2005 Report of the Oklahoma

Beneficial Use Monitoring Program

Lakes Report

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OWRB
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the water agency

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 nonpoint 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 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 55-60 lakes annually is currently occurring. This represents approximately a 40% increase in effort over historical BUMP Lake sampling efforts. 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 nonpoint 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

Data was collected by the OWRB on a quarterly basis for 64 lakes in 2004-2005. For the current sample year, data was collected from the September of 2004 through August of 2005. The results of the sampling efforts are summarized below. As shown in Figure 1, a relatively small percentage (9%) 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." Forty-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, 44% 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 six of the 64 lakes sampled were classified as oligotrophic. Based on the results for trophic state index calculations, 63% of the waters sampled were exhibiting high to excessive levels of primary productivity and nutrient rich conditions characteristic of eutrophic and hypereutrophic waterbodies.

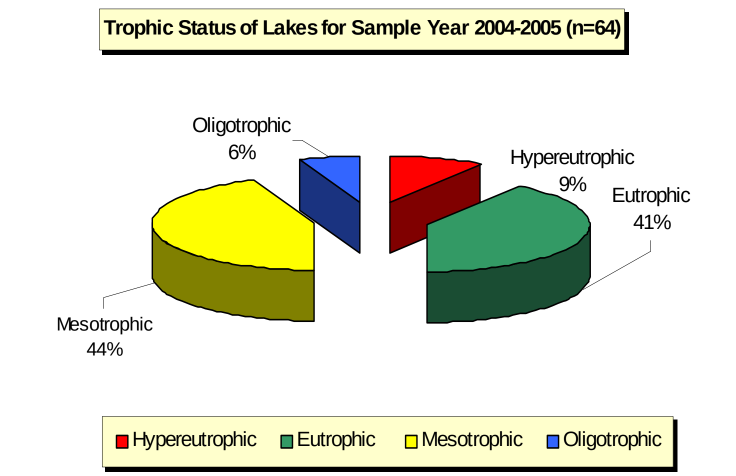

Figure 1. Trophic Status of Lakes Sampled in 2004-2005

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

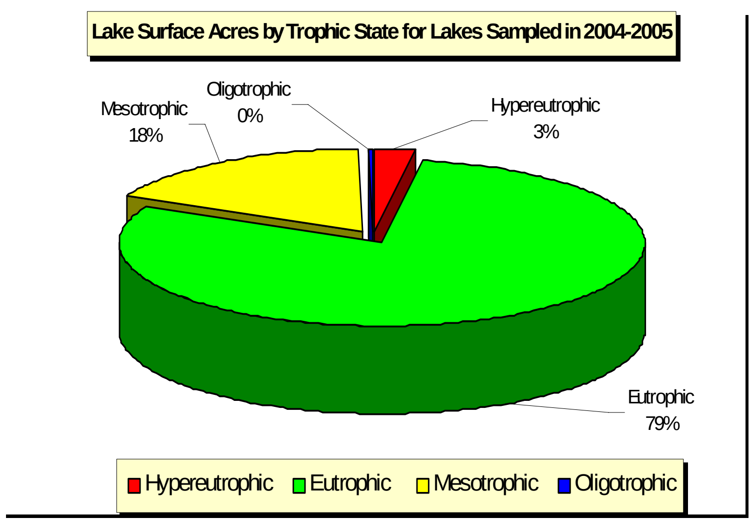

Figure 2. Lakes surface acres segregated by trophic state.

number of lake surface acres in each trophic state category, 79% of all surface acres sampled were eutrophic, 18% were mesotrophic, 3% were hypereutrophic, and 0% were oligotrophic. The three largest reservoirs sampled in 2004-2005 were classified as eutrophic (Eufaula, R.S. Kerr and Texoma), 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, 20 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		2003-2004	D.O.				
Arbuckle	Murray	310800	2004-2005	D.O.				
Arcadia◘	Oklahoma	520710	2004-2005					NLW
Ardmore City	Carter	310800	2004-2005					
Atoka	Atoka	410400	2003-2004	Turbidity D.O.				True Color
Bellcow	Lincoln	520700	2003-2004	D.O.				
Birch	Osage	121300	2004-2005					
Bixhoma	Wagoner		2003-2004	D.O.				
Bluestem	Osage	121300	2003-2004	D.O.				
Boomer	Payne	620900	2004-2005	Turbidity				
Broken Bow	McCurtain	410210	2003-2004	pH D.O.				
Brushy Creek	Sequoyah	220200	2003-2004	pH		Ent.		
Burtschi‡	Grady		2003-2004			Ent.		
Canton	Blaine	720500	2003-2004	Turbidity				
Carl Albert	Latimer	410310	2003-2004					
Carl Blackwell	Payne	620900	2004-2005	Turbidity				
Carter	Marshall	310800	2003-2004					
Cedar (Mena)	LeFlore	410210 410300	2003-2004	D.O. pH				
Chandler	Lincoln	520700	2004-2005					

Lake Name	County	W.Q. Segment #	Last Year Sampled	FWP	PPWS	PBCR	AG	AES
Chickasha ◘	Caddo	310830	2004-2005	Turbidity				NLW
Claremore	Rogers	121500	2003-2004					NLW
Clear Creek	Stephens	310810	2004-2005					
Cleveland City	Pawnee		2003-2004	D.O.				
Clinton ◘	Washita	310830	2003-2004	Turbidity		Ent.		True Color
Coalgate City	Coal	410400	2003-2004	D.O. Turbidity				True Color
Comanche	Stephens	311300	2004-2005					
Copan	Washington	121400	2004-2005	Turbidity D.O.				True Color
Crowder	Washita	310830	2003-2004					NLW
Cushing Municipal	Payne	620900	2003-2004	Turbidity				True Color
Dave Boyer (Walters)	Cotton	311300	2003-2004	Turbidity				True Color
Dripping Springs	Okmulgee	520700	2004-2005	Turbidity D.O.				True Color
Duncan	Stephens	310810	2004-2005					
El Reno ◘	Canadian		2004-2005	Turbidity				True Color NLW
Elk City	Beckham	311500	2003-2004			Ent.		NLW
Ellsworth	Comanche	311300	2003-2004	Turbidity D.O.				
Elmer Thomas	Comanche	311300	2004-2005					
Etling, Carl ◘	Cimarron	720900	2003-2004	Turbidity pH				NLW
Eucha ●	Delaware	121600	2004-2005	D.O.				NLW
Eufaula	Haskell	220600	2004-2005	D.O. Turbidity				True Color
Fairfax City	Osage	621200	2003-2004	D.O.				
Fort Cobb	Caddo	310830	2003-2004	Turbidity		Ent.		NLW
Fort Gibson	Cherokee	121600	2003-2004					NLW
Fort Supply †	Woodward	720500	2001-2002	Turbidity				NLW True Color
Foss	Custer	310800 310810 310820 310830 310840	2004-2005					
Frederick	Tillman	311310	2004-2005	Turbidity				True Color
Fuqua	Stephens	310810	2004-2005					
Grand Lake	Mayes	121600	2003-2004	D.O. Turbidity				
Great Salt Plains	Alfalfa	621010	2003-2004	Turbidity		Ent.	Sulfates & Chlorides	NLW
Greenleaf	Muskogee	120400	2003-2004			Ent.		

LAKE NAME	COUNTY	W.Q. SEGMENT #	LAST YEAR SAMPLED	FWP	PPWS	PBCR	AG	AES
GUTHRIE	LOGAN	620910	2003-2004	TURBIDITY		ENT.		
HEALDTON CITY	CARTER	311100	2003-2004	TURBIDITY				TRUE COLOR
HEFNER	OKLAHOMA	520520 520530	2003-2004	TURBIDITY				
HENRYETTA ♦	OKMULGEE	520700	2004-2005	TURBIDITY				TRUE COLOR
HEYBURN	CREEK	120420	2004-2005	D.O. TURBIDITY		ENT.		TRUE COLOR
HOLDENVILLE	HUGHES	520800	2001-2002	D.O.		ENT.		
HOMINY MUNICIPAL	OSAGE	121300	2003-2004	D.O.				
HUDSON	OSAGE		2003-2004	D.O.				
HUDSON	MAYES	121600	2004-2005					
HUGO	CHOCTAW	410300	2004-2005	TURBIDITY				TRUE COLOR
HULAH	OSAGE	121400	2004-2005	TURBIDITY				NLW
HUMPHREYS	STEPHENS	310810	2004-2005					
JEAN NEUSTADT	CARTER	310800	2004-2005					
JOHN WELLS	HASKELL	220200	2003-2004					
KAW	OSAGE	621210	2004-2005	TURBIDITY D.O.				
KEYSTONE	TULSA	621200	2003-2004	TURBIDITY		ENT.		
KONAWA	SEMINOLE		2004-2005					
LANGSTON	LOGAN	620900	2003-2004					
LAWTONKA	COMANCHE	311300	2003-2004					
LIBERTY	LOGAN	620910	2003-2004	TURBIDITY		ENT.		
LLOYD CHURCH	LATIMER	220100	2003-2004	D.O.				
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	2003-2004	D.O. PH				
MCMURTRY	NOBLE	620900	2004-2005	TURBIDITY				
MEEKER	LINCOLN	520700	2003-2004	TURBIDITY				TRUE COLOR
MURRAY	LOVE	311100	2003-2004	D.O.				
NANIH WAIYA	PUSHMATAHA		2004-2005					
NEW SPIRO ◘	LEFLORE	220100	2003-2004	D.O.				NLW
OKEMAH	OKFUSKEE	520700	2004-2005	D.O.				TRUE COLOR
OKMULGEE	OKMULGEE	520700	2004-2005	D.O.				TRUE COLOR

Lake Name	County	W.Q. Segment #	Last Year Sampled	FWP	PPWS	PBCR	AG	AES
Oologah	Rogers	121510	2004-2005	Turbidity D.O.				
Overholser ◘	Oklahoma	520520 520530	2003-2004	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	2003-2004					
Perry	Noble	621200	2004-2005	Turbidity				True Color
Pine Creek	McCurtain	410210	2003-2004	D.O. Turbidity pH				
Ponca	Kay	621200	2004-2005	D.O.				
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	2004-2005	D.O.				
Rocky (Hobart) ◘	Washita	311500	2003-2004	Turbidity		Ent.		NLW
Sahoma	Creek	120420	2003-2004	D.O. Turbidity				True Color
Sardis	Pushmataha	410310	2004-2005	D.O. Turbidity				True Color
Shawnee Twin # 1	Pottawatomie	520510	2003-2004					
Shawnee Twin # 2	Pottawatomie	520510	2003-2004					
Shell	Osage	120420	2003-2004	D.O.				
Skiatook	Osage	121300	2004-2005	D.O.				
Sooner	Pawnee		2004-2005					
Spavinaw ●	Mayes	121600	2004-2005	D.O.				NLW
Sportsman	Seminole	520500	2004-2005	Turbidity				True Color
Stanley Draper	Cleveland		2003-2004					
Stilwell City	Adair	220200	2003-2004	D.O.				
Stroud	Creek	520700	2003-2004					
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					

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

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

‡ These Lakes will not be recommended for listing as part of the next WQS revision due to insufficient data

♣ 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	PL = PROVISIONALLY LISTED

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 groundwaters 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 groundwaters 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 antidegradation 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 Nonpoint 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 55 to 60 lakes on a quarterly basis. Under this scenario, repeat sampling on a lake will occur approximately every other year, 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 2004-2005, 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 14 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 64 lakes across the state from the fall of 2004 through the summer of 2005 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 conductance, 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 2004-2005 are shown in Figure 3. Lake locations are identified on the map and are shaded in different colors based on their calculated TSI values.

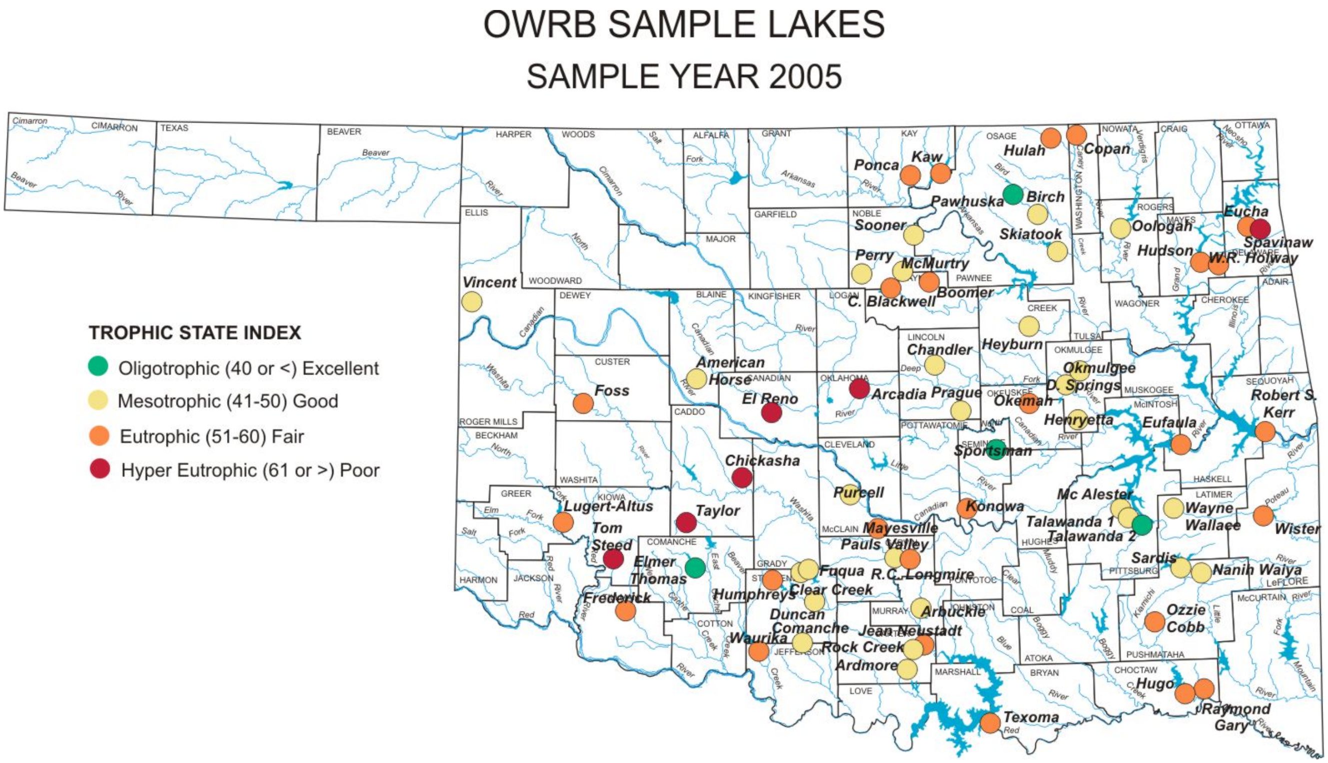

Figure 3. Lakes Sampled by the Beneficial Use Monitoring Program.

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:

$$TSI = 9.81 \times \ln(\text{chlorophyll-}\underline{a}) + 30.6.$$

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 volume of water 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 volume 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 provisionally listed 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 has been determined 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 2004-2005 as well as the percentages of the total. As shown in Table 3, six lakes were hypereutrophic, twenty-six were eutrophic, twenty-eight were mesotrophic, and four were oligotrophic. Of the total 418,680 surface acres sampled, 11,021 were classified hypereutrophic, 332,969 were classified as eutrophic, 73,711 were classified as mesotrophic and 979 acres were classified as oligotrophic. TSI results, county, surface area, and volume for lakes sampled in 2004-2005 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	**6**	**9%**	**11,021**	**3%**
Eutrophic	**26**	**41%**	**332,969**	**80%**
Mesotrophic	**28**	**53%**	**73,711**	**18%**
Oligotrophic	**4**	**6%**	**979**	**0%**
Totals =	**64**	**100%**	**418,680**	**100%**

Table 4. List of Lakes Sampled in Sample Year 2004-2005.

LAKE NAME	COUNTY	SURFACE AREA	VOLUME	TSI	CARLSON'S TSI
AMERICAN HORSE	BLAINE	100	2,200	49	MESOTROPHIC
ARBUCKLE	MURRAY	2,350	72,400	46	MESOTROPHIC
ARCADIA	OKLAHOMA	1,820	27,520	62	HYPEREUTROPHIC
ARDMORE CITY	CARTER	142	600	49	MESOTROPHIC
BIRCH	OSAGE	1,137	19,200	50	MESOTROPHIC
BOOMER	PAYNE	260	3,200	53	EUTROPHIC
CARL BLACKWELL	PAYNE	3,370	61,500	56	EUTROPHIC
CHANDLER	LINCOLN	129	2,778	50	MESOTROPHIC
CHICKASHA	CADDO	820	41,080	66	HYPEREUTROPHIC
CLEAR CREEK	STEPHENS	722	7,710	48	MESOTROPHIC
COMANCHE	STEPHENS	184	2,500	46	MESOTROPHIC
COPAN	WASHINGTON	4,850	43,400	51	EUTROPHIC
DRIPPING SPRINGS	OKMULGEE	1,150	16,200	41	MESOTROPHIC
DUNCAN	STEPHENS	500	7,200	48	MESOTROPHIC
EL RENO	CANADIAN	170	709	63	HYPEREUTROPHIC
ELMER THOMAS	COMANCHE	334	12,000	33	OLIGOTROPHIC
EUCHA*	DELAWARE	2,860	79,600	56	EUTROPHIC
EUFAULA	HASKELL	105,500	2,314,600	52	EUTROPHIC

LAKE NAME	COUNTY	SURFACE AREA	VOLUME	TSI	CARLSON'S TSI
FOSS	CUSTER	8,800	256,220	52	EUTROPHIC
FREDERICK	TILLMAN	925	9,526	51	EUTROPHIC
FUQUA	STEPHENS	1,500	21,100	48	MESOTROPHIC
HENRYETTA♦	OKMULGEE	450	6600	47	MESOTROPHIC
HEYBURN	CREEK	880	7,105	47	MESOTROPHIC
HUDSON	MAYES	10,900	200,300	60	EUTROPHIC
HUGO	CHOCTAW	13,250	157,600	53	EUTROPHIC
HULAH	OSAGE	3,570	31,160	54	EUTROPHIC
HUMPHREYS	STEPHENS	882	14,041	58	EUTROPHIC
JEAN NEUSTADT	CARTER	462	6,106	52	EUTROPHIC
KAW	OSAGE	17,040	428,600	56	EUTROPHIC
KONAWA	SEMINOLE	1,350	23,000	53	EUTROPHIC
LONGMIRE, R.C.	GARVIN	918		56	EUTROPHIC
LUGERT-ALTUS	GREER	6,260	132,830	59	EUTROPHIC
MAYSVILLE	MCCLAIN	302	2,082	57	EUTROPHIC
MCALESTER	PITTSBURG	1,521	13,398	42	MESOTROPHIC
MCMURTRY	NOBLE	1,155	19,733	47	MESOTROPHIC
NANIH WAIYA	PUSHMATAHA	131	1,064	45	MESOTROPHIC
OKEMAH	OKMULGEE	761	13,100	51	EUTROPHIC
OKMULGEE	OKMULGEE	668	14,170	45	MESOTROPHIC
OOLOGAH	ROGERS	29,460	553,400	46	MESOTROPHIC
OZZIE COBB	PUSHMATAHA	116	833	55	EUTROPHIC
PAULS VALLEY	GARVIN	750	8,730	49	MESOTROPHIC
PAWHUSKA	OSAGE	96	3,600	39	OLIGOTROPHIC
PERRY	NOBLE	614	6,892	44	MESOTROPHIC
PONCA	KAY	805	14,440	52	EUTROPHIC
PRAGUE	LINCOLN	225	2,415	45	MESOTROPHIC
PURCELL	MCCLAIN	150	2,600	50	MESOTROPHIC
RAYMOND GARY	CHOCTAW	263	1,681	54	EUTROPHIC
ROBERT S. KERR	SEQUOYAH	43,380	525,700	58	EUTROPHIC
ROCK CREEK	CARTER	248	3,588	48	MESOTROPHIC
SARDIS	PUSHMATAHA	13,610	274,330	50	MESOTROPHIC
SKIATOOK	OSAGE	10,190	322,700	43	MESOTROPHIC
SOONER	PAWNEE	5,400	149,000	48	MESOTROPHIC
SPAVINAW*	MAYES	1,584	38,000	61	HYPEREUTROPHIC
SPORTSMAN	SEMINOLE	354	5,349	40	OLIGOTROPHIC

Lake Name	County	Surface Area	Volume	TSI	Carlson's TSI
Talawanda No. 1	Pittsburg	91	1,200	44	Mesotrophic
Talawanda No. 2	Pittsburg	195	2,750	39	Oligotrophic
Taylor (Marlow)	Grady	227	1,877	63	Hypereutrophic
Texoma	Bryan	88,000	2,643,300	56	Eutrophic
Tom Steed	Kiowa	6,400	88,970	70	Hypereutrophic
Vincent, Loyd	Ellis	160	2,579	44	Mesotrophic
W.R. Holway	Mayes	712	48,000	53	Eutrophic
Waurika	Jefferson	10,100	203,100	60	Eutrophic
Wayne Wallace	Latimer	94	1,746	41	Mesotrophic
Wister$^{\Omega}$	LeFlore	7,333	62,360	52	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, six lakes were hypereutrophic, twenty-six lakes were eutrophic, twenty-eight lakes were mesotrophic, and four 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. Twenty-four lakes were hypereutrophic, twenty lakes were eutrophic, nineteen lakes were mesotrophic and one was oligotrophic using the total phosphorus variable for TSI. For the secchi disk depth trophic evaluation, forty-nine lakes were identified as hypereutrophic, eleven lakes were eutrophic, three lakes were mesotrophic and one was oligotrophic. The TSI values calculated using secchi depth were the highest of the three variables. For example, Heyburn 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 2004-2005.

LAKE NAME	CHL-A	TROPHIC STATE	TOTAL P	TROPHIC STATE	SECCHI	TROPHIC STATE
AMERICAN HORSE LAKE	49	Mesotrophic	53	Eutrophic	45	Mesotrophic
ARBUCKLE RESERVOIR	46	Mesotrophic	50	Mesotrophic	53	Eutrophic
ARCADIA LAKE	62	Hypereutrophic	65	Hypereutrophic	66	Hypereutrophic
ARDMORE CITY LAKE	49	Mesotrophic	48	Mesotrophic	60	Hypereutrophic
BIRCH LAKE	50	Mesotrophic	52	Eutrophic	63	Hypereutrophic
BOOMER LAKE	53	Eutrophic	57	Eutrophic	67	Hypereutrophic
LAKE CARL BLACKWELL	56	Eutrophic	56	Eutrophic	68	Hypereutrophic
CHANDLER LAKE	50	Mesotrophic	55	Eutrophic	62	Hypereutrophic
LAKE CHICKASHA	66	Hypereutrophic	61	Hypereutrophic	69	Hypereutrophic
CLEAR CREEK LAKE	48	Mesotrophic	46	Mesotrophic	61	Hypereutrophic
COMANCHE LAKE	46	Mesotrophic	47	Mesotrophic	60	Hypereutrophic
COPAN LAKE	51	Eutrophic	69	Hypereutrophic	80	Hypereutrophic
DRIPPING SPRINGS LAKE	41	Mesotrophic	50	Mesotrophic	63	Hypereutrophic
DUNCAN LAKE	48	Mesotrophic	50	Mesotrophic	63	Hypereutrophic
LAKE EL RENO	63	Hypereutrophic	83	Hypereutrophic	76	Hypereutrophic
ELMER THOMAS LAKE	33	Oligotrophic	37	Oligotrophic	39	Oligotrophic
EUCHA* LAKE	56	Eutrophic	59	Eutrophic	60	Eutrophic
EUFAULA LAKE	52	Eutrophic	67	Hypereutrophic	68	Hypereutrophic
FOSS RESERVOIR	52	Eutrophic	49	Mesotrophic	60	Eutrophic
LAKE FREDERICK	51	Eutrophic	63	Hypereutrophic	87	Hypereutrophic
FUQUA LAKE	48	Mesotrophic	47	Mesotrophic	62	Hypereutrophic
LAKE HENRYETTA	47	Mesotrophic	68	Hypereutrophic	81	Hypereutrophic
HEYBURN LAKE	47	Mesotrophic	58	Eutrophic	74	Hypereutrophic
LAKE HUDSON	60	Eutrophic	71	Hypereutrophic	66	Hypereutrophic
HUGO LAKE	53	Eutrophic	64	Hypereutrophic	75	Hypereutrophic
HULAH LAKE	54	Eutrophic	67	Hypereutrophic	79	Hypereutrophic
HUMPHREYS LAKE	58	Eutrophic	58	Eutrophic	61	Hypereutrophic
LAKE JEAN NEUSTADT	52	Eutrophic	55	Eutrophic	64	Hypereutrophic
KAW LAKE	56	Eutrophic	79	Hypereutrophic	66	Hypereutrophic
KONAWA RESERVOIR	53	Eutrophic	55	Eutrophic	61	Hypereutrophic
LONGMIRE, R.C. LAKE	56	Eutrophic	57	Eutrophic	67	Hypereutrophic
LUGERT-ALTUS RESERVOIR	59	Eutrophic	61	Hypereutrophic	74	Hypereutrophic
LAKE MCALESTER	42	Mesotrophic	75	Hypereutrophic	86	Hypereutrophic
LAKE MCMURTRY	47	Mesotrophic	50	Eutrophic	65	Hypereutrophic
LAKE NANIH WAIYA	45	Mesotrophic	47	Mesotrophic	55	Eutrophic
OKEMAH LAKE	51	Eutrophic	47	Mesotrophic	61	Hypereutrophic
OKMULGEE LAKE	45	Mesotrophic	45	Mesotrophic	57	Eutrophic
OOLOGAH LAKE	46	Mesotrophic	66	Hypereutrophic	68	Hypereutrophic

Lake Name	CHL-A	Trophic State	Total P	Trophic State	Secchi	Trophic State
Lake Ozzie Cobb	55	Eutrophic	56	Eutrophic	66	Hypereutrophic
Pauls Valley City Lake	49	Mesotrophic	56	Eutrophic	69	Hypereutrophic
Lake Pawhuska	39	Oligotrophic	41	Mesotrophic	45	Mesotrophic
Perry Lake	44	Mesotrophic	66	Hypereutrophic	75	Hypereutrophic
Lake Ponca	52	Eutrophic	55	Eutrophic	62	Hypereutrophic
Prague City Lake	45	Mesotrophic	46	Mesotrophic	61	Hypereutrophic
Purcell Lake	50	Mesotrophic	54	Eutrophic	66	Hypereutrophic
Lake Raymond Gary	54	Eutrophic	62	Hypereutrophic	65	Hypereutrophic
R. S. Kerr Reservoir	58	Eutrophic	74	Hypereutrophic	73	Hypereutrophic
Rock Creek Reservoir	48	Mesotrophic	52	Eutrophic	66	Hypereutrophic
Sardis Lake	50	Mesotrophic	53	Eutrophic	64	Hypereutrophic
Skiatook Lake	43	Mesotrophic	45	Mesotrophic	62	Hypereutrophic
Sooner Reservoir	48	Mesotrophic	47	Mesotrophic	58	Eutrophic
Spavinaw LAKE	61	Hypereutrophic	56	Eutrophic	58	Eutrophic
Sportsman Lake	40	Oligotrophic	49	Mesotrophic	63	Hypereutrophic
Talawanda Lake No. 1	44	Mesotrophic	49	Mesotrophic	48	Mesotrophic
Talawanda Lake No. 2	38	Oligotrophic	42	Mesotrophic	55	Eutrophic
Taylor (Marlow) Lake	63	Hypereutrophic	71	Hypereutrophic	68	Hypereutrophic
Lake Texoma	56	Eutrophic	64	Hypereutrophic	64	Hypereutrophic
Tom Steed Reservoir	70	Hypereutrophic	71	Hypereutrophic	74	Hypereutrophic
Lake Vincent, Loyd	44	Mesotrophic	53	Eutrophic	66	Hypereutrophic
W.R. Holway Reservoir	53	Eutrophic	67	Hypereutrophic	57	Eutrophic
Waurika Lake	60	Eutrophic	68	Hypereutrophic	67	Hypereutrophic
Lake Wayne Wallace	41	Mesotrophic	53	Eutrophic	63	Hypereutrophic
WileyPostMemorial Lake	57	Eutrophic	72	Hypereutrophic	82	Hypereutrophic
Wister Lake	52	Eutrophic	73	Hypereutrophic	80	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 65 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		2003-2004	D.O.				
Arbuckle	Murray	310800	2004-2005	D.O.				
Arcadia◘	Oklahoma	520710	2004-2005					NLW
Ardmore City	Carter	310800	2004-2005					
Atoka	Atoka	410400	2003-2004	Turbidity D.O.				True Color
Bellcow	Lincoln	520700	2003-2004	D.O.				
Birch	Osage	121300	2004-2005					
Bixhoma	Wagoner		2003-2004	D.O.				
Bluestem	Osage	121300	2003-2004	D.O.				
Boomer	Payne	620900	2004-2005	Turbidity				
Broken Bow	McCurtain	410210	2003-2004	pH D.O.				
Brushy Creek	Sequoyah	220200	2003-2004	pH		Ent.		
Burtschi‡	Grady		2003-2004			Ent.		
Canton	Blaine	720500	2003-2004	Turbidity				
Carl Albert	Latimer	410310	2003-2004					
Carl Blackwell	Payne	620900	2004-2005	Turbidity				
Carter	Marshall	310800	2003-2004					
Cedar (Mena)	LeFlore	410210 410300	2003-2004	D.O. pH				
Chandler	Lincoln	520700	2004-2005					
Chickasha◘	Caddo	310830	2004-2005	Turbidity				NLW
Claremore	Rogers	121500	2003-2004					NLW
Clear Creek	Stephens	310810	2004-2005					
Cleveland City	Pawnee		2003-2004	D.O.				
Clinton◘	Washita	310830	2003-2004	Turbidity		Ent.		True Color
Coalgate City	Coal	410400	2003-2004	D.O. Turbidity				True Color
Comanche	Stephens	311300	2004-2005					
Copan	Washington	121400	2004-2005	Turbidity D.O.				True Color
Crowder	Washita	310830	2003-2004					NLW
Cushing Municipal	Payne	620900	2003-2004	Turbidity				True Color
Dave Boyer (Walters)	Cotton	311300	2003-2004	Turbidity				True Color
Dripping Springs	Okmulgee	520700	2004-2005	Turbidity D.O.				True Color

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Lake Name	County	W.Q. Segment #	Last Year Sampled	FWP	PPWS	PBCR	AG	AES
Duncan	Stephens	310810	2004-2005					
El Reno ◘	Canadian		2004-2005	Turbidity				True Color NLW
Elk City	Beckham	311500	2003-2004			Ent.		NLW
Ellsworth	Comanche	311300	2003-2004	Turbidity D.O.				
Elmer Thomas	Comanche	311300	2004-2005					
Etling, Carl	Cimarron	720900	2003-2004	Turbidity pH				
Eucha ●	Delaware	121600	2004-2005	D.O.				NLW
Eufaula	Haskell	220600	2004-2005	D.O. Turbidity				True Color
Fairfax City	Osage	621200	2003-2004	D.O.				
Fort Cobb	Caddo	310830	2003-2004	Turbidity		Ent.		NLW
Fort Gibson	Cherokee	121600	2003-2004					NLW
Fort Supply †	Woodward	720500	2001-2002	Turbidity				NLW True Color
Foss	Custer	310800 310810 310820 310830 310840	2004-2005					
Frederick	Tillman	311310	2004-2005	Turbidity				True Color
Fuqua	Stephens	310810	2004-2005					
Grand Lake	Mayes	121600	2003-2004	D.O. Turbidity				
Great Salt Plains	Alfalfa	621010	2003-2004	Turbidity		Ent.	Sulfates & Chlorides	NLW
Greenleaf	Muskogee	120400	2003-2004			Ent.		
Guthrie	Logan	620910	2003-2004	Turbidity		Ent.		
Healdton City	Carter	311100	2003-2004	Turbidity				True Color
Hefner	Oklahoma	520520 520530	2003-2004	Turbidity				
Henryetta ♦	Okmulgee	520700	2004-2005	Turbidity				True Color
Heyburn	Creek	120420	2004-2005	D.O. Turbidity		Ent.		True Color
Holdenville	Hughes	520800	2001-2002	D.O.		Ent.		
Hominy Municipal	Osage	121300	2003-2004	D.O.				
Hudson	Osage		2003-2004	D.O.				
Hudson	Mayes	121600	2004-2005					
Hugo	Choctaw	410300	2004-2005	Turbidity				True Color
Hulah	Osage	121400	2004-2005	Turbidity				NLW
Humphreys	Stephens	310810	2004-2005					

Lake Name	County	W.Q. Segment #	Last Year Sampled	FWP	PPWS	PBCR	AG	AES
Jean Neustadt	Carter	310800	2004-2005					
John Wells	Haskell	220200	2003-2004					
Kaw	Osage	621210	2004-2005	Turbidity D.O.				
Keystone	Tulsa	621200	2003-2004	Turbidity		Ent.		
Konawa	Seminole		2004-2005					
Langston	Logan	620900	2003-2004					
Lawtonka	Comanche	311300	2003-2004					
Liberty	Logan	620910	2003-2004	Turbidity		Ent.		
Lloyd Church	Latimer	220100	2003-2004	D.O.				
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	2003-2004	D.O. pH				
McMurtry	Noble	620900	2004-2005	Turbidity				
Meeker	Lincoln	520700	2003-2004	Turbidity				True Color
Murray	Love	311100	2003-2004	D.O.				
Nanih Waiya	Pushmataha		2004-2005					
New Spiro ◘	LeFlore	220100	2003-2004	D.O.				NLW
Okemah	Okfuskee	520700	2004-2005	D.O.				True Color
Okmulgee	Okmulgee	520700	2004-2005	D.O.				True Color
Oologah	Rogers	121510	2004-2005	Turbidity D.O.				
Overholser ◘	Oklahoma	520520 520530	2003-2004	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	2003-2004					
Perry	Noble	621200	2004-2005	Turbidity				True Color
Pine Creek	McCurtain	410210	2003-2004	D.O. Turbidity pH				
Ponca	Kay	621200	2004-2005	D.O.				
Prague City	Lincoln	520510	2004-2005					
Purcell	McClain	520610	2004-2005	Turbidity				

LAKE NAME	COUNTY	W.Q. SEGMENT #	LAST YEAR SAMPLED	FWP	PPWS	PBCR	AG	AES
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	2004-2005	D.O.				
ROCKY (HOBART) ◘	WASHITA	311500	2003-2004	TURBIDITY		ENT.		NLW
SAHOMA	CREEK	120420	2003-2004	D.O. TURBIDITY				TRUE COLOR
SARDIS	PUSHMATAHA	410310	2004-2005	D.O. TURBIDITY				TRUE COLOR
SHAWNEE TWIN # 1	POTTAWATOMIE	520510	2003-2004					
SHAWNEE TWIN # 2	POTTAWATOMIE	520510	2003-2004					
SHELL	OSAGE	120420	2003-2004	D.O.				
SKIATOOK	OSAGE	121300	2004-2005	D.O.				
SOONER	PAWNEE		2004-2005					
SPAVINAW ●	MAYES	121600	2004-2005	D.O.				NLW
SPORTSMAN	SEMINOLE	520500	2004-2005	TURBIDITY				TRUE COLOR
STANLEY DRAPER	CLEVELAND		2003-2004					
STILWELL CITY	ADAIR	220200	2003-2004	D.O.				
STROUD	CREEK	520700	2003-2004					
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	2003-2004	D.O.				
TEXOMA◘	BRYAN	311100 310800	2004-2005	D.O. TURBIDITY				TRUE COLOR
THUNDERBIRD	CLEVELAND	520810	2003-2004	TURBIDITY				
TOM STEED◘	KIOWA	311500	2004-2005	TURBIDITY				NLW
VANDERWORK	WASHITA	310830	2003-2004					NLW
VINCENT, LOYD	ELLIS	720500	2004-2005	D.O.				
W.R. HOLWAY	MAYES		2004-2005					
WAURIKA	JEFFERSON	311210	2004-2005	TURBIDITY				
WAXHOMA	OSAGE		2003-2004	D.O.		ENT.		
WAYNE WALLACE	LATIMER	220100	2004-2005					
WEBBERS FALLS	MUSKOGEE	121400	2003-2004			ENT.		
WES WATKINS	POTTAWATOMIE	520510	2003-2004					

LAKE NAME	COUNTY	W.Q. SEGMENT #	LAST YEAR SAMPLED	FWP	PPWS	PBCR	AG	AES
WETUMKA	HUGHES		2003-2004	D.O.				
WEWOKA	SEMINOLE	520500	2003-2004					
WISTER♣	LEFLORE	220100	2004-2005	D.O. TURBIDITY				NLW TRUE COLOR
YAHOLA●	TULSA	121300	1998-1999					

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

‡ These Lakes will not be recommended for listing as part of the next WQS revision due to insufficient data

♣ 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	PL = PROVISIONALLY LISTED

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 64lakes sampled in 2004-2005 were listed as partially supporting the FWP beneficial use based on pH values and two lakes 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 64 lakes sampled in 2004-2005, twenty-two lakes were not supporting their Fish & Wildlife Propagation (FWP) beneficial use, eleven were partially supporting the and thirty-one 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 2004-2005, 19 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 64 lakes sampled in 2004-2005, only one was 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 continuing into the future. Analysis of the chloride and sulfate data revealed that

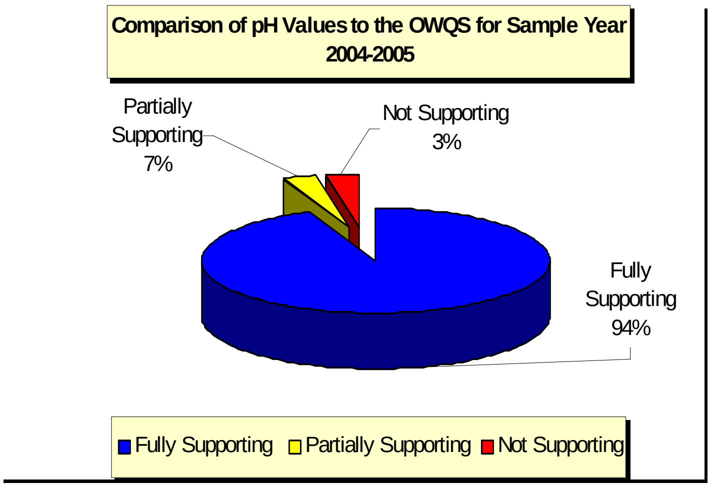

Figure 4. Percent of lakes assessed that exceeds or meets the WQS for pH.

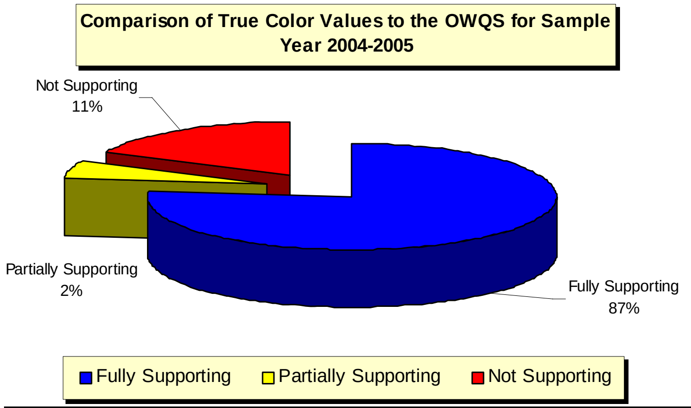

Figure 5. Percent of lakes assessed that exceeds or meets the WQS for true color.

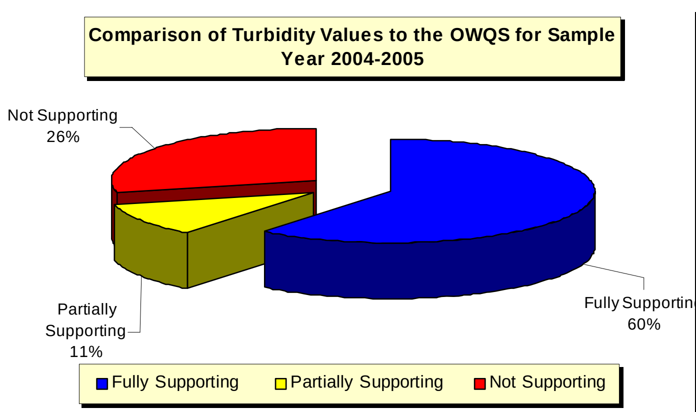

Figure 6. Percent of lakes assessed that exceeds or meets the WQS for turbidity.

only one sampled lake was not supporting its agriculture beneficial use (See Figure 8). The lake not supporting was Great Salt Plains Reservoir. This was not an unexpected result. Analysis of the bacteria data indicated that three lakes were not 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 64 lakes sampled in 2004-2005 as well as the 65 lakes sampled in 2003-2004 is discussed in alphabetical order on the following pages.

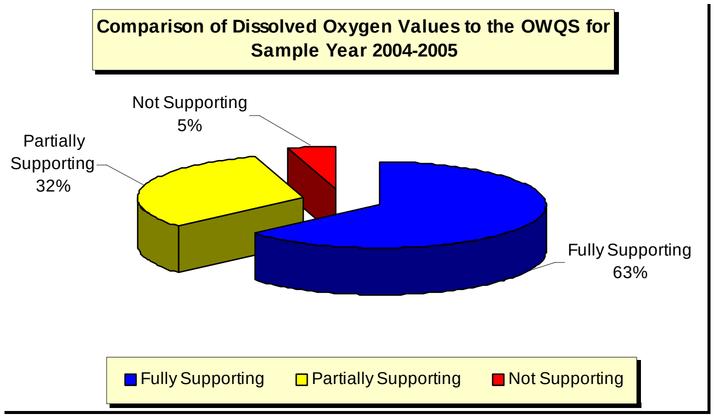

Figure 7. Percent of lakes assessed and their support status of the WQS for dissolved oxygen

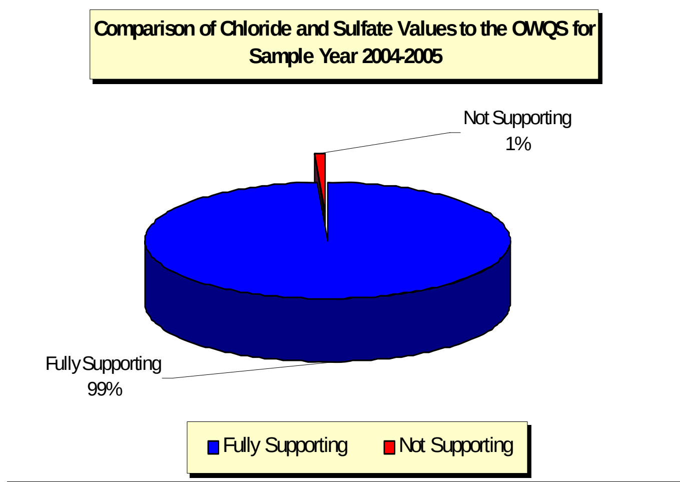

Figure 9. Percent of lakes assessed and their support status of the WQS for chlorides & sulfates.

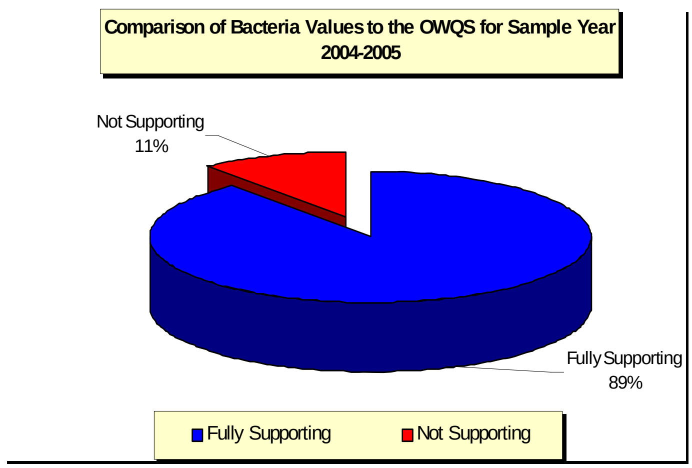

Figure 8. Percent of lakes assessed and their support status of the WQS for bacteria.

LAKES MONITORING PROGRAM