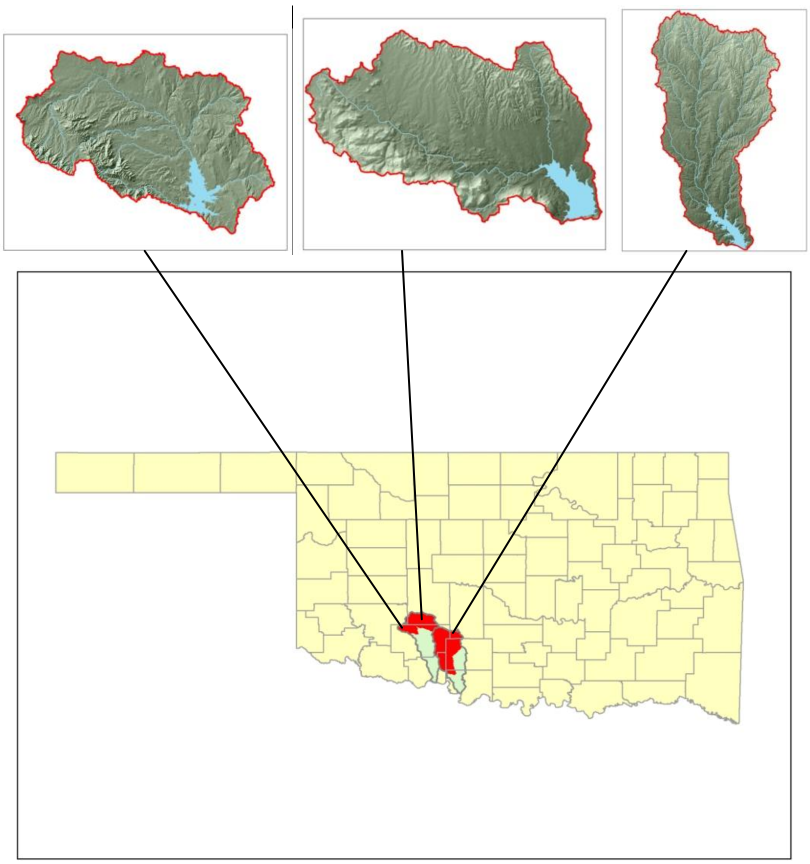
FINAL

CHLOROPHYLL-*a* TOTAL MAXIMUM DAILY LOADS FOR LAKE LAWTONKA (OK311300040070_00), WAURIKA LAKE (OK311210000020_00), AND LAKE ELLSWORTH (OK311300030020_00)



Prepared for:

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

Prepared by:

PARSONS

SEPTEMBER 2013

FINAL

CHLOROPHYLL-*a*
TOTAL MAXIMUM DAILY LOADS
FOR LAKE LAWTONKA (OK311300040070_00), WAURIKA LAKE (OK311210000020_00), AND LAKE ELLSWORTH (OK311300030020_00)

Prepared for:

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

Prepared by:

PARSONS

8000 Centre Park Drive, Suite 200
Austin, TX 78754

SEPTEMBER 2013

TABLE OF CONTENTS

EXECUTIVE SUMMARY ES-1
E.1 Problem Identification and Water Quality Target ES-2
E.2 Pollutant Source Assessment ES-4
E.3 Technical Approach and Methods ES-7
E.4 TMDLs and Load Allocations ES-9
E.5 Public Participation ES-11
SECTION 1 INTRODUCTION 1-1
1.1 TMDL Program Background 1-1
1.2 Watershed and Lake Description 1-2
1.2.1. Lake Characteristics 1-2
1.2.2 General 1-4
1.2.3 Climate 1-4
1.2.4 Land Use 1-5
1.3 Flow Characteristics 1-6
SECTION 2 PROBLEM IDENTIFICATION AND WATER QUALITY TARGET 2-1
2.1 Oklahoma Water Quality Standards 2-1
2.2 Problem Identification 2-3
2.2.1 Chlorophyll-*a* Data Summary 2-4
2.2.2 Nutrient Data Summary 2-6
2.3 Water Quality Target 2-7
SECTION 3 POLLUTANT SOURCE ASSESSMENT 3-1
3.1 Assessment of Point Sources 3-1
3.2 Estimation of Existing Pollutant Loads 3-4
3.2.1 SWAT Model Development for Pollutant Source Loadings 3-4
3.2.2 Model-Estimated Nutrient Loading from Point and Nonpoint Sources 3-9
SECTION 4 TECHNICAL APPROACH AND METHODS 4-1
4.1 BATHTUB Model Description 4-1
4.2 BATHTUB Model Setup and Input Data 4-1
4.2.1 Lake Morphometry 4-1
4.2.2 Meteorology 4-2
4.2.3 Inflows and Loads 4-2
4.2.4 Empirical Equations 4-3
4.3 BATHTUB Model Calibrations and Output 4-3
4.4 BATHTUB Model Sensitivity Analysis 4-4
4.5 BATHTUB Uncertainty Analysis 4-6

4.6 Modeled Load Reduction Scenarios 4-10
SECTION 5 TMDLS AND LOAD ALLOCATIONS 5-1
5.1 Wasteload Allocation 5-1
5.2 Load Allocation 5-1
5.3 Seasonal Variability 5-1
5.4 Margin of Safety 5-1
5.5 TMDL Calculations 5-2
5.6 TMDL Implementation 5-3
5.6.1 Point Sources 5-4
5.6.2 Nonpoint Sources 5-4
SECTION 6 PUBLIC PARTICIPATION 6-1
SECTION 7 REFERENCES 7-1

APPENDICES

Appendix A State of Oklahoma Antidegradation Policy
Appendix B Ambient Water Quality Data
Appendix C SWAT Model
Appendix D Response to Public Comments

LIST OF FIGURES

Figure ES-1 Total N and Total P Combinations Resulting in 10 µg/L Chlorophyll-*a* – Lake Lawtonka ES-9
Figure 1-1 Lake Lawtonka, Waurika Lake, and Lake Ellsworth 1-3
Figure 1-2 Lake Lawtonka, Waurika Lake, and Lake Ellsworth Watershed Land Use 1-6
Figure 3-1 NPDES No-Discharge Facilities in the Study Area 3-3
Figure 3-2 Sub-Watersheds Simulated in the SWAT Watershed Model 3-7
Figure 3-3 Observed and SWAT Modeled Average Monthly Flows 3-8
Figure 3-4 Observed and SWAT Modeled Nutrient Concentrations 3-9
Figure 3-5 Average Total Phosphorus Loading from SWAT Sub-Watersheds 3-11
Figure 3-6 Average Total Nitrogen Loading from SWAT Sub-Watersheds 3-12
Figure 4-1 Characterization Matrix for BATHTUB Parameters for Lake Lawtonka 4-4
Figure 4-2 Characterization Matrix for BATHTUB Parameters for Waurika Lake 4-5
Figure 4-3 Characterization Matrix for BATHTUB Parameters for Lake Ellsworth 4-5
Figure 4-4 Monte Carlo Simulation Results for Lake Lawtonka 4-7
Figure 4-5 Monte Carlo Simulation Results for Waurika Lake 4-8
Figure 4-6 Monte Carlo Simulation Results for Lake Ellsworth 4-9
Figure 4-7 Total N and Total P Combinations Resulting in 10 µg/L Chlorophyll-*a* – Lake Lawtonka 4-12
Figure 4-8 Total N and Total P Reduction Combinations Resulting in 10 µg/L Chlorophyll-*a* – Waurika Lake 4-12
Figure 4-9 Total N and Total P Reduction Combinations Resulting in 9 µg/L Chlorophyll-*a* – Lake Ellsworth 4-13
Figure C-2 Model Segmentation and Calibration Stations C-5
Figure C-3 Locations of NPDES Point Sources C-6

LIST OF TABLES

Table ES-1 Excerpt from the 2010 Integrated Report – Oklahoma §303(d) List of Impaired Waters (Category 5a) ES-2

Table ES-2 Average Flows and Nutrient Loads Discharging to Lake Lawtonka, Waurika Lake and Lake Ellsworth ES-6

Table ES-3 Model Predicted and Measured Water Quality Parameter Concentrations ES-7

Table ES-4 Total Phosphorus and Nitrogen Load Reductions Needed to Meet Chlorophyll-*a* In-lake Water Quality Targets ES-8

Table ES-5 TMDLs for Chlorophyll-*a* Expressed in Kilograms of Total Phosphorus and Nitrogen Per Day ES-11

Table 1-1 General Lake Characteristics 1-2

Table 1-2 County Population and Density 1-4

Table 1-3 Average Annual Precipitation by Watershed (1994-2010) 1-5

Table 1-4 Land Use Summary by Watershed 1-5

Table 2-1 Excerpt from the 2010 Integrated Report – Oklahoma §303(d) List of Impaired Waters (Category 5a) 2-1

Table 2-2 Water Quality Monitoring Stations used for 2010 §303(d) Listing Decision 2-3

Table 2-3 Summary of Chlorophyll-a Measurements in Lake Lawtonka 2002-2011 (all values in µg/L) 2-4

Table 2-4 Summary of Chlorophyll-a Measurements in Waurika Lake 2002-2008 (all values in µg/L) 2-5

Table 2-5 Summary of Chlorophyll-a Measurements in Lake Ellsworth 2002-2009 (all values in µg/L) 2-5

Table 2-6 Summary of Average Nutrient Measurements in Lake Lawtonka 1998-2011 (all values in mg/L)‡ 2-6

Table 2-7 Summary of Average Nutrient Measurements in Waurika Lake 1999-2008 (all values in mg/L)‡ 2-6

Table 2-8 Summary of Average Nutrient Measurements in Lake Ellsworth 1998-2009 (all values in mg/L)‡ 2-7

Table 3-1 NPDES No-Discharge Facilities in the Study Area 3-2

Table 3-2 Sanitary Sewer Overflow Summary for Period 2003-2012 3-2

Table 3-3 Average Flows and Nutrient Loads Discharging to Lake Lawtonka, Waurika Lake, and Lake Ellsworth 3-10

Table 4-1 Estimate of Atmospheric Loads 4-2

Table 4-2 Calibration Factors Used for Lakes 4-3

Table 4-3 Model Predicted and Measured Water Quality Parameter Concentrations....4-3
Table 4-4 Selected Distribution of Parameters for BATHTUB Uncertainty Analysis....4-6
Table 4-5 Existing Loads (in kg/yr)....4-10
Table 4-6 Total Phosphorus and Nitrogen Load Reductions Needed to Meet Chlorophyll-*a* In-lake Water Quality Targets....4-10
Table 5-1 TMDLs for Chlorophyll-*a* Expressed in Kilograms of Total Phosphorus and Nitrogen Per Day....5-3
Table 5-2 Partial List of Oklahoma Water Quality Management Agencies....5-4
Appendix B, Table-1: Ambient Water Quality Data for Lake Lawtonka, 1998-2011....B-2
Appendix B, Table-2: Ambient Water Quality Data for Waurika Lake, 1999-2008....B-27
Appendix B, Table-3: Ambient Water Quality Data for Lake Ellsworth, 1998-2009....B-45
Appendix C, Table-1: Distribution of Land Cover in the Modeled Watershed....C-3
Appendix C, Table-9: Average Flows and Nutrient Loads Discharging to Lake Lawtonka, Waurika Lake and Lake Ellsworth....C-21

ACRONYMS AND ABBREVIATIONS

µg/L	Microgram per liter
BUMP	Beneficial Use Monitoring Program
CAFO	Concentrated Animal Feeding Operation
CDL	Cropland Data Layer
CFR	Code of Federal Regulations
CV	Coefficient of Variation
CWA	Clean Water Act
DEQ	Oklahoma Department of Environmental Quality
DMR	Discharge monitoring report
EPA	United States Environmental Protection Agency
HUC	Hydrologic unit code
kg	Kilograms
kg/ha/yr	Kilograms per hectare per year
LA	Load allocation
MCS	Monte Carlo simulation
mg/L	Milligram per liter
MOS	Margin of safety
MS4	Municipal separate storm sewer system
NASS	National Agricultural Statistics Service
NLW	Nutrient limited watershed
NPDES	National Pollutant Discharge Elimination System
NSE	Nash-Sutcliffe Efficiency
O.S.	Oklahoma statutes
OAC	Oklahoma Administrative Code
OSWD	Onsite wastewater disposal
OWRB	Oklahoma Water Resources Board
r^2	Correlation coefficient
SWAT	Soil and Water Assessment Tool
SWS	Sensitive public and private water supply
TMDL	Total maximum daily load
TN	Total nitrogen
TP	Total phosphorus
TSI	Trophic state index
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WAKO2, aka WAUB	Beaver Creek at Waurika
WLA	Wasteload allocation
WQM	Water quality monitoring
WQMP	Water quality management plan
WQS	Water quality standard
WWTF	Wastewater treatment facility

Executive Summary

This report documents the data and assessment methods used to establish total maximum daily loads (TMDL) for Lake Lawtonka [Oklahoma Waterbody ID (OK WBID) number OK311300040070_00], Waurika Lake (OK311210000020_00), and Lake Ellsworth (OK311300030020_00). The Oklahoma Department of Environmental Quality (DEQ) placed these waterbodies in Category 5 of the Oklahoma 2010 Integrated Report for nonsupport of the public and private water supply designated use because of elevated levels of chlorophyll-*a*.

The three lakes (reservoirs) are located in the Upper Red River Sub-basin [hydrologic unit code (HUC) 1113]. Lake Lawtonka is a 2,398-acre lake in Comanche County with conservation pool storage of 56,574 acre-feet. It was impounded in 1905, and serves as a recreational lake and is utilized for water supply by the City of Lawton and surrounding communities (Oklahoma Water Resources Board [OWRB] 2009). Medicine Creek (OK311300040060_00), which is 17.71 miles long, is the primary tributary flowing to Lake Lawtonka.

Waurika Lake is a 10,100-acre lake in Cotton, Jefferson, and Stephens Counties with conservation pool storage of 203,100 acre-feet. Waurika Lake was first impounded by the U.S. Army Corp of Engineers (OWRB 2009) in 1977 and serves as a recreational lake, flood control, irrigation, and as a municipal water supply. Beaver Creek (46.9 miles long) and Little Beaver Creek (39.5 miles long) are the primary tributaries flowing to Waurika Lake.

Lake Ellsworth, located on the East Cache Creek, is a 5,600-acre lake in Comanche and Caddo Counties with conservation pool storage of 95,200 acre-feet. It was first impounded in 1962 and serves as a multipurpose waterbody for recreational use and as a municipal water supply for the City of Lawton (OWRB 2009). Chandler Creek (10.5 miles long) and Tony Creek (5.7 miles long) are the primary tributaries flowing to Lake Ellsworth.

There is little developed land bordering the shoreline of any of the three lakes. All lakes are popular fishing and boating recreation destinations. The watersheds of all three lakes are sparsely populated, with developed land accounting for less than 1% of the watershed area. The most common land use category throughout each watershed is grassland/herbaceous. The contributing watersheds are herein after referred to as the Study Area.

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), United States Environmental Protection Agency (EPA) guidance, and Oklahoma Water Quality Standards (WQS) [Oklahoma Administrative Code (OAC) Title 785, Chapter 45]. The Oklahoma Department of Environmental Quality (DEQ) is required to submit all TMDLs to EPA for review and approval. Once 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 watershed-based nutrient load allocations necessary for reducing chlorophyll-*a* levels in the lakes, which is the first step toward restoring water quality and protecting public health. TMDLs determine the pollutant loading a waterbody can assimilate without exceeding applicable WQS. TMDLs also establish the pollutant load allocation necessary to meet the WQS established for a waterbody based on the relationship between pollutant sources and water quality conditions in the waterbody. A TMDL consists of a wasteload allocation (WLA), load allocation (LA), and a margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources, and includes stormwater discharges regulated under the National Pollutant Discharge Elimination System (NPDES) as point sources. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. The MOS is a percentage of the TMDL set aside to account for the lack of knowledge associated with natural processes in aquatic systems, model assumptions, and data limitations.

This report does not stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce nutrients 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.

E.1 Problem Identification and Water Quality Target

This TMDL report focuses on the waterbodies identified in Table ES-1 that DEQ placed in Category 5 of the *Water Quality in Oklahoma 2010 Integrated Report* for nonsupport of the Public Private Water Supply use. Elevated levels of chlorophyll-*a* in lakes reflect excessive algae growth, which can have deleterious effects on the quality and treatment costs of drinking water. Excessive algae growth can also negatively affect the aquatic biological communities of lakes. Elevated chlorophyll-*a* levels typically indicate excessive loading of the primary growth-limiting algal nutrients such as nitrogen and phosphorus to the waterbody, a process known as eutrophication.

Table ES-1 Excerpt from the 2010 Integrated Report – Oklahoma §303(d) List of Impaired Waters (Category 5a)

<table>
<tr><th>Waterbody Name and WBID</th><th>Waterbody Size (Acres)</th><th>TMDL Date</th><th>TMDL Priority</th><th>Causes of Impairment</th><th>Designated Use Not Supported</th></tr>
<tr><td>Lake Lawtonka (OK311300040070_00)</td><td>2,398</td><td>2012</td><td>1</td><td>▪ Chlorophyll-a</td><td>▪ Public and Private Water Supply</td></tr>
<tr><td rowspan="2">Waurika Lake (OK311210000020_00)</td><td rowspan="2">10,100</td><td rowspan="2">2012</td><td rowspan="2">1</td><td>▪ Chlorophyll-a</td><td>▪ Public and Private Water Supply</td></tr>
<tr><td>▪ Turbidity</td><td>▪ Warm Water Aquatic Community</td></tr>
<tr><td rowspan="4">Lake Ellsworth (OK311300030020_00)</td><td rowspan="4">5,600</td><td rowspan="4">2012</td><td rowspan="4">1</td><td>▪ Chlorophyll-a</td><td>▪ Public and Private Water Supply</td></tr>
<tr><td>▪ Enterococcus</td><td>▪ Primary Body Contact Recreation</td></tr>
<tr><td>▪ Oxygen, dissolved</td><td>▪ Warm Water Aquatic Community</td></tr>
<tr><td>▪ Turbidity</td><td>▪ Warm Water Aquatic Community</td></tr>
</table>

Source: 2010 Integrated Report, DEQ 2010.

Sensitive Public and Private Water Supply (SWS) lakes are defined in the Oklahoma Water Quality Standards - Oklahoma Administrative Code (OAC) Title 785, Chapter 45:

785:45-5-25(c)(4)(A). In Appendix A.3 of the WQS, Lake Lawtonka, Waurika Lake, and Lake Ellsworth are all listed as SWS lakes.

> The numeric criterion set for chlorophyll-*a* for SWS lakes is also found in the WQS [785:45-5-10(7)] which states, "*The long-term average concentration of chlorophyll-a at a depth of 0.5 meters below the surface shall not exceed 0.010 milligrams per liter in Wister Lake, Tenkiller Ferry Reservoir, nor any waterbody designated SWS in Appendix A of this Chapter. Wherever such criterion is exceeded, numerical phosphorus or nitrogen criteria or both may be promulgated.*

Surface level sampling data, collected from the lakes' Water Quality Monitoring (WQM) stations, was used to support the decision to place these lakes in the Lawtonka/ Ellsworth/Waurika watersheds on the DEQ 2010 §303(d) list for non-support of the Public and Private Water Supply Use in an SWS lake:

- Between 2002 and 2011, Lake Lawtonka chlorophyll-*a* samples averaged 17.5 µg/L which is equivalent to a Carlson's TSI of 59 (Carlson 1977).
- Between 2002 and 2008, Waurika Lake chlorophyll-*a* samples averaged 13.4 µg/L (TSI = 56).
- Between 2002 and 2009, Lake Ellsworth chlorophyll-*a* samples averaged 12.2 µg/L (TSI = 55).

Between 1998 to 2011, total nitrogen levels (TN) and total phosphorus (TP) levels were as follows for the lakes in the Study Area. In addition, thermal stratification was not observed during the 2005-2006 assessment period, likely due to the shallow nature of the lakes (OWRB 2007). Thus, nutrient fluxes from sediments were available year-round in the photic zone where light permits algal photosynthesis.

- Lake Lawtonka: TN levels averaged approximately 0.66 mg/L and TP levels averaged 0.03 mg/L (Table 2-6).
- Waurika Lake: TN levels averaged approximately 0.81 mg/L, and TP levels averaged 0.09 mg/L (Table 2-7).
- Lake Ellsworth: TN levels averaged approximately 0.83 mg/L, and TP levels averaged 0.07 mg/L (Table 2-8).

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 target established for each lake must demonstrate compliance with the numeric criterion prescribed for SWS lakes in the Oklahoma WQS (OWRB 2011). Therefore, the water quality target established for all three lakes is to achieve a long-term average in-lake concentration of 10 µg/L for chlorophyll-*a*.

Waurika Lake and Lake Ellsworth are also included in the 303(d) list for turbidity. Additionally, Lake Ellsworth is listed for Enterococcus and dissolved oxygen criteria exceedances. These water quality issues will be addressed specifically on a future date.

Determining which nutrients limit phytoplankton growth is an important step in the development of effective lake and watershed management strategies (Dodds and Priscu 1990; Elser *et al.* 1990; Smith *et al.* 2002). It is often assumed that algal productivity of most freshwater lakes and reservoirs is primarily limited by the availability of the nutrient phosphorus. However, more recent studies in reservoirs indicate that both nitrogen and phosphorus play key roles, along with light, mixing conditions, predation by zooplankton, and residence time, in limiting algal growth (Kimmel et al. 1990).

E.2 Pollutant Source Assessment

This section includes an assessment of the known and suspected sources of nutrients contributing to the eutrophication of Lake Lawtonka, Waurika Lake, and Lake Ellsworth. Nutrient sources identified are categorized and quantified to the extent that reliable information is available. Generally, nutrient loadings causing eutrophication of lakes originate from point or nonpoint sources of pollution. Point sources are permitted through the NPDES program. 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 nutrient loads to surface water as a result of rainfall runoff. For the TMDLs in this report, all sources of pollutant loading not regulated by NPDES are considered nonpoint sources.

Under 40 CFR §122.2, a point source is described as a discernible, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. NPDES-permitted facilities classified as point sources that may contribute nutrient loading include:

- NPDES municipal wastewater treatment facility (WWTF) discharges;
- NPDES industrial WWTF discharges;
- NPDES no-discharge WWTFs;
- NPDES concentrated animal feeding operations (CAFO); and
- NPDES regulated stormwater discharges [MS4 (Municipal separate storm sewer system)/Industrial/Construction].

There are no discharges from any of these classes of NPDES-permitted point source discharges in the watersheds of Lake Lawtonka, Waurika Lake, and Lake Ellsworth except for NPDES no-discharge WWTFs (six within the Waurika Lake watershed and one in the Lake Ellsworth watershed). Given the small size of the wastewater collection systems of these no-discharge facilities, the contributions of nutrient loads would be negligible. Therefore, almost all nutrient loading to these three lakes originates from 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 forest and grasslands have a strong influence on the origin and pathways of nutrient sources to surface water. Nutrient sources in rural watersheds originate from soil erosion, agricultural fertilization, residues from mowing and harvesting, leaf litter, and fecal waste deposited in the watershed by livestock. Causes of soil erosion can include natural causes such as flooding and winds, construction activities, vehicular traffic, and agricultural activities. Other sources of nutrient loading in a watershed include atmospheric deposition, failing onsite wastewater disposal (OSWD) systems, and fecal matter deposited in the watershed by wildlife and pets.

Given the lack of in-stream water quality data and pollutant source data available to quantify nutrient and sediment loading directly from the tributaries of Lake Lawtonka, Waurika Lake, and Lake Ellsworth, a watershed loading model – the Soil and Water Assessment Tool (SWAT) – was used to develop nonpoint source loading estimates. These estimates from SWAT were used to quantify the nutrient contributions to each lake. SWAT is a basin-scale watershed model that can be operated on a daily time step (Neitsch et al. 2009). SWAT is designed to predict the impact of management strategies on water, nutrient, sediment, and agricultural chemical yields. The model is physically (and empirically) based, computationally efficient, and capable of continuous simulation over long time periods. Major components of the model include weather, hydrology, soil temperature and properties, plant growth, nutrients, and land management.

There are no stream flow gages in the tributaries to Lake Lawtonka, Waurika Lake, or Lake Ellsworth. There are water quality monitoring stations in the tributaries to Lake Lawtonka [Medicine Creek: Oklahoma Conservation Commission (OCC) monitoring site OK311300-04-0060H] and Waurika Lake (Little Beaver Creek: OCC monitoring site OK311210-00-0050D), but none in the tributaries to Lake Ellsworth. To calibrate the SWAT model, it was necessary to extend the modeled area to encompass watersheds with stream flow gages and nutrient concentration measurements. Thus, the SWAT model simulated two adjacent watersheds: Cache (HUC 11130202) and Northern Beaver HUC 11130208). The modeled domain is a 1,620 square mile area that includes the contributing watersheds of the three lakes. The main streams located in the model domain are East Cache Creek, Little Beaver Creek, Beaver Creek, Cow Creek, and Medicine Creek.

A 17-year period (1994 - 2010) was simulated in the SWAT model. However, the first four years were considered a "spin-up" period for stabilizing model initial conditions, and the model output consisted of only the latter 13 years (1998 - 2010). The variables simulated in SWAT included flow, organic phosphorus, mineral ortho-phosphorus, organic nitrogen, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, and total suspended solids.

The SWAT hydrologic calibration was primarily performed based on flow data available at the USGS (United States Geological Survey) gage located on East Cache Creek (USGS Station 07311000) and the United States Army Corps of Engineers (USACE) gage located on Beaver Creek at Waurika (WAKO2, aka WAUB). In addition, the model simulated inflow to Waurika Lake was compared to daily records reported by USACE. Overall, the model reproduces the annual flows within the 15% target for most years, with overall errors below the target for all the locations (1% for East Cache Creek, 6% for Beaver Creek, and -6% for Waurika Lake inflow). Resulting Nash-Sutcliffe Efficiency coefficients (NSE) and correlation coefficient (r^2) values for annual flows were 0.987 and 0.990 for Cimarron East Cache Creek, 0.983 and 0.995 for Beaver Creek, and 0.981 and 0.986 for Waurika Lake inflow. The high resulting coefficients indicate very good model performance for annual flows.

After hydrologic calibration, the SWAT-predicted nutrient concentrations were calibrated to the observed nutrient concentrations at five water quality stations: East Cache Creek at

SH 53 near Walters (OWRB monitoring site 311300010020-001AT), Little Beaver Creek (OCC monitoring site OK311210-00-0050D), Medicine Creek (OCC monitoring site OK311300-04-0060H), OCC's uppermost monitoring site on East Cache Creek (OK311300-02-0010M), and Cow Creek (OCC monitoring site OK311200-00-0060L). It is noted that, with exception of the station on East Cache Creek at SH 53, all the TSS and nutrient measurements for the remaining stations were below detection limits. For purposes of calculating averages to compare to modeled values, non-detects were assumed equal to half of the detection limit. The detection limit varied among events and among sampling sites, hence, the difference in calculated averages for sub-watersheds[1] 7, 9, 28 and 42. It is noted that, with exception of the measurements at the station on East Cache Creek at SH 53 and the NO_3 (nitrate) concentrations at the station on Cow Creek, all the TSS and nutrient measurements for the remaining stations were below detection limits. In most cases, the SWAT model reproduced the average nutrient concentrations within 25% of the measured averages. In some instances, the model does not replicate particular nutrient species well for a given period, but nevertheless the total phosphorus and nitrogen predicted averages are within the 25% target. However, it is noted that monitoring data available for calibration are from low to moderate flow conditions. As a result, there is more uncertainty on high flow loading values.

Based on the calibrated SWAT model, average loads of nutrients from each of the individual sub-watersheds were estimated for the period 1998 to 2010. The average daily flows and loads into Lake Lawtonka, Waurika Lake, and Lake Ellsworth are displayed in Table ES-2. Under current conditions, Lake Lawtonka is estimated to receive a total annual load of 7,200 kg of phosphorus and 52,800 kg of nitrogen, on average, from nonpoint sources in its watershed. Waurika Lake is estimated to receive a total annual load of 47,200 kg of phosphorus and 275,500 kg of nitrogen, on average, from sources in its watershed. Lake Ellsworth is estimated to receive a total annual load of 27,100 kg of phosphorus and 234,800 kg of nitrogen, on average, from nonpoint sources in its watershed.

Table ES-2 Average Flows and Nutrient Loads Discharging to Lake Lawtonka, Waurika Lake and Lake Ellsworth

Parameter	Lake Lawtonka	Waurika Lake	Lake Ellsworth
Watershed Size (square miles)	93	562	235
Flow (m^3/day)	8.87×10^4	3.75×10^5	2.24×10^5
Organic Phosphorus (kg/year)	4,700	38,000	22,300
Mineral Ortho-Phosphorus (kg/year)	2,500	9,200	4,800
Total Phosphorus (kg/year)	**7,200**	**47,200**	**27,100**
Organic Nitrogen (kg/year)	24,600	141,600	125,700
Ammonia Nitrogen (kg/year)	200	8,800	10,100
Nitrate+Nitrite Nitrogen (kg/year)	28,000	125,100	99,000
Total Nitrogen (kg/year)	**52,800**	**275,500**	**234,800**

[1] The location of these sub-watersheds can be found in Figure 3-2.

E.3 Technical Approach and Methods

The objective of a TMDL is to estimate allowable pollutant loads and allocate those loads to the known pollutant sources in the watershed so appropriate control measures can be implemented and the WQS achieved. To ascertain the effect of management measures on in-lake water quality, it is necessary to establish a linkage between the external loading of nutrients (TN and TP) and the waterbody response in terms of lake water quality conditions, as evaluated by chlorophyll-*a* concentrations. The following paragraphs describe the water quality analysis of the linkage between chlorophyll-*a* levels in Lake Lawtonka, Waurika Lake, and Lake Ellsworth and the nutrient loadings from their watersheds.

The water quality linkage analysis was performed using the BATHTUB model (Walker 1986). BATHTUB is a U.S. Army Corps of Engineers model designed to simulate eutrophication in reservoirs and lakes. BATHTUB has been cited as an effective tool for reservoir and lake water quality assessment and management, particularly where data are limited. The model incorporates several empirical equations of nutrient settling and algal growth to predict steady-state water column nutrient and chlorophyll-*a* concentrations based on waterbody characteristics, hydraulic characteristics, and external nutrient loadings.

The model was run under existing average, steady-state conditions. An averaging period of one year was used to depict the duration of mass-balance calculations for each lake. A single, well-mixed lake was assumed for all three reservoirs. Key water quality parameters for BATHTUB input include total phosphorus, inorganic ortho-phosphorus, total nitrogen, and inorganic nitrogen. Output from the SWAT model was the primary source of data input to the BATHTUB model. Although SWAT can provide daily output, BATHTUB is a steady-state model and not appropriate for interpreting short-term responses of lakes to nutrients. Therefore, the long-term average annual loads from the SWAT-modeled period were applied as inputs to BATHTUB.

The BATHTUB models for each lake were run under average existing conditions, and calibrated to measure in-lake water quality conditions (based on 2002-2011 data) using phosphorus and nitrogen calibration factors. The model-predicted concentrations of total nitrogen, total phosphorus, chlorophyll-*a*, and Secchi depth under existing average conditions are compared to average measured concentrations from each lake in Table ES-3.

Table ES-3 Model Predicted and Measured Water Quality Parameter Concentrations

Water Quality Parameter	Lake Lawtonka		Waurika Lake		Lake Ellsworth	
	Modeled	Measured	Modeled	Measured	Modeled	Measured
Total Phosphorus (mg/L)	0.026	0.026	0.086	0.086	0.066	0.067
Total Nitrogen (mg/L)	0.66	0.66	0.80	0.80	0.84	0.84
Chlorophyll-*a* (µg/L)	17.5	17.1	13.4	13.5	12.3	12.4
Secchi depth (meters)	1.1	1.1	0.6	0.6	0.4	0.3

Simulations were performed using the BATHTUB model to evaluate the effect of watershed loading reductions on chlorophyll-*a* levels. Atmospheric loads were maintained at their existing estimated levels. Simulations indicated that the water quality target of 10 µg/L chlorophyll-*a* as a long-term average concentration could be achieved if the total phosphorus and nitrogen watershed loads to Lake Lawtonka were reduced by 55% from the existing loads, to 3,240 kg/year of total phosphorus and 23,760 kg/year of total nitrogen. In Waurika Lake, the water quality target of 10 µg/L chlorophyll-*a* could be achieved if the existing watershed loads were reduced by 40% to 28,320 kg/year of total phosphorus and 165,300 kg/year of total nitrogen. In Lake Ellsworth, the water quality target of 9 µg/L chlorophyll-*a* could be achieved if the existing watershed loads were reduced by 45% to 14,900 kg/year of total phosphorus and 129,140 kg/year of total nitrogen. As discussed above the uncertainty analysis demonstrated that to ensure at least a 50% probability of meeting water quality standards, a water quality target of 9 µg/L chlorophyll-*a* was set for Lake Ellsworth. Table ES-4 summarizes the percent reduction goals for nutrient loading established for each lake. These maximum allowable loads include an inherent margin of safety through the use of limits on loading of both nitrogen and phosphorus.

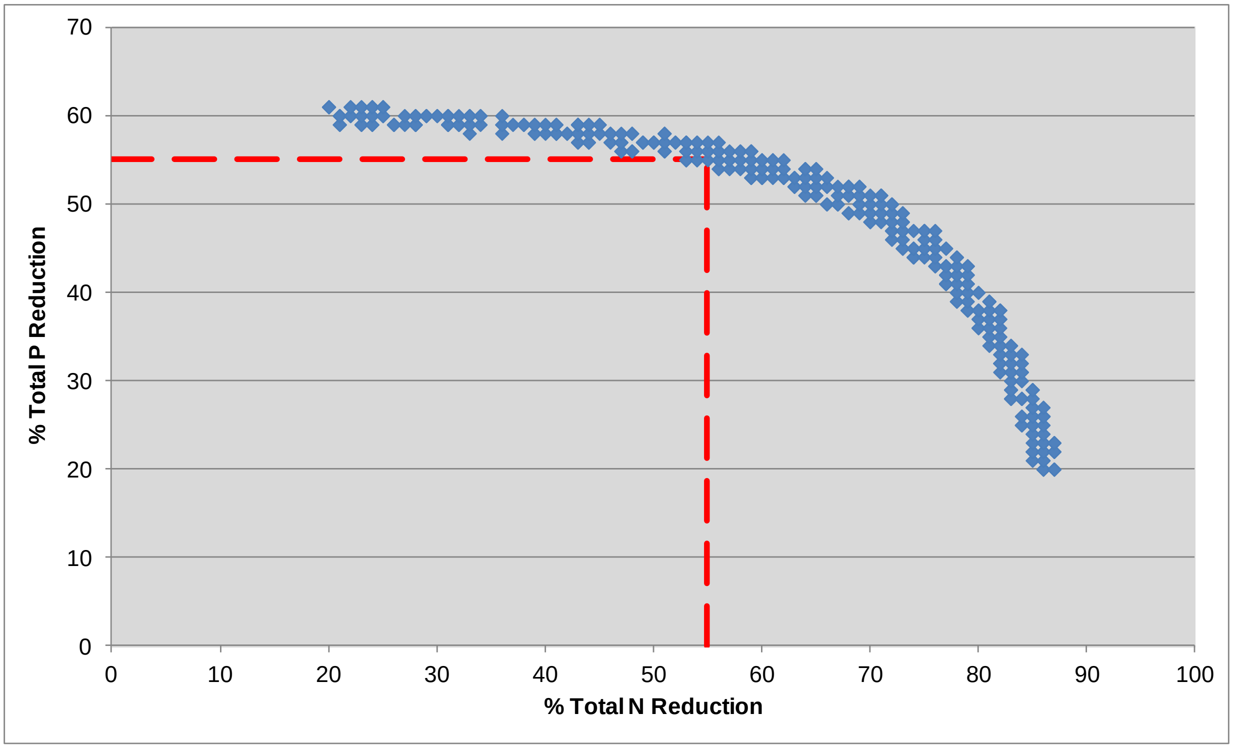
Table ES-4 Total Phosphorus and Nitrogen Load Reductions Needed to Meet Chlorophyll-*a* In-lake Water Quality Targets

Lake	Chlorophyll-*a* In-lake Target (µg/L)	Percent Reduction	Maximum Allowable Load (kg/yr)[a]	
			Total Phosphorus	Total Nitrogen
Lake Lawtonka	10	55%	3,240	23,760
Waurika Lake	10	40%	28,320	165,300
Lake Ellsworth	9	45%	14,900	129,140

[a] Loads do not include atmospheric deposition

While the relative importance of nitrogen or phosphorus in limiting algal productivity in Lawtonka, Waurika, and Ellsworth Lakes has not been definitively established, this TMDL calculates load allocations for both nitrogen and phosphorus as a conservative approach to ensure that water quality targets are met. Since there are infinite combinations of TN and TP concentrations that could result in the desired chlorophyll-*a* concentration and BATHTUB is not capable of discerning between them, a practical starting point for implementation is to begin with equal percent reduction goals for both nutrient parameters. For example, in Figure ES-1, the 55% reduction goal is plotted for both nutrient parameters for Lake Lawtonka. However, depending on local environmental and socio-economical conditions, different percent reductions for the two nutrients based on the curve in Figure ES-1, could be used during the implementation of the TMDL for Lawtonka Lake and still achieve the target chlorophyll-*a* concentration in the Lake.

Figure ES-1 Total N and Total P Combinations Resulting in 10 µg/L Chlorophyll-*a* – Lake Lawtonka



E.4 TMDLs and Load Allocations

TMDLs for the §303(d)-listed waterbodies covered in this report were derived using the outputs from the BATHTUB model. 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 uncertainty concerning the relationship between loading limitations and water quality. This definition can be expressed by the following equation:

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

There are no point sources of wastewater discharging to Lake Lawtonka, Waurika Lake, or Lake Ellsworth or their tributaries. Furthermore, Oklahoma's implementation of WQS (OAC 785:46-13-4) prohibits new point source discharges to these lakes, except for stormwater with approval from DEQ (OWRB 2011b). "*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".*

The City of Lawton (MS4 Stormwater Permit #OKR040004) and Fort Sill Army Base (OKR040040) are designated as Phase II MS4 permitted entities and are included in the SWAT Model. However, these jurisdictions are not located in any of the contributing watersheds of the three lakes. Therefore, the WLA established for each waterbody is zero.

The load allocation for watershed nonpoint sources to Lake Lawtonka was conservatively estimated as 3,240 kg/yr of total phosphorus and 23,760 kg/yr of total nitrogen, necessitating a 55% reduction from existing loading to achieve the desired water quality target. The load allocation for watershed nonpoint sources to Waurika Lake was conservatively estimated as 28,320 kg/yr of total phosphorus and 165,300 kg/yr of total nitrogen, necessitating a 40% reduction from existing loading to achieve the desired water quality target. The load allocation for watershed nonpoint sources to Lake Ellsworth was conservatively estimated as 14,900 kg/yr of total phosphorus and 129,140 kg/yr of total nitrogen, necessitating a 45% reduction from existing loading to achieve the desired water quality target.

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.

The TMDLs for Lawtonka and Waurika Lakes include an implicit MOS that is incorporated by the application of load reductions for both nitrogen and phosphorus. The TMDL for Ellsworth Lake includes an explicit 10% MOS results in the use of a water quality target set at 9 µg/L, which ensures a cumulative probability that the WQS of 10 µg/L will be achieved more than 57% of the time. Seasonal variation was accounted for in these TMDLs by using more than five years of water quality data collected in each of the four seasons.

Load reduction scenario simulations were run using the BATHTUB model to calculate annual average phosphorus and nitrogen loads (in kg/yr) that, if achieved, should decrease chlorophyll-*a* concentrations to meet the water quality target. Given that transport, assimilation, and dynamics of nutrients vary both temporally and spatially, nutrient loading to both lakes from a practical perspective must be managed on a long-term basis typically as pounds or kilograms per year. However, a recent court decision (*Friends of the Earth, Inc. v. EPA, et al.*, often referred to as the Anacostia decision) states that TMDLs must include a daily load expression. It is important to recognize that the chlorophyll-*a* response to nutrient loading in Lake Lawtonka, Waurika Lake, and Lake Ellsworth is affected by many factors such as: internal lake nutrient loading, water residence time, wind action and the interaction between light penetration, nutrients, sediment load, and algal response. As such it is important to note that expressing this TMDL in daily time steps does not imply a daily response to a daily load is practical from an implementation perspective.

The EPA's *Technical Support Document for Water Quality-Based Toxics Control* (EPA 1991a) provides a statistical method for identifying a statistical maximum daily limit based on a long-term average and considering variation in a dataset. The method is represented by the following equation:

$$MDL = LTA \times e^{z\sigma - 0.5\sigma^2}$$

where
- MDL = maximum daily load
- LTA = long-term average load
- z = z statistic of the probability of occurrence (1.645 is used for this value)
- $\sigma^2 = \ln(CV^2+1)$
- CV = coefficient of variation

The coefficients of variation of daily nitrogen and phosphorus NPS loads, calculated from SWAT model output, were 7.3 and 8.6 for Lake Lawtonka, 8.5 and 8.7 for Waurika Lake, and 6.1 and 6.4 for Lake Ellsworth, respectively. As a practical starting point for TMDL implementation an equal reduction goal for both TN and TP loading is recommended. Using equal reductions for both nutrient parameters (55% for Lawtonka, 40% for Waurika and 45% for Ellsworth), the maximum daily load corresponding to the allowable annual average loads are provided in Table ES-5. Reduction of TP and TN watershed loads to lake tributaries to these levels is expected to result in achievement of WQS for chlorophyll-*a* in each lake.

Table ES-5 TMDLs for Chlorophyll-*a* Expressed in Kilograms of Total Phosphorus and Nitrogen Per Day

Waterbody Name	Waterbody ID	Nutrient	TMDL	WLA	LA	MOS
Lake Lawtonka	OK311300040070_00	Total Phosphorus	31.3	0	31.3	Implicit
		Total Nitrogen	236.7	0	236.7	Implicit
Waurika Lake	OK311210000020_00	Total Phosphorus	272.6	0	272.6	Implicit
		Total Nitrogen	1,599	0	1,599	Implicit
Lake Ellsworth	OK311300030020_00	Total Phosphorus	151.3	0	136.2	15.1
		Total Nitrogen	1,323	0	1,191	132

E.5 Public Participation

The public had the opportunity to review the draft TMDL report and make written comments. The public comment period lasted 45 days. One set of comments representing two agencies was received. The responses to those comments are in Appendix D. There were no requests for a public meeting.

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 in-stream water quality conditions, so states can implement water quality-based controls to reduce pollution from point and nonpoint sources and restore and maintain water quality (EPA 1991).

This report documents the data and assessments used to establish chlorophyll-*a* TMDLs for Lake Lawtonka [Oklahoma Waterbody ID (OK WBID) number OK311300040070_00], Waurika Lake (OK311210000020_00), and Lake Ellsworth (OK311300030020_00) in the Upper Red River (hydrologic unit code [HUC] 1113) sub-basin. DEQ placed these waterbodies in Category 5 [303(d) list] of the *Water Quality in Oklahoma, 2010 Integrated Report* (2010 Integrated Report) for non-support of the Public and Private Water Supply Use. Figure 1-1 is a location map showing these Oklahoma waterbodies and their contributing watersheds. This map displays locations of the water quality monitoring (WQM) stations used as the basis for placement of these waterbodies on the Oklahoma §303(d) list. These waterbodies and their surrounding watersheds are hereinafter referred to as the Study Area.

Elevated levels of chlorophyll-*a* in lakes reflect excessive algae growth which can have deleterious effects on the quality and treatment costs of drinking water. Excessive algae growth can also negatively affect the aquatic biological communities of lakes. Elevated chlorophyll-*a* levels typically indicate excessive loading of the primary growth-limiting algal nutrients nitrogen and phosphorus to the waterbody, a process known as eutrophication. 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 Water Quality Standards (WQS) [Oklahoma Administrative Code (OAC) Title 785, Chapter 45]. The Oklahoma Department of Environmental Quality (DEQ) is required to submit all TMDLs to EPA for review and approval. Once 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 WQS is achieved (EPA 2003).

The purpose of this TMDL report is to establish nutrient load allocations necessary for reducing chlorophyll-*a* levels in the lakes, which is the first step toward restoring water quality and protecting public health. TMDLs determine the pollutant loading a waterbody can assimilate without exceeding applicable 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 water quality conditions in the waterbody. 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. An implicit MOS is achieved by using conservative assumptions in the TMDL calculations. The MOS is a percentage of the TMDL set aside to account for the lack of knowledge associated with natural process in aquatic systems, model assumptions, and data limitations.

This report does not stipulate specific control actions (regulatory controls) or management measures (voluntary best management practices) necessary to reduce nutrients 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.

1.2 Watershed and Lake Description

1.2.1. Lake Characteristics

Lake Lawtonka is a 2,398 acre lake in Comanche County with a conservation pool storage of 56,574 acre-feet. It was impounded in 1905, and serves as a recreational lake and is utilized for water supply by the City of Lawton and surrounding communities (Oklahoma Water Resources Board [OWRB] 2009). Medicine Creek, which is 17.71 miles long, is the primary tributary flowing to Lake Lawtonka.

Waurika Lake is a 10,100 acre lake in Cotton, Jefferson, and Stephens Counties with a conservation pool storage of 203,100 acre-feet. Waurika Lake was first impounded by the U.S. Army Corp of Engineers (OWRB 2009) in 1977 and serves as a lake for recreation, flood control, irrigation, and municipal water supply. Beaver Creek (46.9 miles long) and Little Beaver Creek (39.5 miles long) are the primary tributaries flowing to Waurika Lake.

Lake Ellsworth, located on the East Cache Creek, is a 5,600 acre lake in Comanche and Caddo Counties with a conservation pool storage of 95,200 acre-feet. It was first impounded in 1962 and serves as a multipurpose waterbody for recreational use and as a municipal water supply for the City of Lawton (OWRB 2009). Chandler Creek (10.5 miles long) and Tony Creek (5.7 miles long) are the primary tributaries flowing to Lake Ellsworth. There is little developed land bordering the shoreline of any of the three lakes. All lakes are popular fishing and boating recreation destinations. Table 1-1 provides general characteristics of each lake.

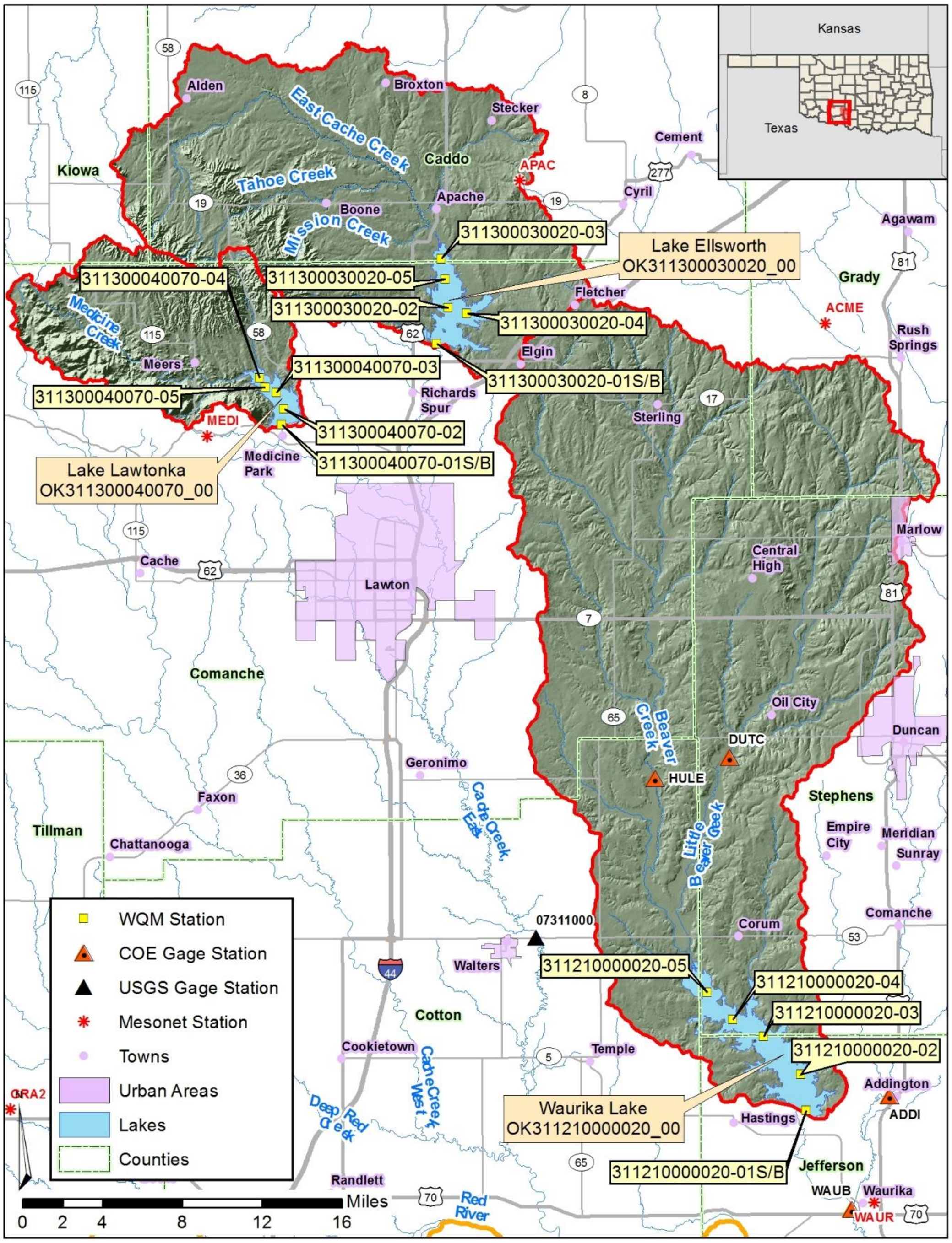
Table 1-1 General Lake Characteristics

Waterbody Name and WBID	Surface Area (Acres)	Conservation Pool Storage (Acre- Feet)	Normal Elevation (Feet MSL)	Average Depth (Feet)	Shoreline (Miles)	Management Agency
Lake Lawtonka (OK311300040070_00)	2,398	56,574	1,335	23.6	19	City of Lawton
Waurika Lake (OK311210000020_00)	10,100	203,100	951	20.0	80	U.S. Army Corps of Engineers

Waterbody Name and WBID	Surface Area (Acres)	Conservation Pool Storage (Acre- Feet)	Normal Elevation (Feet MSL)	Average Depth (Feet)	Shoreline (Miles)	Management Agency
Lake Ellsworth (OK311300030020_00)	5,600	95,200	81,224	15.8	53	City of Lawton

MSL = Mean Sea Level

Figure 1-1 Lake Lawtonka, Waurika Lake, and Lake Ellsworth



1.2.2 General

All three lakes are within the Red River basin, located in the southwestern portion of Oklahoma.

Lake Lawtonka is located approximately nine miles north of the City of Lawton in Comanche County on Medicine Creek, which is a tributary of East Cache Creek. The small town of Meers is located upstream of Lake Lawtonka. Lake Lawtonka is located in the Central Great Plains ecoregions (Woods et al. 2005), which features mixed grass prairie. The majority of the land cover in the Lake Lawtonka watershed is grasslands and deciduous forest, with some evergreen forest.

Waurika Lake is located on Beaver Creek, a tributary of Red River, approximately six miles northwest of the City of Waurika. The Lake lies in portions of Jefferson, Cotton, and Stephens Counties. Waurika Lake is located in the Central Great Plains ecoregions (Woods et al. 2005), which features mixed grass prairie.

Lake Ellsworth is located approximately 11 miles northeast of the City of Lawton in Comanche County. Lake Ellsworth flows into East Cache Creek, which is a tributary of Red River. The small towns of Alden, Apache, Boone, Broxton, and Stecker are located upstream of Lake Ellsworth within the contributing watershed. Lake Ellsworth is located in the Central Great Plains ecoregions (Woods, et al. 2005), which consists mainly of mixed grass prairie. The majority of the land cover in the Lake Ellsworth watershed is devoted to agricultural purposes with the majority being used for grasslands, small grains, row crops, and pasture/hay.

Table 1-2, derived from the 2010 U.S. census, demonstrates that the counties in which the watersheds are located are sparsely populated (U.S. Census Bureau 2010).

Table 1-2 County Population and Density

County Name	Population (2010 Census)	Population Density (per square mile)
Caddo	29,485	23
Grady	51,819	47
Kiowa	9,528	9
Comanche	114,230	105
Stephens	43,977	49
Cotton	6,373	10
Jefferson	6,384	8

1.2.3 Climate

Table 1-3 summarizes the average annual precipitation for Lake Lawtonka, Waurika Lake, and Lake Ellsworth. Average annual precipitation values were derived from the Oklahoma Mesonet Dataset (http://www.mesonet.org) based on a period of record of 1994 to 2010 at six stations in the vicinity of the lake watersheds (Figure 1-1).

Table 1-3 Average Annual Precipitation by Watershed (1994-2010)

Waterbody Name	Waterbody ID	Average Annual Precipitation (inches)
Lake Lawtonka	OK311300040070_00	31.14
Waurika Lake	OK311210000020_00	29.79
Lake Ellsworth	OK311300030020_00	29.97

1.2.4 Land Use

The contributing drainage areas of Lake Lawtonka, Waurika Lake, and Lake Ellsworth watersheds are approximately 93, 562, and 235 square miles, respectively. Table 1-4 summarizes the percentages and acreages of the land use categories for the contributing watersheds. Land use/land cover data were derived from the National Agricultural Statistics Service (NASS) 2008 Cropland Data Layer (CDL). The CDL is a crop-specific land cover classification data set. Land use in the watersheds of Lake Lawtonka, Waurika Lake, and Lake Ellsworth is displayed in Figure 1-2. The most common land use category throughout the Study Area is grassland herbaceous. Waurika Lake and Lake Ellsworth also have a significant percentage of land classified as winter wheat. Lake Lawtonka has a significant percentage of land classified as deciduous forest. The aggregate total of low, medium, and high intensity developed land accounts for less than 1% of the land use in each watershed.

Table 1-4 Land Use Summary by Watershed

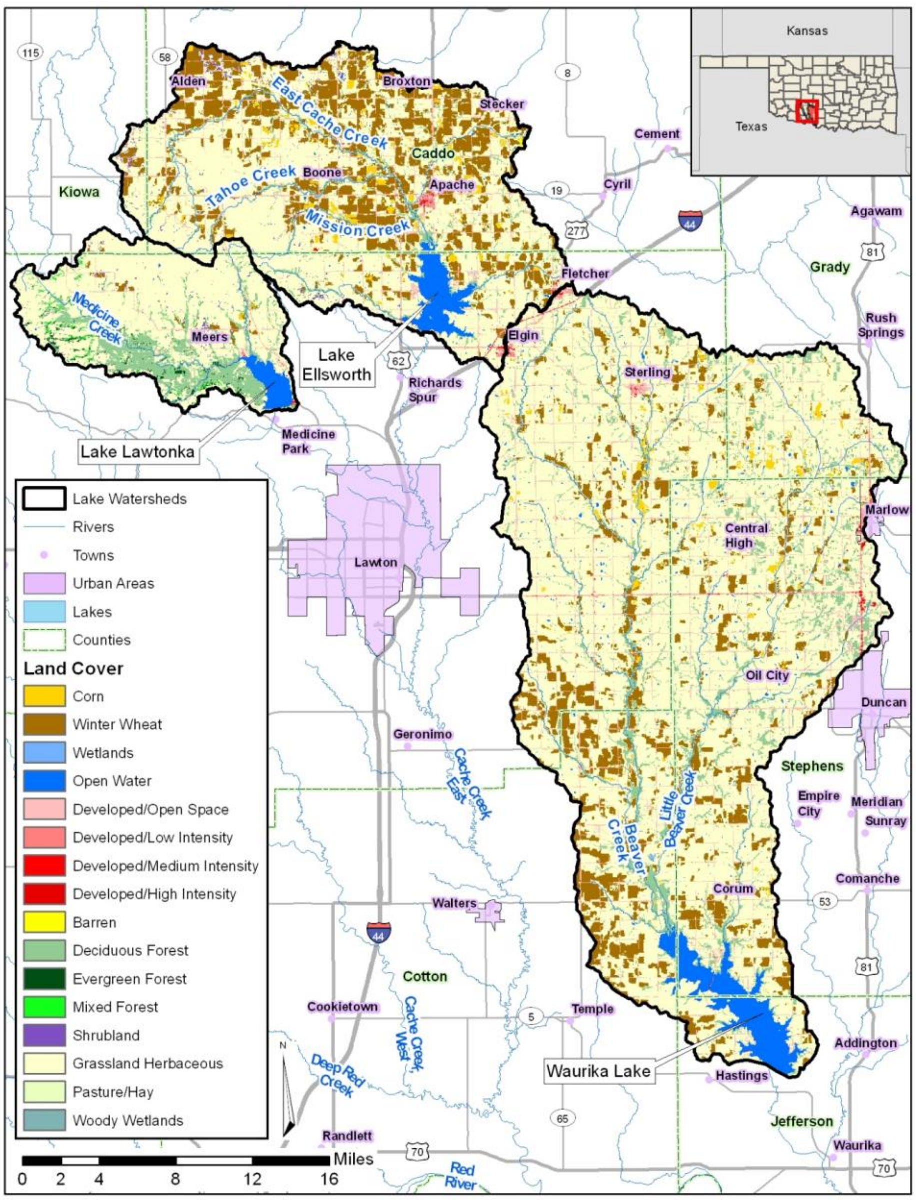
Description	Lake Lawtonka		Waurika Lake		Lake Ellsworth	
	Acres	Percent[1]	Acres	Percent[1]	Acres	Percent[1]
Corn	96	0	3,671	1	3,777	2
Winter Wheat	673	1	39,956	11	39,292	25
Wetlands	0	0	46	0	0	0
Open Water	2,335	4	11,629	3	5,500	3
Developed/Open Space	1,277	2	18,190	5	9,166	6
Developed/Low Intensity	73	0	1,350	0	616	0
Developed/Medium Intensity	18	0	375	0	178	0
Developed/High Intensity	6	0	83	0	43	0
Barren	2	0	25	0	98	0
Deciduous Forest	10,239	17	26,119	7	5,028	3
Evergreen Forest	1,088	2	10	0	40	0
Mixed Forest	1,257	2	1	0	102	0
Shrubland	695	1	28	0	1,595	1
Grassland Herbaceous	41,255	70	257,735	72	92,751	59
Pasture/Hay	0	0	264	0	3	0
Woody Wetlands	0	0	1	0	1	0
Total Drainage Area	**59,012**		**359,483**		**150,355**	

1=Rounding of numbers accounts for percentage total not equaling 100.

1.3 Flow Characteristics

Stream flow characteristics and data are key information when conducting water quality assessments such as TMDLs. However, there are no flow gages located on any of the tributaries to Lake Lawtonka, Waurika Lake, or Lake Ellsworth, at the lake outlets of Lakes Lawtonka or Ellsworth, or on the major tributaries between the lake outlets. A flow gage does exist on the East Cache Creek at SH53 near Walters, OK northwest of Waurika Lake and the United States Army Corps of Engineers (USACE) has daily release records for Waurika Lake. Given the lack of historical stream flow data, flow estimates for Lake tributaries were developed using a watershed model calibrated to flow measurements at U.S. Geological Survey (USGS) gage stations in adjacent watersheds. This is discussed in further detail in Section 3.

Figure 1-2 Lake Lawtonka, Waurika Lake, and Lake Ellsworth Watershed Land Use



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 in Chapter 45 (OWRB 2011) and implementation procedures in Chapter 46 (OWRB 2011b). The Oklahoma Water Resources Board has statutory authority and responsibility concerning establishment of State water quality standards, as provided under 82 Oklahoma Statute [O.S.], §1085.30. This statute authorizes the OWRB to promulgate rules *…which establish classifications of uses of waters of the State, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters.* [O.S. 82:1085:30(A)]. Beneficial uses are designated for all waters of the State. Such uses are protected through restrictions imposed by the antidegradation policy statement, narrative water quality criteria, and numerical criteria (OWRB 2011). An excerpt of the Oklahoma WQS (Chapter 45, Title 785) summarizing the State of Oklahoma Antidegradation Policy is provided in Appendix A. Beneficial uses designated for Lake Lawtonka, Waurika Lake, and Lake Ellsworth are aesthetic, irrigation, agricultural water supply, the warm water aquatic community subcategory of the fish and wildlife propagation, fish consumption, primary body contact recreation, and public and private water supply. Table 2-1, an excerpt from the 2010 Integrated Report (DEQ 2010), summarizes the designated use attainment status and the waterbody/pollutant combinations that require TMDLs for the three waterbodies. The TMDL priority shown in Table 2-1 is directly related to the TMDL target date. The TMDLs established in this report, which are a necessary step in the process of restoring water quality, only address the non-attainment of the public and private water supply use.

Table 2-1 Excerpt from the 2010 Integrated Report – Oklahoma §303(d) List of Impaired Waters (Category 5a)

Waterbody Name and WBID	Waterbody Size (Acres)	TMDL Date	TMDL Priority	Causes of Impairment	Designated Use Not Supported
Lake Lawtonka (OK311300040070_00)	2,398	2012	1	▪ Chlorophyll-*a*	▪ Public and Private Water Supply
Waurika Lake (OK311210000020_00)	10,100	2012	1	▪ Chlorophyll-*a*	▪ Public and Private Water Supply
				▪ Turbidity	▪ Warm Water Aquatic Community
Lake Ellsworth (OK311300030020_00)	5,600	2012	1	▪ Chlorophyll-*a*	▪ Public and Private Water Supply
				▪ Enterococcus	▪ Primary Body Contact Recreation
				▪ Oxygen, dissolved	▪ Warm Water Aquatic Community
				▪ Turbidity	▪ Warm Water Aquatic Community

Source: 2010 Integrated Report, DEQ 2010.

Lake Lawtonka, Waurika Lake, and Lake Ellsworth are designated as SWS lakes. The definition of SWS is summarized by the following excerpt from the Oklahoma Administrative Code (OAC) 785:45-5-25 of the Oklahoma WQS (OWRB 2011).

Sensitive Public and Private Water Supplies (SWS)

(A) Waters designated "SWS" are those waters of the State which constitute sensitive public and private water supplies as a result of their unique physical conditions and are listed in Appendix A of this Chapter as "SWS" waters. These are waters (a) currently used as water supply lakes, (b) that generally possess a watershed of less than approximately 100 square miles or (c) as otherwise designated by the Board.

(B) 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 this Chapter 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 that new point source discharge(s) or increased load of specified pollutants described in 785:45-5-25(b) may be approved by the permitting authority in those circumstances where the discharger demonstrates to the satisfaction of the permitting authority that a new point source discharge or increased load from an existing point source discharge will result in maintaining or improving the water quality of both the direct receiving water and any downstream waterbodies designated SWS.

Sensitive Public and Private Water Supply (SWS) lakes are defined in the Oklahoma Water Quality Standards - Oklahoma Administrative Code (OAC) Title 785, Chapter 45: 785:45-5-25(c)(4)(A). In Appendix A.3 of the WQS, Lake Lawtonka, Waurika Lake, and Lake Ellsworth are all listed as SWS lakes.

> The numeric criterion set for chlorophyll-*a* for SWS lakes is also found in the WQS [785:45-5-10(7)] which states, "*The long-term average concentration of chlorophyll-a at a depth of 0.5 meters below the surface shall not exceed 0.010 milligrams per liter in Wister Lake, Tenkiller Ferry Reservoir, nor any waterbody designated SWS in Appendix A of this Chapter. Wherever such criterion is exceeded, numerical phosphorus or nitrogen criteria or both may be promulgated.*

But none of the lakes in this Study (Lake Lawtonka, Waurika Lake, or Lake Ellsworth) has been assigned the designation of "nutrient limited watershed" (NLW) in OAC 785:45-5-29. An NLW means a watershed of a waterbody with a designated beneficial use that is adversely affected by excess nutrients as determined by Carlson's Trophic State Index (TSI) (using chlorophyll-*a*) of 62 or greater, or is otherwise listed as "NLW" in Appendix A of Chapter 45 (OWRB 2010).

2.2 Problem Identification

In this subsection, water quality data indicating waterbody impairment caused by elevated levels of chlorophyll-*a* are summarized. Water quality data available for other nutrient parameters are also summarized. Table 2-2 provides the locations of WQM stations on each lake. These WQM stations are part of the Oklahoma Beneficial Use Monitoring Program (BUMP) network (OWRB 2007). Table 2-2 also provides a hyperlink to the OWRB Data Viewer from which lake water quality data were obtained. Locations of the WQM stations for Lake Lawtonka, Waurika Lake, and Lake Ellsworth are illustrated in Figure 1-1.

Table 2-2 Water Quality Monitoring Stations used for 2010 §303(d) Listing Decision

Waterbody ID	Station ID	Latitude	Longitude	Site Description
Lake Lawtonka				
311300040070_00	311300040070-01B	34.73737	-98.50345	Bottom
311300040070_00	311300040070-01S	34.73737	-98.50345	Near Surface
311300040070_00	311300040070-02	34.74867	-98.50159	Near Surface
311300040070_00	311300040070-03	34.76051	-98.50784	Near Surface
311300040070_00	311300040070-04	34.77128	-98.52314	Near Surface
311300040070_00	311300040070-05	34.76431	-98.51764	Near Surface
Waurika Lake				
311210000020_00	311210000020-01B	34.23487	-98.04696	Bottom
311210000020_00	311210000020-01S	34.23487	-98.04696	Near Surface
311210000020_00	311210000020-02	34.26137	-98.05110	Near Surface
311210000020_00	311210000020-03	34.28921	-98.08345	Near Surface
311210000020_00	311210000020-04	34.30163	-98.11058	Near Surface
311210000020_00	311210000020-05	34.32185	-98.13283	Near Surface
Lake Ellsworth				
311300030020_00	311300030020-01B	34.79546	-98.36642	Bottom
311300030020_00	311300030020-01S	34.79546	-98.36642	Near Surface
311300030020_00	311300030020-02	34.82185	-98.35596	Near Surface
311300030020_00	311300030020-03	34.85740	-98.36202	Near Surface
311300030020_00	311300030020-04	34.81763	-98.33971	Near Surface
311300030020_00	311300030020-05	34.84256	-98.35842	Near Surface

* Hyperlinks are active in the electronic version of this document.

2.2.1 Chlorophyll-*a* Data Summary

Table 2-3 summarizes chlorophyll-*a* data collected from Lake Lawtonka WQM stations from 2002 through 2011. 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 criterion of 10 µg/L chlorophyll-*a*, as a long-term average at a depth of one-half meter. Chlorophyll-*a* from surface level samples averaged 17.5 µg/L, which is equivalent to a Carlson's TSI of 59 (Carlson 1977). According to the 2010-2011 Beneficial Use Monitoring Program (BUMP) Report, using water quality samples collected between December 2010 and August 2011, the TSI calculated for Lake Lawtonka was 56 (OWRB 2011a). As stipulated in the Implementation Procedures for Oklahoma's Water Quality Standards [785:46-15-3(c)] the most recent 10 years of water quality data are used as the basis for evaluating the beneficial use support for lakes (OWRB 2011b). Chlorophyll-*a* data collected from Lake Lawtonka WQM stations between 2002 and 2007 were used to support the decision to place the lake on the DEQ 2010 §303(d) list (DEQ 2010) for non-support of the Public and Private Water Supply Use in an SWS lake. Water quality data are provided in Appendix B.

Table 2-3 Summary of Chlorophyll-a Measurements in Lake Lawtonka 2002-2011 (all values in µg/L)

Station ID	Number of Samples	Minimum	Maximum	Average	Median
311300040070-01B†	7	14.1	27.5	17.6	16.1
311300040070-01S	11	6.3	27.1	18.3	17.2
311300040070-02	14	3.6	32.6	18.7	19.0
311300040070-03	12	3.8	26.9	16.0	17.2
311300040070-04	13	2.9	23.2	14.1	12.9
311300040070-05	11	11.5	40.7	20.6	19.4
Overall Surface Samples*	61	2.9	40.7	17.5	17.2

†note that data from this bottom station cannot be compared to the water quality criterion, which applies to samples collected at a depth of 0.5 meters. It is included for informational purposes only.
*Bottom data were excluded

Table 2-4 summarizes chlorophyll-*a* measurements collected from Waurika Lake from 2002 through 2008. Pooling data from surface level sites, chlorophyll-*a* levels averaged 13.4 µg/L (TSI = 56). According to the 2008-2009 BUMP Report, using water quality samples collected between October 2007 and July 2008, the TSI calculated for Waurika Lake was 54 (OWRB 2009). As stipulated in the Implementation Procedures for Oklahoma's Water Quality Standards [785:46-15-3(c)] the most recent 10 years of water quality data are used as the basis for evaluating the beneficial use support for lakes (OWRB 2011b). Chlorophyll-*a* data collected from Waurika Lake WQM stations between 2002 and 2008 were used to support the decision to place the lake on the DEQ

2010 §303(d) list (DEQ 2010) for non-support of the Public and Private Water Supply Use in an SWS lake. Water quality data are provided in Appendix B.

Table 2-4 Summary of Chlorophyll-a Measurements in Waurika Lake 2002-2008 (all values in µg/L)

Station ID	Number of Samples	Minimum	Maximum	Average	Median
311210000020-01B†	10	8.4	19.3	13.5	12.7
311210000020-02	10	2.6	29.1	14.6	12.8
311210000020-03	9	3.9	30.7	13.8	12.1
311210000020-04	10	3.4	30.5	11.9	11.4
Overall Surface Samples*	29	2.6	30.7	13.4	12.1

†note that data from this bottom station cannot be compared to the water quality criterion, which applies to samples collected at a depth of 0.5 meters. It is included for informational purposes only.

*Bottom data were excluded

Table 2-5 summarizes chlorophyll-*a* measurements collected from Lake Ellsworth from 2002 through 2009. Pooling data from surface level sites, chlorophyll-*a* levels averaged 12.2 µg/L (TSI = 55). According to the 2008-2009 BUMP Report, using water quality samples collected between October 2008 and August 2009, the TSI calculated for Waurika Lake was 54 (OWRB 2009). The Implementation Procedures for Oklahoma's Water Quality Standards [785:46-15-3(c)] use the most recent 10 years of water quality data as the basis for evaluating the beneficial use support for lakes (OWRB 2011b). Chlorophyll-*a* data collected from Lake Ellsworth WQM stations between 2002 and 2009 were used to support the decision to place the lake on the DEQ 2010 §303(d) list (DEQ 2010) for non-support of the Public and Private Water Supply Use in an SWS lake. Water quality data are provided in Appendix B.

Table 2-5 Summary of Chlorophyll-a Measurements in Lake Ellsworth 2002-2009 (all values in µg/L)

Station ID	Number of Samples	Minimum	Maximum	Average	Median
311300030020-01B	7	3.2	21.9	11.3	10.5
311300030020-01S	12	0.1	16.6	7.8	7.8
311300030020-02	12	0.1	24.3	11.9	9.6
311300030020-03	12	2.6	38.2	15.5	14.3
311300030020-04	11	4.3	23.5	11.6	11.2
311300030020-05	12	4.1	32.6	14.2	13.1
Overall Surface Samples*	59	0.1	38.2	12.2	10.5

†note that data from this bottom station cannot be compared to the water quality criterion, which applies to samples collected at a depth of 0.5 meters. It is included for informational purposes only.

*Bottom data were excluded

2.2.2 Nutrient Data Summary

During the years 1998 to 2011, total nitrogen levels in Lake Lawtonka averaged approximately 0.66 mg/L, and total phosphorus levels averaged 0.03 mg/L (Table 2-6). Total nitrogen is calculated as the sum of Kjeldahl nitrogen and two inorganic forms in different oxidation states: nitrate and nitrite nitrogen. Kjeldahl nitrogen is the sum of organic nitrogen and ammonia nitrogen. Total phosphorus is measured directly and composed of organic phosphorus, inorganic orthophosphorus, and inorganic polyphosphates. Thermal stratification was not observed during the 2005-2006 assessment period, likely due to the shallow nature of the Lake (OWRB 2007). Thus, nutrient fluxes from sediments were available year-round in the photic zone, where light permits algal photosynthesis.

Table 2-6 Summary of Average Nutrient Measurements in Lake Lawtonka 1998-2011 (all values in mg/L)‡

Station ID	Nitrogen, Ammonia	Nitrogen, Kjeldahl	Nitrogen, Nitrate+Nitrite	Phosphorus, Ortho	Phosphorus, Total
311300040070-01B	0.20	0.58	0.18	0.04	0.07
311300040070-01S	0.05	0.48	0.19	0.01	0.03
311300040070-02	0.07	0.44	0.17	0.01	0.02
311300040070-03	0.05	0.47	0.17	0.01	0.02
311300040070-04	0.06	0.48	0.17	0.01	0.03
311300040070-05	0.06	0.57	0.22	0.01	0.03
Overall Surface Samples*	0.06	0.48	0.18	0.01	0.03

‡ Non-detects were averaged at the detection limit
* bottom data were excluded

Total nitrogen levels in Waurika Lake averaged approximately 0.81 mg/L, and total phosphorus levels averaged 0.09 mg/L (Table 2-7). As in Lake Lawtonka, thermal stratification was not observed during 2005-2006 in Waurika Lake (OWRB 2007).

Table 2-7 Summary of Average Nutrient Measurements in Waurika Lake 1999-2008 (all values in mg/L)‡

Station ID	Nitrogen, Ammonia	Nitrogen, Kjeldahl	Nitrogen, Nitrate+Nitrite	Phosphorus, Ortho	Phosphorus, Total
311210000020-01B	0.11	0.67	0.19	0.06	0.11
311210000020-01S	0.05	0.62	0.15	0.04	0.07
311210000020-02	0.06	0.63	0.15	0.03	0.07
311210000020-03	0.05	0.61	0.14	0.03	0.07

Station ID	Nitrogen, Ammonia	Nitrogen, Kjeldahl	Nitrogen, Nitrate+Nitrite	Phosphorus, Ortho	Phosphorus, Total
311210000020-04	0.05	0.71	0.15	0.07	0.12
311210000020-05	0.05	0.74	0.15	0.07	0.10
Overall Surface Samples*	0.05	0.66	0.15	0.05	0.09

‡ Non-detects were averaged at the detection limit
* Bottom data were excluded

Total nitrogen levels in Lake Ellsworth averaged approximately 0.83 mg/L, and total phosphorus levels averaged 0.07 mg/L (Table 2-8). As in Lake Lawtonka, thermal stratification was not observed during 2005-2006 in Lake Ellsworth (OWRB 2007). Water quality data for nutrient parameters in all three lakes are provided in Appendix B.

Table 2-8 Summary of Average Nutrient Measurements in Lake Ellsworth 1998-2009 (all values in mg/L)‡

Station ID	Nitrogen, Ammonia	Nitrogen, Kjeldahl	Nitrogen, Nitrate+Nitrite	Phosphorus, Ortho	Phosphorus, Total
311300030020-01B	0.17	0.59	0.29	0.07	0.12
311300030020-01S	0.08	0.56	0.25	0.03	0.06
311300030020-02	0.07	0.58	0.28	0.04	0.07
311300030020-03	0.07	0.65	0.25	0.04	0.08
311300030020-04	0.06	0.60	0.17	0.03	0.06
311300030020-05	0.06	0.64	0.16	0.04	0.07
Overall Surface Samples*	0.07	0.60	0.23	0.04	0.07

‡ Non-detects were averaged at the detection limit
* Bottom data were excluded

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 target established for each lake must demonstrate compliance with the numeric criterion prescribed for SWS lakes in the Oklahoma WQS (OWRB 2011). Therefore, the water quality target established for Lake Lawtonka, Waurika Lake, and Lake Ellsworth is to achieve a long-term average in-lake concentration of 10 µg/L for chlorophyll-*a*. Waurika Lake and Lake Ellsworth are also included in the 303(d) list for turbidity. Additionally, Lake Ellsworth is listed for Enterococcus and dissolved oxygen criteria exceedances. These water quality issues will be addressed specifically at a future date.

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. This section includes an assessment of the known and suspected sources of nutrients contributing to the eutrophication of Lake Lawtonka, Waurika Lake, and Lake Ellsworth. Nutrient sources identified are categorized and quantified to the extent that reliable information is available. Generally, nutrient loadings causing eutrophication of lakes originate from point or nonpoint sources of pollution. Point sources are permitted through the NPDES program. 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 nutrient loads to surface water as a result of rainfall runoff. For the TMDLs in this report, all sources of pollutant loading not regulated by NPDES are considered nonpoint sources. The following discussion provides a general summary of the point and nonpoint sources of nutrients emanating from the contributing watersheds of each lake.

3.1 Assessment of Point Sources

Under 40 CFR §122.2, a point source is described as a discernible, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. NPDES-permitted facilities classified as point sources that may contribute nutrient loading include:

- NPDES municipal wastewater treatment facility (WWTF) discharges;
- NPDES industrial WWTF discharges;
- NPDES no-discharge WWTFs;
- NPDES concentrated animal feeding operations (CAFO); and
- NPDES-regulated stormwater discharges [MS4 (Municipal separate storm sewer system)/Industrial/Construction].

There are no continuous point source discharge facilities (municipal or industrial), CAFOs, or NPDES regulated stormwater discharges within the Lake Lawtonka, Waurika Lake, or Lake Ellsworth watersheds. However, there are six no-discharge facilities within the Waurika Lake watershed and a single no-discharge facility in the Lake Ellsworth watershed (Table 3-1, Figure 3-1). It is possible the wastewater collection systems associated with these no-discharge facilities could be a source of nutrient loading, or that discharges from the wastewater facility may occur during large rainfall events that exceed the systems' storage capacities.

Sanitary sewer overflow (SSO) from wastewater collection systems, although infrequent, can be a major source of nutrient 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. Table 3-2 presents a summary of the data from four non-discharge facilities in the Study Area that have reported SSOs between 2001 and 2012. During that period, 10 overflows were reported ranging from 200 to 150,000 gallons. Given the small size of the wastewater collection systems of these no-discharge facilities and the low occurrence of reported overflows, the contributions of nutrient loads would be negligible. Therefore, for the purposes of these TMDLs, no-discharge facilities are not considered a source of nutrient loading.

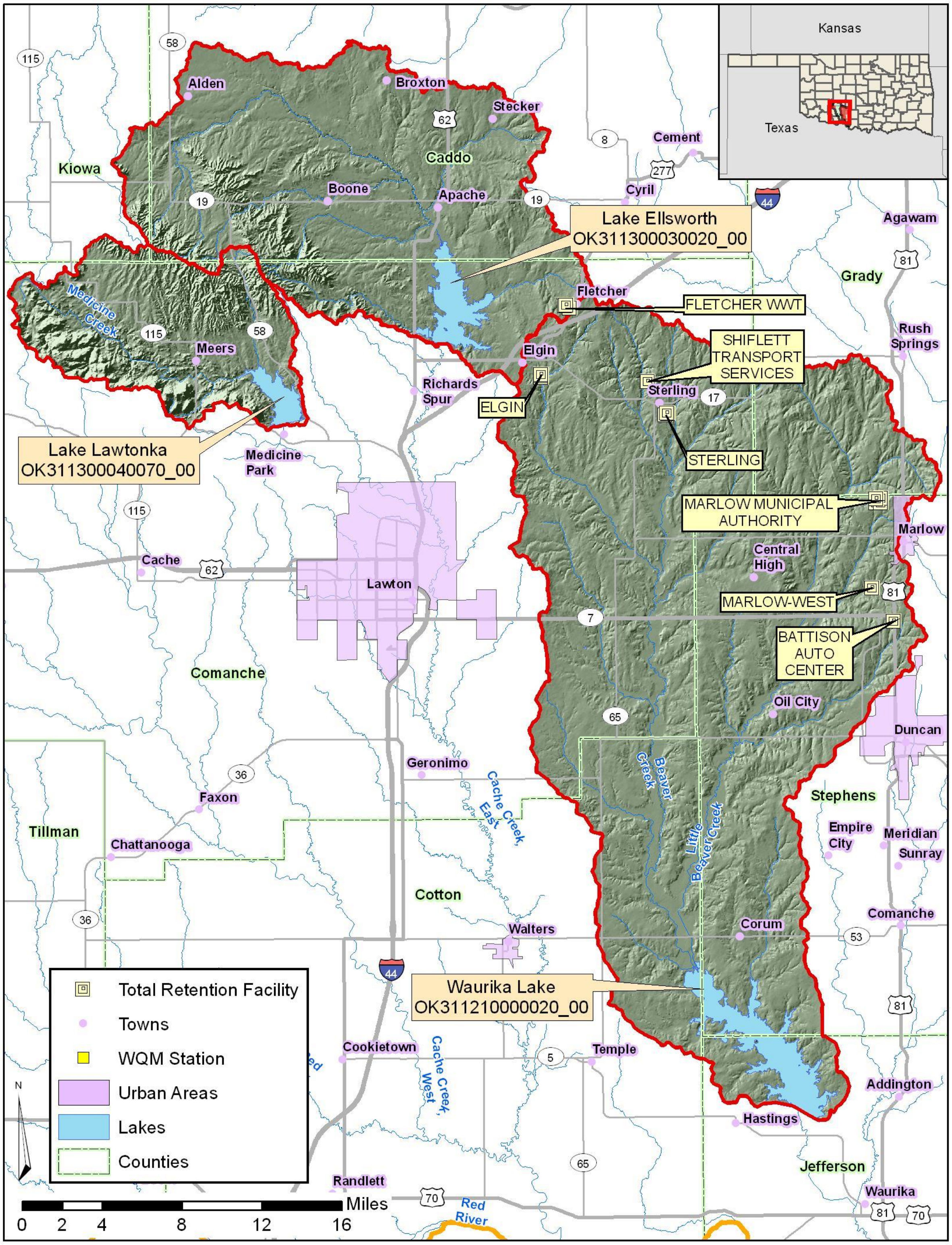
Table 3-1 NPDES No-Discharge Facilities in the Study Area

Facility	Facility ID	County	Facility Type	Type	Waterbody ID	Waterbody Name
Elgin WWT	11202	Comanche	Lagoon Total Retention	Municipal	OK311210000020_00	Waurika Lake
Sterling WWT	11201	Comanche	Land Application	Municipal	OK311210000020_00	Waurika Lake
Marlow-West WWT	11220	Stephens	Lagoon Total Retention	Municipal	OK311210000020_00	Waurika Lake
Marlow Northwest Lagoon	11222	Stephens	Land Application	Municipal	OK311210000020_00	Waurika Lake
Shiflett Transport Svcs Maint	WD98-014	Comanche	Total Retention	Industrial	OK311210000020_00	Waurika Lake
Battison Auto Center	OKGC3T010	Stephens	Total Retention	Industrial	OK311210000020_00	Waurika Lake
Fletcher WWT	11302	Comanche	Lagoon Total Retention	Municipal	OK311300030020_00	Lake Ellsworth

Table 3-2 Sanitary Sewer Overflow Summary for Period 2003-2012

Facility Name	Facility ID	Receiving Water	Number of Occurrences	Date Range		Amount (Gallons)	
				From	To	Min	Max
Elgin WWT	11202	OK311210000020_00	4	6/27/2007	4/29/2009	1000	72,000
Sterling WWT	11201	OK311210000020_00	3	6/26/2007	3/25/2012	200	150,000
Marlow-West WWT	11220	OK311210000020_00	1	7/17/2003	-	-	10,000
Fletcher WWT	11302	OK311300030020_00	2	6/29/2007	8/13/2009	-	1000

Figure 3-1 NPDES No-Discharge Facilities in the Study Area



3.2 Estimation of Existing Pollutant Loads

As previously stated, there are no continuous point source discharge facilities within the watersheds of Lake Lawtonka, Waurika Lake or Lake Ellsworth. The industrial facilities located in the Waurika Lake watershed[2] are not considered a source of nutrient loading. Therefore, all nutrient loading to Lake Lawtonka, Lake Ellsworth and Waurika Lake originate from 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 forest, grasslands and winter wheat have a strong influence on the origin and pathways of nutrient sources to surface water. Nutrient sources in rural watersheds originate from soil erosion, agricultural fertilization, residues from mowing and harvesting, leaf litter, and fecal waste deposited in the watershed by livestock. Causes of soil erosion can include natural causes such as flooding and winds, construction activities, vehicular traffic, and agricultural activities. Other sources of nutrient loading in a watershed include atmospheric deposition, failing onsite wastewater disposal (OSWD) systems, and fecal matter deposited in the watershed by wildlife and pets. The following sections provide general information on nonpoint sources contributing nutrient loading within the Study Area.

3.2.1 SWAT Model Development for Pollutant Source Loadings

Given the lack of in-stream water quality data and pollutant source data available to quantify nutrient and sediment loading directly from the tributaries of Lake Lawtonka, Waurika Lake, and Lake Ellsworth, a watershed loading model – the Soil and Water Assessment Tool (SWAT) – was used to develop nonpoint source loading estimates. These estimates from SWAT were used to quantify the nutrient contributions to each lake. SWAT is a basin-scale watershed model that can be operated on a daily time step (Neitsch et al. 2009). SWAT is designed to predict the impact of management strategies on water, nutrient, sediment, and agricultural chemical yields. The model is physically (and empirically) based, computationally efficient, and capable of continuous simulation over long time periods. Major components of the model include weather, hydrology, soil temperature and properties, plant growth, nutrients, and land management. A brief description of inputs and calibration of the SWAT model is presented in Appendix C. A summary of the SWAT modeling of pollutant sources is provided below.

There are no stream flow gages in the tributaries to Lake Lawtonka, Waurika Lake, or Lake Ellsworth. There are water quality monitoring stations in the tributaries to Lake Lawtonka [Medicine Creek: Oklahoma Conservation Commission (OCC) monitoring site OK311300-04-0060H] and Waurika Lake (Little Beaver Creek: OCC monitoring site OK311210-00-0050D), but none in the tributaries to Lake Ellsworth. To calibrate the SWAT model, it was necessary to extend the modeled area to encompass watersheds with stream flow gages and nutrient concentration measurements. Thus, the SWAT model simulated two adjacent watersheds: Cache [HUC (Hydrologic Unit Code) 11130202] and Northern Beaver (HUC 11130208). The modeled domain displayed in

[2] Shiflett Transport Services Maintenance, and Battison Auto Center

Figure 3-2 is a 1,620 square mile area that includes the contributing watersheds of the three lakes. The main streams located in the model domain are East Cache Creek, Little Beaver Creek, Beaver Creek, Cow Creek, and Medicine Creek. The watershed is predominantly rural with a few small cities and towns, including all or parts of Lawton, Elgin, Apache, Sterling, Medicine Park, Stecker, Meers, Broxton, and Oil City. The modeled area was divided into 47 sub-watersheds (Figure 3-2) based on the National Elevation Dataset (http://ned.usgs.gov) and the National Hydrography Dataset (http://nhd.usgs.gov) of the USGS. The watersheds of Lake Lawtonka, Waurika Lake, and Lake Ellsworth are outlined in black in Figure 3-2. This figure also shows the locations of flow gages and water quality monitoring stations at which the SWAT model was calibrated.

Soil data were derived from the STATSGO State Soil Geographic Database of the United States Department of Agriculture (USDA) Natural Resource Conservation Service (http://soils.usda.gov/survey/geography/statsgo/). Land use and land cover data were derived from the USDA National Agricultural Statistics Service (NASS) 2008 Cropland Data Layer (http://www.nass.usda.gov/research/Cropland/SARS1a.htm) (USDA 2008). County-level summaries of annual cattle population estimates from the NASS were evenly distributed across pasture land (USDA 2007). Soil available phosphorus concentrations were the county averages for the period 1994 to 2001 from the Oklahoma State University Department of Plant and Soil Science (Storm et al. 2000).

Point source discharges of pollutants in the modeled watershed were included in the SWAT model, using discharge monitoring reports (DMR) to indicate flows and loads. CAFOs were not included in the SWAT model, given the insignificant contributions from the only no-discharge CAFO facility (located downstream of Waurika Lake). OSWD systems (septic systems) were also not included in the SWAT model. Using data from the 1990 census to estimate a density of household with OSWDs, it was estimated that there were 4,095 OSWD systems within the simulated watershed. Of these, approximately 105 OSWDs were estimated to lie within the Lake Lawtonka watershed, 1,574 within the Waurika Lake watershed, and 258 within the watershed of Lake Ellsworth. More recent OSWD data are not available. Because the areas with the highest density of septic systems are close to urban developments that currently have a permitted WWTF (e.g., City of Lawton, Duncan Public Utility, Comanche Public Service), it was assumed that about half of the properties that utilized OSWDs for wastewater disposal in 1990 have since connected to municipal sewer collection systems. Using an 8% rate of OSWD systems malfunctioning derived from a 2001 study by Reed, Stowe & Yanke, LLC done in the Texas panhandle, a total of 163 systems are assumed to be malfunctioning and leaking wastewater to the modeled watershed (Reed, Stowe & Yanke LLC 2001). Using the same calculations, only four of those malfunctioning OSWD systems would be present in the Lake Lawtonka watershed, 62 in Waurika Lake watershed, and 10 in the watershed of Lake Ellsworth. In addition, the areas with high density of septic systems are close to the headwaters of the tributaries to Waurika Lake, which results in diminished impact on the lake water quality. Because the estimated number of malfunctioning OSWD systems is small, nutrient loadings from these systems were not included in the SWAT model.

A 17-year period (1994 - 2010) was simulated in the SWAT model. However, the first four years were considered a "spin-up" period for stabilizing model initial conditions, and the model output consisted of only the latter 13 years (1998 - 2010). The variables simulated in SWAT included flow, organic phosphorus, mineral ortho-phosphorus, organic nitrogen, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, and total suspended solids.

The SWAT hydrologic calibration was primarily performed based on flow data available at the USGS gage located on East Cache Creek (USGS Station 07311000) and the USACE gage located on Beaver Creek at Waurika (WAKO2, aka WAUB) (Figure 3-2). In addition, the model simulated inflow to Waurika Lake was compared to daily records reported by USACE. Primary calibration targets were annual flows, but modeled monthly flows which are displayed in the graphs shown in Figure 3-3, and the resulting flow duration curves were also compared to measured values. Overall, the model reproduces the annual flows within the 15% target for most years, with overall errors below the target for all the locations (1% for East Cache Creek, 6% for Beaver Creek, and -6% for Waurika Lake inflow). Resulting Nash-Sutcliffe Efficiency coefficients (NSE) and correlation coefficient (r^2) values were 0.987 and 0.990 for Cimarron East Cache Creek, 0.983 and 0.995 for Beaver Creek, and 0.981 and 0.986 for Waurika Lake inflow. The high resulting coefficients indicate very good model performance for annual flows. Additional model calibration information is provided in Appendix C.

After hydrologic calibration, the SWAT-predicted nutrient concentrations were calibrated to the observed nutrient concentrations at five water quality stations (Figure 3-2): East Cache Creek at SH 53 near Walters (OWRB monitoring site 311300010020-001AT), Little Beaver Creek (OCC monitoring site OK311210-00-0050D), Medicine Creek (OCC monitoring site OK311300-04-0060H), OCC monitoring site located in the upper part of East Cache Creek (OK311300-02-0010M), and Cow Creek (OCC monitoring site OK311200-00-0060L). For purposes of calculating averages to compare to modeled values, non-detects were assumed equal to half of the detection limit. The detection limit varied among events and among sampling sites, hence, the difference in calculated averages for sub-watersheds[3] 7, 9, 28 and 42 in Figure 3-4. It is noted that, with exception of the measurements at the station on East Cache Creek at SH 53 and the NO_3 (nitrate) concentrations at the station on Cow Creek, all the TSS and nutrient measurements for the remaining stations were below detection limits. In most cases, the SWAT model reproduced the average nutrient concentrations within 25% of the measured averages (Figure 3-4). In some instances, the model does not replicate particular nutrient species well for a given period, but nevertheless the total phosphorus and nitrogen predicted averages are within the 25% target. However, it is noted that monitoring data available for calibration are from low to moderate flow conditions. As a result, there is more uncertainty on high flow loading values.

[3] The location of these sub-watersheds can be found in Figure 3-2.

Figure 3-2 Sub-Watersheds Simulated in the SWAT Watershed Model

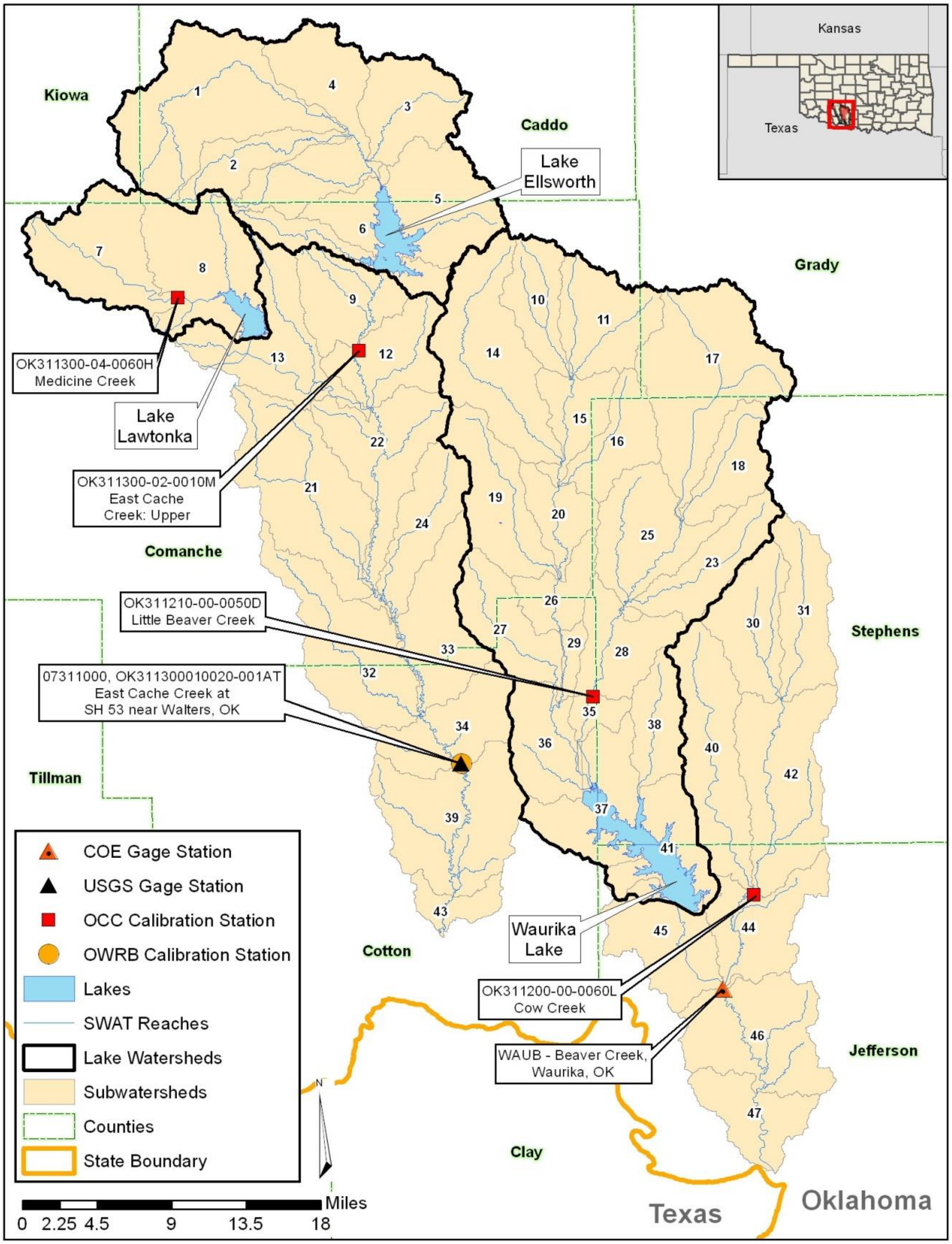


Figure 3-3 Observed and SWAT Modeled Average Monthly Flows

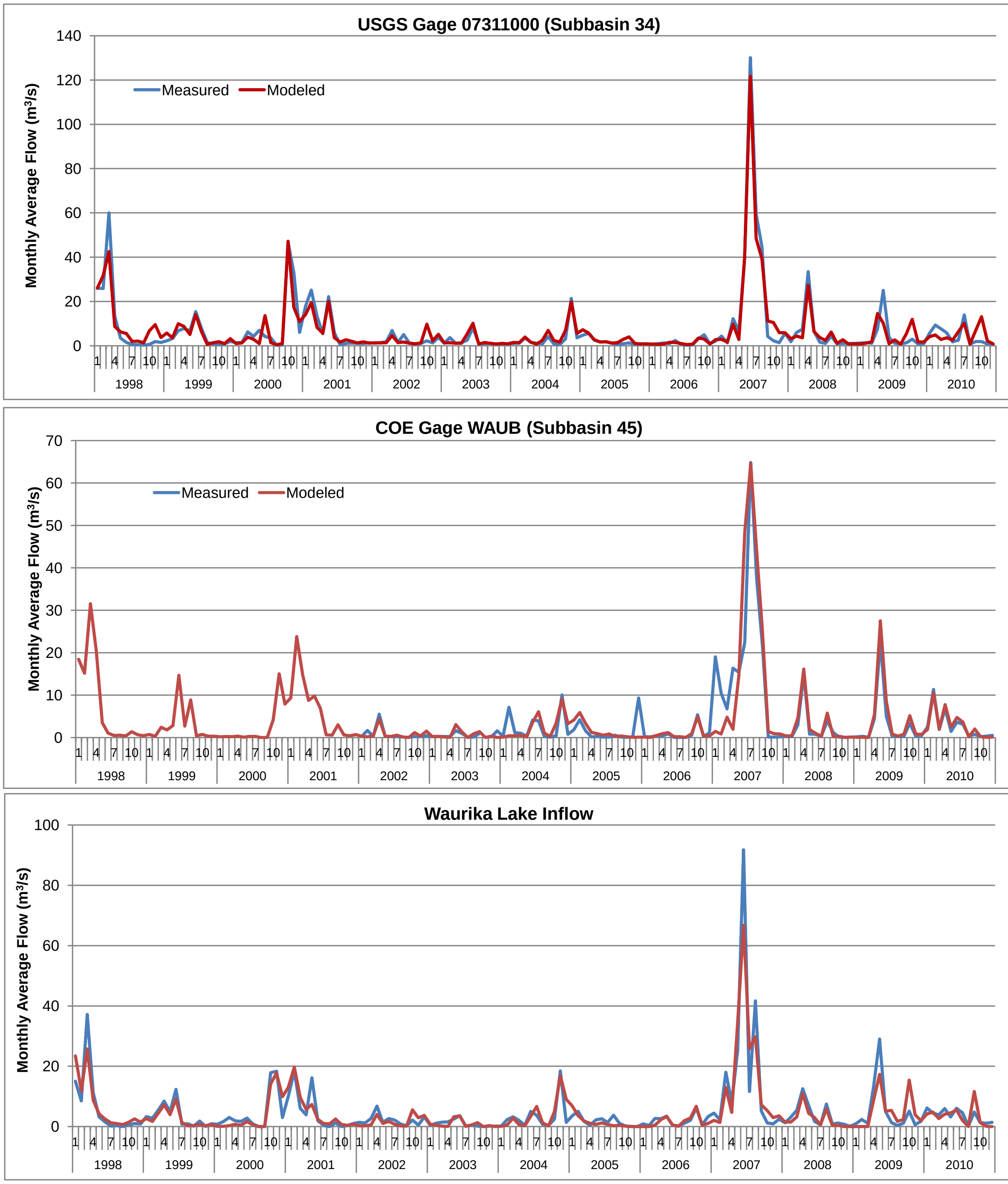
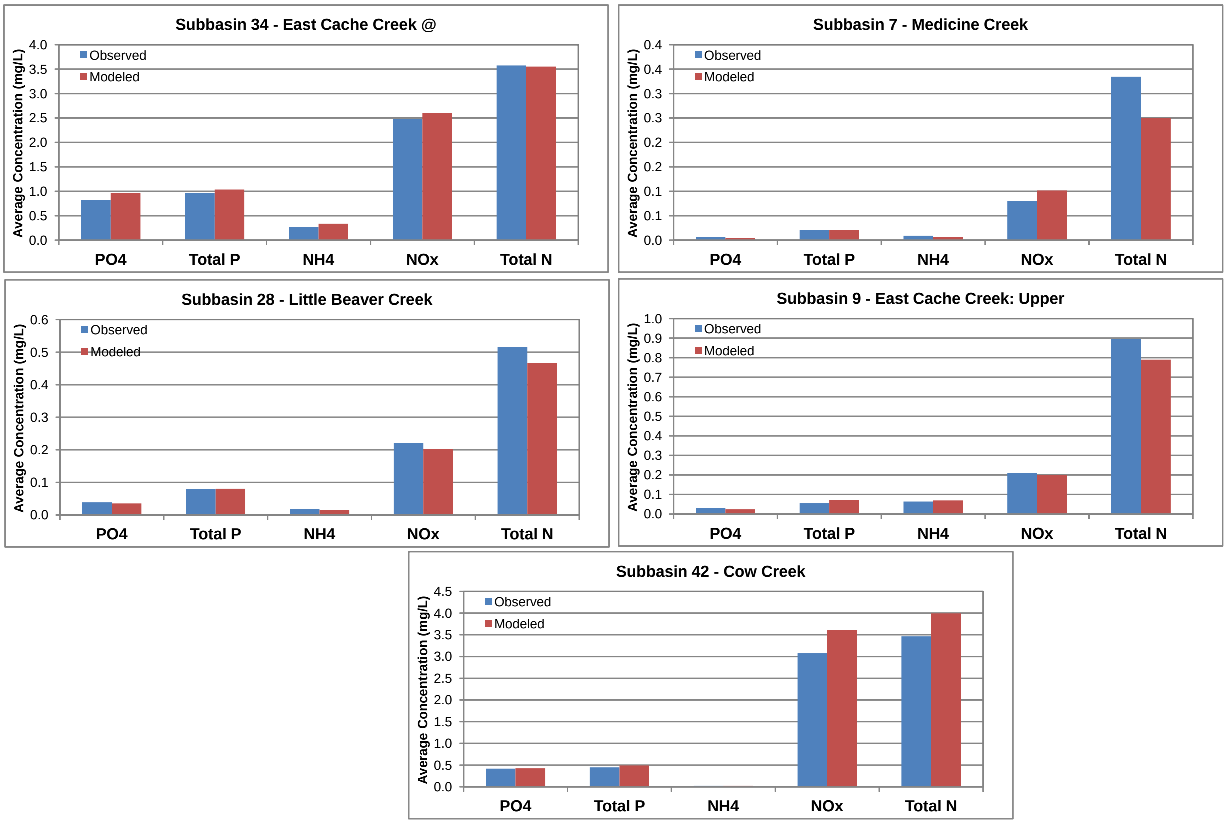


Figure 3-4 Observed and SWAT Modeled Nutrient Concentrations



PO4 = mineral phosphate phosphorus; TP = total phosphorus; NH4 = ammonia nitrogen; NOx = nitrate+nitrite nitrogen; Total N = total nitrogen

3.2.2 Model-Estimated Nutrient Loading from Point and Nonpoint Sources

The SWAT model was used to estimate nutrient loads from processes such as soil erosion, agricultural fertilization, residues from mowing and harvesting, and fecal waste deposited in the field by livestock. Nutrient loading associated with atmospheric deposition is incorporated into the lake model BATHTUB (see Section 4). Fecal waste deposited in the watershed by wildlife and pets is not considered to be a significant source of nutrient loading to the lake watersheds so it was not quantified as a model input. Nutrient loading from developed lands was simulated using land use-specific regression equations of Driver and Tasker (1988), as implemented in SWAT.

Based on the calibrated SWAT model, average loads of nutrients from each of the individual subwatersheds were estimated for the period 1998 to 2010. For comparative purposes, the phosphorus and nitrogen loads are expressed on an aerial basis in kilograms per hectare per year (kg/ha/yr) in Figures 3-5 and 3-6. The average daily flows and loads into Lake Lawtonka, Waurika Lake, and Lake Ellsworth are displayed in Table 3-3. Under current conditions, Lake Lawtonka is estimated to receive a total annual load of 7,200 kg of phosphorus and 52,800 kg of nitrogen, on average, from nonpoint sources in its watershed. Waurika Lake is estimated to receive a total annual load of 47,200 kg of phosphorus and 275,500 kg of nitrogen, on average, from sources in its watershed. Lake Ellsworth is estimated to receive a total annual load of 27,100 kg of phosphorus and 234,800 kg of nitrogen, on average, from nonpoint sources in its watershed.

Table 3-3 Average Flows and Nutrient Loads Discharging to Lake Lawtonka, Waurika Lake, and Lake Ellsworth

Parameter	Lake Lawtonka	Waurika Lake	Lake Ellsworth
Watershed Size (square miles)	93	562	235
Flow (m^3/day)	8.87×10^4	3.75×10^5	2.24×10^5
Organic Phosphorus (kg/year)	4,700	38,000	22,300
Mineral Ortho-Phosphorus (kg/year)	2,500	9,200	4,800
Total Phosphorus (kg/year)	**7,200**	**47,200**	**27,100**
Organic Nitrogen (kg/year)	24,600	141,600	125,700
Ammonia Nitrogen (kg/year)	200	8,800	10,100
Nitrate+Nitrite Nitrogen (kg/year)	28,000	125,100	99,000
Total Nitrogen (kg/year)	**52,800**	**275,500**	**234,800**

Figure 3-5 Average Total Phosphorus Loading from SWAT Sub-Watersheds

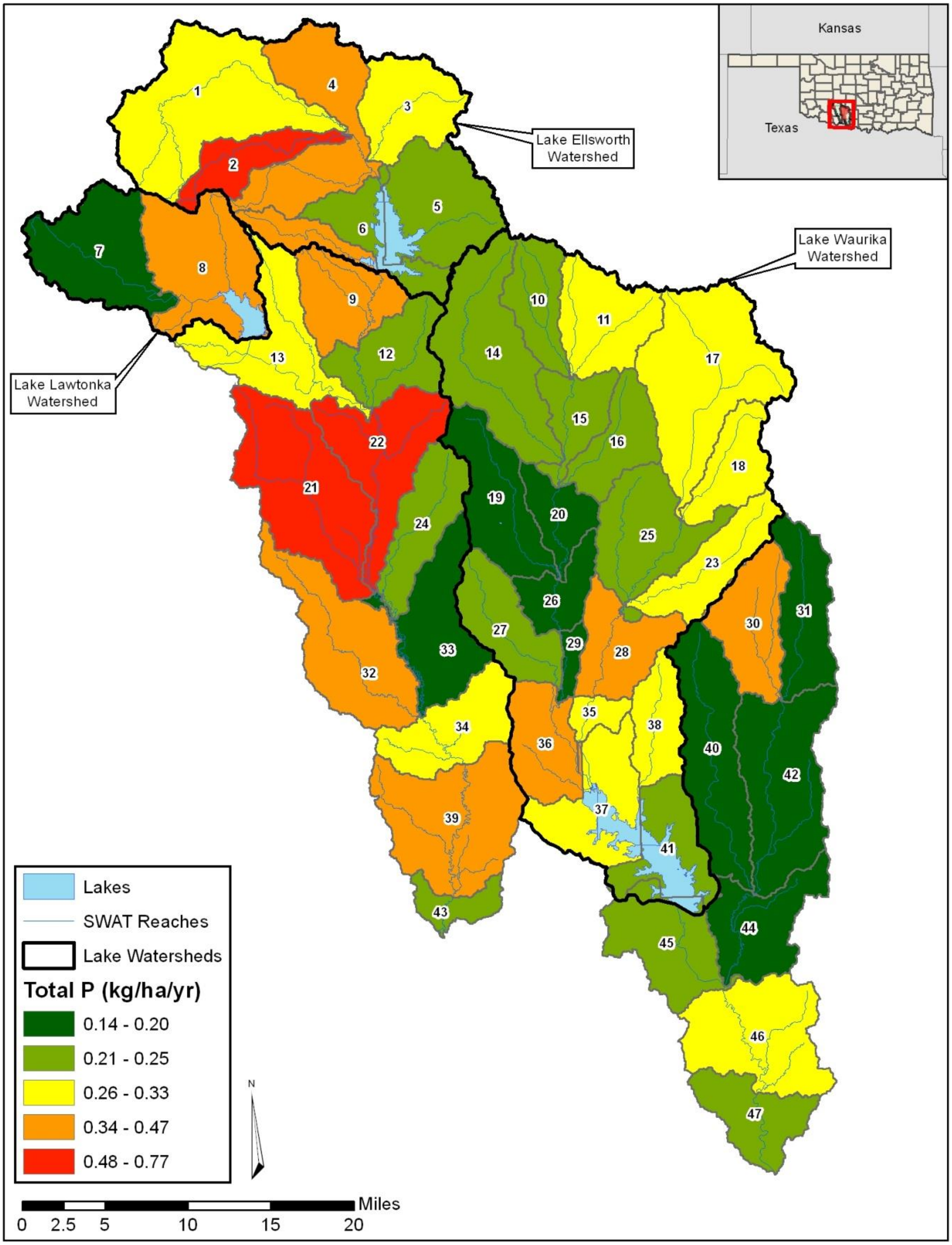
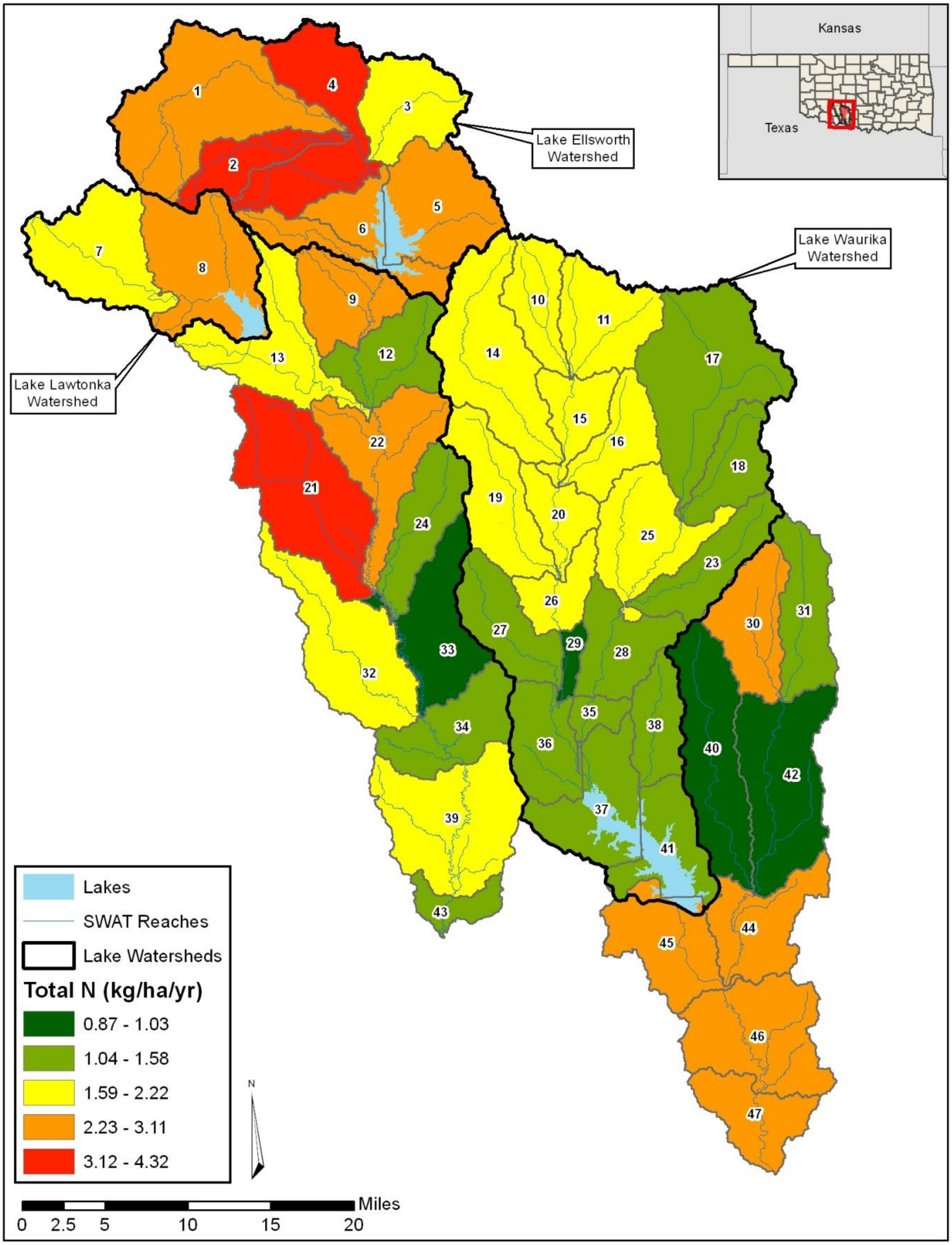


Figure 3-6 Average Total Nitrogen Loading from SWAT Sub-Watersheds



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. To ascertain the effect of management measures on in-lake water quality, it is necessary to establish a linkage between the external loading of nutrients and the waterbody response in terms of lake water quality conditions, as evaluated by chlorophyll-*a* concentrations. This section describes the water quality data analysis methods used to demonstrate the linkage between chlorophyll-*a* levels in Lake Lawtonka, Waurika Lake or Lake Ellsworth and the nutrient loadings from their watersheds.

The report *Technical Methods Summary for Watershed and Water Quality Modeling of Sensitive Water Supply Lakes in Oklahoma* (Parsons 2010) provides a thorough description of the water quality modeling analysis. The subsections below summarize the inputs and results of the modeling approach used to establish TMDL calculations.

4.1 BATHTUB Model Description

The water quality linkage analysis was performed using the BATHTUB model (Walker 1986). BATHTUB is a USACE model designed to simulate eutrophication in reservoirs and lakes. BATHTUB has been cited as an effective tool for reservoir and lake water quality assessment and management, particularly where data are limited. The model incorporates several empirical equations of nutrient settling and algal growth to predict steady-state water column nutrient and chlorophyll-*a* concentrations based on waterbody characteristics, hydraulic characteristics, and external nutrient loadings.

BATHTUB predicts steady-state concentrations of chlorophyll-*a*, total phosphorus, total nitrogen, water transparency, and a conservative substance (e.g., chloride or a dye tracer) in a waterbody under various hydrologic and loading conditions. To do this, the model requires inputs that describe the physical characteristics of each lake (e.g., depth, surface area), tributary flow rates and loadings (which can be estimated by BATHTUB or input from another model), and observed water quality concentrations to use as calibration targets.

4.2 BATHTUB Model Setup and Input Data

The model was run under average, steady-state conditions.

4.2.1 Lake Morphometry

BATHTUB allows the user to segment a lake into a hydraulic network. However, significant lake morphometry data are required to justify the complex assumptions inherent in partitioning a reservoir into multiple hydraulically linked segments. Bathymetric data for Lake Lawtonka and Lake Ellsworth were available through the Oklahoma Water Resources Board (http://www.owrb.ok.gov/studies/quality/lakes_watersheds.php#bathymetric). Because there is only one major input to each of the lakes and inflows from direct runoff are not expected to affect horizontal mixing, the three lakes are considered relatively well-mixed horizontally. Thus, a single segment was deemed applicable for the reservoirs. Based on availability of both flow and water quality data, for the purposes of TMDL development, a single segment was determined as sufficient for each of the three lakes. In addition, without monthly or seasonal data to characterize residence time of each lake an averaging period of one year was used to depict the duration of mass-balance calculations (e.g., a single filling and emptying event in a year) for the lakes.

4.2.2 Meteorology

The BATHTUB model requires both precipitation and evaporation data. Precipitation data, summarized in Section 1.2, were derived from the Oklahoma MESONET system. Monthly water surface evaporation rates for several locations in Oklahoma were estimated by NOAA (http://www.nws.noaa.gov/oh/hrl/dmip/2/evap.html). MESONET also calculates a daily pan evaporation value for its stations with measured climatological data (http://agweather.mesonet.org/index.php/data/section/soil_water). Using a conversion factor of 0.77, water surface evaporation can be estimated from the MESONET pan evaporation data. Based on these two sets of data, a rate of 47 inches per year was applied for Lake Lawtonka, Waurika Lake, and Ellsworth Lake.

4.2.3 Inflows and Loads

Key water quality parameters for BATHTUB input include total phosphorus, inorganic ortho-phosphorus, total nitrogen, and inorganic nitrogen. Output from the SWAT model, described in Section 3.2, was the primary source of data inputs to the BATHTUB model. Although SWAT can provide daily output, BATHTUB is a steady-state model and not appropriate for interpreting short-term responses of lakes to nutrients. Therefore, the long-term average annual loads from the SWAT modeled period were applied as inputs to BATHTUB.

BATHTUB also requires an estimate of atmospheric deposition of total and inorganic nitrogen and phosphorus. Atmospheric deposition can contribute a significant amount of phosphorus and nitrogen directly to a lake surface when the ratio of watershed area to lake surface area is low. Atmospheric deposition measurements from site OK17 (Kessler Farm Field Laboratory, in McClain County) of the National Atmospheric Deposition Program (http://nadp.sws.uiuc.edu/) were used. Table 4-1 summarizes the estimate of atmospheric nitrogen loads based on the data compiled from site OK17 for the period 1983-2010. These loads are 20%, 17% and 10%, respectively, of the watershed loads to Lawtonka, Waurika, and Ellsworth Lakes.

Table 4-1 Estimate of Atmospheric Loads

Atmospheric Loads	Areal Mean (mg/m^2-yr)	Estimated Load to Lake Lawtonka (kg/year)	Estimated Load to Waurika Lake (kg/year)	Estimated Load to Lake Ellsworth (kg/year)	CV
Total Nitrogen	1127	10,599	46,247	23,315	0.2
Inorganic Nitrogen	200	1,881	8,207	4,138	0.04

4.2.4 Empirical Equations

BATHTUB consists of a series of empirical equations that have been calibrated and tested for lake application (for a description of the equations, see Model Documentation available online at http://wwwalker.net/bathtub/help/bathtubWebMain.html). These empirical relationships are used to calculate steady-state concentrations of total phosphorus, total nitrogen, chlorophyll-*a*, and water transparency based on the inputs and forcing functions. To predict each output (e.g., total phosphorus concentration), one of several built-in empirical equations must be selected. The BATHTUB model was run using the following options:

- Phosphorus and nitrogen balance: second-order decay rate function
- Chlorophyll-*a*: phosphorus, nitrogen, light, flushing
- Water transparency: Secchi depth vs. chlorophyll-*a* and turbidity

4.3 BATHTUB Model Calibrations and Output

The model was run under average existing conditions, and calibrated to measured in-lake water quality conditions (based on 2002-2011 data) using phosphorus, nitrogen, chlorophyll-a and secchi disk calibration factors. Table 4-2 includes the calibration factors used for the three lakes.

Table 4-2 Calibration Factors Used for Lakes

Calibration Factor	Lake Lawtonka	Waurika Lake	Lake Ellsworth
Total Phosphorus	0.60	0.06	0.18
Total Nitrogen	0.63	0.74	1.23
Chlorophyll-a	4.45	1.02	1.11
Secchi Disk	2.90	0.80	0.44

The model-predicted concentrations of total nitrogen, total phosphorus, chlorophyll-*a*, and Secchi depth under existing average conditions are compared to average measured concentrations from each lake in Table 4-3.

Table 4-3 Model Predicted and Measured Water Quality Parameter Concentrations

Water Quality Parameter	Lake Lawtonka		Waurika Lake		Lake Ellsworth	
	Modeled	Measured	Modeled	Measured	Modeled	Measured
Total Phosphorus (mg/L)	0.026	0.026	0.086	0.086	0.066	0.067
Total Nitrogen (mg/L)	0.66	0.66	0.80	0.80	0.84	0.84
Chlorophyll-*a* (µg/L)	17.5	17.1	13.4	13.5	12.3	12.4
Secchi depth (meters)	1.1	1.1	0.6	0.6	0.4	0.3

4.4 BATHTUB Model Sensitivity Analysis

Because of uncertainty and variability in input parameter values, BATHTUB modeling can result in output uncertainty. Quantifying this uncertainty is important for assessing the potential water quality of the lakes in this study. Given the large number of parameters in the model, a preliminary sensitivity analysis was performed before the Monte Carlo-based uncertainty analysis to identify the parameters contributing most to the uncertainty of model predictions. The Monte Carlo analyses will provide the probability of compliance with the water quality goal, given reductions in TN, TP, or both. Since TN and TP are then both candidates for TMDL reductions to control chlorophyll-*a* in the reservoirs these species, which can be used as inputs to the BATHTUB model, both must be omitted from the Monte Carlo analyses since their values are set to obtain compliance with the chlorophyll-*a* water quality targets.

The model output of concern is average chlorophyll-*a* concentration. A one-at-a-time sensitivity analysis of the model output was conducted using the minimum and maximum values for each of the parameters selected. Results obtained after completing the steps previously described are summarized in the Characterization Matrices for each lake presented as Figures 4-1, 4-2 and 4-3 for Lake Lawtonka, Waurika Lake, and Lake Ellsworth, respectively. In these figures, the sensitivity of the input parameters is on the y-axis, while the variability of the output (change with the respect to the value for the base case) is on the x-axis. The top three most sensitive parameters were chosen for further analysis utilizing Monte Carlo techniques described below. These three parameters are circled in each of the plots. The parameters chosen for all three lakes are non-algal turbidity, chlorophyll-*a* calibration factor, and mixed layer depth.

Figure 4-1 Characterization Matrix for BATHTUB Parameters for Lake Lawtonka

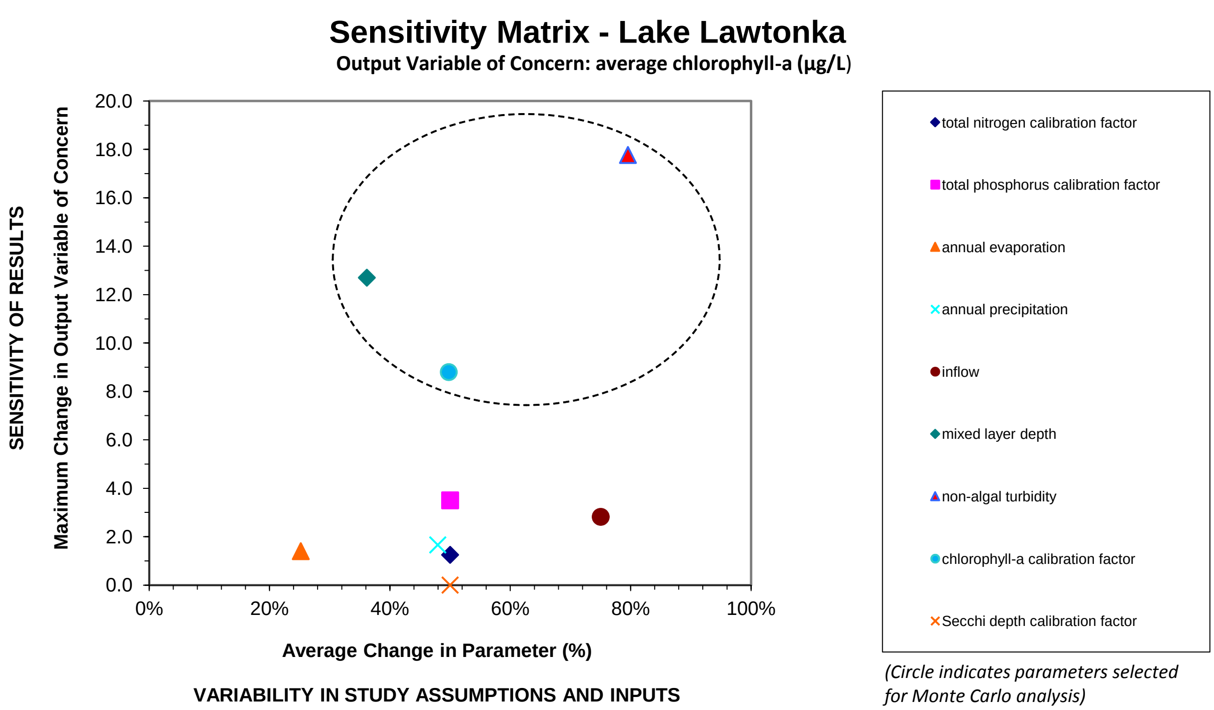


Figure 4-2 Characterization Matrix for BATHTUB Parameters for Waurika Lake

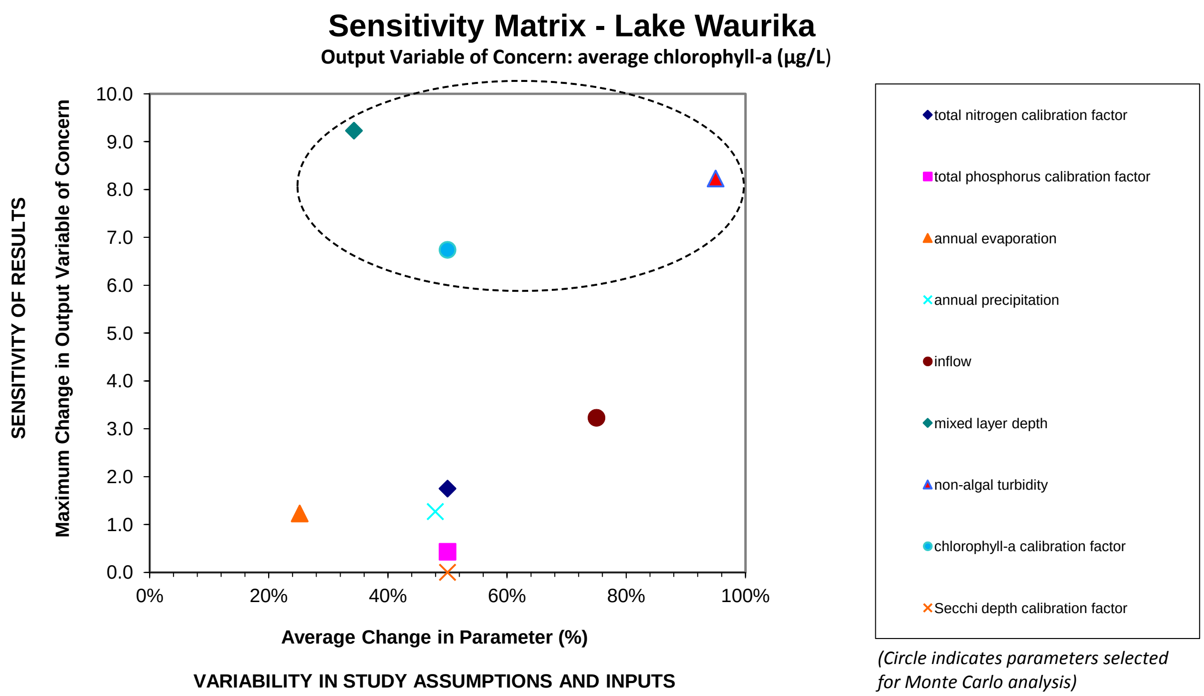
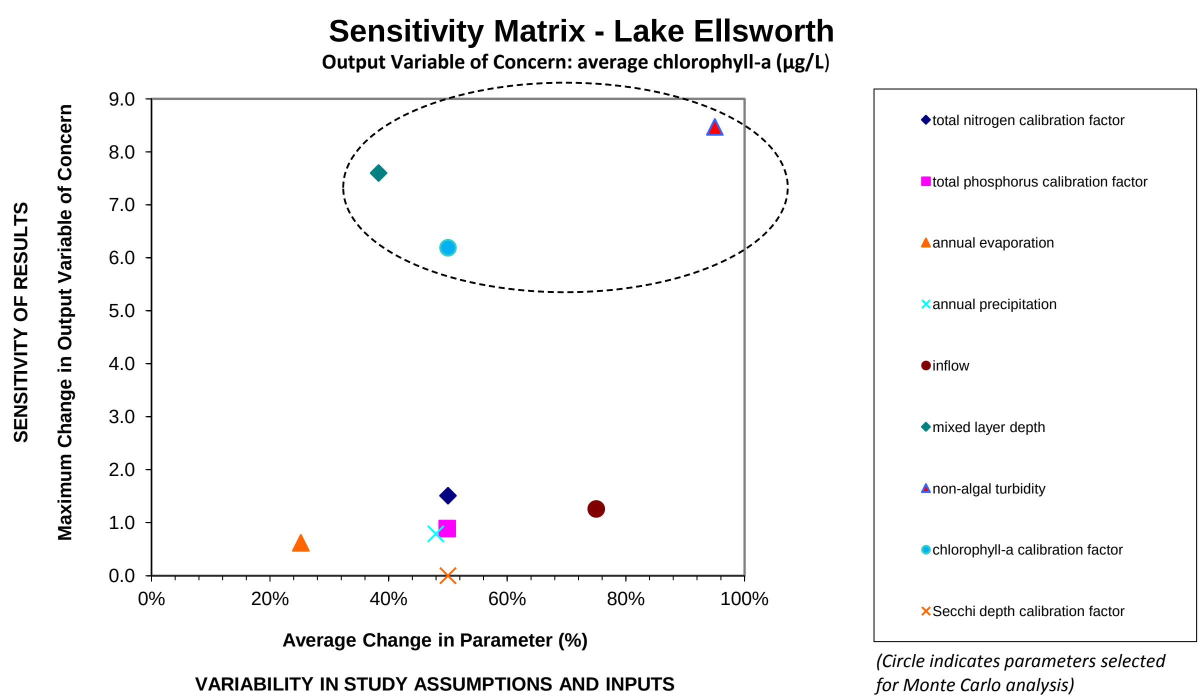


Figure 4-3 Characterization Matrix for BATHTUB Parameters for Lake Ellsworth



4.5 BATHTUB Uncertainty Analysis

Based on the results of the sensitivity analysis described above, three parameters were selected for the uncertainty analysis. Those correspond to parameters that exhibit both high sensitivity and high variability. An uncertainty analysis was conducted using Monte Carlo simulations (MCS) incorporating the parameters and distributions summarized in Table 4-4. A detailed description of the Monte Carlo analysis is provided in *Technical Methods Summary for Watershed and Water Quality Modeling of Sensitive Water Supply Lakes in Oklahoma* (Parsons 2010). Means and standard deviations for the parameters used in the Monte Carlo simulations are calculated directly from the population of values where possible. In this application, however, the parameters of concern generally prove to be model parameters and factors that have no population of time series of potential values. As a result, for these parameters the mean is generally set to the calibrated value utilized in the calibrated model and the standard deviation is an estimate of the potential variance of the parameter from the calibrated value. In this case, the mean and standard deviation just serve to bound the selection of potential values for the selected Monte Carlo parameter.

Table 4-4 Selected Distribution of Parameters for BATHTUB Uncertainty Analysis

Parameter†	Definition	Distribution
a	Non-algal turbidity (1/m)	Normal (Lawtonka: mean = 2.2, std. dev. = 0.85; Waurika: mean = 1.0, std. dev = 0.5; Ellsworth: mean = 1.0, std. dev = 0.5)
Kc	Calibration factor for chlorophyll-*a* (unitless)	Normal (Lawtonka: mean = 4.45, std. dev. = 1.3; Waurika: mean = 1.02, std. dev = 0.45; Ellsworth: mean = 1.11, std. dev = 0.45)
zmx	Mixed layer depth (m)	Normal (Lawtonka: mean = 6.0, std. dev. = 1.75; Waurika: mean = 5.0, std. dev = 1.5; Ellsworth: mean = 5.8, std. dev = 1.5)

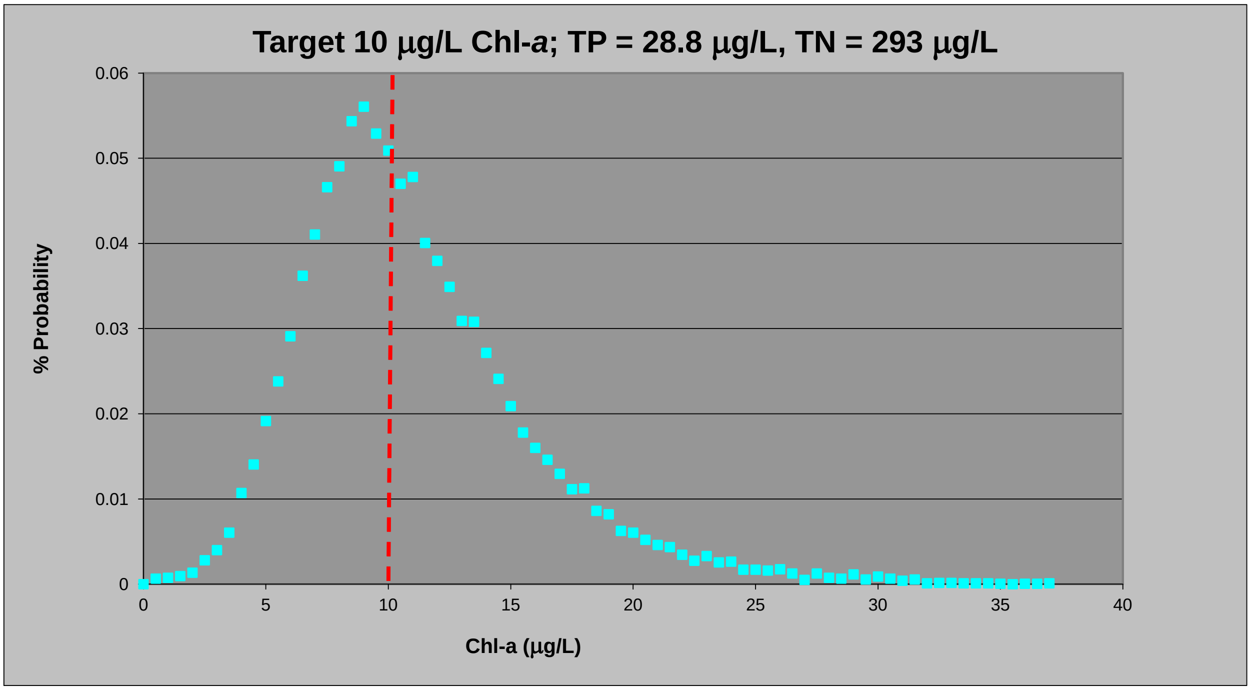
† The listed parameters were identified in a one-at-a-time sensitivity analysis to cause the most impact on modeled average chlorophyll-*a* concentrations.

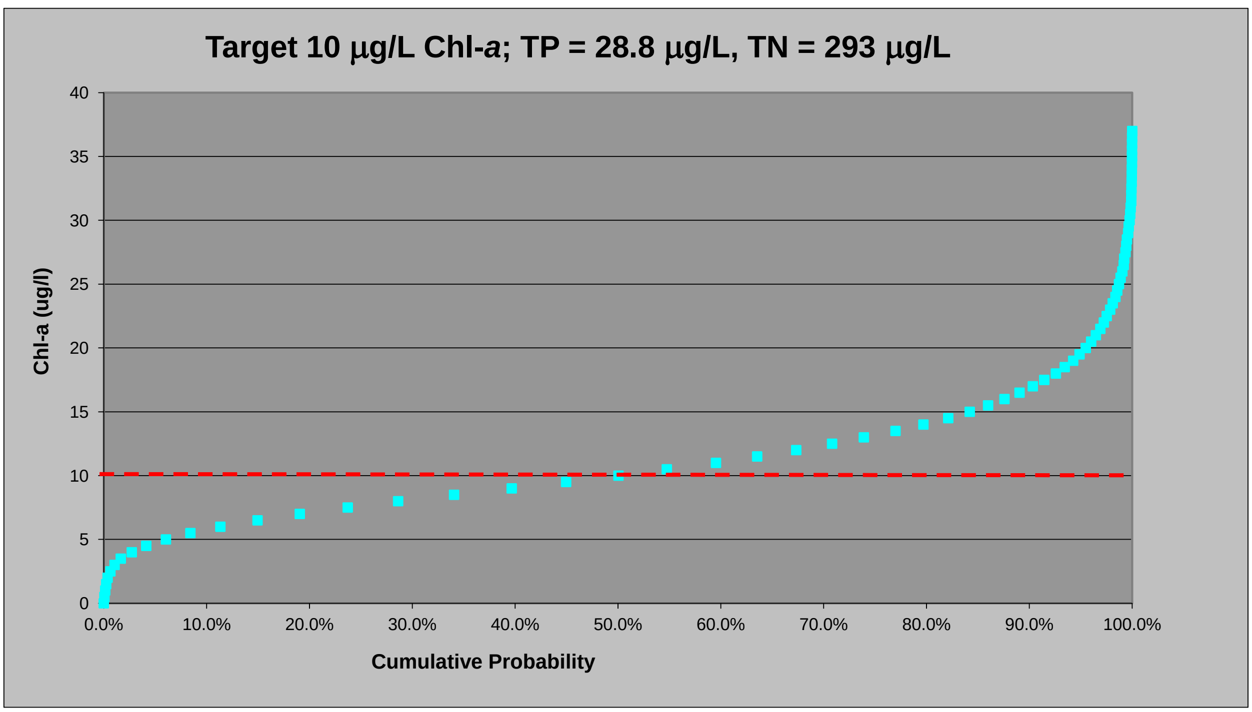
Figure 4-4 shows probability and cumulative probability plots of average chlorophyll-*a* concentrations for the 20,000 iterations of the MCS for Lake Lawtonka for an in-lake water quality target of 10 μg/L. Results indicate that, given the very high variability in inflow to the lake, the average chlorophyll-*a* concentration has a 50% probability of being less than 10 μg/L.

Likewise, Figure 4-5 shows probability and cumulative probability plots of average chlorophyll-*a* concentrations for the 20,000 iterations of the MCS for Waurika Lake for an in-lake water quality target of 10 μg/L. Results indicate that, given the very high variability in inflow to the lake, the average chlorophyll-*a* concentration has a 50% probability of being less than 10 μg/L.

For Lake Ellsworth, the cumulative probability distribution for an in-stream lake water quality target of 10 μg/L showed that the probability of meeting the water quality standard was less than 50%. Thus, a 10% explicit margin of safety was included in the TMDL calculation for this Lake and a new Monte Carlo simulation was run for a 9 μg/L target. Figure 4-6 shows probability and cumulative probability plots of average chlorophyll-*a* concentrations for the 20,000 iterations of the MCS for Lake Ellsworth for an in-lake water quality target of 9 µg/L. Results indicate that, despite the high variability in inflow to the Lake, the average chlorophyll-*a* concentration has a 57% probability of being less than 10 µg/L.

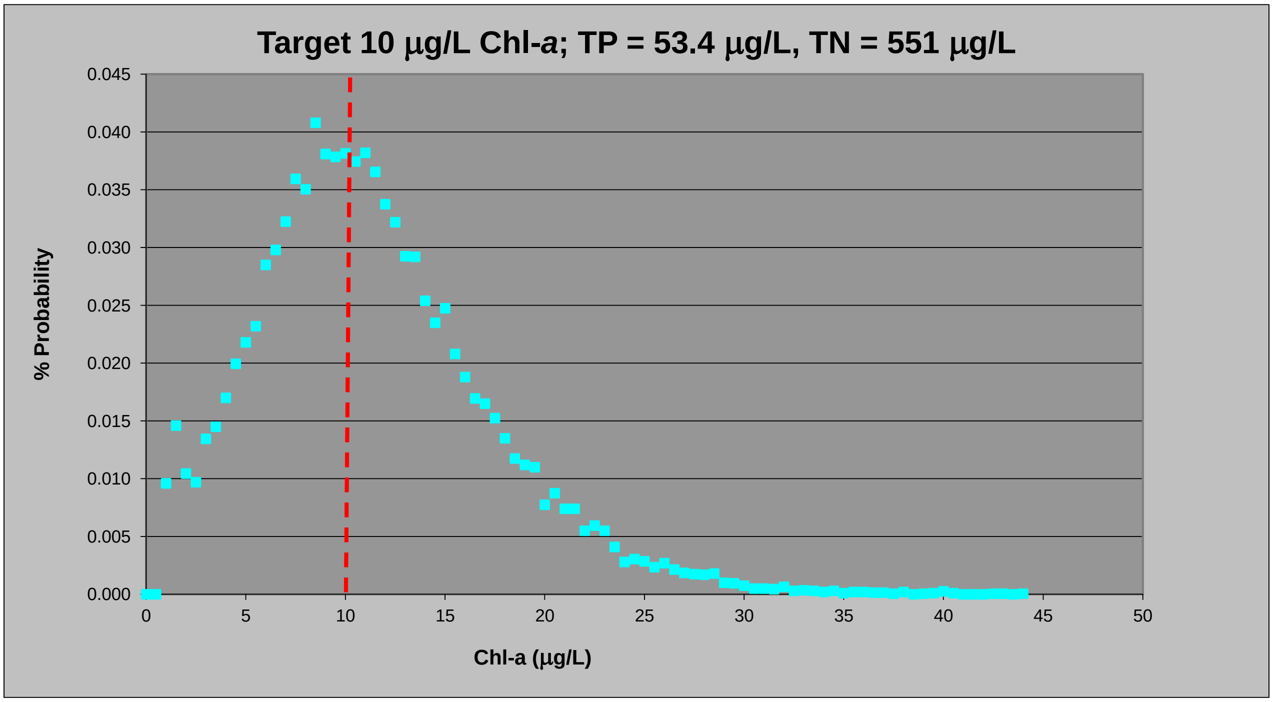
Figure 4-4 Monte Carlo Simulation Results for Lake Lawtonka

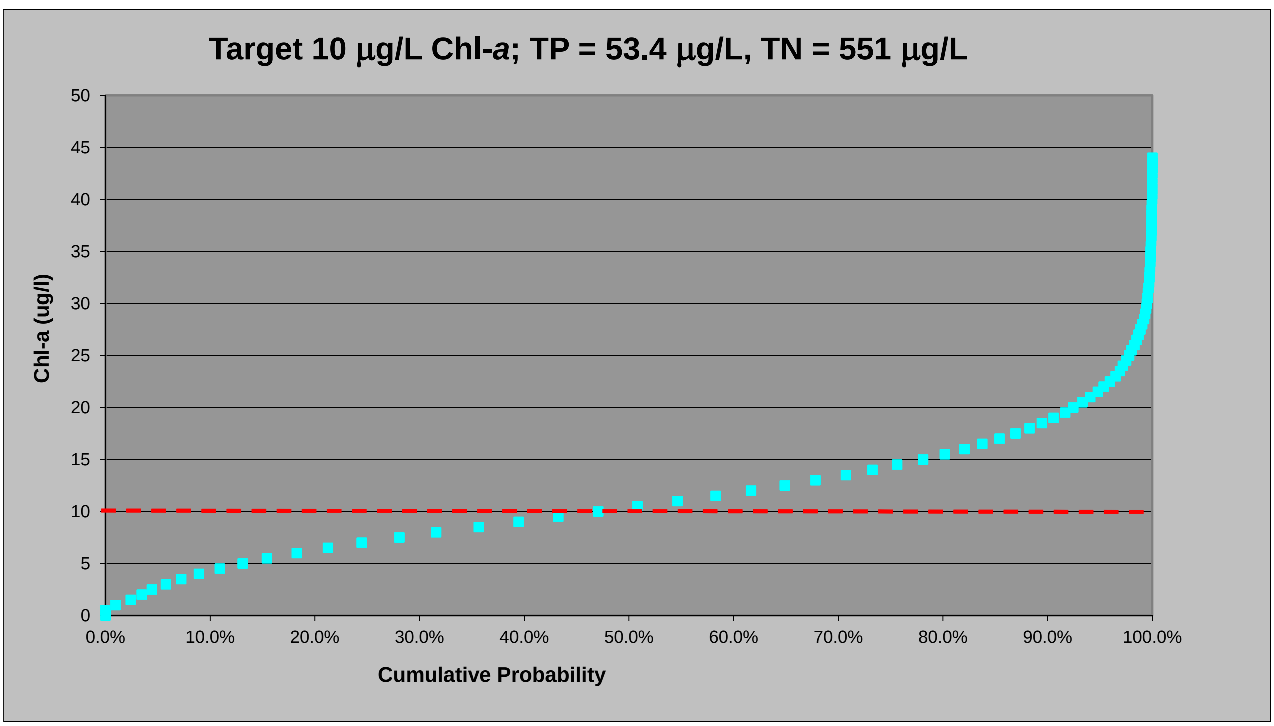




Note: Chl-a is the target to achieve. TP and TN values are tributary incoming concentrations, not in-lake concentrations.

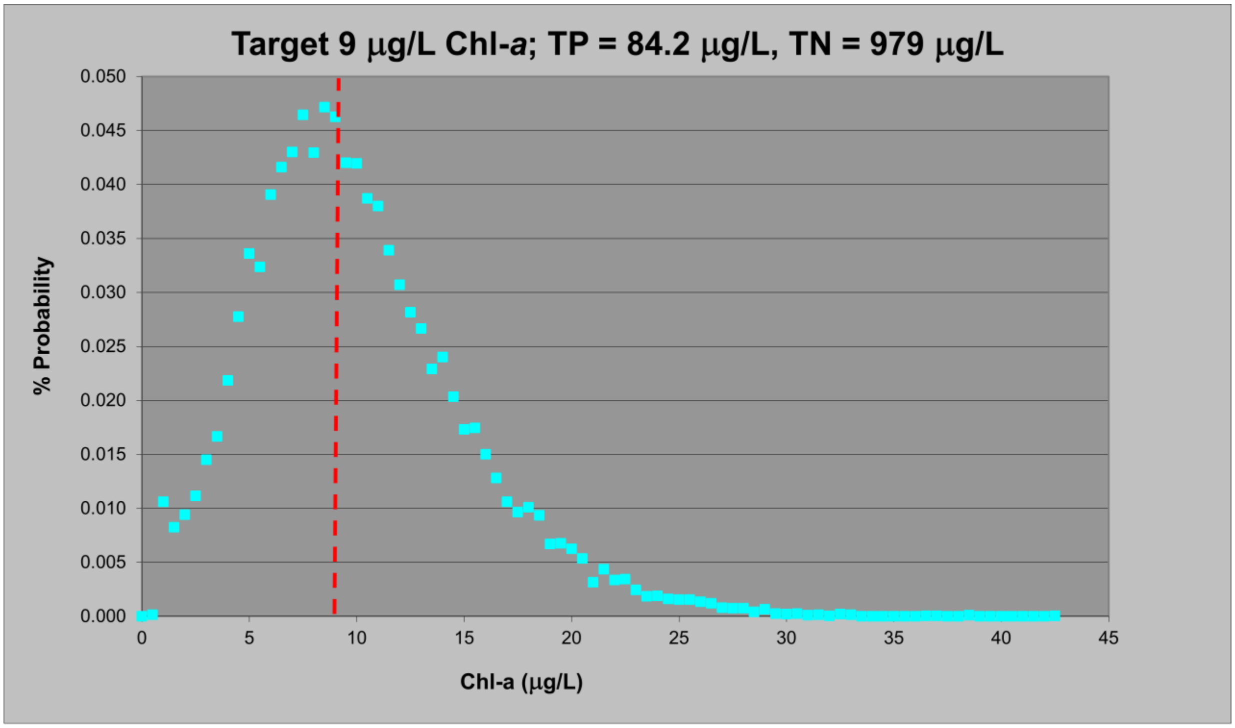
Figure 4-5 Monte Carlo Simulation Results for Waurika Lake

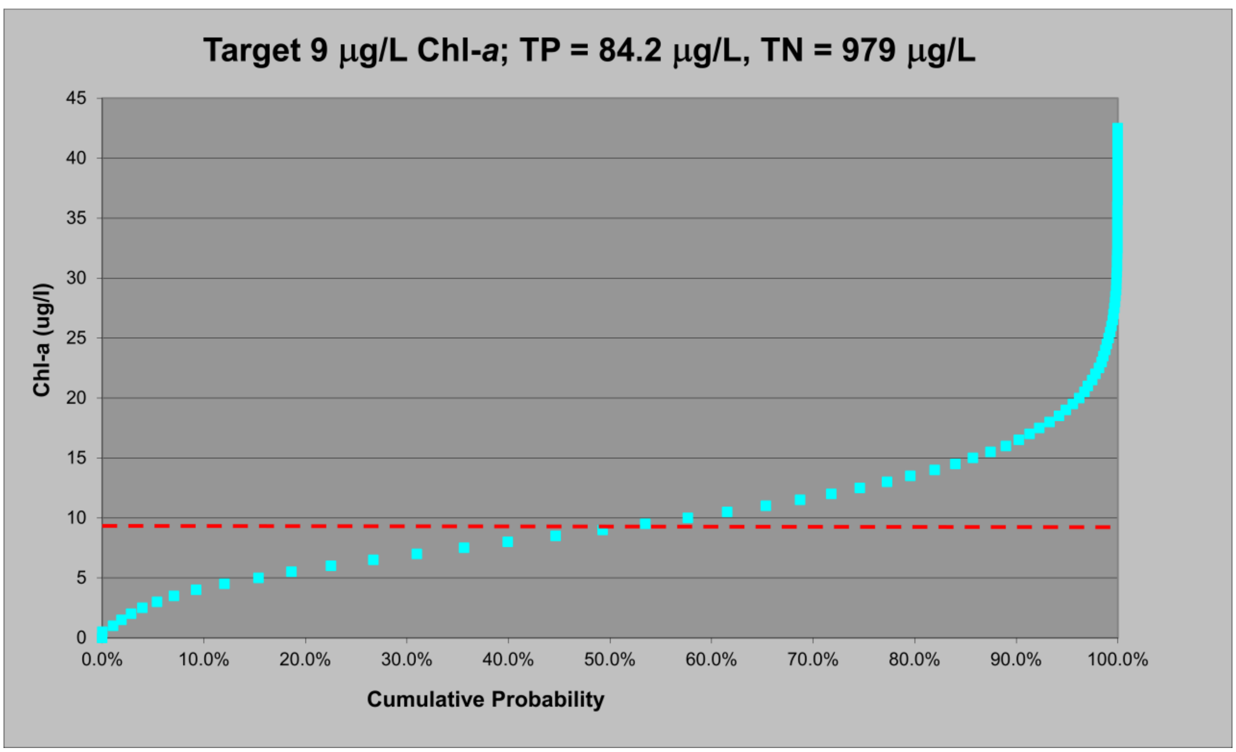




Note: Chl-a is the target to achieve. TP and TN values are tributary incoming concentrations, not in-lake concentrations.

Figure 4-6 Monte Carlo Simulation Results for Lake Ellsworth





4.6 Modeled Load Reduction Scenarios

A summary of the existing loads to Lake Lawtonka, Waurika Lake, and Lake Ellsworth simulated in BATHTUB is presented in Table 4-5.

Table 4-5 Existing Loads (in kg/yr)

Water Quality Parameter	Lake Lawtonka		Waurika Lake		Lake Ellsworth	
	Watershed	Atmospheric	Watershed	Atmospheric	Watershed	Atmospheric
Total Phosphorus	7,200	0[a]	47,200	0[a]	27,100	0[a]
Orthophosphorus	2,500	0[a]	9,200	0[a]	4,800	0[a]
Total Nitrogen	52,800	10,599	275,500	46,247	234,800	23,315
Inorganic Nitrogen	28,200	1,881	133,900	8,207	109,100	4,138

[a] Atmospheric deposition of phosphorus is expected to be negligible and, thus, is assumed to be zero.

Simulations were performed using the BATHTUB model to evaluate the effect of watershed loading reductions on chlorophyll-*a* levels. Atmospheric loads were maintained at their existing estimated levels. Simulations indicated that the water quality target of 10 µg/L chlorophyll-*a* as a long-term average concentration could be achieved if the total phosphorus and nitrogen watershed loads to Lake Lawtonka were reduced by 55% from the existing loads, to 3,240 kg/year of total phosphorus and 23,760 kg/year of total nitrogen. In Waurika Lake, the water quality target of 10 µg/L chlorophyll-*a* could be achieved if the existing watershed loads were reduced by 40% to 28,320 kg/year of total phosphorus and 165,300 kg/year of total nitrogen. In Lake Ellsworth, the water quality target of 9 µg/L chlorophyll-*a* could be achieved if the existing watershed loads were reduced by 45% to 14,900 kg/year of total phosphorus and 129,140 kg/year of total nitrogen. As discussed above the uncertainty analysis demonstrated that to ensure at least a 50% probability of meeting water quality standards, a water quality target of 9 µg/L chlorophyll-*a* was set for Lake Ellsworth. Table 4-6 summarizes the percent reduction goals for nutrient loading established for each lake. These maximum loads include an inherent margin of safety through the use of limits on loading of both nitrogen and phosphorus.

Table 4-6 Total Phosphorus and Nitrogen Load Reductions Needed to Meet Chlorophyll-*a* In-lake Water Quality Targets

Lake	Chlorophyll-*a* In-lake Target (µg/L)	Percent Reduction	Maximum Allowable Load (kg/yr)[a]	
			Total Phosphorus	Total Nitrogen
Lake Lawtonka	10	55%	3,240	23,760
Waurika Lake	10	40%	28,320	165,300
Lake Ellsworth	9	45%	14,900	129,140

[a] Loads do not include atmospheric deposition

Eutrophication is one of the leading causes of pollution in lakes and reservoirs throughout the world (Smith 2003). Therefore, determining which nutrients limit phytoplankton growth is an important step in the development of effective lake and watershed management strategies

(Dodds and Priscu 1990; Elser *et al.* 1990; Smith *et al.* 2002). It is often assumed that algal productivity of most freshwater lakes and reservoirs is primarily limited by the availability of the nutrient phosphorus. Therefore, limits on phosphorus loading to lakes are sometimes considered a necessary, and typically sufficient, mechanism to reduce eutrophication. However, more recent studies in reservoirs indicate that both nitrogen and phosphorus play key roles, along with light, mixing conditions, predation by zooplankton, and residence time, in limiting algal growth (Kimmel et al. 1990). In a study of 19 Kansas reservoirs, Dzialowski et al. (2005) utilized bioassays to measure algal growth limitation, and found that phytoplankton growth substantially increased with phosphorus addition (implying that phosphorus alone limited growth) in only 8% of the bioassays. Nitrogen was the sole limiting nutrient in 16% of the bioassays. In 67% of the bioassays, significant algal growth did not occur upon addition of nitrogen or phosphorus singly, but did grow in response to addition of both nitrogen and phosphorus. In these systems, algal growth was considered to be co-limited by availability of phosphorus and nitrogen. Co-limitation by nitrogen and phosphorus was also reported to be the most common condition for two lakes in north Texas (Chrzanowski and Grover 2001). In some cases, growth limitation by phosphorus has been observed to be more common in the spring, followed by a shift to nitrogen limitation in the summer and fall.

Figures 4-7, 4-8, and 4-9 display summary plots of multiple combinations of TN and TP concentrations and percent reductions that result in 10 µg/L chlorophyll-*a* for Lawtonka and Waurika Lakes and 9 µg/L for Lake Ellsworth estimated using BATHTUB. The data points in the plots correspond to the subset of MCS iterations that resulted in the target chlorophyll-*a* levels. While the relative importance of nitrogen and phosphorus in limiting algal productivity in Lawtonka, Waurika, and Ellsworth Lakes has not been definitively established, this TMDL calculates load allocations for both nitrogen and phosphorus as a conservative approach to ensure that water quality targets are met. While the BATHTUB model is capable of simulating chlorophyll-*a* concentrations from both TP and TN concentrations, it is an empirically derived statistical algorithm that does not include the concept of a limiting nutrient. In other words, chlorophyll-*a* concentrations are a continuous function of both TN and TP contributions that can vary from season to season. Since there are infinite combinations of TN and TP concentrations that could result in the desired chlorophyll-*a* concentration and BATHTUB is not capable of discerning between them, a practical starting point for implementation is to begin with equal percent reduction goals for both nutrient parameters. However, depending on the local environmental and socio-economic conditions, different percent reductions for the two nutrients based on the curves in Figures 4-7, 4-8, and Figure 4-9 could be used during the implementation of each TMDL to achieve the target chlorophyll-*a* level in the lakes.

Figure 4-7 Total N and Total P Combinations Resulting in 10 µg/L Chlorophyll-*a* – Lake Lawtonka

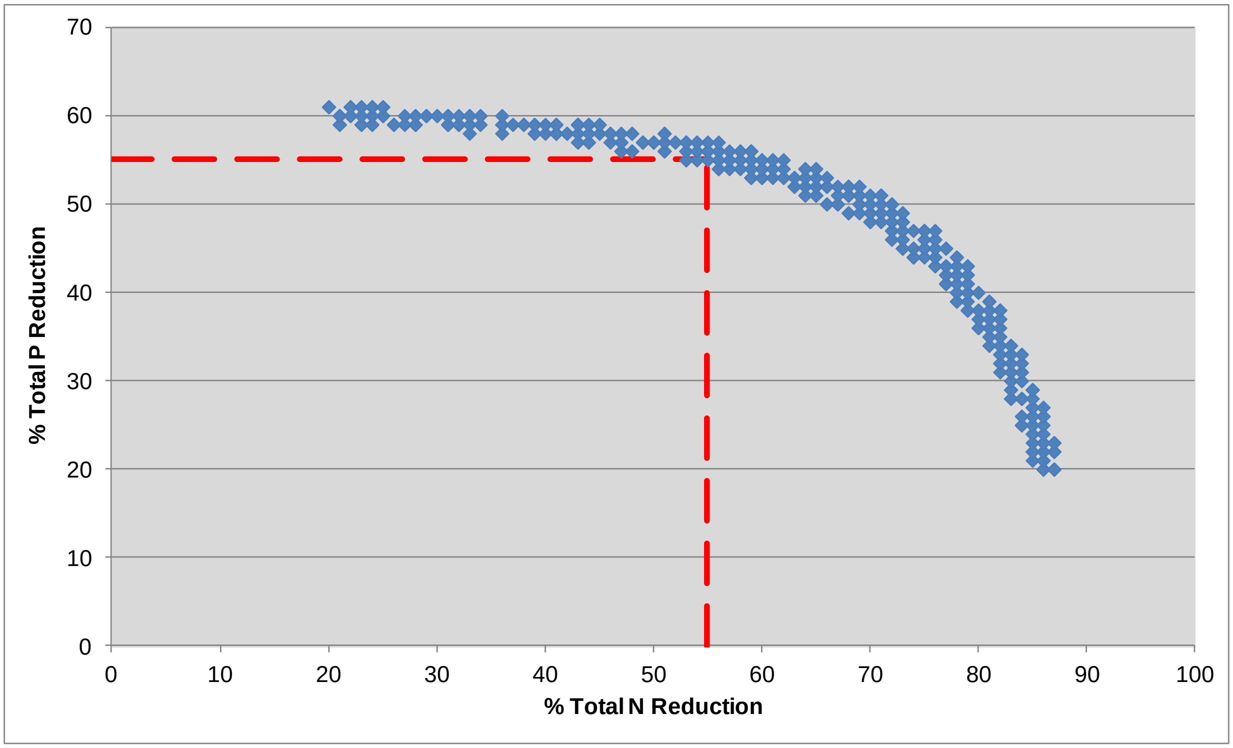


Figure 4-8 Total N and Total P Reduction Combinations Resulting in 10 µg/L Chlorophyll-*a* – Waurika Lake

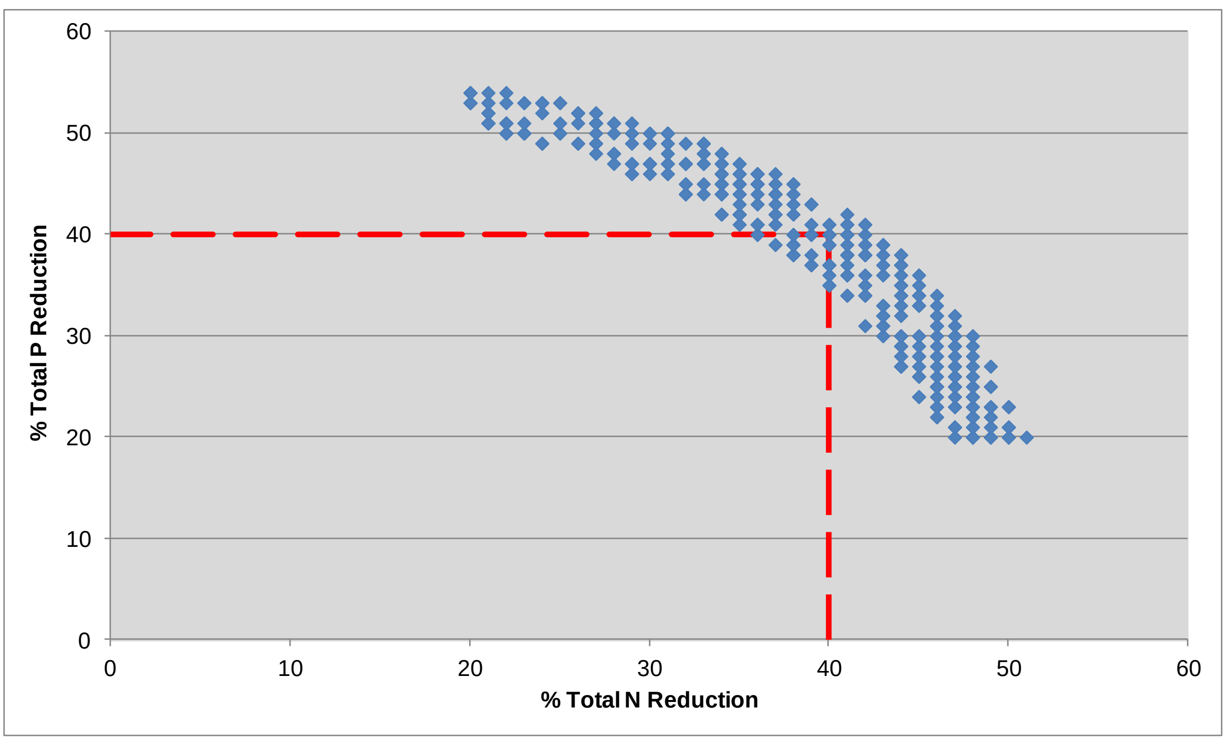
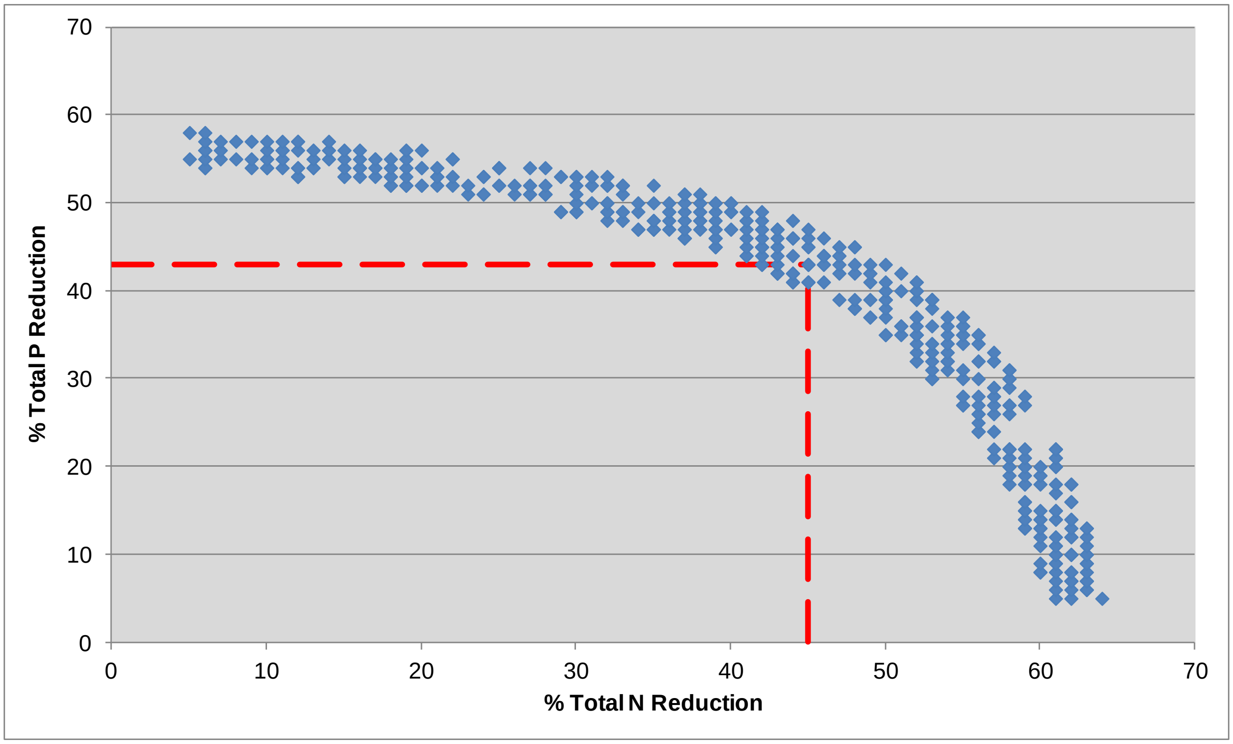


Figure 4-9 Total N and Total P Reduction Combinations Resulting in 9 µg/L Chlorophyll-*a* – Lake Ellsworth



SECTION 5
TMDLS AND LOAD ALLOCATIONS

Models were used to calculate TMDLs for each lake as annual average phosphorus and nitrogen loads (kg/yr) that, if achieved, should meet the water quality target established for chlorophyll-*a*. For reporting purpose, the final TMDLs, according to EPA guideline, are expressed for each lake as daily maximum loads (kg/day).

5.1 Wasteload Allocation

There are no point sources of wastewater discharging to Lake Lawtonka, Waurika Lake or Lake Ellsworth or their tributaries. Furthermore, Oklahoma's implementation of WQS (OAC 785:46-13-4) prohibits new point source discharges to these lakes, except for stormwater with approval from DEQ (OWRB 2011b). *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."*

The City of Lawton (MS4 Stormwater Permit #OKR040004) and Fort Sill Army Base (OKR040040) are designated as Phase II MS4 permitted entities and are included in the SWAT Model. However, these jurisdictions are not located in any of the contributing watersheds of the three lakes. Therefore, the wasteload allocation established for each waterbody is zero.

5.2 Load Allocation

The load allocation for watershed nonpoint sources to Lake Lawtonka was conservatively estimated as 3,240 kg/yr of total phosphorus and 23,760 kg/yr of total nitrogen, necessitating a 55% reduction from existing loading to achieve the desired water quality target.

The load allocation for watershed nonpoint sources to Waurika Lake was conservatively estimated as 28,320 kg/yr of total phosphorus and 165,300 kg/yr of total nitrogen, necessitating a 40% reduction from existing loading to achieve the desired water quality target.

The load allocation for watershed nonpoint sources to Lake Ellsworth was conservatively estimated as 14,900 kg/yr of total phosphorus and 129,140 kg/yr of total nitrogen, necessitating a 45% reduction from existing loading to achieve the desired water quality target.

5.3 Seasonal Variability

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs account for seasonal variation in watershed conditions and pollutant loading. The WQS for chlorophyll-*a* specifically applies as a long-term average concentration (OAC 785:45-5-10(7)). Oklahoma procedures to implement WQS (OAC 785:46-7-2) specify that the mean annual average outflow represents the long-term average flow in lakes (OWRB 2011b). Seasonal variation was accounted for in these TMDLs by using more than five years of water quality data collected in each of the four seasons.

5.4 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.

In developing the TMDLs for the Study Area, an explicit MOS was included if the cumulative probability plots of the MCS showed that the probability of meeting the WQS was less than 50%. The TMDLs for Lawtonka and Waurika Lakes include an implicit MOS that is incorporated by the application of load reductions for both nitrogen and phosphorus. The TMDL for Ellsworth Lake includes an explicit 10% MOS based on the use of a water quality target set at 9 µg/L target, which ensures a cumulative probability that the WQS of 10 µg/L will be achieved more than 57% of the time.

5.5 TMDL Calculations

A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for the uncertainty concerning the relationship between loading limitations and water quality. This definition can be expressed by the following equation:

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

Load reduction scenario simulations were run using the BATHTUB model to calculate annual average phosphorus and nitrogen loads (in kg/yr) that, if achieved, should decrease chlorophyll-*a* concentrations to meet the water quality target. Given that transport, assimilation, and dynamics of nutrients vary both temporally and spatially, nutrient loading to both lakes from a practical perspective must be managed on a long-term basis typically as pounds or kilograms per year. However, a recent court decision (*Friends of the Earth, Inc. v. EPA, et al.*, often referred to as the Anacostia decision) states that TMDLs must include a daily load expression. It is important to recognize that the chlorophyll-*a* response to nutrient loading in Lake Lawtonka, Waurika Lake, and Lake Ellsworth is affected by many factors such as: internal lake nutrient loading, water residence time, wind action and the interaction between light penetration, nutrients, sediment load, and algal response. As such it is important to note that expressing this TMDL in daily time steps does not imply a daily response to a daily load is practical from an implementation perspective.

The EPA's *Technical Support Document for Water Quality-Based Toxics Control* (EPA 1991a) provides a statistical method for identifying a statistical maximum daily limit based on a long-term average and considering variation in a dataset. The method is represented by the following equation:

$$MDL = LTA \times e^{z\sigma - 0.5\sigma^2}$$

where MDL = maximum daily load
LTA = long-term average load
z = z statistic of the probability of occurrence (1.645 is used for this value)
$\sigma^2 = \ln(CV^2+1)$
CV = coefficient of variation

The coefficients of variation of daily nitrogen and phosphorus NPS loads, calculated from SWAT model output, were 7.3 and 8.6 for Lake Lawtonka, 8.5 and 8.7 for Waurika Lake, and 6.1 and 6.4 for Lake Ellsworth, respectively. As illustrated in Figures 4-7, 4-8 and 4-9, there are infinite combinations of TN and TP reductions, as calculated by BATHTUB, that will achieve the 10 µg/L chlorophyll-*a* criterion. As a practical starting point for TMDL implementation an equal reduction goal for both TN and TP loading is recommended. During implementation, it may become evident that some other combination of TN and TP reductions is more cost effective.

Using equal reductions for both nutrient parameters (55% for Lawtonka, 40% for Waurika and 45% for Ellsworth), the maximum daily load corresponding to the allowable annual average loads are provided in Table 5-1. In Lawtonka Lake the 3,240 kg of phosphorus and 23,760 kg of nitrogen per year is translated to a daily maximum load of 31.3 kg/day of phosphorus and 236.7 kg/day of nitrogen. For Waurika Lake, the allowable average load of 28,320 kg of phosphorus and 165,300 kg of nitrogen per year is translated to a daily maximum load of 272.6 kg/day of phosphorus and 1,599 kg/day of nitrogen. For Lake Ellsworth, the allowable average load of 14,900 kg of phosphorus and 129,140 kg of nitrogen per year is translated to a daily maximum load of 151.3 kg/day of phosphorus and 1,323 kg/day of nitrogen. Reduction of TP and TN loads in lake tributaries to these levels is expected to result in achievement of WQS for chlorophyll-*a* in each lake.

Table 5-1 TMDLs for Chlorophyll-*a* Expressed in Kilograms of Total Phosphorus and Nitrogen Per Day

Waterbody Name	Waterbody ID	Nutrient	TMDL	WLA	LA	MOS
Lake Lawtonka	OK311300040070_00	Total Phosphorus	31.3	0	31.3	Implicit
		Total Nitrogen	236.7	0	236.7	Implicit
Waurika Lake	OK311210000020_00	Total Phosphorus	272.6	0	272.6	Implicit
		Total Nitrogen	1,599	0	1,599	Implicit
Lake Ellsworth	OK311300030020_00	Total Phosphorus	151.3	0	136.2	15.1
		Total Nitrogen	1,323	0	1,191	132

5.6 TMDL Implementation

DEQ will collaborate with a host of other State agencies and local governments working within the boundaries of State and local regulations to target available funding and technical assistance to support implementation of pollution controls and management measures. Various water quality management programs and funding sources will be utilized so that the pollutant reductions as required by these TMDLs can be achieved and water quality can be restored to maintain designated uses. DEQ's Continuing Planning Process (CPP), required by the CWA §303(e)(3) and 40 CFR 130.5, summarizes Oklahoma's commitments and programs aimed at restoring and protecting water quality throughout the State (DEQ 2012). The CPP can be viewed from DEQ's website at:
http://www.deq.state.ok.us/wqdnew/305b_303d/Final%20CPP.pdf.

Table 5-2 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 5-2 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

5.6.1 Point Sources

As authorized by Section 402 of the CWA, 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 and gas industry (retained by Oklahoma Corporation Commission), for which 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.

5.6.2 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 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 in nutrient loading called for in this TMDL report are as high as 55%. DEQ recognizes that achieving such high reductions will be a challenge, especially since unregulated nonpoint sources are a major cause of nutrient loading.

SECTION 6
PUBLIC PARTICIPATION

The draft *Chlorophyll-a TMDLs for Lakes Lawtonka, Waurika, and Ellsworth* TMDL report was preliminarily reviewed by EPA before being sent out for public notice. After EPA's review of this draft, DEQ was given approval to submit this Report for Public Notice. A public notice and draft 208 Factsheet was sent to local newspapers, to stakeholders in the Study Area affected by these draft TMDLs, and to stakeholders who have requested all copies of TMDL public notices. The public notice, draft 208 Factsheet, and draft TMDL report was also posted at the DEQ website: http://www.deq.state.ok.us/wqdnew/index.htm.

The public comment period lasted 45 days and was open from July 5, 2013 to August 19, 2013. One set of comments representing two agencies was received. The responses to those comments are in Appendix D. There were no requests for a public meeting.

After EPA's final approval, the 208 Factsheet and 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 in-stream criterion is predicted to be met.

SECTION 7
REFERENCES

Carlson, R.E. 1977. A Trophic State Index for Lakes. *Limnology and Oceanography*. 22:361-369.

Chrzanowski, T.H. and J.P. Grover. 2001. Effects of Mineral Nutrients on the Growth of Bacteria and Phytoplankton in Two Southern Reservoirs. *Limnology and Oceanography* 46(6): 1319-1330.

DEQ 2010. *Water Quality in Oklahoma, 2010 Integrated Report*. 2010. http://www.deq.state.ok.us/wqdnew/305b_303d/2010/2010%20Oklahoma%20Integrated%20Report_complete.pdf

DEQ 2012. The State of Oklahoma 2012 Continuing Planning Process. http://www.deq.state.ok.us/wqdnew/305b_303d/Final%20CPP.pdf.

DEQ 2012. DEQ ArcGIS Flexviewer. http://gis.deq.ok.gov/flexviewer/.

Dodds, W. K. and J.C. Priscu. 1990. A comparison of methods for assessment of nutrient deficiency of phytoplankton in a large oligotrophic lake. *Can. J. Fish. Aquat. Sci*., 4, 2328–2338.

Driver, N.E., and G.D. Tasker. 1988. Techniques for estimation of storm-runoff loads, volumes, and selected constituent concentrations in urban watersheds in the United States. U.S. Department of the Interior, U.S. Geological Survey: Open File Reports 88-191.

Dzialowski, A.R., S-H Wang, N-C Lim, W.W. Spotts, and D.G. Huggins. 2005. Nutrient Limitation of Phytoplankton Growth in Central Plains Reservoirs, USA. *J. Plankton Res*. 27(60: 587-595.

Elser, J.J., E.R. Marzolf, and C.R. Goldman. 1990. Phosphorus and nitrogen limitation of phytoplankton growth in the freshwaters of North America: a review and critique of experimental enrichment. *Can. J. Fish. Aquat. Sci*., 47, 1468–1477.

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

EPA 1991a. Technical Support Document for Water Quality-Based Toxics Control. Office of Water, EPA 505/2-90-001.EPA 2003. Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the Clean Water Act, TMDL -01-03 - Diane Regas-- July 21, 2003.

EPA 2009. Soil and Water Assessment Tool 2005, part of BASINS 4.0 (Better Assessment Science Integrating point & Non-point Sources). http://water.epa.gov/scitech/datait/models/basins/index.cfm

Kimmel, B.L., O.T. Lind, and L.J. Paulson. 1990. Reservoir Primary Production. In Reservoir Limnology: Ecological Perspectives. Thornton, K.W., B.L. Kimmel, and F.E. Payne, eds. Wiley-Interscience: New York, NY.

Neitsch, S.L., J.G. Arnold, J.R. Kiniry, and J.R. Williams. 2009. Soil and Water Assessment Tool Theoretical Documentation, Version 2005. Temple, TX: USDA-ARS Grassland, Soil and Water Research Laboratory. Available at http://swatmodel.tamu.edu/media/1292/SWAT2005theory.pdf Accessed June 28, 2010.

National Water Quality Monitoring Council; 2012. Water Quality Portal of the USGS, EPA, and National Water Quality Monitoring Council. http://www.waterqualitydata.us.

NRCS 2012. STATSGO database access. http://soildatamart.nrcs.usda.gov/.

NRCS 2012. U.S. General Soil Map and STATSGO database description. http://soils.usda.gov/survey/geography/statsgo/description.html.

National Cooperative Soil Survey; 2012. National Cooperative Soil Characterization Database. http://ncsslabdatamart.sc.egov.usda.gov/.

Oklahoma Conservation Commission 2012. http://www.ok.gov/conservation/Agency_Divisions/Water_Quality_Division/WQ_Monitoring/WQ_Assessment_Rotating_Basin_Monitoring_Program.html.

Oklahoma Department of Agriculture, Food and Forestry 2005. CAFO Program. http://www.oda.state.ok.us/aems/cafo.htm.

Oklahoma Department of Commerce, 2010. Policy, Research, and Economic Analysis Division: http://okcommerce.gov/data-and-research/demographics-and-population-data/

Oklahoma Mesonet; 2012. Oklahoma Mesonet Meteorological Data. http://www.mesonet.org/.

OWRB 2007. Oklahoma Water Resources Board. 2007 Report of the Oklahoma Beneficial Use Monitoring Program. Lakes Report. Available at http://www.owrb.ok.gov/quality/monitoring/bump.php

OWRB 2009. Oklahoma Water Resources Board. 2008-2009 Oklahoma Lakes Report. Beneficial Use Monitoring Program. Available at http://www.owrb.ok.gov/quality/monitoring/bump.php

OWRB 2011. Oklahoma Water Resources Board. Title 785, Chapter 45, *Oklahoma's Water Quality Standards*. July 1, 2011. http://www.owrb.ok.gov/util/rules/pdf_rul/RulesCurrent2011/Ch45-Current2011.pdf

OWRB 2011a. Oklahoma Water Resources Board. 2010-2011 Oklahoma Lakes Report. Beneficial Use Monitoring Program. Available at http://www.owrb.ok.gov/quality/monitoring/bump.php.

OWRB 2011b. Oklahoma Water Resources Board. Title 785, Chapter 46, *Implementation of Oklahoma's Water Quality Standards.* July 1, 2011. http://www.owrb.ok.gov/util/rules/pdf_rul/RulesCurrent2011/Ch46Current2011.pdf

OWRB; 2012. Oklahoma Water Resources Board Water Quality Monitoring Sites. http://www.owrb.ok.gov/maps/pmg/owrbdata_SW.html.

Parsons 2010. *Technical Methods Summary for Watershed and Water Quality Modeling of Sensitive Water Supply Lakes in Oklahoma.* November 2010.

Pitt, R. Maestro, A. and R. Morquecho, 2008. National Stormwater Quality Database, Version 3. http://unix.eng.ua.edu/~rpitt/Research/ms4; Table NSQD v3 Feb 03, 2008

PRISM Climate Group; 2012. Precipitation Averages 1981-2010. http://prism.oregonstate.edu/products/viewer.phtml?file=/pub/prism/us_30s/grids/ppt/Normals/us_ppt_1981_2010.14.gz&year=1981_2010&vartype=ppt&month=14&status=final.

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

Smith, V.H. 2003. Eutrophication of freshwater and coastal marine ecosystems: a global problem. *Environ. Sci. Pollut. Res. Int.*, 10,126–139.

Smith, V.H., J. Sieber-Denlinger, F. deNoyelles. 2002. Managing taste and odor problems in a eutrophic drinking water reservoir. *J. Lake Reserv. Manage.*, 18, 319–323.

Storm, D.E., D. Gade, R. Tejral, M.D. Smolen, P. Kenkel, and M.S. Gregory. 2000. Estimating Watershed Level Nonpoint Source Loading for the State of Oklahoma. Final Report. Accessed at http://storm.okstate.edu/reports/vol_1&2_draft_okstate_nonpoint_loading_final_report_rev_4_pdf.zip

University of Oklahoma Center for Spatial Analysis; 2007. Roads of Oklahoma. http://geo.ou.edu/oeb/Statewide/R2000.txt.

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

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

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

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

USDA 2007. Census of Agriculture, National Agricultural Statistics Service, United States Department of Agriculture. http://www.nass.usda.gov/Census/Create_Census_US_CNTY.jsp

USDA-NRCS (U.S. Department of Agriculture - Natural Resources Conservation Service); 1986. Technical Release 55 – Urban Hydrology for Small Watersheds. Second Edition. 210-VI-TR-55. Washington, DC. June 1986.

U.S. Army Corps of Engineers 2004. FLUX, PROFILE and BATHTUB: Simplified Procedures for Eutrophication Assessment and Prediction. http://el.erdc.usace.army.mil/elmodels/emiinfo.html.

USDA 2008. USDA National Agricultural Statistics Service (NASS) 2008 Cropland Data Layer (CDL). Available at (http://www.nass.usda.gov/research/Cropland/SARS1a.htm). Accessed April 2011.

USGS; 2012. USGS National Land Cover Dataset. http://www.mrlc.gov/index.asp.

USGS; 2012. USGS Daily Streamflow Data. http://waterdata.usgs.gov/ok/nwis/rt.

USGS. 2012. USGS National Elevation Dataset. http://ned.usgs.gov/

USGS; 2012. USGS National Water Information System. http://waterdata.usgs.gov/ok/nwis/nwis.

USGS; 2012. The National Map Viewer, version 2.0: http://viewer.nationalmap.gov/viewer/.

USGS, 2013. National Hydrography Dataset : http://nhd.usgs.gov/data.html.

Walker, W.W. 1986. Empirical Methods for Predicting Eutrophication in Impoundments; Report 3, Phase III: Applications Manual. Technical Report E-81-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

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

APPENDIX A

STATE OF OKLAHOMA ANTIDEGRADATION POLICY

Appendix A
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 Sensitive Public and Private Water Supplies (SWS). It is recognized that certain public and private water supplies possess conditions that make them more susceptible to pollution events and require additional protection. These sensitive water supplies shall be maintained and protected.

(d) 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.

(e) 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 B

AMBIENT WATER QUALITY DATA

CHLOROPHYLL-*a* DATA — 2002 TO 2011

PHOSPHORUS AND NITROGEN DATA – 1998 TO 2011

SECHI DEPTH AND TURBIDITY DATA – 2001 TO 2011

TOTAL SUSPENDED SOLIDS DATA — 1998 TO 2000

Appendix B, Table-1: Ambient Water Quality Data for Lake Lawtonka, 1998-2011

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-01B	8/12/2002	Corrected Chlorophyll-a	17.85	mg/m3
311300040070-01B	4/14/2004	Corrected Chlorophyll-a	14.1	mg/m3
311300040070-01B	7/14/2004	Corrected Chlorophyll-a	18.3	mg/m3
311300040070-01B	10/24/2006	Corrected Chlorophyll-a	27.5	mg/m3
311300040070-01B	1/29/2007	Corrected Chlorophyll-a	14.9	mg/m3
311300040070-01B	4/30/2007	Corrected Chlorophyll-a	16.1	mg/m3
311300040070-01B	7/25/2007	Corrected Chlorophyll-a	14.53	mg/m3
311300040070-01S	8/12/2002	Corrected Chlorophyll-a	14.55	mg/m3
311300040070-01S	8/12/2002	Corrected Chlorophyll-a	16.8	mg/m3
311300040070-01S	10/22/2003	Corrected Chlorophyll-a	17.7	mg/m3
311300040070-01S	10/22/2003	Corrected Chlorophyll-a	19.9	mg/m3
311300040070-01S	1/14/2004	Corrected Chlorophyll-a	19.8	mg/m3
311300040070-01S	1/14/2004	Corrected Chlorophyll-a	23.6	mg/m3
311300040070-01S	1/14/2004	Corrected Chlorophyll-a	21.3	mg/m3
311300040070-01S	4/14/2004	Corrected Chlorophyll-a	14.6	mg/m3
311300040070-01S	4/14/2004	Corrected Chlorophyll-a	6.3	mg/m3
311300040070-01S	7/14/2004	Corrected Chlorophyll-a	18.9	mg/m3
311300040070-01S	7/14/2004	Corrected Chlorophyll-a	21.1	mg/m3
311300040070-01S	8/12/2004	Corrected Chlorophyll-a	22.9	mg/m3
311300040070-01S	10/24/2006	Corrected Chlorophyll-a	23	mg/m3
311300040070-01S	10/24/2006	Corrected Chlorophyll-a	27.1	mg/m3
311300040070-01S	1/29/2007	Corrected Chlorophyll-a	14.5	mg/m3
311300040070-01S	1/30/2007	Corrected Chlorophyll-a	14.7	mg/m3
311300040070-01S	4/30/2007	Corrected Chlorophyll-a	14.6	mg/m3
311300040070-01S	4/30/2007	Corrected Chlorophyll-a	13.4	mg/m3
311300040070-01S	7/25/2007	Corrected Chlorophyll-a	14.13	mg/m3
311300040070-01S	7/25/2007	Corrected Chlorophyll-a	14.88	mg/m3
311300040070-02	8/12/2002	Corrected Chlorophyll-a	22	mg/m3
311300040070-02	10/22/2003	Corrected Chlorophyll-a	23	mg/m3
311300040070-02	1/14/2004	Corrected Chlorophyll-a	18.8	mg/m3
311300040070-02	4/14/2004	Corrected Chlorophyll-a	12.3	mg/m3
311300040070-02	7/14/2004	Corrected Chlorophyll-a	19	mg/m3
311300040070-02	8/12/2004	Corrected Chlorophyll-a	25.5	mg/m3
311300040070-02	10/24/2006	Corrected Chlorophyll-a	27.2	mg/m3
311300040070-02	1/29/2007	Corrected Chlorophyll-a	14.4	mg/m3
311300040070-02	4/30/2007	Corrected Chlorophyll-a	21	mg/m3
311300040070-02	7/25/2007	Corrected Chlorophyll-a	18.99	mg/m3
311300040070-02	12/6/2010	Corrected Chlorophyll-a	16.6	mg/m3
311300040070-02	2/15/2011	Corrected Chlorophyll-a	3.63	mg/m3

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-02	5/10/2011	Corrected Chlorophyll-a	6.74	mg/m3
311300040070-02	8/1/2011	Corrected Chlorophyll-a	32.6	mg/m3
311300040070-03	8/12/2002	Corrected Chlorophyll-a	20.24	mg/m3
311300040070-03	10/22/2003	Corrected Chlorophyll-a	19.2	mg/m3
311300040070-03	1/14/2004	Corrected Chlorophyll-a	17.2	mg/m3
311300040070-03	4/14/2004	Corrected Chlorophyll-a	11.1	mg/m3
311300040070-03	7/14/2004	Corrected Chlorophyll-a	17.4	mg/m3
311300040070-03	10/24/2006	Corrected Chlorophyll-a	26.9	mg/m3
311300040070-03	1/29/2007	Corrected Chlorophyll-a	13.9	mg/m3
311300040070-03	7/25/2007	Corrected Chlorophyll-a	17.25	mg/m3
311300040070-03	12/6/2010	Corrected Chlorophyll-a	15.6	mg/m3
311300040070-03	2/15/2011	Corrected Chlorophyll-a	3.76	mg/m3
311300040070-03	5/10/2011	Corrected Chlorophyll-a	5.79	mg/m3
311300040070-03	8/1/2011	Corrected Chlorophyll-a	23.1	mg/m3
311300040070-04	8/12/2002	Corrected Chlorophyll-a	20.32	mg/m3
311300040070-04	10/22/2003	Corrected Chlorophyll-a	11.2	mg/m3
311300040070-04	1/14/2004	Corrected Chlorophyll-a	12	mg/m3
311300040070-04	4/14/2004	Corrected Chlorophyll-a	12.6	mg/m3
311300040070-04	7/14/2004	Corrected Chlorophyll-a	12.9	mg/m3
311300040070-04	10/24/2006	Corrected Chlorophyll-a	23.2	mg/m3
311300040070-04	1/30/2007	Corrected Chlorophyll-a	13.6	mg/m3
311300040070-04	4/30/2007	Corrected Chlorophyll-a	18.5	mg/m3
311300040070-04	7/25/2007	Corrected Chlorophyll-a	19.8	mg/m3
311300040070-04	12/6/2010	Corrected Chlorophyll-a	11.6	mg/m3
311300040070-04	2/15/2011	Corrected Chlorophyll-a	2.89	mg/m3
311300040070-04	5/10/2011	Corrected Chlorophyll-a	7.53	mg/m3
311300040070-04	8/1/2011	Corrected Chlorophyll-a	16.8	mg/m3
311300040070-05	8/12/2002	Corrected Chlorophyll-a	19.44	mg/m3
311300040070-05	10/22/2003	Corrected Chlorophyll-a	13.9	mg/m3
311300040070-05	1/14/2004	Corrected Chlorophyll-a	16.1	mg/m3
311300040070-05	4/14/2004	Corrected Chlorophyll-a	11.5	mg/m3
311300040070-05	7/14/2004	Corrected Chlorophyll-a	16.2	mg/m3
311300040070-05	8/12/2004	Corrected Chlorophyll-a	21.5	mg/m3
311300040070-05	10/24/2006	Corrected Chlorophyll-a	40.7	mg/m3
311300040070-05	1/30/2007	Corrected Chlorophyll-a	13.9	mg/m3
311300040070-05	4/30/2007	Corrected Chlorophyll-a	23.9	mg/m3
311300040070-05	4/30/2007	Corrected Chlorophyll-a	27	mg/m3
311300040070-05	7/25/2007	Corrected Chlorophyll-a	22.25	mg/m3
311300040070-01B	4/15/1998	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01B	7/8/1998	Nitrogen, Ammonia	0.18	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-01B	1/6/1999	Nitrogen, Ammonia	0.1	mg/L
311300040070-01B	4/12/1999	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01B	7/7/1999	Nitrogen, Ammonia	0.27	mg/L
311300040070-01B	2/11/2002	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01B	5/13/2002	Nitrogen, Ammonia	0.08	mg/L
311300040070-01B	8/12/2002	Nitrogen, Ammonia	1.02	mg/L
311300040070-01B	10/22/2003	Nitrogen, Ammonia	0.09	mg/L
311300040070-01B	1/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01B	4/14/2004	Nitrogen, Ammonia	0.15	mg/L
311300040070-01B	7/14/2004	Nitrogen, Ammonia	0.29	mg/L
311300040070-01S	4/15/1998	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	4/15/1998	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	7/8/1998	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	7/8/1998	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	7/8/1998	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	1/6/1999	Nitrogen, Ammonia	0.07	mg/L
311300040070-01S	1/6/1999	Nitrogen, Ammonia	0.05	mg/L
311300040070-01S	4/12/1999	Nitrogen, Ammonia	0.1	mg/L
311300040070-01S	4/12/1999	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	4/29/1999	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	4/29/1999	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	7/7/1999	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	7/7/1999	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	7/7/1999	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	11/7/2001	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	2/11/2002	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	2/11/2002	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	5/13/2002	Nitrogen, Ammonia	0.08	mg/L
311300040070-01S	5/13/2002	Nitrogen, Ammonia	0.08	mg/L
311300040070-01S	8/12/2002	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	10/22/2003	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	10/22/2003	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	1/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	1/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	4/14/2004	Nitrogen, Ammonia	0.08	mg/L
311300040070-01S	4/14/2004	Nitrogen, Ammonia	0.08	mg/L
311300040070-01S	7/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300040070-01S	7/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300040070-02	4/15/1998	Nitrogen, Ammonia	0.06	mg/L
311300040070-02	4/15/1998	Nitrogen, Ammonia	0.05	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-02	7/8/1998	Nitrogen, Ammonia	<0.05	mg/L
311300040070-02	1/6/1999	Nitrogen, Ammonia	0.23	mg/L
311300040070-02	4/29/1999	Nitrogen, Ammonia	<0.05	mg/L
311300040070-02	7/7/1999	Nitrogen, Ammonia	<0.05	mg/L
311300040070-02	11/7/2001	Nitrogen, Ammonia	<0.05	mg/L
311300040070-02	2/11/2002	Nitrogen, Ammonia	<0.05	mg/L
311300040070-02	5/13/2002	Nitrogen, Ammonia	0.07	mg/L
311300040070-02	8/12/2002	Nitrogen, Ammonia	<0.05	mg/L
311300040070-02	10/22/2003	Nitrogen, Ammonia	<0.05	mg/L
311300040070-02	1/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300040070-02	4/14/2004	Nitrogen, Ammonia	0.08	mg/L
311300040070-02	7/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300040070-03	4/15/1998	Nitrogen, Ammonia	<0.05	mg/L
311300040070-03	4/15/1998	Nitrogen, Ammonia	<0.05	mg/L
311300040070-03	7/8/1998	Nitrogen, Ammonia	<0.05	mg/L
311300040070-03	1/6/1999	Nitrogen, Ammonia	<0.05	mg/L
311300040070-03	4/29/1999	Nitrogen, Ammonia	<0.05	mg/L
311300040070-03	7/7/1999	Nitrogen, Ammonia	<0.05	mg/L
311300040070-03	11/7/2001	Nitrogen, Ammonia	<0.05	mg/L
311300040070-03	2/11/2002	Nitrogen, Ammonia	<0.05	mg/L
311300040070-03	5/13/2002	Nitrogen, Ammonia	0.07	mg/L
311300040070-03	8/12/2002	Nitrogen, Ammonia	<0.05	mg/L
311300040070-03	10/22/2003	Nitrogen, Ammonia	<0.05	mg/L
311300040070-03	1/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300040070-03	4/14/2004	Nitrogen, Ammonia	0.08	mg/L
311300040070-03	7/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300040070-04	4/15/1998	Nitrogen, Ammonia	<0.05	mg/L
311300040070-04	7/8/1998	Nitrogen, Ammonia	<0.05	mg/L
311300040070-04	1/6/1999	Nitrogen, Ammonia	0.1	mg/L
311300040070-04	4/29/1999	Nitrogen, Ammonia	<0.05	mg/L
311300040070-04	7/7/1999	Nitrogen, Ammonia	<0.05	mg/L
311300040070-04	11/7/2001	Nitrogen, Ammonia	<0.05	mg/L
311300040070-04	2/11/2002	Nitrogen, Ammonia	<0.05	mg/L
311300040070-04	5/13/2002	Nitrogen, Ammonia	0.06	mg/L
311300040070-04	8/12/2002	Nitrogen, Ammonia	<0.05	mg/L
311300040070-04	10/22/2003	Nitrogen, Ammonia	<0.05	mg/L
311300040070-04	1/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300040070-04	4/14/2004	Nitrogen, Ammonia	0.06	mg/L
311300040070-04	7/14/2004	Nitrogen, Ammonia	0.05	mg/L
311300040070-05	11/7/2001	Nitrogen, Ammonia	<0.05	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-05	2/11/2002	Nitrogen, Ammonia	<0.05	mg/L
311300040070-05	5/13/2002	Nitrogen, Ammonia	0.07	mg/L
311300040070-05	8/12/2002	Nitrogen, Ammonia	0.05	mg/L
311300040070-05	10/22/2003	Nitrogen, Ammonia	<0.05	mg/L
311300040070-05	1/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300040070-05	4/14/2004	Nitrogen, Ammonia	0.07	mg/L
311300040070-05	7/14/2004	Nitrogen, Ammonia	0.05	mg/L
311300040070-01B	4/15/1998	Nitrogen, Kjeldahl	0.11	mg/L
311300040070-01B	7/8/1998	Nitrogen, Kjeldahl	0.65	mg/L
311300040070-01B	1/6/1999	Nitrogen, Kjeldahl	0.29	mg/L
311300040070-01B	4/12/1999	Nitrogen, Kjeldahl	0.32	mg/L
311300040070-01B	7/7/1999	Nitrogen, Kjeldahl	0.59	mg/L
311300040070-01B	2/11/2002	Nitrogen, Kjeldahl	0.34	mg/L
311300040070-01B	5/13/2002	Nitrogen, Kjeldahl	0.69	mg/L
311300040070-01B	8/12/2002	Nitrogen, Kjeldahl	1.52	mg/L
311300040070-01B	10/22/2003	Nitrogen, Kjeldahl	0.72	mg/L
311300040070-01B	1/14/2004	Nitrogen, Kjeldahl	0.61	mg/L
311300040070-01B	4/14/2004	Nitrogen, Kjeldahl	0.33	mg/L
311300040070-01B	7/14/2004	Nitrogen, Kjeldahl	0.74	mg/L
311300040070-01S	4/15/1998	Nitrogen, Kjeldahl	0.06	mg/L
311300040070-01S	4/15/1998	Nitrogen, Kjeldahl	0.67	mg/L
311300040070-01S	7/8/1998	Nitrogen, Kjeldahl	0.31	mg/L
311300040070-01S	7/8/1998	Nitrogen, Kjeldahl	0.37	mg/L
311300040070-01S	1/6/1999	Nitrogen, Kjeldahl	0.67	mg/L
311300040070-01S	1/6/1999	Nitrogen, Kjeldahl	0.34	mg/L
311300040070-01S	4/12/1999	Nitrogen, Kjeldahl	0.35	mg/L
311300040070-01S	4/12/1999	Nitrogen, Kjeldahl	0.25	mg/L
311300040070-01S	4/29/1999	Nitrogen, Kjeldahl	<0.05	mg/L
311300040070-01S	4/29/1999	Nitrogen, Kjeldahl	<0.05	mg/L
311300040070-01S	7/7/1999	Nitrogen, Kjeldahl	0.49	mg/L
311300040070-01S	7/7/1999	Nitrogen, Kjeldahl	0.56	mg/L
311300040070-01S	7/7/1999	Nitrogen, Kjeldahl	0.56	mg/L
311300040070-01S	11/7/2001	Nitrogen, Kjeldahl	0.39	mg/L
311300040070-01S	2/11/2002	Nitrogen, Kjeldahl	0.44	mg/L
311300040070-01S	2/11/2002	Nitrogen, Kjeldahl	0.42	mg/L
311300040070-01S	5/13/2002	Nitrogen, Kjeldahl	0.44	mg/L
311300040070-01S	5/13/2002	Nitrogen, Kjeldahl	0.51	mg/L
311300040070-01S	8/12/2002	Nitrogen, Kjeldahl	0.52	mg/L
311300040070-01S	10/22/2003	Nitrogen, Kjeldahl	0.72	mg/L
311300040070-01S	10/22/2003	Nitrogen, Kjeldahl	0.53	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-01S	1/14/2004	Nitrogen, Kjeldahl	0.54	mg/L
311300040070-01S	1/14/2004	Nitrogen, Kjeldahl	0.79	mg/L
311300040070-01S	4/14/2004	Nitrogen, Kjeldahl	1.19	mg/L
311300040070-01S	4/14/2004	Nitrogen, Kjeldahl	0.25	mg/L
311300040070-01S	7/14/2004	Nitrogen, Kjeldahl	0.58	mg/L
311300040070-01S	7/14/2004	Nitrogen, Kjeldahl	0.63	mg/L
311300040070-01S	10/25/2006	Nitrogen, Kjeldahl	0.76	mg/L
311300040070-01S	10/25/2006	Nitrogen, Kjeldahl	0.72	mg/L
311300040070-01S	1/30/2007	Nitrogen, Kjeldahl	0.61	mg/L
311300040070-01S	1/30/2007	Nitrogen, Kjeldahl	0.61	mg/L
311300040070-01S	7/25/2007	Nitrogen, Kjeldahl	1.3	mg/L
311300040070-01S	7/25/2007	Nitrogen, Kjeldahl	0.51	mg/L
311300040070-02	4/15/1998	Nitrogen, Kjeldahl	0.06	mg/L
311300040070-02	4/15/1998	Nitrogen, Kjeldahl	0.22	mg/L
311300040070-02	7/8/1998	Nitrogen, Kjeldahl	0.41	mg/L
311300040070-02	1/6/1999	Nitrogen, Kjeldahl	0.28	mg/L
311300040070-02	4/29/1999	Nitrogen, Kjeldahl	<0.05	mg/L
311300040070-02	7/7/1999	Nitrogen, Kjeldahl	0.45	mg/L
311300040070-02	11/7/2001	Nitrogen, Kjeldahl	0.27	mg/L
311300040070-02	2/11/2002	Nitrogen, Kjeldahl	0.42	mg/L
311300040070-02	5/13/2002	Nitrogen, Kjeldahl	0.3	mg/L
311300040070-02	8/12/2002	Nitrogen, Kjeldahl	0.57	mg/L
311300040070-02	10/22/2003	Nitrogen, Kjeldahl	0.87	mg/L
311300040070-02	1/14/2004	Nitrogen, Kjeldahl	0.72	mg/L
311300040070-02	4/14/2004	Nitrogen, Kjeldahl	0.31	mg/L
311300040070-02	7/14/2004	Nitrogen, Kjeldahl	0.54	mg/L
311300040070-02	10/25/2006	Nitrogen, Kjeldahl	0.69	mg/L
311300040070-02	1/30/2007	Nitrogen, Kjeldahl	0.58	mg/L
311300040070-02	4/30/2007	Nitrogen, Kjeldahl	0.66	mg/L
311300040070-02	7/25/2007	Nitrogen, Kjeldahl	0.65	mg/L
311300040070-02	12/6/2010	Nitrogen, Kjeldahl	0.57	mg/L
311300040070-02	2/15/2011	Nitrogen, Kjeldahl	0.3	mg/L
311300040070-02	5/10/2011	Nitrogen, Kjeldahl	0.35	mg/L
311300040070-03	4/15/1998	Nitrogen, Kjeldahl	0.34	mg/L
311300040070-03	4/15/1998	Nitrogen, Kjeldahl	0.25	mg/L
311300040070-03	7/8/1998	Nitrogen, Kjeldahl	0.32	mg/L
311300040070-03	1/6/1999	Nitrogen, Kjeldahl	0.24	mg/L
311300040070-03	4/29/1999	Nitrogen, Kjeldahl	<0.05	mg/L
311300040070-03	7/7/1999	Nitrogen, Kjeldahl	0.41	mg/L
311300040070-03	11/7/2001	Nitrogen, Kjeldahl	0.2	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-03	2/11/2002	Nitrogen, Kjeldahl	0.48	mg/L
311300040070-03	5/13/2002	Nitrogen, Kjeldahl	0.37	mg/L
311300040070-03	8/12/2002	Nitrogen, Kjeldahl	0.5	mg/L
311300040070-03	10/22/2003	Nitrogen, Kjeldahl	0.69	mg/L
311300040070-03	1/14/2004	Nitrogen, Kjeldahl	0.67	mg/L
311300040070-03	4/14/2004	Nitrogen, Kjeldahl	0.46	mg/L
311300040070-03	7/14/2004	Nitrogen, Kjeldahl	0.66	mg/L
311300040070-03	10/25/2006	Nitrogen, Kjeldahl	0.75	mg/L
311300040070-03	1/30/2007	Nitrogen, Kjeldahl	0.56	mg/L
311300040070-03	4/30/2007	Nitrogen, Kjeldahl	0.8	mg/L
311300040070-03	7/25/2007	Nitrogen, Kjeldahl	0.81	mg/L
311300040070-03	12/6/2010	Nitrogen, Kjeldahl	0.58	mg/L
311300040070-03	2/15/2011	Nitrogen, Kjeldahl	0.31	mg/L
311300040070-03	5/10/2011	Nitrogen, Kjeldahl	0.37	mg/L
311300040070-04	4/15/1998	Nitrogen, Kjeldahl	0.2	mg/L
311300040070-04	1/6/1999	Nitrogen, Kjeldahl	0.27	mg/L
311300040070-04	4/29/1999	Nitrogen, Kjeldahl	<0.05	mg/L
311300040070-04	7/7/1999	Nitrogen, Kjeldahl	0.43	mg/L
311300040070-04	11/7/2001	Nitrogen, Kjeldahl	0.21	mg/L
311300040070-04	2/11/2002	Nitrogen, Kjeldahl	0.46	mg/L
311300040070-04	5/13/2002	Nitrogen, Kjeldahl	0.39	mg/L
311300040070-04	8/12/2002	Nitrogen, Kjeldahl	0.46	mg/L
311300040070-04	10/22/2003	Nitrogen, Kjeldahl	0.72	mg/L
311300040070-04	1/14/2004	Nitrogen, Kjeldahl	0.6	mg/L
311300040070-04	4/14/2004	Nitrogen, Kjeldahl	0.57	mg/L
311300040070-04	7/14/2004	Nitrogen, Kjeldahl	0.57	mg/L
311300040070-04	10/25/2006	Nitrogen, Kjeldahl	0.81	mg/L
311300040070-04	1/30/2007	Nitrogen, Kjeldahl	0.57	mg/L
311300040070-04	4/30/2007	Nitrogen, Kjeldahl	0.7	mg/L
311300040070-04	7/25/2007	Nitrogen, Kjeldahl	0.74	mg/L
311300040070-04	12/6/2010	Nitrogen, Kjeldahl	0.77	mg/L
311300040070-04	2/15/2011	Nitrogen, Kjeldahl	0.25	mg/L
311300040070-04	5/10/2011	Nitrogen, Kjeldahl	0.44	mg/L
311300040070-05	11/7/2001	Nitrogen, Kjeldahl	0.19	mg/L
311300040070-05	2/11/2002	Nitrogen, Kjeldahl	0.4	mg/L
311300040070-05	5/13/2002	Nitrogen, Kjeldahl	0.41	mg/L
311300040070-05	8/12/2002	Nitrogen, Kjeldahl	0.51	mg/L
311300040070-05	10/22/2003	Nitrogen, Kjeldahl	0.92	mg/L
311300040070-05	1/14/2004	Nitrogen, Kjeldahl	0.58	mg/L
311300040070-05	4/14/2004	Nitrogen, Kjeldahl	0.42	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-05	7/14/2004	Nitrogen, Kjeldahl	0.64	mg/L
311300040070-05	10/25/2006	Nitrogen, Kjeldahl	0.75	mg/L
311300040070-05	1/30/2007	Nitrogen, Kjeldahl	0.59	mg/L
311300040070-05	4/30/2007	Nitrogen, Kjeldahl	0.71	mg/L
311300040070-05	7/25/2007	Nitrogen, Kjeldahl	0.72	mg/L
311300040070-01B	4/15/1998	Nitrogen, Nitrate as N	0.25	mg/L
311300040070-01B	7/8/1998	Nitrogen, Nitrate as N	0.06	mg/L
311300040070-01B	1/6/1999	Nitrogen, Nitrate as N	0.41	mg/L
311300040070-01B	4/12/1999	Nitrogen, Nitrate as N	0.38	mg/L
311300040070-01B	7/7/1999	Nitrogen, Nitrate as N	0.1	mg/L
311300040070-01B	2/11/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01B	5/13/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01B	8/12/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01B	10/22/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01B	1/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01B	4/14/2004	Nitrogen, Nitrate as N	0.05	mg/L
311300040070-01B	7/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	4/15/1998	Nitrogen, Nitrate as N	0.23	mg/L
311300040070-01S	4/15/1998	Nitrogen, Nitrate as N	0.26	mg/L
311300040070-01S	7/8/1998	Nitrogen, Nitrate as N	0.11	mg/L
311300040070-01S	7/8/1998	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	7/8/1998	Nitrogen, Nitrate as N	<0.105	mg/L
311300040070-01S	1/6/1999	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	1/6/1999	Nitrogen, Nitrate as N	0.38	mg/L
311300040070-01S	4/12/1999	Nitrogen, Nitrate as N	0.38	mg/L
311300040070-01S	4/12/1999	Nitrogen, Nitrate as N	0.34	mg/L
311300040070-01S	4/29/1999	Nitrogen, Nitrate as N	0.35	mg/L
311300040070-01S	4/29/1999	Nitrogen, Nitrate as N	0.35	mg/L
311300040070-01S	7/7/1999	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	7/7/1999	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	7/7/1999	Nitrogen, Nitrate as N	<0.17	mg/L
311300040070-01S	11/7/2001	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	2/11/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	2/11/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	5/13/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	5/13/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	8/12/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	10/22/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	10/22/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	1/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-01S	1/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	4/14/2004	Nitrogen, Nitrate as N	0.05	mg/L
311300040070-01S	4/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	7/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	7/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-02	4/15/1998	Nitrogen, Nitrate as N	0.25	mg/L
311300040070-02	4/15/1998	Nitrogen, Nitrate as N	0.26	mg/L
311300040070-02	7/8/1998	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-02	1/6/1999	Nitrogen, Nitrate as N	0.38	mg/L
311300040070-02	4/29/1999	Nitrogen, Nitrate as N	0.33	mg/L
311300040070-02	7/7/1999	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-02	11/7/2001	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-02	2/11/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-02	5/13/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-02	8/12/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-02	10/22/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-02	1/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-02	4/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-02	7/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-03	4/15/1998	Nitrogen, Nitrate as N	0.22	mg/L
311300040070-03	4/15/1998	Nitrogen, Nitrate as N	0.23	mg/L
311300040070-03	7/8/1998	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-03	1/6/1999	Nitrogen, Nitrate as N	0.4	mg/L
311300040070-03	4/29/1999	Nitrogen, Nitrate as N	0.36	mg/L
311300040070-03	7/7/1999	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-03	11/7/2001	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-03	2/11/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-03	5/13/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-03	8/12/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-03	10/22/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-03	1/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-03	4/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-03	7/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-04	4/15/1998	Nitrogen, Nitrate as N	0.21	mg/L
311300040070-04	7/8/1998	Nitrogen, Nitrate as N	0.06	mg/L
311300040070-04	1/6/1999	Nitrogen, Nitrate as N	0.39	mg/L
311300040070-04	4/29/1999	Nitrogen, Nitrate as N	0.39	mg/L
311300040070-04	7/7/1999	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-04	11/7/2001	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-04	2/11/2002	Nitrogen, Nitrate as N	<0.05	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-04	5/13/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-04	8/12/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-04	10/22/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-04	1/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-04	4/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-04	7/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-05	11/7/2001	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-05	2/11/2002	Nitrogen, Nitrate as N	1.03	mg/L
311300040070-05	5/13/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-05	8/12/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-05	10/22/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-05	1/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-05	4/14/2004	Nitrogen, Nitrate as N	0.05	mg/L
311300040070-05	7/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300040070-01S	10/25/2006	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-01S	10/25/2006	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-01S	1/30/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-01S	1/30/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-01S	7/25/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-01S	7/25/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-02	10/25/2006	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-02	1/30/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-02	4/30/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-02	7/25/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-02	12/6/2010	Nitrogen, Nitrate/Nitrite as N	0.11	mg/L
311300040070-02	2/15/2011	Nitrogen, Nitrate/Nitrite as N	0.14	mg/L
311300040070-02	5/10/2011	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-03	10/25/2006	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-03	1/30/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-03	4/30/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-03	7/25/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-03	12/6/2010	Nitrogen, Nitrate/Nitrite as N	0.11	mg/L
311300040070-03	2/15/2011	Nitrogen, Nitrate/Nitrite as N	0.14	mg/L
311300040070-03	5/10/2011	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-04	10/25/2006	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-04	1/30/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-04	4/30/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-04	7/25/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-04	12/6/2010	Nitrogen, Nitrate/Nitrite as N	0.11	mg/L
311300040070-04	2/15/2011	Nitrogen, Nitrate/Nitrite as N	0.1	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-04	5/10/2011	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-05	10/25/2006	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-05	1/30/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-05	4/30/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-05	7/25/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300040070-01B	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01B	7/8/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01B	1/6/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01B	4/12/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01B	7/7/1999	Nitrogen, Nitrite as N	0.05	mg/L
311300040070-01B	2/11/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01B	5/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01B	8/12/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01B	10/22/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01B	1/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01B	4/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01B	7/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	7/8/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	7/8/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	7/8/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	1/6/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	1/6/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	4/12/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	4/12/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	4/29/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	4/29/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	7/7/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	7/7/1999	Nitrogen, Nitrite as N	0.05	mg/L
311300040070-01S	7/7/1999	Nitrogen, Nitrite as N	0.05	mg/L
311300040070-01S	11/7/2001	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	2/11/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	2/11/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	5/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	5/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	8/12/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	10/22/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	10/22/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	1/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-01S	1/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	4/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	4/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	7/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01S	7/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-02	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-02	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-02	7/8/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-02	1/6/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-02	4/29/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-02	7/7/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-02	11/7/2001	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-02	2/11/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-02	5/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-02	8/12/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-02	10/22/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-02	1/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-02	4/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-02	7/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-03	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-03	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-03	7/8/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-03	1/6/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-03	4/29/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-03	7/7/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-03	11/7/2001	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-03	2/11/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-03	5/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-03	8/12/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-03	10/22/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-03	1/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-03	4/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-03	7/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-04	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-04	7/8/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-04	1/6/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-04	4/29/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-04	7/7/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-04	11/7/2001	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-04	2/11/2002	Nitrogen, Nitrite as N	<0.05	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-04	5/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-04	8/12/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-04	10/22/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-04	1/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-04	4/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-04	7/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-05	11/7/2001	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-05	2/11/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-05	5/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-05	8/12/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-05	10/22/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-05	1/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-05	4/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-05	7/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300040070-01B	4/15/1998	Nitrogen, Organic	0.11	mg/L
311300040070-01B	7/8/1998	Nitrogen, Organic	0.47	mg/L
311300040070-01B	1/6/1999	Nitrogen, Organic	0.19	mg/L
311300040070-01B	4/12/1999	Nitrogen, Organic	0.32	mg/L
311300040070-01B	7/7/1999	Nitrogen, Organic	0.32	mg/L
311300040070-01S	4/15/1998	Nitrogen, Organic	0.06	mg/L
311300040070-01S	4/15/1998	Nitrogen, Organic	0.67	mg/L
311300040070-01S	7/8/1998	Nitrogen, Organic	0.31	mg/L
311300040070-01S	7/8/1998	Nitrogen, Organic	0.37	mg/L
311300040070-01S	1/6/1999	Nitrogen, Organic	0.6	mg/L
311300040070-01S	1/6/1999	Nitrogen, Organic	0.29	mg/L
311300040070-01S	4/12/1999	Nitrogen, Organic	0.25	mg/L
311300040070-01S	4/12/1999	Nitrogen, Organic	0.25	mg/L
311300040070-01S	4/29/1999	Nitrogen, Organic	<0.05	mg/L
311300040070-01S	4/29/1999	Nitrogen, Organic	<0.05	mg/L
311300040070-01S	7/7/1999	Nitrogen, Organic	0.49	mg/L
311300040070-01S	7/7/1999	Nitrogen, Organic	0.56	mg/L
311300040070-01S	7/7/1999	Nitrogen, Organic	0.56	mg/L
311300040070-02	4/15/1998	Nitrogen, Organic	<0.05	mg/L
311300040070-02	4/15/1998	Nitrogen, Organic	<0.22	mg/L
311300040070-02	7/8/1998	Nitrogen, Organic	0.41	mg/L
311300040070-02	1/6/1999	Nitrogen, Organic	0.05	mg/L
311300040070-02	4/29/1999	Nitrogen, Organic	<0.05	mg/L
311300040070-02	7/7/1999	Nitrogen, Organic	0.45	mg/L
311300040070-03	4/15/1998	Nitrogen, Organic	0.34	mg/L
311300040070-03	4/15/1998	Nitrogen, Organic	0.25	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-03	7/8/1998	Nitrogen, Organic	0.32	mg/L
311300040070-03	1/6/1999	Nitrogen, Organic	0.24	mg/L
311300040070-03	4/29/1999	Nitrogen, Organic	<0.05	mg/L
311300040070-03	7/7/1999	Nitrogen, Organic	0.41	mg/L
311300040070-04	4/15/1998	Nitrogen, Organic	0.2	mg/L
311300040070-04	1/6/1999	Nitrogen, Organic	0.17	mg/L
311300040070-04	4/29/1999	Nitrogen, Organic	<0.05	mg/L
311300040070-04	7/7/1999	Nitrogen, Organic	0.43	mg/L
311300040070-01B	4/15/1998	Nitrogen, Total	0.36	mg/L
311300040070-01B	7/8/1998	Nitrogen, Total	0.71	mg/L
311300040070-01B	1/6/1999	Nitrogen, Total	0.7	mg/L
311300040070-01B	4/12/1999	Nitrogen, Total	0.7	mg/L
311300040070-01B	7/7/1999	Nitrogen, Total	0.74	mg/L
311300040070-01S	4/15/1998	Nitrogen, Total	0.29	mg/L
311300040070-01S	4/15/1998	Nitrogen, Total	0.93	mg/L
311300040070-01S	7/8/1998	Nitrogen, Total	0.31	mg/L
311300040070-01S	7/8/1998	Nitrogen, Total	0.475	mg/L
311300040070-01S	1/6/1999	Nitrogen, Total	0.67	mg/L
311300040070-01S	1/6/1999	Nitrogen, Total	0.72	mg/L
311300040070-01S	4/12/1999	Nitrogen, Total	0.73	mg/L
311300040070-01S	4/12/1999	Nitrogen, Total	0.59	mg/L
311300040070-01S	4/29/1999	Nitrogen, Total	0.35	mg/L
311300040070-01S	4/29/1999	Nitrogen, Total	0.35	mg/L
311300040070-01S	7/7/1999	Nitrogen, Total	0.49	mg/L
311300040070-01S	7/7/1999	Nitrogen, Total	0.61	mg/L
311300040070-01S	7/7/1999	Nitrogen, Total	0.78	mg/L
311300040070-02	4/15/1998	Nitrogen, Total	0.31	mg/L
311300040070-02	4/15/1998	Nitrogen, Total	0.48	mg/L
311300040070-02	7/8/1998	Nitrogen, Total	0.41	mg/L
311300040070-02	1/6/1999	Nitrogen, Total	0.66	mg/L
311300040070-02	4/29/1999	Nitrogen, Total	0.33	mg/L
311300040070-02	7/7/1999	Nitrogen, Total	0.45	mg/L
311300040070-03	4/15/1998	Nitrogen, Total	0.56	mg/L
311300040070-03	4/15/1998	Nitrogen, Total	0.48	mg/L
311300040070-03	7/8/1998	Nitrogen, Total	0.32	mg/L
311300040070-03	1/6/1999	Nitrogen, Total	0.64	mg/L
311300040070-03	4/29/1999	Nitrogen, Total	0.36	mg/L
311300040070-03	7/7/1999	Nitrogen, Total	0.41	mg/L
311300040070-04	4/15/1998	Nitrogen, Total	0.41	mg/L
311300040070-04	1/6/1999	Nitrogen, Total	0.66	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-04	4/29/1999	Nitrogen, Total	0.39	mg/L
311300040070-04	7/7/1999	Nitrogen, Total	0.43	mg/L
311300040070-01B	8/12/2002	Pheophytin A	<0.1	mg/m3
311300040070-01B	4/14/2004	Pheophytin A	2.8	mg/m3
311300040070-01B	7/14/2004	Pheophytin A	1.7	mg/m3
311300040070-01B	10/24/2006	Pheophytin A	4.43	mg/m3
311300040070-01B	1/29/2007	Pheophytin A	1.43	mg/m3
311300040070-01B	4/30/2007	Pheophytin A	<0.1	mg/m3
311300040070-01B	7/25/2007	Pheophytin A	1.97	mg/m3
311300040070-01S	8/12/2002	Pheophytin A	1.45	mg/m3
311300040070-01S	8/12/2002	Pheophytin A	1.23	mg/m3
311300040070-01S	10/22/2003	Pheophytin A	2.3	mg/m3
311300040070-01S	10/22/2003	Pheophytin A	2.6	mg/m3
311300040070-01S	1/14/2004	Pheophytin A	0.9	mg/m3
311300040070-01S	1/14/2004	Pheophytin A	<0.1	mg/m3
311300040070-01S	1/14/2004	Pheophytin A	<1.2	mg/m3
311300040070-01S	4/14/2004	Pheophytin A	3.1	mg/m3
311300040070-01S	4/14/2004	Pheophytin A	1.5	mg/m3
311300040070-01S	7/14/2004	Pheophytin A	1.6	mg/m3
311300040070-01S	7/14/2004	Pheophytin A	2	mg/m3
311300040070-01S	8/12/2004	Pheophytin A	2.5	mg/m3
311300040070-01S	10/24/2006	Pheophytin A	2.16	mg/m3
311300040070-01S	10/24/2006	Pheophytin A	4.98	mg/m3
311300040070-01S	1/29/2007	Pheophytin A	1.48	mg/m3
311300040070-01S	1/30/2007	Pheophytin A	1.69	mg/m3
311300040070-01S	4/30/2007	Pheophytin A	<0.1	mg/m3
311300040070-01S	4/30/2007	Pheophytin A	0.66	mg/m3
311300040070-01S	7/25/2007	Pheophytin A	1.63	mg/m3
311300040070-01S	7/25/2007	Pheophytin A	2.38	mg/m3
311300040070-02	8/12/2002	Pheophytin A	1.1	mg/m3
311300040070-02	10/22/2003	Pheophytin A	3.1	mg/m3
311300040070-02	1/14/2004	Pheophytin A	1	mg/m3
311300040070-02	4/14/2004	Pheophytin A	5	mg/m3
311300040070-02	7/14/2004	Pheophytin A	1.7	mg/m3
311300040070-02	8/12/2004	Pheophytin A	3	mg/m3
311300040070-02	10/24/2006	Pheophytin A	5.46	mg/m3
311300040070-02	1/29/2007	Pheophytin A	1.89	mg/m3
311300040070-02	4/30/2007	Pheophytin A	0.62	mg/m3
311300040070-02	7/25/2007	Pheophytin A	2.13	mg/m3
311300040070-02	12/6/2010	Pheophytin A	2.1	mg/m3

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-02	2/15/2011	Pheophytin A	0.44	mg/m3
311300040070-02	5/10/2011	Pheophytin A	1.06	mg/m3
311300040070-02	8/1/2011	Pheophytin A	0.98	mg/m3
311300040070-03	8/12/2002	Pheophytin A	0.72	mg/m3
311300040070-03	10/22/2003	Pheophytin A	2.4	mg/m3
311300040070-03	1/14/2004	Pheophytin A	1.3	mg/m3
311300040070-03	4/14/2004	Pheophytin A	3.8	mg/m3
311300040070-03	7/14/2004	Pheophytin A	1	mg/m3
311300040070-03	10/24/2006	Pheophytin A	5.17	mg/m3
311300040070-03	1/29/2007	Pheophytin A	2.54	mg/m3
311300040070-03	7/25/2007	Pheophytin A	2.06	mg/m3
311300040070-03	12/6/2010	Pheophytin A	<0.1	mg/m3
311300040070-03	2/15/2011	Pheophytin A	0.46	mg/m3
311300040070-03	5/10/2011	Pheophytin A	1.19	mg/m3
311300040070-03	8/1/2011	Pheophytin A	0.78	mg/m3
311300040070-04	8/12/2002	Pheophytin A	2.48	mg/m3
311300040070-04	10/22/2003	Pheophytin A	2.5	mg/m3
311300040070-04	1/14/2004	Pheophytin A	1.5	mg/m3
311300040070-04	4/14/2004	Pheophytin A	2.6	mg/m3
311300040070-04	7/14/2004	Pheophytin A	<0.1	mg/m3
311300040070-04	10/24/2006	Pheophytin A	2.92	mg/m3
311300040070-04	1/30/2007	Pheophytin A	2.16	mg/m3
311300040070-04	4/30/2007	Pheophytin A	1.03	mg/m3
311300040070-04	7/25/2007	Pheophytin A	2.92	mg/m3
311300040070-04	12/6/2010	Pheophytin A	0.6	mg/m3
311300040070-04	2/15/2011	Pheophytin A	0.43	mg/m3
311300040070-04	5/10/2011	Pheophytin A	2.04	mg/m3
311300040070-04	8/1/2011	Pheophytin A	1.28	mg/m3
311300040070-01B	4/15/1998	Phosphorous, Ortho	0.015	mg/L
311300040070-01B	7/8/1998	Phosphorous, Ortho	0.072	mg/L
311300040070-01B	1/6/1999	Phosphorous, Ortho	0.023	mg/L
311300040070-01B	4/12/1999	Phosphorous, Ortho	0.028	mg/L
311300040070-01B	7/7/1999	Phosphorous, Ortho	0.049	mg/L
311300040070-01B	2/11/2002	Phosphorous, Ortho	<0.005	mg/L
311300040070-01B	5/13/2002	Phosphorous, Ortho	0.024	mg/L
311300040070-01B	8/12/2002	Phosphorous, Ortho	0.117	mg/L
311300040070-01B	10/22/2003	Phosphorous, Ortho	0.012	mg/L
311300040070-01B	1/14/2004	Phosphorous, Ortho	0.01	mg/L
311300040070-01B	4/14/2004	Phosphorous, Ortho	0.013	mg/L
311300040070-01B	7/14/2004	Phosphorous, Ortho	0.065	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-01S	4/15/1998	Phosphorous, Ortho	0.018	mg/L
311300040070-01S	4/15/1998	Phosphorous, Ortho	0.015	mg/L
311300040070-01S	7/8/1998	Phosphorous, Ortho	0.005	mg/L
311300040070-01S	7/8/1998	Phosphorous, Ortho	0.008	mg/L
311300040070-01S	7/8/1998	Phosphorous, Ortho	0.008	mg/L
311300040070-01S	1/6/1999	Phosphorous, Ortho	0.019	mg/L
311300040070-01S	1/6/1999	Phosphorous, Ortho	0.023	mg/L
311300040070-01S	4/12/1999	Phosphorous, Ortho	0.014	mg/L
311300040070-01S	4/12/1999	Phosphorous, Ortho	0.013	mg/L
311300040070-01S	4/29/1999	Phosphorous, Ortho	0.01	mg/L
311300040070-01S	4/29/1999	Phosphorous, Ortho	0.008	mg/L
311300040070-01S	7/7/1999	Phosphorous, Ortho	0.013	mg/L
311300040070-01S	7/7/1999	Phosphorous, Ortho	0.017	mg/L
311300040070-01S	7/7/1999	Phosphorous, Ortho	0.02	mg/L
311300040070-01S	11/7/2001	Phosphorous, Ortho	0.009	mg/L
311300040070-01S	2/11/2002	Phosphorous, Ortho	0.006	mg/L
311300040070-01S	2/11/2002	Phosphorous, Ortho	<0.005	mg/L
311300040070-01S	5/13/2002	Phosphorous, Ortho	0.006	mg/L
311300040070-01S	5/13/2002	Phosphorous, Ortho	0.007	mg/L
311300040070-01S	8/12/2002	Phosphorous, Ortho	<0.005	mg/L
311300040070-01S	10/22/2003	Phosphorous, Ortho	0.008	mg/L
311300040070-01S	10/22/2003	Phosphorous, Ortho	0.008	mg/L
311300040070-01S	1/14/2004	Phosphorous, Ortho	0.01	mg/L
311300040070-01S	1/14/2004	Phosphorous, Ortho	0.01	mg/L
311300040070-01S	4/14/2004	Phosphorous, Ortho	0.007	mg/L
311300040070-01S	4/14/2004	Phosphorous, Ortho	0.008	mg/L
311300040070-01S	7/14/2004	Phosphorous, Ortho	0.005	mg/L
311300040070-01S	7/14/2004	Phosphorous, Ortho	0.006	mg/L
311300040070-01S	10/25/2006	Phosphorous, Ortho	0.008	mg/L
311300040070-01S	10/25/2006	Phosphorous, Ortho	0.008	mg/L
311300040070-01S	1/30/2007	Phosphorous, Ortho	0.005	mg/L
311300040070-01S	1/30/2007	Phosphorous, Ortho	0.005	mg/L
311300040070-01S	7/25/2007	Phosphorous, Ortho	<0.005	mg/L
311300040070-01S	7/25/2007	Phosphorous, Ortho	<0.005	mg/L
311300040070-02	4/15/1998	Phosphorous, Ortho	0.013	mg/L
311300040070-02	4/15/1998	Phosphorous, Ortho	0.018	mg/L
311300040070-02	7/8/1998	Phosphorous, Ortho	0.006	mg/L
311300040070-02	1/6/1999	Phosphorous, Ortho	0.021	mg/L
311300040070-02	4/29/1999	Phosphorous, Ortho	0.006	mg/L
311300040070-02	7/7/1999	Phosphorous, Ortho	0.014	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-02	11/7/2001	Phosphorous, Ortho	0.008	mg/L
311300040070-02	2/11/2002	Phosphorous, Ortho	<0.005	mg/L
311300040070-02	5/13/2002	Phosphorous, Ortho	0.007	mg/L
311300040070-02	8/12/2002	Phosphorous, Ortho	<0.005	mg/L
311300040070-02	10/22/2003	Phosphorous, Ortho	0.009	mg/L
311300040070-02	1/14/2004	Phosphorous, Ortho	0.01	mg/L
311300040070-02	4/14/2004	Phosphorous, Ortho	0.008	mg/L
311300040070-02	7/14/2004	Phosphorous, Ortho	0.005	mg/L
311300040070-02	10/25/2006	Phosphorous, Ortho	0.007	mg/L
311300040070-02	4/30/2007	Phosphorous, Ortho	0.005	mg/L
311300040070-02	7/25/2007	Phosphorous, Ortho	<0.005	mg/L
311300040070-03	4/15/1998	Phosphorous, Ortho	0.013	mg/L
311300040070-03	4/15/1998	Phosphorous, Ortho	0.015	mg/L
311300040070-03	7/8/1998	Phosphorous, Ortho	0.011	mg/L
311300040070-03	1/6/1999	Phosphorous, Ortho	0.02	mg/L
311300040070-03	4/29/1999	Phosphorous, Ortho	0.009	mg/L
311300040070-03	7/7/1999	Phosphorous, Ortho	0.015	mg/L
311300040070-03	11/7/2001	Phosphorous, Ortho	0.006	mg/L
311300040070-03	2/11/2002	Phosphorous, Ortho	0.006	mg/L
311300040070-03	5/13/2002	Phosphorous, Ortho	0.007	mg/L
311300040070-03	8/12/2002	Phosphorous, Ortho	<0.005	mg/L
311300040070-03	10/22/2003	Phosphorous, Ortho	0.009	mg/L
311300040070-03	1/14/2004	Phosphorous, Ortho	0.01	mg/L
311300040070-03	4/14/2004	Phosphorous, Ortho	0.008	mg/L
311300040070-03	7/14/2004	Phosphorous, Ortho	0.006	mg/L
311300040070-03	10/25/2006	Phosphorous, Ortho	0.006	mg/L
311300040070-03	1/30/2007	Phosphorous, Ortho	0.005	mg/L
311300040070-03	4/30/2007	Phosphorous, Ortho	0.005	mg/L
311300040070-03	7/25/2007	Phosphorous, Ortho	<0.005	mg/L
311300040070-04	4/15/1998	Phosphorous, Ortho	0.013	mg/L
311300040070-04	7/8/1998	Phosphorous, Ortho	0.005	mg/L
311300040070-04	1/6/1999	Phosphorous, Ortho	0.018	mg/L
311300040070-04	4/29/1999	Phosphorous, Ortho	0.011	mg/L
311300040070-04	7/7/1999	Phosphorous, Ortho	0.016	mg/L
311300040070-04	11/7/2001	Phosphorous, Ortho	0.008	mg/L
311300040070-04	2/11/2002	Phosphorous, Ortho	0.007	mg/L
311300040070-04	5/13/2002	Phosphorous, Ortho	0.007	mg/L
311300040070-04	8/12/2002	Phosphorous, Ortho	0.005	mg/L
311300040070-04	10/22/2003	Phosphorous, Ortho	0.009	mg/L
311300040070-04	1/14/2004	Phosphorous, Ortho	0.012	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-04	4/14/2004	Phosphorous, Ortho	0.01	mg/L
311300040070-04	7/14/2004	Phosphorous, Ortho	0.007	mg/L
311300040070-04	10/25/2006	Phosphorous, Ortho	0.008	mg/L
311300040070-04	1/30/2007	Phosphorous, Ortho	0.005	mg/L
311300040070-04	4/30/2007	Phosphorous, Ortho	0.005	mg/L
311300040070-04	7/25/2007	Phosphorous, Ortho	<0.005	mg/L
311300040070-05	11/7/2001	Phosphorous, Ortho	0.008	mg/L
311300040070-05	2/11/2002	Phosphorous, Ortho	0.006	mg/L
311300040070-05	5/13/2002	Phosphorous, Ortho	0.006	mg/L
311300040070-05	8/12/2002	Phosphorous, Ortho	<0.005	mg/L
311300040070-05	10/22/2003	Phosphorous, Ortho	0.009	mg/L
311300040070-05	1/14/2004	Phosphorous, Ortho	0.01	mg/L
311300040070-05	4/14/2004	Phosphorous, Ortho	0.008	mg/L
311300040070-05	7/14/2004	Phosphorous, Ortho	0.007	mg/L
311300040070-05	10/25/2006	Phosphorous, Ortho	0.01	mg/L
311300040070-05	1/30/2007	Phosphorous, Ortho	0.005	mg/L
311300040070-05	4/30/2007	Phosphorous, Ortho	0.006	mg/L
311300040070-05	7/25/2007	Phosphorous, Ortho	<0.005	mg/L
311300040070-01B	4/15/1998	Phosphorous, Total	0.029	mg/L
311300040070-01B	7/8/1998	Phosphorous, Total	0.131	mg/L
311300040070-01B	1/6/1999	Phosphorous, Total	0.056	mg/L
311300040070-01B	4/12/1999	Phosphorous, Total	0.041	mg/L
311300040070-01B	7/7/1999	Phosphorous, Total	0.063	mg/L
311300040070-01B	2/11/2002	Phosphorous, Total	0.008	mg/L
311300040070-01B	5/13/2002	Phosphorous, Total	0.082	mg/L
311300040070-01B	8/12/2002	Phosphorous, Total	0.167	mg/L
311300040070-01B	10/22/2003	Phosphorous, Total	0.04	mg/L
311300040070-01B	1/14/2004	Phosphorous, Total	0.025	mg/L
311300040070-01B	4/14/2004	Phosphorous, Total	0.038	mg/L
311300040070-01B	7/14/2004	Phosphorous, Total	0.115	mg/L
311300040070-01S	4/15/1998	Phosphorous, Total	0.028	mg/L
311300040070-01S	4/15/1998	Phosphorous, Total	0.035	mg/L
311300040070-01S	7/8/1998	Phosphorous, Total	0.018	mg/L
311300040070-01S	7/8/1998	Phosphorous, Total	0.018	mg/L
311300040070-01S	1/6/1999	Phosphorous, Total	0.067	mg/L
311300040070-01S	1/6/1999	Phosphorous, Total	0.035	mg/L
311300040070-01S	4/12/1999	Phosphorous, Total	0.029	mg/L
311300040070-01S	4/12/1999	Phosphorous, Total	0.046	mg/L
311300040070-01S	4/29/1999	Phosphorous, Total	0.022	mg/L
311300040070-01S	4/29/1999	Phosphorous, Total	0.016	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-01S	7/7/1999	Phosphorous, Total	0.014	mg/L
311300040070-01S	7/7/1999	Phosphorous, Total	0.028	mg/L
311300040070-01S	7/7/1999	Phosphorous, Total	0.025	mg/L
311300040070-01S	11/7/2001	Phosphorous, Total	0.015	mg/L
311300040070-01S	2/11/2002	Phosphorous, Total	0.018	mg/L
311300040070-01S	2/11/2002	Phosphorous, Total	0.018	mg/L
311300040070-01S	5/13/2002	Phosphorous, Total	0.03	mg/L
311300040070-01S	5/13/2002	Phosphorous, Total	0.027	mg/L
311300040070-01S	8/12/2002	Phosphorous, Total	0.021	mg/L
311300040070-01S	10/22/2003	Phosphorous, Total	0.028	mg/L
311300040070-01S	10/22/2003	Phosphorous, Total	0.028	mg/L
311300040070-01S	1/14/2004	Phosphorous, Total	0.02	mg/L
311300040070-01S	1/14/2004	Phosphorous, Total	0.023	mg/L
311300040070-01S	4/14/2004	Phosphorous, Total	0.026	mg/L
311300040070-01S	4/14/2004	Phosphorous, Total	0.026	mg/L
311300040070-01S	7/14/2004	Phosphorous, Total	0.03	mg/L
311300040070-01S	7/14/2004	Phosphorous, Total	0.028	mg/L
311300040070-01S	10/25/2006	Phosphorous, Total	0.046	mg/L
311300040070-01S	10/25/2006	Phosphorous, Total	0.046	mg/L
311300040070-01S	1/30/2007	Phosphorous, Total	0.019	mg/L
311300040070-01S	1/30/2007	Phosphorous, Total	0.02	mg/L
311300040070-01S	7/25/2007	Phosphorous, Total	0.026	mg/L
311300040070-01S	7/25/2007	Phosphorous, Total	0.026	mg/L
311300040070-02	4/15/1998	Phosphorous, Total	0.015	mg/L
311300040070-02	4/15/1998	Phosphorous, Total	0.032	mg/L
311300040070-02	7/8/1998	Phosphorous, Total	0.013	mg/L
311300040070-02	1/6/1999	Phosphorous, Total	0.034	mg/L
311300040070-02	4/29/1999	Phosphorous, Total	0.017	mg/L
311300040070-02	7/7/1999	Phosphorous, Total	0.023	mg/L
311300040070-02	11/7/2001	Phosphorous, Total	0.009	mg/L
311300040070-02	2/11/2002	Phosphorous, Total	0.017	mg/L
311300040070-02	5/13/2002	Phosphorous, Total	0.025	mg/L
311300040070-02	8/12/2002	Phosphorous, Total	0.023	mg/L
311300040070-02	10/22/2003	Phosphorous, Total	0.031	mg/L
311300040070-02	1/14/2004	Phosphorous, Total	0.025	mg/L
311300040070-02	4/14/2004	Phosphorous, Total	0.024	mg/L
311300040070-02	7/14/2004	Phosphorous, Total	0.03	mg/L
311300040070-02	10/25/2006	Phosphorous, Total	0.046	mg/L
311300040070-02	1/30/2007	Phosphorous, Total	0.019	mg/L
311300040070-02	4/30/2007	Phosphorous, Total	0.016	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-02	7/25/2007	Phosphorous, Total	0.031	mg/L
311300040070-02	12/6/2010	Phosphorous, Total	0.031	mg/L
311300040070-02	2/15/2011	Phosphorous, Total	0.019	mg/L
311300040070-02	5/10/2011	Phosphorous, Total	0.015	mg/L
311300040070-03	4/15/1998	Phosphorous, Total	0.027	mg/L
311300040070-03	4/15/1998	Phosphorous, Total	0.022	mg/L
311300040070-03	7/8/1998	Phosphorous, Total	0.014	mg/L
311300040070-03	1/6/1999	Phosphorous, Total	0.058	mg/L
311300040070-03	4/29/1999	Phosphorous, Total	0.017	mg/L
311300040070-03	7/7/1999	Phosphorous, Total	0.022	mg/L
311300040070-03	11/7/2001	Phosphorous, Total	0.009	mg/L
311300040070-03	2/11/2002	Phosphorous, Total	0.019	mg/L
311300040070-03	5/13/2002	Phosphorous, Total	0.024	mg/L
311300040070-03	8/12/2002	Phosphorous, Total	0.026	mg/L
311300040070-03	10/22/2003	Phosphorous, Total	0.03	mg/L
311300040070-03	1/14/2004	Phosphorous, Total	0.024	mg/L
311300040070-03	4/14/2004	Phosphorous, Total	0.022	mg/L
311300040070-03	7/14/2004	Phosphorous, Total	0.033	mg/L
311300040070-03	10/25/2006	Phosphorous, Total	0.045	mg/L
311300040070-03	1/30/2007	Phosphorous, Total	0.017	mg/L
311300040070-03	4/30/2007	Phosphorous, Total	0.017	mg/L
311300040070-03	7/25/2007	Phosphorous, Total	0.029	mg/L
311300040070-03	12/6/2010	Phosphorous, Total	0.031	mg/L
311300040070-03	2/15/2011	Phosphorous, Total	0.018	mg/L
311300040070-03	5/10/2011	Phosphorous, Total	0.016	mg/L
311300040070-04	4/15/1998	Phosphorous, Total	0.026	mg/L
311300040070-04	1/6/1999	Phosphorous, Total	0.074	mg/L
311300040070-04	4/29/1999	Phosphorous, Total	0.018	mg/L
311300040070-04	7/7/1999	Phosphorous, Total	0.022	mg/L
311300040070-04	11/7/2001	Phosphorous, Total	0.008	mg/L
311300040070-04	2/11/2002	Phosphorous, Total	0.019	mg/L
311300040070-04	5/13/2002	Phosphorous, Total	0.026	mg/L
311300040070-04	8/12/2002	Phosphorous, Total	0.042	mg/L
311300040070-04	10/22/2003	Phosphorous, Total	0.035	mg/L
311300040070-04	1/14/2004	Phosphorous, Total	0.026	mg/L
311300040070-04	4/14/2004	Phosphorous, Total	0.025	mg/L
311300040070-04	7/14/2004	Phosphorous, Total	0.032	mg/L
311300040070-04	10/25/2006	Phosphorous, Total	0.058	mg/L
311300040070-04	1/30/2007	Phosphorous, Total	0.018	mg/L
311300040070-04	4/30/2007	Phosphorous, Total	0.017	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-04	7/25/2007	Phosphorous, Total	0.044	mg/L
311300040070-04	12/6/2010	Phosphorous, Total	0.03	mg/L
311300040070-04	2/15/2011	Phosphorous, Total	0.021	mg/L
311300040070-04	5/10/2011	Phosphorous, Total	0.026	mg/L
311300040070-05	11/7/2001	Phosphorous, Total	0.015	mg/L
311300040070-05	2/11/2002	Phosphorous, Total	0.018	mg/L
311300040070-05	5/13/2002	Phosphorous, Total	0.022	mg/L
311300040070-05	8/12/2002	Phosphorous, Total	0.03	mg/L
311300040070-05	10/22/2003	Phosphorous, Total	0.032	mg/L
311300040070-05	1/14/2004	Phosphorous, Total	0.025	mg/L
311300040070-05	4/14/2004	Phosphorous, Total	0.022	mg/L
311300040070-05	7/14/2004	Phosphorous, Total	0.036	mg/L
311300040070-05	10/25/2006	Phosphorous, Total	0.049	mg/L
311300040070-05	1/30/2007	Phosphorous, Total	0.019	mg/L
311300040070-05	4/30/2007	Phosphorous, Total	0.017	mg/L
311300040070-05	7/25/2007	Phosphorous, Total	0.034	mg/L
311300040070-01S	10/22/2003	Secchi Depth	99	cm
311300040070-01S	1/14/2004	Secchi Depth	101	cm
311300040070-01S	4/14/2004	Secchi Depth	146	cm
311300040070-01S	7/14/2004	Secchi Depth	97	cm
311300040070-02	11/7/2001	Secchi Depth	85	cm
311300040070-02	10/22/2003	Secchi Depth	98	cm
311300040070-02	1/14/2004	Secchi Depth	109	cm
311300040070-02	4/14/2004	Secchi Depth	114	cm
311300040070-02	7/14/2004	Secchi Depth	110	cm
311300040070-02	12/6/2010	Secchi Depth	94	cm
311300040070-02	2/15/2011	Secchi Depth	210	cm
311300040070-02	5/10/2011	Secchi Depth	165	cm
311300040070-02	8/1/2011	Secchi Depth	79	cm
311300040070-03	11/7/2001	Secchi Depth	86	cm
311300040070-03	10/22/2003	Secchi Depth	99	cm
311300040070-03	1/14/2004	Secchi Depth	108	cm
311300040070-03	4/14/2004	Secchi Depth	118	cm
311300040070-03	7/14/2004	Secchi Depth	84	cm
311300040070-03	12/6/2010	Secchi Depth	96	cm
311300040070-03	2/15/2011	Secchi Depth	210	cm
311300040070-03	5/10/2011	Secchi Depth	171	cm
311300040070-03	8/1/2011	Secchi Depth	69	cm
311300040070-04	10/22/2003	Secchi Depth	83	cm
311300040070-04	1/14/2004	Secchi Depth	75	cm

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-04	4/14/2004	Secchi Depth	88	cm
311300040070-04	7/14/2004	Secchi Depth	100	cm
311300040070-04	12/6/2010	Secchi Depth	95	cm
311300040070-04	2/15/2011	Secchi Depth	150	cm
311300040070-04	5/10/2011	Secchi Depth	100	cm
311300040070-04	8/1/2011	Secchi Depth	62	cm
311300040070-05	2/11/2002	Secchi Depth	120	cm
311300040070-05	10/22/2003	Secchi Depth	98	cm
311300040070-05	1/14/2004	Secchi Depth	99	cm
311300040070-05	4/14/2004	Secchi Depth	120	cm
311300040070-05	7/14/2004	Secchi Depth	90	cm
311300040070-01B	4/15/1998	Solids, Suspended	12	mg/L
311300040070-01B	7/8/1998	Solids, Suspended	6	mg/L
311300040070-01B	1/6/1999	Solids, Suspended	5	mg/L
311300040070-01B	4/12/1999	Solids, Suspended	24	mg/L
311300040070-01B	7/7/1999	Solids, Suspended	5	mg/L
311300040070-01S	4/15/1998	Solids, Suspended	13	mg/L
311300040070-01S	4/15/1998	Solids, Suspended	15	mg/L
311300040070-01S	7/8/1998	Solids, Suspended	8	mg/L
311300040070-01S	7/8/1998	Solids, Suspended	8	mg/L
311300040070-01S	7/8/1998	Solids, Suspended	8	mg/L
311300040070-01S	1/6/1999	Solids, Suspended	6	mg/L
311300040070-01S	1/6/1999	Solids, Suspended	9	mg/L
311300040070-01S	4/12/1999	Solids, Suspended	21	mg/L
311300040070-01S	4/12/1999	Solids, Suspended	17	mg/L
311300040070-01S	4/29/1999	Solids, Suspended	5	mg/L
311300040070-01S	4/29/1999	Solids, Suspended	6	mg/L
311300040070-01S	7/7/1999	Solids, Suspended	1	mg/L
311300040070-01S	7/7/1999	Solids, Suspended	1	mg/L
311300040070-01S	7/7/1999	Solids, Suspended	2	mg/L
311300040070-02	4/15/1998	Solids, Suspended	13	mg/L
311300040070-02	4/15/1998	Solids, Suspended	14	mg/L
311300040070-02	7/8/1998	Solids, Suspended	6	mg/L
311300040070-02	1/6/1999	Solids, Suspended	6	mg/L
311300040070-02	4/29/1999	Solids, Suspended	4	mg/L
311300040070-02	7/7/1999	Solids, Suspended	6	mg/L
311300040070-03	4/15/1998	Solids, Suspended	7	mg/L
311300040070-03	4/15/1998	Solids, Suspended	9	mg/L
311300040070-03	7/8/1998	Solids, Suspended	10	mg/L
311300040070-03	1/6/1999	Solids, Suspended	8	mg/L

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-03	4/29/1999	Solids, Suspended	6	mg/L
311300040070-03	7/7/1999	Solids, Suspended	1	mg/L
311300040070-04	4/15/1998	Solids, Suspended	7	mg/L
311300040070-04	7/8/1998	Solids, Suspended	8	mg/L
311300040070-04	1/6/1999	Solids, Suspended	4	mg/L
311300040070-04	4/29/1999	Solids, Suspended	4	mg/L
311300040070-04	7/7/1999	Solids, Suspended	2	mg/L
311300040070-01B	2/11/2002	Turbidity, Field	7	NTU
311300040070-01S	2/11/2002	Turbidity, Field	8	NTU
311300040070-01S	2/11/2002	Turbidity, Field	7	NTU
311300040070-01S	5/13/2002	Turbidity, Field	8	NTU
311300040070-01S	5/13/2002	Turbidity, Field	14	NTU
311300040070-01S	10/22/2003	Turbidity, Field	6	NTU
311300040070-01S	10/22/2003	Turbidity, Field	6	NTU
311300040070-01S	1/14/2004	Turbidity, Field	5	NTU
311300040070-01S	1/14/2004	Turbidity, Field	5	NTU
311300040070-01S	4/14/2004	Turbidity, Field	5	NTU
311300040070-01S	4/14/2004	Turbidity, Field	5	NTU
311300040070-01S	7/14/2004	Turbidity, Field	7	NTU
311300040070-01S	7/14/2004	Turbidity, Field	6	NTU
311300040070-01S	10/25/2006	Turbidity, Field	7	NTU
311300040070-01S	1/30/2007	Turbidity, Field	8	NTU
311300040070-01S	1/30/2007	Turbidity, Field	9	NTU
311300040070-01S	7/25/2007	Turbidity, Field	5	NTU
311300040070-01S	7/25/2007	Turbidity, Field	5	NTU
311300040070-02	11/7/2001	Turbidity, Field	9	NTU
311300040070-02	2/11/2002	Turbidity, Field	6	NTU
311300040070-02	5/13/2002	Turbidity, Field	13	NTU
311300040070-02	10/22/2003	Turbidity, Field	7	NTU
311300040070-02	1/14/2004	Turbidity, Field	4	NTU
311300040070-02	4/14/2004	Turbidity, Field	6	NTU
311300040070-02	7/14/2004	Turbidity, Field	6	NTU
311300040070-02	10/25/2006	Turbidity, Field	9	NTU
311300040070-02	1/30/2007	Turbidity, Field	8	NTU
311300040070-02	4/30/2007	Turbidity, Field	4	NTU
311300040070-02	7/25/2007	Turbidity, Field	7	NTU
311300040070-02	12/6/2010	Turbidity, Field	9	NTU
311300040070-02	2/15/2011	Turbidity, Field	3	NTU
311300040070-02	5/10/2011	Turbidity, Field	3	NTU
311300040070-02	8/1/2011	Turbidity, Field	8	NTU

Lake Lawtonka WQM Station	Date	Parameter	Value	Units
311300040070-03	11/7/2001	Turbidity, Field	10	NTU
311300040070-03	2/11/2002	Turbidity, Field	7	NTU
311300040070-03	5/13/2002	Turbidity, Field	9	NTU
311300040070-03	10/22/2003	Turbidity, Field	8	NTU
311300040070-03	1/14/2004	Turbidity, Field	6	NTU
311300040070-03	4/14/2004	Turbidity, Field	7	NTU
311300040070-03	7/14/2004	Turbidity, Field	8	NTU
311300040070-03	10/25/2006	Turbidity, Field	11	NTU
311300040070-03	1/30/2007	Turbidity, Field	9	NTU
311300040070-03	4/30/2007	Turbidity, Field	5	NTU
311300040070-03	7/25/2007	Turbidity, Field	6	NTU
311300040070-03	12/6/2010	Turbidity, Field	9	NTU
311300040070-03	2/15/2011	Turbidity, Field	4	NTU
311300040070-03	5/10/2011	Turbidity, Field	4	NTU
311300040070-03	8/1/2011	Turbidity, Field	12	NTU
311300040070-04	11/7/2001	Turbidity, Field	8	NTU
311300040070-04	2/11/2002	Turbidity, Field	8	NTU
311300040070-04	5/13/2002	Turbidity, Field	11	NTU
311300040070-04	10/22/2003	Turbidity, Field	9	NTU
311300040070-04	1/14/2004	Turbidity, Field	7	NTU
311300040070-04	4/14/2004	Turbidity, Field	9	NTU
311300040070-04	7/14/2004	Turbidity, Field	8	NTU
311300040070-04	10/25/2006	Turbidity, Field	16	NTU
311300040070-04	1/30/2007	Turbidity, Field	8	NTU
311300040070-04	4/30/2007	Turbidity, Field	6	NTU
311300040070-04	7/25/2007	Turbidity, Field	15	NTU
311300040070-04	12/6/2010	Turbidity, Field	9	NTU
311300040070-04	2/15/2011	Turbidity, Field	5	NTU
311300040070-04	5/10/2011	Turbidity, Field	7	NTU
311300040070-04	8/1/2011	Turbidity, Field	15	NTU
311300040070-05	11/7/2001	Turbidity, Field	9	NTU
311300040070-05	2/11/2002	Turbidity, Field	5	NTU
311300040070-05	5/13/2002	Turbidity, Field	8	NTU
311300040070-05	10/22/2003	Turbidity, Field	9	NTU
311300040070-05	1/14/2004	Turbidity, Field	5	NTU
311300040070-05	4/14/2004	Turbidity, Field	6	NTU
311300040070-05	7/14/2004	Turbidity, Field	8	NTU
311300040070-05	1/30/2007	Turbidity, Field	9	NTU
311300040070-05	4/30/2007	Turbidity, Field	5	NTU
311300040070-05	7/25/2007	Turbidity, Field	9	NTU

Appendix B, Table-2: Ambient Water Quality Data for Waurika Lake, 1999-2008

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-01B	11/13/2002	Corrected Chlorophyll-a	13.16	mg/m3
311210000020-01B	2/11/2003	Corrected Chlorophyll-a	12.3	mg/m3
311210000020-01B	5/13/2003	Corrected Chlorophyll-a	8.4	mg/m3
311210000020-01B	1/17/2005	Corrected Chlorophyll-a	11.9	mg/m3
311210000020-01B	10/5/2004	Corrected Chlorophyll-a	19.3	mg/m3
311210000020-01B	7/11/2005	Corrected Chlorophyll-a	16.7	mg/m3
311210000020-01B	10/2/2007	Corrected Chlorophyll-a	18.64	mg/m3
311210000020-01B	4/2/2008	Corrected Chlorophyll-a	15.1	mg/m3
311210000020-01B	1/7/2008	Corrected Chlorophyll-a	8.65	mg/m3
311210000020-01B	7/3/2008	Corrected Chlorophyll-a	10.8	mg/m3
311210000020-02	11/13/2002	Corrected Chlorophyll-a	8.22	mg/m3
311210000020-02	2/11/2003	Corrected Chlorophyll-a	14.1	mg/m3
311210000020-02	5/13/2003	Corrected Chlorophyll-a	13.4	mg/m3
311210000020-02	1/17/2005	Corrected Chlorophyll-a	23.7	mg/m3
311210000020-02	10/5/2004	Corrected Chlorophyll-a	29.1	mg/m3
311210000020-02	7/11/2005	Corrected Chlorophyll-a	27.4	mg/m3
311210000020-02	10/2/2007	Corrected Chlorophyll-a	2.6	mg/m3
311210000020-02	4/2/2008	Corrected Chlorophyll-a	5.01	mg/m3
311210000020-02	1/7/2008	Corrected Chlorophyll-a	9.77	mg/m3
311210000020-02	7/3/2008	Corrected Chlorophyll-a	12.2	mg/m3
311210000020-03	11/13/2002	Corrected Chlorophyll-a	10.85	mg/m3
311210000020-03	2/11/2003	Corrected Chlorophyll-a	15.1	mg/m3
311210000020-03	5/13/2003	Corrected Chlorophyll-a	13.2	mg/m3
311210000020-03	1/17/2005	Corrected Chlorophyll-a	11.2	mg/m3
311210000020-03	10/5/2004	Corrected Chlorophyll-a	30.7	mg/m3
311210000020-03	7/11/2005	Corrected Chlorophyll-a	16.3	mg/m3
311210000020-03	4/2/2008	Corrected Chlorophyll-a	10.4	mg/m3
311210000020-03	10/2/2007	Corrected Chlorophyll-a	3.9	mg/m3
311210000020-03	1/7/2008	Corrected Chlorophyll-a	12.1	mg/m3
311210000020-04	11/13/2002	Corrected Chlorophyll-a	16.19	mg/m3
311210000020-04	2/11/2003	Corrected Chlorophyll-a	4.4	mg/m3
311210000020-04	5/13/2003	Corrected Chlorophyll-a	11.8	mg/m3
311210000020-04	1/17/2005	Corrected Chlorophyll-a	3.92	mg/m3
311210000020-04	10/5/2004	Corrected Chlorophyll-a	30.5	mg/m3
311210000020-04	7/11/2005	Corrected Chlorophyll-a	14.9	mg/m3
311210000020-04	4/2/2008	Corrected Chlorophyll-a	11.1	mg/m3
311210000020-04	10/2/2007	Corrected Chlorophyll-a	3.35	mg/m3
311210000020-04	1/7/2008	Corrected Chlorophyll-a	13.8	mg/m3
311210000020-04	7/3/2008	Corrected Chlorophyll-a	8.89	mg/m3

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-01S	11/1/1999	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	2/1/2000	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	5/1/2000	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	7/31/2000	Nitrogen, Ammonia	0.05	mg/L
311210000020-01S	11/13/2002	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	2/11/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	5/13/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	8/12/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	10/5/2004	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	4/20/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	7/11/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-05	11/13/2002	Nitrogen, Ammonia	<0.05	mg/L
311210000020-05	2/11/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-05	5/13/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-05	8/12/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-05	10/5/2004	Nitrogen, Ammonia	<0.05	mg/L
311210000020-05	1/17/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-05	4/20/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-05	7/11/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	11/1/1999	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	2/1/2000	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	5/1/2000	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	7/31/2000	Nitrogen, Ammonia	0.05	mg/L
311210000020-01S	11/13/2002	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	2/11/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	5/13/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	8/12/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	10/5/2004	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	1/17/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	4/20/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	7/11/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01B	11/13/2002	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01B	11/1/1999	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01B	5/13/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01B	2/11/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01B	8/12/2003	Nitrogen, Ammonia	0.62	mg/L
311210000020-01B	2/1/2000	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01B	7/31/2000	Nitrogen, Ammonia	0.08	mg/L
311210000020-01B	5/1/2000	Nitrogen, Ammonia	0.08	mg/L
311210000020-01B	10/5/2004	Nitrogen, Ammonia	<0.05	mg/L

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-01B	1/17/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-02	11/13/2002	Nitrogen, Ammonia	<0.05	mg/L
311210000020-02	11/1/1999	Nitrogen, Ammonia	<0.05	mg/L
311210000020-02	5/13/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-02	2/11/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-02	8/12/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-02	2/1/2000	Nitrogen, Ammonia	<0.05	mg/L
311210000020-02	7/31/2000	Nitrogen, Ammonia	0.06	mg/L
311210000020-02	5/1/2000	Nitrogen, Ammonia	0.05	mg/L
311210000020-02	10/5/2004	Nitrogen, Ammonia	<0.05	mg/L
311210000020-02	4/20/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-02	1/17/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-02	7/11/2005	Nitrogen, Ammonia	0.11	mg/L
311210000020-03	11/13/2002	Nitrogen, Ammonia	<0.05	mg/L
311210000020-03	5/13/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-03	2/11/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-03	8/12/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-03	2/1/2000	Nitrogen, Ammonia	<0.05	mg/L
311210000020-03	7/31/2000	Nitrogen, Ammonia	0.05	mg/L
311210000020-03	5/1/2000	Nitrogen, Ammonia	<0.05	mg/L
311210000020-03	10/5/2004	Nitrogen, Ammonia	<0.05	mg/L
311210000020-03	4/20/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-03	1/17/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-03	7/11/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-04	11/13/2002	Nitrogen, Ammonia	<0.05	mg/L
311210000020-04	5/13/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-04	2/11/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-04	8/12/2003	Nitrogen, Ammonia	<0.05	mg/L
311210000020-04	2/1/2000	Nitrogen, Ammonia	<0.05	mg/L
311210000020-04	7/31/2000	Nitrogen, Ammonia	0.07	mg/L
311210000020-04	5/1/2000	Nitrogen, Ammonia	<0.05	mg/L
311210000020-04	10/5/2004	Nitrogen, Ammonia	<0.05	mg/L
311210000020-04	4/20/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-04	1/17/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-04	7/11/2005	Nitrogen, Ammonia	<0.05	mg/L
311210000020-01S	11/1/1999	Nitrogen, Kjeldahl	0.63	mg/L
311210000020-01S	2/1/2000	Nitrogen, Kjeldahl	0.46	mg/L
311210000020-01S	5/1/2000	Nitrogen, Kjeldahl	0.4	mg/L
311210000020-01S	7/31/2000	Nitrogen, Kjeldahl	0.66	mg/L
311210000020-01S	11/13/2002	Nitrogen, Kjeldahl	0.54	mg/L

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-01S	2/11/2003	Nitrogen, Kjeldahl	0.43	mg/L
311210000020-01S	5/13/2003	Nitrogen, Kjeldahl	0.65	mg/L
311210000020-01S	8/12/2003	Nitrogen, Kjeldahl	0.89	mg/L
311210000020-01S	10/5/2004	Nitrogen, Kjeldahl	0.88	mg/L
311210000020-01S	4/20/2005	Nitrogen, Kjeldahl	0.65	mg/L
311210000020-01S	7/11/2005	Nitrogen, Kjeldahl	0.62	mg/L
311210000020-01S	10/2/2007	Nitrogen, Kjeldahl	0.66	mg/L
311210000020-01S	1/7/2008	Nitrogen, Kjeldahl	0.59	mg/L
311210000020-01S	4/2/2008	Nitrogen, Kjeldahl	0.67	mg/L
311210000020-01S	7/2/2008	Nitrogen, Kjeldahl	0.57	mg/L
311210000020-05	11/13/2002	Nitrogen, Kjeldahl	0.56	mg/L
311210000020-05	2/11/2003	Nitrogen, Kjeldahl	0.27	mg/L
311210000020-05	5/13/2003	Nitrogen, Kjeldahl	0.67	mg/L
311210000020-05	8/12/2003	Nitrogen, Kjeldahl	1.08	mg/L
311210000020-05	10/5/2004	Nitrogen, Kjeldahl	1.01	mg/L
311210000020-05	1/17/2005	Nitrogen, Kjeldahl	0.52	mg/L
311210000020-05	4/20/2005	Nitrogen, Kjeldahl	0.7	mg/L
311210000020-05	7/11/2005	Nitrogen, Kjeldahl	0.77	mg/L
311210000020-05	10/2/2007	Nitrogen, Kjeldahl	1.09	mg/L
311210000020-05	1/7/2008	Nitrogen, Kjeldahl	0.67	mg/L
311210000020-05	4/2/2008	Nitrogen, Kjeldahl	0.83	mg/L
311210000020-05	7/2/2008	Nitrogen, Kjeldahl	0.74	mg/L
311210000020-01S	11/1/1999	Nitrogen, Kjeldahl	0.63	mg/L
311210000020-01S	2/1/2000	Nitrogen, Kjeldahl	0.46	mg/L
311210000020-01S	5/1/2000	Nitrogen, Kjeldahl	0.4	mg/L
311210000020-01S	7/31/2000	Nitrogen, Kjeldahl	0.66	mg/L
311210000020-01S	11/13/2002	Nitrogen, Kjeldahl	0.54	mg/L
311210000020-01S	2/11/2003	Nitrogen, Kjeldahl	0.43	mg/L
311210000020-01S	5/13/2003	Nitrogen, Kjeldahl	0.65	mg/L
311210000020-01S	8/12/2003	Nitrogen, Kjeldahl	0.89	mg/L
311210000020-01S	10/5/2004	Nitrogen, Kjeldahl	0.88	mg/L
311210000020-01S	1/17/2005	Nitrogen, Kjeldahl	0.5	mg/L
311210000020-01S	4/20/2005	Nitrogen, Kjeldahl	0.65	mg/L
311210000020-01S	7/11/2005	Nitrogen, Kjeldahl	0.62	mg/L
311210000020-01S	10/2/2007	Nitrogen, Kjeldahl	0.66	mg/L
311210000020-01S	1/7/2008	Nitrogen, Kjeldahl	0.59	mg/L
311210000020-01S	4/2/2008	Nitrogen, Kjeldahl	0.67	mg/L
311210000020-01S	7/2/2008	Nitrogen, Kjeldahl	0.57	mg/L
311210000020-01B	11/13/2002	Nitrogen, Kjeldahl	0.4	mg/L
311210000020-01B	11/1/1999	Nitrogen, Kjeldahl	0.69	mg/L

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-01B	5/13/2003	Nitrogen, Kjeldahl	0.73	mg/L
311210000020-01B	2/11/2003	Nitrogen, Kjeldahl	0.47	mg/L
311210000020-01B	8/12/2003	Nitrogen, Kjeldahl	1.51	mg/L
311210000020-01B	2/1/2000	Nitrogen, Kjeldahl	0.46	mg/L
311210000020-01B	7/31/2000	Nitrogen, Kjeldahl	0.51	mg/L
311210000020-01B	5/1/2000	Nitrogen, Kjeldahl	0.48	mg/L
311210000020-01B	10/5/2004	Nitrogen, Kjeldahl	0.91	mg/L
311210000020-01B	1/17/2005	Nitrogen, Kjeldahl	0.5	mg/L
311210000020-02	11/13/2002	Nitrogen, Kjeldahl	0.64	mg/L
311210000020-02	11/1/1999	Nitrogen, Kjeldahl	0.56	mg/L
311210000020-02	5/13/2003	Nitrogen, Kjeldahl	0.67	mg/L
311210000020-02	2/11/2003	Nitrogen, Kjeldahl	0.46	mg/L
311210000020-02	8/12/2003	Nitrogen, Kjeldahl	0.98	mg/L
311210000020-02	2/1/2000	Nitrogen, Kjeldahl	0.63	mg/L
311210000020-02	7/31/2000	Nitrogen, Kjeldahl	0.46	mg/L
311210000020-02	5/1/2000	Nitrogen, Kjeldahl	0.35	mg/L
311210000020-02	10/5/2004	Nitrogen, Kjeldahl	0.87	mg/L
311210000020-02	4/20/2005	Nitrogen, Kjeldahl	0.85	mg/L
311210000020-02	1/17/2005	Nitrogen, Kjeldahl	0.56	mg/L
311210000020-02	7/11/2005	Nitrogen, Kjeldahl	0.78	mg/L
311210000020-02	10/2/2007	Nitrogen, Kjeldahl	0.68	mg/L
311210000020-02	1/7/2008	Nitrogen, Kjeldahl	0.48	mg/L
311210000020-02	7/2/2008	Nitrogen, Kjeldahl	0.53	mg/L
311210000020-02	4/2/2008	Nitrogen, Kjeldahl	0.54	mg/L
311210000020-03	11/13/2002	Nitrogen, Kjeldahl	0.58	mg/L
311210000020-03	5/13/2003	Nitrogen, Kjeldahl	0.6	mg/L
311210000020-03	2/11/2003	Nitrogen, Kjeldahl	0.33	mg/L
311210000020-03	8/12/2003	Nitrogen, Kjeldahl	0.99	mg/L
311210000020-03	2/1/2000	Nitrogen, Kjeldahl	0.53	mg/L
311210000020-03	7/31/2000	Nitrogen, Kjeldahl	0.57	mg/L
311210000020-03	5/1/2000	Nitrogen, Kjeldahl	0.35	mg/L
311210000020-03	10/5/2004	Nitrogen, Kjeldahl	0.79	mg/L
311210000020-03	4/20/2005	Nitrogen, Kjeldahl	0.73	mg/L
311210000020-03	1/17/2005	Nitrogen, Kjeldahl	0.52	mg/L
311210000020-03	7/11/2005	Nitrogen, Kjeldahl	0.73	mg/L
311210000020-03	10/2/2007	Nitrogen, Kjeldahl	0.69	mg/L
311210000020-03	1/7/2008	Nitrogen, Kjeldahl	0.51	mg/L
311210000020-03	7/2/2008	Nitrogen, Kjeldahl	0.54	mg/L
311210000020-03	4/2/2008	Nitrogen, Kjeldahl	0.66	mg/L
311210000020-04	11/13/2002	Nitrogen, Kjeldahl	0.58	mg/L

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-04	5/13/2003	Nitrogen, Kjeldahl	0.68	mg/L
311210000020-04	2/11/2003	Nitrogen, Kjeldahl	0.43	mg/L
311210000020-04	8/12/2003	Nitrogen, Kjeldahl	0.83	mg/L
311210000020-04	2/1/2000	Nitrogen, Kjeldahl	0.46	mg/L
311210000020-04	7/31/2000	Nitrogen, Kjeldahl	0.73	mg/L
311210000020-04	5/1/2000	Nitrogen, Kjeldahl	0.58	mg/L
311210000020-04	10/5/2004	Nitrogen, Kjeldahl	0.95	mg/L
311210000020-04	4/20/2005	Nitrogen, Kjeldahl	0.79	mg/L
311210000020-04	1/17/2005	Nitrogen, Kjeldahl	0.82	mg/L
311210000020-04	7/11/2005	Nitrogen, Kjeldahl	0.75	mg/L
311210000020-04	10/2/2007	Nitrogen, Kjeldahl	0.9	mg/L
311210000020-04	1/7/2008	Nitrogen, Kjeldahl	0.63	mg/L
311210000020-04	7/2/2008	Nitrogen, Kjeldahl	0.62	mg/L
311210000020-04	4/2/2008	Nitrogen, Kjeldahl	0.85	mg/L
311210000020-01S	11/1/1999	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-01S	2/1/2000	Nitrogen, Nitrate as N	0.19	mg/L
311210000020-01S	5/1/2000	Nitrogen, Nitrate as N	0.05	mg/L
311210000020-01S	7/31/2000	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-01S	11/13/2002	Nitrogen, Nitrate as N	0.18	mg/L
311210000020-01S	2/11/2003	Nitrogen, Nitrate as N	0.16	mg/L
311210000020-01S	5/13/2003	Nitrogen, Nitrate as N	0.07	mg/L
311210000020-01S	8/12/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-01S	10/5/2004	Nitrogen, Nitrate as N	0.07	mg/L
311210000020-05	11/13/2002	Nitrogen, Nitrate as N	0.13	mg/L
311210000020-05	2/11/2003	Nitrogen, Nitrate as N	0.14	mg/L
311210000020-05	5/13/2003	Nitrogen, Nitrate as N	0.05	mg/L
311210000020-05	8/12/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-05	10/5/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-05	1/17/2005	Nitrogen, Nitrate as N	0.13	mg/L
311210000020-01S	11/1/1999	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-01S	2/1/2000	Nitrogen, Nitrate as N	0.19	mg/L
311210000020-01S	5/1/2000	Nitrogen, Nitrate as N	0.05	mg/L
311210000020-01S	7/31/2000	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-01S	11/13/2002	Nitrogen, Nitrate as N	0.18	mg/L
311210000020-01S	2/11/2003	Nitrogen, Nitrate as N	0.16	mg/L
311210000020-01S	5/13/2003	Nitrogen, Nitrate as N	0.07	mg/L
311210000020-01S	8/12/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-01S	10/5/2004	Nitrogen, Nitrate as N	0.07	mg/L
311210000020-01S	1/17/2005	Nitrogen, Nitrate as N	0.14	mg/L
311210000020-01B	11/13/2002	Nitrogen, Nitrate as N	0.18	mg/L

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-01B	11/1/1999	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-01B	5/13/2003	Nitrogen, Nitrate as N	0.32	mg/L
311210000020-01B	2/11/2003	Nitrogen, Nitrate as N	0.16	mg/L
311210000020-01B	8/12/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-01B	2/1/2000	Nitrogen, Nitrate as N	0.19	mg/L
311210000020-01B	7/31/2000	Nitrogen, Nitrate as N	0.16	mg/L
311210000020-01B	5/1/2000	Nitrogen, Nitrate as N	0.07	mg/L
311210000020-01B	10/5/2004	Nitrogen, Nitrate as N	0.07	mg/L
311210000020-01B	1/17/2005	Nitrogen, Nitrate as N	0.14	mg/L
311210000020-02	11/13/2002	Nitrogen, Nitrate as N	0.19	mg/L
311210000020-02	11/1/1999	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-02	5/13/2003	Nitrogen, Nitrate as N	0.05	mg/L
311210000020-02	2/11/2003	Nitrogen, Nitrate as N	0.15	mg/L
311210000020-02	8/12/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-02	2/1/2000	Nitrogen, Nitrate as N	0.18	mg/L
311210000020-02	7/31/2000	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-02	5/1/2000	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-02	10/5/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-02	1/17/2005	Nitrogen, Nitrate as N	0.13	mg/L
311210000020-03	11/13/2002	Nitrogen, Nitrate as N	0.15	mg/L
311210000020-03	5/13/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-03	2/11/2003	Nitrogen, Nitrate as N	0.1	mg/L
311210000020-03	8/12/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-03	2/1/2000	Nitrogen, Nitrate as N	0.16	mg/L
311210000020-03	7/31/2000	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-03	5/1/2000	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-03	10/5/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-03	1/17/2005	Nitrogen, Nitrate as N	0.14	mg/L
311210000020-04	11/13/2002	Nitrogen, Nitrate as N	0.12	mg/L
311210000020-04	5/13/2003	Nitrogen, Nitrate as N	0.06	mg/L
311210000020-04	2/11/2003	Nitrogen, Nitrate as N	0.17	mg/L
311210000020-04	8/12/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-04	2/1/2000	Nitrogen, Nitrate as N	0.06	mg/L
311210000020-04	7/31/2000	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-04	5/1/2000	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-04	10/5/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311210000020-04	1/17/2005	Nitrogen, Nitrate as N	0.23	mg/L
311210000020-01S	4/20/2005	Nitrogen, Nitrate/Nitrite as N	0.1	mg/L
311210000020-01S	7/11/2005	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-01S	10/2/2007	Nitrogen, Nitrate/Nitrite as N	0.24	mg/L

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-01S	1/7/2008	Nitrogen, Nitrate/Nitrite as N	0.23	mg/L
311210000020-01S	4/2/2008	Nitrogen, Nitrate/Nitrite as N	0.05	mg/L
311210000020-01S	7/2/2008	Nitrogen, Nitrate/Nitrite as N	0.05	mg/L
311210000020-05	4/20/2005	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-05	7/11/2005	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-05	10/2/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-05	1/7/2008	Nitrogen, Nitrate/Nitrite as N	0.15	mg/L
311210000020-05	4/2/2008	Nitrogen, Nitrate/Nitrite as N	0.1	mg/L
311210000020-05	7/2/2008	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-01S	4/20/2005	Nitrogen, Nitrate/Nitrite as N	0.1	mg/L
311210000020-01S	7/11/2005	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-01S	10/2/2007	Nitrogen, Nitrate/Nitrite as N	0.24	mg/L
311210000020-01S	1/7/2008	Nitrogen, Nitrate/Nitrite as N	0.23	mg/L
311210000020-01S	4/2/2008	Nitrogen, Nitrate/Nitrite as N	0.05	mg/L
311210000020-01S	7/2/2008	Nitrogen, Nitrate/Nitrite as N	0.05	mg/L
311210000020-02	4/20/2005	Nitrogen, Nitrate/Nitrite as N	0.06	mg/L
311210000020-02	7/11/2005	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-02	10/2/2007	Nitrogen, Nitrate/Nitrite as N	0.18	mg/L
311210000020-02	1/7/2008	Nitrogen, Nitrate/Nitrite as N	0.22	mg/L
311210000020-02	7/2/2008	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-02	4/2/2008	Nitrogen, Nitrate/Nitrite as N	0.09	mg/L
311210000020-03	4/20/2005	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-03	7/11/2005	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-03	10/2/2007	Nitrogen, Nitrate/Nitrite as N	0.15	mg/L
311210000020-03	1/7/2008	Nitrogen, Nitrate/Nitrite as N	0.17	mg/L
311210000020-03	7/2/2008	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-03	4/2/2008	Nitrogen, Nitrate/Nitrite as N	0.07	mg/L
311210000020-04	4/20/2005	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-04	7/11/2005	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-04	10/2/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-04	1/7/2008	Nitrogen, Nitrate/Nitrite as N	0.17	mg/L
311210000020-04	7/2/2008	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311210000020-04	4/2/2008	Nitrogen, Nitrate/Nitrite as N	0.11	mg/L
311210000020-01S	11/1/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	2/1/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	5/1/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	7/31/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	11/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	2/11/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	5/13/2003	Nitrogen, Nitrite as N	<0.05	mg/L

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-01S	8/12/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	10/5/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-05	11/13/2002	Nitrogen, Nitrite as N	0.08	mg/L
311210000020-05	2/11/2003	Nitrogen, Nitrite as N	0.07	mg/L
311210000020-05	5/13/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-05	8/12/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-05	10/5/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-05	1/17/2005	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	11/1/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	2/1/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	5/1/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	7/31/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	11/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	2/11/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	5/13/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	8/12/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	10/5/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01S	1/17/2005	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01B	11/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01B	11/1/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01B	5/13/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01B	2/11/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01B	8/12/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01B	2/1/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01B	7/31/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01B	5/1/2000	Nitrogen, Nitrite as N	0.06	mg/L
311210000020-01B	10/5/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-01B	1/17/2005	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-02	11/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-02	11/1/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-02	5/13/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-02	2/11/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-02	8/12/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-02	2/1/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-02	7/31/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-02	5/1/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-02	10/5/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-02	1/17/2005	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-03	11/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-03	5/13/2003	Nitrogen, Nitrite as N	0.06	mg/L

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-03	2/11/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-03	8/12/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-03	2/1/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-03	7/31/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-03	5/1/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-03	10/5/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-03	1/17/2005	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-04	11/13/2002	Nitrogen, Nitrite as N	0.07	mg/L
311210000020-04	5/13/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-04	2/11/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-04	8/12/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-04	2/1/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-04	7/31/2000	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-04	5/1/2000	Nitrogen, Nitrite as N	0.05	mg/L
311210000020-04	10/5/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311210000020-04	1/17/2005	Nitrogen, Nitrite as N	0.06	mg/L
311210000020-01S	11/1/1999	Nitrogen, Organic	0.63	mg/L
311210000020-01S	2/1/2000	Nitrogen, Organic	0.46	mg/L
311210000020-01S	11/1/1999	Nitrogen, Organic	0.63	mg/L
311210000020-01S	2/1/2000	Nitrogen, Organic	0.46	mg/L
311210000020-01B	11/1/1999	Nitrogen, Organic	0.69	mg/L
311210000020-01B	2/1/2000	Nitrogen, Organic	0.46	mg/L
311210000020-02	11/1/1999	Nitrogen, Organic	0.56	mg/L
311210000020-02	2/1/2000	Nitrogen, Organic	0.63	mg/L
311210000020-03	2/1/2000	Nitrogen, Organic	0.53	mg/L
311210000020-04	2/1/2000	Nitrogen, Organic	0.46	mg/L
311210000020-01S	11/1/1999	Nitrogen, Total	0.63	mg/L
311210000020-01S	2/1/2000	Nitrogen, Total	0.65	mg/L
311210000020-01S	11/1/1999	Nitrogen, Total	0.63	mg/L
311210000020-01S	2/1/2000	Nitrogen, Total	0.65	mg/L
311210000020-01B	11/1/1999	Nitrogen, Total	0.69	mg/L
311210000020-01B	2/1/2000	Nitrogen, Total	0.65	mg/L
311210000020-02	11/1/1999	Nitrogen, Total	0.56	mg/L
311210000020-02	2/1/2000	Nitrogen, Total	0.81	mg/L
311210000020-03	2/1/2000	Nitrogen, Total	0.69	mg/L
311210000020-04	2/1/2000	Nitrogen, Total	0.52	mg/L
311210000020-01B	11/13/2002	Pheophytin A	<0.1	mg/m3
311210000020-01B	2/11/2003	Pheophytin A	4	mg/m3
311210000020-01B	5/13/2003	Pheophytin A	3.4	mg/m3
311210000020-01B	1/17/2005	Pheophytin A	4.89	mg/m3

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-01B	10/5/2004	Pheophytin A	3.5	mg/m3
311210000020-01B	7/11/2005	Pheophytin A	3.89	mg/m3
311210000020-01B	10/2/2007	Pheophytin A	3.24	mg/m3
311210000020-01B	4/2/2008	Pheophytin A	9.89	mg/m3
311210000020-01B	1/7/2008	Pheophytin A	3.29	mg/m3
311210000020-01B	7/3/2008	Pheophytin A	4.97	mg/m3
311210000020-02	11/13/2002	Pheophytin A	5.02	mg/m3
311210000020-02	2/11/2003	Pheophytin A	3	mg/m3
311210000020-02	5/13/2003	Pheophytin A	3.7	mg/m3
311210000020-02	1/17/2005	Pheophytin A	8.81	mg/m3
311210000020-02	10/5/2004	Pheophytin A	4.6	mg/m3
311210000020-02	7/11/2005	Pheophytin A	5.13	mg/m3
311210000020-02	10/2/2007	Pheophytin A	1.25	mg/m3
311210000020-02	4/2/2008	Pheophytin A	5.73	mg/m3
311210000020-02	1/7/2008	Pheophytin A	3.8	mg/m3
311210000020-02	7/3/2008	Pheophytin A	5.08	mg/m3
311210000020-03	11/13/2002	Pheophytin A	5.84	mg/m3
311210000020-03	2/11/2003	Pheophytin A	4.3	mg/m3
311210000020-03	5/13/2003	Pheophytin A	3.4	mg/m3
311210000020-03	1/17/2005	Pheophytin A	5.21	mg/m3
311210000020-03	10/5/2004	Pheophytin A	4.4	mg/m3
311210000020-03	7/11/2005	Pheophytin A	1.87	mg/m3
311210000020-03	4/2/2008	Pheophytin A	7.63	mg/m3
311210000020-03	10/2/2007	Pheophytin A	3.32	mg/m3
311210000020-03	1/7/2008	Pheophytin A	3.86	mg/m3
311210000020-04	11/13/2002	Pheophytin A	5.29	mg/m3
311210000020-04	2/11/2003	Pheophytin A	4.7	mg/m3
311210000020-04	5/13/2003	Pheophytin A	4.7	mg/m3
311210000020-04	1/17/2005	Pheophytin A	1.37	mg/m3
311210000020-04	10/5/2004	Pheophytin A	6.4	mg/m3
311210000020-04	7/11/2005	Pheophytin A	2.54	mg/m3
311210000020-04	4/2/2008	Pheophytin A	10.4	mg/m3
311210000020-04	10/2/2007	Pheophytin A	0.11	mg/m3
311210000020-04	1/7/2008	Pheophytin A	4.33	mg/m3
311210000020-04	7/3/2008	Pheophytin A	3.67	mg/m3
311210000020-01S	11/1/1999	Phosphorous, Ortho	<0.005	mg/L
311210000020-01S	2/1/2000	Phosphorous, Ortho	0.023	mg/L
311210000020-01S	5/1/2000	Phosphorous, Ortho	0.028	mg/L
311210000020-01S	7/31/2000	Phosphorous, Ortho	0.044	mg/L
311210000020-01S	11/13/2002	Phosphorous, Ortho	0.033	mg/L

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-01S	2/11/2003	Phosphorous, Ortho	0.03	mg/L
311210000020-01S	5/13/2003	Phosphorous, Ortho	0.017	mg/L
311210000020-01S	8/12/2003	Phosphorous, Ortho	0.009	mg/L
311210000020-01S	10/5/2004	Phosphorous, Ortho	0.031	mg/L
311210000020-01S	4/20/2005	Phosphorous, Ortho	0.035	mg/L
311210000020-01S	7/11/2005	Phosphorous, Ortho	0.024	mg/L
311210000020-01S	10/2/2007	Phosphorous, Ortho	0.078	mg/L
311210000020-01S	1/7/2008	Phosphorous, Ortho	0.061	mg/L
311210000020-01S	4/2/2008	Phosphorous, Ortho	0.033	mg/L
311210000020-01S	7/2/2008	Phosphorous, Ortho	0.056	mg/L
311210000020-05	11/13/2002	Phosphorous, Ortho	0.057	mg/L
311210000020-05	2/11/2003	Phosphorous, Ortho	0.079	mg/L
311210000020-05	5/13/2003	Phosphorous, Ortho	0.086	mg/L
311210000020-05	8/12/2003	Phosphorous, Ortho	0.075	mg/L
311210000020-05	10/5/2004	Phosphorous, Ortho	0.087	mg/L
311210000020-05	1/17/2005	Phosphorous, Ortho	0.045	mg/L
311210000020-05	4/20/2005	Phosphorous, Ortho	0.053	mg/L
311210000020-05	7/11/2005	Phosphorous, Ortho	0.042	mg/L
311210000020-05	10/2/2007	Phosphorous, Ortho	0.056	mg/L
311210000020-05	1/7/2008	Phosphorous, Ortho	0.053	mg/L
311210000020-05	4/2/2008	Phosphorous, Ortho	0.063	mg/L
311210000020-05	7/2/2008	Phosphorous, Ortho	0.107	mg/L
311210000020-01S	11/1/1999	Phosphorous, Ortho	<0.005	mg/L
311210000020-01S	2/1/2000	Phosphorous, Ortho	0.023	mg/L
311210000020-01S	5/1/2000	Phosphorous, Ortho	0.028	mg/L
311210000020-01S	7/31/2000	Phosphorous, Ortho	0.044	mg/L
311210000020-01S	11/13/2002	Phosphorous, Ortho	0.033	mg/L
311210000020-01S	2/11/2003	Phosphorous, Ortho	0.03	mg/L
311210000020-01S	5/13/2003	Phosphorous, Ortho	0.017	mg/L
311210000020-01S	8/12/2003	Phosphorous, Ortho	0.009	mg/L
311210000020-01S	10/5/2004	Phosphorous, Ortho	0.031	mg/L
311210000020-01S	1/17/2005	Phosphorous, Ortho	0.047	mg/L
311210000020-01S	4/20/2005	Phosphorous, Ortho	0.035	mg/L
311210000020-01S	7/11/2005	Phosphorous, Ortho	0.024	mg/L
311210000020-01S	10/2/2007	Phosphorous, Ortho	0.078	mg/L
311210000020-01S	1/7/2008	Phosphorous, Ortho	0.061	mg/L
311210000020-01S	4/2/2008	Phosphorous, Ortho	0.033	mg/L
311210000020-01S	7/2/2008	Phosphorous, Ortho	0.056	mg/L
311210000020-01B	11/13/2002	Phosphorous, Ortho	0.033	mg/L
311210000020-01B	11/1/1999	Phosphorous, Ortho	0.057	mg/L

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-01B	5/13/2003	Phosphorous, Ortho	0.077	mg/L
311210000020-01B	2/11/2003	Phosphorous, Ortho	0.061	mg/L
311210000020-01B	8/12/2003	Phosphorous, Ortho	0.168	mg/L
311210000020-01B	2/1/2000	Phosphorous, Ortho	0.031	mg/L
311210000020-01B	7/31/2000	Phosphorous, Ortho	0.087	mg/L
311210000020-01B	5/1/2000	Phosphorous, Ortho	0.042	mg/L
311210000020-01B	10/5/2004	Phosphorous, Ortho	0.046	mg/L
311210000020-01B	1/17/2005	Phosphorous, Ortho	0.047	mg/L
311210000020-02	11/13/2002	Phosphorous, Ortho	0.033	mg/L
311210000020-02	11/1/1999	Phosphorous, Ortho	0.041	mg/L
311210000020-02	5/13/2003	Phosphorous, Ortho	0.017	mg/L
311210000020-02	2/11/2003	Phosphorous, Ortho	0.025	mg/L
311210000020-02	8/12/2003	Phosphorous, Ortho	0.01	mg/L
311210000020-02	2/1/2000	Phosphorous, Ortho	0.03	mg/L
311210000020-02	7/31/2000	Phosphorous, Ortho	0.045	mg/L
311210000020-02	5/1/2000	Phosphorous, Ortho	0.017	mg/L
311210000020-02	10/5/2004	Phosphorous, Ortho	0.022	mg/L
311210000020-02	4/20/2005	Phosphorous, Ortho	0.029	mg/L
311210000020-02	1/17/2005	Phosphorous, Ortho	0.045	mg/L
311210000020-02	7/11/2005	Phosphorous, Ortho	0.013	mg/L
311210000020-02	10/2/2007	Phosphorous, Ortho	0.072	mg/L
311210000020-02	1/7/2008	Phosphorous, Ortho	0.058	mg/L
311210000020-02	7/2/2008	Phosphorous, Ortho	0.047	mg/L
311210000020-02	4/2/2008	Phosphorous, Ortho	0.047	mg/L
311210000020-03	11/13/2002	Phosphorous, Ortho	0.029	mg/L
311210000020-03	5/13/2003	Phosphorous, Ortho	0.02	mg/L
311210000020-03	2/11/2003	Phosphorous, Ortho	0.028	mg/L
311210000020-03	8/12/2003	Phosphorous, Ortho	0.017	mg/L
311210000020-03	2/1/2000	Phosphorous, Ortho	0.024	mg/L
311210000020-03	7/31/2000	Phosphorous, Ortho	0.033	mg/L
311210000020-03	5/1/2000	Phosphorous, Ortho	0.014	mg/L
311210000020-03	10/5/2004	Phosphorous, Ortho	0.023	mg/L
311210000020-03	4/20/2005	Phosphorous, Ortho	0.018	mg/L
311210000020-03	1/17/2005	Phosphorous, Ortho	0.047	mg/L
311210000020-03	7/11/2005	Phosphorous, Ortho	0.007	mg/L
311210000020-03	10/2/2007	Phosphorous, Ortho	0.07	mg/L
311210000020-03	1/7/2008	Phosphorous, Ortho	0.049	mg/L
311210000020-03	7/2/2008	Phosphorous, Ortho	0.047	mg/L
311210000020-03	4/2/2008	Phosphorous, Ortho	0.038	mg/L
311210000020-04	11/13/2002	Phosphorous, Ortho	0.055	mg/L

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-04	5/13/2003	Phosphorous, Ortho	0.083	mg/L
311210000020-04	2/11/2003	Phosphorous, Ortho	0.074	mg/L
311210000020-04	8/12/2003	Phosphorous, Ortho	0.073	mg/L
311210000020-04	2/1/2000	Phosphorous, Ortho	0.032	mg/L
311210000020-04	7/31/2000	Phosphorous, Ortho	0.063	mg/L
311210000020-04	5/1/2000	Phosphorous, Ortho	0.049	mg/L
311210000020-04	10/5/2004	Phosphorous, Ortho	0.076	mg/L
311210000020-04	4/20/2005	Phosphorous, Ortho	0.015	mg/L
311210000020-04	1/17/2005	Phosphorous, Ortho	0.191	mg/L
311210000020-04	7/11/2005	Phosphorous, Ortho	0.019	mg/L
311210000020-04	10/2/2007	Phosphorous, Ortho	0.069	mg/L
311210000020-04	1/7/2008	Phosphorous, Ortho	0.049	mg/L
311210000020-04	7/2/2008	Phosphorous, Ortho	0.081	mg/L
311210000020-04	4/2/2008	Phosphorous, Ortho	0.064	mg/L
311210000020-01S	11/1/1999	Phosphorous, Total	0.097	mg/L
311210000020-01S	2/1/2000	Phosphorous, Total	0.071	mg/L
311210000020-01S	5/1/2000	Phosphorous, Total	0.078	mg/L
311210000020-01S	7/31/2000	Phosphorous, Total	0.122	mg/L
311210000020-01S	11/13/2002	Phosphorous, Total	0.048	mg/L
311210000020-01S	2/11/2003	Phosphorous, Total	0.051	mg/L
311210000020-01S	5/13/2003	Phosphorous, Total	0.048	mg/L
311210000020-01S	8/12/2003	Phosphorous, Total	0.062	mg/L
311210000020-01S	10/5/2004	Phosphorous, Total	0.066	mg/L
311210000020-01S	4/20/2005	Phosphorous, Total	0.067	mg/L
311210000020-01S	7/11/2005	Phosphorous, Total	0.076	mg/L
311210000020-01S	10/2/2007	Phosphorous, Total	0.105	mg/L
311210000020-01S	1/7/2008	Phosphorous, Total	0.074	mg/L
311210000020-01S	4/2/2008	Phosphorous, Total	0.067	mg/L
311210000020-01S	7/2/2008	Phosphorous, Total	0.079	mg/L
311210000020-05	11/13/2002	Phosphorous, Total	0.079	mg/L
311210000020-05	2/11/2003	Phosphorous, Total	0.09	mg/L
311210000020-05	5/13/2003	Phosphorous, Total	0.097	mg/L
311210000020-05	8/12/2003	Phosphorous, Total	0.15	mg/L
311210000020-05	10/5/2004	Phosphorous, Total	0.143	mg/L
311210000020-05	1/17/2005	Phosphorous, Total	0.075	mg/L
311210000020-05	4/20/2005	Phosphorous, Total	0.094	mg/L
311210000020-05	7/11/2005	Phosphorous, Total	0.01	mg/L
311210000020-05	10/2/2007	Phosphorous, Total	0.154	mg/L
311210000020-05	1/7/2008	Phosphorous, Total	0.087	mg/L
311210000020-05	4/2/2008	Phosphorous, Total	0.116	mg/L

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-05	7/2/2008	Phosphorous, Total	0.141	mg/L
311210000020-01S	11/1/1999	Phosphorous, Total	0.097	mg/L
311210000020-01S	2/1/2000	Phosphorous, Total	0.071	mg/L
311210000020-01S	5/1/2000	Phosphorous, Total	0.078	mg/L
311210000020-01S	7/31/2000	Phosphorous, Total	0.122	mg/L
311210000020-01S	11/13/2002	Phosphorous, Total	0.048	mg/L
311210000020-01S	2/11/2003	Phosphorous, Total	0.051	mg/L
311210000020-01S	5/13/2003	Phosphorous, Total	0.048	mg/L
311210000020-01S	8/12/2003	Phosphorous, Total	0.062	mg/L
311210000020-01S	10/5/2004	Phosphorous, Total	0.066	mg/L
311210000020-01S	1/17/2005	Phosphorous, Total	0.074	mg/L
311210000020-01S	4/20/2005	Phosphorous, Total	0.067	mg/L
311210000020-01S	7/11/2005	Phosphorous, Total	0.076	mg/L
311210000020-01S	10/2/2007	Phosphorous, Total	0.105	mg/L
311210000020-01S	1/7/2008	Phosphorous, Total	0.074	mg/L
311210000020-01S	4/2/2008	Phosphorous, Total	0.067	mg/L
311210000020-01S	7/2/2008	Phosphorous, Total	0.079	mg/L
311210000020-01B	11/13/2002	Phosphorous, Total	0.059	mg/L
311210000020-01B	11/1/1999	Phosphorous, Total	0.081	mg/L
311210000020-01B	5/13/2003	Phosphorous, Total	0.1	mg/L
311210000020-01B	2/11/2003	Phosphorous, Total	0.122	mg/L
311210000020-01B	8/12/2003	Phosphorous, Total	0.26	mg/L
311210000020-01B	2/1/2000	Phosphorous, Total	0.068	mg/L
311210000020-01B	7/31/2000	Phosphorous, Total	0.142	mg/L
311210000020-01B	5/1/2000	Phosphorous, Total	0.074	mg/L
311210000020-01B	10/5/2004	Phosphorous, Total	0.084	mg/L
311210000020-01B	1/17/2005	Phosphorous, Total	0.075	mg/L
311210000020-02	11/13/2002	Phosphorous, Total	0.048	mg/L
311210000020-02	11/1/1999	Phosphorous, Total	0.085	mg/L
311210000020-02	5/13/2003	Phosphorous, Total	0.047	mg/L
311210000020-02	2/11/2003	Phosphorous, Total	0.049	mg/L
311210000020-02	8/12/2003	Phosphorous, Total	0.064	mg/L
311210000020-02	2/1/2000	Phosphorous, Total	0.069	mg/L
311210000020-02	7/31/2000	Phosphorous, Total	0.111	mg/L
311210000020-02	5/1/2000	Phosphorous, Total	0.061	mg/L
311210000020-02	10/5/2004	Phosphorous, Total	0.065	mg/L
311210000020-02	4/20/2005	Phosphorous, Total	0.071	mg/L
311210000020-02	1/17/2005	Phosphorous, Total	0.076	mg/L
311210000020-02	7/11/2005	Phosphorous, Total	0.074	mg/L
311210000020-02	10/2/2007	Phosphorous, Total	0.094	mg/L

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-02	1/7/2008	Phosphorous, Total	0.075	mg/L
311210000020-02	7/2/2008	Phosphorous, Total	0.071	mg/L
311210000020-02	4/2/2008	Phosphorous, Total	0.063	mg/L
311210000020-03	11/13/2002	Phosphorous, Total	0.045	mg/L
311210000020-03	5/13/2003	Phosphorous, Total	0.05	mg/L
311210000020-03	2/11/2003	Phosphorous, Total	0.055	mg/L
311210000020-03	8/12/2003	Phosphorous, Total	0.084	mg/L
311210000020-03	2/1/2000	Phosphorous, Total	0.065	mg/L
311210000020-03	7/31/2000	Phosphorous, Total	0.12	mg/L
311210000020-03	5/1/2000	Phosphorous, Total	0.069	mg/L
311210000020-03	10/5/2004	Phosphorous, Total	0.072	mg/L
311210000020-03	4/20/2005	Phosphorous, Total	0.072	mg/L
311210000020-03	1/17/2005	Phosphorous, Total	0.077	mg/L
311210000020-03	7/11/2005	Phosphorous, Total	0.052	mg/L
311210000020-03	10/2/2007	Phosphorous, Total	0.105	mg/L
311210000020-03	1/7/2008	Phosphorous, Total	0.074	mg/L
311210000020-03	7/2/2008	Phosphorous, Total	0.071	mg/L
311210000020-03	4/2/2008	Phosphorous, Total	0.066	mg/L
311210000020-04	11/13/2002	Phosphorous, Total	0.071	mg/L
311210000020-04	5/13/2003	Phosphorous, Total	0.095	mg/L
311210000020-04	2/11/2003	Phosphorous, Total	0.084	mg/L
311210000020-04	8/12/2003	Phosphorous, Total	0.126	mg/L
311210000020-04	2/1/2000	Phosphorous, Total	0.087	mg/L
311210000020-04	7/31/2000	Phosphorous, Total	0.227	mg/L
311210000020-04	5/1/2000	Phosphorous, Total	0.113	mg/L
311210000020-04	10/5/2004	Phosphorous, Total	0.122	mg/L
311210000020-04	4/20/2005	Phosphorous, Total	0.068	mg/L
311210000020-04	1/17/2005	Phosphorous, Total	0.223	mg/L
311210000020-04	7/11/2005	Phosphorous, Total	0.073	mg/L
311210000020-04	10/2/2007	Phosphorous, Total	0.131	mg/L
311210000020-04	1/7/2008	Phosphorous, Total	0.078	mg/L
311210000020-04	7/2/2008	Phosphorous, Total	0.112	mg/L
311210000020-04	4/2/2008	Phosphorous, Total	0.13	mg/L
311210000020-01S	7/11/2005	Secchi Depth	120	cm
311210000020-05	10/5/2004	Secchi Depth	26	cm
311210000020-05	1/17/2005	Secchi Depth	60	cm
311210000020-05	4/20/2005	Secchi Depth	40	cm
311210000020-05	7/11/2005	Secchi Depth	34	cm
311210000020-01S	10/5/2004	Secchi Depth	95	cm
311210000020-01S	1/17/2005	Secchi Depth	64	cm

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-01S	4/20/2005	Secchi Depth	70	cm
311210000020-01S	7/11/2005	Secchi Depth	120	cm
311210000020-01B	10/5/2004	Secchi Depth	95	cm
311210000020-01B	1/17/2005	Secchi Depth	64	cm
311210000020-02	10/5/2004	Secchi Depth	79	cm
311210000020-02	4/20/2005	Secchi Depth	50	cm
311210000020-02	1/17/2005	Secchi Depth	65	cm
311210000020-02	7/11/2005	Secchi Depth	83	cm
311210000020-03	10/5/2004	Secchi Depth	68	cm
311210000020-03	4/20/2005	Secchi Depth	60	cm
311210000020-03	1/17/2005	Secchi Depth	60	cm
311210000020-03	7/11/2005	Secchi Depth	64	cm
311210000020-04	10/5/2004	Secchi Depth	32	cm
311210000020-04	4/20/2005	Secchi Depth	50	cm
311210000020-04	1/17/2005	Secchi Depth	15	cm
311210000020-04	7/11/2005	Secchi Depth	54	cm
311210000020-01S	11/1/1999	Solids, Suspended	12	mg/L
311210000020-01S	2/1/2000	Solids, Suspended	7	mg/L
311210000020-01S	5/1/2000	Solids, Suspended	12	mg/L
311210000020-01S	7/31/2000	Solids, Suspended	18	mg/L
311210000020-01S	11/1/1999	Solids, Suspended	12	mg/L
311210000020-01S	2/1/2000	Solids, Suspended	7	mg/L
311210000020-01S	5/1/2000	Solids, Suspended	12	mg/L
311210000020-01S	7/31/2000	Solids, Suspended	18	mg/L
311210000020-01B	11/1/1999	Solids, Suspended	28	mg/L
311210000020-01B	2/1/2000	Solids, Suspended	5	mg/L
311210000020-01B	7/31/2000	Solids, Suspended	14	mg/L
311210000020-01B	5/1/2000	Solids, Suspended	12	mg/L
311210000020-02	11/1/1999	Solids, Suspended	26	mg/L
311210000020-02	2/1/2000	Solids, Suspended	4	mg/L
311210000020-02	7/31/2000	Solids, Suspended	12	mg/L
311210000020-02	5/1/2000	Solids, Suspended	8	mg/L
311210000020-03	2/1/2000	Solids, Suspended	3	mg/L
311210000020-03	7/31/2000	Solids, Suspended	16	mg/L
311210000020-03	5/1/2000	Solids, Suspended	14	mg/L
311210000020-04	2/1/2000	Solids, Suspended	11	mg/L
311210000020-04	7/31/2000	Solids, Suspended	26	mg/L
311210000020-04	5/1/2000	Solids, Suspended	21	mg/L
311210000020-01S	4/20/2005	Turbidity, Field	10	NTU
311210000020-01S	7/11/2005	Turbidity, Field	5	NTU

Waurika Lake WQM Station	Date	Parameter	Value	Units
311210000020-05	10/5/2004	Turbidity, Field	61	NTU
311210000020-05	1/17/2005	Turbidity, Field	11	NTU
311210000020-05	4/20/2005	Turbidity, Field	32	NTU
311210000020-05	7/11/2005	Turbidity, Field	21	NTU
311210000020-01S	10/5/2004	Turbidity, Field	10	NTU
311210000020-01S	1/17/2005	Turbidity, Field	14	NTU
311210000020-01S	4/20/2005	Turbidity, Field	10	NTU
311210000020-01S	7/11/2005	Turbidity, Field	5	NTU
311210000020-01B	10/5/2004	Turbidity, Field	10	NTU
311210000020-01B	1/17/2005	Turbidity, Field	14	NTU
311210000020-02	10/5/2004	Turbidity, Field	9	NTU
311210000020-02	4/20/2005	Turbidity, Field	17	NTU
311210000020-02	1/17/2005	Turbidity, Field	10	NTU
311210000020-02	7/11/2005	Turbidity, Field	8	NTU
311210000020-03	10/5/2004	Turbidity, Field	13	NTU
311210000020-03	4/20/2005	Turbidity, Field	15	NTU
311210000020-03	1/17/2005	Turbidity, Field	13	NTU
311210000020-03	7/11/2005	Turbidity, Field	11	NTU
311210000020-04	10/5/2004	Turbidity, Field	47	NTU
311210000020-04	4/20/2005	Turbidity, Field	18	NTU
311210000020-04	1/17/2005	Turbidity, Field	94	NTU
311210000020-04	7/11/2005	Turbidity, Field	13	NTU

Appendix B, Table-3: Ambient Water Quality Data for Lake Ellsworth, 1998-2009

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-01B	8/12/2002	Corrected Chlorophyll-a	10.51	mg/m3
311300030020-01B	4/14/2004	Corrected Chlorophyll-a	3.2	mg/m3
311300030020-01B	7/14/2004	Corrected Chlorophyll-a	16	mg/m3
311300030020-01B	10/25/2006	Corrected Chlorophyll-a	15.2	mg/m3
311300030020-01B	4/30/2007	Corrected Chlorophyll-a	4.81	mg/m3
311300030020-01B	7/25/2007	Corrected Chlorophyll-a	21.93	mg/m3
311300030020-01B	10/29/2008	Corrected Chlorophyll-a	7.45	mg/m3
311300030020-01S	8/12/2002	Corrected Chlorophyll-a	10.31	mg/m3
311300030020-01S	10/22/2003	Corrected Chlorophyll-a	6.1	mg/m3
311300030020-01S	10/22/2003	Corrected Chlorophyll-a	6.3	mg/m3
311300030020-01S	1/14/2004	Corrected Chlorophyll-a	8.6	mg/m3
311300030020-01S	1/14/2004	Corrected Chlorophyll-a	8.5	mg/m3
311300030020-01S	1/14/2004	Corrected Chlorophyll-a	8.2	mg/m3
311300030020-01S	4/14/2004	Corrected Chlorophyll-a	3.8	mg/m3
311300030020-01S	4/14/2004	Corrected Chlorophyll-a	4.1	mg/m3
311300030020-01S	7/14/2004	Corrected Chlorophyll-a	9.9	mg/m3
311300030020-01S	7/14/2004	Corrected Chlorophyll-a	12.9	mg/m3
311300030020-01S	10/25/2006	Corrected Chlorophyll-a	16.2	mg/m3
311300030020-01S	10/25/2006	Corrected Chlorophyll-a	11	mg/m3
311300030020-01S	4/30/2007	Corrected Chlorophyll-a	6.5	mg/m3
311300030020-01S	4/30/2007	Corrected Chlorophyll-a	<0.1	mg/m3
311300030020-01S	7/25/2007	Corrected Chlorophyll-a	18.4	mg/m3
311300030020-01S	7/25/2007	Corrected Chlorophyll-a	6.97	mg/m3
311300030020-01S	7/25/2007	Corrected Chlorophyll-a	16.59	mg/m3
311300030020-01S	10/29/2008	Corrected Chlorophyll-a	6.39	mg/m3
311300030020-01S	10/29/2008	Corrected Chlorophyll-a	7.45	mg/m3
311300030020-02	8/12/2002	Corrected Chlorophyll-a	16.49	mg/m3
311300030020-02	10/22/2003	Corrected Chlorophyll-a	4.8	mg/m3
311300030020-02	1/14/2004	Corrected Chlorophyll-a	4.8	mg/m3
311300030020-02	4/14/2004	Corrected Chlorophyll-a	<0.1	mg/m3
311300030020-02	7/14/2004	Corrected Chlorophyll-a	21.9	mg/m3
311300030020-02	10/25/2006	Corrected Chlorophyll-a	24.3	mg/m3
311300030020-02	1/30/2007	Corrected Chlorophyll-a	4.89	mg/m3
311300030020-02	4/30/2007	Corrected Chlorophyll-a	10.5	mg/m3
311300030020-02	7/25/2007	Corrected Chlorophyll-a	19.71	mg/m3
311300030020-02	10/29/2008	Corrected Chlorophyll-a	8.74	mg/m3
311300030020-02	2/2/2009	Corrected Chlorophyll-a	8.52	mg/m3
311300030020-02	8/4/2009	Corrected Chlorophyll-a	18.5	mg/m3
311300030020-03	8/12/2002	Corrected Chlorophyll-a	14.54	mg/m3

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-03	10/22/2003	Corrected Chlorophyll-a	15.2	mg/m3
311300030020-03	1/14/2004	Corrected Chlorophyll-a	6.8	mg/m3
311300030020-03	4/14/2004	Corrected Chlorophyll-a	2.6	mg/m3
311300030020-03	7/14/2004	Corrected Chlorophyll-a	38.2	mg/m3
311300030020-03	10/25/2006	Corrected Chlorophyll-a	28.8	mg/m3
311300030020-03	1/30/2007	Corrected Chlorophyll-a	4.34	mg/m3
311300030020-03	4/30/2007	Corrected Chlorophyll-a	14	mg/m3
311300030020-03	7/25/2007	Corrected Chlorophyll-a	21.44	mg/m3
311300030020-03	10/29/2008	Corrected Chlorophyll-a	13.6	mg/m3
311300030020-03	2/2/2009	Corrected Chlorophyll-a	7.95	mg/m3
311300030020-03	8/4/2009	Corrected Chlorophyll-a	18.8	mg/m3
311300030020-04	8/12/2002	Corrected Chlorophyll-a	14.9	mg/m3
311300030020-04	10/22/2003	Corrected Chlorophyll-a	5.6	mg/m3
311300030020-04	1/14/2004	Corrected Chlorophyll-a	5.1	mg/m3
311300030020-04	4/14/2004	Corrected Chlorophyll-a	4.6	mg/m3
311300030020-04	7/14/2004	Corrected Chlorophyll-a	16.4	mg/m3
311300030020-04	10/25/2006	Corrected Chlorophyll-a	23.5	mg/m3
311300030020-04	1/30/2007	Corrected Chlorophyll-a	4.26	mg/m3
311300030020-04	4/30/2007	Corrected Chlorophyll-a	11.2	mg/m3
311300030020-04	10/29/2008	Corrected Chlorophyll-a	12.5	mg/m3
311300030020-04	2/2/2009	Corrected Chlorophyll-a	7.91	mg/m3
311300030020-04	8/4/2009	Corrected Chlorophyll-a	21.6	mg/m3
311300030020-05	8/12/2002	Corrected Chlorophyll-a	15.17	mg/m3
311300030020-05	10/22/2003	Corrected Chlorophyll-a	11.1	mg/m3
311300030020-05	1/14/2004	Corrected Chlorophyll-a	5.5	mg/m3
311300030020-05	4/14/2004	Corrected Chlorophyll-a	4.2	mg/m3
311300030020-05	7/14/2004	Corrected Chlorophyll-a	32.6	mg/m3
311300030020-05	10/25/2006	Corrected Chlorophyll-a	22	mg/m3
311300030020-05	1/30/2007	Corrected Chlorophyll-a	4.1	mg/m3
311300030020-05	4/30/2007	Corrected Chlorophyll-a	17.5	mg/m3
311300030020-05	7/25/2007	Corrected Chlorophyll-a	20.02	mg/m3
311300030020-05	10/29/2008	Corrected Chlorophyll-a	9.67	mg/m3
311300030020-05	2/2/2009	Corrected Chlorophyll-a	7.56	mg/m3
311300030020-05	8/4/2009	Corrected Chlorophyll-a	20.7	mg/m3
311300030020-01B	4/15/1998	Nitrogen, Ammonia	0.09	mg/L
311300030020-01B	7/8/1998	Nitrogen, Ammonia	0.41	mg/L
311300030020-01B	1/6/1999	Nitrogen, Ammonia	0.16	mg/L
311300030020-01B	4/12/1999	Nitrogen, Ammonia	0.08	mg/L
311300030020-01B	7/7/1999	Nitrogen, Ammonia	0.16	mg/L
311300030020-01B	2/11/2002	Nitrogen, Ammonia	<0.05	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-01B	5/15/2002	Nitrogen, Ammonia	0.07	mg/L
311300030020-01B	8/12/2002	Nitrogen, Ammonia	0.39	mg/L
311300030020-01B	10/22/2003	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01B	1/14/2004	Nitrogen, Ammonia	0.05	mg/L
311300030020-01B	4/14/2004	Nitrogen, Ammonia	0.08	mg/L
311300030020-01B	7/14/2004	Nitrogen, Ammonia	0.39	mg/L
311300030020-01S	4/15/1998	Nitrogen, Ammonia	0.06	mg/L
311300030020-01S	4/15/1998	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	4/15/1998	Nitrogen, Ammonia	0.1	mg/L
311300030020-01S	7/8/1998	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	7/8/1998	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	1/6/1999	Nitrogen, Ammonia	0.12	mg/L
311300030020-01S	1/6/1999	Nitrogen, Ammonia	0.27	mg/L
311300030020-01S	4/12/1999	Nitrogen, Ammonia	0.05	mg/L
311300030020-01S	4/12/1999	Nitrogen, Ammonia	0.18	mg/L
311300030020-01S	7/7/1999	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	7/7/1999	Nitrogen, Ammonia	0.07	mg/L
311300030020-01S	7/7/1999	Nitrogen, Ammonia	0.08	mg/L
311300030020-01S	11/7/2001	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	11/7/2001	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	2/11/2002	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	2/11/2002	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	5/13/2002	Nitrogen, Ammonia	0.08	mg/L
311300030020-01S	5/13/2002	Nitrogen, Ammonia	0.08	mg/L
311300030020-01S	8/12/2002	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	8/12/2002	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	8/12/2002	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	10/22/2003	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	10/22/2003	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	1/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	1/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300030020-01S	4/14/2004	Nitrogen, Ammonia	0.09	mg/L
311300030020-01S	4/14/2004	Nitrogen, Ammonia	0.08	mg/L
311300030020-01S	7/14/2004	Nitrogen, Ammonia	0.05	mg/L
311300030020-01S	7/14/2004	Nitrogen, Ammonia	0.05	mg/L
311300030020-02	4/15/1998	Nitrogen, Ammonia	0.1	mg/L
311300030020-02	4/15/1998	Nitrogen, Ammonia	0.09	mg/L
311300030020-02	7/8/1998	Nitrogen, Ammonia	<0.05	mg/L
311300030020-02	1/6/1999	Nitrogen, Ammonia	0.12	mg/L
311300030020-02	4/12/1999	Nitrogen, Ammonia	<0.05	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-02	7/7/1999	Nitrogen, Ammonia	<0.05	mg/L
311300030020-02	11/7/2001	Nitrogen, Ammonia	<0.05	mg/L
311300030020-02	2/11/2002	Nitrogen, Ammonia	<0.05	mg/L
311300030020-02	5/13/2002	Nitrogen, Ammonia	0.08	mg/L
311300030020-02	8/12/2002	Nitrogen, Ammonia	<0.05	mg/L
311300030020-02	10/22/2003	Nitrogen, Ammonia	<0.05	mg/L
311300030020-02	1/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300030020-02	4/14/2004	Nitrogen, Ammonia	0.08	mg/L
311300030020-02	7/14/2004	Nitrogen, Ammonia	0.05	mg/L
311300030020-03	4/15/1998	Nitrogen, Ammonia	0.07	mg/L
311300030020-03	7/8/1998	Nitrogen, Ammonia	<0.05	mg/L
311300030020-03	1/6/1999	Nitrogen, Ammonia	0.21	mg/L
311300030020-03	4/12/1999	Nitrogen, Ammonia	<0.05	mg/L
311300030020-03	7/7/1999	Nitrogen, Ammonia	<0.05	mg/L
311300030020-03	11/7/2001	Nitrogen, Ammonia	<0.05	mg/L
311300030020-03	2/11/2002	Nitrogen, Ammonia	<0.05	mg/L
311300030020-03	5/13/2002	Nitrogen, Ammonia	0.08	mg/L
311300030020-03	8/12/2002	Nitrogen, Ammonia	<0.05	mg/L
311300030020-03	10/22/2003	Nitrogen, Ammonia	<0.05	mg/L
311300030020-03	1/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300030020-03	4/14/2004	Nitrogen, Ammonia	0.09	mg/L
311300030020-03	7/14/2004	Nitrogen, Ammonia	0.06	mg/L
311300030020-04	11/7/2001	Nitrogen, Ammonia	<0.05	mg/L
311300030020-04	2/11/2002	Nitrogen, Ammonia	<0.05	mg/L
311300030020-04	5/13/2002	Nitrogen, Ammonia	0.08	mg/L
311300030020-04	8/12/2002	Nitrogen, Ammonia	<0.05	mg/L
311300030020-04	10/22/2003	Nitrogen, Ammonia	<0.05	mg/L
311300030020-04	1/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300030020-04	4/14/2004	Nitrogen, Ammonia	0.07	mg/L
311300030020-04	7/14/2004	Nitrogen, Ammonia	0.05	mg/L
311300030020-05	11/7/2001	Nitrogen, Ammonia	<0.05	mg/L
311300030020-05	2/11/2002	Nitrogen, Ammonia	<0.05	mg/L
311300030020-05	5/13/2002	Nitrogen, Ammonia	0.08	mg/L
311300030020-05	8/12/2002	Nitrogen, Ammonia	<0.05	mg/L
311300030020-05	10/22/2003	Nitrogen, Ammonia	<0.05	mg/L
311300030020-05	1/14/2004	Nitrogen, Ammonia	<0.05	mg/L
311300030020-05	4/14/2004	Nitrogen, Ammonia	0.08	mg/L
311300030020-05	7/14/2004	Nitrogen, Ammonia	0.05	mg/L
311300030020-01B	4/15/1998	Nitrogen, Kjeldahl	0.84	mg/L
311300030020-01B	7/8/1998	Nitrogen, Kjeldahl	R0	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-01B	1/6/1999	Nitrogen, Kjeldahl	0.34	mg/L
311300030020-01B	4/12/1999	Nitrogen, Kjeldahl	0.36	mg/L
311300030020-01B	7/7/1999	Nitrogen, Kjeldahl	0.55	mg/L
311300030020-01B	2/11/2002	Nitrogen, Kjeldahl	0.57	mg/L
311300030020-01B	5/15/2002	Nitrogen, Kjeldahl	0.62	mg/L
311300030020-01B	8/12/2002	Nitrogen, Kjeldahl	0.74	mg/L
311300030020-01B	10/22/2003	Nitrogen, Kjeldahl	0.53	mg/L
311300030020-01B	1/14/2004	Nitrogen, Kjeldahl	0.49	mg/L
311300030020-01B	4/14/2004	Nitrogen, Kjeldahl	0.48	mg/L
311300030020-01B	7/14/2004	Nitrogen, Kjeldahl	0.97	mg/L
311300030020-01S	4/15/1998	Nitrogen, Kjeldahl	0.7	mg/L
311300030020-01S	4/15/1998	Nitrogen, Kjeldahl	0.2	mg/L
311300030020-01S	4/15/1998	Nitrogen, Kjeldahl	0.84	mg/L
311300030020-01S	7/8/1998	Nitrogen, Kjeldahl	R0	mg/L
311300030020-01S	7/8/1998	Nitrogen, Kjeldahl	R0	mg/L
311300030020-01S	1/6/1999	Nitrogen, Kjeldahl	0.36	mg/L
311300030020-01S	1/6/1999	Nitrogen, Kjeldahl	0.42	mg/L
311300030020-01S	4/12/1999	Nitrogen, Kjeldahl	0.39	mg/L
311300030020-01S	4/12/1999	Nitrogen, Kjeldahl	0.39	mg/L
311300030020-01S	7/7/1999	Nitrogen, Kjeldahl	0.52	mg/L
311300030020-01S	7/7/1999	Nitrogen, Kjeldahl	0.58	mg/L
311300030020-01S	7/7/1999	Nitrogen, Kjeldahl	0.55	mg/L
311300030020-01S	11/7/2001	Nitrogen, Kjeldahl	0.26	mg/L
311300030020-01S	11/7/2001	Nitrogen, Kjeldahl	0.28	mg/L
311300030020-01S	2/11/2002	Nitrogen, Kjeldahl	0.57	mg/L
311300030020-01S	2/11/2002	Nitrogen, Kjeldahl	0.57	mg/L
311300030020-01S	5/13/2002	Nitrogen, Kjeldahl	0.41	mg/L
311300030020-01S	5/13/2002	Nitrogen, Kjeldahl	0.44	mg/L
311300030020-01S	8/12/2002	Nitrogen, Kjeldahl	0.46	mg/L
311300030020-01S	8/12/2002	Nitrogen, Kjeldahl	0.49	mg/L
311300030020-01S	8/12/2002	Nitrogen, Kjeldahl	0.4	mg/L
311300030020-01S	10/22/2003	Nitrogen, Kjeldahl	0.62	mg/L
311300030020-01S	10/22/2003	Nitrogen, Kjeldahl	0.53	mg/L
311300030020-01S	1/14/2004	Nitrogen, Kjeldahl	0.68	mg/L
311300030020-01S	1/14/2004	Nitrogen, Kjeldahl	0.62	mg/L
311300030020-01S	4/14/2004	Nitrogen, Kjeldahl	0.37	mg/L
311300030020-01S	4/14/2004	Nitrogen, Kjeldahl	0.41	mg/L
311300030020-01S	7/14/2004	Nitrogen, Kjeldahl	<0.05	mg/L
311300030020-01S	7/14/2004	Nitrogen, Kjeldahl	0.53	mg/L
311300030020-01S	10/25/2006	Nitrogen, Kjeldahl	0.68	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-01S	10/25/2006	Nitrogen, Kjeldahl	1.01	mg/L
311300030020-01S	1/30/2007	Nitrogen, Kjeldahl	0.77	mg/L
311300030020-01S	1/30/2007	Nitrogen, Kjeldahl	0.75	mg/L
311300030020-01S	7/25/2007	Nitrogen, Kjeldahl	0.67	mg/L
311300030020-01S	7/25/2007	Nitrogen, Kjeldahl	0.58	mg/L
311300030020-01S	10/29/2008	Nitrogen, Kjeldahl	0.56	mg/L
311300030020-01S	10/29/2008	Nitrogen, Kjeldahl	0.54	mg/L
311300030020-01S	2/2/2009	Nitrogen, Kjeldahl	0.62	mg/L
311300030020-02	4/15/1998	Nitrogen, Kjeldahl	0.67	mg/L
311300030020-02	4/15/1998	Nitrogen, Kjeldahl	0.67	mg/L
311300030020-02	7/8/1998	Nitrogen, Kjeldahl	R0	mg/L
311300030020-02	1/6/1999	Nitrogen, Kjeldahl	0.29	mg/L
311300030020-02	4/12/1999	Nitrogen, Kjeldahl	0.41	mg/L
311300030020-02	7/7/1999	Nitrogen, Kjeldahl	0.63	mg/L
311300030020-02	11/7/2001	Nitrogen, Kjeldahl	0.36	mg/L
311300030020-02	2/11/2002	Nitrogen, Kjeldahl	0.55	mg/L
311300030020-02	5/13/2002	Nitrogen, Kjeldahl	0.42	mg/L
311300030020-02	8/12/2002	Nitrogen, Kjeldahl	0.54	mg/L
311300030020-02	10/22/2003	Nitrogen, Kjeldahl	0.6	mg/L
311300030020-02	1/14/2004	Nitrogen, Kjeldahl	0.52	mg/L
311300030020-02	4/14/2004	Nitrogen, Kjeldahl	0.29	mg/L
311300030020-02	7/14/2004	Nitrogen, Kjeldahl	0.98	mg/L
311300030020-02	10/25/2006	Nitrogen, Kjeldahl	0.76	mg/L
311300030020-02	1/30/2007	Nitrogen, Kjeldahl	0.8	mg/L
311300030020-02	4/30/2007	Nitrogen, Kjeldahl	0.65	mg/L
311300030020-02	7/25/2007	Nitrogen, Kjeldahl	0.57	mg/L
311300030020-02	10/29/2008	Nitrogen, Kjeldahl	0.56	mg/L
311300030020-02	2/2/2009	Nitrogen, Kjeldahl	0.57	mg/L
311300030020-02	5/5/2009	Nitrogen, Kjeldahl	0.7	mg/L
311300030020-03	4/15/1998	Nitrogen, Kjeldahl	0.67	mg/L
311300030020-03	7/8/1998	Nitrogen, Kjeldahl	R0	mg/L
311300030020-03	1/6/1999	Nitrogen, Kjeldahl	0.31	mg/L
311300030020-03	4/12/1999	Nitrogen, Kjeldahl	0.29	mg/L
311300030020-03	7/7/1999	Nitrogen, Kjeldahl	0.56	mg/L
311300030020-03	11/7/2001	Nitrogen, Kjeldahl	0.38	mg/L
311300030020-03	2/11/2002	Nitrogen, Kjeldahl	0.58	mg/L
311300030020-03	5/13/2002	Nitrogen, Kjeldahl	0.75	mg/L
311300030020-03	8/12/2002	Nitrogen, Kjeldahl	0.37	mg/L
311300030020-03	10/22/2003	Nitrogen, Kjeldahl	0.93	mg/L
311300030020-03	1/14/2004	Nitrogen, Kjeldahl	0.68	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-03	4/14/2004	Nitrogen, Kjeldahl	0.39	mg/L
311300030020-03	7/14/2004	Nitrogen, Kjeldahl	1.25	mg/L
311300030020-03	10/25/2006	Nitrogen, Kjeldahl	1.13	mg/L
311300030020-03	1/30/2007	Nitrogen, Kjeldahl	0.75	mg/L
311300030020-03	4/30/2007	Nitrogen, Kjeldahl	0.67	mg/L
311300030020-03	7/25/2007	Nitrogen, Kjeldahl	0.65	mg/L
311300030020-03	10/29/2008	Nitrogen, Kjeldahl	0.61	mg/L
311300030020-03	2/2/2009	Nitrogen, Kjeldahl	0.59	mg/L
311300030020-03	5/5/2009	Nitrogen, Kjeldahl	0.72	mg/L
311300030020-04	11/7/2001	Nitrogen, Kjeldahl	0.35	mg/L
311300030020-04	2/11/2002	Nitrogen, Kjeldahl	0.59	mg/L
311300030020-04	5/13/2002	Nitrogen, Kjeldahl	0.42	mg/L
311300030020-04	8/12/2002	Nitrogen, Kjeldahl	0.48	mg/L
311300030020-04	10/22/2003	Nitrogen, Kjeldahl	0.66	mg/L
311300030020-04	1/14/2004	Nitrogen, Kjeldahl	0.63	mg/L
311300030020-04	4/14/2004	Nitrogen, Kjeldahl	0.32	mg/L
311300030020-04	7/14/2004	Nitrogen, Kjeldahl	0.7	mg/L
311300030020-04	10/25/2006	Nitrogen, Kjeldahl	0.72	mg/L
311300030020-04	1/30/2007	Nitrogen, Kjeldahl	0.85	mg/L
311300030020-04	4/30/2007	Nitrogen, Kjeldahl	0.69	mg/L
311300030020-04	7/25/2007	Nitrogen, Kjeldahl	0.63	mg/L
311300030020-04	10/29/2008	Nitrogen, Kjeldahl	0.62	mg/L
311300030020-04	2/2/2009	Nitrogen, Kjeldahl	0.59	mg/L
311300030020-04	5/5/2009	Nitrogen, Kjeldahl	0.69	mg/L
311300030020-05	11/7/2001	Nitrogen, Kjeldahl	0.39	mg/L
311300030020-05	2/11/2002	Nitrogen, Kjeldahl	0.56	mg/L
311300030020-05	5/13/2002	Nitrogen, Kjeldahl	0.48	mg/L
311300030020-05	8/12/2002	Nitrogen, Kjeldahl	0.4	mg/L
311300030020-05	10/22/2003	Nitrogen, Kjeldahl	0.88	mg/L
311300030020-05	1/14/2004	Nitrogen, Kjeldahl	0.63	mg/L
311300030020-05	4/14/2004	Nitrogen, Kjeldahl	0.3	mg/L
311300030020-05	7/14/2004	Nitrogen, Kjeldahl	1	mg/L
311300030020-05	10/25/2006	Nitrogen, Kjeldahl	0.99	mg/L
311300030020-05	1/30/2007	Nitrogen, Kjeldahl	0.79	mg/L
311300030020-05	4/30/2007	Nitrogen, Kjeldahl	0.7	mg/L
311300030020-05	7/25/2007	Nitrogen, Kjeldahl	0.59	mg/L
311300030020-05	10/29/2008	Nitrogen, Kjeldahl	0.6	mg/L
311300030020-05	2/2/2009	Nitrogen, Kjeldahl	0.56	mg/L
311300030020-05	5/5/2009	Nitrogen, Kjeldahl	0.69	mg/L
311300030020-01B	4/15/1998	Nitrogen, Nitrate as N	0.55	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-01B	7/8/1998	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-01B	1/6/1999	Nitrogen, Nitrate as N	0.45	mg/L
311300030020-01B	4/12/1999	Nitrogen, Nitrate as N	0.54	mg/L
311300030020-01B	7/7/1999	Nitrogen, Nitrate as N	0.28	mg/L
311300030020-01B	2/11/2002	Nitrogen, Nitrate as N	0.05	mg/L
311300030020-01B	5/15/2002	Nitrogen, Nitrate as N	0.15	mg/L
311300030020-01B	8/12/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-01B	10/22/2003	Nitrogen, Nitrate as N	0.18	mg/L
311300030020-01B	1/14/2004	Nitrogen, Nitrate as N	0.32	mg/L
311300030020-01B	4/14/2004	Nitrogen, Nitrate as N	0.23	mg/L
311300030020-01B	7/14/2004	Nitrogen, Nitrate as N	0.07	mg/L
311300030020-01S	4/15/1998	Nitrogen, Nitrate as N	0.55	mg/L
311300030020-01S	4/15/1998	Nitrogen, Nitrate as N	0.06	mg/L
311300030020-01S	4/15/1998	Nitrogen, Nitrate as N	0.56	mg/L
311300030020-01S	7/8/1998	Nitrogen, Nitrate as N	0.13	mg/L
311300030020-01S	7/8/1998	Nitrogen, Nitrate as N	0.11	mg/L
311300030020-01S	1/6/1999	Nitrogen, Nitrate as N	0.46	mg/L
311300030020-01S	1/6/1999	Nitrogen, Nitrate as N	0.23	mg/L
311300030020-01S	4/12/1999	Nitrogen, Nitrate as N	0.54	mg/L
311300030020-01S	4/12/1999	Nitrogen, Nitrate as N	0.54	mg/L
311300030020-01S	7/7/1999	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-01S	7/7/1999	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-01S	7/7/1999	Nitrogen, Nitrate as N	0.2	mg/L
311300030020-01S	11/7/2001	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-01S	11/7/2001	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-01S	2/11/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-01S	2/11/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-01S	5/13/2002	Nitrogen, Nitrate as N	0.14	mg/L
311300030020-01S	5/13/2002	Nitrogen, Nitrate as N	0.14	mg/L
311300030020-01S	8/12/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-01S	8/12/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-01S	8/12/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-01S	10/22/2003	Nitrogen, Nitrate as N	0.17	mg/L
311300030020-01S	10/22/2003	Nitrogen, Nitrate as N	0.17	mg/L
311300030020-01S	1/14/2004	Nitrogen, Nitrate as N	0.27	mg/L
311300030020-01S	1/14/2004	Nitrogen, Nitrate as N	0.27	mg/L
311300030020-01S	4/14/2004	Nitrogen, Nitrate as N	0.21	mg/L
311300030020-01S	4/14/2004	Nitrogen, Nitrate as N	0.22	mg/L
311300030020-01S	7/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-01S	7/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-02	4/15/1998	Nitrogen, Nitrate as N	0.53	mg/L
311300030020-02	4/15/1998	Nitrogen, Nitrate as N	0.57	mg/L
311300030020-02	7/8/1998	Nitrogen, Nitrate as N	0.05	mg/L
311300030020-02	1/6/1999	Nitrogen, Nitrate as N	0.49	mg/L
311300030020-02	4/12/1999	Nitrogen, Nitrate as N	0.57	mg/L
311300030020-02	7/7/1999	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-02	11/7/2001	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-02	2/11/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-02	5/13/2002	Nitrogen, Nitrate as N	0.13	mg/L
311300030020-02	8/12/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-02	10/22/2003	Nitrogen, Nitrate as N	0.13	mg/L
311300030020-02	1/14/2004	Nitrogen, Nitrate as N	0.32	mg/L
311300030020-02	4/14/2004	Nitrogen, Nitrate as N	0.21	mg/L
311300030020-02	7/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-03	4/15/1998	Nitrogen, Nitrate as N	0.61	mg/L
311300030020-03	7/8/1998	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-03	1/6/1999	Nitrogen, Nitrate as N	0.49	mg/L
311300030020-03	4/12/1999	Nitrogen, Nitrate as N	0.56	mg/L
311300030020-03	7/7/1999	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-03	11/7/2001	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-03	2/11/2002	Nitrogen, Nitrate as N	0.05	mg/L
311300030020-03	5/13/2002	Nitrogen, Nitrate as N	0.14	mg/L
311300030020-03	8/12/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-03	10/22/2003	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-03	1/14/2004	Nitrogen, Nitrate as N	0.29	mg/L
311300030020-03	4/14/2004	Nitrogen, Nitrate as N	0.2	mg/L
311300030020-03	7/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-04	11/7/2001	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-04	2/11/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-04	5/13/2002	Nitrogen, Nitrate as N	0.12	mg/L
311300030020-04	8/12/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-04	10/22/2003	Nitrogen, Nitrate as N	0.13	mg/L
311300030020-04	1/14/2004	Nitrogen, Nitrate as N	0.28	mg/L
311300030020-04	4/14/2004	Nitrogen, Nitrate as N	0.2	mg/L
311300030020-04	7/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-05	11/7/2001	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-05	2/11/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-05	5/13/2002	Nitrogen, Nitrate as N	0.13	mg/L
311300030020-05	8/12/2002	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-05	10/22/2003	Nitrogen, Nitrate as N	0.06	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-05	1/14/2004	Nitrogen, Nitrate as N	0.3	mg/L
311300030020-05	4/14/2004	Nitrogen, Nitrate as N	0.2	mg/L
311300030020-05	7/14/2004	Nitrogen, Nitrate as N	<0.05	mg/L
311300030020-01S	10/25/2006	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300030020-01S	10/25/2006	Nitrogen, Nitrate/Nitrite as N	0.19	mg/L
311300030020-01S	1/30/2007	Nitrogen, Nitrate/Nitrite as N	0.15	mg/L
311300030020-01S	1/30/2007	Nitrogen, Nitrate/Nitrite as N	0.15	mg/L
311300030020-01S	7/25/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300030020-01S	7/25/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300030020-01S	10/29/2008	Nitrogen, Nitrate/Nitrite as N	0.19	mg/L
311300030020-01S	10/29/2008	Nitrogen, Nitrate/Nitrite as N	0.19	mg/L
311300030020-01S	2/2/2009	Nitrogen, Nitrate/Nitrite as N	0.28	mg/L
311300030020-02	10/25/2006	Nitrogen, Nitrate/Nitrite as N	0.12	mg/L
311300030020-02	1/30/2007	Nitrogen, Nitrate/Nitrite as N	0.14	mg/L
311300030020-02	4/30/2007	Nitrogen, Nitrate/Nitrite as N	0.27	mg/L
311300030020-02	7/25/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300030020-02	10/29/2008	Nitrogen, Nitrate/Nitrite as N	0.18	mg/L
311300030020-02	2/2/2009	Nitrogen, Nitrate/Nitrite as N	0.29	mg/L
311300030020-02	5/5/2009	Nitrogen, Nitrate/Nitrite as N	0.35	mg/L
311300030020-03	10/25/2006	Nitrogen, Nitrate/Nitrite as N	0.11	mg/L
311300030020-03	1/30/2007	Nitrogen, Nitrate/Nitrite as N	0.15	mg/L
311300030020-03	4/30/2007	Nitrogen, Nitrate/Nitrite as N	0.26	mg/L
311300030020-03	7/25/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300030020-03	10/29/2008	Nitrogen, Nitrate/Nitrite as N	0.15	mg/L
311300030020-03	2/2/2009	Nitrogen, Nitrate/Nitrite as N	0.28	mg/L
311300030020-03	5/5/2009	Nitrogen, Nitrate/Nitrite as N	0.37	mg/L
311300030020-04	10/25/2006	Nitrogen, Nitrate/Nitrite as N	0.12	mg/L
311300030020-04	1/30/2007	Nitrogen, Nitrate/Nitrite as N	0.14	mg/L
311300030020-04	4/30/2007	Nitrogen, Nitrate/Nitrite as N	0.28	mg/L
311300030020-04	7/25/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300030020-04	10/29/2008	Nitrogen, Nitrate/Nitrite as N	0.14	mg/L
311300030020-04	2/2/2009	Nitrogen, Nitrate/Nitrite as N	0.28	mg/L
311300030020-04	5/5/2009	Nitrogen, Nitrate/Nitrite as N	0.34	mg/L
311300030020-05	10/25/2006	Nitrogen, Nitrate/Nitrite as N	0.11	mg/L
311300030020-05	1/30/2007	Nitrogen, Nitrate/Nitrite as N	0.15	mg/L
311300030020-05	4/30/2007	Nitrogen, Nitrate/Nitrite as N	0.25	mg/L
311300030020-05	7/25/2007	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
311300030020-05	10/29/2008	Nitrogen, Nitrate/Nitrite as N	0.18	mg/L
311300030020-05	2/2/2009	Nitrogen, Nitrate/Nitrite as N	0.29	mg/L
311300030020-05	5/5/2009	Nitrogen, Nitrate/Nitrite as N	0.36	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-01B	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01B	7/8/1998	Nitrogen, Nitrite as N	0.05	mg/L
311300030020-01B	1/6/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01B	4/12/1999	Nitrogen, Nitrite as N	0.05	mg/L
311300030020-01B	7/7/1999	Nitrogen, Nitrite as N	0.06	mg/L
311300030020-01B	2/11/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01B	5/15/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01B	8/12/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01B	10/22/2003	Nitrogen, Nitrite as N	0.05	mg/L
311300030020-01B	1/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01B	4/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01B	7/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	7/8/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	7/8/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	1/6/1999	Nitrogen, Nitrite as N	0.05	mg/L
311300030020-01S	1/6/1999	Nitrogen, Nitrite as N	0.25	mg/L
311300030020-01S	4/12/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	4/12/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	7/7/1999	Nitrogen, Nitrite as N	0.06	mg/L
311300030020-01S	7/7/1999	Nitrogen, Nitrite as N	0.07	mg/L
311300030020-01S	7/7/1999	Nitrogen, Nitrite as N	0.06	mg/L
311300030020-01S	11/7/2001	Nitrogen, Nitrite as N	0.05	mg/L
311300030020-01S	11/7/2001	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	2/11/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	2/11/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	5/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	5/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	8/12/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	8/12/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	8/12/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	10/22/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	10/22/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	1/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	1/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	4/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	4/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01S	7/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-01S	7/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-02	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-02	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-02	7/8/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-02	1/6/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-02	4/12/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-02	7/7/1999	Nitrogen, Nitrite as N	0.05	mg/L
311300030020-02	11/7/2001	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-02	2/11/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-02	5/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-02	8/12/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-02	10/22/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-02	1/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-02	4/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-02	7/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-03	4/15/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-03	7/8/1998	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-03	1/6/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-03	4/12/1999	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-03	7/7/1999	Nitrogen, Nitrite as N	0.06	mg/L
311300030020-03	11/7/2001	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-03	2/11/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-03	5/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-03	8/12/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-03	10/22/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-03	1/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-03	4/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-03	7/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-04	11/7/2001	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-04	2/11/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-04	5/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-04	8/12/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-04	10/22/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-04	1/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-04	4/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-04	7/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-05	11/7/2001	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-05	2/11/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-05	5/13/2002	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-05	8/12/2002	Nitrogen, Nitrite as N	<0.05	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-05	10/22/2003	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-05	1/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-05	4/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-05	7/14/2004	Nitrogen, Nitrite as N	<0.05	mg/L
311300030020-01B	4/15/1998	Nitrogen, Organic	0.75	mg/L
311300030020-01B	7/8/1998	Nitrogen, Organic	R0	mg/L
311300030020-01B	1/6/1999	Nitrogen, Organic	0.18	mg/L
311300030020-01B	4/12/1999	Nitrogen, Organic	0.28	mg/L
311300030020-01B	7/7/1999	Nitrogen, Organic	0.39	mg/L
311300030020-01S	4/15/1998	Nitrogen, Organic	0.64	mg/L
311300030020-01S	4/15/1998	Nitrogen, Organic	0.2	mg/L
311300030020-01S	4/15/1998	Nitrogen, Organic	0.74	mg/L
311300030020-01S	7/8/1998	Nitrogen, Organic	R0	mg/L
311300030020-01S	7/8/1998	Nitrogen, Organic	R0	mg/L
311300030020-01S	1/6/1999	Nitrogen, Organic	0.24	mg/L
311300030020-01S	1/6/1999	Nitrogen, Organic	0.15	mg/L
311300030020-01S	4/12/1999	Nitrogen, Organic	0.34	mg/L
311300030020-01S	4/12/1999	Nitrogen, Organic	0.21	mg/L
311300030020-01S	7/7/1999	Nitrogen, Organic	0.52	mg/L
311300030020-01S	7/7/1999	Nitrogen, Organic	0.51	mg/L
311300030020-01S	7/7/1999	Nitrogen, Organic	0.47	mg/L
311300030020-02	4/15/1998	Nitrogen, Organic	0.57	mg/L
311300030020-02	4/15/1998	Nitrogen, Organic	0.58	mg/L
311300030020-02	7/8/1998	Nitrogen, Organic	R0	mg/L
311300030020-02	1/6/1999	Nitrogen, Organic	0.17	mg/L
311300030020-02	4/12/1999	Nitrogen, Organic	0.41	mg/L
311300030020-02	7/7/1999	Nitrogen, Organic	0.63	mg/L
311300030020-03	4/15/1998	Nitrogen, Organic	0.6	mg/L
311300030020-03	7/8/1998	Nitrogen, Organic	R0	mg/L
311300030020-03	1/6/1999	Nitrogen, Organic	0.1	mg/L
311300030020-03	4/12/1999	Nitrogen, Organic	0.29	mg/L
311300030020-03	7/7/1999	Nitrogen, Organic	0.56	mg/L
311300030020-01B	4/15/1998	Nitrogen, Total	1.39	mg/L
311300030020-01B	7/8/1998	Nitrogen, Total	R0	mg/L
311300030020-01B	1/6/1999	Nitrogen, Total	0.79	mg/L
311300030020-01B	4/12/1999	Nitrogen, Total	0.95	mg/L
311300030020-01B	7/7/1999	Nitrogen, Total	0.89	mg/L
311300030020-01S	4/15/1998	Nitrogen, Total	1.25	mg/L
311300030020-01S	4/15/1998	Nitrogen, Total	0.26	mg/L
311300030020-01S	4/15/1998	Nitrogen, Total	1.4	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-01S	7/8/1998	Nitrogen, Total	R0	mg/L
311300030020-01S	7/8/1998	Nitrogen, Total	R0	mg/L
311300030020-01S	1/6/1999	Nitrogen, Total	0.87	mg/L
311300030020-01S	1/6/1999	Nitrogen, Total	0.9	mg/L
311300030020-01S	4/12/1999	Nitrogen, Total	0.93	mg/L
311300030020-01S	4/12/1999	Nitrogen, Total	0.93	mg/L
311300030020-01S	7/7/1999	Nitrogen, Total	0.58	mg/L
311300030020-01S	7/7/1999	Nitrogen, Total	0.65	mg/L
311300030020-01S	7/7/1999	Nitrogen, Total	0.81	mg/L
311300030020-02	4/15/1998	Nitrogen, Total	1.2	mg/L
311300030020-02	4/15/1998	Nitrogen, Total	1.24	mg/L
311300030020-02	7/8/1998	Nitrogen, Total	R0	mg/L
311300030020-02	1/6/1999	Nitrogen, Total	0.78	mg/L
311300030020-02	4/12/1999	Nitrogen, Total	0.98	mg/L
311300030020-02	7/7/1999	Nitrogen, Total	0.68	mg/L
311300030020-03	4/15/1998	Nitrogen, Total	1.28	mg/L
311300030020-03	7/8/1998	Nitrogen, Total	R0	mg/L
311300030020-03	1/6/1999	Nitrogen, Total	0.8	mg/L
311300030020-03	4/12/1999	Nitrogen, Total	0.85	mg/L
311300030020-03	7/7/1999	Nitrogen, Total	0.62	mg/L
311300030020-01B	8/12/2002	Pheophytin A	1.74	mg/m3
311300030020-01B	4/14/2004	Pheophytin A	6.2	mg/m3
311300030020-01B	7/14/2004	Pheophytin A	<0.1	mg/m3
311300030020-01B	10/25/2006	Pheophytin A	6.36	mg/m3
311300030020-01B	4/30/2007	Pheophytin A	0.7	mg/m3
311300030020-01B	7/25/2007	Pheophytin A	6.22	mg/m3
311300030020-01B	10/29/2008	Pheophytin A	2.52	mg/m3
311300030020-01S	8/12/2002	Pheophytin A	1.48	mg/m3
311300030020-01S	10/22/2003	Pheophytin A	1.4	mg/m3
311300030020-01S	10/22/2003	Pheophytin A	1.9	mg/m3
311300030020-01S	1/14/2004	Pheophytin A	3	mg/m3
311300030020-01S	1/14/2004	Pheophytin A	3.4	mg/m3
311300030020-01S	1/14/2004	Pheophytin A	3.5	mg/m3
311300030020-01S	4/14/2004	Pheophytin A	5.4	mg/m3
311300030020-01S	4/14/2004	Pheophytin A	5.1	mg/m3
311300030020-01S	7/14/2004	Pheophytin A	<0.1	mg/m3
311300030020-01S	7/14/2004	Pheophytin A	<0.1	mg/m3
311300030020-01S	10/25/2006	Pheophytin A	5.64	mg/m3
311300030020-01S	10/25/2006	Pheophytin A	3.46	mg/m3
311300030020-01S	4/30/2007	Pheophytin A	<0.1	mg/m3

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-01S	4/30/2007	Pheophytin A	12.6	mg/m3
311300030020-01S	7/25/2007	Pheophytin A	4.23	mg/m3
311300030020-01S	7/25/2007	Pheophytin A	1.89	mg/m3
311300030020-01S	7/25/2007	Pheophytin A	3.78	mg/m3
311300030020-01S	10/29/2008	Pheophytin A	3.15	mg/m3
311300030020-01S	10/29/2008	Pheophytin A	2.86	mg/m3
311300030020-02	8/12/2002	Pheophytin A	2.69	mg/m3
311300030020-02	10/22/2003	Pheophytin A	1.9	mg/m3
311300030020-02	1/14/2004	Pheophytin A	1	mg/m3
311300030020-02	4/14/2004	Pheophytin A	13.7	mg/m3
311300030020-02	7/14/2004	Pheophytin A	1	mg/m3
311300030020-02	10/25/2006	Pheophytin A	8.17	mg/m3
311300030020-02	1/30/2007	Pheophytin A	3.15	mg/m3
311300030020-02	4/30/2007	Pheophytin A	1.61	mg/m3
311300030020-02	7/25/2007	Pheophytin A	3.68	mg/m3
311300030020-02	10/29/2008	Pheophytin A	3.53	mg/m3
311300030020-02	2/2/2009	Pheophytin A	0.9	mg/m3
311300030020-02	8/4/2009	Pheophytin A	3.4	mg/m3
311300030020-03	8/12/2002	Pheophytin A	3.69	mg/m3
311300030020-03	10/22/2003	Pheophytin A	5.1	mg/m3
311300030020-03	1/14/2004	Pheophytin A	1.1	mg/m3
311300030020-03	4/14/2004	Pheophytin A	10.1	mg/m3
311300030020-03	7/14/2004	Pheophytin A	0.3	mg/m3
311300030020-03	10/25/2006	Pheophytin A	10.1	mg/m3
311300030020-03	1/30/2007	Pheophytin A	2.56	mg/m3
311300030020-03	4/30/2007	Pheophytin A	1.29	mg/m3
311300030020-03	7/25/2007	Pheophytin A	4.16	mg/m3
311300030020-03	10/29/2008	Pheophytin A	3.46	mg/m3
311300030020-03	2/2/2009	Pheophytin A	1	mg/m3
311300030020-03	8/4/2009	Pheophytin A	4.83	mg/m3
311300030020-04	8/12/2002	Pheophytin A	2.65	mg/m3
311300030020-04	10/22/2003	Pheophytin A	3.3	mg/m3
311300030020-04	1/14/2004	Pheophytin A	1.3	mg/m3
311300030020-04	4/14/2004	Pheophytin A	7.6	mg/m3
311300030020-04	7/14/2004	Pheophytin A	<0.1	mg/m3
311300030020-04	10/25/2006	Pheophytin A	7.41	mg/m3
311300030020-04	1/30/2007	Pheophytin A	2.56	mg/m3
311300030020-04	4/30/2007	Pheophytin A	1.34	mg/m3
311300030020-04	10/29/2008	Pheophytin A	3.47	mg/m3
311300030020-04	2/2/2009	Pheophytin A	1.22	mg/m3

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-04	8/4/2009	Pheophytin A	3.86	mg/m3
311300030020-05	8/12/2002	Pheophytin A	3.37	mg/m3
311300030020-05	10/22/2003	Pheophytin A	4.3	mg/m3
311300030020-05	1/14/2004	Pheophytin A	0.8	mg/m3
311300030020-05	4/14/2004	Pheophytin A	7.3	mg/m3
311300030020-05	7/14/2004	Pheophytin A	2.6	mg/m3
311300030020-05	10/25/2006	Pheophytin A	33.3	mg/m3
311300030020-05	1/30/2007	Pheophytin A	3.59	mg/m3
311300030020-05	4/30/2007	Pheophytin A	0.65	mg/m3
311300030020-05	7/25/2007	Pheophytin A	3.37	mg/m3
311300030020-05	10/29/2008	Pheophytin A	3.96	mg/m3
311300030020-05	2/2/2009	Pheophytin A	1.26	mg/m3
311300030020-05	8/4/2009	Pheophytin A	5.87	mg/m3
311300030020-01B	4/15/1998	Phosphorous, Ortho	0.042	mg/L
311300030020-01B	7/8/1998	Phosphorous, Ortho	0.007	mg/L
311300030020-01B	1/6/1999	Phosphorous, Ortho	0.051	mg/L
311300030020-01B	4/12/1999	Phosphorous, Ortho	0.047	mg/L
311300030020-01B	7/7/1999	Phosphorous, Ortho	0.105	mg/L
311300030020-01B	2/11/2002	Phosphorous, Ortho	0.021	mg/L
311300030020-01B	5/15/2002	Phosphorous, Ortho	0.042	mg/L
311300030020-01B	8/12/2002	Phosphorous, Ortho	0.165	mg/L
311300030020-01B	10/22/2003	Phosphorous, Ortho	0.061	mg/L
311300030020-01B	1/14/2004	Phosphorous, Ortho	0.058	mg/L
311300030020-01B	4/14/2004	Phosphorous, Ortho	0.048	mg/L
311300030020-01B	7/14/2004	Phosphorous, Ortho	0.24	mg/L
311300030020-01S	4/15/1998	Phosphorous, Ortho	0.036	mg/L
311300030020-01S	4/15/1998	Phosphorous, Ortho	<0.005	mg/L
311300030020-01S	4/15/1998	Phosphorous, Ortho	0.037	mg/L
311300030020-01S	7/8/1998	Phosphorous, Ortho	0.019	mg/L
311300030020-01S	7/8/1998	Phosphorous, Ortho	0.017	mg/L
311300030020-01S	1/6/1999	Phosphorous, Ortho	0.051	mg/L
311300030020-01S	1/6/1999	Phosphorous, Ortho	0.053	mg/L
311300030020-01S	4/12/1999	Phosphorous, Ortho	0.041	mg/L
311300030020-01S	4/12/1999	Phosphorous, Ortho	0.043	mg/L
311300030020-01S	7/7/1999	Phosphorous, Ortho	0.019	mg/L
311300030020-01S	7/7/1999	Phosphorous, Ortho	0.018	mg/L
311300030020-01S	7/7/1999	Phosphorous, Ortho	0.053	mg/L
311300030020-01S	11/7/2001	Phosphorous, Ortho	0.023	mg/L
311300030020-01S	11/7/2001	Phosphorous, Ortho	0.021	mg/L
311300030020-01S	2/11/2002	Phosphorous, Ortho	0.019	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-01S	2/11/2002	Phosphorous, Ortho	0.022	mg/L
311300030020-01S	5/13/2002	Phosphorous, Ortho	0.038	mg/L
311300030020-01S	5/13/2002	Phosphorous, Ortho	0.038	mg/L
311300030020-01S	8/12/2002	Phosphorous, Ortho	0.007	mg/L
311300030020-01S	8/12/2002	Phosphorous, Ortho	<0.005	mg/L
311300030020-01S	8/12/2002	Phosphorous, Ortho	0.008	mg/L
311300030020-01S	10/22/2003	Phosphorous, Ortho	0.045	mg/L
311300030020-01S	10/22/2003	Phosphorous, Ortho	0.046	mg/L
311300030020-01S	1/14/2004	Phosphorous, Ortho	0.049	mg/L
311300030020-01S	1/14/2004	Phosphorous, Ortho	0.048	mg/L
311300030020-01S	4/14/2004	Phosphorous, Ortho	0.036	mg/L
311300030020-01S	4/14/2004	Phosphorous, Ortho	0.034	mg/L
311300030020-01S	7/14/2004	Phosphorous, Ortho	0.015	mg/L
311300030020-01S	7/14/2004	Phosphorous, Ortho	0.014	mg/L
311300030020-01S	10/25/2006	Phosphorous, Ortho	0.045	mg/L
311300030020-01S	10/25/2006	Phosphorous, Ortho	0.046	mg/L
311300030020-01S	1/30/2007	Phosphorous, Ortho	0.036	mg/L
311300030020-01S	1/30/2007	Phosphorous, Ortho	0.037	mg/L
311300030020-01S	7/25/2007	Phosphorous, Ortho	0.056	mg/L
311300030020-01S	7/25/2007	Phosphorous, Ortho	0.057	mg/L
311300030020-02	4/15/1998	Phosphorous, Ortho	0.039	mg/L
311300030020-02	4/15/1998	Phosphorous, Ortho	0.042	mg/L
311300030020-02	7/8/1998	Phosphorous, Ortho	0.028	mg/L
311300030020-02	1/6/1999	Phosphorous, Ortho	0.051	mg/L
311300030020-02	4/12/1999	Phosphorous, Ortho	0.042	mg/L
311300030020-02	7/7/1999	Phosphorous, Ortho	0.033	mg/L
311300030020-02	11/7/2001	Phosphorous, Ortho	0.035	mg/L
311300030020-02	2/11/2002	Phosphorous, Ortho	0.023	mg/L
311300030020-02	5/13/2002	Phosphorous, Ortho	0.046	mg/L
311300030020-02	8/12/2002	Phosphorous, Ortho	0.007	mg/L
311300030020-02	10/22/2003	Phosphorous, Ortho	0.017	mg/L
311300030020-02	1/14/2004	Phosphorous, Ortho	0.054	mg/L
311300030020-02	4/14/2004	Phosphorous, Ortho	0.039	mg/L
311300030020-02	7/14/2004	Phosphorous, Ortho	0.015	mg/L
311300030020-02	10/25/2006	Phosphorous, Ortho	0.041	mg/L
311300030020-02	1/30/2007	Phosphorous, Ortho	0.037	mg/L
311300030020-02	4/30/2007	Phosphorous, Ortho	0.056	mg/L
311300030020-02	7/25/2007	Phosphorous, Ortho	0.06	mg/L
311300030020-02	8/4/2009	Phosphorous, Ortho	0	mg/L
311300030020-03	4/15/1998	Phosphorous, Ortho	0.034	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-03	7/8/1998	Phosphorous, Ortho	0.021	mg/L
311300030020-03	1/6/1999	Phosphorous, Ortho	0.05	mg/L
311300030020-03	4/12/1999	Phosphorous, Ortho	0.041	mg/L
311300030020-03	7/7/1999	Phosphorous, Ortho	0.033	mg/L
311300030020-03	11/7/2001	Phosphorous, Ortho	0.031	mg/L
311300030020-03	2/11/2002	Phosphorous, Ortho	0.03	mg/L
311300030020-03	5/13/2002	Phosphorous, Ortho	0.054	mg/L
311300030020-03	8/12/2002	Phosphorous, Ortho	0.015	mg/L
311300030020-03	10/22/2003	Phosphorous, Ortho	0.034	mg/L
311300030020-03	1/14/2004	Phosphorous, Ortho	0.061	mg/L
311300030020-03	4/14/2004	Phosphorous, Ortho	0.108	mg/L
311300030020-03	7/14/2004	Phosphorous, Ortho	0.021	mg/L
311300030020-03	10/25/2006	Phosphorous, Ortho	0.042	mg/L
311300030020-03	1/30/2007	Phosphorous, Ortho	0.041	mg/L
311300030020-03	4/30/2007	Phosphorous, Ortho	0.06	mg/L
311300030020-03	7/25/2007	Phosphorous, Ortho	0.051	mg/L
311300030020-03	8/4/2009	Phosphorous, Ortho	0	mg/L
311300030020-04	11/7/2001	Phosphorous, Ortho	0.022	mg/L
311300030020-04	2/11/2002	Phosphorous, Ortho	0.025	mg/L
311300030020-04	5/13/2002	Phosphorous, Ortho	0.051	mg/L
311300030020-04	8/12/2002	Phosphorous, Ortho	0.007	mg/L
311300030020-04	10/22/2003	Phosphorous, Ortho	0.047	mg/L
311300030020-04	1/14/2004	Phosphorous, Ortho	0.055	mg/L
311300030020-04	4/14/2004	Phosphorous, Ortho	0.041	mg/L
311300030020-04	7/14/2004	Phosphorous, Ortho	0.01	mg/L
311300030020-04	10/25/2006	Phosphorous, Ortho	0.035	mg/L
311300030020-04	1/30/2007	Phosphorous, Ortho	0.038	mg/L
311300030020-04	4/30/2007	Phosphorous, Ortho	0.059	mg/L
311300030020-04	7/25/2007	Phosphorous, Ortho	0.063	mg/L
311300030020-04	8/4/2009	Phosphorous, Ortho	0	mg/L
311300030020-05	11/7/2001	Phosphorous, Ortho	0.035	mg/L
311300030020-05	2/11/2002	Phosphorous, Ortho	0.025	mg/L
311300030020-05	5/13/2002	Phosphorous, Ortho	0.049	mg/L
311300030020-05	8/12/2002	Phosphorous, Ortho	0.009	mg/L
311300030020-05	10/22/2003	Phosphorous, Ortho	0.042	mg/L
311300030020-05	1/14/2004	Phosphorous, Ortho	0.055	mg/L
311300030020-05	4/14/2004	Phosphorous, Ortho	0.054	mg/L
311300030020-05	7/14/2004	Phosphorous, Ortho	0.016	mg/L
311300030020-05	10/25/2006	Phosphorous, Ortho	0.034	mg/L
311300030020-05	1/30/2007	Phosphorous, Ortho	0.039	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-05	4/30/2007	Phosphorous, Ortho	0.054	mg/L
311300030020-05	7/25/2007	Phosphorous, Ortho	0.054	mg/L
311300030020-05	8/4/2009	Phosphorous, Ortho	0	mg/L
311300030020-01B	4/15/1998	Phosphorous, Total	0.108	mg/L
311300030020-01B	7/8/1998	Phosphorous, Total	R0	mg/L
311300030020-01B	1/6/1999	Phosphorous, Total	0.098	mg/L
311300030020-01B	4/12/1999	Phosphorous, Total	0.09	mg/L
311300030020-01B	7/7/1999	Phosphorous, Total	0.129	mg/L
311300030020-01B	2/11/2002	Phosphorous, Total	0.043	mg/L
311300030020-01B	5/15/2002	Phosphorous, Total	0.077	mg/L
311300030020-01B	8/12/2002	Phosphorous, Total	0.231	mg/L
311300030020-01B	10/22/2003	Phosphorous, Total	0.102	mg/L
311300030020-01B	1/14/2004	Phosphorous, Total	0.067	mg/L
311300030020-01B	4/14/2004	Phosphorous, Total	0.054	mg/L
311300030020-01B	7/14/2004	Phosphorous, Total	0.308	mg/L
311300030020-01S	4/15/1998	Phosphorous, Total	0.066	mg/L
311300030020-01S	4/15/1998	Phosphorous, Total	0.008	mg/L
311300030020-01S	4/15/1998	Phosphorous, Total	0.055	mg/L
311300030020-01S	7/8/1998	Phosphorous, Total	R0	mg/L
311300030020-01S	7/8/1998	Phosphorous, Total	R0	mg/L
311300030020-01S	1/6/1999	Phosphorous, Total	0.098	mg/L
311300030020-01S	1/6/1999	Phosphorous, Total	0.065	mg/L
311300030020-01S	4/12/1999	Phosphorous, Total	0.074	mg/L
311300030020-01S	4/12/1999	Phosphorous, Total	0.076	mg/L
311300030020-01S	7/7/1999	Phosphorous, Total	0.054	mg/L
311300030020-01S	7/7/1999	Phosphorous, Total	0.041	mg/L
311300030020-01S	7/7/1999	Phosphorous, Total	0.076	mg/L
311300030020-01S	11/7/2001	Phosphorous, Total	0.036	mg/L
311300030020-01S	11/7/2001	Phosphorous, Total	0.036	mg/L
311300030020-01S	2/11/2002	Phosphorous, Total	0.04	mg/L
311300030020-01S	2/11/2002	Phosphorous, Total	0.043	mg/L
311300030020-01S	5/13/2002	Phosphorous, Total	0.05	mg/L
311300030020-01S	5/13/2002	Phosphorous, Total	0.05	mg/L
311300030020-01S	8/12/2002	Phosphorous, Total	0.042	mg/L
311300030020-01S	8/12/2002	Phosphorous, Total	0.02	mg/L
311300030020-01S	8/12/2002	Phosphorous, Total	0.042	mg/L
311300030020-01S	10/22/2003	Phosphorous, Total	0.07	mg/L
311300030020-01S	10/22/2003	Phosphorous, Total	0.069	mg/L
311300030020-01S	1/14/2004	Phosphorous, Total	0.062	mg/L
311300030020-01S	1/14/2004	Phosphorous, Total	0.059	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-01S	4/14/2004	Phosphorous, Total	0.05	mg/L
311300030020-01S	4/14/2004	Phosphorous, Total	0.046	mg/L
311300030020-01S	7/14/2004	Phosphorous, Total	0.056	mg/L
311300030020-01S	7/14/2004	Phosphorous, Total	0.055	mg/L
311300030020-01S	10/25/2006	Phosphorous, Total	0.095	mg/L
311300030020-01S	10/25/2006	Phosphorous, Total	0.091	mg/L
311300030020-01S	1/30/2007	Phosphorous, Total	0.053	mg/L
311300030020-01S	1/30/2007	Phosphorous, Total	0.056	mg/L
311300030020-01S	7/25/2007	Phosphorous, Total	0.102	mg/L
311300030020-01S	7/25/2007	Phosphorous, Total	0.1	mg/L
311300030020-01S	10/29/2008	Phosphorous, Total	0.036	mg/L
311300030020-01S	10/29/2008	Phosphorous, Total	0.033	mg/L
311300030020-01S	2/2/2009	Phosphorous, Total	0.036	mg/L
311300030020-02	4/15/1998	Phosphorous, Total	0.093	mg/L
311300030020-02	4/15/1998	Phosphorous, Total	0.055	mg/L
311300030020-02	7/8/1998	Phosphorous, Total	R0	mg/L
311300030020-02	1/6/1999	Phosphorous, Total	0.06	mg/L
311300030020-02	4/12/1999	Phosphorous, Total	0.069	mg/L
311300030020-02	7/7/1999	Phosphorous, Total	0.047	mg/L
311300030020-02	11/7/2001	Phosphorous, Total	0.041	mg/L
311300030020-02	2/11/2002	Phosphorous, Total	0.048	mg/L
311300030020-02	5/13/2002	Phosphorous, Total	0.061	mg/L
311300030020-02	8/12/2002	Phosphorous, Total	0.053	mg/L
311300030020-02	10/22/2003	Phosphorous, Total	0.078	mg/L
311300030020-02	1/14/2004	Phosphorous, Total	0.061	mg/L
311300030020-02	4/14/2004	Phosphorous, Total	0.048	mg/L
311300030020-02	7/14/2004	Phosphorous, Total	0.062	mg/L
311300030020-02	10/25/2006	Phosphorous, Total	0.122	mg/L
311300030020-02	1/30/2007	Phosphorous, Total	0.06	mg/L
311300030020-02	4/30/2007	Phosphorous, Total	0.064	mg/L
311300030020-02	7/25/2007	Phosphorous, Total	0.107	mg/L
311300030020-02	10/29/2008	Phosphorous, Total	0.044	mg/L
311300030020-02	2/2/2009	Phosphorous, Total	0.047	mg/L
311300030020-02	5/5/2009	Phosphorous, Total	0.085	mg/L
311300030020-03	4/15/1998	Phosphorous, Total	0.062	mg/L
311300030020-03	7/8/1998	Phosphorous, Total	R0	mg/L
311300030020-03	1/6/1999	Phosphorous, Total	0.072	mg/L
311300030020-03	4/12/1999	Phosphorous, Total	0.045	mg/L
311300030020-03	7/7/1999	Phosphorous, Total	0.042	mg/L
311300030020-03	11/7/2001	Phosphorous, Total	0.038	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-03	2/11/2002	Phosphorous, Total	0.054	mg/L
311300030020-03	5/13/2002	Phosphorous, Total	0.066	mg/L
311300030020-03	8/12/2002	Phosphorous, Total	0.076	mg/L
311300030020-03	10/22/2003	Phosphorous, Total	0.103	mg/L
311300030020-03	1/14/2004	Phosphorous, Total	0.072	mg/L
311300030020-03	4/14/2004	Phosphorous, Total	0.115	mg/L
311300030020-03	7/14/2004	Phosphorous, Total	0.085	mg/L
311300030020-03	10/25/2006	Phosphorous, Total	0.235	mg/L
311300030020-03	1/30/2007	Phosphorous, Total	0.056	mg/L
311300030020-03	4/30/2007	Phosphorous, Total	0.067	mg/L
311300030020-03	7/25/2007	Phosphorous, Total	0.107	mg/L
311300030020-03	10/29/2008	Phosphorous, Total	0.044	mg/L
311300030020-03	2/2/2009	Phosphorous, Total	0.053	mg/L
311300030020-03	5/5/2009	Phosphorous, Total	0.094	mg/L
311300030020-04	11/7/2001	Phosphorous, Total	0.033	mg/L
311300030020-04	2/11/2002	Phosphorous, Total	0.054	mg/L
311300030020-04	5/13/2002	Phosphorous, Total	0.063	mg/L
311300030020-04	8/12/2002	Phosphorous, Total	0.053	mg/L
311300030020-04	10/22/2003	Phosphorous, Total	0.089	mg/L
311300030020-04	1/14/2004	Phosphorous, Total	0.062	mg/L
311300030020-04	4/14/2004	Phosphorous, Total	0.052	mg/L
311300030020-04	7/14/2004	Phosphorous, Total	0.048	mg/L
311300030020-04	10/25/2006	Phosphorous, Total	0.101	mg/L
311300030020-04	1/30/2007	Phosphorous, Total	0.059	mg/L
311300030020-04	4/30/2007	Phosphorous, Total	0.064	mg/L
311300030020-04	7/25/2007	Phosphorous, Total	0.108	mg/L
311300030020-04	10/29/2008	Phosphorous, Total	0.041	mg/L
311300030020-04	2/2/2009	Phosphorous, Total	0.045	mg/L
311300030020-04	5/5/2009	Phosphorous, Total	0.086	mg/L
311300030020-05	11/7/2001	Phosphorous, Total	0.038	mg/L
311300030020-05	2/11/2002	Phosphorous, Total	0.048	mg/L
311300030020-05	5/13/2002	Phosphorous, Total	0.064	mg/L
311300030020-05	8/12/2002	Phosphorous, Total	0.06	mg/L
311300030020-05	10/22/2003	Phosphorous, Total	0.101	mg/L
311300030020-05	1/14/2004	Phosphorous, Total	0.063	mg/L
311300030020-05	4/14/2004	Phosphorous, Total	0.057	mg/L
311300030020-05	7/14/2004	Phosphorous, Total	0.068	mg/L
311300030020-05	10/25/2006	Phosphorous, Total	0.163	mg/L
311300030020-05	1/30/2007	Phosphorous, Total	0.056	mg/L
311300030020-05	4/30/2007	Phosphorous, Total	0.065	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-05	7/25/2007	Phosphorous, Total	0.099	mg/L
311300030020-05	10/29/2008	Phosphorous, Total	0.042	mg/L
311300030020-05	2/2/2009	Phosphorous, Total	0.043	mg/L
311300030020-05	5/5/2009	Phosphorous, Total	0.089	mg/L
311300030020-01S	11/7/2001	Secchi Depth	48	cm
311300030020-01S	2/11/2002	Secchi Depth	41	cm
311300030020-01S	8/12/2002	Secchi Depth	63	cm
311300030020-02	11/7/2001	Secchi Depth	42	cm
311300030020-02	2/11/2002	Secchi Depth	42	cm
311300030020-02	8/12/2002	Secchi Depth	47	cm
311300030020-02	5/5/2009	Secchi Depth	20	cm
311300030020-02	8/4/2009	Secchi Depth	38	cm
311300030020-03	11/7/2001	Secchi Depth	30	cm
311300030020-03	8/12/2002	Secchi Depth	27	cm
311300030020-03	5/5/2009	Secchi Depth	13	cm
311300030020-03	8/4/2009	Secchi Depth	37	cm
311300030020-04	11/7/2001	Secchi Depth	20	cm
311300030020-04	2/11/2002	Secchi Depth	26	cm
311300030020-04	8/12/2002	Secchi Depth	31	cm
311300030020-04	5/5/2009	Secchi Depth	20	cm
311300030020-04	8/4/2009	Secchi Depth	39	cm
311300030020-05	11/7/2001	Secchi Depth	28	cm
311300030020-05	2/11/2002	Secchi Depth	33	cm
311300030020-05	8/12/2002	Secchi Depth	29	cm
311300030020-05	1/30/2007	Secchi Depth	48	cm
311300030020-05	5/5/2009	Secchi Depth	22	cm
311300030020-05	8/4/2009	Secchi Depth	37	cm
311300030020-01B	4/15/1998	Solids, Suspended	27	mg/L
311300030020-01B	7/8/1998	Solids, Suspended	58	mg/L
311300030020-01B	1/6/1999	Solids, Suspended	8	mg/L
311300030020-01B	4/12/1999	Solids, Suspended	18	mg/L
311300030020-01B	7/7/1999	Solids, Suspended	24	mg/L
311300030020-01S	4/15/1998	Solids, Suspended	20	mg/L
311300030020-01S	4/15/1998	Solids, Suspended	<1	mg/L
311300030020-01S	4/15/1998	Solids, Suspended	19	mg/L
311300030020-01S	7/8/1998	Solids, Suspended	10	mg/L
311300030020-01S	7/8/1998	Solids, Suspended	12	mg/L
311300030020-01S	1/6/1999	Solids, Suspended	9	mg/L
311300030020-01S	1/6/1999	Solids, Suspended	7	mg/L
311300030020-01S	4/12/1999	Solids, Suspended	19	mg/L

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-01S	4/12/1999	Solids, Suspended	28	mg/L
311300030020-01S	7/7/1999	Solids, Suspended	10	mg/L
311300030020-01S	7/7/1999	Solids, Suspended	9	mg/L
311300030020-01S	7/7/1999	Solids, Suspended	15	mg/L
311300030020-02	4/15/1998	Solids, Suspended	24	mg/L
311300030020-02	4/15/1998	Solids, Suspended	25	mg/L
311300030020-02	7/8/1998	Solids, Suspended	18	mg/L
311300030020-02	1/6/1999	Solids, Suspended	9	mg/L
311300030020-02	4/12/1999	Solids, Suspended	1	mg/L
311300030020-02	7/7/1999	Solids, Suspended	15	mg/L
311300030020-03	4/15/1998	Solids, Suspended	46	mg/L
311300030020-03	7/8/1998	Solids, Suspended	16	mg/L
311300030020-03	1/6/1999	Solids, Suspended	8	mg/L
311300030020-03	4/12/1999	Solids, Suspended	19	mg/L
311300030020-03	7/7/1999	Solids, Suspended	14	mg/L
311300030020-01S	11/7/2001	Turbidity, Field	20	NTU
311300030020-01S	11/7/2001	Turbidity, Field	20	NTU
311300030020-01S	2/11/2002	Turbidity, Field	20	NTU
311300030020-01S	2/11/2002	Turbidity, Field	18	NTU
311300030020-01S	5/13/2002	Turbidity, Field	23	NTU
311300030020-01S	5/13/2002	Turbidity, Field	23	NTU
311300030020-01S	8/12/2002	Turbidity, Field	15	NTU
311300030020-01S	8/12/2002	Turbidity, Field	14	NTU
311300030020-01S	10/25/2006	Turbidity, Field	30	NTU
311300030020-01S	10/25/2006	Turbidity, Field	33	NTU
311300030020-01S	1/30/2007	Turbidity, Field	32	NTU
311300030020-01S	1/30/2007	Turbidity, Field	34	NTU
311300030020-01S	7/25/2007	Turbidity, Field	8	NTU
311300030020-01S	7/25/2007	Turbidity, Field	9	NTU
311300030020-02	11/7/2001	Turbidity, Field	22	NTU
311300030020-02	2/11/2002	Turbidity, Field	28	NTU
311300030020-02	5/13/2002	Turbidity, Field	32	NTU
311300030020-02	8/12/2002	Turbidity, Field	19	NTU
311300030020-02	10/25/2006	Turbidity, Field	57	NTU
311300030020-02	1/30/2007	Turbidity, Field	48	NTU
311300030020-02	4/30/2007	Turbidity, Field	31	NTU
311300030020-02	7/25/2007	Turbidity, Field	20	NTU
311300030020-02	5/5/2009	Turbidity, Field	36	NTU
311300030020-02	8/4/2009	Turbidity, Field	15	NTU
311300030020-03	11/7/2001	Turbidity, Field	25	NTU

Lake Ellsworth WQM Station	Date	Parameter	Value	Units
311300030020-03	2/11/2002	Turbidity, Field	39	NTU
311300030020-03	5/13/2002	Turbidity, Field	40	NTU
311300030020-03	8/12/2002	Turbidity, Field	43	NTU
311300030020-03	10/25/2006	Turbidity, Field	200	NTU
311300030020-03	1/30/2007	Turbidity, Field	36	NTU
311300030020-03	4/30/2007	Turbidity, Field	38	NTU
311300030020-03	7/25/2007	Turbidity, Field	26	NTU
311300030020-03	5/5/2009	Turbidity, Field	45	NTU
311300030020-03	8/4/2009	Turbidity, Field	18	NTU
311300030020-04	11/7/2001	Turbidity, Field	25	NTU
311300030020-04	2/11/2002	Turbidity, Field	32	NTU
311300030020-04	5/13/2002	Turbidity, Field	35	NTU
311300030020-04	8/12/2002	Turbidity, Field	25	NTU
311300030020-04	10/25/2006	Turbidity, Field	51	NTU
311300030020-04	1/30/2007	Turbidity, Field	34	NTU
311300030020-04	4/30/2007	Turbidity, Field	32	NTU
311300030020-04	7/25/2007	Turbidity, Field	9	NTU
311300030020-04	5/5/2009	Turbidity, Field	46	NTU
311300030020-04	8/4/2009	Turbidity, Field	12	NTU
311300030020-05	11/7/2001	Turbidity, Field	31	NTU
311300030020-05	2/11/2002	Turbidity, Field	30	NTU
311300030020-05	5/13/2002	Turbidity, Field	36	NTU
311300030020-05	8/12/2002	Turbidity, Field	31	NTU
311300030020-05	10/25/2006	Turbidity, Field	122	NTU
311300030020-05	1/30/2007	Turbidity, Field	42	NTU
311300030020-05	4/30/2007	Turbidity, Field	32	NTU
311300030020-05	7/25/2007	Turbidity, Field	8	NTU
311300030020-05	5/5/2009	Turbidity, Field	39	NTU
311300030020-05	8/4/2009	Turbidity, Field	14	NTU

APPENDIX C

SWAT MODEL INPUT AND CALIBRATION

Appendix C

SWAT Model Input and Calibration

Given the lack of flow gage data available to quantify loadings directly from the tributaries of Lake Lawtonka, Waurika Lake and Lake Ellsworth, a watershed loading model – the Soil and Water Assessment Tool (SWAT) – was used to develop nonpoint source loading estimates. These estimates from SWAT were used to quantify the nutrient contributions to each lake. SWAT is a basin-scale watershed model that can be operated on a daily time step (Neitsch et al. 2005). SWAT is designed to predict the impact of management strategies on water, nutrient, sediment, and agricultural chemical yields. The model is physically (and empirically) based, computationally efficient, and capable of continuous simulation over long time periods. The major components of the model include weather, hydrology, soil temperature and properties, plant growth, nutrients, and land management.

C-1. Model Inputs

All the GIS layers were processed using the ArcSWAT 2009.93.5 interface for SWAT2009 (Winchell et al. 2009). The interface was also used to change input parameters to achieve calibration and to export the model results to a Microsoft Access database. Electronic copies of the calibrated input files are attached to this report.

C-1.1 Elevation Data

The 2002/2004 30-meter United States Geographical Survey (USGS) National Elevation Dataset (NED) was used for watershed delineation. The NED was also used to calculate the slopes and determine the stream network incorporated into SWAT. Slopes were divided into three categories: 0-1, 1-5, and > 5%.

C-1.2 Soil Data

Soil data used for this model were derived using the Natural Resources Conservation Service (NRCS) State Soil Geographic (STATSGO) soils database incorporated in ArcSWAT.

C-1.3 Land Use Data

Land use and land cover data were derived from NASS 2008 Cropland Data Layer (CDL) (http://www.nass.usda.gov/research/Cropland/SARS1a.htm) (USDA 2008). Two main crops were included in the model: winter wheat and corn.

Appendix C, Table-1: Distribution of Land Cover in the Modeled Watershed

Description	SWAT Code	Area (acres)	Percent of Total Watershed Area
Open Water	WATR	22,127	2.1
Developed, Low Density	URLD	61,341	5.9
Developed, Medium/Low Density	URMD	17,167	1.7
Developed, Medium Density	URHD	6,535	0.6
Developed, High Density	UIDU	2,963	0.3
Corn	AGRR	12,115	1.2
Winter Wheat	WWHT	140,887	13.6
Southwestern US (Arid) Range	SWRN	872	0.1
Deciduous Forest	FRSD	77,316	7.5
Evergreen Forest	FRSE	1,210	0.1
Forest-Mixed	FRST	1,600	0.2
Range-Brush	RNGB	3,979	0.4
Range-Grasses	RNGE	687,413	66.4
Hay	HAY	518	0.1
Wetlands, Forested	WETF	2	<0.1
Wetlands, Non-Forested	WETN	48	<0.1

C-1.4 Meteorology

The meteorological data for the simulation period of 1994 to 2010 was derived from five Oklahoma Mesonet stations (Acme, Apache, Ketchum Ranch, Medicine Park, and Waurika). Weather station locations are shown in Figure C-1. Daily time-series of precipitation, temperature, solar radiation, wind speed, and relative humidity were imported into the SWAT model along with the station coordinates and SWAT subsequently assigned the precipitation to the various subwatersheds using the nearest station (Neitsch et al., 2005).

C-1.5 Subwatershed Delineation

The modeled area was split into 47 sub-watersheds (Figure C-2) based on the National Elevation Dataset (http://ned.usgs.gov) and the National Hydrography Dataset (http://nhd.usgs.gov) of the USGS. The watersheds of Lake Lawtonka, Waurika Lake and Lake Ellsworth are outlined in black in Figure C-2. This figure also shows the locations of flow gages and water quality monitoring stations at which the SWAT model was calibrated.

C-1.6 Point Sources

SWAT also allows the user to input data from point sources [mainly municipal and industrial wastewater treatment facilities (WWTF)]. Several WWTF outfalls are located in the model area, as shown in Figure C-3. To develop datasets for pollutant loads from the point sources, the modeling team gathered data from Discharge Monitoring Reports (DMR) for the various outfalls (Table C-2).

Figure C-1 Weather Station Locations

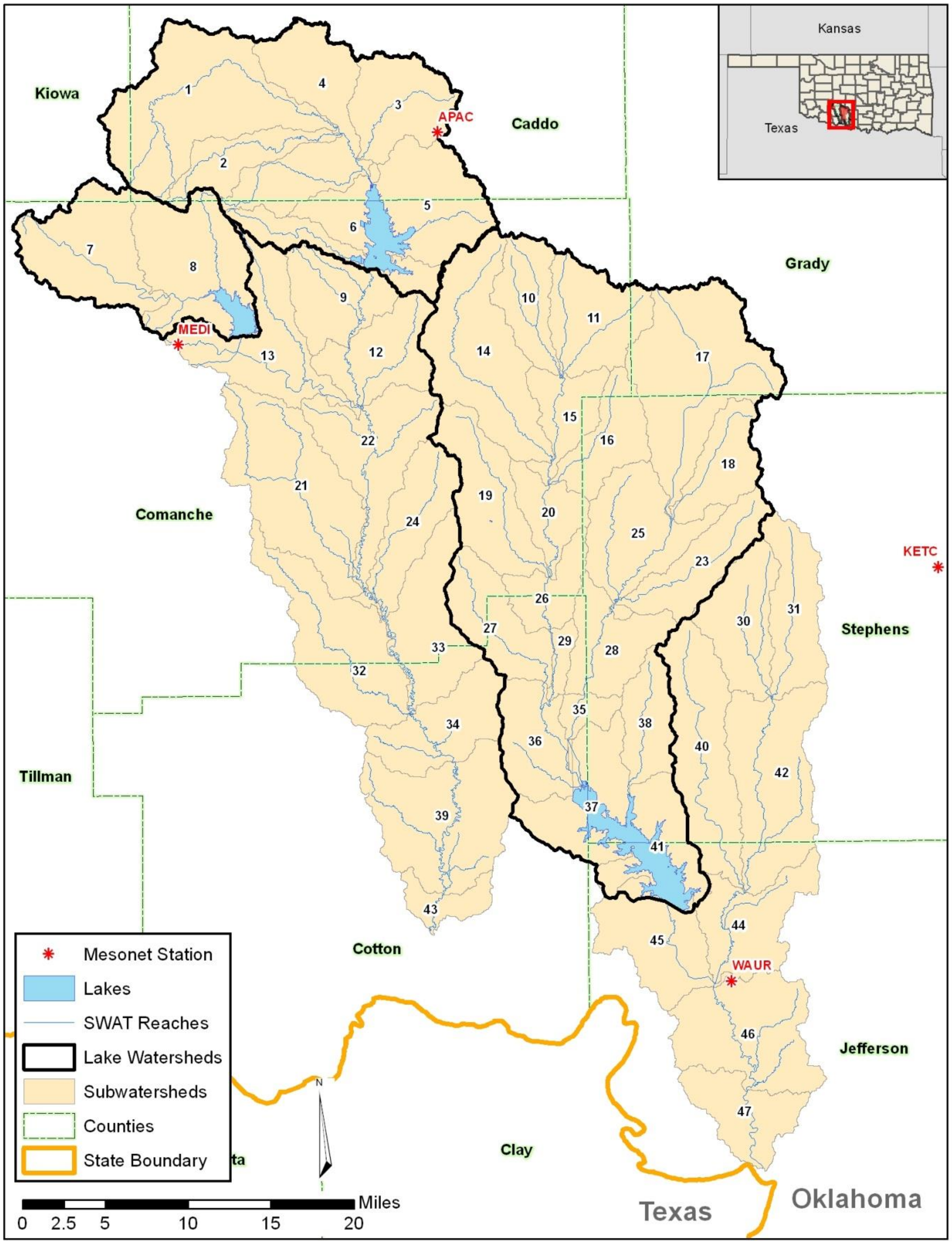


Figure C-2 Model Segmentation and Calibration Stations

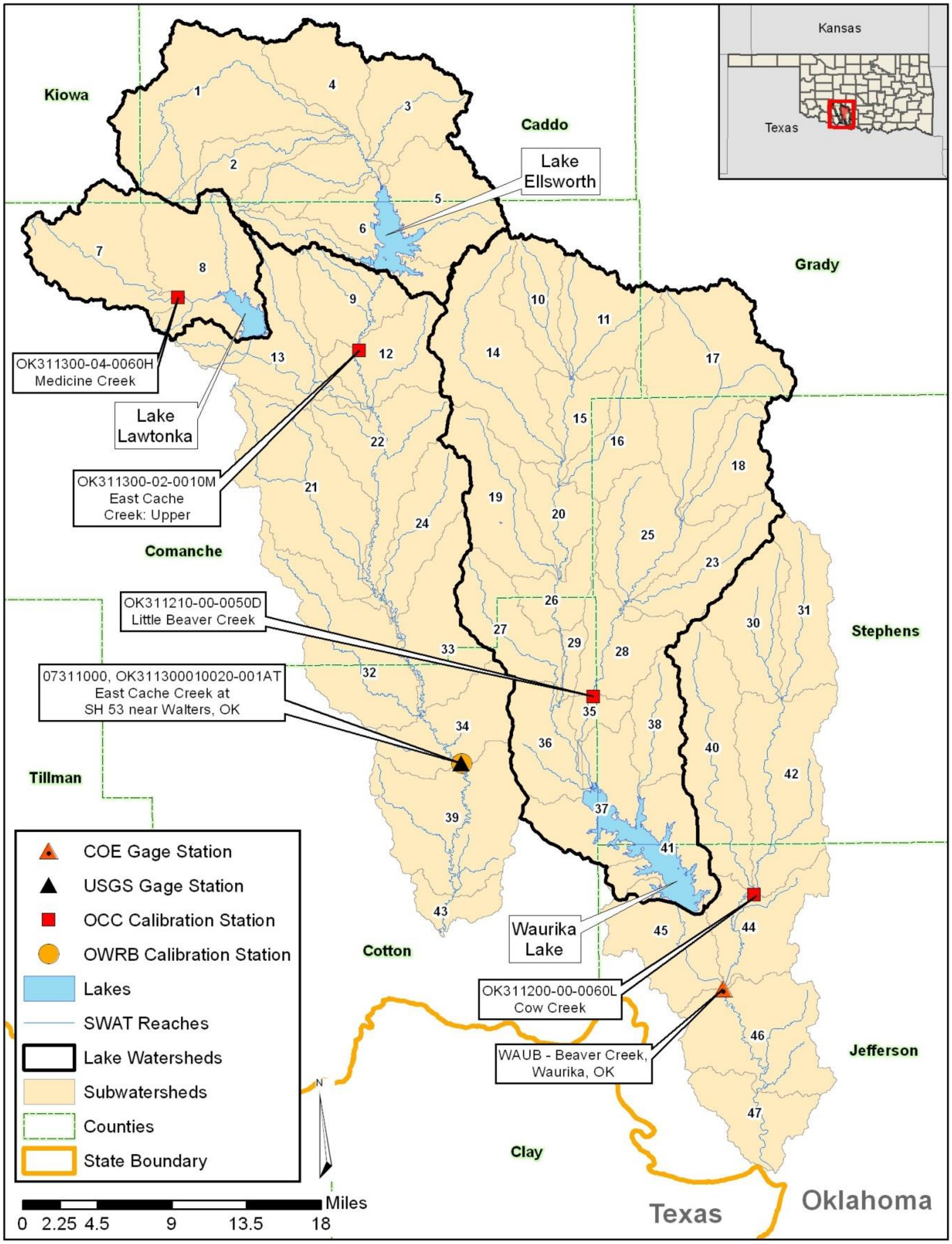
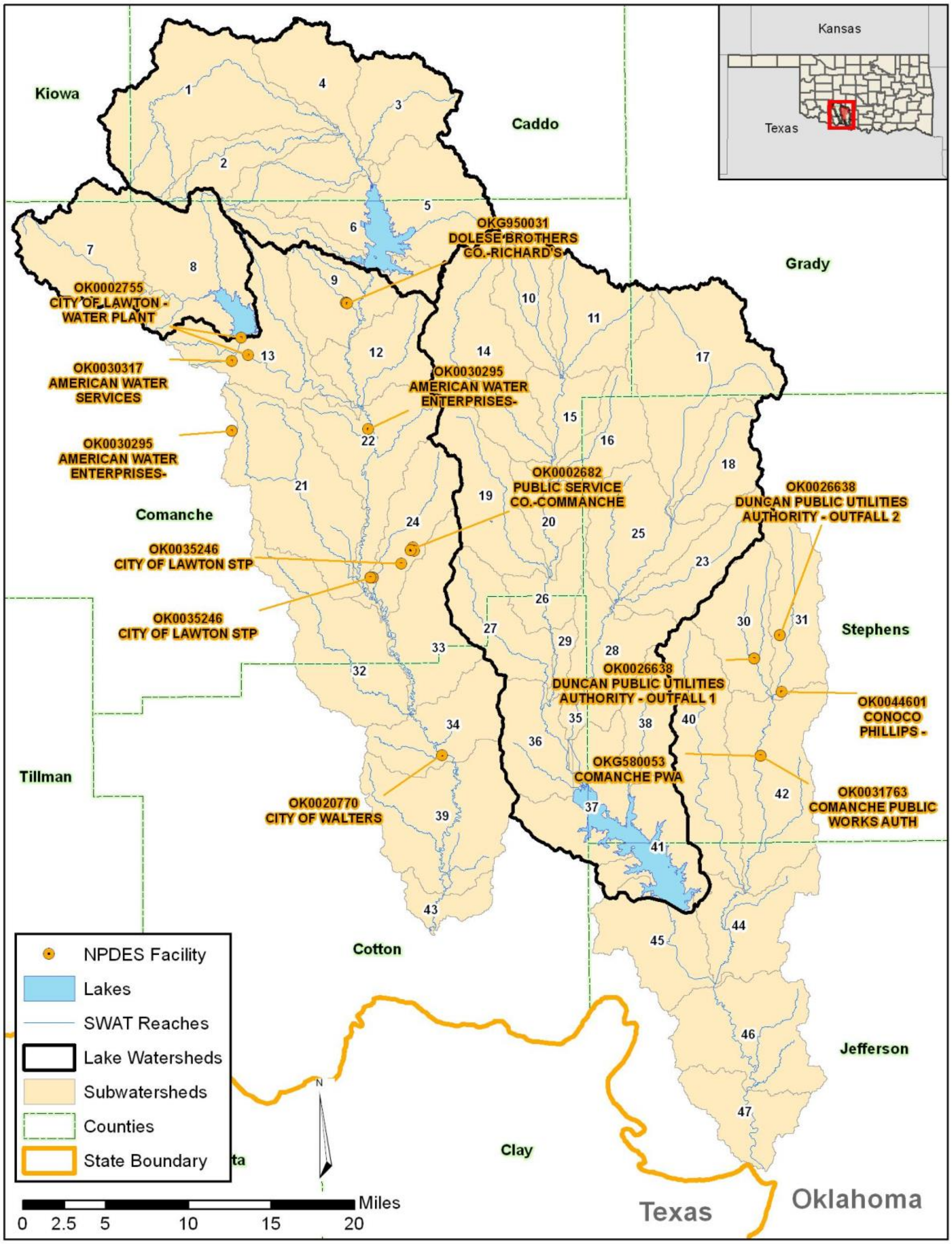


Figure C-3 Locations of NPDES Point Sources



Appendix C, Table-2: Summary of DMR Data for Point Sources in Model Area

Facility Name	NPDES	Average of Reported Monthly Average Values	
		Flow (MGD)	TSS (mg/L)
Dolese Brothers Co.-Richard's	OKG950031	0.37	9.72
Lawton, City Water Plant	OK0002755	0.82	19.78
American Water Services - Letra Beach WWT Facility	OK0030317	0.04	4.08
American Water Services - Fort Sill	OK0030295	2.08	10.62
Public Service Co.-Commanche	OK0002682	111.01	0.00
Lawton, City of Lawton STP	OK0035246	15.67	257.79
Duncan Public Utilities Authority - Outfall 001	OK0026638	3.32	40.03
Duncan Public Utilities Authority - Outfall 002	OK0026638	2.77	51.28
Conoco Phillips	OK0044601	0.20	33.34
Walters, City Of	OK0020770	0.33	115.40
Comanche Public Works Auth	OK0031763	*	*
Comanche PWA	OKG580053	0.17	128.97

This table is for reference only. Input time-series for the various point sources were prepared using monthly data.
Some discharges are non-continuous; average is for months when a discharge was reported.

* Facility started discharging in 2011, so it was not included in the model.

Point source flows were input in monthly increments as reported in the DMRs. For months without data, the average of the period of record for a given facility was assumed. Subsequently, the flows from all the outfalls were added on a subwatershed basis and input to the model as a single point per subwatershed.

C-1.7 Concentrated Animal Feeding Operations

Only one concentrated animal feeding operation (CAFO) is located in the modeled watershed. CAFOs were not included in the SWAT model given the insignificant contributions from the only no-discharge CAFO facility located in the model domain.

C-1.8 Management

SWAT defines management as a series of individual operations for each land cover. No modifications were made to the default management input files for urban, forest, and wetland land covers.

Cultivated Crop

The operations for wheat and corn are listed below:

<u>Wheat</u>

2/15 Fertilize 110 lb/acre of 46-00-00 (yields 50 lb/acre of N)

6/1 Harvest wheat

6/30 Disk plow with two passes

7/1 Springtooth harrow

8/10 Fertilize 150 lb/acre of 18-46-00 (yields 30 lb/acre P_2O_5 & 27 lb/acre of N)

8/10 Fertilize 52 lb/acre of 46-00-00 (yields 23 lb/acre of N)

10/1 Plant wheat

12/1 Grazing 1/3 au/acre for 90 days

<u>Corn</u>

3/15 Harvest and kill wheat

3/16 Fertilize 5 lb/acre of P_2O_5

3/16 Fertilize 120 lb/acre of 46-00-00 (yields 55 lb/acre of N)

3/25 Disk plow with two passes

3/26 Springtooth harrow

3/27 Plant corn

3/28 Irrigation begins based on plant water demand

9/16 Harvest and kill corn

9/25 Fertilize 60 lb/acre of 46-00-00 (yields 28 lb/acre of N)

9/26 Disk plow with two passes

9/26 Springtooth harrow

10/1 Plant wheat

Pasture

The stocking rate used for pastures in the SWAT model was calculated using the actual number of cattle in the basin. County level NASS estimates for the period 1997-2008 were combined with land cover data to estimate the number of cattle within the model area (USDA 2007). It was assumed that cattle were evenly distributed across all pastures in the six counties encompassing the basin. The estimated number of cattle and calves in the model area is 139,774 head (Table C-3).

Appendix C, Table-3: Cattle Estimates for SWAT Watershed

County	Average number of cattle (head)[a]	Area of range land cover in county (acre)[b]	Density (head/acre rangeland)[c]	Area of range land cover in SWAT (acre)	Estimated # cattle in watershed (head)[d]
Caddo	140,111	476,921	0.29	67,091	19,710
Comanche	70,084	490,515	0.14	281,871	40,273
Grady	124,350	489,936	0.25	25,263	6,412
Stephens	73,728	387,871	0.19	155,564	29,570
Cotton	68,183	208,903	0.33	76,835	25,078
Jefferson	90,815	359,966	0.25	74,244	18,731
Total					**139,774**

[a] Average of 1998-2007 NASS estimates at the county level
[b] Derived using ArcGIS to intersect the land cover raster with the county shapefile
[c] Number of cattle in county divided by the area of rangeland for that county (assumes cattle are evenly distributed)
[d] Density times the area of rangeland of a given county that is within the modeled watershed

The operation schedule for pastures is summarized below:

3/1 Grazing 0.4 au/acre for 300 days

C-1.9 Soil Nutrients

Mehlich III Soil Test Phosphorus (STP) for cropland and pasture were derived from Oklahoma State University Department of Plant and Soil Science county level averages for the period 1994 to 2001 (obtained from Storm et al. 2000). A summary of the soil concentrations by county is provided in Table C-4.

Appendix C, Table-4: Average Mehlich III Phosphorus Soil Test Results by County

County	Average County Mehlich III STP (lb/acre)		
	Pasture	Wheat	Corn
Caddo	74	81	92
Comanche	79	74	
Grady	66	71	73
Stephens	61	79	46
Cotton	67	63	
Jefferson	85	97	

Source: The STP concentrations were obtained from "Estimating Watershed Level Nonpoint Source Loading for the State of Oklahoma – Final Report" by Daniel Storm et al.

Soil nitrogen levels were estimated by the SWAT model based on the organic carbon data included in the soils database.

C-1.10 Simulation Period and Variables of Concern

A 17 year period (1994 - 2010) was simulated in the SWAT model. However, the first four years were considered a “spin-up” period for stabilizing model initial conditions, and the model output consisted of only the latter 13 years (1998 - 2010). The variables simulated in SWAT included flow, organic phosphorus, mineral ortho-phosphorus, organic nitrogen, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, and total suspended solids.

C-2. Calibration

C-2.1 Hydrologic Calibration

The lakes were simulated as reservoirs in SWAT. The SWAT hydrologic calibration was primarily performed based on flow data available at the USGS gage located on East Cache Creek (07311000) and the COE gage located on Beaver Creek at Waurika (WAKO2, AKA WAUB) (Figure C-2). In addition, the model simulated inflow to Waurika Lake was compared to daily records reported by COE. Table C-5 summarizes the parameters changed during calibration along with their calibrated value. The parameters were changed on a watershed level (overall change across the 47 subwatersheds), except when noted in the table.

Appendix C, Table-5: List of Adjusted Parameters for Hydrologic Calibration of SWAT Model

<table>
<tr><th>Parameter</th><th>Units</th><th>Description</th><th>Location in SWAT Input</th><th>Default Value</th><th>Sub-basin</th><th>Calibrated Value</th></tr>
<tr><td>ALPHA_BF</td><td>day</td><td>Baseflow recession constant</td><td>**.gw</td><td>0.048</td><td>All</td><td>1</td></tr>
<tr><td rowspan="3">RCHR_DP</td><td rowspan="3">--</td><td rowspan="3">Percent of infiltrated water lost to a regional aquifer</td><td rowspan="3">**.gw</td><td rowspan="3">0.05</td><td>17,18,19,25,29, 35,36,37,41</td><td>0.15</td></tr>
<tr><td>30,31,40,42,44, 45</td><td>0.4</td></tr>
<tr><td>All others</td><td>0.05</td></tr>
<tr><td>GW_DELAY</td><td>day</td><td>Groundwater delay time</td><td>**.gw</td><td>31</td><td>All</td><td>100</td></tr>
<tr><td>ESCO</td><td>--</td><td>Evaporation coefficient</td><td>**.bsn</td><td>0.95</td><td>All</td><td>0.7</td></tr>
<tr><td>SURLAG</td><td>day</td><td>Surface runoff lag coefficient</td><td>**.bsn</td><td>4</td><td>All</td><td>1</td></tr>
</table>

Parameter	Units	Description	Location in SWAT Input	Default Value	Sub-basin	Calibrated Value
CN2	--	SCS curve number	**.mgt	-	All	x0.9
CH_K1	mm/hr	Effective hydraulic conductivity in tributary channel	**.sub	0.5	30,31,40,42,44,45	1.5

The primary calibration targets included annual water balances. But modeled monthly flows and the resulting flow duration curves were also compared to measured values. Figures C-4 and C-5 display time series of observed vs. predicted annual and monthly flows in East Cache Creek at SH53 near Walters (sub-basin 34), Beaver Creek at Waurika (sub-basin 45), and Waurika Lake inflows. Table C-6 summarizes the statistics computed to evaluate model performance for annual flows. Overall, the model reproduces the annual flows within the 15% target for most years, with overall errors below the target for all the locations (1% for East Cache Creek, 6% for Beaver Creek, and -6% for Waurika Lake inflow). Resulting Nash-Sutcliffe Efficiency coefficients (NSE) and correlation coefficient (r^2) values were 0.987 and 0.990 for Cimarron East Cache Creek, 0.983 and 0.995 for Beaver Creek, and 0.981 and 0.986 for Waurika Lake inflow. The high resulting coefficients indicate very good model performance for annual flows.

Figure C-6 compares the modeled and observed daily flow duration curves for sub-watersheds[4] 34 and 45 and for Waurika Lake inflow. A flow duration curve depicts the percentage of the time that a given flow is not exceeded. The model simulation agrees well with the observed flow duration curves across all flow conditions.

4 The location of these sub-watersheds can be found in Figure 3-2.

Figure C-4 Observed and Modeled Annual Flows

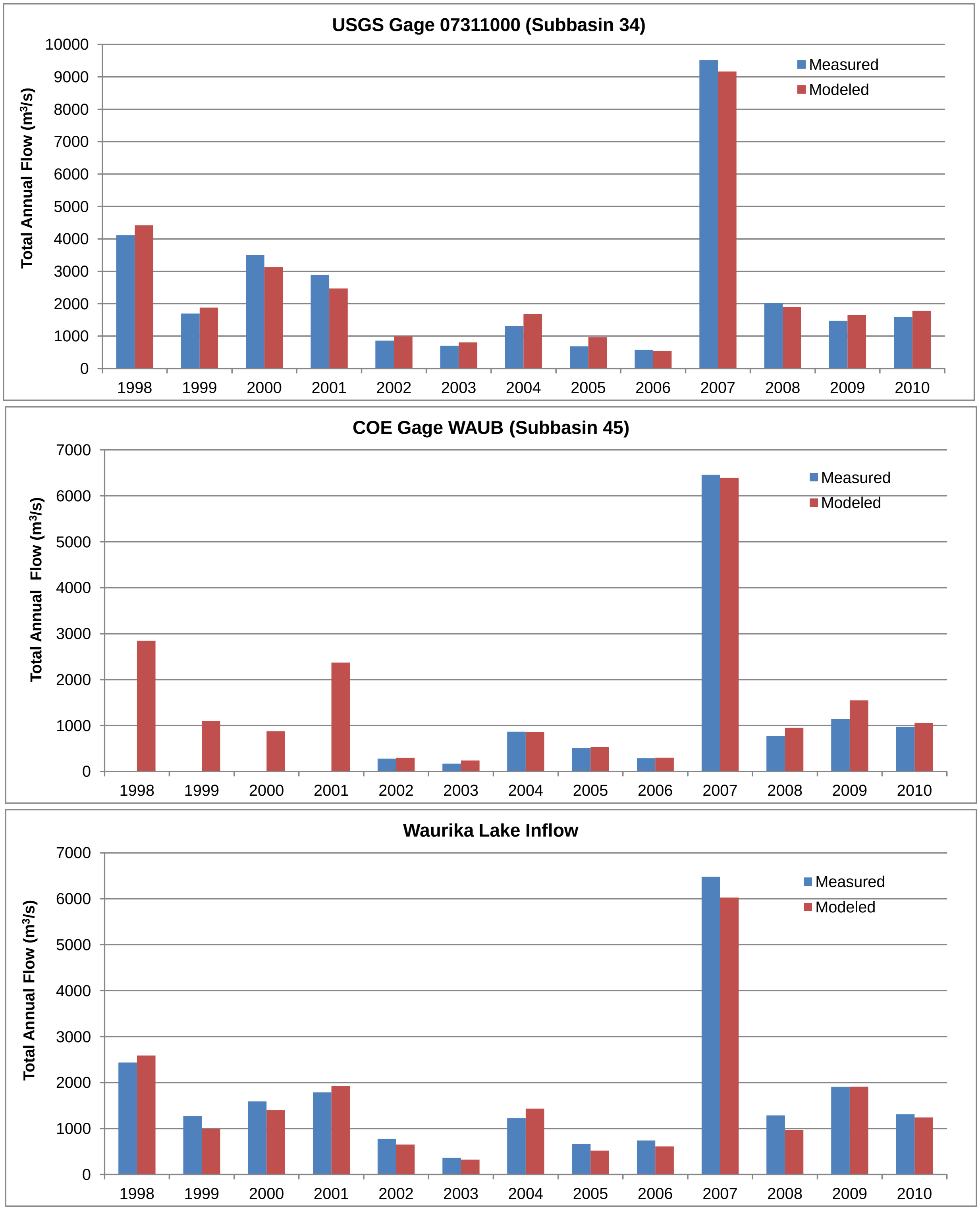
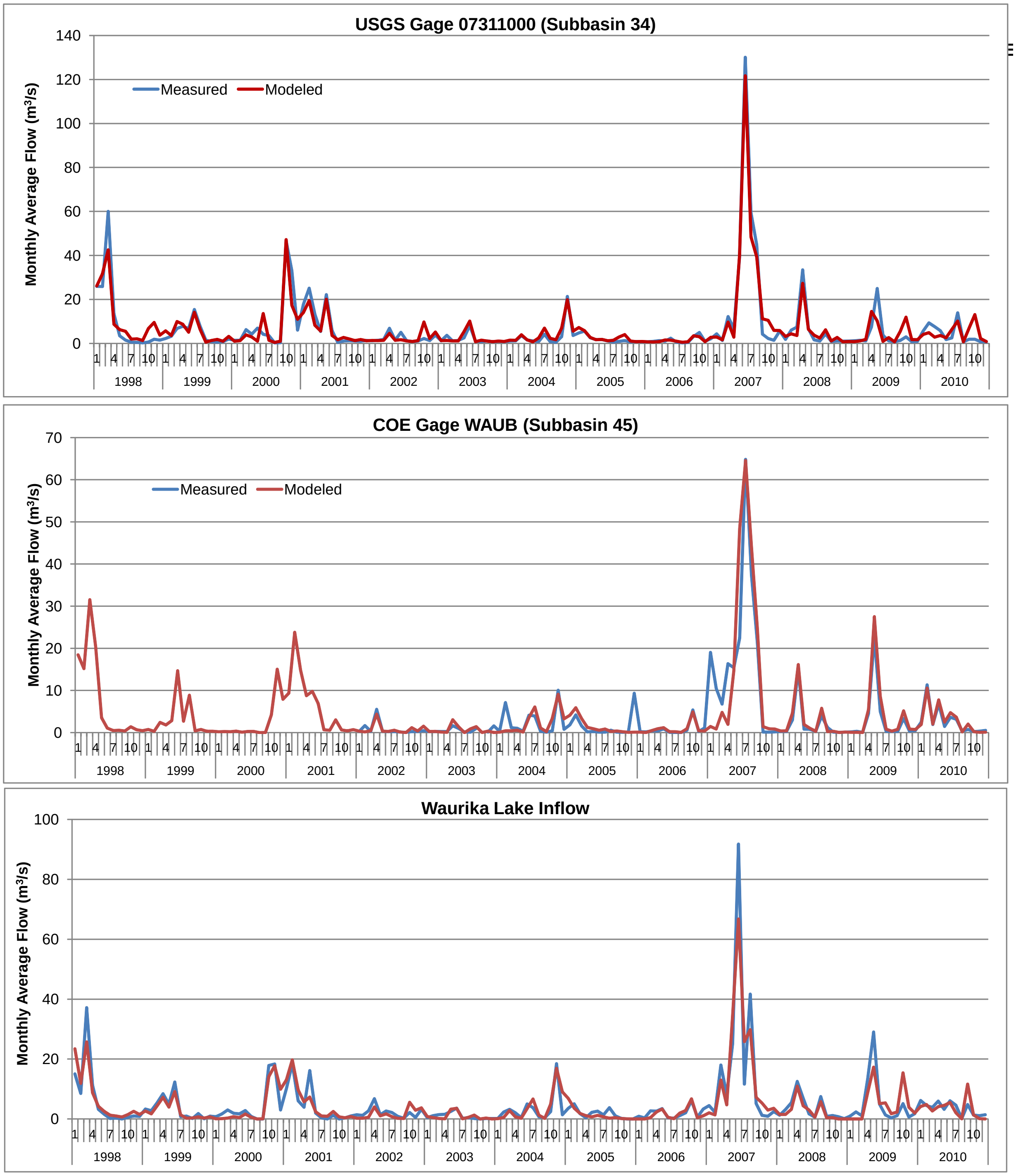


Figure C-5 Observed and Modeled Average Monthly Flows



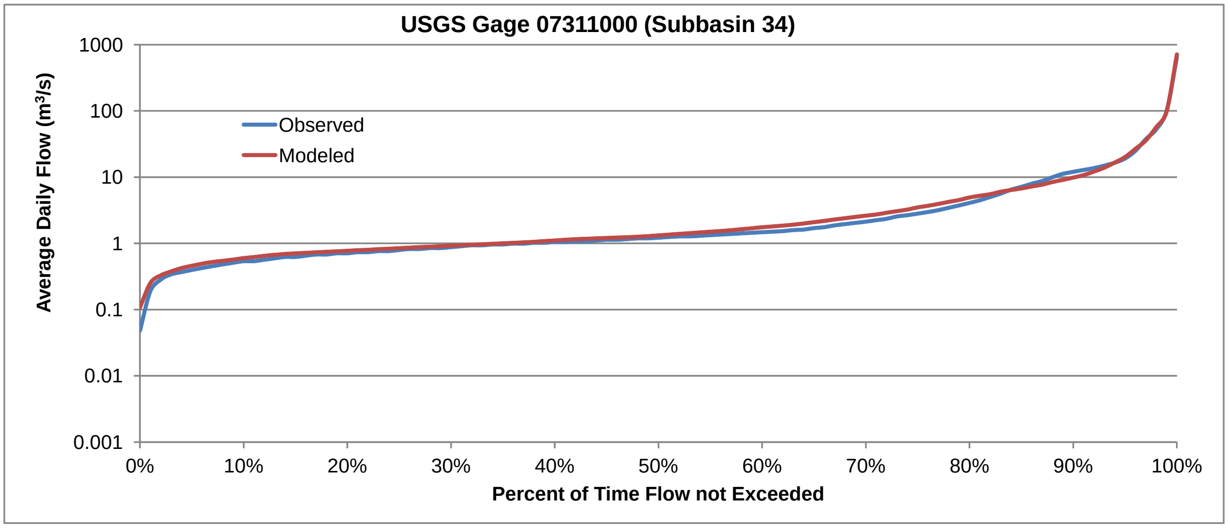
Appendix C, Table-6: Summary of Model Performance for Water Quantity

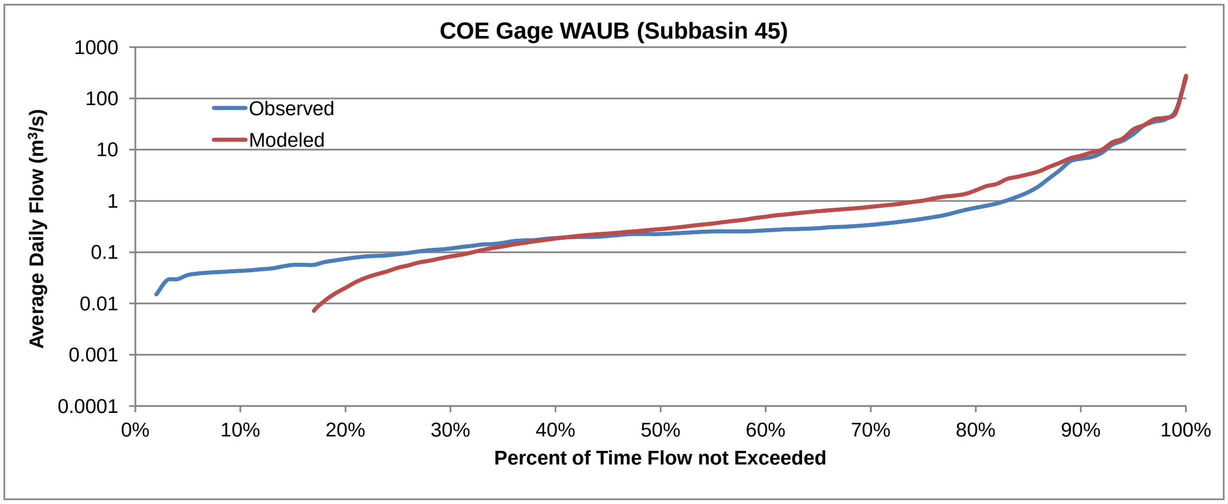
Year	USGS 07311000 (Sub-watershed 34)					COE WAKO2 (Sub-watershed 45)					Waurika Lake Inflows				
	Total Annual Flow (m^3/s)		Model Error	NSE [a,b]	r^2 [a]	Total Annual Flow (m^3/s)		Model Error	NSE [a,b]	r^2 [a]	Total Annual Flow (m3/s)		Model Error	NSE [a,b]	r^2 [a]
	Observed	Modeled				Observed	Modeled				Observed	Modeled			
1998	4,108	4,419	8%			-	-	-			2,435	2,587	6%		
1999	1,699	1,880	11%			-	-	-			1,273	995	-22%		
2000	3,500	3,129	-11%			-	-	-			1,588	1,400	-12%		
2001	2,887	2,468	-15%			-	-	-			1,788	1,926	8%		
2002	860	991	15%			280	296	6%			774	650	-16%		
2003	707	808	14%			171	238	39%			362	323	-11%		
2004	1,308	1,681	29%			865	863	0%			1,226	1,434	17%		
2005	685	960	40%	**0.99**	**0.99**	511	534	4%	**0.98**	**0.99**	667	518	-22%	**0.98**	**0.98**
2006	577	540	-6%			288	300	4%			739	610	-17%		
2007	9,510	9,162	-4%			6,457	6,393	-1%			6,481	6,029	-7%		
2008	2,016	1,903	-6%			779	950	22%			1,284	970	-24%		
2009	1,473	1,647	12%			1,147	1,548	35%			1,906	1,909	0%		
2010	1,596	1,784	12%			973	1,057	9%			1,309	1,243	-5%		
Overall	**30,926**	**31,373**	**1%**			**11,473**	**12,180**	**6%**			**21,833**	**20,593**	**-6%**		

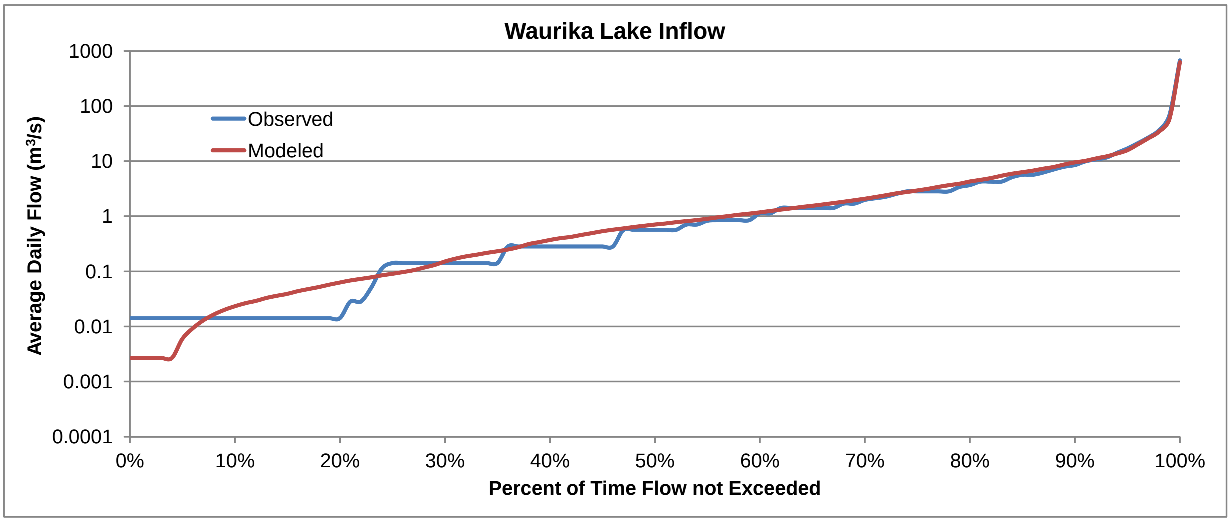
[a] Calculated using average monthly flows

[b] Nash-Sutcliffe Efficiency Coefficient = $1 - \frac{\sum(obs - mod)^2}{\sum(obs - obs_{avg})^2}$

Figure C-6 Observed and Modeled Daily Flow Duration Curves







C-2.2 Water Quality Calibration

There are water quality monitoring stations in the tributaries to Lake Lawtonka (OCC monitoring station OK311300-04-0060H - Medicine Creek) and Waurika Lake (OCC monitoring station OK311210-00-0050D – Little Beaver Creek), but none in the tributaries to Lake Ellsworth. The SWAT model was calibrated at five stream water quality monitoring stations in the modeled domain (Figure C-2): East Cache Creek at SH 53 near Walters (OWRB monitoring station 311300010020-001AT), Little Beaver Creek (OCC monitoring station OK311210-00-0050D), Medicine Creek (OCC monitoring station OK311300-04-0060H), OCC monitoring station in the upper part of East Cache Creek (OK311300-02-0010M), and Cow Creek (OCC monitoring station OK311200-00-0060L). The goal of the water quality calibration was to match average modeled concentrations to average measured concentrations within a 25% error. SWAT model calibration input files can be provided by DEQ upon request.

Figure C-7 shows a comparison of observed and modeled TSS concentrations for the five calibration stations. The model predicts the average of the measured TSS concentrations at the various locations within the 25% target error.

Figure C-7 Observed and Modeled Average TSS Concentrations

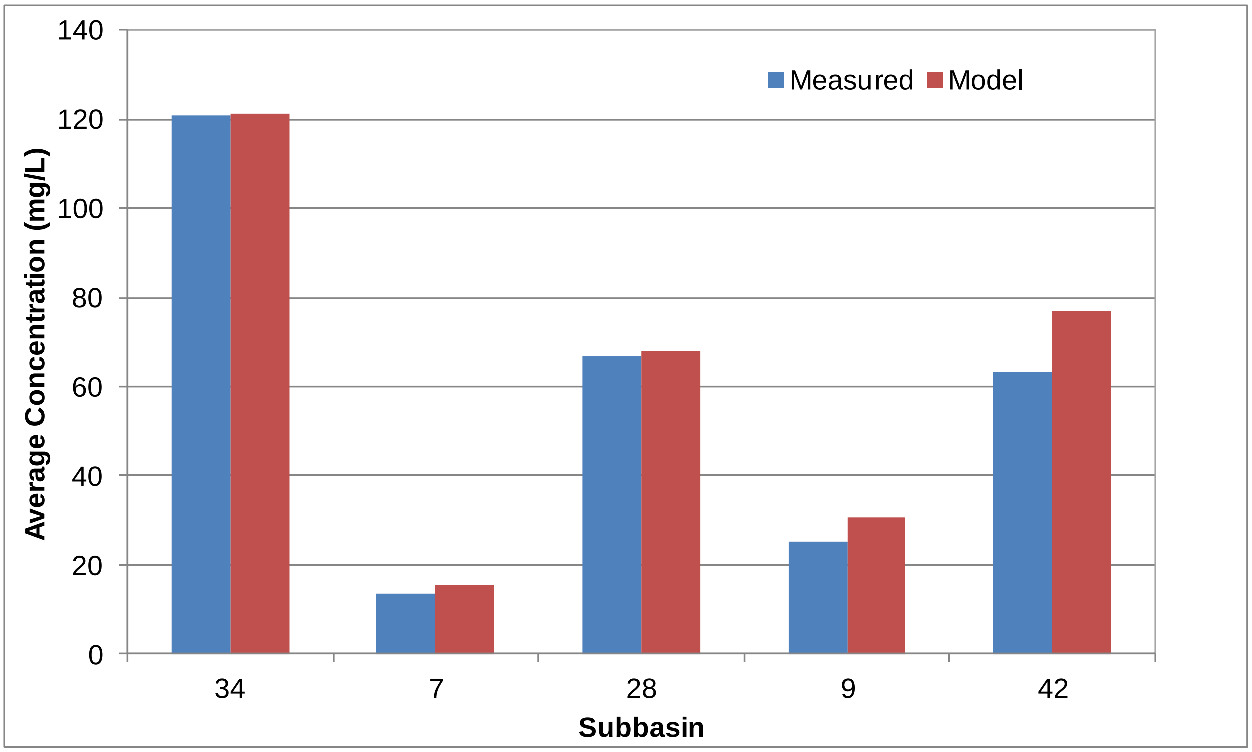


Table C-7 summarizes the model error for the various nutrients. As can be seen, in most cases, the SWAT model reproduced the average nutrient concentrations within 25% of the measured averages (Figure C-8). In some instances, the model does not replicate speciation for a given period, but nevertheless the total phosphorus and nitrogen predicted averages are within or close to the 25% target. For purposes of calculating averages to compare to modeled values, non-detects were assumed equal to half of the detection limit. The detection limit varied among events and among sampling sites, hence, the difference in calculated averages for sub-watersheds 7, 9, 28 and 42 in Figure C-8. It is noted that, with exception of the measurements at the station on East Cache Creek at SH 53 and the NO_3 concentrations at the station on Cow Creek, all the TSS and nutrient measurements for the remaining stations were below detection limits. The monitoring data available for calibration are from low to moderate flow conditions. As a result, there is more uncertainty on high flow loading values.

Appendix C, Table-7: Summary of Model Error for Nutrient Predictions

Parameter	Subb 34[a]	Subb 7[b]	Subb 28[b]	Subb 9[b]	Subb 42[b]
PO_4	16%	-25%	-10%	-22%	1%
Total Phosphorus	8%	1%	2%	32%	10%
NH_4	24%	-29%	-14%	8%	11%
NO_x	43%	1%	0%	-1%	18%
Total Nitrogen	5%	27%	-8%	-6%	17%

[a] Only values above detection limits were used for calculating model error statistics

[b] All the measurements were below detection limits and were assumed equal to ½ DL

Figure C-8 Observed and Modeled Average Nutrient Concentrations

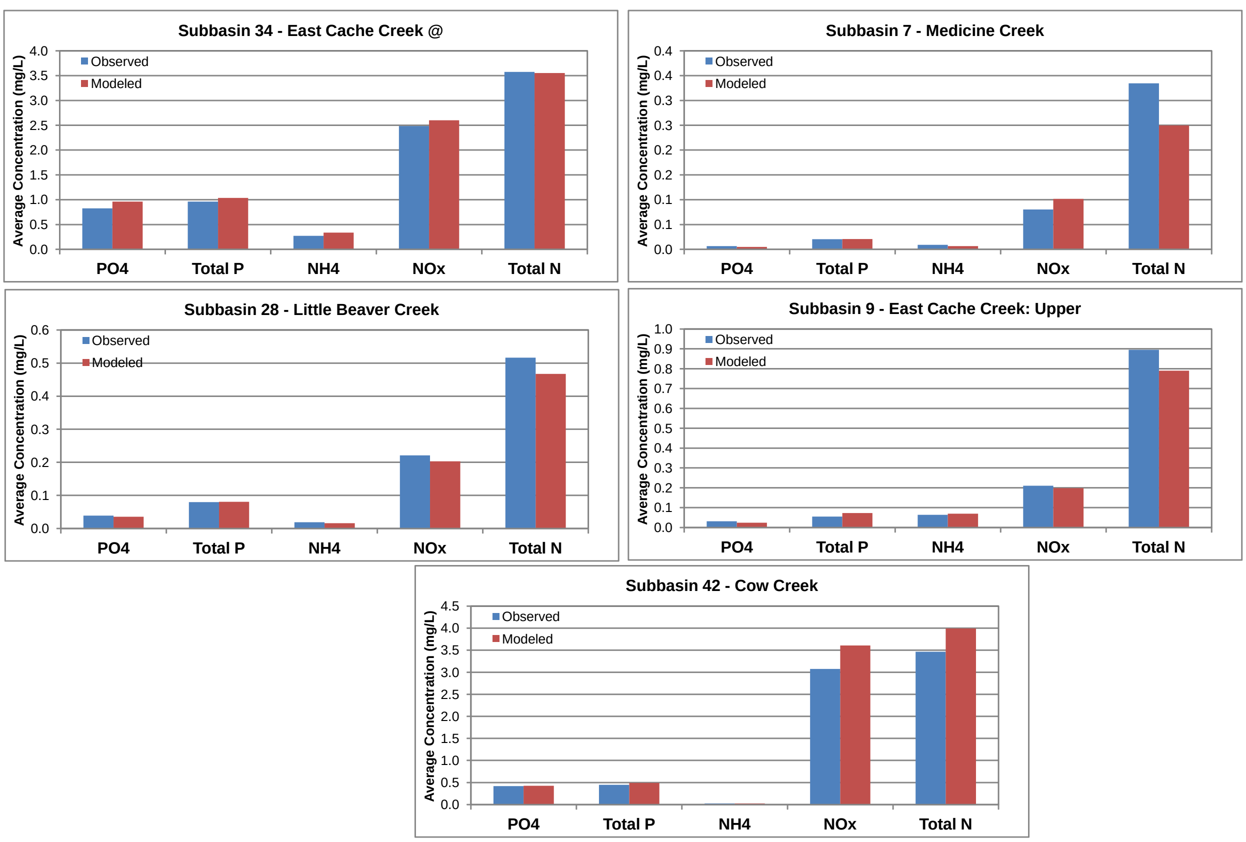


Table C-8 summarizes the statistics computed to evaluate water quality model performance. Statistics were calculated only for the station on East Cache Creek at SH53 (sub-basin 34) since that is the only location with measurements above detection limits. As can be seen, the model reproduces overall averages within 25% of the observed averages for both sediment and nutrients.

Appendix C, Table-8: Summary of Model Performance for Water Quality

Parameter	Sub-watershed	Avg observed (mg/L)	Avg modeled (mg/L)[a]	Error	NSE[a,b]	r^2 [a]
TSS	34	120.9	121.4	0%	0.79	0.83
	7	13.6	15.3	12%	-	-
	28	66.8	68.0	2%	-	-
	9	25.0	30.5	22%	-	-
	42	63.1	77.0	22%	-	-
Total Phosphorus	34	0.96	1.04	8%	0.37	0.39
	7	0.02	0.02	1%	-	-
	28	0.08	0.08	2%	-	-
	9	0.06	0.07	32%	-	-
	42	0.45	0.49	10%	-	-
Total Nitrogen	34	3.58	3.55	-1%	0.21	0.25
	7	0.33	0.25	-25%	-	-
	28	0.52	0.47	-10%	-	-
	9	0.90	0.79	-12%	-	-
	42	3.46	3.99	15%	-	-

[a] Calculated using paired data using measured values above detection limits

[b] Nash-Sutcliffe Efficiency Coefficient = $1 - \frac{\sum(obs - mod)^2}{\sum(obs - obs_{avg})^2}$

C-3. Model Results

Figures C-9 and C-10 show the average annual load of nutrients from runoff for each of the 47 sub-watersheds in the model domain. Total phosphorus loads ranged from 0.14 to 0.77 kg/ha/year. Total nitrogen loads varied between 0.87 and 4.32 kg/ha/yr.

Figure C-9 Average Total Phosphorus Loading from SWAT Sub-Watersheds

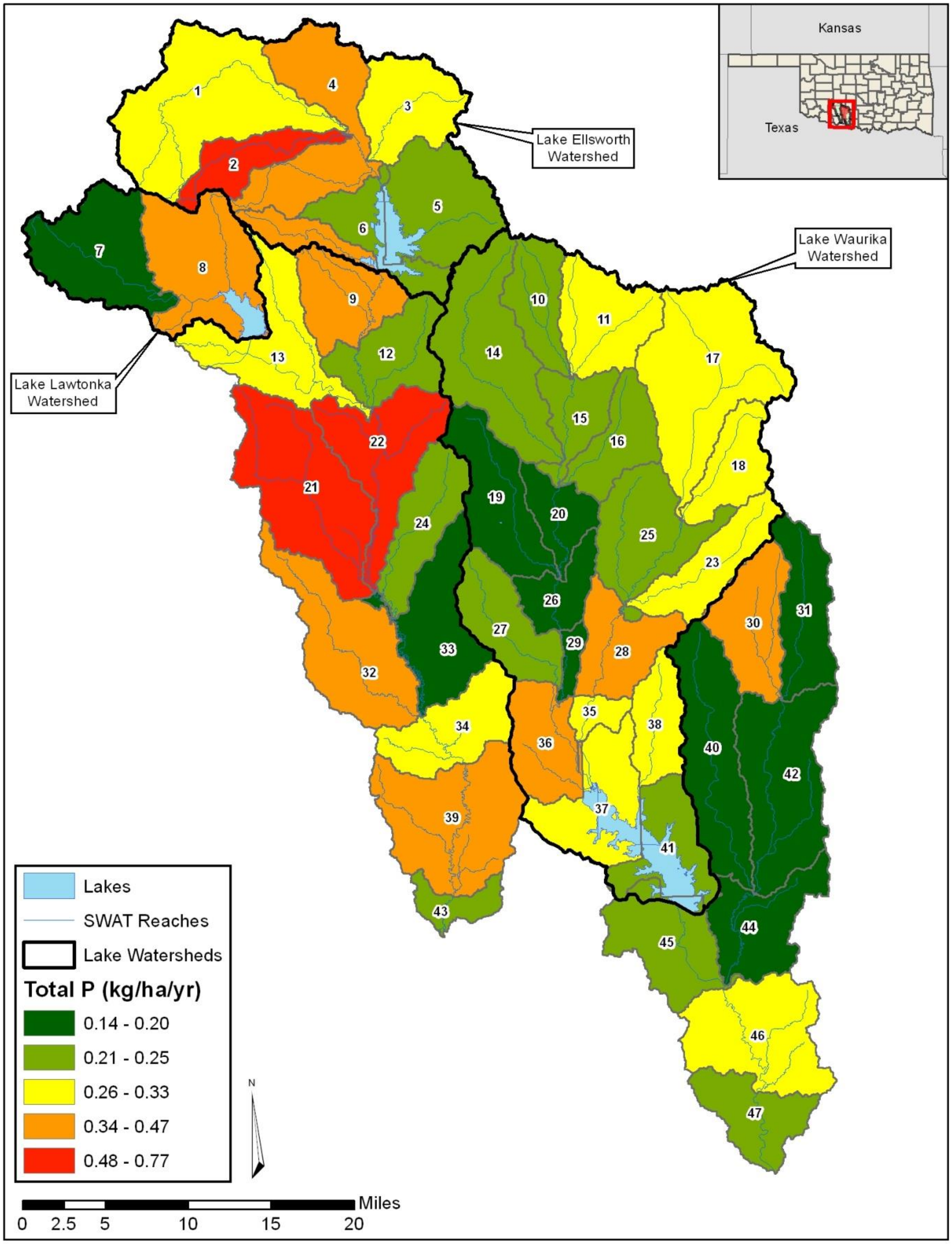
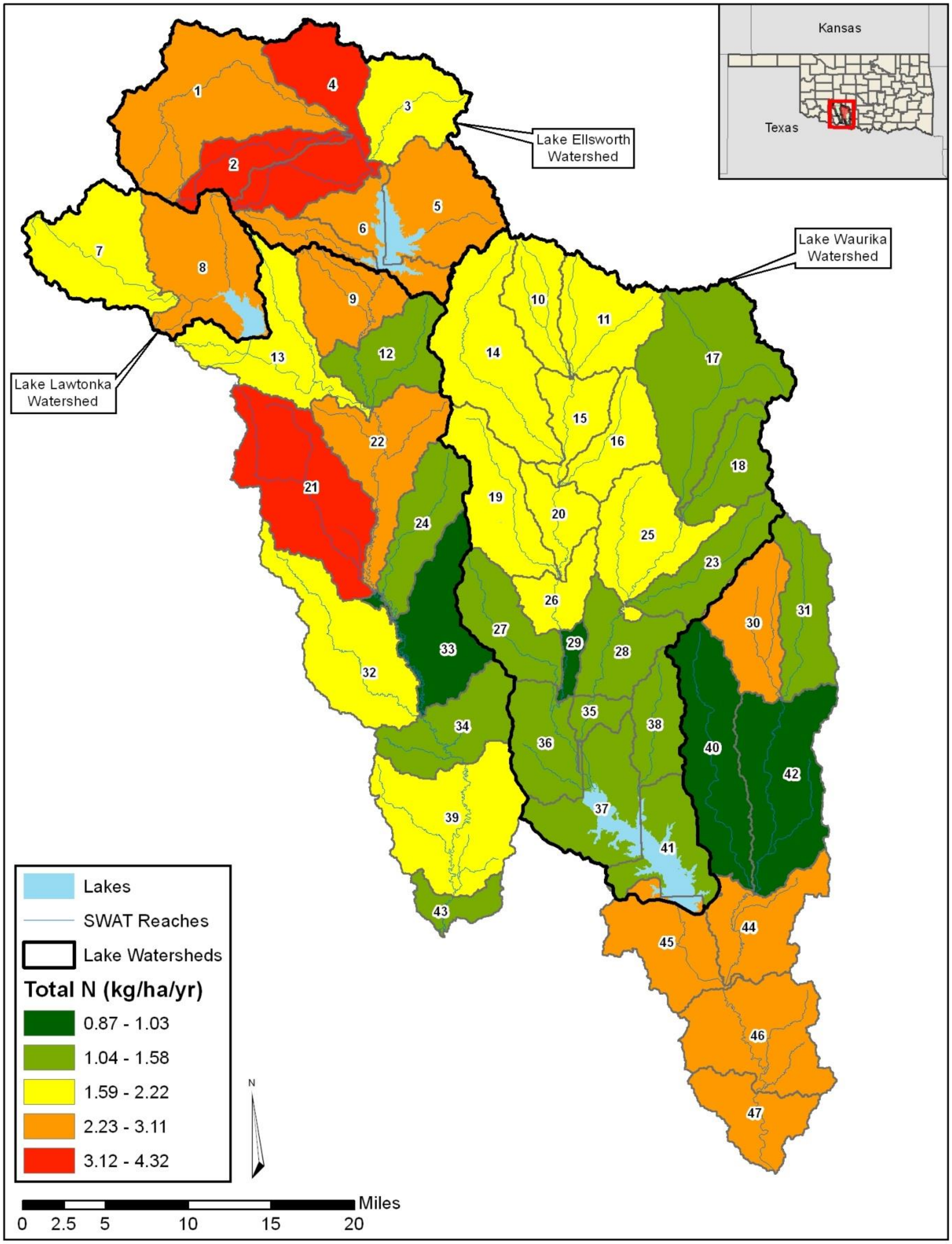


Figure C-10 Average Total Nitrogen Loading from SWAT Sub-Watersheds



A summary of average daily values for the sub-watersheds draining to Lake Lawtonka, Waurika Lake and Lake Ellsworth is included in Table C-9. Under current conditions, Lake Lawtonka is estimated to receive a total annual load of 7,200 kg of phosphorus and 52,800 kg of nitrogen, on average, from nonpoint sources in its watershed. Waurika Lake is estimated to receive a total annual load of 47,200 kg of phosphorus and 275,500 kg of nitrogen, on average, from sources in its watershed. Lake Ellsworth is estimated to receive a total annual load of 27,100 kg of phosphorus and 234,800 kg of nitrogen, on average, from nonpoint sources in its watershed. These values serve as the input data to the BATHTUB model to simulate average conditions for flow and nutrient loading to both lakes.

Appendix C, Table-9: Average Flows and Nutrient Loads Discharging to Lake Lawtonka, Waurika Lake and Lake Ellsworth

Parameter	Lake Lawtonka	Waurika Lake	Lake Ellsworth
Watershed Size (square miles)	93	562	248
Flow (m^3/day)	8.87×10^4	3.75×10^5	2.24×10^5
Organic Phosphorus (kg/year)	4,700	38,000	22,300
Mineral Ortho-Phosphorus (kg/year)	2,500	9,200	4,800
Total Phosphorus (kg/year)	**7,200**	**47,200**	**27,100**
Organic Nitrogen (kg/year)	24,600	141,600	125,700
Ammonia Nitrogen (kg/year)	200	8,800	10,100
Nitrate+Nitrite Nitrogen (kg/year)	28,000	125,100	99,000
Total Nitrogen (kg/year)	**52,800**	**275,500**	**234,800**

References

Haan, C.T., B.J. Barfield, and J.C. Hayes. 1994. Design Hydrology and Sedimentation for Small Catchments. Academic Press INC.

Neitsch, S.L., J.G. Arnold, J.R. Kiniry, and J.R. Williams, 2005. *Soil and Water Assessment Tool Theoretical Documentation: Version 2005*. USDA Agricultural Research Center and Texas A&M University Agricultural Experiment Station.

Storm, D.E., D. Gade, R. Tejral, M.D. Smolen, P. Kenkel, and M.S. Gregory. 2000. Estimating Watershed Level Nonpoint Source Loading for the State of Oklahoma. Oklahoma State University, Departments of Biosystems and Agricultural Engineering and Department of Agricultural Economics, University of Tennessee. Prepared for the Oklahoma Conservation Commission and the U.S. Environmental Protection Agency. August 24, 2000.

USDA 2007. Census of Agriculture, National Agricultural Statistics Service, United States Department of Agriculture. http://www.nass.usda.gov/Census/Create_Census_US_CNTY.jsp

USDA 2008. USDA National Agricultural Statistics Service (NASS) 2008 Cropland Data Layer (CDL). Available at (http://www.nass.usda.gov/research/Cropland/SARS1a.htm). Accessed April 2011.

Winchell, M., R. Srinivasan, M. Di Luzio, and J. Arnold. 2009. ArcSWAT 2.34 Interface for SWAT 2005 – User's Guide. Blackland Research Center, Texas Agricultural Experiment Station.

APPENDIX D

RESPONSE TO PUBLIC COMMENTS

Steve A. Thompson
Executive Director

Mary Fallin
Governor

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

Public Comments from the City of Lawton (Lakes Ellsworth and Lawtonka) and from the Waurika Master Conservancy District (Waurika Lake) in Response to the *Draft Chlorophyll-a TMDL Report for Lakes Lawtonka, Waurika, and Ellsworth*

August 28, 2013

1. With the data and the information that is submitted by the regulatory agency, it is not established that these three lakes ever were supporting the SWS beneficial use. Therefore, the application of SWS instead of public and private water supply is in question.

    Response 1:

    Lakes Waurika, Lawtonka and Ellsworth are designated as SWS lakes in the Oklahoma Water Quality Standards (OWQS) [Title 785, Chapter 45, Appendix A.3, page 56 for Waurika Lake and page 57 for Lake Lawtonka and Ellsworth Lake] so the application of that designation is not in question. This study was undertaken because these lakes are not currently supporting their designated beneficial uses [the waterbody assessment for Lake Lawtonka and Ellsworth Lake can be found on Page 71 of Appendix B of the 2010 Integrated Report[5] and on Page 69 for Waurika Lake]. When a waterbody is impaired [in Appendix C of the 2010 of the Integrated Report (aka the 303(d) list), the impairment of Waurika Lake is on Page 28,for Lake Lawtonka is on Page 30, and for Lake Ellsworth is on Page 29], the State is required to develop TMDLs for the waterbody. If the commenters wish to investigate the removal of the SWS designations, they should contact the Oklahoma Water Resources Board.*

2. The method 12000H of Standard Methods states that the method of analysis is not very accurate. The concentration of chlorophyll a could be "significantly under or over estimated" due to interferences from the test as well as other constituents of the water. Because of this possible error within the method itself, the results should only be used as an estimation of the chlorophyll a concentration and not used as a determining factor. There is no correlation in the document showing a link to the

[5] It remains the same for in the draft 2012 Integrated Report.

chlorophyll a concentration and the nutrients nitrogen and phosphorus present in the sample in Lawtonka, Ellsworth, and Waurika Lakes. With the low concentration of nutrients measured and reported, it cannot be established with any certainty at what level of nutrients will have an effect on the chlorophyll a therefore causing unwanted biological results within the water body.

Response 2:

The analytic method for chlorophyll-a is an EPA approved method, is widely used and is considered acceptable. There is inherent uncertainty in any analysis and the results could be under- or over-estimated for an individual measurement. However, the applicable chlorophyll-a criterion is a long-term average criterion. With a large number of samples, analytical uncertainty is minimized and the resulting long term average result will be reasonably accurate. The number of samples for this study ranged from 29 to 61, which is considered sufficient.

Evaluation of the cause and impact between water quality parameters can be very complex for a watershed and lake system. The relationships between these parameters may not be straight forward. Statistical analysis of observed data may even show poor correlations between chlorophyll-a and nutrients. This does not mean that the relationships between chlorophyll-a and nutrients do not exist. It only tells us that the statistical analysis of observed data can not reveal the relationship. That is why a water quality model was used to link chlorophyll-a to total nitrogen, total phosphorus, and other water quality parameters. The water quality models for Lake Waurika, Lawtonka and Ellsworth clearly showed that a reduction in nutrients will lead to lower levels of chlorophyll-a in the lakes.

3. The document has indicated that the detection limit of some analysis were different than that of others, then the modeler proceeded to assume presence of chlorophyll a at ½ detection limit in the case of samples that indicates presence of chlorophyll a at a concentration less than detection limit. This methodology is flawed and not based on any scientific statistical method for calculating average concentration, therefore the results are skewed.

Response 3:

Response: Using ½ the detection limit for samples with values below the detection limit is a widely used approximation for such samples when there is no other information regarding the true value. In the dataset used for this study, there are no undetected chlorophyll-a samples for Lake Lawtonka or Lake Waurika so this comment does not apply to these two lakes. There were only *two undetected chlorophyll-a samples (<0.1 ug/L) out of a total of 59 samples for Lake Ellsworth (see Appendix B & Table 2-5). The average of all samples is 12.2 ug/L. The approximated values for these 2 samples out of 59 will have a very negligible impact in the outcome of the assessment.*

4. In this document, the data used for verification of support of the beneficial use is based on data that has been collected in a duration of less than 10 years, but the requirement of verification is use of data that has been collected in a span of 10 years.

   Response 4:

   The 10-year reference is a limit on the time period to be used for beneficial use assessment, not a minimum requirement. According to 785:46-15-3 (d), the minimum number of samples required for assessment of lakes is 20 samples for lakes of more 250 surface acres or 10 samples for lakes of less than 250 surface acres. There are more than enough samples for each of the three lakes to satisfy the minimum data requirement for beneficial uses assessment.

5. The flow rate data used for verification/calibration of the model was collected in 13 years, USGS uses at least 25 years of data for decision making process.

   Response 5:

   While more data may be better, 13 years flow data are sufficient for the water quality modeling exercise in this study.

6. None of these lakes are on 303(d) lists for nutrients, the data submitted for total nitrogen and phosphorous indicates that these lakes are not nutrient limited. The analytical, statistical, the number of data all have attributed to identification of overabundance of an indicator species. However all of the information used for identification of presence, the concentration, the application, and correlation are miss applied *(sic)*, therefore the consequential conclusion is erroneous.

   Response 6:

   All three lakes are impaired due to elevated levels of chlorophyll-a (not supporting Public and Private Water Supply beneficial use) according to Oklahoma 2010 303(d) list. Those assessments are based on extensive data collected over several years and analyzed using the duly adopted Use Support Assessment Protocols. The state is required to develop TMDLs for the impaired uses. The chlorophyll-a criterion for SWS lakes does apply in these TMDLs.

There is no question that elevated levels of chlorophyll-a are directly related to nutrients.

7. The TMDL document does not include any provisions for WLA for future dischargers.

   Response 7:

   Please refer to section 5.1 of the TMDL report. New point source discharges are generally prohibited in SWS waterbodies and watersheds except in certain limited circumstances. If a future discharge was to be permitted, this TMDL would need to be revised.

8. Therefore based on the information depicted above, we question use of Chlorophyll –a and the 10 µg/l criterion for distinguishing between impaired and supporting water body.

   Response 8:

   Please refer to the above responses.

9. Page 4-11 of the draft TMDL says:(sic) "*Figures 4-7, 4-8, and 4-9 display summary plots of multiple combinations of TN and TP concentrations and percent reductions that result in 10 µg/L chlorophyll-a for Lawtonka and Waurika Lakes and 9 µg/L for Lake Ellsworth estimated using BATHTUB. The data points in the plots correspond to the subset of MCS iterations that resulted in the target chlorophyll-a levels. While the relative importance of nitrogen and phosphorus in limiting algal productivity in Lawtonka, Waurika, and Ellsworth Lakes has not been definitively established, this TMDL calculates load allocations for both nitrogen and phosphorus as a conservative approach to ensure that water quality targets are met. While the BATHTUB model is capable of simulating chlorophyll-a concentrations from both TP and TN concentrations, it is an empirically derived statistical algorithm that does not include the concept of a limiting nutrient. In other words, chlorophyll-a concentrations are a continuous function of both TN and TP contributions that can vary from season to season. Since there are infinite combinations of TN and TP concentrations that could result in the desired chlorophyll-a concentration and BATHTUB is not capable of discerning between them…*"

   Therefore, the available data as well as the model indicated in the TMDL document refutes applicability of the method used in calculation of load reduction for the purpose of achieving compliance with the beneficial use In the above excerpt from the full report, precise reduction goals are being generated from an imprecise set of results. Assumptions have to be made based on the data. A larger data set would help to determine the goals, especially if the data were taken in what is considered "normal" timeframes of 10 and 25 years.

Response 9:

The cited paragraph continues as follows: "a practical starting point for implementation is to begin with equal percent reduction goals for both nutrient parameters. However, depending on the local environmental and socio-economical conditions, different percent reductions for the two nutrients based on the curves in Figures 4-7, 4-8, and Figure 4-9 could be used during the implementation of each TMDL to achieve the target chlorophyll-a level in the lakes."

This paragraph does not refute the applicability of any methods used. The point of this section is that any combination of nitrogen and phosphorus values that falls on the plotted curve would achieve the target chlorophyll-a concentration. The TMDL is calculated based on an equal percent reduction but any other combination based on the curves would also be acceptable. This provision would allow for a different combination of nitrogen and phosphorus to be in compliance with the TMDL. If, for example, it is found that greater reduction of phosphorus is more easily or economically attainable, a lesser reduction of nitrogen determined from the curves would be acceptable. The data, the methods, the models and the results are all considered acceptable for TMDL purposes.