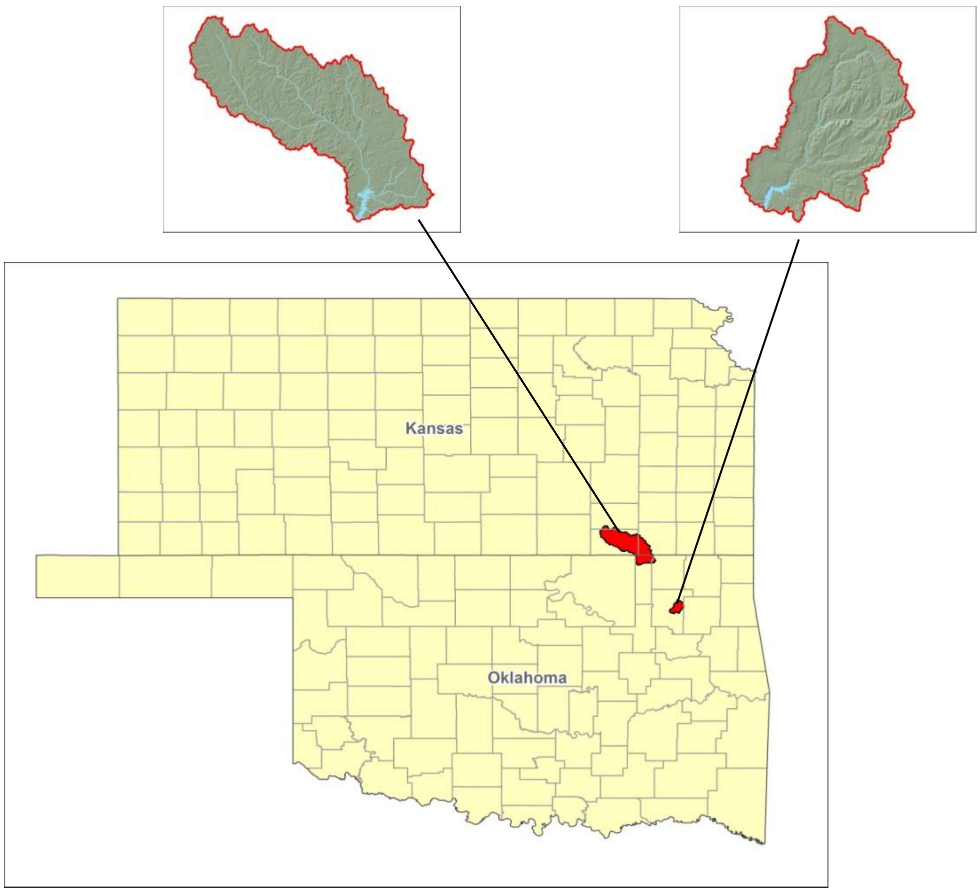
FINAL

CHLOROPHYLL-*a* TOTAL MAXIMUM DAILY LOADS FOR COPAN LAKE (OK121400050020_00) AND LAKE CLAREMORE (OK121500040020_00)



Prepared for:

Oklahoma Department of Environmental Quality

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ACRONYMS AND ABBREVIATIONS

AEMS	Agricultural Environmental Management Service
AFO	Animal Feeding Operation
AgPDES	Agriculture Pollutant Discharge Elimination System
µg/L	Microgram per liter
BUMP	Beneficial Use Monitoring Program
CAFO	Concentrated Animal Feeding Operation
CBOD	Carbonaceous Biochemical Oxygen Demand
CDL	Cropland Data Layer
CFR	Code of Federal Regulations
CPP	Continuing Planning Process
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
LDC	Load duration curve
MCS	Monte Carlo simulation
mgd	Million gallons per day
mg/L	Milligram per liter
mL	Milliliter
MOS	Margin of safety
MS4	Municipal separate storm sewer system
MSGP	Multi-Sector General Permit
NASS	National Agricultural Statistics Service
NPDES	National Pollutant Discharge Elimination System

NPS	Nonpoint source
NSE	Nash-Sutcliffe Efficiency
O.S.	Oklahoma statutes
OAC	Oklahoma Administrative Code
OCC	Oklahoma Conservation Commission
OPDES	Oklahoma Pollutant Discharge Elimination System
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
WBID	Waterbody Identification
WLA	Wasteload allocation
WQ	Water Quality
WQM	Water quality monitoring
WQMP	Water Quality Management Plan
WQS	Water quality standard
WWAQ	Warm Water Aquatic Community
WWTF	Wastewater treatment facility

Executive Summary

ES - 1 Overview

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

This total maximum daily load (TMDL) report documents the data and assessment used to establish TMDLs for Copan Lake [Oklahoma Waterbody ID (OK WBID) number OK121400050020_00] and Lake Claremore (OK121500040020_00). The Oklahoma Department of Environmental Quality (DEQ) placed these waterbodies in Category 5 of the Oklahoma 2012 Integrated Report for nonsupport of the public and private water supply designated use because of elevated levels of chlorophyll-*a*.

The two lakes (reservoirs) are located in the Neosho/Grand Sub-basin [hydrologic unit code (HUC) 1107]. Copan Lake is a 4,850-acre lake in Washington County with conservation pool storage of 43,400 acre-feet. It was impounded in 1983, and serves as a recreational lake, fish and wildlife propagation, and is utilized for flood control, water quality control, and water supply [Oklahoma Water Resources Board (OWRB) 2011]. Most of the 30-mile shoreline is undeveloped. The contributing watershed of Copan Lake is 505 square miles. The Little Caney River (Caney Creek), which is 5.52 miles long, is the primary tributary flowing to Lake Copan.

Lake Claremore is a 470-acre lake in Rogers County with a conservation pool storage of 7,900 acre-feet. Lake Claremore was first impounded by the City of Claremore (OWRB 2010) in 1930 and serves as a lake for recreation and municipal water supply. Most of the nine-mile shoreline is undeveloped, however roadways surrounding the lake to provide access to almost the entire shoreline. The contributing watershed of Lake Claremore is 58 square miles. Dog Creek (16.87 miles long) and Little Dog Creek (5.9 miles long) are the primary tributaries flowing to Lake Claremore.

Based on a review of satellite imagery from Google Earth Maps there appears to be little developed land bordering the shoreline of either of the two lakes. Both lakes are popular fishing and boating recreation destinations. The watersheds of both lakes are sparsely populated, with developed land accounting for less than 1% of the watershed area. The most common land use categories throughout both watersheds are pasture/hay, grassland, and deciduous forest. The contributing watersheds are herein after referred to as the Study Area. Data assessment and TMDL calculations were conducted in accordance with requirements of Section 303(d) of the CWA, Water Quality Planning and Management Regulations (40 CFR Part 130), EPA guidance, and DEQ guidance and procedures. DEQ is required to develop TMDLs for all impaired waterbodies which are on the 303(d) List. The draft TMDL went to EPA for review before it was submitted for public comment. After the public comment period, the TMDL was submitted to EPA for final approval. Once EPA approves the final TMDL, then the waterbody is moved to Category 4a of the Integrated Report, where it remains until it reaches compliance with Oklahoma's water quality standards (WQS).

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

The purpose of this TMDL study was 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 established 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 wasteload allocations (WLA), load allocations (LA), and a margin of safety (MOS). A WLA is the fraction of the total pollutant load apportioned to point sources, and includes stormwater discharges regulated under OPDES as point sources. An LA is the fraction of the total pollutant load apportioned to nonpoint sources. 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.

ES - 2 Problem Identification and Water Quality Target

This TMDL study focused on the waterbodies identified in **Table ES-1** that DEQ placed in Category 5 of the *Water Quality in Oklahoma 2012 Integrated Report* for nonsupport of the Public & Private Water Supply beneficial 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.

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, Copan Lake and Lake Claremore are both listed as SWS lakes.

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

Waterbody Name and Waterbody Identification Number (WBID)	Waterbody Size (Acres)	TMDL Date	TMDL Priority	Causes of Impairment	Designated Use Not Supported
Copan Lake (OK121400050020_00)	4,850	2023	4	Chlorophyll-*a*	Public and Private Water Supply
Lake Claremore (OK121500040020_00)	470	2020	3	Chlorophyll-*a*	Public and Private Water Supply
				Color	Aesthetic
				Turbidity	Warm Water Aquatic Community

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 Copan/Claremore watersheds on the DEQ 2012 §303(d) List for non-support of the Public and Private Water Supply Use in an SWS lake:

- Between 2003 and 2012, Copan Lake chlorophyll-*a* samples averaged 19.0 µg/L which is equivalent to a Carlson's TSI of 59.5 (Carlson 1977).
- Between 2003 and 2010, Lake Claremore chlorophyll-*a* samples averaged 30.4 µg/L (TSI = 64.1).

Between 1999 to 2012, total nitrogen levels (TN) and total phosphorus (TP) levels were as follows for the lakes in the Study Area:

- Copan Lake: TN levels averaged approximately 0.65 mg/L and TP levels averaged 0.09 mg/L (**Table 2-5**). Thermal stratification was evident and anoxic conditions were present during the summer sampling interval (OWRB 2007).
- Lake Claremore: TN levels averaged approximately 1.07 mg/L, and TP levels averaged 0.08 mg/L (**Table 2-6**). Thermal stratification was not observed in the fall and dissolved oxygen levels remained well above 5 mg/L during the BUMP assessment period (OWRB 2007). Thus, nutrient fluxes from sediments were available year-round in the photic zone where light permits algal photosynthesis.

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 2013). Therefore, the water quality target established for each lake was to achieve a long-term average in-lake concentration of 10 µg/L for chlorophyll-*a*.

Copan Lake was also included in the 303(d) List for turbidity and color. These water quality issues will be addressed specifically at 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).

ES - 3 Pollutant Source Assessment

This section includes an assessment of the known and suspected sources of nutrients contributing to the eutrophication of Copan Lake and Lake Claremore. Nutrient sources identified were categorized and quantified to the extent that reliable information was available. Generally, nutrient loadings causing eutrophication of lakes originate from point or nonpoint sources of pollution. Point sources are permitted through the OPDES 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 OPDES were 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. OPDES-permitted facilities classified as point sources that may contribute nutrient loading include:

- Continuous Point Source Dischargers
  - OPDES municipal wastewater treatment facilities (WWTF)
  - OPDES Industrial WWTF Discharges
- OPDES-regulated stormwater discharges
  - Municipal separate storm sewer system (MS4) discharges – OKR04
    - Phase 1 MS4
    - Phase 2 MS4
  - Multi-sector general permits (OKR05)
    - Regulated Sector J Discharges
    - Rock, Sand and Gravel Quarries
  - Construction stormwater discharges (OKR10)
- No-discharge WWTF
- Sanitary sewer overflow (SSO)
- NPDES Animal Feeding Operations (AFO)
  - Concentrated Animal Feeding Operations (CAFO)
  - Swine Feeding Operation (SFO)
  - Poultry Feeding Operation (PFO)

There were no AFOs, no-discharge facilities, or continuous industrial point source discharges within the Copan Lake or Lake Claremore watersheds at the time of the TMDL study. However, there were two continuous municipal point source discharge facilities within the Study Area (one in each watershed). The facility located on the Copan Lake watershed

(Copan Public Works Authority) is a wastewater plant and, thus, was a source of nutrient loading. However, the Copan PWA made a formal request on May 5, 2014 to move the discharge point to the stream segment just below the lake. After Copan PWA moves their discharge point, there will be no continuous point source discharge in Copan Lake watershed. Conversely, the facility on the Lake Claremore watershed is a water treatment plant, which was not likely a source of nutrients.

A small portion of the MS4 permit for the City of Claremore falls within the watershed of Lake Claremore. Discharges from stormwater are potential sources of nutrient loadings. However, because only 1% of the watershed is within the MS4 boundaries, permitted stormwater was not considered a significant source of nutrient loading. Therefore, a WLA was not required for the City of Claremore's stormwater permit.

Most of the nutrient loading to these two 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 Copan Lake and Lake Claremore, 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. 2011). 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 or water quality monitoring stations in the tributaries to Copan Lake and Lake Claremore. 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: Caney [HUC (Hydrologic Unit Code) 11070106] and a portion of Lower Verdigris (HUC 11070105). The modeled domain displayed in **Figure 3-2** is a 2,420 square mile area that includes the contributing watersheds of the two lakes. The main streams located in the model domain are Caney River, Little Caney River (Caney Creek), Sand Creek, Verdigris River, and Dog Creek.

A 19-year period (1994 - 2012) was simulated in the SWAT model. However, the first 4 years were considered a "spin-up" period for stabilizing model initial conditions, and the model output consisted of only the latter 15 years (1998 - 2012). 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 gages located on Caney River near Elgin, KS (USGS Station 07172000), Caney River at US-75 (USGS Station 07175500), and Verdigris River at SH-20 (USGS Station 07176000) (**Figure 3-2**). In addition, the model simulated inflow to Copan Lake was compared to daily records reported by USACE (Station CPLO2). Overall, the model reproduces the annual flows within the 15% target for most years, with overall errors below the target for all the locations (2% for Caney Creek near Elgin, 6% for Caney Creek at US-75, -1% for Verdigris River at SH-20, and 10% for Copan Lake inflow). Resulting Nash-Sutcliffe Efficiency coefficients (NSE) and correlation coefficient (r^2) values were 0.961 and 0.955 for Caney Creek near Elgin, 0.948 and 0.952 for Caney Creek at US-75, 0.993 and 0.992 for Verdigris River at SH-20, and 0.943 and 0.989 for Copan 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 four water quality stations: Caney Creek at US-75 (OWRB monitoring site 121400010010-001AT), Sand Creek (OCC monitoring site OK121400-04-0010F), Verdigris River at SH-20 (OWRB monitoring site 121500030010-001AT), and Dog Creek: Spavinaw Flowline (OCC monitoring site OK121500-02-0360D). For purposes of calculating averages to compare to modeled values, non-detects were assumed equal to half of the detection limit. 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 were within the 25% target. However, it is noted that monitoring data available for calibration were from low to moderate flow conditions. As a result, there was 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 2012. Under current conditions, Copan Lake was estimated to receive a total annual load of 475,400 kg of phosphorus and 1,376,700 kg of nitrogen, on average, from nonpoint sources in its watershed. Claremore Lake was estimated to receive a total annual load of 22,400 kg of phosphorus and 108,100 kg of nitrogen, on average, from sources in its watershed.

Table ES- 2: Avg Flows & Nutrient Loads Discharging to Copan Lake/Lake Claremore

Parameter	Copan Lake	Lake Claremore
Watershed Size (square miles)	507	58
Flow (m^3/day)	1.07×10^6	1.98×10^5
Organic Phosphorus (kg/year)	412,400	10,100
Mineral Ortho-Phosphorus (kg/year)	63,000	12,300
Total Phosphorus (kg/year)	475,400	22,400
Organic Nitrogen (kg/year)	1,145,100	23,800
Ammonia Nitrogen (kg/year)	69,600	10,600
Nitrate+Nitrite Nitrogen (kg/year)	161,900	73,700
Total Nitrogen (kg/year)	1,376,700	108,100

ES - 4 Technical Approach and Methods

The objective of a TMDL was 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 was 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 Copan Lake and Lake Claremore and the nutrient loadings from their watersheds.

The water quality linkage analysis was performed using the BATHTUB model (Walker 1986). BATHTUB is an 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 1999-2012 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 were 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	Copan Lake		Lake Claremore	
	Modeled	Measured	Modeled	Measured
Total Phosphorus (mg/L)	0.089	0.090	0.083	0.080
Total Nitrogen (mg/L)	0.66	0.65	1.06	1.07
Chlorophyll-*a* (µg/L)	19.3	19.0	29.9	30.4
Secchi depth (meters)	0.32	0.30	0.31	0.30

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 Copan Lake were reduced by 50% from the existing loads, to

237,700 kg/year of total phosphorus and 688,350 kg/year of total nitrogen. In Lake Claremore, the water quality target of 10 µg/L chlorophyll-*a* could be achieved if the existing watershed loads were reduced by 73% to 6,048 kg/year of total phosphorus and 29,187 kg/year of total nitrogen. **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.

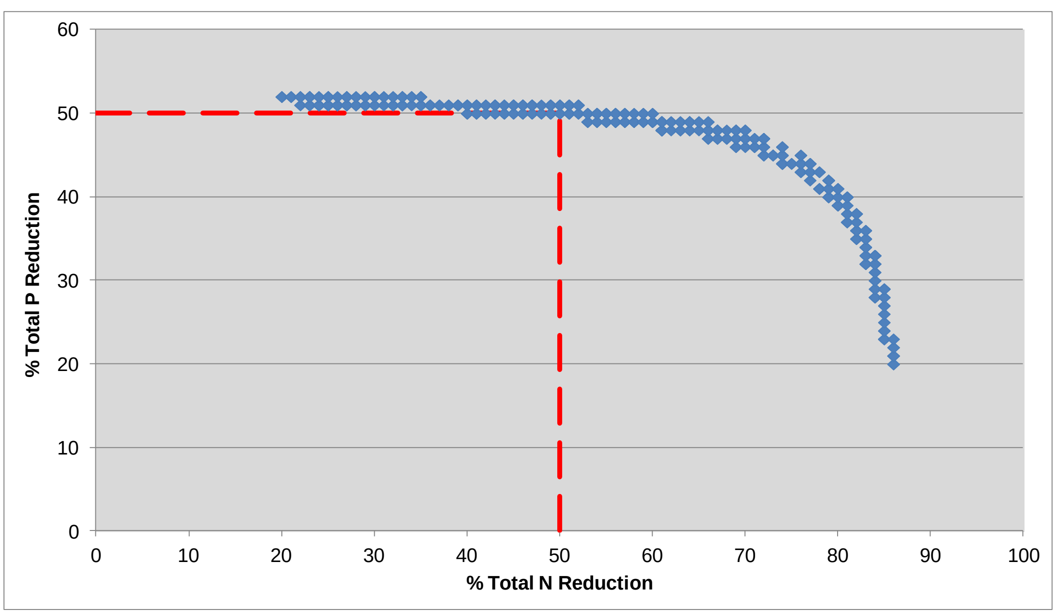
Table ES- 4: Total Phosphorus and Nitrogen Load Reductions Needed to Meet Chlorophyll-*a* In-lake Water Quality Targets

Lake	Percent Reduction	Maximum Allowable Load (kg/yr)[a]	
		Total Phosphorus	Total Nitrogen
Copan Lake	50%	237,700	688,350
Lake Claremore	73%	6,048	29,187

[a] Loads do not include atmospheric deposition or the point source discharging to Copan Lake.

While the relative importance of nitrogen or phosphorus in limiting algal productivity in Copan and Claremore 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 was to begin with equal percent reduction goals for both nutrient parameters. For example, in **Figure ES-1**, the 50% reduction goal was plotted for both nutrient parameters for Copan Lake. 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 Copan 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* – Copan Lake



ES - 5 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:

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

There were no point sources of wastewater discharging to Lake Claremore, but there is a point source of wastewater discharging to a tributary of Copan Lake. 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 2013a). *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."*

For Copan Lake, the OPDES-permitted facility was allocated a daily wasteload calculated as its permitted flow rate multiplied by TP and TN concentrations derived from loading time series provided to EPA for the Illinois River watershed. This was due to the fact that Copan Public Works Authority (OK0020168) does not have a permit limit for nutrients, nor does it report nutrient concentrations. The WLA_WWTP was derived as follows:

WLA_WWTP = Nutrient concentration * flow * unit conversion factor (kg/day)

Where:

Nutrient concentration = 4.5 mg/L for TP and 18 mg/L for TN

Flow (mgd) = permitted average daily flow = 0.13

Unit conversion factor = 3.785

Thus, the WLA_WWTP for Copan Public Works Authority was 2.2 kg/day for Total Phosphorus and 8.9 kg/day for Total Nitrogen.

Part of the City of Claremore Phase II MS4 permit for stormwater discharges and stormwater management (Permit #OKR040028). The City of Claremore comprises only 1% of the Lake Claremore watershed, therefore, a WLA_MS4 was not assigned, rather the small portion of the watershed accounted for by the MS4 area was included in the Load Allocation (LA) for Lake Claremore.

The load allocation for watershed nonpoint sources to both lakes were calculated as the difference between the TMDL, MOS, and WLA, as follows:

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

The total allowable load to Copan Lake was conservatively estimated as 237,700 kg/yr of total phosphorus and 688,350 kg/yr of total nitrogen, necessitating a 50% reduction from existing loading to achieve the desired water quality target.

The load allocation for watershed nonpoint sources to Lake Claremore was conservatively estimated as 6,048 kg/yr of total phosphorus and 29,187 kg/yr of total nitrogen, necessitating a 73% 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 were used in development of the TMDL, or conservative factors were 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 Copan and Claremore Lakes include an implicit MOS that was incorporated by the application of load reductions for both nitrogen and phosphorus.

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 Copan Lake and Lake Claremore 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 was important to note that expressing this TMDL in daily time steps does not imply a daily response to a daily load was practical from an implementation perspective.

The EPA's *Technical Support Document for Water Quality-Based Toxics Control* (EPA 1991) 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 was used for this value)*

$\boldsymbol{\sigma^2} = ln(CV^2+1)$ ***CV*** *= coefficient of variation*

The coefficients of variation of daily phosphorus and nitrogen NPS loads, calculated from SWAT model output, were 6.9 and 6.4 for Copan Lake, and 4.4 and 2.5 for Lake Claremore, respectively. Using equal reductions for both nutrient parameters (50% for Copan and 73% for Claremore), the maximum daily loads correspond to the allowable annual average loads provided in **Table ES-4**. In Copan Lake the 237,700 kg of phosphorus and 688,350 kg of nitrogen per year was translated to a daily maximum load of 605.1 kg/day of phosphorus and 1826.8 kg/day of nitrogen. For Lake Claremore, the allowable average load of 6,048 kg of phosphorus and 29,187 kg of nitrogen per year was translated to a daily maximum load of 19.1 kg/day of phosphorus and 112.6 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 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
Copan Lake	OK121400050020_00	**Total Phosphorus**	**605.1**	**0**	**605.1**	Implicit
		Total Nitrogen	**1826.8**	**0**	**1826.8**	Implicit
Lake Claremore	OK121500040020_00	**Total Phosphorus**	**19.1**	**0**	**19.1**	Implicit
		Total Nitrogen	**112.6**	**0**	**112.6**	Implicit

ES - 6 PUBLIC PARTICIPATION

A public notice was sent to local newspapers, to stakeholders in the Study Area affected by these draft TMDLs, and to stakeholders who requested copies of all TMDL public notices. The public notice, draft TMDL report, and draft 208 Factsheet were posted at the following DEQ website: www.deq.state.ok.us/wqdnew/index.htm.

The public had 45 days (July 25, 2014 to September 8, 2014) to review the draft TMDL report and make written comments. Two sets of written comments were received during the public notice period. These comments, along with DEQ's responses, are now part of the public record of this TMDL report in **Appendix D**. These comments were considered, and revisions were made to the final TMDL report.

There were no requests for a public meeting.

The *Lake Copan and Claremore Lake Chlorophyll-a TMDL Report* was finalized and submitted to EPA for final approval.

SECTION 1 - INTRODUCTION

1.1 TMDL Program Background

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

Section 303(d) of the CWA and EPA Water Quality Planning and Management Regulations (40 Code of Federal Regulations [CFR] Part 130) require states to develop total maximum daily loads (TMDL) for all 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 Copan Lake [Oklahoma Waterbody ID (OK WBID) number OK121400050020_00] in the Caney River sub-basin (hydrologic unit code [HUC] 11070106) and Lake Claremore (OK121500040020_00) in the Lower Verdigris River (HUC 11070105) sub-basin. Oklahoma Department of Environmental Quality (DEQ) placed Copan Lake in Category 5 [303(d) List] of the *Water Quality in Oklahoma, 2012 Integrated Report* (2012 Integrated Report) for non-support of the Aesthetic, Fish and Wildlife Propagation-Warm Water Aquatic Community (WWAC), and Public and Private Water Supply Use. DEQ placed Lake Claremore in Category 5 [303(d) List] of the 2012 Integrated Report for non-support of the Public and Private Water Supply Use. **Figures 1-1** (Copan Lake) and **1-2** (Lake Claremore) are location maps showing these Oklahoma waterbodies and their contributing watersheds. The maps display locations of the water quality monitoring (WQM) stations used as the basis for placement of these waterbodies on the Oklahoma §303(d) List. These waterbodies and their surrounding watersheds are hereinafter referred to as the Study Area.

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 were 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]. 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 study was 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 OPDES 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. An explicit 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.

1.2 Lake and Watershed Characteristics

1.2.1 Lake Characteristics

Copan Lake is a 4,850-acre lake in Washington County with conservation pool storage of 43,400 acre-feet. It was impounded in 1983, and serves as a recreational lake, fish and wildlife propagation, and is utilized for flood control, water quality control, and water supply (Oklahoma Water Resources Board [OWRB] 2011). Most of the 30 mile shoreline is undeveloped. The contributing watershed of Copan Lake is 507 square miles. The Little Caney River (Caney Creek) is the primary tributary flowing to Copan Lake. **Figure 1-1** displays the contributing watershed of Copan Lake of which 84% is located in Kansas.

Lake Claremore is a 470-acre lake in Rogers County with conservation pool storage of 7,900 acre-feet. Lake Claremore was first impounded by the City of Claremore (OWRB 2010) in 1930 and serves as a lake for recreation and municipal water supply. Most of the nine-mile shoreline is undeveloped. However roadways surrounding the lake provide access to almost the entire shoreline. The contributing watershed of Lake Claremore is 58 square miles. Dog Creek (OK121500040010_00) and Little Dog Creek (OK121500040030_00) are the primary tributaries flowing to Lake Claremore. **Figure 1-2** displays the contributing watershed of Lake Claremore.

Table 1-1: General Lake Characteristics

Waterbody Name and WBID	Surface Area (Acres)	Conservation Pool Storage (Acre- Feet)	Normal Elevation (Feet Mean Sea Level)	Average Depth (Feet)	Shoreline (Miles)	Management Agency
Copan Lake (OK121400050020_00)	4,850	43,400	710	9	30	U.S. Army Corps of Engineers
Lake Claremore (OK121500040020_00)	470	7,900	610	16.8	9	City of Claremore

1.2.2 General

Both lakes are within the Verdigris River basin, located in the northeastern portion of Oklahoma. The Town of Copan is located near the southeast shoreline of Copan Lake, approximately nine miles north of Bartlesville in Washington County. Copan Lake is located in the Osage Cuestas ecoregion of the Central Irregular Plains (Woods et al. 2005), which features an irregular to undulating tall grass prairie mixed with oak-hickory forest in the eastern area. The majority of the land cover in the Copan Lake watershed is pasture/hay, deciduous forest and pasture/grass.

Lake Claremore is located northeast of the City of Claremore in Rogers County. Lake Claremore is also located in the Osage Cuestas ecoregion of the Central Irregular Plains (Woods, et al. 2005), which consists mainly of an irregular to undulating tall grass prairie mixed with oak-hickory forest in the eastern area. The majority of the land cover in the Lake Claremore watershed is deciduous forest, pasture/hay and pasture/grass.

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	State Name	Population (2010 Census)	Population Density (per square mile)
Mayes	**Oklahoma**	41259	60.4
Nowata	**Oklahoma**	10536	18.1
Osage	**Oklahoma**	47472	20.6
Rogers	**Oklahoma**	86905	122.1
Washington	**Oklahoma**	50976	120.2
Chautauqua	Kansas	3669	5.7
Elk	Kansas	2882	4.4
Montgomery	Kansas	35471	54.4

1.2.3 Climate

Table 1-3 summarizes the average annual precipitation for Copan Lake and Lake Claremore. 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 from six stations in the vicinity of the lake watersheds.

Table 1-3: Average Annual Precipitation by Watershed (1994-2012)

Waterbody Name	Waterbody ID	Average Annual Precipitation (inches)
Copan Lake	OK121400050020_00	38.2
Lake Claremore	OK121500040020_00	39.0

Figure 1-1: Copan Lake

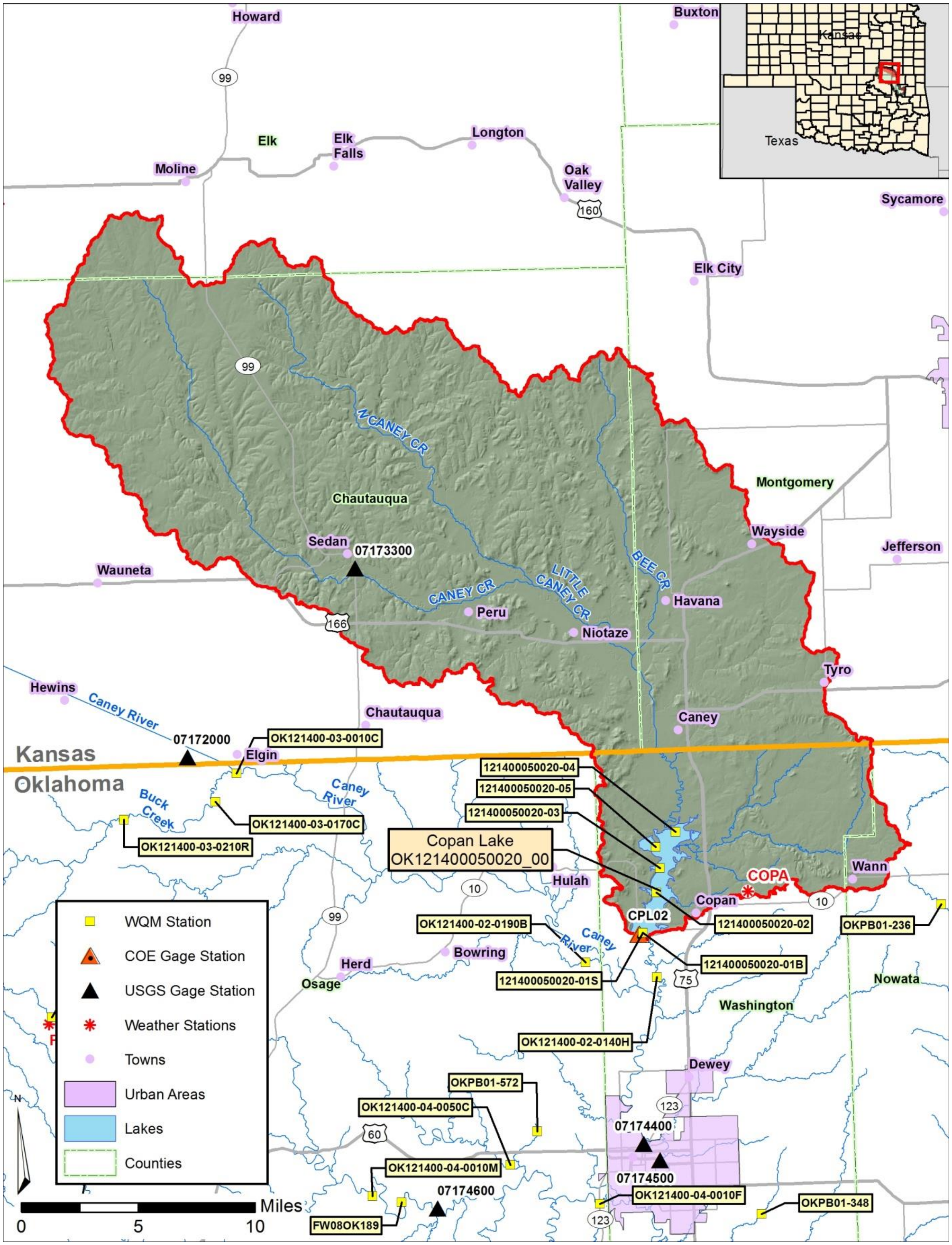
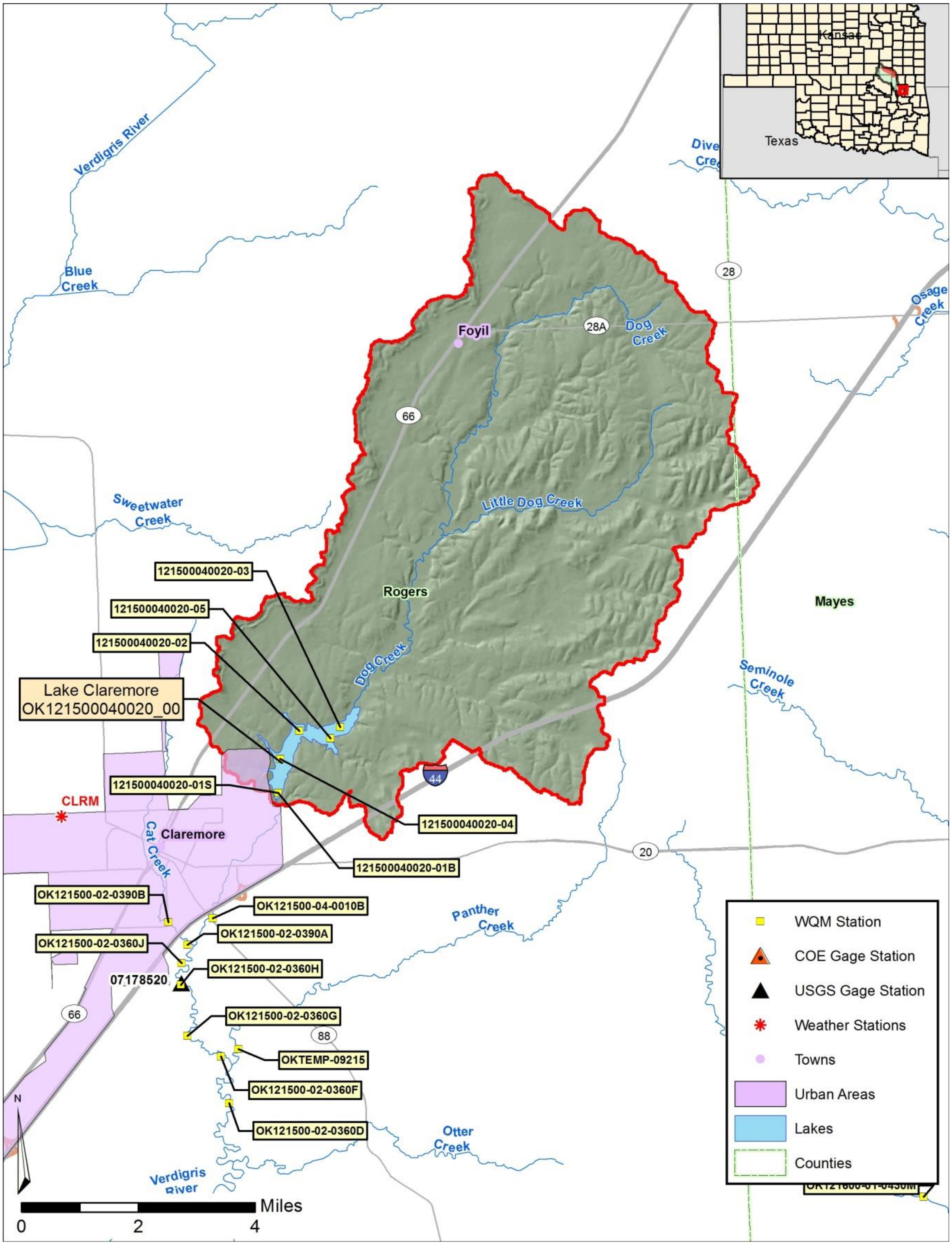


Figure 1-2: Lake Claremore



1.2.4 Land Use

The contributing drainage areas of the watersheds are approximately 507 square miles (Copan Lake) and 58 square miles (Lake Claremore). **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) 2012 Cropland Data Layer (CDL). The CDL is a crop-specific land cover classification data set. Land use in the watersheds of Copan Lake and Lake Claremore is displayed in **Figures 1-3 and 1-4**. The most common land use category in the Copan watershed is pasture/hay and in the Claremore watershed is deciduous forest. Copan Lake also has a significant percentage of land classified as deciduous forest and grassland. Lake Claremore has a significant percentage of land classified as pasture/hay and grassland. Based on a review of satellite imagery from Google Earth Maps there appears to be little developed land bordering the shoreline of either of the two lakes. 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 Copan		Claremore Lake	
	Acres	Percent§	Acres	Percent§
Barren	34	0%	0	0%
Corn	3,839	1%	21	0%
Cotton	4,442	1%	18	0%
Deciduous Forest	56,014	17%	16,352	44%
Developed/High Intensity	63	0%	28	0%
Developed/Low Intensity	1,991	1%	356	1%
Developed/Medium Intensity	277	0%	111	0%
Developed/Open Space	13,153	4%	2,834	8%
Evergreen Forest	68	0%	6	0%
Mixed Forest	74	0%	0	0%
Open Water	7,941	2%	663	2%
Grassland	50,936	16%	4,875	13%
Pasture/Hay	176,757	54%	11,985	32%
Shrubland	2	0%	0	0%
Soybeans	8,676	3%	32	0%
Woody Wetlands	201	0%	3	0%
Total Drainage Area	324,467		37,283	

§ 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 Copan Lake or Lake Claremore or at the lake outlet of Lake Claremore. The United States Army Corps of Engineers (USACE) has daily release records for Copan 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 1-3: Copan Lake Watershed Land Use

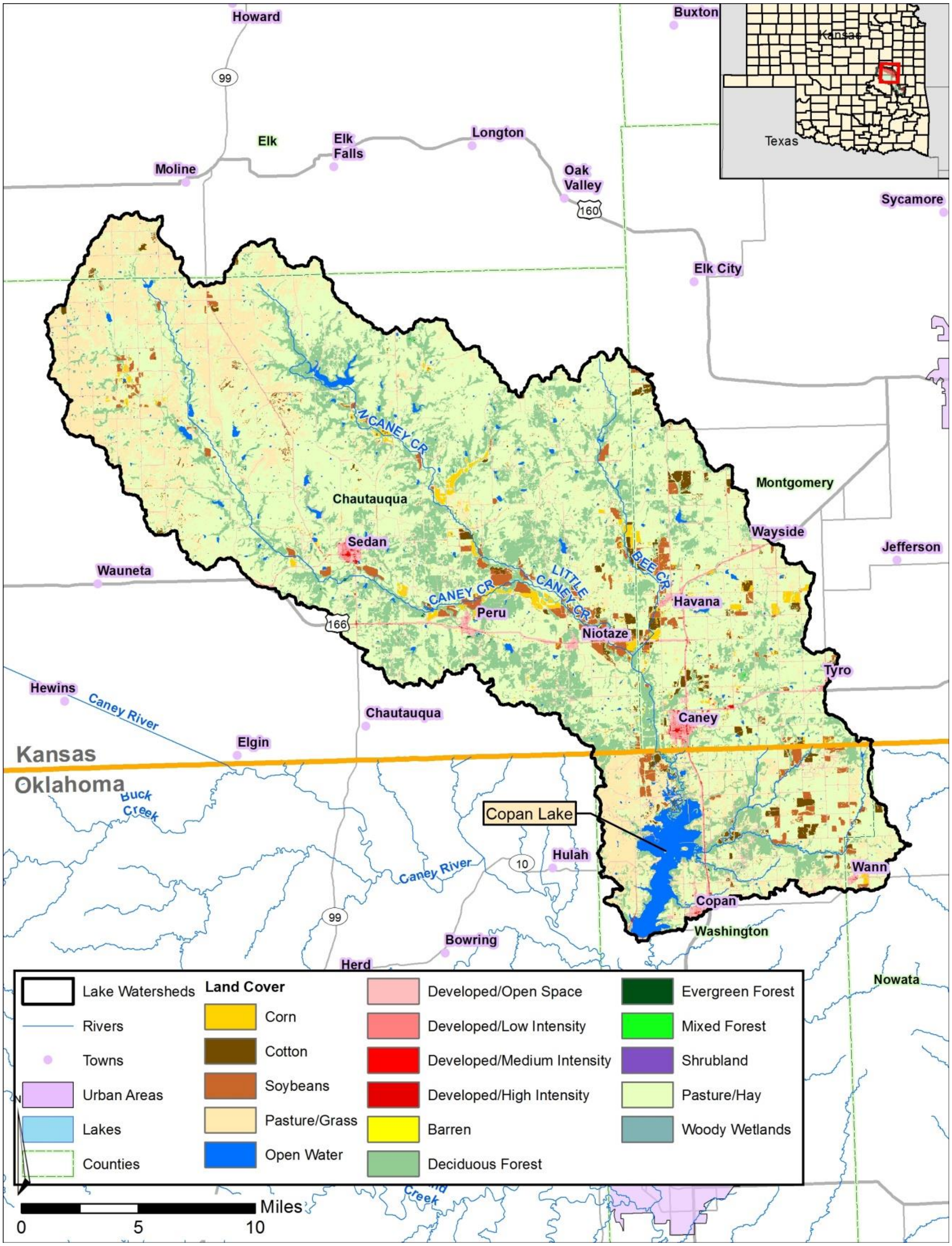
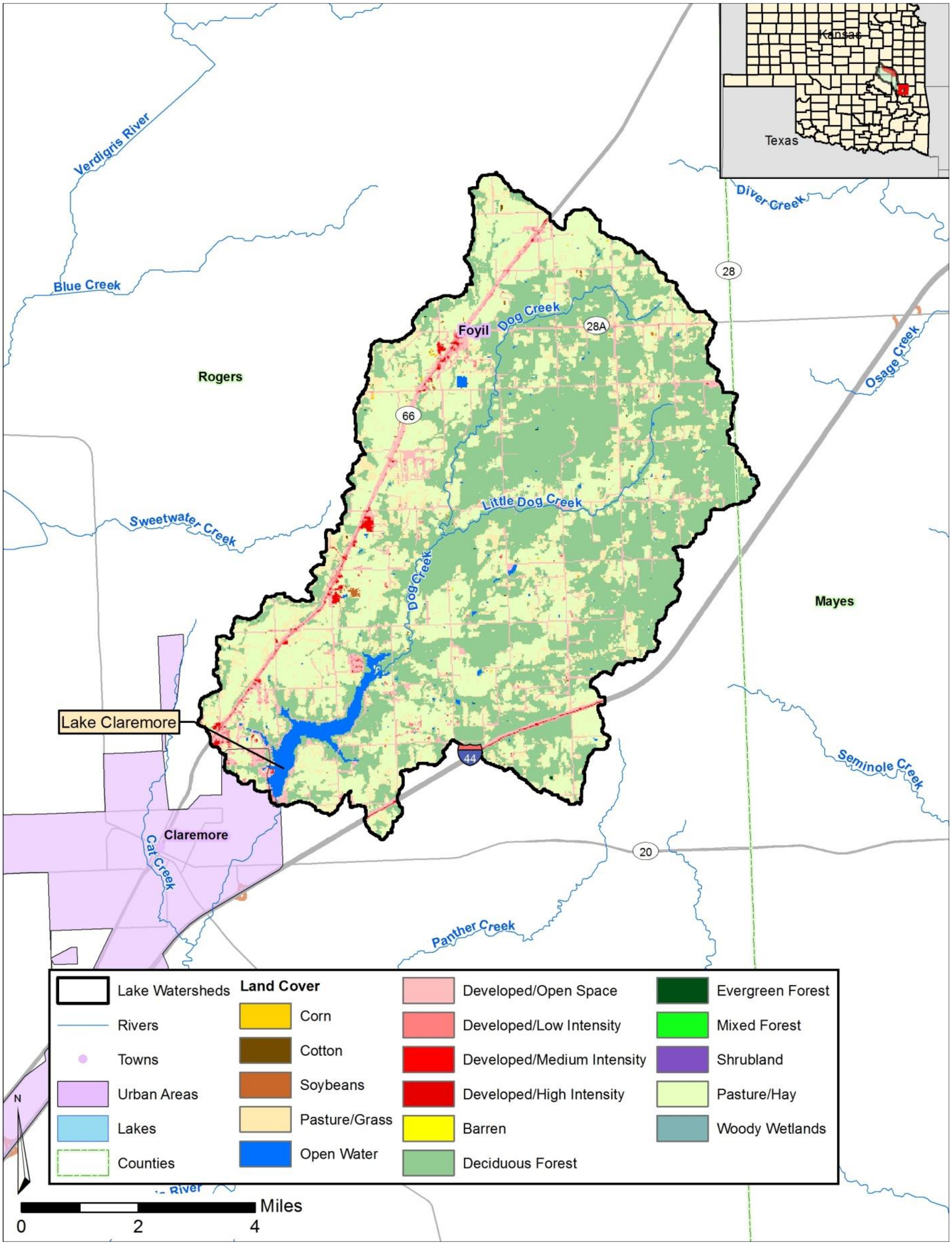


Figure 1-4: Lake Claremore Watershed Land Use



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 2013) and implementation procedures in Chapter 46 (OWRB 2013). 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 2013). An excerpt of the Oklahoma WQS (Chapter 45, Title 785) summarizing the State of Oklahoma's Antidegradation Policy is provided in **Appendix A**. Beneficial uses designated for Copan Lake and Lake Claremore are aesthetic, irrigation, agricultural water supply, the WWAC subcategory of the fish and wildlife propagation, fish consumption, sensitive public and private water supply, and primary body contact recreation. Lake Claremore is also designated as a nutrient-limited watershed. **Table 2-1**, an excerpt from the 2012 Integrated Report (DEQ 2013), summarizes the designated use attainment status and the waterbody/pollutant combinations that require TMDLs for the two 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 2012 Integrated Report – Oklahoma §303(d) List of Impaired Waters (Category 5a)

Waterbody Name and OKWBID	Waterbody Size (Acres)	TMDL Date	TMDL Priority	Causes of Impairment	Designated Use Not Supported
Copan Lake (OK121400050020_00)	4,850	2023	4	Chlorophyll-*a*	Public and Private Water Supply
Lake Claremore (OK121500040020_00)	470	2020	3	Chlorophyll-*a*	Public and Private Water Supply
				Color	Aesthetic
				Turbidity	Warm Water Aquatic Community

Copan Lake and Lake Claremore 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 2013).

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, Copan Lake and Lake Claremore are both 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.*"

Lake Claremore 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 Copan Lake and Lake Claremore are illustrated in **Figures 1-1 and 1-2**.

Table 2-2: Water Quality Monitoring Stations used for 2012 §303(d) Listing Decision

Waterbody ID	Station ID	Latitude	Longitude	Site Description
Copan Lake				
121400050020_00	121400050020-01B	36.88641	-95.96789	Bottom
121400050020_00	121400050020-01S	36.88641	-95.96789	Near Surface
121400050020_00	121400050020-02	36.91109	-95.95636	Near Surface
121400050020_00	121400050020-03	36.92622	-95.95282	Near Surface
121400050020_00	121400050020-04	36.94839	-95.94006	Near Surface
121400050020_00	121400050020-05	36.93934	-95.95587	Near Surface

Waterbody ID	Station ID	Latitude	Longitude	Site Description
Lake Claremore				
121500040020_00	121500040020-01B	36.32514	-95.57958	Bottom
121500040020_00	121500040020-01S	36.32514	-95.57958	Near Surface
121500040020_00	121500040020-02	36.34031	-95.57251	Near Surface
121500040020_00	121500040020-03	36.34092	-95.5599	Near Surface
121500040020_00	121500040020-04	36.33351	-95.57858	Near Surface
121500040020_00	121500040020-05	36.33818	-95.56298	Near Surface

* Hyperlinks are active in the electronic version of this document. Source: OWRB Data Viewer 2014

2.2.1 Chlorophyll-*a* Data Summary

Table 2-3 summarizes chlorophyll-*a* data collected from Copan Lake WQM stations from 2003 through 2012. 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 19.0 µg/L, which is equivalent to a Carlson's TSI of 59.5 (Carlson 1977). According to the 2010-2011 BUMP Report, using water quality samples collected between October 2007 and July 2008, the TSI calculated for Copan Lake was 60 (OWRB 2011). 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 were used as the basis for evaluating the beneficial use support for lakes (OWRB 2013). Chlorophyll-*a* data collected from Copan Lake WQM stations between 2003 and 2012 were used to support the decision to place the lake on the DEQ 2012 §303(d) List 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 Copan Lake (all values in µg/L) ‡

Station ID	Minimum Date	Maximum Date	Number of Samples	Minimum	Maximum	Average	Median
121400050020-01B†	01/24/05	07/22/08	6	3.1	28.7	12.9	11.8
121400050020-01S	01/13/03	10/15/12	9	2.9	28.5	12.8	11.5
121400050020-02	01/13/03	10/15/12	10	2.5	38.9	16.6	15.6
121400050020-03	01/13/03	10/15/12	10	2.1	71.1	24.6	16.8
121400050020-04	01/13/03	10/15/12	10	2.7	37.6	19.0	19.8
121400050020-05	01/13/03	10/15/12	10	2.3	44.3	22.1	18.6
Overall Surface Samples*			49	2.1	71.1	19.0	16.8

†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 was included for informational purposes only.

*Bottom data were excluded

‡ Non-detects were averaged at the detection limit

Table 2-4 summarizes chlorophyll-*a* measurements collected from Lake Claremore from 2003 through 2010. Pooling data from surface level sites, chlorophyll-*a* levels averaged 30.4 µg/L (TSI = 64.1). According to the 2010-2011 BUMP Report, using water quality samples collected between November 2006 and August 2006, the TSI calculated for Lake

Claremore was 67 (OWRB 2011). As stipulated in the *Implementation of Oklahoma's Water Quality Standards* [785:46-15-3(c)], the most recent 10 years of water quality data were used as the basis for evaluating the beneficial use support for lakes (OWRB 2013). Chlorophyll-*a* data collected from Lake Claremore WQM stations between 2003 and 2010 were used to support the decision to place the lake on the DEQ 2012 §303(d) List 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 Lake Claremore (all values in µg/L) ‡

Station ID	Minimum Date	Maximum Date	Number of Samples	Minimum	Maximum	Average	Median
121500040020-01B†	03/01/04	08/31/06	5	14.5	54.5	36.6	41.1
121500040020-01S	09/02/03	08/17/10	10	12.2	63.2	30.9	25.6
121500040020-02	09/02/03	08/17/10	10	7.8	59.6	31.9	30.2
121500040020-03	09/02/03	08/17/10	9	14.8	56.3	32.8	25.3
121500040020-04	09/02/03	08/31/06	7	9.8	39.6	25.9	26.3
121500040020-05	09/02/03	08/31/06	7	9.7	54.7	30.3	27.0
Overall Surface Samples*			**43**	**7.8**	**63.2**	**30.4**	**26.3**

†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 was included for informational purposes only.

*Bottom data were excluded

‡ Non-detects were averaged at the detection limit

2.2.2 Nutrient Data Summary

During the years 1999 to 2012, total nitrogen levels in Copan Lake averaged approximately 0.65 mg/L, and total phosphorus levels averaged 0.09 mg/L (**Table 2-5**). Total nitrogen was 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 evident and anoxic conditions were present during the summer sampling interval (OWRB 2013).

Table 2-5: Summary of Average Nutrient Measurements in Copan Lake (all values in mg/L)‡

Station ID	Data Period	Nitrogen, Ammonia	Nitrogen, Kjeldahl	Nitrogen, Nitrate + Nitrite	Phosphorus Ortho	Phosphorus Total
121400050020-01B†	10/99 – 01/05	0.06	0.37	0.18	0.04	0.08
121400050020-01S	10/99 – 10/12	0.05	0.53	0.16	0.05	0.07
121400050020-02	10/99 – 10/12	0.05	0.61	0.15	0.05	0.08
121400050020-03	10/99 – 10/12	0.05	0.67	0.15	0.05	0.10
121400050020-04	10/99 – 10/12	0.06	0.65	0.14	0.06	0.11
121400050020-05	10/02 – 10/12	0.06	0.73	0.12	0.06	0.10
Overall Surface Samples*		0.05	0.64	0.14	0.05	0.09

†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 was included for informational purposes only.

*Bottom data were excluded

‡ Non-detects were averaged at the detection limit

Total nitrogen levels in Lake Claremore averaged approximately 1.07 mg/L, and total phosphorus levels averaged 0.08 mg/L (**Table 2-6**). The lake was not thermally stratified in the fall and dissolved oxygen levels remained well above 5 mg/L during the BUMP assessment period (OWRB 2007). In the spring quarter of 2006 the lake was weakly stratified with anoxic conditions present only in the bottom of the water column (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 Claremore (all values in mg/L)‡

Station ID	Data Period	Nitrogen, Ammonia	Nitrogen, Kjeldahl	Nitrogen, Nitrate + Nitrite	Phosphorus Ortho	Phosphorus Total
121500040020-01B†	10/01 – 06/04	0.15	0.85	0.10	0.02	0.09
121500040020-01S	10/01 – 08/10	0.08	0.93	0.08	0.01	0.07
121500040020-02	10/01 – 08/10	0.06	0.95	0.08	0.01	0.07
121500040020-03	10/01 – 08/10	0.06	0.97	0.09	0.02	0.09
121500040020-04	09/03 – 08/06	0.10	1.05	0.08	0.01	0.07
121500040020-05	09/03 – 08/06	0.05	1.04	0.08	0.02	0.09
Overall Surface Samples*		0.07	0.99	0.08	0.01	0.08

†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 was included for informational purposes only.

*Bottom data were excluded

‡ Non-detects were averaged at the detection limit

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 2013). Therefore, the water quality target established for Copan Lake and Lake Claremore is to achieve a long-term average in-lake concentration of 10 µg/L for chlorophyll-*a*. Copan Lake is also included in the 303(d) List for turbidity and color. These water quality issues will be addressed specifically at a future date.

SECTION 3 - POLLUTANT SOURCE ASSESSMENT

3.1 Overview

A pollutant source assessment characterizes known and suspected sources of pollutant loading to impaired waterbodies. Sources within a watershed were categorized and quantified to the extent that information was available. This section includes an assessment of the known and suspected sources of nutrients contributing to the eutrophication of Copan Lake and Lake Claremore. Nutrient sources identified were categorized and quantified to the extent that reliable information was available. Generally, nutrient loadings causing eutrophication of lakes originate from point or nonpoint sources of pollution. Point sources are permitted through the OPDES program. Where information was available on point and nonpoint sources of nutrients originating in Kansas from within the Little Caney Creek and Bee Creek sub-watersheds, data were provided and summarized. These data were provided to demonstrate that some of the nutrient loading outside of Oklahoma's jurisdiction may contribute to nonsupport of the PWS use in Oklahoma. It is recognized that Oklahoma has no enforcement authority over sources of nutrients originating beyond the Oklahoma State boundary.

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 OPDES were 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.

3.2 Assessment of OPDES-Permitted Facilities

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. OPDES-permitted facilities classified as point sources that may contribute nutrient loading include:

- Continuous Point Source Dischargers
  - OPDES municipal wastewater treatment facilities (WWTF)
  - OPDES Industrial WWTF Discharges
- OPDES-regulated stormwater discharges
  - Municipal separate storm sewer system (MS4) discharges
    - Phase 1 MS4
    - Phase 2 MS4 – OKR04
  - Multi-sector general permits (OKR05)
  - Construction stormwater discharges (OKR10)
- No-discharge WWTF
- Sanitary sewer overflow (SSO)
- NPDES Animal Feeding Operations (AFO)
  - Concentrated Animal Feeding Operations (CAFO)
  - Swine Feeding Operation (SFO)
  - Poultry Feeding Operation (PFO)

3.2.1 Continuous Point Source Dischargers

The locations of the OPDES-permitted facilities that discharge wastewater to the lakes addressed in this TMDL report are listed in **Table 3-1** and displayed in **Figures 3-1 & 3-2**.

3.2.1.1 Municipal OPDES WWTFs

There are two continuous municipal point source discharge facilities within the Study Area (one in each watershed) (**Table 3-1**). The facility located in the Copan Lake watershed (Copan Public Works Authority in **Figure 3-1**) is a wastewater plant and, thus, could be a source of nutrient loading. However, the Copan PWA made a formal request on May 5, 2014 to move the discharge point to the stream segment just below the lake. The wasteload allocations for the new discharging point are secondary lagoon treatment (30 mg/L BOD5 & 90 mg/L TSS). After Copan PWA moves their discharge point, there will be no continuous point source discharge. Therefore, WLAs to Copan Lake will be zero.

Point source discharges located in Kansas side of watershed were considered as Load Allocation (LA) in this TMDL report. Please refer to **Appendix C** for more details on the discharges located in Kansas.

The facility in the Lake Claremore watershed (**Figure 3-2**) is a water treatment plant, which is not likely a source of nutrients.

3.2.1.2 Industrial OPDES WWTFs

There were no OPDES industrial point source dischargers in this Study Area.

Table 3-1: OPDES Continuous Discharge Facilities in the Study Area

Facility	OPDES ID	County	SIC Code	Waterbody ID	Waterbody Name
Copan Public Works Authority	OK0020168	Washington	4952	OK121400050020_00	Copan Lake
City of Claremore (Water)	OK0038466	Rogers	4941	OK121400050020_00	Lake Claremore

3.2.2 Stormwater Permits

Stormwater runoff from OPDES-permitted facilities [MS4s, facilities with multi-sector general permits (MSGP), and construction sites] can contain impairments. EPA regulations [40 C.F.R. §130.2(h)] require that OPDES-regulated stormwater discharges must be addressed by the WLA component of a TMDL.

3.2.2.1 Municipal Separate Storm Sewer System Permit

3.2.2.1.1 Phase I MS4

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

Figure 3-1: OPDES Facilities in the Copan Lake Watershed

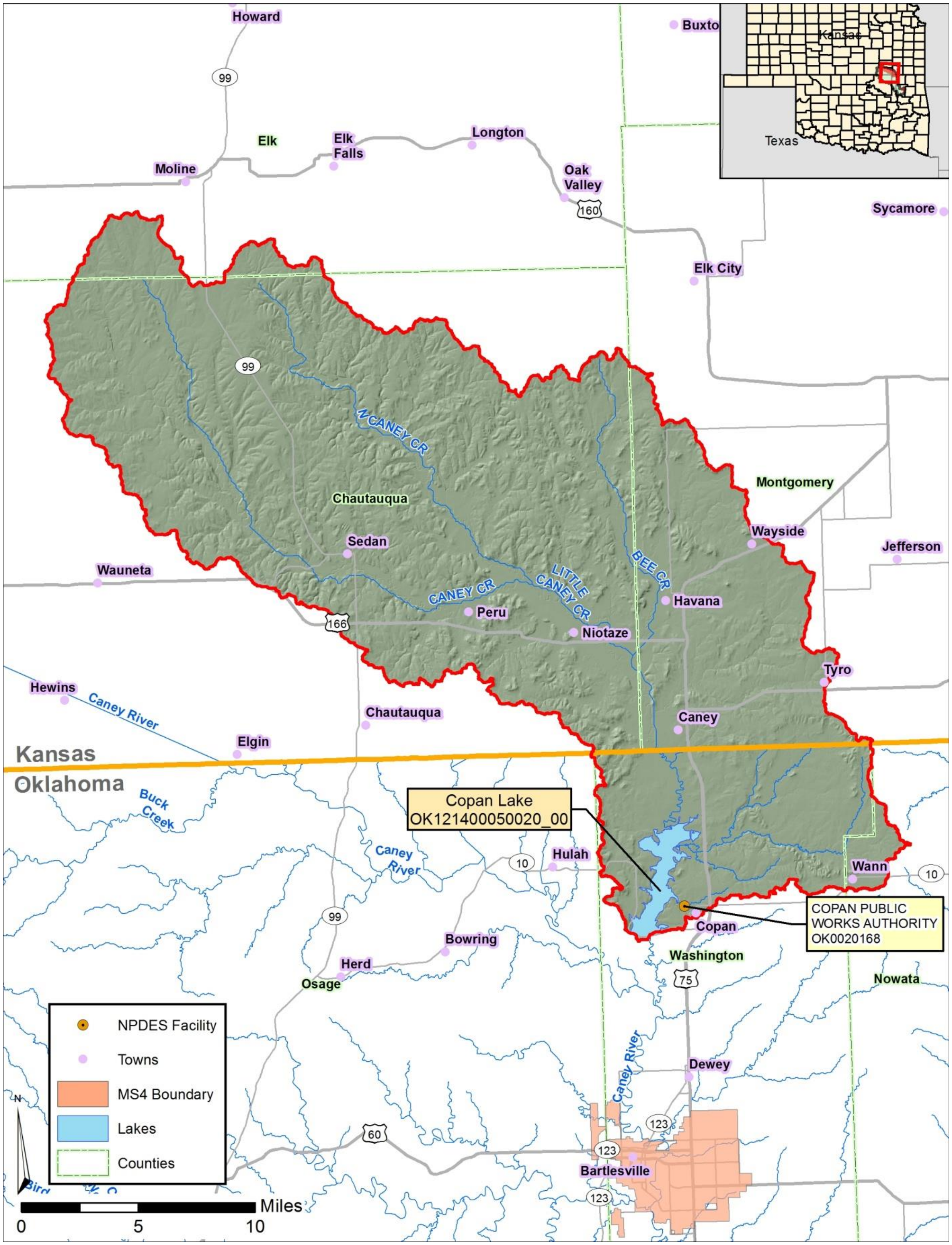
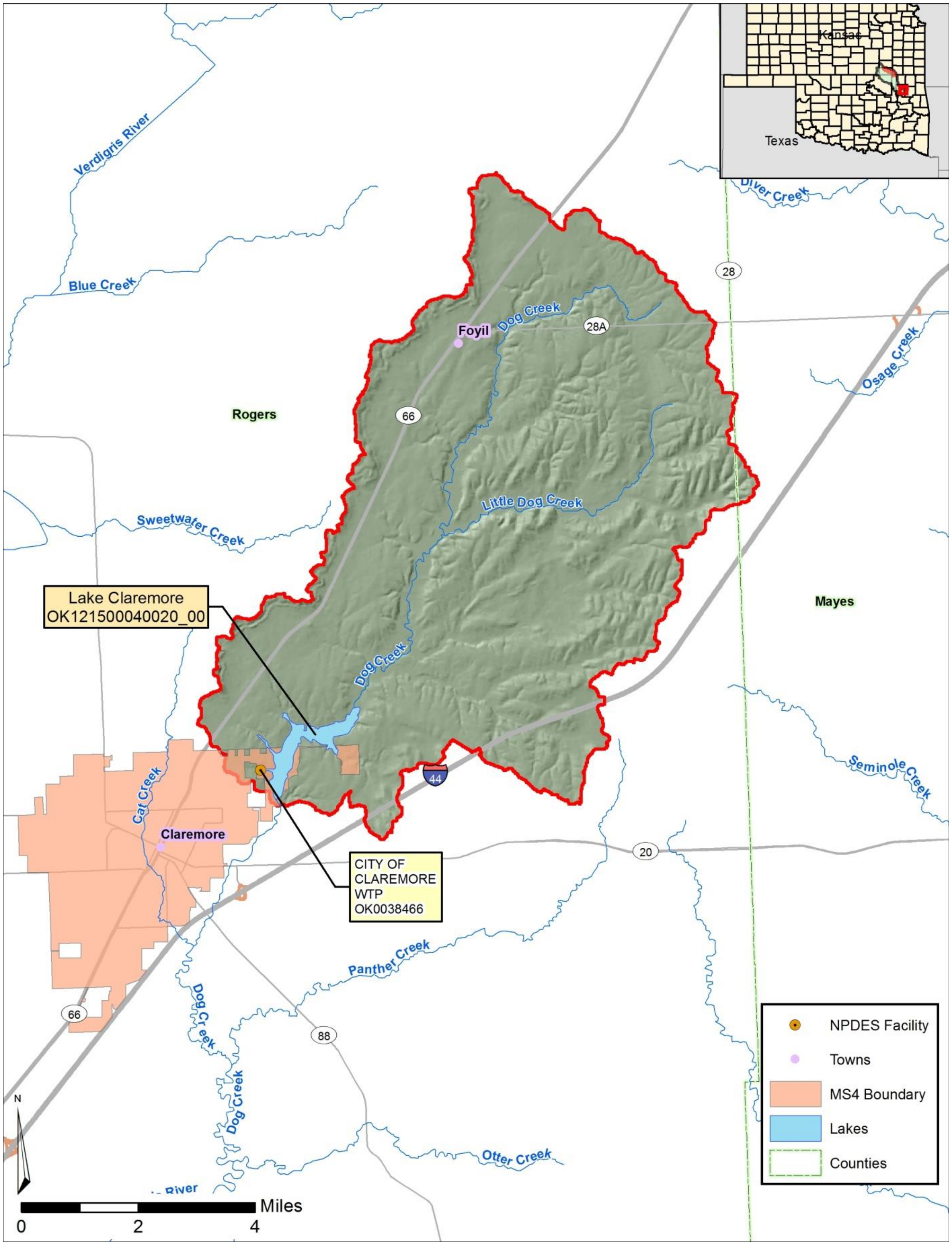


Figure 3-2: OPDES Facilities in the Lake Claremore Watershed



3.2.2.1.2 Phase II MS4 (OKR04)

In 1999, Phase II began requiring certain small MS4s to comply with the OPDES stormwater program. Small MS4s are defined as any MS4 that is not a medium or large MS4 covered by Phase I of the OPDES Stormwater Program. Phase II requires operators of regulated small MS4s to obtain OPDES permits and develop a stormwater management program. Programs are designed to reduce discharges of pollutants to the "maximum extent practicable," to protect water quality, and to satisfy appropriate water quality requirements of the CWA. Phase II MS4 stormwater programs must address the following six minimum control measures:

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

In Oklahoma, Phase II General Permit (OKR04) for small MS4 communities has been in effect since 2005. Information about DEQ's MS4 program can be found on-line at the following DEQ website:
www.deq.state.ok.us/WQDnew/stormwater/ms4/.

The City of Claremore has a Phase II MS4 permit, but just a small portion of the permitted area falls within the Lake Claremore watershed (**Figure 3-2**). Discharges from stormwater are potential sources of nutrient loadings. However because only 1% of the watershed is within the MS4 boundary, permitted stormwater was not considered a significant source of nutrient loading. Therefore, a WLA was not required for the City of Claremore's stormwater permit.

3.2.2.2 Multi-Sector General Permits (OKR05)

A DEQ multi-sector industrial general permit (MSGP) is required for stormwater discharges from all industrial facilities (DEQ 2011) whose Standard Industrial Classification (SIC) code is listed on Table 1-2 of the MSGP. However, facilities with those SIC codes are not sources of nutrients so their stormwater discharge were not considered in this study.

3.2.2.3 General Permit for Construction Activities (OKR10)

A DEQ stormwater general permit for construction activities is required for any stormwater discharges in the State of Oklahoma associated with construction activities that result in land disturbance equal to or greater than one acre or less than one acre if they are part of a larger common plan of development or sale that totals at least one acre. However, stormwater from construction sites is not a source of nutrients so it was not considered in this study.

3.2.3 No-Discharge Facilities

Some facilities are classified as no-discharge. These facilities are required to sign an affidavit of no discharge. But none of these facilities was in this Study Area.

3.2.4 Sanitary Sewer Overflows

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 OPDES permittee. The reporting of SSOs has been strongly encouraged by EPA, primarily through enforcement and fines. While not all sewer overflows were reported, DEQ has some data on SSOs available.

Table 3-2 presents a summary of the data from one OPDES facility in the Study Area that has reported SSOs between 1999 and 2005. During that period, 14 overflows were reported ranging from 2 million to 5 million gallons. Given the low occurrence of reported overflows, the contribution of nutrient loads is considered to be negligible.

Table 3-2: Sanitary Sewer Overflow Summary for Period 1999-2005

Facility Name	Facility ID	Receiving Water	Number of Occurrences	Date Range		Amount in millions of gallons	
				From	To	Min	Max
Copan Public Works Authority	21401	OK121400050020_00	14	4/25/1999	6/15/2005	2	5

3.2.5 Animal Feeding Operations

The Agricultural Environmental Management Services (AEMS) of the Oklahoma Department of Agriculture, Food and Forestry (ODAFF) was created to help develop, coordinate, and oversee environmental policies and programs aimed at protecting the Oklahoma environment from pollutants associated with agricultural animals and their waste. ODAFF is the NPDES-permitting authority for CAFOs and SFOs in Oklahoma under what ODAFF calls the Agriculture Pollutant Discharge Elimination System (AgPDES). Through regulations (rules) established by the Oklahoma Concentrated Animal Feeding Operation (CAFO) Act (Title 2, Chapter 1, Article 20 – 40 to Article 20 – 64 of the State Statutes), Swine Feeding Operation (SFO) Act (Title 2, Chapter 1, Article 20 – 1 to Article 20 – 29 of the State Statutes), and Poultry Feeding Operation (PFO) Registration Act (Title 2, Chapter 10-9.1 to 10-9.25 of the State Statutes), AEMS works with producers and concerned citizens to ensure that animal waste does not impact the waters of the State. However, there were no AFOs within the Copan Lake or Lake Claremore watersheds at the time of the TMDL study.

3.3 ESTIMATION OF EXISTING POLLUTANT LOADS

As previously stated, there is one water treatment facility located in the Lake Claremore watershed[1], but it was not considered a source of nutrient loading. In addition, only 1% of the Lake Claremore watershed falls under the City of Claremore MS4 permit. Therefore, most of the nutrient loading to Lake Claremore originates from nonpoint sources. There is a continuous point source discharge within the Copan Lake watershed[2], which contributes a small portion of the nutrient loading. However, most of the nutrient loading to Copan Lake 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, 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, livestock and pets. The following sections provide general information on nonpoint sources contributing nutrient loading within the Study Area.

3.3.1 SWAT Model Development for Pollutant Source Loadings

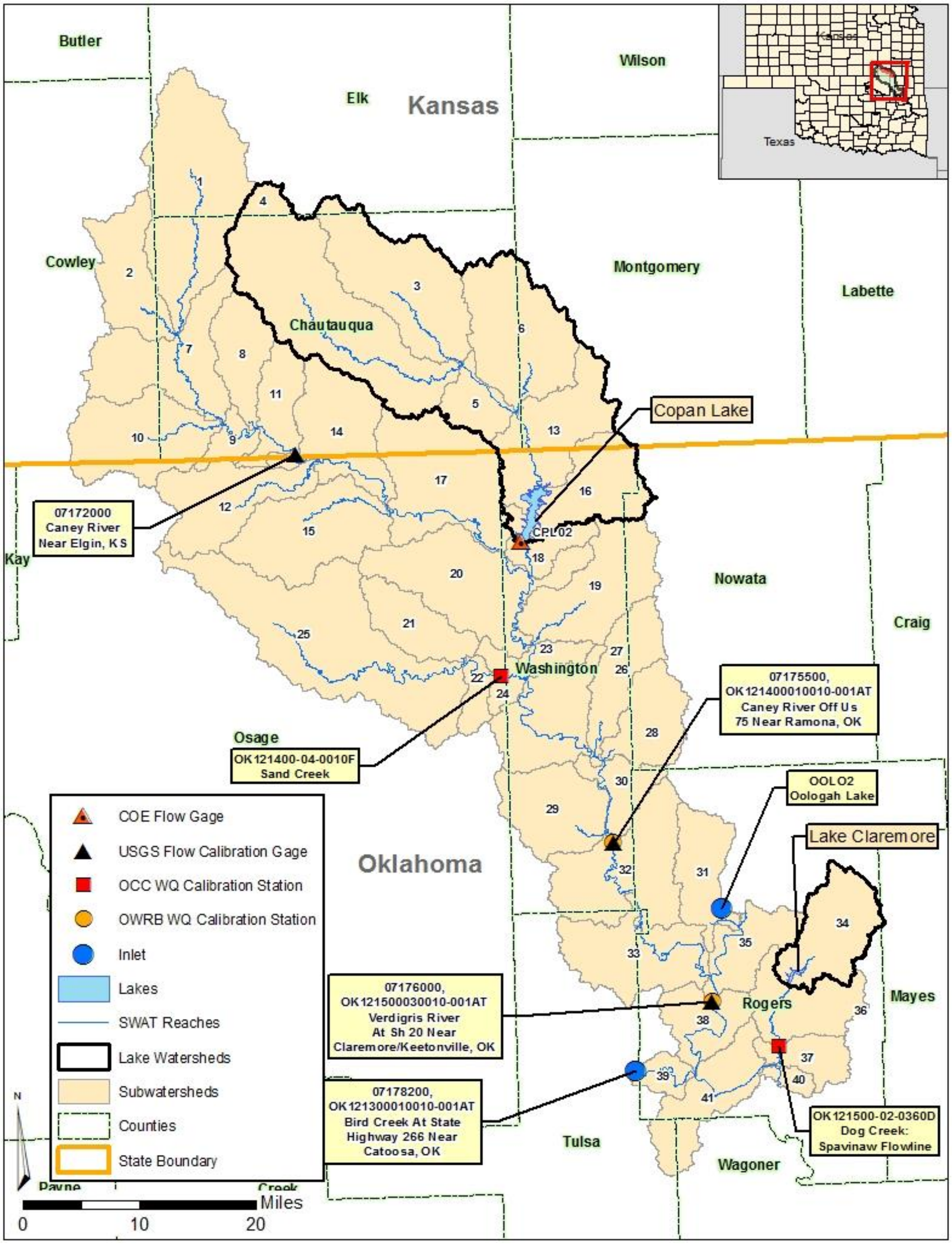
Given the lack of in-stream water quality data and pollutant source data available to quantify nutrient and sediment loading directly from the tributaries of Copan Lake and Lake Claremore, a watershed loading model – the Soil and Water Assessment Tool (SWAT) – was used to develop nonpoint source loading 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. 2011). 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 or water quality monitoring stations in the tributaries to Copan Lake and Lake Claremore. 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: Caney [HUC (Hydrologic Unit Code) 11070106] and a portion of Lower Verdigris (HUC 11070105). The modeled domain displayed in **Figure 3-3** is a 2,420 square mile area that includes the contributing watersheds of the two lakes. The main streams located in the model domain are Caney River, Little Caney River (Caney Creek), Sand Creek, Verdigris River, and Dog Creek.

[1] OK0038466 - City of Claremore (Water)

[2] OK0020168 – Copan Public Works Authority

Figure 3-3: SWAT Model Segmentation and Calibration Stations



The watershed is predominantly rural with a few small cities and towns, including all or parts of Bartlesville, Owasso, Claremore, and Tulsa. The modeled area was divided into 41 sub-watersheds (**Figure 3-3**) 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 Copan Lake and Lake Claremore are outlined in black in **Figure 3-3**. 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 Web Soil Survey and Geospatial Data Gateway from the United States Department of Agriculture's (USDA) Natural Resource Conservation Service (NRCS). Land use and land cover data were derived from the USDA National Agricultural Statistics Service (NASS) 2012 Cropland Data Layer (USDA 2013). County-level summaries of annual cattle population estimates from the NASS were evenly distributed across pasture land (USDA 2012). 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. OSWD systems (septic systems) were 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 15,811 OSWD systems within the simulated watershed. Of these, approximately 1,248 OSWDs were estimated to lie within the Copan Lake watershed (between 0.01 and 0.04 septics per acre), and 1,697 within the watershed of Lake Claremore (< 0.1 septics per acre). More recent OSWD data were 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., Cities of Claremore, Bartlesville, and Catoosa), 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 117 systems were assumed to be malfunctioning and leaking wastewater to the modeled watershed (Reed, Stowe & Yanke LLC 2001). Using the same calculations, only 49 of those malfunctioning OSWD systems would be present in the Copan Lake watershed, and 67 in the watershed of Lake Claremore. In addition to the low density of septic systems within the watersheds, the areas with high density of septic systems are close to the headwaters of the tributaries to Lake Claremore, which results in diminished impact on the lake water quality. Because the estimated number of malfunctioning OSWD systems was small, nutrient loadings from these systems were not included in the SWAT model.

A 19-year period (1994 - 2012) 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 15 years (1998 - 2012). 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 gages located on Caney River near Elgin, KS (USGS Station 07172000), Caney River at US-75US-75 (USGS Station 07175500), and Verdigris River at SH-20 (USGS Station 07176000) (**Figure 3-3**). In addition, the model simulated inflow to Copan Lake was compared to daily records reported by USACE (Station CPLO2). 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 (2% for Caney Creek near Elgin, 6% for Caney Creek at US-75, -1% for Verdigris River at SH-20, and 10% for Copan Lake inflow). Resulting Nash-Sutcliffe Efficiency coefficients (NSE) and correlation coefficient (r^2) values were 0.961 and 0.955 for Caney Creek near Elgin, 0.948 and 0.952 for Caney Creek at US-75, 0.993 and 0.992 for Verdigris River at SH-20, and 0.943 and 0.989 for Copan 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 four water quality stations (**Figure 3-3**): Caney Creek at US-75 (OWRB monitoring site 121400010010-001AT), Sand Creek (OCC monitoring site OK121400-04-0010F), Verdigris River at SH-20 (OWRB monitoring site 121500030010-001AT), and Dog Creek: Spavinaw Flowline (OCC monitoring site OK121500-02-0360D). For purposes of calculating averages to compare to modeled values, non-detects were assumed equal to half of the detection limit. In all cases, the SWAT model reproduced the average TP and TN concentrations within 25% of the measured averages (**Figure 3-4**). In some instances, as shown in **Table Appendix C-7** of **Appendix C**, the model does not replicate particular nutrient species within the 25% target for a given period particular individual station. This was most likely a result of the limited amount of nutrient data available. However, the overall measures for the whole watershed were within 25% target for all nutrient species. Furthermore, these slight variances for some of the nutrient species were not considered critical since the data results were used to develop annual average loading estimates in the lake water quality model BATHTUB.

3.3.2 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 was incorporated into the lake model BATHTUB (see Section 4). Fecal waste deposited in the watershed by wildlife and pets was 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 sub-watersheds were estimated for the period 1998 to 2012. 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 Copan Lake and Lake Claremore are displayed in **Table 3-3**. Under current conditions, Copan Lake was estimated to receive a total annual load of 475,400 kg of phosphorus and 1,376,700 kg of nitrogen, on average, from nonpoint sources in its watershed. Claremore Lake was estimated to receive a total annual load of 22,400 kg of phosphorus and 108,100 kg of nitrogen, on average, from sources in its watershed.

Figure 3-4: Observed and SWAT Modeled Average Monthly Flows

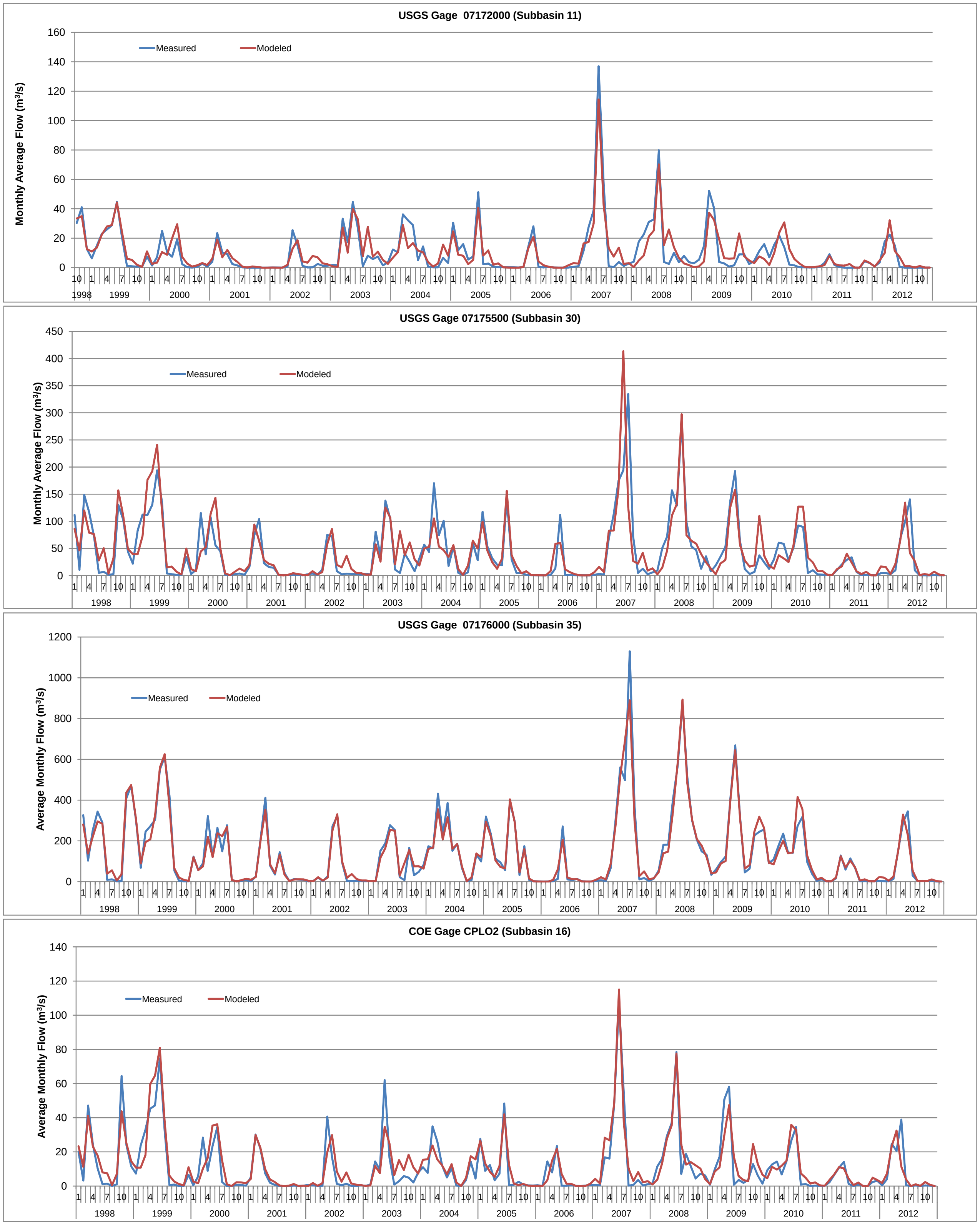
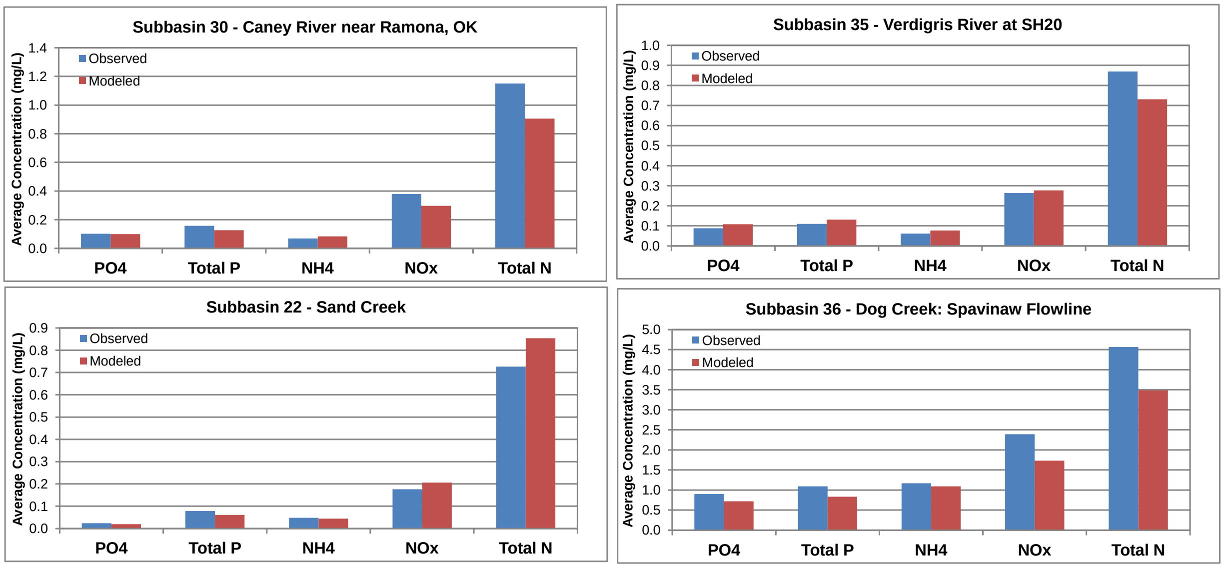


Figure 3-5: Observed and SWAT Modeled Nutrient Concentrations



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

Table 3-3: Average Annual Flows and Nutrient Loads Discharging to Copan Lake and Lake Claremore

Parameter	Copan Lake	Lake Claremore
Watershed Size (square miles)	507	58
Flow (m^3/day)	1.07×10^6	1.98×10^5
Organic Phosphorus (kg/year)	412,400	10,100
Mineral Ortho-Phosphorus (kg/year)	63,000	12,300
Total Phosphorus (kg/year)	475,400	22,400
Organic Nitrogen (kg/year)	1,145,100	23,800
Ammonia Nitrogen (kg/year)	69,600	10,600
Nitrate+Nitrite Nitrogen (kg/year)	161,900	73,700
Total Nitrogen (kg/year)	1,376,700	108,100

Figure 3-6: Average Total Phosphorus Loading from SWAT Sub-Watersheds

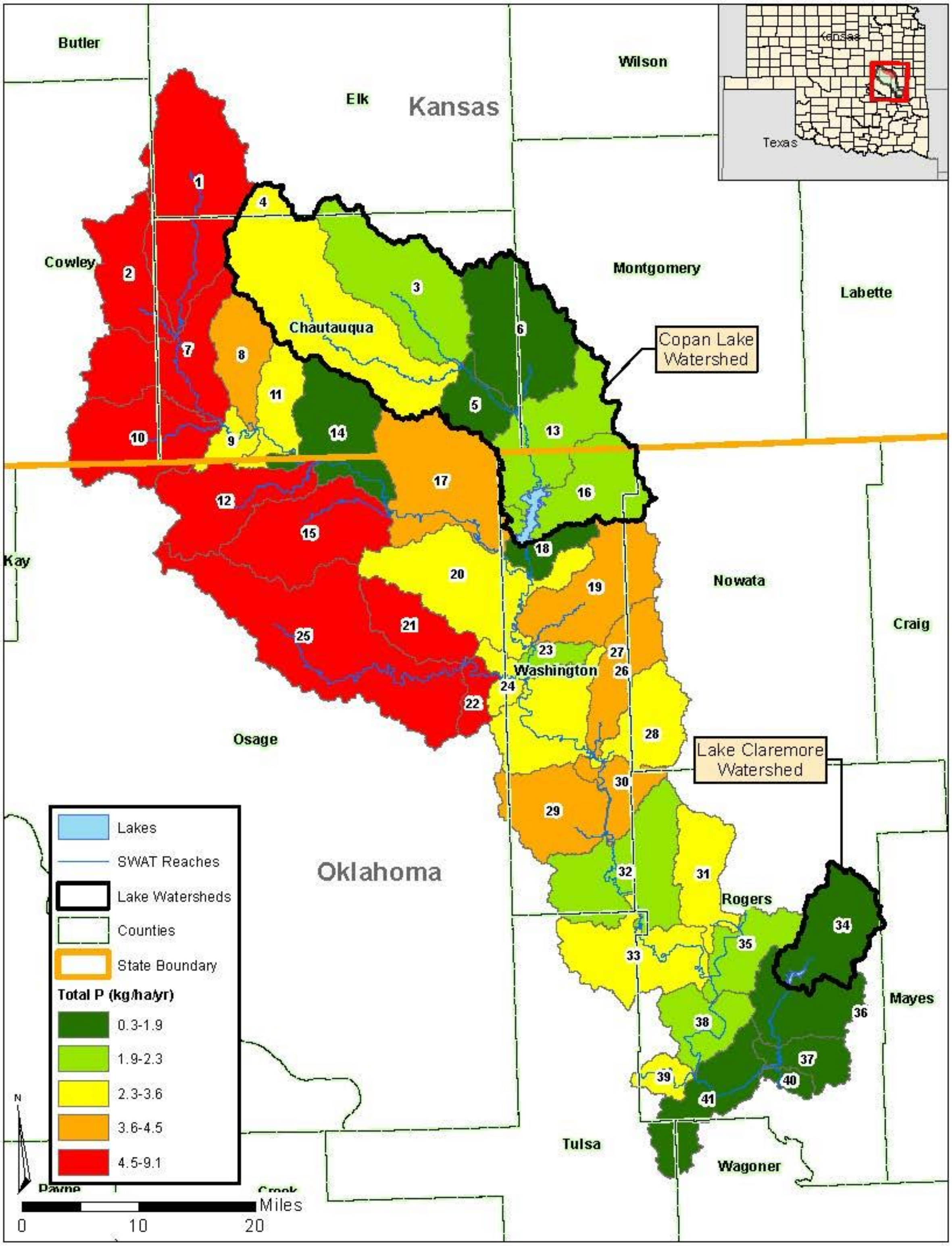
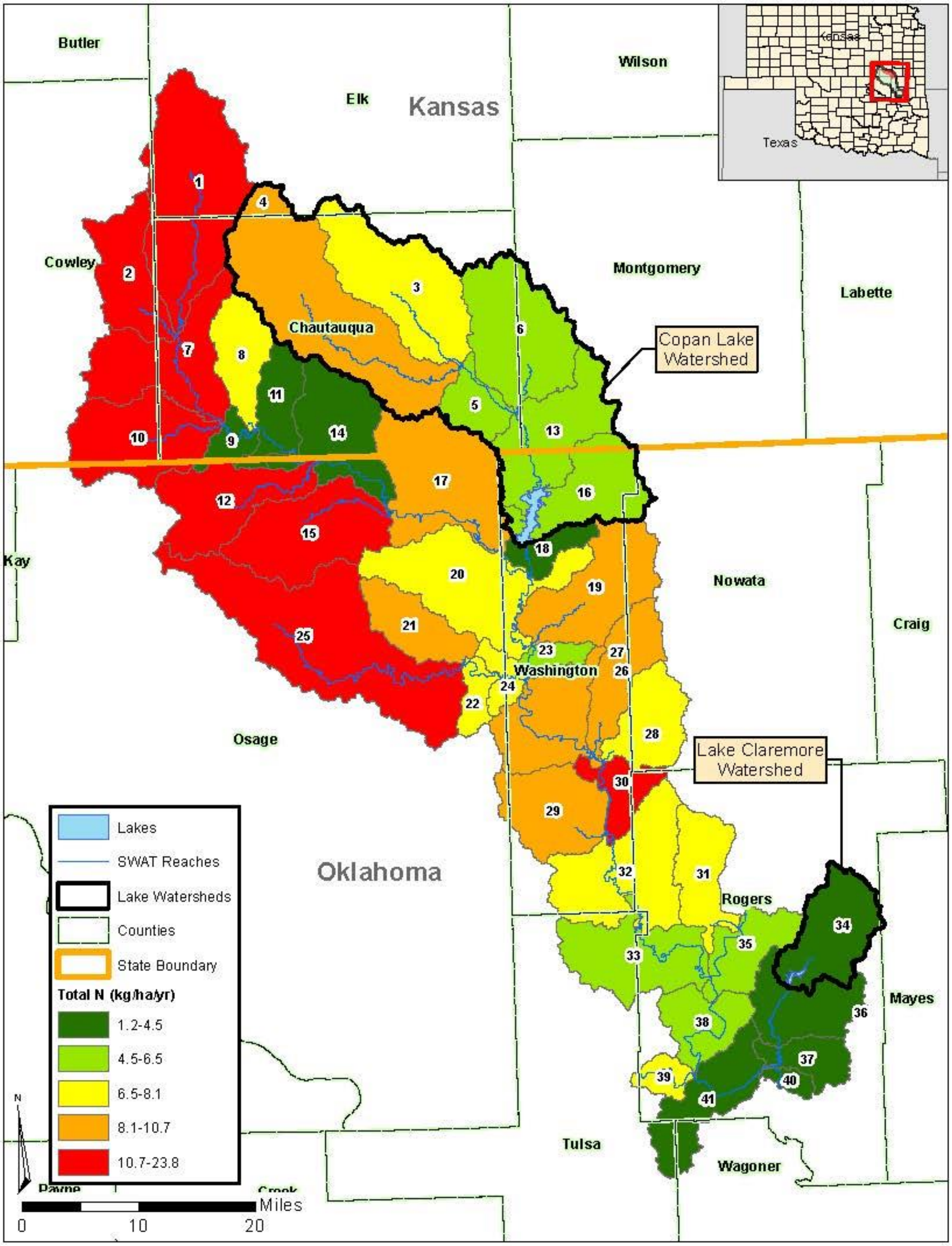


Figure 3-7: Average Total Nitrogen Loading from SWAT Sub-Watersheds



SECTION 4 - TECHNICAL APPROACH AND METHODS

4.1 TMDL MODELS

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 was 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 Copan Lake or Lake Claremore 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.

4.2 BATHTUB MODEL DESCRIPTION

The water quality linkage analysis was performed using the BATHTUB model (Walker 1986). BATHTUB is an 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.

4.3 BATHTUB MODEL SETUP AND INPUT DATA

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

4.3.1 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 Claremore is available through the Oklahoma Water Resources Board (http://www.owrb.ok.gov/news/publications/lok/lok.php). Because there is only one major input to each of the lakes and inflows from direct runoff were not expected to affect horizontal mixing, the lakes were 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 two 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.

4.3.2 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 53 inches per year was applied for Copan Lake and Lake Claremore.

4.3.3 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 3.3, 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) 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 were 20%, and 10%, respectively, of the watershed loads to Copan and Claremore Lakes.

For Copan Lake, nutrient loadings from the OPDES-permitted facility discharging in close proximity to the lake (Copan Public Works Authority, OK0020168) were also input into the BATHTUB model. The point source was simulated using the permitted flow for the facility (0.13 mgd) and concentrations equal to 4.5 mg/L for TP and 18 mg/L for TN[1], which are equivalent to 803 kg/year for TP and 3248 kg/year for TN.

Table 4-1: Estimate of Atmospheric Loads

Atmospheric Loads	Areal Mean (mg/m^2-yr)	Estimated Load to Copan Lake (kg/year)	Estimated Load to Lake Claremore (kg/year)	CV
Total Nitrogen	1127	22,120	2,144	0.2
Inorganic Nitrogen	200	3,925	380	0.04

[1] Concentrations were derived from loading time series provided to EPA for the Illinois River watershed.

4.3.4 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 were 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

4.4 BATHTUB Model Calibrations and Output

The model was run under average existing conditions, and calibrated to measured in-lake water quality conditions (based on 1999-2012 data) using phosphorus, nitrogen, chlorophyll-*a* and Secchi disk calibration factors. **Table 4-2** includes the calibration factors used for each lake.

Table 4-2: Calibration Factors Used for Lakes

Calibration Factor	Copan Lake	Lake Claremore
Total Phosphorus	1.80	10.0
Total Nitrogen	3.50	3.75
Chlorophyll-*a*	1.90	1.95
Secchi Disk	1.0	1.0

The model-predicted concentrations of total nitrogen, total phosphorus, chlorophyll-*a*, and Secchi depth under existing average conditions were 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	Copan Lake		Lake Claremore	
	Modeled	Measured	Modeled	Measured
Total Phosphorus (mg/L)	0.089	0.090	0.083	0.080
Total Nitrogen (mg/L)	0.66	0.65	1.06	1.07
Chlorophyll-*a* (µg/L)	19.3	19.0	29.9	30.4
Secchi depth (meters)	0.32	0.30	0.31	0.30

4.5 BATHTUB Model Sensitivity Analysis

Because of uncertainty and variability in input parameter values, BATHTUB modeling can result in output uncertainty. Quantifying this uncertainty was 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 were 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 were set to obtain compliance with the chlorophyll-*a* water quality targets.

The model output of concern was 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 presented for Copan Lake (**Figure 4-1**) and Lake Claremore (**Figure 4-2**). 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 both lakes are non-algal turbidity, chlorophyll-*a* calibration factor, and mixed layer depth.

Figure 4-1: Characterization Matrix for BATHTUB Parameters for Copan Lake

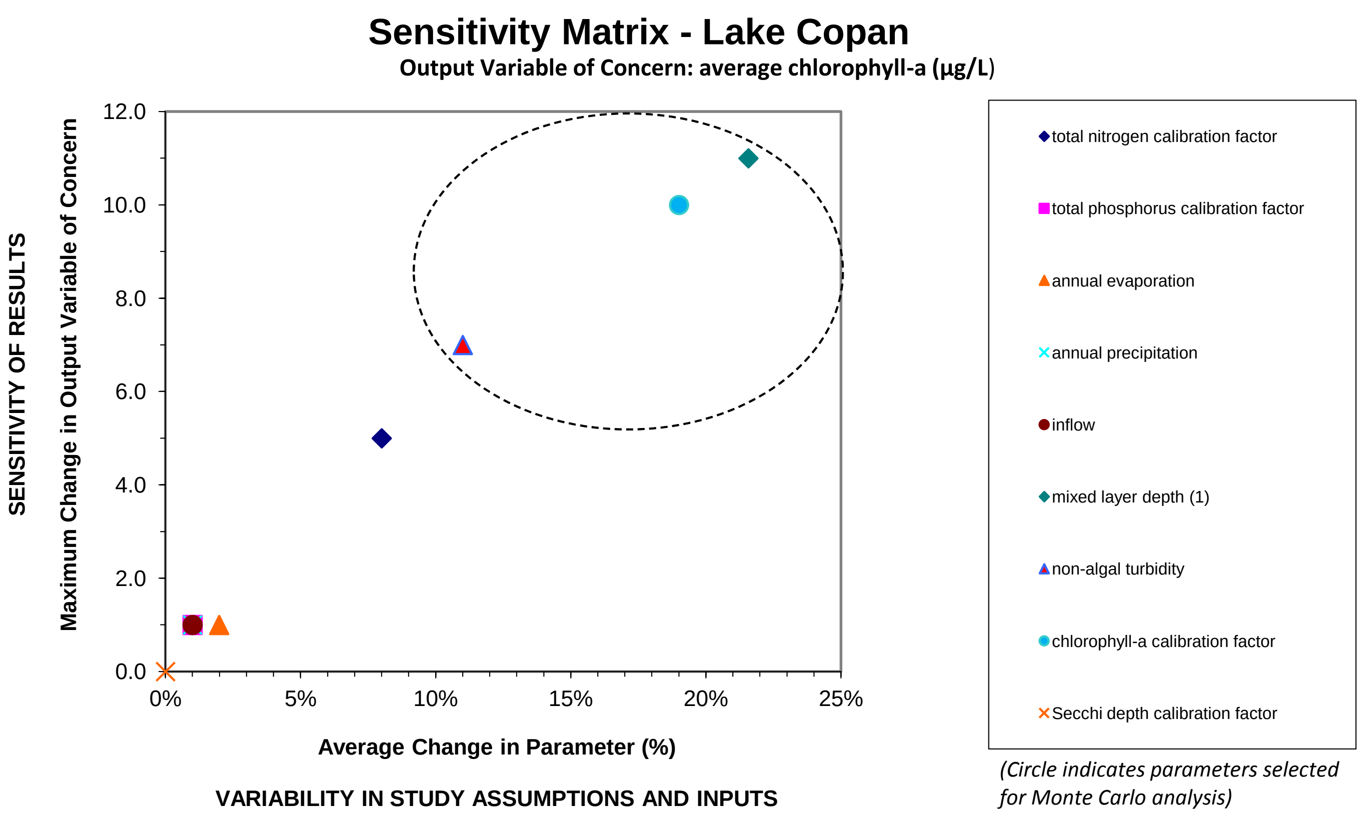
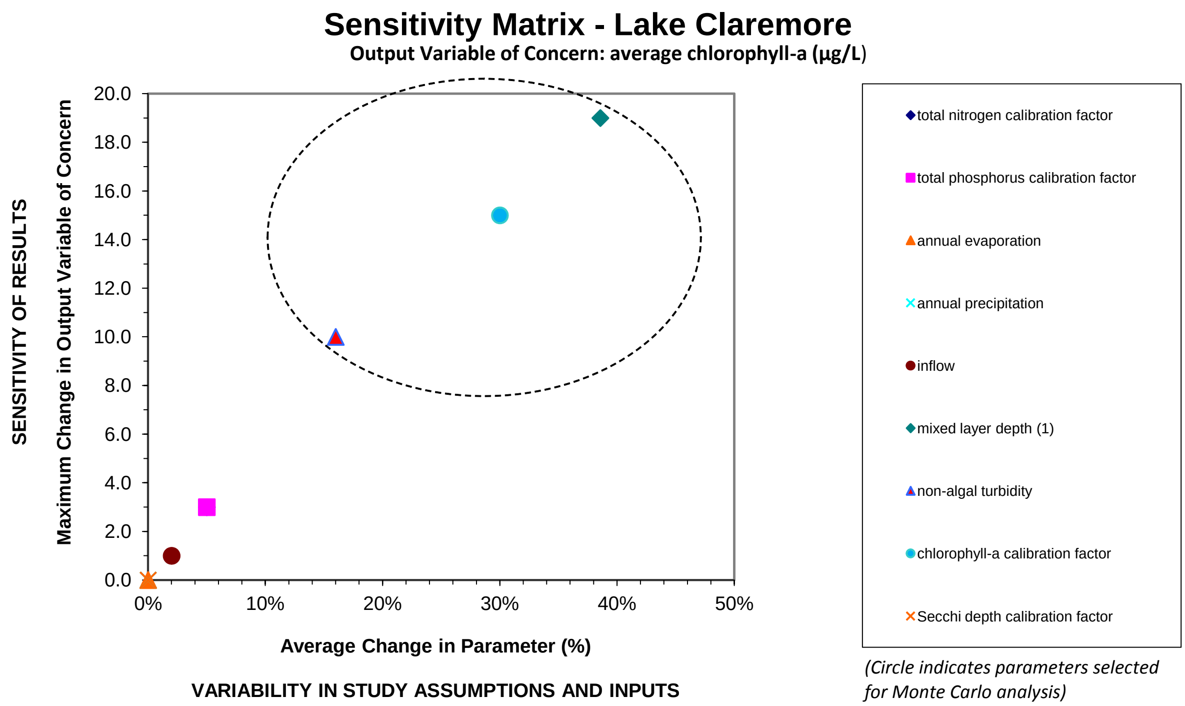


Figure 4-2: Characterization Matrix for BATHTUB Parameters for Lake Claremore



4.6 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 were 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 was generally set to the calibrated value utilized in the calibrated model and the standard deviation was 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

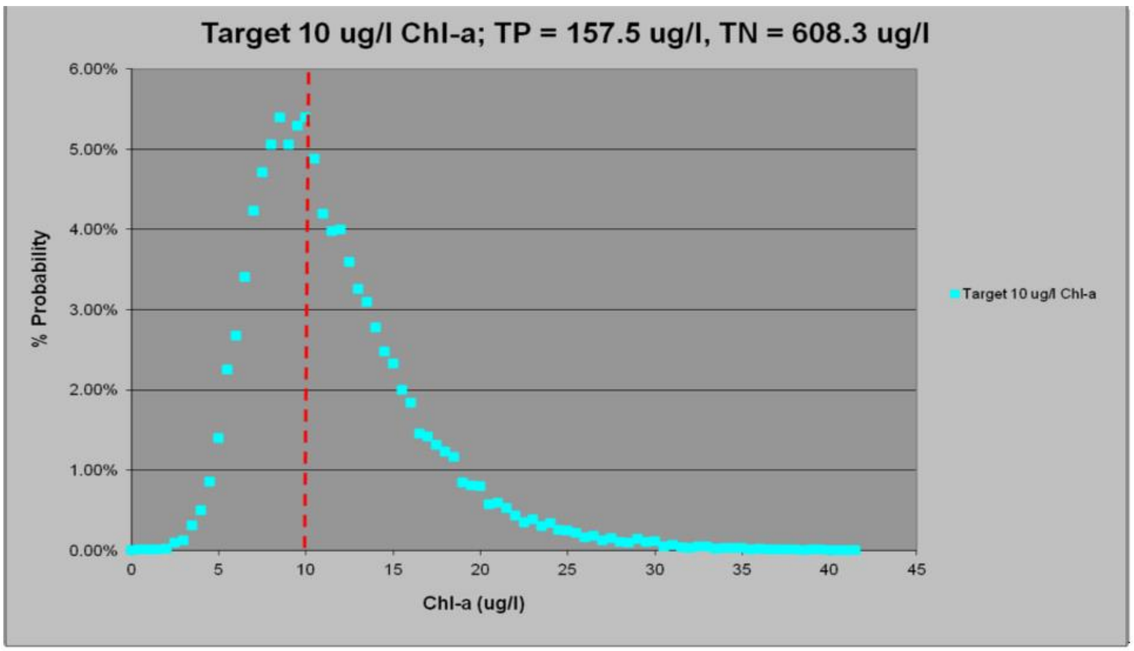
Parameter[†]	Definition	Distribution
a	Non-algal turbidity (1/m)	Normal (Copan: mean = 2.59, std. dev. = 0.7; Claremore: mean = 2.31, std. dev = 0.7)
Kc	Calibration factor for chlorophyll-*a* (unitless)	Normal (Copan: mean = 1.9, std. dev. = 0.45; Claremore: mean = 1.95, std. dev = 0.5)
zmx	Mixed layer depth (m)	Normal (Copan: mean = 2.7, std. dev. = 1.2; Claremore: mean = 2.5, std. dev = 1.2)

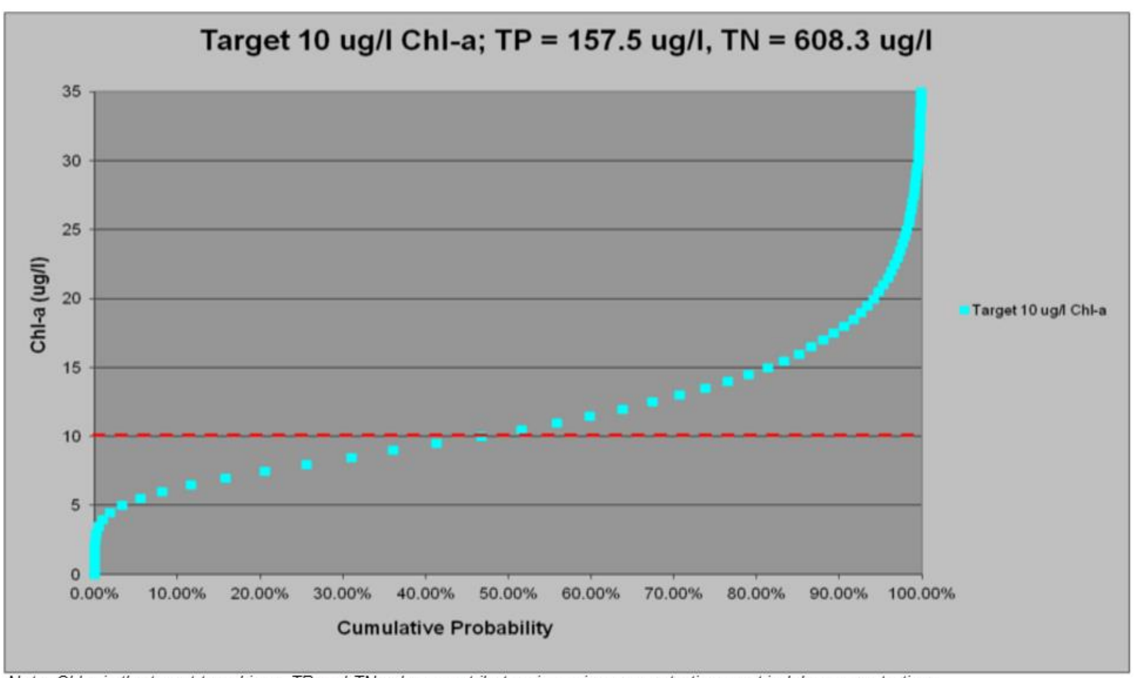
† The listed parameters were identified in a one-at-a-time sensitivity analysis to cause the most impact on modeled average chlorophyll-*a* concentrations.

Figure 4-3 shows probability and cumulative probability plots of average chlorophyll-*a* concentrations for the 20,000 iterations of the MCS for Copan 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.

Likewise, **Figure 4-4** shows probability and cumulative probability plots of average chlorophyll-*a* concentrations for the 20,000 iterations of the MCS for Lake Claremore 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.

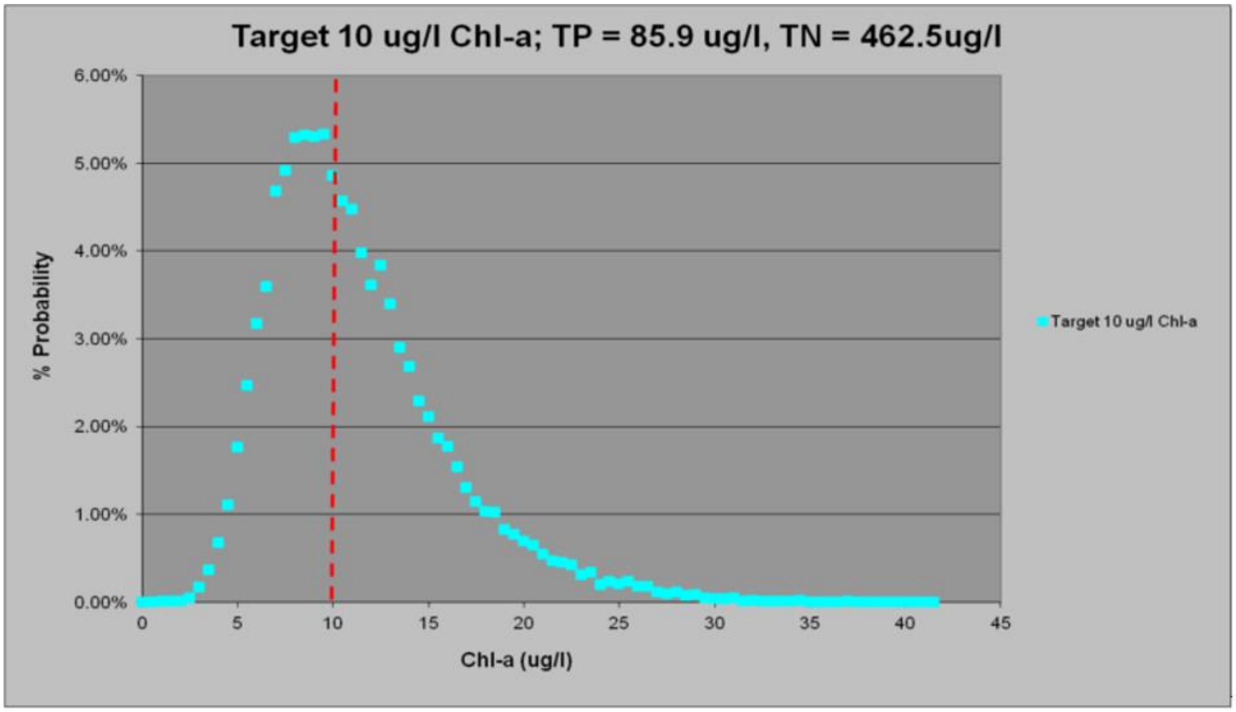
Figure 4-3: Monte Carlo Simulation Results for Copan Lake

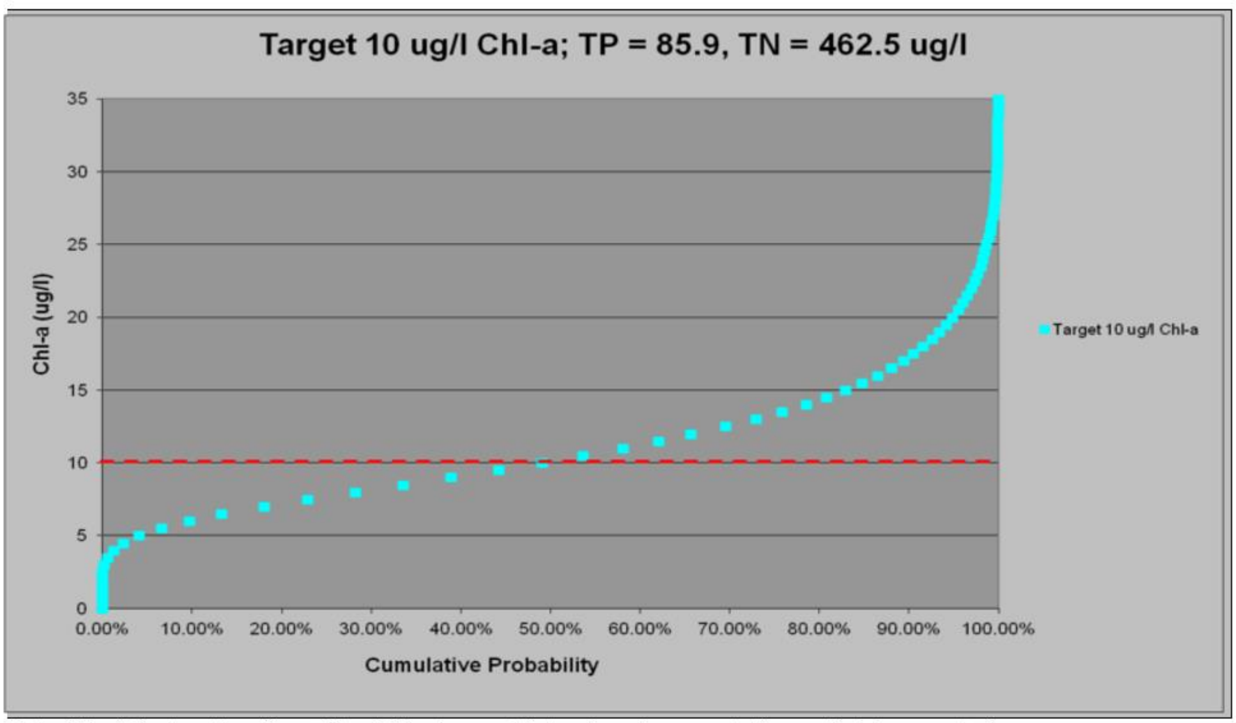




Note: Chl-a is the target to achieve. TP and TN values are tributary incoming concentrations, not in-lake concentrations.

Figure 4-4: Monte Carlo Simulation Results for Lake Claremore





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

4.7 MODELED LOAD REDUCTION SCENARIOS

A summary of the existing loads to Copan Lake and Lake Claremore simulated in BATHTUB is presented in **Table 4-5**.

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

Water Quality Parameter	Copan Lake			Lake Claremore	
	Watershed	Point Source	Atmospheric	Watershed	Atmospheric
Total Phosphorus	475,400	803	0[a]	22,400	0[a]
Orthophosphorus	63,000	502[b]	0[a]	12,300	0[a]
Total Nitrogen	1,376,700	3,248	22,120	108,100	2,144
Inorganic Nitrogen	231,500	1,949[c]	3,995	84,300	380

[a] Atmospheric deposition of phosphorus was expected to be negligible and, thus, was assumed to be zero.
[b] Estimated using PO4:TP ratio for medium untreated domestic wastewater (Metcalf & Eddy, 1979).
[c] Estimated using InorgN:TN ratio for medium untreated domestic wastewater (Metcalf & Eddy, 1979).

Simulations were performed using the BATHTUB model to evaluate the effect of watershed loading reductions on chlorophyll-*a* levels. Atmospheric loads and the point source to Copan Lake only 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 Copan Lake were reduced by 50% from the existing loads, to 237,700 kg/year of total phosphorus and 688,350 kg/year of total nitrogen. In Lake Claremore, the water quality target of 10 µg/L chlorophyll-*a* could be achieved if the existing watershed loads were reduced by 73% to 6,048 kg/year of total phosphorus and 29,187 kg/year of total nitrogen. As discussed above the uncertainty analysis demonstrated that even varying these two parameters within their entire expected range, the water quality target can be met at least 50% or more of the time. **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	Percent Reduction	Maximum Allowable Load (kg/yr)[a]	
		Total Phosphorus	Total Nitrogen
Copan Lake	**50%**	237,700	688,350
Lake Claremore	**73%**	6,048	29,187

[a] Loads do not include atmospheric deposition or the point source discharging to Copan Lake.

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 was often assumed that algal productivity of most freshwater lakes and reservoirs was 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. Therefore, it is important to reduce both phosphorus and nitrogen loadings to the lakes.

Figures 4-5 and 4-6 display summary plots of multiple combinations of TN and TP concentrations and percent reductions that result in 10 µg/L chlorophyll-*a* for both lakes 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 Copan and Claremore 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 was 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 4-5 and 4-6** could be used during the implementation of each TMDL to achieve the target chlorophyll-*a* level in the lakes.

Figure 4-5: Total N and Total P Combinations Resulting in 10 µg/L Chlorophyll-*a* – Copan Lake

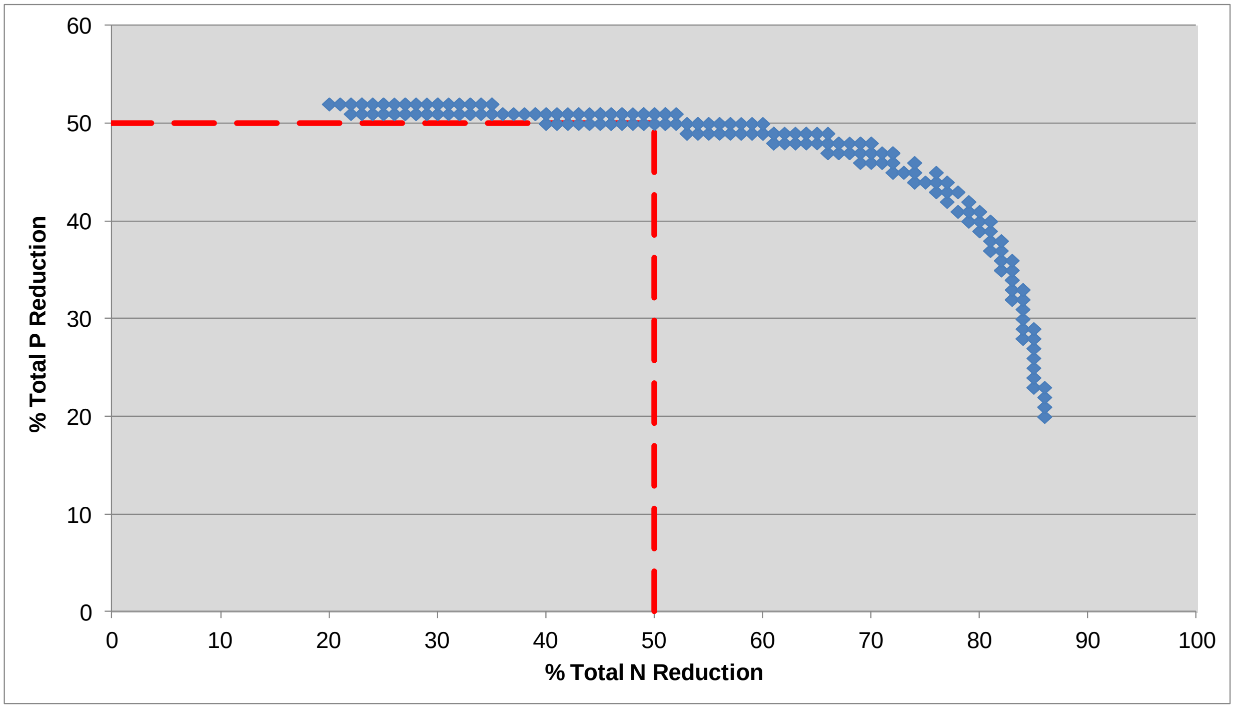
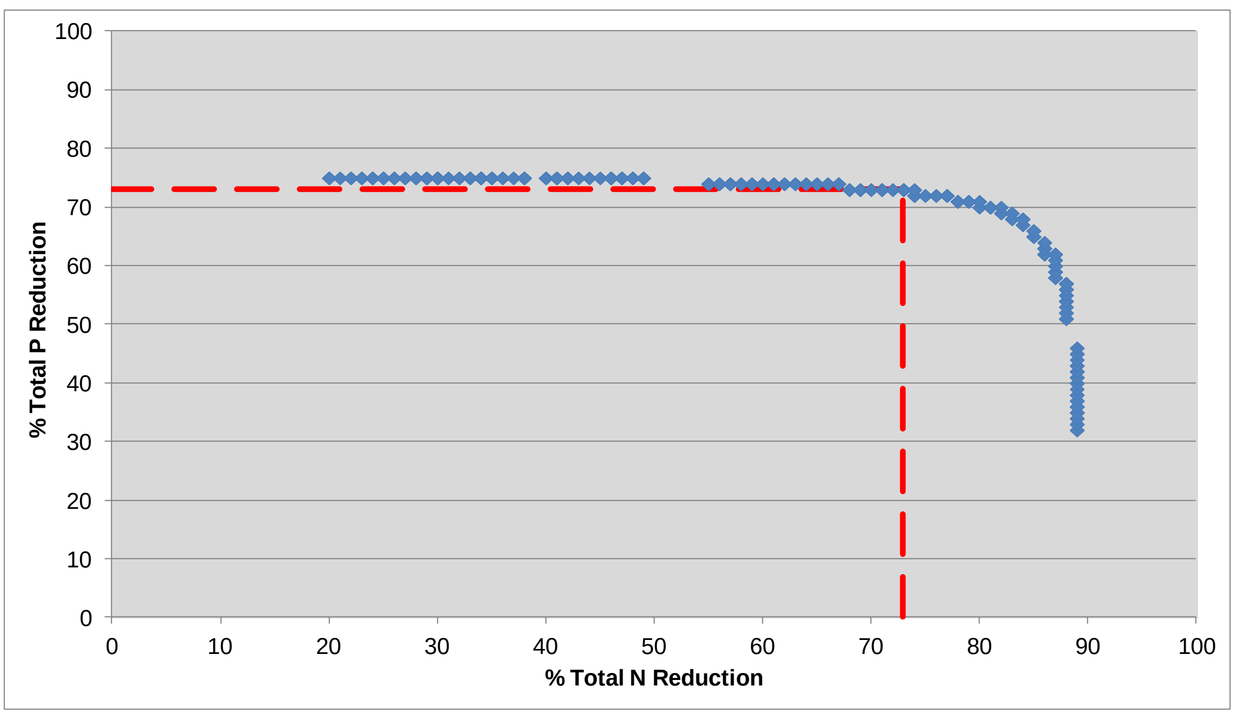


Figure 4-6: Total N and Total P Reduction Combinations Resulting in 10 µg/L Chlorophyll-*a* – Lake Claremore



SECTION 5 - TMDLS AND LOAD ALLOCATIONS

5.1 POLLUTANT LOADS AND TMDLS

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, were expressed for each lake as daily maximum loads (kg/day).

5.2 WASTELOAD ALLOCATION

There were no point sources of wastewater discharging nutrient loadings to Lake Claremore, but there is a point source of wastewater discharging to a tributary of Copan Lake. However, Copan PWA is moving their discharging point outside of the watershed of Copan Lake. There will be no point source discharges in Copan Lake watershed. 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 2013). *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."*

For Copan Lake, Copan PWA is moving their discharge outside of the watershed so the WLAs contributing to the Copan Lake will be zero. For wastewater treatment facilities in Kansas, WLAs are not calculated because the state of Oklahoma does not have any regulatory authority over these facilities. The nutrients load from these facilities will be included as load allocations (LA) in the TMDL calculations.

As discussed in Section 3, the City of Claremore has a Phase II MS4 permit for stormwater discharges and stormwater management (Permit #OKR040028). The City of Claremore comprises 1% of the Lake Claremore watershed. Since the Claremore City urban area accounts for a very small contribution to the total watershed area, a WLA_MS4 was not assigned, rather the small portion of the watershed accounted for by the MS4 area was included in the Load Allocation (LA) for Lake Claremore.

5.3 LOAD ALLOCATION

The LAs for both lakes were calculated as the difference between the TMDL, MOS, and WLA, as follows:

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

The total allowable load to Copan Lake was conservatively estimated as 237,700 kg/yr of total phosphorus and 688,350 kg/yr of total nitrogen, necessitating a 50% reduction from existing loading to achieve the desired water quality target.

The load allocation for watershed nonpoint sources to Lake Claremore was conservatively estimated as 6,048 kg/yr of total phosphorus and 29,187 kg/yr of total nitrogen, necessitating a 73% reduction from existing loading to achieve the desired water quality target.

5.4 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 2013). 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.

5.5 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 were used in development of the TMDL, or conservative factors were 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 Copan and Claremore Lakes include an implicit MOS that was incorporated by the application of load reductions for both nitrogen and phosphorus.

5.6 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:

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

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 Copan Lake and Lake Claremore 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 was used for this value)

$\boldsymbol{\sigma^2}$ = $\ln(CV^2+1)$ ***CV*** = coefficient of variation

The coefficients of variation of daily phosphorus and nitrogen NPS loads, calculated from SWAT model output, were 6.9 and 6.4 for Copan Lake, and 4.4 and 2.5 for Lake Claremore, respectively. As illustrated in **Figures 4-5 and 4-6**, 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 was 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 (50% for Copan and 73% for Claremore), the maximum daily load corresponding to the allowable annual average loads are provided in **Table 5-1**. In Copan Lake the 237,700 kg of phosphorus and 688,350 kg of nitrogen per year was translated to a daily maximum load of 605.1 kg/day of phosphorus and 1826.8 kg/day of nitrogen. For Lake Claremore, the allowable average load of 6,048 kg of phosphorus and 29,187 kg of nitrogen per year was translated to a daily maximum load of 19.1 kg/day of phosphorus and 112.6 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* in kg of Total Phosphorus and Nitrogen Per Day

Waterbody Name	Waterbody ID	Nutrient	TMDL	WLA	LA	MOS
Copan Lake	OK121400050020_00	Total Phosphorus	605.1	0	605.1	Implicit
		Total Nitrogen	1826.8	0	1826.8	Implicit
Lake Claremore	OK121500040020_00	Total Phosphorus	19.1	0	19.1	Implicit
		Total Nitrogen	112.6	0	112.6	Implicit

5.7 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: 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	www.ok.gov/conservation/Agency_Divisions/Water_Quality_Division
Oklahoma Department of Wildlife Conservation	www.wildlifedepartment.com/wildlifemgmt/endangeredspecies.htm

Agency	Web Link
Oklahoma Department of Agriculture, Food, and Forestry	http://www.ok.gov/~okag/aems/
Oklahoma Water Resources Board	http://www.owrb.ok.gov/quality/index.php

5.7.1 Point Sources

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

5.7.2 Nonpoint Sources

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

The reduction rates in nutrient loading called for in this TMDL report were as high as 85%. 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

This report was preliminary reviewed by EPA. After EPA reviewed the draft TMDL report, DEQ was given approval on July 15, 2014 to submit this Report for Public Notice. The Public Notice was sent to local newspapers, to stakeholders in the Study Area affected by these draft TMDLs, and to stakeholders who requested all copies of TMDL public notices. The Public Notice was also posted at the DEQ website: http://www.deq.state.ok.us/wqdnew/index.htm.

The public comment period lasted 45 days from July 25, 2014 to September 8, 2014. During that time, the public had the opportunity to review the TMDL report and make written comments. Written comments received during the public notice period are a part of the public record of the TMDL Report and can be found in Appendix D. Based on the comments received, some revisions were made to the *Lake Copan and Claremore Lake Chlorophyll-a TMDL Report* before it was submitted to EPA for final approval.

There were no requests for a public meeting.

After EPA's final approval, each TMDL and 208 Factsheet were adopted into the WQMP.

SECTION 7 - REFERENCES

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APPENDIX A: STATE OF OKLAHOMA'S ANTIDEGRADATION POLICY

Appendix A

State of Oklahoma's Antidegradation Policy

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

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

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

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

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

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

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

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

785:46-13-1. Applicability and scope

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

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

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

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

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

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

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

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

785:46-13-2. Definitions

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

"Specified pollutants" means

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

(B) Ammonia Nitrogen and/or Total Organic Nitrogen

(C) Phosphorus

(D) Total Suspended Solids (TSS)

(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 — 2003 TO 2012

PHOSPHORUS AND NITROGEN DATA – 1999 TO 2012

TOTAL SUSPENDED SOLIDS DATA — 1999 TO 2000

Table Appendix B-1: Ambient Water Quality Data for Copan Lake, 1999-2012

Lake Copan WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
121400050020-01B	01/24/2005	General Environmental Sample	Corrected Chlorophyll-*a*	3.08	mg/m^3
121400050020-01B	07/25/2005	General Environmental Sample	Corrected Chlorophyll-*a*	12.4	mg/m^3
121400050020-01B	10/15/2007	General Environmental Sample	Corrected Chlorophyll-*a*	6.54	mg/m^3
121400050020-01B	02/13/2008	General Environmental Sample	Corrected Chlorophyll-*a*	15.5	mg/m^3
121400050020-01B	04/23/2008	General Environmental Sample	Corrected Chlorophyll-*a*	28.7	mg/m^3
121400050020-01B	07/22/2008	General Environmental Sample	Corrected Chlorophyll-*a*	11.1	mg/m^3
121400050020-01S	01/13/2003	General Duplicate	Corrected Chlorophyll-*a*	16.6	mg/m^3
121400050020-01S	01/13/2003	General Environmental Sample	Corrected Chlorophyll-*a*	16.6	mg/m^3
121400050020-01S	06/16/2003	General Environmental Sample	Corrected Chlorophyll-*a*	18.9	mg/m^3
121400050020-01S	06/16/2003	General Environmental Sample	Corrected Chlorophyll-*a*	13.9	mg/m^3
121400050020-01S	07/14/2003	General Duplicate	Corrected Chlorophyll-*a*	9.2	mg/m^3
121400050020-01S	07/14/2003	General Duplicate	Corrected Chlorophyll-*a*	9.8	mg/m^3
121400050020-01S	07/14/2003	General Environmental Sample	Corrected Chlorophyll-*a*	8	mg/m^3
121400050020-01S	07/14/2003	General Environmental Sample	Corrected Chlorophyll-*a*	12.8	mg/m^3
121400050020-01S	01/24/2005	General Duplicate	Corrected Chlorophyll-*a*	2.81	mg/m^3
121400050020-01S	01/24/2005	General Environmental Sample	Corrected Chlorophyll-*a*	2.96	mg/m^3
121400050020-01S	07/25/2005	General Duplicate	Corrected Chlorophyll-*a*	11.1	mg/m^3
121400050020-01S	07/25/2005	General Environmental Sample	Corrected Chlorophyll-*a*	11.8	mg/m^3
121400050020-01S	02/13/2008	General Duplicate	Corrected Chlorophyll-*a*	14.6	mg/m^3
121400050020-01S	02/13/2008	General Environmental Sample	Corrected Chlorophyll-*a*	15.9	mg/m^3
121400050020-01S	04/23/2008	General Duplicate	Corrected Chlorophyll-*a*	28.5	mg/m^3
121400050020-01S	04/23/2008	General Environmental Sample	Corrected Chlorophyll-*a*	28.5	mg/m^3
121400050020-01S	07/22/2008	General Duplicate	Corrected Chlorophyll-*a*	10.9	mg/m^3
121400050020-01S	07/22/2008	General Environmental Sample	Corrected Chlorophyll-*a*	10.9	mg/m^3
121400050020-01S	10/15/2012	Churn Duplicate	Corrected Chlorophyll-*a*	2.82	mg/m^3
121400050020-01S	10/15/2012	Environmental Churn Duplicate	Corrected Chlorophyll-*a*	4.14	mg/m^3
121400050020-02	01/13/2003	General Environmental Sample	Corrected Chlorophyll-*a*	15.6	mg/m^3
121400050020-02	06/16/2003	General Environmental Sample	Corrected Chlorophyll-*a*	17.2	mg/m^3
121400050020-02	06/16/2003	General Environmental Sample	Corrected Chlorophyll-*a*	13.8	mg/m^3
121400050020-02	07/14/2003	General Environmental Sample	Corrected Chlorophyll-*a*	16.4	mg/m^3
121400050020-02	01/24/2005	General Environmental Sample	Corrected Chlorophyll-*a*	2.53	mg/m^3
121400050020-02	07/25/2005	General Environmental Sample	Corrected Chlorophyll-*a*	14.7	mg/m^3
121400050020-02	10/15/2007	General Environmental Sample	Corrected Chlorophyll-*a*	15.05	mg/m^3
121400050020-02	02/13/2008	General Environmental Sample	Corrected Chlorophyll-*a*	17.2	mg/m^3
121400050020-02	04/23/2008	General Environmental Sample	Corrected Chlorophyll-*a*	24.9	mg/m^3
121400050020-02	07/22/2008	General Environmental Sample	Corrected Chlorophyll-*a*	38.9	mg/m^3
121400050020-02	10/15/2012	General Environmental Sample	Corrected Chlorophyll-*a*	5.25	mg/m^3
121400050020-03	01/13/2003	General Environmental Sample	Corrected Chlorophyll-*a*	12.7	mg/m^3
121400050020-03	06/16/2003	General Environmental Sample	Corrected Chlorophyll-*a*	20.2	mg/m^3
121400050020-03	06/16/2003	General Environmental Sample	Corrected Chlorophyll-*a*	19.3	mg/m^3
121400050020-03	07/14/2003	General Environmental Sample	Corrected Chlorophyll-*a*	52.1	mg/m^3
121400050020-03	07/14/2003	General Environmental Sample	Corrected Chlorophyll-*a*	60.3	mg/m^3
121400050020-03	01/24/2005	General Environmental Sample	Corrected Chlorophyll-*a*	2.14	mg/m^3
121400050020-03	07/25/2005	General Environmental Sample	Corrected Chlorophyll-*a*	17.2	mg/m^3

Lake Copan WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
121400050020-03	10/15/2007	General Environmental Sample	Corrected Chlorophyll-*a*	12.43	mg/m^3
121400050020-03	02/13/2008	General Environmental Sample	Corrected Chlorophyll-*a*	16.4	mg/m^3
121400050020-03	04/23/2008	General Environmental Sample	Corrected Chlorophyll-*a*	32.5	mg/m^3
121400050020-03	07/22/2008	General Environmental Sample	Corrected Chlorophyll-*a*	71.1	mg/m^3
121400050020-03	10/15/2012	General Environmental Sample	Corrected Chlorophyll-*a*	5.75	mg/m^3
121400050020-04	01/13/2003	General Environmental Sample	Corrected Chlorophyll-*a*	12.6	mg/m^3
121400050020-04	06/16/2003	General Environmental Sample	Corrected Chlorophyll-*a*	13	mg/m^3
121400050020-04	06/16/2003	General Environmental Sample	Corrected Chlorophyll-*a*	21.1	mg/m^3
121400050020-04	07/14/2003	General Environmental Sample	Corrected Chlorophyll-*a*	23.6	mg/m^3
121400050020-04	07/14/2003	General Environmental Sample	Corrected Chlorophyll-*a*	24.6	mg/m^3
121400050020-04	01/24/2005	General Environmental Sample	Corrected Chlorophyll-*a*	2.7	mg/m^3
121400050020-04	07/25/2005	General Environmental Sample	Corrected Chlorophyll-*a*	22.6	mg/m^3
121400050020-04	10/15/2007	General Environmental Sample	Corrected Chlorophyll-*a*	25.22	mg/m^3
121400050020-04	02/13/2008	General Environmental Sample	Corrected Chlorophyll-*a*	10.4	mg/m^3
121400050020-04	04/23/2008	General Environmental Sample	Corrected Chlorophyll-*a*	25	mg/m^3
121400050020-04	07/22/2008	General Environmental Sample	Corrected Chlorophyll-*a*	37.6	mg/m^3
121400050020-04	10/15/2012	General Environmental Sample	Corrected Chlorophyll-*a*	13.1	mg/m^3
121400050020-05	01/13/2003	General Environmental Sample	Corrected Chlorophyll-*a*	13.9	mg/m^3
121400050020-05	06/16/2003	General Environmental Sample	Corrected Chlorophyll-*a*	33.9	mg/m^3
121400050020-05	06/16/2003	General Environmental Sample	Corrected Chlorophyll-*a*	31.2	mg/m^3
121400050020-05	07/14/2003	General Environmental Sample	Corrected Chlorophyll-*a*	24.4	mg/m^3
121400050020-05	07/14/2003	General Environmental Sample	Corrected Chlorophyll-*a*	18.9	mg/m^3
121400050020-05	01/24/2005	General Environmental Sample	Corrected Chlorophyll-*a*	2.28	mg/m^3
121400050020-05	07/25/2005	General Environmental Sample	Corrected Chlorophyll-*a*	28.9	mg/m^3
121400050020-05	10/15/2007	General Environmental Sample	Corrected Chlorophyll-*a*	44.31	mg/m^3
121400050020-05	02/13/2008	General Environmental Sample	Corrected Chlorophyll-*a*	13.8	mg/m^3
121400050020-05	04/23/2008	General Environmental Sample	Corrected Chlorophyll-*a*	15.5	mg/m^3
121400050020-05	07/22/2008	General Environmental Sample	Corrected Chlorophyll-*a*	38.9	mg/m^3
121400050020-05	10/15/2012	General Environmental Sample	Corrected Chlorophyll-*a*	9.28	mg/m^3
121400050020-01B	10/17/1999	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01B	01/18/2000	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
121400050020-01B	04/25/2000	General Environmental Sample	Nitrogen, Ammonia	0.05	mg/L
121400050020-01B	07/24/2000	General Environmental Sample	Nitrogen, Ammonia	0.11	mg/L
121400050020-01B	10/14/2002	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01B	01/13/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01B	04/14/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01B	07/14/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01B	10/25/2004	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
121400050020-01B	01/24/2005	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
121400050020-01S	10/17/1999	General Duplicate	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	10/17/1999	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	01/18/2000	General Duplicate	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	01/18/2000	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	04/25/2000	General Duplicate	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	04/25/2000	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	07/24/2000	General Duplicate	Nitrogen, Ammonia	0.05	mg/L

Lake Copan WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
121400050020-01S	07/24/2000	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
121400050020-01S	10/14/2002	General Duplicate	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	10/14/2002	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	01/13/2003	General Duplicate	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	01/13/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	04/14/2003	General Duplicate	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	04/14/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	07/14/2003	General Duplicate	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	07/14/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	10/25/2004	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
121400050020-01S	01/24/2005	General Duplicate	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	01/24/2005	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
121400050020-01S	05/03/2005	General Duplicate	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	05/03/2005	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01S	07/25/2005	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-02	10/17/1999	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-02	01/18/2000	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-02	04/25/2000	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-02	07/24/2000	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
121400050020-02	10/14/2002	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-02	01/13/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-02	04/14/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-02	07/14/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-02	10/25/2004	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
121400050020-02	01/24/2005	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
121400050020-02	05/03/2005	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-02	07/25/2005	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-03	10/17/1999	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-03	01/18/2000	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-03	04/25/2000	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-03	07/24/2000	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
121400050020-03	10/14/2002	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-03	01/13/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-03	04/14/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-03	07/14/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-03	10/25/2004	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
121400050020-03	01/24/2005	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
121400050020-03	05/03/2005	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-03	07/25/2005	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-04	10/17/1999	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-04	01/18/2000	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
121400050020-04	04/25/2000	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-04	07/24/2000	General Environmental Sample	Nitrogen, Ammonia	0.07	mg/L
121400050020-04	10/14/2002	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-04	01/13/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-04	04/14/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L

Lake Copan WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
121400050020-04	07/14/2003	General Environmental Sample	Nitrogen, Ammonia	0.1	mg/L
121400050020-04	10/25/2004	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
121400050020-04	01/24/2005	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-04	05/03/2005	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-04	07/25/2005	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-05	10/14/2002	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-05	01/13/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-05	04/14/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-05	07/14/2003	General Environmental Sample	Nitrogen, Ammonia	0.09	mg/L
121400050020-05	10/25/2004	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
121400050020-05	01/24/2005	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-05	05/03/2005	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-05	07/25/2005	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121400050020-01B	10/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.37	mg/L
121400050020-01B	01/18/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.34	mg/L
121400050020-01B	04/25/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.41	mg/L
121400050020-01B	07/24/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.45	mg/L
121400050020-01B	10/14/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.28	mg/L
121400050020-01B	01/13/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.28	mg/L
121400050020-01B	04/14/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.17	mg/L
121400050020-01B	07/14/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.42	mg/L
121400050020-01B	10/25/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.36	mg/L
121400050020-01B	01/24/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.58	mg/L
121400050020-01S	10/17/1999	General Duplicate	Nitrogen, Kjeldahl	0.34	mg/L
121400050020-01S	10/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.24	mg/L
121400050020-01S	01/18/2000	General Duplicate	Nitrogen, Kjeldahl	0.42	mg/L
121400050020-01S	01/18/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.27	mg/L
121400050020-01S	04/25/2000	General Duplicate	Nitrogen, Kjeldahl	0.37	mg/L
121400050020-01S	04/25/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.51	mg/L
121400050020-01S	07/24/2000	General Duplicate	Nitrogen, Kjeldahl	0.36	mg/L
121400050020-01S	07/24/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.5	mg/L
121400050020-01S	10/14/2002	General Duplicate	Nitrogen, Kjeldahl	0.42	mg/L
121400050020-01S	10/14/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.28	mg/L
121400050020-01S	01/13/2003	General Duplicate	Nitrogen, Kjeldahl	0.51	mg/L
121400050020-01S	01/13/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.25	mg/L
121400050020-01S	04/14/2003	General Duplicate	Nitrogen, Kjeldahl	0.26	mg/L
121400050020-01S	04/14/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.28	mg/L
121400050020-01S	07/14/2003	General Duplicate	Nitrogen, Kjeldahl	0.85	mg/L
121400050020-01S	07/14/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.63	mg/L
121400050020-01S	10/25/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.56	mg/L
121400050020-01S	01/24/2005	General Duplicate	Nitrogen, Kjeldahl	0.53	mg/L
121400050020-01S	01/24/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.48	mg/L
121400050020-01S	05/03/2005	General Duplicate	Nitrogen, Kjeldahl	0.6	mg/L
121400050020-01S	05/03/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.79	mg/L
121400050020-01S	07/25/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.7	mg/L
121400050020-01S	10/15/2007	General Duplicate	Nitrogen, Kjeldahl	0.52	mg/L

Lake Copan WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
121400050020-01S	10/15/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.53	mg/L
121400050020-01S	02/13/2008	General Duplicate	Nitrogen, Kjeldahl	0.65	mg/L
121400050020-01S	02/13/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.62	mg/L
121400050020-01S	04/23/2008	General Duplicate	Nitrogen, Kjeldahl	0.99	mg/L
121400050020-01S	04/23/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.99	mg/L
121400050020-01S	07/22/2008	General Duplicate	Nitrogen, Kjeldahl	0.45	mg/L
121400050020-01S	07/22/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.49	mg/L
121400050020-01S	10/15/2012	Churn Duplicate	Nitrogen, Kjeldahl	0.68	mg/L
121400050020-01S	10/15/2012	Environmental Churn Duplicate	Nitrogen, Kjeldahl	0.64	mg/L
121400050020-02	10/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.37	mg/L
121400050020-02	01/18/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.27	mg/L
121400050020-02	04/25/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.61	mg/L
121400050020-02	07/24/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.5	mg/L
121400050020-02	10/14/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.36	mg/L
121400050020-02	01/13/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.29	mg/L
121400050020-02	04/14/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.23	mg/L
121400050020-02	07/14/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.87	mg/L
121400050020-02	10/25/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.49	mg/L
121400050020-02	01/24/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.54	mg/L
121400050020-02	05/03/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.59	mg/L
121400050020-02	07/25/2005	General Environmental Sample	Nitrogen, Kjeldahl	1.3	mg/L
121400050020-02	10/15/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.64	mg/L
121400050020-02	02/13/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.62	mg/L
121400050020-02	04/23/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.95	mg/L
121400050020-02	07/22/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.96	mg/L
121400050020-02	10/15/2012	General Environmental Sample	Nitrogen, Kjeldahl	0.77	mg/L
121400050020-03	10/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.44	mg/L
121400050020-03	01/18/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.51	mg/L
121400050020-03	04/25/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.44	mg/L
121400050020-03	07/24/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.5	mg/L
121400050020-03	10/14/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.27	mg/L
121400050020-03	01/13/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.3	mg/L
121400050020-03	04/14/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.39	mg/L
121400050020-03	07/14/2003	General Environmental Sample	Nitrogen, Kjeldahl	1.38	mg/L
121400050020-03	10/25/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.48	mg/L
121400050020-03	01/24/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.51	mg/L
121400050020-03	05/03/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.57	mg/L
121400050020-03	07/25/2005	General Environmental Sample	Nitrogen, Kjeldahl	1.44	mg/L
121400050020-03	10/15/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.56	mg/L
121400050020-03	02/13/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.7	mg/L
121400050020-03	04/23/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.93	mg/L
121400050020-03	07/22/2008	General Environmental Sample	Nitrogen, Kjeldahl	1.22	mg/L
121400050020-03	10/15/2012	General Environmental Sample	Nitrogen, Kjeldahl	0.74	mg/L
121400050020-04	10/17/1999	General Environmental Sample	Nitrogen, Kjeldahl	0.44	mg/L
121400050020-04	01/18/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.51	mg/L
121400050020-04	04/25/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.48	mg/L

Lake Copan WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
121400050020-04	07/24/2000	General Environmental Sample	Nitrogen, Kjeldahl	0.45	mg/L
121400050020-04	10/14/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.39	mg/L
121400050020-04	01/13/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.31	mg/L
121400050020-04	04/14/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.26	mg/L
121400050020-04	07/14/2003	General Environmental Sample	Nitrogen, Kjeldahl	1.16	mg/L
121400050020-04	10/25/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.59	mg/L
121400050020-04	01/24/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.57	mg/L
121400050020-04	05/03/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.71	mg/L
121400050020-04	07/25/2005	General Environmental Sample	Nitrogen, Kjeldahl	1.01	mg/L
121400050020-04	10/15/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.83	mg/L
121400050020-04	02/13/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.82	mg/L
121400050020-04	04/23/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.85	mg/L
121400050020-04	07/22/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.9	mg/L
121400050020-04	10/15/2012	General Environmental Sample	Nitrogen, Kjeldahl	0.85	mg/L
121400050020-05	10/14/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.7	mg/L
121400050020-05	01/13/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.29	mg/L
121400050020-05	04/14/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.27	mg/L
121400050020-05	07/14/2003	General Environmental Sample	Nitrogen, Kjeldahl	1.04	mg/L
121400050020-05	10/25/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.48	mg/L
121400050020-05	01/24/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.86	mg/L
121400050020-05	05/03/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.57	mg/L
121400050020-05	07/25/2005	General Environmental Sample	Nitrogen, Kjeldahl	1.11	mg/L
121400050020-05	10/15/2007	General Environmental Sample	Nitrogen, Kjeldahl	0.91	mg/L
121400050020-05	02/13/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.8	mg/L
121400050020-05	04/23/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.79	mg/L
121400050020-05	07/22/2008	General Environmental Sample	Nitrogen, Kjeldahl	0.84	mg/L
121400050020-05	10/15/2012	General Environmental Sample	Nitrogen, Kjeldahl	0.81	mg/L
121400050020-01B	10/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.33	mg/L
121400050020-01B	01/18/2000	General Environmental Sample	Nitrogen, Nitrate as N	0.13	mg/L
121400050020-01B	04/25/2000	General Environmental Sample	Nitrogen, Nitrate as N	0.13	mg/L
121400050020-01B	07/24/2000	General Environmental Sample	Nitrogen, Nitrate as N	0.14	mg/L
121400050020-01B	10/14/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.07	mg/L
121400050020-01B	01/13/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-01B	04/14/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-01B	07/14/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.14	mg/L
121400050020-01B	10/25/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-01B	01/24/2005	General Environmental Sample	Nitrogen, Nitrate as N	0.21	mg/L
121400050020-01S	10/17/1999	General Duplicate	Nitrogen, Nitrate as N	0.25	mg/L
121400050020-01S	10/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.34	mg/L
121400050020-01S	01/18/2000	General Duplicate	Nitrogen, Nitrate as N	0.12	mg/L
121400050020-01S	01/18/2000	General Environmental Sample	Nitrogen, Nitrate as N	0.14	mg/L
121400050020-01S	04/25/2000	General Duplicate	Nitrogen, Nitrate as N	0.12	mg/L
121400050020-01S	04/25/2000	General Environmental Sample	Nitrogen, Nitrate as N	0.11	mg/L
121400050020-01S	07/24/2000	General Duplicate	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-01S	07/24/2000	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-01S	10/14/2002	General Duplicate	Nitrogen, Nitrate as N	0.11	mg/L

Lake Copan WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
121400050020-01S	10/14/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.1	mg/L
121400050020-01S	01/13/2003	General Duplicate	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-01S	01/13/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-01S	04/14/2003	General Duplicate	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-01S	04/14/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-01S	07/14/2003	General Duplicate	Nitrogen, Nitrate as N	0.05	mg/L
121400050020-01S	07/14/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.05	mg/L
121400050020-01S	10/25/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-01S	01/24/2005	General Duplicate	Nitrogen, Nitrate as N	0.17	mg/L
121400050020-01S	01/24/2005	General Environmental Sample	Nitrogen, Nitrate as N	0.2	mg/L
121400050020-02	10/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.31	mg/L
121400050020-02	01/18/2000	General Environmental Sample	Nitrogen, Nitrate as N	0.14	mg/L
121400050020-02	04/25/2000	General Environmental Sample	Nitrogen, Nitrate as N	0.06	mg/L
121400050020-02	07/24/2000	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-02	10/14/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.08	mg/L
121400050020-02	01/13/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-02	04/14/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-02	07/14/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-02	10/25/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-02	01/24/2005	General Environmental Sample	Nitrogen, Nitrate as N	0.21	mg/L
121400050020-03	10/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.3	mg/L
121400050020-03	01/18/2000	General Environmental Sample	Nitrogen, Nitrate as N	0.13	mg/L
121400050020-03	04/25/2000	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-03	07/24/2000	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-03	10/14/2002	General Environmental Sample	Nitrogen, Nitrate as N	0.09	mg/L
121400050020-03	01/13/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-03	04/14/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-03	07/14/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-03	10/25/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-03	01/24/2005	General Environmental Sample	Nitrogen, Nitrate as N	0.21	mg/L
121400050020-04	10/17/1999	General Environmental Sample	Nitrogen, Nitrate as N	0.25	mg/L
121400050020-04	01/18/2000	General Environmental Sample	Nitrogen, Nitrate as N	0.14	mg/L
121400050020-04	04/25/2000	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-04	07/24/2000	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-04	10/14/2002	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-04	01/13/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-04	04/14/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-04	07/14/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.08	mg/L
121400050020-04	10/25/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-04	01/24/2005	General Environmental Sample	Nitrogen, Nitrate as N	0.22	mg/L
121400050020-05	10/14/2002	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-05	01/13/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-05	04/14/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-05	07/14/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.07	mg/L
121400050020-05	10/25/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121400050020-05	01/24/2005	General Environmental Sample	Nitrogen, Nitrate as N	0.17	mg/L

Lake Copan WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
121400050020-01S	05/03/2005	General Duplicate	Nitrogen, Nitrate/Nitrite as N	0.16	mg/L
121400050020-01S	05/03/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.15	mg/L
121400050020-01S	07/25/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-01S	10/15/2007	General Duplicate	Nitrogen, Nitrate/Nitrite as N	0.4	mg/L
121400050020-01S	10/15/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.4	mg/L
121400050020-01S	02/13/2008	General Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-01S	02/13/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-01S	04/23/2008	General Duplicate	Nitrogen, Nitrate/Nitrite as N	0.25	mg/L
121400050020-01S	04/23/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.25	mg/L
121400050020-01S	07/22/2008	General Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-01S	07/22/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-01S	10/15/2012	Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	0.22	mg/L
121400050020-01S	10/15/2012	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	0.22	mg/L
121400050020-02	05/03/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.13	mg/L
121400050020-02	07/25/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-02	10/15/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.34	mg/L
121400050020-02	02/13/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-02	04/23/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.21	mg/L
121400050020-02	07/22/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-02	10/15/2012	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.21	mg/L
121400050020-03	05/03/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.11	mg/L
121400050020-03	07/25/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-03	10/15/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.31	mg/L
121400050020-03	02/13/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-03	04/23/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.19	mg/L
121400050020-03	07/22/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-03	10/15/2012	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.2	mg/L
121400050020-04	05/03/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-04	07/25/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-04	10/15/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.19	mg/L
121400050020-04	02/13/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.2	mg/L
121400050020-04	04/23/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.19	mg/L
121400050020-04	07/22/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-04	10/15/2012	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.14	mg/L
121400050020-05	05/03/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.06	mg/L
121400050020-05	07/25/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-05	10/15/2007	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.13	mg/L
121400050020-05	02/13/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.18	mg/L
121400050020-05	04/23/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.17	mg/L
121400050020-05	07/22/2008	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121400050020-05	10/15/2012	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.16	mg/L
121400050020-01B	10/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01B	01/18/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01B	04/25/2000	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
121400050020-01B	07/24/2000	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
121400050020-01B	10/14/2002	General Environmental Sample	Nitrogen, Nitrite as N	0.07	mg/L

Lake Copan WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
121400050020-01B	01/13/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01B	04/14/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01B	07/14/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01B	10/25/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01B	01/24/2005	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01S	10/17/1999	General Duplicate	Nitrogen, Nitrite as N	0.11	mg/L
121400050020-01S	10/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01S	01/18/2000	General Duplicate	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01S	01/18/2000	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
121400050020-01S	04/25/2000	General Duplicate	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01S	04/25/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01S	07/24/2000	General Duplicate	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01S	07/24/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01S	10/14/2002	General Duplicate	Nitrogen, Nitrite as N	0.05	mg/L
121400050020-01S	10/14/2002	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
121400050020-01S	01/13/2003	General Duplicate	Nitrogen, Nitrite as N	0.06	mg/L
121400050020-01S	01/13/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01S	04/14/2003	General Duplicate	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01S	04/14/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01S	07/14/2003	General Duplicate	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01S	07/14/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01S	10/25/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01S	01/24/2005	General Duplicate	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01S	01/24/2005	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-02	10/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
121400050020-02	01/18/2000	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
121400050020-02	04/25/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-02	07/24/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-02	10/14/2002	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
121400050020-02	01/13/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-02	04/14/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-02	07/14/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-02	10/25/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-02	01/24/2005	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-03	10/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	0.06	mg/L
121400050020-03	01/18/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-03	04/25/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-03	07/24/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-03	10/14/2002	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
121400050020-03	01/13/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-03	04/14/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-03	07/14/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-03	10/25/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-03	01/24/2005	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-04	10/17/1999	General Environmental Sample	Nitrogen, Nitrite as N	0.06	mg/L
121400050020-04	01/18/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L

Lake Copan WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
121400050020-04	04/25/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-04	07/24/2000	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-04	10/14/2002	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
121400050020-04	01/13/2003	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
121400050020-04	04/14/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-04	07/14/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-04	10/25/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-04	01/24/2005	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-05	10/14/2002	General Environmental Sample	Nitrogen, Nitrite as N	0.05	mg/L
121400050020-05	01/13/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-05	04/14/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-05	07/14/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-05	10/25/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-05	01/24/2005	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121400050020-01B	10/17/1999	General Environmental Sample	Nitrogen, Organic	0.37	mg/L
121400050020-01B	01/18/2000	General Environmental Sample	Nitrogen, Organic	0.27	mg/L
121400050020-01S	10/17/1999	General Duplicate	Nitrogen, Organic	0.34	mg/L
121400050020-01S	10/17/1999	General Environmental Sample	Nitrogen, Organic	0.24	mg/L
121400050020-01S	01/18/2000	General Duplicate	Nitrogen, Organic	0.42	mg/L
121400050020-01S	01/18/2000	General Environmental Sample	Nitrogen, Organic	0.27	mg/L
121400050020-02	10/17/1999	General Environmental Sample	Nitrogen, Organic	0.37	mg/L
121400050020-02	01/18/2000	General Environmental Sample	Nitrogen, Organic	0.27	mg/L
121400050020-03	10/17/1999	General Environmental Sample	Nitrogen, Organic	0.44	mg/L
121400050020-03	01/18/2000	General Environmental Sample	Nitrogen, Organic	0.51	mg/L
121400050020-04	10/17/1999	General Environmental Sample	Nitrogen, Organic	0.44	mg/L
121400050020-04	01/18/2000	General Environmental Sample	Nitrogen, Organic	0.45	mg/L
121400050020-01B	10/17/1999	General Environmental Sample	Nitrogen, Total	0.7	mg/L
121400050020-01B	01/18/2000	General Environmental Sample	Nitrogen, Total	0.47	mg/L
121400050020-01S	10/17/1999	General Duplicate	Nitrogen, Total	0.7	mg/L
121400050020-01S	10/17/1999	General Environmental Sample	Nitrogen, Total	0.58	mg/L
121400050020-01S	01/18/2000	General Duplicate	Nitrogen, Total	0.54	mg/L
121400050020-01S	01/18/2000	General Environmental Sample	Nitrogen, Total	0.46	mg/L
121400050020-02	10/17/1999	General Environmental Sample	Nitrogen, Total	0.73	mg/L
121400050020-02	01/18/2000	General Environmental Sample	Nitrogen, Total	0.46	mg/L
121400050020-03	10/17/1999	General Environmental Sample	Nitrogen, Total	0.8	mg/L
121400050020-03	01/18/2000	General Environmental Sample	Nitrogen, Total	0.64	mg/L
121400050020-04	10/17/1999	General Environmental Sample	Nitrogen, Total	0.75	mg/L
121400050020-04	01/18/2000	General Environmental Sample	Nitrogen, Total	0.65	mg/L
121400050020-01S	10/15/2012	Churn Duplicate	Ortho Phosphate, method 8048	0.33	mg/l
121400050020-01S	10/15/2012	Environmental Churn Duplicate	Ortho Phosphate, method 8048	0.32	mg/l
121400050020-02	10/15/2012	General Environmental Sample	Ortho Phosphate, method 8048	0.26	mg/l
121400050020-03	10/15/2012	General Environmental Sample	Ortho Phosphate, method 8048	0.22	mg/l
121400050020-04	10/15/2012	General Environmental Sample	Ortho Phosphate, method 8048	0.15	mg/l
121400050020-05	10/15/2012	General Environmental Sample	Ortho Phosphate, method 8048	0.18	mg/l
121400050020-01B	10/17/1999	General Environmental Sample	Phosphorous, Ortho	0.09	mg/L
121400050020-01B	01/18/2000	General Environmental Sample	Phosphorous, Ortho	0.017	mg/L

Lake Copan WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
121400050020-01B	04/25/2000	General Environmental Sample	Phosphorous, Ortho	0.055	mg/L
121400050020-01B	07/24/2000	General Environmental Sample	Phosphorous, Ortho	0.034	mg/L
121400050020-01B	10/14/2002	General Environmental Sample	Phosphorous, Ortho	0.048	mg/L
121400050020-01B	01/13/2003	General Environmental Sample	Phosphorous, Ortho	0.01	mg/L
121400050020-01B	04/14/2003	General Environmental Sample	Phosphorous, Ortho	0.029	mg/L
121400050020-01B	07/14/2003	General Environmental Sample	Phosphorous, Ortho	0.044	mg/L
121400050020-01B	10/25/2004	General Environmental Sample	Phosphorous, Ortho	0.029	mg/L
121400050020-01B	01/24/2005	General Environmental Sample	Phosphorous, Ortho	0.076	mg/L
121400050020-01S	10/17/1999	General Duplicate	Phosphorous, Ortho	0.082	mg/L
121400050020-01S	10/17/1999	General Environmental Sample	Phosphorous, Ortho	0.083	mg/L
121400050020-01S	01/18/2000	General Duplicate	Phosphorous, Ortho	0.017	mg/L
121400050020-01S	01/18/2000	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
121400050020-01S	04/25/2000	General Duplicate	Phosphorous, Ortho	0.039	mg/L
121400050020-01S	04/25/2000	General Environmental Sample	Phosphorous, Ortho	0.04	mg/L
121400050020-01S	07/24/2000	General Duplicate	Phosphorous, Ortho	0.008	mg/L
121400050020-01S	07/24/2000	General Environmental Sample	Phosphorous, Ortho	0.008	mg/L
121400050020-01S	10/14/2002	General Duplicate	Phosphorous, Ortho	0.052	mg/L
121400050020-01S	10/14/2002	General Environmental Sample	Phosphorous, Ortho	0.051	mg/L
121400050020-01S	01/13/2003	General Duplicate	Phosphorous, Ortho	0.01	mg/L
121400050020-01S	01/13/2003	General Environmental Sample	Phosphorous, Ortho	0.01	mg/L
121400050020-01S	04/14/2003	General Duplicate	Phosphorous, Ortho	0.022	mg/L
121400050020-01S	04/14/2003	General Environmental Sample	Phosphorous, Ortho	0.023	mg/L
121400050020-01S	07/14/2003	General Duplicate	Phosphorous, Ortho	0.024	mg/L
121400050020-01S	07/14/2003	General Environmental Sample	Phosphorous, Ortho	0.025	mg/L
121400050020-01S	10/25/2004	General Environmental Sample	Phosphorous, Ortho	0.029	mg/L
121400050020-01S	01/24/2005	General Duplicate	Phosphorous, Ortho	0.074	mg/L
121400050020-01S	01/24/2005	General Environmental Sample	Phosphorous, Ortho	0.075	mg/L
121400050020-01S	05/03/2005	General Duplicate	Phosphorous, Ortho	0.084	mg/L
121400050020-01S	05/03/2005	General Environmental Sample	Phosphorous, Ortho	0.082	mg/L
121400050020-01S	07/25/2005	General Environmental Sample	Phosphorous, Ortho	0.026	mg/L
121400050020-01S	10/15/2007	General Duplicate	Phosphorous, Ortho	0.035	mg/L
121400050020-01S	10/15/2007	General Environmental Sample	Phosphorous, Ortho	0.041	mg/L
121400050020-01S	02/13/2008	General Duplicate	Phosphorous, Ortho	0.006	mg/L
121400050020-01S	02/13/2008	General Environmental Sample	Phosphorous, Ortho	0.007	mg/L
121400050020-01S	04/23/2008	General Duplicate	Phosphorous, Ortho	0.057	mg/L
121400050020-01S	04/23/2008	General Environmental Sample	Phosphorous, Ortho	0.058	mg/L
121400050020-01S	07/22/2008	General Duplicate	Phosphorous, Ortho	0.021	mg/L
121400050020-01S	07/22/2008	General Environmental Sample	Phosphorous, Ortho	0.022	mg/L
121400050020-02	10/17/1999	General Environmental Sample	Phosphorous, Ortho	0.073	mg/L
121400050020-02	01/18/2000	General Environmental Sample	Phosphorous, Ortho	0.017	mg/L
121400050020-02	04/25/2000	General Environmental Sample	Phosphorous, Ortho	0.034	mg/L
121400050020-02	07/24/2000	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
121400050020-02	10/14/2002	General Environmental Sample	Phosphorous, Ortho	0.045	mg/L
121400050020-02	01/13/2003	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L
121400050020-02	04/14/2003	General Environmental Sample	Phosphorous, Ortho	0.019	mg/L
121400050020-02	07/14/2003	General Environmental Sample	Phosphorous, Ortho	0.049	mg/L

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121400050020-02	10/25/2004	General Environmental Sample	Phosphorous, Ortho	0.022	mg/L
121400050020-02	01/24/2005	General Environmental Sample	Phosphorous, Ortho	0.075	mg/L
121400050020-02	05/03/2005	General Environmental Sample	Phosphorous, Ortho	0.083	mg/L
121400050020-02	07/25/2005	General Environmental Sample	Phosphorous, Ortho	0.035	mg/L
121400050020-02	10/15/2007	General Environmental Sample	Phosphorous, Ortho	0.033	mg/L
121400050020-02	02/13/2008	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L
121400050020-02	04/23/2008	General Environmental Sample	Phosphorous, Ortho	0.055	mg/L
121400050020-02	07/22/2008	General Environmental Sample	Phosphorous, Ortho	0.045	mg/L
121400050020-03	10/17/1999	General Environmental Sample	Phosphorous, Ortho	0.071	mg/L
121400050020-03	01/18/2000	General Environmental Sample	Phosphorous, Ortho	0.022	mg/L
121400050020-03	04/25/2000	General Environmental Sample	Phosphorous, Ortho	0.038	mg/L
121400050020-03	07/24/2000	General Environmental Sample	Phosphorous, Ortho	0.019	mg/L
121400050020-03	10/14/2002	General Environmental Sample	Phosphorous, Ortho	0.046	mg/L
121400050020-03	01/13/2003	General Environmental Sample	Phosphorous, Ortho	0.015	mg/L
121400050020-03	04/14/2003	General Environmental Sample	Phosphorous, Ortho	0.024	mg/L
121400050020-03	07/14/2003	General Environmental Sample	Phosphorous, Ortho	0.06	mg/L
121400050020-03	10/25/2004	General Environmental Sample	Phosphorous, Ortho	0.033	mg/L
121400050020-03	01/24/2005	General Environmental Sample	Phosphorous, Ortho	0.075	mg/L
121400050020-03	05/03/2005	General Environmental Sample	Phosphorous, Ortho	0.083	mg/L
121400050020-03	07/25/2005	General Environmental Sample	Phosphorous, Ortho	0.042	mg/L
121400050020-03	10/15/2007	General Environmental Sample	Phosphorous, Ortho	0.033	mg/L
121400050020-03	02/13/2008	General Environmental Sample	Phosphorous, Ortho	0.015	mg/L
121400050020-03	04/23/2008	General Environmental Sample	Phosphorous, Ortho	0.049	mg/L
121400050020-03	07/22/2008	General Environmental Sample	Phosphorous, Ortho	0.06	mg/L
121400050020-04	10/17/1999	General Environmental Sample	Phosphorous, Ortho	0.079	mg/L
121400050020-04	01/18/2000	General Environmental Sample	Phosphorous, Ortho	0.035	mg/L
121400050020-04	04/25/2000	General Environmental Sample	Phosphorous, Ortho	0.046	mg/L
121400050020-04	07/24/2000	General Environmental Sample	Phosphorous, Ortho	0.022	mg/L
121400050020-04	10/14/2002	General Environmental Sample	Phosphorous, Ortho	0.05	mg/L
121400050020-04	01/13/2003	General Environmental Sample	Phosphorous, Ortho	0.019	mg/L
121400050020-04	04/14/2003	General Environmental Sample	Phosphorous, Ortho	0.047	mg/L
121400050020-04	07/14/2003	General Environmental Sample	Phosphorous, Ortho	0.078	mg/L
121400050020-04	10/25/2004	General Environmental Sample	Phosphorous, Ortho	0.023	mg/L
121400050020-04	01/24/2005	General Environmental Sample	Phosphorous, Ortho	0.08	mg/L
121400050020-04	05/03/2005	General Environmental Sample	Phosphorous, Ortho	0.078	mg/L
121400050020-04	07/25/2005	General Environmental Sample	Phosphorous, Ortho	0.065	mg/L
121400050020-04	10/15/2007	General Environmental Sample	Phosphorous, Ortho	0.042	mg/L
121400050020-04	02/13/2008	General Environmental Sample	Phosphorous, Ortho	0.027	mg/L
121400050020-04	04/23/2008	General Environmental Sample	Phosphorous, Ortho	0.05	mg/L
121400050020-04	07/22/2008	General Environmental Sample	Phosphorous, Ortho	0.051	mg/L
121400050020-05	10/14/2002	General Environmental Sample	Phosphorous, Ortho	0.044	mg/L
121400050020-05	01/13/2003	General Environmental Sample	Phosphorous, Ortho	0.02	mg/L
121400050020-05	04/14/2003	General Environmental Sample	Phosphorous, Ortho	0.039	mg/L
121400050020-05	07/14/2003	General Environmental Sample	Phosphorous, Ortho	0.068	mg/L
121400050020-05	10/25/2004	General Environmental Sample	Phosphorous, Ortho	0.03	mg/L
121400050020-05	01/24/2005	General Environmental Sample	Phosphorous, Ortho	0.058	mg/L

Lake Copan WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
121400050020-05	05/03/2005	General Environmental Sample	Phosphorous, Ortho	0.087	mg/L
121400050020-05	07/25/2005	General Environmental Sample	Phosphorous, Ortho	0.061	mg/L
121400050020-05	10/15/2007	General Environmental Sample	Phosphorous, Ortho	0.029	mg/L
121400050020-05	02/13/2008	General Environmental Sample	Phosphorous, Ortho	0.029	mg/L
121400050020-05	04/23/2008	General Environmental Sample	Phosphorous, Ortho	0.048	mg/L
121400050020-05	07/22/2008	General Environmental Sample	Phosphorous, Ortho	0.04	mg/L
121400050020-01B	10/17/1999	General Environmental Sample	Phosphorous, Total	0.121	mg/L
121400050020-01B	01/18/2000	General Environmental Sample	Phosphorous, Total	0.052	mg/L
121400050020-01B	04/25/2000	General Environmental Sample	Phosphorous, Total	0.09	mg/L
121400050020-01B	07/24/2000	General Environmental Sample	Phosphorous, Total	0.108	mg/L
121400050020-01B	10/14/2002	General Environmental Sample	Phosphorous, Total	0.073	mg/L
121400050020-01B	01/13/2003	General Environmental Sample	Phosphorous, Total	0.024	mg/L
121400050020-01B	04/14/2003	General Environmental Sample	Phosphorous, Total	0.06	mg/L
121400050020-01B	07/14/2003	General Environmental Sample	Phosphorous, Total	0.07	mg/L
121400050020-01B	10/25/2004	General Environmental Sample	Phosphorous, Total	0.048	mg/L
121400050020-01B	01/24/2005	General Environmental Sample	Phosphorous, Total	0.11	mg/L
121400050020-01S	10/17/1999	General Duplicate	Phosphorous, Total	0.137	mg/L
121400050020-01S	10/17/1999	General Environmental Sample	Phosphorous, Total	0.113	mg/L
121400050020-01S	01/18/2000	General Duplicate	Phosphorous, Total	0.054	mg/L
121400050020-01S	01/18/2000	General Environmental Sample	Phosphorous, Total	0.062	mg/L
121400050020-01S	04/25/2000	General Duplicate	Phosphorous, Total	0.084	mg/L
121400050020-01S	04/25/2000	General Environmental Sample	Phosphorous, Total	0.11	mg/L
121400050020-01S	07/24/2000	General Duplicate	Phosphorous, Total	0.049	mg/L
121400050020-01S	07/24/2000	General Environmental Sample	Phosphorous, Total	0.045	mg/L
121400050020-01S	10/14/2002	General Duplicate	Phosphorous, Total	0.072	mg/L
121400050020-01S	10/14/2002	General Environmental Sample	Phosphorous, Total	0.076	mg/L
121400050020-01S	01/13/2003	General Duplicate	Phosphorous, Total	0.023	mg/L
121400050020-01S	01/13/2003	General Environmental Sample	Phosphorous, Total	0.023	mg/L
121400050020-01S	04/14/2003	General Duplicate	Phosphorous, Total	0.057	mg/L
121400050020-01S	04/14/2003	General Environmental Sample	Phosphorous, Total	0.05	mg/L
121400050020-01S	07/14/2003	General Duplicate	Phosphorous, Total	0.054	mg/L
121400050020-01S	07/14/2003	General Environmental Sample	Phosphorous, Total	0.055	mg/L
121400050020-01S	10/25/2004	General Environmental Sample	Phosphorous, Total	0.065	mg/L
121400050020-01S	01/24/2005	General Duplicate	Phosphorous, Total	0.109	mg/L
121400050020-01S	01/24/2005	General Environmental Sample	Phosphorous, Total	0.105	mg/L
121400050020-01S	05/03/2005	General Duplicate	Phosphorous, Total	0.114	mg/L
121400050020-01S	05/03/2005	General Environmental Sample	Phosphorous, Total	0.111	mg/L
121400050020-01S	07/25/2005	General Environmental Sample	Phosphorous, Total	0.058	mg/L
121400050020-01S	10/15/2007	General Duplicate	Phosphorous, Total	0.073	mg/L
121400050020-01S	10/15/2007	General Environmental Sample	Phosphorous, Total	0.069	mg/L
121400050020-01S	02/13/2008	General Duplicate	Phosphorous, Total	0.033	mg/L
121400050020-01S	02/13/2008	General Environmental Sample	Phosphorous, Total	0.034	mg/L
121400050020-01S	04/23/2008	General Duplicate	Phosphorous, Total	0.125	mg/L
121400050020-01S	04/23/2008	General Environmental Sample	Phosphorous, Total	0.116	mg/L
121400050020-01S	07/22/2008	General Duplicate	Phosphorous, Total	0.044	mg/L
121400050020-01S	07/22/2008	General Environmental Sample	Phosphorous, Total	0.045	mg/L

Lake Copan WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
121400050020-01S	10/15/2012	Churn Duplicate	Phosphorous, Total	0.096	mg/L
121400050020-01S	10/15/2012	Environmental Churn Duplicate	Phosphorous, Total	0.095	mg/L
121400050020-02	10/17/1999	General Environmental Sample	Phosphorous, Total	0.106	mg/L
121400050020-02	01/18/2000	General Environmental Sample	Phosphorous, Total	0.059	mg/L
121400050020-02	04/25/2000	General Environmental Sample	Phosphorous, Total	0.095	mg/L
121400050020-02	07/24/2000	General Environmental Sample	Phosphorous, Total	0.067	mg/L
121400050020-02	10/14/2002	General Environmental Sample	Phosphorous, Total	0.08	mg/L
121400050020-02	01/13/2003	General Environmental Sample	Phosphorous, Total	0.026	mg/L
121400050020-02	04/14/2003	General Environmental Sample	Phosphorous, Total	0.05	mg/L
121400050020-02	07/14/2003	General Environmental Sample	Phosphorous, Total	0.107	mg/L
121400050020-02	10/25/2004	General Environmental Sample	Phosphorous, Total	0.054	mg/L
121400050020-02	01/24/2005	General Environmental Sample	Phosphorous, Total	0.112	mg/L
121400050020-02	05/03/2005	General Environmental Sample	Phosphorous, Total	0.111	mg/L
121400050020-02	07/25/2005	General Environmental Sample	Phosphorous, Total	0.078	mg/L
121400050020-02	10/15/2007	General Environmental Sample	Phosphorous, Total	0.081	mg/L
121400050020-02	02/13/2008	General Environmental Sample	Phosphorous, Total	0.048	mg/L
121400050020-02	04/23/2008	General Environmental Sample	Phosphorous, Total	0.108	mg/L
121400050020-02	07/22/2008	General Environmental Sample	Phosphorous, Total	0.11	mg/L
121400050020-02	10/15/2012	General Environmental Sample	Phosphorous, Total	0.101	mg/L
121400050020-03	10/17/1999	General Environmental Sample	Phosphorous, Total	0.136	mg/L
121400050020-03	01/18/2000	General Environmental Sample	Phosphorous, Total	0.086	mg/L
121400050020-03	04/25/2000	General Environmental Sample	Phosphorous, Total	0.114	mg/L
121400050020-03	07/24/2000	General Environmental Sample	Phosphorous, Total	0.068	mg/L
121400050020-03	10/14/2002	General Environmental Sample	Phosphorous, Total	0.079	mg/L
121400050020-03	01/13/2003	General Environmental Sample	Phosphorous, Total	0.027	mg/L
121400050020-03	04/14/2003	General Environmental Sample	Phosphorous, Total	0.06	mg/L
121400050020-03	07/14/2003	General Environmental Sample	Phosphorous, Total	0.182	mg/L
121400050020-03	10/25/2004	General Environmental Sample	Phosphorous, Total	0.051	mg/L
121400050020-03	01/24/2005	General Environmental Sample	Phosphorous, Total	0.112	mg/L
121400050020-03	05/03/2005	General Environmental Sample	Phosphorous, Total	0.113	mg/L
121400050020-03	07/25/2005	General Environmental Sample	Phosphorous, Total	0.088	mg/L
121400050020-03	10/15/2007	General Environmental Sample	Phosphorous, Total	0.073	mg/L
121400050020-03	02/13/2008	General Environmental Sample	Phosphorous, Total	0.056	mg/L
121400050020-03	04/23/2008	General Environmental Sample	Phosphorous, Total	0.11	mg/L
121400050020-03	07/22/2008	General Environmental Sample	Phosphorous, Total	0.16	mg/L
121400050020-03	10/15/2012	General Environmental Sample	Phosphorous, Total	0.105	mg/L
121400050020-04	10/17/1999	General Environmental Sample	Phosphorous, Total	0.162	mg/L
121400050020-04	01/18/2000	General Environmental Sample	Phosphorous, Total	0.093	mg/L
121400050020-04	04/25/2000	General Environmental Sample	Phosphorous, Total	0.113	mg/L
121400050020-04	07/24/2000	General Environmental Sample	Phosphorous, Total	0.079	mg/L
121400050020-04	10/14/2002	General Environmental Sample	Phosphorous, Total	0.12	mg/L
121400050020-04	01/13/2003	General Environmental Sample	Phosphorous, Total	0.03	mg/L
121400050020-04	04/14/2003	General Environmental Sample	Phosphorous, Total	0.092	mg/L
121400050020-04	07/14/2003	General Environmental Sample	Phosphorous, Total	0.184	mg/L
121400050020-04	10/25/2004	General Environmental Sample	Phosphorous, Total	0.056	mg/L
121400050020-04	01/24/2005	General Environmental Sample	Phosphorous, Total	0.117	mg/L

Lake Copan WQM Station	Date	QA Category (OWRB)	Parameter	Value	Units
121400050020-04	05/03/2005	General Environmental Sample	Phosphorous, Total	0.132	mg/L
121400050020-04	07/25/2005	General Environmental Sample	Phosphorous, Total	0.124	mg/L
121400050020-04	10/15/2007	General Environmental Sample	Phosphorous, Total	0.102	mg/L
121400050020-04	02/13/2008	General Environmental Sample	Phosphorous, Total	0.083	mg/L
121400050020-04	04/23/2008	General Environmental Sample	Phosphorous, Total	0.106	mg/L
121400050020-04	07/22/2008	General Environmental Sample	Phosphorous, Total	0.112	mg/L
121400050020-04	10/15/2012	General Environmental Sample	Phosphorous, Total	0.138	mg/L
121400050020-05	10/14/2002	General Environmental Sample	Phosphorous, Total	0.104	mg/L
121400050020-05	01/13/2003	General Environmental Sample	Phosphorous, Total	0.033	mg/L
121400050020-05	04/14/2003	General Environmental Sample	Phosphorous, Total	0.076	mg/L
121400050020-05	07/14/2003	General Environmental Sample	Phosphorous, Total	0.141	mg/L
121400050020-05	10/25/2004	General Environmental Sample	Phosphorous, Total	0.055	mg/L
121400050020-05	01/24/2005	General Environmental Sample	Phosphorous, Total	0.07	mg/L
121400050020-05	05/03/2005	General Environmental Sample	Phosphorous, Total	0.123	mg/L
121400050020-05	07/25/2005	General Environmental Sample	Phosphorous, Total	0.114	mg/L
121400050020-05	10/15/2007	General Environmental Sample	Phosphorous, Total	0.127	mg/L
121400050020-05	02/13/2008	General Environmental Sample	Phosphorous, Total	0.086	mg/L
121400050020-05	04/23/2008	General Environmental Sample	Phosphorous, Total	0.092	mg/L
121400050020-05	07/22/2008	General Environmental Sample	Phosphorous, Total	0.1	mg/L
121400050020-05	10/15/2012	General Environmental Sample	Phosphorous, Total	0.123	mg/L
121400050020-01B	10/17/1999	General Environmental Sample	Solids, Suspended	44	mg/L
121400050020-01B	01/18/2000	General Environmental Sample	Solids, Suspended	11	mg/L
121400050020-01B	04/25/2000	General Environmental Sample	Solids, Suspended	36	mg/L
121400050020-01B	07/24/2000	General Environmental Sample	Solids, Suspended	308	mg/L
121400050020-01S	10/17/1999	General Duplicate	Solids, Suspended	36	mg/L
121400050020-01S	10/17/1999	General Environmental Sample	Solids, Suspended	40	mg/L
121400050020-01S	01/18/2000	General Duplicate	Solids, Suspended	11	mg/L
121400050020-01S	01/18/2000	General Environmental Sample	Solids, Suspended	11	mg/L
121400050020-01S	04/25/2000	General Duplicate	Solids, Suspended	600	mg/L
121400050020-01S	04/25/2000	General Environmental Sample	Solids, Suspended	25	mg/L
121400050020-01S	07/24/2000	General Duplicate	Solids, Suspended	302	mg/L
121400050020-01S	07/24/2000	General Environmental Sample	Solids, Suspended	316	mg/L
121400050020-02	10/17/1999	General Environmental Sample	Solids, Suspended	34	mg/L
121400050020-02	01/18/2000	General Environmental Sample	Solids, Suspended	12	mg/L
121400050020-02	04/25/2000	General Environmental Sample	Solids, Suspended	33	mg/L
121400050020-02	07/24/2000	General Environmental Sample	Solids, Suspended	360	mg/L
121400050020-03	10/17/1999	General Environmental Sample	Solids, Suspended	42	mg/L
121400050020-03	01/18/2000	General Environmental Sample	Solids, Suspended	22	mg/L
121400050020-03	04/25/2000	General Environmental Sample	Solids, Suspended	40	mg/L
121400050020-03	07/24/2000	General Environmental Sample	Solids, Suspended	304	mg/L
121400050020-04	10/17/1999	General Environmental Sample	Solids, Suspended	50	mg/L
121400050020-04	01/18/2000	General Environmental Sample	Solids, Suspended	34	mg/L
121400050020-04	04/25/2000	General Environmental Sample	Solids, Suspended	41	mg/L
121400050020-04	07/24/2000	General Environmental Sample	Solids, Suspended	352	mg/L

Table Appendix B-2: Ambient Water Quality Data for Lake Claremore, 2001-2010

Lake Claremore WQM Station	Date	QA Category	Parameter	Value	Units
121500040020-01B	03/01/2004	General Environmental Sample	Corrected Chlorophyll-*a*	14.5	mg/m^3
121500040020-01B	06/01/2004	General Environmental Sample	Corrected Chlorophyll-*a*	23.8	mg/m^3
121500040020-01B	11/29/2005	General Environmental Sample	Corrected Chlorophyll-*a*	49	mg/m^3
121500040020-01B	05/30/2006	General Environmental Sample	Corrected Chlorophyll-*a*	41.05	mg/m^3
121500040020-01B	08/31/2006	General Environmental Sample	Corrected Chlorophyll-*a*	54.5	mg/m^3
121500040020-01S	09/02/2003	General Duplicate	Corrected Chlorophyll-*a*	12.9	mg/m^3
121500040020-01S	09/02/2003	General Environmental Sample	Corrected Chlorophyll-*a*	25.7	mg/m^3
121500040020-01S	09/02/2003	General Environmental Sample	Corrected Chlorophyll-*a*	22.3	mg/m^3
121500040020-01S	12/01/2003	General Duplicate	Corrected Chlorophyll-*a*	23.8	mg/m^3
121500040020-01S	03/01/2004	General Duplicate	Corrected Chlorophyll-*a*	10.4	mg/m^3
121500040020-01S	03/01/2004	General Environmental Sample	Corrected Chlorophyll-*a*	15.2	mg/m^3
121500040020-01S	06/01/2004	General Duplicate	Corrected Chlorophyll-*a*	27.2	mg/m^3
121500040020-01S	06/01/2004	General Environmental Sample	Corrected Chlorophyll-*a*	24.6	mg/m^3
121500040020-01S	11/29/2005	General Duplicate	Corrected Chlorophyll-*a*	37	mg/m^3
121500040020-01S	11/29/2005	General Environmental Sample	Corrected Chlorophyll-*a*	30	mg/m^3
121500040020-01S	05/30/2006	General Duplicate	Corrected Chlorophyll-*a*	40.29	mg/m^3
121500040020-01S	05/30/2006	General Environmental Sample	Corrected Chlorophyll-*a*	45.8	mg/m^3
121500040020-01S	08/31/2006	General Duplicate	Corrected Chlorophyll-*a*	47.4	mg/m^3
121500040020-01S	08/31/2006	General Environmental Sample	Corrected Chlorophyll-*a*	49.9	mg/m^3
121500040020-01S	12/01/2009	Churn Duplicate	Corrected Chlorophyll-*a*	25.2	mg/m^3
121500040020-01S	12/01/2009	Environmental Churn Duplicate	Corrected Chlorophyll-*a*	25.3	mg/m^3
121500040020-01S	05/25/2010	Churn Duplicate	Corrected Chlorophyll-*a*	11.7	mg/m^3
121500040020-01S	05/25/2010	Environmental Churn Duplicate	Corrected Chlorophyll-*a*	12.7	mg/m^3
121500040020-01S	08/17/2010	Churn Duplicate	Corrected Chlorophyll-*a*	63.5	mg/m^3
121500040020-01S	08/17/2010	Environmental Churn Duplicate	Corrected Chlorophyll-*a*	62.9	mg/m^3
121500040020-02	09/02/2003	General Environmental Sample	Corrected Chlorophyll-*a*	32.3	mg/m^3
121500040020-02	12/01/2003	General Environmental Sample	Corrected Chlorophyll-*a*	22.3	mg/m^3
121500040020-02	03/01/2004	General Environmental Sample	Corrected Chlorophyll-*a*	7.8	mg/m^3
121500040020-02	06/01/2004	General Environmental Sample	Corrected Chlorophyll-*a*	32.3	mg/m^3
121500040020-02	11/29/2005	General Environmental Sample	Corrected Chlorophyll-*a*	28	mg/m^3
121500040020-02	05/30/2006	General Environmental Sample	Corrected Chlorophyll-*a*	45.98	mg/m^3
121500040020-02	08/31/2006	General Environmental Sample	Corrected Chlorophyll-*a*	48.8	mg/m^3
121500040020-02	12/01/2009	General Environmental Sample	Corrected Chlorophyll-*a*	22	mg/m^3
121500040020-02	05/25/2010	General Environmental Sample	Corrected Chlorophyll-*a*	19.6	mg/m^3
121500040020-02	08/17/2010	General Environmental Sample	Corrected Chlorophyll-*a*	59.6	mg/m^3
121500040020-03	09/02/2003	General Environmental Sample	Corrected Chlorophyll-*a*	32.1	mg/m^3
121500040020-03	12/01/2003	General Environmental Sample	Corrected Chlorophyll-*a*	23.3	mg/m^3
121500040020-03	06/01/2004	General Environmental Sample	Corrected Chlorophyll-*a*	23.5	mg/m^3
121500040020-03	11/29/2005	General Environmental Sample	Corrected Chlorophyll-*a*	23	mg/m^3
121500040020-03	05/30/2006	General Environmental Sample	Corrected Chlorophyll-*a*	46.26	mg/m^3
121500040020-03	08/31/2006	General Environmental Sample	Corrected Chlorophyll-*a*	51	mg/m^3
121500040020-03	12/01/2009	General Environmental Sample	Corrected Chlorophyll-*a*	14.8	mg/m^3
121500040020-03	05/25/2010	General Environmental Sample	Corrected Chlorophyll-*a*	25.3	mg/m^3

Lake Claremore WQM Station	Date	QA Category	Parameter	Value	Units
121500040020-03	08/17/2010	General Environmental Sample	Corrected Chlorophyll-*a*	56.3	mg/m^3
121500040020-04	09/02/2003	General Environmental Sample	Corrected Chlorophyll-*a*	13.6	mg/m^3
121500040020-04	12/01/2003	General Environmental Sample	Corrected Chlorophyll-*a*	22.9	mg/m^3
121500040020-04	03/01/2004	General Environmental Sample	Corrected Chlorophyll-*a*	9.8	mg/m^3
121500040020-04	06/01/2004	General Environmental Sample	Corrected Chlorophyll-*a*	26.3	mg/m^3
121500040020-04	11/29/2005	General Environmental Sample	Corrected Chlorophyll-*a*	32	mg/m^3
121500040020-04	05/30/2006	General Environmental Sample	Corrected Chlorophyll-*a*	39.64	mg/m^3
121500040020-04	08/31/2006	General Environmental Sample	Corrected Chlorophyll-*a*	36.9	mg/m^3
121500040020-05	09/02/2003	General Environmental Sample	Corrected Chlorophyll-*a*	23.9	mg/m^3
121500040020-05	12/01/2003	General Environmental Sample	Corrected Chlorophyll-*a*	20.1	mg/m^3
121500040020-05	03/01/2004	General Environmental Sample	Corrected Chlorophyll-*a*	9.7	mg/m^3
121500040020-05	06/01/2004	General Environmental Sample	Corrected Chlorophyll-*a*	36.8	mg/m^3
121500040020-05	11/29/2005	General Environmental Sample	Corrected Chlorophyll-*a*	27	mg/m^3
121500040020-05	05/30/2006	General Environmental Sample	Corrected Chlorophyll-*a*	40.03	mg/m^3
121500040020-05	08/31/2006	General Environmental Sample	Corrected Chlorophyll-*a*	54.7	mg/m^3
121500040020-01B	01/02/2002	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-01B	04/01/2002	General Environmental Sample	Nitrogen, Ammonia	0.09	mg/L
121500040020-01B	07/01/2002	General Environmental Sample	Nitrogen, Ammonia	0.2	mg/L
121500040020-01B	09/02/2003	General Environmental Sample	Nitrogen, Ammonia	0.2	mg/L
121500040020-01B	12/01/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-01B	03/01/2004	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-01B	06/01/2004	General Environmental Sample	Nitrogen, Ammonia	0.43	mg/L
121500040020-01S	01/02/2002	General Duplicate	Nitrogen, Ammonia	<0.05	mg/L
121500040020-01S	01/02/2002	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-01S	04/01/2002	General Duplicate	Nitrogen, Ammonia	0.09	mg/L
121500040020-01S	04/01/2002	General Environmental Sample	Nitrogen, Ammonia	0.09	mg/L
121500040020-01S	07/01/2002	General Duplicate	Nitrogen, Ammonia	<0.05	mg/L
121500040020-01S	07/01/2002	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-01S	09/02/2003	General Duplicate	Nitrogen, Ammonia	0.21	mg/L
121500040020-01S	09/02/2003	General Environmental Sample	Nitrogen, Ammonia	0.21	mg/L
121500040020-01S	12/01/2003	General Duplicate	Nitrogen, Ammonia	<0.05	mg/L
121500040020-01S	12/01/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-01S	03/01/2004	General Duplicate	Nitrogen, Ammonia	<0.05	mg/L
121500040020-01S	03/01/2004	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-01S	06/01/2004	General Duplicate	Nitrogen, Ammonia	0.06	mg/L
121500040020-01S	06/01/2004	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
121500040020-02	01/02/2002	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-02	04/01/2002	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
121500040020-02	07/01/2002	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-02	09/02/2003	General Environmental Sample	Nitrogen, Ammonia	0.12	mg/L
121500040020-02	12/01/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-02	03/01/2004	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-02	06/01/2004	General Environmental Sample	Nitrogen, Ammonia	0.05	mg/L
121500040020-03	04/01/2002	General Environmental Sample	Nitrogen, Ammonia	0.11	mg/L

Lake Claremore WQM Station	Date	QA Category	Parameter	Value	Units
121500040020-03	07/01/2002	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-03	09/02/2003	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
121500040020-03	12/01/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-03	03/01/2004	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-03	06/01/2004	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-04	09/02/2003	General Environmental Sample	Nitrogen, Ammonia	0.22	mg/L
121500040020-04	12/01/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-04	03/01/2004	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-04	06/01/2004	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
121500040020-05	09/02/2003	General Environmental Sample	Nitrogen, Ammonia	0.06	mg/L
121500040020-05	12/01/2003	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-05	03/01/2004	General Environmental Sample	Nitrogen, Ammonia	<0.05	mg/L
121500040020-05	06/01/2004	General Environmental Sample	Nitrogen, Ammonia	0.05	mg/L
121500040020-01B	10/01/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.95	mg/L
121500040020-01B	01/02/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.68	mg/L
121500040020-01B	04/01/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.62	mg/L
121500040020-01B	07/01/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.92	mg/L
121500040020-01B	09/02/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.83	mg/L
121500040020-01B	12/01/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.82	mg/L
121500040020-01B	03/01/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.83	mg/L
121500040020-01B	06/01/2004	General Environmental Sample	Nitrogen, Kjeldahl	1.18	mg/L
121500040020-01S	10/01/2001	General Duplicate	Nitrogen, Kjeldahl	0.91	mg/L
121500040020-01S	10/01/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.96	mg/L
121500040020-01S	01/02/2002	General Duplicate	Nitrogen, Kjeldahl	0.68	mg/L
121500040020-01S	01/02/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.61	mg/L
121500040020-01S	04/01/2002	General Duplicate	Nitrogen, Kjeldahl	0.79	mg/L
121500040020-01S	04/01/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.65	mg/L
121500040020-01S	07/01/2002	General Duplicate	Nitrogen, Kjeldahl	0.78	mg/L
121500040020-01S	07/01/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.83	mg/L
121500040020-01S	09/02/2003	General Duplicate	Nitrogen, Kjeldahl	0.83	mg/L
121500040020-01S	09/02/2003	General Environmental Sample	Nitrogen, Kjeldahl	1.08	mg/L
121500040020-01S	12/01/2003	General Duplicate	Nitrogen, Kjeldahl	0.89	mg/L
121500040020-01S	12/01/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.78	mg/L
121500040020-01S	03/01/2004	General Duplicate	Nitrogen, Kjeldahl	0.88	mg/L
121500040020-01S	03/01/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.73	mg/L
121500040020-01S	06/01/2004	General Duplicate	Nitrogen, Kjeldahl	0.84	mg/L
121500040020-01S	06/01/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.77	mg/L
121500040020-01S	11/29/2005	General Duplicate	Nitrogen, Kjeldahl	0.97	mg/L
121500040020-01S	11/29/2005	General Environmental Sample	Nitrogen, Kjeldahl	1.07	mg/L
121500040020-01S	05/30/2006	General Duplicate	Nitrogen, Kjeldahl	0.92	mg/L
121500040020-01S	05/30/2006	General Environmental Sample	Nitrogen, Kjeldahl	0.95	mg/L
121500040020-01S	08/30/2006	General Duplicate	Nitrogen, Kjeldahl	1.53	mg/L
121500040020-01S	08/30/2006	General Environmental Sample	Nitrogen, Kjeldahl	1.62	mg/L
121500040020-01S	12/01/2009	Churn Duplicate	Nitrogen, Kjeldahl	0.62	mg/L
121500040020-01S	12/01/2009	Environmental Churn Duplicate	Nitrogen, Kjeldahl	0.66	mg/L

Lake Claremore WQM Station	Date	QA Category	Parameter	Value	Units
121500040020-01S	08/17/2010	Churn Duplicate	Nitrogen, Kjeldahl	1.34	mg/L
121500040020-01S	08/17/2010	Environmental Churn Duplicate	Nitrogen, Kjeldahl	1.36	mg/L
121500040020-02	10/01/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.88	mg/L
121500040020-02	01/02/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.6	mg/L
121500040020-02	04/01/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.71	mg/L
121500040020-02	07/01/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.81	mg/L
121500040020-02	09/02/2003	General Environmental Sample	Nitrogen, Kjeldahl	1.32	mg/L
121500040020-02	12/01/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.86	mg/L
121500040020-02	03/01/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.79	mg/L
121500040020-02	06/01/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.93	mg/L
121500040020-02	11/29/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.91	mg/L
121500040020-02	05/30/2006	General Environmental Sample	Nitrogen, Kjeldahl	1	mg/L
121500040020-02	08/30/2006	General Environmental Sample	Nitrogen, Kjeldahl	1.59	mg/L
121500040020-02	12/01/2009	General Environmental Sample	Nitrogen, Kjeldahl	0.66	mg/L
121500040020-02	08/17/2010	General Environmental Sample	Nitrogen, Kjeldahl	1.24	mg/L
121500040020-03	10/01/2001	General Environmental Sample	Nitrogen, Kjeldahl	0.92	mg/L
121500040020-03	04/01/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.7	mg/L
121500040020-03	07/01/2002	General Environmental Sample	Nitrogen, Kjeldahl	0.86	mg/L
121500040020-03	09/02/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.67	mg/L
121500040020-03	12/01/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.9	mg/L
121500040020-03	03/01/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.74	mg/L
121500040020-03	06/01/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.95	mg/L
121500040020-03	11/29/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.92	mg/L
121500040020-03	05/30/2006	General Environmental Sample	Nitrogen, Kjeldahl	0.99	mg/L
121500040020-03	08/30/2006	General Environmental Sample	Nitrogen, Kjeldahl	2	mg/L
121500040020-03	12/01/2009	General Environmental Sample	Nitrogen, Kjeldahl	0.58	mg/L
121500040020-03	08/17/2010	General Environmental Sample	Nitrogen, Kjeldahl	1.35	mg/L
121500040020-04	09/02/2003	General Environmental Sample	Nitrogen, Kjeldahl	1.25	mg/L
121500040020-04	12/01/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.88	mg/L
121500040020-04	03/01/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.85	mg/L
121500040020-04	06/01/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.82	mg/L
121500040020-04	11/29/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.95	mg/L
121500040020-04	05/30/2006	General Environmental Sample	Nitrogen, Kjeldahl	0.92	mg/L
121500040020-04	08/30/2006	General Environmental Sample	Nitrogen, Kjeldahl	1.69	mg/L
121500040020-05	09/02/2003	General Environmental Sample	Nitrogen, Kjeldahl	1.21	mg/L
121500040020-05	12/01/2003	General Environmental Sample	Nitrogen, Kjeldahl	0.85	mg/L
121500040020-05	03/01/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.72	mg/L
121500040020-05	06/01/2004	General Environmental Sample	Nitrogen, Kjeldahl	0.94	mg/L
121500040020-05	11/29/2005	General Environmental Sample	Nitrogen, Kjeldahl	0.83	mg/L
121500040020-05	05/30/2006	General Environmental Sample	Nitrogen, Kjeldahl	0.93	mg/L
121500040020-05	08/30/2006	General Environmental Sample	Nitrogen, Kjeldahl	1.83	mg/L
121500040020-01B	10/01/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01B	01/02/2002	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01B	04/01/2002	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01B	07/01/2002	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L

Lake Claremore WQM Station	Date	QA Category	Parameter	Value	Units
121500040020-01B	09/02/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.05	mg/L
121500040020-01B	12/01/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01B	03/01/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01B	06/01/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	10/01/2001	General Duplicate	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	10/01/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	01/02/2002	General Duplicate	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	01/02/2002	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	04/01/2002	General Duplicate	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	04/01/2002	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	07/01/2002	General Duplicate	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	07/01/2002	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	09/02/2003	General Duplicate	Nitrogen, Nitrate as N	0.07	mg/L
121500040020-01S	09/02/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.05	mg/L
121500040020-01S	12/01/2003	General Duplicate	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	12/01/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	03/01/2004	General Duplicate	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	03/01/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	06/01/2004	General Duplicate	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	06/01/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-02	10/01/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-02	01/02/2002	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-02	04/01/2002	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-02	07/01/2002	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-02	09/02/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.06	mg/L
121500040020-02	12/01/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-02	03/01/2004	General Environmental Sample	Nitrogen, Nitrate as N	0.06	mg/L
121500040020-02	06/01/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-03	10/01/2001	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-03	04/01/2002	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-03	07/01/2002	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-03	09/02/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.12	mg/L
121500040020-03	12/01/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-03	03/01/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-03	06/01/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-04	09/02/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.07	mg/L
121500040020-04	12/01/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-04	03/01/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-04	06/01/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-05	09/02/2003	General Environmental Sample	Nitrogen, Nitrate as N	0.09	mg/L
121500040020-05	12/01/2003	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-05	03/01/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-05	06/01/2004	General Environmental Sample	Nitrogen, Nitrate as N	<0.05	mg/L
121500040020-01S	11/29/2005	General Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-01S	11/29/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L

Lake Claremore WQM Station	Date	QA Category	Parameter	Value	Units
121500040020-01S	05/30/2006	General Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-01S	05/30/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-01S	08/30/2006	General Duplicate	Nitrogen, Nitrate/Nitrite as N	0.07	mg/L
121500040020-01S	08/30/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.07	mg/L
121500040020-01S	12/01/2009	Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-01S	12/01/2009	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-01S	08/17/2010	Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-01S	08/17/2010	Environmental Churn Duplicate	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-02	11/29/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-02	05/30/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-02	08/30/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.05	mg/L
121500040020-02	12/01/2009	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-02	08/17/2010	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-03	11/29/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-03	05/30/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-03	08/30/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-03	12/01/2009	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-03	08/17/2010	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-04	11/29/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-04	05/30/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-04	08/30/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	0.07	mg/L
121500040020-05	11/29/2005	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-05	05/30/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-05	08/30/2006	General Environmental Sample	Nitrogen, Nitrate/Nitrite as N	<0.05	mg/L
121500040020-01B	10/01/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01B	01/02/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01B	04/01/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01B	07/01/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01B	09/02/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01B	12/01/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01B	03/01/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01B	06/01/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	10/01/2001	General Duplicate	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	10/01/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	01/02/2002	General Duplicate	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	01/02/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	04/01/2002	General Duplicate	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	04/01/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	07/01/2002	General Duplicate	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	07/01/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	09/02/2003	General Duplicate	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	09/02/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	12/01/2003	General Duplicate	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	12/01/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	03/01/2004	General Duplicate	Nitrogen, Nitrite as N	<0.05	mg/L

Lake Claremore WQM Station	Date	QA Category	Parameter	Value	Units
121500040020-01S	03/01/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	06/01/2004	General Duplicate	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01S	06/01/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-02	10/01/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-02	01/02/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-02	04/01/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-02	07/01/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-02	09/02/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-02	12/01/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-02	03/01/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-02	06/01/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-03	10/01/2001	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-03	04/01/2002	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-03	07/01/2002	General Environmental Sample	Nitrogen, Nitrite as N	0.09	mg/L
121500040020-03	09/02/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-03	12/01/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-03	03/01/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-03	06/01/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-04	09/02/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-04	12/01/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-04	03/01/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-04	06/01/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-05	09/02/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-05	12/01/2003	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-05	03/01/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-05	06/01/2004	General Environmental Sample	Nitrogen, Nitrite as N	<0.05	mg/L
121500040020-01B	10/01/2001	General Environmental Sample	Phosphorous, Ortho	0.023	mg/L
121500040020-01B	01/02/2002	General Environmental Sample	Phosphorous, Ortho	0.006	mg/L
121500040020-01B	04/01/2002	General Environmental Sample	Phosphorous, Ortho	0.01	mg/L
121500040020-01B	07/01/2002	General Environmental Sample	Phosphorous, Ortho	0.032	mg/L
121500040020-01B	09/02/2003	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L
121500040020-01B	12/01/2003	General Environmental Sample	Phosphorous, Ortho	0.02	mg/L
121500040020-01B	03/01/2004	General Environmental Sample	Phosphorous, Ortho	0.01	mg/L
121500040020-01B	06/01/2004	General Environmental Sample	Phosphorous, Ortho	0.023	mg/L
121500040020-01S	10/01/2001	General Duplicate	Phosphorous, Ortho	0.019	mg/L
121500040020-01S	10/01/2001	General Environmental Sample	Phosphorous, Ortho	0.019	mg/L
121500040020-01S	01/02/2002	General Duplicate	Phosphorous, Ortho	0.007	mg/L
121500040020-01S	01/02/2002	General Environmental Sample	Phosphorous, Ortho	0.008	mg/L
121500040020-01S	04/01/2002	General Duplicate	Phosphorous, Ortho	0.009	mg/L
121500040020-01S	04/01/2002	General Environmental Sample	Phosphorous, Ortho	0.009	mg/L
121500040020-01S	07/01/2002	General Duplicate	Phosphorous, Ortho	0.006	mg/L
121500040020-01S	07/01/2002	General Environmental Sample	Phosphorous, Ortho	0.006	mg/L
121500040020-01S	09/02/2003	General Duplicate	Phosphorous, Ortho	0.012	mg/L
121500040020-01S	09/02/2003	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L

Lake Claremore WQM Station	Date	QA Category	Parameter	Value	Units
121500040020-01S	12/01/2003	General Duplicate	Phosphorous, Ortho	0.016	mg/L
121500040020-01S	12/01/2003	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
121500040020-01S	03/01/2004	General Duplicate	Phosphorous, Ortho	0.01	mg/L
121500040020-01S	03/01/2004	General Environmental Sample	Phosphorous, Ortho	0.009	mg/L
121500040020-01S	06/01/2004	General Duplicate	Phosphorous, Ortho	0.015	mg/L
121500040020-01S	06/01/2004	General Environmental Sample	Phosphorous, Ortho	0.015	mg/L
121500040020-01S	11/29/2005	General Duplicate	Phosphorous, Ortho	0.019	mg/L
121500040020-01S	11/29/2005	General Environmental Sample	Phosphorous, Ortho	0.019	mg/L
121500040020-01S	05/30/2006	General Duplicate	Phosphorous, Ortho	0.008	mg/L
121500040020-01S	05/30/2006	General Environmental Sample	Phosphorous, Ortho	0.007	mg/L
121500040020-01S	08/30/2006	General Duplicate	Phosphorous, Ortho	0.012	mg/L
121500040020-01S	08/30/2006	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
121500040020-02	10/01/2001	General Environmental Sample	Phosphorous, Ortho	0.019	mg/L
121500040020-02	01/02/2002	General Environmental Sample	Phosphorous, Ortho	0.007	mg/L
121500040020-02	04/01/2002	General Environmental Sample	Phosphorous, Ortho	0.007	mg/L
121500040020-02	07/01/2002	General Environmental Sample	Phosphorous, Ortho	0.007	mg/L
121500040020-02	09/02/2003	General Environmental Sample	Phosphorous, Ortho	0.013	mg/L
121500040020-02	12/01/2003	General Environmental Sample	Phosphorous, Ortho	0.017	mg/L
121500040020-02	03/01/2004	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
121500040020-02	06/01/2004	General Environmental Sample	Phosphorous, Ortho	0.017	mg/L
121500040020-02	11/29/2005	General Environmental Sample	Phosphorous, Ortho	0.019	mg/L
121500040020-02	05/30/2006	General Environmental Sample	Phosphorous, Ortho	0.009	mg/L
121500040020-02	08/30/2006	General Environmental Sample	Phosphorous, Ortho	0.017	mg/L
121500040020-03	10/01/2001	General Environmental Sample	Phosphorous, Ortho	0.022	mg/L
121500040020-03	04/01/2002	General Environmental Sample	Phosphorous, Ortho	0.008	mg/L
121500040020-03	07/01/2002	General Environmental Sample	Phosphorous, Ortho	0.01	mg/L
121500040020-03	09/02/2003	General Environmental Sample	Phosphorous, Ortho	0.014	mg/L
121500040020-03	12/01/2003	General Environmental Sample	Phosphorous, Ortho	0.019	mg/L
121500040020-03	03/01/2004	General Environmental Sample	Phosphorous, Ortho	0.013	mg/L
121500040020-03	06/01/2004	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
121500040020-03	11/29/2005	General Environmental Sample	Phosphorous, Ortho	0.02	mg/L
121500040020-03	05/30/2006	General Environmental Sample	Phosphorous, Ortho	0.01	mg/L
121500040020-03	08/30/2006	General Environmental Sample	Phosphorous, Ortho	0.025	mg/L
121500040020-04	09/02/2003	General Environmental Sample	Phosphorous, Ortho	0.011	mg/L
121500040020-04	12/01/2003	General Environmental Sample	Phosphorous, Ortho	0.016	mg/L
121500040020-04	03/01/2004	General Environmental Sample	Phosphorous, Ortho	0.009	mg/L
121500040020-04	06/01/2004	General Environmental Sample	Phosphorous, Ortho	0.015	mg/L
121500040020-04	11/29/2005	General Environmental Sample	Phosphorous, Ortho	0.017	mg/L
121500040020-04	05/30/2006	General Environmental Sample	Phosphorous, Ortho	0.008	mg/L
121500040020-04	08/30/2006	General Environmental Sample	Phosphorous, Ortho	0.013	mg/L
121500040020-05	09/02/2003	General Environmental Sample	Phosphorous, Ortho	0.014	mg/L
121500040020-05	12/01/2003	General Environmental Sample	Phosphorous, Ortho	0.019	mg/L
121500040020-05	03/01/2004	General Environmental Sample	Phosphorous, Ortho	0.012	mg/L
121500040020-05	06/01/2004	General Environmental Sample	Phosphorous, Ortho	0.018	mg/L
121500040020-05	11/29/2005	General Environmental Sample	Phosphorous, Ortho	0.023	mg/L

Lake Claremore WQM Station	Date	QA Category	Parameter	Value	Units
121500040020-05	05/30/2006	General Environmental Sample	Phosphorous, Ortho	0.008	mg/L
121500040020-05	08/30/2006	General Environmental Sample	Phosphorous, Ortho	0.02	mg/L
121500040020-01B	10/01/2001	General Environmental Sample	Phosphorous, Total	0.139	mg/L
121500040020-01B	01/02/2002	General Environmental Sample	Phosphorous, Total	0.05	mg/L
121500040020-01B	04/01/2002	General Environmental Sample	Phosphorous, Total	0.056	mg/L
121500040020-01B	07/01/2002	General Environmental Sample	Phosphorous, Total	0.173	mg/L
121500040020-01B	09/02/2003	General Environmental Sample	Phosphorous, Total	0.085	mg/L
121500040020-01B	12/01/2003	General Environmental Sample	Phosphorous, Total	0.052	mg/L
121500040020-01B	03/01/2004	General Environmental Sample	Phosphorous, Total	0.05	mg/L
121500040020-01B	06/01/2004	General Environmental Sample	Phosphorous, Total	0.082	mg/L
121500040020-01S	10/01/2001	General Duplicate	Phosphorous, Total	0.103	mg/L
121500040020-01S	10/01/2001	General Environmental Sample	Phosphorous, Total	0.107	mg/L
121500040020-01S	01/02/2002	General Duplicate	Phosphorous, Total	0.047	mg/L
121500040020-01S	01/02/2002	General Environmental Sample	Phosphorous, Total	0.041	mg/L
121500040020-01S	04/01/2002	General Duplicate	Phosphorous, Total	0.054	mg/L
121500040020-01S	04/01/2002	General Environmental Sample	Phosphorous, Total	0.054	mg/L
121500040020-01S	07/01/2002	General Duplicate	Phosphorous, Total	0.051	mg/L
121500040020-01S	07/01/2002	General Environmental Sample	Phosphorous, Total	0.053	mg/L
121500040020-01S	09/02/2003	General Duplicate	Phosphorous, Total	0.102	mg/L
121500040020-01S	09/02/2003	General Environmental Sample	Phosphorous, Total	0.079	mg/L
121500040020-01S	12/01/2003	General Duplicate	Phosphorous, Total	0.042	mg/L
121500040020-01S	12/01/2003	General Environmental Sample	Phosphorous, Total	0.038	mg/L
121500040020-01S	03/01/2004	General Duplicate	Phosphorous, Total	0.05	mg/L
121500040020-01S	03/01/2004	General Environmental Sample	Phosphorous, Total	0.047	mg/L
121500040020-01S	06/01/2004	General Duplicate	Phosphorous, Total	0.052	mg/L
121500040020-01S	06/01/2004	General Environmental Sample	Phosphorous, Total	0.053	mg/L
121500040020-01S	11/29/2005	General Duplicate	Phosphorous, Total	0.082	mg/L
121500040020-01S	11/29/2005	General Environmental Sample	Phosphorous, Total	0.083	mg/L
121500040020-01S	05/30/2006	General Duplicate	Phosphorous, Total	0.074	mg/L
121500040020-01S	05/30/2006	General Environmental Sample	Phosphorous, Total	0.072	mg/L
121500040020-01S	08/30/2006	General Duplicate	Phosphorous, Total	0.093	mg/L
121500040020-01S	08/30/2006	General Environmental Sample	Phosphorous, Total	0.107	mg/L
121500040020-01S	12/01/2009	Churn Duplicate	Phosphorous, Total	0.052	mg/L
121500040020-01S	12/01/2009	Environmental Churn Duplicate	Phosphorous, Total	0.051	mg/L
121500040020-01S	08/17/2010	Churn Duplicate	Phosphorous, Total	0.084	mg/L
121500040020-01S	08/17/2010	Environmental Churn Duplicate	Phosphorous, Total	0.088	mg/L
121500040020-02	10/01/2001	General Environmental Sample	Phosphorous, Total	0.094	mg/L
121500040020-02	01/02/2002	General Environmental Sample	Phosphorous, Total	0.044	mg/L
121500040020-02	04/01/2002	General Environmental Sample	Phosphorous, Total	0.049	mg/L
121500040020-02	07/01/2002	General Environmental Sample	Phosphorous, Total	0.055	mg/L
121500040020-02	09/02/2003	General Environmental Sample	Phosphorous, Total	0.09	mg/L
121500040020-02	12/01/2003	General Environmental Sample	Phosphorous, Total	0.041	mg/L
121500040020-02	03/01/2004	General Environmental Sample	Phosphorous, Total	0.053	mg/L
121500040020-02	06/01/2004	General Environmental Sample	Phosphorous, Total	0.067	mg/L
121500040020-02	11/29/2005	General Environmental Sample	Phosphorous, Total	0.081	mg/L

Lake Claremore WQM Station	Date	QA Category	Parameter	Value	Units
121500040020-02	05/30/2006	General Environmental Sample	Phosphorous, Total	0.086	mg/L
121500040020-02	08/30/2006	General Environmental Sample	Phosphorous, Total	0.136	mg/L
121500040020-02	12/01/2009	General Environmental Sample	Phosphorous, Total	0.05	mg/L
121500040020-02	08/17/2010	General Environmental Sample	Phosphorous, Total	0.095	mg/L
121500040020-03	10/01/2001	General Environmental Sample	Phosphorous, Total	0.106	mg/L
121500040020-03	04/01/2002	General Environmental Sample	Phosphorous, Total	0.056	mg/L
121500040020-03	07/01/2002	General Environmental Sample	Phosphorous, Total	0.082	mg/L
121500040020-03	09/02/2003	General Environmental Sample	Phosphorous, Total	0.104	mg/L
121500040020-03	12/01/2003	General Environmental Sample	Phosphorous, Total	0.046	mg/L
121500040020-03	03/01/2004	General Environmental Sample	Phosphorous, Total	0.057	mg/L
121500040020-03	06/01/2004	General Environmental Sample	Phosphorous, Total	0.059	mg/L
121500040020-03	11/29/2005	General Environmental Sample	Phosphorous, Total	0.09	mg/L
121500040020-03	05/30/2006	General Environmental Sample	Phosphorous, Total	0.091	mg/L
121500040020-03	08/30/2006	General Environmental Sample	Phosphorous, Total	0.193	mg/L
121500040020-03	12/01/2009	General Environmental Sample	Phosphorous, Total	0.048	mg/L
121500040020-03	08/17/2010	General Environmental Sample	Phosphorous, Total	0.098	mg/L
121500040020-04	09/02/2003	General Environmental Sample	Phosphorous, Total	0.08	mg/L
121500040020-04	12/01/2003	General Environmental Sample	Phosphorous, Total	0.04	mg/L
121500040020-04	03/01/2004	General Environmental Sample	Phosphorous, Total	0.05	mg/L
121500040020-04	06/01/2004	General Environmental Sample	Phosphorous, Total	0.054	mg/L
121500040020-04	11/29/2005	General Environmental Sample	Phosphorous, Total	0.08	mg/L
121500040020-04	05/30/2006	General Environmental Sample	Phosphorous, Total	0.076	mg/L
121500040020-04	08/30/2006	General Environmental Sample	Phosphorous, Total	0.113	mg/L
121500040020-05	09/02/2003	General Environmental Sample	Phosphorous, Total	0.101	mg/L
121500040020-05	12/01/2003	General Environmental Sample	Phosphorous, Total	0.044	mg/L
121500040020-05	03/01/2004	General Environmental Sample	Phosphorous, Total	0.06	mg/L
121500040020-05	06/01/2004	General Environmental Sample	Phosphorous, Total	0.07	mg/L
121500040020-05	11/29/2005	General Environmental Sample	Phosphorous, Total	0.092	mg/L
121500040020-05	05/30/2006	General Environmental Sample	Phosphorous, Total	0.087	mg/L
121500040020-05	08/30/2006	General Environmental Sample	Phosphorous, Total	0.162	mg/L

APPENDIX C: SWAT MODEL INPUT AND CALIBRATION

SWAT Model Input and Calibration

Given the lack of flow gage data available to quantify loadings directly from the tributaries of Copan Lake and Lake Claremore, 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. 2011). 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 2012.10.1.12 interface for SWAT2012 (Winchell et al. 2013). 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.

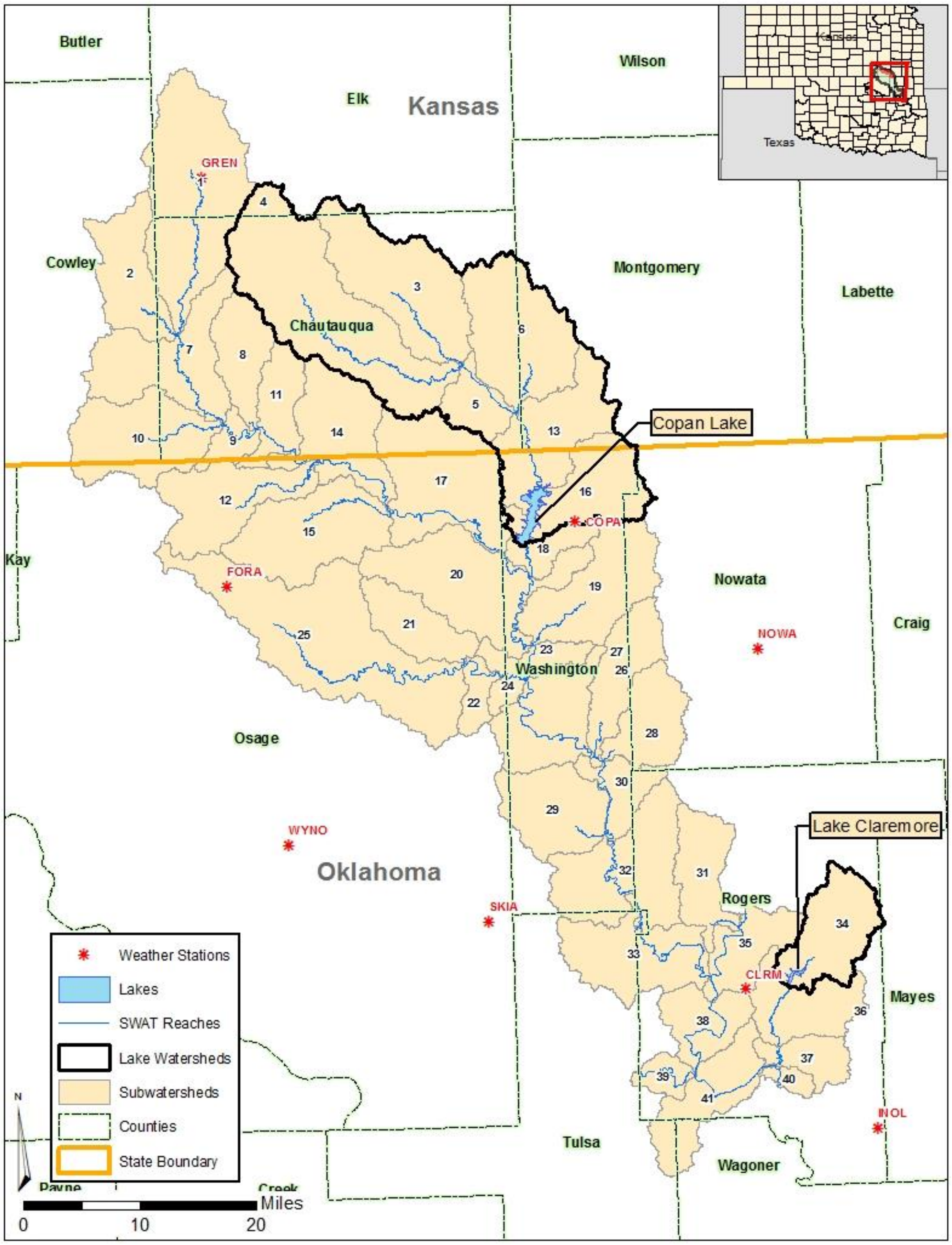
C-1.3 Land Use Data

Land use and land cover data were derived from NASS 2012 Cropland Data Layer (CDL) (http://www.nass.usda.gov/research/Cropland/SARS1a.htm) (USDA 2013). Three main crops were included in the model: corn, cotton and soybeans.

C-1.4 Meteorology

The meteorological data for the simulation period of 1994 to 2012 was derived from seven Oklahoma Mesonet stations (Claremore, Copan, Foraker, Inola, Nowata, Skiatook, & Wynona), and one Kansas Weather station (Grenola 1N). Weather station locations are shown in **Figure Appendix 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 sub-watersheds using the nearest station (Neitsch et al., 2011).

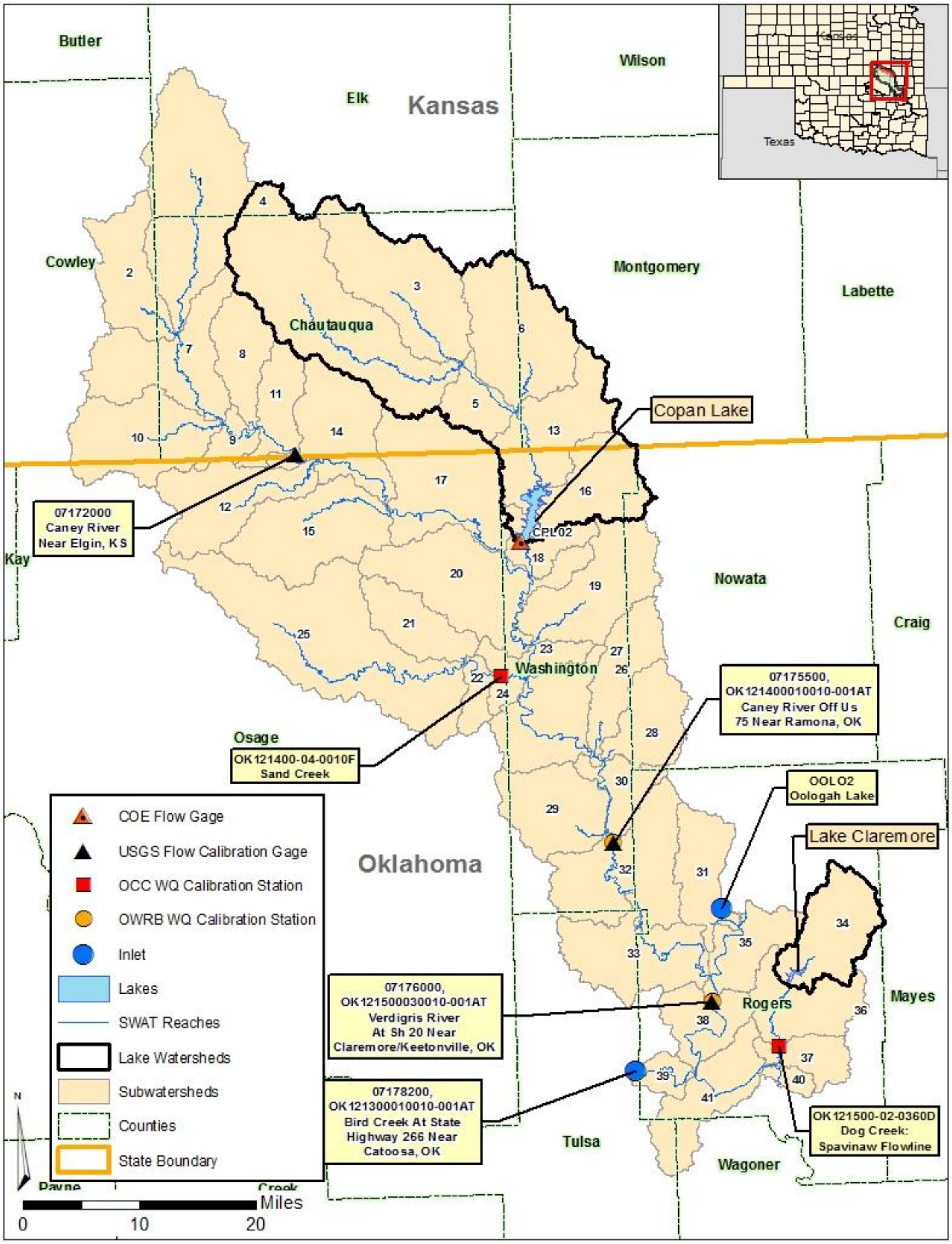
Figure Appendix C-1: Weather Station Locations



C-1.5 Sub-watershed Delineation

The modeled area was split into 41 sub-watersheds (**Figure Appendix 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 Copan Lake and Lake Claremore are outlined in black in **Figure Appendix C-2**. This figure also shows the locations of flow gages and water quality monitoring stations at which the SWAT model was calibrated.

Figure Appendix C-2: Model Segmentation and Calibration Stations



C-1.6 Point Sources

SWAT also allows the user to input data from point sources [mainly municipal and industrial wastewater treatment facilities (WWTF)]. WWTF outfalls, including five facilities in Kansas, are located in the model area, as shown in **Figure Appendix 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 Appendix C-1**).

Table Appendix C-1: Summary of DMR Data for Point Sources in Model Area

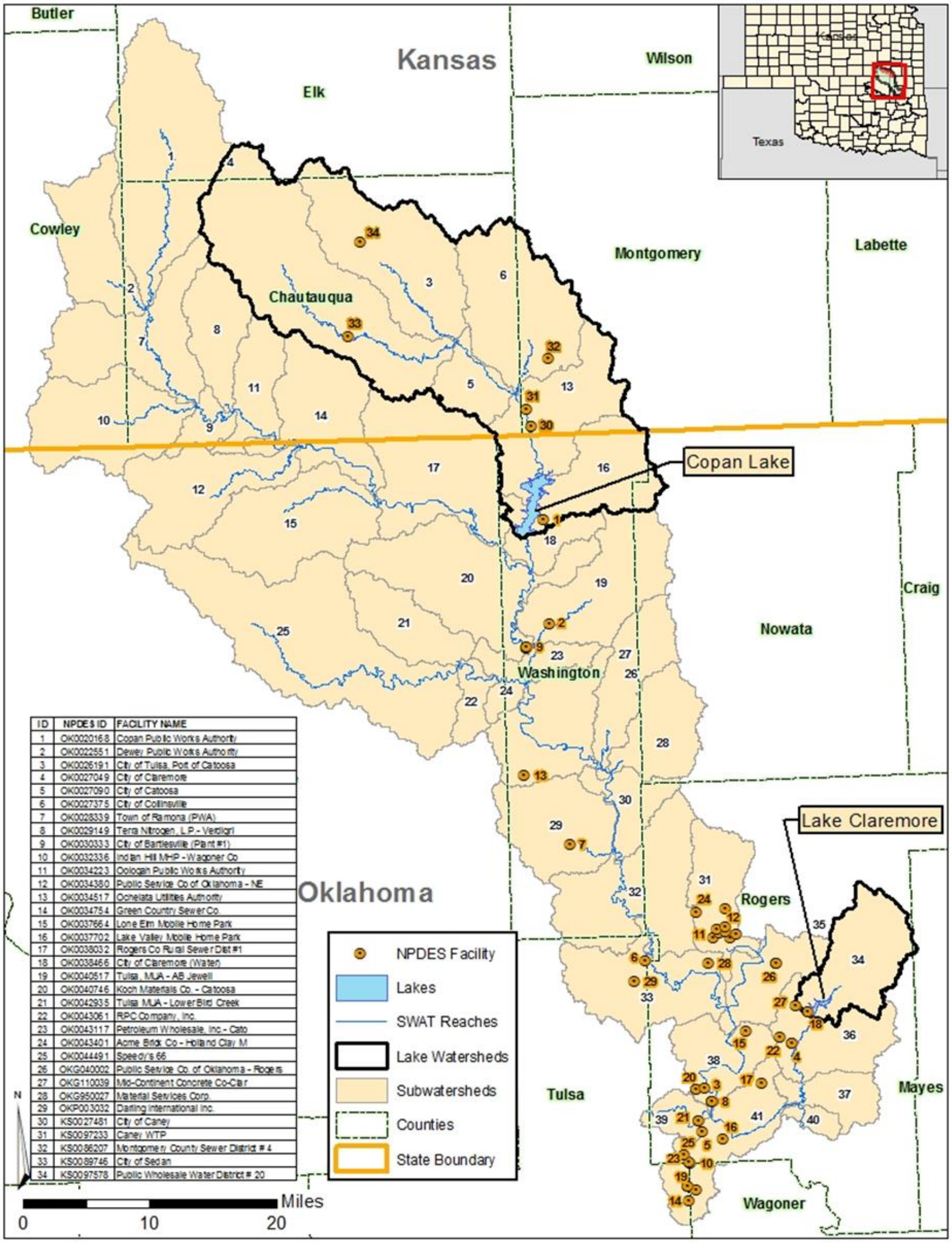
Facility Name	OPDES	Model Sub-watershed	Average of Reported Monthly Average Values	
			Flow (MGD)	TSS (mg/L)
Public Wholesale Water District # 20	KS0097578	3	NA	NA
City of Sedan	KS0089746	4	NA	11
Montgomery County Sewer District # 4	KS0086207	6	NA	NA
City of Caney	KS0027481	13	0.25	7.3
Caney WTP	KS0097233	13	NA	5.0
Copan Public Works Authority	OK0020168	16	0.05	6.2
Dewey Public Works Authority	OK0022551	19	0.17	6.4
City of Bartlesville (Plant #1)	OK0030333	20	6.85	5.0
Ochelata Utilities Authority	OK0034517	27	0.02	22.5
Town of Ramona (PWA)	OK0028339	29	0.02	37.8
Oologah Public Works Authority	OK0034223	31	0.16	10.7
Public Service Co of Oklahoma - NE	OK0034380	31	19.96	0.0
Acme Brick Co - Holland Clay M	OK0043401	31	0.02	2.9
Darling International Inc.	OKP003032	33	0.06	112.0
Material Services Corp.	OKG950027	33	ND	ND
City of Collinsville	OK0027375	33	0.56	32.3
City of Claremore (Water)	OK0038466	34	2.51	18.3
Public Service Co. of Oklahoma - Rogers	OKG040002	35	NA	NA
City of Claremore	OK0027049	36	2.50	14.6
RPC Company, Inc.	OK0043061	36	NA	NA
Mid-Continent Concrete Co-Clar	OKG110039	36	NA	NA
Terra Nitrogen, L.P.- Verdigri	OK0029149	38	1.39	9.4
Koch Materials Co. - Catoosa	OK0040746	38	NA	NA
City of Tulsa, Port of Catoosa	OK0026191	38	NA	NA
Lone Elm Mobile Home Park	OK0037664	38	0.06	5.4
Tulsa MUA - Lower Bird Creek	OK0042935	39	0.36	14.7
Green Country Sewer Co.	OK0034754	41	0.55	11.1
Tulsa, MUA - Ab Jewell	OK0040517	41	1.53	9.0
Indian Hill MHP - Wagoner Co	OK0032336	41	NA	NA
Petroleum Wholesale, Inc.- Cato	OK0043117	41	NA	NA
Speedy's 66	OK0044491	41	ND	ND
Lake Valley Mobile Home Park	OK0037702	41	0.05	14.0
City of Catoosa	OK0027090	41	0.10	7.1
Rogers Co Rural Sewer Dist #1	OK0038032	41	0.24	15.8

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.

NA = not reported DMR data available

ND = facility reported no discharge for the available monitoring period

Figure Appendix C-3: Locations of OPDES Point Sources



ID	NPDES ID	FACILITY NAME
1	OK0020168	Copan Public Works Authority
2	OK0022551	Dewey Public Works Authority
3	OK0026191	City of Tulsa, Port of Catoosa
4	OK0027049	City of Claremore
5	OK0027090	City of Catoosa
6	OK0027375	City of Collinsville
7	OK0028339	Town of Ramona (PWA)
8	OK0029149	Terra Nitrogen, L.P.- Verdigri
9	OK0030333	City of Bartlesville (Plant #1)
10	OK0032336	Indian Hill MHP - Wagoner Co
11	OK0034223	Oologah Public Works Authority
12	OK0034380	Public Service Co of Oklahoma - NE
13	OK0034517	Ochelata Utilities Authority
14	OK0034754	Green Country Sewer Co.
15	OK0037664	Lone Elm Mobile Home Park
16	OK0037702	Lake Valley Mobile Home Park
17	OK0038032	Rogers Co Rural Sewer Dist #1
18	OK0038466	City of Claremore (Water)
19	OK0040517	Tulsa, MUA - AB Jewell
20	OK0040746	Koch Materials Co. - Catoosa
21	OK0042935	Tulsa MUA - Lower Bird Creek
22	OK0043061	RPC Company, Inc.
23	OK0043117	Petroleum Wholesale, Inc - Cato
24	OK0043401	Acme Brick Co - Holland Clay M
25	OK0044491	Speedy's 66
26	OKG040002	Public Service Co. of Oklahoma - Rogers
27	OKG110039	Mid-Continent Concrete Co-Clar
28	OKG950027	Material Services Corp.
29	OKP003032	Darling International Inc.
30	KS0027481	City of Caney
31	KS0097233	Caney WTP
32	KS0086207	Montgomery County Sewer District # 4
33	KS0089746	City of Sedan
34	KS0097578	Public Wholesale Water District # 20

C-1.7 Animal Feeding Operations

There is one small state-permitted animal feeding operation located in the Kansas portion of the modeled watershed. However, the State of Oklahoma has no enforcement authority over sources of nutrients originating beyond the Oklahoma State boundary.

C-1.8 Management

SWAT defines management as a series of individual operations for each land cover (**Table Appendix C-2**). No modifications were made to the default management input files for urban, forest, and wetland land covers.

Table Appendix C-2: Distribution of Land Cover in the Modeled Watershed

Description	SWAT Code	Area (acres)	Percent of Total Watershed Area
Corn	CORN	6,002	0.4%
Cotton	AGRR	15,772	1.0%
Soybean	SOYB	24,765	1.6%
Range-Grasses	RNGE	534,243	34.5%
Open Water	WATR	22,407	1.5%
Residential-Low Density	URLD	78,557	5.1%
Residential-Medium Density	URMD	17,124	1.1%
Residential-High Density	URHD	5,268	0.3%
Industrial	UIDU	2,029	0.1%
Southwestern US (Arid) Range	SWRN	625	<0.1%
Forest-Deciduous	FRSD	308,643	19.9%
Forest-Evergreen	FRSE	560	<0.1%
Forest-Mixed	FRST	195	<0.1%
Range-Brush	RNGB	7	<0.1%
Hay	HAY	531,258	34.3%
Wetlands-Forested	WETF	1,007	0.1%

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 Appendix C-3**.

Table Appendix C-3: Average Mehlich III Phosphorus Soil Test Results by County

County	Average County Mehlich III STP (lb/acre)			
	Pasture	Corn	Cotton	Soybean
Osage	53			71
Washington	59	54		87
Nowata	36	83		102
Rogers	38	90		56
Tulsa	47	45		42
Wagoner	32	78	16	56

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. No data was available for counties in Kansas.

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

Cultivated Crop: The operations for corn, cotton, and soybeans are listed below:

Corn

- 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

Cotton

- 3/1 Disk plow
- 5/1 Fertilize 150 lb/acre of 18-46-00 (yields 30 lb/acre P_2O_5 and 27 lb/acre of N)
- 5/1 Fertilize 52 lb/acre of 46-00-00 (yields 23 lb/acre of N)
- 5/15 Plant cotton
- 7/1 Fertilize 110 lb/acre of 46-00-00 (yields 50 lb/acre of N)
- 11/1 Harvest cotton

Soybean

- 4/15 Fertilize 10 lb/acre of P_2O_5
- 4/15 Fertilize 24 lb/acre of 46-00-00 (yields 11 lb/acre of N)
- 5/01 Plant soybean
- 6/15 Fertilize 13 lb/acre of anhydrous ammonia (yields 11 lb/acre of N)
- 9/25 Harvest and kill soybean

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 1997-2013 were combined with land cover data to estimate the number of cattle within the model area (USDA 2013). It was assumed that cattle were evenly distributed across all pastures in the ten counties encompassing the basin. The estimated number of cattle and calves in the model area was 204,109 head (**Table Appendix C-4**).

Table Appendix C-4: 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]
Osage - OK	160,152	828,448	0.19	197,821	38,242
Washington - OK	33,368	86,932	0.38	79,221	30,408
Nowata - OK	67,373	98,647	0.68	25,683	17,541
Rogers - OK	66,085	80,490	0.82	47,458	38,964
Tulsa - OK	20,380	50,117	0.41	7,497	3,049
Wagoner - OK	39,520	43,218	0.91	740	676
Chautauqua - KS	44,463	77,162	0.58	76,204	43,911
Cowley - KS	65,112	391,341	0.17	56,477	9,397
Elk - KS	41,084	99,868	0.41	39,106	16,087
Montgomery - KS	37,551	16,436	2.28	2,553	5,833
Total					**204,109**

[a] Average of 1997-2013 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 were evenly distributed)
[d] Density times the area of rangeland of a given county that was within the modeled watershed

The operation schedule for pastures is: 3/1 Grazing 0.4 au/acre for 300 days

C-1.10 Simulation Period and Variables of Concern

A 19-year period (1994 - 2012) 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 15 years (1998 - 2012). 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 gages located on Caney River near Elgin, KS (USGS Station 07172000), Caney River at US-75 (USGS Station 07175500), and Verdigris River at SH-20 (USGS Station 07176000) (**Figure Appendix C-2**). In addition, the model simulated inflow to Copan Lake was compared to daily records reported by COE (Station CPLO2). **Table Appendix 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 41 sub-watersheds), except when noted in the table.

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

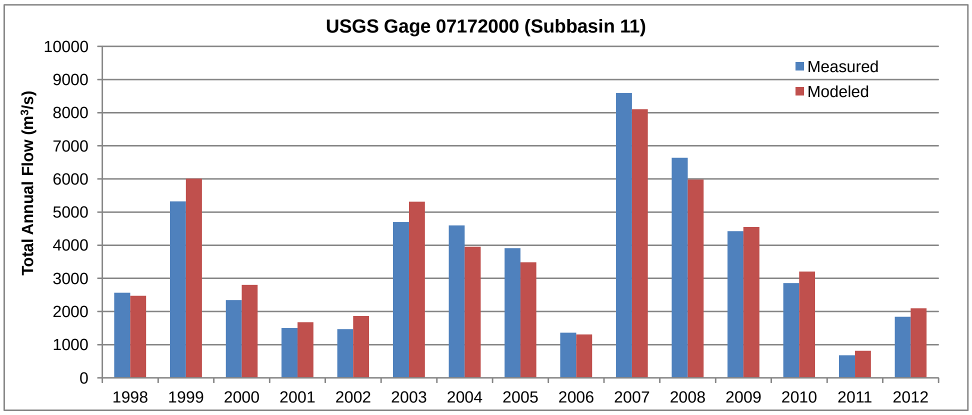
Parameter	Units	Description	Location in SWAT Input	Default Value	Sub-basin	Calibrated Value
RCHR_DP	--	Percent of infiltrated water lost to a regional aquifer	**.gw	0.05	1,2,7-11	0.01
					All others	0.05
GW_DELAY	day	Groundwater delay time	**.gw	31	3-6, 12-41	10
					1,2,7,8,9,10,11	31
GW_REVAP			**.gw	0.02	1-11,13,16,31-41	0.02
					12,14,15,17-30	0.1
ESCO	--	Evaporation coefficient	**.bsn	0.95	All	0.9
CN2	--	SCS curve number	**.mgt	-	All	x0.9
SOL_AWC			**.sol	-	All	x1.5
CH_K1	mm/hr	Effective hydraulic conductivity in tributary channel	**.sub	0.5	3-6,12-41	0
					1,2,7,8,9,10,11	1

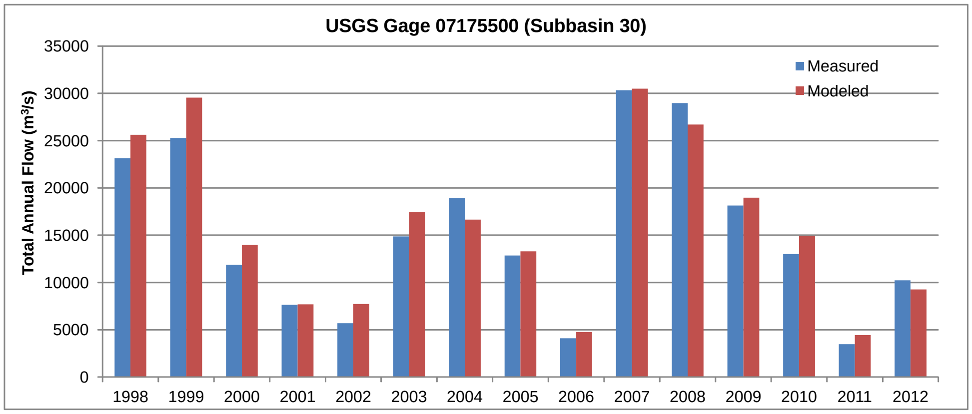
The primary calibration targets included annual water balances. But modeled monthly flows and the resulting flow duration curves were also compared to measured values. **Figure Appendix C-4** and **Figure Appendix C-5** display time series of observed vs. predicted annual and monthly flows in Caney River near Elgin, KS (sub-basin 11), Caney River at US-75 (sub-basin 30), Verdigris River at SH-20 (sub-basin 35), and Copan Lake inflows. **Table Appendix 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 (2% for Caney Creek near Elgin, 6% for Caney Creek at US-75, -1% for Verdigris River at SH-20, and 10% for Copan Lake inflow). Resulting Nash-Sutcliffe Efficiency coefficients (NSE) and correlation coefficient (r^2) values were 0.961 and 0.955 for Caney Creek near Elgin, 0.948 and 0.952 for Caney Creek at US-75, 0.993 and 0.992 for Verdigris River at SH-20, and 0.943 and 0.989 for Copan Lake inflow. The high resulting coefficients indicate very good model performance for annual flows.

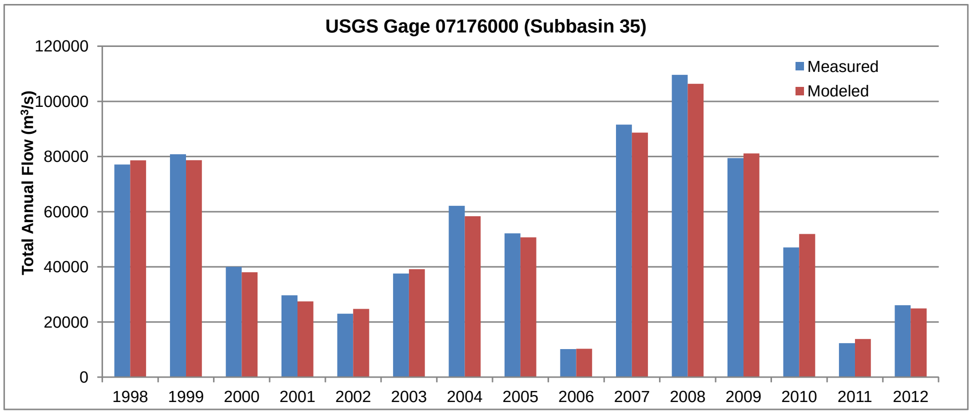
Figure Appendix C-6 compares the modeled and observed daily flow duration curves for sub-watersheds[1] 11, 30 and 35 and for Copan Lake inflow. A flow duration curve depicts the percentage of the time that a given flow is not exceeded. The model simulation agrees well with the observed flow duration curves across all flow conditions.

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

Figure Appendix C-4: Observed and Modeled Annual Flows







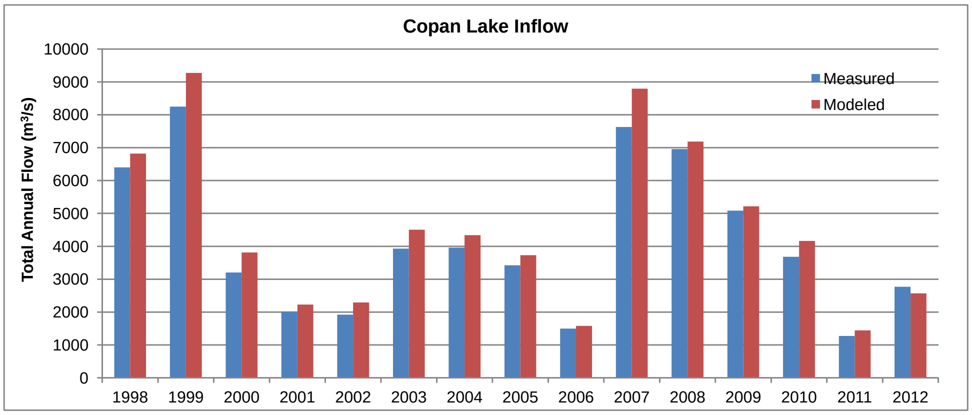


Figure Appendix C-5: Observed and Modeled Average Monthly Flows

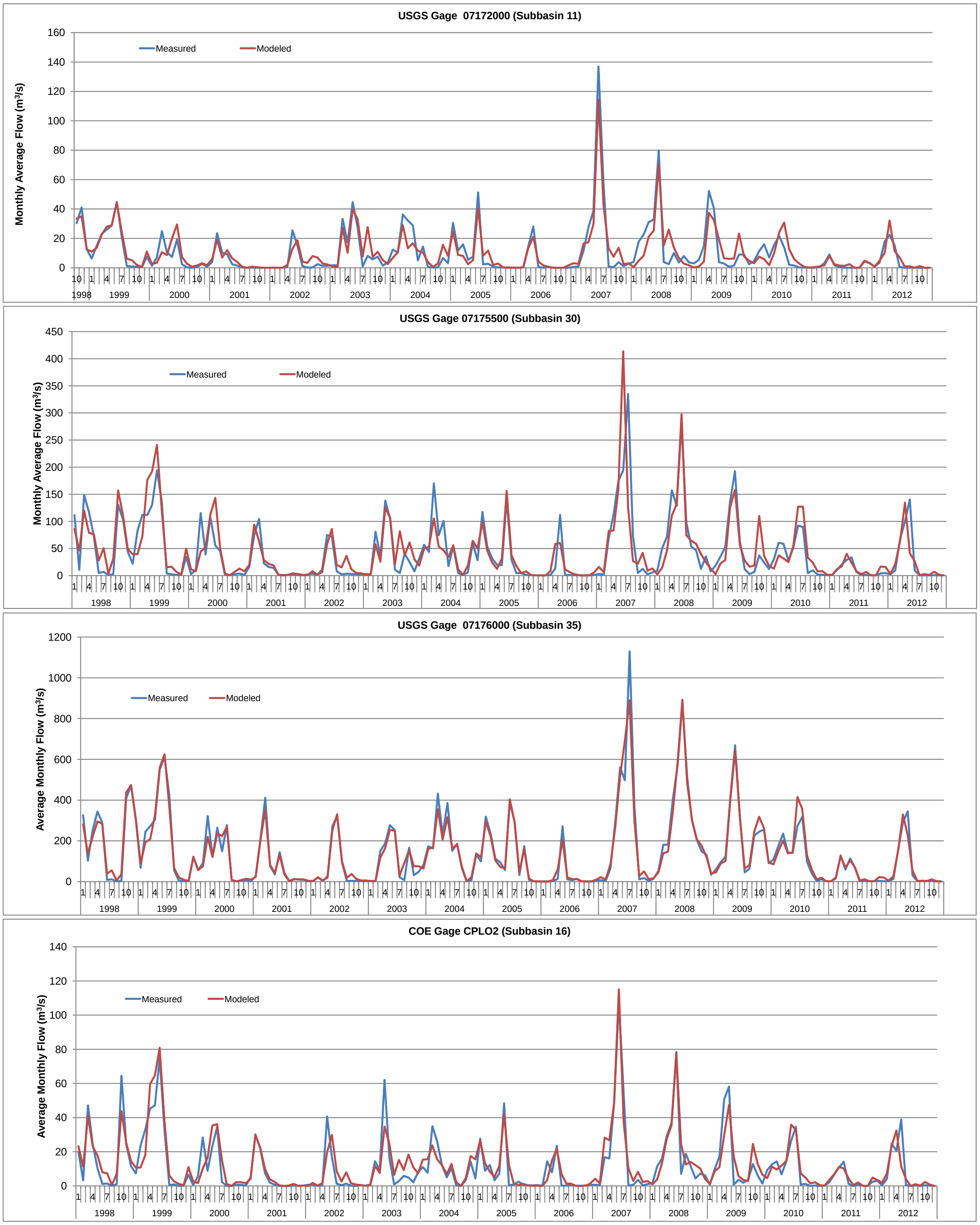


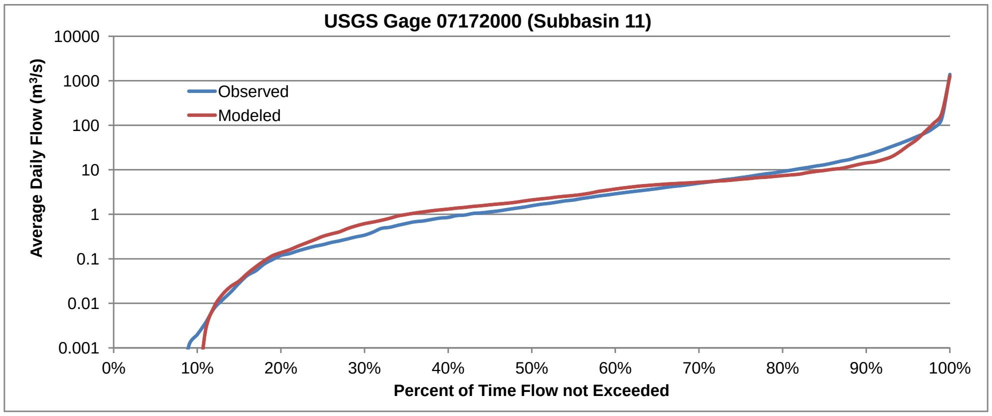
Table Appendix C-6: Summary of Model Performance for Water Quantity

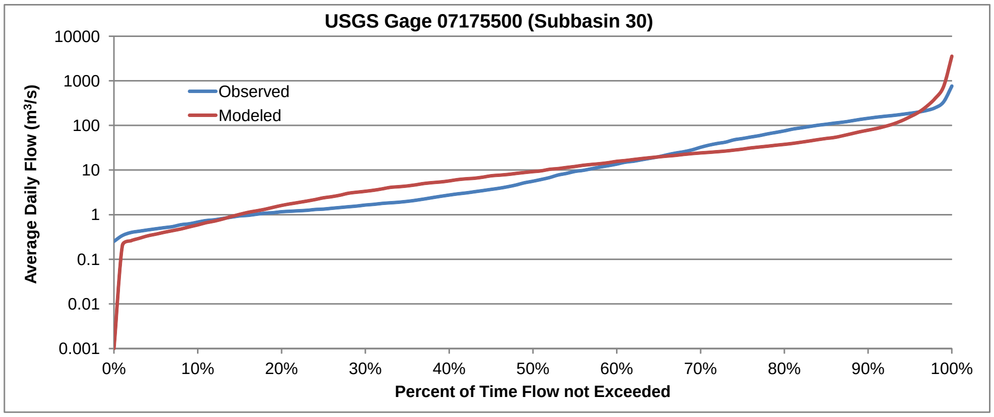
Year	USGS 07172000 (Sub-watershed 11)				USGS 07175500 (Sub-watershed 30)				USGS 07176000 (Sub-watershed 35)				Copan Lake Inflow			
	Total Annual Flow (m^3/s)		Model Error (%)	NSE/r^2 (a,b)	Total Annual Flow (m^3/s)		Model Error (%)	NSE/r^2 (a,b)	Total Annual Flow (m3/s)		Model Error (%)	NSE/r^2 (a,b)	Total Annual Flow (m^3/s)		Model Error (%)	NSE /r^2 (a,b)
	Observed	Modeled			Observed	Modeled			Observed	Modeled			Observed	Modeled		
1998	2,565	2,475	-4		23,132	25,613	11		77,082	78,604	2		6,404	6,819	6	
1999	5,323	6,011	13		25,290	29,545	17		80,827	78,662	-3		8,249	9,274	12	
2000	2,344	2,803	20		11,877	13,977	18		40,023	38,062	-5		3,201	3,814	19	
2001	1,502	1,676	12		7,648	7,695	1		29,660	27,454	-7		2,016	2,227	10	
2002	1,468	1,867	27		5,690	7,720	36		23,002	24,764	8		1,920	2,292	19	
2003	4,698	5,313	13		14,877	17,432	17		37,565	39,119	4		3,930	4,505	15	
2004	4,597	3,953	-14		18,921	16,644	-12		62,106	58,333	-6		3,960	4,340	10	
2005	3,909	3,484	-11	**0.961/ 0.955**	12,860	13,288	3	**0.948/ 0.952**	52,124	50,722	-3	**0.993/ 0.992**	3,424	3,732	9	**0.943/ 0.989**
2006	1,364	1,308	-4		4,096	4,763	16		10,161	10,277	1		1,496	1,579	6	
2007	8,594	8,107	-6		30,327	30,487	1		91,568	88,628	-3		7,632	8,795	15	
2008	6,642	5,980	-10		28,966	26,695	-8		109,621	106,377	-3		6,955	7,185	3	
2009	4,426	4,551	3		18,136	18,963	5		79,425	81,090	2		5,087	5,215	3	
2010	2,856	3,207	12		13,003	14,942	15		47,049	51,906	10		3,681	4,164	13	
2011	680	817	20		3,482	4,440	27		12,331	13,841	12		1,274	1,445	13	
2012	1,840	2,099	14		10,225	9,273	-9		26,085	24,953	-4		2,770	2,570	-7	
Overall	**52,807**	**53,653**	**2**		**228,530**	**241,479**	**6**		**778,631**	**772,791**	**-1**		**61,999**	**67,955**	**10**	

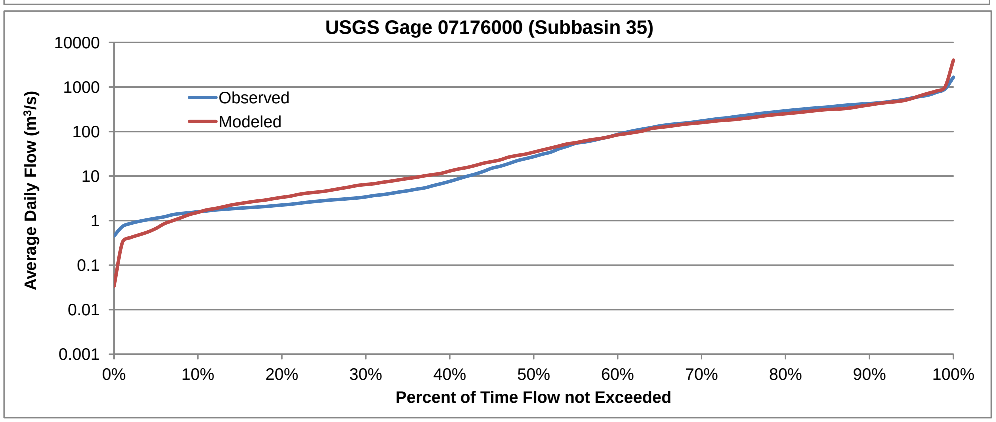
[a] Calculated using average monthly flows

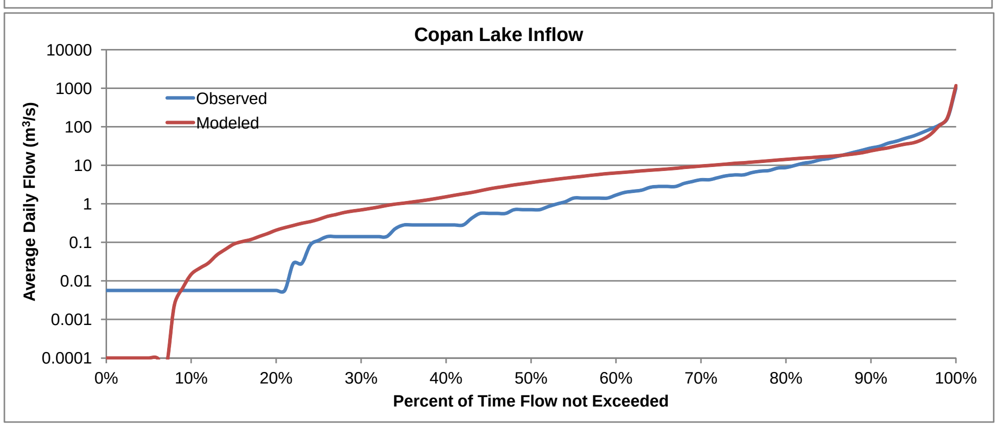
[b] Nash-Sutcliffe Efficiency Coefficient = $1 - \frac{\sum(obs - mod)^2}{\sum(obs - obs_{avg})^2}$

Figure Appendix C-6: Observed and Modeled Daily Flow Duration Curves









C-2.2 Water Quality Calibration

There are no water quality monitoring stations in the tributaries to Copan Lake and Lake Claremore. The SWAT model was calibrated at four stream water quality monitoring stations in the modeled domain (**Figure Appendix C-2**): Caney Creek at US-75 (OWRB monitoring site 121400010010-001AT), Sand Creek (OCC monitoring site OK121400-04-0010F), Verdigris River at SH-20 (OWRB monitoring site 121500030010-001AT), and Dog Creek: Spavinaw Flowline (OCC monitoring site OK121500-02-0360D). 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 Appendix 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 Appendix C-7: Observed and Modeled Average TSS Concentrations

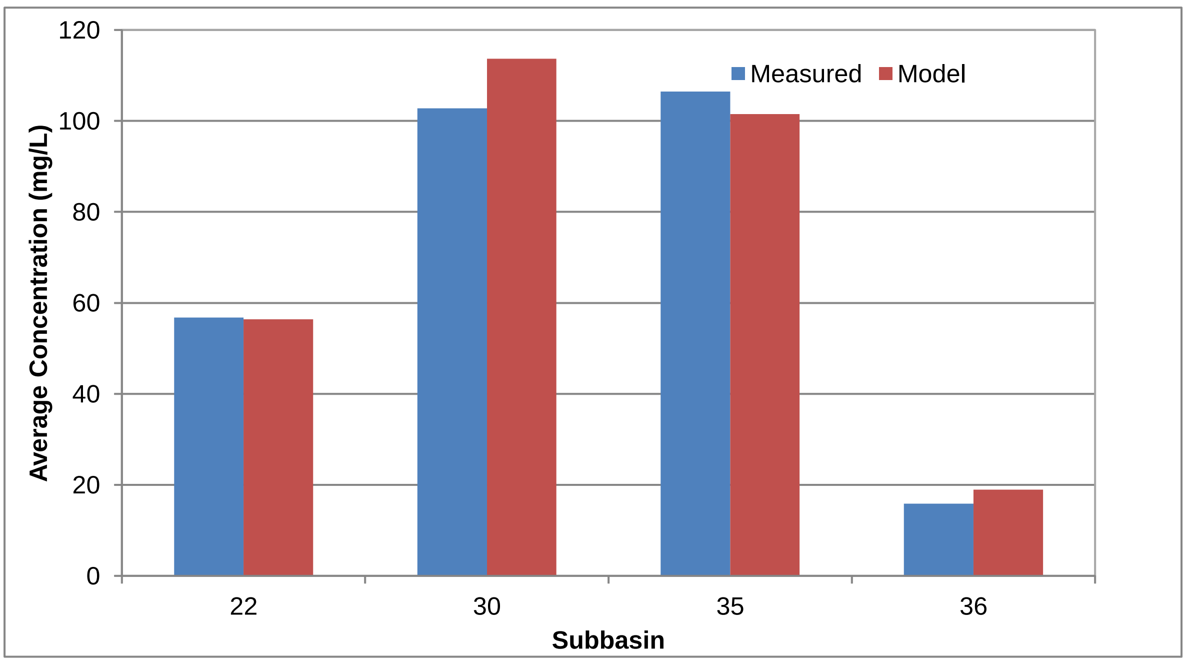


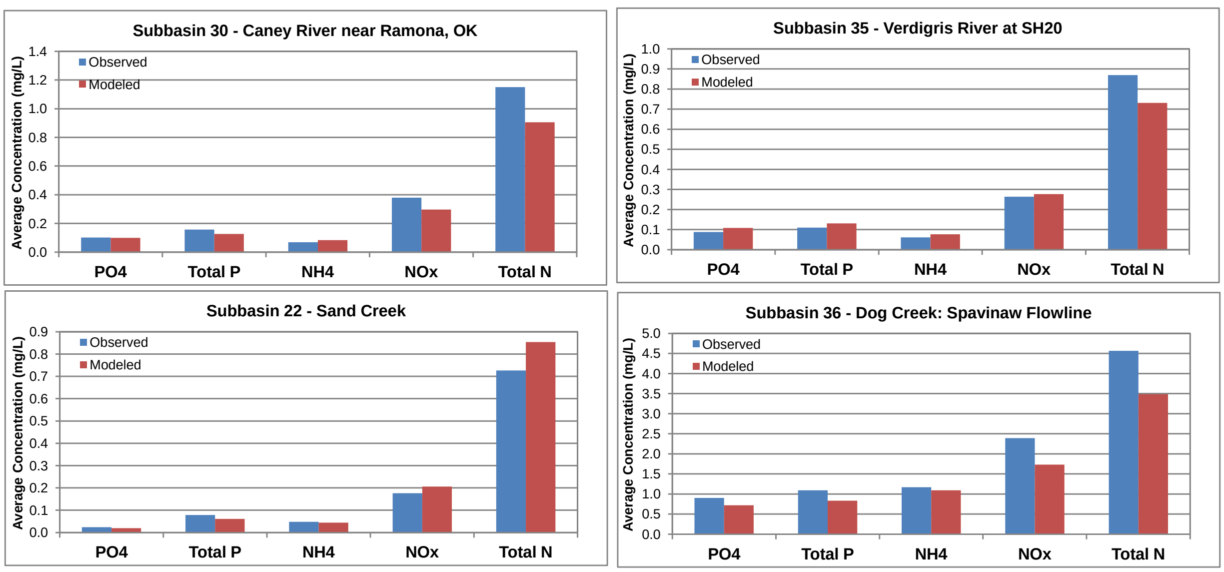
Table Appendix C-7 summarizes the model error for the various nutrients. As can be seen, in most cases, the SWAT model reproduced the average nutrient concentrations within 25% of the measured averages (**Figure Appendix C-8**). In some instances, the model does not replicate speciation for a given period, but nevertheless the total phosphorus and nitrogen predicted averages were 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 monitoring data available for calibration were from low to moderate flow conditions. As a result, there was more uncertainty on high flow loading values.

Table Appendix C-7: Summary of Model Error for Nutrient Predictions (mg/L)

Parameter	Subb 30			Subb 35			Subb 22			Subb 36		
	Observed	Modeled	Error (%)	Observed	Modeled	Error (%)	Observed	Modeled	Error (%)	Observed	Modeled	Error (%)
PO4	0.10	0.10	-3	0.09	0.11	23	0.02	0.02	-18	0.90	0.72	-20
Total P	0.16	0.13	-20	0.11	0.13	19	0.08	0.06	-22	1.09	0.83	-24
NH_4	0.07	0.08	22	0.06	0.08	25	0.05	0.04	-7	1.17	1.09	-6
NO_x	0.38	0.30	-22	0.26	0.28	5	0.18	0.21	17	2.39	1.73	-28
Total N	1.15	0.91	-21	0.87	0.73	-16	0.73	0.85	18	4.57	3.48	-24

Non-detects were assumed equal to ½ DL

Figure Appendix C-8: Observed and Modeled Average Nutrient Concentrations



C-3. Model Results

Figure Appendix C-9 and **Figure Appendix C-10** show the average annual load of nutrients from runoff for each of the 41 sub-watersheds in the model domain. Total phosphorus loads ranged from 0.3 to 9.1 kg/ha/year. Total nitrogen loads varied between 1.2 and 23.8 kg/ha/yr.

A summary of average daily values for the sub-watersheds draining to Copan Lake and Lake Claremore is included in **Table Appendix C-9**. Under current conditions, Copan Lake was estimated to receive a total annual load of 475,400 kg of phosphorus and 1,376,700 kg of nitrogen, on average, from nonpoint sources in its watershed. Claremore Lake was estimated to receive a total annual load of 22,400 kg of phosphorus and 108,100 kg of nitrogen, on average, from 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.

Table Appendix C-8: Average Flows and Nutrient Loads Discharging to Copan Lake and Lake Claremore

Parameter	Copan Lake	Lake Claremore
Watershed Size (square miles)	507	58
Flow (m^3/day)	1.07×10^6	1.98×10^5
Organic Phosphorus (kg/year)	412,400	10,100
Mineral Ortho-Phosphorus (kg/year)	63,000	12,300
Total Phosphorus (kg/year)	**475,400**	**22,400**
Organic Nitrogen (kg/year)	1,145,100	23,800
Ammonia Nitrogen (kg/year)	69,600	10,600
Nitrate+Nitrite Nitrogen (kg/year)	161,900	73,700
Total Nitrogen (kg/year)	**1,376,700**	**108,100**

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

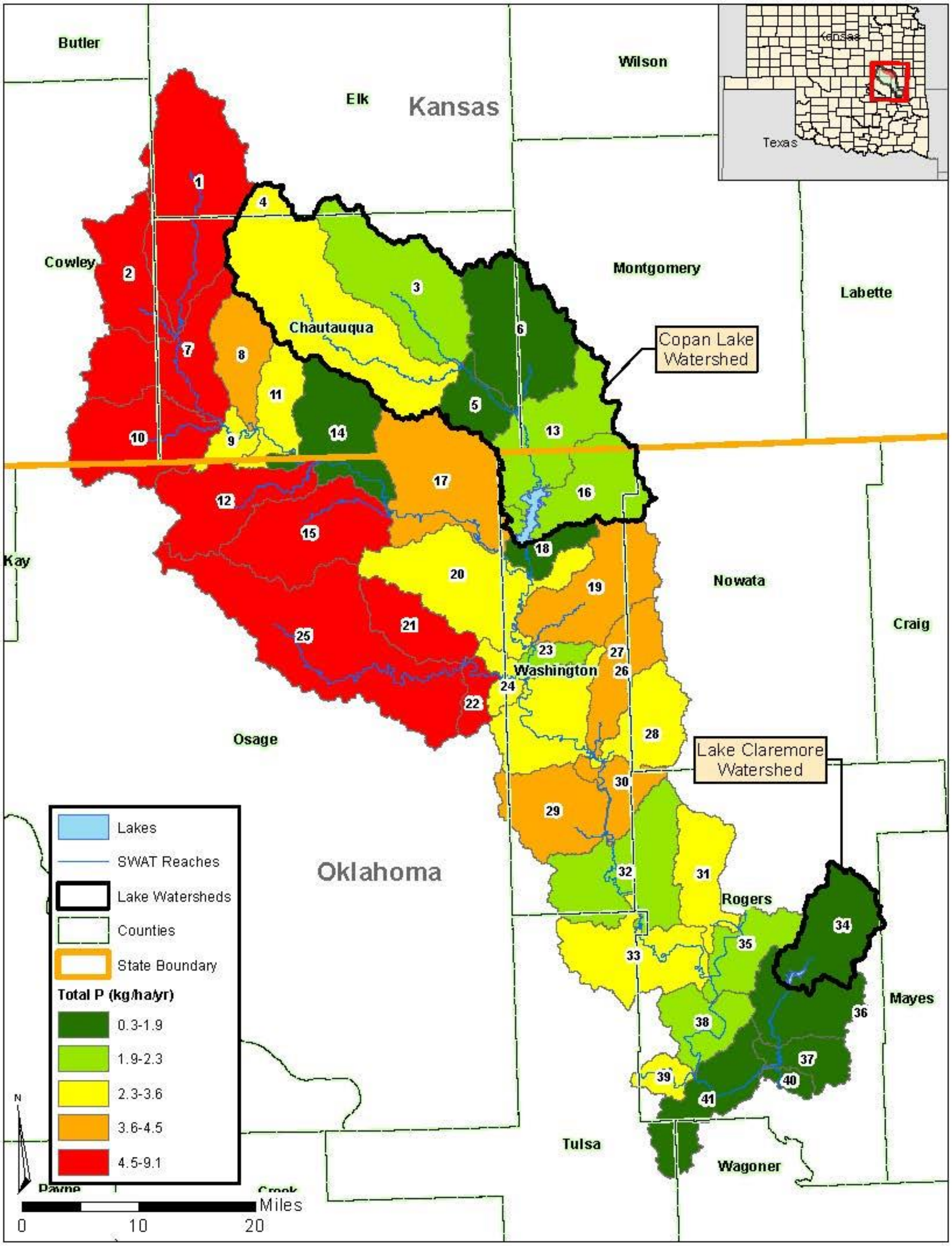
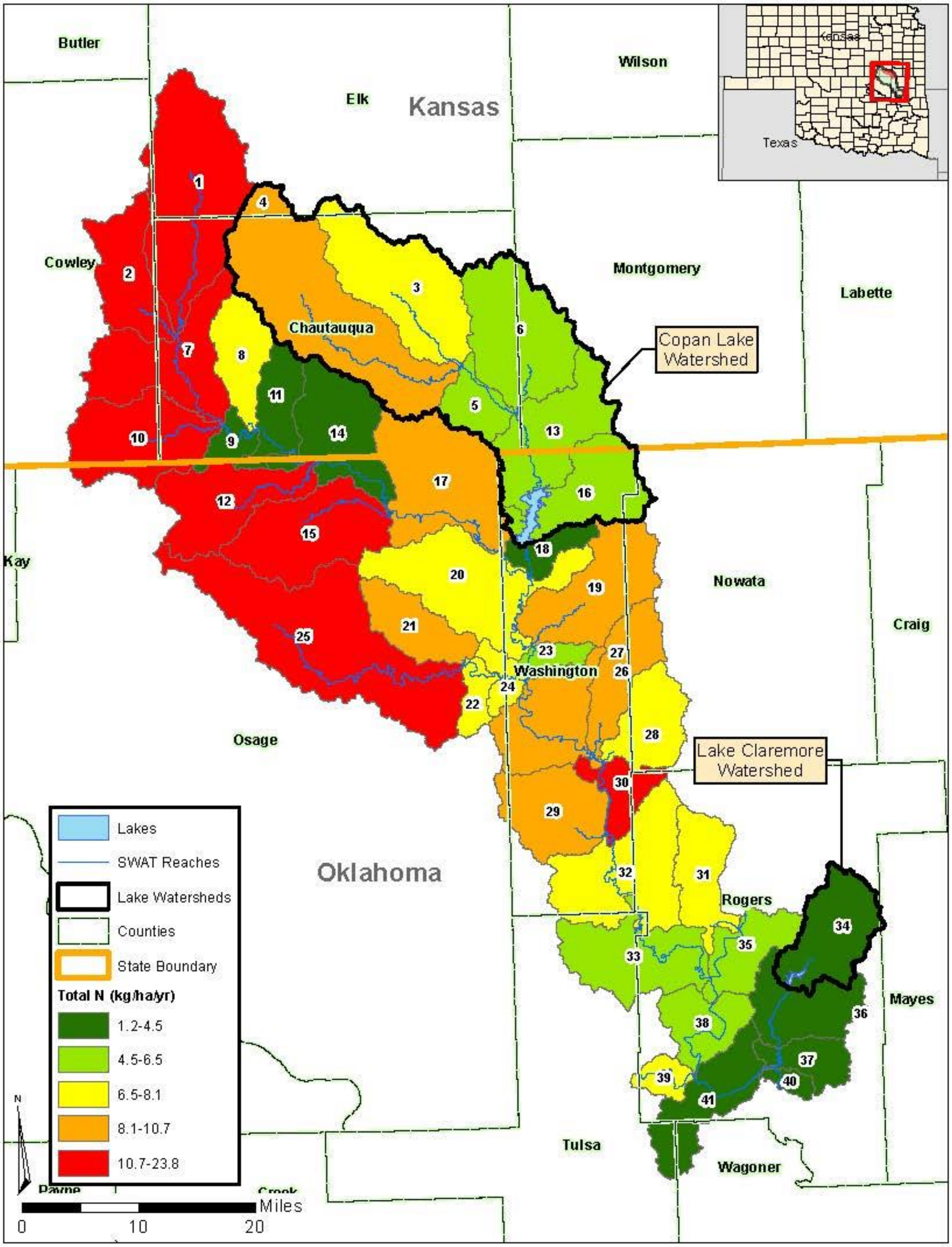


Figure Appendix C-10: Average Total Nitrogen Loading from SWAT Sub-Watersheds



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APPENDIX D: RESPONSES TO PUBLIC COMMENTS

Scott A. Thompson
Executive Director

Mary Fallin
Governor

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

Response to Public Comments Received for the Draft Chlorophyll-a TMDL Report for Lake Copan and Claremore Lake

September 22, 2014

1. Comment received via email from Jeremy P. McKinney:

I am sure you already knew this but it wasn't mentioned in the report. Caney KS municipal waste water discharges into the watershed just upstream of Copan Lake as well a few other small towns. I know we have no control over what they discharge but they are definitely a contributor to the water shed [sic].

DEQ Response:

The Executive Summary, Pollutant Source Assessment (Section 3) and TMDLs And Load Allocations (Section 5) sections of the report were updated to include information on the point source discharges in the Kansas side of the watershed. The watershed SWAT model (Appendix C) was updated to incorporate these discharges. These changes increased the modeled nutrient loads to the lake by less than one percent, which was considered insignificant. No changes were made to the lake model and the TMDL results were not affected. No wasteload allocations (WLAs) were given for these facilities (Section 3.2.1.1). They are considered in Load Allocations (LA). It is recognized that Oklahoma has no enforcement authority over sources of nutrients originating beyond the Oklahoma State boundary. However, language was added to Section 4 and Section 7 stating that the same percent reduction goal should be considered to apply throughout the watershed.

2. Comment sent via email from Quang Pham, ODAFF AgPDES Deputy Director:

We have the following comments on the above subject TMDL report for Copan Lake and Lake Claremore:

1- Under Section ES-3 Pollutant Source Assessment, page ES-4, third paragraph, the report stated that:

> *"**There are no CAFOs**, no discharge facilities, or continuous industrial point source discharges within the Copan Lake or Lake Claremore watersheds". This statement should be **"There are no AFOs….".***

2- *The same comment on section C-1.7, page C-7 of Appendix C on Animal Feeding Operations. It stated that: "**There are not concentrated animal feeding operation (CAFO)** facilities located in the modeled watershed". This statement should be: " **There are no Animal Feeding Operations (AFOs)** ……"*

It is noted that at the end of Sub-Section 3.2.5 on Animal Feeding Operations (AFOs), page 3-6, the report indicated that there are no AFOs in the watersheds: "…..However, there are no AFOs within the Copan Lake or Lake Claremore watersheds".

DEQ Response:

Those changes were made in this Report. Based on additional information received, Section C-1.7 now reads:

> *There is one small state-permitted animal feeding operation located in the Kansas portion of the modeled watershed. However, the State of Oklahoma has no enforcement authority over sources of nutrients originating beyond the Oklahoma State boundary.*

Thank you for your comments.

3. <u>Staff Identified Corrections:</u>

- Language and tables in the Executive Summary regarding wasteload allocations were corrected to reflect contents of the body of the report.
- Some values in Section 5.3 were corrected to be consistent with the rest of the report.