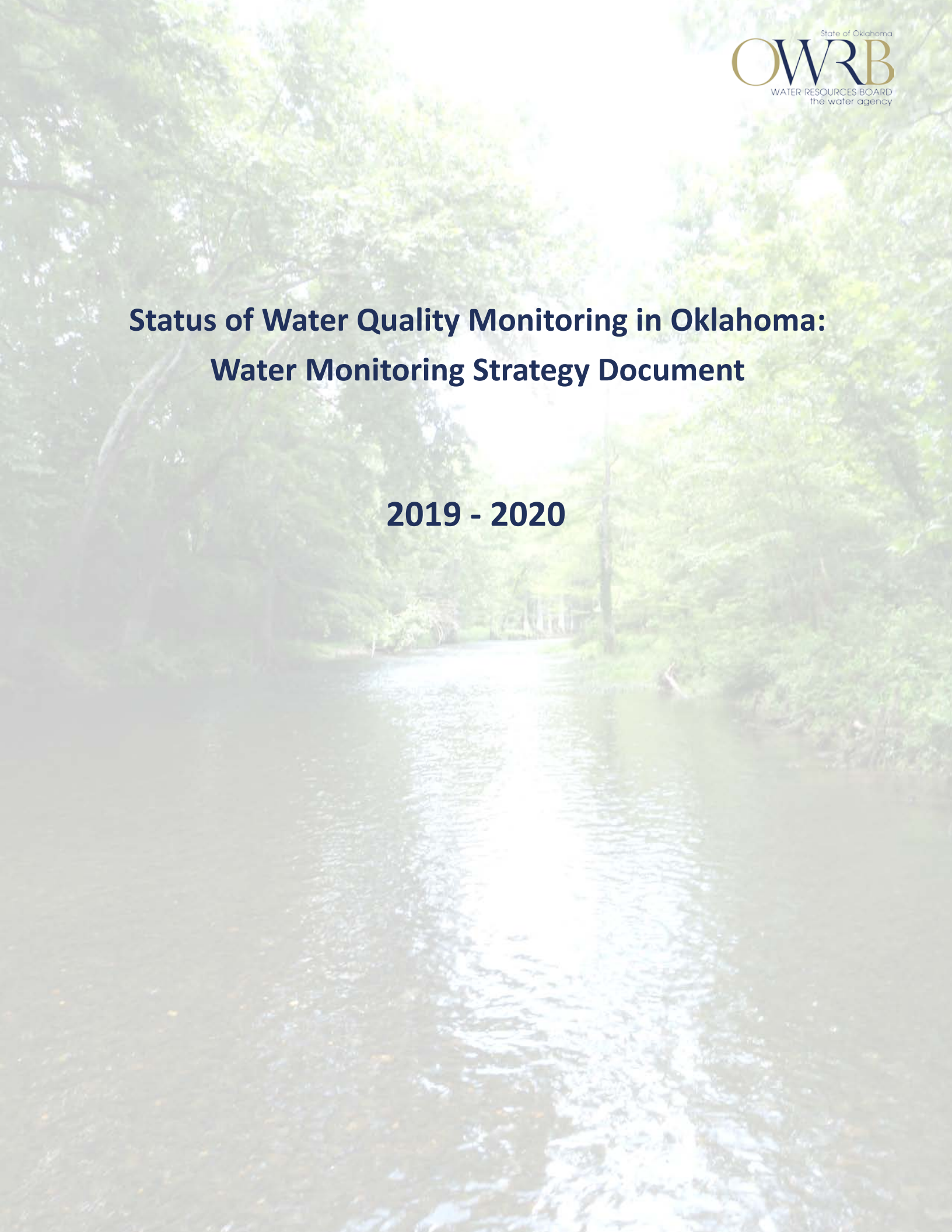


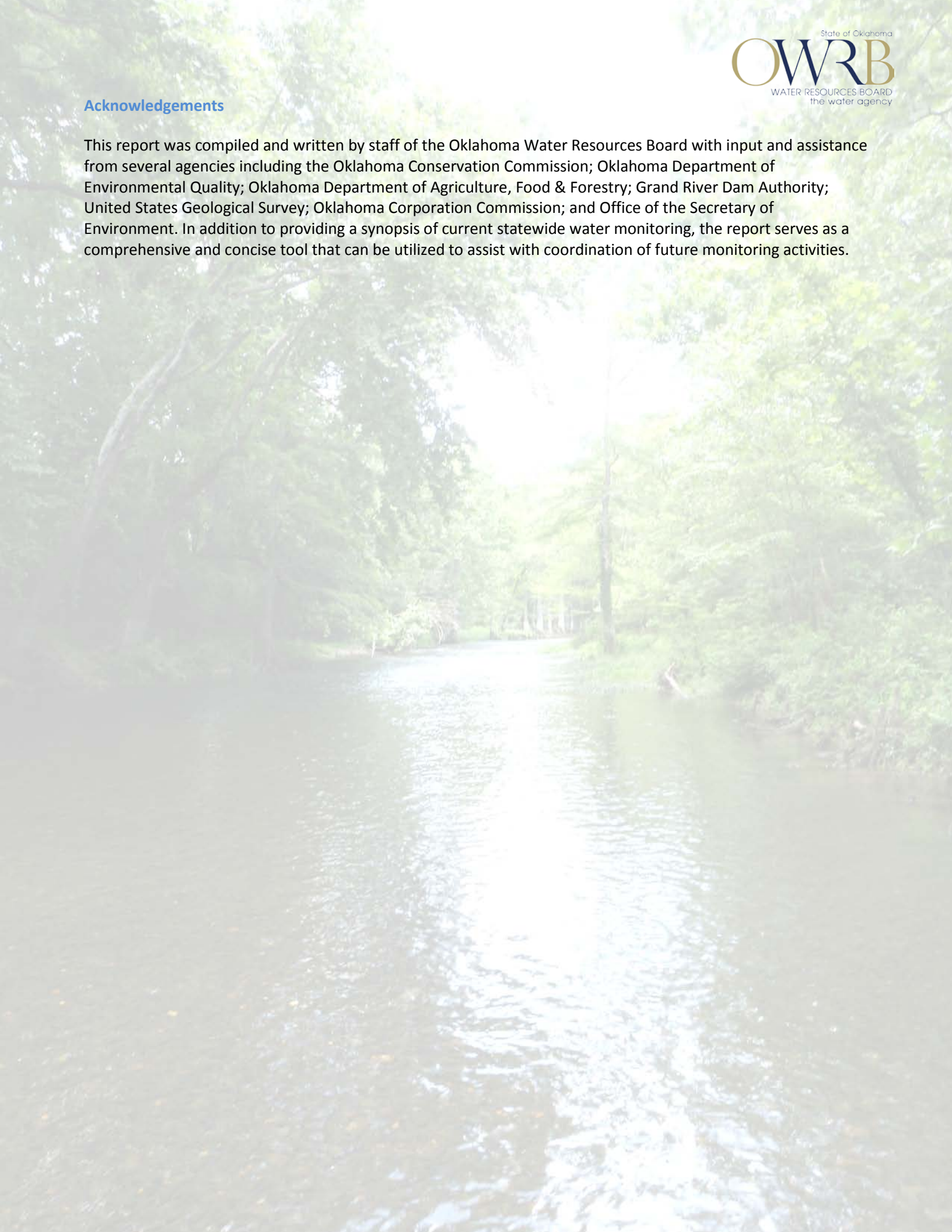
State of Oklahoma
OWRB
WATER RESOURCES BOARD
the water agency

Status of Water Quality Monitoring in Oklahoma: Water Monitoring Strategy Document

2019 - 2020

Acknowledgements

This report was compiled and written by staff of the Oklahoma Water Resources Board with input and assistance from several agencies including the Oklahoma Conservation Commission; Oklahoma Department of Environmental Quality; Oklahoma Department of Agriculture, Food & Forestry; Grand River Dam Authority; United States Geological Survey; Oklahoma Corporation Commission; and Office of the Secretary of Environment. In addition to providing a synopsis of current statewide water monitoring, the report serves as a comprehensive and concise tool that can be utilized to assist with coordination of future monitoring activities.



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Executive Summary and Recommendations

According to Oklahoma Statutes, Title 27A Section 1-1-202 Paragraph E, it is the responsibility of the Oklahoma Water Resources Board to submit a biennial report to the Oklahoma Legislature discussing the status of water quality monitoring in Oklahoma.

It is also a requirement by the United States Environmental Protection Agency (EPA) that Oklahoma submit a document for their approval that outlines the state's water monitoring strategy. The Clean Water Act (CWA) specifies that "the Administrator shall not make any grant under this section (106) to any State which has not provided or is not carrying out as a part of its program- the establishment and operation of appropriate devices, methods, systems, and procedures necessary to monitor, and to compile and analyze data on (including classification according to trophic condition), the quality of navigable waters and to the extent practicable ground waters including biological monitoring; and provision for annually updating such data...".

This document, the culmination of these two charges, outlines current monitoring activities conducted by the State of Oklahoma and recommends modifications or improvements to water quality monitoring initiatives.

Included within this report are summaries of the various activities undertaken by the state to monitor water quality, compile information, establish data quality objectives, analyze environmental data, and store data. Numerous state agencies have monitoring programs that exist for a variety of purposes. Much of this monitoring is related to federal programs or federal requirements. These programs are discussed in detail in the various sections of this document.

Recommendations for Improving Water Monitoring in Oklahoma

Improvements to statewide monitoring efforts should be pursued to ensure that the best available data is collected to assist decision makers in managing, protecting, and improving Oklahoma's water resources. Some recommendations to enhance the state's monitoring efforts are presented below:

- Additional monitoring should be implemented on Oklahoma's rivers and streams.

- Biological monitoring on lakes should be expanded and continued in streams and rivers. Biological monitoring allows use support determinations to be made at a relatively inexpensive financial cost, and more importantly provides a direct measure of the effects of water quality on the aquatic community.

- Further work should be pursued in the development of Use Support Assessment Protocols (USAP). New protocols need to be developed for all beneficial uses and current protocols need to be refined.

- Diurnal dissolved oxygen monitoring should be conducted on a widespread basis. This has been a recommendation in previous Strategy Documents, but has never been implemented systematically.

- Monitoring for harmful algal blooms (HAB's) and their associated toxins should be funded in lakes and large boatable river across the state. HAB's can impact both water supplies and recreation in our state's valued water resources.

- Metals and organics sampling occurs on a very limited basis. Much more extensive ambient sampling for these types of compounds would help to better understand general toxicity in aquatic environments and protect human health. The Oklahoma Conservation Commission (OCC) evaluates results of bioassessment studies to select streams for metals and organics monitoring in order to avoid spending limited resources on streams that have no biota problems.

- Toxics monitoring related to fish consumption by humans is an area that could be greatly expanded in the future. The Oklahoma Department of Environmental Quality (ODEQ) currently conducts a fish tissue toxics monitoring program on a limited scale on lakes, with monitoring on streams and rivers occurring very sporadically. Additional monitoring of this nature is critical if the Fish Consumption Beneficial Use is to be assessed in a holistic manner.

- Causal analysis and diagnostic studies should be pursued more extensively to relate pollutants to beneficial use impairments in both lakes and rivers/streams. These studies are vital to understand the relationship between stressors and environmental response. Only by understanding the local environmental response, can pollutants be reduced effectively.

- More work needs to be focused on lake monitoring, especially the impact of nutrients. Oklahoma lakes are utilized extensively as water supply sources and as recreational outlets both for Oklahomans and out-of-state visitors. Compared to streams monitoring, fewer resources are focused on monitoring lakes. It is also necessary that Nutrient Limited Watershed (NLW) impairment studies be conducted on identified lakes to assess if nutrient impairments are present. Further monitoring should be focused on more intensive growing season monitoring, quantifying internal nutrient loads, characterizing planktonic community structure and stress, and understanding the extent of anoxia and mixing, ,

- The OWRB/U.S. Geological Survey (USGS) Cooperative Program for stream flow monitoring should continue to be a priority for Oklahoma. It is not necessary to have exact measurements of flow for all monitoring activities, but it is necessary to know if stream flow is at seasonal base flow to make numerous beneficial use support determinations. More exact measurements for flow at all levels are necessary for such activities as calculating a Total Maximum Daily Load (TMDL), trend analysis, and other technical studies. An assessment of the Cooperative Program has helped to identify the number and location of stream gages needed to support the Oklahoma Comprehensive Water Plan. With funding issues arising each year, there is a very real possibility that the Cooperative Program between the OWRB and the USGS will no longer meet the data needs for the state of Oklahoma. A long-term funding solution for the program should be pursued.

- Monitoring activities in Oklahoma should continue to be closely coordinated with implementation of the Oklahoma Comprehensive Water Plan (OCWP), which is vital to mapping the state's water future.

- Partnerships between state and federal agencies should be further enhanced and initiated to help meet the needs of all parties. This will allow for the most efficient and effective utilization of available resources. Relationships between state environmental agencies should be enhanced to maximize benefit to the state.

Resource Needs for Oklahoma Surface Water Monitoring

Although significant resources are currently utilized for water quality monitoring activities in the state, a sizable funding gap continues to exist for increasing these efforts to a level that will meet both EPA requirements and various state data needs. This funding gap was significantly decreased through the additional funding for monitoring activities approved by the Oklahoma Legislature in 2012. The Oklahoma Conservation Commission was appropriated an additional $500,000 to support non-point source monitoring activities and the Oklahoma Water Resources Board was appropriated an additional $1.3 million dollars for the Beneficial Use Monitoring Program (BUMP). However, since the increase in funding in 2012, appropriated dollars and the amount given to NPS has dropped in each successive year. A continued commitment to dedicating additional resources is important for further enhancements to water quality monitoring activities across the state.

Introduction

Numerous agencies are engaged in water quality monitoring in Oklahoma for a variety of purposes. Monitoring is often conducted as part of a federal project, where the type and duration of the monitoring are very strictly outlined as a condition of the grant award. Before any meaningful discussion of monitoring in Oklahoma can begin, it is essential to outline the various types of monitoring that occur, and the benefits offered by each type.

The monitoring objective often determines the type of monitoring that occurs for each project. For example, if water quality monitoring is required as part of a federal grant, the monitoring will most likely be initiated to document water quality concerns or impairments to a specific waterbody or watershed and for a specific water quality parameter or parameters. In the case of remedial activities, the monitoring program will be designed to document the success or failure of the remediation. For general ambient water quality monitoring, a large suite of parameters will be monitored to assess use support for numerous beneficial uses.

Therefore, a critical aspect of most water quality-monitoring programs is that they are designed around the idea of answering a specific question. For example, monitoring to document the effectiveness of Best Management Practices (BMPs) for improving water quality in the Washita River is fundamentally different than a monitoring program designed to look at long-term water quality trends in the Illinois River Basin. These examples demonstrate differences based on several factors, such as density of the monitoring sites in an area (scale of the project), parameters monitored for, time frame of the monitoring (several years versus monitoring of at least 10 years or longer), etc.

During the past few decades, heightened interest in the State's 303(d) list and development of Total Maximum Daily Loads (TMDLs) has served to highlight the monitoring efforts of various state environmental agencies. In general, development and refinement of the 303(d) list and Integrated Water Quality Assessment Report has resulted in a greater understanding by all concerned parties that improvements in monitoring initiatives are necessary.

An examination of the state's monitoring process identified a small number of data and data assessment problems. Several key points can be made when discussing the state's water quality monitoring programs:

- Monitoring has historically been conducted by various environmental agencies with the express purpose of meeting federal program requirements and Oklahoma statutory mandates for each agency. This has resulted in a fragmented monitoring program for the state as a whole. Although a coordinated holistic monitoring program for Oklahoma does not currently exist, the ODEQ, OWRB and OCC are working together to ensure that water quality monitoring in Oklahoma is conducted in as efficient and effective a manner as possible.

- Monitoring of water resources in Oklahoma has historically been inadequate to assess the water quality status of many state water supply sources. In recent years, mitigation efforts have increased through additional monitoring by state environmental agencies; however, there is a continued need for increased monitoring in new and emerging areas to ensure that the public is adequately protected

- Due to lack of historical baseline information on many state waters and lack of consistent protocols for assessing use support, the job of protecting and preserving state water resources has been made much more difficult. Baseline information is absolutely essential for the

identification of “abnormal” water quality conditions. Numerous environmental agencies, such as the OCC, ODEQ, and OWRB, have collected environmental data and worked extensively to identify baseline conditions across Oklahoma. With the development of Use Support Assessment Protocols (USAP), codified into the OWRB rules, consistent protocols now exist. Protocols continue to be refined and developed for all beneficial uses. Additionally, as monitoring continues throughout the state on lakes, rivers and streams, the ability to detect trends in water quality allows for agencies to determine if water quality is improving or declining and to manage our water resources more effectively.

- Compared to resources allocated to other aspects of water quality management, such as lake and stream restoration, permitting, and permit compliance, or regulation, relatively few resources have been allocated to monitoring programs. Additional resources for monitoring are critical to ensure sound scientific and resource management decisions.

In general, water quality monitoring efforts by state environmental agencies have greatly improved during the last decade. With funding of the Beneficial Use Monitoring Program (BUMP) at the state level and the increased funding to federal programs such as §106 and §319, a major step has been taken to address some of the monitoring deficiencies discussed previously. However, with recent federal and state budget cuts, monitoring initiatives continue to fall short of meeting all of Oklahoma’s data needs. With the requirement to develop TMDLs for waters listed on the 303(d), both the state and EPA should continue to find ways to increase support for monitoring activities. It is vital that a greater understanding of water quality conditions be fostered and that resources be dedicated to areas where adverse water quality impacts are greatest or where the quality of the most outstanding water resources is threatened.

Several tools have been developed to facilitate monitoring in Oklahoma. A state environmental database is maintained by the ODEQ to assist in managing data. Another important tool is the EPA Storage and Retrieval (STORET) database. STORET is a national database that is used to house environmental data collected using federal dollars. The Ambient Water Quality Monitoring System (AWQMS) is another database used by agencies that houses the bulk of the state’s ambient water quality and water level data. OWRB have partnered with numerous other states and tribes to develop AWQMS as a tool to ease the state’s environmental reporting procedures and allow rapid and efficient data dissemination.

The following is a brief discussion of the major statewide monitoring initiatives currently conducted by state agencies concerning surface water quality/quantity monitoring and groundwater quality/quantity monitoring. This discussion focuses directly on state agencies with additional discussion of federal agency monitoring programs as they intersect with the state programs. The discussion focuses only on programs that are far-reaching or conducted on a statewide scale. Recommendations are made concerning ways to improve Oklahoma’s holistic monitoring initiative.

Oklahoma Water Quality Monitoring Programs

Oklahoma has numerous agencies that are actively involved in the water quality monitoring arena. The various agencies with their associated statutory responsibilities are outlined in Appendix A. The following is a brief description of agency monitoring efforts.

Water Quality Monitoring Agencies

Oklahoma Water Resources Board

The Oklahoma Water Resources Board (OWRB) conducts monitoring on surface waters to assess beneficial use support attainment through the Beneficial Use Monitoring Program (BUMP). In 2013, a groundwater quality monitoring component, which encompasses all major and some minor aquifers within the state, was added to BUMP to complement its historical groundwater level program. In addition, the OWRB conducts monitoring on numerous lakes and rivers across the state to determine trends in water quality, diagnose water quality problems and make recommendations for actions or activities that can be implemented to improve water quality, document attainment of pollutant reduction goals, and develop criteria for Oklahoma's Water Quality Standards (OWQS), which includes bathymetric mapping studies. Monitoring of wetlands and performance of Use Attainment Analyses (UAAs) are also conducted on a limited or as needed basis. The OWRB and USGS work together through a cooperative program to conduct flow monitoring and water quality monitoring on many sites across the state. The OWRB has conducted numerous groundwater basin studies in cooperation with the USGS looking at the quality of Oklahoma's groundwater resources and assessing the vulnerability of groundwater basins to pollution. Additionally, the OWRB also conducts hydrological investigations and groundwater basin studies to assess water quantity needs and water resources available to be put to a beneficial use.

Oklahoma Conservation Commission

The Oklahoma Conservation Commission (OCC) monitors rivers and streams across Oklahoma to assess the impacts of nonpoint source (NPS) pollution of state waters in support of the §319(h) Nonpoint Source Program. The OCC performs monitoring to educate citizens about water quality and determine the following:

- Impact of NPS pollution on a waterbody.
- Identification of NPS pollution sources.
- Success of efforts to reduce NPS impacts through education, conservation practices (CPs), or other remediation efforts.

To accomplish these goals, the OCC collects baseline water quality, habitat, and biological monitoring data statewide primarily through a rotating basin sampling program. OCC also collects information on land-use and other activities in any watershed that might be a source of NPS pollution. This data is collected for inclusion in numerous state water quality lists and reports and specifically for the Nonpoint Source Assessment Report. The OCC also performs project-specific monitoring to document success of implemented CPs in improving water quality. The OCC assists the Department of Environmental Quality (ODEQ) in their wellhead protection program and conducts an education and volunteer monitoring program, Blue Thumb. Monitoring of wetlands has not historically occurred at the OCC, but is currently

being implemented in cooperation for national assessments and to assist in developing assessment tools used for restoration and mitigation.

Oklahoma Department of Environmental Quality

The Oklahoma Department of Environmental Quality (ODEQ) conducts certain surface water quality monitoring activities to determine the presence of selected toxic substances in fish tissue through its Toxics and Reservoirs Program. Biotic integrity/aquatic habitat trends monitoring is conducted through the ODEQ's Fish Community Biotrend Monitoring Program. Segment-specific pollutant loading characteristics and capacities monitoring is conducted through TMDL studies. On a site or segment specific basis, selected surface water quality monitoring may also be conducted as an adjunct to complaint investigations. Many ODEQ surface water and groundwater quality monitoring activities are a function of the agency's regulatory programs in Point Source Discharge (OPDES) Permitting, Public Water Supply, Solid Waste Management, Hazardous Waste Permitting and Corrective Action, Underground Injection Control, Radiation Management, Brownfields Redevelopment, and Superfund.

Oklahoma Department of Agriculture, Food & Forestry

The Oklahoma Department of Agriculture Food and Forestry (ODAFF) conducts a monitoring program of wastewater retention structures at Large Swine Feeding Operations by annually sampling monitoring wells installed in the vicinities of the structures to detect potential leaks that may contaminate groundwater sources.

Oklahoma Corporation Commission

Monitoring conducted by the Corporation Commission focuses on identification of areas adversely impacted by oil and gas activities.

Grand River Dam Authority

The Grand River Dam Authority (GRDA) was created in 1935 as a conservation and reclamation district for the waters of the Grand River and its tributaries. Recently, GRDA Board Policy was amended to reflect that the aims, purposes, and objectives of the Board to protect water quality associated with lakes and streams are under its jurisdiction.

United States Geological Survey

The United States Geological Survey (USGS) conducts a monitoring program on many rivers and streams across Oklahoma, looking at stream flow and water quality conditions. The USGS coordinates with the state of Oklahoma through the Cooperative Program managed by the OWRB.

United States Army Corps of Engineers

The United States Army Corps of Engineers (USACE) conducts monitoring programs on the reservoirs that it oversees through intensive water quality studies on a small number of lakes each year. The USACE and the OWRB actively share data.

General Water Quality Monitoring Background Information

In general, entities currently involved in conducting state-wide water quality monitoring programs with a primary focus of assessing beneficial use support include the OWRB, ODEQ, OCC, USGS, and USACE. Numerous other state agencies are involved to a lesser degree in water quality monitoring in Oklahoma, predominantly on a project specific basis. This report does not contain information on all water quality monitoring efforts occurring in Oklahoma, but offers a brief summary of the major statewide efforts currently being conducted.

Historically, few state or federal resources have been devoted to conducting routine water quality monitoring. In the last few years, with increased federal funding in connection with the §319 nonpoint source program and the §106 program and with state funding of the BUMP, Oklahoma has begun to make progress in terms of understanding current water quality conditions. This has resulted in more effective identification and prioritization of areas where resources should be focused.

Through the promulgation into rule of Use Support Assessment Protocols (USAP) developed through input from the various environmental entities in Oklahoma, a standardized protocol for identifying beneficial use threats or impairments has been developed. This effort is a major step forward in state monitoring initiatives. The USAP will continue to undergo modification and refinement over time. The rule needs flexibility to address more complex water quality problems, use support areas not included in USAP, and changing state/federal priorities.

Though federal funding for monitoring activities not associated with specific localized project areas has increased, monitoring is still often geared towards statutory authorities and requirements. This sometimes results in a lack of coordination between the various localized water quality monitoring projects. More effective coordination of efforts is still a goal of the various agencies involved in water quality monitoring. A comprehensive holistic program for monitoring Oklahoma's waters is not currently in place and is vitally needed to manage the state's water resources. There are several water quality monitoring programs that could be initiated or enhanced. For example, while the OCC and the OWRB aggressively conducts biological monitoring on rivers and streams, biological monitoring on lakes should be expanded or implemented.

Collection of fish tissue samples for analysis of toxics is an area of water quality monitoring that could be greatly enhanced with increased funding. In general, while monitoring programs sufficient for establishing a base level currently exist, more extensive monitoring is required to allow Oklahoma to meet its goals for protecting and preserving its water resources and assessing all assigned beneficial uses in the Oklahoma Water Quality Standards (OWQS). Federal funding alone does not currently meet the water quality monitoring needs of Oklahoma. It is envisioned that a joint state and federal initiative is required to accomplish these goals.

Oklahoma Monitoring Objectives

Numerous reasons for performing water quality monitoring activities are listed below. The list highlights the primary objectives of ambient and regulatory monitoring programs conducted by most state environmental agencies:

- Determination of beneficial use support status.
- Determination of water quality trends.

- Identification of pollutant sources.
- Understanding relationships between stressors and beneficial use impairment
- Regulatory compliance monitoring.
- Effectiveness of Best Management Practices (BMPs).

All monitoring programs differ in data quality objectives. For the OWRB Beneficial Use Monitoring Program (BUMP), the three primary objectives are 1) beneficial use support assessment, 2) water quality trend status, and 3) refinement/development of the Oklahoma Water Quality Standards (OWQS) and USAP language. The OCC rotational stream monitoring network is primarily focused on use support determination, source identification, and effectiveness of BMP implementation. The ODEQ conducts monitoring with the objective of source identification, collecting needed data for a TMDL, trend monitoring, and public health issues (e.g., Lakes Toxics Monitoring). Monitoring conducted by the Corporation Commission focuses on beneficial use support and identification of areas adversely impacted by oil and gas activities.

Data is collected by several agencies for compliance monitoring, but monitoring conducted for that purpose is not discussed in this document, which focuses on surface water and groundwater ambient monitoring activities that do not directly relate to permitting and compliance monitoring.

State Water Monitoring Initiatives and Programs

Oklahoma Conservation Commission

The Oklahoma Conservation Commission (OCC) has an extensive and unique monitoring program. While OCC conducts several distinct types of monitoring activities, it is important to note that monitoring efforts are primarily focused on determining the extent, nature, and probable source(s) of nonpoint source (NPS) pollution. The principal goal of the OCC monitoring program is direct and vital support of the agency's mission:

> *To conserve and improve the water resources of the State of Oklahoma through assessment, planning, education, & implementation.*

The Oklahoma Conservation Commission conducts several types of monitoring:

1. **Ambient Monitoring:** routine efforts to collect information about the physical, chemical, and biological characteristics of streams to determine status and trends. Ambient monitoring is the backbone of any statewide monitoring program and occurs at either fixed or randomly selected sites. Ambient monitoring is crucial for determining what problems, if any, exist and where they occur. With nearly 250 sites statewide, the OCC's Rotating Basin Monitoring Program constitutes a significant component of the state's ambient monitoring efforts for streams.
2. **Diagnostic Monitoring:** in systems where ambient monitoring has identified potential NPS problems, more robust monitoring is initiated to confirm/refute the suspected problem(s), more accurately document causes and effects, and identify sources. Diagnostic monitoring usually involves an intensification of monitoring effort (i.e., more sites, more parameters) but may also include activities such as land use assessments, watershed modeling, and a more complex bioassessment.

3. **Implementation Monitoring:** performed to determine the effects of conservation practices (CPs) on water quality. As the technical lead for Oklahoma's NPS Program, OCC partners with other various state and federal agencies, tribal programs, municipalities, and non-government organizations to cost share with landowners in watersheds to administer various CPs to improve and protect water quality throughout the state. It is necessary to know whether these practices are successful so that changes can potentially be made to achieve the desired effect. Implementation monitoring usually involves sampling streams during defined periods before and after CPs are installed in the upstream watershed (see Figure 1 as an example).

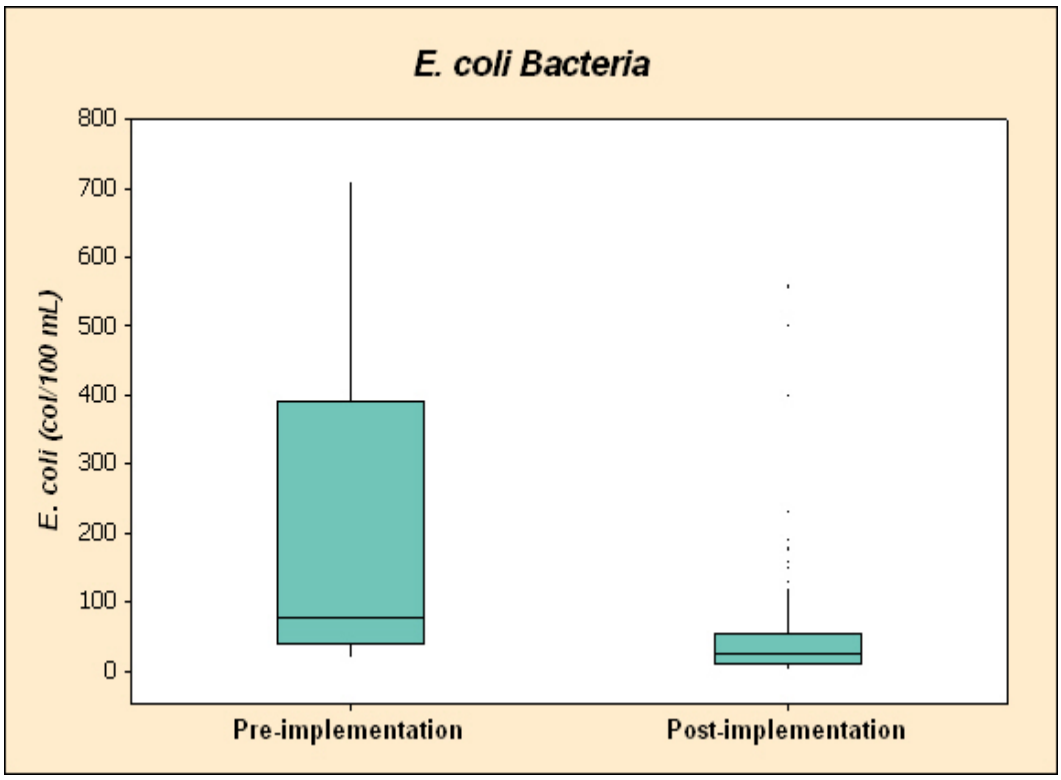

Figure 1. Analysis of implementation monitoring data showing significant reduction in *E. coli* (OCC Beaty Creek Watershed Implementation Project).

4. **Reference Condition Monitoring:** waterbodies differ naturally in their physical, chemical, and biological conditions. Such variation is due to landscape level changes in native plant communities, geology, soils, slope, climate, and other factors. Likewise, the resident communities of aquatic organisms vary by region for similar reasons. To determine whether a stream is polluted or whether its aquatic community is healthy, it is necessary to know the natural conditions of stream water quality and their biological communities such as fish and benthic macroinvertebrates. Reference condition monitoring allows state and federal agencies to make such determinations. Reference condition data is essential to conduct bioassessments and establish biological criteria in support of water quality standards.
5. **Other:** specialized types of monitoring are conducted by the OCC, although rather infrequently and generally at the request of other agencies. Examples include monitoring to protect endangered species and TMDL monitoring. Monitoring to protect endangered or threatened

species is conducted in response to a specific threat to a species of concern. Such monitoring is triggered by and conducted in cooperation with other agencies such as the Oklahoma Department of Wildlife Conservation and the U.S. Fish and Wildlife Service. Monitoring in support of the TMDL process is crucial to the development of models used to set effective endpoints to pollutants that will improve and protect waterbodies. The TMDL process is used to divide up the total amount of allowable pollutant loads among all activities in the watershed that generate the specific pollutant. To accomplish this, monitoring must be conducted to determine how much of the pollutant is currently being generated by point and nonpoint sources. Data from TMDL monitoring are then used in modeling efforts to determine load reductions necessary to support water quality standards.

During the 2018 and 2019 Oklahoma legislative sessions, the OCC was appropriated state funding to support the agency's monitoring initiatives. This money, paired with federal money, allowed the OCC to more effectively meet Oklahoma's monitoring needs related to nonpoint source pollution. The OCC collects numerous types of data including water quality (physical and chemical) (Figure 2), in-stream habitat, biological samples (fish, benthic macroinvertebrates, and algae), landuse, and soil. Water samples are used to assay various conditions of stream water quality and to determine whether pollutants exist in concentrations high enough to cause problems. Habitat surveys are conducted to determine the quantity and quality of livable space for aquatic organisms and whether or not it has been negatively impacted by human activities. When compared to reference streams or sites, biological samples can show whether an aquatic community is degraded and indicate streams that are impacted by pollutants not detected during sampling due to episodic events or due to uncommon pollutants not included in the suite of normal lab parameters. Soil samples suggest areas in a watershed where nutrients are likely to run off the land surface during storm events or percolate into the shallow groundwater.

Figure 2. Measuring water quality parameters.

During 2018 and 2019, OCC staff collected more than 2,200 water samples for analysis of conventional pollutants at over 200 sites. Biologists completed approximately 95 fish collections (Figure 3) with concurrent aquatic habitat assessments and completed over 300 invertebrate collections. A more complete description of the sampling by project will follow. All OCC monitoring is conducted following methods

Figure 3. Collecting fish by seine.

and sampling plans established in EPA approved Quality Assurance Project Plans (QAPPs). These QAPPs are subject to peer agency review and approval by the Office of the Secretary of Energy and Environment.

OCC data is used for many purposes including use support assessments for Oklahoma's Integrated Report, general project reporting, trend analysis, watershed targeting, TMDL development, and effectiveness monitoring. The OCC's extensive biological database has afforded opportunity to take a significant step toward development of much needed statewide reference conditions. All OCC collected data is stored electronically in a Microsoft Access® database and is being imported into the Ambient Water Quality Monitoring System (AWQMS). The data is spatially referenced so it can be used in Geographic Information Systems (GIS) analysis. A data manager answers formal data requests. The OCC data has and continues to be uploaded to EPA's STORET database.

The OCC projects differ regarding data objectives, scope, and uses. Therefore, a brief discussion of monitoring efforts for current projects will follow. Recent projects include the Statewide Rotating Basin Project, New Spiro Lake/Holi-Tuska Creek, the NWQI project on Little Beaver Creek, and the RCPP project on Elk City Lake.

Rotating Basin Monitoring Program

In the late 1990s, the OCC, in cooperation with other sister agencies through the state's Water Quality Monitoring Council, agreed to coordinate efforts to ensure that all complete USGS eleven digit (HUC 11) watersheds across the state were monitored in a five year rotation cycle. This effort, known as the Rotating Basin Monitoring Program, comprises a significant component of Oklahoma's ambient monitoring for streams. The purpose of this program is to collect routine water quality (physical and chemical), in-stream habitat, and biological (fish and benthic macroinvertebrates) data in support of EPA mandates to assess state waters regarding their attainment/nonattainment of water quality standards. It serves a dualistic role in fulfilling NPS Program requirements for a *NPS Assessment Report* as data are analyzed and submitted biannually to the ODEQ for compilation in the state's Integrated Report.

The OCC is scheduled to complete the fourth five year cycle and begin the fifth round in the initial basins in the spring of 2021. A schedule of the basins for this project and the historical statewide distribution of sites sampled for the Rotating Basin Program are presented in Figure 4. Each year, the OCC uses GIS spatial and historical data analysis to determine the best site locations to fulfill the monitoring goals through the Statewide Rotating Basin Program. An initial statewide list of projected sites for the Rotating Basin Project for the fourth cycle is included in Table 1.

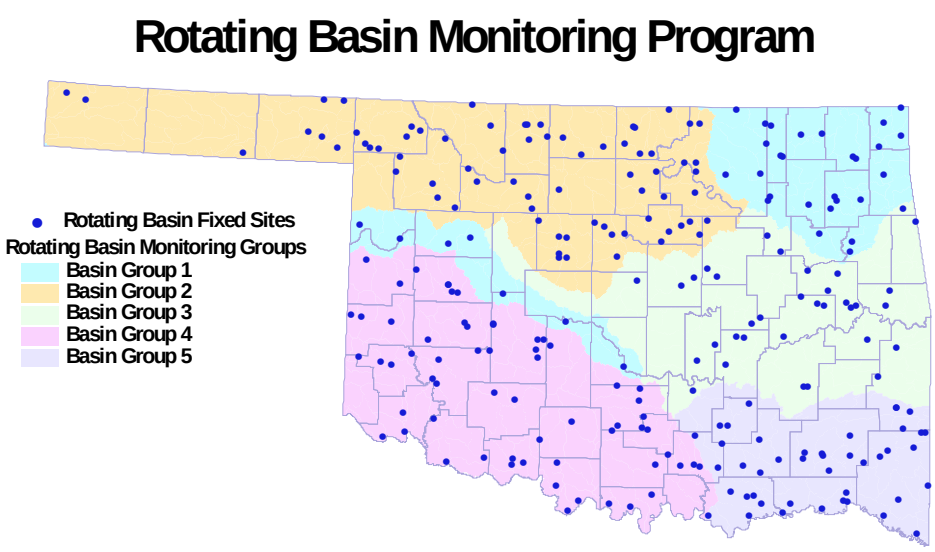

Figure 4. Rotating Basin Program basin schedule and historical distribution of sites sampled

Table 1. Projected Statewide Rotating Basin Program site list (colors indicate basin groups) for the fifth cycle beginning Spring 2021.

RB/ yr	Site Name	WBID
1	Mission Creek	OK121400-02-0190B
1	Sand Creek	OK121400-04-0010F
1	Bird Creek	OK121300-02-0010C
1	Hominy Creek: upper	OK121300-04-0280G
1	Delaware Creek: West Turley	OK121300-01-0150H
1	California Creek	OK121510-02-0050C
1	Big Creek	OK121510-03-0010D
1	Lightning Creek	OK121510-01-0130N
1	Bull Creek	OK121500-02-0090D
1	Saline Creek	OK121600-02-0030D
1	Little Saline Creek	OK121600-02-0070G
1	Drowning Creek	OK121600-03-0090G
1	Horse Creek	OK121600-03-0160G
1	Little Cabin Creek	OK121600-06-0080C
1	Pryor Creek: HWY 20	OK121610-00-0050D
1	Chouteau Creek	OK121600-01-0430P
1	Fourteenmile Creek	OK121600-01-0100G
1	Ranger Creek	OK121600-01-0060D
1	Tar Creek	OK121600-04-0060D
1	Sycamore Creek	OK121600-03-0510D
1	Little Horse Creek	OK121600-03-0190G
1	Fivemile Creek	OK121600-07-0110G
1	Whitewater Creek	OK121600-03-0320G
1	Lost Creek	OK121600-03-0560G
1	Elm Creek	OK121600-04-0150G
1	Mud Creek	OK121600-04-0175M
1	Russell Creek	OK121600-04-0200F
1	Brush Creek	OK121600-05-0140G
1	Beaty Creek: Oak Hill Rd	OK121600-05-0160E
1	Beaty Creek: Lower	OK121600-05-0160G
1	Big Cabin Creek	OK121600-06-0220I
1	Pawpaw Creek	OK121600-06-0240G
1	Warren Branch	OK121600-07-0050G
1	Commission Creek	OK520620-05-0160C
1	Hackberry Creek	OK520620-04-0050D
1	Red Creek	OK520620-03-0110F
1	Lone Creek	OK520620-03-0020C
1	Trail Creek	OK520620-02-0090G
1	Deer Creek	OK520620-06-0010F
1	Buggy Creek	OK520610-02-0120C
1	Walnut Creek	OK520610-03-0010G
1	Willow Creek	OK520610-01-0080H
1	North Fork Walnut Creek	OK520610-03-0080E
1	Bear Creek	OK520620-01-0120G
2	Beaver Creek	OK621210-00-0050L
2	Yelowstone Creek	OK621010-01-0270C
2	Turkey Creek	OK621010-01-0230G
2	Driftwood Creek	OK621010-03-0030C
2	Medicine Lodge Creek	OK621010-03-0010D
2	Sandy Creek	OK621010-02-0010D
2	West Clay Creek	OK621010-01-0130R
2	Wild Horse Creek	OK621000-02-0040F
2	Pond Creek	OK621000-05-0010D
2	Deer Creek	OK621000-04-0010D
2	Bois d' Arc Creek	OK621000-03-0010C
2	Bitter Creek	OK621100-00-0100G
2	Red Rock Creek: upper	OK621200-05-0010M
2	Red Rock Creek: lower	OK621200-05-0010K
2	Doga Creek	OK621200-02-0020C
2	Salt Creek: middle	OK621200-04-0010K
2	Salt Creek: lower	OK621200-04-0010F
2	Black Bear Creek: upper	OK621200-03-0260B
2	Clear Creek	OK720500-02-0300F
2	Duck Pond Creek	OK720500-02-0250F
2	Kiowa Creek	OK720500-02-0130C
2	Clear Creek	OK720500-02-0070G
2	Persimmon Creek	OK720500-01-0150G
2	Bent Creek	OK720500-01-0070D
2	Crooked Creek	OK620930-00-0100G
2	Buffalo Creek: lower	OK620920-05-0010G

RB/ yr	Site Name	WBID
2	Long Creek	OK620920-02-0080D
2	Main Creek	OK620920-01-0180F
2	Griever Creek	OK620920-01-0130G
2	Eagle Chief Creek: upper	OK620920-04-0010G
2	Eagle Chief Creek: lower	OK620920-04-0010C
2	Indian Creek	OK620910-02-0310C
2	Deep Creek	OK620910-02-0250C
2	Salt Creek	OK620910-02-0100D
2	Cooper Creek	OK620910-02-0040C
2	Turkey Creek: Wheat Capital Rd	OK620910-06-0010R
2	Turkey Creek: lower	OK620910-06-0010B
2	Kingfisher Creek	OK620910-05-0010J
2	Dead Indian Creek	OK620910-05-0080A
2	Uncle John's Creek	OK620910-05-0030C
2	Cottonwood Creek	OK620910-04-0010E
2	Skeleton Creek: Upper	OK620910-03-0010S
2	Otter Creek	OK620910-03-0040C
2	Beaver Creek	OK620900-03-0230C
2	Stillwater Creek: upper	OK620900-04-0070T
2	Stillwater Creek: lower	OK620900-04-0040W
2	Council Creek	OK620900-02-0050H
2	Salt Creek	OK620900-02-0020D
2	Euchee Creek	OK620900-01-0290D
2	Lagoon Creek	OK620900-01-0180J
2	Crooked Creek	OK621000-06-0010G
3	Canadian Sandy Creek	OK520600-03-0010D
3	Hog Creek	OK520810-00-0030D
3	Pecan Creek	OK520800-02-0080C
3	Salt Creek	OK520800-03-0010D
3	Bird Creek	OK520800-01-0050G
3	Brushy Creek	OK220600-03-0010L
3	Peaceable Creek	OK220600-03-0050F
3	Gaines Creek	OK220600-04-0010P
3	Coal Creek	OK220600-02-0010F
3	Mill Creek	OK220600-01-0100P
3	Longtown Creek	OK220600-01-0070P
3	Emachaya Creek	OK220300-00-0040C
3	Polecat Creek	OK120420-02-0050G

RB/ yr	Site Name	WBID
3	Snake Creek	OK120410-01-0220G
3	Ash Creek	OK120410-01-0110E
3	Cloud Creek	OK120410-02-0010H
3	Pecan Creek	OK120410-01-0030D
3	Manard Bayou	OK120400-01-0280E
3	Greenleaf Creek	OK120400-01-0120C
3	Elk Creek	OK120400-02-0190F
3	George's Fk Dirty Creek	OK120400-02-0110D
3	S. Fk. Dirty Creek	OK120400-02-0030F
3	Ballard Creek	OK121700-03-0370G
3	Battle Creek	OK121700-06-0040G
3	Deep Branch Creek	OK121700-01-0020A
3	San Bois Creek	OK220200-04-0010G
3	Vian Creek	OK220200-02-0130E
3	Sallisaw Creek: Lower	OK220200-03-0010C
3	Big Skin Bayou	OK220200-01-0030H
3	Big Creek	OK220100-02-0080B
3	Fourche Maline Creek	OK220100-04-0010M
3	Caston Creek	OK220100-01-0180B
3	Sugar Loaf Creek	OK220100-01-0160G
3	Brazil Creek	OK220100-03-0010G
3	Turkey Creek	OK520510-00-0100F
3	Gar Creek	OK520510-00-0080C
3	Wewoka Creek	OK520500-02-0010C
3	Little Wewoka Creek	OK520500-02-0090D
3	Alabama Creek	OK520500-01-0200D
3	Bad Creek	OK520500-01-0170E
3	Bear Creek	OK520700-05-0170A
3	Captain Creek	OK520700-05-0140H
3	Quapaw Creek	OK520700-04-0260C
3	Dry Creek	OK520700-04-0020F
3	Salt Creek	OK520700-03-0100B
3	Sandy Creek	OK520700-03-0040F
3	Little Deep Fork	OK520700-06-0010D
3	Nuyaka Creek	OK520700-02-0200D
3	Montezumah Creek	OK520700-01-0220D
4	Rush Creek	OK310840-02-0210H
4	Sandstone Creek	OK310840-02-0020C
4	Quartermaster Creek	OK310840-01-0060B

RB/ yr	Site Name	WBID
4	West Barnitz Creek	OK310830-03-0230C
4	East Barnitz Creek	OK310830-03-0210C
4	Beaver Creek	OK310830-03-0190C
4	Boggy Creek	OK310830-03-0100C
4	Cavalry Creek	OK310830-03-0070D
4	Rainy Mountain Creek	OK310830-02-0060G
4	Stinking Creek	OK310830-02-0020D
4	Cobb Creek	OK310830-06-0050K
4	Lake Creek	OK310830-06-0040J
4	Sugar Creek	OK310830-05-0010D
4	Delaware Creek	OK310830-01-0030G
4	Stinking Creek	OK310830-04-0030K
4	Bitter Creek	OK310820-01-0030D
4	Little Washita River	OK310820-02-0010A
4	Salt Creek	OK310820-01-0140B
4	Roaring Creek	OK310810-02-0170B
4	Criner Creek	OK310810-02-0050D
4	Finn Creek	OK310810-02-0020D
4	Peavine Creek	OK310810-01-0120M
4	Rush Creek	OK310810-01-0090G
4	Wildhorse Creek (nr Tatums)	OK310810-03-0010R
4	Salt Creek	OK310810-03-0080G
4	Wildhorse Creek (nr Davis)	OK310810-01-0020G
4	Chigley Sandy Creek	OK310800-02-0190D
4	Caddo Creek	OK310800-03-0010F
4	Mill Creek	OK310800-01-0190G
4	Pennington Creek	OK310800-01-0120G
4	Oil Creek	OK310800-01-0240P
4	Big Sandy Creek	OK310800-01-0090G
4	Buffalo Creek	OK311510-02-0090D
4	Timber Creek	OK311510-01-0090G
4	Lake Creek	OK311510-01-0040D
4	Tepee Creek	OK311500-01-0110D
4	Trail Creek	OK311500-03-0070D
4	Little Elk Creek	OK311500-03-0040D
4	Otter Creek	OK311500-01-0080F
4	North Elm Creek	OK311800-00-0170G
4	Fish Creek	OK311800-00-0130G
4	Station Creek	OK311800-00-0060G

RB/ yr	Site Name	WBID
4	Haystack Creek	OK311800-00-0040D
4	Turkey Creek	OK311600-02-0060J
4	Gypsum Creek	OK311600-01-0020F
4	Suttle Creek	OK311310-01-0070H
4	Red Creek	OK311100-01-0290D
4	North Mud Creek	OK311100-04-0030C
4	Walnut Bayou	OK311100-03-0010G
4	Mud Creek	OK311100-04-0010G
4	East Cache Creek	OK311300-03-0010M
4	Medicine Creek	OK311300-04-0060H
4	Jack Creek	OK311310-03-0030B
4	Little Deep Red Creek	OK311310-03-0040E
4	Deep Red Creek	OK311310-03-0010D
4	Post Oak Creek	OK311310-02-0070B
4	Beaver Creek	OK311210-00-0010D
4	Little Beaver Creek	OK311210-00-0050D
4	Hickory Creek	OK311100-02-0010M
5	Sand Creek	OK410700-00-0260G
5	Island Bayou	OK410700-00-0040G
5	Whitegrass Creek	OK410400-01-0210G
5	Horse Creek	OK410400-01-0040G
5	One Creek	OK410300-03-0060F
5	Sandy Creek	OK410600-02-0020G
5	Mineral Bayou	OK410600-01-0300G
5	Bokchito Creek	OK410600-01-0090G
5	Sulphur Creek	OK410600-01-0030G
5	Caney Boggy Creek	OK410400-06-0120G
5	N Boggy Creek	OK410400-08-0010E
5	McGee Creek	OK410400-07-0010L
5	Lick Creek	OK410400-01-0130G
5	Clear Boggy Creek	OK410400-03-0230K
5	Delaware Creek	OK410400-03-0240M
5	Caney Creek (HWY 69)	OK410400-03-0020C
5	Caney Creek	OK410400-02-0200G
5	Billy Creek	OK410310-02-0070C
5	Buck Creek	OK410300-03-0420C
5	Cedar Creek	OK410300-03-0020M
5	Tenmile Creek	OK410300-03-0270C
5	Rock Creek @ HWY 3	OK410300-02-0190G

RB/ yr	Site Name	WBID
5	Waterhole Creek	OK410100-01-0340D
5	Norwood Creek	OK410100-01-0050H
5	McKinney Creek	OK410100-02-0030J
5	Black Fork Little River	OK410210-03-0020C
5	Honobia Creek	OK410210-03-0150H
5	Cloudy Creek	OK410210-02-0300C
5	Terrapin Creek	OK410210-02-0150G
5	Cypress Creek	OK410210-01-0070D
5	East Fk Glover River	OK410210-09-0010G
5	West Fk Glover River	OK410210-08-0010M
5	Lukfata Creek	OK410210-07-0010G
5	Beech Creek	OK410210-06-0320G
5	Cow Creek	OK410210-06-0350G
5	Big Eagle Creek	OK410210-06-0160I
5	Buffalo Creek	OK410210-06-0020G
5	Rock Creek	OK410200-03-0010G
5	Buffalo Creek	OK410310-03-0030N

To determine the support status of each site and the cause(s) of impairment, water quality sampling, biological monitoring, habitat assessments, and landuse assessment are conducted. Water quality data is collected at 20 even intervals over a two-year period. Typical water quality parameters include dissolved oxygen, water temperature, pH, turbidity, conductivity, total alkalinity, total hardness, instantaneous discharge, nitrite, nitrate, total Kjeldahl nitrogen, orthophosphate, total phosphorous, chloride, sulfate, total dissolved solids, and total suspended solids. Samples are also collected for *Escherichia coli* only during the recreation season from May through September. Ammonia is now analyzed three times between May and September. Biological samples include fish and in-stream habitat, which is collected once for each rotation cycle, and benthic macroinvertebrates collected during the summer and winter index periods for each of the two years water quality samples are collected.

In 2008, the OCC decided to initiate a probabilistic sampling design, or sampling of sites that have been randomly selected to represent a population of sites with known statistical confidence, through the Rotating Basin Program. To accomplish this, EPA staff from the Corvallis Lab randomly generated a 150 site panel of possible sites for each basin in the rotational scheme. Access permissions were obtained according to the order of sites listed until a total of fifty sites were achieved (EPA scientists have determined a minimum of fifty sites is necessary to achieve statistical confidence). Each site had one collection for all parameters listed for the rotating basin project during the summer index period. The final basins in the state were completed in the summer of 2012. Resulting data have been used to make statements with statistical confidence regarding the status of all streams (no greater than Strahler order of 6) from the basin sampled. The basins were sampled according to the same schedule as those referenced in Figure 1. Following the analysis of the probabilistic monitoring data, it was determined that the results remained generally in agreement with the results of the fixed sites monitoring data. Since the probabilistic monitoring results corroborated the results of the rotating basin fixed sites monitoring, probabilistic monitoring has been temporarily suspended. With different analytical tools, probabilistic design offers a variety of analysis possibilities and can be used to answer an array of questions fixed site monitoring does not allow. Consideration was given to the analysis of risk assessment. However, the initial analysis of risk assessment did not offer OCC any insight in the management of non-point source pollution. Given the potential for added utility, probabilistic monitoring may be reinitiated to look at landscape scale changes in the future. The design will likely remain the same and each 5 year cycle will cover the entire state as explained in the previous paragraph.

Special Projects Monitoring

Monitoring is a vital part of OCC partnership projects implemented watersheds across the state. Data are needed to characterize pollutant loading from sources in the watershed and to prioritize areas for implementation of practices to reduce the particular pollution. Water quality data is also vital to evaluate the success of load reduction strategies and pollution abatement measures. From 1986 to present, OCC has utilized automated water samplers (autosamplers) for calculating loading in tracking water quality changes and for use in developing TMDLs. These samplers were installed and used to collect high flow water samples from strategic locations in the watershed. Due to the required schedule of most OCC partnership projects, in which project implementation begins almost immediate to fund receipt and ends on a tight schedule, OCC has not been able to employ autosamplers to monitor these project results in all projects, instead utilizing routine grab samples. However OCC does assist partners to employ autosamplers on special projects to collect continuous, flow-weighted, composite samples. This type of monitoring allows for a continuous assessment of both a true average concentration of constituents in the stream water and continuous discharge data, both of which improve the calculation of accurate loading estimates. These estimates do improve the overall accuracy in determining changes in the water quality of a target watershed where conservation based landuse changes were brought about by technical and cost share assistance, and where the project timeline allows for their use.

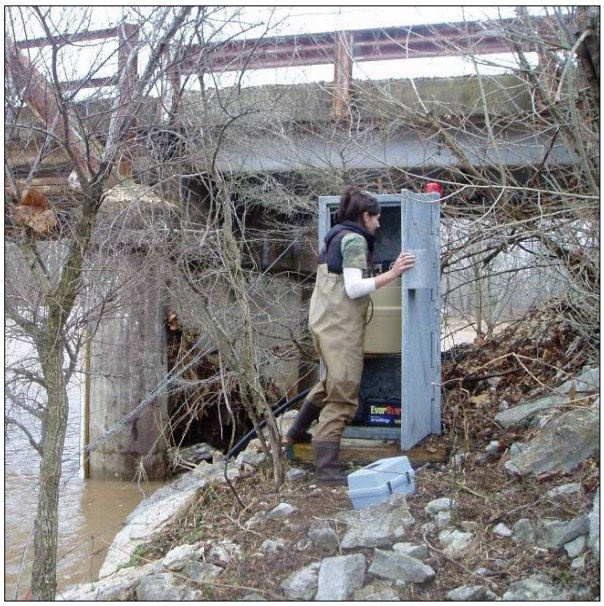

Figure 5. Field specialist accessing autosampler.

Over the last decade, the OCC has completed several special projects partially or entirely using autosamplers. Most of these special projects were watershed implementation projects and involved the use of cost share incentives for landuse changes in priority watersheds. Recently completed projects include: Spavinaw Creek Watershed Implementation Project; Honey Creek Watershed Implementation Project; North Canadian River Watershed Implementation Project; Illinois River Implementation Project; and Lake Thunderbird Watershed Implementation Project.

Ongoing Projects

EPA 319 funds for use in watershed implementation projects have been cut. OCC continues strengthening partnerships so that 319 water quality monitoring funds can be used to assist partners with watershed implementation targeting and with tracking the outcome of those conservation efforts within watersheds. Water quality data collected according to approved methods and at strategically located sites within watersheds are crucial to showing the effects of the implementation of conservation practices. Although OCC has demonstrated the benefits of the employment of autosamplers, this sampling strategy is expensive in both equipment and employee time, and also requires the deployment and operation of the autosampler through a necessary calibration phase prior to the implementation of

conservation practices. The effective and efficient execution of this strategy requires the dedication of an employee to these project areas, thereby limiting the location of these projects. OCC has demonstrated effectiveness of detecting and tracking water quality changes in response to the implementation of conservation practices through the techniques employed in the rotating basin ambient monitoring. OCC remains prepared to employ both monitoring strategies depending on the data quality objectives of specific projects. Below are examples and discussion of both types of current projects.

Elk City Lake Regional Conservation Partnership Program (RCPP)

The Elk City Lake watershed is a USDA PL-566 lake constructed in 1970 primarily for flood control but is now operated by the City of Elk City for recreation. Elk City Lake is listed in Oklahoma's Integrated Report as being impaired by turbidity. In addition, reports surfaced earlier this year of a significant fish kill and bluegreen algae blooms have become a problem. Some of these latest water quality problems are likely exacerbated by low water levels caused by the recent drought in Oklahoma. Declining water levels make it even more important to implement actions to reduce water quality degradation. In late 2006, the City of Elk City, which owns and operates the lake, approached the Oklahoma Conservation Commission Water Quality Division (OCC) about implementing a watershed project to address the sources of the lake's impairments. At that point in time, the OCC developed a Watershed Plan to address water quality concerns in the watershed. Land use in the watershed is primarily range, pasture, and cropland with little to no riparian buffer along the streams and direct access by livestock. The lake has also sometimes had problems with bacteria impairments although recent data does not indicate a current problem. Because there are no municipal discharges or feedlot operations in the watershed, it is most probable that the potential sources of sediment and nutrients contributing to the lake's impairment are resulting from these land uses.

The Regional Conservation Partnership Program (RCPP) promotes coordination between the USDA Natural Resources Conservation Service (NRCS) and its partners to deliver conservation assistance to producers and landowners. NRCS provides assistance to producers through partnership agreements and through program contracts or easement agreements.

RCPP combines the authorities of four former conservation programs – the Agricultural Water Enhancement Program, the Chesapeake Bay Watershed Program, the Cooperative Conservation Partnership Initiative and the Great Lakes Basin Program. Assistance is delivered in accordance with the rules of EQIP, CSP, ACEP and HFRP; and in certain areas the Watershed Operations and Flood Prevention Program.

OCC submitted a proposal and was selected to enter into this partnership agreement. One requirement of this agreement is to conduct an assessment of the project's effects. In order to assess the effects, OCC has added an upstream site on West Elk Creek to evaluate the stream for water quality improvement. Water quality monitoring at this stream site typically occurs on a monthly basis and will be conducted at fixed intervals throughout the program period. Typical water quality parameters include dissolved oxygen, water temperature, pH, turbidity, conductivity, total alkalinity, total hardness, instantaneous discharge, nitrite, nitrate, total Kjeldahl nitrogen, orthophosphate, total phosphorous, chloride, sulfate, total dissolved solids, and total suspended solids. Samples are also collected for *Escherichia coli* only during the recreation season from May through September. Ammonia is now analyzed three times between May and September.

Middle and Lower Neosho River Basin/Grand Lake Regional Conservation Partnership Program (RCPP)

Grand Lake is an important water supply, flood water retention, electrical power generation, and recreation source for the region. Eutrophication in the lake led to severe blue-green algae blooms in 2011 and bacteria outbreaks at beaches in 2014**.**

The Neosho River Watershed is a high priority for both Kansas and Oklahoma and each state has devoted significant effort towards diagnosing and solving water quality degradation in the watershed.

The Regional Conservation Partnership Program (RCPP), created by the farm bill of 2014, promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners.

Many of the streams, rivers, and reservoirs in the watershed have water quality problems and impairments related to excess nutrients, sedimentation, and bacteria. Of particular concern to both states are watersheds in the Middle and Lower Neosho Basin, because of concerns raised by stakeholders in the watershed and, in part, because these watersheds contribute directly to water quality degradation in Grand Lake.

OCC entered into this partnership agreement. One requirement of this agreement is to conduct an assessment of the project's effects. In order to assess the effects, OCC has added five monitoring sites in Ottawa and Craig counties to evaluate the stream for water quality improvement. Water quality monitoring at these stream sites typically occurs on a monthly basis and will be conducted at fixed intervals throughout the program period. Typical water quality parameters include dissolved oxygen, water temperature, pH, turbidity, conductivity, total alkalinity, total hardness, instantaneous discharge, nitrite, nitrate, total Kjeldahl nitrogen, orthophosphate, total phosphorous, chloride, sulfate, total dissolved solids, and total suspended solids. Samples are also collected for *Escherichia coli* only during the recreation season from May through September. Ammonia is now analyzed three times between May and September.

Little Beaver Creek National Water Quality Initiative (NWQI)

Little Beaver Creek was listed as impaired on Oklahoma's 2012 Integrated Report for high levels of *E. coli* bacteria. Waurika Lake is listed as impaired for chlorophyll–*a* and turbidity.

In 2015, four sub-watersheds of the Little Beaver Watershed were chosen as NRCS National Water Quality Initiative (NWQI) watersheds. Through NWQI, NRCS provides technical and financial assistance to help farmers and ranchers install conservation practices that will improve downstream water quality.

The OCC began collecting water quality data on Little Beaver Creek in 2015, sampling at three locations approximately once per month to evaluate the stream for water quality improvement. Water quality monitoring at these stream sites typically occurs on a monthly basis and will be conducted at fixed intervals throughout the program period. Typical water quality parameters include dissolved oxygen, water temperature, pH, turbidity, conductivity, total alkalinity, total hardness, instantaneous discharge, nitrite, nitrate, total Kjeldahl nitrogen, orthophosphate, total phosphorous, chloride, sulfate, total dissolved solids, and total suspended solids. Samples are also collected for *Escherichia coli* only during the recreation season from May through September. Ammonia is now analyzed three times between May and September.

New Spiro Lake Watershed Project

The water quality of New Spiro Lake has deteriorated over the past several decades. The lake frequently supports extensive summer algal blooms. The results of water quality sampling by the Oklahoma Water Resources Board have led to the lake being placed on the State of Oklahoma's 303(d) List of Impaired Waters. The lake has excessive chlorophyll-*a* and too little dissolved oxygen which impairs its beneficial uses as a public water supply and as warm water aquatic habitat (ODEQ 2014).

The Oklahoma Conservation Commission has recently prepared a draft Watershed Based Plan for Holi-Tuska Creek and New Spiro Lake, and the Natural Resources Conservation Service has identified the Holi-Tuska Creek watershed as one of its National Water Quality Initiative sites in Oklahoma. The NWQI initiative makes additional matching funds available to land owners in the watershed to implement conservation practices that will improve water quality. This monitoring project will support and inform these water quality improvement efforts.

The monitoring program was developed to (1) provide a data baseline for water quality in the watershed and thereby provide a basis on which to track future water quality improvement; and (2) assist in the refinement of the Watershed Based Plan for the watershed and the Source Water Protection Plan for the lake. Monitoring Holi-Tuska Creek provides data that may be used to calibrate future watershed models. Quantitative estimates of the loads of nutrients and sediment entering New Spiro Lake may be used for future lake water quality modeling and lake restoration plan development.

The OCC has assisted the City of Spiro with the deployment, maintenance and troubleshooting of an autosampler on Holi-Tuska Creek. The monitoring is being completed by a consultant hired by the City of Spiro. The sampling consists of approximately 24 samples per year, once per month during base flow conditions plus a minimum of 12 targeted runoff events per year in accordance with OCC standard operating procedures (SOPs). Grab samples are analyzed for nitrate-nitrogen, ammonia-nitrogen, total nitrogen, ortho-phosphorus, total phosphorus, chlorophyll-*a*, total organic carbon, total suspended solids, alkalinity, chloride, sulfate, and total dissolved solids.

The autosampler has been utilized to collect continuous, flow weighted storm event samples for water chemistry analysis in accordance with OCC SOPs (OCC 2017, 2018, 2019). Samples have been analyzed for nitrate-nitrogen, ammonia-nitrogen, total nitrogen, ortho-phosphorus, total phosphorus, chlorophyll-*a*, total organic carbon, and total suspended solids. In the event of autosampler failure, grab samples are taken and analyzed for these parameters. A grab sample has been collected when possible during high flow events and analyzed for ammonia-nitrogen, alkalinity, chloride, sulfate, and total dissolved solids.

Field parameters have been measured at Holi-Tuska Creek concurrent with all water sample collections and include temperature, dissolved oxygen, pH, conductivity, turbidity, and instantaneous discharge. Two grab samples per month have been collected and analyzed for *E. coli* during the summer recreational season, from May 1 through September 30.

Blue Thumb (BT) is the water pollution education program of the Oklahoma Conservation Commission's Water Quality Division. Volunteer monitoring is a fundamental component of the BT Program. Monitoring volunteers complete a rigorous training (generally 12+ hours spread out over two days) to become certified volunteers. During this training, they learn the essentials of sampling methodology, use of volunteer kits for sample analysis, and related safety and procedural lessons. The training also provides background on NPS pollution, aquatic ecology, and CPs. Volunteers participate in quality assurance sessions four times each year.

Figure 6. BT volunteers collecting fish

BT volunteers collect water quality data at least monthly at their designated sites. Typical parameters include temperature, dissolved oxygen, chloride, nitrate, nitrite, ammonia, pH, orthophosphorus, estimated discharge, and in some cases fecal bacteria. Benthic macroinvertebrate sampling is completed bi-annually at sites and fish collections (Figure 6) are completed once every three to five years by BT staff with volunteer assistance.

After each fish collection, data are compiled and analyzed by BT staff and given to the volunteers. The volunteers use this information, along with the knowledge they gain from monitoring, to write up a data interpretation about their creek monitoring site. This data interpretation and other water quality information are used by the volunteers to educate landowners, businesses, school children, and other groups in the local community about water quality related issues. One of the values of the Blue Thumb volunteer monitoring is the procurement of data on streams where OCC staff do not routinely monitor. There are currently active programs in Beaver, Canadian, Cherokee, Cleveland, Comanche, Custer, Haskell, Hughes, Johnston, Latimer, LeFlore, Murray, Muskogee, Nowata, Oklahoma, Okmulgee, Osage, Ottawa, Payne, Pontotoc, Pushmataha, Rogers, Tulsa, and Washington Counties.

Figure 7. BT volunteers educate in their community

Blue Thumb also conducts groundwater screenings in areas where wells are common. These groundwater screening events are led by professional staff and trained volunteers and involve conducting basic tests on water samples from local citizens. Groundwater screenings test alkalinity, sulfate, chloride, nitrate and pH. Data is explained to the well owner relative to the safety of their water supply, potential sources of any contamination observed, and precautions to take to help protect their well. Information about threatened or polluted wells is provided to the local Conservation District who can then help the landowner locate likely sources and recommend protective CPs. These analyses are screenings, so anytime the results suggest cause for concern (levels above or closely below water quality standards), the well owner is encouraged to contact a certified lab (county or state ODEQ office) about having the well professionally tested. Because these are screenings, information, while maintained in BT records, is not stored in the WQ database.

In addition, Blue Thumb volunteers help staff education programs like natural resource days and classroom visits around the state (Figure 7).

Wetlands Program

The OCC is the lead agency to develop the state's Wetlands Strategy and functions to build program capacity to conserve the state's wetlands resources effectively.

OKRAM Riverine Development

In cooperation with Oklahoma State University (OSU), a classification protocol for Oklahoma's wetlands has been developed that is the foundation of the ongoing effort to develop an effective monitoring design. This monitoring design centers on the development of the Oklahoma Rapid Assessment Method for wetlands (OKRAM). The OKRAM is being developed for the specific diverse conditions and wetlands of Oklahoma. The OKRAM should prove most valuable in pre-assessing wetlands where a known disturbance will occur and as one tool in tracking the development of restoration and/or mitigation of wetlands. OCC has again worked with State, Federal, academic, Tribal, and local partners as well as NGOs to develop and vet the Oklahoma Rapid Assessment Method for wetlands. Once again, OSU is the primary partner in developing and vetting the OKRAM. The OKRAM was developed, calibrated, and tested initially in isolated depressional wetlands in North Central Oklahoma. This effort was vetted against intensive monitoring data collected in conjunction with the OKRAM data collection. The OKRAM worked well in depressional wetlands. In 2015 an effort began to further develop and vet the OKRAM in riverine wetland systems but widespread and continual flooding shifted this effort to lacustrine wetland systems. Although the OKRAM showed some utility, it was determined additional development is required before widespread use of the OKRAM in lacustrine wetlands. In the late spring of 2018, OSU renewed their effort in revising and vetting the OKRAM for riverine wetlands. Riverine wetlands were visited in 2018 and 2019 and data was collected for further development of the OKRAM and comparison of results to more intensive data to judge the effectiveness of OKRAM in determining the condition of riverine wetlands. Final results of this effort should be available in early 2021.

National Wetlands Condition Assessment (NWCA)

In 2011, the OCC coordinated state efforts in participating in the National Wetland Condition Assessment (NWCA), EPA's first-ever national survey on the condition of the Nation's wetlands. The survey was designed to provide national estimates of the ecological integrity and biological condition of wetlands, and has the potential to provide regional estimates. The process of designing and conducting the survey is also intended to help build state and tribal capacity to monitor and analyze wetland conditions while promoting collaboration across jurisdictional boundaries. The OCC again completed Oklahoma's field portion of the NWCA in the summer of 2016. The (NWCA) survey uses a probability-based sample design that results in statistically-valid estimates of condition for a population of wetlands. The OCC and state partners from across the U.S. participate in the design, planning, and field assessment of the NWCA. A consistent field assessment procedure ensures the results can be compared across the country. The OCC and state partners conducted surveys on 19 sites statewide during the summer of 2016. Once complete, and in concert with similar surveys on the Nation's coastal waters, wadeable streams, rivers, and lakes, the NWCA will inform decision-makers on how to better protect, maintain, and restore water-quality to the Nation's aquatic resources. The NWCA report should be available in 2020. Planning and coordination of the 2021 NWCA field season will begin in mid- to late 2020.

In addition to completion of the sampling of 19 sites in 2016, OCC has completed the field portion of assessing 30 additional wetland sites across central Oklahoma. This sampling was completed for the dual purpose of an intensification study to determine the general status of wetlands in this region and to compare the national method and the developing Oklahoma Rapid Assessment Method for wetlands. It is likely that OKRAM, in the format used, overestimated the quality of some wetlands in this study. OKRAM was initially calibrated for depressional wetlands and we have found good agreement between OKRAM condition and more intensive vegetation assessments of depressional wetlands. However, many of the wetlands included in this study were riverine. We observed that several of the metrics don't adequately account for the types of anthropogenic stress that occurs at riverine wetlands. The results of this study and anecdotal observations, allowed us to consider alternative methods of calculating three of the metrics.

Statewide Application of the Restorable Wetlands Identification Protocol and Wetland Program Plan Update

The OCC receives numerous requests for assistance with voluntary restoration and mitigation. The first and generally most important step in wetland restoration, whether voluntary restoration or for mitigation, is determining site suitability or locating suitable sites. The Restorable Wetlands Identification Protocol (RWIP) has been applied statewide. Potentially restorable sites have been both identified and ranked for the potential to reduce landscape impacts to receiving waters. OCC staff is currently in the process of securing landowner permissions and verifying the accuracy of the RWIP. A final report that includes our findings will be completed by December 2020.

Additionally, the OCC has coordinated several meetings of the Oklahoma Wetland Technical Working Group to develop a draft Oklahoma Wetland Program Plan (WPP). The WPP is currently in review and comment by the larger Oklahoma Wetland Working Group. A final draft should be completed by late 2020, following the incorporation of comments from the OWWG.

Oklahoma Water Resources Board

Beneficial Use Monitoring Program (BUMP)

The overall program goal of the Oklahoma Water Resources Board's (OWRB) BUMP is "to document beneficial use impairments, detect water quality trends, and provide needed information for the Oklahoma Water Quality Standard (OWQS) development and refinement process and to facilitate the prioritization of pollution control activities." Development of data quality objectives (DQOs) and collection of data sufficient to meet the stated DQOs are essential to program success.

Figure 8. Stream sampling from a bridge

Monitoring Rivers & Streams: The OWRB is currently monitoring approximately 84 stations on an 8-week rotation as part of the Statewide Ambient Trend Monitoring Network. Ambient trend monitoring is based largely upon the 84 planning basins as outlined in the Oklahoma Comprehensive Water Plan (OCWP). In general, at least one sample station is located at the terminal end of each of the planning basins. The intent is to implement Oklahoma's Use Support Assessment Protocols (USAP) to document/quantify impairments of the beneficial uses assigned in the Oklahoma Water Quality Standards (OWQS)

- Goals of the program include:
    - Long term assessment of beneficial use attainment status
    - Assessment of water quality trends
    - Data for loading estimates of various pollutants—TMDL's
    - Data for 305(b) report, 303(d) list (integrated listing process)
    - Provision of a statewide, long-term water quality data set to assist in management decisions and planning (e.g., Arkansas River Compact Commission Oklahoma Scenic River analyses)
    - Provision of empirical data for the periodic revisions of the OWQS

The OWRB also conducts on-going special studies and monitors at 25-30 probabilistic stations annually. The probability-based survey was designed to assist Oklahoma's water quality managers in several ways. Furthermore, in keeping with the environmental goals of the state as outlined in the comprehensive water plan, an effective long-term management strategy based on sound science and defensible data can be developed using this data. The four over-arching goals were:

1. Estimate the condition of multi-assemblage biological indicators for Oklahoma's waters through a statistically-valid approach.
2. Estimate the extent of stressors that may be associated with biological condition.
3. Evaluate the relationship between stressors and condition for use in various long and short term environmental management strategies.
4. Assess waters for inclusion in Oklahoma's Integrated Water Quality Report.

Fixed Station Load Monitoring: The OWRB is currently working with several partners including the US Geological Survey (USGS), US Army Corps of Engineers (USACE), Grand River Dam Authority (GRDA) and, National Weather Service to conduct flow monitoring on all fixed station sites that are not part of the State of Oklahoma/USGS Cooperative Gaging Network. This cooperative effort will allow for loadings to be calculated and trends to be assessed statewide, providing much needed data for the Use Support Assessment Process.

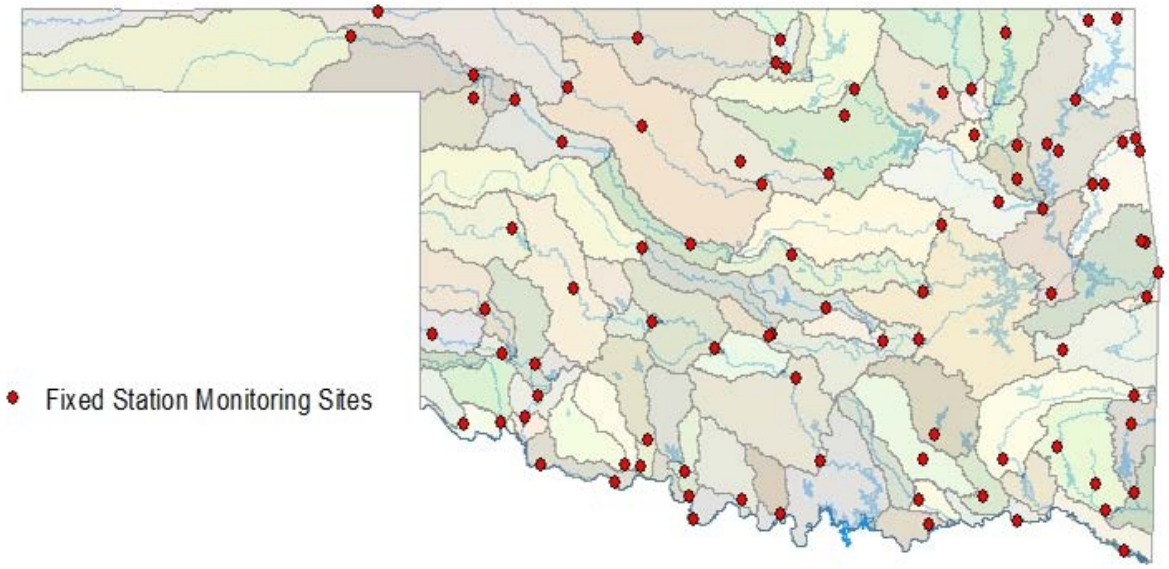

Figure 9. BUMP permanent stream monitoring sites

Fixed Station Lakes Monitoring: The OWRB conducts sampling on lakes and reservoirs across the State of Oklahoma through a fixed station monitoring approach. This design allows the state's objectives to be met, as well as ensure various sized waterbodies are represented adequately. All lakes 50 surface acres or larger are monitored by OWRB and encompasses 206 individual water bodies. The population is divided into two categories; lakes larger than 500 surface acres and lakes less than 500 surface acres. Sampling is conducted on a quarterly basis, following the hydrologic year, which runs October through September. Over a five-year timeframe, large lakes are sampled twice in non-consecutive years, while smaller lakes are sampled once. During that timeframe, the goal is to sample each lake at least once. Each year, OWRB samples between 35-40 lakes, depending on size. Many of these smaller lakes are municipal water supplies and have not historically been sampled through BUMP.

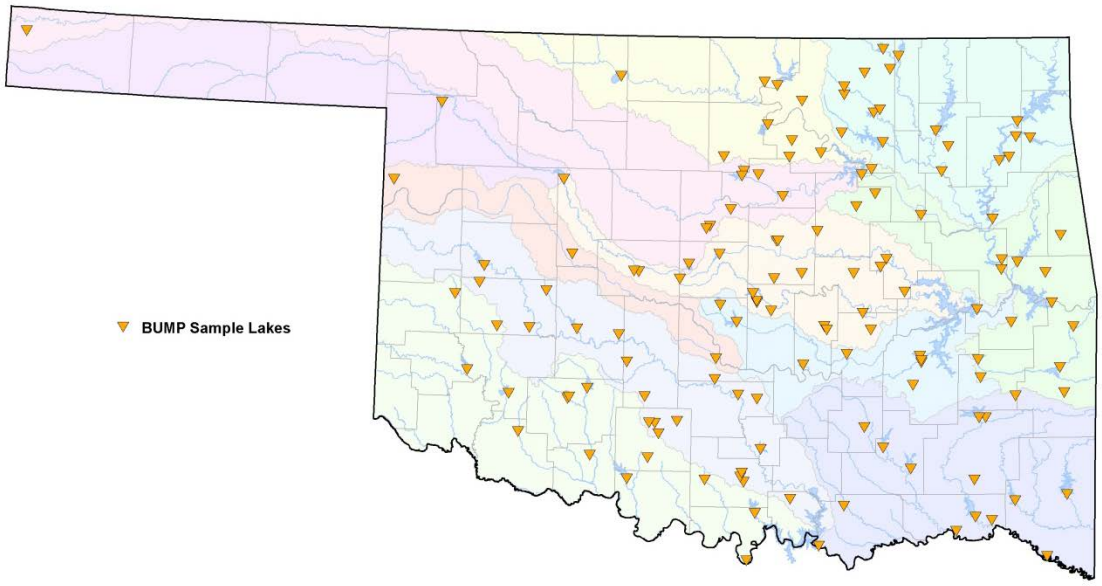

Figure 10. Lakes monitored by the BUMP

Many of the 68 large lakes are managed by federal partners including the United States Army Corps of Engineers (USACE) and the Bureau of Reclamation (BOR). The OWRB works with these partner agencies for inclusion of additional information when possible on waterbodies under their management. Data collected consists primarily of water chemistry, nutrients, and chlorophyll-a information. In general, a minimum of three to five stations per reservoir are sampled, depending on the reservoir's size. Stations are located such that they represent the lacustrine, transitional, and riverine zones of the lake. On many larger reservoirs, additional sites are monitored to include major arms of the reservoir, as appropriate. Water quality parameters have been added to the lakes sampling effort over the years to enhance BUMP's ability to make use support determinations.

Groundwater Monitoring (GMAP): This program was made possible as result of a $1,500,000 increase in funding received from the Oklahoma Legislature for water quality/quantity monitoring based on recommendations of the 2012 Update of the Oklahoma Comprehensive Water Plan. These additional monies were utilized to restore funding levels of the Beneficial Use Monitoring Program as well as to implement the new groundwater program. The new groundwater program prioritizes efforts on Oklahoma's major groundwater aquifers and has been completely phased in.

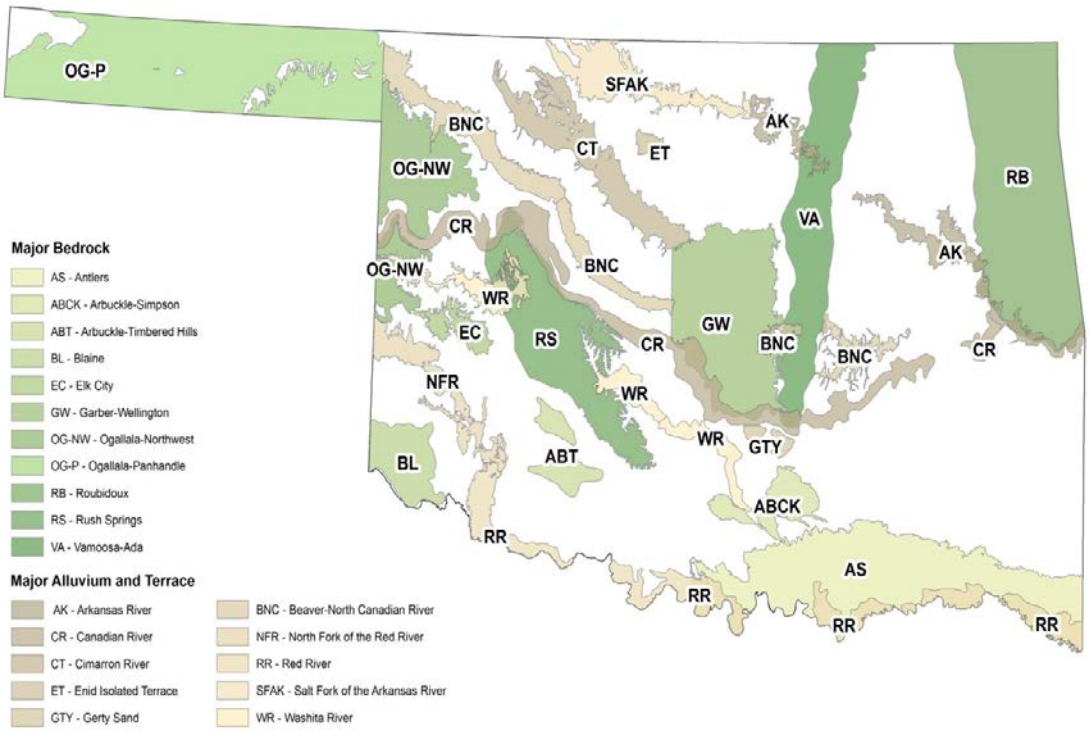

Figure 11. Major Bedrock and Alluvium and Terrace Aquifers in Oklahoma

This baseline period concluded in 2018 and assessed concentrations of nutrients, metals and major ion species. Water quality data was collected from networks of wells on the basis of an aquifer's areal extent. This design feature generated sample populations of at least 30 wells for each of Oklahoma's 15 largest aquifers. Smaller aquifers were represented by fewer wells but proportionally had more sites per areal extent.

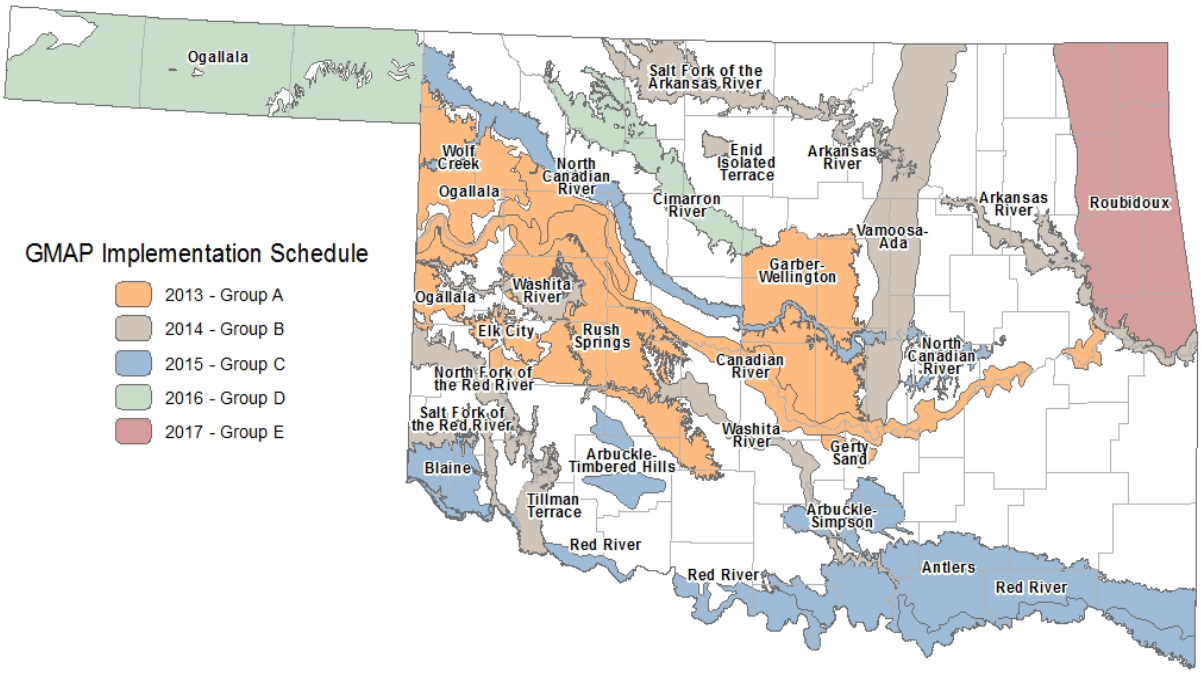

Figure 12. GMAP implementation schedule

During the baseline period over 750 wells in the state's major aquifers and a few associated minors were sampled for water quality, and 961 wells were measured for water level. Due to the lack of monitoring wells in the state, these wells are a a mix of construction and use types including domestic, irrigation, public water supply, stock tank, and oil and gas water supply wells and are almost entirely privately owned, A subset of wells was retained for the OWRB's permanent water level network, which has nearly doubled in capacity (from around 530 to around 920 wells) and has been spatially redistributed to more adequately characterize the state. For about one third of the water level network (around 295 wells), manual measurements have become triannual events. Additionally, over the baseline period, the OWRB has installed 33 continuous water level recorders in 14 aquifers across the state to obtain daily or hourly measurements that are more sensitive to detecting seasonal changes (brought on by drought or variable climate conditions) than can be obtained by annual measurements.

Following the GMAP baseline period, in 2019 the OWRB implemented a permanent groundwater quality monitoring network alongside its existing water level network. The aim of the program is to provide an ongoing characterization of the states groundwater quality and detect trends over time, as well as characterizing seasonal fluctuations in water chemistry. A subset of baseline wells was chosen for the permanent network, as well as a small number of new sites which are brought in annually to replace wells lost from the program either through degradation or damage to a well or through changes in landowner permissions.

Table 2. Baseline and Trend Groundwater Quality Monitoring Sample Variables.

SAMPLE VARIABLES		
General Chemistry		
Total Alkalinity	Total Hardness	Total Dissolved Solids
pH	Calculated Bicarbonate*	
Major Ions (Dissolved)		
Calcium	Magnesium	Potassium
Sodium	Silica	Bromide
Chloride	Fluoride	Sulfate
Nutrients (Dissolved)		
Nitrate + Nitrite	Total Dissolved Phosphorus	Ammonia
Metals & Trace Elements (Dissolved)		
Aluminum	Antimony	*Arsenic*[#]
Barium	Beryllium	Boron
Cadmium	*Chromium*[#]	Cobalt
Copper	*Iron*[#]	Lead
Manganese[#]	Mercury	Molybdenum
Nickel	*Selenium*[#]	Silver
Thallium	*Uranium*[#]	Vanadium
Zinc		

*Calculated from total and phenolphthalein alkalinity values. [#]*Trace* metals still sampled for the trend program.

Intensive Investigations: Historically, occurred in the early years of the program, but no work of this nature has occurred in the last several years. Work was discontinued to address other monitoring needs as the costs to operate the program have continued to increase since program inception.

The lake and stream sample programs collect water quality data on a broad suite of parameters. See Table 3 for a list of parameters collected on streams. A similar suite of parameters is collected on lakes with a few slight differences. Lakes collections include chlorophyll-a, and Secchi disk depth data that are not generally collected in the streams program. The BUMP added biological collections to the streams portion of the program in the summer of 2003 to assess the Fish & Wildlife Propagation beneficial use and to aid in the development of nutrient criteria. Biological sampling has been initiated in ecoregions for which biocriteria has been developed and promulgated into rule. Biological collections will be expanded into other ecoregions in Oklahoma as biocriteria are developed and promulgated into rule.

Flow data is collected at all stream sites either using USGS gaging station information or instantaneous flow data is collected on the stream by OWRB personnel following EPA approved protocols.

With the development of biocriteria and their promulgation into rule via the OWQS process, biological monitoring on streams has been implemented into the program. Biological monitoring (other than chlorophyll) on lakes is a long-term goal of the program, and has recently been expanded to include zooplankton and phytoplankton; however development and promulgation of biocriteria associated with lakes is not something that is expected to occur within the next 5 years.

Table 3. Stream and Lake Monitoring Sample Variables.

SAMPLE VARIABLES		
General Water Quality – Sampled 8 to 10 times annually for streams & quarterly for lakes		
Total Dissolved Solids	Total Alkalinity	Total Hardness
Chloride	Nephelometric Turbidity	Sulfate
Secchi Disk Depth (Lakes Only)	Chlorophyll-a	
Nutrients – Sampled 8 to 10 times annually & quarterly for lakes		
*Kjeldahl Nitrogen	Ortho-Phosphorus (Lakes Only)	Total Phosphorus
*Nitrate/Nitrite Nitrogen	Ammonia Nitrogen	
Metals – Sampled as needed		
Arsenic	Cadmium	Chromium
Copper	Lead	Mercury
Nickel	Selenium	Silver
Zinc	Thallium	
Organics – Site specific sampling as needed		
Analysis of Pesticides, Herbicides, Fungicides, and other organics		
Bacteriological Communities – Sampled 5-10 times annually (during recreational season)		
Escherichia coli	Enterococci	
Biological Communities – Sampled as described below		
Sestonic Chlorophyll-a (10 times annually — site specific)	Benthic Chlorophyll-a (as needed during summer)	Fish (once every 4-5 years)
Benthic Macroinvertebrates (2 summer/2 winter 2 out of every 5 years	Habitat (sampled with fish and macroinvertebrate sampling)	

* OWRB staff, based upon concentrations for these compounds, calculates total nitrogen.

* OWRB is currently not sampling for bacterial communities.

However, data from targeted sites are only representative of conditions at that location. It is not appropriate to extrapolate data from targeted sites to describe statewide stream or lake conditions.

Streams Probabilistic Monitoring Program

Historically, most water quality monitoring done by the OWRB has been at targeted, non-randomly selected sites. Most of these targeted sites are at bridges on larger rivers. Data from targeted sites are important in determining compliance with water quality standards, tracking general water quality trends at a particular location, and identifying pollution problems.

Figure 13. OWRB staff collecting stream biota

Answering big questions about water quality conditions in Oklahoma requires a probabilistic monitoring approach. Probabilistic monitoring is the sampling of randomly selected lakes and stream sites. These sites throughout the state are selected at random by a computer program. Each waterbody has an equal probability or chance of being selected for monitoring. This approach is very similar to how public opinion polls are conducted for large groups of people where the data from a relatively small, representative, random sample are used to describe the characteristics of a much larger population

The goal of this program is to provide statistically sound, unbiased information on the health and condition of lakes, streams and rivers across Oklahoma. At each site, the following suite of parameters is collected to affectively assess the chemical and biological integrity of the stream or lake:

1. Water Chemistry: Water samples are taken from sampling sites and analyzed for variety parameters, such as nutrients, minerals, alkalinity, hardness, turbidity, chlorophyll-a, dissolved oxygen, pH, and specific conductivity.
2. Algal Collection: Samples are collected and analyzed for types and amounts of algae present in both the water column and on the bottom substrate in the case of streams, or just in the water column for lakes. Additionally, zooplankton samples are collected from lakes.
3. Macroinvertebrate collection: Aquatic macroinvertebrates are collected from various habitats within each stream reach. Macroinvertebrates are not collected in a lake setting.

Figure 14. OWRB staff assessing physical habitat

4. Fish Collection: Fish are collected from each stream reach using seines or electro-fishing equipment (if water conditions permit). All large fish and most easily identifiable fish will be released. At selected sites, some predator fish are kept for fish tissue analysis. Fish are not collected as part of the lakes probabilistic program. This component may be added in the future.

Figure 15. OWRB staff seining Stream

5. Physical Habitat Assessment: A visual habitat assessment is performed at each stream reach or lake site. A habitat assessment involves measuring and estimating several characteristics of the waterbody. For streams, things such as stream substrate composition, stream width and depth, canopy cover, bank vegetation, stream discharge, erosion and riparian condition are measured. For lakes littoral zone, presence of aquatic plants, substrate composition, drawdown etc. are measured.

Biocriteria Development: Biological Monitoring

Biocriteria, as referenced in the WQS (785:45-5-12(e)(5)(A)(1)), allows for comparison of environmental data to regional reference data from similar waters, using metrics that characterize community structure and relationships. This concept, that similar waters with similar habitats and ecological characteristics will contain similar aquatic communities, is a basic tenet of the biomonitoring approach. At its most basic level, it suggests that environmental alterations, whether chemical, physical or biological, will be manifest in the aquatic community. Quantification of these aquatic community differences drives biocriteria and is dependent upon the establishment of the "reference condition". Oklahoma's Conservation Commission (OCC), a contributing party to this process, developed project-specific "reference streams" under separate grant support based upon chemical and biological factors. Currently the OWRB uses both developed biocriteria for fish analysis, as well as the OCC's wadeable streams indices of biological integrity. Additionally, for benthic macroinvertebrates, the OWRB uses OCC IBI's.

Since 2002, Oklahoma has worked towards the systematic evaluation of their biological and water quality monitoring programs to support implementation of and any revisions to the state's biological criteria. An evaluation of the Oklahoma biological program was conducted April 2013 by Midwest Biodiversity Institute, Center for Applied Bioassessment and Biocriteria, under contract with EPA. The recommendations of the biological evaluation are as follows[i]:

1. Natural Variability–Modernizing the approach to account for regional variation and stratification in the classification of stream and riverine assemblages is needed.
2. Reference Site Selection–A quantitative stressor gradient approach is needed to screen reference sites with a primary reliance on abiotic factors. Developing the approach is necessary to address reference condition and support improvements in discriminatory power.
3. Reference Conditions–The sufficiency of reference site density across stream classes and waterbody types will need to be determined.
4. Ecological Attributes–Will require updating the fish and macroinvertebrate IBIs using contemporary approaches to metric and index development and calibration.
5. Discriminatory Capacity–Improving the discriminatory power is contingent on addressing natural variability, reference sites selection, reference condition, and ecological attributes.

One of the difficulties in setting protective biological criteria is the accurate determination of thresholds at which significant ecological changes are taking place. The Oklahoma biological program evaluation recommendations provide the critical framework to make these determinations and provide for future state revision and increased resolution of existing biological criteria.

In 2018, the state undertook a Regional Applied Research Effort (RARE) project with EPA Region 6 staff and EPA Scientists at the National Environmental Effects Research Laboratory to update both biological indices and reference condition for wadeable and non-wadeable streams. This project proposed the development of alternative biological criteria approaches and proof-of-concept for wadeable streams as outlined in the tasks identified. The proof-of-concept is intended to be deliberative and collaborative illustrating how multiple data sets and a variety of relevant information – such as the physical

environment (e.g. habitat and land use) and chemical characteristics – can be integrated and synthesized. The results of this project will create a roadmap for Oklahoma agencies by delineating a stepwise analytical process and identifying critical path decisions in the biological criteria development process for wadeable streams. This project is currently in its final stages, with a final report due in early summer 2020. Future work with the RARE program will included further refinement of wadeable streams to include more macroinvertebrate collection types and w a winter index period IBI, as well as extensive development of reference condition and IBI's for large wadeable and boatable rivers.

Harmful Algae Bloom (HAB) Monitoring

Figure 16. Algal Sample from Taylor-Marlow Lake

Many types of phytoplankton (algae) possess the ability to form dense mats or blooms. Sometimes the algal species composing a bloom are capable of releasing toxins into the aquatic environment. These types of events are referred to as Harmful Algal Blooms (HABs). Cyanobacteria, or blue-green algae, are a potentially bloom-forming group of phytoplankton commonly found in Oklahoma waters. Among these, cyanobacteria genera such as *Anabaena*, *Aphanizomenon*, *Cylindrospermopsis*, *Microcystis*, and *Oscillatoria* can produce hepatotoxins or neurotoxins that may be harmful or lethal to animals, including humans (Downing et al. 2001, Komarek 2003, Komarek et al. 2003). Cyanobacteria are also known to cause taste and odor problems in public drinking water supplies and have negative impacts on lake recreation industries (Komarek 2003, Smith 2001). Currently, there isn't a systematic program to routinely monitor lakes for possible HABs in Oklahoma. The Oklahoma Department of Environmental Quality works with municipalities to do monitoring on municipal water supply lakes and the United States Army Corps of Engineers (COE) work to monitor the COE lakes in Oklahoma. The Oklahoma Department of Tourism is responsible for issuing swimming advisories for the state of Oklahoma.

Water Well Mass Measurement Program

Groundwater level information collected as part of the state's water well measurement program is used to predict water use trends and future availability of Oklahoma's groundwater supplies. Water level data for selected aquifers pre-dates 1950. A state-wide network has been in place since the late 1970s. The OWRB and the USGS were partners in this endeavor from 1978 through around 1990. Data collected from this program supported several planning and management objectives, including determination of maximum annual yields of state groundwater basins, water budget estimations, and quantity or availability definition(s). Also, water well drilling firms, industry, water suppliers, and private well owners can obtain accurate information relative to target depths to drill water wells. Data from the program also helped track water level changes and identify areas experiencing groundwater depletion. Beginning in 2018, the historical Mass Measurement program was fully incorporated into the Groundwater Monitoring and Assessment Program (GMAP) permanent network. The GMAP water level network includes all major aquifers of the state, several minor aquifers studied during the baseline characterization period, and other minor aquifers which were not studied as part of GMAP but which have historical data through the Mass Measurement program. Measurement of those minor aquifers will continue under GMAP and data from those sites is included in the annual GMAP report.

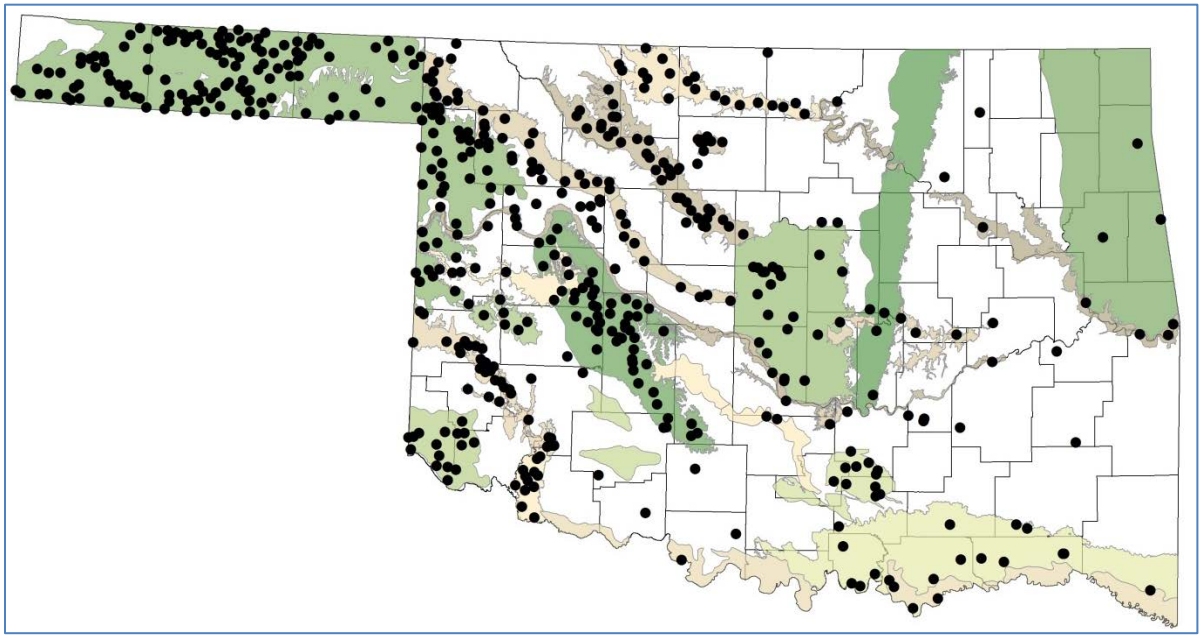

Figure 17. Historical Well Network for the Mass Measurement Program, Prior to GMAP implementation

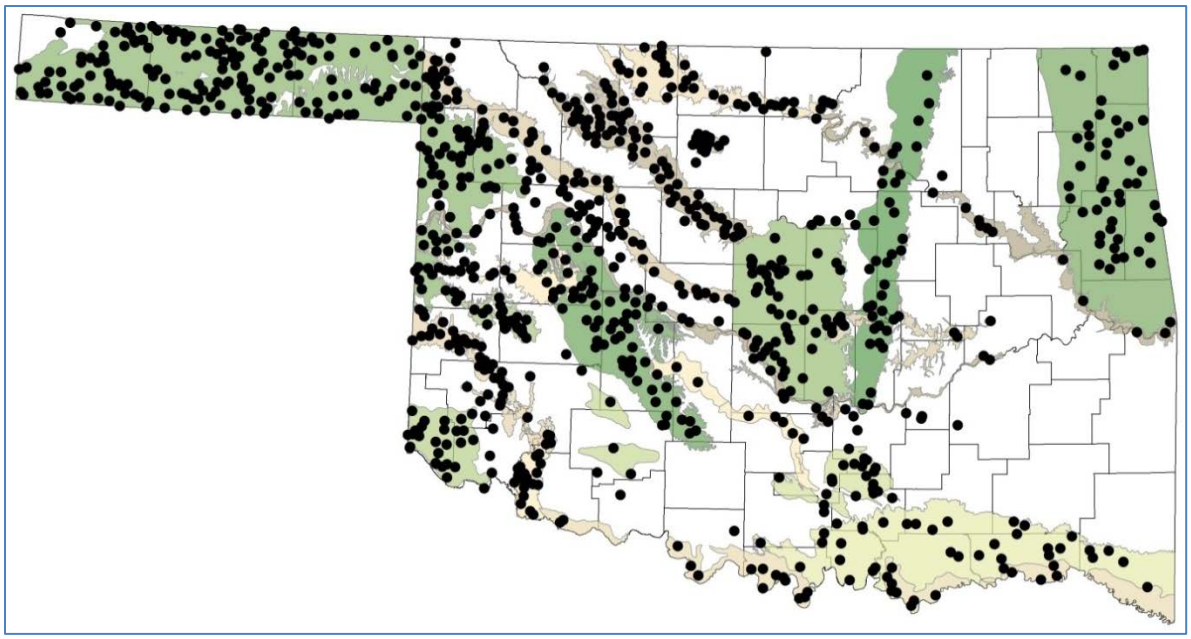

Figure 18. GMAP Network in 2018

Groundwater measurements combined with land surface elevation (determined by GPS) and base of aquifer depths (determined through well log analysis) can be used for point determinations of aquifer subsurface water level elevation and saturated thickness. In combination with a spatially distributed network of wells, mapping of aquifer saturated thickness, potentiometric surface (water table), groundwater flow direction and gradient can be generated. A groundwater level monitoring network also can be used to track changes in groundwater levels over time related to drought, seasonal variation and groundwater usage. With an expanded, spatially distributed network of wells, assessments of aquifer wide groundwater level changes will be possible. GMAP's new groundwater level network design will provide data that more comprehensively reflect the range of possible water level fluctuations in an aquifer through increased frequency of measurements and measurement periods that coincide with discharge (Spring-Summer) and recharge (Fall-Winter) intervals. More information on groundwater level monitoring can be found under the Groundwater Monitoring and Assessment Program section of this report.

Special Projects

Lake Arcadia

The OWRB, in cooperation with the Oklahoma Department of Environmental Quality (ODEQ), is conducting a pre-TMDL study on Lake Arcadia. Lake Arcadia is a 1,676-acre, hyper-eutrophic, urban lake in the City of Edmond, Oklahoma. Lake Arcadia appears on the 303(d) list for several impairments related to turbidity and chlorophyll-*a*; however, these impairments have not been definitively documented. The intent of this project is to collect water quality data to verify waterbody impairment in order to support TMDL development for the lake. Data collection is designed to assist in identifying the source(s) and extent of Lake Arcadia's impairments. The specific objectives are listed below:

- Establish if Lake Arcadia is currently meeting its assigned beneficial uses.
- Determine the extent of impairments to the waterbodies.
- Provide data for TMDL development in Lake Arcadia.
- Gather historical data (if available) to be used in Phase 1 of the TMDL process.
- Gather data to characterize the watershed and assist in TMDL development.

Lake Thunderbird

Lake Thunderbird is an important water supply lake that serves several metro communities and has suffered increasing eutrophication, due to nutrient loading. The OWRB has worked with the Central Oklahoma Master Conservancy District (COMCD) for 20 years to provide water quality monitoring and analysis, creating a long term dataset important for helping COMCD to make lake management decisions. Additionally, the OWRB provides the COMCD with data and assessment relevant to the super saturated dissolved oxygen system, the SDOX, to identify any direct effects on lake processes.

City of Norman TMDL Stormwater Monitoring Project

Lake Thunderbird has been identified as not attaining for its Fish and Wildlife Propagation beneficial use and Public and Private Water Supply beneficial use. These beneficial uses are impaired due to turbidity, dissolved oxygen, and chlorophyll-*a*. Since its inclusion on the state's 303(d) list, a Total Maximum Daily Load (TMDL) was required to enhance the water quality of the lake. In turn, the TMDL final report required the cities of Oklahoma City, Moore, and Norman to create a TMDL Compliance Plans in order to reduce the amount of pollutants entering the watershed. The City of Norman created a monitoring plan to determine trends and effectiveness of best management practices (BMPs) and to identify the main sources of pollutants flowing into Lake Thunderbird. Water collections, discharge measurements, sediment loadings, and nutrient loadings will be used to analyze these objectives.

National Lakes Assessment (NLA)

In 2017, the OWRB participated in the National Lakes Assessment (NLA), EPA's national survey on the condition of the Nation's lakes and reservoirs for the third time. The survey is designed to provide national and regional estimates of the condition of lakes. The survey is a collaborative effort between EPA, states, tribes, federal agencies, and other organizations. The OWRB completed the field portion of the survey in the summer of 2017. The NLA survey uses a probability-based sample design that results in statistically-valid estimates of condition to represent the population of lakes in their ecological region. Additionally, the OWRB and state partners from across the U.S. participate in the design, planning, and field assessment of the NLA. Consistent field assessment procedure ensures the results can be compared across the country. The OWRB conducted surveys on 32 lakes statewide during the summer of 2017. Once complete, and in concert with similar surveys on the Nation's coastal waters, wadeable streams, rivers, and wetlands, the NLA will inform decision-makers on how to better protect, maintain, and restore water-quality to the Nation's aquatic resources. The NLA report should be available in 2021.

National Rivers and Streams Assessment (NRSA)

In 2018/19, the OWRB participated in the National Rivers and Streams Assessment (NRSA), EPA's national survey on the condition of the Nation's rivers and streams for the second time. The survey is designed to provide information on the ecological condition of the nation's rivers and streams and the key stressors that affect them, both on a national and an ecoregional scale. The survey is a collaborative effort between EPA, states, tribes, federal agencies, and other organizations. The OWRB completed the field portion of the survey over the summers of 2018 and 2019. The NRSA survey uses a probability-based sample design that results in statistically-valid estimates of condition to represent the population of rivers and streams in their ecological region. Consistent field assessment procedure ensures the results can be compared across the country. The OWRB conducted surveys on 50 rivers and streams statewide during the two summers. Once complete, and in concert with similar surveys on the Nation's coastal waters, lakes, and wetlands, the NRSA will inform decision-makers on how to better protect, maintain, and restore water-quality to the Nation's aquatic resources. The NRSA report should be available in 2020.

Nutrient Stressor Response in Reservoirs

The USEPA Nutrient Scientific Technical Exchanger Partnership Support (NSTEPS) program was engaged in 2016 by OWRB to provide supporting technical analysis of lake nutrient and nutrient enrichment response data. This technical analysis aligns with OWRB's ongoing efforts to advance water management focused on beneficial use protection from the effects of nutrient pollution. The objective of these projects is to support the development of water quality thresholds that can serve as translators for existing narrative nutrient criteria and be applied in various water quality programs to protect or restore lake and reservoir designated uses. Working in collaboration, EPA NSTEPS conducted a series of meetings with OWRB staff to understand existing programs, goals, outline a conceptual model of nutrient pollution effects on Oklahoma lakes, coordinate data transfer, develop an analysis plan based on the available data, and held regular meetings throughout the data analysis process to receive feedback on progress.

A Phase 1 project was completed in 2018. The objective of the analysis was to explore nutrient stressor response relationships in Oklahoma lakes to support development of numeric thresholds for chlorophyll and nutrients. The data to be used for this analysis were compiled under a related NSTEPS analysis task and included Oklahoma's extensive lakes water quality dataset. Intended outcomes of this work included an analysis of the relationship of chlorophyll to dissolved oxygen, nuisance algal density/phytoplankton composition, and other potential assessment endpoints in these reservoirs to provide analyses to support selection of protective chlorophyll a concentration targets, and also to analyze nutrient – chlorophyll response yield curves to support selection of protective TN and TP concentrations consistent with chlorophyll *a* targets. The analyses developed were in support of the OWRB nutrient analysis effort and are only one component of a broader effort, which may include other lines of evidence including but not limited to other stressor-response analyses, literature review, reference based analysis, and mechanistic modeling. Several conclusions were developed from the Phase 1 project, including:

1. Oklahoma has an impressive lakes water quality data set, with more than 10,000 paired nutrient chlorophyll values, over 10,000 lake profiles, and hundreds of planktonic samples.
2. Nutrient chlorophyll yield curve models for Oklahoma lakes are significant and relatively precise.
3. Oklahoma lakes differ from east to west. Some of this difference will be explored in Phase 2.
4. Chlorophyll targets to protect dissolved oxygen, nuisance taxa, and zooplankton can be identified.

The Phase 1 report is available at the OWRB website or by request. In 2019, the OWRB began collaborating with the N-STEPS program on Phase 2 of this project to further explore conclusions from Phase 1 and broaden the original project to include other analyses. This project is still ongoing.

In 2018, another project began with the N-STEPS program to use satellite-based estimates of cyanobacterial abundance to protect lake designated uses in Oklahoma. Satellite remote sensing of lake biological properties has the potential to create greater awareness and a deeper understanding of the biogeochemical processes that link nutrient pollution to designated use impacts. The broad temporal and spatial resolution offered by satellite-based imagery expands current ambient surface water quality observations and offers complimentary data that can enhance existing empirical models (e.g., reference models, stressor-response models). This project seeks to relate satellite-based estimates of cyanobacterial abundance from EPA ORD's newly generated data sets derived from MERIS and Sentinel satellite sensors with surface water quality data acquired by the OWRB monitoring program. To date,

the project research has explored the use of satellite-based measures of cyanobacteria (bluegreen algae) bloom frequency in supporting analyses to set protective thresholds. Stressor–response models have been developed to relate algal bloom frequency, chlorophyll, and nutrients. Hinge-point analysis and summary statistics have been used to characterize existing water quality concentrations. Finally, an algal bloom model used to estimate long-term algal bloom frequency for smaller lakes is being developed. The project is nearing completion, and a final report should be available soon.

These projects have been a collaboration between the USEPA N-STEPS program, USEPA Office of Science and Technology, USEPA Region 6, Lead Scientists with TetraTech, and the OWRB. These projects are ongoing efforts to use Oklahoma's valuable monitoring data to protect our vital natural resources for water supply, recreation, and fisheries beneficial uses.

Wetlands: Riverine and Oxbow Wetland Hydrogeographic and Biogeochemical Study

This project is a cross-discipline, high resolution monitoring effort designed to assess the hydrological, biogeochemical and structural functioning of two wetland types (riverine and oxbow lakes), under a range of stress conditions, at the local, landscape and wider watershed scales. This will develop a baseline of hydrologic, biogeochemical and biological functioning against which other assessment methods can be compared. This data will be used to implement the Oklahoma Wetland Program Plan (WPP), by advancing four of its five core elements; 1) Monitoring and Assessment, 2) Voluntary Restoration And Protection, 3) Water Quality Standards, 4) Education and Outreach and to help development of the Muscogee (Creek) Nation **(**MCN) WPP. The high resolution hydrologic data will also allow the calculation of groundwater recharge and the conversion of biogeochemical nutrient data into nutrient cycling rates. Quantification of water availability (and potential shortages) to wetlands under varying climatic conditions will be possible. An attempt will be made to use the state's surface water allocation model (used to support water rights decisions) to demonstrate the maintenance of baseflow by wetlands from wet to dry periods.

Wetlands: Lacustrine Wetlands: Refining identification in NWI through modern dataset mapping analysis and risk-stressor assessment

This project is a multi-disciplinary approach with two distinct components. The first is aimed towards updating and increasing the accuracy of the National Wetlands Inventory (NWI) by using current remote sensing datasets and determination of gain or loss of lacustrine and palustrine wetlands.

A key outcome of this project will be an enhanced/current map of lacustrine wetlands adjacent to a subset of gauged reservoirs in Oklahoma including areal determination and Cowardin classification. Current extent of lacustrine and palustrine wetlands will be more accurately identified using the available NWI dataset, near-infrared and RGB National Agriculture Imagery Program (NAIP) imagery, and additional data sources, such as LiDAR and NRCS soil surveys, resulting in an updated map of those lacustrine wetlands adjacent to gauged reservoirs. The second component is the assessment of risk to these wetlands utilizing a mostly desk-based, detailed study of abiotic and biotic broad scale stressors including hydrological impacts to inundation frequency/duration. Maps of inundation frequency/duration will be combined with soil property data measured during field verification to explore relationships of hydrology to sediment properties. These relationships, as well as other factors, including potential for vegetation growth and adjacent stream influence, will be used to indicate where wetland creation could be successful.

Data Management - Ambient Water Quality Monitoring System (AWQMS).

OWRB has received two large grants from the EPA's National Environmental Information Exchange Network program to work with other states and tribes to make enhancements to the Ambient Water Quality Monitoring System (AWQMS). This system is an advanced environmental database capable of not only storing environmental data from all media, but also interacting seamlessly with the national EPA and USGS environmental databases. The project will allow the system to be customized to meet the State's evolving data management and reporting needs; ODEQ and OCC are vital partners ensuring this process is successful. This will allow AWQMS to function as an advanced water quality assessment and reporting tool, easing much of the time consuming work involved in processes such as 303(d) assessments and TMDL tracking. In addition, this project will provide the ability to automate IBI calculations, improve ATTAINS needs, streamline the water quality public portal, and investigate mobile app utilities for data collection.

OWRB and United States Geological Survey (USGS) Cooperative Program

Purpose of the Cooperative Program

[1]The USGS operates and maintains an extensive stream monitoring network for multiple purposes. The stream flow monitoring network is used for forecasting flood events, for determining base flow, for calculating pollutant loadings (based upon flow data), and the USGS also conducts routine water quality monitoring at numerous stations across the state. The USGS has a very extensive historical record on many streams across the state. The existence of this historical record is very useful in the management of Oklahoma's water resources and the continuation of the network in its present form should be preserved if possible.

The USGS stream flow monitoring program provides hydrologic information needed to help define, use, and manage the state's water resources. The program provides a continuous, well-documented, well-archived, unbiased, and broad-based source of reliable and consistent water data. Because of the nationally consistent, prescribed standards by which the data are collected and processed, the data from individual stations are commonly used for purposes beyond the original purpose for an individual station. Those possible uses include, but are not limited to:

- Characterizing current water-quality conditions
- Providing data for forecasting and managing floods
- Monitoring compliance with minimum flow requirements
- Setting permit requirements for discharge of treated wastewater
- Delineating and managing flood plains
- Magnitude and frequency of floods and droughts
- Operating and designing multipurpose reservoirs
- Designing, operating, and maintaining navigation and recreational facilities

[1] Much of the language for this section was taken from several USGS publications, including "Cooperative Water Program – A Partnership in the Nation's Water-Resources Program" by Bruce E. Taggart and "Description of the Cooperative Water Program". The content has been synthesized down and modified to address Oklahoma specific issues.

- Allocating water for municipal, industrial, and irrigation uses
- Administering compacts or resolving conflicts on interstate rivers
- Undertaking scientific studies of long-term changes in the hydrologic-cycle

Data for one or more of these purposes are needed at some point in time on virtually every stream in the country, and a data-collection system must be in place to provide the required information. The general objective of the stream flow monitoring program is to provide information on stream-flow characteristics at any point on any stream. Stream-flow data are needed for immediate decision making and future planning and planning and project design. Data, such as that needed to issue and update flood or drought forecasts are referred to as "data for current needs". Other data, such as needed for the design of a future bridge or reservoir, are referred to as "data for future or long-term needs". Some data, of course, fit into both classifications; a station that supplies data for flood forecasting also can provide data to define long-term trends, clearly fits both classifications.

In addition to the extensive USGS flow monitoring network, the OCC, OWRB and DEQ conduct routine flow monitoring on all water quality monitoring sites or sites monitored for TMDL purposes they sample that are not monitored for flow by the USGS. This ensures that flow data is available for all monitoring conducted by the listed agencies to determine beneficial use support has the required flow information to assess support status. Please refer to the appropriate agencies QAPP or SOP documents for a detailed discussion of how flow is determined.

Description of the Program

As the primary Federal science agency for water-resource information, the USGS monitors the quantity and quality of water in the Nation's rivers and aquifers, assesses the sources and fate of contaminants in aquatic systems, develops tools to improve the application of hydrologic information, and ensures that its information and tools are available to all potential users. This broad, diverse mission cannot be accomplished effectively without the contributions of the Cooperative Water (Coop) Program. For more than 100 years, the Coop Program has been a highly successful cost-sharing partnership between the USGS and water-resource agencies at the state, local, and tribal levels.

Most work in the Coop Program is directed toward potential and emerging long-term problems, such as water supply, waste disposal, and ground-water quality, effects of agricultural chemicals, floods, droughts, and environmental protection. Standardized methods are used so that study results are transferable to similar problems in other areas and contribute to issues that have interstate, regional, or international significance. Data collected by USGS and the results of its studies are accepted by parties on both sides of disputes and furnish the basis required for interstate and international compacts, Federal law and court decrees, congressionally mandated studies, regional and national water-resources assessments, and planning activities.

The jointly planned and funded Coop Program provides assurance that the information needed to meet national and local needs will be produced and shared. Because rivers and aquifers cross jurisdictional lines, studies and data collected in one county or one state have great value in adjacent counties or states.

Program priorities are developed in response to mutual federal, regional, state, and local requirements. Thus, the USGS and cooperating agencies work together in a continuing process that leads to

adjustments in the program each year. These cooperators include state, county, municipal and tribal agencies. Through the pooling of support, the OWRB and USGS are able to conduct studies that lead to an improved understanding of Oklahoma's water resources to the mutual benefit of all levels of government--at substantial financial savings to any one agency.

Within the Coop Program funds are used to support data-collection activities and interpretive studies. To maximize the usefulness of hydrologic data and the results of interpretive studies, the USGS compiles and analyzes information resulting from these activities into regional and national synthesis products using modest amounts of funding from other USGS programs.

Data-Collection Activities

All water quality and quantity management decisions depend heavily on the state/USGS Cooperative Program for flow and water quality data. The stream-flow gaging-station network for Oklahoma is critical for the growth and development of the state's water resources. Data recorded and analyzed from this network of stream-flow gages provides the information needed to help define, use and manage the state's water resources. This program provides a continuous, well-documented, well-archived, unbiased, and broad-based source of reliable and consistent water data.

The USGS provides current ("real-time") stream stage and streamflow, water-quality, and ground-water levels for approximately 200 sites in Oklahoma. Some of the gages in the program have existed for almost 100 year. Data from these gages are used to make informed water management decisions that balance resource utilization and ecological integrity. Unfortunately, the long-term sustainability of many of these gages is in jeopardy due to continued funding pressures.

In addition, the Coop Program supports collection of data on surface-water quality, which is becoming increasingly important to the states as they monitor TMDLs, to comply with the requirements of the Clean Water Act.

All these data provide resource managers with the information they need to determine the suitability of water for various uses, identify trends in water quality, and evaluate the effects of various stresses on the Nation's ground-water and surface-water resources. Much of the data collected at USGS monitoring sites is provided free of charge on the internet to all interested parties via the USGS National Water Information System. This includes historical data, as well as real-time data, which are generally less than four hours old. The real-time data are used routinely by emergency management agencies, state and municipal agencies, businesses, and recreational boaters and fishers.

Most of the USGS data-collection stations serve multiple purposes and many are funded, wholly or in part, through cooperative agreements. Normally, these stations, though funded by various organizations, are operated as part of an integrated network rather than as stand-alone entities. For this reason, cooperating organizations are billed on the basis of AVERAGE station cost, rather than ACTUAL cost, which rarely can be precisely known. This procedure benefits these organizations and the USGS in at least two ways: administrative costs are reduced because financial transactions are simplified, and definitive cost information is available to all parties for planning purposes at the beginning of the fiscal year. This arrangement also assures that data collection in remote areas or areas which may be otherwise problematic during a given period of time (due to vandals, extreme flooding, lightning strikes, etc.) do not become so expensive that they must be dropped from the network.

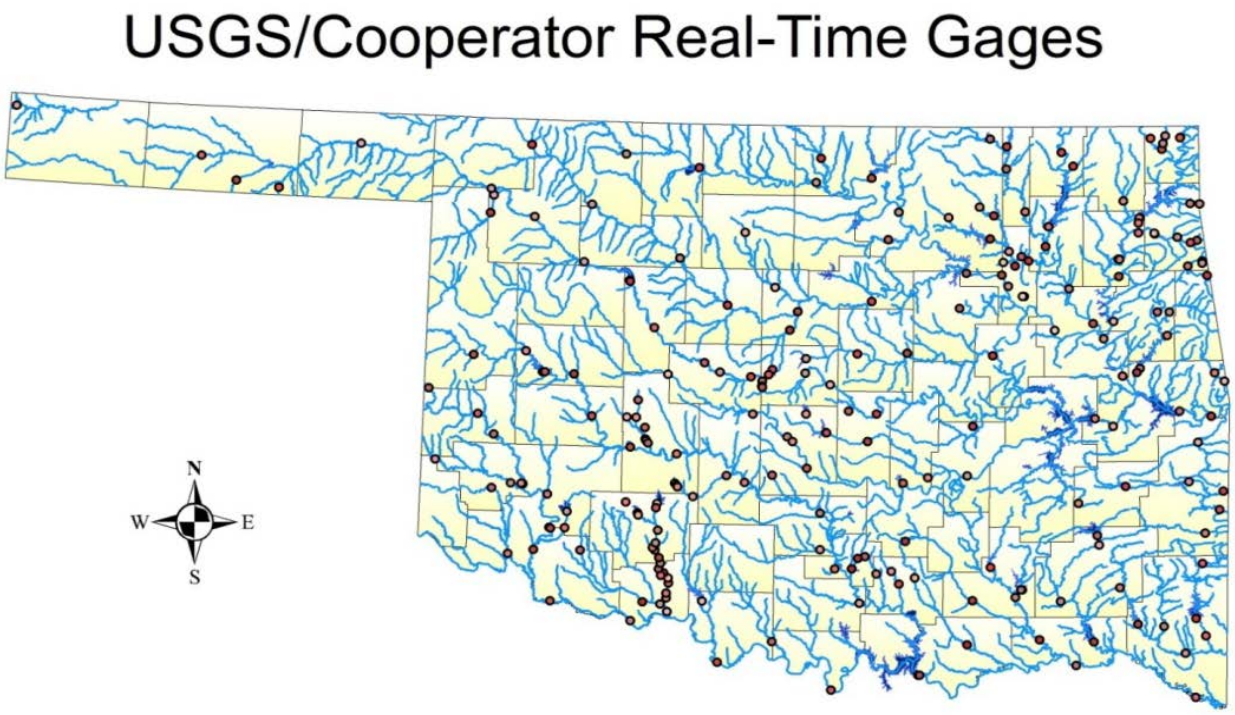

Figure 19. USGS Cooperator Gages

Increasingly, the Nation's water resources are vital to the long-term health of its citizens and the stability of its economy. These resources – rivers, lakes, and aquifers – supply drinking water, support industries, transport products, and provide recreational opportunities. Management of these resources is a complex task involving all levels of government and a multitude of laws, regulations, and competing interests. USGS employees use nationally consistent procedures and quality-assurance protocols in conducting cooperative projects. These standards ensure that all data from the Cooperative Water Program are directly comparable from one region to another and available from USGS databases for use by citizens, public officials, industry, and scientists nationwide. The state of Oklahoma also conducts stream gaging as well and the OWRB uses procedures and protocols consistent with the USGS. Agencies, or "Cooperators," that participate in the Coop Program are primarily state, tribal, county, and municipal agencies with water-resources management and policy responsibilities.

The network is funded through the financial support of multiple partners, e.g., cities, water conservancy districts, master conservancy, river commissions, local, state and federal agencies, and tribes. This inter-related funding arrangement between agencies makes any partner's shortfall crippling to the network. Funding for long-term stream-flow data-collection gages is critical to the future of Oklahoma, emphasizing the critical nature of communicating and coordinating the Coop Program among all data users.

While the costs to collect manage and report the data continue to rise - federal dollars continue to shrink. Several cooperators have stepped up and contributed monies to the program to help maintain a core network of gages in Oklahoma through funding gages of specific interest to them. Even so, funding for this program as a whole falls short of that necessary to the support the program.

Oklahoma Department of Environmental Quality

Total Maximum Daily Loading (TMDL) Studies

Section 303(d) of the CWA requires that waters of the state that are not currently achieving the beneficial use classification contained in the OWQS, after implementation of prescribed technology-based controls has been shown to be inadequate, be listed on the state's "303(d) list." As a result of this listing the CWA also requires that a TMDL be established for each pollutant category (cause) for each listed water. A TMDL, simply stated, is the maximum amount of a specific pollutant that a waterbody can assimilate and still meet numeric and narrative water quality criteria. Development of a TMDL consists generally of five activities:

1. Selection of pollutant(s) or stressor(s) to be considered. This is generally derived from the listed cause(s) on the 303(d) list.
2. Establishing water quality targets; typically water quality targets are tied to water quality standards which apply to the study stream.
3. Analysis and estimation of the pollutants from all sources both point and non-point.
4. Estimation of the waterbody's assimilative capacity.
5. Establishing the allowable loads for point, non-point sources and margin of safety.

In order to complete a TMDL for a listed water, reliable water quality data are necessary to establish both the current and allowable pollutant loading. This may require additional water quality monitoring to be conducted as historical water quality data may be very limited.

Objectives

- To obtain reliable water quality information on each waterbody selected for study via the priority-ranked 303(d) list.
- To develop a TMDL that will ensure the quality of listed waters will be protective of its designated beneficial use(s).

Program Description

An initial site inspection is performed before initiation of data collection activities to address environmental and logistical problems likely to be encountered at the site. The problem to be addressed can be clearly identified at this stage, and relevant parameters determined. The prime objective of the initial site inspection is to collect as much information as possible about the site and the surrounding area that might impact the site. Any information that will help in better understanding the system being studied is considered. Other state agencies are notified, if necessary, depending on the nature of the individual project. Stream and lake data gathered through the OWRB's BUMP program and the Oklahoma Conservation Commission's Rotating Basin Monitoring Program are critical resources. In addition, local councils of government (COG), such as INCOG in the Tulsa area and ACOG in the Oklahoma City area, may participate in TMDL monitoring and analysis activities.

Monitoring Requirements

Time of travel studies are conducted at the site to determine flow rates and velocities. Routine sampling is conducted at each monitoring location to determine a base flow condition. Routine sampling for most parameters is generally performed on a monthly basis. More intensive, short –term studies for dissolved oxygen problems may also be performed. Sampling in such cases is performed two to four times in a 24-hour period, the total sampling period lasting 24 hours. The parametric coverage includes the constituents causing the impairment of the waterbody's beneficial use(s) and grab samples for flow, dissolved oxygen, temperature, pH and specific conductivity. Composite samples are generally collected for the 24-hour period from any storm drains or tributaries known or seen to be discharging. Other parameters, including inorganics, organics and/or heavy metals, may require special sampling consideration. Habitat modification may also require assessment. Wet weather sampling is conducted after storm events, as necessary, to quantify the non-point source contribution to the waterbody's impairment. Parametric coverage is generally the same as for base flow monitoring.

Monitoring Locations

Site-specific sampling plans are developed jointly by the field personnel and the engineer responsible for modeling. Sample sites, by necessity, are selected considering accessibility to the sites, significance of data, and anything else gleaned from the initial site inspection that may be relevant to the outcome of the study. Sampling plans are developed which include the proposed sites and the analyses to be conducted for each site.

Data Evaluation

The monitoring data collected is evaluated to determine the waterbody's assimilative capacity and the pollution load from all sources, both point and non-point.

Actions Taken or Prescribed

The allowable daily pollutant load is determined through water quality modeling. Once the TMDL has been established, the pollutant load is allocated between point sources, non-point sources, and future growth, after applying a margin of safety. Compliance with TMDL allocations will allow the waterbody to meet applicable water quality criteria.

Time Lines

TMDL studies are an ongoing process dictated by the priority-ranked 303(d) list. Duration of monitoring is project-specific and is generally determined by project logistics and availability of historical data.

Mercury in Fish Program

Mercury is a potent neurotoxin that accumulates in the muscle tissue of fish. Over time common exposure sources of mercury such as thermometers, thermostats, and light switches have been removed from general circulation. Today, 99 percent of most U.S. residents exposure to mercury comes through the consumption of commercial and locally-caught fish.

In 2005 ODEQ lowered the level at which advisories are issued due to mercury levels in fish. This was done in response to changes in risk assessment values made by EPA. With the lowering of the advisory level it was determined that data was not sufficient to evaluate the safety of eating fish from Oklahoma's lakes.

In 2008, a screening level assessment of predator fish mercury concentrations in Oklahoma lakes was initiated with the cooperation of the Oklahoma Department of Wildlife Conservation (ODWC). The screening level assessment was followed in 2009 by intensive sampling at lakes that had fish with higher levels of mercury in the initial assessment. As a result, consumption advisories were issued at 16 lakes in 2010.

The Mercury in Fish program has expanded and evolved over time to include evaluation of 94 lakes. In addition, all gamefish species are now targeted during the initial collection instead of using a screening process focusing first on predator species. This has led to the issuance of consumption advisories at 63 lakes. Lakes are targeted for sampling every 5 years to determine if mercury levels have changed over time and to adjust advisories based on recent data.

Program Objectives

The overall objective is to protect public health by evaluating levels of mercury in fish in Oklahoma reservoirs and, when necessary, issue fish consumption advisories to the public in cooperation with other state agencies.

PROGRAM DESCRIPTION

Samples of available game-fish species are collected from Oklahoma lakes and analyzed for total mercury. Data is evaluated and compared to risk –based thresholds designed to protect public health.

If mercury levels exceed advisory thresholds, a consumption advisory is issued to inform the public which species and lengths of fish are unsafe to eat in unlimited amounts. Since eating uncontaminated fish provides many desirable health benefits, the public is also informed which species and lengths are safe to consume. The public is encouraged to make smart, informed decisions about the fish they choose to eat and feed their families.

MONITORING REQUIREMENTS

Sample Collection

Since the intent of the program is to measure toxics in fish flesh, any legal method of obtaining uncontaminated samples is acceptable. This includes gill nets, seines, trot line, electrofishing, rod and reel, and angler surveys. ODEQ generally uses electrofishing collection methods. ODEQ has a working agreement with the ODWC to assist with difficult to collect species and waterbodies.
The ODEQ supplements these collections, when necessary, with fish collected by rod and reel, gill net or seine.

Five to 8 individual fish of each species are collected. Fish should be of a size typically consumed by fishermen (this will vary by species). It is desired that fish collected represent the full range of consumable sizes available in a waterbody.

MONITORING LOCATIONS

Table 1 lists the lakes routinely sampled on a rotating basis and the number of monitoring sites for each listed lake.

DATA EVALUATION

Sample Analysis
Fish tissue samples are analyzed for mercury using analytical methods detailed in the SEL Quality Assurance Plan.

Modeling and Evaluation
Mercury levels in fish are generally correlated with length, i.e. the longer the fish the higher the mercury level. This concept is used to evaluate the data and determine species and lengths that may be unsafe to consume in unlimited quantities.

Data is sorted by lake and species. Plots with trend lines are generated that compare length vs. concentration for each species in each lake. The points at which the trend line crosses advisory threshold are noted. If the noted length of fish is within a typical consumable range, an advisory will be considered. If the data does not follow the typical length vs. concentration model, alternative methods are used to evaluate the data. This will be typically include using the mean or median value of each species.

ACTIONS TAKEN OR PRESCRIBED

Consumption Advisories
Consumption advisories may be issued for a particular species or a general category of fish, e.g.: predator species. Consumption advisories may also be issued within size ranges, e.g.: largemouth bass greater than 14” in length.

Consumption advisories are only issued after sufficient data indicates contaminant levels are above DEQ advisory thresholds. Selective sampling techniques are used to determine if only certain species or categories of fish are affected. Consumption advisories are issued in the consultation with ODWC and lake managers. In addition, other interested parties are notified and consulted before consumption advisories are issued. These may include other state and federal agencies, tribes, and municipalities.

Consumption advisories are rescinded only after sufficient data indicates contaminant levels that are below DEQ standards. Lakes will be evaluated with screening level samples every 5 to 7 years to determine if changes in mercury concentrations have occurred. Advisories are based on the most recent data with no advisory based on data more than 10 years old.

PROGRAM RESULTS

Currently there are 63 active consumption advisories for mercury in the State of Oklahoma:

Advisories due to mercury are in effect at:

- Arbuckle Lake
- Atoka Lake
- Arcadia Lake
- Birch
- Bixhoma Lake
- Boomer Lake
- Broken Bow Reservoir
- Canton Lake
- Lake Carl Albert
- Lake Carl Blackwell
- Carlton Lake
- Cedar Lake
- Clayton Lake
- Coalgate City Lake
- Copan Reservoir
- Cushing Lake
- Draper Lake
- Dripping Springs Lake
- El Reno Lake
- Elmer Thomas Lake
- Lake Eufaula
- Frederick City Lake
- Greenleaf Lake
- Lake Heyburn
- Holdenville Lake
- Hominy Lake
- Hugo Reservoir
- Hulah Reservoir
- Kaw Reservoir
- Lloyd Church Lake
- Lone Chimney Lake
- McAlester City Lake
- McGee Creek Reservoir
- Lake McMurtry
- Meeker Lake
- Lake Murray
- Nanih Waiya Lake
- Okemah City Lake
- Okmulgee City Lake
- Lake Ozzie Cobb
- Pawnee City Lake
- Ponca Lake
- Pine Creek Reservoir
- Prague Lake
- Quanah Parker Lake
- Rush Lake
- Sahoma Lake
- Sardis Lake
- Schooler Lake
- Shell lake
- Skiatook Lake
- Sportsman Lake
- Stillwell City Lake
- Stroud Lake
- Lake Talawanda #1
- Lake Talawanda #2
- Tom Steed Reservoir
- Waurika Lake
- Lake Wayne Wallace
- Wetumka Lake
- Wewoka Lake
- Wister Lake

DEQ has also issued a statewide advisory for mercury in Oklahoma lakes and streams that have not been sampled.

In addition, DEQ maintains advisories based other legacy pollutants:

- Catfish at Bitter Creek in Jackson County due to DDT and Toxaphene
- Several species in the Spring and Neosho Rivers and Grand Lake due to elevated levels of lead.

TIME LINES

Reservoirs are routinely screened for mercury every 5 to 7 years. Streams are sampled on a case-by-case basis at locations where contamination is known or suspected to exist. If sample results indicate elevated levels of contaminants, sampling frequency is usually increased to annual unless it is determined that contaminant sources are unlikely to change for an extended time.

Table 4. Waterbodies sampled as part of the Mercury in Fish Program

Lake	Sites	Next Scheduled	Lake	Sites	Next Scheduled
Arbuckle Lake	2	2020	Lake Lawtonka	2	2022
Arcadia Lake	1	2020	Lloyd Church Lake	1	2022
Atoka Reservoir	1	2020	Lone Chimney Lake	1	2022
Bell Cow Lake	1	2020	McAlester City Lake	1	2022
Birch Lake	1	2020	McGee Creek Reservoir	2	2022
Bixhoma Lake	1	2020	Lake McMurtry	1	2022
Boomer Lake	1	2020	Meeker Lake	1	2022
Broken Bow Reservoir	3	2020	Lake Murray	2	2022
Canton Lake	2	2020	Nanih Waiya Lake	1	2022
Carl Albert Lake	1	2020	New Spiro Lake	1	2022
Lake Carl Blackwell	2	2020	Okemah Lake	1	2023
Lake Carlton	1	2020	Okmulgee Lake	1	2023
Cedar Lake	1	2020	Lake Oolagah	3	2023
Chandler Lake	1	2020	Lake Overholser	1	2023
Clayton Lake	1	2020	Ozzie Cobb Lake	1	2023
Cleveland Lake	1	2020	Pawnee Lake	1	2023
Coalgate City Lake	1	2020	Pine Creek Reservoir	2	2023
Copan Reservoir	2	2020	Lake Ponca	1	2023
Cushing Lake	1	2020	Prague Lake	1	2023
Draper Lake	2	2021	Quanah Parker Lake	1	2023

Lake	Sites	Next Scheduled	Lake	Sites	Next Scheduled
Dripping Springs Lake	1	2021	R S Kerr Reservoir	3	2023
El Reno City Lake	1	2021	Lake Raymond Gary	1	2023
Lake Ellsworth	2	2021	Rush Lake	1	2023
Elmer Thomas Lake	1	2021	Lake Sahoma	1	2023
Eucha Lake	1	2021	Lake Sardis	3	2023
Lake Eufaula	5	2021	Schooler Lake	1	2023
Fort Cobb Lake	2	2021	Shawnee Twin Lakes	2	2023
Fort Gibson Reservoir	3	2021	Shell Lake	1	2023
Fort Supply Reservoir	1	2021	Skiatook Lake	3	2024
Foss Reservoir	2	2021	Sooner Lake	1	2024
Frederick Lake	1	2021	Lake Spavinaw	1	2024
Lake Fuqua	1	2021	Sportsman Lake	1	2024
Grand Lake	3	2021	Stillwell City Lake	1	2024
Greenleaf Lake	1	2021	Stroud Lake	1	2024
Guthrie Lake	1	2021	Lake Talawanda # 1	1	2024
Lake Hefner	1	2022	Lake Talawanda # 2	1	2024
Heyburn Lake	1	2022	Lake Tenkiller	3	2024
Holdenville Lake	1	2022	Lake Texoma	3	2024
Hominy Lake	1	2022	Lake Thunderbird	2	2024
Lake Hudson	3	2022	Tom Steed Reservoir	2	2024
Lake Hugo	3	2022	W.D. Mayo Lake	1	2024
Lake Hulah	2	2022	Waurika Lake	3	2024
Lake Jean Nuestadt	1	2022	Lake Wayne Wallace	1	2024
Lake John Wells	1	2022	Wes Watkins Lake	1	2024
Kaw Reservoir	3	2022	Wetumka Lake	1	2024
Lake Keystone	3	2022	Wewoka Lake	1	2024
Lake Konawa	1	2022	Wister Lake	2	2024
			Zoo Lake	1	2024

Oklahoma Department of Agriculture, Food and Forestry

Licensed Managed Feeding Operations Monitoring Well Program

The Oklahoma Department of Agriculture, Food, and Forestry (ODAFF) has the sole statutory and regulatory authority over the operation and management of animal feeding operations in the state of Oklahoma. The swine industry's rapid growth through the early to mid-1990's led to increased concern regarding potential impacts to the groundwater and surface water resources from the waste generated at concentrated animal feeding operations (CAFOs). The passage of the Oklahoma Concentrated Animal Feeding Operations Act (Act) and the Swine Feeding Operations Act, effective August 1, 1998, led to significant changes in the state's approach to managing wastes generated and stored by swine operations in Oklahoma. Large swine producing facilities (i.e. CAFOs) were built by corporations across the state. Licensed Managed Feeding Operations (LMFOs) are defined as CAFOs that contain more than 1,000 animal units in roof-covered structures for 90 consecutive days or more in a 12-month period and use liquid waste management systems.

Key provisions of the Act include: 1) standards for liquid waste retention structures; 2) liner requirements (including annual inspections to ensure liner integrity) to retain liquid animal wastes; 3) establishment of a minimum separation (10 feet) between the bottom of the retention structure and the maximum historical groundwater elevation; 4) installation of a leak detection system or sufficient monitoring wells around the perimeter of each retention structure; and 5) collection of groundwater samples for comparison against established baseline data.

Numerous LMFOs in Oklahoma overlie groundwater regions characterized by their soil type, depth to water and permeability to have the very highest risk or vulnerability to land practices, which could impact the quality of the groundwater. To prevent contamination of groundwater from possible leaking LMFO lagoons, the Oklahoma CAFO Act and ODAFF rules have strict lagoon and liner construction criteria in place; however, even with proper lagoon construction, leakage from the lagoon to groundwater has the potential to occur. Therefore, the Act allows limited leakage from clay lined lagoons. The Oklahoma CAFO Act required all swine LMFOs licensed by ODAFF on or after August 1, 1998 to install a leak detection system or monitoring wells around the perimeter of each animal wastewater lagoon prior to lagoon operation and sampling of the monitoring wells at LMFOs at least annually. LMFO companies had a one-year grace period to install an ODAFF approved groundwater-monitoring system at their facilities.

The Act further states "samples of water shall be collected by the State Department of Agriculture and tested at least annually by a qualified environmental laboratory certified by the Department of Environmental Quality". Test results prior to operation of the facility would establish the baseline character of the groundwater for the facility. If no tests were conducted prior to the facilities operation, then the test results from the first year of sampling are considered the applicable baseline data (for older concentrated feeding operations).

The main goal of the monitoring program is to ascertain if groundwater at or near the LMFOs has degraded because of the operation of the facility and storage of the liquid animal wastes. A facility's baseline data serves as the reference point to potential change in groundwater quality over time. During each fiscal year since 1999, sampling and analysis of the LMFO monitoring wells has been conducted to determine if contamination by animal wastes could be detected.

Currently, the OWRB is the ODAFF contractor for this project. Uniform sampling procedures, documented in the QAPP, are used to ensure sample representativeness. A minimum of three well volumes are pumped/bailed from each monitoring well to purge stagnant water from the water column. Water quality parameters (i.e. pH, specific conductance, temperature and dissolved oxygen) are collected during bailing, and after pumping/bailing, to ensure that a stable representative sample of aquifer water is collected for analysis.

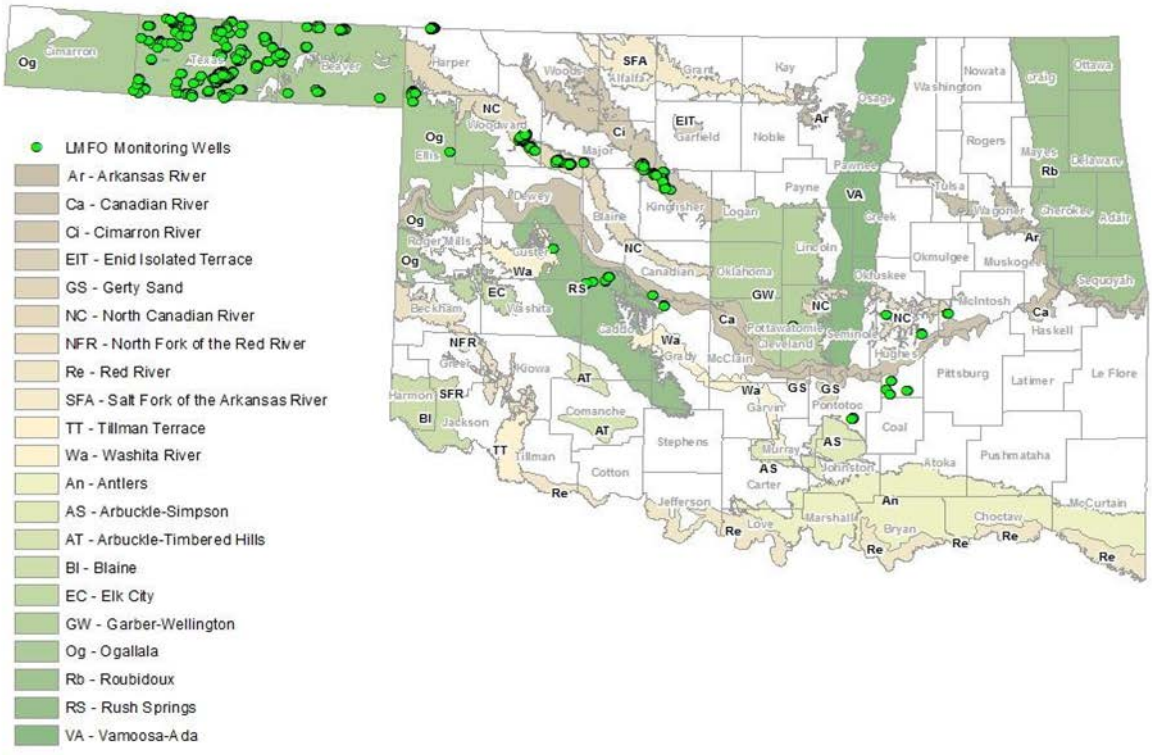

Figure 20. LMFO Monitoring Site Locations for 2016 - 2019

The data collected during each year's monitoring:

- Determines water characteristics from each water sample and will serve as indicators of stable ambient water prior to sample collection. The precision at which the parameters can be determined and reported are linked to the method of water extraction from the well.

- Determines nitrate and ammonia nitrogen, total phosphorus, specific conductivity, pH and fecal coliform bacteria content. The ODAFF Laboratory Services Division, Inorganic Section performs the analysis. They are certified to perform general water quality by the ODEQ through its laboratory certification program.

- Evaluates over time if the nitrates in the groundwater are increasing above 10 mg/L, which is the Safe Drinking Water Act contaminate level.

Each year, a Final Report is written by the ODAFF and OWRB that includes a comprehensive summary of all laboratory and field data results, an analysis of sampling protocols, ArcView GIS shape files that incorporate

location and attribute information for monitoring wells, an accounting of the total expenditures and a general overview with suggestions for possible additional remediation, corrective actions or future steps to be taken by ODAFF. Table 5 summarizes the LMFO monitoring well sample results from 2000 to the most recent data collected in 2019.Concerning Dry Wells and Frequency of Evaluation: Beginning in FY07, HB 3015 was enacted into law on July 1, 2006 and stipulated that the frequency of sampling/evaluating wells may be reduced to once every three years if they were found to be dry for at least three consecutive years. As a result of HB 3015, the total number of monitoring wells investigated and total number of reported dry wells is variable over time. The total number of wells that were dry for at least three consecutive years through July 1, 2006 were 493 leaving only 59 (493 + 59 = 552) to evaluate in 2007. After July 1, 2007, 40 of the 59 wells met the three-consecutive year dry status criteria leaving only 19 to evaluate in 2008. The 2009 monitoring period showed an even further drop to 11 wells. For the FY10 sample period, the initial 493 dry monitoring wells referenced above were reassessed to evaluate if any of these wells had recharged, in accordance with HB 3015. Only two out of 493 historically dry monitoring wells had sufficient amount(s) of recharge or column water to sample during the FY10 sample period. The number of dry wells assessed in FY11 through FY19 were 56, 34, 36, 512, 556, 570, 43, 256 and 7 wells, respectively.

Table 5. Monitoring Well Sampling Results, 2000 to 2019

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Monitoring Wells Investigated (includes sampled and dry wells)	810	779	930	1005	1088	1054	1060	575	560	562	1083	640	578	606	899	930	939	408	627	344
Wells Sampled	362	437	457	496	582	519	521	515	541	551	590	584	544	386	387	374	369	365	371	337
Dry Wells	448	342	473	509	506	535	552	59	19	11	493	56	34	36	512	556	570	43	256	7
Nitrate-nitrogen detections (≥0.02 mg/L)	328	425	442	482	495	485	506	497	529	526	528	515	530	373	378	355	359	363	365	353
Nitrate-nitrogen ≥10 mg/L (Includes 1st and re-sample events)	90	138	192	210	215	213	232	234	259	271	272	292	304	362	184	155	160	164	184	184
Nitrate-nitrogen < 0.02 mg/l												10	10	13	7	29	17	5	36	58
Ammonium-nitrogen detections (≥0.11 mg/L)	7	34	68	35	29	25	48	25	28	23	25	29	17	23	17	16	15	13	20	18
Ammonium-nitrogen ≥1 mg/L (Includes 1st and re-sample events)	3	17	16	8	12	10	12	7	6	10	7	6	10	11	4	5	5	6	6	6
Ammonium-nitrogen < 0.11 mg/L												375	389	363	368	345	360	159	381	394
Total Phosphorus detections (≥0.02 mg/L)	341	327	351	362	391	382	368	360	396	396	380	391	389	377	376	363	353	353	222	345
Total Phosphorous > 0.5 mg/L	35	33	75	85	130	76	71	78	72	78	91	155	132	178	134	166	140	170	68	130
Total Phosphorous < 0.02 mg/L												19	17	9	9	16	31	19	167	66
Wells with fecal coliform (FEC)	N/A	N/A	13	12	14	12	19	16	11	18	17	12	13	12	15	6	6	52	24	29
Wells ≥3 FEC colonies							11	8	7	15	9	7	7	6	9	3	5	34	5	17

Laboratory analytical detection limits for nitrate-nitrogen, ammonium-nitrogen and total phosphorous are 0.02, 0.11 and 0.02 mg/L respectively.

Oklahoma Corporation Commission

Types of Environmental Water Quality Monitoring:

The Corporation Commission (Corp. Comm.) does three types of surface water environmental monitoring:

1. Stream, pond, and spring sampling at Brownfields sites where there could be residual pollution because of the prior property use;

2. Stream, pond, and spring water sampling near obvious spills, purging wells, and other ongoing or catastrophic pollution sources to determine their impacts;

3. Stream, pond, and spring sampling around pits and producing locations where there have been allegations of pollution to determine the extent and possible sources;

4. Stream, pond, spring and other surface water sampling in historic oilfield areas to determine the overall impact of historical oilfield activity.

The Corp Comm. continues to perform and work with partners on general stream water quality and standards sampling. Currently, Corp Comm. maintains a GIS-based plan implemented by staff to sample streams in support of water quality decisions for the Integrated Report, including the 303(d) impaired stream listings.

Grand River Dam Authority

In 2004, the Grand River Dam Authority (GRDA) created the department of Ecosystems and Lake Management to act as stewards of the natural resources and waters of the Grand River. Upon Completion of the Water Quality Research Lab at the Ecosystems and Education Center in 2010, water quality monitoring has been a priority for GRDA. Partnerships forged with Oklahoma State University and the University of Oklahoma has led to graduate research on nutrient limitation of algae, internal phosphorus loading, heavy metals contamination and remediation, storm water runoff, and aerial drones. Partnerships with state agencies have led to improved oxygen conditions in the tailraces of GRDA hydroelectric facilities. Further research and cooperation is expected to aid GRDA in future management decisions to fulfill its mission as a conservation and reclamation district for the waters of the Grand River.

In 2019, GRDA extended the research partnerships with both the University of Oklahoma and Oklahoma State University to continue providing research opportunities for faculty and students, as well as quality research products to GRDA. To reflect on the hard work and knowledge gained from this partnership, GRDA produced its first 10 year partnership review titled "Ecosystems Explorations", which highlighted the research projects completed over the term of our first partnership period with all our research partners. This document can be found at https://www.grda.com/wp-content/uploads/2020/01/Ecosystems-Explorations-10-Year-Review-FINAL-12.16.2019-Spreads1.pdf.

Lake Monitoring

The water quality monitoring program was established in 2011 to monitor water conditions on GRDA Lakes. Data generated by this program will provide researchers with a comprehensive water quality database and can be used in future policy and lake management decisions. Furthermore, these data are used in real time to protect heath and public safety in the event of blue green algae blooms and bacteria issues.

Sampling of GRDA lakes occurs twice a month during the summer season (May-September) and once a month during the winter season (October-May). Water is collected from fifteen locations on Grand Lake, six locations on Lake Hudson, and one location on W.R. Holloway. Samples are tested for nitrogen and phosphorus species, bacteria, blue green algae, and various other physical and chemical parameters. The most recent data are displayed publicly on the GRDA website (https://www.grda.com/water-quality-advisory-map/) on the water quality map page.

Scenic Rivers Partnerships and Monitoring

On July 1, 2016, the GRDA inherited the duties and responsibilities of the, Oklahoma Scenic Rivers Commission (ORSC). To support this continued mission of ORSC, GRDA has formed a partnership with Northeastern State University (NSU) at Tahlequah to begin a monitoring and research program to support these priceless resources along with keeping previous commitments with partners agencies at the state and federal level. This program involves students at NSU via internships, research opportunities and scholarships to promote conservation and research of the Scenic Rivers and their watersheds including establishing a laboratory presence on campus.

Currently, GRDA is monitoring the Illinois River, Barren Fork River, Flint Creek, Lee Creek, Little Lee Creek, and the Mountain Fork River as part of its ongoing efforts to protect the Scenic Rivers. The monitoring program began in earnest in 2018 following the establishment of the NSU/GRDA Scenic Rivers and Watershed Research Laboratory. Through this partnership, students at NSU have been able to gain hands on experience sampling local streams around NSU as well as join GRDA personnel on sampling trips on the Scenic Rivers. As this

laboratory and program continues to develop, GRDA anticipates expanded sampling of the Scenic Rivers and their watersheds to include freshwater organisms such as macroinvertebrates and mussels. Finally, GRDA has been working with NSU to develop a freshwater sciences curriculum that will provide students at NSU with coursework and direction as they prepare themselves to work in water resources science and management.

Watershed Education and Outreach

GRDA has worked with Blue Thumb, Oklahoma Conservation Commission, OU Water Survey, and others to assist and provide educational opportunities for children, adults and professionals around both Grand Lake and the Illinois River. In 2019 GRDA secured an EPA Environmental Education grant to expand our outreach to the local Grand Lake watershed community. Through this, GRDA has been working with the OU Water Survey to develop 4th grade appropriate science modules focusing on watersheds and conservation. Furthermore, GRDA is offering workshops for teachers within the watershed to train on the module and other water quality topics. Attendees will be eligible for a grant to purchase educational supplies related to water education. Finally, GRDA will be providing workshops for business and homeowners around Grand Lake which will teach them methods they can use to limit runoff and help improve lake water quality.

Use Support Assessment Protocols

The Oklahoma Water Resources Board (OWRB) in conjunction with the various state environmental agencies has worked to develop use support assessment protocols (USAP) to ensure that agencies are making use support determinations based on comparable decision criteria. The most recently approved USAP language is included below. The USAP as it currently exists represents a significant step forward in the states monitoring initiatives and continued development and refinement of the protocols will result in the collection of quality data by all monitoring parties and will hopefully also serve as a template for the state's tribal programs to build upon.

The rules went through the public participation requirements associated with Oklahoma's OWQS setting process. The rule outlines how use support determinations are to be made and is utilized by all parties making use support determinations. Chapter 15 of the rule is the USAP[2]. Where the USAP is silent on a use support determination, then Oklahoma's Continuing Planning Process[3] (CPP) Document addresses the issue.

Quality Assurance/Quality Control Procedures

All data collected by the OWRB, OCC and ODEQ for beneficial use assessment purposes is covered by an EPA approved Quality Assurance Project Plan (QAPP). For detailed information on agency quality assurance and quality control procedures, please contact the appropriate agency for a copy of their QAPP documents and/or their Standard Operating Procedures (SOP) documents.

[2] To view the USAP language please select the hyperlink - http://www.owrb.ok.gov/rules/pdf/current/Ch46.pdf

[3] To view the 2012 CPP language please select the hyperlink - http://www.deq.state.ok.us/wqdnew/305b_303d/Final%20CPP.pdf

Appendix A – Oklahoma Environmental Agency Statutory Authorities

Oklahoma Statutes Citationized

Title 27A. Environment and Natural Resources

Chapter 1 - Oklahoma Environmental Quality Act

Article III - Jurisdiction of Environmental Agencies

Section 1-3-101 - Responsibilities and Jurisdiction of State Environmental Agencies

§ 1-3-101. Responsibilities and Jurisdiction of State Environmental Agencies

A. The provisions of this section specify the jurisdictional areas of responsibility for each state environmental agency and state agencies with limited environmental responsibility. The jurisdictional areas of environmental responsibility specified in this section shall be in addition to those otherwise provided by law and assigned to the specific state environmental agency; provided that any rule, interagency agreement or executive order enacted or entered into prior to the effective date of this section which conflicts with the assignment of jurisdictional environmental responsibilities specified by this section is hereby superseded. The provisions of this subsection shall not nullify any financial obligation arising from services rendered pursuant to any interagency agreement or executive order entered into prior to July 1, 1993, nor nullify any obligations or agreements with private persons or parties entered into with any state environmental agency before July 1, 1993.

B. Department of Environmental Quality. The Department of Environmental Quality shall have the following jurisdictional areas of environmental responsibility:

1. All point source discharges of pollutants and storm water to waters of the state which originate from municipal, industrial, commercial, mining, transportation and utilities, construction, trade, real estate and finance, services, public administration, manufacturing and other sources, facilities and activities, except as provided in subsections D and E of this section;

2. All nonpoint source discharges and pollution except as provided in subsections D, E and F of this section;

3. Technical lead agency for point source, nonpoint source and storm water pollution control programs funded under Section 106 of the federal Clean Water Act, for areas within the Department's jurisdiction as provided in this subsection;

4. Surface water and groundwater quality and protection and water quality certifications;

5. Waterworks and wastewater works operator certification;

6. Public and private water supplies;

7. Underground injection control pursuant to the federal Safe Drinking Water Act and 40 CFR Parts 144 through 148, except for Class II injection wells, Class V injection wells utilized in the remediation of groundwater associated with underground or aboveground storage tanks regulated by the Corporation Commission, and those wells used for the recovery, injection or disposal of mineral brines as defined in the Oklahoma Brine Development Act regulated by the Commission;

8. Air quality under the federal Clean Air Act and applicable state law, except for indoor air quality and asbestos as regulated for worker safety by the federal Occupational Safety and Health Act and by Chapter 11 of Title 40 of the Oklahoma Statutes;

9. Hazardous waste and solid waste, including industrial, commercial and municipal waste;

10. Superfund responsibilities of the state under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 and amendments thereto, except the planning requirements of Title III of the Superfund Amendment and Reauthorization Act of 1986;

11. Radioactive waste and all regulatory activities for the use of atomic energy and sources of radiation except for the use of sources of radiation by diagnostic x-ray facilities;

12. Water, waste, and wastewater treatment systems including, but not limited to, septic tanks or other public or private waste disposal systems;

13. Emergency response as specified by law;

14. Environmental laboratory services and laboratory certification;

15. Hazardous substances other than branding, package and labeling requirements;

16. Freshwater wellhead protection;

17. Groundwater protection for activities subject to the jurisdictional areas of environmental responsibility of the Department;

18. Utilization and enforcement of Oklahoma Water Quality Standards and implementation documents;

19. Environmental regulation of any entity or activity, and the prevention, control and abatement of any pollution, not subject to the specific statutory authority of another state environmental agency;

20. Development and maintenance of a computerized information system relating to water quality pursuant to Section 1-4-107 of this title; and

21. Development and promulgation of a Water Quality Standards Implementation Plan pursuant to Section 1-1-202 of this title for its jurisdictional area of environmental responsibility.

C. Oklahoma Water Resources Board. The Oklahoma Water Resources Board shall have the following jurisdictional areas of environmental responsibility:

1. Water quantity including, but not limited to, water rights, surface water and underground water, planning, and interstate stream compacts;

2. Weather modification;

3. Dam safety;

4. Flood plain management;

5. State water/wastewater loans and grants revolving fund and other related financial aid programs;

6. Administration of the federal State Revolving Fund Program including, but not limited to, making application for and receiving capitalization grant awards, wastewater prioritization for funding, technical project reviews, environmental review process, and financial review and administration;

7. Water well drillers/pump installers licensing;

8. Technical lead agency for clean lakes eligible for funding under Section 314 of the federal Clean Water Act or other applicable sections of the federal Clean Water Act or other subsequent state and federal clean lakes programs; administration of a state program for assessing, monitoring, studying and restoring Oklahoma lakes with administration to include, but not be limited to, receipt and expenditure of funds from federal, state and private sources for clean lakes and implementation of a volunteer monitoring program to assess and monitor state water resources, provided such funds from federal Clean Water Act sources are administered and disbursed by the Office of the Secretary of Environment;

9. Statewide water quality standards and their accompanying use support assessment protocols, anti-degradation policy and implementation, and policies generally affecting Oklahoma Water Quality Standards application and implementation including but not limited to mixing zones, low flows and variances or any modification or change thereof pursuant to Section 1085.30 of Title 82 of the Oklahoma Statutes;

10. Groundwater protection for activities subject to the jurisdictional areas of environmental responsibility of the Board;

11. Development and promulgation of a Water Quality Standards Implementation Plan pursuant to Section 1-1-202 of this title for its jurisdictional area of environmental responsibility;

12. Development of classifications and identification of permitted uses of groundwater, in recognized water rights, and associated groundwater recharge areas;

13. Establishment and implementation of a statewide beneficial use monitoring program for waters of the state in coordination with the other state environmental agencies;

14. Coordination with other state environmental agencies and other public entities of water resource investigations conducted by the federal United States Geological Survey for water quality and quantity monitoring in the state; and

15. Development and submission of a report concerning the status of water quality monitoring in this state pursuant to Section 1-1-202 of this title.

D. Oklahoma Department of Agriculture, Food, and Forestry. 1. The Oklahoma Department of Agriculture, Food, and Forestry shall have the following jurisdictional areas of environmental responsibility except as provided in paragraph 2 of this subsection:

a. point source discharges and nonpoint source runoff from agricultural crop production, agricultural services, livestock production, silviculture, feed yards, livestock markets and animal waste,

b. pesticide control,

c. forestry and nurseries,

d. fertilizer,

e. facilities which store grain, feed, seed, fertilizer and agricultural chemicals,

f. dairy waste and wastewater associated with milk production facilities,

g. groundwater protection for activities subject to the jurisdictional areas of environmental responsibility of the Department,

h. utilization and enforcement of Oklahoma Water Quality Standards and implementation documents,

i. development and promulgation of a Water Quality Standards Implementation Plan pursuant to Section 1-1-202 of this title for its jurisdictional areas of environmental responsibility, and

j. storm water discharges for activities subject to the jurisdictional areas of environmental responsibility of the Department.

2. In addition to the jurisdictional areas of environmental responsibility specified in subsection B of this section, the Department of Environmental Quality shall have environmental jurisdiction over:

a. (1) commercial manufacturers of fertilizers, grain and feed products, and chemicals, and over manufacturing of food and kindred products, tobacco, paper, lumber, wood, textile mill and other agricultural products,

(2) slaughterhouses, but not including feedlots at these facilities, and

(3) aquaculture and fish hatcheries,

including, but not limited to, discharges of pollutants and storm water to waters of the state, surface impoundments and land application of wastes and sludge, and other pollution originating at these facilities, and

b. facilities which store grain, feed, seed, fertilizer, and agricultural chemicals that are required by federal NPDES regulations to obtain a permit for storm water discharges shall only be subject to the jurisdiction of the Department of Environmental Quality with respect to such storm water discharges.

E. Corporation Commission. 1. The Corporation Commission is hereby vested with exclusive jurisdiction, power and authority, and it shall be its duty to promulgate and enforce rules, and issue and enforce orders governing and regulating:

a. the conservation of oil and gas,

b. field operations for geologic and geophysical exploration for oil, gas and brine, including seismic survey wells, stratigraphic test wells and core test wells,

c. the exploration, drilling, development, producing or processing for oil and gas on the lease site,

d. the exploration, drilling, development, production and operation of wells used in connection with the recovery, injection or disposal of mineral brines,

e. reclaiming facilities only for the processing of salt water, crude oil, natural gas condensate and tank bottoms or basic sediment from crude oil tanks, pipelines, pits and equipment associated with the exploration, drilling, development, producing or transportation of oil or gas,

f. underground injection control pursuant to the federal Safe Drinking Water Act and 40 CFR Parts 144 through 148, of Class II injection wells, Class V injection wells utilized in the remediation of groundwater associated with underground or aboveground storage tanks regulated by the Commission, and those wells used for the recovery, injection or disposal of mineral brines as defined in the Oklahoma Brine Development Act. Any substance that the United States Environmental Protection Agency allows to be injected into a Class II well may continue to be so injected,

g. tank farms for storage of crude oil and petroleum products which are located outside the boundaries of refineries, petrochemical manufacturing plants, natural gas liquid extraction plants, or other facilities which are subject to the jurisdiction of the Department of Environmental Quality with regard to point source discharges,

h. the construction and operation of pipelines and associated rights-of-way, equipment, facilities or buildings used in the transportation of oil, gas, petroleum, petroleum products, anhydrous ammonia or mineral brine, or in the treatment of oil, gas or mineral brine during the course of transportation but not including line pipes in any:

(1) natural gas liquids extraction plant,

(2) refinery,

(3) reclaiming facility other than for those specified within subparagraph e of this subsection,

(4) mineral brine processing plant, and

(5) petrochemical manufacturing plant,

i. the handling, transportation, storage and disposition of saltwater, mineral brines, waste oil and other deleterious substances produced from or obtained or used in connection with the drilling, development, producing and operating of oil and gas wells, at:

(1) any facility or activity specifically listed in paragraphs 1 and 2 of this subsection as being subject to the jurisdiction of the Commission, and

(2) other oil and gas extraction facilities and activities,

j. spills of deleterious substances associated with facilities and activities specified in paragraph 1 of this subsection or associated with other oil and gas extraction facilities and activities,

k. subsurface storage of oil, natural gas and liquefied petroleum gas in geologic strata,

l. groundwater protection for activities subject to the jurisdictional areas of environmental responsibility of the Commission,

m. utilization and enforcement of Oklahoma Water Quality Standards and implementation documents, and

n. development and promulgation of a Water Quality Standards Implementation Plan pursuant to Section 1-1-202 of this title for its jurisdictional areas of environmental responsibility.

2. The exclusive jurisdiction, power and authority of the Commission shall also extend to the construction, operation, maintenance, site remediation, closure and abandonment of the facilities and activities described in paragraph 1 of this subsection.

3. When a deleterious substance from a Commission-regulated facility or activity enters a point source discharge of pollutants or storm water from a facility or activity regulated by the Department of Environmental Quality, the Department shall have sole jurisdiction over the point source discharge of the commingled pollutants and storm water from the two facilities or activities insofar as Department-regulated facilities and activities are concerned.

4. For purposes of the federal Clean Water Act, any facility or activity which is subject to the jurisdiction of the Commission pursuant to paragraph 1 of this subsection and any other oil and gas extraction facility or activity which requires a permit for the discharge of a pollutant or storm water to waters of the United States shall be subject to the direct jurisdiction of the federal Environmental Protection Agency and shall not be required to be permitted by the Department of Environmental Quality or the Commission for such discharge.

5. The Commission shall have jurisdiction over:

a. underground storage tanks that contain antifreeze, motor oil, motor fuel, gasoline, kerosene, diesel, or aviation fuel and that are not located at refineries or at the upstream or intermediate shipment points of pipeline operations, including, but not limited to, tanks from which these materials are dispensed into vehicles, or tanks used in wholesale or bulk distribution activities, as well as leaks from pumps, hoses, dispensers, and other ancillary equipment associated with the tanks, whether above the ground or below; provided, that any point source discharge of a pollutant to waters of the United States during site remediation or the off-site disposal of contaminated soil, media, or debris shall be regulated by the Department of Environmental Quality,

b. aboveground storage tanks that contain antifreeze, motor oil, motor fuel, gasoline, kerosene, diesel, or aviation fuel and that are not located at refineries or at the upstream or intermediate shipment points of pipeline operations, including, but not limited to, tanks from which these materials are dispensed into vehicles, or tanks used in wholesale or bulk distribution activities, as well as leaks from pumps, hoses, dispensers, and other ancillary equipment associated with the tanks, whether above the ground or below; provided, that any point source discharge of a pollutant to waters of the United States during site remediation or the off-site disposal of contaminated soil, media, or debris shall be regulated by the Department of Environmental Quality, and

c. the Petroleum Storage Tank Release Environmental Cleanup Indemnity Fund, the Oklahoma Petroleum Storage Tank Release Indemnity Program, and the Oklahoma Leaking Underground Storage Tank Trust Fund.

6. The Department of Environmental Quality shall have sole jurisdiction to regulate the transportation, discharge or release of deleterious substances or solid or hazardous waste or other pollutants from rolling stock and rail facilities.

7. The Department of Environmental Quality shall have sole environmental jurisdiction for point and nonpoint source discharges of pollutants and storm water to waters of the state from:

a. refineries, petrochemical manufacturing plants and natural gas liquid extraction plants,

b. manufacturing of equipment and products related to oil and gas,

c. bulk terminals, aboveground and underground storage tanks not subject to the jurisdiction of the Commission pursuant to this subsection, and

d. other facilities, activities and sources not subject to the jurisdiction of the Commission or the Oklahoma Department of Agriculture, Food, and Forestry as specified by this section.

8. The Department of Environmental Quality shall have sole environmental jurisdiction to regulate air emissions from all facilities and sources subject to operating permit requirements under Title V of the federal Clean Air Act as amended.

F. Oklahoma Conservation Commission. The Oklahoma Conservation Commission shall have the following jurisdictional areas of environmental responsibility:

1. Soil conservation, erosion control and nonpoint source management except as otherwise provided by law;

2. Monitoring, evaluation and assessment of waters to determine the condition of streams and rivers being impacted by nonpoint source pollution. In carrying out this area of responsibility, the Oklahoma Conservation Commission shall serve as the technical lead agency for nonpoint source categories as defined in Section 319 of the federal Clean Water Act or other subsequent federal or state nonpoint source programs, except for activities related to industrial and municipal storm water or as otherwise provided by state law;

3. Wetlands strategy;

4. Abandoned mine reclamation;

5. Cost-share program for land use activities;

6. Assessment and conservation plan development and implementation in watersheds of clean lakes, as specified by law;

7. Complaint data management;

8. Coordination of environmental and natural resources education;

9. Federal upstream flood control program;

10. Groundwater protection for activities subject to the jurisdictional areas of environmental responsibility of the Commission;

11. Development and promulgation of a Water Quality Standards Implementation Plan pursuant to Section 1-1-202 of this title for its jurisdictional areas of environmental responsibility; and

12. Utilization of Oklahoma Water Quality Standards and Implementation documents.

G. Department of Mines. The Department of Mines shall have the following jurisdictional areas of environmental responsibility:

1. Mining regulation;

2. Mining reclamation of active mines;

3. Groundwater protection for activities subject to the jurisdictional areas of environmental responsibility of the Commission; and

4. Development and promulgation of a Water Quality Standards Implementation Plan pursuant to Section 1-1-202 of this title for its jurisdictional areas of responsibility.

H. Department of Wildlife Conservation. The Department of Wildlife Conservation shall have the following jurisdictional areas of environmental responsibilities:

1. Investigating wildlife kills;

2. Wildlife protection and seeking wildlife damage claims; and

3. Development and promulgation of a Water Quality Standards Implementation Plan pursuant to Section 1-1-202 of this title for its jurisdictional areas of environmental responsibility.

I. Department of Public Safety. The Department of Public Safety shall have the following jurisdictional areas of environmental responsibilities:

1. Hazardous waste, substances and material transportation inspections as authorized by the Hazardous Materials Transportation Act; and

2. Inspection and audit activities of hazardous waste and materials carriers and handlers as authorized by the Hazardous Materials Transportation Act.

J. Department of Labor. The Department of Labor shall have the following jurisdictional areas of environmental responsibility:

1. Regulation of asbestos in the workplace pursuant to Chapter 11 of Title 40 of the Oklahoma Statutes;

2. Asbestos monitoring in public and private buildings; and

3. Indoor air quality as regulated under the authority of the Oklahoma Occupational Health and Safety Standards Act, except for those indoor air quality issues specifically authorized to be regulated by another agency.

Such programs shall be a function of the Department's occupational safety and health jurisdiction.

K. Oklahoma Department of Emergency Management. The Oklahoma Department of Emergency Management shall have the following jurisdictional areas of environmental responsibilities:

1. Coordination of all emergency resources and activities relating to threats to citizens' lives and property pursuant to the Oklahoma Emergency Resources Management Act of 1967;

2. Administer and enforce the planning requirements of Title III of the Superfund Amendments and Reauthorization Act of 1986 and develop such other emergency operations plans that will enable the state to prepare for, respond to, recover from and mitigate potential environmental emergencies and disasters pursuant to the Oklahoma Hazardous Materials Planning and Notification Act;

3. Administer and conduct periodic exercises of emergency operations plans provided for in this subsection pursuant to the Oklahoma Emergency Resources Management Act of 1967;

4. Administer and facilitate hazardous materials training for state and local emergency planners and first responders pursuant to the Oklahoma Emergency Resources Management Act of 1967; and

5. Maintain a computerized emergency information system allowing state and local access to information regarding hazardous materials' location, quantity and potential threat.

Historical Data

Added by Laws 1992, HB 2227, c. 398, § 6, emerg. eff. July 1, 1993; Amended by Laws 1993, HB 1002, c. 145, § 11, emerg. eff. July 1, 1993; Renumbered from 27A O.S. § 6 by Laws 1993, HB 1002, c. 145, § 359, emerg. eff. July 1, 1993; Amended by Laws 1993, SB 361, c. 324, § 6, emerg. eff. July 1, 1993; Amended by Laws 1994, HB 1916, c. 140, § 24, eff. September 1, 1994; Amended by Laws 1997, SB 365, c. 217, § 1, emerg. eff. July 1, 1997 (superseded document available); Amended by Laws 1999, SB 549, c. 413. § 4, eff. November 1, 1999 (superseded document available); Amended by Laws 2000, SB 1223, c. 364, § 1, emerg. eff. June 6, 2000 (superseded document available); Amended by Laws 2002, HB 2302, c. 397, § 1, eff. November 1, 2002 (superseded document available); Amended by Laws 2004, SB 1204, c. 100, § 2, emerg. eff. July 1, 2004; Amended by Laws 2004, HB 2616, c. 430, § 11, emerg. eff. June 4, 2004 (superseded document available).

[i] Oklahoma Biological Assessment. Midwest Biodiversity Institute, Center for Applied Bioassessment and Biocriteria. April 2014.