620900-03-0080C	04/07/09	9.62	10	low
OK620900040040_00	OK620900-04-0040C	01/06/04	23.7	17	low
OK620900040040_00	OK620900-04-0040C	02/10/04	223	140	high
OK620900040040_00	OK620900-04-0040C	03/16/04	64.1	53	high
OK620900040040_00	OK620900-04-0040C	04/20/04	15.4	10	low
OK620900040040_00	OK620900-04-0040C	06/08/04	517	63	low
OK620900040040_00	OK620900-04-0040C	08/03/04	44.7	41	low
OK620900040040_00	OK620900-04-0040C	08/31/04	34.5	19	low
OK620900040040_00	OK620900-04-0040C	09/21/04	40.2	31	low
OK620900040040_00	OK620900-04-0040C	10/25/04	39.4	30	low

Waterbody ID	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
OK620900040040_00	OK620900-04-0040C	11/29/04	34.5	18	high
OK620900040040_00	OK620900-04-0040C	01/10/05	68.4	69	high
OK620900040040_00	OK620900-04-0040C	02/08/05	105	62	high
OK620900040040_00	OK620900-04-0040C	03/23/05	29.9	18	high
OK620900040040_00	OK620900-04-0040C	04/19/05	19.8	16	low
OK620900040040_00	OK620900-04-0040C	05/25/05	45.9	50	low
OK620900040040_00	OK620900-04-0040C	06/28/05	69	50	low
OK620900040040_00	OK620900-04-0040C	07/26/05	44.1	37	low
OK620900040040_00	OK620900-04-0040C	09/07/05	32.9	30	low
OK620900040040_00	OK620900-04-0040C	10/04/05	112	55	high
OK620900040040_00	OK620900-04-0040C	11/08/05	29.9	20	low
OK620900040040_00	OK620900-04-0040C	12/13/05	11.8	17	low
OK620900040040_00	OK620900-04-0040C	01/31/06	16.3	17	low
OK620900040040_00	OK620900-04-0040C	02/28/06	19.4	11	low
OK620900040040_00	OK620900-04-0040C	04/11/06	20.3	26	low
OK620900040040_00	OK620900-04-0040C	05/16/06	15.5	11	low
OK620900040040_00	OK620900-04-0040C	06/19/06	198	26	high
OK620900040040_00	OK620900-04-0040C	07/24/06	16.3	10	low
OK620900040040_00	OK620900-04-0040C	08/29/06	66.1	35	low
OK620900040040_00	OK620900-04-0040C	05/29/07	354	792	high
OK620900040040_00	OK620900-04-0040C	06/25/07	42.5	57	high
OK620900040040_00	OK620900-04-0040C	07/30/07	45.8	54	high
OK620900040040_00	OK620900-04-0040C	09/10/07	113	121	high
OK620900040040_00	OK620900-04-0040C	10/16/07	61.4	41	high
OK620900040040_00	OK620900-04-0040C	11/14/07	10.6	10	low
OK620900040040_00	OK620900-04-0040C	12/17/07	32	10	high
OK620900040040_00	OK620900-04-0040C	01/23/08	8.35	10	low
OK620900040040_00	OK620900-04-0040C	03/03/08	>1000	859	high
OK620900040040_00	OK620900-04-0040C	04/08/08	>1000	2463	high
OK620900040040_00	OK620900-04-0040C	05/12/08	94.3	70	high
OK620900040040_00	OK620900-04-0040C	07/21/08	37.7	43	high
OK620900040040_00	OK620900-04-0040C	08/26/08	35	19	low
OK620900040040_00	OK620900-04-0040C	09/04/08	26		low
OK620900040040_00	OK620900-04-0040C	09/30/08	32.9	18	low
OK620900040040_00	OK620900-04-0040C	11/04/08	32.5	19	low
OK620900040040_00	OK620900-04-0040C	12/15/08		10	low
OK620900040040_00	OK620900-04-0040C	02/02/09	10.5	10	low
OK620900040040_00	OK620900-04-0040C	03/03/09	13.3	10	low
OK620900040040_00	OK620900-04-0040C	04/06/09	18.9	17	low

Waterbody ID	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
OK620900020050_00	OK620900-02-0050H	01/05/04	12.3	10	low
OK620900020050_00	OK620900-02-0050H	02/09/04	63.7	12	low
OK620900020050_00	OK620900-02-0050H	03/15/04	16.4	21	low
OK620900020050_00	OK620900-02-0050H	04/19/04	16.6	10	low
OK620900020050_00	OK620900-02-0050H	06/07/04	6.14	10	high
OK620900020050_00	OK620900-02-0050H	05/18/07	9.19		low
OK620900020050_00	OK620900-02-0050H	05/19/07	222	161	high
OK620900020050_00	OK620900-02-0050H	06/25/07	13	10	high
OK620900020050_00	OK620900-02-0050H	07/03/07			high
OK620900020050_00	OK620900-02-0050H	08/07/07	7.99	10	low
OK620900020050_00	OK620900-02-0050H	09/10/07	68.8	59	high
OK620900020050_00	OK620900-02-0050H	10/09/07	5.7		low
OK620900020050_00	OK620900-02-0050H	10/15/07	9.31	10	low
OK620900020050_00	OK620900-02-0050H	11/13/07	5.73	10	low
OK620900020050_00	OK620900-02-0050H	12/17/07	52.8	10	low
OK620900020050_00	OK620900-02-0050H	01/22/08	5.16	10	low
OK620900020050_00	OK620900-02-0050H	03/03/08	805	1060	high
OK620900020050_00	OK620900-02-0050H	04/07/08	16	10	high
OK620900020050_00	OK620900-02-0050H	05/12/08	16.5	10	high
OK620900020050_00	OK620900-02-0050H	06/17/08	522	569	high
OK620900020050_00	OK620900-02-0050H	06/24/08			high
OK620900020050_00	OK620900-02-0050H	07/22/08	7.95	10	low
OK620900020050_00	OK620900-02-0050H	08/26/08	6.15	10	low
OK620900020050_00	OK620900-02-0050H	09/30/08	5.03	10	low
OK620900020050_00	OK620900-02-0050H	11/03/08	2.5	10	low
OK620900020050_00	OK620900-02-0050H	12/15/08	4.14	10	low
OK620900020050_00	OK620900-02-0050H	02/02/09	3.54	10	low
OK620900020050_00	OK620900-02-0050H	03/02/09	4.54	10	low
OK620900020050_00	OK620900-02-0050H	04/14/09	77.8	25	high
OK620900020020_00	OK620900-02-0020D	01/05/04	8.23	10	low
OK620900020020_00	OK620900-02-0020D	02/09/04	24.7	22	high
OK620900020020_00	OK620900-02-0020D	03/15/04	10.1	13	high
OK620900020020_00	OK620900-02-0020D	04/19/04	10.2	10	low
OK620900020020_00	OK620900-02-0020D	06/07/04	31.2	20	high
OK620900020020_00	OK620900-02-0020D	05/21/07	9.58		low
OK620900020020_00	OK620900-02-0020D	05/29/07	72.7	27	high
OK620900020020_00	OK620900-02-0020D	06/25/07	25.4	13	high
OK620900020020_00	OK620900-02-0020D	07/03/07			high
OK620900020020_00	OK620900-02-0020D	08/07/07	13.1	10	low

Waterbody ID	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
OK620900020020_00	OK620900-02-0020D	09/10/07	32	20	high
OK620900020020_00	OK620900-02-0020D	10/15/07	13.5	13	low
OK620900020020_00	OK620900-02-0020D	11/13/07	9.94	10	low
OK620900020020_00	OK620900-02-0020D	12/17/07	27	10	high
OK620900020020_00	OK620900-02-0020D	01/22/08	5.93	10	low
OK620900020020_00	OK620900-02-0020D	03/03/08	390	406	high
OK620900020020_00	OK620900-02-0020D	04/07/08	5.47	281	high
OK620900020020_00	OK620900-02-0020D	05/12/08		10	high
OK620900020020_00	OK620900-02-0020D	06/17/08	257	223	high
OK620900020020_00	OK620900-02-0020D	06/24/08			high
OK620900020020_00	OK620900-02-0020D	07/22/08	22	18	low
OK620900020020_00	OK620900-02-0020D	08/26/08	23.7	13	low
OK620900020020_00	OK620900-02-0020D	09/30/08	18.5	13	low
OK620900020020_00	OK620900-02-0020D	11/03/08	7.66	10	low
OK620900020020_00	OK620900-02-0020D	12/15/08	7.12	10	low
OK620900020020_00	OK620900-02-0020D	01/21/09			low
OK620900020020_00	OK620900-02-0020D	02/02/09	3.8	10	low
OK620900020020_00	OK620900-02-0020D	03/02/09	5.5	10	low
OK620900020020_00	OK620900-02-0020D	04/14/09	48.3	12	high
OK620900010290_00	OK620900-01-0290D	01/05/04	15.7	10	low
OK620900010290_00	OK620900-01-0290D	02/09/04	76.7	23	low
OK620900010290_00	OK620900-01-0290D	03/15/04	31.3	29	high
OK620900010290_00	OK620900-01-0290D	04/19/04	14.4	10	low
OK620900010290_00	OK620900-01-0290D	06/07/04	57.4	53	low
OK620900010290_00	OK620900-01-0290D	05/29/07	102	43	high
OK620900010290_00	OK620900-01-0290D	06/25/07	30	21	low
OK620900010290_00	OK620900-01-0290D	07/03/07			high
OK620900010290_00	OK620900-01-0290D	08/07/07	25.3	23	low
OK620900010290_00	OK620900-01-0290D	08/16/07			low
OK620900010290_00	OK620900-01-0290D	09/10/07	62.9	34	high
OK620900010290_00	OK620900-01-0290D	10/04/07	19.8		low
OK620900010290_00	OK620900-01-0290D	10/15/07	20.2	20	low
OK620900010290_00	OK620900-01-0290D	11/13/07	17.1	14	low
OK620900010290_00	OK620900-01-0290D	12/17/07	40.2	10	high
OK620900010290_00	OK620900-01-0290D	01/03/08			low
OK620900010290_00	OK620900-01-0290D	01/22/08	10.4	10	low
OK620900010290_00	OK620900-01-0290D	03/03/08	606	734	high
OK620900010290_00	OK620900-01-0290D	04/07/08	10.8	10	high
OK620900010290_00	OK620900-01-0290D	05/12/08	30.6	25	high

Waterbody ID	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
OK620900010290_00	OK620900-01-0290D	06/17/08	295	212	high
OK620900010290_00	OK620900-01-0290D	06/24/08			high
OK620900010290_00	OK620900-01-0290D	07/22/08	21.9	30	high
OK620900010290_00	OK620900-01-0290D	08/21/08	13.6		low
OK620900010290_00	OK620900-01-0290D	08/26/08	44.4	42	low
OK620900010290_00	OK620900-01-0290D	09/30/08	56.7	35	low
OK620900010290_00	OK620900-01-0290D	11/03/08	11.7	10	low
OK620900010290_00	OK620900-01-0290D	12/15/08	17.4	10	low
OK620900010290_00	OK620900-01-0290D	01/21/09			low
OK620900010290_00	OK620900-01-0290D	02/02/09	6.75	10	low
OK620900010290_00	OK620900-01-0290D	03/02/09	17.3	13	low
OK620900010290_00	OK620900-01-0290D	04/14/09	118	42	high
OK620900010170_10	620900010170-001AT	01/31/06	11		low
OK620900010170_10	620900010170-001AT	02/27/06	17		low
OK620900010170_10	620900010170-001AT	04/04/06	12		low
OK620900010170_10	620900010170-001AT	05/08/06	108		low
OK620900010170_10	620900010170-001AT	06/13/06	18		low
OK620900010170_10	620900010170-001AT	07/26/06	134		low
OK620900010170_10	620900010170-001AT	08/21/06	69		low
OK620900010170_10	620900010170-001AT	10/02/06	114		low
OK620900010170_10	620900010170-001AT	11/06/06			low
OK620900010170_10	620900010170-001AT	12/12/06	18		low
OK620900010170_10	620900010170-001AT	01/29/07	11		low
OK620900010170_10	620900010170-001AT	03/05/07	9		low
OK620900010170_10	620900010170-001AT	04/02/07	1001		low
OK620900010170_10	620900010170-001AT	04/30/07	87		high
OK620900010170_10	620900010170-001AT	06/04/07	672		low
OK620900010170_10	620900010170-001AT	07/16/07	494		high
OK620900010170_10	620900010170-001AT	08/13/07	493		low
OK620900010170_10	620900010170-001AT	09/24/07	38		low
OK620900010170_10	620900010170-001AT	10/22/07	1000		low
OK620900010170_10	620900010170-001AT	11/26/07	12		low
OK620900010170_10	620900010170-001AT	01/28/08	10		low
OK620900010170_10	620900010170-001AT	03/03/08	637		low
OK620900010170_10	620900010170-001AT	04/15/08	432		low
OK620900010170_10	620900010170-001AT	05/27/08	1001		high
OK620900010170_10	620900010170-001AT	07/21/08	47		low
OK620900010170_10	620900010170-001AT	09/15/08	1000		high
OK620900010170_10	620900010170-001AT	11/10/08	328		low

Waterbody ID	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
OK620900010170_10	620900010170-001AT	01/20/09	5		low
OK620900010170_10	620900010170-001AT	01/20/09	5		low
OK620900010170_10	620900010170-001AT	03/16/09	7.75		low
OK620900010170_10	620900010170-001AT	04/13/09	313		low
OK620900010170_10	620900010170-001AT	05/26/09	22		low
OK620900010170_10	620900010170-001AT	07/06/09	37.33		low
OK620900010170_10	620900010170-001AT	08/24/09	1000		low
OK620900010170_10	620900010170-001AT	11/02/09	1000		low
OK620900010170_10	620900010170-001AT	01/04/10	9.7		low
OK620900010170_10	620900010170-001AT	03/15/10	39.3		low
OK620900010170_10	620900010170-001AT	05/17/10	357		low
OK620900010170_10	620900010170-001AT	07/19/10	72.7		low
OK620900010170_10	620900010170-001AT	09/13/10	70.3		low
OK620900010170_10	620900010170-001AT	11/29/10	55.7		low
OK620900010170_10	620900010170-001AT	01/03/11	7.3333		low
OK620900010170_10	620900010170-001AT	03/15/11	14.3		low
OK620900010180_00	OK620900-01-0180J	01/06/04	9.42	10	low
OK620900010180_00	OK620900-01-0180J	02/10/04	46	20	high
OK620900010180_00	OK620900-01-0180J	03/16/04	15.6	19	low
OK620900010180_00	OK620900-01-0180J	04/20/04	8.53	10	low
OK620900010180_00	OK620900-01-0180J	06/08/04	57.1	22	low
OK620900010180_00	OK620900-01-0180J	05/21/07	7.32		low
OK620900010180_00	OK620900-01-0180J	05/29/07	99	37	high
OK620900010180_00	OK620900-01-0180J	06/25/07	24.6	13	high
OK620900010180_00	OK620900-01-0180J	07/03/07			high
OK620900010180_00	OK620900-01-0180J	08/07/07	34.9	43	low
OK620900010180_00	OK620900-01-0180J	09/10/07	120	46	high
OK620900010180_00	OK620900-01-0180J	10/15/07	21.1	15	low
OK620900010180_00	OK620900-01-0180J	11/13/07	8.48	10	low
OK620900010180_00	OK620900-01-0180J	12/17/07	40.6	10	high
OK620900010180_00	OK620900-01-0180J	01/22/08	11.1	10	low
OK620900010180_00	OK620900-01-0180J	03/03/08	761	621	high
OK620900010180_00	OK620900-01-0180J	04/07/08	6.44	10	high
OK620900010180_00	OK620900-01-0180J	05/12/08	18	17	high
OK620900010180_00	OK620900-01-0180J	06/17/08	133	69	high
OK620900010180_00	OK620900-01-0180J	06/24/08			high
OK620900010180_00	OK620900-01-0180J	07/22/08	9.84	10	low
OK620900010180_00	OK620900-01-0180J	08/26/08	9.87	10	low
OK620900010180_00	OK620900-01-0180J	09/30/08	4.6	10	low

Waterbody ID	WQM Station	Date	Turbidity (NTU)	TSS (mg/L)	Flow Condition
OK620900010180_00	OK620900-01-0180J	11/03/08	1.62	10	low
OK620900010180_00	OK620900-01-0180J	12/15/08	12	10	low
OK620900010180_00	OK620900-01-0180J	02/02/09	5.18	10	low
OK620900010180_00	OK620900-01-0180J	03/02/09	3.44	10	low
OK620900010180_00	OK620900-01-0180J	04/14/09	71.5	14	high

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

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

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

b. The watershed average curve number is calculated from soil properties and land cover as described in the U.S. Department of Agriculture (USDA) Publication *TR-55: Urban Hydrology for Small Watersheds*. The soil hydrologic group is extracted from NRCS STATSGO soil data, and land use category from the 2001 National Land Cover Dataset (NLCD). Based on land use and the hydrologic soil group, SCS curve numbers are estimated at the 30-meter resolution of the NLCD grid as shown in Table 7. The average curve number is then calculated from all the grid cells within the delineated watershed.

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

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

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

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).

<u>Furness Method</u>

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.

<u>Wurbs Modified NRCS Method</u>

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:

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

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

Generalized Flow Projection Methodology

In the first several versions of the Oklahoma TMDL toolbox, all flows at ungaged sites that required projection from a gaged site were performed with the Modified NRCS CN method. This led a number of problems with flow projections in the early versions. As described previously, the NRCS method, in common with all others, reproduces the mean or central tendency best but the accuracy of the fit degrades towards the extremes of the frequency spectrum. Part of the degradation in accuracy is due to the quite non-linear nature of the NRCS equations. On the low flow end of the frequency spectrum, Equation 2 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 and no gages are present upstream or downstream, flows will be estimated for the WQM station from a gage on an adjacent watershed of similar size and properties, via the same procedure described above for upstream or downstream gages.

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, Janyary/February 2006, ASCE

Table B-2 Estimated Flow Exceedance Percentiles

WBID	OK620910030040_00	OK620900030260_00	OK620900030230_00	OK620910040140_00	OK620900030010_00	OK620900030080_00	OK620900040040_00	OK620900020050_00	OK620900020020_00	OK620900010310_00	OK620900010290_00	OK620900010170_10	OK620900010180_00
USGS Gage Reference	7160500 (adjacent)	7160500 (adjacent)	7160500 (adjacent)	7160500 (adjacent)	7158000 (downstream)	7160500 (adjacent)	7160500 (adjacent)	7153000 (adjacent)	7153000 (adjacent)	7153000 (adjacent)	7153000 (adjacent)	7164500 (downstream)	7153000 (adjacent)
Projected Gage	3125	3125	3125	3125	3856	3125	3125	3567	3567	3567	3567	3778	3567
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
0	11,821	2,616.5	8,536	3,317	34,071	3,131	25,591	2,739	2,183	450	4,717	231,573	3,032
1	796	176	575	223	2,615	211	1,723	403	321	66.2	695	55,719	446
2	440	97.5	318	124	1,433	117	953	273	217	44.8	470	40,991	302
3	279	61.8	202	78.3	977	74.0	605	202	161	33.1	347	34,869	223
4	192	42.5	138	53.8	720	50.8	415	152	121	25.0	262	30,078	168
5	138	30.6	99.7	38.8	584	36.6	299	121	96.3	19.8	208	26,972	134
6	107	23.6	77.1	30.0	491	28.3	231	95.9	76.4	15.7	165	24,577	106
7	84.7	18.8	61.2	23.8	421	22.4	183	78.8	62.8	12.9	136	22,359	87.3
8	70.3	15.6	50.7	19.7	372	18.6	152	64.7	51.6	10.6	111	20,496	71.6
9	60.6	13.4	43.8	17.0	333	16.1	131	53.5	42.6	8.8	92.1	18,987	59.2
10	54.3	12.0	39.2	15.2	302	14.4	118	45.2	36.0	7.4	77.8	17,656	50.0
11	48.9	10.8	35.3	13.7	278	12.9	106	38.5	30.7	6.3	66.3	16,414	42.6
12	44.0	9.7	31.8	12.4	258	11.7	95.3	33.4	26.6	5.5	57.6	14,906	37.0
13	39.2	8.7	28.3	11.0	238	10.4	84.9	29.7	23.6	4.9	51.1	13,841	32.8
14	35.3	7.8	25.5	9.9	224	9.3	76.4	25.7	20.5	4.2	44.2	12,954	28.4
15	32.0	7.1	23.1	9.0	213	8.5	69.2	22.6	18.1	3.7	39.0	12,155	25.1
16	29.0	6.4	20.9	8.1	202	7.7	62.7	20.2	16.1	3.3	34.7	11,623	22.3
17	26.8	5.9	19.4	7.5	191	7.1	58.1	18.2	14.5	3.0	31.4	11,179	20.2
18	24.4	5.4	17.6	6.9	182	6.5	52.9	16.3	13.0	2.7	28.0	10,736	18.0
19	22.9	5.1	16.5	6.4	173	6.1	49.6	14.7	11.7	2.4	25.3	10,381	16.2

WBID	OK620910030040_00	OK620900030260_00	OK620900030230_00	OK620910040140_00	OK620900030010_00	OK620900030080_00	OK620900040040_00	OK620900020050_00	OK620900020020_00	OK620900010310_00	OK620900010290_00	OK620900010170_10	OK620900010180_00
USGS Gage Reference	**7160500 (adjacent)**	**7160500 (adjacent)**	**7160500 (adjacent)**	**7160500 (adjacent)**	**7158000 (downstream)**	**7160500 (adjacent)**	**7160500 (adjacent)**	**7153000 (adjacent)**	**7153000 (adjacent)**	**7153000 (adjacent)**	**7153000 (adjacent)**	**7164500 (downstream)**	**7153000 (adjacent)**
Projected Gage	**3125**	**3125**	**3125**	**3125**	**3856**	**3125**	**3125**	**3567**	**3567**	**3567**	**3567**	**3778**	**3567**
Percentile	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**	**Q (cfs)**
20	21.4	4.7	15.5	6.0	166	5.7	46.4	13.3	10.6	2.2	22.8	9,848	14.7
21	19.9	4.4	14.4	5.6	159	5.3	43.1	12.1	9.6	2.0	20.8	9,316	13.4
22	18.4	4.1	13.3	5.2	153	4.9	39.8	11.0	8.8	1.8	18.9	8,766	12.2
23	17.2	3.8	12.4	4.8	147	4.6	37.2	10.1	8.1	1.7	17.5	8,331	11.2
24	16.3	3.6	11.8	4.6	141	4.3	35.3	9.3	7.4	1.5	16.0	7,897	10.3
25	15.4	3.4	11.1	4.3	136	4.1	33.3	8.5	6.8	1.4	14.7	7,524	9.4
26	14.5	3.2	10.5	4.1	131	3.8	31.3	7.9	6.3	1.3	13.6	7,204	8.7
27	13.6	3.0	9.8	3.8	125	3.6	29.4	7.2	5.8	1.2	12.4	6,929	8.0
28	13.0	2.9	9.4	3.6	121	3.4	28.1	6.7	5.3	1.1	11.5	6,672	7.4
29	12.4	2.7	8.9	3.5	117	3.3	26.8	6.1	4.9	1.0	10.6	6,388	6.8
30	11.8	2.6	8.5	3.3	112	3.1	25.5	5.7	4.6	0.9	9.8	6,175	6.3
31	11.2	2.5	8.1	3.1	109	3.0	24.2	5.4	4.3	0.9	9.3	5,971	6.0
32	10.6	2.3	7.6	3.0	105	2.8	22.8	5.1	4.0	0.8	8.7	5,732	5.6
33	10.3	2.3	7.4	2.9	101	2.7	22.2	4.7	3.8	0.8	8.2	5,519	5.3
34	10.0	2.2	7.2	2.8	97.7	2.6	21.5	4.4	3.5	0.7	7.6	5,324	4.9
35	9.3	2.1	6.8	2.6	94.4	2.5	20.2	4.2	3.4	0.7	7.2	5,111	4.7
36	9.0	2.0	6.5	2.5	91.1	2.4	19.6	3.9	3.1	0.6	6.7	4,924	4.3
37	8.7	1.9	6.3	2.5	87.8	2.3	18.9	3.7	2.9	0.6	6.3	4,711	4.1
38	8.4	1.9	6.1	2.4	85.2	2.2	18.3	3.6	2.8	0.6	6.1	4,525	3.9
39	8.1	1.8	5.9	2.3	81.9	2.2	17.6	3.3	2.7	0.5	5.8	4,383	3.7
40	7.8	1.7	5.7	2.2	79.2	2.1	17.0	3.1	2.5	0.5	5.4	4,223	3.5

WBID	OK620910030040_00	OK620900030260_00	OK620900030230_00	OK620910040140_00	OK620900030010_00	OK620900030080_00	OK620900040040_00	OK620900020050_00	OK620900020020_00	OK620900010310_00	OK620900010290_00	OK620900010170_10	OK620900010180_00
USGS Gage Reference	7160500 (adjacent)	7160500 (adjacent)	7160500 (adjacent)	7160500 (adjacent)	7158000 (downstream)	7160500 (adjacent)	7160500 (adjacent)	7153000 (adjacent)	7153000 (adjacent)	7153000 (adjacent)	7153000 (adjacent)	7164500 (downstream)	7153000 (adjacent)
Projected Gage	3125	3125	3125	3125	3856	3125	3125	3567	3567	3567	3567	3778	3567
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
41	7.5	1.7	5.4	2.1	76.6	2.0	16.3	2.9	2.3	0.5	5.0	4,081	3.2
42	7.2	1.6	5.2	2.0	74.0	1.9	15.7	2.8	2.2	0.5	4.8	3,922	3.1
43	6.9	1.5	5.0	1.9	71.3	1.8	15.0	2.6	2.1	0.4	4.5	3,797	2.9
44	6.9	1.5	5.0	1.9	69.3	1.8	15.0	2.5	2.0	0.4	4.3	3,638	2.7
45	6.6	1.5	4.8	1.9	66.7	1.8	14.4	2.4	1.9	0.4	4.1	3,531	2.6
46	6.3	1.4	4.6	1.8	64.7	1.7	13.7	2.3	1.8	0.4	3.9	3,398	2.5
47	6.0	1.3	4.4	1.7	62.7	1.6	13.1	2.2	1.7	0.4	3.7	3,283	2.4
48	5.7	1.3	4.1	1.6	60.7	1.5	12.4	2.2	1.7	0.4	3.7	3,176	2.4
49	5.7	1.3	4.1	1.6	58.8	1.5	12.4	2.0	1.6	0.3	3.5	3,061	2.3
50	5.4	1.2	3.9	1.5	57.2	1.4	11.8	1.9	1.5	0.3	3.3	2,959	2.1
51	5.1	1.1	3.7	1.4	55.5	1.4	11.1	1.8	1.5	0.3	3.2	2,857	2.0
52	5.1	1.1	3.7	1.4	52.8	1.4	11.1	1.7	1.4	0.3	3.0	2,777	1.9
53	4.8	1.1	3.5	1.4	51.5	1.3	10.4	1.6	1.3	0.3	2.8	2,671	1.8
54	4.8	1.1	3.5	1.4	48.9	1.3	10.4	1.6	1.3	0.3	2.8	2,582	1.8
55	4.5	1.0	3.3	1.3	46.9	1.2	9.8	1.5	1.2	0.2	2.6	2,520	1.7
56	4.5	1.0	3.3	1.3	45.6	1.2	9.8	1.4	1.1	0.2	2.4	2,431	1.6
57	4.2	0.9	3.0	1.2	43.6	1.1	9.1	1.4	1.1	0.2	2.4	2,342	1.6
58	4.2	0.9	3.0	1.2	41.6	1.1	9.1	1.3	1.0	0.2	2.2	2,271	1.4
59	3.9	0.9	2.8	1.1	39.6	1.0	8.5	1.3	1.0	0.2	2.2	2,183	1.4
60	3.9	0.9	2.8	1.1	37.6	1.0	8.5	1.2	0.9	0.2	2.0	2,129	1.3
61	3.6	0.8	2.6	1.0	35.7	1.0	7.8	1.2	0.9	0.2	2.0	2,058	1.3

WBID	OK620910030040_00	OK620900030260_00	OK620900030230_00	OK620910040140_00	OK620900030010_00	OK620900030080_00	OK620900040040_00	OK620900020050_00	OK620900020020_00	OK620900010310_00	OK620900010290_00	OK620900010170_10	OK620900010180_00
USGS Gage Reference	7160500 (adjacent)	7160500 (adjacent)	7160500 (adjacent)	7160500 (adjacent)	7158000 (downstream)	7160500 (adjacent)	7160500 (adjacent)	7153000 (adjacent)	7153000 (adjacent)	7153000 (adjacent)	7153000 (adjacent)	7164500 (downstream)	7153000 (adjacent)
Projected Gage	3125	3125	3125	3125	3856	3125	3125	3567	3567	3567	3567	3778	3567
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
62	3.6	0.8	2.6	1.0	34.3	1.0	7.8	1.1	0.9	0.2	1.9	1,987	1.2
63	3.6	0.8	2.6	1.0	33.0	1.0	7.8	1.0	0.8	0.2	1.8	1,952	1.1
64	3.3	0.7	2.4	0.9	31.0	0.9	7.2	1.0	0.8	0.2	1.7	1,881	1.1
65	3.3	0.7	2.4	0.9	29.7	0.9	7.2	0.9	0.7	0.2	1.6	1,810	1.0
66	3.3	0.7	2.4	0.9	27.7	0.9	7.2	0.9	0.7	0.1	1.5	1,757	1.0
67	3.0	0.7	2.2	0.8	26.4	0.8	6.5	0.8	0.7	0.1	1.4	1,677	0.9
68	3.0	0.7	2.2	0.8	25.1	0.8	6.5	0.8	0.6	0.1	1.3	1,597	0.9
69	3.0	0.7	2.2	0.8	23.1	0.8	6.5	0.7	0.6	0.1	1.3	1,570	0.8
70	2.9	0.6	2.1	0.8	21.8	0.8	6.2	0.7	0.6	0.1	1.2	1,491	0.8
71	2.8	0.6	2.0	0.8	19.8	0.7	6.1	0.7	0.5	0.1	1.1	1,428	0.7
72	2.7	0.6	2.0	0.8	18.5	0.7	5.9	0.6	0.5	0.1	1.1	1,393	0.7
73	2.7	0.6	1.9	0.7	17.2	0.7	5.7	0.6	0.5	0.1	1.0	1,322	0.7
74	2.6	0.6	1.9	0.7	15.8	0.7	5.5	0.6	0.4	0.1	1.0	1,269	0.6
75	2.5	0.5	1.8	0.7	14.5	0.7	5.4	0.5	0.4	0.1	0.9	1,224	0.6
76	2.4	0.5	1.7	0.7	13.2	0.6	5.2	0.5	0.4	0.1	0.9	1,153	0.5
77	2.3	0.5	1.7	0.7	11.9	0.6	5.0	0.5	0.4	0.1	0.8	1,118	0.5
78	2.2	0.5	1.6	0.6	9.9	0.6	4.8	0.4	0.3	0.1	0.7	1,074	0.5
79	2.1	0.5	1.5	0.6	8.6	0.6	4.6	0.4	0.3	0.1	0.7	1,020	0.5
80	2.1	0.5	1.5	0.6	7.3	0.5	4.4	0.4	0.3	0.1	0.7	985	0.4
81	2.0	0.4	1.4	0.5	6.6	0.5	4.2	0.4	0.3	0.1	0.6	949	0.4
82	1.9	0.4	1.4	0.5	5.3	0.5	4.0	0.3	0.3	0.1	0.6	896	0.4

WBID	OK620910030040_00	OK620900030260_00	OK620900030230_00	OK620910040140_00	OK620900030010_00	OK620900030080_00	OK620900040040_00	OK620900020050_00	OK620900020020_00	OK620900010310_00	OK620900010290_00	OK620900010170_10	OK620900010180_00
USGS Gage Reference	7160500 (adjacent)	7160500 (adjacent)	7160500 (adjacent)	7160500 (adjacent)	7158000 (downstream)	7160500 (adjacent)	7160500 (adjacent)	7153000 (adjacent)	7153000 (adjacent)	7153000 (adjacent)	7153000 (adjacent)	7164500 (downstream)	7153000 (adjacent)
Projected Gage	3125	3125	3125	3125	3856	3125	3125	3567	3567	3567	3567	3778	3567
Percentile	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
83	1.8	0.4	1.3	0.5	4.5	0.5	3.9	0.3	0.2	0.1	0.5	861	0.3
84	1.7	0.4	1.2	0.5	3.6	0.5	3.7	0.3	0.2	0.0	0.5	814	0.3
85	1.7	0.4	1.2	0.5	3.0	0.4	3.6	0.2	0.2	0.0	0.4	762	0.3
86	1.6	0.3	1.1	0.4	2.2	0.4	3.4	0.2	0.2	0.0	0.4	739	0.3
87	1.5	0.3	1.1	0.4	1.7	0.4	3.3	0.2	0.2	0.0	0.4	692	0.2
88	1.4	0.3	1.0	0.4	1.3	0.4	3.1	0.2	0.1	0.0	0.3	648	0.2
89	1.4	0.3	1.0	0.4	0.8	0.4	2.9	0.2	0.1	0.0	0.3	612	0.2
90	1.3	0.3	0.9	0.4	0.5	0.3	2.7	0.1	0.1	0.0	0.2	559	0.1
91	1.2	0.3	0.9	0.3	0.3	0.3	2.6	0.1	0.1	0.0	0.2	515	0.1
92	1.1	0.2	0.8	0.3	0.1	0.3	2.4	0.1	0.1	0.0	0.2	470	0.1
93	1.1	0.2	0.8	0.3	0.0	0.3	2.3	0.1	0.1	0.0	0.1	410	0.1
94	1.0	0.2	0.7	0.3	0.0	0.3	2.1	0.1	0.0	0.0	0.1	355	0.1
95	0.9	0.2	0.6	0.2	0.0	0.2	1.9	0.0	0.0	0.0	0.1	310	0.0
96	0.8	0.2	0.5	0.2	0.0	0.2	1.6	0.0	0.0	0.0	0.0	261	0.0
97	0.6	0.1	0.5	0.2	0.0	0.2	1.4	0.0	0.0	0.0	0.0	206	0.0
98	0.5	0.1	0.3	0.1	0.0	0.1	1.0	0.0	0.0	0.0	0.0	165	0.0
99	0.2	0.0	0.2	0.1	0.0	0.1	0.5	0.0	0.0	0.0	0.0	102	0.0
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.7	0.0

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

NPDES DISCHARGE MONITORING REPORT DATA

Table D-1 NPDES Discharge Monitoring Report Data

NPDES No.	Outfall	Monitoring Date	Max FC Concentration (cfu/100ml)	Average FC Concentration (cfu/100ml)	Max TSS (mg/L)	Average TSS (mg/L)
OK0026077	001	7/31/2006	88	20		
OK0026077	001	8/31/2006	93	21		
OK0026077	001	9/30/2006	194	24		
OK0026077	001	10/31/2006				
OK0026077	001	11/30/2006				
OK0026077	001	12/31/2006				
OK0026077	001	1/31/2006				
OK0026077	001	2/28/2007				
OK0026077	001	3/31/2007				
OK0026077	001	4/30/2007				
OK0026077	001	5/31/2007	252	14		
OK0026077	001	6/30/2007	90	23		
OK0026077	001	7/31/2007	102	26		
OK0026077	001	8/31/2007	**471***	64		
OK0026077	001	9/30/2007	237	17		
OK0026077	001	10/31/2007				
OK0026077	001	11/30/2007				
OK0026077	001	12/31/2007				
OK0026077	001	1/31/2008				
OK0026077	001	2/29/2008				
OK0026077	001	3/31/2008				
OK0026077	001	4/30/2008				
OK0026077	001	5/31/2008	7	4		
OK0026077	001	6/30/2008	102	86		
OK0026077	001	7/31/2008	45	41		
OK0026077	001	8/31/2008	26	25		
OK0026077	001	9/30/2008	48	34		
OK0026077	001	10/31/2008				
OK0026077	001	11/30/2008				
OK0026077	001	12/31/2008				
OK0026077	001	1/31/2009				
OK0026077	001	2/28/3009				
OK0026077	001	3/31/2009				
OK0026077	001	4/30/2009				
OK0026077	001	5/31/2009	6	4		
OK0026077	001	6/30/2009	61	16		
OK0026077	001	7/31/2009	109	40		

* Red highlights show permit limit exceedances for TSS and FC. Facility permit limits are shown in **Table 3-1 Point Source Discharges in the Study Area**.

NPDES No.	Outfall	Monitoring Date	Max FC Concentration (cfu/100ml)	Average FC Concentration (cfu/100ml)	Max TSS (mg/L)	Average TSS (mg/L)
OK0026077	001	8/31/2009	60	38		
OK0026077	001	9/30/2009	67	58		
OK0026077	001	10/31/2009				
OK0026077	001	11/30/2009				
OK0026077	001	12/31/2009				
OK0026077	001	1/31/2010				
OK0026077	001	2/28/2010				
OK0026077	001	3/31/2010				
OK0026077	001	4/30/2010				
OK0026077	001	5/31/2010	17	16		
OK0026077	001	6/30/2010	191	42		
OK0026077	001	7/31/2010	59	42		
OK0026077	001	8/31/2010	59	55		
OK0026077	001	9/30/2010	165	129		
OK0026077	001	10/31/2010				
OK0026077	001	11/30/2010				
OK0026077	001	12/31/2010				
OK0026077	001	1/31/2011				
OK0026077	001	2/28/2011				
OK0026077	001	3/31/2011				
OK0026077	001	4/30/2011				
OK0026077	001	5/31/2011	23	5		
OK0026077	001	6/30/2011	101	93		
OK0027511	001	7/31/2006	25	10		
OK0027511	001	8/31/2006				
OK0027511	001	9/30/2006	1	1		
OK0027511	001	10/31/2006				
OK0027511	001	11/30/2006				
OK0027511	001	12/31/2006				
OK0027511	001	1/31/2006				
OK0027511	001	2/28/2007				
OK0027511	001	3/31/2007				
OK0027511	001	4/30/2007				
OK0027511	001	5/31/2007	1	1		
OK0027511	001	6/30/2007	1	1		
OK0027511	001	7/31/2007	1	1		
OK0027511	001	8/31/2007	1	1		
OK0027511	001	9/30/2007	1	1		
OK0027511	001	10/31/2007				
OK0027511	001	11/30/2007				
OK0027511	001	12/31/2007				
OK0027511	001	1/31/2008				
OK0027511	001	2/29/2008				

NPDES No.	Outfall	Monitoring Date	Max FC Concentration (cfu/100ml)	Average FC Concentration (cfu/100ml)	Max TSS (mg/L)	Average TSS (mg/L)
OK0027511	001	3/31/2008				
OK0027511	001	4/30/2008				
OK0027511	001	5/31/2008	1	1		
OK0027511	001	6/30/2008	**670***[*]	**260***[*]		
OK0027511	001	7/31/2008	31	22		
OK0027511	001	8/31/2008	2	1		
OK0027511	001	9/30/2008	85	24		
OK0027511	001	10/31/2008				
OK0027511	001	11/30/2008				
OK0027511	001	12/31/2008				
OK0027511	001	1/31/2009				
OK0027511	001	2/28/3009				
OK0027511	001	3/31/2009				
OK0027511	001	4/30/2009				
OK0027511	001	5/31/2009	2	1		
OK0027511	001	6/30/2009	7	3		
OK0027511	001	7/31/2009	6	2		
OK0027511	001	8/31/2009	5	2		
OK0027511	001	9/30/2009	2	1		
OK0027511	001	10/31/2009				
OK0027511	001	11/30/2009				
OK0027511	001	12/31/2009				
OK0027511	001	1/31/2010				
OK0027511	001	2/28/2010				
OK0027511	001	3/31/2010				
OK0027511	001	4/30/2010				
OK0027511	001	5/31/2010	18	5		
OK0027511	001	6/30/2010	12	3		
OK0027511	001	7/31/2010	2	2		
OK0027511	001	8/31/2010	31	5		
OK0027511	001	9/30/2010	6	2		
OK0027511	001	10/31/2010				
OK0027511	001	11/30/2010				
OK0027511	001	12/31/2010				
OK0027511	001	1/31/2011				
OK0027511	001	2/28/2011				
OK0027511	001	3/31/2011				
OK0027511	001	4/30/2011				
OK0027511	001	5/31/2011	31	2		

[*] Red highlights show permit limit exceedances for TSS and FC. Facility permit limits are shown in **Table 3-1 Point Source Discharges in the Study Area**.

NPDES No.	Outfall	Monitoring Date	Max FC Concentration (cfu/100ml)	Average FC Concentration (cfu/100ml)	Max TSS (mg/L)	Average TSS (mg/L)
OK0027511	001	6/30/2011	24	2		
OK0028801	001	2/28/2007				
OK0028801	001	3/31/2007				
OK0028801	001	4/30/2007				
OK0028801	001	5/31/2007				
OK0028801	001	6/30/2007				
OK0028801	001	7/31/2007				
OK0028801	001	8/31/2007				
OK0028801	001	9/30/2007				
OK0028801	001	10/31/2007				
OK0028801	001	11/30/2007				
OK0028801	001	12/31/2007				
OK0028801	001	1/31/2008				
OK0028801	001	2/29/2008				
OK0028801	001	3/31/2008				
OK0028801	001	4/30/2008				
OK0028801	001	5/31/2008				
OK0028801	001	6/30/2008				
OK0028801	001	7/31/2008				
OK0028801	001	8/31/2008				
OK0028801	001	9/30/2008				
OK0028801	001	10/31/2008				
OK0028801	001	11/30/2008				
OK0028801	001	12/31/2008				
OK0028801	001	1/31/2009				
OK0028801	001	2/28/3009				
OK0028801	001	3/31/2009				
OK0028801	001	4/30/2009				
OK0028801	001	5/31/2009				
OK0028801	001	6/30/2009				
OK0028801	001	7/31/2009				
OK0028801	001	8/31/2009				
OK0028801	001	9/30/2009				
OK0028801	001	11/30/2009				
OK0028801	001	12/31/2009				
OK0028801	001	1/31/2010				
OK0028801	001	2/28/2010				
OK0028801	001	3/31/2010				
OK0028801	001	4/30/2010				
OK0028801	001	5/31/2010				

NPDES No.	Outfall	Monitoring Date	Max FC Concentration (cfu/100ml)	Average FC Concentration (cfu/100ml)	Max TSS (mg/L)	Average TSS (mg/L)
OK0028801	001	6/30/2010				
OK0028801	001	7/31/2010	3500*	798*		
OK0028801	001	8/31/2010	2300*	1006*		
OK0028801	001	9/30/2010	3200*	1186*		
OK0028801	001	10/31/2010				
OK0028801	001	11/30/2010				
OK0028801	001	12/31/2010				
OK0028801	001	1/31/2011				
OK0028801	001	2/28/2011				
OK0028801	001	3/31/2011				
OK0028801	001	4/30/2011				
OK0028801	001	5/31/2011	11000*	9258*		
OK0028801	001	6/30/2011	18000*	10221*		
OKG580029	001	12/31/2006				
OKG580029	001	1/31/2006				
OKG580029	001	2/28/2007				
OKG580029	001	3/31/2007				
OKG580029	001	4/30/2007				
OKG580029	001	5/31/2007				
OKG580029	001	6/30/2007				
OKG580029	001	7/31/2007				
OKG580029	001	8/31/2007				
OKG580029	001	9/30/2007				
OKG580029	001	10/31/2007				
OKG580029	001	11/30/2007				
OKG580029	001	12/31/2007				
OKG580029	001	1/31/2008				
OKG580029	001	2/29/2008				
OKG580029	001	3/31/2008				
OKG580029	001	4/30/2008				
OKG580029	001	5/31/2008				
OKG580029	001	6/30/2008				
OKG580029	001	7/31/2008				
OKG580029	001	8/31/2008				
OKG580029	001	9/30/2008				
OKG580029	001	10/31/2008				

* Red highlights show permit limit exceedances for TSS and FC. Facility permit limits are shown in **Table 3-1 Point Source Discharges in the Study Area**.

* Red highlights show permit limit exceedances for TSS and FC. Facility permit limits are shown in **Table 3-1 Point Source Discharges in the Study Area**.

NPDES No.	Outfall	Monitoring Date	Max FC Concentration (cfu/100ml)	Average FC Concentration (cfu/100ml)	Max TSS (mg/L)	Average TSS (mg/L)
OKG580029	001	11/30/2008				
OKG580029	001	12/31/2008				
OKG580029	001	1/31/2009				
OKG580029	001	2/28/3009				
OKG580029	001	3/31/2009				
OKG580029	001	4/30/2009				
OKG580029	001	5/31/2009				
OKG580029	001	9/30/2009				
OKG580029	001	10/31/2009				
OKG580029	001	11/30/2009				
OKG580029	001	12/31/2009				
OKG580029	001	1/31/2010				
OKG580029	001	2/28/2010				
OKG580029	001	3/31/2010				
OKG580029	001	4/30/2010				
OKG580029	001	5/31/2010				
OKG580029	001	6/30/2010				
OKG580029	001	7/31/2010				
OKG580029	001	9/30/2010				
OKG580029	001	10/31/2010				
OKG580029	001	11/30/2010				
OKG580029	001	12/31/2010				
OKG580029	001	1/31/2011				
OKG580029	001	2/28/2011				
OKG580029	001	3/31/2011				
OK0026701	001	7/31/2006	**900***	53.3		
OK0026701	001	8/31/2006	130	21.1		
OK0026701	001	9/30/2006	**430***	42.8		
OK0026701	001	10/31/2006				
OK0026701	001	11/30/2006				
OK0026701	001	12/31/2006				
OK0026701	001	1/31/2006				
OK0026701	001	2/28/2007				
OK0026701	001	3/31/2007				
OK0026701	001	4/30/2007				
OK0026701	001	5/31/2007	37	3.6		
OK0026701	001	6/30/2007	16	6.6		
OK0026701	001	7/31/2007	40	6.8		
OK0026701	001	8/31/2007	16	2.7		

* Red highlights show permit limit exceedances for TSS and FC. Facility permit limits are shown in **Table 3-1 Point Source Discharges in the Study Area**.

NPDES No.	Outfall	Monitoring Date	Max FC Concentration (cfu/100ml)	Average FC Concentration (cfu/100ml)	Max TSS (mg/L)	Average TSS (mg/L)
OK0026701	001	9/30/2007	150	41.7		
OK0026701	001	10/31/2007				
OK0026701	001	11/30/2007				
OK0026701	001	12/31/2007				
OK0026701	001	1/31/2008				
OK0026701	001	2/29/2008				
OK0026701	001	3/31/2008				
OK0026701	001	4/30/2008				
OK0026701	001	5/31/2008	50	13.8		
OK0026701	001	6/30/2008	43	7.5		
OK0026701	001	7/31/2008	**420***	62.8		
OK0026701	001	8/31/2008	27	4.9		
OK0026701	001	9/30/2008	37	9.9		
OK0026701	001	10/31/2008				
OK0026701	001	11/30/2008				
OK0026701	001	12/31/2008				
OK0026701	001	1/31/2009				
OK0026701	001	2/28/3009				
OK0026701	001	3/31/2009				
OK0026701	001	4/30/2009				
OK0026701	001	5/31/2009	86	20.4		
OK0026701	001	6/30/2009	340	55.7		
OK0026701	001	7/31/2009	**1400***	8.9		
OK0026701	001	8/31/2009	230	11.2		
OK0026701	001	9/30/2009	**4100***	50.6		
OK0026701	001	10/31/2009				
OK0026701	001	11/30/2009				
OK0026701	001	12/31/2009				
OK0026701	001	1/31/2010				
OK0026701	001	2/28/2010				
OK0026701	001	3/31/2010				
OK0026701	001	4/30/2010				
OK0026701	001	5/31/2010	**820***	28.4		
OK0026701	001	6/30/2010	**460***	91.4		
OK0026701	001	7/31/2010	220	25		
OK0026701	001	8/31/2010	**720***	76.4		
OK0026701	001	9/30/2010	120	14.2		
OK0026701	001	10/31/2010				
OK0026701	001	11/30/2010				

* Red highlights show permit limit exceedances for TSS and FC. Facility permit limits are shown in **Table 3-1 Point Source Discharges in the Study Area**.

NPDES No.	Outfall	Monitoring Date	Max FC Concentration (cfu/100ml)	Average FC Concentration (cfu/100ml)	Max TSS (mg/L)	Average TSS (mg/L)
OK0026701	001	12/31/2010				
OK0026701	001	1/31/2011				
OK0026701	001	2/28/2011				
OK0026701	001	3/31/2011				
OK0026701	001	4/30/2011				
OK0026701	001	5/31/2011	260	18.4		
OK0026701	001	6/30/2011	39	8.9		
OK0022501	001	7/31/2006	320	45		
OK0022501	001	8/31/2006	53	18		
OK0022501	001	9/30/2006	**400***	87.3		
OK0022501	001	10/31/2006				
OK0022501	001	11/30/2006				
OK0022501	001	12/31/2006				
OK0022501	001	1/31/2006				
OK0022501	001	2/28/2007				
OK0022501	001	3/31/2007				
OK0022501	001	4/30/2007				
OK0022501	001	5/31/2007	**1263***	**560***		
OK0022501	001	6/30/2007	100	32		
OK0022501	001	7/31/2007	**2800***	**245***		
OK0022501	001	8/31/2007	**1236***	**219***		
OK0022501	001	9/30/2007	62	16		
OK0022501	001	10/31/2007				
OK0022501	001	11/30/2007				
OK0022501	001	12/31/2007				
OK0022501	001	1/31/2008				
OK0022501	001	2/29/2008				
OK0022501	001	3/31/2008				
OK0022501	001	4/30/2008				
OK0022501	001	5/31/2008	48	3.6		
OK0022501	001	6/30/2008	140	16		
OK0022501	001	7/31/2008	1	1		
OK0022501	001	8/31/2008	**590***	8		
OK0022501	001	9/30/2008	1	1		
OK0022501	001	10/31/2008				
OK0022501	001	11/30/2008				
OK0022501	001	12/31/2008				
OK0022501	001	1/31/2009				
OK0022501	001	2/28/3009				

* Red highlights show permit limit exceedances for TSS and FC. Facility permit limits are shown in **Table 3-1 Point Source Discharges in the Study Area**.

NPDES No.	Outfall	Monitoring Date	Max FC Concentration (cfu/100ml)	Average FC Concentration (cfu/100ml)	Max TSS (mg/L)	Average TSS (mg/L)
OK0022501	001	3/31/2009				
OK0022501	001	4/30/2009				
OK0022501	001	5/31/2009	200	102		
OK0022501	001	6/30/2009	**440***	62		
OK0022501	001	7/31/2009	**2100***	199		
OK0022501	001	8/31/2009	100	54		
OK0022501	001	9/30/2009	97	59		
OK0022501	001	10/31/2009				
OK0022501	001	11/30/2009				
OK0022501	001	12/31/2009				
OK0022501	001	1/31/2010				
OK0022501	001	2/28/2010				
OK0022501	001	3/31/2010				
OK0022501	001	4/30/2010				
OK0022501	001	5/31/2010	2	1.3		
OK0022501	001	6/30/2010	22	3.5		
OK0022501	001	7/31/2010	31	4		
OK0022501	001	8/31/2010	37	7		
OK0022501	001	9/30/2010	6	1.8		
OK0022501	001	10/31/2010				
OK0022501	001	11/30/2010				
OK0022501	001	12/31/2010				
OK0022501	001	1/31/2011				
OK0022501	001	2/28/2011				
OK0022501	001	3/31/2011				
OK0022501	001	4/30/2011				
OK0022501	001	5/31/2011	**700***	101		
OK0022501	001	6/30/2011	34	23		
OK0035599	001	7/31/2006				
OK0035599	001	8/31/2006				
OK0035599	001	9/30/2006				
OK0035599	001	10/31/2006				
OK0035599	001	11/30/2006				
OK0035599	001	12/31/2006				
OK0035599	001	1/31/2006				
OK0035599	001	2/28/2007				
OK0035599	001	3/31/2007				
OK0035599	001	4/30/2007				
OK0035599	001	5/31/2007				

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NPDES No.	Outfall	Monitoring Date	Max FC Concentration (cfu/100ml)	Average FC Concentration (cfu/100ml)	Max TSS (mg/L)	Average TSS (mg/L)
OK0035599	001	6/30/2007				
OK0035599	001	8/31/2007				
OK0035599	001	9/30/2007				
OK0035599	001	10/31/2007				
OK0035599	001	11/30/2007				
OK0035599	001	12/31/2007				
OK0035599	001	1/31/2008				
OK0035599	001	2/29/2008				
OK0035599	001	3/31/2008				
OK0035599	001	4/30/2008				
OK0035599	001	5/31/2008				
OK0035599	001	6/30/2008				
OK0035599	001	7/31/2008				
OK0035599	001	8/31/2008				
OK0035599	001	9/30/2008				
OK0035599	001	10/31/2008				
OK0035599	001	11/30/2008				
OK0035599	001	12/31/2008				
OK0035599	001	5/31/2009				
OK0035599	001	6/30/2009	0	0		
OK0035599	001	7/31/2009				
OK0035599	001	8/31/2009				
OK0035599	001	9/30/2009				
OK0035599	001	10/31/2009				
OK0035599	001	11/30/2009				
OK0035599	001	12/31/2009				
OK0035599	001	1/31/2010				
OK0035599	001	2/28/2010				
OK0035599	001	3/31/2010				
OK0035599	001	4/30/2010				
OK0035599	001	5/31/2010	0	0		
OK0035599	001	6/30/2010				
OK0035599	001	7/31/2010	0	0		
OK0035599	001	9/30/2010	**580***	**490***		
OK0035599	001	10/31/2010				
OK0035599	001	11/30/2010				
OK0035599	001	12/31/2010				
OK0035599	001	1/31/2011				
OK0035599	001	2/28/2011				

* Red highlights show permit limit exceedances for TSS and FC. Facility permit limits are shown in **Table 3-1 Point Source Discharges in the Study Area**.

NPDES No.	Outfall	Monitoring Date	Max FC Concentration (cfu/100ml)	Average FC Concentration (cfu/100ml)	Max TSS (mg/L)	Average TSS (mg/L)
OK0035599	001	3/31/2011				
OK0035599	001	4/30/2011				
OK0035599	001	5/31/2011				
OK0035599	001	6/30/2011	320	**320***		
OK0043320	001A	6/30/2007			2	2
OK0043320	001A	7/31/2007			2	2
OK0043320	001A	8/31/2007			0	0
OK0043320	001A	9/30/2007			0	0
OK0043320	001A	12/31/2007			0	0
OK0043320	001A	2/29/2008			4	4
OK0043320	001A	4/30/2008			3	3
OK0043320	001A	5/31/2008			4	4
OK0043320	001A	6/30/2008			2	2
OK0043320	001A	9/30/2008			0	0
OK0043320	001A	10/31/2008			4	4
OK0043320	001A	12/31/2008			3	3
OK0043320	001A	2/28/2009			0	0
OK0043320	001A	6/30/2009			0	0
OK0043320	001A	8/31/2009			0	0
OK0043320	001A	10/31/2009			0	0
OK0043320	001A	11/30/2009			0	0
OK0043320	001A	2/28/2010			2.5	2.5
OK0043320	001A	3/31/2010			0	0
OK0043320	001A	5/31/2010			0	0
OK0043320	001A	6/30/2010			3	3
OK0043320	001A	7/31/2010			2.5	2.5
OK0043320	001A	12/31/2010			0	0
OK0043320	001A	5/31/2011			3.5	3.5
OK0043320	001A	1/31/2012			0	0
OK0043320	001A	3/31/2012			0	0
OK0043320	001A	5/31/2012			0	0

APPENDIX E

DEQ SANITARY SEWER OVERFLOW DATA – 1990-2007

Table E-1 DEQ Sanitary Sewer Overflow Data

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
COVINGTON	S20936	5/9/1995	2.00	LAGOON CELL(EVAPORATION PONDS)	115		X	RAIN I/I
COVINGTON	S20936	10/28/1996	288.00	LAGOON	0			CELLS WERE FULL & SEVERE DAMAGE WAS OCCURRING TO DIKE WALLS
COVINGTON	S20936	5/7/1998		LAGOONS				RAIN
COVINGTON	S20936	11/2/1998		LAGOON ON S.W. SIDE OF TOWN			X	RAINFALL
COVINGTON	S20936	3/10/1999		TOWN LAGOONS	>4 MILLN		X	RAINS
COVINGTON	S20936	5/1/1999		LAGOON			X	LAGOONS FULL
COVINGTON	S20936	4/12/2001		LAGOON			X	PITS FULL
COVINGTON	S20936	11/1/2002	0.00	S.W. OF TOWN	605,200	X		RAIN
COVINGTON	S20936	11/1/2002	0.00	S.W. OF TOWN				RAIN
COVINGTON	S20936	11/1/2002	0.00	LAGOON				RAIN
COVINGTON	S20936	11/1/2002	0.00	LAGOON				RAIN
COVINGTON	S20936	11/15/2002	0.00					
COVINGTON	S20936	11/8/2002	0.00					
COVINGTON	S20936	11/12/2002	0.00					
COVINGTON	S20936	11/18/2002	0.00					
COVINGTON	S20936	11/21/2002	0.00					
COVINGTON	S20936	11/30/2002	0.00					
COVINGTON	S20936	3/21/2003	0.00					
BETHANY/WARR ACRES	S20925	1/5/1990		NW 40 & HAMMOND SE CORNER	0			BLOCKAGE
BETHANY/WARR ACRES	S20925	2/28/1990		MANHOLE AT 7321 N. HAMMOND				HEAVY RAINFALL
BETHANY/WARR ACRES	S20925	3/14/1990		192ND ST. & EDMOND ROAD	30,000			DISCHARGE FROM AN INFLUENT
BETHANY/WARR ACRES	S20925	4/13/1990		FLOOD PUMP LINE AT THE PLANT DISCHARGE				VALVE FAILURE AND EXCESSIVE RAINFALL
BETHANY/WARR ACRES	S20925	4/17/1990		NOT GIVIN	0			HEAVY RAINS
BETHANY/WARR ACRES	S20925	7/3/1990		NW 43 ST. 1.5 BLOCKS WEST OF MERIDIAN	2,000			OLD LINE BACKFEEDING TO LOCATION DUE TO

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
								OBSTRUCTION
BETHANY/WARR ACRES	S20925	8/14/1990		ARBYS NW HWY				PRIVATE LINE BLOCK
BETHANY/WARR ACRES	S20925	8/14/1990		WESTERN SIZZLIN				SERVICE LINE BLOCK
BETHANY/WARR ACRES	S20925	3/28/1991		8301 NW 39TH EXPRESSWAY	120			
BETHANY/WARR ACRES	S20925	7/3/1991	4.00	MANHOLE BETWEEN 192ND AND EDMOND ROAD IN AN OPEN FIELD	40,000			RAIN
BETHANY/WARR ACRES	S20925	7/3/1991	4.00	192TH EDMOND ROAD S OF DANFORTH IN FIELD	40,000	X		HEAVY RAIN
BETHANY/WARR ACRES	S20925	7/4/1991	386.00	Bluff Creek WWTP	34,560	X		Defective concrete pipe over Bluff Creek
BETHANY/WARR ACRES	S20925	10/3/1991	7.00	7800 N.W. 23RD	8	X		COLAPSED LINE
BETHANY/WARR ACRES	S20925	10/4/1991	7.00	7824 NW 21	8,400	X		LINE COLLAPSED
BETHANY/WARR ACRES	S20925	10/24/1991	3.00	7824 NW 21	4,800	X		LINE STOPPAGE
BETHANY/WARR ACRES	S20925	10/25/1991	3.00	7824 NW 21st Street	8,400	X		Collapsed Line
BETHANY/WARR ACRES	S20925	11/5/1991	0.00	6200 N. W. 31st	200	X		Grease in the line
BETHANY/WARR ACRES	S20925	11/6/1991	22.00	2100 College in Bethany	6,500	X		Mechanical Failure of pumps in Lift Sta. 3 blocks away
BETHANY/WARR ACRES	S20925	11/12/1991	4.00	2001 Keeton	1,700	x		Road surface - sludge in the lines
BETHANY/WARR ACRES	S20925	11/12/1991	9.00	2104 College	3,800	x		Road surface - Sludge in the sewage lines.
BETHANY/WARR ACRES	S20925	12/12/1991	3.00	1/2 MILE S OF PLANT BETWEEN 192ND AND EDMOND ROAD		X		HEAVY RAINFALL
BETHANY/WARR ACRES	S20925	12/20/1991	0.00	South of plant	0	X		Flooding of the area South of 192nd
BETHANY/WARR ACRES	S20925	1/8/1992		WWTP		X	X	HYDROLIC OVERLAD OF PLANT BY RAINFALL
BETHANY/WARR ACRES	S20925	2/18/1992	45.00	2104 North College	700	x		impeler quit turning in pump
BETHANY/WARR ACRES	S20925	10/10/1992	2.00	8301 NW 39TH	15,000	X		LIFT STATION FAILURE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
BETHANY/WARR ACRES	S20925	3/16/1993	11.00	NW 25TH AND PENIEL	1,100	X		STATION CONTROLS BURNED OUT
BETHANY/WARR ACRES	S20925	3/16/1993	14.00	8301 N W 39TH	27,000	X		POWER OUTAGE
WARR ACRES	S20925	5/6/1993	5.00	NW 66TH AND CHEROKEE DRIVE	25	X		DEBRIS IN MANHOLE
BETHANY/WARR ACRES	S20925	5/8/1993	1.00	200 FT. NORTH OF NORTHWEST 192ND.		X		EXCESSIVE RAINFALL
BETHANY/WARR ACRES	S20925	5/8/1993	12.00	2105 N COLLEGE		X		RAIN STORM
BETHANY/WARR ACRES	S20925	5/8/1993	12.00	2001 KEETON		X		RAIN STORM
BETHANY/WARR ACRES	S20925	5/8/1993	12.00	7809 NW 29TH ST		X		RAIN STORM
BETHANY/WARR ACRES	S20925	5/8/1993	12.00	2502 EAGLE LANE		X		RAIN STORM
BETHANY/WARR ACRES	S20925	5/8/1993	0.00	BLUFF CREEK PLANT SOUTH OF PLANT		X		HYDROLIC OVERLOAD FROM I/I
WARR ACRES	S20925	5/8/1993	29.00	5801 NW 56TH		X		EXCESSIVE RAINFALL
WARR ACRES	S20925	5/8/1993	29.00	5748 NW 48TH		X		EXCESSIVE RAINFALL
WARR ACRES	S20925	5/8/1993	29.00	6124 COVINGTON LANE		X		EXCESSIVE RAINFALL
WARR ACRES	S20925	5/8/1993	29.00	NW 65 & MAC ARUTHER		X		EXCESSIVE RAINFALL
BETHANY/WARR ARCES	S20925	6/23/1993	1.00	3100 N GRANT	4,500	X		LINE STOPPAGE
BETHANY\WARR ACRES	S20925	7/29/1993	8.00	N W 30TH & PENIL LIFT STATION		X		PUMP FAILURE
BETHANY	S20925	2/23/1994	1.00	1711 N GLEASON	500	X		GREASE BLOCKAGE
BETHANY	S20925	4/21/1994	0.00	7920 NW 21ST	500	X		LIFT STATION BUBBLER LEAK
BETHANY	S20925	5/10/1994	1.00	7824 21ST ST	0	X		GREASE BLOCKAGE
BETHANY	S20925	5/10/1994	1.00	7204 44TH	100	X		GREASE STOPPAGE
BETHANY	S20925	5/10/1994	2.00	6609 29TH ST	250	X		GREASE BLOCKAGE
BETHANY	S20925	5/11/1994	1.00	6609 29TH	100	X		GREASE BLOCKAGE
BETHANY	S20925	5/17/1994	1.00	7920 21ST ST	1,500	X		BUBBLER WENT OUT
BETHANY	S20925	5/17/1994	2.00	3106 PENIEL(LIFT sTATION)	2,250	X		ELECTRICAL FAILURE
BETHANY	S20925	5/19/1994	3.00	2502 EAGLE	1,800	X	X	CONTROL FAILURE AT LIFT STATION

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
BETHANY	S20925	5/19/1994	2.00	8304 NW 34TH	1,800	X	X	ROOT STOPPAGE
BETHANY	S20925	5/26/1994	1.00	3106 PENIEL	1,800	X		LIFT STATION CONTROLS FAILED
BETHANY	S20925	6/4/1994	1.00	6012 32ND ST	100	X		RAINFALL I/I
BETHANY	S20925	6/4/1994	1.00	2502N EAGLE LANE LIFT STATION	200	X		STROM WATER PUMP FAILURE
BETHANY	S20925	6/6/1994	1.00	2502 EAGLE LIFT STATION	50	X		FLOAT FAILED
BETHANY	S20925	6/14/1994	1.00	7824 N W 21ST STREET	120	X		GREASE STOPPAGE
BETHANY	S20925	6/14/1994	2.00	7824 N W 21ST STREET	250	X		GREASE STOPPAGE
BETHANY	S20925	8/15/1994	1.00	8301 N W 39TH STREET	30,000	X		LIFT STATION PUYMP FAILED
BETHANY	S20925	9/2/1994		7532 NW 23RD	48,000	X		COLLAPSED LINE
BETHANY	S20925	9/26/1994	1.00	1712 ROCKWELL	400	X		LINE BLOCKAGE
BETHANY	S20925	9/26/1994	2.00	3114 COLLEGE	1,100	X		LINE BLOCKAGE
BETHANY	S20925	9/26/1994	1.00	6300 NW 32ND	2,000	X		LINE BLOCKAGE
BETHANY	S20925	9/26/1994	3.00	RECOVERY POND	100,000	X		OPERATION ERROR
BETHANY	S20925	11/24/1994	13.00	8336 N W 25TH STREET	21,000	X		DEBRIS BLOCKAGE(GRASS CLIPPINGS)
BETHANY	S20925	12/29/1994	3.00	6703 NW 59TH TERRACE	500	X		ROOT STOPPAGE
BETHANY	S20925	12/31/1994	2.00	3102 PINAL ST	500	X		ELECTRICAL FAILURE
BETHANY	S20925	12/31/1994	12.00	6703 59TH TERRACE ST	2,000	X		ROOTS AND GREASE BLOCKAGE
BETHANY	S20925	2/22/1995	24.00	28TH AND EULER LIFT STATION	40	X		AIR RELIEF VALVE LEAKED
POTEAU	S20925	2/22/1995	120.00	1706 1/2 CENTRAL STREET	300	X		LINE PLUGGED
BETHANY	S20925	5/4/1995	12.00	8301 NW 39TH EXPRESSWAY(LIFT STATION)	300,000	X		FORCE MAIN BROKE AT LIFT STATION
BETHANY WARR ACRES	S20925	5/8/1995	12.00	SOUTH OF WWTP IN A FIELD	0	X		RAIN I/I
OKC (BLUFF CREEK)	S20925	5/26/1995	24.00	S OF NW 192 & PORTLAND	0	X		RAIN I/I
BETHANY	S20925	5/26/1995	4.00	6611 NW 24TH	10,000	X		RAIN I/I
BETHANY	S20925	5/26/1995	4.00	2105 COLLEGE	10,000	X		RAIN I/I
BETHANY	S20925	5/26/1995	4.00	2001 KEETON	10,000	X		RAIN I/I
BETHANY	S20925	5/26/1995	4.00	6804 24TH CIRCLE	10,000	X		RAIN I/I

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
BETHANY	S20925	5/26/1995	4.00	2502 EAGLE LANE	10,000	X		RAIN I/I
BETHANY WARR ACRES	S20925	6/5/1995	6.00	BETWEEN 192ND AND 178TH,4301 N W 192ND	0	X		RAIN I/I
BETHANY	S20925	7/24/1995	48.00	6801 NW 23RD LIFT STATION	30,000	X		LOST POWER DUE TO STORM DAMAGE
BETHANY	S20925	7/24/1995	48.00	1701 NORTH ROCKWELL LIFT STATION	40,000	X		LOST POWER DUE TO STORM DAMAGE
BETHANY	S20925	7/24/1995	48.00	2502 EAST LANE LIFT STATION	75,000	X		LOST POWER DUE TO STORM DAMAGE
BETHANY	S20925	7/24/1995	48.00	8304 NW 39TH LIFT STATION	300,000	X		LOST POWER DUE TO STORM DAMAGE
BETHANY	S20925	11/6/1995	60.00	8301 NW 5OTH	2,000,000	X		PUMP SHELLED OUT
BETHANY-WARR ACRES	S20925	8/19/1996	1.00	MH 1/2 MILE N. OF N.W. 178 & 1/8 MILE E. OF MERIDIAN AVE.	0			HEAVY RAINFALL
BETHANY	S20925	1/6/1997		8301 N.W. 39 EXPRESSWAY		X		ELECTRICAL FAILURE
BETHANY-WARR ACRES	S20925	4/11/1997	6.50	MH'S BETWEEN N.W. 178TH & N.W. 192ND				RAIN
BETHANY	S20925	4/16/1997	0.50	4705 ROCKWELL	>50	X		CUSTOMER SERVICE LINE SENT DIRT INTO MAIN
BETHANY	S20925	7/3/1997		N. OF N.W. 39TH; S. OF N.W. 50TH;W. OF COUNCIL		X		PUMP MALFUNCTION
BETHANY	S20925	8/20/1997	12.00	8301 N.W. 39TH EXPRESSWAY	750,000			
BETHANY	S20925	8/30/1997	2.00	8301 N.W. 39TH	100,000	X		CONTROL FAILURE ON L.S.
BETHANY	S20925	10/3/1997		1700 DIVIS	120,000	X		L.S. FAILURE
BETHANY	S20925	10/3/1997	72.00	8301 N.W. 39TH	300,000	X		INTERCEPTOR BREAK
BETHANY-WARR ACRES	S20925	3/16/1998	26.00	S. OF 192ND BETWEEN PORTLAND & MERIDIAN		X		RAIN
BETHANY-WARR ACRES	S20925	7/30/1998	1.00	N.W. 37 & ANN ARBOR AT WOODBRIER APTS.	2,500	X		GREASE MALFUNCTION PUMPS
BETHANY-WARR ACRES	S20925	4/30/2000		7225 N. HAMMON			X	RAIN
WARR ACRES	S20925	6/1/2000		N.W. 50TH & GROVE	500	X		BLOWN FUSE
BETHANY	S20925	12/9/2000	5.00	7620 N.W. 28 TERR	2,500	X		SERVICE LINE BAD

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
BETHANY	S20925	12/12/2000	2.00	7620 N.W. 28 TERR	2,000	X		DIRT & SAND IN LINE
WARR ACRES	S20925	1/7/2001	1.30	N.W. 37TH & ANN ARBOR		X		PUMP FAILURE
BETHANY	S20925	4/11/2001	28.00	7200 N.W. 50	14,000	X		COLLAPSED SEWER LINE
BETHANY	S20925	4/11/2001	24.00	2209 BEAVER	28,800	X		PLUMBER ACCIDENT
BETHANY	S20925	4/11/2001	1.50	7020 N.W. 20				GREASE
WARR ACRES	S20925	5/28/2001	2.00	NW 37TH & ANN ARBOR, 1/4 BLK TO LIFT STATION	1,000	X		WIND STORM BLEW TREES DOWN ON ELECTRIC LINES
BETHANY	S20925	5/28/2001	6.50	7940 N.W. 21	10,000	X		POWER LINES DOWN
BETHANY	S20925	8/28/2001		7124 N.W. 17	140,000	X		POWER FAILURE
WARR ACRES	S20925	9/5/2001	0.30	N.W. 37TH & ANN ARBOR	300	X		PUMP FAILURE
WARR ACRES	S20925	11/8/2001	0.30	37TH & ANN ARBOR	300	X		GREASE
WARR ACRES	S20925	1/17/2002	0.30	38TH & ANN ARBOR	500	X		ELECTRICAL FAILURE
WARR ACRES	S20925	1/30/2002	3.50	3809 N. ANN ARBOR	2,000	X		POWER FAILURE
BETHANY	S20925	1/30/2002	0.00	3100 N. PENIAL	15,750	X		POWER LINES DOWN
BETHANY	S20925	1/30/2002	0.00	7130-32-34 N.W. 17TH	184,500	X		POWER FAILURE
BETHANY	S20925	1/30/2002	0.00	7200 N.W. 17	210,000			
BETHANY	S20925	1/31/2002	1.50	2109 COLLEGE	12,000	X		RELIEF LINE FLOODED
BETHANY	S20925	1/31/2002	46.00	2502 EAGLE LANE	69,600	X		LINES DOWN
WARR ACRES	S20925	4/8/2002	2.00	N.W. 37TH & ANN ARBOR		X		POWER FAILURE
WARR ACRES	S20925	6/13/2002	7.00	38TH & ANN ARBOR	101,000	X		BROKEN BY CONSTRUCTION
WARR ACRES	S20925	7/2/2002	0.20	N.W. 38TH & ANN ARBOR	300	X		GREASE
BETHANY	S20925	11/15/2002	1.70	N.W. 50TH & MCMILLAN	17,500	X		WET WELLS PLUGGED WITH GRIT & GREASE
WARR ACRES	S20925	12/6/2002	0.00	N.W. 37TH & ANN ARBOR	2,500	X		BLOWN BREAKER
BETHANY	S20925	12/21/2002	2.00	7225 N.W. 46	500	X		STOPPAGE
BETHANY	S20925	12/21/2002	2.00	2105 COLLEGE	10,000	X		POWER LINE DOWN
WARR ACRES	S20925	2/13/2003	0.60	N.W. 37TH & ANN ARBOR		X		L.S. MALFUNCTION
WARR	S20925	3/4/2003	1.50	N.W. 38TH & ANN ARBOR	1,000	X		ELECTRICAL PROBLEM

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
ACRES								
BETHANY	S20925	3/15/2003	0.50	4701 MCMILLEN	60,000	X		L.S. MALFUNCTION
BETHANY	S20925	3/30/2003	1.50	2105 N. COLLEGE	6,000	X		O.G. & E. LINE FAILURE
BETHANY	S20925	3/31/2003	0.50	7020 N.W. 23	1,000	X		GREASE
BETHANY	S20925	3/31/2003	3.00	6800 N.W. 16	2,000	X		PUMP FAILURE
BETHANY	S20925	4/19/2003	1.00	7109 N.W. 19TH	<500	X		ROOTS
BETHANY	S20925	4/20/2003	1.40	6703 N.W. 59TH TERR.	<750	X		
BETHANY	S20925	4/25/2003	0.50	7016 N.W. 20	750	X		GREASE
BETHANY	S20925	5/10/2003	9.00	7940 N.W. 23	9,000	X		POWER FAILURE
BETHANY	S20925	5/10/2003	8.00	2502 EAGLE LN.	24,000	X		L.S. HIT BY TORNADO
BETHANY	S20925	5/10/2003	12.50	3200 N. PENIEL	<1,000	X		STORM DAMAGE
BETHANY	S20925	10/2/2003	5.50	1/4 MI. S. OF N.W. 50TH, W. OF COUNCIL RD.	350,000	X		L.S. DOWN
BETHANY	S20925	10/6/2003	3.00	50TH & MCMILLAN	10,000			BLOCKAGE
WARR ACRES	S20925	12/16/2003	0.00	N.W. 37TH & ST. CHARLES	100	X		GREASE
WARR ACRES	S20925	12/17/2003	0.00	N.W. 37TH & CHARLES	100	X		GREASE
WARR ACRES	S20925	1/23/2004	1.30	LIFT STATION - N.W. 37TH & ANN ARBOR	2,500	X		POWER OUTAGE
BETHANY	S20925	3/11/2004	4.50	2105 COLLEGE	25,000	X		BLOCKAGE
BETHANY	S20925	4/5/2004	1.00	7920 N.W. 21	<1,000	X		GREASE
BETHANY	S20925	5/3/2004	0.30	7214 N.W. 17	>500	X		L.S. MALFUNCTION
BETHANY	S20925	8/11/2004	2.00	2001 KEETON	30,000	X		STOPPAGE
BETHANY	S20925	10/1/2004	1.00	2105 N. COLLEGE	2,500	X		CONSTRUCTION REPAIR
BETHANY	S20925	12/2/2004	0.50	2109 COLLEGE	<100	X		GREASE
BETHANY	S20925	2/2/2005	3.00	N.W. 17TH & DIVIS	3,500	X		GENERATOR MALFUNCTION
BETHANY	S20925	2/26/2005	48.00	50TH & MCMILLAN		X		BLOWN FUSES
BETHANY	S20925	9/6/2005	0.40	7940 N.W. 21	<1,000			GREASE
WARR ACRES	S20925	1/8/2006	3.00	N.W. 63RD & MACARTUR	200,000	X		DEBRIS
BETHANY	S20925	3/24/2006	1.00	3403 N. WILLOW	25	X		GREASE
BETHANY	S20925	4/2/2006	5.00	6200 BLK. OF N.W. 31ST TERR.	250	X		GREASE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
WARR ACRES	S20925	4/14/2006	2.00	N.W. 43RD MERIDIAN 1 BLK W. TO N.W. 43RD L.S.	200	X		PUMP FAILURE
WARR ACRES	S20925	7/13/2006	6.00	N.W. 50TH & GROVE	1,000	X		L.S. MALFUNCTION
BETHANY-WARR ACRES	S20925	9/4/2006	8.50	N.W. 21ST. & COUNCIL RD.		X		BAD WIRING
BETHANY	S20925	10/18/2006	5.00	1720 GLEASON	50	X		BLOCKAGE
BETHANY	S20925	10/26/2006	0.50	1720 N. GLEASON	5,000	X		STOPPAGE
BETHANY	S20925	12/4/2006	1.30	7120 N.W. 32	150	X		STOPPAGE
WARR ACRES	S20925	12/7/2006	0.50	34TH & HAMMON	200	X		MAIN BREAK
BETHANY	S20925	12/7/2006	0.70	N.W. 34TH & HAMMOND	250	X		GREASE
BETHANY	S20925	12/16/2006	1.50	6908 N.W. 25	100	X		STOPPAGE
BETHANY	S20925	2/4/2007	0.70	LIFT STATION - 30TH TERR. & PENIEL	1,000	X		PUMP FAILURE
BETHANY	S20925	2/5/2007	1.30	31ST TERR. & HAMMOND	2,000	X		STOPPAGE
BETHANY	S20925	3/18/2007	2.50	LIFT STATION	3,000	X		L.S. DOWN
WARR ACRES	S20925	3/30/2007	8.00	6124 N. COVINGTON			X	RAIN
BETHANY	S20925				250,000			STORMS
WARR ACRES	S20925		0.00					
LANGSTON	S20967	11/29/2005	0.00	LOGAN ST. AT TURNER N.E.		X		BLOCKAGE
PERKINS	S20941	1/10/1994	1.00	400'NORTH OF KIRK ST BY MASONIC HALL	500	X		LINE BLOCKAGE
PERKINS	S20941	12/12/1994	23.00	N OF KIRK, WEST OF MESONIC LODGE	0	X		ROOT BLOCKAGE
PERKINS	S20941	6/7/1995	2.00	UNK	0	X		LINE STOPPAGE
PERKINS	S20941	12/18/1995	0.00	608 SHARPS CIRCLE	0	X		COLLAPSED LINE
PERKINS	S20941	5/30/2001	21.00	CIMARRON DR. & S.E. 3RD		X		LINE BREAK
PERKINS	S20941	7/11/2003	3.90	1/4 MILE E. OF JCT. 33 & 177 N. SIDE OF HWY 33 AT L.S.	1,700	X		FAILED TRANSFORMER
PERKINS	S20941		0.00					L.S. DOWN
TRYON	S20942	9/27/2001			<300	X		ROOTS
TRYON	S20942	5/10/2002	3.00	EAST OF TOWN	25	X		ROOTS & GREASE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
TRYON	S20942	11/9/2002	2.50	410 N. OKLAHOMA	150	X		CLOGGED SEWER
TRYON	S20942	6/28/2004	2.50	513 N. SECOND	30	X		BLOCKAGE
CUSHING	S20951	2/28/1990		10 MANHOLES IN LOW-LYING AREAS NEAR DRAINAGE CHANNELS				RAINFALL INFILTRATION
CUSHING	S20951	3/2/1990		10 MANHOLES ADJACENT TO A CREEK				RAINFALL AND INFILTRATION INFLOW
CUSHING	S20951	3/11/1990		16 MANHOLES IN LOW-LYING AREAS NEAR DRAINAGE CHANNELS				HEAVY RAINFALL
CUSHING	S20951	10/25/1990		OAK & MICHIGAN				LINE BLOCK
CUSHING	S20951	10/26/1990		MICH & OAK	0			MAIN BLOCK
CUSHING	S20951	10/30/1990		MH 1000-1100	0			LINE BLOCK
CUSHING	S20951	10/30/1990		SEWER MAIN	0			LINE BLOCK
CUSHING	S20951	3/16/1992	3.00	MANHOLE #745 AND 746	0	X		TREE ROOTS BLOCKAGE
CUSHING	S20951	3/17/1992	7.00	MH #745&746		X		ROOT BLOCKAGE
CUSHING	S20951	4/20/1992	1.00	1100 block E. Walnut	0	X		Trash
CUSHING	S20951	4/20/1992	1.00	MH 389 AT 100 BLOCK OF EAST WALNUT		X		VANDALISM TRASH THROWN IN MH
CUSHING	S20951	7/28/1992	0.00	9th and Linwood	0	x		rupture sewer
CUSHING	S20951	7/28/1992	29.00	9TH AND LINWOOD		X		RUPTURED SEWER MAIN
CUSHING	S20951	8/5/1992	24.00	208 E 9TH PLACE	1,000	X		I/I FROM EXCESSIVE RAINFALL
CUSHING	S20951	8/11/1992	2.00	ASH AND HOWERTON	100	X		LINE STOPPAGE
CUSHING	S20951	8/24/1992	9.00	manhole 200 ft. east of Quail Creek Apts.		x		tree roots plugged Main sewer line
CUSHING	S20951	10/6/1992		S. side of Cushing High Sch. & E. side on Jones St.	0	x		stopped sewer main
CUSHING	S20951	10/13/1992		behind apartment	0	x		clogged line plumber repair
CUSHING	S20951	10/26/1992	6.00	200 FT EAST OF QUAIL CREEK APARTMENTS	0	X		CLOGGED MAIN LINE
CUSHING	S20951	12/14/1992	9.00	MH 256	2,000	X		RAINFALL
CUSHING	S20951	12/14/1992	9.00	MH 711	2,000	X		RAINFALL
CUSHING	S20951	12/14/1992	9.00	MH 167B	2,000	X		RAINFALL
CUSHING	S20951	12/14/1992	9.00	MH 521	2,000	X		RAINFALL

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	12/14/1992	9.00	MH 734	2,000	X		RAINFALL
CUSHING	S20951	12/14/1992	9.00	MH 731C	2,000	X		RAINFALL
CUSHING	S20951	12/14/1992	9.00	MH 731A	2,000	X		RAINFALL
CUSHING	S20951	12/14/1992	9.00	MH 717	2,000	X		RAINFALL
CUSHING	S20951	12/14/1992	9.00	MH 719	2,000	X		RAINFALL
CUSHING	S20951	12/14/1992	9.00	MH 720	2,000	X		RAINFALL
CUSHING	S20951	12/14/1992	9.00	MH 374A	2,000	X		RAINFALL
CUSHING	S20951	12/14/1992	9.00	MH 48B	2,000	X		RAINFALL
CUSHING	S20951	12/14/1992	9.00	MH 265A	2,000	X		RAINFALL
CUSHING	S20951	12/23/1992	3.00	MH 824	0	X		ROOT BLOCKAGE
CUSHING	S20951	12/23/1992	3.00	MH 592	0	X		ROOT BOLCKAGE
CUSHING	S20951	12/23/1992		MANHOLE # 592 AND 824		X		ROOT BLOCKAGE
CUSHING	S20951	12/23/1992		MANHOLE # 592 AND 824		X		ROOT BLOCKAGE
CUSHING	S20951	2/10/1993	6.00	MH SOUTH END OF HOWERTON	500	X		RAINFALL
CUSHING	S20951	3/23/1993	2.00	1216 E 6TH ST	50	X		ROOT BLOCKAGE
CUSHING	S20951	3/24/1993	3.00	1216 E 6TH	0	x		PLUGGED WITH ROOTS
CUSHING	S20951	4/28/1993	16.00	MH 48B	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 719	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 256A	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 256C	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 240	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	4/28/1993	16.00	MH 711	0	X		HEAVY RAINFALL
CUSHING	S20951	5/8/1993	30.00	MH#711,256APH,167BRAV,731APH, 521,734,731CHA.717,719,720,ETC.		X		HEAVY RAIN FALL
CUSHING	S20951	5/10/1993	7.00	STORM HOLDING BASIN		X		HEAVY RAINS
CUSHING	S20951	5/11/1993	24.00	MH 592 & 282 ON EAST SIDE OF TOWN	0	X		LINE BLOCKAGE
CUSHING	S20951	5/11/1993	35.00	MH 592 & 822	0	X		ROOT BLOCKAGE
CUSHING	S20951	5/24/1993	3.00	MH592	0	X		ROOT BLOCKAGE
CUSHING	S20951	5/24/1993	3.00	MH 822	0	X		ROOT BLOCKAGE
CUSHING	S20951	6/14/1993	5.00		0	X		ROOTS BLOCKAGE
CUSHING	S20951	10/6/1993	2.00	MH 728 NEAR 16TH PLACE	0	X		LINE BLOCKAGE
CUSHING	S20951	11/21/1993	3.00	MANHOLE # 559	0	X		OBSTRUCTION

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	11/26/1993	2.00	MH # 261	0	X		LINE BLOCKAGE
CUSHING	S20951	12/2/1993	4.00	MANHOLE #271	0	X		RAIN/MASSIVE ROOTS.
CUSHING	S20951	1/1/1994	1.00	1115 E VINE	0	X		ROOT STOPAGE
CUSHING	S20951	1/1/1994	1.00	AIRPORT HOUSE	0	X		ROOT STOPAGE
CUSHING	S20951	1/13/1994	1.00	1321 EAST BROADWAY	20	X		ROOT BLOCKAGE
CUSHING	S20951	1/21/1994	1.00	121 S EAST STREET	200	X		LINE STOPPAGE
CUSHING	S20951	2/11/1994	1.00	1437 JOHNSON DRIVE MH 636	50	X		ROOT STOPPAGE
CUSHING	S20951	2/15/1994	1.00	MH 809	50	X		LINE BLOCKAGE
CUSHING	S20951	2/16/1994	2.00	SOUTH NOBLE BETWEEN 7TH AND 8TH MH287	0	X		UNKNOWN
CUSHING	S20951	5/18/1994	1.00	MH 37 HIWAY 18 N BETWEEN GREENLEE AND PECAN	50	X		SLUDGE STOPPAGE
CUSHING	S20951	7/11/1994	1.00	CREEK CROSSING REPAIR	0	X		REPAIRING BROKEN LINE
CUSHING	S20951	7/19/1994	2.00	ON HARRISON BETWEEN 7TH AND 8TH	200	X		LINE STOPPAGE
CUSHING	S20951	7/20/1994	1.00	CRYSTAL SPRINGS TRAILER COURT	0	X		LINE BLOCKAGE
CUSHING	S20951	7/29/1994	0.00	1/2 BLK EAST OF VIOLET ON NORTH ST MH 870	1,000	X		BROKEN LINE BY STREET CONTRACTOR
CUSHING	S20951	8/9/1994	24.00	311 WEST KATY	0	X		ROAD CONSTRUCTION DEMOLISHED TOP OF MANHOLE
CUSHING	S20951	8/15/1994	0.00	HOLE IN LINE OVER CREEK ON N 9TH	0	X		HOLE IN CREEK CROSSING
CUSHING	S20951	8/15/1994	24.00	MH 652 827 BRIARWOOD	0	X		LINE STOPPAGE
CUSHING	S20951	8/25/1994	1.00	LANDMARK 1 BUILDINGS C1 & C2	50	X		ROOT STOPPAGE
CUSHING	S20951	8/30/1994	2.00	MH 639 SOUTHGATE DR BETWEEN WILL ROGERS & JOHNSON DRS	0	X		ROOT AND GREASE STOPPAGE
CUSHING	S20951	9/7/1994	10.00	1300 E 2ND MH 348A	0	X		CRACK IN MH
CUSHING	S20951	9/15/1994	1.00	LINE REPAIR AT BROADWAY AND CHERRY	0	X		SPILL GOT BY RETENTION STRUCTURE
CUSHING	S20951	11/10/1994	72.00	820 EAST 4TH	100	X		ROOT BLOCKAGE
CUSHING	S20951	11/17/1994	1.00	1113 EAST PECAN	5	X		ROOT STOPPAGE
CUSHING	S20951	11/18/1994	1.00	200 HOWERTON ST BETWEEN ASH AND MOSES	100	X		ROOT BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	11/21/1994	1.00	940 3RD STREET MH 272	200	X		LINE BLOCKAGE
CUSHING	S20951	12/8/1994	0.00	MH 572	0	X		RAIN I/I
CUSHING	S20951	12/8/1994	0.00	MH 556A	0	X		RAIN I/I
CUSHING	S20951	12/8/1994	0.00	MEMORIAL PARK	0	X		RAIN I/I
CUSHING	S20951	12/9/1994	48.00	EAST SIDE OF SOUTHGATE ADDITION MH 629&630	5,000	X		BROKEN MAIN DUE TO GROUND SHIFT
CUSHING	S20951	12/15/1994	0.00	N.S. 400 HIGH STREET MH 256C	100	X		LINE BLOCKAGE
CUSHING	S20951	12/15/1994	0.00	CONCRETE BOX BETWEEN MH1719 AND MH 1720 IN LION PARK	100	X		LINE BLOCKAGE
CUSHING	S20951	12/19/1994	1.00	LH 449 1400 BLOCK EAST MAIN	50	X		LINE PROBLEM
CUSHING	S20951	1/9/1995	2.00	9TH AND MICHIGAN MH 338-A	0	X		LINE BLOCKAGE
CUSHING	S20951	1/9/1995	1.00	1 1/2 MILES N HIWAY 33 AND HIWAY 18	50	X		DEBRIS BLOCKAGE
CUSHING	S20951	1/17/1995	1.00	LANDMARK APTS,SOUTHGATE APT C1,C2	25	X		GREASE BLOCKAGE
CUSHING	S20951	1/23/1995		SERVICE LINE AT 1118 E MAPLE	0	X		LINE OBSTRUCTION
CUSHING	S20951	2/1/1995	0.00	1118 MAPLE	0	X		ROOT BLOCKAGE
CUSHING	S20951	2/6/1995	3.00	1000 BLK BETWEEN 3RD & 4TH STREETS MH 358	50	X		LINE BLOCKAGE
CUSHING	S20951	2/10/1995	0.00	1411 E 16TH PLACE MH 730 & 730A	10	X		LINE BLOCKAGE
CUSHING	S20951	3/8/1995	48.00	NEAR THOMPSON & PARKVIEW DRIVE MH 557	50	X		ROOTS AND DEBRIS
CUSHING	S20951	3/10/1995	2.00	850 E THOMPSON PLACE	0	X		ROOTS IN HOUSE LATERAL
CUSHING	S20951	3/11/1995	3.00	850 E THOMPSON PLACE	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	6.00	BETWEEN MH 716 AND 717	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	1.00	1109 E 9TH STREET	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	6.00	HOWERTON & BELL CREEK	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	8.00	LIONS PARK MH 716	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	12.00	LIONS PARK MH 717	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	24.00	LIONS PARK MH 719	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	48.00	LIONS PARK MH 719A	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	6.00	400 S HIGH MH 256C	0	X		RAIN I/I

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	3/13/1995	6.00	MEMORIAL MH 256A	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	24.00	MEMORIAL MH 571	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	6.00	MEMORIAL MH 571B	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	8.00	1109 E 9TH MH341	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	6.00	CUSHING HIGH SCHOOL MH 504	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	48.00	NEAR 9TH & TIMBERRISGE MH 738	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	24.00	3RD & MICHIGAN MH 348	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	24.00	ALLEY, 1000 E 2ND MH 242	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	6.00	8TH & MICHIGAN MH 522	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	8.00	8TH & MICHIGAN MH 523	0	X		RAIN I/I
CUSHING	S20951	3/13/1995	6.00	MH 711 HOWERTON & BELL CREEK DRIVE	1,000	X		RAIN I/I
CUSHING	S20951	3/13/1995	12.00	MH 716 LIONS PARK	1,000	X		RAIN I/I
CUSHING	S20951	3/13/1995	12.00	MH 717 LIONS PARK	1,000	X		RAIN I/I
CUSHING	S20951	3/13/1995	6.00	MH 256C 400 S HIGH STREET	1,000	X		RAIN I/I
CUSHING	S20951	3/13/1995	6.00	MH 256A MEMORIAL PARK	1,000	X		RAIN I/I
CUSHING	S20951	3/13/1995	6.00	MH 571 MEMORIAL PARK	1,000	X		RAIN I/I
CUSHING	S20951	3/13/1995	6.00	MH 571B MEMORIAL PARK	1,000	X		RAIN I/I
CUSHING	S20951	3/24/1995	3.00	300 SOUTH 7TH (BACKED UP IN BARBER SHOP)	25	X		OLD TAP COLLAPSED INTO LINE
CUSHING	S20951	3/27/1995	1.00	701 S INDEPENDANCE LH	5	X		LINE BLOCKAGE
CUSHING	S20951	3/28/1995	1.00	216 W VINE	5	X		CRUSHED LINE WITH BACKHOE
CUSHING	S20951	3/31/1995	2.00	MH 421	100	X	L	INE BLOCKAGE
CUSHING	S20951	4/5/1995	8.00	BROADWAY PARK 1200 EAST BROADWAY	10,000	X		CONSTRUCTION CRUSHED PIPE
CUSHING	S20951	4/10/1995	0.00	UNK	0	X		I/I
CUSHING	S20951	4/12/1995	1.00	1000 W WALNUT	100	X		OBSTRUCTION IN LINE
CUSHING	S20951	4/12/1995	3.00	1000 W WALNUT	100	X		OBSTRUCTION IN LINE
CUSHING	S20951	4/16/1995	24.00	216 WEST VINE	0	X		STREET DEPT CRUSHED LINE
CUSHING	S20951	4/17/1995	8.00	LIONS PARK MH'S 719 AND 719A	5,000	X		RAIN I/I

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	4/22/1995	18.00	MH 523	1,000	X		RAIN I/I
CUSHING	S20951	4/22/1995	18.00	MH 571	1,000	X		RAIN I/I
CUSHING	S20951	4/22/1995	18.00	MH 571A	1,000	X		RAIN I/I
CUSHING	S20951	4/22/1995	18.00	MH 738	1,000	X		RAIN I/I
CUSHING	S20951	4/22/1995	18.00	MH 719	1,000	X		RAIN I/I
CUSHING	S20951	4/22/1995	18.00	MH 719A	1,000	X		RAIN I/I
CUSHING	S20951	4/22/1995	18.00	ASSEMBLY OF GOD CHURCH	1,000	X		RAIN I/I
CUSHING	S20951	4/22/1995	18.00	WALNUT AND LITTLE	1,000	X		RAIN I/I
CUSHING	S20951	4/26/1995	1.00	1022 EAST 6TH	200	X		LINE STOPPAGE
CUSHING	S20951	4/29/1995	4.00	311 WEST KATY	1,000	X		DEBRIS BLOCKAGE
CUSHING	S20951	4/29/1995	4.00	MH 719	1,000	X		RAIN I/I
CUSHING	S20951	4/29/1995	4.00	MH 719A	1,000	X		RAIN I/I
CUSHING	S20951	4/29/1995	4.00	MH 571	1,000	X		RAIN I/I
CUSHING	S20951	4/29/1995	4.00	MH 571B	1,000	X		RAIN I/I
CUSHING	S20951	4/29/1995	4.00	MH 256C	1,000	X		RAIN I/I
CUSHING	S20951	4/29/1995	4.00	MH 523	1,000	X		RAIN I/I
CUSHING	S20951	5/5/1995	0.00	509 EAST CHERRY	0	X		COLLAPSED TAP AT RESIDENCE
CUSHING	S20951	5/6/1995	0.00	MH 73	0	X		RAIN I/I
CUSHING	S20951	5/6/1995	5.00	MH 711	1,000	X		RAIN I/I
CUSHING	S20951	5/6/1995	5.00	MH 715	1,000	X		RAIN I/I
CUSHING	S20951	5/6/1995	5.00	MH 719	1,000	X		RAIN I/I
CUSHING	S20951	5/6/1995	5.00	MH 523	1,000	X		RAIN I/I
CUSHING	S20951	5/6/1995	5.00	MH 571	1,000	X		RAIN I/I
CUSHING	S20951	5/6/1995	5.00	MH 571A	1,000	X		RAIN I/I
CUSHING	S20951	5/6/1995	5.00	MH 256C	1,000	X		RAIN I/I
CUSHING	S20951	5/22/1995	2.00	823 S LITTLE	20	X		LINE STOPPAGE
CUSHING	S20951	5/23/1995	8.00	MH 256C	0	X		RAIN I/I
CUSHING	S20951	5/23/1995	8.00	MH 571	0	X		RAIN I/I
CUSHING	S20951	5/23/1995	8.00	MH 719	0	X		RAIN I/I

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	5/23/1995	8.00	MH 719 A (LIONS PARK)	0	X		RAIN I/I
CUSHING	S20951	5/26/1995	0.00	MH # 523	0	X		RAIN I/I
CUSHING	S20951	5/26/1995	0.00	MH # 571	0	X		RAIN I/I
CUSHING	S20951	5/26/1995	0.00	MH # 256A	0	X		RAIN I/I
CUSHING	S20951	5/26/1995	0.00	MH # 256C	0	X		RAIN I/I
CUSHING	S20951	5/26/1995	0.00	MH # 504	0	X		RAIN I/I
CUSHING	S20951	5/26/1995	0.00	MH # 344	0	X		RAIN I/I
CUSHING	S20951	5/26/1995	0.00	MH # 719	0	X		RAIN I/I
CUSHING	S20951	5/26/1995	0.00	MH # 719A	0	X		RAIN I/I
CUSHING	S20951	6/3/1995	36.00	MH 504	10,000	X		RAIN I/I
CUSHING	S20951	6/3/1995	36.00	MH 719	10,000	X		RAIN I/I
CUSHING	S20951	6/3/1995	36.00	MH 719 A	10,000	X		RAIN I/I
CUSHING	S20951	6/3/1995	36.00	MH 256 C	10,000	X		RAIN I/I
CUSHING	S20951	6/3/1995	36.00	MH 571	10,000	X		RAIN I/I
CUSHING	S20951	6/3/1995	36.00	MH 572 A	10,000	X		RAIN I/I
CUSHING	S20951	6/3/1995	36.00	MH 523	10,000	X		RAIN I/I
CUSHING	S20951	6/3/1995	36.00	MH 73	10,000	X		RAIN I/I
CUSHING	S20951	6/3/1995	36.00	MH 74	10,000	X		RAIN I/I
CUSHING	S20951	6/4/1995	0.00	834 EAST BROADWAY	0	X		OBSTRUCTION IN LINE
CUSHING	S20951	6/4/1995	0.00	803 THOMPSON AVE	0	X		OBSTRUCTION IN LINE
CUSHING	S20951	6/5/1995	0.00	101 HARTMAN	0	X		RAIN I/I
CUSHING	S20951	6/6/1995	2.00	1121 EAST MAPLE	100	X		ROOT STOPPAGE
CUSHING	S20951	6/9/1995	0.00	MH 256A	0	X		RAIN I/I
CUSHING	S20951	6/9/1995	0.00	MH 571	0	X		RAIN I/I
CUSHING	S20951	6/9/1995	0.00	MH 256C	0	X		RAIN I/I
CUSHING	S20951	6/9/1995	0.00	MH 523	0	X		RAIN I/I
CUSHING	S20951	6/9/1995	0.00	MH 716	0	X		RAIN I/I
CUSHING	S20951	6/9/1995	0.00	MH 718A	0	X		RAIN I/I
CUSHING	S20951	6/9/1995	0.00	MH 719	0	X		RAIN I/I

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	6/9/1995	0.00	MH 504	0	X		RAIN I/I
CUSHING	S20951	6/9/1995	0.00	MH 599	0	X		RAIN I/I
CUSHING	S20951	6/25/1995	1.00	MYERS AND BROADWAY	10	X		LINE STOPPAGE
CUSHING	S20951	7/20/1995	1.00	1115 SOUTH HIGHLAND	100	X		LINE STOPPAGE
CUSHING	S20951	7/20/1995	1.00	MH 719A	500	X		RAIN I/I
CUSHING	S20951	7/20/1995	1.00	MH 256C	500	X		RAIN I/I
CUSHING	S20951	7/20/1995	1.00	MH 571	500	X		RAIN I/I
CUSHING	S20951	7/20/1995	1.00	MH 571B	500	X		RAIN I/I
CUSHING	S20951	9/7/1995	6.00	MH 719A LIONS PARK	0	X		RAIN I/I
CUSHING	S20951	9/7/1995	3.00	MH 571	0	X		RAIN I/I
CUSHING	S20951	9/7/1995	1.00	MH 571B	0	X		RAIN I/I
CUSHING	S20951	9/15/1995	0.00	800 THOMPSON PL MH 303A	0	X		DEBRIS BLOCKAGE
CUSHING	S20951	9/16/1995	0.00	MH 571	0	X		RAIN I/I
CUSHING	S20951	9/16/1995	0.00	MH 719	0	X		RAIN I/I
CUSHING	S20951	9/16/1995	0.00	MH 719A	0	X		RAIN I/I
CUSHING	S20951	9/16/1995	0.00	MH 256A MUNICIPAL PARK	0	X		RAIN I/I
CUSHING	S20951	9/19/1995	1.00	MH 256C	0	X		RAIN I/I
CUSHING	S20951	9/19/1995	1.00	MH 571	0	X		RAIN I/I
CUSHING	S20951	10/2/1995	3.00	MH 582	0	X		RAIN I/I
CUSHING	S20951	10/2/1995	3.00	MH 719	0	X		RAIN I/I
CUSHING	S20951	10/2/1995	3.00	MH 719A	0	X		RAIN I/I
CUSHING	S20951	10/2/1995	3.00	MH 256C	0	X		RAIN I/I
CUSHING	S20951	10/2/1995	3.00	MH 256A	0	X		RAIN I/I
CUSHING	S20951	10/2/1995	3.00	MH 572A	0	X		RAIN I/I
CUSHING	S20951	10/11/1995	0.00	2ND AND WILSON	0	X		REPAIRING LINE
CUSHING	S20951	10/16/1995	1.00	823 SOUTH LITTLE	0	X		STOPPAGE
CUSHING	S20951	10/18/1995	0.00	MH 745	0	X		LINE BLOCKAGE
CUSHING	S20951	10/18/1995	0.00	MH 746	0	X		LINE BLOCKAGE
CUSHING	S20951	10/18/1995	0.00	100 NORTH CENTRAL	0	X		LINE BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	10/24/1995	3.00	818 PARKWAY	0	X		OBSTRUCTION IN LINE
CUSHING	S20951	11/22/1995	1.00	500 BLK EAST SOUTHGATE	50	X		LINE STOPPAGE
CUSHING	S20951	11/28/1995	1.00	801 & 809 DUNGUN ST	25	X		STOPPAGE
CUSHING	S20951	12/2/1995		1200 BLK OF S. HIGHLAND	0	X		SEWER LEAK
CUSHING	S20951	12/4/1995	1.00	LAMPOLE #488;1500 BLK E. MOSES	10	X		OBSTRUCTION IN THE LINE
CUSHING	S20951	12/19/1995	0.00	323 WEST PINE	0	X		NEEDED NEW TAP
CUSHING	S20951	1/5/1996		811 S. HARRISON		X		CLOGGED UP SEWER MAIN
CUSHING	S20951	1/9/1996	1.00	ALLEY/1500 BLK E. OAK & MAPLE;MANHOLE #363	100	X		OBSTRUCTION IN SEWER LINE
CUSHING	S20951	1/9/1996	4.00	BROADWAY PARK & MANHOLE #368	500	X		MANHOLE CLOGGED WITH RUBBLE
CUSHING	S20951	1/11/1996	72.00	S. OF CUSHING H.S.	5,000	X		VANDALS TOOK MANHOLES OFF & PUT LIMBS INTO MANHOLES
CUSHING	S20951	1/15/1996	18.00	323 N. JONES	150	X		BLOCKED SEWER MAIN
CUSHING	S20951	1/15/1996	18.00	323 N. JONES		X		OBSTRUCTION IN SEWER MAIN
CUSHING	S20951	1/17/1996	1.00	MCDONALDS - 2230 E. MAIN ST.	0	X		UNKNOWN
CUSHING	S20951	2/8/1996	24.00	BEHIND RESIDENT AT 1336 E. BROADWAY	1,000	X		LARGE RAG CLOGGING MAIN
CUSHING	S20951	2/12/1996		1000 BLK OF E. 9TH PL./MANHOLE #578	20	X		SLUDGE IN THE LINE
CUSHING	S20951	2/20/1996	1.00	N. HWY 18; CUSHING VET CLINIC; MANHOLE #809	3	X		MANURE & HAY STOPPED UP LINE
CUSHING	S20951	2/21/1996	3.00	MANHOLE #631	20	X		MAIN STOPPED
CUSHING	S20951	2/22/1996		N. LITTLE ST. NEAR BRESSY BETWEEN MANHOLE #600 & 603	1,000	X		OBSTRUCTION IN SEWER MAIN/SLUDGE
CUSHING	S20951	2/26/1996		HARRISON & VINE ST./MANHOLE #45	1,000	X		OBSTRUCTION IN LINE
CUSHING	S20951	3/10/1996	2.00	NORTH ST. & WILSON / MANHOLE #421	1,000	X		MATERIALS IN LINE
CUSHING	S20951	3/10/1996		MH # 421	1,000	X		MATERIALS IN LINE
CUSHING	S20951	3/22/1996	5.00	16TH PL.;MANHOLE #730	26,000	X		ROOTS BLOCKING MAIN
CUSHING	S20951	3/24/1996		MH #559	500	X		BLOCKAGE
CUSHING	S20951	3/30/1996		MH 749	150,000	X		ROOTS IN LINE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	3/30/1996		S.E. CORNER OF CUSHING & SECT. 11				
CUSHING	S20951	4/4/1996		S. OF CITY PARK; MANHOLE #557	50	X		ROOTS IN MAIN
CUSHING	S20951	4/12/1996		925 E. MOSES ST.				OBSTRUCTION IN SEWER MAIN
CUSHING	S20951	4/22/1996	6.00	MEMORIAL PK. MH #571/LIONS PK. MH #719/SEWER PLANT MH #749		X		ROOTS
CUSHING	S20951	4/22/1996		MH # 571, 719,719A & 749		X		RAIN
CUSHING	S20951	4/25/1996		MAPLE & NOBLE ST.		X		BLOCKED
CUSHING	S20951	5/11/1996		901 E. BROADWAY ST.	150	X		ROOTS OBSTRUCTED SEWER MAIN
CUSHING	S20951	5/12/1996		MANHOLE #711 S. OF HOWERDTON & BELL CREEK DR.	1,000	X		OBSTRUCTION IN MAIN
CUSHING	S20951	5/12/1996		S. OF HOWERTON & BELL CREEK DR.	1,000	X		OBSTRUCTION IN MAIN
CUSHING	S20951	5/13/1996		MANHOLE #660; 900 BLK OF SOUTHGATE	0	X		OBSTRUCTION IN LINE
CUSHING	S20951	5/23/1996		701 S. HIGHLAND	100	X		MAIN STOPPAGE
CUSHING	S20951	5/26/1996		LAMP HOLE #617/ 9TH ST.				
CUSHING	S20951	5/27/1996	2.00	1433 JOHNSON DR.	5			OBSTRUCTION
CUSHING	S20951	6/1/1996		BETWEEN MH #75 & 76; 612 E. GRANDSTAFF BEHIND MATHEWS CO.	25			BROKEN BELL ON MAIN
CUSHING	S20951	6/2/1996		FIELD W. OF HOWERTON ST. & BELL CREEK DR.	500	X		OBSTRUCTION
CUSHING	S20951	6/10/1996		LANDMARK I APTS. A BUILDING	4	X		ROOTS
CUSHING	S20951	6/29/1996		715 LAKEVIEW DR.	50			N/A
CUSHING	S20951	7/3/1996		LION PARK AREA	5,000	X		
CUSHING	S20951	7/11/1996		MANHOLE #719;DRIVEWAY ON LION'S PARK	50	X		RAINFALL
CUSHING	S20951	7/17/1996	3.00	MANHOLE #669 / 1012 E. 11	55	X		ROOTS
CUSHING	S20951	7/20/1996		NW/4 SEC. 11, T17N, R5E	50			ROOTS
CUSHING	S20951	7/28/1996		847 E. MOSES	55	X		
CUSHING	S20951	8/6/1996	1.00	LINWOOD & CHERRY; MH #462	10	X		OBSTRUCTION IN MAIN
CUSHING	S20951	8/6/1996		MH #463	15			

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	8/9/1996	4.00	1012 E. 11 ST.	50	X		ROOTS
CUSHING	S20951	8/9/1996	3.00	MH #669	50			ROOTS
CUSHING	S20951	8/11/1996		1242 E. 5TH	2			MAIN PLUGGED
CUSHING	S20951	8/12/1996	2.00	400 SOUTH MICHIGAN MH 344	1,000,000	X		ROOT STOPPAGE
CUSHING	S20951	8/13/1996		MH #745 & 746	50			ROOTS
CUSHING	S20951	8/13/1996		1219 S. HIGHLAND	150			OBSTRUCTION IN MAIN
CUSHING	S20951	8/17/1996		MH #344; 400 BLK N. MICHIGAN	750			ROOTS, DOG CHAIN, ETC.
CUSHING	S20951	8/21/1996		100 BLK. OF N. HIGHLAND ST. LH #210	5	X		UNKNOWN
CUSHING	S20951	8/23/1996		MH #745 & 746	5,000	X		
CUSHING	S20951	9/17/1996		TIMBERRIDGE PLACE & TIMBERRIDGE LANE	37			
CUSHING	S20951	9/20/1996		743 E. MAPLE ST.	10	X		UNKNOWN OBSTRUCTION IN SEWER
CUSHING	S20951	9/26/1996	4.00	MH #256C; 571B; 719A; 523	3	X		RAINWATER
CUSHING	S20951	9/26/1996		317 W. GREENLEA				
CUSHING	S20951	10/4/1996		1005 E. 4TH	5	X		
CUSHING	S20951	10/4/1996		1334 E. BROADWAY	30	X		
CUSHING	S20951	10/9/1996	1.00	900 BLK. N. CLEVELAND MH #43	15	X		ROOTS
CUSHING	S20951	10/23/1996		BELL CREEK DR. MH #700	10			ROOTS
CUSHING	S20951	10/27/1996		MEMORIAL PARK MH #571B	50	X		RAIN
CUSHING	S20951	10/27/1996		1200 BLK. OF E. 6TH MH #509				RAIN
CUSHING	S20951	11/6/1996		745,847,925 E. MOSES;704 S. MICHIGAN (NUMEROUS MANHOLES)	0	X		RAINWATER
CUSHING	S20951	11/16/1996		1022 E. 6TH	15			MAIN STOPPED
CUSHING	S20951	11/16/1996		MANHOLES #256A,256C,572A,719,344,374B,509				
CUSHING	S20951	11/17/1996		1100 BLK. E. WALNUT ST. MH #389 & 390				
CUSHING	S20951	11/26/1996		819 E. 3	5	X		ROOTS
CUSHING	S20951	11/29/1996		MANHOLES 509,344,256A,256C,717,719,719A				RAIN
CUSHING	S20951	12/1/1996		603 E. OAK		X		SEWER BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	12/6/1996		600 BLK. E. NORTH ST. MH #420				GREASE & ROOTS
CUSHING	S20951	1/4/1997						RAIN
CUSHING	S20951	1/11/1997		300 BLK. S. STEELE AVE.; MH #269				
CUSHING	S20951	1/13/1997		GREENLEE & WILSON	1	X		OBSTRUCTION
CUSHING	S20951	1/18/1997		802 PARKVIEW				MAIN STOPPED
CUSHING	S20951	1/23/1997		1000 BLK. E. 2ND				
CUSHING	S20951	2/1/1997		200 BLK. E. 9	5			
CUSHING	S20951	2/15/1997	1.00	6108 W. 9	1	X		ROOTS
CUSHING	S20951	2/16/1997		WALNUT & CENTRAL - MH #4B	25			OBSTRUCTION
CUSHING	S20951	2/19/1997		1300 BLK. OF S. HIGHLAND - MH #679	20			ROOTS
CUSHING	S20951	2/20/1997		8TH & MICHIGAN;LIONS PARK;800 PARKVIEW;400 S. HIGH;1200 E. 6				RAIN
CUSHING	S20951	2/26/1997		8 & MICHIGAN; 1200 S. LINWOOD; LIONS PARK; 818 DUNGAN ST.				
CUSHING	S20951	3/17/1997		317 N. LINWOOD/1337 E. ASH				LINE PROBLEMS
CUSHING	S20951	4/11/1997		#256 IN MEMORIAL PK.;#556 IN 800 PARKVIEW;#509 IN 1300 E. 6				RAIN
CUSHING	S20951	4/11/1997		#348 IN 300 S. MICHIGAN;#719 IN LIONS PK.				RAIN
CUSHING	S20951	4/11/1997		#350A IN 1300 E. CHERRY; #256C IN 400 S. HIGH				RAIN
CUSHING	S20951	4/14/1997		SW/4 OF SEC. 27, T18N,R5E				PUMP MALFUNCTION
CUSHING	S20951	4/28/1997	2.50	BROADWAY & KINGS HWY - MH #130	100			
CUSHING	S20951	6/5/1997		CENTRAL & PINE MH #48 & 48A		X		OBSTRUCTION
CUSHING	S20951	6/10/1997		1011 E. 10TH - MH #669	100	X		ROOTS
CUSHING	S20951	7/14/1997		N.E. OF PINE & CLEVELAND - MH #48				OBSTRUCTION
CUSHING	S20951	7/16/1997		MH #587 NEAR QUALL CREEK APTS.				ROCKS IN MH
CUSHING	S20951	9/15/1997	1.00	3RD & WILSON - MH #242	150	X		SHOP RAGS
CUSHING	S20951	9/23/1997	2.00	400 BLK. S. HIGH 256C/PARKVIEW & THOMPSON 556/LIONS PARK 719				RAIN

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	10/7/1997	1.00	701 S. INDEPENDENCE	10			BLOCKAGE
CUSHING	S20951	11/17/1997	1.50	MH #709 IN PASTURE S.W. OF HOWERTON & BELL CREEK DR.	50			ROOTS
CUSHING	S20951	12/1/1997	4.50	MH #434; 1100 BLK. OF E. VINE ST.	5	X		ROOTS
CUSHING	S20951	12/10/1997			100			DAMAGED PIPE
CUSHING	S20951	12/15/1997		818 PARKVIEW DR. - MH #559/560	500	X		
CUSHING	S20951	12/18/1997		1231 E. 5	50			OBSTRUCTION
CUSHING	S20951	12/23/1997		MH'S 523,719,719A,509,256A,256C,557		X		I&I
CUSHING	S20951	12/25/1997		MH #374B	150			RAIN
CUSHING	S20951	1/31/1998		819 E. 3RD	15			SYOPPED MAIN
CUSHING	S20951	2/3/1998		JOHNSON DR. & SOUTHGATE DR. - MH #639	200	X		OBSTRUCTION
CUSHING	S20951	3/1/1998	1.50	820 E. 4TH - MH #297A	2	X		OBSTRUCTION
CUSHING	S20951	3/7/1998		MANHOLES				RAIN
CUSHING	S20951	3/12/1998	1.00	MH #69 NEAR SOUTHGATE & JOHNSON DR.	50			PAPER
CUSHING	S20951	3/15/1998		MANHOLES				RAIN
CUSHING	S20951	3/19/1998		MH'S: 523,509,719A,350A,556,256C,48A,48 C				RAINS
CUSHING	S20951	4/13/1998	1.30	801 E. 9TH - MH	25	X		OVERFLOW
CUSHING	S20951	4/16/1998		MH 594 IN WODDED AREA EDGE OF CUSHING				ROOTS
CUSHING	S20951	4/22/1998	1.00	MH 809 FRONT OF VETERNARY CLINIC N. HWY 18	50	X		ANIMAL WASTE
CUSHING	S20951	4/26/1998		1000 BLK. OF E. 12 & VARIOUS MH'S				RAINFALL
CUSHING	S20951	4/30/1998		MH'S 584/585 CUSHING H.S.				BROKEN MAIN
CUSHING	S20951	6/23/1998		1316 E. BROADWAY	10	X		OBSTRUCTION
CUSHING	S20951	7/1/1998	1.00	MH #256C - 400 BLK. S. HIGH ST.				RAIN
CUSHING	S20951	7/1/1998	1.00	400 BLK. S. HIGH				RAINFALL
CUSHING	S20951	9/3/1998		NORTH & HOUGH ST.	50	X		WASTE IN SEWER
CUSHING	S20951	9/21/1998		HWY 18 N. & BRESSY ST.				OBSTRUCTION

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	9/22/1998		MH'S IN THE AREA OF MEMORIAL PARK				RAINFALL
CUSHING	S20951	10/1/1998		MANHOLES IN AREA OF LIONS PARK & MEMORIAL PARK				
CUSHING	S20951	10/5/1998		VARIOUS MANHOLES				
CUSHING	S20951	10/17/1998		1216 E. 6TH	25			RAIN
CUSHING	S20951	11/1/1998		1500 BLK. OF E. WALNUT ST.	10			
CUSHING	S20951	11/1/1998		1500 BLK. E. WALNUT	10	X		ROOTS
CUSHING	S20951	11/1/1998		MH'S IN CITY				RAIN
CUSHING	S20951	11/19/1998		1232 E. 5	100			OBSTRUCTION
CUSHING	S20951	12/2/1998		600 BLK S. LINWOOD AVE.	5	X		
CUSHING	S20951	12/7/1998	1.70	1434 LANDMARK I DR.	100	X		OBSRTUCTION
CUSHING	S20951	1/7/1999	1.70	1139 E. BROADWAY	20			BLOCKAGE
CUSHING	S20951	1/19/1999		1220 S. LINWOOD	5			OBSTRUCTION
CUSHING	S20951	1/27/1999	2.00	819 E. 3	2			BLOCKAGE
CUSHING	S20951	1/30/1999		MANHOLES				RAIN
CUSHING	S20951	2/16/1999		NORTH ST. & HUFF ST.				GREASE
CUSHING	S20951	3/3/1999		100 BLK. E. OF PECAN ST.	100			
CUSHING	S20951	3/8/1999		MANHOLES THROUGHOUT CITY				
CUSHING	S20951	3/12/1999		MANHOLES IN CITY				RAIN
CUSHING	S20951	4/25/1999	48.00	MH'S				RAIN
CUSHING	S20951	5/4/1999		MANHOLES IN CITY				RAINS
CUSHING	S20951	5/10/1999		MH'S 716,719A				
CUSHING	S20951	5/19/1999		818 DUNGAN AVE. & MH'S				RAIN
CUSHING	S20951	6/19/1999						RAIN
CUSHING	S20951	6/23/1999		208 E. 9TH PL. & MH'S				RAIN
CUSHING	S20951	6/24/1999		VARIOUS MANHOLE'S				RAINS
CUSHING	S20951	6/30/1999		VARIOUS MH'S				RAIN
CUSHING	S20951	7/15/1999		S. OF TIMBER RIDGE PL. & TIMBER RIDGE LN.				STOPPED MAIN
CUSHING	S20951	8/10/1999		500 BLK SOUTHGATE DR.	20			

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	8/18/1999		1426 WILL ROGERS DR.	>1,000			OBSTRUCTION
CUSHING	S20951	9/7/1999		MH'S IN MEMORIAL PARK				RAINFALL
CUSHING	S20951	9/10/1999		MH'S				RAINS
CUSHING	S20951	9/27/1999		800 BLK PARKVIEW DR.				
CUSHING	S20951	11/29/1999		9TH & MICHIGAN	5			
CUSHING	S20951	12/4/1999		MH		X		RAIN
CUSHING	S20951	12/9/1999						RAIN
CUSHING	S20951	12/19/1999		1313 S. HIGHLAND AVE.	100			STOPPED MAIN
CUSHING	S20951	12/21/1999		1000 BLK N. LITTLE AVE.				LEAK
CUSHING	S20951	1/22/2000		702 S. HOWARDTON	100	X		OBSTRUCTION
CUSHING	S20951	1/22/2000		1200 BLK. E. 6TH ST.	100	X		OBSTRUCTION
CUSHING	S20951	1/25/2000		400 BLK. N. HARTMAN				SEWER BACKUP
CUSHING	S20951	2/10/2000		MH 338A - 9TH & MICHIGAN	10			OBSTRUCTION
CUSHING	S20951	4/3/2000		800 E. 4TH	30	X		ROOTS
CUSHING	S20951	4/3/2000	2.00	800 BLK E. 4TH	50	X		ROOTS
CUSHING	S20951	4/30/2000		MH'S IN MEMORIAL PARK		X		RAIN
CUSHING	S20951	5/1/2000		710 E. CHERRY ST.				OBSTRUCTION
CUSHING	S20951	5/12/2000		906 SOUTHGATE DR.				ROOTS
CUSHING	S20951	5/14/2000		1017 CHRISTMAS TREE LANE				OBSTRUCTION
CUSHING	S20951	5/24/2000		MH'S				RAIN
CUSHING	S20951	5/27/2000		211 S. EAST ST	25	X		OBSTRUCTION
CUSHING	S20951	5/27/2000		MH'S				RAIN
CUSHING	S20951	6/21/2000		MH'S				RAINS
CUSHING	S20951	6/21/2000						RAINS
CUSHING	S20951	6/22/2000		1142 E. VINE				STOPPED MAIN
CUSHING	S20951	6/26/2000		719A IN LIONS PARK				RAIN
CUSHING	S20951	6/28/2000		MH				RAIN
CUSHING	S20951	7/3/2000		MH @ LIONS PARK		X		RAINWATER
CUSHING	S20951	7/10/2000	0.50	1313 S. HIGHLAND	5			OBSTRUCTION

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	7/21/2000		MH'S				RAIN
CUSHING	S20951	7/26/2000		OAK ST. & PARK DR. AT CREEK				BROKEN PIPE
CUSHING	S20951	8/16/2000		1212 E. MAIN	15			OBSTRUCTION
CUSHING	S20951	8/24/2000		MH #691 AT 1300 BLK E. 9				OBSTRUCTION
CUSHING	S20951	9/2/2000		724 S. WILSON	10	X		OBSTRUCTION
CUSHING	S20951	9/27/2000	0.50	415 N. CLEVELAND	25	X		OBSTRUCTION
CUSHING	S20951	11/8/2000		LIONS PARK	1,000			WEATHER
CUSHING	S20951	11/25/2000		900 BLK E. 2ND	10,000	X		OBSTRUCTION
CUSHING	S20951	12/5/2000		E. OF LITTLE AVE. ON ESECO RD.	200	X		FAULTY VALVE
CUSHING	S20951	12/7/2000		MH AT 9TH & LINWOOD	2,000	X		OBSTRUCTION
CUSHING	S20951	1/4/2001		E. OF LITTLE AVE.	200			VALVE PROBLEMS
CUSHING	S20951	1/6/2001		1300 BLK E. 9	200	X		BLOCKAGE
CUSHING	S20951	1/9/2001		MH AT 900 S. MICHIGAN AVE	5			OBSTRUCTION
CUSHING	S20951	1/29/2001		415 N. CLEVELAND	10			STOPPED MAIN
CUSHING	S20951	1/29/2001		WILSON & MAIN	200			DAMAGED MAIN
CUSHING	S20951	1/29/2001		LION'S PARK	500			RAIN
CUSHING	S20951	1/31/2001		1600 E. MAIN	5			DEBRIS
CUSHING	S20951	2/4/2001		REGIONAL HOSPITAL	2,000			OBSTRUCTION
CUSHING	S20951	2/16/2001		415 N. CLEVELAND	100	X		TOWELS
CUSHING	S20951	2/22/2001		900 BLK S. CLEVELAND	50	X		OBSTRUCTION
CUSHING	S20951	2/23/2001		11 MH'S & YARD OF 1261 E 2ND ST	20000			I & I
CUSHING	S20951	3/2/2001		1261 E. 2	30			
CUSHING	S20951	3/8/2001		928 E. 3	10			BLOCKAGE
CUSHING	S20951	4/6/2001		SOUTHGATE DR. & LANDMARK	200			OBSTRUCTION
CUSHING	S20951	4/22/2001		1400 BELL CREEK DR.	50	X		UNKNOWN
ENID	S20951	4/25/2001	1.00	2045 WINDMILL	60	X		STOPPAGE
CUSHING	S20951	5/4/2001		800 E. 9TH	50			SLUDGE
CUSHING	S20951	5/29/2001		MH				RAIN
CUSHING	S20951	6/22/2001		307 S. NOBLE	35			OBSTRUCTION

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	7/16/2001		1227 E. PECAN	20	X		OBSTRUCTION
CUSHING	S20951	10/8/2001		CIMMARON T.P.	50			OBSTRUCTION
CUSHING	S20951	10/12/2001		LINWOOD & 9TH	10,000			OBSTRUCTION
CUSHING	S20951	10/19/2001		MYERS & BROADWAY	30	X		OBSTRUCTION
CUSHING	S20951	10/31/2001		400 BLK S. NOBLE AVE	75	X		OBSTRUCTION
CUSHING	S20951	11/14/2001		2100 E. MAIN	10	X		OBSTRUCTION
CUSHING	S20951	12/2/2001		1216 E. 6TH	20			BLOCKAGE
CUSHING	S20951	12/3/2001		817 S. DUNGAN ST.	30			STOPPAGE
CUSHING	S20951	12/17/2001	0.70	1313 S. HIGHLAND AVE	<50	X		CLOGGED MAIN
CUSHING	S20951	12/24/2001	0.00	924 S. HARRISON	200	X		OBSTRUCTION
CUSHING	S20951	1/4/2002	0.80	1029 E. 11	50	X		ROOTS
CUSHING	S20951	1/28/2002	1.00	902 LAKEVIEW	150	X		OBSTRUCTED
CUSHING	S20951	1/30/2002	5.50	LIONS PARK	15,000	X		RAIN & ROOTS
CUSHING	S20951	3/26/2002	0.50	WALNUT & CENTRAL	10	X		ROOTS
CUSHING	S20951	3/26/2002	0.00	CEDAR RIDGE & SOUTHGATE DR.	500	X		ROOTS
CUSHING	S20951	4/8/2002	1.00	SOUTHGATE DR. & WILL ROGERS	150	X		OBSTRUCTION
CUSHING	S20951	4/13/2002	3.00	LIONS PARK	1,000			RAIN
CUSHING	S20951	4/17/2002	1.00	N. HWY 18	50			PLASTIC BAG IN SEWER
CUSHING	S20951	4/22/2002	1.00	1227 E. PECAN	10	X		OBSTRUCTION
CUSHING	S20951	5/17/2002	0.00	LIONS PARK/ 1300 E. CHERRY/ 300 S. MICHIGAN	20,000	X		RAIN
CUSHING	S20951	5/28/2002	0.70	1310 E. CHERRY	50	X		RAGS
CUSHING	S20951	5/30/2002	0.60	1212 E. MAIN	5	X		GREASE & DEBRIS
CUSHING	S20951	6/1/2002	0.00	CLEANOUT AT CRYSTAL SPRINGS MHP ON E. CARSON ST	500	X		OBSTRUCTION
CUSHING	S20951	6/12/2002	1.00	1200 BLK. ON CHERRY ST.	25	X		RAIN
CUSHING	S20951	6/12/2002	1.00	S. LINWOOD NEAR LIONS PARK	50	X		RAIN
CUSHING	S20951	6/12/2002	1.00	S. MICHIGAN	100	X		RAIN
CUSHING	S20951	6/12/2002	1.00	LIONS PARK	200	X		RAIN
CUSHING	S20951	7/2/2002	1.00	LION'S PARK	500	X		RAIN

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	7/16/2002	0.50	1227 E. PECAN	10			OBSTRUCTION
CUSHING	S20951	7/16/2002	0.00	CIMMARON CORR. FAC./ KINGS HWY & TEXACO RD.	200	X		VALVE CORRODED CAUSING LEAK
CUSHING	S20951	7/25/2002	0.00	CUSHING AQUATIC CENTER AT 5TH & LITTLE		X		OPEN VALVE
CUSHING	S20951	9/9/2002	0.00	BEHIND 1701 E. 9TH	40	X		OBSTRUCTION
CUSHING	S20951	9/25/2002	0.70	IN PASTURE BEHIND 810 GRANDSTAFF RD.	1,500	X		BACKHOE HIT FORCE MAIN
CUSHING	S20951	10/14/2002	0.00	BROADWAY & MYERS	30			OBSTRUCTION
CUSHING	S20951	11/1/2002	1.00	400 BLK N. HOWERTON AVE	100	X		OBSTRUCTION
CUSHING	S20951	11/18/2002	0.00	924 S. HARRISON AVE	50	X		STOPPED MAIN
CUSHING	S20951	11/29/2002	0.00	BEHIND 924 S. HARRISON	30	X		OBSTRUCTION
CUSHING	S20951	12/1/2002	0.00	BEHIND MASONIC LODGE 400 BLK. S. WILSON	<50	X		CLOGGED LINE
CUSHING	S20951	12/9/2002	0.00	CIMMARON TP	40	X		OBSTRUCTION
CUSHING	S20951	12/23/2002	1.30	719 W. MOSES	300	X		OBSTRUCTION IN MAIN
CUSHING	S20951	12/30/2002		600 BLK. W. CHERRY ST.	1,000	X		MAIN BLOCKED BY 2 ELECTRIC MOTORS
CUSHING	S20951	1/5/2003	0.00	700 BLK. E. CHERRY	100	X		OBSTRUCTION
CUSHING	S20951	1/17/2003	0.00	16TH PL. & LINWOOD AVE.	100	X		ROOTS
CUSHING	S20951	1/28/2003	0.00	TIMBERIDGE DR. & CHERRY LN.	5,000	X		ROOTS
CUSHING	S20951	2/1/2003	0.00	1116 E. MAPLE	25	X		MAIN BACKUP
CUSHING	S20951	3/3/2003	0.00	3300 BLK. N. RUTH AVE	75	X		OBSTRUCTION
CUSHING	S20951	3/17/2003	0.00	FOUNTAINE BLEU APTS.	100	X		OBSTRUCTION
CUSHING	S20951	3/19/2003	0.00	500 BLK N. HOWERTON	1,000	X		GREASE
CUSHING	S20951	3/19/2003	0.00	LIONS PARK	3,000	X		I&I
CUSHING	S20951	3/22/2003	0.00	100 BLK. S.HOUGH AVE.	100	X		OBSTRUCTION
CUSHING	S20951	3/31/2003	0.00	8TH & MICHIGAN AVE.	2,000			ROOTS
CUSHING	S20951	5/9/2003	0.00	1300 E. MAIN	500	X		GREASE
CUSHING	S20951	5/10/2003	0.00	1200 BLK. E. MAIN	5	X		GREASE
CUSHING	S20951	5/11/2003	0.00	1200 BLK. E. MAPLE	5,000	X		OBSTRUCTION
CUSHING	S20951	5/14/2003	0.00	LION'S PARK	200	X		RAINWATER

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	5/16/2003	0.00	719 "A"	2,500	X		RAINFALL
CUSHING	S20951	5/16/2003	0.00	350 "A"				RAINFALL
CUSHING	S20951	5/20/2003	0.00	E. SIDE OF CITY	1,000			OBSTRUCTION
CUSHING	S20951	6/6/2003	0.00	S. OF CUSHING H.S.	1,000	X		VANDALISM
CUSHING	S20951	6/25/2003	1.00	MH'S	100	X		RAIN
CUSHING	S20951	6/27/2003	0.00	TIMBERRIDGE DR. & CHERRY LN.	1,000			ROOTS
CUSHING	S20951	9/21/2003	0.00	LION'S PARK	2,000	X		RAIN
CUSHING	S20951	10/9/2003	0.00	1200 E. CHERRY/ LION'S PARK	7,500	X		RAIN
CUSHING	S20951	10/27/2003	0.00	BROADWAY & MYER	5	X		OBSTRUCTION
CUSHING	S20951	11/13/2003	0.00	TIMBERIDGE DR.	5,000	X		ROOTS
CUSHING	S20951	12/22/2003	0.50	1100 BLK. GREENLEE	100	X		ROOTS
CUSHING	S20951	1/17/2004	0.00	TIMBERRIDGE PL.	10,000	X		RAIN
CUSHING	S20951	1/19/2004	0.00	600 BLK. W. CHERRY	100	X		OBSTRUCTION
CUSHING	S20951	1/25/2004	0.00	TIMBERRIDGE PL.	5,000	X		OBSTRUCTION
CUSHING	S20951	2/18/2004	0.00	PASTURE BEHIND 1701 E. 9TH	>20,000	X		OBSTRUCTION
CUSHING	S20951	3/4/2004	0.00					RAIN
CUSHING	S20951	3/4/2004	0.00	1200 N. CLEVELAND AVE.		X		RAIN
CUSHING	S20951	3/4/2004	0.00	1200 E. CHERRY		X		RAIN
CUSHING	S20951	3/4/2004	0.00	1200 E. OAK		X		RAIN
CUSHING	S20951	3/4/2004	0.00	900 S. MICHIGAN AVE.		X		RAINS
CUSHING	S20951	3/4/2004	0.00	N. HWY. 18		X		RAINS
CUSHING	S20951	3/4/2004	0.00	1300 S. LINWOOD		X		RAINS
CUSHING	S20951	3/4/2004	0.00	LIONS PARK		X		RAINS
CUSHING	S20951	3/9/2004	0.00	600 BLK S. LINWOOD	5	X		ROOTS
CUSHING	S20951	4/22/2004	0.00	LIONS PARK & 800 S. MICHIGAN	250	X		RAIN
CUSHING	S20951	5/5/2004	3.00	200 S. WILSON AVE.	100	X		TOWELS IN MAIN
CUSHING	S20951	5/12/2004	0.00	900 BLK E. 3RD	100	X		OBSTRUCTION
CUSHING	S20951	5/22/2004	2.00	ON LITTLE ST. AT 3RD	100	X		ROOTS
CUSHING	S20951	6/7/2004	0.00	1500 BLK CEDAR RIDGE LN.	100	X		OBSTRUCTION

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	6/9/2004	0.00	LION'S PARK	500	X		RAIN
CUSHING	S20951	6/21/2004	0.00	LIONS PARK	1,000	X		RAIN
CUSHING	S20951	7/6/2004	0.00	W. OF CUSHING HOSPITAL AT CHERRY ST. & WILSON AVE.	100	X		PAPER TOWELS
CUSHING	S20951	9/28/2004	0.00	1400 BLK. E. CHERRY	4	X		ROOTS
CUSHING	S20951	10/18/2004	0.00	1300 E. BROADWAY	10	X		OBSTRUCTION
CUSHING	S20951	12/9/2004	0.00	900 BLK. E. 2ND	500	X		BLOCKAGE
CUSHING	S20951	1/2/2005	0.00	MAIN ST. & HOWERTON AVE.	100	X		PAPER
CUSHING	S20951	1/2/2005	0.00	1100 BLK. E. MAIN				
CUSHING	S20951	1/10/2005	0.00	400 W. CHERRY	50	X		ROOTS
CUSHING	S20951	1/17/2005	0.00	400 BLK. HOWERTON AVE.	10	X		PAPER TOWELS
CUSHING	S20951	2/2/2005	0.00	700 BLK. S. HIGHLAND	20	X		DAMAGED MAIN
CUSHING	S20951	2/17/2005	0.00	OAK ST. & MICHIGAN AVE. AT CREEK	500	X		OBSTRUCTION
CUSHING	S20951	3/3/2005	0.00	900 E. CHERRY ST.	20	X		OBSTRUCTION
CUSHING	S20951	3/3/2005	0.00	12TH & HIGHLAND	150	X		ROOTS
CUSHING	S20951	4/4/2005	0.00	S. OF CUSHING H.S.	100	X		BLOCKAGE
CUSHING	S20951	5/31/2005	0.00	BEHIND TIMBERRIDGE APTS	50	X		I&I
CUSHING	S20951	6/12/2005	5.00		400	X		RAIN
CUSHING	S20951	8/12/2005	0.00	1300 BLK E. 2ND	10	X		CRACK IN MH
CUSHING	S20951	8/23/2005	6.00	1300 BLK. OF CHERRY	500	X		RAIN
CUSHING	S20951	8/23/2005	6.00	1300 BLK. OF ASH	500	X		RAIN
CUSHING	S20951	8/23/2005	6.00	6TH & MICHIGAN	1,000	X		RAIN
CUSHING	S20951	8/23/2005	6.00	8TH & MICHIGAN	1,500	X		RAIN
CUSHING	S20951	8/23/2005	6.00	BELL CREEK & HOWERTON	2,500	X		RAIN
CUSHING	S20951	8/23/2005	6.00	LIONS PARK	30,000	X		RAIN
CUSHING	S20951	12/7/2005	0.50	500 BLK. N. HOWERTON	100	X		GREASE
CUSHING	S20951	1/25/2006	0.00	1500 CEDAR RIDGE PL. & SOUTHGATE DR.	100	X		ROOTS
CUSHING	S20951	3/4/2006	0.00	500 BLK. S. HOWERTON	100	X		RAGS & DEBRIS
CUSHING	S20951	3/6/2006	0.00	2ND & WILSON	300	X		RAGS

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
CUSHING	S20951	4/29/2006	0.00	LIONS PARK	1,000	X		RAIN
CUSHING	S20951	5/4/2006	0.00	LIONS PARK, TIMBERRIDGE DR., 900 S.MICHIGAN ST.	5,000	X		RAIN
CUSHING	S20951	5/12/2006	0.00	BEHIND TIMBERRIDGE GARDEN APTS.	5,000	X		VANDALISM/ ROCKS
CUSHING	S20951	8/9/2006	0.00	TIMBERIDGE GARDEN APTS. AT TIMBERRIDGE DR.	5,000	X		VANDALISM
CUSHING	S20951	9/27/2006	2.00	924 E. 2ND	5,000	X		RAGS, TOWELS FROM HOSPITAL
CUSHING	S20951	11/26/2006	1.50	200 N. PARK	100	X		ROOTS
CUSHING	S20951	12/20/2006	0.00	TIMBERRIDGE RD. BEHIND TIMBERRIDGE APTS.	1,000	X		RAIN
CUSHING	S20951	12/30/2006	0.00	BEHIND TIMBERIDGE APTS.	100	X		RAIN
CUSHING	S20951	2/9/2007	0.00	TIMBERRIDGE GARDENS APTS.	50	X		OBSTRUCTION
CUSHING	S20951	2/11/2007	0.00	1400 BLK. E. MAPLE	30	X		OBSTRUCTION
CUSHING	S20951	3/3/2007	0.00	1730 E. 9TH	30	X		ROOTS
CUSHING	S20951			E. 9TH ST.	50			OBSTRUCTION
CUSHING	S20951			1219 S. HIGHLAND ST.	150			OBSTRUCTION
CUSHING	S20951			N.W. CORNER OF MAPLE & NOBLE/#9				SEWER MAIN CLOGGED
CUSHING	S20951			901 E. BROADWAY; MANHOLE #366				
CUSHING	S20951			715 LAKEVIEW DR.; MANHOLE #538				
CUSHING	S20951			MANHOLE #745 & 746		X		OBSTRUCTION
CUSHING	S20951			1242 E. 5TH				
CUSHING	S20951							
CUSHING	S20951		0.00	CREEK NEAR 224 W. HICKORY	>2,000	X		OBSTRUCTION
DRUMRIGHT	S20952	1/7/1998	134.00	B 800 N. MAIN				RAIN
DRUMRIGHT	S20952	6/23/2000		WEST OF CITY ON HWY 33	5,000	X		MOTOR BURNOUT
DRUMRIGHT	S20952	6/23/2000	90.00	WEST OF CITY ON HWY 33	5,000	X		MOTORS BURNT UP
DRUMRIGHT	S20952	8/23/2000		EAST & WEST END OF TOWN		X		BAD VALVES & LEAK
DRUMRIGHT	S20952	6/29/2001	2.50		1,000	X		LINE SEPARATED
DRUMRIGHT	S20952	3/21/2002	18.00	CORNER OF PENN & OAK IN FIELD	2,000	X		MANHOLE STOPPED UP

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
DRUMRIGHT	S20952	9/9/2002	30.00	326 E. FULKERSON	5,000	X		ELECTRICAL PROBLEMS
DRUMRIGHT	S20952	11/25/2002	1.80	N. CIMMARON & BROADWAY IN CREEK	275	X		PIPE SEPARATED IN COLLAR
DRUMRIGHT	S20952	12/16/2002	7.70	306 E. FULKERSON	150	X		ELECTRICAL PROBLEMS
DRUMRIGHT	S20952	12/17/2002	4.30	CREEK BEHIND 320 S. CREEK	15	X		STOPPED MH
DRUMRIGHT	S20952	12/18/2002	0.00	306 E. FULKERSON	10	X		L.S. DOWN
DRUMRIGHT	S20952	1/14/2003	0.50	400 N. PENN - CORNER OF PENN & OAK	15	X		GREASE
DRUMRIGHT	S20952	1/24/2003	0.70	ALLEY AT 417 S. GRAND	10	X		ROOTS
DRUMRIGHT	S20952	1/30/2003	2.50	2ND & OHIO	100	X		DEBRIS
DRUMRIGHT	S20952	2/12/2003	0.00	ALLEY AT SMATHERS AT DALE & SHAFFER	10	X		STOPPAGE
DRUMRIGHT	S20952	3/2/2003	0.70	WWTP	200	X		MOTOR BURNOUT
DRUMRIGHT	S20952	3/5/2003	0.70	315 S. CREEK	15	X		BLOCKAGE
DRUMRIGHT	S20952	3/6/2003	1.00	315 S. CREEK	5	X		TRASH
DRUMRIGHT	S20952	3/21/2003	0.70	813 N. OHIO	20			BLOCKAGE
DRUMRIGHT	S20952	3/24/2003	0.50	400 N. PENN	20			GREASE
DRUMRIGHT	S20952	3/25/2003	0.30	100 BLK N. BRISTOW	5			ROOTS
DRUMRIGHT	S20952	4/21/2003	0.50	ALLEY AT 900 BLK SMOTHERS	25	X		STOPPED SEWER
DRUMRIGHT	S20952	4/27/2003	2.50	2ND & OHIO	200	X		STOPPED LINE
DRUMRIGHT	S20952	5/3/2003	0.00	1ST & OHIO	85			LINE BOKE AT COLLAR
DRUMRIGHT	S20952	5/10/2003	3.00	BRISTOW & CIMMARON	500	X		ROOTS
DRUMRIGHT	S20952	7/10/2003	2.20	IN CREEK OFF BROADWAY & CIMARRON	100	X		PIPE BREAK
DRUMRIGHT	S20952	10/2/2003	0.70	105 E. MAGNOLIA	15	X		ROOTS
DRUMRIGHT	S20952	10/3/2003	0.40	ALLEY BEHIND 319 N. TEXAS	20	X		RAGS
DRUMRIGHT	S20952	10/4/2003	1.10	IN CREEK BETWEEN BRISTOW & CIMMARRON	200	X		ROOTS
DRUMRIGHT	S20952	10/8/2003	0.70	BRISTOW & CIMMARON	150	X		ROOTS
DRUMRIGHT	S20952	10/21/2003	13.70	CREEK BOTTOM IN BRISTOW & CIMMARON	1,000	X		ROOTS
DRUMRIGHT	S20952	3/4/2004	0.40	900 BLK. N. SMATHERS	100	X		RAIN
DRUMRIGHT	S20952	3/4/2004	0.70	1ST & OHIO	100	X		RAIN

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
DRUMRIGHT	S20952	3/24/2004	0.00	IN CANYON AT N. BRISTOW & N. CIMARRON	600	X		BLOCKAGE
DRUMRIGHT	S20952	4/23/2004	0.40	304 E. 2ND IN ALLEY	20	X		BLOCKAGE
DRUMRIGHT	S20952	5/3/2004	0.40	ALLEY AT 400 BLK E. WOOD	100	X		BLOCKAGE
DRUMRIGHT	S20952	5/28/2004	0.50	OHIO AT 1ST & 2ND	75	X		RAGS
DRUMRIGHT	S20952	5/29/2004	0.50	420 S. OHIO	75	X		BLOCKAGE
DRUMRIGHT	S20952	7/20/2004	2.30	IN PARK OFF BROADWAY	100	X		LINE BREAK
DRUMRIGHT	S20952	12/5/2004	0.00	803 N. CENTER	25	X		
DRUMRIGHT	S20952	2/28/2005	3.30	ALLEY AT 519 E. DRUMRIGHT IN ALLEY OF TEXAS & DRUMRIGHT	150	X		LINE PLUGGED
DRUMRIGHT	S20952	3/1/2005	2.30	ALLEY BEHIND 413 N. PENN	55	X		STOPPAGE
DRUMRIGHT	S20952	3/3/2005	0.90	ALLEY BEHIND 519 E. DRUMRIGHT OFF DRUMRIGHT & TEXAS	50	X		LINE PLUGGED
DRUMRIGHT	S20952	3/3/2005	0.50	519 E. DRUMRIGHT	50	X		BLOCKAGE
DRUMRIGHT	S20952	3/7/2005	1.30	IN CREEK BED OFF BROADWAY IN PARK	200	X		PLUGGED LINE
DRUMRIGHT	S20952	3/21/2005	0.70	COUNTRY CLUB HEIGHTS	50	X		ELECTRICAL PROBLEM
DRUMRIGHT	S20952	4/3/2005	0.70	400 N. PENN	100	X		RAGS
DRUMRIGHT	S20952	4/5/2005	0.70	CREEK W. OF CITY HALL ON BROADWAY	100	X		RAGS
DRUMRIGHT	S20952	5/16/2005	0.50	AT SKINNER & LAYTON IN ALLEY OFF BROADWAY	50	X		LEAK IN LINE
DRUMRIGHT	S20952	7/27/2005	0.50	COUNTRY CLUB HEIGHTS L.S.	20	X		ELECTRICAL PROBLEMS
DRUMRIGHT	S20952	8/30/2005	0.60	DEAD END OF FULKERSON OFF VIRGINIA	75	X		LOST PRIME ON PUMP
DRUMRIGHT	S20952	9/1/2005	5.40	410 W. HICKORY	100	X		BLOCKAGE
DRUMRIGHT	S20952	1/9/2006	0.40	E. SIDE OF BRIDGE N.E. CORNER OF PENN & DRUMRIGHT	85	X		BLOCKAGE
DRUMRIGHT	S20952	1/13/2006	0.70	WEST LIFT STATION JUST WEST OF 1226 W. BROADWAY	200	X		MALFUNCTION
DRUMRIGHT	S20952	1/25/2006	0.00	HARLEY & BROADWAY	100	X		BLOCKAGE
NICOMA PARK	S20952	2/4/2006	0.50	11321 N.E. 10TH	200	X		MALFUNCTION
DRUMRIGHT	S20952	2/14/2006	1.20	TIGER CREEK AT PENN & DRUMRIGHT	85	X		BLOCKAGE
DRUMRIGHT	S20952	2/23/2006	0.00	WWTP - 811 N. MAIN		X		BEARING BROKE ON TRICKLING FILTER

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
DRUMRIGHT	S20952	2/24/2006	1.20	W. LIFT STATION - W. OF 1226	75	X		MOTOR BURNOUT
DRUMRIGHT	S20952	3/11/2006	3.00	NEAR LIFT STATION AT 306 E. FUCKERSON ST.	150	X		BLOCKAGE
DRUMRIGHT	S20952	3/15/2006	2.00	1226 W. BROADWAY - JUST W. OF DENTAL CLINIC ON HWY 33	200	X		POWER FAILURE
DRUMRIGHT	S20952	4/22/2006	0.40	PENN & OAK	40	X		LINE PLUGGED
DRUMRIGHT	S20952	4/25/2006	2.30	WEST LIFT STATION	200	X		POWER FAILURE
DRUMRIGHT	S20952	5/17/2006	0.80	312 W. BROADWAY	100	X		ROOTS
DRUMRIGHT	S20952	7/5/2006	2.30	300 BLK. E. HICKORY	125	X		LINE BREAK
DRUMRIGHT	S20952	8/21/2006	0.70	EAST LIFT STATION AT 306 E. FULKERSON	200	X		STORMS
DRUMRIGHT	S20952	9/15/2006	0.60	EAST LIFT STATION	100	X		RAGS
DRUMRIGHT	S20952	11/25/2006	0.70	3RD & VIRGINIA	150	X		LINE PLUGGED
DRUMRIGHT	S20952	12/29/2006	0.70	607 W. CHERRY	55	X		PLUGGED LINE
DRUMRIGHT	S20952	12/29/2006	2.00	PENN & OAK	175	X		ROOTS
DRUMRIGHT	S20952	1/8/2007	4.50	WAY PARK AT CIMMARRON & BROADWAY	75	X		TREE ROOTS
DRUMRIGHT	S20952	1/10/2007	0.00	DRUMRIGHT & CENTER	25	X		BLOCKAGE
DRUMRIGHT	S20952	2/26/2007	1.30	148 E. SHAFFER IN ALLEY	150	X		COLLAPSED LINE
DRUMRIGHT	S20952		0.00	400 N. PENN	100			ROOTS & RAGS
DRUMRIGHT	S20952		0.00	PARK OFF BROADWAY				LINE BREAK
DRUMRIGHT	S20952		0.00	EAST L.S.				RAINSTORM
OILTON	S20953	5/9/1990		OILTON LAGOON				HEAVY RAINS CAUSE WATER LEVEL TO HIGHER THAN MANHOLE
OILTON	S20953	6/28/1991	999.00	at entrance to treatment site	9,999,999	X		The effulent pipe plugged to make total retention
OILTON	S20953	8/18/1992	240.00	LAGOONS	900,000	X	X	SEASONALY HIGH RAINS
OILTON	S20953	3/3/1993	0.00	3RD CELL LAGOON		X	X	EXCESSIVE RAINFALL
OILTON	S20953	5/5/1993	24.00	LAGOONS	100,000	X		HYDROLIC OVERLOAD EXCESSIVE RAINS
OILTON	S20953	11/17/2001	0.50	E. 200 BLK AT 4TH & 5TH IN ALLEY				SOAP & GREASE
OILTON	S20953	4/12/2002	0.50	6TH & "A" ST	<50	X		BLOCKAGE

Facility Name	Facility ID	Date	Duration (hrs)	Location	Amount (gallons)	Raw	Treated	Cause
OILTON	S20953	4/1/2003	144.00	N.E. CORNER OF CELL	474,720		X	EMERGENCY BYPASS TO PREVENT FAILURE OF DYKE
OILTON	S20953	4/8/2003	0.00	N.E. CORNER OF CELL #2	474,720		X	EMERGENCY BYPASS
OILTON	S20953	4/15/2003	0.00	N.E. CORNER OF CELL #2	371,520		X	EMERGENCY BYPASS
OILTON	S20953	4/18/2003	0.00	N.E. CORNER OF CELL #2	928,800		X	EMERGENCY BYPASS
OILTON	S20953	5/1/2003	384.00	CELL #2	>1 MILLN		X	EMERGENCY BYPASS
OILTON	S20953	5/9/2003	0.00	N.E. CORNER OF CELL #2	701,760		X	EMERGENCY BYPASS
OILTON	S20953	5/15/2003	0.00	CELL #2	260,064		X	EMERGENCY BYPASS
OILTON	S20953	5/15/2003	144.00	N.E. CORNER OF CELL #2	939,120		X	EMERGENCY BYPASS
OILTON	S20953	6/5/2003	120.00	CELL #2	14,860		X	EMERGENCY BYPASS
OILTON	S20953	6/10/2003	0.00	CELL #2	>27 MILL		X	EMERGENCY BYPASS
OILTON	S20953	7/1/2003	168.00	CELL #2	>1 MILLN		X	EMERGENCY BYPASS
OILTON	S20953	7/8/2003	120.00	CELL #2	>55 MILL		X	EMERGENCY BYPASS
MULHALL	S20938	3/31/1999		DYKE AT NORTH CELL		X		RAIN
MULHALL	S20938	1/5/2000		NORTH LAGOON		X		PUMP BROKEN
MULHALL	S20938	3/4/2004	39.00	N. LAGOON			X	RAIN

Appendix F

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

A. BACKGROUND

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

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

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

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

This approach was further elaborated in a guidance memo issued in 2002. [See Memorandum from Robert Wayland, Director of OWOW and James Hanlon, Director of OWM to Regional Water Division Directors: "Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit requirements Based on Those WLAs " (Date published: 11/22/2002)] "The policy outlined in this memorandum affirms the appropriateness of an iterative, adaptive management BMP approach, whereby permits include effluent limits (e.g., a combination of structural and non-structural BMPs) that address storm water discharges, implement mechanisms to evaluate the performance of such controls, and make adjustments (i.e., more stringent controls or specific BMPs) as necessary to protect water quality. If it is determined that a BMP approach (including an iterative BMP approach) is appropriate to meet the storm water component of the TMDL, EPA recommends that the TMDL reflect this." This BMP-based approach to stormwater sources in TMDLs is also recognized and described in the most recent EPA guidance. [See "TMDLs To Stormwater Permits Handbook" (DRAFT), EPA, November 2008] This TMDL adopts the EPA recommended approach and relies on appropriate BMPs for implementation. No numeric effluent limitations are required or anticipated for municipal stormwater discharge permits.

B. SPECIFIC SWMP/SWPPP REQUIREMENTS

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

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

Table F-1. MS4 Permits Affected by This Bacteria TMDL Report

Entities	Phase 1/Phase 2 MS4	Permit #	Date Issued
Oklahoma City[1]	Phase 1 MS4	OKS000101	01/19/2007
The Village	Phase 2 MS4	OKR040002	11/14/2005

[1] Co-permittee with ODOT and OTA

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

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

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

As noted above, when a BMP approach is selected a coordinated monitoring program is necessary to establish the effectiveness of the selected BMPs and demonstrate progress toward attaining water quality standards. The monitoring results should be used to refine bacteria controls in the future.

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

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

1. Develop a Bacteria Reduction Plan

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

a. Consideration of ordinances or other regulatory mechanisms to require bacteria pollution control, as well enforcement procedures for noncompliance;

b. Evaluation of the existing SWMP in relation to TMDL reduction goals;

c. An evaluation to identify potential significant sources of bacteria entering your MS4. Develop (or modify an existing program as necessary) and implement a program to reduce the discharge of bacteria in municipal storm water contributed by any other significant source identified in the source identification evaluation

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

e. Investigation and implementation of BMPs that prevent additional storm water bacteria pollution associated with new development and re-development;

f. Develop (or modify an existing program as necessary) and implement a program to reduce the discharge of bacteria in municipal storm water contributed by areas within your MS4 served by on-site wastewater treatment systems

g. Implementation of BMPs applicable to bacteria. Table F-2 below presents summary information on some BMPs that may be considered. Permittees are not limited to BMPs on this list and should select BMPs appropriate to the local community that are expected to result in progress toward meeting the reduction goals established in the TMDL.

h. Modifications to the dry weather field screening and illicit discharge detection and elimination provisions of the SWMP to consider storm water sampling and other measures intended to specifically identify bacterial pollution sources and high priority areas for bacteria reductions.

i. Periodic evaluation of the effectiveness of the bacteria reduction plan to ensure progress toward attainment of water quality standards.

j. An implementation schedule leading to modification of the SWMP and full implementation of the plan within 3 years of notification.

2. Develop or Participate In a Bacteria Monitoring Program

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

a. Within 18 months of notification, the permittee shall prepare and submit to the DEQ either a TMDL monitoring plan or a commitment to participate in a coordinated regional monitoring program. Unless disapproved by the Director within 60 days of submission, the plan shall be approved and then implemented by the permittee. The plan or program shall include:

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

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

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

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

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

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

3. Annual Reporting

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

Table F-2. Some BMPs Applicable to Bacteria

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
Animal waste management: A planned system designed to manage liquid and solid waste from livestock and poultry. It improves water quality by storing and spreading waste at the proper time, rate and location.	X		75 %[1]	
Artificial wetland/rock reed microbial filter: A long shallow hydroponic plant/rock filter system that treats polluted waste and wastewater. It combines horizontal and vertical flow of water through the filter, which is filled with aquatic and semi-aquatic plants and microorganisms and provides a high surface area of support media, such as rocks or crushed stone.	X	X		
Compost facility: Treating organic agricultural wastes in order to reduce the pollution potential to surface and ground water. The composting facility must be constructed, operated and maintained without polluting air and/or water resources.	X	X		Permit may be needed
Conservation landscaping: The placement of vegetation in and around stormwater management BMPs. Its purpose is to help stabilize disturbed areas, enhance the pollutant removal capabilities of stormwater BMP, and improve the overall aesthetics of a stormwater BMP.		X		
Diversions: Establishing a channel with a supporting ridge on the lower side constructed along the general land slope which improves water quality by directing nutrient and sediment laden water to sites where it can be used or disposed of safely.	X	X		
Drain Inlet Inserts: A proprietary BMP that is generally easily installed in a drain inlet or catch basin to treat storm water runoff. Three basic types of inlet insert are available, the tray type, bag type and basket type. The tray type allows flow to pass through filter media residing in a tray located around the perimeter of the inlet.	X	X	5%[2]	
Dry detention pond/basin: Detention ponds/basins that have been designed to temporarily detain stormwater runoff. These ponds fill with stormwater and release it over a period of a few days. They can also be used to provide flood control by including additional flood detention storage.	X	X	40%[2] 51%[3] 88% [4]	
Earthen embankments: A raised impounding structure made from compacted soil. It is appropriate for use with infiltration, detention, extended-detention or retention facilities.	X	X		
Drip irrigation: An irrigation method that supplies a slow, even application of low-pressure water through polyethylene tubing running from supply line directly to a plant's base. Water soaks into the soil gradually, reducing runoff and evaporation (i.e., salinity). Transmission of nutrients and pathogens spread by splashing water and wet foliage created by overhead sprinkler irrigation is greatly reduced. Weed growth is minimized, thereby reducing herbicide applications. Vegetable farming and virtually every type of landscape situation can benefit from the use of drip irrigation.	X	X		

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
Fencing: A constructed barrier to livestock, wildlife or people. Standard or conventional (barbed or smooth wire), suspension, woven wire, or electric fences consist of acceptable fencing designs to control the animal(s) or people of concern and meet the intended life of the practice.	X		75%[1]	
Filtration (e.g., sand filters): Intermittent sand filters capture, pre-treat to remove sediments, store while awaiting treatment, and treat to remove pollutants (by percolation through sand media) the most polluted stormwater from a site. Intermittent sand filter BMPs may be constructed in underground vaults, in paved trenches within or at the perimeter of impervious surfaces, or in either earthen or concrete open basins.	X	X	30%[1] 55%[2] 37%[4]	
Infiltration Basin: A vegetated open impoundment where incoming stormwater runoff is stored until it gradually infiltrates into the soil strata. While flooding and channel erosion control may be achieved within an infiltration basin, they are primarily used for water quality enhancement.		X	50%[1]	
Infiltration Trench: A shallow, excavated trench backfilled with a coarse stone aggregate to create an underground reservoir. Stormwater runoff diverted into the trench gradually infiltrates into the surrounding soils from the bottom and sides of the trench. The trench can be either an open surface trench or an underground facility.		X	50%[1]	
Irrigation water management: The process of determining and controlling the volume, frequency, and application rate of irrigation water in a planned, efficient manner. An irrigation system adapted for site conditions (soil, slope, crop grown, climate, water quantity and quality, etc.) must be available and capable of applying water to meet the intended purpose(s).	X	X		
Lagoon pump out: A waste treatment impoundment made by constructing an embankment and/or excavating a pit or dugout in order to biologically treat waste (such as manure and wastewater) and thereby reduce pollution potential by serving as a treatment component of a waste management system.	X	X		
Land-use conversion: BMPs that involve a change in land use in order to retire land contributing detrimentally to the environment. Some examples of BMPs with associated land use changes are: Conservation Reserve Program (CRP) - cropland to pasture; Forest conservation - pervious urban to forest; Forest/grass buffers - cropland to forest/pasture; Tree planting - cropland/pasture to forest; and Conservation tillage – conventional tillage to conservation tillage.	X	X		
Limit livestock access: Excluding livestock from areas where grazing or trampling will cause erosion of stream banks and lowering of water quality by livestock activity in or adjacent to the water. Limitation is generally accomplished by permanent or temporary fencing. In addition, installation of an alternative water source away from the stream has been shown to reduce livestock access.	X			
Litter control: Litter includes larger items and particulates deposited on street surfaces, such as paper, vegetation residues, animal feces, bottles and broken glass, plastics and fallen leaves. Litter-control programs can reduce the amount of deposition of pollutants by as much as 50%, and may be an effective measure of controlling pollution by storm runoff.		X		

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
Livestock water crossing facility: Providing a controlled crossing for livestock and/or farm machinery in order to prevent streambed erosion and reduce sediment.	X		100%[1]	
Manufactured BMP systems: Structural measures which are specifically designed and sized by the manufacturer to intercept stormwater runoff and prevent the transfer of pollutants downstream. They are used solely for water quality enhancement in urban and ultra-urban areas where surface BMPs are not feasible.	X	X		
Onsite treatment system installation: Conventional onsite wastewater treatment and disposal system (onsite system) consists of three major components: a septic tank, a distribution box, and a subsurface soil absorption field (consisting of individual trenches). This system relies on gravity to carry household waste to the septic tank, move effluent from the septic tank to the distribution box, and distribute effluent from the distribution box throughout the subsurface soil absorption field. All of these components are essential for a conventional onsite system to function in an acceptable manner.		X		
Porous pavement: An alternative to conventional pavement, it is made from asphalt (in which fine filler fractions are missing) or modular or poured-in concrete pavements. Its use allows rainfall to percolate through it to the sub-base, providing storage and enhancing soil infiltration that can be used to reduce runoff and combined sewer overflows. The water stored in the sub-base then gradually infiltrates the subsoil.		X	50%[1]	
Proper site selection for animal feeding facility: Establishing or relocating confined feeding facilities away from environmentally vulnerable areas such as sinkholes, streams, and rivers in order to reduce or eliminate the amount of pollutant runoff reaching these areas.	X			
Rain garden/bio-retention basin: Rain gardens are landscaped gardens of trees, shrubs, and plants located in commercial or residential areas in order to treat stormwater runoff through temporary collection of the water before infiltration. They are slightly depressed areas into which storm water runoff is channeled by pipes, curb openings, or gravity.		X	40%[1]	
Range and pasture management: Systems of practices to protect the vegetative cover on improved pasture and native rangelands. It includes practices such as seeding or reseeding, brush management (mechanical, chemical, physical, or biological), proper stocking rates and proper grazing use, and deferred rotational systems.	X		50%[1]	
Wet retention ponds/basins: A storm water facility that includes a permanent pool of water and, therefore, is normally wet even during non-rainfall periods. Inflows from storm water runoff may be temporarily stored above this permanent pool.	X	X	32%[1] 70%[4]	
Riparian buffer zones: A protection method used along streams to reduce erosion, sedimentation, and the pollution of water from agricultural non-point sources.	X	X	43–57%[1]	Forested buffer w/o incentive payment

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
Septic system pump-out: A typical septic system consists of a tank that receives waste from a residence or business, and a drain field or subsurface absorption system consisting of a series of percolation lines for the disposal of the liquid effluent. Solids (sludge) that remain after decomposition by bacteria in the tank must be pumped out periodically.		X	5%[1]	
Sewer line maintenance (e.g., sewer flushing): Sewer flushing during dry weather is designed to periodically remove solids that have deposited on the bottom of the sewer and the biological slime that grows on the walls of combined sewers during periods of low-flow. Flushing is especially necessary in sewer systems that have low grades which has resulted in velocities during low-flow periods that fall below those needed for self-cleaning.		X		
Stream bank protection and stabilization (e.g., riprap, gabions): Stabilizing shoreline areas that are being eroded by landscaping, constructing bulkheads, riprap revetments, gabion systems, or establishing vegetation.	X	X	40-75%[1]	40 % w/o fencing; 75 % w/fencing
Street sweeping: The practice of passing over an impervious surface, usually a street or a parking lot, with a vacuum or a rotating brush for the purpose of collecting and disposing of accumulated debris, litter, sand and sediments. In areas with defined wet and dry seasons, sweeping prior to the wet season is likely to be beneficial; following snowmelt and heavy leaf fall are also opportune times.		X		
Terrace: An earth embankment, or a combination ridge and channel, constructed across the field slope. Terraces can be used when there is a need to conserve water, excessive runoff is a problem, and the soils and topography are such that terraces can be constructed and farmed with reasonable effort.	X	X		
Vegetated filter strip: A densely vegetated strip of land engineered to accept runoff from upstream development as overland sheet flow. It may adopt any naturally vegetated form, from grassy meadow to small forest. The purpose of a vegetated filter strip is to enhance the quality of stormwater runoff through filtration, sediment deposition, infiltration and absorption.	X	X	<30% [3]	
Waste system/storage (e.g., lagoons, litter shed): Waste treatment lagoons biologically treat liquid waste to reduce the nutrient and BOD content. Lagoons must be emptied and their contents disposed of properly.	X	X	80–100%[1]	
Water treatment (e.g., disinfection, flocculation, carbon filter system): Physical, chemical and/or biological processes used to treat concentrated discharges. Physical-chemical processes that have been demonstrated to effectively treat discharge include sedimentation, vortex separation, screening (e.g., fine-mesh screening), and sand-peat filters. Chemical additives used to enhance separation of particles from liquid include chemical coagulants such as lime, alum, ferric chloride, and various polyelectrolytes. Biological processes that have been demonstrated to effectively treat discharges include contact stabilization, biodiscs, oxidation ponds, aerated lagoons, and facultative lagoons.	X	X		

BEST MANAGEMENT PRACTICE	Impairment Source		Reported Efficiency	Note
	Agriculture	Urban		
Wetland development/enhancement: The construction of a wetland for the treatment of animal waste runoff or storm water runoff. Wetlands improve water quality by removing nutrients from animal waste or sediments and nutrients from storm water runoff.	X	X	30%[1] 78%[4]	Including creation and restora-tion

Sources

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

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

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

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