TMDL Development for Lakes Eucha and Spavinaw in Oklahoma

Final
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United States Environmental Protection Agency Region 6
and
Oklahoma Department of Environmental Quality

Table of Contents

List of Tables/Figures

INTRODUCTION

Section 303(d) of the Clean Water Act (CWA) and United States Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulation (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that do not meet designated uses even though sources have implemented technology-based controls. A TMDL establishes the allowable load of a pollutant or other quantifiable parameter based on the relationship between pollutant sources and in-stream water quality. A TMDL provides the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of its water resources [USEPA, 1991]. The process of developing a TMDL requires the following:

- Identification of a water quality problem.
- Identification of a water quality goal or endpoint.
- Review and analysis of available data.
- Identification and characterization of the pollutant sources causing the water quality problem.
- Allocation of pollutant loads (i.e., establishing a plan to correct the problem by controlling sources).
- Establishment of a monitoring plan to assess the effectiveness of the source controls.

This document presents the background information, analyses, and proposed TMDL to address the designated-use impairment of Lakes Eucha and Spavinaw in Oklahoma. It is organized as follows:

- *Part I, Problem Understanding*, explains why Eucha Lake (Upper Spavinaw) and Spavinaw Lake were placed on Oklahoma's 303(d) list of water bodies requiring TMDLs, describes the characteristics of the lake that will be useful in analyzing its water quality problem, identifies endpoints that may be used to measure whether the lake is meeting its designated uses, examines the effect of seasonal patterns on water quality, and presents an assessment of pollutant sources causing impairment of lakes.
- *Part II, Technical Approach*, describes the modeling approach, defines the linkage between the selected targets and the identified sources, describes the model testing to reproduce the existing condition, and evaluates lake response to load reductions.
- *Part III, Allocation Analysis*, describes how load reductions were allocated to bring the lakes into compliance with water quality standards. The analysis also discusses the margin of safety incorporated into the TMDL

PART I. PROBLEM UNDERSTANDING

This part provides the basic overview and understanding of the listed water body and associated pollutant sources. Four steps are included in the problem understanding: problem characterization, water quality standards and target limit, impairment analysis, and source assessment.

1.0 Problem Characterization

1.1 Problem Statement

Eucha Lake (Upper Spavinaw) and Spavinaw Lake are located in the Spavinaw Creek watershed (Hydrologic Unit Code 11070209), which straddles the Oklahoma-Arkansas boundary. The Spavinaw Creek flows west-southwest from Arkansas and into Oklahoma, where it drains into Eucha Lake (Upper Spavinaw) before finally flowing into the Arkansas River. Eucha Lake (Upper Spavinaw) is located in the southwestern portion of the basin. The main tributaries to the lake include the Spavinaw Creek, Beaty Creek, Brush Creek, Rattlesnake Creek and Dry Creek. Spavinaw Lake is located approximately 4 miles downstream of Eucha Lake (Upper Spavinaw) on Spavinaw Creek. Spavinaw Creek is the main tributary to Spavinaw Lake. Figure I-1 shows the location of the Spavinaw Creek watershed, the Eucha Lake (Upper Spavinaw) and Spavinaw Lake drainage basin, Eucha Lake (Upper Spavinaw), Spavinaw Lake and their main tributaries.

Eucha Lake (Upper Spavinaw) and Spavinaw Lake are identified on Oklahoma's 2008 303(d) list [ODEQ 2008] as impaired because of Chlorophyll-*a*, total phosphorus and dissolved oxygen. Table I-1 shows the listing details for the lakes. These TMDLs only address the impairment for total phosphorus. The impairment of the Public and Private Water Supplies beneficial use due to excessive algae levels has prompted the funding of extensive data collection and analysis of both Eucha Lake (Upper Spavinaw) and Spavinaw Lake by the City of Tulsa. The eutrophication process in both Eucha Lake (Upper Spavinaw) and Spavinaw Lake are primarily attributed to excess nutrient inputs from both point and nonpoint sources, with phosphorus generally being the limiting nutrient. Review of water quality data collected indicates that eutrophication of the lakes occurs during summer periods. Data assembled from the previous studies of Eucha/Spavinaw watershed along with other monitoring information sources serve as the basis for development of the TMDLs to address total phosphorus loading the lakes. The Oklahoma Water Resources Board (OWRB) 2002 report *Water Quality Evaluation of the Eucha/Spavinaw Lake System* is the technical foundation for these TMDLs.

1.2 Eucha Lake (Upper Spavinaw) & Spavinaw Characterization

Spavinaw Lake was completed in 1924 as a drinking water reservoir for the City of Tulsa, Oklahoma. Eucha Lake (Upper Spavinaw) was constructed in 1952 to serve as an environmental and hydrologic barrier for Spavinaw Lake. Although water isn't taken directly from Eucha Lake (Upper Spavinaw) by the City of Tulsa, it is dependent on the storage capacity of Eucha Lake (Upper Spavinaw) for providing a continuous, dependable water source.

In addition to the public water supply, Eucha Lake (Upper Spavinaw) and Spavinaw Lake include fishery and primary contact recreation designated uses. Table I-2 summarizes the physical characteristics of Eucha Lake (Upper Spavinaw). Table I-3 provides general morphometric characteristics of the lakes. Eucha Lake (Upper Spavinaw)'s drainage area to surface area (DA/SA) ratio is approximately 72.6 with a DA/SA ratio for Spavinaw Lake of 29.97. In general, a DA/SA ratio of less than 10:1 implies that shoreline and near-shore activities are likely to dominate reservoir water quality. A DA/SA ratio of greater than 50:1 implies that activities in the watershed are likely to dominate reservoir water quality.

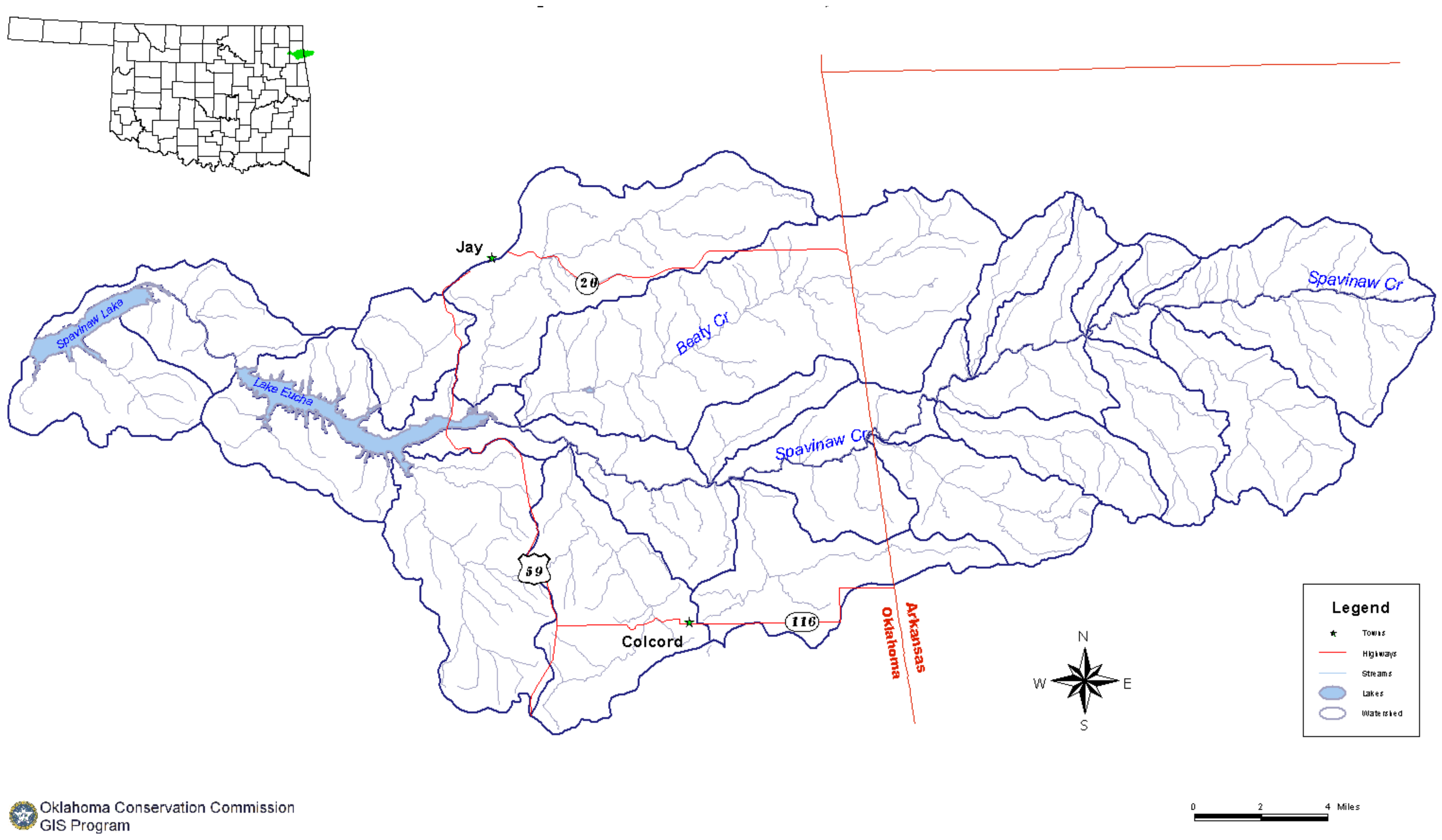

Figure I-1 Eucha Lake (Upper Spavinaw)/ Spavinaw Creek Watershed

Table I-1. Water quality impairments

Water Body Name	303(d) List ID	Designated Uses Evaluated [a]	Causes of Listing	Primary Source
Eucha Lake (Upper Spavinaw)	121600050070	PPWS, Ag, PBCR, WWAC, Aesthetics, SWS	DO & Total Phosphorus	Unknown
Spavinaw Lake	121600050020	PPWS, Ag, PBCR, WWAC, Aesthetics, SWS	DO & Total Phosphorus	Unknown

[a] Public and Private Water Supply {PPWS}, Agriculture Use {Ag}, Primary Body Contact Recreation {PCR}, Fish & Wildlife Propagation for Warm Water Aquatic Communities { WWAC}, Aesthetic Uses {Aesthetics}, Sensitive Water Supply (SWS)

Table I-2. Physical characteristics of Lakes Eucha and Spavinaw

Physical Characteristic	Eucha Lake (Upper Spavinaw)	Spavinaw Lake
Surface area	2807 ac	1575 ac
Drainage area above lake	203,902 ac	47,206 ac
Maximum Length	9.0 km	5.4 km
Length of shoreline	77.8 km	43.7 km
Maximum Width	2.04 km	1.67 km
Maximum depth	24.6 m	14.0 m
Mean depth	8.2 m	5.1 m
Volume	93,602,155 m^3	32,562,903 m^3
Retention time	0.34 yr	0.11 yr

Table I-3. Morphometric parameters of Lakes Eucha and Spavinaw

Morphometric Parameter	Eucha Lake (Upper Spavinaw)	Spavinaw Lake
Mean depth/maximum depth	0.32	0.36
Drainage area/surface area	72.64	29.97

2.0 Water Quality Standards and Target Limit

2.1 Water Quality Standards

Eucha Lake (Upper Spavinaw) and Spavinaw Lake are listed on the Oklahoma 2008 303(d) list [ODEQ 2008] for chlorophyll-*a*, total phosphorus and dissolved oxygen, with a target TMDL year of 2010, making them priority ranking 1. To target a water body for TMDL development, the specific pollutant target must be identified. The section of the Oklahoma Waters Quality standards listed below contains specific numerical phosphorus criteria for Eucha Lake (Upper Spavinaw) and Spavinaw Lake [OWRB 2008].

> PART 3. BENEFICIAL USES AND CRITERIA TO PROTECT USES
> 785:45-5-10. Public and private water supplies
> The following criteria apply to surface waters of the state having the designated beneficial use of Public and Private Water Supplies:
> (8) Phosphorus numerical criterion applicable to certain waters. The long-term average total phosphorus concentration at a depth of 0.5 meters below the surface shall not exceed 0.0168 milligrams per liter in Eucha Lake (Upper Spavinaw) and 0.0141 milligrams per liter in Spavinaw Lake.

These TMDLs were developed to meet the water quality standards for total phosphorus. The fishery beneficial use impairment resulting from low dissolved oxygen will be addressed at a future date.

2.2 Antidegradation Policy

Oklahoma antidegradation policy (OAC 785:45-3) requires protecting all waters of the state from degradation of water quality. The targets of this TMDL, resulting load reduction, in this report were set with regard for all elements of the Oklahoma Water Quality Standards which includes the antidegradation policy.

3.0 Impairment Analysis

3.1 In-Lake Water Quality Inventory

Several studies have documented water quality in Lakes Eucha and Spavinaw since impoundment. In recent years, both OCC [Wagner, K and S. Woodruff. 1997] and the Oklahoma Water Resources Board [OWRB 2002] have conducted lake studies. The bulk of the data used in this modeling was collected during the time of the OWRB study. During the OWRB Study (1998-2001) City of Tulsa staff performed routine field sampling. Additional sampling for aquatic macrophytes, lake sediment and morphometric measurements were performed by OWRB staff. Laboratory analysis or routine samples were provided by the City of Tulsa.

Over 800 lake samples and 400 tributary samples were taken over the course of this project. Figure I-2 shows the location of lake monitoring sites. Each sample was analyzed for 20 to 28 individual parameters encompassing physical, chemical, and biological aspects of water quality. These data provide the foundation for the lake modeling and water quality recommendations contained in this report.

3.2 Listing Confirmation and Magnitude of Impairment

This analysis represents the lake analysis that led to the listing decision and characterizes the magnitude of impairment, which in this case is measured by total phosphorus concentrations of the lakes.

3.2.1 Dissolved Oxygen Violations

Periods of hypolimnetic anoxia occur in both Eucha Lake (Upper Spavinaw) and Spavinaw Lake. Both the Clean Lake Report [Wagner, K and S. Woodruff. 1997] and the OWRB Report [OWRB 2002] based on the 1998 study indicate that the Eucha Lake (Upper Spavinaw) and Spavinaw Lake DO dynamics are typical of a eutrophic system This condition begins at the water-sediment interface because of high oxygen demand from sediment diagenesis. According to the Clean Lakes Report and OWRB data, hypolimnetic anoxia occurred approximately 2 to 3 weeks after stratification and continued through August. During the period of stratification from mid-April through mid-November, a significant portion of each lake was anoxic in the deep portion of the water column. Surface supersaturation of DO was observed, suggesting high algal productivity.

3.2.2 Total Phosphorus

Problems in Eucha Lake (Upper Spavinaw) and Spavinaw Lake include accelerated eutrophication and low DO. These problems have been mentioned in almost every recent report dealing with water quality in the lakes . Both these problems can be attributed, in varying degrees, to elevated phosphorus concentrations in the lakes. The numerical criterion for total phosphorus has been developed to address the impaired Public and Private Water Supply beneficial use. The most recent long term average total phosphorus concentrations in the lakes are consistently in violation of the standard. Therefore the objectives of the TMDLs established here are to develop load reductions necessary to meet the Water Quality Standards for total phosphorus.

3.3 Seasonal Patterns

According to the Clean Lake Report [Wagner, K and S. Woodruff. 1997] and the OWRB data [OWRB 2002], typical surface temperatures of the lake ranged from 5 °C to 32 °C. The lakes are vertically mixed in the winter and exhibit strong thermal stratification in the summer with a surface-bottom temperature difference of up to 18 °C.

The DO pattern, according to the Clean Lake Report and OWRB data, indicates that both Eucha Lake (Upper Spavinaw) and Spavinaw Lake have strong seasonal variability and are routinely in violation of the water quality standard, which requires that the anoxic volume (where DO is less than 2 mg/L) be less than 50 percent of the water column. More detailed data for DO and other nutrient parameters can be found in the recent reports by OCC and OWRB. These TMDLs do not specifically address the DO impairment but the reduction in phosphorus loadings could significantly impact these low DO concentrations.

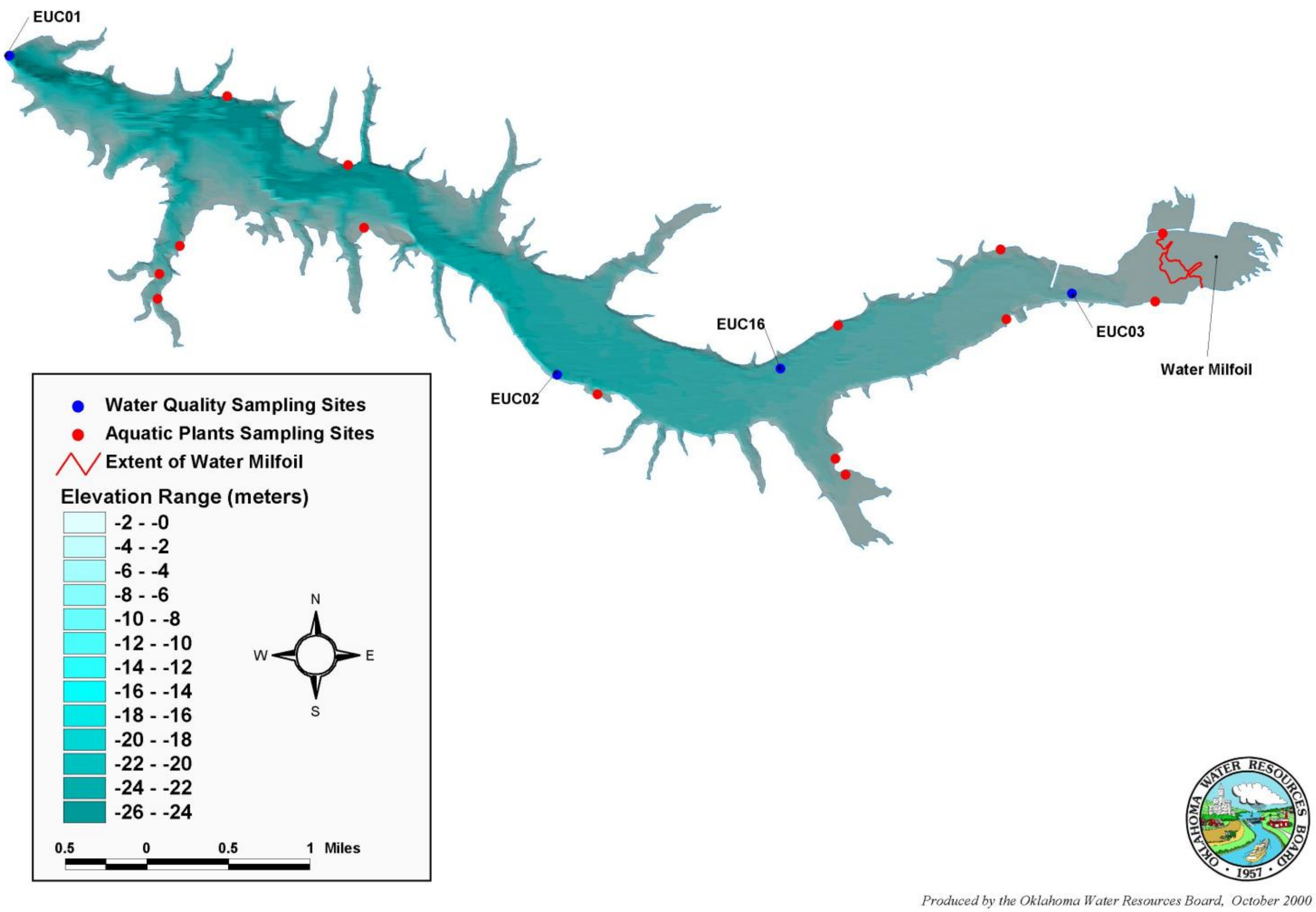

Figure I-2 Eucha Lake (Upper Spavinaw) Monitoring Sites and Bathymetric Map

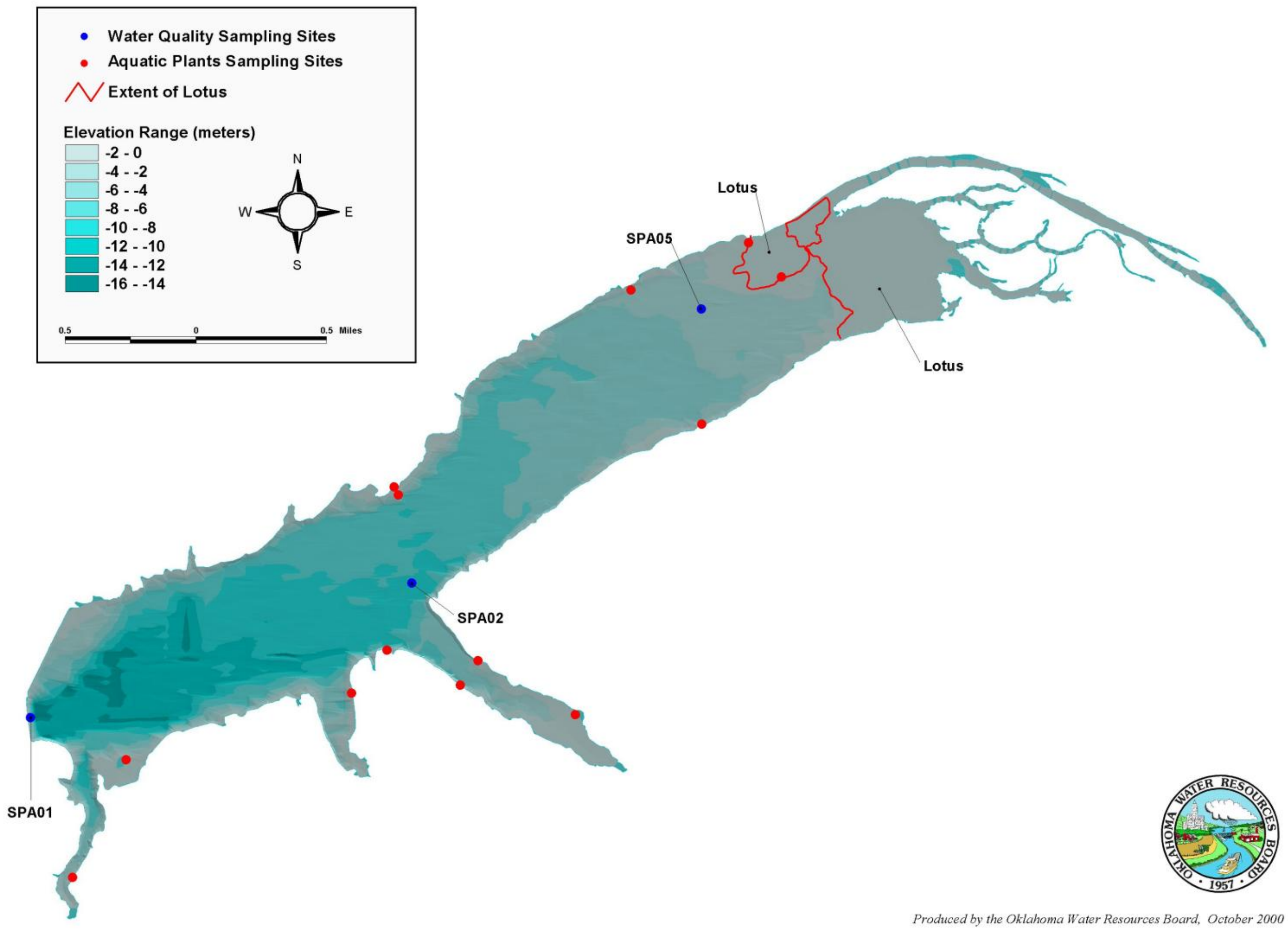

Figure I-3 Spavinaw Lake Monitoring Sites and Bathymetric Map

4.0 Source Assessment

This TMDL report examined the major potential sources of nutrients in the Eucha Lake (Upper Spavinaw) watershed. The source assessment was used as the basis for developing the modeling strategy and ultimate analysis of the TMDL allocation options. To evaluate sources, loads are characterized by the best available information, monitoring data, literature values, and local management activities. This section documents all the available information and interprets it for modeling analysis. Potential sources of nutrients include point sources (such as industries and municipal wastewater treatment plants), nonpoint sources (such as surface runoff from agricultural land), and atmospheric deposition.

There are no point sources discharging to the two segments covered by this document. The WLAs for the two segments are zero as shown in load table in accordance with court decisions made after the Clean Water Act and 40 CFR 130.7 were written. Information is provided below on point sources discharging to upstream segments. Because of the court decision the loads for these upstream facilities are shown under the Load Allocation for the two segments included in this document.

4.1 Assessment of Point Sources

Data retrieved from the Permit Compliance System showed that the City of Decatur, AR is the only major point source discharge in the Eucha Lake (Upper Spavinaw) watershed. Gravette, AR is the only other permitted point source municipal discharge in the watershed but its nutrient contributions to Eucha Lake (Upper Spavinaw) are considered less significant due to the intermittent nature of the discharge. The City of Decatur has been monitoring for total phosphorus, nitrate nitrogen and ammonia nitrogen since January 1998. This data was used to determine the nutrient loadings for the City of Decatur during the model calibration period.

The current permit for both the City of Decatur and Gravette include a 1 mg/l discharge limit for total phosphorus.

Decatur Wastewater Treatment Facility (WWTF)

Facility Location:

Section 11, Township 19 North, Range 33 West, Indian Meridian
Benton County, Arkansas

Point of Discharge:

Permit Number: AR0022292
Latitude: 36°-20'-35.94" N Longitude: 94°-28'-16.33" W
Planning Segment No. 120400

Current Wasteload Allocation (WLA):

Design Flow: 2.2 MGD
Limits: 10 mg/l $CBOD_5$, 15 mg/l TSS
10 mg/l NH_3-N, 1 mg/l Total Phosphorus

Gravette Wastewater Treatment Facility

Facility Location:

Sections 14, Township 20N, Range 33 West, Indian Meridian
Benton County, Arkansas

Point of Discharge:

Permit Number: AR0023833

Latitude: 36°-24'-46" N Longitude: 94°-27'-45" W
Planning Segment No. 120400

Current Wasteload Allocation (WLA):
Design Flow: 0.56 MGD
Limits: 20 mg/l $CBOD_5$, 20 mg/l TSS
4 mg/l NH_3-N, 1 mg/l Total Phosphorus

4.2 Assessment of Nonpoint Sources

Nonpoint sources of pollutants are typically separated into urban and rural categories. Surface storm runoff is an important source of loading in urban or residential settings with high amounts of paved impervious area. In rural settings, the amount of impervious area is usually much lower; but the sources of nutrients may include runoff of applied fertilizer and manure to agricultural land, runoff of animal wastes associated with the erosion of sediments in grazing fields, runoff from concentrated animal operations, contributions from wildlife, and failing septic tanks.

The Biosystems and Agricultural Engineering Department at Oklahoma State University [Storm, D.E., M.J. White, et al. 2001] did the nonpoint source loading analysis and estimates used to develop this TMDL. They utilized the Soil and Water Assessment Tool (SWAT) model in their assessment. Their analysis and results are detailed in the report *Modeling Phosphorous Loading for the Lake Eucha Basin*.

To spatially analyze nutrient loading, the Eucha Lake (Upper Spavinaw) and Spavinaw watershed was divided into 58 subwatersheds (Figure I-4). The delineation of the 58 subwatersheds was based on Digital Elevation Model data for the basin. Land cover was derived from Oklahoma and Arkansas GAP (Gap Analysis Program) data. The GAP categories were simplified to four categories with the final basin composition being 43.2% pasture, 55.0% forest, 1.7% water, and 0.1% urban. These data were then combined to produce a seamless coverage of the entire area (Figure I-5).

Observed stream and nutrient data was used to calibrate the SWAT model. Three stream gage stations and ten water quality stations were used in the calibration. The model was calibrated for total flow, surface flow, baseflow, soluble phosphorous, total phosphorous, and nitrate.

Streamflow at each of the three gages was first used to calibrate the model. The observed streamflow was split into surface runoff and baseflow. After hydrologic calibration the SWAT model was calibrated using observed nutrient data. Loadings used to calibrate the model were calculated at each station by developing a relationship between flow and observed nutrient concentration. The predicted loadings were compared to observed loadings at 10 water quality stations.

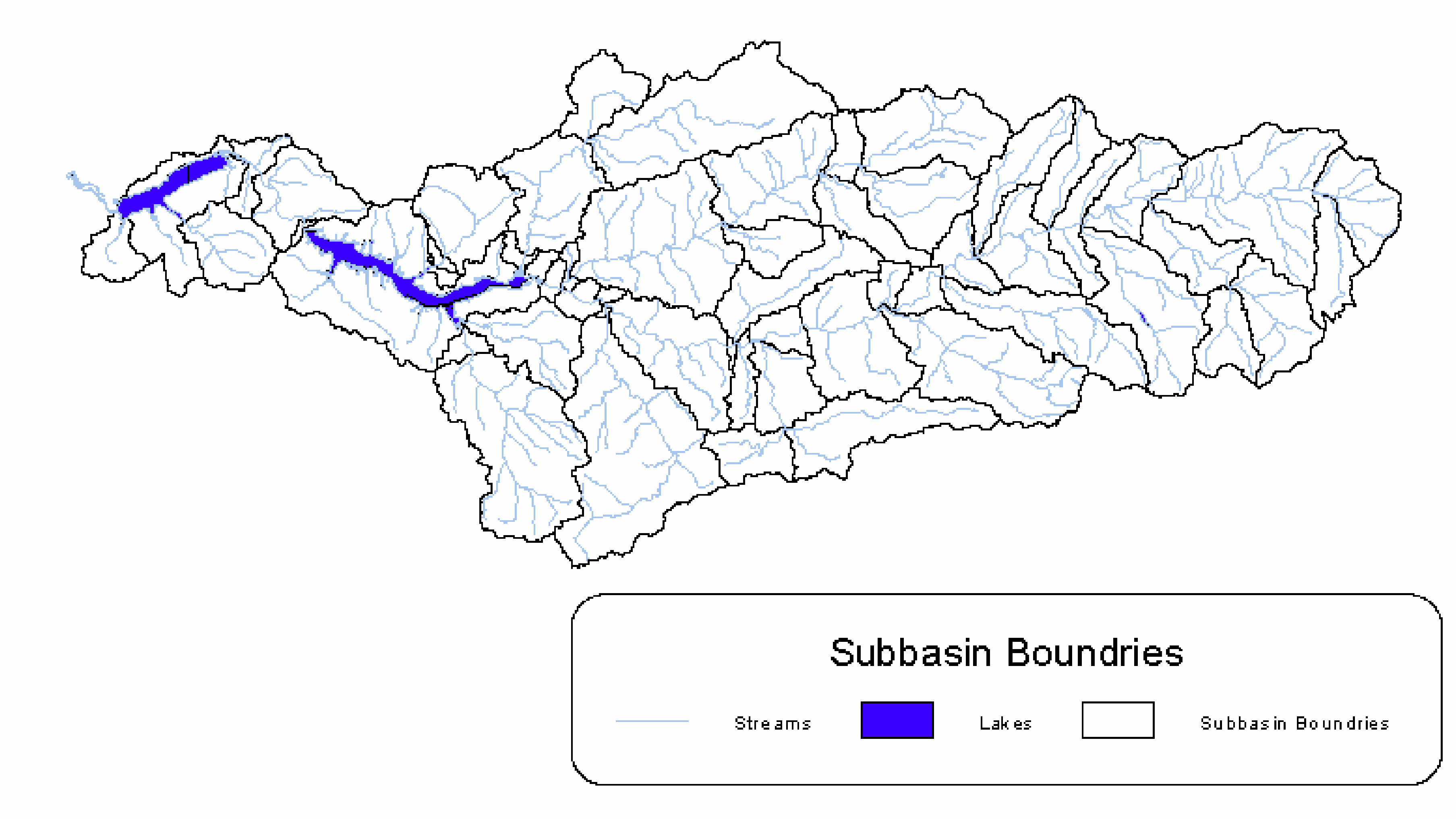

Figure I-4 Eucha Lake (Upper Spavinaw)/Spavinaw Subwatersheds

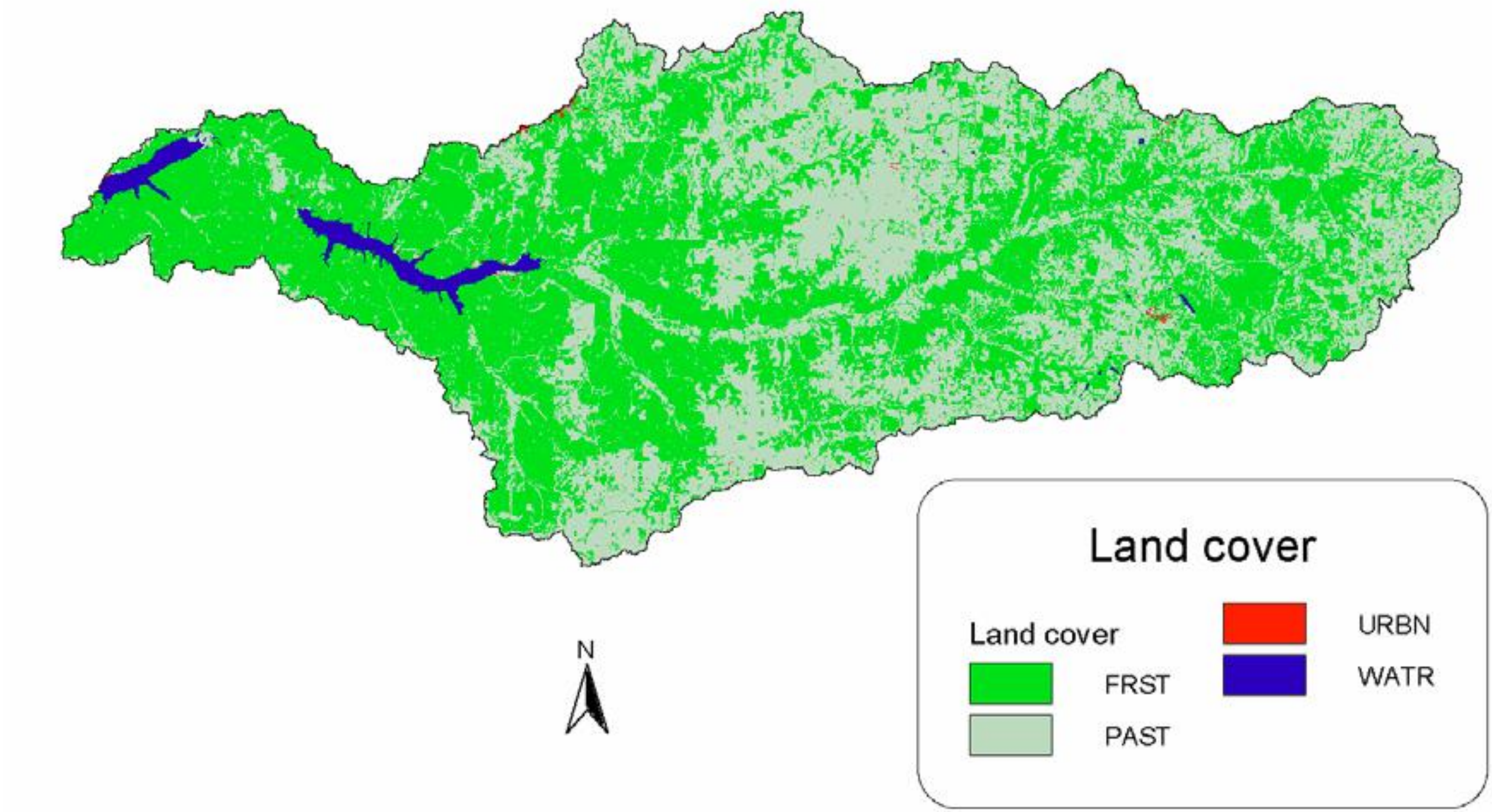

Figure I-5 Gap Analysis Project derived land cover for the Eucha/Spavinaw Basin

PART II. TECHNICAL APPROACH

Establishing the relationship between the Eucha Lake (Upper Spavinaw) water quality target and identified source loads requires an evaluation of management options that will achieve the desired source load reductions. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. This part discusses the selected modeling approach, continues with watershed loading analysis, and concludes with analysis and discussion of Eucha Lake (Upper Spavinaw)'s response to watershed loading. A detailed description of the modeling process is included in the 2002 OWRB report *Water Quality Evaluation of the Eucha/Spavinaw Lake System.*

1.0 Model Selection

To simulate the conditions and behavior of nutrient levels in Eucha Lake (Upper Spavinaw), a linked model regime was developed. This regime consists of a comprehensive watershed model (SWAT) linked to a lake water quality model.

1.1 Watershed Representation

The watershed representation is both a conceptual and a mathematic definition of the drainage area contributing to the listed water body. As described in Part I, Section 4 the SWAT model of the watershed developed by OSU was used to calculate point and nonpoint pollutant loadings to the lakes based on meteorological data, land cover and land use distribution, soil characteristics, and pollutant dynamics in the watershed.

1.2 Lake Representation

The BATHTUB model was used to predict in-lake concentrations of phosphorus and chlorophyll-a. Eucha Lake (Upper Spavinaw) and Spavinaw Lake were analyzed independently. Influent water quantity and the phosphorus concentrations of each lake provided by the data collection efforts were used as inputs to the models. Tributary stormwater runoff and baseflow were estimated from stream water quality and basin land use analyses developed by Oklahoma State University. The model was calibrated to existing lake conditions using data collected during the study.

Pollutant loads entering the lake were represented by the watershed model. Watershed loadings were carried into the lake model in the form of seasonal and annual average concentrations from a single tributary inflow representing Spavinaw Creek. The watershed generated output parameters were, Nitrate, Organic N, Mineral P and Organic P. In the lake model, total phosphorus was the sole focus of the nutrient budget.

1.3 Selection of Model Simulation Period

The BATHTUB model requires inputs for both flow and nutrients. It was determined that the best available data, which met those requirements, was by OWRB in 1999. The model was calibrated to observed inflow conditions. Watershed loadings were calibrated for a longer period to cover a wider range of climatic and hydrologic conditions within the drainage area. This also allows for a more representative analysis of source loading and in-stream conditions.

2.0 Source Loading Analysis

Potential nutrient sources were identified in Part I, Section 4. In Part I, nonpoint sources were initially evaluated according to available county data, which has an inherent accuracy, resolution, age, and scale. This section discusses numerical adjustments and representation of source loads in terms of base flow, point source loading, and surface runoff.

2.1 Point Sources

The City of Decatur was the only point source considered in this analysis. It is the only significant point source discharge in the Eucha watershed and is considered a major source of nutrients to the lake. The Clean Lakes Study (using data collected in 1993-1994) indicated that up to 27% of the phosphorus loading to the watershed comes from the Decatur discharge.

Pollutant loadings from the Decatur discharge were estimated using the facility's reported average monthly BOD_5, ammonia, nitrate total phosphorus (TP) concentrations and flows. These values were taken from PCS records.

2.2 Surface Runoff

The nonpoint sources discussed in Part I were represented in the model to account for their contribution of nutrients to the tributaries and lake via surface runoff. Table II-1 shows the SWAT predicted phosphorus load by source classification.

Source	Soluble P (kg/yr)	% of Total
Litter*	8649	27 %
Soil Phosphorus	5821	19 %
Deforestation	5460	18 %
Point Source	5278	17 %
Background	1147	4 %
Other	4819	15 %
Total	31174	100.%

*Conservative Estimate

Table II-1. Soluble P loading to Eucha Lake (Upper Spavinaw) as predicted by SWAT.

3.0 Lake Model Testing

Output from the watershed model represented the total nutrient loading to Eucha Lake (Upper Spavinaw). The Eucha Lake (Upper Spavinaw)/Spavinaw Lake models were calibrated to re-create the existing condition in the lake. As discussed in Part I, water quality conditions in the lakes were measured at a number of sampling stations. The models were then calibrated to the average conditions for the lake.

4.0 Source Response Evaluation

Model-data comparison analysis for various model input parameters are discussed in more detail in the OWRB report.

PART III. ALLOCATION ANALYSIS

1.0 Margin of Safety

The margin of safety (MOS) is designed to account for lack of knowledge in calculations and is a required element of a TMDL. In this situation an implicit MOS was used based on predictive model runs that incorporate a variety of conservative assumptions (i.e., assume point source discharge at the maximum permitted amount; the average rainfall amount in the sample seasons were above the long-term rainfall average).

2.0 Total Phosphorus TMDL

Using the both the Eucha Lake (Upper Spavinaw) and Spavinaw Lake models, reduction scenarios were performed by reducing nutrient loadings to determine the total phosphorus load reductions required to reach the target criteria. Both the Eucha Lake (Upper Spavinaw) and Spavinaw Lake models were run at average annual flow. The average annual stream flow to Eucha Lake (Upper Spavinaw) was 284.3 hm3/year or 318.4 cfs. Outflow from Eucha Lake (Upper Spavinaw) together with the flow from subbasins between the two lakes (261 + 19 = 280 hm3/year or 313.6 cfs) was the inflow to the Spavinaw Lake model.

The model predicted decreased chlorophyll-a concentrations through reductions of in-lake phosphorus concentration. Moreover, the lake model directly related this phosphorus concentration to external annualized load. The model for Spavinaw Lake shows that a 44.6 percent reduction of phosphorus load to Spavinaw Lake is predicted to meet the Water Quality Standard for total phosphorus of 0.0141 mg/l (Table III-1). A 44.6 percent total phosphorus load reduction does not come close to pristine conditions, but does represent a break point of just less than one-half algae biomass and should result in significant reduction of taste and odor problems.

Since the two reservoirs are inextricably linked, required phosphorus load reduction for Spavinaw Lake must be achieved through the phosphorus load reduction for Eucha Lake (Upper Spavinaw). In order to achieve the 44.5 percent reduction rate and numeric criteria of 0.0141 mg/L in Spavinaw Lake, a 70.4 percent reduction of phosphorus load to Eucha Lake (Upper Spavinaw) is necessary. At the 70.4 percent phosphorus load reduction for Eucha Lake (Upper Spavinaw), the phosphorus concentration in Eucha Lake (Upper Spavinaw) is predicted to be 0.0168 mg/l.

	Reduction	*Criterion Concentration*	*Target Ambient Concentration*	*Existing Concentration*	*TMDL*
	%	(mg/l)	(mg/l)	(mg/l)	kg/day
Pristine Conditions (No Impact)					
Eucha Lake (Upper Spavinaw)	95		0.0048	0.0258	5.14
Spavinaw Lake	80		0.0060	0.0229	4.75
BATHTUB Simulation					
Eucha Lake (Upper Spavinaw)	70.4	0.0168	0.0168	0.0258	30.49
Spavinaw Lake	44.6	0.0141	0.0141	0.0229	13.13

Table III-1. Total Phosphorus Reduction (%) & TMDL

The resultant TMDL's for the two lakes are broken down further in Table III-2. The USEPA Region VI recommends TMDLs not refer to upstream segments or out-of-state upstream loads as "wasteload allocations", and include an assumption of an aggregate Load Allocation from upstream equal to the total from the segments in Oklahoma and in Arkansas that include both point and non-point sources. Therefore, the loading from the two point sources, based on the current permit limits for both the City of Decatur and the City of Gravette, is combined into the load allocation portion of this TMDL.

	Total Maximum Daily Load	Wasteload Allocation	Load Allocation	Margin of Safety
	kg/day	kg/day	kg/day	kg/day
Eucha Lake (Upper Spavinaw)	30.49	0	30.49	Implicit
Spavinaw Lake	13.13	0	13.13	Implicit

Table III-2. Total Maximum Daily Load: Total Phosphorus

3.0 Recommendations

Due to the inherit lake of knowledge in the models and the magnitude of the predicted reductions. The ODEQ recommends the implementation of a TMDL with the initial NPS reductions corresponding to those provided in the court settlement between the City of Tulsa and the poultry producers. This should involve an estimate of the loading reductions that can be achieved through best management practices (BMP's), control technologies and other management scenarios along with their implementation. Adaptive management principles can be applied to improve the efficiency of the installed BMPs, propose different BMPs or a different quantity of BMPs. Adaptive management can also result in the reduction in the quantity of BMPs if the water quality criterion and the beneficial use are being met. The Water Quality Management Plan has a built in update process to account for changes in the information that shapes water quality management decisions. The federal regulatory process involves the public, requires certification by the Governor and approval by the Administrator as each group of changes is made to the state plan.

The City of Decatur and the City of Gravette's permitted phosphorus limit has already been changed to 1.0 mg/l. This TMDL report will not affect the two facilities and no further phosphorus reduction is recommended for these two facilities.

After implementation of these reductions the lake water quality should be evaluated to see what impact these reductions have had.

PART IV. PUBLIC PARTICIPATION

This TMDL report was sent to other related state agencies and local government agencies for peer review. Then the report was submitted to the EPA for technical review and approval. The report was technically approved by the EPA on July 10, 2009. A public was published on July 23, 2009 and the report was made available for public review and comments. The public comment period started on July 23, 2009 and ended on September 8, 2009. Five written comments were received.

All comments were responded and the report was updated accordingly. The response to comments was included in Appendix A of this report.

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APPENDIX A

Response to Comments

Comments from Quang Pham at ODAFF

Comment #1: Since Spavinaw Lake is a major part of this TMDL, it is suggested that the title of this study be: "TMDL Development for Spavinaw Creek Watershed including Lakes Eucha & Spavinaw"
***Response**: The title was modified to "TMDL Development for Lakes Eucha and Spavinaw in Oklahoma".*

Comment #2: Page 14, part III, sec.1.0: Margin of Safety and Table III-2: Since implicit approach for Margin of Safety is applied in this TMDL, the conservative assumptions made in the TMDL development should be further delineated for clarity.
***Response**: Average rainfall in sample seasons was added as another reason for using implicit Margin of Safety.*

Comments from Arkansas Department of Environmental Quality (ADEQ)

Comment #3: The Arkansas Department of Environmental Quality (ADEQ) was provided a copy and has completed a review of your July 2009 Draft "TMDL Development for Eucha Lake (Upper Spavinaw) & Spavinaw Lake Watershed in Oklahoma". ADEQ's comments can be summarized into three primary issues: inaccurate load allocations, the apparent lack of analysis of existing conditions within the water shed, and the apparent use of obsolete data in the development of load allocations.

The recommendations in the TMDL must be clearly stated, including how the proposed Load Allocation (LA) of 30.49 kg/day or 67.22 lb/day should be applied. It is unclear as to whether the LA is for point and non-point sources in Arkansas, Oklahoma, or both. It is also unclear how simply stating that the City of Decatur has a phosphorus limit of 1.0 mg/L is a recommendation. Furthermore, per a telephone conversation my staff' had with EPA on August 14, 2009, concerning this TMDL, it is understood that this TMDL should mention that the cities in Arkansas are not causing an impairment of the lakes and that this TMDL is only for the State of Oklahoma point sources and non-point sources. Therefore, we are asking ODEQ to revise this TMDL to clearly state its recommendations.
Response #3*: The Load Allocation (LA) of 30.49 kg/day was derived from the lake model which includes all nonpoint sources in Oklahoma and point and non-point sources in Arkansas. The DEQ was advised by EPA to include point sources in Arkansas in the LA since Oklahoma does not have authority to regulate these point sources.*

The following language was added to the recommendation: "This TMDL report will not affect the two facilities and no further phosphorus reduction is recommended for these two facilities".

Comment #4: Section 2.1 (Point Source) stated that "The Clean Lake Study indicated that up to 27% of the phosphorus loading to the watershed comes from the Decatur discharge." ADEQ has concluded that this statement was not correct even at the time the study was conducted, i.e. in 1997 (see below for explanation), The same statement is even more questionable in 2009 due to the drastically lower Total Phosphorus (TP) loads discharged from the City of Decatur. The source used to evaluate the point sources was the Wagner, K and S, Woodruff. 1997, *Phase I Clean Lake Project Diagnostic and Feasibility Study of' Lake Eucha,* Oklahoma Conservation Commission, Water Quality Division. A review of this report shows that performance data from 1993-1994 was used for all the analysis. At that time, the City of Decatur did not monitor for TP. Four different methods were used to estimate TP loads in the watershed. The specific method used for the City of Decatur estimated TP levels using measured ammonia and nitrate levels. The report estimated that Decatur discharged 8,153 kg (17,972 lbs) of TP. On page 50 of the report this statement, (which was later used in TMDL report), was made *"If all the phosphorous and nitrogen discharged from Decatur during the study reached the lake, then Decatur would be responsible for* 27% *of the total phosphorous* ". Four paragraphs below (on the same page) the following statement was found *"The data indicate that a large amount of phosphorous is being assimilated in the watershed Only* 2.5% *of the phosphorous input into the watershed (from both point sources and confined animals) is currently reaching the lake."* It appears that these two statements contradict each other. If only 2.5% of TP was reaching the lake, obviously all the TP from Decatur could not reach the lake, so Decatur could not be responsible for 27% of the total load even at that time.

***Response #4**: The TMDL report quotes the Clean Lakes Study using data collected in 1993 – 1994 as stating "up to 27% of the phosphorus loading to **the watershed** comes from the Decatur discharge". At that time, there was no data showing exactly how much phosphorus the City of Decatur was discharging. Therefore, the 27% phosphorus loading was an estimate. The DEQ recognizes that this is not the case currently because a phosphorus limit of 1.0 mg/L has been established for the City of Decatur. The phosphorus concentration used in the SWAT model was 6.53 mg/L which was based on monitoring data from 1998 to 2000. Huge reduction from the City of Decatur has been achieved.*

The DEQ agrees that not all the TP from Decatur could reach the lake. According to the SWAT model, 78% of the phosphorous added by the point source reaches the lake. As a result of this comment, the time reference of the Clean Lakes Study was added in the report.

Comment #5: Based on EPA guidance concerning the development of TMDLs, it appears some important guidelines were not followed and contributions from all potential sources were not evaluated. The impacts from known land application activities in the Beatty Creek watershed were not discussed along with any developments on the Corps of Engineers lakes. Additionally, the nonpoint source evaluation of the watersheds was modeled by land use category, but there is no evidence of data generated for any of the tributaries except Spavinaw Creek. EPA guidance also supports defining applicable critical conditions and to [sic] describing the approach for estimating both point and nonpoint source loadings under such critical conditions. In particular, the TMDL should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

The scientific evidence and literature documents the dynamic relationships between total phosphorus, dissolved oxygen and temperature among other parameters in lentic and lotic environments. The analysis of these relationships as they exist in this watershed is absent. The evaluation of this dynamic process is critical to correctly place allocations in the water in order to protect both Eucha and Spavinaw lakes.

***Response #5**: The DEQ believes the report meets EPA's requirements for TMDL development. The items mentioned in this comment are recommendations not requirements. The DEQ received technical approval from them before the report went for public comments. No change was made as a result of this comment.*

Comment #6: ADEQ would like to express concern for the time frame of data that was used to develop the TMDL. Based on statements made in the TMDL and ADEQ's knowledge of current data collection in the Eucha/Spavinaw watershed, more recent data was available and should have been considered during development of this TMDL. Specifically, the lake evaluations used for this

document appear to be from a Clean Lake report from 1997 and an Oklahoma Water Resources Board (OWRB) report from 2002. The OWRB web site shows Beneficial Use Monitoring Program (BUMP) data from 2006 and 2007 for these lakes. It appears this more recent data was ignored for the development of the TMDL even though the water quality reported appears much improved from the 2002 data. By using data from 2002 and before, the TMDL has also failed to evaluate the resulting changes from the Arkansas Nutrient Management Program that limits the chicken litter applications in this region along with any similar program in Oklahoma.
***Response #6**: the BUMP data is only limited to the lakes. The BUMP monitoring program was not designed for TMDL development. A lot more data from both the lake and streams will be needed to make a meaningful update in the water quality models. The best set of available data at the time of the study was used for this TMDL development. No change was made as a result of this comment.*

Comment #7: Data used for Arkansas' point source dischargers into the watershed is out of date in all cases and completely incorrect in some cases. Specifically, the statement that "Recent estimates of the Decatur National NPDES discharge data indicate that 11,600 kg of phosphorus are discharged a year to the Lake Eucha basin." appears greatly overstated. The City of Decatur has monitored for TP since 1998. In October 2006, an effluent limitation of 1.0 mg/L for TP was included in the NPDES permit. Based on current information, ADEQ calculated the load discharged from the facility between March 2008 and February 2009 to be 2,858 lbs (1,296 kg).

In addition, based on recent monitoring data (AR0003) at the Arkansas-Oklahoma state line along with mean flow data from the United States Geological Service (USGS), a calculation of the loading from Spavinaw Creek shows that approximately 7,136 lb/year (3,237 kg/year) or 20 lb/day (9 kg/day) is discharged into the watershed from Arkansas contributions. It should be noted that the soluble portion is much less than the measured TP. Therefore, the Arkansas contribution from both point and non-point sources is far less than the value reported in the TMDL.
***Response #7**: The DEQ believes that the phosphorus load from Decatur was accurately used in the TMDL calculation. On page 9, the TMDL report states that "The City of Decatur has been monitoring for total phosphorus, nitrate nitrogen and ammonia nitrogen since January 1998. This data was used to determine the nutrient loadings for the City of Decatur during the model calibration period". No change was made as a result of this comment.*

Comment #8: The Department hopes that the above comments will be considered prior to finalization of the TMDL, and therefore suggests the re-development of the TMDL.
***Response #8**: The DEQ understands that a lot of changes have been made in point sources and non-point source practices. For example, 1.0 mg/L phosphorus limit was included in discharge permits for the City of Decatur and the City of Gravette. A court ruling prohibits application of*

chicken litter on land with soil test P greater than 300 mg/kg. As a result, chicken litter was hauled off the watershed. These positive changes will contribute to the overall reduction goal set in this TMDL. The DEQ believes that this TMDL was developed using the best available data at the time it was collected and therefore re-development of the TMDL is not necessary. However, the TMDL report recommends that the lake water quality should be evaluated to see what impacts these reductions have had. It is worth noting that the impact of some phosphorus reduction measures such as hauling chicken litter off the watershed may take years to be observed in water quality monitoring. No change was made as a result of this comment.

Comments from Tyson Food, Inc

Comment #9:
I write on behalf of Tyson Foods, Inc. (Tyson) regarding the draft Clean Water Act Total Maximum Daily Load (TMDL) for Eucha and Spavinaw Lake watershed that was developed by the Oklahoma Department of Environmental Quality (ODEQ). Tyson respectfully submits the following comments regarding the document entitled, "TMDL Development for Eucha Lake (Upper Spavinaw) & Spavinaw lake watershed in Oklahoma."

- As a general matter, Tyson agrees with ODEQ that "after implementation of these reductions (referring to the City of Tulsa vs. Tyson et al. settlement agreement) the lake water quality should be evaluated to see what impact these reductions have had."
- An article written by Dr. Andrew Sharpley entitled, "Phosphorus-Based Nutrient Management in the Eucha-Spavinaw watershed: Results, Accomplishments, and Opportunities" further explains some of the key reductions alluded to the TMDL document. For the record, a copy of the article is attached. Some of these key findings include:
  1. 74% of poultry litter produced in the Eucha / Spavinaw watershed was hauled outside of the watershed between 2004 and 2007.
  2. Between 2004 and 2007, only 7% of the total acreage in the Eucha / Spavinaw watershed was fertilized with poultry litter.
  3. A reduction in average little application rate from 2004 and 2007 of 1.5 tons per acre to 1.2 tons per acre. According to Dr. Sharpley's article, land application rates of poultry litter prior to the settlement were 3 to 5 tons per acre.

Response #9*: Thanks for the reference. The reductions in poultry litter will contribute to meet the TMDL reduction goal. No change was made as a result of this comment.*

Comment #10:
- The SWAT model used in Part II, Technical Approach" of the TMDL is not reliable for the following reasons:
  1. The poultry litter application rates assumed in the model are incorrect. First, paragraph one, page six of the model states, "all litter generated in the sub-basin was assumed to the applied in that sub-basin." That is not an accurate depiction of actual management practices in the watershed. As stated above 74% of all litter produced has been land applied outside of the watershed from 2004 through 2007. Second, the Judge in the City of Tulsa vs. Tyson et al. case set a 300 mg/kg soil test phosphorus threshold. Therefore, any field with soil test phosphorus greater than the threshold cannot receive litter. Thus, assuming that all pasture in a watershed receives litter is factually incorrect.

2. Not all observed phosphorus inputs were used to calibrate the model. Examples include:
   - Phosphorus from forested areas in the watershed was not used. According to the model report, soil test phosphorus observations were unexpectedly high in forested portions of the basin," therefore the author did not use actual data from the watershed to calibrate the model. Instead of using forested areas within the watershed for modeling purposes, an "undisturbed forested area in north central Arkansas" was used for SWAT simulations.
   - Non-vegetated areas such as unpaved roads, riparian erosion sties, construction sites, and other sediment loading areas were not included in the model despite the author stating, "some of these very small area may contribute a thousand times more sediment than a pasture of the same area. Although significant, they cannot be simulated with the current available data." If these areas are "significant" it is invalid to assign load to other sources and not to these "significant" sources.
3. In City of Tulsa v. Tyson et al., the court rules that, "Dr. Storm may not testify as to percentage allocations of phosphorus loading attributable to particular land uses as derived from the SWAT model." Additionally, the court ruled, "The SWAT model outputs resulted in different percentages of allocation each separate time the SWAT model was run by Dr. Storm. These varying results, combined with the lack of validation and the exclusion of potentially significant phosphorus sources from the model, reduces the reliability of the percentage allocations of phosphorus loading and renders them inadmissible for legal causation purposes."
4. Tyson asserts that if a Federal Court deems this work is inadmissible in a court proceeding, then the model should not be used to determine percent allocations in a TMDL.

Response #10:

1. *The SWAT model was calibrated using the water quality data collected during a three year study started in 1998. The SWAT was set up to simulate the watershed conditions for that time. The reductions made since then will contribute to meet the reduction goal of the TMDL.*

2. *Soil test phosphorus (Mehlich III extraction phosphorus) observations do not match exactly to soil phosphorus inputs used in SWAT. In fact, Dr. Storm adjusted ALL labile soil phosphorus input to the model, including both pasture land and forest, based on soil test P results, soil phosphorus algorithm in the SWAT model code, and his experience in applying the model. The DEQ believes that what eventually went into the SWAT model represented the best scientific understanding of labile phosphorus levels in both pasture land and forest in the study area and was appropriate for TMDL development. In addition, the total phosphorus loadings predicted by the SWAT model were calibrated against the observed loadings at 10 monitoring*

stations throughout the watershed. Therefore, the total phosphorus loading to the lakes was reasonably predicted by the SWAT model.

3. *The SWAT model was used to simulate the total load to the lake. The model was not used to determine the percent allocations for any point sources or non-point sources. The court ruled that the SWAT model could not be used to determine percent allocations. But the other uses of the SWAT model are still valid.*

   No change was made as a result of this comment.

Comments from Cherokee Nation

Comment #11:

1. As this waterbody resides in the historic and legal territory of the Cherokee Nation, it is under the jurisdiction and authority of the Cherokee Nation.
2. The water quality standards established by the Oklahoma Department of Environmental Quality (0.0168 milligrams per liter in Eucha Lake (Upper Spavinaw) and 0.0 141 milligrams per liter in Spavinaw Lake) are protective of water quality in those water bodies, but likely unachievable under present technology by just implementing load reductions (see item 6).

***Response #11**: The phosphorus water quality standards for Eucha Lake and Spavinaw Lake were established by the Oklahoma Water Resources Board. It is possible to achieve these standards. Please refer to response #14 & #17 for more information. No change was made as a result of this comment.*

Comment #12:

3. The assignment of load sources is not consistent. Section 2.1, "Point Sources" states that the City of Decatur's wastewater treatment plant contributed 27 percent of total load during the period assessed, yet Table Il-I "Soluble P loading to Eucha Lake (Upper Spavinaw) as predicted by SWAT" indicates only 17 percent came from the point source, while 27 percent was from poultry litter. It is neither unreasonable nor unusual for model results to deviate from monitoring results, as apparently happened in this case. However, given the significance of those differences, they should be addressed in the Waste Load Allocation and Waste Load Reduction phases of the report.
4. The location of the point sources (Decatur and Gravette, AR) should be indicated in Figure 1-1.

***Response #12**: The "27 percent" reference comes from the Clean Lakes Study which was done earlier than the time period of this study. The data for this TMDL study was collected from 1998 to 2000. The "17 percent" applies to the study period. Now, the phosphorus from Decatur is much smaller portion than it used to be. The locations of Decatur and Gravette's discharges were clearly stated in Part I, Section 4.1. No change was made as a result of this comment.*

Comment #13:

5. The estimates of load reductions to achieve those standards (44.6 percent for Lake Spavinaw, and 70.4 percent for Lake Eucha) are not indexed to a time period. Are the load estimates from modeled scenarios from pre-settlement application of poultry litter, and pre-reduction of Decatur's WWTP TP limit? These criteria must be established in order to benchmark reductions in loads from changes in activities in the watershed. The concern is that without benchmarking the load allocations will continually be ratcheted down without appropriate feedback to policy or incentives.

***Response #13**: The water quality data used in this study were collected from 1998 to 2000. Therefore, these reduction goals were indexed to the year 2000. Any positive changes made after*

2000 will contribute the load reduction goal of this TMDL. No change was made as a result of this comment.

Comment #14:

6. According to Table 11-2, reduction of all anthropocentric loads (litter and point source) to Lake Eucha (Upper Spavinaw) will only result in 44 percent reduction in total loads. The target reduction is unachievable by any measure.

Response #14*: The DEQ believes that the referenced table should be Table II-1 on page 14 of the TMDL report. According to this table, only background load (4%) is not related to human activities. All other sources could be anthropocentric loads. Therefore, it can be expected that positive actions taken by stakeholders in the watershed should go a long way towards achieving the reduction goals. No change was made as a result of this comment.*

Comment #15:

7. Unless strategies are implemented to address excess soil phosphorus, restore forests, and reduce background levels, this TMDL will never succeed. The imposition of economic hardship on municipal and agricultural communities for a policy that will not succeed is illegitimate governance and should not proceed. This TMDL is fatally flawed in that regard.
8. Load allocations should be made based upon major geopolitical boundaries - AR and OK, in particular (see Item 7).

Response #15*: The purpose of the TMDL is to establish a reduction goal and a maximum daily load to protect Eucha Lake and Spavinaw Lake so that all entities can work towards achieving the reduction goal. The DEQ understands that achieving these goals is a significant challenge for the stakeholders in the watershed. A court ruling prevented the use of the SWAT model to determine percent allocations. No change was made as a result of this comment.*

Comment #15:

9. From Page 16: "The resultant TMDL's for the two lakes are broken down further in Table 111-2. The USEPA Region VI recommends TMDLs not refer to upstream segments or out-of-state upstream loads as "wasteload allocations", and include an assumption of an aggregate Load Allocation from upstream equal to the total from the segments in Oklahoma and in Arkansas that include both point and non-point sources.. (sic)" There are two periods at the end of the second-to-last sentence of the first paragraph on page 16.

Response #15*: The typo was corrected.*

Comment #16:

10. The approach indicated in this TMDL does not allocate loads to the watershed. This is not very useful; the upstream point source, Decatur, AR, could be contributing as much as 27 percent of total load, according to the TMDL report.

Response #16*: A court ruling prevented the use of the SWAT model to determine percent allocations. No change was made as a result of this comment.*

Comment #17:

11. The reason for this aggregation appears to be to continue the implementation of poultry litter BMPs under an adaptive management strategy and revisit the issue over some unprescribed schedule to assess achievement. There are several problems that must be addressed:
    a. No schedule for monitoring, adaptation, or assessment are provided. This is a fatal flaw in this TMDL, making it all but ineffective.
    b. The point source has been reduced by as much as 90 percent (new NPDES limit for TP is 1.0 mg/L), achieving as much as 25 percent load reductions to the reservoir. Is that considered as 35 percent success in meeting the Lake Eucha goal? What mechanism is in place for characterizing successes, and remedying failures?
    c. Where is the NPS load coming from? OK? AR? This is critical for implementing NPS reduction strategies, even WITH the Tulsa/poultry company settlement.
    d. Do NPS load reductions achieved in recent years under the settlement get consideration? How? When?
    e. If all poultry and point source loads in the watershed were removed (46 percent), how will the 60 percent reduction of the remaining 54 percent of loads be achieved in order to meet the desired 70 percent load reduction? Without this strategy, this TMDL is not complete, and future attainment of water quality standards in the listed waterbodies is not possible.

Response #17*: The DEQ agrees that monitoring of both streams and lakes is necessary to evaluate the impact and effectiveness of reductions in point and non-point sources. However, providing a schedule for future monitoring is not required for a TMDL development.*

Because the TMDL reduction goal was established based on data collected from 1998 to 2000, any reductions made after 2000 should be counted towards achieving the TMDL reduction goal.

The watershed contains drainage area in both Oklahoma and Arkansas. Therefore, NPS load comes from both states. There is no point source in Oklahoma. The phosphorus load from Decatur and Gravette was counted as non-point sources because they are in Arkansas and Oklahoma has no authority to regulate them.

If all poultry and point source load in the watershed were removed, the soil phosphorus will be reduced overtime. Phosphorus loads from deforestation and other sources are also related to anthropocentric activities and may be reduced. Therefore, it should be possible to make significant strides towards achieving the reduction goals though it may be very difficult.

No change was made as a result of this comment.

Comments from Oklahoma Cattlemen's Association

Comment #18:

On behalf of the Oklahoma Cattlemen's Association, Oklahoma Farm Bureau, Oklahoma Poultry Federation, Oklahoma Pork Council, and the American Farmers and Ranchers, I write to respectfully request an extension to the comment periods for the following TMDLs: Lower Cimarron River and Skeleton Creek Draft TMDL, Eucha Lake/Spavinaw Creek Draft TMDL, North Canadian Draft TMDL, and Salt Creek and Sand Creek Draft TMDL.

As you are aware, we have been reviewing these TMDLs. As part of our review, we made an official open records request for records related to one of the four TMDLs (DEQ Public Notice of Draft Bacteria TMDL for the North Canadian River in the Oklahoma City Metropolitan Area and the Oklahoma River).

Your office very graciously fulfilled our request. We were invited to ODEQ headquarters to review the requested data. Upon arrival we were presented with 30 boxes of information. We thank you for providing this information.

However, because of the volume of information provided, we are unable to adequately process this information in time to meet the deadlines for public comment. While we have focused our attention on the aforementioned TMDL we have grave concerns about the methodology used in all four of the TMDLs and therefore the findings and conclusions contained in each.

We respectfully request the deadline for public comment be extended to December 31, 2009 for all pending TMDLs. Reports of this size and scope should be properly vetted and we appreciate your consideration of this request.

***Response #18**: The information presented in this comment does not justify extending public comments period for Lakes Eucha and Spavinaw TMDLs.*