2007 Report of the Oklahoma BENEFICIAL USE MONITORING PROGRAM

Lakes Report

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OWRB

OKLAHOMA WATER RESOURCES BOARD

the water agency

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PLATES

LIST OF TABLES

EXECUTIVE SUMMARY

Beneficial Use Monitoring Program Goal:

The goal of the Beneficial Use Monitoring Program is to document beneficial use impairments, identify impairment sources (if possible), detect water quality trends, provide needed information for the WQS, and facilitate the prioritization of pollution control activities.

The Beneficial Use Monitoring Program exists as a result of the vital economic and social importance of Oklahoma's lakes, streams, wetlands, and aquifers and the associated need for their protection and management. The data contained in this report is scientifically defensible and has been collected and analyzed following procedures outlined in Use Support Assessment Protocols (USAP), developed by Oklahoma Water Resources Board with input and concurrence of Oklahoma's other environmental agencies. Specifically, USAPs establish a consistent method to determine if beneficial uses assigned for individual waters through Oklahoma Water Quality Standards (WQS) are being supported. The legitimacy of data analyzed following protocols other than those outlined in the USAP (or the Oklahoma Continuing Planning Process (CPP) document where the USAP is silent) for use support determination is not appropriate. If the BUMP report indicates that a designated beneficial use is impaired, threatened, or otherwise compromised, measures must be taken to mitigate or restore the water quality.

The Oklahoma Water Resources Board (OWRB) has worked diligently to follow the guidelines outlined in the USAP. Recommendations in this report should be consistent with recommendations for the state's 303(d) list. Although certain inconsistencies do exist, every effort has been taken to assure compatibility between the BUMP Report and the 303(d) list. Issues regarding stream/lake segmenting additional data from non-BUMP sources and unique non-representative conditions all affect the impairment decision-making process

Traditionally, the State of Oklahoma has utilized numerous water monitoring programs conducted by individual state and federal agencies. In general, each environmental agency designs and implements its own program with only limited participation from with other state, municipal, or federal entities. These programs collect information for a specific purpose or project (e.g., development of Total Maximum Daily Loads, WQS process, lake trophic status determination, water quality impact assessments from non-point and point source pollution, stream flow measurement, assessment of best management practices, etc.). Therefore, the information is specific to each project's data quality objectives (DQOs) and is often limited to a very small geographic area.

To synchronize Oklahoma's monitoring efforts related to water quality, the State Legislature appropriated funds in 1998 to create the Beneficial Use Monitoring Program under the direction of the Oklahoma Water Resources Board, who promulgates the WQS and WQS Implementation Rule. The BUMP brings the OWRB's overall water quality management program full circle. From the promulgation of WQS, to permitting and enforcement of permits stemming from WQS-established criteria, to non-point source controls, all agency water quality management activities are intended to work in concert to restore, protect, and maintain designated beneficial uses.

The specific objectives of the BUMP are to detect and quantify water quality trends, document and quantify impairments of assigned beneficial uses, and identify pollution problems before they become a pollution crisis. This report interprets current Oklahoma Lake data collected as part of the comprehensive, long-term program. As the program has matured, the BUMP report has become one of the most important annually published documents in Oklahoma.

BENEFICIAL USE MONITORING PROGRAM COMPONENTS

- **Monitoring Rivers & Streams** - The OWRB is currently monitoring approximately one hundred thirty (130) stations on a monthly basis. These sites are segregated into two discrete types of monitoring activities. The first monitoring activity is focusing on fixed station monitoring on rivers and streams and the second monitoring activity focuses on a number of sample stations whose location rotate on an annual basis. The two monitoring components are explained below.

    - **Fixed Station Monitoring on Rivers & Streams** - - Fixed station monitoring is based largely upon the sixty-seven (67) United States Geological Survey 8-digit hydrologic unit code (HUC) basins present in Oklahoma. In general, at least one (1) sample station was located in all of the HUC watersheds with the exception of some of the smaller HUC watersheds adjacent to the state line or in a HUC that does not contain a free flowing stream at some point during the year. After consultation with the other state environmental agencies and over time the OWRB has identified one hundred seventeen (117) fixed stations of which one hundred (100) are currently being monitored.

    - **Rotating Station Monitoring on Rivers & Streams** - Over the life of the BUMP, rotational sampling has occurred on over two hundred twenty (220) stream segments. Sample stations and variables monitored are based upon Oklahoma's 303(d) list and input from other state environmental agencies on their monitoring needs. Variables monitored as part of this program component are specific for each stream segment monitored

- **Fixed Station Load Monitoring** – The OWRB is currently working with several partners including the USGS, US Army Corp of Engineers, Grand River Dam Authority, and National Weather Service to conduct flow monitoring on all of our fixed station sites that are not part of the Oklahoma/USGS Cooperative Gaging Network. This cooperative effort will allow for loadings to be calculated, trends to be assessed statewide, and provide much needed data for the Use Support Assessment process.

- **Fixed Station Lakes Monitoring** - Quarterly sampling (approximately once every 90 days) of approximately 40-45 lakes annually is currently occurring. In general, a minimum of three stations per reservoir, representing the lacustrine zone, transitional zone, and riverine zone, are designated for sampling at each lake, with additional sites sampled as needed. Additional water quality parameters and lake sites were added to the lake sampling program in 2001 to aid in making use support determinations.

- **Fixed Station Groundwater Monitoring** - Limited monitoring as part of this task has occurred in the program. Results of monitoring are presented in this report. OWRB staff has made recommendations in this report related to the scope and magnitude of groundwater monitoring activities that the state should pursue in the future. Any proposed groundwater monitoring efforts will be coordinated with the Oklahoma Department of Environmental Quality (ODEQ).

- **Intensive Investigation Sampling** - Although no funding was made available for this element of the program, it is important that waters identified as impaired be restored. If routine monitoring identifies impairment, then an intensive study will be undertaken to document the source of the impairment and recommend restorative actions if possible. This task will not be conducted in year one or year two of the program, but thereafter, intensive investigations will be conducted as warranted. If water bodies are not identified for intensive study as part of this task, then monies will be reallocated to Tasks **1** and **3**. Other entities (i.e., tribal or governmental units outside of Oklahoma) are involved as circumstances dictate or allow.

PROGRAM HISTORY/OVERVIEW

Sampling of the numerous lakes, streams, and rivers across this state was initiated in the summer and fall of 1998. Lake sampling in connection with the Beneficial Use Monitoring Program began in July of 1998. Sampling on numerous streams and rivers began in earnest in November of the same year. The two sampling programs, one for lakes and one for streams, had separate starting dates for a number of reasons. First, the OWRB has been conducting a lake-sampling program during the warmer summer months since 1990 as part of the Federal Clean Lakes Program. This historical lake sampling program was funded through federal dollars with the express purpose of determining lake trophic status. The trophic status of a reservoir can range from oligotrophic (low biological productivity) to hypereutrophic (excessive biological productivity). In general, the more productive a reservoir, the more water quality problems it is likely to experience. Federal dollars to fund this trophic state assessment of our state's lakes were discontinued in 1994. At that time, the OWRB searched for other funding sources, and through working with the Secretary of the Environment and the Oklahoma Conservation Commission, the Water Board was able to obtain a one time federal 319 non-point source grant to continue the lake trophic state assessment program. The OWRB subsequently initiated a quarterly lake sampling program in the spring of 1998 and was able to roll the existing lake program into the BUMP.

The OWRB has developed Use Support Assessment Protocols (USAP) for lakes and streams, which are essential if the state is to be consistent in identifying waters that are not meeting their assigned beneficial uses or are threatened. The Water Resources Board has incorporated the USAP into Oklahoma Administrative Code (OAC) 785:46 to ensure that consistent determinations for impairments are made by the all of the monitoring agencies.

The state must follow consistent procedures for listing waters as impaired. Using the OWRB Use Support Assessment Protocols, it has been possible for OWRB staff to assess whether threats or impairments are present in our waterways. With continued funding, identification of impaired waters will be accomplished on additional waters.

Results of Lakes Sampling Efforts

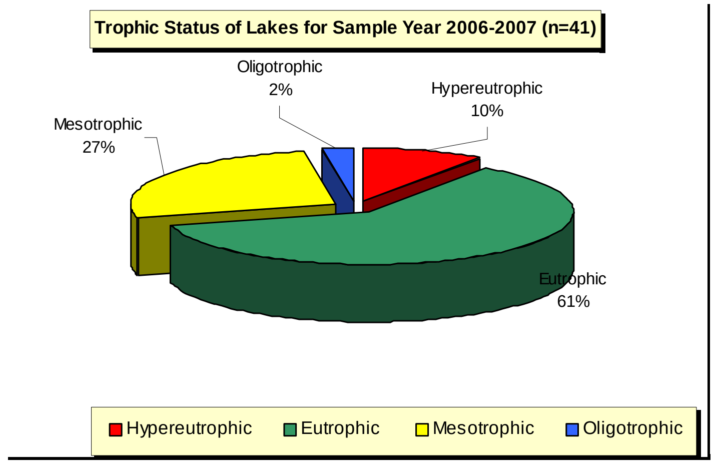


Figure 1. Trophic Status of Lakes Sampled in 2006-2007

Data was collected by the OWRB on a quarterly basis for 41 lakes in 2006-2007. Forty-three lakes were selected for monitoring, however due to drought conditions; staff was unable to launch a boat on 2 of the lakes. For the current sample year, data was collected from the October of 2006 through August of 2007. The results of the sampling efforts are summarized below. As shown in Figure 1, 10% of lakes sampled were determined to have serious water quality nutrient concerns based upon their classification as hypereutrophic reservoirs. Lakes classified as hypereutrophic have the potential for beneficial use impairments due to low dissolved oxygen concentrations, taste and odor problems, nutrient inputs, excessive productivity, and general lake aesthetics. Hypereutrophic waters are adversely impacted primarily by excessive nutrients and primary productivity and should be monitored intensively in the future to document the presence or absence of "beneficial use impairments." Sixty-one percent of the lakes sampled were classified as eutrophic, characterized by high primary productivity and nutrient rich conditions. A eutrophic lake also has the potential for beneficial use impairments, though the potential is less than for hypereutrophic waters. Mesotrophic waters have a small potential for beneficial use impairments and overall are representative of good water quality, low to moderate levels of nutrients, and productivity. Of the lakes sampled, 27% were classified as mesotrophic. Oligotrophic waters have very low levels of primary productivity and usually low concentrations of nutrient constituents. In Oklahoma, oligotrophic waters are either very clear waters with little nutrient inputs and genuinely good water quality conditions, or the waters are very turbid with poor water clarity with the absence of sufficient ambient light inhibiting lake productivity. Only one of the 41 lakes sampled was classified as oligotrophic. Based on the results for trophic state index calculations, 71% of the waters sampled were exhibiting high to excessive levels of primary productivity and nutrient rich conditions characteristic of eutrophic and hypereutrophic waterbodies.

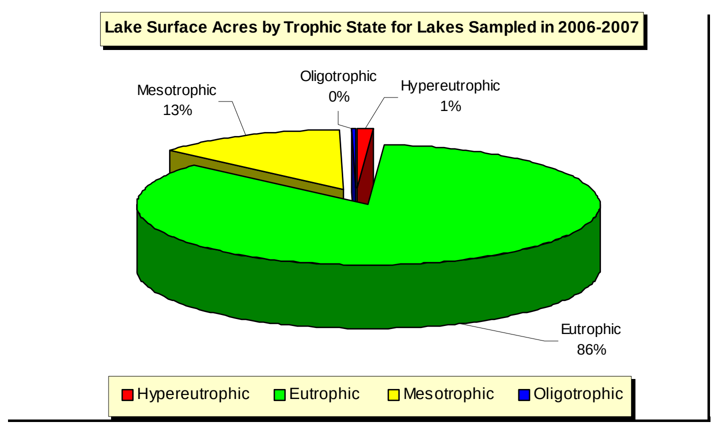


Figure 2. Lakes surface acres segregated by trophic state.

The distribution changes somewhat when the lake surface acres for each reservoir are classified into the corresponding trophic status. Results in Figure 2 are different than Figure 1, indicating the lakes classified as eutrophic were larger in surface acres than the lakes classified as mesotrophic and hypereutrophic. When you look at lake trophic status broken out by the number of lake surface acres in each trophic state category, 86% of all surface acres sampled were eutrophic, 13% were mesotrophic, 1% were hypereutrophic, and 0% were oligotrophic. Two of the largest reservoirs sampled in 2006-2007 were classified as eutrophic (Eufaula and Ft. Gibson), which skewed the surface acres percentages heavily towards the eutrophic category. In general, the larger reservoirs in the state have more extensive watersheds and are generally deeper than smaller lakes, which increase the likelihood of beneficial use impairments being present since a larger surface area is available. During stratification, the larger/deeper reservoirs have a greater portion of the water column that becomes anoxic for long periods of time, which also increases the potential for nutrient release from sediments. It is obvious that many reservoirs in Oklahoma are experiencing adverse environmental impacts. However, with the available data it is not possible to adequately assess if lakes are meeting their assigned beneficial uses as they relate to nutrients. At this time 24 lakes have been identified by the OWRB as “Nutrient-Limited Watersheds” (NLW) in the WQS and efforts should be taken to definitively determine if NLW waters are meeting their uses through initiation of a Nutrient Impairment Study to definitively determine the presence or absence of nutrient impairments in our NLW lakes. NLW are lakes with a TSI ≥ 62, based on Carlson’s trophic state classification system and using chlorophyll-a as the trophic state indicator. Lakes sampled as part of the BUMP, their trophic status, and potential threats or impairments are listed in Table 1.

Table 1. Lakes Sampled by the BUMP with Associated Use Attainment Status.

Lake Name	County	W.Q. Segment #	Last Year Sampled	FWP	PPWS	PBCR	AG	AES
American Horse	Blaine	520620	2003-2004	D.O.				
Arbuckle	Murray	310800	2004-2005	D.O.				
Arcadia	Oklahoma	520710	2006-2007		CHLOR-A			
Ardmore City	Carter	310800	2006-2007	D.O.				
Atoka	Atoka	410400	2006-2007	Turbidity				True Color
Bellcow	Lincoln	520700	2003-2004	D.O.				
Birch	Osage	121300	2006-2007	D.O.				True Color
Bixhoma	Wagoner	120410	2005-2006	D.O.				
Bluestem	Osage	121300	2005-2006	D.O. Turbidity				
Boomer	Payne	620900	2004-2005	Turbidity				
Broken Bow	McCurtain	410210	2005-2006	pH D.O.				
Brushy Creek	Sequoyah	220200	2003-2004	pH		Ent.		
Burtschi◘	Grady	31082002	2005-2006	pH				NLW
Canton	Blaine	720500	2005-2006	Turbidity				
Carl Albert	Latimer	410310	2003-2004					
Carl Blackwell	Payne	620900	2004-2005	Turbidity	CHLOR-A			
Carter	Marshall	310800	2003-2004					
Cedar (Mena)	LeFlore	410210 410300	2005-2006	D.O. pH				

Lake Name	County	W.Q. Segment #	Last Year Sampled	FWP	PPWS	PBCR	AG	AES
Chandler	Lincoln	520700	2004-2005					
Chickasha◘	Caddo	310830	2006-2007	D.O.			Sulfates	NLW
Claremore	Rogers	121500	2005-2006		Chlor-A			NLW
Clear Creek	Stephens	310810	2006-2007					
Cleveland City	Pawnee	621200	2006-2007	D.O.				
Clinton◘	Washita	310830	2003-2004	Turbidity	Chlor-A	Ent.		True Color NLW
Coalgate City	Coal	410400	2006-2007	D.O. Turbidity				True Color
Comanche	Stephens	311300	2004-2005					
Copan	Washington	121400	2004-2005	Turbidity D.O.	Chlor-A			True Color
Crowder	Washita	310830	2005-2006		Chlor-A			NLW
Cushing Municipal	Payne	620900	2006-2007	Turbidity				True Color
Dave Boyer (Walters)	Cotton	311300	2003-2004	Turbidity				True Color
Dripping Springs	Okmulgee	520700	2006-2007	D.O. Turbidity				True Color
Duncan	Stephens	310810	2006-2007					True Color
El Reno◘	Canadian	520530	2006-2007	Turbidity				True Color NLW
Elk City	Beckham	311500	2005-2006					NLW
Ellsworth	Comanche	311300	2006-2007	D.O. Turbidity				True Color
Elmer Thomas	Comanche	311300	2006-2007	pH				
Etling, Carl◘	Cimarron	720900	2003-2004	Turbidity pH				NLW
Eucha●	Delaware	121600	2006-2007	D.O.	Chlor-A			NLW
Eufaula	Haskell	220600	2006-2007	D.O. Turbidity				True Color
Fairfax City	Osage	621200	2006-2007	D.O.				
Fort Cobb	Caddo	310830	2005-2006	Turbidity	Chlor-A			NLW
Fort Gibson	Cherokee	121600	2006-2007	D.O.				NLW
Fort Supply†	Woodward	720500	2005-2006	Turbidity	Chlor-A			NLW
Foss	Custer	310800 310810 310820 310830 310840	2004-2005					
Frederick	Tillman	311310	2006-2007	Turbidity				True Color
Fuqua	Stephens	310810	2006-2007					
Grand Lake	Mayes	121600	2005-2006	D.O.				
Great Salt Plains	Alfalfa	621010	2005-2006	Turbidity			Sulfates & Chlorides	NLW

Lake Name	County	W.Q. Segment #	Last Year Sampled	FWP	PPWS	PBCR	AG	AES
Greenleaf	Muskogee	120400	2005-2006	D.O.	CHLOR-A			
Guthrie◘	Logan	620910	2005-2006		CHLOR-A			NLW
Healdton City	Carter	311100	2005-2006					
Hefner	Oklahoma	520520 520530	2005-2006	D.O.				
Henryetta♦	Okmulgee	520700	2004-2005	Turbidity				True Color
Heyburn	Creek	120420	2004-2005	D.O. Turbidity		Ent.		True Color
Holdenville	Hughes	520800	2006-2007	D.O. pH	CHLOR-A			
Hominy Municipal	Osage	121300	2006-2007	D.O.				
Hudson	Osage		2005-2006	D.O.				
Hudson	Mayes	121600	2006-2007					
Hugo	Choctaw	410300	2004-2005	Turbidity				True Color
Hulah	Osage	121400	2004-2005	Turbidity				NLW
Humphreys	Stephens	310810	2006-2007	D.O.	CHLOR-A			
Jean Neustadt	Carter	310800	2006-2007	D.O.				
John Wells	Haskell	220200	2005-2006					
Kaw	Osage	621210	2004-2005	Turbidity D.O.				
Keystone	Tulsa	621200 620900	2005-2006	Turbidity			Sulfates & Chlorides	
Konawa	Seminole		2004-2005					
Langston	Logan	620900	2003-2004					
Lawtonka	Comanche	311300	2006-2007	D.O.	CHLOR-A			
Liberty	Logan	620910	2005-2006	Turbidity	CHLOR-A			
Lloyd Church	Latimer	220100	2005-2006	D.O. pH				True Color
Lone Chimney	Pawnee	621200	2003-2004					
Lugert-Altus	Greer	311500 311510	2004-2005	Turbidity				
Maysville/Wiley Post	McClain		2004-2005	Turbidity				True Color
McAlester	Pittsburg	220600	2004-2005					True Color
McGee Creek	Atoka	410400	2006-2007	D.O. pH				
McMurtry	Noble	620900	2004-2005	Turbidity				
Meeker	Lincoln	520700	2005-2006	Turbidity				
Murray	Love	311100	2005-2006	D.O.				
Nanih Waiya	Pushmataha		2004-2005					
New Spiro◘	LeFlore	220100	2005-2006	pH	CHLOR-A			NLW

Lake Name	County	W.Q. Segment #	Last Year Sampled	FWP	PPWS	PBCR	AG	AES
Okemah	Okfuskee	520700	2006-2007	D.O. Turbidity		Ent		True Color
Okmulgee	Okmulgee	520700	2006-2007	D.O.				True Color
Oologah	Rogers	121510	2004-2005	Turbidity D.O.				
Overholser	Oklahoma	520520 520530	2005-2006	Turbidity				NLW True Color
Ozzie Cobb	Pushmataha	410300	2004-2005	pH				NLW
Pauls Valley City	Garvin	310810	2004-2005	Turbidity				True Color
Pawhuska	Osage	121600	2004-2005					
Pawnee	Pawnee	621200	2006-2007		Chlor-A			
Perry	Noble	621200	2006-2007	Turbidity				True Color
Pine Creek	McCurtain	410210	2003-2004	D.O. Turbidity pH				
Ponca	Kay	621200	2004-2005	D.O.	Chlor-A			
Prague City	Lincoln	520510	2004-2005					
Purcell	McClain	520610	2004-2005	Turbidity				
Raymond Gary	Choctaw	410300	2004-2005	D.O. Turbidity				True Color
R.C. Longmire	Garvin	310810	2004-2005	D.O.				
Robert S. Kerr	Sequoyah	220200	2004-2005	Turbidity				
Rock Creek	Carter	310800	2006-2007	D.O.				
Rocky (Hobart)	Washita	311500	2006-2007	Turbidity				NLW
Sahoma	Creek	120420	2005-2006	D.O.				
Sardis	Pushmataha	410310	2004-2005	D.O. Turbidity				True Color
Shawnee Twin # 1	Pottawatomie	520510	2005-2006	D.O.				
Shawnee Twin # 2	Pottawatomie	520510	2003-2004					
Shell	Osage	120420	2005-2006	D.O.				
Skiatook	Osage	121300	2006-2007	D.O.				True Color
Sooner	Pawnee		2006-2007	D.O.			Chlorides Sulfates TDS	
Spavinaw	Mayes	121600	2006-2007	D.O.	Chlor-A			NLW
Sportsman	Seminole	520500	2004-2005	Turbidity				True Color
Stanley Draper	Cleveland		2005-2006	D.O.				
Stilwell City	Adair	220200	2005-2006	D.O.				
Stroud	Creek	520700	2005-2006	D.O.			Sulfates & Chlorides	
Talawanda # 1	Pittsburg	220600	2004-2005	D.O. pH				

LAKE NAME	COUNTY	W.Q. SEGMENT #	LAST YEAR SAMPLED	FWP	PPWS	PBCR	AG	AES
TALAWANDA # 2	PITTSBURG	220600	2004-2005	PH				
TAYLOR (MARLOW)	GRADY	310840	2004-2005					NLW
TECUMSEH	POTTAWATOMIE	520510	2003-2004					
TENKILLER FERRY◘	SEQUOYAH	121700	2005-2006	D.O.	CHLOR-A			NLW
TEXOMA	BRYAN	311100 310800	2004-2005	D.O. TURBIDITY				TRUE COLOR
THUNDERBIRD◘	CLEVELAND	520810	2006-2007		CHLOR-A			NLW
TOM STEED◘	KIOWA	311500	2006-2007	TURBIDITY	CHLOR-A			
VANDERWORK	WASHITA	310830	2003-2004					NLW
VINCENT, LLOYD	ELLIS	720500	2004-2005	D.O.				
W.R. HOLWAY	MAYES		2006-2007	D.O.				
WAURIKA	JEFFERSON	311210	2004-2005	TURBIDITY	CHLOR-A			
WAXHOMA	OSAGE		2005-2006	D.O.				
WAYNE WALLACE	LATIMER	220100	2004-2005					
WEBBERS FALLS	MUSKOGEE	121400	2005-2006					
WES WATKINS	POTTAWATOMIE	520510	2005-2006					
WETUMKA	HUGHES		2006-2007	D.O.				TRUE COLOR
WEWOKA	SEMINOLE	520500	2006-2007	Turbidity D.O.				TRUE COLOR
WISTER♣	LEFLORE	220100	2004-2005	D.O. TURBIDITY	CHLOR-A			NLW TRUE COLOR
YAHOLA●	TULSA	121300	1998-1999					

† Lake Listed Based Upon 1995 U.S. Army Corps. Of Engineers Intensive Study

♣ Lake Listed Based Upon OWRB Phase I Clean Lakes Study

♦ Lake does not fit classic definition of oligotrophy. Inorganic particulates are limiting biological productivity

● Lake was not assessed through the BUMP, but through another OWRB project

◘ These Lakes will be recommended for NLW listing as part of the next WQS revision process

IMPAIRMENT CODES		
NS = NOT SUPPORTING	PS = PARTIALLY SUPPORTING	

ACRONYMS	
NLW = NUTRIENT LIMITED WATER	D.O. = DISSOLVED OXYGEN
ENT. = ENTEROCOCCI BACTERIA	

ASSIGNED WQS BENEFICIAL USES	
FWP = FISH & WILDLIFE PROPAGATION	AES = AESTHETICS
PPWS = PUBLIC & PRIVATE WATER SUPPLY	AG = AGRICULTURE
PBCR = PRIMARY BODY CONTACT RECREATION	

INTRODUCTION

Protecting Oklahoma's valuable water resources is essential to maintaining the quality of life for all Oklahomans. Used for a myriad of purposes, such as irrigation, hydropower, public/private water supply, navigation, and a variety of recreational activities, the state's surface and ground waters provide enormous benefits to Oklahoma from both an economic and recreational standpoint.

The National Recreation Lakes Study Commission (NRLSC) estimates that 32,100 people in Oklahoma are employed in support of activities related to our numerous man-made lakes. Also according to the NRLSC, 18,718,000 visitor days are spent on Oklahoma lakes each year and recreation in and around these lakes contributes approximately $2.2 billion each year to Oklahoma's economy. Of additional value are the recreational benefits associated with our smaller municipal/watershed projects, Oklahoma Department of Wildlife lakes, and rivers and streams throughout the state, which infuse millions into state coffers through fishing, hunting, camping, and related activities. (In 1987, the Oklahoma Comprehensive Outdoor Recreation Plan estimated that approximately $10.7 million was realized through camping and $15.2 million through hunting/fishing.[1]) According to a 2001 federal study, fishing activities alone contribute $476,019 dollars to Oklahoma's economy, not including the substantial ancillary costs associated with that extremely popular sport.[2]

In addition to surface waters, abundant ground waters also fuel the state's economy, serving as supply for thousands of municipalities, rural water districts, industrial facilities, and agricultural operations. According to the 1995 update of the *Oklahoma Comprehensive Water Plan*, groundwater represents the primary water supply for approximately 300 cities and towns and comprises 60 percent of the total water used in the state each year.[3] Groundwater resources also supply approximately 90 percent of the state's irrigation needs.

Oklahoma works to protect and manage its water resources through a number of initiatives, with the Oklahoma Water Quality Standards (WQS) serving as the cornerstone of the state's water quality management programs. The Oklahoma Water Resources Board (OWRB) is designated by state statute as the agency responsible for promulgating water quality standards and developing or assisting the other environmental agencies with implementation framework. State agencies are responsible for implementing the WQS as outlined by the OWRB through development of Implementation plans. Protecting our waters is a cooperative effort between many state agencies, and because the WQS are utilized by all agencies and represent a melding of both science and policy, they are an ideal mechanism to assess the effectiveness of our diverse water quality management activities.

The WQS are housed in OAC 785:45 and consist of three main components: beneficial uses, criteria to protect beneficial uses, and an anti-degradation policy. An additional component, which is not directly part of the WQS but necessary to water resource protection, is a monitoring

[1] Oklahoma Statewide Comprehensive Outdoor Recreation Plan (SCORP), 1987.
[2] U.S. Department of Interior, Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. *2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.*
[3] Oklahoma Water Resources Board, *Update of the Oklahoma Comprehensive Water Plan, 1995*.

program. A monitoring program is required in order to ensure that beneficial uses are maintained and protected. If uses are not being maintained, the cause of that impairment must be identified and restoration activities should be implemented to improve water quality such that it can meet its assigned beneficial uses.

All state agencies are currently required to implement Oklahoma's Water Quality Standards within the scope of their jurisdiction through the development of an Implementation Plan specific for their agency. This process, called WQS Implementation, allows the WQS to be utilized by other state agencies in the performance of their regulatory (statutory) responsibilities to manage water quality or to facilitate best management practice initiatives.

With the development of the BUMP, the need for protocols to determine beneficial use impairment was identified. Development of these protocols would facilitate state agencies in directing their time and money to the areas in most need of protection or remediation. The OWRB, working in close concert with other state environmental agencies and concerned parties, developed Use Support Assessment Protocols (USAP) to be used by all parties for assessing if waters were meeting their assigned beneficial uses. In addition, protocols were developed that could be coupled with a trend monitoring system to detect threatened waters before they become seriously impaired. Data collection efforts connected with protocol development and/or implementation also serves a vital purpose in refining numerical criteria currently included in the WQS and in developing appropriate numerical and narrative criteria for future WQS documents. It is essential that our waters meet their assigned uses and that WQS implementation protocols are appropriate. Please see Appendix A for the applicable Oklahoma Administrative Code (OAC) 785:46 related to the USAP. Final approval of the USAP occurred in 2000, and the OWRB has constantly worked every year since then to refine the existing protocols and pursue the addition or modification of USAP protocols to further enhance its utility and effectiveness.

Work to be performed towards development and implementation of the critical fourth component of the WQS program, monitoring, is the subject of this report. All sampling activities described and conducted as part of this program were consistent with the Oklahoma USAP. It is also important to note that they are consistent with Environmental Protection Agency (EPA) reporting requirements for the "*Integrated Water Quality Monitoring and Assessment Report" [305(b) Report and 303(d) list]*, §319 Non-point Source (NPS) Assessment, and §314 Lake Water Quality Assessment (LWQA).

BACKGROUND & PROBLEM DEFINITION

The State of Oklahoma has historically had numerous monitoring programs conducted by several state and federal agencies. In general, each environmental agency conducts their monitoring programs with some degree of integration and coordination with other state, municipal, or federal programs. Most water quality monitoring programs in Oklahoma are designed and implemented by each agency to collect information for one specific purpose or project (i.e., development of Total Maximum Daily Loads, the WQS process, lake trophic status determination, determining water quality impacts from point source dischargers, stream flow measurements, documenting success of best management practices, etc.). Information of this type is very specific to each individual project's data quality objectives (DQOs) and is often limited to a very small geographic area. This document describes sampling activities the OWRB has historically conducted for lakes and efforts that are currently ongoing for lakes and streams across Oklahoma as part of a comprehensive, long-term, statewide Beneficial Use Monitoring

Program (BUMP). The goal of the BUMP is to detect and quantify water quality trends, document and quantify impairments of assigned beneficial uses, and identify pollution problems before they become a pollution crisis.

BENEFICIAL USE MONITORING PROGRAM (BUMP) OVERVIEW

The overall goal of the Beneficial Use Monitoring Program is to document beneficial use impairments, identify impairment sources (if possible), detect water quality trends, provide needed information for the WQS, and facilitate the prioritization of pollution control activities.

BENEFICIAL USE MONITORING PROGRAM COMPONENTS

- **Monitoring Rivers & Streams** - The OWRB is currently monitoring approximately 180 stations on a monthly basis. These sites are segregated into two discrete types of monitoring activities. The first monitoring activity focuses on fixed station monitoring on rivers and streams, and the second monitoring activity focuses on a number of sample stations whose locations rotate on an annual basis. The two monitoring components are explained below.

    - **Fixed Station Monitoring on Rivers & Streams** - Fixed station monitoring is based largely upon the 67 United States Geological Survey (USGS) 8-digit hydrologic unit code (HUC) basins present in Oklahoma. In general, at least one sample station was located in all of the HUC watersheds with the exception of some of the smaller HUC watersheds adjacent to the state line or in a HUC that does not contain a free flowing stream at some point during the year. After consultation with the other state environmental agencies and over time the OWRB has identified 119 fixed stations of which 99 are currently being monitored.

    - **Rotating Station Monitoring on Rivers & Streams** - Over the life of the BUMP, rotational sampling has occurred on 200 stream segments. Sample stations and variables monitored are based upon Oklahoma's 303(d) list and input from other state environmental agencies on their monitoring needs. Variables monitored as part of this program component are specific for each stream segment monitored.

- **Fixed Station Load Monitoring** - The OWRB is currently engaged in a cooperative effort with the USGS to conduct flow monitoring at fixed station BUMP sites that do not currently have an existing USGS flow gage. This effort focuses on collecting both water quality and quantity information in order to calculate pollutant loads, which will provide OWRB staff with the data necessary to make a use support determination. This initiative is facilitated through the OWRB's Cooperative Agreement with USGS and various Compact Commission activities. The USGS cost share program, Oklahoma's 319 program, Oklahoma's 314 program and the 303(d)-process will drive sample site locations associated with this task.

- **Fixed Station Lakes Monitoring** - Fixed station lakes monitoring goal is designed to facilitate sampling on the 130 largest lakes in Oklahoma every other year. To accomplish this task, the OWRB is currently sampling approximately 40 to 45 lakes on a quarterly basis. Under this scenario, repeat sampling on a lake will occur approximately every 2-3 years, with the inclusion of lakes data collected by other sources, like the Corps of Engineers, to meet the goal of 130 lakes every two years. Data collected consists primarily of water chemistry, nutrients, and chlorophyll-a information. In general, three stations per reservoir, representing the lacustrine zone, transitional zone, and riverine zone are sampled. On many reservoirs, additional sites are monitored, including major arms of the reservoir as appropriate. Water quality parameters have been added to the lakes sampling effort over the years to enhance our ability to make use support determinations.

- **Fixed Station Groundwater Monitoring** - Limited monitoring as part of this task has occurred in the program. Results of monitoring are presented in this report. OWRB staff has made recommendations in this report related to the scope and magnitude of groundwater monitoring activities that the state should pursue in the future. Any proposed groundwater monitoring efforts will be coordinated with the Oklahoma Department of Environmental Quality (ODEQ).

Intensive Investigations - If beneficial use impairment is identified or suspected, then all appropriate state agencies will be alerted and an investigation will be initiated to confirm if beneficial use impairment is occurring. If routine monitoring cannot definitively identify impairments, then an intensive study will be undertaken, and if impairment is present, the source of the impairment will be identified if possible. One potential use for the intensive studies envisioned was identified during the data analysis phase of this reporting process. For example, monies could be spent to identify if high turbidity readings in rivers and streams are due to natural processes or due to human activities in the watershed of concern. Some potential causes of beneficial use impairment are improper beneficial use or criteria (Oklahoma Water Resources Board jurisdiction), point source problems (Oklahoma Department of Environmental Quality or Oklahoma Department of Agriculture, Food & Forestry), non-point source problems (Oklahoma Conservation Commission, Oklahoma Department of Agriculture, Oklahoma Corporation Commission, or Oklahoma Department of Environmental Quality), oil and gas contamination (Oklahoma Corporation Commission), agricultural activities (Oklahoma Department of Agriculture, Food & Forestry), or mining activities (Oklahoma Department of Mines). All monitoring activities will be cooperative in nature with the agency with statutory authority assuming the lead role for intensive monitoring. If water bodies are not identified for intensive study as part of this task, then monies will be reallocated for routine monitoring of beneficial use attainment. Other entities (e.g., tribal or governmental units outside of Oklahoma) will be involved as appropriate. All intensive-monitoring activities will be consistent with the WQS and the USAP. If no protocols exist, then best professional judgment or State/Environmental Protection Agency guidance will be used as appropriate.

LAKES MONITORING PROGRAM

Lake trophic status is important from a water quality perspective because it is an indicator of potential nutrient impacts to a lake. In general, the higher the trophic state index (TSI) of a lake, the more nutrient loading into the system is occurring and the more productive the lake. One outcome of historical trophic assessment activity on Oklahoma's lakes was the prioritization of lakes most in need of remediation. Outcomes have included in-lake restoration activities or implementation of best management practices in the lake watershed. Results from the BUMP sampling effort should be viewed as a means to make relative comparisons between lakes and to determine beneficial use impairments based on USAP, detailed in Oklahoma Administrative Code (OAC) 785:46-15-5. Lakes with relatively poor water quality are identified, but that does not necessarily mean that these lakes have beneficial use impairments. Some lakes, due to the nature of their watershed and basin morphometry, may never attain the water quality of some of the state's more pristine waters. For example, an expectation that Broken Bow Lake and Great Salt Plains Reservoir can attain the same level of water quality would be unrealistic, because these two reservoirs exhibit great differences in basin morphometry and substrate material and are located in totally different parts of the state. Soil types such as clays have a very small particle size such that the clay particulates are constantly re-suspended in the lake water column and never settle out, which is evident in some lakes across the state. In addition, the shallow nature of many of our lakes contributes to lake bottom sediments being re-suspended in the water column due to wind action. Because so many factors affect the water quality of a reservoir, comparing lakes from various parts of the state should only be viewed as a relative comparison.

For each lake assessed, a general analysis of water quality was made and a water quality condition map generated. The maps presented are a representation of the water quality throughout the year based on the average of the data collected. Turbidity, measured in nephelometric turbidity units (NTU), and chlorophyll-a values were averaged to obtain an annual value for each site in the lake, and then the maps were generated accordingly. Graphics for seasonal TSI values at each site were also created, as well as seasonal turbidity and true color graphics for each site. A brief narrative summary is included for each lake that presents water quality issues related to the reservoir and assessment of beneficial use support for that lake. Dissolved oxygen/temperature vertical profiles recorded at site 1 (the dam) for each quarter are also included on a graphics page following the lake summary. Hydrolab® profile information is discussed in the narrative section for each lake. The brief synopsis of information presented for each lake should be beneficial in providing a relative comparison of water quality for lakes across the state.

For 2006-2007, the BUMP identified lakes that had beneficial use impairments or threats. However, a data set to truly determine which lakes are not supporting their beneficial uses due to excess nutrients does not currently exist, nor have nutrient criteria for lakes been promulgated into the WQS. The OWRB has previously identified 20 lakes that are listed in the WQS as Nutrient Limited Watersheds (NLW). More intensive work on these lakes is required before a definitive assessment of nutrient impairment or non-support can be made. The OWRB recommends a Nutrient Impairment Study (NIS) be performed on identified NLW lakes. An NLW is defined in the WQS as "a watershed of a waterbody with a designated beneficial use which is adversely affected by excess nutrients as determined by Carlson's TSI (chlorophyll-a) of 62 or greater." If a lake is identified as having a TSI ≥62 based on chlorophyll-a, and the minimum data requirements are met (n=10 on lakes with <250 surface acres; n=20 on lakes with >250 surface acres), it is recommended for listing as an NLW through the WQS setting process. Currently, the parameters that are analyzed to determine whether or not there is beneficial use impairment or threat include turbidity, true color, dissolved oxygen, metals, chloride, sulfates, biological collections, total dissolved solids, and pH values. A brief discussion on lake monitoring procedures and methods is provided below with data results following.

MATERIALS & METHODS FOR LAKE SAMPLING

Data was collected quarterly on 41 lakes across the state from the fall of 2006 through the summer of 2007. Vertical water quality profiles were recorded at one meter intervals from the lake surface to the lake bottom for the following parameters; temperature, pH, dissolved oxygen, salinity, dissolved oxygen % saturation, oxidation-reduction potential (redox), specific conductivity, and total dissolved solids (TDS). A vertical profile was recorded for at least three sites per reservoir: in the central pool area near the dam (lacustrine zone), in the upper portion of the lake and in the major arms of the water body (riverine zone), and in the area between the lacustrine zone and the riverine zone (transitional zone). Turbidity values for each surface site were measured using a HACH portable turbidimeter. For lakes greater than 250 acres in size with only three routine chemical monitoring stations, additional sample sites have been established to ensure minimum data requirements are met. Secchi disk depths (in centimeters) were determined at all routine water chemistry sample sites. Water quality samples were collected at each site at the surface and one meter from the lake bottom at site 1, the dam, and preserved for analysis of nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, Kjeldahl nitrogen, ortho-phosphorus, total phosphorus, true color, chloride, sulfate, and total alkalinity. OWRB staff calculated total nitrogen based on laboratory-derived values. A Van Dorn sampler was used to collect samples near the lake bottom and grab samples were collected at the lake surface. At the dam site, a churn-splitter was used to split the surface sample for Quality Assurance (QA) purposes. Surface samples were also collected at all sites and analyzed for chlorophyll-a and pheophytin concentrations. Additional chlorophyll-a samples were collected for QA purposes. Filtration and grinding (extraction of the chlorophyll-a collected in a filter with acetone) of the samples was performed immediately upon return to the OWRB lab. All chlorophyll-a samples were filtered, as stated in Standard Methods (APHA 1995), within 24 hours and stored for no more than 30 days in the freezer.

SAMPLE LAKE LOCATIONS

Lakes sampled by the BUMP Lakes staff in 2006-2007 are shown in Figure 3. Lake locations are identified on the map and are shaded in different colors based on their calculated TSI values.

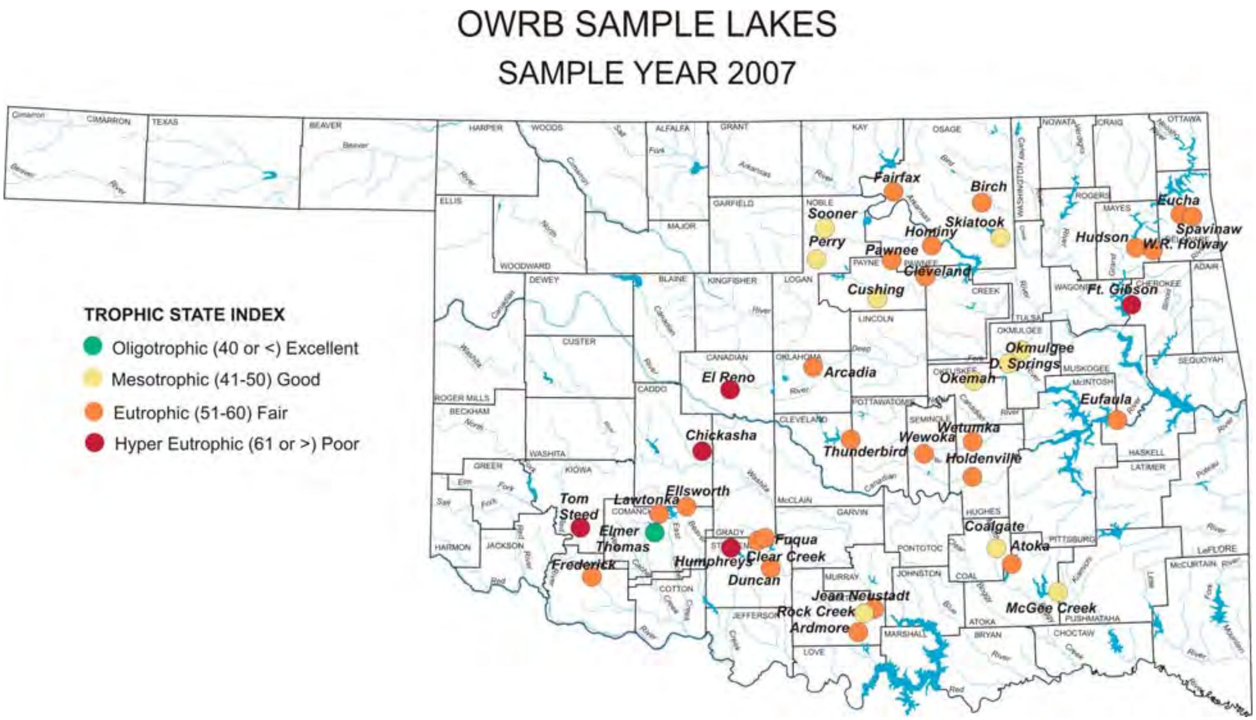


Figure 3 Lakes Sampled by the Beneficial Use Monitoring Program.

LAKE DATA ANALYSIS PROTOCOLS

There are numerous methods available for determining the trophic status of lakes. The majority of the trophic state models rely on a mathematical calculation to generate a single numerical value that is then categorized in an assessment hierarchy. Numerous chemical, and in some cases biological data are utilized in the various trophic indices, which characterize the "trophic status" of a water body. Some of the commonly used water quality parameters utilized in trophic state indices include chlorophyll-a, secchi disc depth, total phosphorus, total nitrogen, aquatic macrophytes, organic nitrogen, turbidity, lake user surveys, and hypolimnetic oxygen depletion rates, etc. Most indices use one or more variables in the determination of trophic status with varying degrees of applicability to reservoir systems. The OWRB has traditionally used Carlson's Trophic State Index (TSI) (Carlson, 1977) for reporting purposes, utilizing chlorophyll-a concentrations in calculating the lake trophic status. Carlson's TSI equation using chlorophyll-a (in µg/L) as the trophic status indicator is as follows:

TSI = 9.81 x ln(chlorophyll-a) + 30.6.

In 1998, 1999, and 2000, the TSI was calculated using chlorophyll-a concentrations from the growing season (spring and summer only). Beginning in sample year 2001, an annualized trophic assessment was made as this was determined to be a more accurate reflection of trophic conditions for each reservoir. In order to make beneficial use determinations, minimum data requirements must be met as listed in OAC 785:46-15-3. A minimum of 20 samples is required on lakes greater than 250 surface acres, and a minimum of 10 samples on lakes 250 surface acres and less. In 2001-2002, sites were added for chlorophyll-a and turbidity collections on lakes greater than 250 surface acres, in order to meet the minimum data requirements annually. Although data can be aggregated and historical values used, there was a concern in using data that was collected in the summer only as this would bias the data. An analysis of the limnological data collected on lakes is performed to determine the trophic state of each lake monitored. Chlorophyll-a concentrations for each lake sample site are determined and all values are averaged for each lake for all four sampling quarters. This annual chlorophyll-a value is then used in Carlson's TSI equation to determine trophic status of the lake. Through use of this technique the presence of localized trophic conditions are minimized (i.e. the effects of a single elevated chlorophyll-a value is minimized in the calculation of the TSI). The derived TSI represents an accurate assessment of the water quality of the reservoir as a whole and individual isolated areas that may be impacted due to eutrophication will be minimized in the reported TSI. A list of lake trophic state categories and corresponding TSI numerical values are displayed in Table 2. There are other descriptive terms and subset categories for trophic status, like dystrophic; however, Carlson's TSI has four major categories and these will be used to describe lake trophic status. Further discussion is included in each of the lake summaries as necessary. As stated earlier, prior to 2001, the TSI was based on growing season (spring and summer) chlorophyll-a concentrations. However, beginning in 2001, all TSI evaluations were based on an annualized chlorophyll-a value for each lake and comparisons to previous TSI calculations will be specified as annual, growing season, or summer only evaluations. Prior to the onset of BUMP collections, lakes were sampled only in the summer and therefore the TSI was typically much higher than the annual assessments that are being done currently.

Table 2. Lake Trophic State Categories.

Carlson TSI No.	Trophic State	Definition
≤ 40	Oligotrophic	Low primary productivity and/or low nutrient levels
41 - 50	Mesotrophic	Moderate primary productivity with moderate nutrient levels
51 – 60	Eutrophic	High primary productivity and nutrient rich
≥ 61	Hypereutrophic	Excessive primary productivity and excessive nutrients

The beneficial use support determinations for the reservoirs sampled were determined following guidelines outline in the Use Support Assessment Protocols (USAP) promulgated into Oklahoma Administrative Code (OAC) 785-46: Subchapter 15. In general the USAP states that environmental data must be collected to take seasonal conditions into consideration. A minimum of 20 samples is required on lakes more than 250 surface acres to assess beneficial use support for water quality parameters such as dissolved oxygen, pH and temperature. In addition, data more than ten years old should not be used for use support purposes unless more recent data is not available. A minimum of 10 samples is required on lakes or lake-arms of 250 surface acres of less. Samples may be aggregated to meet the minimum data requirements. For some parameters such as metals, organic compounds, or toxics, fewer samples are required. Toxicants (metals and organics) require a minimum of 5 samples to determine use support, but less than 5 samples can be used to determine if a use is partially supported or not supported. Furthermore, if at least 2 sample concentrations of a toxicant exceed the criteria prescribed in the WQS by two or more orders of magnitude, then the use is determined to be “not supporting”.

The USAP also addresses the issue of how the data should be used spatially for lake monitoring. In general, when determining what size area the data is representative of best professional judgment is used. Such things as major tributaries and major lake arms are considered when deciding the extent of the area that the data was applied to. Arms or portions of lake may be treated separately from the main body of a lake, however in most instances Water Resources Board staff chose to deal with the lake as a single unit. Unless it was demonstrated to the contrary, a single site was not considered representative of an entire lake or an arm of the lake that was greater than two hundred and fifty surface acres in size.

Default Protocols. USAP outlines the procedures for determining whether a set of data points for a particular variable support, partially support, or do not support a particular beneficial use. These protocols are constructed around two distinct types of numerical variables — short-term averages and long-term averages. In each case, samples collected for the range of water quality parameters are analyzed and aggregated in different ways.

Short-term average numerical variables measure variables with exposure periods of less than seven days (e.g., turbidity or a sample standard for chlorides). In other words, the set of samples that is being analyzed considers each sample as a separate entity. For example, turbidity samples collected monthly from January through December are considered unique samples, and consequently, are not aggregated into a single sample for analysis but are considered a fraction of the whole. Use support determination for short-term numerical variables requires a three-step process:

1. Each sample exceeding the prescribed criterion or screening level for a particular variable is identified,
2. The number of samples exceeding the prescribed criterion or screening level is divided by the total number of samples collected to obtain a percent exceedance, and
3. The percent exceedance is compared to a range of prescribed percent exceedances to determine use support. The prescribed percent exceedances are:
    i) supporting — less than or equal to 10%,
    ii) partially supporting — greater than 10% but less than 25%,
    iii) not supporting — greater than or equal to 25%.

Long-term average numerical variables measure variables with exposure periods of greater than or equal to seven days (e.g., yearly mean standard for chlorides). In other words, the set of samples that is being analyzed is considered a unique entity. For example, chloride samples collected monthly from January through December are aggregated through the calculation of a geometric mean. Use support determination for long-term numerical variables requires a three-step process:

1. Samples for a particular variable are aggregated into a geometric mean,
2. The geometric mean is compared to the prescribed criterion or screening level, and
3. Use support is determined to be supporting if the mean is less than the prescribed criterion or screening level or not supporting if the mean is greater than the prescribed criterion or screening level.

Because the long-term average compares only one value (the geometric mean) to the prescribed criterion or screening level, it cannot be considered partially supporting. In most instances, at least 10 samples are required to calculate a geometric mean.

Assessment of Fish & Wildlife Propagation Beneficial Use Support. The FWP beneficial use utilizes five different water quality variables to assess use support: dissolved oxygen (D.O.) concentration, toxicants, hydrogen ion activity (pH), and turbidity. For purposes of this report, only D.O., metals concentrations in the water column, pH, and turbidity will be used in the assessment. The USAP for dissolved oxygen beneficial use support for lakes reads as follows:

(A) If greater than 70% of the water column at any given sample site in a lake or an arm of a lake is less than 2 mg/L, the Fish and Wildlife Propagation beneficial use shall be deemed to be not supported.
(B) If 50% or more, but not greater than 70%, of the water column at any given sample site in a lake or arm of a lake is less than 2 mg/L, the Fish and Wildlife Propagation beneficial use shall be deemed to be partially supported.
(C) The screening level for surface D.O. in a lake or arm of a lake shall be 4 mg/L from June 16 through October 15 each year and 5.0 mg/L for the remainder of the year.

Use support for dissolved oxygen concentrations was determined following the above criteria. Estimations of lake volume were made based on the depth at each site sampled and USAP criteria were applied accordingly. Water column information at each site is likely representative of lake volume conditions and is currently considered adequate for reporting purposes. A proposal to modify the USAP for assessment of dissolved oxygen during the last WQS revision process was made to more accurately reflect the decision criteria being followed. As of July 1, 2002, the word "volume" was changed to "column" to more accurately reflect the decision criteria utilized. It is possible that in the future a bathymetric map will be constructed for each of the BUMP lakes and a better assessment of dissolved oxygen conditions for the lake volume can be made. For assessing Fish & Wildlife propagation use support related to turbidity concentrations, the criterion outlined in the WQS was used as the screening level. If an average lake-wide turbidity concentration of >25 nephelometric turbidity units was detected, then the lake was listed as not supporting its Fish & Wildlife propagation beneficial use for turbidity. Rain and storm events were considered when making this determination as conditions dictated. The protocol for short-term average numerical parameters is used to assess the level of support.

For assessing the beneficial use support from pH concentrations, the following criteria were used:

1) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be fully supported with respect to pH occurring other than by natural causes if no more than 10% of the sample concentrations from that waterbody fall outside the screening interval prescribed in 785:45-5-12(g)(3).
2) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be partially supported with respect to pH occurring other than by natural causes if greater than 10% but less than 25% of the sample concentrations from that waterbody fall outside the screening interval prescribed in 785:45-5-12(g)(3).
3) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be not supported with respect to pH occurring other than by natural causes if at least 25% of the sample concentrations from that waterbody fall outside the screening interval prescribed in 785:45-5-12(g)(3).

Each lake was profiled using a Hydrolab, and pH concentrations were recorded at all sites for all four quarters. Based on all the data collected per sample year, the percentage of pH values above or below the acceptable range of 6.5 to 9 units was assessed for each site and this percentage determined whether or not the lake was supporting the Fish & Wildlife Propagation beneficial use. All lakes that exceeded the pH criteria have been only listed as not supporting at this point in time as further examination is necessary to determine "natural causes".
Numerical criteria is prescribed for toxicants in WQS 785:45-5-12(g)(6)(G) in a table entitled "Numerical Criteria for Toxic Substances". To determine use support, the protocol for short-term average numerical parameters is used. Sample values must be compared to both acute and

chronic criterion. Both criterions need not be exceeded for the variable to be partially supported or not supported.

Assessment of Agriculture Beneficial Use Support. The AG beneficial use utilizes three variables to assess use support: total dissolved solids, chlorides, and sulfates. Numerical criteria for both yearly mean standards and sample standards are located in Appendix F of OAC 785:45. The yearly mean standard for each variable is compared to the geometric mean of the samples using a long-term average numerical protocol. The sample standard for each variable is also compared to each sample using a short-term average numerical protocol. Use support assessment for each variable requires a three-step process:

1) The sample standard and yearly mean standard for the six digit management segment which encompasses the monitoring must be located in Appendix F of OAC 785:45;
2) The geometric mean of the samples is compared to the yearly mean standard (if the geometric mean exceeds the yearly mean standard, the use is not supported and no further analysis is necessary);
3) If the geometric mean meets the yearly mean standard, the sample standard is compared to each sample and percent exceedance is calculated (depending on the percent exceedance, the variable is supporting, partially supporting, or not supporting). Regardless of the criteria in Appendix F of OAC 785:45, if all TDS samples are less than 750 mg/L and all chloride and sulfate samples are less than 250 mg/L, the AG beneficial use is supported. Only one variable needs to violate the assessment protocol for the beneficial use to be partially supported or not supported.

Assessment of Aesthetics Beneficial Use Support. The Aesthetics beneficial use is assessed using a couple of water quality parameters--true color and nutrients. The sample standard for each variable is compared to the each sample using a short-term average numerical protocol. Criteria are located in OAC 785:45-5-19 and read as follows.

1) **Color.** Surface waters of the state shall be virtually free from all coloring materials that produce an aesthetically unpleasant appearance. Color producing substances, from other than natural sources, shall be limited to concentrations equivalent to 70 Platinum-cobalt true color units.

2) **Nutrients.** Nutrients from point source discharges or other sources shall not cause excessive growth of periphyton, phytoplankton, or aquatic macrophyte communities, which impairs any existing or designated beneficial use.

For assessing the Aesthetics beneficial use support status for color, data collected was compared to the numerical standard of 70 units for true color. Assessment of use support for this water quality parameter was simple and straightforward.

For assessing the Aesthetics beneficial use support status for nutrients, Carlson's TSI was applied. As stated in Table 2 a TSI value ≥ 61 is considered to be characteristic of a hypereutrophic lake (excessive primary productivity). Guidelines for determining if a lake is a Nutrient Limited Watershed (NLW) are outlined in the WQS that states a Carlson's TSI value of > 62 is to be the criterion to be used to classify a lake as an NLW. Classification as an NLW in Appendix A of the WQS means that a lake is considered to be threatened due to nutrients. A TSI value of 62 was chosen as the "break-point" because it is a conservative number. As noted in Table 5, several lakes had a TSI value greater than 62 and have not yet been listed as an NLW, and likewise, there are lakes listed as NLW that have a TSI less than 62. This will be addressed during the next standards revision process. If it can be demonstrated that nutrient loading to a lake may be adversely impacting a beneficial use designated for that lake, then the OWRB may determine that the lake and its watershed is an NLW and the lake and watershed will be identified as NLW in Appendix A of OAC 785:45. Once a lake is identified as an NLW, it is assumed to be threatened until an NLW Impairment Study has been conducted to definitively assess if the water body is partially supporting or not supporting. If an NLW Impairment Study demonstrates that beneficial uses are not threatened, then the Board will remove the NLW identification in the WQS.

Assessment of Primary Body Contact Recreation (PBCR) Support. The PBCR beneficial use utilizes two different bacteriological classes and one bacteriological species to assess use support: fecal coliform (FC), *Escherichia coli* (*E. coli*), and enterococci (Ent.). The assessment is performed by using the long-term average numerical protocol to compare to a prescribed geometric mean and by using a modified version of the short-term average numerical protocol to compare each sample to a prescribed screening level. The prescribed geometric means (GM) and screening levels (SL) are: FC—GM of 400 colony forming units/mL (cfu/mL) and SL of 400 cfu/mL; *E. coli*—GM of 126 cfu/mL and SL of 235 cfu/mL in scenic rivers and 406 cfu/mL in all other waters; and Ent.—GM of 33 cfu/mL and SL of 61 cfu/mL in scenic rivers and 406 cfu/mL in all other waters. For *E. coli* and Ent., both the SL (only one sample exceedance is necessary) and the GM must be exceeded for the use to not be supported. If all of the samples meet the SL or the GM is met, the use is supported. In the case of FC, the use may only be supported if the GM is met and no greater than 25% of the sample concentrations exceed the SL. If either the GM is exceeded or greater than 25% of the sample concentrations exceed the SL, the use is not supported for FC. In no instance is the PBCR beneficial use partially supported. Furthermore, PBCR support is only determined from samples collected during the recreational season from May 1 through September 30 of each year. Only one variable needs to violate the assessment protocol for the beneficial use to be not supported.

LAKE MONITORING RESULTS & DISCUSSION

A lake-wide annual average of the chlorophyll-a values was calculated for each lake and used in the final calculation of the TSI. A summary table is included (Table 3) to present the number of lakes and appropriate surface acre size for each of the four trophic categories in 2005-2006 as well as the percentages of the total. As shown in Table 3, ten lakes were hypereutrophic, fourteen were eutrophic, nine were mesotrophic, and three were oligotrophic. Of the total 166,431 surface acres sampled, 41,745 were classified hypereutrophic, 97,879 were classified as eutrophic, 3,979 were classified as mesotrophic and 22,828 acres were classified as oligotrophic. TSI results, county, surface area, and volume for lakes sampled in 2005-2006 are listed in Table 4.

Although TSI based on the chlorophyll-a concentration is used for the BUMP, a comparison of TSI values calculated with total phosphorus and secchi disk depth was generated and is displayed as Table 5. Data displayed is for the growing season using the various water quality parameters that can be used in calculating Carlson's TSI. The chlorophyll and phosphorus TSI calculations were derived through results of regression analysis relating secchi disk depth to the other two variables.

Table 3. Summary of Lake Trophic Status Results

Trophic Status	Number of Lakes	% of Total Lakes	Surface Area (Acres)	% of Total Surface Acres
Hyper-Eutrophic	5	12%	41,475	25%
Eutrophic	24	59%	97,879	59%
Mesotrophic	11	53%	3,979	2%
Oligotrophic	1	2%	22,828	14%
Totals =	41	100%	166,161	100%

Table 4. List of Lakes Sampled in Sample Year 2006-2007.

Lake Name	County	Surface Area	Volume	TSI	Year Sampled	Threats or Impairments	Carlson's TSI
Arcadia	Oklahoma	1,820	27,520	62	2007		eutrophic
Ardmore City	Carter	142	600	49	2007	D.O. (PS)	Eutrophic
Atoka	Atoka	5,700	125,000	50	2007	Turbidity (NS) Color (NS)	Eutrophic
Birch	Osage	1,137	19,200	50	2007	D.O. Color (NS)	Eutrophic
Chickasha	Caddo	820	41,080	66	2007	D.O. (PS) NLW Sulfates	Hypereutrophic
Clear Creek	Stephens	722	7,710	48	2007		Eutrophic
Cleveland	Pawnee	159	2,200	50	2007	D.O.	Eutrophic
Coalgate	Coal	352	3,437	46	2007	D.O. Turbidity (NS) Color (NS)	Mesotrophic
CUSHING	PAYNE	591	3,304	51	2007	Turbidity (NS) Color (NS)	Mesotrophic
DRIPPING SPRINGS	OKMULGEE	1,150	16,200	41	2007	D.O. Turbidity (NS) Color (NS)	Mesotrophic
Duncan	Stephens	500	7,200	48	2007	Color (NS)	Eutrophic
El Reno	Canadian	170	709	56	2007	Turbidity (NS) Color (NS) NLW	Hypereutrophic
Ellsworth	Comanche	5,600	95,200	54	2007	Turbidity (NS) Color (PS) D.O. (PS)	Eutrophic
Elmer Thomas	Comanche	334	12,000	33	2007	pH	Oligotrophic
Eucha*	Delaware	2,860	79,600	56	2007	D.O. NLW	Mesotrophic
Eufaula	Haskell	105,500	2,314,600	52	2007	Color (NS) D.O. (PS) Turbidity (NS)	Eutrophic
FAIRFAX	OSAGE	111	1,795	47	2007	D.O.	Eutrophic

Lakes Monitoring Program

Lake Name	County	Surface Area	Volume	TSI	Year Sampled	Threats or Impairments	Carlson's TSI
Frederick	Tillman	925	9,526	51	2007	Turbidity (NS) Color (NS)	Eutrophic
Fort Gibson	Cherokee	14,900	355,200	58	2007	D.O. NLW	Eutrophic
Fuqua	Stephens	1,500	21,100	48	2007		Eutrophic
HOLDENVILLE	HUGHES	550	11,000	50	2007	PH D.O. (PS)	Eutrophic
Hominy	Osage	165	5,000	50	2007	D.O. (PS)	Eutrophic
Hudson	Mayes	10,900	200,300	60	2007	D.O. (PS)	Eutrophic
Humphreys	Stephens	882	14,041	58	2007	D.O. (PS)	Hypereutrophic
Jean Neustadt	Carter	462	6,106	52	2007	D.O.	Eutrophic
Lawtonka	Comanche	2,398	56,574	58	2007	D.O. (PS)	Eutrophic
Lone Chimney	Pawnee	550	6,200	53	2004	D.O. (PS)	Eutrophic
Lugert-Altus	Greer	6,260	132,830	59	2005	Turbidity (NS)	Eutrophic
McGee Creek	Atoka	3,810	113,930	39	2007	D.O. pH	Mesotrophic
OKEMAH	OKMULGEE	761	13,100		2007	D.O. (PS) Turbidity (PS) Color (NS) ENT	Mesotrophic
OKMULGEE	OKMULGEE	668	14,170		2007	D.O. Color (NS)	Mesotrophic
PAWNEE	PAWNEE	257	3,855	51	2007		Eutrophic
Perry	Noble	614	6,892	44	2007	Turbidity (NS) Color (NS)	Mesotrophic
Rocky (Hobart)	Washita	347	4,210	68	2007	Turbidity (NS) NLW	Hypereutrophic
Rock Creek	Carter	248	3,588	48	2007	D.O. (PS)	Mesotrophic
Skiatook	Osage	10,190	322,700	43	2007	D.O. (PS) Color (PS)	Mesotrophic
Sooner	Pawnee	5,400	149,000	48	2007	D.O. (PS) Cl,So4,TDS	Mesotrophic
Spavinaw*	Mayes	1,584	38,000	61	2007	D.O. (PS) NLW	Eutrophic
Thunderbird	Cleveland	6,070	119,600	58	2007	Turbidity (NS) NLW	Eutrophic
Tom Steed	Kiowa	6,400	88,970	70	2007	Turbidity (NS)	Eutrophic
W.R. Holway	Mayes				2007	D.O. (PS)	Eutrophic
Wetumka	Hughes	169	1,839	50	2007	D.O. (PS) Color (NS)	Eutrophic
WEWOKA	SEMINOLE	371	3,301	49	2007	Turbidity (NS) Color (NS) D.O. (PS)	Eutrophic

The TSI calculation using total phosphorus (in mg/m^3) as the variable is:

TSI = 14.42 x ln(total phosphorus) + 4.15.

The TSI calculation using secchi disk depth (in meters) as the variable is:

TSI = 60 – (14.41 x ln(secchi depth)).

Calculations using secchi disk depth could be erroneous, because this is not a good parameter to use in highly turbid reservoirs where turbidity is inorganic in nature or colored lakes, both fairly common occurrences in Oklahoma. Phosphorus may not be an accurate variable to use in calculating the TSI in lakes that are not phosphorus-limited or lakes that are highly turbid due to clay particulates. Carlson (1977) stated chlorophyll-a seems to be the most acceptable parameter to use in calculating TSI, especially during the growing season and for estimating algal biomass. In accordance with historical calculations at OWRB, and Carlson's suggestion to use chlorophyll-a concentration in the growing season, rather than secchi disk depth or total phosphorus, it is the utilized variable for TSI calculations for BUMP. Values displayed in Table 5 were calculated using lake-wide annual averages for all three parameters.

Using chlorophyll-a, ten lakes were hypereutrophic, fourteen lakes were eutrophic, nine lakes were mesotrophic, and three were oligotrophic. Using total phosphorus and secchi disk depth in the TSI calculation produced a much different result, although classification using these two variables is somewhat comparable to each other. Seventeen lakes were hypereutrophic, ten lakes were eutrophic, six lakes were mesotrophic and three was oligotrophic using the total phosphorus variable for TSI. For the secchi disk depth trophic evaluation, twenty-four lakes were identified as hypereutrophic, eleven lakes were eutrophic, zero lakes were mesotrophic and one was oligotrophic. The TSI values calculated using secchi depth were the highest of the three variables. For example, Bluestem Lake was classified as mesotrophic using chlorophyll-a concentration, eutrophic using total phosphorus as the trophic state indicator, and hypereutrophic using secchi disk depth as the trophic state indicator. Most of the TSI values were lowest using the chlorophyll-a concentration; therefore, it seems reasonable to say that this parameter is the most conservative variable to use.

Table 5. Comparison of Methods Used to Calculate Carlson's Trophic State Index for 2006-2007.

Lake Name	CHL-A	Trophic State	Total P	Trophic State	Secchi	Trophic State
Arcadia Lake	58	Eutrophic	64	Hypereutrophic	66	Hypereutrophic
Ardmore City Lake	52	Eutrophic	47	Mesotrophic	59	Eutrophic
Atoka Lake	51	Eutrophic	64	Hypereutrophic	76	Hypereutrophic
Birch Lake	52	Eutrophic	48	Mesotrophic	61	Hypereutrophic
Lake Chickasha	68	Hypereutrophic	58	Eutrophic	66	Hypereutrophic
Clear Creek Lake	58	Eutrophic	54	Eutrophic	65	Hypereutrophic
Cleveland City lake	56	Eutrophic	55	Eutrophic	68	Hypereutrophic
Coalgate City Lake	47	Mesotrophic	70	Hypereutrophic	80	Hypereutrophic
Cushing Municipal Lake	50	Mesotrophic	72	Hypereutrophic	72	Hypereutrophic
Dripping Springs Lake	48	Mesotrophic	52	Eutrophic	64	Hypereutrophic
Duncan Lake	57	Eutrophic	52	Eutrophic	68	Hypereutrophic
Lake El Reno	65	Hypereutrophic	85	Hypereutrophic	75	Hypereutrophic
Lake Ellsworth	57	Eutrophic	69	Hypereutrophic	70	Hypereutrophic
Elmer Thomas Lake	39	Oligotrophic	34	Oligotrophic	52	Eutrophic
Eucha Lake	50	Mesotrophic	46	Mesotrophic	54	Eutrophic
Eufaula Lake	53	Eutrophic	66	Hypereutrophic	67	Hypereutrophic
Fairfax City Lake	57	Eutrophic	51	Eutrophic	65	Hypereutrophic
Lake Frederick	56	Eutrophic	57	Eutrophic	79	Hypereutrophic

Lake Name	CHL-A	Trophic State	Total P	Trophic State	Secchi	Trophic State
Ft. Gibson Lake	61	Hypereutrophic	70	Hypereutrophic	63	Hypereutrophic
Fuqua Lake	52	Eutrophic	53	Eutrophic	68	Hypereutrophic
Holdenville Lake	60	Eutrophic	55	Eutrophic	64	Hypereutrophic
Hominy Municipal Lake	56	Eutrophic	48	Mesotrophic	60	Eutrophic
Lake Hudson (Mayes Co.)	58	Eutrophic	67	Hypereutrophic	60	Eutrophic
Humphreys Lake	61	Hypereutrophic	60	Eutrophic	68	Hypereutrophic
Lake Jean Neustadt	58	Eutrophic	52	Eutrophic	64	Hypereutrophic
Lake Lawtonka	60	Eutrophic	53	Eutrophic	59	Eutrophic
Lone Chimney Lake						
Lugert-Altus Reservoir						
McGee Creek Reservoir	43	Mesotrophic	46	Mesotrophic	56	Eutrophic
Okemah Lake	46	Mesotrophic	51	Eutrophic	63	Hypereutrophic
Okmulgee Lake	46	Mesotrophic	47	Mesotrophic	60	Eutrophic
Pawnee Lake	59	Eutrophic	58	Eutrophic	72	Hypereutrophic
Perry Lake	48	Mesotrophic	72	Hypereutrophic	82	Hypereutrophic
Rocky Lake	69	Hypereutrophic	74	Hypereutrophic	79	Hypereutrophic
Rock Creek Reservoir	48	Mesotrophic	46	Mesotrophic	62	Hypereutrophic
Skiatook Lake	47	Mesotrophic	46	Mesotrophic	60	Eutrophic
Sooner Reservoir	46	Mesotrophic	43	Mesotrophic	58	Eutrophic
Spavinaw Lake	53	Eutrophic	49	Mesotrophic	56	Eutrophic
Lake Thunderbird	57	Eutrophic	63	Hypereutrophic	69	Hypereutrophic
Tom Steed Reservoir	55	Eutrophic	65	Hypereutrophic	68	Hypereutrophic
W.R. Holway Reservoir	58	Eutrophic	63	Hypereutrophic	53	Eutrophic
Wetumka Lake	53	Eutrophic	55	Eutrophic	68	Hypereutrophic
Wewoka Lake	55	Eutrophic	71	Hypereutrophic	75	Hypereutrophic

Results for each of the 130 BUMP lakes from the most recent sampling are listed in Table 6. As stated previously, the OWRB is currently monitoring 40 to 45 lakes with repeat sampling on each reservoir scheduled to occur every two to three years. Prior to 1998, data was only collected once for each lake during the summer months. In 1998, the OWRB began collecting data on lakes on a quarterly basis resulting in a great improvement to the data set available to make management decisions on our lake resources. Lakes that are identified as hypereutrophic should be sampled more often than quarterly, especially during the warmer months. Lakes identified as "Nutrient-Limited Watersheds" (NLW) should also be sampled more intensively to confirm if a water quality threat or impairment is present. Minimum data requirements as listed in USAP were closely followed to make beneficial use determinations. All impairments are listed in Table 6. Toxicity concerns, if present, are listed as provided by the ODEQ as part of their Rotating Lakes Toxics Program and/or through sampling conducted by the OWRB.

Table 6. Lakes Sampled by the BUMP with Their Associated Use Attainment Status.

Lake Name	County	W.Q. Segment #	Last Year Sampled	FWP	PPWS	PBCR	AG	AES
American Horse	Blaine	520620	2003-2004	D.O.				
Arbuckle	Murray	310800	2004-2005	D.O.				
Arcadia	Oklahoma	520710	2006-2007		Chlor -A			
Ardmore City	Carter	310800	2006-2007	D.O.				
Atoka	Atoka	410400	2006-2007	Turbidity				True Color
Bellcow	Lincoln	520700	2003-2004	D.O.				
Birch	Osage	121300	2006-2007	D.O.				True Color
Bixhoma	Wagoner	120410	2005-2006	D.O.				
Bluestem	Osage	121300	2005-2006	D.O. Turbidity				
Boomer	Payne	620900	2004-2005	Turbidity				
Broken Bow	McCurtain	410210	2005-2006	pH D.O.				
Brushy Creek	Sequoyah	220200	2003-2004	pH		Ent.		
Burtschi◘	Grady	31082002	2005-2006	pH				NLW
Canton	Blaine	720500	2005-2006	Turbidity				
Carl Albert	Latimer	410310	2003-2004					
Carl Blackwell	Payne	620900	2004-2005	Turbidity	Chlor -A			
Carter	Marshall	310800	2003-2004					
Cedar (Mena)	LeFlore	410210 410300	2005-2006	D.O. pH				
Chandler	Lincoln	520700	2004-2005					
Chickasha◘	Caddo	310830	2006-2007	D.O.			Sulfates	NLW
Claremore	Rogers	121500	2005-2006		Chlor -A			NLW
Clear Creek	Stephens	310810	2006-2007					
Cleveland City	Pawnee	621200	2006-2007	D.O.				
Clinton ◘	Washita	310830	2003-2004	Turbidity	Chlor -A	Ent.		True Color NLW
Coalgate City	Coal	410400	2006-2007	D.O. Turbidity				True Color
Comanche	Stephens	311300	2004-2005					
Copan	Washington	121400	2004-2005	Turbidity D.O.	Chlor -A			True Color
Crowder	Washita	310830	2005-2006		Chlor -A			NLW
Cushing Municipal	Payne	620900	2006-2007	Turbidity				True Color
Dave Boyer (Walters)	Cotton	311300	2003-2004	Turbidity				True Color

Lake Name	County	W.Q. Segment #	Last Year Sampled	FWP	PPWS	PBCR	AG	AES
Dripping Springs	Okmulgee	520700	2006-2007	D.O. Turbidity				True Color
Duncan	Stephens	310810	2006-2007					True Color
El Reno ◘	Canadian	520530	2006-2007	Turbidity				True Color NLW
Elk City	Beckham	311500	2005-2006					NLW
Ellsworth	Comanche	311300	2006-2007	Turbidity D.O.				True Color
Elmer Thomas	Comanche	311300	2006-2007	pH				
Etling, Carl ◘	Cimarron	720900	2003-2004	Turbidity pH				NLW
Eucha ●	Delaware	121600	2006-2007	D.O.	Chlor -A			NLW
Eufaula	Haskell	220600	2006-2007	D.O. Turbidity				True Color
Fairfax City	Osage	621200	2006-2007	D.O.				
Fort Cobb	Caddo	310830	2005-2006	Turbidity	Chlor -A			NLW
Fort Gibson	Cherokee	121600	2006-2007	D.O.				NLW
Fort Supply †	Woodward	720500	2005-2006	Turbidity	Chlor -A			NLW
Foss	Custer	310800 310810 310820 310830 310840	2004-2005					
Frederick	Tillman	311310	2006-2007	Turbidity				True Color
Fuqua	Stephens	310810	2006-2007					
Grand Lake	Mayes	121600	2005-2006	D.O.				
Great Salt Plains	Alfalfa	621010	2005-2006	Turbidity			Sulfates & Chlorides	NLW
Greenleaf	Muskogee	120400	2005-2006	D.O.	Chlor -A			
Guthrie ◘	Logan	620910	2005-2006		Chlor -A			NLW
Healdton City	Carter	311100	2005-2006					
Hefner	Oklahoma	520520 520530	2005-2006	D.O.				
Henryetta ♦	Okmulgee	520700	2004-2005	Turbidity				True Color
Heyburn	Creek	120420	2004-2005	D.O. Turbidity		Ent.		True Color
Holdenville	Hughes	520800	2006-2007	D.O. pH	Chlor -A			
Hominy Municipal	Osage	121300	2006-2007	D.O.				
Hudson	Osage		2005-2006	D.O.				
Hudson	Mayes	121600	2006-2007					
Hugo	Choctaw	410300	2004-2005	Turbidity				True Color
Hulah	Osage	121400	2004-2005	Turbidity				NLW

LAKE NAME	COUNTY	W.Q. SEGMENT #	LAST YEAR SAMPLED	FWP	PPWS	PBCR	AG	AES
HUMPHREYS	STEPHENS	310810	2006-2007	D.O.	CHLOR -A			
JEAN NEUSTADT	CARTER	310800	2006-2007	D.O.				
JOHN WELLS	HASKELL	220200	2005-2006					
KAW	OSAGE	621210	2004-2005	TURBIDITY D.O.				
KEYSTONE	TULSA	621200 620900	2005-2006	TURBIDITY			SULFATES & CHLORIDES	
KONAWA	SEMINOLE		2004-2005					
LANGSTON	LOGAN	620900	2003-2004					
LAWTONKA	COMANCHE	311300	2006-2007	D.O.	CHLOR -A			
LIBERTY	LOGAN	620910	2005-2006	TURBIDITY	CHLOR -A			
LLOYD CHURCH	LATIMER	220100	2005-2006	D.O. PH				TRUE COLOR
LONE CHIMNEY	PAWNEE	621200	2003-2004					
LUGERT-ALTUS	GREER	311500 311510	2004-2005	TURBIDITY				
MAYSVILLE/WILEY POST	MCCLAIN		2004-2005	TURBIDITY				TRUE COLOR
MCALESTER	PITTSBURG	220600	2004-2005					TRUE COLOR
MCGEE CREEK	ATOKA	410400	2006-2007	D.O. PH				
MCMURTRY	NOBLE	620900	2004-2005	TURBIDITY				
MEEKER	LINCOLN	520700	2005-2006	TURBIDITY				
MURRAY	LOVE	311100	2005-2006	D.O.				
NANIH WAIYA	PUSHMATAHA		2004-2005					
NEW SPIRO	LEFLORE	220100	2005-2006	PH	CHLOR -A			NLW
OKEMAH	OKFUSKEE	520700	2006-2007	D.O. TURBIDITY		ENT		TRUE COLOR
OKMULGEE	OKMULGEE	520700	2006-2007	D.O.				TRUE COLOR
OOLOGAH	ROGERS	121510	2004-2005	TURBIDITY D.O.				
OVERHOLSER	OKLAHOMA	520520 520530	2005-2006	TURBIDITY				NLW TRUE COLOR
OZZIE COBB	PUSHMATAHA	410300	2004-2005	PH				NLW
PAULS VALLEY CITY	GARVIN	310810	2004-2005	TURBIDITY				TRUE COLOR
PAWHUSKA	OSAGE	121600	2004-2005					
PAWNEE	PAWNEE	621200	2006-2007		CHLOR -A			
PERRY	NOBLE	621200	2006-2007	TURBIDITY				TRUE COLOR
PINE CREEK	MCCURTAIN	410210	2003-2004	D.O. TURBIDITY PH				
PONCA	KAY	621200	2004-2005	D.O.	CHLOR -A			

Lake Name	County	W.Q. Segment #	Last Year Sampled	FWP	PPWS	PBCR	AG	AES
Prague City	Lincoln	520510	2004-2005					
Purcell	McClain	520610	2004-2005	Turbidity				
Raymond Gary	Choctaw	410300	2004-2005	D.O. Turbidity				True Color
R.C. Longmire	Garvin	310810	2004-2005	D.O.				
Robert S. Kerr	Sequoyah	220200	2004-2005	Turbidity				
Rock Creek	Carter	310800	2006-2007	D.O.				
Rocky (Hobart) ◘	Washita	311500	2006-2007	Turbidity				NLW
Sahoma	Creek	120420	2005-2006	D.O.				
Sardis	Pushmataha	410310	2004-2005	D.O. Turbidity				True Color
Shawnee Twin # 1	Pottawatomie	520510	2005-2006	D.O.				
Shawnee Twin # 2	Pottawatomie	520510	2003-2004					
Shell	Osage	120420	2005-2006	D.O.				
Skiatook	Osage	121300	2006-2007	D.O.				True Color
Sooner	Pawnee		2006-2007	D.O.			Chlorides Sulfates TDS	
Spavinaw ●	Mayes	121600	2006-2007	D.O.	Chlor -A			NLW
Sportsman	Seminole	520500	2004-2005	Turbidity				True Color
Stanley Draper	Cleveland		2005-2006	D.O.				
Stilwell City	Adair	220200	2005-2006	D.O.				
Stroud	Creek	520700	2005-2006	D.O.			Sulfates	
Talawanda # 1	Pittsburg	220600	2004-2005	D.O. pH				
Talawanda # 2	Pittsburg	220600	2004-2005	pH				
Taylor (Marlow)	Grady	310840	2004-2005					NLW
Tecumseh	Pottawatomie	520510	2003-2004					
Tenkiller Ferry◘	Sequoyah	121700	2005-2006	D.O.	Chlor -A			NLW
Texoma	Bryan	311100 310800	2004-2005	D.O. Turbidity				True Color
Thunderbird◘	Cleveland	520810	2006-2007		Chlor -A			NLW
Tom Steed◘	Kiowa	311500	2006-2007	Turbidity	Chlor -A			
Vanderwork	Washita	310830	2003-2004					NLW
Vincent, Lloyd	Ellis	720500	2004-2005	D.O.				
W.R. Holway	Mayes		2006-2007	D.O.				
Waurika	Jefferson	311210	2004-2005	Turbidity	Chlor -A			
Waxhoma	Osage		2005-2006	D.O.				

Lake Name	County	W.Q. Segment #	Last Year Sampled	FWP	PPWS	PBCR	AG	AES
Wayne Wallace	Latimer	220100	2004-2005					
Webbers Falls	Muskogee	121400	2005-2006					
Wes Watkins	Pottawatomie	520510	2005-2006					
Wetumka	Hughes		2006-2007	D.O.				True Color
Wewoka	Seminole	520500	2006-2007	Turbidity D.O.				True Color
Wister♣	LeFlore	220100	2004-2005	D.O. Turbidity	Chlor -a			NLW True Color
Yahola●	Tulsa	121300	1998-1999					

† Lake Listed Based Upon 1995 U.S. Army Corps. Of Engineers Intensive Study

♣ Lake Listed Based Upon OWRB Phase I Clean Lakes Study

♦ Lake does not fit classic definition of oligotrophy. Inorganic particulates are limiting biological productivity

● Lake was not assessed through the BUMP, but through another OWRB project

◘ These Lakes will be recommended for NLW listing as part of the next WQS revision process

Impairment Codes		
NS = Not Supporting	PS = Partially Supporting	

Acronyms	
NLW = Nutrient Limited Water	D.O. = Dissolved Oxygen
Ent. = Enterococci Bacteria	

Assigned WQS Beneficial Uses	
FWP = Fish & Wildlife Propagation	AES = Aesthetics
PPWS = Public & Private Water Supply	AG = Agriculture
PBCR = Primary Body Contact Recreation	

The pH was examined and compared to the WQS for pH, 6.5 to 9 units, listed in 785:45-5. Two of the 41 lakes sampled in 2006-2007 were listed as partially supporting the FWP beneficial use based on pH values and one lake were listed as not supporting (Figure 4). Turbidity, in Nephelometric turbidity units (NTU), was measured via a HACH turbidimeter for all sites on each lake sampled to identify lakes that exceeded the WQS of 25 NTU. Seasonal turbidity values at each site are displayed for each lake as well as the lake-wide annual turbidity value. Of the 41 lakes sampled in 2006-2007, twelve lakes were not supporting their Fish & Wildlife Propagation (FWP) beneficial use, one was p artially supporting the use and twenty-eight were fully supporting their FWP beneficial use based on turbidity values (see Figure 6). True color units were also averaged for the year to compare to the WQS of 70 units. Seasonal true color values per site are displayed graphically for each lake (see Figure 5.). In 2006-2007, fourteen lakes were not supporting the Aesthetics beneficial use based on high true color values. Vertical profiles recorded with a Hydrolab® were examined to determine if anoxic conditions were present and whether or not the lake was meeting the FWP beneficial use. The USAP lists dissolved oxygen violations as values below 2.0 mg/L for 70% of the entire water column and partially supporting if between 50% and 70% of the lake. Of the 41 lakes sampled in 2006-2007, eleven were not supporting the FWP beneficial use based on anoxic conditions, primarily in the summer season (See Figure 9.). Chloride and sulfate water quality parameters were also added to the lake sampling program in year 2003-2004. These additions allow for an assessment of the agriculture beneficial use of our reservoirs and much like metals sampling is a sampling effort that we plan on

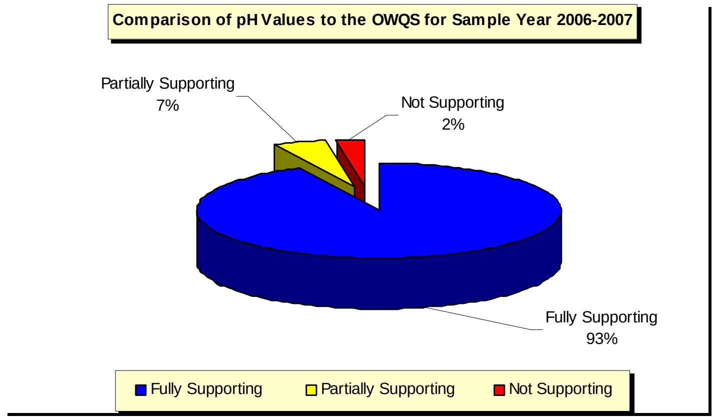


Figure 4. Percent of lakes assessed that exceeds or meets the WQS for pH.

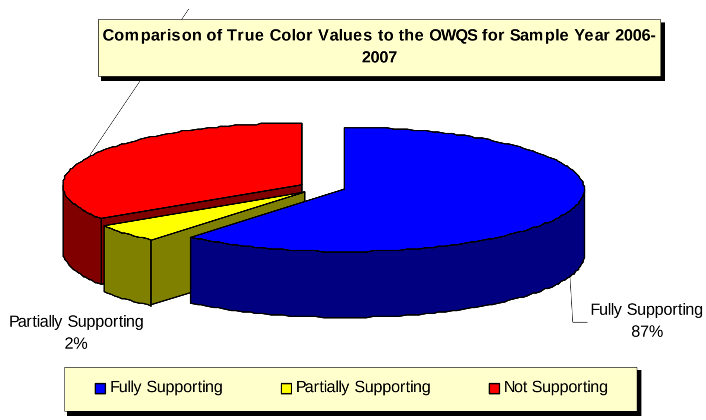


Figure 5. Percent of lakes assessed that exceeds or meets the WQS for true color.

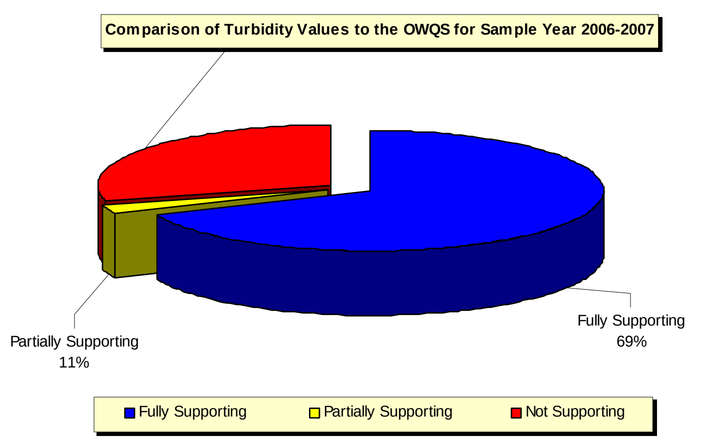


Figure 6. Percent of lakes assessed that exceeds or meets the WQS for turbidity.

LAKES MONITORING PROGRAM

continuing into the future. Analysis of the chloride and sulfate data revealed that only three lakes sampled were not supporting the agriculture beneficial use (See Figure 8). Analysis of the bacteria data indicated forty of the lakes sampled were supporting their Primary Body Contact Recreation beneficial use (See Figure 8).
It is the intent of the OWRB monitoring program to pursue adding additional monitoring parameters to the lake sampling initiative to allow all beneficial uses to be assessed. It is also the OWRB intent to accomplish this without having to reduce the number of lakes sampled annually.

A brief synopsis of the results from OWRB field sampling for each of the 41 lakes sampled in 2006-2007 as well as the lakes sampled in 2005-2006 is discussed in alphabetical order on the following pages.

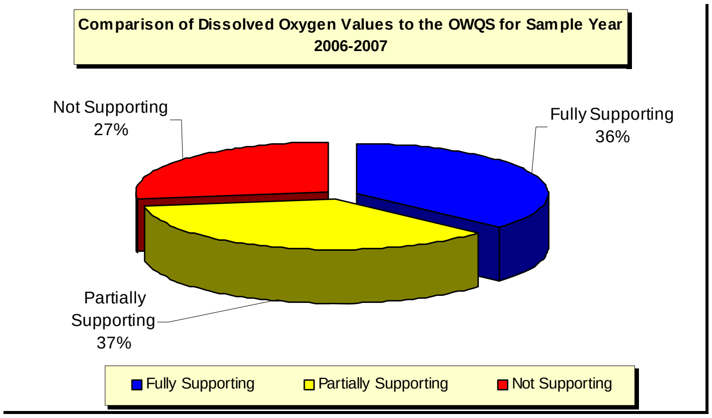


Figure 7. Percent of lakes assessed and their support status of the WQS for dissolved oxygen

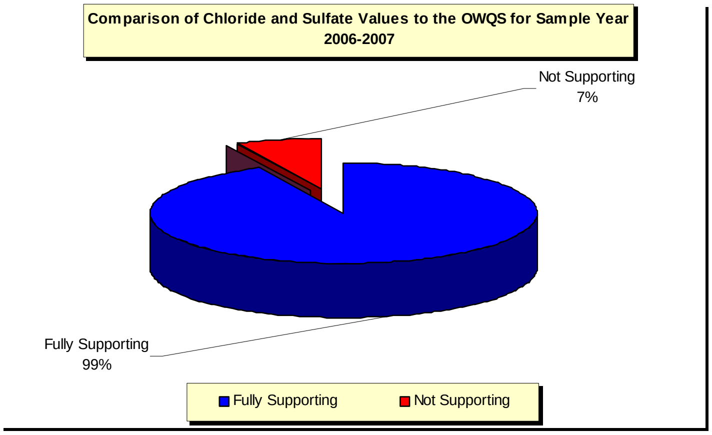


Figure 9. Percent of lakes assessed and their support status of the WQS for chlorides & sulfates.

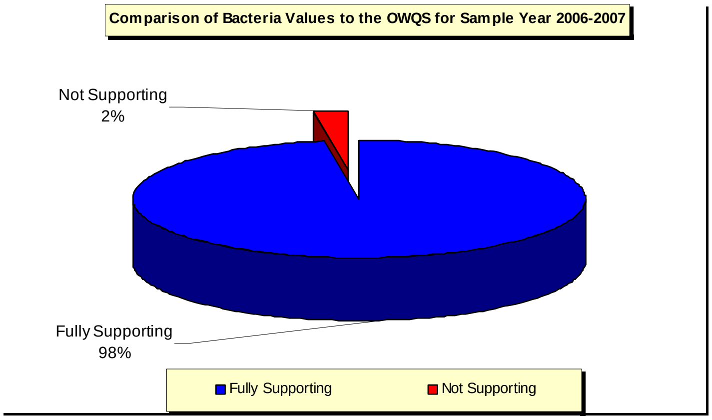
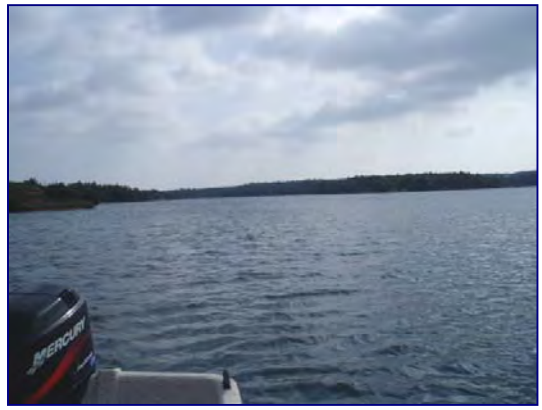


Figure 8. Percent of lakes assessed and their support status of the WQS for bacteria.

American Horse Lake



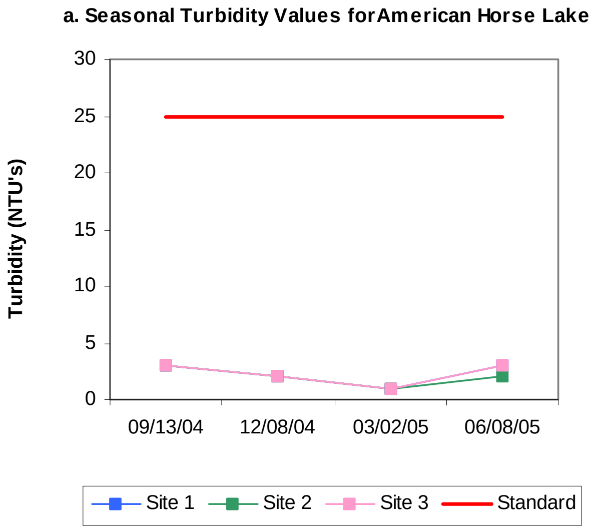
American Horse Lake was sampled for four quarters, from September 2004 through June 2005. Water quality samples were collected at three (3) sites to represent the riverine, transition and lacustrine zones of the lake. Samples were collected from the lake surface at all sites and at 0.5 meters from the bottom at site 1, the dam. The lake-wide annual average turbidity was 2 NTU (Plate 1), true color was 12 units and secchi disk depth was 288 centimeters in sample year 2004-2005. Based on these three parameters, American Horse Lake had excellent water clarity. The trophic state index, using Carlson's TSI (chlorophyll-a) was calculated using values collected at all three sites for four quarters (n=11). The result was a TSI of 49 (Plate 1), classifying the lake as mesotrophic, indicative of moderate levels of primary productivity and nutrient conditions. This is slightly lower than the value calculated in 2003 (TSI=55). The TSI values were upper mesotrophic to eutrophic throughout the year with the exception of the spring quarter when values fell into the oligotrophic category. Seasonal turbidity are displayed in Figure 10a. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With a 100% of the turbidity values well below the Oklahoma Water Quality Standard (WQS) of 25 NTU the lake is meeting the Fish and Wildlife Propagation (FWP) the beneficial use. Seasonal true color values are displayed in (Figure 10b). Applying the same default protocol, the Aesthetics beneficial use is fully supported with all collected values below the WQS of 70 units.

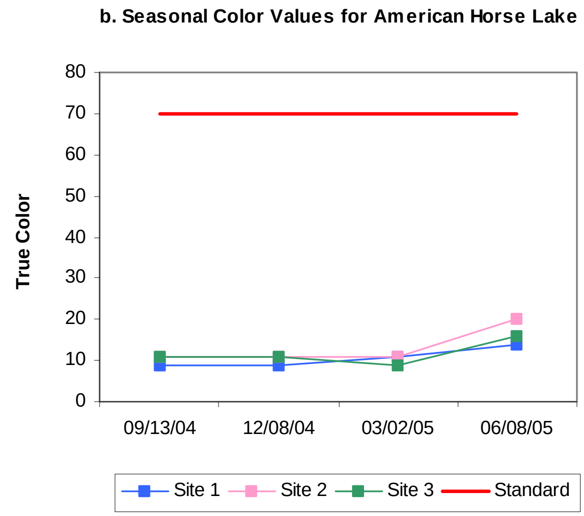
In sample year 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity; oxidation-reduction potential and salinity were recorded at all three sample sites. The salinity ranged from 0.15 parts per thousand (ppt) to 0.18 ppt for this sample year. Specific conductivity ranged from 310 µS/cm to 372.7 µS/cm, which falls within the range of values commonly reported for Oklahoma lakes. These values indicate a moderate level of current conducting ions (salts) were present in the system. The pH values at American Horse Lake ranged from 6.97 to 8.28, representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if they fall outside the range of 6.5 to 9.0 for 25% of the values and they waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Based on pH values collected American Horse Lake is currently supporting its FWP beneficial use. Oxidation-reduction potentials ranged from 3 mV in the fall quarter near the sediment-water interface to 495 mV in the spring. Reducing conditions were present at sites 2 and 3 in the fall sampling interval, when a large portion of the water column was anoxic. During the winter and spring sampling intervals, thermal stratification was not present (Figure 10d-10e). Thermal stratification was evident in both fall and summer quarters and anoxic conditions were present. In the fall stratification occurred at between 7 and 8 meters in depth at which point dissolved oxygen dropped below 2.0 mg/L at all three sites. During the summer quarter the lake exhibited strong thermal stratification between 4 and 5 meters at which point the dissolved oxygen dropped below 2 mg/L for the remainder of the water column (Figure 10f). If the D.O. values are less than 2.0 mg/L for greater than 70% of the water column the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70 % of the water column, the FWP beneficial use is deemed partially supported. In the fall quarter anoxic conditions comprised approximately 58% of the water column at site 2. Similar conditions were present during the summer quarter with 54 to 67% of the water column less than 2.0 mg/L. Based on this information the FWP beneficial use is considered partially supported at American Horse Lake. These conditions could pose a serious concern, threatening fish and wildlife propagation and the lake should be closely monitored in the future. The lake was also sampled for total dissolved solids, chlorides and sulfates to assess the Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported bases on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

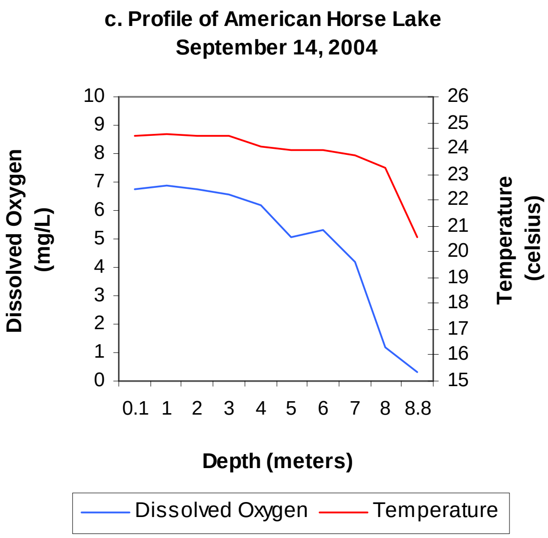
Bacteriological samples were not collected during the study period; therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

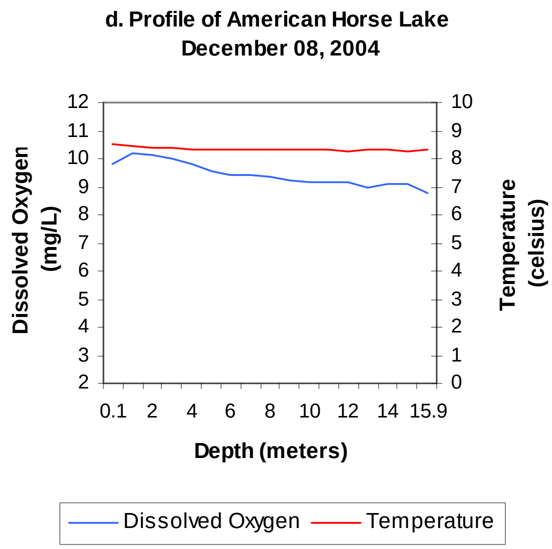
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.63 mg/L. The TN at the surface ranged from 0.46 mg/L in the summer to 0.77 mg/L in the spring quarter. The lake-wide total phosphorus (TP) average was 0.032 mg/L. The total phosphorus at the surfaced ranged from 0.018 mg/L to 0.050 mg/L with lower values occurring in the spring quarter. The nitrogen to phosphorus ration (TN:TP) was 21:1 for sample year 2003. This value is much higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

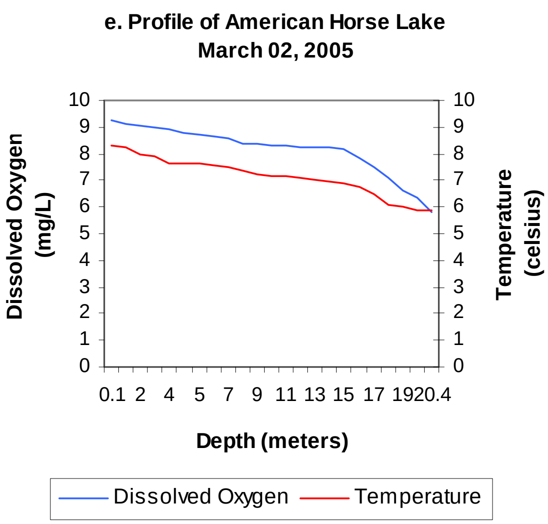
In summary, American Horse Lake was mesotrophic, indicative of moderate primary productivity and nutrient conditions slightly lower than the results from the 2002-2003 data collection efforts. Water clarity was excellent based on true color, turbidity and secchi disk depth. The lake is supporting the FWP beneficial use based on pH, and turbidity. Anoxic conditions present in both fall and summer months constitute a listing of partial support for the FWP beneficial use based on dissolved oxygen concentrations at American Horse Lake. With an annual average for true color of 3 units and a TSI of 49 the Aesthetics beneficial use is supported. This reservoir is located in Blaine County and is managed by the Oklahoma Department of Wildlife Conservation for the recreational purposes.











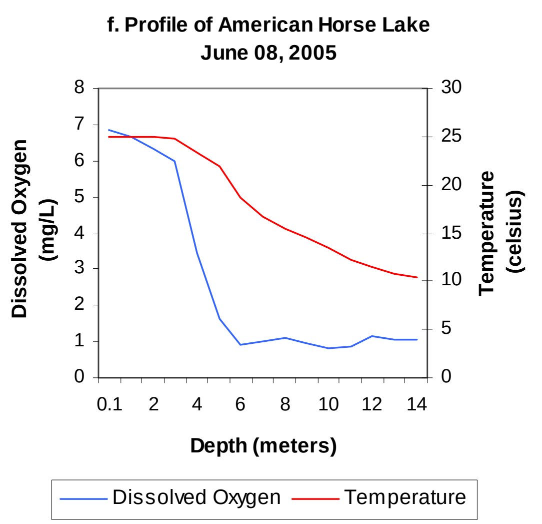


Figure 10a-10f. Graphical representation of data results for American Horse Lake.

Lake Data

Owner	State of Oklahoma
County	Blaine
Constructed in	1966
Surface Area	100 acres
Volume	2,200 acre/feet
Shoreline Length	7 miles
Mean Depth	22.00 feet
Watershed Area	3,124 acres

Plate 1 - Lake Water Quality for
American Horse Lake

Arbuckle Reservoir

Arbuckle Reservoir was sampled for four quarters from November 2004 through August 2005. Water quality samples were collected at five (5) sites to represent the riverine, transition and lacustrine zones of the lake. Samples were collected from the lake surface at all sites and at 0.5 meters from the lake bottom at site 1, the dam. The lake-wide average turbidity was 5 NTU, (Plate 2), true color was 17 units and average secchi disk depth was 166 centimeters. Based on these parameters water clarity at Arbuckle Reservoir was excellent in sample year 2005. The trophic state index using Carlson's TSI (chlorophyll-a) was calculated using values collected at all sites for four quarters (n=20). The result was a TSI of 46 (Plate 2), indicating the lake was mesotrophic in sample year 2005. This value is similar to the one calculated in 2003 (TSI=48), indicating no significant change in productivity has occurred. The TSI values were fairly consistent and ranged from mesotrophic in the fall, spring and summer quarters to oligotrophic at sites 1 and 5 during the winter. Seasonal turbidity values are displayed in Figure 11a. All turbidity values were well below the Oklahoma Water Quality Standard (WQS) turbidity standard of 25 NTU with values ranging between 3 and 6 NTU. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the values below the numerical criteria the lake is considered to be fully supporting its Fish & Wildlife Propagation (FWP) beneficial use. Seasonal true color values are displayed in Figure 11b. All color values were well below the WQS of 70 units; therefore the aesthetics beneficial use is considered fully supported.

In sample year 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential and salinity were recorded at all sample sites. Salinity ranged from 0.18 ppt to 0.22 ppt. This value is within the average range recorded for Oklahoma lakes. Specific conductivity ranged from 357 µS/cm to 467.8 µS/cm, indicating moderate levels of current conducting ions were present in the lake system. Oxidation-reduction potentials (ORP) ranged from 288 mV at the lake bottom in the winter to 480 mV in the summer. Reducing conditions were not present in the reservoir in the 2004-2005-sample year. The pH values at Arbuckle Reservoir ranged from 7.15 in the summer quarter to 8.30 in the spring representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if they fall outside the range of 6.5 to 9.0 for 25% of the values and they waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Based on pH values collected Arbuckle Reservoir is currently supporting its FWP beneficial use. Thermal stratification was not present during the fall, winter or spring quarters and the water column was evenly mixed. Dissolved oxygen (D.O) levels remained above 6.0 mg/L during the fall and above 9 mg/L in the winter sampling quarters respectively (Figure 11c-11e). Thermal stratification was evident and anoxic conditions were present in the summer quarter. In the summer stratification occurred between 6 and 7 meters with dissolved oxygen levels less than 2.0 mg/L from 8 meters below the surface to the lake bottom of 21.8 meters accounting for 65% of the water column at site 1, to be experiencing anoxic conditions (see Figure 11f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With anoxic conditions present in 65% of the water column in the summer Arbuckle Reservoir is considered to be partially supporting the FWP beneficial use. These conditions could however pose a serious concern, threatening the FWP beneficial use and the lake should be monitored closely in the future. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Arbuckle Reservoir was not sampled for bacteria during the study period and an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.43 mg/L. Surface TN ranged from 0.17mg/L to 1.13 mg/L, with the highest values occurring in the summer and lowest in the spring. The lake-wide total phosphorus (TP) average was 0.024 mg/L. Total phosphorus at the surface ranged from 0.013 mg/L to 0.038 mg/L. Similar to nitrogen, surface TP was lowest in the spring quarter however the highest values were recorded during the winter months. The nitrogen to phosphorus ratio (TN:TP) was 18:1 for sample year 2003. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

In summary, Arbuckle Reservoir was classified as mesotrophic indicative of moderate productivity and nutrient levels in 2004-2005 (Plate 2). This classification is the same as that in 2003, indicating no significant increase or decrease in productivity has occurred over time. Water clarity was excellent based on true color, turbidity, and high secchi disk depth readings. The lake is fully supporting the FWP beneficial use based on pH and partially supporting based on anoxic conditions present during the summer. The Aesthetics beneficial use is also supported based on its trophic status and extremely low true color readings. Arbuckle Reservoir, located in Murray County, was constructed by the Bureau of Reclamation and is utilized as a municipal water supply, flood control, and fish and wildlife recreation lake.

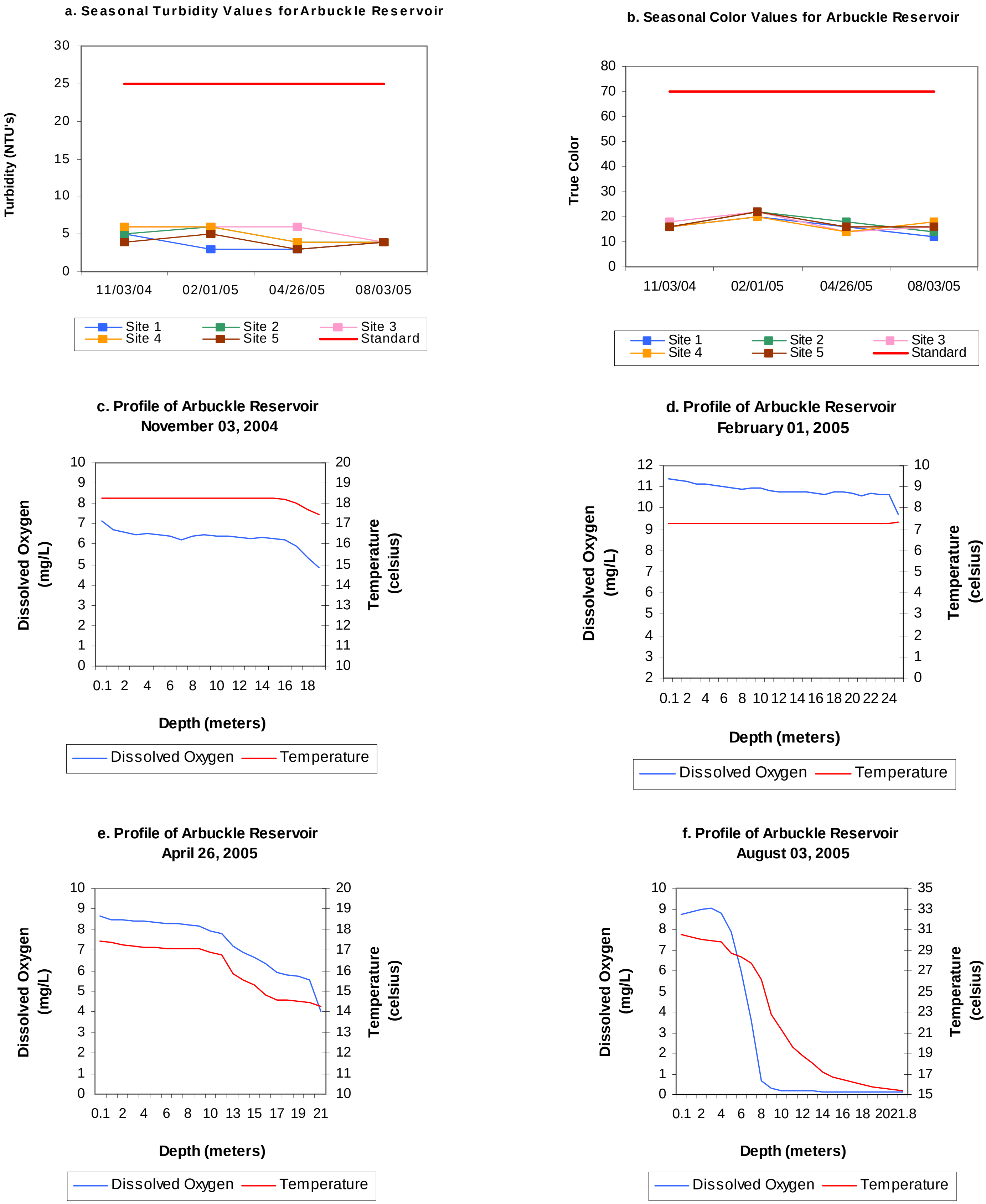
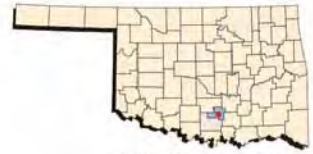


Figure 11a-11f. Graphical representation of data results for Arbuckle Reservoir.

Plate 2 - Lake Water Quality for
Arbuckle Reservoir

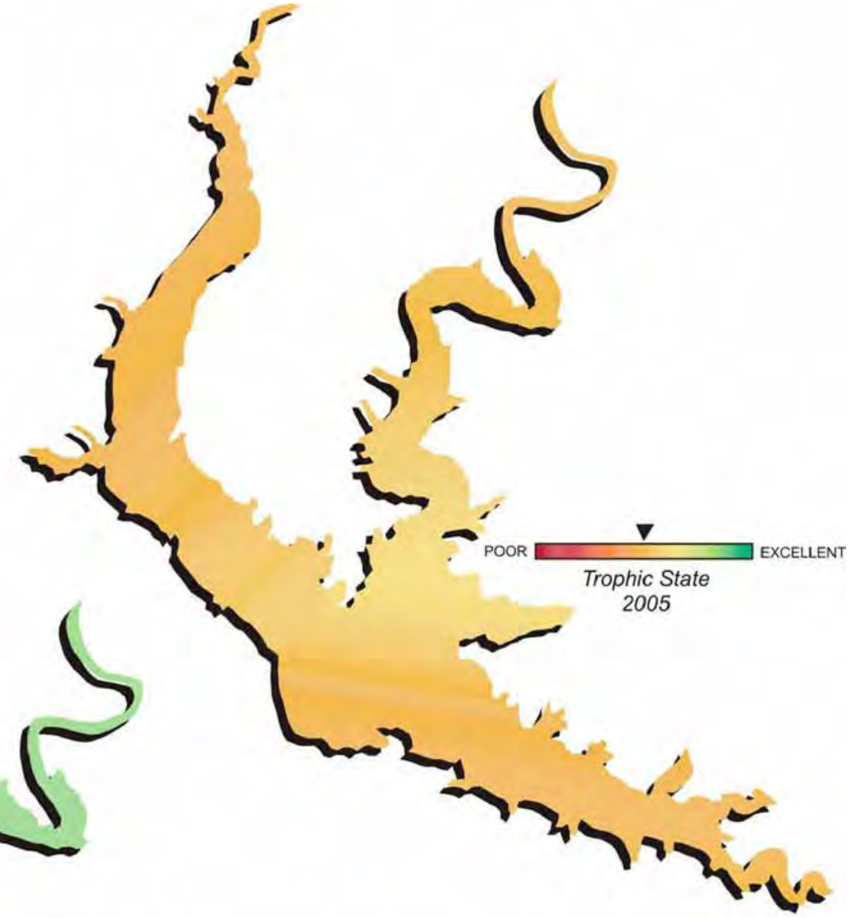
LAKES MONITORING PROGRAM

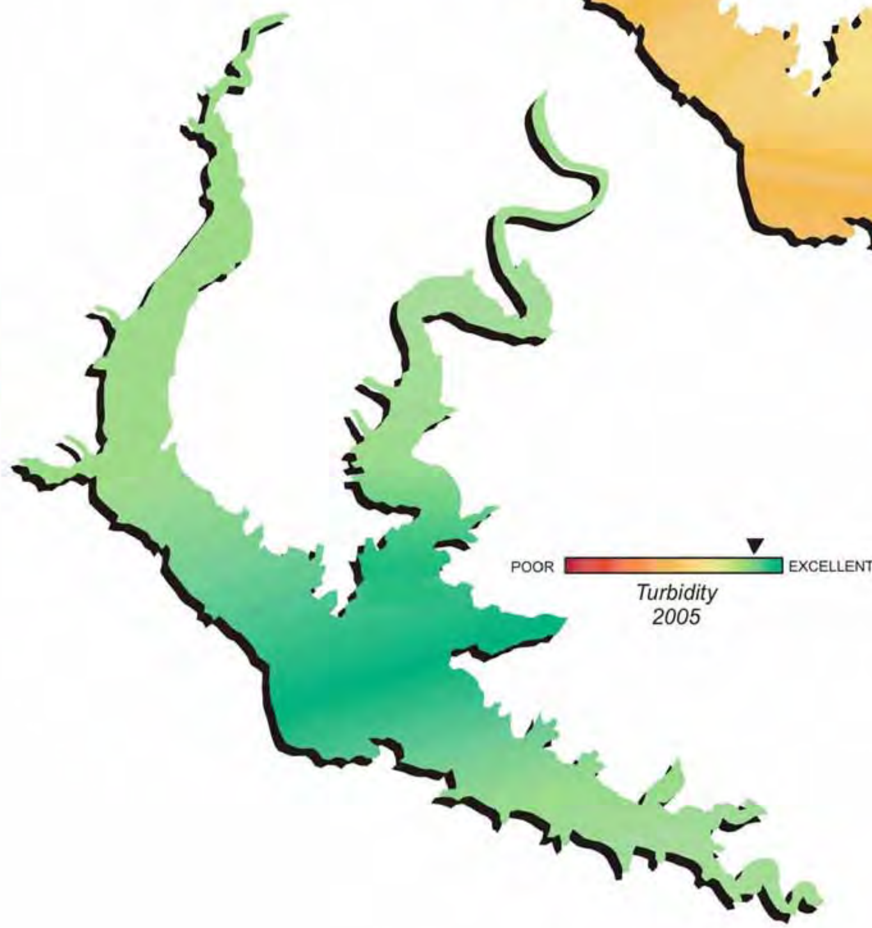
Arbuckle Reservoir and Watershed



Arbuckle Reservoir Location

Lake Data	
Constructed by	Bureau of Reclamation
County	Murray
Constructed in	1967
Surface Area	2,350 acres
Volume	72,400 acre/feet
Shoreline Length	36 miles
Mean Depth	30.8 feet
Watershed Area	126 square miles





Arcadia Lake

Arcadia Lake is a 1,820-acre reservoir, located in Oklahoma County. The reservoir was constructed in 1986 by the United States Army Corps of Engineers (USACE) to serve as the water supply for the City of Edmond as well as flood control and recreation purposes. Arcadia Lake was sampled for four quarters, from October 2006 through August 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transition and lacustrine zones and major arms of the reservoir. Samples were collected from the lake surface at all sites during the study period. The average lake-wide turbidity was 42 nephelometric turbidity units (NTU), true color was 53 units, and average secchi disk depth was 67 centimeters in sample year 2006-2007. Water clarity was average at Arcadia Lake based on these three parameters. Results for turbidity, true color, and secchi disk depth are similar to those recorded in 2005. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI was 58 (Plate 3), indicating the lake was eutrophic, with high levels of productivity and nutrient conditions for sample year 2007. This value is slightly less than the value calculated in 2005 (TSI=62). The TSI for all sites ranged from hypereutrophic in the fall and summer quarters to upper eutrophy in the winter with oligotrophic conditions observed in the spring quarter. Turbidity values were fairly consistent throughout the year with large peaks recorded at sites 4 and 5 during the spring sampling event (see Figure 12a). Of the values collected, six (6) exceeded the Oklahoma Water Quality Standard (OWQS) of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if $\geq$ 25% of the samples exceed the standard of 25 NTU for turbidity. Although 30% of the values exceed the numerical criteria of 25 NTU, field observations recorded by staff along with available flow and rainfall data suggest that this is the result of a seasonal storm event. The Fish and Wildlife Propagation (FWP) beneficial use will therefore be considered supported in regards to turbidity for this sample period. Seasonal true color values are displayed in Figure 12b. A similar pattern was observed in the collected color values, with a large peak at sites 4 and 5 during the spring quarter. Since this too is likely the result of seasonal storm events, the Aesthetics beneficial use is considered fully supported at Arcadia Lake.

In 2006-2007, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all five sample sites. Salinity values ranged from 0.10 parts per thousand (ppt) to 0.20 ppt. This is within the average range of values recorded in Oklahoma reservoirs. Specific conductivity ranged from 209.7 µS/cm to 422 µS/cm, indicative of moderate levels of current conducting ions (salts) in the lake system. The recorded values for pH ranged from 7.32 in the summer to 8.47 in the fall representing a neutral to slightly alkaline lake system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if they fall outside the range of 6.5 to 9.0 for 25% of the values and the waterbody should be listed as not supporting its FWP beneficial use. With 100% of the recorded values within the acceptable range, Arcadia Lake is currently supporting its FWP beneficial use as it relates to pH. Oxidation-reduction potentials (ORP) ranged from 148 mV in the summer to 415 mV, recorded in the fall, indicating reducing conditions were not present at this reservoir during the 2006-2007 sample period. Arcadia Lake was not thermally stratified in the first three sampling quarters (Figure 12c-12e) with dissolved oxygen levels remaining above 5.0 mg/L. During the summer the lake was stratified and anoxic conditions were present in the hypolimnion. Stratification occurred at 7 meters below the surface at both sites 1 (dam) and 2 (near Spring Creek) at which point dissolved oxygen (D.O.) levels dropped below 2 mg/L for the remainder of the water column (Figure 12f). Site 4 was stratified, between 4 and 5 meters in depth with D.O. less than 2 mg/L from 5 meters to the lake bottom of 6.4 meters. According to USAP, If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. levels are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is considered partially supported. With only 20-38% of the water column experiencing anoxic conditions in the summer months Arcadia Lake is considered to be supporting the Fish and Wildlife Propagation beneficial use. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. The PBCR beneficial use cannot be determined as minimum data requirements were not met due to quality control issues for *E. coli* and Enterococci. Of the 10 fecal coliform samples collected, all were below the screening level of 400 cfu/ml and the geometric mean (18.56 cfu/ml) was below the prescribed mean standard of 400 cfu/ml.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.98 mg/L. Surface TN ranged from 0.75 mg/L to 1.85 mg/L with the highest values recorded in the spring quarter and lowest in the fall quarter. The lake-wide total phosphorus (TP) average was 0.064 mg/L. Surface TP ranged from 0.025 mg/L to 0.231 mg/L was also highest in the spring with the low values occurred during the winter sampling quarter. The nitrogen to phosphorus ratio (TN:TP) was 15:1 for sample year 2006-2007. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

Arcadia Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Arcadia Lake was classified as eutrophic indicative of high primary productivity and nutrient levels (Plate 3). Water clarity was average with values for turbidity, true color and secchi disk depth being similar to those recorded in sample year 2005. Although 30% of the turbidity exceeded the WQS of 25 NTU, the lake will be considered supporting the FWP as the spikes in turbidity are related to seasonal storm events at the time of sampling. The Aesthetics beneficial use is considered supported based on trophic status and true color. Of the twenty (20) color values collected, only 2 (10%) exceeded the WQS of 70 units. Similar to turbidity, a large spike occurred in the upper end of the reservoirs and can be attributed to storm events. The lake is currently supporting the FWP beneficial use based on pH as well as dissolved oxygen levels. The PBCR is considered supported for fecal coliform; however due to minmum data requirements not being met for E.coli and enterococci and assessment of these parameters cannot be made. In 2007, the City of Edmond contracted the OWRB to conduct a bathymetric survey of Arcadia Lake to determine current lake volume, capacity and sedimentation rates (Figure 13). For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.

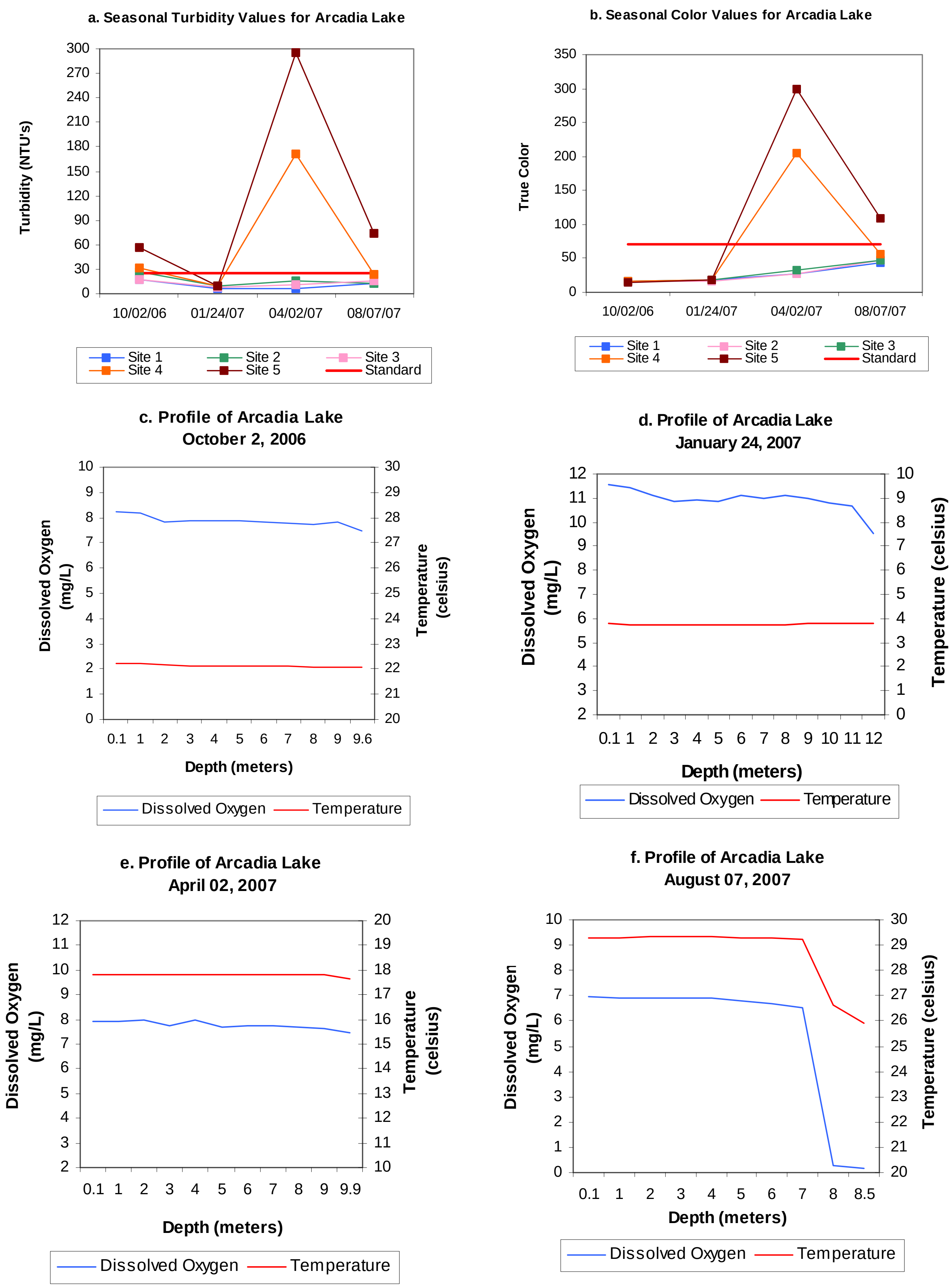
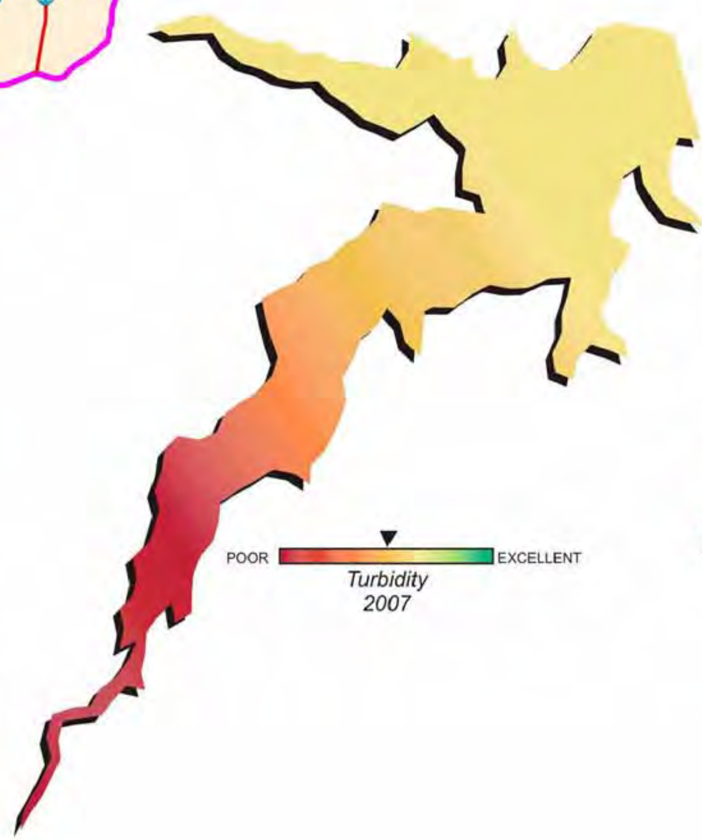
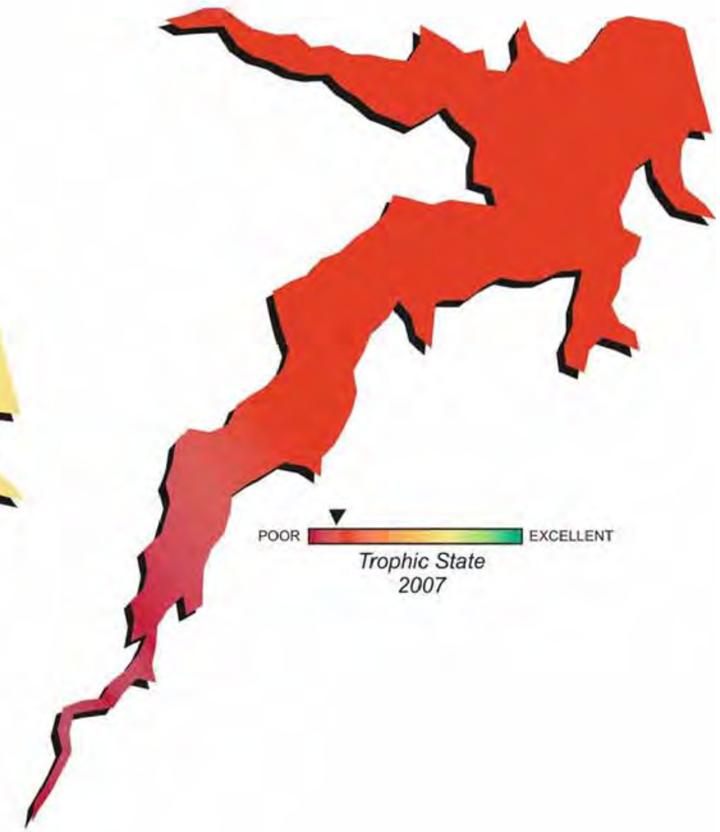


Figure 12a-12f. Graphical representation of data results for Arcadia Lake.





Lake Data

Constructed by	Corps of Engineers
County	Oklahoma
Constructed in	1980
Surface Area	1,820 acres
Volume	27,520 acre/feet
Shoreline Length	26 miles
Mean Depth	15.14 feet
Watershed Area	105 square miles

Plate 3 - Lake Water Quality for

Arcadia Lake

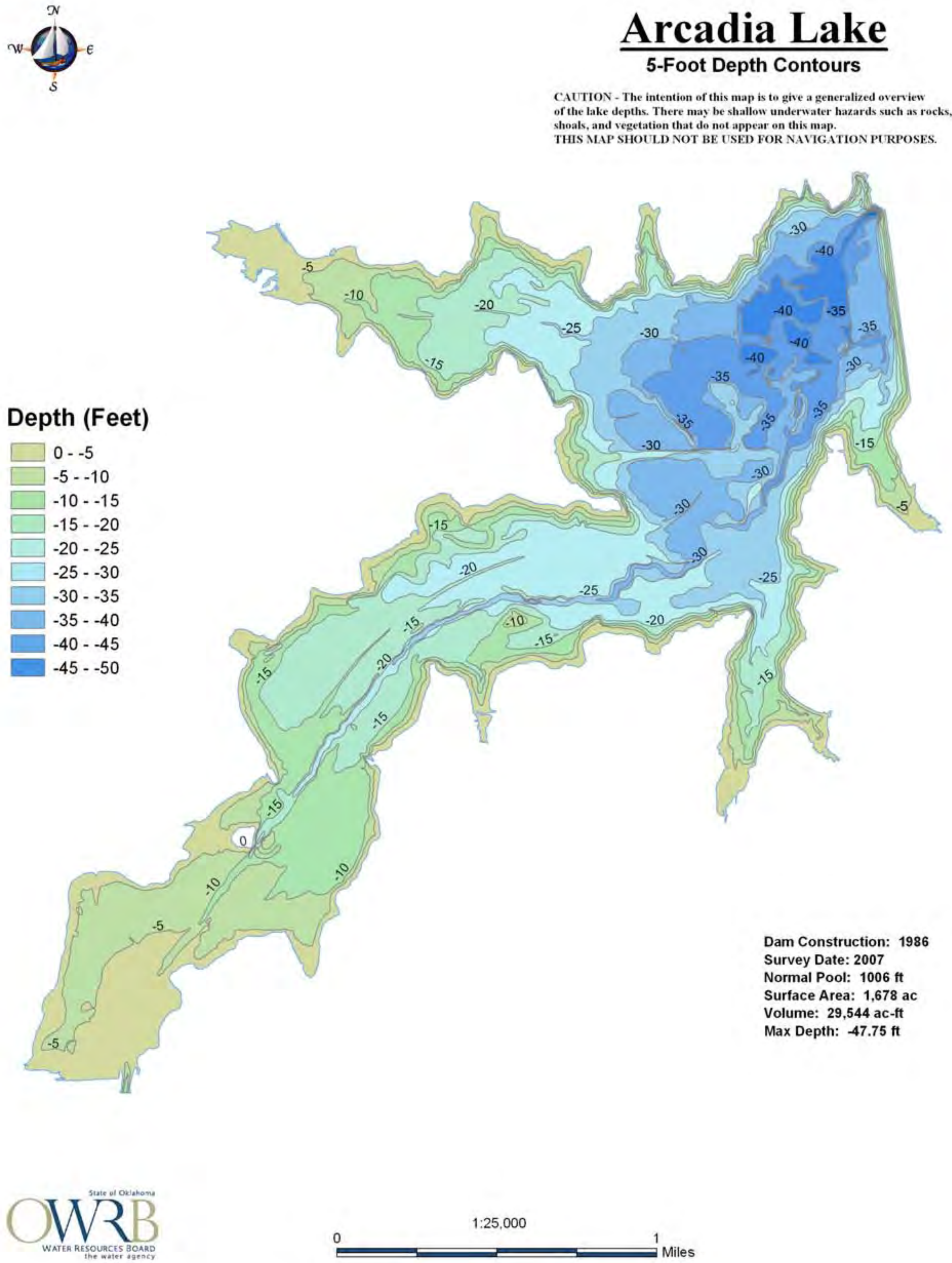


Figure 13. Bathymetric Map of Arcadia Lake.

Ardmore City Lake

Ardmore City Lake, constructed in 1910, is a 142-acre lake owned by the City of Ardmore for the purpose of recreation. Ardmore City Lake was sampled for four quarters, from October 2006 through July of 2007.

Water quality samples were collected at three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The average lake-wide turbidity was 10 NTU, true color was 25 units, and average secchi disk depth was 106 centimeters in sample year 2007. Water clarity was excellent at Ardmore City Lake based on the high secchi disk depth and low turbidity values and is similar to results from the 2005 evaluation. The trophic state index, using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The TSI was 52 (Plate 4), indicating the lake was eutrophic in sample year 2007. The TSI values for all sites were fairly consistent throughout the sample year with values ranging from mid-mesotrophic to mid-eutrophic. In 2005, the calculated TSI value was slightly lower (TSI=49) indicating no significant change in productivity has occurred. Turbidity values ranged from a low of 4 NTU to a maximum of 17 NTU (Figure 14a). With 100% of the turbidity values well below the Oklahoma Water Quality Standard (WQS) of 25 NTU the lake is meeting the Fish and Wildlife Propagation (FWP) beneficial use. Similar to turbidity, all color values were well below the aesthetics WQS for color 70 units (see Figure 14b). Applying the same default protocol the Aesthetics beneficial use is considered supported at Ardmore City Lake.

In 2007, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all three sample sites. Salinity values ranged from 0.13 parts per thousand (ppt) to 0.18 ppt, which is within the average range of values observed in Oklahoma reservoirs. Specific conductivity ranged from 278.6 µS/cm to 365 µS/cm, indicative of moderate levels of current conducting ions (salts) in the lake system. The recorded values for pH ranged from 7.16 to 8.85 representing a neutral to slightly alkaline lake system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if they fall outside the range of 6.5 to 9.0 for 25% of the values and they waterbody should be listed as not supporting its FWP beneficial use. Based on pH values collected during the study period Ardmore City Lake is currently supporting its FWP beneficial use as it relates to pH. Oxidation-reduction potentials (redox) ranged from 48 mV near the sediment-water interface in the spring at site 1 to 436 mV in the fall quarter. Although all redox values were positive, they were approaching reducing conditions were near the sediment-water during the spring quarter. This is not uncommon when a large portion of the water column is anoxic. The lake was well mixed and thermal stratification was not present during the fall and winter sampling events (Figure 14c-14d) Thermal stratification was evident and anoxic conditions were present during both the spring and summer sampling quarters. In the spring, the lake was stratified at both sites 1 and 2, the deepest sites. Stratification occurred between 2 and 3 meters below the surface, with dissolved oxygen levels dropping below 2.0 mg/L from 4 meters to the lake bottom of 8.2 meters. Similar conditions were recorded in the summer with D.O. below 2 mg/L from 4 meters to the lake bottom of 8.4 meters with anoxic conditions comprising 60-65% of the water column at sites 1 and 2, respectively (Figure 14e,14f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. levels are less than 2.0 mg/L for 50 to 70% of the water column the FWP beneficial use is considered partially supported. At this time Ardmore City Lake is considered partially supporting the FWP beneficial use based on dissolved oxygen concentrations. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. All sample results were at or below the detection limit, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.45 mg/L at the surface. Surface TN ranged from 0.32 mg/L to 0.62 mg/L with the highest values recorded in the summer quarter and lowest in the fall. The lake-wide total phosphorus (TP) average was 0.020 mg/L at the surface. Surface TP ranged from 0.009 mg/L to 0.035 mg/L. Similar to TN, the highest TP values were reported in the summer months while the lowest values occurred during the spring sampling quarter. The nitrogen to phosphorus ratio (TN:TP) was 22:1 for sample year 2007. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

Ardmore City Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Ardmore City Lake was classified as eutrophic, indicative of high primary productivity and nutrient levels in sample year 2007 (Plate 4). Water clarity was excellent based on turbidity, true color, and secchi disk depth readings. The results for these parameters are similar to those of previous sampling efforts conducted in 2005, indicating little change in clarity has occurred over time. The lake is currently supporting the Fish and Wildlife Propagation (FWP) beneficial use based on pH and turbidity values reported during the sample year. With anoxic conditions present in 60-65% of the water column in the spring and summer the lake is considered partially supporting the FWP beneficial use. The Aesthetics beneficial use is also considered supported based on trophic status and true color, with 100% of the color values well below the WQS of 70 units. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Of the 10 samples collected, only 1 exceeded the screening level for fecal coliform, therefore the PBCR is considered supported.

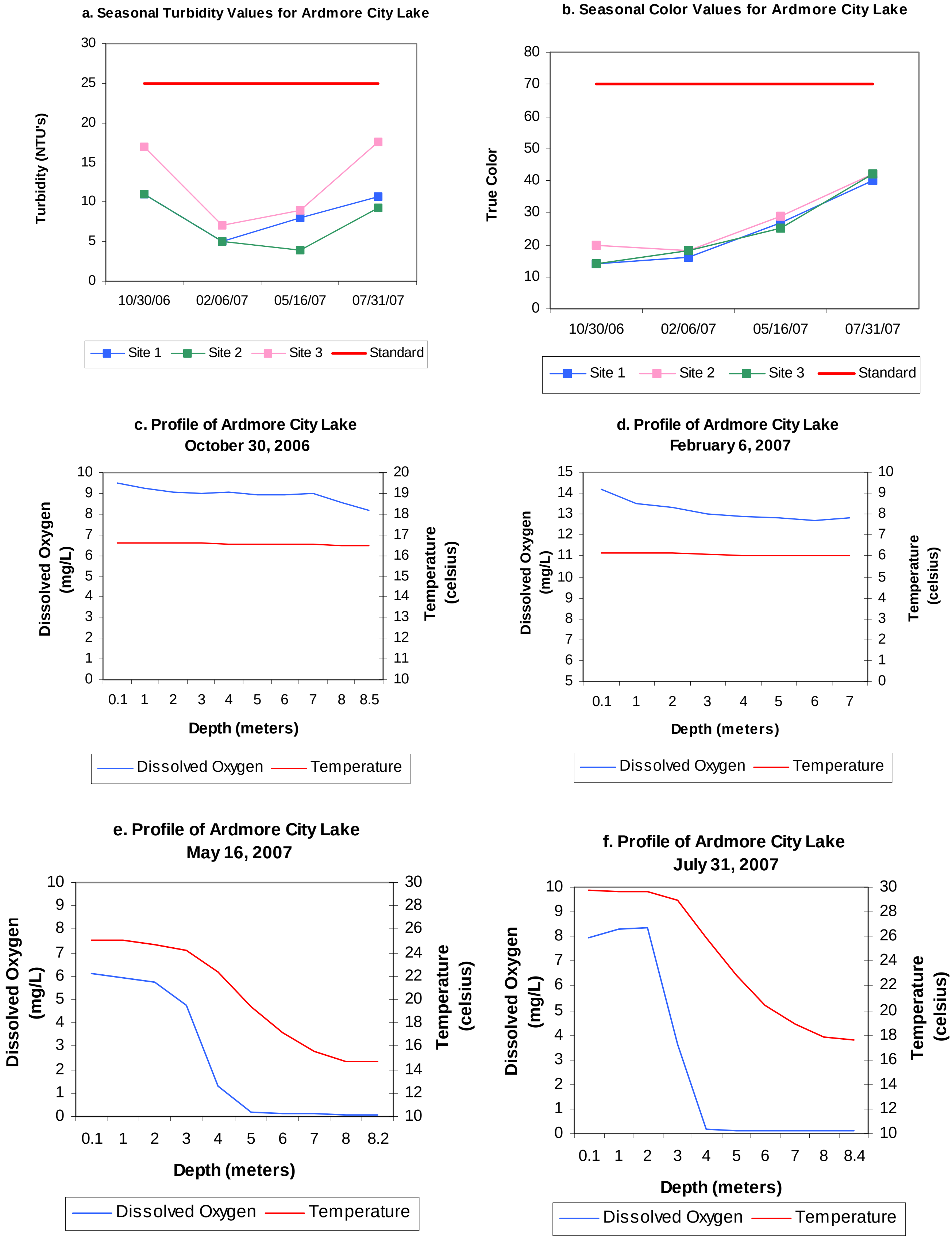


Figure 14a-14e. Graphical representation of data results for Ardmore City Lake.

Plate 4 - Lake Water Quality for

Ardmore City Lake

Ardmore City Lake Location

Lake Data	
Owner	City of Ardmore
County	Carter
Constructed in	1910
Surface Area	142 acres
Volume	600 acre/feet
Shoreline Length	5 miles
Mean Depth	4.23 feet
Watershed Area	2,046 acres

LAKES MONITORING PROGRAM

Atoka Lake

Atoka Lake, constructed in 1964, is a recreational reservoir managed by the City of Oklahoma City. The lake also serves as a water supply for the city with water from Atoka Lake transported via pipeline to Lake Stanley Draper. It is then treated and transported to Oklahoma City water customers. Atoka Lake was sampled for four quarters, from October 2006 through July of 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The average lake-wide turbidity was 53 NTU, true color was 160 units, and average secchi disk depth was 33 centimeters in sample year 2006-2007. Water clarity was poor at Atoka Lake based on the low secchi disk depth and high turbidity values. Atoka Lake has a historty of high levels of clay particulates suspended in the water column, which results in low water clarity. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI was 51 (Plate 5), indicating the lake was eutrophic bordering mesotrophic in sample year 2006-2007. The TSI values for all sites throughout the sample year were fairly consistent with all values in the mesotrophic and eutrophic categories. The only exception to this was sites 4 and 5 during the month of January, which was oligotrophic. Seasonal turbidity values per site for this sample year are displayed in Figure 16a. Of the twenty (20) turbidity values collected, 17 were above the turbidity standard of 25 NTU with the lowest recorded value of 18 NTU and the maximum value of 95 NTU. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. With 85% of the values exceeding the numerical criteria the lake is considered not supporting its Fish & Wildlife Propagation (FWP) beneficial use. However, in the case of Atoka Lake, evidence suggests that the high turbidity readings are natural based on the local soil conditions. Seasonal true color values are displayed in Figure 16b. The lake-wide average for color was calculated at 160 units, which greatly exceeded the Aesthetics WQS of 70 units for color. Applying the same default protocol, Atoka Lake is not meeting the Aesthetics beneficial use based on true color.

In 2006-2007, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all five sample sites. The salinity values for Atoka Lake ranged from 0.01 parts per thousand (ppt) to 0.04 ppt for this sample year. Specific conductivity ranged from 44.1 to 97.7 µS/cm, which falls within the range of values commonly reported for Oklahoma reservoirs. These values indicate relatively low levels of ions present in the system. The pH values at Atoka Lake ranged from 6.36 units to 8.41, representing a slightly acidic to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if they fall outside the range of 6.5 to 9.0 for 25% of the values and the waterbody should be listed as not supporting its FWP beneficial use. Only 12 (6.9%) pH values collected were below 6.5 units, therefore Atoka Lake is considered supporting its FWP beneficial use as it relates to pH. Oxidation-reduction potentials ranged from 325mV in the in the fall to 457mV in the spring, indicating reducing conditions were not present at this reservoir in 2007 sample year. Stratification was not present during the fall, winter and spring quarters. The lake was well mixed, and dissolved oxygen values were generally above 7 mg/L (see Figure 16c-16e). At site 1, (the dam) thermal stratification was evident during the summer with dissolved oxygen (D.O.) falling below 2 mg/L from 10 meters below the surface to the lake bottom of 18.5 meters (see Figure 16f). Sites 2, 3, 4 and 5 also exhibited stratification with anoxic conditions comprising 14-50% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With 14 to 50% of the water column less than 2.0 mg/L the lake is considered to be supporting its FWP beneficial use based on dissolved oxygen concentrations. The lake was also sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. All sample results were at or below the detection limit, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.71 mg/L. The TN at the surface ranged from 0.46 mg/L in the fall to 1.06 mg/L in the winter months. The lake-wide total phosphorus (TP) average was 0.105 mg/L. The TP at the surface ranged from 0.039 mg/L to 0.198 mg/L. The surface TP was highest in the fall quarter and lowest in the winter. The nitrogen to phosphorus ratio (TN:TP) was approximately 11:1 for sample year 2006-2007. This value is close to the 7:1 ratio generally used to determine the limiting nutrient, characterizing the lake as potentially phosphorus-limited to co-limited (Wetzel, 1983).

Atoka Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Atoka Lake was classified as eutrophic bordering mesotrophic with moderate to high productivity and nutrient levels in 2006-2007. This is consistent with previous data collection efforts in 2004 (TSI=50), indicating little change in lake productivity or nutrient levels has occurred. Water clarity was poor based on secchi disk depth, high turbidity and true color values and is likely to always be poor based on the soil composition of the area. The lake is supporting its FWP based on dissolved oxygen concentrations; however the beneficial use is not supported based on turbidity with 17 of the 20 values exceeding the standard of 25 NTU. With only 6% of the pH values less than 6.5 units, the FWP beneficial use is supporting as it relates to pH. The lake is supporting its Aesthetics beneficial use based on its trophic status, but is not supporting the use due to extremely high true color concentrations. The PBCR beneficial use is considered supported based on bacteria samples collected during the recreation season. In 1997 the Oklahoma Legislature directed the OWRB to conduct a study on the impact of Confined Animal Feeding Operations (CAFO) in watersheds that supply potable water to municipalities with a population over 250,000. As part of this study a bathymetric survey was completed on Oklahoma City's water supply reservoirs. A bathymetric map (Figure 17) was generated to determine current storage capacity and identify areas of extreme sedimentation.

For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.

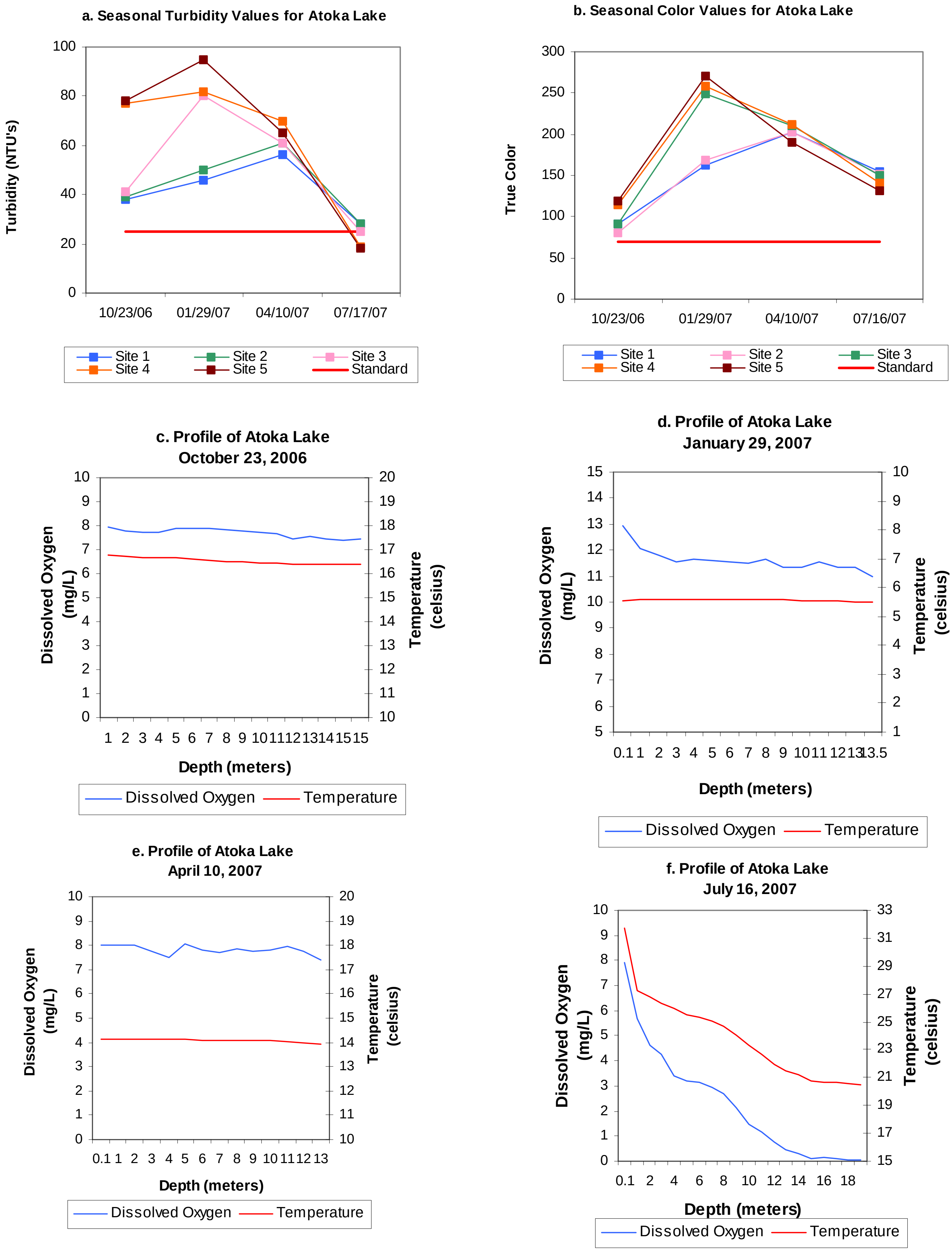
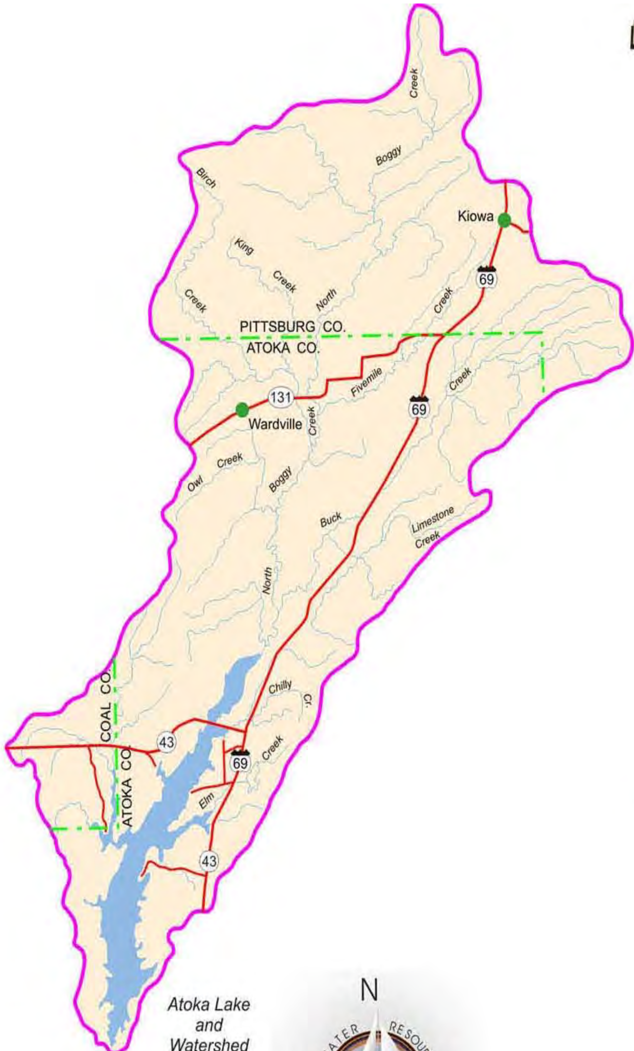


Figure 16a-16f. Graphical representation of data results for Atoka Lake.



Atoka Lake and Watershed

Atoka Lake Location

Lake Data	
Owner	City of Oklahoma City
County	Atoka
Constructed in	1964
Surface Area	5,537 acres
Volume	105,195 acre/feet
Shoreline Length	70.02 miles
Mean Depth	18.32 feet
Watershed Area	172 square miles

POOR EXCELLENT

Turbidity 2007

POOR EXCELLENT

Trophic State 2007

Plate 5 - Lake Water Quality for

Atoka Lake

LAKES MONITORING PROGRAM

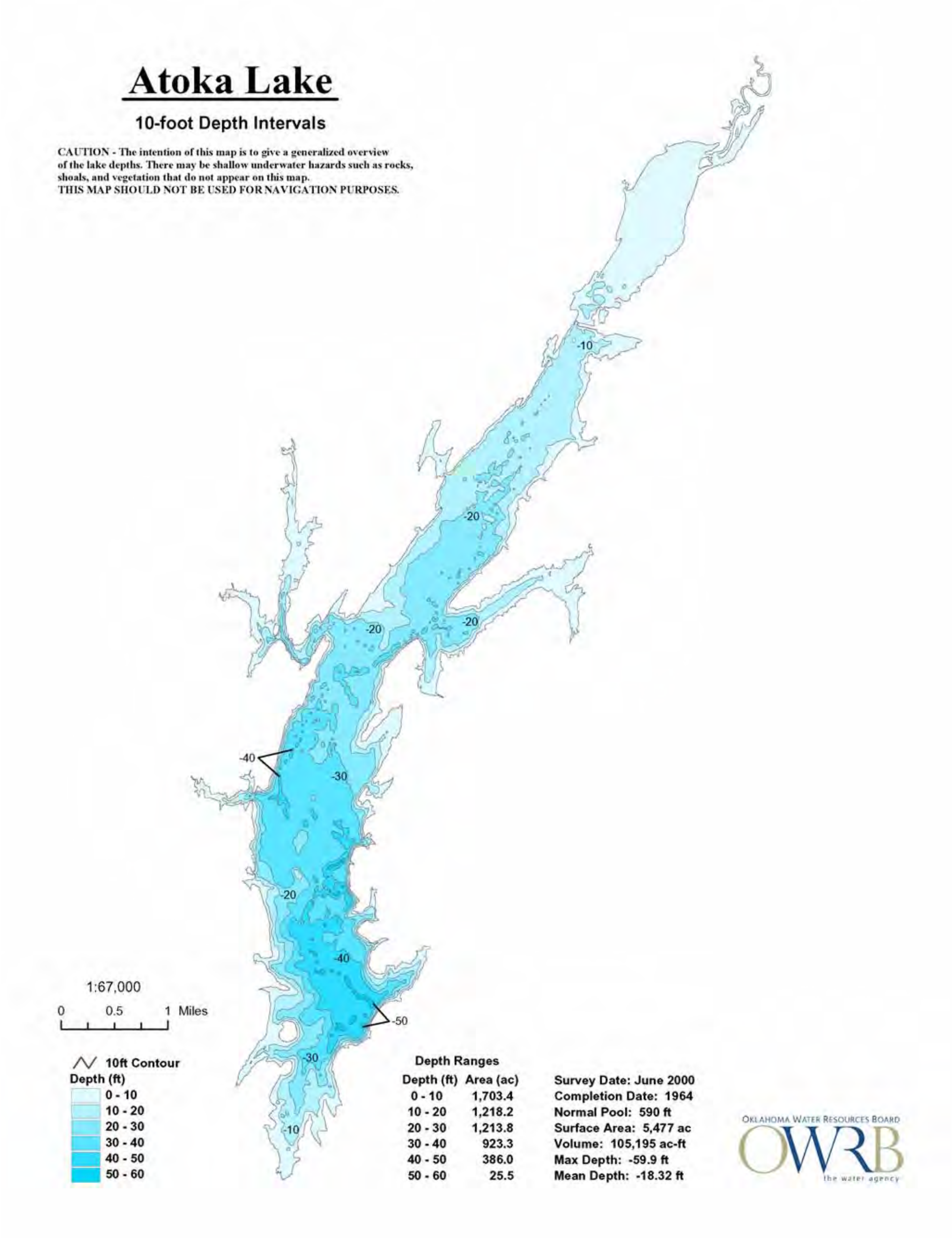


Figure 17. Bathymetric Map of Atoka Lake.

Bellcow Lake

Bellcow Lake was sampled for four quarters, from November 2003 through August 2004. Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and an additional sample was collected at 0.5 meters from the lake bottom at site 1, the dam. The lake-wide average turbidity value was 18 NTU (Plate 6), true color was 19 units, and average secchi disk depth was 66 centimeters. Water clarity was average based on the secchi disk depth, and turbidity values, similar to the previous sampling in 2001. True color values were excellent throughout the reservoir. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites (n=20). The TSI was 49 (Plate 6), indicating the lake was mesotrophic, indicative of moderate primary productivity and nutrient conditions in sample year 2003-2004. The TSI values for all sites throughout the sample year varied from lower mesotrophy to upper eutrophy. According to seasonal observations, Bellcow Lake is typically mesotrophic in the fall and winter to upper mesotrophic spring and is at the high end of eutrophy during the warmer summer months. Turbidity values for the sample year are displayed in Figure 18a. Turbidity values collected throughout all four sampling intervals were below the Oklahoma Water Quality Standards (WQS) of 25 NTU, with the exception of the site 3 located in the upper end of the lake, which exceeded the WQS in the spring. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. The lake is fully supporting its Fish & Wildlife Propagation (FWP) beneficial use for turbidity with 5% of the collected values exceeding 25 NTU. Seasonal true color values are displayed in Figure 18b. All true color values were well below the Aesthetics WQS of 70 units; therefore the beneficial use is considered fully supported.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all five sample sites. Salinity readings ranged from 0.15 parts per thousand (ppt) to 0.20 ppt throughout sample year 2003-2004. Specific conductivity values were moderate in nature, ranging from 310 µS/cm at the lake surface in the winter to 396.8 µS/cm at the lake bottom in the summer. These values are comparable to levels seen in most Oklahoma reservoirs, indicating there are moderate amounts of salts or ions in Bellcow Lake. Values for pH ranged from 7.51 to 8.65 units, indicating the lake was neutral to slightly alkaline in nature. Of the pH values collected, none exceeded the numerical pH criteria for FWP specified in OAC 785:45-5-12. According to Use Support Assessment Protocols (USAP) in OAC 785:46-15-5, if more than 25% of pH values fall outside the 6.5 to 9.0 numerical criteria range the FWP beneficial use is not being met. All recorded values were within the acceptable range, therefore the lake is considered fully supporting the FWP use for pH. Oxidation-reduction potentials (redox) ranged from 403 mV to 483 mV, indicating the absence of reducing conditions in the lake system. Thermal stratification was not evident in the fall, winter or spring quarters and the lake was well oxygenated with dissolved oxygen (D.O) remaining above 5.7 mg/L (Figure 18c-18e). In the summer, a thermocline was present between 3 and 4 meters, with dissolved oxygen (D.O.) values dropping below 2.0mg/L from 5-meters below the surface to the lake bottom of 10.4 meters at site 1, the dam (Figure 18f). During the summer sampling interval all sites exhibited stratification and the presence of anoxic conditions. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With 50% of the water column experiencing anoxic conditions at site 1, the dam, the lake is considered partially supporting its FWP beneficial use. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2003-2004 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September. All sample results were at or below the detection limit, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.75 mg/L and 1.05 at the lake bottom. The surface TN ranged from 0.47 mg/L to 1.05 mg/L. TN was highest in the winter quarter and lowest in the fall quarter. The lake-wide total phosphorus (TP) average was 0.027 mg/L at the surface and 0.079 at the lake bottom. The TP ranged from 0.024 mg/L to 0.033 mg/L. TP was highest in the spring and lowest in the winter. The nitrogen to phosphorus ratio (TN:TP) was 27:1 for sample year 2001-2002. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

In summary, Bellcow Lake was mesotrophic, indicative of moderate to high primary productivity and nutrient levels. Results were slightly lower than previous historical data. Water clarity was average in comparison to other Oklahoma reservoirs based on turbidity, true color values and secchi disk depth. The lake was fully supporting its Aesthetics beneficial use based on true color and trophic state. The lake was fully supporting its FWP beneficial use based on turbidity and pH concentrations, but will be listed as partially supporting based on D.O. concentrations. Bellcow Lake, constructed by the Natural Resource Conservation Service (NRCS), was constructed to serve for flood control, water supply, recreation and fish and wildlife purposes.

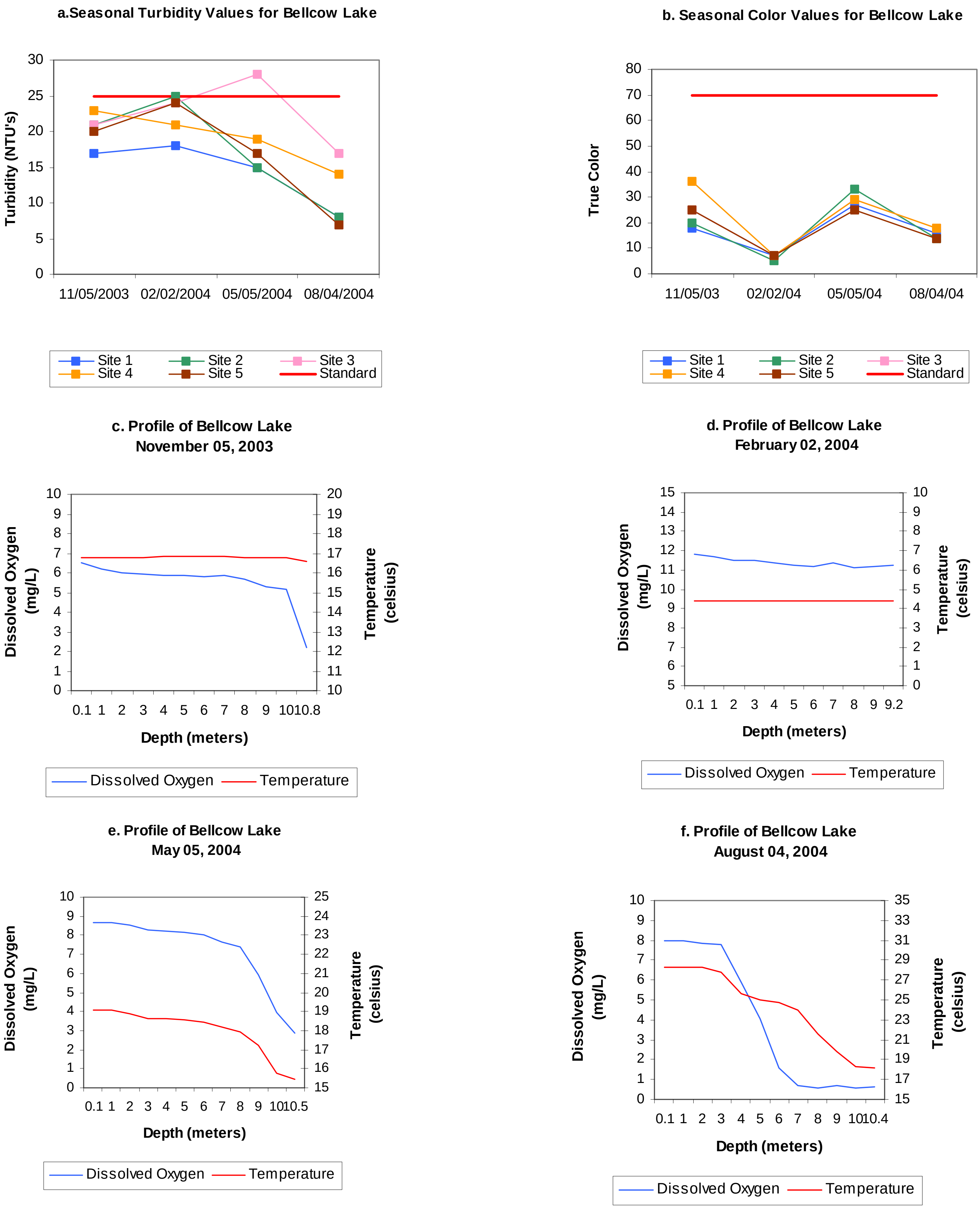
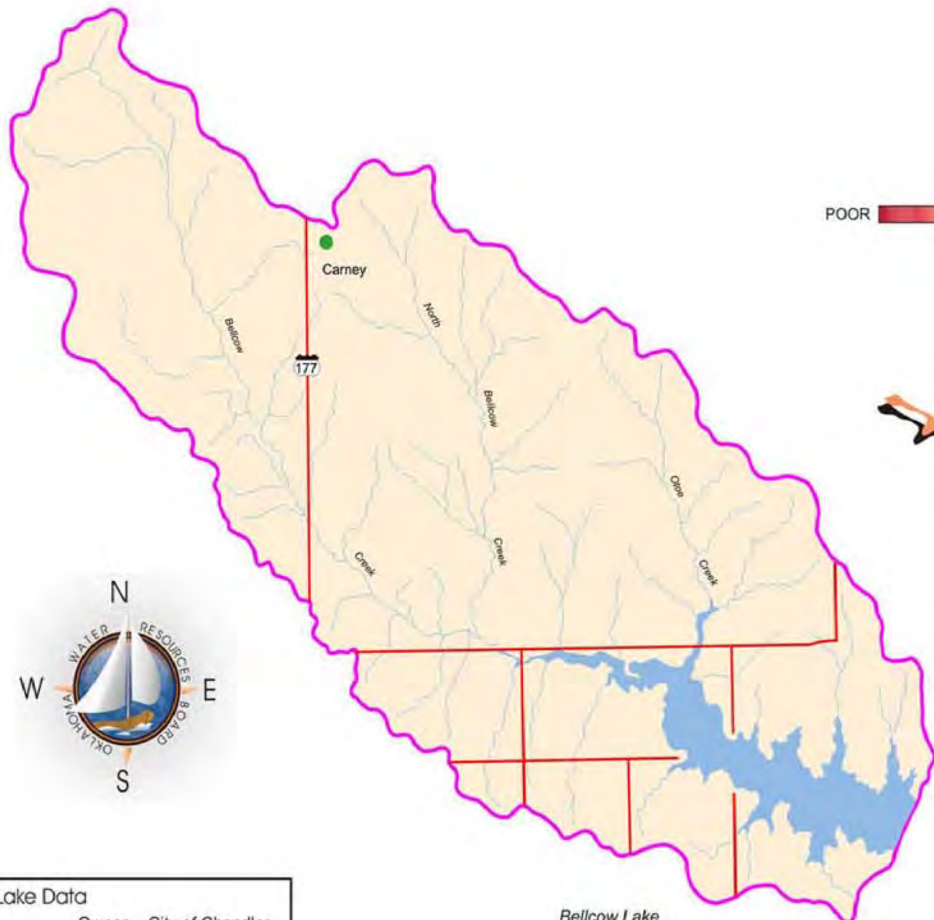


Figure 18a-18f. Graphical representation of data results for Bellcow Lake.

Plate 6 - Lake Water Quality for

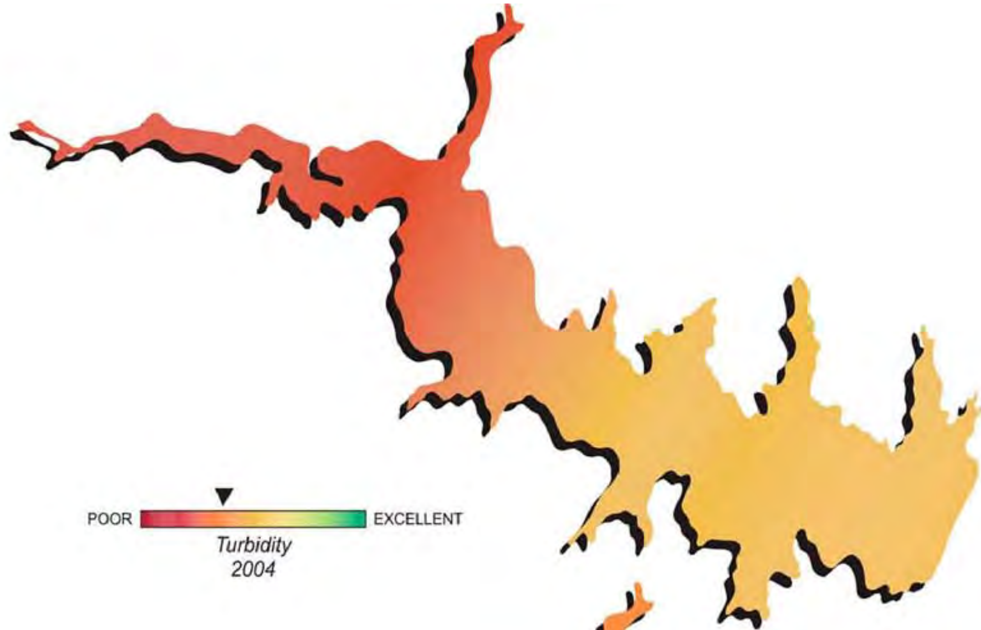
Bellcow Lake

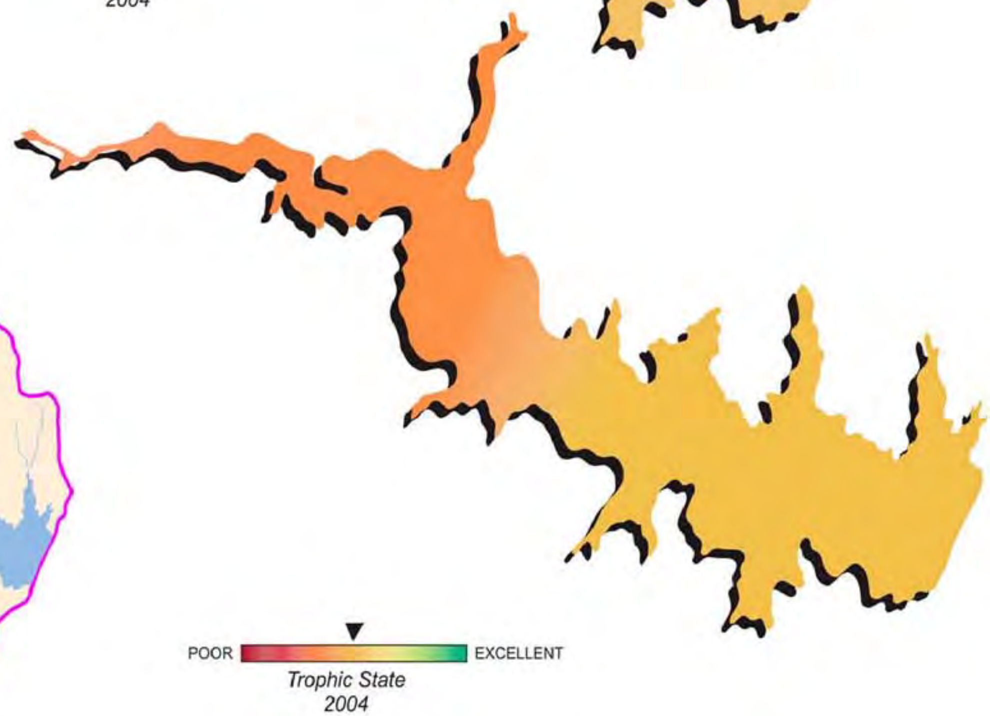


Bellcow Lake and Watershed

Lake Data

Owner	City of Chandler
County	Lincoln
Constructed in	1990
Surface Area	1,113 acres
Volume	16,500 acre/feet
Shoreline Length	19 miles
Mean Depth	14.82 feet
Watershed Area	33 square miles





Birch Lake

Birch Lake is located in Osage County and was constructed in 1977. The 1,137-acre reservoir was constructed by the United States Army Corps of Engineers (USACE) to serve as a water supply, flood control and recreation reservoir. Birch Lake was sampled for four quarters, from November 2006 through August 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected at the lake surface at all sites during the study period. The lake-wide average turbidity was 12 NTU, true color was 55 units and average secchi disk depth was 90 centimeters in sample year 2006-2007. Based on these three parameters water clarity was good at Birch Lake. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=19). The TSI was 52 (Plate 7), indicating the lake was eutrophic in current sample year. This value is similar to that in 2005 (TSI = 50) indicating no significant increase or decrease in productivity has occurred. The TSI values for all sites throughout the sample year were fairly consistent and ranged from upper mesotrophic to upper eutrophic. Seasonal turbidity values per site are displayed in Figure 19a. Although a spike in values occurred during the spring quarter, only one of the twenty values exceeded the Oklahoma Water Quality Standard (WQS) of 25 NTU. With only 5% of the values exceeding the criteria the Fish and Wildlife Propagation (FWP) beneficial use is therefore considered supported as it relates to turbidity. Seasonal true color values are displayed in Figure 19b. A peak in true color was observed in the spring quarter and approximately 30% of the values were greater than the numerical criteria of 70 units. Applying the same default protocol, Birch Lake is not supporting its Aesthetics beneficial use.

Vertical profiles for dissolved oxygen; pH, temperature, specific conductivity; oxidation-reduction potential and salinity were recorded at all five sample sites during the sample year. Salinity values ranged from 0.03 parts per thousand (ppt) in the spring to 0.09 ppt in the summer. Specific conductivity ranged from 86.6 µS/cm to 196.9 µS/cm, which falls within the range of values commonly observed in Oklahoma reservoirs. These values indicate low levels of current conducting compounds (salts) in the lake system. The pH values were generally neutral and ranged from 6.47 units to 7.92 units. According to Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC 785:46-15-5), pH values are exceeding standards if they fall outside the range of 6.5 to 9.0 for 25% of the values and they waterbody should be listed as not supporting its FWP beneficial use. Only 5 (2.7%) pH values collected were below 6.5 units, therefore Birch Lake is considered supporting its FWP beneficial use as it relates to pH. Oxidation-reduction potentials ranged from 4 mV to 482 mV both occurring in the summer. Low redox values in the hypolimnion are not uncommon when a lake is strongly thermally stratified and anoxic conditions are present as seen in the summer quarter. Dissolved oxygen (D.O.) levels remained above 7.0 mg/L during both the fall and winter sampling quarters (see Figure 19c-19d) when the water column was evenly mixed. Thermal stratification was evident and anoxic conditions were present in both the spring and summer quarters. In the spring stratification occurred at sites 1, 2, 3, and 4 with anoxic conditions comprising 44-73% of the water column (Figure 19e). During the summer sampling interval stratification occurred at all five sites. At this time anoxic conditions were present for 20 to 57% of the water column (see Figure 19f). According to USAP, if D.O. values are less than 2.0 mg/L for greater than 50% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). Birch Lake is considered not supporting the FWP beneficial use based on anoxic conditions present in the spring and summer sampling intervals. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. All sample results were at or below the detection limit, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.61 mg/L at the surface. Surface TN ranged from 0.43 mg/L to 0.82 mg/L with the highest values recorded in the spring quarter and lowest in the winter. The lake-wide total phosphorus (TP) average was 0.021 mg/L at the surface. Surface TP ranged from 0.008 mg/L to 0.037 mg/L and was highest in the summer sampling interval. The lowest values occurred during the winter sampling quarter. The nitrogen to phosphorus ratio (TN:TP) was 29:1 for sample year 2007. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

Birch Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Birch Lake was classified as eutrophic with high productivity and nutrient levels. This classification is the similar to that of the previous evaluation in 2005, indicating little change in productivity has occurred over time. Water clarity was good based on true color, turbidity, and secchi disk depth. The lake is fully supporting the Fish and Wildlife propagation (FWP) beneficial use based on pH and turbidity values. Based on anoxic conditions in both spring and summer quarters the lake is not supporting the FWP as it relates to dissolved oxygen. Birch Lake is supporting the Aesthetics beneficial use based on its trophic status. However, with 30% of the reported true color values exceeding the WQS of 70 units, the Aesthetics beneficial use is considered not supported as it relates to color. The PBCR beneficial use was assessed and is considered supported as all bacterial samples collected were at or below the detection limit.

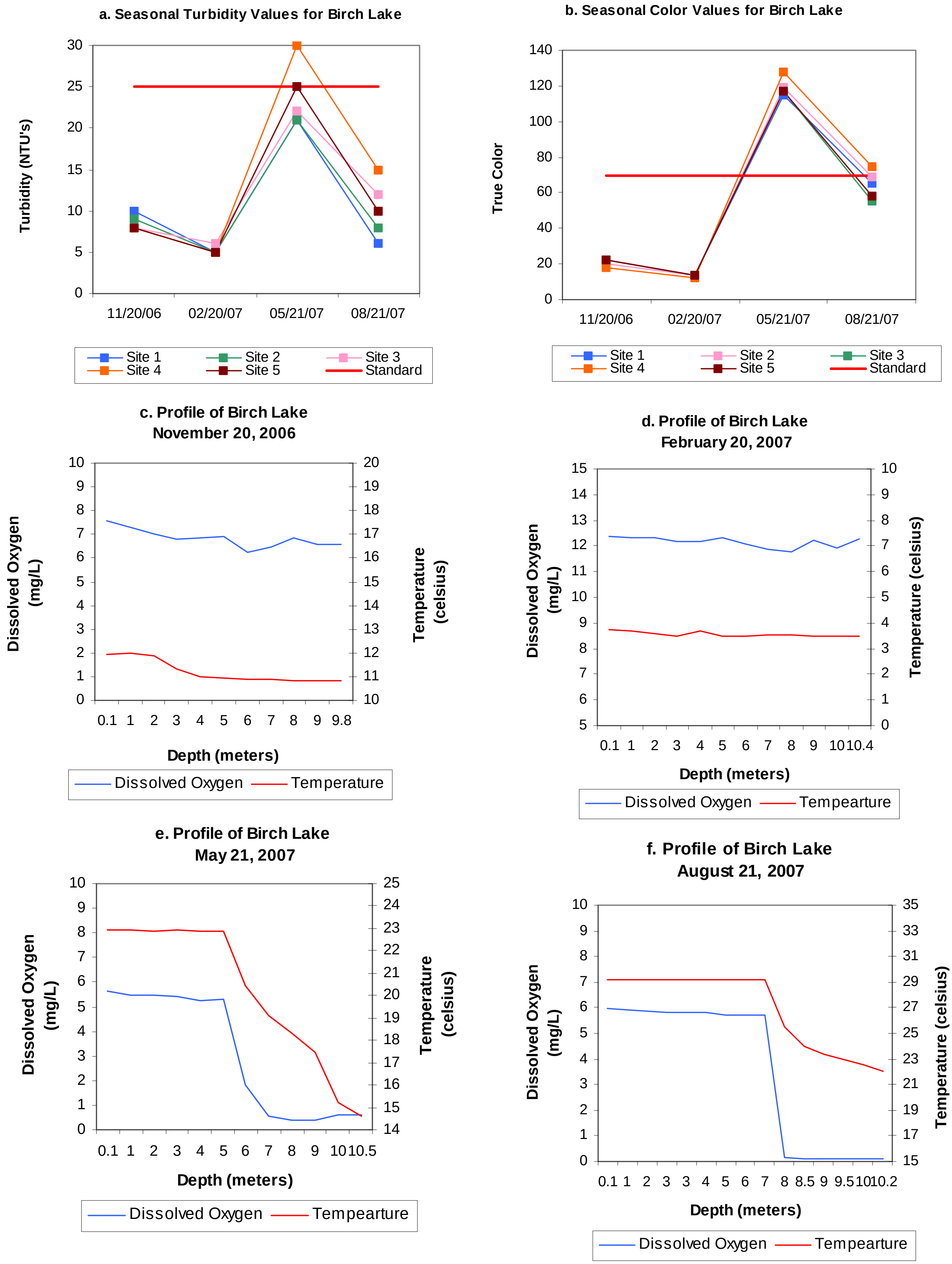


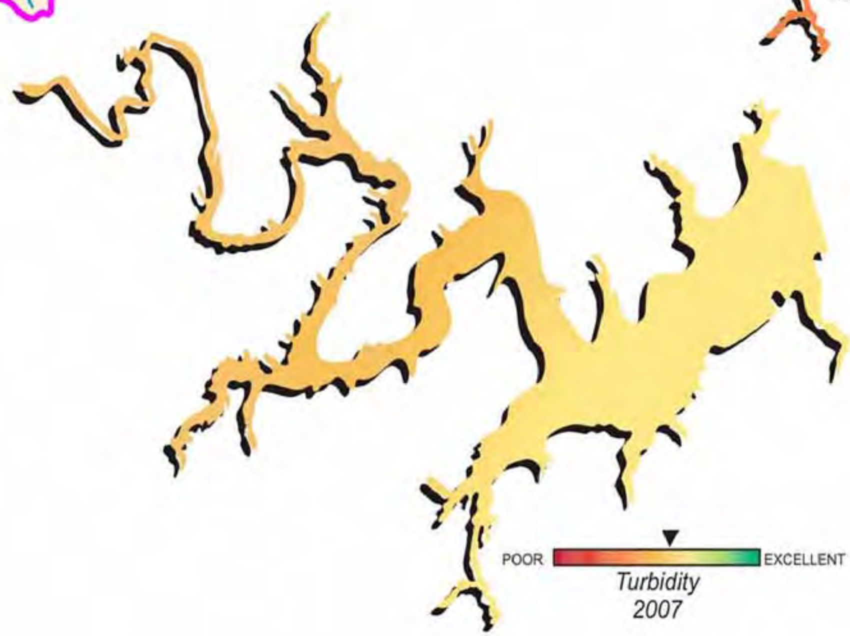
Figure 19a-19f. Graphical representation of data results for Birch Lake.

Plate 7 - Lake Water Quality for
Birch Lake

Birch Lake and Watershed

Birch Lake Location

Trophic State 2007



Turbidity 2007

Lake Data

Constructed by	Corps of Engineers
County	Osage
Constructed in	1977
Surface Area	1,137 acres
Volume	19,200 acre/feet
Shoreline Length	27 miles
Mean Depth	16.88 feet
Watershed Area	66 square miles

LAKES MONITORING PROGRAM

Lake Bixhoma

Lake Bixhoma, located in Wagoner County, is owned by the City of Bixby and was constructed in 1965 to serve as a water supply and recreational outlet for the public use. Lake Bixhoma was sampled for four quarters, from October 2005 through July 2006.

Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the lake. Samples were collected from the lake surface at all sites. The lake-wide average turbidity value was 5 NTU (Plate 8), true color was 23 units, and average secchi disk depth was 146 centimeters in sample year 2006. Water clarity was excellent based on these three parameters and is consistent with the evaluation in 2003-2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The TSI was 45 (Plate 8), indicating the lake was mesotrophic, indicative of moderate primary productivity and nutrient conditions. This is very similar to the value calculated in 2004 (TSI=48), indicating no significant increase or decrease in productivity has occurred over time. The TSI values varied seasonally throughout the year, ranging from oligotrophic in the spring and summer to mesotrophic in the winter quarter, and eutrophic conditions observed in the fall All turbidity values per site for the sample year were all well below the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 20a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. The lake is fully supporting its Fish & Wildlife Propagation (FWP) beneficial use as it relates to turbidity. Seasonal true color values are displayed in Figure 20b. All true color values were below the Aesthetics WQS of 70 units and were consistent throughout all four-sample quarters.   Applying the same default protocol, the lake was fully supporting its Aesthetics beneficial use for true color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity values ranged from 0.01 parts per thousand (ppt) to 0.05 ppt, well within the range of values if not lower than most values observed in Oklahoma lakes. Specific conductivity values ranged from 47.4μS/cm to 127.5 μS/cm, also indicative of negligible salt content and ion levels in the lake system. Values for pH were generally neutral, ranging from 6.44 to 8.63 in the summer. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. The low pH values recorded primarily in the summer at Lake Bixhoma may be due to natural conditions and with only 2.3% of the values recorded falling outside the acceptable range the lake is supporting the FWP beneficial use. Oxidation-reduction potentials (ORP) were positive at all sample sites and ranged from 111mV at the lake bottom in the fall to 482mV in the winter. In general, reducing conditions were not present in the reservoir during the study period. Thermal stratification was not evident in either the winter or spring intervals (Figure 20d-20e). In the fall, Lake Bixhoma was thermally stratified between 5 and 6 meters in depth with 42 to 56% of the water column having a dissolved oxygen (D.O.) concentration below 2.0 mg/L at both sites 1 and 2 (see Figure 20c). In the summer quarter, stratification occurred at multiple 1-meter intervals, the first being between 3 and 4 meters below the lake surface. The next point of stratification occurred between 4 and 5 meters with dissolved oxygen concentrations less than 2.0 mg/L from 6 meters in depth to the lake bottom of 17.1 meters (Figure 20f). When D.O. values are less than 2.0 mg/L for greater than 70% of the lake volume, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With anoxic conditions present in 56% of the water column in the fall and 67% in the summer, the FWP beneficial use is considered partially supported at Lake Bixhoma. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.36 mg/L. The TN at the surface ranged from 0.25 mg/L to 0.45 mg/L. The highest surface TN was recorded in the winter quarter and lowest in the fall. The lake-wide total phosphorus (TP) average was 0.017 mg/L. The TP ranged from 0.010 mg/L to 0.026 mg/L. Similar to total nitrogen surface TP was lowest in the fall, however and the highest observation was recorded in the spring. The nitrogen to phosphorus ratio (TN:TP) was approximately 22:1 for sample year 2003-2004. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Lake Bixhoma was also sample for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Lake Bixhoma was classified as mesotrophic, indicative of moderate primary productivity and moderate nutrient conditions (Plate 8). Water clarity was excellent based on true color; turbidity and secchi disk depth and is consistent with observations in the previous evaluation. The FWP beneficial use was fully supported as it relates to turbidity and pH; however was only partially supporting the FWP based on D.O. values in the fall and summer months. The lake is fully supporting its Aesthetics beneficial use based on true color data and trophic status. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

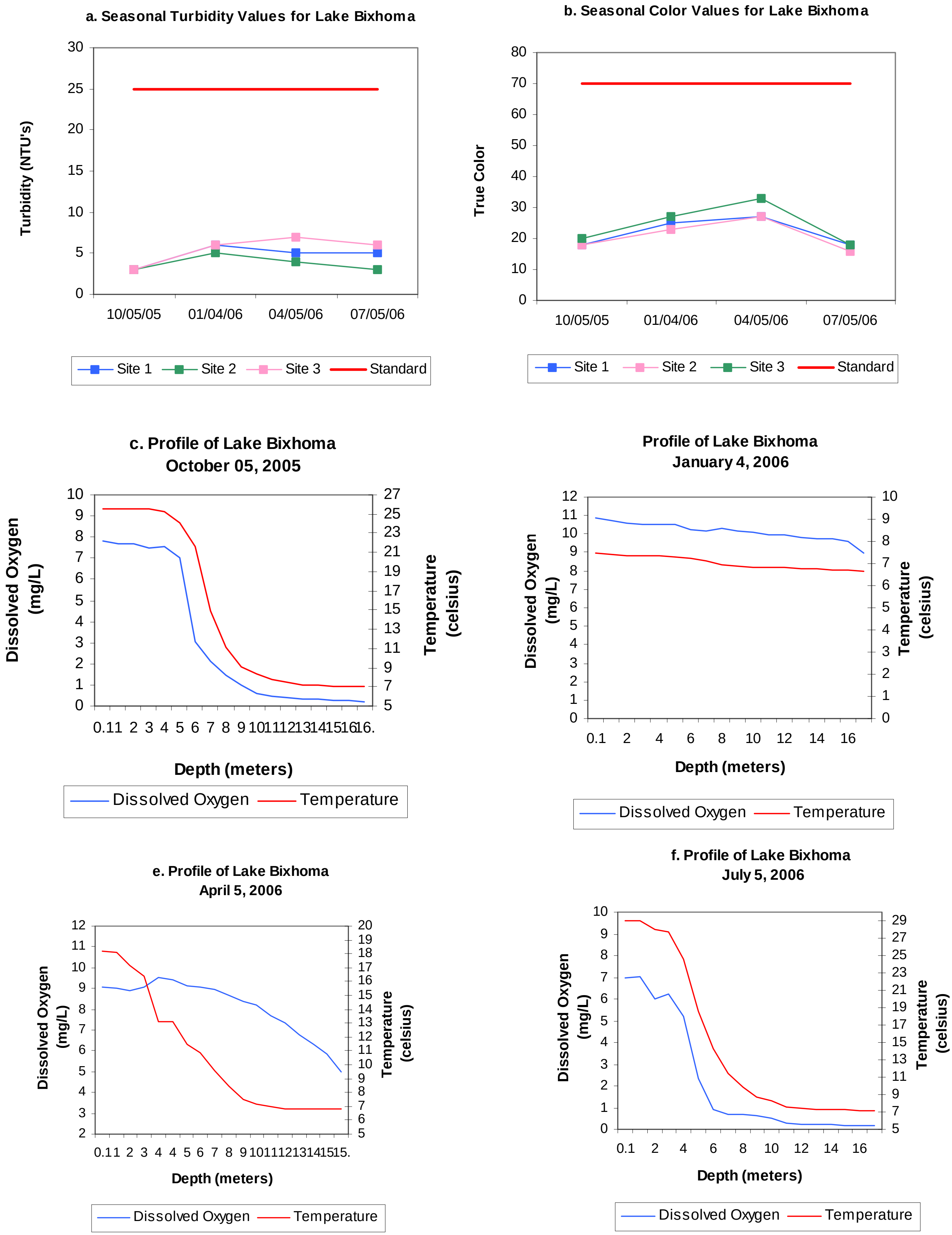
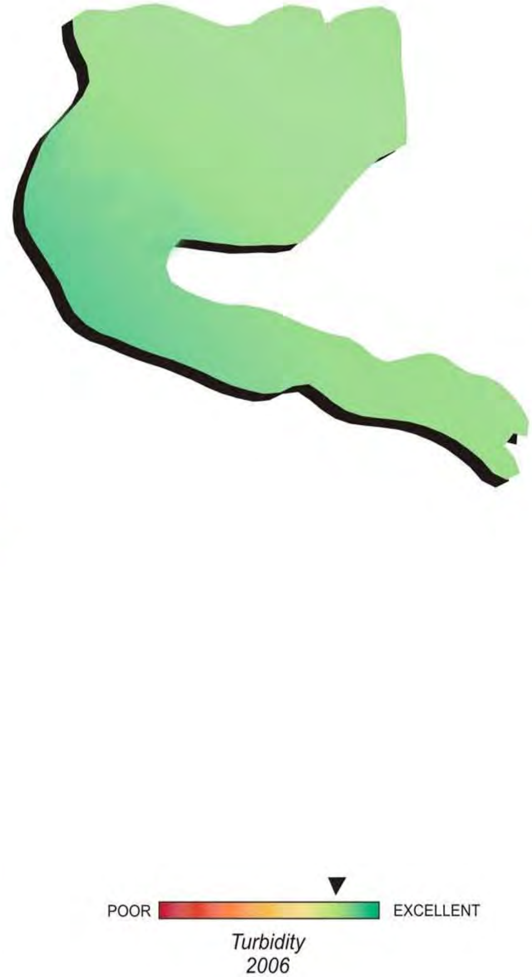


Figure 20a-20f. Graphical representation of data results for Lake Bixhoma.

Lake Data	
Owner	City of Bixby
County	Wagoner
Constructed in	1965
Surface Area	110 acres
Volume	3,130 acre/feet
Shoreline Length	3 miles
Mean Depth	28.45 feet
Watershed Area	3,007 acres



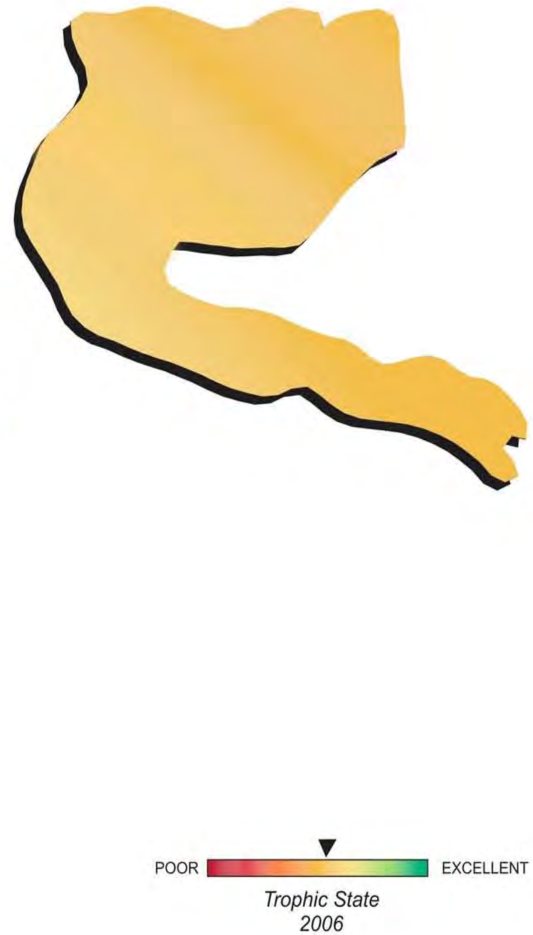


Plate 8 - Lake Water Quality for

Bixhoma Lake

Bluestem Lake

Bluestem Lake, located in Osage County, is approximately 4 miles northwest of the city of Pawhuska. The lake serves as the municipal water supply reservoir for the City of Pawhuska and is also utilized for both flood control and recreational purposes. Bluestem Lake was sampled for four quarters, from October 2005 through July 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Water quality samples were collected from the lake surface at all sites. The lake-wide average turbidity was 14 NTU (Plate 9), true color was 20 units, and average secchi disk depth was 84 centimeters. Water clarity was good based on secchi disk depth, true color and turbidity. Results for these parameters were better than previous lake sampling efforts conducted in 2003-2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=19). The TSI was 44 (Plate 9), indicating the lake was mesotrophic with moderate primary productivity and nutrient conditions. Due to a post-processing error, no sample for site 3 was submitted for analysis from winter data collection efforts. The current TSI value is consistent with previous monitoring results from 2003-2004 where the calculated TSI was also mesotrophic (TSI=43). The TSI values throughout the sample year were primarily mesotrophic with the exception of site 2 in the winter quarter, which was the only oligotrophic value recorded. During the spring sampling interval, the chlorophyll-a value was much lower and pheophytin value was higher for site 5 than the values reported for the other sample sites. Turbidity values were fairly consistent throughout the year with values ranging from 6 to 27 NTU (see Figure 21a). Only two (10.5%) of the nineteen values exceeded the Oklahoma Water Quality Standard (WQS) of 25 NTU. According to the Use Support Assessment Protocols (USAP) specified in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 10.5% of the turbidity values greater than 25 NTU, Bluestem Lake is considered partially supporting its Fish & Wildlife Propagation (FWP) beneficial use. Seasonal true color values are displayed in Figure 21b. All true color values throughout the sample year were below the Aesthetics WQS of 70 units. Applying the same default protocol, the lake was fully supporting its Aesthetics beneficial use for true color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all five sample sites during the study period. Salinity values were consistent throughout the water column for each quarter, ranging from 0.14 parts per thousand (ppt) to 0.18 ppt. Readings for specific conductivity were relatively consistent throughout the water column for each quarter, ranging from 290.7 µS/cm (fall) to 366.6 µS/cm (winter). Both salinity and conductivity values were consistent with values seen in other Oklahoma reservoirs, indicating low to moderate levels of current conducting compounds or salts were present in the lake system. The pH was generally neutral to slightly alkaline with values ranging from 7.18 units to 8.41 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. All pH values recorded were within the range therefore meeting the FWP beneficial use. The oxidation-reduction potential (redox) ranged from 113 mV to 437 mV, indicating an absence of reducing conditions during the study period. Bluestem Lake was well mixed in the winter and spring quarters with thermal stratification absent and dissolved oxygen (D.O.) concentrations above 7.5 mg/L in all instances (see Figure 21d-21e). Thermal stratification and anoxic conditions were present in both fall and summer sampling events. In the fall, the lake was stratified between 9-10 meters with D.O. concentrations falling below 2.0 mg/L to the lake bottom of 14.0 meters (Figure 21c). In the summer, stratification occurred between 6 and 7 meters below the surface at sites 1, 2 and 5. Anoxic conditions were present in approximately 53% of the water column at site 1, the dam (see Figure 21f). When D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported at Bluestem Lake with anoxic conditions present in 53% of the water column during the summer sampling interval. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average for the current sample year was 0.36 mg/L. The TN at the surface ranged from 0.15 mg/L to 0.54 mg/L. Surface TN was highest in the winter and lowest in the fall quarter. The lake-wide total phosphorus (TP) average was 0.030 mg/L. The total phosphorus values ranged from 0.016 mg/L to 0.132 mg/L. The highest TP was recorded in the spring and lowest values were seen in the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 12:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Bluestem Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Bluestem Lake was classified as mesotrophic, indicative of low to moderate primary productivity and nutrient levels (Plate 9). The current TSI value (TSI=44) is consistent with previous monitoring results from 2003-2004 (TSI=43), indicating no significant increase or decrease in productivity has occurred since the previous evaluation. Water clarity was good based on true color, turbidity, and secchi disk depth, slightly better than results reported during the previous study period. With 10.5% of the reported turbidity values exceeding the WQS of 25 NTU, the FWP beneficial use was partially supported as it relates to turbidity The FWP beneficial use was fully supported as it relates to pH; however was only partially supporting the FWP based on anoxic conditions present during the summer months. Bluestem Lake is fully supporting its Aesthetics beneficial use based on trophic status and true color as 100% of the color values recorded were below the WQS of 70 units. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

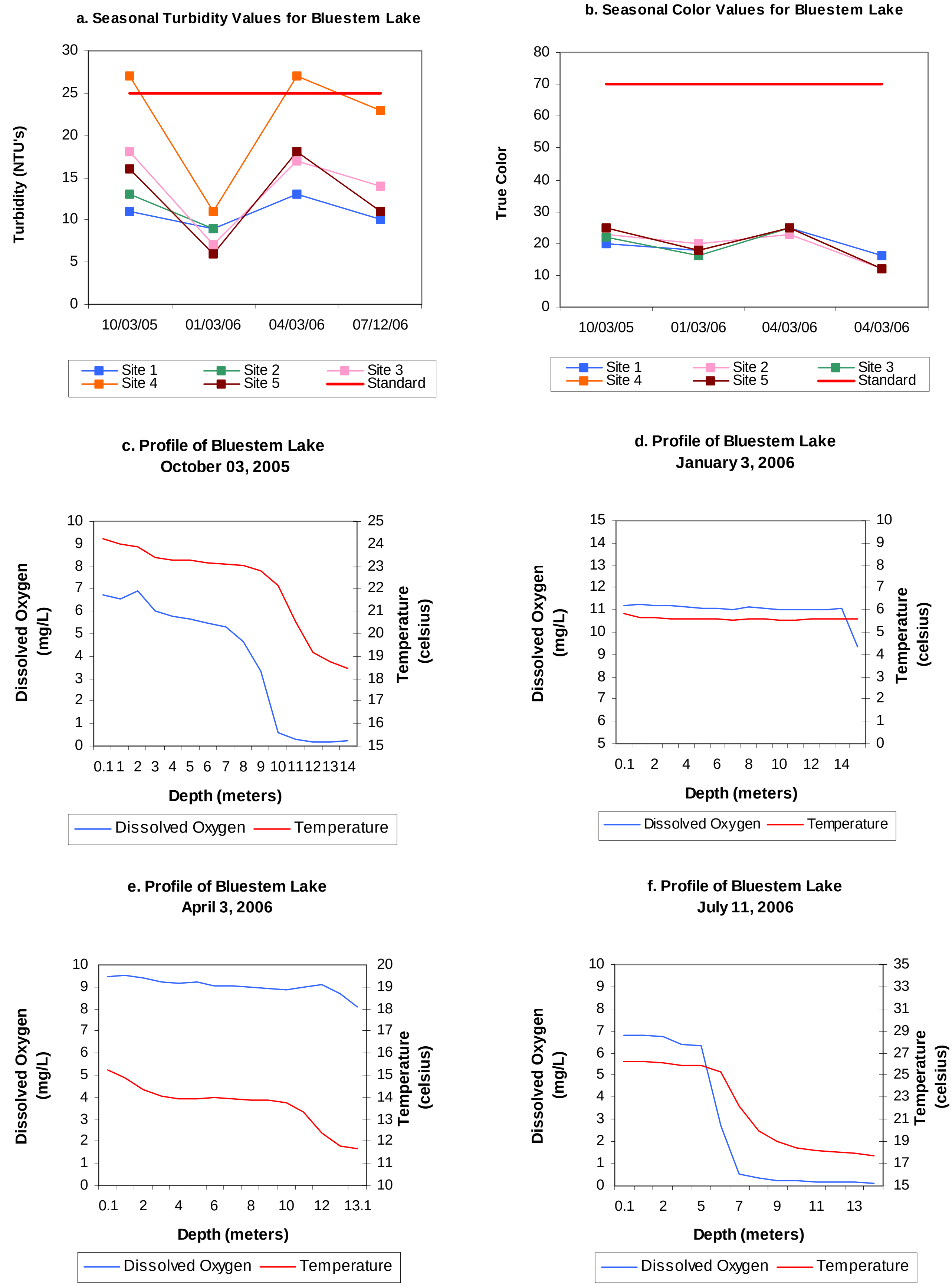
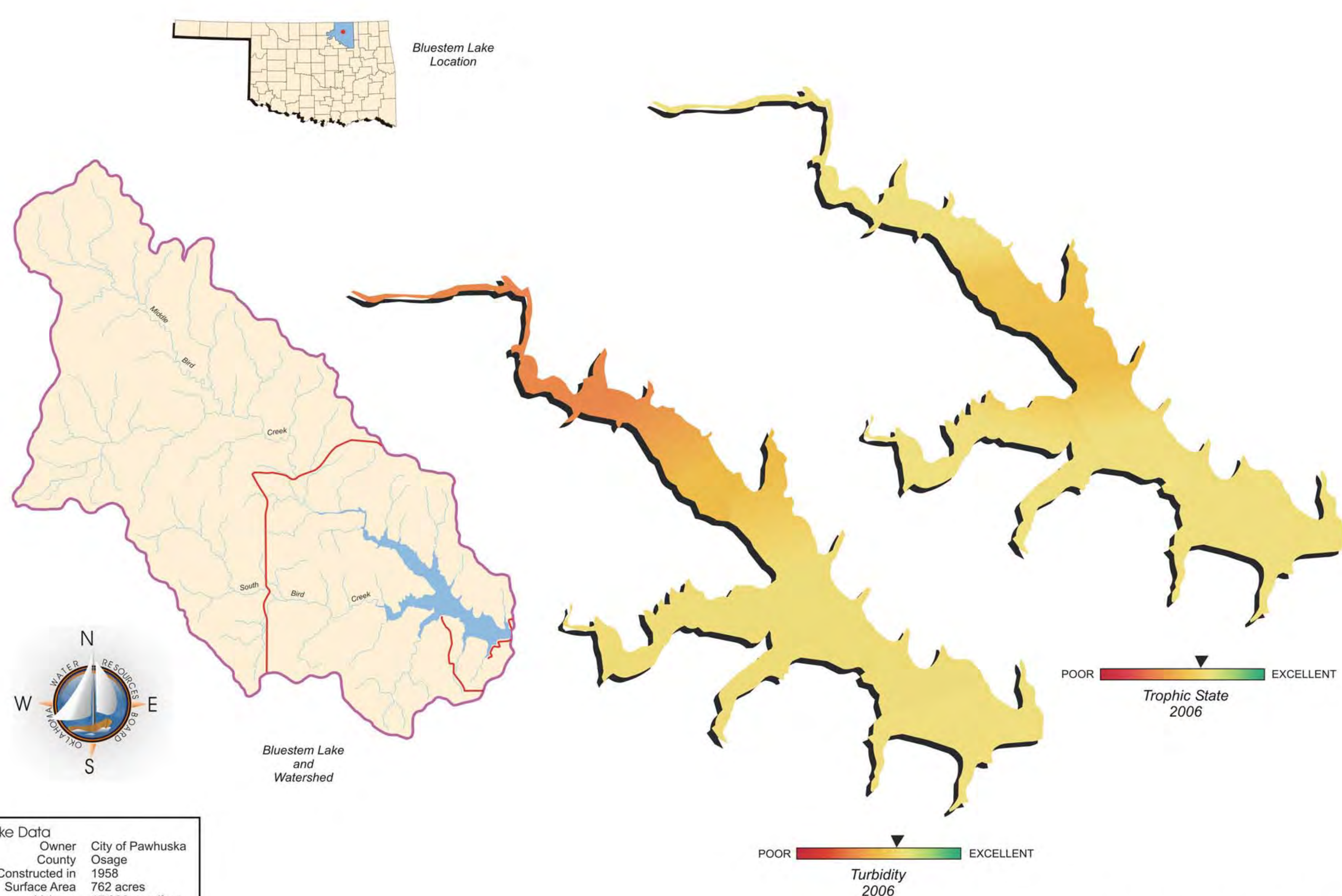


Figure 21a-21f. Graphical representation of data results for Bluestem Lake.



Lake Data	
Owner	City of Pawhuska
County	Osage
Constructed in	1958
Surface Area	762 acres
Volume	17,000 acre/feet
Shoreline Length	19 miles
Mean Depth	22.31 feet
Watershed Area	47 square miles

Plate 9 - Lake Water Quality for

Bluestem Lake

Boomer Lake

Boomer Lake was sampled for four quarters, from September 2004 through June 2005. Water quality samples were collected at five (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide turbidity value was 22 NTU (Plate 10), true color was 30 units, and average secchi disk depth was 60 centimeters in 2004-2005. Water clarity was average to slightly poor based on these parameters and is similar to that of 2002. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI calculated was 53 (Plate 10), indicating the lake was eutrophic, indicative of high primary productivity and nutrient rich conditions. The TSI values were generally eutrophic throughout the sample year with mesotrophic values only occurring during the spring sampling interval. Of the turbidity values collected, 7 (35%) were above the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 22a). According to the Use Support Assessment Protocols (USAP) specified in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Boomer Lake is not supporting its Fish & Wildlife Propagation (FWP) beneficial use due to high turbidity concentrations. Seasonal true color values are also displayed in Figure 22b. All true color values were well below the Aesthetics WQS of 70 units therefore the Aesthetics beneficial use is being supported based on true color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.09 parts per thousand (ppt) to 0.18 ppt, which was within the range of observed values for Oklahoma lakes, reflecting the minimal presence of chlorides or other salts in the lake. Readings for specific conductivity ranged from 191.5 µS/cm to 356.9 µS/cm in the summer. Specific conductivity values were also within the expected range for Oklahoma reservoirs, indicating relatively low levels of electrical current conducting compounds like salts. Oxidation-reduction potentials (redox) ranged from 275 mV to 444 mV, indicating that reducing conditions were not present in the water column during any time of the study period. The pH values in Boomer Lake were neutral, ranging from 7.17 in the summer to 8.27 units in the fall. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if they fall outside the range of 6.5 to 9.0 for 25% of the values and they waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Boomer Lake is currently supporting its FWP beneficial use based on pH. The lake was well mixed during the winter and spring quarters with dissolved oxygen (D.O.) values above 7.25 mg/L throughout the water column (see Figure 22d-22e). In both the fall and summer, the lake was stratified between 3 and 4 meters, however D.O. only dropped below 2.0 mg/L near the lake bottom of 5.8 meters. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With only 14% of the water column was below 2.0-mg/L site 1 in both the fall and summer sampling intervals, the FWP beneficial use was fully supported at Boomer Lake. The lake was also sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the study period and an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average for sample year 2004-2005 was 0.58 mg/L at the surface. The surface TN ranged from 0.38 mg/L to 1.10 mg/L. Surface TN was highest in the spring and lowest in the winter. The lake-wide total phosphorus (TP) average was 0.039 mg/L for the surface. The TP ranged from 0.026 mg/L to 0.054 mg/L at the surface. Surface TP was highest in the fall and lowest in the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 11:1 for sample year 2004-2005. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

In summary, Boomer Lake was classified as eutrophic, indicative of high productivity and nutrient levels (Plate 10). Water clarity was average to slightly poor based on turbidity, true color and secchi disk depth. The Fish and Wildlife Propagation (FWP) beneficial use is supported based on pH and dissolved oxygen concentrations. However with 35% of the collected turbidity values exceeding 25 NTU the FWP beneficial is not supported as it relates to turbidity. The Aesthetics beneficial use is fully supporting with 100% of the true color values below 70 units. The Aesthetics use is also fully supported based upon lake trophic status. Boomer Lake is owned by the City of Stillwater and was constructed for hydroelectric power and recreational uses. The lake dam has been reconstructed and a significant portion of the shoreline has been stabilized to prevent erosion from occurring.

LAKES MONITORING PROGRAM

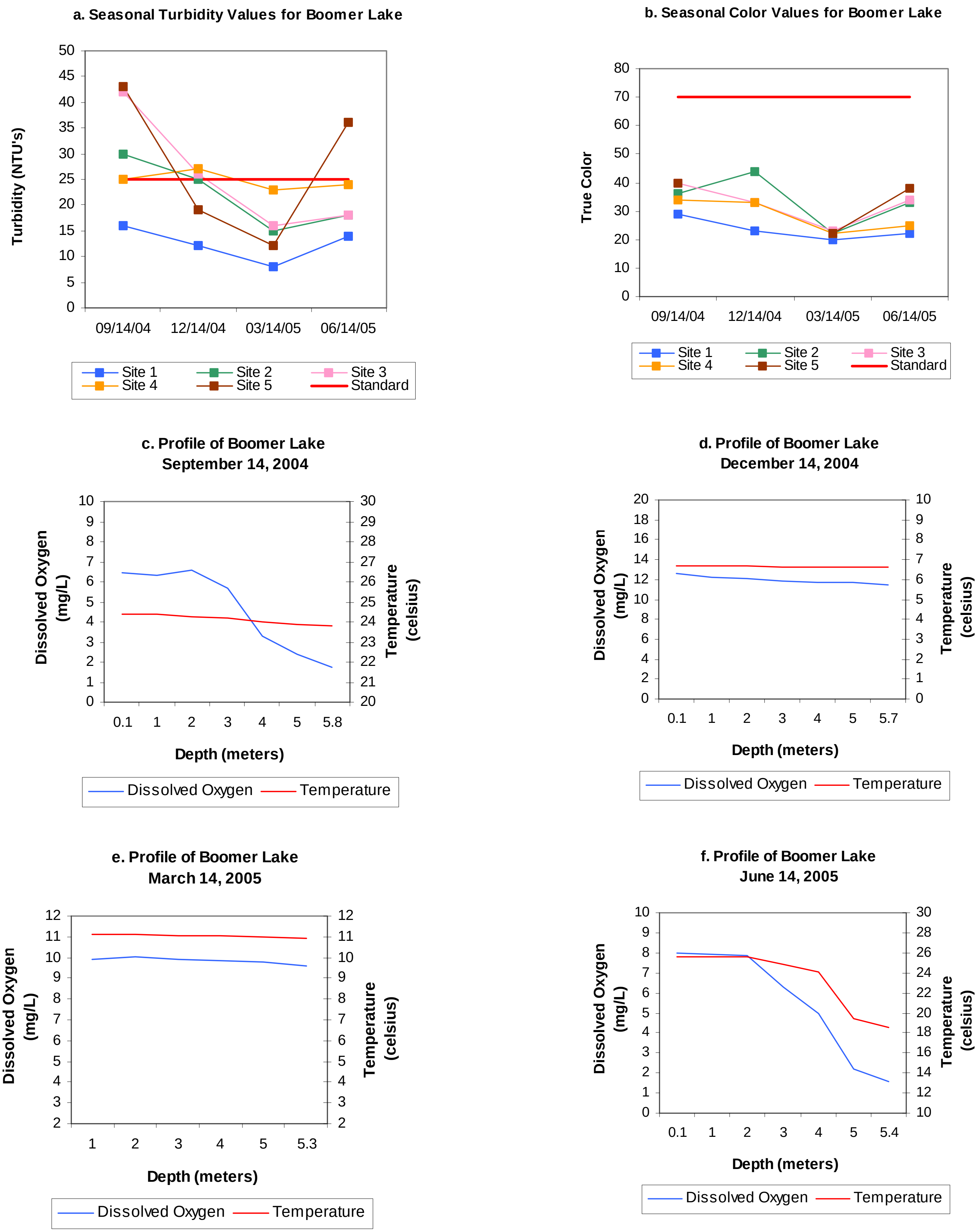
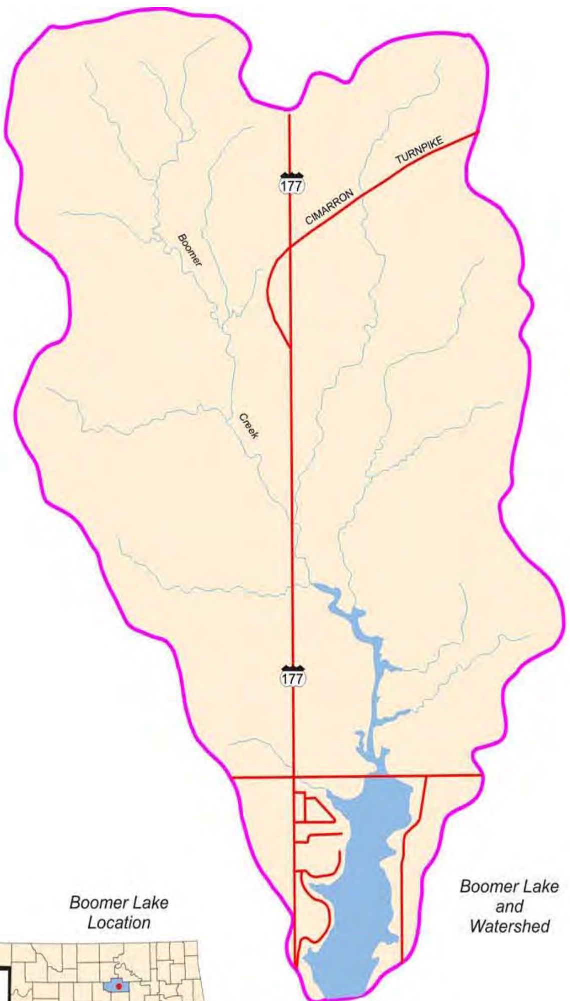


Figure 22a-22f. Graphical representation of data results for Boomer Lake.



Boomer Lake and Watershed

Boomer Lake Location

Lake Data	
Owner	City of Stillwater
County	Payne
Constructed in	1932
Surface Area	260 acres
Volume	3,200 acre/feet
Shoreline Length	6 miles
Mean Depth	12.31 feet
Watershed Area	9 square miles

Plate 10 - Lake Water Quality for
Boomer Lake

Broken Bow Lake

Broken Bow Lake, located in McCurtain County, is situated on the Mountain Fork River approximately 9 miles north of the town of Broken Bow. The lake was constructed by the USACE for flood control, hydroelectric power, water supply, recreation, and fish and wildlife purposes. This is truly one of the nicest lakes in our state and has a trout fishery below the dam. Broken Bow Lake was sampled for four quarters, from October 2005 through July 2006.

Water quality samples were collected at eight (8) sites to represent the riverine, transition, and lacustrine zones of the reservoir as well as the major arms and tributaries. Samples were collected from the lake surface at all sites. The lake-wide average turbidity value was 4 nephelometric turbidity units (NTU) (Plate 11), true color was 14 units, and average secchi disk depth was 293 centimeters in sample year 2006. Water clarity was excellent based on the high secchi disk depth, low turbidity and low true color values. Results for these parameters are similar to that observed in 2003-2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=32). The TSI was 35, indicating the lake was oligotrophic, indicative of low primary productivity and nutrient levels (Plate 11), consistent with 2004 sampling results (TSI=40). The TSI values for all sites throughout the sample year were consistently oligotrophic, with the exception of site 1, which was mesotrophic during the winter quarter. Seasonal turbidity values were all well below the Oklahoma Water Quality Standard (WQS) of 25 NTU, ranging from a low of 1 NTU to a high of 15 NTU (Figure 23a). According to the Use Support Assessment Protocols (USAP) specified in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Broken Bow Lake is considered fully supporting the Fish and Wildlife Propagation (FWP) beneficial use with 100% of the turbidity values below the criteria of 25 NTU. Seasonal true color values are displayed in Figure 23b. All true color values were well below the aesthetics WQS of 70 units. Applying the same default protocol, the Aesthetics beneficial use is considered supported as it relates to true color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity values were very low ranging from 0.0 parts per thousand (ppt) to 0.05 ppt. Similarly, specific conductivity values were also very low, ranging from 25.3 to 66.4 µS/cm. The values recorded for both salinity and specific conductivity are much lower than that typically seen in Oklahoma lakes and reservoirs and are indicative of extremely low concentrations of electrical current conducting ions (salts or other chlorides) in Broken Bow Lake. Waters such as these typically have little buffering capacity and are pH sensitive. Values for pH were slightly acidic to neutral, ranging from 5.73 in the hypolimnion in the spring to 7.56 near the surface in the summer. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 69% of the recorded values less than 6.5, Broken Bow Lake is not supporting the FWP beneficial use based on pH. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Oxidation-reduction potentials (redox) ranged from 193 mV to 532 mV, indicating an absence of reducing conditions during the sample year. In the fall quarter the lake was thermally stratified between 10 and 11 meters at sites 1-5 and between 9 and 10 meters at sites 6-8 in the upper end of the reservoir. Dissolved oxygen concentrations fell below 2.0 mg/L at different points among the sites and accounted for up to 66% (site 6) of the water column to be experiencing anoxic conditions. The lake was not thermally stratified in the winter and the water column was well mixed with dissolved oxygen values generally at or above 6.0 mg/L (see Figure 23d). In the spring quarter, the lake was weakly stratified, however like the winter dissolved oxygen remained above 6.0 mg/L. During the summer quarter, there was a metalimnetic oxygen deficit that occurred throughout the lake to varying degrees between 9 and 11 meters below the surface (Figure 23f). Dissolved oxygen values dip down below 2.0 mg/L within this layer and then raise again. It is not known at this time what causes this to occur and the lake should be studied further as this same phenomena was observed during 2004 data collection efforts. In the upper most reaches of the lake (sites 7 and 8), the water column was stratified at several 1-meter intervals with D.O. falling to below 2.0 mg/L for 48 and 62% of the water column, respectively. When D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (USAP 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported at Broken Bow Lake with up to 66% of the water column at site 6 (fall) and 62% at site 8 (summer) exhibiting anoxic conditions. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.21mg/L at the surface. The TN ranged from 0.07 mg/L to 0.39 mg/L. Both the highest and lowest TN values were reported during the winter sampling interval. The lake-wide total phosphorus (TP) average was 0.011 mg/L at the surface. The TP values ranged from 0.008 mg/L to 0.015 mg/L at the surface. Similar to total nitrogen, surface TP was lowest in the winter; however the highest values were reported during the fall quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 19:1 for 2005-2006. This value is much greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Broken Bow Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Broken Bow Lake was classified as oligotrophic, indicative of low primary productivity and nutrient levels (Plate 11), consistent with 2004 sampling results (TSI=40). Water clarity continues to be excellent at this reservoir based on low turbidity, low true color values and the high secchi disk depths. The lake is fully supporting its Aesthetics beneficial use based with 100% of the true color values below the numeric criteria of 70 units and trophic state. The lake is fully supporting its FWP beneficial use based on nephelometric turbidity and partially supporting the use based on anoxic conditions present in the upper end of the reservoir during the fall and summer quarters. In both 2004 and 2006 data collection efforts a metalimnetic oxygen deficit has been observed to varying degrees throughout the main body of the lake. Respiration (largely bacterial) may be driving the metalimnetic oxygen deficit. Dead and dying algal cells are the most likely source of detritus in the lacustrine zone. Anoxic metalimnetic waters is an indication of eutrophication therefore this lake should be studied further since based on chlorophyll-a alone the lake has an oligotrophic classification. With 69% of the recorded pH values less than 6.5, Broken Bow Lake is not supporting the FWP beneficial use. Low pH values are commonly seen in Southeast Oklahoma and are likely due to natural causes. For this reason the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

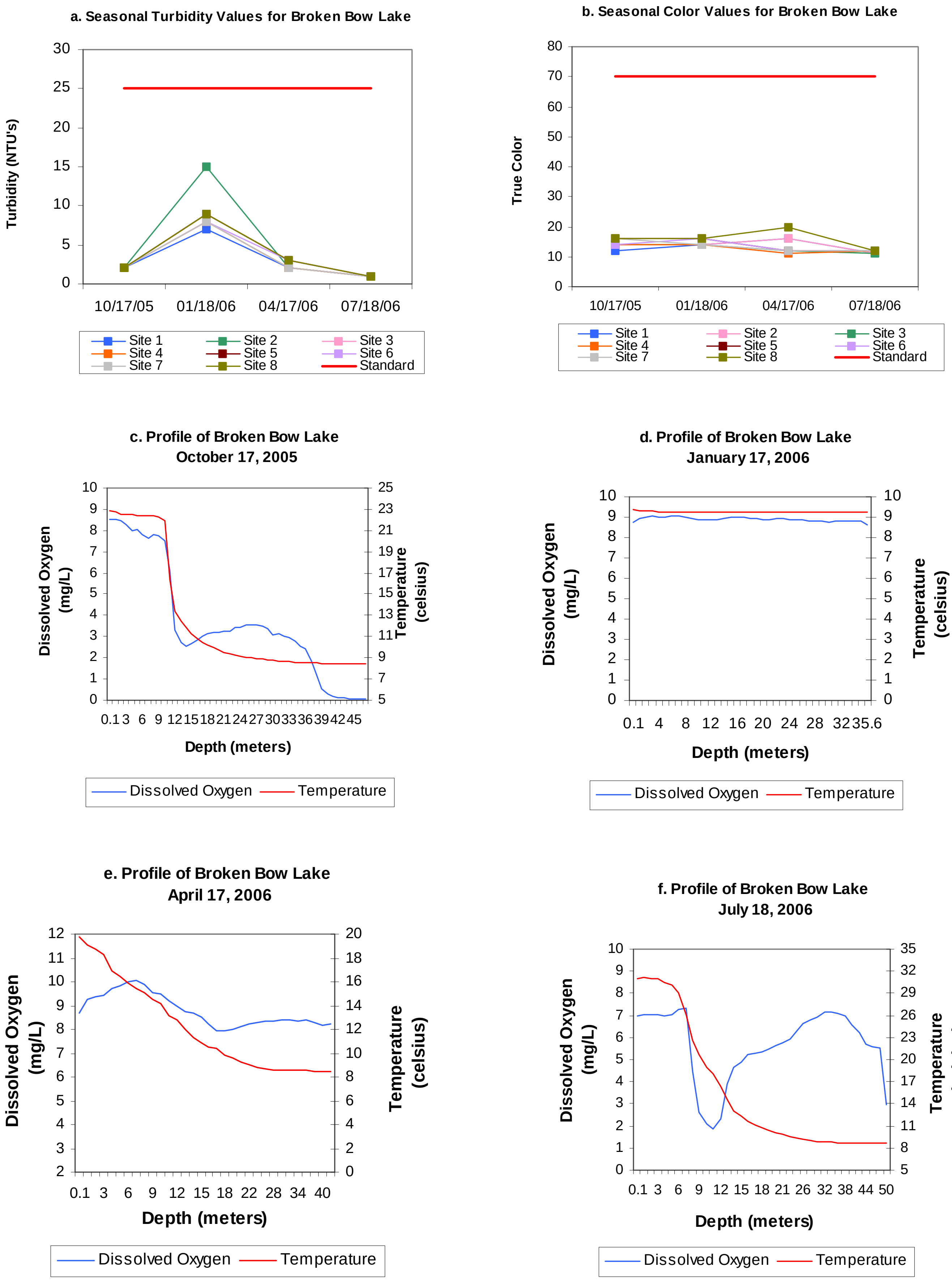
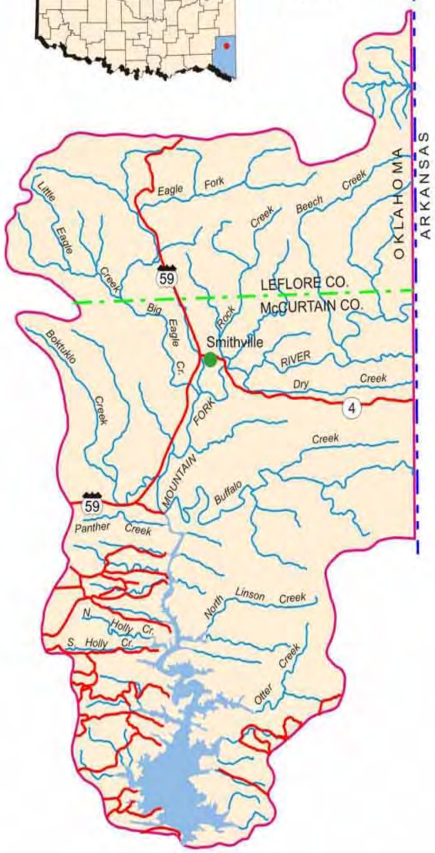


Figure 23a-23f. Graphical representation of data results for Broken Bow Lake.



Broken Bow Lake
and
Watershed

Lake Data	
Constructed by	Corps of Engineers
County	McCurtain
Constructed in	1968
Surface Area	14,200 acres
Volume	918,070 acre/feet
Shoreline Length	180 miles
Mean Depth	64.7 feet
Watershed Area	754 square miles

Plate 11 - Lake Water Quality for
Broken Bow Lake

LAKES MONITORING PROGRAM

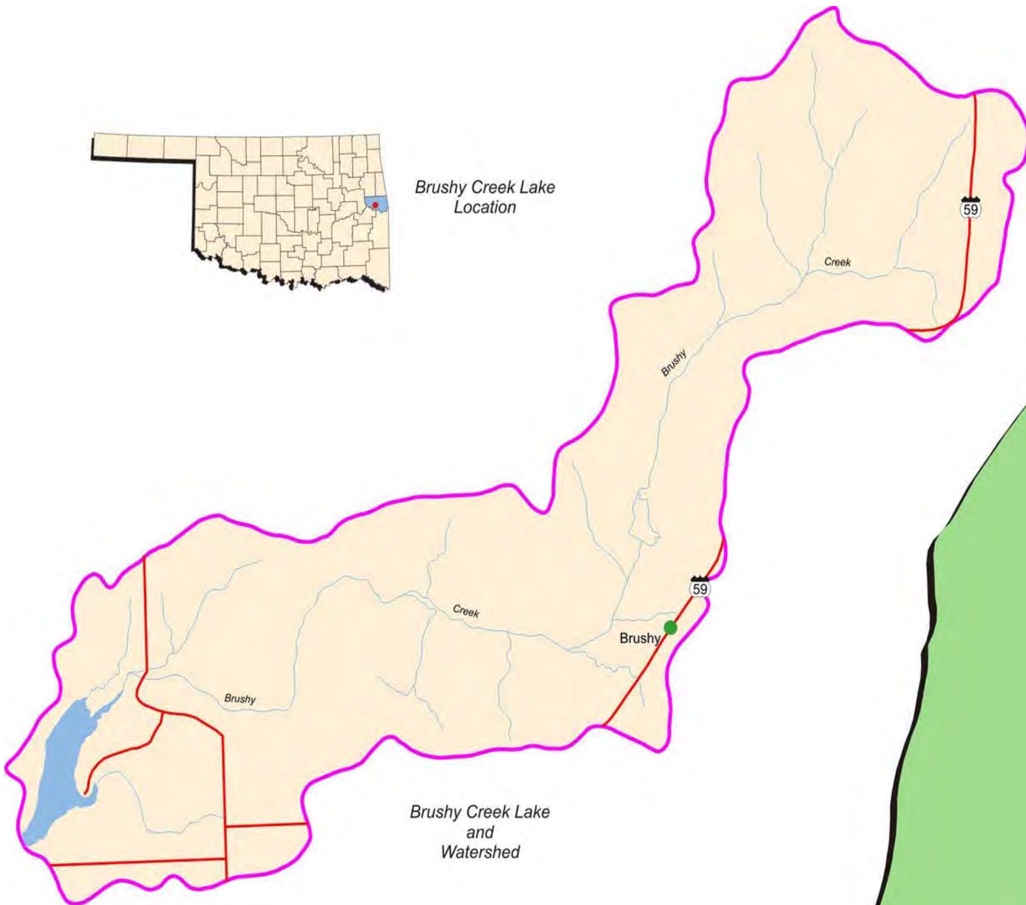
Brushy Creek Reservoir

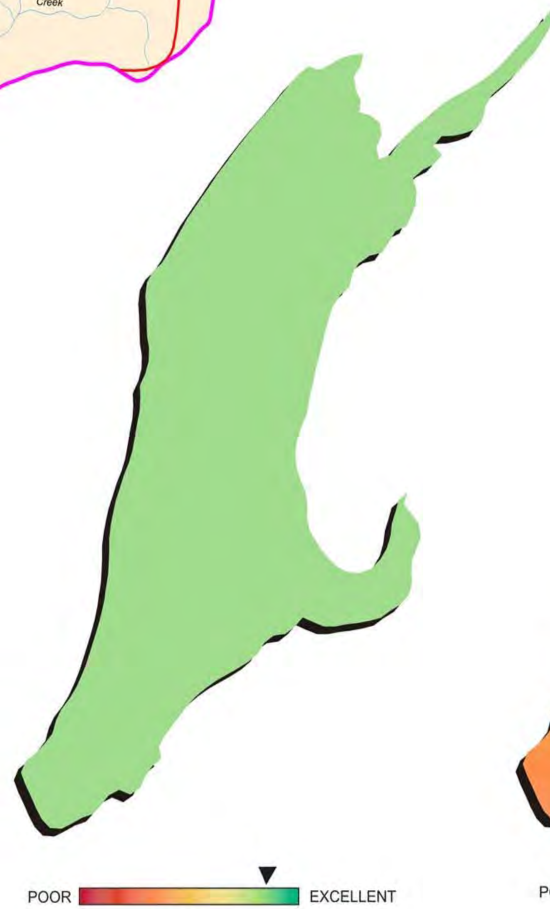
Brushy Creek Reservoir, located in Sequoyah County, is approximately 5 miles north of Sallisaw. The lake was scheduled for sampling during the 2005-2006 sample year however due to the drought conditions lake levels were too low for OWRB staff to launch a boat. The lake will be placed on the next sample rotation once water levels rise enough for staff to access the lake safely.

Brushy Creek Reservoir was sampled for four quarters, from October 2003 through July 2004. Water quality samples were collected at five (5) sites to represent the riverine, transitional, lacustrine zones of the lake. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide average turbidity value was 7 NTU (Plate 12), true color was 22 units, and average secchi disk depth was 112 centimeters in sample year 2004. Based on these three parameters water clarity was excellent. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI was 51, indicating the lake was eutrophic, bordering mesotrophic, with moderate to high primary productivity and nutrient conditions. The TSI values throughout the sample year were primarily mesotrophic with the eutrophic values occurring in the fall and summer quarters. Seasonal turbidity values are displayed in. Turbidity values ranged from 4-10 NTU, well below the Oklahoma Water Quality Standard (WQS) of 25 NTU. All true color values were well below the aesthetics WQS of 70 units although there was evident seasonal variability.

Please refer to the “Beneficial Use Monitoring Report 2004 Draft Final Report” for the full discussion of monitoring results for this lake. The report may be access via the OWRB’s web page at http://www. owrb.state.ok.us or you may contact the Water Resources for a copy of the 2004 BUMP Report on CD. The OWRB may be reached at (405) 530-8800 (ask for Nikki Cole) or at the address below:

Oklahoma Water Resources Board
3800 N. Classen Blvd.
Oklahoma city, Oklahoma 73118
Attn: Nikki Cole





Lake Data

Owner	Leased to State of Oklahoma
County	Sequoyah
Constructed in	1964
Surface Area	358 acres
Volume	3,258 acre/feet
Shoreline Length	4 miles
Mean Depth	9.10 feet
Watershed Area	21 square miles

Plate 12 - Lake Water Quality for
Brushy Creek Lake

Lake Burtschi

Lake Burtschi, located in Grady County is approximately 10 miles southwest of Chickasha. The State of Oklahoma via the Oklahoma Department of Wildlife Conservation (ODWC) constructed Lake Burtschi in 1954 for the express purpose of promoting recreational activities, primarily fishing. The lake is managed by the ODWC specifically for the purpose of promoting angling activities. Lake Burtschi was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites. The lake-wide turbidity value was 11 NTU (Plate 13), true color was 18 units, and average secchi disk depth was 72 centimeters. Water clarity was good based on secchi disk depth, turbidity, and true color values. Results for these parameters were similar to historical data collection efforts in 2004. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=11). Due to a post-processing error no sample for site 3 was submitted for analysis from spring data collection efforts. The TSI calculated was 63 (Plate 13), indicating the lake was hypereutrophic in sample year 2005-2006. The TSI values throughout the sample year were fairly consistent with eutrophic conditions present in the winter, spring and summer quarters and hypereutrophic in the fall. The only exception to this occurred at site 1, which was mesotrophic in the winter quarter. Based on the trophic classification, the lake will be recommended for listing in the next Oklahoma Water Quality Standards (WQS) revision process as a Nutrient Limited watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Turbidity values per site were all below the WQS of 25 nephelometric turbidity units (NTU) for all seasons with values ranging from 7 to 24 NTU (see Figure 24a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Based upon turbidity concentrations Lake Burtschi was meeting its Fish & Wildlife Propagation (FWP) beneficial use. Seasonal true color values are displayed in Figure 24b. All true color values were below the Aesthetics Oklahoma Water Quality Standard (WQS) of 70 units. Applying the same default protocol Lake Burtschi is considered meeting its Aesthetics beneficial as it relates to true color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity values ranged from 0.53 part per thousand (ppt) in the fall to 0.67 ppt recorded in the summer. Moderate salinity values in the water column indicate chlorides or salts were present in large concentrations in the lake system. Specific conductivity was also greater than most values recorded in Oklahoma reservoirs, indicating moderate to high levels of electrical current conducting compounds like salts present in the water column. Values ranged from 1011 µS/cm in the spring to 1273 µS/cm in the summer of 2006. Lake pH values were neutral to slightly alkaline, ranging from 7.19 to 10.74 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 16% of the recorded values greater than 9.0, Lake Burtschi is partially supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (redox) ranged from 42 to 428 mV recorded at site 1 in the summer. Reducing conditions were not present at the time of sampling. Low redox values in the hypolimnion are not uncommon when a lake is thermally stratified and anoxic conditions are present. The lake was not thermally stratified in the fall or winter; however stratification was evident during the spring and summer sampling intervals. (Figure 24c-24f). In the spring quarter the lake was weakly stratified with dissolved oxygen (D.O.) only dipping down to 2.04 mg/L at the lake bottom of 7.4 meters (Figure 24c). The lake was strongly thermally stratified in the summer between 3 and 4 meters with D.O. concentrations less than 1.0 mg/L from 5 meters in depth to the lake bottom of 6.9 meters (see Figure 24f). Although D.O. concentrations fell below 2.0 mg/L, (only 38% of the water column), at site 1, this is not sufficient to result in listing the lake as not supporting its FWP beneficial use. When D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (USAP 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered fully supported at Lake Burtschi. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.36 mg/L, which is a relatively high value when compared to other lakes across the state. The TN at the surface ranged from 0.92 mg/L to 1.82 mg/L. Surface TN was highest in the fall, winter, and summer quarters and lowest in the spring. The lake-wide total phosphorus (TP) average was 0.056 mg/L for sample year 2006. The TP ranged from 0.027 mg/L to 0.109 mg/L at the surface. Surface TP was highest in the fall and lowest in the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 24:1 for 2005-2006. This value is much greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Lake Burtschi was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Lake Burtschi was classified as hypereutrophic in nature, indicative of excessive primary productivity and nutrient conditions (Plate 13). The lake is fully supporting its Aesthetics beneficial use for true color with 100% of the reported values below the standard of 70 units. Based on the calculated TSI, the lake will be recommended for listing as a Nutrient Limited Watershed (NLW) in the next WQS revision process and its Aesthetic beneficial use considered threatened until a study can be conducted to confirm non-support status. Lake Burtschi is fully supporting its FWP beneficial use based on D.O. and nephelometric turbidity. With 16% of the recorded pH values above 9.0 units, the FWP beneficial use is considered partially supported as it related to pH. Bacteriological samples were also collected during the recreation season to assess the Primary Body Contact Recreation (PBCR) beneficial use. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

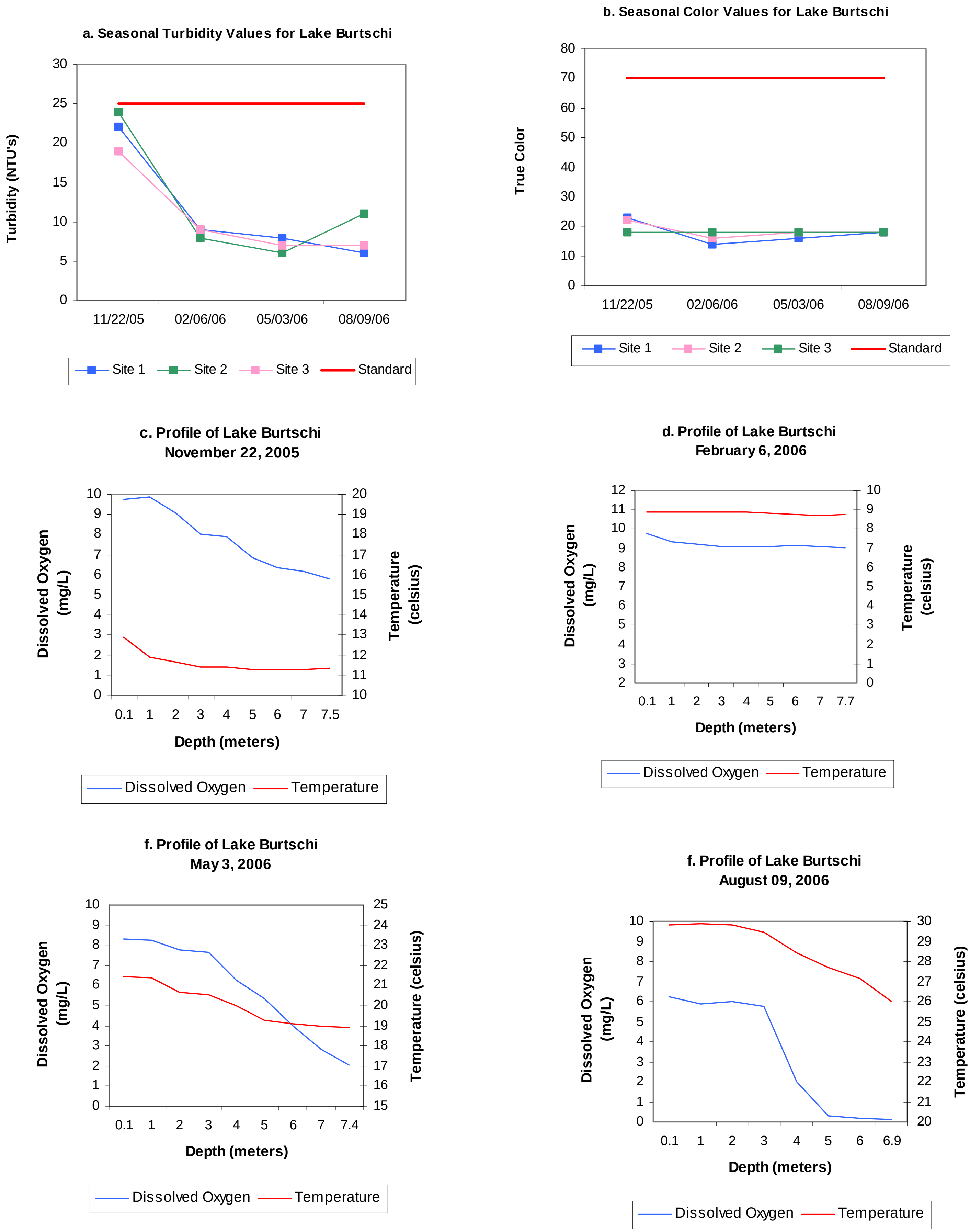
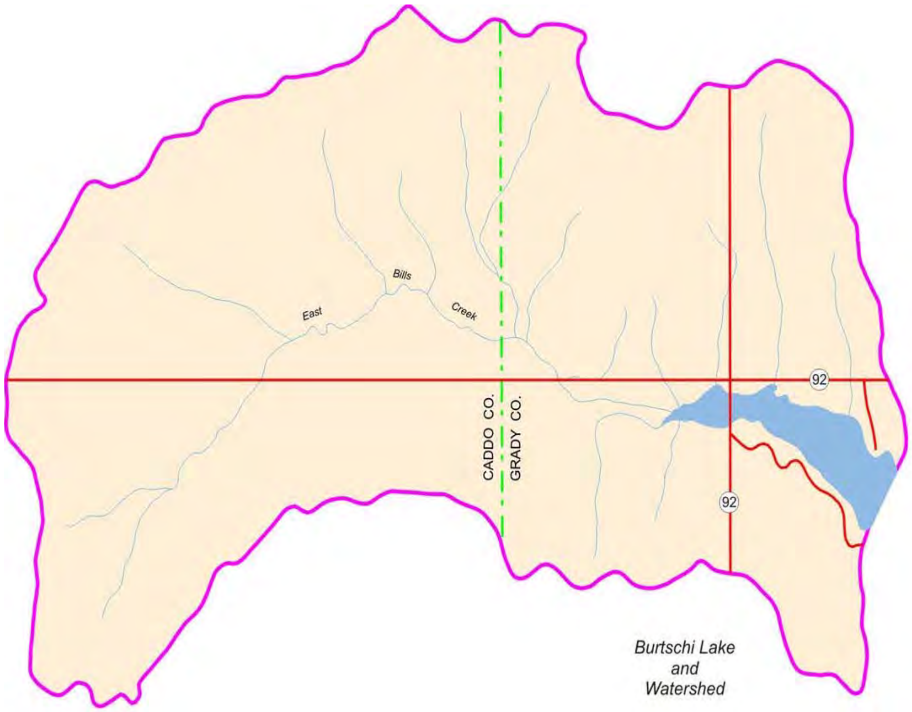


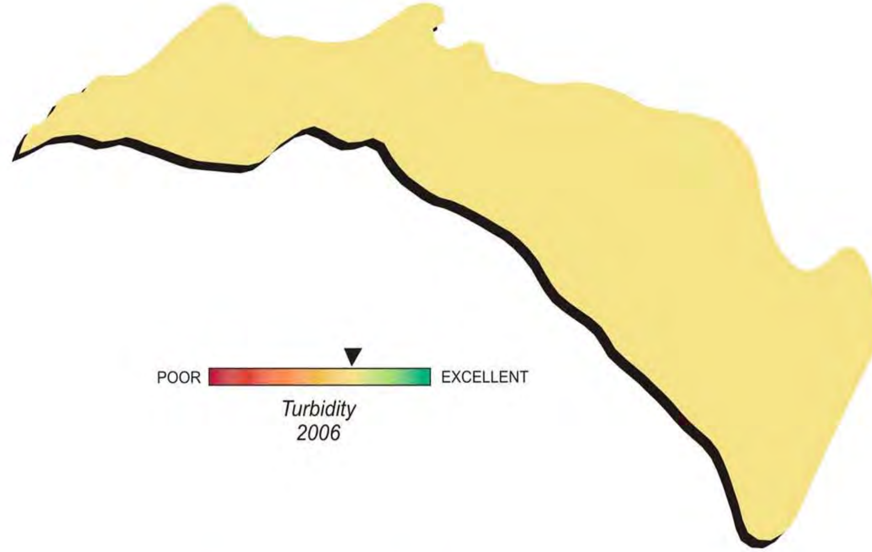
Figure 24a-24f. Graphical representation of data results for Lake Burtschi.

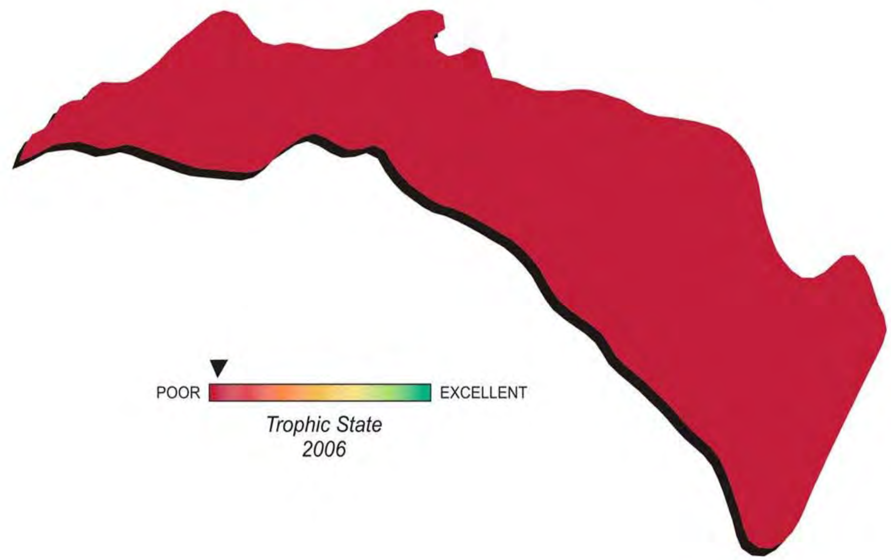


Burtschi Lake
and
Watershed

N
W
E
S

Burtschi Lake
Location





Lake Data

Owner	State of Oklahoma
County	Grady
Constructed in	1954
Surface Area	180 acres
Volume	2,140 acre/feet
Shoreline Length	3 miles
Mean Depth	11.89 feet
Watershed Area	4,692 acres

Plate 13 - Lake Water Quality for
Burtschi Lake

Canton Lake

Canton Lake, located in Blaine County, is approximately 2 miles north of the town of Canton. The United States Army Corps of Engineers constructed Canton Lake in 1948 to serve as a flood control, water supply and irrigation reservoir. The lake also serves as a municipal water supply reservoir for the City of Oklahoma City, which pays to have water released from the lake for water supply purposes when necessary. Additionally the lake is famous among anglers for it's walleye rodeo fishing event that is held annually. Canton Lake was sampled for four quarters, from October 2005 through July 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Water chemistry samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 16 NTU (Plate 14), true color was 18 units, and secchi disk depth was 63 centimeters. Water clarity was average based on secchi disk depth, turbidity, and true color values and results for these parameters were similar to that in 2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI was calculated at 57 (Plate 14), indicative of high primary productivity and nutrient rich conditions. This is similar to previous data collection efforts, indicating no significant change in productivity has occurred. The TSI values throughout the sample year were fairly consistent with hypereutrophic conditions in the fall and eutrophic conditions observed the remaining three sampling intervals. The only exception to this occurred at sites 1 and 2, which were mesotrophic in the summer. Turbidity values ranged from a low of 7 NTU to a maximum of 40 NTU, with the highest values recorded at site 4 in the upper end of the reservoir. Of the twenty values recorded 3 (15%) exceeded the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 25a). According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Canton Lake is considered partially supporting the Fish & Wildlife Propagation (FWP) beneficial use based on turbidity values recorded for the reservoir. Seasonal true color values are displayed in Figure 25b. All true color values were below the Aesthetics WQS of 70 units for sample year 2005-2006. Applying the same default protocol to determine the average for true color, the Aesthetics beneficial use is supported.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity values ranged from 0.63 parts per thousand (ppt) in the winter to 0.93 ppt in the summer. Salinity concentrations were consistently higher than the range of expected values for Oklahoma lakes, reflecting the moderate to high presence of chlorides or other salts in the lake. Specific conductivity values were also higher than the expected range for Oklahoma reservoirs, indicating a high level of electrical current conducting compounds (i.e. salts). Values ranged from 1201 µS/cm in the winter to 1743 µS/cm in the summer. Lake pH values were neutral to moderately alkaline, ranging from 7.51 to 8.49 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Canton Lake is supporting its FWP beneficial use as it relates to pH with 100% of the collected values falling within the acceptable range. Oxidation-reduction potentials ranged from 368 mV in the summer to 487 mV in the fall, indicating reducing conditions were not present throughout the year. The lake was not stratified during the fall, winter or spring quarters (Figure 25c-25e). During the summer sampling interval thermal stratification was evident and anoxic condition present in 25% of the water column at sites 1 and 2. Stratification occurred between 4 and 5 meters below the surface with dissolved oxygen (D.O.) dropping below 2.0 mg/L from 6 meters to the lake bottom of 6.5 meters (Figure 25f). In previous evaluations there has been an absence of stratification for the entire sample year, which may be attributed to its fairly shallow nature. According to the Use Support Assessment Protocols (USAP), if D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. The FWP beneficial use is fully supported at Canton Lake based on D.O. with anoxic conditions present in only 25% of the water column The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) was 0.78 mg/L at the lake surface in sample year 2006. The surface (surface) TN ranged from 0.63 mg/L to 1.03 mg/L. TN was highest at site 5 in the fall. The lake-wide total phosphorus (TP) average was 0.062 mg/L at the lake surface. The TP ranged from 0.033 mg/L to 0.167 mg/L at the surface. Similar to TN, the highest TP was reported both in the fall with the lowest values reported during the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 13:1 for sample year 2005-2005. This value is greater than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 1999 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening level or consumption advisory level. The lake is fully supporting its Fish Consumption beneficial use. Canton Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Canton Lake was classified as eutrophic, indicative of high primary productivity and nutrient levels (Plate 14). The trophic status of the reservoir was primarily eutrophic with hypereutrophic conditions in the fall of 2005. Water clarity was average based on secchi disk depth, turbidity, and true color values and results for these parameters were similar to that in

2004. The lake is supporting its FWP beneficial use based on pH and D.O. concentrations however only partially supporting the beneficial use with 15% of the turbidity values exceeding the WQS of 25 NTU. The lake was fully supporting its Aesthetics beneficial use for both trophic state and true color. Of the twenty color values collected, 100% were below the standard of 70 units. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

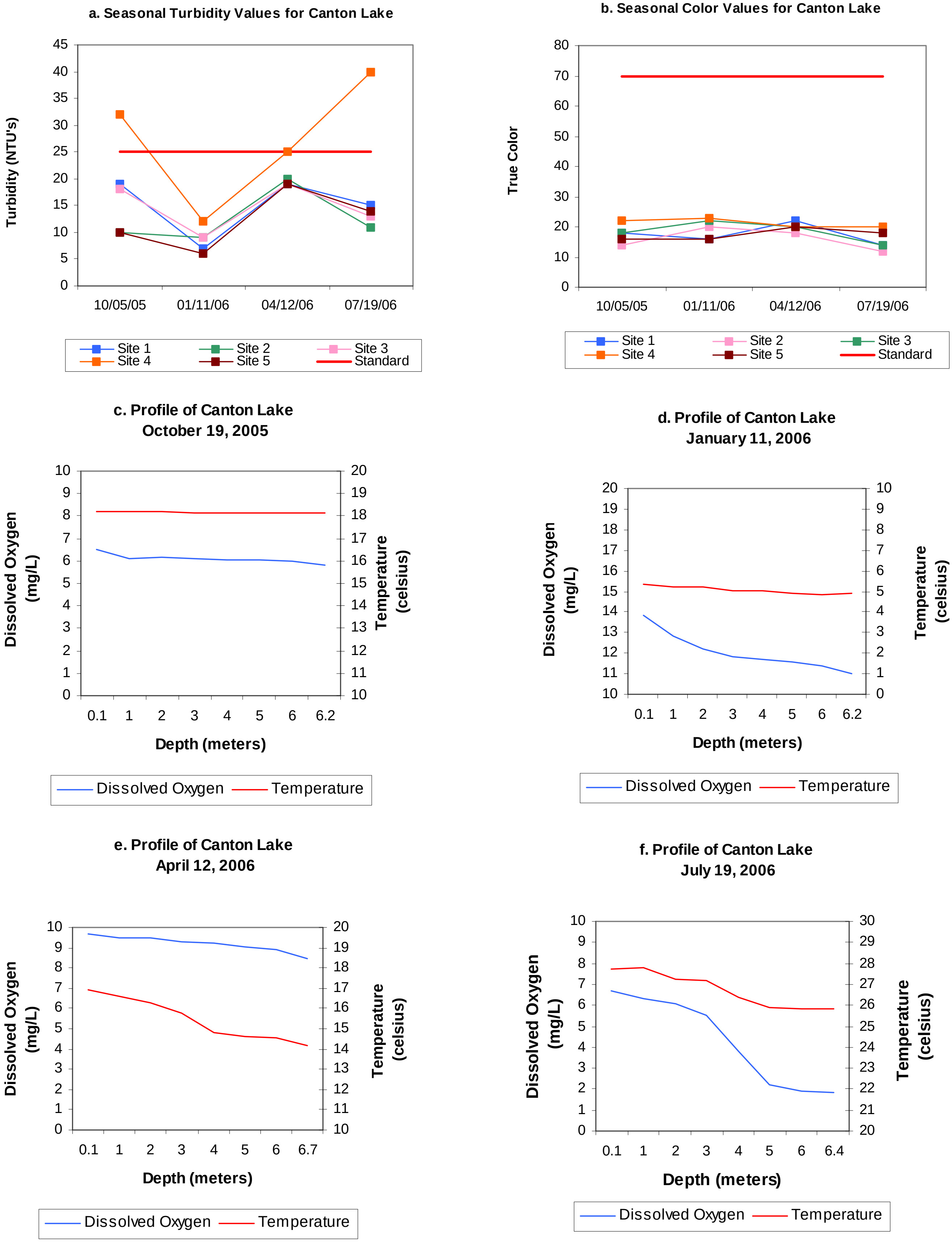
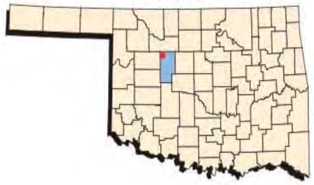
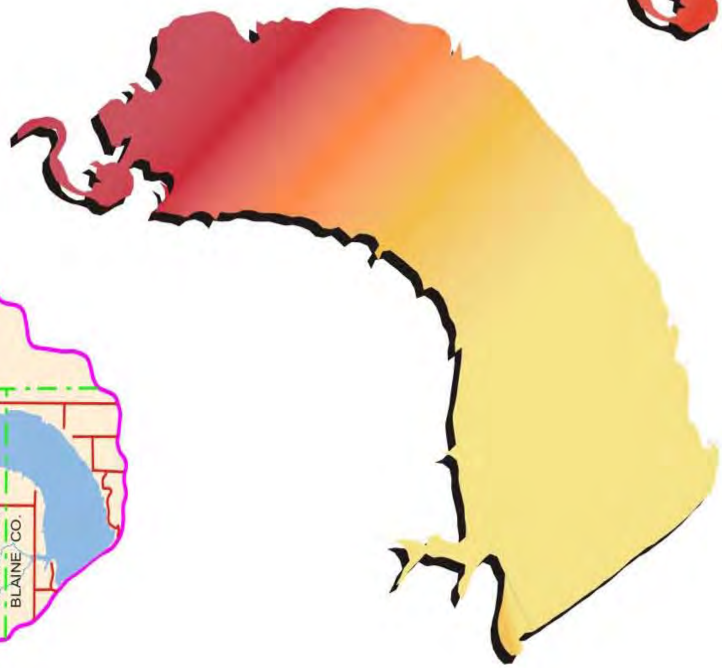


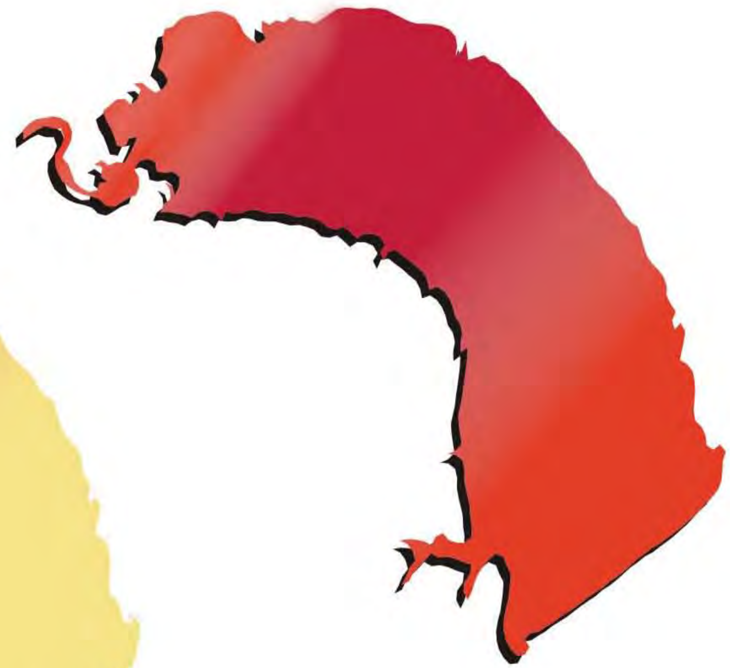
Figure 25a-25f. Graphical representation of data results for Canton Lake.

Canton Lake
Location



Canton Lake
and
Watershed





Lake Data

Constructed by	Corps of Engineers
County	Blaine
Constructed in	1948
Surface Area	7,910 acres
Volume	111,310 acre/feet
Shoreline Length	45 miles
Mean Depth	14.99 feet
Watershed Area	12,483 square miles

Plate 14 - Lake Water Quality for
Canton Lake

LAKES MONITORING PROGRAM

Carl Albert Lake

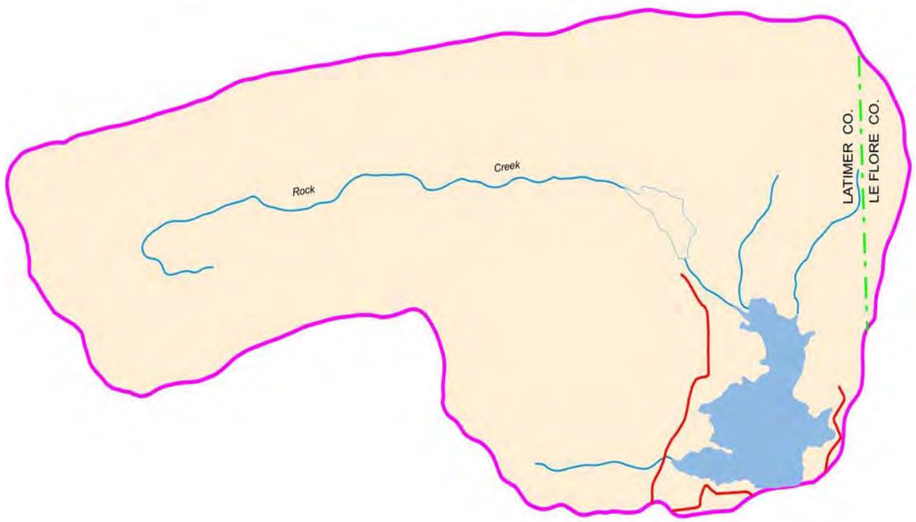
Carl Albert Lake, located in Latimer County, is approximately 1 mile north of Talihina. Carl Albert Lake was constructed in 1964 for the purpose of water supply, flood control and recreation. The lake was scheduled for sampling during the 2005-2006 sample year however due to the drought conditions lake levels were too low for OWRB staff to launch a boat. The lake will be placed on the next sample rotation once water levels rise enough for staff to access the lake safely.

Water quality samples were collected at three sites to represent the riverine, transitional, and lacustrine zones. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide average turbidity was 7 NTU (Plate 15), true color was 31 units, and average secchi disk depth was 127 centimeters. Water clarity was excellent based on secchi disk depth, turbidity, and true color values. Results for these parameters were slightly better than the results found in 2001. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The TSI was 41 (Plate 15), indicating the lake was mesotrophic, bordering oligotrophic, indicative of low to moderate primary productivity and nutrient conditions in sample year 2004. The TSI in 2001 was also 41, indicating no significant increase or decrease has occurred since previous data collection efforts. The TSI values at all sites were oligotrophic in the fall and winter with mesotrophic values in the spring and summer. Turbidity values were fairly consistent among sites with values ranging from 4 to 10 NTU. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Carl Albert Lake is currently supporting its Fish & Wildlife Propagation (FWP) beneficial use with 100% of values recorded for the reservoir well below the prescribed numeric criteria. Seasonal true color values are displayed in. All true color values were below the aesthetics WQS of 70 units. Applying the same default protocol, the Aesthetics beneficial use is considered supported.

Please refer to the "Beneficial Use Monitoring Report 2004 Draft Final Report" for the full discussion of monitoring results for this lake. The report may be access via the OWRB's web page at http://www. owrb.state.ok.us or you may contact the Water Resources for a copy of the 2004 BUMP Report on CD. The OWRB may be reached at (405) 530-8800 (ask for Nikki Cole) or at the address below:

Oklahoma Water Resources Board
3800 N. Classen Blvd.
Oklahoma city, Oklahoma 73118
Attn: Nikki Cole

Carl Albert Lake Location



Carl Albert Lake and Watershed

Lake Data

Owner	City of Talihina
County	Latimer
Constructed in	1964
Surface Area	183 acres
Volume	2,739 acre/feet
Shoreline Length	4 miles
Mean Depth	14.97 feet
Watershed Area	3850 acres

Turbidity 2004

Trophic State 2004

Plate 15 - Lake Water Quality for

Carl Albert Lake

Lake Carl Blackwell

Lake Carl Blackwell was sampled for four quarters, from September 2004 through June 2005. Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir as well as major arms. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide annual turbidity value was 22 NTU (Plate 16), true color was 24 units, and secchi disk depth was 56 centimeters in 2004-2005. Based on these three parameters, Lake Carl Blackwell had good to fair water clarity, similar to that of the previous evaluation. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The calculated TSI was 56 (Plate 16), indicating the lake was eutrophic with high primary productivity and nutrient conditions. This value is nearly identical to that calculated for 2001-2002 (TSI=55), indicating no significant change in productivity has occurred. The TSI values varied throughout the sample year from upper eutrophic and hypereutrophic in the fall and winter to meso-eutrophic in both spring and summer. Seasonal turbidity values are displayed in Figure 26a. Of the turbidity values collected, only 20% exceeded the turbidity standard of 25 NTU for lakes. According to the Use support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Lake Carl Blackwell is considered supporting its Fish & Wildlife Propagation (FWP) beneficial use based on turbidity. Seasonal true color values are displayed in Figure 26b. All true color values were below the aesthetics WQS of 70 units. Applying the same default protocol to determine the average for true color the Aesthetics beneficial use is supported.

In 2004-2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all five sites during the study period. Salinity ranged from 0.18 to 0.22 parts per thousand (ppt), which was consistent with values, recorded most Oklahoma reservoirs. Specific conductivity ranged from 355.2 µS/cm to 449.7 µS/cm, indicative of low to moderate levels of current conducting ionic compounds (or other analogous materials) in the lake. The pH values at Lake Carl Blackwell were neutral to slightly alkaline ranging from 7.21 to 8.44 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if they fall outside the range of 6.5 to 9.0 for 25% of the values and they waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Lake Carl Blackwell is currently supporting its FWP beneficial use based on pH values. Oxidation-reduction potentials (redox) ranged from 211 mV in the spring to 431 mV in the winter, indicating an absence of reducing conditions within the lake system. During the fall quarter the lake was fairly well mixed with weak stratification occurring only in the lower portions of the water column. Dissolved Oxygen (D.O.) only fell below 2.0 mg/L between 12 and 13 meters, the lake bottom (Figure 26c). The lake was not thermally stratified in the winter or spring and dissolved oxygen (D.O.) concentrations remained well above 7.0 mg/L throughout the water (see Figure 26d-26e). In the summer, the lake was thermally stratified at several 1-meter intervals. However; similar to the fall, quarter; D.O. only fell below 2.0 mg/L near the lake bottom between 9 and 10 meters (see Figure 26f). Anoxic conditions were not present at any of the other sites probably because they are shallower in depth. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the lake is fully supporting its FWP beneficial use with 10% of the water column in the summer less than the prescribed 2.0-mg/L water quality standard. The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the study period therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average for sample year 2004-2005 was 0.55 mg/L at the lake surface. The epilimnetic (surface) TN ranged from 0.34 mg/L to 0.85 mg/L. TN was highest at site 1 in the fall and lowest in the spring also at site 1, the dam. The lake-wide total phosphorus (TP) average was 0.036 mg/L for the lake surface. The TP ranged from 0.024 mg/L to 0.062 mg/L at the lake surface. Similar to total nitrogen, TP was highest in the winter and lowest in the spring. The nitrogen to phosphorus ratio (TN:TP) was approximately 15:1 for sample year 2004-2005. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

In summary, Lake Carl Blackwell was classified as eutrophic, indicative of high primary productivity and nutrient rich conditions (Plate 16). The current classification is the same as that observed in 2002 (TSI=55), indicating no significant increase or decrease in productivity has occurred. Water clarity was average to fair based on turbidity, true color, and secchi disk depth. The Aesthetics beneficial use was fully supported based on true color data and trophic status. Additionally, the FWP beneficial use is fully supported based on pH data and D.O. conditions, and partially supporting for turbidity. Bacteria data were not collected during the recreational season and an assessment of the PBCR use cannot be made. The OWRB has recently completed a demonstration of shoreline erosion control at Lake Carl Blackwell funded through Section 319 of the Clean Water Act. These relatively low cost and fish friendly methods have been enacted in cooperation with Oklahoma State University. In addition Oklahoma Water Watch has an active volunteer monitoring group at Lake Carl Blackwell. For more information on these programs contact Derek Smithee at (405) 530-8800. Lake Carl Blackwell is owned and managed by Oklahoma State University and the State of Oklahoma. The lake is managed as a municipal water supply and source of recreational activities.

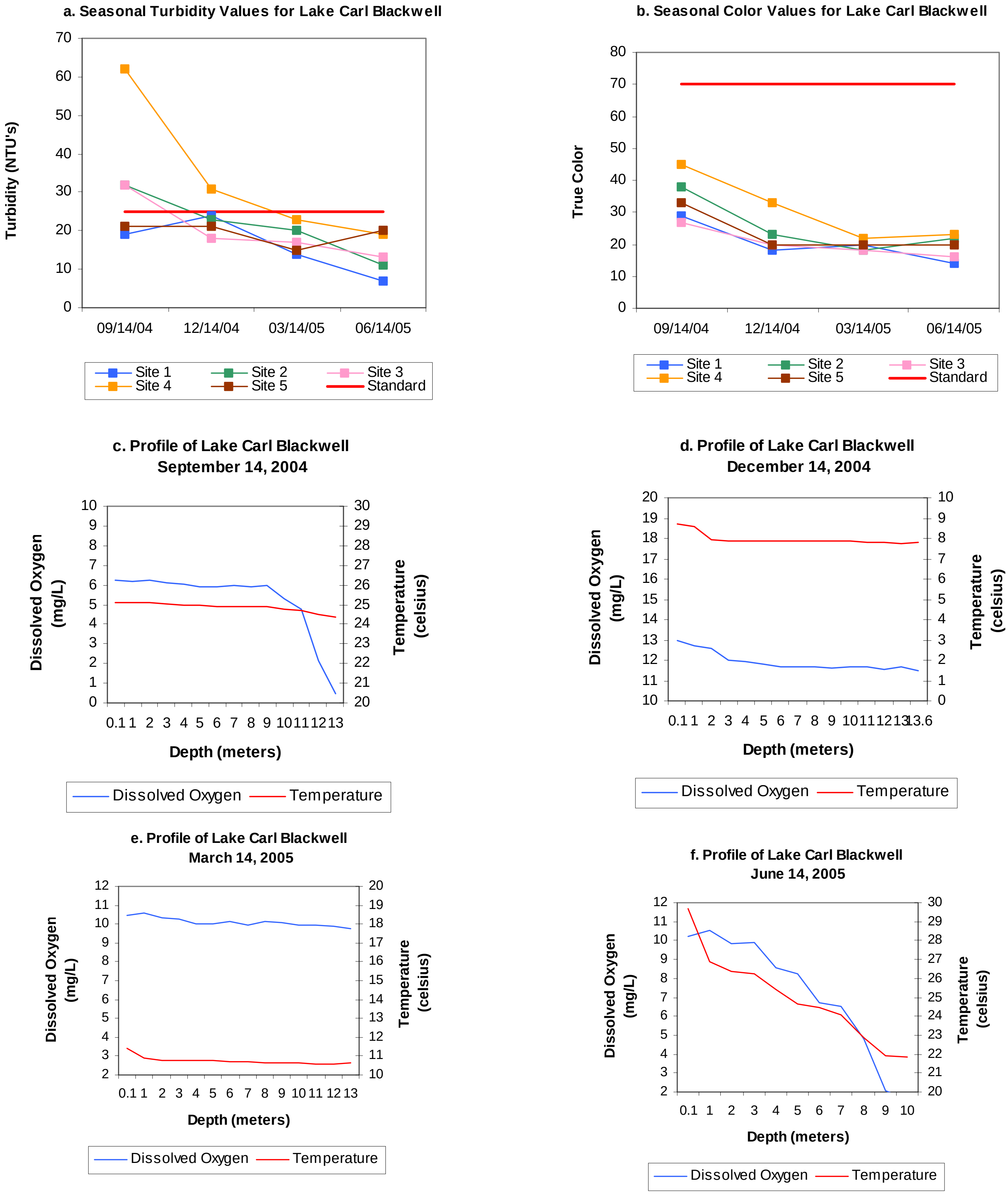
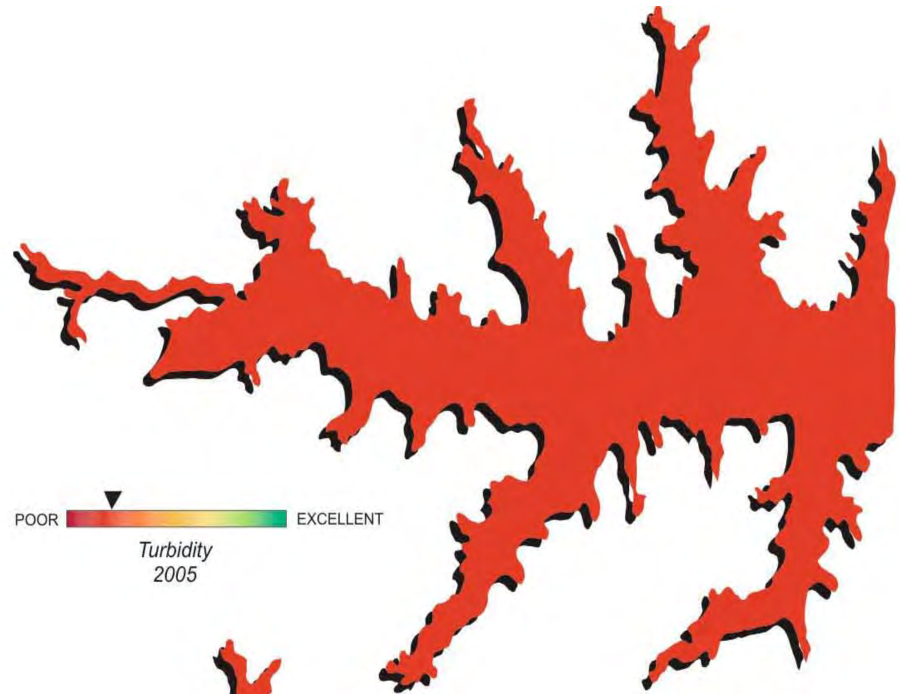
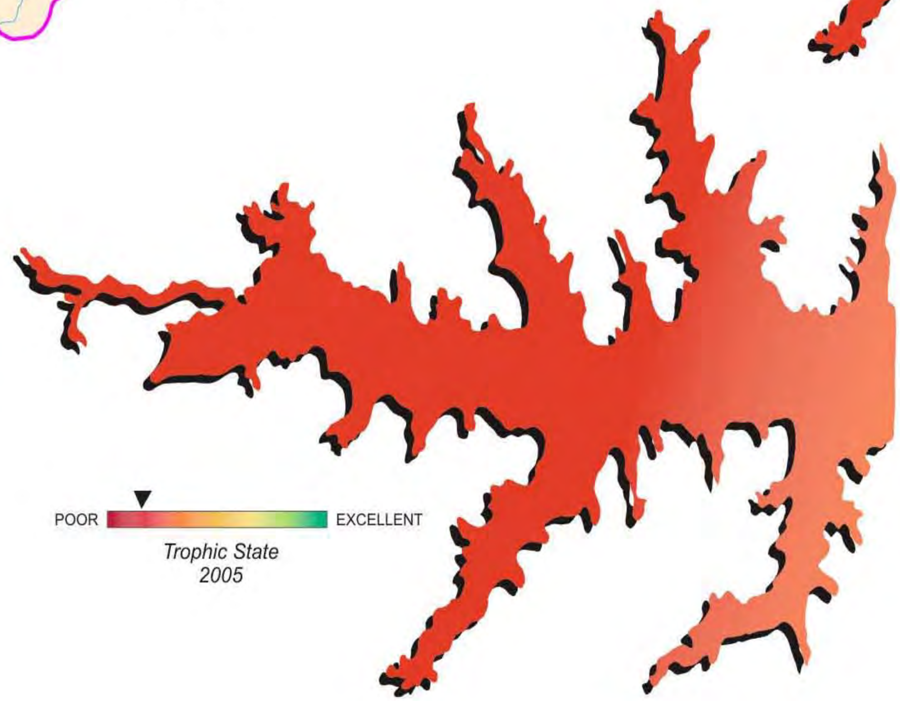


Figure 26a-26f. Graphical representation of data results for Lake Carl Blackwell.

Lake Carl Blackwell and Watershed

Lake Carl Blackwell Location





Lake Data

Owner	Oklahoma State University
County	Payne
Constructed in	1937
Surface Area	3,370 acres
Volume	61,500 acre/feet
Shoreline Length	58 miles
Mean Depth	18.25 feet
Watershed Area	49,278 square miles

Plate 16 - Lake Water Quality for
Lake Carl Blackwell

LAKES MONITORING PROGRAM

Carter Lake

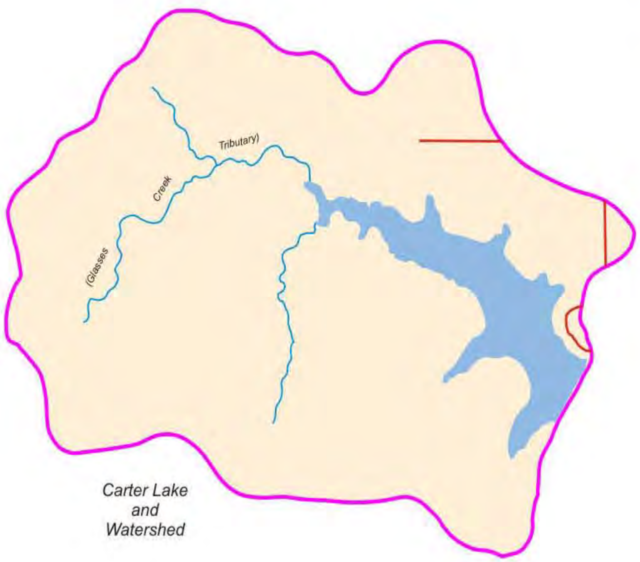
Carter Lake, located in Marshall County, is approximately 5 mile northwest of Madill. The lake was constructed in 1960 and is managed by the city for both water supply and recreation purposes. The lake was scheduled for sampling during the 2005-2006 sample year however due to the drought conditions lake levels were too low for OWRB staff to launch a boat. The lake will be placed on the next sample rotation once water levels raise enough for staff to access the lake safely.

Water quality samples were collected at three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and as well as 0.5 meters from the lake bottom at site 1, the dam. The lake-wide turbidity value was 8 NTU (Plate 17), true color was 15 units, and average secchi disk depth was 108 centimeters. Water clarity was excellent based on secchi disk depth, turbidity, and true color values. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The TSI was 40, indicating the lake was oligotrophic bordering mesotrophic with low primary productivity and nutrient conditions in sample year 2004. This value is less than that reported in 2001 (TSI=44); however it is likely a more accurate depiction of lake productivity as it is based on four seasons of data versus three in the previous evaluation. The TSI values throughout the sample year were primarily oligotrophic with mesotrophic values at all sites in the spring and site 3 during the summer. Seasonal turbidity values per site for the sample year were below the Oklahoma Water Quality Standard (WQS) of 25 NTU for all seasons. According to the Use support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. The lake is considered supporting its Fish & Wildlife Propagation (FWP) beneficial use with 100% of the collected turbidity data below the criteria. Similar to turbidity, all true color values were below the aesthetics WQS of 70 units. Applying the same default protocol to determine the average for true color the Aesthetics beneficial use is supported.

Please refer to the "Beneficial Use Monitoring Report 2004 Draft Final Report" for the full discussion of monitoring results for this lake. The report may be access via the OWRB's web page at http://www. owrb.state.ok.us or you may contact the Water Resources for a copy of the 2004 BUMP Report on CD. The OWRB may be reached at (405) 530-8800 (ask for Nikki Cole) or at the address below:

Oklahoma Water Resources Board
3800 N. Classen Blvd.
Oklahoma city, Oklahoma 73118
Attn: Nikki Cole

Carter Lake
Location



Carter Lake
and
Watershed

POOR — EXCELLENT
Turbidity
2004

POOR — EXCELLENT
Trophic State
2004

Lake Data	
Owner	City of Madill
County	Marshall
Constructed in	1960
Surface Area	108 acres
Volume	990 acre/feet
Shoreline Length	4 miles
Mean Depth	9.17 feet
Watershed Area	1,134 acres

Plate 17 - Lake Water Quality for
Carter Lake

LAKES MONITORING PROGRAM

Cedar Lake

Cedar Lake, located in Le Flore County, is approximately 3 miles N.W of the town of Stapp. The USDA constructed this lake in the Ouchita National Forest in 1937 for recreational purposes. Cedar Lake was sampled for four quarters, from October 2005 through July 2006.

Water quality samples were collected at three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide turbidity value was 4 NTU (Plate 18), true color was 19 units, and average secchi disk depth was 162 centimeters. Water clarity was excellent based on secchi disk depth, turbidity, and true color values. Results for these parameters were similar to if not slightly better than the results of the 2004 data collection efforts. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for three quarters (n=9). The TSI was 53, indicating the lake was eutrophic with high primary productivity and nutrient conditions. This is consistent with the previous evaluation in 2004, which had a calculated TSI of 55. Due to a post processing error no samples were submitted for analysis from the winter data collection efforts. The TSI values throughout the sample year varied seasonally from mesotrophic in the fall and spring to upper eutrophic during the summer quarter. Turbidity values per site for sample year 2004 were well below the Oklahoma Water Quality Standard (WQS) of 25 NTU for all seasons (See Figure 27a). The lake-wide annual turbidity of 4 NTU seems to accurately represent conditions at Cedar Lake. According to the Use support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. The lake is considered supporting its Fish & Wildlife Propagation (FWP) beneficial use with 100% of the collected turbidity data below the criteria. Seasonal true color values are displayed in Figure 27b. All true color values were below the Aesthetics WQS of 70 units. Applying the same default protocol to determine the average for true color, the Aesthetics beneficial use is supported.

In 2006, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all three sample sites. The salinity ranged from 0.0 parts per thousand (ppt) to 0.09 ppt for this sample year. Specific conductivity ranged from 4.9 µS/cm to 195.7 µS/cm, which falls within the range, if not lower than values commonly reported for Oklahoma lakes. These values indicate a minimal presence of ions (chlorides or other salts) present in the system. The pH values at Cedar Lake ranged from 5.43 to 9.16, representing a slightly acidic system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 36% of the recorded values falling below 6.5 pH units and 6% of the values greater than 9 pH units the FWP beneficial use is considered not supporting based on pH concentrations. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Due to these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Oxidation-reduction potentials (ORP) were positive at all sites and ranged from 18 mV in the summer to 560 mV in the fall. The near reducing conditions observed in the summer correspond to the anoxic conditions present in a large portion of the water column recorded at site 1, the dam site. Thermal stratification was evident and anoxic conditions present in three of the four sampling intervals (Figure 27c-27f). In the fall quarter, stratification occurred between 4 and 5 meters at sites 1 and 2, at which point dissolved oxygen (D.O) was below 2.0 mg/L to the lake bottom 8.7 meters. The lake was stratified between 2 and 3 meters below the surface in the spring with oxygen concentrations less than 2.0 mg/L in 20-22% of the water column at the same two sites (Figure 27e). During the summer quarter the lake was strongly thermally stratified between 1 and 2 meters below the surface with dissolved oxygen levels below 1 mg/L for up to 70% water column at site 1 (Figure 27f). According to the Use Support Assessment Protocols (USAP), if the D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With 70% of the water column falling below 2.0 mg/L at site 1 in the summer, the FWP beneficial use is not supported at Cedar Lake. Low dissolved oxygen concentrations in the water column throughout most of the year could pose a threat to fish and wildlife propagation and the lake should be monitored closely in the future. The lake was also sampled for chlorides, and sulfates to assess the Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.48 mg/L at the surface. The TN at the surface ranged from 0.34 mg/L in the spring to 0.84 mg/L in the summer sampling interval. The lake-wide total phosphorus (TP) average was 0.072 mg/L at the surface. The total phosphorus at the surface ranged from 0.019 mg/L to 0.376 mg/L with lower values occurring in the fall quarter. The nitrogen to phosphorus ratio (TN:TP) was 7:1 for sample year 2005-2006. This value is the same as 7:1, characterizing the lake possibly co-limited (Wetzel, 1983).

Cedar Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Cedar Lake is classified as eutrophic, with high levels of primary productivity and nutrient rich conditions (Plate 18). Results were similar to 2004 (TSI=55) indicating no significant increase or decrease in productivity has occurred over time. Water clarity continues to be excellent in comparison to other Oklahoma lakes based on true color, turbidity and high secchi disk depths. The FWP beneficial use is supported as it relates to turbidity with 100% of the recorded values below the WQS of 25 NTU and is not supported for dissolved oxygen concentrations. Anoxic conditions were present in three of the four sampling intervals with approximately 70% of the water column less than 2.0 mg/L during the summer; therefore the FWP use is not supported. Low dissolved oxygen (D.O.) throughout most of the year could pose a threat to fish and wildlife propagation. Cedar Lake was also not supporting the FWP beneficial use with 36% of the pH values less than 6.5 units. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. The Aesthetics beneficial use is considered fully supported based on trophic status and true color.

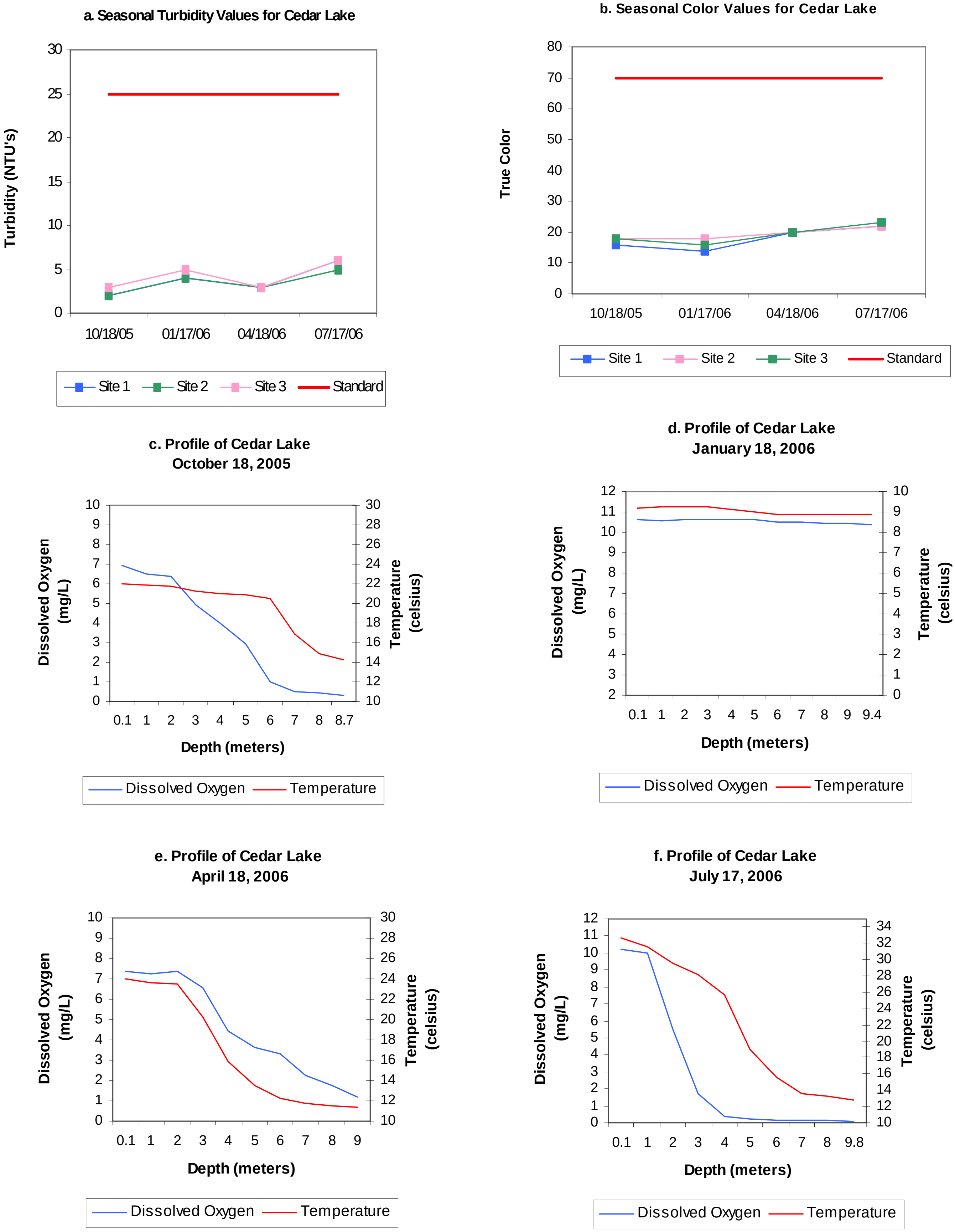
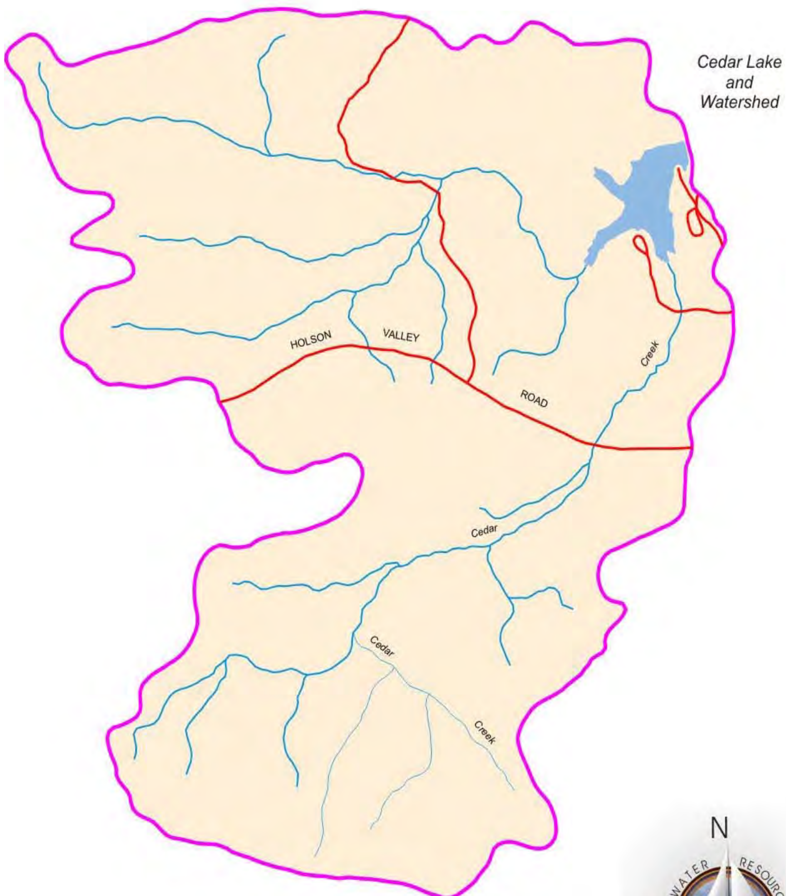


Figure 27a-27f. Graphical representation of data results for Cedar Lake.



Lake Data	
Owner	U.S. Dept. of Agriculture
County	LeFlore
Constructed in	1937
Surface Area	78 acres
Volume	1,000 acre/feet
Shoreline Length	3 miles
Mean Depth	12.82 feet
Watershed Area	9 square miles

Plate 18 - Lake Water Quality for
Cedar Lake

Chandler Lake

Chandler Lake was sampled for four quarters, from September 2004 through June 2005. Water quality samples were collected at three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide annual turbidity value was 11 NTU (Plate 19), true color was 17 units, and secchi disk depth was 87 centimeters in 2005. Water clarity was good based on secchi disk depth, turbidity, and true color values. Compared to values recorded in 2003, results for these parameters are very similar, although secchi disk depth was a little lower than previously reported. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The TSI was 50 (Plate 14), indicating the lake was mesotrophic bordering eutrophic with moderate to high primary productivity and nutrient conditions in sample year 2005. The TSI values throughout the sample year varied seasonally from eutrophic in the fall, mesotrophic in the winter and back to eutrophic during the summer. Seasonal turbidity values are displayed in Figure 28a. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Of the twelve values collected, only 1 (8.3%) exceeded the numerical criteria of 25 NTU. The FWP beneficial use is therefore considered fully supported. Seasonal true color values are displayed in Figure 28b. All true color values collected during the study period were below the aesthetics WQS of 70 units. Applying the same default protocol, Chandler Lake is meeting the Aesthetic beneficial use.

In 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all three sample sites. The salinity ranged from 0.13 parts per thousand (ppt) to 0.29 ppt for this sample year, which falls within the range of values commonly reported for Oklahoma lakes. Specific conductivity ranged from 270.7 µS/cm to 565.1 µS/cm, indicative of moderate levels of ions (chlorides or other salts) present in the system. The pH values at Chandler Lake ranged from 7.14 to 8.56, representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if they fall outside the range of 6.5 to 9.0 for 25% of the values and they waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Chandler Lake is currently supporting its FWP beneficial use based on pH values. Oxidation-reduction potentials (ORP) were positive at all sites and ranged from 49 mV in the fall to 474 mV in the winter. In general, reducing conditions were not present in this reservoir. The low value of 49 was the only value indicative of near reducing conditions and most likely resulted because it was recorded at the lake bottom at the dam site. The lake exhibited strong thermal stratification during the fall quarter with approximately half the water column below 2.0 mg/L (Figure 28c). During the winter and spring quarters (see Figure 28d-28e) the lake was well mixed with dissolved oxygen (D.O.) concentrations above 7.0 mg/L throughout the lake. During the summer quarter the lake exhibited thermal stratification between 3 and 4 meters and again between 5 and 6 meters at which point the dissolved oxygen dropped below 1 mg/L for the remainder of the water column. If the D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70 % of the water column, the FWP beneficial use is deemed partially supported. With approximately 38% of the water column experiencing anoxic conditions at site 1, the FWP beneficial use is considered supported at Chandler Lake. The lake was also sampled for total dissolved solids, chlorides, and sulfates to assess the Agriculture beneficial use. Sampling 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the study period, therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.68mg/L at the surface. The TN at the surface ranged from 0.49 mg/L in the summer to 0.88 mg/L in the fall. The lake-wide total phosphorus (TP) average was 0.035 mg/L at the surface. The total phosphorus at the surfaced ranged from 0.023 mg/L to 0.053 mg/L with lower values occurring in the summer quarter. The nitrogen to phosphorus ration (TN:TP) was 20:1 for sample year 2004-2005. This value is much higher than 7:l, characterizing the lake as phosphorus limited (Wetzel, 1983).

In summary, Chandler Lake was classified as mesotrophic bordering eutrophic, indicative of moderate primary productivity and nutrient conditions (Plate 19). Water clarity was good based on turbidity, true color and secchi disk depth and results were similar to those observed in 2003. The lake is supporting the FWP beneficial use based on pH and turbidity, dissolved oxygen levels. The Aesthetics beneficial use is also being met by both the trophic status and true color concentrations. An assessment of the PBCR cannot be at this time as bacteria samples were not collected during the study period. Chandler Lake is located in Lincoln County and is owned by the city of Chandler. Constructed in 1954 it serves as the city's municipal water supply and is also utilized for recreation.

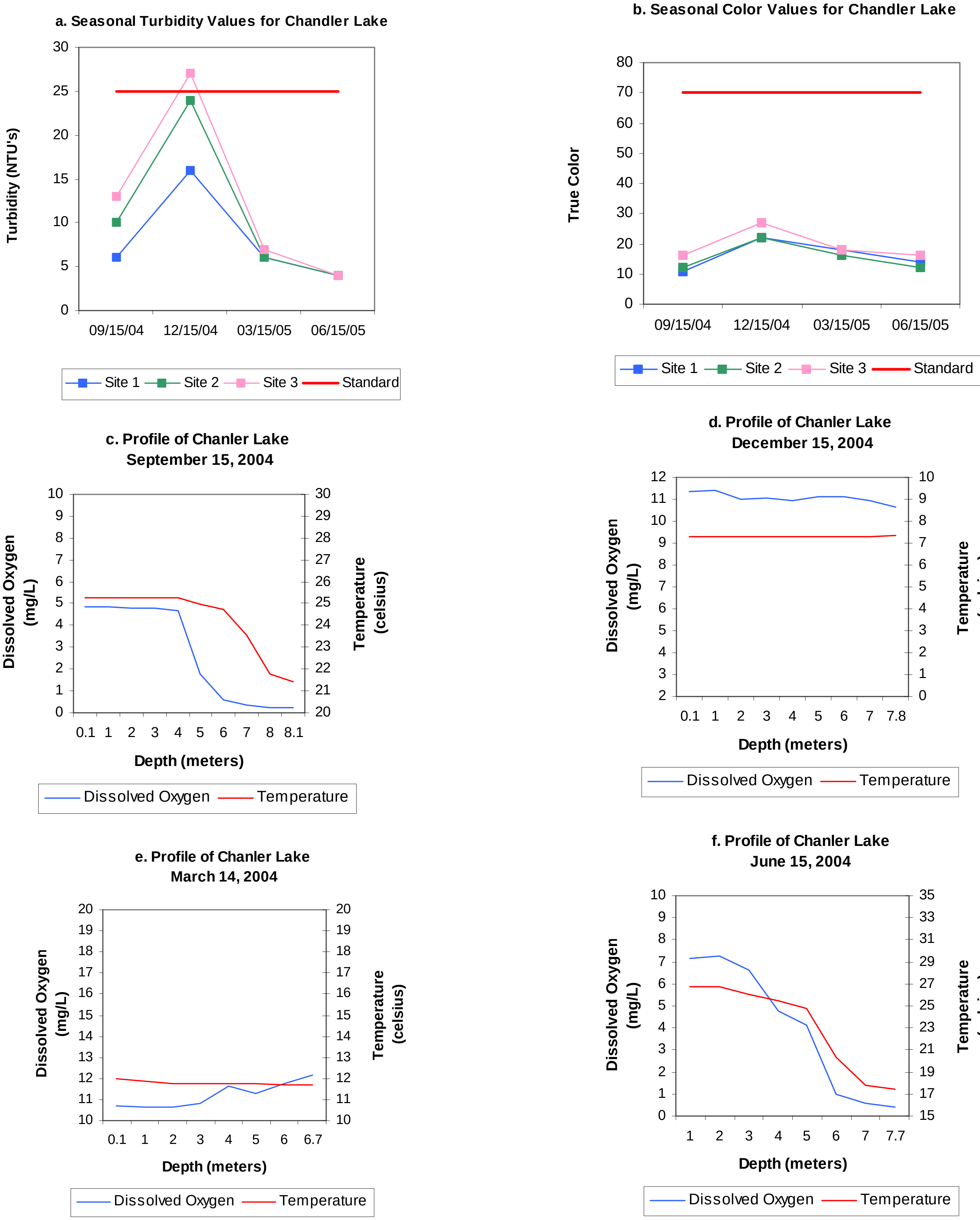
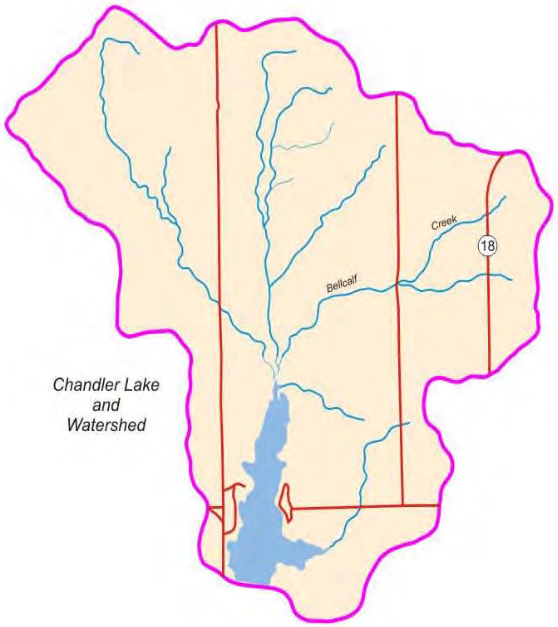


Figure 28a-28f. Graphical representation of data results for Chandler Lake.

Plate 19 - Lake Water Quality for
Chandler Lake



Lake Data	
Owner	City of Chandler
County	Lincoln
Constructed in	1954
Surface Area	129 acres
Volume	2,778 acre/feet
Shoreline Length	4 miles
Mean Depth	21.53
Watershed Area	3,403 acres

LAKES MONITORING PROGRAM

Lake Chickasha

Lake Chickasha is an 820-acre reservoir located in Caddo County. The lake owned by the city of Chickasha and serves as a municipal water supply as well as a recreational reservoir. Lake Chickasha was sampled for four quarters, from November 2006 through July 2007.

Water quality samples were collected at five (5) sites to represent the lacustrine, transition and riverine zones of the reservoir. Samples were collected at the lake surface at all sites during the study period. The average lake-wide turbidity was 10 NTU (Plate 15), true color was 23 units, and annual average secchi disk depth was 64 centimeters. Based on these three parameters water clarity was good at Lake Chickasha in sample year 2007. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The result was a TSI of 62, indicating the lake was hypereutrophic with excessive primary productivity and nutrient levels in sample year 2006-2007. Although this value is slightly less than that calculated in 2005 (TSI=66), the trophic category is the same. The TSI values were consistent throughout the year with upper eutrophic conditions occurring in the winter and hypereutrophic conditions the remainder of the year. Based on the trophic classification, the lake is currently listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Seasonal turbidity values ranged from a low of 8 NTU to a maximum of 14 NTU and are displayed in Figure 29a. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. With 100% of the turbidity below 25 NTU the lake is fully supporting the FWP beneficial use. Seasonal true color values were all well below the WQS of 70 units and are displayed in Figure 29b. Applying the same default protocol, Lake Chickasha is meeting the Aesthetic beneficial use as it relates to true color.

In 2007, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential and salinity were recorded at all five sample sites. The salinity ranged from 1.01 parts per thousand (ppt) to 2.11 ppt for this sample year. Specific conductivity ranged from 1884 µS/cm to 3872 µS/cm, which is higher than most Oklahoma reservoirs. These values indicate the presence of high levels of electrical current conducting compounds (salts) in the lake, consistent with the elevated salinity concentrations. The pH values at Lake Chickasha ranged from 7.02 to 8.30, representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if they fall outside the range of 6.5 to 9.0 for 25% of the values and they waterbody should be listed as not supporting its FWP beneficial use. With all recorded values within the acceptable range, Lake Chickasha is currently supporting its FWP beneficial use based on pH values. Oxidation-reduction potentials (ORP) ranged from -141 mV in the hypolimnion in the summer to 498 mV in the winter sampling interval. Low redox conditions are not unusual when anoxic conditions are present in a large portion of the water column. The lake was not stratified during the first two sampling quarters (see Figure 29c-29d) and dissolved oxygen (D.O.) levels were generally above 6.0 mg/L. In the spring the lake experienced some anoxia with dissolved oxygen only dropping below 2 mg/L near the lake bottom. The near absence of stratification during much of the year may be attributed to the shallow nature of this reservoir where wind and wave action keep the lake well mixed. Lake Chickasha was stratified and anoxic conditions were present in a large portion of the water column during the summer sampling interval. All sample sites exhibited stratification to varying degrees with anoxic conditions present in 43% (site 2) to 57% (site 3) of the water column. If the D.O. values are less than 2.0 mg/L for greater than 70% of the water column the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70 % of the water column, the FWP beneficial use is deemed partially supported. With up to 57% (Figure 29f) of the water column below 2.0 mg/L during the summer quarter, the FWP beneficial use is considered partially supported at Lake Chickasha for this sample year. The lake was also sampled for total dissolved solids, chlorides and sulfates to assess the Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supporting for total dissolved solids and chlorides but not supporting for sulfates based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September 2007. The PBCR beneficial use cannot be determined as minimum data requirements were not met due to quality control issues for enteroccocci. Of the 10 *E.coli* and fecal coliform samples collected, all were below both the prescribed screening level and the geometric mean.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 2.53 mg/L at the surface. The TN at the surface ranged from 1.61 mg/L in the summer to 3.72 mg/L in the winter. The lake-wide total phosphorus (TP) average was 0.034 mg/L at the surface. The total phosphorus at the surface ranged from 0.016 mg/L to 0.082 mg/L with lower values also occurring in the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was 73:1 for sample year 2007. This value is much higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

Lake Chickasha was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Lake Chickasha continues to be classified as hypereutrophic, indicative of excessive primary productivity and nutrient rich conditions. Water clarity was good based on turbidity, true color and secchi disk depth. The lake is supporting the FWP beneficial use based on pH and turbidity. With up to 57% of the water column experiencing anoxic conditions during the summer sampling interval, the FWP beneficial use is considered partially supported as it relates to dissolved oxygen. The Aesthetics beneficial use is being met in regards to color with 100% of the true color values below the WQS of 70 units. However, the lake is currently listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. The PBCR beneficial use is considered supported based on *E. coli* and fecal coliform however due to minmum data requirements not being met for enterococci and assessment of this parameter cannot be made.
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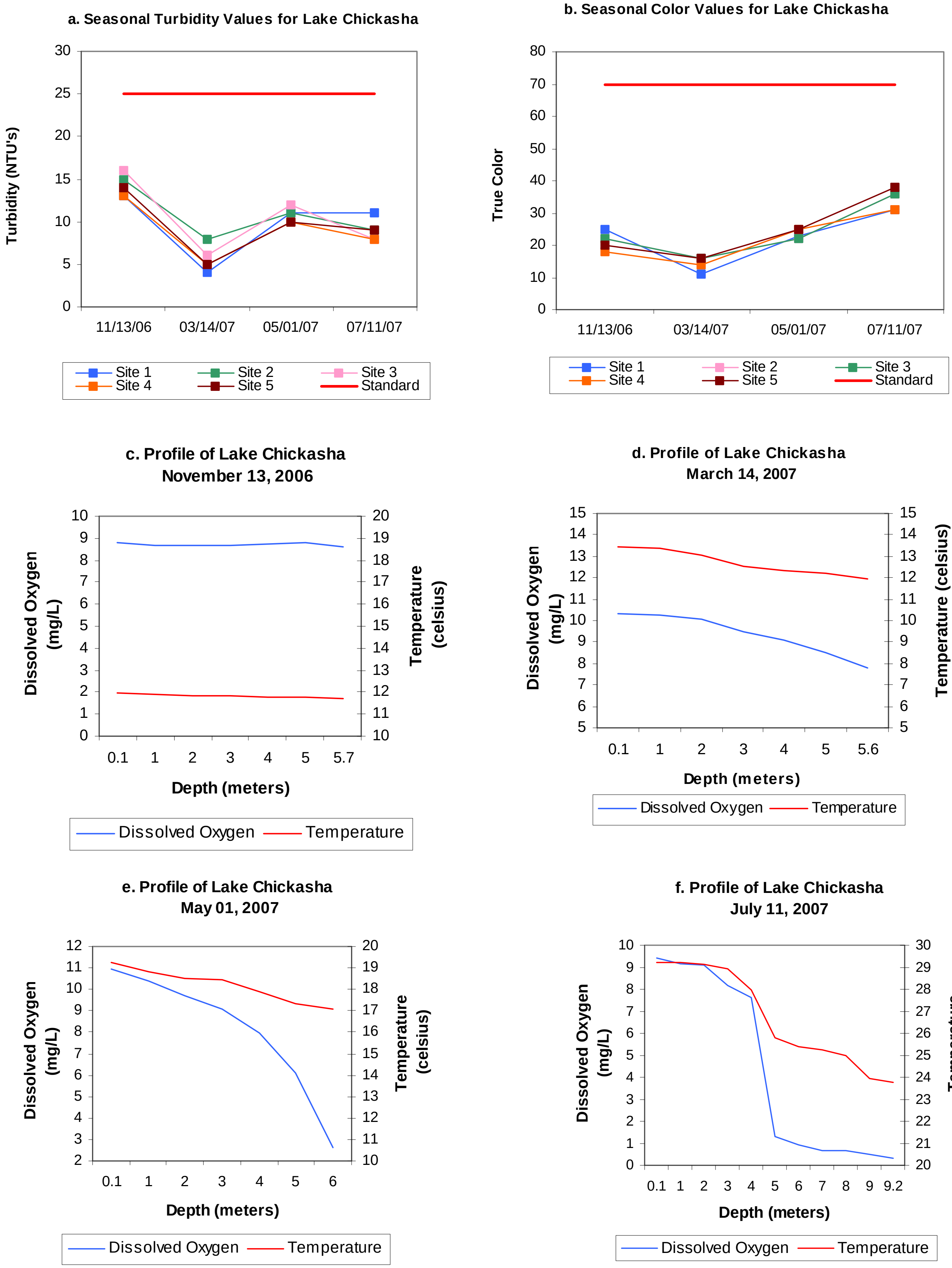
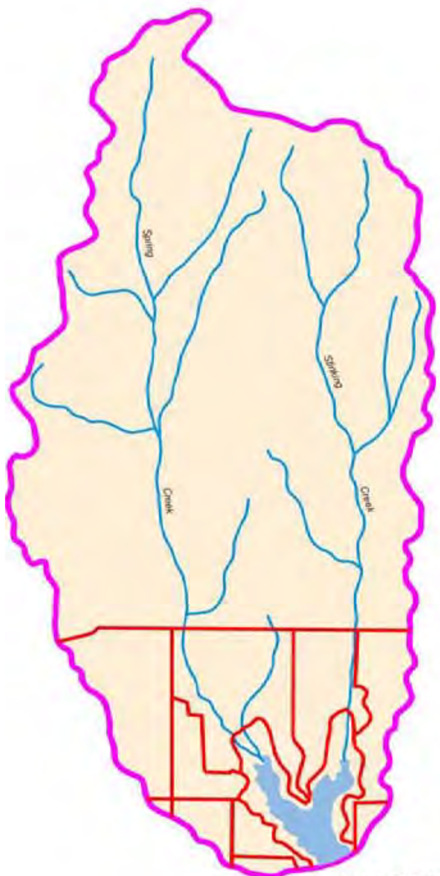


Figure 29a-29f. Graphical representation of data results for Lake Chickasha.



Lake Chickasha and Watershed

Lake Chickasha Location

Trophic State 2007

Turbidity 2007

Lake Data	
Owner	City of Chickasha
County	Caddo
Constructed in	1958
Surface Area	820 acres
Volume	41,080 acre/feet
Shoreline Length	10 miles
Mean Depth	50.10 feet
Watershed Area	74 square miles

N W E S

Plate 20 - Lake Water Quality for
Lake Chickasha

LAKES MONITORING PROGRAM

Claremore Lake

Claremore Lake, located in Rogers County, is the municipal water supply reservoir for the City of Claremore and is owned and operated by the city. The lake was constructed in 1930 and also provides recreational opportunities for the public. Claremore Lake was sampled for three quarters from November 2005 through August 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. All water samples were collected from the lake surface during the study period. The lake-wide annual turbidity value was 19 NTU (Plate 21), true color was 24 units, and secchi disk depth was 41 centimeters in 2005-2006. Based on these three parameters, Claremore Lake had average to good water clarity in comparison to other Oklahoma reservoirs. These findings are similar to those observed in 2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for three quarters (n=15). Due to low lake levels the lake was closed and OWRB staff were unable to collect data during the winter sampling interval. The calculated TSI was 67 (Plate 21), indicating the lake was hypereutrophic during the study period. The TSI values throughout the sample year were consistently in the hypereutrophic range. These results are consistent with historical data collection efforts on the lake, which also found the lake to be hypereutrophic in nature. The lake is currently listed as a Nutrient Limited Watershed (NLW) in the Oklahoma Water Quality Standards (WQS) and is considered nutrient threatened. Seasonal turbidity values are displayed in Figure 30a. According to the Use Support Assessment Protocols (USAP) specified in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Although 2 (13%) of the 15 turbidity values recorded exceeded the water quality standard of 25 NTU, an assessment of the Fish & Wildlife Propagation (FWP) beneficial use based on turbidity cannot be made at this time as minimum data requirements were not met for this sample year. Seasonal true color values are displayed in Figure 30b. Although none of values exceeded the standard of 70 units, the minimum data requirements were not met and a definitive assessment of beneficial uses cannot be made.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. The salinity concentrations at Claremore Lake ranged from 0.11 parts per thousand (ppt) to 0.12 ppt. This is well within the range of expected values for Oklahoma lakes, reflecting the minimal presence of chlorides or other salts in the lake. Specific conductivity values were also well within the expected range for Oklahoma reservoirs, indicating minimal presence of electrical current conducting compounds like salts. Specific conductivity values ranged from 242.0 µS/cm in the spring quarter to 257.4 µS/cm recorded in the fall quarter. The pH values at Claremore Lake were neutral to slightly alkaline ranging from 7.03 to 8.10 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of collected values within the acceptable range Claremore Lake is meeting its FWP beneficial use for pH. Oxidation-reduction potentials (redox) ranged from 252 mV to 454 mV with both the high and low recorded in the spring quarter, which indicated an absence of reducing conditions. The lake was not thermally stratified in the fall and dissolved oxygen levels remained well above 5 mg/L (Figure 30c). In the spring quarter the lake was weakly stratified with anoxic conditions present only in the bottom of the water column (See Figure 30d). Due to low lake levels in the winter and a Hydrolab malfunction in the summer quarter, profile data is unavailable for assessment. When D.O. values are less than 2 .0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, Claremore Lake is fully supporting its FWP beneficial use based on the available information with 29% of the water column less than 2.0 mg/L. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.23 mg/L at the lake surface during the study period. The TN at the surface ranged from 0.91 mg/L to 2.00 mg/L. The highest surface TN value was reported in the summer quarter and the lowest was in the fall quarter. The lake-wide total phosphorus (TP) average was 0.103 mg/L at the lake surface. The TP ranged from 0.072 mg/L to 0.193 mg/L at the lake surface. Similar to TN, the highest surface TP values were reported in the summer quarter however the lowest were in the spring quarter. The nitrogen to phosphorus ratio (TN:TP) was 12:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Claremore Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Claremore Lake was classified as hypereutrophic, indicative of excessive primary productivity and nutrient levels (Plate 21). This finding is consistent with historical data collection efforts in 2004 (TSI=61). Currently, the lake is listed in the WQS as a NLW indicating that the Aesthetics beneficial use is considered threatened by nutrients until studies can be conducted to confirm non-support status. The Aesthetics beneficial use is considered undetermined for the current sample year as it relates to true color due to insufficient data. Based on available data Claremore Lake is fully supporting the FWP beneficial use based on pH and dissolved oxygen levels. Although 2 (13%) of the 15 turbidity values recorded exceeded the water quality standard of 25 NTU, an assessment of the Fish & Wildlife Propagation (FWP) beneficial use based on turbidity cannot be made at this time as minimum data requirements have not met for this sample year. The PBCR beneficial use is considered fully supported for sample year 2005-2006 as all sample results were below both the screening level and geometric mean.

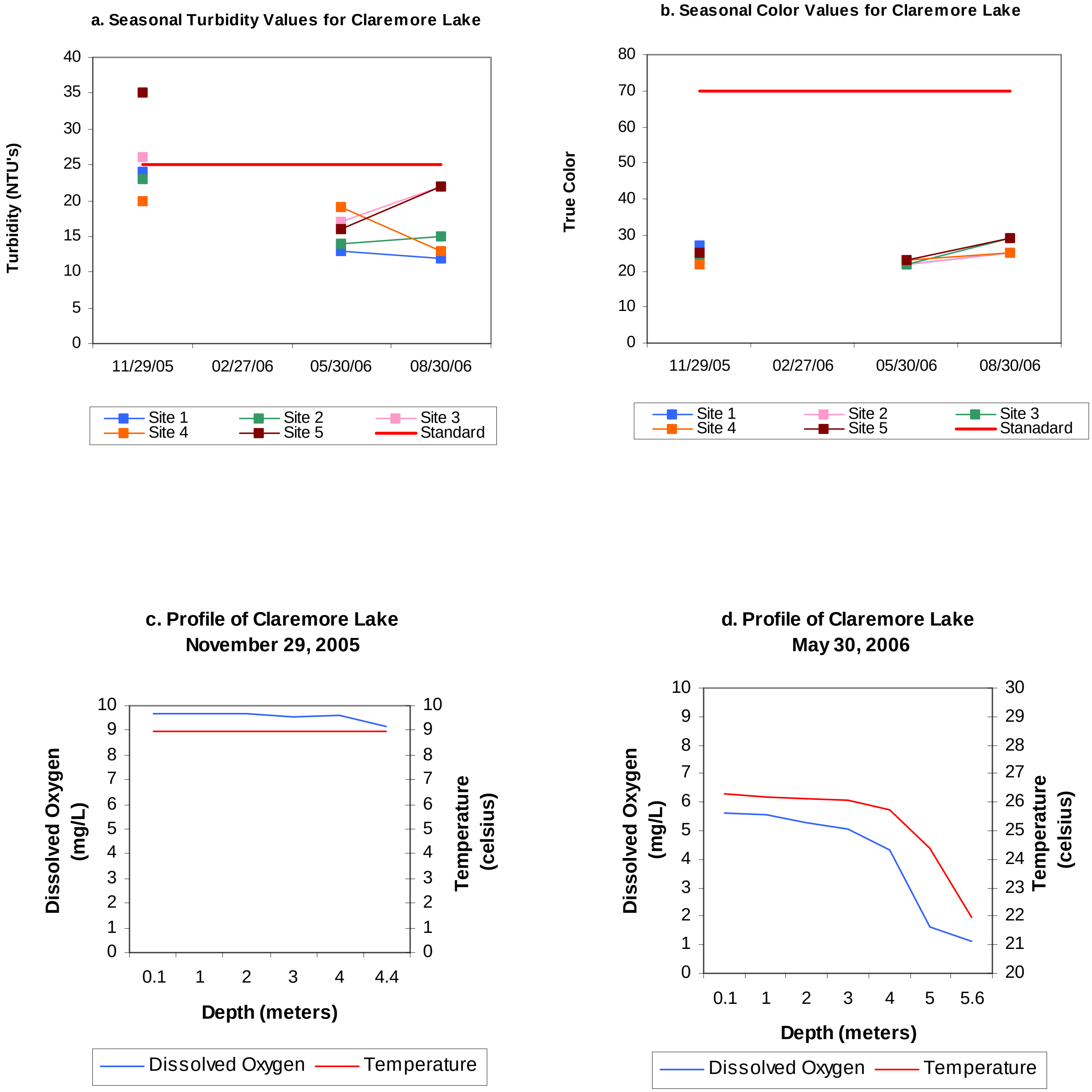
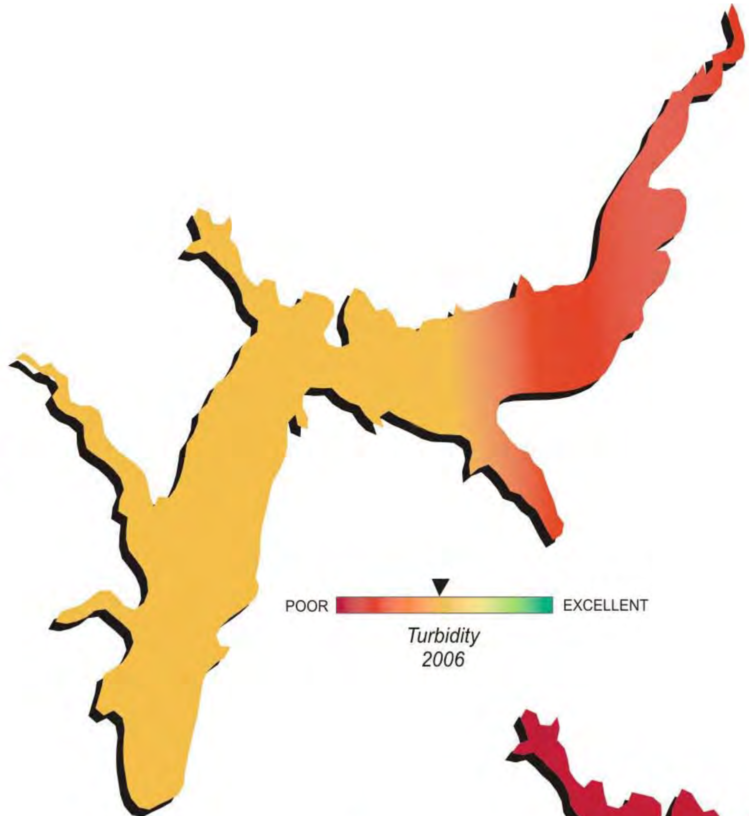
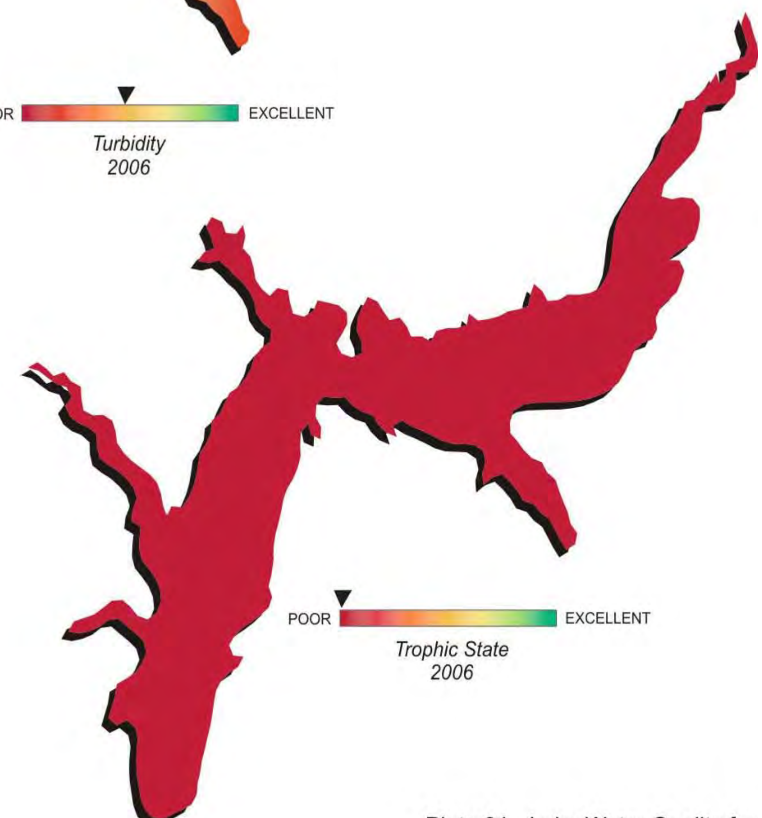


Figure 30a-30d. Graphical Representation of data results for Claremore Lake.

Claremore Lake and Watershed

Claremore Lake Location





Lake Data

Owner	City of Claremore
County	Rogers
Constructed in	1930
Surface Area	470 acres
Volume	7,900 acre/feet
Shoreline Length	9 miles
Mean Depth	16.81 feet
Watershed Area	57 square miles

Plate 21 - Lake Water Quality for

Claremore Lake

Clear Creek Lake

Clear Creek Lake, located in Stephens County, serves as a municipal water supply as well as a recreational reservoir for the city of Duncan. Clear Creek Lake was sampled for four quarters, from November 2006 through August 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 12 NTU (Plate 22), true color was 32 units, and secchi disk depth was 70 centimeters in 2007. Based on these three parameters, Clear Creek Lake had average water clarity. Color values and secchi disk depths values differ from those observed in 2005 and are likely the result of excessive rainfall that occurred during the spring and summer sampling intervals. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI was 58, indicating the lake was eutrophic with high primary productivity and nutrient conditions in sample year 2007. The TSI values varied throughout the sample year ranging from mesotrophic in the winter to eutrophic in both the fall and summer and mesotrophic during the summer quarter. Turbidity values for the sample year are displayed in Figure 31a. Turbidity values collected throughout all four sampling intervals were generally well below the Oklahoma Water Quality Standard (WQS) of 25 NTU. The only exception occurred during the month of August at site 3, in the upper end of the reservoir, when a value of 25 NTU was recorded. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if $\geq$ 25% of the samples exceed the WQS of 25 NTU. With only 1 of the values equal to 25 NTU, the Fish and Wildlife Propagation (FWP) beneficial use is considered supported based on turbidity. Seasonal true color values are displayed in Figure 31b. All color values were well below the WQS of 70 units in the first three sampling intervals with a peak occurring during summer sampling. Available flow and rainfall data suggest that the peak in true color, which occurred in August is likely due to seasonal storm events, therefore Clear Creek Lake will be listed as supporting its Aesthetics beneficial use.

In 2006-2007 vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential and salinity were recorded at all five sample sites. The salinity ranged from 0.22 parts per thousand (ppt) to 0.40 ppt for this sample year. Specific conductivity ranged from 441.1 µS/cm to 771 µS/cm, which is higher than most Oklahoma reservoirs. These values indicate the presence of moderate levels of current conducting compounds (salts) in the lake, consistent with recorded salinity concentrations. The pH values at Clear Creek Lake ranged from 7.21 to 8.34, representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. With 100% of collected values within the acceptable range Clear Creek Lake is meeting its FWP beneficial use based on pH. Oxidation-reduction potentials (ORP) were ranged from -109 mV in the hypolimnion during the summer to 443 mV in the fall quarter. Low redox values are not uncommon when anoxic conditions are present in a large portion of the water column. The lake was well mixed and dissolved oxygen (D.O.) concentrations were generally above 7.0g/L in the first three sampling intervals (see Figure 31c-31e). Thermal stratification and anoxic conditions were evident in the summer sampling interval. Stratification occurred at several 1-meter intervals throughout the water column with dissolved oxygen levels dropping below 2.0 mg/L from 7 meters to the lake bottom of 9.4 meters. If the D.O. values are less than 2.0 mg/L for greater than 70% of the water column the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70 % of the water column, the FWP beneficial use is deemed partially supported. With 36% of the water column below 2.0 mg/L during the summer, the FWP beneficial use is considered supported at Clear Creek Lake. The lake was also sampled for total dissolved solids, chlorides and sulfates to assess the Agriculture beneficial use. Sampling 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September 2007. The PBCR beneficial use cannot be determined as minimum data requirements were not met due to quality control issues for *E.coli*. Of the 10 enterococci and fecal coliform samples collected, all were below both the prescribed screening level and the geometric mean.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.81 mg/L at the surface. The TN at the surface ranged from 0.66 mg/L in the spring to 0.96 mg/L in the winter quarter. The lake-wide total phosphorus (TP) average was 0.032 mg/L at the surface. The total phosphorus at the surface ranged from 0.020 mg/L to 0.059 mg/L. The lowest TP values were recorded in the winter with higher values reported in the spring quarter. The nitrogen to phosphorus ration (TN:TP) was 25:1 for sample year 2004-2005. This value is much higher than 7:I, characterizing the lake as phosphorus limited (Wetzel, 1983).

Clear Creek Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Clear Creek Lake was classified as eutrophic, indicative of high primary productivity and nutrient conditions (Plate 22). This classification differs from both the 2003 and 2005 evaluations, which had an annual TSI of 48, placing the lake in the mesotrophic category. The lake should be studied further to determine if a change in productivity has occurred. Water clarity was average based on turbidity, true color and secchi disk depth. The lake is fully supporting the FWP beneficial use based on pH and turbidity. Although anoxic conditions were present in 36% of the water column, the FWP beneficial use is still considered supported as it relates to dissolved oxygen concentrations. The Aesthetics beneficial use is supported based on trophic status and true color values. Although 25% of the color values were greater than the WQS of 70 units, this is likely due to seasonal storm events therefore the beneficial use is still considered supported at this time. The PBCR is considered supported for enterococci and fecal coliform; however due to minmum data requirements not being met for E.coli an assessment of this parameter cannot be made.

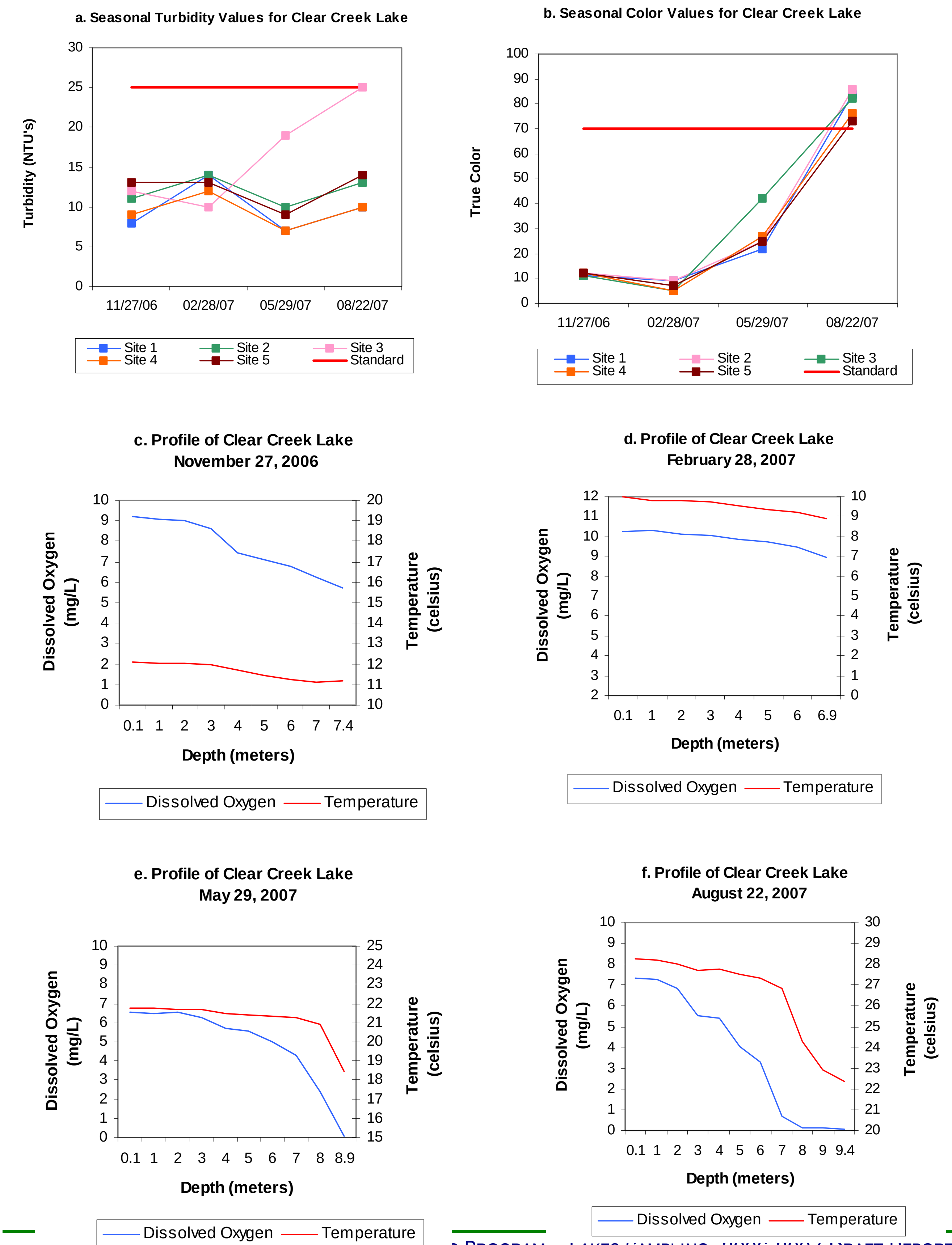
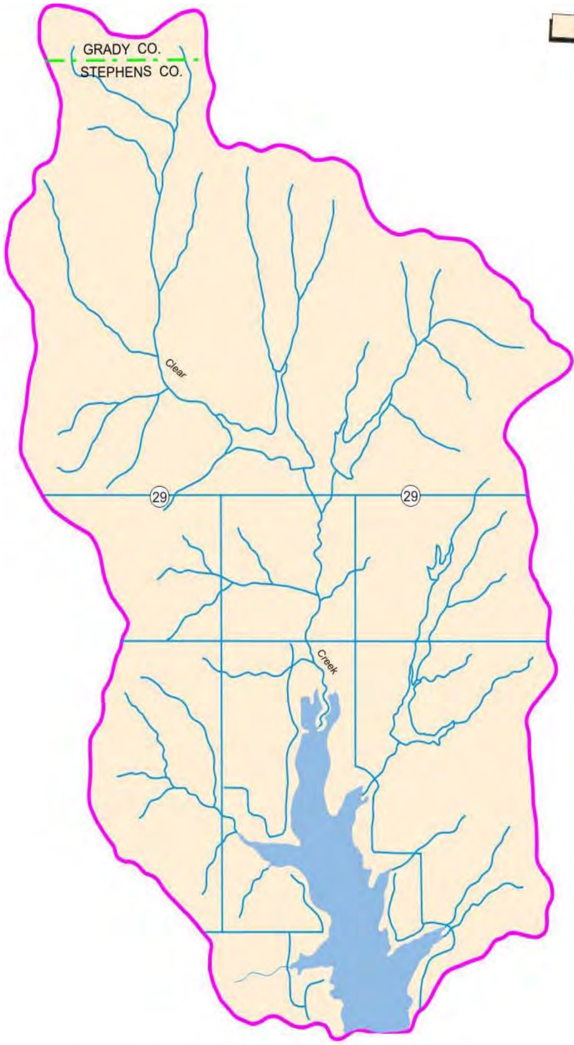


Figure 31a-31f. Graphical representation of data results for Clear Creek Lake.



Clear Creek Lake and Watershed

Clear Creek Lake Location

Lake Data	
Owner	City of Duncan
County	Stephens
Constructed in	1948
Surface Area	722 acres
Volume	7,710 acre/feet
Shoreline Length	11 miles
Mean Depth	10.68 feet
Watershed Area	20 square miles

Turbidity 2007

Trophic State 2007

Plate 22 - Lake Water Quality for

Clear Creek Lake

LAKES MONITORING PROGRAM

Cleveland City Lake

Cleveland City Lake is a 159-acre reservoir, which is owned and operated by the City of Cleveland. The lake serves as the municipal water supply reservoir for the city and is also utilized for recreation purposes. Cleveland City Lake was sampled for four quarters, from November 2006 through August 2007.

Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the surface at all sites during the sample year. The lake-wide annual turbidity value was 17 NTU (Plate 23), true color was 63 units, and secchi disk depth was 56 centimeters. Based on these three parameters, Cleveland City Lake had moderate to fair water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average calculated TSI was 56, indicating the lake was eutrophic with high levels of primary productivity and nutrients conditions. The TSI values throughout the sample year varied seasonally from upper mesotrophic in the winter to upper eutrophic the remainder of the year. Seasonal turbidity values ranged from a low of 12 NTU to a maximum of 32 NTU. Of the twelve values collected, only one (8%) was above the turbidity standard of 25 NTU (see Figure 32a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). The Fish and Wildlife Propagation (FWP) beneficial use is considered supported based on turbidity. Seasonal true color values are displayed in Figure 32b. A peak in true color occurred in the spring quarter, accounting for 25% of the true color values to be exceeding the WQS of 70 units. This increase is likely the result of seasonal storm events and the Aesthetics beneficial use is considered supported at Cleveland City Lake.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity values ranged from 0.08 parts per thousand (ppt) to 0.11 ppt. This is well within the range of expected values for Oklahoma lakes, reflecting the minimal presence of chlorides or other other analogous material in the lake. Specific conductivity values were also well within the expected range for Oklahoma reservoirs, coinciding with the low salinity concentrations. Specific Conductivity values ranged from 173.3 µS/cm in the spring to 235 µS/cm in the winter. Oxidation-reduction potentials (redox) ranged from 82 mV in the summer quarter to 438 mV in the fall season, indicating reducing conditions were not present in the lake during the study period. The pH values indicated that the lake was neutral to slightly alkaline with values ranging from 6.93 to 8.64 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. With 100% of collected values within the acceptable range Cleveland City Lake is meeting its FWP beneficial use based on pH. The lake was not thermally stratified and the water column appeared to be well mixed during the fall and winter months (see Figure 32c-32d). Thermal stratification and anoxic conditions were present in both spring and summer sampling intervals. In the spring quarter the lake was stratified with anoxic conditions present for 70% of the water column (Figure 32e) at the dam site. In the summer, the lake was strongly thermally stratified between 2 and 3 meters from the lake surface. Below this point, the D.O. concentrations fell below 2.0 mg/L all the way to the lake bottom at 5.7 meters (see Figure 32f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With 70% of the water column of Cleveland Lake being less than 2.0 mg/L in the spring, the lake is listed as not supporting its FWP beneficial use. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September 2007. The PBCR beneficial use is considered supported as no screening level or geometric mean was exceeded.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.01 mg/L at the lake surface. The TN at the surface ranged from 0.85 mg/L to 1.24 mg/L. The highest surface TN value was reported in the fall quarter and the lowest was in the summer quarter. The lake-wide total phosphorus (TP) average was 0.034 mg/L at the lake surface. The TP ranged from 0.021 mg/l to 0.050 mg/L. The highest surface TP values were reported in the summer quarter and the lowest were seen in the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was 30:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Cleveland City Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Cleveland City Lake was classified as eutrophic, indicative of high primary productivity and nutrient rich conditions. Water clarity was moderate to fair in this reservoir when compared to other Oklahoma reservoirs. The lake is considered fully supporting its Aesthetics beneficial based on and trophic state (for nutrients). Of the true color values collected, 25% were above the standard of 70 units; however available flow and rainfall data suggest the elevated readings are likely the result of storm events and the lake will be listed as supporting its Fish & Wildlife Propagation (FWP) beneficial use as it relates to turbidity. Cleveland City Lake is fully supporting its FWP beneficial use based on pH and turbidity; however the use is not supported based on anoxic conditions present in 70% of the water column during the spring sampling interval. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. The PBCR beneficial is considered supported for the current sample year.

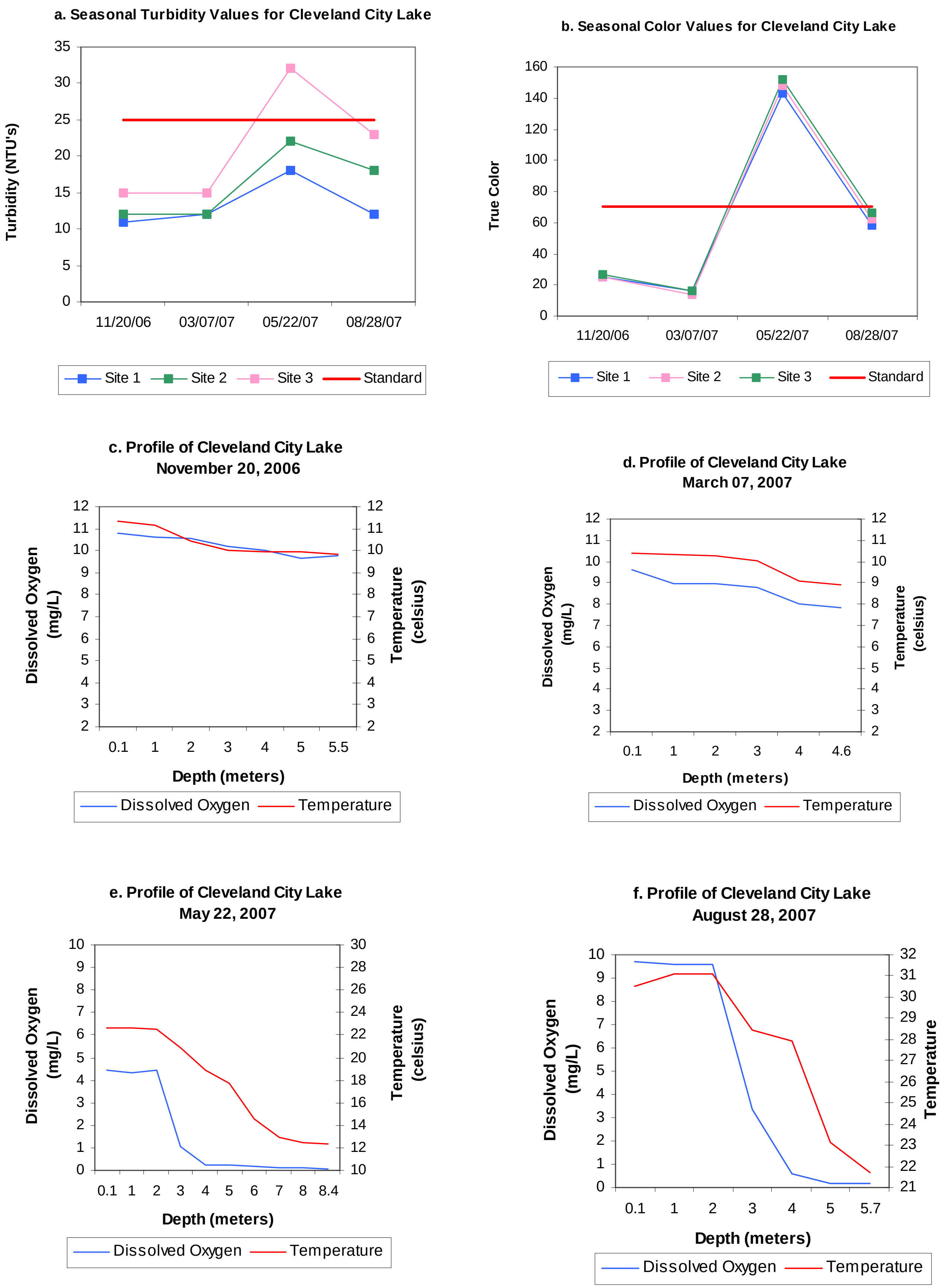
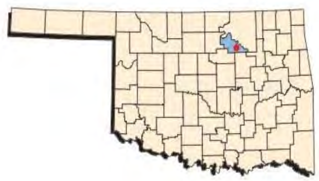
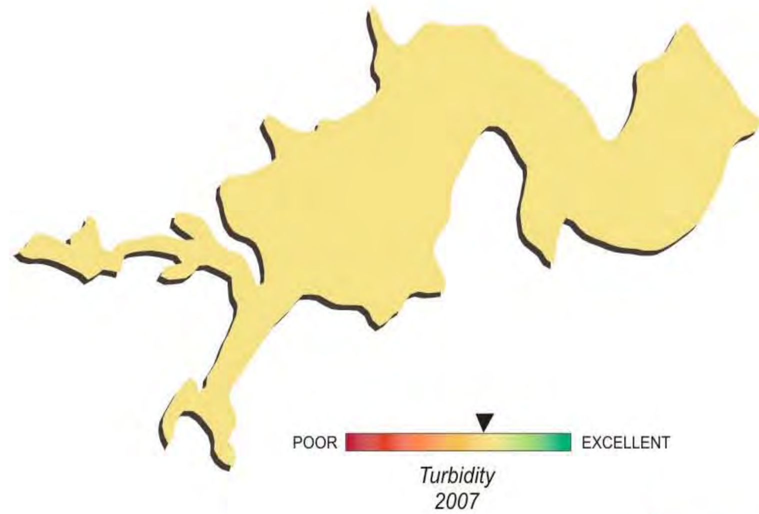
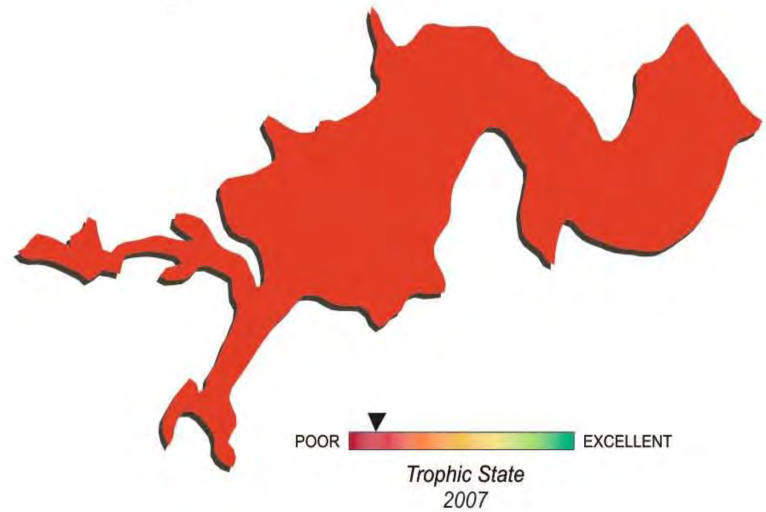


Figure 32a-32f. Graphical representation of data results for Cleveland City Lake.

Plate 23 - Lake Water Quality for
Cleveland Lake







Lake Data

Owner	City of Cleveland
County	Pawnee
Constructed in	1936
Surface Area	159 acres
Volume	2,200 acre/feet
Shoreline Length	5 miles
Mean Depth	13.84 feet
Watershed Area	22 square miles

Clinton Lake

Clinton Lake was sampled for four quarters, from October 2003 through July 2004. Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the surface at all sites and an additional sample was collected at 0.5 meters from the lake bottom at sample site 1, the dam. The lake-wide annual turbidity value was 67 NTU (Plate 24), true color was 36 units, and secchi disk depth was 23 centimeters. Based on these three parameters, Clinton Lake had poor water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 66 (Plate 24), indicating the lake was hypereutrophic in nature, with high to excessive levels of productivity and nutrients. The TSI values fluctuated very little based on the season and sample site, never varying from upper eutrophy to hypereutrophic at all sites. Based on the trophic classification, the lake will be recommended for listing in the next Oklahoma Water Quality Standards (WQS) revision process as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Turbidity values per site were generally above the Oklahoma Water Quality Standard (WQS) of 25 NTU for all seasons with 80% of the collected data exceeding the WQS (see Figure 33a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting its FWP beneficial use. The lake-wide annual turbidity of 67 NTU was representative of conditions at Clinton Lake in 2003-2004 and consistent with historical findings. Clinton Lake is currently not meeting its Fish & Wildlife Propagation (FWP) beneficial use due to high turbidity values. The system should be further examined to determine if the high turbidity present is due to natural conditions. Seasonal true color values are displayed in (Figure 33b). Of the 12 values collected, three (15%) exceeded the numeric criteria of 70 units. Applying the same default protocol, the Aesthetics use is partially supported.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity values ranged from 0.23 parts per thousand (ppt) to 0.33ppt, which slightly higher than the range of values observed in most Oklahoma lakes. Reflecting moderate levels of chlorides or other salts in the lake. Specific conductivity values were also slightly higher than most Oklahoma reservoirs, with values ranging from 460.4 µS/cm in the summer to 642.9 µS/cm in the fall. Oxidation-reduction potentials ranged from 149 mV to 534 mV, indicating reducing conditions were not present in the lake. The pH was neutral to slightly alkaline with values ranging from 8.0 to 8.74 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if they fall outside the range of 6.5 to 9.0 for 25% of the values and they waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Based on pH values collected Clinton Lake is currently supporting its FWP beneficial use. The lake was not thermally stratified and the water column appeared to be well mixed throughout all four quarters, this can be attributed to the shallow nature of the lake and limited shoreline structure to prevent wind-mixing of the lake (see Figure 33c-33f). Dissolved oxygen (D.O.) values remained above 4.0 mg/L and the D.O. percent saturation was never less than 50% in any of the sample quarters except at the very bottom of the lake. The FWP beneficial use is fully supported based on D.O. concentrations. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2003-2004 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. Of the 10 enterococci samples collected five (5) or 50% exceeded the prescribed screening level of 61 cfu/ml and the geometric mean (42.3 cfu/ml) exceed the prescribed mean standard of 33 cfu/ml. The PBCR beneficial use is therefore considered not supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.94 mg/L at the surface and 1.80mg/L at the lake bottom. The TN at the surface ranged from 1.36 mg/L to 3.06 mg/L, which is higher than generally seen in Oklahoma lakes. The highest surface TN value was reported in the summer quarter and the lowest was in the spring quarter. The lake-wide total phosphorus (TP) average was 0.152 mg/L at the surface and 0.157 mg/L at the lake bottom. The TP ranged from 0.089 mg/L to 0.244 mg/L at the lake surface. The highest surface TP values were reported in the fall quarter and the lowest were in the spring quarter. Nitrogen values in Clinton Lake were higher than normally seen in most Oklahoma Lakes. The nitrogen to phosphorus ratio (TN:TP) was approximately 13:1 for sample year 2003-2004. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

In summary, Clinton Lake was classified as hypereutrophic, indicative of high to excessive primary productivity and nutrient levels (Plate 24). The lake will be recommended for listing as an NLW in the next WQS revision process and its Aesthetics beneficial use is considered nutrient threatened. Based on reported true color values the Aesthetics use is partially supported at Clinton Lake. D.O. and pH values were fully supporting the FWP beneficial use, however the Lake was not meeting its FWP beneficial use due to high turbidity values. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Of the 10 enterococci samples collected five (5) or 50% exceeded the prescribed screening level of 61 cfu/ml and the geometric mean (42.3 cfu/ml) exceed the prescribed mean standard of 33 cfu/ml. The PBCR beneficial use is therefore considered not supported. Clinton Lake is one of the municipal water supply reservoirs for the City of Clinton and is utilized for recreation purposes. The lake was constructed in 1931 and is owned by the City of Clinton.

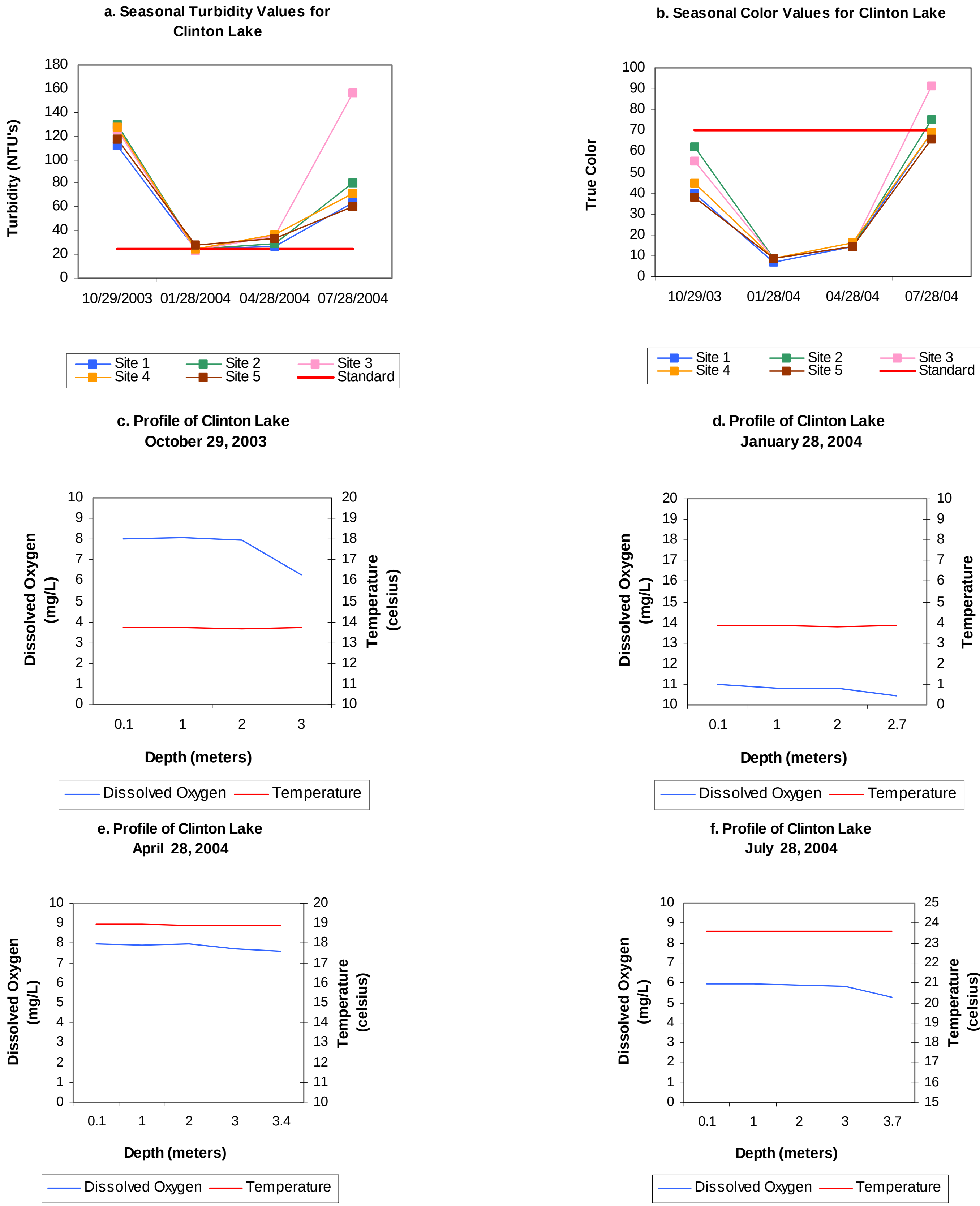


Figure 33a-33f. Graphical representation of data results for Clinton Lake.

Plate 24- Lake Water Quality for Clinton Lake

Lake Data	
Owner	City Clinton
County	Washita
Constructed	1931
Surface Area	335 acres
Volume	3,980 acre/feet
Shoreline Length	5 miles
Mean Depth	11.88 feet
Watershed Area	27 square miles

Coalgate City Lake

Coalgate City Lake (352-acres) is the municipal water supply reservoir for the City of Coalgate and is owned and operated by the city. The lake is also utilized for recreational and flood control purposes. Coalgate City Lake was sampled for four quarters, from October 2006 through July 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. All samples were collected at the lake surface during the study period. The lake-wide annual turbidity value was 92 nephelometric turbidity units (NTU) (Plate 25), true color was 249 units, and secchi disk depth was 26 centimeters. Based on these three parameters, Coalgate City Lake had poor water clarity in comparison to other Oklahoma reservoirs. Values reported during this evaluation are similar with previous data collection efforts in 2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 47, indicating the lake was mesotrophic, with moderate levels of productivity and nutrients. This value is consistent with historical data collection efforts, indicating no significant change in productivity has occurred over time. The TSI values were generally mesotrophic with eutrophic conditions present in the summer season. Turbidity values ranged from a low of 20 NTU to a maximum of 145 NTU and nearly all were above the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 34a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity. The current lake-wide annual turbidity of 92 NTU at Coalgate City Lake is consistent with historical findings for this reservoir. Coalgate Lake is currently not meeting its Fish & Wildlife Propagation (FWP) beneficial use based on high turbidity. Of the twenty samples collected, 100% of the true color values were above the aesthetics WQS of 70 units, (see Figure 34b). Applying the same default protocol for determining the short-term average for true color, the Aesthetics beneficial use is considered not supported.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity values ranged from 0.01 parts per thousand (ppt) to 0.02 ppt, well within the expected range for most Oklahoma lakes if not less than what is normally seen. Values reflect the minimal presence of chlorides or other salts in the lake system. Specific conductivity values followed a similar pattern and were much lower than most Oklahoma reservoirs, with values ranging from 47.1 µS/cm to t 72.7 µS/cm, both occurring in the summer. This indicates a very low content of electrical current conducting compounds or salts. Oxidation-reduction potentials ranged from 230 mV to 445 mV, indicating reducing conditions were not present in the reservoir at the time data collection occurred. The pH was generally neutral with values ranging from 6.32 to 8.03 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 for and the waterbody should be listed as not supporting its FWP beneficial use. With only 8% of the recorded values less than 6.5 units, Coalgate Lake is fully supporting its FWP beneficial use as it relates to pH. Due to equipment failure, there are no profile data available for the fall sampling interval. The lake was not thermally stratified in either the winter or spring sampling intervals and the water column was well mixed (see Figure 34c-34d). Dissolved oxygen (D.O.) values remained above 6.0 mg/L in these sampling intervals. In the summer quarter, the lake was stratified between the surface and 1 meter below the surface and again between 2 and 3 meters at which point the D.O. concentration dropped to less than 2.0 mg/L to the lake bottom at 5.0 meters (see Figure 34e). Similar readings were observed at sites 2 through 5 with anoxic conditions comprising 50-71% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the lake volume, the FWP beneficial use is deemed not supported (USAP 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With 50 to 71% of the water column in the summer less than 2.0mg/L, Coalgate Lake is considered not supporting its FWP. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September 2007. The PBCR beneficial use cannot be determined as minimum data requirements were not met due to quality control issues for Fecal Coliform. Of the 10 enterococci and *E.coli* samples collected, all were below the prescribed screening and the geometric mean .

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.18 mg/L at the lake surface. The TN at the surface ranged from 0.90 mg/L to 1.43 mg/L. The highest surface TN value was reported in the spring quarter and the lowest was in the fall quarter. The lake-wide total phosphorus (TP) average was 0.093 mg/L at the lake surface. The TP ranged from 0.061 to 0.155 mg/L at the lake surface. The highest surface TP values were reported in the summer quarter and similar to TN, the lowest reported values were in the fall quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 13:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Coalgate City Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Coalgate City Lake was classified as mesotrophic, indicative of moderate primary productivity and nutrient levels (Plate 25). The high levels of inorganic turbidity contribute to the lack of productivity in the lake as it is limiting the amount if light available. The lake is fully supporting its Aesthetics beneficial use based on trophic state but not supporting the use with 100% of the collected true color values exceeding the WQS of 70 units. Values for pH were not a cause for concern in meeting the FWP beneficial use, as only 8% of the values were less than 6.5 units. The FWP beneficial is considered not supported use based on anoxic conditions present during the summer quarter as well as elevated turbidity in the lake. The PBCR is considered supported for *E.coli* and enterococci; however due to minmum data requirements not being met for fecal coliform an assessment of this parameter cannot be made.

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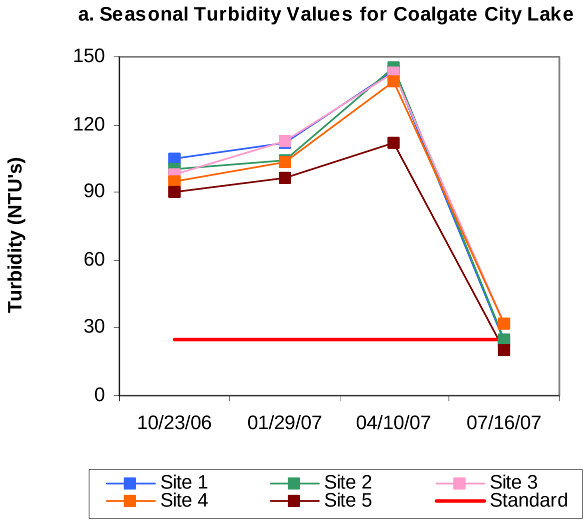
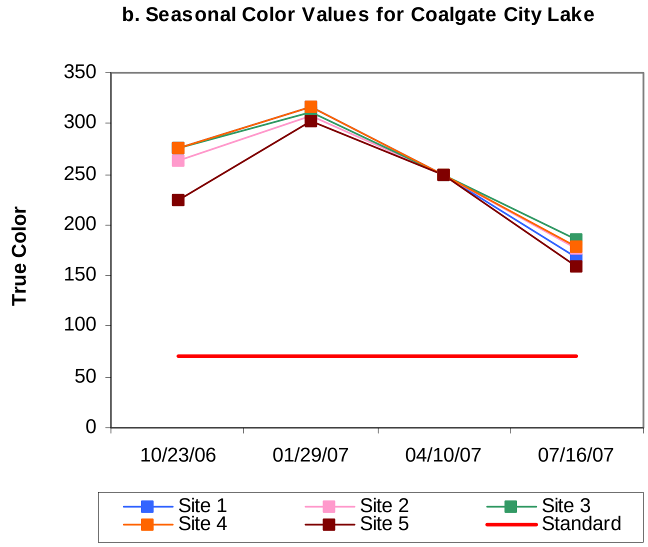
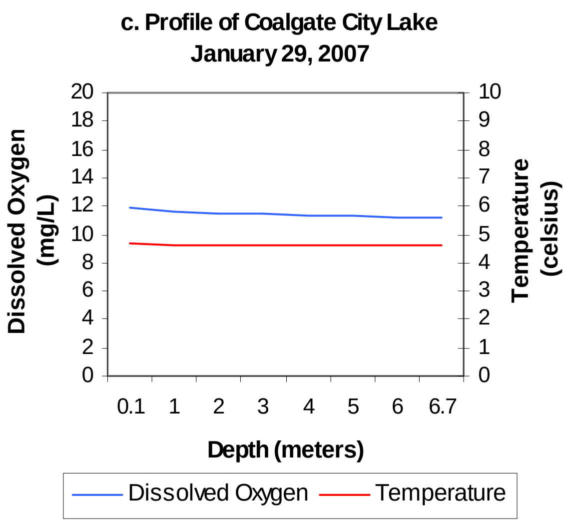
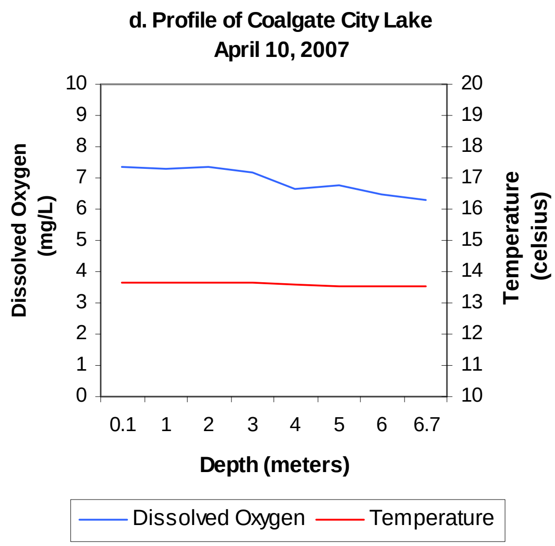








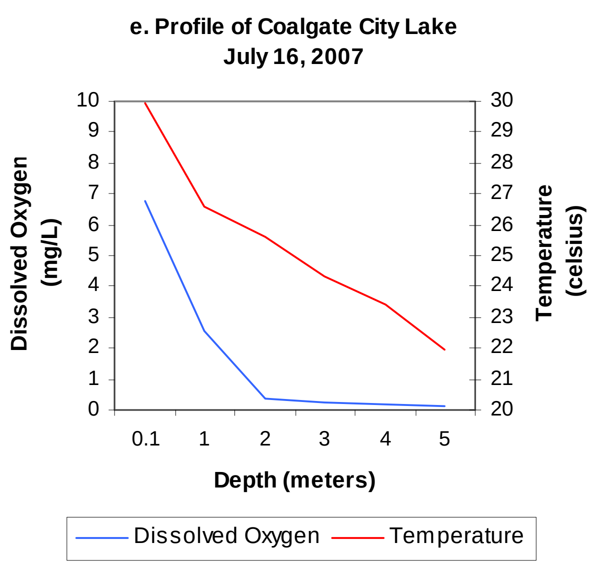
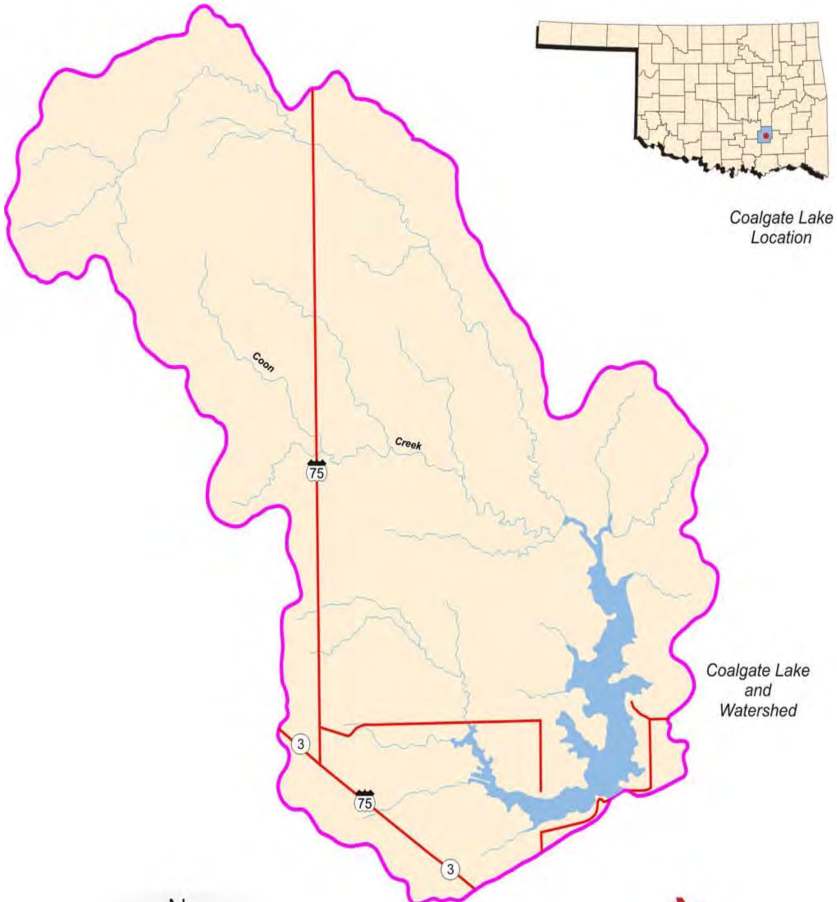


Figure 34a-34e. Graphical representation of data results for Coalgate City Lake.



Coalgate Lake
Location

Coalgate Lake
and
Watershed

N
W
E
S

Lake Data

Owner	City of Coalgate
County	Coal
Constructed in	1965
Surface Area	352 acres
Volume	3,437 acre/feet
Shoreline Length	6 miles
Mean Depth	9.76 feet
Watershed Area	14 square miles

Turbidity
2007

Trophic State
2007

Plate 25 - Lake Water Quality for
Coalgate Lake

Comanche Lake

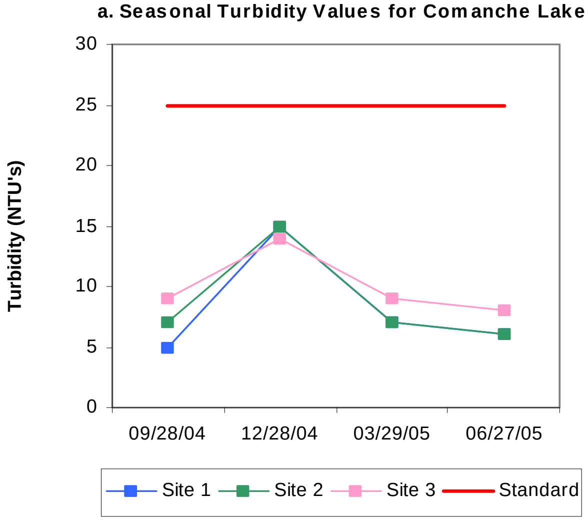
Comanche Lake was sampled for four quarters from September 2004 through June 2005. Water quality samples were collected at three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide annual turbidity value was 9 NTU (Plate 26), true color was 22 units, and secchi disk depth was 101 centimeters in 2005. Based on these three parameters, Comanche Lake had good water clarity in comparison to other Oklahoma reservoirs. Results are similar to those seen in 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The TSI was 46 (Plate 26), indicating the lake was mesotrophic in sample year 2005. This value is similar to the one calculated in 2003(TSI=45), indicating little or no change in productivity has occurred. The TSI values throughout the sample year were fairly consistent with values ranging from the mesotrophic category for three of the four sampling intervals to eutrophic at all sites in the winter. The only exception to this was site 1, which was oligotrophic in both fall and spring quarters. Seasonal turbidity values are displayed in Figure 35a. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the turbidity values well below the standard, the Fish and Wildlife Propagation beneficial use is fully supported based on turbidity. Of the 12 samples collected at Comanche Lake in 2003, none of the true color values exceeded the 70 units criteria listed in WQS (Figure 35b). Applying the same default protocol to determine the short-term average for true color, the Aesthetics beneficial use is supported based on recorded true color values.

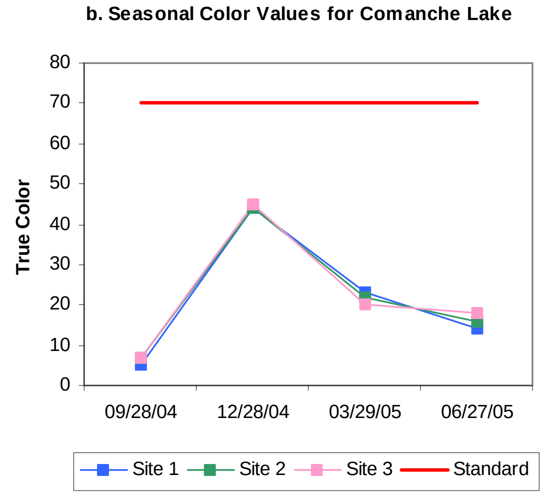
In 2004-2005, vertical al profiles for dissolved oxygen, pH, temperature, specific conductivity; oxidation-reduction potential and salinity were recorded at all three sample sites. The salinity ranged from 0.10 parts per thousand (ppt) to 0.17 ppt for this sample year. Specific conductivity ranged from 237.9 µS/cm to 333.1 µS/cm, which is within the range recorded for most Oklahoma reservoirs. These values indicate the presence of moderate levels of current conducting compounds (chlorides and salts) in the lake. The pH values at Comanche Lake ranged from 6.97 to 8.4, representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of collected values within the acceptable range the lake is meeting its FWP beneficial use based on pH. Oxidation-reduction potentials (ORP) were positive at all sites and ranged from 95 mV in the summer to 446 mV in the spring. In general, reducing conditions were not present in this reservoir. During the fall, the lake was stratified between 7 and 8 meters, at which point with dissolved oxygen concentrations fell below 2.0 mg/L for remainder of the water column (Figure 35c). In both winter and spring quarters, the lake was well mixed stratification was not present (see Figure 35d-35e). Thermal stratification was evident and anoxic conditions were present during the summer. Stratification occurred between 3 and 4 meters in depth at both sites 1 and 2, with anoxic conditions comprising approximately 46% and 38% of the water column respectively (Figure 35f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (USAP 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With 46% of the water column less than 2.0mg/L in the summer, Comanche Lake is considered supporting its FWP. The lake was sampled for total dissolved solids, chlorides, and sulfates to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

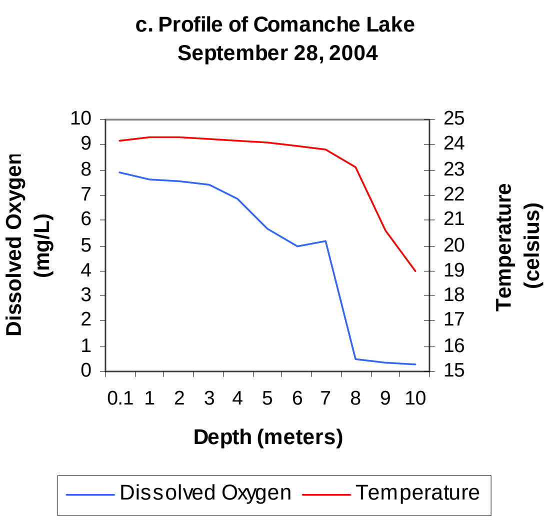
Bacteriological samples were not collected during the current sample year and an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

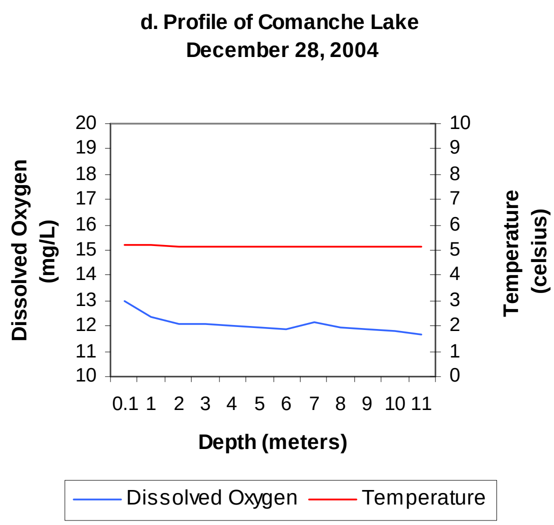
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.48 mg/L at the surface. The TN at the surface ranged from 0.29 mg/L in the winter to 0.83 mg/L in the summer quarter. The lake-wide total phosphorus (TP) average was 0.019 mg/L at the surface. The total phosphorus at the surface ranged from 0.013 mg/L to 0.023 mg/L, with higher values reported during the spring sampling interval. Similar to total nitrogen the lowest TP values were recorded in the spring quarter. The nitrogen to phosphorus ration (TN:TP) was 25:1 for sample year 2004-2005. This value is much higher than 7:I, characterizing the lake as phosphorus limited (Wetzel, 1983).

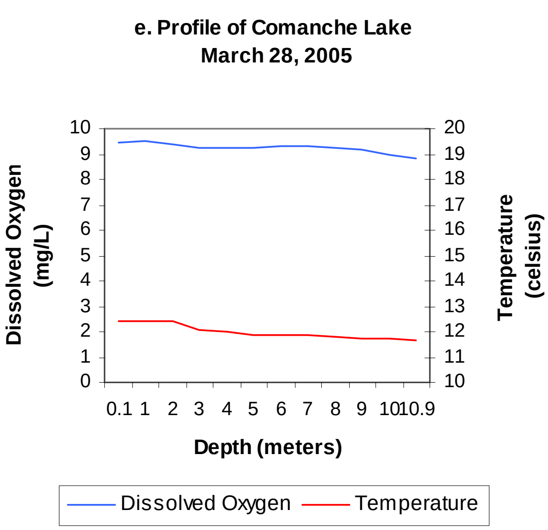
In summary, Comanche was classified as mesotrophic with moderate primary productivity and nutrient conditions in 2004-2005, indicating no significant change has occurred since previous data collection efforts were conducted in 2003. Water clarity was good based on turbidity, true color and secchi disk depth. The lake was found to be supporting the FWP beneficial use based on pH, turbidity, and dissolved oxygen levels recorded during the study period. The Aesthetics beneficial use is also considered fully supported based on true color and trophic status. Bacteriological samples were not collected during the current sample year and an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Comanche Lake is located in Stephens County and serves as a municipal water supply as well as a recreational reservoir for the City of Comanche.











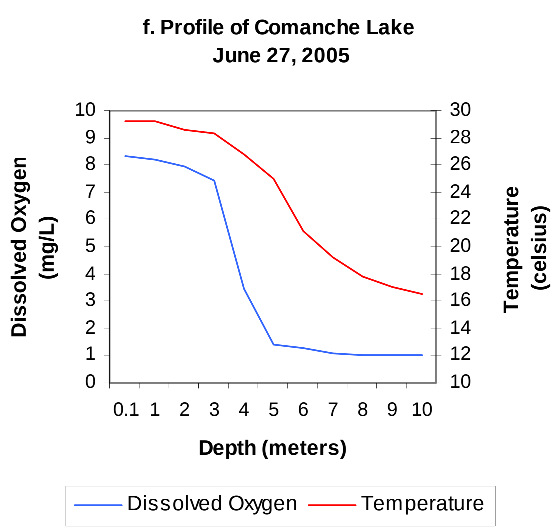
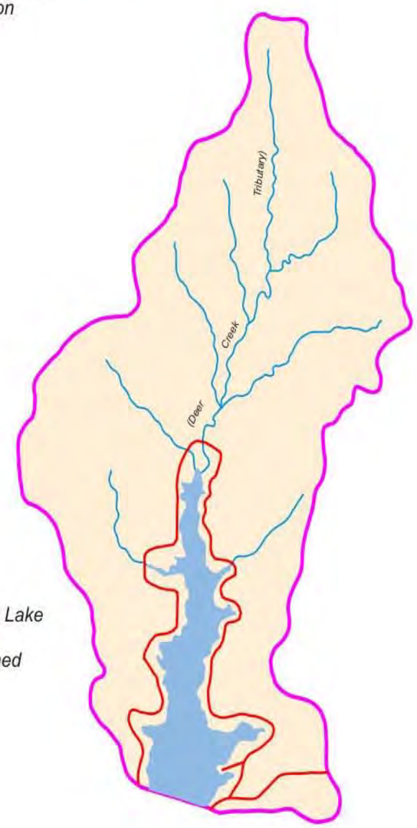


Figure 35a-35f. Graphical representation of data results for Comanche Lake.

Comanche Lake
Location



Comanche Lake
and
Watershed

Lake Data	
Owner	City of Comanche
County	Stephens
Constructed	1960
Surface Area	184 acres
Volume	2,500 acre/feet
Shoreline Length	5 miles
Mean Depth	13.59
Watershed Area	2,288 acres

Turbidity
2005

Trophic State
2005

Plate 26 - Lake Water Quality for
Comanche Lake

LAKES MONITORING PROGRAM

Copan Lake

Copan Lake was sampled for four quarters, from October 2004 through July 2005. Samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites, and at 0.5 meters from the lake bottom at site 1, the dam. The average lake-wide turbidity was 58 NTU (Plate 27), true color was 75 units, and average secchi disk depth was 25 centimeters in sample year 2004-2005. Water clarity was poor at Copan Lake based on these three parameters. Results for turbidity, true color and secchi disk depth are slightly higher than those recorded in 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for three quarters (n=15). The TSI was 51 (Plate 27), indicating the lake was eutrophic, with high levels of productivity and nutrient conditions for sample year 2005. Due to a post-processing error no samples were submitted to lab for analysis from the fall data collection efforts. This value although lower than the value calculated in 2003 (TSI=59), is in the same trophic category, indicating no significant change in productivity has occurred. Chlorophyll samples were not collected during the fall quarter, which may account for the lower annual TSI. The TSI values for all sites were fairly consistent and ranged from lower mesotrophic, bordering oligotrophic, in the winter to lower hypereutrophic at sites 4 and 5 in the summer quarter. Seasonal turbidity values by site are displayed in Figure 36a. Of the twenty values collected, only one was less than the Oklahoma Water Quality Standard (WQS) of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if $\geq$ 25% of the samples exceed the Oklahoma Water Quality Standard (WQS) of 25 NTU for turbidity. If 10 to 25% of the turbidity samples exceed the criteria of 25 NTU, the lake is considered to be partially supporting beneficial uses. The Fish and Wildlife Propagation (FWP) beneficial use is not supported at Copan Lake, as 95% of the values exceed the turbidity standard of 25 NTU. Seasonal true color values are displayed in Figure 36b. Of the 20 samples collected, 50% exceeded the WQS of 70 units. Applying the same default protocol to determine the short-term average for true color, the Aesthetics beneficial use is partially supported based on the true color values.

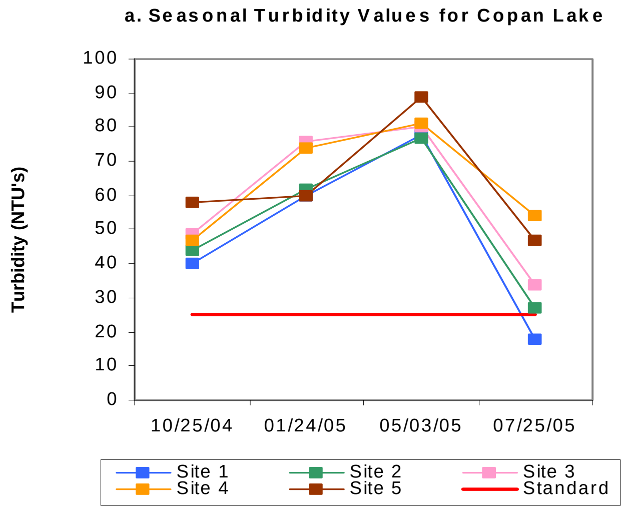
In 2004-2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all five sample sites. Salinity values ranged from 0.08 parts per thousand (ppt) to 0.17 ppt, which is within the range of values seen in Oklahoma reservoirs. Specific conductivity ranged from 176.8 µS/cm to 344.2 µS/cm, indicative of minimal levels of current conducting ions (salts) in the lake system. Values for pH ranged from 6.81 to 8.18, representing a neutral to slightly alkaline lake system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of collected values within the acceptable range, Copan Lake is meeting its FWP beneficial use based on pH. Oxidation-reduction potentials (ORP) ranged from 312mV in the fall to 457 mV in the hypolimnion during the fall. In general, reducing conditions were not present at this reservoir during the 2004-2005-

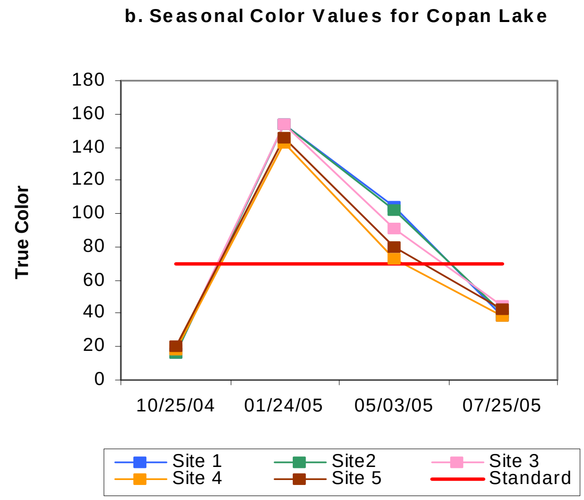
sample year. The lake was well mixed during the fall, winter and spring sampling quarters (see Figure 36c-36e) and dissolved oxygen (D.O.) levels were generally greater than 7.0 mg/L. Thermal stratification was evident and anoxic conditions were present during the summer sampling interval. Dissolved oxygen levels at site 1 dropped below 2.0mg/L between 3 and 4 meters in depth accounting for approximately 50% of the water column to be anoxic. The relatively shallow nature of the lake is likely responsible for keeping rest of the lake well mixed. If the D.O. values are less than 2.0 mg/L for greater than 70% of the water column the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70 % of the water column, the FWP beneficial use is deemed partially supported. With 50% of the water column below 2.0 mg/L during the summer the FWP beneficial use is partially supported at Copan Lake. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

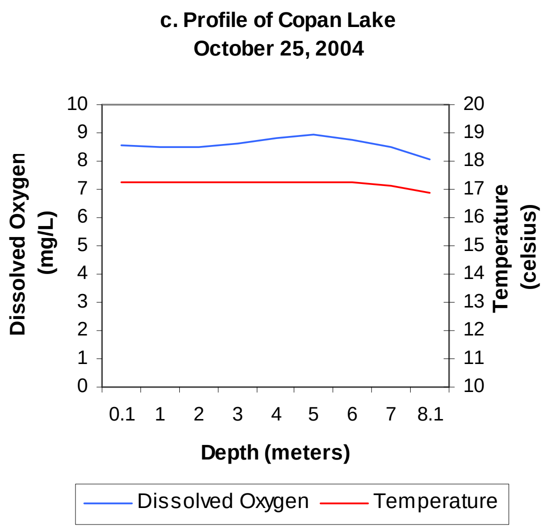
Bacteriological samples were not collected during the current sample year and an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

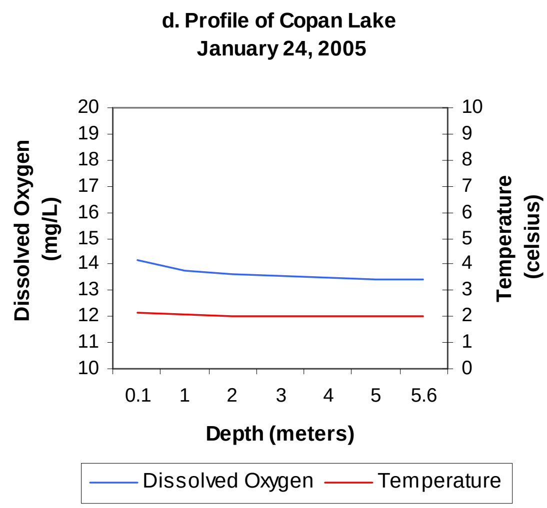
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.79 mg/L at the surface. The TN at the surface ranged from 0.48 mg/L in the fall to 1.44 mg/L in the summer quarter. The lake-wide total phosphorus (TP) average was 0.092 mg/L at the surface. The total phosphorus at the surface ranged from 0.051 mg/L to 0.132 mg/L. Similar to total nitrogen, lower values were reported in the fall; however higher values were reported during the spring sampling interval. Similar to total nitrogen the lowest TP values were recorded in the spring quarter. The nitrogen to phosphorus ration (TN:TP) was approximately 9:1 for sample year 2004-2005. This value is slightly higher than 7:I, characterizing the lake as phosphorus limited (Wetzel, 1983).

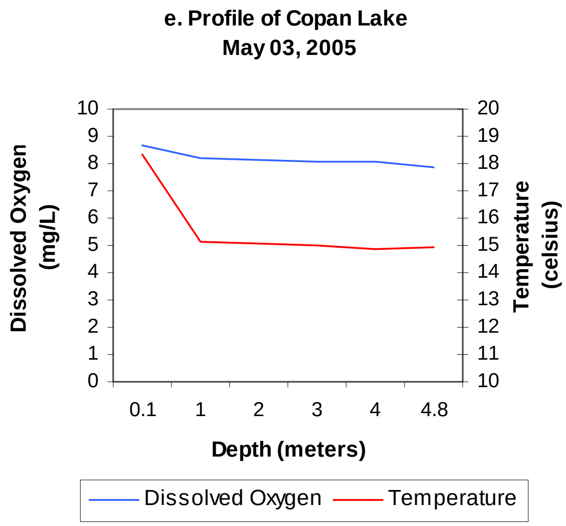
In summary, Copan Lake was classified as eutrophic with high primary productivity and nutrient levels in 2004-2005 (Plate 27). The current TSI value is less than that calculated in 2003 (TSI=59), however it is in the same trophic category. Chlorophyll samples were not submitted during the fall quarter, which may account for the lower annual TSI. Water clarity was poor based on turbidity, true color and secchi disk depth. The lake is supporting the FWP beneficial use based on pH and partially supporting based on dissolved oxygen concentrations recorded during the study period. With 95% of the turbidity values exceeding 25 NTU, the FWP use is not supported as it relates to turbidity. The Aesthetics beneficial use is supported based on the trophic status, but not supported for true color, as 50% of the collected values exceed the WQS of 70 units. Copan Lake is located in Washington County and was constructed by the United States Army Corps of Engineers (USACE) to serve as a flood control, waters supply, and fish and wildlife reservoir.











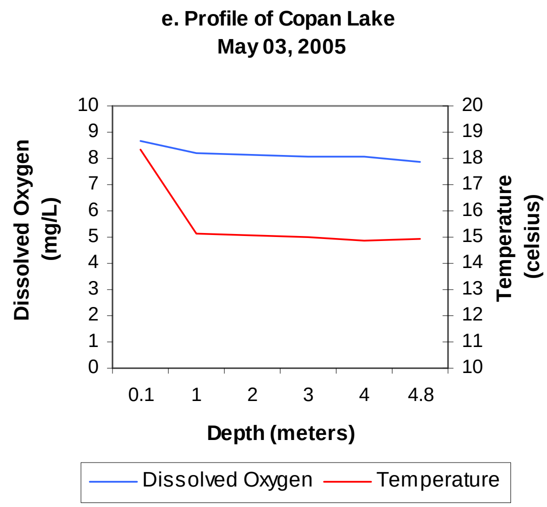


Figure 36a-36f. Graphical representation of data results for Copan Lake.

Copan Lake and Watershed

Copan Lake Location

Lake Data	
Constructed by	Corps of Engineers
County	Washington
Constructed in	1983
Surface Area	4,850 acres
Volume	43,400 acre/feet
Shoreline Length	30 miles
Mean Depth	8.95 feet
Watershed Area	505 square miles

Turbidity 2005

Trophic State 2005

Plate 27 - Lake Water Quality for

Copan Lake

Crowder Lake

Crowder Lake, located in Washita County, is owned and operated by the State of Oklahoma for the express purpose of providing flood control and recreational opportunities to the citizens of Oklahoma. Crowder Lake was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the surface at all sites during the study period. The lake-wide annual turbidity value was 9 NTU (Plate 28), true color was 17 units, and secchi disk depth was 65 centimeters. Based on these three parameters, Crowder Lake had average water clarity in comparison to other Oklahoma reservoirs. Results for these parameters are consistent with values observed in 2003-2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 57 (Plate 28), indicating the lake was eutrophic, with high levels of productivity and nutrients levels. The current calculation is exactly the same as that in 2004 (TSI=57) indicating no significant change in productivity has occurred since the previous evaluation. The TSI values were primarily eutrophic throughout the year with hypereutrophic conditions observed at sites 1 and 2 in the fall and again at site 3 during the summer quarter. Crowder Lake is currently listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Turbidity values per site were all below the WQS of 25 NTU with values ranging from a low of 5 NTU to a maximum of 17 NTU (see Figure 37a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the turbidity values below the standard, the Fish and Wildlife Propagation beneficial use is considered fully supported for sample year 2005-2006. Seasonal true color values are displayed in Figure 37b. Similar to turbidity, all true color values were below the Aesthetics WQS of 70 units. Applying the same default protocol to determine the short-term average for true color, the Aesthetics beneficial use is supported based on the true color values.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity values ranged from 0.38 parts per thousand (ppt) to 0.57 ppt, which is higher than the expected range for most Oklahoma lakes. Salinity values indicate a moderate to high presence of chlorides or other salts in the lake. Specific conductivity values exhibited a similar pattern and were somewhat higher than most Oklahoma reservoirs with values ranging from 744 µS/cm in the fall to 1088 µS/cm in the spring, which is indicative of a high content of electrical current conducting compounds or salts throughout the lake system. Oxidation-reduction potentials (redox) ranged from 275 mV to 445 mV, indicating reducing conditions were not present during the study period. The pH was neutral to slightly alkaline with values ranging from 6.94 to 8.34 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Crowder Lake is fully supporting its FWP as it relates pH. The lake was not thermally stratified and the water column was well mixed at all sites throughout the fall and winter quarters (see Figure 37c-37d). Dissolved oxygen (D.O.) values remained above 4.0 mg/L throughout the water column and were generally above 7.0 mg/L and the dissolved oxygen percent saturation was never less than 65% in the first two seasons. During the spring sampling interval thermal stratification was evident and anoxic conditions were present in 38% of the water column at both sites 1 and 2 (Figure 37e). Stratification occurred between 4 and 5 meters below the lake surface with dissolved oxygen (D.O.) less than 1.0 mg/L from 5 meters to the lake bottom of 6.7 meters. Due to equipment failure there is no profile data available for the summer sampling interval. When D.O. values are less than 2.0 mg/L for greater than 70% of the lake volume, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered fully supported at Crowder Lake based on data collected in the first three quarters. Because the summer profile data is missing an assessment for that season cannot be made at this time. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

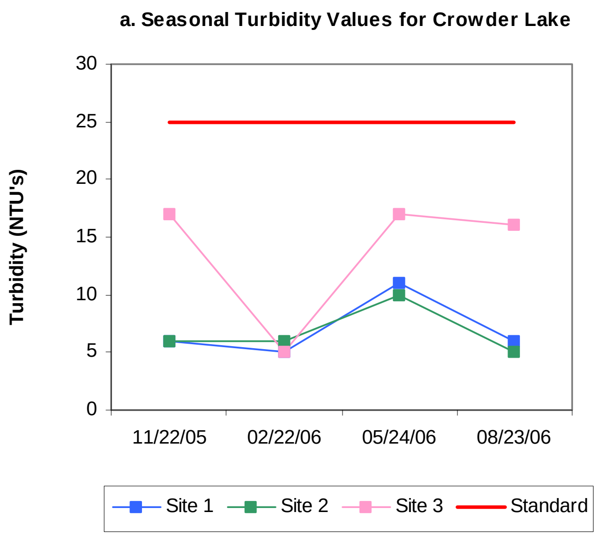
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

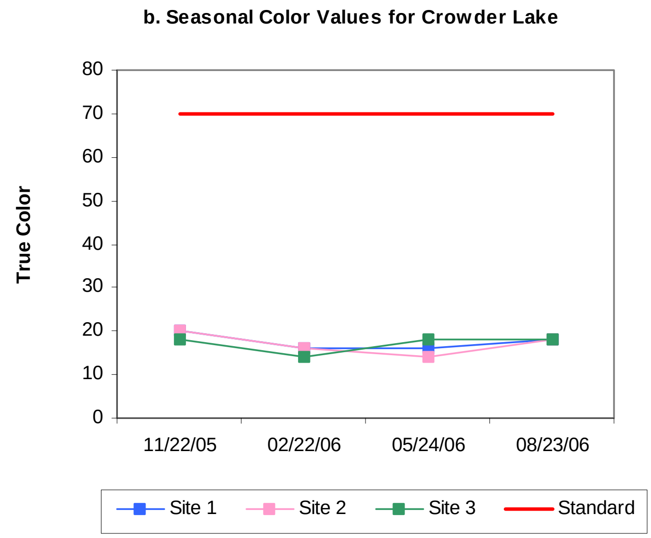
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.73 mg/L at the lake surface. The TN at the surface ranged from 0.54 mg/L to 0.93 mg/L. The highest TN was observed in the winter while the lowest surface TN value was reported in the spring quarter. The lake-wide total phosphorus (TP) average was 0.035 mg/L at the lake surface. The TP ranged from 0.026 mg/L to 0.053 mg/L at the lake surface. The highest surface TP values were reported at site 3 in the summer quarter and the lowest were in the winter quarter. The total nitrogen phosphorus ratio (TN:TP) was 21:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

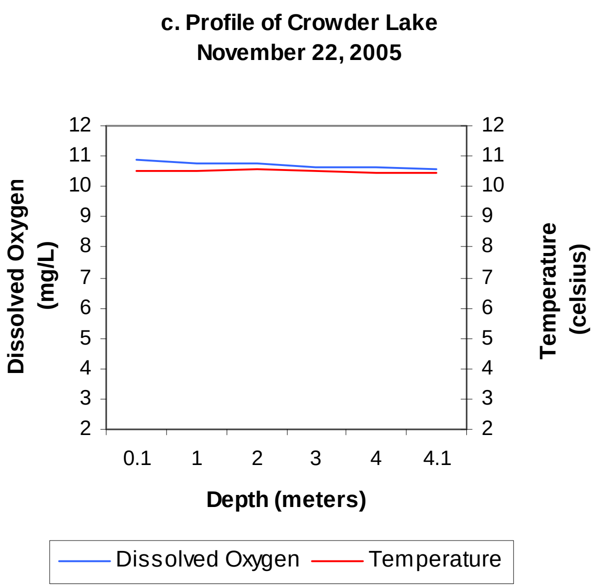
Crowder Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

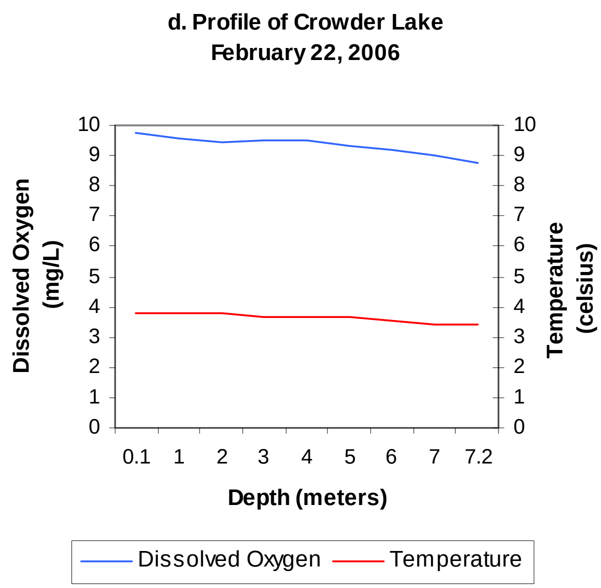
In summary, Crowder Lake was classified as eutrophic bordering on hypereutrophic, indicative of high to excessive primary productivity and nutrient levels (Plate 28). The current TSI is the same as that in 2004 (TSI=57), indicating no significant change in productivity has taken place since the previous evaluation. Based on secchi disk depth, turbidity and true color, Crowder Lake had average water clarity in comparison to other Oklahoma reservoirs. The FWP beneficial use was fully supported based on pH, turbidity and dissolved oxygen levels collected during the study period. With 100% of the reported true color values below the WQS of 70 units, the lake was fully supporting its Aesthetics beneficial use for true color. Crowder Lake is currently listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited

Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.









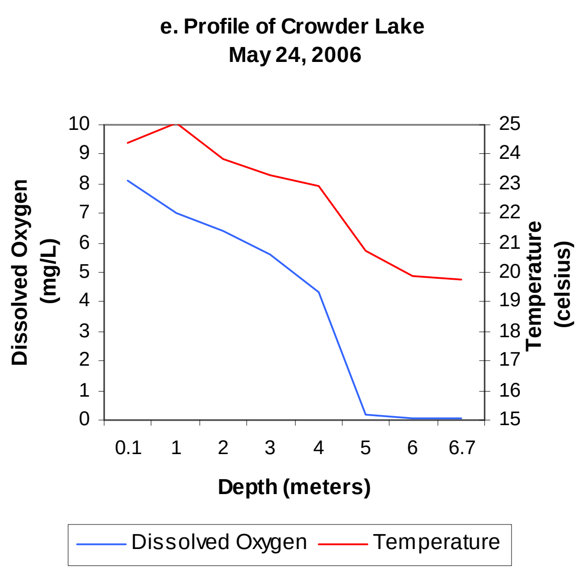
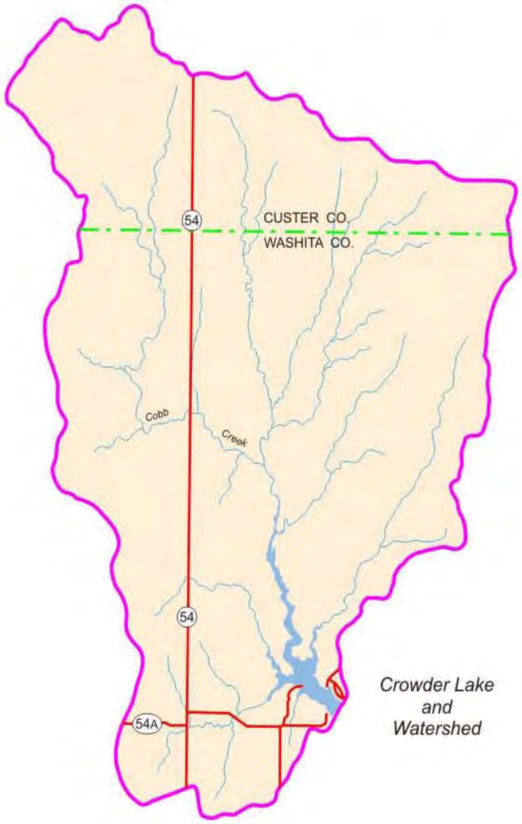


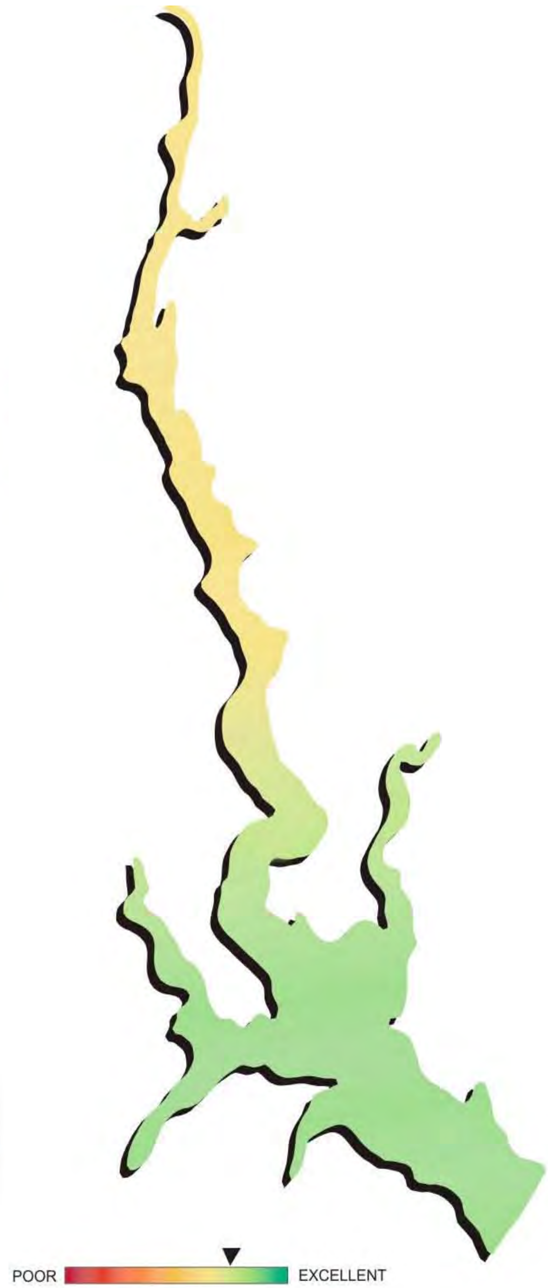
Figure 37a-37e. Graphical representation of data results for Crowder Lake.

Crowder Lake Location

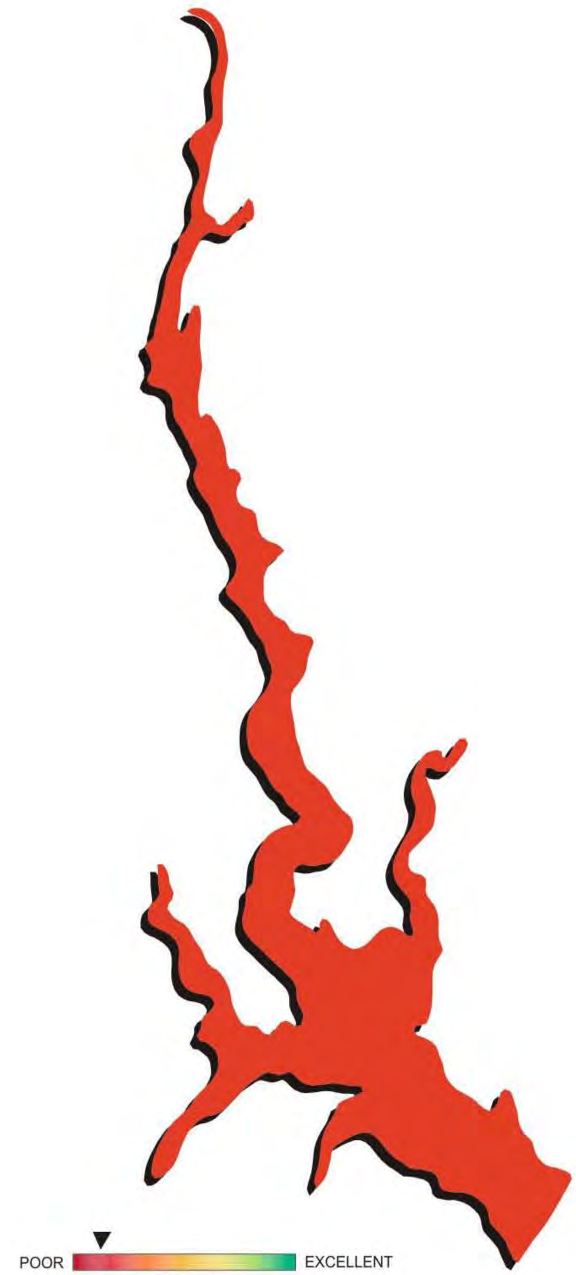


Crowder Lake and Watershed

Lake Data	
Operator	State of Oklahoma
County	Washita
Constructed	1959
Surface Area	158 acres
Volume	2,094 acre/feet
Shoreline Length	9 miles
Mean Depth	13.25 feet
Watershed Area	27 square miles



Turbidity
2006



Trophic State
2006

Plate 28 - Lake Water Quality for
Crowder Lake

LAKES MONITORING PROGRAM

Cushing Municipal Lake

Cushing Municipal Lake is a 591-acre lake located in Payne County. It was constructed in 1950, to serve as the municipal water supply for the City of Cushing and is also utilized for recreational purposes. Cushing Municipal Lake was sampled for four quarters, from October 2006 through July 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Water quality samples were collected at the surface during the study period. The lake-wide annual turbidity value was 45 nephelometric turbidity units (NTU) (Plate 29), true color was 85 units, and secchi disk depth was 43 centimeters. Based on these three parameters, Cushing Municipal Lake had poor water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 50 (Plate 29), indicating the lake was mesotrophic, bordering eutrophic, with moderate to high levels of productivity and nutrients. This is similar to the findings in 2004, indicating little change in productivity has occurred. The TSI values ranged from mid-mesotrophic to mid-eutrophic with some seasonal variation. Turbidity values ranged from a low of 11 NTU to a maximum of 93 NTU (see Figure 38a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). With 70% of the samples collected above the standard, Cushing Lake is not meeting its Fish & Wildlife Propagation (FWP) beneficial use based on turbidity. The lake-wide annual turbidity of 45 NTU is in consistent with historical data collection results seen for the lake. Of the twenty true color values collected 45% were above the aesthetics WQS of 70 units (see Figure 38b). Applying the same default protocol, the Aesthetics beneficial use is considered not supported.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity values ranged from 0.05 parts per thousand (ppt) to 0.15 ppt, which was within the expected range for most Oklahoma lakes and reflecting minimal presence of chlorides or other salts in the lake system. Specific conductivity values were also consistent with values that would normally be seen in Oklahoma reservoirs, with values ranging from 131.5 µS/cm in the summer to 325 µS/cm in the winter. Values did not indicate a high content of electrical current conducting compounds or salts in the lake. Oxidation-reduction potentials ranged from 359 mV to 432 mV, indicating reducing conditions were not present at any time during the sampling period. The pH was neutral to slightly alkaline with values ranging from 6.84 to 8.31 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. The FWP beneficial use was fully supporting based on pH values collected during the study period. The lake was not thermally stratified and the water column appeared to be well mixed throughout the fall, winter and spring sampling quarters at all sites (see Figure 38c-37e). Dissolved oxygen (D.O.) values were generally above 6.5 mg/L and the D.O. percent saturation was never less than 5% in the first three sampling intervals (see Figure 38c-37e). In the summer, the lake was stratified and anoxic conditions present. At site 1 (the dam), thermal stratification stratification occurred between 4 and 5 meters below the surface and the D.O. concentration dropped from 3.07 mg/L to 2.1 mg/L at the lake bottom of 6.0 meters (Figure 38f). If D.O. values are less than 2.0 mg/L for greater than 70% of the lake volume, the (FWP) beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With 17-25% of water column less than 2.0 mg/L, the lake is considered to be supporting its FWP beneficial use. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. Due to quality control issues minimum data requirements were not met, therefore the PBCR beneficial use cannot be assessed at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.00 mg/L at the lake surface. The TN at the surface ranged from 0.66 mg/L to 1.71 mg/L. The highest surface TN value was reported in the spring and the lowest was in the winter quarter. The lake-wide total phosphorus (TP) average was 0.110 mg/L at the lake surface. The TP ranged from 0.036 mg/L to 0.187 mg/L at the lake surface. The highest surface TP values were reported in the summer quarter and the lowest were in the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 9:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as approaching co-limitation (Wetzel, 1983).

Cushing Municipal Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Cushing Municipal Lake was classified as mesotrophic, bordering eutrophic, indicative of moderate to high primary productivity and nutrient levels (Plate 29). Given the level of nutrients present in the lake system, the high levels of inorganic turbidity may be serving as a mitigating factor for lake productivity through light limitation. The lake is fully supporting its Aesthetics beneficial use based on trophic status and not supporting for true color with 45% of the recorded values exceeding the WQS of 70 units. The FWP beneficial use was fully supported based on pH and dissolved oxygen concentrations. Of the twenty turbidity samples collected, 14 (70%) were greater than 25 NTU; therefore the lake is not supporting its FWP beneficial use based on high turbidity.

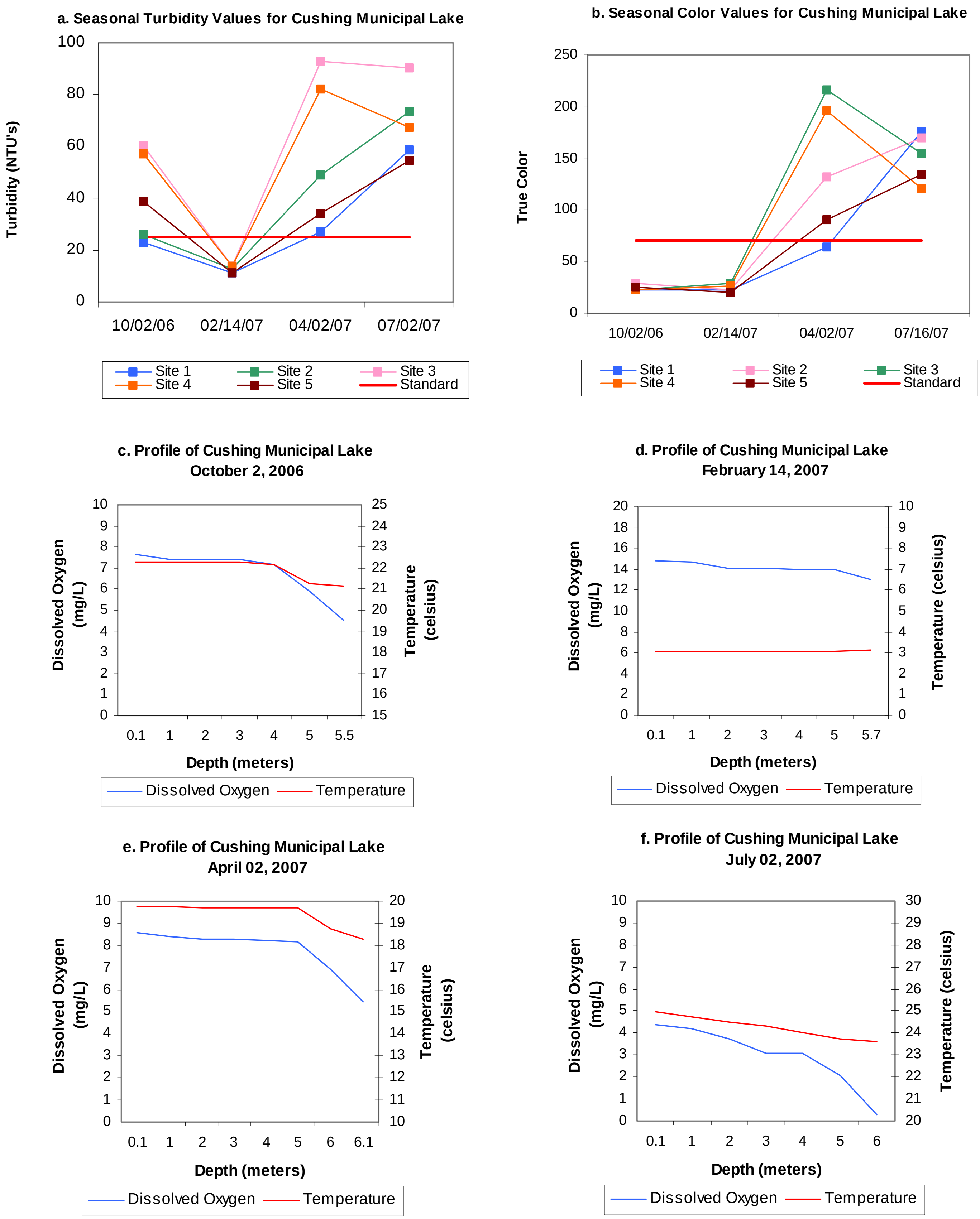
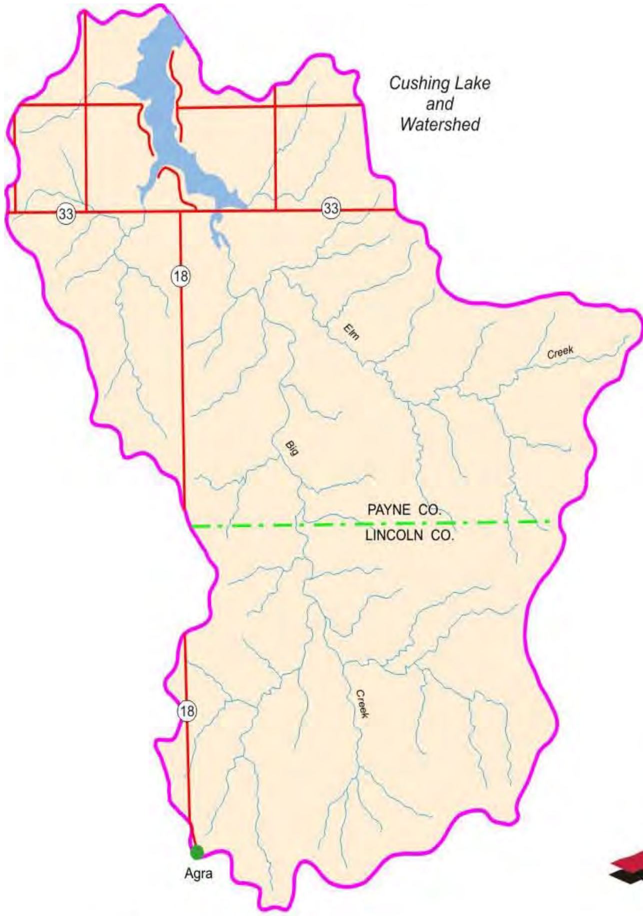


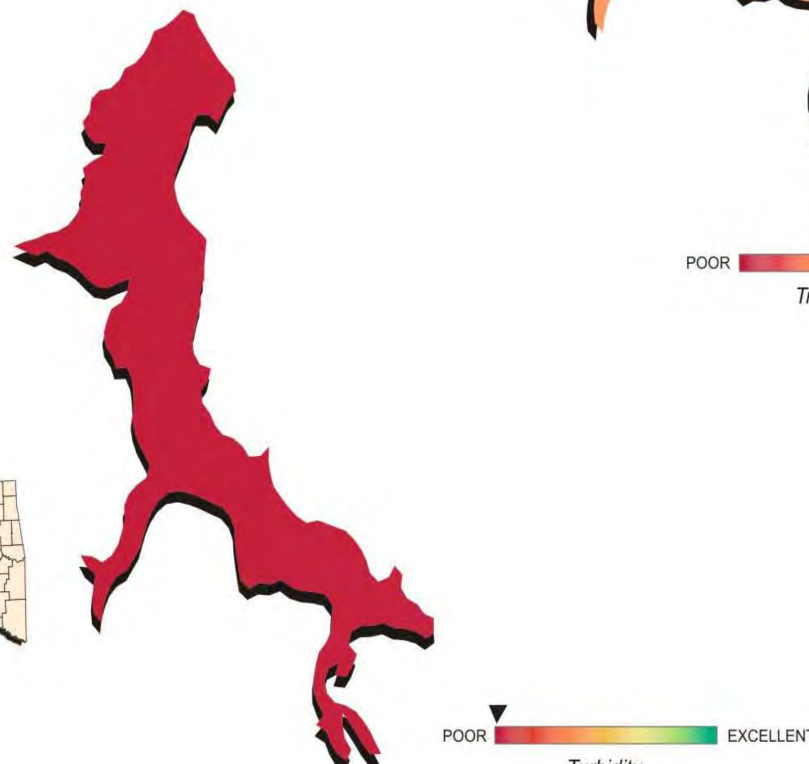
Figure 38a-38f. Graphical representation of data results for Cushing Municipal Lake.

Plate 29 - Lake Water Quality for
Cushing Lake



Lake Data

Owner	City of Cushing
County	Payne
Constructed in	1950
Surface Area	592 acres
Volume	3,304 acre/feet
Shoreline Length	9 miles
Mean Depth	5.58 feet
Watershed Area	32 square miles



LAKES MONITORING PROGRAM

Dave Boyer (Walters) Lake

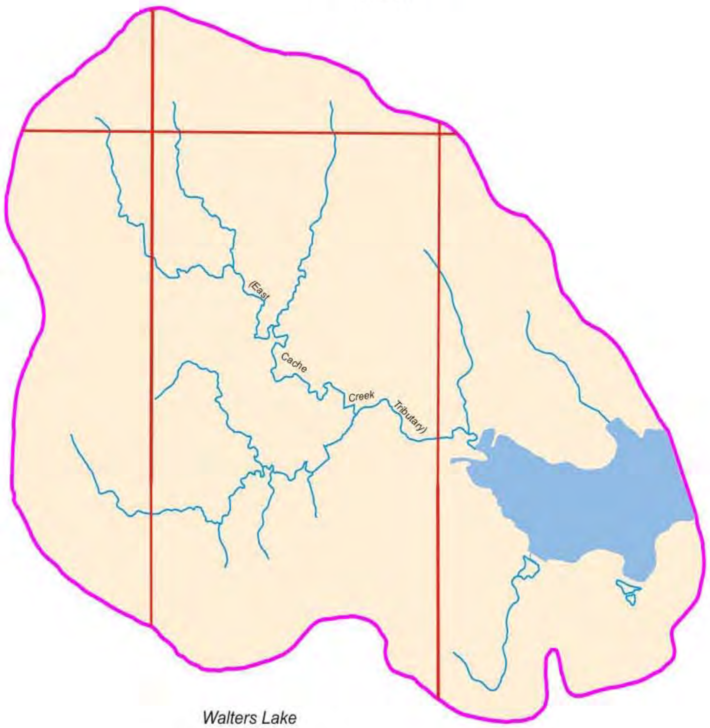
Dave Boyer Lake, located in Cotton County, is owned by the city of Walters and serves as a water supply and recreation reservoir. The lake was scheduled for sampling during the 2005-2006 sample year however due to the drought conditions lake levels were too low for OWRB staff to launch a boat. The lake will be placed on the next sample rotation once water levels rise enough for staff to access the lake safely.

Water quality samples were collected at three sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the surface at all sites and 0.5 meters from the lake bottom at sample site 1, the dam. The lake-wide annual turbidity value was 89 NTU (Plate 120), true color was 48 units, and secchi disk depth was 16 centimeters in 2003-2004. Based on these three parameters, Dave Boyer Lake had poor water clarity in comparison to other Oklahoma reservoirs. Water clarity was similar in the 2001, and is always poor based on the soil composition and nature of this lake. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 52 (Plate 120), indicating the lake was eutrophic with high levels of productivity and nutrients. This value is similar to the TSI in 2001 (TSI= 51), indicating no change in productivity has occurred since the last evaluation. The TSI values were generally eutrophic with the exception of the winter when two of the three sites were mesotrophic. Turbidity values were well above the turbidity standard of 25 NTU at all sites throughout the year. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the Oklahoma Water Quality Standard (WQS) of 25 NTU for turbidity. If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. The FWP beneficial use is considered not supported at Dave Boyer Lake with 100% of the collected values exceeding the numeric criteria of 25 NTU. Of the 12 samples collected at Dave Boyer Lake in 2003-2004, 25% of the true color values exceeded the 70 units criteria listed in WQS. Applying the same default protocol to determine the short-term average for true color, the Aesthetics beneficial use is considered not supported based on the high true color values.

Please refer to the “Beneficial Use Monitoring Report 2004 Draft Final Report” for the full discussion of monitoring results for this lake. The report may be access via the OWRB’s web page at http://www. owrb.state.ok.us or you may contact the Water Resources for a copy of the 2004 BUMP Report on CD. The OWRB may be reached at (405) 530-8800 (ask for Nikki Cole) or at the address below:

Oklahoma Water Resources Board
3800 N. Classen Blvd.
Oklahoma city, Oklahoma 73118
Attn: Nikki Cole

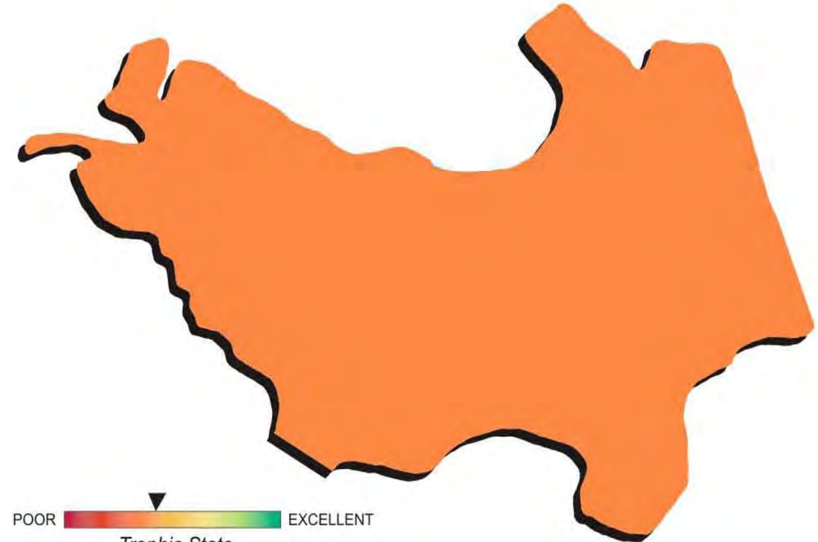
Walters Lake Location



Walters Lake and Watershed

N
W
E
S

Lake Data	
Owner	City of Walters
County	Cotton
Constructed	1936
Surface Area	148 acres
Volume	861 acre/feet
Shoreline Length	3 miles
Mean Depth	5.82 feet
Watershed Area	2,389 acres



POOR EXCELLENT
Trophic State 2004

POOR EXCELLENT
Turbidity 2004

Plate 120 - Lake Water Quality for
Dave Boyer (Walters) Lake

LAKES MONITORING PROGRAM

Dripping Springs Lake

Dripping Springs Lake is a 1,150-acre reservoir, which is owned and operated by the City of Okmulgee. The lake is managed for water supply uses, flood control uses and for recreational purposes. Dripping Springs Lake was sampled for four quarters, from October 2006 through July 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones as well as major arms of the reservoir. Samples were collected at the surface at all sites during the study period. The lake-wide annual turbidity value was 21 nephelometric turbidity units (NTU) (Plate 30), true color was 89 units, and secchi disk depth was 76 centimeters in 2006-2007. Based on these three parameters, Dripping Springs Lake had average water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 48 (Plate 30), indicating the lake was mesotrophic, with moderate levels of productivity and nutrients. This value is slightly higher than the previous TSI calculated in 2005 (TSI=42), although within the same trophic category, indicating no significant increase or decrease in productivity has occurred since the lake was last evaluated. The TSI values were mesotrophic in the fall, winter and spring with eutrophic conditions occurring in the summer. Of the twenty turbidity values collected, 45% were greater than the Oklahoma Water Quality Standard (WQS) of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). The lake is not supporting its Fish & Wildlife Propagation (FWP) beneficial use based on turbidity. Seasonal true color values are displayed in Figure 39 b. Seventy-five percent of the color values exceeded the WQS standard of 70 units. Applying the same default protocol to determine the short-term average for true color, the Aesthetics beneficial use is considered not supported based on the true color values.

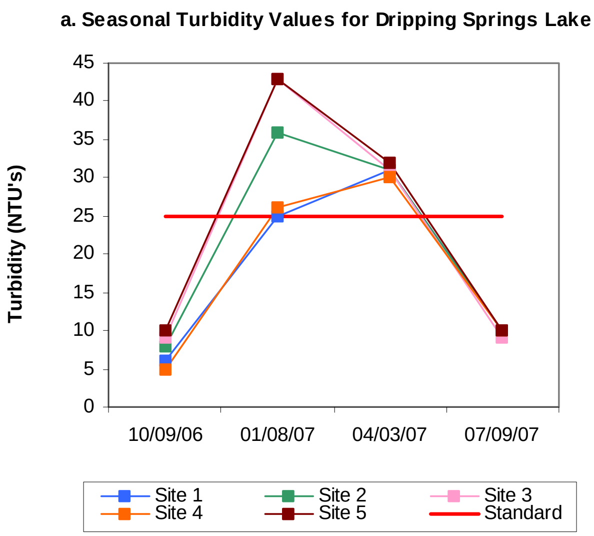
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity values ranged from 0.01 parts per thousand (ppt) to 0.07 ppt, which was well within the expected range for most Oklahoma lakes if not lower than the normally recorded values. The low salinity concentrations reflect a minimal presence of chlorides or other salts in the lake. Specific conductivity values were also very low when compared to most Oklahoma reservoirs, with values ranging from 49.7 µS/cm in the summer quarter to 156 µS/cm in the fall quarter, which is indicative of a very low content of electrical current conducting compounds or salts in the lake system. Oxidation-reduction potentials ranged from 128 mV to 454 mV, indicating reducing conditions were not present at any point in the water column when sampling occurred. The pH was neutral to slightly acidic with values ranging from 6.31 to 7.70 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if they fall outside the range of 6.5 to 9.0 for 25% of the values and they waterbody should be listed as not supporting its FWP beneficial use. With only 7.8% of the pH values collected fall outside the prescribed range, Dripping Spring Lake is meeting its FWP beneficial use based on pH. In the fall quarter, the lake exhibited weak thermal stratification with dissolved oxygen remaining above 2.0 mg/L until the lake bottom of 10.1 meters, which is likely the result of the Hydrolab probe resting on the bottom sediment. The water column appeared to be well mixed in the winter quarter. During this time dissolved oxygen (D.O.) values generally above 9.0 mg/L (see Figure 39d). In the spring quarter there was a gradual decline in both temperature and dissolved oxygen, however D.O. concentration never fell below 5.0 mg/L. Thermal stratification and anoxic conditions were present in the summer quarter. Stratification was present at all five sites and occurred at various depths. At site 1, the dam, the lake was stratified between 3 and 4 meters at which point the D.O. concentration fell below 2.0 mg/L for the remainder of the water column (see Figure 39f). The readings in the lake hypolimnion were anoxic at all sites with approximately 50-70% of the values collected at site 1 were below 2.0 mg/L. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Dripping Springs Lake is partially supporting its FWP beneficial use based on anoxic conditions present during the summer sampling interval. The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

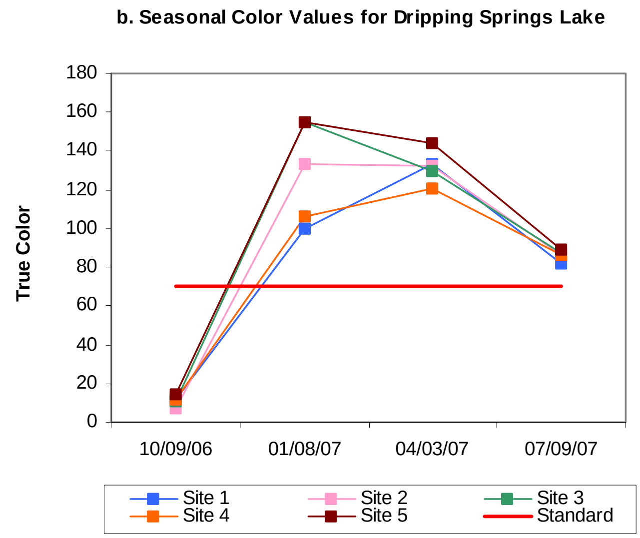
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. The PBCR beneficial use cannot be determined as minimum data requirements were not met due to quality control issues for enterococci and Fecal Coliform. Of the 10 *E.coli* samples collected, all were below the screening level of 235 cfu/ml and the prescribed geometric mean standard of 126 cfu/ml.

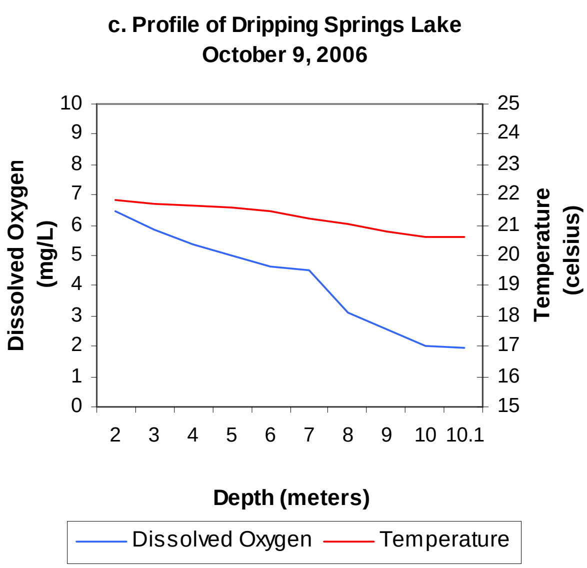
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.71 mg/L at the surface. The TN at the surface ranged from 0.43 mg/L in the fall to 1.07 mg/L in the summer quarter. The lake-wide total phosphorus (TP) average was 0.028 mg/L at the surface. The total phosphorus at the surface ranged from 0.014 mg/L to 0.044 mg/L. Similar to total nitrogen, lower values were reported in the fall with higher values reported during the summer sampling interval. The nitrogen to phosphorus ration (TN:TP) was approximately 26:1 for sample year 2006-2007. This value is slightly higher than 7:I, characterizing the lake as phosphorus limited (Wetzel, 1983).

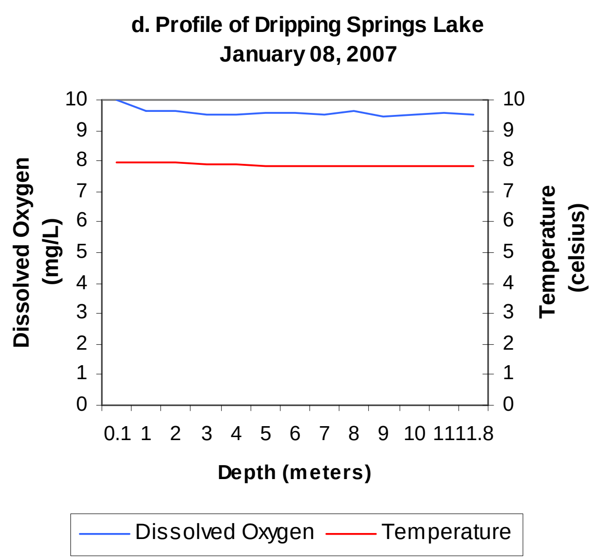
Dripping Springs Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

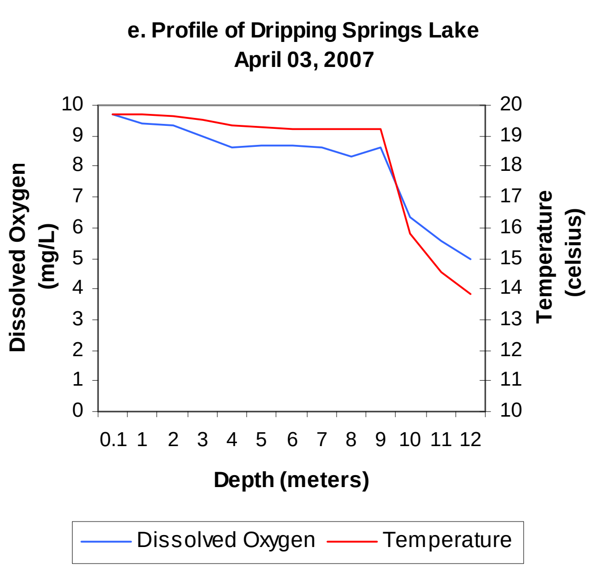
In summary, Dripping Springs Lake was classified as mesotrophic, indicative of moderate primary productivity and nutrient levels (Plate 30). This is consistent with results of 2005, which also found the lake to be mesotrophic in nature (TSI=42). Water clarity was average in comparison to other Oklahoma reservoirs, based on turbidity, true color, and secchi disk depth. The Fish and Wildlife Propagation (FWP) beneficial use was found to be supporting for pH, but partially supported based on anoxic conditions present in up to 70% of the water column during the summer. With 45% of the turbidity values exceeding 25 NTU the FWP use is not supported as it relates to turbidity. The Aesthetics beneficial use was fully supporting based on trophic state, but not supported for true color as 75% of the samples exceeded the WQS of 70 units. The PBCR is considered supported for E.coli; however due to minmum data requirements not being met for fecal coliform and enterococci and assessment of these parameters cannot be made.











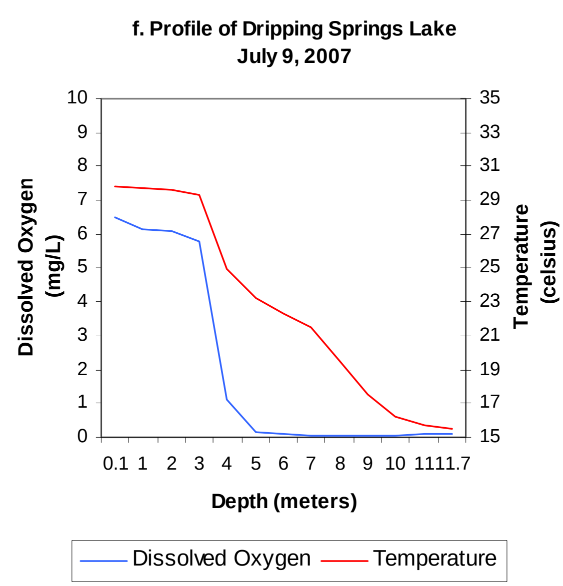
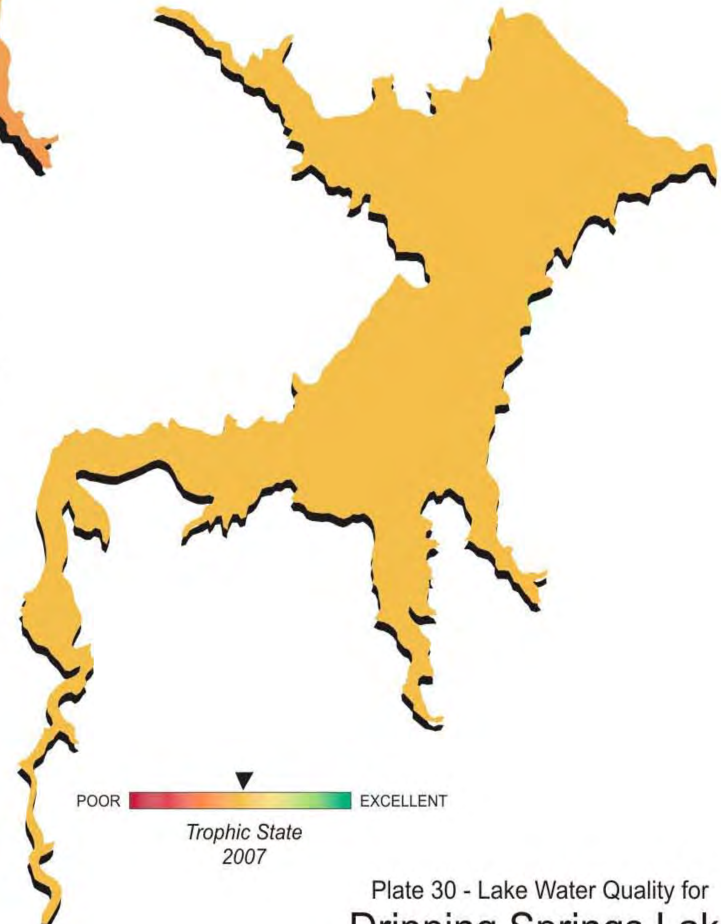


Figure 39a-39f. Graphical representation of data results for Dripping Spring Lake.

Plate 30 - Lake Water Quality for
Dripping Springs Lake

Lake Data

Owner	City of Okmulgee
County	Okmulgee
Constructed in	1976
Surface Area	1,150 acres
Volume	16,200 acre/feet
Shoreline Length	18 miles
Mean Depth	14.09 feet
Watershed Area	25 square miles



Duncan Lake

Duncan Lake is a 500-acre waterbody, located in Stephens County, which serves as a water supply and recreation reservoir for the city of Duncan. Duncan Lake was sampled for four quarters, from November 2006 through August 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the surface at all sites during the study period. The lake-wide annual turbidity value was 15 nephelometric turbidity units (NTU), true color was 34 units, and secchi disk depth was 58 centimeters in 2007. Based on these three parameters, Duncan Lake had average water clarity in comparison to other Oklahoma reservoirs. The results for water clarity were not as good as that observed in 2005 and are likely the result of the increased rainfall that occurred last year. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 57 (Plate 31), indicating the lake was eutrophic, with high levels of productivity and nutrients. The TSI values were fairly consistent with all values in the mid to upper eutrophic except during the summer when hypereutrophic conditions were observed. Seasonal turbidity values are displayed in Figure 40a. All turbidity values recorded during the study period were below the Oklahoma Water Quality Standard (WQS) of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. With 100% of the values below the standard, the Fish and Wildlife Propagation (FWP) beneficial use is fully supported based on turbidity. Seasonal true colors are displayed in Figure 40b. Of the twenty true color values collected 3 (15%) were above the aesthetics WQS of 70 units (see Figure 3840b). Applying the same default protocol, the Aesthetics beneficial use is considered partially supported.

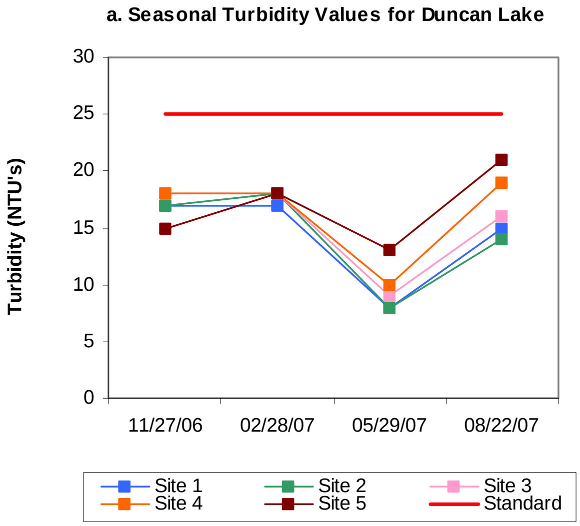
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity; oxidation-reduction potential and salinity were recorded at all five sample sites in 2006-2007. Salinity values ranged from 0.12 parts per thousand (ppt) to 0.24 ppt, which is within the range of values observed in Oklahoma reservoirs. Specific conductivity ranged from 244.5 µS/cm to 472.2 µS/cm, indicative of moderate levels of current conducting ions (chlorides and salts) present in the lake system. The pH values were neutral to slightly alkaline ranging from 7.32 to 8.44 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. With 100% of collected values within the acceptable range Duncan Lake is meeting its FWP beneficial based on pH. Oxidation-reduction potentials (ORP) ranged from 95mV in the summer to 426 mV in the fall. In general, reducing conditions were not present at this reservoir during the 2006-2007-sample year. Duncan Lake was not thermally stratified during the fall, winter and spring quarters (see Figure 40c-40e) and the water column was well mixed and oxygenated. During the summer, dissolved oxygen generally remained above 5 mg/L. Anoxic conditions were present only in the hypolimnion between 7 meters and the lake bottom at 7.7 meters (Figure 40f). Similar conditions were also recorded at site 2, accounting for 22% of the water column to be less than 2.0 mg/L. If the D.O. values are less than 2.0 mg/L for greater than 70% of the water column the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70 % of the water column, the FWP beneficial use is deemed partially supported. With 11-22% of the water column below 2.0 mg/L the FWP beneficial use is supported at Duncan Lake. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

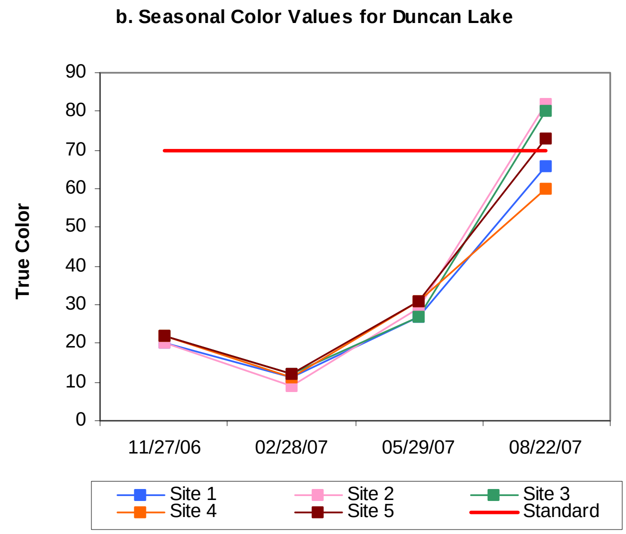
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. Due to quality control issues minimum data requirements were not met, therefore the PBCR beneficial use cannot be assessed at this time.

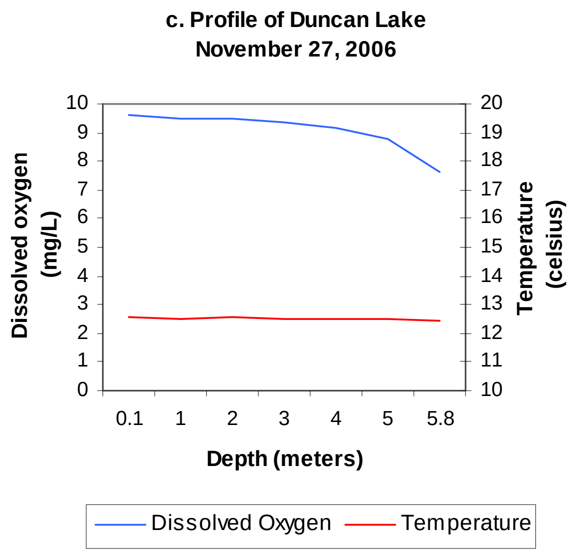
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.73 mg/L at the surface. Surface TN ranged from 0.59 mg/L to 0.84 mg/L with the highest values recorded in the winter quarter and lowest in the spring. The lake-wide total phosphorus (TP) average was 0.028 mg/L at the surface. TP was highest in the summer quarter but lowest were observed in the spring with values ranging from 0.016 mg/L to 0.039 mg/L. The nitrogen to phosphorus ratio (TN:TP) was 26:1 for sample year 2006-2007. This value is higher than 7:1, characterizing the lake phosphorus limited (Wetzel, 1983).

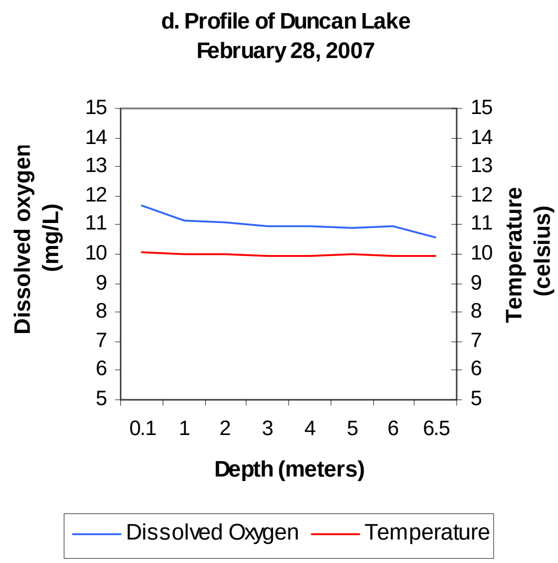
Duncan Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

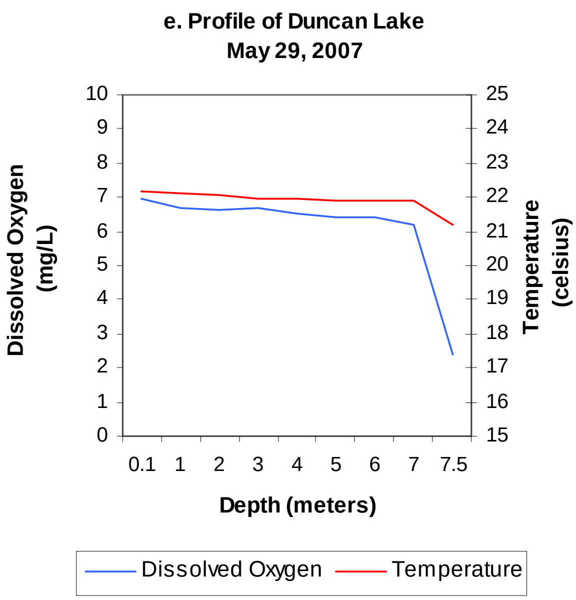
In summary, Duncan Lake was classified as eutrophic with high primary productivity and nutrient levels (Plate 31). Water clarity was average based on turbidity, true color and secchi disk depth. The lake is considered supporting the FWP beneficial use based on turbidity, pH values recorded in 2006-2007. The FWP beneficial use is also supported as it relates to dissolved oxygen, as anoxic conditions were present in only 11-22% of the water column during the summer quarter. The Aesthetics beneficial use is considered supported based on the trophic status however the beneficial us is partially supporting for true color as 15% of reported values exceeded the WQS of 70 units. Due to minimum data requirements not being met an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.











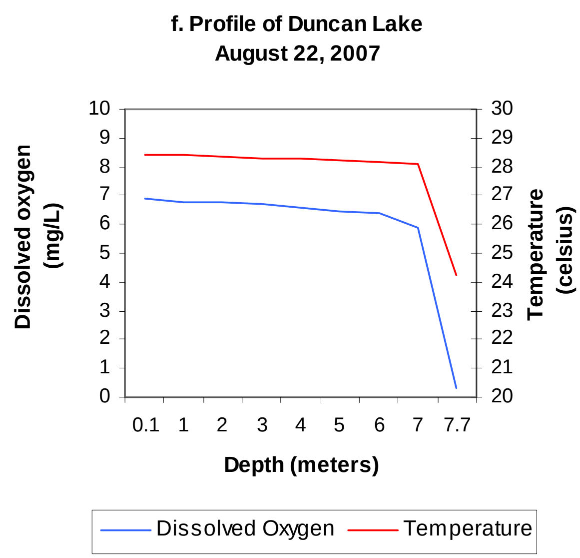
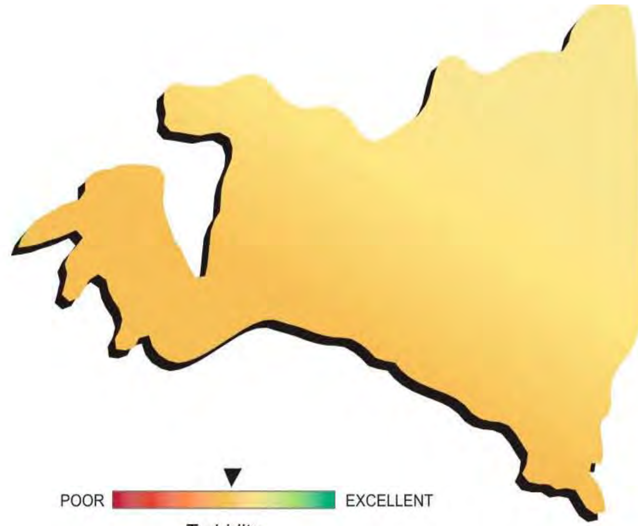
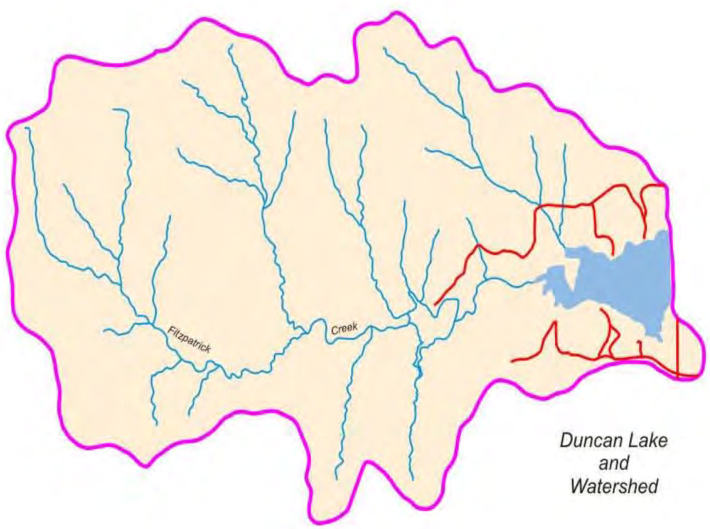


Figure 40a-40f. Graphical representation of data results for Duncan Lake.

Duncan Lake
Location



POOR EXCELLENT
Turbidity
2007



Duncan Lake
and
Watershed

POOR EXCELLENT
Trophic State
2007

Lake Data	
Owner	City of Duncan
County	Stephens
Constructed	1960
Surface Area	500 acres
Volume	7,200 acre/feet
Shoreline Length	4 miles
Mean Depth	14.40 feet
Watershed Area	11 square miles

Plate 31 - Lake Water Quality for
Duncan Lake

LAKES MONITORING PROGRAM

Lake El Reno

Lake El Reno, located in Canadian County, is a 170-acre lake owned by the city of El Reno and serves as a flood control and recreation reservoir. Lake El Reno was sampled for four quarters, from November 2006 through July 2007.

Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 36 nephelometric turbidity units (NTU), true color was 86 units, and secchi disk depth was 35 centimeters in 2007. Based on these three parameters, Lake El Reno had fair to poor water clarity in comparison to other Oklahoma reservoirs. These results are similar to those in 2005. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 65 (Plate 32), indicating the lake is hypereutrophic, indicative of excessive levels of productivity and nutrient rich conditions. This value is similar to the TSI calculated in 2005 (TSI=63), indicating no significant increase or decrease in productivity has occurred since the previous evaluation. The TSI values were primarily hypereutrophic throughout the year. The only exception to this was sites 1 and 2, which were mesotrophic in the summer quarter. Based on the current trophic classification, the lake will be recommended for listing in the next Oklahoma Water Quality Standards (WQS) revision process as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Seasonal turbidity values are displayed in (Figure 41a. Turbidity values ranged from a low of 20 NTU to a maximum of 83 NTU. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. Available flow and rainfall data suggest that the peak in turbidity observed in July is likely the result of a storm event. Not including this data the Fish & Wildlife Propagation (FWP) beneficial use is not supported at Lake El Reno with 25% of the remaining values recorded exceeding the WQS of 25 NTU. Seasonal true color values are displayed in Figure 41b. Similar to turbidity a peak in color values occurred during the summer quarter. Of the twelve values collected, three (25%) exceeded the Aesthetics WQS of 70 units. Beacause this too is likely the result of storm events, the Aesthic beneficial use is considered supported for the current sample year.

In 2006-2007 vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all three sample sites. The salinity ranged from 0.53 parts per thousand (ppt) to 0.79 ppt, which is higher than most Oklahoma reservoirs. Specific conductivity ranged from 1019 µS/cm in the spring to 1494 µS/cm in the fall. These values indicate the presence of moderate to high levels of current conducting compounds (salts) in the lake, consistent with higher recorded salinity concentrations. The pH values ranged from 8.25 to 8.45, representing a slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. With 100% of collected values within the acceptable range, Lake El Reno is meeting its FWP beneficial use for pH. Oxidation-reduction potentials (ORP) were positive at all sites and ranged from 412 mV to 435 mV in the fall. Reducing conditions were not present in this reservoir during the study period. The lake was not stratified during any of the sampling quarters (see Figure 41c-41e) and dissolved oxygen (D.O.) levels were generally above 6.0 mg/L. Due to equipment failure, no profile data is available for the summer quarter; however it is unlikely that stratification would've occurred. The absence of stratification may be attributed to the shallow nature of this reservoir where wind and wave action keep the lake well mixed. If the D.O. values are less than 2.0 mg/L for greater than 70% of the water column the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70 % of the water column, the FWP beneficial use is deemed partially supported. With 100% of the water column above 2.0 mg/L the FWP beneficial use is supported at Lake El Reno. The lake was also sampled for total dissolved solids, chlorides and sulfates to assess the Agriculture beneficial use. Sampling 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. Of the 10 enterococci samples collected, 4 (40%) exceeded the screening level of 61 cfu/ml; however the geometric mean of 33 cfu/ml was not exceeded. The PBCR is therefore considered supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.75 mg/L at the surface. The TN at the surface ranged from 1.39 mg/L in the spring to 2.05 mg/L in the fall. The lake-wide total phosphorus (TP) average was 0.276 mg/L at the surface. The total phosphorus at the surface ranged from 0.093 mg/L in the winter to 0.670 mg/L in the summer quarter. These values are very similar to those seen in 2005. The nitrogen to phosphorus ratio (TN:TP) was 6:1 for sample year 2007. This value is very close to 7:l, characterizing the lake as nitrogen limited or possibly co-limited (Wetzel, 1983).

Lake El Reno was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Lake El Reno was classified as hypereutrophic, indicative of high primary productivity and nutrient conditions (Plate 32). This classification is consistent with that of 2005, which had a TSI of 63. Based on the current trophic classification, the lake will be recommended for listing in the next Oklahoma Water Quality Standards (WQS) revision process as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Water clarity was fair to poor based on turbidity, true color and secchi disk depth. The lake is fully supporting the FWP beneficial use for pH and dissolved oxygen levels, but not supporting based on turbidity. Although 25% of the true color values recorded exceeded the WQS of 70 units the Aesthetics beneficial use is considered supported as this spike in values is liely the result of seasonal storm events that occurred during the summer.

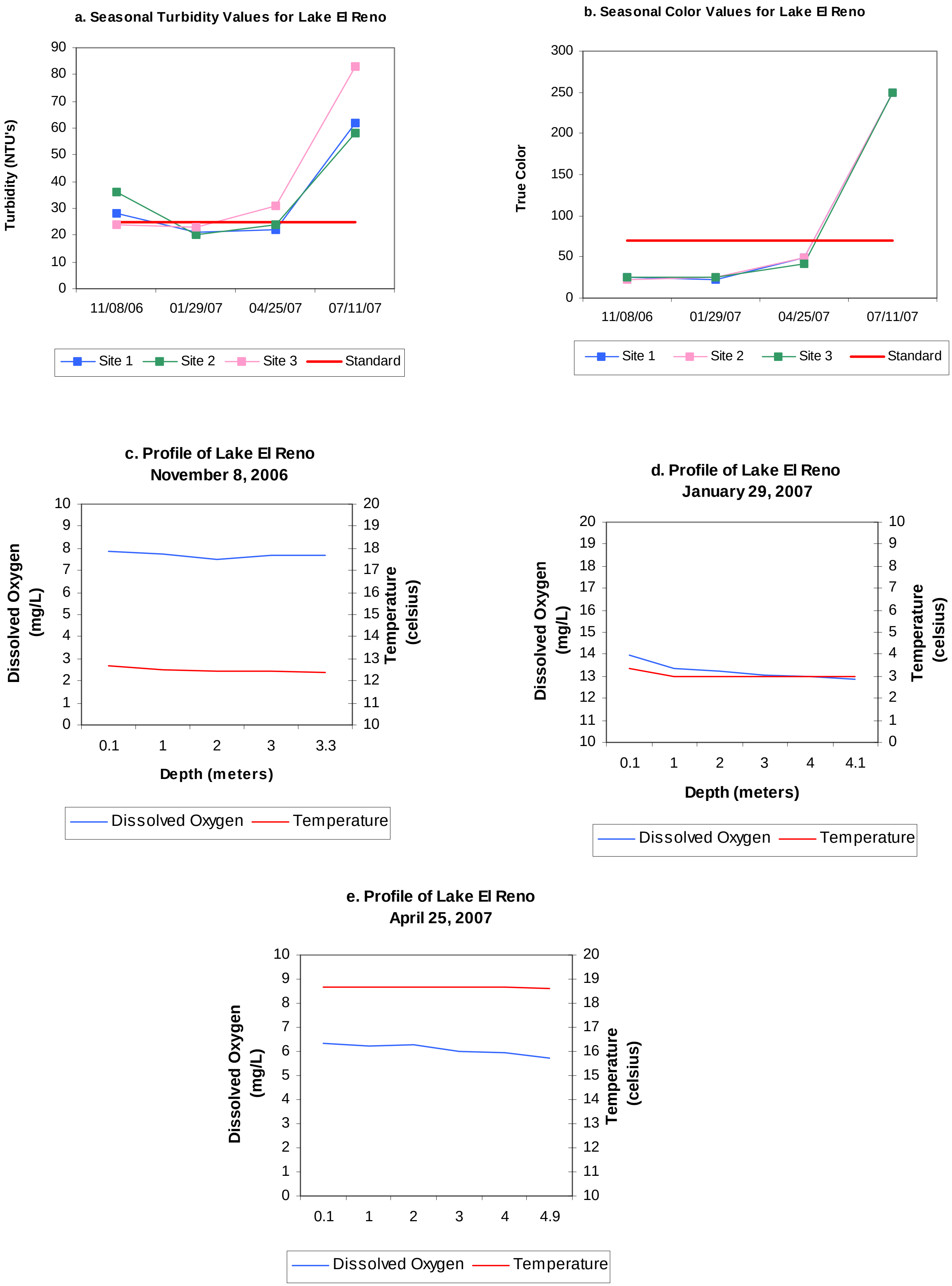


Figure 41a-41e. Graphical representation of data results for Lake El Reno.

El Reno Lake Location

El Reno Lake and Watershed

Lake Data	
Owner	City of El Reno
County	Canadian
Constructed	1966
Surface Area	170 acres
Volume	709 acre/feet
Shoreline Length	4 miles
Mean Depth	4.17 feet
Watershed Area	4,242 acres

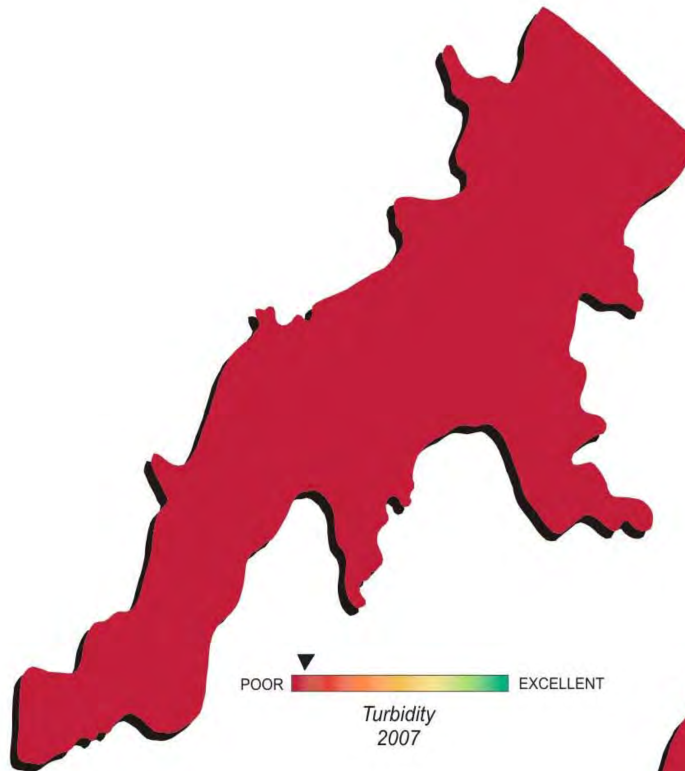


Plate 32 - Lake Water Quality for

Lake El Reno

Lake Elk City

Lake Elk City, located in Beckham County, was constructed in 1970 and is owned and operated by the City of Elk City. The lake is utilized by the city for flood control and recreational purposes. Lake Elk City was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 15 NTU (Plate 33), true color was 26 units, and secchi disk depth was 56 centimeters. Results were similar to those observed during the 2003-2004 evaluation. Based on these three parameters, Lake Elk City had fair to poor water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 59 (Plate 33), indicating the lake was eutrophic, indicative of high levels of productivity and nutrient rich conditions. The TSI values varied seasonally from eutrophic in the winter and spring, with one mesotrophic value present at site 2 in the spring quarter, and hypereutrophic conditions present in the fall and summer quarters. Lake Elk City is currently listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. The lake should be further studied to understand the nutrient dynamics involved. Turbidity values were all below the WQS of 25 NTU (see Figure 42a). According to the Use Support Assessment Protocols (USAP) specified in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Lake Elk City was supporting its Fish & Wildlife Propagation (FWP) beneficial use based on OAC 785:46 during sample year 2005-2006. All true color values were below the Aesthetics WQS of 70 units (See Figure 42b). Applying the same default protocol to determine the short-term average for true color, the Aesthetics beneficial use is supported based on the reported true color values.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were performed at all sample sites and yielded the following results. Salinity readings ranged from 0.30 parts per thousand (ppt) to 0.39 ppt, slightly higher than most values recorded in Oklahoma reservoirs. Readings for specific conductivity were also slightly higher than values normally seen in most Oklahoma reservoirs. Specific Conductivity ranged from 593.3 µS/cm in the fall quarter to 749.9 µS/cm in the spring quarter, indicating moderate to slightly elevated concentrations of electrical current conducting compounds (salts) in the water column. Oxidation-reduction potentials (redox) ranged from 374 mV to 448 mV, indicating reducing conditions were not present during any sampling events. Lake pH values were neutral to slightly alkaline, ranging from 7.70 to 8.49 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its

FWP beneficial use. Lake Elk City was fully supporting its FWP beneficial use based on pH values collected during the study period. The lake was not thermally stratified during the fall and winter quarters (see Figure 42c-42d). The water column was evenly mixed and oxygenated during these two sampling intervals with dissolved oxygen concentrations above 7.0mg/L (see Figure 42c-45d). In the spring the lake was stratified at both sites 1 and 2 with anoxic conditions present from 6 meters below the surface to the lake bottom of 7.3 meters (Figure 42e). Due to equipment failure, there is no profile data available for the summer sampling interval. When D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. The FWP beneficial use is considered supported based on dissolved oxygen data collected in the first three sampling intervals. Because the summer profile data is missing an assessment for that season cannot be made at this time. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.91 mg/L during the study period. The TN at the surface ranged from 0.74 mg/L to 1.08 mg/L. The highest surface TN value was reported in the summer quarter and the lowest was recorded at site 3 in the spring quarter. The lake-wide total phosphorus (TP) average for 2005-2006 was 0.055 mg/L. The TP ranged from 0.037 mg/L to 0.067 mg/L at the lake surface. Similar to TN the lowest total phosphorus value was recorded at site 3 in the spring; however the highest values occurred in the fall quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 17:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

Lake Elk City was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Lake Elk City was as eutrophic, indicative of high primary productivity and nutrient rich conditions (Plate 33). This is consistent with historical data collection efforts in 2004 (TSI=56), indicating no significant increase or decrease in productivity has occurred over time. The lake is fully supporting its FWP beneficial based turbidity pH and D.O. concentrations recorded throughout the study period. With 100% of the true color values below the WQS of 70 units, Elk City Lake is fully supporting its Aesthetics beneficial as it relates to color. Based on the current NLW listing the lake is considered nutrient threatened and should be studied more intensively to confirm the Aesthetics beneficial use non-support status as well as understand the nutrient dynamics at work in the system. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through

September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

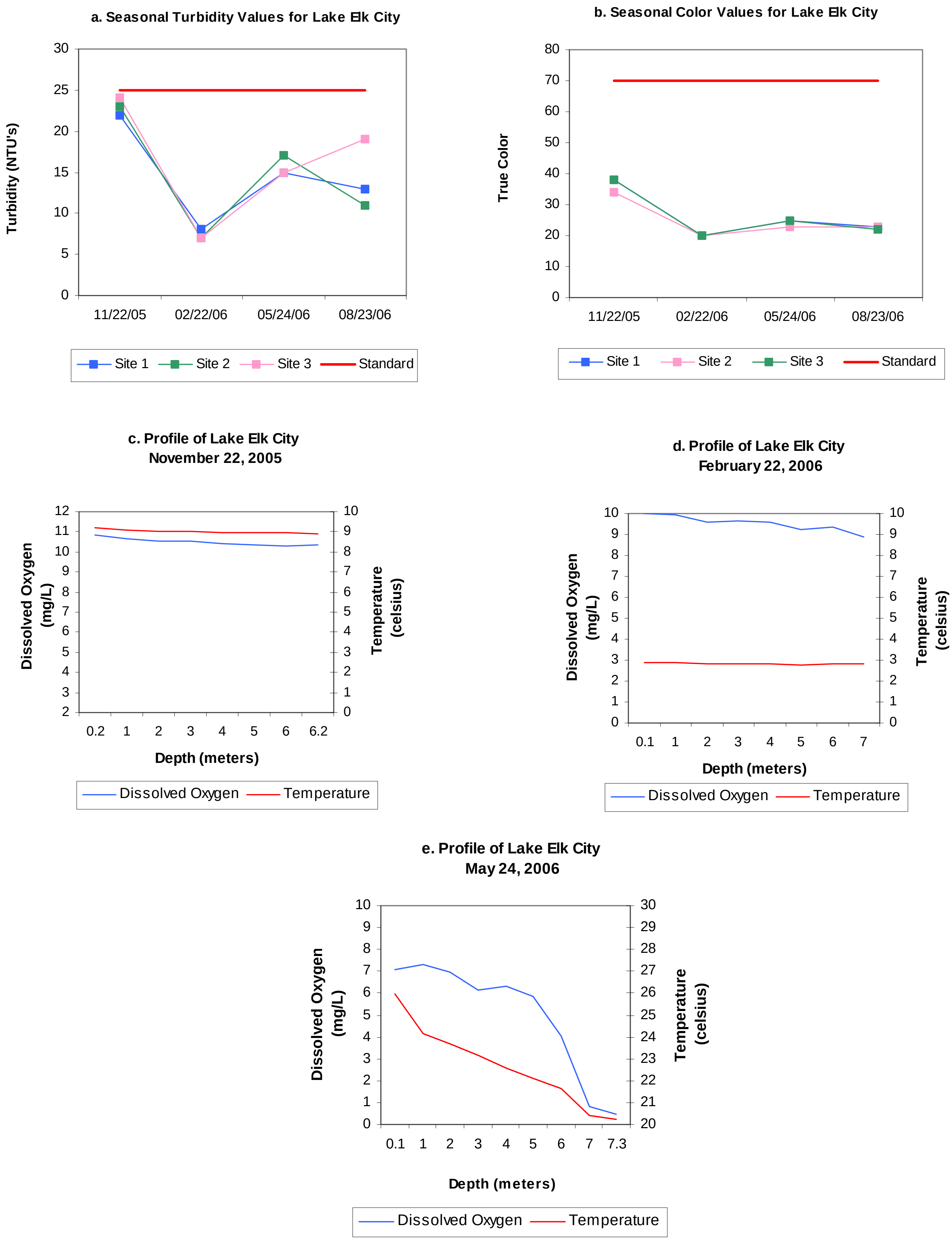


Figure 42a-42e. Graphical representation of data results for Lake Elk City.

Lake Data

Owner	City of Elk City
County	Beckham
Constructed in	1970
Surface Area	240 acres
Volume	2,583 acre/feet
Shoreline Length	5 miles
Mean Depth	10.76 feet
Watershed Area	23 square miles

Plate 33 - Lake Water Quality for

Elk City Lake

LAKES MONITORING PROGRAM

Lake Ellsworth

Lake Ellsworth is a 5,600-acre reservoir that is owned and operated by the City of Lawton. The lake was constructed in 1962. The lake was constructed to serve as a water supply for the city and provide recreational opportunities to the public. Lake Ellsworth was sampled for four quarters, from October 2006 through July 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 45 nephelometric turbidity units (NTU) true color was 52 units, and secchi disk depth was 48 centimeters. Based on these three parameters, Lake Ellsworth had fair to poor water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 57 (Plate 34), classifying the lake as eutrophic, indicative of high levels of productivity and nutrient rich conditions. This value is consistent with the 2004 evaluation, which had a TSI of 54. The TSI values varied seasonally with mesotrophic values present in the winter and eutrophic to hypereutrophic conditions in the fall, spring and summer sampling intervals. Turbidity values for all sites were greater than the Oklahoma Water Quality Standard (WQS) of 25 NTU during the first three quarters and just under the standard in the summer (see Figure 43a). According to Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). The Fish and Wildlife Propagation (FWP) beneficial use is considered not supported at Lake Ellsworth with 80% of the sample values exceeding the criteria. Seasonal true color values are displayed in Figure 43b Of the twenty (20) samples collected, only 2 exceeded the Aesthetics WQS of 70 units. Applying the same default protocol, the Aesthetics beneficial use is partially supported based on true color values collected during the sample year.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were performed at all sample sites and yielded the following results. Salinity readings ranged from 0.11 parts per thousand (ppt) to 0.30 ppt, which is slightly higher than the expected range of values recorded for Oklahoma reservoirs. Readings for specific conductivity were within the range of expected values recorded for most Oklahoma reservoirs. Specific conductivity ranged from 235.1 µS/cm in the summer quarter to 591.6 µS/cm in the fall quarter. This indicates moderate to slightly elevated concentrations of electrical current conducting compounds (salts) in the water column. Oxidation-reduction potentials ranged from 110 mV to 474 mV, indicating reducing conditions were not present during 2006-2007 sampling. Lake pH values were neutral to slightly alkaline, ranging from 6.86 to 8.28 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. The FWP beneficial use is fully supported based on pH with all values within the acceptable range. The lake was not thermally stratified during the fall, winter or spring quarters (see Figure 43c-43e) and the water column was evenly mixed and oxygenated. In the fall there appears to be a sharp drop in the dissolved oxygen (D.O.) between 12 meters and the lake bottom of 12.2 meters. This is likely the result of the probe resting on the lake bottom instead of stratification. In the summer quarter the lake was thermally stratified between 3 and 4 meters below the surface, with dissolved oxygen (D.O.) concentrations dropping below 2.0 mg/L from 5 meters to the lake bottom at 13 meters (see Figure 43f). Anoxic conditions were present in approximately 64% of the water column at site 1, the dam, at this time. The remaining sample sites 2-5 also exhibited stratification to varying degrees. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With approximately 14-64% of the water column experiencing anoxic conditions during summer sampling, the FWP beneficial use according to USAP (OAC 785:46-15-5) is partially supported. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September 2007. The PBCR beneficial use cannot be determined as minimum data requirements were not met due to quality control issues for Fecal Coliform. Of the 10 enterococci samples collected, only 1 exceeded the screening level of 61 cfu/ml and the geometric mean (10.8 cfu/ml) was below the prescribed mean standard of 33 cfu/ml. Similarly, only 1 *E.coli* sample exceed the screening level of 235 cfu/ml; however the geometric mean of (10.3 cfu/ml) was below the prescribed mean of 126 cfu/ml.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.83 mg/L at the lake surface. The TN at the surface ranged from 0.57 mg/L to 0.96 mg/L. The highest surface TN value was reported in the spring quarter and the lowest was in the summer quarter. The lake-wide total phosphorus (TP) average was 0.092 mg/L at the lake surface. The TP ranged from 0.056 mg/L to 0.235 mg/L at the lake surface. The highest surface TP values were reported in the fall quarter and the lowest were in the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 9:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Lake Ellsworth was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Lake Ellsworth was as eutrophic, indicative of high primary productivity and nutrient rich conditions (Plate 34). This is consistent with previous data collections efforts, indicating no significant change in productivity has occurred over time. Water clarity was fair to poor based on turbidity, secchi disk depth and true color values reported during the study period. The FWP beneficial use is considered not supported for turbidity at Lake Ellsworth with 80% of the sample values exceeding the criteria of 25 NTU. The Aesthetics beneficial use is fully supported based on trophic status; however is partially supporting the use as it relates to true color with 10% of the values exceeding 70 units. The FWP beneficial use is considered supported for pH and partially supported for dissolved oxygen due to anoxic conditions present in the summer quarter. Bacteriological samples were also collected to assess the Primary Body

Contact Recreation (PBCR) beneficial use. The PBCR is considered supported for *E.coli* and enterocci; however due to minmum data requirements not being met for fecal coliform an assessment of this parameter cannot be made. In 2006 a bathymetric map of Ellsworth was completed at the request of the OWRB's Planning and Management Division. The purpose of this study was to collect bathymetric on high hazard dams that are located on or release into East Cache Creek. Additionally the bathymetric data was used to update storage capacity figures and bottom contours of the lake (Figure 44). For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.

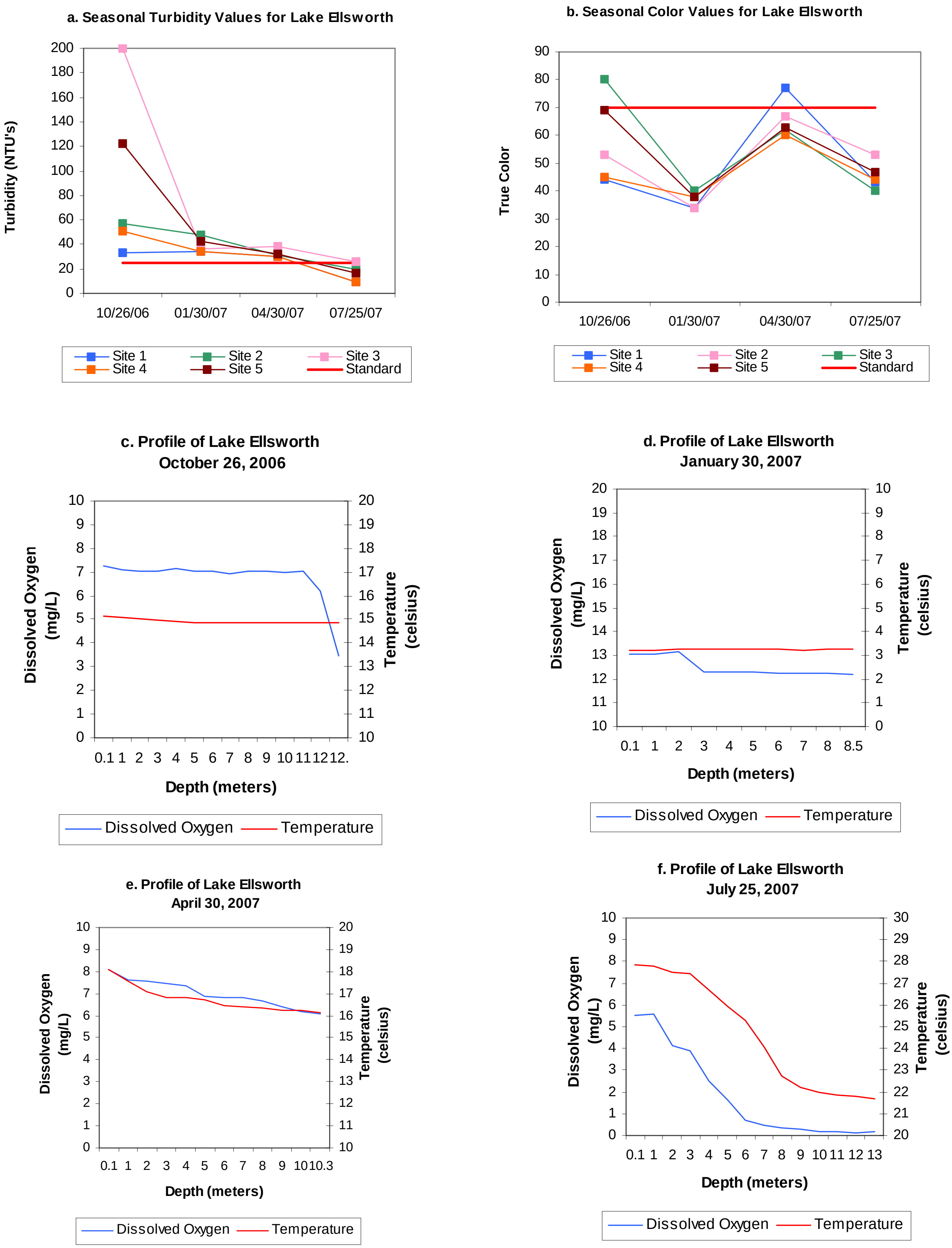


Figure 43a-43f. Graphical representation of data results for Lake Ellsworth.

Plate 34 - Lake Water Quality for Lake Ellsworth

Lake Ellsworth and Watershed

Lake Ellsworth Location

Turbidity 2007

Trophic State 2007

Lake Data	
Owner	City of Lawton
County	Comanche
Constructed	1962
Surface Area	5,600 acres
Volume	95,200 acre/feet
Shoreline Length	43 miles
Mean Depth	17.00 feet
Watershed Area	247 square miles

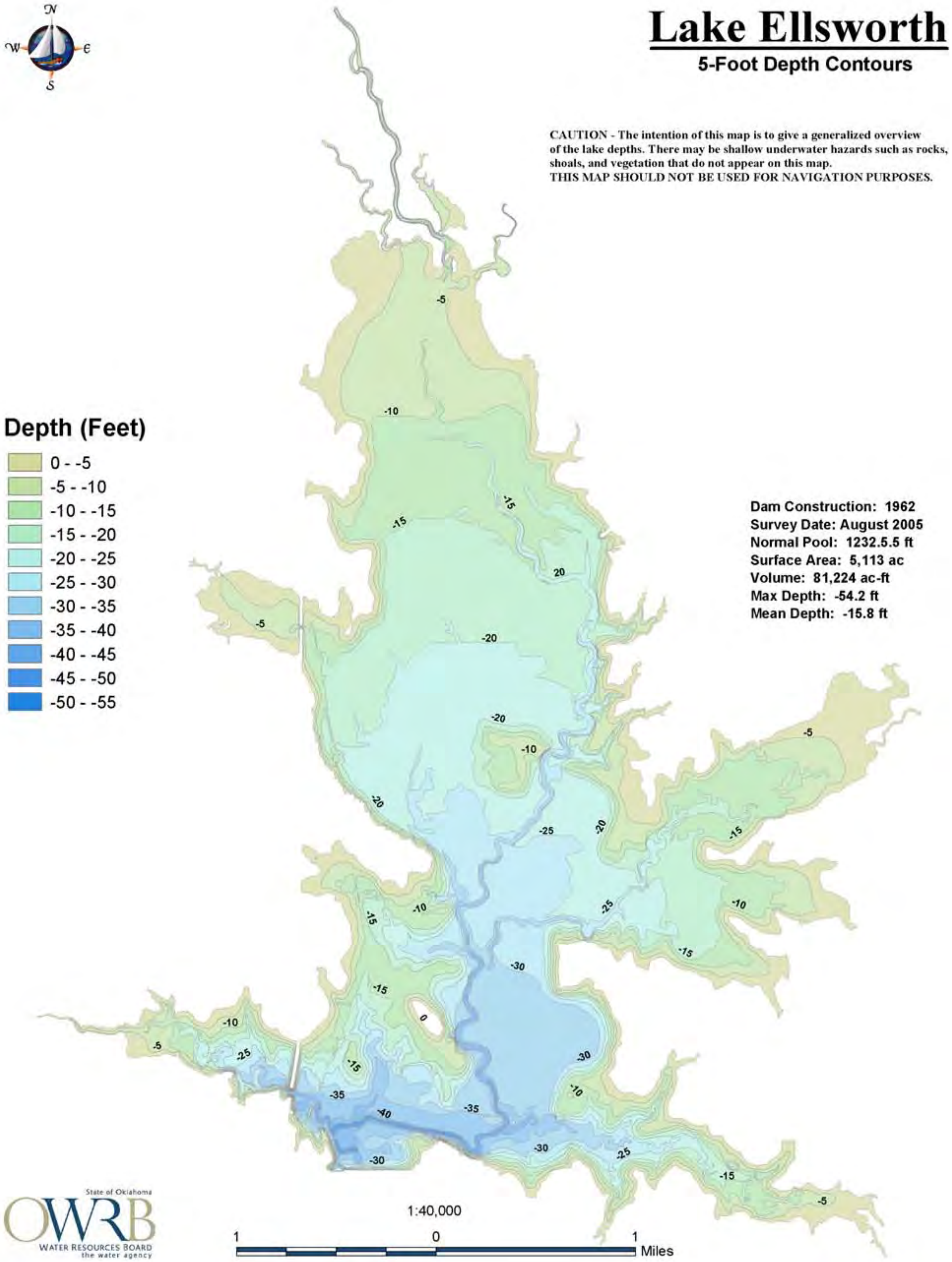


Figure 44. Bathymetric Map of Lake Ellsworth

Elmer Thomas Lake

Elmer Thomas Lake is a 334-acre reservoir, located in Comanche County, which was constructed by the U.S. Department of Interior for the purpose of recreation. Elmer Thomas Lake was sampled for four quarters from October 2006 through July 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity was 2 nephelometric turbidity units (NTU), true color was 27 units and secchi disk depth was 175 centimeters. Water clarity was excellent at Elmer Thomas Lake and is similar to results from the 2005 evaluation. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI was 39 (Plate 35), indicating the lake was oligotrophic, with low primary productivity and nutrient levels in sample year 2006-2007. The TSI values for all sites were consistent with all values in the oligotrophic category. This value is similar to the one calculated in 2003 (TSI=34) and 2005 (TSI=33), indicating no significant increase or decrease in productivity. Seasonal turbidity values are displayed in Figure 45a. Turbidity values were all well below the Oklahoma Water Quality Standard (WQS) of 25 NTU with values ranging from a low of 1 NTU to a maximum of 5 NTU. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. With 100% of the values recorded below the WQS of 25 NTU the Fish & Wildlife Propagation (FWP) beneficial use considered fully supported at Elmer Thomas Lake. Seasonal true color values are displayed in Figure 45b. Similar to turbidity, recorded true color values were very low with all values below the Aesthetics WQS of 70 units. Applying the same default protocol, the Aesthetics beneficial use is fully supported based on true color.

In 2006-2007 vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.01 parts per thousand (ppt) to 0.07 ppt, which is within the range of values observed in Oklahoma reservoirs. Specific conductivity ranged from 36.2 µS/cm to 150.6 µS/cm, indicative of minimal levels of current conducting ions (chlorides and salts) in the lake system. The values for pH were generally neutral to slightly alkaline ranging from 5.43 to 8.13 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 15% of collected values less than 6.5 Elmer Thomas Lake is partially supporting its FWP beneficial based on pH. Oxidation-reduction potentials (ORP) ranged from 41mV in the summer to 522 mV in the fall. Low redox values in the hypolimnion are not uncommon when a lake is strongly thermally stratified and anoxic conditions are present as seen in the summer. In the fall quarter, thermal stratification occurred between 12-13 meters below the surface with dissolved oxygen (D.O.) less than 2 mg/L from 14 meters to the lake bottom of 18.4 meters. Elmer Thomas Lake was not thermally stratified during the winter and D.O. levels were generally above 6.0 mg/L (see

Figure 45d). In the spring, a gradual thermal stratification was evident however D.O. remained above 5.0 mg/L. During the summer quarter the lake was strongly thermally stratified at all sample sites (Figure 45f). At sites 1, 2 and 5 stratification occurred between 3-4 meters below the surface with anoxic condition comprising 60-76% of the water column. If the D.O. values are less than 2.0 mg/L for greater than 70% of the water column the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70 % of the water column, the FWP beneficial use is deemed partially supported. With anoxic conditions present in 43-76% of the water column during the summer, the FWP beneficial use is considered not supporting at Elmer Thomas Lake. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. All sample results were at or below the detection limit, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.39mg/L at the surface. Surface TN ranged from 0.31 mg/L to 0.63 mg/L with the highest values recorded in the fall quarter and lowest in the winter. The lake-wide total phosphorus (TP) average was 0.009 mg/L at the surface. Surface TP was highest in the summer quarter and lowest in the fall with values ranging from 0.005 mg/L to 0.015 mg/L. The nitrogen to phosphorus ratio (TN:TP) was 46:1 for sample year 2007. This value is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

Elmer Thomas Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Elmer Thomas Lake was classified as oligotrophic with low primary productivity and nutrient levels in 2006-2007. This classification is consistent with that of previous evaluations, indicating no significant increase or decrease in productivity has taken place. Water clarity continues to be excellent based on turbidity, true color and secchi disk depth. The lake is currently supporting the FWP beneficial use based on turbidity and dissolved oxygen values recorded during the sample year. With 15% of the recorded values less than 6.5 units the lake is considered partially supporting the FWP use as it relates to pH. The Aesthetics beneficial use is also supported based on the trophic status and for true color. Bacteriological samples were collected during the recreation season during sample year and the Primary Body Contact Recreation (PBCR) beneficial use is considered supported.

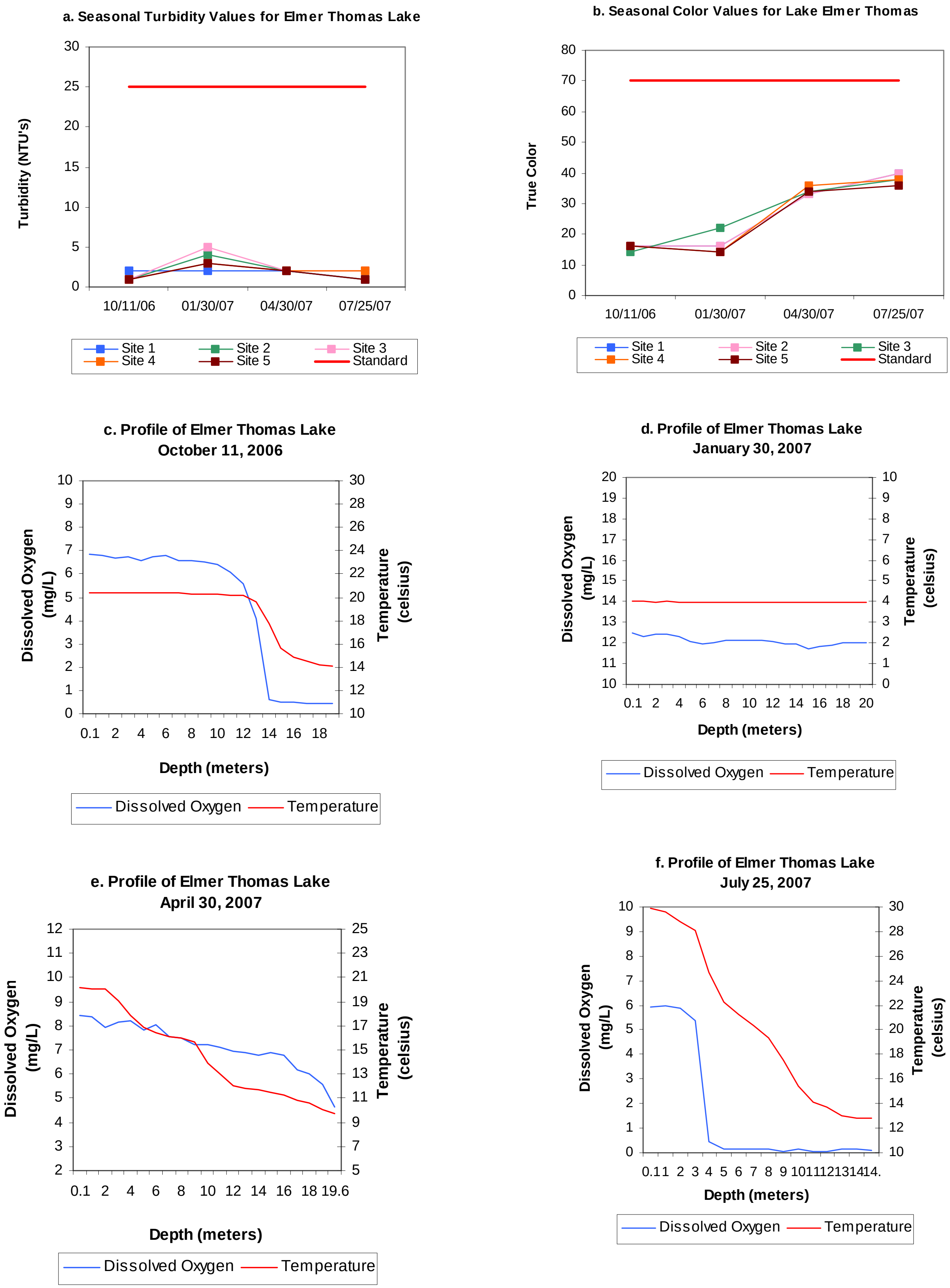
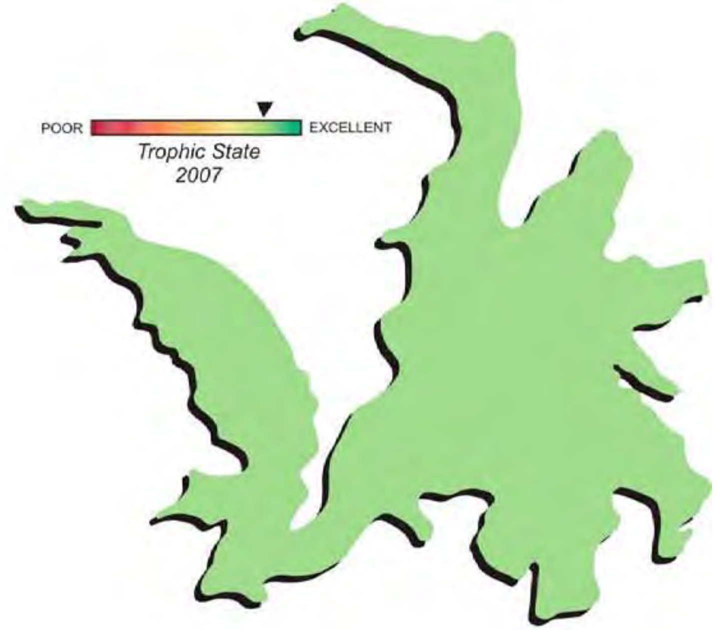
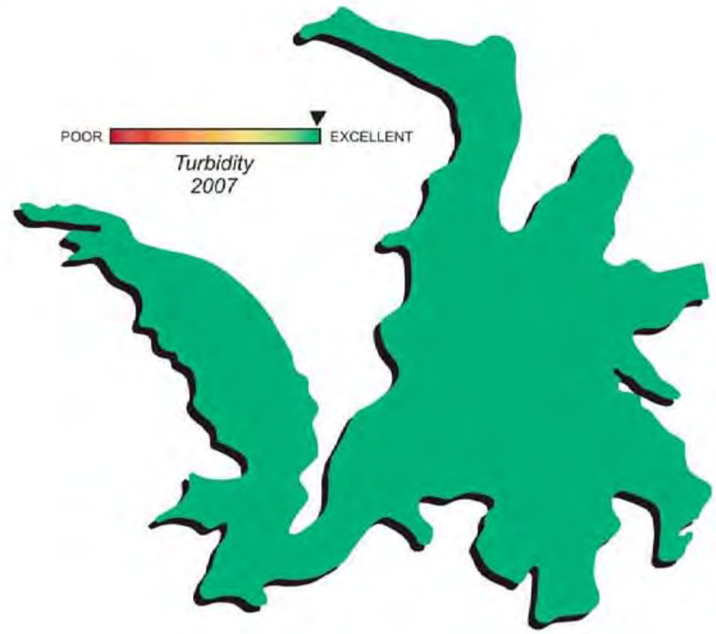


Figure 45a-45f. Graphical representation of data results for Elmer Thomas Lake.

Elmer Thomas Lake and Watershed


Elmer Thomas Lake Location





N
W E
S

Lake Data

Owner	U.S. Dept. of the Interior
County	Comanche
Constructed in	N/A
Surface Area	334 acres
Volume	12,000 acre/feet
Shoreline Length	8 miles
Mean Depth	35.92 feet
Watershed Area	4,377 acres

Plate 35 - Lake Water Quality for
Elmer Thomas Lake

Lake Etling

Lake Etling was sampled for four quarters, from September 2003 through June 2004. Water quality samples were collected at 3 sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites. Due to drought conditions and low lake levels a bottom sample was not taken at any point during the sample year. The lake-wide annual turbidity value was 65 NTU (Plate 36), true color was 18 units, and secchi disk depth was 22 centimeters in 2004. Based on these three parameters, Lake Etling had fair water clarity in comparison to other Oklahoma reservoirs. Water clarity differed from 2001 with both an increase in turbidity and a decline in the average secchi disk depth. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 72, indicating the lake was hypereutrophic, indicative of excessive levels of productivity and nutrient rich conditions. This value is greater than the TSI in 2001 (TSI=57), indicating a significant increase in trophic status since previous data collection efforts were conducted as is likely related to the decrease in lake levels. The TSI values were hypereutrophic at all sites throughout the study period. Based on the trophic classification, the lake will be recommended for listing in the next Oklahoma Water Quality Standards (WQS) revision process as a Nutrient Limited watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Seasonal turbidity values are displayed in (Figure 46a). Only three of the twelve turbidity values were below the WQS of 25 NTU, constituting a listing as not supporting the Fish & Wildlife Propagation (FWP) beneficial use. According to USAP (Oklahoma Administrative Code 785:46-15-5), a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. All true color values were below the aesthetics WQS of 70 units for all four seasons at all sites (Figure 46b). Applying the same default protocol for determining the short-term average for true color, the Aesthetics beneficial use is considered supported.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity values ranged from 0.9 parts per thousand (ppt) to 1.4 ppt, which is higher than the expected range for most Oklahoma lakes. Salinity values indicate a moderate to high presence of chlorides or other salts in the lake. Specific conductivity values exhibited a similar pattern and were somewhat higher than most Oklahoma reservoirs, with values ranging from 1688 µS/cm in the fall to 2596 µS/cm in the summer, which is indicative of a high content of electrical current conducting compounds or salts throughout the lake system. Oxidation-reduction potentials (redox) ranged from 269 mV to 499 mV, indicating reducing conditions were not present during the study period. The pH was alkaline in nature with values ranging from 8.18 to 9.42 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Lake Etling is not supporting the FWP use, with

28% of the collected values falling outside the acceptable range. Slightly alkaline conditions seem to be common in the western part of the state and may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in this portion of the state. The lake was not thermally stratified during any of the four quarters sampled (see Figure 46c-44f). The water column was evenly mixed and oxygenated during the entire study period, which may be attributed to the shallow nature of the lake. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered fully supported at Lake Etling based on dissolved oxygen values. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2003-2004 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. Of the 10 samples none exceeded the prescribed screening level or geometric mean listed in the WQS. The PBCR beneficial use is therefore considered supported.

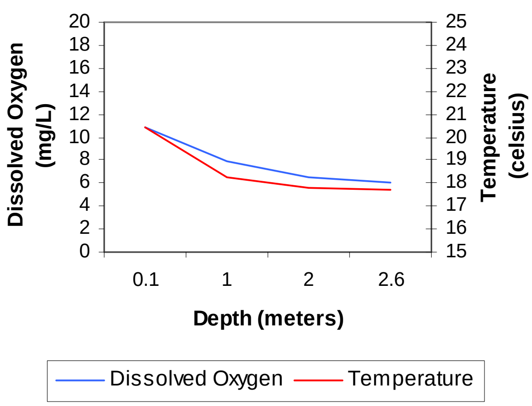
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 3.50 mg/L at the lake surface, much higher than seen in most Oklahoma lakes and reservoirs. The TN at the surface ranged from 2.31 mg/L to 4.51 mg/L. The highest was reported in the summer quarter and lowest surface TN value was reported in the fall quarter. The lake-wide total phosphorus (TP) average was 0.213 mg/L at the lake surface. The TP ranged from 0.122 mg/L to 0.293 mg/L at the lake surface. The highest surface TP values were reported in the spring quarter and the lowest were in the fall quarter. The total nitrogen phosphorus ratio (TN:TP) was 16:1 for sample year 2003-2004. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

In summary, Lake Etling was classified as hypereutrophic, indicative of excessive primary productivity and nutrient levels (Plate 36). Based on secchi disk depth, turbidity and true color, Lake Etling had fair water clarity in 2003-2004. The FWP beneficial use was fully supported based on dissolved oxygen; however the use is not supported as it relates to turbidity. The lake was also found to be “provisionally not supporting” the FWP use as it relates to pH with 28% of the values outside the 6.5 to 9 range listed in the WQS. The lake was fully supporting its Aesthetics beneficial use for true color. Based on the trophic classification, the lake will be recommended for listing in the next Oklahoma Water Quality Standards (WQS) revision process as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Of the 10 samples none exceeded the prescribed screening level or geometric mean listed in the WQS. The PBCR beneficial use is therefore considered supported. Lake Etling is owned and operated by the State of Oklahoma for the purpose of providing recreational opportunities to the citizens of Oklahoma.

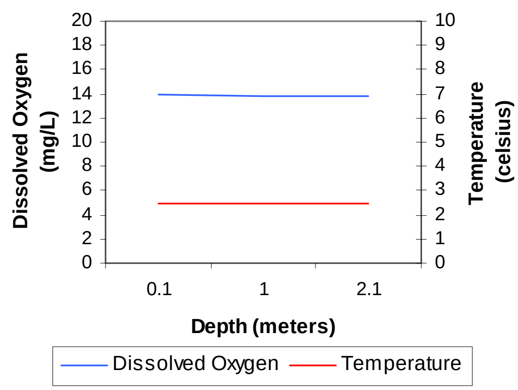
a. Seasonal Turbidity Values for Lake Etling

b. Seasonal Color Values for Lake Etling

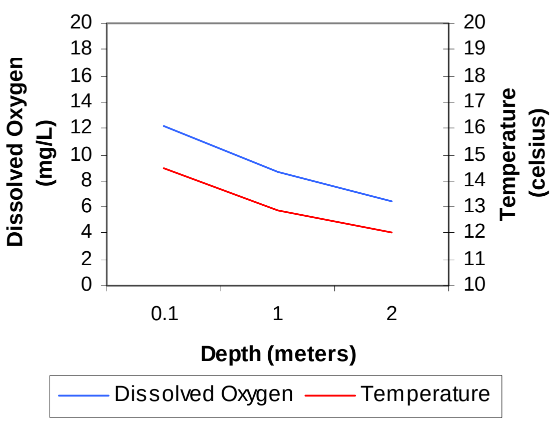
c. Profile of Lake Etling
September 15, 2003



d. Profile of Lake Etling
December 15, 2003



e. Profile of Lake Etling
March 23, 2004



f. Profile of Lake Etling
June 22, 2004

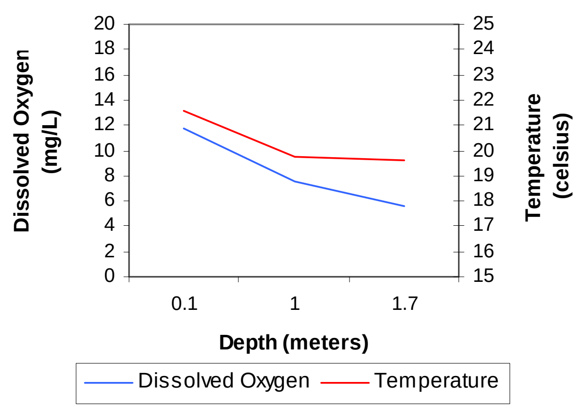
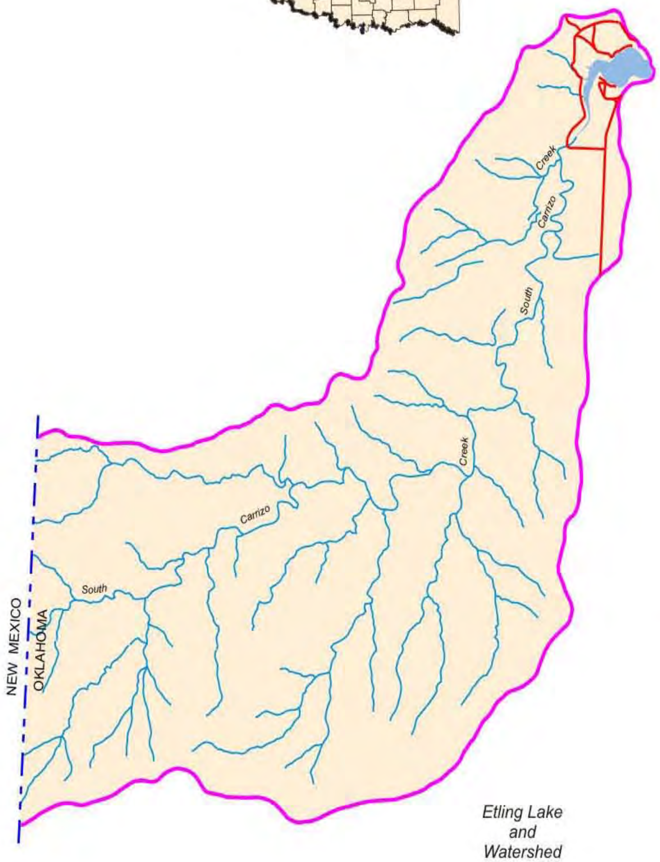
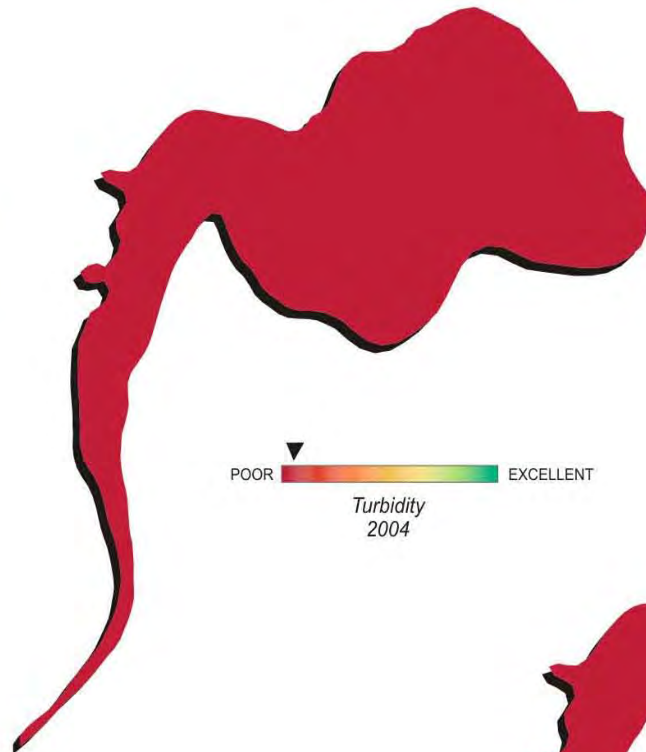


Figure 46a-46f. Graphical representation of data results for Lake Etling.





Lake Data

Owner	State of Oklahoma
County	Cimarron
Constructed in	1958
Surface Area	159 acres
Volume	1,717 acre/feet
Shoreline Length	5 miles
Mean Depth	10.80 feet
Watershed Area	37 square miles (OK only)

Plate 36 - Lake Water Quality for

Lake Etling

LAKES MONITORING PROGRAM

Eucha Lake

Eucha Lake is a 2,860-acre reservoir, located in Delaware County. The lake was constructed in 1952 and is owned by the city of Tulsa utilized for the purpose of water supply and recreation. Eucha Lake was sampled for four quarters from November 2006 through August 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the lake. Samples were collected from the lake surface at all sites during the sample year. The average lake-wide turbidity was 9 nephelometric turbidity units (NTU) true color was 14 units, and secchi disk depth was 151 centimeters. Based on these three parameters water clarity at Eucha Lake was excellent in comparison to other Oklahoma reservoirs. Results for these parameters are similar to those observed in 2005, if not slightly better. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI was 50 (Plate 37), indicating the lake was mesotrophic, bordering eutrophic, indicative of moderate to high primary productivity and nutrient levels in sample year 2006-2007. The TSI values were fairly consistent and generally ranged from mid-mesotrophic to eutrophic throughout the year. The exception being site four, which had very low chlorophyll-a values, reported in the spring and dipped down to oligotrophic. The lake is currently listed as a Nutrient Limited Watershed (NLW) in the Oklahoma Water Quality Standards (WQS). This listing means that the lake is considered threatened from nutrients. Seasonal turbidity values are displayed in Figure 47a. Turbidity values ranged from a low of 2 NTU to a maximum of 7 NTU. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. With 100% of the recorded values well below 25 NTU the Fish and Wildlife Propagation (FWP) beneficial use is considered fully supported. Seasonal true color values were all well below the WQS of 70 units and are displayed in Figure 47b. Applying the same default protocol, the Aesthetics beneficial use is considered supported.

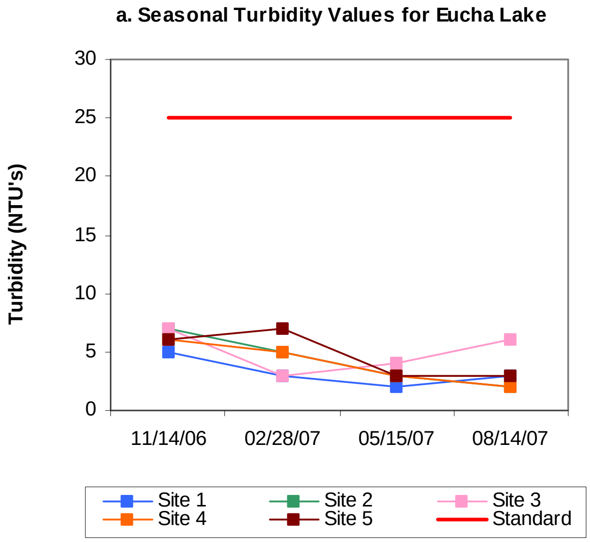
In 2007, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.07 parts per thousand (ppt) to 0.14 ppt, which is within the range of values observed in Oklahoma reservoirs. Specific conductivity ranged from 168.2 µS/cm to 296.3 µS/cm, indicative of minimal levels of current conducting ions (salts) in the lake system. The values for pH ranged from 7.15 to 8.76 representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. With all recorded within the acceptable range, Eucha Lake is fully supporting its FWP beneficial use for pH. Oxidation-reduction potentials (ORP) ranged from 63 mV in the hypolimnion in the summer to 500 mV in the winter quarter. In general, reducing conditions were not present at this reservoir, with all values above 100 mV, with the exception of the summer quarter when anoxic conditions were present for much of the water column (see Figure 47f). Thermal stratification was not observed during the fall and winter quarters when the water column appeared to be well mixed and oxygenated (Figure 47c-47d). The lake was thermally stratified and anoxic conditions were present in the hypolimnion during both spring and summer sampling intervals. In the spring the lake was stratified at several 1-meter intervals with the first one occurring between 3 and 4 meters below the surface. At this time dissolved oxygen (D.O.) levels remained high, only dropping below 2.0 mg/L from 14 meters for the remainder (30%) of the water column at site 4. During the summer sampling interval, stratification also occurred between 3 and 4 meters at site 1 accounting for 71% of the water column being anoxic. Anoxic conditions were also present at sites 2, 4, and 5 where D.O. was below 2.0 mg/L for 50 to 58% of the water column at these sample sites. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With anoxic conditions present for 30% of the water column in the spring and up to 71% of the water column in the summer, Eucha Lake is considered to be not supporting the FWP beneficial use. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

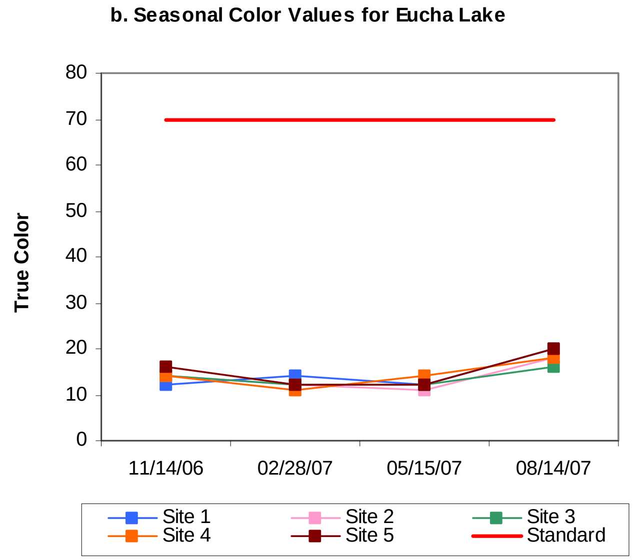
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. All sample results were at or below the detection limit, therefore the PBCR beneficial use is considered fully supported.

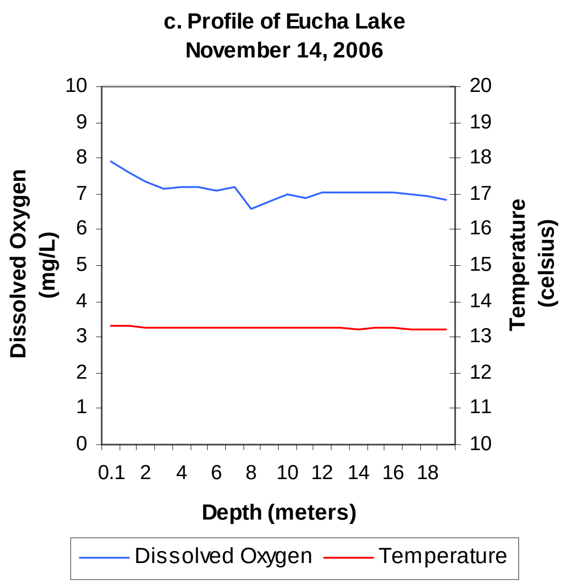
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.32 mg/L at the surface. Surface TN ranged from 0.36 mg/L to 3.26 mg/L with the highest values recorded in the winter quarter and lowest in the summer. The lake-wide total phosphorus (TP) average was 0.019 mg/L at the surface. TP was highest in the summer quarter however lower values were reported in the spring quarter with values ranging from 0.007 mg/L to 0.050 mg/L. The nitrogen to phosphorus ratio (TN:TP) was 71:1 for sample year 2006-2007. This value is much higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

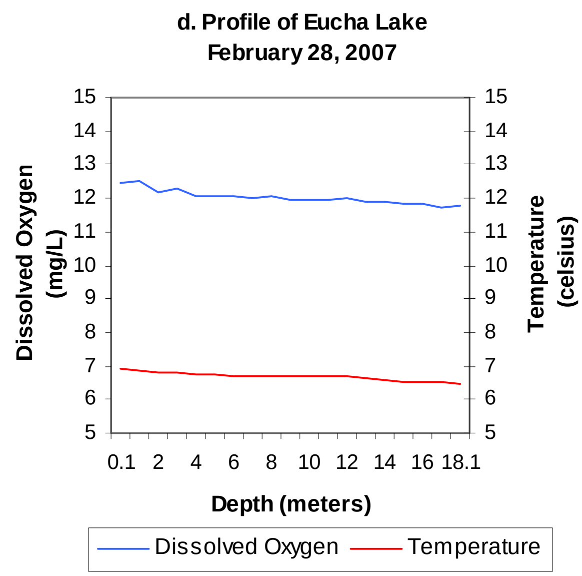
Eucha Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

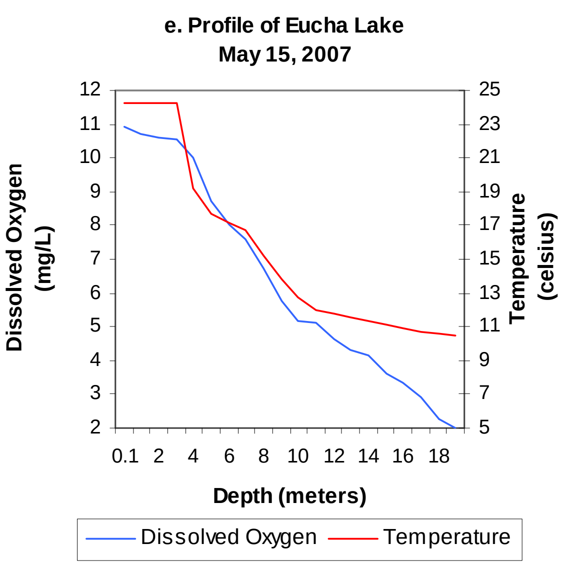
In summary, Eucha Lake was classified as mesotrophic bordering eutrophic, with moderate to high primary productivity and nutrient levels in 2006-2007. The lake is currently listed as a Nutrient Limited Watershed (NLW) in the Oklahoma Water Quality Standards (WQS) and is considered nutrient threatened. Several studies have been conducted in Eucha/Spavinaw complex by the OWRB and other state agencies and can be referenced for further information. Water clarity was excellent based on turbidity, true color and secchi disk depth. The lake is supporting the FWP beneficial use based on pH and turbidity values, however the use is considered not supported with 71% of the water column experiencing anoxic conditions during the summer quarter. With 100% of the true color values well below the WQS of 70 units the Aesthetics beneficial use is supported based on this parameter. In 1999, the Tulsa Municipal Authority contracted the OWRB to conduct a bathymetric survey of Eucha Lake (Figure 48) to determine current lake volume, capacity and sedimentation rates. The survey information was used to support numerical modeling of proposed water quality improvements by the OWRB. For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.











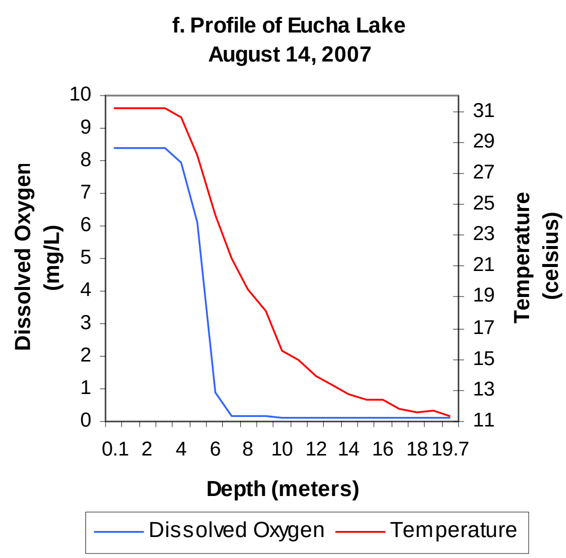
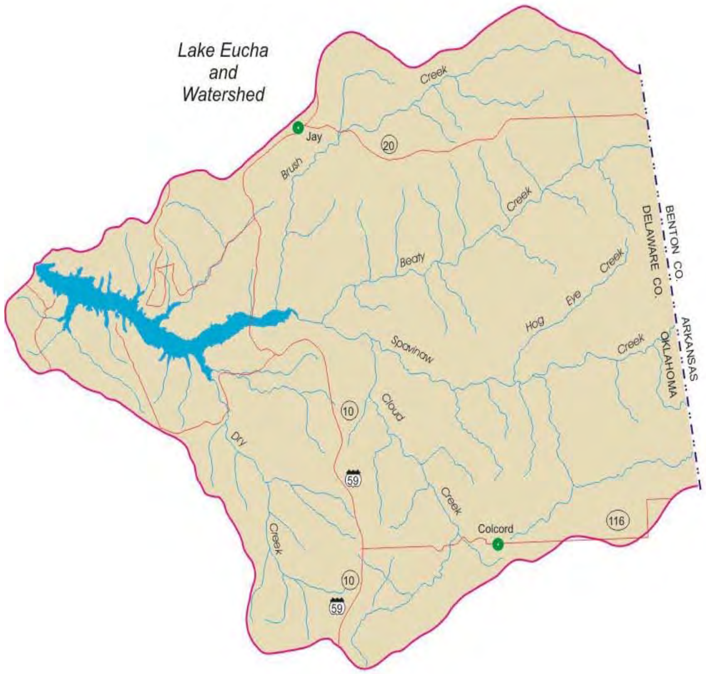


Figure 47a-47f. Graphical representation of data results for Eucha Lake.

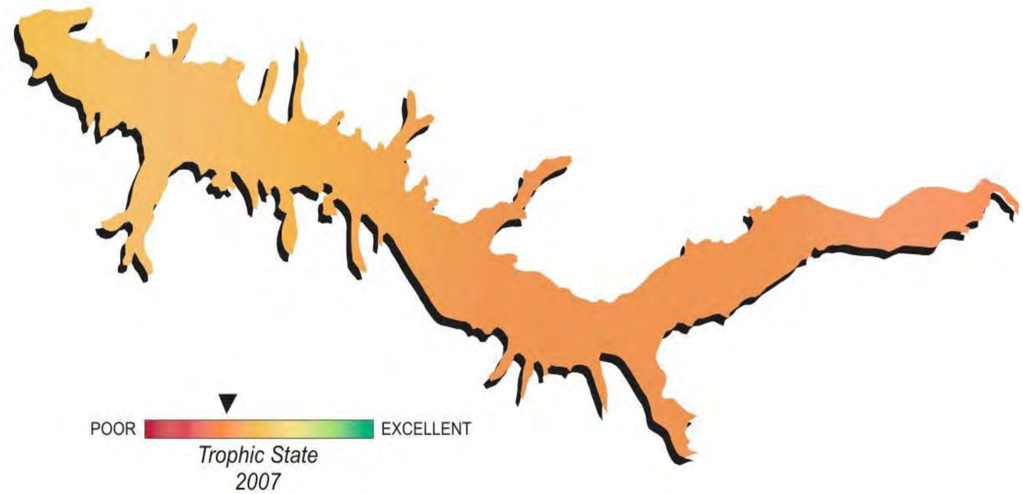
LAKES MONITORING PROGRAM

Plate 37- Lake Water Quality for

Lake Eucha



Lake Data	
Owner	City of Tulsa
County	Delaware
Constructed	1952
Surface Area	2,860 acres
Volume	79,600 acre/feet
Shoreline Length	49 miles
Mean Depth	27.83 feet
Watershed Area	216 square miles



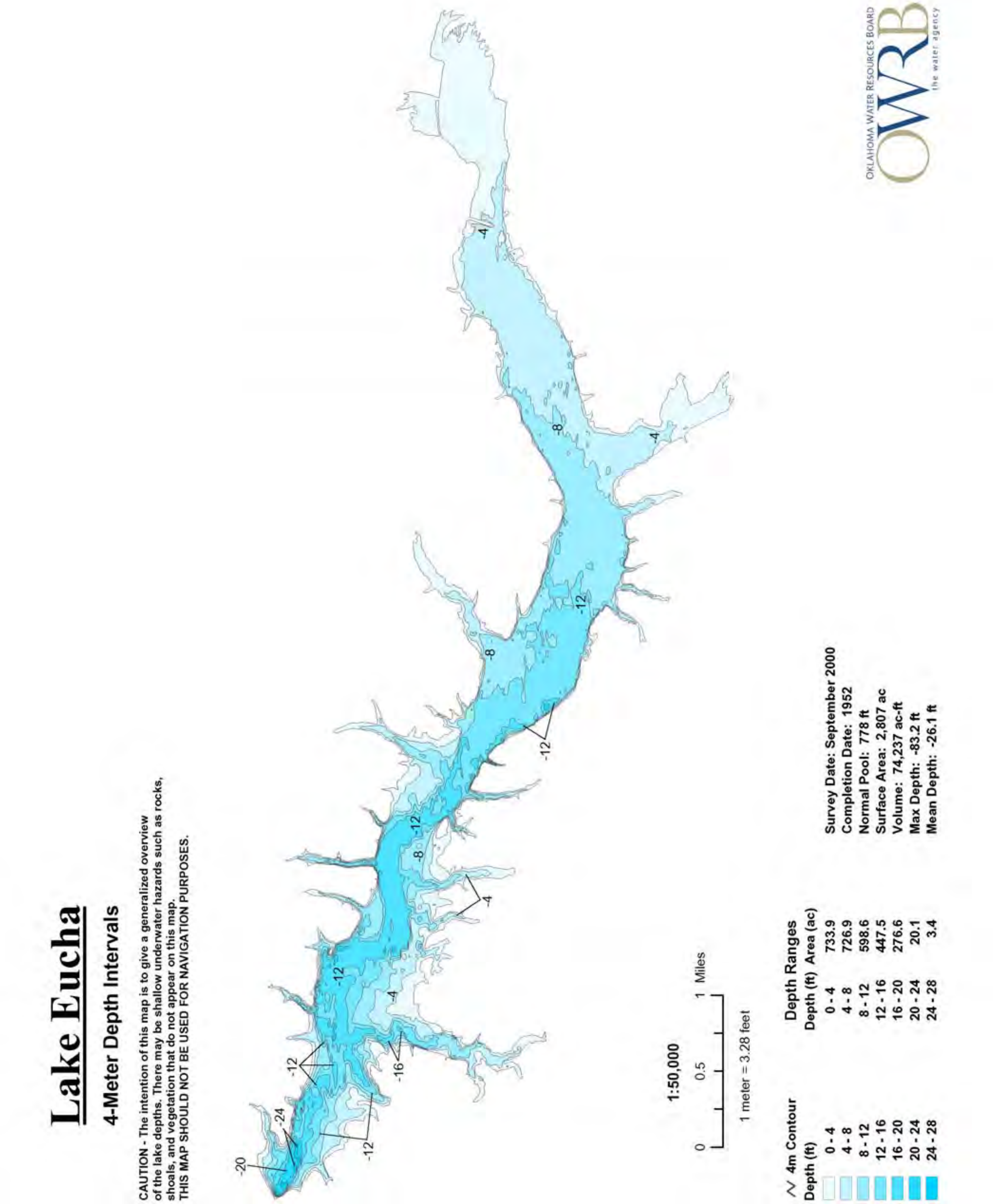


Figure 48. Bathymetric Map of Eucha Lake.

Eufaula Lake

Eufaula Lake, located in Haskell County, is the largest reservoir in Oklahoma at 105,500-acres. The reservoir was constructed by the United State Army Corps of Engineers (USACE) for flood control, water supply, hydroelectric power and navigational purposes. Eufaula Lake was sampled for four quarters from November 2006 through August 2007.

Water quality samples were collected at seventeen (17) sites to represent the riverine, transition and lacustrine zones, and major arms of the reservoir. This is the largest lake monitored by BUMP in both surface acres (105,500 acres) and number of sites sampled. Samples were collected from the lake surface at all sites during the study period. Eufaula Lake is a large dendritic reservoir and has been broken into six management segments; Deep Fork arm, N. Canadian River arm, Eufaula Lake, Canadian River arm, Longtown Creek arm and Gaines Creek arm to represent the reservoir. The following discussion will briefly summarize each segment with a lake-wide summary included at the end of the narrative.

Eufaula Lake, Deep Fork arm

This portion of Eufaula Lake (segment # 520700010020) extends from Deep Fork river inflow down to the highway 150-bridge area and includes BUMP sites 1 and 2 (see Figure 50). The segment-wide turbidity was 24 nephelometric turbidity units (NTU), true color was 71 units and secchi disk depth was 44 centimeters. Water clarity is fair to poor in this portion of the lake based on these three parameters for sample year 2007. This is not unusual as this part of the lake is more riverine in nature. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values (n=6) collected at all sites for four quarters. The average TSI was 56, classifying the segment as eutrophic, indicative of high primary productivity and nutrient conditions. Due to time constraints, OWRB staff was unable to sample the first two sites during the May sampling trip. As a result no samples for sites 1 and 2 were submitted for analysis from spring data collection efforts. Chlorophyll-a values varied among the seasons with the highest values generally reported in the fall and summer quarters. Turbidity values ranged from a low of 5 NTU to a maximum of 61 NTU. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. Although 25% of the values exceeded 25 NTU an assessment of the Fish & Wildlife Propagation (FWP) beneficial use cannot be made, as minimum data requirements were not met. Approximately 67% of the reported true color values were greater than the Aesthetics criteria of 70 units. Similar to turbidity, there are not enough data for this segment to assess the Aesthetics beneficial use as it relates to color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at both sample sites within this segment. Salinity values ranged from 0.10 to 0.30 parts per thousand (ppt), which is within the range of values reported for most Oklahoma lakes. Readings for specific conductivity ranged from 206.4 µS/cm to 596.1 µS/cm, indicating moderate to high amounts of electrical current conducting compounds (salts) in the lake system throughout the year. In general, pH values were slightly neutral to alkaline, ranging from 6.85 to 8.15 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. With 100% of pH values falling within the acceptable range the FWP beneficial use is supported as it relates to pH. Thermal stratification was not evident during the fall sampling interval and the water column appeared to be well mixed. Due to time constraints and equipment malfunction no profile data is available for the winter and spring quarters. In the summer, thermal stratification was evident and anoxic conditions present at both sites 1 and 2. Stratification occurred between 5 and 6 meters with dissolved oxygen less than 2.0 mg/L from 6 meters to the lake bottom of 8.3 meters. At this time anoxic conditions comprised 40-45% of the water column at these two sites. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at Eufaula Lake (segment # 520700010020) with 40% to 45% of the water column experiencing anoxic conditions in the summer quarter.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The segment-wide total nitrogen (TN) average was 0.80 mg/L at the surface. Surface TN ranged from 0.68 mg/L to 0.93 mg/L with the highest values recorded in the winter and lowest in the fall quarter. The segment-wide total phosphorus (TP) average was 0.085 mg/L at the surface. TP values at the surface ranged from 0.061 mg/L to 0.108 mg/L. Similar to TN, the highest TP values were reported in the winter however the lowest value was recorded during the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was 9:1 for sample year 2006-2007. This value is higher than 7:1, characterizing the lake phosphorus limited (Wetzel, 1983).

Eufaula Lake, N. Canadian River arm

This portion of Eufaula Lake (segment # 520500010020) extends from the Fountainhead State Park area down to Eufaula Cove (N) and includes BUMP sites 3 and 4 (see Figure 50). The segment-wide turbidity was 27 (NTU), true color was 69 units and secchi disk depth was 49 centimeters. Water clarity is fair to poor in this portion of the lake based on these three parameters for sample year 2007. This is not unusual as this part of the lake is more riverine in nature and has the inflow of a major tributary (N. Canadian River) just above site 3. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=7). The average TSI was 56, classifying the segment as eutrophic, indicative of high primary productivity and nutrient conditions. Due to time constraints, OWRB staff was unable to sample site 3 during the May sampling trip. As a result no sample for site 3 was submitted for analysis from spring data collection efforts. TSI values were generally eutrophic throughout the year. The only exception occurred at site 4 during the winter, which had a lower chlorophyll–a value and therefore a mesotrophic classification. Turbidity values ranged from a low of 9 NTU to a maximum of 56 NTU. According to the Use Support Assessment Protocols (USAP), a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. Although 25% of the values exceeded 25 NTU an assessment of the Fish & Wildlife Propagation (FWP) beneficial use cannot be made, as minimum data requirements were not met. Approximately 50% of the reported true color values were greater than the Aesthetics criteria of 70 units. Similar to turbidity, there are not enough data for this segment to assess the Aesthetics beneficial use as it relates to color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at both sample sites within this segment. Salinity values ranged from 0.13 to 0.30 parts per thousand (ppt), which is within the range of values reported for most Oklahoma lakes. Readings for specific conductivity ranged from 262.6 µS/cm to 578.7 µS/cm, indicating moderate to high amounts of electrical current conducting compounds (salts) in the lake system throughout the year. In general, pH values were slightly neutral to alkaline, ranging from 6.92 to 8.21 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. With 100% of pH values falling within the acceptable range the FWP beneficial use is supported as it relates to pH. Thermal stratification was not evident during the fall sampling interval and the water column appeared to be well mixed. Due to time constraints and equipment malfunction no profile data is available for the winter and spring quarters. In the summer, thermal stratification was evident and anoxic conditions present at both sites 3 and 4. Stratification occurred between 6 and 7 meters with dissolved oxygen less than 2.0 mg/L from 8 meters to the lake bottom of 8.3 meters at site 3. Anoxic conditions comprised 20-41% of the water column at these two sites. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at Eufaula Lake (segment # 520500010020) with up to 41% of the water column experiencing anoxic conditions in the summer quarter.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The segment-wide total nitrogen (TN) average was 0.97 mg/L at the surface. Surface TN ranged from 0.66 mg/L to 1.52 mg/L with the highest values recorded in the winter and lowest in the fall quarter. The segment-wide total phosphorus (TP) average was 0.088 mg/L at the surface. TP values at the surface ranged from 0.053 mg/L to 0.146 mg/L. Similar to TN, the highest TP values were reported in the winter and the lowest value was recorded during the fall quarter. The nitrogen to phosphorus ratio (TN:TP) was 11:1 for sample year 2006-2007. This value is higher than 7:1, characterizing the lake phosphorus limited (Wetzel, 1983).

Eufaula Lake

This portion of Eufaula Lake (segment # 220600010020) extends from the Eufaula Cove (S) up to the dam site and includes BUMP sites 5-7 (see Figure 50). The segment-wide turbidity was 23 NTU, true color was 62 units and secchi disk depth was 84 centimeters. Water clarity is fair to poor in this portion of the lake based on these three parameters. In general site 7, the dam had the lowest values for turbidity and color and the highest secchi disk depths for this portion of the lake. This is not unusual as you move through the lake and sediment and other materials are starting to settle out. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 55, classifying the segment as eutrophic, indicative of high primary productivity and nutrient conditions. TSI values ranged from eutrophic in the fall and spring to lower hyper eutrophy in the summer. During the winter all three sites had lower chlorophyll–a values and therefore a mesotrophic classification. Turbidity values ranged from a low of 5 NTU to a maximum of 126 NTU. According to the Use Support Assessment Protocols (USAP), a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. Although only 8% of the values exceeded 25 NTU an assessment of the Fish & Wildlife Propagation (FWP) beneficial use cannot be made, as minimum data requirements were not met. Approximately 50% of the reported true color values were greater than the Aesthetics criteria of 70 units. Similar to turbidity, there are not enough data for this segment to assess the Aesthetics beneficial use as it relates to color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at both sample sites within this segment. Salinity values ranged from 0.13 to 0.29 parts per thousand (ppt), which is within the range of values reported for most Oklahoma lakes. Readings for specific conductivity ranged from 272.8 µS/cm to 574.9 µS/cm, indicating moderate to high amounts of electrical current conducting compounds (salts) in the lake system throughout the year. In general, pH values were slightly neutral to alkaline, ranging from 6.95 to 8.16 units. With 100% of pH values falling within the acceptable range (6.5-9) the FWP beneficial use is supported as it relates to pH. Thermal stratification was not evident during the fall sampling interval and the water column appeared to be well mixed. Due to time constraints only the profile at the dam site was recorded during the winter sampling interval and like the fall, the water column appeared to be well mixed with dissolved oxygen (D.O.) remaining above 7.0 mg/L. Due to equipment malfunction no profile data is available for the spring quarter. During the summer, thermal stratification was evident and anoxic conditions present at all three sites within this segment. Stratification occurred between 11 and 12 meters with dissolved oxygen less than 2.0 mg/L from 15 meters to the lake bottom of 27.5 meters at site 7, the dam site. Sites 5 and 6 were also thermally stratified with anoxic conditions present in 50-55% of the water column respectively. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported at Eufaula Lake (segment # 220600010020) with up to 55% of the water column experiencing anoxic conditions in the summer quarter.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The segment-wide total nitrogen (TN) average was 0.90 mg/L at the surface. Surface TN ranged from 0.65 mg/L to 1.46 mg/L with the highest values recorded in the summer and lowest in the winter quarter. The segment-wide total phosphorus (TP) average was 0.088 mg/L at the surface. TP values at the surface ranged from 0.030 mg/L to 0.127 mg/L. Both the highest and lowest TP values were reported during the spring sampling interval. The nitrogen to phosphorus ratio (TN:TP) was 16:1 for sample year 2006-2007. This value is higher than 7:1, characterizing the lake phosphorus limited (Wetzel, 1983).

<u>Eufaula Lake, Longtown Creek arm</u>

This portion of Eufaula Lake (segment # 220600010060) extends from the Highway 9 Landing downward into the Longtown Creek arm and includes BUMP site 8 (see Figure 50). The segment-wide turbidity was 8 NTU, true color was 32 units and secchi disk depth was 86 centimeters. Water clarity is good in this portion of the lake based on these three parameters. A trophic state index (TSI), using Carlson's TSI (chlorophyll-<u>a</u>), was calculated using values collected at all sites for four quarters (n=4). The average TSI was 57, classifying the segment as eutrophic, indicative of high primary productivity and nutrient conditions. TSI values were eutrophic during all 4 sampling intervals. Turbidity values ranged from a low of 6 NTU to a maximum of 10 NTU. According to USAP a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards

(WQS) of 25 NTU for turbidity. Although all values were below 25 NTU an assessment of the Fish & Wildlife Propagation (FWP) beneficial use cannot be made, as minimum data requirements were not met. Like turbidity, no true color value exceeded the Aesthetics criteria of 70 units. Similar to turbidity, there are not enough data for this segment to assess the Aesthetics beneficial use as it relates to color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at both sample sites within this segment. Salinity values ranged from 0.17 to 0.29 parts per thousand (ppt), which is within the range of values reported for most Oklahoma lakes. Readings for specific conductivity ranged from 339.6 µS/cm to 567.4 µS/cm, indicating moderate to high amounts of electrical current conducting compounds (salts) in the lake system throughout the year. In general, pH values were slightly neutral to alkaline, ranging from 6.94 to 8.29 units. With 100% of pH values falling within the acceptable range (6.5-9) the FWP beneficial use is supported as it relates to pH. Thermal stratification was not evident during the fall sampling interval and the water column appeared to be well mixed. Due to time constraints and equipment malfunction no profile data is available for the winter and spring quarters. During the summer, the lake was stratified between 7 and 8 meters, at which point D.O. dropped below 2.0 mg/L and anoxic conditions comprised 38% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at Eufaula Lake (segment # 220600010060) with up to 56% of the water column experiencing anoxic conditions in the summer quarter.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The segment-wide total nitrogen (TN) average was 0.78 mg/L at the surface. Surface TN ranged from 0.61 mg/L to 1.20 mg/L with the highest values recorded in the summer and lowest in the fall quarter. The segment-wide total phosphorus (TP) average was 0.032 mg/L at the surface. TP values at the surface ranged from 0.026 mg/L to 0.034 mg/L. The highest TP value was reported in the fall and the lowest value was recorded during the spring quarter. The nitrogen to phosphorus ratio (TN:TP) was 24:1 for sample year 2006-2007. This value is higher than 7:1, characterizing the lake phosphorus limited (Wetzel, 1983).

Eufaula Lake, Canadian River arm

This portion of Eufaula Lake (segment # 220600010050) extends from the Canadian River inflow up the east side of the Highway 69 bridge and includes BUMP sites 9-11 (see Figure 50). The segment-wide turbidity was 74 nephelometric turbidity units (NTU), true color was 100 units and secchi disk depth was 59 centimeters. Water clarity is fair to poor in this portion of the lake based on these three parameters for sample year 2007. This is not unusual as this part of the lake is more riverine in nature and has the inflow of a major tributary (Canadian River) just above site 10. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 49, classifying the segment as mesotrophic, indicative of moderate primary productivity and nutrient conditions. TSI values were fairly consistent with oligotrophic condition present during the winter and spring and eutrophic conditions in the summer and fall quarters. Turbidity values ranged from a low of 9 NTU to a maximum of 210 NTU. According USAP, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. Although 25% of the values exceeded 25 NTU an assessment of the Fish & Wildlife Propagation (FWP) beneficial use cannot be made, as minimum data requirements were not met. Approximately 50% of the reported true color values were greater than the Aesthetics criteria of 70 units. Similar to turbidity, there are not enough data for this segment to assess the Aesthetics beneficial use as it relates to color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at both sample sites within this segment. Salinity values ranged from 0.20 to 0.30 parts per thousand (ppt), which is within the range of values reported for most Oklahoma lakes. Readings for specific conductivity ranged from 346 µS/cm to 578.9 µS/cm, indicating moderate to high amounts of electrical current conducting compounds (salts) in the lake system throughout the year. In general, pH values were slightly neutral to alkaline, ranging from 7.24 to 8.27 units. With 100% of pH values falling within the acceptable range (6.5-9) the FWP beneficial use is supported as it relates to pH. Thermal stratification was not evident during the fall sampling interval and the water column appeared to be well mixed. Due to time constraints and equipment malfunction no profile data is available for the winter and spring quarters. In the summer, thermal stratification was evident and anoxic conditions were present at all sites within this segment. Site 9 exhibited weak thermal stratification with dissolved oxygen falling below 2.0 mg/L from 7 meters below the surface to the lake bottom of 15 meters, accounting for 56% of the water column to be experiencing anoxic conditions. Sites 10 and 11 were also stratified with anoxic conditions comprising a smaller portion of the water column (9-25%). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported at Eufaula Lake (segment # 220600010050) with up to 56% of the water column experiencing anoxic conditions in the summer quarter.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The segment-wide total nitrogen (TN) average was 1.00 mg/L at the surface. Surface TN ranged from 0.74 mg/L to 1.27 mg/L with the highest values recorded in the spring and lowest in the summer quarter. The segment-wide total phosphorus (TP) average was 0.095 mg/L at the surface. TP values at the surface ranged from 0.045 mg/L to 0.220 mg/L. Similar to TN, the highest TP value was reported in the spring and the lowest value was recorded during the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was 11:1 for sample year 2006-2007. This value is higher than 7:1, characterizing the lake phosphorus limited (Wetzel, 1983).

<u>Eufaula Lake, Gaines Creek arm</u>

This portion of Eufaula Lake (segment # 220600050010) extends from Oak Ridge down to Highway 31 Landing and includes BUMP sites 12-17 (see Figure 50). The segment-wide turbidity was 44 nephelometric turbidity units (NTU), true color was 124 units and secchi disk depth was 55 centimeters. Water clarity is fair to poor in this portion of the lake based on these three parameters. This is not unusual as this part of the lake is more riverine in nature. A trophic state index (TSI), using Carlson's TSI (chlorophyll-<u>a</u>), was calculated using values collected at all sites for four quarters (n=24). The average TSI was 53, classifying the segment as eutrophic, indicative of high primary productivity and nutrient conditions. TSI values were fairly consistent with oligotrophic condition present during the winter and eutrophic conditions the remainder of the year. Turbidity values ranged from a low of 8 NTU to a maximum of 158 NTU. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. With 58% of the values exceeding 25 NTU the Fish & Wildlife Propagation (FWP) beneficial use is considered not supported for this segment. Approximately 63% of the reported true color values were greater than the Aesthetics criteria 70 units. Applying the same default protocol, the Aesthetics use is considered not supported for this segment.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at both sample sites within this segment. Salinity values ranged from 0.0 to 0.26 parts per thousand (ppt), which is within the range of values reported for most Oklahoma lakes. Readings for specific conductivity ranged from 339.6 µS/cm to 567.4 µS/cm, indicating moderate to high amounts of electrical current conducting compounds (salts) in the lake system throughout the year. In general, pH values were slightly neutral to alkaline, ranging from 6.94 to 8.29 units. With 100% of pH values falling within the acceptable range (6.5-9) the FWP beneficial use is supported as it relates to pH. Thermal stratification was not evident during the fall sampling interval and the water column appeared to be well mixed. Due to time constraints and equipment malfunction no profile data is available for the winter and spring quarters. Thermal stratification was evident and anoxic conditions present at all sites within this segment during the summer. Stratification occurred at various points among the sites with anoxic conditions present in 25-43% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at Eufaula Lake (segment # 220600050010) with up to 43% of the water column experiencing anoxic conditions in the summer quarter.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The segment-wide total nitrogen (TN) average was 0.88 mg/L at the surface. Surface TN ranged from 0.55 mg/L to 2.18 mg/L with the highest values recorded in the summer and lowest in the fall quarter. The segment-wide total phosphorus (TP) average was 0.067 mg/L at the surface. TP values at the surface ranged from 0.030 mg/L to 0.129 mg/L. The highest and lowest TP values were reported in the spring quarter. The nitrogen to phosphorus ratio (TN:TP) was 13:1 for sample year 2006-2007. This value is higher than 7:1, characterizing the lake phosphorus limited (Wetzel, 1983).

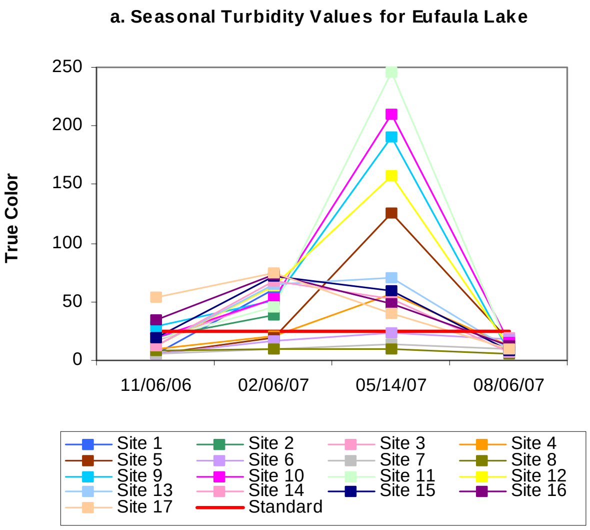
Lake Summary:

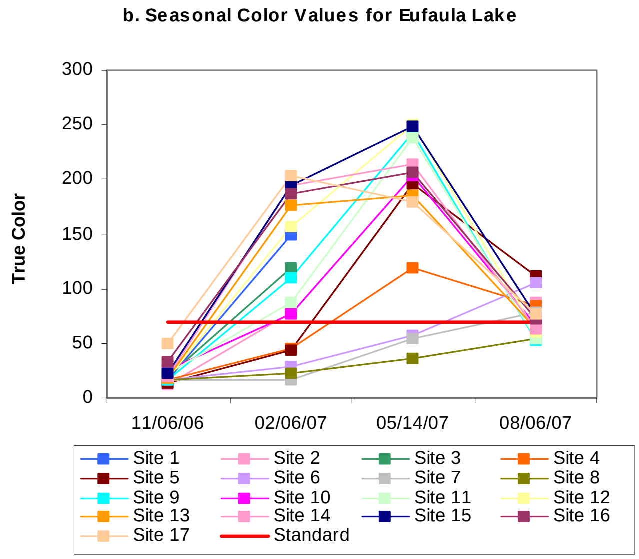
The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

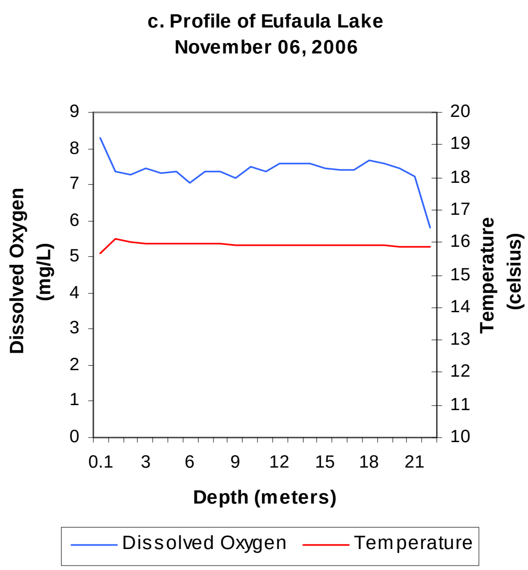
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. Although all samples were below both the prescribed screening level and geometric mean, minimum data requirements for each segment were not met and an assessment of the PBCR beneficial use cannot be made at this time.

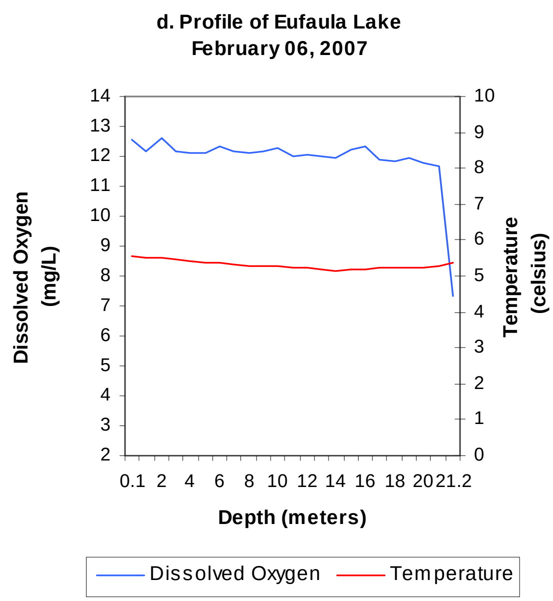
Lake Eufaula was also sampled for total metals at five sites during the spring of 2007; however the minimum data requirements for each segment were not met and an assessment of the FWP beneficial use cannot be made at this time.

In summary, Eufaula Lake was classified as eutrophic with high primary productivity and nutrient rich conditions. The lake-wide average turbidity was 40 NTU (Plate 38), true color was 91 units, and secchi disk depth was 62 centimeters. Water clarity was average at Eufaula Lake in comparison to other Oklahoma reservoirs based on these three parameters, and results are similar to those of the 2005 evaluation. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=65). The TSI was 53 (Plate 38), indicating the lake was eutrophic, indicative of high primary productivity and nutrient levels in sample year 2006-2007. This is the same classification as 2003 and 2005 (TSI=52), indicating no significant increase or decrease in productivity has occurred. The TSI values varied seasonally and ranged from oligotrophic to hypereutrophic. Turbidity values varied by site and by season, but were typically above the Oklahoma Water Quality Standard (WQS) of 25 NTU in the more riverine portions of the lake and below the standard in the lacustrine portions of the lake. The highest turbidity values throughout the year occurred at sites 9-11, the Canadian River arm. With 38% of the turbidity values above the standard, the Fish and Wildlife Propagation (FWP) beneficial use is not supported based on turbidity (see Figure 49a). Seasonal true color values are displayed in Figure 49b. True color values followed the same trend as turbidity, with values exceeding the WQS of 70 units in the more riverine portions of the lake with the highest values recorded at sites 14-17 throughout the year except for the summer quarter. Of the values collected, 51% exceeded 70 units. Applying the same default protocol, the Aesthetic beneficial use is not supported based on true color. Based on anoxic conditions present during the summer (Figure 49f), the FWP is considered partially supported at Eufaula Lake as it relates to dissolved oxygen. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007, however due to minimum data requirements not being met an assessment of the PBCR cannot be made at this time.









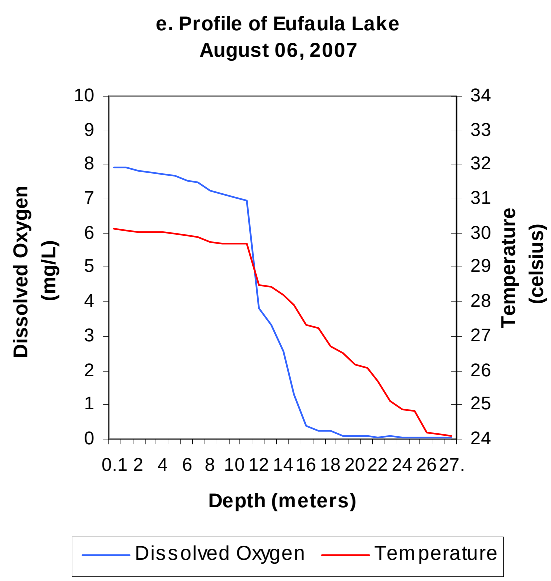
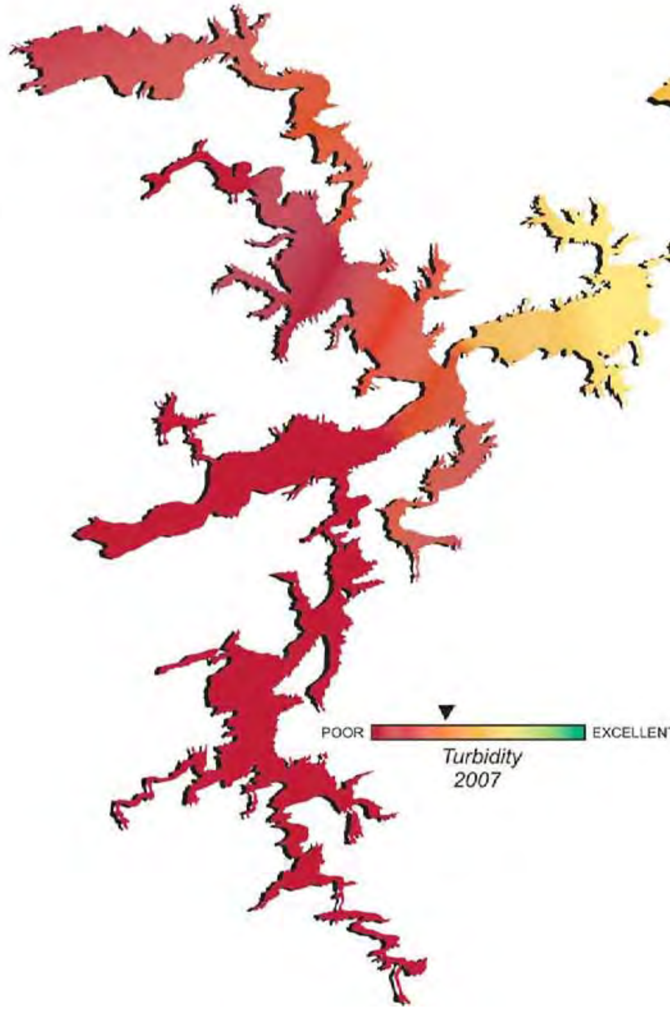
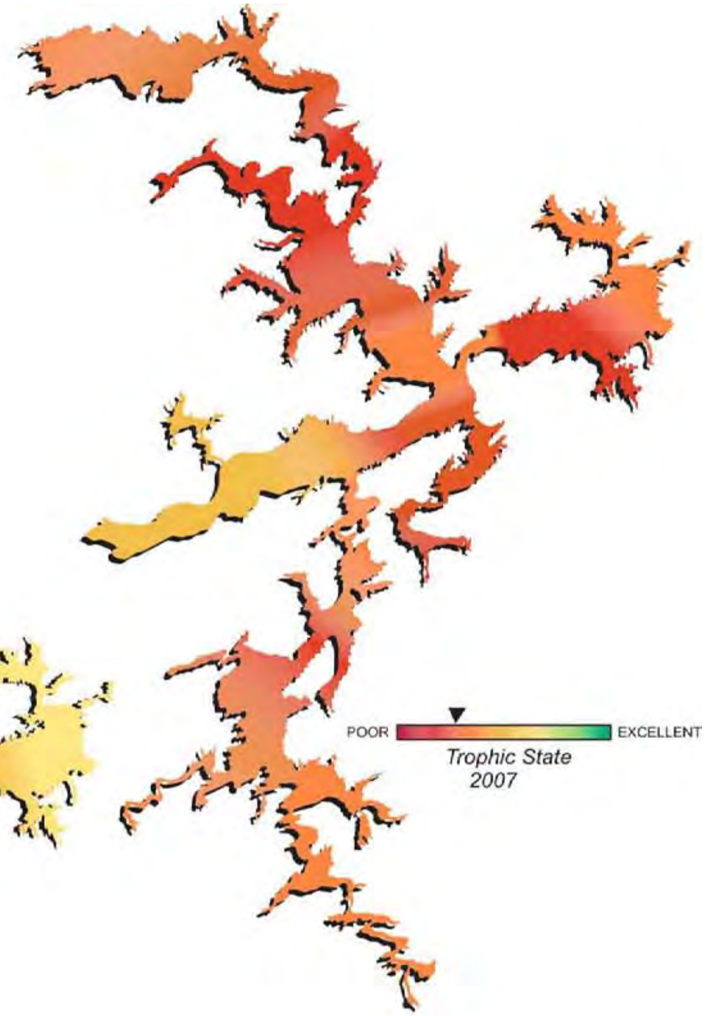


Figure 49a-49f. Graphical representation of data results for Eufaula Lake.





Lake Data

Consrtucted by	Corps of Engineers
County	McIntosh (Dam)
Constructed	1964
Surface Area	105,500 acres
Volume	2,314,600 acre/feet
Shoreline Length	600 miles
Mean Depth	21.94 feet
Watershed Area	47,522 square miles

Plate 38 - Lake Water Quality for
Eufaula Lake

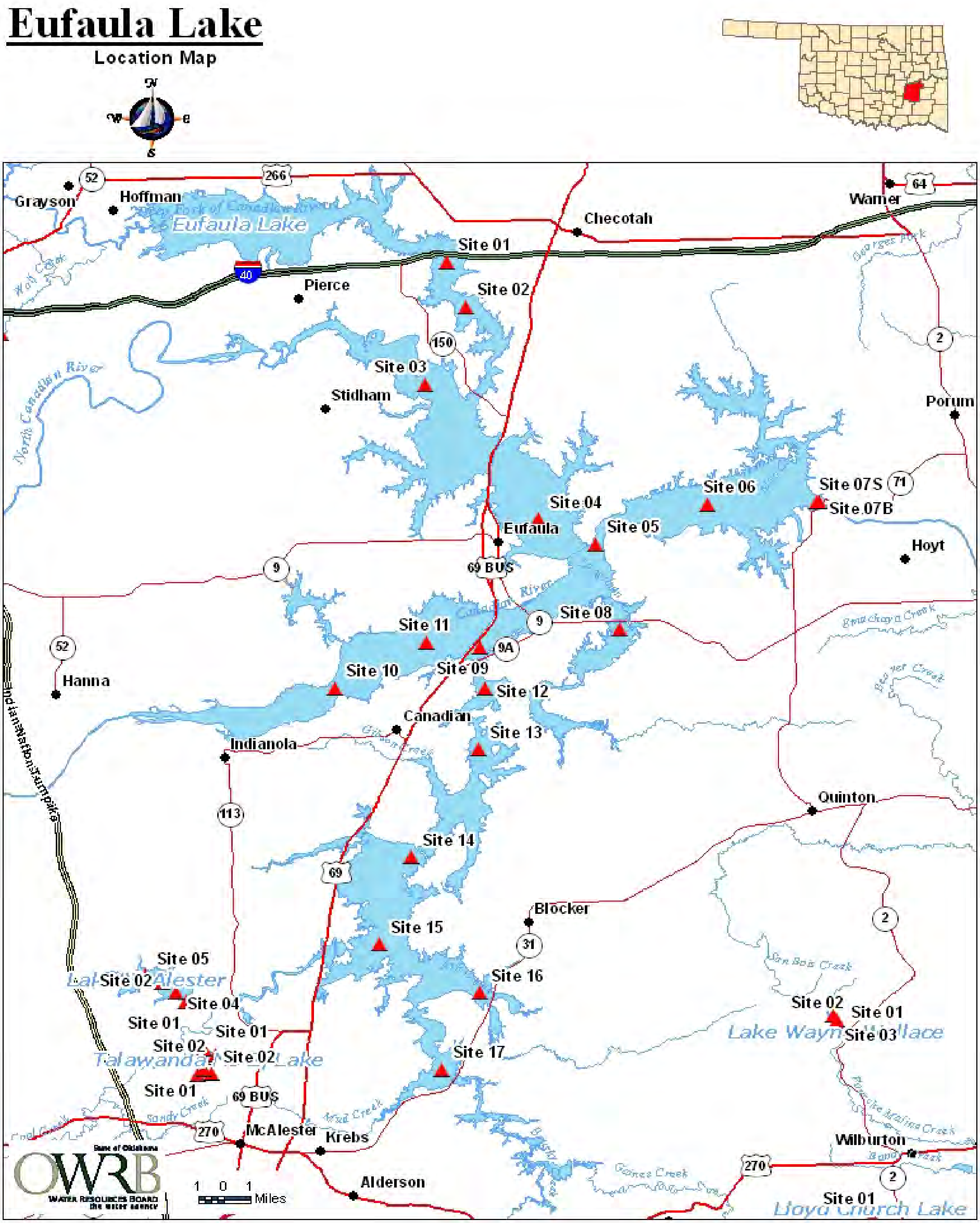


Figure 50. Eufaula Lake Site Map

Fairfax City Lake

Fairfax City Lake is a 111-acre reservoir located in Osage County. The lake is owned and operated by the City of Fairfax and is managed as a water supply reservoir and recreational outlet for the city and the public. Fairfax City Lake was sampled for four seasons, from November 2006 through August 2007.

Water quality samples were collected at three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 10 nephelometric turbidity units (NTU), true color was 41 units, and secchi disk depth was 73 centimeters. Based on these three parameters, Fairfax City Lake had good water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=10). The average TSI was 57 (Plate 39), indicating the lake was eutrophic, indicative of high levels of productivity and nutrient conditions. Due to a post-processing error, no sample for site 3 was submitted for analysis from fall and spring data collection efforts. The TSI values were eutrophic in the first three seasons and hypereutrophic during the summer. Turbidity values were well below the Oklahoma Water Quality Standard (WQS) of 25 NTU in all seasons (See Figure 51a). According to the Use Support Assessment Protocols (USAP) specified in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). With 100% of the samples below 25 NTU, the Fish & Wildlife Propagation (FWP) beneficial use is considered supported in regards to turbidity. Seasonal true color values are displayed in Figure 51b. True color values were well below the Oklahoma Water Quality Standard (WQS) of 70 units in all seasons, with the exception of the spring quarter (Figure 51b). The spike in recorded true color values in the spring it likely the result of seasonal storm events, therefore the Aesthetics beneficial use is considered supported based on the true color values.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were also recorded at all sample sites during the study period. Salinity values ranged from 0.09 parts per thousand (ppt) to 0.13 ppt, within the expected range for Oklahoma reservoirs. Readings for specific conductivity were also well within the range of expected values for most Oklahoma reservoirs. Conductivity ranged from 191.6 µS/cm recorded in the summer quarter to 275.3 µS/cm recorded in the fall quarter of 2006, indicating moderate concentrations of electrical current conducting compounds (salts) in the water column. Oxidation-reduction potentials (redox) ranged from 2 mV in the hypolimnion during the summer to 428 mV recorded in the fall. In general, reducing conditions were not present at this reservoir, with all values above 100 mV, with the exception of the summer quarter when anoxic conditions were present for much of the water column. Lake pH values were neutral to slightly alkaline with values ranging from 7.0 to 8.93. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. The FWP beneficial use was fully supported based on pH values collected during the study period. The lake was not thermally stratified in the fall or winter quarters and the water column was well mixed (See Figure 51c-

51d). Fairfax Lake was strongly thermally stratified in both the spring and summer quarters between 2 and 3 meters in depth at which point dissolved oxygen (D.O.) values fell below 2.0 mg/L to the lake bottom of 10.6 meters (see Figure 51e-51f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With anoxic conditions present in approximately 67% of the water column in the spring and 60% of the water column in the summer the lake is partially supporting its FWP beneficial use based on D.O. concentration. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. All sample results were at or below the detection limit, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.70 mg/L at the lake surface. The TN at the surface ranged from 0.61 mg/L to 0.92 mg/L. The highest surface TN value was reported in the fall quarter and the lowest occurred in the winter and spring quarters. The lake-wide total phosphorus (TP) average was 0.026 mg/L at the lake surface. The TP ranged from 0.016 mg/L to 0.042 mg/L. The highest surface TP values were reported in the summer and the lowest were in the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 27:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Fairfax City Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Fairfax City Lake was classified as eutrophic indicative of high primary productivity and nutrient conditions (Plate 39). Water clarity is good based on turbidity, true color and secchi disk depth. The Aesthetics beneficial use is fully supported based trophic state and true color. Although 25% of the color values exceed the WQS of 70 units, the spike in values during the spring quarter is likely due to seasonal storm events. For this reason the lake will be listed as supporting the Aesthetics beneficial use. Fairfax City Lake was fully supporting the FWP beneficial use based on pH and turbidity; however the use is not supporting based on dissolved oxygen concentrations in the water column. Anoxic conditions were present in a large portion of the water column during both spring and summer sampling intervals. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Of the 10 samples collected, none exceeded the prescribed screening level or the geometric mean. The PBCR beneficial use is therefore considered supported.

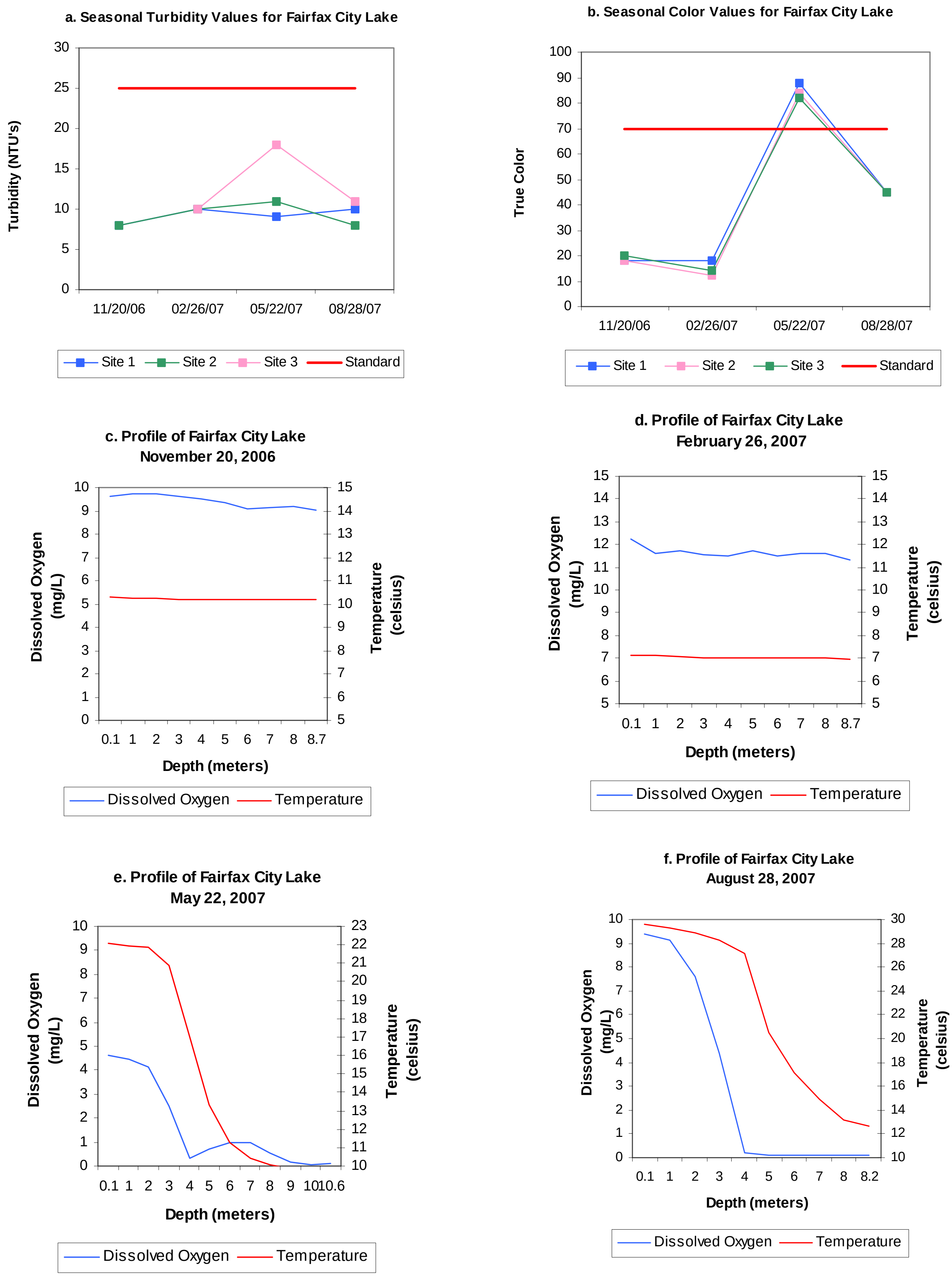
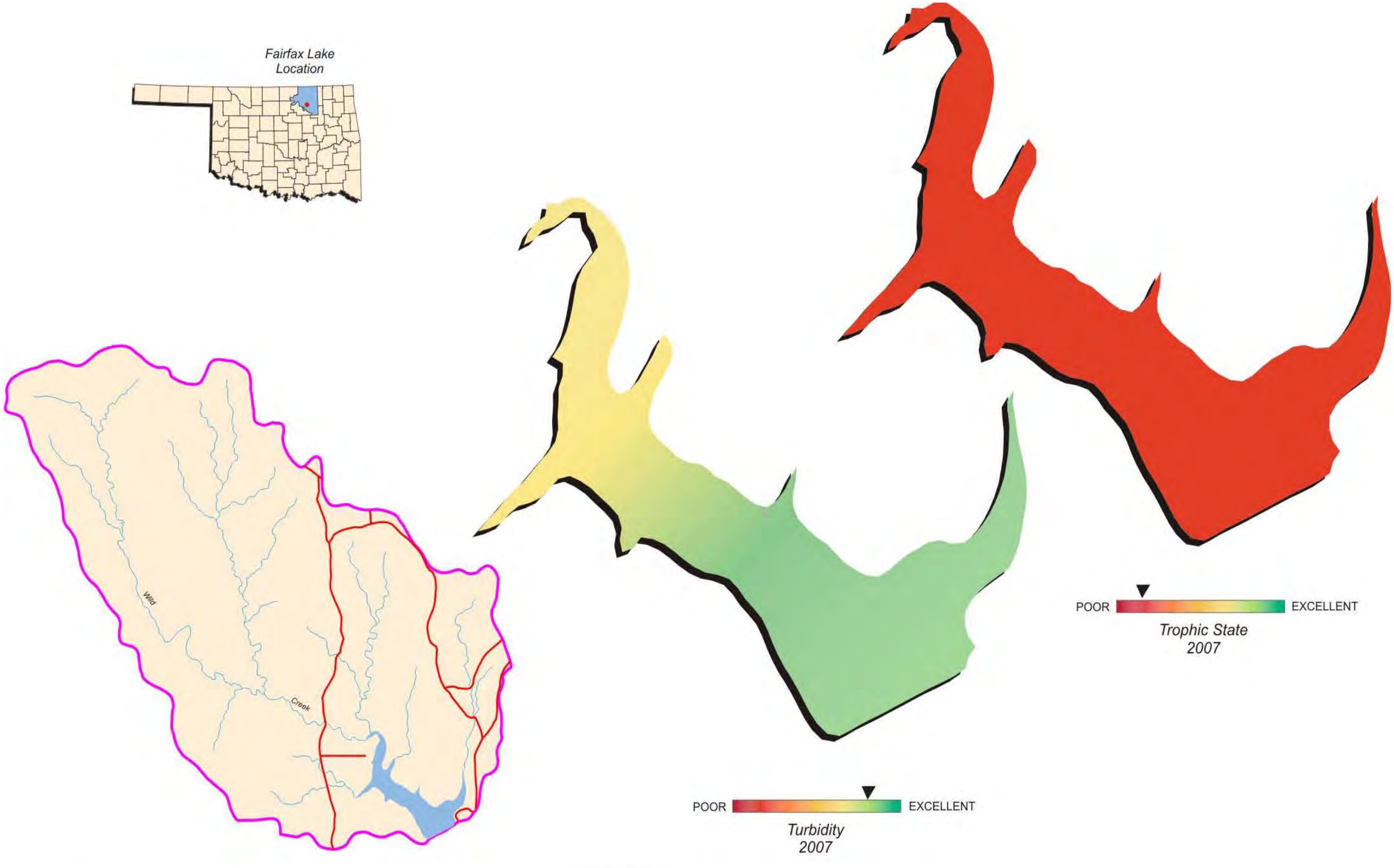


Figure 51a-51f. Graphical representation of data results for Fairfax City Lake.



Lake Data

Owner	City of Fairfax
County	Osage
Constructed	1936
Surface Area	111 acres
Volume	1,795 acre/feet
Shoreline Length	4 miles
Mean Depth	16.17 feet
Watershed Area	9 square miles

Plate 39- Lake Water Quality for
Fairfax Lake

LAKES MONITORING PROGRAM

Fort Cobb Reservoir

Fort Cobb Reservoir, located in Caddo County, is situated on Cobb Creek approximately 14 miles northwest of the town of Anadarko. The reservoir is owned and operated by Bureau of Reclamation and was impounded in 1959. The lake serves multiple uses including municipal water supply, flood control, and recreational purposes. Fort Cobb Reservoir was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at six (6) sites to represent the riverine, transition, and lacustrine zones of the reservoir as well as any major arms and tributaries. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 13 NTU (Plate 40), true color was 20 units, and secchi disk depth was 62 centimeters. Based on these three parameters, Fort Cobb Reservoir had fairly good water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=24). The average TSI was 65 (Plate 40), indicating the lake was hypereutrophic, indicative of excessive levels of productivity and nutrient rich conditions. This finding is consistent with historical data collection efforts and supports the listing of the lake as a Nutrient Limited Watershed (NLW) as listed in the Oklahoma Water Quality Standards (WQS). At this time Fort Cobb is considered threatened due to nutrients until a non-support status can be confirmed. The TSI values varied from mid and upper eutrophic in the fall and winter to hypereutrophic in the spring and summer quarters. Site 4 was the only site consistently hypereutrophic throughout the sample year. Only three (12.5%) of the twenty-four turbidity values exceeded the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 52a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Fort Cobb reservoir is partially supporting its Fish & Wildlife Propagation (FWP) beneficial use as it relates to turbidity. Seasonal true color values are displayed in Figure 52b. All true color values were below the Aesthetics WQS of 70 units for all four quarters at all sites thus meeting the Aesthetics beneficial use for true color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were also recorded at all sample sites during the study period. Salinity values ranged from 0.23 parts per thousand (ppt) to 0.58 ppt, slightly higher than the expected range for most Oklahoma reservoirs. Readings for specific conductivity were within the expected range for Oklahoma reservoirs. Specific conductivity ranged from 451.5 µS/cm in the summer to 1111 µS/cm in the winter quarter, indicating moderate to elevated concentrations of electrical current conducting compounds (salts) in the water column. Oxidation-reduction potentials (redox) ranged from 249 mV near the lake bottom in the summer quarter to 429 mV in the fall quarter, indicating reducing conditions were not present in the lake system during 2005-2006 sampling. Lake pH values were neutral to slightly alkaline with values ranging from 7.26 units to 10.69 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Fort Cobb Reservoir was fully supporting its FWP beneficial use with only 5.6% of the recorded values falling outside the acceptable range. The lake was not thermally stratified in the fall, winter or spring quarters and the lake was well mixed and oxygenated, with dissolved oxygen values above 6.0 mg/L except at the very bottom of the lake (see Figure 52c-52e). During the summer the lake was thermally stratified and anoxic conditions were present. Stratification occurred between 9 and 10 meters below the surface at site 2, at which point dissolved oxygen (D.O.) concentrations fell below 2.0 mg/L and remained below 1.0 mg/L all the way to the lake bottom at 11.7 meters (see Figure 52f). Site three was also stratified with anoxic conditions present in 27% of the water column. When D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With only 23 to 27% of the water column below 2.0 mg/L during the summer quarter the lake is considered to be fully supporting its FWP beneficial use based on D.O. concentrations. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September of 2006. All sample results were below both the screening level and geometric mean. The PBCR beneficial use is therefore considered supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.11 mg/L during the study period. The TN at the surface ranged from 0.77 mg/L in the spring quarter to 1.52 mg/L recorded in the summer quarter. The lake-wide total phosphorus (TP) average was 0.097 mg/L. The TP ranged from 0.050 mg/L to 0.210 mg/L. The highest surface TP values were reported in the summer and the lowest were in the winter sampling interval. The nitrogen to phosphorus ratio (TN:TP) was 11:1 for sample year 2005-2006 . This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Fort Cobb Reservoir was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Fort Cobb Reservoir was classified as hypereutrophic indicative of excessive primary productivity and nutrient rich conditions (Plate 40). This is consistent with findings from previous data collection efforts and further supports the listing of the lake in the WQS as NLW waterbody with nutrient threats present. The high levels of nutrients in the water column, coupled with the relatively good water quality, serves to fuel primary productivity in the lake. The Oklahoma Department of Environmental Quality (ODEQ) recently conducted a Total Maximum Daily Load (TMDL) study on the lake for nutrients and made recommendations for a reduction of both nitrogen and phosphorus. The lake was fully supporting its Aesthetics beneficial use based on true color. With only 23-27% of the water column experiencing anoxic conditions during the summer, the lake is considered supporting the FWP beneficial use as it relates to dissolved oxygen; however the lake is partially supporting the FWP beneficial use for turbidity with 12.5% of the collected values above the WQS criteria of 25 NTU. Fort Cobb Reservoir is fully supporting its FWP beneficial use as it relates to pH with only 5.6% of the recorded values falling outside the acceptable range of 6.5 to 9 pH units. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September of 2006. All sample results were below both the screening level and geometric mean. The PBCR beneficial use is therefore considered supported.

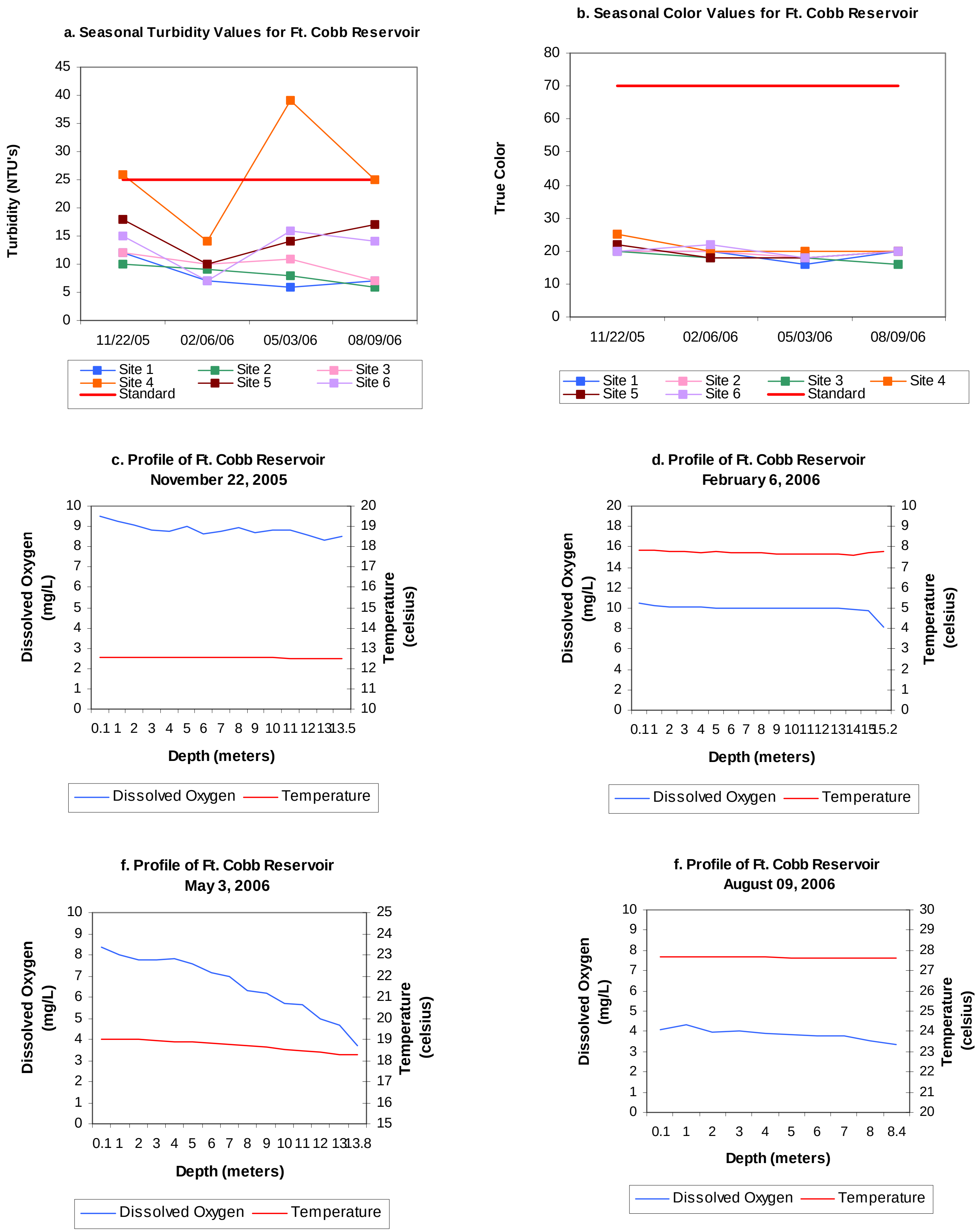
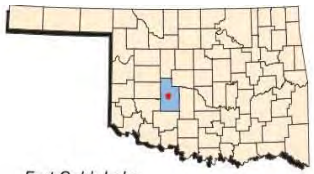
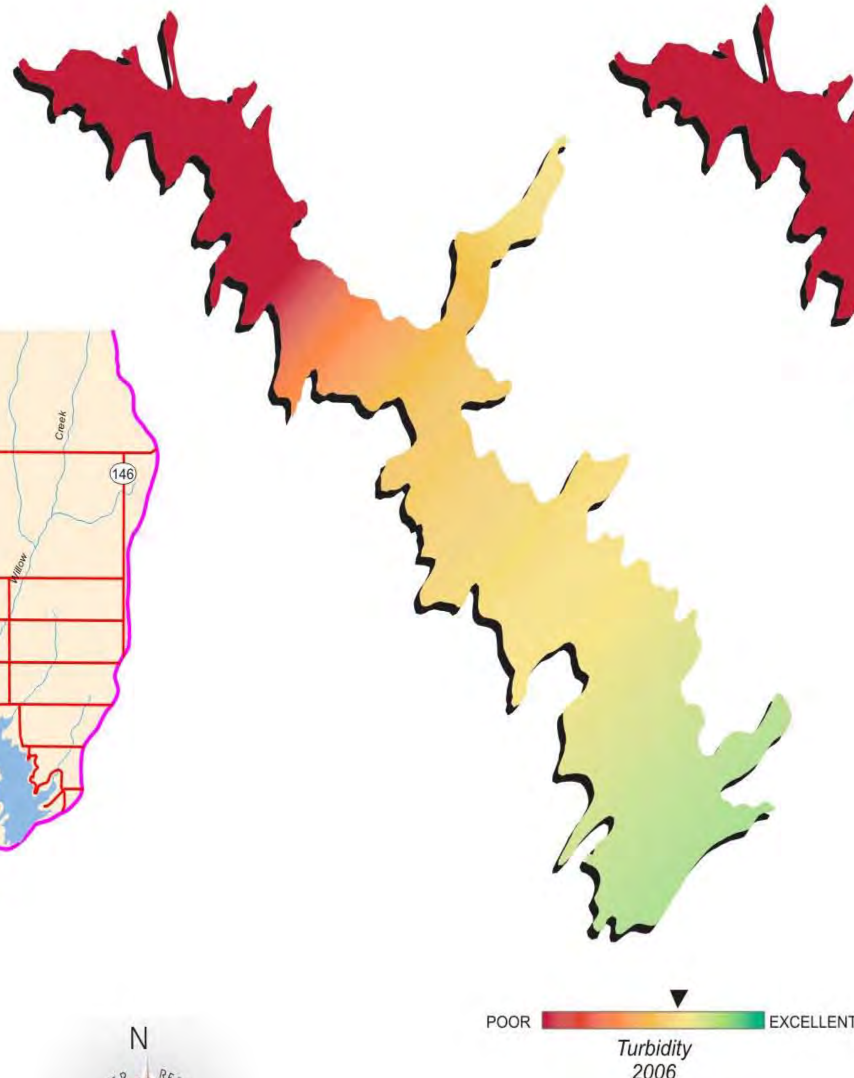


Figure 52a-52f. Graphical representation of data results for Fort Cobb Reservoir.



Fort Cobb Lake
Location

Fort Cobb Lake
and
Watershed



Lake Data	
Consrtucted by	Bureau of Recalmation
County	Caddo
Constructed	1959
Surface Area	4,100 acres
Volume	80,010 acre/feet
Shoreline Length	45 miles
Mean Depth	19.48 feet
Watershed Area	314 square miles

Plate 40 - Lake Water Quality for

Fort Cobb Lake

Fort Gibson Lake

Fort Gibson Lake a 14,900-acre reservoir, constructed by the USACE, was built for flood control and hydroelectric power purpose. The lake also provides many recreational opportunities for the citizens of Oklahoma to enjoy. Fort Gibson Lake was sampled for four quarters, from November 2006 through August 2007.

Water quality samples were collected at eight (8) sites to represent the riverine, transitional, and lacustrine zones of the lake as well as any major arms of the reservoir. Samples were collected from the lake surface at all sites during the study period. Fort Gibson Lake is a large dendritic reservoir and has been broken into two management segments, upper lake and lower lake to represent the riverine, transition, and lacustrine zones of the reservoir. The following discussion will briefly summarize each segment with a lake-wide summary included at the end of the narrative.

Upper Lake:

The upper part of Fort Gibson Lake (segment # 121600010200) extends from the Big Hollow area down to Long Bay Landing and includes BUMP sites 5-8. The segment-wide average turbidity was 10 nephelometric turbidity units (NTU), true color was 33 units, and secchi disk depth was 73 centimeters. Based on these three parameters water clarity for this segment was average for sample year 2007. This is not unusual for this part of the lake since it is more riverine than other lacustrine sites. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=16). The average TSI was 61, classifying the segment as hypereutrophic, indicative of excessive primary productivity and nutrient conditions. Chlorophyll-a values among the sites were consistently upper eutrophic to mid-hypereutrophic during the sample year. Turbidity values ranged from a low of 8 NTU (site 5) to a maximum of 21 NTU (site 8). All true color values were below the Aesthetics criteria 70 units with values ranging from 14 to 58 units.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites within the upper segment. Salinity values ranged from 0.07 parts per thousand (ppt) to 0.15 ppt, which is within the range of expected values for most Oklahoma reservoirs. Specific conductivity ranged from 164.9 µS/cm to 315.1 µS/cm, indicating low to moderate concentrations of current conducting compounds or other analogous material (salts) in the lake system. The pH values ranged from 6.04 to 8.91 representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its Fish and Wildlife Propagation (FWP) beneficial use. With 16.5% of the values less than 6.5 units, this portion of the lake is considered partially supporting the beneficial use based on pH. Thermal stratification was not present during the fall or winter and the water column was well mixed. In the spring the lake was weakly stratified however dissolved oxygen (D.O.) remained above 2 mg/L. During the summer the thermal stratification was evident and anoxic conditions present. All four sites in the upper-end of the lake were stratified between 3 and 4 meters below the surface with anoxic conditions comprising 50-79% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With up to 79% of the water column less than 2.0 mg/L in the summer, the upper segment of Fort Gibson Lake is considered not supporting the FWP beneficial use.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of (Nutrient Limited Watershed) NLW lakes and nutrient criteria development for lakes and reservoirs. In the upper lake the average total nitrogen (TN) was 0.93 mg/L, with values ranging from 0.62 mg/L in the winter to 1.50 mg/L in the spring quarter. The average total phosphorus (TP) was 0.112 mg/L, with values ranging from 0.034 mg/L in the winter to 0.261 mg/L in the fall. The nitrogen to phosphorus ratio (TN:TP) was 8:1, This value is close to 7:1, characterizing this portion of the lake as approaching co-limition (Wetzel, 1983).

<u>Lower Lake:</u>

The lower portion of Fort Gibson Lake (segment # 121600010050) extends downward from Taylor Ferry North to the dam and includes BUMP sites 1-4. The segment-wide average turbidity was 7 NTU, true color was 32 units, and secchi disk depth was 86 centimeters. Based on these three parameters water clarity for this segment was average to good for sample year 2007. This is not unusual as you move through the lake towards the dam area and sediment and other materials have had time to settle out. A trophic state index (TSI), using Carlson's TSI (chlorophyll-<u>a</u>), was calculated using values collected at all sites for four quarters (n=16). The average TSI was 60, classifying the segment as eutrophic bordering hypereutrophic, indicative of high primary productivity and nutrient conditions. Chlorophyll-<u>a</u> values among the sites were generally upper eutrophic to mid-hypereutrophic during the sample year. Turbidity values were all below the Oklahoma Water Quality Standard (WQS) of 25 NTU ranging from a low of 3 NTU (site 2) to a maximum of 14 NTU (site 3). Like turbidity, true color was also low with values ranging from 16-53 units, well below the Aesthetics criteria of 70 units.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites within the upper segment. Salinity values ranged from 0.07 parts per thousand (ppt) to 0.15 ppt, which is within the range of expected values for most Oklahoma reservoirs. Specific conductivity ranged from 168.8 µS/cm to 303.9 µS/cm, indicating low to moderate concentrations of current conducting compounds or other analogous material (salts) in the lake system. The pH values ranged from 6.26 to 8.79 representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its Fish and Wildlife Propagation (FWP) beneficial use. With only 12% of the values less than 6.5 units, this portion of the lake is considered partially supporting the beneficial use based on pH. Thermal stratification was not present during the fall, winter or spring quarters and the water column was well mixed with dissolved oxygen (D.O.) remaining above 6.0 mg/L. During the summer thermal stratification was evident anoxic conditions were present at all four sites. Stratification occurred fairly high in the water column with D.O. levels less than 2 mg/L from 6 meters below the surface to the lake bottom of 22.3 meters and anoxic condition comprising 71% of the water column at site 1, the dam. Similar conditions were recorded at sites 2-4 with dissolved oxygen below 2 mg/L in 50-82% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With as much as 82% (site 4) of the water column less than 2.0 mg/L in the summer, the lower segment of Fort Gibson Lake is considered not supporting the FWP beneficial use.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of (Nutrient Limited Watershed) NLW lakes and nutrient criteria development for lakes and reservoirs. In the lower lake the average total nitrogen (TN) was 0.89 mg/L, with values ranging from 0.62 mg/L in the summer to 1.43 mg/L in the spring quarter. The average total phosphorus (TP) was 0.083 mg/L, with values ranging from 0.038 mg/L in the winter to 0.125 mg/L in the summer. The nitrogen to phosphorus ratio (TN:TP) was 11:1. This value is the close to 7:1, characterizing this portion of the lake as phosphorus-limited (Wetzel, 1983).

<u>Lake Summary</u>

The lake was also sampled for chlorides and sulfates, to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported in all three management segments based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites throughout the lake for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. Although all sample results were below both the screening level and geometric mean, the minimum data requirements for each segment were not met and an assessment of the PBCR beneficial use cannot be made at this time.

Ft. Gibson was also sampled for total metals at five sites during the spring of 2007; however the minimum data requirements for each segment were not met and an assessment of the FWP beneficial use cannot be made at this time.

In summary, Fort Gibson Lake (Plate 41) is classified as hypereutrophic, with excessive primary productivity and nutrient conditions. The lake-wide annual turbidity value was 9 NTU, true color was 31 units, and secchi disk depth was 80 centimeters in 2007. Based on these three parameters, Fort Gibson Lake had good water clarity and is very similar to that of the 2003-2004 data collection efforts. A trophic state index (TSI), using Carlson's TSI (chlorophyll-<u>a</u>), was calculated using values collected at all sites for four quarters (n=32). The average TSI was 61, classifying the lake as hypereutrophic, indicative of excessive levels of productivity and nutrient rich conditions. Based on previous data collection efforts, the lake is currently listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. The TSI values were primarily hypereutrophic or eutrophic at all sites throughout the sample year. Turbidity values ranged from a low of 3 NTU to a maximum of 21 NTU (See Figure 53a). According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). With 100% of the reported values below the standard the FWP use is considered supported based on turbidity. All true color values were below the aesthetics WQS of 70 units throughout the sample year (Figure 53b). Applying the same default protocol, the Aesthetics beneficial use is still considered fully supported. Based on anoxic conditions present in the summer sampling interval, the FWP is considered not supporting as it relates to dissolved oxygen. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use; however the minimum data requirements for each segment were not met and an assessment of the PBCR beneficial use cannot be made at this time.

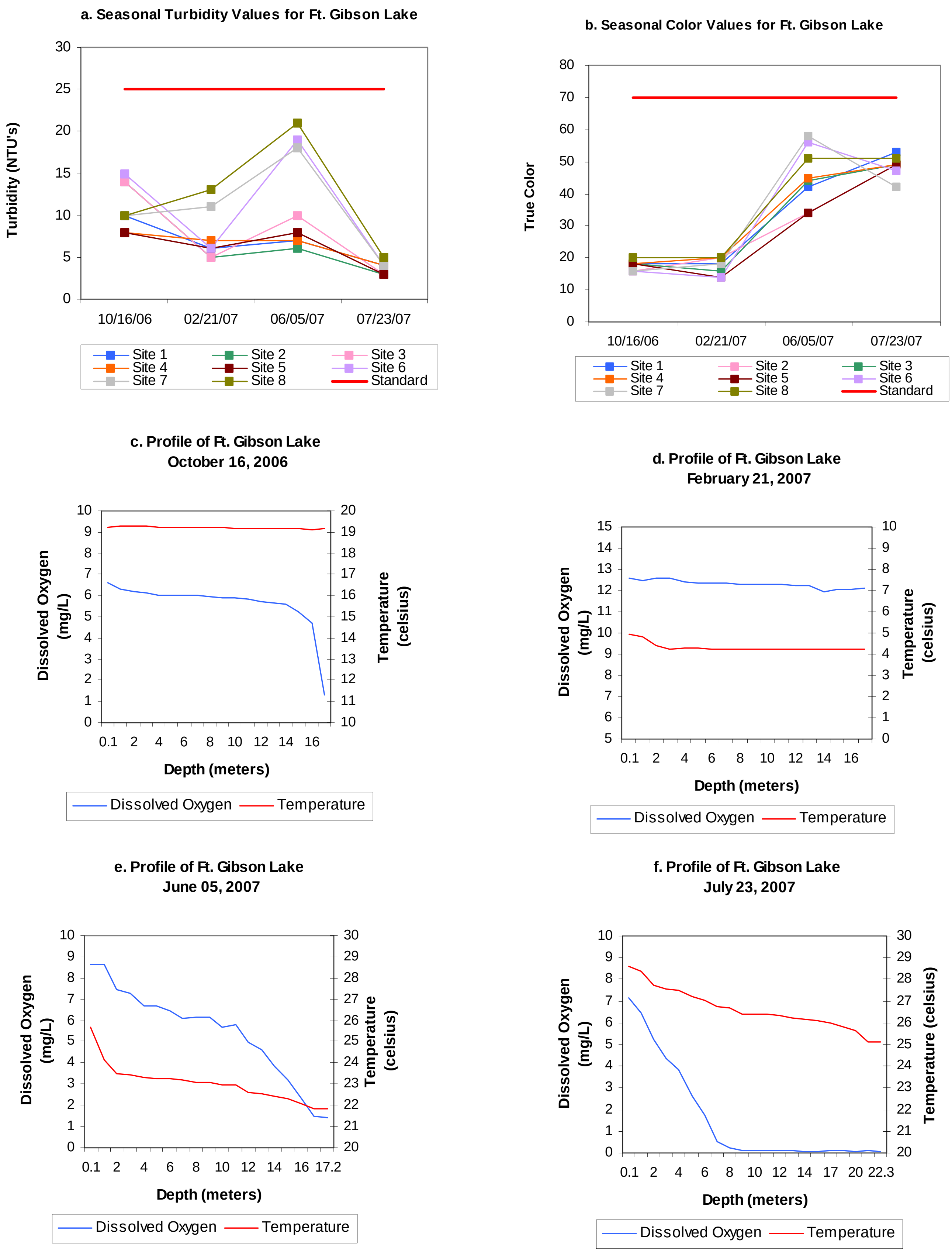
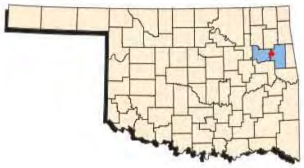
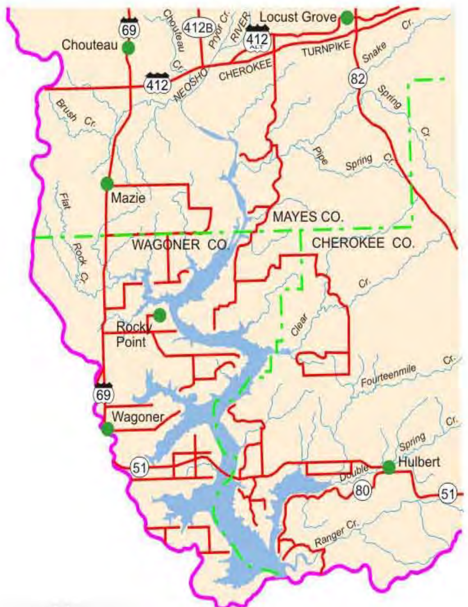


Figure 53a-53f. Graphical representation of data results for Ft. Gibson Lake.

Plate 41 - Lake Water Quality for
Fort Gibson Lake

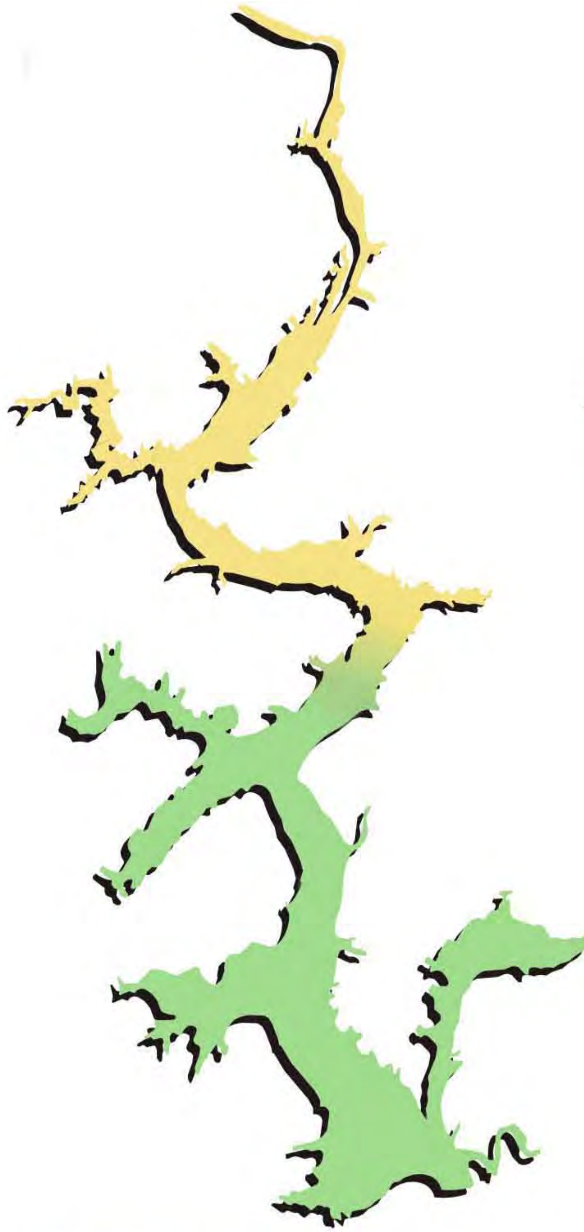


Fort Gibson Lake
Location



Fort Gibson Lake
and
Watershed

Lake Data	
Consrtucted by	Corps of Engineers
County	Cherokee (Dam)
Constructed	1953
Surface Area	19,900 acres
Volume	365,200 acre/feet
Shoreline Length	225 miles
Mean Depth	23.84 feet
Watershed Area	12,492 square miles



POOR EXCELLENT
Turbidity
2007

POOR EXCELLENT
Trophic State
2007

LAKES MONITORING PROGRAM

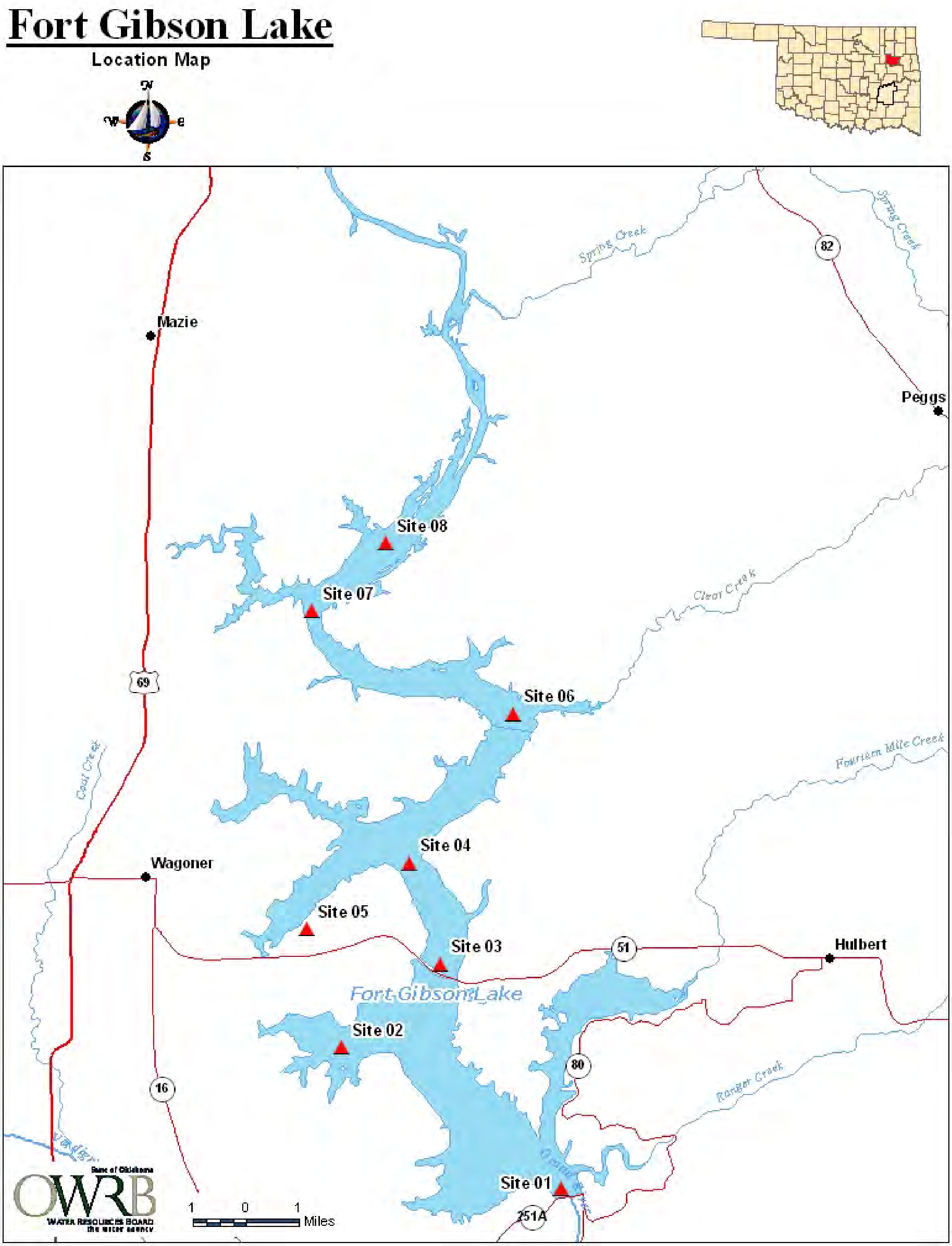


Figure 54. Fort Gibson Lake Site Map

Fort Supply Lake

Fort Supply Lake, located in Woodward County, is approximately 1 mile south of the town of Fort Supply. The United States Army Corps of Engineers built the reservoir in 1942 for flood control and hydroelectric power purposes. Fort Supply Lake was sampled for four quarters, from October 2005 through July 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Water quality samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 45 NTU (Plate 42), true color was 46 units, and secchi disk depth was 34 centimeters. Based on these three parameters, Fort Supply Lake had fair to poor water clarity in 2005-2006, similar to findings in previous data collection efforts. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 57 (Plate 42), classifying the lake in the upper end of eutrophy, indicative of high levels of productivity and high nutrient conditions. This is the same as the TSI calculated in 2004, indicating no significant change in productivity has occurred since the last evaluation. Currently Fort Supply Lake is listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. The TSI values were primarily eutrophic throughout the year with low hypereutrophic conditions observed at half the sites in both the fall and summer quarters. Turbidity values are displayed in Figure 55a. According to the Use Support Assessment Protocols (USAP) detailed in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. The Fish & Wildlife Propagation (FWP) beneficial use is not supporting with 74% of the collected values exceeding the numeric criteria of 25 NTU. Seasonal true color values are shown in Figure 55b. Applying the same default protocol, the Aesthetics beneficial use is considered supporting with 5% of the true color values exceeding the WQS of 70 units.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.45 parts per thousand (ppt) to 0.55 ppt, which is much higher than the range of expected values for Oklahoma lakes, reflecting elevated levels of chlorides or other salts in the lake. Specific conductivity values were also above the expected range for Oklahoma reservoirs, coinciding with the high salinity concentrations. Values ranged from 867.2 µS/cm in the fall to 1053 µS/cm recorded in the summer. Oxidation-reduction potentials (redox) ranged from 345 mV in the summer quarter to 424 mV in the spring, indicating reducing conditions were not present at the time of sampling. Lake pH values were neutral to slightly alkaline with values ranging from 7.33 in the spring to 8.39 in the fall. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With

100% of the pH values recorded within the acceptable range, the lake is supporting its FWP beneficial use as it relates to pH. Thermal stratification was not evident in any quarterly sampling events due to the shallow nature of the reservoir and fact that wind mixing prevents a thermocline from developing (see Figure 55c-55f). Dissolved oxygen (D.O.) values were above 3.5 mg/L throughout the water column at all sites during the study period, indicating the water column was well oxygenated and well mixed. When D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. The FWP beneficial use is considered fully supported at Fort Supply Lake based on D.O. values. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.93 mg/L at the lake surface. The TN at the surface ranged from 0.76 mg/L to 1.36 mg/L. Both the highest and lowest surface TN values were reported in the summer sampling interval. The lake-wide total phosphorus (TP) average was 0.077 mg/L at the lake surface. The TP ranged from 0.035 mg/L to 0.123 mg/L. The highest surface TP value was reported in the summer and the lowest was in the winter. The nitrogen to phosphorus ratio (TN:TP) was 12:1 for sample year 2003-2004. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 2004 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening or consumption advisory levels. Fort Cobb Reservoir was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Fort Supply Lake was classified as eutrophic, bordering hypereutrophic, indicative of high primary productivity and high nutrients (Plate 42). The TSI of 57 is consistent with that of previous data collection efforts in 2004, indicating that no significant increase or decrease in productivity has occurred. Water clarity continues to be fair to poor based on turbidity, true color and secchi disk depth. With only 5% of the true color values exceeding the WQS of 70 units, the lake is supporting its Aesthetics beneficial use as it relates to color. Fort Supply Lake is currently listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. The FWP beneficial use is not supporting with 74% of the turbidity values exceeding the WQS of 25 NTU; however the use is supported based on pH and dissolved oxygen concentrations in the lake. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

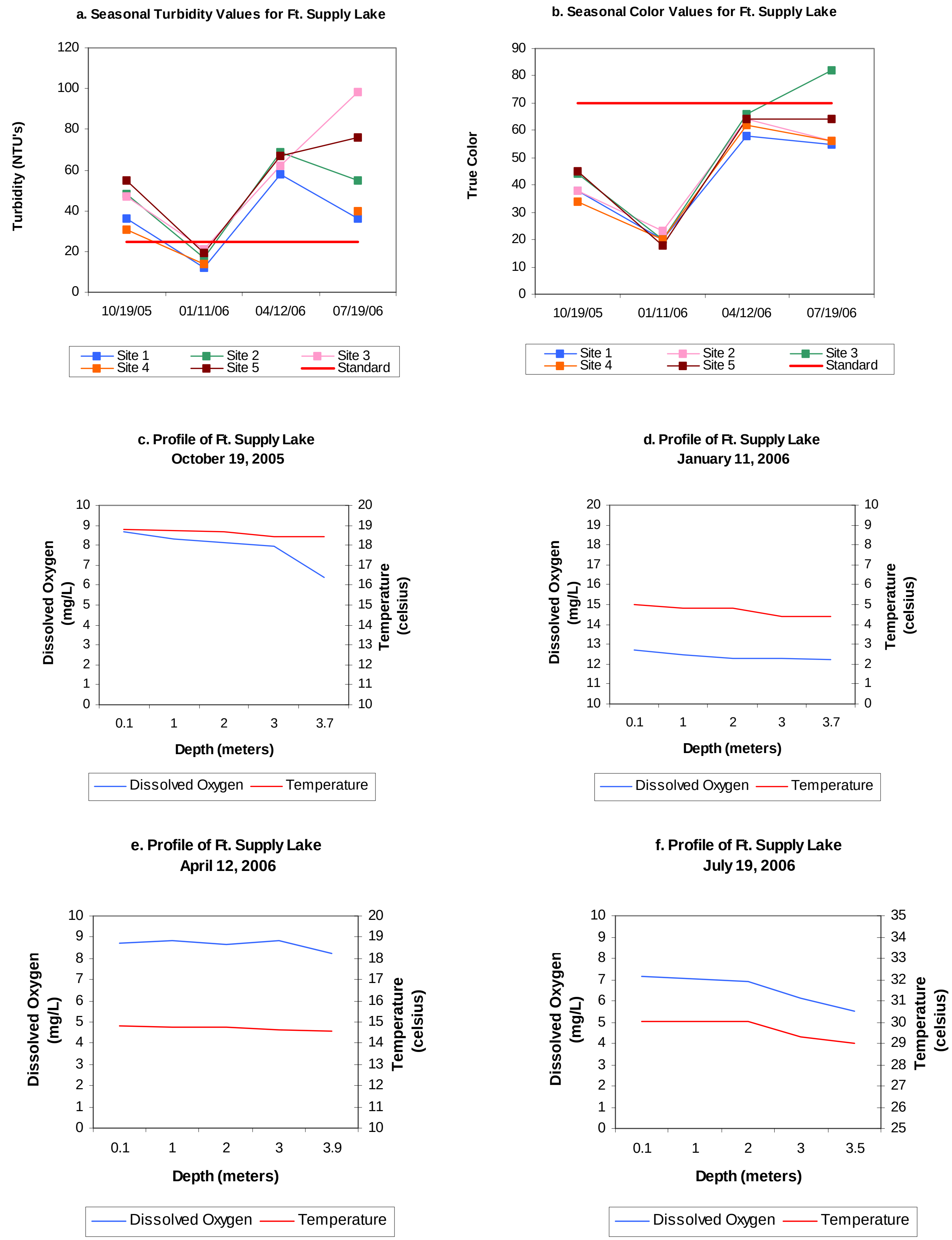
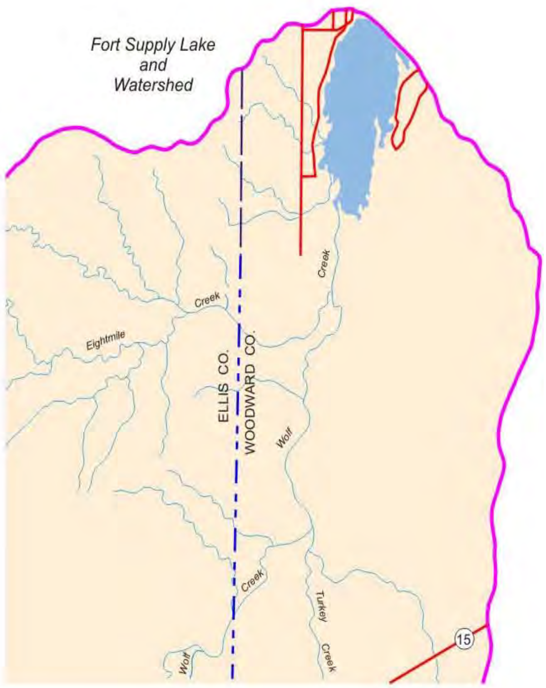


Figure 55a-55f. Graphical representation of data results for Fort Supply Lake.



Lake Data	
Consrtucted by	Corps of Engineers
County	Woodward
Constructed	1942
Surface Area	1,820 acres
Volume	13,900 acre/feet
Shoreline Length	26 miles
Mean Depth	7.64 feet
Watershed Area	1,735 square miles

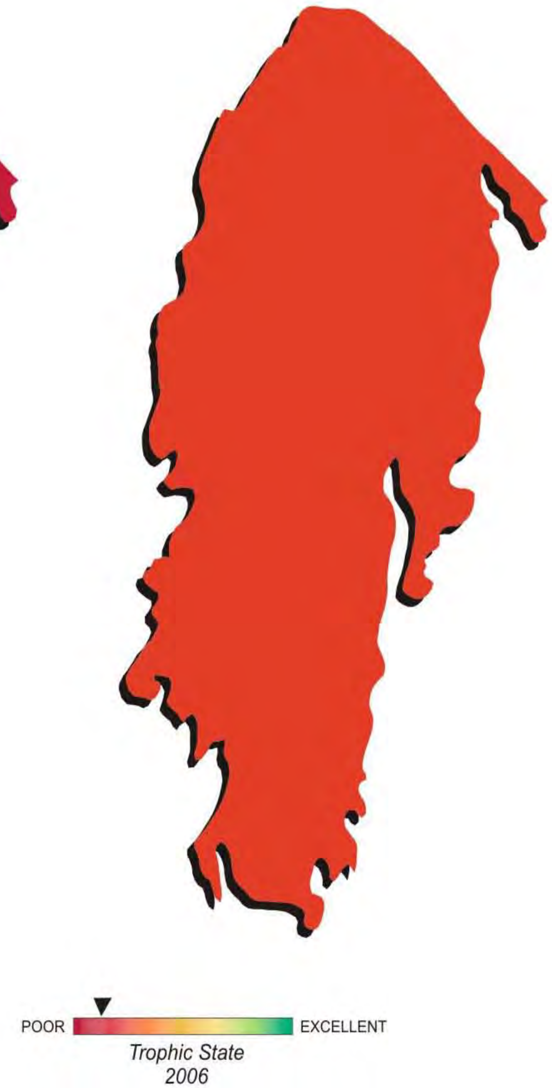
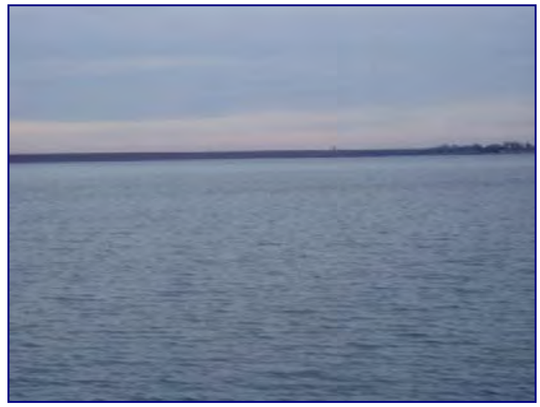


Plate 42 - Lake Water Quality for
Fort Supply Lake

Foss Reservoir



Foss Reservoir was sampled for four quarters, from September 2004 through June 2005. Water quality samples were collected at five (5) sites to represent the riverine, transition and lacustrine zone of the reservoir. Samples were collected from the lake surface at all sites and at 0.5 meters from the lake bottom at site 1, the dam. The average lake-wide turbidity was 9 NTU (Plate 43), true color was 8 units, and average secchi disk depth was 97 centimeters in sample year 2004-2005. Water clarity was good at Foss Reservoir based on these three parameters. Results for turbidity, true color, and secchi disk depth are similar to those recorded in 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The current TSI of 52 (Plate 43) is higher than that calculated in 2003 (TSI=48) placing the lake in a different trophic category. The TSI of 52 indicates the lake was eutrophic, with high levels of productivity and nutrient conditions for sample year 2005. The TSI values for all sites varied seasonally and ranged from oligotrophic in the summer to mesotrophic in the winter and spring with eutrophic values in the fall. The only exception to this pattern occurred at site 5, which generally had higher TSI values through out the year and was even hypereutrophic in the fall. Seasonal turbidity values by site are displayed in Figure 56a. Turbidity values ranged from a low 4 NTU to a maximum of 30 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if $\geq$ 25% of the samples exceed the Oklahoma Water Quality Standard (WQS) of 25 NTU for turbidity. If 10 to 25% of the turbidity samples exceed the criteria of 25 NTU, the lake is considered to be partially supporting beneficial uses. The Fish and Wildlife Propagation (FWP) beneficial use is considered supported at Foss Reservoir with only 1(5)% of the values above the turbidity standard of 25 NTU. Seasonal true color values are displayed in Figure 56b. All color values are well below the aesthetics WQS of 70 units. Applying the same default protocol, the Aesthetics beneficial use is considered supported based on true color data collected during the study period.

In 2004-2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values at Foss Reservoir ranged from 1.06 parts per thousand (ppt) to 1.24 ppt, which is higher than most Oklahoma reservoirs. Specific conductivity was also high ranging from 1963 (summer) µS/cm to 2320 µS/cm (fall), indicating extremely high concentrations of current conducting compounds (chlorides and salts) in the lake, consistent with higher salinity concentrations. The pH values were generally neutral to slightly alkaline ranging from 6.68 at the lake bottom in the spring to 8.3 at the surface in the winter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values recorded within the acceptable range the lake supporting the beneficial use based on pH. Oxidation-reduction potential (ORP) ranged from

357 mV at the surface in the fall to 577 mV during the spring, indicating reducing conditions were not present during any of the sampling intervals. During the fall, winter, and spring thermal stratification was not present and the lake was well mixed with dissolved oxygen values remaining above 6.0 mg/L (see Figure 56c-56e). The lake was thermally stratified during the summer sampling interval however anoxic conditions were not present at any sites at the time of sampling. Stratification generally occurred between 7 and 8 meters at sites 1-3, the deepest sites in the reservoir. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With D.O. greater than 2.0 mg/L in all sampling intervals, Foss Reservoir is considered supporting the FWP beneficial use for sample year 2004-2005. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.67 mg/L at the surface. Surface TN ranged from 0.49 mg/L to 1.12 mg/L with both the highest and lowest values recorded in the winter quarter. The lake-wide total phosphorus (TP) average was 0.022 mg/L at the surface. TP values at the surface ranged from 0.014 mg/L to 0.039 mg/L. The nitrogen to phosphorus ratio (TN:TP) was 30:1 for sample year 2004-2005. This value is much higher than 7:1, characterizing the lake phosphorus limited (Wetzel, 1983).

In summary, Foss Reservoir was classified as eutrophic with high primary productivity and nutrient conditions. The current TSI of 52 (Plate 43) is higher than that calculated in 2003 (TSI=48) placing the lake in a different trophic category. Water clarity was good based on turbidity, true color and secchi disk depth. The FWP beneficial use is supported based on pH, turbidity and dissolved oxygen levels recorded throughout the study period. The Aesthetics beneficial use is also considered supported at Foss Reservoir based on its trophic status and true color. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Foss Reservoir was constructed by Bureau of Reclamation to serve as a flood control, water supply and a fish and wildlife recreation reservoir. Foss State Park is located in western Oklahoma in Custer County.

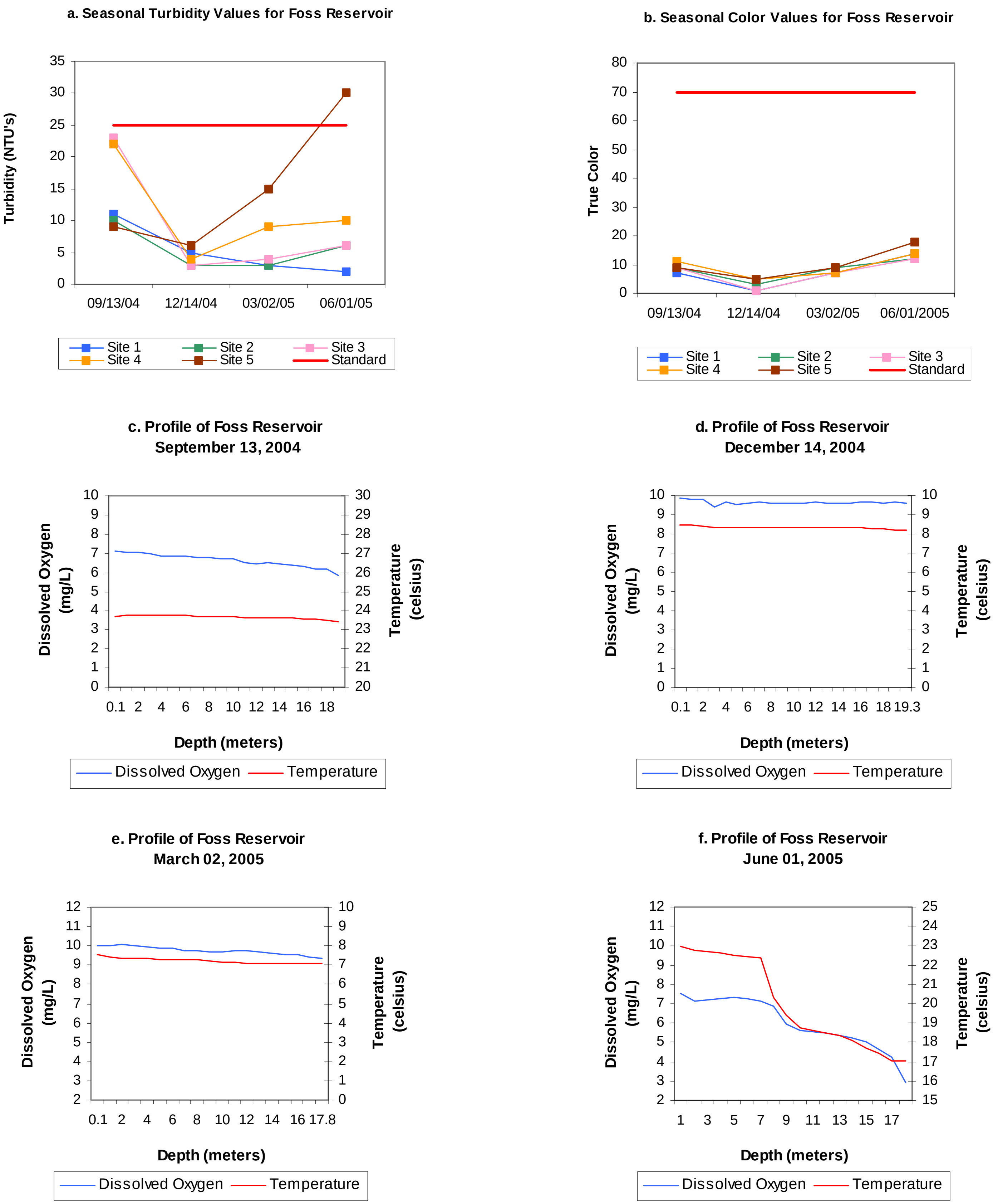
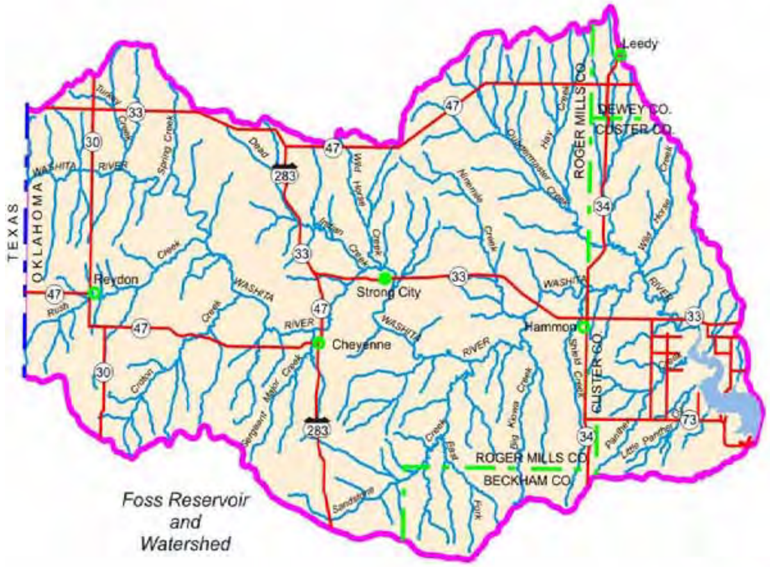
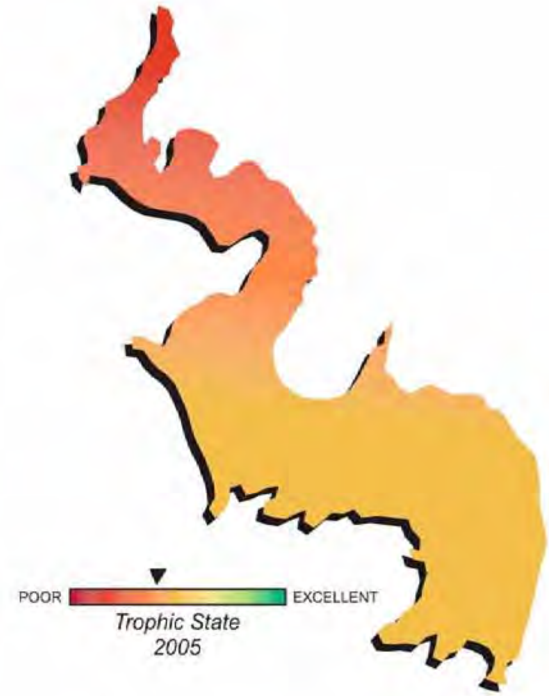


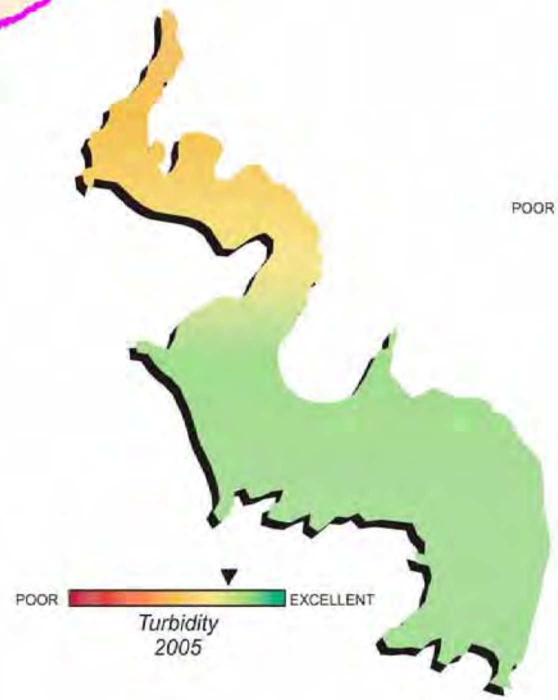
Figure 56a-56f. Graphical representation of data results for Foss Reservoir.



Foss Reservoir and Watershed

Foss Reservoir Location





Lake Data	
Owner	U.S. Dept. of the Interior
County	Custer
Constructed in	1961
Surface Area	8,800 acres
Volume	256,220 acre/feet
Shoreline Length	63 miles
Mean Depth	23.15 feet
Watershed Area	1,496 square miles

Plate 43 - Lake Water Quality for

Foss Reservoir

Lake Frederick

Lake Frederick was constructed in 1974 by the Soil Conservation Service and is located in Tillman County. Lake Frederick was sampled for four quarters from November 2006 through August 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 59 nephelometric turbidity units (NTU), true color was 83 units, and secchi disk depth was 26 centimeters. Based on these three parameters, Frederick Lake had poor water clarity in 2007. Water clarity was similar to historical data and is likely always poor based on the soil composition and nature of this lake. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 56 (Plate 44), classifying the lake as eutrophic, indicative of high levels of productivity and nutrients. This value is consistent with the TSI in 2005 (TSI=55) indicating no significant increase or decrease in productivity has occurred since the previous evaluation. The TSI values varied seasonally from mesotrophic in the spring to eutrophic in the fall and winter with hypereutrophic values at all sites in the summer quarter. Seasonal turbidity values are displayed in Figure 57a. All turbidity values were well above the turbidity standard of 25 NTU with the lowest recorded value of 33 NTU and the maximum value of 94 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥ 25% of the samples exceed the Oklahoma Water Quality Standard (WQS) of 25 NTU for turbidity. With 100% of turbidity values exceeding 25 NTU, the Fish and Wildlife Propagation (FWP) beneficial use is not supported at Lake Frederick. Seasonal true color values are displayed in Figure 57b. Of the twenty values collected, ten (50%) exceeded the WQS of 70 units. Applying the same default protocol, the Aesthetic beneficial use is not supported.

In 2006-2007 vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values at Lake Frederick ranged from 0.12 parts per thousand (ppt) to 0.31 ppt, which is within the range of expected values for most Oklahoma reservoirs in this part of the state. Specific conductivity ranged from 245.5 µS/cm to 614 µS/cm, indicating moderate to high concentrations of current conducting compounds (chlorides and salts) in the lake system. The pH values were neutral to slightly alkaline in nature, ranging from 7.61 to 8.61. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. With 100% of the values recorded within the acceptable range, Lake Frederick is supporting the FWP beneficial use based on pH. Oxidation-reduction potential (ORP) ranged from 47 mV in the summer to 394 mV in the hypolimnion during the spring. Low redox values, like those reported in the summer are not uncommon when anoxic conditions are present. Thermal stratification was not present and the lake was well mixed (see Figure 57c-57d) throughout the fall and winter sampling intervals. The lake was weakly stratified during the spring; however D.O. remained above 5.0 mg/L throughout the entire water column. During the summer thermal stratification was more evident and anoxic conditions were present. At site 1, the dam, stratification occurred between

4 and 5 meters with D.O. dropping below 2 mg/L from 7 meters to the lake bottom of 9.6 meters (Figure 57f). Site 3, 4 and 5 were also stratified with 14-25% of the water column less than 2 mg/L. If the D.O. values are less than 2.0 mg/L for greater than 70% of the water column the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70 % of the water column, the FWP beneficial use is deemed partially supported. With up to 30% of the dissolved oxygen values below 2.0 mg/L during the summer, Lake Frederick is considered to be supporting the FWP beneficial use. The lake was also sampled for total dissolved solids, chlorides and sulfates to assess the Agriculture beneficial use. Sampling 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. All sample results were at or below the detection limit, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.85 mg/L at the surface. Surface TN ranged from 0.74 mg/L to 1.09 mg/L with the highest values recorded in the spring quarter. The lake-wide total phosphorus (TP) average was 0.040 mg/L at the surface. TP values at the surface ranged from 0.023 mg/L to 0.069 mg/L. The nitrogen to phosphorus ratio (TN:TP) was 21:1 for sample year 2006-2007. This value is much higher than 7:1, characterizing the lake phosphorus limited (Wetzel, 1983).

Lake Frederick was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Lake Frederick was classified as eutrophic (TSI=56), indicative of high primary productivity and nutrient rich conditions (Plate 44). This is consistent with the TSI calculated in 2005 and 2003, indicating no significant change has occurred over time. Productivity in the lake is kept in check due to light limitation driven by high turbidity. Water clarity is poor based on turbidity, true color, and secchi disk depth and will likely always be poor based on soil composition of the area. The Fish and Wildlife Propagation beneficial use is supported based on dissolved oxygen and pH, but is not supported as it relates to turbidity values with 100% of the values exceeding 25 NTU. The Aesthetics beneficial use is supported based on its trophic status, however it is considered not supported for true color with 50% of the reported values exceeding the WQS of 70 units. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. Of the 10 samples collected, all were below the prescribed screening level and geometric mean, therefore the PBCR use is considered supported. Due to the lake's use as a municipal water supply reservoir and past and present drought conditions, the city of Frederick was concerned with sedimentation and current lake volumes. During the summer of 2000 the city of Frederick contracted the OWRB to conduct a bathymetric survey of the lake to generate a bathymetric map (Figure 58) and determine current lake volume. For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.

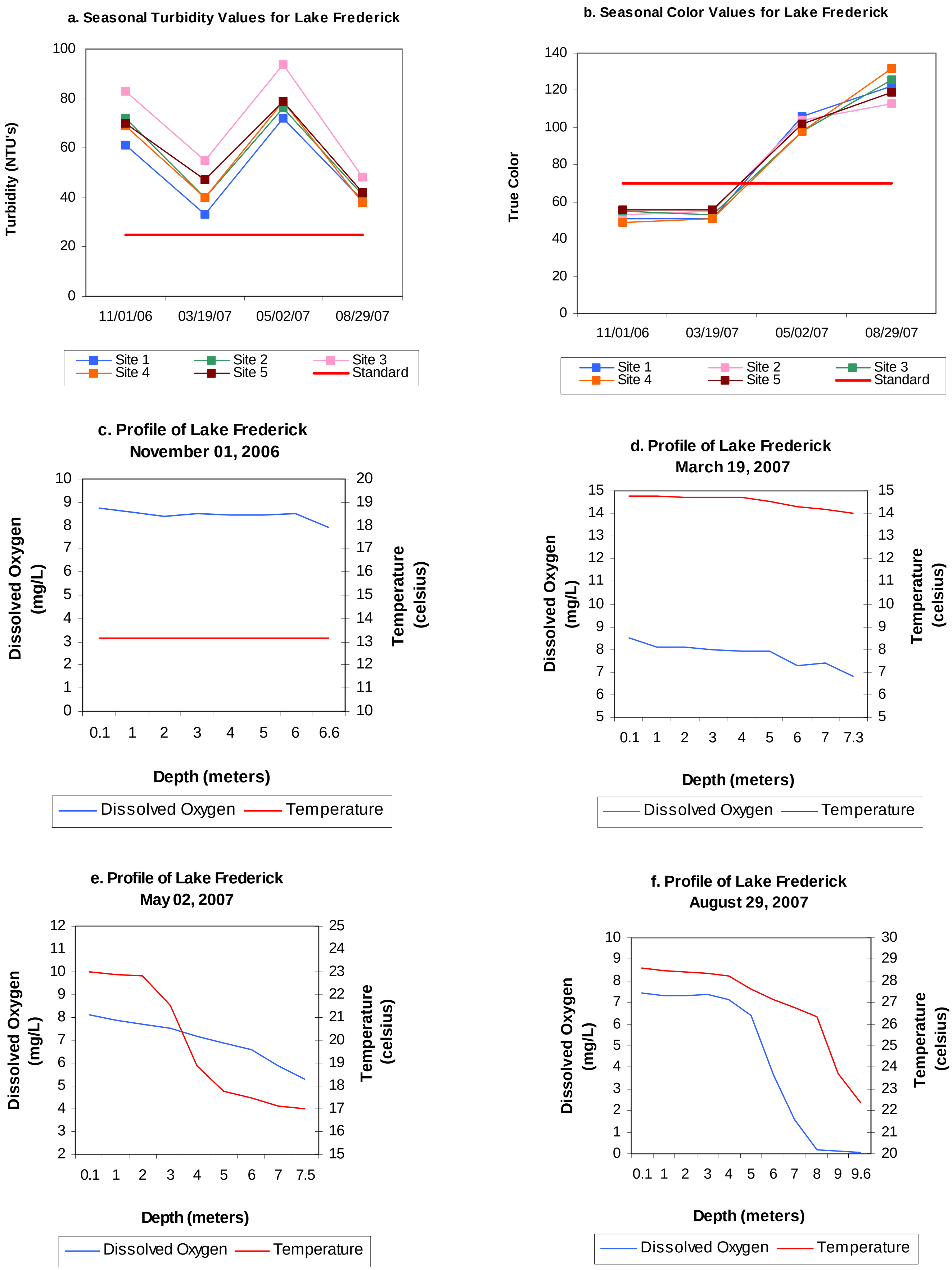
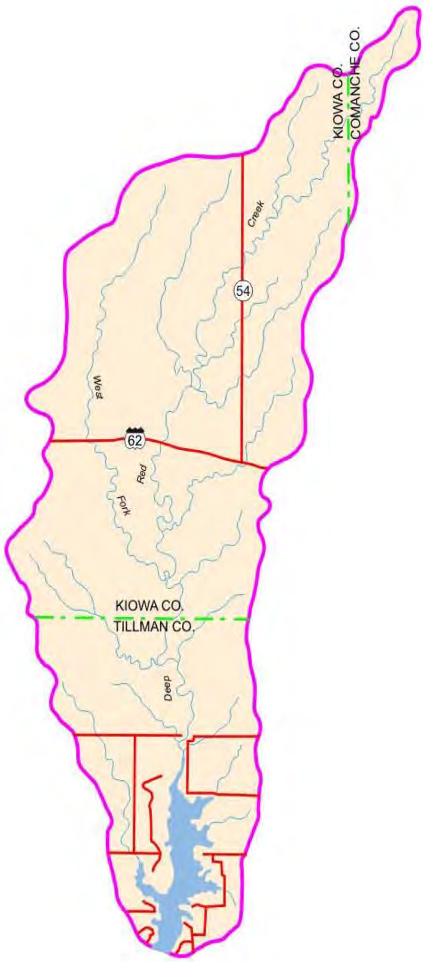


Figure 57a-57f. Graphical representation of data results for Lake Frederick.



Frederick Lake and Watershed

Frederick Lake Location

Turbidity 2007

Trophic State 2007

Lake Data	
Owner	City of Frederick
County	Tillman
Constructed in	1974
Surface Area	876.8 acres
Volume	9,715 acre/feet
Shoreline Length	18.9 miles
Mean Depth	10.83 feet
Watershed Area	57 square miles

Plate 44 - Lake Water Quality for

Lake Frederick

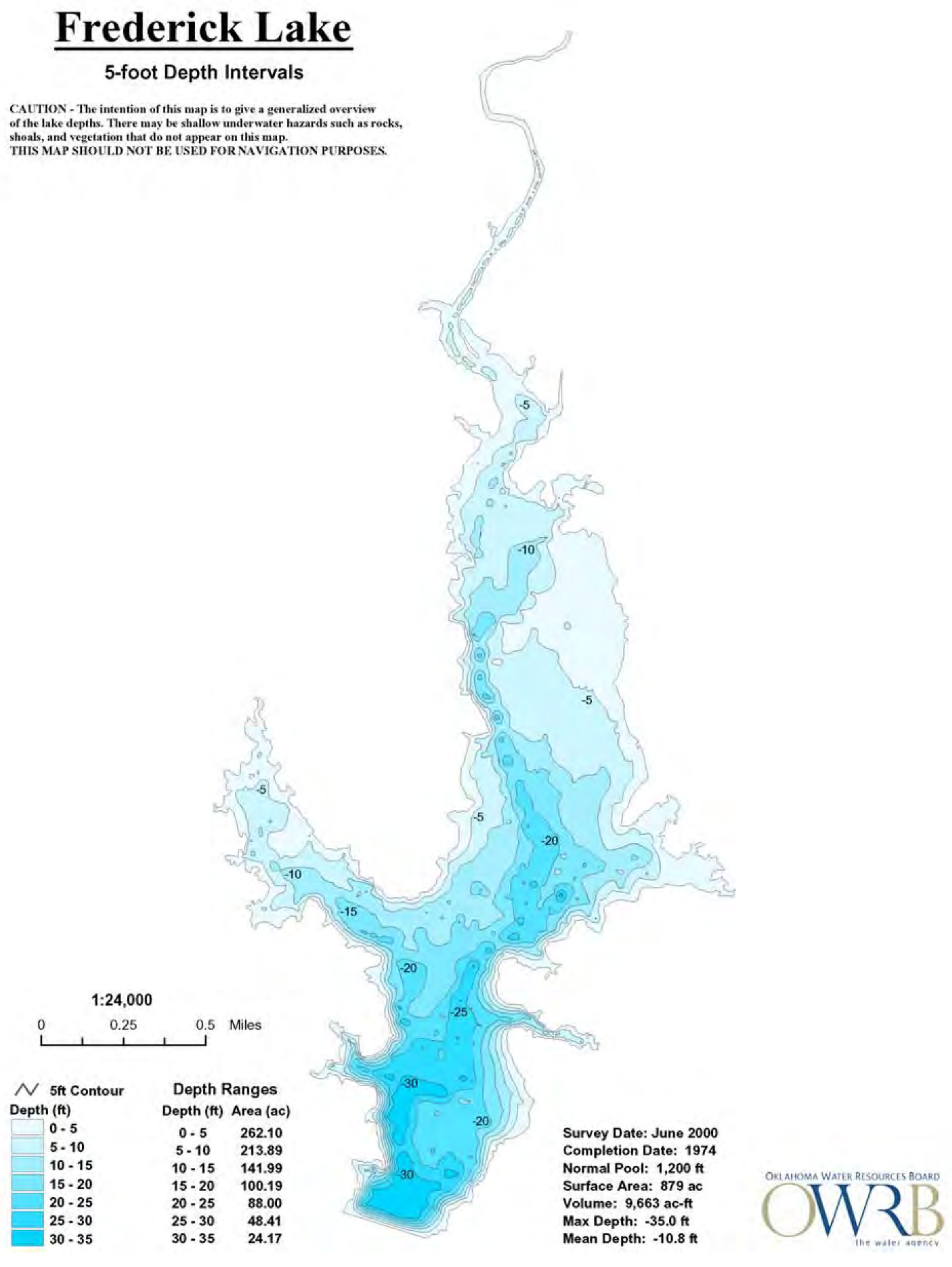


Figure 58. Bathymetric Map of Lake Frederick.

Fuqua Lake

Fuqua Lake is a 1,500-acre lake located in Stephens County. The lake is owned by the city of Duncan and serves as a municipal water supply and recreational reservoir. Fuqua Lake was sampled for four quarters, from November 2006 through August 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones and major arms of the reservoir. Samples were collected from the lake surface at all sites throughout the study period. The lake-wide annual turbidity value was 25 nephelometric turbidity units (NTU) true color was 51 units, and secchi disk depth was 57 centimeters. Based on these three parameters, Fuqua Lake had average water clarity in 2007. Clarity was not as good as it was during the 2005 evaluation and is likely attributed to storm events that occurred during the spring and summer. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI was 52 (Plate 45), classifying the lake as eutrophic, indicative of high levels of productivity and nutrients. The TSI values were fairly consistent with mesotrophic values during the fall and eutrophic conditions present the remainder of the year. Seasonal turbidity values are displayed in Figure 59a. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standard (WQS) of 25 NTU for turbidity. Of the twenty values collected, nine (45%) exceeded the criteria of 25 NTU. Available flow and rainfall data suggest that the peak in turbidity and true color, which occurred in May and August is likely due to seasonal storm events, therefore Fuqua Lake will be listed as supporting its Fish & Wildlife Propagation (FWP) beneficial use for these parameters. Seasonal true color values are displayed in Figure 59b. Similar to turbidity, a spike in color values was observed during both the spring and summer quarters. Applying the same default protocol the Aesthetic beneficial use is fully supported based on true color.

In 2006-2007, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values at Fuqua Lake ranged from 0.13 parts per thousand (ppt) to 0.32ppt, which is within the range of expected values for most Oklahoma reservoirs. Specific conductivity ranged from 84.6 µS/cm to 616.3 µS/cm, indicating moderate concentrations of current conducting compounds or other analogous material (salts) in the lake system. The pH values ranged from 7.29 in the summer to 8.44 during the fall quarter fall representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. With 100% of the values recorded within the acceptable range the lake supporting the beneficial use based on pH. Oxidation-reduction potential (ORP) ranged from 43 mV in the to 472 mV. In general reducing conditions were not present in the lake during the study period; however low values like those observed in the summer are not uncommon when anoxic conditions are present. Thermal stratification was not present and the lake was well mixed with dissolved oxygen (D.O) values remaining above 7.0 mg/L (see Figure 59c-59d) during the first two sampling quarters. Thermal stratification was evident and anoxic conditions present in both the spring and summer intervals. Stratification was gradual in the spring with D.O. dropping below 2.0 mg/L from 8 meters to the lake bottom of 10.5 meters. A similar situation was observed during the summer quarter with dissolved oxygen dropping below 2.0 mg/L from the 9 meters in depth to the lake bottom of 11.4 meters and anoxic conditions comprising 31% of the water column (see Figure 59f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With only 31 to 33% of the water column less than 2.0 mg/L in the spring and summer sampling intervals Fuqua Lake is considered supporting the FWP beneficial use. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. Of the ten enterococci samples collected, three exceeded the screening level of 61 cfu/100 ml. The geometric mean however was not exceeded, therefore the PBCR is still considered supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.56 mg/L at the surface. Surface TN ranged from 0.44 mg/L in the fall to 0.73 mg/L in the spring quarter. The lake-wide total phosphorus (TP) average was 0.029mg/L at the surface. TP values at the surface ranged from 0.015 mg/L in the spring to 0.050 mg/L in the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was 19:1 for sample year 2006-2007. This value is much higher than 7:1, characterizing the lake phosphorus limited (Wetzel, 1983).

Fuqua Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Fuqua Lake was classified as eutrophic with high primary productivity and nutrient levels in 2006-2007 (Plate 45). Water clarity was average based on turbidity, true color, and secchi disk depth, with values slightly higher than those observed in the 2005 evaluation. The lake is supporting its FWP beneficial use as it relates to pH, turbidity and dissolved oxygen values recorded during the study period. The Aesthetics beneficial use is considered supported based on its trophic status and true color values. Available flow and rainfall data suggest that the peak in turbidity and true color, which occurred in May and August is likely due to seasonal storm events, therefore Fuqua Lake will be listed as supporting its Fish & Wildlife Propagation (FWP) and Aesthetics beneficial use for these parameters. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Although three (3) of the enterococci values exceeded the screening level, the geometric mean was not; therefore the PBCR is considered supported
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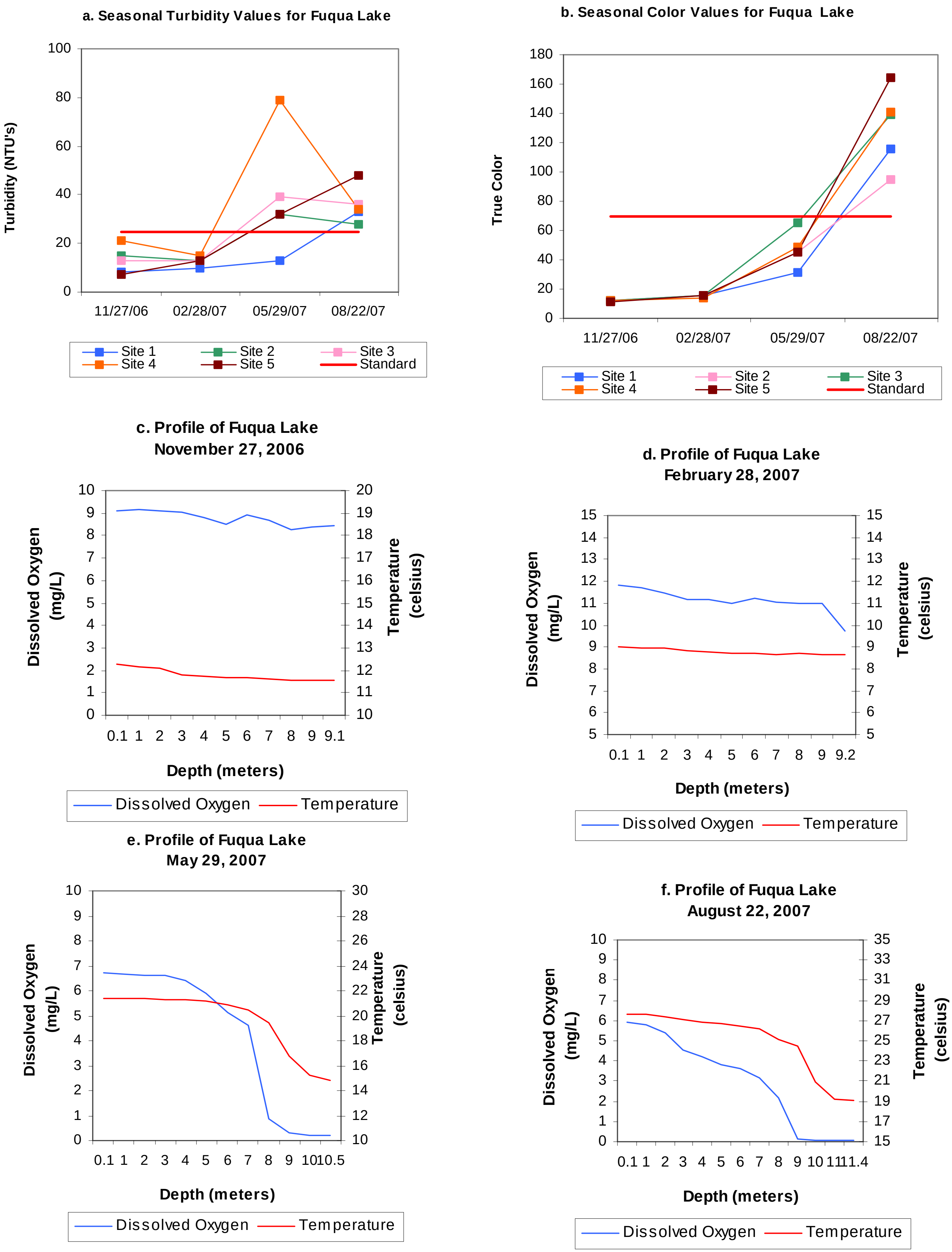
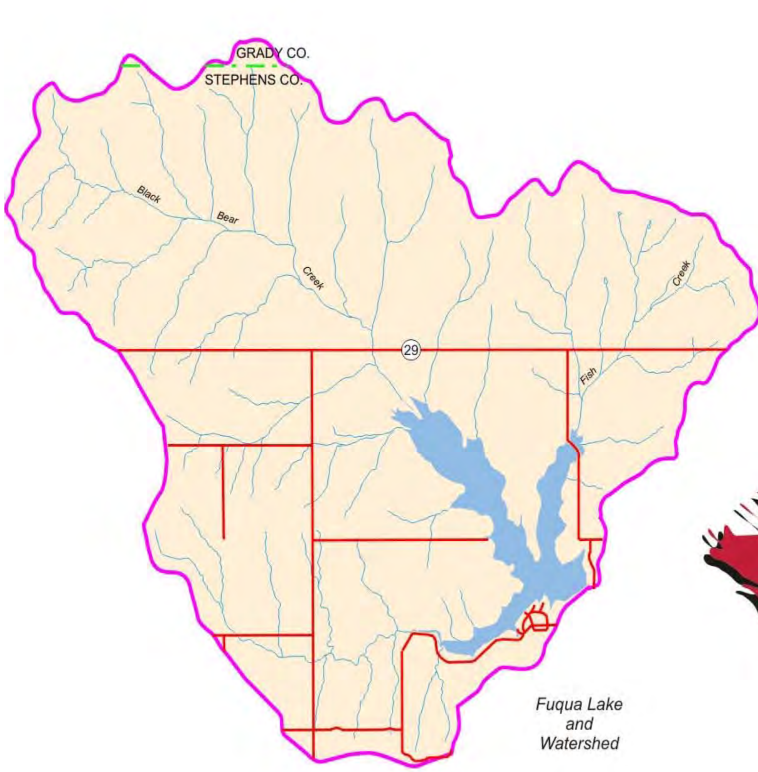


Figure 59a-59f. Graphical representation of data results for Fuqua Lake.



Fuqua Lake and Watershed

Fuqua Lake Location

Lake Data	
Owner	City of Duncan
County	Stephens
Constructed in	1962
Surface Area	1,500 acres
Volume	21,100 acre/feet
Shoreline Length	18 miles
Mean Depth	14.07 feet
Watershed Area	38 square miles

Turbidity 2007

Trophic State 2007

Plate 45- Lake Water Quality for

Fuqua Lake

Grand Lake

Grand Lake, located in Mayes County, is approximately 13 miles southeast of Vinita. The Grand River Dam Authority (GRDA) constructed Grand Lake, the third largest reservoir in Oklahoma, for flood control and hydro-electrical power and is also utilized for various recreational purposes. Grand Lake was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at 13 sites to represent the riverine, transition, and lacustrine zones as well as major arms and tributaries of the reservoir. Samples were collected from the lake surface at all sites during the study period. Grand Lake is a large dendritic reservoir and has been broken into three management segments, upper lake, mid-lake and lower lake to represent the riverine, transition, and lacustrine zones of the reservoir. The following discussion will briefly summarize each segment with a lake-wide summary included at the end of the narrative.

Upper Lake:
The upper part of Grand Lake (segment # 121600030040) extends from the Elk River arm up-lake up to the Twin Bridges area and includes BUMP sites 10-13 (see Figure 61). The segment-wide average turbidity was 13 nephelometric turbidity units (NTU), true color was 25 units, and Secchi disk depth was 69 centimeters. Based on these three parameters water clarity for this segment was average for sample year 2006. This is not unusual for this part of the lake since it is more riverine than other lacustrine sites. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=16). The average TSI was 62, classifying the segment as hypereutrophic, indicative of excessive primary productivity and nutrient conditions. Chlorophyll-a values among the sites were consistently upper eutrophic to mid-hypereutrophic during the sample year. Turbidity values ranged from a low of 5 NTU (site 10) to a maximum of 22 NTU (sites 12 and 13). All true color values were below the Aesthetics criteria 70 units with values ranging from 16 to 42 units.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites within the upper segment. Salinity values ranged from 0.11 parts per thousand (ppt) to 0.23 ppt, which is within the range of expected values for most Oklahoma reservoirs. Specific conductivity ranged from 233.4 µS/cm to 453.7 µS/cm, indicating low to moderate concentrations of current conducting compounds or other analogous material (salts) in the lake system. The pH values ranged from 6.75 to 8.34 representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its Fish and Wildlife Propagation (FWP) beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range, this portion of the lake is considered supporting the beneficial use based on pH. Thermal stratification was not present during the fall, winter or spring quarters and the water column was well mixed. During the summer anoxic conditions were present at all sites to varying degrees accounting for 25-43% of the water column to be below 2.0 mg/L. If D.O. values are less than

2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With up to 43% of the water column less than 2.0 mg/L in the summer, the upper segment of Grand Lake is considered supporting the FWP beneficial use.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of (Nutrient Limited Watershed) NLW lakes and nutrient criteria development for lakes and reservoirs. In the upper lake the average total nitrogen (TN) was 0.89 mg/L, with values ranging from 0.45 mg/L in the fall to 1.79 mg/L in the spring quarter. The average total phosphorus (TP) was 0.115, with values ranging from 0.042 mg/L in the winter to 0.212 mg/L in the summer. The nitrogen to phosphorus ratio (TN:TP) was 8:1, This value is the close to 7:1, characterizing this portion of the lake as possibly co-limited (Wetzel, 1983).

Mid- Lake

The mid-lake portion of Grand Lake (segment # 121600030030) extends from the Elk River arm downward including both Horse creek Cove and the Honey Creek arm of the lake and includes BUMP sites 4-9. The segment average turbidity was 9 NTU, true color was 25 units, and secchi disk depth was 91 centimeters. Based on these three parameters water clarity for this segment was average to good for sample year 2006. This is not unusual as you move through the lake and sediment and other materials are starting to settle out. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=16). The average TSI was 60, classifying the segment as eutrophic, indicative of high primary productivity and nutrient conditions. Chlorophyll-a values among the sites were generally upper eutrophic to mid-hypereutrophic during the sample year. Turbidity values were all below the Oklahoma Water Quality Standard (WQS) of 25 NTU with values ranging from a low of 2 NTU (site 7) to a maximum of 17 NTU (site 8). True color for this portion of the lake ranged from 18 to 44 units.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites within the mid-lake segment. Salinity values ranged from 0.11 parts per thousand (ppt) to 0.15 ppt, which is within the range of expected values for most Oklahoma reservoirs. Specific conductivity ranged from 235.5 µS/cm to 354 µS/cm, indicating low to moderate concentrations of current conducting compounds or other analogous material (salts) in the lake system. The pH values ranged from 6.53 to 8.59 representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range, this portion of the lake is considered supporting the beneficial use based on pH. Thermal stratification was not present during the fall or winter and the water column was well mixed. During the spring sampling interval the water column was weakly stratified with dissolved oxygen only falling below 2.0 mg/l at sites 6 (Honey Creek arm) and 7 near the sediment-water interface. In the summer quarter thermal stratification was more evident and anoxic conditions were present at all sites to varying degrees accounting for 22-47% of the water column to be below 2.0 mg/L. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With 7-11% of the water column in the spring and 22 to 43% of the water column in the summer

less than 2.0 mg/L, the mid-lake portion of Grand Lake is considered supporting the FWP beneficial use.
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. Total nitrogen (TN) in the mid-lake portion ranged from 0.50 mg/L in the winter to 1.54 mg/L in the spring with a segment average of 0.71 mg/L. TP values ranged from 0.031 in the summer to 0.103 mg/L in the fall with an average of 0.075 mg/l. The nitrogen to phosphorus ratio (TN:TP) was 9:1. This value is slightly higher than 7:1, characterizing this portion of the lake as phosphorus limited or possibly co-limited (Wetzel, 1983).

Lower Lake

The lower portion of Grand Lake (segment # 121600030020) extends from Horse Creek Cove downward to the dam and includes BUMP sites 1-3. The segment-wide average turbidity was 5 NTU, true color was 21 units, and secchi disk depth was 134 centimeters. Based on these three parameters water clarity for this segment was excellent for sample year 2006. This is not unusual as you move through the lake towards the dam area and sediment and other materials have had time to settle out. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=16). The average TSI was 50, classifying the segment as mesotrophic bordering eutrophic, indicative of moderate to high primary productivity and nutrient conditions. Chlorophyll-a values among the sites were generally upper eutrophic to mid-hypereutrophic during the sample year. Turbidity values were all below the Oklahoma Water Quality Standard (WQS) of 25 NTU ranging from a low of 2 NTU (site 1) to a maximum of 7 NTU (site 2). Like turbidity, true color was also low with values ranging from 16-23 units, well below the Aesthetics criteria of 70 units.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites within the lower lake segment. Salinity values ranged from 0.13 parts per thousand (ppt) to 0.19 ppt, which is within the range of expected values for most Oklahoma reservoirs. Specific conductivity ranged from 264 µS/cm to 374 µS/cm, indicating low to moderate concentrations of current conducting compounds or other analogous material (salts) in the lake system. The pH values ranged from 7.07 to 8.68 representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range, this portion of the lake is considered supporting the beneficial use based on pH. In the fall, site 1 was weakly stratified with dissolved oxygen (D.O.) below 2.0 mg/l from 25 meters below the surface to the lake bottom of 33.4 meters. Thermal stratification was not present during the winter quarter and the water column was well mixed. During the spring sampling interval the water column was weakly stratified however dissolved oxygen remained above 2.0 mg/L at three sites 6 in this segment. In the summer quarter thermal stratification was more evident and anoxic conditions were present at all sites to varying degrees accounting for 47-62% of the water column to be below 2.0 mg/L. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With up to 62% of the water column in the summer less than 2.0 mg/L, the lower lake portion of Grand Lake is considered partially supporting the FWP beneficial use.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. In the lower portion of the lake the average total nitrogen (TN) was 0.60 mg/L, with values ranging from 0.46 mg/L in the spring to 0.77 mg/l in the winter quarter. The average total phosphorus (TP) was 0.059, with values ranging from 0.023 mg/L in the summer to 0.107 mg/L in the fall. The nitrogen to phosphorus ratio (TN:TP) was 10:1, This value is the close to 7:1, characterizing this portion of the lake as phosphorus limited or possibly co-limited (Wetzel, 1983).

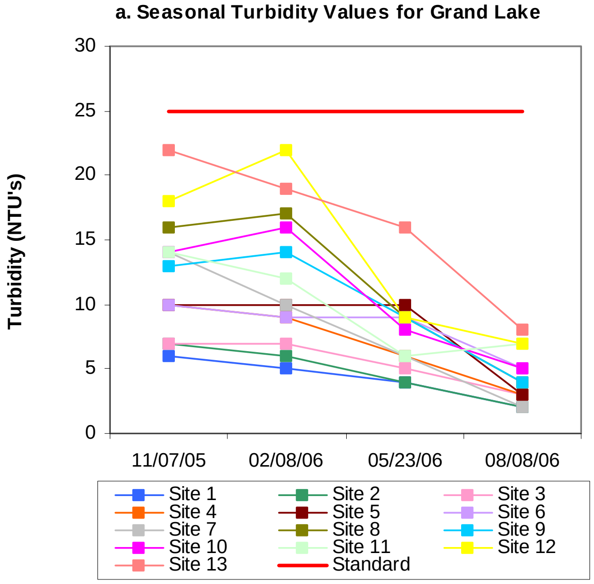
Lake Summary

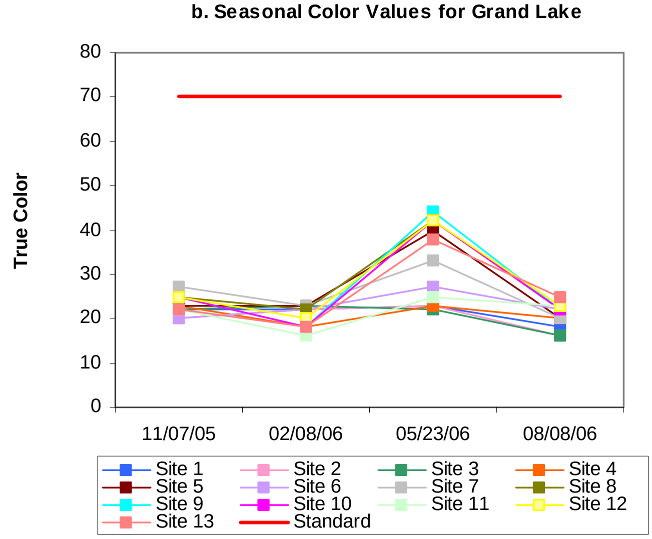
The lake was also sampled for chlorides and sulfates, to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported in all three management segments based on numerical criteria located in OAC 785:45 – Appendix F.

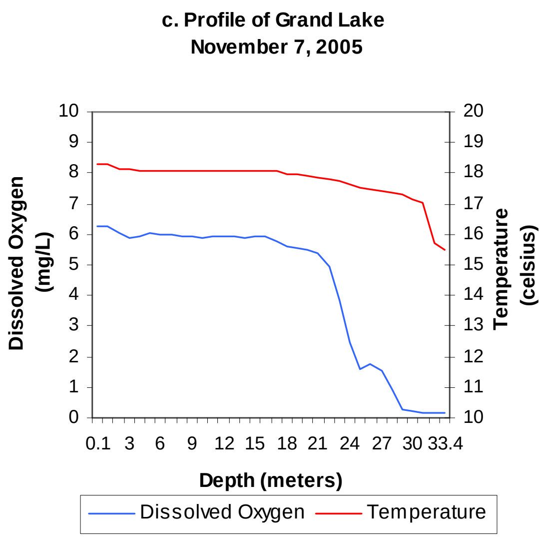
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites throughout the lake for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. Although all sample results were below both the screening level and geometric mean, the minimum data requirements for each segment were not met and an assessment of the PBCR beneficial use cannot be made at this time.

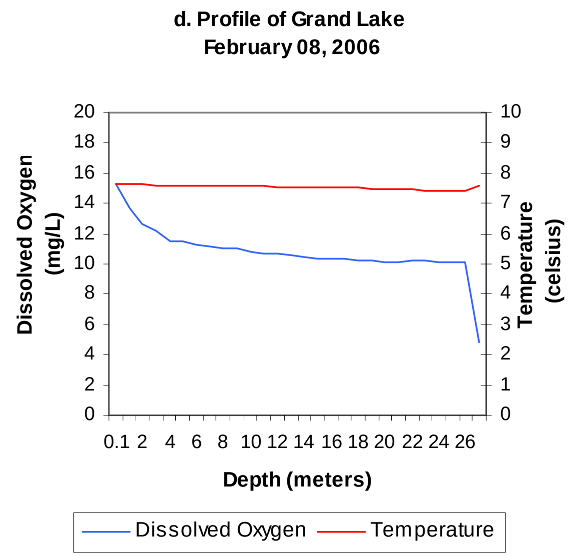
The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 2002 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening level or consumption advisory level. Grand Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

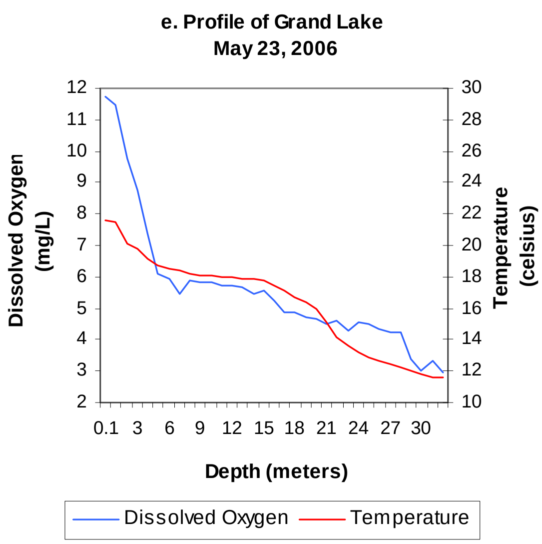
In summary, Grand Lake is classified as eutrophic, with high primary productivity and nutrient rich conditions (Plate 46). The lake-wide annual turbidity value was 9 NTU (Plate 46), true color was 24 units, and secchi disk depth was 93 centimeters. Based on these three parameters, Grand Lake had average to good water clarity, slightly better than that observed in 2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=52). The average TSI was 59 (Plate 46), classifying the lake as eutrophic, indicative of high levels of productivity and nutrient rich conditions. This value is similar to that calculated in 2004 (TSI=57) and 2001 (TSI=59), placing the lake within the same trophic category. Chlorophyll-a values were varied by site and season during the study period at this reservoir. The TSI values ranged from oligotrophic (2%) to hypereutrophic (33%), although most values were in the mesotrophic (21%) or eutrophic category (44%). As expected, the lowest TSI average was at the lower end of the lake (site 1) as well as sites 2 and 3 and the most productive sites were in the tributary arms, Honey Creek (site 6) and Spring/Neosho River arm (sites 12 and 13). Seasonal turbidity values are displayed in Figure 60a. Turbidity values were also variable between sites and seasonally with lower values observed in the more lacustrine areas of the lake. All 52 turbidity values were below the Oklahoma Water Quality Standard (WQS) of 25 NTU. With 100% of the recorded turbidity values below the numeric criteria, the Fish & Wildlife Propagation (FWP) beneficial use is considered fully supported for sample year 2006. Seasonal true color values are displayed in Figure 60b. Like turbidity, none of the 52 true color values exceeded the numeric criteria of 70 units; therefore, the Aesthetics beneficial use is considered fully supported. Based on anoxic conditions present in the summer (Figure 60f), the FWP is considered partially supported at Grand Lake as it relates to dissolved oxygen. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites throughout the lake for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. Although all sample results were below both the screening level and geometric mean, the minimum data requirements for each segment were not met and an assessment of the PBCR beneficial use cannot be made at this time.











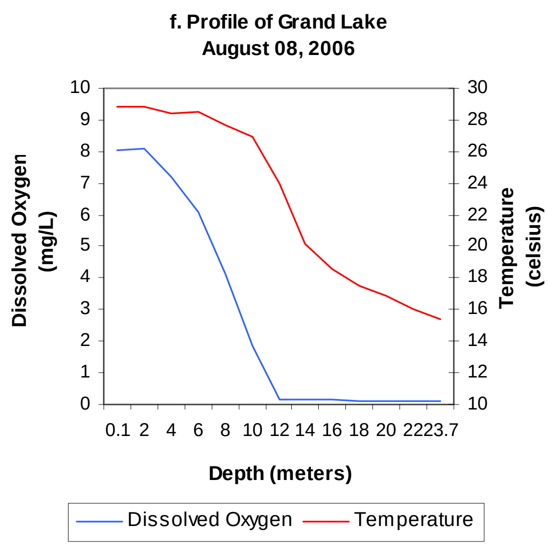
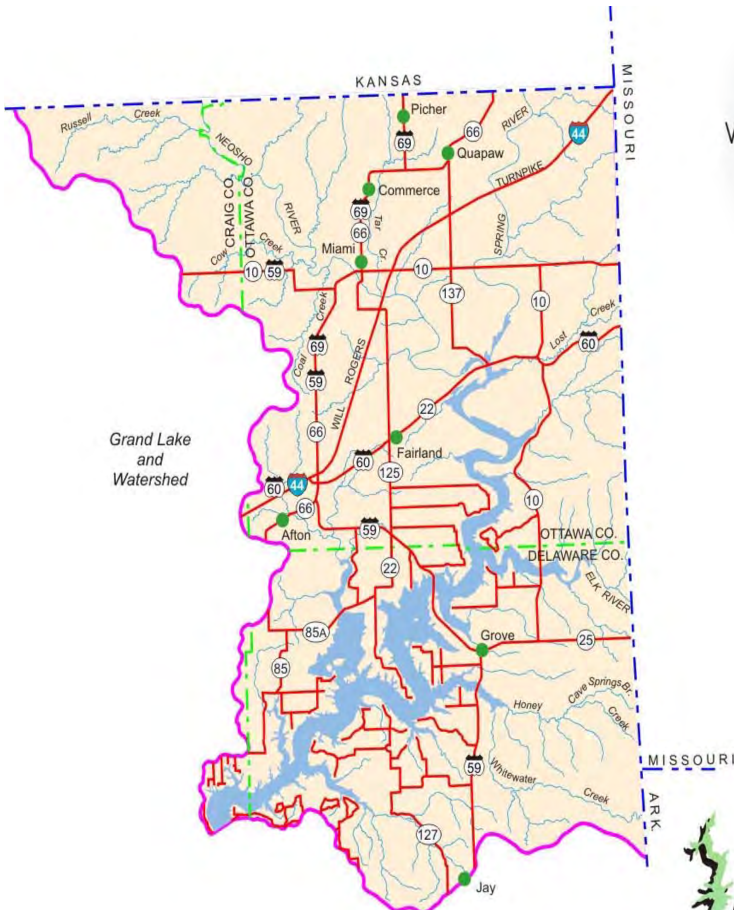
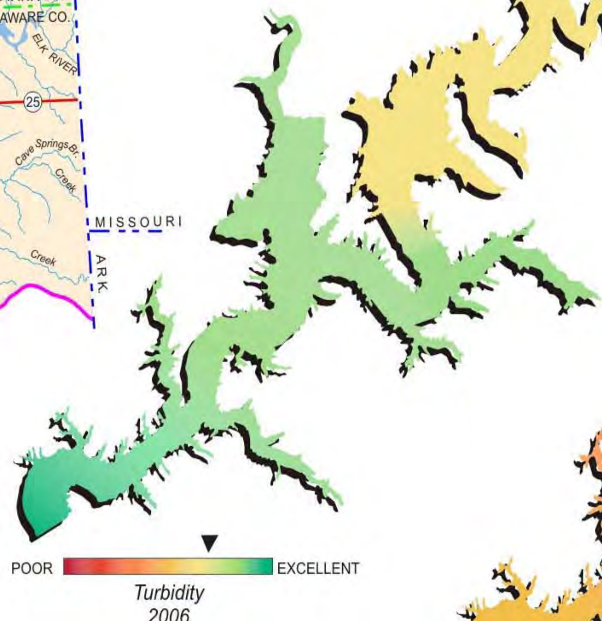


Figure 60a-60f. Graphical representation of data results for Grand Lake.

Plate 46 - Lake Water Quality for Grand Lake



Lake Data	
Constructed by	Corps of Engineers
County	Mayes (Dam)
Constructed	1940
Surface Area	46,500 acres
Volume	1,672,000 acre/feet
Shoreline Length	1,300 miles
Mean Depth	35.96 feet
Watershed Area	10,298 square miles



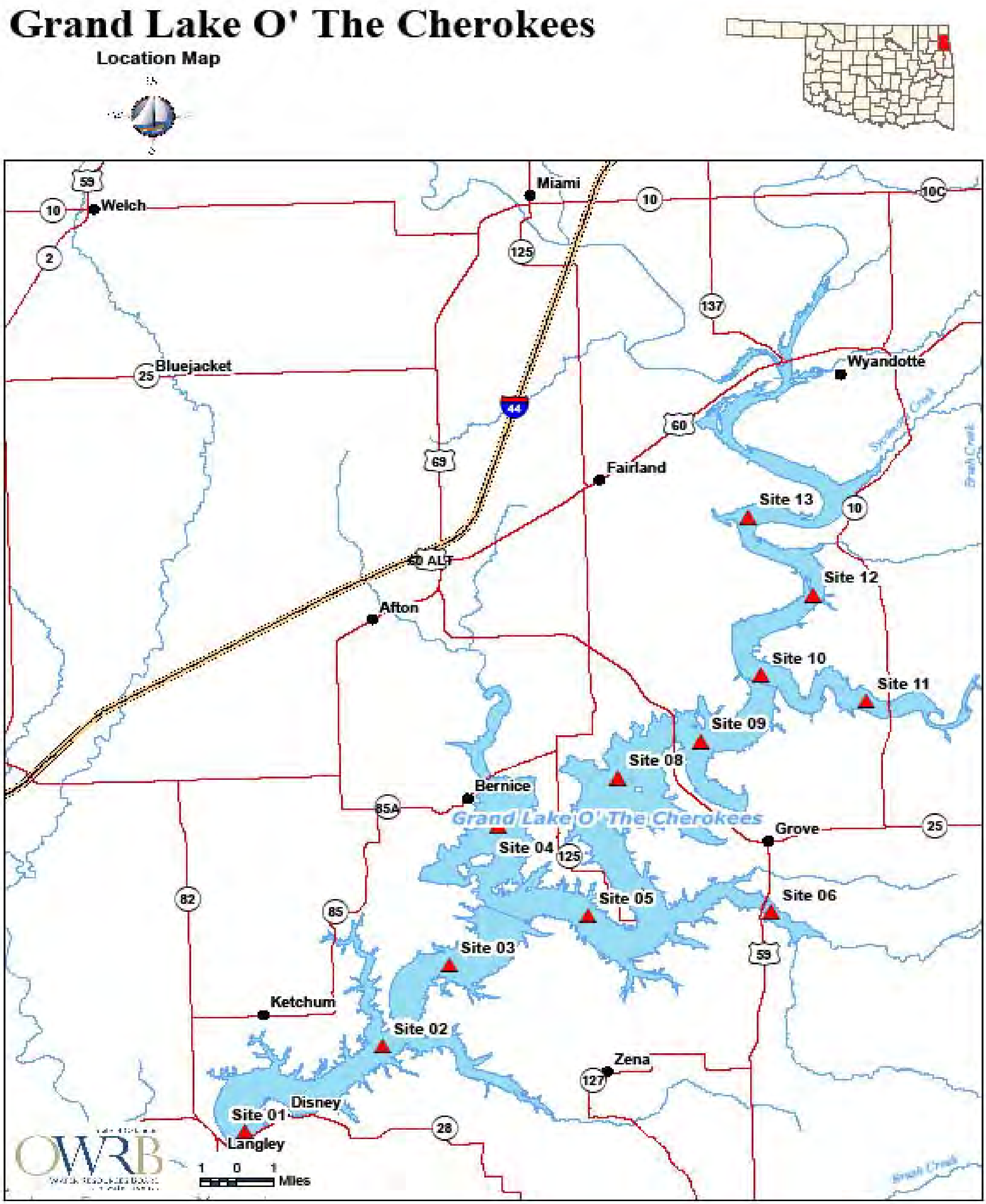


Figure 61. Grand Lake Site Map

LAKES MONITORING PROGRAM

Great Salt Plains Lake

Great Salt Plains Lake is located in Alfalfa County on the Salt Fork of the Arkansas River. The lake and state park are just a few miles north of the town of Jet. The United States Army Corps of Engineers constructed the lake in 1941 for flood control and other conservation purposes and is a popular spot for birding related activities. Great Salt Plains Lake was sampled for two quarters from October 2005 through August 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Water samples were collected from the lake surface at all five sites during the study period. Due to low lake levels, OWRB staff was unable to access the lakes in both the winter and summer sampling intervals. The following data discussion is based on the data collected in October 2005, April 2006 and was aggregated with past historical data collected since the beginning of the BUMP program in 1998. The lake-wide average turbidity value was 193 NTU (Plate 47), true color was 62 units, and secchi disk depth was 10 centimeters. Based on these three parameters, Great Salt Plains Lake had poor water clarity and is likely to always be poor based on the soil composition and shallow morphometry of this lake. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites (n=57). The average TSI was 71 (Plate 47), classifying the lake as hypereutrophic, indicative of excessive levels of primary productivity and nutrients. Currently the lake is listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Fifty-nine of the sixty turbidity values (98%) exceeded the WQS of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Great Salt Plains Lake is currently not supporting its Fish & Wildlife Propagation (FWP) beneficial use based on high turbidity. Of the fifty-one true color values collected, nine (17%) exceed the WQS standard of 70 units. Applying the same default protocol, the Aesthetics beneficial use is considered partially supported in regards to true color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were also recorded at all sample sites during the period of record. Salinity ranged from 0.02 to 5.67 parts per thousand (ppt), which is much higher than the range of expected values for Oklahoma lakes, reflecting the presence of large amounts of chlorides or other salts in the lake. Specific conductivity values ranged from 494.6 µS/cm to 10,016 µS/cm, which also indicated extremely high levels of current conducting ionic compounds (or other analogous materials) present in the water column. Oxidation-reduction potentials (redox) ranged from 93 mV to 490 mV, indicating an absence of reducing conditions at any time in the water column during the course of lake sampling. The pH values were generally neutral to slightly alkaline, ranging from 5.11 to 8.80 units. In the summer of 2002, all recorded pH values were below 6.5 pH units however this is the only instance that this has occurred. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With only 6.4% of the collected values below 6.5 units, the lake is supporting its FWP beneficial use based on pH. Due to the shallow nature of the reservoir thermal stratification was not present in this reservoir at any point during the period of record, and dissolved oxygen (D.O.) concentrations were above 2.0 mg/L at all times and were generally above 6.0 mg/L. If D.O. values are less than 2.0 mg/L for greater than 70% of the lake volume, the FWP beneficial use is deemed not supported and If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the use is deemed partially supported. Based on D.O. concentrations the FWP beneficial use is fully supported at Great Salt Plains Lake. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. With both chlorides and sulfate exceeding the numerical criteria located in OAC 785:45 – Appendix F the Agriculture beneficial use is considered not supported. In accordance with EPA guidance, states may develop site-specific criteria on the basis of natural background conditions. Because the extremely high chloride conditions are due to natural causes; the Water Board is looking at the applicability of developing site-specific criteria for Great Salt Plains Lake.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.64 mg/L at the lake surface. The TN at the surface ranged from 0.75 mg/L to 2.85 mg/L, which is a considerable amount of nitrogen to be present in the water column. The lake-wide total phosphorus (TP) average was 0.290 mg/L at the lake surface, which was also very high value in comparison to other lakes in Oklahoma. The TP ranged from 0.046 mg/L to 1.783 over the period of record. The nitrogen to phosphorus ratio (TN:TP) was approximately 6:1. This value is the just under 7:1, characterizing the lake as nitrogen or possibly co-limited (Wetzel, 1983).

The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 1998 and again in 2005 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening or consumption advisory levels.

In summary, Great Salt Plains Lake was classified as hypereutrophic, indicative of excessive primary productivity and nutrient levels (Plate 47). The lake is currently listed in the WQS as NLW waterbody and should be studied intensively in the future to verify beneficial use non-support status. Although the lake has very high turbidity, this does not appear to limit productivity and an intensive study would help to better understand the nutrient dynamics at work in the reservoir. Until such time, the Aesthetics beneficial use is partially supported based on true color values and considered threatened due to nutrients. Water clarity is consistently poor at this lake and is likely to always be poor based on the soil composition and shallow morphometry of this lake. The lake was not supporting its FWP beneficial use based on extremely high turbidity and is supporting its FWP beneficial use for pH concentrations. The FWP is fully supported based on D.O. concentrations. There was a major fish kill recorded at the reservoir during the summer of 2006. Low lake levels combined with triple digit temperatures are blamed for this event. For further information please contact the Oklahoma Department of Wildlife Conservation. With both chlorides and sulfate exceeding the numerical criteria located in OAC 785:45 – Appendix F the Agriculture beneficial use is considered not supported. In accordance with EPA guidance, states may develop site-specific criteria on the basis of natural background conditions. Because the high chloride levels are due to natural causes, the Water Board is looking at the applicability of developing site-specific criteria for Great Salt Plains Lake.

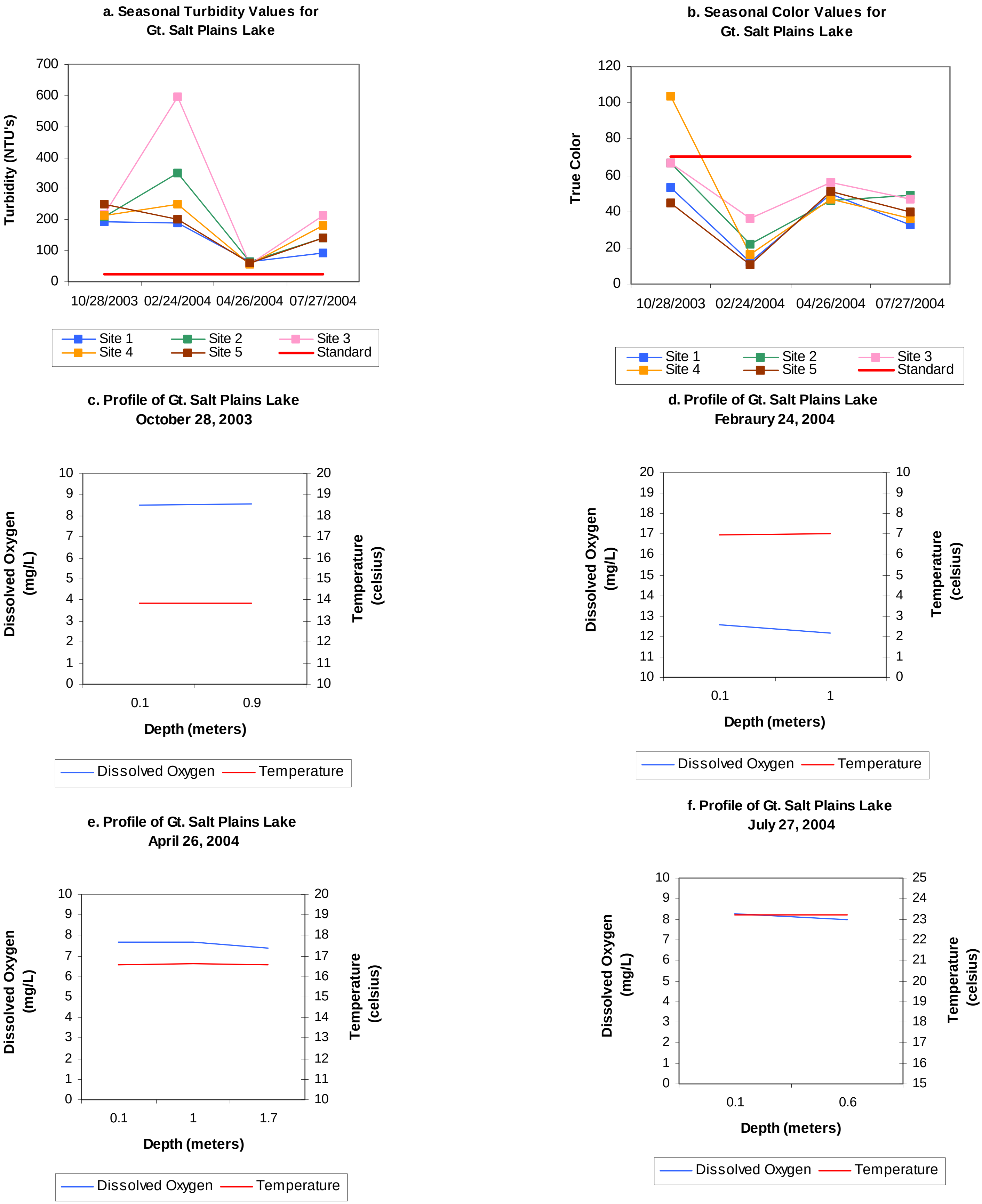


Figure 62a-62f. Graphical representation of data results for Great Salt Plains Lake.

Great Salt Plains Lake
and
Watershed

POOR EXCELLENT

Turbidity
2006

POOR EXCELLENT

Trophic State
2006

Great Salt Plains Lake
Location

Lake Data	
Constructed by	Corps of Engineers
County	Alfalfa
Constructed in	1941
Surface Area	8,690 acres
Volume	31,420 acre/feet
Shoreline Length	41 miles
Mean Depth	4.22 feet
Watershed Area	3,200 square miles

Plate 47 - Lake Water Quality for
Great Salt Plains Lake

Greenleaf Lake

Greenleaf Lake, located in Muskogee County, is just a few miles south of the town of Braggs. The lake was built in 1939 and is leased to the State of Oklahoma for recreational purposes and is within Greenleaf State Park in the eastern part of the state. Greenleaf Lake was sampled for four quarters, from November 2005 through September 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 7 NTU (Plate 48), true color was 15 units, and secchi disk depth was 111 centimeters. Based on these three parameters, Greenleaf Lake had good water clarity in 2006. These results are slightly better than those in 2004 although very similar. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 52 (plate 48), classifying the lake as eutrophic, indicative of high levels of productivity and nutrient rich conditions. This value is the similar to the one calculated in 2004 (TSI=54), indicating no change in trophic status over time. The TSI values varied seasonally with meso-eutrophic conditions in the fall and winter to upper eutrophic in the spring quarter. The exception to this occurred in September when both mesotrophic and oligotrophic conditions were present. The annual TSI of 54 seems representative of conditions at Greenleaf Lake and is consistent with historical data collection efforts conducted in 2001 and 2004. Turbidity values were below the Oklahoma Water Quality Standard (WQS) of 25 NTU with values ranging from a low of 5 NTU to a maximum of 10 NTU (Figure 63a). According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the turbidity values below the WQS of 25 NTU, Greenleaf Lake is supporting its Fish & Wildlife Propagation (FWP) beneficial use. Seasonal true color values are displayed in (Figure 63b). Similar to turbidity, 100% of the samples collected were below the WQS numeric criteria of 70 units. Applying the same default protocol the Aesthetics beneficial use is considered supported at Greenleaf Lake.

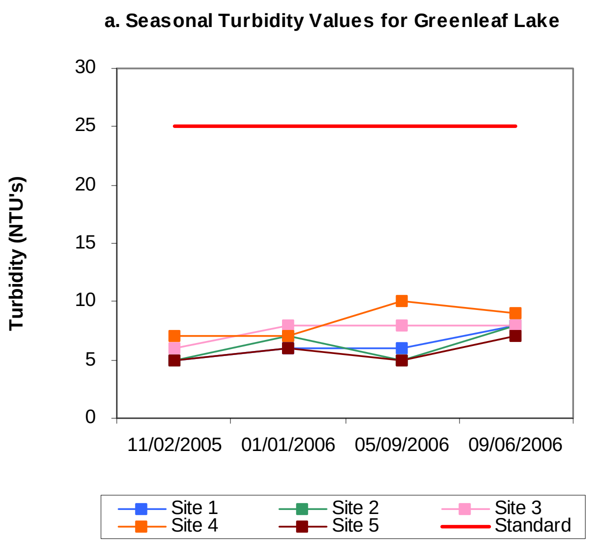
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were also recorded at all sample sites during the study period. Salinity values ranged from 0.06 parts per thousand (ppt) to 0.14 ppt, well within the expected range for most Oklahoma reservoirs if not slightly lower. Readings for specific conductivity were within the expected range for Oklahoma reservoirs. Specific conductivity ranged from 143.6 µS/cm in the spring quarter to 297 µS/cm in the summer quarter, indicating low concentrations of electrical current conducting compounds (salts) in the water column. Oxidation-reduction potentials (redox) ranged from 55mV in the summer quarter near the water to sediment interface near the lake bottom to 511 mV also in the summer quarter. Although all redox values were positive, these near reducing conditions are consistent with anoxic conditions present in a large portion of the water column during the summer sampling interval. Lake pH values were neutral to slightly alkaline with values ranging from 6.81 units to 8.31 all within the WQS range of 6.5-9.0 units, therefore the FWP beneficial use was supported as it relates to pH. Thermal stratification was not evident in either the fall or winter quarters and the water column was well mixed (Figure 63c-63d). During the spring the lake was thermally stratified with 13 to 43% of the water column experiencing anoxic conditions at sites 1,2 and 5, the three deepest sites (Figure 63e). During the summer the lake exhibited strong thermal stratification with dissolved oxygen (D.O.) concentrations less than 1.0 mg/L from 6 meters below the surface to the lake bottom of 12.3 meters at both sites 1 and 2 (see Figure 63f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With up to 71% of the water column in the summer violating the criteria the lake is considered to be not supporting its FWP beneficial use based on D.O. concentrations for sample year 2006. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

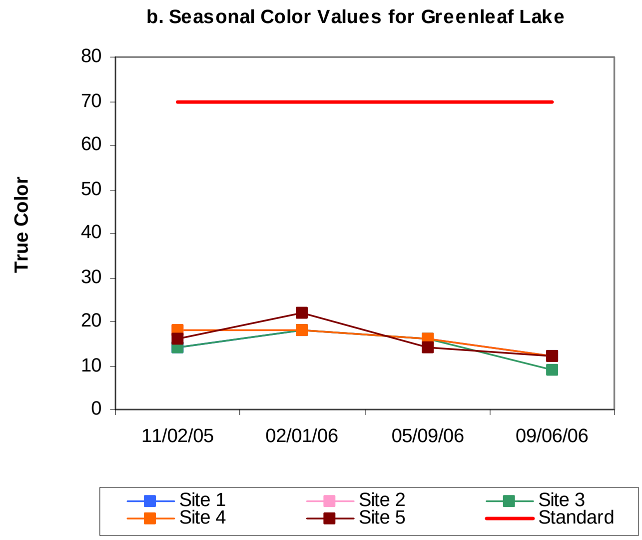
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

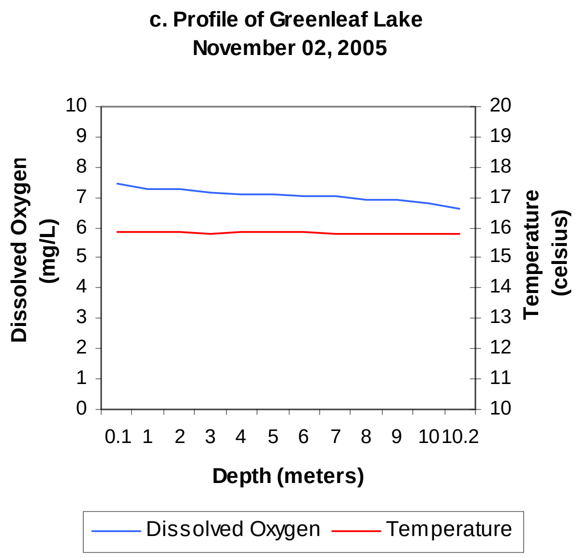
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.58 mg/L at the lake surface. The TN at the surface ranged from 0.42 mg/L in the fall and spring quarters to 0.83 mg/L recorded during the summer quarter. The lake-wide total phosphorus (TP) average was 0.039 mg/L at the lake surface. The TP ranged from 0.025 mg/L to 0.067 mg/L. The highest surface TP values were reported in the spring and the lowest were in the winter. The nitrogen to phosphorus ratio (TN:TP) was 15:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

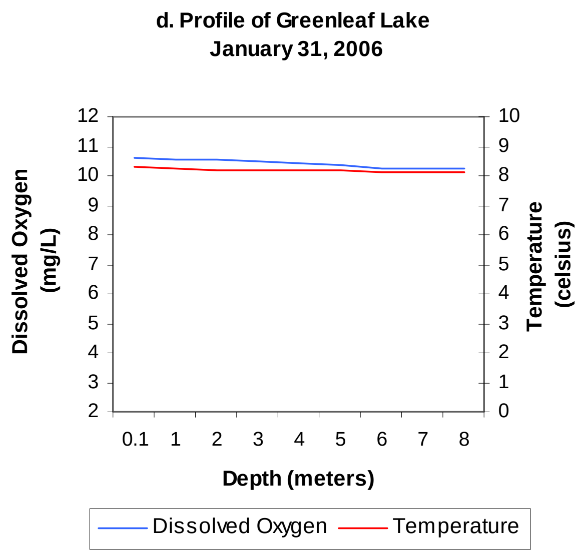
The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 2000 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening level or consumption advisory level. Greenleaf Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

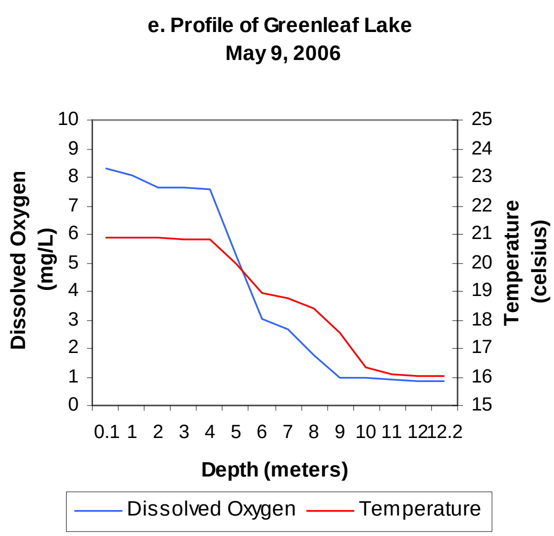
In summary, Greenleaf Lake is classified as eutrophic with high primary productivity and nutrient rich conditions (Plate 48). This classification is consistent previous data collection efforts conducted in 2001 and 2004. Water clarity is good in comparison to other Oklahoma lakes and reservoirs based turbidity, true color and Secchi disk depth readings. The Aesthetics beneficial use is supported based on trophic status and with 100% of the true color values below the WQS of 70 units the beneficial use is also considered supported as it relates to color. The lake is supporting the FWP use as it relates to pH and turbidity however is not supporting with anoxic conditions present in 71% of the water column during the summer sampling interval. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.











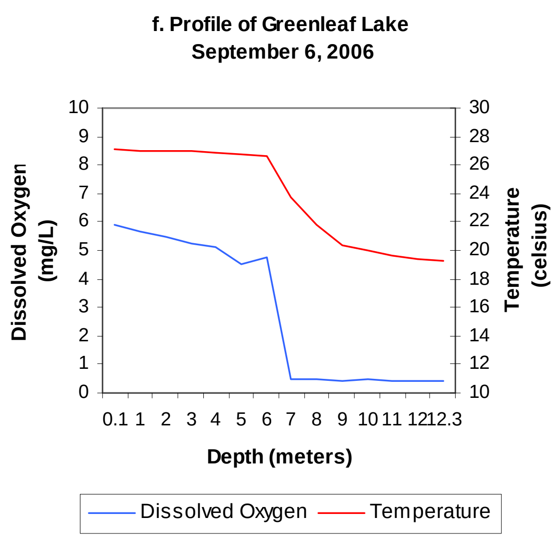
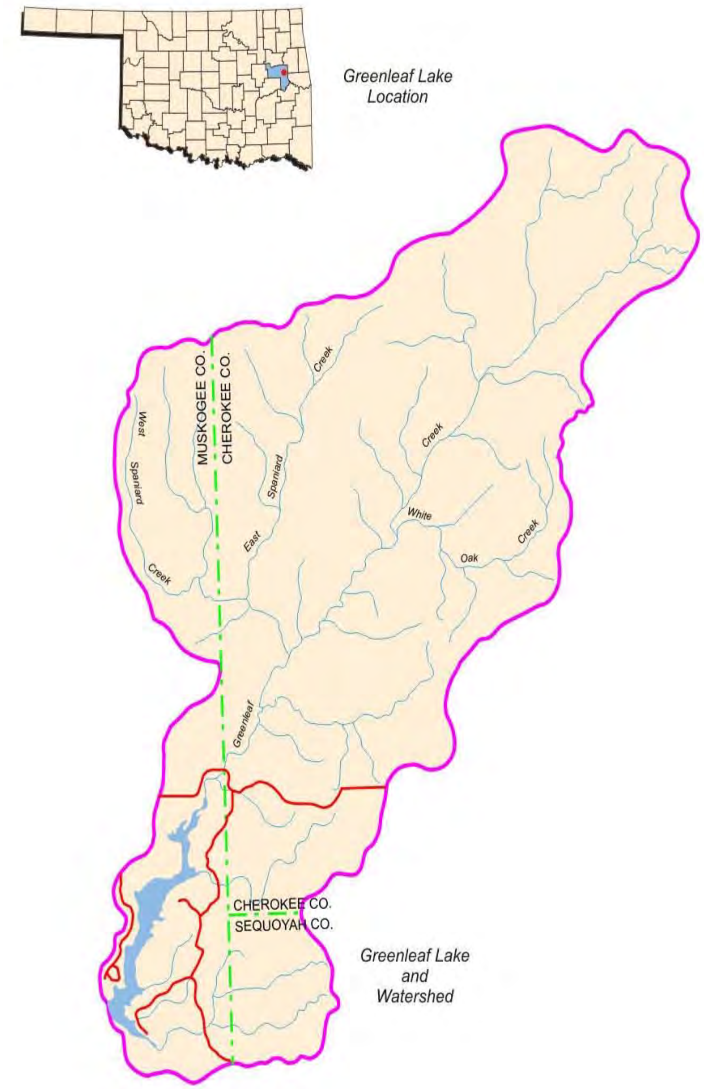
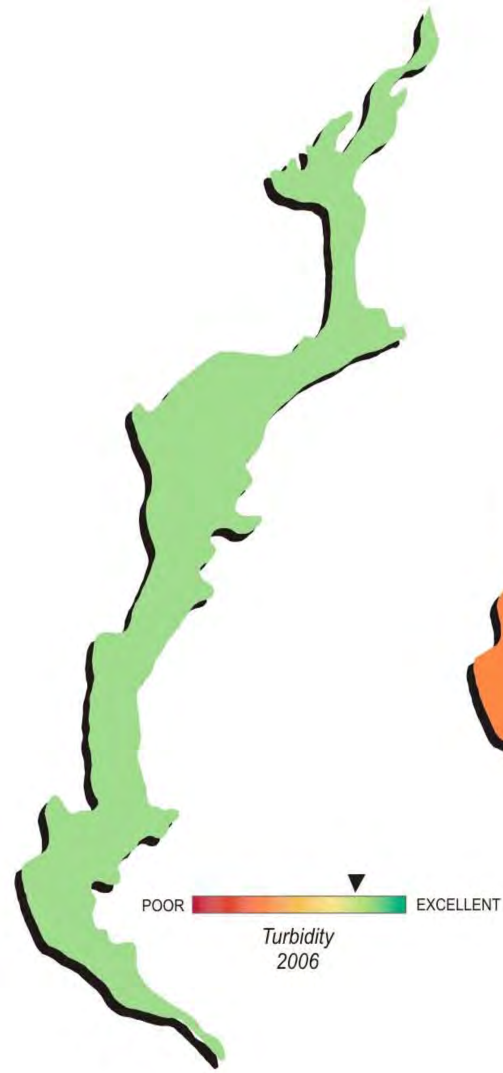


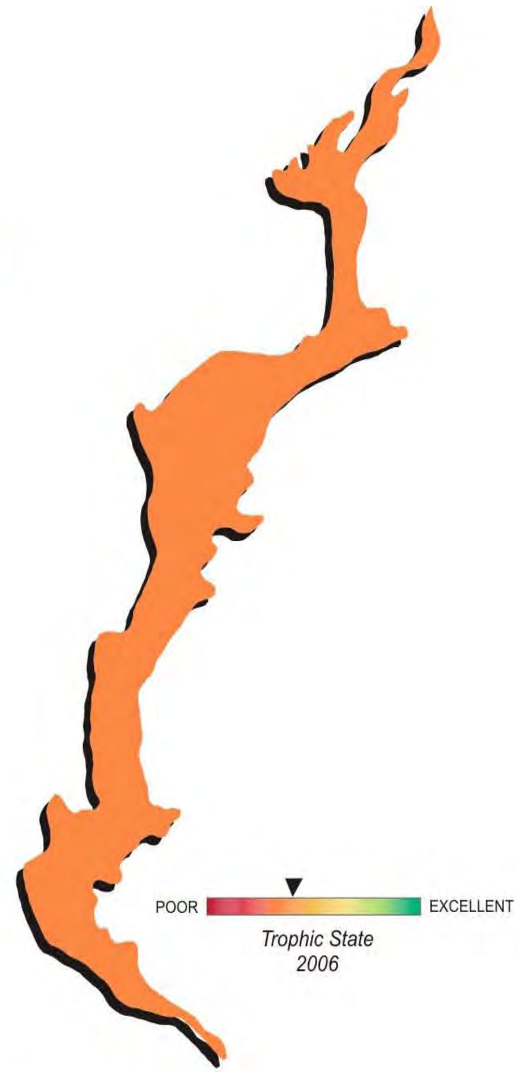
Figure 63a-63f. Graphical representation of data results for Greenleaf Lake.

Plate 48 - Lake Water Quality for

Greenleaf Lake







Lake Data

Owner	Leased to State of Oklahoma
County	Muskogee
Constructed in	1939
Surface Area	920 acres
Volume	14,720 acre/feet
Shoreline Length	18 miles
Mean Depth	16.00
Watershed Area	86 square miles

LAKES MONITORING PROGRAM

Guthrie Lake

Guthrie Lake, located in Logan County, is approximately 4 miles south of Guthrie. The lake was constructed in 1919 and is owned and operated by the City of Guthrie and is utilized for water supply and recreational purposes. Guthrie Lake was sampled for four quarters, from October 2005 through July 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Water quality samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 19 NTU (Plate 49), true color was 21 units, and secchi disk depth was 52 centimeters. Based on these three parameters, Guthrie Lake had average to fairly good water clarity in 2005-2006. Findings for these parameters are similar to those of the 2004 evaluation. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 61 (Plate 49), classifying the hypereutrophic, indicative of excessive primary productivity and nutrient levels. The TSI values ranged from hypereutrophic in the fall and summer quarters with eutrophic conditions in the winter to meso-eutrophic conditions in the spring quarter. This pattern is almost identical to that seen in the 2004 evaluation. Based on the trophic classification, the lake will be recommended for listing in the next Oklahoma Water Quality Standards (WQS) revision process as a Nutrient Limited watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Of the twenty turbidity values collected, four (20%) exceeded the WQS of 25 NTU (see Figure 64a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS. If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Available flow and rainfall data suggest that the peak in turbidity, which occurred in October is likely due to seasonal storm events, therefore the lake will be listed as supporting its Fish & Wildlife Propagation (FWP) based on turbidity. Seasonal true color values are displayed in Figure 64b. None of the true color values exceeded the numeric criteria of 70 units. Applying the same default protocol for determining the short-tem average for true color, the Aesthetics beneficial use is considered fully supported.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity ranged from 0.32 to 0.43 parts per thousand (ppt), which is slightly higher than the expected range for Oklahoma lakes. Readings for specific conductivity ranged from 623.1 µS/cm to 821 µS/cm, indicating moderate to slightly elevated concentrations of electrical current conducting compounds (salts) present in the water column throughout the sample year. In general, pH values were neutral to alkaline, ranging from 7.78 in the spring quarter to 8.14 units in the summer quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Guthrie Lake is meeting its FWP beneficial use as it realties to pH. Oxidation-reduction potentials (redox) ranged from 357mV in the summer to 470mV in the fall, indicating that reducing conditions were not present in the water column during the course of sampling. The lake was not thermally stratified at any point during 2005-2006 and dissolved oxygen (D.O.) concentrations were generally above 5.0 mg/L throughout the water column (see Figure 64c-64f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (USAP 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is fully supported at Guthrie Lake with the absence of anoxic conditions. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.01 mg/L at the lake surface during the sample year. The TN at the surface ranged from 0.61 mg/L to 1.34 mg/L. The highest surface TN values were reported in the summer and fall quarters and the lowest was in the spring quarter. The lake-wide total phosphorus (TP) average was 0.067 mg/L at the lake surface. The TP ranged from 0.041 mg/L to 0.103 mg/L. The highest surface TP value was reported in the summer quarter and the lowest was in the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 15:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 2001 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening level or consumption advisory level. Guthrie Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Guthrie Lake was classified as eutrophic bordering hypereutrophic in 2005-2006, indicating excessive primary productivity and nutrient levels (Plate 49). Water clarity was average to fairly good based on turbidity, true color, and secchi disk depth. The Aesthetics beneficial use is considered supported based on true color and not supported in regards to trophic status. Based on the calculated TSI, the lake will be recommended for listing as a Nutrient Limited Watershed (NLW) in the next WQS revision process and its Aesthetic beneficial use considered threatened until a study can be conducted to confirm non-support status. Guthrie Lake is meeting its FWP beneficial use based on pH and dissolved oxygen concentrations recorded during the sample year. Although 20% of the collected turbidity values exceeded the WQS of 25 NTU, available flow and rainfall data suggest that the peak in turbidity, which occurred in October, is likely due to seasonal storm events, therefore the lake will be listed as supporting its FWP use. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through

September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

LAKES MONITORING PROGRAM

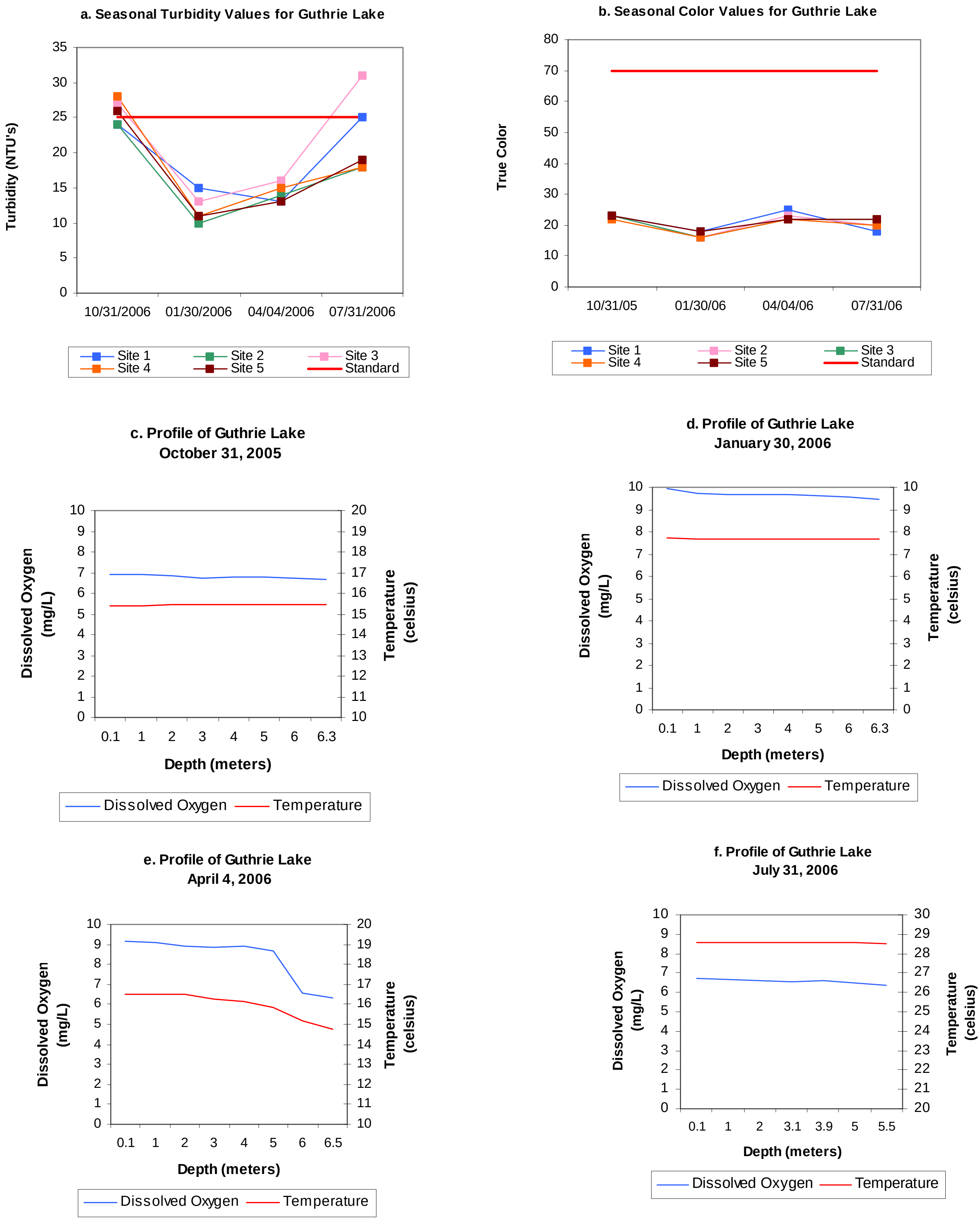
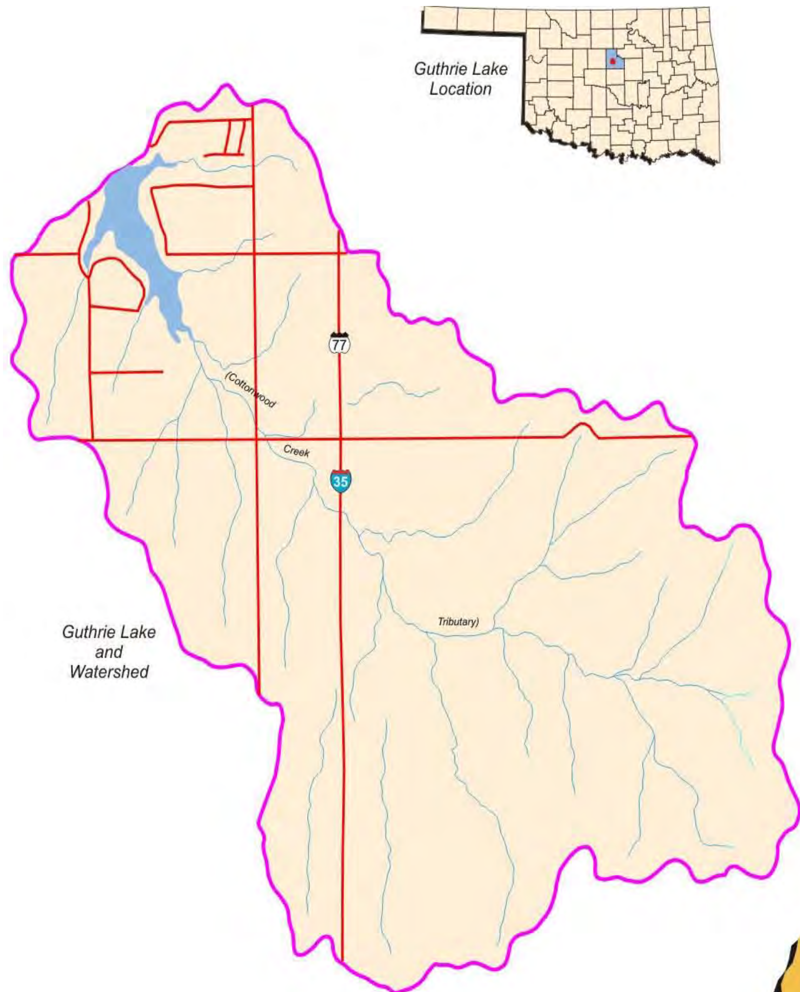


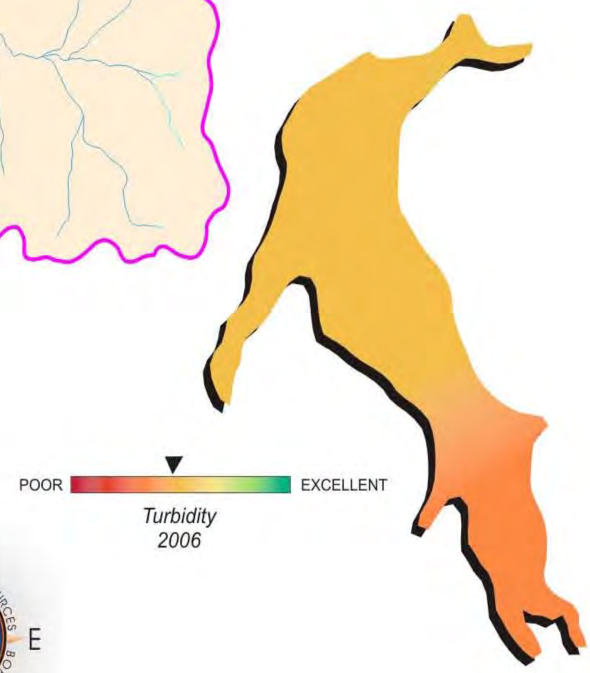
Figure 64a-64f. Graphical representation of data results for Guthrie Lake.

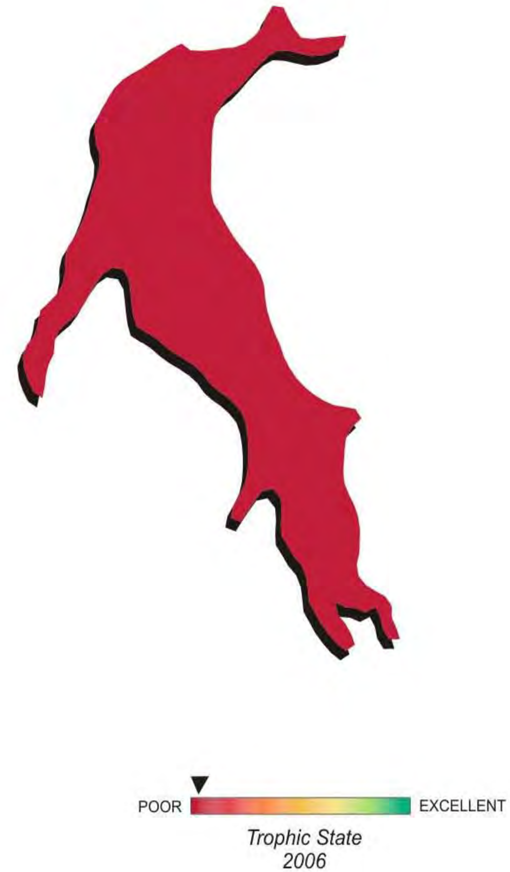
Plate 49 - Lake Water Quality for

Guthrie Lake



Lake Data	
Owner	City of Guthrie
County	Logan
Constructed in	1919
Surface Area	274 acres
Volume	3,875 acre/feet
Shoreline Length	4 miles
Mean Depth	14.14 feet
Watershed Area	13 square miles





Healdton City Lake

Healdton City Lake, located in Carter County, was constructed in 1979 and is owned and operated by the City of Healdton and is utilized for water supply, flood control and recreational purposes. Healdton City Lake was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 48 NTU (Plate 50), true color was 159 units, and secchi disk depth was 34 centimeters. Based on these three parameters, Healdton City Lake had poor water clarity in 2006, which is consistent with historical data collection efforts. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=17). The average TSI was 49, classifying the lake as mesotrophic, indicative of moderate levels of productivity and nutrients. Due to lightening in the area, OWRB staff was unable to continue sampling past the first two sites during the May sampling trip. As a result no samples for sites 3-5 were submitted for analysis from spring data collection efforts. The current TSI value is consistent with previous monitoring results from 2003-2004 where the calculated TSI was also mesotrophic (TSI=45). This value is consistent with findings in 2001 (TSI=42), indicating no significant increase or decrease in productivity has occurred. The TSI values were primarily mesotrophic with eutrophic conditions present at sites 3-5 in the summer. Seasonal turbidity values are displayed in Figure 65a. All turbidity values were above the Oklahoma Water Quality Standard (WQS) of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Although 100% of the turbidity samples collected were above the standard, an assessment of the FWP use cannot be made, as minimum data requirements were not met. True color values are displayed in (Figure 65b). All true color values were also above the Oklahoma Water Quality Standard (WQS) of 70 throughout the sample year. Like turbidity, minimum data requirements were not met and an assessment of the Aesthetics beneficial use is considered cannot be made at this time. In reviewing past data for both turbidity and true color it us unlikely that either beneficial use would be found supporting for these parameters.

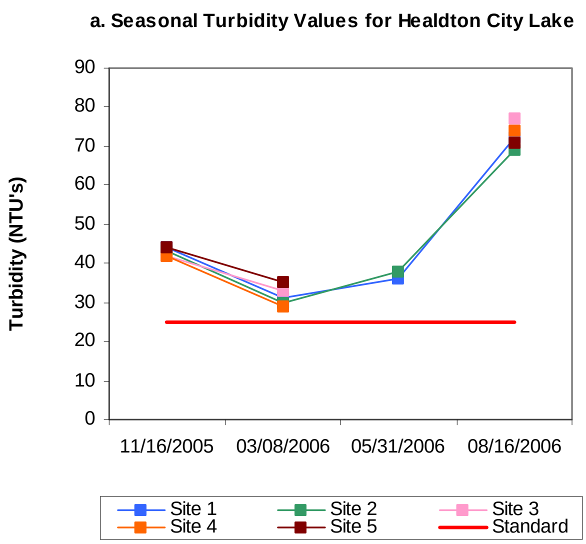
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity ranged from 0.13 to 0.19 parts per thousand (ppt), well within the expected range for Oklahoma lakes. Readings for specific conductivity ranged from 275.6 µS/cm to 378.5 µS/cm, indicating moderate concentrations of electrical current conducting compounds (salts) present in the water column throughout the year. In general, pH values were neutral, ranging from 7.05 in the spring quarter to 7.86 units in the fall quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With all recorded values within the acceptable range, Healdton City Lake is meeting its FWP beneficial use as it relates to pH. Oxidation-reduction potentials (redox) ranged from 304 mV at the sediment-water interface in the fall to 450 mV also in the fall, indicating the absence of reducing conditions in the lake system. The lake was not thermally stratified in the fall or winter sampling intervals and dissolved oxygen (D.O.) concentrations were generally above 6.0 mg/L throughout the water column (see Figure 65c-65d). In the spring quarter, the lake was stratified between 4 and 5 meters below the surface with D.O. values below 2.0 mg/L from 5 meters to the lake bottom of 7.3 meters (Figure 65e). The lake was also thermally stratified in the summer and anoxic conditions were present in 33% of the water column (Figure 65f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (USAP 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is fully supported at Healdton City Lake based with only 33%(summer) to 44%(spring) of these dissolved oxygen levels below 2.0 mg/L. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2003-2004 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

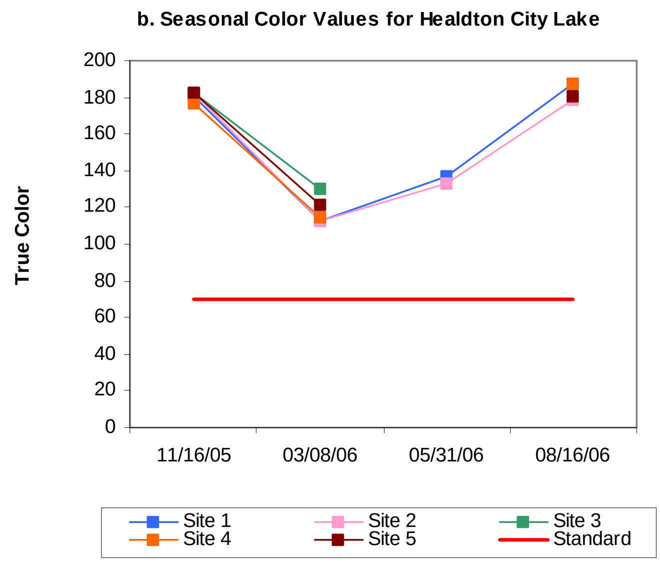
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

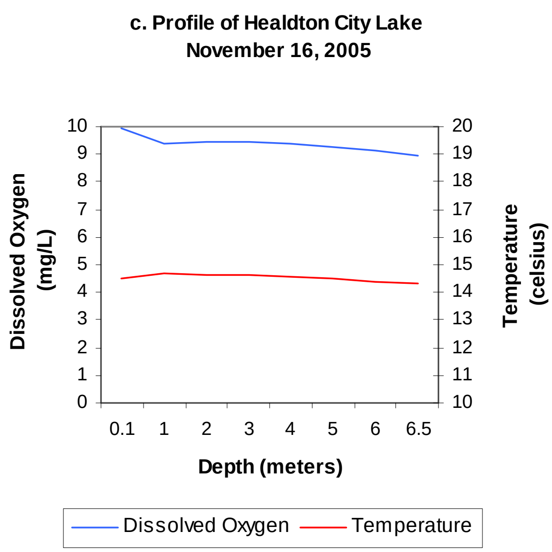
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.74 mg/L at the lake surface. The TN at the surface ranged from 0.59 mg/L to 0.94 mg/L. The highest surface TN value was reported in the summer quarter and the lowest was in the fall quarter. The lake-wide total phosphorus (TP) average was 0.066 mg/L at the lake surface. The TP ranged from 0.043 mg/L to 0.100 mg/L. The highest surface TP value was reported in the summer quarter however the lowest was reported in the spring quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 11:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

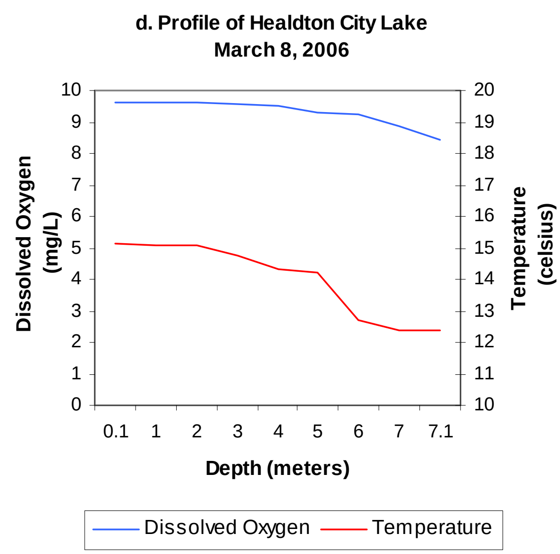
Healdton City Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

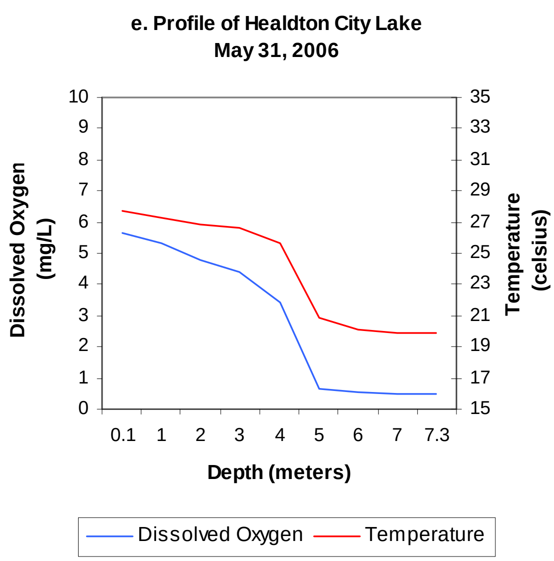
In summary, Healdton City Lake was classified as mesotrophic, indicative of moderate primary productivity and nutrient levels (Plate 50). Water clarity was poor based on turbidity, true color, and secchi disk depth. The Aesthetics beneficial use is considered supported based on trophic status, however an assessment based on true color cannot be made due to minimum data requirements not being met. Healdton Lake is considered meeting its FWP beneficial use based on pH and dissolved oxygen concentrations. Like true color, minimum data requirements were not met and an assessment of the FWP beneficial use as it relates to turbidity cannot be made at this time. In reviewing past data for both turbidity and true color it us unlikely that either beneficial use would be found supporting for these parameters. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.











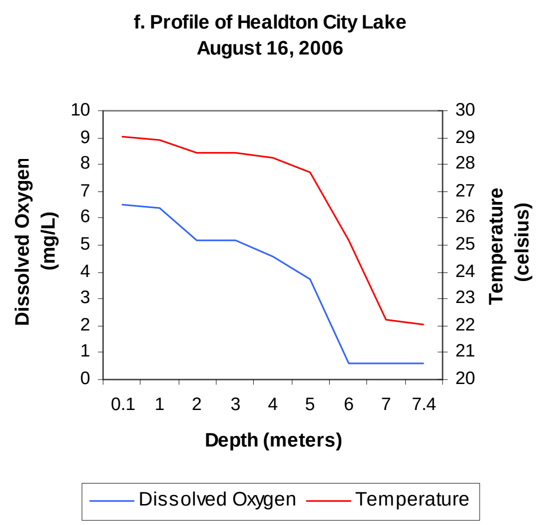
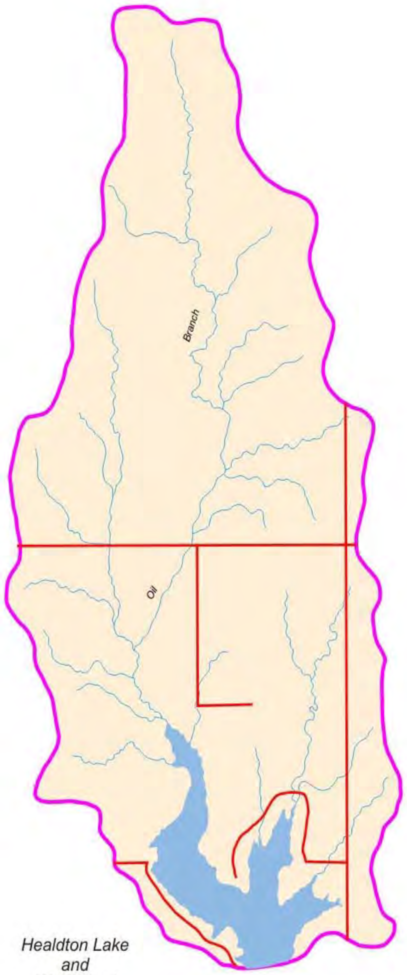


Figure 65a-65f. Graphical representation of data results for Healdton City Lake

Plate 50 - Lake Water Quality for

Healdton Lake



Healdton Lake and Watershed

Healdton Lake Location

Lake Data

Owner	City of Healdton
County	Carter
Constructed in	1979
Surface Area	370 acres
Volume	3,766 acre/feet
Shoreline Length	7 miles
Mean Depth	10.18 feet
Watershed Area	11 square miles

LAKES MONITORING PROGRAM

Lake Hefner

The lake is owned and operated by the City of Oklahoma City and was constructed in 1947. It serves as a water supply for Oklahoma City and also offers a recreational outlet for the public. Hefner is one of the premier sailing lakes in the United States. Lake Hefner was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Water quality samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 7 NTU (Plate 51), true color was 19 units, and secchi disk depth was 92 centimeters. Based on these three parameters, Lake Hefner had good water clarity very similar to that of previous sampling efforts. This is not unexpected as the lake is an off-channel reservoir, meaning that the lake is not located along a stream course. The lake is "filled" through runoff immediately adjacent to the lake with the bulk of the water in the lake being transported from the North Canadian River via diversion into the Bluff Creek canal, which flows into Lake Hefner. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 63 (Plate 51), classifying the lake as hypereutrophic, indicative of excessive primary productivity and nutrient rich conditions. This value is greater than that of 2004 (TSI=55) and 2002 (TSI=56). Although the current TSI is greater than 62, which normally triggers consideration to be included as an NLW, this is the first time since 1999 that this threshold had been crossed and is likely attributable to the low lake levels (approx. 10 ft. below normal) and not an actual change in productivity therefore the lake will not be recommended for inclusion as an NLW during the next Oklahoma Water Quality Standards revision process, but will be monitored closely in the future. Chlorophyll-a values were variable with the lake generally being eutrophic during the winter and spring and hypereutrophic in both fall and summer quarters. The exception to this was site 5 in the spring, which was hypereutrophic. Turbidity values were all well below the Oklahoma Water Quality Standard (WQS) of 25 NTU with values ranging from 4 to 13 NTU (see Figure 66a). According to the Use Support Assessment Protocols (USAP) specified in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Lake Hefner is fully supporting its Fish & Wildlife Propagation (FWP) beneficial use for sample year 2006 based on turbidity. Seasonal true color values are displayed in Figure 66b. None of the collected true color values exceeded the numeric criteria of 70 units; therefore the Aesthetics beneficial is fully supported for true color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity ranged from 0.50 to 0.68 parts per thousand (ppt), which was higher than the expected range of values reported for Oklahoma lakes. Specific conductivity ranged from 959 µS/cm in the fall quarter to 1314 µS/cm in the summer quarter, indicating moderate to elevated concentrations of electrical conducting compounds (salts) were present in the water column. In general, pH values were neutral to alkaline, ranging from 7.77 units in the spring quarter to 8.68 units in the summer quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Lake Hefner is fully supporting its FWP beneficial use based on pH values. Oxidation-reduction potentials (redox) ranged from 47 mV near the sediment-water interface in the summer at site 1 to 460 mV in the winter quarter. Although all redox values were positive, near reducing conditions were present in the summer near the sediment-water, which is not uncommon when a large portion of the water column is anoxic. The lake was not thermally stratified during the fall, winter or spring the sampling intervals with dissolved oxygen (D.O.) concentrations generally above 6.0 mg/L throughout the water column at all sites (see Figure 66c-64e). In the summer thermal stratification was evident and anoxic conditions were present at both sites 1 and 5, the deepest sites. Stratification occurred at several 1-meter intervals at site1, with dissolved oxygen (D.O.) falling below 2.0 mg/L from 9 meters to the lake bottom of 16.6 meters (Figure 66f). Similarly at site 5, D.O. was below 2.0mg/L from 9 meters below the surface to the bottom of 12.6 meters with anoxic condition comprising 36% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is partially supported at Lake Hefner with anoxic conditions present in 50% of the water column during the summer at site 1. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.79mg/L at the lake surface during the study period. The TN at the surface ranged from 0.69 mg/L to 1.06 mg/L. The highest surface TN value was in the summer quarter and the lowest was in the winter quarter. The lake-wide total phosphorus (TP) average was 0.082 mg/L. The TP ranged from 0.055 mg/L to 0.120 mg/L. Similar to TN the lowest surface TP value was reported in the winter however the highest was in the spring quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 10:1 for sample year 2003-2004. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 2001 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening level or consumption advisory level. Lake Hefner was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Lake Hefner was classified as hypereutrophic (TSI=63), indicative of excessive productivity and nutrient rich conditions (Plate 51) for sample year 2005-2006. Although the current TSI is greater than 62, which normally triggers consideration to be included as an NLW, this is the first time since 1999 that this threshold had been crossed. It is hard to say if this increase is due to the lower lake levels brought on by the drought the state is experiencing or an actual change in productivity therefore the lake will not be recommended for inclusion during the next Oklahoma Water Quality Standards revision process, but will be monitored closely in the future. Water clarity is good based on turbidity, true color and Secchi depth readings. The lake is fully supporting its Aesthetics beneficial use true color with 100% of the values below the WQS of 70 units. Lake Hefner is fully supporting its FWP beneficial use based on turbidity and pH values. With 50% of the water column less than 2.0mg/L during the summer, the FWP beneficial use is only partially supported at Lake Hefner. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

In 1997 the Oklahoma Legislature directed the OWRB to conduct a study on the impact of Confined Animal Feeding Operations (CAFO) in watersheds that supply potable water to municipalities with a population over 250,000. As part of this study a bathymetric survey was completed on Oklahoma City's water supply reservoirs. A bathymetric map (Figure 67) was generated to determine current storage capacity and identify areas of extreme sedimentation. For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.

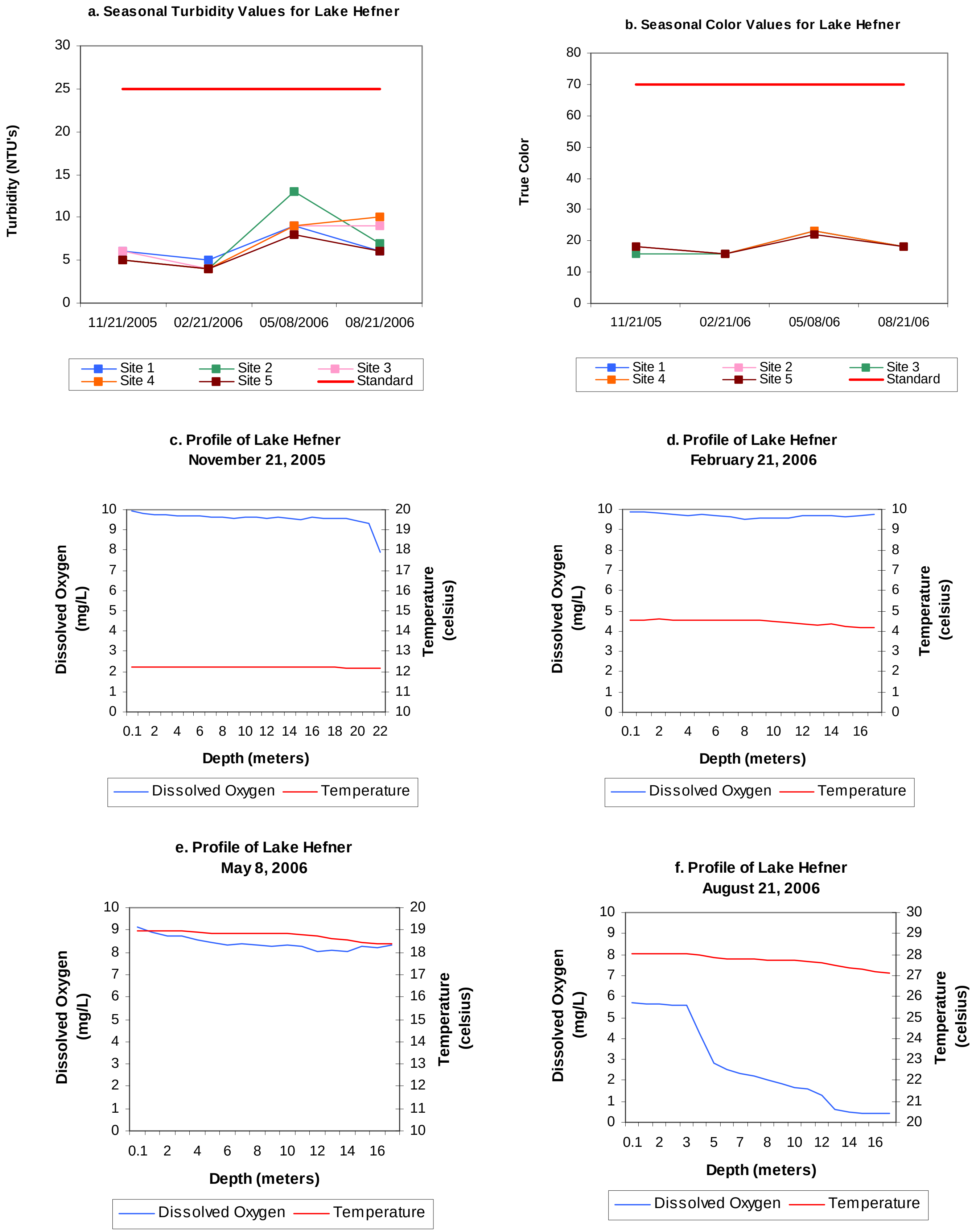
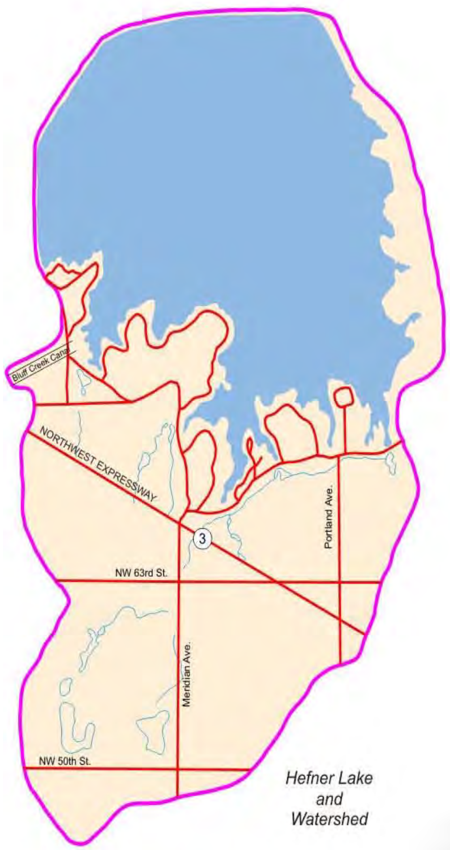


Figure 66a-66f. Graphical representation of data results for Lake Hefner.

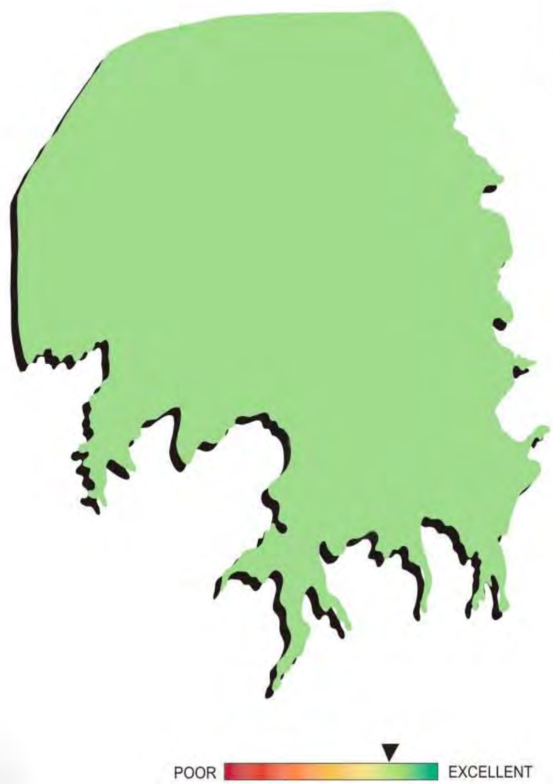
Hefner Lake
Location



Hefner Lake
and
Watershed

Lake Data

Owner	City of Oklahoma City
County	Oklahoma
Constructed in	1947
Surface Area	2,537.9 acres
Volume	68,867 acre/feet
Shoreline Length	15.8 miles
Mean Depth	27.13 feet
Watershed Area	9 square miles



Turbidity
2006

Trophic State
2006

Plate 51 - Lake Water Quality for
Hefner Lake

LAKES MONITORING PROGRAM

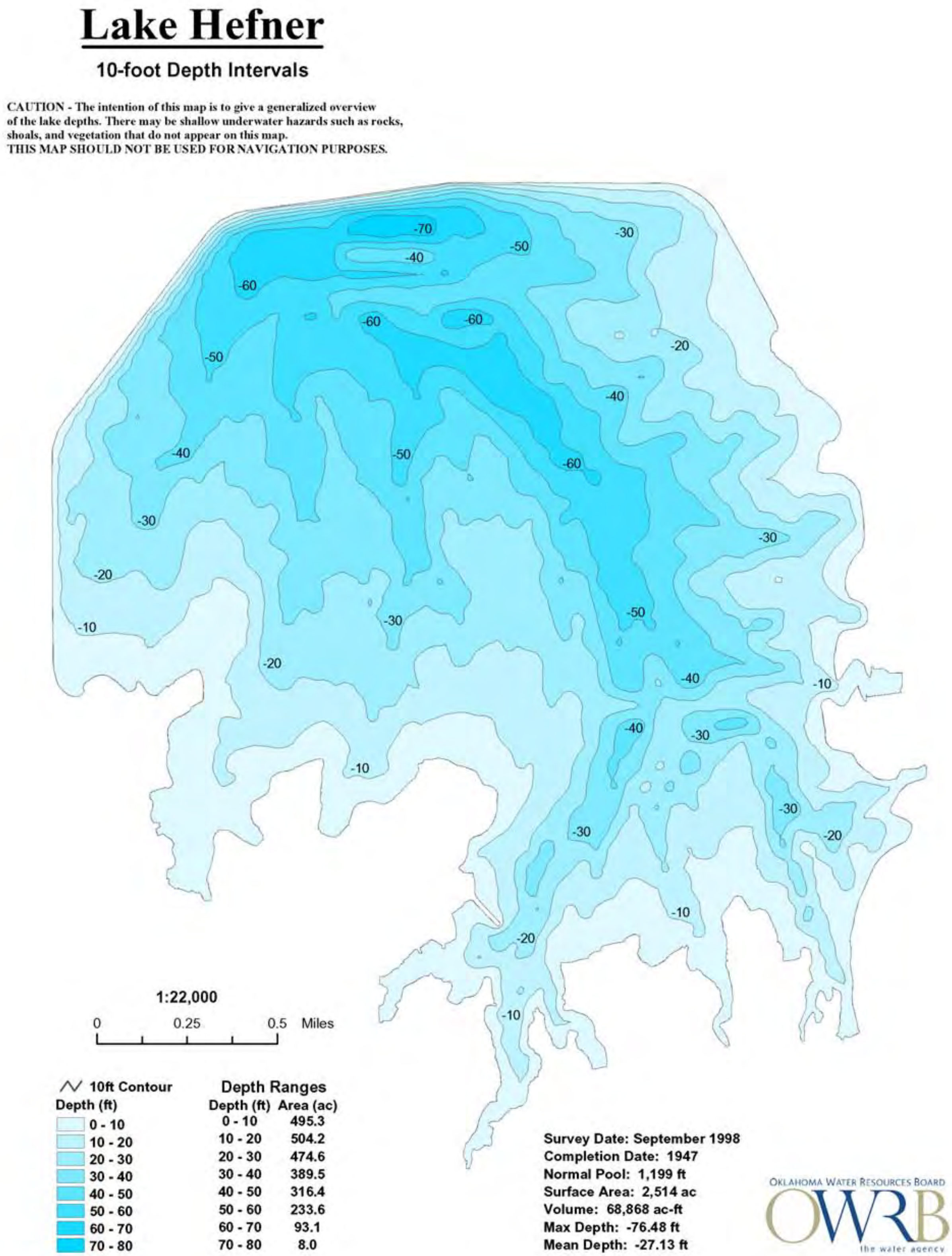


Figure 67. Bathymetric map of Hefner Lake.

Lake Henryetta

Lake Henryetta was sampled for four quarters from November 2004 through August 2005. Water quality samples were collected at five (5) sites to represent the riverine, transition and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide average turbidity was 57 NTU (Plate 52), true color was 237 units and average secchi disk depth was 23 centimeters. Based on these parameters water clarity was poor at Lake Henryetta. Results are similar to those calculated in 2003 indicating no significant increase or decrease over time. The trophic state index (TSI) was calculated using values collected at all sites for four quarters (n=20). The result was a TSI of 47 (Plate 52), indicating the lake was mesotrophic with moderate primary productivity and nutrient conditions. This value is higher than that in 2003 (TSI=43), however, the trophic category is the same. The TSI values were fairly consistent and ranged seasonally from oligotrophic in the fall and winter to mesotrophic and lower eutrophy in the spring and summer. The only exception was a spike in chlorophyll concentration that resulted in a hypereutrophic value at site 5 during the fall quarter. Seasonal turbidity values are displayed in Figure 68a. All turbidity values were well above the turbidity standard of 25 NTU and ranged from a low of 45 NTU to a maximum of 70 NTU. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the turbidity values above the standard, the Fish and Wildlife Propagation (FWP) beneficial use is considered not supported Seasonal true color values are displayed in Figure 68b. True color values followed the same trend as turbidity, with all values exceeding the WQS of 70 units. Applying the same default protocol, the Aesthetics beneficial use is supported at Lake Henryetta.

In 2004-2005 vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were performed at all five-sample sites. The salinity ranged from 0.01 parts per thousand (ppt) to 0.04 ppt, which is lower than that seen in most Oklahoma reservoirs. Specific conductivity ranged from 51.4 µS/cm in the fall to 100.2 µS/cm in the summer, indicating the minimal presence of current conducting ions (salts and chlorides) in the lake system. The pH values ranged from 6.28 to 7.77 representing a neutral to slightly acidic system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Low pH values were recorded during the summer at sites 1,2, and 4. With only 5.5% of the values outside the acceptable range, the FWP beneficial use is considered supported based on pH. Oxidation-reduction potential ranged from 269 mV at the surface in the winter to 527 mV in the hypolimnion in the fall. In general, reducing conditions were not present during the study period. Thermal stratification was not present during the fall, winter, or spring quarters and the lake was well mixed with dissolved oxygen (D.O) levels remaining above 7.0 mg/L (Figure 68c-68e). In the summer the lake exhibited weak thermal stratification between 3 and 4 meters with dissolved oxygen dropping below 2.0 mg/L from 4 meters to the lake bottom of 5.6 meters, accounting for 28.6% of the water column to be anoxic at site 1 (Figure 68f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Lake Henryetta is considered supporting the FWP beneficial use based on dissolved oxygen. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.71 mg/L at the surface. Surface TN ranged from 0.44 mg/L in the summer to 1.07 mg/L in the spring quarter. The lake-wide total phosphorus (TP) average was 0.089 mg/L at the surface. TP values at the surface ranged from 0.067 mg/L in the summer to 0.228 mg/L in the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was 8:1 for sample year 2004-2005. This value slightly higher than 7:1, characterizing the lake phosphorus limited or possibly co-limited (Wetzel, 1983).

In summary, Lake Henryetta was classified as mesotrophic (TSI=47) with moderate primary productivity and nutrient conditions (Plate 52). Although the current value is higher than that of 2003 (TSI = 43), it is within the same trophic category. Water clarity is poor based on true color, turbidity and low secchi disk depth, which is consistent with historical findings. The FWP beneficial use is considered supported based on pH and dissolved oxygen levels recorded during the study period. With 100% of the values exceeding 25 NTU, the lake is not meeting the FWP based high turbidity. The lake is supporting the Aesthetics beneficial use based on its trophic status, however not supporting based on true color with values ranging from 199-250 color units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Lake Henryetta, located in Okmulgee County, constructed in 1928 serves as municipal water supply and recreation reservoir.

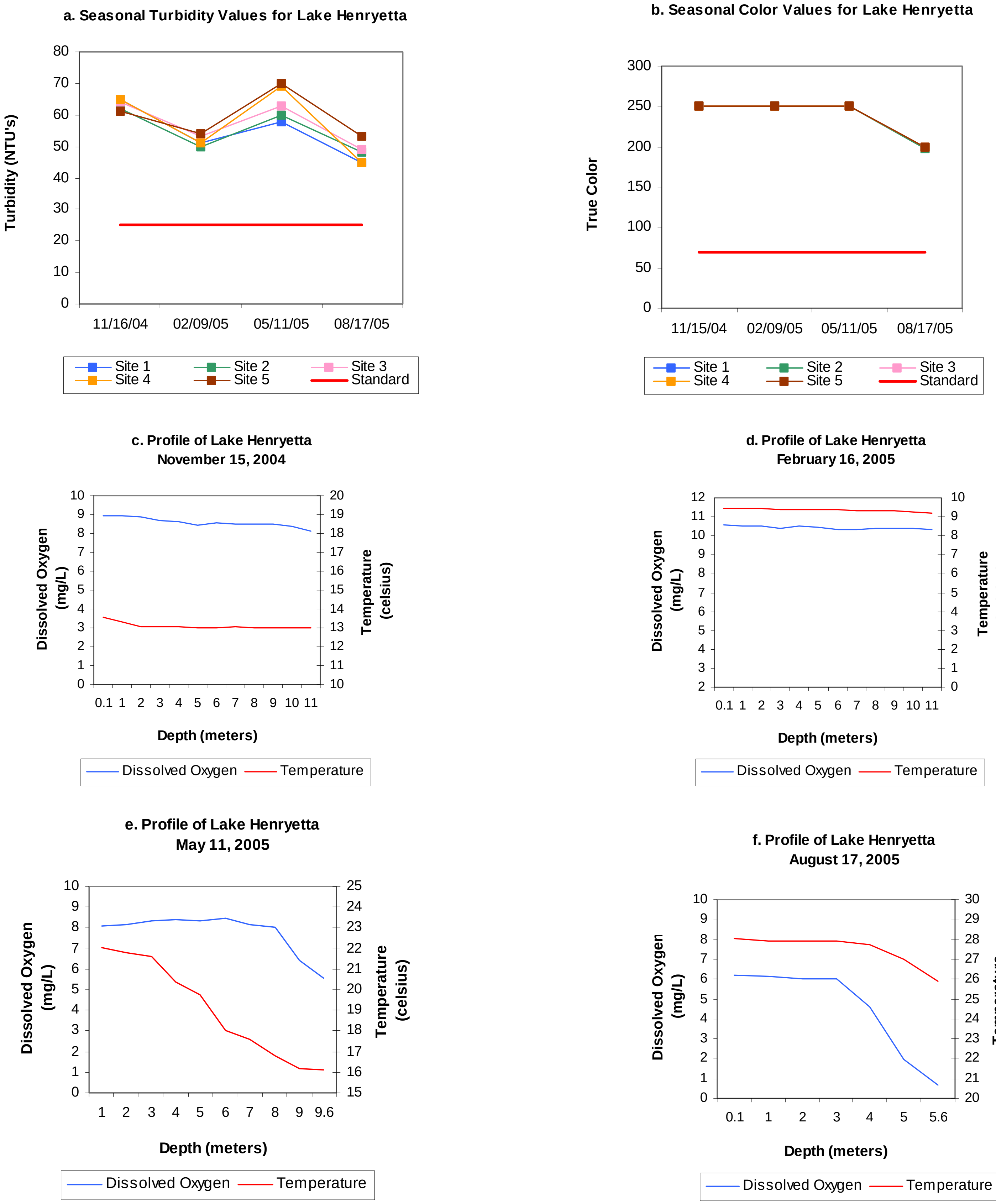
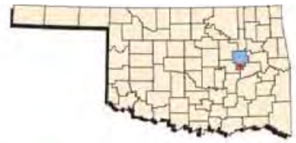
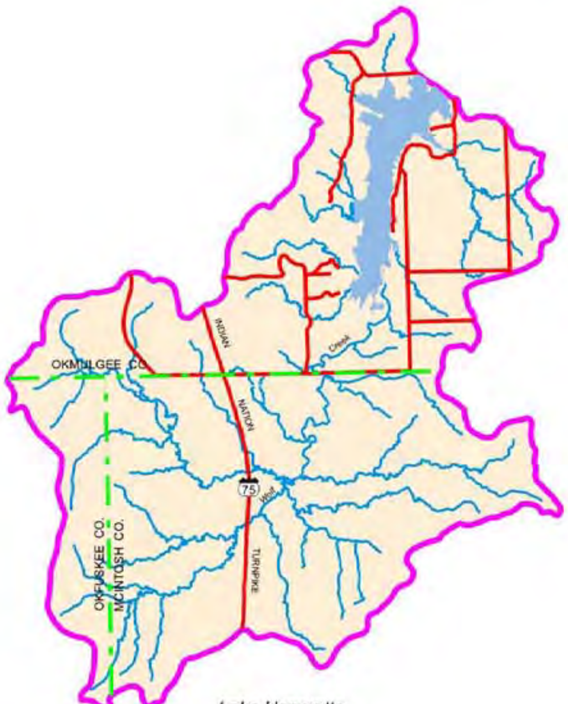


Figure 68a-68f. Graphical representation of data results for Lake Henryetta.



Lake Henryetta
Location



Lake Henryetta
and
Watershed

Lake Data

Owner	City of Henryetta
County	Okmulgee
Constructed in	1928
Surface Area	450 acres
Volume	6,660 acre/feet
Shoreline Length	11 miles
Mean Depth	14.80 feet
Watershed Area	21 square miles

POOR EXCELLENT
Turbidity
2005

POOR EXCELLENT
Trophic State
2005

Plate 52 - Lake Water Quality for
Lake Henryetta

Heyburn Lake

Heyburn Lake was sampled for four quarters from October 2004 through July 2005. Water quality samples were collected at five (5) sites to represent the riverine, transitions and lacustrine zone of the reservoir. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide average turbidity was 40 NTU (Plate 53), true color was 111 units and average secchi disk depth was 37 centimeters. Based on these parameters Heyburn Lake had poor water clarity in comparison to other Oklahoma reservoirs. These values are similar to those calculated in 2003 indicating no significant increase or decrease over time. The trophic state index (TSI) was calculated using values collected at all sites for four quarters (n=20). The result was a TSI of 47 (Plate 53), indicating the lake was mesotrophic during the study period. This value is the similar to that calculated in 2003 (TSI=46), indicating that no significant increase or decrease in productivity has occurred. The TSI values were fairly consistent and varied seasonally from oligotrophic in the winter to upper meso-eutrophic in the fall, with mesotrophic values in both spring, and summer quarters. Seasonal turbidity values are displayed in Figure 69a. Turbidity values ranged from a low of 27 NTU to a maximum of 61 NTU. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the turbidity values above 25 NTU, the Fish and Wildlife Propagation (FWP) beneficial use is not supported based on turbidity. Seasonal true color values are displayed in Figure 69b. Of the twenty values collected 80% were above the WQS of 70 units. Applying the same default protocol, the Heyburn Lake is considered not supporting the Aesthetics beneficial use.

In 2004-2005 vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were performed at all sample sites. Salinity values at Heyburn Lake ranged from 0.08 parts per thousand (ppt) to 0.16 ppt. This is within the average recorded for most Oklahoma reservoirs. Specific conductivity ranged from 174.5 µS/cm to 325.9 µS/cm indicating the minimal presence of current conducting ions (salts and chlorides) in the lake system. The pH values ranged from 6.87 to 8.01 representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range the FWP beneficial use is supported based on pH. Oxidation-reduction potential (ORP) ranged from 318 mV to 480 mV. In general, reducing conditions were not present at any time during the study period. Thermal stratification was not present during any of the first three quarters and the lake was well mixed. (Figure 69c-69e). Thermal stratification was evident and anoxic conditions were present during the summer sampling interval. Stratification occurred between 1 and 2 meters at which point the dissolved oxygen dropped below 2.0 mg/L to bottom of the lake (5.5 meters) accounting for 71% of the water column to be experiencing anoxic conditions. Sites 2 and 5 were also stratified between 1 and 2 meters with 33 and 50% of the water column below 2.0 mg/L. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Heyburn Lake is considered not supporting the FWP beneficial use based on low D.O. values in the summer. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.60 mg/L at the surface. Surface TN ranged from 0.39 mg/L in the fall to 0.80 mg/L in the summer quarter. The lake-wide total phosphorus (TP) average was 0.043 mg/L at the surface. Similar to total nitrogen, TP values at the surface ranged from 0.029 mg/L in the fall to 0.067 mg/L in the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was 14:1 for sample year 2004-2005. This value is higher than 7:1, characterizing the lake phosphorus limited (Wetzel, 1983).

In summary, Heyburn Lake was classified as mesotrophic, indicative of moderate primary productivity and nutrient levels. This current TSI is similar to that calculated in 2003 (TSI=46), indicating that no significant increase or decrease in productivity has occurred. Water clarity was poor based on turbidity, true color, and low secchi disk depth readings. Light limitation driven by the high turbidity may play a role in keeping nutrients at bay. The FWP beneficial use is supported based on pH, but not supported based on low dissolved oxygen and on high turbidity values recorded during the sample year. The Aesthetics beneficial use is supported based on its trophic status. With 80% of the true color values exceeding the WQS of 70 units the Aesthetics beneficial use is considered not supported as it relates to color. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. The Oklahoma Department of Environmental Quality (ODEQ) sampled Heyburn Lake in 2002 as part of the Toxics and Reservoirs program. Mercury residue exceeding the advisory level was found in fish tissue and the ODEQ recommends continued sampling. The United States Army Corps of Engineers (USACE) constructed Heyburn Lake for flood control and other recreation purposes. In 2004 a bathymetric map of Heyburn Lake was completed to update current storage capacity and bottom contours of the lake (). For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.

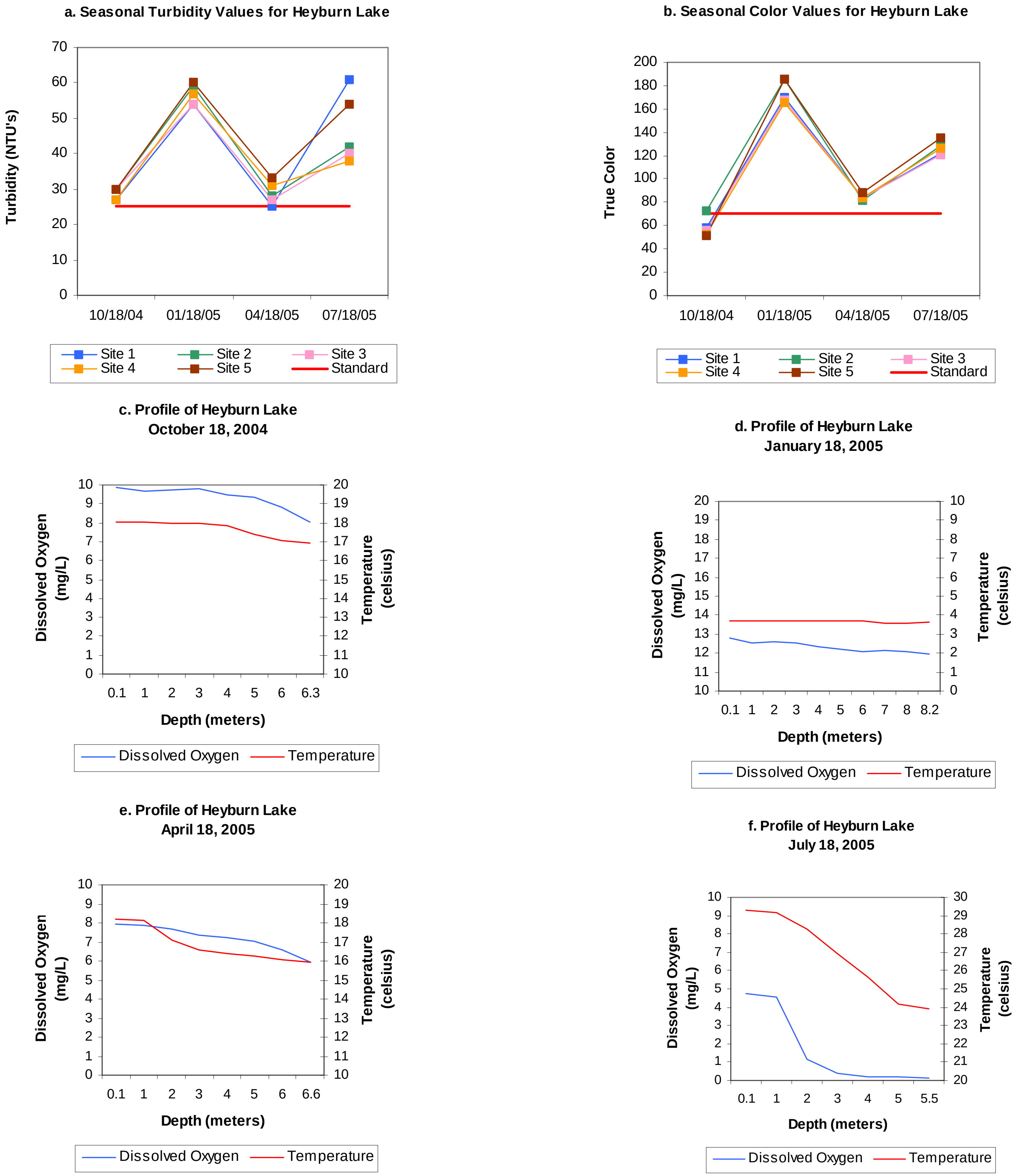
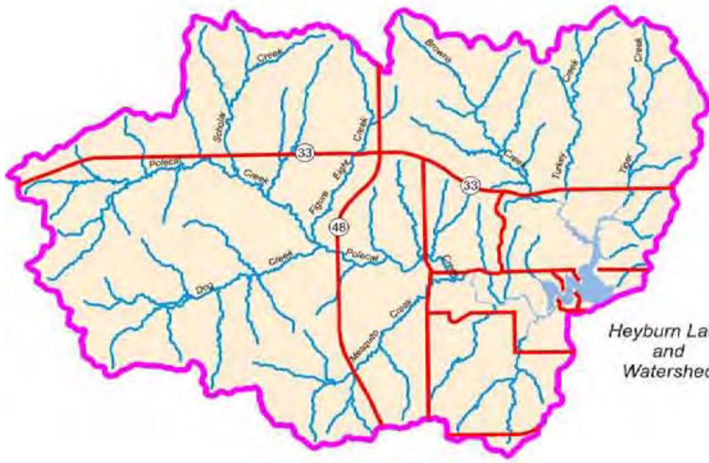
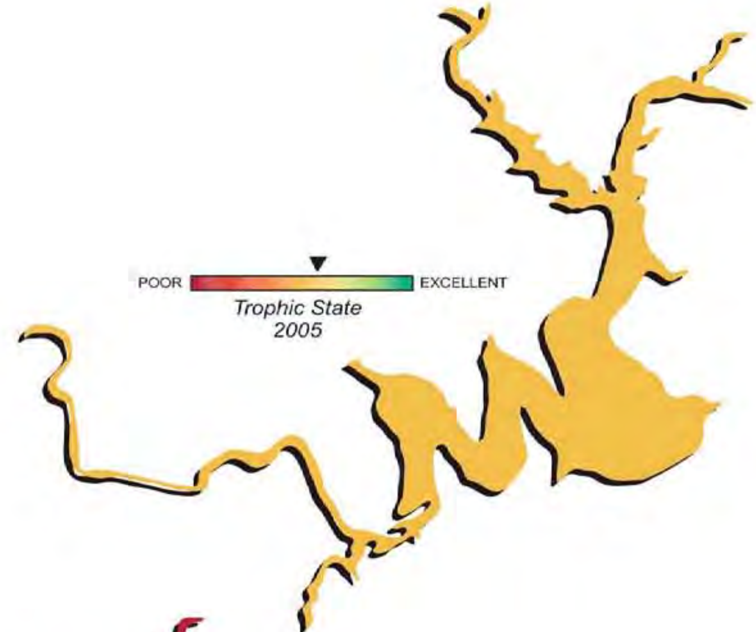


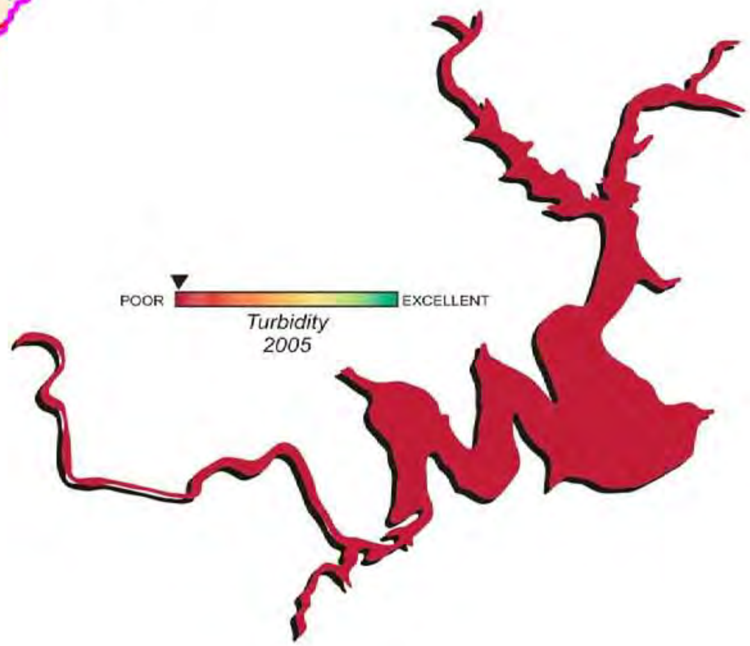
Figure 69a-69f. Graphical representation of data results for Heyburn Lake.

Heyburn Lake
Location



Heyburn Lake
and
Watershed





Lake Data

Owner	Corps of Engineers
County	Creek
Constructed in	1950
Surface Area	880 acres
Volume	7,101 acre/feet
Shoreline Length	50 miles
Mean Depth	8.37 feet
Watershed Area	123 square miles

Plate 53 - Lake Water Quality for
Heyburn Lake

Heyburn Lake

5-foot Depth Intervals

CAUTION - The intention of this map is to give a generalized overview of the lake depths. There may be shallow underwater hazards such as rocks, shoals, and vegetation that do not appear on this map.
THIS MAP SHOULD NOT BE USED FOR NAVIGATION PURPOSES.

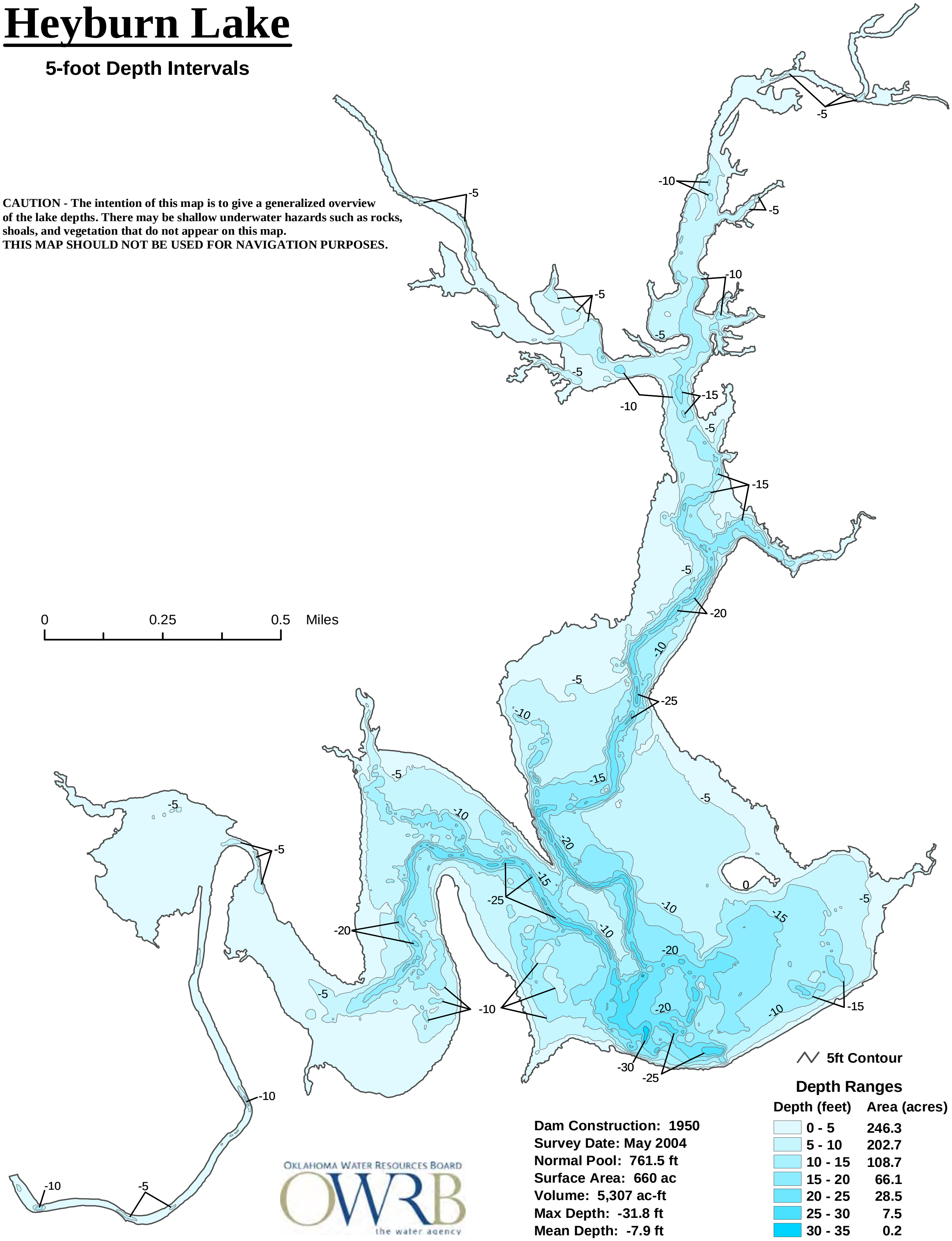


Figure 70. Bathymetric Map of Heyburn Lake.

Holdenville Lake

Holdenville Lake (550-acres) was constructed in 1931 and is owned and operated by the City of Holdenville. The lake is managed to serve as the Holdenville's municipal water supply and also offers a recreational outlet for the general public to utilize. Holdenville Lake was sampled for three quarters, from October 2006 through July 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the sample year. The lake-wide annual turbidity value was 16 nephelometric turbidity units (NTU), true color was 42 units, and secchi disk depth was 75 centimeters. Based on these three parameters, Holdenville Lake had average to good water clarity, consistent with those values observed in 2005 A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for three quarters (n=15). Due to low lake levels OWRB staff was unable to conduct winter sampling and no samples were available for chlorophyll analysis. The average TSI was 60 (Plate 54), classifying the lake as eutrophic, bordering hypereutrophic, indicative of high levels of productivity and nutrient conditions. This differs from the trophic state previously calculated in 2005 (TSI=50), and may be attributed to having only three quarters of data. The TSI values were fairly consistent with all ranging from upper eutrophic to lower hypereutrophic. The only exception to this occurred in the fall at site 4, which was mesotrophic. Three of the fifteen turbidity values collected were above the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 71a). According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). Although 20% of the samples collected in 2006-2007 were above the standard, minimum data requirements were not met therefore assessment of the Fish & Wildlife Propagation (FWP) beneficial cannot be made at this time. Seasonal true color values are displayed in Figure 71b. All true color values were below the aesthetics WQS of 70 units. Similar to turbidity, minimum data requirements and an assessment of the Aesthetics beneficial use cannot be made for Holdenville Lake.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity ranged from 0.06 parts per thousand (ppt) to 0.19 ppt, well within the range of expected values for Oklahoma lakes and reflecting the minimal presence of chlorides or other salts in the lake. Specific conductivity values were also well within the expected range for Oklahoma reservoirs, coinciding with the low salinity values seen for the lake. Values ranged from 141.6 µS/cm to 391.7 µS/cm in the winter quarter. Oxidation-reduction potentials (redox) ranged from 2 mV near the sediment-water interface at the lake bottom in the summer to 577 mV in the spring in the water column. Low redox values like those recorded in the summer are not uncommon when such a large portion of the water is experiencing anoxic conditions. Lake pH values ranged from 6.10 to 8.26 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if ≥ 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Holdenville Lake is considered partially supporting its FWP beneficial use based on pH as 11.4 % of the recorded values were below 6.5 units. Thermal stratification was not evident in the fall quarter and dissolved oxygen (D.O.) remained above 6.0 mg/L (see Figure 71c). The water column was weakly stratified during the spring sampling interval however dissolved oxygen (D.O.) remained above 2.0 mg/L throughout the entire column. Thermal stratification was evident and anoxic conditions were present during the summer quarter. The lake was stratified between 2 and 3 meters below the surface and D.O. concentrations were 1.0 mg/L or less from 4 meters to the lake bottom at 11.5 meters (see Figure 71f). At this time anoxic conditions comprised approximately 83% of the water column. Similar conditions were observed at sites 2, 3, and 5 with anoxic conditions present from 20-80% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial is considered not supported at Holdenville Lake as anoxic conditions were present in up to 80% of the water column in the summer. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

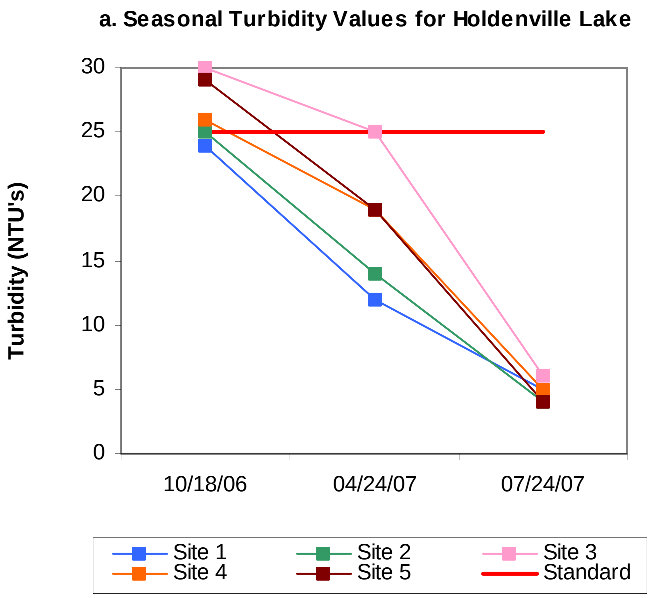
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September. Of the 10 enterococci samples collected one exceeded the prescribed screening level of 400 cfu/ml for fecal coliform and one value exceeded the prescribed mean standard of 235 cfu/ml for *E. coli*. The geometric mean however was not exceeded, therefore the PBCR is still considered supported.

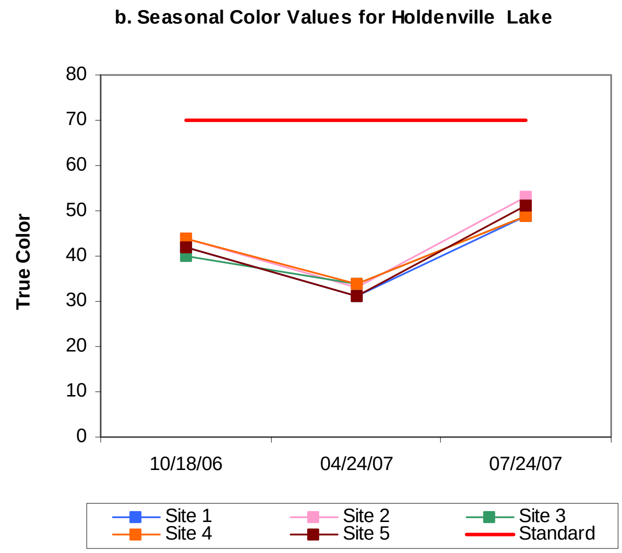
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.73 mg/L at the lake surface. The TN at the surface ranged from 0.57 mg/L to 0.1.01 mg/L. The highest surface TN value was reported in the summer quarter and the lowest was in the fall quarter. The lake-wide total phosphorus (TP) average was 0.035 mg/L at the lake surface. The TP ranged from 0.015 mg/L to 0.067 mg/L. Similar to TN, the highest surface TP value was reported in the summer quarter however the lowest was in the fall quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 21:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

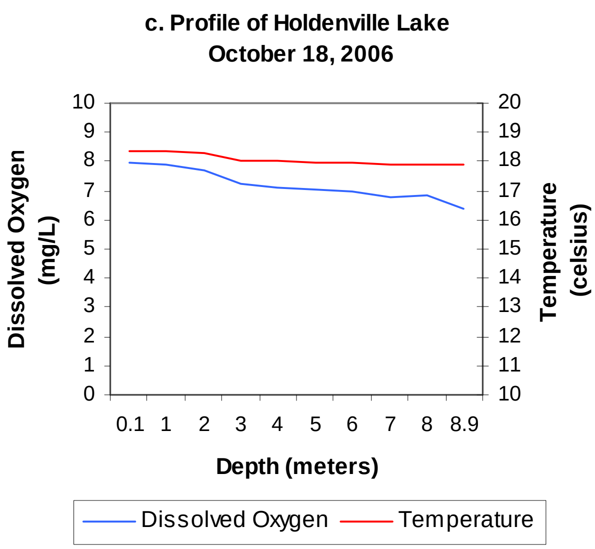
Holdenville Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

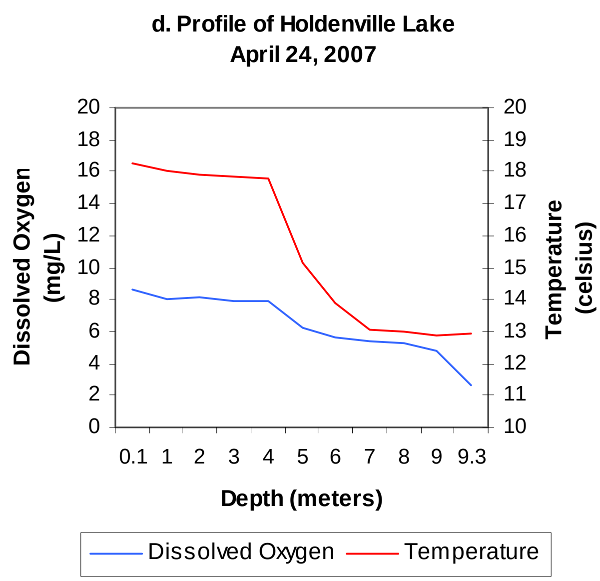
In summary, Holdenville Lake is currently mesotrophic bordering eutrophic, indicative of high primary productivity and nutrient conditions (Plate 54). Water clarity is average to good based on turbidity, true color and secchi disk depth. Holdenville Lake is partially supporting its FWP beneficial use as it relates to pH and an assessment based on turbidity cannot be made due to minimum data requirements not being met for this sample year. Anoxic conditions were present in up to 80% of the water column during the summer therefore the lake is considered not supporting its FWP beneficial used based on D.O. concentrations. The lake is fully supporting its Aesthetics beneficial use based on its trophic status. Similar to turbidity, minimum data requirements were not met for true color, therefore an assessment of the Aesthetics beneficial use based on color cannot be made. Bacteriological samples were also collected to assess the

Primary Body Contact Recreation (PBCR) beneficial use. Of the 10 enterococci and *E.coli* samples collected one (10%) exceeded the prescribed screening levels of 400 cfu/ml and 235 cfu/ml however the geometric mean was not exceeded. The PBCR is still considered supported at this time.









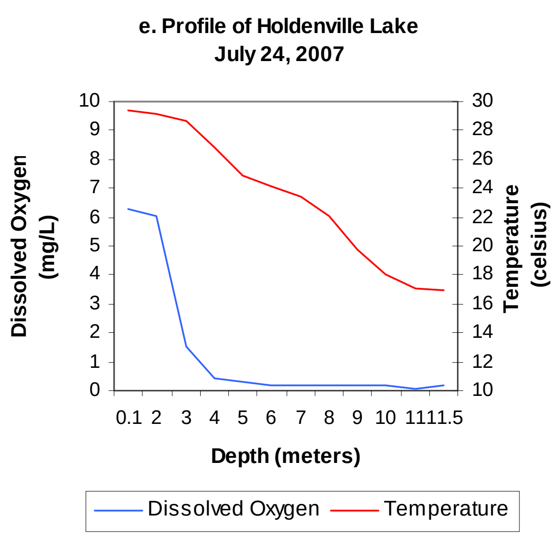
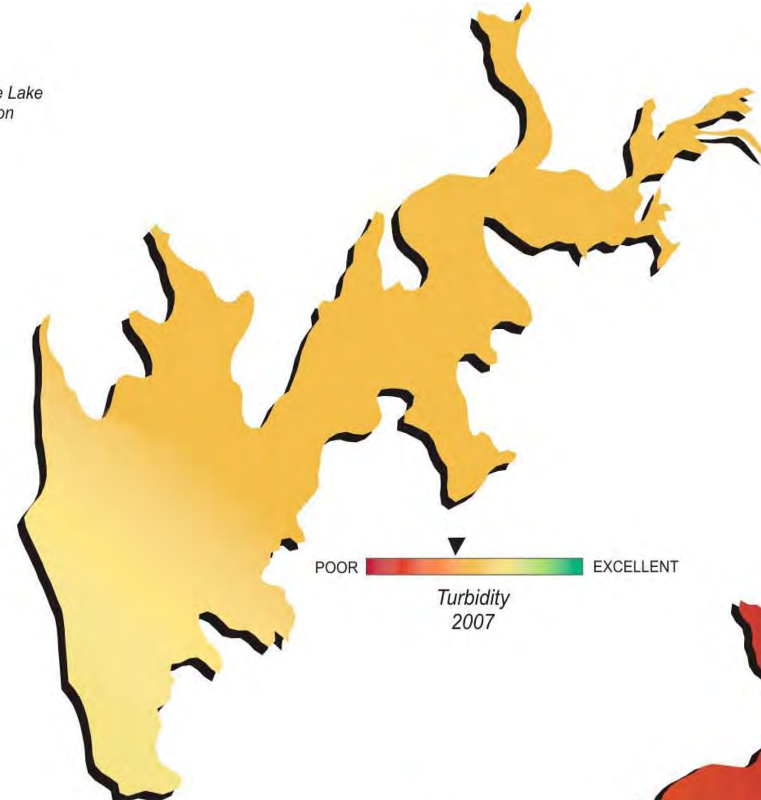
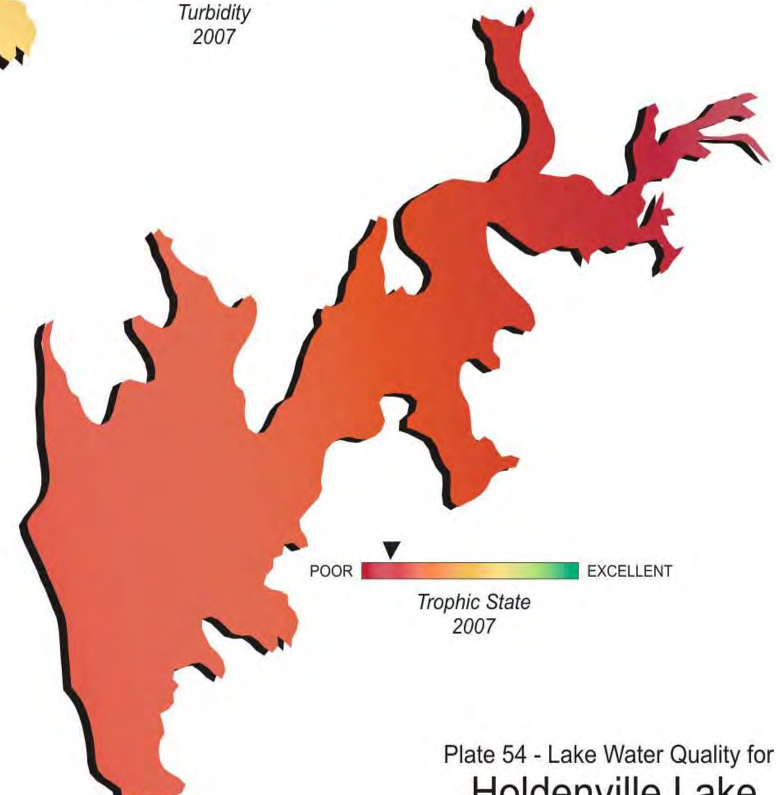


Figure 71a-71f. Graphical representation of data results for Holdenville Lake.

Plate 54 - Lake Water Quality for Holdenville Lake

Lake Data	
Owner	City of Holdenville
County	Hughes
Constructed in	1931
Surface Area	550 acres
Volume	11,000 acre/feet
Shoreline Length	11 miles
Mean Depth	20.00 feet
Watershed Area	9 square miles





LAKES MONITORING PROGRAM

Hominy Municipal Lake

Hominy Municipal Lake, located in Osage County, is the municipal water supply for the City of Hominy and is owned and operated by the city. The lake was constructed in 1940 and is also utilized for recreational purposes. Hominy Municipal Lake was sampled for four quarters, from November 2006 through August 2007.

Water quality samples were collected at three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 9 nephelometric turbidity units (NTU), true color was 35 units, and secchi disk depth was 101 centimeters. Based on these three parameters, Hominy Municipal Lake had excellent water clarity in 2006-2007. Results for these parameters are consistent with previous data collection efforts in 2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for three quarters (n=8). The average TSI was 56 (Plate 55), classifying the lake as eutrophic, indicative of high levels of productivity and nutrients. Due to low lake levels the city closed the boat ramps and OWRB staff was unable to conduct winter sampling and no samples were available for chlorophyll analysis. This current TSI value is greater than the TSI in 2004 (TSI=49), indicating an increase in trophic status since previous data collection efforts were conducted as is likely related to the decrease in lake levels. The TSI values were generally eutrophic with hypereutrophic conditions present during the spring sampling interval. All turbidity values were below the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 72a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). Although 100% of the samples below the standard, the Fish & Wildlife Propagation (FWP) beneficial use cannot be assessed as minimum data requirements were not met. Seasonal true color values are displayed in Figure 72b. True color values were all below the aesthetics WQS of 70 units (see Figure 72b). Similar to turbidity, minimum data requirements were not for true color, therefore the Aesthetics beneficial use cannot be assessed at this time.

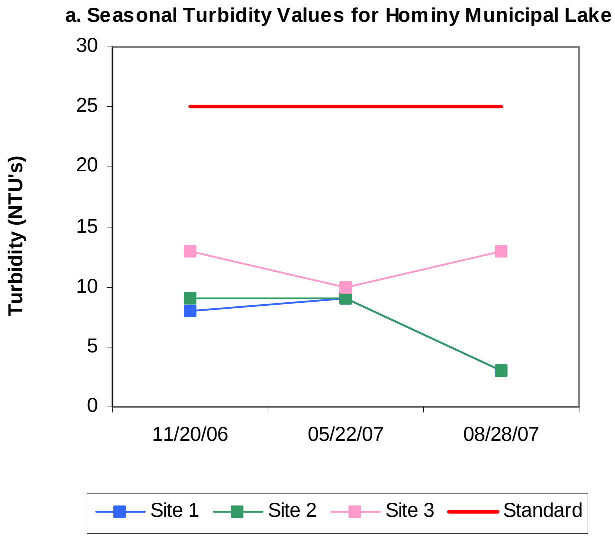
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all three sample sites. The salinity values ranged from 0.10 parts per thousand (ppt) to 0.14 ppt, which is within the expected range for Oklahoma reservoirs. Readings for specific conductivity were also within the normal range of values recorded in most Oklahoma lakes, ranging from 224 µS/cm in the spring to 297.7 µS/cm in the summer quarter. These values indicate relatively low concentrations of electrical current conducting materials (salts) were present in the lake system, which corresponds with the low salinity values. In general, pH values were neutral to slightly alkaline, ranging from 7.12 to 8.66 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. Hominy Municipal Lake is fully supporting its FWP beneficial use based on pH as 100% of recorded values were within the acceptable range. Oxidation-reduction potentials (redox) ranged from -22 mV in the hypolimnion during the summer quarter to 430 mV in the fall quarter. Low redox readings are not uncommon when a large portion of the water column is anoxic as was the case during summer sampling. The lake was well mixed in the fall quarter with dissolved oxygen (D.O.) concentrations in the water column remained above 7.0 mg/L (Figure 72c). Although no profile data is available for the winter quarter, historical data and the time of year suggest that the lake would be well mixed and oxygenated. During the spring and summer sampling intervals thermals stratification was evident and anoxic conditions present. The lake was stratified between 3 and 4 meters with D.O. below 2 mg/L from 7 meters to the lake bottom of 11 meters (Figure 72d) during the spring. In the summer the lake was strongly thermally stratified between 3 and 4 meters, at both sites 1 and 2, with D.O. values falling below 2.0 mg/L from 5 meters to the lake bottom of 11.3 meters and anoxic conditions comprising 62% of the water column (see Figure 72f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is partially supported at Hominy Municipal Lake with approximately 43% (spring) and 62% (summer) of the water column experiencing anoxic conditions. During the fall quarter, only 33% of the water column has D.O. concentrations of less than 2.0 mg/L. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

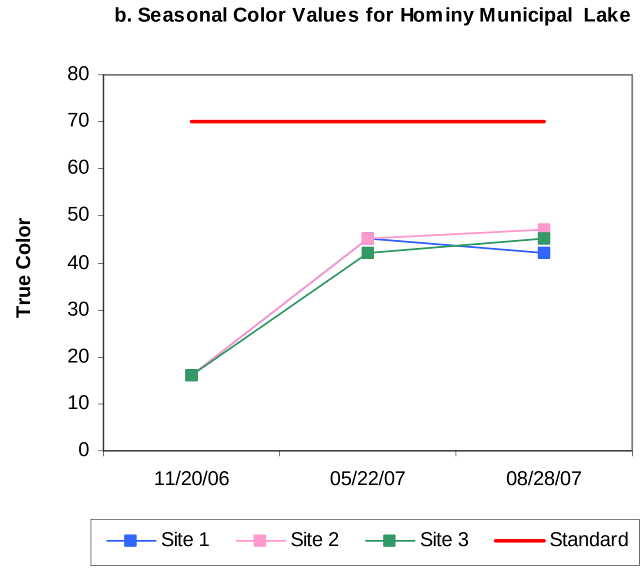
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September. Of the 10 samples collected all were at or below the detection limit. The PBCR beneficial use is therefore considered supported.

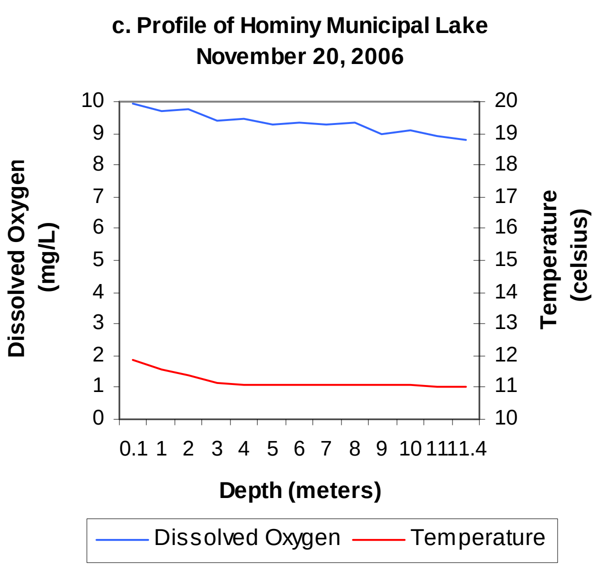
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.72 mg/L at the lake surface. The TN at the surface ranged from 0.45 mg/L to 0.98 mg/L. The highest surface TN value was reported in the fall quarter and the lowest was in the summer quarter. The lake-wide total phosphorus (TP) average was 0.021 mg/L at the lake surface. The surface TP ranged from 0.010 mg/L to 0.028 mg/L. The highest surface TP value was reported in the spring and the lowest was recorded in the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was 34:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

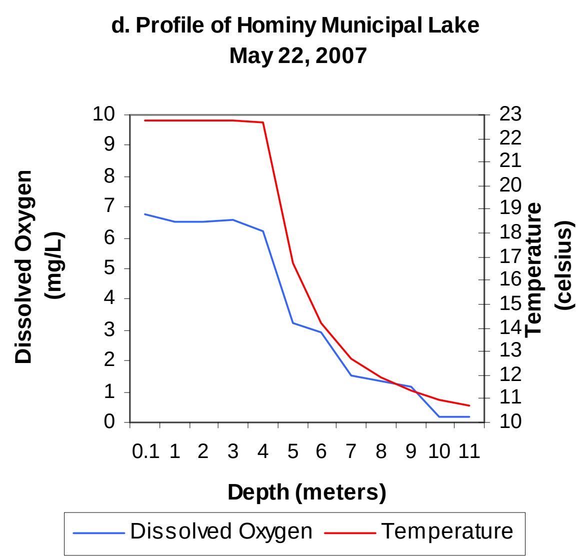
Hominy Municipal Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Hominy Municipal Lake was classified as eutrophic, indicating high productivity and nutrient levels (Plate 55). Water clarity continues to be excellent based on turbidity, true color and secchi disk depth. The FWP beneficial use is fully supporting based pH values, however the use is partially supported based on anoxic conditions present during in the water column during the spring and summer sampling intervals. Due to minimum data requirements not being met the FWP cannot be assessed for turbidity for the current sample year. The Aesthetics beneficial use was supported based the trophic status; however like turbidity minimum data requirements were not met for true color values. Bacteriological samples were all at or below the detection limit, therefore the Primary Body Contact Recreation (PBCR) beneficial use is considered supported. In general, the lake is one of the nicer small municipal lakes in Oklahoma and has good water quality.









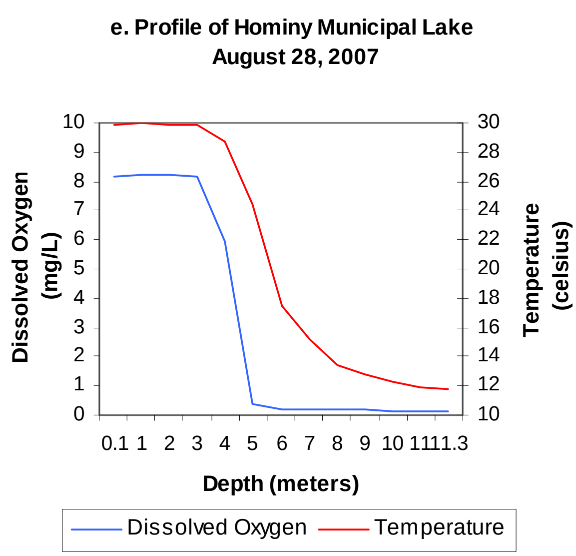
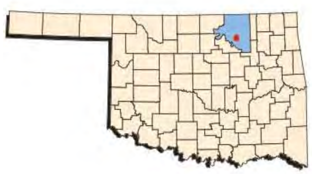
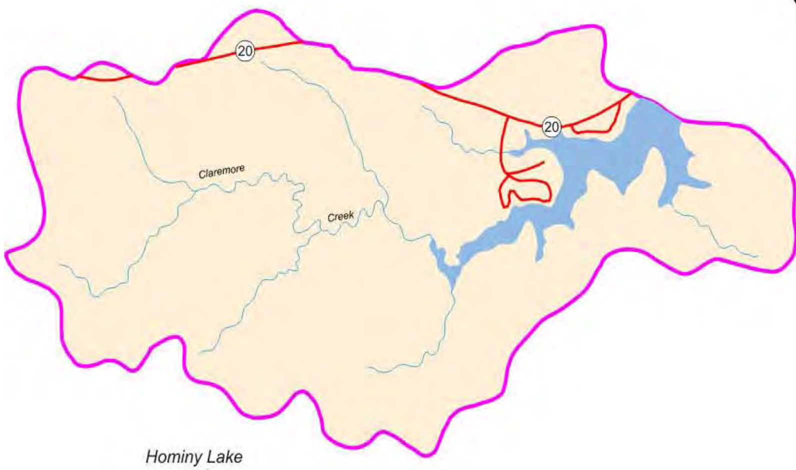
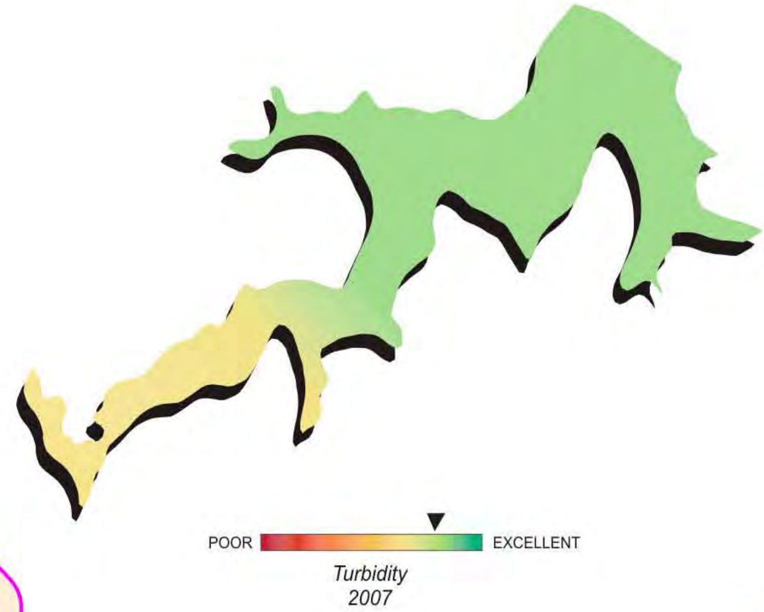


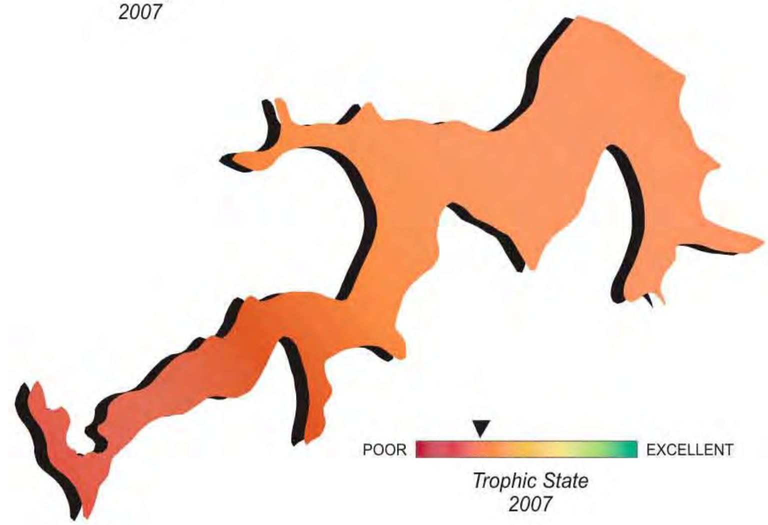
Figure 72a-72f. Graphical representation of data results for Hominy Municipal Lake.

Plate 55 - Lake Water Quality for
Hominy Lake









Lake Data

Owner	City of Hominy
County	Osage
Constructed in	1940
Surface Area	165 acres
Volume	5,000 acre/feet
Shoreline Length	6 miles
Mean Depth	30.30 feet
Watershed Area	3,282 acres

LAKES MONITORING PROGRAM

Hudson Lake (Osage County)

Hudson Lake (Osage County), is owned and operated by the City of Bartlesville and was constructed in 1949 to serve as a municipal water supply for the city and to offer recreational opportunities for the public. Hudson Lake was sampled for four quarters, from October 2005 through July 2006.

Water quality samples were collected at three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 8 NTU (Plate 57), true color was 21 units, and secchi disk depth was 98 centimeters. Based on these three parameters, Hudson Lake (Osage County) had good water clarity in 2005-2006, slightly better than that of the previous evaluation in 2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 57 (Plate 57), classifying the lake as eutrophic, indicative of high levels of productivity and nutrient rich conditions. This is very similar to the TSI in 2004 (TSI=54), indicating no significant increase or decrease in productivity has occurred over time. The TSI values varied seasonally at Hudson Lake (Osage County) from mesotrophic in the winter, to upper mesotrophic in the spring and eutrophic in the fall and even hypereutrophic conditions in the summer quarter. All turbidity values were below the Oklahoma Water Quality Standard (WQS) of 25 NTU with values ranging from a low of 5 NTU to a maximum of 16 NTU (see Figure 73a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the collected values below the WQS of 25 NTU, the lake is considered supporting its Fish & Wildlife Propagation (FWP) beneficial use. Seasonal true color values are displayed in Figure 73b. Similar to turbidity, all true color values were well below the standard throughout the sample year. The Aesthetics beneficial use is therefore considered supported based on true color concentrations in the water column.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all three sample sites. Salinity values ranged from 0.08 parts per thousand (ppt) to 0.14 ppt, which is within the range of values reported for Oklahoma lakes. Readings for specific conductivity ranged from 178.3 µS/cm to 297.4 µS/cm, indicating low to moderate concentrations of electrical current conducting compounds (salts) were present in the water column throughout the year. These values also corresponded with the recorded salinity values. In general, pH values were neutral to very slightly alkaline, ranging from 6.84 to 8.75 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the recorded values within the acceptable range, Hudson Lake is fully supporting its FWP beneficial use based on pH values. Oxidation-reduction potentials (redox) ranged from 61 mV at the water-sediment interface in the summer to 442 mV in the fall quarter. Redox readings indicated that reducing conditions were not present in the reservoir, in fact; only 5 readings were less than 200 mV in 2005-2006. In the fall quarter the lake exhibited thermal stratification at several 1-meter intervals at site 1, with dissolved oxygen (D.O.) recorded as less than 2.0 mg/L from 8 meters to the lake bottom of 9.2 meters (Figure 73c). The lake did not exhibit thermal stratification in the winter or spring quarters (see Figure 73d-68e). In the summer the lake was stratified between 4 and 5 meters at sites 1 and the D.O. concentration was less than 2.0 mg/L below 5 meters extending to the lake bottom at 7.7 meters (see Figure 73f). Anoxic conditions were present in approximately 33 (site 2) to 44% (site 1) of the water column during the summer sampling interval. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With up to 44% of the water column at site 1 experiencing anoxic conditions in the summer, the FWP beneficial use is considered supported at Hudson Lake (Osage County). The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.62 mg/L at the lake surface and ranged from 0.45 mg/L to 1.01 mg/L. The highest surface TN value was reported in the summer quarter and the lowest was in the fall quarter. The lake-wide total phosphorus (TP) average was 0.034 mg/L at the lake surface. The surface TP ranged from 0.021 mg/L to 0.073 mg/L. Similar to TN, the highest surface TP value was reported in the summer however the lowest was in the winter. The nitrogen to phosphorus ratio (TN:TP) was approximately 18:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Hudson Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Hudson Lake (Osage County) was classified as eutrophic, indicative of high primary productivity and nutrient rich conditions (Plate 57). This is consistent with past data collection efforts in 2001 and 2004, which also found the lake to be eutrophic. Water clarity was good based on turbidity, true color and secchi depth. The FWP beneficial use was fully supported based on pH, turbidity and dissolved oxygen levels recorded throughout the sample year. The Aesthetics beneficial use was fully supported based on trophic status. With 100% of the reported values below the WQS of 70 units, the Aesthetics beneficial use is also considered supported based on true color concentrations in the water column. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

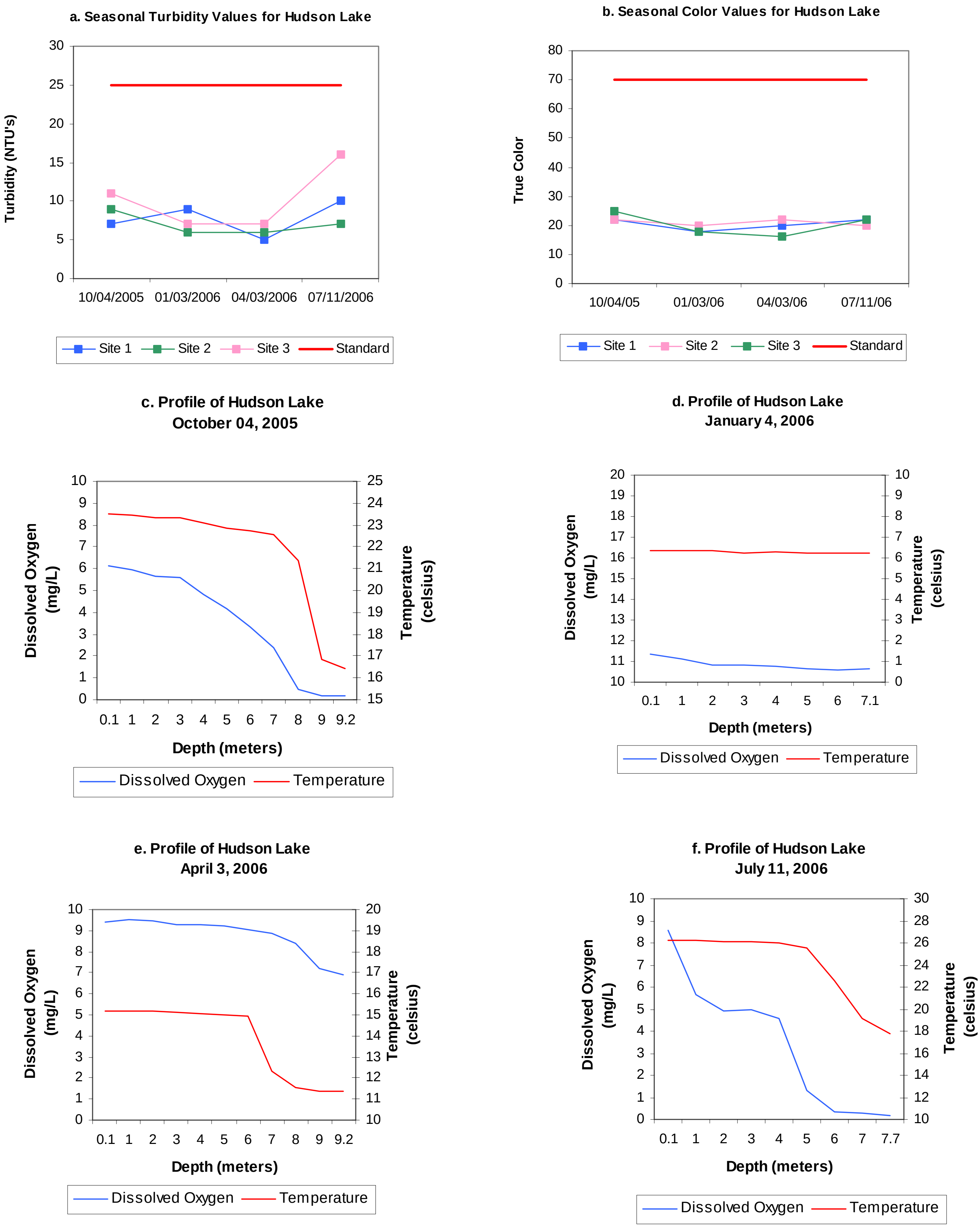
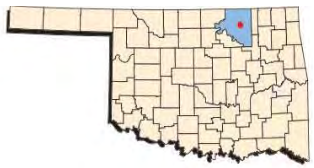
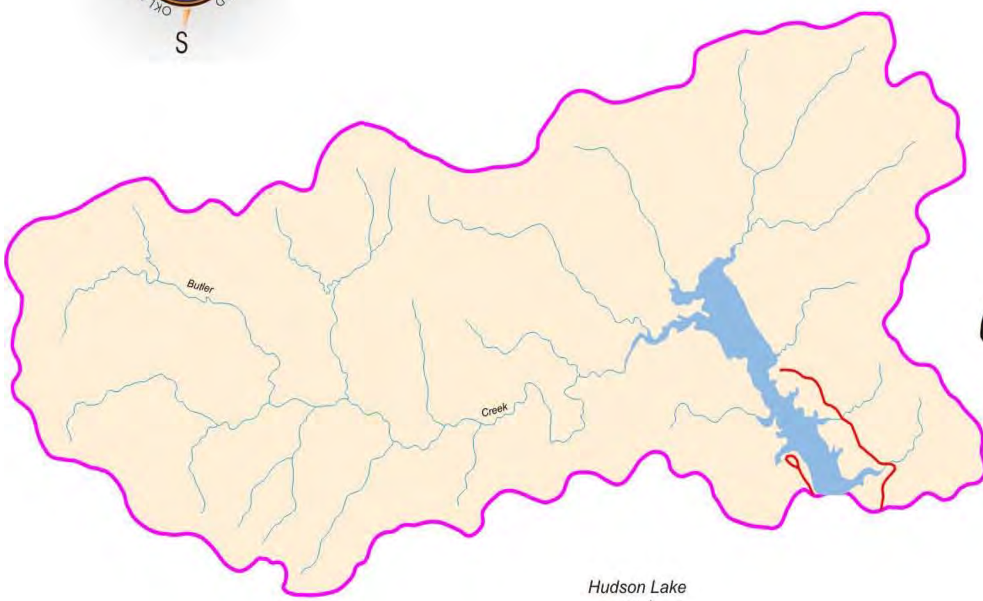


Figure 73a-73f. Graphical representation of data results for Hudson Lake (Osage County).



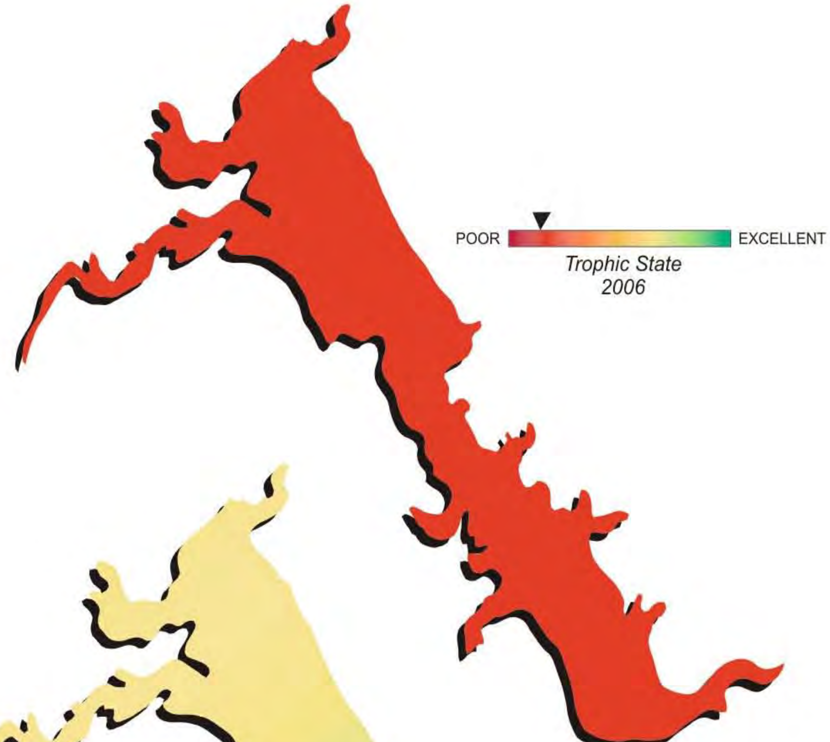
Hudson Lake
Location



Hudson Lake
and
Watershed

Lake Data

Owner	City of Bartlesville
County	Osage
Constructed in	1949
Surface Area	250 acres
Volume	4,000 acre/feet
Shoreline Length	8 miles
Mean Depth	16.00 feet
Watershed Area	14 square miles



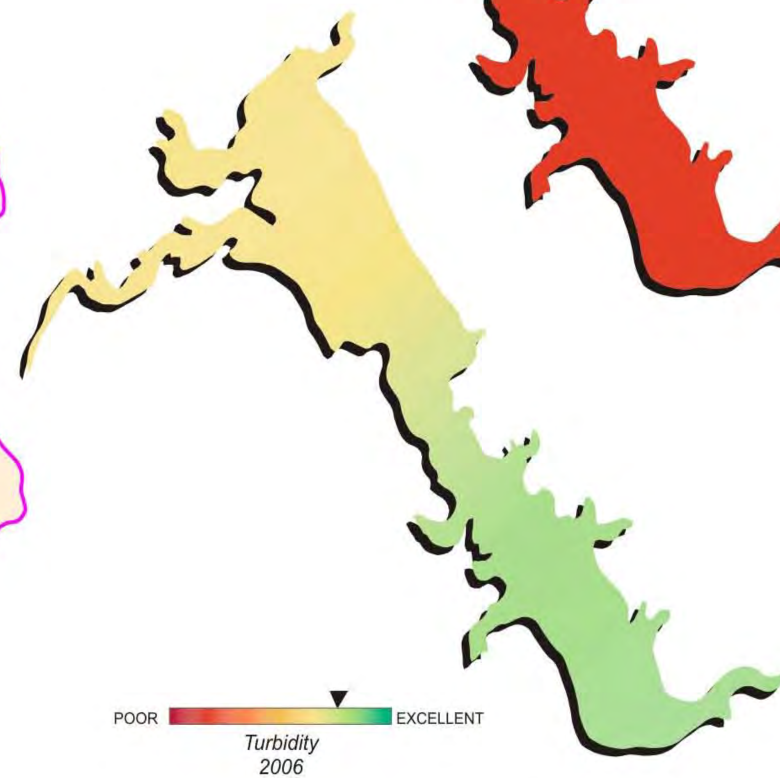


Plate 57 - Lake Water Quality for
Hudson Lake (Osage Co.)

Lake Hudson (Mayes Co.)

Lake Hudson is a 10,900-acre reservoir, which was constructed by the Grand River Dam Authority (GRDA) for flood control and hydroelectric purposes and is located in Mayes County. Lake Hudson was sampled for four quarters from October 2004 through July 2005.

Water quality samples were collected at eight (8) sites to represent the riverine, transition and lacustrine zones and arms of the reservoir. Samples were collected from the lake surface at all sites during the study period. Lake Hudson is a large dendritic reservoir and has been broken into two management segments, upper lake and lower lake to represent the riverine, transition, and lacustrine zones of the reservoir. The following discussion will briefly summarize each segment with a lake-wide summary included at the end of the narrative.

Upper Lake:

The upper part of Lake Hudson (segment # 121600020140) extends from to the highway 20 bridge downward to mid-lake and includes BUMP sites 5-8. The segment-wide average turbidity was 7 nephelometric turbidity units (NTU), true color was 35 units, and secchi disk depth was 90 centimeters. Based on these three parameters water clarity for this segment was good for sample year 2007. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=16). The average TSI was 59, classifying the segment as eutrophic, indicative of high primary productivity and nutrient conditions. Chlorophyll-a values among the sites were consistently upper eutrophic to mid-hypereutrophic during the sample year. Turbidity values ranged from a low of 4 NTU (site 6) to a maximum of 11 NTU (site 5). All true color values were below the Aesthetics criteria 70 units with values ranging from 16 to 69 units.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites within the upper segment. Salinity values ranged from 0.08 parts per thousand (ppt) to 0.14 ppt, which is within the range of expected values for most Oklahoma reservoirs. Specific conductivity ranged from 172.3 µS/cm to 298.7 µS/cm, indicating low to moderate concentrations of current conducting compounds or other analogous material (salts) in the lake system. The pH values ranged from 6.86 to 9.30 representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its Fish and Wildlife Propagation (FWP) beneficial use. With 2.4% of the values greater than 9.0 units, this portion of the lake is considered supporting the beneficial use based on pH. Thermal stratification was not present during the fall or winter and the water column was well mixed. In the spring the lake was weakly stratified however dissolved oxygen (D.O.) remained above 2 mg/L. Similar conditions were recorded during the summer, the only exception being site 8 which had with anoxic conditions comprising 44% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O.

LAKES MONITORING PROGRAM

values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With up to 44% of the water column less than 2.0 mg/L in the summer, the upper segment of Lake Hudson is considered supporting the FWP beneficial use.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of (Nutrient Limited Watershed) NLW lakes and nutrient criteria development for lakes and reservoirs. In the upper lake the average total nitrogen (TN) was 0.93 mg/L, with values ranging from 0.54 mg/L in the fall to 1.74 mg/L in the spring quarter. The average total phosphorus (TP) was 0.080, with values ranging from 0.032 mg/L in the summer to 0.128 mg/L in the spring. The nitrogen to phosphorus ratio (TN:TP) was 12:1. This value is the close to 7:1, characterizing this portion of the lake as phosphorus-limited (Wetzel, 1983).

<u>Lower Lake:</u>

The lower portion of Lake Hudson (segment # 121600020020) extends from Snowdale State Park downward to the dam and includes BUMP sites 1-4. The segment-wide average turbidity was 7 NTU, true color was 32 units, and secchi disk depth was 107 centimeters. Based on these three parameters water clarity for this segment was excellent for sample year 2007. This is not unusual as you move through the lake towards the dam area and sediment and other materials have had time to settle out. A trophic state index (TSI), using Carlson's TSI (chlorophyll-<u>a</u>), was calculated using values collected at all sites for four quarters (n=16). The average TSI was 58, classifying the segment as eutrophic bordering hypereutrophic, indicative of high primary productivity and nutrient conditions. Chlorophyll-<u>a</u> values among the sites were generally upper eutrophic with a few hypereutrophic during the sample year. Turbidity values were all below the Oklahoma Water Quality Standard (WQS) of 25 NTU ranging from a low of 3 NTU (site 3) to a maximum of 18 NTU (site 3). Like turbidity, true color was also low with values ranging from 18-62 units, with all values below the Aesthetics criteria of 70 units.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites within the upper segment. Salinity values ranged from 0.08 parts per thousand (ppt) to 0.14 ppt, which is within the range of expected values for most Oklahoma reservoirs. Specific conductivity ranged from 172.8 µS/cm to 286.2 µS/cm, indicating low to moderate concentrations of current conducting compounds or other analogous material (salts) in the lake system. The pH values ranged from 6.98 to 9.36 representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its Fish and Wildlife Propagation (FWP) beneficial use. With only 0.28% of the values greater than 9.0 units, this portion of the lake is considered supporting the beneficial use based on pH. Thermal stratification was not present during the fall, winter or spring quarters and the water column was well mixed with dissolved oxygen (D.O.) remaining above 6.0 mg/L (Figure 74c-71e). During the summer thermal stratification was evident and anoxic conditions were present at all four sites. Stratification occurred at several 1-meter intervals among the sites with anoxic conditions up to 43% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With as much as 43% (site 3) of the water column less than 2.0 mg/L in the summer, the lower segment of Lake Hudson is considered supporting the FWP beneficial use.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of (Nutrient Limited Watershed) NLW lakes and nutrient criteria development for lakes and reservoirs. In the lower lake the average total nitrogen (TN) was 0.91mg/L, with values ranging from 0.53 mg/L in the summer to 1.75 mg/L in the spring quarter. The average total phosphorus (TP) was 0.077, with values ranging from 0.051 mg/L in the winter to 0.118 mg/L in the summer. The nitrogen to phosphorus ratio (TN:TP) was 12:1, this value is the close to 7:1, characterizing this portion of the lake as phosphorus-limited (Wetzel, 1983).

Lake Summary

The lake was also sampled for chlorides and sulfates, to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported in both management segments based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites throughout the lake for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. Although all sample results were below both the screening level and geometric mean, the minimum data requirements for each segment were not met and an assessment of the PBCR beneficial use cannot be made at this time.

Lake Hudson was also sampled for total metals at five sites during the spring of 2007; however the minimum data requirements for each segment were not met and an assessment of the FWP beneficial use cannot be made at this time.

In summary, Lake Hudson is classified as eutrophic, with high primary productivity and nutrient conditions (Plate 56). The lake-wide average turbidity was 7 NTU, true color was 34 units and average secchi disk depth was 98 centimeters. Based on these three parameters Lake Hudson had good water clarity in 2007. These values are similar to the values reported in 2005 if not slightly better. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a) was calculated using values at all site for four quarters (n=32). The TSI was 58, indicating the lake was eutrophic with high primary productivity and nutrient levels. This is consistent with previous data collection efforts in 2005 (TSI=60) and 2003, (TSI= 55), indicating no significant change in productivity has occurred. The TSI values varied were generally mid to upper eutrophic during the year with a few hypereutrophic values reported in the spring quarter. Seasonal turbidity values are displayed in Figure 74a. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the values below the standard the Fish and Wildlife Propagation beneficial use is deemed fully supported. Seasonal true color values are displayed in Figure 74b. Similar to turbidity, all true color values were well below the WQS of 70 units for all quarters during the sample year. Applying the same default protocol the Aesthetics beneficial use is supported based on true color. Due to minimum data requirements not being met for each segment the PBCR beneficial use cannot be assessed at this time. In 2008 a bathymetric map of Lake Hudson was completed to update current storage capacity and bottom contours of the lake (Figure 76). For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.

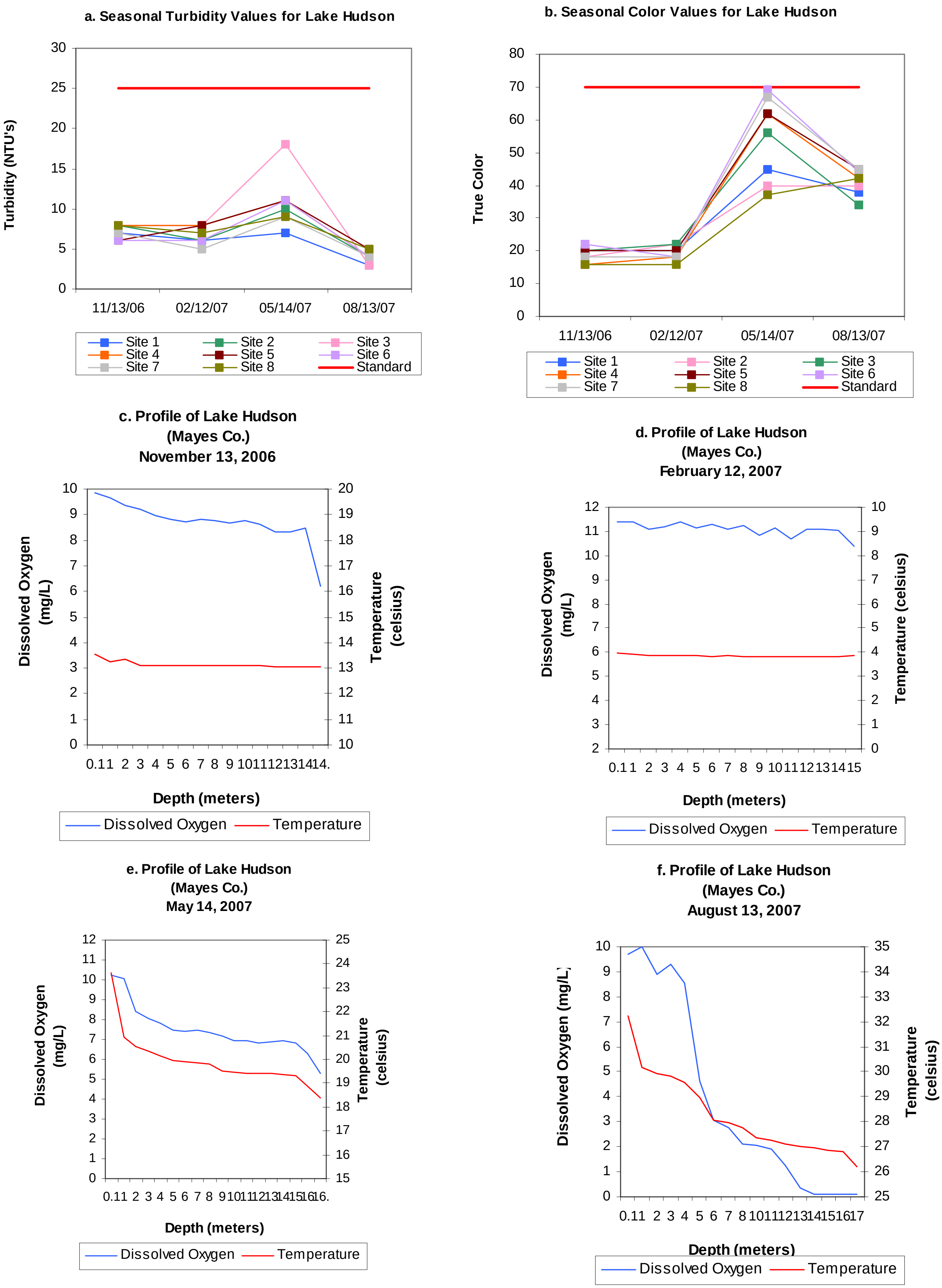
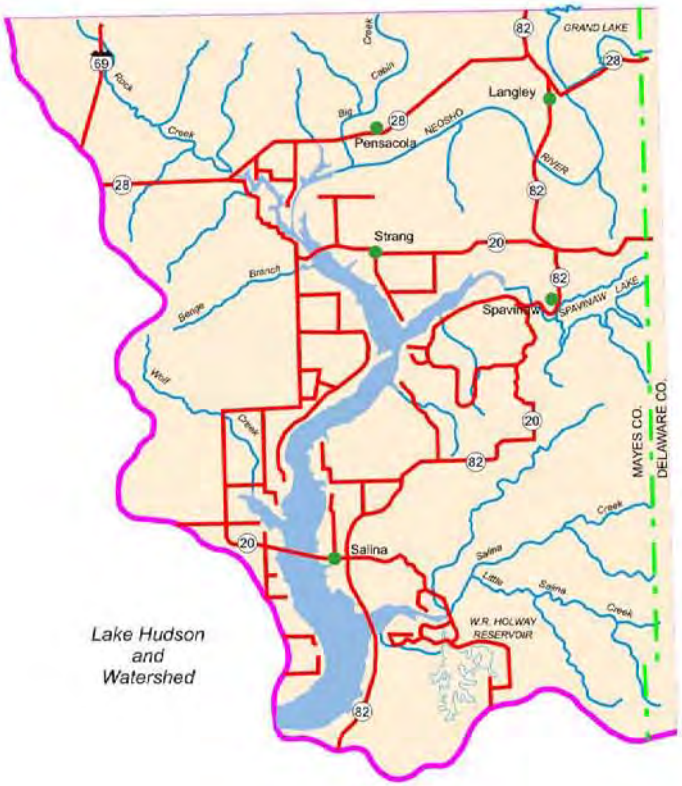


Figure 74a-74e. Graphical representation of data results for Lake Hudson (Mayes Co.).



Lake Data	
Constructed by	Grand River Dam Authority
County	Mayes
Constructed in	1964
Surface Area	10,900 acres
Volume	200,300 acre/feet
Shoreline Length	200 miles
Mean Depth	19.38 feet
Watershed Area	11,533 square miles

Plate 56 - Lake Water Quality for

Lake Hudson (Mayes Co.)

LAKES MONITORING PROGRAM

Figure 75. Lake Hudson Site Map

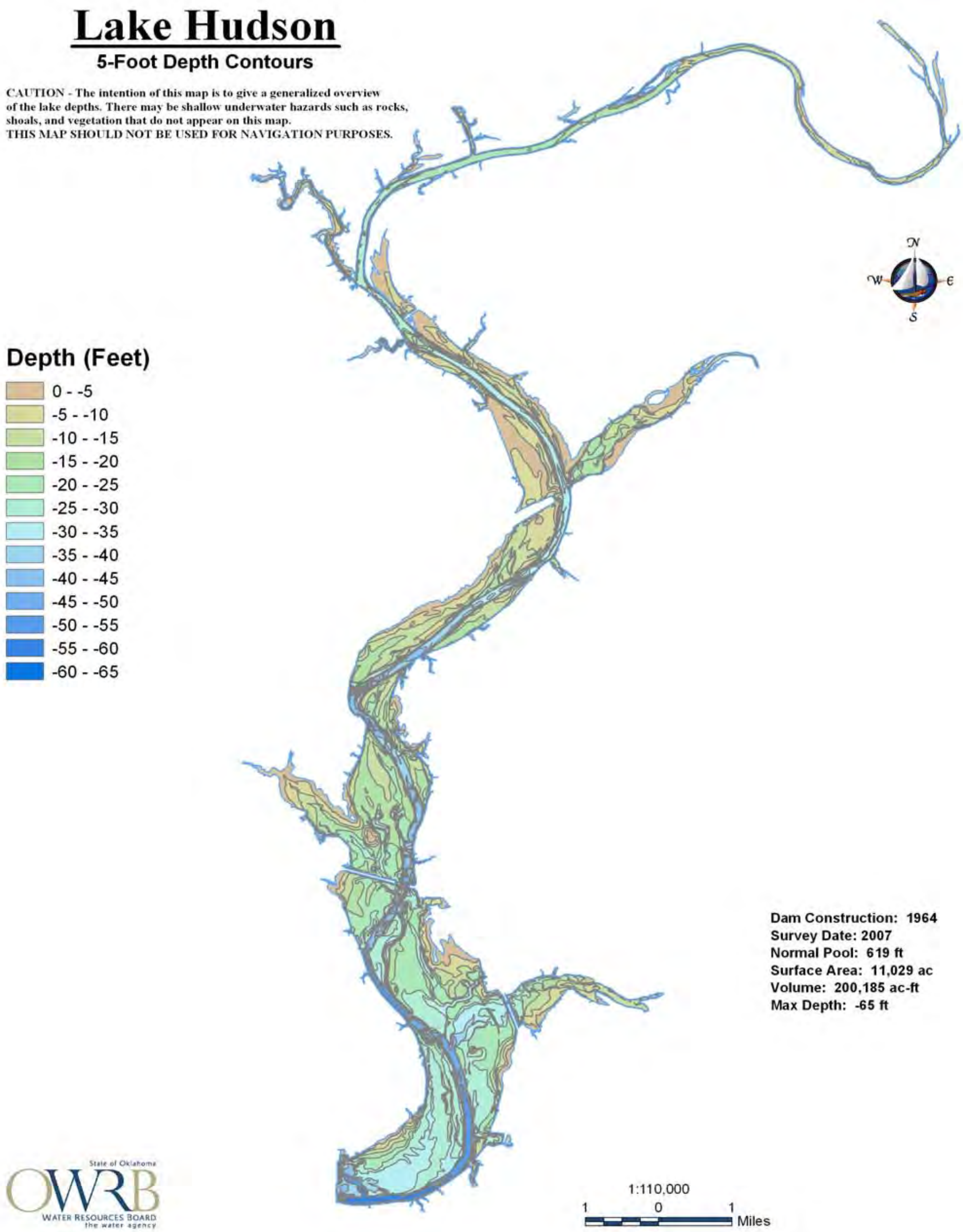


Figure 76. Bathymetric Map of Lake Hudson

Hugo Lake

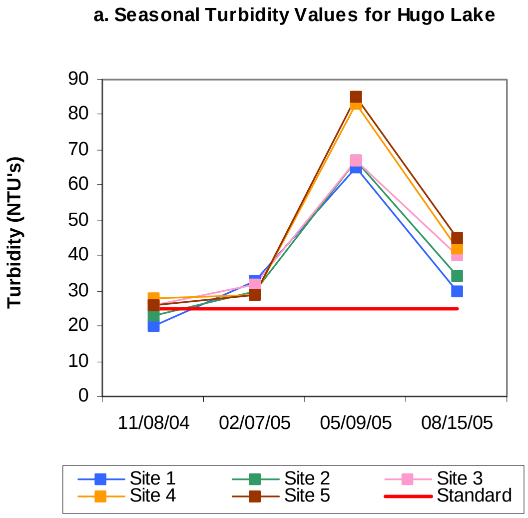
Hugo Lake was sampled for four quarters from November 2004 through August 2005. Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide annual turbidity value was 42 NTU (Plate 58), true color was 123 units, and secchi disk depth was 36 centimeters. Based on these three parameters, Hugo Lake had poor water clarity in comparison to other Oklahoma reservoirs. Water clarity is similar to historical data and is likely always poor based on the soil composition and nature of this lake. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 53 (Plate 58), classifying the lake as eutrophic, indicative of high levels of productivity and nutrients. This value is the similar to the TSI in 2003 (TSI=55), indicating no significant change in productivity has occurred since the last evaluation. The values varied seasonally and were generally eutrophic with mesotrophic values observed in the spring quarter. The only exception to this was sites 4 and 5, which also had lower TSI values during the winter. Seasonal turbidity values are displayed in Figure. In general turbidity values exceeded the Oklahoma Water Quality Standard (WQS) of 25 NTU with the exception of sites 1-2 in the fall (see Figure 77a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if $\geq$ 25% of the samples exceed the Oklahoma Water Quality Standard (WQS) of 25 NTU for turbidity. If 10 to 25% of the turbidity samples exceed the criteria of 25 NTU, the lake is considered to be partially supporting beneficial uses. The Fish and Wildlife Propagation (FWP) beneficial use is not supported at Hugo Lake with 90% of the collected values exceeding the standard. Seasonal true color values are displayed in Figure 77b. Like turbidity, all true color values were greater than the aesthetics WQS of 70 units with the exception of sites 1 and 3 in the fall quarter. With 90% of the collected values exceeding the standard the lake is not supporting the Aesthetics beneficial use.

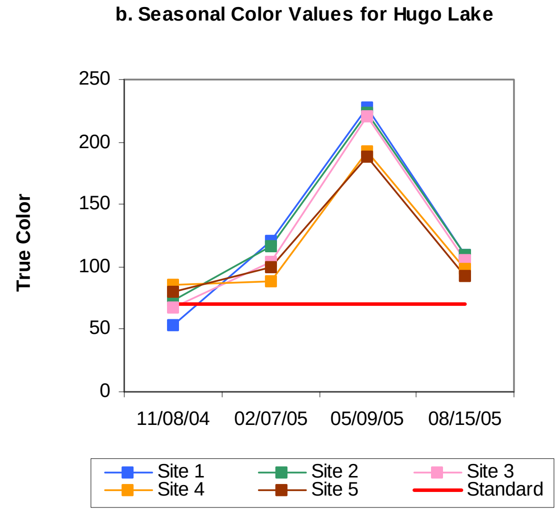
In 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values at Hugo Lake ranged from 0.01 parts per thousand (ppt) to 0.05 ppt, which is within the range of expected values for most Oklahoma reservoirs. Specific conductivity ranged from 41.4 µS/cm to 130.7 µS/cm, indicating minimal concentrations of current conducting compounds (chlorides and salts) in the lake system. The pH values ranged from 6.49 to 8.22 in the fall representing a neutral to slightly acidic system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Low pH values were recorded only recorded at site 5 in the winter. With only 2.1% of the values falling outside the acceptable range the lake is considered supporting the beneficial use based on pH. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Oxidation-reduction potential (ORP) ranged from 171 mV in the fall to 489 mV in during the summer. All ORP values were positive and above 100 mV indicating reducing conditions were not present in the lake at the time of sampling. Thermal stratification was not present during the fall, winter and spring and the lake was well mixed with dissolved oxygen (D.O) values remaining above 5.0 mg/L (see Figure 77c-77e). The lake was stratified in the summer at sites 2 and 4 between 7 and 9 meters in depth at which point the dissolved oxygen (D.O) fell below 2.0 mg/L to the lake bottom of 11.9 meters, accounting for 38 and 31%, respectively of the water column to be anoxic. Site 1 also showed a gradual stratification however D.O. remained greater than 2.0 mg/L (see Figure 77f). If the D.O. values are less than 2.0 mg/L for greater than 70% of the water column the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70 % of the water column, the FWP beneficial use is deemed partially supported. With 31 to 38 % of the water column less than 2.0 mg/L, therefore the FWP beneficial use is considered supported at Hugo Lake. The lake was also sampled for total dissolved solids, chlorides and sulfates to assess the Agriculture beneficial use. Sampling 2004-2005 found the Agriculture beneficial use to be fully supported bases on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

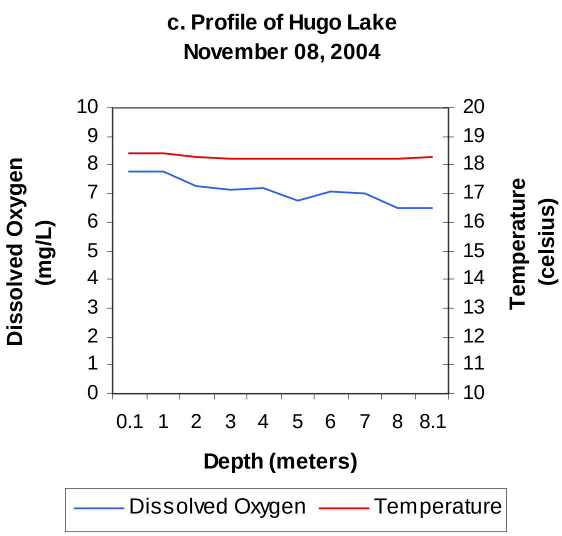
Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

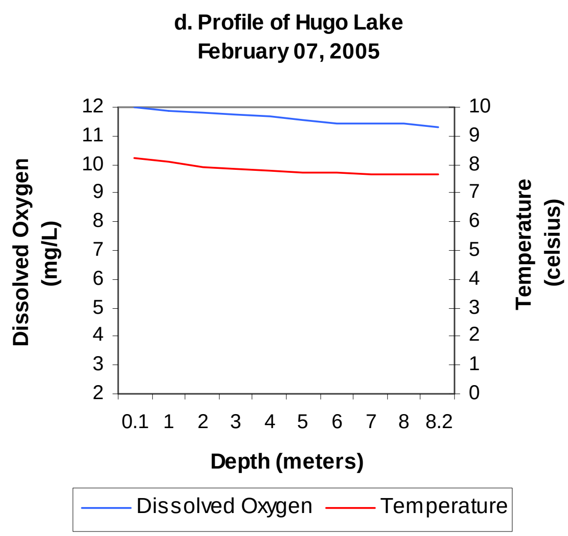
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.54 mg/L at the surface. Surface TN ranged from 0.27 mg/L to 1.06 mg/L, with the highest values seen in the fall and lowest in the winter. The lake-wide total phosphorus (TP) average was 0.063 mg/L at the surface. Total phosphorus at the surface ranged from 0.042 mg/L to 0.097 mg/L. Surface TP was highest in the spring quarter and lowest during the winter. The nitrogen to phosphorus ratio (TN:TP) was approximately 9:1 for sample year 2004-2005. This is only slightly higher with the 7:1 ratio used to determine the limiting nutrient, characterizing the lake as potentially phosphorus limited to co-limited (Wetzel, 1983).

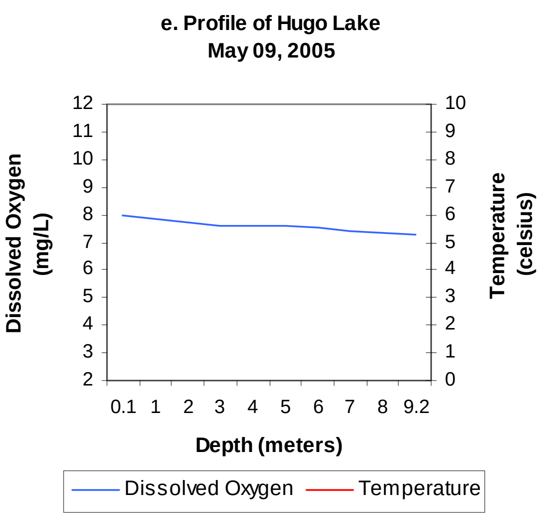
In summary, Hugo Lake was classified as eutrophic, indicative of high primary productivity and nutrient conditions. This is consistent with the 2003 evaluation indicating little to no change in productivity has occurred. Water clarity was poor based on turbidity, true color and low secchi disk depth and is likely to always be poor based on the soil composition and nature of this lake. The lake is supporting the FWP beneficial use based on pH and dissolved oxygen, but not supporting based turbidity. The Aesthetics beneficial use is supported based on its trophic status, and not supporting the use with 90% of the true color values of the reported exceeding the WQS of 70 units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. In 1999, a bathymetric survey was conducted at Hugo Lake (Figure 78) as part of the Kamahi River Development Project. The purpose of the survey was to generate a 3-D simulation of water level changes within the reservoir in response to concerns local citizens had regarding the potential transfer of water to other areas of the state and /or the north Texas area. Specific concerns included fluctuating lake levels and the subsequent impacts on fish/wildlife, recreation, tourism and economic development in the area. For further information about this study or bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800. The United States Army Corps of Engineers (USACE) constructed Hugo Lake for flood control, water supply, fish and wildlife and recreational purposes. The lake is located in Choctaw County approximately 7 miles east of the city of Hugo.











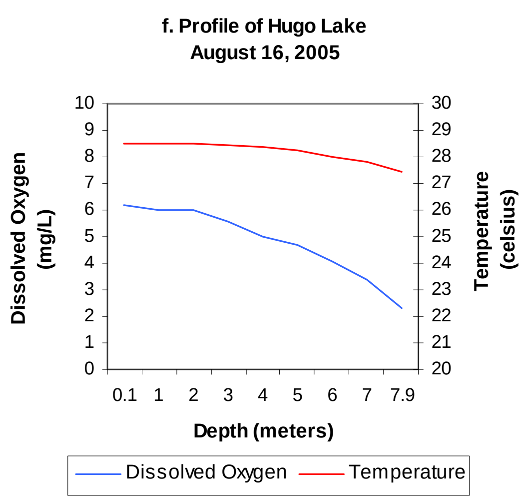


Figure 77a-77f. Graphical representation of data results for Hugo Lake.

Lake Data

Constructed by	Corps of Engineers
County	Choctaw
Constructed in	1974
Surface Area	11,592 acres
Volume	126,740 acre/feet
Shoreline Length	71.33 miles
Mean Depth	10.56 feet
Watershed Area	1,709 square miles

Plate 58 - Lake Water Quality for
Hugo Lake

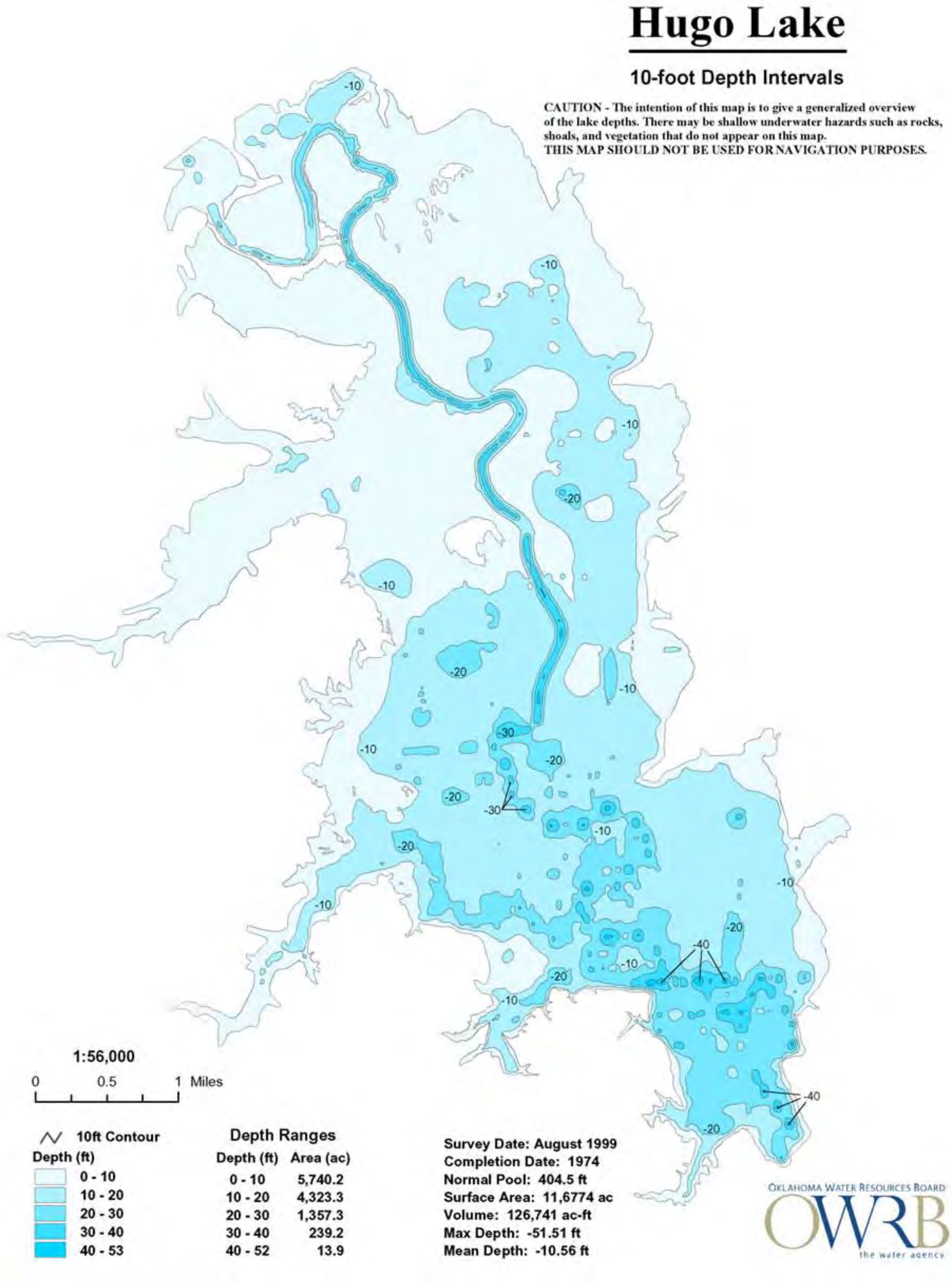


Figure 78. Bathymetric Map of Hugo Lake.

Hulah Lake

Hulah Lake was sampled for four quarters from October 2004 through July 2005. Water quality samples were collected from five (5) sites to represent the riverine, transition and lacustrine zones of the reservoir. Samples were collected at the lake surface at all sites and at 0.5 meters from the lake bottom at site 1, the dam site. The average lake-wide turbidity was 45 NTU (Plate 59), true color was 48 units and average secchi disk depth was 28 centimeters in sample year 2003. Based on these three parameters water clarity was poor at Hulah Lake in 2005, consistent with results from 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for three quarters (n=15). Due to a post-processing error no samples were submitted to lab for analysis from the fall data collection efforts. The average TSI was 54 (Plate 59), classifying the lake as eutrophic, indicative of high levels of productivity and nutrients. Although based on only three quarters, this value is the similar to the TSI in 2003 (TSI=55), indicating no significant change in productivity has occurred since the previous evaluation. The TSI values for all sites were mesotrophic in the winter and eutrophic during both spring and summer. The only exception was site 3, which was oligotrophic in the winter quarter. The lake is currently listed as a Nutrient Limited Watershed (NLW) in the Oklahoma Water Quality Standards (WQS). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Seasonal turbidity values are displayed in Figure 79a. Only one of the twenty values collected was below the Oklahoma Water Quality Standard (WQS) of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥ 25% of the samples exceed the WQS of 25 NTU for turbidity. If 10 to 25% of the turbidity samples exceed the criteria of 25 NTU, the lake is considered to be partially supporting beneficial uses. With 95% of the collected values exceeding the numerical criteria of 25 NTU, the Fish and Wildlife Propagation (FWP) beneficial use is not supported. Seasonal true color values are displayed in Figure 79b. True color values ranged from 25 to 84 units. Applying the same default protocol the Aesthetics beneficial use is considered as only 5% of the reported values exceeded the WQS of 70 units.

In 2005 vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values at Hulah Lake ranged from 0.11 parts per thousand (ppt) to 0.23 ppt. This is within the range of expected values for most Oklahoma reservoirs. Specific conductivity ranged from 242.3 µS/cm to 358.3 µS/cm, indicating moderate concentrations of electrical current conducting compounds (chlorides and salts) in the lake system. The pH values ranged from 7.23 to 8.43 representing a neutral system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With all values within the acceptable range the lake is considered supporting the FWP beneficial use based on pH. Oxidation-reduction potential (ORP) ranged from 184 mV in the hypolimnion during the fall to 487 mV during the spring quarter. All ORP values were positive indicating reducing conditions were not present in the lake. Thermal stratification was not present during the fall, winter and spring sampling intervals and the lake was well mixed (see Figure 79c-79e). In the summer dissolved oxygen (D.O) only fell below 2.0 mg/L at the sediment-water interface, which may be the result of the Hydrolab probe resting on the lake bottom (see Figure 79f). This lake is very shallow and generally stays well mixed due to wind and wave action. If the D.O. values are less than 2.0 mg/L for greater than 70% of the water column the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70 % of the water column, the FWP beneficial use is deemed partially supported. The FWP beneficial use is considered supported at Hulah Lake with only 1D.O. reading below 2.0 mg/L during the summer. The lake was also sampled for total dissolved solids, chlorides and sulfates to assess the Agriculture beneficial use. Sampling 2004-2005 found the Agriculture beneficial use to be fully supported bases on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.62 mg/L at the surface. Surface TN ranged from 0.31 mg/L to 1.44 mg/L, with the highest values seen in the summer and lowest in the spring quarter. The lake-wide total phosphorus (TP) average was 0.080 mg/L at the surface. Total phosphorus at the surface ranged from 0.056 mg/L to 0.129 mg/L. Similar to TN surface TP was highest in the summer and lowest during the spring. The nitrogen to phosphorus ratio (TN:TP) was approximately 8:1 for sample year 2004-2005. This is only slightly higher with the 7:1 ratio used to determine the limiting nutrient, characterizing the lake as potentially phosphorus limited to co-limited (Wetzel, 1983).

In summary, Hulah Lake was eutrophic, indicative of high primary productivity and nutrient levels in 2004-2005. This is consistent with the evaluation in 2003, indicating no significant change in productivity has occurred since the lake was last sampled. The lake is currently listed as a Nutrient Limited Watershed (NLW) in the Oklahoma Water Quality Standards. This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Water clarity was poor based on true color, turbidity and secchi disk depth. The lake is supporting the FWP beneficial use based on pH and dissolved oxygen values, but not supporting based on high turbidity levels. With only 5% of the values exceeding the WQS of 70 units, the Aesthetics beneficial is considered supported based on true color. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Hulah Lake, located in Osage County, was constructed by the United States Army Corps of Engineers (USACE) for the purpose of flood control, water supply, low-flow regulation and conservation.

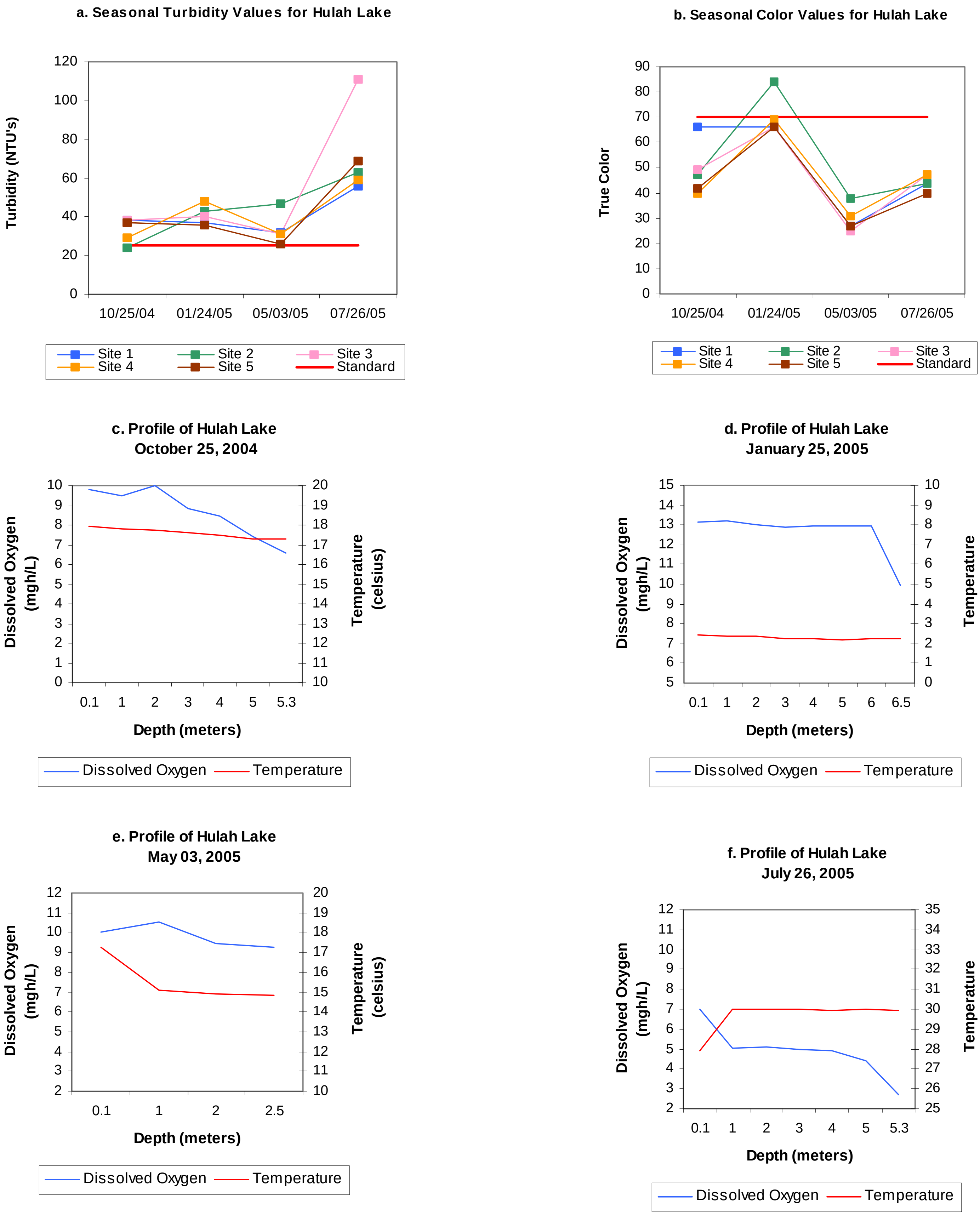
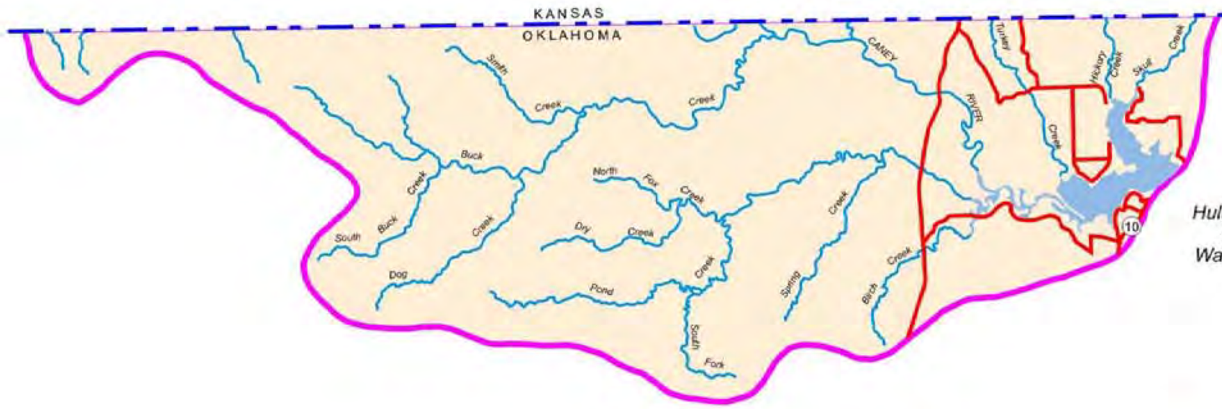
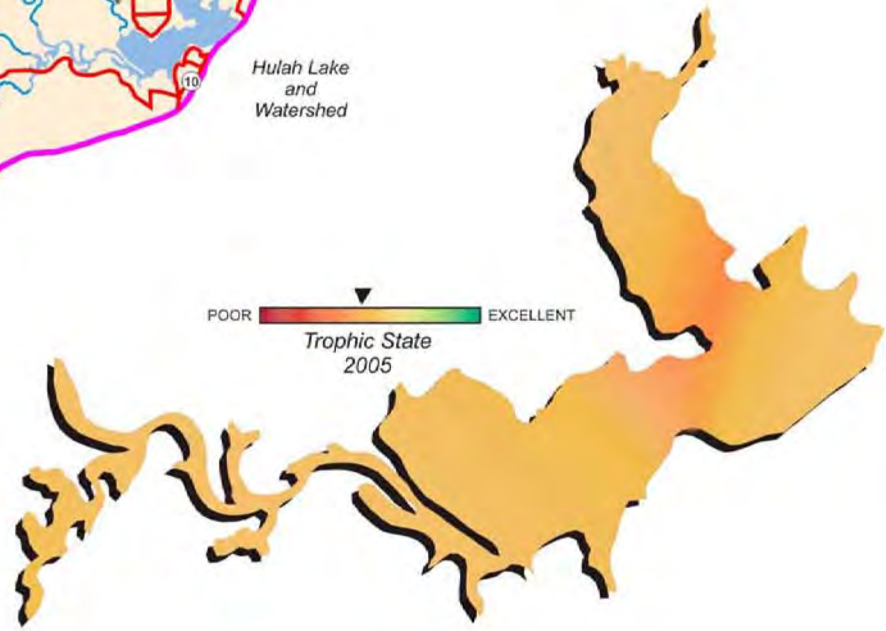


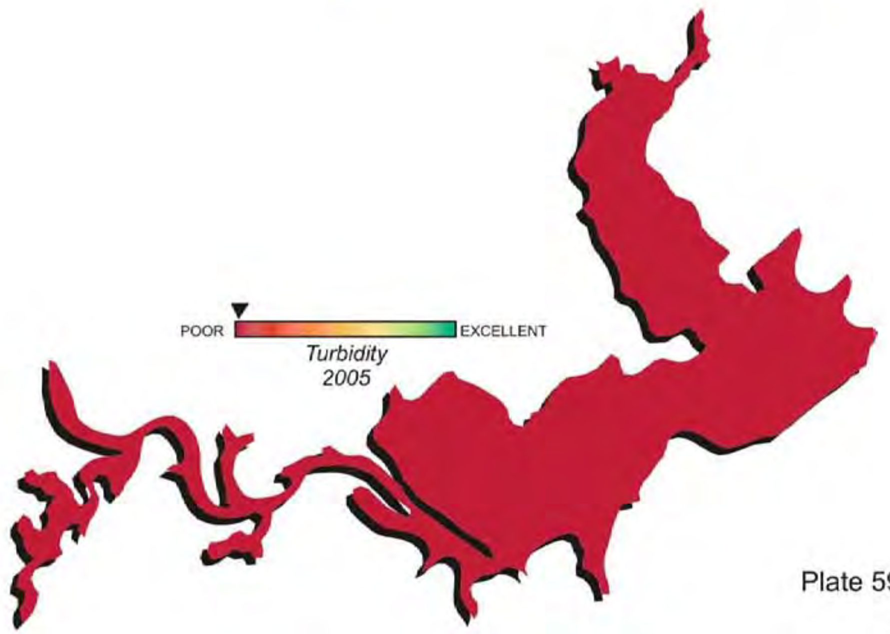
Figure 79a-79f. Graphical representation of data results for Hulah Lake.

LAKES MONITORING PROGRAM

Plate 59 - Lake Water Quality for
Hulah Lake







Lake Data

Constructed by	Corps of Engineers
County	Osage
Constructed in	1951
Surface Area	3,570 acres
Volume	31,160 acre/feet
Shoreline Length	62 miles
Mean Depth	9.64 feet
Watershed Area	732 square miles

Humphreys Lake

Humphreys Lake is an 882-acre lake, which is owned by the City of Duncan and serves as a flood control, water supply, and recreational reservoir. Humphreys Lake was sampled for four quarters, November 2006 through August 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the sample year. The lake-wide annual turbidity value was 16 nephelometric turbidity units (NTU), true color was 32 units, and secchi disk depth was 58 centimeters. Based on these three parameters, Humphreys Lake had good to average water clarity in 2007. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 61 (Plate 60), classifying the lake as hypereutrophic, bordering eutrophic, indicative of high to excessive levels of productivity and nutrient rich conditions. This value is similar, although slightly higher than the value calculated in 2005(TSI=58) and 2003 (TSI=56). The TSI values ranged seasonally from mid to upper-eutrophic in the fall and winter with hypereutrophic conditions in the spring and summer quarters. Seasonal turbidity values ranged from a low of 9 NTU to a maximum of 28 NTU and are displayed in Figure 80a. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if $\geq$ 25% of the samples exceed the Oklahoma Water Quality Standard (WQS) of 25 NTU for turbidity. If 10 to 25% of the turbidity samples exceed the criteria of 25 NTU, the lake is considered to be partially supporting beneficial uses. With 10% of the turbidity values exceeding the WQS of 25 NTU the Fish and Wildlife Propagation beneficial use is considered supported. Seasonal true color values are displayed in Figure 80b. All true color values were below the WQS of 70 units. Applying the same default protocol the Aesthetics beneficial use is considered supported.

In 2006-2007 vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values at Humphreys Lake ranged from 0.19 parts per thousand (ppt) to 0.34 ppt. This is within the average range of expected values for most Oklahoma reservoirs. Specific conductivity ranged from 389.8 µS/cm to 659.3 µS/cm, indicating moderate concentrations of electrical current conducting compounds (chlorides and salts) in the lake system, consistent with salinity readings. The pH values ranged from 7.32 to 8.3 representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. With 100% of the values within the acceptable range the lake is considered supporting the FWP beneficial use based on pH. Oxidation-reduction potential (ORP) ranged from -61 mV in hypolimnion during the summer to 435 mV in the fall. Low redox values like those recorded in the summer quarter are not unusual when a large portion of the water column is anoxic. The lake was well mixed with dissolved oxygen levels above 7.0 mg/L in the fall and winter sampling intervals (see Figure 80c-76d). Thermal stratification and anoxic conditions were present in both spring and summer quarters. During the spring, stratification occurred between 6 and 7 meters with dissolved oxygen (D.O.) less than 2.0 mg/L in approximately for 43% of the water column. Similar conditions were observed in the summer, with stratification occurring between 4 and 5 meters with dissolved oxygen concentrations (D.O.) falling below 2.0 mg/L from 6 meters in depth to the lake bottom of 11.3 meters accounting for approximately 54 % of the water column at site 1 to be experiencing anoxic conditions (see Figure 80f). If the D.O. values are less than 2.0 mg/L for greater than 70% of the water column the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70 % of the water column, the FWP beneficial use is deemed partially supported. With 43% (spring) and 54% (summer) of the water column experiencing anoxic conditions, the FWP beneficial use is considered partially supported at Humphreys Lake. The lake was also sampled for total dissolved solids, chlorides and sulfates to assess the Agriculture beneficial use. Sampling 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. The PBCR beneficial use cannot be determined as minimum data requirements were not met due to quality control issues for *E. coli* and enterococci. Of the 10 fecal coliform samples collected, all were below the screening level of 400 cfu/ml and the geometric mean of 400 cfu/ml.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.95 mg/L at the surface. Surface TN ranged from 0.61 mg/L to 1.20 mg/L, with the highest values occurring in the winter sampling interval. The lake-wide total phosphorus (TP) average was 0.048 mg/L at the surface. Total phosphorus at the surface ranged from 0.026 mg/L to 0.091 mg/L. Surface TP was highest in the summer and lowest during the spring. The nitrogen to phosphorus ratio (TN:TP) was approximately 20:1 for sample year 2006-2007. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

Humphreys Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Humphreys Lake is classified as hypereutrophic, indicative of high to excessive primary productivity and nutrient conditions (Plate 60). Water clarity was good to average based on turbidity, true color and secchi disk depth. The lake is supporting the FWP beneficial use based on turbidity and pH values recorded during the sample year. The FWP use is partially supported as it relates to dissolved oxygen with up to 54 % of the values reported below 2 mg/L. The Aesthetics beneficial use is supported based on true color with 100% of the values below the WQS of 70 units. The PBCR is considered supported for fecal coliform; however due to minmum data requirements not being met for E.coli and enterococci and assessment of these parameters cannot be made.

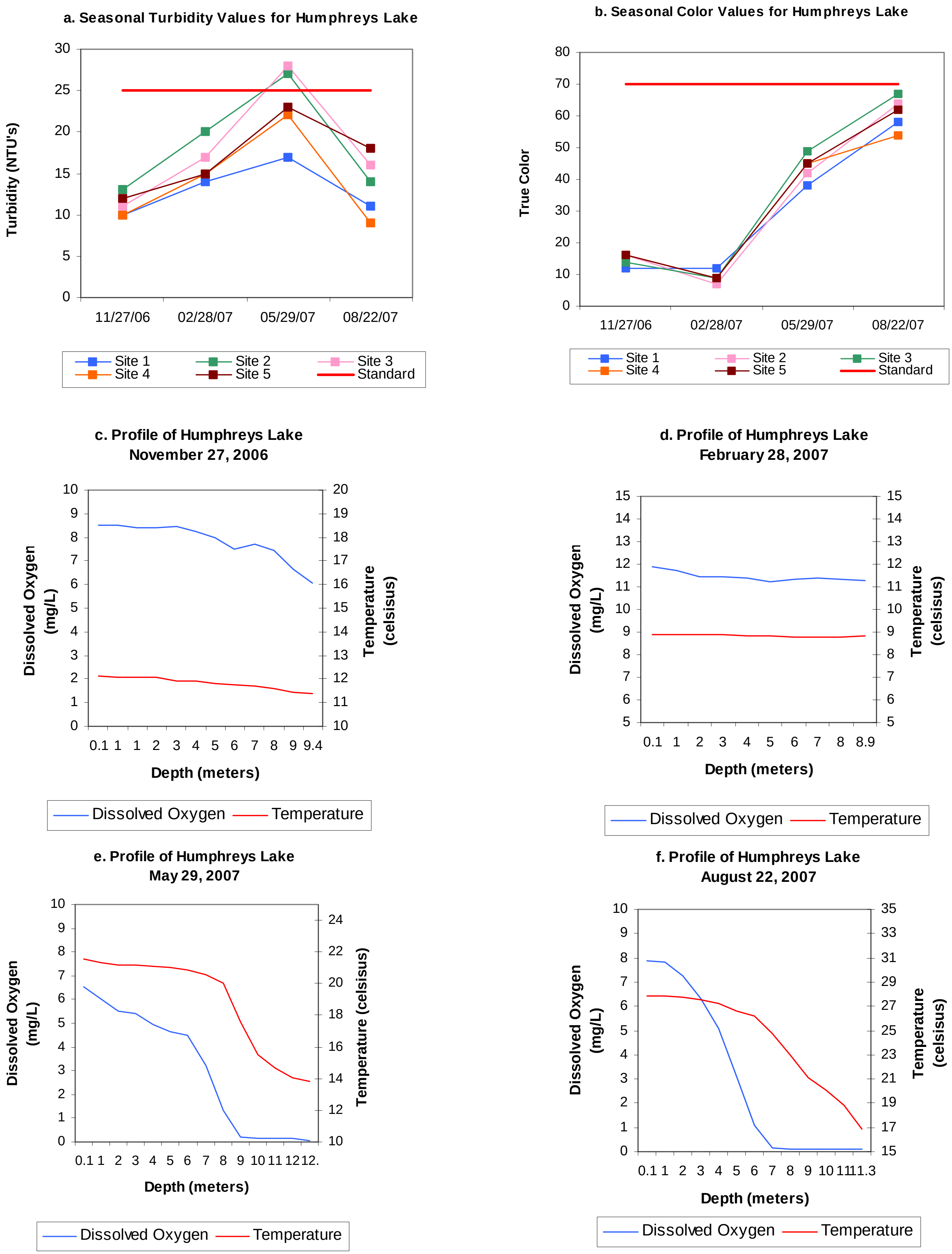


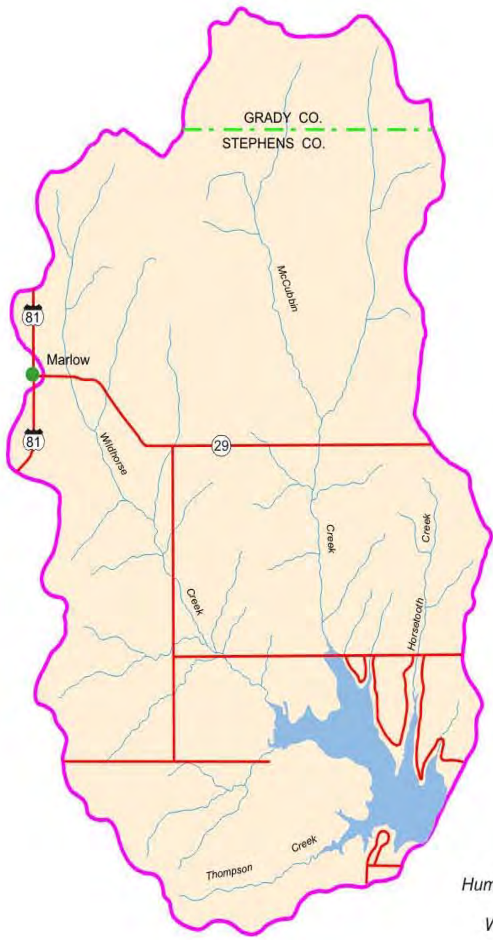
Figure 80a-80f. Graphical representation of data results for Humphreys Lake.

LAKES MONITORING PROGRAM

Plate 60 - Lake Water Quality for

Humphreys Lake

Humphreys Lake Location



Humphreys Lake and Watershed

Lake Data	
Owner	City of Duncan
County	Stephens
Constructed in	1958
Surface Area	882 acres
Volume	14,041 acre/feet
Shoreline Length	17 miles
Mean Depth	15.92 feet
Watershed Area	31 square miles

LAKES MONITORING PROGRAM

Lake Jean Neustadt

Lake Jean Neustadt is a 462-acre reservoir, which is located in Carter County. The lake serves as a recreational reservoir for the City of Ardmore. Lake Jean Neustadt was sampled for four quarters, from October 2006 through July 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity was 13 nephelometric turbidity units (NTU), true color was 27 units, and secchi disk depth was 76 centimeters. Based on these three parameters, Lake Jean Neustadt had good water clarity in 2007. Results are almost identical with results from the 2005 data collection efforts. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 58 (Plate 61), classifying the lake as eutrophic, indicative of high levels of productivity and nutrient conditions. This value is higher than the one calculated in 2005 (TSI=52) however the trophic category is the same. The TSI values were eutrophic in the fall, winter and spring and hypereutrophic during the summer quarter. Site 3 was the only site to have a mesotrophic value, which occurred in the fall quarter. Seasonal turbidity values per site are displayed in Figure 81a. All turbidity values were below the Oklahoma Water Quality Standard (WQS) of 25 NTU and ranged from a low 6 NTU to a high of 19 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if $\geq$ 25% of the samples exceed the Oklahoma Water Quality Standard (WQS) of 25 NTU for turbidity. With 100% of the turbidity recorded below the standard, the FWP beneficial use is considered supported. Seasonal true color values are displayed in Figure 81b. All true color values were below the aesthetics WQS of 70 units at all sites. Applying the same default protocol, the Aesthetics beneficial use is fully supported at Lake Jean Neustadt.

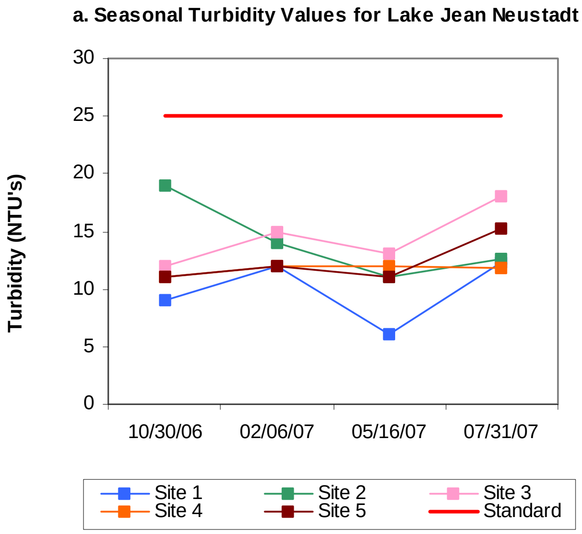
In 2006-2007 vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all five sample sites. Salinity values at Lake Jean Neustadt ranged from 0.11 parts per thousand (ppt) to 0.16 ppt. This is within the average range of values for most Oklahoma reservoirs. Specific conductivity ranged from 231.1 µS/cm to 332.4 µS/cm, indicating minimal concentrations of electrical current conducting compounds (chlorides and salts) in the lake system consistent with salinity readings. The pH values ranged from 7.16 to 8.78 representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. With 100% of the values within the acceptable range the lake is considered supporting the FWP beneficial use based on pH. Oxidation-reduction potential (ORP) ranged from 95 mV in the summer to 440 mV in the fall quarter. Reducing conditions were not present with all recorded values, with the exception of one value recorded at the lake bottom at site 5, in the summer, above 100 mV. In the fall and winter sampling intervals the lake appeared to be well mixed (see Figure 81c-81d) with dissolved oxygen remaining above 7.0 mg/L during this time. Thermal stratification was evident and anoxic conditions were present in the spring and summer quarters. In the spring, the lake was strongly stratified between 4 and 5 meters in depth at both sites 1 and 4, with anoxic conditions comprising 44 to 62% of the water column. (Figure 81e). Sites 2 and 5 were also stratified with 50-56% of the water column less than 2 mg/L. During the summer, thermal stratification occurred higher in the water column with D.O. less than 2 mg/L from 3 meters below the surface to the lake bottom at all five sites. At this time anoxic conditions comprised 40-70% of the water column. If the D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70 % of the water column, the FWP beneficial use is deemed partially supported. The FWP beneficial use is considered not supported at Lake Jean Neustadt based anoxic conditions comprising up to 62% of the water column in the spring and up to 70% during the summer months. The lake was also sampled for total dissolved solids, chlorides and sulfates to assess the Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported bases on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

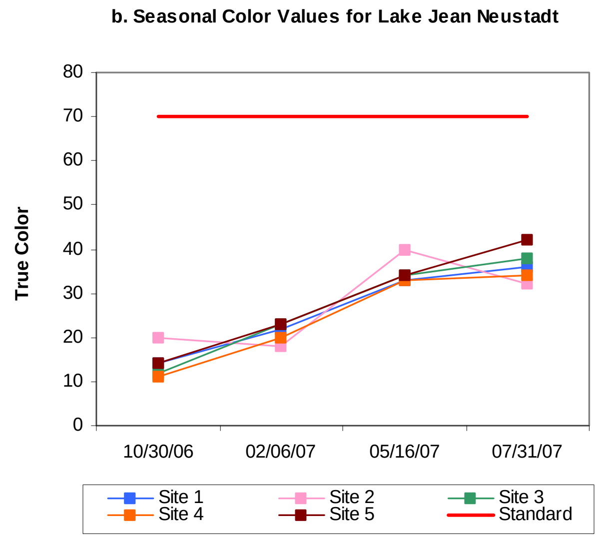
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. All sample results were at or below the detection limit, therefore the PBCR beneficial use is considered fully supported.

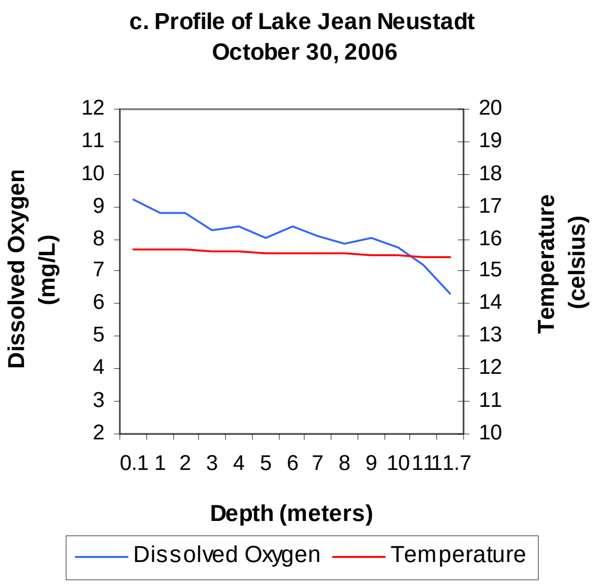
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.76 mg/L at the surface. Surface TN ranged from 0.45 mg/L to 0.98 mg/L, with the highest values reported in the winter and the lowest values in the spring. The lake-wide total phosphorus (TP) average was 0.028 mg/L at the surface. Total phosphorus at the surface ranged from 0.015 mg/L to 0.048 mg/L. TP was highest in the summer and lowest during the spring quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 27:1 for sample year 2006-2007. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

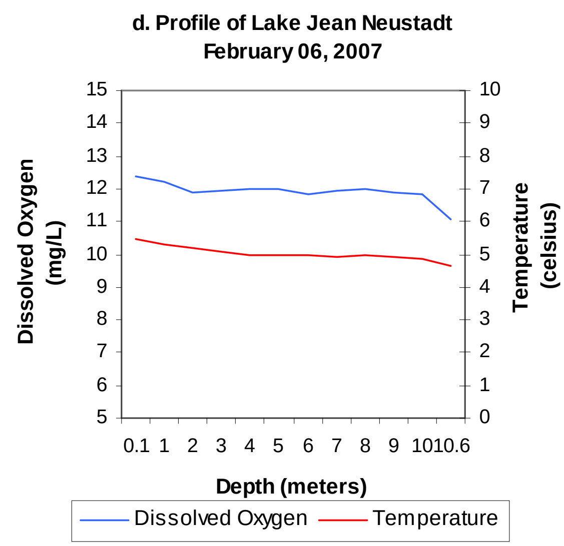
Lake Jean Neustadt was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

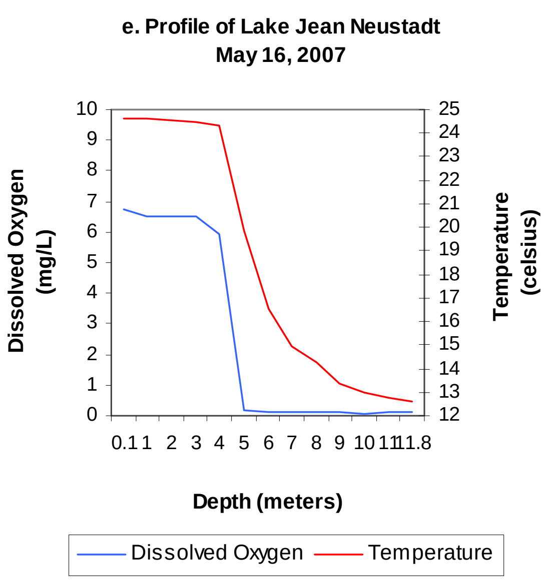
In summary, Lake Jean Neustadt was classified as eutrophic, indicative of high primary productivity and nutrient conditions (Plate 61). This classification is consistent with the 2005 (TSI=52) data collection efforts. Water clarity was good based on true color, turbidity, and secchi disk depth. The FWP beneficial use is considered supported as it relates to turbidity and pH values recorded during the sample year. With anoxic conditions present in a large portion of the water column in both spring and summer quarters the FWP use is considered not supported. The Aesthetics beneficial use is supported based on its trophic status as well as true color with 100% of the color values were well below the WQS of 70 units. Bacteriological samples were collected during the 2007 recreation season and no screening level or geometric mean was exceeded, therefore the Primary Body Contact Recreation (PBCR) beneficial use is considered supported.











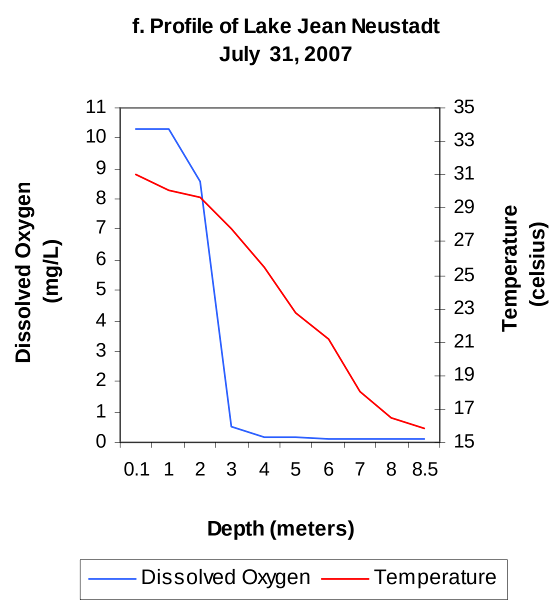
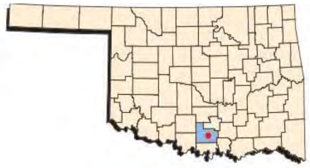


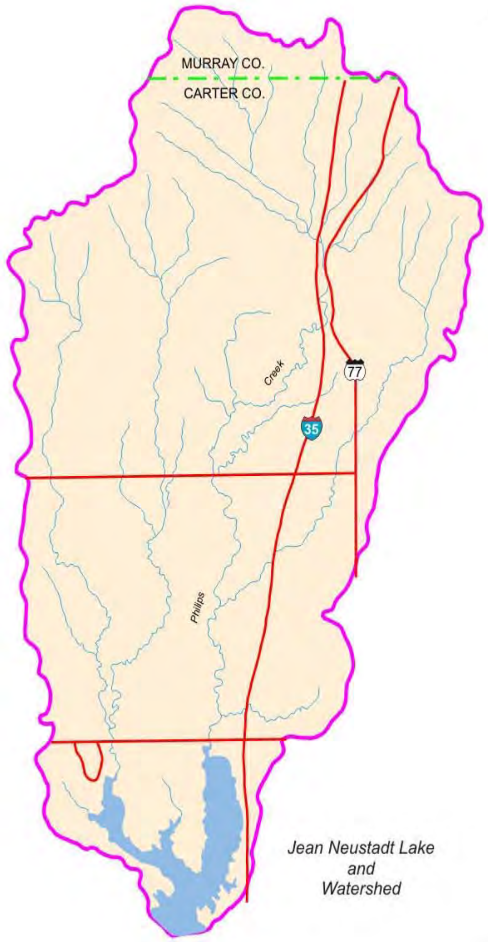
Figure 81a-81f. Graphical representation of data results for Lake Jean Neustadt.

Plate 61 - Lake Water Quality for

Lake Jean Neustadt



Jean Neustadt Lake Location



Jean Neustadt Lake and Watershed

Lake Data	
Owner	City of Ardmore
County	Carter
Constructed in	1969
Surface Area	462 acres
Volume	6,106 acre/feet
Shoreline Length	10 miles
Mean Depth	13.22 feet
Watershed Area	17 square miles

LAKES MONITORING PROGRAM

John Wells Lake

John Wells Lake is owned and operated by the City of Stigler and is used as a municipal water supply for Stigler and provides numerous recreational opportunities for the public. John Wells Lake was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 5 NTU (Plate 62), true color was 16 units, and secchi disk depth was 151 centimeters. Based on these three parameters, John Wells Lake had excellent water clarity in 2005-2006. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 46 (Plate 62), classifying the lake as mesotrophic, indicative of moderate levels of productivity and nutrient conditions. The TSI values were mesotrophic throughout the entire sample year. All turbidity values were below the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 82a) with values ranging from a low of 4 NTU to a maximum of 10 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. John Wells Lake is considered fully supporting its Fish & Wildlife Propagation (FWP) beneficial use based on turbidity collected in sample year 2006. Seasonal true color values are displayed in Figure 82b. True color values were all well below the aesthetics WQS of 70 units at all sites. Applying the same default protocol to determine the short-term average for true color, the Aesthetics beneficial use is supported based on the true color values. In general, John Wells Lake is one of the nicer small municipal reservoirs in Oklahoma.

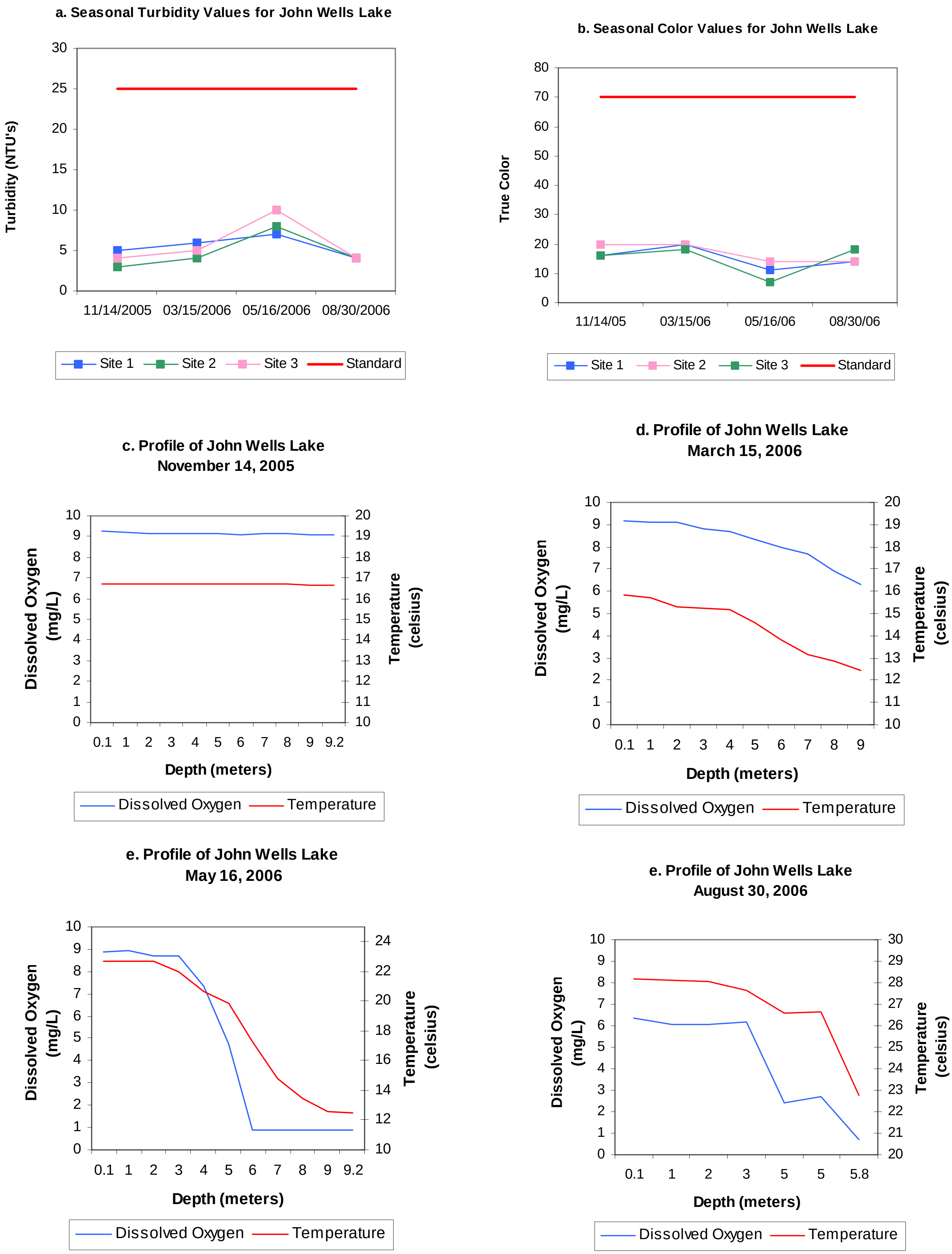
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all three sample sites. Salinity values ranged from 0.01 parts per thousand (ppt) to 0.05 ppt, well within the expected range of salinity values reported for most Oklahoma lakes. Readings for specific conductivity ranged from 59.8 µS/cm to 117.9 µS/cm, indicating low concentrations of electrical current conducting compounds (salts) were present in the water column. In general, pH values were neutral to slightly alkaline, ranging from 6.40 in the winter to 8.38 units in the spring. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With only 1% of the recorded values outside the acceptable range, the FWP use is considered supported as it relates to pH. Oxidation-reduction potentials (redox) ranged from 189 mV at the sediment-water interface in the spring to 483 mV in the winter. Redox readings indicated that reducing conditions were not present in the reservoir in an appreciable way. Values were generally above 200 mV only falling below this point when anoxic conditions were present in approximately 45% of the water column during spring sampling. The lake was not thermally stratified in either the fall or winter sampling intervals and the water column was well mixed (Figure 82c-82d). In the spring the lake was thermally stratified at several 1-meter intervals with dissolved oxygen (D.O.) less than 2.0mg/L from 6 meters below the surface to the lake bottom of 9.2 meters (Figure 82e). In the summer the lake was again stratified however not to the same extent observed in the spring (Figure 82f). Lake levels in the summer quarter were about half of that recorded in the spring and this may explain the difference in the amount of the water column experiencing anoxic conditions. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered fully supported at John Wells Lake with 45% of the water column being anoxic at site 1 in the spring quarter. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.42 mg/L at the lake surface. The TN at the surface ranged from 0.20 mg/L to 0.56 mg/L. The highest surface TN value was reported in the winter quarter and the lowest was in the fall quarter. The lake-wide total phosphorus (TP) average was 0.016 mg/L at the lake surface. The surface TP ranged from 0.013 mg/L to 0.020 mg/L. The highest surface TP value was reported in the summer quarter and the lowest was in the spring quarter. The nitrogen to phosphorus ratio (TN:TP) was 27:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

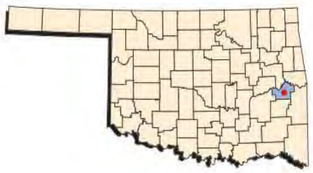
John Wells Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, John Wells Lake was classified as mesotrophic, indicative of moderate productivity and nutrient conditions (Plate 62). Water clarity was excellent based on true color, turbidity, and secchi disk depth. This is consistent with previous data collection efforts conducted in 2003-2004. Both true color and trophic status were fully supporting the Aesthetics beneficial use. John Wells Lake was fully supporting the FWP beneficial use based on pH and D.O. values as recorded during the study period. With 100% percent of the values below the WQS of 25 NTU, the lake was also fully supporting the FWP beneficial use for turbidity. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

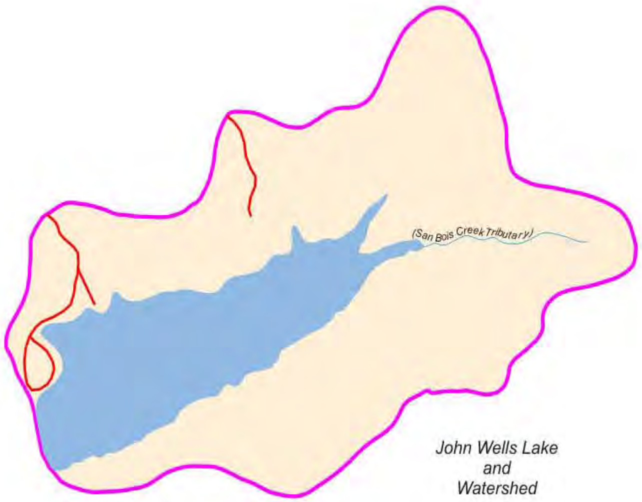


LAKES MONITORING PROGRAM

Figure 82a-82e. Graphical representation of data results for John Wells Lake.

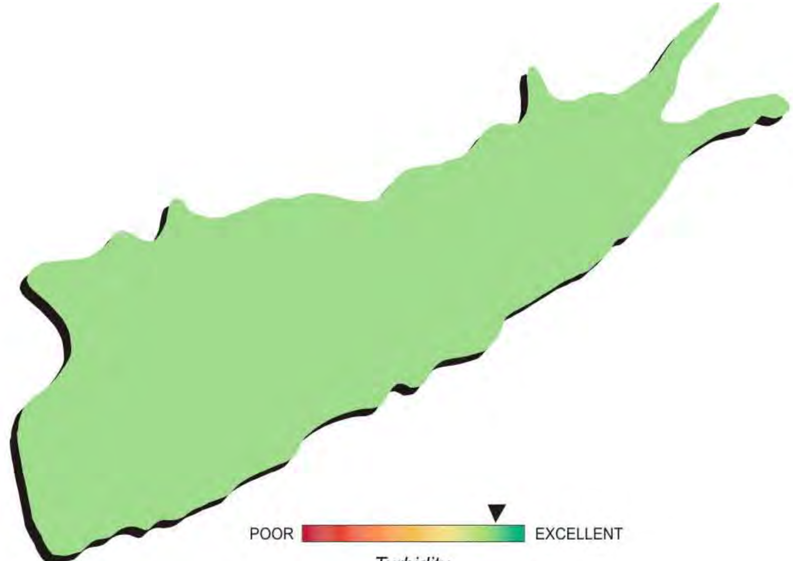


John Wells Lake Location

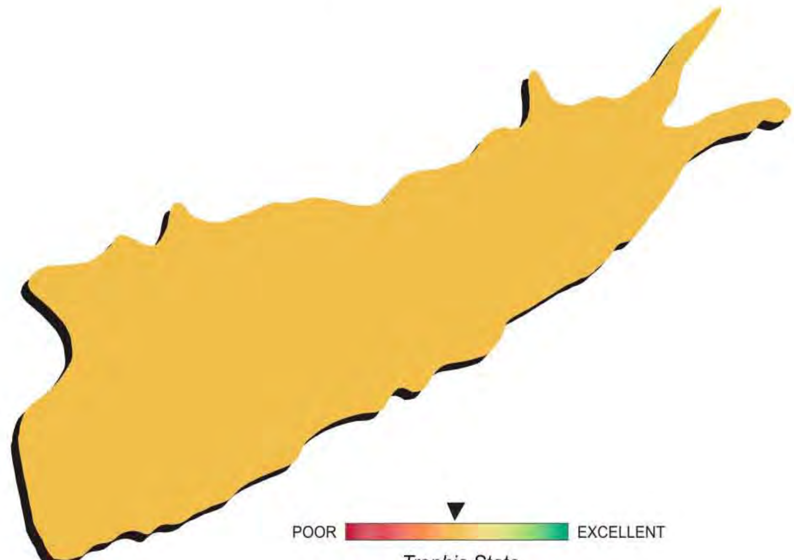


John Wells Lake and Watershed

Lake Data	
Owner	City of Stigler
County	Haskell
Constructed in	1936
Surface Area	194 acres
Volume	1,352 acre/feet
Shoreline Length	3 miles
Mean Depth	6.97 feet
Watershed Area	961 acres



Turbidity 2006



Trophic State 2006

Plate 62 - Lake Water Quality for

John Wells Lake

Kaw Lake

Kaw Lake was sampled for four quarters from November 2004 through August 2005. Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones and arms of the reservoir. Samples were collected from the lake surface at all sites and from 0.5 meters from the lake bottom at site 1, the dam. The lake-wide average turbidity was 17 NTU (Plate 63), true color was 37 units, and average secchi disk depth was 67 centimeters. Based on these three parameters Kaw Lake had average water clarity in sample year 2005, better than that observed in 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 56 (Plate 63), classifying the lake as eutrophic, indicative of high levels of primary productivity and nutrient conditions. This value is similar to that from 2003 (TSI=53), indicating no significant change in productivity has occurred since the last evaluation. Seasonal TSI values varied by site and season and spanned all trophic categories in sample year 2005. In the fall and winter sampling quarters values were generally oligotrophic to mesotrophic. In the spring, values ranged from oligotrophic at sites 1, eutrophic at site 2, and hypereutrophic at sites 3-5. TSI values in the summer were all hypereutrophic with the exception of site 1, which had the lowest TSI throughout the year. The highest values throughout the year occurred at site 5 in the upper end of the reservoir. Seasonal turbidity values per site are displayed in Figure 83a. Turbidity ranged from a low of 10 NTU to a maximum of 29 NTU in 2005. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 20% of the recorded values exceeding the WQS of 25 NTU, Kaw Lake is partially supporting its Fish and Wildlife Propagation (FWP) beneficial use based on turbidity. Seasonal true color values are displayed in Figure 83b. Applying the same default protocol to determine the short-term average for true color, the Aesthetics beneficial use is considered supported with 100% of the true color values were below the WQS of 70 units.

In 2004-2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sites. Salinity values ranged from 0.23 parts per thousand (ppt) to 0.62 ppt, which is higher than most values reported for Oklahoma lakes. Specific conductivity ranged from 563.1 µS/cm to 1172 µS/cm indicating that very high concentrations of electrical current conducting compounds (salts) were present in the lake system, consistent with the elevated salinity readings. The highest salinity and specific conductivity values occurred at sites 3 and 5 in the Arkansas River arm during the spring and summer. The pH values at Kaw Lake ranged from 6.94 to 8.2, representing a to neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range the lake is considered supporting the FWP beneficial use based on pH. Oxidation-reduction potential (ORP) ranged from 157 mV in the hypolimnion in the fall to 420 mV in the winter. In general, reducing conditions were not present at this reservoir. During the fall, winter, and spring quarters, stratification was not present and the lake was well mixed with dissolved oxygen (D.O.) levels generally above 5.0 mg/L (Figure 83c-83e). Thermal stratification was evident in the summer and anoxic conditions were present. Stratification occurred at several 1-meter intervals throughout the entire lake with 14 to 61% of the water column experiencing anoxic conditions (Figure 83f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported at Kaw Lake, with 14 to 61% of the water column below 2.0 mg/L in the summer quarter. The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.32 mg/L at the surface. Surface TN ranged from 0.61 mg/L to 1.99 mg/L, with the highest values reported in the fall and the lowest values in the summer quarter. The lake-wide total phosphorus (TP) average was 0.175 mg/L at the surface. Total phosphorus at the surface ranged from 0.124 mg/L to 0.236 mg/L. TP was highest in the summer and lowest at site 4 during the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 8:1 for sample year 2004-2005 This is only slightly higher with the 7:1 ratio used to determine the limiting nutrient, characterizing the lake as potentially phosphorus limited to co-limited (Wetzel, 1983).

In summary, Kaw Lake was classified as eutrophic, indicative of high levels of primary productivity and nutrient conditions (Plate 63). This value is consistent with that from evaluation (TSI=53), indicating no significant change in productivity has occurred since the last evaluation. Water clarity was average at Kaw Lake based on true color, secchi disk depth and turbidity readings, better than that observed in 2003. The lake is considered supporting the FWP beneficial use based on pH, but partially supporting for dissolved oxygen and turbidity. The Aesthetics beneficial use is supported based on its trophic status as well as true color with 100% of the collected values below the WQS of 70 units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. The United States Army Corps of Engineers (USACE) constructed Kaw Lake for the purpose of flood control, water supply and quality, recreation and fish and wildlife. The lake is located in Osage County approximately 8 miles east of Ponca City.

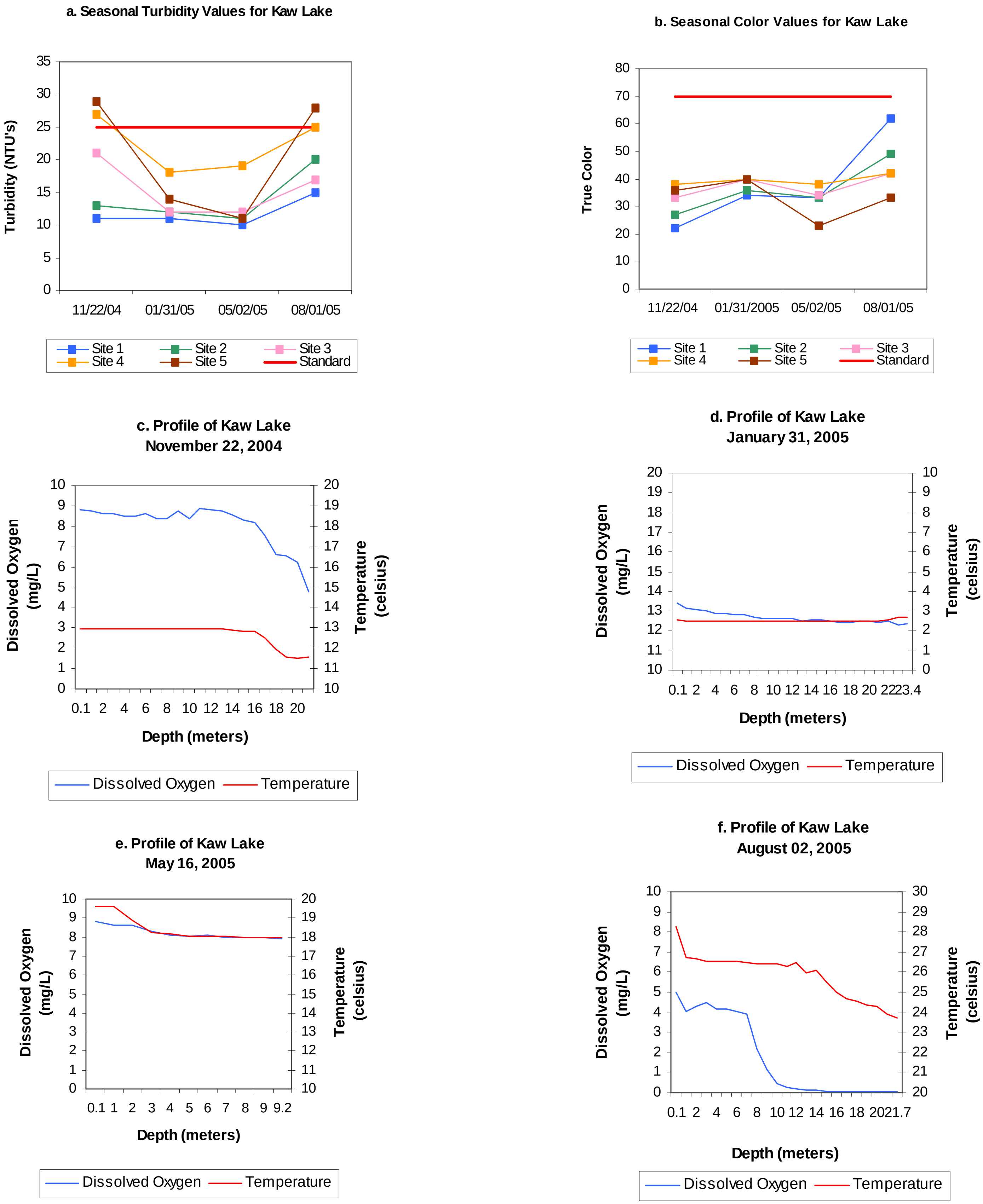


Figure 83a-83f. Graphical representation of data results for Kaw Lake.

Lake Data

Constructed by	Corps of Engineers
County	Osage
Constructed in	1976
Surface Area	17,040 acres
Volume	428,600 acre/feet
Shoreline Length	168 miles
Mean Depth	25.21 feet
Watershed Area	46,530 square miles

Plate 63- Lake Water Quality for
Kaw Lake

Keystone Lake

Keystone Lake is managed by the United States Army Corps of Engineers and was constructed in 1964 to serve as a flood control, water supply, hydroelectric power, navigation, and fish and wildlife resource. Keystone Lake has the reputation as one of the "saltiest" lakes in Oklahoma. Keystone Lake was sampled for four quarters from October 2005 through July 2006.

Water quality samples were collected at twelve (12) sites to represent the riverine, transition, and lacustrine zones of the reservoir as well as major arms of the lake. Samples were collected from the lake surface at all 12 sites throughout the study period. Keystone Lake is large dendritic reservoir, which has both the Arkansas and Cimarron rivers flowing into the lake,. To better understand the influence these rivers has on the waterbody and the lake dynamics it has been broken into four management segments: Keystone Lake; Keystone Lake, Arkansas River arm; Keystone Lake, Cimarron River arm, lower and Keystone Lake, Cimarron River arm, upper. The following discussion will briefly summarize each segment with a lake-wide summary included at the end of the narrative.

Keystone Lake

This portion of Keystone Lake (segment # 621200010020) extends from the dam up to the Washington Irving Cove (S) area in the Arkansas River arm of the reservoir and includes BUMP sites 1 and 2 (see Figure 85). The segment-wide average turbidity was 13 nephelometric turbidity units (NTU), true color was 29 units and secchi disk depth was 91 centimeters in sample year 2006. Water clarity is good in this portion of the lake, based on these three parameters. This is expected since these sites are the farthest away from the inflow of both the Arkansas and Cimarron Rivers and materials have had more time to settle out. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=8). The average TSI was 54, classifying the segment as eutrophic, indicative of high primary productivity and nutrient conditions. Chlorophyll-a values varied among the seasons with the highest values reported in the spring and summer quarters. Turbidity values ranged from a low of 4 NTU to a maximum of 30 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered partially supported if 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Although 12.5% of the values exceeded 25 NTU an assessment of the Fish & Wildlife Propagation (FWP) beneficial use cannot be made, as minimum data requirements are not being met. All true color values were below the Aesthetics criteria 70 units however like turbidity there are not enough data for this segment to assess the Aesthetics beneficial use.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at both sample sites within this segment. Salinity values ranged from 0.45 to 4.03 parts per thousand (ppt) indicating moderate to very high salt content within the lake depending on the location of the sample site. Salinity readings were higher than the normal range of salinity values reported for most Oklahoma lakes. In general, salinity values are very high in the Cimarron River arm of the reservoir. Readings for specific conductivity were also very high, ranging from 867 µS/cm to 7232 µS/cm, indicating extremely high amounts of electrical current conducting compounds (salts) in the lake system throughout the year. In general, pH values were slightly neutral to alkaline, ranging from 7.16 to 8.56 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of pH values falling within the acceptable range the FWP beneficial use is supported as it relates to pH. Thermal stratification was not evident during the fall, winter or spring sampling intervals and the water column appeared to be well mixed. In the summer, thermal stratification was evident and anoxic conditions present at both sites 1 and 2. At site 1, the temperature ranged from 27.84^0 C at the surface to 20.72^0 C at the bottom with dissolved oxygen (D.O.) less than 2.0 mg/L in approximately 62% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported at Keystone Lake (segment # 621200010020) with 40% to 62% of the water column experiencing anoxic conditions in the summer quarter.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of (Nutrient Limited Watershed) NLW lakes and nutrient criteria development for lakes and reservoirs. In this segment of the lake the average total nitrogen (TN) was 0.86 mg/L, with values ranging from 0.65 mg/L in the summer to 1.10 mg/l in the fall quarter. The average total phosphorus (TP) was 0.106, with values ranging from 0.063 mg/L in the spring to 0.193 mg/L in the fall. The nitrogen to phosphorus ratio (TN:TP) was 8:1, this value is close to 7:1, characterizing for this portion of the lake as possibly co-limited (Wetzel, 1983).

Keystone Lake, Arkansas River Arm

This portion of Keystone Lake (segment # 621200010050) extends from Washington Irving Cove (S) up to the Osage Point area in the Arkansas River arm of the reservoir and includes BUMP sites 3, 4 and 5. The segment-wide average turbidity was 51 NTU, true color was 40 units and secchi disk depth was 47 centimeters in sample year 2006. Based on these three parameters water clarity is average in this portion of the lake. This is not unusual since this segment is more riverine and has greater tributary influence as well as the Arkansas River flowing in. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 64, classifying the segment as hypereutrophic, indicative of excessive primary productivity and nutrient conditions. Chlorophyll-a values were consistently upper eutrophic to mid-hypereutrophic in 3 of the 4 sampling intervals. Turbidity values ranged from a low of 7 NTU (site 3) to a maximum of 254 NTU (site 5). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered partially supported if 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Although eight (12.5%) of the twelve values exceeded 25 NTU an assessment of the Fish & Wildlife Propagation (FWP) beneficial use cannot be made due to minimum data requirements are not being met. Only 1 (8.3%) of the true color values were below the Aesthetics criteria 70 units however like turbidity there are not enough data for this segment to assess the Aesthetics beneficial use.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all three sample sites within this segment. Salinity values ranged from 0.28 to 1.24 parts per thousand (ppt) indicating moderate to high salt content within is segment of the waterbody. Salinity readings were higher than the normal range of salinity values reported for most Oklahoma lakes. Readings for specific conductivity were also high, ranging from 542 µS/cm to 2317 µS/cm, indicating high amounts of electrical current conducting compounds (salts) in the lake system throughout the year. In general, pH values were slightly neutral to alkaline, ranging from 7.34 to 8.96 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of pH values falling within the acceptable range the FWP beneficial use is supported as it relates to pH. Thermal stratification was not evident during the fall, winter or spring sampling intervals and the water column appeared to be well mixed. In the summer, the water column was weakly stratified with anoxic conditions present at both sites 3 and 4. At site 3, the temperature ranged from 28.58^0 C at the surface to 25.17^0 C at the bottom with dissolved oxygen (D.O.) less than 2.0 mg/L in approximately 20% of the water column. Site 5, is very shallow and did not stratify during this time period likely as a result of wind mixing. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at Keystone Lake (segment # 621200010050) with only 18% to 20% of the water column experiencing anoxic conditions in the summer quarter.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of (Nutrient Limited Watershed) NLW lakes and nutrient criteria development for lakes and reservoirs. In the Arkansas River segment of the lake the average total nitrogen (TN) was 1.04 mg/L, with values ranging from 0.64 mg/L in the summer to 2.04 mg/l in the fall quarter. The average total phosphorus (TP) was 0.167, with values ranging from 0.094 mg/L in the winter to 0.362 mg/L in the fall. The nitrogen to phosphorus ratio (TN:TP) was 6:1; this value is the close to 7:1, characterizing for this portion of the lake as possibly co-limited (Wetzel, 1983).

Keystone Lake, Cimarron River, Lower Arm

This portion of Keystone Lake (segment # 620900010020) extends from the marina area to Salt Creek Cove (S) area and up to Sandy Park in the Cimarron River arm of the reservoir and includes BUMP sites 6 through 9. The segment-wide average turbidity was 14 NTU, true color was 28 units and secchi disk depth was 76 centimeters in sample year 2006. Water clarity is good in this portion of the lake, based on these three parameters as is expected since these sites are still a good distance away from the inflow of the Cimarron River and materials have had some time to settle out. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=16). The average TSI was 60, classifying the segment as eutrophic, indicative of high primary productivity and nutrient conditions. Chlorophyll-a values were generally upper eutrophic to mid-hypereutrophic during the sample year with the lowest values reported in the fall quarter. Turbidity values ranged from a low of 4 NTU (site 6) to a maximum of 28 NTU (site 9). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered partially supported if 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Although three (18%) of the sixteen values exceeded 25 NTU an assessment of the Fish & Wildlife Propagation (FWP) beneficial use cannot be made due to minimum data requirements not being met. All true color values were below the Aesthetics criteria 70 units however like turbidity there are not enough data for this segment to assess the Aesthetics beneficial use.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites within this segment. Salinity values ranged from 0.15 to 2.66 parts per thousand (ppt) indicating moderate to high salt content within the lake depending where the sample site was located. Salinity readings were higher than the normal range of salinity values reported for most Oklahoma lakes. In general, salinity values are high in the Cimarron River arm of the reservoir. Readings for specific conductivity were also very high, ranging from 314 µS/cm to 4849 µS/cm, indicating extremely high amounts of electrical current conducting compounds (salts) in the lake system throughout the year. In general, pH values were slightly neutral to alkaline, ranging from 7.36 to 8.56 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of pH values falling within the acceptable range the FWP beneficial use is supported as it relates to pH. Thermal stratification was not evident during the fall, winter or spring sampling intervals and the water column appeared to be well mixed. In the summer, stratification was gradual and anoxic conditions present from 9 meters below the surface to the lake bottom. At site 6, the temperature ranged from 27.47^0 C at the surface to 25.21^0 C at the bottom with dissolved oxygen (D.O.) less than 2.0 mg/L in approximately 47% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at Keystone Lake (segment # 620900010020) with 27% to 47% of the water column experiencing anoxic conditions in the summer quarter.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of (Nutrient Limited Watershed) NLW lakes and nutrient criteria development for lakes and reservoirs. In the Lower Cimarron River segment of the lake the average total nitrogen (TN) was 0.84 mg/L, with values ranging from 0.61 mg/L in the summer to 1.20 mg/l in the fall quarter. The average total phosphorus (TP) was 0.101, with values ranging from 0.055 mg/L in the winter to 0.186 mg/L in the fall. The nitrogen to phosphorus ratio (TN:TP) was 8:1; this value is the close to 7:1, characterizing for this portion of the lake as possibly co-limited (Wetzel, 1983).

<u>Keystone Lake, Cimarron River, Upper Arm</u>

This portion of Keystone Lake (segment # 620900010090) extends from Appalachia Bay up to Pawnee Cove (S) area in the Cimarron River arm of the reservoir and includes BUMP sites 10 through 12. The segment-wide average turbidity was 41 NTU, true color was 40 units and secchi disk depth was 41 centimeters in sample year 2006. Based on these three parameters water clarity is average in this portion of the lake. This is not unusual since this segment is more riverine and has greater influence from the Cimarron River flowing in. A trophic state index (TSI), using Carlson's TSI (chlorophyll-<u>a</u>), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 63, classifying the segment as eutrophic, indicative of high primary productivity and nutrient conditions. Chlorophyll-<u>a</u> values were generally upper eutrophic to mid-hypereutrophic throughout the sample year. Turbidity values ranged from a low of 7 NTU (site 10) to a maximum of 147 NTU (site 12). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered partially supported if 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Although seven (58%) of the twelve values exceeded 25 NTU an assessment of the Fish & Wildlife Propagation (FWP) beneficial use cannot be made as minimum data requirements not being met. Only 2 (16.6%) of the true color values were below the Aesthetics criteria 70 units however like turbidity there are not enough data for this segment to assess the Aesthetics beneficial use.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites within this segment. Salinity values ranged from 0.73 to 6.34 parts per thousand (ppt) indicating moderate to very high salt content within this segment of the lake. Salinity readings were much higher than the normal range of salinity values reported for most Oklahoma lakes. In general, salinity values tend to be higher in the Cimarron River arm of the reservoir. Readings for specific conductivity were also very high, ranging from 1373 µS/cm to 11,134 µS/cm, indicating extremely high amounts of electrical current conducting compounds (salts) in the lake system throughout the year. The only other lake with values this high is Great Salt Plains Reservoir, near Jet. In general, pH values were slightly neutral to alkaline, ranging from 7.39 to 8.38 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of pH values falling within the acceptable range the FWP beneficial use is supported as it relates to pH. Thermal stratification was not evident during the fall, winter or spring sampling intervals and the water column appeared to be well mixed. In the summer, thermal stratification was minimal however anoxic conditions were still present. Site 10, which is the deepest site in this segment, had dissolved oxygen less than 2.0 mg/L from 9 meters below the surface to the lake bottom of 15 meters. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at Keystone Lake (segment # 620900010090) with 25% to 31% of the water column experiencing anoxic conditions in the summer quarter.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of (Nutrient Limited Watershed) NLW lakes and nutrient criteria development for lakes and reservoirs. In the Upper Cimarron River segment of the lake the average total nitrogen (TN) was 1.08 mg/L, with values ranging from 0.66 mg/L in the spring to 1.77 mg/l in the fall quarter. The average total phosphorus (TP) was 0.143, with values ranging from 0.059 mg/L in the summer to 0.328 mg/L in the fall. The nitrogen to phosphorus ratio (TN:TP) was 8:1; this value is the close to 7:1, characterizing for this portion of the lake as possibly co-limited (Wetzel, 1983).

Lake Summary

The lake was also sampled for chlorides and sulfates, to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported in the main lake and Arkansas River arm; however the use was not supported due to high chloride concentrations in the Cimarron River arms of the lake based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites throughout the lake for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. Although all sample results were below both the screening level and geometric mean, however the minimum data requirements for each segment were not met and an assessment of the PBCR beneficial use cannot be made at this time.

The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 1998 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening level or consumption advisory level. The lake was re-sampled in 2005, however the results are not available at this time and will be included as they become available. Keystone Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Keystone Lake was classified as hypereutrophic, indicative of excessive productivity and nutrient levels (Plate 64) for sample year 2005-2006. The lake-wide annual turbidity value was 35 NTU (Plate 64), true color was 34 units, and secchi disk depth was 62 centimeters in 2005-2006. Based on these three parameters, Keystone Lake had average water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=48). The average TSI was 61 (Plate 64), classifying the lake as hypereutrophic, indicative of excessive levels of productivity and nutrients. In the spring and summer quarters the vast majority of the lake was either eutrophic or hypereutrophic in nature. The sites in the upper most reaches of the lake (4, 5, 11, and 12) were the most productive throughout the entire year. Seasonal turbidity values are displayed in Figure 84a. Turbidity values were variable with lower values recorded in the more lacustrine areas of the lake. Eighteen of the 48 turbidity values exceeded the Oklahoma Water Quality Standard (WQS) of 25 NTU. With 37.5% of the recorded turbidity values above the numeric criteria, the Fish & Wildlife Propagation (FWP) beneficial use is considered not supported for sample year 2006. Seasonal true color values are displayed in Figure 84b. Only three (6.25%) of the 48 true color values exceeded the numeric criteria of 70 units; therefore, the Aesthetics beneficial use is considered fully supported. Based on anoxic condition present in the summer (Figure 84f), the FWP is considered partially supported at Keystone Lake as it relates to dissolved oxygen. Keystone is fully supporting its FWP beneficial with all pH values within the range of 6.5 to 9 pH units. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites throughout the lake for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. Although all sample results were below both the screening level and geometric mean, however the minimum data requirements for each segment were not met and an assessment of the PBCR beneficial use cannot be made at this time.

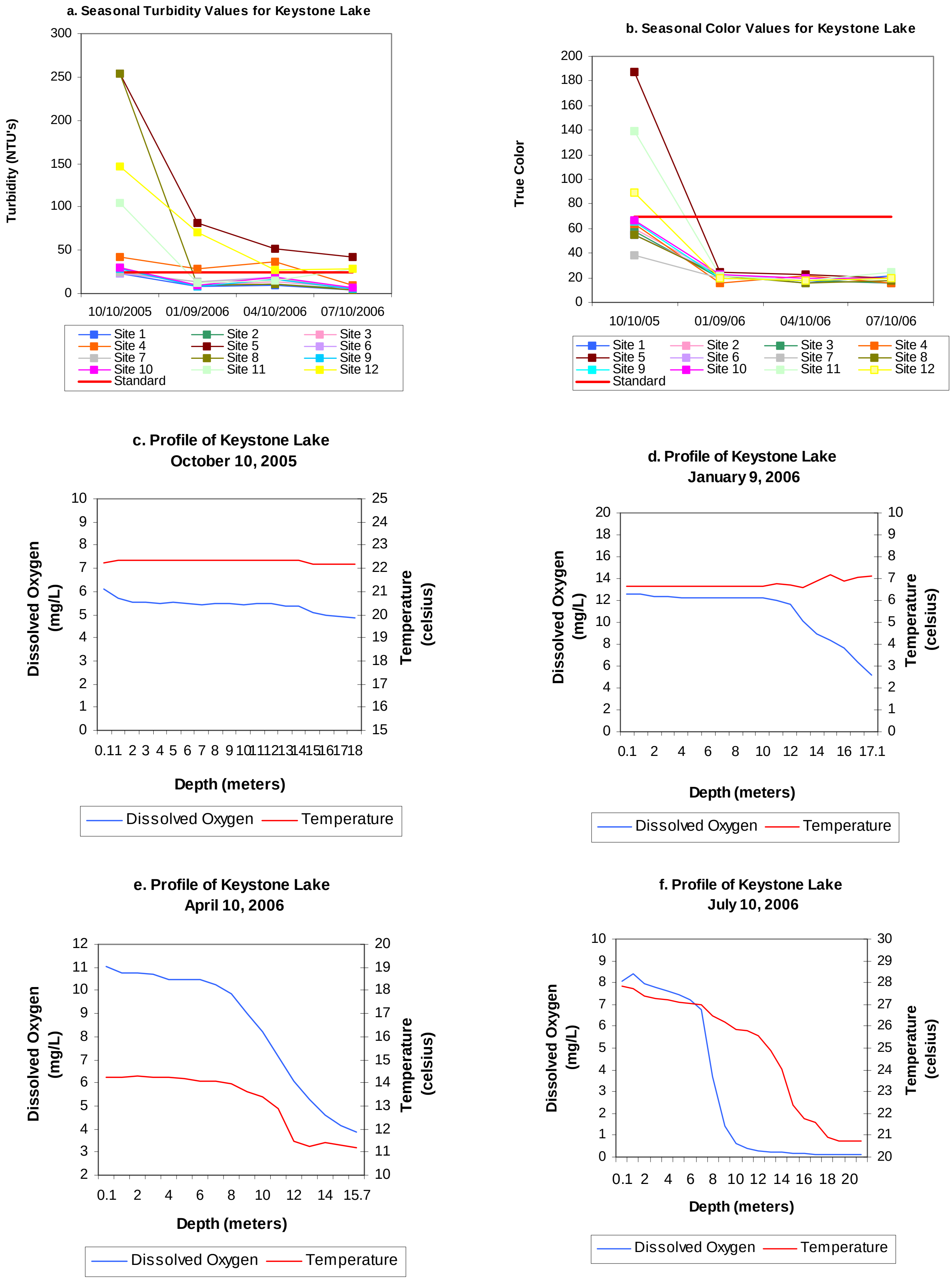
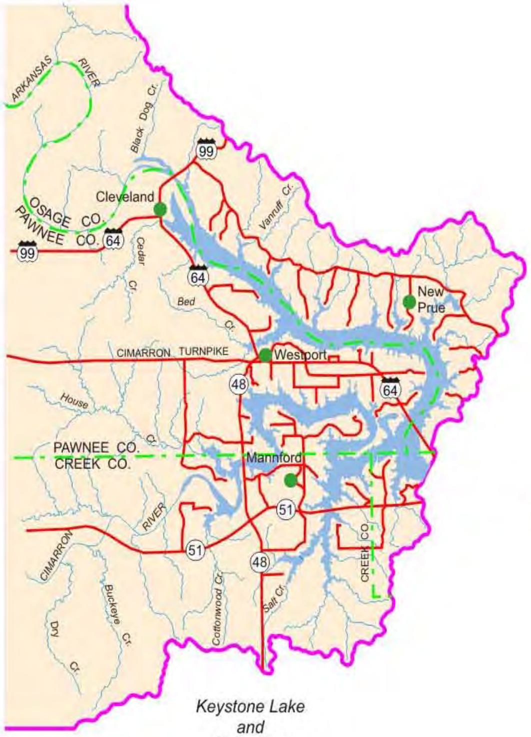


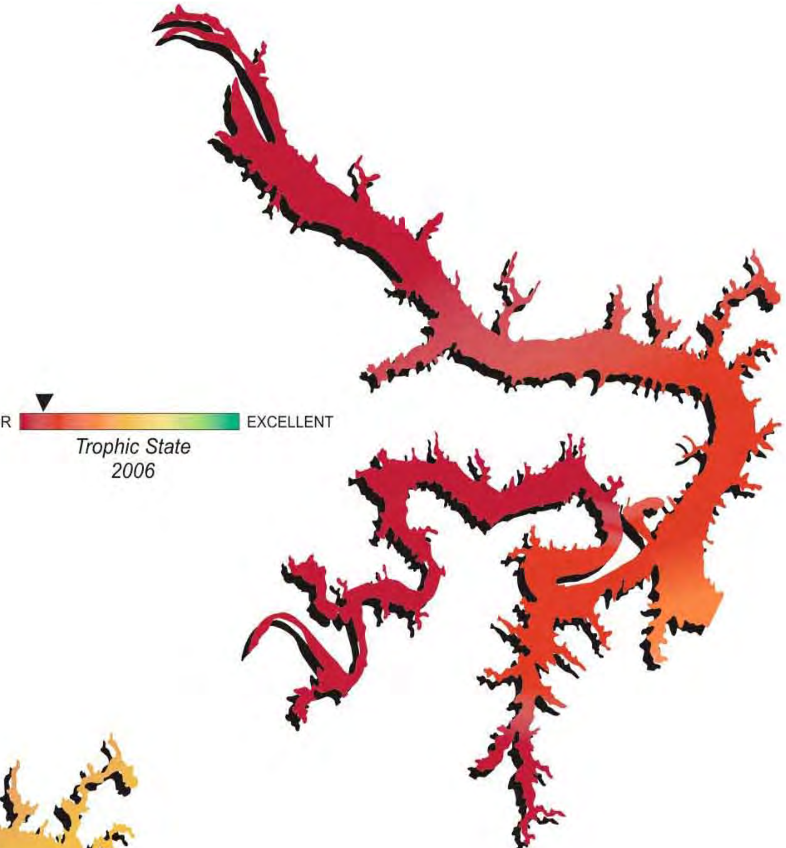
Figure 84a-84f. Graphical representation of data results for Keystone Lake.

Plate 64 - Lake Water Quality for
Keystone Lake

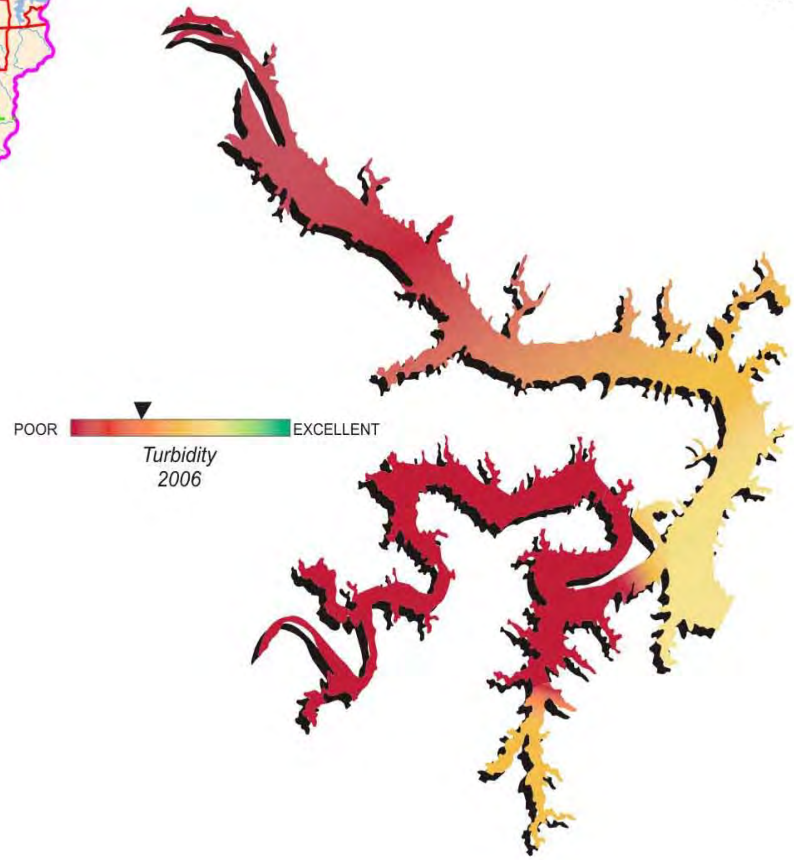


Keystone Lake and Watershed

Keystone Lake Location



Trophic State 2006



Turbidity 2006

Lake Data

Constructed by	Corps of Engineers
County	Tulsa
Constructed in	1964
Surface Area	23,610 acres
Volume	557,600 acre/feet
Shoreline Length	330 miles
Mean Depth	23.62 feet
Watershed Area	74,506 square miles

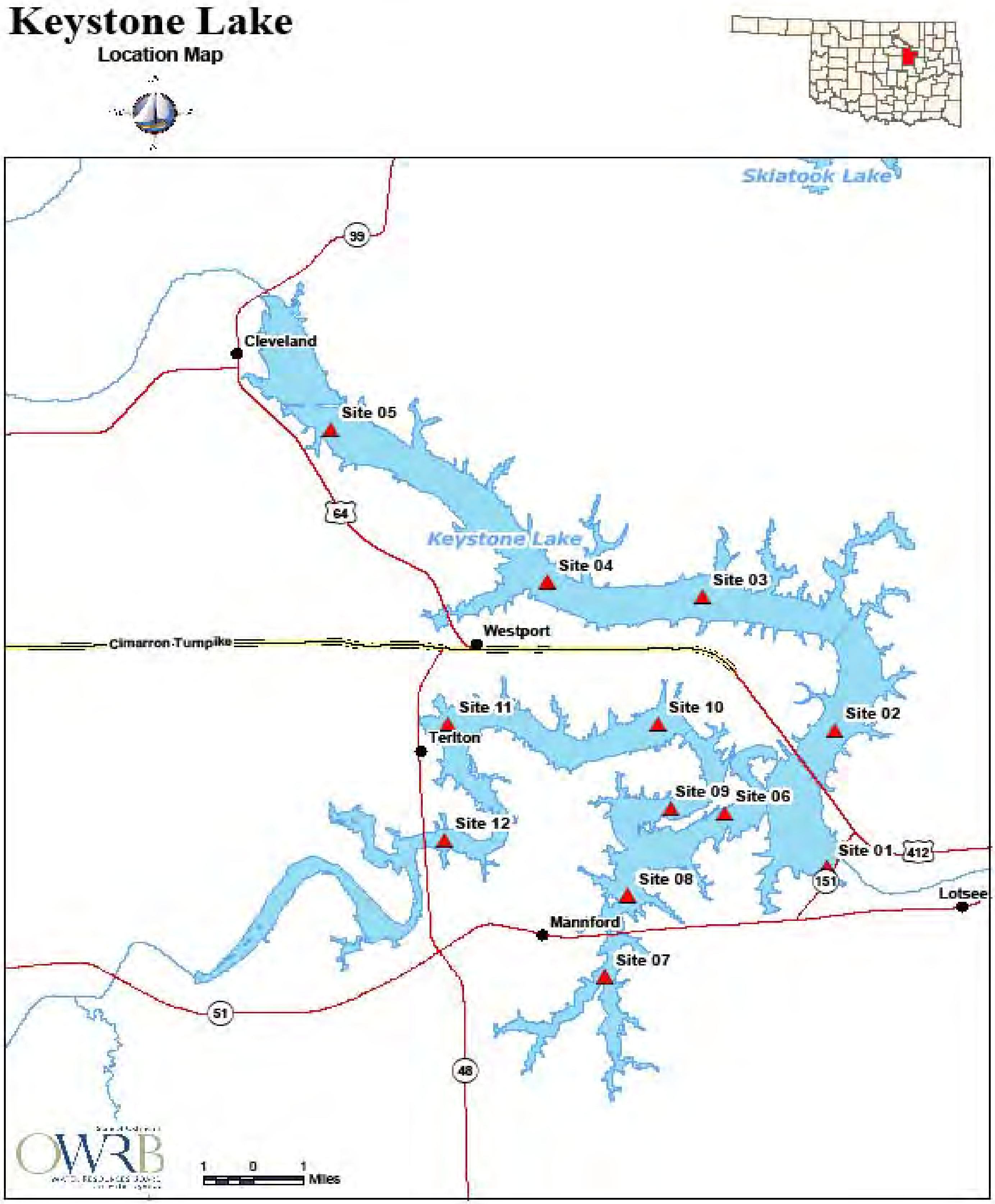


Figure 85. Keystone Lake Site Map

Konawa Reservoir

Konawa Reservoir was sampled for three seasons, from November 2004 through September 2005. Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide annual turbidity value was 7 NTU (Plate 65), true color was 18 units, and secchi disk depth was 94 centimeters in sample year 2005. Based on these three parameters, Konawa Reservoir had good to excellent water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 53 (Plate 65), classifying the lake as eutrophic, indicative of high levels of primary productivity and nutrients. This is consistent with that of the previous evaluation in 2002 (TSI=54), indicating no change in productivity has occurred. The TSI values were fairly constant from season to season in the eutrophic range with only a small number of instances where the lake was classified in the upper end of mesotrophy. Seasonal turbidity values are displayed in Figure 86a. Of the twenty values collected only one was at the Oklahoma Water Quality Standard (WQS) of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Konawa Lake is fully supporting its Fish & Wildlife Propagation (FWP) beneficial use as it pertains to turbidity with only 5% of the values at the standard of 25 NTU. Seasonal true color values are displayed in Figure 86b. All of the true color values were below the numeric criteria of 70 units. Applying the same default protocol, the Aesthetic beneficial use is considered supported based on true color.

In 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.66 parts per thousand (ppt) to 0.74 ppt much higher than the range of values normally observed in Oklahoma reservoirs. Readings for specific conductivity were also elevated with values ranging from 1234 µS/cm to 1428 µS/cm, indicating the strong presence of electrical current conducting compounds (salts) in the water column throughout the year. In general, pH values were neutral to slightly alkaline, ranging from 7.29 to 8.7 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range the lake is considered supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (redox) ranged from –75 mV at the sediment-water interface in the summer to 435 mV also recorded in the summer. Redox readings indicated that reducing conditions were not present in the reservoir to any appreciable degree. The lake was not thermally stratified in the fall or winter and dissolved oxygen (D.O.) values were above 5.0 mg/L throughout the water column at all sites (see Figure 86c-86d). Thermal stratification and anoxic conditions were present in both spring and summer sampling intervals. Site 1 was the only site in the spring exhibit stratification with dissolved oxygen (D.O.) less than 2.0 mg/L from 9 meters to the lake bottom of 10.6 meters. In the summer, the lake exhibited weak thermal stratification at sites 1 and 3 with 33-36% of the water column less than 2.0 mg/L (see Figure 86f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70%

of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at Konawa Reservoir, with 33 to 36% of the water column experiencing anoxic conditions in the summer quarter. The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.69 mg/L at the surface. Surface TN ranged from 0.38 mg/L to 0.96 mg/L, with the highest values reported in the summer and the lowest values in the winter quarter. The lake-wide total phosphorus (TP) average was 0.033 mg/L at the surface. Total phosphorus at the surface ranged from 0.021 mg/L to 0.044 mg/L. TP was highest in the spring and lowest in the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 21:1 for sample year 2004-2005 This is higher with the 7:1 ratio characterizing the lake as phosphorus limited (Wetzel, 1983).

In summary, Konawa Reservoir was classified as eutrophic, indicative of high primary productivity and nutrient levels in 2004-2005 (Plate 65). This is consistent with that of the previous evaluation in 2002 (TSI=54), indicating no change in productivity has occurred. Water clarity was good based on turbidity, true color and secchi disk depth. Konawa Reservoir was meeting its FWP beneficial use based on recorded pH, turbidity, and D.O. values. Konawa Reservoir was meeting its Aesthetics beneficial use based on trophic status and true color as all values reported during the study period were well below the WQS of 70 units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Konawa Reservoir was constructed in 1968 and is owned and operated by the Oklahoma Gas & Electric Company. Although it serves as a cooling reservoir it offers numerous recreational opportunities for the public.

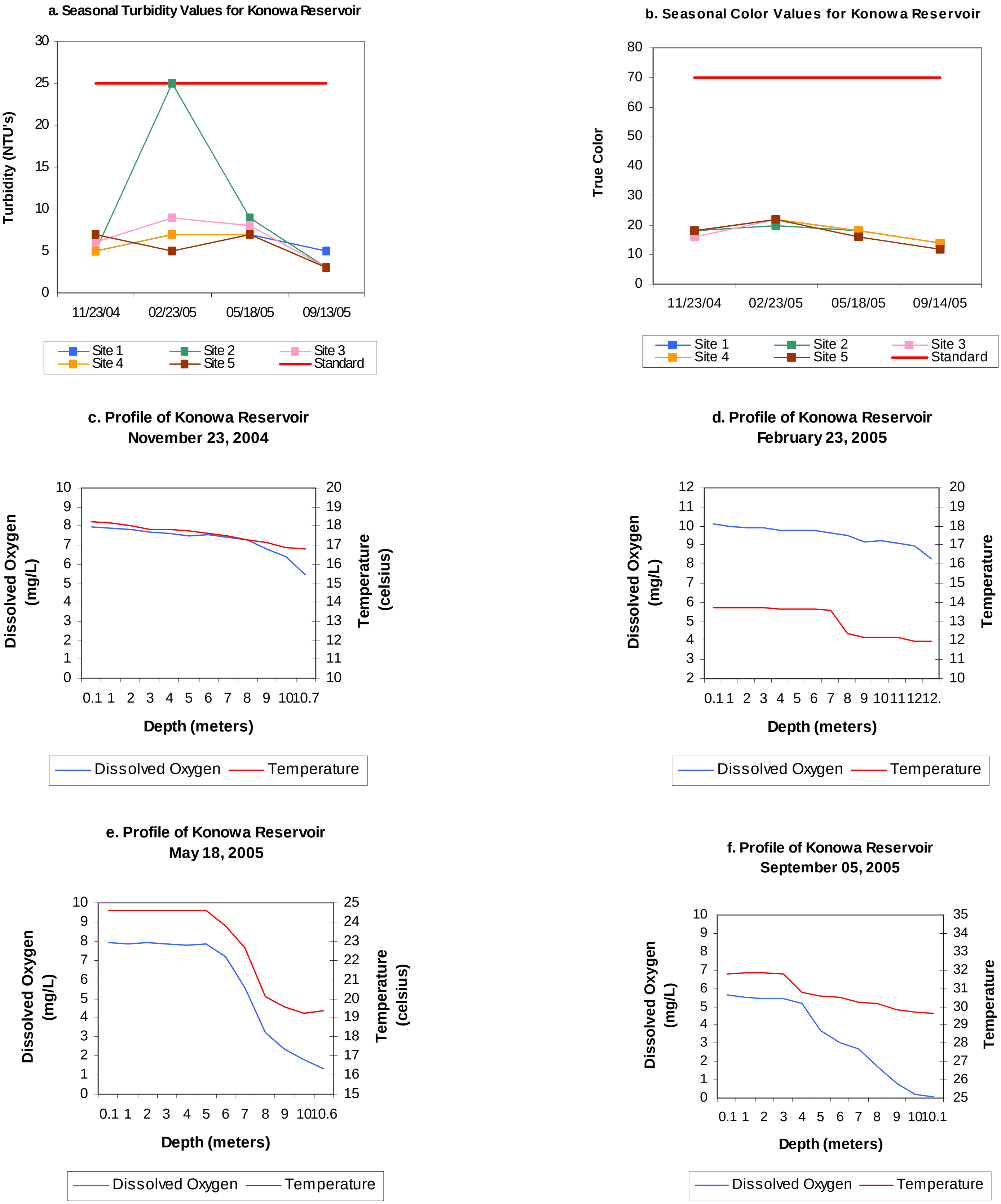
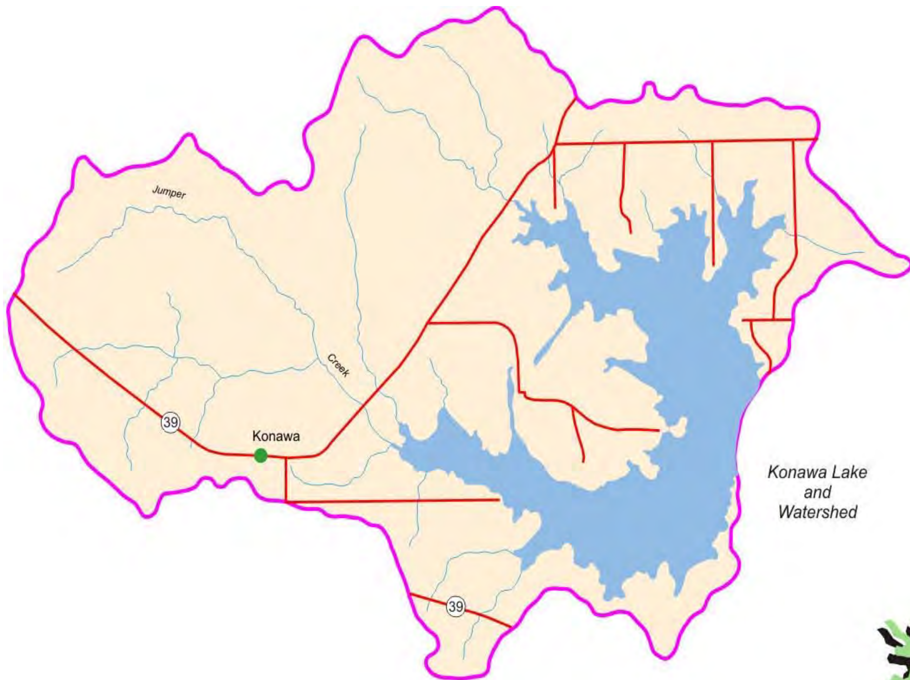


Figure 86a-86f. Graphical representation of data results for Konawa Reservoir.

Plate 65 - Lake Water Quality for

Konawa Lake

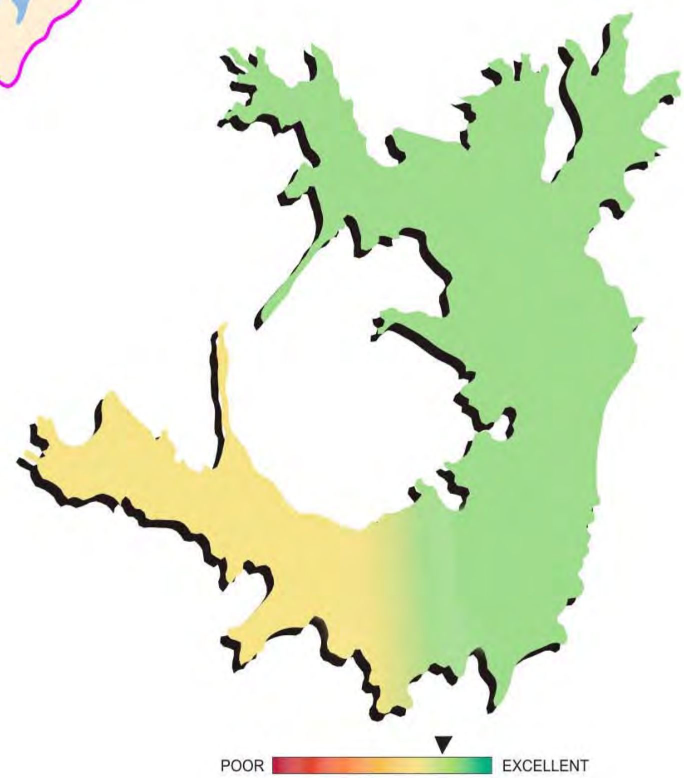


Konawa Lake and Watershed

Konawa Lake Location

Lake Data

Owner	Oklahoma Gas & Electric Co.
County	Seminole
Constructed in	1968
Surface Area	1,350 acres
Volume	23,000 acre/feet
Shoreline Length	20 miles
Mean Depth	17.04 feet
Watershed Area	12 square miles



Turbidity 2005

Trophic State 2005

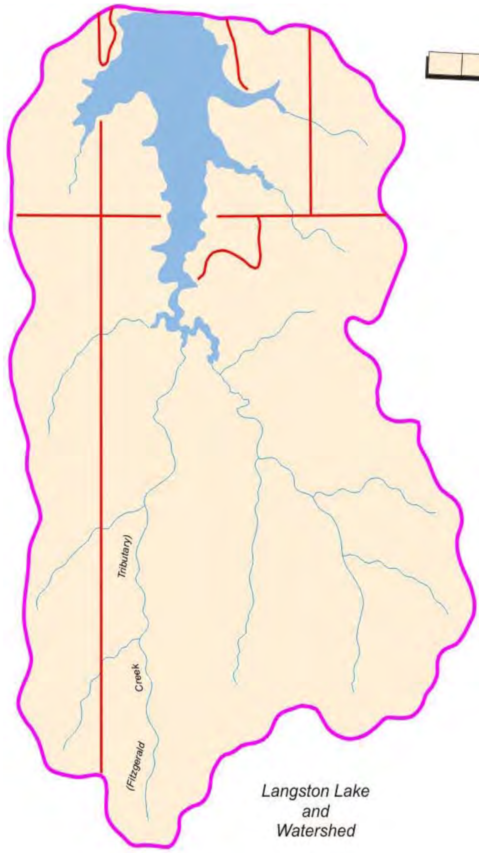
Langston Lake

Langston Lake, located in Logan County, was constructed in 1966 and is owned and operated by the City of Langston. The lake serves as a municipal water supply for the city and also serves as a flood control structure. The lake also offers many recreational opportunities for the public. The lake was scheduled for sampling during the 2005-2006 sample year however due to the drought conditions lake levels were too low for OWRB staff to launch a boat. The lake will be placed on the next sample rotation once water levels rise enough for staff to access the lake safely.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the lake. Samples were collected at all sites from the lake surface and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide annual turbidity value was 11 NTU (Plate 66), true color was 12 units, and secchi disk depth was 103 centimeters. Based on these three parameters, Langston Lake had excellent water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 47 (Plate 66), classifying the lake as mesotrophic, indicative of moderate levels of productivity and nutrients. This finding is very similar to that of 2002 (TSI=44), indicating that no significant increase or decrease in productivity has occurred over time. The TSI values were consistently mesotrophic throughout all four quarters sampled 2003-2004. All turbidity values collected were less than the Oklahoma Water Quality Standard (WQS) of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With only 10% of the collected turbidity values exceeding the WQS, Langston Lake is fully supporting its Fish & Wildlife Propagation (FWP) beneficial use as it relates to turbidity. All of the true color values were below the numeric criteria of 70 units. Applying the same default protocol, the Aesthetics beneficial is considered fully supported.

Please refer to the “Beneficial Use Monitoring Report 2004 Draft Final Report” for the full discussion of monitoring results for this lake. The report may be access via the OWRB’s web page at http://www. owrb.state.ok.us or you may contact the Water Resources for a copy of the 2004 BUMP Report on CD. The OWRB may be reached at (405) 530-8800 (ask for Nikki Cole) or at the address below:

Oklahoma Water Resources Board
3800 N. Classen Blvd.
Oklahoma city, Oklahoma 73118
Attn: Nikki Cole



Langston Lake and Watershed

Langston Lake Location

Turbidity 2004

Trophic State 2004

Lake Data

Owner	City of Langston
County	Logan
Constructed in	1966
Surface Area	304 acres
Volume	5,792 acre/feet
Shoreline Length	8 miles
Mean Depth	19.05 feet
Watershed Area	3798 acres

Plate 66 - Lake Water Quality for

Langston Lake

Lake Lawtonka

Lake Lawtonka is the municipal water supply for the City of Lawton and is owned and operated by the city. The lake is also provides numerous recreational activities for the citizens of Oklahoma. Lake Lawtonka was sampled for four quarters, from October 2006 through July 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir as well as any major arms of the lake. Samples were collected from the lake surface during the study period. The lake-wide annual turbidity value was 8 nephelometric turbidity units (NTU), true color was 26 units, and secchi disk depth was 108 centimeters. Based on these three parameters, Lake Lawtonka had good water clarity in comparison to other Oklahoma reservoirs. Results were almost identical to those of the previous evaluation. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 60 (Plate 67), classifying the lake as eutrophic with high primary productivity and nutrient conditions. Results in 2004 were very similar (TSI=58), indicating no significant increase or decrease in productivity has occurred. The TSI values were fairly consistent with values ranging from upper-eutrophic in the winter to hypereutrophic during the fall, spring and summer quarters. The turbidity values for Lake Lawtonka were all less than the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 87a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). Lake Lawtonka is fully supporting its Fish & Wildlife Propagation (FWP) beneficial use based on turbidity values. Seasonal true color values are displayed in Figure 87b. All of the true color values were well below the numeric criteria of 70 units. Applying the same default protocol, the Aesthetics beneficial use is supported based on the true color values.

Vertical profiles for dissolved oxygen; pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all five (5) sample sites. Salinity values ranged from 0.11 parts per thousand (ppt) to 0.24 ppt and were within the expected range of salinity values reported for most Oklahoma lakes. Readings for specific conductivity were also within the range of expected values for Oklahoma lakes, ranging from 225.2 cm/cm to 469.7 cm/cm, indicating moderate levels of electrical current conducting compounds (salts) in the water column throughout the year. In general, pH values were neutral to slightly alkaline, ranging from 6.76 in the summer to 8.60 units in the spring quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. None of the collected pH values were outside the acceptable range. Lake Lawtonka is fully supporting its FWP beneficial use based on pH values recorded during the study period. Oxidation-reduction potentials (redox) ranged from 42 mV in the hypolimnion during the summer to 419 mV in the spring quarter. Low redox readings like those recorded in the summer are not uncommon when a large portion of the water column is anoxic. The lake was not thermally stratified in the fall or winter quarters and dissolved oxygen (D.O.) values were generally above 5.0 mg/L throughout most of the water column. (Figure 87c-87d). The lake was weakly stratified in the spring however like the previous quarters D.O. remained above 5.0 mg/L. During the summer, the lake was strongly stratified between 4 and 5 meters below the lake surface. D.O. readings below 9 meters were less than 1.0 mg/L extending all the way to the lake bottom at 16.5 meters at site 1, the dam (see Figure 87f). Site 2 was stratified between 4 and 5 meters and like site 1, anoxic conditions comprised 67% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (USAP 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered fully supported at Lake Lawtonka with 67% of the water column experiencing anoxic conditions at sites 1 and 2 during the summer. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. Of the 10 samples none exceeded the prescribed screening level or geometric mean for any of the three parameters. The PBCR beneficial use is therefore considered supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.68 mg/L at the lake surface. The TN at the surface ranged from 0.59 mg/L in the winter quarter to 0.81 mg/L in the fall quarter. The lake-wide total phosphorus (TP) average was 0.029 mg/L at the lake surface. The surface TP ranged from 0.015 mg/L in the spring quarter to 0.058 mg/L in the fall quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 23:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Lake Lawtonka was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Lake Lawtonka was classified as eutrophic, indicative of high primary productivity and nutrient levels (Plate 67). Water clarity continues to be good based on true color, turbidity and secchi disk depth. Lake Lawtonka is fully supporting the FWP beneficial use as it relates to turbidity and pH values recorded during the study period. With up to 67% of the water column anoxic at both sites 1 and 2 during the summer quarter, the FWP is considered partially supported based on D.O. levels. The lake is also fully supporting its Aesthetics beneficial use based on its trophic status and true color as 100% of the values were below the WQS of 70 units. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. With all values below the prescribed screening level and geometric mean for each parameter, the PBCR is considered supported.

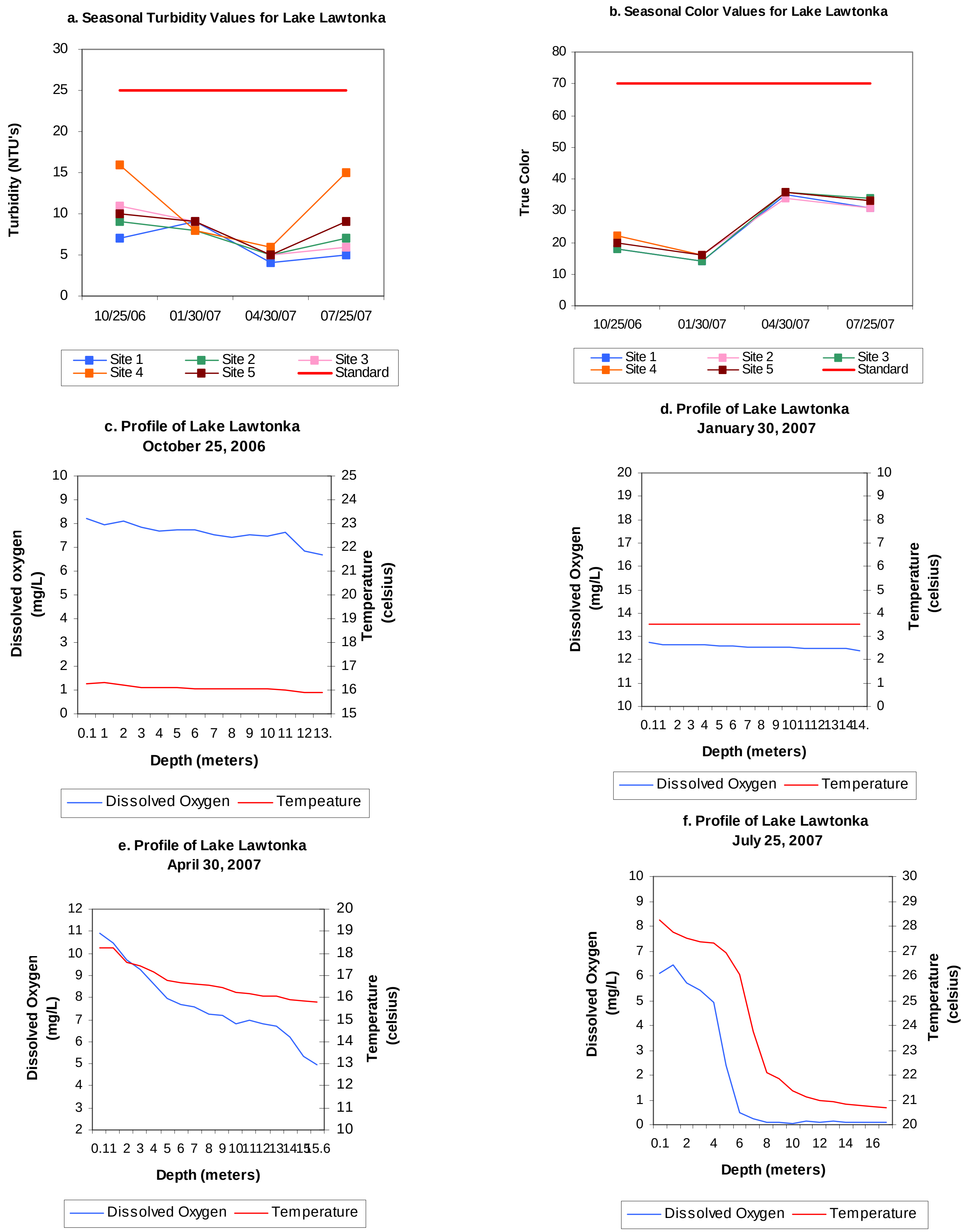
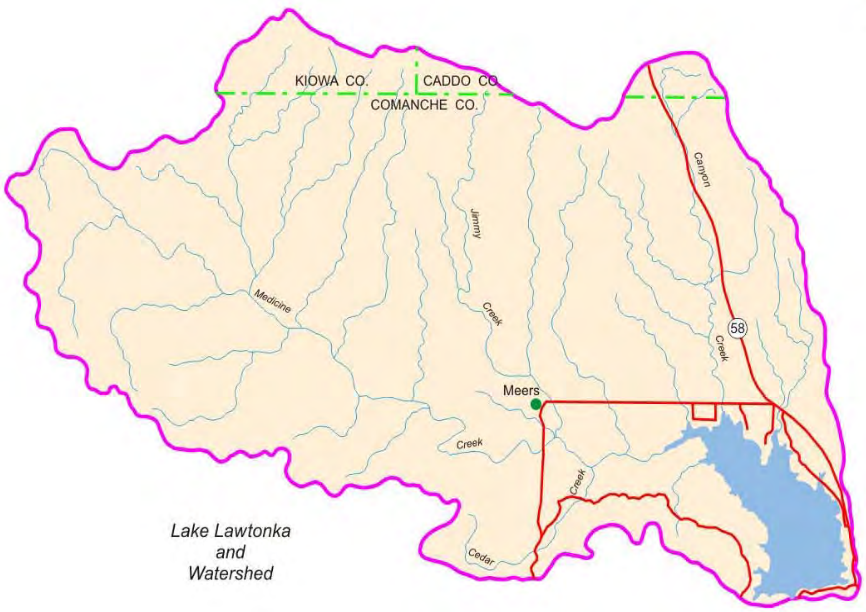


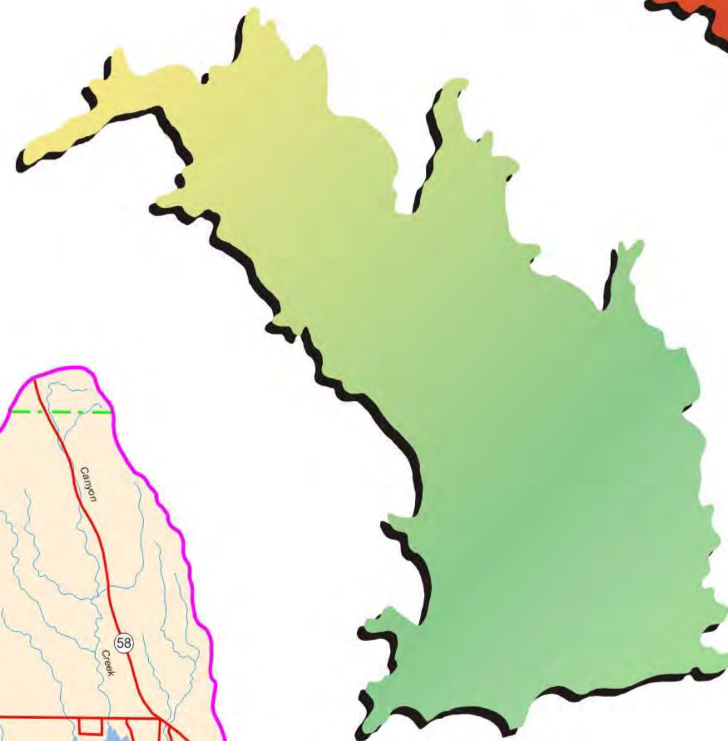
Figure 87a-87f. Graphical representation of data results for Lake Lawtonka.

Lake Lawtonka Location



Lake Lawtonka and Watershed

Lake Data	
Owner	City of Lawton
County	Comanche
Constructed in	1905
Surface Area	2,398 acres
Volume	55,574 acre/feet
Shoreline Length	21 miles
Mean Depth	23.59 feet
Watershed Area	92 square miles



POOR EXCELLENT

Turbidity 2007

POOR EXCELLENT

Trophic State 2004

Plate 67 - Lake Water Quality for

Lake Lawtonka

LAKES MONITORING PROGRAM

Liberty Lake

Liberty Lake, located in Logan County, was constructed in 1948 and serves as a municipal water supply for the City of Guthrie. The lake is also used as a recreational outlet for the general public. Liberty Lake was sampled for four quarters, from October 2005 through July 2006.

Water quality samples were collected at three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at three sites during the study period. The lake-wide annual turbidity value was 21 NTU (Plate 68), true color was 20 units, and secchi disk depth was 42 centimeters. Results were similar to that of the 2004 evaluation. Based on these three parameters, Liberty Lake had good water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for all quarters (n=12). The average TSI was 67 (Plate 68), classifying the lake as hypereutrophic, indicative of excessive primary productivity and nutrient rich conditions. This value is higher than that of 2004 (TSI=56) and 2002 (TSI=55), indicating a significant increase in trophic status since previous data collection efforts were conducted. Although the current TSI is greater than 62, which normally triggers consideration to be included as an NLW, this is the first time since 1999 that this threshold had been crossed. It is hard to say if this increase is due to the lower lake levels brought on by the drought the state is experiencing or an actual change in productivity therefore the lake will not be recommended for inclusion during the next Oklahoma Water Quality Standards revision process, but will be monitored closely in the future. The TSI values were consistently in the hypereutrophic range for the entire sample year. The turbidity values for the lake were all below the Oklahoma Water Quality Standard (WQS) of 25 NTU except for two values recorded in spring and summer quarters for site 3 at the upper end of the lake (see Figure 88a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Liberty Lake is partially supporting its Fish & Wildlife Propagation (FWP) beneficial use based on turbidity concentrations in the lake as only 16.7% of the collected values exceeded the criteria. Seasonal true color values are displayed in Figure 88b. All of the true color values recorded were below the numeric criteria of 70 units, therefore, the Aesthetics beneficial use is considered fully supported as it relates to true color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all three sample sites. Salinity values ranged from 0.22 parts per thousand (ppt) to 0.30 ppt, which is higher than the expected range of values for Oklahoma lakes indicating above average salt content levels. Readings for specific conductivity ranged from 439.1 µS/cm to 580.5 µS/cm, indicating the presence of moderate levels of electrical current conducting compounds (salts) in the water column throughout the year. These values were also paralleled by the recorded salinity values. In general, pH values were neutral to slightly alkaline in nature, ranging from 7.94 units in the spring quarter to 8.48 units in the fall quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. All pH values collected on Liberty Lake were within the allowable range therefore the lake is fully supporting its FWP beneficial use based on pH. Oxidation-reduction potentials (redox) ranged from 404 mV in the fall to 544 mV recorded in the winter quarter. Redox readings indicated that reducing conditions were not present in the reservoir during the sample year. The lake was not thermally stratified in the fall, winter or spring quarters and the dissolved oxygen (D.O.) values were above 7.0 mg/L throughout the water column at all sites and times (see Figure 88c-88e). Profile data for the summer is not available for assessment due to equipment failure. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (USAP 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered fully supported at Liberty Lake with anoxic conditions absent during the first three sampling intervals. Without profile data available for the summer, an assessment of this quarter cannot be made. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.10 mg/L at the lake surface. The TN at the surface ranged from 0.82mg/L recorded in the spring quarter to 1.19 mg/L in the fall quarter. The lake-wide total phosphorus (TP) average was 0.071 mg/L at the lake surface. The surface TP ranged from 0.056 mg/L in the fall quarter to 0.110 mg/L recorded in the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 16:1 for sample year 2003-2004. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 1998 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening level or consumption advisory level. The lake was re-sampled in 2005, however the results are not available at this time and will be included as they become available. Liberty Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Liberty Lake was classified as hypereutrophic TSI=67), indicative of high primary productivity and nutrient levels (Plate 68). Although the current TSI is greater than 62, which normally triggers consideration to be included as an NLW, this is the first time since 1999 that this threshold had been crossed. It is hard to say if this increase is due to the lower lake levels brought on by the drought the state is experiencing or an actual change in productivity therefore the lake will not be recommended for inclusion during the next Oklahoma Water Quality

Standards revision process, but will be monitored closely in the future. Based on true color, turbidity and secchi disk depth, water clarity was good at Liberty Lake. The lake is meeting its FWP beneficial use for dissolved oxygen and pH, but partially supporting for turbidity, with 16.7% of the values exceeding the WQS of 25 NTU. Liberty Lake is also fully supporting its based on true color with 100% of the reported values below the WQS of 70 units. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

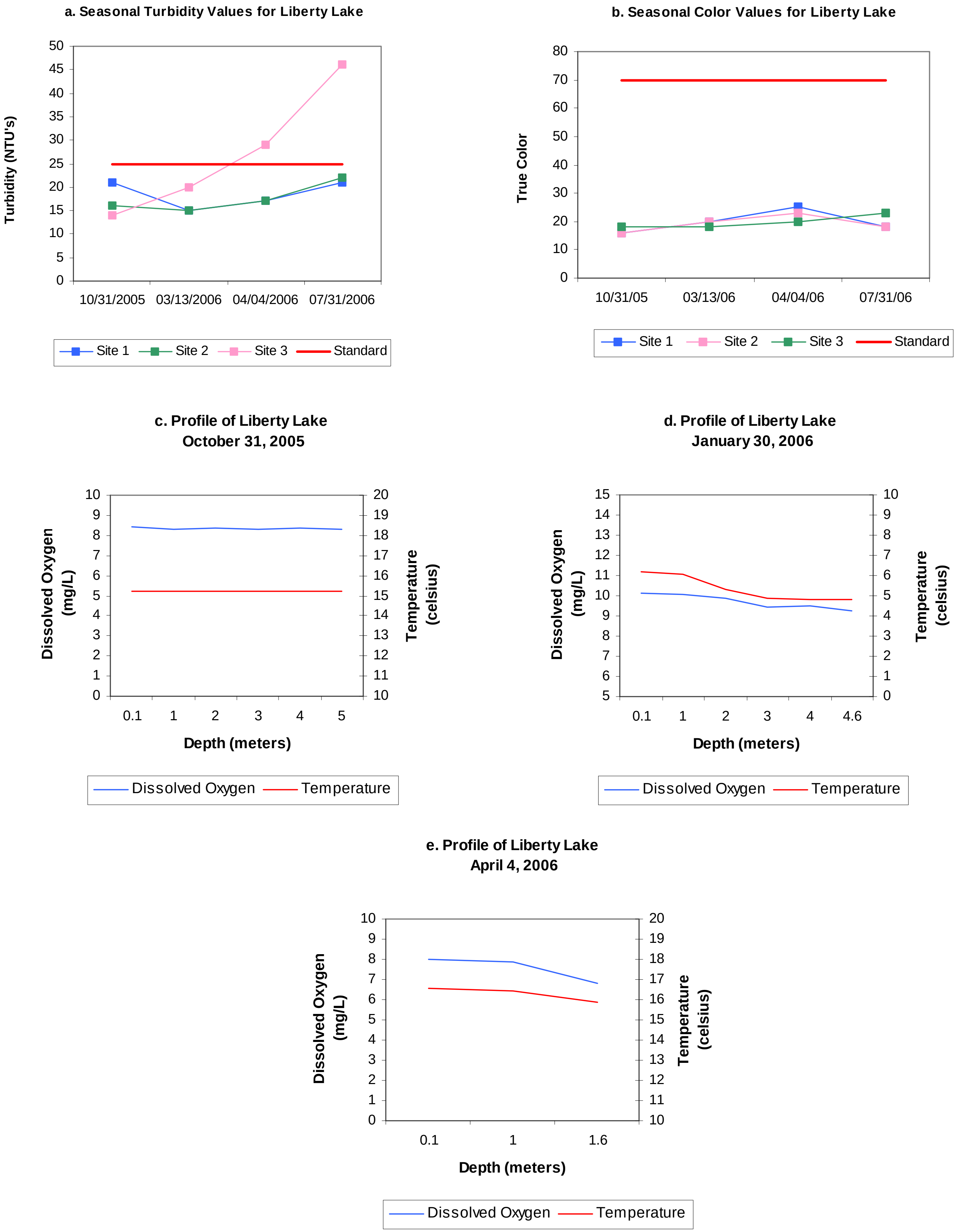
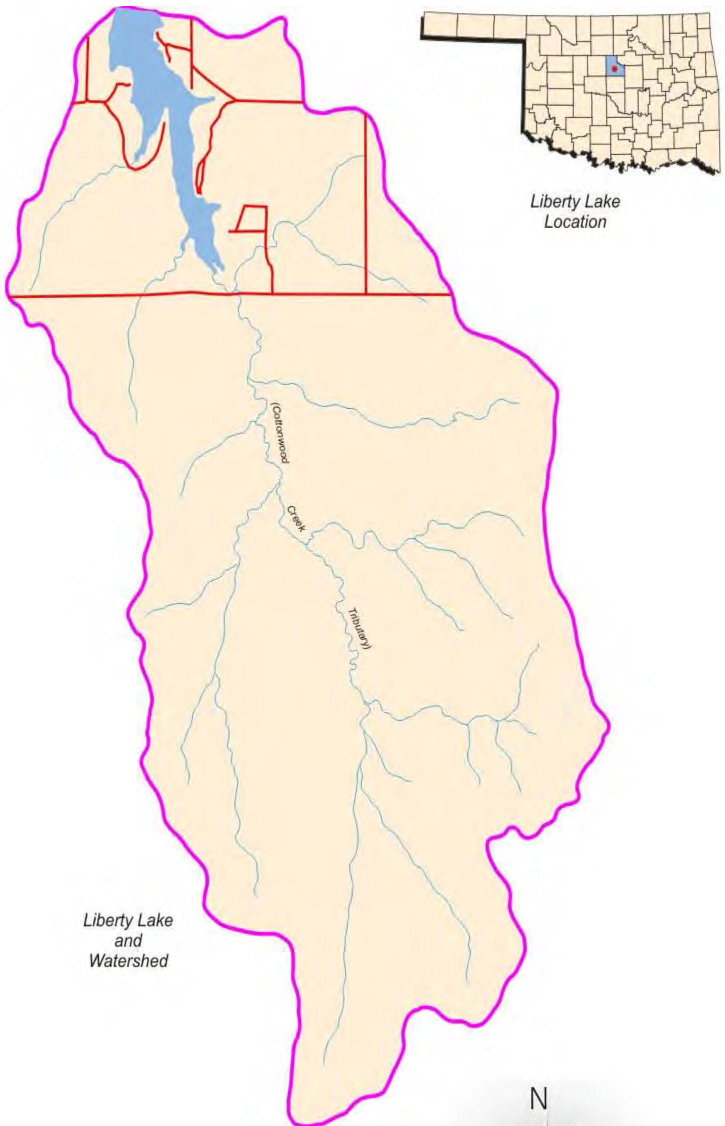


Figure 88a-88f. Graphical representation of data results for Liberty Lake.



Liberty Lake and Watershed

Liberty Lake Location

N W E S

Lake Data	
Owner	City of Guthrie
County	Logan
Constructed in	1948
Surface Area	167 acres
Volume	2,740 acre/feet
Shoreline Length	5 miles
Mean Depth	16.41 feet
Watershed Area	11 square miles

Turbidity 2006

Trophic State 2006

Plate 68- Lake Water Quality for

Liberty Lake

Lloyd Church (Wilburton) Lake

Lloyd Church Lake, located in Latimer County, serves as the municipal water supply for the city of Wilburton. Lloyd Church Lake was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at three sites during the study period. The lake-wide annual turbidity value was 14 NTU, true color was 79 units, and secchi disk depth was 64 centimeters. Based on these three parameters, Lloyd Church Lake had fairly good water clarity in comparison to other Oklahoma reservoirs. Water clarity was similar to that reported in 2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 45, classifying the lake as mesotrophic, indicative of moderate levels of productivity and nutrients. This value is consistent with the one calculated in 2004 (TSI=44), indicating no significant change in productivity has occurred since previous data collection efforts were conducted on the lake. The TSI values were oligotrophic in the fall and winter quarters and mesotrophic in the spring and summer sampling intervals. Of the twelve turbidity values collected, three (25%) exceeded the Oklahoma Water Quality Standard (WQS) of 25 for sample year 2006 (Figure 89a). According to USAP (OAC 785:46-15-5), a beneficial use is considered not supported if ≥25% of the samples exceeds the screening level prescribed in WQS (25 NTU for turbidity). If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Available flow and rainfall data suggest that the peak in turbidity, which occurred in March is likely due to seasonal storm events, therefore Lloyd Church Lake will be listed as supporting its Fish & Wildlife Propagation (FWP) beneficial use for turbidity. Seasonal true color values are displayed in Figure 89b. Values throughout the sample year were above the standard of 70 units, with the exception of the summer quarter. The Aesthetics beneficial use is considered not supported at Lloyd Church Lake with 75% of the values exceeding 70 units.

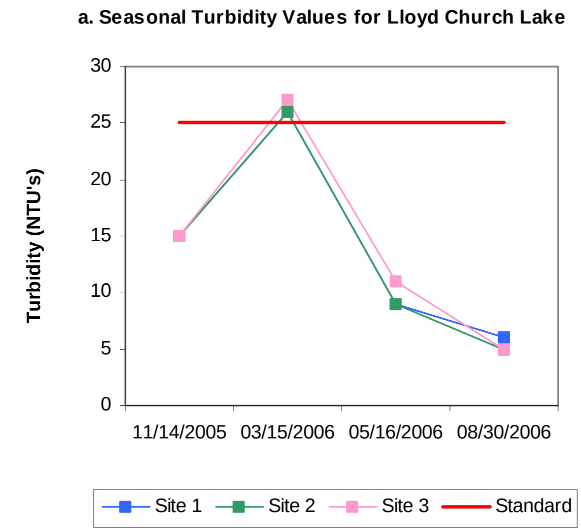
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity values ranged from 0.0 parts per thousand (ppt) to 0.01 ppt. Specific conductivity values were also very low, ranging from 25.4 µS/cm to 71.9 µS/cm. The values recorded for both salinity and specific conductivity are much lower than that typically seen in Oklahoma lakes and reservoirs and are indicative of extremely low concentrations of electrical current conducting ions (salts or other chlorides) in the lake system. Values for pH were slightly acidic to neutral, ranging from 5.9 in the hypolimnion in the spring to 7.51 in the summer quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 26% of the recorded values falling outside the acceptable range the FWP beneficial use is considered not supported based on pH concentrations. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Continued monitoring should be conducted to determine if impairment due to pH exists. Oxidation-reduction potentials (redox) ranged from 79 mV to 503 mV, indicating an absence of reducing conditions during the sample year. Low redox values in the hypolimnion are not uncommon when a lake is strongly thermally stratified and anoxic conditions are present as seen in the summer quarter. The lake was not thermally stratified in the fall or winter quarters and the dissolved oxygen (D.O.) values were above 7.0 mg/L throughout the water column at all sites (see Figure 89c-89d). During the spring the lake was thermally stratified between 8 and 9 meters, however dissolved oxygen (D.O.) never fell below 3.0 mg/L (Figure 89e). In the summer, the lake was strongly thermally stratified between 4 and 5 meters with anoxic conditions comprising approximately 62% of the water column at site 1 (see Figure 89f). Site 2 also exhibited stratification at the same point in the water column with D.O. values less than 2.0 mg/L from 4 meters to the lake bottom of 4.5 meters. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (USAP 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported at Lloyd Church Lake with approximately 62% of the water column less than 2.0 mg/L at site 1 in the summer quarter. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

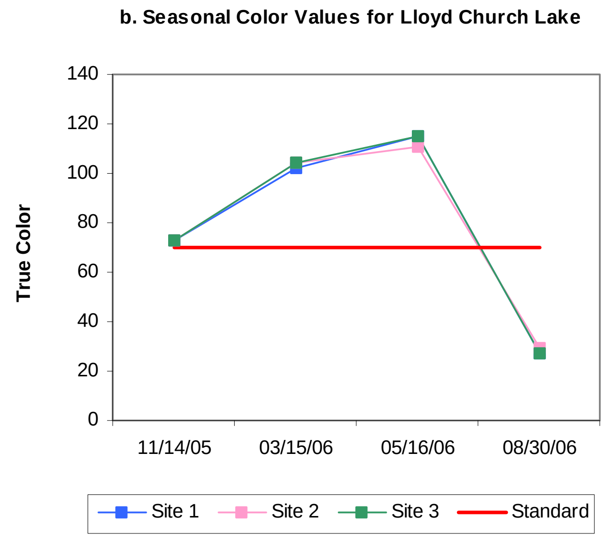
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September. Of the 10 fecal coliform samples collected only one exceeded the prescribed screening level or geometric mean The PBCR beneficial use is therefore considered fully supported.

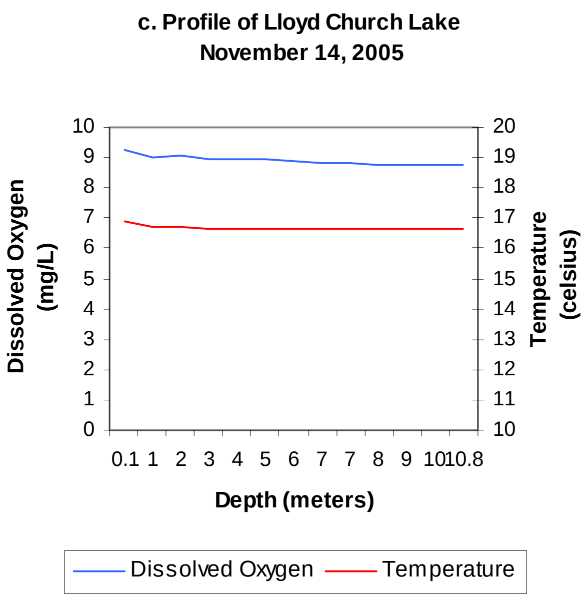
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.38 mg/L at the lake surface. The TN at the surface ranged from 0.15 mg/L recorded in the fall quarter to 0.57 mg/L in the spring quarter. The lake-wide total phosphorus (TP) average was 0.031 mg/L at the lake surface. The surface TP ranged from 0.020 mg/L in the summer quarter to 0.043 mg/L recorded in the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 12:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

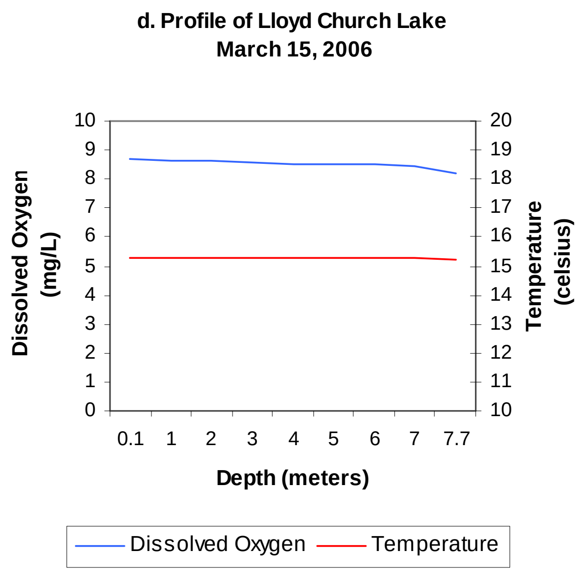
Lloyd Church Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

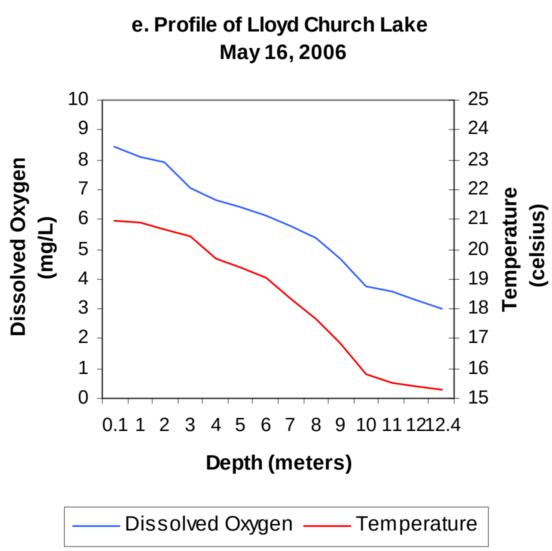
In summary Lloyd Church Lake was classified as mesotrophic, indicative of moderate levels of productivity and nutrients. This value is consistent with the one calculated in 2004 (TSI=44), indicating no significant change in productivity has occurred since previous data collection efforts were conducted on the lake. Based on turbidity, true color and secchi disk depth Lloyd Church Lake had fairly good water clarity. The FWP beneficial use is considered partially supporting with approximately 62% of the water column experiencing anoxic conditions. Although 25% of the turbidity values exceeding the WQS of 25 NTU, available flow and rainfall data suggest that the peak in turbidity, which occurred in March is likely due to seasonal storm events, and the lake will be listed as supporting its Fish & Wildlife Propagation (FWP) beneficial use as it relates turbidity.. With 26% of the recorded values falling outside the acceptable range, the FWP beneficial use is considered not supported based on pH concentrations. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Continued monitoring should be conducted to determine if impairment due to pH exists. The Aesthetics use is also considered supported based on trophic status however is not supporting with 75% of the reported true color values exceeding the standard of 70 units. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September. Of the 10 fecal coliform samples collected only one exceeded the prescribed screening level or geometric mean The PBCR beneficial use is therefore considered fully supported.











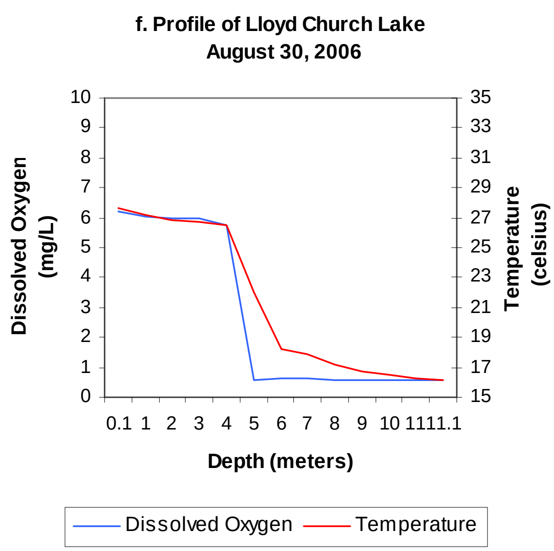
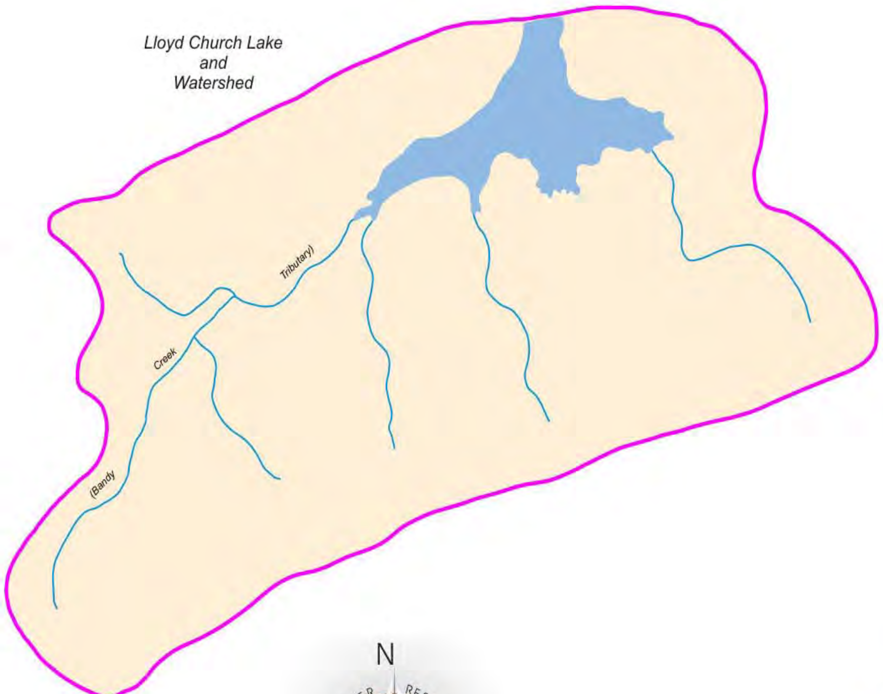
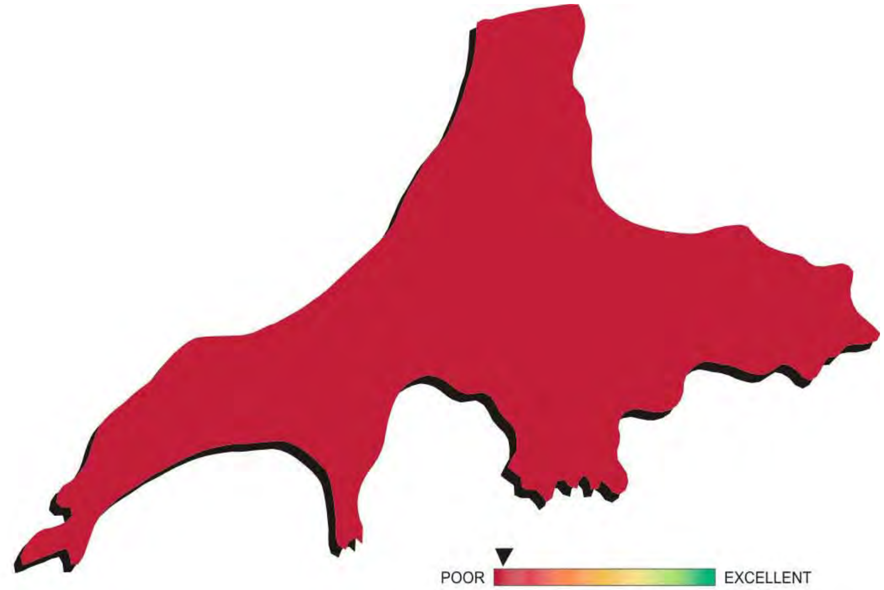


Figure 89a-89f. Graphical representation of data results for Lloyd Church Lake.

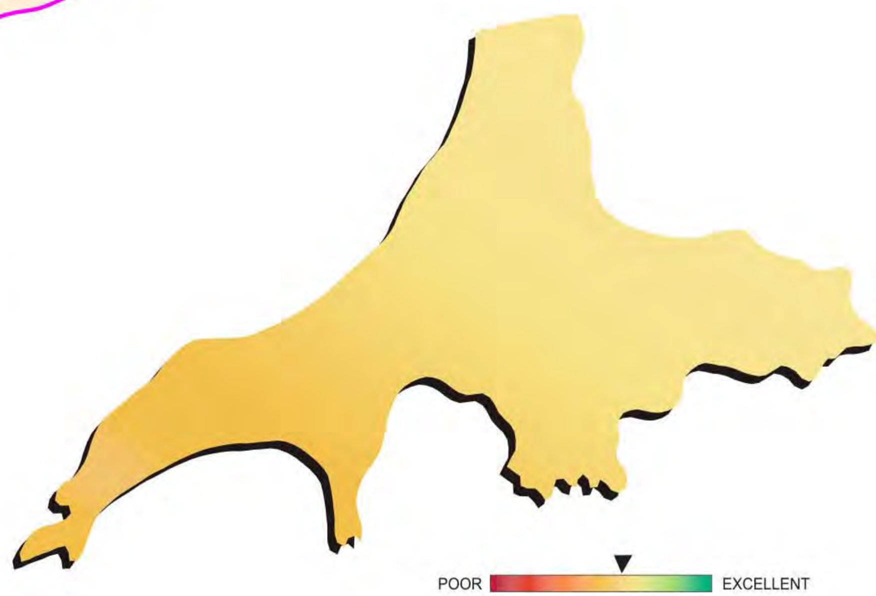
Lloyd Church Lake Location



Lloyd Church Lake and Watershed



Trophic State 2006



Turbidity 2006

Lake Data

Owner	City of Wilburton
County	Latimer
Constructed in	1964
Surface Area	160 acres
Volume	3,060 acre/feet
Shoreline Length	4 miles
Mean Depth	19.13 feet
Watershed Area	2,627 acres

Plate 69 - Lake Water Quality for
Lake Lloyd Church

LAKES MONITORING PROGRAM

Lone Chimney Lake

Due to extreme drought and low lake levels Lone Chimney lake OWRB sraff were unable to access Lone Chiney lake during the 2006-2007 sample year. The following is the summary of the previous evaluation.

Lone Chimney Lake was sampled for four quarters, from October 2003 through June 2004. Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface with an additional sample taken at 0.5 meters from the lake bottom at site 1, near the dam. The lake-wide annual turbidity value was 18 NTU (Plate 70), true color was 41 units, and secchi disk depth was 63 centimeters. Based on these three parameters, Lone Chimney Lake had fair to good water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for all quarters (n=20). The average TSI was 53 (Plate 70), classifying the lake as eutrophic, indicative of high levels of primary productivity and nutrients. The TSI values were consistent throughout all four quarters and ranged from the lower end of eutrophy to the upper end of eutrophy. The turbidity values were below the Oklahoma Water Quality Standard (WQS) of 25 NTU with the exception of the spring quarter when all five sites were above the standard (see Figure 90a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Available flow and rainfall data suggest that the peak in turbidity, which occurred in March is likely due to seasonal storm events, therefore Lone Chimney Lake will be listed as supporting its Fish & Wildlife Propagation (FWP) beneficial use. Seasonal true color values are displayed in Figure 90b. Of the true color values collected 20% were above the numeric criteria of 70 units. Similar to turbidity a peak in true color occurred in the spring quarter and is likely the result of seasonal storm events and therefore the Aesthetics beneficial will be considered supported at Lone Chimney Lake.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.06 parts per thousand (ppt) to 0.17 ppt indicating low to moderate salt content and well within the expected range of salinity values reported for most Oklahoma lakes. Readings for specific conductivity were somewhat lower, ranging from 156.9 µS/cm to 312.5 µS/cm, indicating low to moderate electrical current conducting compounds (salts) in the water column throughout the year. In general, pH values were neutral to slightly alkaline, ranging from 7.01 units near the lake bottom in the spring quarter to 8.31 units recorded in the winter quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With all collected pH values falling well within the acceptable range of pH, Lone Chimney Lake was fully supporting its FWP beneficial use. Oxidation-reduction potentials (redox) ranged from 319 mV in the summer to 552 mV near the sediment-water interface in the winter quarter. Redox readings indicated that reducing conditions were not present in the reservoir. In the fall, weak thermal stratification was evident and anoxic conditions were present in approximately 23% of the water column (Figure 90c). The lake was not thermally stratified in the winter or spring quarters and the dissolved oxygen (D.O.) values were above 5.0 mg/L throughout the water column except near the lake bottom (see Figure 90d-90e). In the summer, the lake was again strongly thermally stratified between 4 and 5 meters and below 4 meters from the surface the D.O. values were less than 1.0 mg/L to the lake bottom at sites 1 and 2 (see Figure 90f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered fully supported at Lone Chimney Lake because 23% of the water column was anoxic in the fall quarter and 44% of the water column during the summer quarter. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2003-2004 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September. Of the 10 enterococci samples collected one (10%) exceeded the prescribed screening level of 61 cfu/ml, however the geometric was not exceeded. The PBCR beneficial use is therefore considered supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.77 mg/L at the lake surface. The TN at the surface ranged from 0.58 mg/L in the winter quarter to 1.05 mg/L recorded in the spring. The lake-wide total phosphorus (TP) average was 0.041 mg/L at the lake surface. The surface TP ranged from 0.021 mg/L in the winter to 0.083 mg/L in the spring. The nitrogen to phosphorus ratio (TN:TP) was approximately 19:1. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

In summary, Lone Chimney Lake was classified as eutrophic, indicative of high primary productivity and nutrient levels (Plate 70). The lake was fully supporting its FWP beneficial use based on pH and dissolved oxygen values recorded during the study period. Available flow and rainfall data suggest that the peak in turbidity, which occurred in March is likely due to seasonal storm events, therefore Lone Chimney Lake will be listed as supporting its Fish & Wildlife Propagation (FWP) beneficial use. Lone Chimney was supporting its Aesthetics beneficial used based on its assessed trophic status. Similar to turbidity a peak in true color occurred in the spring quarter and is likely the result of seasonal storm events and therefore the Aesthetics beneficial will be considered supported at Lone Chimney Lake.. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Of the 10 enterococci samples collected one (10%) exceeded the prescribed screening level of 61 cfu/ml, however the geometric was not exceeded. The PBCR beneficial use is therefore considered supported. Lone Chimney Lake was constructed in 1984 and is owned and operated by the Tri-county Development Authority. The lake serves as a municipal water supply and is also used for flood control and recreational purposes.

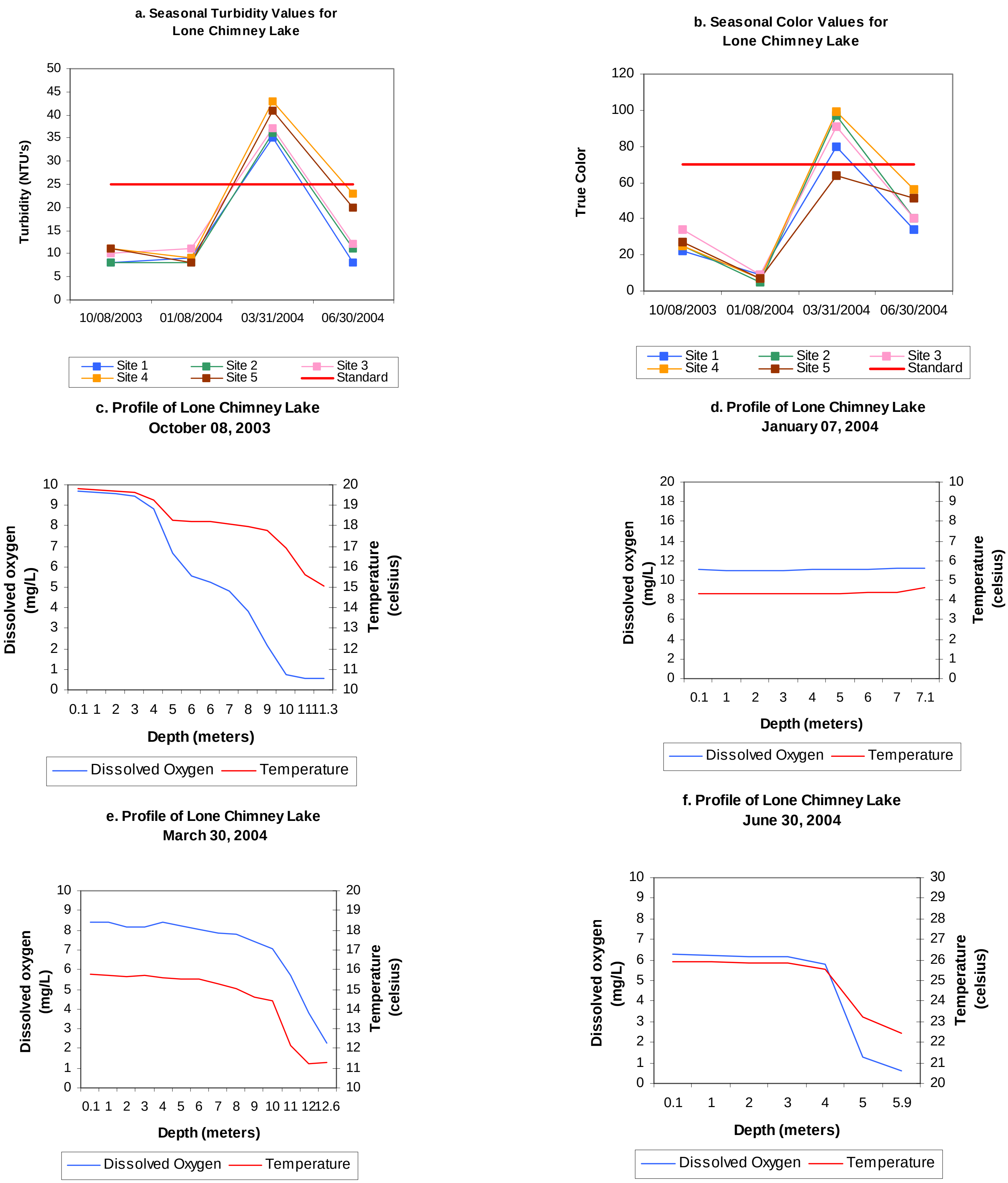
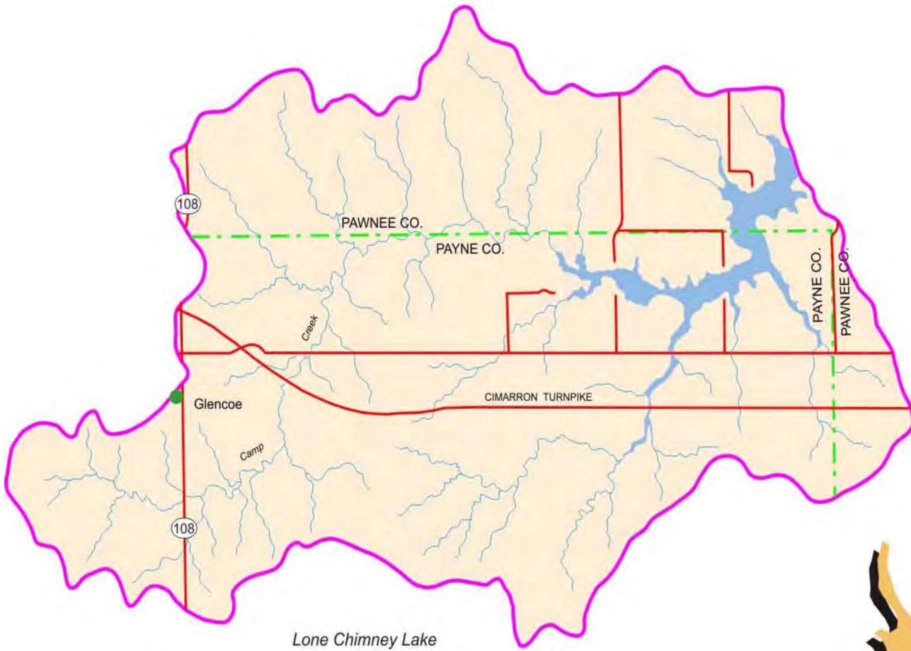


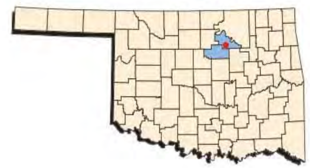
Figure 90a-90f. Graphical representation of data results for Lone Chimney Lake.

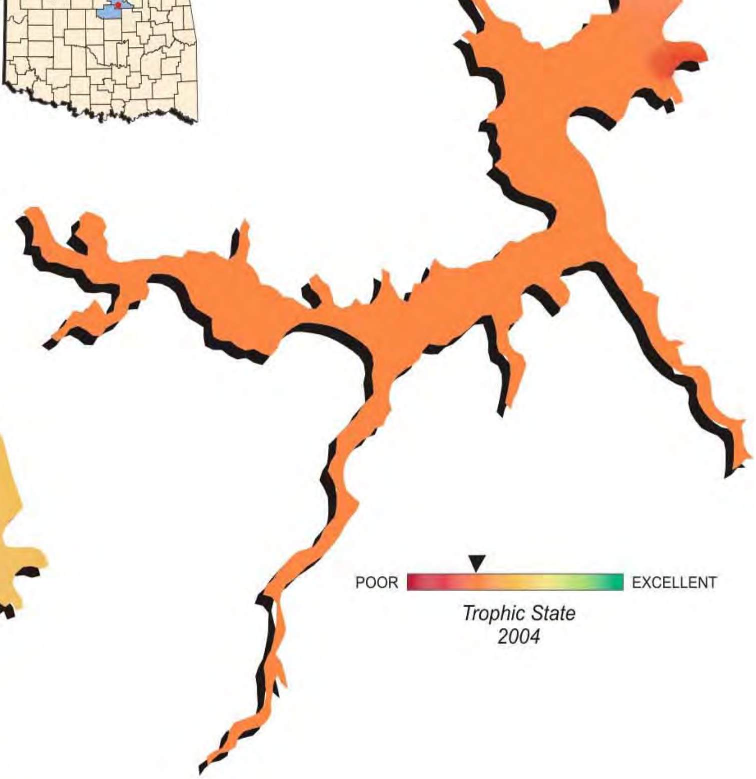
Plate 70 - Lake Water Quality for
Lone Chimney Lake



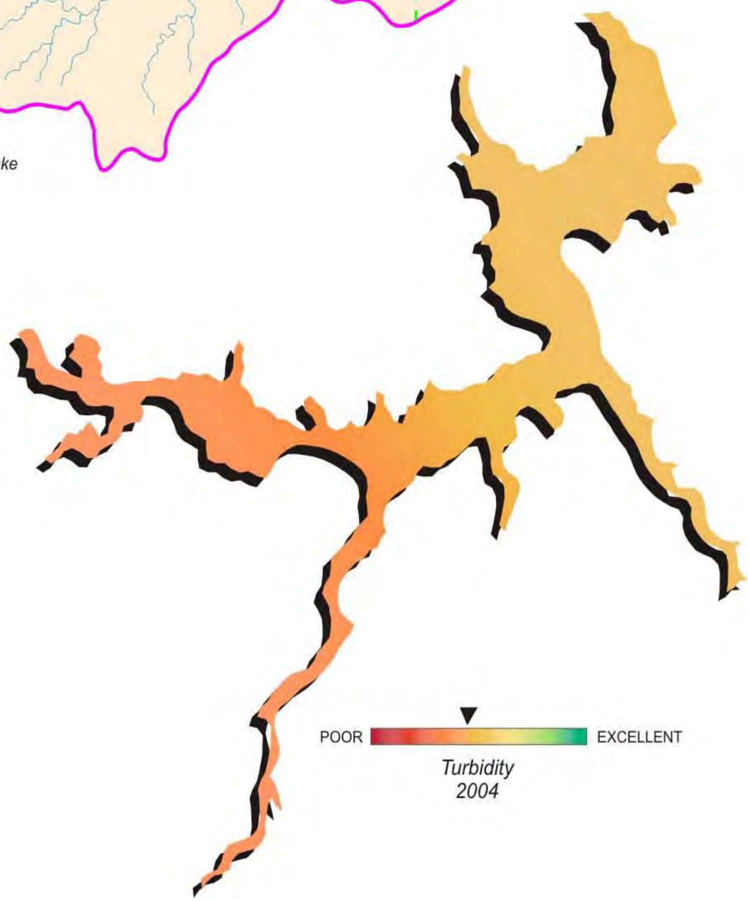
Lone Chimney Lake and Watershed

Lone Chimney Lake Location





Trophic State 2004



Turbidity 2004

Lake Data

Owner	Tri-County Dev. Auth.
County	Pawnee
Constructed in	1984
Surface Area	550 acres
Volume	6,200 acre/feet
Shoreline Length	17 miles
Mean Depth	11.27 feet
Watershed Area	26 square miles

Lugert-Altus Reservoir

Due to extreme drought and low lake Lugert-Altus Reservoir OWRB sraff were unable to access Lone Chiney lake during the 2006-2007 sample year. The following is the summary of the previous evaluation.

Lugert-Altus Reservoir was sampled for four quarters from September 2004 through June 2005. Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and at 0.5 meters from the lake bottom at site 1, the dam. The average lake wide turbidity was 23 NTU (Plate 71), true color was 18 units, and average secchi disk depth was 37 centimeters. Results are consistent with those observed in the 2003 evaluation. Based on these three parameters, Lugert-Altus Reservoir had fair water clarity. The trophic state index, using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=19). The result was a TSI of 59 (Plate 71), indicating the lake was eutrophic, bordering hypereutrophic, with high primary productivity and nutrient conditions in sample year 2005. The TSI values ranged from hypereutrophic in the fall and winter, eutrophic in the spring to mesotrophic in the summer. The steady increase in productivity over the last several years is likely the result of lower lake levels due to drought conditions. Seasonal turbidity values are displayed in Figure 91a. Turbidity values ranged from a low of 10 NTU to a maximum of 53 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if $\geq$ 25% of the samples exceed the screening level prescribed in the Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. With 30% of the samples exceeding 25 NTU, the beneficial use of Fish and Wildlife propagation (FWP) should be considered not supported in regards to turbidity. Seasonal true color values are displayed in Figure 91b. All color values were well below the aesthetics WQS of 70 units. Applying the same default protocol, the Aesthetic beneficial use is considered supported based on reported true color values.

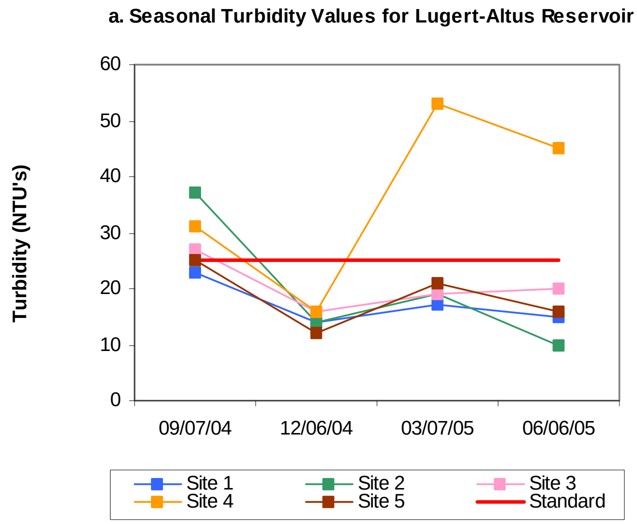
In 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all five sample sites. The salinity values for Lugert-Altus Reservoir ranged from 1.01 parts per thousand (ppt) to 1.29 ppt for this sample year. Specific conductivity ranged from 1866 to 2397 µS/cm, which is higher than most Oklahoma reservoirs. These values indicate the presence high levels of electrical current conducting compounds (salts) in the lake, consistent with higher salinity concentrations. The pH values were neutral to slightly alkaline, ranging from 7.67 in the winter to 8.22 in the fall. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range the lake is considered supporting the FWP beneficial use based on pH. Oxidation-reduction potentials ranged from 343 mV in the fall to 480 mV recorded in the hypolimnion during the fall, indicating reducing conditions were not present at the time of sampling. The water column was not stratified and was well mixed with dissolved oxygen (D.O.)

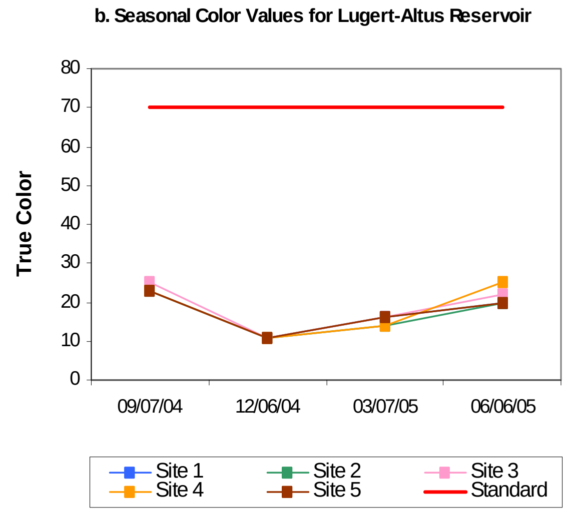
remaining above 5.0 mg/L during the winter, spring and summer sampling intervals (see Figure 91c-91e). Due to equipment failure no Hydrolab readings were recorded and an assessment of conditions during the fall quarter cannot be made. If D.O. values are less than 2 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With 100% of the collected values greater than 2.0 mg/L, the lake is fully supporting its FWP beneficial use based on dissolved oxygen. The lake was also sampled for chlorides, sulfates and total dissolved solids to assess the Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

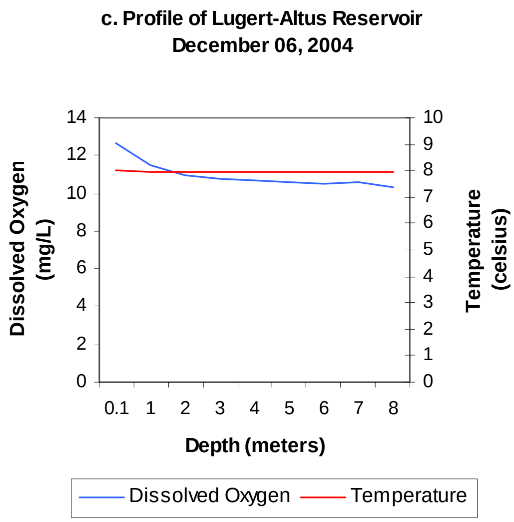
Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

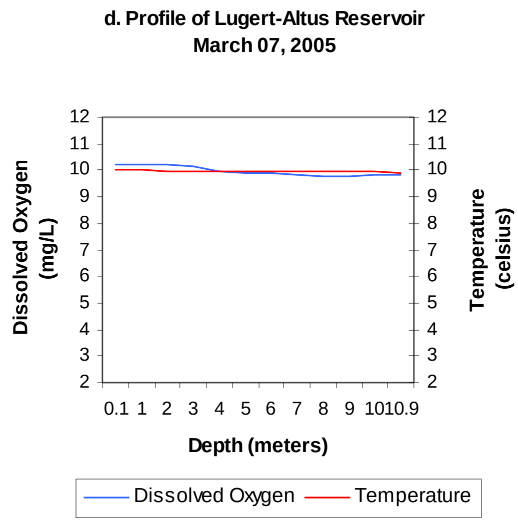
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.88 mg/L. The TN at the surface ranged from 0.69 mg/L to 1.17 mg/L in the upper reaches of the lake. Surface total nitrogen was highest in the winter and lowest in the summer. The lake-wide total phosphorus (TP) was 0.051 mg/L. The TP at the surface ranged from 0.031 mg/L to 0.084 mg/L. Similar to nitrogen, surface TP was highest in the winter and lowest in the summer. The nitrogen to phosphorus ratio (TN:TP) was 17:1 for sample year 2002-2003. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

In summary, Lugert-Altus Reservoir was classified as eutrophic bordering hypereutrophic, with high primary productivity and nutrient conditions in sample year 2005. The steady increase in productivity over the last several years is likely the result of lower lake levels due to drought conditions. Water clarity was fair based on turbidity, true color, and secchi disk depth. The lake is supporting its FWP beneficial use based on dissolved oxygen values and on pH, however with 30% of the turbidity values exceeding the WQS of 25 NTU, the FWP beneficial use is not supported as it relates to turbidity. The lake is currently supporting the Aesthetics beneficial use based on true color as well as trophic status (TSI=59). Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Lugert-Altus Reservoir is located in Greer County and is utilized for water supply, flood control, and irrigation purposes.









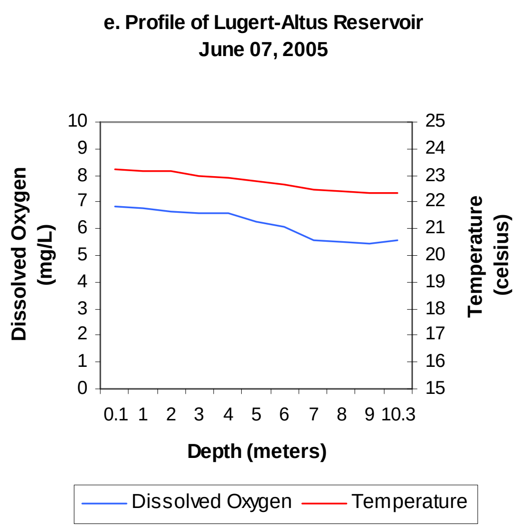


Figure 91a-91e. Graphical representation of data results for Lugert-Altus Reservoir.

Lake Data

Constructed by	Bureau of Reclamation
County	Greer
Constructed in	1948
Surface Area	6,260 acres
Volume	132,830 acre/feet
Shoreline Length	49 miles
Mean Depth	21.22 feet
Watershed Area	2,515 acres

Plate 71 - Lake Water Quality for

Lugert-Altus Lake

Maysville (Wiley Post) Lake

Maysville Lake was sampled for four quarters, from September 2004 through June 2005. Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at three sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide annual turbidity value was 63 NTU (Plate 128), true color was 102 units, and secchi disk depth was 22 centimeters in 2004-2005. Based on these three parameters, Maysville Lake had poor water clarity in comparison to other Oklahoma reservoirs and was slightly worse than reported in 2002. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 57 (Plate 128), classifying the lake as eutrophic, indicative of high levels of primary productivity and nutrients. This value is the same as that calculated in 2002, indicating no significant increase or decrease in productivity has taken place. The TSI values were fairly consistent with values in the eutrophic category in the first three sampling intervals and hypereutrophic during the summer. Site 5 showed the most variability ranging from hypereutrophic in the fall to mesotrophic in the winter. The turbidity values collected on this lake consistently exceeded the Oklahoma Water Quality Standard (WQS) of 25 NTU (Figure 92a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the samples collected exceeding the turbidity criteria, the Fish and Wildlife Propagation (FWP) beneficial use is considered not supported Maysville Lake. Seasonal true color values are displayed in Figure 92b. Of the twenty true color values collected 50% were above the numeric criteria of 70 units. Applying the same default protocol, the Aesthetics beneficial use is also considered not supporting for true color.

In 2004-2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.18 parts per thousand (ppt) to 0.27 ppt, which is within the expected range of salinity values, reported for most Oklahoma lakes. Readings for specific conductivity ranged from 324 cm/cm in the winter to 538.9 cm/cm in the summer, indicating the presence of moderate amounts of electrical current conducting compounds (salts) in the water column throughout the year. In general, pH values were neutral to slightly alkaline in nature, ranging from 7.46 units in the summer quarter to 8.29 units in the fall. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range the lake is considered supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (redox) ranged from 275 mV at the sediment-water interface in the summer to 567 mV in the fall quarter. Redox readings indicated that reducing conditions were not present in the reservoir at any point during the sample year. The lake was not thermally stratified in the fall, winter or spring quarters and dissolved oxygen (D.O.) values were above 6.0 mg/L (see Figure 92c-92e). In the summer the lake was strongly thermally stratified between 2 and 3 meters and also between 3 and 4 meters. In a lake that was only 4 meters deep when sampled in the summer quarter this was an unexpected occurrence. The water column at site 1 had only one D.O. reading less than 2.0 mg/L from 3 meters to the lake bottom accounting for anoxic conditions in 25% of the water column (see Figure 92f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (USAP 785:46-15-5). If D.O. concentration is less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at Maysville Lake although approximately 25% of the water column was anoxic at site 1 in the summer quarter. This is not a situation that is normally seen for such a shallow reservoir and can only be attributed to a long period of calm winds and/or a pattern where little rainfall occurred. The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.83 mg/L. The TN at the surface ranged from 0.48 mg/L in the spring to 1.26 mg/L in the summer quarter. The lake-wide total phosphorus (TP) average was 0.109 mg/L. The surface TP ranged from 0.064 mg/L in the summer quarter to 0.143 mg/L in the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 8:1 for sample year 2004-2005. This value is slightly greater than 7:1, characterizing the lake as phosphorus-limited or co-limited (Wetzel, 1983).

In summary, Maysville Lake was classified as eutrophic, indicative of high primary productivity and nutrient levels (Plate 128). This is identical to the 2002 evaluation, indicating no significant increase or decrease in productivity has taken place. Based on turbidity, true color, and secchi disk depth, Maysville Lake had poor water clarity in comparison to other Oklahoma reservoirs. With 100% of the turbidity values greatest than the WQS of 25 NTU, the FWP beneficial use is considered not supporting. The lake was fully supporting the FWP beneficial use based on pH and dissolved oxygen. The lake is fully supporting its Aesthetics beneficial use based on the lakes trophic status however the use is not supported in regards to true color, with half of the reported true color values exceeding the numerical criteria of 70 units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Maysville Lake was constructed in 1971 and is owned and operated by the City of Maysville and serves as a municipal water supply. The lake is also used for flood control and recreational purposes.

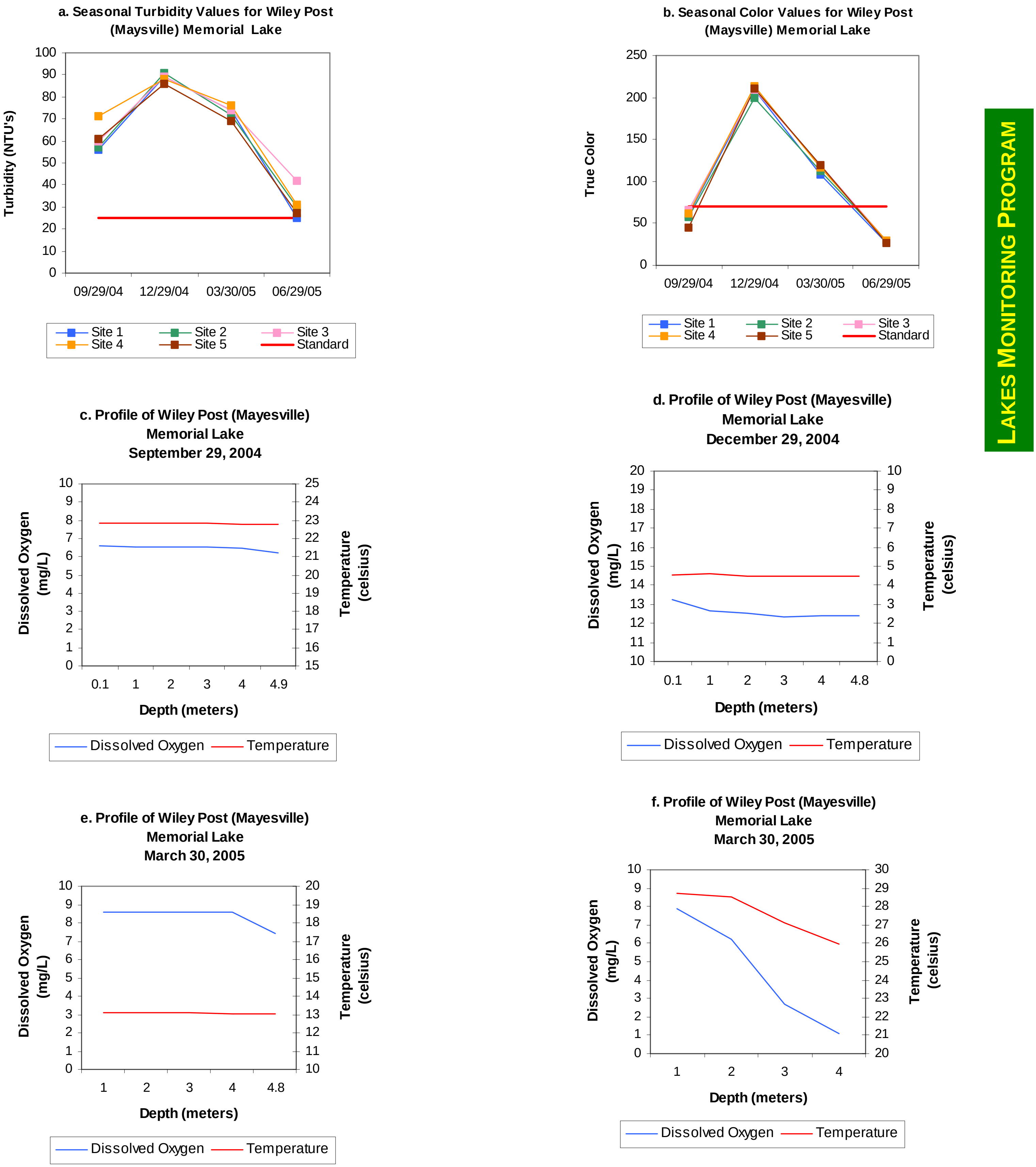
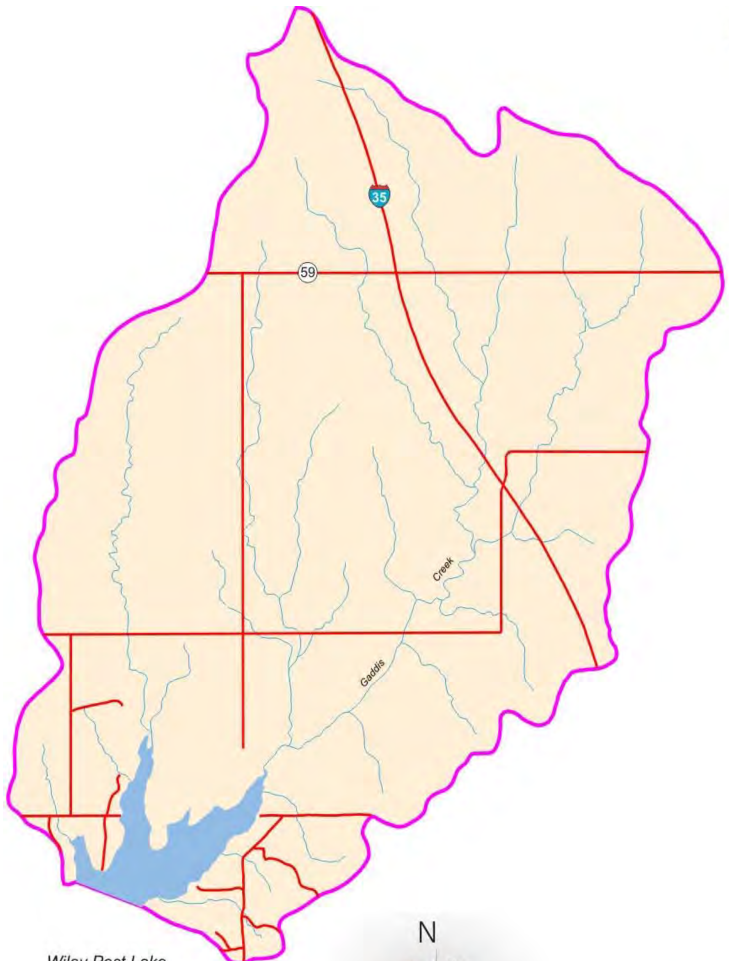
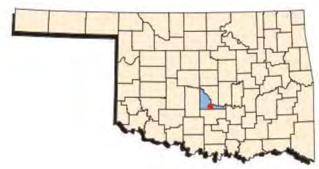


Figure 92a-92f. Graphical representation of data results for Maysville Lake.

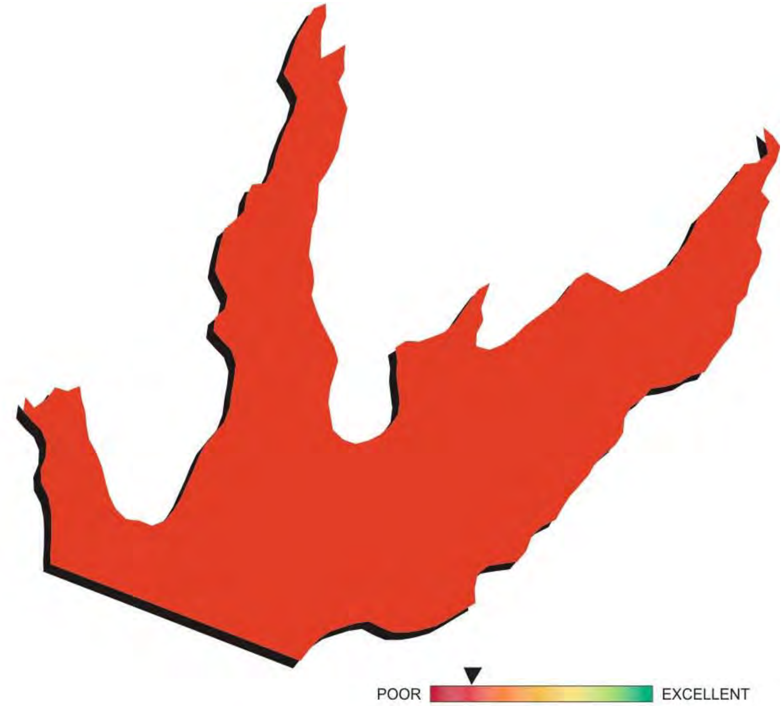
Plate 128 - Lake Water Quality for
Wiley Post (Maysville) Lake



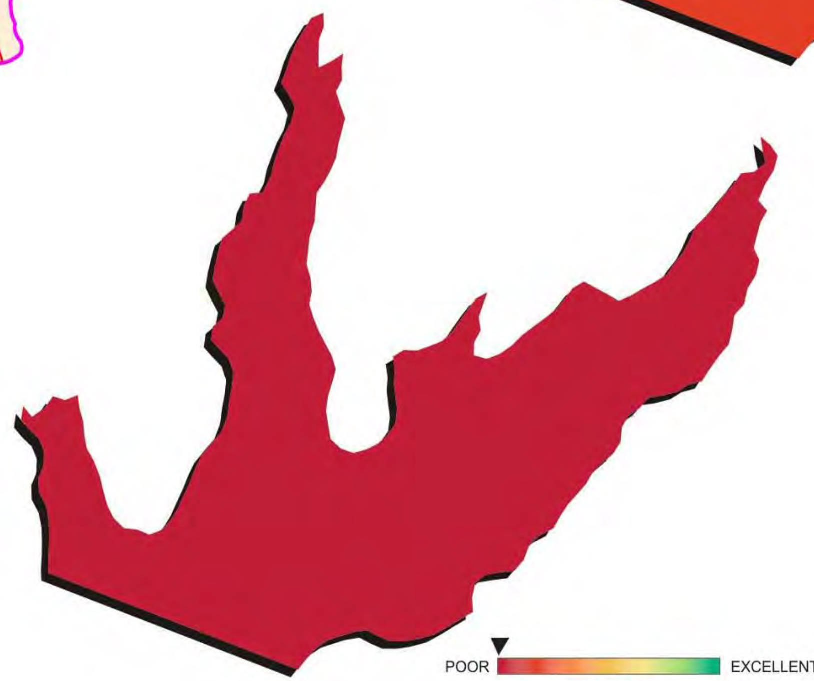
Wiley Post Lake and Watershed



Wiley Post Lake Location



Trophic State 2005



Turbidity 2005

Lake Data

Owner	City of Maysville
County	McClain
Constructed in	1971
Surface Area	302 acres
Volume	2,082 acre/feet
Shoreline Length	5 miles
Mean Depth	6.89 feet
Watershed Area	13 square miles

LAKES MONITORING PROGRAM

Lake McAlester

Lake McAlester was sampled for four quarters, from September 2004 through June 2005. Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide average turbidity value was 107 NTU (Plate 72), true color was 250 units, and secchi disk depth was 17 centimeters in 2005. Based on these three parameters, Lake McAlester had poor water clarity. This is consistent with historical observations and is likely always poor based on the soil composition. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 42 (Plate 72), classifying the lake as mesotrophic, indicative of moderate levels of productivity and nutrients. This value is similar to the one calculated in 2003 (TSI=42), and in the same trophic category, indicating no significant change in productivity has occurred. The high turbidity and true color values are probably the reason for the trophic state determination, as inorganic turbidity is a limiting factor in lake productivity. The TSI varied by site and season with values in both oligotrophic and mesotrophic categories the majority of the year. Turbidity values ranged from a low of 71 NTU to a maximum of 152 NTU (see Figure 93a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Due to a post-processing error turbidity was not run for any of the summer samples. Although 100% of the samples collected in 2005 exceeded the WQS of 25 NTU and assessment of the, Fish and Wildlife Propagation (FWP) beneficial use cannot be made due to minimum data requirements not being met. Based upon current and historical data sets, it is likely that the use would not be supported. Seasonal true color is displayed in Figure 93b. The Aesthetics beneficial use is not supported with all samples having a reporting of value of 250 units, greatly exceeding the WQS of 70.

In 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sites. Salinity values ranged from 0.01 parts per thousand (ppt) to 0.04 ppt. This is well within the average values reported for Oklahoma lakes. Specific conductivity ranged from 45 µS/cm to 100.5 µS/cm indicating that minimal concentrations of electrical current conducting compounds were present in the lake system. The pH values at Lake McAlester ranged from 6.32 in the summer to 8.28 in the hypolimnion in the spring, representing a slightly acidic to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With only 7.7% of the collected values outside the acceptable range the lake is considered to be supporting the beneficial use based on pH. Oxidation-reduction potential (ORP) ranged from 407 mV in the summer to 578 mV in the winter. Reducing conditions were not present at this reservoir with all values being positive and above 100 mV throughout the study period. In the winter, and spring quarters, stratification was not present and the lake was well mixed with dissolved oxygen (D.O.) levels generally above 5.0 mg/L (Figure 93d-93e). During both fall and summer quarters, thermal stratification was evident, however dissolved oxygen remained above 2.0 mg/L. (Figure 93c, 93f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at Lake McAlester based with all D.O. values above 2.0 mg/L. The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.94 mg/L. Surface TN ranged from 0.72mg/L to 1.06 mg/L, with the highest values reported in the spring and the lowest values in the fall. The lake-wide total phosphorus (TP) average was 0.140 mg/L. Total phosphorus at the surface ranged from 0.095 mg/L to 0.202 mg/L. Surface TP was highest in the winter and lowest during the spring quarter. This is the same as the 7:1 ratio used to determine the limiting nutrient, characterizing the lake as potentially phosphorus limited to co-limited (Wetzel, 1983).

In summary, Lake McAlester was classified as mesotrophic, indicative of moderate primary productivity and nutrient conditions (Plate 72). Similar conditions were found during the 2003 evaluation, indicating that no significant increase or decrease in productivity has occurred. Water clarity was poor based on true color, turbidity and secchi disk depth and is likely to always be poor based on the soil composition of the area. The lake is supporting the FWP beneficial use based on pH and on dissolved oxygen values recorded during the study period, however an assessment based on turbidity could not be made due to minimum data requirements not being met. High inorganic turbidity is a limiting factor in lake productivity, keeping nutrients at bay. The Aesthetics beneficial use is supported based on its trophic status, however it is not supported for true color with 100% of the values exceeding the WQS of 70 units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Lake McAlester is located in Pittsburg County and was constructed in 1930 for water supply and recreational purposes.

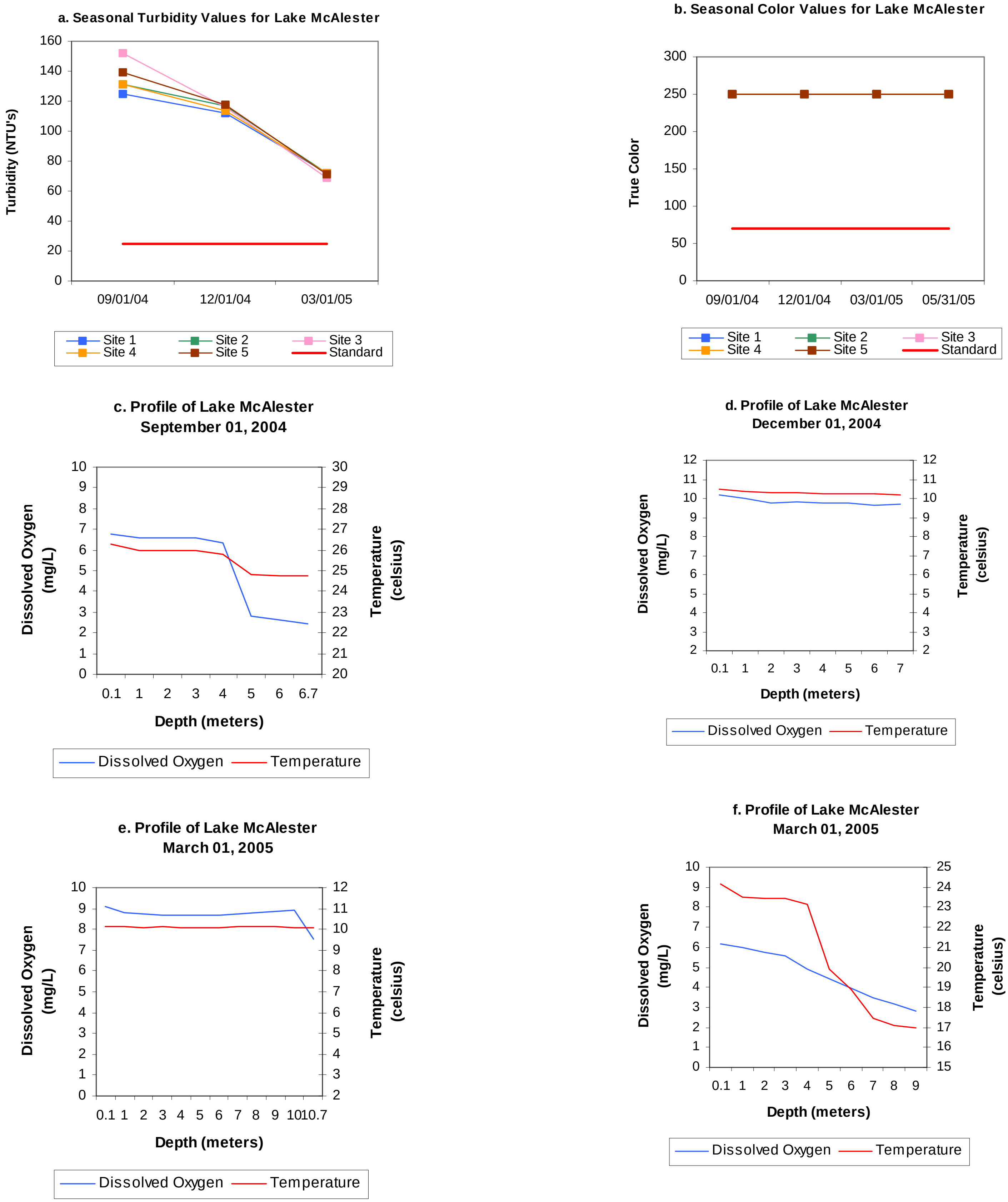
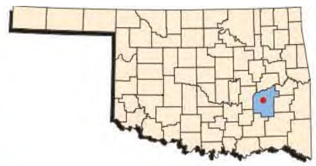
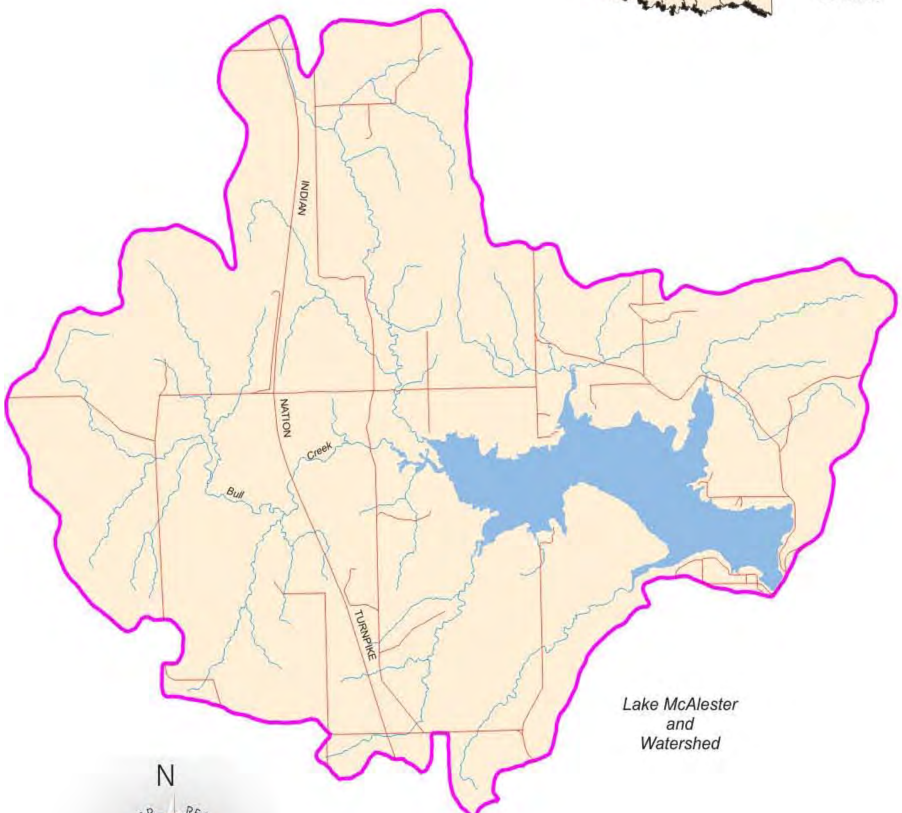
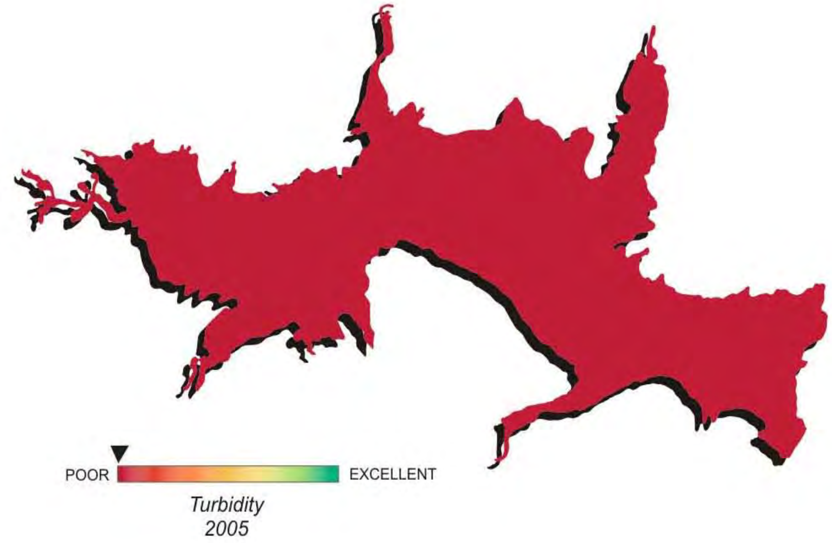


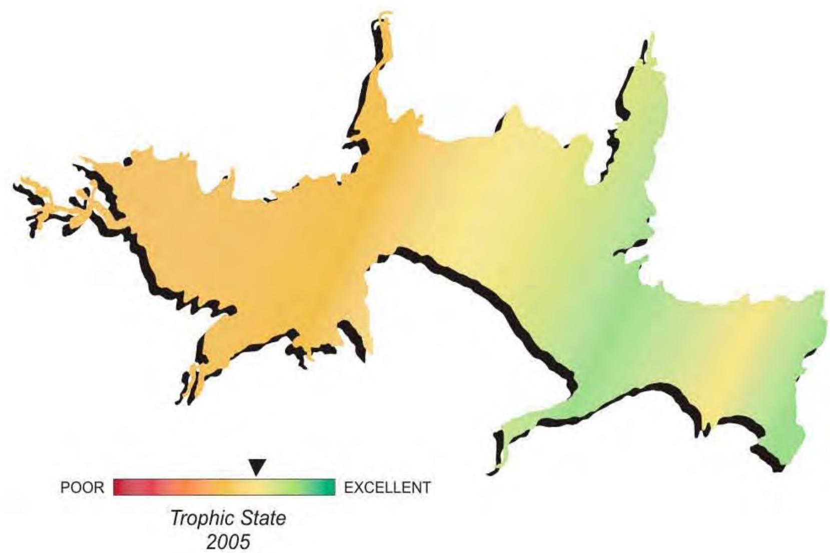
Figure 93a-93f. Graphical representation of data results for Lake McAlester.

Plate 72 - Lake Water Quality for
Lake McAlester









Lake Data

Owner	City of McAlester
County	Pittsburg
Constructed in	1930
Surface Area	1,521 acres
Volume	13,398 acre/feet
Shoreline Length	20 miles
Mean Depth	8.81 feet
Watershed Area	31 square miles

McGee Creek Lake

McGee Creek Lake was constructed in 1988 and is owned and operated by the Bureau of Reclamation. The lake serves as a municipal water supply source, flood control, fish & wildlife habitat, and offers many recreational opportunities for the citizens of Oklahoma. The City of Oklahoma City can transfer water from McGee Creek Lake to Lake Atoka and then pump that water to Lake Stanley Draper where it can be used by the citizens of Oklahoma City and its suburbs. McGee Creek Lake was sampled for four quarters, from October 2003 through July 2004.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir as well as major lake arms. Samples were collected from the lake surface during the sample year. The lake-wide annual turbidity value was 9 nephelometric turbidity units (NTU), true color was 52 units, and secchi disk depth was 132 centimeters. Based on these three parameters, McGee Creek Lake had good water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for all four quarters (n=20). The average TSI was 43 (Plate 73), classifying the lake as mesotrophic, indicative of low to moderate levels of primary productivity and nutrients. The TSI values varied seasonally with oligotrophic conditions primarily occurring in the fall and winter and mesotrophic conditions in the spring and summer sampling intervals. The most productive quarter observed in the lake was actually in the summer, where four of the five sites were classified as upper-mesotrophic. Site 2 had the highest chlorophyll-a value for the year at 9.81mg/m^3. Seasonal turbidity values ranged from a low of 3 NTU to a maximum of 35 NTU (see Figure 94a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). McGee Creek Lake is fully supporting its Fish & Wildlife Propagation (FWP) beneficial use as it relates to nephelometric turbidity. Seasonal true color values are displayed in Figure 94b. Only two of the true color values exceeded the numeric criteria of 70 units. Applying the same default protocol to determine the short-term average for true color, the Aesthetics beneficial use is fully supported based on the true color values.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all three sample sites. Salinity values ranged from 0.0 parts per thousand (ppt) to 0.03ppt; well within the expected range of salinity values reported for most Oklahoma lakes. Readings for specific conductivity were also extremely low, ranging from 0.6 µS/cm to 76.9 µS/cm, indicating the presence of little to no electrical current conducting compounds (salts) in the water column throughout the year. In general, pH values were slightly acidic to neutral, ranging from 5.58 in the summer quarter to 7.63 units at site 1 in the spring quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. With 41% of the recorded values less than 6.5, McGee Creek Lake is not supporting the FWP beneficial use as it relates to turbidity. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes;

therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Oxidation-reduction potentials (redox) ranged from -43 mV at the sediment-water interface in the fall quarter to 486 mV in the winter. Low redox readings like those present in the fall and summer are not unusual when a large portion of the water column is anoxic. The lake was thermally stratified and anoxic conditions were present in fall quarter between 12 and 13 meters below the lake surface at sites 1,2 and 5. Approximately 46 to 57% of the water column was experiencing dissolved oxygen (D.O.) concentrations below 1.0 mg/L at sites 1 and 5 respectively (see Figure 94c). McGee Creek was not thermally stratified in the winter quarter and D.O. values were above 7.0 mg/L throughout the water column (See Figure 94d). In the spring, the lake was strongly thermally stratified between 7 and 8 meters below the lake surface; however all D.O. concentrations remained above 6.0 mg/L throughout the water column at all sites (see Figure 94e). In the summer quarter, stratification occurred higher in the water column between 2 and 3 meters at which point dissolved oxygen was less than 2 mg/L to the lake bottom of 32 meters at site 1, the dam (Figure 94f). The same conditions were recorded at sites 2, 3, 4 and 5, with anoxic conditions present in 56 to 85% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. In the fall quarter up to 57% of the water column at sites 1, 2 and 5 had dissolved oxygen readings of less than 2.0 mg/l. During the summer anoxic conditions were present at all sites with 85% of the water column having dissolved oxygen levels less than 2 mg/L. McGee Creek Lake is considered not supporting its FWP beneficial use based on low D.O. readings in the water column. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. Of the 10 samples none exceeded the prescribed screening level or geometric mean for any of the three parameters. The PBCR beneficial use is therefore considered supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.47 mg/L at the lake surface. The TN at the surface ranged from 0.27 mg/L in the fall quarter to 0.82 mg/L in the winter. The lake-wide total phosphorus (TP) average was 0.018 mg/L at the lake surface. The surface TP ranged from 0.011 mg/L in the fall to 0.042 mg/L also recorded in the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 26:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

McGee Creek Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, McGee Creek Lake was classified as mesotrophic, indicative of low to moderate primary productivity and nutrient levels in 2006-2007 (Plate 73). Water clarity continues to be good at this reservoir based on turbidity, true color and secchi disk depth. The lake was fully supporting its FWP based on turbidity readings, however is not supported based on anoxic conditions present in a large portion of the water column during both the fall and summer quarters. With 41% of the pH values recorded below 6.5 units the FWP beneficial is considered not supported. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. The Aesthetics beneficial use is fully supported based trophic status and true color readings with 90% of the values being below the WQS of 70 units. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. The PBCR beneficial use is considered supported as the screening level and geometric means for each parameter were not exceeded. In 1997 the Oklahoma Legislature directed the OWRB to conduct a study on the impact of Confined Animal Feeding Operations (CAFO) in watersheds that supply potable water to municipalities with a population over 250,000. As part of this study a bathymetric survey was completed on Oklahoma City's water supply reservoirs. A bathymetric map (Figure 95) was generated to determine current storage capacity and identify areas of extreme sedimentation. For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.

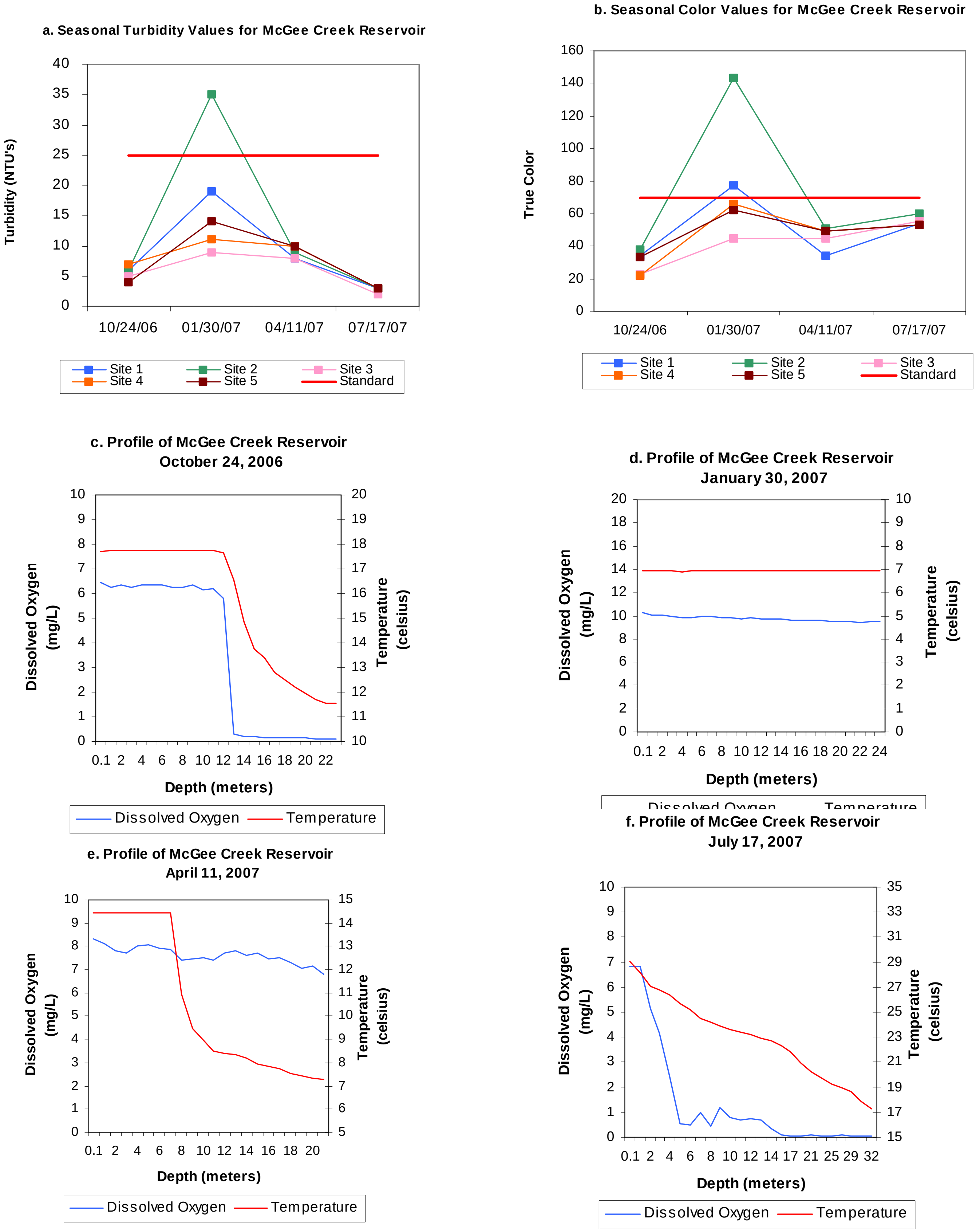
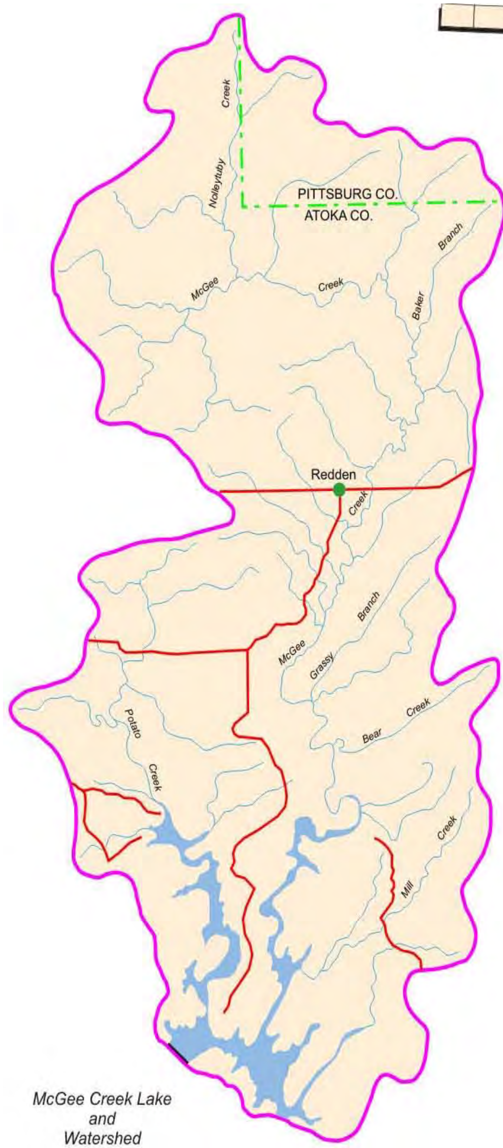


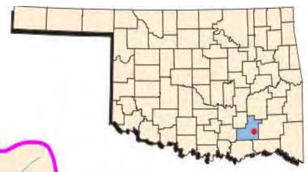
Figure 94a-94f. Graphical representation of data results for McGee Creek Lake.

Plate 73 - Lake Water Quality for

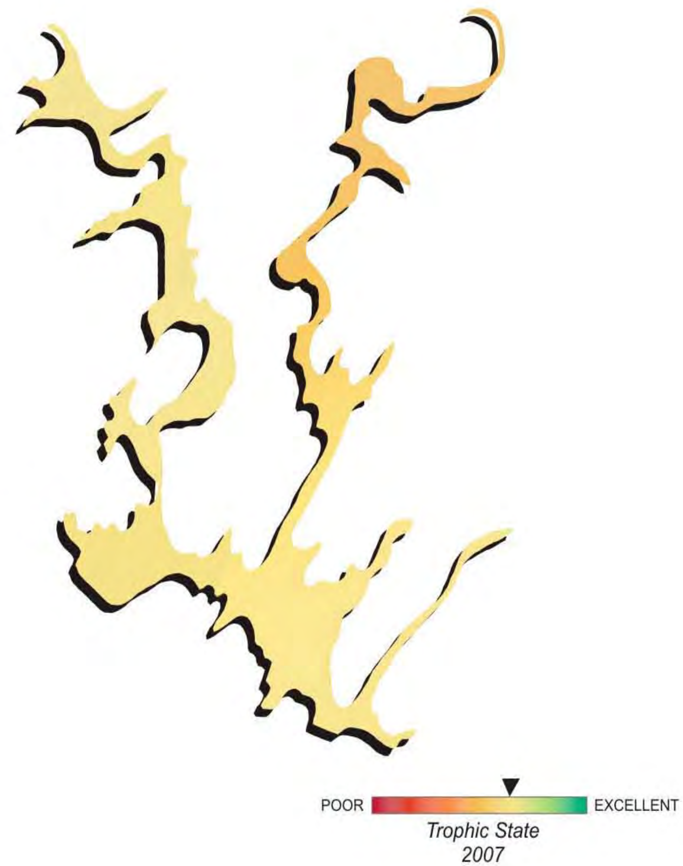
McGee Creek Lake

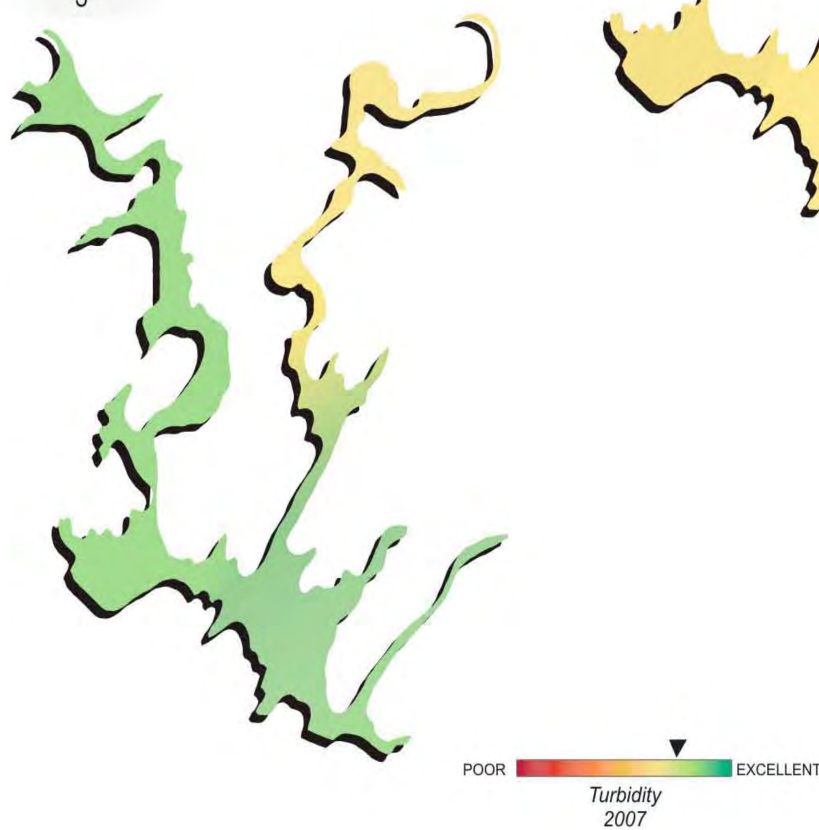


McGee Creek Lake and Watershed



McGee Creek Lake Location





Lake Data

Constructed by	Bureau of Reclamation
County	Atoka
Constructed in	1987
Surface Area	3,709 acres
Volume	100,146 acre/feet
Shoreline Length	80 miles
Mean Depth	26.9 feet
Watershed Area	178 square miles

LAKES MONITORING PROGRAM

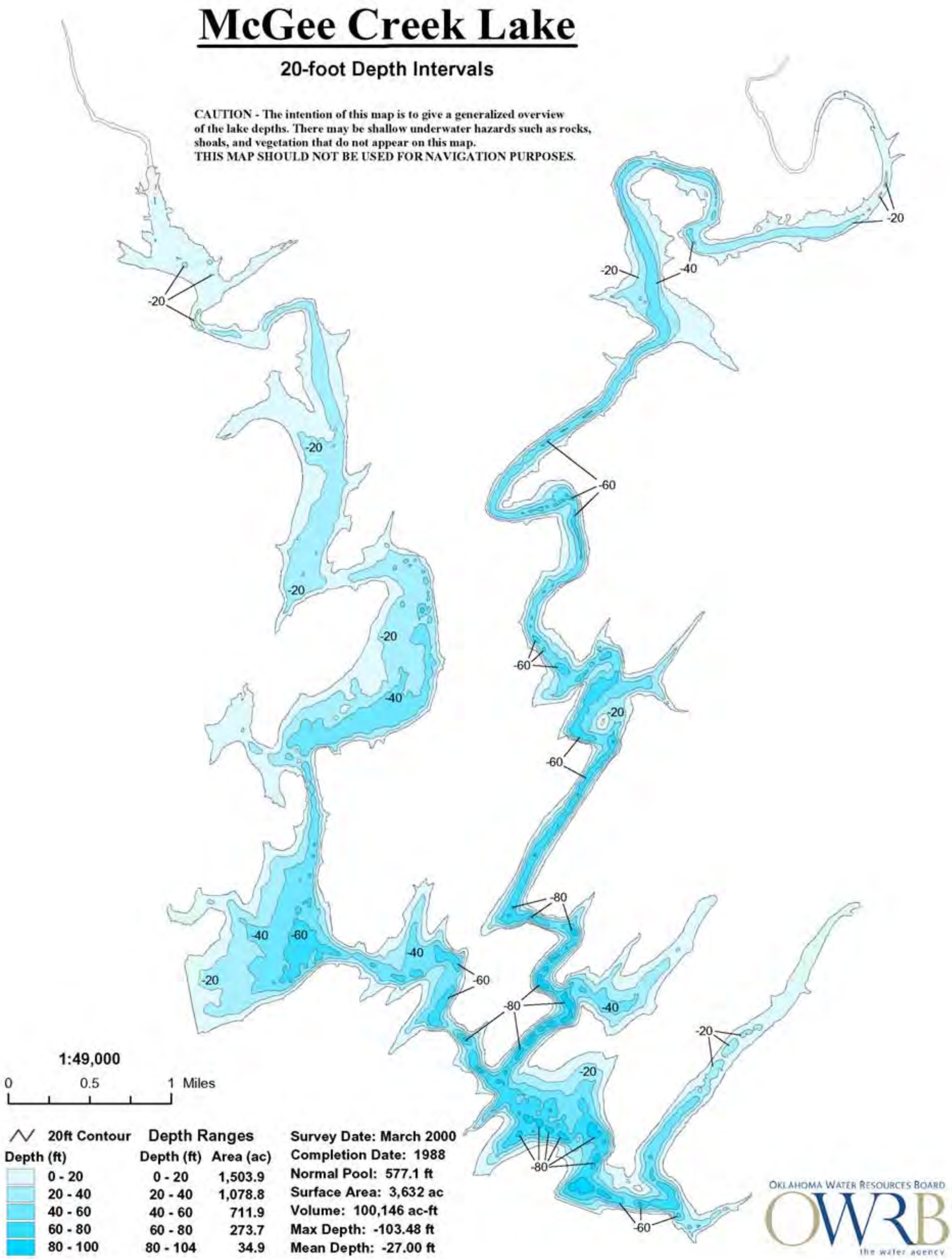


Figure 95. Bathymetric map of McGee Creek Reservoir.

Lake McMurtry

Lake McMurtry was sampled for four quarters from September 2004 through June 2005. Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir as well as any major lake arms. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide annual turbidity value was 17 NTU (Plate 74), true color was 17 units, and secchi disk depth was 73 centimeters in 2005. Based on these three parameters, Lake McMurtry had average water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 47 (Plate 74), classifying the lake at the upper end of mesotrophy, indicative of moderate levels of primary productivity and nutrients. The TSI values were primarily mesotrophic with eutrophic condition present during the fall quarter. The only exception to this was site 1, which had low chlorophyll-a values reported in both winter and spring quarters, placing the site in the oligotrophic category in two of the four sampling intervals. Seasonal turbidity values are displayed in Figure 96a. Of the twenty values collected, only two were greater than the Oklahoma Water Quality Standard (WQS) of 25 NTU. These values were collected at sites 3 and 5 at the upper end of the lake in the fall quarter (see Figure 96a). According to the Use Support Assessment Protocols (USAP) specified in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With only 20% of the samples collected above the standard the lake is partially fully supporting its Fish & Wildlife Propagation (FWP) use based on nephelometric turbidity. Seasonal true color values are displayed in Figure 96b. All true color values well below the WQS of 70 units in sample year 2004-2005. Applying the same default protocol, the Aesthetics beneficial use is considered supported.

In 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.16 parts per thousand (ppt) to 0.23ppt, indicating low to moderate salt content. Collected values were well within the range of salinity values reported for most Oklahoma lakes. Readings for specific conductivity were also within the range of normally encountered values, ranging from 320.3 µS/cm in the fall to 449.2 µS/cm in the summer, indicating moderate presence of electrical current conducting compounds (salts) in the water column throughout the year. In general, pH values were neutral to slightly alkaline with values ranging from 7.43 to 8.39. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range, the FWP beneficial is considered supported based on pH. Oxidation-reduction potentials (redox) ranged from 126 mV in the fall to 430 mV in the winter quarter, indicating an absence of reducing conditions during the study period. Lake McMurtry was not thermally stratified in the winter or spring quarters and dissolved oxygen (D.O.) values were above 7.5 mg/L throughout the water column (see Figure 96d-96e). In the fall quarter the lake was only stratified near the lake bottom and only two D.O. values were below 2.0 mg/L (see Figure 96e). In the summer, the lake was thermally stratified between 5 to 6 meters in depth, however D.O. was only below 2.0 mg/L from 9 meters to the lake bottom of 10.5 meters (see Figure 96f). If D.O. values are less than 2.0 mg/L for greater than 70% of the lake volume, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at Lake McMurtry with 14% of the water column in the fall and 18% in the summer below 2.0 mg/L. The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.48 mg/L at the lake surface. The TN at the surface ranged from 0.34 mg/L to 0.81 mg/L. The highest surface TN value was reported in the spring quarter and the lowest was in the winter quarter. The lake-wide total phosphorus (TP) average was 0.023 mg/L at the lake surface. The surface TP ranged from 0.019 mg/L to 0.034 mg/L. The highest surface TP value was reported in the summer quarter and the lowest was in the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 21:1 for sample year 2004-2005. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

In summary, Lake McMurtry was classified as upper mesotrophic, indicative of moderate primary productivity and nutrient levels (Plate 74). Water clarity was average based on turbidity, true color and secchi disk depth. The lake was fully supporting its FWP beneficial use based on dissolved oxygen and pH and partially supporting the use based on turbidity with 20% of the values exceeding the WQS of 25 NTU. The lake was fully supporting its Aesthetics beneficial use based on true color and lake trophic status. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Lake McMurtry was constructed in 1971 and is owned and operated by the City of Stillwater. The lake is used as a municipal water supply and for flood control and recreational purposes.

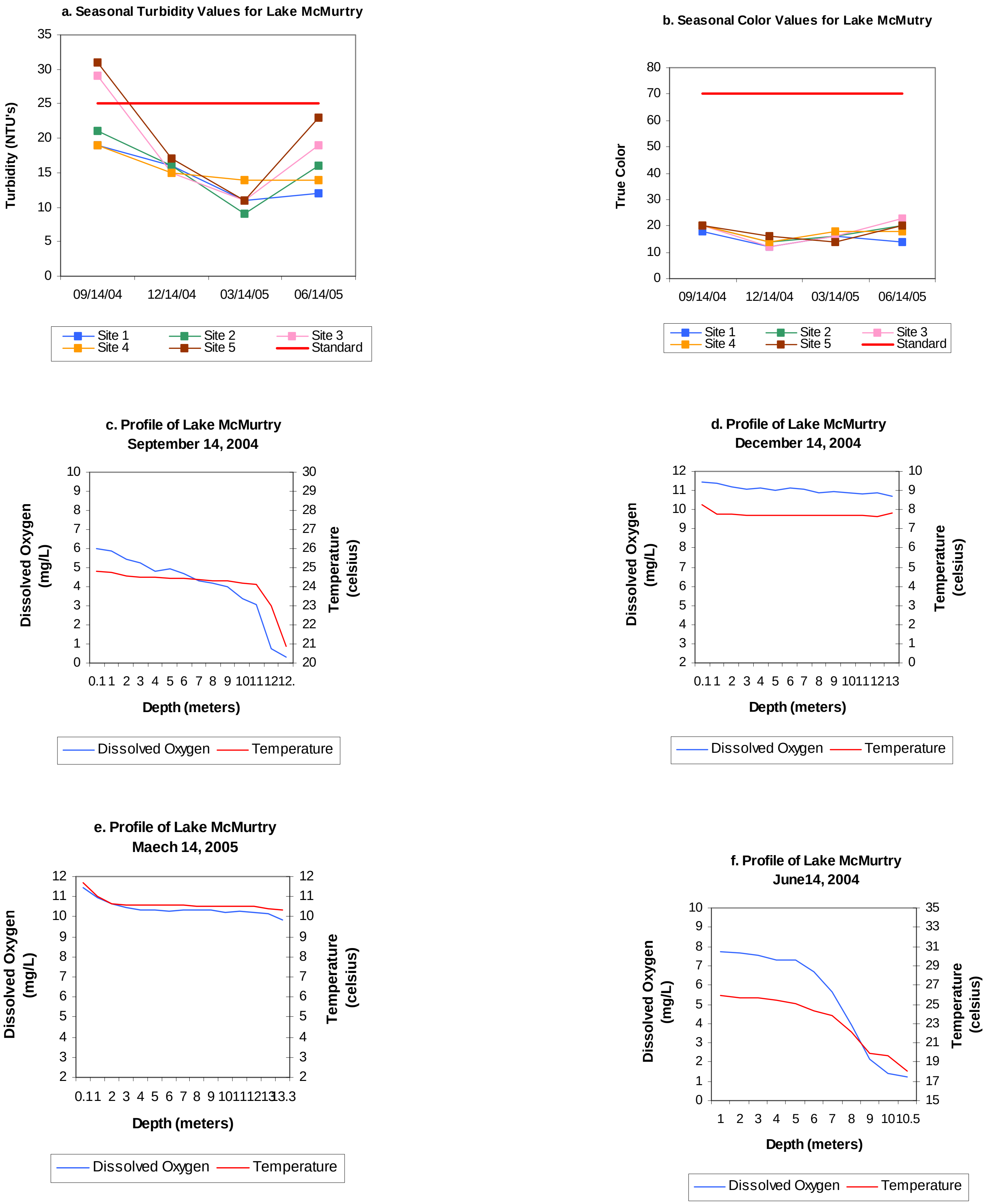
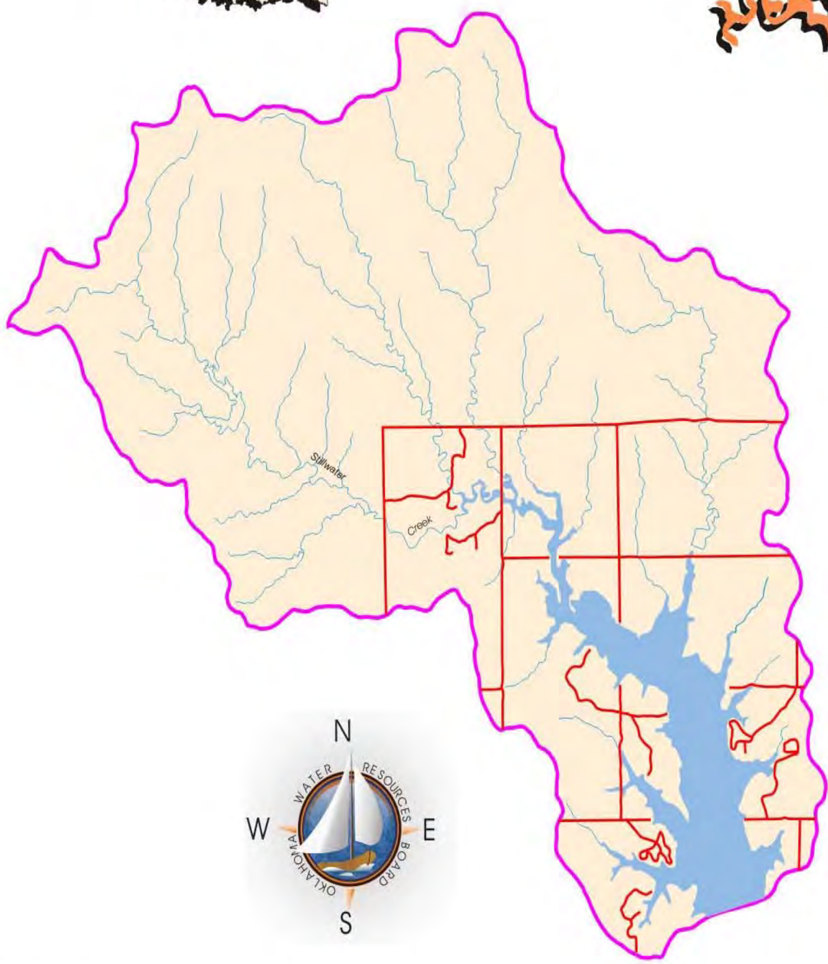


Figure 96a-96f. Graphical representation of data results for Lake McMurtry.

LAKES MONITORING PROGRAM

Plate 74 - Lake Water Quality for
Lake McMurtry

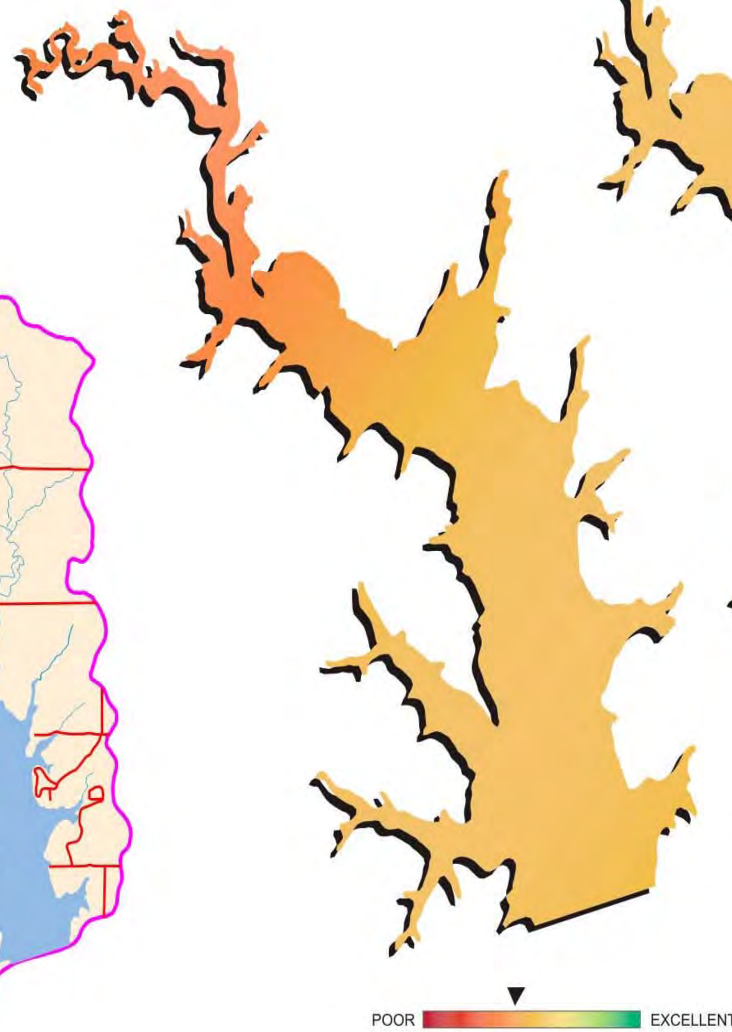

McMurtry Lake Location



McMurtry Lake and Watershed

Lake Data

Owner	City of Stillwater
County	Noble
Constructed	1971
Surface Area	950 acres
Volume	19,733 acre/feet
Shoreline Length	28 miles
Mean Depth	17.08 feet
Watershed Area	25 square miles



Turbidity 2005

Trophic State 2005

Meeker Lake

Meeker Lake, located in Lincoln County, was constructed in 1970 and is owned and operated by the City of Meeker. The lake is utilized as a municipal water supply, for flood control, and for recreational purposes. Meeker Lake was sampled for four quarters, from October 2005 through August 2006.

Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 48 NTU (Plate 75), true color was 43 units, and secchi disk depth was 39 centimeters. Results are almost identical to that observed in 2004. Based on these three parameters, Meeker Lake had fair to poor water clarity when compared to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 50 (Plate 75), classifying the lake as mesotrophic bordering eutrophic, indicative of moderate to high levels of primary productivity and nutrients. The TSI values were fairly consistent with mesotrophic conditions in the fall and winter and eutrophic during the spring and summer quarters. Of the twelve values collected, nine of the turbidity values in 2005-2006 were above the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 97a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 75% of the collected turbidity values exceeding the criteria the lake is not meeting its Fish & Wildlife Propagation (FWP) beneficial use based on nephelometric turbidity. Seasonal true color values are displayed in Figure 97b. Although all sites were near the standard in the fall, none of the true color values recorded exceeded the WQS of 70 units; therefore the Aesthetics beneficial use is considered fully supported.

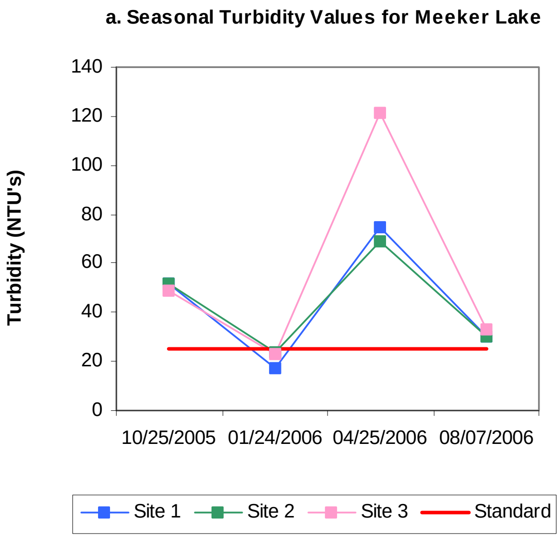
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values were 0.12 parts per thousand (ppt) to 0.36 ppt throughout the study period, indicating minimal salt content and within the expected range of salinity values reported for most Oklahoma lakes. Readings for specific conductivity were also within the expected range of values reported for most Oklahoma lakes, ranging from 253.2 µS/cm to 705.4 µS/cm, indicating the presence of minimal concentrations of electrical current conducting compounds (salts) in the water column. In general, pH values were neutral to slightly alkaline with values ranging from 7.67 units in the summer to 8.72 in the spring quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range the lake is fully supporting its FWP beneficial use based on pH. Oxidation-reduction potentials (redox) ranged from 37 mV in the hypolimnion during the summer winter to 451 mV in the winter quarter, indicating an absence of reducing conditions in the water column during any of the sampling events. Meeker Lake was not thermally stratified in the fall, winter, or spring quarters and dissolved oxygen (D.O.) values were above 6.0 mg/L throughout the water column in all three seasons (see Figure 97c-97e). In the summer the lake was thermally stratified between 2 and 3 meters with D.O. falling below 2.0 mg/L from 5 meters below the surface to the lake bottom of 6.4 meters (see Figure 97f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered fully supported at Meeker Lake with only 38% of the water column experiencing anoxic conditions in the summer. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

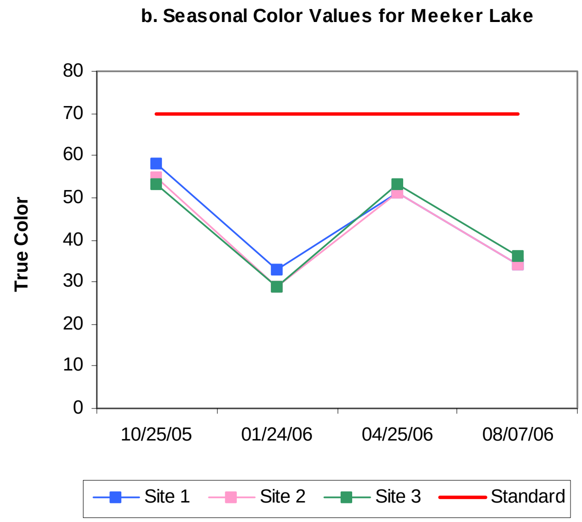
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

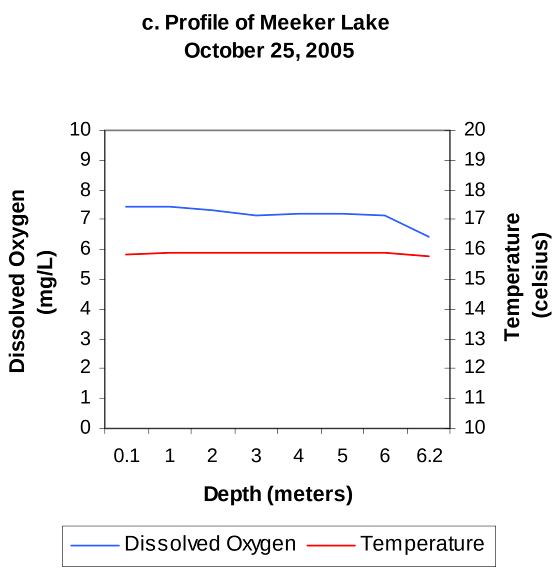
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) was 0.63 mg/L at the lake surface. The TN at the surface ranged from 0.50 mg/L to 0.89 mg/L. The highest surface TN value was reported in the fall quarter while lowest values were reported during the spring sampling interval. The lake-wide total phosphorus (TP) average was 0.047 mg/L at the lake surface. The surface TP ranged from 0.027 mg/L to 0.090 mg/L. The highest surface TP value was reported in the spring quarter and the lowest was in the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 13:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

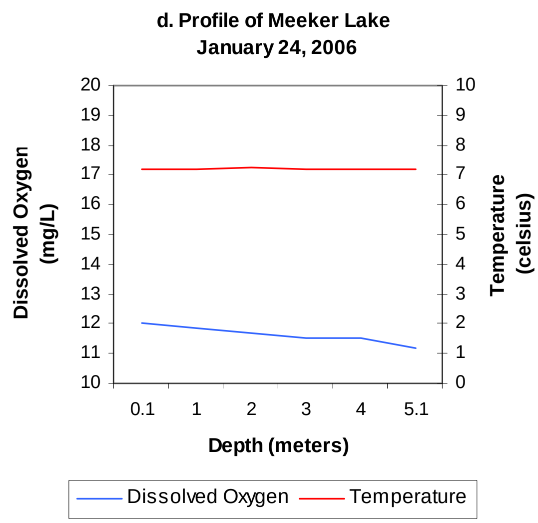
Meeker Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

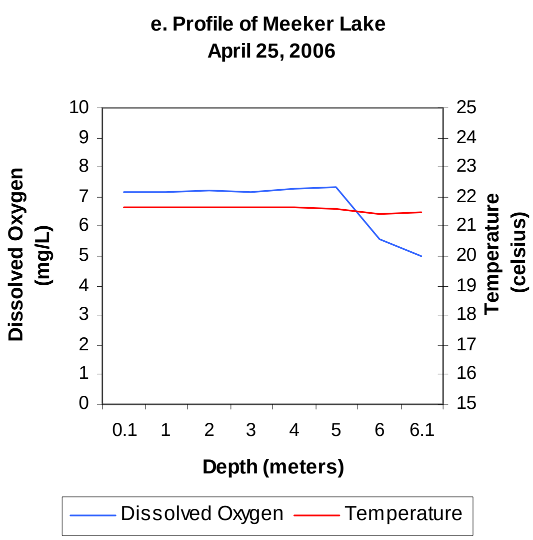
In summary, Meeker Lake was classified as mesotrophic (TSI=50) bordering eutrophic, indicative of moderate to high levels of primary productivity and nutrients (Plate 65). Water clarity is fair to poor based on turbidity, true color and Secchi disk depth. The lake is fully supporting its Aesthetics beneficial use based on its trophic state as well as true color with 100% of the values below the WQS of 70 units. The lake is fully supporting its FWP beneficial use based on pH and D.O. concentrations recorded in the water column, however it is not supporting the use based on high nephelometric turbidity concentrations in the lake. Meeker Lake is one of Oklahoma's more turbid reservoirs. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.











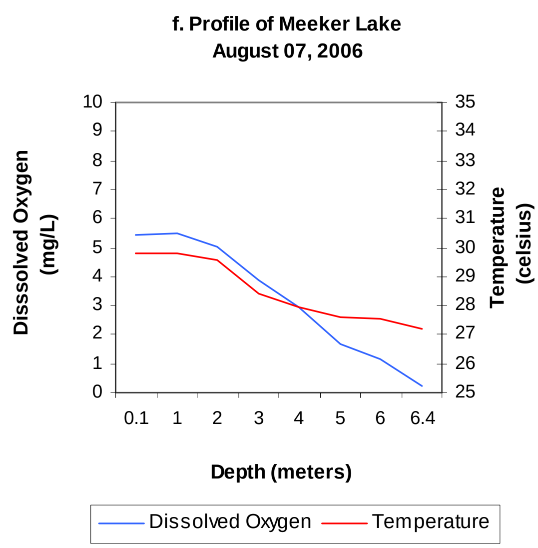
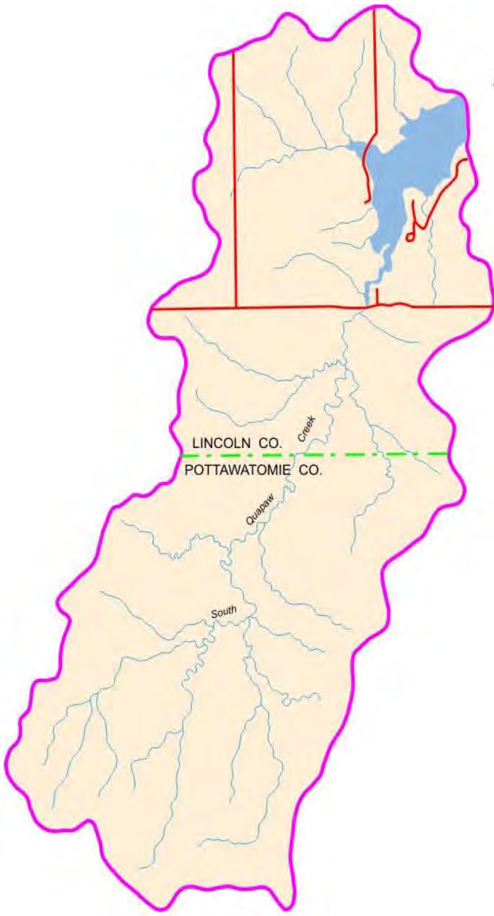
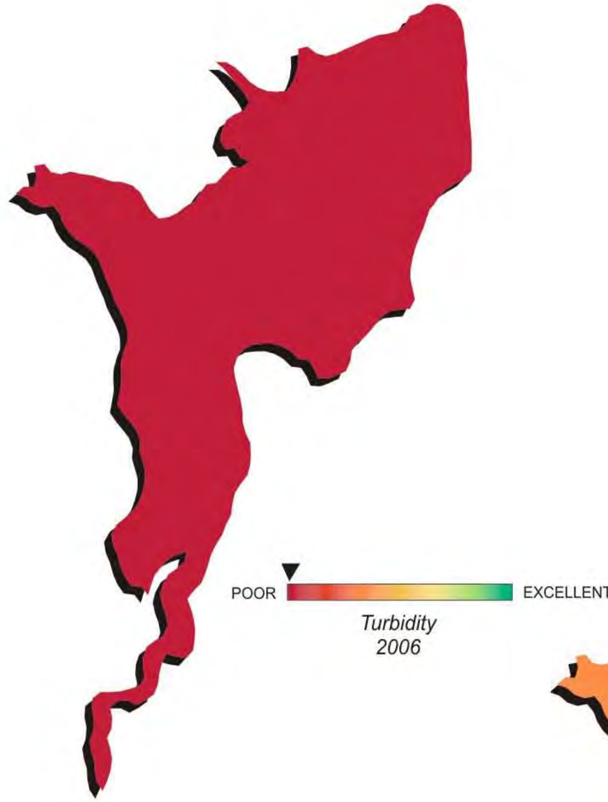


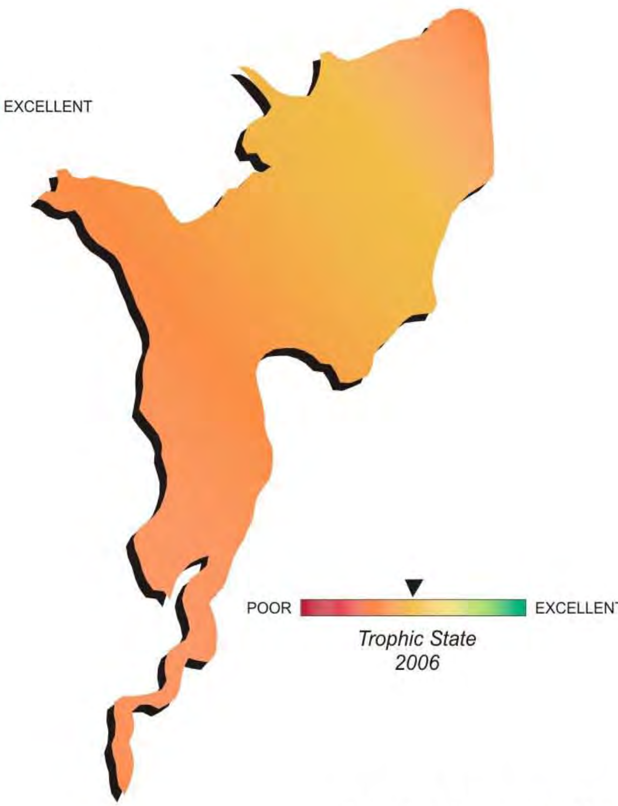
Figure 97a-97f. Graphical representation of data results for Meeker Lake.

Plate 75 - Lake Water Quality for

Meeker Lake







Lake Data

Owner	City of Meeker
County	Lincoln
Constructed in	1970
Surface Area	250 acres
Volume	1,818 acre/feet
Shoreline Length	5 miles
Mean Depth	7.27 feet
Watershed Area	12 square miles

LAKES MONITORING PROGRAM

Lake Murray

Lake Murray, located in Love County is owned by the State of Oklahoma and is utilized for recreational purposes. Lake Murray and the state park surrounding it are one of the state's nicer recreational get aways. Lake Murray was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones and major arms of the reservoir. Samples were collected from the lake surface at all sites during the sample year. The lake-wide annual turbidity value was 4 NTU (Plate 76), true color was 12 units, and secchi disk depth was 184 centimeters. Based on these three parameters, Lake Murray had excellent water clarity in sample year 2006. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 36 (Plate 76), classifying the lake as oligotrophic, indicative of low levels of productivity and nutrients. This value is consistent with the one calculated in 2004 (TSI=34) indicating no change in productivity since previous data collection efforts. The TSI values were consistently oligotrophic in all seasons, with the exception of site 5 in the summer, which was borderline mesotrophic. All turbidity values were below the Oklahoma Water Quality Standard (WQS) of 25 NTU ranging from a low of 1 NTU to a maximum of 5 NTU (Figure 98a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the collected turbidity values well below the criteria, the lake is meeting its Fish & Wildlife Propagation (FWP) beneficial use based on nephelometric turbidity. Seasonal true color values are displayed in Figure 98b. Similar to turbidity 100% of the true color values were below the WQS of 70 units. Applying the same default protocol, the Aesthetic beneficial use is considered fully supported at Lake Murray.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values were 0.11 parts per thousand (ppt) to 0.15 ppt. Readings indicate low to moderate salt content and are within the expected range of salinity values reported for most Oklahoma lakes. Readings for specific conductivity were also within the expected range of values reported for most Oklahoma lakes, ranging from 230 µS/cm to 311.9 µS/cm, indicating the presence of low to moderate concentrations of electrical current conducting compounds (salts) in the water column. In general, pH values were neutral to slightly alkaline with values ranging from 7.16 units in the spring to 8.34 in the summer quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range the lake is fully supporting its FWP beneficial use based on pH. Oxidation-reduction potentials (redox) ranged from 147 mV in the summer to 496 mV in the fall quarter, indicating an absence of reducing conditions during any of the sampling period. Lake Murray was not thermally stratified in the fall or winter quarters and dissolved oxygen (D.O.) values were above 7.0 mg/L throughout the water column (see Figure 98c-98d). Thermal stratification was gradual in the spring quarter between 9 and 10 meters in depth, with dissolved oxygen remaining well above 2.0 mg/L except at the very bottom at sites 1 and 4 (Figure 98e). In the summer the lake was thermally stratified at several 1-meter intervals and anoxic conditions were present in a large portion of the water column. Below the thermocline D.O. values were less than 2.0 mg/L, extending from 11 meters below the surface to the lake bottom of 28.7 meters at site 1, the dam (see Figure 98f). The same pattern was observed at site 2 with 48% of the water column less than 2.0 mg/L. Due to equipment failure the profile was unable to be completed at site 3-5. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With 70% of the water column experiencing anoxic conditions in the summer quarter, Lake Murray is partially supporting the FWP beneficial use based on dissolved oxygen values. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) was 0.27 mg/L at the lake surface during the study period. The TN at the surface ranged from 0.20 mg/L to 0.36 mg/L. The highest TN value was reported in the winter quarter and lowest surface TN value was reported in the fall quarter. The lake-wide total phosphorus (TP) average was 0.017 mg/L at the lake surface. The surface TP ranged from 0.008 mg/L to 0.026 mg/L. Similar to TN, the highest a TP value was reported in the winter however the lowest occurred in the fall quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 16:1 for sample year 2003-2004. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 1998 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening level or consumption advisory level. The ODEQ re-sampled the lake in 2004 and found Mercury residue in largemouth bass exceeding both the ODEQ detection limit and screening level, however no species was found to be exceeding the ODEQ advisory level. Lake Murray was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Lake Murray was classified as oligotrophic, with low primary productivity and nutrient conditions (Plate 76). This value is consistent with the one calculated in 2004 (TSI=34) indicating no change in productivity since previous data collection efforts. Water clarity continues to be excellent at this reservoir based on turbidity, true color and secchi disk depth. The FWP beneficial use is fully supported based on turbidity and pH, however the lake is partially supporting the use with anoxic conditions present in 70% of the water column during the summer. The Aesthetic beneficial use is considered fully supported based on trophic status and low true color values reported during the study period. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported. In 2001, a bathymetric survey (Figure 99) was conducted to determine current storage capacity and volume as well as create a database for future determination of sedimentation and assesses shoreline exposure during lake level fluctuations. The data collected was also used to create a water usage plan for the reservoir. For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.

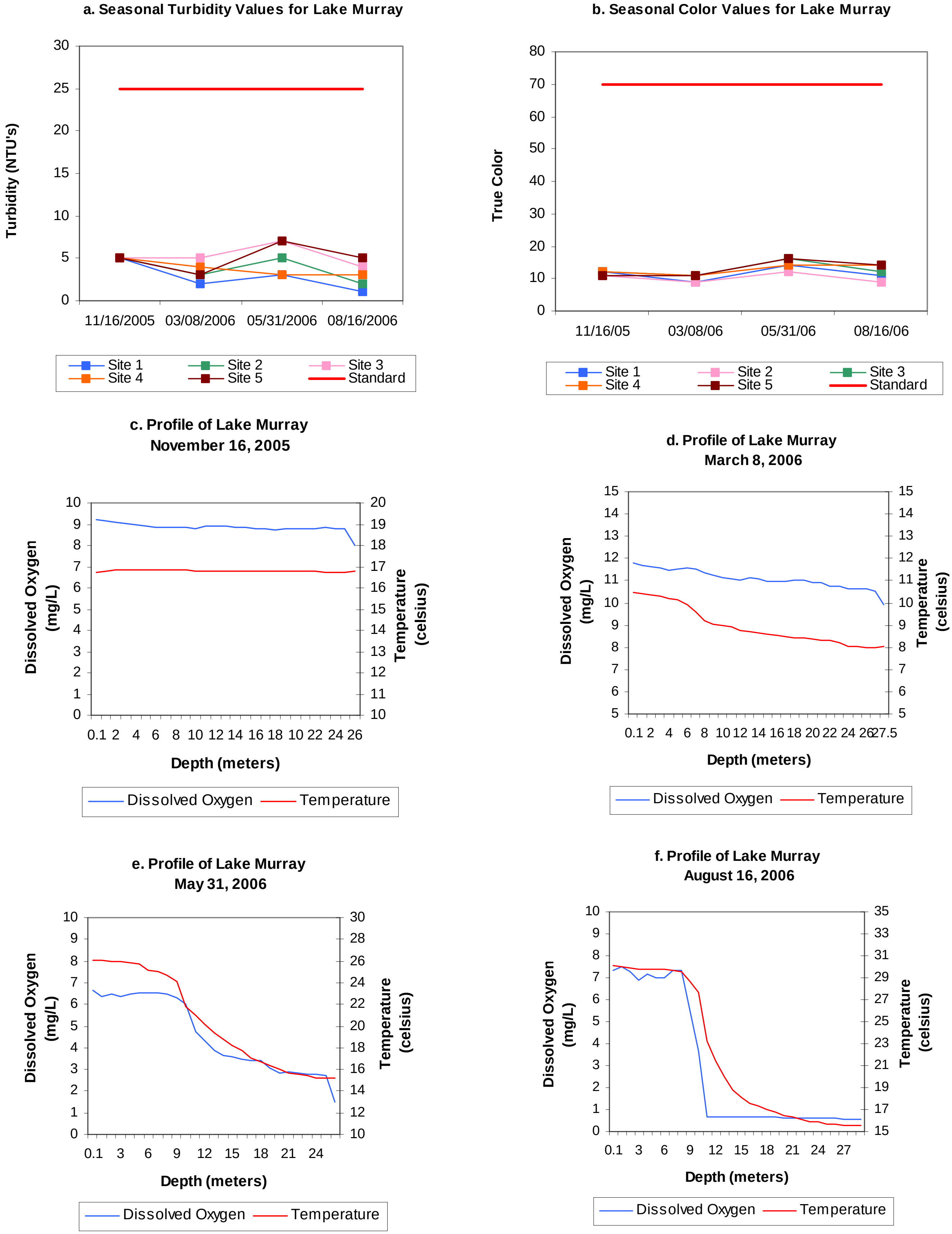


Figure 98a-98f. Graphical representation of data results for Lake Murray.

Plate 76- Lake Water Quality for
Lake Murray

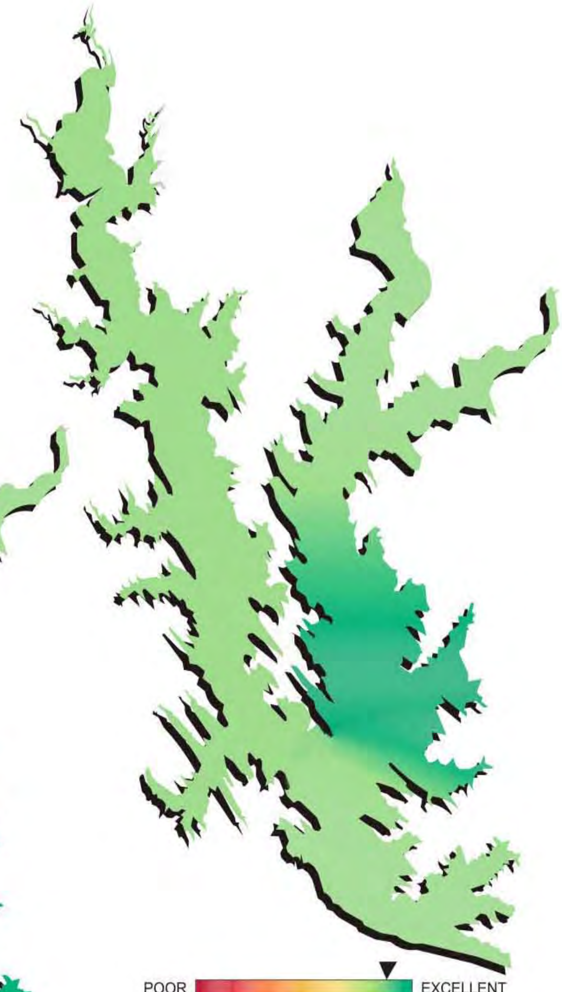
Lake Murray and Watershed

Lake Murray Location

Lake Data

Owner	State of Oklahoma
County	Love (Dam)
Constructed	1960
Surface Area	5,728 acres
Volume	153,250 acre/feet
Shoreline Length	67 miles
Mean Depth	26.75 feet
Watershed Area	55 square miles

Turbidity 2006



Trophic State 2006

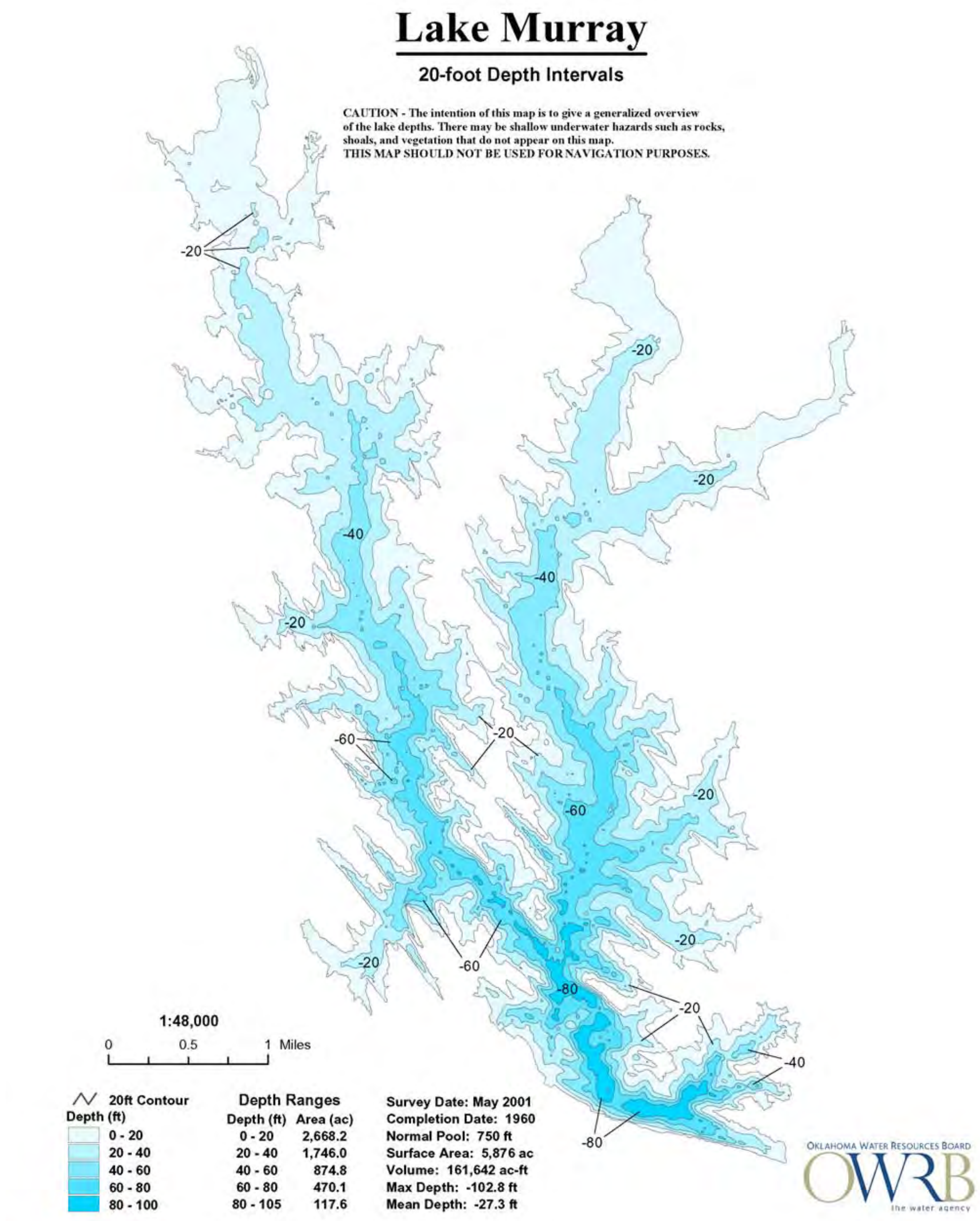


Figure 99. Bathymetric map of Lake Murray.

Lake Nanih Waiya

Lake Nanih Waiya was sampled for four quarters, from October 2004 through July 2005. Water quality samples were collected from three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and from 0.5 meters from the lake bottom at site 1, the dam. The average lake-wide turbidity was 8 NTU (Plate 77), true color was 29 units, and average secchi disk depth was 143 centimeters. Based on these three parameters Lake Nanih Waiya had excellent water clarity in sample year 2004-2005, similar to that observed in 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a) was calculated using values collected at all sites for four quarters (n=12). The TSI was 45 (Plate 77), classifying the lake as mesotrophic, indicative of moderate primary productivity and nutrient conditions. This is identical to the value calculated in 2003 (TSI=45), indicating no significant change in productivity has taken place. The TSI values were fairly consistent with all values in the mesotrophic category with the exception of site 3, in the spring, which dipped down to the oligotrophic category. Seasonal turbidity values are displayed in Figure 100a. Turbidity values ranged from a low 2 NTU to a maximum of 25 NTU, both recorded at site 3. According to the Use Support Assessment Protocols (USAP) specified in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With only 8.3% of the samples collected above the standard the lake is fully supporting its Fish & Wildlife Propagation (FWP) use based on nephelometric turbidity. Seasonal true color values are displayed in Figure 100b. Applying the same default protocol, the Aesthetics beneficial use is considered fully supported with 100% of the collected values below the WQS of 70 units.

In 2004-2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sites. Salinity values ranged from 0.02 parts per thousand (ppt) to 0.08 ppt. This is lower than the average range of values reported for Oklahoma lakes. Readings for specific conductivity ranged from 58 µS/cm to 178 µS/cm, indicating that low concentrations of electrical current conducting compounds (salts) were present in the lake system. Values for pH were slightly acidic to neutral, ranging from 6.57 in the hypolimnion in the summer to 7.48 near the surface in the fall. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With only one of the recorded values less than 6.5, Lake Nanih Waiya is supporting the FWP beneficial use. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Oxidation-reduction potential (ORP) ranged from 316 mV in the winter to 481 mV in the summer. In general, reducing conditions were not present at this reservoir with all values being positive and above 100 mV throughout the study period.

Stratification was not present during the fall, winter or spring and the lake was well mixed with dissolved oxygen (D.O.) levels generally above 6.0 mg/L (see Figure 100c-100e). Thermal stratification was evident in the summer and anoxic conditions were present. In the summer sampling quarter, stratification occurred between 2 and 3 meters at which point the D.O. fell below 2.0 mg/L to the lake bottom of 5.4 meters. This accounts for approximately 43% of the water column, at site 1 to be experiencing anoxic conditions. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at Lake Nanih Waiya based on D.O. values in the summer quarter. This is not a situation that is normally seen in such a shallow reservoir and may be attributed to a long period of calm winds and/or a pattern where little rainfall occurred. The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.35 mg/L at the lake surface. The TN at the surface ranged from 0.19 mg/L to 0.63 mg/L. The highest surface TN value was reported in the fall quarter and the lowest was in the winter quarter. The lake-wide total phosphorus (TP) average was 0.020 mg/L at the lake surface. The surface TP ranged from 0.012 mg/L to 0.025mg/L. Similar to TN, the highest surface TP value was reported in the fall quarter, however the lowest was in the winter spring. The nitrogen to phosphorus ratio (TN:TP) was approximately 18:1 for sample year 2004-2005. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

In summary, Lake Nanih Waiya was classified as mesotrophic, indicative of moderate primary productivity and nutrient conditions (Plate 77). This is identical to the value calculated in 2003 (TSI=45), indicating no significant change in productivity has taken place. Water clarity was excellent based on turbidity, true color and secchi disk depth. The lake is supporting the FWP beneficial used based on turbidity, pH values and D.O. values reported during the study period. The Aesthetics beneficial use is fully supported based on its trophic status and true color values. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Lake Nanih Waiya, located in Pushmataha County, is owned by the State of Oklahoma and is utilized for recreational purposes.

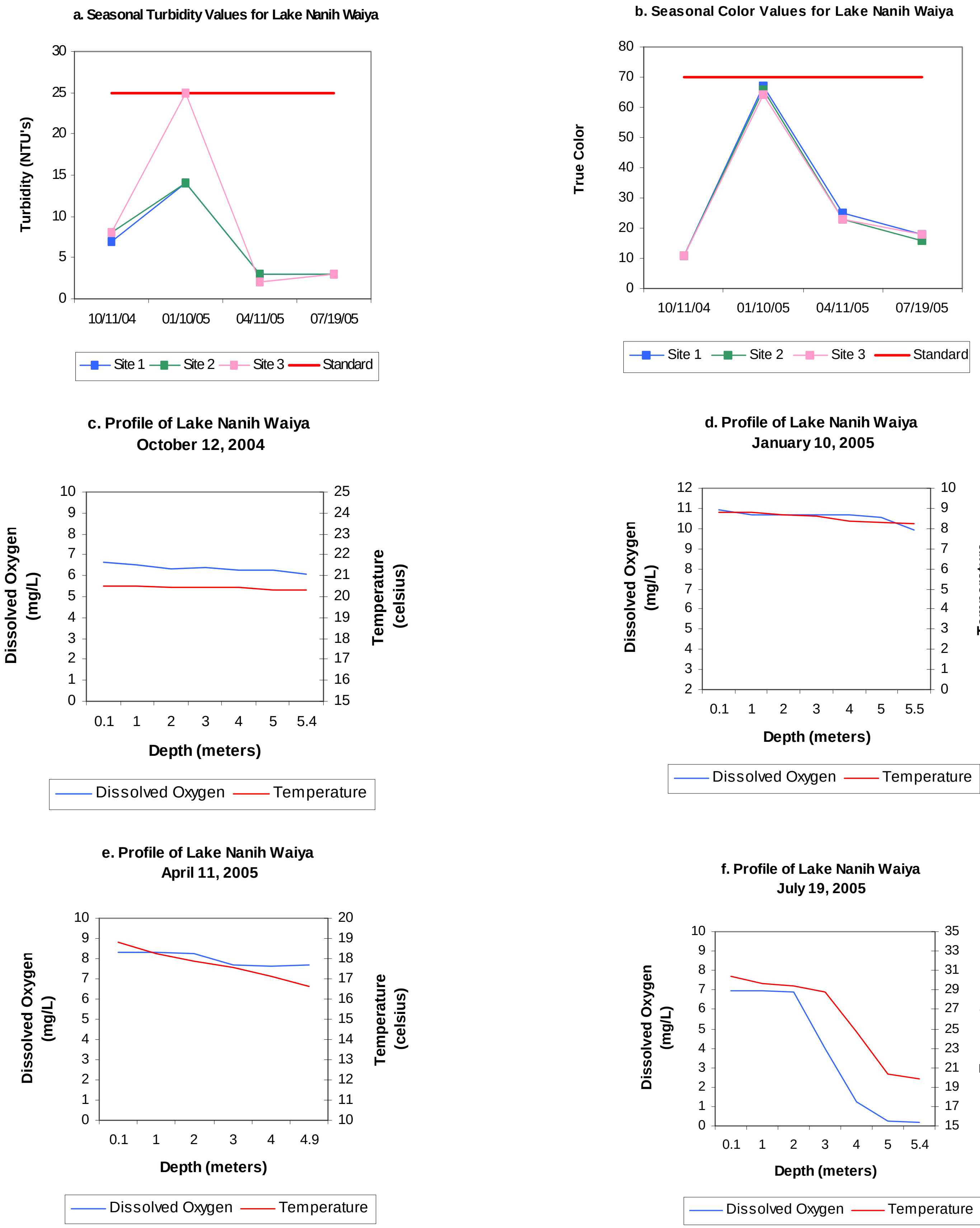
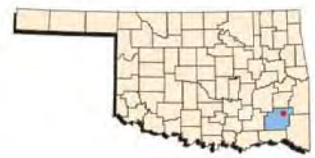


Figure 100a-100f. Graphical representation of data results for Lake Nanih Waiya.

LAKES MONITORING PROGRAM



Lake Data

Owner	State of Oklahoma
County	Pushmataha
Constructed in	1958
Surface Area	131 acres
Volume	1,064 acre/feet
Shoreline Length	3 miles
Mean Depth	8.12 feet
Watershed Area	2,848 acres

Plate 77 - Lake Water Quality for
Lake Nanih Waiya

LAKES MONITORING PROGRAM

Okemah Lake

Okemah Lake is owned and operated by the City of Okemah and serves as a municipal water supply and offers numerous recreational opportunities to the public. Okemah Lake is one of the nicer small municipal reservoirs in Oklahoma and should be managed and preserved to ensure that its water quality is not degraded over time. Okemah Lake was sampled for four quarters, from October 2006 through July 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at five sites throughout the study period. The lake-wide annual turbidity value was 17 nephelometric turbidity units (NTU) true color was 61 units, and secchi disk depth was 78 centimeters in 2006-2007. Based on these three parameters, Okemah Lake had average water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI was 46 (Plate 78), indicating the lake was mesotrophic, indicative of moderate primary productivity and nutrients levels. The TSI values ranged form mesotrophic in the fall and spring to eutrophic during the summer quarter. Oligotrophic conditions were recorded at all sites during winter sampling. Seasonal turbidity values are displayed in Figure 101a. In general turbidity values were below the turbidity standard of 25 NTU with the exception of values reported at site 4 during the winter and spring quarters. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Of the twenty samples collected, (20%) exceeded the criteria of 25 NTU, therefore the FWP is considered partially supported for this sample year. Seasonal true color values are displayed in Figure 101b. Values reported in the winter, spring and summer were near or greater than the numerical criteria of 70 units at half of the sample sites. Applying the same default protocol, the Aesthetic beneficial use is considered not supported.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.06 parts per thousand (ppt) to 0.14 ppt, well within the expected range of salinity values reported for most Oklahoma lakes. Readings for specific conductivity were also low, ranging from 140.7 µS/cm to 289.3 µS/cm, indicating the minimal presence of electrical current conducting compounds (salts) in the water column throughout the year. In general, pH values were neutral to alkaline in nature with values ranging from 6.71 to 8.03 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the recorded values within the acceptable range, Okemah Lake is supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (redox) ranged from 126 mV in the summer to 426 mV in the fall, indicating an absence of any significant reducing conditions in the lake. During the fall, the lake was fairly consistent, however dissolved oxygen (D.O.) dropped from 6.0 mg/L at 6 meters in depth to 2.7 mg/L at the lake bottom of 9 meters (Figure 101c). In the winter quarter, the lake was well mixed with D.O. values generally above 8.0 mg/L throughout the water column at this time (see Figure 101d). Thermal stratification and anoxic conditions were present in both spring and summer sampling intervals. In the spring the lake was stratified between 8 and 9 meters; however dissolved oxygen remained above 7 mg/L at site 1, the dam. Due to equipment failure profile data is not available for the remaining sample sites. Although no profile data is available for sites 2, 4 and 5 for the spring sampling interval it is likely that similar conditions would be found based on the time of year. During the summer quarter, the lake was strongly thermally stratified between 3 and 4 meters (see Figure 101f) at which point dissolved oxygen was less than 1.0 mg/L to the lake bottom at 11.5 meters. Sites 2-5 exhibited similar conditions with anoxic conditions comprising 50-63% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, with up to 69% of the water column at site 1 in the summer less than 2.0 mg/L, the FWP beneficial use is partially supported at Okemah Lake. The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. Of the 10 enterococci samples collected 4 (40%) exceeded the screening level of 61-cfu/100 ml and the geometric mean of 37.06 exceeds the prescribed mean of 33. Both *E.coli* and fecal coliform samples exceed the prescribed screening levels however the respective geometric means were not exceeded. The PBCR beneficial use is therefore considered supported for E.coli and fecal coliform however the use is not supported as it relates to enterococci.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.60 mg/L. The TN at the surface ranged from 0.38 mg/L to 1.01 mg/L. The highest surface TN value was reported in the winter quarter and the lowest was in the fall quarter. The lake-wide total phosphorus (TP) average was 0.026 mg/L at the lake surface. The surface TP ranged from 0.012 mg/L to 0.063 mg/L. The highest surface TP value was reported in the winter quarter and the lowest was also in the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 23:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Okemah Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Okemah Lake was classified as mesotrophic, indicative of moderate primary productivity and nutrient levels (Plate 78). Water clarity was average based on turbidity, true color and secchi disk depth. The lake was fully supporting its Aesthetics beneficial use based on its trophic status and not supported based on true color with 35% of the values exceeding the WQS of 70 units. Okemah Lake was fully supporting its FWP beneficial use based on pH, partially supporting as 20% of the turbidity values excceded the WQS of 25 NTU. The FWP beneficial use is also considered partially supported based on anoxic conditions present during the summer sampling interval. Bacteriological samples were collected during the recreation season of May through September 2007 to assess the Primary Body Contact Recreation (PBCR) beneficial use. Of the 10 samples collected, 40% of the enterococci samples exceed the prescribed screening level of 61 cfu/100ml and the geometric mean of 33 was also exceeded. In 2004 a bathymetric map of Okemah was completed at the request of the OWRB's Planning and Management Division. The bathymetric data collected was used to produce an updated storage capacity figure and bottom contour map of the lake (see Figure 102). For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.

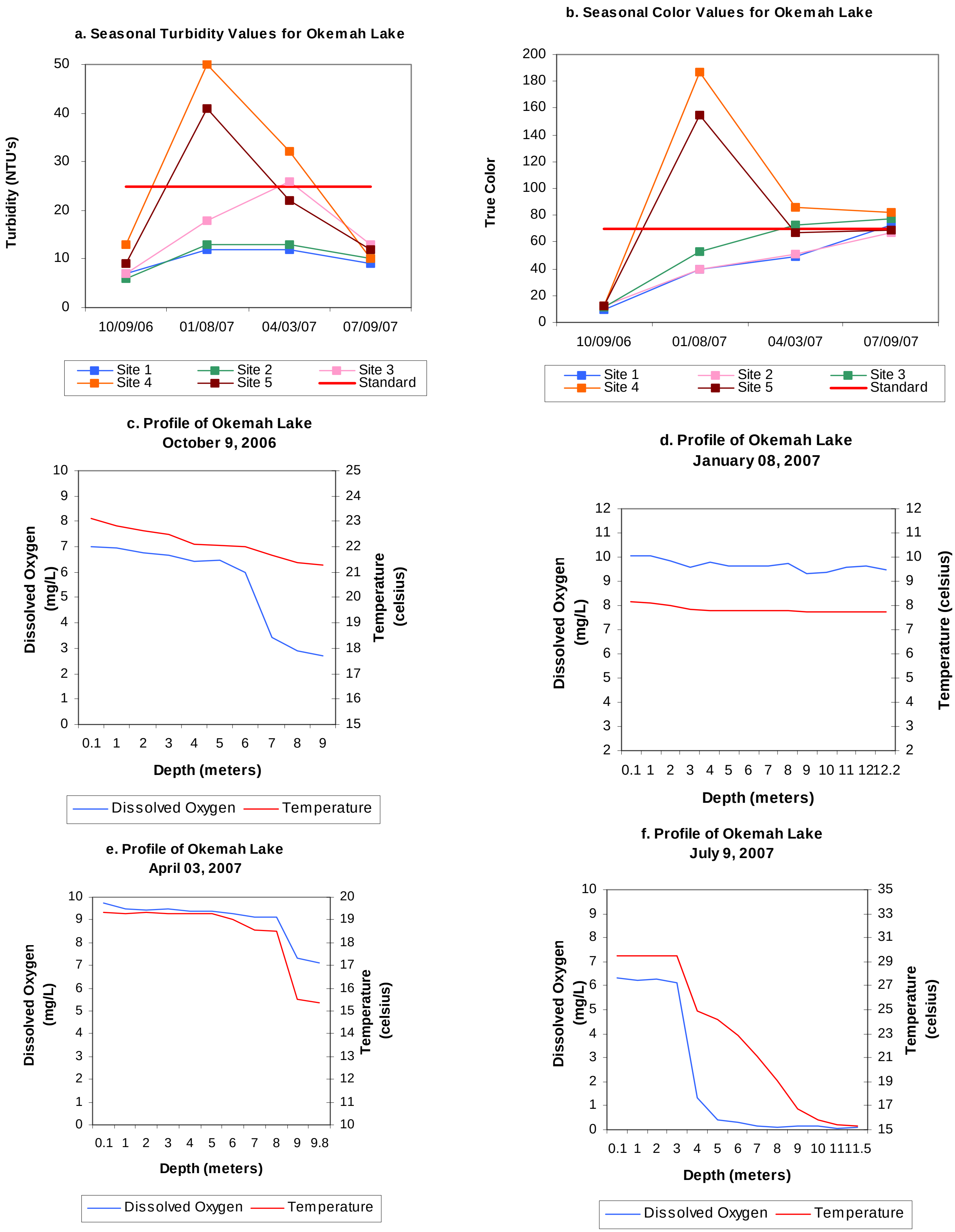
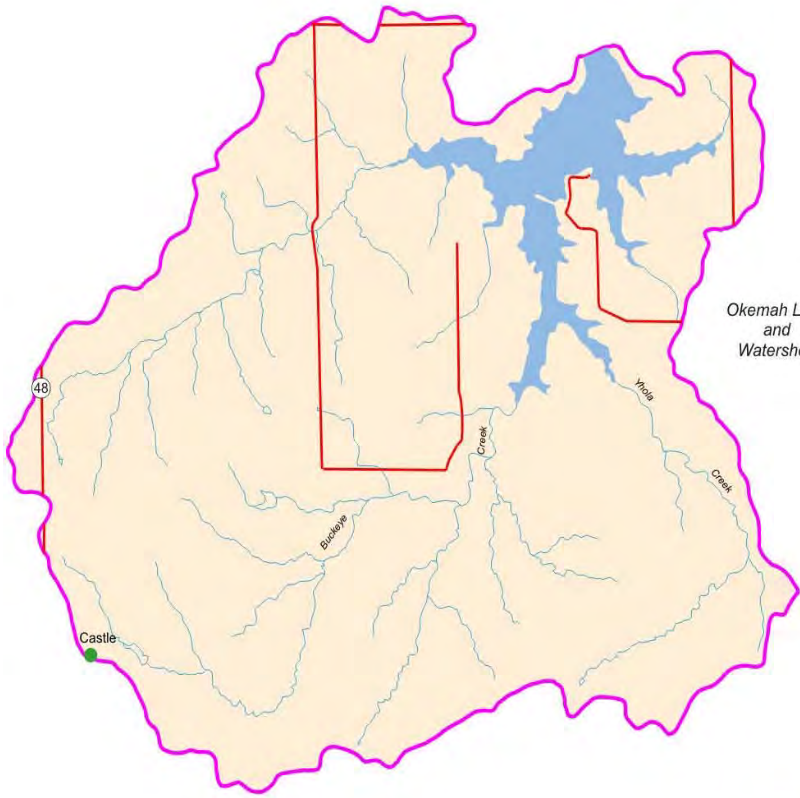
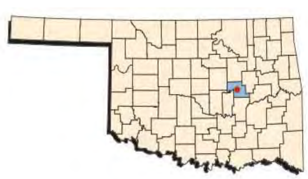


Figure 101a-101f. Graphical representation of data results for Okemah Lake.

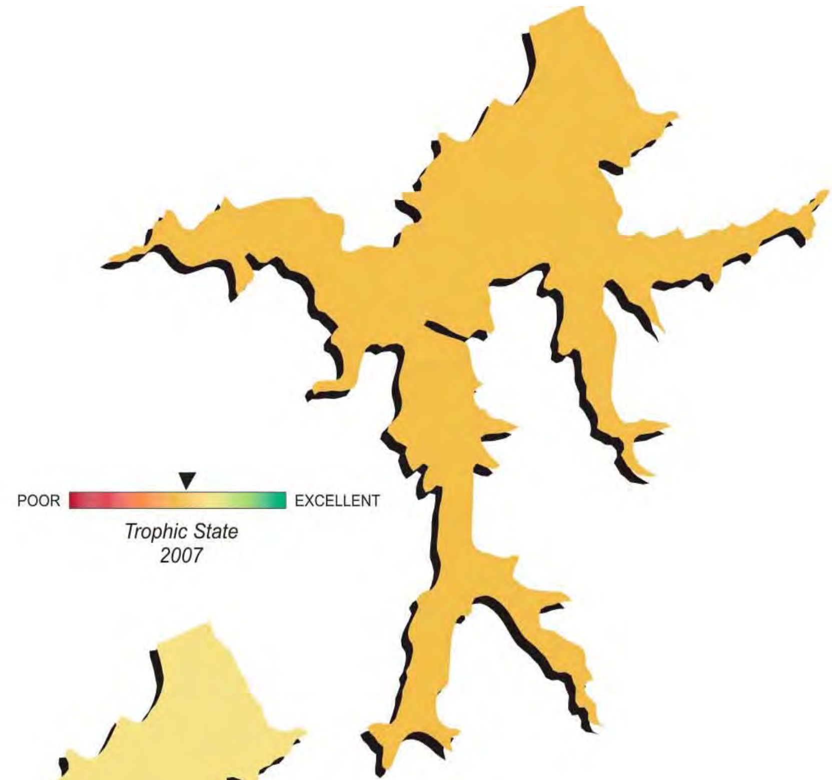
Plate 78 - Lake Water Quality for
Okemah Lake

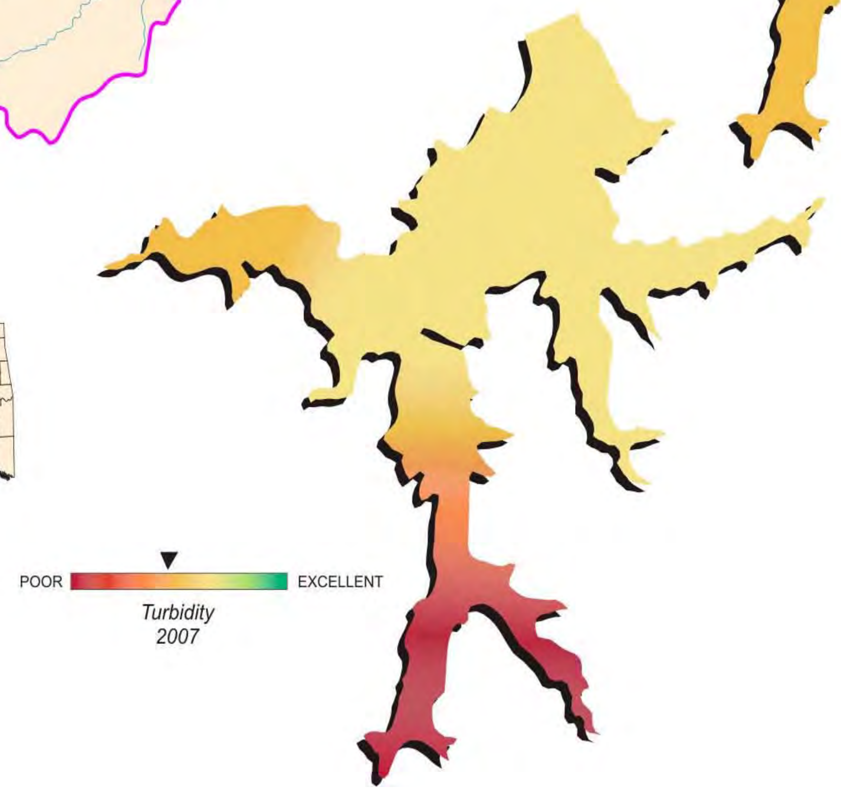


Okemah Lake
and
Watershed



Okemah Lake
Location





Lake Data

Owner	City of Okemah
County	Okfuskee
Constructed in	NA
Surface Area	761 acres
Volume	13,100 acre/feet
Shoreline Length	16 miles
Mean Depth	17.21 feet
Watershed Area	20 square miles

LAKES MONITORING PROGRAM

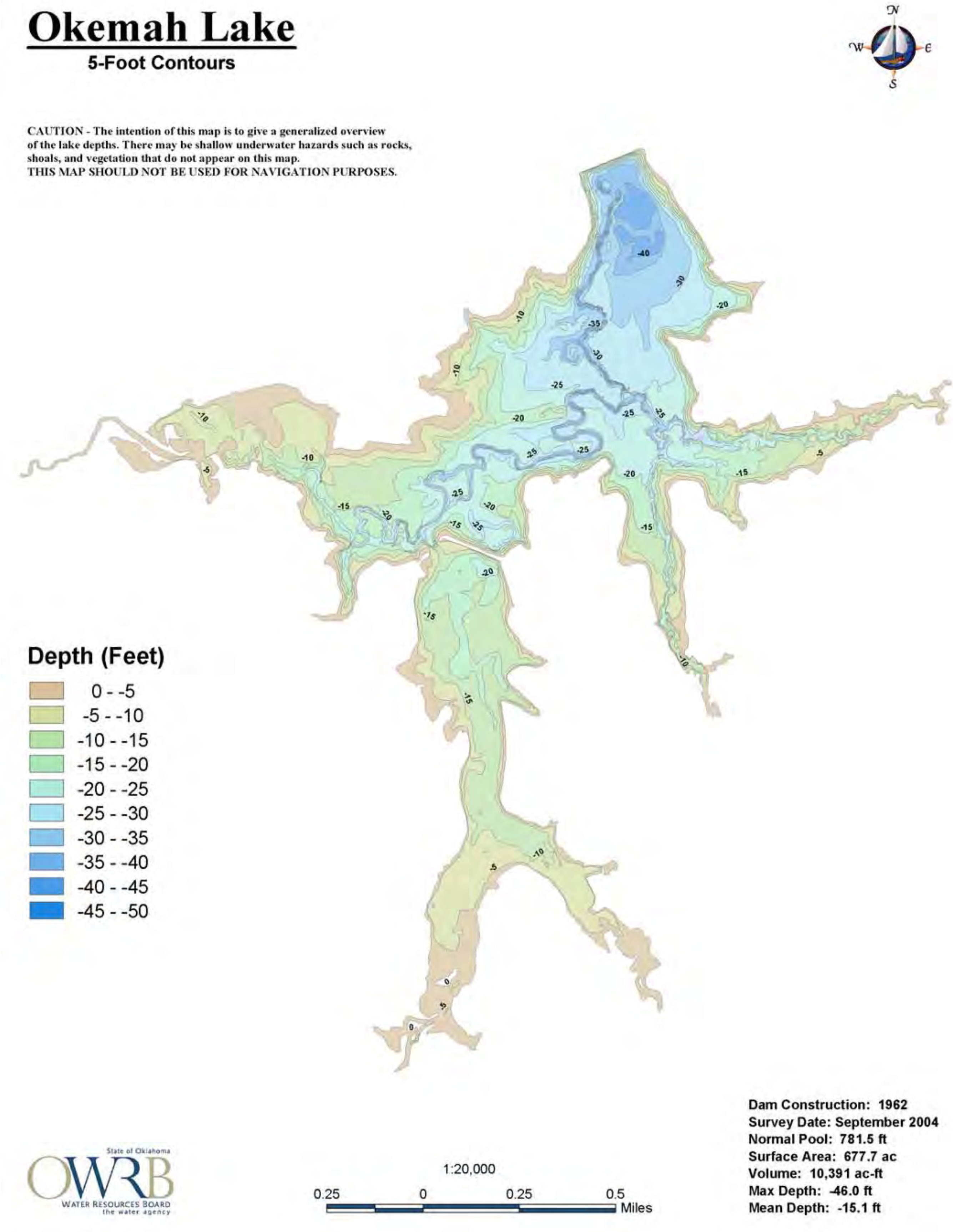


Figure 102 Bathymetric Map of Okemah Lake.

Okmulgee Lake

Okmulgee Lake, located in Okmulgee County, was constructed in 1928 and is owned and operated by the City of Okmulgee. The lake is the municipal water supply for the city and is also utilized for recreational purposes. Okmulgee Lake was sampled for four quarters, from October 2006 through July 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Water quality samples were collected from the lake surface at all sites during the sample year. The lake-wide annual turbidity value was 11 nephelometric turbidity units (NTU) true color was 56 units, and secchi disk depth was 99 centimeters in 2006-2007. Based on these three parameters, Okmulgee Lake had good water clarity in comparison to other Oklahoma reservoirs. Results are similar to those observed in 2005 with the current true color average being slightly higher. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=17). Due to a lab accident there are no chlorophyll-a data results for sites 1,2 and 4 from the summer sampling interval. The calculated TSI was 46 (Plate 79), indicating the lake was mesotrophic with moderate primary productivity and nutrient conditions. This is consistent with previous data collection efforts in 2005 (TSI=46) and 2002 (TSI=45), indicating no significant change in productivity has taken place. The TSI values were mesotrophic during the sample year. The only exceptions to this was site 3 in the winter when low chlorophyll-a values were reported, placing this site in the oligotrophic category. Seasonal turbidity is displayed in Figure 103a. Turbidity values ranged from a low 4 NTU to a maximum of 16 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). With 100% of the recorded turbidity values were below the criteria, so the Fish & Wildlife Propagation (FWP) beneficial use is fully supported as it relates to turbidity. Seasonal true color values are displayed in Figure 103b. True color values were below the WQS of 70 units in three of the four quarters. In the summer all sites were above the standard, accounting for 30% of the values to be exceeding the standard. Applying the same default protocol, the lake is not supporting the Aesthetics beneficial use.

In 2006-2007, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.02 parts per thousand (ppt) to 0.10 ppt, indicating low salt content and all values were well within the expected range of salinity reported for most Oklahoma lakes. Readings for specific conductivity were very low, ranging from 71.3 µS/cm to 209.8 µS/cm, indicating minimal presence of electrical current conducting compounds (salts) in the water column throughout the year. In general, pH values were slightly acidic to alkaline with values ranging from 6.36 units in the summer quarter to 7.9 in the fall quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. Only 6.1% of the pH values recorded at Okmulgee Lake were below 6.5 units and therefore it is fully supporting its FWP beneficial use based on pH. Oxidation-reduction potentials (redox) ranged from 194 mV to

600 mV, indicating an absence of reducing conditions. In the fall the lake stratified between 6 and 7 meters with dissolved oxygen (D.O.) less than 2.0 mg/l from 9 meters to the lake bottom at 12.3 meters (Figure 103c). The lake was not stratified during the winter and the water column was well mixed (see Figure 103d) with D.O. generally above 7 mg/L at all sites. During the spring the lake was stratified at several 1-meter intervals however the water column was well oxygenated as values remained above 6.0 mg/L (Figure 103e). In the summer the lake was thermally stratified between 2 and 3 meters below the surface with anoxic conditions comprising approximately 71% of the water column (see Figure 103f). Anoxic conditions were also present in 33-64% of the water column at sites 2-5 during this sampling interval. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is not supported based on dissolved oxygen levels recorded during the summer quarter. The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

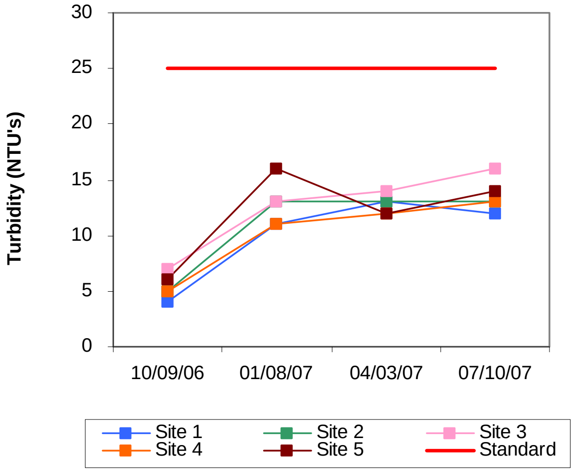
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. Of the 10 enteroccoci samples collected, only one exceeded the prescribed screening level of 61 cfu/100ml. The PBCR beneficial use is therefore considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.57 mg/L at the lake surface. The TN at the surface ranged from 0.36 mg/L to 0.77 mg/L. The highest surface TN value was reported in the winter and the lowest was in the fall quarter. The lake-wide total phosphorus (TP) average was 0.019 mg/L at the lake surface. The surface TP ranged from 0.011 mg/L to 0.034 mg/L. The highest surface TP value was reported in the summer and the lowest was in the winter quarter. The nitrogen to phosphorus ratio (TN: TP) was approximately 30:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

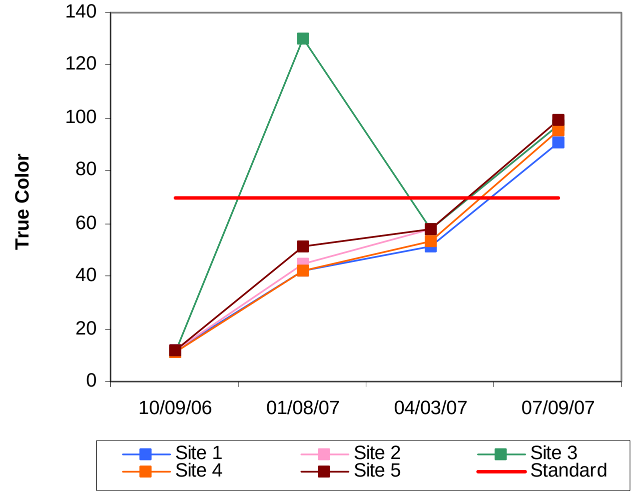
Okmulgee Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Okmulgee Lake was classified as mesotrophic, indicative of moderate primary productivity and nutrient levels (Plate 79). This is consistent previous data collection efforts, indicating no significant change in productivity has taken place. Water clarity was good at Okmulgee Lake based on true color, turbidity, and secchi disk depth. The lake was fully supporting its FWP beneficial use based on turbidity and pH concentrations, however the lake was not supporting based on anoxic conditions in up to 71% of the water column during the summer interval. The lake was fully supporting its Aesthetics beneficial use based on trophic state; however the use is considered not supported for true color with 35% of the collected values exceeding the WQS if 70 units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. With only 1 enterococci sample exceeding the prescribed screening level, the PBCR is considered supported for the current sample year.

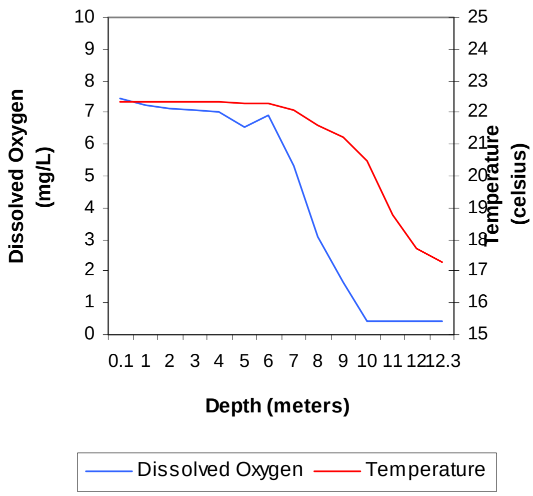
a. Seasonal Turbidity Values for Okmulgee Lake



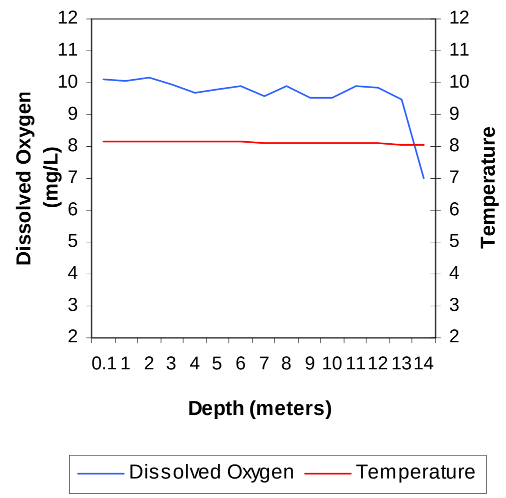
b. Seasonal Color Values for Okmulgee Lake



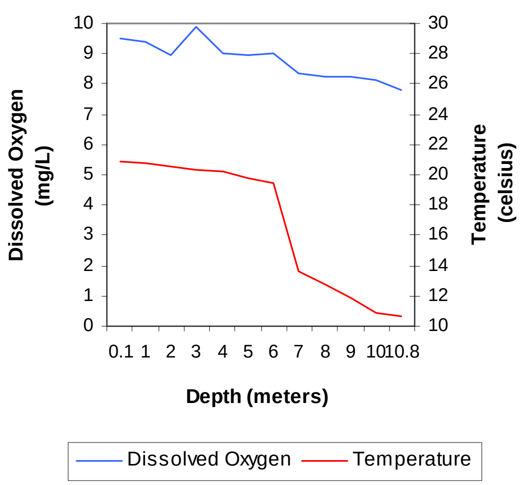
c. Profile of Okmulgee Lake
October 9, 2006



d. Profile of Okmulgee Lake
January 08, 2007



e. Profile of Okmulgee Lake
April 03, 2007



f. Profile of Okmulgee Lake
July 9, 2007

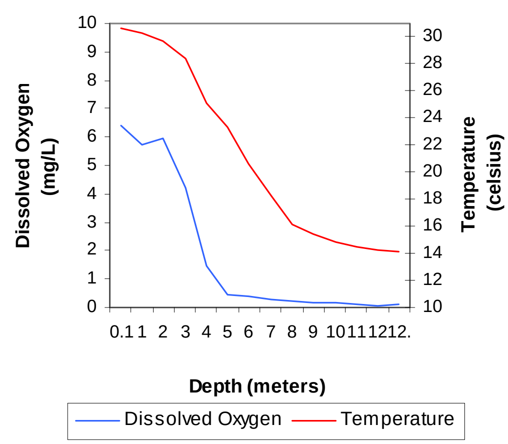
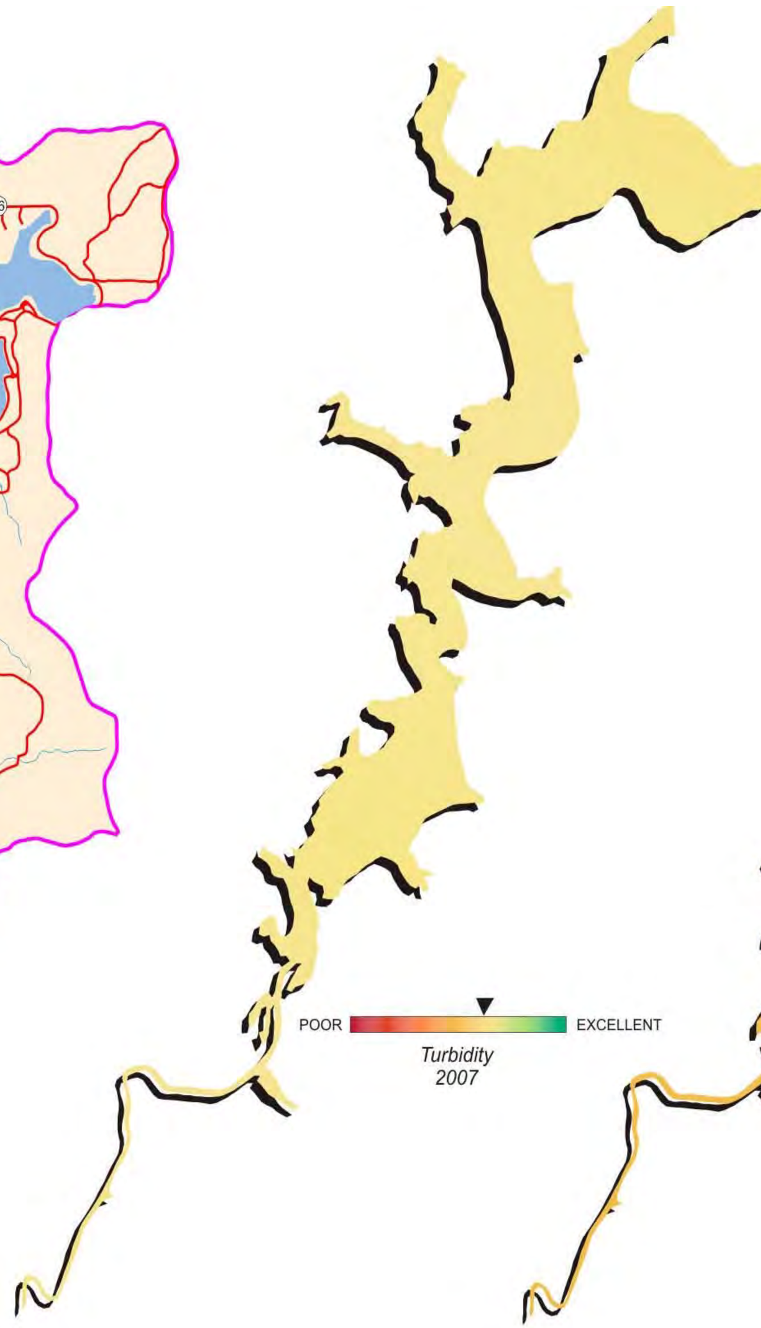


Figure 103a-103 f. Graphical representation of data results for Okmulgee Lake.

Lake Data

Owner	City of Okmulgee
County	Okmulgee
Constructed in	1928
Surface Area	668 acres
Volume	14,170 acre/feet
Shoreline Length	19 miles
Mean Depth	21.21 feet
Watershed Area	14 square miles



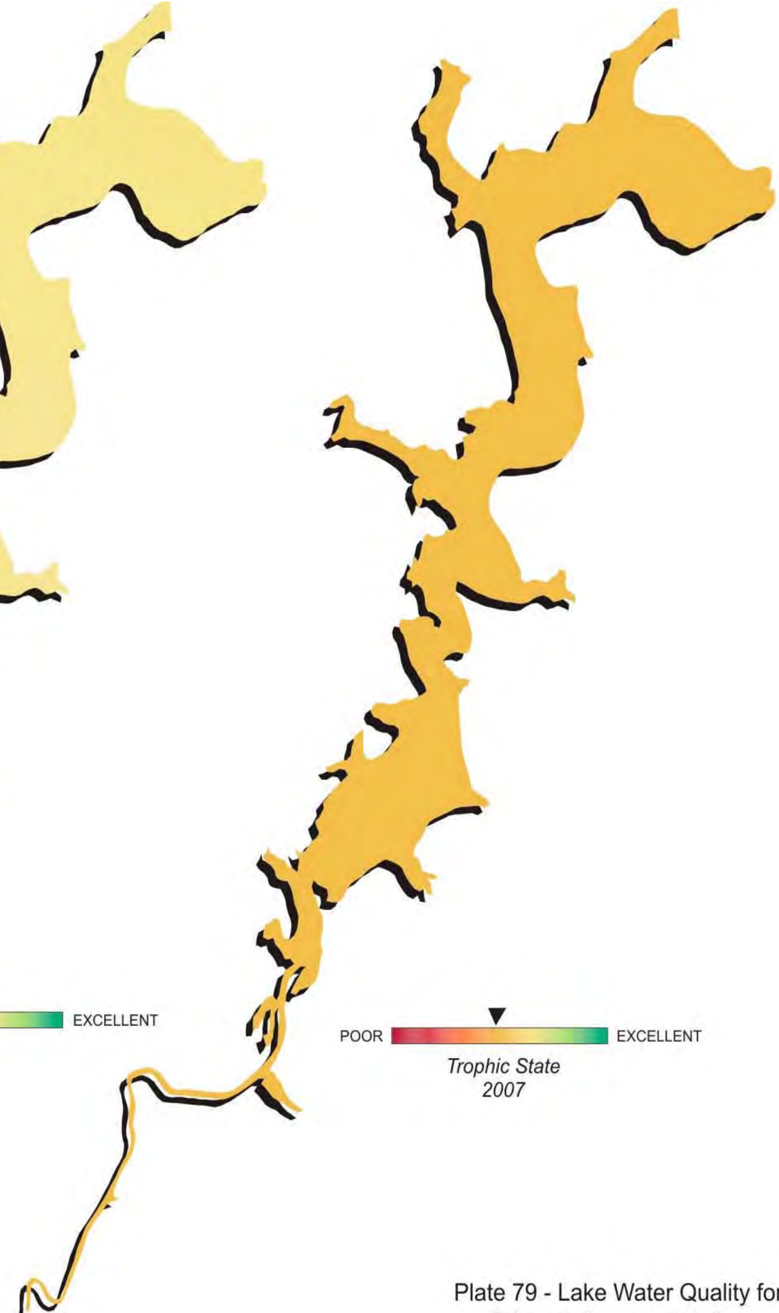


Plate 79 - Lake Water Quality for
Okmulgee Lake

Oologah Lake

Oologah Lake was sampled for four quarters, from October 2004 through July 2005. Water quality samples were collected at seven (7) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Water quality samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide average turbidity value was 26 NTU (Plate 80), true color was 44 units, and secchi disk depth was 56 centimeters in 2004-2005. Based on these three parameters, Oologah Lake had fair water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=28). The TSI was 46 (Plate 80), indicating the lake was mesotrophic with moderate primary productivity and nutrient conditions. This is similar to the value calculated in 2002 (TSI=48), no significant change in productivity has occurred since the last evaluation. The TSI values varied by site and season and ranged mesotrophic to eutrophic in the fall, spring and summer, with Oligotrophic conditions present during the winter interval. Site 1 had low chlorophyll - a reported in 3 of the 4 quarters. Seasonal turbidity values are displayed in Figure 104a. Turbidity ranged from a low of 6 NTU to a maximum of 100 NTU, with the highest values being recorded at sites 5-7 throughout sample year 2004-2005. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 28.5% of the recorded turbidity values above the standard the Fish and Wildlife Propagation (FWP) beneficial use is not supported based on turbidity. Seasonal true color values are displayed in Figure 104b. Like turbidity, true color values were highest at sites 5-7 and lowest at sites 1-4. Of the twenty values recorded three (10.7%) exceeded the WQS of 70 units. Applying the same default protocol, the Aesthetics beneficial use is partially supported based on true color values.

In 2004-2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sites. Salinity values at Oologah Lake ranged from 0.12 parts per thousand (ppt) to 0.22 ppt. This is within the average range of values reported for Oklahoma reservoirs. Specific conductivity ranged from 245 µS/cm to 437.7 µS/cm, indicating that low to moderate concentrations of electrical current conducting materials (salts) were present in the lake system. Values for pH ranged from 6.82 to 8.26 representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With all values within the acceptable range, Oolagah Lake is meeting the FWP use as it relates to pH. Oxidation-reduction potentials ranged from 69 mV in the fall to 499 mV in the summer. In general, reducing conditions were not present in 2005, with all recorded values positive and above 100 mV. The one value recorded at site 4 in the fall is the only instance where values fell below 100 and is likely the result of the Hydrolab probe resting on the lake bottom. Thermal stratification was not present during the fall, winter, or spring sampling quarters, and the lake was well mixed with dissolved oxygen (D.O) levels remaining above 6.0 mg/L (see Figure 104c-96e). In the summer, stratification was evident and anoxic conditions were present at sites 1,2 and 4. Dissolved oxygen was less than 2.0 mg/L from 9 meters in depth to the lake bottom of 21.1 meters accounting for 10 to 59% of the water column to be experiencing anoxic conditions (see Figure 104f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, Oologah Lake is considered partially supporting the FWP beneficial based on dissolved oxygen, as 59% of the water column was anoxic at site 1, the dam. The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.61 mg/L at the surface. Surface TN ranged from 0.26 mg/L to 1.01 mg/L, with the highest values reported in the winter and lowest values in the fall. The lake-wide total phosphorus (TP) average was 0.071 mg/L at the surface. Total phosphorus at the surface ranged from 0.033 mg/L to 0.178 mg/L. Similar to TN, surface TP was highest in the spring, however, the lowest values were recorded during the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 9:1 for sample year 2004-2005. This is slightly higher than 7:1, characterizing the lake as potentially phosphorus limited to co-limited (Wetzel, 1983).

In summary, Oologah Lake was classified as mesotrophic, indicative of moderate primary productivity and nutrient conditions (Plate 80). This is similar to the value calculated in 2002 (TSI=48), no significant change in productivity has occurred since the last evaluation. Water clarity was fair based on turbidity, true color and secchi disk depth readings. The lake is supporting the FWP beneficial use based on pH, partially supporting based on dissolved oxygen, and not supporting the use based on turbidity. The Aesthetics beneficial use is supported based on both its trophic status and partially supported for true color with 10.7% of the values exceeding the standard values. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Oologah Lake, constructed by the United States Army Corps of Engineers (UASCE), serves a water supply for the City of Tulsa and is utilized for flood control and navigational purposes.

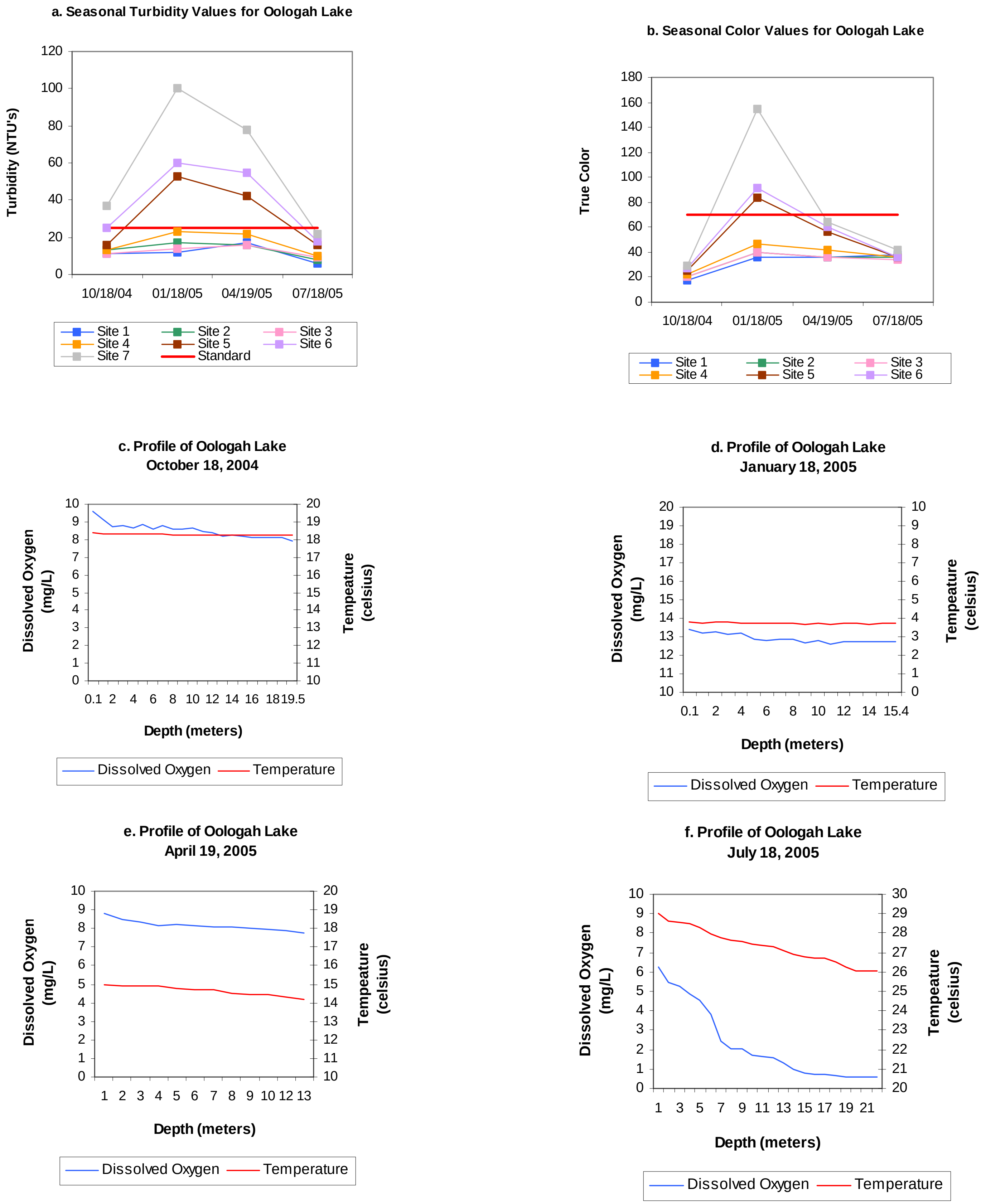


Figure 104a-104f. Graphical representation of data results for Oologah Lake.

Oologah Lake and Watershed

Oologah Lake Location

Lake Data	
Constructed by	Corps of Engineers
County	Rogers
Constructed in	1974
Surface Area	29,460 acres
Volume	553,400 acre/feet
Shoreline Length	180 miles
Mean Depth	18.7 feet
Watershed Area	4,339 square miles

Turbidity 2005

Trophic State 2005

Plate 80 - Lake Water Quality for

Oologah Lake

LAKES MONITORING PROGRAM

Lake Overholser

Lake Overholser was constructed in 1919 and is owned and operated by Oklahoma City. It serves as a municipal water supply and offers recreational opportunities to the public. Lake Overholser was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Water quality samples were collected from the lake surface at three sites during the sample year. The lake-wide annual turbidity value was 60 nephelometric turbidity units (NTU) (Plate 81), true color was 38 units, and secchi disk depth was 32 centimeters. Based on these three parameters, Lake Overholser had fair to poor water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI was calculated at 67 (Plate 81), indicating the lake was hypereutrophic with excessive primary productivity and nutrient levels in sample year 2005-2006. This is consistent with the TSI calculated in 2004 (TSI=64) and 2002 (TSI=68), which also found the lake to be hypereutrophic. The TSI values were consistent ranging from eutrophic in the fall and winter quarters to hypereutrophic in the spring and summer sampling intervals. Based on the trophic classification, the lake is listed in the last Oklahoma Water Quality Standards (WQS) revision process as a Nutrient Limited watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Turbidity values were also elevated in the lake with 75% of the collected data exceeding the WQS of 25 NTU (see Figure 105a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Lake Overholser is not supporting its Fish & Wildlife Propagation (FWP) beneficial use based on high nephelometric turbidity concentrations in the water column. Seasonal true color values are displayed in Figure 105b. All true color values were below the Aesthetics WQS of 70 units except sites 4 and 5, which were just above, during the fall sampling interval. With 90% of the values below than the standard, the Aesthetics beneficial use is considered partially supporting for true color.

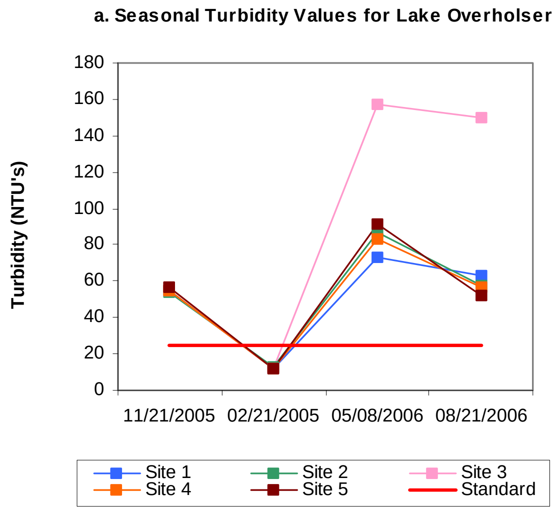
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.04 parts per thousand (ppt) to 0.74 ppt, indicating moderate to high amounts of salts in the water column when compared to most Oklahoma lakes. Readings for specific conductivity were also very high, ranging from 102 µS/cm to 1399 µS/cm, indicating moderate to high amounts of electrical current conducting compounds (salts) in the water column throughout the year. In general, pH values were neutral to slightly alkaline with values ranging from 7.80 units in the winter quarter to 8.64 units in the summer quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. All pH values were within the accepted range therefore supporting the FWP beneficial use as it relates to pH. Oxidation-reduction potentials (redox) ranged from 359 mV in the summer quarter to 431 mV in the winter quarter, indicating an absence of reducing conditions during the study period. Lake Overholser was not thermally stratified in any of the sampling quarters and dissolved oxygen (D.O.) values were above 6.0 mg/L throughout the water column in all four seasons (see Figure 105c-105f). This lake is very shallow (about 2.5 meters deep) and it is likely wind mixing precludes the onset of thermal stratification. If D.O. values are less than 2.0 mg/L for greater than 70% of the lake volume, the Fish & Wildlife Propagation (FWP) beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is fully supported at Lake Overholser. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

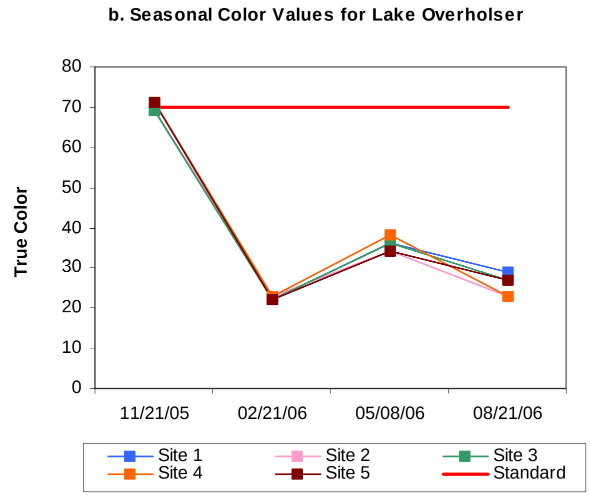
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. Of the 10 enterococci samples collected, six (60%) exceeded the prescribed screening level and geometric means. The PBCR beneficial use is therefore considered not supported.

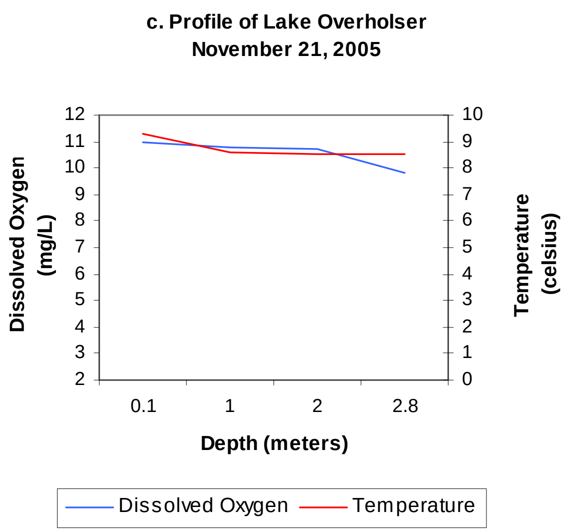
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.47 mg/L at the lake surface. The TN at the surface ranged from 0.88 mg/L to 2.38 mg/L. The highest surface TN value was reported in the summer quarter and the lowest was in the winter quarter. The lake-wide total phosphorus (TP) average was 0.211 mg/L at the lake surface. The surface TP ranged from 0.100 mg/L to 0.317 mg/L. Similar to total nitrogen, the highest surface TP value was reported in the summer quarter and the lowest was in the winter quarter. In general, nutrient concentrations in this lake were very high, probably due to its shallow nature and re-suspension of nutrient laden sediment into the water column. The nitrogen to phosphorus ratio (TN: TP) was approximately 7:1. This value is identical to 7:1, characterizing the lake possibly co-limited (Wetzel, 1983).

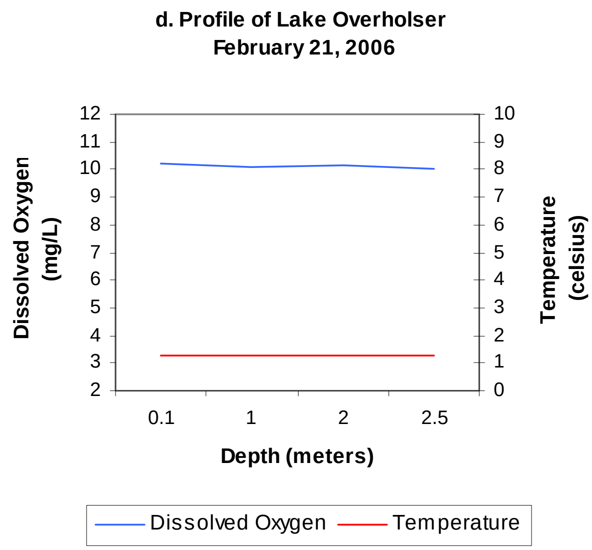
The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 2004 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening level or consumption advisory level. Lake Overholser was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

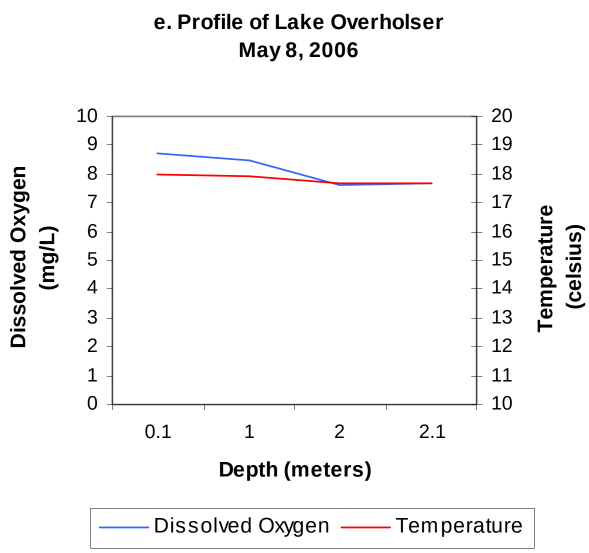
In summary, Lake Overholser was classified as hypereutrophic, indicative of excessive primary productivity and nutrient levels (Plate 81). Water clarity was fair to poor based on turbidity, true color and secchi depth. The lake was recommended for listing as a Nutrient Limited watershed (NLW) in the next WQS revision process and its Aesthetics beneficial use is considered nutrient threatened until studies can be conducted to confirm non-support status. The Aesthetics use is partially supported with 10% of the reported values exceeding 70 units. The lake is fully supporting its FWP beneficial use based on pH and dissolved oxygen, however, the lake is not supporting the use due to high nephelometric turbidity readings. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. Of the 10 enterococci samples collected, six (60%) exceeded the prescribed screening level and geometric means. The PBCR beneficial use is therefore considered not supported. In 1997 the Oklahoma Legislature directed the OWRB to conduct a study on the impact of Confined Animal Feeding Operations (CAFO) in watersheds that supply potable water to municipalities with a population over 250,000. As part of this study a bathymetric survey was completed on Oklahoma City's water supply reservoirs. A bathymetric map (Figure 106) was generated to determine current storage capacity and identify areas of extreme sedimentation. For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.











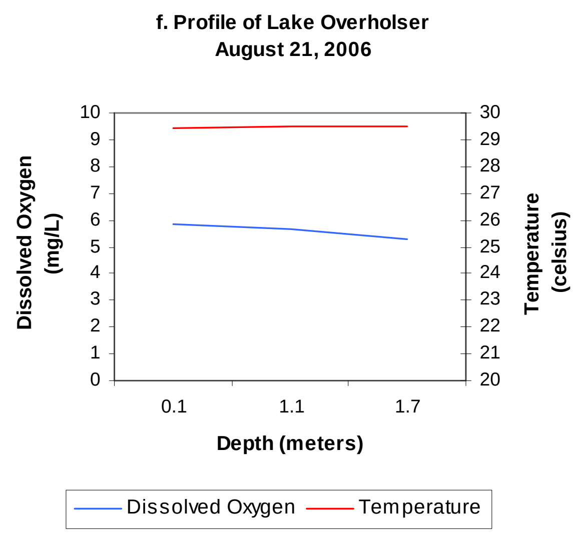
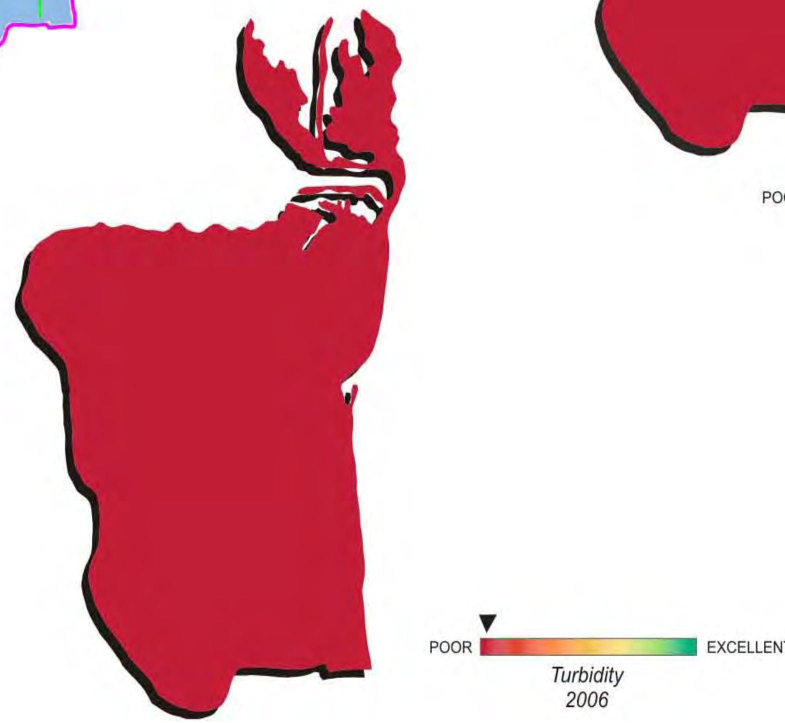


Figure 105a-105f. Graphical representation of data results for Lake Overholser.

Overholser Lake and Watershed

Overholser Lake Location

Lake Data	
Owner	City of Oklahoma City
County	Oklahoma
Constructed in	1919
Surface Area	1,591 acres
Volume	13,913 acre/feet
Shoreline Length	7.4 miles
Mean Depth	18.75 feet
Watershed Area	13,215 square miles



Turbidity
2006

Trophic State
2006

Plate 81 - Lake Water Quality for
Overholser Lake

LAKES MONITORING PROGRAM

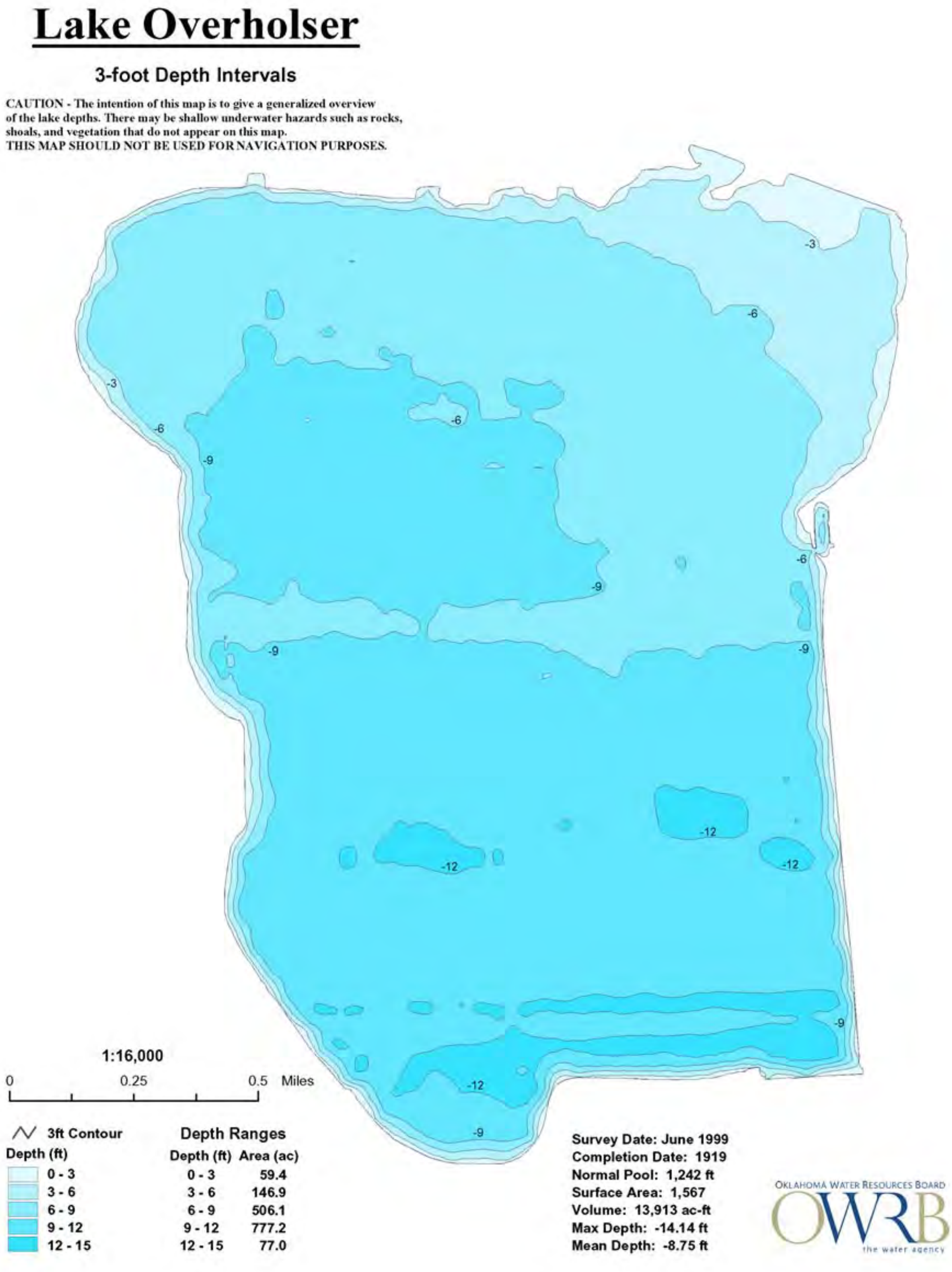


Figure 106. Bathymetric map of Lake Overholser.

Lake Ozzie Cobb

Lake Ozzie Cobb was sampled for four quarters, from November 2004 through August 2005. Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Water quality samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide annual turbidity value was 16 NTU (Plate 82), true color was 58 units, and secchi disk depth was 66 centimeters. Based on these three parameters, Lake Ozzie Cobb had fair to average water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The TSI was calculated at 55 (Plate 82), indicating the lake was eutrophic with high primary productivity and nutrient levels in sample year 2004-2005. This is similar to the value calculated in 2003, (TSI=54), indicating no significant increase or decrease in productivity has occurred. Lake Ozzie Cobb is listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. The TSI values varied seasonally and were generally eutrophic in the fall and summer and mesotrophic in the winter and spring quarters. Seasonal turbidity values are displayed in Figure 107a. Turbidity values ranged from a low of 8 NTU to a maximum of 35 NTU with the highest values reported in the winter quarter. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if $\geq$ 25% of the samples exceed the screening level prescribed in the Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. With 16.6% of the samples exceeding 25 NTU, the beneficial use of Fish and Wildlife propagation (FWP) is considered not supporting in regards to turbidity. Seasonal true color values are displayed in Figure 107b. Applying the same default protocols, the Aesthetics beneficial use is considered not supported with 25% of the reported values exceeding the WQS of 70 units.

In 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. The salinity values for Lake Ozzie Cobb ranged from 0.01 parts per thousand (ppt) to 0.04 ppt for this sample year. Specific conductivity ranged from 20.3 to 162.7 µS/cm, which is much lower than most Oklahoma reservoirs. These values indicate the low to minimal presence of electrical current conducting compounds (salts) in the lake, consistent with low salinity concentrations. The pH values at Lake Ozzie Cobb were slightly acidic to neutral, ranging from 6.05 to 7.05. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 33.9% of the values recorded being less than 6.5 the lake should be listed as not supporting the FWP beneficial use based on pH. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Oxidation-reduction potentials ranged from 266 mV to 487 mV. Reducing conditions were not present at this reservoir in the 2004-2005-sample year. During the fall and winter quarters stratification was not present and dissolved oxygen (D.O.) values were generally above 7 mg/L (see Figure 107c-107d). Thermal stratification was evident in both spring and summer quarters. In the spring, the lake was stratified between 1 and 2 meters however D.O. remained above 2.0 mg/L (Figure 107e). In the summer stratification also occurred between 1 and 2 meters with dissolved oxygen below 2.0 mg/L to the lake bottom of 4 meters, accounting for 40% of the water column experiencing anoxic conditions (Figure 107f). If D.O. values are less than 2 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the lake is supporting its FWP beneficial use based on dissolved oxygen values. The lake was also sampled for chlorides, sulfates and total dissolved solids to assess the Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.50 mg/L at the surface. Surface TN ranged from 0.23 mg/L to 0.84 mg/L, with the highest values reported in the summer and lowest values in the winter. The lake-wide total phosphorus (TP) average was 0.036 mg/L at the surface. Total phosphorus at the surface ranged from 0.028 mg/L to 0.048 mg/L. Similar to TN, surface TP was highest in the summer, however the lowest values were recorded during the spring quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 9:1 for sample year 2004-2005. This is slightly higher than 7:1, characterizing the lake as potentially phosphorus limited to co-limited (Wetzel, 1983).

In summary, Lake Ozzie Cobb was classified as eutrophic, indicative of high primary productivity and nutrient conditions in 2004-2005. This is similar to the value calculated in 2003, (TSI=54), indicating no significant increase or decrease in productivity has occurred. Lake Ozzie Cobb is listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Water clarity was fair to average based on true color, turbidity and secchi disk depth. The lake is supporting the FWP beneficial use and dissolved oxygen, partially supporting for turbidity, but not supporting due to low pH values reported throughout the year. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. The Aesthetics beneficial use is considered not supported based on true color with 25% of the recorded values exceeding the WQS of 70 units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Lake Ozzie Cobb is owned by the State of Oklahoma and is utilized for recreation.

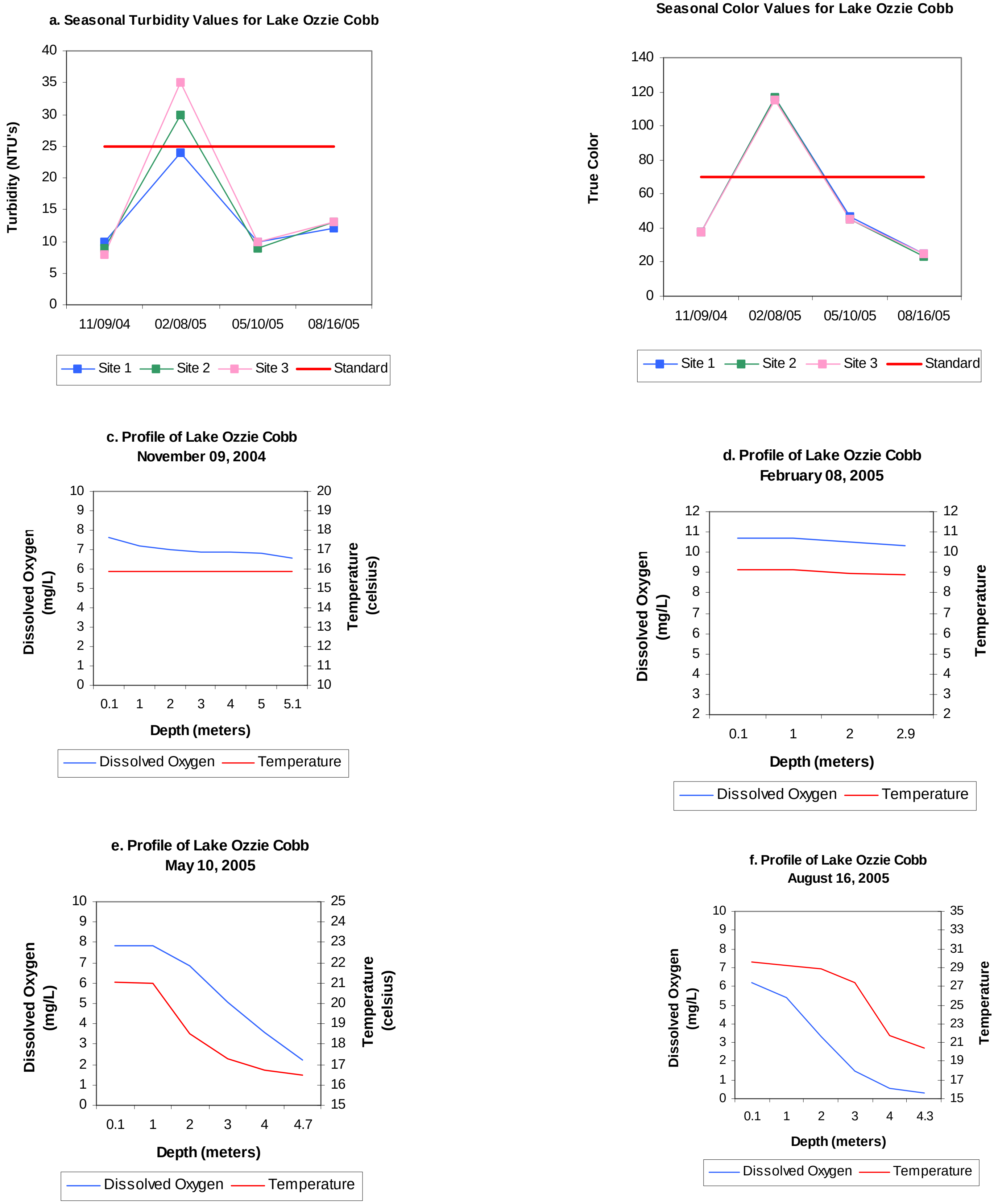
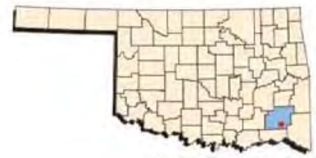


Figure 107a-107f. Graphical representation of data results for Lake Ozzie Cobb.

LAKES MONITORING PROGRAM

Lake Ozzie Cobb
and
Watershed



Lake Ozzie Cobb
Location

N W E S

Lake Data	
Owner	State of Oklahoma
County	Pushmataha
Constructed in	1958
Surface Area	116 acres
Volume	833 acre/feet
Shoreline Length	4 miles
Mean Depth	7.18 feet
Watershed Area	4,378 acres

POOR EXCELLENT
Turbidity
2005

POOR EXCELLENT
Trophic State
2005

Plate 82 - Lake Water Quality for
Lake Ozzie Cobb

Pauls Valley City Lake

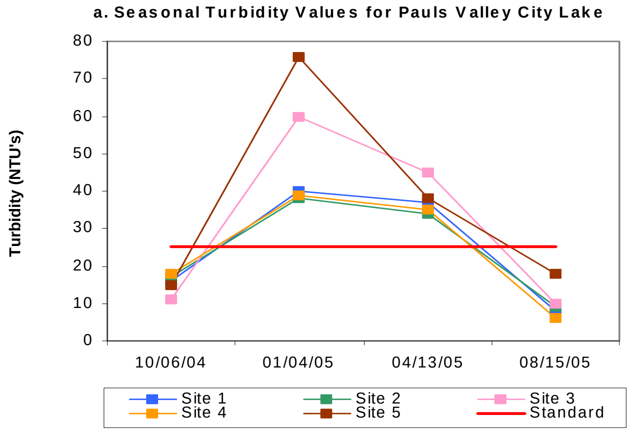
Pauls Valley City Lake was sampled for four quarters, from October 2004 through August 2005. Water quality samples were collected at five (5) to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the lake surface at all sample sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide annual turbidity value was 29 NTU (Plate 83), true color was 58 units, and secchi disk depth was 54 centimeters. Based on these three parameters, Pauls Valley City Lake had average water clarity in sample year 2004-2005. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI was 49 (Plate 83), indicating the lake was mesotrophic with moderate primary productivity and nutrient conditions. The TSI values throughout the sample year were fairly consistent with values ranging from upper mesotrophic to lower eutrophic at all sites throughout the year. Seasonal turbidity values are displayed in Figure 108a. Turbidity values in the winter, spring and summer seasons were below the turbidity standard of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 50% of the collected values exceeding 25 NTU, the FWP use is considered not supported for turbidity. Seasonal true color values are displayed in Figure 108b. True color values followed the same pattern as turbidity with higher values observed in the winter and spring sampling quarters. Applying the same default protocol, the Aesthetics beneficial use is considered not supported with 50% of samples above the 70-unit standard.

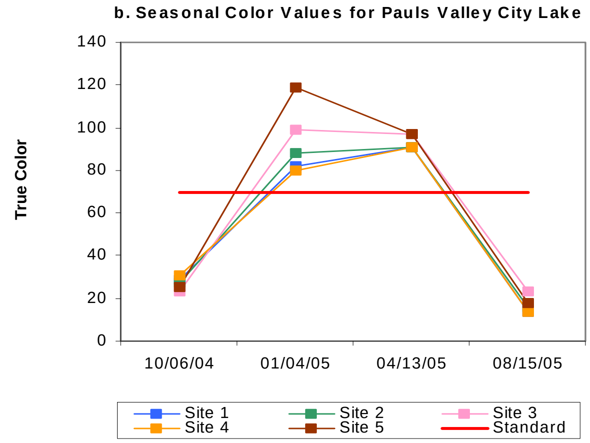
In 2004-2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation- reduction potential, and salinity were recorded at all sample sites. Salinity values for Pauls Valley City Lake ranged from 0.09 parts per thousand (ppt) to 0.15 ppt for this sample year. This is within the average range of values reported in most Oklahoma reservoirs. Specific conductivity ranged from 200.1 to 314.1 cm/cm, indicating the minimal presence of electrical current conducting compounds (salts) in the lake, consistent with salinity concentrations. In general pH values were neutral to slightly alkaline with values ranging from 7.28 to 8.33 during the study period. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With all recorded values within the acceptable range the lake is supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (ORP) ranged from 191 mV to 427 mV, indicating an absence of reducing conditions. During the fall, winter and spring quarters, stratification was not present and lake was well mixed (see Figure 108c-108e). In the spring, the lake was weakly stratified between 4 and 5 meters, however dissolved oxygen (D.O.) remained above 2.0mg/L. In the summer, thermal stratification was evident and anoxic conditions were present below the thermocline (see Figure 108f). In the summer stratification occurred at between 5 and 6 meters with D.O. falling below 2.0 mg/L from 6 meters to the lake bottom of 8 meters, accounting for approximately 33% of the water column experiencing anoxic conditions. Sites 2 and 4 were also stratified between 5 and 6 meters with 25% of the water column at both sites below 2.0 mg/L. If D.O. values are less than 2 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Pauls Valley City Lake is supporting its FWP beneficial use based on dissolved oxygen values recorded during the summer sampling interval. The lake was also sampled for chlorides, sulfates and total dissolved solids to assess the Agriculture beneficial use. Sampling in 2004-2004 found the Agriculture beneficial use to be fully supported based on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

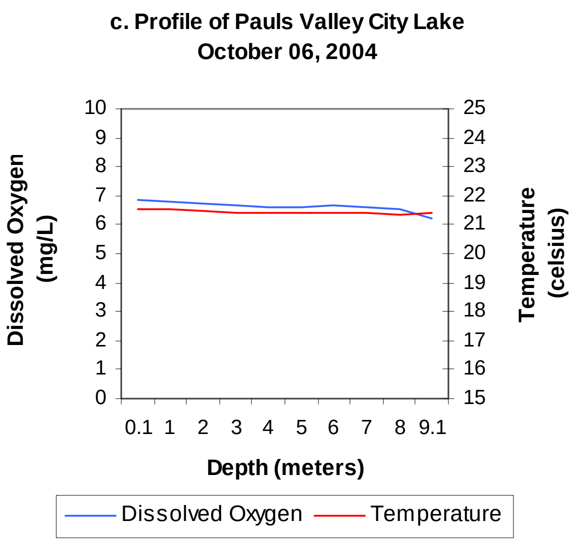
Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

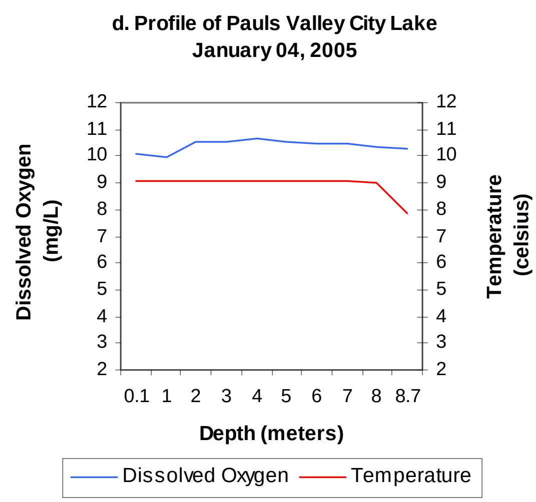
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.57 mg/L at the surface. Surface TN ranged from 0.40 mg/L to 0.85 mg/L, with the highest values reported in the summer and lowest values in the fall. The lake-wide total phosphorus (TP) average was 0.038 mg/L at the surface. Total phosphorus at the surface ranged from 0.022mg/L to 0.073 mg/L. Surface TP was highest in the winter, with the lowest values recorded during the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 15:1 for sample year 2004-2005. This is slightly higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

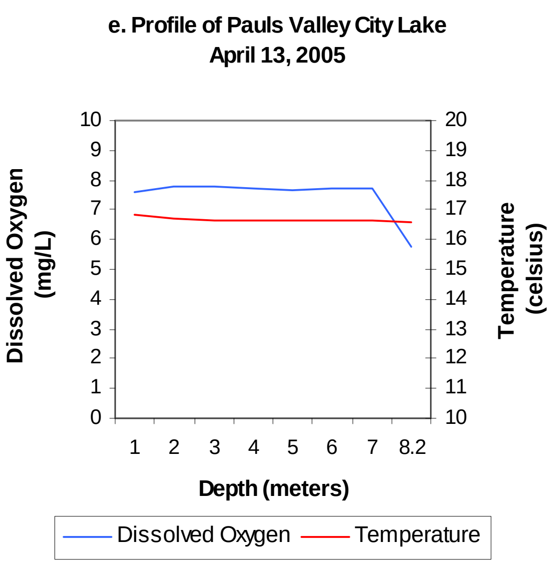
In summary, Pauls Valley City Lake was classified as mesotrophic, indicative of moderate primary productivity and nutrient conditions. Water clarity was average based on turbidity, true color and secchi disk depth. The lake is supporting the FWP beneficial use based on pH and dissolved oxygen values but is not supporting the use as it relates to turbidity. The Aesthetic beneficial use is supported based on its trophic status, however the use is not supporting for true color as 50% of the values exceeded the WQS of 70 units. Bacteriological samples were not collected during the 2005 recreation season, therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Pauls Valley City Lake is located in Garvin County and serves as a water supply and recreational reservoir for the city.











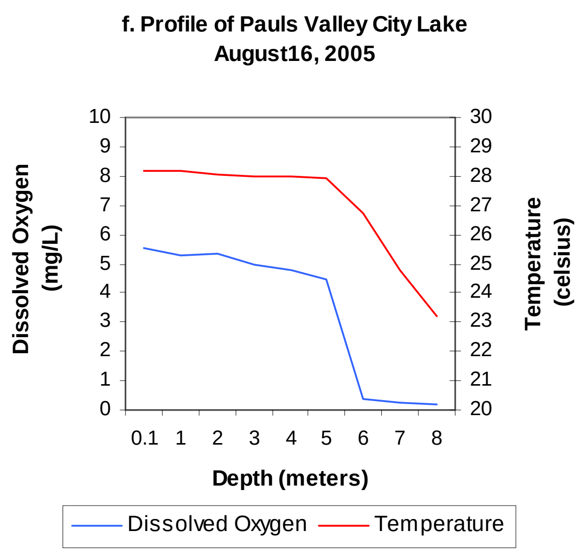
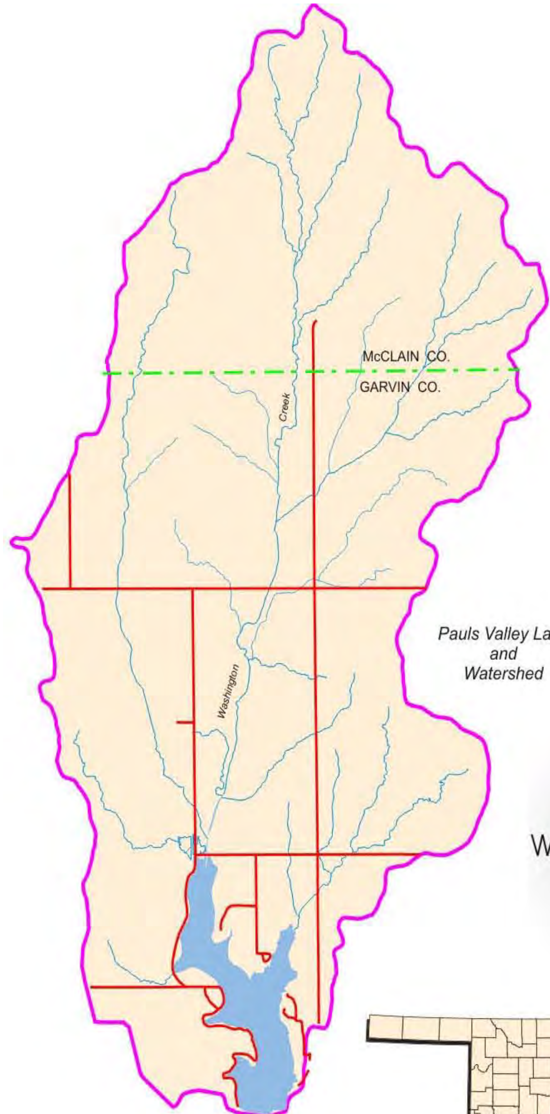


Figure 108a-108f. Graphical representation of data results for Pauls Valley City Lake.



Pauls Valley Lake
and
Watershed

Pauls Valley Lake
Location

Lake Data

Owner	City of Pauls Valley
County	Garvin
Constructed	1954
Surface Area	750 acres
Volume	8,730 acre/feet
Shoreline Length	8 miles
Mean Depth	11.64 feet
Watershed Area	21 square miles

Turbidity
2005

Trophic State
2005

Plate 83 - Lake Water Quality for

Pauls Valley Lake

Lake Pawhuska

Lake Pawhuska was sampled for four quarters, from October 2004 through July 2005. Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the lake surface at all sample sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide average turbidity was 2 NTU (Plate 84), true color was 10 units, and secchi disk depth was 274 centimeters. Based on these three parameters, Lake Pawhuska had excellent water clarity in sample year 2004-2005, consistent with data reported in 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The TSI was 39 (Plate 84), indicating the lake was oligotrophic with low primary productivity and nutrient levels in sample year 2005 (Plate 73). The TSI values throughout the sample year were fairly consistent with values ranging from mesotrophic at all sites in the fall and winter to oligotrophic in the spring and summer. Seasonal turbidity values per site are displayed in Figure 109a. Turbidity values throughout the year were all well below the turbidity standard of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. The Fish and Wildlife Propagation (FWP) beneficial use is considered supported based on turbidity. Seasonal true color values are displayed in Figure 109b. True color values followed the same pattern as turbidity with all reported values well below the standard of 70 units, therefore the Aesthetics beneficial use is considered fully supported based on true color.

In 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.17 parts per thousand (ppt) to 0.22 ppt, which is within the average range of values reported in most Oklahoma reservoirs. Specific conductivity ranged from 338.4 µS/cm to 441.4 µS/cm, indicating the moderate presence of electrical current conducting compounds (salts) in the lake, consistent with salinity concentrations. The pH values were neutral to slightly alkaline with values ranging from 7.09 to 8.24 during the study period. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With all recorded values within the acceptable range the lake is supporting the FWP beneficial use based on pH. The ORP ranged from 125 mV to 440 mV, indicating an absence of reducing conditions during the study period. During the fall, and spring winter quarters, stratification was not present and lake was well mixed (see Figure 109c-109e). In the summer, thermal stratification was evident and anoxic conditions were present below the thermocline. In the summer stratification occurred at several 1-meter intervals with D.O. falling below 2.0 mg/L from 7 meters to the lake bottom of 10.9 meters, accounting for approximately 27.3% of the water column at sites 1 and 2 to be experiencing anoxic conditions (Figure 109f). If

D.O. values are less than 2 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With 27.3% of the water column below 2.0 mg/L the FWP beneficial use is considered partially supported based on dissolved oxygen values. The lake was also sampled for chlorides, sulfates and total dissolved solids to assess the Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.22 mg/L at the surface. Surface TN ranged from 0.13 mg/L to 0.51 mg/L, with the highest values reported in the summer and lowest values in the winter quarter. The lake-wide total phosphorus (TP) average was 0.013 mg/L at the surface. Total phosphorus at the surface ranged from 0.011mg/L to 0.017 mg/L. Surface TP was highest in the winter, and the lowest values were recorded during the spring quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 17:1 for sample year 2004-2005. This is slightly higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

In summary, Lake Pawhuska was classified as oligotrophic, indicative of low primary productivity and nutrient conditions (Plate 84). Water clarity continues to be excellent based on true color, turbidity and the high secchi disk depths. The lake is supporting the FWP beneficial use based on turbidity and pH values collected during the study period. Although 27.3% of the water column was anoxic during the summer, the FWP beneficial use is considered supported based on low D.O. values in the summer. The Aesthetics beneficial use is fully supported as it relates to trophic status and true color. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Lake Pawhuska was constructed in 1936 and for the purpose of water supply and recreation. The lake is located in Osage County and is one of the nicer small lakes in the state.

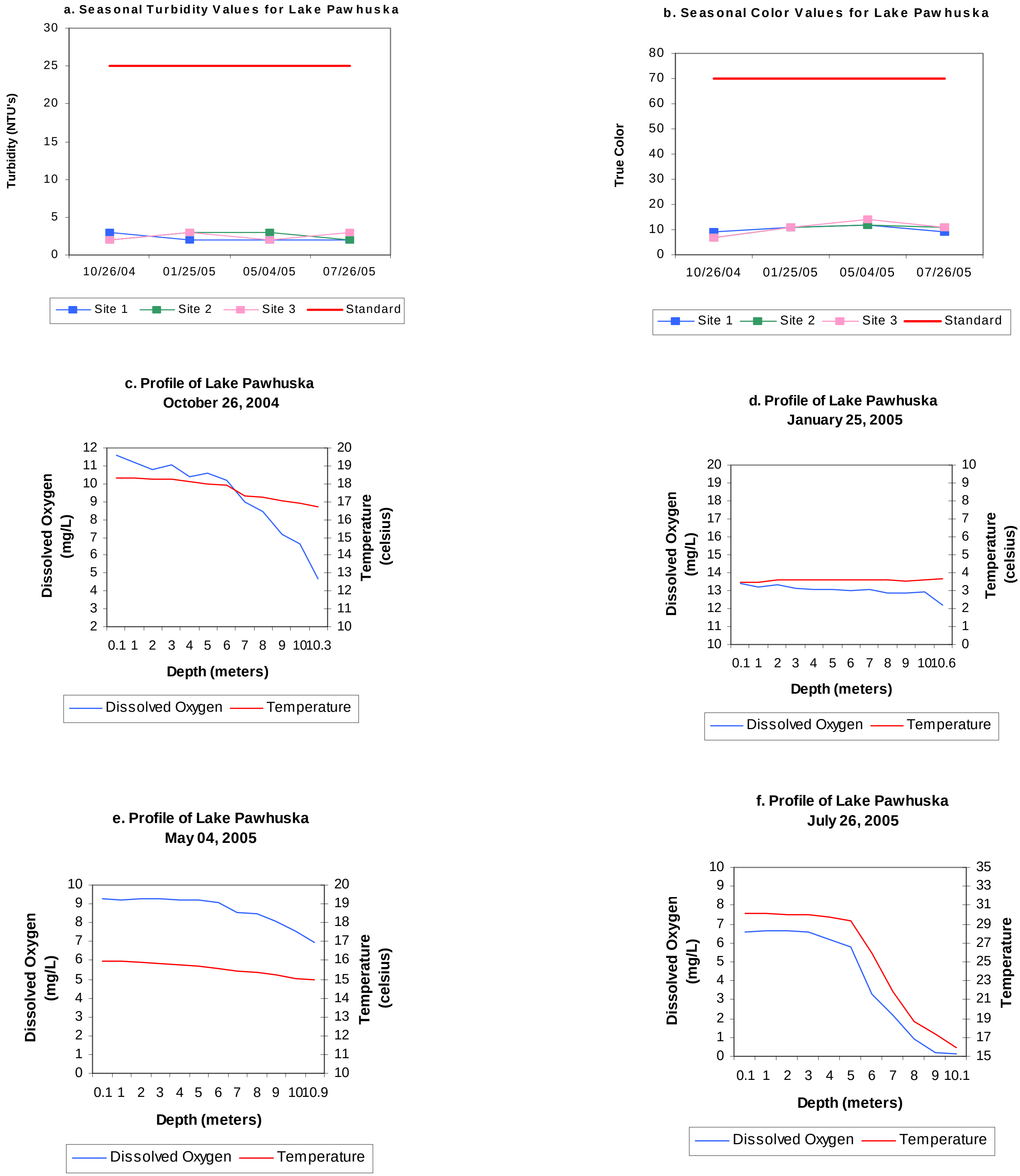
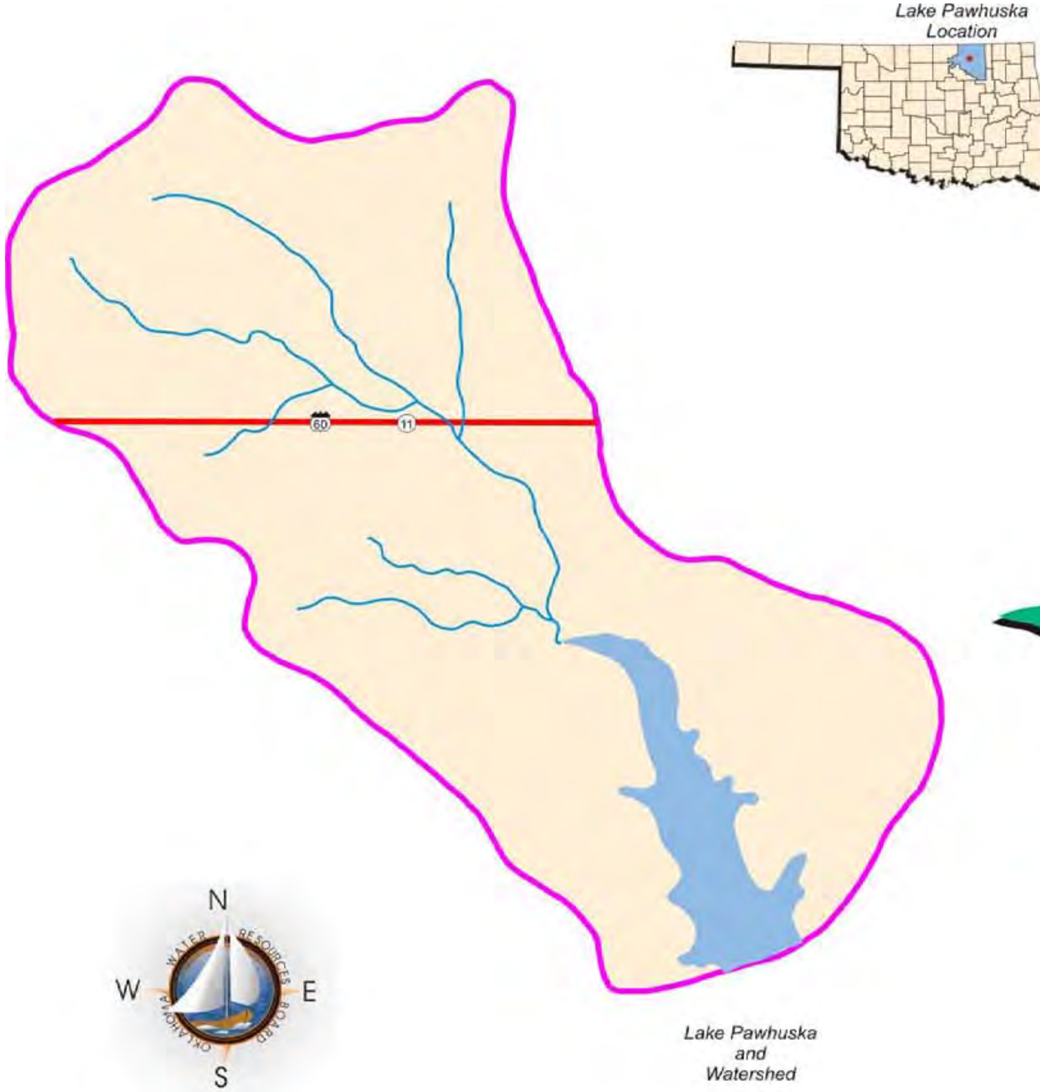


Figure 109a-109f. Graphical representation of data results for Lake Pawhuska.



Lake Pawhuska and Watershed

Lake Pawhuska Location

Lake Data	
Owner	City of Pawhuska
County	Osage
Constructed in	1936
Surface Area	96 acres
Volume	3,600 acre/feet
Shoreline Length	3 miles
Mean Depth	37.50 feet
Watershed Area	1754 acres

Trophic State 2005

Turbidity 2005

Plate 84 - Lake Water Quality for

Lake Pawhuska

Pawnee Lake

Pawnee Lake is a 257-acre lake, which was constructed in 1932 and is owned and operated by the City of Pawnee. The lake is managed as a municipal water supply and offers numerous recreational opportunities to the public. Pawnee Lake was sampled for four quarters, from November 2006 through August 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites with an additional sample taken at 0.5 meters during the study period. The lake-wide annual turbidity value was 22 nephelometric turbidity units (NTU), true color was 66 units, and secchi disk depth was 44 centimeters. Based on these three parameters, Pawnee Lake had average water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI was 59 indicating the lake was eutrophic with high levels of primary productivity and nutrients. This is consistent with the value calculated in 2002 (TSI=55) and 2005 (TSI=59) indicating no significant increase or decrease in productivity occurred over time. The TSI values throughout the sample year were fairly consistent with mesotrophic conditions in the fall and spring and hypereutrophic conditions during the winter and summer quarters. In the spring quarter site 5 was the only site in the eutrophic category. Turbidity readings ranged from a low of 2 NTU to a high of 37 NTU (see Figure 110a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). Although 30% of the turbidity values exceed 25 NTU, available flow and rainfall data suggest that the peak in turbidity, which occurred in May is likely due to seasonal storm events, therefore Pawnee Lake will be listed as supporting its Fish & Wildlife Propagation (FWP) beneficial use. Seasonal true color values are displayed in Figure 110b. True color values were below the aesthetics WQS of 70 units in both the fall and winter (see Figure 110b). Similar to turbidity a peak in true color occurred in the spring as well as the summer quarter and is likely the result of seasonal storm events and therefore the Aesthetics beneficial will be considered supported at Pawnee Lake.

In 2006-2007, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.09 parts per thousand (ppt) to 0.16 ppt, indicating moderate salt content in the lake system. Values were slightly higher than the expected range of salinity readings reported for most Oklahoma lakes. Readings for specific conductivity were also within the range of expected values, ranging from 205.9 µS/cm to 331 µS/cm, also indicative of moderate amounts of electrical current conducting compounds (salts) in the water column throughout the year. In general, pH values were neutral to slightly alkaline with values ranging from 7.25 units in the spring quarter to 8.69 units in the summer quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. With all values within the acceptable range the lake is fully supporting its FWP beneficial use as it relates to pH. Oxidation-reduction potentials (redox) ranged from 73 mV to 506 mV, both in the summer quarter, indicating an absence of reducing conditions in the lake at the time it was sampled. Pawnee Lake was not thermally stratified in the fall or winter quarters and dissolved oxygen (D.O.) values were above 7.0 mg/L throughout the water column in the first two seasons (see Figure 110c-110d). During the spring quarter the lake was stratified between 5 and 6 meters with dissolved oxygen below 2.0 mg/L from 6 meters in depth to the lake bottom of 7 meters. In the summer, the lake was strongly thermally stratified, and anoxic conditions were also present at sites 1 and 2 (see Figure 110f). Although this lake is fairly shallow (about 7 meters deep), about 38% of the water column was anoxic at these to sites. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered fully supported at Pawnee Lake with only 25% to 38% of the water column less than 2.0 mg/L in the spring and summer quarters. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. Of the 10 samples collected none exceeded the prescribed screening level or geometric mean. The PBCR is therefore considered supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.98 mg/L at the lake surface. The TN at the surface ranged from 0.80 mg/L to 1.25 mg/L. Both the highest and lowest surface TN values were reported in the summer quarter. The lake-wide total phosphorus (TP) average was 0.041 mg/L at the lake surface. The surface TP ranged from 0.023 mg/L to 0.060 mg/L. The highest surface TP value was reported in the fall quarter and the lowest was in the winter quarter. The nitrogen to phosphorus ratio (TN: TP) was approximately 24:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Pawnee Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Pawnee Lake was classified as eutrophic, indicative of high primary productivity and nutrient levels (Plate 85). This is consistent with previous data collection efforts, indicating no significant increase or decrease in productivity occurred over time. Water clarity is average based on true color, turbidity and secchi disk depth. The lake was fully supporting its Aesthetics beneficial use based on trophic status. Although 50% of the true color values were exceeding the WQS of 70 units, the peak in the spring and summer quarters is likely the result of seasonal storm events, therefore the Aesthetics beneficial will be considered supported at Pawnee Lake. Pawnee was fully supporting its FWP beneficial use based on pH, and D.O. readings recorded throughout the study period. Available flow and rainfall data suggest that the peak in turbidity, which occurred in May is likely due to seasonal storm events, therefore Pawnee Lake will be listed as supporting its Fish & Wildlife Propagation (FWP) beneficial use. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. All samples were below the prescribed screening level and geometric mean, therefore the PBCR is considered supported for the current sample year.

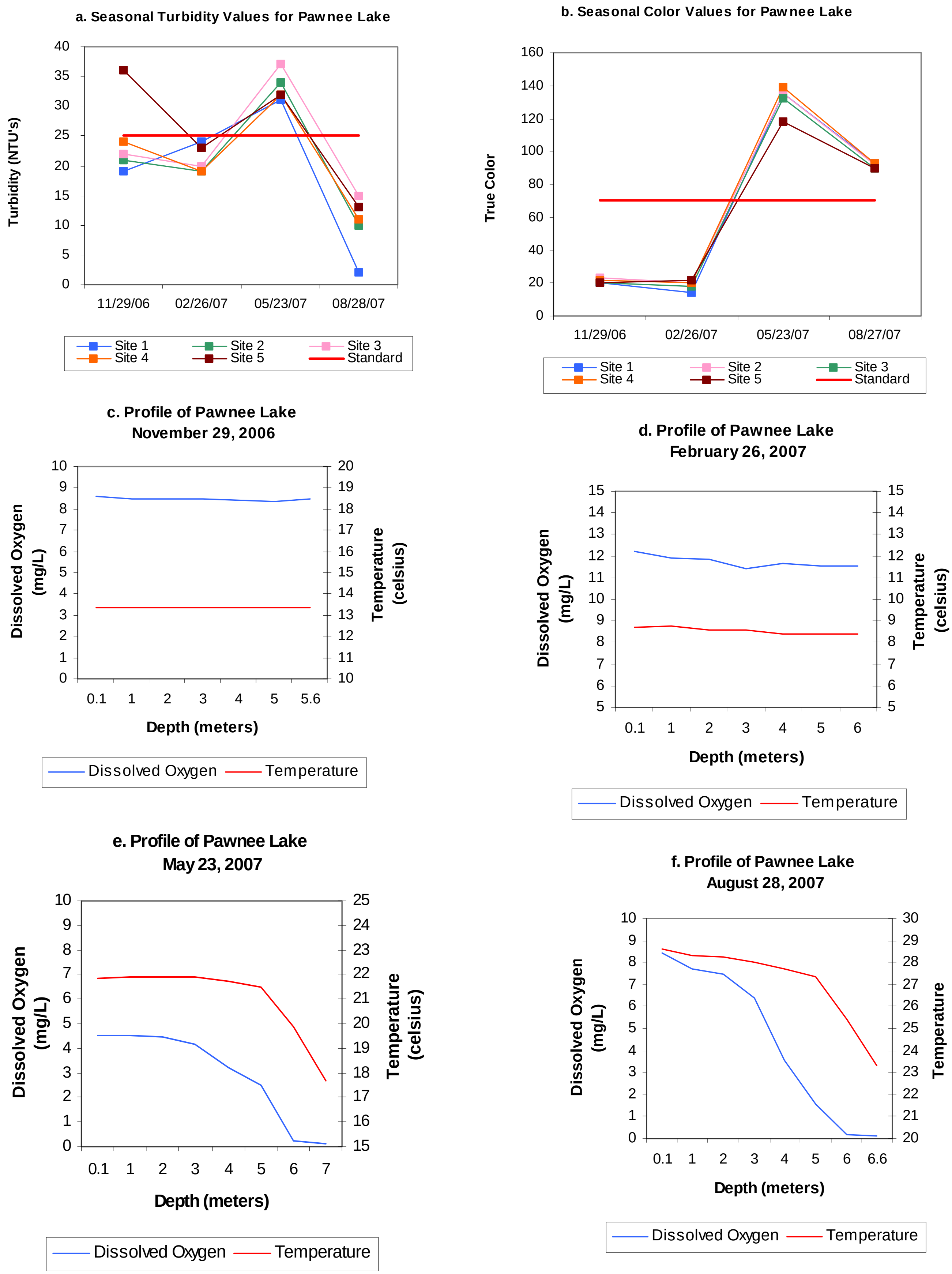
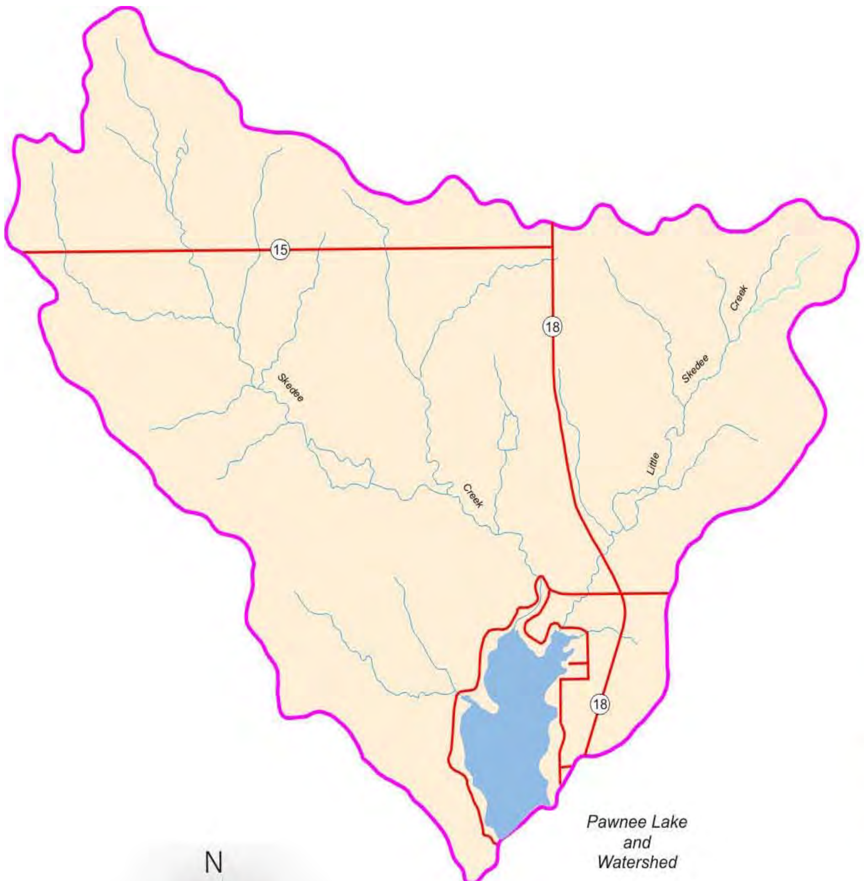
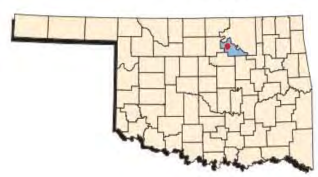


Figure 110a-110f. Graphical representation of data results for Pawnee Lake.



Pawnee Lake
and
Watershed

Pawnee Lake
Location



Lake Data	
Owner	City of Pawnee
County	Pawnee
Constructed in	1932
Surface Area	257 acres
Volume	3,855 acre/feet
Shoreline Length	4 miles
Mean Depth	15.00 feet
Watershed Area	13 square miles

Turbidity
2007

Trophic State
2007

Plate 85 - Lake Water Quality for
Pawnee Lake

LAKES MONITORING PROGRAM

Perry Lake

Perry Lake, located in Noble County, was constructed for the purpose of flood control, water supply, and recreation. Perry Lake was sampled for four quarters, from November 2006 through August 2007.

Water quality samples were collected from five (5) sites to represent the riverine, transition and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the sample year. The average lake-wide turbidity was 75 nephelometric turbidity units (NTU) true color was 143 units, and average secchi disk depth was 22 centimeters. Based on these three parameters, Perry Lake had poor water clarity. These results are similar to those in 2005 indicating no significant change has occurred over time. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=19). Due to a lab accident there are no chlorophyll-a data results for site 1 from the spring sampling interval. The calculated TSI was 48 (Plate 86) indicating the lake was mesotrophic in sample year 2006-2007 with moderate levels of primary productivity and nutrient levels. This value is similar to the TSI calculated in 2005 (TSI=44), and is in the same trophic category, indicating no significant change in productivity has occurred since the last time sampled. The TSI values were primarily upper mesotrophic throughout the sample year. Seasonal turbidity values are displayed in Figure 111a. Turbidity ranged from a low of 25 NTU to a maximum of 140 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. With 100% of the collected values exceeding the standard of 25 NTU, the Fish and Wildlife Propagation (FWP) beneficial use is considered not supported. Seasonal true color values are displayed in Figure 111b. Of the 20 values collected, 10 (50%) were greater than the WQS of 70 units. Applying the same default protocol, the Aesthetics beneficial use is considered not supported.

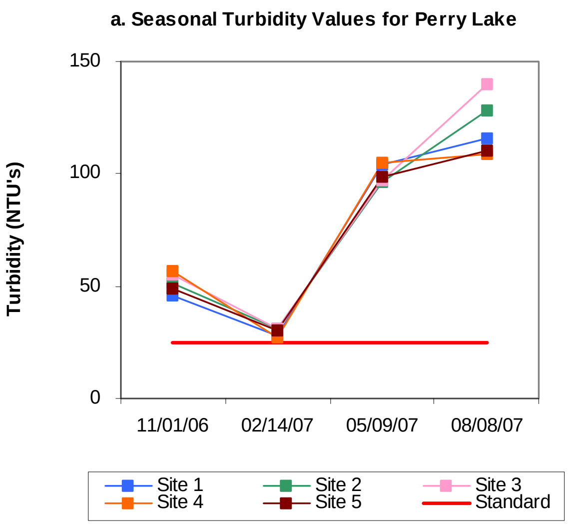
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at sample sites during the study period. The salinity values ranged from 0.08 parts per thousand (ppt) to 0.21 ppt, which is within the average range of values for most Oklahoma reservoirs. Specific conductivity ranged from 181.9 µS/cm to 415 µS/cm indicating low to moderate concentrations of electrical current conducting materials (salts) were present in the lake. These values are also within the range commonly seen in Oklahoma reservoirs and are consistent with recorded salinity values. The pH values were neutral to slightly alkaline ranging from 6.9 to 8.19. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. With 100% of the recorded values with the acceptable range, the FWP use is supported based on pH. Oxidation-reduction potentials (ORP) ranged from 339 mV in the summer to 435 mV in the fall, indicating reducing conditions were not present in sample year 2006-2007. Stratification was not evident in the fall quarter and the lake was well mixed with dissolved oxygen (D.O.) remaining above 7.0 mg/L (Figure 111c). Due to equipment failure no profile data is available for the winter quarter, however based on historical data and the time of year it is unlikely stratification would be present. In both spring and summer quarters, the lake exhibited thermal stratification; however anoxic conditions were not present below the thermocline during the spring (see Figure 111e). During the summer stratification occurred between 7 and 8 meters below the surface at sites 1, 2 and 5 at which point dissolved oxygen (D.O.) fell below 2.0 mg/L. Anoxic conditions comprised approximately 20-36% of the water at these sites. If D.O. values are less than 2 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP is considered supported as it relates to dissolved oxygen with only 20-36% of the water column less than 2.0 mg/L during the study period. The lake was also sampled for chlorides, sulfates and total dissolved solids to assess the Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

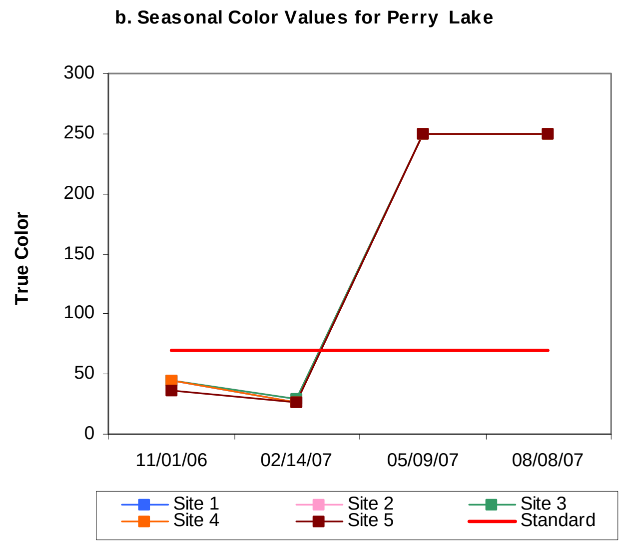
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. Of the 10 samples collected 5, (50%) of the *E. coli* samples exceeded the prescribed screening level of 235 cfu/100 mL however the geometric mean of 126 was not exceeded. Similarly, 50% of the fecal coliform samples exceeded the screening level of 400 cfu/100 mL however the geometric mean (51.9) was below the prescribed mean of 400. The PBCR is therefore considered supported based on fecal coliform and *E. coli*. Due to quality control issues minimum data requirements for enterococci were not met therefore an assessment of the PBCR cannot be made at this time as it relates to this parameter.

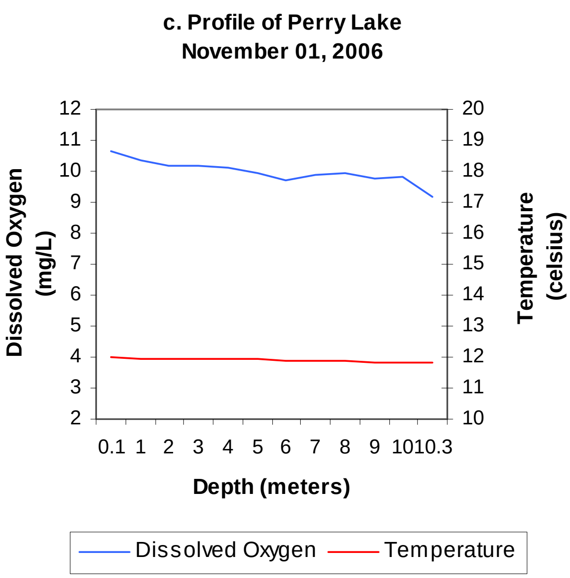
Collected water quality samples were analyzed for nutrients including total nitrogen and total phosphorus, although there are currently no numerical WQS for these parameters. The lake-wide total nitrogen (TN) average was 0.88 mg/L at the surface. Surface TN ranged from 0.50 mg/L to 1.35 mg/L, with the highest values reported in the spring and lowest values in the winter quarter. The lake-wide total phosphorus (TP) average was 0.113 mg/L at the surface. Total phosphorus at the surface ranged from 0.027 mg/L to 0.253 mg/L. Surface TP was highest in the fall, and like TN, the lowest values were recorded during the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 9:1 for sample year 2006-2007. This is slightly higher than 8:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

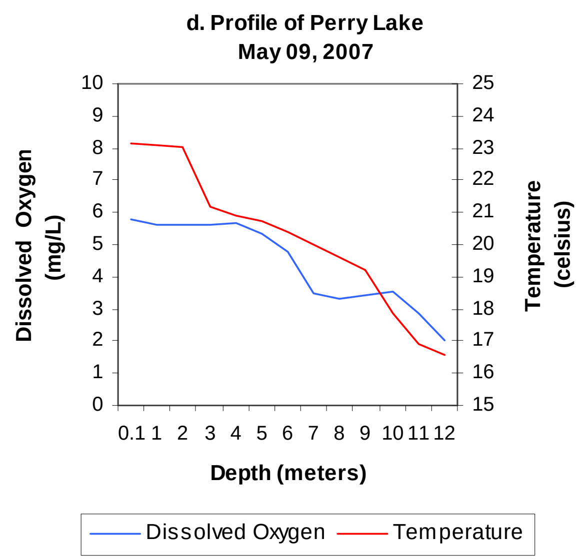
Perry Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Perry Lake was classified as mesotrophic, indicative of moderate primary productivity and nutrient conditions (Plate 86). The current trophic consistent with previous evaluation conducted in 2003 and 2005 indicating little or no change in productivity has occurred. Water clarity continues to be poor based on true color, turbidity and secchi depth and is likely to always be poor based on soil composition of the area. The FWP beneficial use is supported based on pH and dissolved oxygen and not supported based on high turbidity values with 100% of the values exceeding the WQS of 25 NTU. The Aesthetics beneficial use is supported based on trophic status, however the use not supported based on true color with 50% of the values exceeding the WQS of 70 units. Bacteriological samples were collected during the 2007 recreation season to assess the Primary Body Contact Recreation (PBCR) beneficial use. Although samples for both *E.coli* and fecal coliform exceeded the screening levels the geometric means were below the values prescribed for these parameters and the use is considered supported. An assessment of the PBCR based on enterococci cannot be made at this time due to minimum data requirements not being met.









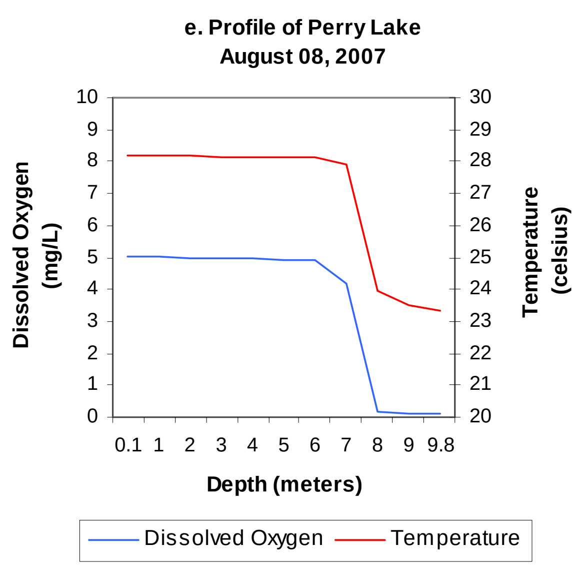


Figure 111a-111f. Graphical representation of data results for Perry Lake.

Lake Data

Owner	City of Perry
County	Noble
Constructed in	1937
Surface Area	614 acres
Volume	6,892 acre/feet
Shoreline Length	11 miles
Mean Depth	11.22 feet
Watershed Area	16 square miles

Plate 86 - Lake Water Quality for

Perry Lake

Pine Creek Lake

Pine Creek Lake was sampled for four quarters from October 2003 through July 2004. Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir as well as major lake arms and tributaries. Samples were collected at the lake surface at all sample sites and 0.5 meters from the lake bottom at site 1,near the dam. The lake-wide annual turbidity value was 13 NTU (Plate 87), true color was 26 units, and secchi disk depth was 89 centimeters. Results for true color and secchi disk depth were better than that observed in 2001-2002. Based on these three parameters, Pine Creek Lake had good water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The TSI was 54 (Plate 87), indicating the lake was eutrophic in nature with high levels of primary productivity and nutrients. This is identical to the value calculated in 2002 (TSI=54), indicating no significant increase or decrease in productivity has occurred. The TSI values throughout the sample year were predominantly eutrophic with only the winter quarter experiencing mesotrophic and oligotrophic conditions. This same pattern occurred in the 2001-2002 evaluation. Turbidity values in the fall, spring and summer seasons were below the Oklahoma Water Quality Standard (WQS) for turbidity of 25 NTU (see Figure 112a). There was a spike in turbidity in the winter quarter, possibly due to seasonal rain events, at which point values were at or above the standard at sites 3,4 and 5. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 10% of the collected values exceeding the criteria, the lake is partially supporting its Fish & Wildlife Propagation (FWP) beneficial use. Seasonal true color values are displayed in Figure 112b. True color values varied seasonally and with 100% of the sample values below the WQS of 70 units the lake is fully supporting its Aesthetics beneficial use for true color (see Figure 112b).

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.0 parts per thousand (ppt) to 0.02 ppt, well within the expected range of salinity values if not less than reported values for most Oklahoma lakes. Readings for specific conductivity were also lower than the expected range for most Oklahoma lakes, ranging from 0.0 µS/cm to 66.5 µS/cm, indicating the presence of little or no electrical current conducting compounds (salts) in the water column throughout the year. In general, pH values were neutral to slightly acidic with values ranging from 5.73 units in the summer quarter to 7.56 also in the summer quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 56% of the values recorded as less than 6.5 units Pine Creek Lake is not supporting the FWP as it relates to pH. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Oxidation-reduction potentials (redox) ranged from 323 mV in the summer quarter to 524 mV recorded at the lake surface in the winter quarter. Reducing conditions were not present during the study period. Pine Creek Lake was not thermally stratified in the fall or winter quarters and dissolved oxygen (D.O.) readings were above 3.0 mg/L (see Figure 112c-112d). The lake was weakly thermally stratified in the spring quarter between 12 and 13 meters below the lake surface at site 1; however, D.O. readings remained above 2.0 mg/L until very near the lake bottom at 17.1 meters (see Figure 112e). In the summer, the lake was strongly thermally stratified at several 1-meter intervals among all five sites with the first occurring between 2 and 3 meters below the surface. Dissolved oxygen was below 2.0 mg/L from 4 meters in depth to the lake bottom at 14 meters at site 1, the dam (see Figure 112f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. In the summer quarter 73% of the water column at site 1 was experiencing anoxic conditions, which is cause for classifying the lake as not supporting its FWP beneficial use based on D.O. concentrations in the water column. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling found the Agriculture beneficial use to be fully supported based on criteria in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. Of the 10 enterococci samples collected one (10%) exceeded the prescribed screening level of 61 cfu/ml for enterococci, however the geometric was not exceeded. The PBCR beneficial use is therefore considered supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.61 mg/L at the lake surface. The TN at the surface ranged from 0.10 mg/L to 2.16 mg/L. The highest surface TN value was reported in the summer quarter and the lowest was in the spring quarter. The lake-wide total phosphorus (TP) average was 0.025 mg/L at the lake surface. The surface TP ranged from 0.015 mg/L to 0.38 mg/L. The highest surface TP value was reported in the winter quarter and the lowest was in the fall quarter. The nitrogen to phosphorus ratio (TN: TP) was approximately 25:1 for sample year 2003-2004. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 2000 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening level or consumption advisory level. The lake is fully supporting its Fish Consumption beneficial use.

In summary, Pine Creek Lake was classified as eutrophic, indicating high primary productivity and nutrient levels (Plate 87). This is similar to the value calculated in 2002 (TSI=54), indicating no significant increase or decrease in productivity has occurred. Based on true color, turbidity and secchi disk depth, Pine Creek Lake had good water clarity in 2003-2004. The lake is fully supporting its Aesthetics beneficial use based on its trophic status and true color values recorded during the study period. The lake was partially supporting its FWP beneficial use based on nephelometric turbidity and not supporting for D.O. due to anoxic conditions present in 73% of the water column in the summer. With 56% of the pH values less than 6.5 the FWP beneficial use is not supported based on collected pH values. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Of the 10 enterococci samples collected one (10%) exceeded the prescribed screening level of 61 cfu/ml, however the geometric was not exceeded. The PBCR beneficial use is therefore considered supported. Pine Creek Lake, was constructed in 1969 by the United States Army Corps of Engineers for multiple purposes including, flood control, municipal water supply, fish & wildlife, and general recreation.

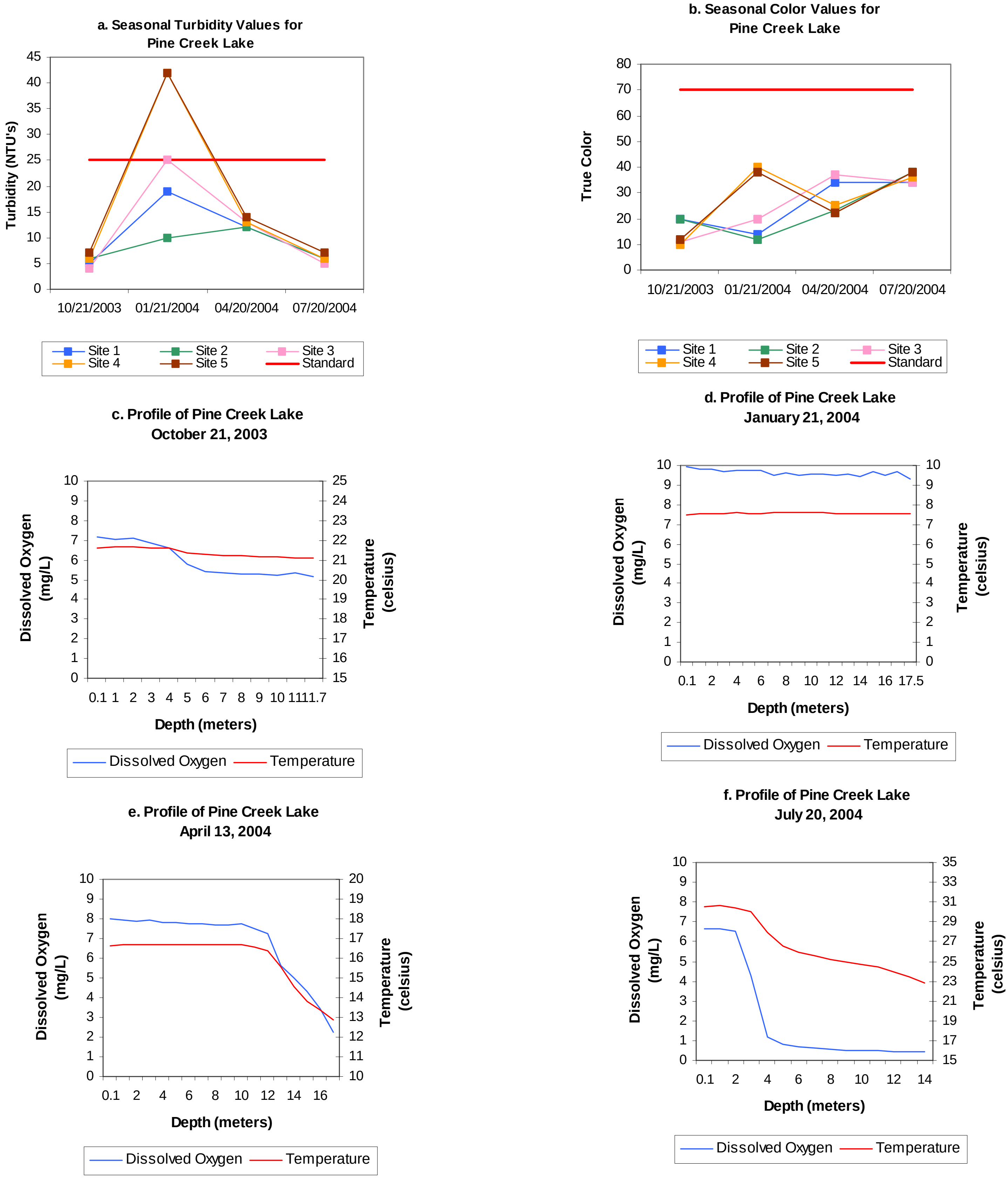


Figure 112a-112f. Graphical representation of data results for Pine Creek Lake.

Pine Creek Lake and Watershed

Pine Creek Lake Location

Lake Data	
Constructed by	Corps of Engineers
County	McCurtain
Constructed in	1969
Surface Area	3,750 acres
Volume	53,750 acre/feet
Shoreline Length	74 miles
Mean Depth	14.2 feet
Watershed Area	635 square miles

Turbidity 2004

Trophic State 2004

Plate 87 - Lake Water Quality for

Pine Creek Lake

Lake Ponca

Lake Ponca was sampled for four quarters, from November 2004 through August 2005. Water quality samples were collected from five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and from 0.5 meters from the lake bottom at site 1, the dam. The average lake-wide turbidity was 10 NTU (Plate 88), true color was 21 units and average secchi disk depth was 90 centimeters. Based on these three parameters, Lake Ponca had good water clarity. These values are similar to if not better than those reported in 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI was 52 (Plate 88), indicating the lake was eutrophic with high levels of primary productivity and nutrient levels. This value is similar to that from 2003 (TSI=54), indicating no significant change in productivity has occurred since the last evaluation. Seasonal TSI values varied by site and season and spanned three trophic categories in sample year 2005. In the fall, spring, and summer sampling quarters values were generally eutrophic. In the fall, values ranged from oligotrophic at site 4 to mesotrophic at sites 1 and 2, and eutrophic at sites 3 and 5. Seasonal turbidity values per site are displayed in Figure 113a. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. All turbidity values were below the Oklahoma Water Quality Standard (WQS) of 25 NTU, therefore meeting the Fish and Wildlife (FWP) beneficial use. Seasonal true color values are displayed in Figure 113b. True color values ranged from a low of 12 to a maximum of 34 during the sample year. Applying the same default protocol, the Aesthetics beneficial use is considered fully supported with 100% of the reported values well below the WQS of 70 units.

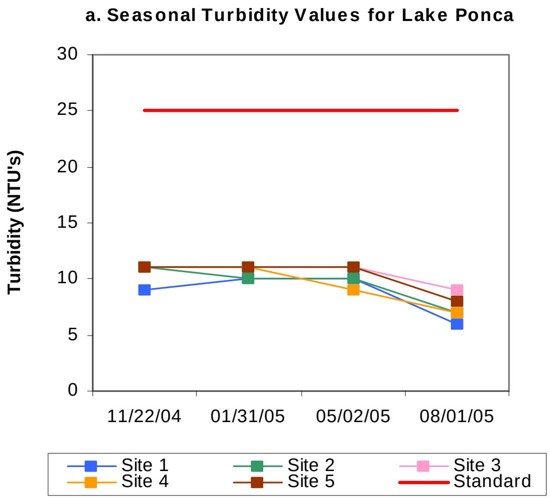
In 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.15 parts per thousand (ppt) to 0.21 ppt, which is within the average range of values, reported in most Oklahoma reservoirs. Specific conductivity ranged from 291 to 414.8 µS/cm, indicating low to moderate concentrations of electrical current conducting compounds (salts & chlorides) in the lake, consistent with salinity concentrations. The pH values were neutral to slightly alkaline with values ranging from 7.07 in the summer to 8.31 also recorded in the summer quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With all recorded values within the acceptable range the lake is supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (ORP) ranged from 54 mV in the hypolimnion in the summer to 414 mV in the spring. Reducing conditions were present during the summer interval when anoxic conditions were present in a large portion of the water column. During the fall or winter stratification was not present and lake was well mixed with dissolved oxygen generally above

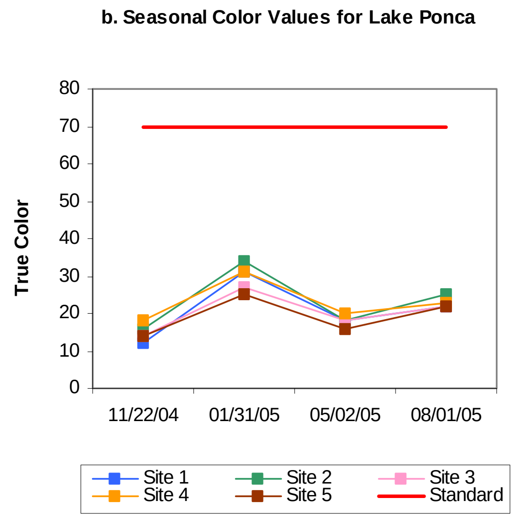
7.0 mg/L (see Figure 113c-113d). Although the lake exhibited weak thermal stratification in the spring, the dissolved oxygen was generally above 4.0 mg/L throughout the water column (Figure 113e). In the summer stratification occurred at several 1-meter intervals with dissolved oxygen (D.O.) falling below 2.0 mg/L between 4 and 5 meters throughout the lake, accounting for 55 to 65% of the water column to be experiencing anoxic conditions. If D.O. values are less than 2 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported based anoxic conditions present at 4 of the 5 sites within the lake. The lake was also sampled for chlorides, sulfates and total dissolved solids to assess the Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

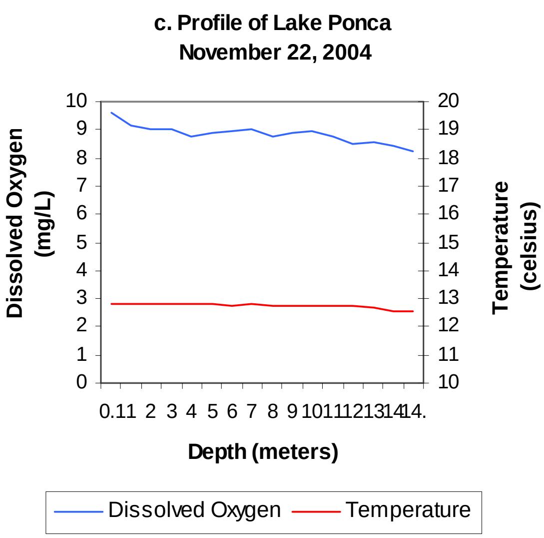
Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

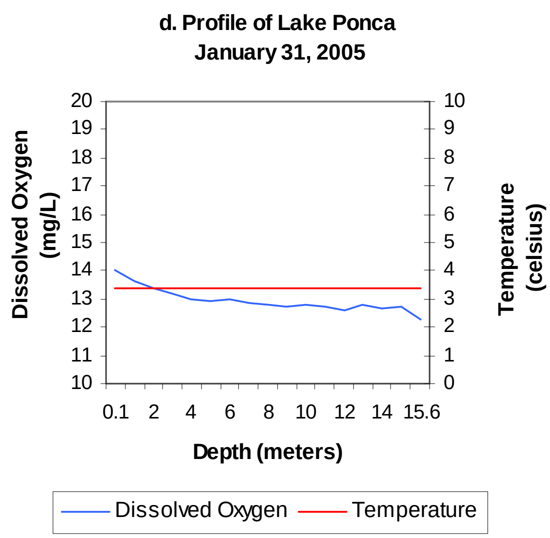
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.72 mg/L at the surface. Surface TN ranged from 0.13 mg/L to 1.24 mg/L, with the highest values reported in the summer and lowest values in the spring quarter. The lake-wide total phosphorus (TP) average was 0.034 mg/L at the surface. Total phosphorus at the surface ranged from 0.025mg/L to 0.052 mg/L. Surface TP was highest in the winter, and the lowest values were recorded during the spring quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 21:1 for sample year 2004-2005. This is slightly higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

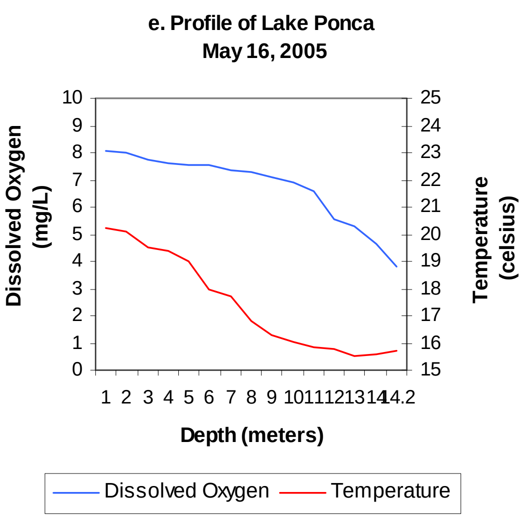
In summary, Lake Ponca was classified as eutrophic, indicative of high primary productivity and nutrient conditions in 2004-2005. This is consistent with the 2003 evaluation indicating no significant change in productivity has occurred. Based on true color, turbidity, and secchi disk depth, Lake Ponca had good water clarity in comparison to other Oklahoma lakes. The lake is supporting the FWP beneficial use based on turbidity and pH, and partially supporting based on low dissolved oxygen and anoxic conditions present in the summer quarter. The Aesthetics beneficial use is supported based on its trophic status and low true color values reported during the sample year. All color values were well below the WQS of 70 units. Bacteriological samples were not collected during the 2005 recreation season, therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Lake Ponca is a water supply and recreational reservoir for the city of Ponca City.











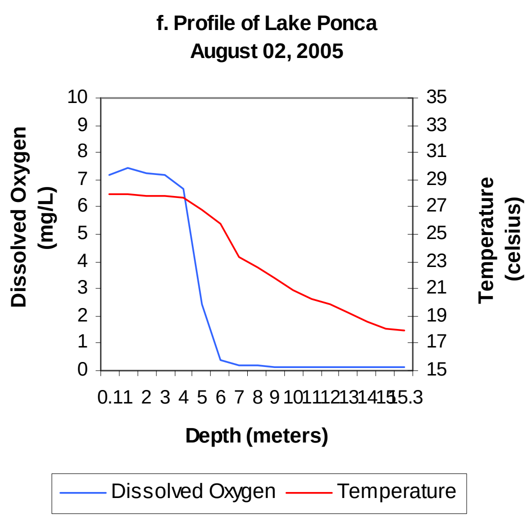


Figure 113a-113f. Graphical representation of data results for Lake Ponca.

Lake Ponca Location

Lake Ponca and Watershed

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Lake Data	
Owner	City of Ponca City
County	Kay
Constructed in	1935
Surface Area	805 acres
Volume	14,440 acre/feet
Shoreline Length	16 miles
Mean Depth	17.94 feet
Watershed Area	28 square miles

Turbidity 2005

Trophic State 2005

Plate 88 - Lake Water Quality for

Lake Ponca

LAKES MONITORING PROGRAM

Prague City Lake

Prague City Lake was sampled for four quarters, from November 2004 through August 2005. Water quality samples were collected from three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and from 0.5 meters from the lake bottom at site 1, the dam. The average lake-wide turbidity was 7 NTU (Plate 89), true color was 20 units and average secchi disk depth was 92 centimeters. Based on these three parameters, Prague City Lake had good water clarity in 2005. These values are similar to those in 2003, indicating no significant change in clarity has occurred over time. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The TSI was 45 (Plate 89), indicating the lake was mesotrophic indicative of moderate levels of primary productivity and nutrient levels. This value is similar to that from 2003 (TSI=43), indicating no significant change in productivity has occurred since the last evaluation. Seasonal TSI values were fairly consistent with oligotrophic conditions in the spring and mesotrophic conditions in the fall, winter and summer sampling intervals. Seasonal turbidity values per site are displayed in Figure 114a. Turbidity ranged from a low of 4 NTU to a maximum of 16 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the turbidity values below the Oklahoma Water Quality Standard (WQS) of 25 NTU, the lake is meeting the Fish and Wildlife Propagation (FWP) beneficial use. Seasonal true color values are displayed in Figure 114b. Similar to turbidity, 100% of the collected values were well below the WQS of 70 units; therefore the lake is considered supporting the Aesthetics beneficial use.

In 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.11 parts per thousand (ppt) to 0.18 ppt for this sample year. This is within the average range of values reported in most Oklahoma reservoirs. Specific conductivity ranged from 227.8 to 359.4 µS/cm, indicating low concentrations of electrical current conducting compounds (salts) in the lake, consistent with salinity concentrations. The pH values were neutral to slightly alkaline with values ranging from 7.49 to 8.46 According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With all recorded values within the acceptable range the lake is supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (ORP) ranged from 211 mV in the hypolimnion in the fall to 537 mV in the winter, indicating the absence of reducing conditions. In the fall quarter the lake was weakly stratified with dissolved oxygen (D.O.) less than 2.0 mg/L from 6 meters to the lake bottom of 7.4 meters, accounting for approximately 22% of the water column at site 1 to be anoxic (see Figure 114c). The lake was not thermally stratified in the winter or spring quarters with dissolved oxygen (D.O) above 8.0 mg/L (Figure 114d-114e). During the summer sampling interval, thermal stratification was evident and anoxic conditions present. Stratification occurred between 2 and 3 meters with dissolved oxygen falling below 2.0 mg/L to the lake bottom of 7.3 meters. This accounted for approximately 44% of the water column at site 1 being anoxic (Figure 114f). If D.O. values are less than 2 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. The FWP beneficial use is considered supported at Prague City Lake with anoxic conditions present in 44% water column during summer sampling. The lake was also sampled for chlorides, sulfates and total dissolved solids to assess the Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.42mg/L at the surface. Surface TN ranged from 0.33 mg/L to 0.54 mg/L, with the highest values reported in the fall and lowest values in the summer quarter. The lake-wide total phosphorus (TP) average was 0.019 mg/L at the surface. Total phosphorus at the surface ranged from 0.014mg/L to 0.024 mg/L. Surface TP was highest in the winter, and the lowest values were recorded during the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 22:1 for sample year 2004-2005. This is slightly higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

In summary, Prague City Lake was classified as mesotrophic, indicative of moderate primary productivity and nutrient conditions in 2004-2005. This is consistent with the 2000 evaluation (TSI=43), indicating no significant increase or decrease in productivity has occurred. Water clarity was good based on turbidity, true color, and secchi disk depth. The lake is supporting the FWP beneficial use based on turbidity, pH, and dissolved oxygen values recorded during the study period. The Aesthetics beneficial use is supported by both trophic status and true color. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Prague City Lake was constructed in 1984 for the purpose of flood control, water supply and recreation.

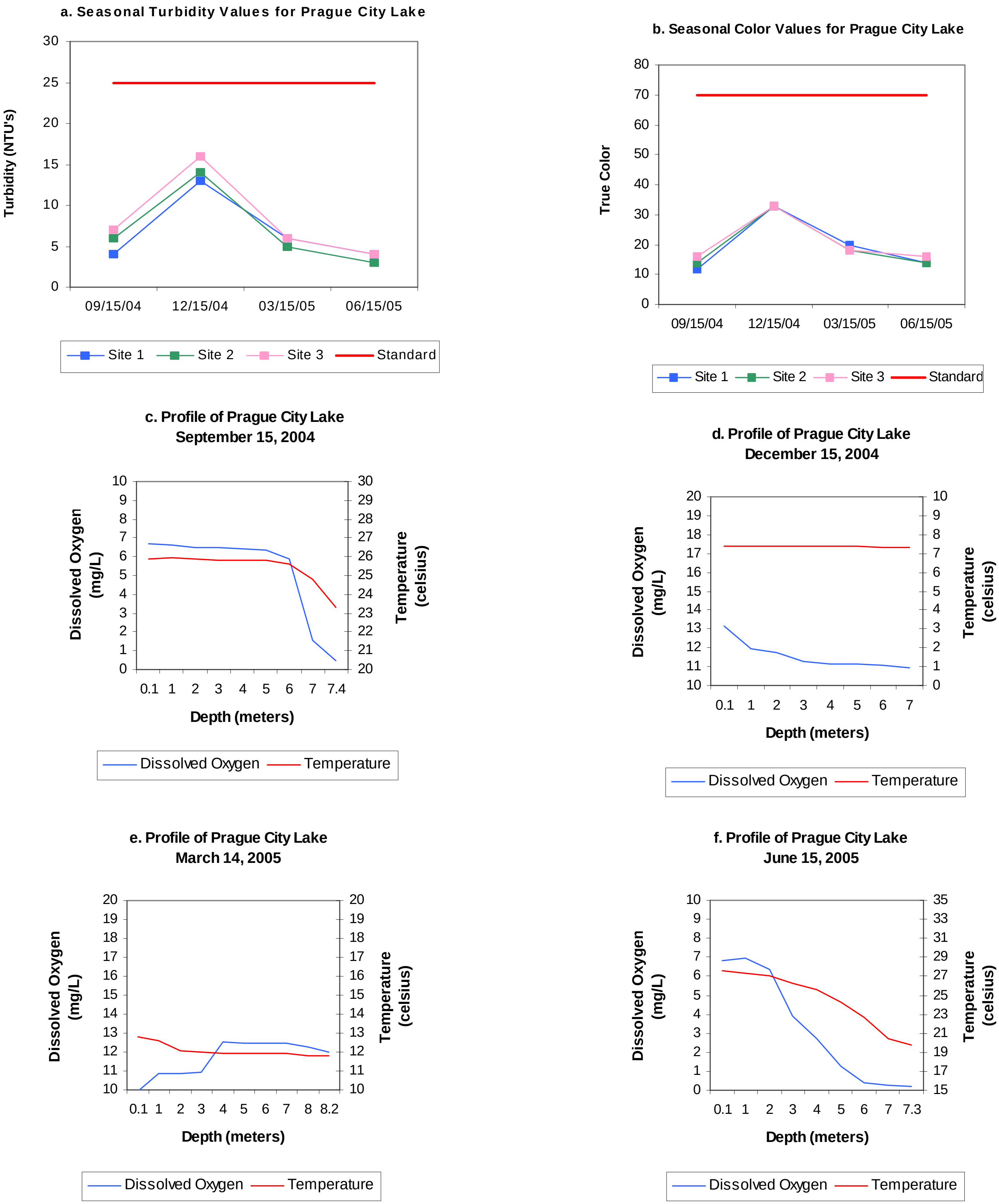
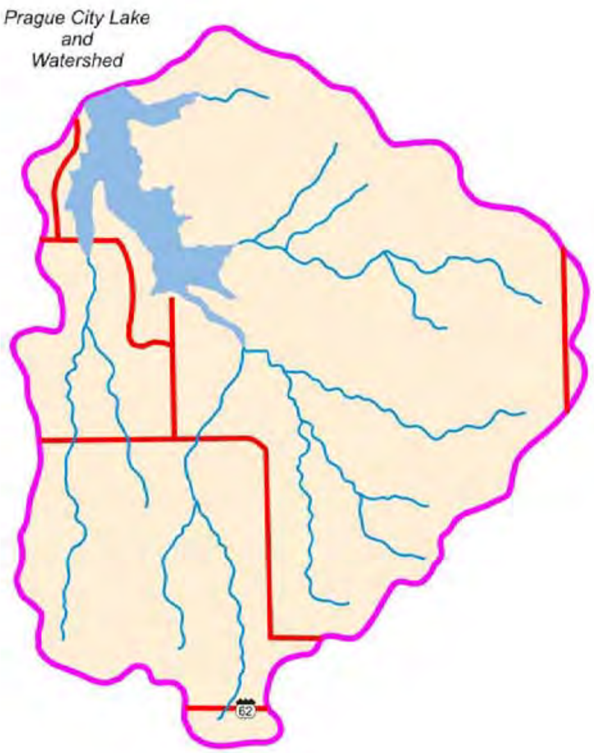


Figure 114a-114f. Graphical representation of data results for Prague City Lake.



Lake Data	
Owner	City of Prague
County	Lincoln
Constructed in	1984
Surface Area	225 acres
Volume	2,415 acre/feet
Shoreline Length	6 miles
Mean Depth	10.73 feet
Watershed Area	4,322 acres

Plate 89 - Lake Water Quality for

Prague City Lake

LAKES MONITORING PROGRAM

Purcell Lake

Purcell Lake was sampled for four quarters, from September 2004 through June 2005. Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide annual turbidity value was 14 NTU (Plate 90), true color was 20 units, and secchi disk depth was 66 centimeters in 2004-2005. Based on turbidity, true color and secchi disk depth water clarity was average in comparison to other Oklahoma lakes. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 50 (Plate 90), indicating the lake was mesotrophic bordering eutrophic, with moderate to high levels of productivity and nutrient conditions. The TSI values ranged from eutrophic in the fall and summer quarters to mesotrophic in the winter and spring quarters. Seasonal turbidity by site is displayed in Figure 115a. Only two of the values collected were greater than the WQS of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Purcell Lake is partially supporting its Fish & Wildlife Propagation (FWP) beneficial use with 16.6% of the values exceeding the prescribed standard for nephelometric turbidity. Seasonal true color values are displayed in Figure 115b. All true color values were below the Aesthetics WQS of 70 units therefore Purcell Lake is fully supporting its Aesthetics beneficial use as it relates to true color.

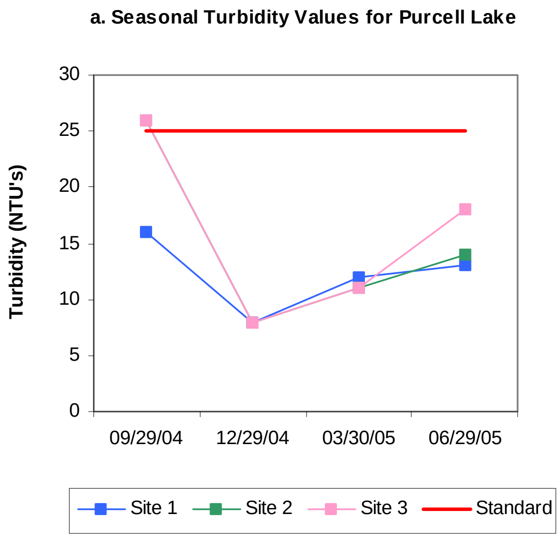
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all three sample sites in 2004-2005. Salinity ranged from 0.17 parts per thousand (ppt) in the fall to 0.24 ppt in the summer, which is within the expected range of salinity values reported for most Oklahoma lakes. Specific conductivity ranged from 347.3 µS/cm in the fall quarter to 480.3 µS/cm in the summer quarter indicating that moderate levels of electrical conducting compounds (salts) were present in the lake system. In general, pH values were neutral to slightly alkaline, with values ranging from 7.21 units in the summer to 8.31 units in the fall quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. All collected values were within the acceptable range; therefore the lake is fully supporting its FWP beneficial use based on pH. Oxidation-reduction potentials (redox) ranged from 49 mV near the sediment-water interface in the summer to 463 mV in the fall. In general reducing conditions were not present during the study period. The lake was not thermally stratified in the fall, winter or spring quarters and was well mixed with dissolved oxygen (D.O.) concentrations above 6.0 mg/L throughout the water column (see Figure 115c-115e). In the summer the lake was thermally stratified between 3 and 4 meters below the surface at which point D.O. was below 2.0 mg/L to the lake bottom (5.1 meters), making about 33% of the water column anoxic (see Figure 115f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the

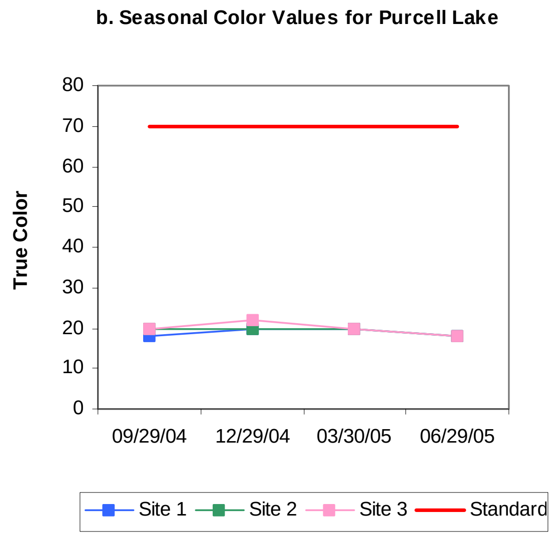
FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at Purcell Lake based on dissolved oxygen concentration. The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

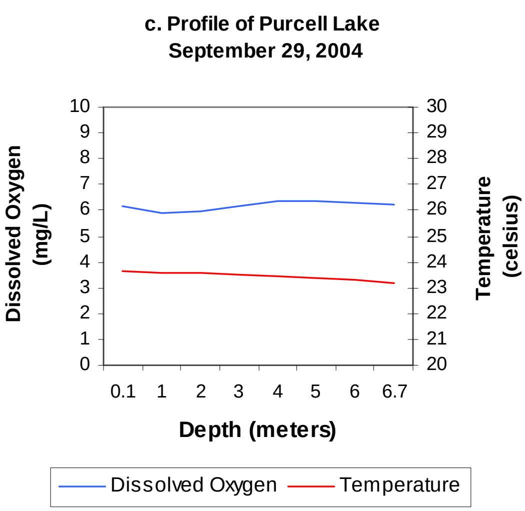
Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

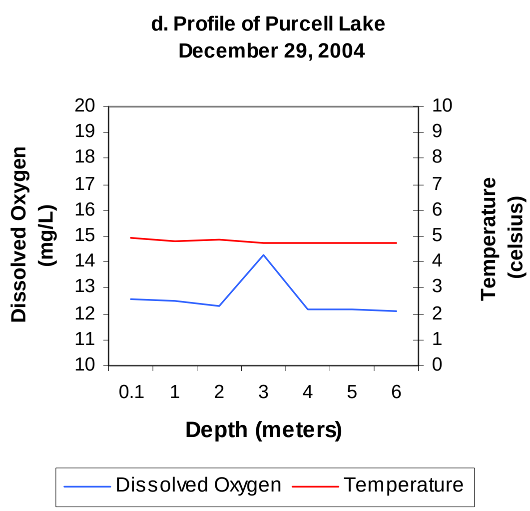
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.63 mg/L at the surface. Surface TN ranged from 0.40 mg/L to 0.88 mg/L, with the highest values reported in the fall and lowest values in the spring quarter. The lake-wide total phosphorus (TP) average was 0.032 mg/L at the surface. Total phosphorus at the surface ranged from 0.022mg/L to 0.044 mg/L. Both the high and low TP values were reported during the winter sampling interval. The nitrogen to phosphorus ratio (TN:TP) was approximately 20:1 for sample year 2004-2005. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

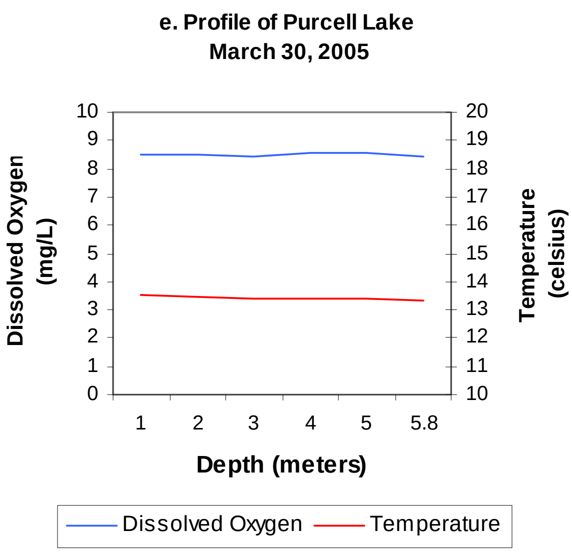
In summary, Purcell Lake was classified as mesotrophic bordering eutrophic, indicating moderate to high primary productivity and nutrient conditions (Plate 90). Water clarity was average based on turbidity, true color and secchi disk depth. The lake was fully supporting its Aesthetics beneficial use based on trophic status and true color readings as all color values were well below the WQS of 70 units. The lake was fully supporting its FWP beneficial use based on nephelometric turbidity, pH, and water column D.O. readings. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Purcell Lake was constructed in 1930 and is owned and operated by the City of Purcell. The lake is managed as a municipal water supply and is also utilized for recreational purposes.











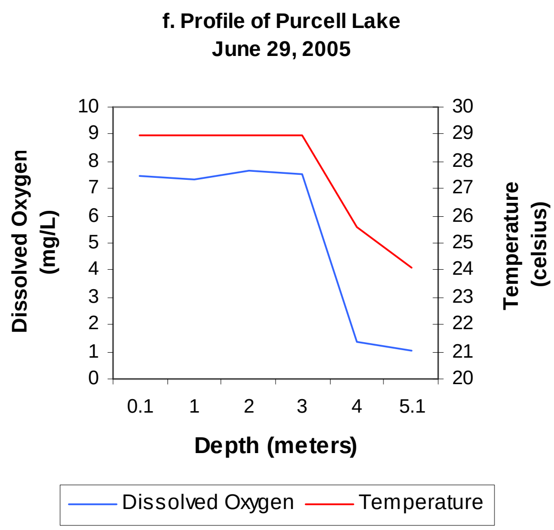
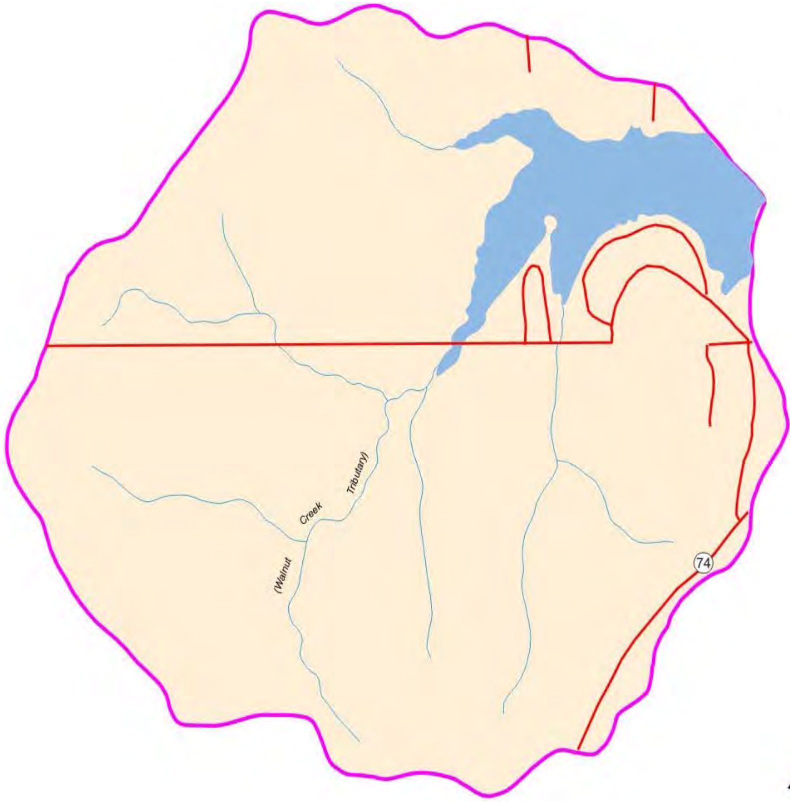


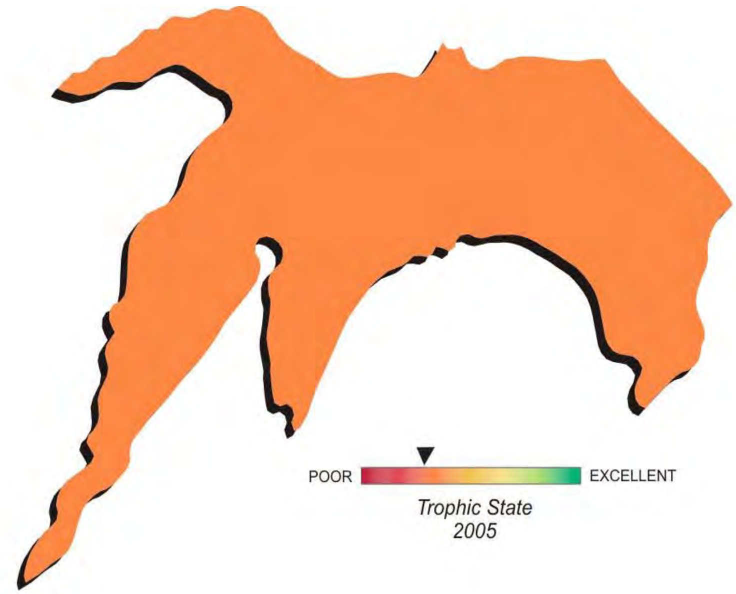
Figure 115a-115f. Graphical representation of data results for Purcell Lake.



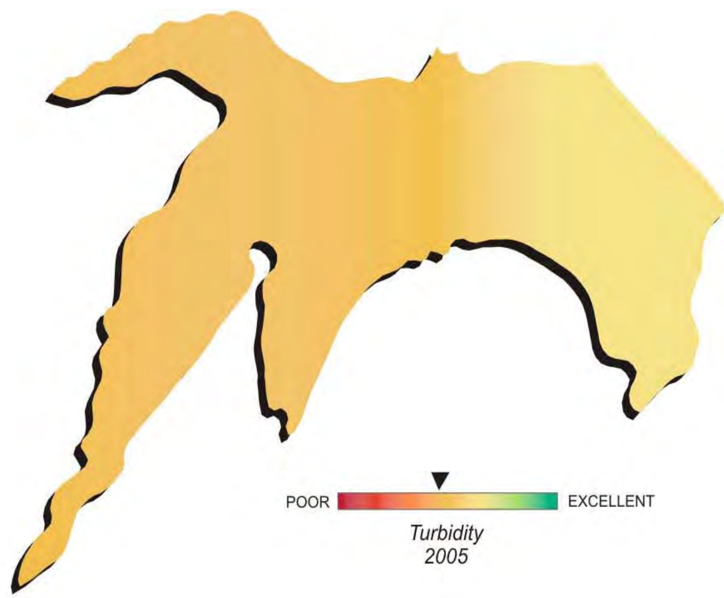
Purcell Lake
and
Watershed

Purcell Lake
Location

Lake Data	
Owner	City of Purcell
County	McClain
Constructed in	1930
Surface Area	150 acres
Volume	2,600 acre/feet
Shoreline Length	4 miles
Mean Depth	17.33 feet
Watershed Area	2,432 acres



Trophic State
2005



Turbidity
2005

Plate 90 - Lake Water Quality for

Purcell Lake

Lake Raymond Gary

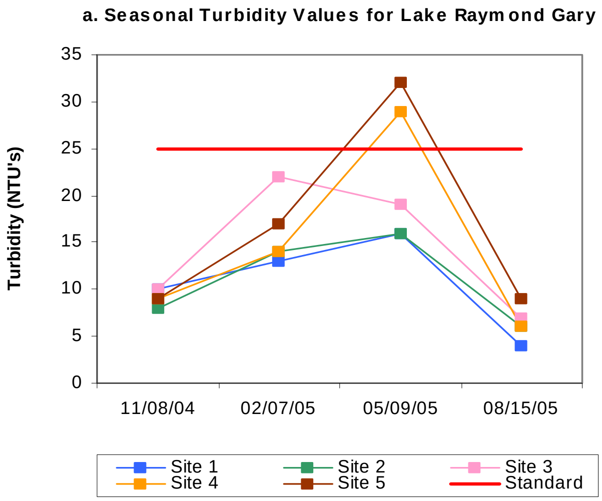
Lake Raymond Gary was sampled for four quarters, from November 2004 through August 2005. Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide annual turbidity value was 14 NTU (Plate 91), true color was 48 units, and secchi disk depth was 71 centimeters. Based on these parameters water clarity was average in 2005. Results for these parameters were similar to the results found in 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 50 (Plate 91), indicating the lake was mesotrophic bordering eutrophic, with moderate to high levels of productivity and nutrient conditions. The TSI values were primarily eutrophic in 2005, with the exception of the winter quarter. During the winter sites 2 and 4 were mesotrophic and site 3 dipped down into the oligotrophic category. Seasonal turbidity values are displayed in Figure 116a. Turbidity ranged from a low of 4 NTU to a maximum of 32 NTU, with higher values reported for all sites in the spring sampling quarter. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 2 (10%) of the values above the Oklahoma Water Quality Standard (WQS) of 25 NTU the Fish and Wildlife Propagation (FWP) beneficial use is partially supported in regards to turbidity. Seasonal true color values are displayed in Figure 116b. Applying the same default protocol, the Aesthetics beneficial use is considered partially supported with 15% of the reported values exceeding the WQS 70 units.

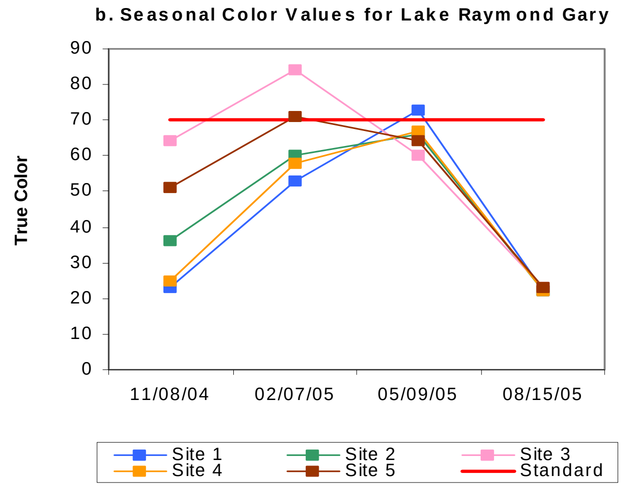
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were performed at all sample sites during the sample year. Salinity values ranged from 0.01 parts per thousand (ppt) in the winter to 0.78 ppt in the summer. Readings for specific conductivity ranged from 47 µS/cm in the winter to 1465 µS/cm in the summer, indicating that concentrations of chlorides or salts in the lake varied seasonally from very low to the very high in the summer. The higher readings were only recorded at sites 1, 2 and 4, both near the dam. The heavier saline waters have settled here, as these sites are located in the deepest part of the lake. The pH values at Lake Raymond Gary were slightly acidic, ranging from 6.21 in the winter to 7.48 in the summer. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 9.5 % of the values recorded being less than 6.5 the lake will be listed as supporting based on pH. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Oxidation-reduction potentials ranged from 221 mV in the hypolimnion in the fall to 449 mV in the spring, indicating the absence of reducing conditions. The lake was not thermally stratified during the fall or winter and the lake was well mixed with dissolved oxygen (D.O.) values above 6.0 mg/L throughout the water column (Figure 116c-116d). In the spring, sites 1, 2 and 4 were the only sites to stratify however D.O. did not fall below 3.0 mg/L (Figure 116e). The lake exhibited strong thermal stratification in the summer and dissolved oxygen values were below 2.0 mg/L for 25 to 50% of the water column at sites 1, 2, and 4 (Figure 116f). This is not a situation that is normally seen in such a shallow reservoir and may be attributed to a long period of calm winds and/or a pattern where little rainfall occurred. If D.O. values are less than 2 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Lake Raymond Gary is considered partially supporting the FWP beneficial use based on dissolved oxygen values reported in the summer quarter. The lake was also sampled for chlorides, sulfates and total dissolved solids to assess the Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

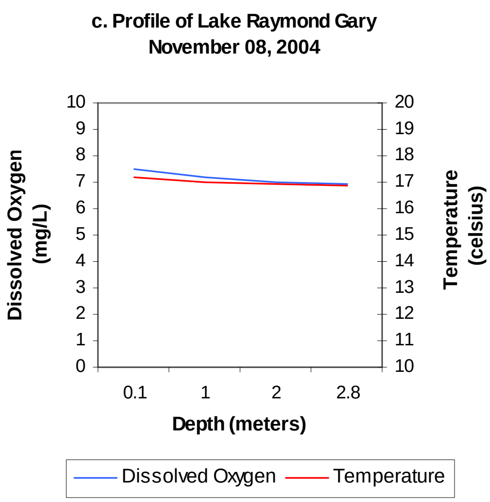
Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

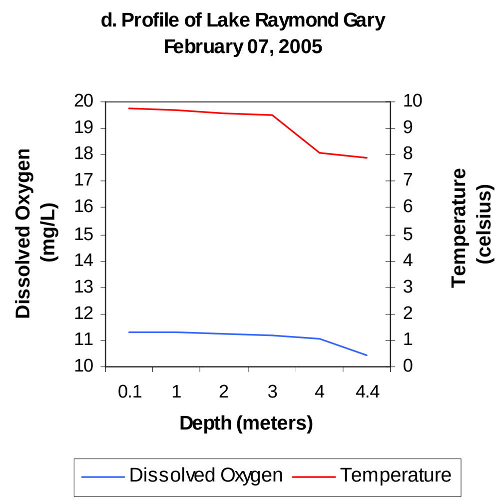
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.43 mg/L at the surface. Surface TN ranged from 0.16 mg/L to 1.87 mg/L, with the highest values reported in the fall and lowest values in the summer quarter. The lake-wide total phosphorus (TP) average was 0.054 mg/L at the surface. Total phosphorus at the surface ranged from 0.027mg/L to 0.045 mg/L. Surface TP was highest in the winter, and the lowest values were recorded during the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 8:1 for sample year 2004-2005. This is the very near the 7:1 ratio used to determine the limiting nutrient, characterizing the lake as potentially phosphorus limited to co-limited (Wetzel, 1983).

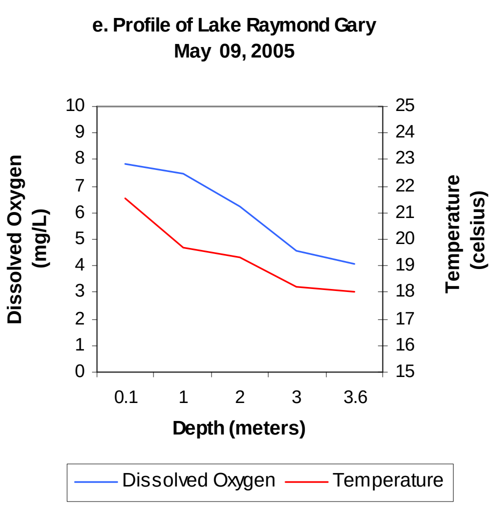
In summary, Lake Raymond Gary was classified as mesotrophic bordering eutrophic, indicative of moderate to high primary productivity and nutrient conditions. Water clarity was good in sample year 2004-2005, based on turbidity, true color, and secchi disk depth. The lake is partially supporting the FWP beneficial use based on turbidity and low dissolved oxygen levels in the summer quarter. With 9.5% of the recorded pH values less the 6.5 units the lake is also supporting the FWP beneficial use. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes, therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. The Aesthetics beneficial is supported based on its trophic status, and partially supported for true color as 15% of the reported values were exceeding the WQS of 70 units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Lake Raymond Gary, near Fort Towson, is a recreational reservoir owned by the State of Oklahoma.











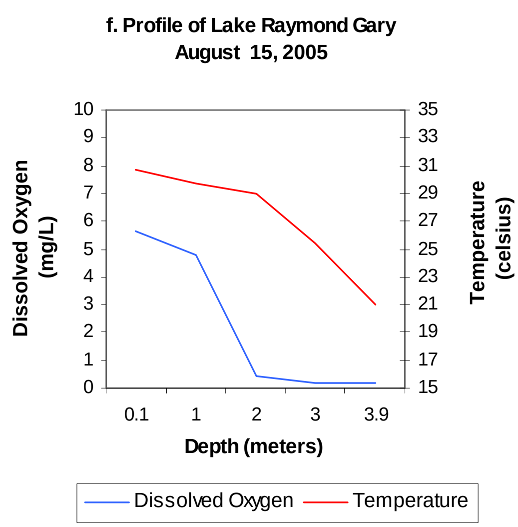
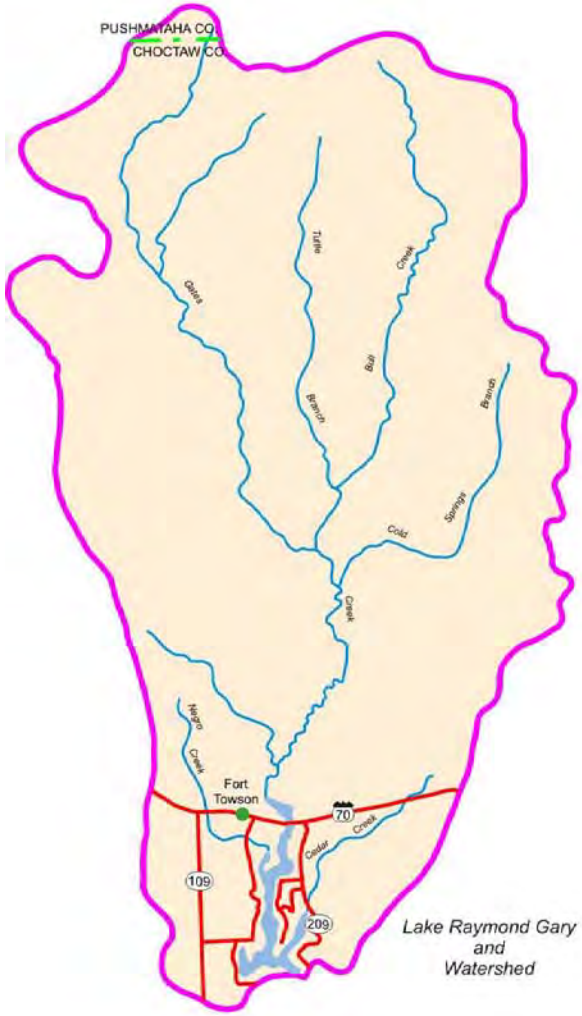
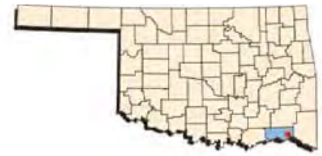


Figure 116a-116f. Graphical representation of data results for Lake Raymond Gary.



Lake Raymond Gary
and
Watershed



Lake Raymond Gary
Location

Turbidity
2005

Trophic State
2005

Lake Data

Owner	State of Oklahoma
County	Choctaw
Constructed in	1956
Surface Area	263 acres
Volume	1,681 acre/feet
Shoreline Length	10 miles
Mean Depth	6.39 feet
Watershed Area	56 square miles

Plate 91 - Lake Water Quality for
Lake Raymond Gary

R.C. Longmire Lake

R.C. Longmire Lake was sampled for four quarters, from October 2004 through August 2005. Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The average lake-wide turbidity value was 15 NTU (Plate 92), true color was 25 units, and secchi disk depth was 63 centimeters. Water clarity was good based on secchi disk depth, turbidity, and true color values. Results for these parameters are similar to the results found in 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 56 (Plate 92), indicating the lake was eutrophic, with high levels of productivity and nutrient conditions. This value is higher than the TSI in 2003 (TSI=47). The TSI values were fairly consistent and generally eutrophic with hypereutrophic conditions occurring in the winter. The exception to this occurred at site 1 and 5, which were mesotrophic in the spring and summer. Seasonal turbidity values are displayed in Figure 117a. Only one turbidity value exceeded the Oklahoma Water Quality Standard (WQS) of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (70 units for color). If 10 to 25% of the values exceed the numeric criteria, the lake should be listed as partially supporting beneficial uses. The Fish and Wildlife Propagation (FWP) beneficial use is considered supported with 95% of the turbidity values below the standard. True color values varied seasonally and were below the aesthetics WQS of 70 units (Figure 117b). Applying the same default protocol, the Aesthetic beneficial use is considered supported based on true color values reported during the study period.

In 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values for R.C. Longmire Lake ranged from 0.08 parts per thousand (ppt) to 0.29 ppt for this sample year. This is within the average range of values reported in most Oklahoma reservoirs. Specific conductivity ranged from 175.8 to 572.3 µS/cm, indicating a low to moderate presence of electrical current conducting compounds (salts) in the lake, consistent with salinity concentrations. In general pH values were neutral to slightly alkaline with values ranging from 7.05 in the summer to 8.44 in the winter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range the lake is considered supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (ORP) ranged from 155 mV in the summer to 519 mV also in the summer, indicating reducing conditions were not present at the time of sampling. Thermal stratification was not present during the fall, winter, or spring quarters and lake was well mixed (see Figure 117c-117e). In the summer the lake was strongly stratified between 4 and 5 meters in depth, at site 1, with dissolved oxygen (D.O.) falling below 2.0 mg/L to the lake bottom of 11.1 meters, accounting for 62% of the water column to be anoxic (Figure 117f). Site 4 also had D.O. levels of less than 2.0 mg/L for approximately 40% of the water column. If D.O. values are less than 2 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. R.C. Longmire Lake is partially supporting its FWP beneficial use with 40 to 62% of the water column experiencing anoxic conditions in the summer quarter. The lake was also sampled for chlorides, sulfates and total dissolved solids to assess the Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.71 mg/L at the surface. The TN at the surface ranged from 0.62 mg/L to 0.84 mg/L. The highest surface total nitrogen was reported at site 5 in the winter. The lake-wide total phosphorus (TP) average was 0.039 mg/L at the lake surface. The surface TP ranged from 0.026 mg/L to 0.059 mg/L. The highest surface TP was reported in the winter and the lowest value seen during the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 18:1 for sample year 2002-2003. This is higher than the 7:1 ratio used to determine the limiting nutrient, characterizing the lake as phosphorus limited (Wetzel, 1983).

In summary, R.C. Longmire Lake was classified as eutrophic, indicative of high primary productivity and nutrient conditions in 2004-2005. Water clarity is good based on turbidity, true color and secchi disk depth, similar to the 2003 evaluation. The lake is supporting the Fish and Wildlife Propagation (FWP) beneficial use based on turbidity and pH, but is partially supporting based on anoxic conditions present in the summer. The lake is supporting the Aesthetics based on its trophic status, and true color with 100% of the color values well below the WQS of 70 units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. R.C. Longmire Lake is located in Garvin County and is a popular fishing lake.

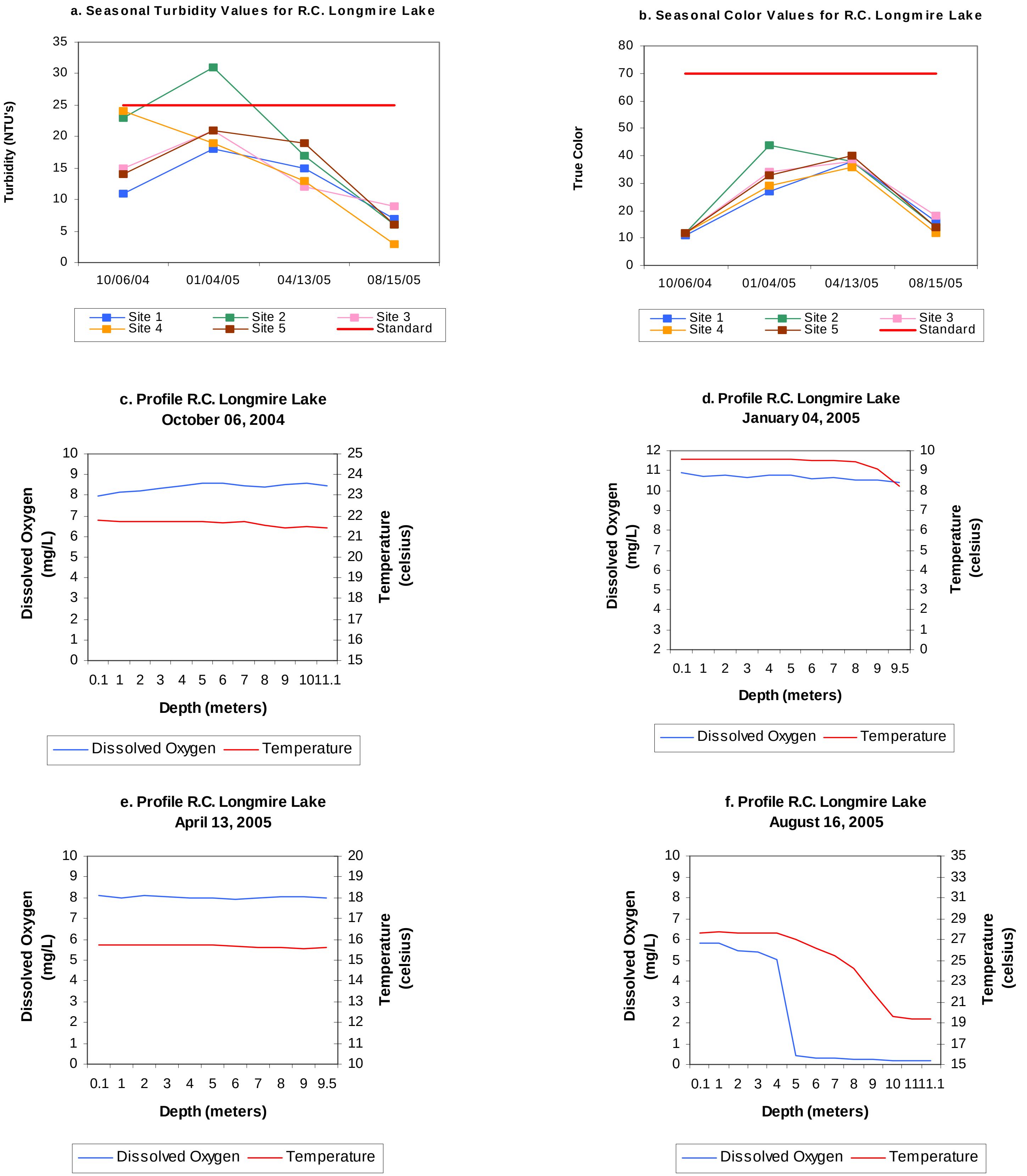
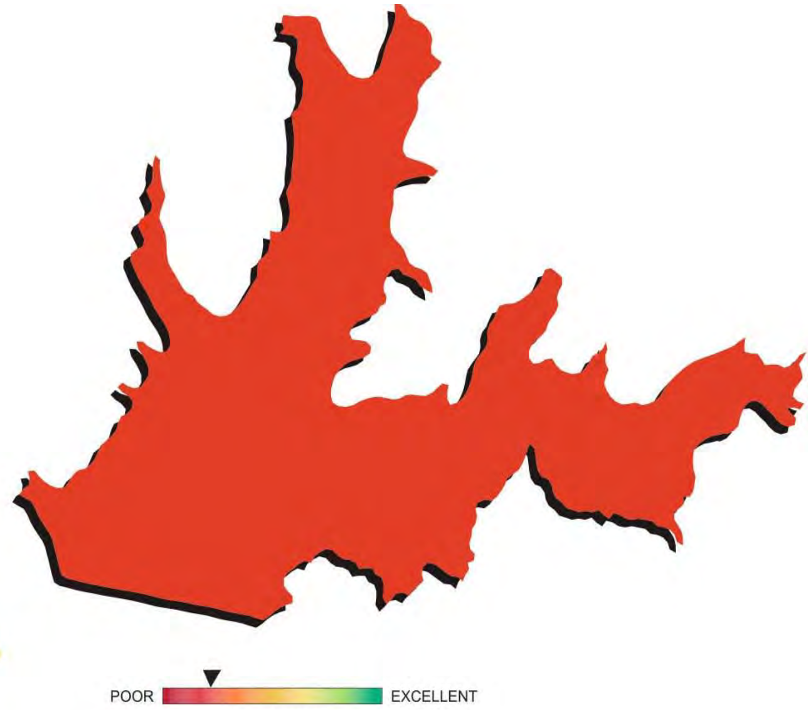


Figure 117a-117f. Graphical representation of data results for R.C. Longmire Lake.

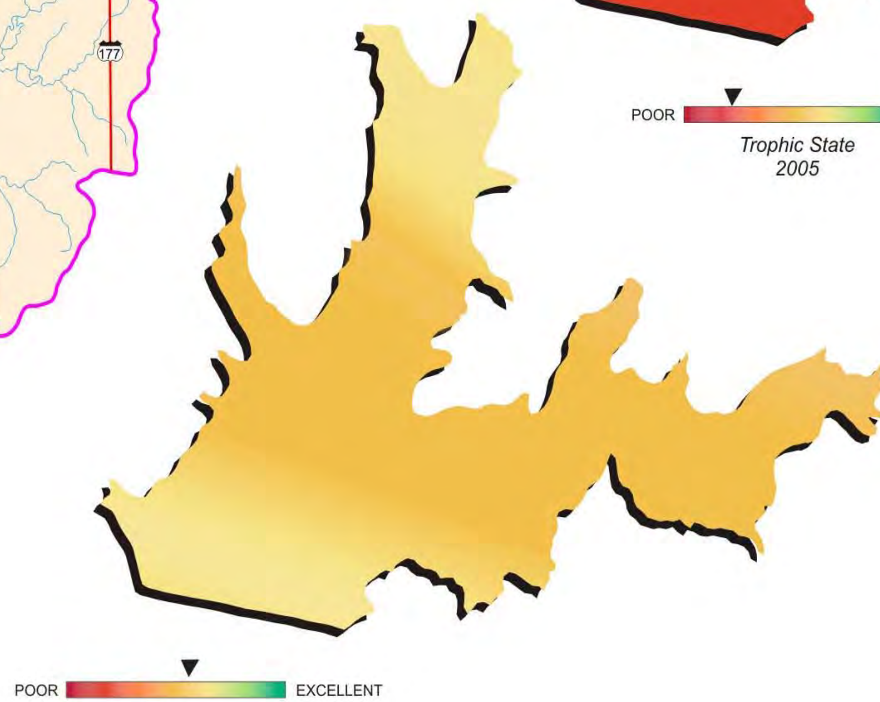
Plate 92 - Lake Water Quality for R. C. Longmire Lake

R. C. Longmire Lake and Watershed

R. C. Longmire Lake Location



Trophic State 2005



Turbidity 2005

Lake Data	
Owner	City of Pauls Valley
County	Garvin
Constructed in	1989
Surface Area	745 acres
Volume	14,424 acre/feet
Shoreline Length	12 miles
Mean Depth	19.36
Watershed Area	29 square miles

Robert S. Kerr Reservoir

Robert S. Kerr Reservoir was sampled for four quarters, from November 2004 through August 2005. Water quality samples were collected from six (6) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and at 0.5 meters from the lake bottom at site 1, the dam. The average lake-wide turbidity was 33 NTU (Plate 95), true color was 44 units and average secchi disk depth was 39 centimeters. Based on these three parameters, water clarity at R.S. Kerr Reservoir was fairly poor. Results are similar to those reported in 2003, indicating little change has occurred over time. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=24). The average TSI was 58 (Plate 95), indicating the lake was eutrophic, with high levels of primary productivity and nutrient conditions. This value is similar to the one calculated in 2003 (TSI=55), indicating the no significant increase or decrease in productivity has occurred since the previous evaluation. The TSI values varied by site and season throughout the year from mesotrophic (sites 1 and 2) in the fall and winter to upper eutrophic and even hypereutrophic (sites 3 – 6) in the spring and summer. Seasonal turbidity values are displayed in Figure 118a. Turbidity values were fairly consistent with values ranging from 16 to 62 NTU with lower values occurring during the summer. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 75% of the samples collected in 2003 exceeding the standard, the lake is not supporting the Fish and Wildlife Propagation (FWP) beneficial use. Seasonal true color values are displayed (Figure 118b). Like turbidity the lowest color values were recorded in the summer quarter. Applying the same default protocol, the Aesthetics beneficial use is considered supported with 100% of the values below the WQS of 70-units for true color.

In 2005 vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.17 parts per thousand (ppt) in the fall to 0.46 ppt in the winter. This is slightly higher than the average range of values reported for most Oklahoma reservoirs, however R.S. Kerr reservoir main tributary is the Arkansas River. Specific conductivity ranged from 340 to 877.4 µS/cm, indicating moderate to high concentrations of electrical current conducting compounds (salts) within the lake, consistent with the elevated salinity readings. In general, pH values were neutral to slightly alkaline with values ranging from 7.35 to 8.47 during the study period. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range the lake is considered supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (ORP) ranged from 335 mV in the spring to 540 mV in the fall, indicating reducing conditions were not present during the study period. The lake did not exhibit stratification during any of the sampling intervals and was well mixed with dissolved oxygen (D.O.) generally above 5.0 mg/L (Figure 118c-118f). The riverine nature of this reservoir aids in keeping it well oxygenated. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at R.S. Kerr Reservoir, with only 33 to 36% of the water column experiencing anoxic conditions in the summer quarter. The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.91 mg/L at the surface. The TN at the surface ranged from 0.61 mg/L to 1.48 mg/L. The highest surface total nitrogen was reported in the winter and lowest in the spring. The lake-wide total phosphorus (TP) average was 0.123 mg/L at the lake surface. The surface TP ranged from 0.048 mg/L to 0.178 mg/L. The highest surface TP was reported in the summer and the lowest values were seen during the spring quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 7:1 for sample year 2002-2003. This is the same as the 7:1 ratio used to determine the limiting nutrient, characterizing the lake as potentially phosphorus limited to co-limited (Wetzel, 1983).

In summary, Robert S. Kerr Reservoir was classified as eutrophic with high primary productivity and nutrient conditions (Plate 95). This is similar to the value calculated in 2003(TSI=55), indicating no significant increase or decrease in productivity has occurred since the last evaluation. Water clarity was poor based on turbidity, true color, and secchi disk depth. The lake is supporting the FWP beneficial use based on dissolved oxygen and pH values, but not supporting for turbidity with 75% of the values above the WQS of 25 NTU. The Aesthetics beneficial use is supported based on its trophic status as well as supporting based on true color values reported during the sample year. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. The United States Army Corps of Engineers (USACE) constructed Robert S. Kerr Reservoir in 1971 for navigation, hydro-electrical and recreation purposes. The lake is located in both Sequoyah and LeFlore Counties approximately 8 miles south of Sallisaw.

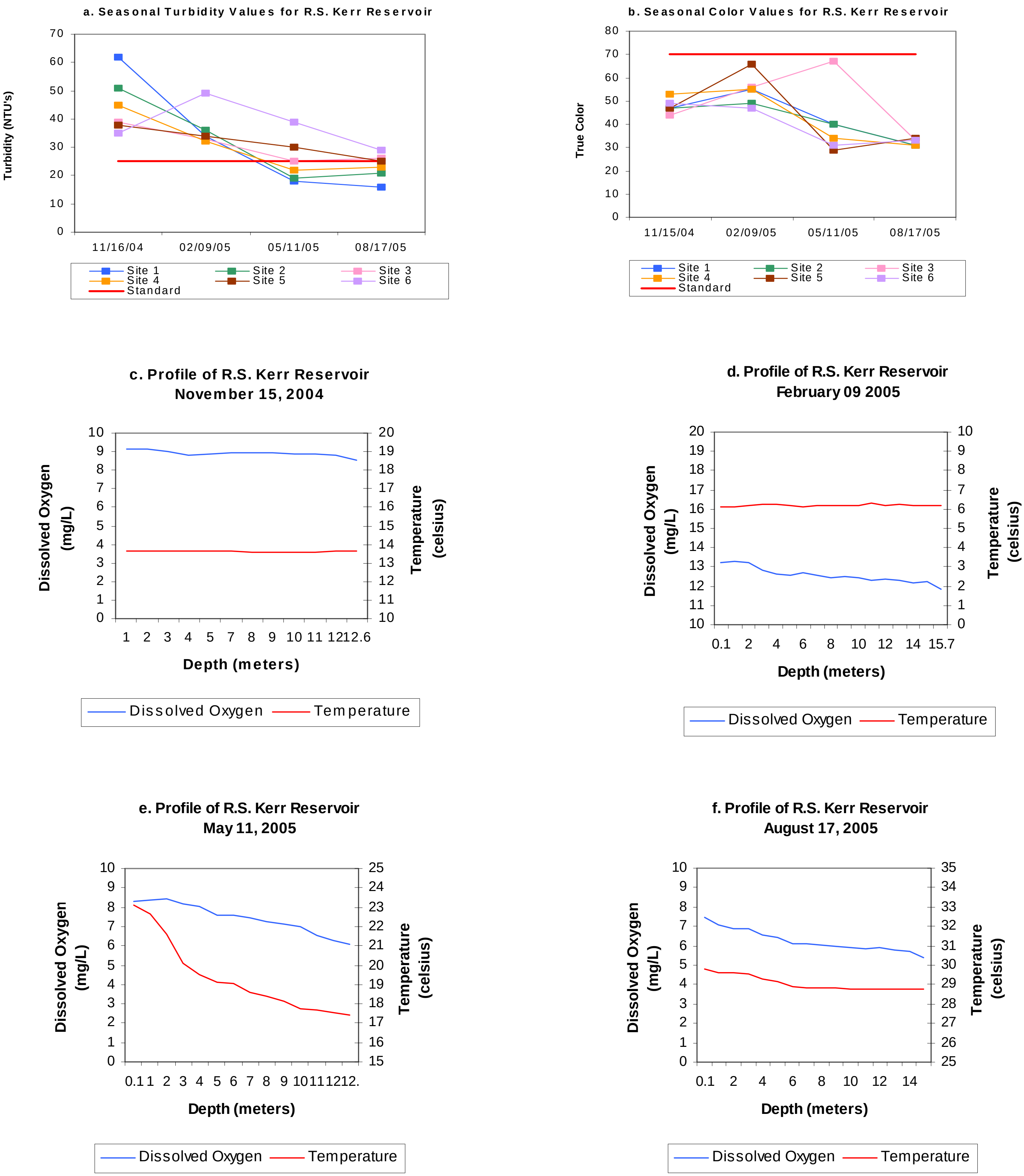
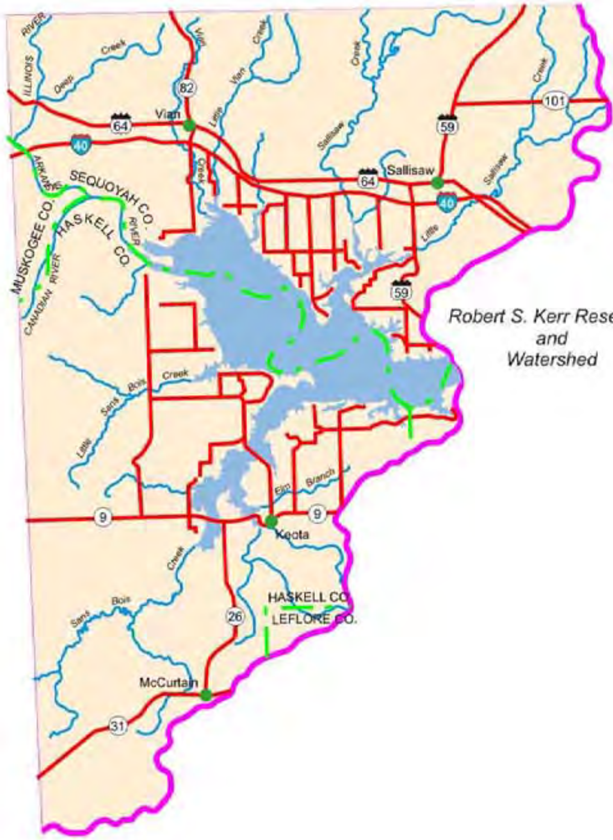
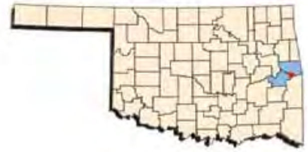


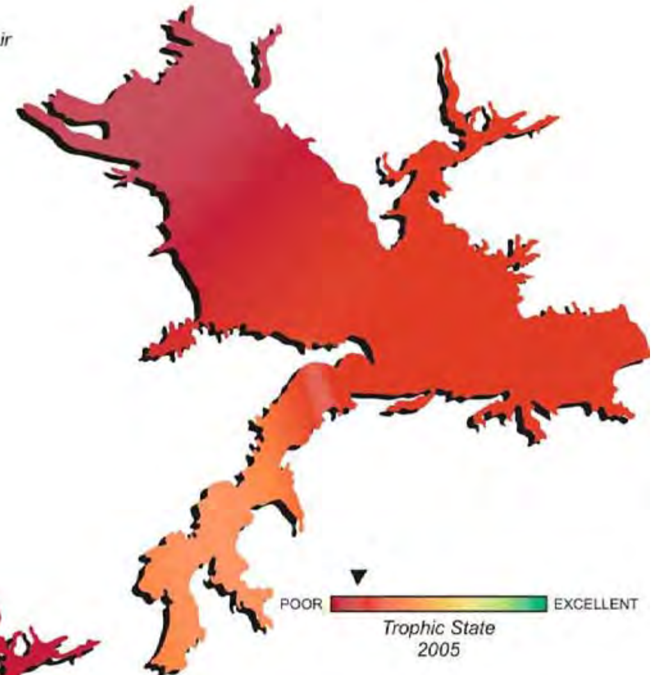
Figure 118a-118f. Graphical representation of data results for R.S. Kerr Reservoir.

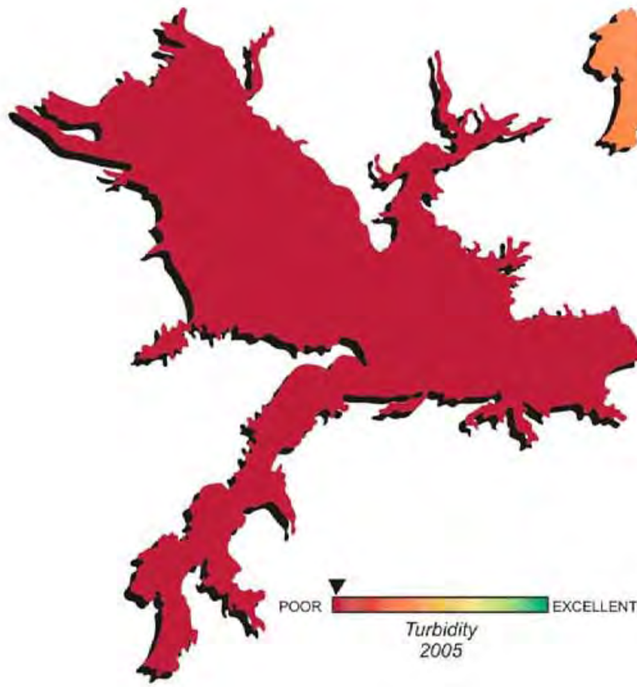


Robert S. Kerr Reservoir and Watershed



Robert S. Kerr Reservoir Location





Lake Data	
Constructed by	Corps of Engineers
County	Sequoyah/LeFlore
Constructed in	1971
Surface Area	43,800 acres
Volume	525,700 acre/feet
Shoreline Length	250 miles
Mean Depth	11.75 feet
Watershed Area	147,756 square miles

Plate 95 - Lake Water Quality for

Robert S. Kerr Reservoir

LAKES MONITORING PROGRAM

Rock Creek Reservoir

Rock Creek Reservoir is a 248-acre reservoir located in Carter County. The reservoir was constructed in 1979 and serves as a recreational reservoir for the City of Ardmore. Rock Creek Reservoir was sampled for four quarters, from October 2006 through July 2007.

Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the lake surface at all sample sites. The lake-wide annual average turbidity value was 13 nephelometric turbidity units (NTU), true color was 26 units, and secchi disk depth was 85 centimeters. Based on these three parameters, Rock Creek Reservoir had good water clarity in 2007. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 48 (Plate 93), indicating the lake was mesotrophic, with moderate levels of productivity and nutrient conditions. This value is similar to the TSI in 2003 (TSI=50) and in 2005 (TSI=48), and in the same trophic category, indicating no significant increase or decrease over time. The TSI values are primarily mesotrophic with eutrophic conditions observed in the fall. Seasonal turbidity values are displayed in Figure 119a. All turbidity values were below the Oklahoma Water Quality Standard (WQS) of 25 NTU. With 100% of the samples below the standard, the Fish and Wildlife Propagation (FWP) beneficial use is considered supported for sample year 2007. True color values were below the aesthetics WQS of 70 units at all sites throughout the year (Figure 119b). Applying the same default protocol, the lake is supporting the Aesthetics beneficial use.

In 2007 vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.12 parts per thousand (ppt) to 0.16 ppt, which is within the average range of values, reported for most Oklahoma reservoirs. Specific conductivity values ranged from 250.7 to 333.0 µS/cm, indicating low to moderate concentrations of electrical current conducting compounds (salts) were present in the lake. This is consistent with the salinity readings recorded during the sample year. In general pH values were neutral to slightly alkaline with values ranging from 7.20 to 8.71 during the study period. With all recorded values within the acceptable range (6.5 to 9.0) the lake is supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (ORP) ranged from 97 mV in the summer to 519 mV in the winter, indicating reducing conditions were not present during the study period. The lake was thermally stratified during the spring and summer quarters (Figure 119c-119e). During the spring and summer, the thermocline occurred high in the water column (between 3 and 4 meters), falling below 2.0 mg/L from 4 meters to the lake bottom of 8.7 meters at site 1 (Figure 119f). If D.O. values are less than 2 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Rock Creek Reservoir is partially supporting its FWP beneficial use with 43-60% of the D.O. values in the spring and summer fell below 2.0 mg/L. The lake was also sampled for chlorides, sulfates and total dissolved solids to assess the Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2007. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.60 mg/L at the surface. Surface TN ranged from 0.44 mg/L to 0.96 mg/L, with the highest values reported in the winter and lowest values in the autumn quarter. The lake-wide total phosphorus (TP) average was 0.018 mg/L at the surface. Total phosphorus at the surface ranged from 0.011 mg/L to 0.032 mg/L. Surface TP was highest in the autumn, and the lowest values were recorded during the spring quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 33:1 for sample year 2006-2007. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

Rock Creek Reservoir was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Rock Creek Reservoir was classified as mesotrophic, indicative of moderate primary productivity and nutrient conditions in 2006-2007. This is consistent with the 2005 evaluation, indicating no significant change in productivity has occurred over time. Water clarity was average based on true color, secchi disk depth and turbidity. The lake is supporting the FWP beneficial use based on turbidity and pH, but only partially supporting the use due to anoxic conditions in 43-60% of the water column during the spring and summer quarter. The Aesthetic beneficial use is fully supported by both trophic status and collected true color values with 100% of the values well below the WQS of 70 units for color. Bacteriological samples indicate that the Primary Body Contact Recreation (PBCR) beneficial use is supported as all samples were below both the prescribed screening level and geometric mean
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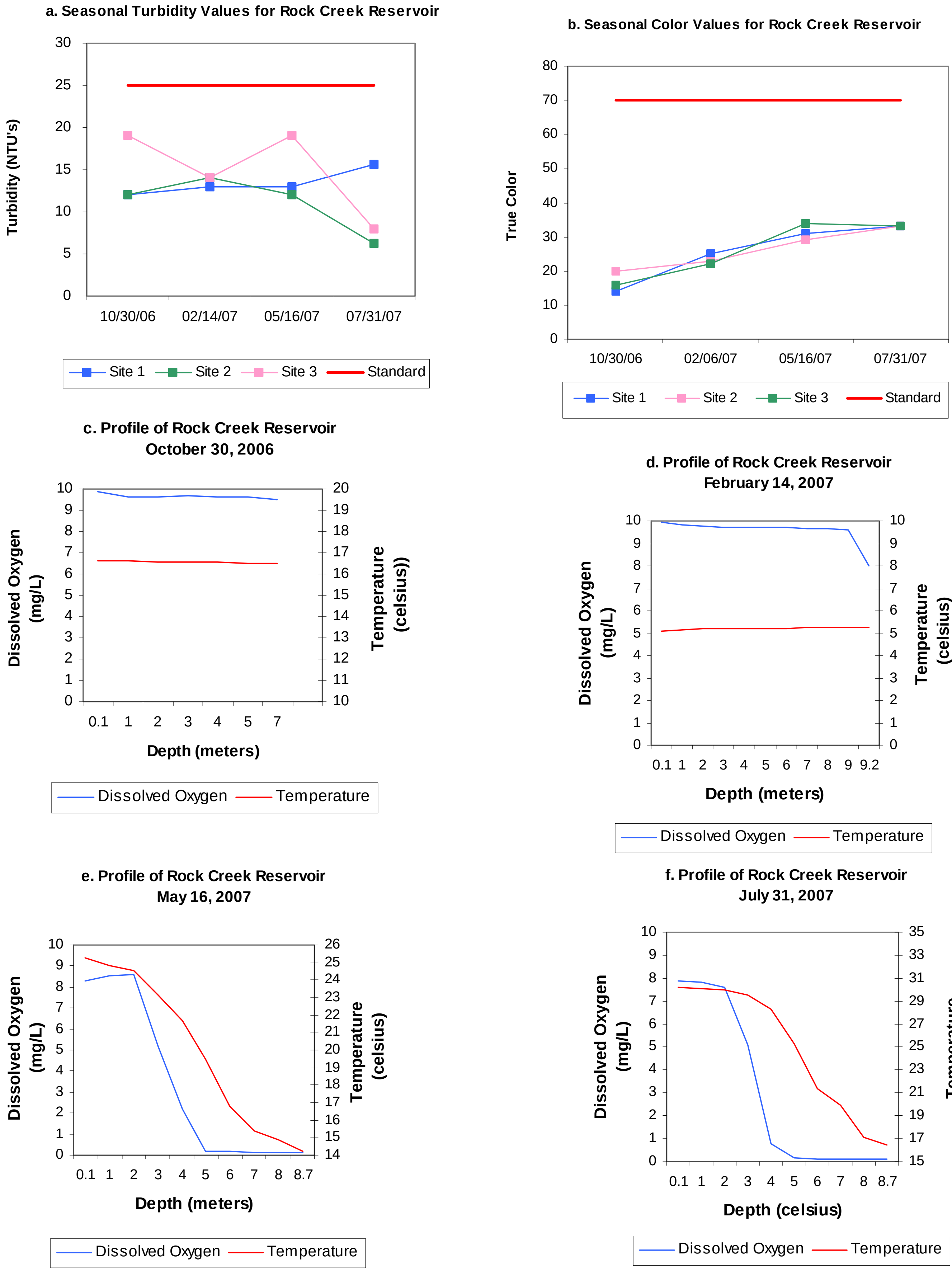
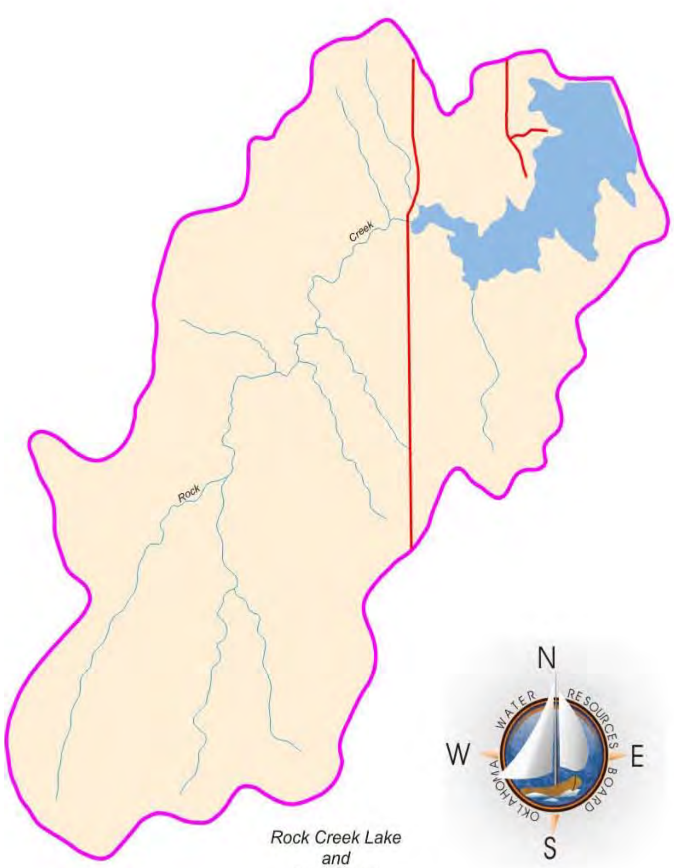


Figure 119a-119f. Graphical representation of data results for Rock Creek Reservoir.

Plate 93 - Lake Water Quality for
Rock Creek Reservoir

Rock Creek Lake
Location



Rock Creek Lake
and
Watershed

Lake Data

Owner	City of Ardmore
County	Carter
Constructed in	1979
Surface Area	248 acres
Volume	3,588 acre/feet
Shoreline Length	6 miles
Mean Depth	14.47 feet
Watershed Area	3,545 acres

POOR EXCELLENT
Turbidity
2007

POOR EXCELLENT
Trophic State
2007

LAKES MONITORING PROGRAM

Rocky (Hobart) Lake

Rocky Lake is a 347-acre reservoir located in Washita County. The lake was constructed in 1933 and serves as a recreational reservoir and also the municipal water supply for the city of Hobart. Rocky Lake was sampled for four quarters from November 2006 through August 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the sampling period. The lake-wide annual turbidity value was 46 nephelometric turbidity units (NTU), true color was 46 units, and secchi disk depth was 27 centimeters. These values are similar to values collected during the 2003-2004 sampling season. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 69 (Plate 94), classifying the lake as hypereutrophic, indicative of excessive levels of productivity and nutrients. This value is very similar to the one calculated in 2004 (TSI=68) indicating little or no change in trophic status over time. The TSI values were hypereutrophic at all sites during the sample year. The lake is currently listed as a Nutrient Limited Watershed in accordance with the Oklahoma Water Quality Standards. This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. All turbidity values, except for two sites in the summer, were above the Oklahoma Water Quality Standard (WQS) of 25 NTU (Figure 120a). With 90% of the turbidity values exceeding the WQS of 25NTU, the Fish and Wildlife Propagation (FWP) beneficial us is considered not supported. Seasonal true color values are displayed in Figure 120b. All true color values were below the numeric criteria of 70 units and the lake is therefore the Aesthetics Beneficial Use is considered fully supported.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were performed at all sample sites and yielded the following results. Salinity readings ranged from 0.24 parts per thousand (ppt) to 0.34ppt, slightly higher than most values recorded in Oklahoma reservoirs. Readings for specific conductivity were also slightly higher than values normally seen in most Oklahoma reservoirs. Specific Conductivity ranged from 471.5 µS/cm in the spring quarter to 652.6 cm/cm in the winter quarter, indicating moderate to slightly elevated concentrations of electrical current conducting compounds (salts) in the water column. Oxidation-reduction potentials (redox) ranged from 264 mV to 430 mV, indicating reducing conditions were not present during any sampling events. Recorded pH values were neutral to slightly alkaline, ranging from 7.77 to 8.67 units. Rocky Lake was fully supporting its FWP beneficial use based on pH values collected during the study period. Thermal stratification did not occur in the lake during the study period. The water column was evenly mixed and oxygenated during the entire study period, which may be attributed to the shallow nature of the lake (mean depth of 1.3 meters). Dissolved oxygen (D.O.) concentrations never fell below 2.0 mg/L in the water column except for one point during the summer of 2007. The FWP beneficial use is considered supported based on dissolved oxygen concentrations. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use.

Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. The PBCR beneficial use cannot be determined as minimum data requirements were not met due to quality control issues for *E. coli* and Fecal Coliform. Of the 10 enterococci samples collected, were below the screening level of 61 cfu/ml and the geometric mean (6.6 cfu/ml) was below the prescribed mean standard of 33 cfu/ml.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.48 mg/L at the lake surface. The TN at the surface ranged from 1.23 mg/L to 1.81 mg/L. The highest surface TN value was reported in the summer quarter and the lowest was in the winter quarter. The lake-wide total phosphorus (TP) average was 0.127 mg/L at the lake surface. The TP ranged from 0.074 mg/L to 0.181 mg/L at the lake surface. These high and low values also correlated with the TN high and low values. The nitrogen to phosphorus ratio (TN:TP) was approximately 11:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

Rocky Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Rocky Lake was classified as hypereutrophic, indicative of excessive primary productivity and nutrient rich conditions (Plate 94). This is consistent with historical data collection efforts in 2001 (TSI=66) and 2004 (TSI=68), indicating no significant increase or decrease in productivity has occurred over time. Water clarity continues to be poor at this lake based on true color secchi disk depth and high turbidity values. Based on its trophic status the lake is currently listed as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Rocky Lake is fully supporting its Aesthetics beneficial use based on true color readings. The FWP beneficial use is fully supporting based on pH and D.O., and is not supported for turbidity as 90% of the collected values exceeded the WQS of 25 NTU. The PBCR is considered supported for enterococci; however due to minmum data requirements not being met for *E.coli* and fecal coliform and assessment of these parameters cannot be made.

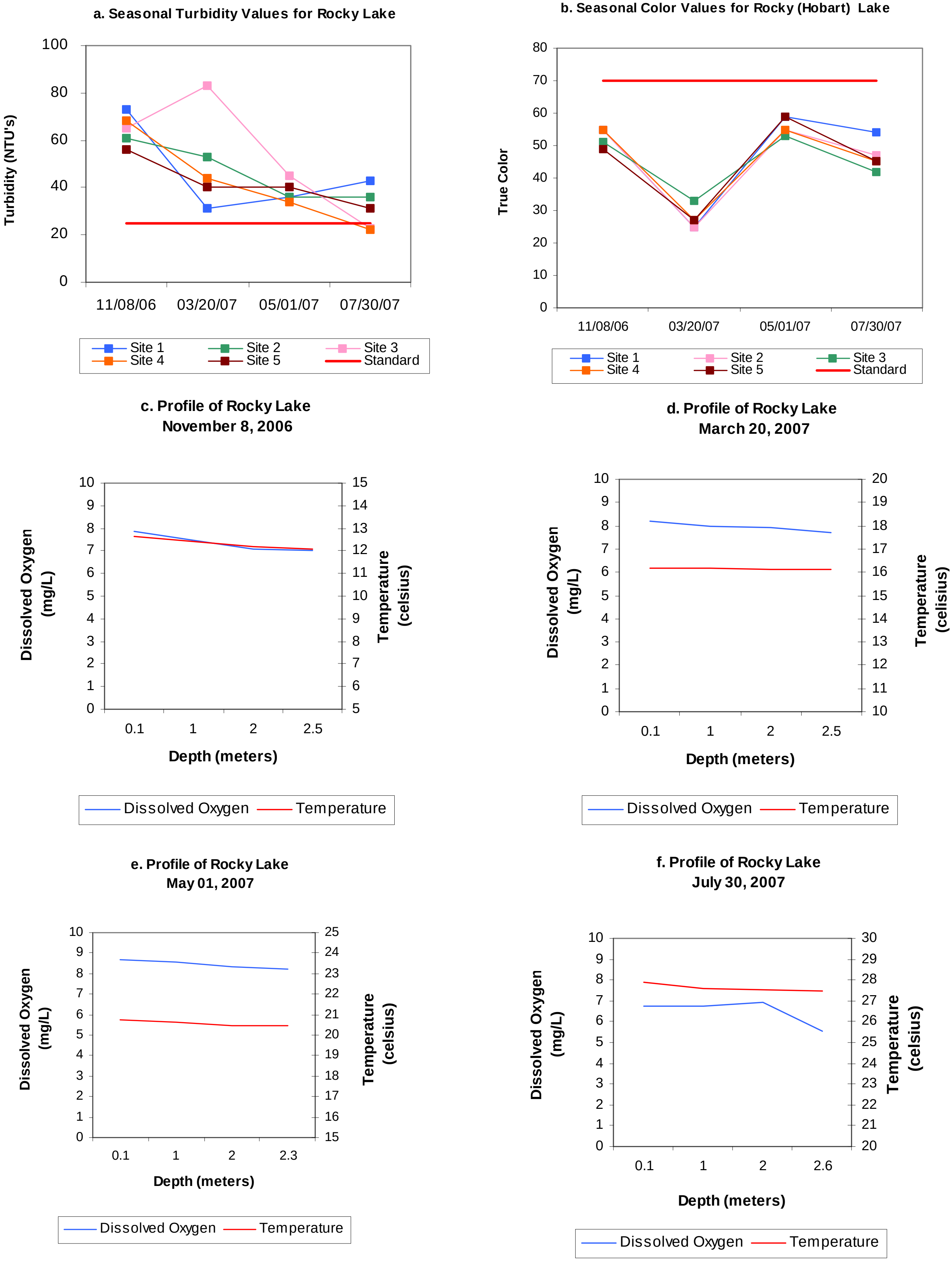
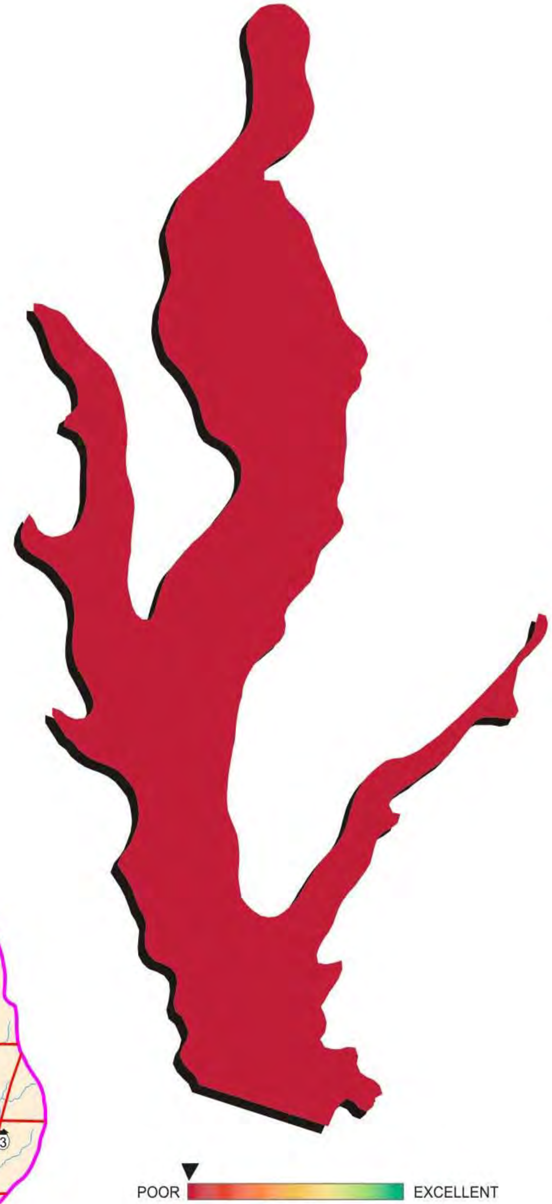


Figure 120a-120e. Graphical representation of data results for Rocky Lake.

Lake Data

Owner	City of Hobart
County	Washita
Constructed in	1933
Surface Area	347 acres
Volume	4,210 acre/feet
Shoreline Length	8 miles
Mean Depth	11.64 feet
Watershed Area	58 square miles



Turbidity
2007

Trophic State
2007

Plate 94 - Lake Water Quality for
Rocky (Hobart) Lake

LAKES MONITORING PROGRAM

Lake Sahoma

Lake Sahoma is a 312-acre reservoir that was constructed in 1947 and is owned and operated by the City of Sapulpa. The lake is managed as a municipal water supply and offers numerous recreational opportunities to the public. Lake Sahoma was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Water quality samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 9 NTU (Plate 96), true color was 30 units, and secchi disk depth was 73 centimeters. Water clarity was fair based on secchi disk depth, turbidity, and true color values collected in sample year 2006. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 51 (Plate 96), indicating the lake was eutrophic, with high levels of productivity and nutrient rich conditions. This is identical to the TSI calculated in 2004, indicating no significant increase or decrease in productivity has occurred. The TSI values varied seasonally ranging from oligotrophic in the winter to mesotrophic in the fall and eutrophic in both the spring and summer quarters. Turbidity values were all below the Oklahoma Water Quality Standard (WQS) of 25 NTU ranging from a low of 6 NTU to a maximum of 18 NTU (see Figure 121a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the collected turbidity values below the criteria, Lake Sahoma is supporting its Fish & Wildlife Propagation (FWP) beneficial use. Seasonal true color values are displayed in Figure 121b. Similar to turbidity 100% of the true color values were below the Aesthetics WQS of 70 units. Applying the same default protocol, the lake is considered supporting its Aesthetics beneficial use.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity ranged from 0.08 parts per thousand (ppt) in the spring to 0.09 ppt in the fall and winter quarter, indicating low salt content and lower than the expected range of salinity values reported for most Oklahoma lakes. Specific conductivity ranged from 184.1 µS/cm to 203.1 µS/cm in the spring quarter, indicating that very low levels of electrical conducting compounds (salts) were present in the lake system. In general, pH values were neutral with values ranging from 7.02 units to 7.8 units in the spring quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. All collected pH values were within the acceptable range, therefore Lake Sahoma is fully supporting its FWP beneficial as it relates to pH. Oxidation-reduction potentials (redox) ranged from 125 mV to 451 mV, indicating reducing conditions were not present during the sampling events. In the fall and winter quarters the lake was well mixed and dissolved oxygen (D.O.) concentrations were above

7.0 mg/L throughout the water column. Thermal stratification was evident and anoxic conditions present to some degree at all sites in the spring quarter. Stratification occurred between 3 and 4 meters below the surface at site 1 with anoxic conditions present in approximately 69% of the water column (Figure 121e). Sites 2-5 were all stratified at the same point and anoxic conditions were present in 20-56% of the water column among the various sites. Due to equipment malfunction profile data is not available for assessment for the summer sampling interval. It is likely that stratification and anoxic conditions would be present with the lake stratifying so strongly in the spring. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported at Lake Sahoma with approximately 69% of the water column anoxic during the spring. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.66 mg/L at the lake surface during the study period. The TN at the surface ranged from 0.58 mg/L to 0.74 mg/L. The highest surface TN values were reported in the spring and summer quarter and the lowest occurred in the fall and winter quarters. The lake-wide total phosphorus (TP) average was 0.031 mg/L at the lake surface. The surface TP ranged from 0.023 mg/L to 0.039 mg/L. The highest surface TP value was reported in the spring quarter and the lowest was in the fall quarter. The nitrogen to phosphorus ratio (TN: TP) was approximately 22:1 for sample year 2003-2004. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Lake Sahoma was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Lake Sahoma was classified as eutrophic (TSI=51), indicating high primary productivity and nutrient rich conditions (Plate 96). This is identical to the TSI calculated in 2004, indicating no significant increase or decrease in productivity has occurred. Water clarity was fair based on secchi disk depth, turbidity, and true color values. The lake was fully supporting its Aesthetics beneficial use based on its trophic status (for nutrients) as well as for true color as 100% of the recorded values were below the WQS of 70 units. Sahoma was fully supporting its FWP beneficial use based on pH and nephelometric turbidity however is partially supporting based on anoxic conditions present during the spring sampling interval. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

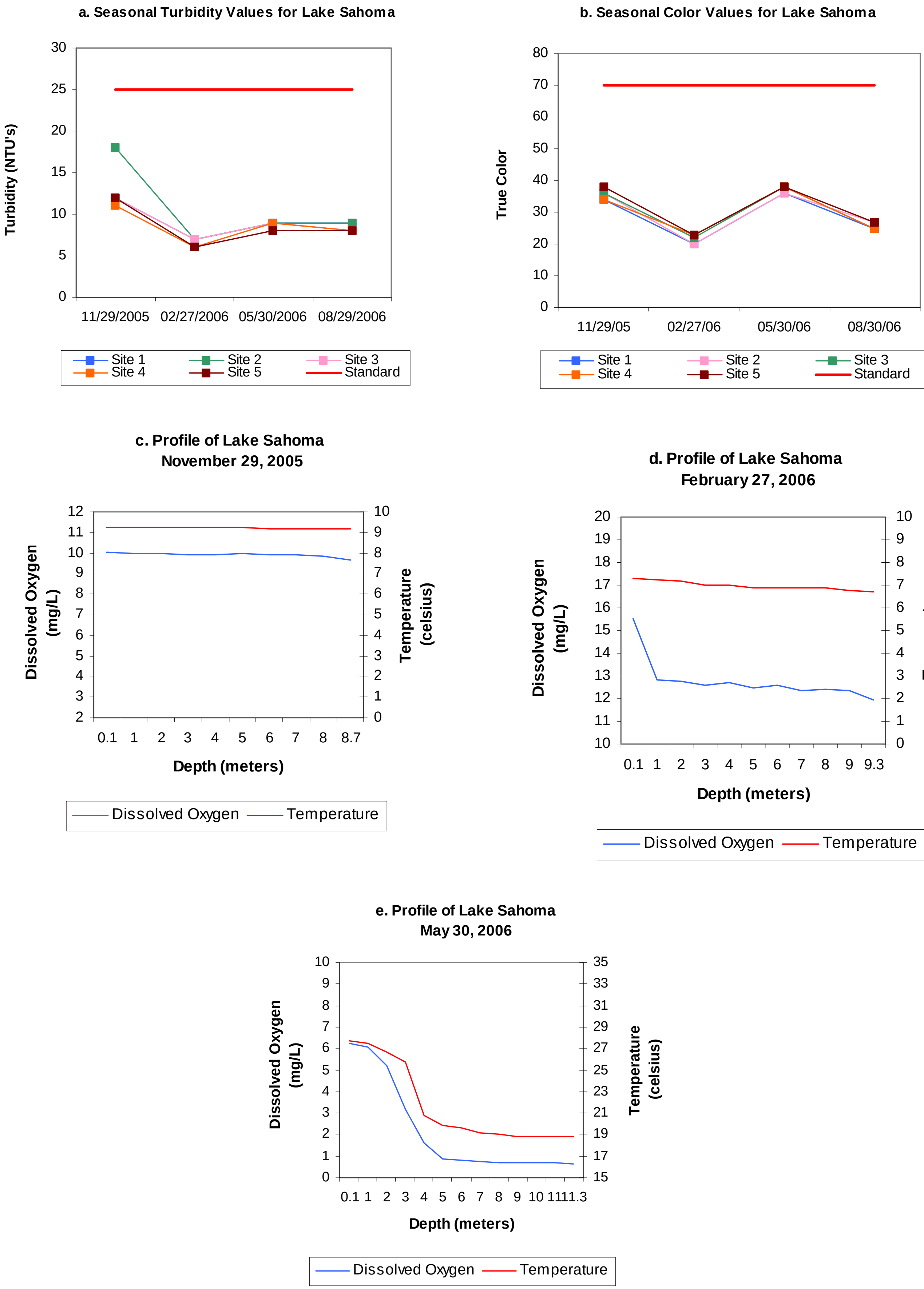
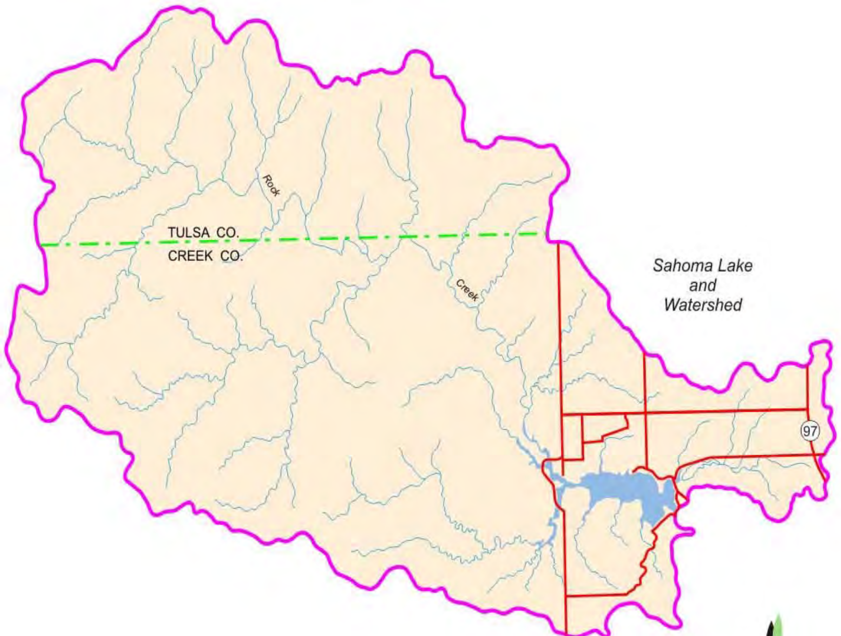
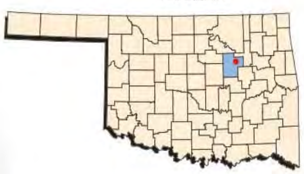
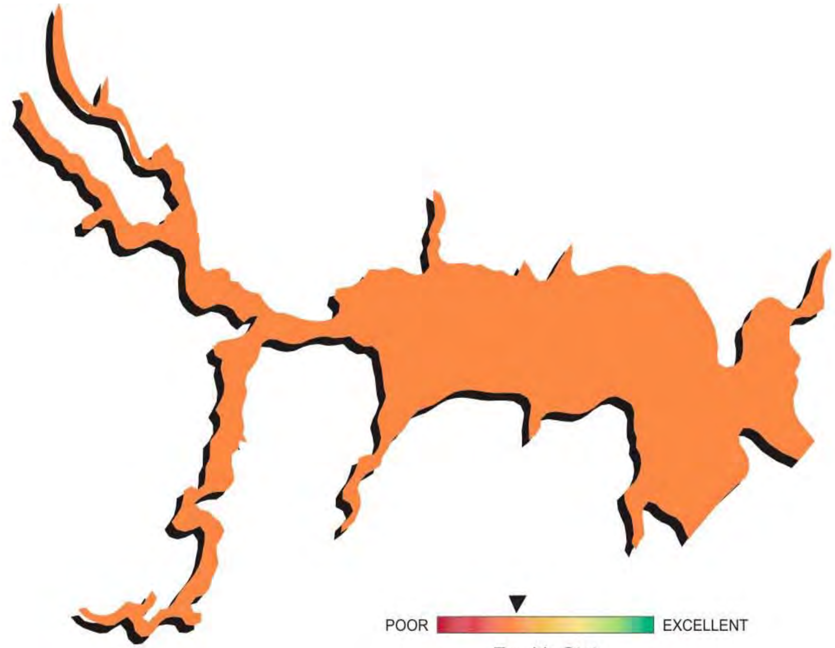


Figure 121a-121e Graphical representation of data results for Lake Sahoma.





Lake Data	
Owner	City of Sapulpa
County	Creek
Constructed in	1947
Surface Area	312 acres
Volume	4,850 acre/feet
Shoreline Length	11 miles
Mean Depth	15.54 feet
Watershed Area	40 square miles



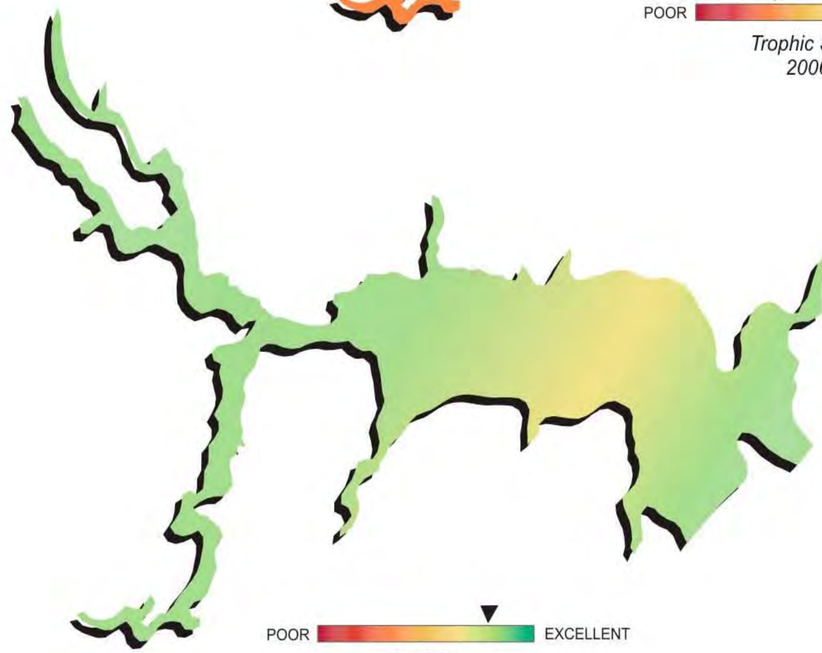


Plate 96 - Lake Water Quality for
Sahoma Lake

Sardis Lake

Sardis Lake is a 13,610-acre reservoir located in Pushmataha County. The lake was constructed by the United States Army Corps of Engineers (USACE) in 1982 to serve as flood control, water supply, fish and wildlife, and recreational opportunities in the area. Sardis Lake was sampled for four quarters, from October 2004 through July 2005.

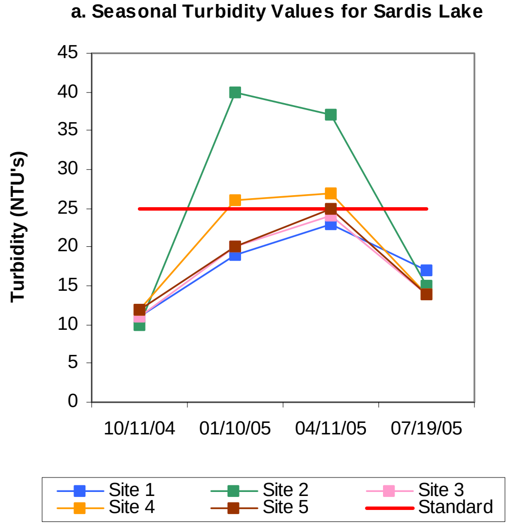
Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and from 0.5 meters from the lake bottom at site 1, the dam. The average lake-wide turbidity was 20 NTU (Plate 97), true color was 65 units, and average secchi disk depth was 74 centimeters. Based on these three parameters, Sardis Lake had average water clarity, in comparison to other Oklahoma reservoirs. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a) was calculated using values at all sites for four quarters (n=20). The TSI was 50 (Plate 97), classifying the lake as mesotrophic bordering eutrophic, with moderate to high primary productivity and nutrient conditions. This is very similar to the value calculated in 2003 (TSI=45), indicating no significant change in productivity has occurred. The TSI values were primarily upper mesotrophic throughout the year with eutrophic values in the winter quarter. The only exception to this was site 2, which remained in the mesotrophic category at the time of winter sampling. Seasonal turbidity values are displayed in Figure 122a. Turbidity varied throughout the year with the lowest values recorded in the fall and summer and the highest recorded in both winter and spring quarters. Available rainfall data suggest the peak in turbidity is likely due to seasonal storm events; however when this data is excluded 10% of the remaining values are still greater than 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Sardis Lake will be listed as partially supporting the FWP use. Seasonal true color values are displayed in Figure 122b. True color followed the same pattern as turbidity with elevated values reported in the spring sampling interval. Applying the same default protocol, the Aesthetics beneficial use is also partially supported.

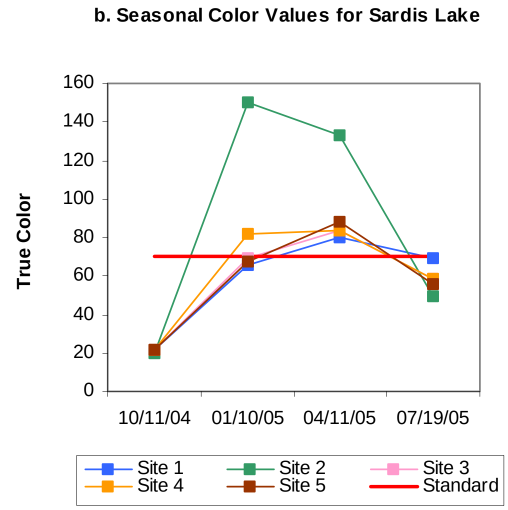
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites in 2004-2005. Salinity values ranged from 0.00 parts per thousand (ppt) to 0.02 ppt throughout the study period. This is much lower than the average range of values reported for most Oklahoma reservoirs. Specific conductivity ranged from 37.5 to 63.2 µS/cm, indicating extremely low concentrations of electrical current conducting compounds (salts) were present in the lake, consistent with the salinity readings. The pH values at were slightly acidic, ranging from 6.12 in the summer to 7.65 in the fall. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 7.5 % of the values recorded being less than 6.5 the lake will be listed as supporting based on pH. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Oxidation-reduction potentials (ORP) ranged from 315 mV to 474 mV, indicating the absence of reducing conditions during the sample year. The lake was not stratified during the winter or spring sampling quarters and the lake was well mixed (Figure 122d-122e). Thermal stratification and anoxic conditions were present during the summer. In the summer the lake was stratified between 5 and 6 meters at which point dissolved oxygen (D.O.) fell below 2.0 mg/L for 60% of the water column (Figure 122f). Due to equipment failure no Hydrolab readings were recorded and an assessment of conditions during the fall quarter cannot be made. If D.O. values are less than 2 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Sardis Lake is partially supporting its FWP beneficial use due to anoxic conditions in the summer. The lake was also sampled for chlorides, sulfates and total dissolved solids to assess the Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

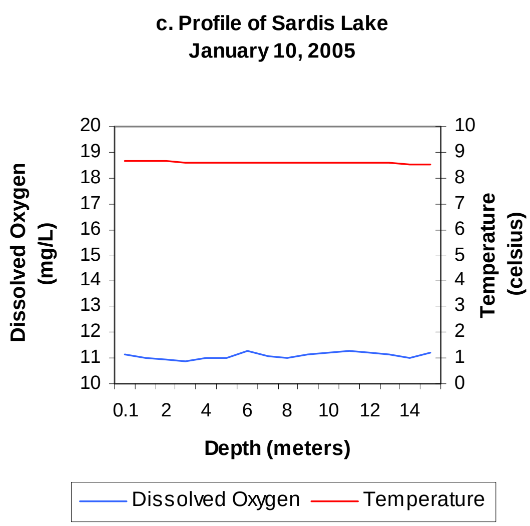
Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

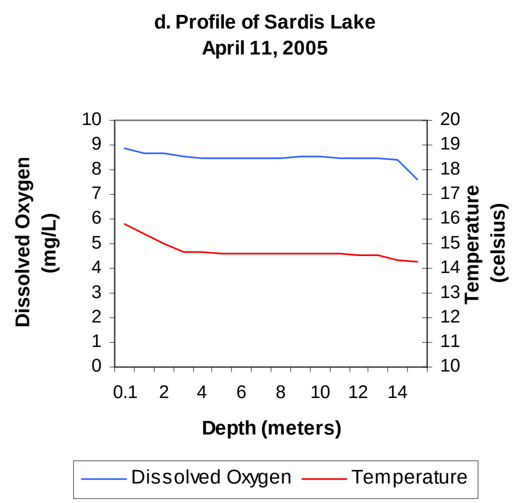
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.46 mg/L at the surface. Surface TN ranged from 0.22 mg/L to 1.01 mg/L, with the highest values reported in the spring and lowest values in the winter quarter. The lake-wide total phosphorus (TP) average was 0.030 mg/L at the surface. Total phosphorus at the surface ranged from 0.021mg/L to 0.054 mg/L. Similar to TN, surface TP was highest in the spring, however lower values were recorded during the fall quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 15:1 for sample year 2004-2005. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

In summary, Sardis Lake was classified as mesotrophic with moderate primary productivity and nutrient conditions in 2005, consistent with results from the 2003 evaluation. Water clarity was average based on true color, turbidity, and secchi disk depth. The FWP beneficial use is partially supported by both turbidity as well as D.O. with anoxic conditions present in 60% of the water column during the summer. With 7.5% of the recorded pH values less the 6.5 units the lake is also supporting the FWP beneficial use. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. The lake is supporting the Aesthetics beneficial use based on its trophic status and partially supporting the use for true color values. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. In 1999, a bathymetric survey was conducted at Sardis Lake (Figure 123) as part of the Kiamichi River Development Project. The purpose of the survey was to generate a 3-D simulation of water level changes within the reservoir in response to concerns local citizens had regarding the potential transfer of water to other areas of the state and /or the north Texas area. Specific concerns included fluctuating lake levels and the subsequent impacts on fish/wildlife, recreation, tourism and economic development in the area. For further information about this study or bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.









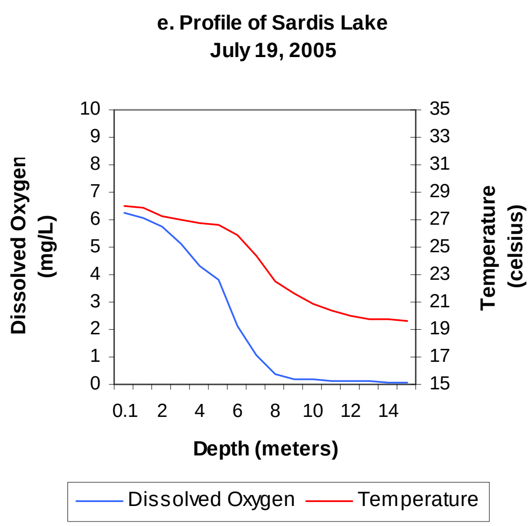
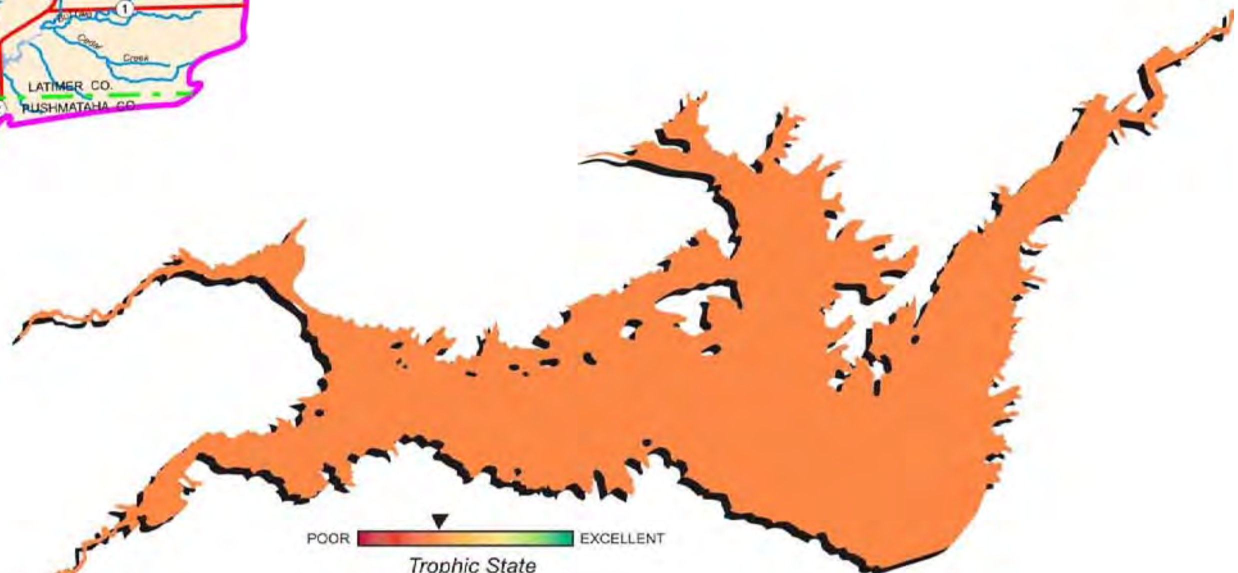
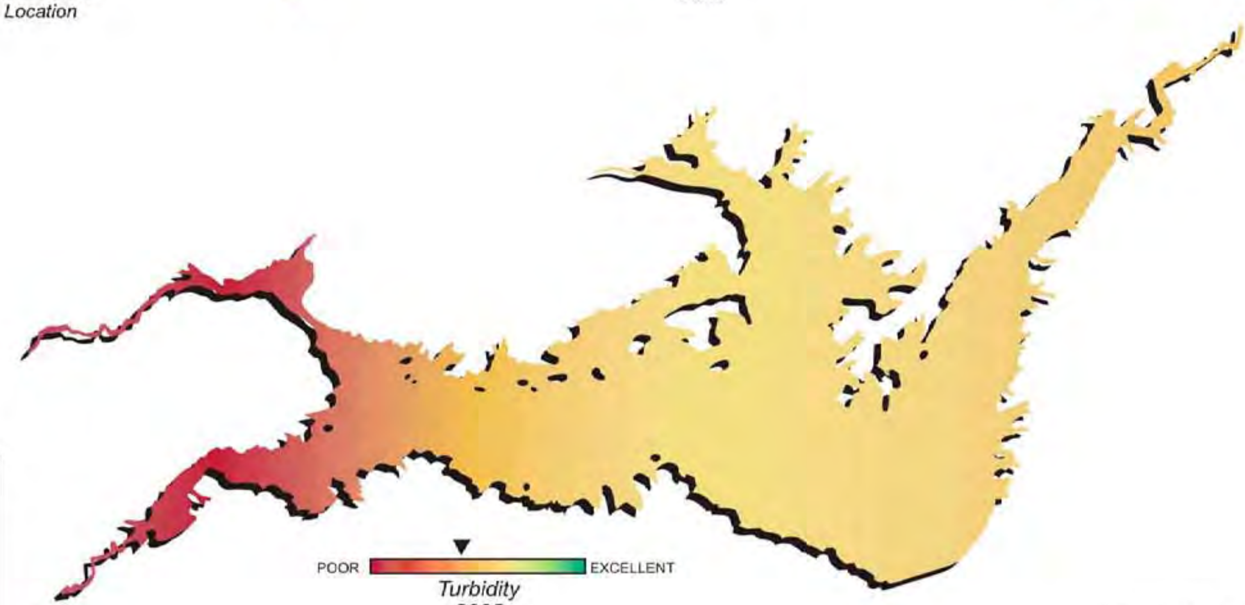


Figure 122a-122f. Graphical representation of data results for Sardis Lake.


Sardis Lake
Location





N
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Lake Data	
Constructed by	Corps of Engineers
County	Pushmataha
Constructed in	1983
Surface Area	13,589 acres
Volume	233,053 acre/feet
Shoreline Length	92.5 miles
Mean Depth	16.47 feet
Watershed Area	275 square miles

Plate 97 - Lake Water Quality for
Sardis Lake

LAKES MONITORING PROGRAM

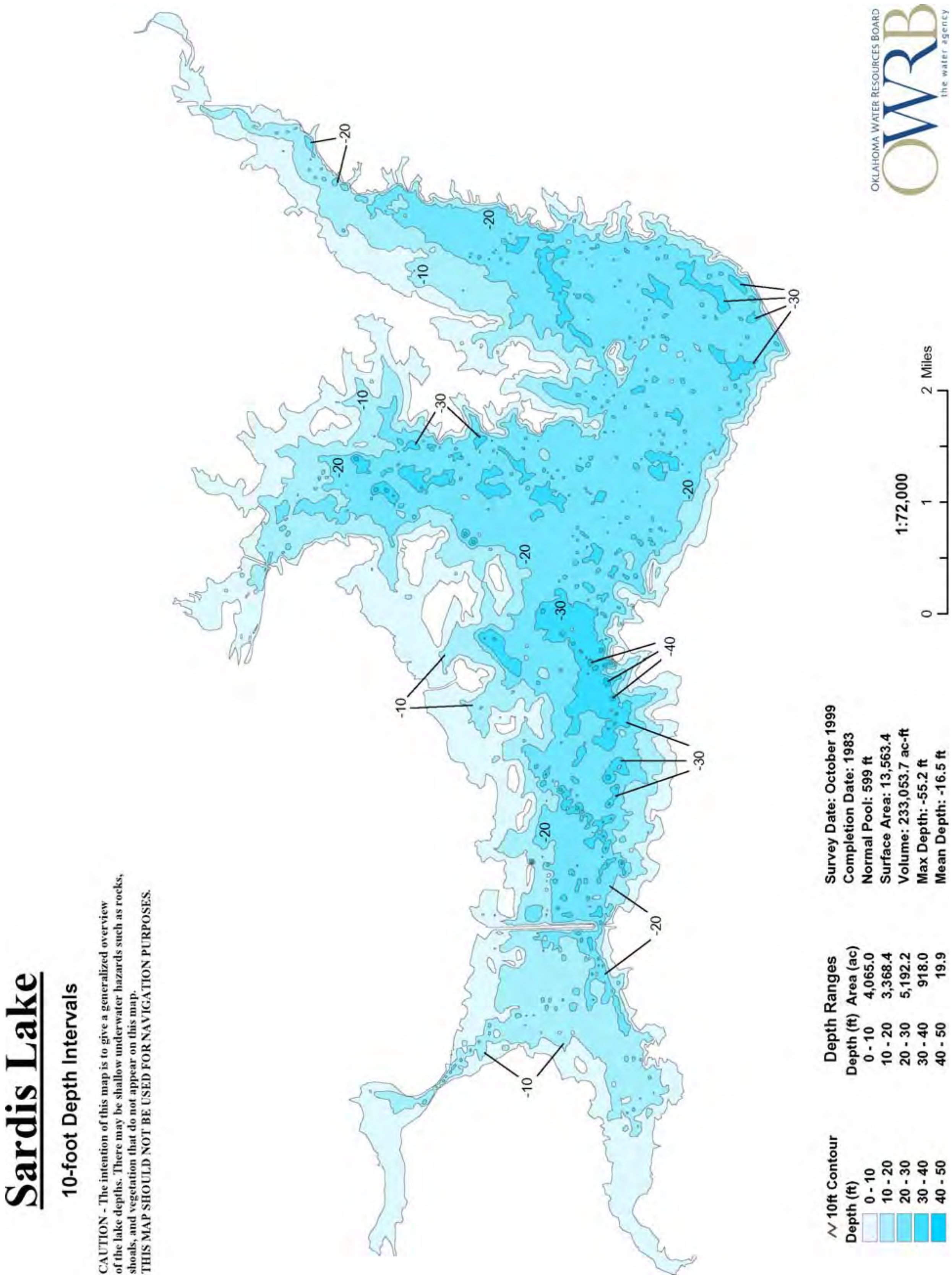


Figure 123. Bathymetric Map of Sardis Lake.

Shawnee Twin Lake # 1

Shawnee Twin Lake # 1 is a 1,336-acre reservoir constructed in 1935, which is owned and operated by the City of Shawnee. The lake is utilized as a municipal water supply and affords numerous recreational opportunities to the public. Shawnee Twin Lake # 1 was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir as well as any major arms. Samples were collected from the lake surface at all five sites during the study period. Due to low lake levels OWRB staff were unable to access the lake in both the winter and summer sampling intervals. Lake levels were so low that the City of Shawnee closed both Twin Lakes and the canal joining the two lakes was completely dry. The following data discussion is based on the data collected in November 2005, February 2006 and was aggregated with past historical data collected since the beginning of the BUMP program in 1998. The lake-wide average turbidity value was 15 NTU (Plate 98), true color was 29 units, and secchi disk depth was 67 centimeters. Based on these three parameters, Shawnee Twin Lake # 1 had good water clarity. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites (n=73). The average TSI was 41 (Plate 98), indicating the lake was mesotrophic, bordering oligotrophic, with low to moderate levels of primary productivity and nutrient conditions. Turbidity values were generally well below the Oklahoma Water Quality Standard (WQS) of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Of the seventy-three samples collected, only 7 (9%) of the values were above the criteria therefore the lake is considered supporting its Fish & Wildlife Propagation (FWP) beneficial use. True color followed a similar pattern with values generally below the aesthetics WQS of 70 units at all sites throughout the sample period. With only 7% of the collected samples below the numerical criteria for true color, the lake is fully supporting its Aesthetics beneficial use.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites throughout the period of record. Salinity ranged from 0.08 parts per thousand (ppt) to 0.22 ppt, which is within the range of salinity concentrations reported for most Oklahoma lakes. Specific conductivity ranged from 82 µS/cm to 433.5 µS/cm, indicating that low to moderate levels of electrical conducting compounds (salts) were present in the lake system. In general, pH values were neutral with values ranging from 7.08 units to 9.85 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With only 0.34% of the recorded values outside the allowable range, the lake is fully supporting its FWP beneficial use based on pH. Oxidation-reduction potentials (redox) ranged from 43 mV to 523 mV indicating that reducing conditions were not present during any of the sampling events.

Lower redox values are not uncommon when a large portion of the water column is experiencing anoxic conditions as was the case in the summer of 1998 and 1999. Upon reviewing the profile data from 1998 to the present, the lake is generally well mixed in the fall, winter and spring sampling intervals with dissolved oxygen (D.O.) levels remaining above 2.0mg/L. Thermal stratification and anoxic conditions are evident during the warmer summer months with up to 67% (in 1999) of the water at site 1 having D.O. levels below 2.0 mg/L. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported at Shawnee Twin Lake # 1 due to anoxic conditions present during the summer months. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

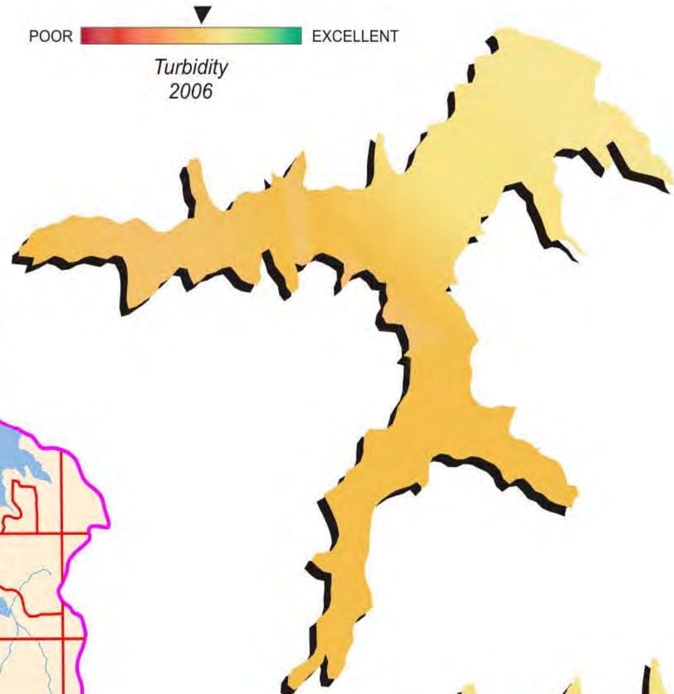
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average for the period of record is 0.42 mg/L at the lake surface. The TN at the surface ranged from 0.06 mg/L to 2.33 mg/L. The lake-wide total phosphorus (TP) average is 0.019 mg/L at the lake surface. The surface TP ranged from 0.003 mg/L to 0.078 mg/L. The nitrogen to phosphorus ratio (TN:TP) was approximately 22:1. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

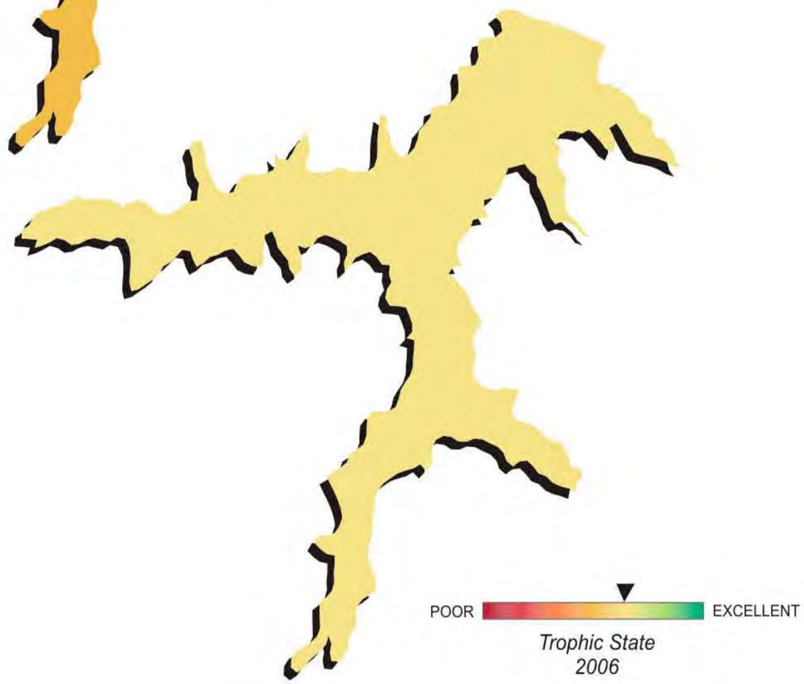
The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 1999 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening level or consumption advisory level. The lake is fully supporting its Fish Consumption beneficial use.

In summary, Shawnee Twin Lake # 1 was classified as mesotrophic bordering oligotrophic, indicating low to moderate primary productivity and nutrient conditions (Plate 98). Water clarity is good based on turbidity, true color and Secchi disk depth. The lake is currently fully supporting its Aesthetics beneficial use based on the trophic status (nutrients) and true color. In reviewing profile data for the period of record the lake was fully supporting its FWP beneficial for pH and partially supporting the use as it relates to dissolved oxygen. With only 9% of the values exceeding the criteria of 25 NTU, the lake is considered supporting its Fish & Wildlife Propagation (FWP) beneficial use.

Shawnee Twin Lake No. 1
Location

Shawnee Twin Lake No. 1
and
Watershed





Lake Data	
Owner	City of Shawnee
County	Pottawatomie
Constructed	1935
Surface Area	1,336 acres
Volume	22,600 acre/feet
Shoreline Length	16 miles
Mean Depth	16.92 feet
Watershed Area	21 square miles

Plate 98 - Lake Water Quality for

Shawnee Twin Lake No. 1

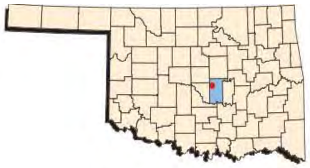
Shawnee Twin Lake # 2

Shawnee Twin Lake # 2, located in Pottawatomie County, was constructed in 1960 and is owned and operated by the City of Shawnee. The 1,100-acre reservoir is utilized as a municipal water supply and affords numerous recreational opportunities to the public. The lake was scheduled for sampling during the 2005-2006 sample year however due to the drought conditions lake levels were too low for OWRB staff access the lake. The lake will be sampled in the 2007-2008 season once water levels raise enough for staff to access the lake safely. The data reported here are from the 2003-2004.

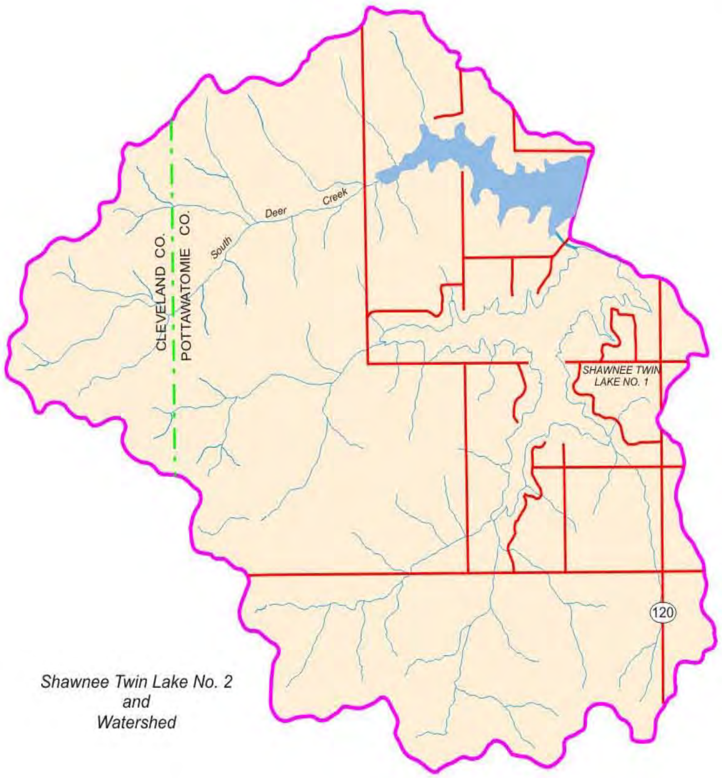
Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir as well as any major lake arms Water quality samples were collected from the lake surface at five sites and 0.5 meters from the lake bottom at site 1, the dam. The lake-wide annual turbidity value was 25 NTU (Plate 99), true color was 34 units, and secchi disk depth was 47 centimeters in 2003-2004. Based on these three parameters, Shawnee Twin Lake # 2 had good water clarity in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for all four quarters (n=20). The average TSI was 42 (Plate 99), classifying the lake as mesotrophic, indicative of moderate levels of primary productivity and nutrients. This value is exactly the same as that calculated in 2002, indicating that no significant change in trophic status has occurred. Seasonal TSI values were mesotrophic throughout the year except for site 3 in the winter quarter, which dipped down into the oligotrophic category in the winter quarter. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Although 25% of the values were above the criteria, available flow data suggests the peak in turbidity that occurred in May is likely due to seasonal storm events and the lake will be listed as supporting its Fish & Wildlife Propagation (FWP) beneficial use. Of the twenty true color values collected, three (15%) were above the WQS of 70 units, corresponding with the elevated turbidity readings. The Aesthetics beneficial use is considered supported as the high true color readings are likely due to seasonal rain events.

Please refer to the “Beneficial Use Monitoring Report 2004 Draft Final Report” for the full discussion of monitoring results for this lake. The report may be access via the OWRB’s web page at http://www. owrb.state.ok.us or you may contact the Water Resources for a copy of the 2004 BUMP Report on CD. The OWRB may be reached at (405) 530-8800 (ask for Nikki Cole) or at the address below:

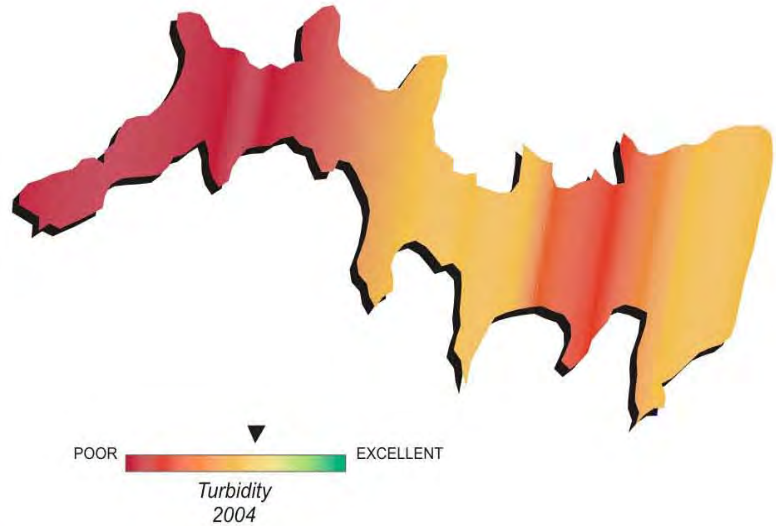
Oklahoma Water Resources Board
3800 N. Classen Blvd.
Oklahoma city, Oklahoma 73118
Attn: Nikki Cole

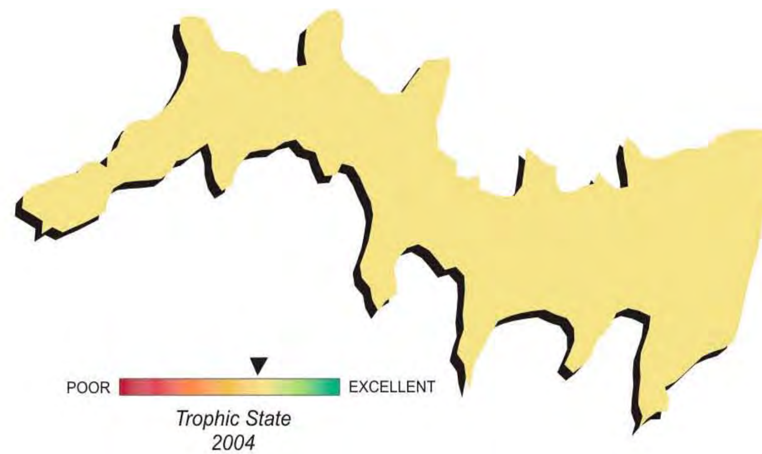


Shawnee Twin Lake No. 2
Location



Shawnee Twin Lake No. 2
and
Watershed





Lake Data

Owner	City of Shawnee
County	Pottawatomie
Constructed	1960
Surface Area	1,100 acres
Volume	11,400 acre/feet
Shoreline Length	9 miles
Mean Depth	10.36 feet
Watershed Area	11 square miles

Plate 99 - Lake Water Quality for
Shawnee Twin Lake No. 2

Shell Lake

Shell Lake, located in Osage County, was constructed in 1922 and is owned and operated by the City of Sand Springs. The 573-acre reservoir is maintained as a municipal water supply offers numerous recreational opportunities to the public. Shell Lake was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones as well as any major arms of the reservoir. Samples were collected at the lake surface at all sample sites during the study period. The lake-wide annual turbidity value was 9 NTU (Plate 100), true color was 21 units, and secchi disk depth was 83 centimeters in 2005-2006. Based on these three parameters water clarity at Shell Lake was excellent at the time of sampling. This is consistent with the previous data collection efforts of 2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 53 (Plate 100), classifying the lake as eutrophic, indicative of high levels of primary productivity and nutrient rich conditions. This value is similar to that calculated in 2004 (TSI=52) and 2002 (TSI=51), indicating no significant change in productivity has occurred over time. The TSI values varied seasonally from mesotrophic in the fall and winter quarters, to lower eutrophy in the spring, to upper eutrophy in the summer quarter All turbidity values were well below the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 124a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With a lake-wide annual turbidity average of 11 NTU Shell Lake is fully supporting its Fish & Wildlife Propagation (FWP) beneficial use based on nephelometric turbidity. Seasonal true color values are displayed in Figure 124b. All of the true color values were below the numeric criteria of 70 units in 2005-2006. Applying the same default protocol; Shell Lake is supporting the Aesthetics beneficial use.

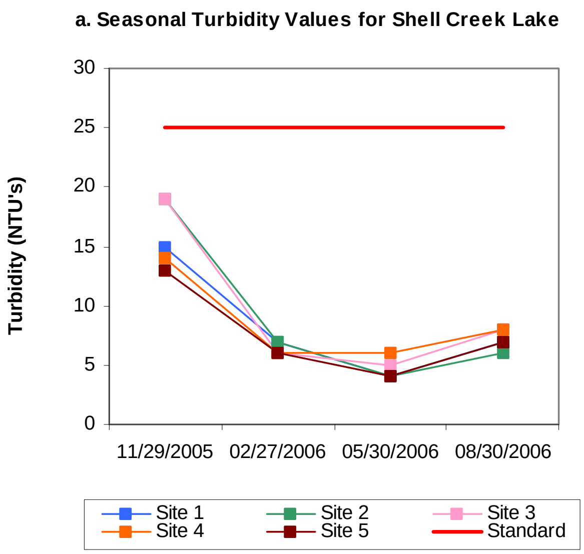
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.08 parts per thousand (ppt) to 0.20 ppt, indicating low salt content and were well within the expected range of salinity values reported for most Oklahoma lakes and reservoirs. Specific conductivity ranged from 172.2 µS/cm to 280.5 µS/cm, indicating very low levels of electrical conducting compounds (salts) were present in the lake system, corresponding with the recorded salinity values. In general, pH values were neutral to slightly alkaline, ranging from 6.74 units to 8.52 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the collected pH values within the acceptable range; Shell Lake is fully supporting its FWP beneficial use based on pH. Oxidation-reduction potentials (redox) ranged from 327 mV at the sediment-water interface in the spring to 496 mV also in the spring quarter. Redox readings indicated that reducing conditions were not present in the reservoir during the study period. The lake was not thermally stratified in the fall or winter quarters and dissolved oxygen (D.O.) values were above 7.0 mg/L throughout the water column (see Figure 124c-124d). In the spring the lake was strongly thermally stratified between 3 and 4 meters in depth with dissolved oxygen (D.O.) concentrations below 2.0 mg/L from 5 meters to the lake bottom of 13.9 meters. Approximately 67% of the water column at site 1, the dam, was experiencing anoxic conditions at the time of sampling (Figure 124e). Sites 2,3 and 5 were all stratified at the same point and anoxic conditions were present in 33-38% of the water column among the various sites. Due to equipment malfunction profile data is not available for assessment for the summer sampling interval. It is likely that stratification and anoxic conditions would be present with the lake stratifying so strongly in the spring. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported at Shell Lake with approximately 67% of the water column anoxic during the spring. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported.

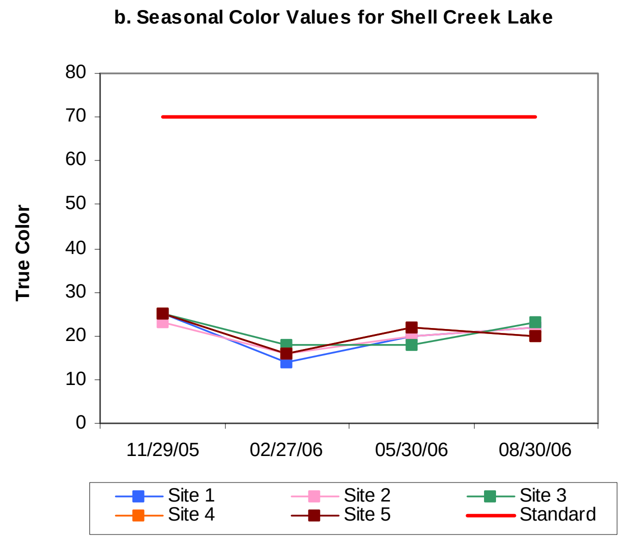
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

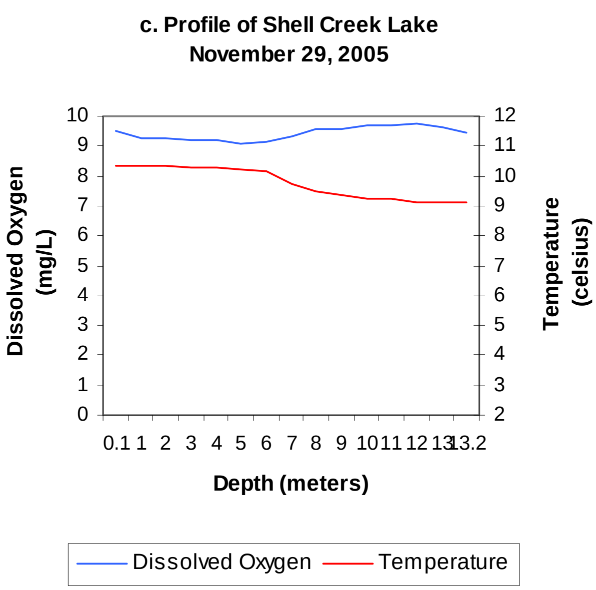
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average for sample year 2005-2006 was 0.76 mg/L at the lake surface. The TN at the surface ranged from 0.55 mg/L to 0.96 mg/L. The highest surface TN value was reported in the winter quarter and the lowest was in the spring. The lake-wide total phosphorus (TP) average was 0.022 mg/L at the lake surface. The surface TP ranged from 0.019 mg/L to 0.027 mg/L. The highest surface TP value was reported in the fall and the lowest was in the spring quarter. The values for both parameters are very similar to those of the previous evaluation in 2004. The nitrogen to phosphorus ratio (TN: TP) was approximately 35:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

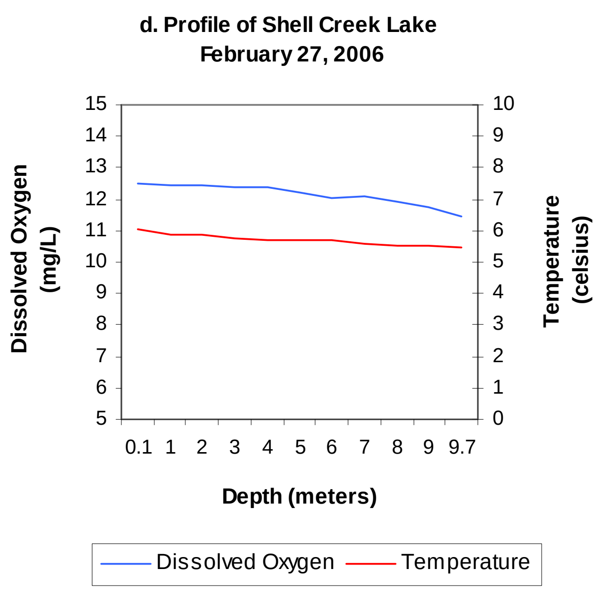
Shell Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Shell Lake was eutrophic, indicative of high primary productivity and nutrient rich conditions (Plate). The current TSI is similar to that calculated in 2004 (TSI=52) and 2002 (TSI=51), indicating no significant change in productivity has occurred over time. Based on turbidity, true color and secchi disk depth water clarity at Shell Lake was excellent at the time of sampling. This is also consistent with the previous data collection efforts of 2004. Shell Lake is fully supporting its Aesthetics beneficial use based on nutrients and true color for sample year 2005-2006. The FWP beneficial use was fully supported for turbidity and pH, but was partially supported for D.O. with 33-67% of the water column being anoxic during the spring sampling interval. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. All bacteriological sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.









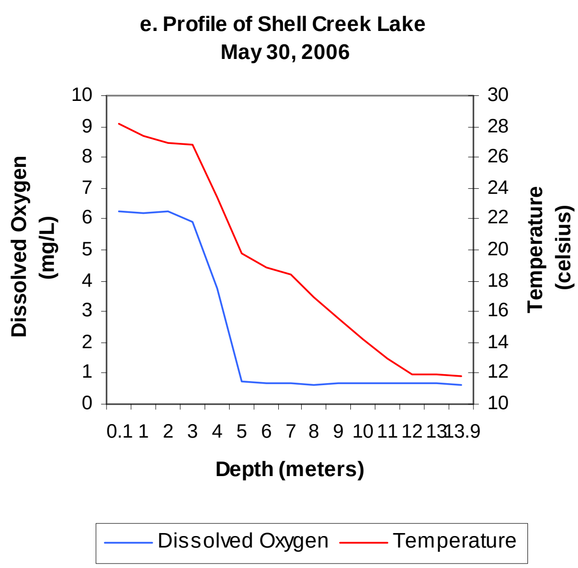
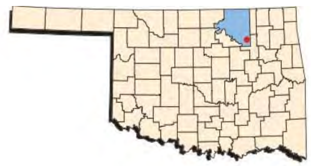
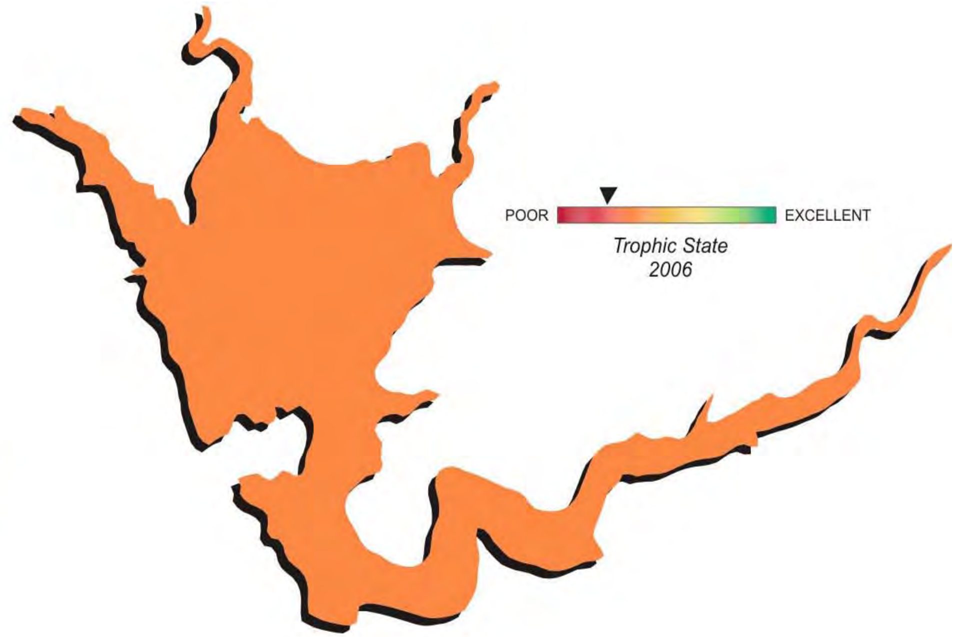
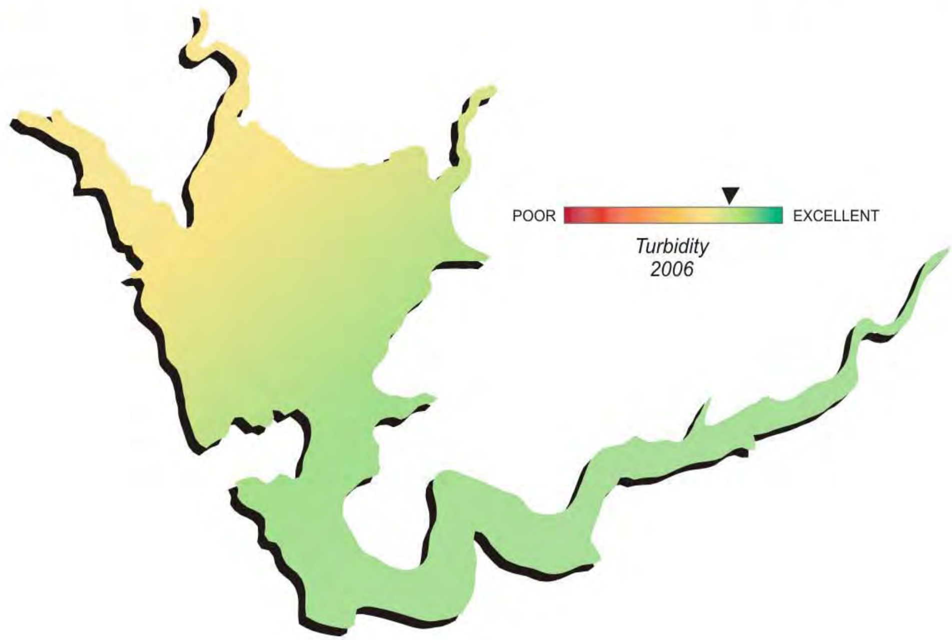


Figure 124a-124e. Graphical representation of data results for Shell Lake.



Shell Lake
and
Watershed





Lake Data

Owner	City of Sand Springs
County	Osage
Constructed in	1922
Surface Area	573 acres
Volume	9,500 acre/feet
Shoreline Length	13 miles
Mean Depth	16.58 feet
Watershed Area	15 square miles

Plate 100 - Lake Water Quality for

Shell Lake

Skiatook Lake

Skiatook Lake was constructed by the United States Army Corps of Engineers (USACE) for flood control, water supply and quality control, recreation, fish and wildlife purposes. The 10,190-acre reservoir is located in Osage County approximately five miles west of the City of Skiatook. Skiatook Lake was sampled for four quarters, from November 2006 through August 2007.

Water quality samples were collected at seven (7) sites to represent the riverine, transitional, and lacustrine zones and major arms of the reservoir. Samples were collected at the lake surface at all sample sites. The average lake-wide annual turbidity value was 13 NTU (Plate 101), true color was 34 units, and average secchi disk depth was 98 centimeters. Based on these three parameters, Skiatook Lake had good water clarity in 2006-2007, similar to that reported in sample years 2003 and 2005. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=28). The average TSI was 47 (Plate 101), classifying the lake as mesotrophic, indicative of moderate levels of primary productivity and nutrient conditions. This value is similar to the TSI calculated in 2003 (TSI=45) and in 2005 (TSI=43), and in the same trophic category, indicating no significant change in productivity has occurred since the previous evaluation. Seasonal turbidity values are displayed in Figure 125a. Turbidity values were below the Oklahoma Water Quality Standard (WQS) of 25 NTU throughout the year, except sites 4 (Hominy Creek arm) and 5 (Bull Creek arm) in the spring. With only 7% of the samples exceeding the standard, the Fish and Wildlife Propagation (FWP) beneficial use is considered fully supported for 2006-2007 sampling season. Seasonal true color values are displayed in Figure 125b. True color followed the same pattern as turbidity with all values below the WQS of 70, except for sites 3, 4, 5, and 6, which had values of 100, 249, 199 and 80 units, respectively reported in the spring quarter. As such, 10% of the color values are above the criteria of 70 and therefore the Aesthetics beneficial use is only partially supported.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites in 2006-2007. Salinity values ranged from 0.07 parts per thousand (ppt) to 0.15 ppt during the study period. This is within the average range of values reported for most Oklahoma reservoirs. Specific conductivity ranged from 7.5 to 305.5 µS/cm, indicating the presence of minimal concentrations of electrical current conducting compounds (salts) were present in the lake, consistent with the salinity readings. In general, pH values were neutral to slightly alkaline with values ranging from 6.8 to 8.05 during the study period. With 100% of the recorded values within the acceptable range of 6.5 to 9.0, the lake is considered supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (ORP) ranged from 38 mV in the hypolimnion during summer to 395 mV in the spring quarter. In general reducing conditions were not present at the time of sampling, although near reducing conditions were present in the summer when a large portion of the water column was anoxic. The lake was not stratified in the winter or spring sampling quarters and the water column was well mixed with dissolved oxygen (D.O.) concentrations generally above 6.0 mg/L

(Figure 125d-125e). Thermal stratification was evident and anoxic conditions were present in both the spring and summer quarters. In the summer, the lake was stratified between 7 and 9 meters at sites 1-3 and 6-7 at which point D.O. fell below 2.0 mg/L for the rest of the water column (Figure 125c). Anoxic conditions were present in 34% (site 6) to 59% (site 3) of the water column during the summer sampling interval. Site 3 (Osage Park) had the largest portion of the water column less than 2.0 mg/L during this time period. If D.O. values are less than 2 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Skiatook Lake is partially supporting its FWP beneficial use due to anoxic conditions in the summer sampling quarter. The lake was also sampled for chlorides, sulfates and total dissolved solids to assess the Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

Bacteriological samples were collected during the 2007 recreation season (May through August) in order to make an assessment of the Primary Body Contact Recreation (PBCR) beneficial use. Fecal coliform, Enterococci, and *E. coli* were all sampled during both the spring and summer quarters and all were below the prescribed screening levels and the geometric mean and therefore the PBCR is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.529 mg/L at the surface. Surface TN ranged from 0.35 mg/L to 1.02 mg/L, with the highest values reported in the spring and lowest values in the summer quarter. The lake-wide total phosphorus (TP) average was 0.018 mg/L at the surface. Total phosphorus at the surface ranged from 0.006 mg/L to 0.054 mg/L. Surface TP was highest in the spring, and the lowest values were recorded during the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 29:1 for sample year 2004-2005. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

Skiatook Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Skiatook Lake was classified as mesotrophic, indicative of moderate primary productivity and nutrient conditions (Plate 101). These results are similar to those reported in 2005, indicating no significant increase or decrease in productivity has occurred. Water clarity was good based on turbidity, true color and secchi disk depth. The lake is supporting the FWP beneficial use based on turbidity and pH, but only partially supporting due to anoxic conditions present during the summer quarter. With anoxic conditions present for such a large portion of the water column the lake should be monitored closely in the future. The Aesthetics beneficial use is supported based on trophic status; however the use is partially supported due to 10% true color values exceeding the WQS of 70 units. Bacteriological samples indicate that the Primary Body Contact Recreation (PBCR) beneficial use is fully supported for the 2006-2007 sampling season

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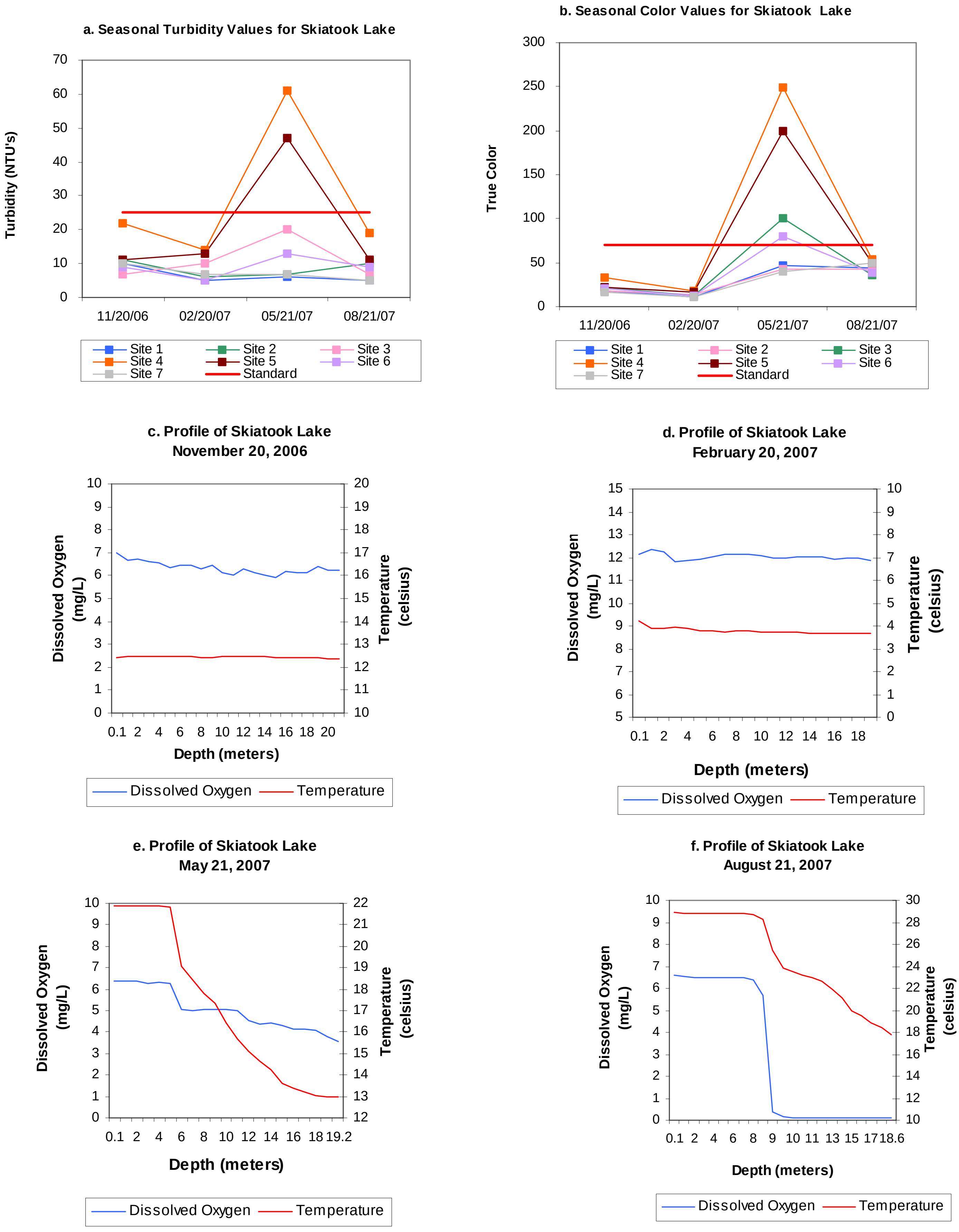
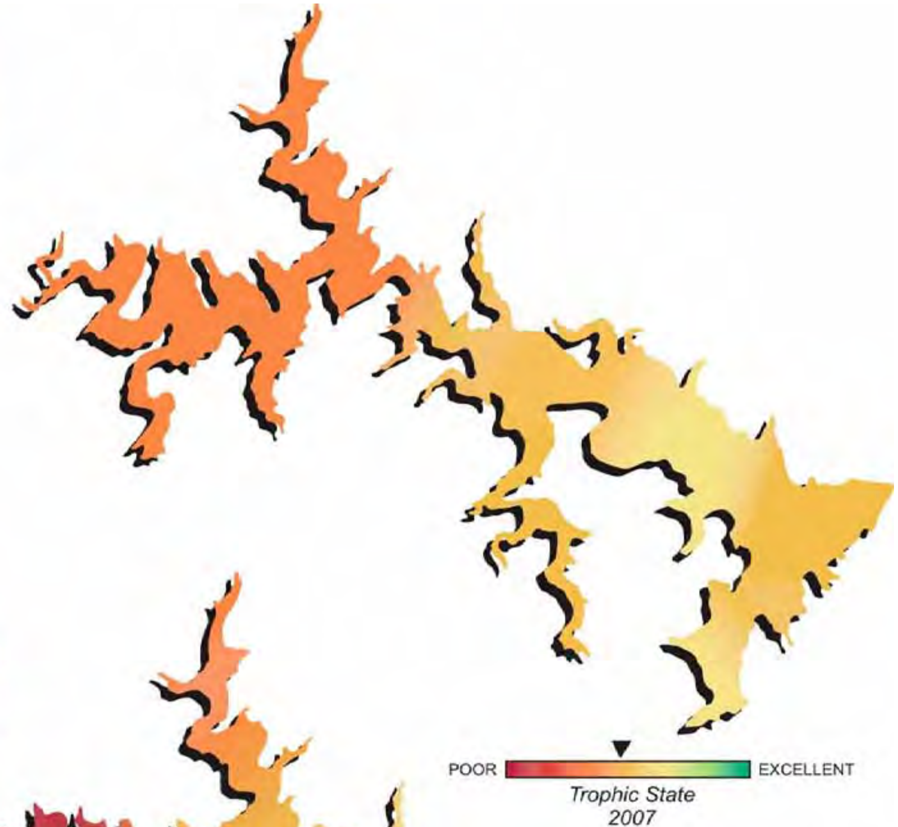
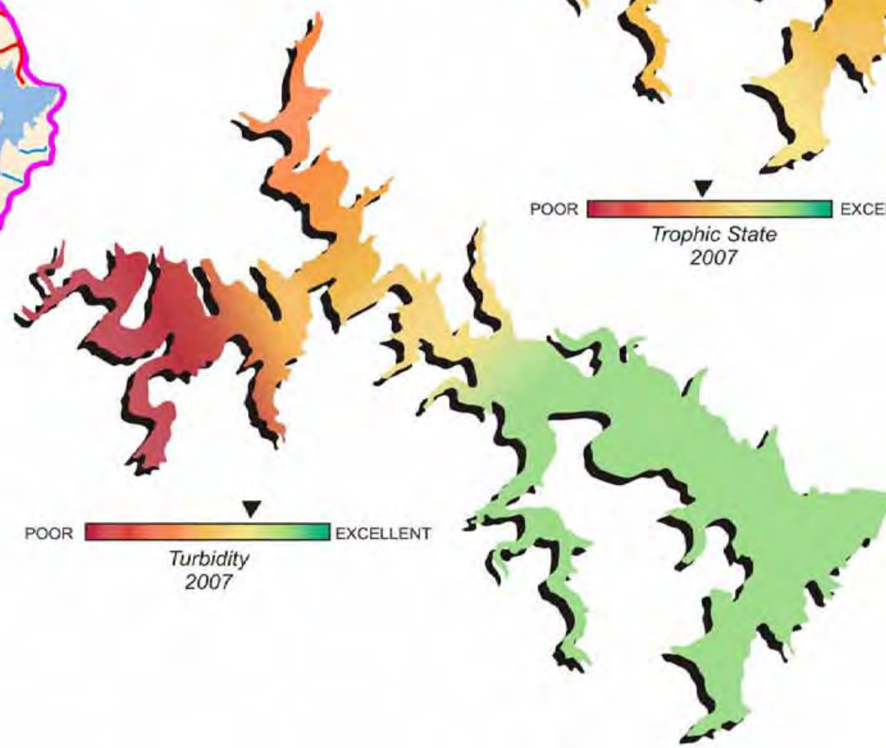


Figure 125a-125f. Graphical representation of data results for Skiatook Lake.





Lake Data

Constructed by	Corps of Engineers
County	Osage
Constructed in	1984
Surface Area	10,190 acres
Volume	322,700 acre/feet
Shoreline Length	160 miles
Mean Depth	31.42 feet
Watershed Area	354 square miles

Plate 101 - Lake Water Quality for
Skiatook Lake

Sooner Reservoir

Sooner Reservoir, located in Pawnee County, is owned and operated by the Oklahoma Gas and Electric Company (OG&E). This 5,400-acre reservoir was constructed in 1972 to serve as a cooling reservoir. Sampling on Sooner Reservoir was conducted for four quarters from November 2006 to August 2007.

Water quality samples were collected at five (5) to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the lake surface at all sample sites. The average lake-wide turbidity value was 6 NTU (Plate 102), true color was 20 units, and average secchi disk depth was 115 centimeters. Based on these three parameters, Sooner Reservoir had excellent water clarity during the study period. These results are similar to those in 2003 and 2005, indicating no change has occurred in clarity over time. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 46 (Plate 102), classifying the lake as mesotrophic, indicative of moderate levels of primary productivity and nutrient conditions. This value is slightly lower than the value calculated in 2003 and 2005 (TSI=48), indicating little change in productivity has occurred since the last evaluation. The TSI values were primarily mesotrophic throughout the year. The exception to this occurred at sites 3 and 5 in the summer, when conditions at these sites were eutrophic. Seasonal turbidity per site is displayed in Figure 126a. All turbidity values were below the Oklahoma Water Quality Standard (WQS) of 25 NTU. With 100% of the samples below the standard, the Fish and Wildlife Propagation (FWP) beneficial use is considered supported for sample year 2007. Seasonal true color values are displayed in Figure 126b. All of the true color values were below the numeric criteria of 70 units, with values ranging from a low of 7 to a maximum of 38 units. Applying the same default protocol, the Aesthetic beneficial use is considered supported.

In 2007, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.54 parts per thousand (ppt) to 1.10 ppt during the study period. This is much higher than the average range of values reported for most Oklahoma reservoirs. Specific conductivity ranged from 1039µS/cm to 2066 µS/cm indicating high concentrations of electrical current conducting compounds (salts) were present in the lake, consistent with the elevated salinity readings. In general, pH values were neutral to slightly alkaline with values ranging from 7.21 to 8.46 during the study period. With 100% of the recorded values within the acceptable range of 6.5 to 9.0, Sooner Reservoir is considered supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (ORP) ranged from 269 mV near the sediment-water interface in the spring to 485 mV in the summer, indicating the absence of reducing conditions. During the autumn, winter, and spring quarters, the lake was well mixed with dissolved oxygen generally above 5.0 mg/L (Figure 126c-126d). Thermal stratification occurred during the summer quarter between 10 and 11 meters (Figure 126f). Dissolved oxygen below this level was less than 2.0 mg/L. Profile data is only available at sites 1 and 4 during the summer quarter due to equipment malfunction. At both of these sites, 52% of the water column was anoxic. If D.O. values are less than 2 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Sooner Reservoir is considered partially supporting its FWP beneficial use with 52% of the water column experiencing anoxic conditions in the fall sampling quarter. The lake was also sampled for chlorides, sulfates and total dissolved solids to assess the Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be not supported for sulfates.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci analysis during the recreation season of May through September. PBCR beneficial use cannot be determined as minimum data requirements were not met due to lab and quality control issues for enterococci and fecal coliform. Of the 10 *E. coli* samples collected, all of them were below the screening level of 235 cfu/ml and the geometric mean (11.9 cfu/ml) was below the prescribed mean standard of 126 cfu/ml.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.57 mg/L at the surface. Surface TN ranged from 0.46 mg/L to 0.69 mg/L, with the highest and lowest values reported in the summer quarter. The lake-wide total phosphorus (TP) average was 0.015 mg/L at the surface. Total phosphorus at the surface ranged from 0.007 mg/L to 0.027 mg/L. Surface TP was highest in the summer, and the lowest values were recorded during the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 38:1 for sample year 2006-2007. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

Sooner Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Sooner Reservoir was classified as mesotrophic with moderate primary productivity and nutrient conditions (Plate 102). This is similar to previous evaluations, indicating no change in productivity has occurred over time. Water clarity was excellent in 2006-2007, based on true color, turbidity and secchi disk depth. The FWP beneficial use is fully supported based on turbidity, pH, and partially supported based on dissolved oxygen levels reported during the study period. The lake is supporting the Aesthetics beneficial use based on its trophic status and true color with 100% of the collected true color values well below the standard of 70 units. Primary Body Contact Recreation (PBCR) beneficial use determination cannot be made at this time because minimum data requirements were not met.

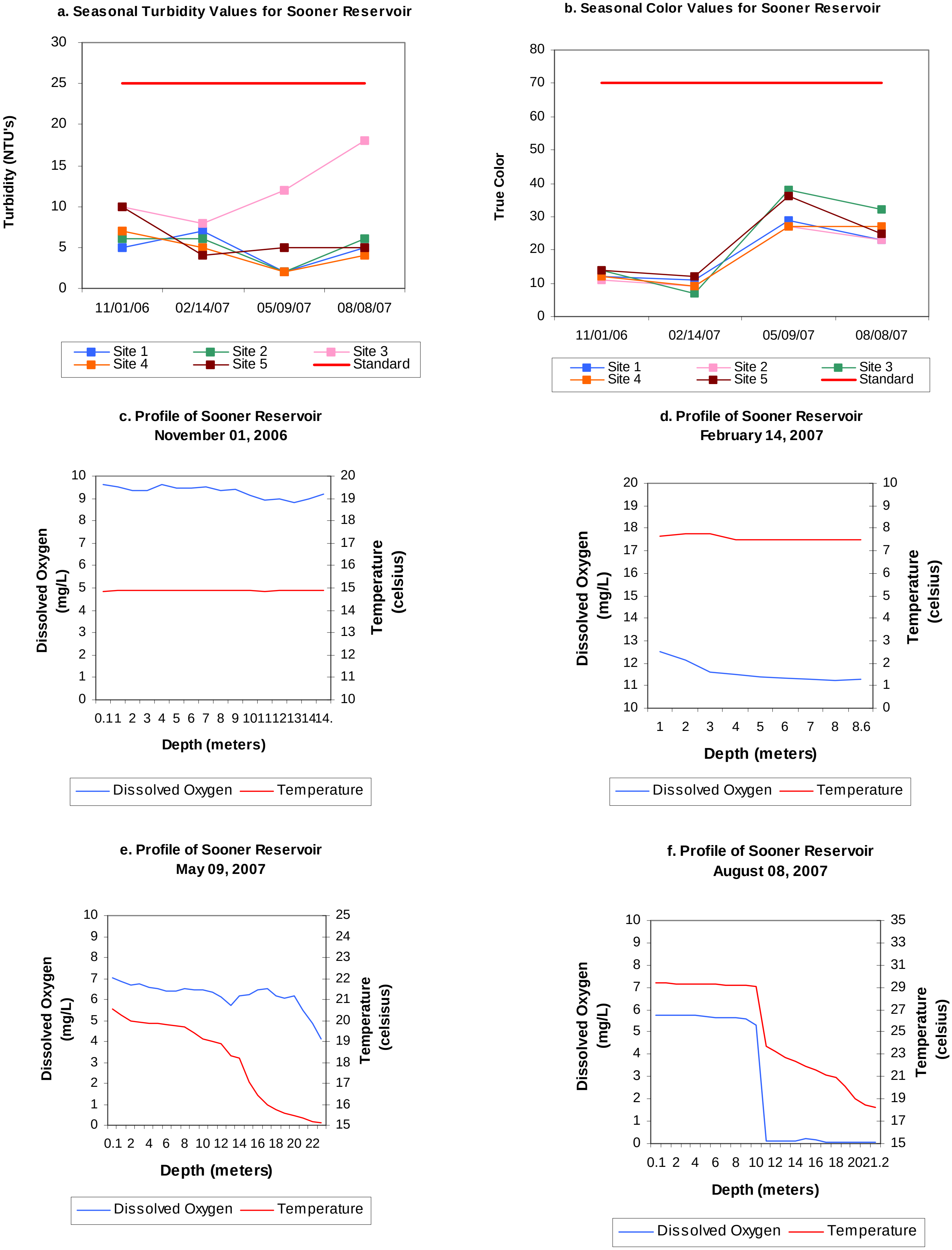
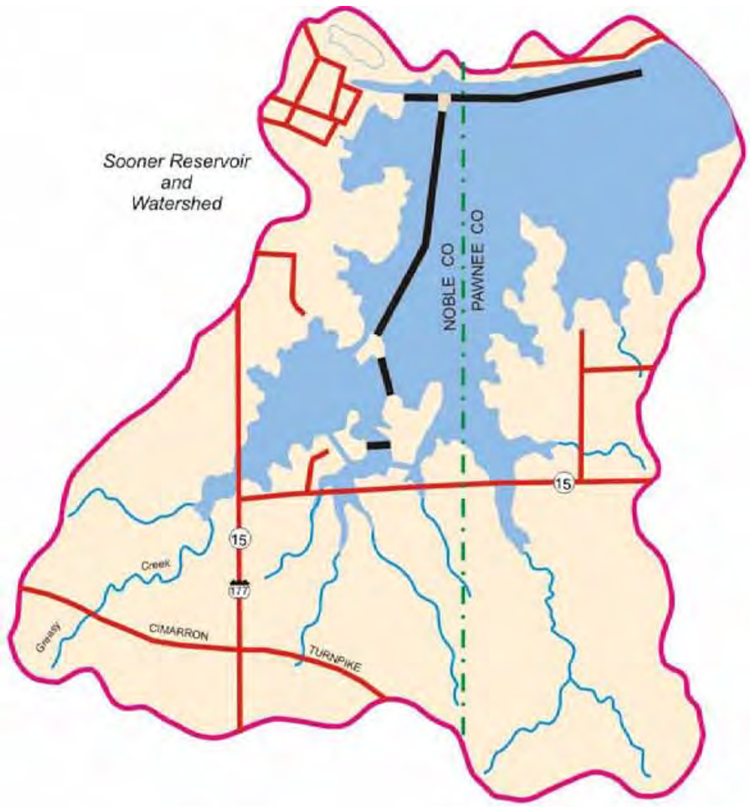
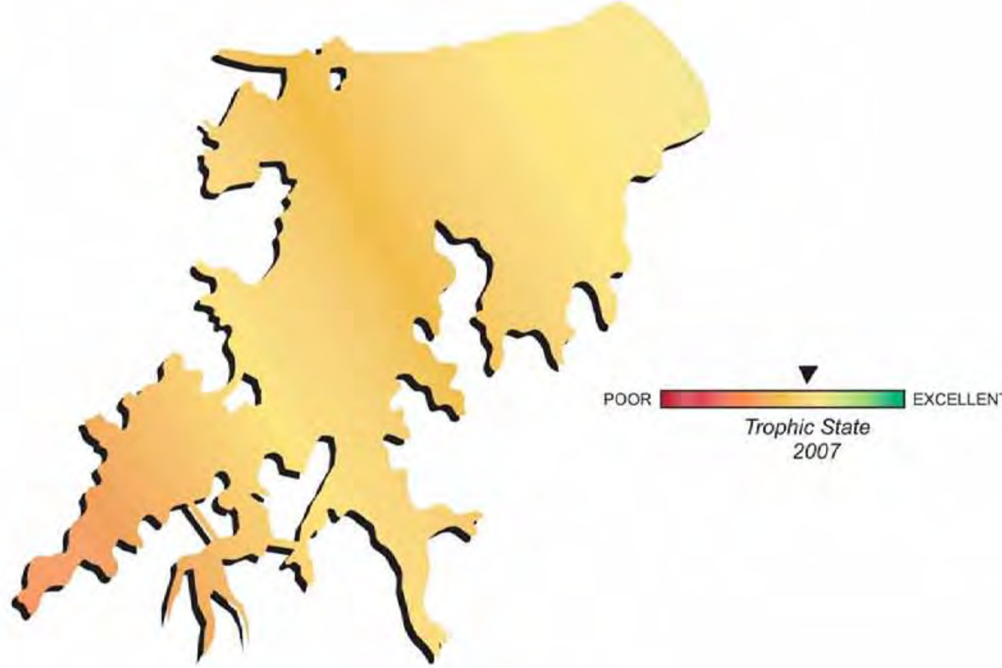
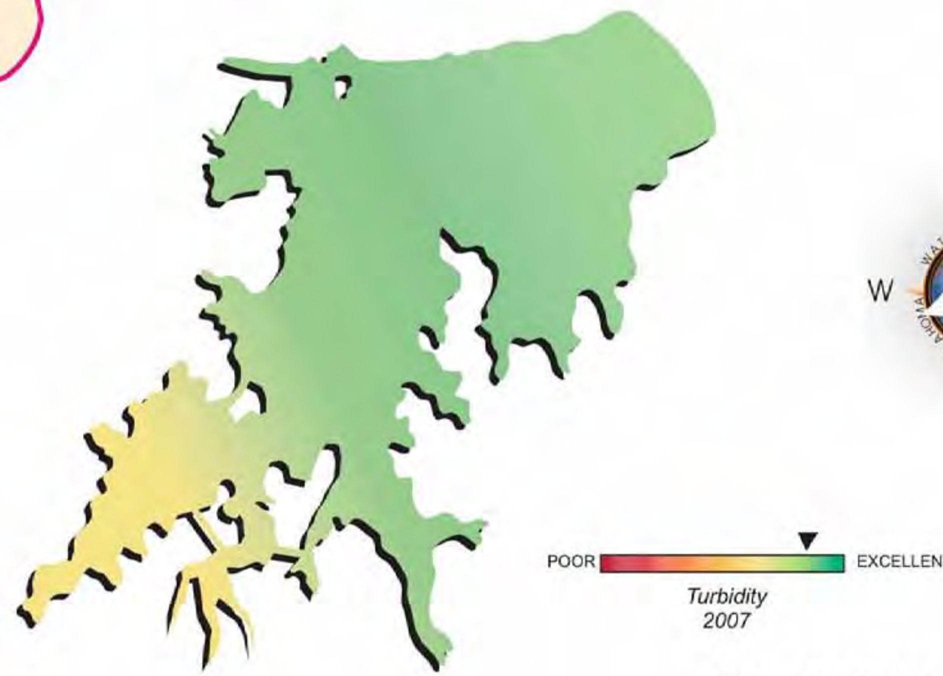


Figure 126a-126f. Graphical representation of data results for Sooner Reservoir.

Plate 102 - Lake Water Quality for Sooner Reservoir







Lake Data

Owner	OG & E*
County	Pawnee (dam)
Constructed	1972
Surface Area	5,400 acres
Volume	149,000 acre/feet
Shoreline Length	42 miles
Mean Depth	27.59 feet
Watershed Area	18,536 acres

*Oklahoma Gas and Electric Co.

Spavinaw Lake

Spavinaw Lake, located in Mayes County, is owned by the city of Tulsa and utilized for a water supply, recreation, and wildlife reservoir. This 1,584-acre reservoir was constructed in 1924. Spavinaw Lake was sampled for four quarters, from November 2006 through August 2007.

Water quality samples were collected at five (5) sites to represent the riverine, transition, and lacustrine zones of the lake. Samples were collected from the lake surface at all sites. The average lake-wide turbidity was 6 NTU (Plate 103), true color was 15 units, and secchi disk depth was 131 centimeters. Based on these three parameters water clarity at Spavinaw Lake was excellent in sample year 2006-2007. Results for these parameters are similar to that observed during the 2005 evaluation. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The TSI was 53 (Plate 103), indicating the lake was eutrophic, indicative of high primary productivity and nutrient levels in sample year 2007. The lake is currently listed as a Nutrient Limited Watershed (NLW) in the Oklahoma Water Quality Standards (WQS) and the lake is considered nutrient impaired. Seasonal turbidity values are displayed in Figure 127a. Turbidity values were well below the Oklahoma Water Quality Standard (WQS) of 25 NTU and ranged from a low of 3 NTU (site 3) to a maximum of 14 NTU (site 5). With 100% of the recorded values below 25 NTU, the Fish and Wildlife Propagation (FWP) beneficial use is considered fully supported. Seasonal true color values were all well below the WQS of 70 units and are displayed in Figure 127b. Applying the same default protocol, the Aesthetic beneficial use is considered supported at Spavinaw Lake.

In 2007, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.07 parts per thousand (ppt) to 0.16 ppt, which is within the range of values observed in Oklahoma reservoirs. Specific conductivity ranged from 167.9 µS/cm to 331.2 µS/cm, indicative of low to moderate levels of current conducting ions (salts) in the lake system. The recorded values for pH ranged from 7.22 to 8.89, representing a neutral to slightly alkaline system. With all the collected values within the acceptable range of 6.5 to 9.0, Spavinaw Lake is fully supporting its FWP beneficial use for pH. Oxidation-reduction potentials (ORP) ranged from 58 mV in the hypolimnion in the summer to 485 mV in the spring quarter. The low ORP values were during periods of thermal stratification and suggest reducing conditions were forming in parts of the hypolimnion of the lake. The lake was not stratified in the autumn or winter quarters and some anoxia began to develop in the spring quarter (see Figure 127c-127e). Thermal stratification was evident and anoxic conditions were present throughout the lake in the summer (Figure 127f). During the summer sampling interval, stratification occurred between 3 and 5 meters at which point dissolved oxygen dropped below 2.0 mg/L to the lake bottom. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With anoxic conditions accounting for 43 to 62% of the water column, in the summer, Spavinaw Lake is considered to be partially supporting the FWP beneficial use. These conditions could pose a serious concern, threatening fish and wildlife propagation and the lake should be monitored closely in the future. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were collected during the 2007 recreation season (May through August) in order to make an assessment of the Primary Body Contact Recreation (PBCR) beneficial use. Fecal coliform, Enterococci, and *E. coli* were all sampled during both the spring and summer quarters and all were below the prescribed screening levels and the geometric mean and therefore the PBCR is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.78 mg/L at the surface. Surface TN ranged from 0.44 mg/L to 1.24 mg/L, with the highest values reported in the winter and lowest values in the summer quarter. The lake-wide total phosphorus (TP) average was 0.023 mg/L at the surface. Total phosphorus at the surface ranged from 0.009 mg/L to 0.038 mg/L. The highest TP value occurred in the autumn, and the lowest values were recorded during the spring quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 33:1 for sample year 2006-2007. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

Spavinaw Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Spavinaw Lake was classified as eutrophic, with high primary productivity and nutrient levels in 2006-2007. The lake is currently listed as a Nutrient Limited Watershed (NLW) in the Oklahoma Water Quality Standards (WQS) and is considered nutrient impaired. Several studies have been conducted in Eucha/Spavinaw complex by the OWRB and other state agencies and can be referenced for further information. Water clarity was excellent based on turbidity, true color and secchi disk depth. The lake is supporting the FWP beneficial use based on pH and turbidity, but partially supporting based on low dissolved oxygen values occurring in the summer. The Aesthetics beneficial use is currently supported based on the true color, as all collected values were below the WQS of 70 units. Bacteriological samples indicate that the Primary Body Contact Recreation (PBCR) beneficial use is supported. In 1999, the Tulsa Municipal Authority contracted the OWRB to conduct bathymetric survey of Spavinaw Lake (Figure 128) to determine current lake volume, capacity, and sedimentation rates. The survey information was used to support numerical modeling of proposed water quality improvements by the OWRB. For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.

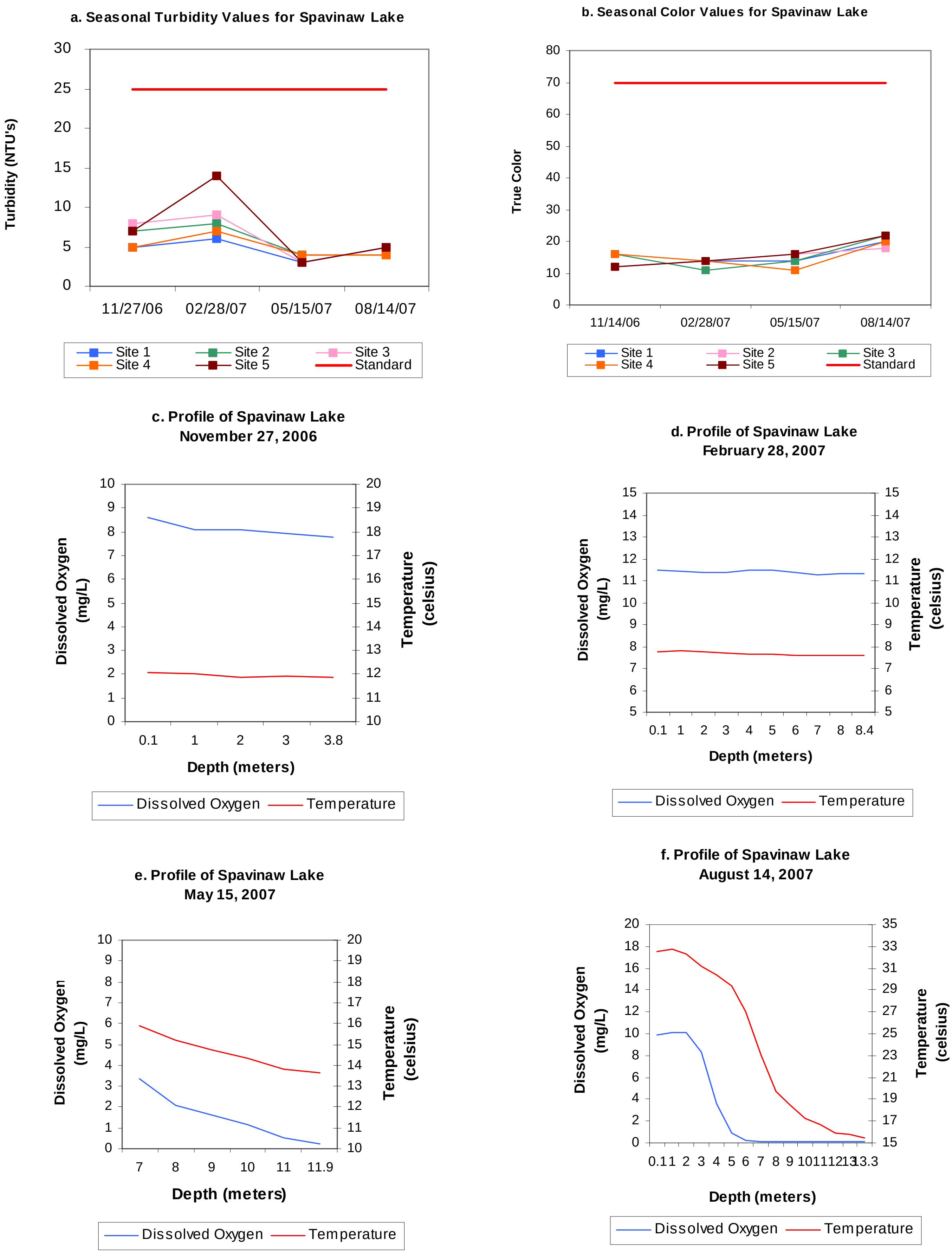
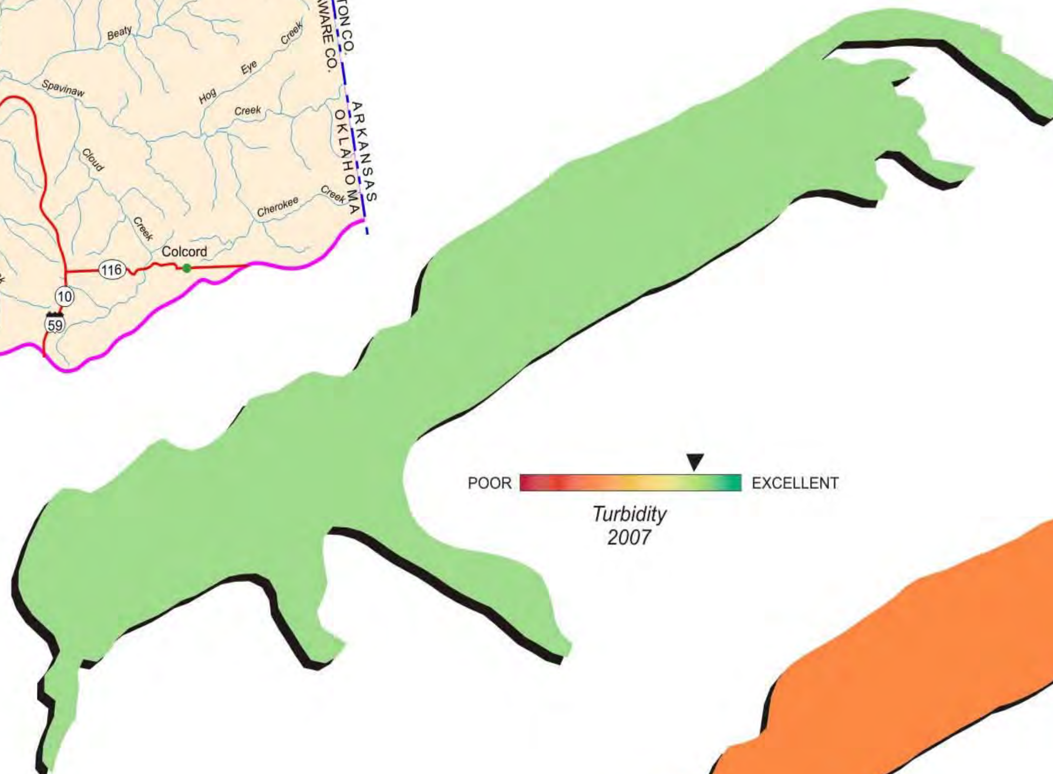


Figure 127a-127f. Graphical representation of data results for Spavinaw Lake.

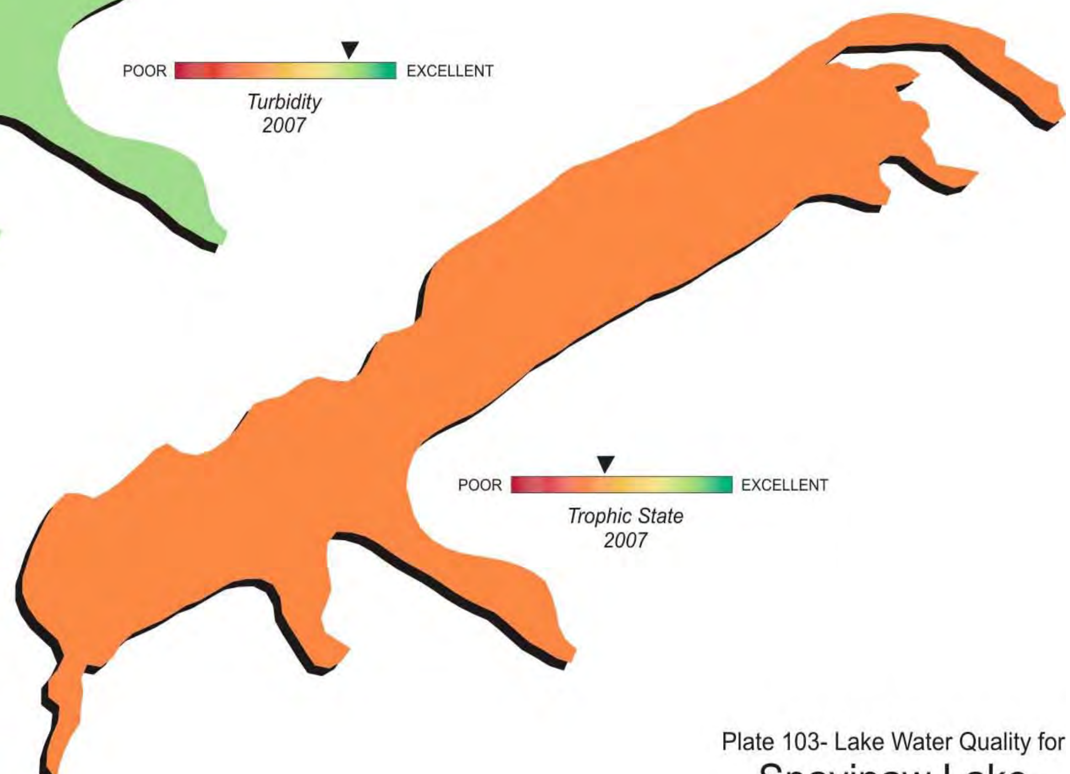
Spavinaw Lake
and
Watershed

Spavinaw Lake
Location

Lake Data	
Constructed by	City of Tulsa
County	Delaware/Mayes
Constructed in	1924
Surface Area	1,578 acres
Volume	25,941 acre/feet
Shoreline Length	26.71 miles
Mean Depth	16.10 feet
Watershed Area	248 square miles



Turbidity
2007



Trophic State
2007

Plate 103- Lake Water Quality for
Spavinaw Lake

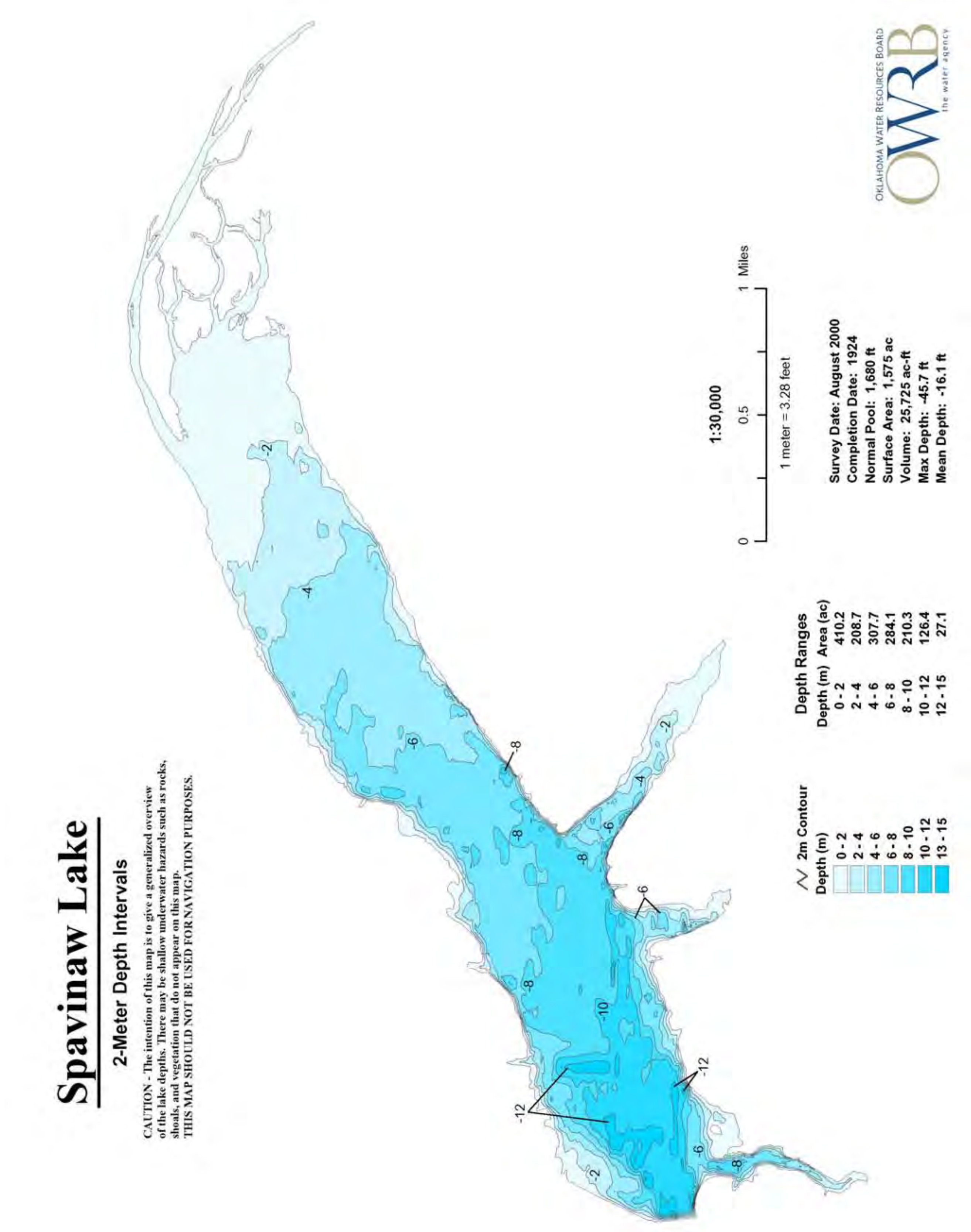


Figure 128. Bathymetric Map of Spavinaw Lake.

Spiro Lake

New Spiro Lake is a 254-acre reservoir located in Le Flore County. It was constructed in 1960, is owned and operated by the City of Spiro, and serves as a municipal water supply and offers numerous recreational opportunities to the public. New Spiro Lake was sampled for four quarters, from October 2005 through August 2006.

Water quality samples were collected at three sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all three sites during the study period. The lake-wide annual turbidity value was 18 NTU (Plate 104), true color was 26 units, and secchi disk depth was 47 centimeters in 2005-2006. Based on these three parameters, New Spiro Lake had good water clarity in comparison to other Oklahoma reservoirs. Water clarity is similar to previous collection efforts conducted in 2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The TSI was calculated at 68 (Plate 104), indicating the lake was hypereutrophic, with excessive primary productivity and nutrient conditions. This is consistent with the TSI calculated in 2004 (TSI=64) and 2002 (TSI=68), which also found the lake to be hypereutrophic. The TSI values were hypereutrophic at all sites throughout the sample year. Based on the trophic classification, the lake is listed in the last Oklahoma Water Quality Standards (WQS) revision process as a Nutrient Limited watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Seasonal turbidity values are displayed in Figure 129a. Only one (8%) of the twelve samples collected exceeded the WQS of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 92% of the values below the WQS the lake is considered fully supporting its Fish & Wildlife Propagation (FWP) beneficial use based on turbidity. Seasonal true color values are displayed in Figure 129b. 100% of the true color values were below the aesthetics WQS of 70 units at all times. Applying the same default protocol, the Aesthetics beneficial use is considered fully supported.

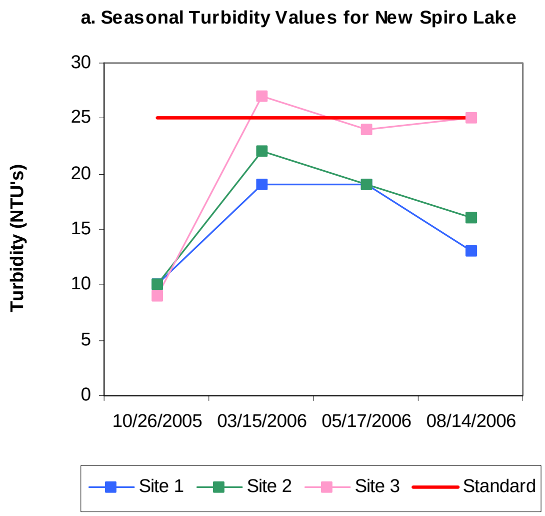
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.04 parts per thousand (ppt) to 0.07 ppt, indicating low salt content in the lake and were well within the expected range of, if not slightly lower than, salinity values reported for most Oklahoma lakes. Readings for specific conductivity were low, ranging from 106.8 µS/cm to 155.4 µS/cm, indicating the minimal presence of electrical current conducting compounds (salts) in the water column throughout the year. In general, pH values were neutral to alkaline in nature with values ranging from 7.09 units in the spring quarter to 9.24 in the summer quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 10% values greater than 9.0 units the lake is partially supporting its FWP beneficial use based on pH values. Oxidation-reduction potentials (redox) ranged from 121 mV at the water-sediment interface in the spring to 155.4 mV in the fall, indicating an absence of reducing conditions in the lake. New Spiro Lake was not stratified in the fall or winter quarters and dissolved oxygen (D.O.) values were above 7.0 mg/L throughout the water column. (See Figure 129c-129d). The lake was thermally stratified and anoxic conditions were present in both spring and summer quarters. In the spring the lake was stratified between 3-4 meters with dissolved oxygen levels below 2.0 mg/L for 33% of the water column at site 1 (Figure 129e-129f). During the summer quarter, the lake was thermally stratified between 1 and 2 meters at all sites (see Figure 129f). Anoxic conditions were present below the 2-meter depth at all three sites and D.O. readings were below 1.0 mg/L from 3 meters to the lake bottom at 3.1 meters. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, with 17-33% of the water column less than 2.0 mg/L during the spring and summer sampling intervals, the FWP beneficial use is considered supported at New Spiro Lake. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

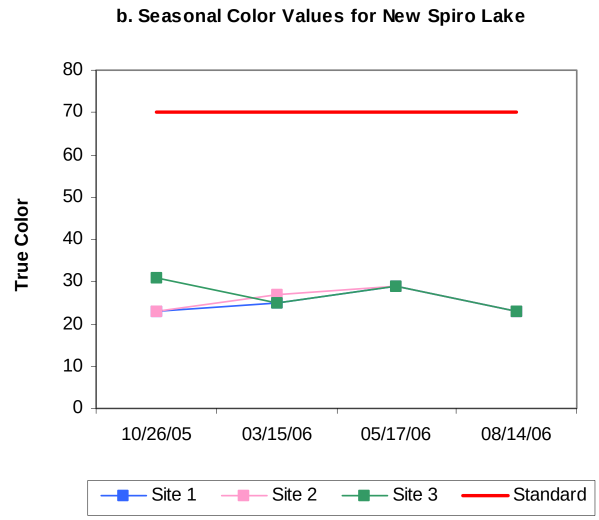
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

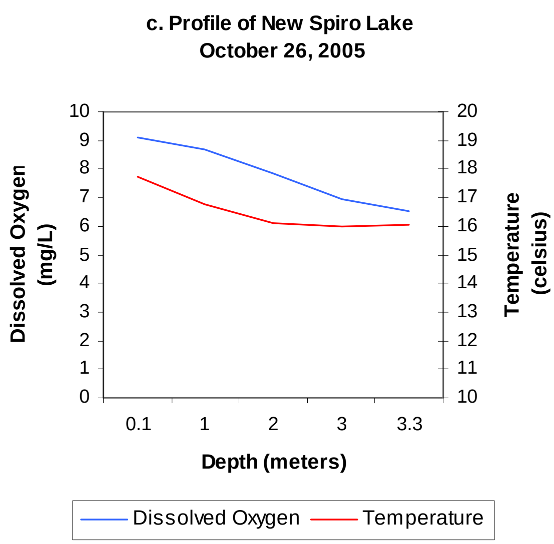
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average for sample year 2005-2006 was 1.22 mg/L at the lake surface. The TN at the surface ranged from 0.98 mg/L to 1.68 mg/L. The highest surface TN value was reported in the summer quarter and the lowest was in the fall quarter. The lake-wide total phosphorus (TP) average for sample year was 0.111 mg/L at the lake surface. The surface TP ranged from 0.076 mg/L to 0.170 mg/L. Similar to TN the highest surface TP value was reported in the summer quarter and the lowest occurred in the fall quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 11:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

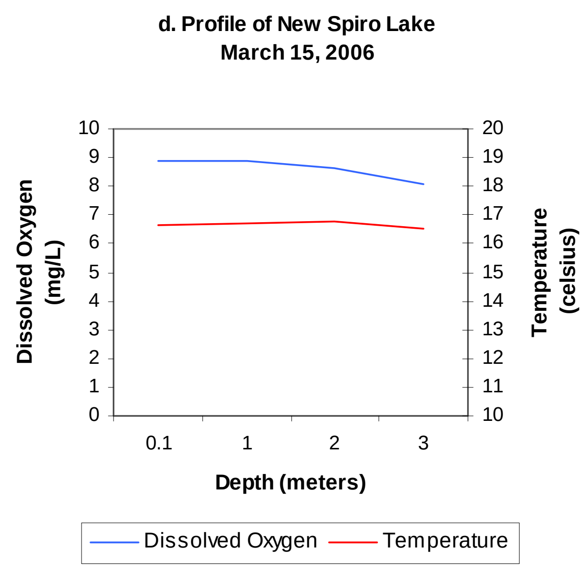
New Spiro Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

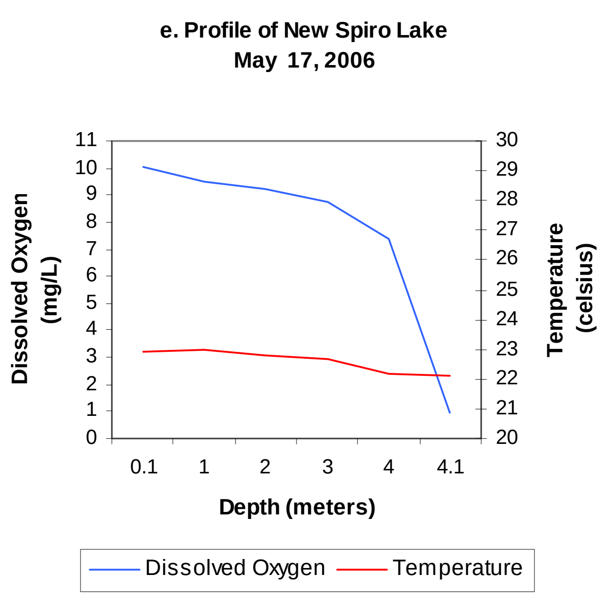
In summary, New Spiro Lake was classified as hypereutrophic, with excessive primary productivity and nutrient levels in sample year 2006 (Plate 104). This is consistent with the TSI calculated in 2004 (TSI=64) and 2002 (TSI=68), which also found the lake to be hypereutrophic. The TSI values were hypereutrophic at all sites throughout the sample year. Based on the trophic classification, the lake was recommended for listing in the last Oklahoma Water Quality Standards (WQS) revision process as a Nutrient Limited watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. With 100% of the reported values below the WQS of 70 units the lake was fully supporting its Aesthetics beneficial use as it relates true color. New Spiro Lake was fully supporting its FWP beneficial use based on turbidity and dissolved oxygen concentrations. With 10% values greater than 9.0 units the lake is partially supporting its FWP beneficial use based on pH values.. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.











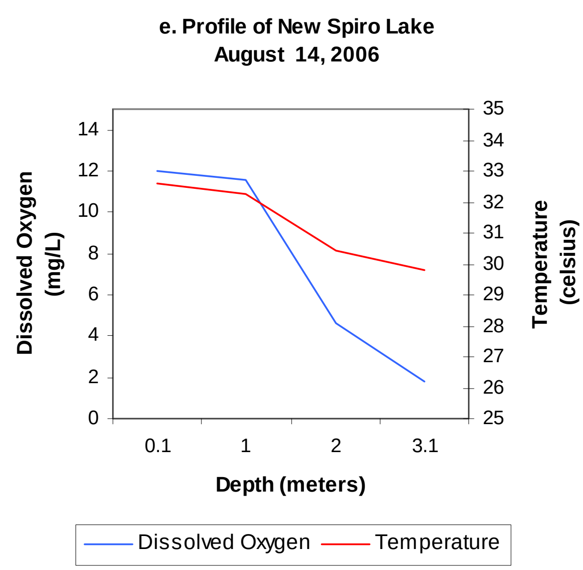
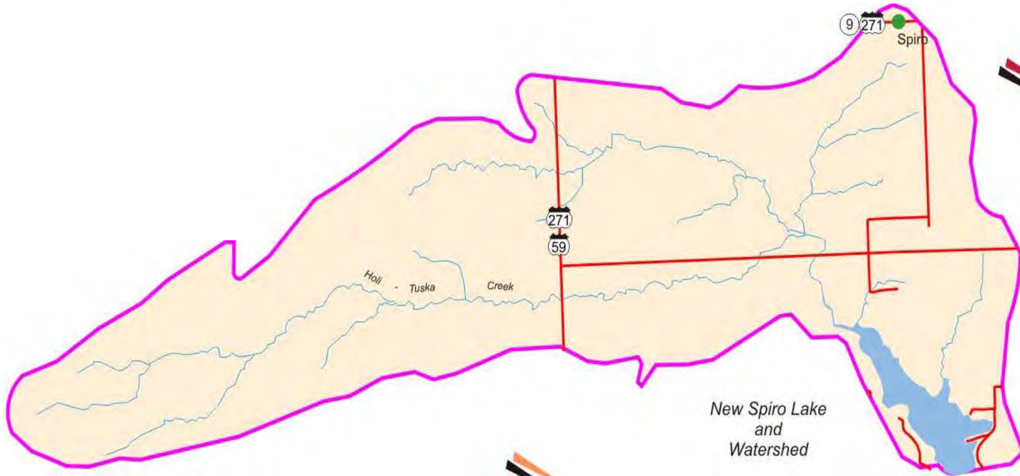


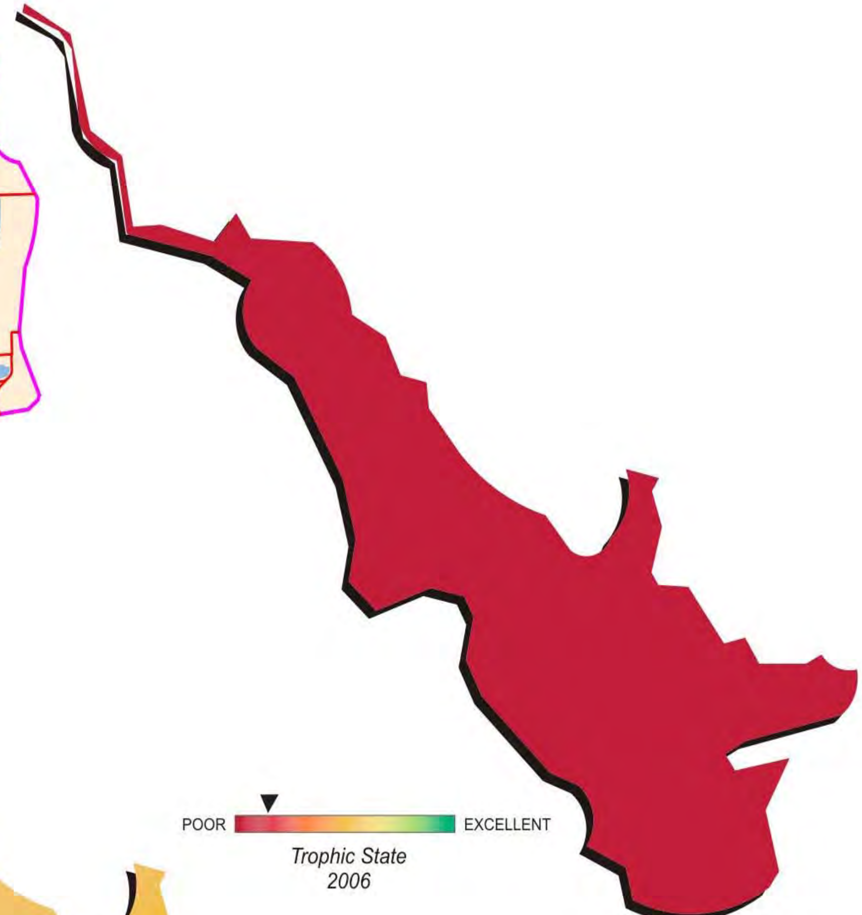
Figure 129a-129f. Graphical representation of data results for New Spiro Lake.

Plate 104 - Lake Water Quality for

Spiro (New) Lake

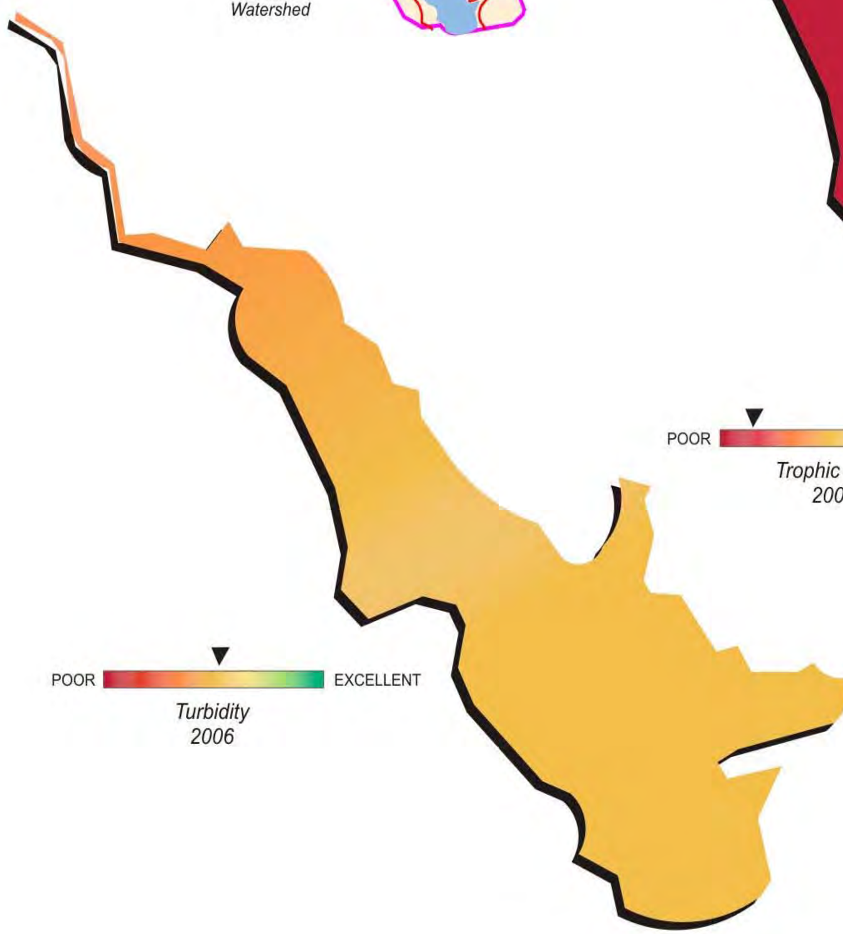


New Spiro Lake
and
Watershed



POOR EXCELLENT

Trophic State
2006



POOR EXCELLENT

Turbidity
2006

New Spiro Lake
Location

Lake Data

Owner	City of Spiro
County	LeFlore
Constructed	1960
Surface Area	254 acres
Volume	2,160 acre/feet
Shoreline Length	5 miles
Mean Depth	8.50 feet
Watershed Area	14 square miles

Sportsman Lake

Sportsman Lake was constructed in 1958 and is owned and operated by the City of Seminole in the county of Seminole. It is a 354-acre reservoir utilized for flood control and offers numerous recreational opportunities to the public.

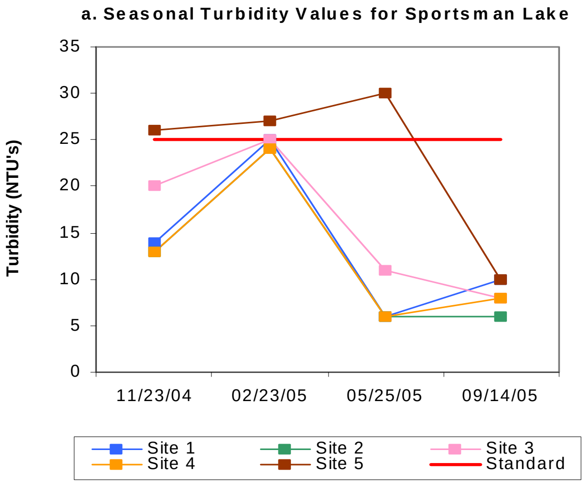
Sportsman Lake was sampled for four quarters, from November 2004 through September 2005. Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Water quality samples were collected at the lake surface at all sample sites and 0.5 meters from the lake bottom at sample site 1. The lake-wide annual turbidity value was 16 NTU (Plate 105), true color was 59 units, and secchi disk depth was 82 centimeters in 2004-2005. Water clarity was average based on these three parameters. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 40 (Plate 105), classifying the lake as oligotrophic bordering mesotrophic, indicative of low to moderate levels of primary productivity and nutrient conditions. This is similar to the 2003 evaluation, which had a calculated TSI of 41. The TSI values varied seasonally from oligotrophic in the fall and spring quarter to lower mesotrophy in the winter and summer quarters. Seasonal turbidity values are displayed in Figure 130a. Turbidity values ranged from a low of 6 NTU to a maximum of 30 NTU. Turbidity at site 5 exceeded the standard in three of the four sampling intervals. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 20% of the values exceeding 25 NTU, Sportsman Lake is partially supporting its Fish & Wildlife Propagation (FWP) beneficial use as it relates to nephelometric turbidity. Seasonal true color values are displayed in Figure 130b. Of the twenty values collected, seven (35%) exceeded the WQS of 70 units. Applying the same default protocol, the Aesthetic beneficial use is considered not supported.

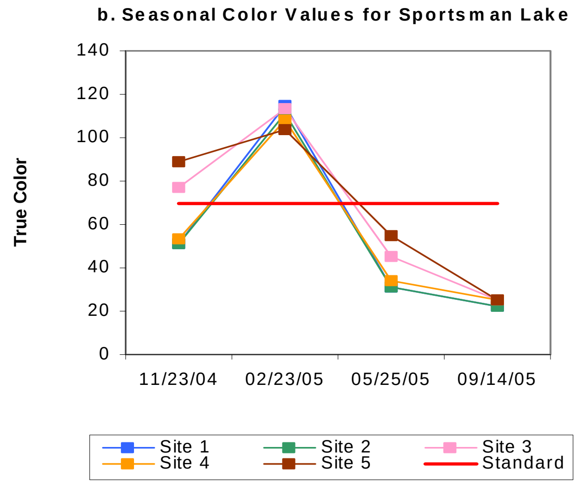
In 2004-2005, vertical profiles for dissolved oxygen, pH, temperature; specific conductivity, oxidation-reduction potential, and salinity were recorded at all three water chemistry sample sites. The salinity values ranged from 0.05 parts per thousand (ppt) to 0.19 ppt, which is within the expected range of salinity values, reported for most Oklahoma lakes. Specific conductivity ranged from 118.3 µS/cm in the fall quarter to 382.4 µS/cm in the summer, indicating low to moderate levels of electrical conducting compounds (salts) were present in the lake system. In general, pH values were neutral, ranging from 6.76 to 7.85 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range, Sportsman was fully supporting its FWP beneficial use as it relates to pH. Oxidation-reduction potentials (redox) ranged from 165 mV at the sediment-water interface in the summer to 449 mV in the spring quarter. Redox readings indicated that reducing conditions were not present in the reservoir during any of the sampling events. The lake was not thermally stratified in the fall or winter quarter and dissolved oxygen (D.O.) values were above 7.0 mg/L throughout the water column (see Figure 130c-130d). In the spring, the lake was stratified at several 1-meter intervals, the first one between 2 and 3 meters at sites 1 and 2 and again between 7 and 8 meters at site 1 (see Figure 130e). Below the 7-meter depth at sites 1 and 2, the D.O. concentrations were less than 2.0 mg/L extending to the lake bottom at 8.2 meters (see Figure 130e). In the summer, the lake was strongly thermally stratified between 5 and 6 meters, at which point D.O. values were less than 2.0 mg/L all the way to the lake bottom at 9.9 meters (see Figure 130f). If D.O. values are less than 2.0 mg/L for greater than 70% of the lake volume, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered fully supported at as in the spring only 22% of the water column was less than 2.0 mg/L and in the summer only 46% of the water column. The lake was sampled for total dissolved solids, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

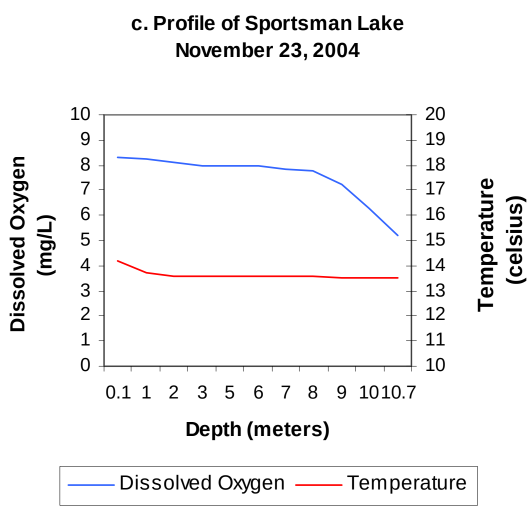
Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

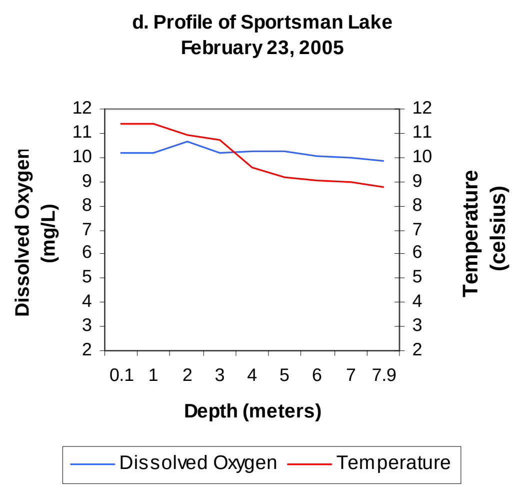
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.43 mg/L at the surface. Surface TN ranged from 0.19 mg/L to 0.82 mg/L, with the highest values reported in the summer and lowest values in the winter quarter. The lake-wide total phosphorus (TP) average was 0.023 mg/L at the surface. Total phosphorus at the surface ranged from 0.015 mg/L to 0.032 mg/L. Surface TP was highest in the winter, and the lowest values were recorded during the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 18:1 for sample year 2004-2005. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

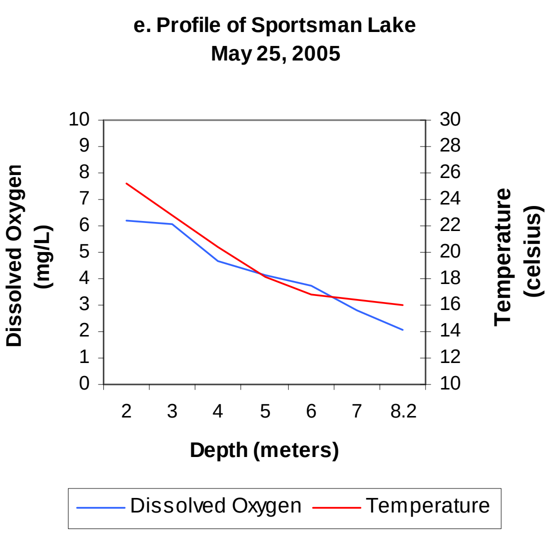
In summary, Sportsman Lake was oligotrophic bordering mesotrophic, indicative of low to moderate to low primary productivity and nutrient conditions (Plate 105). Water clarity was average based on turbidity, true color, and secchi disk depth. Sportsman Lake was fully supporting its Aesthetics beneficial use based on its trophic state and not supporting for true color with 35% of the values greater than the WQS of 70 units. The FWP beneficial use was fully supporting for pH and D.O. in the water column and partially supporting the use based on turbidity. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.











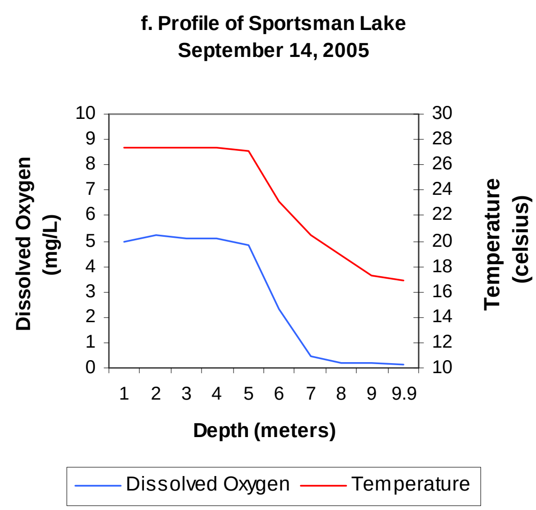
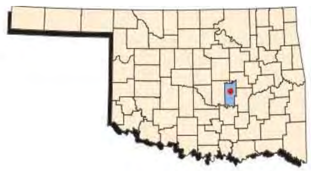
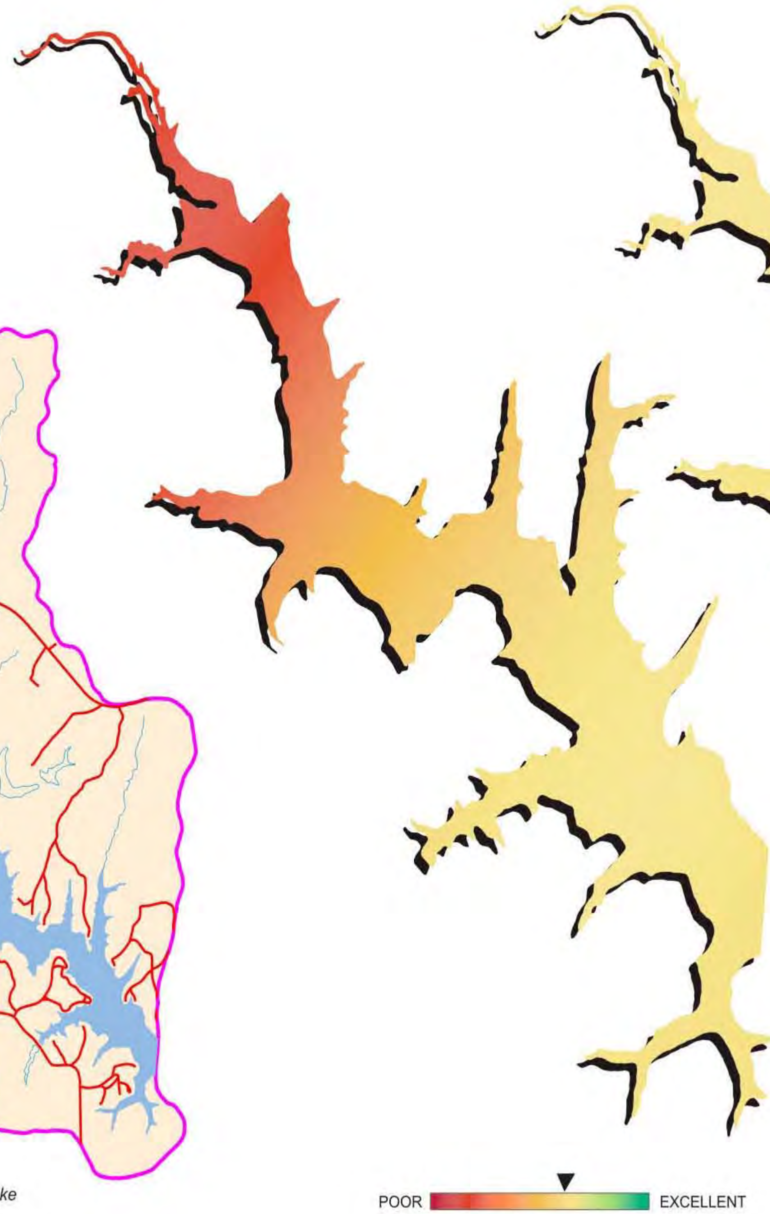


Figure 130a-130f. Graphical representation of data results for Sportsman Lake.



Sportsman Lake
and
Watershed

Lake Data	
Owner	City of Seminole
County	Seminole
Constructed	1958
Surface Area	354 acres
Volume	5,349 acre/feet
Shoreline Length	15 miles
Mean Depth	15.11 feet
Watershed Area	13 square miles



Turbidity
2005

Trophic State
2005

Plate 105 - Lake Water Quality for
Sportsman Lake

LAKES MONITORING PROGRAM

Lake Stanley Draper

Lake Stanley Draper is a 2,900-acre reservoir located in Cleveland County. It was constructed in 1962 and is owned and operated by the City of Oklahoma City and is utilized as a municipal water supply and for recreational purposes. The lake is "filled" via pipeline, which flows from Atoka Lake in S.E. Oklahoma. Lake Stanley Draper was sampled for four quarters, from November 2005 through August 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir as well as any major lake arms. Samples were collected at the lake surface at all sample sites during the study period. The lake-wide annual turbidity value was 7 NTU (Plate 106), true color was 28 units, and secchi disk depth was 133 centimeters in 2005-2006. Water clarity was good based on these three parameters, better than that observed in previous data collection efforts conducted in sample year 2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 40 (Plate 106), classifying the lake as Oligotrophic bordering mesotrophic, indicative of low levels of primary productivity and nutrient conditions. The calculated TSI for 2004 (TSI=39) and 2002 (TSI=40), are very similar indicating that no significant change in productivity has occurred. The TSI values were fairly consistent ranging from oligotrophic in the fall, winter and summer quarters to lower mesotrophy in the spring quarter. Seasonal turbidity values are displayed in (Figure 131a) and ranged from a low of 4 NTU to a maximum of 13 NTU all below the Oklahoma Water Quality Standard (WQS) of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the of the turbidity values below the criteria of 25 NTU, the lake is considered supporting its Fish & Wildlife Propagation (FWP) beneficial use. Seasonal true color values are displayed in Figure 131b. Similar to turbidity, all color values were below the WQS of 70 units, therefore the Aesthetics beneficial use is considered supported for sample year 2006.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all five sample sites. Salinity values ranged from 0.03 parts per thousand (ppt) to 0.09 ppt, indicating low salt content and values were well within the expected range of salinity values reported for most Oklahoma lakes if not slightly lower. Specific conductivity ranged from 95 µS/cm in the summer to 191.5 µS/cm in the fall quarter, indicating very low levels of electrical conducting compounds (salts) were present in the lake system, corresponding with the recorded salinity values. In general, pH values were neutral to slightly alkaline, ranging from 6.90 units to 8.18 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Lake Stanley Draper was fully supporting its FWP beneficial use based on pH. Oxidation-reduction potentials (redox) ranged from 356 mV in the summer quarter to 445 mV at the sediment-water interface in the spring. Redox readings indicate that reducing conditions were not present in the reservoir during the sample period. Thermal stratification was not evident in the fall, winter or spring quarters and the water column was well mixed. Dissolved oxygen (D.O.) remained above 7.0 mg/L throughout the water column during these first three sampling intervals (Figure 131c-131e). In the summer quarter the lake was thermally stratified and anoxic conditions were present. Stratification occurred at several 1-meter intervals with D.O. less than 2.0 mg/l from 11 meters below the surface to the lake bottom of 21.7 meters at site 1, the dam (Figure 131f). The same pattern was also observed at sites 2 and 3 with anoxic conditions present in 31-45% of the water column. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. The FWP beneficial use is considered partially supported at Lake Stanley Draper with 52% of the water column experiencing anoxic conditions at site 1 in the summer quarter. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average for sample year 2005-2006 was 0.24mg/L at the lake surface. The TN at the surface ranged from 0.16 mg/L to 0.33mg/L. The highest surface TN value was reported in the summer quarter and the lowest was in the fall quarter. The lake-wide total phosphorus (TP) average for sample year was 0.012 mg/L at the lake surface. The surface TP ranged from 0.010 mg/L to 0.015 mg/L. Similar to TN the highest surface TP value was reported in the summer, however the lowest occurred in the spring quarter. The nitrogen to phosphorus ratio (TN: TP) was approximately 20:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 2001 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening level or consumption advisory level. Lake Stanley Draper was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Lake Stanley Draper was oligotrophic, indicative of low primary productivity (Plate 106). This is consistent with previous data collection efforts conducted in 2002 and 2004, indicating no significant change in productivity has occurred. Water clarity was good based on turbidity, true color and secchi disk depth and was better than that observed in sample year 2004. The lake is fully supporting its Fish & Wildlife Propagation (FWP) beneficial use for turbidity, pH and partially supporting the use based on anoxic conditions present during the summer sampling interval. The lake was fully supporting its Aesthetics use based on both the trophic state and on true color. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported. In 1997 the Oklahoma Legislature directed the OWRB to conduct a study on the impact of Confined Animal Feeding Operations (CAFO) in watersheds that supply potable water to municipalities with a population over 250,000. As part of this study a bathymetric survey was completed on Oklahoma City's water supply reservoirs. A bathymetric map (Figure 132) was generated to determine current storage capacity and identify areas of extreme sedimentation. For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.

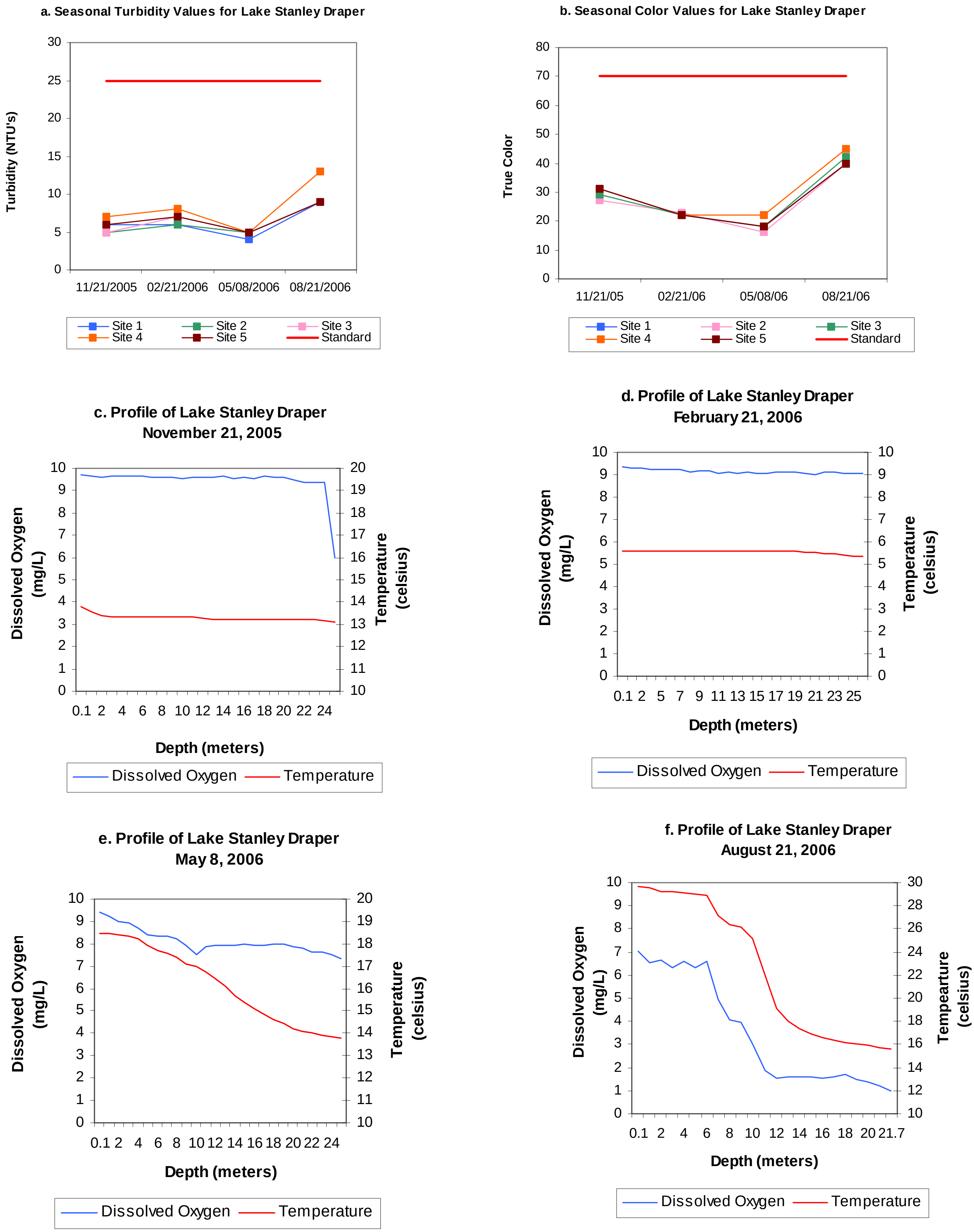
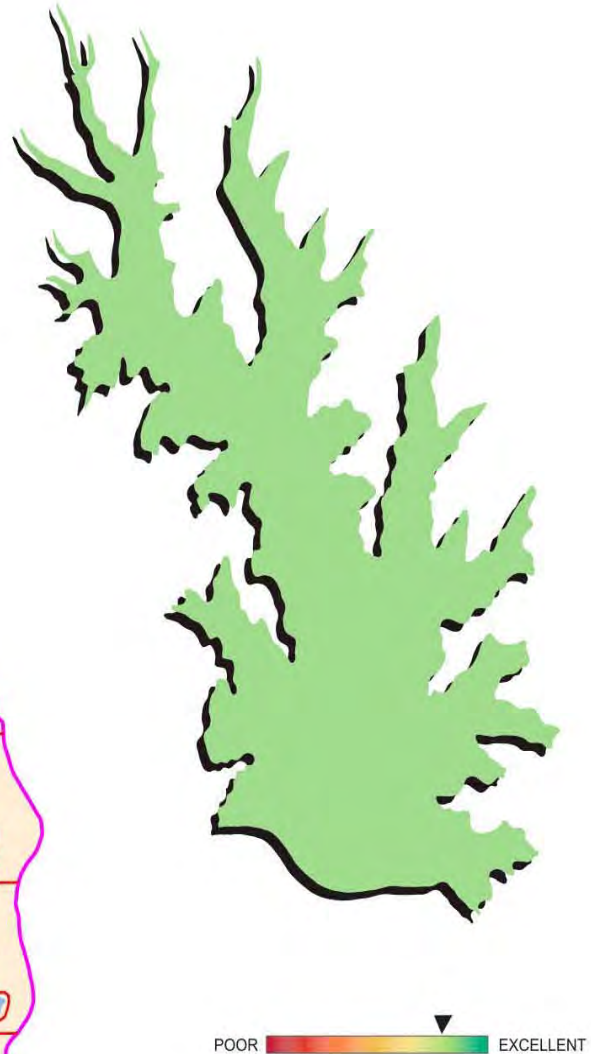


Figure 131a-131f. Graphical representation of data results for Lake Stanley Draper.

Stanley Draper Lake and Watershed



Turbidity 2006

Trophic State 2006

Lake Data

Owner	City of Oklahoma City
County	Cleveland
Constructed in	1962
Surface Area	2,519 acres
Volume	87,296 acre/feet
Shoreline Length	33.8 miles
Mean Depth	34.6 feet
Watershed Area	12 square miles

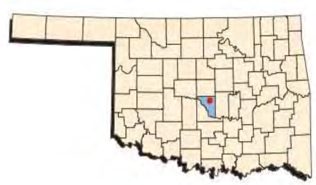

Stanley Draper Lake Location

Plate 106 - Lake Water Quality for
Stanley Draper Lake

LAKES MONITORING PROGRAM

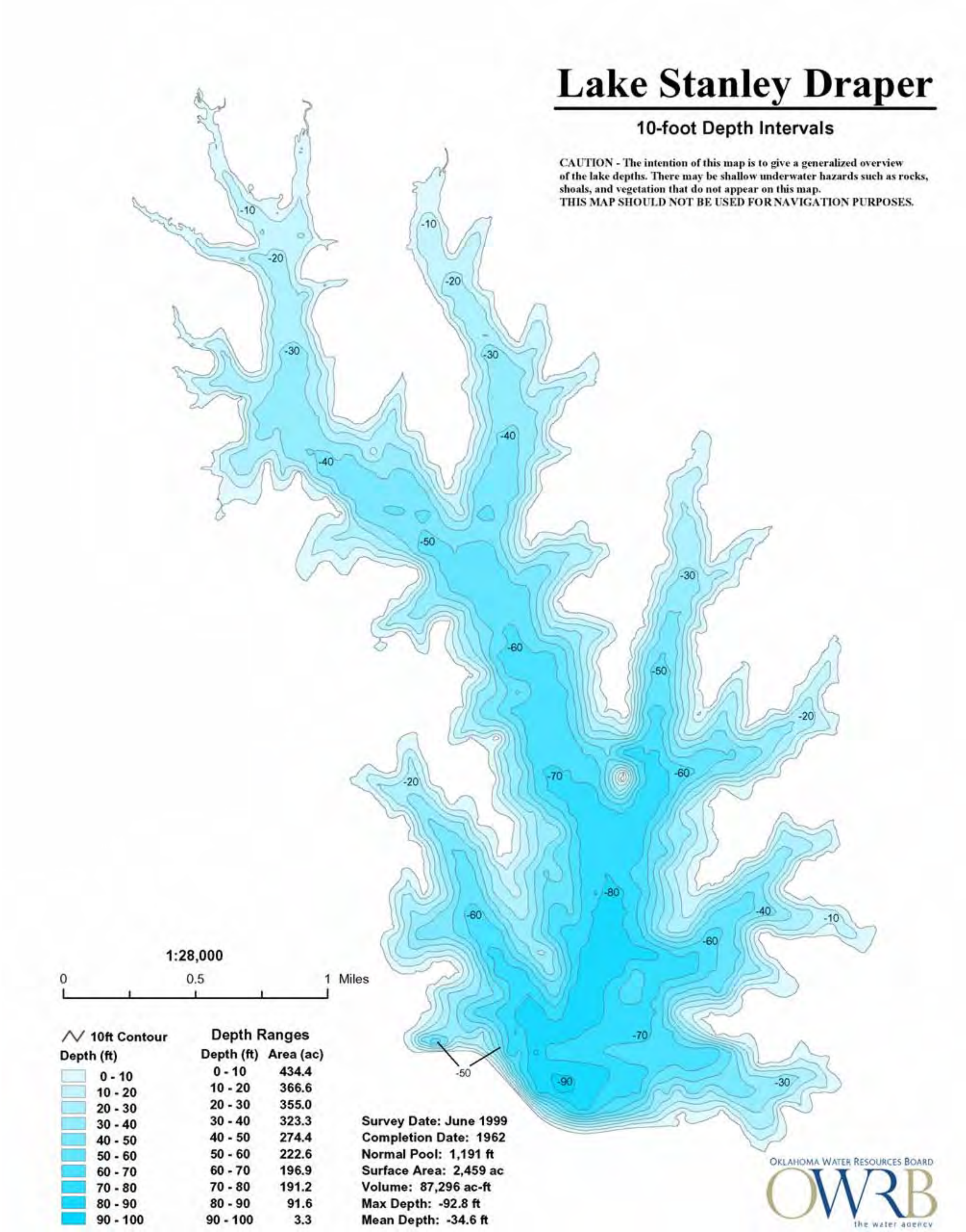


Figure 132. Bathymetric map of Lake Stanley Draper.

Stilwell City Lake

Stilwell Lake, a 188-acre reservoir located in Adair County, was constructed in 1965 and is owned and operated by the City of Stilwell. The lake is approximately 4 miles south of the city of Stilwell and serves as a municipal water supply, for flood control and offers numerous recreational opportunities to the public. This is one of the nicer small municipal lakes in Oklahoma. Stilwell City Lake was sampled for three quarters, from October 2005 through August 2006.

Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the lake surface at all sample sites during the study period. The lake-wide annual turbidity value was 6 NTU (Plate 107), true color was 14 units, and secchi disk depth was 161 centimeters in 2005-2006. Based on these three parameters water clarity was excellent in comparison to other Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for three quarters (n=9). Due to low lake levels OWRB staff were unable to access the lake during the winter data collection efforts. The average TSI was 54 (Plate 107), classifying the lake as eutrophic, indicative of high levels of primary productivity and nutrient rich conditions. Although the current value is based on three quarters of data, the value is very similar to the one calculated in 2004 (TSI=55), indicating little or no change in trophic status over time. The TSI values varied seasonally, from upper mesotrophic in the fall to eutrophic in the spring and summer. The only exception to this was site 1, which was hypereutrophic in the spring quarter. Seasonal turbidity values were all low ranging from 3 NTU to 9 NTU and are displayed in Figure 133a. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the values below the numerical criteria of 25 NTU, Stilwell City Lake is considered supporting its Fish & Wildlife Propagation (FWP) beneficial use based on nephelometric turbidity. Seasonal true color values are displayed in Figure 133b. Applying the same default protocol, Stilwell City Lake is considered fully supporting the Aesthetics beneficial use with 100% of the true color values below the Aesthetics numeric criteria of 70 units.

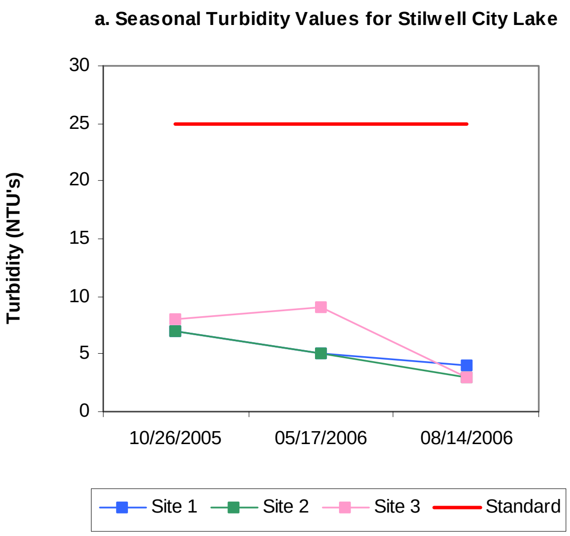
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all three sample sites. Salinity values ranged from 0.07 parts per thousand (ppt) to 0.14 ppt, indicating low salt content and readings were well within the expected range of salinity values reported for most Oklahoma lakes. Specific conductivity ranged from 159.1 µS/cm in the spring to 297.2 µS/cm in the summer, indicating low levels of electrical conducting compounds (salts) were present in the lake system. In general, pH values were neutral to slightly alkaline, ranging from 6.87 to 8.53 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. The lake is fully supporting its FWP beneficial as it relates to pH. Oxidation-reduction potentials (redox) ranged from 88 mV at the sediment-water interface in the summer to 452 mV in the fall quarter. Redox values less than 100 are not uncommon when large portions of the water column are anoxic as was the case during the summer. Thermal stratification was evident and anoxic conditions were present to some extent in all three sampling intervals. In the fall stratification occurred between 6 and 7 meters with dissolved oxygen (D.O.) below 2.0 mg/L from 8 meters to the lake bottom of 11.7 meters at site 1, the dam Figure 133c). During the spring stratification occurred between 4 and 5 meters with approximately 46% of the water column less than 2.0 mg/L (Figure 133d). In the summer, the lake was strongly thermally stratified between 3 and 4 meters below the lake surface at both sites 1 and 2. Water column D.O. values were less than 2.0 mg/L from 5 meters in depth to the lake bottom at 11.3 meters accounting for 50 to 64% of the water column to be anoxic (See Figure 133f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported at Stilwell City Lake, as 38 to 64% of the water column was anoxic among the three sampling intervals. These conditions could pose a serious concern, threatening fish and wildlife propagation and the lake should be monitored closely in the future. The lake was sampled for, chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

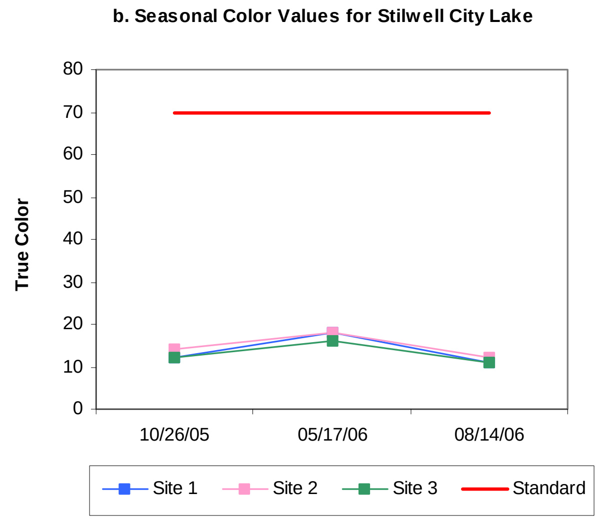
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

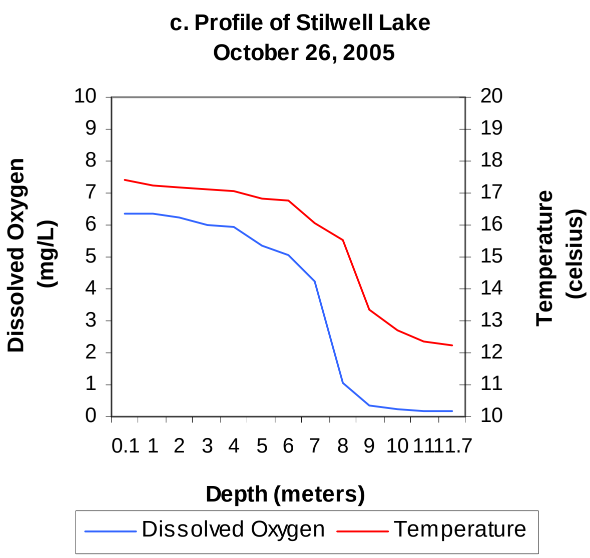
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.51 mg/L at the lake surface during the study period. The TN at the surface ranged from 0.32 mg/L to 0.88 mg/L. The highest surface TN value was reported in the summer quarter and the lowest was recorded in the fall. The lake-wide total phosphorus (TP) average was 0.025 mg/L at the lake surface. The surface TP ranged from 0.019 mg/L to 0.044 mg/L. The highest surface TP value was reported in the spring and similar to TN, the lowest was reported in the fall quarter. The nitrogen to phosphorus ratio (TN: TP) was approximately 20:1 for sample year 2005-2006. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

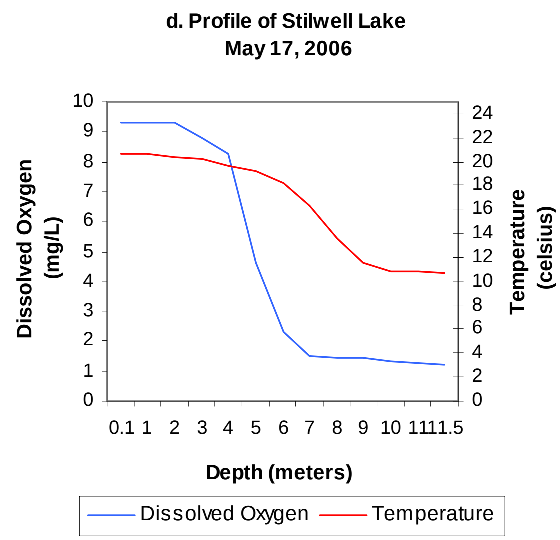
Stilwell City Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Stilwell Lake was eutrophic, indicative of high primary productivity and nutrient conditions (Plate 107). This is consistent with results from 2004 data collection efforts (TSI=55), indicating no significant increase or decrease in productivity has occurred. Water clarity was excellent at this lake during the study period. The lake was fully supporting its Aesthetics beneficial use based on its trophic state and true color with 100% of the values below the numeric criteria of 70 units. The lake was fully supporting its FWP beneficial use based on turbidity and pH and partially supporting based on low D.O. values in the summer quarter. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.









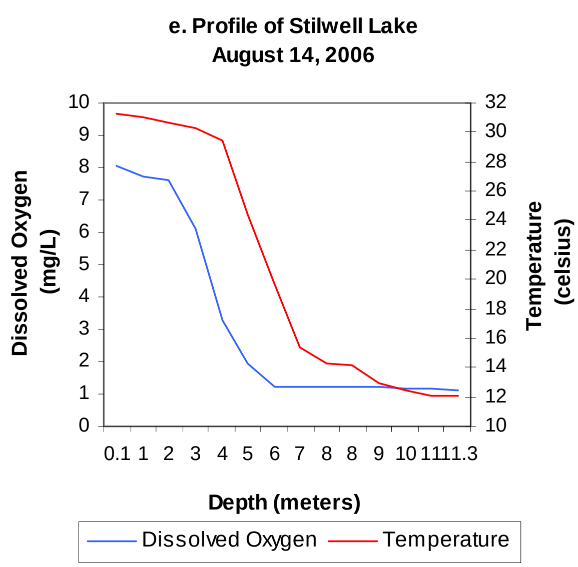
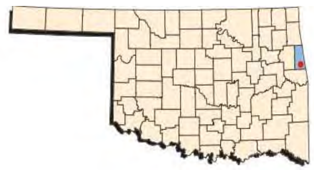
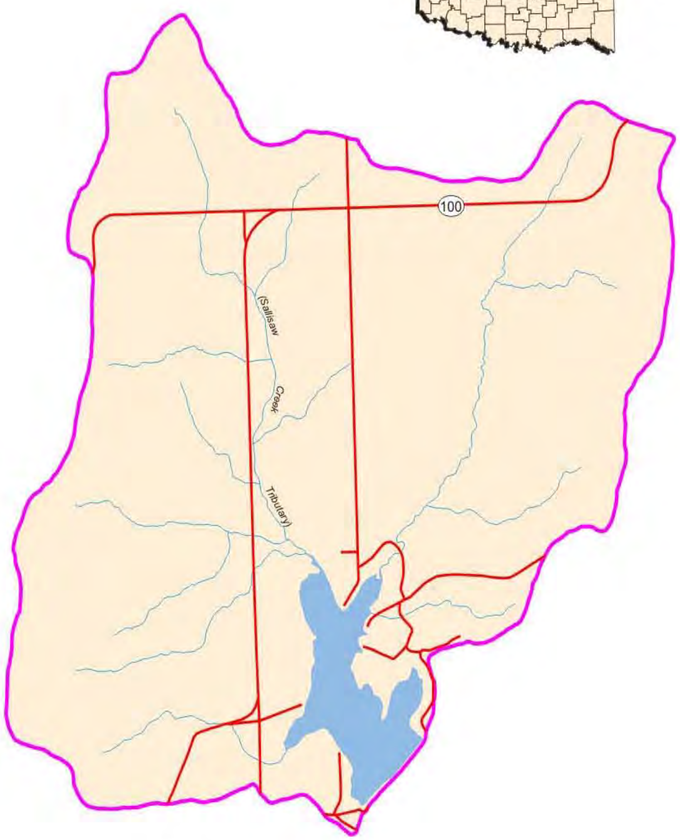


Figure 133a- 133e. Graphical representation of data results for Stilwell Lake.





Lake Stilwell
and
Watershed

Lake Data

Owner	City of Stilwell
County	Adair
Constructed	1965
Surface Area	188 acres
Volume	3,110 acre/feet
Shoreline Length	4 miles
Mean Depth	16.54 feet
Watershed Area	4,693 acres

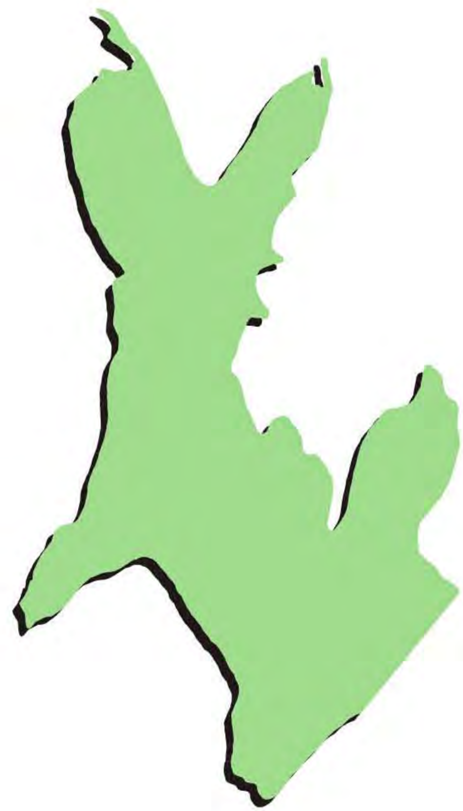


Plate 107 - Lake Water Quality for

Stilwell Lake

LAKES MONITORING PROGRAM

Stroud Lake

Stroud Lake was constructed in 1968 and is owned and operated by the City of Stroud. The 600-acre reservoir serves as a municipal water supply, for flood control and offers numerous recreational opportunities to the public. Stroud Lake was sampled for four quarters, from October 2005 through July 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones as well as any major arms of the reservoir. Water quality samples were collected at the lake surface at all sample sites during the study period. The lake-wide annual turbidity value was 5 NTU (Plate 108), true color was 15 units, and secchi disk depth was 126 centimeters in. Based on these three parameters the lake had excellent water clarity in comparison to other Oklahoma lakes. The results for these parameters are consistent with previous data collection efforts conducted in 2003-2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 41 (Plate 108), classifying the lake as mesotrophic, indicative of moderate levels of primary productivity and nutrients. The TSI values varied seasonally with the lake being oligotrophic in the spring to mesotrophic the remainder of the year. All turbidity values collected were well below the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 134a) with values ranging from a low of 4 NTU to a maximum of 9 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Stroud Lake is fully supporting its Fish & Wildlife Propagation (FWP) beneficial use based on nephelometric turbidity. Seasonal true color values are displayed in Figure 134b. All of the true color values were below the numeric criteria of 70 units, therefore the Aesthetics beneficial use is considered supported.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all five sample sites. Salinity values ranged from 0.08 parts per thousand (ppt) to 0.10 ppt, indicating low salt content and readings were well within the expected range of salinity values reported for most Oklahoma lakes. Specific conductivity ranged from 178.6 µS/cm in the winter quarter to 214.5 µS/cm in the spring, indicating low levels of electrical conducting compounds (salts) were present in the lake system. In general, pH values were neutral, ranging from 7.03 to 8.90 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the values within the acceptable range the lake is fully supporting its FWP beneficial use based on pH. Oxidation-reduction potentials (redox) ranged from 155 mV at the sediment-water interface in the summer to 500 mV in the winter quarter. Redox readings indicate that reducing conditions were not present in the reservoir during sampling events in 2005-2006. The lake was thermally stratified in the fall near the lake bottom at site 1 between 9 and 10 meters with dissolved oxygen (D.O.) falling below 2.0 mg/L to the lake bottom of 10.9 (see Figure 134c). The lake was well mixed in the winter and spring sampling intervals with D.O. generally above 7.0 mg/L (Figure 134d-134e). In the summer quarter, the lake was thermally stratified and anoxic conditions present at both sites 1 and 2. The water column was stratified between 6 and 7 meters below the lake surface at site 1 and between 5 and 6 meters at site 2, accounting for 30-60% of the water column to be experiencing anoxic conditions (Figure 134f). If D.O. values are less than 2.0 mg/L for greater than 70% of the lake volume, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported at Stroud Lake with up to 60% of the water column anoxic during summer sampling. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use not supported based on numerical criteria for sulfates located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average during the study period was 0.28 mg/L at the lake surface. The TN at the surface ranged from 0.10 mg/L to 0.41 mg/L. The highest surface TN value was reported in the summer quarter and the lowest was also recorded in the fall. The lake-wide total phosphorus (TP) average was 0.013 mg/L at the lake surface. The surface TP ranged from 0.008 mg/L to 0.020 mg/L. Similar to TN, the highest surface TP value was reported in the summer and the lowest was in the fall quarter. The nitrogen to phosphorus ratio (TN: TP) was approximately 22:1 for sample year 2003-2004. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Stroud Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Stroud Lake was mesotrophic, indicative of moderate primary productivity and nutrient conditions (Plate 108). Although the current TSI is lower than that of 2004 (TSI=47) it is with the same trophic category, indicating no significant change in productivity has occurred. Water clarity continues to be excellent based on secchi disk depth, turbidity and true color values. The lake was fully supporting its Aesthetics beneficial use based on its trophic state and for true color. The lake was also fully supporting its FWP beneficial use based on nephelometric turbidity, pH and is partially supporting based on dissolved oxygen. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported. The Agriculture beneficial use was found to be not supporting based on sulfate values which exceed the numerical criteria supply, located in OAC 785:45 – Appendix F.

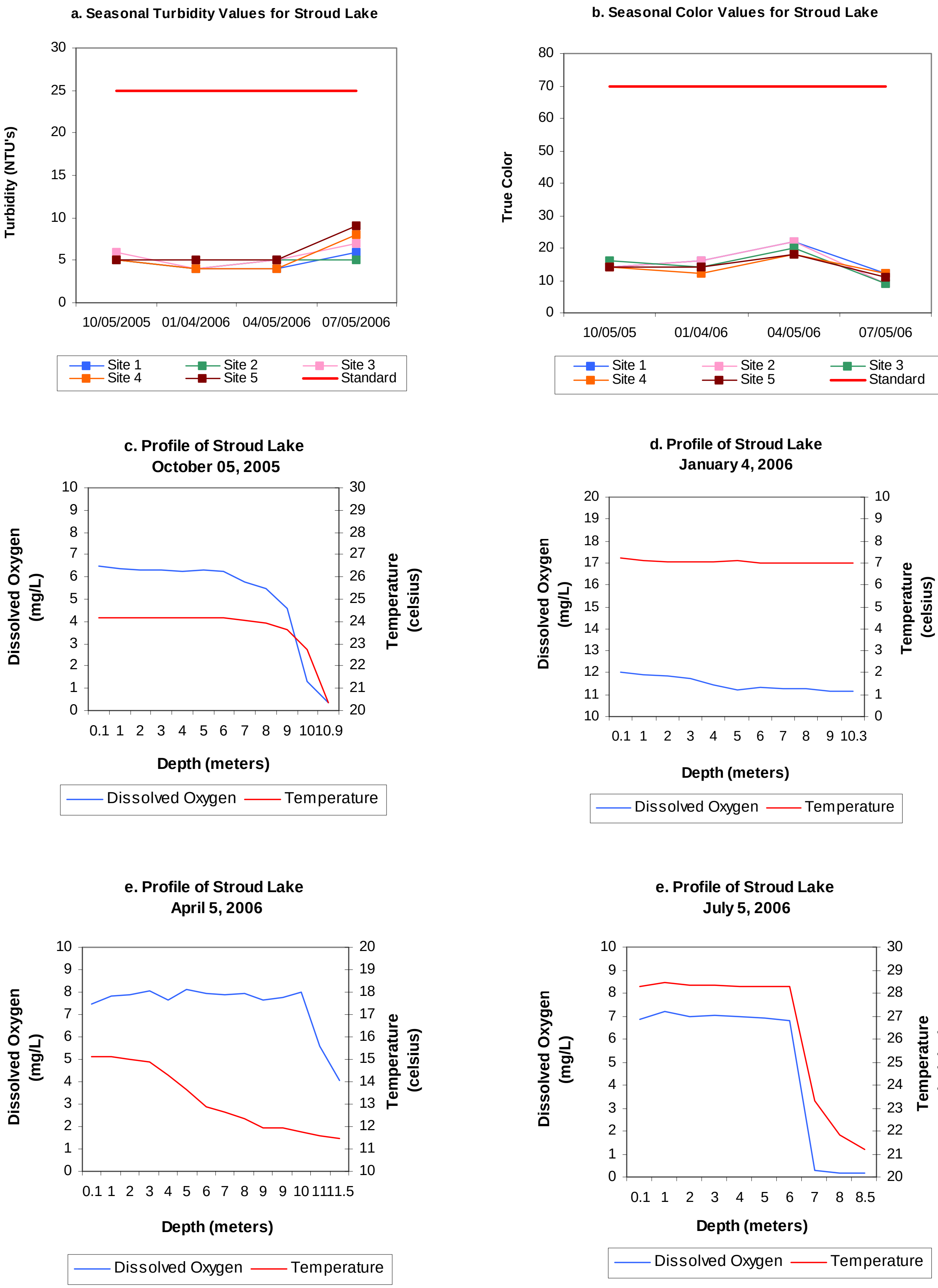


Figure 134a-134f. Graphical representation of data results for Stroud Lake.

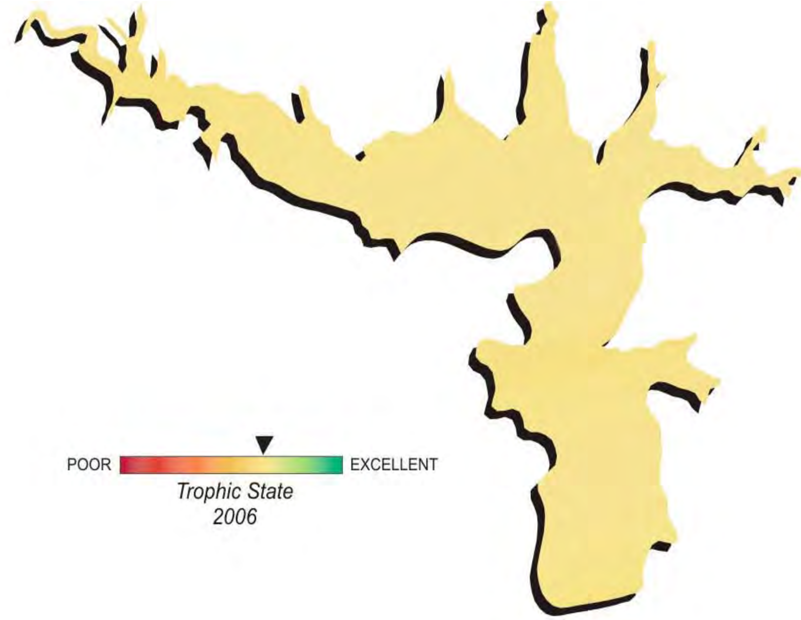
Plate 108 - Lake Water Quality for

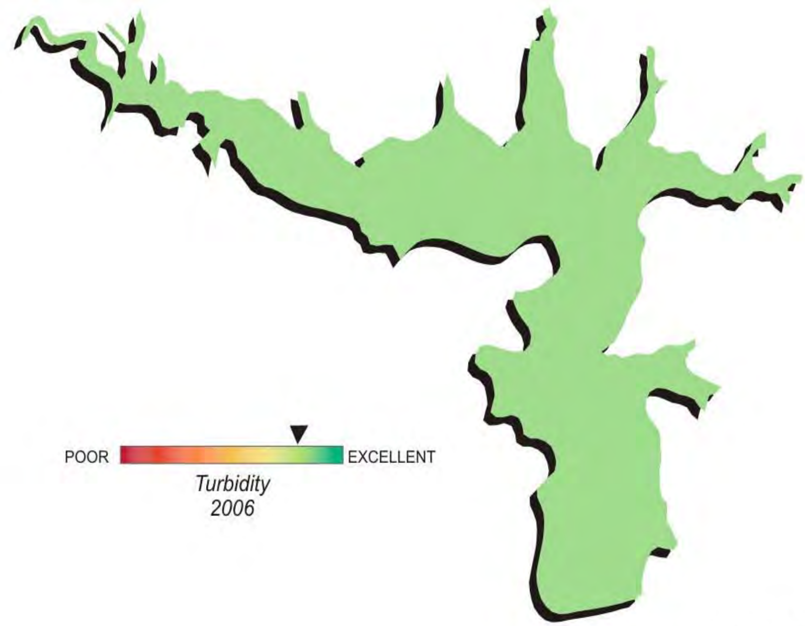
Stroud Lake

Stroud Lake and Watershed

Stroud Lake Location

Lake Data	
Owner	City of Stroud
County	Lincoln
Constructed in	1968
Surface Area	600 acres
Volume	8,800 acre/feet
Shoreline Length	13 miles
Mean Depth	14.67 feet
Watershed Area	16 square miles





LAKES MONITORING PROGRAM

Talawanda Lake No.1

Talawanda Lake No. 1, owned by the City of McAlester, was constructed in 1902. The 91-acre reservoir in Pittsburg County was constructed to serve as a recreational lake.

Talawanda Lake No.1 was sampled for four quarters, from September 2004 through May 2005. Water quality samples were collected at 3 sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the lake surface at all sample sites and 0.5 meters from the lake bottom at sample site 1. The average lake-wide turbidity value was 2 NTU (Plate 109), true color was 19 units, and secchi disk depth was 230 centimeters. Based on these three parameters, Talawanda Lake No.1 had excellent water clarity, very similar to values in 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 44 (Plate 109), classifying the lake as mesotrophic, indicative of moderate levels of primary productivity and nutrients. This value is similar to the one calculated in 2001 (TSI=45) indicating no significant change in productivity has occurred since the last evaluation. The TSI values were primarily mesotrophic during sample year 2004-2005. The exception to this pattern occurred in the spring quarter when sites 1 and 3 were oligotrophic and site 2 was eutrophic. All turbidity values were well below the Oklahoma Water Quality Standard (WQS) of 25 NTU and are displayed in Figure 135a. Due to a post-processing error turbidity was not run for any of the summer samples. Although 100% of the samples collected in 2005 were below the WQS of 25 NTU and assessment of the Fish and Wildlife Propagation (FWP) beneficial use cannot be made due to minimum data requirements not being met. Based upon current and historical data sets, it is likely that the use would be fully supported. Seasonal true color values are displayed in Figure 135b. All of the true color values were well below the numeric criteria of 70 units therefore, the Aesthetics beneficial use is considered fully supported.

In 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.02 parts per thousand (ppt) to 0.06 ppt, which is lower than the range of values commonly observed in Oklahoma reservoirs. Specific conductivity ranged from 64.4 µS/cm to 141.4 µS/cm; indicative of low levels of current conducting ions (salts) in the lake system. The pH values at were slightly acidic, ranging from 6.12 in the summer to 7.48 in the winter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 23.8 % of the values recorded being less than 6.5 the lake will be listed as partially supporting based on pH. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Oxidation-reduction potentials (ORP) ranged from 170 mV to 469 mV indicating reducing conditions were not present at this reservoir during the study period. Due equipment failure in the fall, a vertical profile of the water column is not available and an assessment cannot be made for this sampling interval. In the winter and spring quarters the water column was well mixed with dissolved oxygen (D.O.) values generally above 8.0 mg/L (see Figure 135c-135d). Thermal stratification was evident and anoxic conditions were present throughout the lake in the summer. Stratification occurred between 3 and 4 meters, accounting for 33 to 40 % of the water column to be anoxic (Figure 135f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Talawanda Lake No.1 is considered to be partially supporting the FWP beneficial use based on anoxic conditions present in the summer. These conditions could pose a serious concern, threatening fish and wildlife propagation and the lake should be monitored closely in the future. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.56 mg/L at the surface. Surface TN ranged from 0.30 mg/L to 0.91 mg/L, with the highest values reported in the spring and lowest values in the fall quarter. The lake-wide total phosphorus (TP) average was 0.015 mg/L at the surface. Total phosphorus at the surface ranged from 0.011mg/L to 0.019 mg/L. Surface TP was highest in the spring, and the lowest values were recorded during the spring winter. The nitrogen to phosphorus ratio (TN:TP) was approximately 39:1 for sample year 2004-2005. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

In summary, Talawanda Lake No.1 was classified as mesotrophic, indicative of moderate primary productivity and nutrient conditions in sample year 2005. This is consistent with historical data collection efforts, indicating no significant increase or decrease in productivity has occurred. Water clarity was excellent based on turbidity, true color, and secchi disk depth. The FWP beneficial use is partially supported based on dissolved oxygen values recorded during the study period. Although 100% of the samples collected in 2005 were below the WQS of 25 NTU and assessment of the Fish and Wildlife Propagation (FWP) beneficial use cannot be made due to minimum data requirements not being met. Based upon current and historical data sets, it is likely that the use would be fully supported. With 23.8 % of the values recorded being less than 6.5 the lake will be listed as partially supporting based on pH. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. The lake is supporting the Aesthetics beneficial use based on its trophic status and true color values with all values well below the WQS of 70 units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

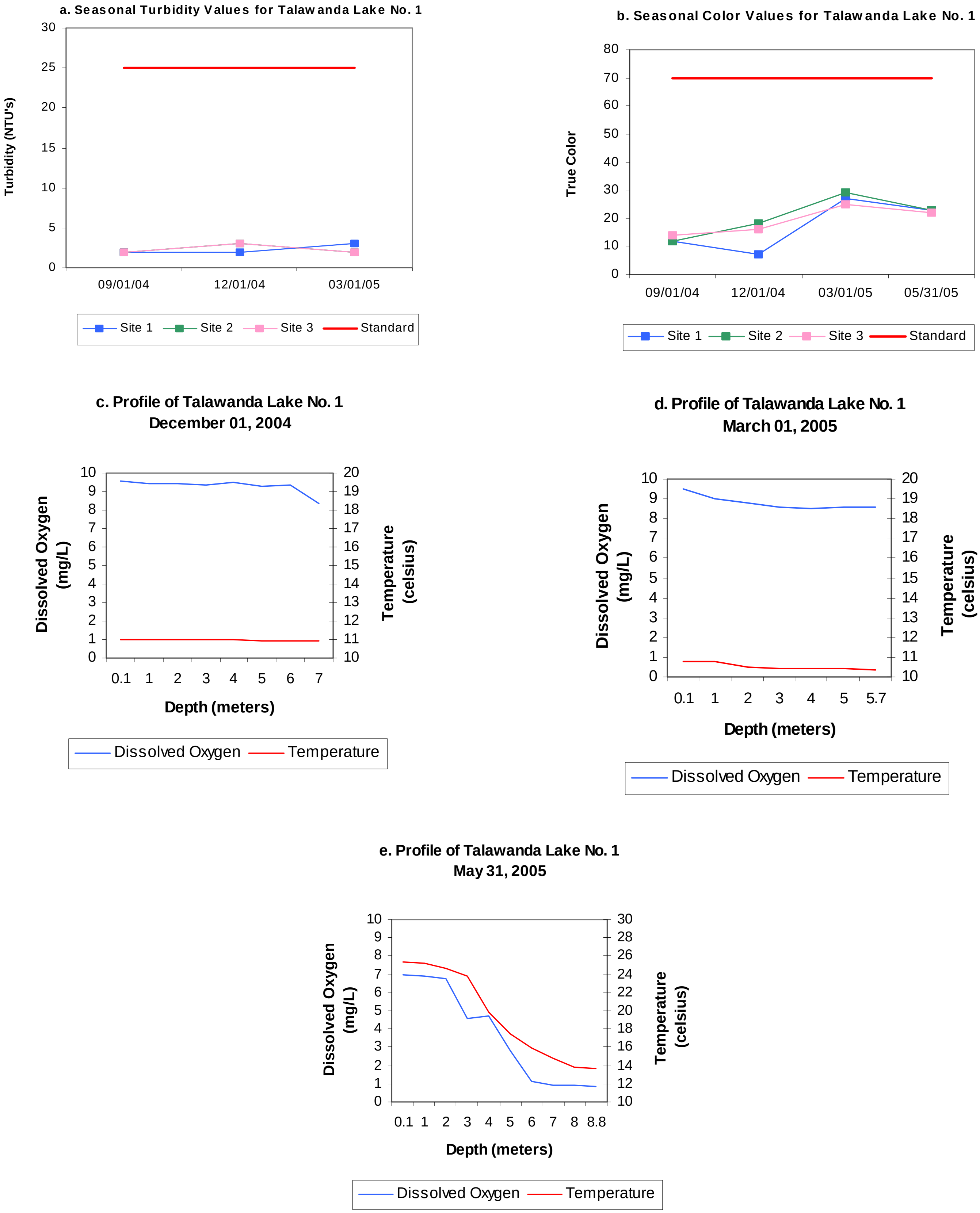
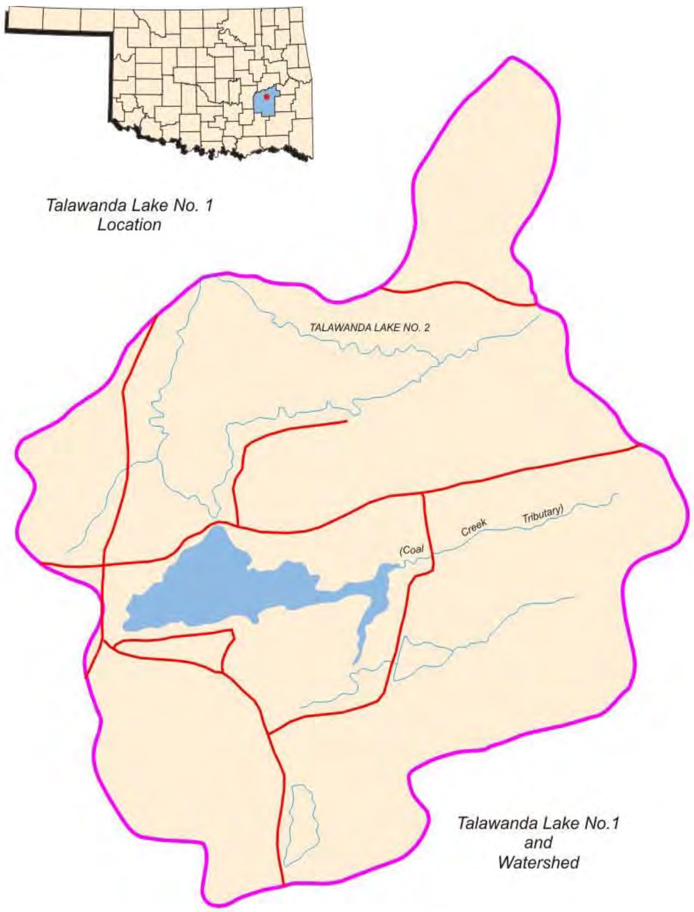


Figure 135a-135e. Graphical representation of data results for Talawanda Lake No.1



Talawanda Lake No. 1
Location

Talawanda Lake No.1
and
Watershed

Lake Data	
Owner	City of McAlester
County	Pittsburg
Constructed	1902
Surface Area	91 acres
Volume	1,200 acre/feet
Shoreline Length	3 miles
Mean Depth	14.10 feet
Watershed Area	1,271 acres

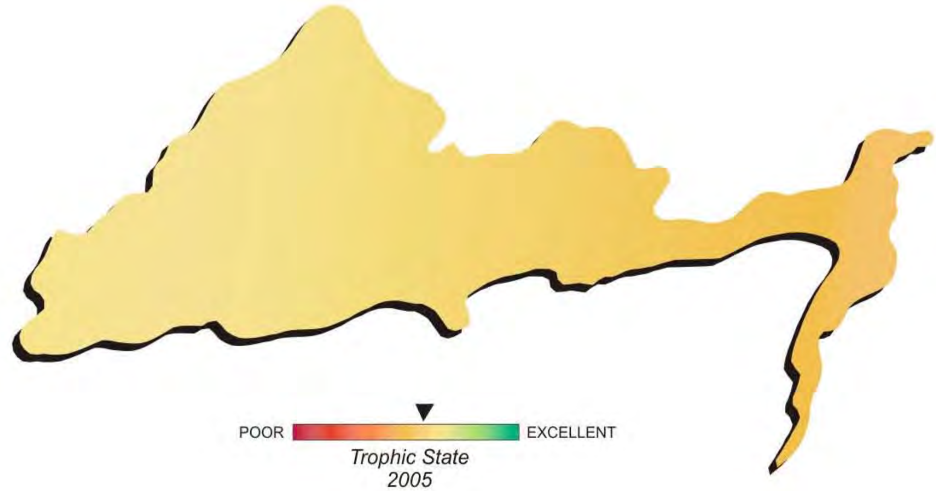


Plate 109 - Lake Water Quality for
Talawanda Lake No. 1

Talawanda Lake No. 2

Talawanda Lake No. 2 is a 195-acre reservoir that was constructed in 1924 and serves as a water supply and recreational reservoir. It is located in Pittsburg County and owned by the City of McAlester.

Talawanda Lake No. 2 was sampled for four quarters, from September 2004 through May 2005. Water quality samples were collected at 3 sites to represent the reservoir. Samples were collected at the lake surface at all sites and 0.5 meters from the lake bottom at site 1, the dam. The average lake-wide turbidity value was 7 NTU (Plate 110), true color was 16 units, and secchi disk depth was 138 centimeters. Based on these three parameters, Talawanda Lake No. 2 had excellent water clarity, similar to the values reported in 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 38 (Plate 110), classifying the lake as oligotrophic, indicative of low levels of primary productivity and nutrients. This value is similar to the one calculated in 2003 (TSI=39) indicating no significant increase or decrease in productivity has occurred since the previous evaluation. TSI values were primarily oligotrophic with site 3 in the mesotrophic category in both spring and summer sampling intervals. Seasonal turbidly values are displayed in Figure 136a. All turbidity values ranged from a low of 3 NTU to a maximum of 10 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the turbidity values below the standard the Fish and Wildlife Propagation (FWP) beneficial use is considered supported as it relates to turbidity. Seasonal true color values are displayed in Figure 136b. All of the true color values were well below the numeric criteria of 70 units therefore, the Aesthetics beneficial use is considered fully supported.

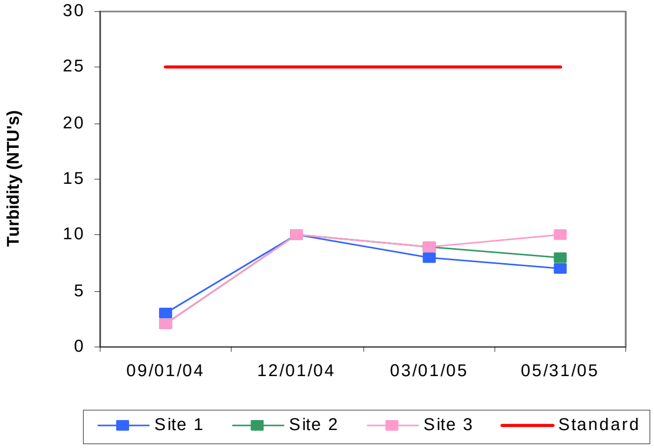
In 2004-2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.01 parts per thousand (ppt) to 0.05 ppt, which is lower than the range of values observed in Oklahoma reservoirs. Specific conductivity ranged from 51.8 µS/cm to 122.4 µS/cm, indicative of extremely low levels of current conducting ions (salts) in the lake system. The pH values at were slightly acidic, ranging from 6.19 in the summer to 7.87 in the winter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 12.6 % of the values recorded being less than 6.5 the lake will be listed as partially supporting based on pH. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Oxidation-reduction potentials (ORP) ranged from 388 mV to 489 mV indicating reducing conditions were not present at this reservoir at the time of sampling. In the fall, the lake was stratified at site 1 between 7 and 8 meters at which point dissolved oxygen (D.O.) dropped below 2.0 mg/L to the lake bottom of 12.4 meters (Figure 136c). At this time approximately 43% of the water column at site was experiencing anoxic conditions. In the winter and spring quarters the water column was well mixed with dissolved oxygen (D.O.) values generally above 8.0 mg/L (see Figure 136d-136e). Thermal stratification was evident and anoxic conditions were present throughout the lake in the summer. The temperature at site 1 ranged from 25.5 ^{0} C at the surface to 14.51 ^{0} C at the lake bottom. Stratification occurred between 4 and 5 meters, with 18 to 36 % of the water column experiencing anoxic conditions. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Based on recorded D.O. values present in the summer and fall the FWP use is considered supported. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

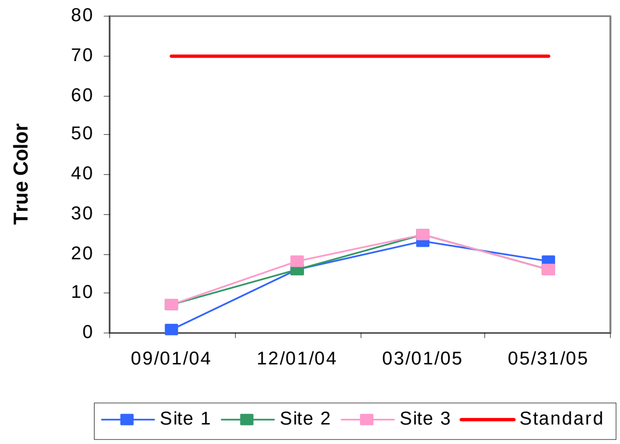
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.30 mg/L at the surface. Surface TN ranged from 0.18 mg/L to 0.46 mg/L, with the highest values reported in the spring and lowest values in the winter quarter. The lake-wide total phosphorus (TP) average was 0.014 mg/L at the surface. Total phosphorus at the surface ranged from 0.011mg/L to 0.015 mg/L. Surface TP was highest in the winter, and the lowest values were recorded during the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 22:1 for sample year 2004-2005. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

In summary, Talawanda Lake No.2 was classified as oligotrophic, indicative of low primary productivity and nutrient conditions (Plate110). This is consistent with historical data collection efforts, indicating no significant increase or decrease in productivity has occurred. Water clarity continues to be excellent based on turbidity, true color, and secchi disk depth. The FWP beneficial use is supported based on turbidity and dissolved oxygen values recorded during the study period. With 12.6 % of the values recorded being less than 6.5 the lake will be listed as partially supporting based on pH. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. The lake is supporting the Aesthetics beneficial use based on its trophic status and true color values as 100% of the values were well below the WQS of 70 units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Talawanda Lake No. 2, owned by the City of McAlester, serves as a water supply and recreational reservoir.

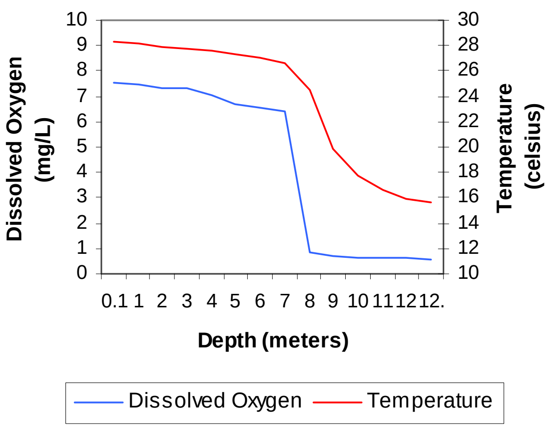
a. Seasonal Turbidity Values for Talawanda Lake No. 2



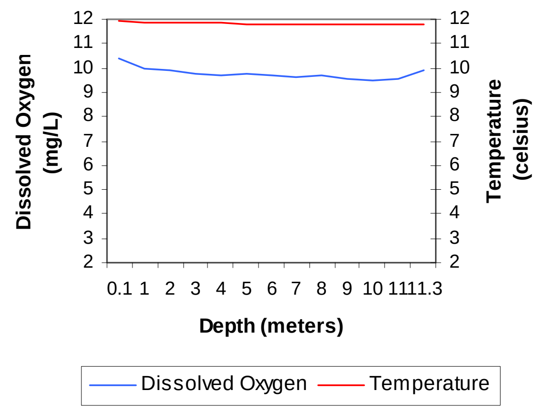
b. Seasonal Color Values for Talawanda Lake No. 2



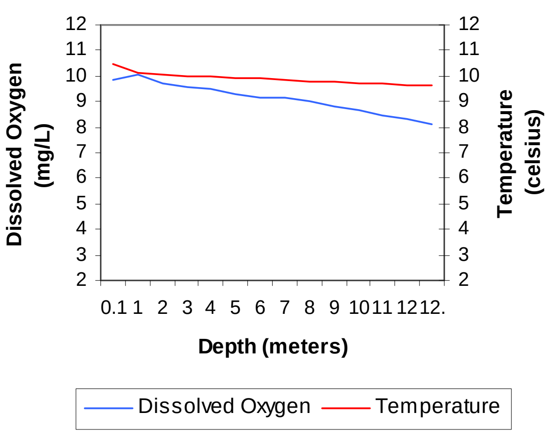
c. Profile of Talawanda Lake No. 2
September 01, 2004



d. Profile of Talawanda Lake No. 2
December 01, 2004



e. Profile of Talawanda Lake No. 2
March 01, 2005



f. Profile of Talawanda Lake No. 2
May 31, 2005

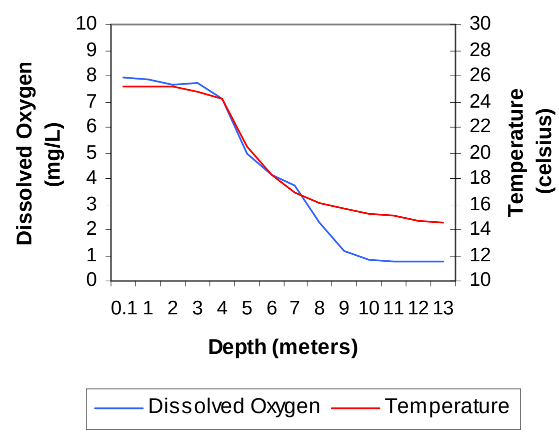
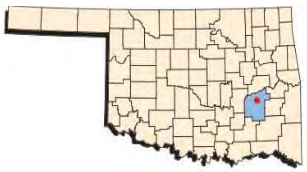
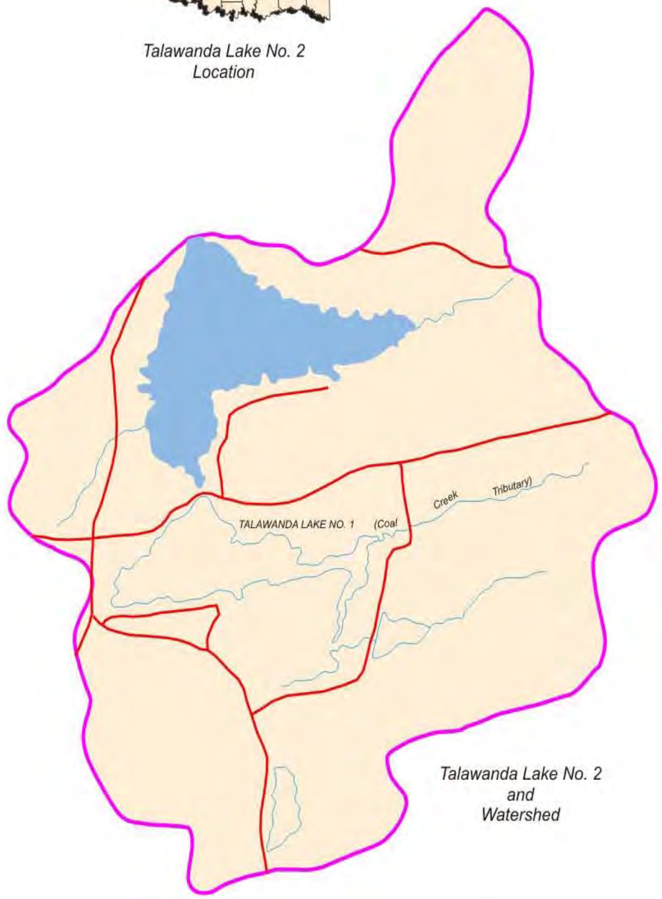


Figure 136a-136f Graphical representation of data results for Talawanda Lake No.2



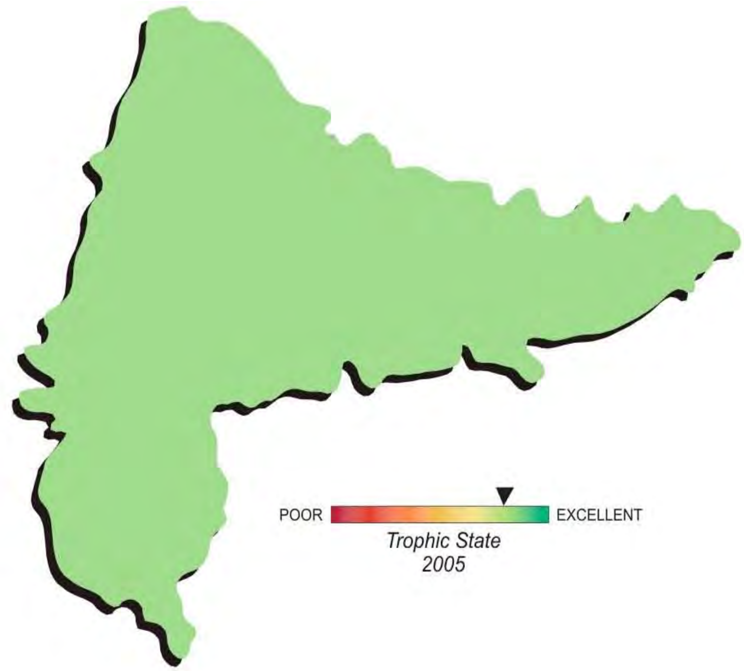
Talawanda Lake No. 2
Location



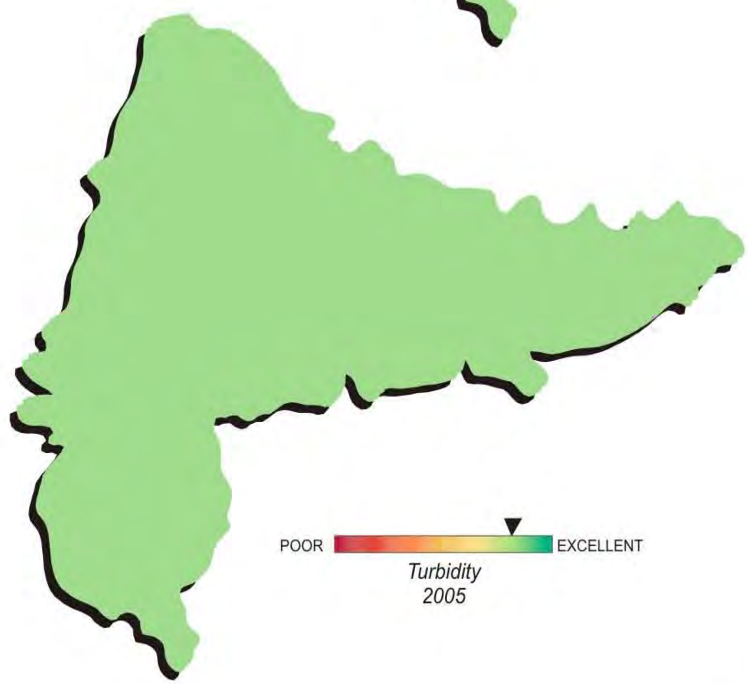
Talawanda Lake No. 2
and
Watershed

Lake Data

Owner	City of McAlester
County	Pittsburg
Constructed	1924
Surface Area	195 acres
Volume	2750 acre/feet
Shoreline Length	4 miles
Mean Depth	14.10 feet
Watershed Area	2,304 acres



Trophic State
2005



Turbidity
2005

Plate 110 - Lake Water Quality for
Talawanda Lake No. 2

Taylor Lake

Taylor Lake was constructed in 1960 and is leased to the City of Marlow. The 227-acre reservoir in Grady County serves as a flood control, water supply, and recreational reservoir. Taylor Lake was sampled for four quarters, from November 2004 through July 2005.

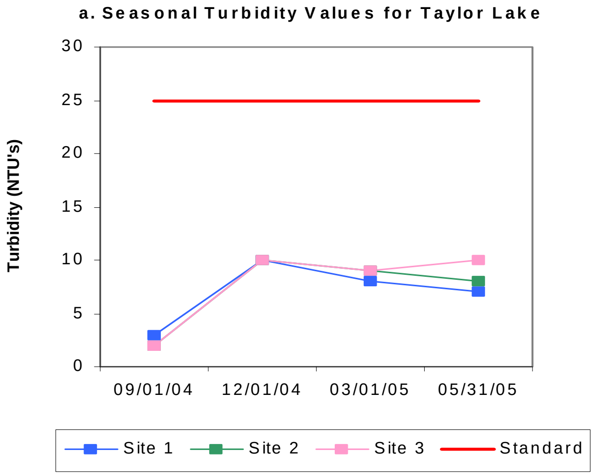
Water quality samples were collected from three (3) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and at 0.5 meters from the lake bottom at site 1, the dam. The average lake-wide turbidity was 14 NTU (Plate 111), true color was 19 units, and average secchi disk depth was 57 centimeters. Based on these three parameters, Taylor Lake had average water clarity in comparison to other Oklahoma reservoirs. Results are similar to those observed in 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 63 (Plate 111), classifying the lake as hypereutrophic, indicative of excessive primary productivity and nutrient levels. This value is similar to the one calculated in 2003 (TSI=62) indicating no significant increase or decrease in productivity has occurred since the previous evaluation. TSI values were fairly consistent with values ranging from upper eutrophic in the spring to hypereutrophic the remainder of the year. Currently, the lake listed as a Nutrient Limited Watershed (NLW) in the Oklahoma Water Quality Standards (WQS). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Seasonal turbidity values are displayed in Figure 137a. Turbidity values ranged from a low of 2 NTU to a maximum of 10 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if $\geq$ 25% of the samples exceed the Oklahoma Water Quality Standard (WQS) of 25 NTU for turbidity. If 10 to 25% of the turbidity samples exceed the criteria of 25 NTU, the lake is considered to be partially supporting beneficial uses. The Fish and Wildlife Propagation (FWP) beneficial use is considered supported at Taylor Lake with 100% of the values below the turbidity standard of 25 NTU. Seasonal true color values were all well below the WQS of 70 and are displayed in Figure 137b. Applying the same default protocol, the Aesthetics beneficial use is fully supported based on true color values.

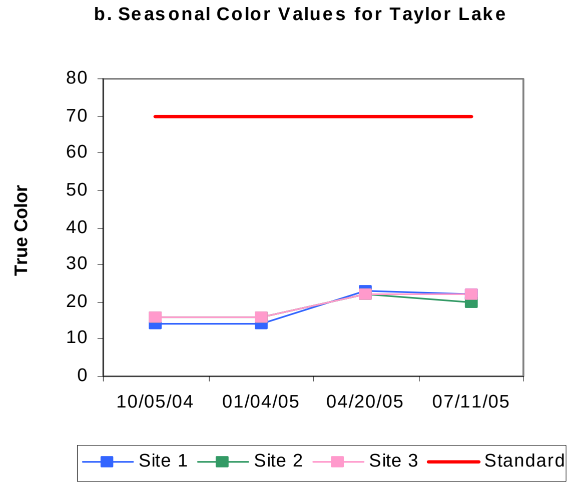
In 2004-2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.26 parts per thousand (pp t) to 0.35 ppt, which is within the range of values recorded in Oklahoma reservoirs. Specific conductivity ranged from 508.3 µS/cm to 676.3 µS/cm, indicative of moderate levels of current conducting ions (salts) in the lake system. The pH values were neutral to slightly alkaline ranging from 7.06 to 8.49 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Oxidation-reduction potentials (ORP) ranged from 242 mV to 401 mV indicating the absence of reducing conditions during the study. The lake was not stratified during the fall, winter, or spring sampling quarters and the water column was well mixed (see Figure 137c-137e). In the summer, thermal stratification was evident and anoxic conditions were present (Figure 137f). Stratification occurred between 3 and 4 meters, with 33% of the water column experiencing anoxic conditions. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With only 33% of the collected dissolved oxygen values below 2.0 mg/L, Taylor Lake is considered supporting the FWP beneficial use. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

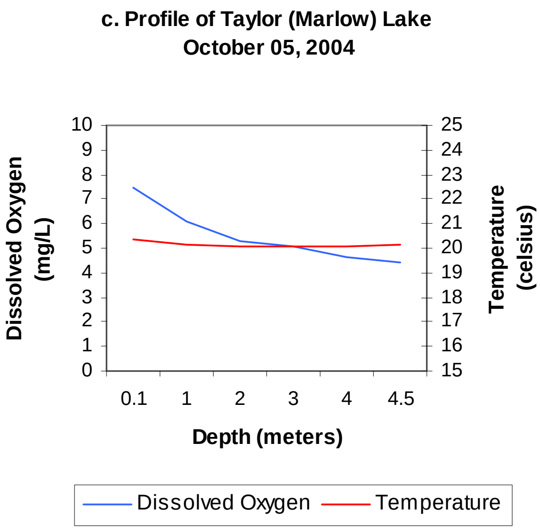
Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

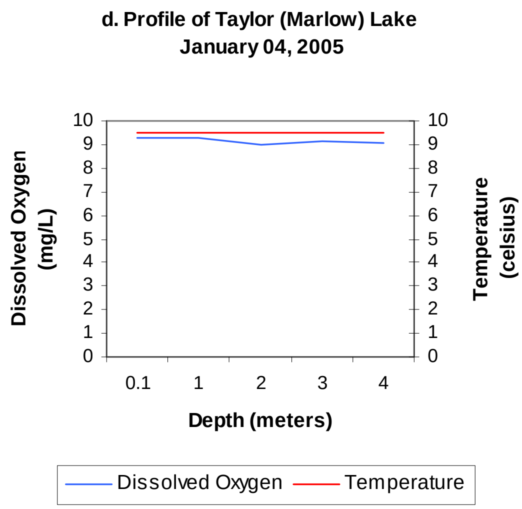
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.03 mg/L at the surface. Surface TN ranged from 0.88 mg/L to 1.25 mg/L, with the highest values reported in the summer and lowest values in the winter quarter. The lake-wide total phosphorus (TP) average was 0.104 mg/L at the surface. Total phosphorus at the surface ranged from 0.067mg/L to 0.138 mg/L. Surface TP was highest in the fall, and the lowest values were recorded during the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 10:1 for sample year 2004-2005. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

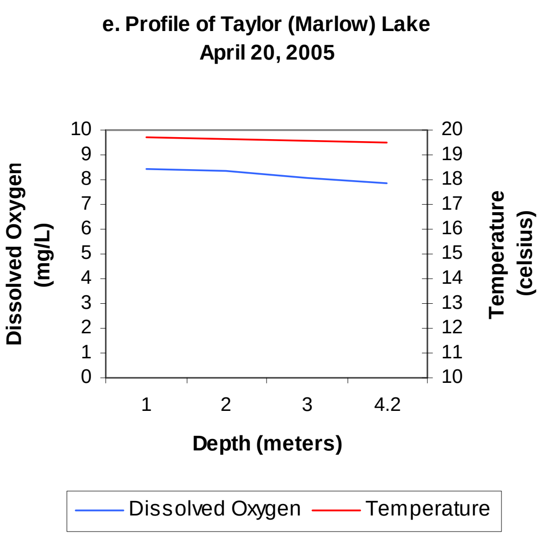
In summary, Taylor Lake was classified as hypereutrophic, indicative of excessive primary productivity and nutrient levels in sample year 2005. The calculated TSI was similar to that in 2003 (TSI=62), indicating no significant increase or decrease has occurred since the last evaluation. Water clarity was average based on true color, turbidity, and secchi disk depth. The FWP beneficial use is supported based on pH, turbidity, and dissolved oxygen values recorded during the study period. With 100% of the values well below the WQS of 70 units, the Aesthetics beneficial use is considered supported based on true color. Currently, the lake listed as a Nutrient Limited Watershed (NLW) in the Oklahoma Water Quality Standards (WQS). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.











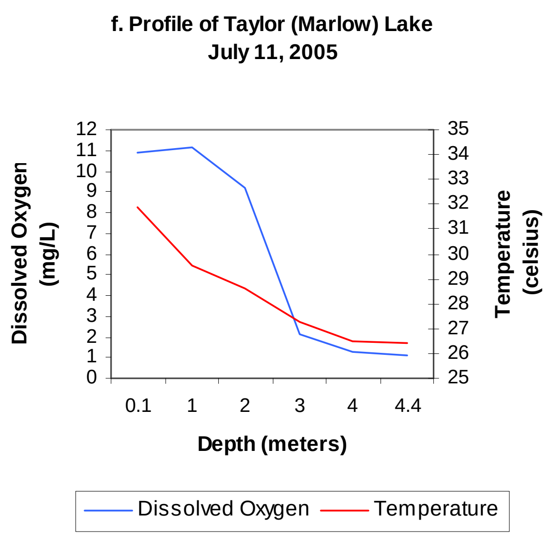
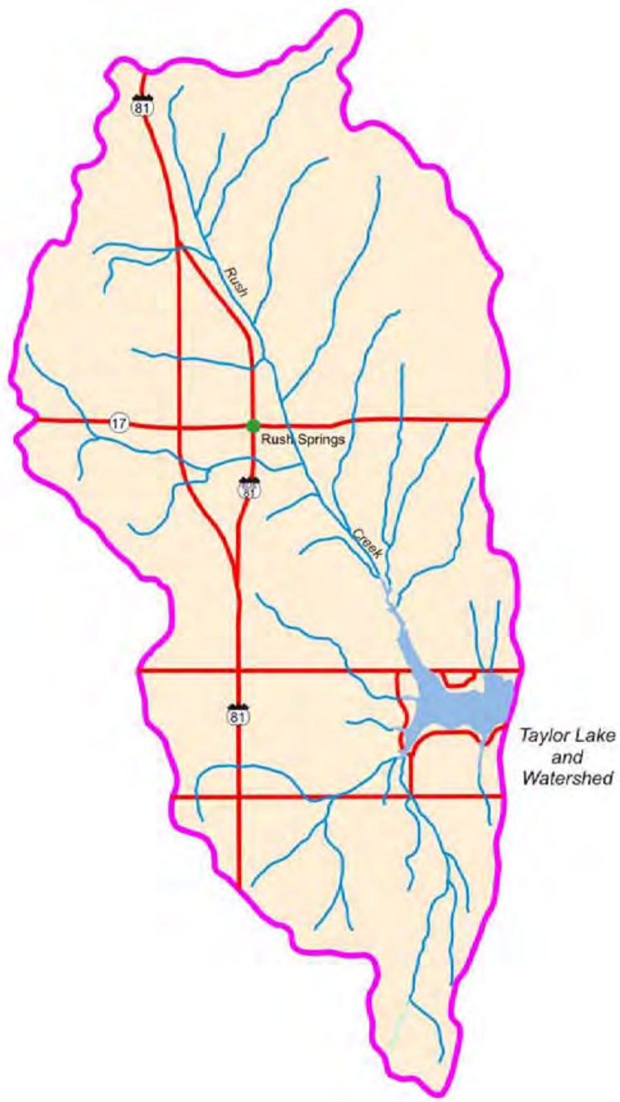


Figure 137a-137f. Graphical representation of data results for Taylor Lake.



Lake Data

Owner	Leased to City of Marlow
County	Grady
Constructed in	1960
Surface Area	227 acres
Volume	1,877 acre/feet
Shoreline Length	7 miles
Mean Depth	8.27 feet
Watershed Area	21 square miles

Plate 111 - Lake Water Quality for

Taylor Lake

Tecumseh Lake

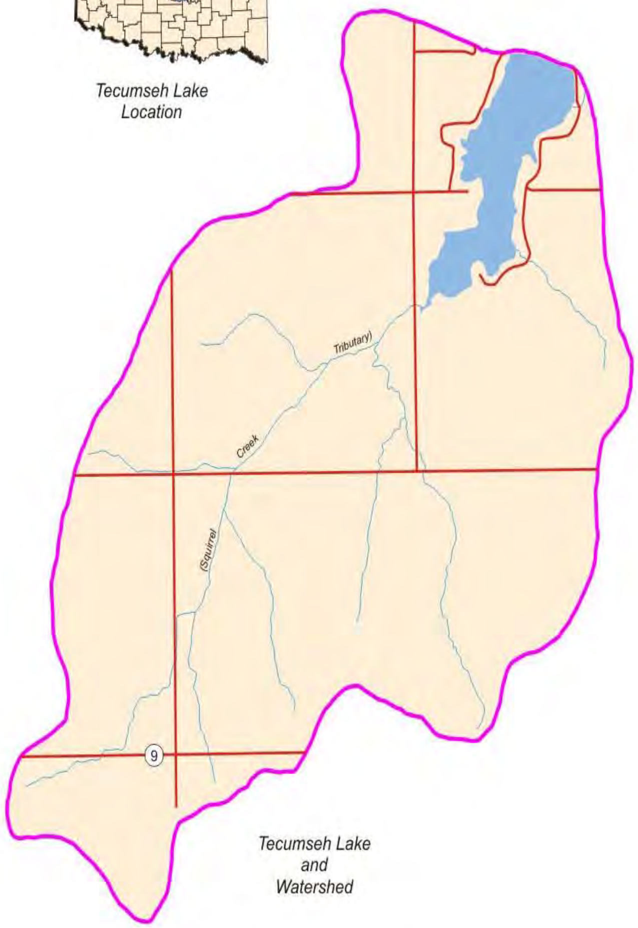
Tecumseh Lake is a 127-acre reservoir that was constructed in 1934 and is owned and operated by the City of Tecumseh. The lake is managed as a municipal water supply and offers recreational opportunities to the public. The lake was unable to be sampled during the 2005-2006 sample year due to drought conditions. The lake will be placed on the next sample rotation once water levels rise enough for staff to access the lake safely. The data presented are from the last sampling in 2003-2004.

Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the lake surface at all sample sites and 0.5 meters from the lake bottom at sample site 1. The lake-wide annual turbidity value was 87 NTU (Plate 112), true color was 106 units, and secchi disk depth was 18 centimeters. Based on these three parameters, Tecumseh Lake had poor water clarity. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for three quarters (n=9). The average TSI was 57 (Plate 112), classifying the lake as eutrophic, indicative of high levels of primary productivity and nutrients. Although based on a smaller data set this value is similar to the one calculated in 2002 (TSI=51), indicating that no significant change in productivity has occurred since the last evaluation. TSI values for this lake varied seasonally from hypereutrophic to oligo-mesotrophic in the spring and to meso-eutrophic in the summer quarter. Unlike the vast majority of Oklahoma reservoirs, Tecumseh Lake was most productive in the late fall early winter, which is not commonly seen. This correlates with the fact that turbidity readings were much lower than those seen in both spring and summer quarters. With the increased availability of light to the biota the lake became much more productive. All turbidity values were above the Oklahoma Water Quality Standard (WQS) of 25 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Although the minimum data requirements for a lake of this size were not met it is likely that Tecumseh Lake would not be supporting its Fish & Wildlife Propagation (FWP) beneficial use based on turbidity. With 66% of the true color values well above the numeric criteria of 70 units, the lake should be listed as not supporting its Aesthetics beneficial use based on true color values; however due to data requirements not being met a definitive assessment can not be made at this time.

Please refer to the "Beneficial Use Monitoring Report 2004 Draft Final Report" for the full discussion of monitoring results for this lake. The report may be access via the OWRB's web page at http://www. owrb.state.ok.us or you may contact the Water Resources for a copy of the 2004 BUMP Report on CD. The OWRB may be reached at (405) 530-8800 (ask for Nikki Cole) or at the address below:

Oklahoma Water Resources Board
3800 N. Classen Blvd.
Oklahoma city, Oklahoma 73118
Attn: Nikki Cole

Tecumseh Lake Location



Tecumseh Lake and Watershed

Lake Data

Owner	City of Tecumseh
County	Pottawatomie
Constructed	1934
Surface Area	127 acres
Volume	1,118 acre/feet
Shoreline Length	3 miles
Mean Depth	8.80 feet
Watershed Area	3,124 acres

Turbidity 2004

Trophic State 2004

Plate 112 - Lake Water Quality for

Tecumseh Lake

LAKES MONITORING PROGRAM

Tenkiller Ferry Lake

The United States Army Corps of Engineers constructed Tenkiller Ferry Lake in 1953. The 12,900-acre lake was authorized to serve for flood control and hydroelectric power. Today the lake serves many other purposes and is one of the most heavily used recreational lakes in Oklahoma. Tenkiller Ferry Lake is one of the lake jewels of Oklahoma and it should be managed and maintained in that fashion. Tenkiller Ferry Lake was sampled for four quarters, from October 2005 through July 2006.

Water quality samples were collected at seven (7) sites to represent the riverine, transitional, and lacustrine zones of the lake as well as major arms. Samples were collected at the lake surface at all sites during the study period. Tenkiller Ferry Lake is a larger reservoir with many tributaries, including the Illinois River flowing into the waterbody and has been split into two management segments. The following discussion will briefly summarize each segment with a lake-wide summary included at the end of the narrative.

Tenkiller Ferry Lake, Lower Lake

This portion of Tenkiller Ferry Lake (segment # 121700020020) extends from the dam up to the Sixshooter Camp area of the reservoir and includes BUMP sites 1 (dam), 2 (Chicken Ck.) and 7 (Blackgum Landing) see Figure 139. The segment-wide average turbidity was 2 nephelometric turbidity units (NTU), true color was 11 units and secchi disk depth was 217 centimeters in sample year 2006. Based on these three parameters water clarity is excellent in this segment of the lake. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 48, classifying the segment as mesotrophic, indicative of moderate primary productivity and nutrient conditions. Chlorophyll-a values were generally mid-mesotrophic to mid-eutrophic throughout the sample year. Turbidity values ranged from a low of 1 NTU to a maximum of 6 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered partially supported if 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Although 100% of the values are below 25 NTU an assessment of the Fish & Wildlife Propagation (FWP) beneficial use cannot be made due to minimum data requirements not being met. Like turbidity, all true color values were below the Aesthetics criteria 70 units however like turbidity there are not enough data for this segment to assess the Aesthetics beneficial use.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.05 parts per thousand (ppt) to 0.42 ppt, indicating low to moderate salt content compared to most Oklahoma lakes. Specific conductivity ranged from 135.3 µS/cm to 806.2 µS/cm in the spring, indicating minimal to moderate levels of electrical conducting compounds (salts) were present in the lake system. In general, pH values were neutral to slightly alkaline, ranging from

6.57 to 10.45 units, with elevated values recorded at sites 1 and 2 in the spring quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 10% of the pH values outside the acceptable range this segment Tenkiller Ferry Lake is partially supporting its FWP beneficial use based on pH. This is the first instance that this has occurred and will be looked at closely in the future to see if this is an actual impairment or an equipment malfunction. The lake was not thermally stratified in the winter or spring quarters and dissolved oxygen (D.O.) readings were generally above 6.0 mg/L in the majority of the water column (Figure 138d-130e). The lake was thermally stratified in the fall quarter between 13 and 14 meters below the lake surface and D.O. values were below 2.0 mg/L from the 14 meter depth to the lake bottom at 33.7 meters at sites 1, 2 and 7 (Figure 138d), with 52% of the water column at site 1 experiencing anoxic conditions. In the summer, stratification occurred between the 7 and 8-meters depth, accounting for a larger portion of the water column to have D.O. values less than 2.0 mg/L. At site 1, stratification occurred between 7 and 8 meters as mentioned above; however D.O. rose to above 2.0 mg/l between 10 and 20 meters and dropped below 2.0 mg/L from 28 meters to the lake bottom at 38.5 meters (see Figure 138f). This is the first time this metalimnetic minimum has been observed at this reservoir and should be looked into more closely in the future. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported at Tenkiller Ferry Lake as 17 to 52% of the water column was anoxic in the fall at sites 1, 2 and 7. In the summer quarter, the percent of the water column experiencing anoxic conditions was much greater ranging from 52% (site 2) to 69% at (site 7), which is also a partially supporting designation.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of (Nutrient Limited Watershed) NLW lakes and nutrient criteria development for lakes and reservoirs. In this segment of the lake the average total nitrogen (TN) was 0.28 mg/L, with values ranging from 0.11 mg/L in the fall to 0.46 mg/l in the winter quarter. The average total phosphorus (TP) was 0.012, with values ranging from 0.009 mg/L in the fall to 0.0.022 mg/L in the winter. The nitrogen to phosphorus ratio (TN:TP) for sample year 2005-2006 was 23:1. This value is higher than 7:1, characterizing for this portion of the lake as phosphorus limited (Wetzel, 1983).

Tenkiller Ferry Lake, Illinois River Arm

This portion of Tenkiller Ferry Lake (segment # 121700020220) extends from the Cookson Bend area up-lake to where the Illinois River enters the reservoir and includes BUMP sites 3, 4 (Elk Ck. Landing), 5 (Caney Ridge) and 6 (Illinois River). The segment-wide average turbidity was 7 nephelometric turbidity units (NTU), true color was 13 units and secchi disk depth was 106 centimeters in sample year 2006. Based on these three parameters water clarity is excellent in this segment of the lake. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=16). The average TSI was 59, classifying the segment as upper-eutrophic, indicative of high primary productivity and nutrient conditions. Chlorophyll-a values were generally mid to upper-eutrophic throughout the sample year, with higher values generally reported in the spring and summer. Turbidity values ranged from a low of 3 NTU to a maximum of 12 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC)

785:46-15-5, a beneficial use is considered partially supported if 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Although 100% of the values are below 25 NTU an assessment of the Fish & Wildlife Propagation (FWP) beneficial use cannot be made due to minimum data requirements not being met. Like turbidity, all true color values were below the Aesthetics criteria 70 units however like turbidity there are not enough data for this segment to assess the Aesthetics beneficial use.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.07 parts per thousand (ppt) to 0.41 ppt, indicating low to moderate salt content compared to most Oklahoma lakes. Specific conductivity ranged from 159.3 µS/cm in the fall to 786.4 µS/cm in the spring, indicating minimal to moderate levels of electrical conducting compounds (salts) were present in the lake system. In general, pH values were neutral to slightly alkaline, ranging from 7.02 to 9.23 units, with elevated values recorded at site 3 in the spring quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With only six (4%) of the pH values outside the acceptable range, this segment of Tenkiller Ferry Lake is supporting its FWP beneficial use based on pH. The upper segment of the lake was not thermally stratified in the fall or winter quarters and dissolved oxygen (D.O.) readings were generally above 6.0 mg/L. In the spring, the water column was weakly stratified however dissolved oxygen remained above 5.0 mg/L. In the summer, stratification occurred between the 2 and 3 meters below the surface, accounting for a larger portion of the water column to have D.O. values less than 2.0 mg/L. Approximately 50-60% of the water column was experiencing anoxic conditions at all four sites within this segment of the lake. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered partially supported at Tenkiller Ferry Lake, Illinois River arm with dissolved oxygen readings less than 2.0 mg/L in 50 to 60% of the water column during the summer sampling interval.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of (Nutrient Limited Watershed) NLW lakes and nutrient criteria development for lakes and reservoirs. In this segment of the lake the average total nitrogen (TN) was 0.45 mg/L, with values ranging from 0.19 mg/L in the fall to 0.79 mg/l in the winter quarter. The average total phosphorus (TP) was 0.044, with values ranging from 0.015 mg/L in the winter to 0.085 mg/L in the fall. The nitrogen to phosphorus ratio (TN:TP) for sample year 2005-2006 was 10:1. This value is higher than 7:1, characterizing for this portion of the lake as phosphorus limited (Wetzel, 1983).

Lake Summary

The lake was also sampled for chlorides and sulfates, to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported in all three management segments based on numerical criteria located in OAC 785:45 – Appendix F.

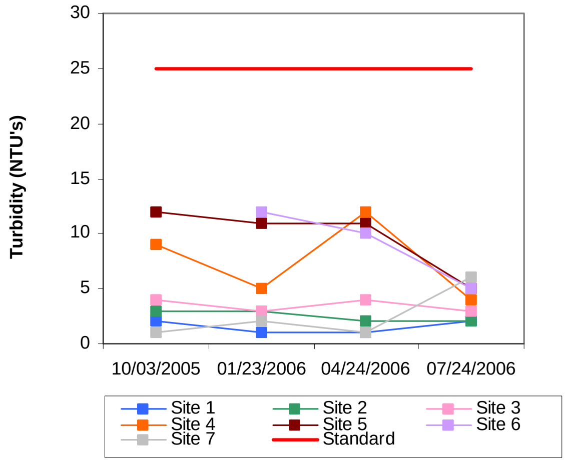
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites throughout the lake for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006.

Although all sample results were below both the screening level and geometric mean, the minimum data requirements for each segment were not met and an assessment of the PBCR beneficial use cannot be made at this time.

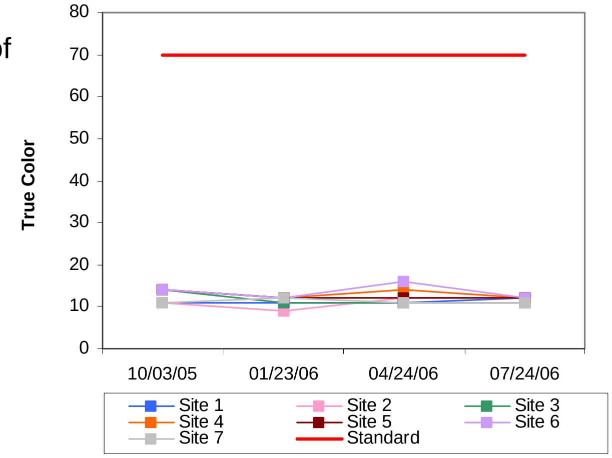
The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 1999 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening level or fish consumption advisory level. The lake is fully supporting its Fish Consumption beneficial use. Tenkiller Ferry Lake was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Tenkiller Ferry Lake was classified as eutrophic, indicative of high primary productivity and nutrient levels (Plate 113). Water clarity was excellent during the study period and may be attributed to the absence of inorganic turbidity (Plate 113) levels that are commonly seen in most Oklahoma reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=28). The average TSI was 55 classifying the lake as eutrophic, indicative of high levels of primary productivity and nutrients. This value is similar to the TSI calculated in both 2004 and 2002 (TSI=56), indicating no significant change in productivity. TSI values varied by site and season with lower values generally occurring in the lower end of the lake near the dam. At the upper end of the lake TSI values were generally mid to upper-eutrophic throughout the year. All turbidity values were well below the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 138a), therefore meeting the FWP beneficial use as it relates to turbidity. Seasonal true color values are displayed in Figure 138b. All of the true color values were well below the numeric criteria of 70 units and the Aesthetics beneficial use is considered fully supported. Tenkiller Ferry Lake was supporting its FWP beneficial use based on nephelometric turbidity and partially supporting the beneficial use based on low D.O. concentrations in the water column. The low D.O. values observed in the summer at several sites are a cause for concern and should be studied further. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites throughout the lake for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. Although all sample results were below both the screening level and geometric mean, the minimum data requirements for each segment were not met and an assessment of the PBCR beneficial use cannot be made at this time.

a. Seasonal Turbidity Values for Tenkiller Ferry Lake



b. Seasonal Color Values for Tenkiller Ferry Lake



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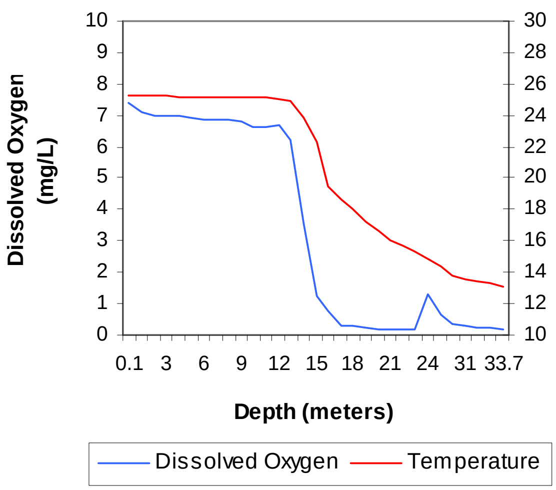
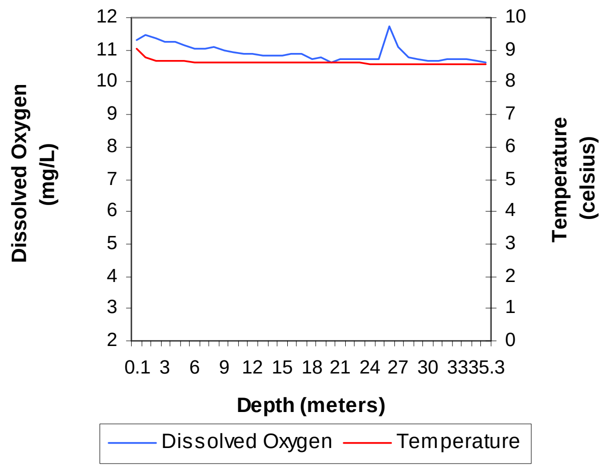
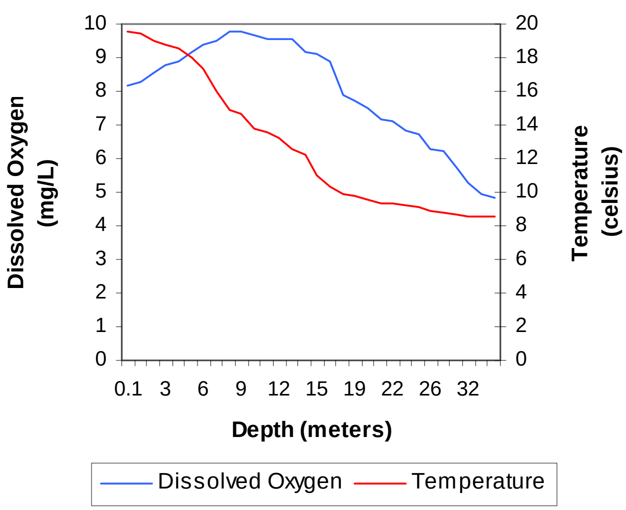
c. Profile of Tenkiller Ferry Lake
October 03, 2005



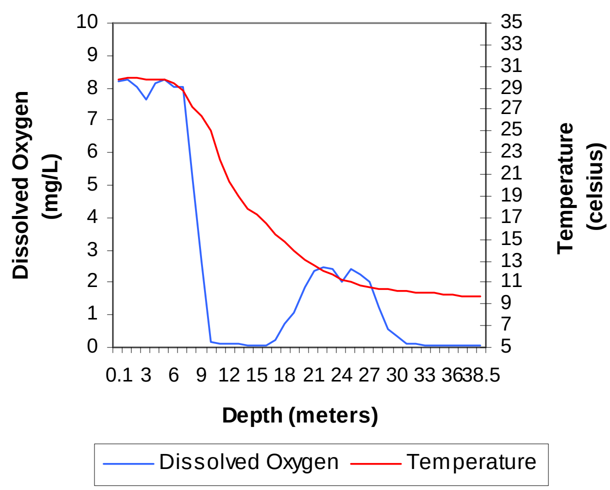
d. Profile of Tenkiller Ferry Lake
January 23, 2006



e. Profile of Tenkiller Ferry Lake
April 24, 2006



f. Profile ofTenkiller Ferry Lake
July 24, 2006



Lake Data

Constructed by	Corps of Engineers
County	Sequoyah
Constructed in	1953
Surface Area	12,900 acres
Volume	654,100 acre/feet
Shoreline Length	130 miles
Mean Depth	50.7 feet
Watershed Area	1,610 square miles

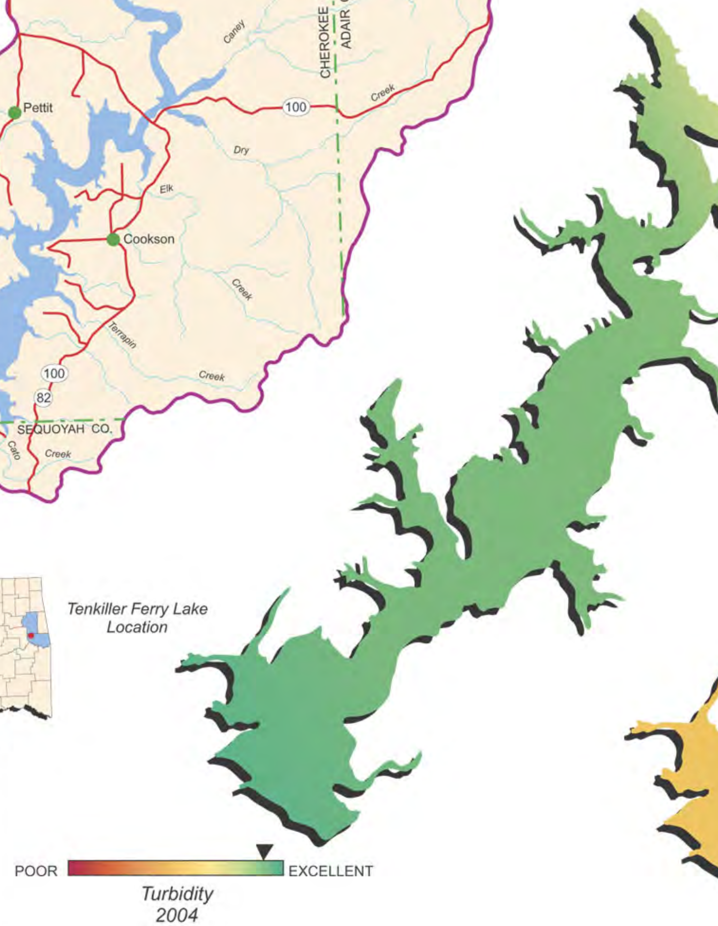


Plate 113 - Lake Water Quality for

Tenkiller Ferry Lake

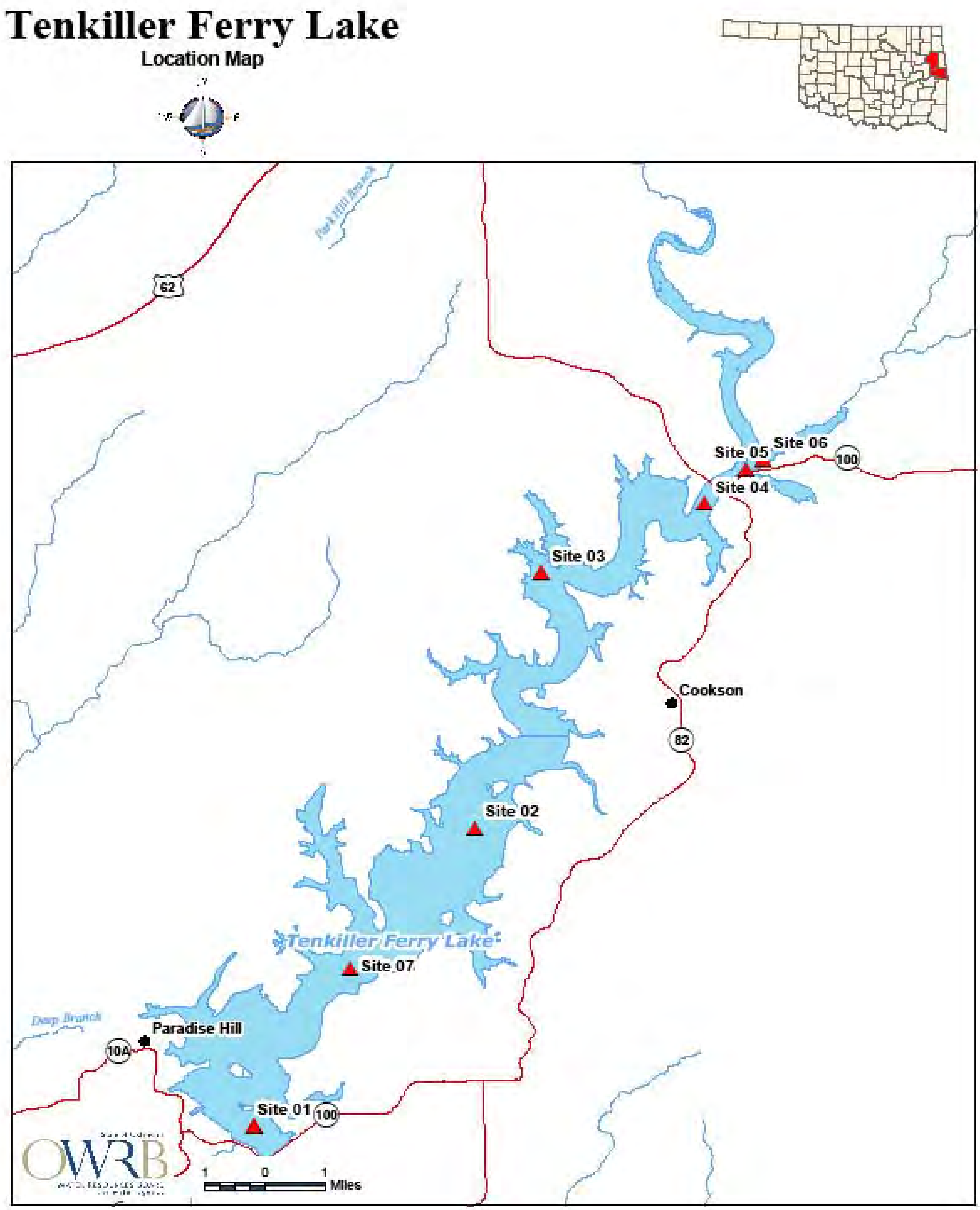


Figure 139. Tenkiller Ferry Lake Site Map

Lake Texoma

Lake Texoma is an 88,000-acre reservoir, which was built in 1944. It was constructed by the United States Army Corps of Engineers (USACE) is utilized for flood control, water supply, hydroelectric power, flow regulation, navigation, and recreation purposes. Lake Texoma was sampled for four quarters, from November 2004 through August 2005.

Water quality samples were collected from thirteen (13) sites to represent the riverine, transition, and lacustrine zones and major arms of the reservoir. Samples were collected at the lake surface at all sites and 0.5 meters from the lake bottom at sample site 1, the dam. The average lake-wide turbidity value was 18 NTU (Plate 114), true color was 30 units, and secchi disk depth was 76 centimeters. Based on these three parameters, Lake Texoma had average water clarity compared to other Oklahoma lakes. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=52). The average TSI was 56 (Plate 114), classifying the lake as eutrophic, indicative of high levels of primary productivity and nutrient conditions. This is similar to the TSI from 2003 (TSI=54), indicating no significant increase or decrease in productivity has occurred since the last evaluation. The TSI values varied by site and season ranging from mesotrophic to hypereutrophic. Sites 8-13 (Red River arm) were generally eutrophic to hypereutrophic throughout the sample year. Site 4 had a very low chlorophyll-a value reported during the winter, placing it in the oligotrophic category. In the summer quarter, sites were generally divided between the eutrophic and hypereutrophic categories. Seasonal turbidity values ranged from a low of 2 NTU to a maximum of 128 NTU and are displayed in Figure 140a. Turbidity was generally higher at sites 10-13, located in the Red River arm of the lake. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Lake Texoma is partially supporting its Fish and Wildlife Propagation (FWP) beneficial use with 18% of the collected turbidity values exceeding the standard. Seasonal true color values are displayed in Figure 140b. Of the 52 values collected, 5 (10%) were well above the numeric criteria of 70 units therefore the Aesthetics beneficial use is considered partially supported.

In 2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.53 parts per thousand (ppt) at site 4 (Washita River arm) to 2.06 ppt at site 12 (Red River arm), which is higher than the range of values recorded in Oklahoma reservoirs. Specific conductivity ranged from 1005 µS/cm in the fall to 3781 µS/cm in the spring, indicative of high levels of current conducting ions (chlorides and salts) in the lake system, consistent with salinity values. The recorded values for pH ranged from 6.26 to 8.4, representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With less than 1%

of the collected values less than 6.5, the lake is considered supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (ORP) ranged from -80 mV in the hypolimnion during the summer to 561 mV in the winter. In general reducing conditions were not present at this reservoir with values above 100 mV except at sites 1, 3, and 5 during the summer when a large portion of the water column experiencing anoxic conditions. Stratification was not evident during the fall and winter sampling quarters and the water column was well mixed (see Figure 140c-140d). During the spring, the lake was stratified at several 1-meter intervals throughout the lake with dissolved oxygen (D.O.) falling below 2.0 mg/L between 18 and 19 meters, accounting for 5 to 15 % of the water column to be anoxic (Figure 140e). In the summer, strong thermal stratification was evident and anoxic conditions were present below the thermocline. Stratification occurred at varying depths throughout the lake, with 8 to 76% of the water column experiencing anoxic conditions (Figure 140f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Lake Texoma is considered partially supporting the FWP beneficial use based on low dissolved oxygen values recorded during the summer. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.81 mg/L at the surface. Surface TN ranged from 0.47 mg/L to 1.38 mg/L, with the highest values reported in the summer and lowest values in the fall quarter. The lake-wide total phosphorus (TP) average was 0.062 mg/L at the surface. Total phosphorus at the surface ranged from 0.025 mg/L to 0.277 mg/L. Surface TP was highest in the summer, and the lowest values were recorded during the winter quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 13:1 for sample year 2004-2005. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

In summary, Lake Texoma was classified as eutrophic, indicative of high primary productivity and nutrient conditions in sample year 2004-2005. These results are similar to those of 2003 (TSI=54), indicating no significant increase or decrease in productivity has occurred over time. Water clarity was average based on turbidity, true color, and secchi disk depth. The FWP beneficial use is fully supported based on pH, but partially supported based on turbidity and dissolved oxygen values. The Aesthetics beneficial use is supported based on its trophic status and partially supported with 10% true color values exceeding the WQS of 70 units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

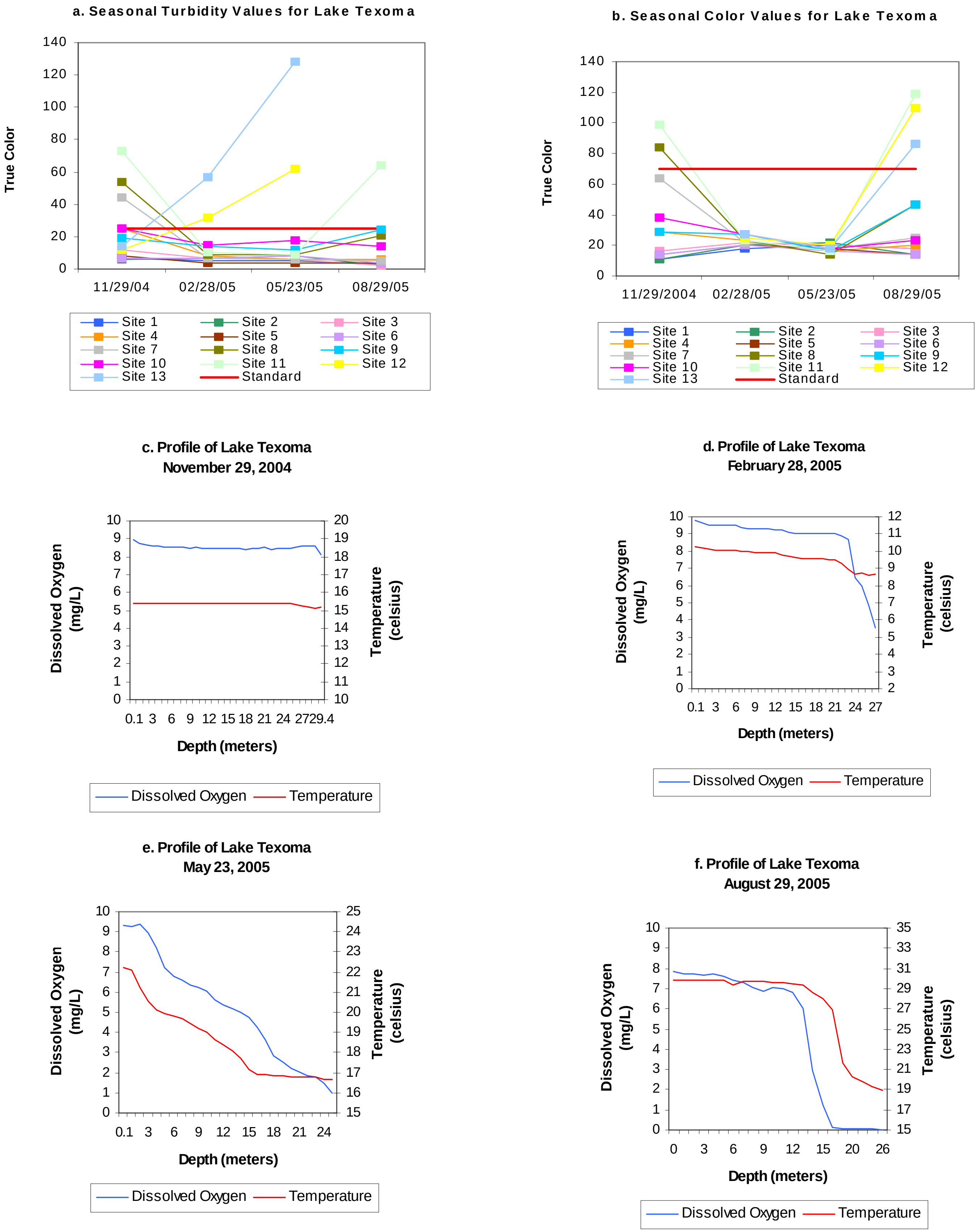
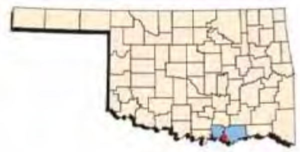
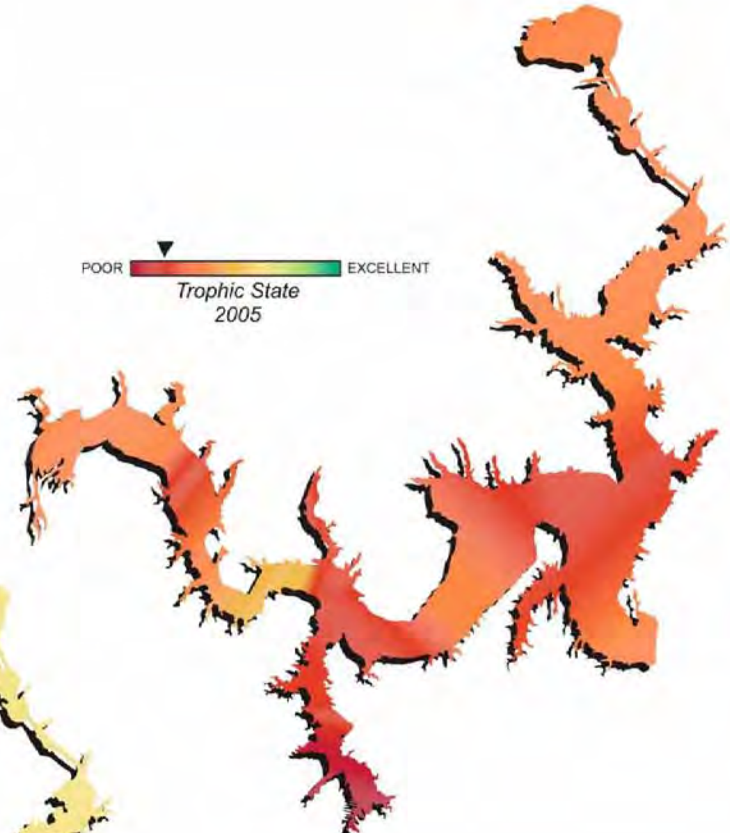
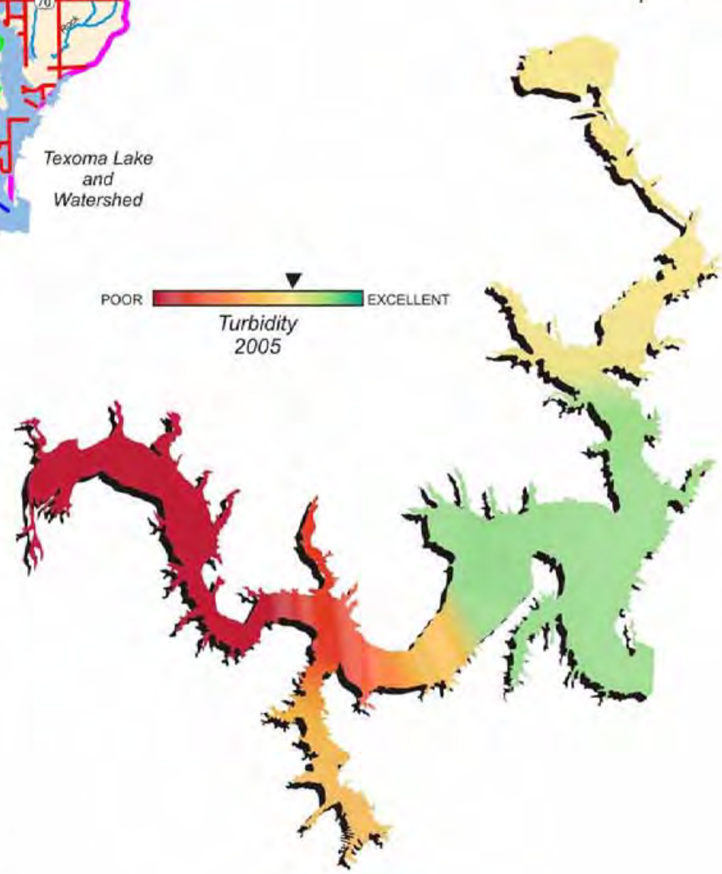


Figure 140a-140f. Graphical representation of data results for Lake Texoma.







Lake Data

Constructed by	Corps of Engineers
County	Bryan
Constructed in	1949
Surface Area	88,000 acres
Volume	2,643,300 acre/feet
Shoreline Length	580 miles
Mean Depth	30.6 feet
Watershed Area	39,719 square miles

Plate 114 - Lake Water Quality for

Texoma Lake

Lake Thunderbird

Lake Thunderbird was constructed in 1965 and is owned by the Bureau of Reclamation. The 6,070-acre reservoir located in Cleveland County serves as a municipal water supply for flood control, fish and wildlife and offers numerous recreational opportunities to the public. Lake Thunderbird was sampled for four quarters, from October 2006 through June 2007.

Water quality samples were collected at seven (7) sites to represent the riverine, transitional, and lacustrine zones of the reservoir as well as any major arms. Samples were collected at the lake surface at all sample sites. The lake-wide annual turbidity value was 28 NTU, true color was 32 units, and secchi disk depth was 53 centimeters in 2006-2007. Based on these three parameters, Lake Thunderbird had average water clarity, similar to water clarity in 2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=28). The average TSI was 57 (Plate 115), classifying the lake as eutrophic, indicative of high levels of productivity and nutrient rich conditions. The TSI values varied seasonally ranging from hypereutrophic in the winter to mesotrophic and eutrophic in the fall, spring, and summer quarters. Lake Thunderbird is currently listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Seasonal turbidity values are displayed in (Figure 141a). Of the 28 turbidity values samples collected, 13 (46%) exceeded the Oklahoma Water Quality Standard (WQS) of 25 NTU. The Fish & Wildlife Propagation (FWP) beneficial use for turbidity is considered not supported. Seasonal true color values are displayed in (Figure 141b). All true color values except three samples (one each at sites 5, 6, and 7 during the spring quarter) were below the numeric criteria of 70 units. These 3 sites represent only 7% of the values exceeding the standard and therefore the Aesthetics beneficial use is considered fully supported.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.18 parts per thousand (ppt) to 0.23 ppt, indicating low salt content and readings were well within the expected range of salinity values reported for most Oklahoma lakes. Specific conductivity ranged from 367.5 µS/cm in the spring quarter to 460.9 µS/cm in the summer, indicating low to moderate levels of electrical conducting compounds (salts) were present in the lake system. In general, pH values were neutral to slightly alkaline, ranging from 7.28 to 8.57 units. This is within the range of 6.5 to 9.0 and the lake is fully supporting its FWP beneficial use based on pH. Oxidation-reduction potentials (redox) ranged from 95 mV at the sediment-water interface to 447 mV, both occurring in the summer quarter. The low Redox readings indicate that reducing conditions may have been forming, but were in isolated areas and were not present throughout the reservoir. The lake was thermally stratified between 8 and 9 meters in the summer at sites 1, 2, and 4. Dissolved oxygen (D.O.) fell below 2.0 mg/L from 9 meters in depth to the lake bottom of 10.3, (see Figure 141c). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O.

concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered supported at Lake Thunderbird, as only 47% of the water column was anoxic at site 1, 36% at site 2, 40% at site 4, and 25% at site 5 in the summer. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria for chlorides and sulfates located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E. coli*, fecal coliform and enterococci during the recreation season of May through September. Of the 10 samples collected, only one (1) or 10% of the samples exceed the screening level of 61cfu/ml for enterococci, however the geometric was not exceeded. *E. coli* could not be assessed due to minimum data requirements not being met. The PBCR beneficial use is therefore considered supported for enterococci and fecal coliform.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.78 mg/L at the lake surface. The TN at the surface ranged from 0.59 mg/L in the summer to 1.18 mg/L in the spring. The lake-wide total phosphorus (TP) average was 0.059 mg/L at the lake surface. The surface TP ranged from 0.023 mg/L in the winter to 0.429 mg/L in the spring. The nitrogen to phosphorus ratio (TN: TP) was approximately 13:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Lake Thunderbid was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

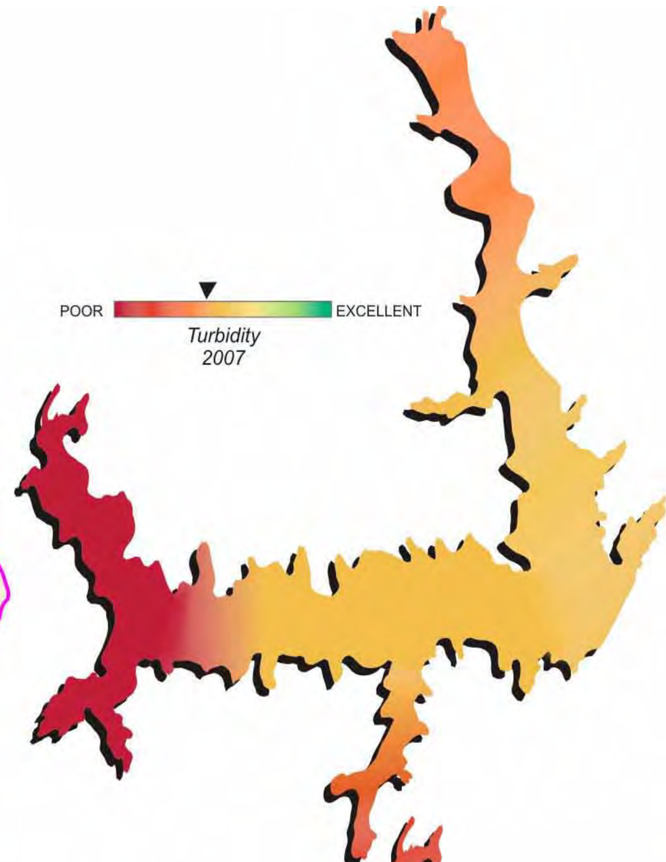
In summary, Lake Thunderbird was eutrophic, indicative of high primary productivity and nutrient conditions (Plate). The calculated TSI was very similar to that sample year 2004 (TSI=56), indicating no significant change in productivity has occurred. Water clarity was average based on secchi disk depth, turbidity and true color values. The lake was fully supporting its Aesthetics beneficial use based on true color. The lake is listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. The lake is also fully supporting its FWP beneficial use based on pH, and dissolved oxygen. With 46% of the turbidity values greater than 25 NTU, the FWP is not supported as it relates to turbidity. Bacteriological samples were also collected to assess the Primary Body contact Recreation (PBCR) beneficial use and it is considered supported for enterococci and fecal coliform and were unable to be determined for *E. coli*. In 2001 a bathymetric survey (Figure 142) was conducted to determine current capacity and assess sedimentation rates due to lake Thunderbird's turbidity problems. For more information on bathymetric mapping visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800.

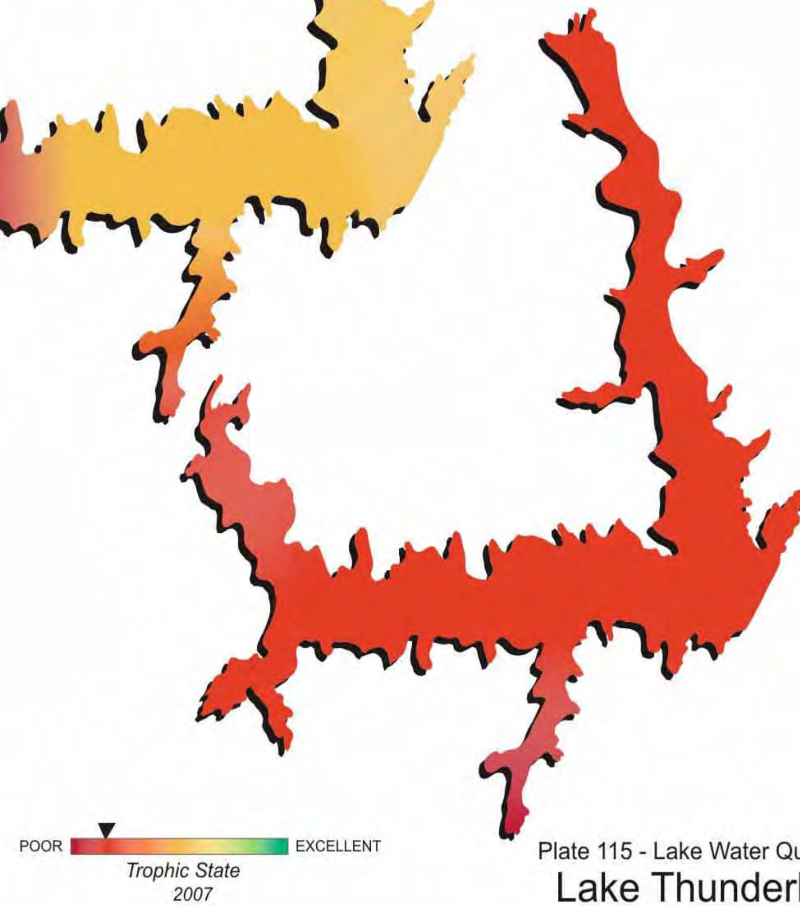
Plate 115 - Lake Water Quality for
Lake Thunderbird

Lake Thunderbird Location

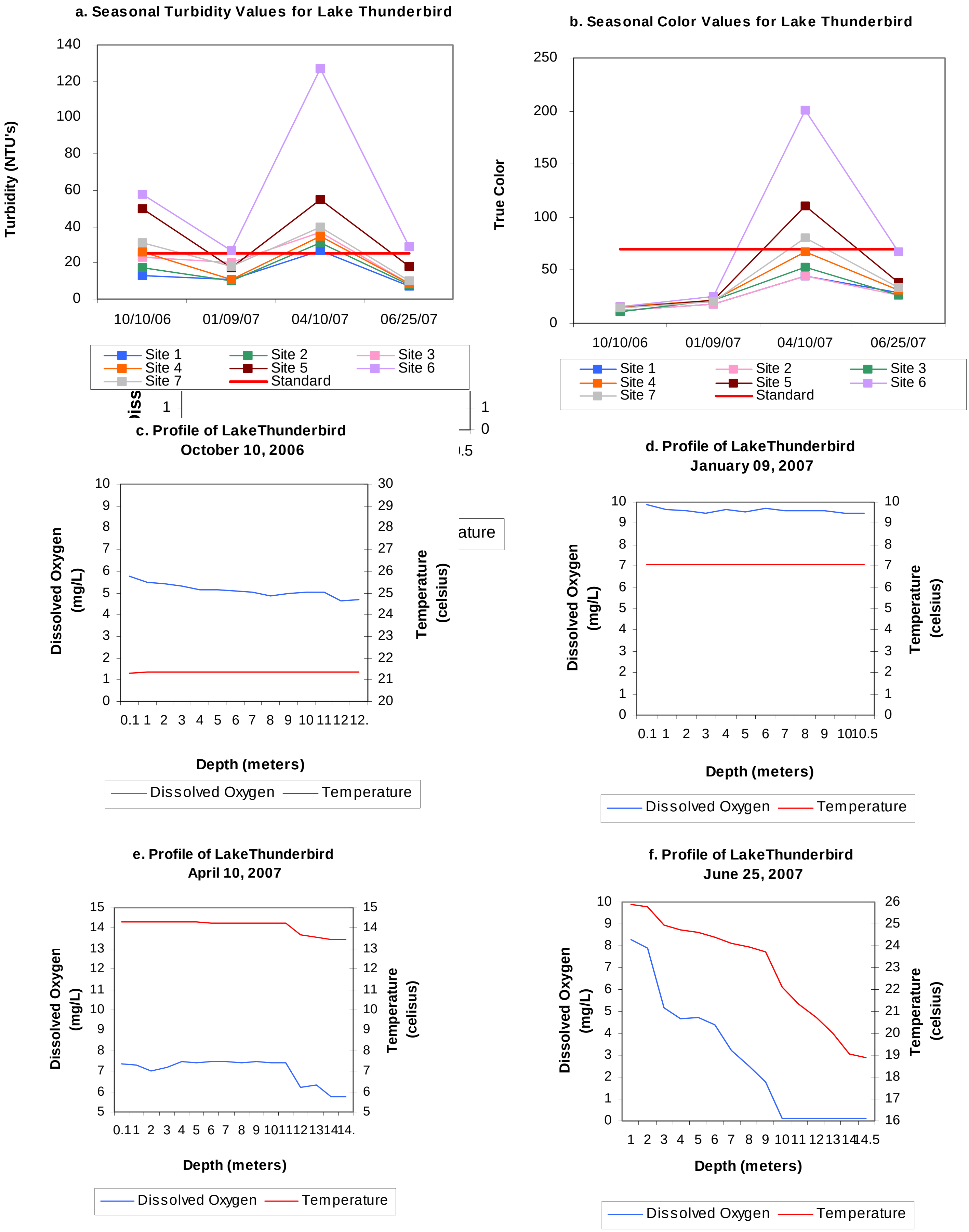
Lake Thunderbird and Watershed

Lake Data	
Constructed by	Bureau of Reclamation
County	Cleveland
Constructed	1965
Surface Area	6,070 acres
Volume	119,600 acre/feet
Shoreline Length	86 miles
Mean Depth	19.70 feet
Watershed Area	256 square miles





LAKES MONITORING PROGRAM



LAKES MONITORING PROGRAM

Figure 141a-141f. Graphical representation of data results for Lake Thunderbird.

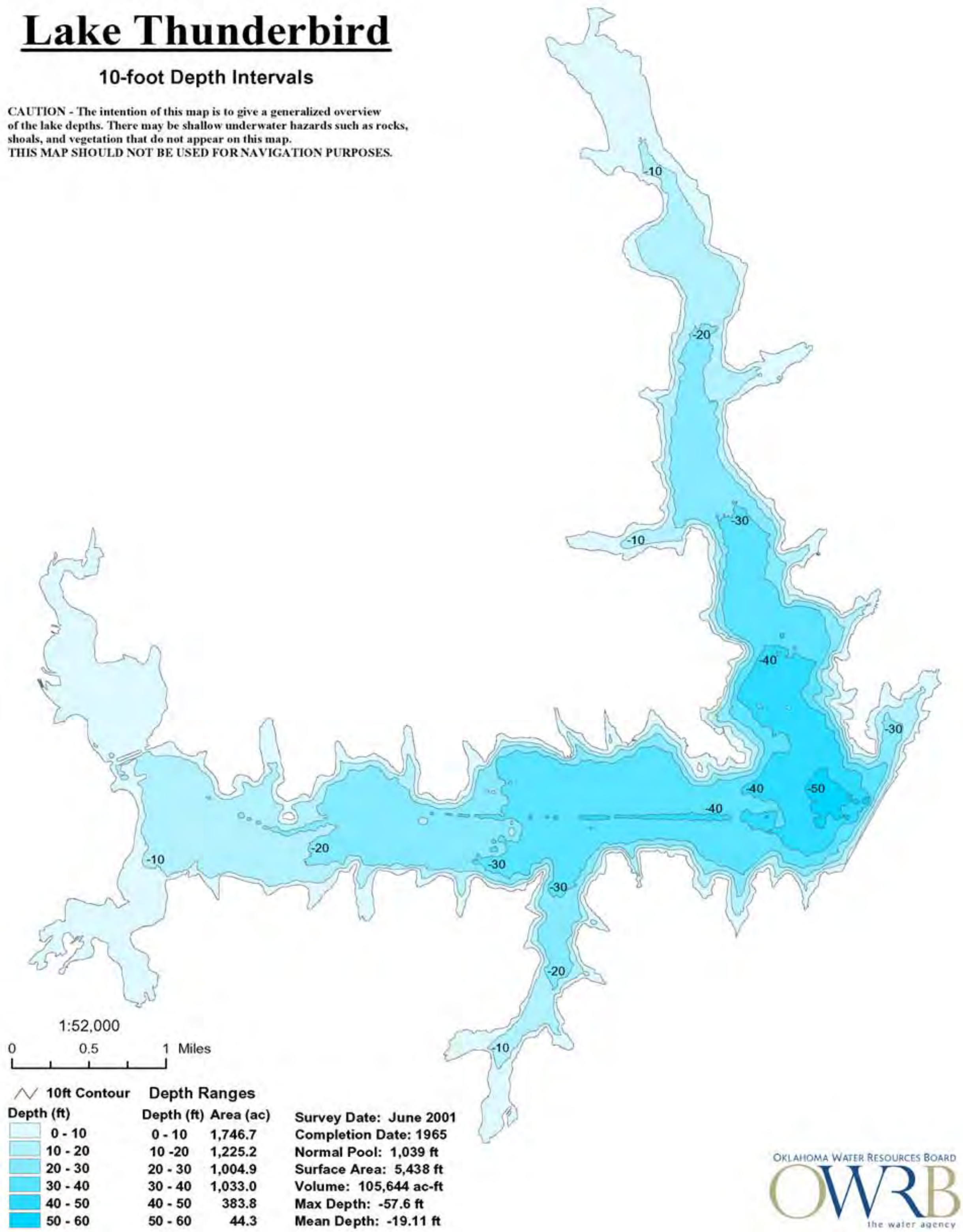


Figure 142. Bathymetric map of Lake Thunderbird.

Tom Steed Reservoir

The Bureau of Reclamation constructed Tom Steed Reservoir for municipal and industrial water supply, flood control, and fish and wildlife purposes. It is a 6,400-acre reservoir located in Kiowa County and was constructed in 1975. Tom Steed Reservoir was sampled for four quarters, from November 2006 through July 2007.

Water quality samples were collected from five (5) sites to represent the riverine, transition, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites. The average lake-wide turbidity was 30 NTU (Plate 116), true color was 40 units, and average secchi disk depth was 57 centimeters. Based on these three parameters Tom Steed Reservoir had poor water clarity in sample year 2007. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a) was calculated using values collected at all sites four quarters (n=20). The TSI was 55 (Plate 116), indicating the lake was eutrophic with excessive primary productivity and nutrient conditions. This is lower than the 2005 assessment (TSI=70) and very similar to the TSI in 2003 (TSI=52). The TSI values were generally upper eutrophic throughout the sample year. Seasonal turbidity values are displayed in Figure 143a. Turbidity values ranged from a low of 6 NTU to a maximum of 62 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if $\geq$ 25% of the samples exceed the screening level prescribed in the Oklahoma Water Quality Standards (WQS) of 25 NTU for turbidity. With 50% of the samples exceeding 25 NTU, the beneficial use of Fish and Wildlife propagation (FWP) should be considered not supported in regards to turbidity. Seasonal true color values are displayed in Figure 143b. True color values average 40 units and all values were below the aesthetics WQS of 70 units. Applying the same default protocol the Aesthetics beneficial use is considered fully supported.

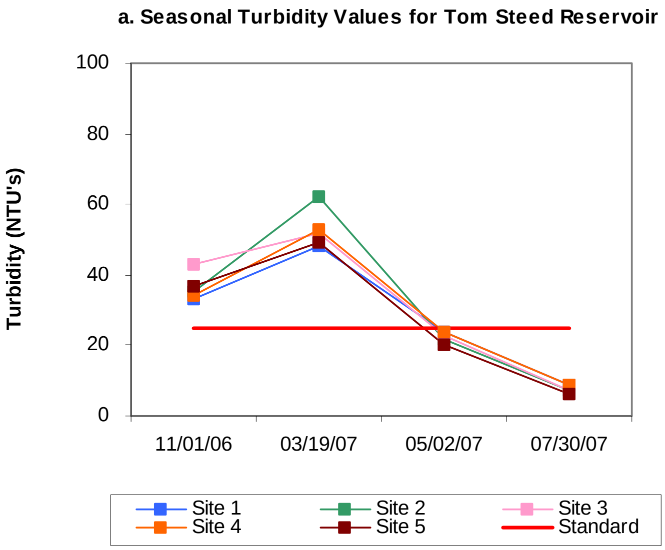
In 2007, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all five sample sites. Salinity values ranged from 0.37 parts per thousand (ppt) to 0.52 ppt for this sample year. Specific conductivity ranged from 722.9 to 1001.0 µS/cm, which is higher than most Oklahoma reservoirs. These values are indicative of moderate to high levels of electrical current conducting compounds (salts) in the lake, consistent with elevated salinity concentrations. The pH values at Tom Steed Reservoir were generally neutral to slightly alkaline, ranging from 7.70 in the spring to 8.55 in the summer. With 100% of the values within the acceptable range (6.5 to 9.0), the lake is supporting the FWP beneficial use based on pH. Oxidation-reduction potentials ranged from 277 mV in autumn to 399 mV in the spring, indicating the absence of reducing conditions during the study period. Due to the shallow nature of the lake, thermal stratification was not present during any of the sampling (see Figure 143c-143e). However, an area of anoxic water did develop during the summer at site 3. This anoxia only represented 25% of the water column and the lake is considered fully supporting its FWP beneficial use based on dissolved oxygen. The lake was also sampled for chlorides, sulfates and total dissolved solids to assess the Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria for these parameters located in OAC 785:45 – Appendix F.

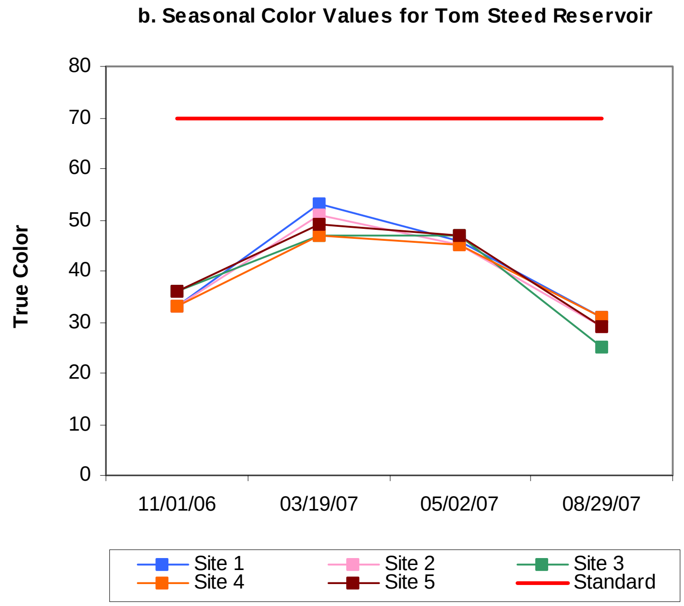
Bacteriological samples were also collected to assess the Primary Body contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E. coli*, fecal coliform and enterococci during the recreation season of May through September. Of the 10 samples collected, none of the samples exceed the screening level of 126cfu/ml for *E. coli*. However, enterococci and fecal coliform could not be assessed due to minimum data requirements not being met. The PBCR beneficial use is therefore considered supported for *E. coli* and undetermined for enterococci and fecal coliform.

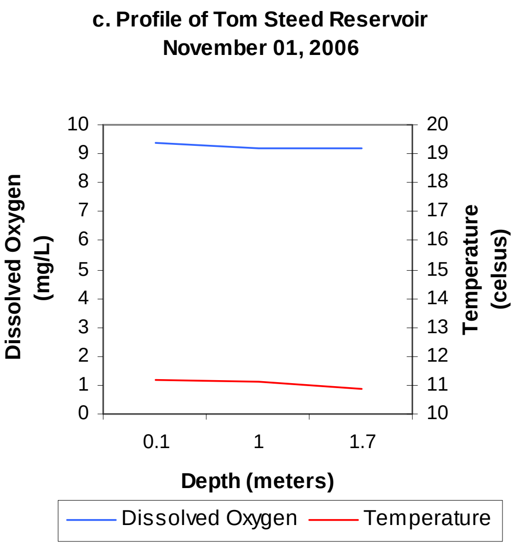
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.78 mg/L at the surface. Surface TN ranged from 0.59 mg/L in the summer to 1.04 mg/L in the spring. The lake-wide total phosphorus (TP) average was 0.066 mg/L at the surface. Total phosphorus at the surface ranged from 0.038 mg/L in the spring to 0.108 mg/L in autumn. The nitrogen to phosphorus ratio (TN:TP) was approximately 12:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

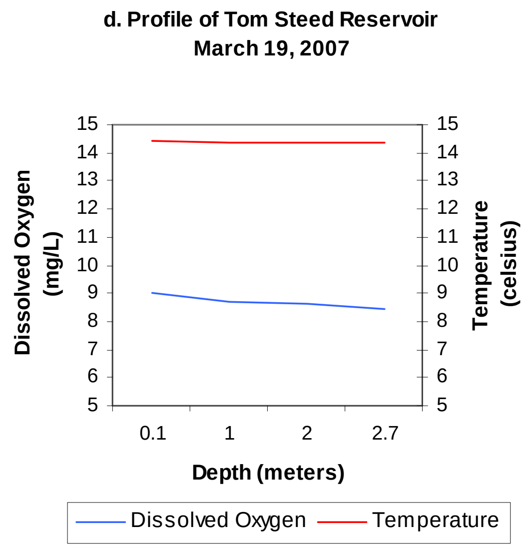
Tom Steed Reservoir was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

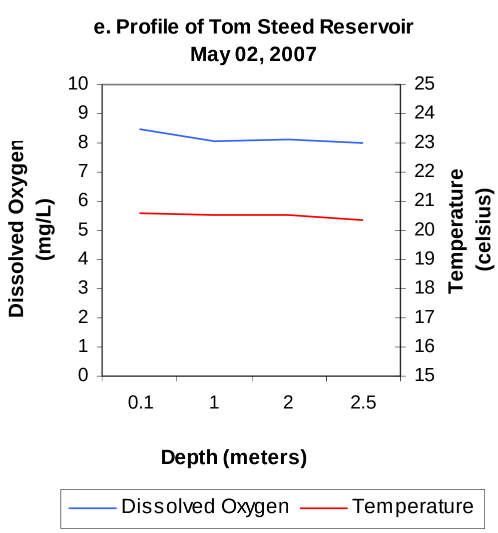
In summary, Tom Steed Reservoir was classified as eutrophic with high primary productivity and nutrient conditions. TSI values were lower than those of 2005 and similar to those in 2003 (TSI=52). Water clarity was poor based on turbidity, true color, and secchi disk depth in 2006-2007. The lake is supporting the FWP beneficial use based on dissolved oxygen and pH, however is not supporting the use with 50% of the turbidity values exceeding the WQS of 25 NTU. The Aesthetics beneficial use is considered supported based on trophic state and true color values reported during the study period. The PBCR is considered supported for *E.coli*; however due to minmum data requirements not being met for fecal coliform and enterococci and assessment of these parameters cannot be made.











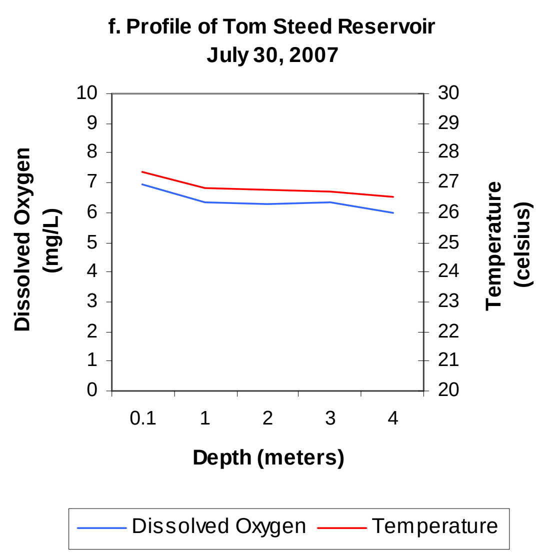
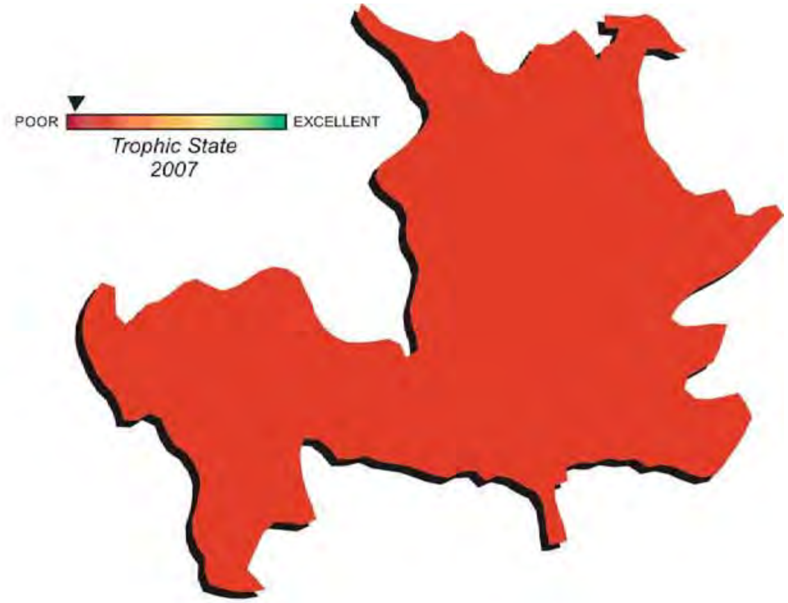


Figure 143a-143f. Graphical representation of data results for Tom Steed Reservoir.

Tom Steed Reservoir and Watershed

Tom Steed Reservoir Location



Lake Data

Constructed by	Bureau of Reclamation
County	Kiowa
Constructed in	1980
Surface Area	6,400 acres
Volume	88,970 acre/feet
Shoreline Length	31 miles
Mean Depth	15.08 feet
Watershed Area	681 square miles

Plate 116 - Lake Water Quality for

Tom Steed Reservoir

Lake Vanderwork

Vanderwork was constructed in 1968 and is owned and operated by the State of Oklahoma. The 135-acre reservoir located in Washita County is managed by the Oklahoma Department Wildlife Conservation and serves as a fishery.

Lake Vanderwork was sampled for four quarters, from September 2003 through June 2004. Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the lake surface at all sample sites and 0.5 meters from the lake bottom at sample site 1. The lake-wide annual turbidity value was 8 NTU (Plate117), true color was 11 units, and secchi disk depth was 71 centimeters in 2003-2004. Based on these three parameters, Lake Vanderwork had average to good water clarity in comparison to other Oklahoma lakes. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 60 (Plate 117), classifying the lake as eutrophic bordering hypereutrophic, indicative of high levels of productivity and nutrient rich conditions. The TSI values varied seasonally with the fall quarter characterized by hypereutrophic conditions and the other three quarters at the upper end of eutrophy bordering at hypereutrophic. These results are slightly lower than in the previous evaluation in 2002 (TSI=63). Lake Vanderwork is currently listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited Watershed (NLW). This listing means the lake is considered threatened due to nutrients and a nutrient impairment study should be initiated to determine if the Aesthetics beneficial use is supporting or not supporting. All turbidity values were below the WQS of 25 NTU (see Figure 144a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Lake Vanderwork is fully supporting its Fish and Wildlife Propagation (FWP) beneficial use based on nephelometric turbidity. Seasonal true color values are displayed in Figure 144b. All true color values were less than the Aesthetics criteria of 70 units, therefore, the use is considered fully supported.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 1.03 parts per thousand (ppt) to 1.09 ppt. Values were higher than the range of expected values for Oklahoma lakes, reflecting the presence of high concentrations of chlorides or other salts in the lake. Specific conductivity values were also elevated above the expected range for Oklahoma reservoirs, indicative of high salinity concentrations. Values ranged from 1923 µS/cm in the spring quarter to 2031 µS/cm at site 1 in the winter, indicating that high levels of electrical conducting compounds (salts) were present in the lake system. Oxidation-reduction potentials (redox) ranged from 377 mV at the sediment-water interface in the winter to 528 mV in the spring, indicating reducing conditions were not present in the lake during the study period. The pH values were neutral to slightly alkaline with values ranging from 7.36 units in the spring quarter to 8.07 recorded in the fall quarter. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. None of the collected pH values were outside the acceptable range; therefore the lake is fully supporting its FWP beneficial use based on pH. Thermal stratification was not evident in the fall, winter, or spring quarters and dissolved oxygen (D.O.) values were above 6.0 mg/L throughout the water column (see Figure 144c-136e). Due to equipment failure there is no profile data available for the summer sampling interval. However it is likely that thermal stratification occurred and anoxic conditions would be present based on seasonality and previous evaluations. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is considered fully supported at Lake Vanderwork with all values in the first three quarters well above 2.0 mg/L. Because the summer profile data is missing an assessment for that season cannot be made at this time. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2003-2004 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for E. coli, fecal coliform and enterococci analysis during the recreation season of May through September. Of the 10 samples collected one (1) or 10% of the samples collected exceed the screening level of 61cfu/ml, however the geometric was not exceeded. The PBCR beneficial use is therefore considered supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 1.40 mg/L at the lake surface and 1.56 mg/L at the lake bottom. The TN at the surface ranged from 1.01 mg/L to 1.77 mg/L. The highest surface TN value was reported in the winter quarter and the lowest was in the summer. The lake-wide total phosphorus (TP) average was 0.044 mg/L at the lake surface and 0.049 mg/L at the lake bottom. The surface TP ranged from 0.007 mg/L to 0.63 mg/L. Both the highest and lowest reported values occurred in the summer. The nitrogen to phosphorus ratio (TN: TP) was approximately 32:1 for sample year 2003-2004. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

In summary, Lake Vanderwork was classified as eutrophic bordering hypereutrophic, indicative of excessive primary productivity and nutrient rich conditions (Plate). The Aesthetics beneficial use is considered fully supported based on true color values, however a determination cannot be made based on trophic status. Currently, the lake is listed in the WQS as a NLW indicating that the Aesthetics beneficial use is considered threatened by nutrients. The lake should be monitored intensively to determine if the Aesthetics beneficial use is supported for nutrients. The FWP beneficial use is fully supported based on nephelometric turbidity, pH, and D.O. concentrations in the water column. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Of the 10 samples collected one (1) or 10% of the samples collected exceed the screening level of 61cfu/ml, however the geometric was not exceeded. The PBCR beneficial use is therefore considered supported. Lake

LAKES MONITORING PROGRAM

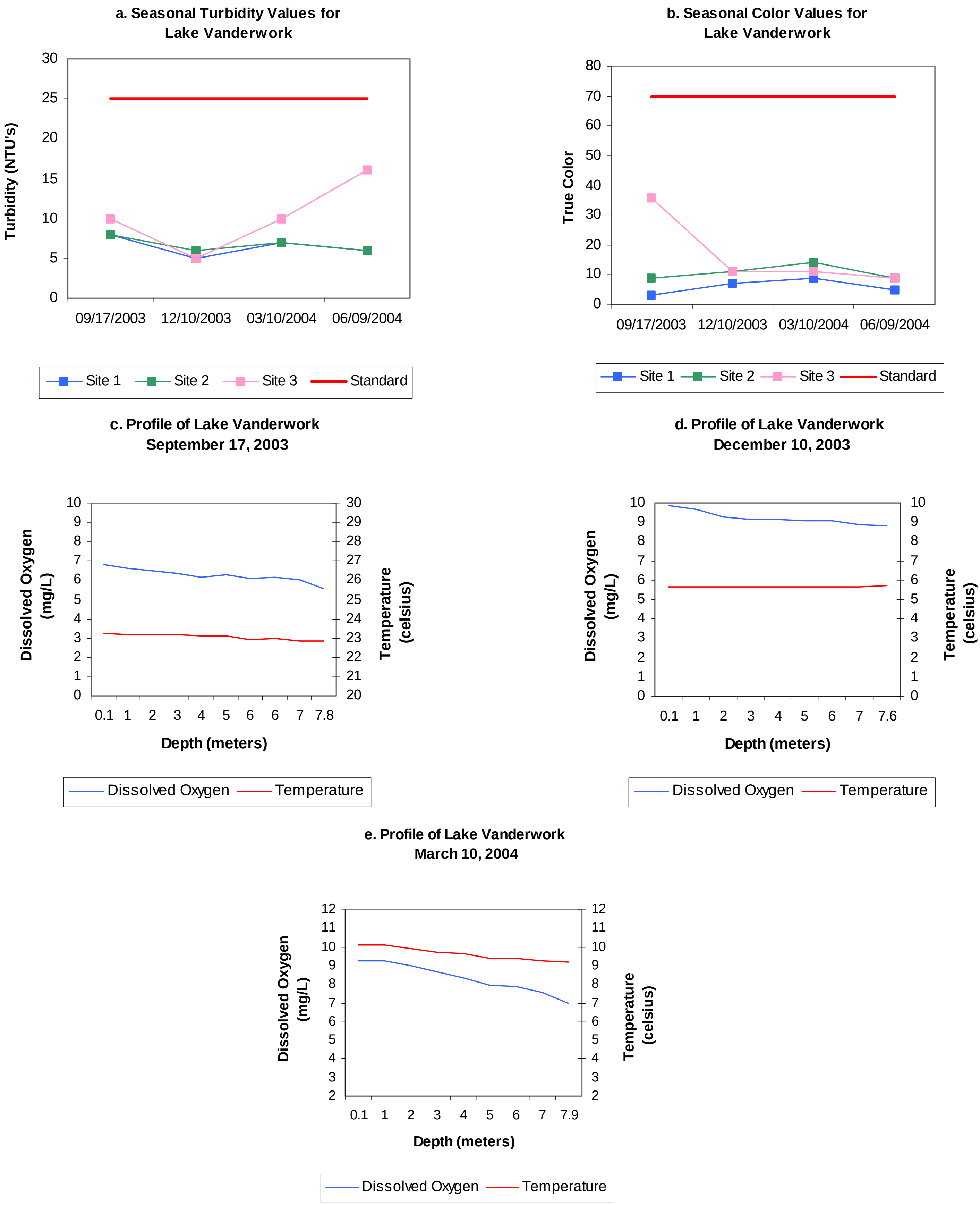
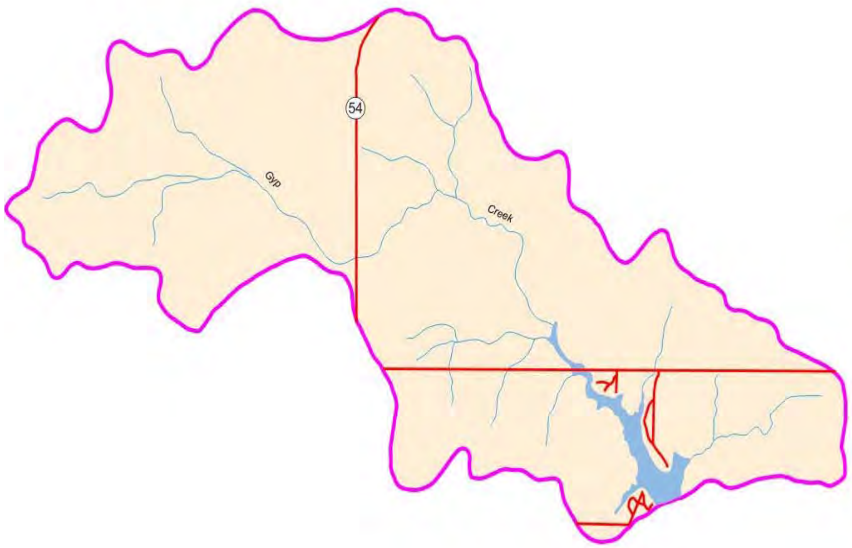


Figure 144a-144e. Graphical representation of data results for Lake Vanderwork.

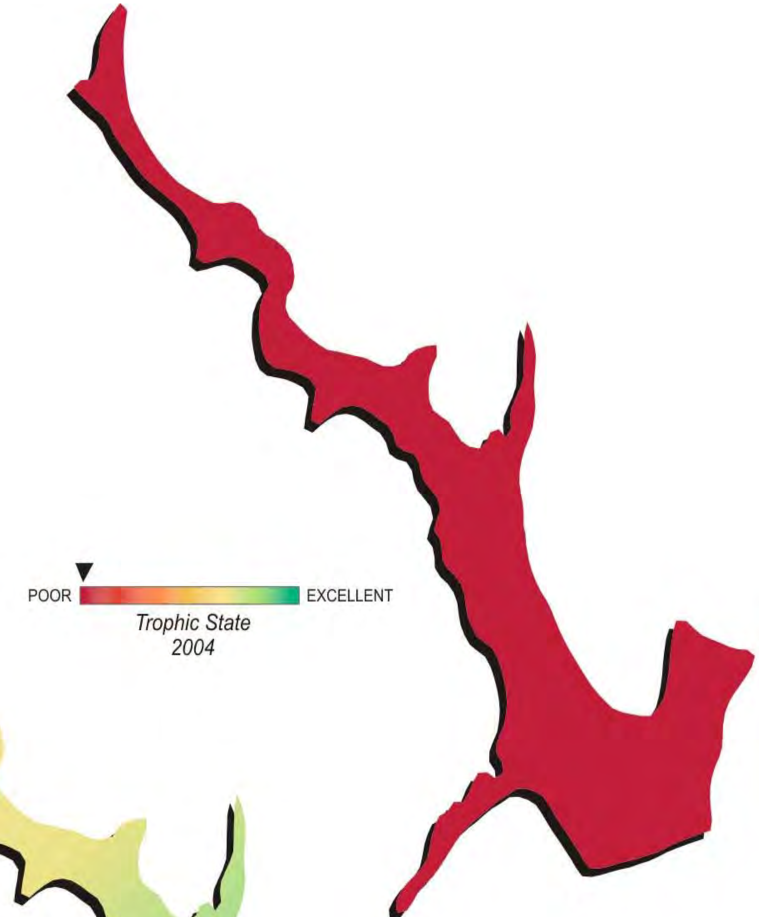
Vanderwork Lake
Location



Vanderwork Lake
and
Watershed

Lake Data

Owner	State of Oklahoma
County	Washita
Constructed in	1968
Surface Area	135 acres
Volume	1,578 acre/feet
Shoreline Length	6 miles
Mean Depth	11.69 feet
Watershed Area	10 square miles



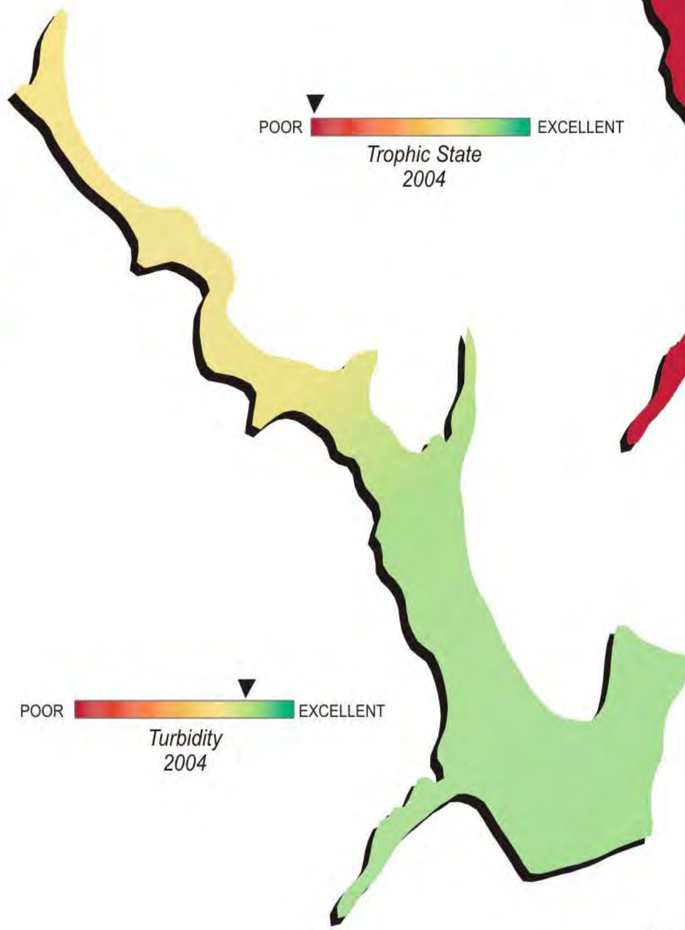


Plate 117 - Lake Water Quality for
Vanderwork Lake

LAKES MONITORING PROGRAM

Lake Vincent

Lake Vincent is a 160-acre reservoir located in Ellis County. It was constructed in 1961 and is managed by the Oklahoma Department of Wildlife Conservation for recreational purposes.

Lake Vincent was sampled for four quarters, from October 2004 through July 2005. Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the lake surface at all sample sites and 0.5 meters from the lake bottom at sample site 1. The average lake-wide turbidity value was 15 NTU (Plate 118), true color was 21 units, and secchi disk depth was 66 centimeters. Based on these three parameters, Lake Vincent had good water clarity in comparison to other Oklahoma lakes. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 44 (Plate 118), classifying the lake as mesotrophic, indicative of moderate levels of productivity and nutrient conditions. This is similar to results in 2003 (TSI=42), indicating no significant increase or decrease in productivity has occurred over time. The TSI values were at the upper end of mesotrophy in both fall and summer and oligotrophic during winter and spring sampling intervals Seasonal turbidity values are displayed in Figure 145a. Turbidity values ranged from a low of 6 NTU to a maximum of 34 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the collected values below the WQS of 25 NTU, Lake Vincent is fully supporting its Fish and Wildlife Propagation (FWP) beneficial use based on turbidity. Seasonal true color values are displayed in Figure 145b. All true color values were less than the Aesthetics criteria of 70 units, therefore, the use is considered fully supported.

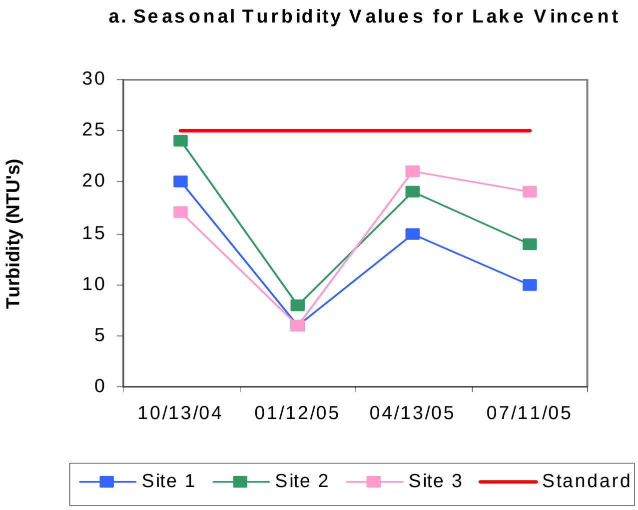
In 2004-2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.39 parts per thousand (ppt) to 0.41 ppt, which is higher than the average range of values recorded in Oklahoma reservoirs. Specific conductivity ranged from 746.4 µS/cm to 784.5 µS/cm, indicative of moderate to high levels of current conducting ions (salts) in the lake system. The pH values ranged from 7.38 to 8.48, representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With all of the collected values within the acceptable range, the lake is supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (ORP) ranged from 108 mV in the hypolimnion in the summer to 526 mV in the spring. In general, reducing conditions were not present with recorded values above 100 mV during the study period. The lake was not stratified during the fall, winter, or spring sampling quarters and the water column was well mixed (see Figure 145c-

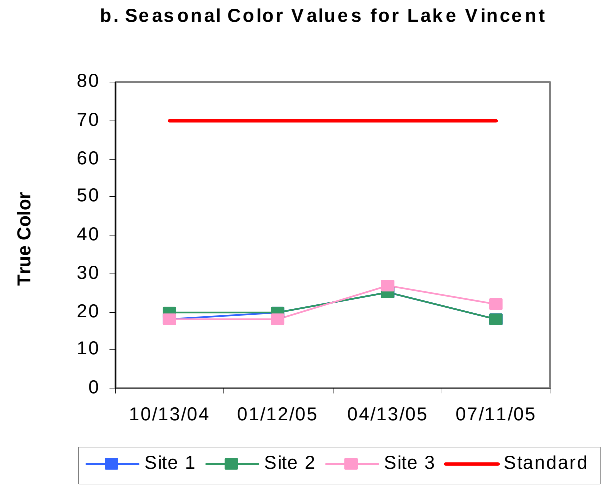
137e). In the summer, thermal stratification was evident and anoxic conditions were present below the thermocline. The lake was stratified between 4 and 5 meters throughout the lake, with dissolved oxygen less than 2.0 mg/L from 6 meters to the lake bottom of 10 meters. Approximately 50% of the water column, at site 1 experienced anoxic conditions during the summer quarter (Figure 145f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With 50% of the collected dissolved oxygen values below 2.0 mg/L, Lake Vincent is considered partially supporting the FWP beneficial use. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

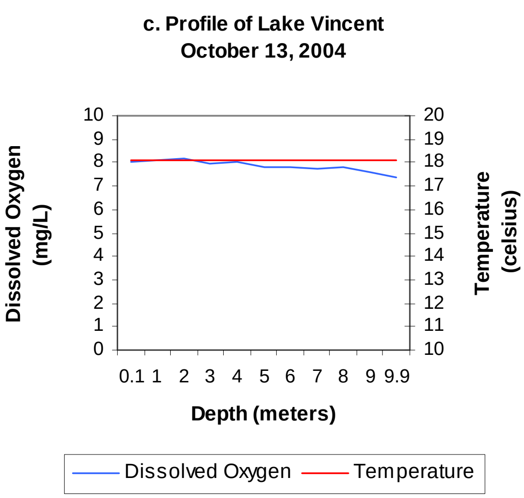
Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

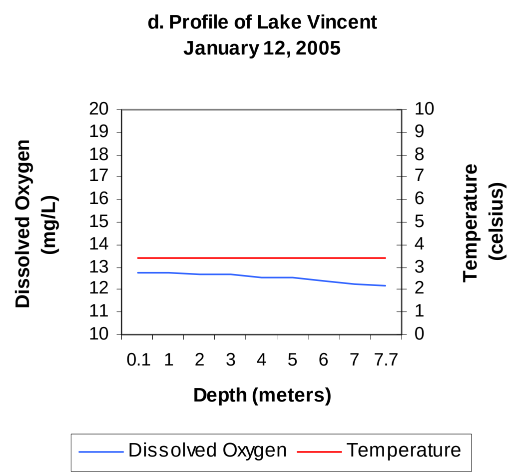
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.52 mg/L at the surface. Surface TN ranged from 0.36 mg/L to 0.70 mg/L, with the highest values reported in the fall and lowest values in the winter quarter. The lake-wide total phosphorus (TP) average was 0.029 mg/L at the surface. Total phosphorus at the surface ranged from 0.020mg/L to 0.038 mg/L. Surface TP was highest in the fall and summer, while the lowest values were recorded during the spring quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 18:1 for sample year 2004-2005. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

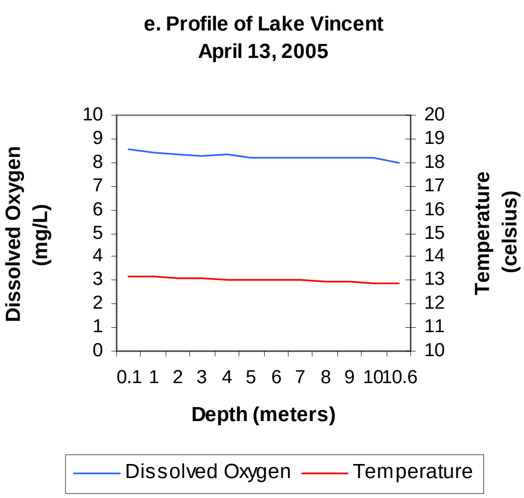
In summary, Lake Vincent was classified as mesotrophic, indicative of moderate primary productivity and nutrient conditions (Plate 118). This is consistent with past data collection efforts in 2003 (TSI=42), indicating that no significant increase or decrease in productivity has occurred over time. Water clarity was good based on true color, turbidity, and secchi disk depth. The FWP beneficial use is fully supported based on turbidity and pH, but only partially supported based on anoxic conditions present in 50% of the water column during the summer. The Aesthetics beneficial use is fully supported based on its trophic status as well as true color with 100% of the reported values less than the WQS of 70 units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.











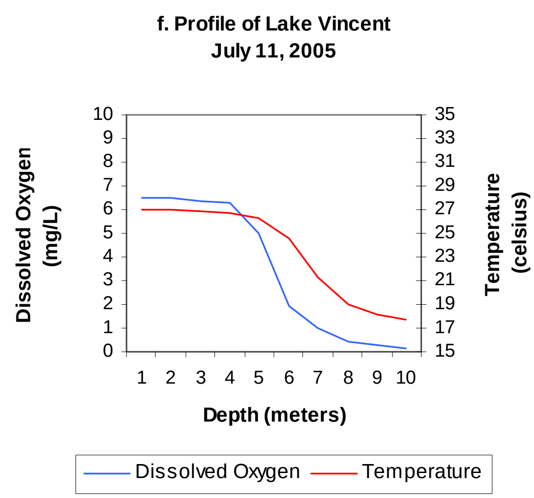
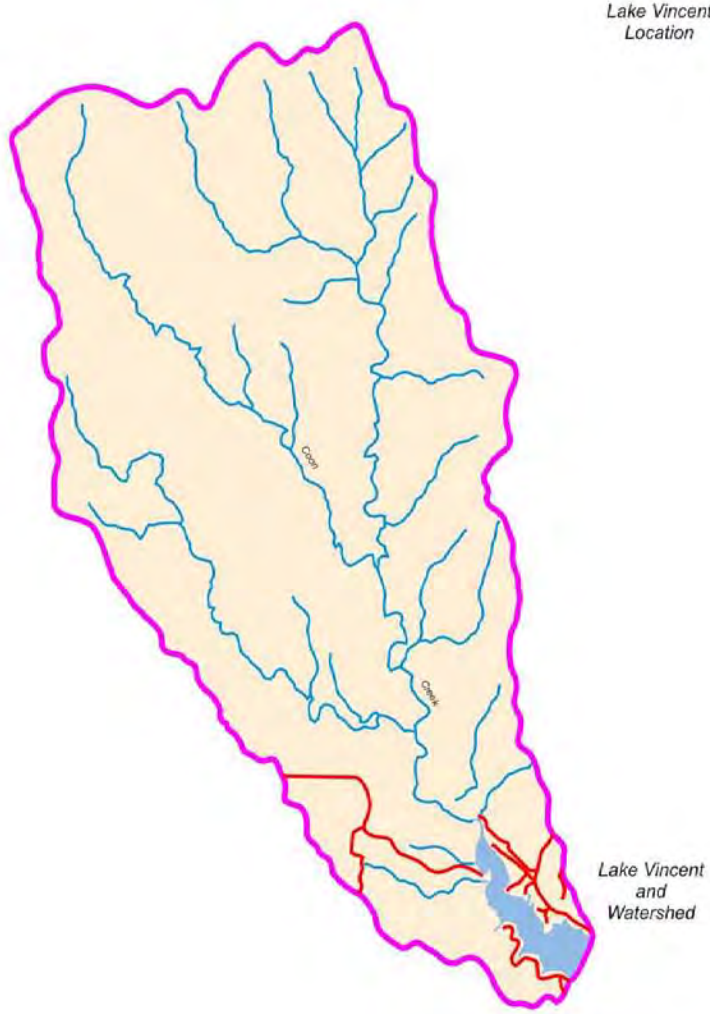


Figure 145a145f. Graphical representation of data results for Lake Vincent.



Lake Data

Owner	State of Oklahoma
County	Ellis
Constructed in	1961
Surface Area	160 acres
Volume	2,579 acre/feet
Shoreline Length	5 miles
Mean Depth	16.12 feet
Watershed Area	13 square miles

Plate 118 - Lake Water Quality for

Lake Vincent

W.R. Holway Reservoir

W.R. Holway Reservoir is owned by the Grand River Dam Authority (GRDA) and serves as a water supply, hydroelectric, and recreational reservoir. It is a 712-acre reservoir located in Mayes County. W.R. Holway Reservoir was sampled for four quarters, from November 2006 through August 2007.

Water quality samples were collected from five (5) sites to represent the riverine, transition, and lacustrine zone of the reservoir. Samples were collected from the lake surface at all sites. The average lake-wide turbidity was 4 NTU (Plate 119), true color was 24 units, and average secchi disk depth was 161 centimeters. Based on theses three parameters, W.R. Holway Reservoir had excellent water clarity, similar to that in 2005 and 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 58 (Plate 119), classifying the lake as eutrophic, with moderate levels of productivity and nutrient conditions. The TSI values ranged from mesotrophy in the winter to hypereutrophy in the spring. Seasonal turbidity values are displayed in Figure 146a. Turbidity values ranged from a low of 2 NTU to a maximum of 7 NTU. With all collected values well below the WQS of 25 NTU, W.R. Holway is fully supporting its Fish and Wildlife Propagation (FWP) beneficial use in regards to turbidity. Seasonal true color values are displayed in Figure 146b. All true color values were less than the Aesthetics criteria of 70 units, therefore the beneficial use is considered supported.

In 2007, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.09 parts per thousand (ppt) to 0.16 ppt, which is within the average the range of values recorded in Oklahoma reservoirs. Specific conductivity ranged from 190.1 µS/cm to 322.2 µS/cm, indicating the presence of low to moderate levels of current conducting ions (salts) in the lake system. The pH values ranged from 7.10 in the fall to 9.25 in the summer. The high pH values occurred during the spring and summer in the surface waters and never accounted for more than 8% above the standard (range of 6.5 to 9.0). Therefore, the FWP is supported based on pH. Oxidation-reduction potentials (ORP) ranged from 263 mV to 514 mV, indicating reducing conditions were not present at this reservoir during any of the sampling intervals. The lake was still well mixed during the autumn, winter, and spring quarters with no anoxia present (Figure 146c-146e). In the summer, thermal stratification was evident and anoxic conditions were present below the thermocline, as is to be expected in a reservoir this deep (Figure 146f). Anoxia occurred below 21 meters deep at the surveyed sites to the lake bottom (47.7 meters at site 1). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Currently, W.R. Holway Reservoir considered partially supporting the FWP beneficial use with up to 55% of the water column experiencing anoxic conditions. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E. coli*, fecal coliform and enterococci during the recreation season of May through September. Of the 10 samples collected, none of the samples exceed the prescribed screening level or geometric mean. The PBCR is considered supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.80 mg/L at the surface. Surface TN ranged from 0.52 mg/L to 1.35 mg/L. The lake-wide total phosphorus (TP) average was 0.061 mg/L at the surface. Total phosphorus at the surface ranged from 0.022 mg/L to 0.088 mg/L. The nitrogen to phosphorus ratio (TN:TP) was approximately 13:1 for sample year 2006-2007. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

W.R. Holway Reservoir was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, W.R. Holway Reservoir was classified as eutrophic, indicative of high primary productivity and nutrient conditions in 2006-2007. Water clarity continues to be excellent based on true color, turbidity, and secchi disk depth. The FWP beneficial use is considered fully supported based on turbidity and pH, and partially supporting for dissolved oxygen levels during the study period. The Aesthetics beneficial use is supported based on its trophic status and true color as all values were well below the WQS of 70 units. Bacteriological samples collected during the 2007 recreation season for the Primary Body Contact Recreation (PBCR) beneficial use. With all samples below the prescribed screening level and geometric mean, the PBCR is considered supported.

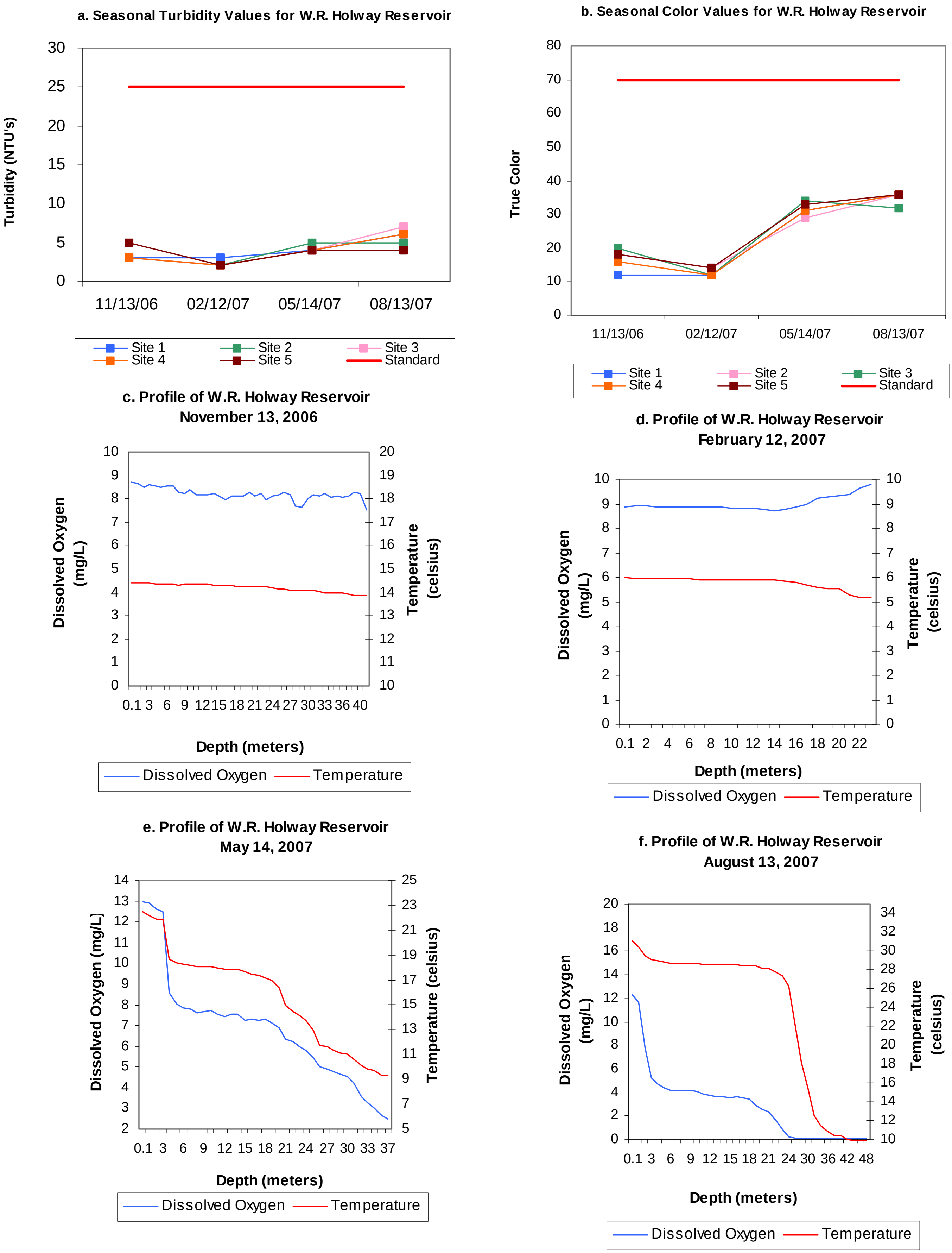
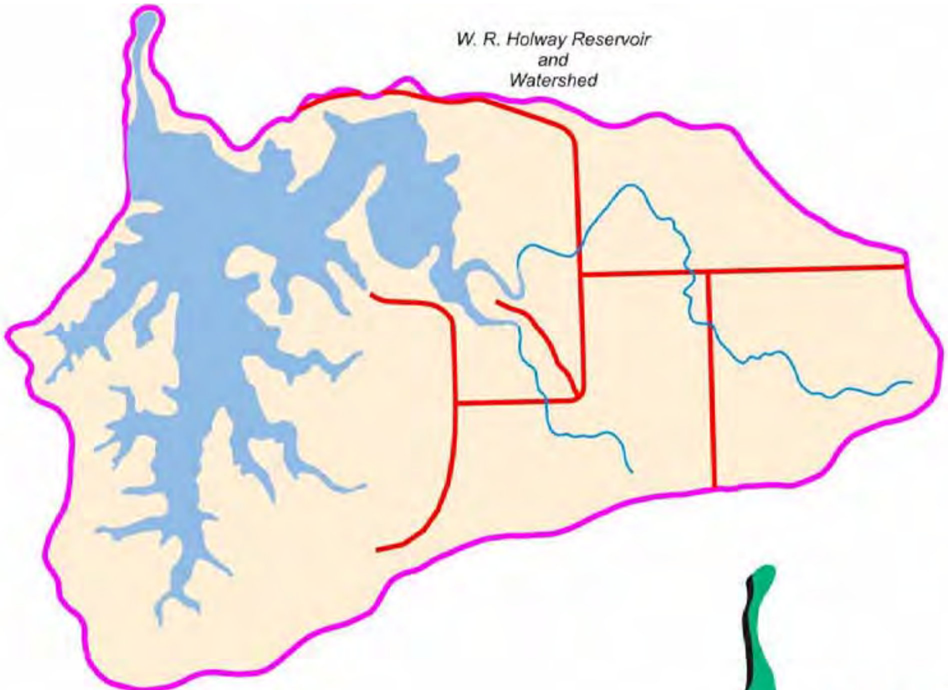


Figure 146a-146e. Graphical representation of data results for W.R. Holway Reservoir.



Lake Data	
Owner	GRDA
County	Mayes
Constructed in	1968
Surface Area	712 acres
Volume	48,000 acre/feet
Shoreline Length	21 miles
Mean Depth	67.42 feet
Watershed Area	3490 acres

Plate 119- Lake Water Quality for

W. R. Holway Reservoir

Waurika Lake

Waurika Lake, 10,100-acre reservoir located in Jefferson County, was constructed by the United States Army Corps of Engineers (USACE) in 1977 and is utilized for flood control, irrigation, water supply and quality and recreational purposes. Waurika Lake was sampled for four quarters, from October 2004 through July 2005.

Water quality samples were collected from five (5) sites to represent the riverine, transition, and lacustrine zone of the reservoir. Samples were collected from the lake surface at all sites and at 0.5 meters from the lake bottom at site 1, the dam. The average lake-wide turbidity was 22 NTU (Plate 121), true color was 27 units, and average secchi disk depth was 59 centimeters. Based on these three parameters, Waurika Lake had average water clarity in 2004-2005. Results are similar to those reported during the previous evaluation in 2003. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 60 (Plate 121), classifying the lake as eutrophic bordering hypereutrophic, with high levels of primary productivity and nutrient conditions. This is higher than results in 2003 (TSI=56), however it is still in the same trophic category. The TSI values were primarily upper eutrophic to hypereutrophic throughout the sample year. The only exception being site 4, which had a low chlorophyll-a value reported in the winter quarter, placing the site in the mesotrophic category for this sampling interval. Turbidity values ranged from a low of 5 NTU to a maximum of 94 NTU with higher values reported at sites 4 and 5 in the upper end of the reservoir (Figure 147a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 20% of the values exceeding the WQS of 25 NTU, Waurika Lake is partially supporting its Fish and Wildlife Propagation (FWP) beneficial use in regards to turbidity. Seasonal true color values are displayed in Figure 147b. Only 1 of the true color values exceeded the Aesthetics criteria of 70 units, therefore the beneficial use is considered supported.

In 2004-2005, vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.22 parts per thousand (ppt) to 0.35 ppt, which is slightly higher than the average range of values recorded in Oklahoma reservoirs. Specific conductivity ranged from 443.3 µS/cm to 684.9 µS/cm, indicating the presence moderate levels of current conducting ions (salts) in the lake system. The pH values ranged from 7.24 to 8.75representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the collected values within the acceptable range the lake is supporting the FWP beneficial use based on pH. Oxidation-reduction potentials (ORP) ranged from 86 mV to 451 mV, indicating reducing conditions were not present in this reservoir the time of sampling. The only instance an ORP value was below 100 mV occurred at site 1 during the fall quarter and is likely the result of the Hydrolab probe resting on the lake bottom. In the fall winter, and spring intervals stratification was not evident and the water column was well mixed with dissolved oxygen (D.O.) values generally above 5.0 mg/L (Figure 147c-139e). In the summer, thermal stratification was evident and anoxic conditions were present below the thermocline, at both sites 1 and 2 (Figure 147f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With 10 to 28.6% of the water column less than 2.0 mg/L in the summer, Waurika Lake is considered supporting the FWP beneficial use. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.78 mg/L at the surface. Surface TN ranged from 0.64 mg/L to 1.05 mg/L; with the highest value reported at site 4 in the winter and lowest value occurred at site 1 in the summer quarter. The lake-wide total phosphorus (TP) average was 0.085 mg/L at the surface. Total phosphorus at the surface ranged from 0.052mg/L to 0.143 mg/L. Surface TP was highest in the winter, and the lowest values were recorded during the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 9:1 for sample year 2004-2005. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

In summary, Waurika Lake was classified as eutrophic, classifying the lake as eutrophic bordering hypereutrophic, with high levels of primary productivity and nutrient conditions (Plate 121). This is higher than results in 2003 (TSI=56), however it is still in the same trophic category. Based on turbidity, true color, and secchi disk depth, water clarity was average in comparison to other Oklahoma reservoirs. The FWP beneficial use is supported based on pH and dissolved oxygen, but only partially supporting the use based on turbidity with 20% of the reported values greater than 25 NTU. The lake is supporting the Aesthetics beneficial use based on its trophic status and reported true color values, as 95% of the color values were less than the WQS of 70 units. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

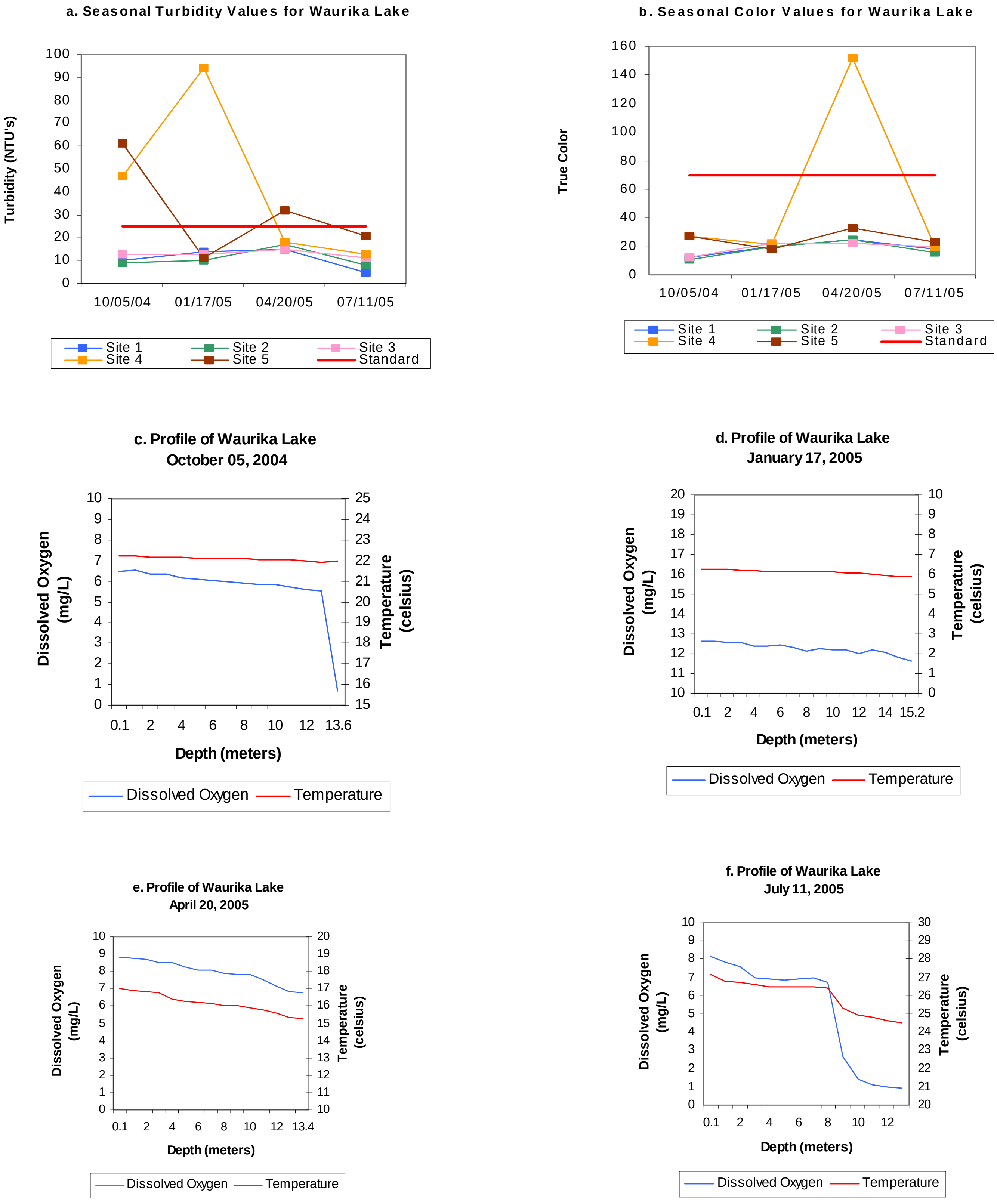
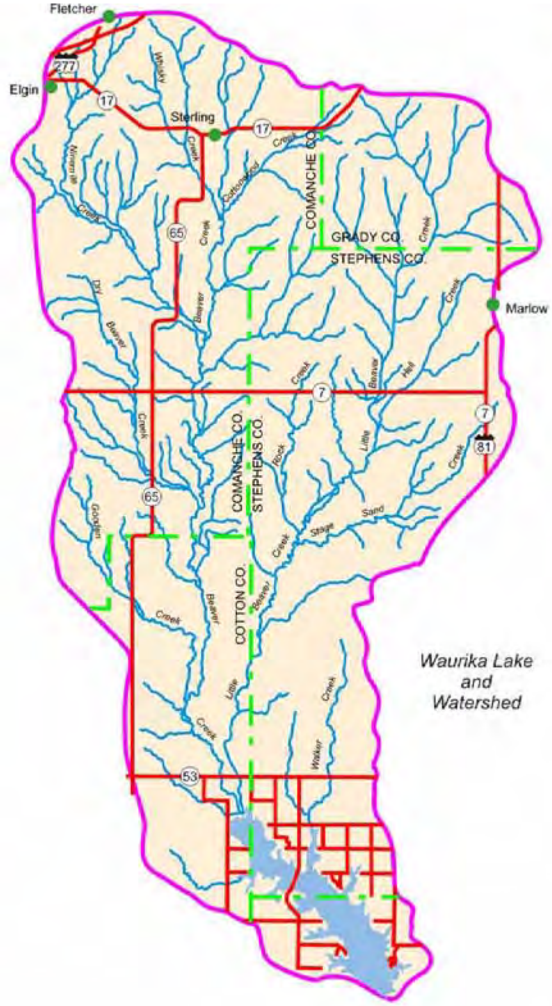
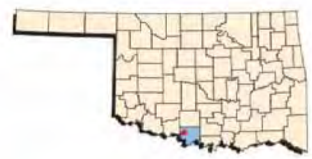


Figure 147a-147f. Graphical representation of data results for Waurika Lake.

Plate 121 - Lake Water Quality for
Waurika Lake



Waurika Lake and Watershed



Waurika Lake Location

Trophic State 2005

Turbidity 2005

Lake Data	
Constructed by	Corps of Engineers
County	Jefferson
Constructed in	1980
Surface Area	10,100 acres
Volume	203,100 acre/feet
Shoreline Length	80 miles
Mean Depth	19.4 feet
Watershed Area	562 square miles

LAKES MONITORING PROGRAM

Lake Waxhoma

Lake Waxhoma, located in Osage County, was constructed in 1955 and is owned and operated by the City of Barnsdall. The 197-acre reservoir is managed as a municipal water supply and offers numerous recreational opportunities to the public. Lake Waxhoma was sampled for four seasons extending from October 2005 through July 2006.

Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 5 NTU (Plate 122), true color was 18 units, and secchi disk depth was 153 centimeters. Based on these three parameters, Lake Waxhoma had excellent water clarity, better than that observed in sample year 2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=11). The average TSI was 45 (Plate 122), classifying the lake as mesotrophic, indicative of moderate levels of productivity and nutrient rich conditions. Due to a laboratory accident no data is available for site 2 from winter data collection efforts. The current TSI value is consistent with previous monitoring results from 2003-2004 where the calculated TSI was also mesotrophic (TSI=43). The TSI varied seasonally with the lake being at the lower end of mesotrophy in the fall and winter quarters and oligotrophic in the spring. During the summer quarter the lake was again experiencing mesotrophic conditions. The exception this occurred at site 2, which had slightly higher a chlorophyll-a concentration, placing it in the eutrophic category during the spring sampling interval. None of the 12 turbidity samples collected for the nephelometric turbidity exceeded the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 148a). With 100% of the values below 25NTU, the lake is considered supporting the Fish & Wildlife Propagation (FWP) beneficial use based on turbidity. Seasonal true color values are displayed in Figure 148b. Similar to turbidity, all true color values wee below the numeric criteria, therefore the Aesthetics beneficial use is considered supported at Lake Waxhoma.

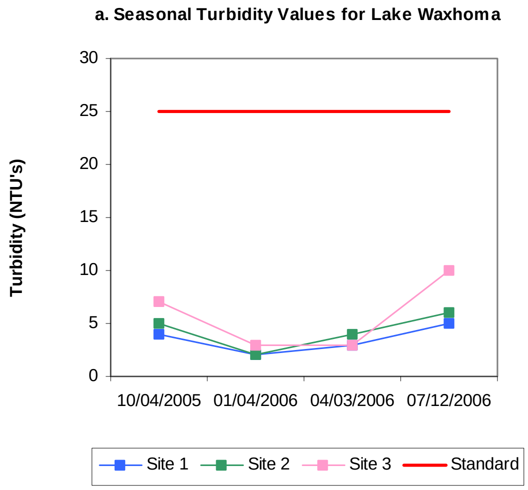
Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites in during the sample year. Salinity values ranged from 0.09 parts per thousand (ppt) to 0.111 ppt. Salinity readings were within the range of expected values for Oklahoma lakes and reflected the presence of minimal amounts of chlorides or other salts in the lake. Specific conductivity values were also well within the range of values recorded in Oklahoma reservoirs, if not slightly lower. Values ranged from 187.6 µS/cm recorded in the winter quarter to 231.6 µS/cm in the summer, indicating low levels of electrical conducting compounds (salts) were present in the lake. Oxidation-reduction potentials (redox) ranged from 135 mV at the sediment-water interface in the summer to 438 mV in the fall. Redox showed that reducing conditions were not present in the lake during the study period. The pH values were neutral to slightly alkaline with values ranging from 6.77 to 8.27 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. Lake Waxhoma is supporting its FWP beneficial use for pH as all collected data fell within the allowable range. Thermal stratification was not evident in the lake in the winter or spring quarters and dissolved oxygen (D.O.) values were above 8.0 mg/L throughout the water column at all sites (see Figure 148d-140e). In the fall quarter the lake was thermally stratified between 6 and 7 meters below the lake surface, with D.O. values falling below 2.0 mg/L at site 1, the dam (see Figure 148c). The lake was also strongly thermally stratified in the summer quarter between 3 and 4 meters below the lake surface. From the 5-meter depth at site 1 to the lake bottom at 11.4 meters, all recorded D.O. values were less than 2.0 mg/L (see Figure 148f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is partially supported at Lake Waxhoma as 36% of the water column had D.O. values less than 2.0 mg/L in the fall and 14-62% in the summer. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F

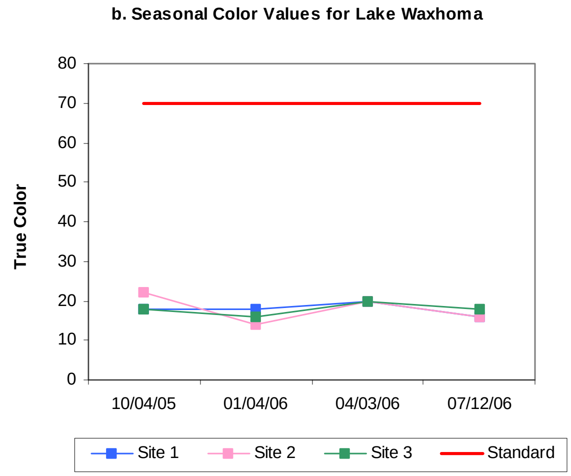
Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

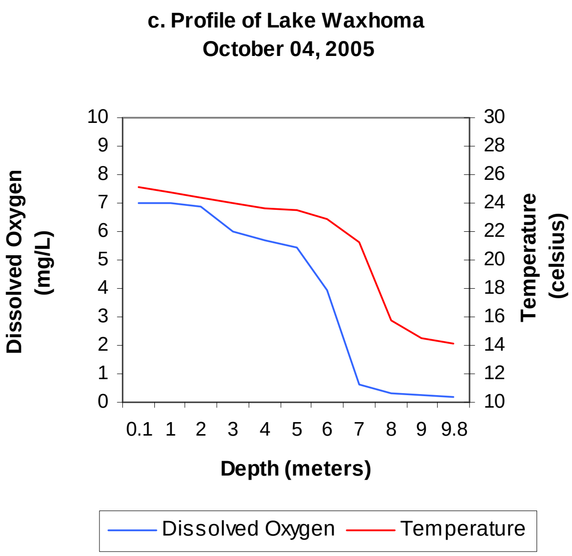
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.32 mg/L for sample year 2006. The TN at the surface ranged from 0.15 mg/L to 0.49 mg/L. The highest surface TN value was reported in the summer quarter and the lowest was in the fall. The lake-wide total phosphorus (TP) average was 0.023 mg/L at the lake surface. The surface TP ranged from 0.011 mg/L to 0.023 mg/L. The highest surface TP value was reported in the summer and the lowest was in the fall quarter. The nitrogen to phosphorus ratio (TN: TP) was approximately 14:1 for sample year 2003-2004. This value is higher than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

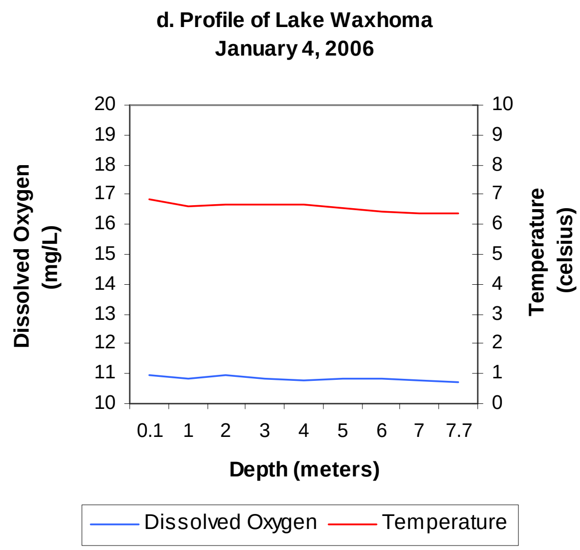
Lake Waxhoma was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

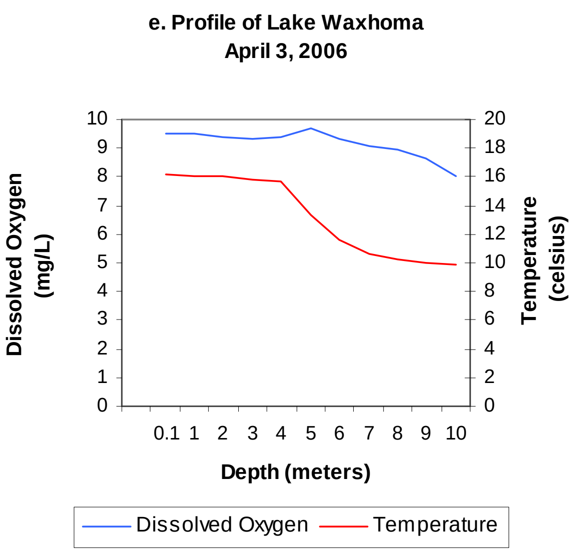
In summary, Lake Waxhoma was classified as mesotrophic, indicative of moderate levels of primary productivity and nutrient conditions (Plate 122). Based on turbidity, true color, and secchi disk depth water clarity, Lake Waxhoma had excellent water clarity, better than that observed in sample year 2004. The lake was fully supporting its FWP beneficial use for pH and turbidity, however is partially supported based on anoxic conditions present in the summer sampling interval. The lake was fully supporting its Aesthetics beneficial use based on its trophic status as well as true color with 100% of the color values were well below the numerical criteria of 70 units. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.











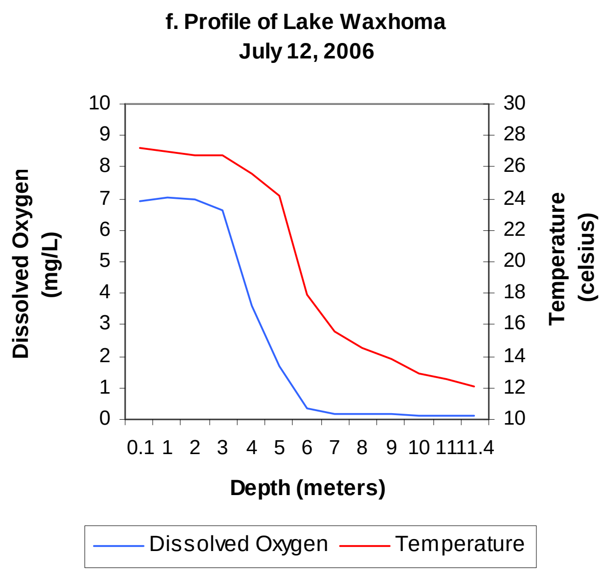
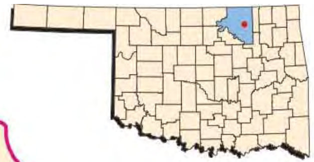
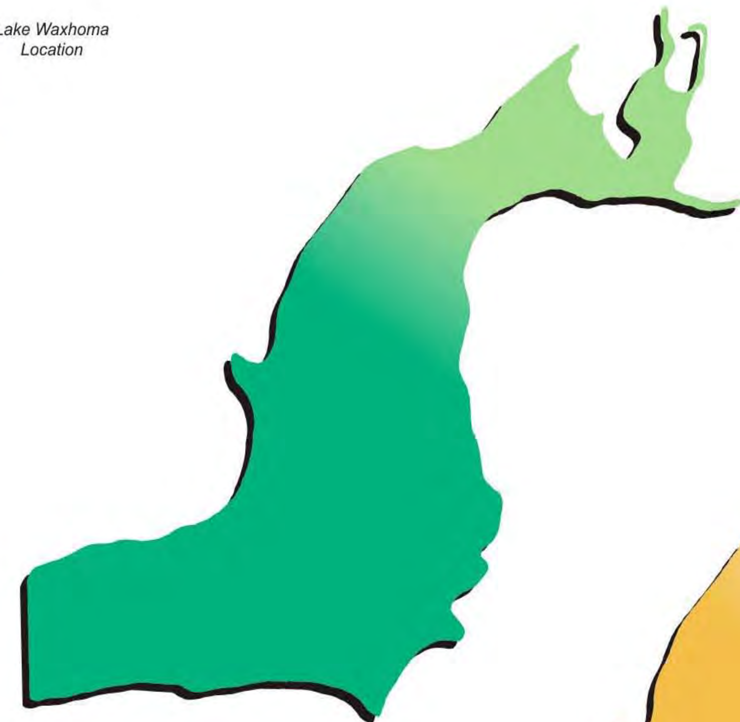


Figure 148a-148f. Graphical representation of data results for Lake Waxhoma.





POOR EXCELLENT

Turbidity
2006

POOR EXCELLENT

Trophic State
2006

Lake Data

Owner	City of Barnsdall
County	Osage
Constructed	1955
Surface Area	197 acres
Volume	2,000 acre/feet
Shoreline Length	3 miles
Mean Depth	10.15 feet
Watershed Area	2,467 acres

Plate 122 - Lake Water Quality for
Lake Waxhoma

Lake Wayne Wallace

Lake Wayne Wallace, located in Latimer County is owned by the State of Oklahoma and is utilized for flood control and recreation purposes. The 94-acre reservoir was constructed in 1969. Lake Wayne Wallace was sampled for four quarters, from October 2004 through July 2005.

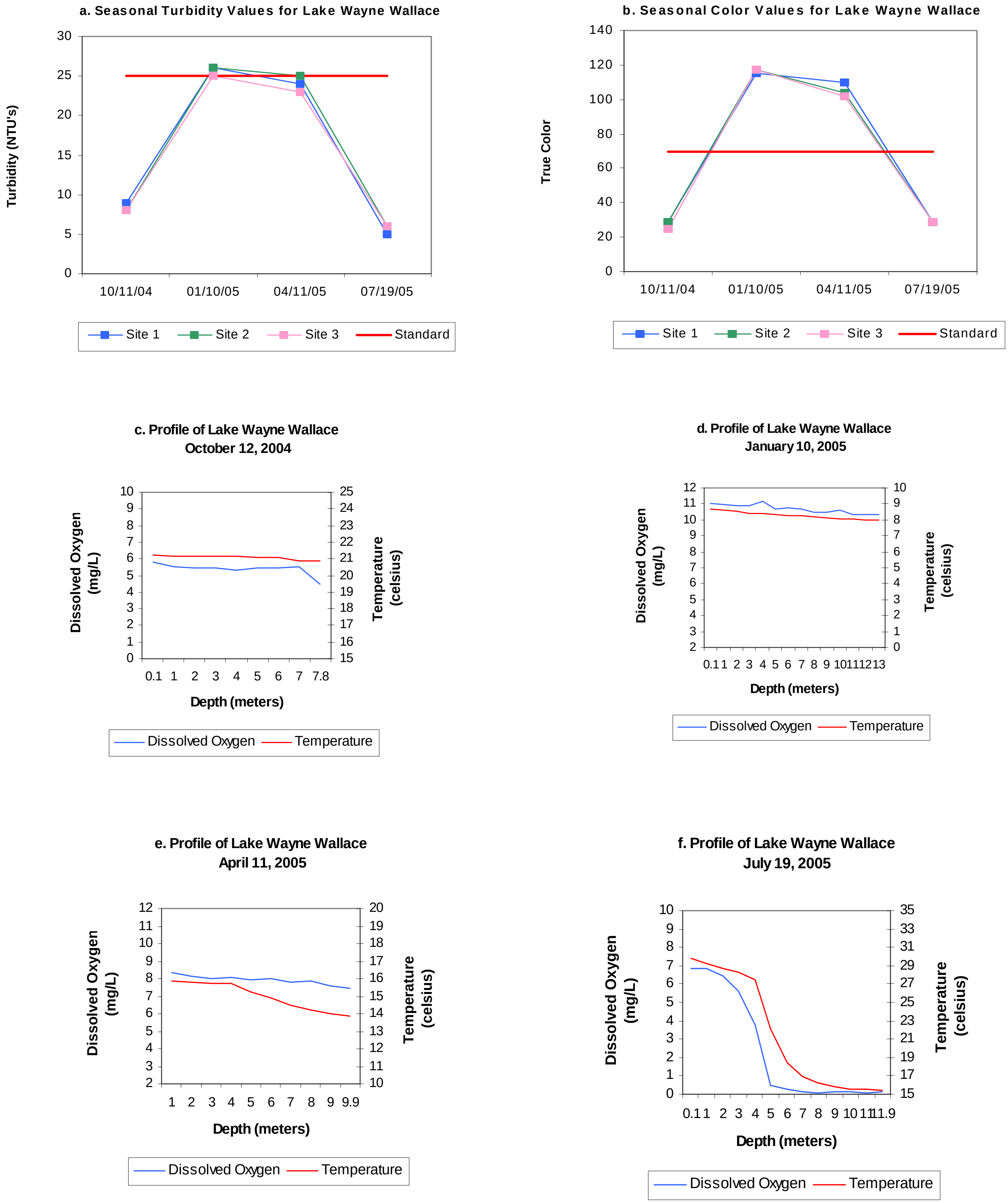
Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at sample site 1, the dam. The average lake-wide turbidity was 16 NTU (Plate 123), true color was 70 units, and average secchi disk depth was 81 centimeters. Based on these three parameters, Lake Wayne Wallace had good water clarity. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The average TSI was 41 (Plate 123), classifying the lake as mesotrophic, indicative of moderate levels of productivity and nutrient conditions. This classification is similar to that in 2003 (TSI=44), indicating no significant change in productivity has occurred since the last evaluation. The TSI values were fairly consistent ranging from mesotrophic in the fall, spring and summer sampling quarters to oligotrophic during the winter. Seasonal turbidity values are displayed in Figure 149a. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Lake Wayne Wallace is currently supporting Fish & Wildlife Propagation (FWP) beneficial use based on turbidity. Seasonal true color values are displayed in Figure 149b. Of the twelve true color values collected, five (42%) were above the WQS of 70 units. Applying the same default protocol, the Aesthetics beneficial use is considered not supported.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.00 parts per thousand (ppt) to 0.02 ppt in sample year 2004-2005. This is lower than the average the range of values recorded in Oklahoma reservoirs. Specific conductivity ranged from 31.2 µS/cm to 67.3 µS/cm, indicating the presence low levels of current conducting ions (salts or chlorides) in the lake system. The pH values ranged from 6.01 to 6.96 representing a slightly acidic to neutral system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With approximately 17% of the values recorded being less than 6.5 the lake should be listed as not supporting based on pH. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Oxidation-reduction potentials (ORP) ranged from 312 mV to 481 mV, indicating reducing conditions were not present at this reservoir during the study period. During the fall, winter and spring sampling intervals stratification was not evident and the water column was well mixed with dissolved oxygen (D.O.) values generally above 5.0 mg/L (Figure 149c-141e). In the summer, thermal stratification was evident and anoxic conditions were present below the thermocline, at both sites 1 and 2 (Figure 149f). Dissolved oxygen was less than 2.0 mg/L from 5 meters to the lake bottom, accounting for 37.5 to 61.5 % of the water column to be experiencing anoxic conditions. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to UASP, Lake Wayne Wallace is considered partially supporting the FWP beneficial use based on anoxic conditions present during the summer quarter. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

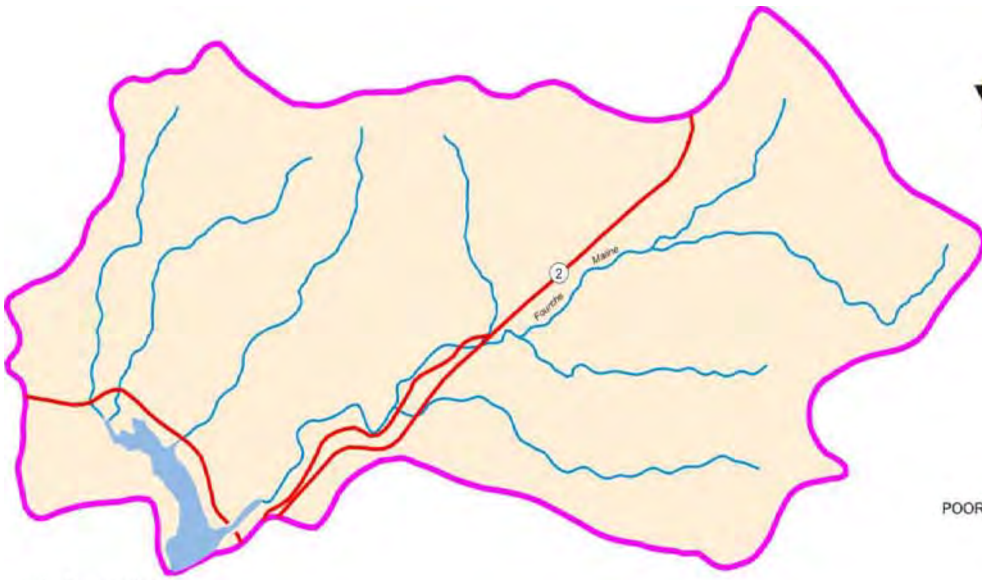
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.32 mg/L at the surface. Surface TN ranged from 0.15 mg/L to 0.64 mg/L, with both highest and lowest values reported in the summer quarter. The lake-wide total phosphorus (TP) average was 0.030 mg/L at the surface. Total phosphorus at the surface ranged from 0.022mg/L to 0.039 mg/L. Surface TP was highest in the winter, and the lowest values were recorded during the summer quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 11:1 for sample year 2004-2005. This is higher than 7:1, characterizing the lake as phosphorus limited (Wetzel, 1983).

In summary, Lake Wayne Wallace was classified as mesotrophic, indicative of moderate primary productivity and nutrient conditions in 2002-2005. This classification is consistent with the previous evaluation in 2003 (TSI=44). Water clarity was good based on turbidity, true color, and secchi disk depths. The FWP beneficial use is supported based on turbidity and partially supported based on dissolved oxygen. With 17% of the pH values less than 6.5 the lake will is partially supporting the FWP based on pH. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. The Aesthetics beneficial use is considered supported in regards to trophic status and true color. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time. Lake Wayne Wallace, located in Latimer County is owned by the State of Oklahoma and is utilized for flood control and recreation purposes.



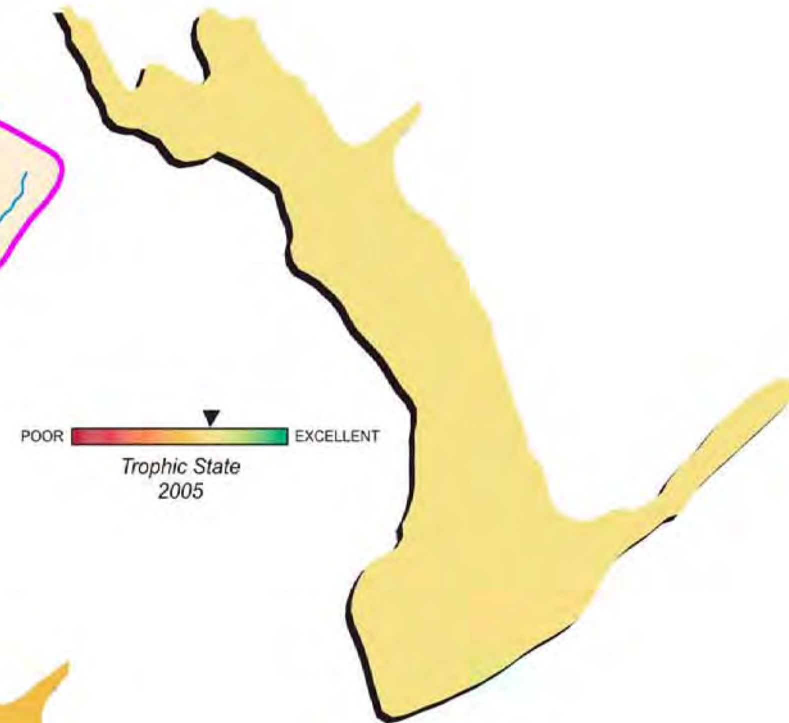
LAKES MONITORING PROGRAM

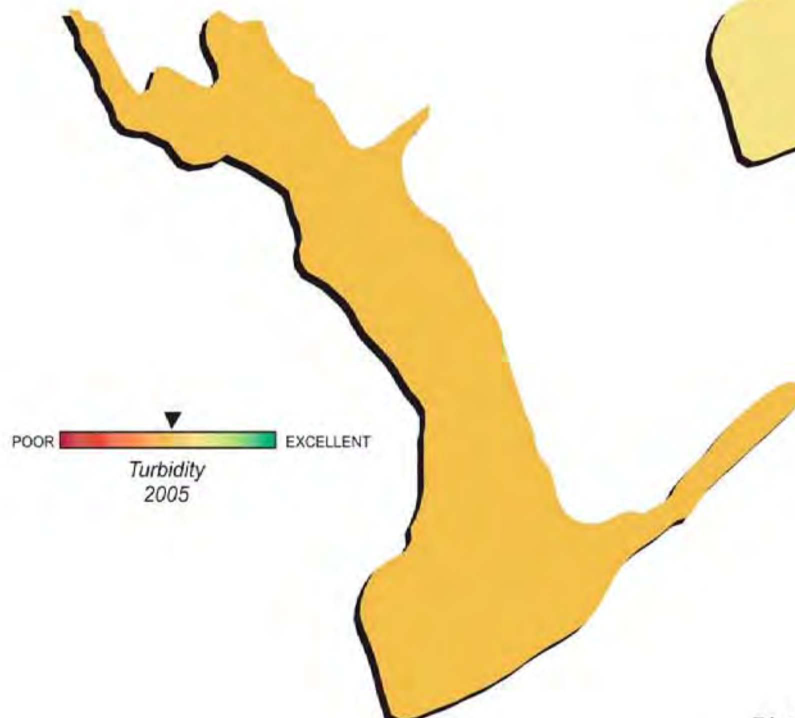
Figure 149a-149f. Graphical representation of data results for Lake Wayne Wallace.



Lake Wayne Wallace
and
Watershed


Lake Wayne Wallace
Location





Lake Data

Owner	State of Oklahoma
County	Latimer
Constructed in	1969
Surface Area	94 acres
Volume	1,746 acre/feet
Shoreline Length	3 miles
Mean Depth	18.57 feet
Watershed Area	11 square miles

N W E S

Plate 123 - Lake Water Quality for
Lake Wayne Wallace

Webbers Falls Reservoir

The United States Army Corps of Engineers (USACE) constructed the Webbers Falls lock and dam in 1970 on the Arkansas River for the purpose of navigation and generation of hydroelectric power. The 11,600-acre reservoir was sampled from November 2005 through September 2006.

Water quality samples were collected at six (6) sites to represent the riverine, transitional, and lacustrine zones of the reservoir as well as any major arms. Samples were collected from the lake surface at all sites and 0.5 meters during the study period. The lake-wide annual turbidity value was 21 NTU (Plate 124), true color was 32 units, and secchi disk depth was 53 centimeters in 2006. Results for these parameters were consistent with previous data collections efforts if not slightly better. Based on these three parameters, Webbers Falls Reservoir had average water clarity in comparison to other reservoirs. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=24). The average TSI was 56 (Plate 124), classifying the lake as eutrophic, indicative of high levels of productivity and nutrient rich conditions. This value is similar to the TSI in 2004 (TSI=59) and 2001 (TSI=57), indicating no significant change in productivity has occurred over time. The majority of the TSI values were eutrophic although all trophic categories were represented at some time during the sample year. Site 1 exhibited the most variability throughout the year, which can be expected, as this is the location of the lock and dam on the Arkansas River. Seasonal turbidity values ranged from a low of 9 NTU to a maximum of 54 NTU and are displayed in Figure 150a. According to the Use Support Assessment Protocols (USAP) outlined in Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in WQS (25 NTU for turbidity). If 10 to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Seven of the 23 turbidity values (30%) exceeded the Oklahoma Water Quality Standard (WQS) of 25 NTU, however available flow and rainfall data suggest that the peak in turbidity, which occurred in May is likely due to seasonal storm events, therefore Webbers Falls Lake will be listed as supporting its Fish & Wildlife Propagation (FWP) beneficial use. Seasonal true color values are displayed in Figure 150b. Approximately 4% (1) of the collected values exceeded the WQS numeric criteria of 70 units. Applying the same default protocol, the Aesthetics beneficial use is therefore considered supported.

Vertical profiles for dissolved oxygen, pH, temperature; specific conductivity, oxidation-reduction potential, and salinity were recorded at all six sample sites throughout the sample year. Salinity values ranged from 0.37 parts per thousand (ppt) to 1.47 ppt. This is higher than the average the range of values recorded in most Oklahoma reservoirs and indicative of moderate to high levels of salts. Specific conductivity ranged from 718 µS/cm in the fall to 2733 µS/cm in the winter, indicating the presence moderate to high levels of current conducting ions (salts or chlorides) in the lake system. The pH values ranged from 7.32 to 8.56 representing a neutral to slightly alkaline system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With all recorded values within the acceptable range, the lake is supporting the FWP beneficial use as it relates to pH. Oxidation-reduction potentials (ORP) ranged from 346 mV in the summer to 451 mV during the fall, indicating reducing conditions were not present at this reservoir in sample year 2005-2006. Thermal stratification was not evident during any of the sampling intervals and dissolved oxygen levels remained above 4.0 mg/L throughout the water column at all sites (see Figure 150c-139f). This may be attributed to the fact that Webbers Falls Reservoir is very riverine in nature as it is a portion of the Arkansas River. With the absence of anoxic conditions throughout the entire study period the lake is considered supporting the FWP beneficial use. The lake was also sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.99 mg/L at the surface for the current sample year. Surface TN ranged from 0.73 mg/L to 1.39 mg/L with the highest values recorded in the winter quarter and lowest in the summer. The lake-wide total phosphorus (TP) average was 0.172 mg/L at the surface. Both the high and low TP values occurred during the winter sampling interval with values ranging from 0.117 mg/L to 0.230 mg/L. The nitrogen to phosphorus ratio (TN:TP) was approximately 6:1 for sample year 2005-2006 This value is slightly less than 7:1, characterizing the lake possibly co- limited (Wetzel, 1983).

The Oklahoma Department of Environmental Quality (ODEQ) sampled the lake in 2000 as part of their Toxics Monitoring Program and detected no compounds at the ODEQ screening level or consumption advisory level. The lake is fully supporting its Fish Consumption beneficial use. Webbers Falls Reservoir was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Webbers Falls Reservoir was classified as eutrophic, indicative of high primary productivity and nutrient conditions in 2005-2006. This classification is consistent with both 2004 (TSI=59) and 2001 (TSI=57), indicating little or no significant change has occurred since the previous evaluations. Water clarity was average based on turbidity, true color, and secchi disk depths. The FWP beneficial use is supported based on D.O and pH readings recorded throughout the study period. Seven of the 23 turbidity values (30%) exceeded the Oklahoma Water Quality Standard (WQS) of 25 NTU, however available flow and rainfall data suggest that the peak in turbidity, which occurred in May is likely due to seasonal storm events, therefore Webbers Falls Lake will be listed as supporting its Fish & Wildlife Propagation (FWP) use. The Aesthetics beneficial use is considered supported in regards to both trophic status and true color. Bacteriological samples were also collected to assess the Primary Body Contact All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

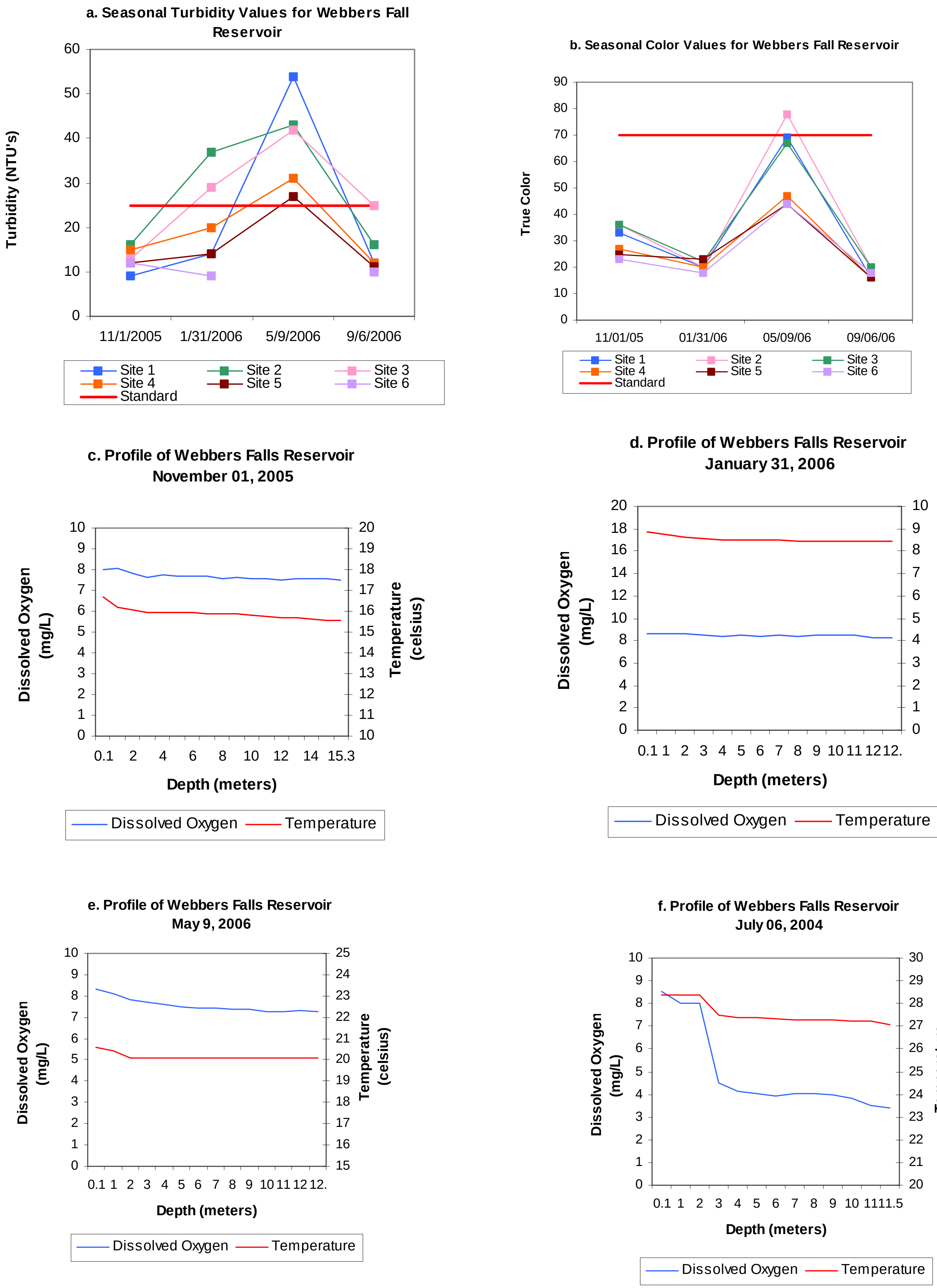
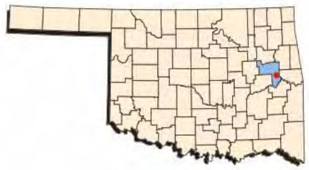
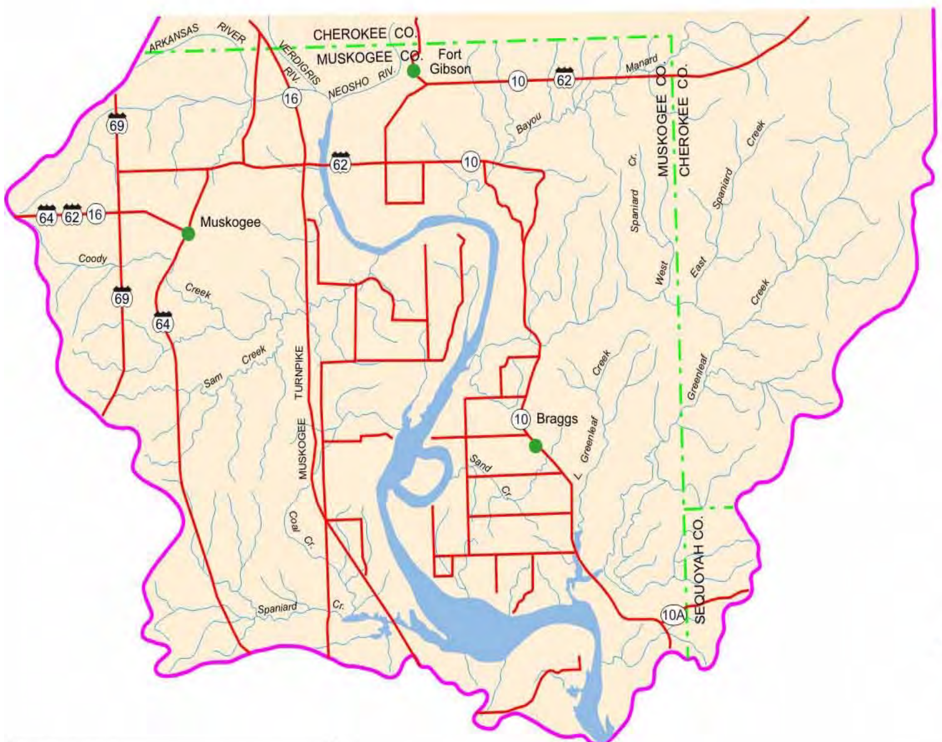


Figure 150a-150f. Graphical representation of data results for Webbers Falls Reservoir.



Webbers Falls Lake
Location



Webbers Falls Lake
and
Watershed

Lake Data

Constructed by	Corps of Engineers
County	Muskogee
Constructed in	1970
Surface Area	11,600 acres
Volume	170,100 acre/feet
Shoreline Length	175 miles
Mean Depth	15.2
Watershed Area	97,033 square miles

Turbidity
2006

Trophic State
2006

Plate 124 - Lake Water Quality for
Webbers Falls Reservoir

LAKES MONITORING PROGRAM

Wes Watkins (North Deer Creek) Reservoir

Wes Watkins Reservoir is located in Pottawatomie County, just south of the town of McCloud. The Natural Resource Conservation Service (NRCS) constructed 1,142-acre reservoir in 1997 for the purpose of flood control, water supply, recreation and fish and wildlife purposes. Wes Watkins (North Deer Creek) Reservoir was sampled for four quarters from October 2005 through August 2006.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir as well as any major arms. Samples were collected from the lake surface at all sites during the study period. The lake-wide annual turbidity value was 8 NTU (Plate 125), true color was 19 units, and secchi disk depth was 92 centimeters. Based on these three parameters, Wes Watkins (North Deer Creek) Reservoir had good water clarity, slightly better than that in 2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=19). Due to low lake levels OWRB staff were unable to reach site 5, which is located in a heavily wooded portion area in the upper reaches of the lake. The average TSI was 53 (Plate 125), classifying the lake as eutrophic, indicative of high levels of primary productivity and nutrient rich conditions. The TSI values were primarily eutrophic with mesotrophic conditions present at sites 1-3 during the spring quarter. 100% of the turbidity values collected were below the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 151a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. Although all turbidity values were below the numeric criteria, minimum data requirements were not met due to a lack of data collected at site 5 during spring data collection efforts and therefore an assessment of the FWP beneficial use cannot be made at this time in regards to turbidity. Seasonal true color values are displayed in Figure 151b. All true color values throughout the year were below the Aesthetics criteria of 70 units; however like turbidity minimum data requirements were not met therefore the Aesthetics beneficial use cannot be assessed. Upon reviewing past data it is likely that both parameters would be meeting there respective uses.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all five sample sites. Salinity values ranged from 0.13 parts per thousand (ppt) to 0.15 ppt, well within the range of expected values for Oklahoma lakes, reflecting moderate levels of chlorides or other salts in the lake. Specific conductivity values were also within the range of expected values recorded in Oklahoma reservoirs. Values ranged from 262.4 µS/cm in the fall quarter to 313.7 µS/cm in the spring quarter, indicating that moderate levels of electrical conducting compounds (salts) were present in the lake system. Oxidation-reduction potentials ranged from 377 mV in the summer to 452 mV in the fall quarter, indicating that reducing conditions were absent during the study period. The pH values were neutral to slightly alkaline with values ranging from 7.38 units to 8.13 units. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With 100% of the pH values within the acceptable range, the lake is fully supporting its FWP beneficial use based on pH. Thermal stratification was not evident in the fall, winter or spring quarters (see Figure 151c-151e). Generally the water column was well oxygenated and mixed with dissolved oxygen (D.O.) remaining above 5.0 mg/L. In the summer a power failure occurred with the Hydrolab and only a partial profile for site 1 was completed. Without profile information available for the remainder of the lake an assessment of summer conditions cannot be made. If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. According to USAP, the FWP beneficial use is fully supported based on D.O. levels present in the first three sampling intervals at Wes Watkins (North Deer Creek) Reservoir. The lake was also sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2005-2006 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.93 mg/L at the lake surface. The TN at the surface ranged from 0.57 mg/L to 1.25 mg/L. The highest surface TN value was reported in the winter quarter and the lowest was in the fall. The lake-wide total phosphorus (TP) average for sample was 0.027 mg/L at the lake surface. The surface TP ranged from 0.016 mg/L to 0.043 mg/L. Similar to TN, the highest surface TP value was reported in the winter quarter and lowest in the fall quarter. The nitrogen to phosphorus ratio (TN: TP) was approximately 34:1 for sample year 2005-2006. This value is higher than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

Wes Watkins Reservoir was also sampled for total metals at five sites during the spring of 2006. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Wes Watkins (North Deer Creek) Reservoir was classified as eutrophic, indicative of high levels of primary productivity and nutrient rich conditions (Plate 125). Based on true color, turbidity, and secchi disk depth water clarity was good at Wes Watkins Reservoir, slightly better than that observed in sample year 2004. The lake was fully supporting its Aesthetics beneficial use based on its trophic state, however due to minimum data requirements not being met an assessment based on true color cannot be made at this time. The FWP beneficial use is considered fully supported based on dissolved oxygen and pH reading recorded during the study period. Similar to true color, the minimum data requirements were not met for turbidity assessment of the FWP use based on turbidity cannot be made. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E.coli*, fecal coliform, and enterococci during the recreation season of May through September 2006. All sample results were below both the screening level and geometric mean, therefore the PBCR beneficial use is considered fully supported.

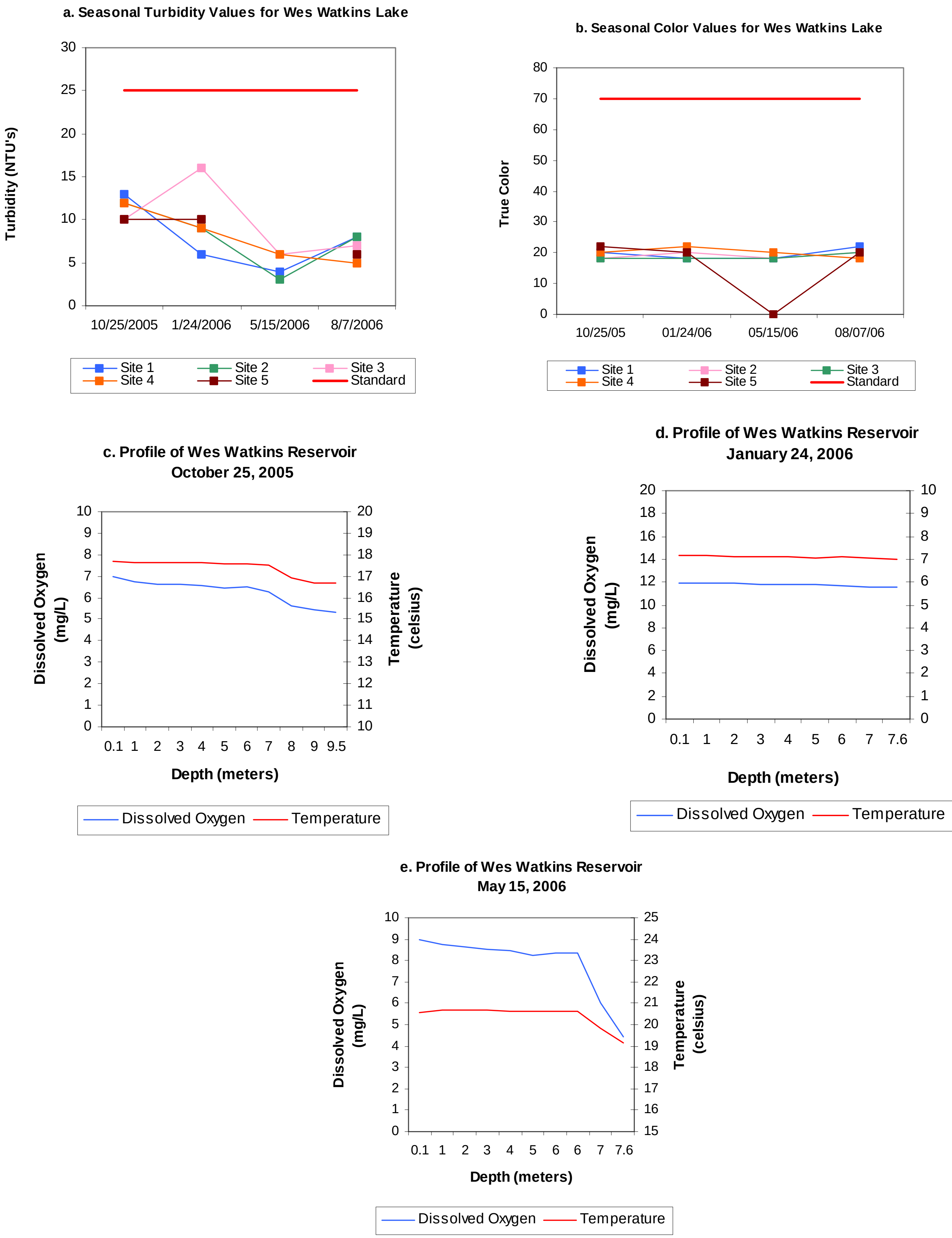
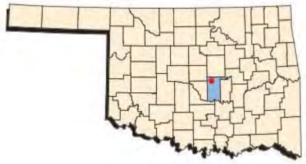


Figure 151a-151e. Graphical representation of data results for Wes Watkins (North Deer Creek) Reservoir.



Lake Data	
Owner	Pottawatomie Co. Dev. Auth.
County	Pottawatomie
Constructed in	1995
Surface Area	1,132 acres
Volume	14,065 acre/feet
Shoreline Length	17 miles
Mean Depth	12.42 feet
Watershed Area	39 square miles

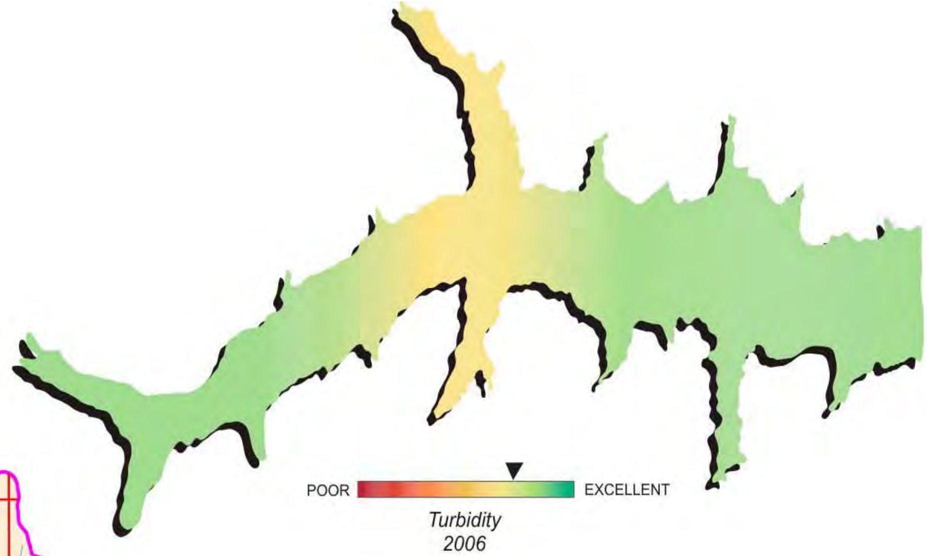


Plate 125 - Lake Water Quality for
Wes Watkins Reservoir

LAKES MONITORING PROGRAM

Wetumka Lake

Wetumka Lake, located in Hughes County, is owned by the city of Wetumka. The 169-acre reservoir was constructed in 1939 and serves as a water supply and recreational reservoir. Wetumka Lake was sampled for four quarters, from October 2006 through July 2007.

Water quality samples were collected at three (3) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected at the lake surface at all sample sites. The lake-wide annual turbidity value was 18 NTU (Plate 126), true color was 66 units, and secchi disk depth was 59 centimeters. Based on these three parameters, Wetumka Lake had fair water clarity, similar to previous values in 2004. A trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=12). The calculated TSI was 53 (Plate 126), classifying the lake as eutrophic, indicative of high levels of primary productivity and nutrient rich conditions. This value is slightly lower than the one calculated in 2001 (TSI=52). TSI values ranged from mesotrophic in autumn and winter to eutrophic during the spring and summer. Seasonal turbidity values are displayed in Figure 152a. With only 8% of the samples above the standard of 25 NTU, the lake is fully supporting the Fish & Wildlife Propagation (FWP) beneficial use. True color values averaged 66 units with 58% of the samples above the Aesthetics WQS of 70 throughout the year (see Figure 152b). Applying the same default protocol, the Aesthetics beneficial use is considered not supported at Wetumka Lake.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites during the study period. Salinity values ranged from 0.03 parts per thousand (ppt) to 0.08 ppt, which was well within the expected range for most Oklahoma lakes. Specific conductivity ranged from 92.4 µS/cm to 173.3 µS/cm in the summer quarter, indicative of minimal levels of electrical current conducting compounds or salts in the lake system. Oxidation-reduction potentials ranged from 98 mV to 461 mV, indicating reducing conditions were not present at any point in the sample year. The pH was neutral to alkaline with values ranging from 6.49 to 7.90 units. With all values within the acceptable range of 6.5 to 9.0, Wetumka Lake is meeting its FWP beneficial use based on pH. The lake was not thermally stratified and the water column appeared to be well mixed in the fall, winter, and spring sampling events (see Figure 152c-152e). Dissolved oxygen (D.O.) values generally remained above 5.0 mg/L. In the summer, thermal stratification was evident and anoxic conditions were present at two of the three sites. Stratification occurred between 2-3 meters below the lake surface at site 1, 2, and 3 at which point D.O. levels fell below 2.0 mg/L to the lake bottom of 7.4 meters (Figure 152f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Approximately 40-67% of the water column was experiencing anoxic conditions at sites 1, 2, and 3 in the summer sampling interval. Wetumka Lake is considered partially supporting its FWP beneficial use based on D.O. concentrations. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use.

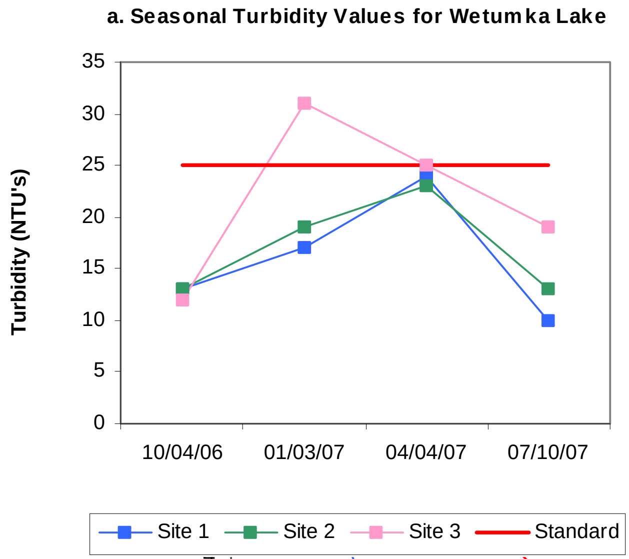
Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

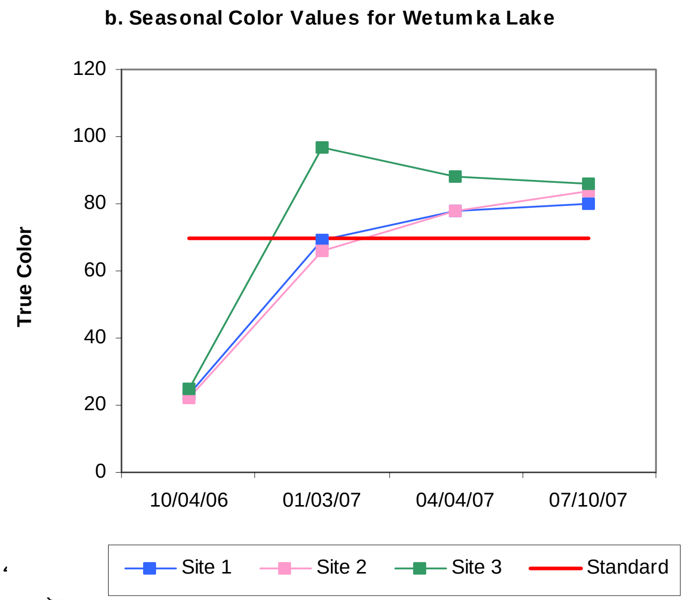
Bacteriological samples were also collected to assess the Primary Body contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E. coli*, fecal coliform and enterococci during the recreation season of May through September. Of the 10 samples collected, 3 of the samples exceed the screening level of 126cfu/ml for *E. coli,* however the geometric mean was not exceeded. Enterococci and fecal coliform could not be assessed due to minimum data requirements not being met. The PBCR beneficial use is therefore considered supported for *E. coli* and undetermined for enterococci and fecal coliform.

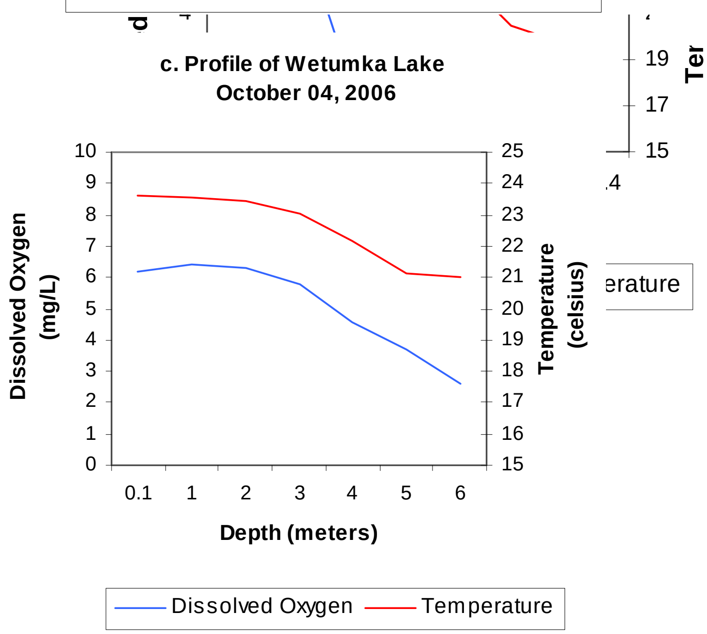
Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.68 mg/L at the lake surface. The TN at the surface ranged from 0.47 mg/L to 0.97 mg/L. The lake-wide total phosphorus (TP) average was 0.033 mg/L at the lake surface. The TP ranged from 0.021 mg/L to 0.053 mg/L at the lake surface. The nitrogen to phosphorus ratio (TN:TP) was approximately 20:1 for sample year 2006-2007. This value is greater than 7:1, characterizing the lake as phosphorus-limited (Wetzel, 1983).

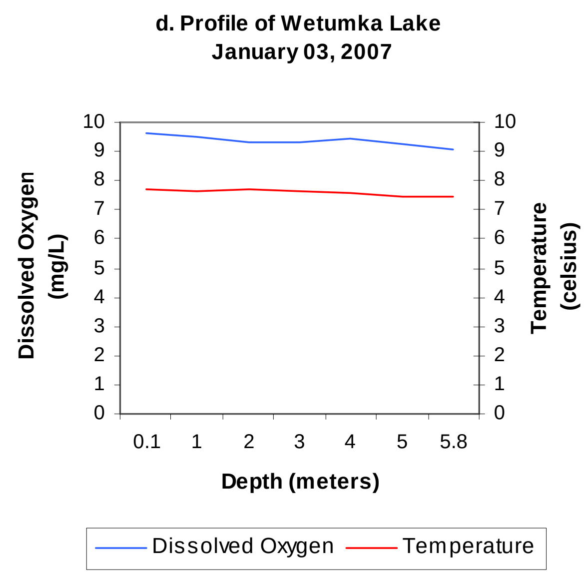
Wetumka Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

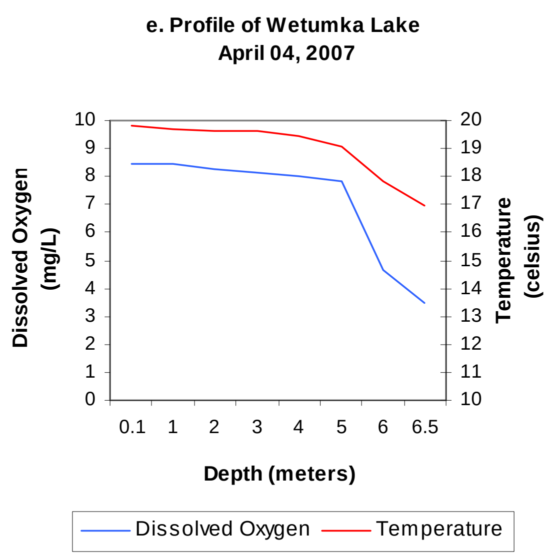
In summary, Wetumka Lake was classified as mesotrophic bordering eutrophic, indicative of moderate to high primary productivity and nutrient levels (Plate 126). Water clarity was fair in sample year 2007 based on turbidity, true color and secchi disk depth. The Aesthetics beneficial use was not supported based on true color with 58% of the collected values above the numeric criteria of 70 true color units. The FWP beneficial use is considered fully supported for pH and turbidity. Based on anoxic conditions present in the summer the lake is considered partially supporting the FWP beneficial use. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Of the ten samples collected three (30%) of the samples exceeded the screening level of 126 cfu/ml, however the geometric was not exceeded for *E. coli*. The PBCR beneficial use is therefore considered supported for *E. coli* and undetermined for enterococci and fecal coliform.











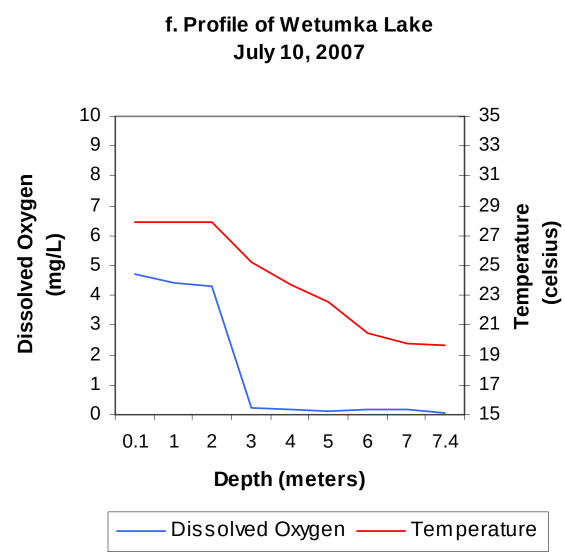


Figure 152a-152f. Graphical representation of data results for Wetumka Lake.

Plate 126 - Lake Water Quality for
Wetumka Lake

Wetumka Lake and Watershed

Wetumka Lake Location

Lake Data

Owner	City of Wetumka
County	Hughes
Constructed	1939
Surface Area	169 acres
Volume	1,839 acre/feet
Shoreline Length	6 miles
Mean Depth	10.88 feet
Watershed Area	2,689 acres

Turbidity 2007

Trophic State 2007

LAKES MONITORING PROGRAM

Wewoka Lake

Wewoka Lake was constructed in 1925 and is owned and operated by the City of Wewoka. The 371-acre reservoir in Seminole County is utilized as a municipal water supply and offers numerous recreational opportunities to the public. Wewoka Lake was sampled from October 2006 through July 2007 for four quarters.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Water chemistry samples were collected from the lake surface at all sites. The lake-wide annual turbidity value was 59 nephelometric turbidity units (NTU), true color was 103 units, and secchi disk depth was 35 centimeters. Based on these three parameters, Wewoka Lake had poor water clarity, worse than what was observed in 2004. A trophic state index, using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The calculated TSI was 55 (Plate 127), classifying the lake as eutrophic, indicative of high levels of productivity and nutrient conditions. Of the 20 turbidity values generated, 75% of them exceeded the Oklahoma Water Quality Standard (WQS) of 25 NTU (see Figure 153a). According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). Wewoka Lake is currently not supporting its Fish & Wildlife Propagation (FWP) beneficial use for nephelometric turbidity. Seasonal true color values are displayed in Figure 153b. Of the true color values collected, 60% were above the Aesthetics numerical criteria of 70 units. Applying the same default protocol, the lake is not supporting the Aesthetics beneficial use for true color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Lake salinity values ranged from 0.00 parts per thousand (ppt) to 0.10 ppt, which is within the range of expected values for Oklahoma lakes, reflecting minimal amounts of chlorides or other salts in the lake system. Specific conductivity values were also consistent with the expected range of values recorded in Oklahoma reservoirs, if not somewhat lower. Values ranged from 25.6 µS/cm to 219 µS/cm in the summer quarter near the lake bottom, indicating that low levels of electrical conducting compounds (salts) were present in the lake. Oxidation-reduction potentials (redox) ranged from 139 mV in the summer quarter to 447 mV in the autumn quarter, indicating reducing conditions were not present during the study period. The pH values were generally slightly acidic to slightly alkaline with values ranging from 6.67 units to 8.18 units. All recorded pH values were all within the acceptable range (6.5 to 9.0) supporting the FWP beneficial use. Thermal stratification was not evident in the fall, winter, or spring quarters and dissolved oxygen (D.O.) values never fell below 6.0 mg/L in the water column at any site (see Figure 153c-153e). In the summer quarter, the lake was thermally stratified at only site 1, the dam. Stratification occurred between 2 and 3 meters to the lake bottom of 8.3 meters. This led to 60% of the water column being anoxic (see Figure 153f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. concentrations are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. With 60% of the water column less than 2.0 mg/L in the summer the FWP beneficial use is partially supported at Wewoka Lake. The lake was sampled for chlorides and sulfates to assess its Agriculture beneficial use. Sampling in 2006-2007 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. Samples were collected at five sites for *E. coli,* fecal coliform, and enterococci analysis during the recreation season of May through September. No assessment can be made for these parameters due to quality control issues.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.91 mg/L at the lake surface. The TN at the surface ranged from 0.67 mg/L in the spring to 1.32 mg/L in the summer. The lake-wide total phosphorus (TP) average was 0.101 mg/L at the lake surface. The surface TP ranged from 0.021 mg/L in the spring to 0.830 mg/L in the summer. The nitrogen to phosphorus ratio (TN: TP) was approximately 9:1 for sample year 2006-2007. This value is slightly higher than 7:1, characterizing the lake as phosphorus-limited to possibly a co-limitation system (Wetzel, 1983).

Wewoka Lake was also sampled for total metals at five sites during the spring of 2007. Results of sampling showed the lake to be fully supporting its FWP beneficial use based on toxic (metals) compounds in the water column.

In summary, Wewoka Lake was classified as eutrophic, indicative high levels of primary productivity and nutrient conditions (Plate 127). Water clarity was poor in comparison to other lakes based on turbidity, true color and secchi disk depth. The lake was fully supporting its Aesthetics beneficial use for trophic state and not supporting for true color. Wewoka Lake was fully supporting its FWP beneficial use for pH and not supporting based on turbidity. In the summer, 60% of the water column was exhibiting anoxic conditions therefore the FWP is also partially supported based on D.O. concentrations in the water column. Bacteriological samples were also collected to assess the Primary Body Contact Recreation (PBCR) beneficial use. An assessment for PBCR cannot be made at this time due to quality control issues with the data.

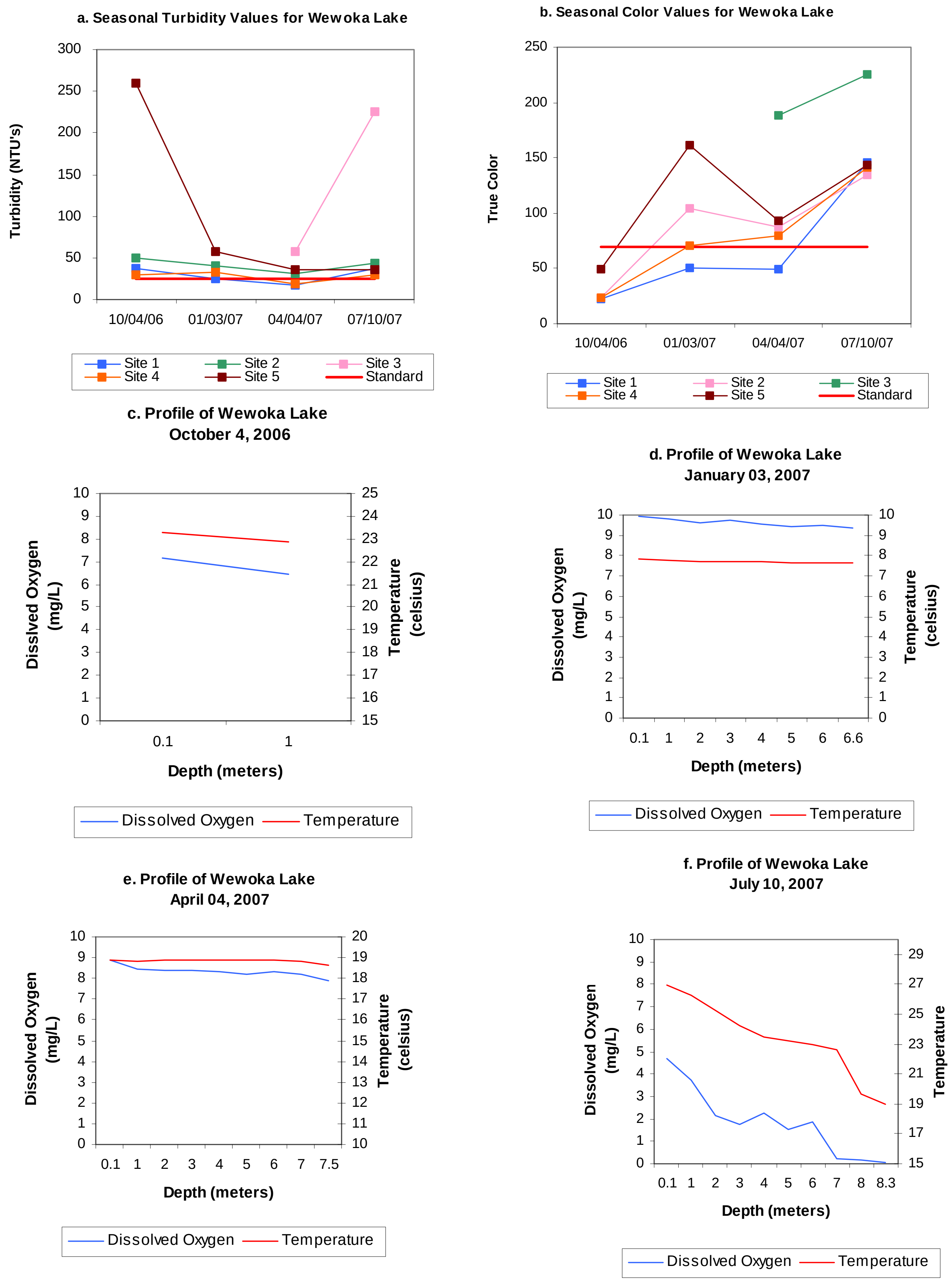
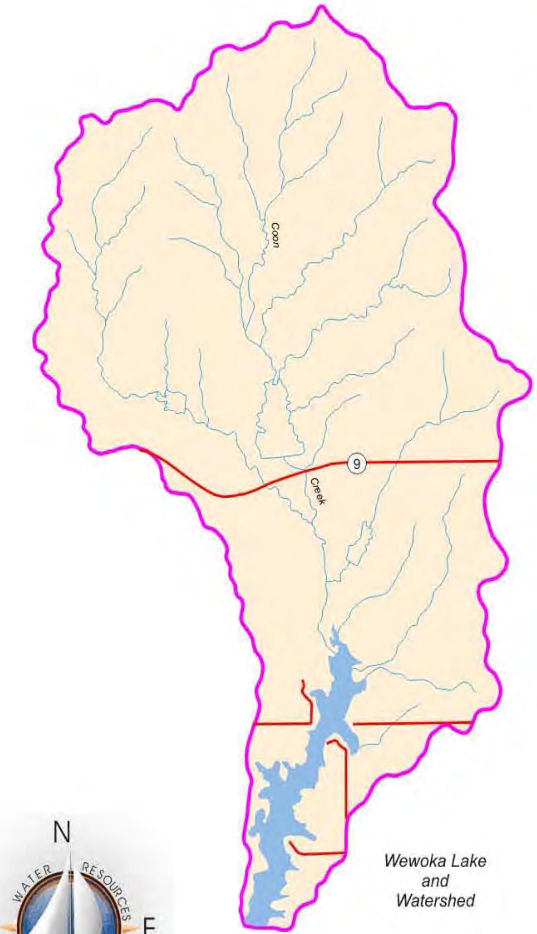


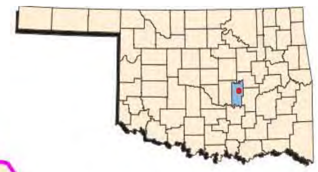
Figure 153a-153f. Graphical representation of data results for Wewoka Lake.

Plate 127 - Lake Water Quality for

Wewoka Lake



Wewoka Lake and Watershed



Wewoka Lake Location

POOR EXCELLENT

Turbidity 2007

POOR EXCELLENT

Trophic State 2007

Lake Data

Owner	City of Wewoka
County	Seminole
Constructed in	1925
Surface Area	371 acres
Volume	3,301 acre/feet
Shoreline Length	10 miles
Mean Depth	8.90 feet
Watershed Area	16 square miles

Wister Lake

Wister Lake is a 7,333-acre reservoir located in LeFlore County. It was constructed in 1949 by the U.S. Army Corps of Engineers (USACE) to serve as flood control, water supply, flow regulation, and conservation. Wister Lake was sampled for four quarters, October 2004 through July 2005.

Water quality samples were collected at five (5) sites to represent the riverine, transitional, and lacustrine zones of the reservoir. Samples were collected from the lake surface at all sites and 0.5 meters from the lake bottom at sample site 1, the dam. The average lake-wide turbidity was 62 NTU (Plate 129), true color was 150 units, and average secchi disk depth was 24 centimeters. Based on these three parameters, Wister Lake had poor water clarity in comparison to other Oklahoma reservoirs. The trophic state index (TSI), using Carlson's TSI (chlorophyll-a), was calculated using values collected at all sites for four quarters (n=20). The average TSI was 52 (Plate 129), classifying the lake as eutrophic, indicative of high levels of productivity and nutrient conditions. This is similar to 2003 (TSI=54), indicating no change in productivity has occurred since the previous evaluation. The TSI values were fairly consistent ranging from eutrophic in the fall, spring and summer quarters to mesotrophic in the winter. The only exception was site 3, which was classified oligotrophic in both fall and winter sampling intervals. Wister Lake is listed in the Oklahoma Water Quality Standards (WQS) as a Nutrient Limited Watershed (NLW). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Seasonal turbidity values are displayed in Figure 154a. Turbidity values ranged from a low of 25NTU to a maximum of 124 NTU. According to the Use Support Assessment Protocols (USAP) outlined in the Oklahoma Administrative Code (OAC) 785:46-15-5, a beneficial use is considered not supported if ≥25% of the samples exceed the screening level prescribed in the WQS (25 NTU for turbidity). If 10% to 25% of the turbidity values exceed the numeric criteria of 25 NTU, the lake should be listed as partially supporting beneficial uses. With 100% of the collected values exceeding the standard Wister Lake is considered not supporting the Fish and Wildlife Propagation (FWP) beneficial use based on turbidity. Seasonal true color values are displayed in Figure 154b. All true color values were above the WQS of 70 units. Applying the same default protocol, the Aesthetics beneficial use is considered not supported based on true color.

Vertical profiles for dissolved oxygen, pH, temperature, specific conductivity, oxidation-reduction potential, and salinity were recorded at all sample sites. Salinity values ranged from 0.01 parts per thousand (ppt) to 0.04 ppt in sample year 2004-2005. This is lower than the average the range of values recorded in Oklahoma reservoirs. Specific conductivity ranged from 41.4 µS/cm to 96.9 µS/cm, indicating the presence of low levels of current conducting ions (salts or chlorides) in the lake system. The pH values ranged from 6.32 to 7.42 representing a slightly acidic to neutral system. According to USAP (OAC 785:46-15-5), pH values are exceeding standards if 25% of the values fall outside the range of 6.5 to 9.0 and the waterbody should be listed as not supporting its FWP beneficial use. If 10 to 25% of the pH values fall outside the range of 6.5 to 9.0, the lake should be listed as partially supporting its FWP beneficial use. With approximately 9.5% of the values recorded being less than 6.5 the lake is supporting based on pH. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. Oxidation-reduction potentials (ORP) ranged from 217 mV to 501 mV, indicating reducing conditions were not present at this reservoir during the study period. During the fall, winter, and spring sampling intervals, stratification was not evident and the water column was well mixed (Figure 154c-154e). In the summer, the lake exhibited weak stratification with dissolved oxygen (D.O.) levels only dropping below 2.0 mg/L at the sediment-water interface (Figure 154f). If D.O. values are less than 2.0 mg/L for greater than 70% of the water column, the FWP beneficial use is deemed not supported (OAC 785:46-15-5). If D.O. values are less than 2.0 mg/L for 50 to 70% of the water column, the FWP beneficial use is deemed partially supported. Wister Lake is considered to be partially supporting the FWP beneficial use with 54.5% of the recorded values falling below 2.0 mg/L. The lake was also sampled for chlorides, sulfates, and total dissolved solids to assess its Agriculture beneficial use. Sampling in 2004-2005 found the Agriculture beneficial use to be fully supported based on numerical criteria located in OAC 785:45 – Appendix F.

Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

Water quality samples were analyzed for nutrients including total nitrogen and total phosphorus. These data will be used to aid in future identification of NLW lakes and nutrient criteria development for lakes and reservoirs. The lake-wide total nitrogen (TN) average was 0.57 mg/L at the surface. Surface TN ranged from 0.38 mg/L to 0.85 mg/L, with the highest values reported in the summer and lowest values in the spring quarter. The lake-wide total phosphorus (TP) average was 0.118 mg/L at the surface. Total phosphorus at the surface ranged from 0.069mg/L to 0.201 mg/L. Surface TP was highest in both spring and summer quarters, and the lowest values were recorded during the fall quarter. The nitrogen to phosphorus ratio (TN:TP) was approximately 5:1 for sample year 2004-2005. This is higher than 7:1, characterizing the lake as nitrogen limited (Wetzel, 1983).

In summary, Wister Lake was classified as eutrophic, indicative of high primary productivity and nutrient conditions. This is similar to 2003 (TSI=54), indicating no significant increase or decrease in productivity has occurred since the 2000 evaluation. The lake is currently listed as a Nutrient Limited Watershed (NLW) in the Oklahoma Water Quality Standards (WQS). This listing means that the lake is considered threatened from nutrients until a more intensive study can confirm the Aesthetics beneficial use non-support status. Water clarity was poor based on turbidity, true color and secchi disk depth. The FWP beneficial use is partially supported based on dissolved oxygen during the summer, but not supported based on high turbidity values recorded throughout the year. With 9.5% of the recorded pH values less than 6.5 the lake is also supporting the FWP as it relates to pH. Slightly acidic conditions are not unusual in this part of the state due to relatively low soil pH and lack of soluble bedrock. Because of these conditions it is likely that the low pH values may be due to natural causes; therefore the Water Board is looking at the applicability of developing site-specific criteria for waters in the southeastern portion of the state. The Aesthetics beneficial use is considered not supported based on true color values. Bacteriological samples were not collected during the 2005 recreation season therefore an assessment of the Primary Body Contact Recreation (PBCR) beneficial use cannot be made at this time.

In 2002, the OWRB conducted a bathymetric survey of Wister Lake (Figure 155) to obtain current conservation pool elevations to assist in identifying management alternatives to improve conditions such as nutrient reduction at Wister Lake. Outputs of this study included the annual hydraulic residence time, identification of sediment suspension zones, depth-selective flow-routed outflow and aeration techniques. For further information on bathymetric mapping please visit our website at www.owrb.state.ok.us or contact Jody Cason at (405) 530-8800. Wister Lake, constructed by the United States Army Corps of Engineers (USACE), is utilized for flood control, water supply, low flow augmentation, water conservation and sedimentation purpose.

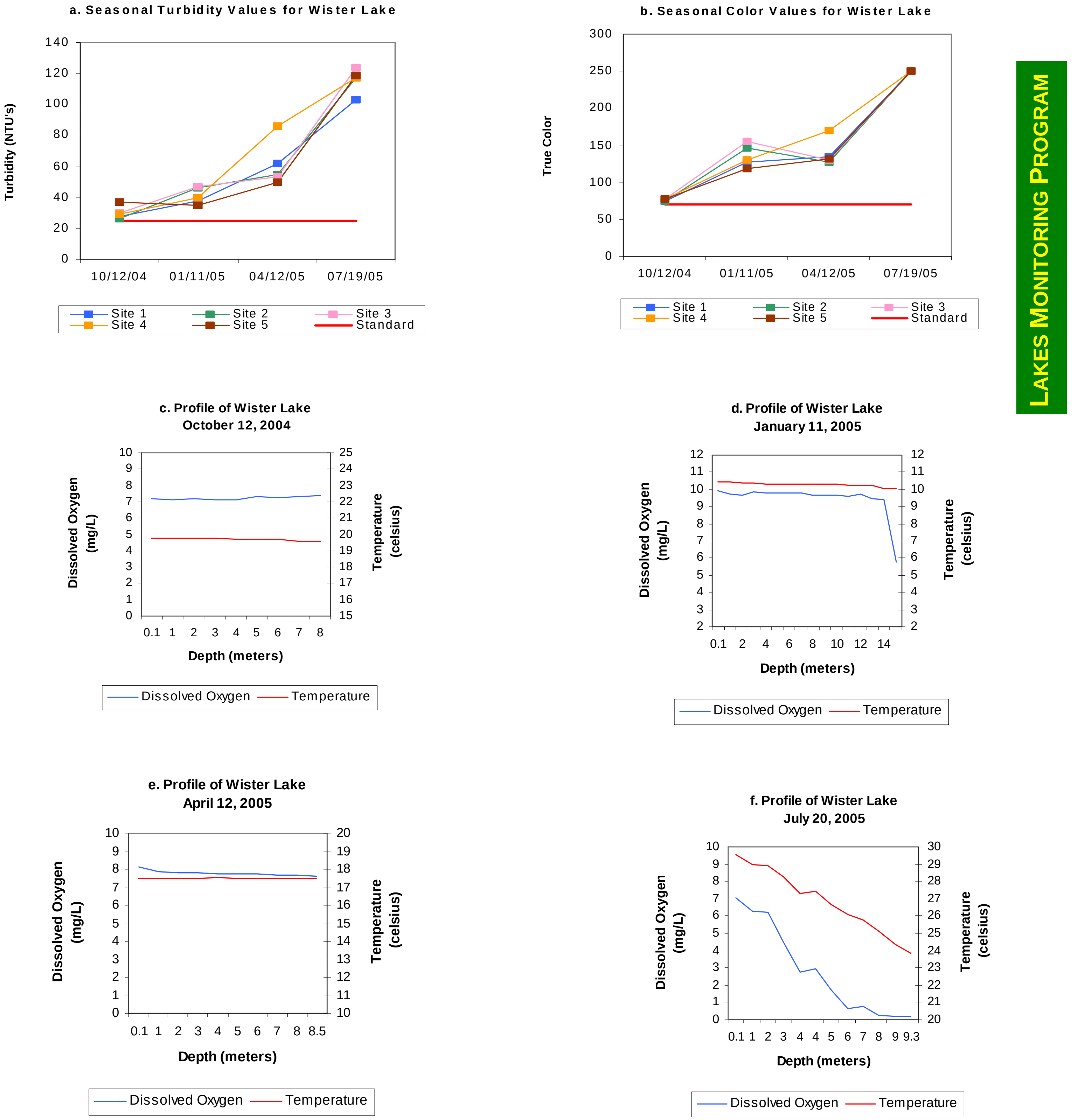
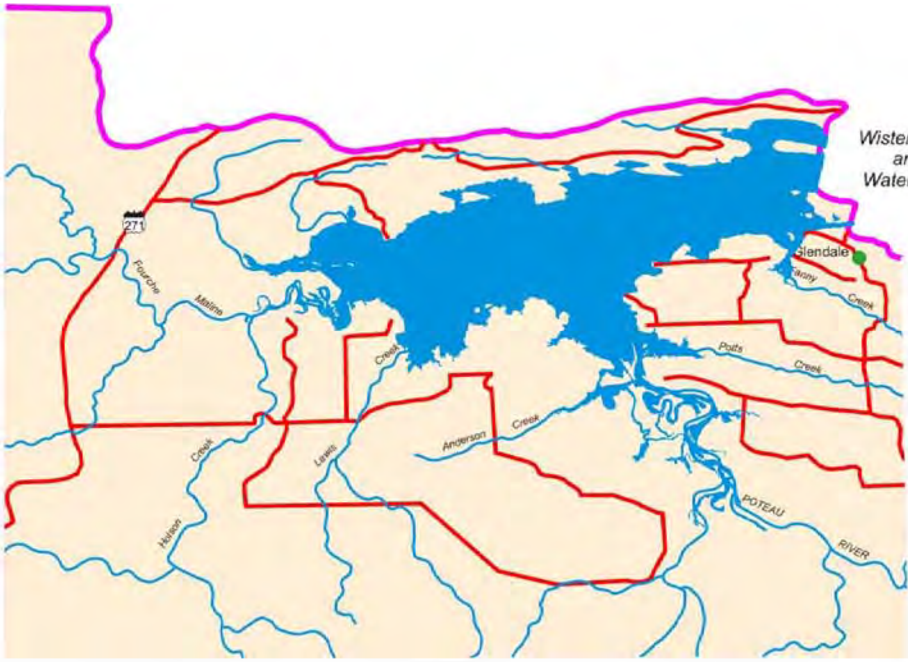
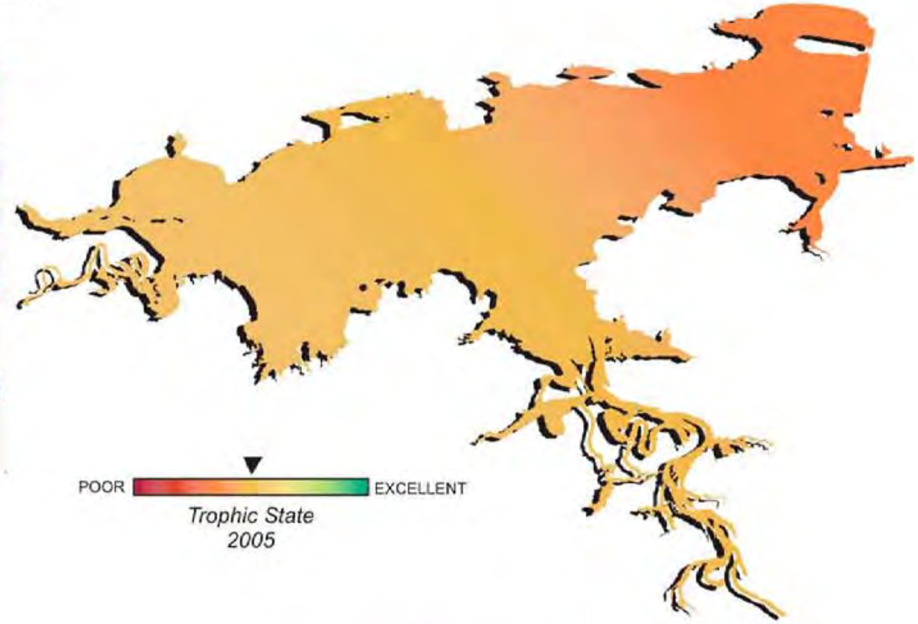
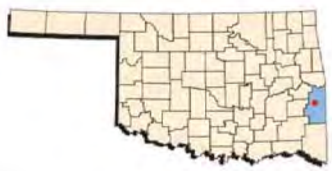


Figure 154a-154f. Graphical representation of data results for Wister Lake.







Lake Data

Owner	Corps of Engineers
County	LeFlore
Constructed in	1949
Surface Area	6,077 acres
Volume	47,414 acre/feet
Shoreline Length	93.89 miles
Mean Depth	7.40 feet
Watershed Area	993 square miles

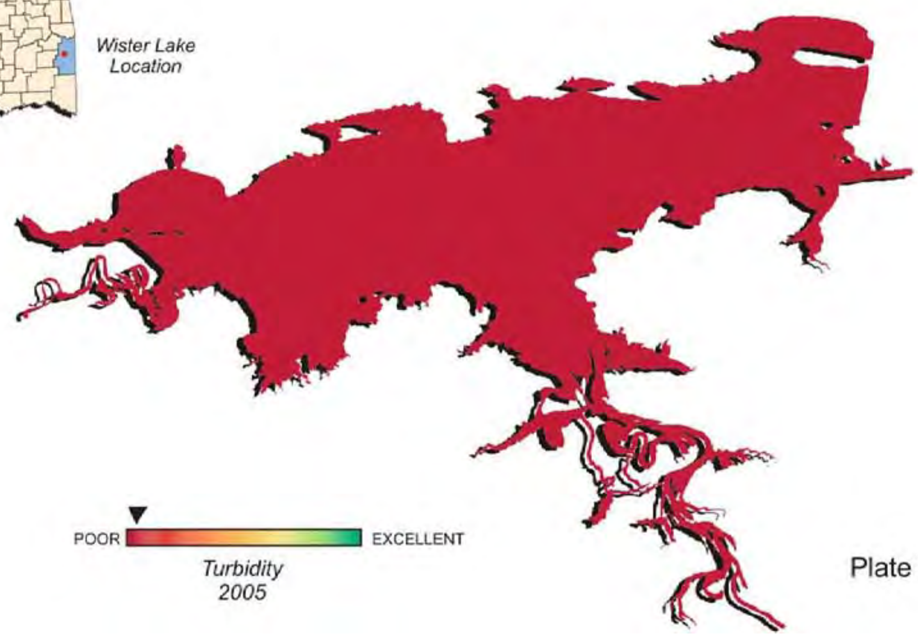


Plate 129- Lake Water Quality for
Wister Lake

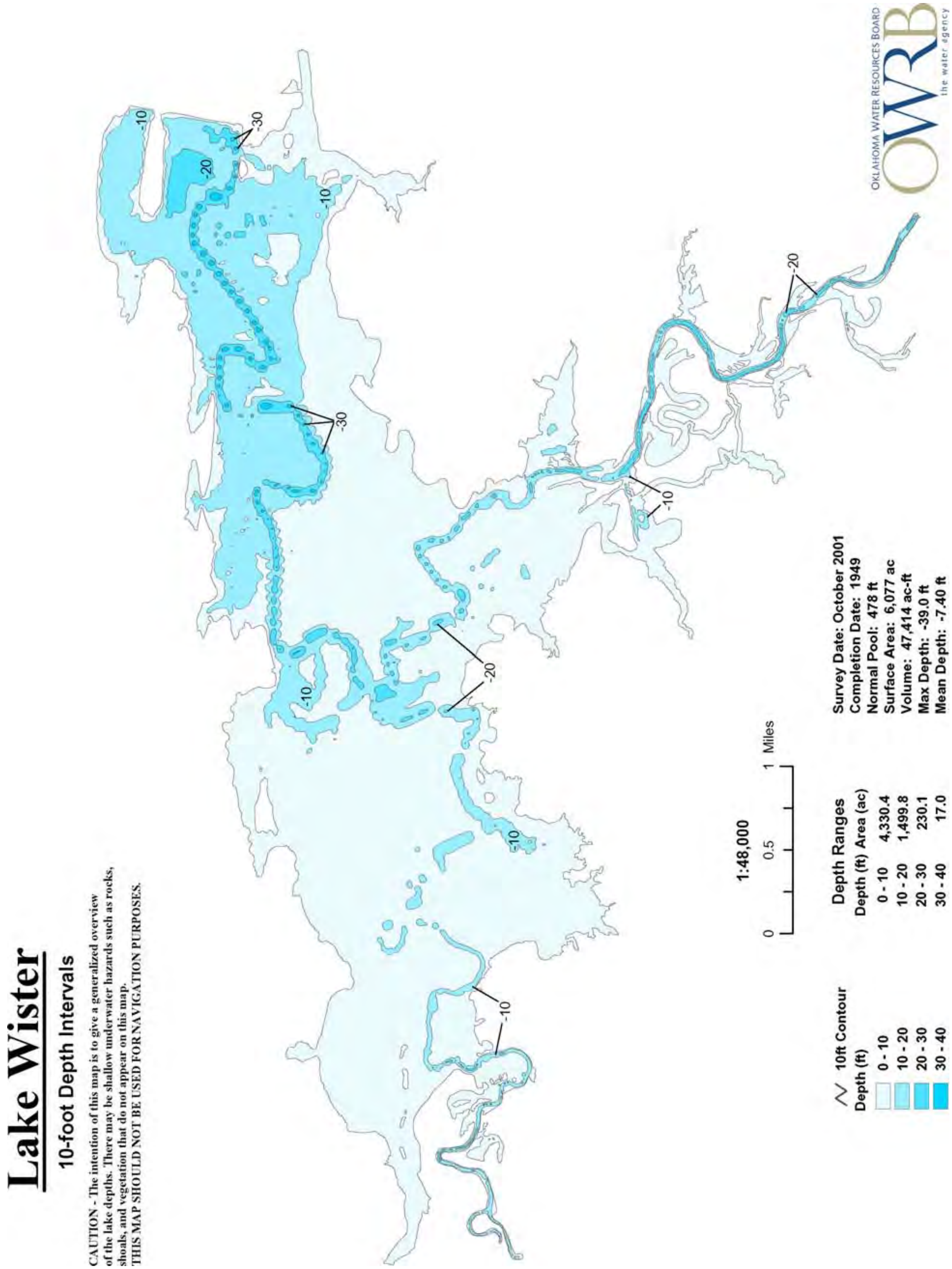


Figure 155 Bathymetric Map of Wister Lake.

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INDEX

A

B

C

D

E

F

G

H

J

K

INDEX

L

M

INDEX

N

O

P

R

S

T

V

W

APPENDIX A

Oklahoma's Use Support Assessment Protocols

APPENDIX A

TITLE 785. OKLAHOMA WATER RESOURCES BOARD
CHAPTER 46. IMPLEMENTATION OF OKLAHOMA'S WATER QUALITY STANDARDS

SUBCHAPTER 15. USE SUPPORT ASSESSMENT PROTOCOLS

785:46-15-1. Scope and applicability

(a) **General**. The rules in this Subchapter provide protocols which shall be used on and after October 1, 2000 to determine whether certain beneficial uses of waters of the state designated in OAC 785:45 are being supported. Such determinations shall be made only to the extent that pertinent provisions of OAC 785:45 apply to a waterbody or its designated uses. The rules in this Subchapter are not intended and should not be construed to limit any actions by federal or state agencies or citizens to prevent pollution or to limit remedies to abate pollution from a single incident or activity or series of incidents or activities.

(b) **Significance of assessment that a use is other than fully supported**. A determination based upon application of the rules in this Subchapter that a waterbody's beneficial use is not supported or is partially supported creates a presumption that the use is impaired or not attained for that waterbody and that the waterbody segment is a water quality limited segment.

[Source: Added at 17 Ok Reg 1775, eff 7-1-00; Amended at 21 Ok Reg 1910, eff 7-1-04]

785:46-15-2. Definitions

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

"**Ecoregion**" means a geographical area within which ecosystems and the type, quality and quantity of environmental resources are generally similar, as more specifically described in EPA's 1997 revision of Omernick, "Ecoregions of the Conterminous United States", Annals of the Association of American Geographers.

"**Impaired**" means one or more designated beneficial uses are not being attained.

"**MQL**" means minimum quantification level.

"**Non-wadable**" means a stream which is not wadable.

"**Rolling average**" means the mathematical average of data values across a fixed length of time that incrementally changes its starting point but retains a fixed length of time by also incrementally changing its end point for each recalculation of the average. This term is also known as "moving average".

"**Screening level**" means an evaluation threshold based upon criteria prescribed in OAC 785:45 to protect a designated beneficial use.

"**Seasonal base flow**" means the sustained or fair-weather runoff, which includes but is not limited to groundwater runoff and delayed subsurface runoff.

"**303(d) List**" means the list of waterbodies with uses that are either threatened or impaired, developed for the State of Oklahoma in accordance with Section 303(d) of the federal Clean Water Act.

"**305(b) Report**" means the report of water quality in the State of Oklahoma developed in accordance with Section 305(b) of the federal Clean Water Act.

"**Wadable**" means a stream or segment thereof, at least 10 percent of which under seasonal base flow conditions is:

(1) less than 1.25 meters deep at its thalweg, and
(2) has an instantaneous discharge of less than 10 cubic feet per second, or has a velocity of less than 10 centimeters per second.

"Waterbody" means a body of waters of the state.
[Source: Added at 17 Ok Reg 1775, eff 7-1-00; Amended at 18 Ok Reg 3379, eff 8-13-01; Amended at 19 Ok Reg 2512, eff 6-27-02; Amended at 24 Ok Reg 2445, eff 7-1-07]

785:46-15-3. Data requirements

(a) **General**. In order to determine whether a given beneficial use of a waterbody is supported, scientific data from the waterbody shall be used as prescribed in this Section. Data shall be collected and analyzed in a manner consistent with testing procedures provided in 785:45-1-4 or practices that are institutionally recognized and appropriate for the parameter of concern and documented in accordance with 785:46-15-3(g). All existing data available for a waterbody shall be used in the analysis, subject to the spatial, temporal and other requirements of this Section.

(b) **Spatial coverage**.

(1) **General for streams.** The spatial extent of assessment of use support in terms of stream miles shall be determined after taking into account existing data, spatial distribution of monitoring sites, sources of pollution and influence of tributaries. Major hydrological features, such as the confluence of a major tributary or a dam, may limit the spatial extent of an assessment based on one station.

(2) **Non-wadable streams.** Unless it is demonstrated to the contrary, a single monitoring site shall be considered representative of no more than 25 stream miles for non-wadable streams.

(3) **Wadable streams.** Unless it is demonstrated to the contrary, a single monitoring site shall be considered representative of no more than 10 stream miles for wadable streams.

(4) **Lakes.** The spatial extent of assessment of use support in terms of lake surface acres shall be estimated based on the spatial distribution of monitoring sites having the requisite number of samples, sources of pollution, influence of tributaries and best professional judgment. Arms or portions of a lake may be treated separately from the main body of a lake. Unless it is demonstrated to the contrary, a single site shall be considered representative of an entire lake or an arm of no more than two hundred and fifty surface acres in size.

(5) **Spatial limitation for sampling sites.** For purposes of this Subchapter, observations, samples, and other data shall not be taken within any regulatory mixing zone.

(c) **Temporal coverage**.

(1) **General.** Observations, samples or other data collected for purposes of assessing use support shall be taken to avoid temporal bias, and seasonality shall be represented in the sampling scheme.

(2) **Streams.** Data no older than five years old shall be utilized in assessing use support for a stream unless

(A) the data available from the preceding five year period is insufficient to satisfy the requirements of 785:46-15-3(d) or other more specific minimum requirements provided in this Subchapter, in which case data older than five years old may be utilized, or

(B) the provisions of 785:46-15-4(b)(3) or 785:46-15-4(c)(3) apply.

(3) **Lakes.** Data no older than ten years old shall be utilized in assessing use support for a lake unless

(A) the data available from the preceding ten year period is insufficient to satisfy the requirements of 785:46-15-3(d) or other more specific minimum requirements provided in this Subchapter, in which case data older than ten years old may be utilized, or

(B) the provisions of 785:46-15-4(b)(3) or 785:46-15-4(c)(3) apply.

(d) **Minimum number of samples**.

(1) **Streams.** Except when (f) of this Section or any of subsections (e), (h), (i), (j), (k), (l), or (m) of 785:46-15-5 applies, a minimum of 10 samples shall be required to assess beneficial use support due to field parameters including but not limited to DO, pH and temperature, and due to routine water quality constituents including but not limited to coliform bacteria, dissolved solids and salts. Analyses may be aggregated to meet the 10 sample minimum requirements in non-wadable stream reaches that are 25 miles or less in length, and in wadable stream reaches that are 10 miles or less in length, if water quality conditions are similar at all sites. Provided, a minimum of 10 samples shall not be necessary if the existing samples already assure exceedance of the applicable percentage of a prescribed screening level.

(2) **Lakes.** Except when (f) of this Section applies, a minimum of 20 samples shall be required on lakes of more than 250 surface acres to assess beneficial use support due to water quality parameters including but not limited to DO, pH and temperature. A minimum of 20 samples shall likewise be required on such lakes for other routine water quality constituents including but not limited to coliform bacteria, chlorophyll a, and dissolved solids. A minimum of 10 samples shall be required on lakes or arms of 250 surface acres or less. Samples may be aggregated to meet the minimum requirements of this paragraph.

(3) **Toxicants.** Notwithstanding any other provision of this Subchapter, a minimum of five samples shall be required to determine that a beneficial use is supported with respect to all toxicants in water. A determination that a beneficial use is partially supported or not supported with respect to toxicants may be made upon less than five samples. Samples may be aggregated consistent with the spatial and temporal requirements prescribed in (b) and (c) of this Section in order to satisfy the minimum sample requirement of this paragraph. Additional samples for the calculation of pH and hardness dependent acute and chronic criteria shall be collected as required by OAC 785:46-5-8.

(e) **Application of PQL**.

(1) **Criteria above PQL.**

(A) If sample values are below the PQL for a parameter whose criterion is above the PQL, appropriate nonparametric statistical measures shall be used to determine the reporting value.

(B) For waterbodies identified as impaired on the current 303(d) List or 305(b) Report, if sample values are nondetectable for a parameter whose criterion is above the PQL, then such value shall be deemed to be one-half (1/2) of the parameter PQL.

(C) All sample values that are above the PQL shall be the reported values.

(2) **Criteria equal to or below PQL.**

(A) If sample values are below the PQL for a criterion which is less than or equal to one-half (1/2) of the PQL, then the values shall be deemed to be zero (0) until the first test result above the PQL appears. After that time, sample values which are equal to or below the PQL shall be deemed to be equal to the criterion value until four (4) subsequent contiguous samples are shown to be below the PQL. Any subsequent sample values which are nondetectable may be treated as zero (0) until the next test result appears above the PQL.

(B) For those parameters whose criteria are at least two (2) orders of magnitude below the PQL, evidence considered with respect to assessment of use support shall include fish tissue analysis, biological community analysis, biological thresholds wherever available, or other holistic indicators which are appropriate for the beneficial use in question.

(C) If sample values are below the PQL for a criterion which is greater than or equal to one-half (1/2) of the PQL but less than the PQL, then the values shall be deemed to be one-half (1/2) of the criterion value until the first test result above the PQL appears. After that time, sample values which are below the PQL shall be deemed to be equal to the criterion value until four (4) subsequent contiguous samples are shown to be below the PQL. Any subsequent sample values which are nondetectable may be treated as equal to one-half (1/2) of the criterion value until the next test result appears above the PQL.

(D) For waterbodies identified as impaired on the current 303(d) List or 305(b) Report, if sample values are nondetectable for a parameter whose criterion is below the PQL, then such value shall be deemed to be one-half (1/2) of the criterion value.

(E) All sample values that are above the PQL shall be the reported values.

(f) **Magnitude of criteria exceedance**.

(1) **General.** The magnitude of exceedance, as well as frequency of exceedances, shall be used in determining beneficial use support. Samples shall be taken only during conditions when criteria apply.

(2) **Toxicants.** If two or more concentrations of toxicants exceed criteria or screening levels to protect human health or aquatic life by two orders of magnitude or more, the associated beneficial use shall be deemed to be not supported.

(3) **Dissolved oxygen.** If more than two concentrations of DO in a stream are observed to be below 2 mg/L in any given year, the Fish and Wildlife Propagation beneficial use shall be deemed to be not supported.

(4) **Other parameters.** The magnitude and frequency of exceedances to be used for determining beneficial use support for parameters other than toxicants and DO shall be as prescribed in the rules elsewhere in this Subchapter.

(g) **Quality assurance.** On and after July 1, 2002, data collected for purposes of use support assessment shall be collected using documented programmatic quality assurance and quality control methods substantially in accordance with those required by "EPA Requirements for Quality Assurance Project Plans", EPA publication no. EPA/240/B-01/003 (March 2001). The sampling and testing methods used shall protect the integrity of the sample and provide detailed documentation of analysis.

[Source: Added at 17 Ok Reg 1775, eff 7-1-00; Amended at 18 Ok Reg 3379, eff 8-13-01; Amended at 19 Ok Reg 2512, eff 6-27-02; Amended at 20 Ok Reg 1429, eff 7-1-03; Amended at 22 Ok Reg 1607, eff 7-1-05; Amended at 23 Ok Reg 1568, eff 7-1-06]

785:46-15-4. Default protocols

(a) **General**. The protocols prescribed in this Section shall apply whenever the more specific protocols prescribed elsewhere in this Subchapter do not apply.

(b) **Short term average numerical parameters**.

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

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

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

(4) A beneficial use shall be deemed to be partially supported for a given parameter whose criterion is based upon a short term average if greater than 10% but less than 25%

of the samples for that parameter exceed the applicable screening level prescribed in this Subchapter.

(5) A beneficial use shall be deemed to be not supported for a given parameter whose criterion is based upon a short term average if at least 25% of the samples for that parameter exceed the applicable screening level prescribed in this Subchapter.

(c) **Long term average numerical parameters.**

(1) Long term average numerical parameters are based upon exposure periods of seven days or longer. Long term average parameters to which this Section applies include, but are not limited to, fish consumption water column numerical criteria and yearly mean standards. For purposes of assessing use support, calculations of means shall be limited to a two-year rolling average for those beneficial use applications requiring long term averages.

(2) A beneficial use shall be deemed to be fully supported for a given parameter whose criterion is based upon a long term average if the mean of the sample results does not exceed the long term average.

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

(4) Because means are compared with screening levels when addressing long term average numerical parameters, such parameters are not susceptible to an assessment that a use is partially supported.

(5) A beneficial use shall be deemed to be not supported for a given parameter whose criterion is based upon a long term average if the mean of the sample results exceeds the criterion or screening level.

[Source: Added at 17 Ok Reg 1775, eff 7-1-00; Amended at 19 Ok Reg 2512, eff 6-27-02]

785:46-15-5. Assessment of Fish and Wildlife Propagation support

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

(b) **Dissolved oxygen**.

(1) **Screening levels for DO in streams.**

(A) Screening levels for DO in habitat limited aquatic communities shall be 4.0 mg/L from April 1 through June 15 each year and 3.0 mg/L for the remainder of the year.

(B) Screening levels for DO in warm water aquatic communities shall be 4.0 mg/L from June 16 through October 15 each year and 5.0 mg/L for the remainder of the year.

(C) Screening levels for DO in cool water aquatic communities and trout fisheries shall be 5.0 mg/L from June 1 through October 15 each year and 6.0 mg/L for the remainder of the year.

(2) **Screening levels for DO in lakes.**

(A) If greater than 70% of the water column at any given sample site in a lake or an arm of a lake is less than 2 mg/L due to other than naturally occurring conditions, the Fish and Wildlife Propagation beneficial use shall be deemed to be not supported.

(B) If 50% or more, but not greater than 70%, of the water column at any given sample site in a lake or arm of a lake is less than 2 mg/L due to other than naturally occurring conditions, the Fish and Wildlife Propagation beneficial use shall be deemed to be partially supported.

(C) The screening level for surface DO in a lake or arm of a lake shall be 4 mg/L from June 16 through October 15 each year and 5.0 mg/L for the remainder of the year.

(3) **Support tests.**

(A) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be fully supported with respect to the DO criterion if no more than 10% of the samples from a waterbody are less than the screening level for DO prescribed in (b)(1) or (b)(2)(C) of this Section and such result is due to other than naturally occurring conditions.

(B) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be partially supported with respect to the DO criterion if greater than 10% but less than 25% of the samples from a waterbody are less than the screening level for DO prescribed in (b)(1) or (b)(2)(C) of this Section.

(C) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be not supported with respect to the DO criterion if at least 25% of the samples from a waterbody are less than the screening level for DO prescribed in (b)(1) or (b)(2)(C) of this Section.

(c) **Toxicants.**

(1) Test for Full Support

(A) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be fully supported with respect to any individual toxicant parameter if no more than one of the sample concentrations from the waterbody exceeds the acute criterion for that toxicant prescribed in the numerical criteria for toxic substances in OAC 785:45-5-12(f)(6)(D) and (E) and 785:45 Appendix G, Table 2.

(B) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be fully supported with respect to any individual toxicant parameter if not more than 1 sample concentration or not more than 10% of the sample concentrations from the waterbody exceeds the chronic criterion for that toxicant prescribed in the numerical criteria for toxic substances in OAC 785:45-5-12(f)(6)(D), (E) and 785:45 Appendix G, Table 2.

(2) Test for Non-Support

(A) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be not supported with respect to any individual toxicant parameter if more than one of the sample concentrations from the waterbody exceed the acute criterion for that toxicant prescribed in the numerical criteria for toxic substances in OAC 785:45-5-12(f)(6)(D) and (E) and 785:45 Appendix G, Table 2.

(B) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be not supported with respect to any individual toxicant parameter if more than 10 % of the sample concentrations from the waterbody exceed chronic criterion for that toxicant prescribed in the numerical criteria for toxic substances in OAC 785:45-5-12(f)(6)(D) and (E) and 785:45 Appendix G, Table 2

(d) **pH.**

(1) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be fully supported with respect to pH occurring other than by natural causes if no more than 10% of the sample concentrations from that waterbody fall outside the screening interval prescribed in 785:45-5-12(f)(3).

(2) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be partially supported with respect to pH occurring other than by natural causes if greater than 10% but less than 25% of the sample concentrations from that waterbody fall outside the screening interval prescribed in 785:45-5-12(f)(3).

(3) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be not supported with respect to pH occurring other than by natural causes if at least 25% of the sample concentrations from that waterbody fall outside the screening interval prescribed in 785:45-5-12(f)(3).

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

(f) **Oil and grease.**

(1) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be fully supported with respect to oil and grease if a visible sheen or bottom deposits of oil or grease are observed on that waterbody in 10% or less of the observations.

(2) The Fish and Wildlife Propagation beneficial use designated for a waterbody shall be deemed to be not supported with respect to oil and grease if a visible sheen or bottom deposits of oil or grease are observed on that waterbody in more than 10% of the observations.

(g) **Suspended and Bedded Sediments.**

(1) If a stream is supporting the biological criteria assigned to that stream as provided in (e) and (i) through (n) of this section, then that stream will be deemed to be supporting its assigned Fish and Wildlife Propagation beneficial use with respect to suspended and bedded sediments.

(2) If a stream is not supporting the biological criteria assigned to that stream as provided in (e) and (i) through (n) of this section, then a habitat assessment must be conducted using the habitat assessment protocols found in OWRB Technical Report TRWQ2001-1, "Unified Protocols for Beneficial Use Assignment for Oklahoma Wadable Streams." The results of the habitat assessment shall then be compared to either historical conditions or regional reference conditions in order to determine attainment with respect to suspended and bedded sediments in that stream.

(3) The method for establishing reference conditions shall meet the following requirements:

(A) a minimum of five (5) reference streams or reaches shall be assessed;

(B) all of the reference streams or reaches must be within the same ecoregion as the test stream;

(C) all of the reference streams or reaches must be streams with similar flow regimes no more than two (2) stream orders removed from the test stream; and

(D) the reference streams shall be selected from the least impacted streams in the ecoregion whose watersheds contain soils, vegetation, land uses, and topography typical of the watershed of the test stream(s).

(4) The Fish and Wildlife Propagation beneficial use will be considered to be not supported with respect to suspended and bedded sediments if any of the following habitat parameters deviate from the reference conditions by the specified amount:

(A) The total percent of clay, silt, and loose sand in the pool bottom substrate of the test stream is increased by more than 30% over the reference condition;

(B) Cobble embeddedness in the test stream is increased by 15% or more over the reference condition;

(C) The percentage of the length of the reach containing fresh (non-vegetated) point bars and/or islands in the test stream is 20 or more percentage points above that of the reference condition; or

(D) The percentage of the length of the reach dominated by pools of a depth of 0.5 meters or more in the test stream is less than 70% of that of the reference condition.

(5) If all of the habitat parameters identified in (h)(4) of this section deviate from the reference conditions by less than the amounts specified in (h)(4) of this section, then the Fish and Wildlife Propagation beneficial use is not impaired due to suspended and bedded sediments.

(h) **Metals.** The Fish and Wildlife Propagation beneficial use designated for a waterbody may be assessed using either total recoverable or dissolved metals. When available, the concentrations of dissolved metals shall be compared following the provisions of (c) of this subsection to the criteria in OAC 785:45 Appendix G converted to dissolved criteria by multiplying the total metal criterion listed in table 2 by the appropriate conversion factor listed in Table 3. Preference shall be given to the beneficial use determinations based upon dissolved metals.

(i) **Biological criteria.**

(1) If data demonstrate that an assemblage of fish or macro invertebrates from a waterbody is significantly degraded, according to 785:45-5-12(f)(5), from that expected for the subcategory of Fish and Wildlife Propagation designated in OAC 785:45 for that waterbody, then that subcategory may be deemed by the appropriate state environmental agency to be not supported.

(2) All physical assessments and biological collections shall be performed in accordance with the requirements set forth in OWRB Technical Report No. 99-3 entitled "Standard Operating Procedures for Stream Assessments and Biological Collections Related to Biological Criteria in Oklahoma".

(3) Evaluation of the biological collections shall include identification of fish samples to species level. Determinations of tolerance level shall be made according to Jester et al. 1992, "The Fishes of Oklahoma, Their Gross Habitats, and Their Tolerance of Degradation in Water Quality and Habitat", Proceedings of Oklahoma Academy of Sciences, 72:7-19.

(4) The determination of whether the use of Fish and Wildlife Propagation is supported in wadable streams in Oklahoma ecoregions shall be made according to all of the requirements of this subsection (e), the application of Appendix C of this Chapter, and the special provisions in subsections (i) through (o), where applicable, of this Section. Streams with undetermined use support status shall be subject to additional investigation that considers stream order, habitat factors and local reference streams before the use support determination is made. A finding of impairment for biocriteria due to any one of the parameters listed in this section shall trigger an evaluation of all likely causes, not precluding monitoring, assessment, and subsequent support determination of the Fish and Wildlife beneficial use for any of the other parameters in this section.

(j) **Special provisions for Ouachita Mountains wadable streams.** The determination of whether the use of Fish and Wildlife Propagation is supported for wadable streams located in the Ouachita Mountains ecoregion shall be made according to the application of Appendix C of this Chapter, together with this subsection, as follows:

(1) Where designated, the subcategory of Warm Water Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 35 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 24 or less. If a score is 25 to 34 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(2) Where designated, the subcategory of Habitat Limited Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 27 or more. Such subcategory shall be deemed not supported if the application of Appendix C

produces a score of 18 or less. If a score is 19 to 26 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(k) **Special provisions for Arkansas Valley wadable streams.** The determination of whether the use of Fish and Wildlife Propagation is supported for wadable streams located in the Arkansas Valley ecoregion shall be made according to the application of Appendix C of this Chapter, together with this subsection, as follows:

(1) Where designated, the subcategory of Warm Water Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 35 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 24 or less. If a score is 25 to 34 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(2) Where designated, the subcategory of Habitat Limited Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 27 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 18 or less. If a score is 19 to 26 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(l) **Special provisions for Boston Mountains and Ozark Highlands wadable streams.** The determination of whether the use of Fish and Wildlife Propagation is supported for wadable streams located in the Boston Mountains and Ozark Highlands ecoregions shall be made according to the application of Appendix C of this Chapter, together with this subsection, as follows:

(1) Where designated, the subcategory of Cool Water Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 37 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 29 or less. If a score is 30 to 36 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(2) Where designated, the subcategory of Warm Water Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 31 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 22 or less. If a score is 23 to 30 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(m) **Special provisions for Central Irregular Plains wadable streams.** The determination of whether the use of Fish and Wildlife Propagation is supported for wadable streams located in the Central Irregular Plains ecoregion shall be made according to the application of Appendix C of this Chapter, together with this subsection, as follows:

(1) Where designated, the subcategory of Cool Water Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 35 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 28 or less. If a score is 29 to 34 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(2) Where designated, the subcategory of Warm Water Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 30 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 22 or less. If a score is 23 to 29 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(3) Where designated, the subcategory of Habitat Limited Aquatic Community shall be deemed fully supported if the application of Appendix C produces a score of 25 or more. Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 16 or less. If a score is 17 to 24 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(n) **Special provisions for Central Oklahoma - Texas Plains wadable streams.** The determination of whether the Warm Water Aquatic Community subcategory of the Fish and Wildlife Propagation beneficial use is supported for wadable streams located in the Central Oklahoma - Texas Plains ecoregion shall be made according to the application of Appendix C of this Chapter, together with this subsection, as follows:

(1) Such subcategory shall be deemed fully supported if the application of Appendix C produces a score of 26 or more.

(2) Such subcategory shall be deemed not supported if the application of Appendix C produces a score of 19 or less.

(3) If the application of Appendix C produces a score of 20 to 25 inclusive, the issue of whether this subcategory is supported shall be deemed undetermined.

(o) **Special provisions for Central Great Plains wadable streams.** The subcategory of Warm Water Aquatic Community of the beneficial use of Fish and Wildlife Propagation in the wadable streams located in the Central Great Plains ecoregion shall be deemed fully supported if the application of Appendix C of this Chapter produces a score of 22 or more. Such subcategory shall be deemed not supported for the streams in this ecoregion if the application of Appendix C produces a score of 18 or less. If the application of Appendix C produces a score of 19 to 21 inclusive, the issue of whether this subcategory is supported for the streams in this ecoregion shall be deemed undetermined. Provided, however, this subsection does not apply to the area bounded by State Highway 54 on the west, U.S. Highway 62 on the south, U.S. Highway 281 on the east and State Highway 19 on the north.

[Source: Added at 17 Ok Reg 1775, eff 7-1-00; Amended at 18 Ok Reg 171, eff 10-25-00 (emergency); Amended at 18 Ok Reg 3379, eff 8-13-01; Amended at 19 Ok Reg 2512, eff 6-27-02; Amended at 20 Ok Reg 1429, eff 7-1-03; Amended at 21 Ok Reg 1910, eff 7-1-04; Amended at 22 Ok Reg 1607, eff 7-1-05; Amended at 24 Ok Reg 2445, eff 7-1-07]

785:46-15-6. Assessment of Primary Body Contact Recreation support

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

(b) **Screening levels.**

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

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

(3) The screening level for enterococci shall be a density of 61 colonies per 100 ml in streams designated in OAC 785:45 as Scenic Rivers and in lakes, and 406 colonies per 100 ml in all other waters of the state designated as Primary Body Contact Recreation.

(c) **Fecal coliform.**

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

(2) The parameter of fecal coliform is not susceptible to an assessment that Primary Body Contact Recreation is partially supported.

(3) The Primary Body Contact Recreation subcategory designated for a waterbody shall be deemed to be not supported with respect to fecal coliform if the geometric mean of 400 colonies per 100 ml is not met, or greater than 25% of the sample concentrations from that

APPENDIX A

waterbody exceed the screening level prescribed in (b) of this Section, or both such conditions exist.

(d) **Escherichia coli (*E. coli*).**

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

(2) The parameter of *E. coli* is not susceptible to an assessment that Primary Body Contact Recreation is partially supported.

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

(e) **Enterococci.**

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

(2) The parameter of enterococci is not susceptible to an assessment that Primary Body Contact Recreation is partially supported.

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

[Source: Added at 17 Ok Reg 1775, eff 7-1-00; Amended at 21 Ok Reg 1910, eff 7-1-04]

785:46-15-7. Assessment of Public and Private Water Supply support

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

(b) **Toxicants.**

(1) The Public and Private Water Supply beneficial use designated for a waterbody shall be deemed to be fully supported with respect to any substance with criteria for such use listed in OAC 785:45 Appendix G if the sample concentrations from that waterbody do not exceed the criterion for that substance prescribed in OAC 785:45 Appendix G more than 10% of the time, or drinking water use restrictions are not in effect, or both such conditions exist.

(2) The Public and Private Water Supply beneficial use designated for a waterbody shall be deemed to be partially supported with respect to any substance with criteria for such use listed in OAC 785:45 Appendix G if the sample concentrations from that waterbody exceed the criterion for that substance prescribed in OAC 785:45 Appendix G more than 10% but less than 25% of the time, or drinking water use restrictions imposed by an agency with jurisdiction in effect require more than conventional treatment, or both such conditions exist.

(3) The Public and Private Water Supply beneficial use designated for a waterbody shall be deemed to be not supported with respect to any substance with criteria for such use listed in OAC 785:45 Appendix G if the sample concentrations from that waterbody

exceed the criterion for that substance prescribed in OAC 785:45 Appendix G more than 25% of the time, or drinking water use restrictions imposed by an agency with jurisdiction in effect require closure of the water supply, or both such conditions exist.

(c) **Bacteria.** The screening level for fecal coliform bacteria shall be 5000 colonies per 100 ml. The tests for use support shall follow the default protocol in 785:46-15-4.

(d) **Threatened water supplies.** Waters of the state designated in OAC 785:45 as Public and Private Water Supply shall be presumed to be threatened when toxicants are detected but do not exceed the applicable criteria prescribed in OAC 785:45 Appendix G, or some drinking water use restrictions have been put into effect by an agency with jurisdiction, or the potential for adverse impacts to water quality exists, or more than one such conditions exist.

(e) **Oil and grease.**

(1) The Public and Private Water Supply beneficial use designated for a waterbody shall be deemed to be fully supported with respect to oil and grease if a visible sheen or bottom deposits of oil or grease are observed on that waterbody in 10% or less of the observations, and drinking water use restrictions that require more than conventional treatment related to oil and grease have not been put into effect by an agency with jurisdiction.

(2) The Public and Private Water Supply beneficial use designated for a waterbody shall be deemed to be not supported with respect to oil and grease if a visible sheen or bottom deposits of oil or grease are observed on that waterbody in more than 10% of the observations, or drinking water use restrictions that require more than conventional treatment related to oil and grease have been put into effect by an agency with jurisdiction.

[Source: Added at 17 Ok Reg 1775, eff 7-1-00; Amended at 21 Ok Reg 1910, eff 7-1-04]

785:46-15-8. Assessment of Agriculture support

(a) **Scope.** The provisions of this Section shall be used to determine whether the beneficial use of Agriculture designated in OAC 785:45 for a waterbody is supported.

(b) **General support tests for chlorides, sulfates and TDS.**

(1) The Agriculture beneficial use designated for a waterbody shall be deemed to be fully supported with respect to chlorides, sulfates and TDS if the mean of all chlorides, sulfates and TDS sample concentrations from that waterbody do not exceed the yearly mean standard prescribed in Appendix F of OAC 785:45 and no more than 10% of the sample concentrations from that waterbody exceed the sample standard prescribed in Appendix F of OAC 785:45. Provided, if the TDS sample concentrations are less than 700 mg/L and the chlorides and sulfates are each less than 250 mg/L, then the Agriculture beneficial use shall be deemed to be fully supported with respect to those substances.

(2) The Agriculture beneficial use designated for a waterbody shall be deemed to be partially supported with respect to chlorides, sulfates and TDS if the mean of all chlorides, sulfates and TDS sample concentrations from that waterbody does not exceed the yearly mean standard prescribed in Appendix F of OAC 785:45 and more than 10% but less than 25% of the sample concentrations from that waterbody exceed the sample standard prescribed in Appendix F of OAC 785:45.

(3) The Agriculture beneficial use designated for a waterbody shall be deemed to be not supported with respect to chlorides, sulfates and TDS if the mean of all chlorides, sulfates and TDS sample concentrations from that waterbody exceeds the yearly mean standard prescribed in Appendix F of OAC 785:45, or at least 25% of the sample concentrations from that waterbody exceed the sample standard prescribed in Appendix F of OAC 785:45, or both such conditions exist.

(c) **Use of site specific data.** If the appropriate state environmental agency determines that the stream segment averages prescribed in Appendix F of OAC 785:45 are not appropriate for the entirety of a given stream segment or there is no value listed in Appendix F for the stream segment average for the parameter of concern, then yearly mean standards and sample standards developed from site specific data may be used to assess whether the use of Agriculture is supported for that waterbody.

(d) **Use of data for lakes.**

(1) Lakes with one WBID segment. For support assessment in lakes with a single WBID segment, the segment averaged value prescribed in Appendix F to that same WQM segment shall be used.

(2) Lakes with multiple WBID segments. For support assessment in lakes with multiple WBID segments, each segment shall use the segment averaged value prescribed in Appendix F to that same WQM segment when available. If a WBID segment in a lake has no corresponding WQM segment data available in Appendix F, the segment averaged value prescribed in Appendix F to the WQM segment immediately downstream of the lake shall be used.

[Source: Added at 17 Ok Reg 1775, eff 7-1-00; Amended at 22 Ok Reg 1607, eff 7-1-05; Amended at 24 Ok Reg 2445, eff 7-1-07]

785:46-15-9. Assessment of Fish Consumption support

(a) **Scope.** The provisions of this Section shall be used to determine whether the beneficial use of Fish Consumption designated in OAC 785:45 for a waterbody is supported.

(b) **Support tests.**

(1) The Fish Consumption beneficial use designated for a waterbody shall be deemed to be partially supported if restricted consumption as imposed by an agency with jurisdiction is in effect or if a fish or shellfish ban is in effect for a sub-population thereof.

(2) The Fish Consumption beneficial use designated for a waterbody shall be deemed to be not supported if an aquatic life closure or if a "no consumption" advisory imposed by an agency with jurisdiction is in effect.

(3) The water column criteria for protection of the Fish Consumption beneficial use stated in 785:45 Appendix G Table 2 shall be used according to the default protocol in 785:46-15-4(c) to determine use support.

[Source: Added at 17 Ok Reg 1775, eff 7-1-00; Amended at 19 Ok Reg 2512, eff 6-27-02]

785:46-15-10. Nutrients

(a) **General.** OAC 785:45-3-2(c) prohibits water quality degradation by nutrients which will interfere with the attainment or maintenance of any existing or designated beneficial use. OAC 785:46-13-3(a)(1) requires maintenance of any existing or designated beneficial use. This Section provides a framework which shall be used in assessing threats or impairments to beneficial uses and waterbodies and watersheds caused by nutrients, and the consequences of such assessments.

(b) **Determining whether a stream is nutrient-threatened.** The dichotomous process stated in this subsection shall be used in the determination of whether a stream is nutrient-threatened.

(1) The stream order shall be identified. If the stream order is 1, 2 or 3, then proceed to paragraph (2). If the stream order is not 1, 2 or 3, then proceed to paragraph (9).

(2) The stream slope shall be identified. If the stream slope is greater than or equal to 17 feet per mile, then proceed to paragraph (3). If the stream slope is less than 17 feet per mile, then proceed to paragraph (4).

(3) Subject to the application of the foregoing paragraphs of this subsection, if phosphorus concentrations in the stream are greater than 0.24 mg/L or if nitrite plus nitrate concentrations in the stream are greater than 4.95 mg/L, then proceed to paragraph (5). If such nutrient concentrations are less than the levels specified in this paragraph, then the stream is not threatened by nutrients.

APPENDIX A

(4) Subject to the application of the foregoing paragraphs of this subsection, if phosphorus concentrations in the stream are greater than 0.15 mg/L or if nitrite plus nitrate concentrations in the stream are greater than 2.4 mg/L, then proceed to paragraph (5). If such nutrient concentrations are less than the levels specified in this paragraph, then the stream is not threatened by nutrients.

(5) Subject to the application of the foregoing paragraphs of this subsection, if the percentage of canopy shading is greater than or equal to 80%, then the stream is not threatened by nutrients. If the percentage of canopy shading is less than 80%, then proceed to paragraph (6).

(6) Subject to the application of the foregoing paragraphs of this subsection, if the stream's turbidity is organic, then proceed to paragraph (7). If the stream's turbidity is inorganic, then proceed to paragraph (8).

(7) Subject to the application of the foregoing paragraphs of this subsection, if turbidity measured at seasonal base flow conditions is less than 20 NTU, then the stream is not threatened by nutrients. If turbidity measured at seasonal base flow conditions is 20 or more NTU, then the stream is threatened by nutrients.

(8) Subject to the application of the foregoing paragraphs of this subsection, if turbidity measured at seasonal base flow conditions is less than 20 NTU, then the stream is threatened by nutrients. If turbidity measured at seasonal base flow conditions is 20 or more NTU, then the stream is not threatened by nutrients.

(9) Subject to the application of the foregoing paragraphs of this subsection, if the stream slope is greater than or equal to 17 feet per mile, then proceed to paragraph (10). If the stream slope is less than 17 feet per mile, then proceed to paragraph (11).

(10) Subject to the application of the foregoing paragraphs of this subsection, if phosphorus concentrations in the stream are greater than 1.00 mg/L, or if nitrite plus nitrate concentrations in the stream are greater than 4.65 mg/L, then proceed to paragraph (12). If such nutrient concentrations are less than the levels specified in this paragraph, then the stream is not threatened by nutrients.

(11) Subject to the application of the foregoing paragraphs of this subsection, if phosphorus concentrations in the stream are greater than 0.36 mg/L, or if nitrite plus nitrate concentrations in the stream are greater than 5.0 mg/L, then proceed to paragraph (12). If such nutrient concentrations are less than the levels specified in this paragraph, then the stream is not threatened by nutrients.

(12) Subject to the application of the foregoing paragraphs of this subsection, if the stream's inorganic turbidity measured at seasonal base flow conditions is greater than or equal to 20 NTU, then the stream is not threatened by nutrients. If the stream's inorganic turbidity measured at seasonal base flow conditions is less than 20 NTU, then the stream is threatened.

(c) **Alternative to dichotomous process for streams.**

(1) A wadable stream shall be deemed threatened by nutrients if the arithmetic mean of benthic chlorophyll-a data exceeds 100 mg per square meter under seasonal base flow conditions, or if two or more benthic chlorophyll-a measurements exceed 200 mg per square meter under seasonal base flow conditions. A non-wadable stream shall be deemed threatened by nutrients if planktonic chlorophyll-a values in the water column indicate it has a Carlson's Trophic State Index of 62 or greater.

(2) If clear and convincing evidence indicates a result for a stream different from that obtained from application of the dichotomous process in (b) of this Section, then the appropriate state environmental agency may, after completing the public participation process developed by the Secretary of Environment pursuant to 27A O.S. 1-2-101, accordingly identify the stream as threatened or not threatened by nutrients.

(d) **Demonstration that nutrients may be adversely impacting a beneficial use in a lake.** If it is demonstrated that nutrient loading in a lake may be adversely impacting a beneficial use designated for that waterbody, then the Board may determine that the lake and its watershed is an NLW, and shall identify the lake and watershed as NLW in Appendix A of OAC 785:45.

(e) **Consequence of identification as NLW; results of study.** If a lake or its watershed is identified as NLW in Appendix A of OAC 785:45, then the Board or other appropriate state environmental agency may cause an NLW Impairment Study to be performed. The beneficial uses designated for lakes identified in OAC 785:45 Appendix A as NLW shall be presumed to be fully supported but threatened, unless an NLW Impairment Study demonstrates that the uses are partially supported or not supported; provided, if an NLW Impairment Study demonstrates that the uses are not threatened, then the Board shall consider deleting the NLW identification.

(f) **Consequence of assessment that use is threatened by nutrients.** If it is determined that one or more beneficial uses designated for a waterbody are threatened by nutrients, then that waterbody shall be presumed to be nutrient-threatened. If it is determined or presumed, in accordance with this Section, that a waterbody is nutrient-threatened, then before the waterbody is determined to be nutrient-impaired, an NLW Impairment Study if a lake or an impairment study if a stream must be completed by the appropriate state environmental agency.

(g) **Result of impairment study.**

(1) **Impaired or threatened.** If, independent of or in addition to the process set forth in (b) of this Section, an impairment study of a waterbody demonstrates that a waterbody is impaired or threatened by nutrients, then the appropriate state environmental agency shall initiate the appropriate listing procedure developed by the Secretary of Environment pursuant to 27A O.S. 1-2-101.

(2) **Not threatened nor impaired.** If, independent of or in addition to the process set forth in (b) of this Section, an impairment study of a waterbody demonstrates that a waterbody is neither threatened nor impaired by nutrients, then the appropriate state environmental agency shall initiate the appropriate de-listing procedure developed by the Secretary of Environment pursuant to 27A O.S. 1-2-101.

(h) **Special provisions for Scenic Rivers.**

(1) **Scope and applicability.** This subsection (h) shall be used to determine whether the beneficial use of Aesthetics designated for a segment of a Scenic River is supported with respect to the criterion of total phosphorus.

(2) **Data and procedure.**

(A) The data used shall satisfy all of the requirements of 785:46-15-3 except subsection (f) thereof. Notwithstanding such requirements, the data shall include samples collected from stream flow of at least six (6) storm events per calendar year or, if fewer than nine (9) storm events occurred in that year, then the majority of the storm events that occurred that year.

(B) Whenever multiple samples are taken from a single storm event, the event mean concentration shall be determined and used as representative of that storm event.

(C) A three-calendar-month geometric mean concentration shall be determined each month using the total phosphorus data from that month together with such data from the preceding two calendar months.

(3) **Support tests.**

(A) The Aesthetics beneficial use designated for a segment of a Scenic River shall be deemed to be supported with respect to total phosphorus if less than 25% of the monthly determinations made in accordance with (h)(2)(C) of this Section exceed 0.037 mg/L total phosphorus.

(B) The Aesthetics beneficial use designated for a segment of a Scenic River shall be deemed to be not supported with respect to total phosphorus if 25% or greater of the monthly determinations made in accordance with (h)(2)(C) of this Section exceed 0.037 mg/L total phosphorus.

[Source: Added at 17 Ok Reg 1775, eff 7-1-00; Amended at 18 Ok Reg 171, eff 10-25-00 (emergency); Amended at 18 Ok Reg 3379, eff 8-13-01; Amended at 21 Ok Reg 1910, eff 7-1-04; Amended at 22 Ok Reg 1607, eff 7-1-05]

785:46-15-11. Assessment of Hydroelectric Power Generation support [REVOKED]
[Source: Added at 21 Ok Reg 1910, eff 7-1-04; Revoked at 24 Ok Reg 2445, eff 7-1-07]

785:46-15-12. Assessment of Industrial and Municipal Process and Cooling Water support [REVOKED]
[Source: Added at 21 Ok Reg 1910, eff 7-1-04; Revoked at 24 Ok Reg 2445, eff 7-1-07]

785:46-15-13. Assessment of Navigation support [REVOKED]
[Source: Added at 21 Ok Reg 1910, eff 7-1-04; Revoked at 24 Ok Reg 2445, eff 7-1-07

APPENDIX A