Water Quality In Oklahoma

2016 Integrated Report

Prepared Pursuant to Section 303(d) and Section 305(b) of the Clean Water Act

by

Oklahoma Department of Environmental Quality

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Acronyms and Definitions

Agencies

ODAFF	Oklahoma Department of Agriculture Food and Forestry
OCC	Oklahoma Conservation Commission
Corporation Commission	Oklahoma Corporation Commission
OSDH	Oklahoma State Department of Health
OSE	Office of the Oklahoma Secretary of Energy & Environment
DEQ	Oklahoma Department of Environmental Quality
OWRB	Oklahoma Water Resources Board
Wildlife Department	Oklahoma Department of Wildlife Conservation

Terminologies

303(d)	This section of the Clean Water Act requires each state to identify waters that do not or are not expected to meet applicable Water Quality Standards with technology-based controls alone. States are required to establish a priority ranking for the waters, taking into account the pollution severity and designated uses of the waters. Once identification and priority ranking are completed, states are to develop Total Maximum Daily Loads at a level necessary to achieve the applicable state Water Quality Standards.
304(l)	This section of the Clean Water Act requires each state to identify those waters that fail to meet Water Quality Standards due to toxic pollutants and other sources of toxicity. It also requires the preparation of individual control strategies that will reduce point source discharges of toxic pollutants.
305(b)	This section of the Clean Water Act requires each state to report its water quality on a biennial cycle.
314	This section of the Clean Water Act requires each state to establish a Lake Water Quality Assessment Report. This section provides federal funds for each state to submit a classification of lakes according to trophic condition, develop processes and methods to control sources of pollution and to work with other agencies in restoring the quality of those lakes. Section 314 establishes the guidelines for conducting Clean Lake Studies Phase I and II.
319(h)	This section of the Clean Water Act requires each state to develop a State Assessment Report and a Management Program for Nonpoint Source pollution problems. The Assessment Report is to describe the nature, extent, and effects of Nonpoint Source pollution, the causes and sources of such pollution, and programs and methods used for controlling this pollution.

BMPs Best Management Practices: A technique that is determined to be the most effective, practical means of preventing or reducing pollutants from nonpoint sources in order to achieve water quality goals.

BOD_5 Biochemical Oxygen Demand (5-Day): The oxygen used in meeting the metabolic needs of aerobic microorganisms in water rich in organic matter -- called also biological oxygen demand; the test requires five days of laboratory time and results may vary when toxic substances are present which effect bacteria.

$CBOD_5$ Carbonaceous Biochemical Oxygen Demand (5-Day): That portion of the BOD that is not due to oxidation of nitrogenous compounds.

CTSI Carlson's Trophic State Index (CTSI = 9.81 ln[chl-α] + 30.6).

CWA Clean Water Act: Public Law 92-500 enacted in 1972 provides for a comprehensive program of water pollution control; two goals are proclaimed in this Act: (1) to achieve swimmable, fishable waters wherever attainable by July 1, 1983, and (2) by 1985 eliminate the discharge of pollutants into navigable waters.

DDT Dichlorodiphenyltrichloroethane: A colorless odorless water-insoluble crystalline insecticide $C_{14}H_9Cl_5$ that tends to accumulate in ecosystems and has toxic effects on many vertebrates.

DO Dissolved Oxygen: The amount of oxygen dissolved in water. DO concentrations range from a few parts per million up to about 10 ppm for most Oklahoma streams. A level of DO around 7 ppm is essential to sustain desired species of game fish. If DO drops below 5 ppm the danger of a fish kill is present and malodorous conditions will result. The major factors determining DO levels in water are temperature, atmospheric pressure, plant photosynthesis, rate of aeration and the presence of oxygen demanding substances such as organic wastes. In addition to its effect on aquatic life, DO also prevents the chemical reduction and subsequent movement of iron and manganese from the sediments and thereby reduces the cost of water treatment.

µg/L Microgram/liter.

NPDES National Pollutant Discharge Elimination System: A permit program established by Section 402 of the Clean Water Act. This program regulates discharges into the nation's water from point sources, including municipal, industrial, commercial and certain agricultural sources.

NTU Nephelometric Turbidity Units: The measurement of the extent or degree of cloudiness by means of a nephelometer (an instrument for determining the concentration or particle size of suspensions by means of transmitted or reflected light).

OKWBID Oklahoma Waterbody Identification number: A unique identifier assigned to each waterbody in Oklahoma. For a complete description of OKWBIDs, please see Appendix A.

PCB(s) Polychlorinated Biphenyl(s): Any of several compounds that are produced by replacing hydrogen atoms in biphenyl with chlorine, have various industrial applications, and are poisonous environmental pollutants which tend to accumulate in animal tissues.

pH The negative logarithm of the effective hydrogen ion concentration or hydrogen-ion activity in gram equivalents per liter used in expressing both acidity and alkalinity on a scale whose values run from 0 to 14 with 7 representing neutrality, numbers less

	than 7 increasing acidity, and numbers greater than 7 increasing alkalinity.
Playa Lakes / Prairie Potholes	Shallow, small, ephemeral to permanent closed basin lake, typically found in high plains and deserts.
TDS	Total Dissolved Solids: The complete amount of solid matter dissolved in water or wastewater.
TMDL	Total Maximum Daily Load: The sum of individual wasteload allocations for point sources, safety, reserves, and loads from nonpoint source and natural backgrounds.
WLA	Wasteload Allocation: The assignment of target loads to point sources so as to achieve Water Quality Standards in the most efficient manner. The wasteload allocation is designed to allocate or allow certain quantities, rates or concentration of pollutants discharged from contributing point sources which empty their effluent into the same river segment. The purpose of the wasteload allocation is to eliminate an undue "wasteload burden" on a given stream segment.
WQS	Water Quality Standards: rules which establish classifications of uses of waters of the State, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters. The purpose of the Standards is to promote and protect as many beneficial uses as are attainable and to assure that degradation of existing quality of waters of the State does not occur. These rules can be found at OAC 785:45.

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Executive Summary/Overview

Clean Water Act (CWA) Section 303(d) Requirements

The 1972 amendments to the Clean Water Act include Section 303(d). The regulations implementing Section 303(d) require states to develop lists of water bodies that do not meet Water Quality Standards and to submit updated lists to the U. S. Environmental Protection Agency (EPA) every two years. Water quality standards, as defined in the Code of Federal Regulations, include beneficial uses, water quality objectives (narrative and numerical) and anti-degradation requirements. The EPA is required to review impaired water body lists submitted by each state and approve or disapprove all or part of the list.

For waterbodies on the 303(d) list, the Clean Water Act requires that a pollutant load reduction plan or TMDL be developed to correct each cause of impairment. TMDLs must document the nature of the water quality impairment, determine the maximum amount of a pollutant which can be discharged and still meet standards, and identify allowable loads from the contributing sources. The elements of a TMDL include a problem statement, description of the desired future condition (numeric target), pollutant source analysis, load allocations, description of how allocations relate to meeting targets, and margin of safety.

CWA Section 305(b) Requirements

The 1972 amendments to the Clean Water Act also include Section 305(b). The regulations implementing Section 305(b) require states to develop an inventory of the water quality of all water bodies in the state and to submit an updated report to the EPA every two years. This process was established as a means for the EPA and the U. S. Congress to determine the status of the nation's waters.

The 305(b) Report also includes: an analysis of the extent to which water bodies comply with the "fishable/swimmable" goal of the CWA; an analysis of the extent to which the elimination of the discharge of pollutants and a level of water quality achieving the "fishable/swimmable" goal have been or will be attained, with recommendations of additional actions necessary to achieve this goal; an estimate of a) the environmental impact, b) the economic and social costs, c) the economic and social benefits, and d) the estimated date of such achievement; and finally, a description of the nature and extent of nonpoint sources of pollutants, and recommendations of programs needed to control them- including an estimate of the costs of implementing such programs.

Integrated Report Guidance

The US Environmental Protection Agency (EPA) issued guidance (EPA, 2005) for the development of an Integrated Water Quality Monitoring and Assessment Report (Integrated Report) by the states. This guidance recommends that states integrate their Water Quality Inventory Report (Section 305(b) of the CWA) and their Impaired Waterbodies List (Section 303(d) of the CWA). The Integrated Report is intended to provide an effective tool for maintaining high quality waters and improving the quality of waters that do not attain Water Quality Standards. The Integrated Report will also provide water resources managers and citizens with detailed information regarding the following:

- Delineation of water quality assessment units providing geographic display of assessment results
- Progress toward achieving comprehensive assessment of all waters
- Water quality standards attainment status
- Methods used to assess Water Quality Standards attainment status
- Additional monitoring needs and schedules
- Pollutants and watersheds requiring Total Maximum Daily Loads (TMDLs)
- Pollutants and watersheds requiring alternative pollution control measures
- Management strategies (including TMDLs) under development to attain Water Quality Standards
- TMDL development schedules

The Integrated Report will streamline water quality reporting since data sources and assessment methods will be described in detail, providing a sound technical basis for assessment decisions. Assessment results will also be conveyed in a spatial context, allowing a clearer picture of water quality status and issues. Monitoring needs and

schedules will be described, facilitating the articulation of monitoring priorities and identifying opportunities for cooperation with other agencies and watershed partners. TMDL needs and schedules will be defined to convey plans for water quality improvements. The public participation aspects will provide opportunities for data submittal and open discussion of water quality assessment methods and results.

The Integrated Report combines the non-regulatory requirements of the Water Quality Inventory Report (305b) with regulation driven List of Impaired Waterbodies (303d) (i.e., only the latter mandates TMDL development). Successful integration into a single report requires a careful meshing of requirements and procedures. In general, Category 5 of the Integrated Report satisfies EPA reporting requirements under Section 303d (Impaired Waterbodies) and combined with the remaining Categories document assessment under Section 305b (Water Quality Inventory). Therefore, the regulatory requirements (i.e., EPA approval and adoption; public participation, etc.) for 303d impaired waterbodies listing only apply to Category 5 of the Integrated Report.

The methods used to develop the 2016 Integrated Report (and subsequent Reports) are described in the Continuing Planning Process (CPP). One goal of the CPP is to provide an objective and scientifically sound waterbody assessment listing methodology including:

- A description of the data that the State will use to assess attainment of surface Water Quality Standards
- The quality assurance aspects of the data
- A detailed description of the methods used to evaluate Water Quality Standards attainment
- The placement of waterbodies in one of 5 Categories:

Category 1 **- Attaining the water quality standard and no use is threatened.**

Waterbodies listed in this category are characterized by data and information that meet the requirements of the CPP to support a determination that the water quality standard is attained and no use is threatened. Consideration will be given to scheduling these waterbodies for future monitoring to determine if the water quality standard continues to be attained.

Category 2 **- Attaining some of the designated uses; no use is threatened; and insufficient or no data and information is available to determine if the remaining uses are attained or threatened.**

Waterbodies listed in this category are characterized by data and information which meet the requirements of the CPP to support a determination that some, but not all, uses are attained and none are threatened. Attainment status of the remaining uses is unknown because there is insufficient or no data or information. Monitoring shall be scheduled for these waterbodies to determine if the uses previously found to be in attainment remain in attainment, and to determine the attainment status of those uses for which data and information was previously insufficient to make a determination.

Category 3 **- Insufficient or no data and information to determine if any designated use is attained.**

Waterbodies are listed in this category when the data or information to support an attainment determination for any use is not available, consistent with the requirements of the CPP. To assess the attainment status of these waterbodies, supplementary data and information shall be obtained, or monitoring shall be scheduled as needed.

Category 4 **- Impaired or threatened for one or more designated uses but does not require the development of a TMDL.**

4A - TMDL has been completed.
Waterbodies are listed in this subcategory once all TMDL(s) have been developed and approved by EPA that, when implemented, are expected to result in full attainment of the standard. Where more than one pollutant is associated with the impairment of a waterbody, the waterbody will remain in Category 5 until all TMDLs for each pollutant have been completed and approved by EPA. Monitoring shall be scheduled for these waterbodies to verify that the water quality standard is met when the water quality management actions needed to achieve all TMDLs are implemented.

4B - Other pollution control requirements are reasonably expected to result in the attainment of the water quality standard in the near future.
Consistent with the regulation under 130.7(b)(i),(ii), and (iii), waterbodies are listed in this subcategory when other pollution control requirements required by local, state, or federal authority are stringent enough to implement any water quality standard (WQS) applicable to such waters. These requirements must be specifically applicable to the particular water quality problem. Monitoring shall be scheduled for these waterbodies to verify that the water quality standard is attained as expected.

4C - Impairment is not caused by a pollutant.
Waterbodies are listed in this subcategory if the impairment is not caused by a pollutant. Scheduling of these waterbodies for monitoring to confirm that there continues to be no pollutant-caused impairment and to support water quality management actions necessary to address the cause(s) of the impairment, shall be considered.

Category 5 **- The water quality standard is not attained. The waterbody is impaired or threatened for one or more designated uses by a pollutant(s), and requires a TMDL.**

This category constitutes the Section 303(d) list of waters impaired or threatened by a pollutant(s) for which one or more TMDL(s) are needed. A waterbody is listed in this category if it is determined, in accordance with the CPP, that a pollutant has caused, is suspected of causing, or is projected to cause an impairment. Where more than one pollutant is associated with the impairment of a single waterbody, the waterbody will remain in Category 5 until TMDLs for all pollutants have been completed and approved by EPA. For waterbodies listed in this category, monitoring schedules shall be provided that describe when data and information will be collected to support TMDL establishment and to determine if the standard is attained. While the waterbody is being monitored for a specific pollutant to develop a TMDL, the watershed shall also be monitored to assess the attainment status of other uses. A schedule for the establishment of TMDLs for all waters in Category 5 shall be submitted. This schedule shall reflect the priority ranking of the listed waters. Category 5 waterbodies are further divided into the following subcategories:

5A – TMDL is underway or will be scheduled.

5B – A review of the Water Quality Standards will be conducted before a TMDL is scheduled.

5C – Additional data and information will be collected before a TMDL or review of the Water Quality Standards is scheduled.

The CPP will provide a companion to the 2016 Integrated Report. It is anticipated that this will be a living document and will be modified, as appropriate, to accompany subsequent Integrated Reports.

Oklahoma's comprehensive waterbody category list is available in Appendix B. Impaired waterbodies (Category 4 & 5) can be viewed exclusively in Appendix C.

Synopsis

During the 2015/2016 reporting cycle, there were a total of 4,212 waterbodies delineated into the Oklahoma Assessment Database (ADB). These waters include approximately 621,051 lake acres, and 33,016 river and stream miles, of which approximately 517 miles form the border with the State of Texas.

The water quality data used in this report was collected by the Oklahoma Conservation Commission (OCC), Oklahoma Department of Environmental Quality (DEQ), Oklahoma Corporation Commission (Corp. Comm.), Oklahoma Water Resources Board (OWRB), United States Geological Survey, City of Tulsa, Cherokee Nation, and citizens of the State. Only data collected prior to April 30, 2015 was utilized for this report.

Data used in this report came from several sources, including the *Toxics Monitoring Survey of Oklahoma Reservoirs* (OSDH, 1995), *Nonpoint Source Pollution Assessment Report (Section 319(h))* (OCC, 1988, 1994), Clean Lakes Programs (Section 314) (OCC & OWRB), *Lake Water Quality Assessment Report* (OCC & OWRB, 1994), *The Water Quality of Oklahoma 2014 Integrated Report* (DEQ, 2014), Data Gaps Monitoring Projects (OCC 2002, 2003), Beneficial Use Monitoring Program, Rotating Basin Monitoring Program, intensive and rapid bio-assessment surveys. Historical data and assessments (prior to May 1, 2008) were only used when insufficient current data was available to assess a waterbody.

The State considers data gathered by interested citizens of the State of Oklahoma to be an important part of the water quality assessment process. Blue Thumb volunteers collect water quality samples on a monthly basis to screen for potential problems in streams. They also participate in fish and macroinvertebrate collections with OCC staff and these results are used for biological assessment. For more information on Blue Thumb, contact the Oklahoma Conservation Commission.

Additional monitoring will allow the State agencies to refine and modify the descriptions of the quality of the State's waters. This report reflects water quality determinations made in the past and such determinations will be confirmed or modified, as additional monitoring data becomes available. Where some waterbodies are indicated to be impaired, and suspected cause of impairment is listed, this information is also subject to confirmation or modification based on additional studies and evaluation by State agencies.

Table 1 shows the size and number of lakes in the State of Oklahoma designated as one of the five available categories outlined in the Integrated List Guidance above, while Table 2 does the same for river and stream miles.

TABLE 1. LAKE CATEGORY SUMMARY

Category	Size (Acres)	Number of Waterbodies
1	1,086	3
2	68,672	38
3	20,506	258
4a	9,820	4
5a	509,521	116
5b	10	1
5c	11,436	9

TABLE 2. RIVER AND STREAM CATEGORY SUMMARY

Category	Size (Miles)	Number of Waterbodies
1	98	3
2	3,080	267
3	18,860	2,854
4a	2,231	109
5a	6,538	346
5b	1,382	135
5c	827	69

Table 3 details the attainment status of each designated beneficial use assigned to lake acres in Oklahoma, while Table 4 does the same for river and stream miles. Each beneficial use for a waterbody must have only one attainment status associated with that use: supporting, not supporting, insufficient information, or not assessed (no information). The methodology for assigning the attainment status of a beneficial use of a waterbody is outlined in the Assessment Methodology and Summary Data section of this report.

TABLE 3. LAKE BENEFICIAL USE SUPPORT SUMMARY

Lake Acres					
Use	Total Size	Size Fully Supporting	Size Not Supporting	Size Not Assessed	Size with Insufficient Info
Aesthetic	621,051	464,959	25,251	13,476	117,365
Agriculture	611,911	564,871	21,605	13,341	12,094
Fish Consumption	621,051	105,504	252,805	13,714	249,028
Warm Water Aquatic Community	621,051	3,521	488,480	13,485	115,565
Navigation	84,440	84,440	0	0	0
Primary Body Contact Recreation	621,051	305,896	9,602	13,826	291,727
Public and Private Water Supply	570,403	76,007	71,586	2,477	420,333
Emergency Water Supply	12,950	12,950	0	0	0

TABLE 4. RIVER AND STREAM BENEFICIAL USE SUPPORT SUMMARY

River Miles					
USE	**Total Size**	**Size Fully Supporting**	**Size Not Supporting**	**Size Not Assessed**	**Size with Insufficient Info**
Aesthetic	32,989	5,571	190	17,927	9,301
Agriculture	32,918	7,782	3,165	18,220	3,751
Emergency Water Supply	1,601	1,573	0	28	0
Fish Consumption	32,920	2,431	999	28,865	625
Cool Water Aquatic Community Subcategory	1,630	546	502	442	140
Habitat Limited Aquatic Community Subcategory	885	93	122	548	122
Trout Fishery	34	0	11	23	0
Warm Water Aquatic Community Subcategory	30,467	2,807	6,566	15,481	5,613
Navigation	214	214	0	0	0
Primary Body Contact Recreation	31,767	1,189	7,775	21,603	1,200
Public and Private Water Supply	14,828	1,670	233	6,617	6,308
Secondary Body Contact Recreation	1,249	195	47	883	123

Table 5 shows the number of lake acres impaired by specific pollutant and Table 6 shows the same for the number of river and stream miles.

TABLE 5. LAKE ACRES IMPAIRED BY SPECIFIC POLLUTANT

Cause	Size (Acres)
Turbidity	391,529
Mercury	214,483
Dissolved Oxygen	135,124
Chlorophyll-α	71,586
pH	63,341
Lead	49,511
Phosphorus (Total)	25,251
Chloride	19,224
Cadmium	14,200
Enterococcus	9,602
Sulfates	2,381
Copper	352

TABLE 6. RIVER AND STREAM MILES IMPAIRED BY SPECIFIC POLLUTANT

Impairment	Size (Miles)
Enterococcus	7,537
Dissolved Oxygen	2,960
Escherichia coli	2,731
Turbidity	2,477
Sulfates	1,913
Chloride	1,759
Total Dissolved Solids	1,750
Fishes Bioassessments	1,660
Benthic Macroinvertebrate Bioassessments	1,383
Lead	1,165
pH	847
Selenium	612
Sedimentation/Siltation	436
Silver	198
Oil and Grease	128
Mercury	121
Chromium (total)	116
Total Phosphorus	95
Zinc	101
Copper	74
Cadmium	63
Nitrates	63
Ammonia	41
DDT	30
Toxaphene	30
Dieldrin	18
Diazinon	11
Arsenic	6
Barium	4

Table 7 shows the number of lake acres impaired by potential sources, and Table 8 shows the number of river and stream miles impaired by potential sources.

TABLE 7. LAKE ACRES IMPAIRED BY POTENTIAL SOURCE

Potential Source	Size (Acres)
Source Unknown	530,735
Mine Tailings	38,322
Rangeland Grazing	22,554
Wildlife Other than Waterfowl	22,554
Natural Sources	18,249
Grazing in Riparian or Shoreline Zones	17,522
Wastes from Pets	17,522
Animal Feeding Operations	9,476
Impacts from Land Application of Wastes	9,476
Sources Outside State Jurisdiction or Borders	9,476
On-site Treatment Systems (Septic Systems and Similar Decentralized Systems)	4,870
Petroleum/Natural Gas Activities (Legacy)	35
Silviculture Harvesting	25

TABLE 8. RIVER AND STREAM MILES IMPAIRED BY POTENTIAL SOURCE

Potential Source	Size (Miles)
Source Unknown	11,344
Grazing in Riparian or Shoreline Zones	7,703
Wildlife Other than Waterfowl	7,517
Rangeland Grazing	7,322
On-site Treatment Systems (Septic Systems and Similar Decentralized Systems	7,298
Residential Districts	5,807
Wastes from Pets	5,467
Highway/Road/Bridge Runoff (Non-construction Related)	3,982
Non-Irrigated Crop Production	3,893
Impacts from Land Application of Wastes	3,871
Municipal Point Source Discharges	3,574
Petroleum/Natural Gas Activities (Legacy)	3,024
Drought-related impacts	1,418
Total Retention Domestic Sewage Lagoons	966
Agriculture	870
Permitted Runoff from Confined Animal Feeding Operations (CAFOs)	704
Animal Feeding Operations (NPS)	647
Clean Sediments	331
Impacts from Hydrostructure Flow Regulation/Modification	296
Natural Sources	258
Impacts from Abandoned Mine Lands	246

Potential Source	Size (Miles)
Other Spill Related Impacts (Recent Spills)	243
Landfills	233
Loss of Riparian Habitat	194
Mine Tailings	177
Industrial Point Source Discharge	162
Municipal (Urbanized High Density Area)	150
Sources outside State Jurisdiction or Borders	153
Atmospheric Deposition - Acidity	107
Discharges from Municipal Separate Storm Sewer Systems (MS4)	91
Silviculture Plantation Management	52
Acid Mine Drainage	42
Land Application of Wastewater Biosolids (Non-agricultural)	40
Drainage/filling/loss of wetlands	34
Leaking Underground Storage Tanks	28
Silviculture Harvesting	27
Dredging (E.g., for Navigation Channels)	25
Atmospheric Deposition - Toxics	25
Municipal point source impacts from inadequate industrial/commercial pretreatment	18
Woodlot site management	18
Spills from Trucks or Trains	17
Discharges from Biosolids (SLUDGE) Storage, Application or Disposal	17
Surface Mining	14
Irrigated Crop Production	14
CERCLA NPL (Superfund) Sites	12
Habitat Modification – other than Hydromodification	5

Statewide probabilistic estimates of fish communities, macroinvertebrate communities, benthic algae, and sestonic algae in rivers and streams are depicted in Tables 9 through 12, respectively. A description of the State of Oklahoma's probabilistic monitoring program can be found in Appendix F of this report. The full report can be found on the OWRB website at:
http://www.owrb.ok.gov/studies/reports/reports_pdf/StatewideStreamProbMonitoringNetwork2008-2011.pdf

TABLE 9. STATEWIDE PROBABILISTIC ASSESSMENT OF FISH IN RIVERS AND STREAMS

Resource	Unit	Study Period	Cause Name	State Attainment Category	Size in Category	Conf Level	Lower Conf	Upper Conf
Rivers/Streams	Miles	2008-2011	Fish	Good	12,232	95%	9,499	15,165
Rivers/Streams	Miles	2008-2011	Fish	Fair	1,215	95%	577	1,854
Rivers/Streams	Miles	2008-2011	Fish	Poor	7,470	95%	4,656	10,285

TABLE 10. STATEWIDE PROBABILISTIC ASSESSMENT OF MACROINVERTEBRATES IN RIVERS AND STREAMS

Resource	Unit	Study Period	Cause Name	State Attainment Category	Size in Category	Conf Level	Lower Conf	Upper Conf
Rivers/Streams	Miles	2008-2011	Macroinvertebrates	Good	4,693	95%	2,419	6,966
Rivers/Streams	Miles	2008-2011	Macroinvertebrates	Fair	8,954	95%	6,178	11,729
Rivers/Streams	Miles	2008-2011	Macroinvertebrates	Poor	7,371	95%	4,854	9,888

TABLE 11. STATEWIDE PROBABILISTIC ASSESSMENT OF BENTHIC ALGAE IN RIVERS AND STREAMS

Resource	Unit	Study Period	Cause Name	State Attainment Category	Size in Category	Conf Level	Lower Conf	Upper Conf
Rivers/Streams	Miles	2008-2011	Benthic Algae	Good	16,326	95%	14,613	18,038
Rivers/Streams	Miles	2008-2011	Benthic Algae	Fair	2,554	95%	1,193	3,916
Rivers/Streams	Miles	2008-2011	Benthic Algae	Poor	2,138	95%	1,030	3,246

TABLE 12. STATEWIDE PROBABILISTIC ASSESSMENT OF SESTONIC ALGAE IN RIVERS AND STREAMS

Resource	Unit	Study Period	Cause Name	State Attainment Category	Size in Category	Conf Level	Lower Conf	Upper Conf
Rivers/Streams	Miles	2008-2011	Sestonic Algae	Good	11,543	95%	8,879	14,207
Rivers/Streams	Miles	2008-2011	Sestonic Algae	Fair	4,841	95%	2,555	7,127
Rivers/Streams	Miles	2008-2011	Sestonic Algae	Poor	4,634	95%	3,108	6,160

Surface Water Quality

Oklahoma's Water Quality Standards (WQS) are set forth under statutory authority of the OWRB authorized under 82 O.S. § 1085.30. Under these statutes, OWRB "is required to set Water Quality Standards which are practical and in the best public interest and to classify the State's waters with respect to their best present and future uses. These WQS are designed to enhance the quality of the waters, to protect their beneficial uses, and to aid in the prevention, control and abatement of water pollution in the State of Oklahoma" (OWRB, 2006). The WQS have established designated beneficial uses and standards for all of Oklahoma's waters.

The overall support and attainment of the "fishable/swimmable" goals of the CWA is based upon "total waters." The EPA requires all states to report their attainment of the goals of the CWA based on total waters. Relying solely upon this portrayal probably overly inflates estimates of the impaired and threatened conditions of the State's waters since monitoring efforts are typically focused on known problem areas. It would be too cost prohibitive to assess all of the waters within the State. Therefore, all assessment work performed in the State is conducted in a manner that will best utilize available funding resources. For lake total water reporting, the acreage includes Natural Resource Conservation Service (NRCS) (formerly the Soil Conservation Service) assisted farm ponds. Oklahoma lists approximately 1,041,884 total lake acres for the State. Of this number, 330,000 acres comprise approximately 220,000 NRCS assisted farm ponds. These farm ponds are not included in EPA's total water database. Although not considered as "significant lakes," Oklahoma considers them as important natural resources for the agricultural and rural communities. These farm ponds provide a significant amount of water for livestock, a source of primary recreation for many, used as flood control devices, sediment catchments, and add to the recharge of groundwater aquifers.

Canals, laterals and most all of the wetlands have not been assessed for the goals of the CWA nor have they been assessed for their beneficial uses. Canals and laterals are manmade watercourses and have not been included in the Appendix A of the WQS. By default, these waters would be assigned primary protection under the 2008 WQS (OWRB, 2008). Due to a lack of funding, no assessment projects have been initiated on these types of waterbodies. Wetlands have not been assigned specific WQS and therefore fall under the same scenario as canals and laterals. Several projects and ventures have been initiated to inventory the wetlands within the State, but little assessment work has been completed.

The major factors affecting the overall use support of the rivers and streams of the State were from the following causes: pathogens, turbidity and low dissolved oxygen. The major factors affecting the overall use support of the lakes of the State were from the following causes: oxygen depletion, turbidity and color.

All unlisted waters, not included in Appendix A of the WQS, are assumed to have the beneficial uses consistent with the CWA's primary protection requirements. All beneficial use determinations are subject to administrative proceedings including the public hearing process.

Currently, DEQ develops draft National Pollutant Discharge Elimination System (NPDES) permits for the control and abatement of municipal and industrial pollution. DEQ issues the final NPDES permit for municipalities and industrial dischargers. Permit compliance is monitored by both the discharger and inspectors for DEQ.

Since the inception of the CWA in 1972 and its amendments, EPA administered the National Pollutant Discharge Elimination System (NPDES) program, which addresses the management of industrial and municipal wastewater discharges. Previously, the functions related to wastewater were found in the OSDH, for municipal wastewater, and OWRB for industrial wastewater. The scattering of the NPDES jurisdiction between two agencies that were independently pursuing delegation of their portion from the NPDES program did not appear to be conducive for Oklahoma to assume the program from EPA. Consolidation of the two agencies into DEQ in July 1993 solved this problem and the work began for the agency to develop its required program documents, rules and statute changes in preparation of submitting its formal NPDES application to EPA, Region 6 office in Dallas, Texas.

DEQ obtained NPDES program assumption from EPA on November 19, 1996. This is indicative of the agency having jurisdiction over the basic permitting, compliance and enforcement elements of the NPDES program, in addition to having authority over toxicity reduction, sewage sludge and pretreatment programs. In September 1997, program assumption to issue storm water permits was obtained from EPA.

ODAFF received delegation of a partial NPDES program from EPA on December 20, 2012. ODAFF is the NPDES permitting authority for discharges from concentrated animal feeding operations (CAFOs), discharges from the application of biological or chemical pesticides, discharges from silviculture activities, and construction stormwater discharges at agricultural operations.

Ground Water Quality

The Safe Drinking Water Act (SDWA) was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and requires many actions to protect drinking water and its sources: rivers, lakes, reservoirs, springs, and ground water wells. (SDWA does not regulate private wells which serve fewer than 25 individuals.) Several State agencies are involved in the protection of Oklahoma's groundwater. These include DEQ, ODAFF, Corporation Commission, OCC, and OWRB. DEQ is designated as the lead agency for the Wellhead Protection Program (WHPP).

There are instances of man induced groundwater pollution in the State. Except in a few old oilfields, they appear to be isolated instances and not general contamination of groundwater drinking water supplies. Historical data indicates water is of good quality from most aquifers.

Oklahoma has Groundwater Standards located in OAC 785:45-7. Designated beneficial uses for the groundwaters of the State are determined by Total Dissolved Solids (TDS). Groundwater with a mean concentration of TDS of less than 3,000 milligrams per liter has assigned beneficial uses of Public and Private Water Supply, Agriculture, and Industrial and Municipal Process and Cooling Water. Groundwater with a mean concentration of TDS of greater than or equal to 3,000 milligrams per liter but less than 10,000 milligrams per liter has assigned beneficial uses of Agriculture and Industrial and Municipal Process and Cooling Water. Groundwater is protected to background quality and, once polluted as a result of human activities, is restored to a quality to support its designated beneficial uses. Ensuring that groundwater meets Water Quality Standards is an important reason for developing and continuing a Water Quality monitoring Program.

- The Oklahoma Legislature passed Senate Bill 1627 (SB1627) in 2008 requiring OWRB to establish a technical work group to analyze the potential for expanded use of "Marginal Quality Water" (MQW) from various sources throughout Oklahoma. SB1627 required that the group include representatives from State and federal agencies, industry, and other stakeholders. Through facilitated discussions, the group defined MQW as water that historically may have been unusable because of technological or economic issues with diverting, treating, and/or conveying the water. Five categories of MQWs were identified for further characterization and technical analysis.
- Work on this project is ongoing. In 2012, its results were integrated into the overall Oklahoma Comprehensive Water Plan as a Supplemental Report of the issues, ultimately residing as part of the Conservation, Efficiency and Reuse Priority Recommendation. A statewide screening analysis was conducted to accomplish the following: Quantifying and characterizing MQW sources temporally through 2060 and geographically across the State
- Assessing constraints to MQW use
- Matching projected water shortages across Oklahoma with MQW sources and assessing the feasibility of utilizing MQW

This screening provided some insights as to viability for meeting the state's future needs resulting in general strategies and recommendations for moving forward. Those recommendations, paraphrased in brief, are:

- Treated wastewater effluent: PWS and Users should consider this option where socially acceptable and the state develop a detailed reuse regulatory framework.
- Stormwater runoff: examine potential for storage to meet future non-potable demand, probably in areas of fairly high precipitation and existing infrastructure.
- Oil and gas flowback/produced water: Continue to seek cost-effective opportunities to reuse *produced water to help meet drilling and fracking water needs (see below).
- Brackish surface and groundwater: follow the ongoing USGS study to characterize accessible brackish water and spatially connect potential supply with potential demands for various levels of quality.

- Water with elevated levels of key constituents: State should support research and development of cost-effective advanced treatment for use of MQW sources. This may have the greatest practical use statewide.

Produced water (PW) from the O&G industry is currently the focus of a new Produced Water Working Group initiative by Governor Fallin to find solutions and options for PW other than injecting it into deep disposal wells currently seen as the major source for Oklahoma's momentous uptick in seismicity around the state. While the earlier study addressed PW, priorities and economics have changed to the point where PW may be feasible for non-potable uses other than just the O&G industry.

Marginal Quality Water is expected to play an indispensable role in the quest to meet the goals of the Water for 2060 Initiative to use no more freshwater in 2060 than the state used in 2010. These recommendations will be addressed as resources and funding allow over these remaining years to 2060.

Background

Diversity and Ecology

Oklahoma is a diverse State in its ecology, geology, hydrology, and its rainfall. Oklahoma is comprised of the following ecoregions: Arkansas Valley, Boston Mountains, Central Great Plains, Central Irregular Plains, Central Oklahoma/Texas Plains, Flint Hills, Ouachita Mountains, Ozark Highlands, South Central Plains, Southwestern Tablelands, and Western High Plains. These ecoregions (Figure 1) range from short grass prairies to Loblolly Pine (*Pinus taeda*)/Short-leaf Pine (*P. echinata*)/Oak (*Quercus spp.*) mixed community.

Much of Oklahoma's original plant and some animal species are either extinct or are greatly reduced in their distribution. The reduction in native vegetation is mainly due to urban development, cultivation, conversion of native prairie to pasture, timber cutting, and erosion. There are approximately 2,540 species of plants, 81 species of reptiles, 53 species of amphibians, 101 species of mammals, 400 species of birds, and 175 species of fish. Agriculture is the number one land use business in Oklahoma. Wheat is the number one cash grain crop grown in Oklahoma. Wheat is valuable during the winter as pasture feed for cattle, sheep and dairy stock. Other important grain crops for the State include fall and spring oats, barley, rye, sorghum, soybeans, and corn. In addition, pecans, fruits, vegetables, cotton, and timber all constitute a significant source of income for the State. Other important agricultural land use practices include cattle, dairy stock, sheep, horses, goats, poultry, and select exotics (e.g., llamas and ostriches).

The latitude and longitude coordinate for the corners of the State, excluding the Panhandle are: Southeast 033°38'15"/ 094°29'08"; Northeast 036°59'54"/094°37'04"; Southwest 034°33'38"/100°00'00"; and Northwest 037°00'00"/100°00'00". The coordinates for the Panhandle are: Southeast 036°30'00"/ 100°00'00"; Northeast 037°00'00"/100°00'00"; Southwest 036°30'00"/103°00'00"; and Northwest 037°00'00"/103°00'00". Oklahoma runs approximately 481.51 miles east to west and 230.16 miles north to south. The surface area of Oklahoma occupies approximately 69,919 square miles or 44,000,000 acres. Oklahoma varies in its elevation from its lowest point of 287 feet above sea level on the Little River in McCurtain County on the border with Arkansas to its highest point of 4,973 feet above sea level, near Black Mesa in Cimarron County on the border with New Mexico. There are ten major geologic provinces in Oklahoma with the Northern Shelf Areas being the largest (Figure 2) (Oklahoma Geological Survey, 1972). Oklahoma is composed of 77 counties with Osage being the largest (Figure 3). Basic statistics on Oklahoma can be found in Table 9.

Information contained in Table 9 came from a variety of sources including the 2010 U.S. Census, United States Geological Survey data, OWRB data, Oklahoma Water Atlas, Reach File 3/Digital Line Graph Data, ground surveys, the Wildlife Department, United States Fish and Wildlife Service, and planimeter data. For the lakes information, Oklahoma uses the information from the *Oklahoma Water Atlas*. Oklahoma's environmental agencies feel that the information contained in the *Oklahoma Water Atlas* better represents the total of lakes and lake acres contained within the State. For the remaining rivers, creeks, canals and laterals we will be using a combination of sources for our data.

The total of fresh-water wetland acres was derived from information obtained from the Wildlife Department and United States Fish and Wildlife Service reports *Riparian Areas of Western Oklahoma* and *Bottomland Hardwoods of Eastern Oklahoma*. These reports contain information on 58 of the 77 counties in the State. The information in Table 11 was derived from taking the total of the largest most recent estimate for each county listed in the two reports. This total underestimates the actual number of wetland acres for the State and should be used with extreme caution when making comparison or trend analysis on Oklahoma's loss of wetlands.

FIGURE 1. ECOREGIONS OF OKLAHOMA

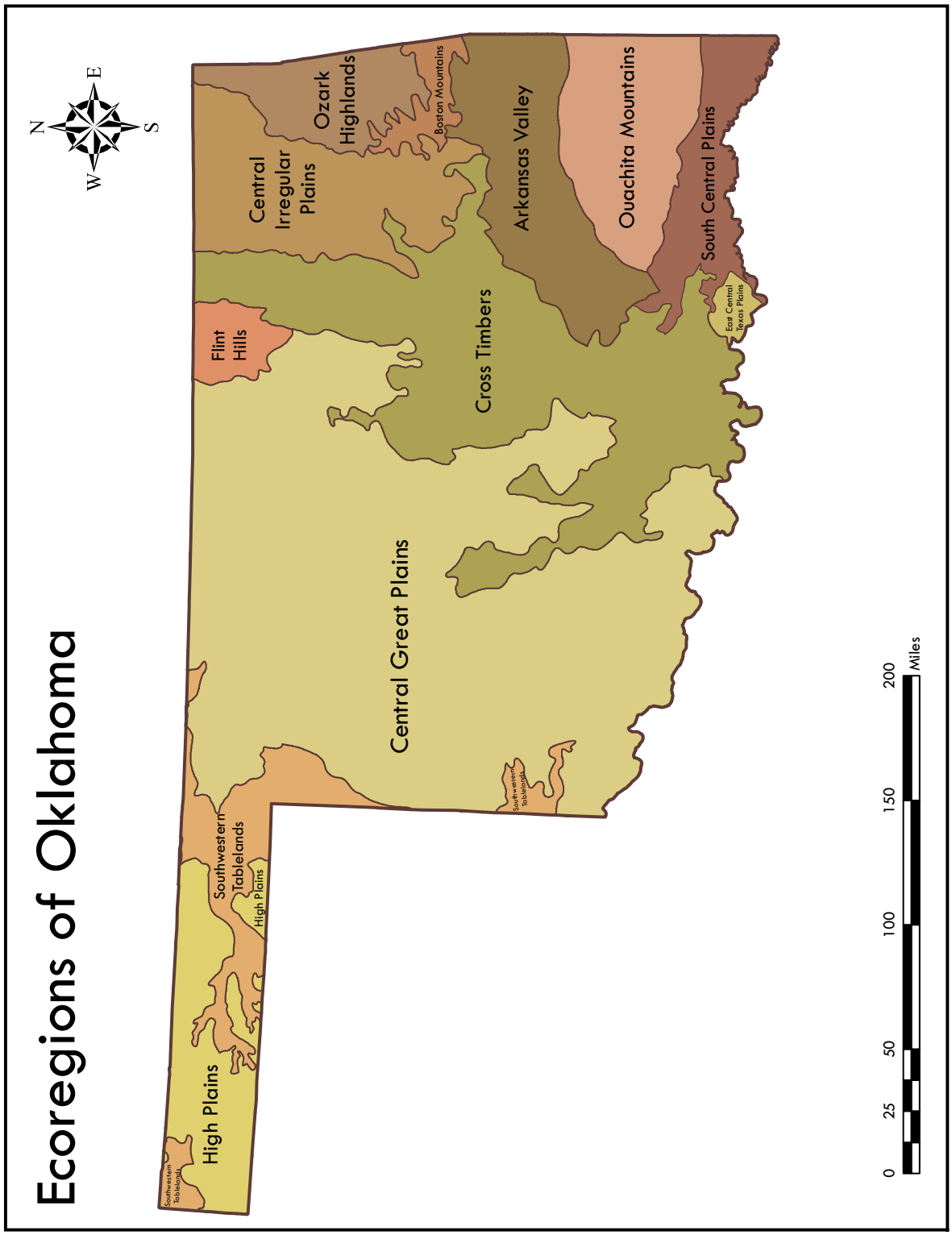


FIGURE 2. OKLAHOMA GEOLOGY

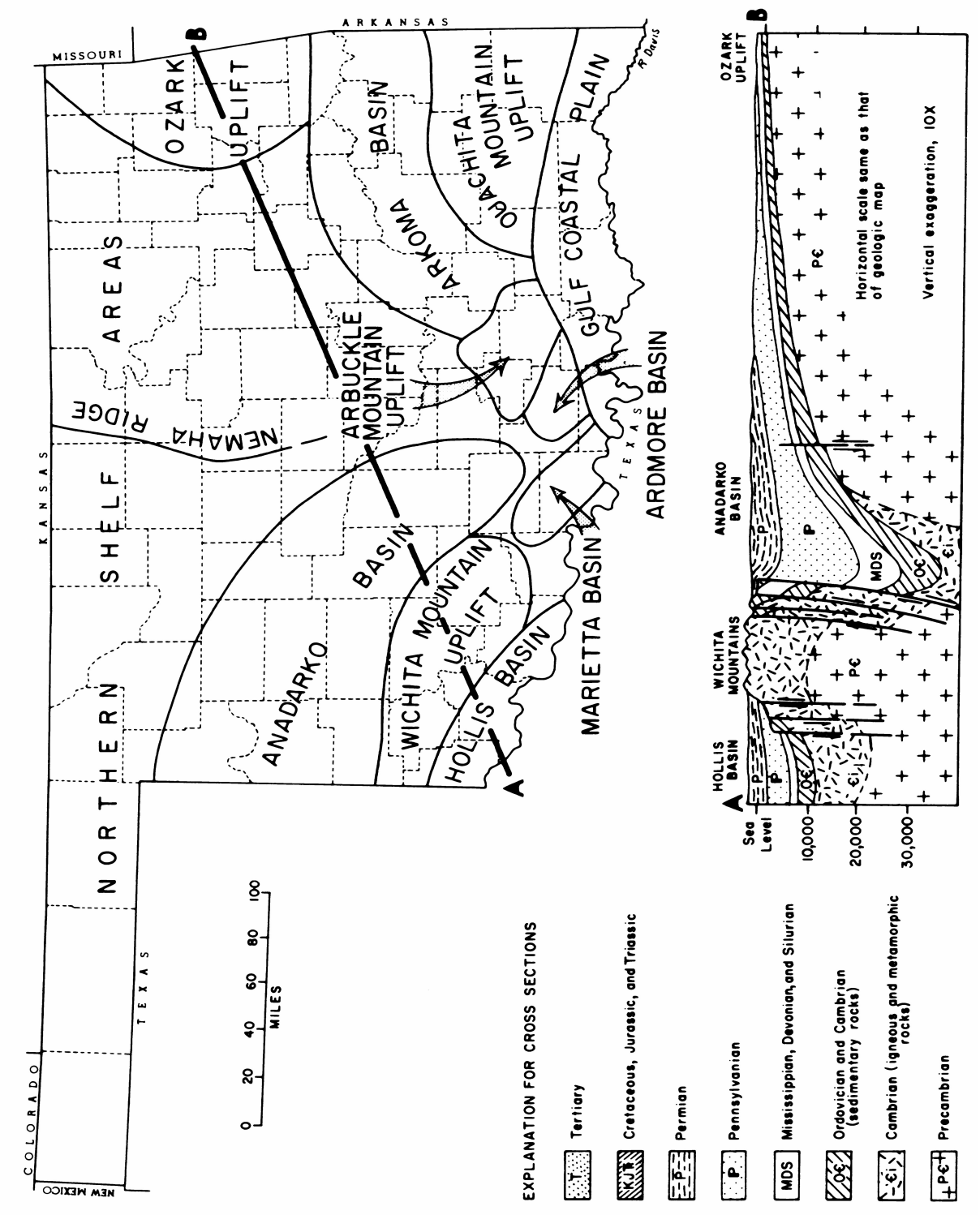


FIGURE 3. OKLAHOMA COUNTIES

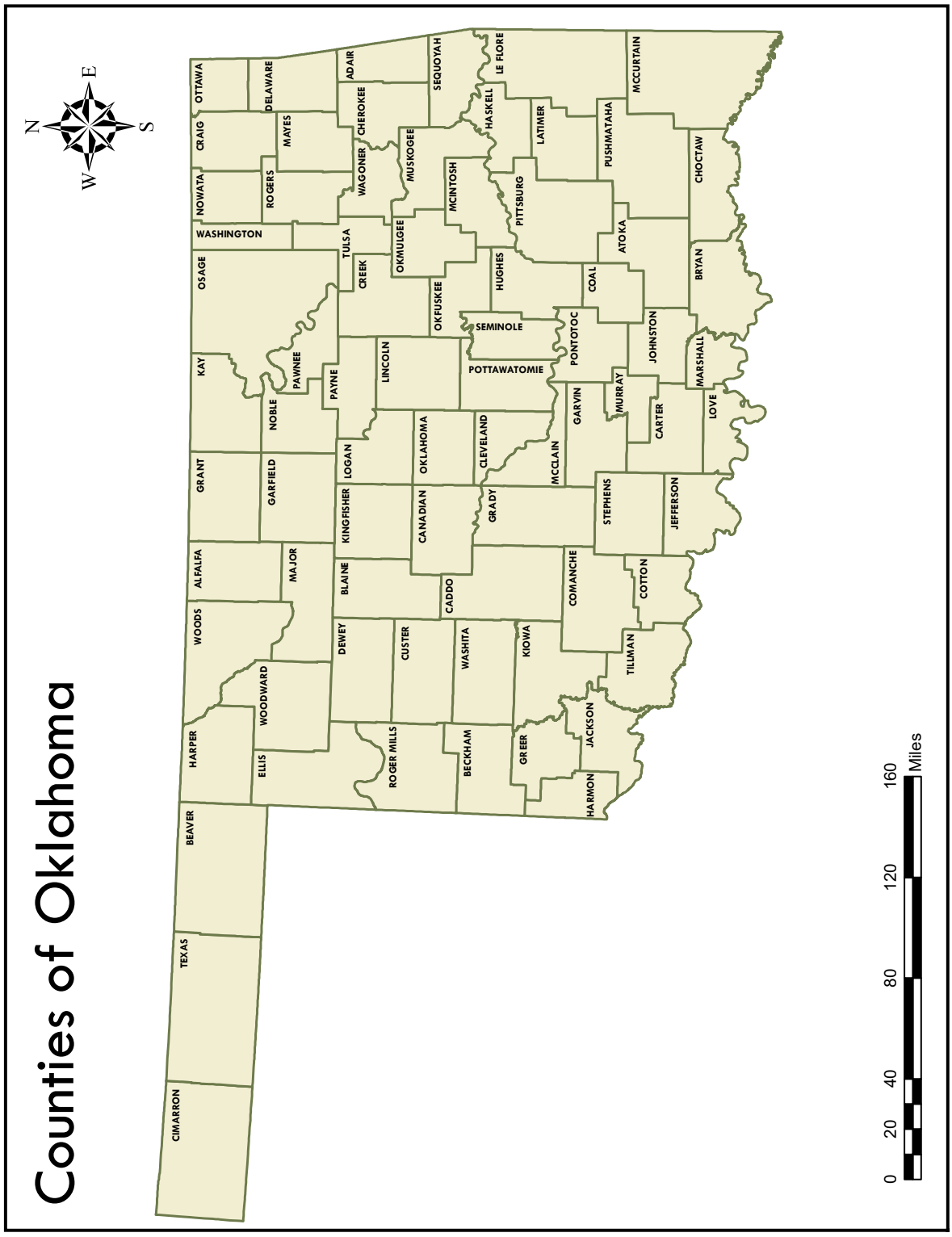


TABLE 13. ATLAS OF OKLAHOMA

State Population♦	3,911,338
State Surface Area, Square Miles♦♦	69,919
Number of Major Watershed Basins	7
Total Number of River and Stream Miles♣ Number of Perennial River and Stream Miles♣ Number of Intermittent Stream Miles♣ Number of Canals or Ditches♣ Number of River Border Miles♦♦♦	78,778 22,386 55,413 175 517
Total Number of Lakes/Reservoirs/Playa/Ponds♣♣ Number of Large Lakes♣♣ Number of Public & Private Lakes♣♣ Number of Watershed Protection Lakes♣♣ Number of Playa Lakes (wet season only)♣♣ Number of Oxbow Lakes (≥ 10 Acres)♣♣ Number of Farm Ponds (Soil Conservation Service assisted)♣♣	224,948 34 2,303 1,964 585 62 220,000
Total Number of Lakes/Reservoirs/Playa/Ponds Acres♣♣ Major Lake Acres♣♣ Public & Private Lake Acres♣♣ Watershed Protection Lake Acres♣♣ Playa Lakes Acres♣♣ Oxbow Lake Acres♣♣ Farm Pond Acres♣♣	1,041,884 555,450 89,836 54,261 9,572 2,765 330,000
Total Number of Freshwater Wetland Acres♣♣♣	733,895

♦ 2015 U.S. Census Bureau Estimates
♦♦ Based upon United States Geological Survey information
♦♦♦ OWRB Data
♣ Reach File 3/Digital Line Graph Data
♣♣ Oklahoma Water Atlas, 1990
♣♣♣ Estimates compiled from the Wildlife Department & U.S. Fish & Wildlife Service

Climate

Oklahoma has a continental type of climate. There are pronounced seasonal and geographical ranges in both temperature and precipitation. Average annual temperature varies from 53.6°F in the western part of the Panhandle up to 63.8°F in the southeast part of the State. Annual rainfall varies from approximately 17 inches in the far western part of the Panhandle to over 55 inches per year near the LeFlore County/McCurtain County/Arkansas border. The average growing season varies from 180 days in the Panhandle to 240 days in the southeast corner. Typically, 75% of Oklahoma's annual precipitation falls during the growing season.

Water Pollution Control Programs

The myriad and complex water quality problems remaining today require a more comprehensive approach to find workable and effective solutions. As we continue to have success reducing impacts from point sources, pollution from nonpoint sources takes on more significance. Non-traditional concerns such as habitat degradation and conservation of biological diversity also call for a comprehensive approach.

The watershed approach provides such a management framework. Utilizing support from the 104(b)(3) program, Oklahoma has taken the first steps to implement the watershed approach for water quality management in the State. The following accomplishments have been achieved:

- A Whole Basin Planning Approach Working Group was established to coordinate planning and implementation of the watershed approach in Oklahoma. Representatives of the various state and federal agencies with a role in water quality management were represented on the Working Group.

- A cooperative project with USGS produced a new digital elevation model and digital watershed maps for the state. Existing 8-digit cataloging units were subdivided into 11-digit watersheds. These watershed maps are the basis for the state program. The maps have been published on CD-ROM and are available to all agencies and the public.

- Utilizing the new watershed boundaries, the Working Group delineated 11 Watershed Management Units that are used to implement the watershed approach. The intent is that planning, monitoring, permitting, and other water quality programs will eventually be coordinated and organized at this scale when the watershed approach is fully implemented.

- Accurate locational data on all dischargers has been gathered using the Global Positioning System. These data have been built into a GIS-compatible format for analysis. Links to permitting and monitoring data in the PCS system have been established for analysis and assessment purposes.

- A technical committee was established to develop an implementation plan to utilize the new Watershed Management Units and watershed boundaries in the various reporting and planning programs. Water Quality Standards, the 303(d) list, the 208 Plan, and the 305(b) Report were targeted for this effort.

Water Quality Standards Program

Oklahoma's WQS are set forth under statutory authority of OWRB authorized under 82 O.S. § 1085.30. Under these statutes, OWRB "is required to set Water Quality Standards which are practical and in the best public interest and to classify the State's waters with respect to their best present and future uses. These WQS are designed to enhance the quality of the waters, to protect their beneficial uses, and to aid in the prevention, control and abatement of water pollution in the State of Oklahoma" (OWRB, 2006). The WQS have established designated beneficial uses and standards for all of Oklahoma's waters.

Oklahoma defines waters of the State to mean "all streams, lakes, ponds, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface and underground, natural or artificial, public or private, which are contained within, flow through, or border upon this State or any portion thereof 82 O.S. § 1084.2(3).

Much of the work developing WQS over the past three decades has been dedicated to the control of point source discharges through chemical-specific criteria and permit limits. Over the past three reporting cycles, biological water quality criteria have also been used to determine use support assessment and manage water quality in streams and lakes. Oklahoma continues to refine the use of biological criteria to more holistically determine use support and develop stressor/response models to implement water quality management strategies. Additionally, Oklahoma continues work to develop both translators and criteria endpoints to manage nutrients in Oklahoma's waters.

Point Source Control Program

Oklahoma's point source pollution control programs are administered and carried out by DEQ. DEQ administers both municipal and industrial dischargers and issues permits. DEQ is responsible for monitoring the dischargers to ensure compliance with permit limitations and conditions as well as to receive and review the permittee's self-monitoring data.

For industrial dischargers, DEQ relies on a two-step process for permit development. In the first step, minimum treatment level standards, based on the industry type, are established. These are termed "technology-based limits." The technology-based limits are evaluated to determine if a potential exists to violate the WQS. If the potential to violate the WQS exists, more stringent "water quality-based limits" will be selected for use in the permit.

Each permit specifies both monitoring and reporting requirements for the facility. The permit provides the effective dates of limits, parameters to be tested, applicable limits for each parameter, frequency of analysis, and sample type of monitoring. Monitoring results are summarized on a monitoring report form and submitted to DEQ according to the schedule in the permit. All Discharge Monitoring Reports (DMR) and reports from the permittee are reviewed and violations noted. The permittee's compliance is tracked using the Permit Compliance System (PCS). The administrative staff utilizes violation review criteria to screen for significant violations. This screening process assures that limited enforcement resources concentrate on the most significant violations. The following criteria are used to identify significant violations:

- Two or more excursions of 40% or more for inorganic and oxygen demanding pollutants during a six-month period.
- Two or more excursions of 20% or more for toxic pollutants during a six-month period.
- Non-reporting violations.
- Chronic violations, any violation of any monthly effluent limit for any four or more months in a six month period.
- Any effluent violation that causes or has potential to cause a water quality or human health problem.
- Permit schedule violations.
- Violations of enforcement orders
- Any unauthorized bypass, unpermitted discharge, or pass through of pollutants which may cause a water quality or human health problem.
- Construction or modification of sewage treatment works, Publicly Owned Treatment Works conveyance system or industrial wastewater impoundment, without a permit.

The criteria used for determining significant violations are based on the EPA's current policy, which is used to evaluate all major and minor permits under DEQ's jurisdiction.

Quality assurance strategies are used by DEQ to ensure that facilities comply with their permit. Field inspections are conducted on a regular basis with samples of the discharge collected for analyses. The Customer Assistance Division maintains the laboratory certification program. This program assures that industries follow all Quality Assurance and Quality Control methods when analyzing their effluent samples. All permits require that all analyses used to determine permit compliance be performed by a DEQ certified lab.

The limits for the permits are "water quality based" and are designed to protect the beneficial uses of the receiving stream. All permits are tracked through the State's Water Quality Management Plan. The plan is updated as needed. The updates to the Plan occur on a regular basis with the last full annual update to the Plan being in 1984.

Each permit is written for a single facility. Most facilities have only one discharge; however, some do have multiple discharges. The information found in each permit includes: latitude and longitude for the facility and/or its point of discharge; effective date(s) of the permit; limits; self-monitoring frequency and sampling type for each discharge point; etc. In addition, the permit also requires the permittee to prepare and submit monthly Discharge Monitoring Reports, which give a summary of the results of the self-monitoring. The Discharge Monitoring Reports are submitted to DEQ.

All Discharge Monitoring Reports from the permittee are reviewed with violations being noted. The permittee's compliance is then tracked using the PCS (an EPA computer database system). DEQ screens the DMR for significant violations. This screening process allows DEQ to concentrate its funding where it is needed most.

Quality Assurance/Quality Control practices are used by DEQ to ensure that publicly owned treatment works are complying with permit conditions. Regular inspections of publicly owned treatment works facilities are conducted by DEQ and/or EPA inspectors with samples of a facility discharge collected for analysis. DEQ requires that all operators and laboratory technicians of publicly owned treatment works be properly trained and certified.

Nonpoint Source Control Program

The Oklahoma Conservation Commission (OCC) serves as the lead technical agency for Oklahoma's Nonpoint Source (NPS) Management program with specific jurisdictional exceptions such as: 1) oil and gas activities and petroleum storage tanks, which are under Corp. Comm. jurisdiction; 2) silviculture and pesticides which are under ODAFF jurisdiction; and 3) industrial and municipal stormwater which is under DEQ jurisdiction. The OCC is the statutory pass through recipient of EPA Clean Water Act Section 319 monies, which fund annual base programming for technical support, water quality monitoring, education and implementation to abate priority NPS pollutants. Oklahoma's NPS program is a cooperative effort of state, federal and local agencies/partners, including but not limited to OCC, ODEQ, ODAFF, OWRB, Corp. Comm., US EPA, USDA-NRCS, conservation districts, and local landowners/producers. Oklahoma's NPS Management Program Plan (https://www.ok.gov/conservation/documents/2014%20NPS%20Mgmt%20Plan.pdf) details goals and related actions as it regards four key program areas: assessment, planning, education, and implementation. It also identifies principle state, federal and local agencies and other entities and their associated roles in NPS management.

The 2014 revision of the NPS Management Program document outlines the State's stepwise pattern to address NPS water quality problems:

1. The process begins with assessment of physical, chemical, and biological health of waters of the state to identify threats and impairments, along with their cause, source, and extent. This is largely accomplished through both OCC's and OWRB's ambient monitoring programs. For details, the reader is encouraged to reference the "Assessment of NPS Pollution" section of the document.

2. The second step involves prioritization and planning. The State maintains a Unified Watershed Assessment (UWA) to prioritize waterbodies listed as impaired in the current Integrated Report. The NPS Program, through the NPS Working Group, narrows this list to watersheds prioritized for NPS action. These NPS Priority watersheds are selected because sufficient historical information has been collected to identify the nature of the problem, corrective actions are most likely to be successful, the water quality problem primarily stems primarily from NPS-related causes and sources, and a significant portion of the watershed is in Oklahoma where the program could affect practices independent of the actions of another state. Following prioritization, a TMDL, Watershed Based Plan, or some other implementation plan is developed to reduce or remedy the problem.

3. The third step, implementation, involves the application of remedial efforts, such as conservation practices (CPs), educational activities, and other innovative efforts tailored to address NPS water quality pollution. There are three basic classes of BMPs: 1.) practices that reduce the pollutants available for transport by the normal rainfall/runoff process (changes in management), 2.) devices that reduce the amount of pollutants in the runoff before it is discharged to a surface water body (structural practices), and 3.) vegetative practices. Education is a critical portion of implementation and is accomplished through the Blue Thumb program as well as through project-specific workshops, tours, and trainings. In general, the goal of most implementation projects is to achieve a level of change in an entire watershed. NPS programs rely on

voluntary cooperation of landowners to implement projects, and landowners must understand the importance of their cooperation, and how participation can help them protect their assets and improve their return.

4. The fourth stage of the process involves evaluation of the program to determine its successes and failures and to recommend changes for the next round of the process. This involves post-implementation monitoring of the water resources and other evaluations of the success of the program (such as percent of priority areas with implemented practices or extent of education programs). Once this step has been completed and the outcome evaluated, the process can begin anew.

Current and recent NPS projects/efforts are ongoing in the watersheds of Lake Eucha, Illinois River, Grand Lake, the North Canadian River between Canton Lake and Lake Overholser, Lake Thunderbird, New Spiro Lake, Little Beaver Creek, and Elk City Lake in cooperation with the Natural Resources Conservation Service (NRCS), USEPA, ODAFF, GRDA, local conservation districts, and state universities, among other entities. The OCC also oversees the implementation of the Conservation Reserve Enhancement Program (CREP). CREP is a $20.6 million cooperative conservation partnership agreement between USDA and Oklahoma. The program pays eligible landowners to establish and protect riparian buffers along streams for 10 – 15 years. Focused in Northeast Oklahoma, CREP will protect approximately 9,000 acres of riparian land in the Eucha/Spavinaw and Illinois River Watersheds. Key CREP partners include City of Tulsa's Metropolitan Utility Authority, OSRC, Conservation Districts in Adair, Cherokee, and Delaware counties, the USDA Farm Services Agency, NRCS, and USEPA.

The ODAFF has authorities under the Oklahoma Concentrated Animal Feeding Operations (CAFO) Act, the Oklahoma Swine Feeding Operations (SFO) Act and the Registered Poultry Feeding Operations (RPFO) Act to enforce regulations governing the owners and/or operators of concentrated animal feeding operations, swine feeding operations and poultry feeding operations. The CAFO Act and SFO Act require all animal wastes and wastewaters from such operations be held in a total retention system preventing its discharge to the waters of the State and that waste generated in these operations be disposed of in a proper manner. The CAFO Act and SFO Act also require owners/operators to develop and implement Pollution Prevention Plans that include Best Management Practices (BMPs) at these operations. Site-specific Animal Waste Management Plans (AWMPs) containing equivalent requirements of the PPP may substitute for BMPs for CAFO facilities, and site-specific Swine Waste Management Plans could be used in place of BMPs for SFOs. Similarly, the RPFO Act requires poultry feeding operations to develop and implement AWMPs in storing, handling and utilizing poultry litter. The CAFO, SFO and RPFO Acts also require minimum education and training in waste management and related fields be obtained by owners/operators of these facilities. The Oklahoma Poultry Waste Applicators Certification (PWAC) Act requires the applicators be certified by ODAFF, obtain the latest soil and litter tests to determine the proper application rates on any field to which they apply litter, and attend educational courses on poultry waste handling. Applicators shall report to ODAFF each year the amounts of litter and locations where litter is applied. All four Acts require that land applications of either manure, litter or liquid animal waste be performed at agronomic rates. More rigorous requirements are imposed on land applications in the nutrient limited watersheds or in the areas designated as nutrient vulnerable ground water. The CAFO, SFO and RPFO Acts were designed to prevent and abate pollution from entering and contaminating any surface or groundwater. Under these Acts, the ODAFF is required to conduct annual inspections of these operations as well as investigate any complaints filed against such operations. The ODAFF can take regulatory action against a violator as deemed necessary.

The ODAFF has authorities under the Oklahoma Fertilizer Law to enforce the proper handling and storage of commercial fertilizers. The ODAFF licenses all bulk fertilizer storage facilities. All fertilizer materials shall be stored, applied, and handled in a manner, which prevents pollution of groundwater by minimizing losses of the fertilizer materials. This law is designed to prevent and abate the pollution of surface and groundwater within the State. Under this law, the ODAFF has the authority to conduct routine inspections of bulk storage facilities as well as investigate complaint received on a facility. The ODAFF can take regulatory action against a violator as deemed necessary.

The ODAFF has authorities under the Combined Pesticide Law and Rules to enforce the proper handling, storage, and use of commercial pesticides. These laws give the ODAFF authority to mandate regulations for the use of pesticides, how they are to be stored, and who can purchase them for application. These laws are designed to prevent or abate pollution of the waters of the State. Under these laws, the ODAFF must conduct routine inspections and investigates complaints on all facilities or individuals who store, sell, or apply pesticides. The ODAFF can take regulatory action against a violator as deemed necessary.

The ODAFF is also funding a program to collect and properly dispose of unwanted pesticides. All Oklahoma farmers, ranchers, pesticide dealers, commercial applicators and non-commercial applicators are eligible to participate in this program. The ODAFF has contracted a licensed hazardous waste company to collect and properly dispose of waste pesticides in Oklahoma.

Under Oklahoma Forestry Codes, ODAFF's Forestry Services' water quality program monitors the effects of forest practices on water quality, administers silvicultural best management practices and provides training and education of landowners, loggers and forest managers.

Corp Comm has worked with the Integrated Petroleum Environmental Consortium (IPEC), a consortium of the University of Tulsa (TU), the University of Oklahoma (OU), Oklahoma State University (OSU), and the University of Arkansas (UA) at Fayetteville, and the Marginal Well Commission to develop and disseminate best management practices for the hundreds of small oil and gas operators in the State. IPEC and Well Commission meetings and workshops, along with the brochures, checklists, kits, videos, and other materials provided by IPEC, have helped producers reduce the environmental impacts from their oil and gas activities. In addition, Corp Comm has adopted and enforced rules on site operation, pollution containment BMPs, land application, and spill cleanup with site restoration that help to minimize non-point source impacts.

There are other nonpoint source projects that affect either a specific watershed area, or are Statewide projects that will affect several waterbodies. In addition, there are projects planned in other areas of concern other than agriculturally related problems. Continuation of this program is dependent largely on federal grant support.

Nonpoint Source Management Program Success Stories

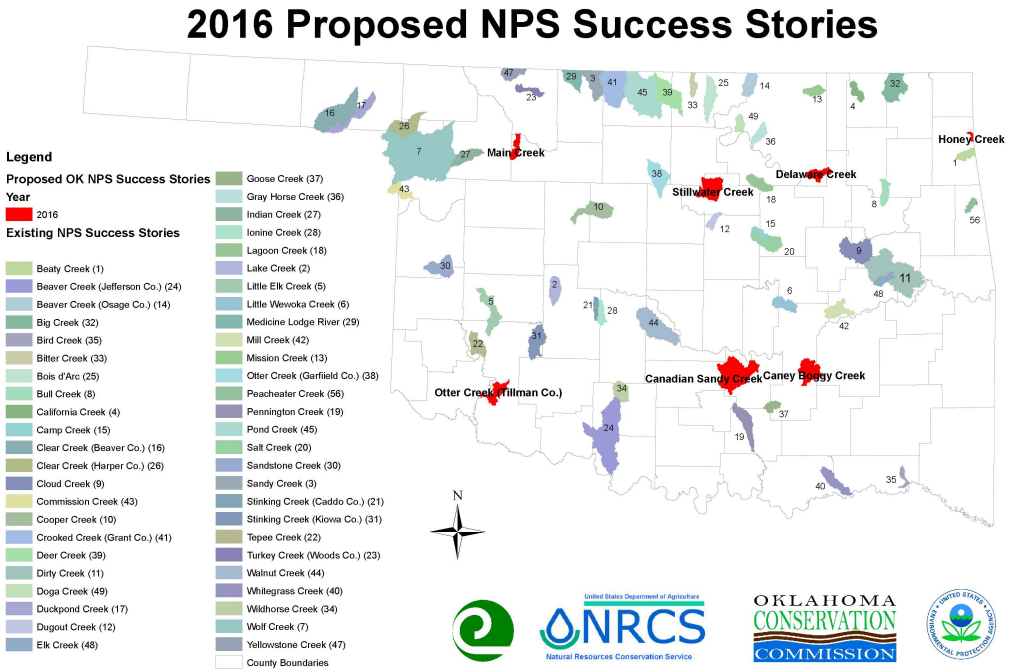
Led by the Oklahoma Conservation Commission (OCC), Oklahoma's Nonpoint Source Management program ranks second in the nation for the number of waterbody improvements documented on the Environmental Protection Agency's (EPA) "Nonpoint Source Success Stories" website (https://www.epa.gov/nps/nonpoint-source-success-stories). As of late 2016, these 53 stories represent the results of cooperative efforts between the local Natural Resources Conservation Service (NRCS), OCC, Conservation Districts, and volunteer landowners/producers to implement conservation practices to improve water quality. These successes represent streams that have been removed from the State's list of impaired waters (i.e., 303d List) for documented improvement in one or more water quality parameters. Candidates for success stories must meet stringent criteria that support likelihood of improvement due to conservation activities and management in the upstream watershed.

These stories reflect the synergistic efforts and funding of the Conservation Partnership in planning, implementation, and monitoring of instream water quality to document any improvements that result. Principle partners and their roles include: USDA-NRCS (financial and technical assistance); OCC (planning, monitoring, education, financial and technical assistance), US EPA (financial and technical assistance to OCC), local conservation districts (technical assistance, local management), state legislature (funding), local landowner/producer (voluntary participation in conservation implementation and cost share). Most success stories to date represent improvements due to reductions in bacteria, sediment, and nutrient loading from watersheds in the middle of "working lands" Oklahoma. Typical conservation practices which have led to the improvements chronicled in these stories include:

- Grazing Management
- Cross-fencing
- Alternative water supplies
- Supplemental hay planting
- Brush and weed management
- Nutrient management
- Heavy use area protection
- Conservation tillage (no-till, mulch till, strip till)
- Conservation crop rotations
- Waste storage facilities
- Contour farming (terraces, diversions, waterways)
- Riparian fencing

Funding for the implementation of these practices came from NRCS programs (federal funds), local cost-share (state funds), and from the landowners themselves. Funding for the monitoring that allowed documentation of the improvements was primarily from the EPA through the Section 319 Nonpoint Source Program. Please refer to Figure 4 for a map of NPS success stories (https://www.ok.gov/conservation/News/2016_Water_Quality_Success_Stories.html).

FIGURE 4. OKLAHOMA NON-POINT SOURCE MANAGEMENT SUCCESS STORIES



Superfund Program

Historical hazardous waste problems did not fit into the regulatory hazardous waste system until the passage of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund) of 1980. This act created a large scale national program to identify and remediate sites contaminated from historical hazardous waste problems and whose owners were no longer available or financially solvent to pay for the cleanup, or whose owners were no longer around. The term "Superfund" was coined to describe the source of funding for this program. Funding for remedial action was initially obtained from a national revolving fund. The fund obtained its monies through taxes paid on chemical feedstocks used in the manufacture of chemical products that were likely to become hazardous waste. This fund has not been reauthorized since 1996 and funding now relies on general appropriations from Congress. Superfund also established a mechanism to recover cleanup costs from potentially responsible parties.

DEQ's Superfund Program conducts and oversees pre-remedial and remedial activities on several Superfund sites. The Oklahoma Superfund Program relies on federal monies awarded through a cooperative agreement with EPA. There are fourteen sites (and one proposed site) in Oklahoma that are on the EPA National Priority List (NPL). EPA ranks sites for clean-up based on the actual or potential risks posed to human health or the environment.

DEQ's Voluntary Cleanup Program and Brownfields Program have several large Superfund-like sites that are undergoing investigation and cleanup. In addition to these larger sites the Voluntary Cleanup Program and the Brownfields program have dozens of sites that are undergoing remediation for groundwater contamination that are not listed here. There are also many RCRA sites that are undergoing corrective action for groundwater contamination that are not listed here.

DEQ also has authority under 27A O.S. §2-7-123 for risk based remediations, and/or 27A O.S. §2-15-107 for Brownfields sites to place notices on property deeds of risk-based remediation and also allows for restrictions on certain uses, including the use of groundwater if appropriate. Some of the sites listed below have such notices and restrictions filed in their respective county land records.

Refer to Table 14, "Superfund, NPL, and Non-NPL Sites Impacting on Groundwater and Surface Water" for a listing of sites within Oklahoma.

TABLE 14. SUPERFUND, NPL, AND NON-NPL SITES IMPACTING ON GROUNDWATER AND SURFACE WATER

Sites	Legal	County	Contaminant of Concern	Groundwater Impacted (Yes/No)	Surface Water Impacted (Yes/No)
Tar Creek Mining Activities	R24E T29N S16-21 R24E T29N S29-32 R24E T28N S5-6 R23E T28N S05-08 R23E T28N S18-19 R23E T28N S30 R23E T29N S13-36 R22E T28N S01 R22E T28N S12-13 R22E T28N S24-25 R22E T28N S30 R22E T29N S13 R22E T29N S24 R22E T29N S25 R22E T29N S36	Ottawa	Acid Water Cadmium Iron Lead Sulfates Zinc	Boone Aquifer Yes Roubidoux Aquifer, yes (locally near Picher and Quapaw)	Tar Creek Yes

Sites	Legal	County	Contaminant of Concern	Groundwater Impacted (Yes/No)	Surface Water Impacted (Yes/No)
Sand Springs Petrochemical Complex Refinery/ Solvent Recycling	R11E T19N S13-14	Tulsa	Volatile Organic Compounds	Arkansas River Alluvium Yes	Arkansas River (receives discharges but no identifiable impacts)
Compass Municipal Landfill	R12E T19N S18	Tulsa	Benzene Bleaches Caustics Jet Fuel PCBs Pesticides Solvents	Not Applicable	Arkansas River No
Hardage-Criner Industrial Landfill	R04W T06N S24	McClain	Acids Alcohols Caustics Metals Pesticides Solvents	North Criner Creek Alluvium Yes	North Criner Creek Yes
Tenth Street Salvage Yard	R02W T12N S31	Oklahoma	PCBs	North Canadian Alluvium No	North Canadian River No
Tinker AFB Aircraft Maintenance	R02W T11N S14 R02W T11N S23	Oklahoma	Organic Solvents (TCE) Chromium Petroleum Fuels	Garber-Wellington Aquifer Yes	Soldier Creek Yes
Fourth Street Refinery	SE4 SEC35 T12N R3W & SW4 SEC36 T12N R3W	Oklahoma	Lead BTEX Volatile Organic Compounds	Garber-Wellington Aquifer Yes North Canadian Alluvium Yes	North Canadian River No identifiable impacts
Mosley Road Landfill Municipal Landfill	R02W T12N S21	Oklahoma	Volatile Organic Compounds	Garber-Wellington Aquifer Yes North Canadian Alluvium Yes	North Canadian River No

Sites	Legal	County	Contaminant of Concern	Groundwater Impacted (Yes/No)	Surface Water Impacted (Yes/No)
Double Eagle Refinery Refinery	SE4 SEC35 T12N R3W & SW4 SEC36 T12N R3W	Oklahoma	Lead BTEX Volatile Organic Compounds	Garber-Wellington Aquifer Yes North Canadian Alluvium Yes	North Canadian River No
Oklahoma Refining Co Refinery	R09W T05N S18-19	Caddo	Metals VOCs Petroleum Organics Aromatic Hydrocarbons	Rush Springs Aquifer Yes	Gladys Creek Yes
Kerr-McGee Cushing Refinery Refinery	R05W T18N S22&27	Payne	Acid Oil Sludge Heavy Hydrocarbons	Unconfined Aquifer Yes Vamoosa-Ada Aquifer No	Skull Creek Yes
Kerr-McGee Cleveland Refinery Refinery	R08E T21N S18	Pawnee	Petroleum Coke Asbestos Acid Sludges	Cedar Creek Alluvium Yes Vamoosa-Ada Aquifer Yes	Cedar Creek Yes
Blackwell Zinc Smelter	R01W T27N S21	Kay	Metals	Chikaskia River Alluvium Yes	Unnamed tributary of Chikaskia River Yes
National Zinc	R12E T26N S11	Washington	Metals	Not Applicable	Unnamed tributary of Eliza Creek Cleaned up
Ringling Gasoline Spill	NW4 Sec.35 T4S R4W	Jefferson	BTEX and TPH-GRO	Yes	No
Tulsa Fuels & Manufacturing Smelter	NE4 SE4 NE4 SEC 31 & SW4 NW4 SEC32 T22N R14E 1M	Tulsa	Metals	No	Unnamed drainages Yes (sediment only)

Sites	Legal	County	Contaminant of Concern	Groundwater Impacted (Yes/No)	Surface Water Impacted (Yes/No)
Hudson Refining Refinery	SW4 SEC33 T18N R05E & NE4 NW4 SEC04 T17N R05E 1m	Payne	Hydrocarbons metals	Vanoss Aquifer Yes	Wastewater Ponds On-Site Cleaned up Skull Creek No
Duncan Refinery Refinery	R7W T1S S32	Stephens	Hydrocarbons	Garber Yes Alluvium Yes	Claridy Creek Yes
Collinsville Smelter Smelter	R14E T22N S32	Tulsa	Metals	No	Blackjack Creek Yes (sediment only)
U.S. Zinc Company Smelter	R13E T11N S6	Okmulgee	Metals	No	Yes
Coltec, Inc. Manufacturing	R13E T11N S3	Sequoyah	Solvent (PCE)	Boggy Formation Yes	No
Rab Valley Lumber	R25E T8N S15, S16	LeFlore	PAHs	Yes	Yes
Union Pacific Railroad	R7W T17N S14	Kingfisher	Carbon Tetrachloride	Yes	Yes
Okmulgee Refinery	R13E T13N S31 R13E T12N S6	Okmulgee	BTEX, Metals, PAHs	Yes	Yes
Imperial Refining Corporation	R2E T4S S20, S21	Carter	BTEX, Metals, PAHs	No	Wetlands Cleaned up
Clinton-Sherman Industrial Airpark Airbase	R19W T10N S10-11 R19W T10N S14-15	Washita	Trichloro-ethylene (TCE)	Elk City Sandstone Aquifer Yes	Not Applicable

Sites	Legal	County	Contaminant of Concern	Groundwater Impacted (Yes/No)	Surface Water Impacted (Yes/No)
Dobson Ranch	NW4 SEC 17 T11N R26W IM	Roger Mills	Benzene	Ogallala Yes	No
Cornerstone Shopping Center	SE4 SEC16 T 12N R 4W approx 6 acres of West Park Addition to Oklahoma City	Oklahoma	Tetrachloro-ethene	Quaternary Terrace Deposits Yes	No
Oklahoma City Urban Renewal - Phase I	21.6 acres of the NW4 SEC 3 T11N R3W	Oklahoma	Hydrocarbons	Alluvium and Terrace Deposits Yes	No
Blackstar Performance	SE4 SEC25 T20N R8E & NE4 SEC25 T20N R8E	Pawnee	Chlorinated solvents	Tallant Formation Yes	No
OKC Solvent Plume	80 acres in NE/4 S27 T12N R4W & NW/4 S27 T12N R4W	Oklahoma	Chlorinated solvents	N. Canadian Terrace Deposits Yes	No
Compass Industries Landfill	R12E T9N SEC18 & NE4 SE4 SEC 13 T 19N R 11E	Tulsa	SVOC	Yes	Yes
Anadarko Petroleum	NW1/4 Sec4 T22N R6W	Garfield	Petroleum Hydrocarbons and metals	Yes (Terrace Deposits)	No
Michelin/BFG	N1/2 SW1/4 T28N R22E	Ottawa	VOC	Yes	No
Halliburton Osage Road	SE ¼ of Section 8 Township 1N and Range 7W	Stephens County	Perchlorate, Nitrate	Yes, in the Chickasha and Duncan Formations	No, continues to be monitored
Wilcox Oil Company Refinery	N1/2 Section 29 T16N R9E	Creek	Hydrocarbons Metals	Yes	Sand Creek Unknown, under investigation
Eagle Industries	SESE Section 7 T11N R1W	Oklahoma	TCE	Yes	No

Surface Water Assessment

Surface Water Monitoring Program

The two agencies primarily responsible for carrying out Oklahoma's surface water monitoring programs are the OCC and OWRB.

Brief Summary of Oklahoma Conservation Commission Monitoring Activities

The Oklahoma Conservation Commission (OCC) operates an extensive monitoring program expanding to all areas of Oklahoma. Though OCC conducts several distinct types of monitoring activities, efforts are primarily focused on determining the occurrence, extent, and probable source(s) of non-point source (NPS) pollution and the effect(s) of conservation measures that abate it. Following is a summary of types of monitoring activities OCC conducts across the State.

1. Ambient Monitoring
    a. Routine effort to collect information about the physical, chemical, and biological characteristics of streams.
    b. Monitoring occurs at fixed stations over time to document status and trends. Fulfilled through OCC's Rotating Basin Monitoring Program (RBMP) through which approximately 250 sites are monitored for 24 months on a rotational basis every five years.
    c. Includes collection of physical, chemical, instream habitat, and biological data.
    d. Fulfills the Clean Water Act Section 319 mandate, "to monitor and assess the State's waters for the effects of NPS pollution."
    e. Primary reporting of assessment results occurs in OCC's Rotating Basin final reports (https://www.ok.gov/conservation/Agency_Divisions/Water_Quality_Division/WQ_Monitoring/WQ_Assessment_Rotating_Basin_Monitoring_Program.html) and in the State's biennial Integrated Report.

2. Diagnostic Monitoring
    a. Designed to examine issues discovered during ambient monitoring.
    b. Involves more refined sampling to determine suspected NPS pollution problems, identify most probable sources, and more accurately document cause(s) and effect(s) of discovered issues.
    c. May include land use assessment, modeling, more intensive water quality and biological assessments.

3. Implementation Monitoring
    a. Designed to determine the effects of conservation practices on water quality.
    b. Involves sampling before and after implementation efforts.
    c. Includes physical, chemical, and/or biological assessments and often involves use of automated sampling devices to collect continuous flow weighted samples.

4. Reference Condition Monitoring
    a. Designed to determine what conditions a healthy waterbody should exhibit as a scientific basis for comparison.
    b. Data collection ensures sufficient physical, chemical, and biological assessments to facilitate a ranking process for determination of high quality sites.
    c. Reference monitoring data will be made available to OWRB to help establish/refine biological criteria as part of State Water Quality Standards.

5. Volunteer Monitoring
    a. Designed to provide a continuing opportunity for applied water quality and environmental education.
    b. Volunteers are trained and certified for collection of select physical, chemical, and biological data used for basic assessment and general trend monitoring. OCC staffers supervise all biological collections at volunteer sites, allowing this information to be used for waterbody assessments.

The OCC conducts additional, specialized types of monitoring, although rather infrequently and generally at the request of other agencies/partners. Examples of specialized monitoring include support for:

- Protection of endangered species
- Total maximum daily load (TMDL) development
- Fluvial geomorphology (establishing the relationship between stream shape, climate, and the stream's location in the watershed)
- Documentation of pre- and post-restoration projects to assess effects (e.g., bank restoration or stabilization, in-stream habitat improvement)
- Community assessments for delisting streams when existing data is deemed insufficient or ambiguous
- Investigation of fish kills

All OCC monitoring is conducted in accordance with EPA-approved Quality Assurance Project Plans (QAPPs). These QAPPs are subject to peer agency review and approval by the Office of the Oklahoma Secretary of Energy & Environment. OCC monitoring efforts are coordinated with other state and federal environmental agencies to maximize the use of public resources.

Brief Summary of Oklahoma Water Resources Board Monitoring Activities

OWRB conducts routine monitoring throughout the State. The major monitoring program is the Beneficial Use Monitoring Program (BUMP) out of which an annual report is generated and distributed to all State legislators. BUMP targets sites on lakes and streams in cooperation with DEQ, OCC, and other State agencies. Parameters are selected in order to establish the overall health of State waters and to discover ambient trends, develop TMDLs, and support development of Water Quality Standards. The primary purpose of the BUMP is to assess the beneficial use support status of State surface waters.

In addition to BUMP, OWRB conducts several special monitoring efforts across the State. Parameters, sites, and frequency of monitoring are established on a case-by-case basis for each of these programs. All are established under formal contracts with the various entities.

- Statewide and Regional Probabilistic Monitoring
    - OWRB has completed and reported the second and third Statewide streams probabilistic study in Oklahoma. The report has been submitted to DEQ for inclusion the State's Integrated Report to fulfill OWRB's 305(b) reporting requirement
    - OWRB embarks on a fourth and fifth Statewide stream study in 2013 and will complete in 2015 and 2017, respectively. As before, the study will encompass a 4-year span of all sized flowing waterbodies as well as subsidiary assessment of condition for smaller and larger waterbodies and three large ecoregion groupings within the state.
    - OWRB is completing work on the second Statewide lakes probabilistic study in Oklahoma. The report will be submitted to EPA in 2015 and results will be included in the State's Integrated Report as necessary.
- Clean Lakes & Technical Studies
    - Eucha Lake
        - 319 NPS project installed 6,400 ft^2 of floating wetlands made from recycled plastic bottles
        - Assessing efficacy of floating wetlands to reduce the impact of nutria
    - Ft Cobb Lake
        - Established native aquatic plants in lacustrine fringe area in collaboration with the ODWC as part of a 319 NPS project
        - ODWC will maintain established founder colonies to assist with this long-term effort
    - Lake Thunderbird
        - Monitoring of lake to assess impact of installed SDOX system and determine additional actions to mitigate cultural eutrophication
        - Lake managers, COMCD, installed a liquid oxygen device to oxygenate the hypolimnion of the lake to improve raw drinking water quality through lowered organic content (algae growth) and more complete breakdown of detritus trapped in the hypolimnion
    - Ardmore City Lakes, Jean Neustadt; Scott King, Ardmore City and Mountain Lakes
        - Completed bathymetric/sedimentation surveys for al lakes
        - Complete firm yield analysis for incorporation into Ardmore's long range planning process

  - Waurika Lake
    - Collected bathymetric data of raw water intake area for dredging to ensure water availability during extreme drought (low water) conditions
    - OWRB will perform post dredging bathymetry for verification
  - Lake Stanley Draper
    - OWRB has assisted the City of Oklahoma City to extirpate the invasive aquatic plant, Giant Reed *Phragmites australis*, from the shoreline reducing long term sedimentation, nutrient enrichment and aesthetics.
- Biological Assessments
  - Aimed at establishing biological criteria for inclusion in the Water Quality Standards
  - Combines physical, chemical, and biological measurements in a holistic approach
  - Are making condition assessments for fish, macroinvertebrates, and sestonic and benthic chlorophyll-α in flowing waters, as well as sestonic chlorophyll-α in lakes. Eventually, will make assessments for periphyton communities in flowing waters and zooplankton in lakes.

- Impaired Waterbody Monitoring – 303(d) List
  - Site-specific monitoring under various contracts with DEQ, OCC, and Oklahoma Corporation Commission
  - Aimed at verifying impaired waters listings and/or developing TMDLs
  - All monitoring activities are coordinated with the other state and federal agencies that collect water quality data in order minimize duplication of efforts.

Brief Summary of Oklahoma Corporation Commission Monitoring Activities

The Corporation Commission (Corp Comm) does four types of environmental monitoring:

1. Soil sampling at spill and other potential pollution case sites;
2. Well water sampling near spill and other potential pollution source sites (ground water impacts are discussed in the Ground Water Quality section);
3. Stream water sampling near spills, pits, purging wells, and other potential pollution sources;
4. Stream, and other surface water sampling in historic oilfield areas, to determine the overall impact of historical oilfield activity on the waters of the State; and

Corp Comm continues to perform and work with partners on general stream water quality and standards sampling. Currently, the majority of Corp Comm's surface water sampling has been in relation to nearby pollution cases, due to budgetary constraints. However, all surface water sampling results are considered in making recommendations and providing support for water quality decisions for the Integrated Report, including the 303(d) impaired stream listings.

Assessment Methodology

The following methodologies, along with the procedures described in Figure 5 near the end of this section, shall be used to determine the attainment status of a waterbody's designated beneficial uses and its subsequent categorization in this Integrated Water Quality Report.

A waterbody that is listed on the State's current 303(d) list may only be placed in category 1,2, or 3 of the Integrated Report for "good cause" or if it is demonstrated that new data or information indicate that the waterbody is attaining its designated beneficial uses. "Good cause" shall mean that the State will provide a reasonable basis for the recommendation such as flaws in the original analysis that led to the water being listed; more recent or accurate data; more sophisticated water quality modeling; changes in conditions (e.g., new control equipment or elimination of discharges); or data is insufficient or non-existent to assess that all uses are met and the water should more appropriately be in Category 2 or 3.

Waterbodies in categories 2 & 3 will be prioritized in a manner similar to the category 5 waterbodies. A monitoring schedule will be included for categories 2 & 3 as part of the Integrated Report. Waterbodies included on the most recent 303(d) list will receive the highest priority for future monitoring.

Use Support Assessment Protocol

These procedures closely follow those set forth in the State's Use Support Assessment Protocol (USAP), which can be found in OAC 785:46-15. Where the USAP is silent, this listing methodology should be used. Where there are discrepancies between this methodology and the USAP, the USAP controls.

Beneficial Uses

The Listing Methodology is categorized into beneficial uses. Each beneficial use has a procedure for determining attainment of that use based on various kinds of biological, chemical, and historical data. The result of applying this methodology for any given beneficial use must be one of three choices: "attained", "not attained," and "not enough data to make a determination."

Some beneficial uses have procedures for several different types of data, all of which must be determinable – unless otherwise specified – in order to determine that the beneficial use is attained. Otherwise, the attainment decision must be designated "not enough data to make a determination."

Data Requirements

The data used to make a determination must meet various quantity, quality, spatial, and temporal requirements in order to satisfy the attainment procedures. The following general requirements apply unless otherwise specified in the use-specific procedures that follow. If neither an "attained" nor "not attained" determination can be made, then the overall determination for that beneficial use or subcategory shall be "not enough data to make a determination."

Spatial

- In general, stream sampling locations should take into consideration existing data, spatial distribution of monitoring sites, sources of pollution, and major hydrological features such as tributaries and dams.
- Non-wadable stream samples may represent a maximum of 25 stream miles.
- Wadable stream samples may represent a maximum of 10 stream miles.
- Lake samples may represent a maximum of 250 acres per sample. Arms or portions of lakes may be treated separately from the main body of a lake.
- Samples may not be taken within regulatory mixing zones.

Temporal

- Sampling must represent seasonal variation. Temporal bias should be avoided.
- Multiple samples for a parameter collected on the same stream segment on the same date will be aggregated into one average value representative of the stream condition on that date. This sample aggregation is performed to prevent temporal bias.
- Stream data older than five (5) years should not be used to make use attainment determinations unless insufficient data exists for the previous five (5) year period.
- Lake data older than ten (10) years should not be used to make use attainment determinations unless insufficient data exists for the previous ten (10) year period.

Quantity

- For streams, a minimum of ten (10) samples is required to determine use attainment for parameters such as DO, pH, temperature, coliform bacteria, dissolved solids, and salts.
- For lakes of more than 250 surface acres, a minimum of twenty (20) samples is required to determine use attainment for parameters such as DO, pH, temperature, coliform bacteria, chlorophyll-α, and dissolved solids. For lakes of 250 surface acres or less, a minimum of ten (10) samples is required.
- For toxicants, a minimum of five (5) samples is required to determine use attainment.

- For any type of sample, if existing samples already assure a "not attained" determination, the minimum sample quantity requirement does not apply.

PQLs

Criteria above PQL

If sample values are below the PQL (Practical Quantitation Limit) for a parameter whose criterion is above the PQL, appropriate nonparametric statistical measures shall be used to determine the reporting value.

For waterbodies identified as impaired on the current Integrated Report, if sample values are nondetectable for a parameter whose criterion is above the PQL, then such value shall be deemed to be one-half (1/2) of the parameter PQL.

All sample values that are above the PQL shall be the reported values.

Criteria below PQL

If sample values are below the PQL for a criterion which is less than one-half (1/2) of the PQL, then the values shall be deemed to be zero (0) until the first test result above the PQL appears. After that time, sample values which are below the PQL shall be deemed to be equal to the criterion value until four (4) subsequent contiguous samples are shown to be below the PQL. Any subsequent sample values which are nondetectable may be treated as zero (0) until the next test result appears above the PQL.

For those parameters whose criteria are at least two (2) orders of magnitude below the PQL, evidence considered with respect to assessment of use support shall include fish tissue analysis, biological community analysis, biological thresholds wherever available, or other holistic indicators which are appropriate for the beneficial use in question.

If sample values are below the PQL for a criterion which is greater than or equal to one-half (1/2) of the PQL but less than the PQL, then the values shall be deemed to be one-half (1/2) of the criterion value until the first test result above the PQL appears. After that time, sample values which are below the PQL shall be deemed to be equal to the criterion value until four (4) subsequent contiguous samples are shown to be below the PQL. Any subsequent sample values which are nondetectable may be treated as equal to one-half (1/2) of the criterion value until the next test result appears above the PQL.

For waterbodies identified as impaired in the current Integrated Report, if sample values are nondetectable for a parameter whose criterion is below the PQL, then such value shall be deemed to be one-half (1/2) of the criterion value.

All sample values that are above the PQL shall be the reported values.

Magnitude of Exceedance

- For toxicants, if two or more samples exceed water quality criteria or screening levels by two orders of magnitude or more, the associated beneficial use is determined to be "not attained."
- For DO, if more than two samples in a stream are below 2 mg/L in a given year, the Fish & Wildlife Propagation beneficial use is determined to be "not attained."

Quality Assurance

Data collected for purposes of use support assessment shall be collected using documented programmatic quality assurance and quality control methods substantially in accordance with those required by "EPA Requirements for Quality Assurance Project Plans", EPA publication no. EPA/240/B-01/003 (March 2001).

The methods used shall include protections for sample integrity and the documentation of details on analysis methodologies.

Default Protocol

This method for determining beneficial use attainment should be used where another, more specific method is not provided.

Short Term Average Parameters

Short term average parameters are based on exposure periods of less than seven days, such as sample standards (agriculture beneficial use) and turbidity.

A beneficial use is considered *attained based on the default protocol for a given short term average parameter* if:

10% or fewer of the samples exceed the appropriate screening level or water quality criterion

or

the determination using the default protocol yields "fully supporting but threatened" and the threat will not yield a determination of other than fully supporting within two years of the determination.

A beneficial use is considered *not attained based on the default protocol for a given short term average parameter* if:

greater than 10% of the samples exceed the appropriate screening level or water quality criterion

or

the determination using the default protocol yields "fully supporting but threatened" and the threat will yield a determination of other than fully supporting within two years of the determination.

Long Term Average Parameters

Long term average parameters are based on exposure periods of seven days or longer, such as yearly mean standards (agriculture beneficial use) and fish consumption water column numerical criteria.

A beneficial use is considered *attained based on the default protocol for a given long term average parameter* if:

each 2-year rolling average of the sample results does not exceed the long term average criterion or screening level

or

the determination using the default protocol yields "fully supporting but threatened" and the threat will not yield a determination of other than fully supporting within two years of the determination.

A beneficial use is considered *not attained based on the default protocol for a given long term average parameter* if:

any 2-year rolling average of the sample results exceeds the long term average criterion or screening level

or

the determination using the default protocol yields "fully supporting but threatened" and the threat will yield a determination of other than fully supporting within two years of the determination.

Fish & Wildlife Propagation (F&WP)

The methodology for the Fish & Wildlife Propagation (F&WP) beneficial use consists of eight types of data, each with its own attainment methodology.

The F&WP beneficial use is considered *attained* if:

in the absence of biological data, all six *chemical* methodologies (DO, Toxicants, pH, Turbidity, Oil & Grease, and Toxicants Not Assessed & Not Likely to Occur or Violate Criteria) result in a determination of *attained*

or

*in the absence of adequate data for **all six** chemical data types*, the biological data methodology results in a determination of *attained*.

The F&WP beneficial use is considered *not attained* if ***any*** of the eight data type methodologies result in a determination of *not attained*.

Dissolved Oxygen (DO)

Streams

A minimum of ten (10) samples is required to make an attainment determination.

The F&WP beneficial use is considered *attained with respect to dissolved oxygen* if 10% or fewer of the samples from a waterbody have a DO concentration of less than:

- 4.0 mg/L from April 1 - June 15 (3.0 mg/L from June 16-March 31) for habitat limited aquatic communities (HLAC)
- 6.0 mg/L from April 1 - June 15 (5.0 mg/L from June 16 – March 31) for warm water aquatic communities (WWAC)
- 7.0 mg/L from March 1 - May 31 (6.0 mg/L for the remainder of the year) for trout fisheries and cool water aquatic communities (CWAC)

The F&WP beneficial use is considered to be *undetermined* if the sample results show:

- More than 10% of samples are less than 6.0 mg/L from April 1 – June 15 (5.0 from June 16 – October 15) *and* 10% or fewer of the samples are less than 5.0 mg/L from April 1 – June 15 (4.0 from June 16 – October 15) for warm water aquatic communities (WWAC)
- More than 10% of samples are less than 7.0 mg/L from March 1 – May 31 (6.0 from June 1 – October 15) *and* 10% or fewer of the samples are less than 6.0 mg/L from March 1 – May 31 (5.0 from June 1 – October 15) for trout fisheries and cool water aquatic communities (CWAC).

The F&WP beneficial use is considered *not attained with respect to dissolved oxygen* if more than 10% of the samples from a waterbody have DO concentrations less than the criteria listed below or if more than 2 samples in a given year are below 2 mg/L.

- 4.0 mg/L from April 1 – June 15 (3.0 from June 16 – March 31) for habitat limited aquatic communities (HLAC)
- 5.0 mg/L from October 16 – June 15 (4.0 mg/L from June 16 – October 15) for warm water aquatic communities (WWAC)
- 5.0 mg/L from June 1 – Oct 15 (6.0 mg/L during the remainder of the year) for trout fisheries and cool water aquatic communities (CWAC)

Lakes

For lakes or arms of 250 acres or less, a minimum of ten (10) samples is required to make an attainment determination. For lakes or arms of greater than 250 acres, a minimum of twenty (20) samples is required.

The Warm Water Aquatic Community subcategory of the Fish and Wildlife Propagation designated use for a lake shall be deemed to be attained with respect to dissolved oxygen if both the Surface Criteria and the Water Column Criteria listed below are satisfied. If either the Surface or Water Column criteria produce an undetermined result, the lake beneficial use will be considered *undetermined* with respect to dissolved oxygen. If either the Surface or Water Column criteria produce a result of not attained, the Fish and Wildlife Propagation designated use will be considered *not attained* with respect to dissolved oxygen.

Surface Criteria for WWAC Lakes

The F&WP beneficial use is considered *attained with respect to dissolved oxygen* if:

10% or less of the samples from the epilimnion during periods of thermal stratification, or the entire water column when no stratification is present, are less than 6.0 mg/L from April 1 – June 15 (5.0 mg/L during the remainder of the year).

The F&WP beneficial use is considered *undetermined with respect to dissolved oxygen* if:

More than 10% of the samples from the epilimnion during periods of thermal stratification, or the entire water column when no stratification is present, are less than 5.0 mg/L from June 16 through October 15 (6.0 mg/L from April 1 – June 15)

and

10% or less of the samples are less than 4 mg/L from June 16 through October 15 (5.0 mg/L from April 1 – June 15),

The F&WP beneficial use is considered *not attained with respect to dissolved oxygen* if:

More than 10% of the samples from the epilimnion during periods of thermal stratification, or the entire water column when no stratification is present, are less that 4.0 mg/L from June 16 – October 15 (5.0 mg/L during the remainder of the year).

Water Column Criteria for WWAC Lakes

The F&WP beneficial use is considered *attained with respect to dissolved oxygen* if:

Less than 50% of the lake volume has a DO concentration below 2.0 mg/L

or

If no volumetric data is available, 50% or less of the water column of all sample sites in the lake have a DO concentration below 2.0 mg/L.

The F&WP beneficial use is considered *undetermined* with respect to dissolved oxygen if:

50% or more, but not greater than 70%, of the lake water column at any sample site has a DO concentration of less than 2.0 mg/L

The F&WP beneficial use is considered *not attained with respect to dissolved oxygen* if:

50% or more of the water volume has a DO concentration of less than 2.0 mg/L

or

If no volumetric data is available, more than 70% of the water column at any given sample site has a DO concentration of less than 2 mg/L.

Toxicants

A minimum of five (5) samples is required to make an attainment determination.

The following screening values shall be used to make attainment decisions for toxicants:

- the acute and/or chronic criteria for a given toxicant, as described in Appendix G, Table 2 of the Oklahoma Water Quality Standards, OAC 785:45
- the chronic ammonia toxicity value shown in Table 15 corresponding to the stream pH and temperature at the time of sampling

For metals, preference shall be given to attainment decisions based on dissolved metals in accordance with the procedures specified in OAC 785:46-15-5(h).

Acute Effects

The F&WP beneficial use is considered *attained with respect to an individual toxicant* if no more than one (1) of the samples have concentrations of a toxicant that exceed the acute criterion or screening value for that toxicant.

The F&WP beneficial use is considered not attained with respect to an individual toxicant if more than one (1) of the samples have concentrations of a toxicant that exceed the acute criterion or screening value for that toxicant.

Chronic Effects

The F&WP beneficial use is considered *attained with respect to an individual toxicant* if:

not more than one (1) of the samples have concentrations of a toxicant that exceed the chronic criterion or screening value for that toxicant

or

not more than 10% of the samples have concentrations of a toxicant that exceed the chronic criterion or screening value for that toxicant

The F&WP beneficial use is considered *not attained with respect to an individual toxicant* if more than 10% of the samples have concentrations of a toxicant that exceed the chronic criterion or screening value.

TABLE 15. TEMPERATURE- AND PH-DEPENDENT SCREENING VALUES FOR AMMONIA

	Temperature (°C)									
pH	0	14	16	18	20	22	24	26	28	30
6.5	6.67	6.67	6.06	5.33	4.68	4.12	3.62	3.18	2.80	2.46
6.6	6.57	6.57	5.97	5.25	4.61	4.05	3.56	3.13	2.75	2.42
6.7	6.44	6.44	5.86	5.15	4.52	3.98	3.50	3.07	2.70	2.37
6.8	6.29	6.29	5.72	5.03	4.42	3.89	3.42	3.00	2.64	2.32
6.9	6.12	6.12	5.56	4.89	4.30	3.78	3.32	2.92	2.57	2.25
7.0	5.91	5.91	5.37	4.72	4.15	3.65	3.21	2.82	2.48	2.18
7.1	5.67	5.67	5.15	4.53	3.98	3.50	3.08	2.70	2.38	2.09
7.2	5.39	5.39	4.90	4.31	3.78	3.33	2.92	2.57	2.26	1.99
7.3	5.08	5.08	4.61	4.06	3.57	3.13	2.76	2.42	2.13	1.87
7.4	4.73	4.73	4.30	3.78	3.32	2.92	2.57	2.26	1.98	1.74
7.5	4.36	4.36	3.97	3.49	3.06	2.69	2.37	2.08	1.83	1.61
7.6	3.98	3.98	3.61	3.18	2.79	2.45	2.16	1.90	1.67	1.47
7.7	3.58	3.58	3.25	2.86	2.51	2.21	1.94	1.71	1.50	1.32
7.8	3.18	3.18	2.89	2.54	2.23	1.96	1.73	1.52	1.33	1.17
7.9	2.80	2.80	2.54	2.24	1.96	1.73	1.52	1.33	1.17	1.03
8.0	2.43	2.43	2.21	1.94	1.71	1.50	1.32	1.16	1.02	0.897
8.1	2.10	2.10	1.91	1.68	1.47	1.29	1.14	1.00	0.879	0.773

8.2	1.79	1.79	1.63	1.43	1.26	1.11	0.973	0.855	0.752	0.661
8.3	1.52	1.52	1.39	1.22	1.07	0.941	0.827	0.727	0.639	0.562
8.4	1.29	1.29	1.17	1.03	0.906	0.796	0.700	0.615	0.541	0.475
8.5	1.09	1.09	0.990	0.870	0.765	0.672	0.591	0.520	0.457	0.401
8.6	0.920	0.920	0.836	0.735	0.646	0.568	0.499	0.439	0.386	0.339
8.7	0.778	0.778	0.707	0.622	0.547	0.480	0.422	0.371	0.326	0.287
8.8	0.661	0.661	0.601	0.528	0.464	0.408	0.359	0.315	0.277	0.244
8.9	0.565	0.565	0.513	0.451	0.397	0.349	0.306	0.269	0.237	0.208
9.0	0.486	0.486	0.442	0.389	0.342	0.300	0.264	0.232	0.204	0.179

pH

A minimum of ten (10) samples is required to make an attainment determination.

The F&WP beneficial use is considered *attained with respect to pH* if 10% or fewer of the samples fall outside the screening range of 6.5 (minimum) and 9.0 (maximum).

The F&WP beneficial use is considered *not attained with respect to pH* if more than 10% of the samples fall outside the screening range of 6.5 (minimum) and 9.0 (maximum).

Biological Data

Following are two stand-alone methods for determining impairment based on biological samples—one for benthic macroinvertebrates (BMI) and another for fish. Each acts independent of the other because of the availability of separate cause codes for bioassessments. A cause code does exist for a combined bioassessment, but that particular scenario is not addressed in this methodology. Oklahoma has implemented narrative biocriteria for fish in its Use Support Assessment Protocols (OAC 785:46-15-5(i)), and these biocriteria are included as part of the assessment tool outlined below. However, the same section (OAC 785:46-15-5(i)(1)) states "If data demonstrate that an assemblage of fish or macro invertebrates from a waterbody is significantly degraded, according to 785:45-5-12(f)(5), from that expected for the subcategory of Fish and Wildlife Propagation designated in OAC 785:45 for that waterbody, then that subcategory may be deemed by the appropriate State environmental agency to be not supported." Because of this, it is imperative that a method be developed to assess the large of amount of BMI data collected to date and in the future. Also, it is important to utilize fish data across the State, when the fish biocriteria is either inconclusive (i.e., "undetermined") or unavailable in a particular ecoregion or for a particular aquatic life designation within a promulgated ecoregion. For this reason an alternative fish assessment method has been developed and included in the following methodology. However, the Oklahoma biocriteria trumps the alternative method whenever it returns an assessment of attaining or not attaining.

Biological criteria have been established for various ecoregions in Oklahoma under OAC 785:46-15-5 (see Figure 5). These biocriteria must be referenced when making Fish and Wildlife beneficial use attainment determinations for fish in accordance with method below. OAC 785:46 Appendix C Index of Biological Integrity should be used for these ecoregions. This methodology is only applicable to wadable streams.

For waterbodies where no biological data is available, a resulting determination of "*attained*" with respect to all six chemical data type methodologies (DO, pH, Toxicants, Turbidity, Oil & Grease, and Toxicants Not Assessed & Not Likely to Occur or Violate Criteria) may serve to determine attainment of the F&WP beneficial use.

For waterbodies where *only* biological data is available, a determination of "*attained*" with respect to biological assessment(s) (in accordance with method below) may serve to determine attainment of the F&WP beneficial use. Determinations of attainment of F&WP for both/either fish and/or benthic macroinvertebrates may be made in accordance with the following methods:

Assessment of F&WP Beneficial Use with Fish Collection Data

- Data requirements: Fish collections must be made in accordance with methods outlined in OWRB Technical Report 99-3, Oklahoma Conservation Commission Standard Operating Procedures (SOPs), Oklahoma Water Resources Board SOPs or equivalent and collected under an EPA approved Quality Assurance Project Plan. Collections should be made during a defined seasonal index period (index) in

flowing water. A maximum of 5 collections are allowed for assessment determination for the reporting period (1 index period per year, 5 year reporting period).

Definitions:

- **Collection** – all fish obtained from a single site on a given date.
- **Index** – one seasonal period prescribing defined temporal limits for collection. (Late Spring – Early Fall index – May 15-October 31).

- Collections must be completely enumerated and identified to species. Taxonomic identifications should be performed using keys contained in The Fishes of Oklahoma, The Fishes of Arkansas, or The Fishes of Missouri. Adequate voucher samples should be maintained through specimen collections and/or photo-documentation per SOPs in Section 1.
- Collections must be analyzed using an Index of Biotic Integrity (IBI) approach (EPA, 1989, 1999) comprised of the seven following metrics: number of species, number of sensitive benthic species, number of sunfish species, number of intolerant species, proportion tolerant individuals, proportion insectivorous cyprinid individuals, proportion individuals as lithophilic spawners. The metrics must be derived and scored for each sample in accordance with methods outlined in EPA's Rapid Bioassessment Protocol (EPA 1989 and 1999) (see Table 16). Consult ecoregion reference metric scores (available from OWRB or OCC Water Quality Division offices) as necessary to facilitate scoring process. This method will be known as "OKIBI".

TABLE 16. MATRIX TO DETERMINE METRIC SCORES FOR EACH SAMPLE OF FISH

Metrics	5	3	1
Number of species*	>67%	33-67%	<33%
Number of sensitive benthic species*	>67%	33-67%	<33%
Number of sunfish species*	>67%	33-67%	<33%
Number of intolerant species*	>67%	33-67%	<33%
Proportion tolerant individuals**	<10%	10-25%	>25%
Proportion insectivorous cyprinid individuals**	>45%	20-45%	<20%
Proportion individuals as lithophilic spawners**	>36%	18-36%	<18%

* Sample metric divided by the reference metric for the applicable ecoregion
** Score based on actual value

1. Metric scores for each collection must then be summed to compute a "total OKIBI score." Scores for multiple collections made during the same index for a given year must be averaged to render a single per year score. Total OKIBI scores will then be compared to reference OKIBI scores (available from OWRB or OCC Water Quality Division offices) for the appropriate ecoregion in order to determine final fish support status (Table 17) (adapted from EPA RBP, 1989):

TABLE 17. BIOLOGICAL CONDITION AND ASSOCIATED SUPPORT STATUS BASED UPON FISH COLLECTIONS

% of Reference OKIBI score	Biological Condition Category	Sample Support Status
>80%	Not impaired	Attaining
50-80%	Possible impairment to no impairment	Undetermined
<50	Impaired	Not Attaining

2. Overall fish support status for the OKIBI is determined considering support status of all collections obtained within the reporting period as follows:
   a. If only one sample was collected - support status stands as called
   b. If two or more samples were collected:
      - Determine support status based on majority

- In instances when no majority exists, the final result is undetermined

3. Use Table 18 to determine the final Fish and Wildlife Propagation (FWP) beneficial use assessment for fish. In the following table, fish biocriteria that have been promulgated in Oklahoma's USAP are referred to as OKBIOCRIT, while the method outlined in this document is referred to as OKIBI. *You must determine an OKBIOCRIT result for all collections where applicable. The OKIBI can only be used when the OKBIOCRIT returns an undetermined result or is not promulgated in rule for a particular ecoregion or aquatic life tier.*

TABLE 18. FINAL FWP USE ASSESSMENT BASED UPON FISH COLLECTIONS

OKBIOCRIT Result	OKIBI Result	Final Fish Assessment
Not Available	Attaining	Attaining
Not Available	Not Attaining	Not Attaining
Not Available	Undetermined	Undetermined
Undetermined	Attaining	Attaining
Undetermined	Not Attaining	Not Attaining
Undetermined	Undetermined	Undetermined
Attaining	Undetermined	Attaining
Not Attaining	Undetermined	Not Attaining

Assessment of F&WP Beneficial Use with Benthic Macroinvertebrate Data

1. Data requirements: Macroinvertebrate collections must be made in accordance with methods outlined in OWRB Technical Report 99-3, Oklahoma Conservation Commission (OCC) Standard Operating Procedures (SOPs), Oklahoma Water Resources Board (OWRB) SOPs or equivalent and collected under an EPA approved Quality Assurance Project Plan. Collections should be made during defined seasonal index periods (index) in flowing water and target best available habitats in the following order of importance: rocky riffles, streamside root masses, and woody debris. A minimum of four macroinvertebrate samples (collected over at least a two year period) is required for assessment. A maximum of 10 collections are allowed for the reporting period (2 index periods per year, 5 year reporting period).

   Definitions:

   - **Sample** – macroinvertebrates resulting from a single habitat type (riffle, vegetation, wood) from a single site on a given date.
   - **Collection** – all samples obtained from a single site on a given date. A single collection may include up to three samples, one from each habitat type.
   - **Index** – one of two seasonal periods prescribing defined temporal limits for collection. (Summer index – June 1-September 15; Winter Index – January 1-March 15th).

2. Samples must be picked in accordance with EPA approved SOPs to achieve either a 100 or 300 organism sub-sample to be sent to professionals for identification to genus (when possible). Taxonomic identifications should be performed using keys by Merritt and Cummins, Pennak, or other regional guides with justification.

3. Samples must be analyzed using an Index of Biotic Integrity (IBI) approach (EPA, 1989, 1999) comprised of the six following metrics: total number of taxa, number of EPT taxa, proportion EPT taxa, proportion dominant two taxa, modified Hilsenhoff Biotic Index (HBI), and Shannon Diversity. The metrics must be derived and scored for each sample (e.g., summer-riffle, winter-wood) in accordance with methods outlined in EPA's Rapid Bioassessment Protocol (EPA 1989 and 1999) (see Table 19). Consult ecoregion reference metric scores (available from OWRB or OCC Water Quality Division offices) as necessary to facilitate scoring process.

TABLE 19. MATRIX TO DETERMINE METRIC SCORES FOR EACH SAMPLE OF MACROINVERTEBRATES

Metrics	6	4	2	0
Taxa Richness*	>80%	60-80%	40-60%	<40%
Modified HBI**	>85%	70-85%	50-70%	<50%
EPT/Total***	>30%	20-30%	10-20%	<10%
EPT Taxa*	>90%	80-90%	70-80%	<70%
% Dominant 2 Taxa***	<20%	20-30%	30-40%	>40%
Shannon-Weaver***	>3.5	2.5-3.5	1.5-2.5	<1.5

* sample metric divided by the reference metric for the applicable ecoregion

** reference metric value for the applicable ecoregion divided by the sample metric value

***score based on actual value

4. Metric scores for each sample must then be summed to compute a "total IBI score." Scores for multiple collections made during the same index for a given year must be averaged to render a single index-habitat score per year (e.g., only one score for summer-riffle or winter-wood per year). Total IBI scores will then be compared to reference IBI scores (available from OWRB or OCC Water Quality Division offices) for the appropriate index-habitat and ecoregion to determine final macroinvertebrate support status (Table 20) (adapted from the EPA RBP, 1989). If the macroinvertebrate sample was made as part of a probabilistic monitoring project use Table 19 to determine sample support status.

TABLE 20. BIOLOGICAL CONDITION & ASSOCIATED SUPPORT STATUS BASED UPON MACROINVERTEBRATE SAMPLES

% of Reference IBI score	Biological Condition Category	Sample Attainment Status
>80%	Non-impaired	Attaining
50-80%	Possible impairment to no impairment	Undetermined
<50	Impaired	Not attaining

TABLE 21. BIOLOGICAL CONDITION & ASSOCIATED SUPPORT STATUS BASED UPON PROBABILISTIC MACROINVERTEBRATE SAMPLES

% of Reference IBI score	Biological Condition Category	Sample Attainment Status
>85%	Non-impaired	Attaining
40-85%	Possible impairment to no impairment	Undetermined
<40	Impaired	Not attaining

5. With support status of samples determined, render macroinvertebrate support status for each **collection** as follows:

   a. If a riffle sample was collected, use the support status of the riffle sample to represent the collection.

   b. If riffle sample status is "undetermined," then the support status of the collection will be determined by the better of vegetation or wood scores.

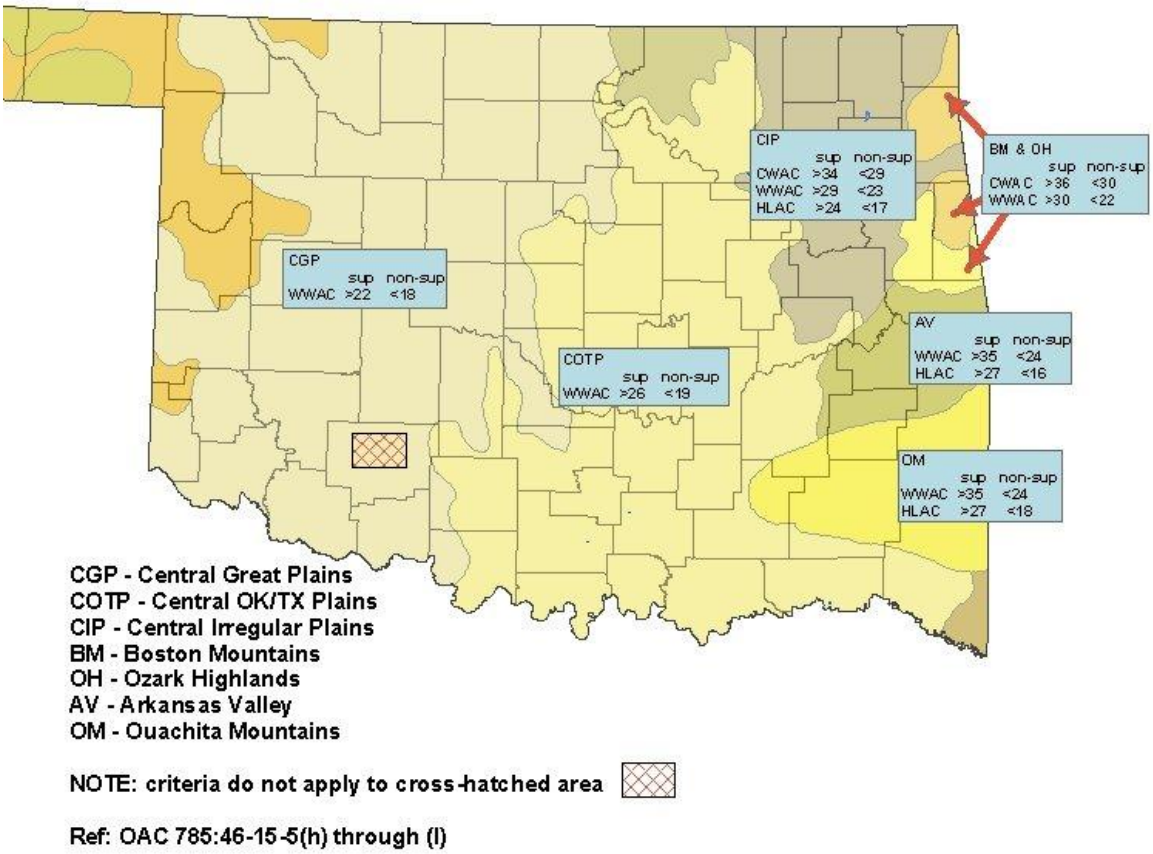
   c. If all samples are "undetermined," then the macroinvertebrate support status for the collection is "undetermined."

6. A minimum of four macroinvertebrate samples (collected over at least a two year period) is required for assessment. Overall Fish and Wildlife Propagation (FWP) beneficial use attainment for macroinvertebrates is determined considering support status of all collections obtained within the reporting period in accordance with Table 22.

TABLE 22. FINAL FWP USE ATTAINMENT DETERMINATION BASED UPON MACROINVERTEBRATES.

Minimum number of "Attaining" collections	Number of "Undetermined" collections	Number of "Not Attaining" collections	Final Macroinvertebrate Assessment
2	any	0	Attaining
any	any	1	Undetermined
any	any	2 or more	not attaining

FIGURE 5. ECOREGIONS WHERE BIOCRITERIA HAVE BEEN ESTABLISHED



Turbidity

A minimum of ten (10) samples collected under seasonal base flow conditions is required to make an attainment determination.

The following numerical criteria shall be used to make attainment decisions for turbidity:

- 10 Nephelometric Turbidity Units (NTUs) for cool water aquatic communities and trout fisheries
- 25 NTUs for lakes
- 50 NTUs for other surface waters

The F&WP beneficial use is considered *attained with respect to turbidity* if:

10% or fewer of the samples exceed the appropriate screening level or water quality criterion.

or

the numerical criteria yield a determination of "fully supporting but threatened" and the threat will not yield a determination of other than fully supporting within two years of the determination.

The F&WP beneficial use is considered *not attained with respect to turbidity* if:

Greater than 10% of the samples exceed the appropriate screening level or water quality criterion

or

the numerical criteria yield a determination of "fully supporting but threatened" and the threat will yield a determination of other than fully supporting within two years of the determination.

The determination of seasonal base flow conditions should be made in accordance with the following methods:

- For recording gaged sites (including ones with gages at the site or near to the site with no intervening inflows):
    1. Calculate the mean and median discharge of the 30 days surrounding the sampling event.
    2. If Q at sampling event not greater than median—**considered baseflow conditions, use in assessment;** OR

       If Q at sampling event greater than median—look at mean
    3. If Q at sampling event not greater than mean, go to step 4; OR

       If Q at sampling event greater than mean - **considered above baseflow conditions, exclude from assessment.**
    4. If Q is greater than the median but not the mean, use the weight of evidence method described below.
- For non-recording gaged or ungaged sites use a weight of evidence of coincident parameters (e.g., instantaneous discharge, turbidity, conductivity, total phosphorus, and total suspended solids), relevant weather station information (as available and applicable), and observational data (e.g., presence of a defined periphyton line, site comments, quantitative flow rating such as “elevated” or “heavy”). Perform the following steps:
    1. Compile concurrent turbidity, turbidity cause qualifier (i.e., abiotic, biotic), Inst. Q, TP, TSS, conductivity, and site observation data (which includes qualitative stream stage and site comments). Sort by site and date.
    2. For each site, move through the data looking for inflections in Inst. Q supported by similar inflections in concurrent parameters (e.g., increase in TP, TSS; decrease in conductivity). Quite a few of the elevated flows are indicated by the qualitative stream stage and site comments (e.g., “recent rainfall”), so the determination is immediate. Mark these events as exceeding baseflow.
    3. Where applicable and practical, compare analysis to nearby mesonet data. This cannot be used to preclude the above analysis but can be used as a confirmation step to add to the weight of evidence approach.
    4. Remove the “elevated flows” and perform the analysis.

For sites where all turbidity values are below the applicable criterion, determination of events exceeding baseflow conditions is not necessary.

Oil & Grease

A minimum of ten (10) visual observations made over a period of at least ten (10) months is required to make an attainment determination.

Any of the following visual characteristics shall indicate the presence of oil or grease:

- a rainbow sheen that flows when stirred, rather than crackling
- a golden tan to dark brown coating or globules on the water or in stream sediment

The F&WP beneficial use is considered *attained with respect to oil & grease* if 10% or fewer observations reveal the presence of oil or grease.

The F&WP beneficial use is considered *not attained with respect to oil & grease* if more than 10% of the observations reveal the presence of oil or grease.

Sediment

The F&WP beneficial use is considered *attained with respect to sediment* if the use is also attained with respect to biological criteria.

If the biological data assessment results in a determination of "not attained," a habitat assessment must be conducted using the habitat assessment protocols found in OWRB Technical Report TRWQ2001-1, "Unified Protocols for Beneficial Use Assignment for Oklahoma Wadable Streams."

The results of the habitat assessment shall then be compared to either historical conditions or regional reference conditions in order to determine attainment with respect to sediment. The method for establishing reference conditions shall meet the following requirements:

- a minimum of five (5) reference streams or reaches shall be assessed
- the reference streams or reaches must be within the same ecoregion as the test stream
- the reference streams or reaches must be within streams with similar flow regimes no more than two (2) stream orders(as defined in 46:1-2) removed from the test stream
- the reference streams or reaches shall be selected from the least impacted streams within the ecoregion whose watersheds contain soils, vegetation, land uses, and topography typical of the watershed of the test stream.

The F&WP beneficial use is considered *not attained with respect to sediment* if any of the following habitat parameters deviate from the reference conditions by the specified amount:

- Pool Bottom Substrate – the total percent of clay, silt, and loose sand in the test stream is increased by more than 30% over the reference condition
- Cobble Embeddedness – cobble embeddedness is increased by 15% or more over the reference condition
- Point Bars and/or Islands – reach length percentage containing fresh (non-vegetated) point bars and/or islands is 20 or more percentage points above that of the reference condition
- Deep Pools – percentage of reach dominated by deep (0.5 meters or more) pools is less than 70% of that of the reference condition

If all of the habitat parameters identified above deviate from the reference conditions by less than the amounts specified, then the Fish and Wildlife Propagation beneficial use is not impaired due to suspended and bedded sediments.

Toxicants Not Assessed and Not Likely to Occur or Violate Criteria

The data required to assess every water quality criterion – specifically toxicants – associated with the F&WP use do not always exist for a particular waterbody. The following procedure may be used to determine attainment of the F&WP beneficial use with respect to toxicants that have not been assessed, but are not likely to occur or violate criteria.

The following three types of information must be available in order to apply this procedure:

1. The results of a review of watershed-specific landuse and historical data that yields patterns of use or nonuse of the toxicant(s) not assessed.

2. A result of either "attained" or "not enough information" for the Toxicants methodology.

3. A result of either "attained" or "not enough information" for the Biological Data methodology.

NOTE: The decision matrix below may be used to determine *attainment of the F&WP beneficial use with respect to the unassessed toxicants* ***only if*** the landuse and historical data review yields no indication that the unassessed toxicants are present or likely to impact the waterbody in question.

TABLE 23. DECISION MATRIX FOR TOXICANTS NOT ASSESSED OR LIKELY TO OCCUR OR VIOLATE F&WP CRITERIA

		Biological Data	
		Attained	Not Enough Information
Toxicants	Attained	F&WP ***Attained*** With Respect To Unassessed Toxicants	F&WP ***Attained*** With Respect To Unassessed Toxicants
	Not Enough Information	F&WP ***Attained*** With Respect To Unassessed Toxicants	***Not Enough Information*** to Determine F&WP Attainment With Respect to Unassessed Toxicants

Primary Body Contact Recreation (PBCR)

A minimum of ten (10) samples is required to make an attainment determination. Samples must be taken during the recreation period of May 1 – September 30.

Geometric means will be calculated using all data meeting the temporal data requirements. The geometric means will be compared to the appropriate screening value.

Escherichia coli (*E. coli*)

The PBCR beneficial use is considered *attained with respect to E. coli* if:

the geometric mean of the samples does not exceed 126 colonies/100 mL

The PBCR beneficial use is considered *not attained with respect to E. coli* if:

the geometric mean of the samples exceeds 126 colonies/100 mL

Enterococci

The PBCR beneficial use is considered *attained with respect to Enterococci* if:

the geometric mean of the samples does not exceed 33 colonies/100 mL

The PBCR beneficial use is considered *not attained with respect to Enterococci* if:

the geometric mean of the samples exceeds 33 colonies/100 mL

Secondary Body Contact

Attainment for the SBCR beneficial use is identical to the PBCR attainment methodology, but using five times (5x) the PBCR numerical criteria and screening levels.

Public and Private Water Supply (PPWS)

In order to determine attainment of the PPWS beneficial use, samples must be taken at the point of a drinking water intake.

Toxicants

A minimum of ten (10) samples is required to make an attainment determination.

The PPWS beneficial use is considered *attained with respect to any individual toxicant* for which there is a water quality criterion established if:

10% or fewer of the samples have concentrations of a toxicant that exceed the criterion for that toxicant

and

no drinking water use restrictions related to source water contamination are in effect

The PPWS beneficial use is considered *not attained with respect to any individual toxicant* for which there is a water quality criterion established if:

more than 10% of the samples have concentrations of a toxicant that exceed the criterion for that toxicant

or

a drinking water use restriction related to source water contamination is in effect

Total Coliform

A minimum of ten (10) samples is required to make an attainment determination.

The following numerical criterion shall be used to make attainment decisions for bacteria:

- 5000 colonies/100 mL

The PPWS beneficial use is considered *attained with respect to bacteria* if:

the numerical criterion yields a determination of "fully supporting" using the default protocol

or

the numerical criterion yields a determination of "fully supporting but threatened" using the default protocol if the threat will not yield a determination of other than fully supporting within two years of the determination

or

the Primary Body Contact Recreation use is attained.

The PPWS beneficial use is considered *not attained with respect to bacteria* if:

the numerical criterion yields a determination of "not supporting" using the default protocol

or

the numerical criterion yields a determination of "fully supporting but threatened" using the default protocol ***if*** the threat will yield a determination of other than fully supporting within two years of the determination.

Oil & Grease

A minimum of ten (10) visual observations made over a period of at least ten (10) months is required to make an attainment determination.

Any of the following visual characteristics shall indicate the presence of oil or grease:

- a rainbow sheen that flows when stirred, rather than crackling
- a golden tan to dark brown coating or globules on the water or in stream sediment

The PPWS beneficial use is considered *attained with respect to oil & grease* if 10% or fewer observations reveal the presence of oil or grease.

The PPWS beneficial use is considered *not attained with respect to oil & grease* if more than 10% of the observations reveal the presence of oil or grease.

Parameters Not Assessed and Not Likely to Occur or Violate Criteria

The data required to assess every water quality criterion associated with PPWS does not always exist for a particular waterbody. In those cases, the following procedure should be followed in order to make an attainment decision.

For parameters not assessed or which are not likely to occur or violate criteria, attainment decisions should be made based on two kinds of information:

1. the results of analysis of chemical-specific parameters routinely monitored by the State's Beneficial Use Monitoring Program (BUMP) as compared to State criteria associated with PPWS
2. the results of a review of watershed-specific landuse and historical data that yields patterns of use for the pollutant in question

The PPWS beneficial use is considered *attained with respect to unassessed parameters* if:

the waterbody is attaining the PPWS use for BUMP parameters according to the Toxicants section of this listing methodology

and

no suspicion of the presence of the unassessed parameters exists based on landuse and historical data review

Chlorophyll-α and Phosphorus

Certain water supplies have specific criteria for chlorophyll-α and/or total phosphorus as specified in OAC 785:45-5-10(7) and (8). Attainment of these criteria will be evaluated using the specified criteria and the long-term average default protocol.

Emergency Water Supply (EWS)

All waterbodies designated with the Emergency Water Supply beneficial use shall be deemed to be attaining the beneficial use for all water quality related issues.

Agriculture

Total dissolved solids (TDS)

A minimum of ten (10) samples is required to make an attainment determination.

The Agriculture beneficial use is considered *attained with respect to TDS* if:

no TDS sample exceeds 700 mg/l

or

the mean of all TDS samples does not exceed the yearly mean standard (YMS) for TDS as listed in the Oklahoma Water Quality Standards (OAC 785:45 Appendix F) or site-specific/watershed-specific criteria (if the YMS in Appendix F is below 700 mg/L, then 700 mg/L shall be used for assessment)

and

10% or fewer TDS samples exceed the sample standard (SS) for TDS as listed in the Oklahoma Water Quality Standards (OAC 785:45 Appendix F) or site-specific/watershed-specific criteria. (if the SS in Appendix F is below 700 mg/L, then 700 mg/L shall be used for assessment)

The Agriculture beneficial use is considered *not attained with respect to TDS* if:

At least one TDS sample exceeds 700 mg/l

and

more than 10% of the samples exceed the sample standard (SS) for TDS as listed in the Oklahoma Water Quality Standards (OAC 785:45 Appendix F) or site-specific/watershed-specific criteria (if the SS in Appendix F is below 700 mg/L, then 700 mg/L shall be used for assessment)

or

the mean of all samples exceeds the yearly mean standard (YMS) for TDS as listed in the Oklahoma Water Quality Standards (OAC 785:45 Appendix F) or site-specific/watershed-specific criteria. (if the YMS in Appendix F is below 700 mg/L, then 700 mg/L shall be used for assessment)

Chlorides

A minimum of ten (10) samples is required to make an attainment determination.

The Agriculture beneficial use is considered *attained with respect to chlorides* if:

no chloride sample exceeds 250 mg/l

or

the mean of all samples does not exceed the yearly mean standard (YMS) for chlorides as listed in the Oklahoma Water Quality Standards (OAC 785:45 Appendix F) or site-specific/watershed-specific criteria (if the YMS in Appendix F is below 250 mg/L, then 250 mg/L shall be used for assessment)

and

10% or fewer samples exceed the sample standard (SS) for chlorides as listed in the Oklahoma Water Quality Standards (OAC 785:45 Appendix F) or site-specific/watershed-specific criteria. (if the SS in Appendix F is below 250 mg/L, then 250 mg/L shall be used for assessment)

The Agriculture beneficial use is considered *not attained with respect to chlorides* if:

At least one chloride sample exceeds 250 mg/l

and

more than 10% of the samples exceed the sample standard (SS) for chlorides as listed in the Oklahoma Water Quality Standards (OAC 785:45 Appendix F) or site-specific/watershed-specific criteria (if the SS in Appendix F is below 250 mg/L, then 250 mg/L shall be used for assessment)

or

the mean of all samples exceeds the yearly mean standard (YMS) for chlorides as listed in the Oklahoma Water Quality Standards (OAC 785:45 Appendix F) or site-specific/watershed-specific criteria. (if the YMS in Appendix F is below 250 mg/L, then 250 mg/L shall be used for assessment)

Sulfates

A minimum of ten (10) samples is required to make an attainment determination.

The Agriculture beneficial use is considered *attained with respect to sulfates* if:

no sulfate sample exceeds 250 mg/l

or

the mean of all samples does not exceed the yearly mean standard (YMS) for sulfates as listed in the Oklahoma Water Quality Standards (OAC 785:45 Appendix F) or site-specific/watershed-

specific criteria (if the YMS in Appendix F is below 250 mg/L, then 250 mg/L shall be used for assessment)

and

10% or fewer samples exceed the sample standard (SS) for sulfates as listed in the Oklahoma Water Quality Standards (OAC 785:45 Appendix F) or site-specific/watershed-specific criteria. (if the SS in Appendix F is below 250 mg/L, then 250 mg/L shall be used for assessment)

The Agriculture beneficial use is considered *not attained with respect to sulfates* if:

At least one sulfate sample exceeds 250 mg/l

and

more than 10% of the samples exceed the sample standard (SS) for sulfates as listed in the Oklahoma Water Quality Standards (OAC 785:45 Appendix F) or site-specific/watershed-specific criteria (if the SS in Appendix F is below 250 mg/L, then 250 mg/L shall be used for assessment)

or

the mean of all samples exceeds the yearly mean standard (YMS) for sulfates as listed in the Oklahoma Water Quality Standards (OAC 785:45 Appendix F) or site-specific/watershed-specific criteria. (if the YMS in Appendix F is below 250 mg/L, then 250 mg/L shall be used for assessment)

Navigation

All waterbodies designated with the Navigation beneficial use shall be deemed to be attaining the beneficial use for all water quality related issues.

Aesthetics

Nutrients

The Aesthetics beneficial use is considered *attained with respect to nutrients* if a nutrient impairment study yields a result of "fully supporting."

The Aesthetics beneficial use is considered *not attained with respect to nutrients* if a nutrient impairment study yields a result of "impaired."

Only a nutrient impairment study may be used to make a determination of *not attained* for aesthetics with respect to nutrients.

Wadable Streams

The aesthetics beneficial use for wadable streams is considered *attained with respect to nutrients* if application of the dichotomous process or application of the alternative to dichotomous process specified in OAC 785:46-15-10 yields a result of “not threatened.”

Lakes and Nonwadable Streams

The aesthetics beneficial use for lakes and nonwadable streams is considered *attained with respect to nutrients* if planktonic chlorophyll-a values in the water column indicate a Carlson's Trophic State Index of less than 62.

Phosphorus

The phosphorus water quality standard applies to waters designated as a Scenic River.

A minimum of ten (10) samples is required to make an attainment determination. Samples must meet the data requirements of OAC 785:46-15-10(h)(2).

Attainment decisions will be made using the procedure specified in OAC 785:46-15-10(h).

Oil & Grease

A minimum of ten (10) visual observations made over a period of at least ten (10) months is required to make an attainment determination.

Any of the following visual characteristics shall indicate the presence of oil or grease:

- a rainbow sheen that flows when stirred, rather than crackling
- a golden tan to dark brown coating or globules on the water or in stream sediment

The aesthetics beneficial use is considered *attained with respect to oil & grease* if 10% or fewer observations reveal the presence of oil or grease.

The aesthetics beneficial use is considered *not attained with respect to oil & grease* if more than 10% of the observations reveal the presence of oil or grease.

Fish Consumption

The Fish Consumption beneficial use is considered *attained* if:

> the numerical criteria for fish consumption in the Oklahoma Water Quality Standards [OAC 785:45-5-20(b)] yields a determination of "fully supporting" using the default protocol for long-term average numerical parameters
>
> ***or***
>
> the numerical criteria for fish consumption in the Oklahoma Water Quality Standards [OAC 785:45-5-20(b)] yields a determination of "fully supporting but threatened" using the default protocol for long-term average numerical parameters if the threat will not yield a determination of other than fully supporting within two years of the determination.

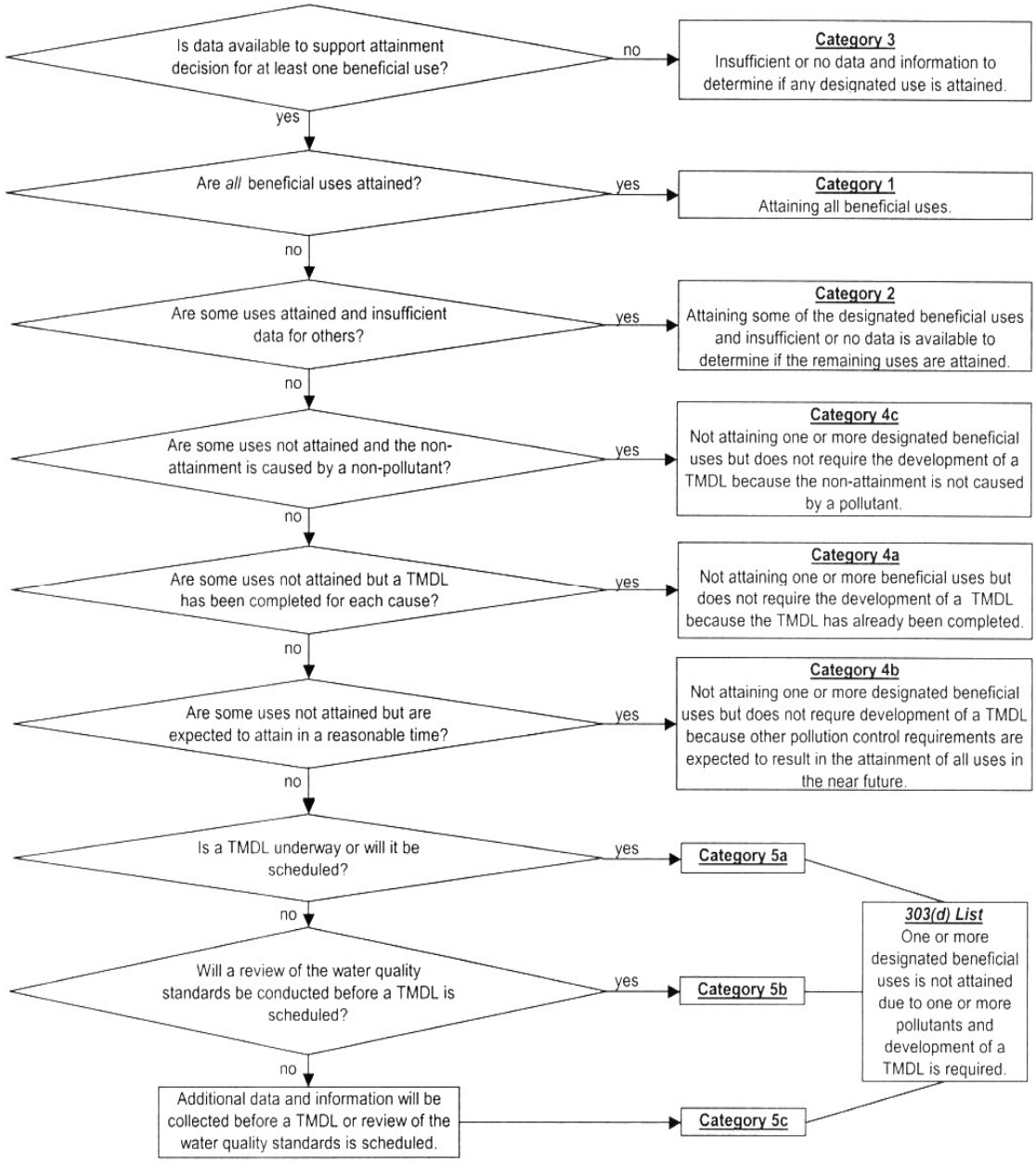
The Fish Consumption beneficial use is considered *not attained* if any of the following conditions apply:

- The numerical criteria for fish consumption in the Oklahoma Water Quality Standards [OAC 785:45-5-20(B)] yields a determination of “not supporting” or “partially supporting” using the default protocol for long-term average numerical parameters.
- a site-specific consumption restriction is imposed
- a site-specific fish or shellfish ban is in effect for a sub-population thereof
- a site-specific aquatic life closure is in effect
- a site-specific "no consumption" advisory is in effect

Category Decision Methodology

The Integrated Water Quality Report contains five categories that describe different levels of beneficial use attainment in each of the State's waters. Each waterbody should be assessed for attainment of each of its individual designated beneficial uses using the methodology outlined above. Following that assessment, the decision tree in Figure 6 below should be used to assign each waterbody to an appropriate category.

FIGURE 6. INTEGRATED REPORT CATEGORY DECISION TREE



Causes of Non-Attainment

The previous methodology outlines the procedures for determining attainment of each designated beneficial use assigned to a waterbody. Causes of non-attainment must also be included in the State's Integrated Water Quality Assessment Report.

The causes and cause codes shown in Table 17 should be applied where applicable to each waterbody upon making a determination of non-attainment for any given designated beneficial use or subcategory of that use. Additional cause codes may be added to the State's Integrated Report in order to provide for numerical criteria in the State's Water Quality Standards not already represented with a cause code.

Sources of Non-Attainment

Sources are the activities, facilities, or conditions that contribute pollutants or stressors resulting in impairment of designated uses in a waterbody.

Determining the sources of designated use impairment can be a difficult process. Ambient monitoring data can give good evidence of the causes of impairment. In some cases, field observations can provide information on obvious, nearby problems; e.g., land use, substrate, and habitat may provide a basis for identifying sources. This is especially the case for "hydromodification" sources.

In most cases, additional information is needed – watershed land use inventories, records of permit compliance, locations of areas with highly erodible soils, areas with poor BMP (best management practice) implementation, measurements of in-place contaminants, or loadings from atmospheric transport or ground water.

For some waterbodies, potential non-point sources have been assigned to a cause using GIS data. Initially, an extensive list of potential sources for each cause is compiled. Geographical information such as the location of permitted activities (e.g., NPDES sources, CAFOs, oil & gas wells) and land use information (e.g., roads, pastures, cropland, municipal boundaries) is then compared to each watershed. Subsequently, potential sources not indicated by the geographic data are removed from the list of potential sources for a watershed. Potential sources not eliminated by the geographic information remain on the list as a potential source of impairment for waterbodies in the watershed.

This method of assigning potential sources has not been applied to all waterbodies and/or causes on the 2016 303(d) list. The intent is to use this methodology to assign potential sources to all 303(d) waterbodies for subsequent 303(d) lists.

A partial list of potential sources is shown in Table 18. Other source codes may be added as the need arises.

TABLE 24. CAUSE CODES

Cause	Cause Code
Ammonia (Unionized) - Toxin	91
Arsenic	96
Barium	104
Cadmium	127
Chloride	138
Chlorophyll-α	150
Chlorpyrifos	153
Chromium (total)	154
Color	160
Copper	163
DDT	214
Diazinon	187
Dieldrin	198
Enterococcus	215
Escherichia coli	217
Fishes Bioassessments (Streams)	230
Lead	267
Nitrates	302
Oil and Grease	317
Oxygen, Dissolved	322
Selenium	372
Sedimentation/Siltation	371
Silver	375
Sulfates	385
Temperature, water	388
Thallium	393
Total Dissolved Solids	399
Toxaphene	496
Fecal Coliform	400
Turbidity	413
Zinc	423
pH	441
Phosphorus (Total)	462

TABLE 25. SOURCE CODES

Potential Source	Source Code
Acid Mine Drainage	2
Agriculture	156
Animal Feeding Operations (NPS)	4
Atmospheric Deposition – Acidity	8
Atmospheric Deposition - Toxics	10
CERCLA NPL (Superfund) Sites	16
Clean Sediments	21
Discharges from Biosolids (SLUDGE) Storage, Application or Disposal	33
Discharges from Municipal Separate Storm Sewer Systems (MS4)	34
Dredging (E.g. for Navigation Channels)	38
Drought-related impacts	39
Grazing in Riparian or Shoreline Zones	46
Highway/Road/Bridge Runoff (Non-construction related)	49
Impacts from Land Application of Wastes	59
Impacts from Abandoned Mine Lands (Inactive)	56
Impacts from Hydrostructure Flow Regulation/Modification	58
Industrial Point Source Discharge	62
Irrigated Crop Production	66
Land Application of Wastewater Biosolids (Non-agricultural)	68
Landfills	69
Leaking Underground Storage Tanks	70
Mine Tailings	82
Municipal (Urbanized High Density Area)	84
Municipal Point Source Discharges	85
Natural Sources	155
Non-irrigated Crop Production	87
On-site Treatment Systems (Septic Systems and Similar Decentralized Systems)	92
Other Spill Related Impacts	97
Permitted Runoff from Confined Animal Feeding Operations (CAFOs)[1]	100
Petroleum/Natural Gas Production Activities (Legacy)	102
Rangeland Grazing	108
Releases from Waste Sites or Dumps	110

Residential Districts	111
Silviculture Harvesting	119
Spills from Trucks or Trains	124
Surface Mining	127
Source Unknown	140
Sources Outside State Jurisdiction or Borders	146
Total Retention Domestic Sewage Lagoons	128
Wastes from Pets	133
Wildlife Other than Waterfowl	136

TABLE 26. USEFUL INFORMATION IN DETERMINING SOURCES OF BENEFICIAL USE NON-ATTAINMENT

Source Category	Example Types of Information
Industrial Point Sources	Permit compliance records • analysis of DMRs • compliance monitoring or special monitoring in permits • WET or TIE bioassay tests Monitoring/modeling studies • upstream/downstream chemical, biological, and habitat monitoring • intensive surveys combined with WLA/TMDL modeling • complaint investigations • data from volunteer monitoring
Municipal Point Sources	Permit compliance records • analysis of routine DMRs • compliance monitoring or special monitoring in permits • WET or TIE toxicity bioassay tests Monitoring/modeling studies • upstream/downstream chemical, biological, and habitat monitoring • intensive surveys combined with WLA/TMDL modeling • complaint investigations • data from volunteer monitoring
Combined Sewer Overflows (CSOs)	Permit compliance records • records of nonachievement of targets for frequency of wet weather overflows • implementation of other minimum control and pollution prevention methods (as in EPA CSO Control Policy) Monitoring/modeling studies • upstream/downstream chemical, biological, or physical monitoring comparing wet weather and normal flow conditions • intensive surveys combined with WLA/TMDL modeling • complaint investigations

Source Category	Example Types of Information
Agricultural Point Sources (e.g., CAFOs)	Permit compliance records • observation of overflows from total retention (non-discharge) facilities • compliance with provisions for off-site disposal of animal wastes (e.g., land application, composting) Monitoring studies • upstream/downstream chemical, biological, or physical monitoring (especially for nutrients and pathogens) • complaint investigations
Agriculture (NPS)	Information from monitoring and field observations (e.g., to document bad actors) • edge of field monitoring of runoff from animal holding areas, cropped areas, or pastures • monitoring of inputs from irrigation return flows, sub-surface drains, or drainage ditches • proper installation of screens or other measures to avoid fish losses in drainage/irrigation ditches • serious rill or gully erosion in agricultural fields • sedimentation problems in agricultural watersheds • indications of unmanaged livestock in streamside management zones • complaint investigations or data from volunteer monitoring or inventories Records on watershed BMP implementation status • documented low implementation level (e.g., less than a 70% target) of recommended water quality BMPs • documented problems with specific agricultural operators Modeling • use of such models as AGNPS, SWAT or ANSWERS to estimate pollutant loads and improvement from BMP implementation • intensive surveys combined with WLA/TMDL modeling
Silviculture (NPS)	Monitoring and field observations documenting instances of high sediment delivery to receiving waters • BMPs not followed on logging road, skid paths, or stream crossings • BMPs not followed to protect streamside management zones • serious sedimentation problems (cobble embeddedness or interstitial D.O. problems) in watersheds that are largely silvicultural Records on watershed BMP/management measure) • implementation status • documented low implementation level of recommended water quality-oriented BMPs Results of modeling or cumulative effects analyses • use of such models as WRENSS to estimate pollutant loads and likely improvement from BMP implementation • use of water temperature models to help quantify impacts on cold water fisheries • use of landscape analysis techniques (e.g., the RAPID method or Integrated Riparian Area Evaluation method) to document cumulative effects • intensive surveys combined with WLA/ TMDL modeling

Source Category	Example Types of Information
Construction	Information from monitoring and field observations (primarily to document problem areas or bad actors) • sedimentation problems documented in watersheds with major construction activity • complaint investigations and volunteer monitoring data Information from sediment control management agencies • records of implementation of sediment control measures
Urban Runoff & Storm Sewers	Monitoring/modeling studies • upstream/downstream chemical, biological, or habitat monitoring comparing wet weather and normal flow conditions near outfalls • special monitoring for BMP effectiveness-wet ponds, artificial wetlands, grass swales • intensive surveys combined with WLA/ TMDL modeling and catchment models such as SWMM • complaint investigations Information from management agencies • documented low implementation level of recommended/required water quality-oriented BMPs • documented problems with BMP operation and maintenance information from monitoring and field observations (primarily to document problem areas or bad actors)
Resource Extraction (Petroleum)	Information from monitoring and field observations (primarily to document problem areas or bad actors) • evidence of oil and brine spills affecting areas near receiving waters; elevated TDS, toxicity, oil and grease aesthetic impacts; increased erosion and sedimentation problems • complaint investigations and volunteer monitoring data Electro-Magnetic (EM) surveys, land or helicopter (HEM) based • Detect high conductivity/high cation/anion levels in soil • Detect high conductivity/high cation/anion levels in groundwater, up to ~60 m deep • High ion levels can be due to Na and Cl (natural, O&G brines), excess litter/fertilizer application, leaking waste pits, etc. Information from petroleum management agencies monitoring data in streams, shallow wells, and springs in oilfield areas • records of problems with spills, pipeline breaks, over-topping of pit berms, land application violations
Resource Extraction (mainly surface mining)	Information from monitoring and field observations (primarily to document problem areas or bad actors) • evidence of decreases in pH, toxicity from heavy metals, excessive sedimentation, or stream reaches with iron bacteria in watersheds with active mining • complaint investigations and volunteer monitoring data Information from mining management agencies • records of recurrent permit violations (e.g., over-berming of settling ponds, failure to contain leachates, or failure to revegetate or restore mined areas)

Source Category	Example Types of Information
Land Disposal	Monitoring and field observations (primarily to document problem areas or bad actors) • monitoring indicates leachate migration from disposal area or industrial or domestic leach field failures • complaint investigations and volunteer monitoring Modeling • solute transport or plume models (e.g., PRIZM) indicate high potential for pollutants to reach receiving water
Hydromodification (dams, flow regulation)	Monitoring and field observations • recurring problems with inadequate instream flows (e.g., dewatering of streams, reduced pollutant assimilation, unnatural water temperatures) • documented interference with fish migration and spawning movements (e.g., for such anadromous fish as salmon or rockfish but also for inland fish that seek spawning habitat outside lakes or large rivers) Modeling • analysis using PHABSIM or other instream flow models to document adverse impacts • analysis related to FERC permit renewal and State 401 Certification, habitat recovery plans under the ESA, or TMDL studies (e.g., problems with anoxic or nutrient-laden releases from hydrostructures)
Hydromodification (channelization, dredging, removal of riparian vegetation, streambank modification, draining/filling of wetlands)	Monitoring (usually over considerable period of time) documenting adverse changes: • severe channel downcutting or widening • elimination of vegetation in streamside management zones • excessive streambank erosion and sloughing • loss of significant wetland area in watershed • failure of wetland mitigation projects Modeling studies • decreases in pollutant assimilation from habitat modification • adverse impacts on hydrology, water temperatures, or habitat
Natural	Monitoring and field observations of the presence of sources that are clearly not anthropogenic • saline water due to natural mineral salt deposits • low DO or pH caused by poor aeration and natural organic materials • excessive siltation due to glacial deposits • high temperatures due to low flow conditions or drought Note: the Natural Sources category should be reserved for waterbodies impaired due to naturally occurring conditions

Prioritization of TMDL Development

After the final determination of beneficial use attainment is made, a four-level priority ranking for TMDL development will be established including waters targeted for TMDL development within the next two years (Priority 1). In accordance with EPA guidelines, priority determinations will take into account the severity of the impairments and the designated uses of the waters impacted. Waters in Category 5 (the State's 303(d) list) will be aggregated and prioritized according to their eleven digit hydrologic unit code (HUC11) watershed. The prioritization process will closely follow that used to develop the Unified Watershed Assessment except where changes are necessary due to programmatic and logistical differences between the two programs. Primary and secondary criteria were developed to evaluate and prioritize watersheds for TMDL development. The primary evaluation criteria used were the vulnerability of waters to degradation, the risks to public health and the threat to aquatic life.

A watershed's vulnerability for degradation was evaluated by first calculating the percentage of impaired waters for each HUC11 watershed based on the stream miles or equivalent stream miles (for lakes) listed as impaired divided by the total equivalent stream miles within the watershed. A Pollutant Priority Score was also developed and used based on a pairwise comparison matrix rank of all pollutant(s) and then calculating the mean of the values for those pollutants causing impairments within each watershed. The presence of protected waters or EQIP local emphasis areas were also used to evaluate watershed vulnerability.

The threat to public health was also considered in the prioritization by evaluating both the population served by Public Water Supplies (PWS) and number of PWS intakes in the watershed. In both cases the more population served and the higher the number of intakes the more weight given to the risks to public health.

In assessing of the threats to aquatic life within a watershed consideration was given to the presence of threatened or endangered species along with the area of waters of recreational and/or ecological significance listed in Appendix B of the Oklahoma Water Quality Standards. Calculating the percent change in wetland area for each HUC11 watershed along with the presence of priority wetlands designated by the United States Fish and Wildlife Service were also used to evaluate the threats to aquatic life.

The outline below summarizes both the primary and secondary criteria used to establish the TMDL priority for each HUC11 watershed.

1) **Vulnerability of waterbodies to degradation**
    a) Percent Stream Length/Lake Area Impaired
    b) Pollutant Priority Score (Pairwise pollutant comparison rating)
    c) Pristine Waters
        i) Scenic Rivers
        ii) Outstanding Resource Waters
        iii) High Quality Waters
        iv) Sensitive Water Supplies
    d) EQIP Local Emphasis Area
2) **Risks to public health**
    a) Public Water Supply Customers
    b) Public Water Supply Intakes
3) **Threat to aquatic life and other water-dependent wildlife**
    a) Presence of threatened and endangered species.
    b) Area of Waters of Recreational and/or Ecological Significance (Appendix B)
    c) Wetland Area
        i) Presence of USFWS Priority Wetlands
        ii) Change in Wetland Area

The priority ranking was established by giving each of the criteria above a ranking/points based on its overall importance. The criteria rankings or points were then totaled to give an overall score for each watershed. Table 27 below contains a more detailed summary of the actual weight given to each criterion.

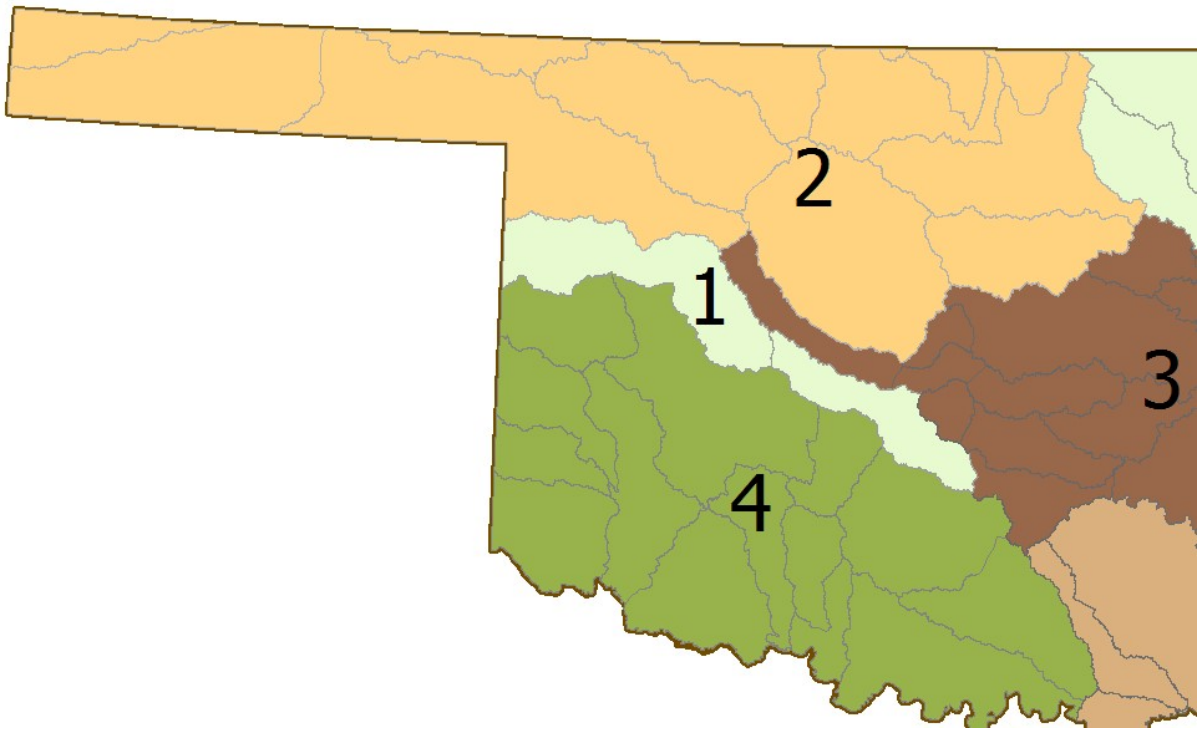
TABLE 27. TMDL PRIORITIZATION-POINT RANKING

Points	Total Percent Impaired	Pollutant Priority Score	Wetland Percent Change	USFWS T&E Species	USFWS Wetland Priority	EQIP Local Emphasis Area	Highest Designated Protected Waterbody	Percent Appendix B Areas	PWS Intakes in HUC	PWS Customers Served
15	85	> 75th Quartile	>20%	≥ 3			Scenic R or ORW		≥ 4	≥ 100,000
10	65	Median to 75th Quartile	>10% to 20%	2			HQW		3	99,999 to 10,000
5	45	25th Quartile to Median	>5 to 10%	1	Yes	Yes	SWS	Upper 50th Percentile	2	9,999 to 1,000
3	25	< 25th Quartile	1 to 5%					Lower 50th Percentile	1	999 to 1
0	0	No Impairments	Gain or <1%		No	No		None	0	0

Future Monitoring

Where practicable, the State's Rotating Basin plan (Figure 7) will be used to schedule data collection projects for Oklahoma Conservation Commission stream monitoring activities.

FIGURE 7. ROTATING BASIN PLAN WATERSHEDS BY YEAR



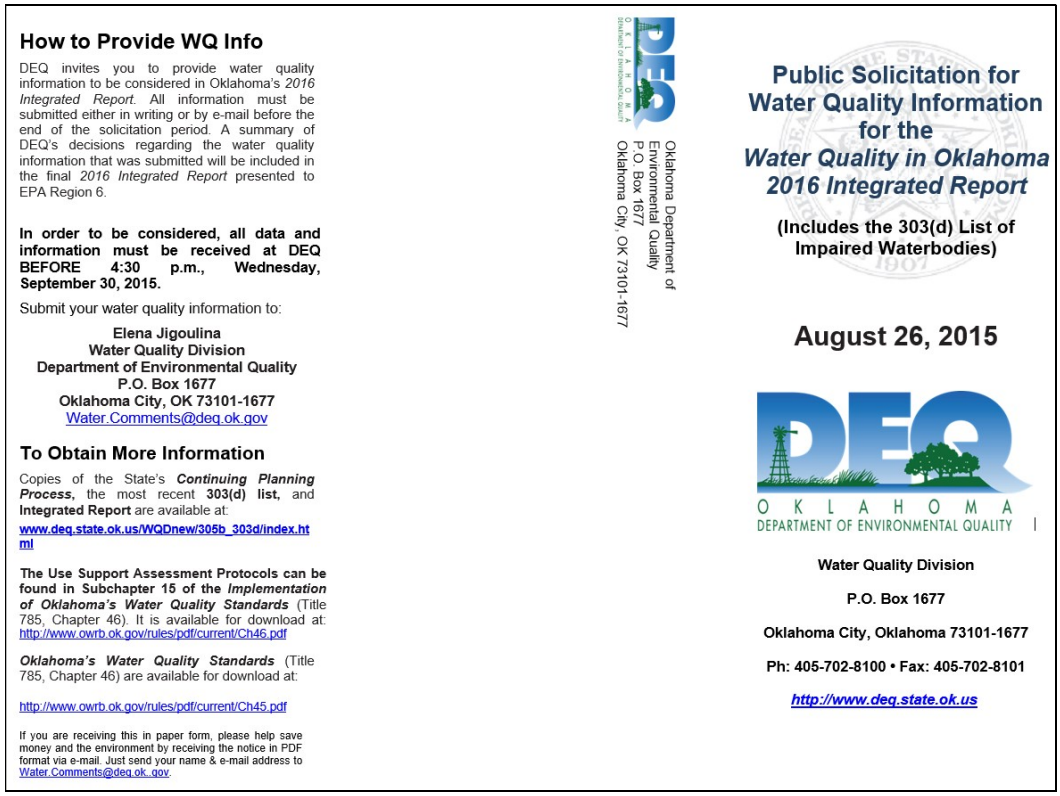
Coordination, Review, And Approval

DEQ has coordinated the development and submittal of the Integrated Water Quality Report. The process began with a notice and request for input sent to EPA Region 6, State environmental agencies, and Tribal environmental offices. A series of interagency meetings were conducted to review the listing methodology, review and discuss the draft list along with priority rankings and scheduling, and facilitate the exchange of information. The draft list will be circulated to EPA Region 6, and state environmental agencies for comment prior to release for public participation.

Public participation will be undertaken in two phases. When the process to identify candidate waters began, nominations from the public were solicited. This involved distribution of the mailout shown in Figure 8 in August, 2015. Once the final draft list is compiled, it shall be submitted for formal public review with notice and a 30-day comment period. Upon the close of the comment period, a responsiveness summary will be prepared. DEQ will coordinate public participation activities. After the public review period and finalization of the list, it will be formally submitted to EPA Region 6 for review and approval.

FIGURE 8. MAILOUT REQUEST FOR PUBLIC INPUT

Front



How to Provide WQ Info

DEQ invites you to provide water quality information to be considered in Oklahoma's *2016 Integrated Report*. All information must be submitted either in writing or by e-mail before the end of the solicitation period. A summary of DEQ's decisions regarding the water quality information that was submitted will be included in the final *2016 Integrated Report* presented to EPA Region 6.

In order to be considered, all data and information must be received at DEQ BEFORE 4:30 p.m., Wednesday, September 30, 2015.

Submit your water quality information to:

Elena Jigoulina
Water Quality Division
Department of Environmental Quality
P.O. Box 1677
Oklahoma City, OK 73101-1677
Water.Comments@deq.ok.gov

To Obtain More Information

Copies of the State's ***Continuing Planning Process***, the most recent **303(d) list,** and **Integrated Report** are available at:
www.deq.state.ok.us/WQDnew/305b_303d/index.html

The Use Support Assessment Protocols can be found in Subchapter 15 of the *Implementation of Oklahoma's Water Quality Standards* (Title 785, Chapter 46). It is available for download at: http://www.owrb.ok.gov/rules/pdf/current/Ch46.pdf

Oklahoma's Water Quality Standards (Title 785, Chapter 46) are available for download at:

http://www.owrb.ok.gov/rules/pdf/current/Ch45.pdf

If you are receiving this in paper form, please help save money and the environment by receiving the notice in PDF format via e-mail. Just send your name & e-mail address to Water.Comments@deq.ok..gov.

Oklahoma Department of Environmental Quality
P.O. Box 1677
Oklahoma City, OK 73101-1677

Public Solicitation for Water Quality Information for the *Water Quality in Oklahoma 2016 Integrated Report*

(Includes the 303(d) List of Impaired Waterbodies)

August 26, 2015

OKLAHOMA
DEPARTMENT OF ENVIRONMENTAL QUALITY

Water Quality Division

P.O. Box 1677

Oklahoma City, Oklahoma 73101-1677

Ph: 405-702-8100 • Fax: 405-702-8101

http://www.deq.state.ok.us

Back

BACKGROUND

The Oklahoma Department of Environmental Quality is in the process of developing Oklahoma's *2016 Integrated Report*. The Integrated Report combines into one document the reporting requirements under the Federal Clean Water Act (CWA) Section 305(b) - *Surface Water Quality Assessment* - and the reporting requirements under CWA Section 303(d) - *List of Impaired Waters*.

The Integrated Report is a biennial assessment of all Oklahoma waterbodies. The methods used to develop/revise the Integrated Report are described in the Continuing Planning Process (CPP) document. One goal of the CPP is to provide an objective and scientifically sound waterbody assessment listing methodology. The CWA requires states to develop Water Quality Standards (WQS) and have designated beneficial uses assigned to all waterbodies. Beneficial uses are the kinds of activities that a waterbody can be used for including but not limited to drinking, fishing, swimming, recreation, and irrigation.

The waterbodies that can't meet minimum WQS are considered to be "impaired" and are listed as such on the 303(d) List of Impaired Waters. DEQ develops plans - known as Total Maximum Daily Loads (TMDLs) - with goals and pollution control targets for improving water quality in impaired waterbodies so that the waterbodies can achieve their WQS beneficial uses. The 303(d) list is also used to establish priorities for TMDL development.

Federal regulations governing the 303(d) listing process and TMDL development are found in 40 CFR Part 130. The Environmental Protection Agency (EPA) releases their Integrated Reporting guidance to assist states in developing Integrated Reports. EPA emphasized that their Integrated Reporting guidance does not alter the statutory provisions in sections 305b and 303d of the CWA, nor does it change existing rules governing development of impaired waterbodies lists previously discussed.

WATER QUALITY DATA REQUIREMENTS

This solicitation notice serves as a means of gaining information about water quality from the public. Once the information is reviewed, then a draft of the Integrated Report is submitted for public review which includes a 30-day comment period. Near the end of the public comment period, there will be a public meeting to go over the draft Report and answer any questions about the Report.

EPA regulations (40 CFR 130.7) require that "all existing and readily available water quality related data and information" must be evaluated in developing the 303(d) list. A complete list of criteria and information necessary for consideration is found in the *Integrated Water Quality Report Listing Methodology* section of the current CPP.

In general, water quality data must meet the following criteria to be considered:

- The data cannot be more than 5 years old for rivers (10 years for lakes) for parameters associated with designated uses.
- Only data collected before **April 30, 2015** will be used in use attainment determinations.
- Impairments must be due to specific pollutants for which TMDLs can be developed. The specific cause of the impairment must be noted in the submittal, if known.

All nominations **must** include the following information:

✓ ***Waterbody Identification***

Oklahoma uses a 14-digit waterbody identification (WBID) system. If you do not know the appropriate WBID number for your particular segment, you can provide latitude and longitude coordinates for your segment of concern. In addition, please supply the common name for the waterbody as it is listed on a United States Geological Survey topographical map.

✓ ***Justification for Listing Decision***

All decisions about a waterbody's listing in the Integrated Report are based on ample data and documentation to prove whether or not that waterbody meets WQS. As a result, your submittal should include a summary of the data used to support the decision, the complete data set (or reference to the complete data set if it is contained in a published report), and an analysis showing a violation of WQS or proof the waterbody is no longer impaired. Oklahoma's WQS (Title 785, Chapter 45), Use Support Assessment Protocols (Subchapter 15, Title 785, Chapter 46), and the procedures in the CPP should be consulted and utilized in your justification and analysis.

✓ ***QA/QC Procedures Used***

Data submitted should include information on sampling and analyses, including Quality Assurance and Quality Control (QA/QC) procedures used. DEQ will evaluate the QA/QC protocols used in gathering and analyzing the samples to decide if and how that data will be used. To be used, data must use QA/QC methods that are in accordance with "EPA Requirements for QA Project Plans" (QA/R5, December 2002).

Groundwater Quality

Overview

Groundwater is an important natural resource in Oklahoma. There are twenty-one major groundwater basins in the State and approximately 150 minor basins. These major basins are used as primary source of community drinking water and are estimated to hold over 320 million acre-feet of fresh water. See Figure 9 for a detailed map of the "Major Groundwater Aquifers in Oklahoma".

The Oklahoma CAFO and Swine Feeding Operation (SFO) Acts puts measures into place that prohibit a hydrologic connection between generated wastewater and waters of the State. The SFO Act further states that samples of water from Licensed Managed Feeding Operations (LMFO) monitoring wells located around swine lagoons shall be collected by the ODAFF and tested at least annually. LMFOs licensed on or after August 1, 1998 had to install a monitoring "system" (leak detection or wells) before using the retention structure to store liquid wastes. The main goal of the monitoring program is to ascertain if groundwater resources at or near the LMFOs are being subject to any degradation as result of the operation of the facilities and storage of the liquid animal waste. The baseline data for the facilities serves as a reference point to potential change in groundwater quality over time. Beginning in the Fall of 1999 to present date, the Department has been involved with the annual sampling and evaluation of over 1,000 monitoring wells at swine LMFOs as required by provisions in the Act.

The Corporation Commission continues to collect and analyze groundwater samples near known and suspected oil and gas spill sites and/or in response to complaints from citizens. These are taken in domestic and other water wells; in monitoring wells installed to investigate possible groundwater pollution; from water seeping into borings and dug trenches; from springs and seeps where groundwater emerges at the surface; and from other sources.

Samples are analyzed for TDS, chlorides, sulfates , petroleum, metals, or other parameters as appropriate, in order to determine what actions are needed in each case. Because sampling is usually done in response to a complaint, following a known spill, or because of a problem noticed by a field inspector, and is in or near historic oil and gas areas, this data may be biased. In other words, our sampling data is more likely to show water quality problems much more often than random sampling would.

In 1984, OWRB established a monitoring network to determine the ambient quality of major aquifers for the development of numeric groundwater quality standards. Between 1984 and 1992, OWRB collected annual samples from a network of more than 200 domestic, irrigation, stock, and municipal water wells. Samples were analyzed for major ions and metals. Unfortunately, this program was discontinued after nine years of data collection due to lack of funding. However, in 2012 OWRB received funding for development and implementation of a statewide, aquifer-based water quality program. The Groundwater Monitoring and Assessment Program (GMAP) began its baseline phase in 2013. As of 2016, 690 wells from 21 major aquifers had been sampled, with an additional major aquifer scheduled for characterization in 2017. Beginning in 2018, a subset of wells from all major aquifers will be sampled semiannually to monitor long-term and seasonal trends in water quality. Samples are analyzed for major ions, nutrients, and metals.

OWRB has also conducted Statewide monitoring of groundwater *quantity* since 1937 through the mass measurement program, which has been expanded through implementation of GMAP. The historical network of 550 wells had increased to approximately 800 wells measured annually in 2016 in order to assess long-term trends in groundwater levels and aquifer storage. Approximately 290 of those wells are measured three times per year in order to assess seasonal trends.
OWRB contracts with Oklahoma Department of Agriculture (with the assistance of an EPA grant) to perform compliance groundwater monitoring at swine Licensed Managed Feeding Operations and the number of observation wells in the annual water level measurement program is approximately 500 beginning 2008.

DEQ has two monitoring programs that address groundwater: the Public Water Supply Compliance Sampling and a 106 Ambient Groundwater Monitoring program. Public water supplies must collect samples at various intervals and locations to determine if the water they serve the public complies with primary drinking water standards as set forth in the Safe Drinking Water Act. Most of these samples are collected at points of entry into the distribution system. The water entering the system at the points of entry can represent one or several groundwater sources. This data is compiled and used to determine areas of contamination and to set expected concentration ranges of various chemical contaminants. Historic data has been compiled going back to the 1920's and future data can be compared to

historic ranges to determine changes over time. Intentions are to identify potential concerns before they become major problems.

DEQ's 106 Groundwater Monitoring Program used public water supply operators to collect samples from 420 randomly selected PWS wells. Samples were analyzed for secondary drinking water parameters and major ions. Data was used to evaluate and classify groundwater quality and determine aquifer homogeneity. The three years of monitoring data, analyzed, verified, and compiled are available to State agencies, federal agencies, and the citizens of Oklahoma for their use. This information is available on the Oklahoma Department of Environmental Quality's website at http://www.deq.state.ok.us/WQDnew/groundwater/index.html. Maps of water quality are included here for nitrates, sulfates, and total dissolved solids in the major aquifers. Trends established by this ambient monitoring program can be used to identify sources of polluted runoff that potentially could adversely impact vulnerable groundwater resources.

DEQ has several remediation programs that identify, monitor, and when needed, remediate local sources of ground water pollution from releases at regulated facilities, historical releases, and spills. Most of these sources are very localized and are not included as areas with problems or concerns.

Major Aquifers with Anthropogenic Water Quality Problems or Concerns

Major aquifers are defined as aquifers which can effectively yield 150 gallons per minute or greater. The following information is based on samples submitted to DEQ of domestic wells and through the PWS program. This information is based upon the most recent information provided to this division as of December of 2002. For location of the major groundwater aquifers of Oklahoma, please refer to Figure 9.

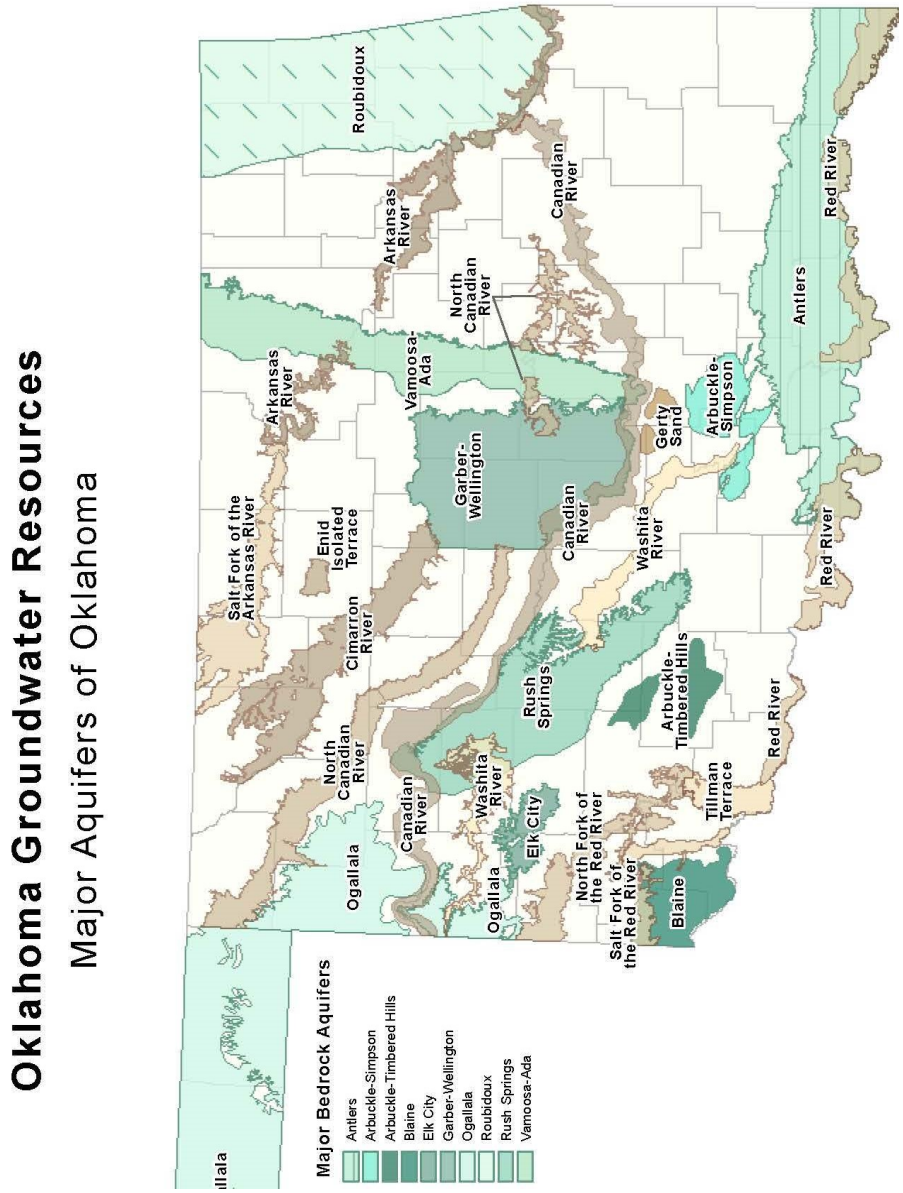
Alluvium and Terrace Deposits of the Salt Fork of the Arkansas River

DEQ has identified several wells and well fields in this aquifer with elevated nitrate levels.

Alluvium and Terrace Deposits of the Arkansas River

DEQ has identified several wells and well fields in this aquifer with elevated nitrate levels.

FIGURE 9. GROUNDWATER AQUIFERS OF OKLAHOMA



Alluvium and Terrace Deposits of the Enid Isolated Terrace Deposits

DEQ has identified a well in this aquifer with elevated nitrate levels.

Alluvium and Terrace Deposits of the Cimarron River

DEQ has identified several wells and well fields in this aquifer with elevated nitrate levels.

Alluvium and Terrace Deposits of the Beaver-North Canadian River

DEQ has identified several wells and well fields in this aquifer with elevated nitrate levels.

Alluvium and Terrace Deposits of the Canadian River

DEQ has identified several wells and well fields in this aquifer with elevated nitrate levels.

Alluvium and Terrace Deposits of the Washita River

DEQ has identified a well field in this aquifer with elevated nitrate levels.

Alluvium and Terrace Deposits of the North Fork of the Red River

DEQ has identified several wells and well fields in this aquifer with elevated nitrate levels.

Alluvium and Terrace Deposits of the Red River

DEQ has identified several wells and well fields in this aquifer with elevated nitrate levels.

Ogallala Formation

DEQ has identified a well field in this aquifer with elevated nitrate levels. Some of the wells showed elevated levels of selenium, probably of natural origin.

Antlers Sandstone

DEQ has identified several monitoring wells in this aquifer with elevated nitrate levels. Some of the wells showed consistently low pH values.

Rush Springs Sandstone

DEQ has identified several wells, monitoring wells and well fields in this aquifer with elevated nitrate levels and a well field with hydrocarbon and chloride contaminations. The contamination is the result of historic oil and gas activities (extraction, refinement, and salt-water disposal).

Garber Sandstone and Wellington Formation

DEQ has identified several wells in this aquifer with gross alpha activity above the maximum allowable limit of 15 pCi/L. The Department has also identified several wells and well fields with selenium contamination. Localized wells and monitoring wells have been identified with industrial solvent contamination. Several wells have been detected with elevated levels of nitrates and chlorides. Arsenic is naturally occurring within this aquifer and several excursions above the new MCL of 10 µg/L have been noted via DEQ source monitoring actions.

Roubidoux Formation

DEQ has identified several newly installed wells in this aquifer that show local elevated iron, sulfate, and total dissolved solid levels in Ottawa County attributed to mine water contamination from historical mining from the Tar Creek Superfund site. The intervening Boone Formation is heavily impacted by the mining and is the source for localized problems within the Roubidoux. DEQ and EPA continue to monitor water quality in this area under the After Action Monitoring Program.

Vamoosa Formation

DEQ has identified several wells in this aquifer with elevated fluoride levels. DEQ, OWRB, and the and the United States Geological Survey (USGS) have identified several wells and well fields with chloride contamination.

The Arbuckle Formation

DEQ has identified several monitoring wells in this aquifer with elevated fluoride levels and a tendency towards excessive hardness. There are no known groundwater based community public drinking water systems experiencing

water quality problems. The source appears to be natural and has therefore limited the usefulness of this formation as a drinking water source.

Non-major Aquifers with Anthropogenic Water Quality Problems or Concerns

Non-major aquifers are defined as aquifers which effectively yield less than 150 gallons per minute. The following information is based primarily on individual wells or well fields that were affected by problems. These wells may or may not constitute a public water supply. In most cases, the problem wells are not in use, or have had their water blended with other sources to reduce the contaminant(s) to acceptable level(s). For location of the major aquifers, please refer to the maps "Alluvium and Terrace Deposits in Oklahoma" and "Major Bedrock Aquifers in Oklahoma".

The Boone Formation/Boone Chert/Keokuk and Reeds Springs Formation

DEQ and OWRB have identified several monitoring wells in this aquifer at the Tar Creek Superfund site in Ottawa County with low pH levels and heavy metal contamination. The source of contamination is from historic mining operations. This formation overlays the Roubidoux Formation. The Roubidoux Formation is threatened and locally impacted near several monitoring wells due to the severity of the contamination in the overlaying formations.

The Oscar "A" Formation

DEQ has identified several wells in this aquifer with elevated nitrate levels and gross alpha activity above the maximum allowable limit of 15 pCi/L. These concerns are similar to those expressed for the Garber/Wellington Formation.

McAlester and Hartshorne Formation-Savanna Formation/McAlester Formation/Hartshorne Sandstone Formation

DEQ has identified several monitoring wells in this aquifer with low pH levels, heavy metal contamination, chlorides, and some controlled industrial wastes. The source of contamination is from historic mining operations and off-site disposal pits for oil field and industrial waste.

Walnut Creek Alluvium Deposits

DEQ has identified two well fields in this aquifer with elevated nitrate levels.

Tillman Terrace Deposits

DEQ has identified two well fields in this aquifer with elevated nitrate levels and elevated levels of selenium.

Little Sandy Creek Alluvium Deposits

DEQ has identified a well field in this aquifer with elevated nitrate levels.

West Cache Creek Terrace

DEQ has identified a well field in this aquifer with elevated nitrate levels.

Major Sources of Contamination

The major sources of contamination within the State are listed in Table 28. The basis used for establishing the priority ranking system was based upon information collected from the various monitoring programs (e.g. the monitoring network, the ambient monitoring program and the wellhead protection program and the Tar Creek After-Action Monitoring Program).

TABLE 28. MAJOR SOURCES OF CONTAMINATION

Contaminant Sources	Highest Priority Sources	Factors Considered in Selecting a Contaminant Source[1]	Contaminants[2]
Agricultural Activities			
Agricultural Chemical Facilities			
Animal Feedlots	√	A - C - D - E	E - J
Drainage Wells			
Fertilizer Applications	√	C - E	E
Irrigation Practices	√	C - E	E
Pesticide Applications			
Storage and Treatment Activities			
Land Application	√	C - D - E	D - E - H - J - L
Material Stockpiles			
Storage Tanks (Above Ground)			
Storage Tanks (Underground)	√	A - C - E	D
Surface Impoundments	√	A - C - D - E	D - E - G - H - J - L
Waste Piles	√	C - D	H
Waste Tailings	√	C - D	H
Disposal Activities			
Deep Injection Wells	√	C - D - E	C - D - G - H
Landfills			
Septic Systems	√	A - C - D - E	E - J - L
Shallow Injection Wells			
Other			
Hazardous Waste Generators			
Hazardous Waste Sites			
Industrial Facilities			
Material Transfer Operations			
Mining and Mine Drainage	√	A – C – D - E	H
Pipelines and Sewer Lines			
Salt Storage and Road Salting			
Salt Water Intrusion	√	C - D - E	G - D
Spills		D	D - G
Transportation of Materials		D	D
Urban Runoff			
Other Sources Abandon Wells (Unplugged)	√	A - C - D - E	A - B - D - E - G - J - L - M

KEY TO TABLE 21

1	2
A. Human health and/or environmental risk (toxicity)	A. Inorganic Pesticides
B. Size of the population at risk	B. Organic Pesticides
C. Location of the sources relative to drinking water sources	C. Halogenated Solvents
D. Number and/or size of contaminant sources	D. Petroleum Compounds
E. Hydrogeologic sensitivity	E. Nitrate
F. State findings, other findings	F. Fluoride
G. Other	G. Salinity/Brine
	H. Metals
	I. Radionuclides
	J. Bacteria
	K. Protozoa
	L. Viruses
	M. Any Unlisted Surface Contaminants

Overview of State Groundwater Protection Programs

Table 29 contains a summary of the State groundwater protection programs.

DEQ received authority under HB 2227 and 1002 and S. B. 361 (clean-up bill for HB 1002) to be the lead agency for Oklahoma's Wellhead Protection Program. Due to the variety of potential causes and sources of groundwater contamination, other State environmental agencies are involved in this program. These include the ODAFF, OWRB, OCC, Corporation Commission, Wildlife Department, and the Department of Mines.

TABLE 29. SUMMARY OF THE STATE GROUNDWATER PROTECTION PROGRAMS

Program or Activities	Check if active	Implementation Status	Responsible Agency
Active SARA Title III Program	√	FE	DEQ
Ambient groundwater monitoring system	√	CE	DEQ
Aquifer vulnerability assessment	√	FE	DEQ*
Aquifer mapping	√	CE	OWRB*
Aquifer characterization	√	CE	OWRB*
Comprehensive data management system	√	CE	DEQ
EPA - endorsed Core Comprehensive State Groundwater Protection Program (CSGWPP)	√	CE	DEQ*
Groundwater discharge permits	√	FE	DEQ*
Groundwater Best Management Practices	√	CE - UR	DEQ*
Groundwater legislation	√	CE	OWRB*
Groundwater classification	√	CE	OWRB*
Groundwater quality standards	√	CE	OWRB*
Interagency coordination for groundwater protection initiatives	√	CE	OSE*
Nonpoint source controls	√	UD	OCC*
Pesticides State Management Plan	√	FE	ODAFF
Pollution Prevention Program	√	FE	DEQ
Resource Conservation and Recovery Act (RCRA) Primacy	√	FE	DEQ

Program or Activities	Check if active	Implementation Status	Responsible Agency
Source Water Assessment and Protection Program (SWAP)	√	FE	DEQ
State Superfund	√	CE	DEQ
State RCRA Program incorporating more stringent requirements than RCRA Primacy	√	CE	DEQ
State septic system regulations	√	FE	DEQ
Underground storage tank installation requirements	√	FE	Corp. Comm
Underground Storage Tank Remediation Fund	√	FE	Corp. Comm
Underground Storage Tank Permit Program	√	FE	Corp. Comm
Oil & Gas well drilling, commercial mud pit, and land application permit programs	√	FE	Corp. Comm.
Special protective rules for pit liners and O&G well casing when close to water wells	√	FE	Corp. Comm.
Oil & Gas injection well UIC Program	√	FE	Corp. Comm.
Oil & Gas State abandoned well plugging fund program	√	FE	Corp. Comm.
Oil & Gas surface and groundwater assessment and remediation oversight programs	√	FE	Corp. Comm.
Oil & Gas orphaned and abandoned well site cleanup program (State authorized industry funded)	√	FE	OERB
Oil & Gas base of fresh/treatable water mapping program	√	CE	Corp. Comm.
Underground Injection Control Program	√	FE	DEQ*
Vulnerability assessment for drinking water / wellhead protection	√	CE	DEQ
Well abandonment regulations	√	FE	OWRB*
Wellhead Protection Program (EPA - approved)	√	CE - FE	DEQ
Well installation regulations	√	FE	OWRB*
LMFO Monitoring Well Sampling Program	√	CE	ODAFF

KEY TO TABLE 29

Implementation Status		Responsible Agency	
CE	Continuing Efforts	DEQ	Oklahoma Dept. of Environmental Quality
FE	Fully Established	OCC	Oklahoma Conservation Commission
NA	Not Applicable	Corp Comm	Oklahoma Corporation Commission
P	Pending	OWRB	Oklahoma Water Resources Board
UD	Under Development	OSE	Office of the Secretary of Environment
UR	Under Revision	OERB	Oklahoma Energy Resources Board
		ODAFF	Oklahoma Dept. of Agriculture Food and Forestry

Oklahoma's Wellhead Protection Program

DEQ developed its Wellhead Protection Program in accordance with the EPA guidelines set forth under the Safe Drinking Water Act ' 1428 (as amended in 1986). Oklahoma's Wellhead Protection Program is a mechanism to assist local communities in protecting their groundwater based drinking supplies. The goal of the Wellhead Protection Program is to delineate protected areas around a drinking water wellhead. In these protected areas, potential causes and sources of groundwater contamination can be identified and managed thus reducing or eliminating the risk of well contamination.

Under Oklahoma's Wellhead Protection Program, managers of groundwater based drinking water systems may contact DEQ to request technical assistance. The State will also offer technical assistance for such tasks as evaluating the potential for groundwater contamination, determining possible sources of contamination, proposing model ordinances for control of potential sources of contamination, and/or preparing a contingency plan in the event of well contamination. The program advocates land use restrictions around the wellhead. At present, emphasis is placed on the development of contingency plans, educational programs and voluntary implementation of best management practices to reduce or eliminate the need for restrictive regulatory protection.

Groundwater Indicators

DEQ routinely monitors finished water for nitrates, coliform bacteria, volatile organic compounds and other drinking water quality parameters. DEQ has regulatory authority for public water supplies under 63 O.S. 1981, ' 1-901 *et seq*. The regulations were last amended by the Oklahoma State Board of Health on February 8, 1990 (effective May 25, 1990) and incorporated into DEQ on January 1, 1993 (effective July 1, 1993 and amended July 1, 2003). Table 30 lists the various supply systems with standards violations within the last 5 years. With the exception of nitrate as nitrogen, most of the contaminants are of natural origin. Note that in the "Date Violation Confirmed" column, some violations are of recent discovery and others have been known for several years.

TABLE 30. PUBLIC WATER SUPPLY STANDARDS VIOLATIONS

System Name	County	Aquifer	Date Violation Confirmed	Current Level (mg/L or pCi/L)	Date of Last Analysis Showing Violation
Nitrate, Maximum Allowable Limit – 10 mg/L (ppm)					
Aline	Alfalfa	Cimarron Terrace	2000	11	12/31/2015
Apache	Caddo	Marlow Formation	2011	29.9	6/14/2011
All 4 One Stop	Caddo	Unknown	2015	15.2	5/1/2015
Apex Fitness	Grady	Unknown	2014	11	11/14/2014
Bethel Baptist Church	Tillman	Tillman Terrace	2010	14	12/13/2011
Blue Ridge MHP	Payne	Unknown	2009	23	12/11/2015
Canadian Co RWD # 1	Canadian	North Canadian River Alluvium	1994	14	11/3/2015
Canute	Washita	Elk City Sandstone	2009	11	8/6/2015
Carmen	Alfalfa	Cimarron Terrace	1995	11	10/15/2015
Cotton Co RWD # 2	Cotton	Red River Terrace	2011	15.5	10/23/2013
Country East MHP	Custer	Rush Springs Sandstone	2010	11	8/7/2013
Currys Bar	Cotton	Red River Terrace	2013	15.5	10/23/2013
Custer County RWD #3	Custer	Rush Springs	2015	11	8/20/2015
Davidson	Tillman	Tillman	2014	16	5/15/2014
Deer Creek	Grant	Arkansas River, Salt Fork Alluvium	1993	11	10/12/2015
Dill City	Washita	Elk City SS	2015	13	7/13/2015

System Name	County	Aquifer	Date Violation Confirmed	Current Level (mg/L or pCi/L)	Date of Last Analysis Showing Violation
Fairhaven TP	Garfield	Enid Terrace	2014	12	3/26/2014
Firehouse BBQ Fairhaven TP	Garfield	Unknown Enid Terrace	2013	12	4/18/2013
Fairview	Major	Cimarron Terrace	2012	11	10/12/2012
Felt Schools	Cimarron	Unknown	2013	13	8/7/2013
Fort Cobb	Caddo	Rush Springs Sandstone	2013	11	10.4.2013
Garber Municipal Authority	Garfield	Garber-Wellington	2010	11	6/4/2013
Geary	Blaine	North Canadian Alluvium	2013	1817	10/19/2015 11/14/2013
Grandfield	Tillman	Red River Terrace	2009	17	11/3/2015
Hang the Rock LLC	Cherokee	Unknown	2012	12	2/27/2012
Harmon Water Corporation	Harmon	Red River, Salt Fork Terrace	2013	13	5/23/2013
Hennessey	Kingfisher	Cimarron River Terrace	2008	12	12/5/2014
Herb Rousey	Cleveland	Unknown	2013	13	7/17/2013
Hollis	Harmon	Red River, Salt Fork Terrace	1993	11	1/5/2016
Hydro PWA	Caddo	Rush Springs SS	2015	11	9/23/2015
Jacks General Store	Major	Cedar Hills Sandstone	2010	11	6/13/2013
Logan Co RWD #2	Logan	Cimarron River Terrace	1993	11	4/12/2013
Loyal	Kingfisher	North Canadian River Alluvium	1998	11	1/4/2016
Magnum PWS	Greer	Red River, North Fork Terrace	2012	11	11/27/2012
Major Co RWD #1	Major	Cimarron Terrace	1996	12	11/2/2015
Margarita Island	Oklahoma	Unknown	2011	21.5	7/1/2011
Mooreland	Woodward	North Canadian River Terrace	1993	11	6/7/2011
Mycoland RV & Mobile Home Park	Osage	Arkansas River Alluvium	1993	12.5	2/7/2011
North Blaine Water	Blaine	North Canadian River Alluvium	1993	11	1/5/2016
Okarche	Kingfisher	North Canadian River Alluvium	2001	14	10/27/2015
Okarche RWD	Kingfisher	North Canadian River Alluvium	1988	15	11/16/2015
Old #9	Cleveland	Garber-Wellington	2012	11	7/16/14
Quartz Mountain Reg Water Authority	Kiowa	Unknown	2011	11	10/19/2015
Skate Fever	Grady	Unknown	2012	11.9	10.1.2012
Shady Acres Custer County	Custer	Unknown	2015	11	8/6/2015
Snyder	Kiowa	Red River, North Fork Terrace	2015	11	1/28/2015
Thirsty Water Corp.	Greer	Red River, North Fork Terrace	2005	11	10/27/2015
Tillman CO RWD#1	Tillman	Cache Creek Alluvium	2013	11	2/13/2013
Tipton	Tillman	Tillman Terrace	2010	13	7/3/2012

System Name	County	Aquifer	Date Violation Confirmed	Current Level (mg/L or pCi/L)	Date of Last Analysis Showing Violation
U.S. Gypsum	N. Canadian River Alluvium	Blaine	2011	14	12/22/2015
Watonga	Blaine	North Canadian Terrace	2012	11	5/23/2012
Willow	Greer	Red River, North Fork Terrace	2015	16	12/1/2015
Woodward CO RWD #2	Woodward	Ogallala	2012	11	2/26/2015
Alpha Particles, Maximum Allowable Limits – 15pCi/L					
Bernice	Delaware	Unknown	2015	17	5/1/2015
Brooksville	Pottawatomie	Oscar "A" Formation	2015	17	2/20/2015
Carney	Lincoln	Oscar "A" Formation	2015	20	5/14/2015
Clearview	Cleveland	Garber-Wellington	2015	18	9/21/2015
Colcord PWA	Delaware	Boone Formation	2010	21	6/25/2014
Cookson Hills Christian School	Adair	Roubidoux	2010	16	3/16/2011
Coyle	Logan	Unknown	2014	24	6/9/2014
Deer Creek	Oklahoma	Garber-Wellington	2014	16-24	6/27/2014
Edmond PWA	Oklahoma	Garber-Wellington	2010	17	1/19/2010
Harrah	Oklahoma	Garber-Wellington	2009	17-24	2/26/2016
Logan Co RWD #1	Logan	Garber-Wellington	2011	16-36	9/4/2012
Meadow Ridge MHP	Pottawatomie	Oscar "A" Formation	2011	40-191	7/29/2011
Meridian	Logan	Unknown	2015	18-38	9/21/2015
Norman	Cleveland	Garber-Wellington	2010	16-26	3/2/2015
Oklahoma Christian University	Oklahoma	Garber-Wellington	2012	17-23	6/9/2014
Pecan Tree estates	Cleveland	Garber Wellington	2011	17-30	9/21/2015
Piedmont	Canadian	Garber-Wellington	2009	57	3/18/2016
Tipton	Tillman	Tillman Terrace	2011	22	12/10/2012
Welch PWA	Craig	Roubidoux	2011	16-25	6/25/2014
Arsenic, Maximum Allowable Limit – 0.010 mg/L (ppm)					
Caddo CO RWD #1 (Lookeba)	Caddo	Rush Springs Sandstone	2012	0.011-0.031	3/14/2016
Clearview MHP	Cleveland	Garber-Wellington	2016	0.011	3/18/2016
Corn PWA	Washita	Rush Springs Sandstone	2007	0.012	3/14/2016
Cotton CO RWD # 2	Cotton	Red River Terrace	2012	0.012	3/14/2016
Country east MHP	Custer	Rush Springs Sandstone	2012	0.011	7/19/2012
Deer Creek	Grant	Arkansas River, Salt Fork Alluvium	2008	0.011	8/22/2013
Eakly Development Corp	Caddo	Rush Springs Sandstone	2009	0.016	3/14/2016
Fairmont	Garfield	Garber-Wellington	2009	0.011	5/23/2013
Hinton	Caddo	Rush Springs Sandstone	2009	0.011	3/14/2016
Meridian Water Supply	Logan	Unknown	2010	0.017-0.035	3/18/2016
Moore	Cleveland	Garber-Wellington	2008	0.012	6/5/2012

System Name	County	Aquifer	Date Violation Confirmed	Current Level (mg/L or pCi/L)	Date of Last Analysis Showing Violation
Mustang	Canadian	Garber-Wellington	2014	0.011-0.015	6/2/2014
Norman	Cleveland	Garber-Wellington	2014	0.011-0.013	6/2/2014
Oklahoma Christian University SA	Oklahoma	Garber-Wellington	2011	0.018	5/9/2012
Weatherford	Custer	Rush Springs Sandstone	2009	0.016	1/13/2012
Benzene, Maximum Allowable Limits - 0.005 mg/L (ppm)					
Texas CO RWD#1	Texas	Ogallala	2013	0.014	1/30/2013
Beta Particles, Maximum Allowable Limits – 50 pCi/L					
Meadow Ridge MHP	Pottawatomie	Oscar "A" Formation	2009	55-76	7/29/2011
Carbon Tetrachloride, Maximum Allowable Limit – 0.005 mg/L (ppm)					
Garber	Garfield	Garber-Wellington	2009	0.006-0.007	2/29/2016
Fluoride, Maximum Allowable Limit – 4.0 mg/L (ppm)					
Three Springs Farm	Cherokee	Unknown	2005	4.1-5.0	2/29/2016
Radium combined, Maximum Allowable Limit – 5 pCi/L					
Choctaw Co RWD #1	Choctaw	Antlers Sand	2009	6	6/25/2014
Colcord PWA	Delaware	Boone Formation	2010	6-7	6/25/2014
Cookson Hills Christian School	Adair	Roubidoux	2010	6-12	3/14/2016
Welch PWA	Graig	Roubidoux	2011	6-10	2/29/2016
Tetrachloroethylene, Maximum Allowable Limit – 0.005 mg/L (ppm)					
Hillside MHPO Oklahoma CO	Oklahoma	Unknown	2013	0.029	7/12/2013
Selenium, Maximum Allowable Limit – 0.05 mg/L					
Tipton	Tillman	Tillman Terrace	2011	0.053	10/27/2011
Uranium, Maximum Allowable Limit – 0.03 mg/L					
Apache	Caddo	Marlow Formation	2015	0.031-0.032	5/1/2015
Brooksville	Pottawatomie	Oskar "A" Formation	2012	0.031-0.042	2/20/2015
Coyle	Logan	Cimarron River Alluvium	2009	0.031-0.035	9/21/2015
Harrah	Oklahoma	Garber-Wellington	2009	0.032	2/24/2011
Holiday Outt MHP	Oklahoma	N. Canadian River Alluvium	2011	0.031-0.035	2/20/2015
Logan Co RWD #1	Logan	Garber-Wellington	2009	0.208	11/8/2012
Meadow Ridge MHP	Pottawatomie	Oscar "A" Formation	2009	0.228	7/29/2011
Meridian Water Supply	Logan	Unknown	2011	0.040-0.069	4/1/2016

System Name	County	Aquifer	Date Violation Confirmed	Current Level (mg/L or pCi/L)	Date of Last Analysis Showing Violation
Pecan Tree Estates Addition	Cleveland	Garber-Wellington	2009	0.032-0.043	3/18/2016
Piedmont	Canadian	Garber-Wellington	2009	0.096	3/18/2016
Ringwood	Major	Cedar Hills SS	2014	0.032-0.037	3/2/2015
Tipton	Tillman	Tillman Terrace	2010	0.034-0.082	12/10/2012

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