2017

City of Tulsa

Source Water Protection Plan

Updated: XXX XX 2018

REVISIONS: All copies of this plan will be reviewed at least annually, and revised if necessary to reflect changes in the critical criteria outlined in this document, the adaptive management strategy, priorities, strategies, new partnerships, watershed issues, water quality criteria, waterbody listings, rules, regulations, laws, local priorities, projects and programs effectiveness, treatment, monitoring, assessment, new identified species, new target species, taxonomy, contact names and numbers, departments, sections, governmental officials/agencies.

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List of Acronyms

AwwaRF	American water works association Research Foundation
BMPs	Best Management Practices
BUMP	Beneficial Use Monitoring Program
COT	City of Tulsa
CWAC	Cool Water Aquatic Community
CWAP	Clean Water Action Plan
E/S	Eucha/Spavinaw
EPA	Environmental Protection Agency
FORM	Foundation for Organic Resource Management
FSA	Farm Service Agency
GRDA	Grand River Dam Authority
HUC	Hydrologic Unit Category
INCOG	Indian Nations Council of Governments
KAWS	Kansas Alliance for Wetlands & Streams
KDA	Kansas Department of Agriculture
KDHE	Kansas Department of Health and Environment
KWO	Kansas Water Office
LIMS	Local Information Management System
NIMS	National Incident Management System
OAC	Oklahoma Administrative Code
OCC	Oklahoma Conservation Commission
ODAFF	Oklahoma Department of Food and Forestry
ODEQ	Oklahoma Department of Environmental Quality
OPDES	Oklahoma Pollution Discharge Elimination System
OWRB	Oklahoma Water Resources Board
PPWS	Public and Private Water Supply
QAQC	Quality Assurance Quality Control
SCC	State Conservation Commission (Kansas)

Table of Acronyms Con't

SWP	Source Water Protection
SWPP	Source Water Protection Plan
TCF	The Conservation Plan
TMDL	Total Maximum Daily Load
TMUA	Tulsa Metropolitan Utility Authority
USACE	United State Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United State Geological Survey
WBID	Waterbody Identification
WPA	Watershed Protection Area
WRAPS	Watershed Restoration and Protection Strategy (Kansas)
WRAS	Watershed Restoration Action Strategy (United States)
WTP	Water Treatment Plant
WWTF	Waste Water Treatment Facility

Part 1 – Overview

1.1 Source Water Protection Plan (SWPP) Purpose (mission)

The basic purpose of the SWPP is to serve as a dynamic, comprehensive guide for the City of Tulsa's (COT) Source Water Protection Program to ensure the protection of the COT's drinking water sources for current and future generations.

The plan builds upon EPA Region 6's first Watershed Restoration Action Strategy (WRAS) developed by COT in 1999 to meet one of the goals established in the 1972 Clean Water Action Plan (CWAP). The WRAS included all nine EPA-recommended elements of watershed –based nonpoint source pollution control plans. The SWPP also incorporates the American Water Works Association 's (AWWA) G300-14 six critical criteria for effective source water protection program which are COT's current (1) vision, (2) goals and targets, (3)action plan, (4) implementation of action plan, (5) characterization of the source watersheds, (6) periodic evaluation and revision of the entire program. The plan also includes a section on verification, and a section for up-to-date contact lists.

1.2 SWPP Vision

The City of Tulsa's SWP Program *vision* statement: *"The City of Tulsa will continue to provide sufficient resources for source water protection efforts and allow the SWP Program vision to be dynamic to reflect changes not yet conceived that will ensure protection of the City of Tulsa's drinking water sources by meeting all water quality standards for Tulsa's source waterbodies for current and future generations."*

1.3 SWPP Application

Uses for this Source Water Protection Plan include (1) setting forth the iterative process for determining future source water protection direction and (2) providing a framework for responding to those changes with actions that protects the City of Tulsa's drinking water sources.

1.4 SWPP Format and Source Watersheds Explained

1.4.1 *Format.* With the exception of the *Vision* criteria, all of the remaining AWWA critical criteria for developing a source water protection plan will fall under the respective source watershed of the City of Tulsa's three source watersheds.

1.4.2 *Tulsa's Source Watersheds.* The City of Tulsa has three source watersheds, the two principle watersheds, the Eucha/Spavinaw and the Verdigris River Basin. The third source watershed, Lake Hudson Watershed is considered a secondary source watershed because it is primarily an emergency backup source for water that is owned and operated by the Grand River Dam Authority (GRDA), and has been rarely used to date. Tulsa's source water watersheds encompass 5,585 square miles, encompassing 12 counties in Kansas, 8 counties in Oklahoma, and 1 county in Arkansas. Tulsa's source watersheds are the first places we can go to reduce contaminants. It is here that risk prevention measures have the greatest potential impact with the lowest cost.

Part 2 – Eucha/Spavinaw Watershed

2.1 Watershed Characterization and Source Water Protection Area

2.1.1 *Delineation.* The Eucha/Spavinaw (E/S) Watershed covers approximately 1,001 km^2 (387 mi^2) in northeast Oklahoma and northwest Arkansas with 63% in Oklahoma and 37% in Arkansas (Figure 2-1).

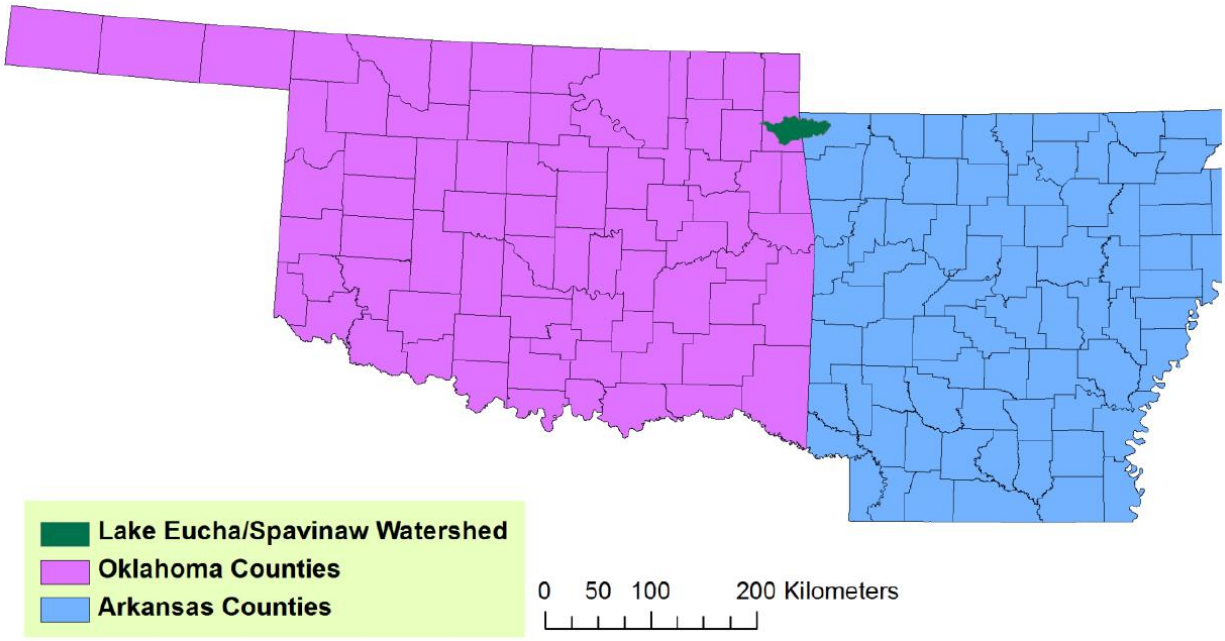

Figure 2-1 Location of the Eucha/Spavinaw Watershed in northwest Arkansas and northeast Oklahoma.

Natural features

The greater portion of the Eucha/Spavinaw Watershed lies in the Ozark Highlands and Central Irregular Plains Level III ecoregions (Woods et al. 2005). The Ozark Highlands ecoregion is a highly dissected, partially forested ecoregion with mainly karst features. The majority of this limestone plateau is predominantly an oak-hickory forest, but stands of oak and pine are also common. The maximum elevation of the Ozark highlands in Oklahoma is about 1,500 feet and the maximum relief between hill crests and valley bottoms is about 400 feet. Soils are often cherty and have developed from carbonate rocks or interbedded chert, sandstone, and shale. Soil thickness can range from less than a few centimeters to several meters, but generally soils are thin and of the Ultisol order. Caves, sinkholes, and underground drainage occur, heavily influencing surface water availability and the potential for surface water pollution. Perennial spring-fed streams with gravel or bedrock bottoms are common. In addition, many small dry valleys occur where overland flow is entirely runoff-driven. The Central Irregular Plains ecoregion is generally composed of a mosaic of bluestem prairie and oak/hickory forest. The sediment load to Lake Eucha indicates that erosion in the watershed does not approach levels considered significant according to United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) standards.

Hydrology

Surface water. The watershed includes Hydrologic Unit Codes (HUC) 11070209050, 110702090940, and 11070209060. The principal streams in the Eucha/Spavinaw Watershed are Spavinaw Creek and Beaty Creek, draining from Arkansas. Spavinaw Creek drains approximately 931km^2 in Arkansas and Oklahoma. Spavinaw Creek drains to Lake Eucha and is impounded downstream to form Spavinaw Lake located approximately four stream miles downstream of the Eucha dam. Other major tributaries to Lake Eucha include Brush Creek, Dry Creek, Rattlesnake Creek, and Cherokee Creek. Lake Eucha acts as an environmental and hydrologic buffer for Spavinaw Lake. Major streams have low gradients, meander considerably, and develop wide valleys except on areas of very hard rocks. Mean residence time, calculated by dividing storage capacity by outflow, during the 1998 – 2011 period was approximately 0.3375 years or 4.05 months for Lake Eucha and 0.2921 years or 3.5 months for Spavinaw Lake (COT, 2012). The raw source water leaving the last source water lake, Spavinaw Lake, travels along a 54-mile pipe before reaching the Mohawk Water Treatment Plant.

Ground water. The watershed, which lies within the Springfield Plateau, is part of the Ozark Plateaus aquifer system. Karst features are common in the Springfield Plateau. The extensive karst features of the Springfield Plateau aquifer system are characterized as providing a relatively free exchange of surface and ground water with limited geologic restrictions on water movement, which makes the aquifer system susceptible to surface contamination. The karst features also create an intricate ground water flow system, which results in rapid and complex interactions between ground and surface water creating unexpected flow directions and plume transport. Soil permeability can be as much as 15.0 cm hr^{-1}, resulting in a high potential for the leaching of contaminants from the surface to ground water (Adamski and Pugh 1966). In general, ionic adsorption capacity of the Ultisols of the Ozark Highlands is minimal. Thus, ionic constituents in infiltrating water are not readily absorbed by most soils and are easily flushed into nearby streams and shallow ground water (Adamski et al. 1995).

2.1.2 *Water Quality/Quantity Data, Monitoring, and Assessment*

2.1.2.1 *Water quality and quantity data.* Source water quality and quantity data are stored in the City of Tulsa's Local Information Management System (LIMS) database. The LIMS database includes historical EPA-approvable QAQC data from1997 to current. Pre-1997 data are stored on a COT shared drive established by the COT's source water quality program administrator entitled Water Quality Specialist.

2.1.2.2 *Water quality monitoring and assessment information.* COT's Water Quality Monitoring Plan is provided in Appendix A. The Lake Eucha and Spavinaw Lake Water Quality assessment report is available in the COT's shared drive [\\main\wsd\WaterSupply] under the folder "Source Water".

2.1.3 *Causes, Contaminant Sources, Land Use, and Other Threats.*

2.1.3.1 *Cause of waterbody impairment.* Both Lake Eucha and Spavinaw lakes are not supporting their Cool Water Aquatic Community (CWAC), Public/Private Water Supply (PPWS) and Aesthetics designated uses. Causes of nonsupport include phosphorus, chlorophll-a, and low dissolved oxygen for both lakes. Nutrients, especially phosphorus in Lakes Eucha and Spavinaw provide for excessive algae growth (TSI above 62) most of the time. In addition, Beaty Creek and Cloud Creek, which are Lake Eucha tributaries, are listed in the 2014 Oklahoma Integrated Report as being impaired by pathogens, specifically *Enterococcus*.

2.1.3.2 *Known contaminant sources.* The major known contaminant is phosphorus (Storm, 2016) due primarily to a long history of intense poultry waste disposal on soils. Since the 1950s, the poultry industry in the watershed has grown significantly and pasture cover has increased to roughly 50 percent. Fifty years ago, the streams and lakes in the Eucha/Spavinaw Watershed were clear with exceptional water quality (Jackson, 1991). The Oklahoma Conservation Commission (OCC, 1997) reported that the total phosphorus (P) in Lake Eucha increased three-fold from 1975 to 1995. The increased P load led to excessive algae growth in Lake Eucha and Spavinaw Lake causing both lakes to be

added to the 303(d) list due to excessive chlorophyll-a (USEPA, 2015). Excessive algae can cause several drinking water problems, including taste and odor issues, decreased water clarity and esthetics, and an increase in the likelihood of harmful cyanotoxin-producing algal blooms. As the short-lived algae die off, their decay process consumes dissolved oxygen; depleting the oxygen for other aquatic species and in severe cases resulting in hypoxic conditions. This has led to impairment due to dissolved oxygen for Lakes Eucha and Spavinaw (USEPA, 2015). The change in these waterbody's trophic state coincides with the rapid increase in poultry production (Cooke et al., 2008).

The Arkansas Agricultural Statistics Service divides the state into nine districts. District 1 in western Arkansas, the location of Benton County, is the largest producer of broilers in Arkansas (360 million annually) and the second largest producer of turkeys (Slaton et al., 2004). Over 80,000 tons of poultry litter is currently produced in the Eucha/Spavinaw Watershed (Storm and Mittlestet., 2015; Sharpley et al, 2012). Poultry litter (poultry waste plus bedding material) is a resource for the poultry growers because it can be applied to pasture to increase forage production, which in turn allows growers to supplement their income by raising beef cattle. However, poultry litter is rich in phosphorus and low in nitrogen relative to plant nutrient requirements. Because poultry litter for decades had been applied to meet crop/pasture nitrogen, phosphorus was applied at rates that exceeded the crop's need. This lead to phosphorus buildup in the soils, known as "Legacy P", and increase phosphorus amounts in runoff during rainfall events. Storm and others (2016) quantified† the amount and location of Legacy P in the E/S Watershed to aid in

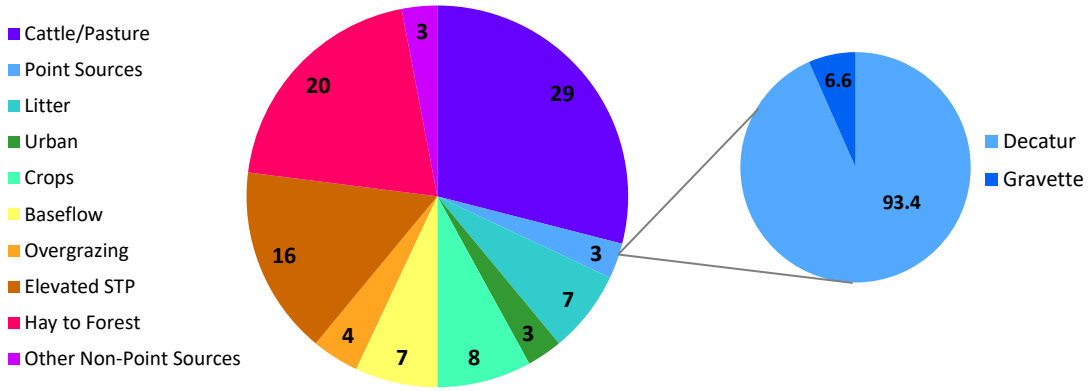

Figure 2-2 Percent phosphorus loading to Lake Eucha by source* with percent phosphorus point source loading. Breakout of Point Sources was determined by City of Tulsa.

† Quantification via calibrated and ground truthed SWAT (Soil Water Assessment Tool) modeling, data from USGS, NRCS, NASA, Mesonet, and the Eucha-Spavinaw Watershed Management Team.

the development of P load reduction strategies for the watershed based plans (i.e. Litter Plans and Comprehensive Nutrient Management Plans) to meet the 0.0168 mg l^{-1} water quality standard for Lake Eucha. Key findings include:

• Updated Oklahoma State University SWAT Model 2004 – 2013. Total phosphorus entering Lake Eucha = 30 Mg yr^{-1} (78% fr AR, 22% fr OK)

• Overall there are 12 specific significant sources of P to the E-S Watershed (Figure 2-3).

• Currently, poultry are adding over 85% of the total P.

• Since 1900, broilers have made up nearly 45% of the P additions and dairy cattle 18% (Figure 2-3).

• Currently, there are five P removals from the E-S Watershed, though the export of litter accounts for over 94% of all removals.

• If the current trends continue, nearly 100% of all litter will be exported out of the watershed in the next decade.

• In 2012, there was 1,150 mega grams (Mg) of P added to the watershed − with removal of 80%, the net addition was 230 Mg.

• Since 1900, over 64,000 Mg of P has been added to the watershed of which 53% was added in the last 30 years. Only 11,000 Mg (17%) of P was removed (Figure 2-4).

• After subtracting removals from additions, an excess of 50,000 Mg P is in the lake, soil, and stream system.

• With over 75% of P in the soil and stream system, P will continue to reach the streams and lake for years to come regardless of the future additions and reductions.

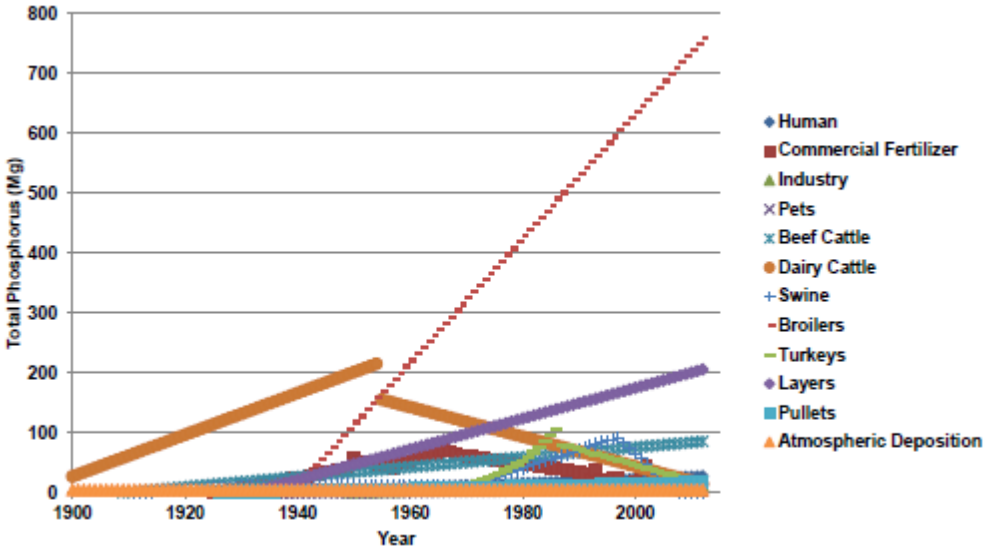

Figure 2-3 Sources of phosphorus contributions in the Eucha-Spavinaw Watershed from 1900 – 2012 using a linear scale.

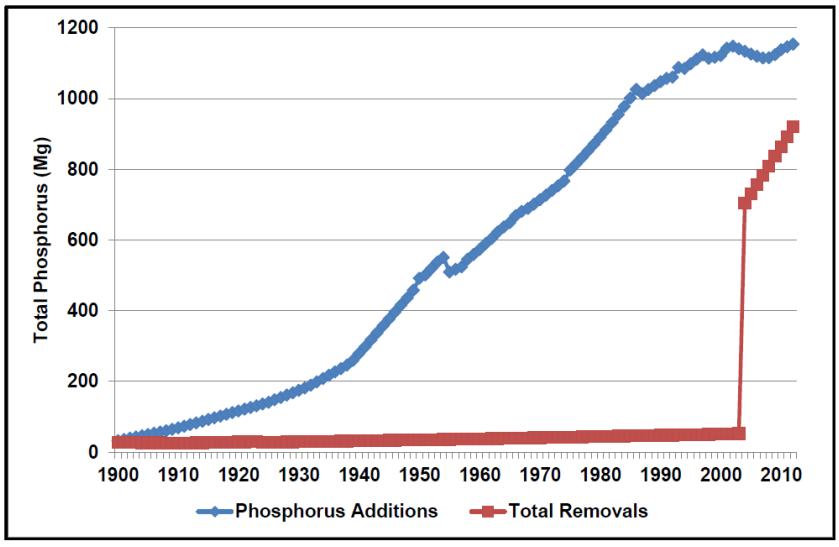

Figure 2-4 The phosphorus additions and removals in the Eucha-Spavinaw Watershed from 1900 – 2012.

2.1.3.3 *Land use activities.* Storm and others (2016) classified fourteen landcover classes for the E/S Watershed (Figure 2-5). Final percentages and areas for each of the fourteen landcovers for the watershed were calculated (Table 2-1).

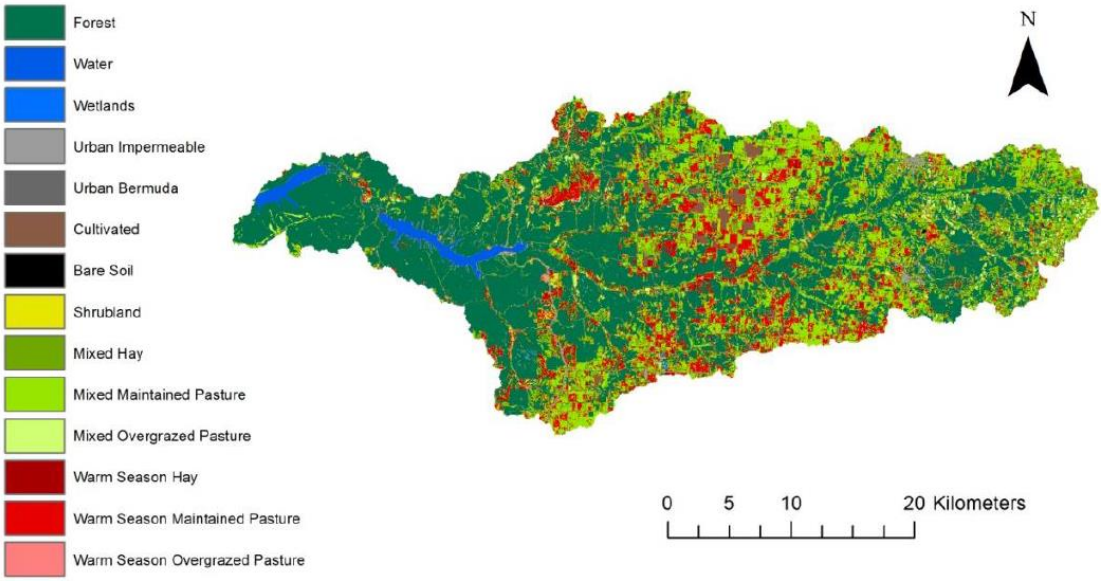

Figure 2-5 Land cover for the Eucha/Spavinaw Watershed (Storm, 2016).

Table 2-1 Area and percent of the watershed for each of the fourteen landcovers in the Eucha/Spavinaw watershed (Storm, 2016).

Landcover Type	**Area (ha)**	**Watershed Area (%)**
Forest	48,586	48.52
Water	1,643	1.64
Wetlands	224	0.22
Urban Impermeable	2,402	2.4
Urban Bermuda	1,351	1.35
Cultivated	1,070	1.07
Bare Soil	88	0.09
Shrubland	2,612	2.61
Mixed Hay	6,171	8.62
Mixed Maintained Pasture	22,041	18.39
Mixed Overgrazed Pasture	1,299	2.46
Warm Season Hay	2,359	2.99
Warm Season Maintained Pasture	9,733	8.76
Warm Season Overgrazed	546	0.87
	100,127	100

The most recent poultry house locations in the Eucha/Spavinaw Watershed are shown in Figure 2-6. A total of 908 houses were identified, but there was no data on the number of houses still active. It was estimated that 508 houses are currently active or 56%. The average Soil Test Phosphorus (STP) levels for each sub-basin in the E/S watershed are delineated in Figure 2-7.

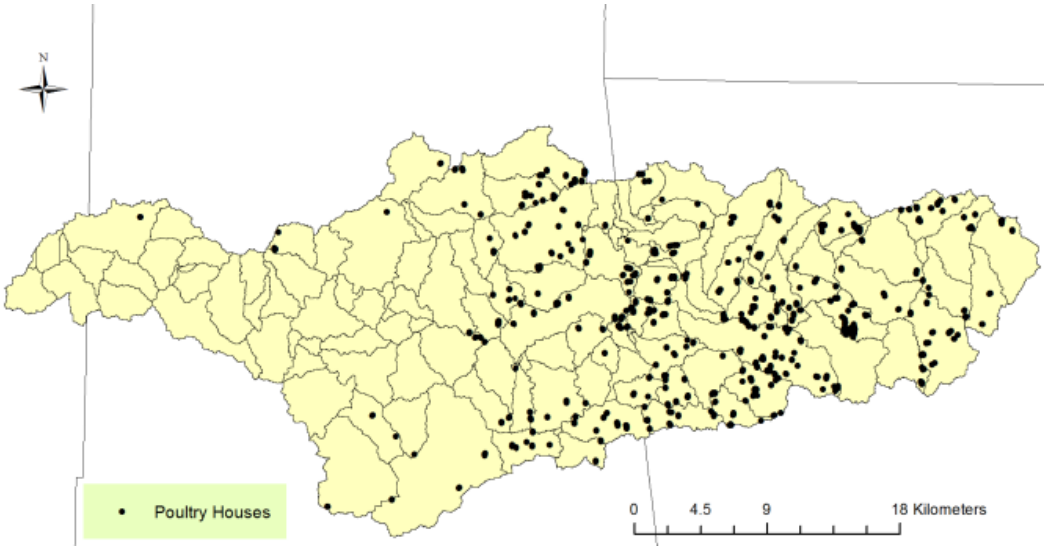

Figure 2-6 Poultry house locations in the Eucha/Spavinaw Watershed.

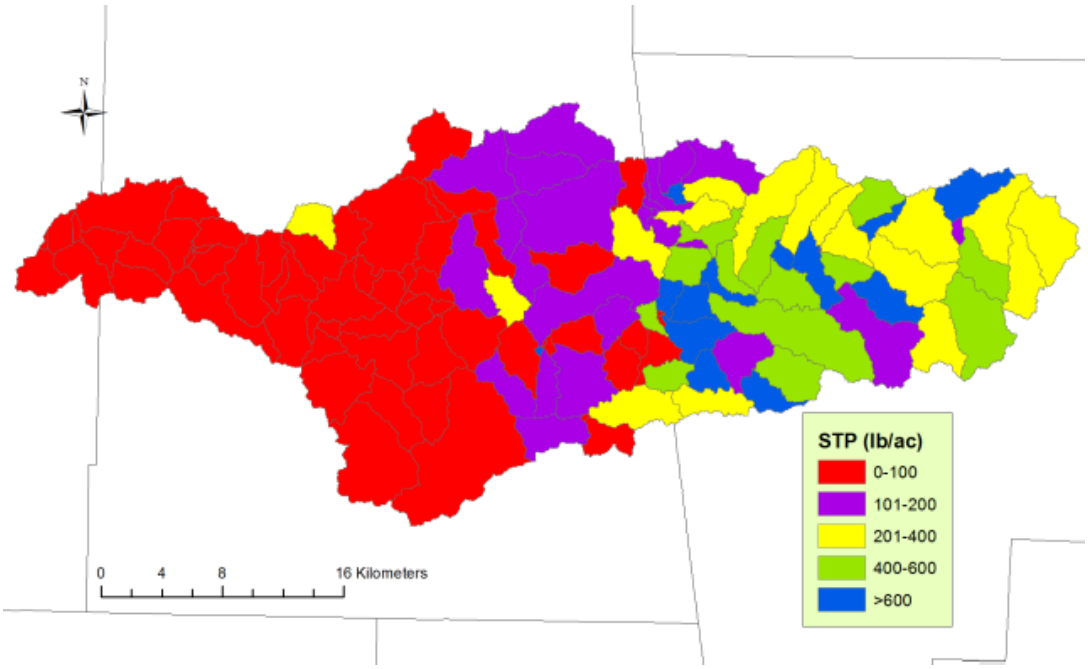

Figure 2-7 Average soil test phosphorus (STP) for each sub-basin in the Eucha/Spavinaw watershed.

2.1.4 *Inventory of Regulations.* The relevant laws, rules and regulations that affect City of Tulsa source water protection are inventoried below.

• The Oklahoma water quality numeric standard for Lake Eucha requires the long-term average total P concentration to not exceed 0.0168 mg L^{-1} at 0.5 m below the water surface (OKLA. ADMIN. CODE § 785:45-5-10(8), 2014 Url: https://www.owrb.ok.gov/rules/pdf/current/Ch45.pdf)

• The Oklahoma water quality numeric standard for Spavinaw Lake requires the long-term average total P concentration to not exceed 0.0141 mg L^{-1} at 0.5 m below the water surface (OKLA. ADMIN. CODE § 785:45-5-10(8), 2014. Url: https://www.owrb.ok.gov/rules/pdf/current/Ch45.pdf)

• Registered Poultry Feeding Operations rules. OAC § 785:35-17-5
https://www.oda.state.ok.us/aems/aemsrulesrpfo.pdf

• Poultry Waste Applicator Certification rules OAC § 785:35-17-7. Url:
https://www.oda.state.ok.us/aems/aemsrulespwa.pdf

• Concentration Animal Feeding Operations rules. OAC § 785:35-17-4
https://www.oda.state.ok.us/aems/CAFOAct.pdf

• Final General Permit for OKO4 for Municipal Stormwater discharges is available at
http://www.deq.state.ok.us/wqdnew/stormwater/

• Final General Permit for OKO5 for Industrial Stormwater discharges is available at
http://www.deq.state.ok.us/wqdnew/stormwater/

• Final General Permit for OKR10 for Construction Stormwater discharges is available at
http://www.deq.state.ok.us/wqdnew/stormwater/

• Final OPDES Permit for municipal and industrial discharges within lands not under Oklahoma or Kansas jurisdiction are available at https://www.epa.gov/npdes

• Pursuant to sections 303 and 101(a) of the Clean Water Act, the federal regulations at 40 CFR 131.10(b) requires that 'In designating uses of a water body and the appropriate criteria for those uses, the State shall take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters". This provision requires states and authorized tribes to consider and ensure the attainment and maintenance of downstream[1] water quality standards (WQS) during the establishment of designated uses and water quality criteria in upstream[2] waters. EPA states that adopting either narrative or numeric criteria to ensure the attainment and maintenance of downstream WQS (i.e. designated uses, criteria and antidegradation requirements) may likely be the preferred path for states/tribes to ensure consistency with 40 CFR 131.10(b).

[1] The EPA interprets the term "downstream' to include both intrastate and interstate waters, as well as waters that form a boundary between adjacent jurisdictions.
[2] EPA uses the term "upstream" to include "instream" when referring to the water body(ies) for which states/tribes are developing designated uses/water quality criteria that will ensure the attainment and maintenance of downstream WQS.

2.2 Stakeholder Involvement

2.2.1 *Past Stakeholder Involvement.*

2.2.1.1 *Alliance structure.* In an effort to reduce nutrient loads to Lake Eucha and protect water quality, in 1997, the Tulsa Metropolitan Utility Authority (TMUA) established a stakeholder-based comprehensive Watershed Management Team to develop a regionally coordinated approach to addressing water quality degradation in the watershed. Participants were drawn from both Arkansas and Oklahoma, and included poultry growers, poultry litter haulers and applicators, representatives of poultry companies, concerned citizens, the USEPA, the Indian

Nations Council of Governments (INCOG), the Foundation for Organic Resources Management (FORM), the Oklahoma Water Resources Board, the Arkansas Soil and Water Commission, the Oklahoma Conservation Commission, the Oklahoma Department of Environmental Quality, NRCS-Oklahoma, NRCS-Arkansas, the Oklahoma Cooperative Extension Service, and the Oklahoma Department of Agriculture.

Three technical working groups were established to focus on technical issues and build a sound scientific and economic basis for water quality protection efforts. The working groups were the (1) Monitoring, Assessment, and Evaluation Working Group led by INCOG, and focused on water quality sampling and monitoring within the watershed; (2) Nutrient Management Working Group, led by FORM, and focused improved nutrient management on farms with the watershed; and (3) Nutrient Export and Marketing Working Group, also led by FORM, and focused on watershed-scale export and marketing of poultry litter.

2.2.1.2 *Activities.* The Watershed management Team and the three working groups were very active and over the course of four years made significant advances in characterizing the nature and causes of the water quality impairments in the watershed and identifying potential mitigation strategies. Major accomplishments included the development of an interactive GIS (available to the public), five scientific studies, a USEPA-approvable Quality Assurance Project Plan, a poultry litter export hot-line, a common data reference library, and the development of Oklahoma's first Watershed Restoration Action Strategy (WRAS). All the 15 goals established by the Eucha/Spavinaw WRAS were met. Numerous intensive studies were completed to address nutrient-related water quality problems by quantifying nutrient loadings, assessing impacts on water quality and algae production, and setting nutrient target values for proper watershed management.

2.2.1.3 *Outcomes.* As the working groups began to complete their studies and accomplish their objectives, it became clear that poultry litter was the major source of phosphorus in the watershed, that measures to reduce phosphorus loadings to receiving waters would need financing and that support from the poultry corporations for such measures was essential. Toward the end of the Working Group process it was evident that the poultry corporations were unwilling to play a significant role in promoting and supporting proper management of poultry litter in the watershed.

2.2.2 *Current Stakeholder Involvement.* Currently, there are twenty four (24) projects, programs, and initiatives in the Eucha/Spavinaw Watershed. Current stakeholder involvement is described in the Eucha/Spavinaw Projects, Programs, and Activities Lists (Appendix A. The lists have the stakeholder's name, agency, lead Project Investigator (PI), project name, start and end date, project description, status, and funding source. The list is emailed quarterly to watershed stakeholders for updates. The kind-worded email reminder also states "The project lists may help water quality efforts in the watershed'' (e.g. reduce redundancy, promote/assist collaboration, etc.). The lists are grouped by current projects, programs, and activities (PPAs), proposed PPAs, and past PPAs. There have been over sixty five (65) completed projects, program, and/or initiatives in the Eucha/Spavinaw Watershed.

2.3 Source Water Protection Goals

The long-term goals established in 1999 for the Eucha/Spavinaw Watershed are to restore the lakes and streams in the watershed for fish and wildlife beneficial use and to preserve Lakes Eucha and Spavinaw as a principal water supply for northeast Oklahoma. The stakeholder-derived fifteen goals established in the 1999 Watershed Restoration Action Strategy (WRAS) [http://www.deq.state.ok.us/WQDnew/pubs/eucha_watershed_wras_final.pdf] for the Eucha/Spavinaw Watershed were all met. Although an "outside" comprehensive study released in 2012 found that the City of Tulsa's SWP Program for the Eucha/Spavinaw Watershed met all six AWWA standards and compared well with two top-tier programs, new immediate goals (listed below) have since evolved.

2.3.1 *Current Program Goals for Eucha/Spavinaw Watershed.* Current goals for Tulsa's source water protection program reflect (1) the current source water quality conditions and (2) current issues stemming from some of the answers/results of some of the completed and current source water protection stakeholder-based projects and programs – an artifact of the dynamic and iterative source water protection program evaluation and revision process.

The overarching goal for the Eucha/Spavinaw Watershed is to reduce total phosphorus (TP) loading to meet the existing numeric water quality TP criteria (source water protection targets) for Lake Eucha and Spavinaw Lake.

2.3.1.1 Addressment of *specific problem.*

As stated in the Watershed Characterization section, the major known contaminant is excess phosphorus. In order to meet the numeric water quality criteria provided in section 2.2.2 for both E/S source water lakes, the Total Phosphorus (TP) loads (kg day^{-1}) to Lake Eucha and Spavinaw Lake will need to decrease from 30.49 to 5.14 and 13.13 to 4.75, respectively (ODEQ, 2009). Storm and others (2016) found that TP load entering Lake Eucha from external sources was 30 Mg yr^{-1}; 78% from Arkansas and 22% from Oklahoma. The internal P loading to the reservoir was 12 mg yr^{-1}. The average percent contribution and P loading originating from Oklahoma and Arkansas was 6.6 Mg yr^{-1} or 16% and 23 Mg yr^{-1} or 56%, respectively. Neglecting internal TP loads and those originating in Arkansas, the P concentration in Lake Eucha was 0.008 mg L^{-1}. This concentration was less than Lake Eucha criterion of 0.0168 mg L^{-1} and therefore Oklahoma was assumed to meet the water quality standard. The average concentration considering only TP loads from Arkansas was 0.021 mg L^{-1}, respectively. Therefore, based from this analysis, Arkansas is not meeting the water quality standard (Storm et al., 2016).

2.3.1.2 Current Eucha/Spavinaw SWP goals

The following stakeholder-derived goals have been established for the Eucha/Spavinaw Watershed to address the specific source water protection problem of excess phosphorus, chlorophyll-a, and low dissolved oxygen in Lake Eucha and Spavinaw Lake.

1. Develop new linked watershed (must include Arkansas portion) and lake models.

2. Using the assessment of newly linked watershed lake models, establish a multi-jurisdictional, comprehensive TMDL that includes both the Oklahoma and Arkansas portions of the Eucha/Spavinaw Watershed and a multi-state implementation plan.

3. As part of the TMDL implementation plan, develop metrics and methods for assessing specifically what BMPs/easements and where in the watershed need to be implemented to achieve the P criterion for Lake Eucha and Spavinaw Lake.

4. As part of the TMDL implementation plan, update/revise the Oklahoma Conservation Commission's (OCC) Watershed Based Plan.

5. As part of the TMDL implementation plan, quantify load reduction of implemented BMPs to date.

6. As part of the TMDL implementation plan, develop P load reduction strategies for the Eucha/Spavinaw watershed based plans to achieve lake criteria for Lakes Eucha and Spavinaw.

7. As part of the TMDL implementation plan, refine and determine all of the high potential P loss areas for the entire Eucha/Spavinaw Watershed to better target conservation easement efforts and agricultural Best Management Practices (BMPs).

8. As part of the TMDL development, continue coordination stakeholder activity for the Eucha/Spavinaw watershed.

9. Continue partnership with the USFWS and The Conservation Fund (TCF) to conserve habitat for USFWS-designated wildlife as well as protect water quality in the Eucha/Spavinaw Watershed.

10. Continue to implement all management actions designated in the most current USFWS-approved Stewardship Management Plans.

11. Establish an accurate GIS map of completed conservation easements in the Eucha/Spavinaw Watershed for easement compliance monitoring and asset management.

12. Continue Eucha/Spavinaw monitoring program.

13. Continue to financially and logistically support the Eucha/Spavinaw Watershed Management Team made up of two ANRC employees, two ODAFF employees, and one individual to lead the team.

14. Continue ongoing stakeholder involvement and education.

15. Include bacteria in the Eucha/Spavinaw Monitoring Plan for Brushy Creek. Future bacteria data may drive 303(d)/305b listing and selection of BMPs, resulting in a possible further reduction in phosphorus loading.

16. Continue monitoring lakes and streams for appropriate water quality parameters.

2.4 Action Plan

2.4.1 *How the Action Plan Was, and Is, Developed.* The City of Tulsa SWP *action plan* was developed initially in 1997 when a regional stakeholder-based comprehensive Watershed Management Team developed the Watershed Restoration Action Strategy (WRAS) [url: http://www.deq.state.ok.us/WQDnew/pubs/eucha_watershed_wras_final.pdf for the Eucha/Spavinaw Watershed. The Eucha/Spavinaw WRAS became the template for the development of subsequent WRASs by the State of Oklahoma. Since 1997, the WRAS has been renamed to "City of Tulsa Source Water Protection Plan" and is periodically revised by the City of Tulsa's source water protection specialist (official title is Water Quality Specialist) after consultation with watershed stakeholders.

2.4.2 *Projects, Program, and Activities Needed to Achieve SWP goals.* Current, proposed, and past Eucha/Spavinaw Waterhed SWP projects, programs, and activities needed to achieve SWP goals are listed and described in Table 2-1. In 1999, the City of Tulsa established a speakers' bureau and met regularly with citizen groups and policy makers in the watershed and around the states of Oklahoma and Arkansas. Tulsa continues to meet with citizens and other stakeholders in the watershed regarding source water protection.

2.4.3 *Prioritization of Specific COT Projects, Programs, and Activities.* Since some projects and programs are monitoring and/or investigative programs while others are restorative in nature (Table 2-1), prioritization of these initiatives is very general at best. Table 2-1 includes the City of Tulsa Project Work Plan (aka monitoring plan) for the Eucha/Spavinaw Watershed Study. The monitoring plan provides detailed descriptions of the continual work activities performed. The plan specifies methodologies, assessment and reporting, analytical scope of work by site and sampler (e.g. USGS, City of Tulsa, etc.), analytical parameters, methods and sampling frequency for stream water and lake water sample site locations, field sampling SOPs for City of Tulsa, USGS, and the Oklahoma Water Resources Board (OWRB), and the City of Tulsa Quality Assurance Laboratory Quality Assurance Plan (Appendix C).

2.4.4 *Necessary Resources / Provisions for Obtaining Resources.* The necessary resources are identified in Table 2-1.

2.4.5 *Potential Barriers to SWPP.* The Eucha/Spavinaw Watershed faces complex and frequently changing multi-state drainage/water quality issues that are far beyond the scope of this plan. The E/S

Watershed includes jurisdictions outside the State of Oklahoma and within the State of Arkansas that do not benefit directly from source water protection, creating an impediment to coordinated protection efforts.

2.4.6 *Controls to Monitor Project/Program Progress.* Project/program monitoring controls include:

- Eucha/Spavinaw Monitoring Program
- Lake Eucha and Spavinaw Lake Water Quality Quarterly Report (reports results of extensive watershed monitioring program)
- Eucha/Spavinaw Watershed Monitoring Team Annual Report
- Annual City of Tulsa SWP Program Conservation Easement Compliance Audit

2.4.7 *Compliance with Regulatory Requirements.* The only regulatory compliance that apply to COT in our source water protection area (floodplain only) is the United States Army Corps of Engineers' (USACE) 404 permit for excavation, suction, etc. The USACE needs to be contacted first to determine whether a 404 permit is necessary.

2.4.8 *Security Planning and Implementation.* Hard copies are on file with Clayton Edwards, City of Tulsa Water and Sewer Director and with Roy Foster, City of Tulsa, Water and Sewer Water Supply Manager.

2.4.9 *Emergency preparedness and response.* The Emergency Operation Plan (EOP) is available at \\main\wsd\UEI\UEIPublic\Emergency Plans. COT also has an Emergency Action Plan (EAP) for Lake Eucha dam and an EAP for Spavinaw Lake dam, which are available at \\main\wsd\UEI\UEIPublic\. Finally, COT has an annually-updated "Cyanotoxin Early Warning and Contingency Plan (CEWCP) which is currently being used as a template by the Oklahoma Department of Environmental Quality (ODEQ, 2015) and the country of Brazil (USACE, 2015) for developing guidelines for other municipalities. The CEWCP is available at \\main\wsd\UEI\UEIPublic\.

2.4.10 *Health and safety management.* Health and safety management plans are available "at \\main\wsd\UEI\UEIPublic\. The source water lakes have health and safety SOP's for staff to follow in the event of water contamination. The COT lake staff are properly trained in operations are current on all vaccination shots needed for Eucha lagoons, and have all applicable licenses. All health and safety procedures are maintained at our Lake Area Manager's Office. In case of a pollution event potentially affecting Tulsa's source waters requiring emergency response, the National Incident Management System (NIMS) will properly and thoroughly facilitate emergency response for the City of Tulsa. NIMS has the responsibility to ensure proper coordination among local, state, and federal organizations.

2.5 Program Implementation

2.5.1 *Responses to Unexpected Challenges/Barriers to Program Implementation.* In the discussion of challenges and barriers to program implementation, it is important to include a brief history of Tulsa's source water protection outcomes from the extensive and active alliance structure created in the late 1990s and their activities. Outcomes were interesting and worthy enough to include in AwwaRF publication entitled Water Utility/Agricultural Alliances: Working Together for cleaner Water (AwwaRF, 205)). Early during the alliance structure, the City of Tulsa developed EPA Region 6's first Watershed Restoration Action Strategy (WRAS) to meet one of the goals established in the 1972 Clean Water Action Plan (CWAP).

As the working groups began to complete their studies and accomplish their objectives, it became clear that poultry litter was the major source of phosphorus in the watershed, that measures to reduce phosphorus export to receiving water would cost money, and that support from the poultry industry for such measures was essential. Toward the end of the Working Group process it was evident that the poultry industry refused to support, or accept, responsibility for effective management of surplus poultry litter in the watershed.

Without adequate voluntary implementation of nutrient reduction activities by the poultry industry and without adequate regulatory requirements to protect raw water quality, the City of Tulsa filed a

legal suit in 2001 against six Arkansas-based poultry companies and the town of Decatur, AR (approximately 90% of the phosphorus influent to Decatur's WWTF was derived from a poultry processing facility). The lawsuit was settled in 2003. The settlement resulted in an increase in the poultry companies' level of responsibility for poultry litter management.

Though the City of Tulsa's cooperative approach to source water protection was ultimately rebuffed by the poultry industry, the COT's significant investment of time and resources has paid off. Through the stakeholder-base Working Group process, the COT and other participants developed a sound scientific and economic understanding of some of the nation's most vexing questions regarding nutrient sources and control measures that has ultimately benefited the E/S Watershed. As stated by AwwaRF (2005) in regard to Tulsa's SWP program "This understanding is the foundation on which future source water protection efforts will be built."

2.5.2 *Current Implementation.* Since 1998, the City of Tulsa has been staffed with a full-time source water protection program administrator. The City of Tulsa has invested a head-spinning amount of time and financial/personnel resources. To date, there have been over sixty-five (65) completed source water protection projects or programs for the E/S Watershed. Currently, there are twenty six (26) projects and programs in the watershed. The current budget for the COT's Source Water Protection Program, exclusive of personnel, is $650,000.

The City of Tulsa's source water protection implementation efforts is evident by its financial and personnel support for continued stakeholder education and involvement coordination of many of the 26 current projects and programs in Appendix 1. Key efforts are goals 9-13 as listed below.

9. Continue partnership with the USFWS and The Conservation Fund (TCF) to conserve habitat for USFWS-designated wildlife as well as protect water quality in the Eucha/Spavinaw Watershed.

10. Continue to implement all management actions designated in the most current USFWS-approved Stewardship Management Plans

11. Establish an accurate GIS map of completed conservation easements in the Eucha/Spavinaw Watershed for easement compliance monitoring.

12. Continue Eucha/Spavinaw City of Tulsa and USGS monitoring program.

13. Continue to financially and logistically support the Eucha/Spavinaw Watershed Management Team made up of two ANRC employees, two ODAFF employees, and one individual to provide team oversight and generate annual reports on team progress.

14. Continue ongoing stakeholder involvement and education

2.5.3 *Implementation Schedule.* Implementation schedule of action plan is provided in Appendix 1.

2.6 Evaluation and Revision

2.6.1 *Evaluation and Revision Process.* Evaluation of the SWP program for the Eucha/Spavinaw Watershed is an iterative process that uses an adaptive management approach (Figure 2-8) adopted from the US Fish and Wildlife Service (USFWS) to measure accomplishments or project/program completion and to identify areas for future improvement. Evaluation and revision of the program is conducted through the City of Tulsa Source Water Protection (SWP) Plan. It was anticipated that the SWP Plan would become a dynamic document that would be revised when necessary to incorporate the latest information, define new partnerships between watershed stakeholders and address new strategies not yet conceived during the initial WRAS and SWP Plan development stage. In order for the SWP Plan to be an integral part of the Eucha/Spavinaw SWP Program, it must include periodic provisions for review and revisions. The front cover of this plan provides provisions for reviewing, etc. along with a line for the annual review date. The provisions state "All copies of this plan will be reviewed at least annually, and revised if necessary to reflect changes in the critical criteria outlined in this document, the adaptive management strategy, priorities, strategies, new partnerships, watershed issues, water quality criteria, waterbody listings, rules, regulations, laws, local priorities, projects and programs effectiveness, treatment, monitoring, assessment, new

identified species, new target species, taxonomy, contact names and numbers, departments, sections, governmental officials/agencies."

The SWP Plan specifies relevant SWP reports that the Water Quality Specialist (aka 'Source Water Protection Program Administrator') will submit to the Water Supply Manager. The Water Supply Manager will submit the appropriate reports to the Tulsa Metropolitan Utility Authority (TMUA) which manages, constructs, and maintains Tulsa's water works. The annual SWP Plan is used in preparation of the Department's budget, which is subsequently approved by the TMUA.

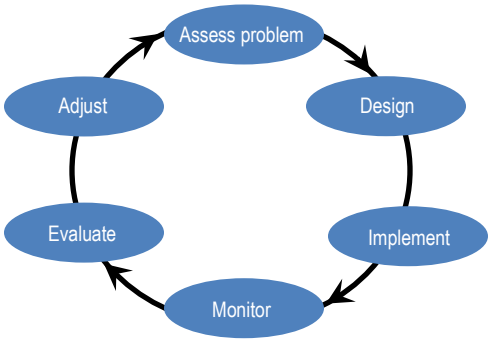

Figure 2-8 Diagram of the Adaptive Management Process adopted from the USFWS.

2.6.2 *SWP Program Effectiveness and How Effectiveness is Measured.* The program has been effective in reducing total phosphorus loading (measure of effectiveness) in the Eucha/Spavinaw Watershed due to the following factors.

• *Point source phosphorus reductions*
The point source, Decatur, AR WWTF, has decreased their mean monthly TP effluent load by 94% during the 1997 – 2017 period. The year 1997 was the year the City of Tulsa began its source water protection program.

• *Export of poultry litter (source of phosphorus) from the Eucha/Spavinaw Watershed*
Approximately 90% of the poultry litter generated in the watershed in 2017 was exported from the watershed compared to no net export of poultry litter when the City of Tulsa's source water protection program began in 1997.

• *Acquisition of permanent conservation easements*
Since 2006, the City of Tulsa has protected 2,560 acres including 10.9 linear miles of protected riparian areas.

• *Extensive changes in agricultural management*
Examples of agricultural Best Management Practices (BMPs) include, but not limited to, off-site cattle watering facilities and fencing of riparian areas.

2.6.3 Documentation of Program Innovation

Below are some specific innovations from Tulsa's source water protection program.

• *Created a source water protection program in 1997.*
Innovative solutions often seem logical in hindsight. So, the act of creating a source water program staffed with a full-time salaried employee today seems logical, but in 1997 it was not a common practice or answer to water quality problems originating in source drinking waters. Innovative outcomes

described below were due, in part, to the City of Tulsa creating a source water protection program in 1997.

• *Developed the State of Oklahoma's first and only lake nutrient criteria. Url: https://www.owrb.ok.gov/rules/pdf/current/Ch45.pdf*

By developing the existing nutrient (i.e. total phosphorus) criteria, these can now serve as (1) the major over-arching target goal for measuring success of Tulsa's SWPP and (2) a key value in determining any future multi-state TMDL (Note: 4 previous TMDLs have been completed).

• *Developed the first Cyanotoxin Early Warning and Contingency Plan in EPA Region 6 and before the City of Toledo, OH.*

The City of Tulsa began development of its *Cyanotoxin Early Warning and Contingency Plan* in May, 2015, one month prior to the release of EPA's *Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water.* The plan describes the actions to be taken in order to minimize the impact of cyanotoxins in the City of Tulsa Water Supply system. The plan combines the City of Tulsa's existing Cyanobacteria Early Warning Monitoring Strategy with the Cyanotoxin Contingency Plan.

• *Identified a pathway for creative leveraging of matching funds for permanent conservation easement acquisition.*

The City of Tulsa's SWPP discovered considerable off-setting mitigation funds (approximately $ 2.3 million) for leveraging matching funds to acquire permanent conservation easements. The off-setting mitigation funds are from a pipeline project that destroyed considerable American Burying Beetle areas. The permanent conservation easements protect riparian areas and water quality as well as ensuring the preservation and function of the protected natural habitats for migratory birds, gray bat habitat, and many other species.

• *Assisted Oklahoma State University in pinpointing and quantifying legacy phosphorus in the Eucha/Spavinaw Watershed to aid in the development of phosphorus load reduction strategies for watershed based plans.*

Phosphorus load allocations can also be used in any future multi-state (Arkansas and Oklahoma) TMDL.

• *The City of Tulsa's SWP Plan includes a current up-to-date "Contact List" of watershed stakeholders as an additional critical criteria in Tulsa's Source Water Protection Plan.*

The up-to-date watershed stakeholder list enables the City of Tulsa's SWPP to be a living functional plan. The list essentially tells the City of Tulsa "…who's on first" and how to contact them quickly, especially in an emergency situation.

2.7 Verification

2.7.1 *Document Retention.* The COT has a document retention policy for all departments. Critical SWP Program documents are maintained in the Source Water Program's filing system on a shared drive. Other documents, including minutes of board meetings, contracts and memoranda of agreement are maintained in the TMUA library, accessible via the COT's intra-net.

2.7.2. *Project Studies.* Project studies are maintained by the COT's Source Water Protection Program's Water Quality Specialist.

2.7.3. *Water Quality/Quantity Data.* Water quality data are available from the following sources.

• COT water quality/quantity data are maintained on the COT's Water Quality Assurance's Laboratory Inventory Management System (LIMS) software.

• COT water quality/quantity reformatted and statistical data are maintained by the COT's Source Water Protection Program's Water Quality Specialist.

• USGS data is available on-line at https://www.waterqualitydata.us/provider/NWIS/USGS-OK/

• Oklahoma Water Resource Board (OWRB) Beneficial Use Program (BUMP) is available on-line at https://www.owrb.ok.gov/quality/monitoring/monitoring.php

• Oklahoma Department of Environmental Quality (ODEQ) is available on-line through EPA's STORET database at https://ofmpub.epa.gov/storpubl/dw_pages.querycriteria

2.7.4 *Nutrient Management Plans and Poultry Litter Export Data.* Nutrient Management Plans for the Eucha/Spavinaw Watershed are maintained with the United States District Court for the Northern District of Oklahoma's court-appointed Eucha/Spavinaw "Watershed Master".

2.7.5 *Source Water Protection Budget.* The current budget for the COT's Source Water Protection Program, exclusive of personnel, is $650,000 (2017). The COT's budget is developed by the staff and approved by the TMUA, followed by the COT mayor, then by the COT City Council.

2.8 Contact Information

For a source water protection plan to be a living useful plan it's essential that it has a complete up-to-date contact list of key source water protection stakeholders, including individuals involved with security incidents/issues, emergency preparedness/response, and health/safety issues. The current contact information for the Eucha/Spavinaw Watershed is provided in the tables below.

Table 2-2 Emergency contact information – City of Tulsa emergency managers

Emergency Contact Information – City of Tulsa Emergency Managers			
Contact	**Work**	**Cell/Pager**	**Home**
City of Tulsa Emergency Managers			
Water Operations Emergency Manager (WOEM) Clayton Edwards, Director of W&S Department Roy Foster ***(Designee)***	918.596.7810 918.596.1344	918.284.1602 918.520.1762	918.492.1357 918.406.8029
Water Supply Systems Roy Foster, WSS Manager Dean Nichols ***(Designee)*** Jennifer Lindley ***(Designee)***	918.596.1344 918.669.6431 918.253.2155	918.520.1762 918.261.9171 918.430.5348	918.406.8029 918.743.0768
Water Quality Assurance (WQA) Jo Brown, WQA Manager	918.596.1344 918.596.8047	918.520.1762 918.261.9145	918.488.0338 918.906.7948
Water Distribution System Eric Parker, Manager Mike Augustine ***(Designee)***	918.596.9480 918.596.9482	918.292.9561 918.527.0182	
Communications Kimberly MacLeod Michelle Brooks ***(Designee)***	918.596.7803 918.596.7270	918.527.0164 918.637.8825	918.493.7176 918.440.4760
Security Mark Weston Lee Isaac ***(Designee)***	918.576.5502 918.527.0174	918.504.6799 918.527.0174	918.357.3826

Emergency Contact Information Con't			
Contact	**Work**	**Cell/Pager**	**Home**
City of Tulsa Emergency Managers			
Other Responding Entities			
Tulsa Health Department On-Call Epidemiologist		918.643.8904	
Tulsa Police Department Captain Brett Bailey	911 918.586.6055	918.728.9167	
Tulsa Fire Department Assistant Chief (phone answered 24/7)	911 918.596.9434		
Tulsa Area Emergency Management Agency Joseph Kralicek, Interim Director	918.596.9898		
Oklahoma Department of Environmental Quality	800.522.0206		
Support Services (Labs, Contractors, Suppliers, etc.)			
AEP (Power Company) Tauren Byrd	918.599.2844 918.599.2648	918.699.9617	

Table 2-3 Emergency contact information – City of Tulsa Water and Sewer

City of Tulsa Water and Sewer Emergency Contact Information			
Title	Name	Office	Mobile
Plant Superintendent (Mohawk)	Dustin Davis	918.591.4028	918.284.9187
Operations Supervisor (Mohawk)	Ethan Prock	918.591.4029	918.200.3545
Plant Superintendent (ABJ)	Stefanie Hunter	918.596.8020	918.277.5152
Operations Supervisor (ABJ)	Steve Goodman	918.596.9188	918.284.4453
Water Supply System Manager	Roy Foster	918.591.4059	918.520.1762
Water and Sewer Director	Clayton Edwards	918.596.7810	918.284.1602

Table 2-4 Table 2-3 Emergency contact information – other

Other Emergency Contact Information		
Emergency Contacts	Office	Mobile
Hazardous Material Team	918.591.4406	918.527.0278
Fire Department	918.596.9977	
Police Department	918.596.9222	
Ambulance	918.596.3135	
Tulsa county Sheriff	918.596.5601	
Oklahoma Highway Patrol	918.627.0440	
City Medical	918.596.7075	
Hospitals		
Hillcrest Hospital	918.579.1000	
OSU Medical Center	918.587.2561	
St. Francis Hospital	918.494.2200	
St. John Hospital	918.744.2345	
South Crest Hospital	918.294.4000	
Regulatory Contacts		
National Response Center (NRC)	1.800.424.8802	
Tulsa County LEPC – Jamie Ott	918.598.596.9891	
Osage County LEPC – Howard Pattison	918.978.3524	

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Part 3 – Verdigris River Basin (Oologah Watershed)

3.1 Watershed Characterization and Source Water Protection Area

3.1.1 *Delineation.* The Verdigris River Basin covers approximately 11,238 km^2 (4,339 mi^2) in northeast Oklahoma and southeast Kansas with 77% in Kansas and 23% in Oklahoma (Figure 2-1). The Verdigris River Basin includes all or portions of 12 counties in Kansas and 4 counties in Oklahoma (Figure 1).

The source water protection area is focused on a 6,094 km^2 area referred to as the Oologah Lake Watershed Protection Area (WPA). These areas of the watershed directly affect and have a greater impact on Lake Ooologah since the four federal reservoirs in Kansas act as a contaminant and sediment trap for those subwatersheds upstream of the those reservoirs.

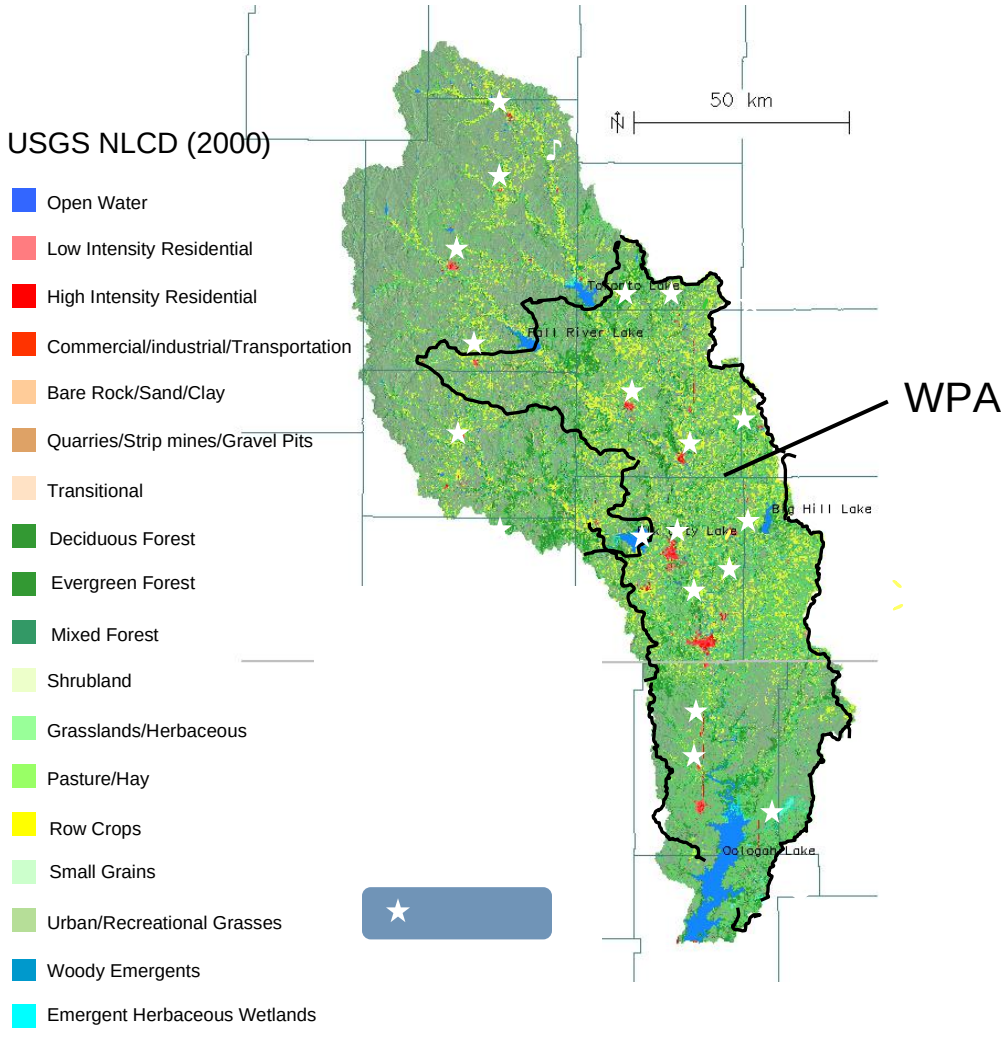

Figure 3-1. Verdigris River Basin's Oologah Lake Watershed Protection Area (WPA).

Natural features

The greater portion of the Verdigris River Basin is in undulating plain. However, the western boundary, formed by the flint Hills in Kansas and the Osage Hills in Oklahoma, is rough and broken with elevations rising to 1,600 feet. The Verdigris River channel is well defined but has relatively high sinuosity, containing many sharp bends in its course through the valley. In terms of soil and geology, Oologah Lake is in the Cherokee Plains subdivision of the Prairie Plains physiographic province. The bedrock strata are shale and limestone of Pennsylvanian age. Sediments consist of silts and clays with scattered outcroppings of sandstone and limestone rock (USACE, 2012). The soils are primarily of the Mollisol Order and moderately fertile but shallow enough to discourage tilling throughout most of the Cherokee plains subdivision.

Much of the indigenous flora and fauna in the WPA has been altered as a result of urbanization, grazing, burning, logging, erosion, oil and gas exploration, and cultivation. The landscape has been fragmented and the vegetation and wildlife associations found in the now-fragmented mosaics of natural ecosystems remaining have changed along with the ecosystem.

Historically, major natural disturbances ere prairie fires and grazing ungulates, such as deer, bison, and antelope. Since settlement, most of the wetland and marshes have been drained for agriculture and a majority of the prairie habitats have been replaced with row crops or pasture. In areas where the native vegetation has been removed, the vegetation is primarily fescue pasture or agricultural crops.
Natural vegetation transitions from mostly tall grass prairie in the west to a combination of tall grass prairie and oak hickory woodland in the east. Upland forest are dominated by shagbark hickory, bitternut hickory, red oak, white oak, blackjack, post oak, with Ohio buckeye, American bladder pod and pawpaw common understory trees. A remnant of the now rare Cross Timbers forest occurs in the basin.

For this SWP Plan, natural vegetation includes wetlands, grasslands, shrublands, and woodlands. Generally, natural vegetation has positive impacts on source water. These impacts include increased infiltration of precipitation into the ground, decreased quantity of storm water runoff, removal of contaminants from source water, reduced potential for erosion and less drastic fluctuations of streamflow.

Areas of natural vegetation, such as grassland, scrubland and open woodland are dominant in all portions of the WPA. These areas of natural vegetation aid in protecting source water by filtering and removing contaminants, reducing sedimentation of waterbodies and reducing the amount of runoff from precipitation events.

Hydrology

Surface water. The WPA includes Hydrologic Unit Codes 11070103 (Middle Verdigris Watershed), 110702090940, and lower portions of 11070102 and 11070101. The principal stream in the WPA is the Verdigris River originating in the Flint Hills of Chase County, Kansas at an elevation of 1,676 feet, and lows generally southeast from the vicinity of Madison to Neodosha, Kansas, then in a southerly direction to its confluence with the Arkansas River, southeast of Oologah Lake in Oklahoma.

Surface water is the predominant source of water for beneficial uses in the Verdigris River Basin, with a very small amount (~1%) derives from alluvial deposits along streams. Surface water makes up over 98% of the water used. The majority of water used in Kansas is for industrial (~35.5%) and municipal (56%) purposes. Recreation (8%), irrigation (<1%), stockwater (<1%) and other uses (<1%) make up the remainder of the water used in the basin. The historic rural nature of the Verdigris River Basin led to many small communities developing their own water supplies, either from direct intakes on the major rivers and streams or from construction of individual community lakes. Federal reservoirs have been built which also provide water supply for numerous communities in the Basin

First federal impoundment: The Verdigris River is impounded by 2,660-acre Toronto Lake, the net drainage to 730 mi2 and approximately four miles southeast of Toronto, Kansas in Woodson country, Kansas. Principal tributaries to the Verdigris River are the Fall and Elk Rivers that enter from the right bank in Kansas (USACE, 2012).

Second federal impoundment: The Fall River is impounded at the 2,350-acre Fall River Lake northwest of Fall River in Greenwood County, Kansas and draining 585 mi2.

Third federal impoundment: The Fall River joins the Verdigris River just south of Neodesha in Wilson County, Kansas. The Elk River is impounded northwest of Independence, Kansas in Montgomery County, KS at 4,118-acre Elk City Lake which drains 634 mi2 and meets the Verdigris River north of Independence in Montgomery County, Kansas.

Fourth federal impoundment: The fourth impoundment is located on Big Hill Creek, a right bank tributary entering the Verdigris River just north of Coffeyville, Kansas and draining 37 mi2.

Collectively, these lakes control 1,986 mi2 of drainage, leaving 2,353 mi2 of uncontrolled drainage area between upstream federal impoundments and Oologah Dam. This area represents 54% of the total drainage in the Verdigris River Basin.

Oologah Lake is directly fed by two major tributaries, the Verdigris River and Big Creek. About 94% of the average annual inflow to the lake is from the Verdigris River. The medium annual hydraulic residence for Oologah Lake is approximately 0.35 years (USACE). The raw source water leaving the Oologah Lake dam, travels along a 23-mile pipe before reaching the ABJ Water Treatment Plant.

Ground water.

Ground water in the basin occurs in consolidated rocks and unconsolidated deposits ranging in age from Mississippian to Quaternary. Water for municipal, industrial, and irrigation supplies generally can be obtained in limited quantities from the alluvial deposits in the stream valleys (USACE, 2012).

3.1.2 *Water Quality and Quantity Data*

3.1.2.1 *Water quality and quantity data storage.* Source water quality and quantity data are stored in (1) the City of Tulsa's Local Information Management System (LIM) database; (2) USACE Tulsa Office; and (3) the Oklahoma Water Resources Board Beneficial Use Program (BUMP) available to the public. The LIMS database includes historical EPA-approvable QAQC data from1997 to current. Pre-1997 data are stored on a COT shared drive established by the COT's source water quality program administrator entitled Water Quality Specialist. Other data sources are NPDES DMR records, and USACE Tulsa District & City of Tulsa "Oologah Lake Watershed Assessment Study" (2012).

3.1.2.2 *Water quality monitoring and assessment information.* The USACE's monitoring information can be obtained via the USACE Tulsa office, while the OWRB BUMP information can be obtain via the OWRB website and office.

3.1.3 *Causes, Contaminant Sources, Land Use, and Other Threats.*

3.1.3.1 *Waterbody impairment (problem identification).* Oologah Lake is not supporting its designated uses for Fish and Wildlife Propagation for a Warm Water Aquatic Community (WWAC) because of dissolved oxygen (DO) and turbidity (OKWBID: OK121510010020-00).

3.1.3.2 *Cause(s) of waterbody impairment.* The causes of the waterbody impairment is because of dissolved oxygen (DO) and turbidity (OKWBID: OK121510010020-00).

Water Quality Targets:

- Turbidity of 25 NTU
- DO (see 785:45-5-12(f)(1)(C)(ii) and Appendix G).

3.1.3.3 *Known contaminant sources (Pollutant Source Assessment).* The following table indicates percentage contribution of pollutant load estimates from nonpoint source ('WS Runoff'), atmospheric deposition, and sediment flux into Oologah Lake. United States Army Corps of Engineers (USACE) SWAT-generated estimate of annual average loads of pollutants found in Table 3-1 found that croplands contributed the highest percentage of sediment(85.1%), organic nutrients (79.8% of organic nitrogen / 79.3% organic phosphorus), and sediment bound phosphorus (54.6%). Soluable pollutant loads are still dominated by contributions from pasture/alfalfa and rangelands.

There are point sources contributing to the source loading, however, ODEQ (2017) stated that "… since there are no NPDES point sources directly discharging into the lake, there is no waste load allocation (WLA)".

Table 3-1 ODEQ's Pollutant load estimates from nonpoint sources (ODEQ, 2017).

Pollutant	Source Load Estimates (%)			
	WS† Runoff	Atm. Deposit.	SedFlux*	Total
Total Nitrogen (TN)	94.5	1.04	4.46	100.0
Total Phosphorus (TP)	86.67	0.04	13.29	100.0
Total Organic Carbon (TOC)	100	0.00	0.00	100.0
Total Suspended Solids (TSS)	100	0.00	0.00	100.0

* SedFlux = Sediment Flux (lake benthic release)

† WS = Watershed

Recommendations from ODEQ's 2017 TMDL Model Results: A 40% loading reduction in TSS, TOC, TN, and TP could achieve water quality criteria compliance for DO and turbidity within a reasonable time frame.

Pollutant Load Allocation from ODEQ's 2017 TMDL Model Results: The linked watershed (HSPF) and lake (EFDC) model framework was used to calculate Existing 'Long Term Average' (LTA) Loading, Load Reduction Rate, Reduced LTA Loading (annual and daily), Maximum Daily Load (MDL), and TMDL for Oologah Lake (Table 3-2).

Table 3-2 ODEQ's pollutant load allocation (ODEQ, 2017).

Pollutant	LTA, Existing Annual (kg/yr)	Load Reduction (%)	LTA, Reduced Annual (kg/yr)	LTA , Reduced Daily (kg/day)	MDL (TMDL) Load (kg/day)
TN	8,160,833	40	4,896,500	13,415	50,906
TP	1,214,873	40	728,924	1,997	7,407
TOC	33,328,891	40	19,997,335	54,787	207,688
TSS	1,842,230,207	40	1,105,338,124	3,028,324	6,524,666

3.1.3.4 *Land use activities.*

Agricultural

Land cover in the basin is a mosaic of unmanaged grassland and managed pasture/hay land (75%) cropland (11%), woodland (8.4%), open water (2.5%), wetland (2%), urban/ commercial/ transportation/barren areas (1%) and the remainder is distributed between other minor land uses. The majority of the land is owned by private landowners and used for agriculture, either for grazing and haying or crop production. Most of the crops are grown in the floodplains of the Verdigris River and its tributaries. Principal crops in the basin are wheat, soybeans, sorghum, pecans, and alfalfa.

Beef cattle producers also comprise a prevalent portion of the agricultural sector. Numerous watershed district dams have been constructed to control flooding in tributaries to facilitate crop production.

Industrial

Because of the history, extent, and proximity of petroleum extraction to Lake Oologah, it warrants a brief discussion. A large, 42-section area along the upper two-thirds of the eastern shore of Oologah Lake is the approximate location of an extensive shallow oil field discovered in the early 1900s. The producing reservoir is the Bartlesville Sand, and the area has been extensively drilled with thousands of wells over the field's history. While some production is still occurring in the area, many of the wells have been abandoned with few records available as to their number and locations. Several thousand of these were plugged in and around Oologah Lake over an approximate 17-year time span (1955 to 1972) prior to impoundment of the reservoir. A number of improperly or unplugged abandoned wells still exist in the area, some of which have been noted to purge oil to surface soils and waters. The Environmental Protection Agency (EPA) and the Oklahoma Corporation Commission conducted a well-plugging project from 2000 to 2006, primarily near the eastern shore of Lake Oologah. More information about the well plugging project can be obtained in Appendix B as well as files under the "West" folder on the City of Tulsa share "wspublic **(**\\main\wsd\watersupply**)".**

Other industries found in the basin include stone, natural gas, coal, cement, clay, zinc products, paint, and oil field equipment.

3.1.4 *Inventory of Regulations.* The relevant laws, rules and regulations that affect City of Tulsa source water protection are inventoried below.

• [O.S. 82:1085:30(A)] statute authorizes the OWRB to promulgate 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.*

• Registered Poultry Feeding Operations rules. OAC § 785:35-17-5
https://www.oda.state.ok.us/aems/aemsrulesrpfo.pdf
• Poultry Waste Applicator Certification rules OAC § 785:35-17-7. Url:
https://www.oda.state.ok.us/aems/aemsrulespwa.pdf

• Concentration Animal Feeding Operations rules. OAC § 785:35-17-4
https://www.oda.state.ok.us/aems/CAFOAct.pdf

• This multi-agency website(https://www.regulations.gov/) serves as an online clearinghouse for materials related to EPA rule makings and is EPA's official on-line comment system. Comment on regulations, and access rules that have been published in the *Federal Register* and related documents.

• Final General Permit for OKO4 for Municipal Stormwater discharges is available at
http://www.deq.state.ok.us/wqdnew/stormwater/

• Final General Permit for OKO5 for Industrial Stormwater discharges is available at
http://www.deq.state.ok.us/wqdnew/stormwater/

• Final General Permit for OKR10 for Construction Stormwater discharges is available at
http://www.deq.state.ok.us/wqdnew/stormwater/

• Final OPDES Permit for municipal and industrial discharges within lands under Oklahoma jurisdiction are available at
http://www.deq.state.ok.us/wqdnew/opdes/index.html

• Final KPDES Permit for municipal and industrial discharges within lands under Kansas jurisdiction are available at https://www.epa.gov/npdes-permits/kansas-npdes-permits

• Final General Stormwater Discharge Permits for Municipal, Industrial, and Construction are available at http://www.kdheks.gov/water/index.html

• Final OPDES Permit for municipal and industrial discharges within lands not under Oklahoma or Kansas jurisdiction are available at https://www.epa.gov/npdes

• Pursuant to sections 303 and 101(a) of the Clean Water Act, the federal regulations at 40 CFR 131.10(b) requires that 'In designating uses of a water body and the appropriate criteria for those uses, the State shall take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters". This provision requires states and authorized tribes to consider and ensure the attainment and maintenance of downstream[1] water quality standards (WQS) during the establishment of designated uses and water quality criteria in upstream[2] waters. EPA states that adopting either narrative or numeric criteria to ensure the attainment and maintenance of downstream WQS (i.e. designated uses, criteria and antidegradation requirements) may likely be the preferred path for states/tribes to ensure consistency with 40 CFR 131.10(b).

[1] The EPA interprets the term "downstream' to include both intrastate and inter state waters, as well as waters that form a boundary between adjacent jurisdictions.
[2] EPA uses the term "upstream" to include "instream" when referring to the water body(ies) for which states/tribes are developing designated uses/water quality criteria that will ensure the attainment and maintenance of downstream WQS.

3.2 Stakeholder Involvement

3.2.1 *Past Stakeholder Involvement.*

3.2.1.1 *Alliance Structure.* These groups included representatives from the following agencies, non-profit groups, universities, and groups of residents living in the watershed who voluntarily participate in local Kansas WRAPS groups:

• US Department of Agriculture, Natural Resources Conservation Service (NRCS)
• US Department of Agriculture, Farm Service Agency (FSA)
• US Environmental Protection Agency (USEPA)
• US Fish and Wildlife Service (USFWS)
• US Geological Survey (USGS)
• Office of the Secretary of Energy and the Environment for Oklahoma
• Oklahoma Water Resources board (OWRB)
• Oklahoma Conservation Commission (OCC)
• Oklahoma Department of Environmental Quality (ODEQ)
• Oklahoma Department of Wildlife Conservation (ODWC)
• Oklahoma Department of Agriculture, Food, and Forestry (ODAFF)
• Oklahoma Energy Resources board (OERB)
• Oklahoma Department of Tourism and Recreation
• Oklahoma Association of Conservation Districts
• Cherokee Hills Resource Conservation and Development Council (OK)
• Cross timbers Resource Conservation and Development Council (OK)
• Tall Grass Prairie Resource Conservation and Development Council (OK)
• Oklahoma State University (OSU)
• University of Oklahoma (OU)
• Grand River Dam Authority, Grand Lake, OK
• Kansas Water Office (KWO)
• Kansas Department of Health and the Environment (KDHE)
• Kansas Department of Agriculture (KDA)
• State Conservation Commission (Kansas) (SCC)
• Kansas Department of Wildlife and Parks (KDWP)

• Kansas Department of Forestry (KDF)
• University of Kansas (UK)
• Pittsburg State University (PSU)
• Kansas Alliance for Wetlands and Streams (KAWS)
• Verdigris Basin Advisory Committee (Volunteer Citizen Watershed Basin Boards) (KS)
• Watershed Restoration and Protection Strategy (WRAPS) Groups (volunteer residents living in the watershed (KS)

3.2.1.2 *Activities.* Given the geographic extent of the WPA and the variety of activities ongoing in the watershed, many agencies and individuals were, and still are, involve in an informal planning process through assisting in identifying needs and issues existing in the watershed. Since no federal, state, or local agency can legally act outside its authority and mission, the formation of partnerships for this watershed is instrumental to the success of restoring, sustaining, and protecting the stream and Oologah Lake.

The City of Tulsa, as the local sponsor of a USACE Oologah Lake Watershed Assessment Study (March 2012) worked proactively with the USACE throughout the process to encourage and engage various stakeholders in a collaborative environment to assist in the assessment. These stakeholders in both Oklahoma and Kansas have participated in identifying needs/issues and presented ideas for potential opportunities for solutions. The stakeholders involved in the collaborative process include individuals who regularly or intermittently participated in many meetings conducted over several years.

3.2.1.3 *Outcomes.* From 2005 through 2010 various stakeholder groups identified both needs or issues and the opportunities to address these needs/issues. The USACE lacks the authority to work with individuals directly in providing financial assistance to implement potential solutions. The majority of the land in the study area is privately owned; therefore, the implementation of any solutions will happen through local partnerships and will not likely involve the USACE.

Over the course of the USACE's watershed assessment, several groups discussed the needs for improvement of conditions in the watershed. These groups included interested citizens that live in the watershed participating in the WRAPS process and Basin Advisory Committee meetings in Kansas and inter-agency meetings in both Oklahoma and Kansas.

The needs/issues discussed at these various meetings to improve existing conditions in the watershed are discussed below.

• *Streambank erosion and sloughing*. This issue was viewed as on of the most important issues throughout the watershed in both Oklahoma and Kansas. Streams in this region are deeply incised, have steep, unvegetated stream banks, and bank erosion seems to increase with each high streamflow event, especially along the mainstems of the Verdigris and Fall Rivers.

• *Low dissolved oxygen levels in streams and lakes*. Some of the tributaries stream in Oklahoma have either not been identified as having low dissolved oxygen (DO) levels or have yet to be evaluated; however, Oologah Lake has experienced periods of low DO events and remains listed as such in the 2016 Draft Integrated Report for Water Quality in Oklahoma. Low DO levels in Kansas were attributed to natural conditions due to pools being disconnected during low flow periods of the year. Low DO was not identified in Kansas as an issue during these meetings.

• *Bacteria Levels*. Although Kansas has had higher bacteria levels in the streams, especially with the accumulation of E. coli, conditions had improved at the time of these discussions so that the Kansas stakeholders did not consider this as a critical issue.

• *Turbidity*. Most discussions did not recognize turbidity as an issue, especially in Kansas. Turbidity conditions in Oologah Lake were generally recognized as more problematic. Turbidity was considered a lower priority in the overall watershed area since other issues were considered more important by many in the stakeholder groups.

The USACE produced an excellent watershed assessment of the Oologah Lake WPA entitled "Oologah Lake Watershed Watershed Study Verdigris River Basin, Oklahoma and Kansas". The study evaluated environmental restoration measures by assessing linked watershed and lake models (SWAT & CE-QUAL-W2) to improve water quality and reduce flood damages within the Verdigris River Basin, Oklahoma and Kansas. The assessment was conducted to identify potential causes of and solutions to impairment issues arising from the uncontrolled portions of the watershed. KWO received this report. A few months later, the COT source water protection staff and the Water Supply manager met with some Kanas agency representatives. Below is a summary of the last important stakeholder meeting.

Oologah Watershed Meeting Summary
August 7, 2013
Wichita, KS 67205

1. Introductions **All**

Attendees: Baker, Debra (KWO); Ann D'Alfonso (KDHE); Shanon Phillips (OCC); DaveJones (KDA) ; jgaggero@kdheks.gov; Rob Reschke (KWO); Roy Foster (COT); Ray West, Ray <RWest (COT)

2. Oologah Watershed Background/History **Ray West/Debra Baker**

The watershed area of interest is the result of the completion of 4 federal (Corps) flood control dams in Kansas (Elk City Lake on the Elk River, Big Hill Lake on Big Hill Cr, Fall River Lake on the Fall River, and Toronto Lake on the Verdigris R.), and the Corp flood control dam at Lake Oologah on the Verdigris river. The Verdigris River is the main river in the watershed of interest with a length of 150 miles. Verdigris R. headwaters begin in Chase County and the river has relatively high sinuosity. The watershed to lake area ratio is 48.5

3. Oologah Lake Watershed Assessment Study **Ray West/Debra Baker**

Back in 2003, the City of Tulsa and the Corps partnered up to try and understand what, if any, proactive measures could be implemented to restore and/or improve conditions in Lake Oologah and it's watershed before the aquatic environment degrades further and becomes both difficult and costly to restore. The Corps used the SWAT model for their assessment. This particular SWAT model assessment functioned on an hourly time-step to predict and evaluate long-term (50 year) land cover and land management practices on the quantity and quality of water that is exported from watersheds with agricultural use. The assessment basically identifies sediment and nutrient export and loading "hot spots", which may help minimize restoration cost. It also included BMP simulations using 15 different theoretical, but commonly used BMPs designed to reduce either sediment export, nutrient export or both. The assessment found that the most effective BMP for reducing sediment and nutrient export from land surface to waterbody (i.e.Oologah) was edge-of-field vegetated filter strips. Vegetated filter strips were at 5- 10- 20- 30- and 40-meter width. Also simulated as highly effective was improved riparian zone BMP.

4. Agency Overview of Past and Current Projects **All**

KWO provided CDs with project overview for the Verdigris River subbasins above the four federal reservoirs. City of Tulsa provided CDs and hard copies of the Corps' Oologah Watershed Assessment.

Ann D'Alfonso: Upper Fall River Watershed and Toronto Watershed (farthest-north sub-watershed of the Verdigris River Basin) both have active WRAPS and have completed their 9 element plan. Both have been implementing BMPs (e.g. restoring brine scares) and monitoring results of BMP implementation. KDHE will re-evaluate results of BMP implementation in 5 years.

Elk and Big Hill Watershed went through the development and assessment phase and found that there wasn't much stakeholder support, so they didn't pursue further (e.g. implementation).

Rob Reschke: $24 million of Kansas state money spent last year for water quality.

Debra Baker: The issue of Verdigris River basin below the four federal reservoirs is not a priority for Kansas. There are no streambank projects on the Verdigris River below the four reservoirs. There is a system in place, either WRAPS or conservation districts. The state/federal basically pays for the whole thing. It seems to have worked. Regarding 319 funding, Kansas does take on cross-border watersheds. Kansas WRAPs our based on HUC8 but target on a HUC 12 level.

Rob Reschke: KCC has well-plugging info/databases going back numerous years.

5. Where do we go from here? **All**

Kansas representatives will distribute the Corps' watershed assessment to the various conservation districts, which may be used as a tool in their planning.

6. Next Meeting **All**

The group decided not to set a date for another meeting, however, another meeting was not ruled out.

3.2.2 *Current Stakeholder Involvement.* See Verdigris River Projects, Program, and Activities (Appendix B). The Verdigris River Basin includes jurisdictions outside the State of Oklahoma and within the State of Kansas that do not benefit directly from source water protection, creating an impediment to coordinated protection efforts.

3.3 Source Water Protection Goals

3.3.1 *Current Program Goals for the Verdigris River Basin SWP Area.* Current goals for Tulsa's source water protection program reflect (1) the current source water quality conditions and (2) current issues stemming from some of the answers/results of some of the completed and current source water protection stakeholder-based projects and programs – an artifact of the dynamic and iterative source water protection program evaluation and revision process.

The overarching goal for the Verdigris River Basin is to reduce loadings of total phosphorus (TP), total nitrogen (TN), total organic carbon (TOC), and total suspended solids (TSS) to meet the existing water quality standard for Turbidity and Dissolved Oxygen (source water protection targets) for Lake Eucha and Spavinaw Lake.

3.3.1.1 Addressment of *specific problem.* Although a current implementation plan would be preferred by the City of Tulsa, implementation plans for TMDLs are not required by the Clean Water Act. The ODEQ does not develop implementation plans for a TMDL straddling state lines because of differences between states in their water quality standards, listing of impaired waters, sources of the pollutant resources, and perhaps level of enthusiasm.

3.3.1.2 Current Verdigris River Basin SWP Area goals

The following stakeholder-derived goals have been established for the Eucha/Spavinaw Watershed to address the specific source water protection problem of excess phosphorus, chlorophyll-a, and low dissolved oxygen in Lake Eucha and Spavinaw Lake.

1. Assist the Oklahoma Conservation Commission's (OCC) is developing an implementation plan or "Watershed Based Plan."

2. As part of any potential TMDL implementation plan by the Oklahoma Conservation Commission partner and assist efforts to better target conservation easement efforts and agricultural Best Management Practices (BMPs) for reducing pollutant loadings.

3. Assist state and federal agencies in developing metrics and methods for assessing specifically what BMPs/easements and where in the watershed need to be implemented to achieve the water quality standards for Oologah Lake.

4. As part of the TMDL implementation plan, assist in quantifying load reduction of implemented BMPs to date.

5. As part of the TMDL implementation plan, develop pollutant load reduction strategies for the Verdigris River Basin "Watershed Based Plans to achieve a 40% loading reduction I TP, TN, TOC, and TSS within a reasonable time frame.

6. As part of a TMDL implementation plan, refine and determine all of the high potential pollutant loss areas for the entire WPA to better target conservation easement efforts and agricultural Best Management Practices (BMPs).

7. Continue sharing updated stakeholder activities for the Verdigris River Basin.

3.4 Action Plan

3.4.1 *How the Action Plan Was, and Is, Developed.* The City of Tulsa SWP *action plan* was developed by the City of Tulsa's source water protection specialist (official title is Water Quality Specialist) after consultation with watershed stakeholders. The Action Plan is based off the results of ODEQ's most recent TMDL study completed in 2017.

3.4.2 *Projects, Program, and Activities Needed to Achieve SWP goals.* Current, proposed, and past Eucha/Spavinaw Waterhed SWP projects, programs, and activities needed to achieve SWP goals are listed and described in Appendix B.

3.4.3 *Prioritization of Specific COT Projects, Programs, and Activities.* Since some projects and programs are monitoring and/or investigative programs while others are restorative in nature (Table 2-1), prioritization of these initiatives is very general at best.

3.4.4 *Necessary Resources/Provisions for Obtaining Resources.* The necessary resources are identified in Appendix.

3.4.5 *Potential Barriers to SWPP.* The Verdigris River Basin faces complex and frequently changing multi-state drainage/water quality issues that are far beyond the scope of this plan. The Verdigris River Basin includes jurisdictions outside the State of Oklahoma and within the State of Kansas that do not benefit directly from source water protection, creating an impediment to coordinated protection efforts. At the last important stakeholder meeting held in August, 2012, Kansas agencies dealing with water quality informed Oklahoma stakeholders that the issue of Verdigris River basin below the four federal reservoirs is not a priority for Kansas.

3.4.6 *Controls to Monitor Project/Program Progress.* Project/program monitoring controls include:

- OWRB's Beneficial Use Monitoring Program (BUMP). More information is available at http://www.owrb.ok.gov/quality/monitoring/monitoring.php

- OWRB's BUMP Report

- OWRB's Streams Probabilistic Monitoring Program. More details at http://www.owrb.ok.gov/quality/monitoring/monitoring.php

3.4.7 *Compliance with Regulatory Requirements.* The only regulatory compliance that apply to COT in our source water protection area (floodplain only) is the United States Army Corps of Engineers (USACE) 404 permit for excavation, suction, etc. The USACE needs to be contacted first to determine whether a 404 permit is necessary.

3.4.8 *Security Planning and Implementation.* Hard copies are on file with Clayton Edwards, City of Tulsa Water and Sewer Director and with Roy Foster, City of Tulsa, Water and Sewer Water Supply Manager.

3.4.9 *Emergency Preparedness and Response.* The Emergency Operation Plan (EOP) is available at \\main\wsd\UEI\UEIPublic\Emergency Plans.

3.4.10 *Health and Safety Management.* Health and safety management plans are available "at \\main\wsd\UEI\UEIPublic\. All health and safety procedures are maintained at the City of Tulsa Water Supply's Raw Water Manager's Office. In case of a pollution event potentially affecting Tulsa's source waters requiring emergency response, the National Incident Management System (NIMS) will properly and thoroughly facilitate emergency response for the City of Tulsa. NIMS has the responsibility to ensure proper coordination among local, state, and federal organizations.

3.5 Program Implementation

3.5.1 *Responses to Unexpected Challenges/Barriers to Program Implementation.* The number one challenge/barrier to program implementation is Kansas's lack of enthusiasm for implementing source water protection efforts in the watershed. Another challenge will be identifying the location of the highest pollutant loss areas within the watershed. After identifying these locations, a formal implementation plan will be critical in ensuring what pollutant controls and management measures are needed, as well as a time frame for achieving incremental improvements.

3.5.2 *Current Implementation.* Current implementation of water quality protection efforts in the watershed are in Appendix B of this report.

3.5.3 *Implementation Schedule.* Implementation schedule of action plan is provided in Appendix B.

3.6 Evaluation and Revision

3.6.1 *Evaluation and Revision Process.* Evaluation of the SWP program for the Verdigris River Basin is an iterative process that uses an adaptive management approach (Figure 2-8) adopted from the US Fish and Wildlife Service (USFWS) to measure accomplishments or project/program completion and to identify areas for future improvement. Evaluation and revision of the program is conducted through the City of Tulsa Source Water Protection (SWP) Plan. It was anticipated that the SWP Plan would become a dynamic document that would be revised when necessary to incorporate the latest information, define new partnerships between watershed stakeholders and address new strategies not yet conceived during the initial SWP Plan development stage. In order for the SWP Plan to be an integral part of the Verdigris River Basin SWP Program, it must include periodic provisions for review and revisions. The front cover of this plan provides provisions for reviewing, etc. along with a line for the annual review date. The provisions state "All copies of this plan will be reviewed at least annually, and revised if necessary to reflect changes in the critical criteria outlined in this document, the adaptive management strategy, priorities, strategies, new partnerships, watershed issues, water quality criteria, waterbody listings, rules, regulations, laws, local priorities, projects and programs effectiveness, treatment, monitoring, assessment, new identified species, new target species, taxonomy, contact names and numbers, departments, sections, governmental officials/agencies."

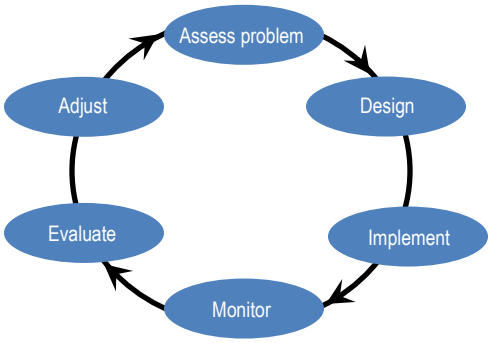

Figure 3-2. Diagram of the Adaptive Management Process adopted from the USFWS.

The SWP Plan specifies relevant SWP reports that the Water Quality Specialist (aka 'Source Water Protection Program Administrator') will submit to the Water Supply Manager. The Water Supply Manager will submit the appropriate reports to the Tulsa Metropolitan Utility Authority (TMUA) which manages, constructs, and maintains Tulsa's water works. The annual SWP Plan is used in preparation of the Department's budget, which is subsequently approved by the TMUA.

3.6.2 SWP *Program Effectiveness and How Effectiveness is Measured*. The SWP program is currently only providing periodic updates of projects and programs to watershed stakeholders in Oklahoma and Kansas.

3.6.3 Documentation and Program Innovation

Below are some specific innovations from Tulsa's source water protection program for the Verdigris River Basin SWP Area.

• *Created a source water protection program in 1997.*

Innovative solutions often seem logical in hindsight. So, the act of creating a source water program staffed with a full-time salaried employee today seems logical, but in 1997 it was not a common practice or answer to water quality problems originating in source drinking waters. Innovative outcomes described below were due, in part, to the City of Tulsa creating a source water protection program in 1997.

• *Developed the first Cyanotoxin Early Warning and Contingency Plan in EPA Region 6 and before the City of Toledo, OH.*

The City of Tulsa began development of its *Cyanotoxin Early Warning and Contingency Plan* in May, 2015, one month prior to the release of EPA's *Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water.* The plan describes the actions to be taken in order to minimize the impact of cyanotoxins in the City of Tulsa Water Supply system. The plan combines the City of Tulsa's existing Cyanobacteria Early Warning Monitoring Strategy with the Cyanotoxin Contingency Plan.

• *The City of Tulsa's SWP Plan includes a current up-to-date "Contact List" of watershed stakeholders as an additional critical criteria in Tulsa's Source Water Protection Plan.*

The up-to-date watershed stakeholder list enables the City of Tulsa's SWPP to be a living functional plan. The list essentially tells the City of Tulsa "…who's on first" and how to contact them quickly, especially in an emergency situation.

3.7 Verification

3.7.1 *Document Retention.* The COT has a document retention policy for all departments. Critical SWP Program documents are maintained in the Source Water Program's filing system on a shared drive. Other documents, including minutes of board meetings, contracts and memoranda of agreement are maintained in the TMUA library, accessible via the COT's intra-net.

3.7.2. *Project Studies.* Project studies are maintain by the COT's Source Water Protection Program's Water Quality Specialist.

3.7.3. *Water Quality/Quantity Data.* Water quality data are available from the following sources.

- USGS data is available on-line at https://www.waterqualitydata.us/provider/NWIS/USGS-OK/

- Oklahoma Water Resource Board (OWRB) Beneficial Use Program (BUMP) is available on-line at https://www.owrb.ok.gov/quality/monitoring/monitoring.php

- Oklahoma Department of Environmental Quality (ODEQ) is available on-line through EPA's STORET database at https://ofmpub.epa.gov/storpubl/dw_pages.querycriteria

- COT water quality/quantity data are maintained on the COT's Water Quality Assurance's Laboratory Inventory Management System (LIMS) software.

3.7.4. *Nutrient Management Plans and Poultry Litter Export Data.* Nutrient Management Plans for the Eucha/Spavinaw Watershed are maintained with the United States District Court for the Northern District of Oklahoma's court-appointed Eucha/Spavinaw "Watershed Master".

3.7.5. *Source Water Protection Budget.* The current budget for the COT's Source Water Protection Program, exclusive of personnel, is $650,000 (2017). The COT's budget is developed by the staff and approved by the TMUA, followed by the COT mayor, then by the COT City Council.

3.8 Contact Information

For a source water protection plan to be a living useful plan it's essential that it has a complete up-to-date contact list of key source water protection stakeholders, including individuals involved with security incidents/issues, emergency preparedness/response, and health/safety issues. The current contact information for the Eucha/Spavinaw Watershed is provided in the tables below.

Table 3-3

Emergency Contact Information			
Contact	**Work**	**Cell/Pager**	**Home**
City of Tulsa Emergency Managers			
Water Operations Emergency Manager (WOEM) Clayton Edwards, Director of W&S Department Roy Foster ***(Designee)***	918.596.7810 918.596.1344	918.284.1602 918.520.1762	918.492.1357 918.406.8029
Water Supply Systems Roy Foster, WSS Manager Dean Nichols ***(Designee)*** Jennifer Lindley ***(Designee)***	 918.596.1344 918.669.6431 918.253.2155	 918.520.1762 918.261.9171 918.430.5348	 918.406.8029 918.743.0768
Water Quality Assurance (WQA) Jo Brown, WQA Manager	918.596.1344 918.596.8047	918.520.1762 918.261.9145	918.488.0338 918.906.7948

Table 3-3 Con't

Emergency Contact Information			
Contact	**Work**	**Cell/Pager**	**Home**
City of Tulsa Emergency Managers			
Water Distribution System Eric Parker, Manager Mike Augustine ***(Designee)***	918.596.9480 918.596.9482	918.292.9561 918.527.0182	
Communications Kimberly MacLeod Michelle Brooks ***(Designee)***	918.596.7803 918.596.7270	918.527.0164 918.637.8825	918.493.7176 918.440.4760
Security Mark Weston Lee Isaac ***(Designee)***	918.576.5502 918.527.0174	918.504.6799 918.527.0174	918.357.3826
Other Responding Entities			
Tulsa Health Department On-Call Epidemiologist		918.643.8904	
Tulsa Police Department Captain Brett Bailey	911 918.586.6055	918.728.9167	
Tulsa Fire Department Assistant Chief (phone answered 24/7)	911 918.596.9434		
Tulsa Area Emergency Management Agency Joseph Kralicek, Interim Director	918.596.9898		
Oklahoma Department of Environmental Quality	800.522.0206		
Support Services (Labs, Contractors, Suppliers, etc.)			
AEP (Power Company) Tauren Byrd	918.599.2844 918.599.2648	918.699.9617	

Table 3-4

City of Tulsa Water and Sewer Emergency Contact Information			
Title	Name	Office	Mobile
Plant Superintendent (Mohawk)	Dustin Davis	918.591.4028	918.284.9187
Operations Supervisor (Mohawk)	Ethan Prock	918.591.4029	918.200.3545
Plant Superintendent (ABJ)	Stefanie Hunter	918.596.8020	918.277.5152
Operations Supervisor (ABJ)	Steve Goodman	918.596.9188	918.284.4453
Water Supply System Manager	Roy Foster	918.591.4059	918.520.1762
Water and Sewer Director	Clayton Edwards	918.596.7810	918.284.1602

Table 3-5

Other Emergency Contact Information		
Emergency Contacts	Office	Mobile
Hazardous Material Team	918.591.4406	918.527.0278
Fire Department	918.596.9977	
Police Department	918.596.9222	
US Army Corps of Engineers	918.669.7366	
Ambulance	918.596.3135	
Tulsa county Sheriff	918.596.5601	
Oklahoma Highway Patrol	918.627.0440	
City Medical	918.596.7075	
Hospitals		
Hillcrest Hospital	918.579.1000	
OSU Medical Center	918.587.2561	
St. Francis Hospital	918.494.2200	
St. John Hospital	918.744.2345	
South Crest Hospital	918.294.4000	
Regulatory Contacts		
National Response Center (NRC)	1.800.424.8802	
Tulsa County LEPC – Jamie Ott	918.598.596.9891	
Osage County LEPC – Howard Pattison	918.978.3524	

3.9 References

USACE, 2012. United States Army Corps of Engineers. Oologah Lake Watershed Assessment Study.

Appendix A –

Eucha/Spavinaw Watershed Projects and Programs

Eucha/Spavinaw Watershed Projects and Programs

December 2017

Lake Eucha owner: City of Tulsa
Lake Eucha operator: City of Tulsa
Storage contractees: City of Jay and City of Tulsa
Lake Eucha flood control responsibility: City of Tulsa

Spavinaw Lake owner: City of Tulsa
Spavinaw Lake operator: City of Tulsa
Spavinaw Lake water right user: City of Jay and City of Tulsa
Spavinaw Lake flood control responsibility: City of Tulsa

	PROJECT	LEAD PI	Start Date	End Date	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
1.	**Poultry Litter Transport from Nutrient Surplus Watersheds in Northwest Arkansas** (ASWCC & BMPs Inc.)	Sheri Herron	Jun 2004	Ongoing	Provide the method(s) for the export of litter from contract grower operations within the Eucha/Spavinaw and Illinois river (ES/IR) watershed in northwest Arkansas (NWA) to row crop, pasture, forage, grass and forest lands of Arkansas outside the surplus nutrient watersheds as defined by ASWCC. Reduce the potential for water quality impacts resulting from continued litter application within the NWA area.			--
2.	**Intensive Grazing Demonstration Farm** (BMPs Inc.)	Sheri Herron	2005	Ongoing	Provide funding for alternative watering sources and electric fencing for beef cattle to establish an intensive grazing program on one demonstration farm. Conduct educational field days for local farmers to provide information on establishment, materials, costs, & programs available for financial assistance.		Eucha/Spav settlement agreement non-profit funds	$ 5,000
3.	**City of Decatur, AR**	James Boston (City of Decatur, AR)	2014	Ongoing	MBR filtration system for WWTF.	An MBR system (utra-filtration membrane of 0.04 microns) will be installed above the clarifiers in 2018.	City of Decatur, AR	
4.	**Eucha/Spavinaw Watershed Habitat/Water Protection Project** (TCF, USFWS, TMUA)	Roy Foster (TMUA)	2017	Ongoing	Purchase conservation easements to protect habitat for wildlife (e.g. bats, migratory birds) as well as protect water quality within the Eucha-Spavinaw Watershed.	Spring Valley Ranch conservation easement (363.22 a.) was completed in November, 2017.	TCF $290,500 TMUA $305,684	$596,184

	PROPOSED PROJECTS / PRORAMS	LEAD PI	Start Date	End Date	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
1.	**An Ecoregion Approach for Recovery and Protection of Karst Dependent Federally-listed Species** (ODWC)	ODWC	NA	NA	Purchasing conservation easements on high quality oak/hickory pine Ozark forest and riparian corridors within the Spavinaw Cr WS in NE OK & AR.	The proposal was recently submitted for funding through the USFWS 's Cooperative Endangered Species Conservation Fund, Recovery Land Acquisition program.	USFWS	
2.	**Poultry Litter Biofuel Project (EQMA)**	TBD (EQMA)	NA	NA	Using saccharification and fermentation reactions to convert poultry litter into fuel ethanol.	Environmental Quality Management Associates, Inc (EQMA)		

	PROGRAMS	CONTACT	Start Date	End Date	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
1.	**Eucha/Spavinaw Watershed Monitoring Program** (COT)	Roy Foster (COT)	Lake: 1968 (Trib: 1998)	Ongoing	Monitor water quality of Lake Eucha, Spavinaw Lake, and tributaries. Parameters include temperature, PH, specific conductance, turbidity, alkalinity, hardness, dissolved silica, dissolved oxygen, oxygen percent of saturation, redox potential, nitrogen and phosphorus constituents, dissolved arsenic, iron, manganese, & zinc, chlorophyll-a, secchi depth, geosmin, MIB, and algal toxins.		TMUA	$ 140,000/yr
2.	**The Ozark Plateau National Wildlife Refuge (USFWS)**	Richard Stark (USFWS)	1986	Ongoing	Provide long term habitat protection at the landscape level to help assure the continuing existence, and aid in recovery of the Ozark Big-eared Bat and Gray Bat and other listed and at-risk cave species. Additional the refuge works with nearby landowners to provide technical assistance on cave and forest management activities on their lands.			
3.	**Beneficial Use Monitoring Program (BUMP) (OWRB)**	Bill Cauthren (OWRB)	1998	Ongoing	Monitor river, streams, and lakes to document beneficial use impairments, detect water quality trends, provide needed information for the OWQS development and refinement process and to facilitate the prioritization of pollution control activities.			
4.	**Oklahoma Litter Market (OSU / ODAFF)**	Litter Market: (OSU-CES)	1998	Ongoing	Match buyers and sellers of poultry litter, and assist litter service providers (e.g. haulers, applicators, brokers) for marketing excess litter in impaired watersheds. Calls received by ODA are transferred to OSU, and OSU County Agents follow up with buyers and sellers. Toll-free Litter Hotline: 800.583.7131. Web:http://www.OK-littermarket.org.			
5.	**Oklahoma Water Watch Monitoring Program (OWRB)**	(OWRB)	1998	Ongoing	OWW is a volunteer monitoring and educational programs that encourages local efforts to protect and maintain the quality of streams and lakes.	The OWW program has been suspended due to significant budget cuts at the OWRB. The OWRB hopes to reinstate the program when the budget allows.		
6.	**Rotating Basin Monitoring Program (OCC)**	OCC	1998	Ongoing	Monitor the overall aquatic health of streams in the HUC 11 watersheds of the Eucha/Spavinaw watershed every 5 years.			
7.	**Blue Thumb Project Monitoring (OCC)**	OCC Candice Miller	2000 E/S WS 1993 (State)	Ongoing	Develop and implement education programs and expand the ongoing blue Thumb volunteer monitoring education efforts in the watershed. The ongoing program uses a corps of volunteers who are primarily involved in stream & wetland monitoring, and groundwater screening.	A website has been developed to keep volunteers updated on Blue thumb activities, as well as, informing the general public about the program.		

	PROGRAMS / ACTIVITIES Con't	CONTACT	Start Date	End Date	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
8.	**Eucha/Spavinaw Watershed Management Team**	Scott Stoodley	2003	Ongoing	Prepare Nutrient Management Plans (NMPs) with Phosphorus Index (PI) for each company farm (i.e.Tyson Foods, Inc.; Cobb-Vantress, Inc.; Peterson Farms, Inc.; Simmons Foods, Inc.;Cargill, Inc.; George's, Inc.), contract grower and application site. Monitor and enforce poultry litter land application and transfer in/out of the Eucha/Spav WS.	The Tulsa Metropolitan Utility Authority (TMUA) and the poultry integrators are continuing the program. TMUA has completed contract service agreements with ODAFF and Arkansas Natural Resource Commission (ANRC.	TMUA	
9.	**Eucha/Spavinaw Lake Area Environmental Management Program (COT)**	Dean Nichols	2003	Ongoing	Protect lakes, tributaries and all other lake property from contamination and pollution while preserving the natural and scenic resources by implementing in-lake and lake area best management practices.		COT	
10.	**Integrated Strategy Pilot for Compliance with New NPDES CAFO Permits at CAFOs in Oklahoma (ODAFF)**	Norma Aldridge	2004	Ongoing	Identify new CAFOs and assist owners/operators to comply with federal permitting requirements.			
11.	**Conservation Reserve Enhancement Program (CREP) for "Illinois River Sub-Basin and Eucha-Spavinaw Lake Watershed Initiative" (OCC) (FSA)**	(Vacant) (OCC) Rod Wanger (FSA)	2007	Ongoing	CREP is a voluntary land retirement program that helps agricultural producers protect environmentally sensitive land, decrease erosion, restore wildlife habitat, and safeguard ground and surface water. The program uses financial incentives to encourage farmers and ranchers to enroll in 10- to 15-year contracts to remove lands from agricultural production. The objective of this program in the Eucha/Spavinaw watershed is to reduce nutrient and sediment loadings to Spavinaw lake through restoration of riparian buffers and implementing water quality BMPs.		FSA State (OCC)	Up to $ 16.5 M Up to $4.1 M

	PROGRAMS / ACTIVITIES Con't	CONTACT	Start Date	End Date	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
12.	**Eucha/Spavinaw Watershed Riparian Protection Initiative (Land Legacy & TMUA)**	Dusti Crace (Land Legacy)	Sep 2007	Ongoing	Continue conservation easement initiative in the Eucha/Spavianw watershed to target key watershed properties, develop an outreach and education program, acquire (through either purchase and/or donation) from landowners, conservation easements, and monitor conditions to effectively document progress. ,	Land Legacy/TMUA have protected 2559.56 acres including 10.9 linear miles of riparian area. These easements have provided $1.78 million in matching funds for CREP. Land Legacy has purchased the following conservation easements: **(1) Three Springs Ranch**, 437 ac. with 2,460 linear ft.along Spav Cr. 11/08 $318,045 (Total) $234,842 (TMUA) Fund sources: EPA & TMUA.Status: Complete. **(2) Green Valley Ranch**, 303 ac. with ~1.65 linear miles of Spav Cr + tribs. 3/09 $232,941(Total) $209,505 (TMUA) Status: Complete. **(3) Brixey Ranch,** 33.46 ac, with 2,100 linear feet of Beaty Cr. located 1 ½ miles north of the Driskill Ranch conservation easement.$39,280 (Total) $29,200 (TMUA). Status: Complete (**4) Clear Spring Homestead,** 20 ac. with 500 linear ft of both sides of Spav Crl between Lakes Eucha and Spavinaaw. 1/10 $37,125 (Total) $30,300 (TMUA). Status: Complete. **(5) Lester Property**, 336 ac.with 4,000' linear ft. along Brush Cr $288,500 (Total) $207,404.00 (TMUA). Status: Complete. **(6) Hollenbeck,** 331.6 ac. along Beaty Cr (>1.5 mi stream miles). $541,420 (Total) $418,912 (TMUA) Status: Closed. Complete. **(7) Pendergraft property**, 28 ac., 2,200 linear ft. along Brush Cr $83,306 (Total) $75,306 (TMUA) 6/12. Status: Complete **(9) Cody (Bill) Smith,** 190.5 a along ~1/4 mi. of Brush Cr. $254,483 (Total) $254,483 (TMUA). Status: Complete. **(10) Hampton Property**, ac. 100 ac. woodland providing for 3/4 of a mile of contiguous Brush Creek protection. Conservation easement purchase price is $156,701 (Total) $132,581 (TMUA). Status: Complete.	EPA+USDA $1,063,838 TMUA $3,299,423	$4,363,261

	PROGRAMS / ACTIVITIES Con't	CONTACT	Start Date	End Date	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
12. Cont						**(11) Burcham Ranch**, a 144 ac. Easement along ~1 mi. of Cloud Cr and ~1.5 mi. of additional riparian drainage. $88,049.17 (Total) , $78,647.17(TMUA), $9,450 (EPA). Status: Complete **(12) Houch Ranch**, 76 ac. encompassing 5,850 linear ft. (includes borders of Beaty Cr). 2/14. $177,185 (Total) $151,685(TMUA). Status: Complete **(13) Rudick Ranch**, 86 ac. w/.3,850 riparian linear ft. 2/14.$181,685 (Total) $169,185 (TMUA). Status: Complete **(14) Sena Property**, 46 ac. w/ approx. 900 riparian linear ft. 2/14$77,185 (Total) $66,685(TMUA). Status: Complete **(15) Prulhire Property**, 94 ac. with1,855 linear ft. of riparian boundary of Beaty Cr tribs. 8/6/14 (RFA signed) $182,585 (Total) $170,085 (TMUA), $12,500 (EPA). Status: Complete. **(16) Downing Property**, 334ac. along northern edge of Beaty Cr. 9/18/17 (RFA signed) $246,485 (Total) $246,485 (TMUA). Status: In encumberance process and close to closing. **16) Rogers Property,** 33.4 ac w/ one half linear miles of Brushy Cr. (RFA sighned) $113,965 (Total) $57,109 (TMUA), $56,856 (EPA). Status: Complete. 17. Husong Ranch, 400 ac. adjacent to COT lakefront property. (RFA sighned) $471,985 (Total) $455,874.55 (TMUA), $16,110.45 (EPA). Status: Complete.		
13.	**Conservation Security Program (CSP): Lower Neosho Watershed (HUC11070209) (NRCS-OK / NRCS-AR)**	Lanny Miller (NRCS-OK) Tim Beard (NRCS-AR)	2007	NA	Assist (through payments) farmers, who have demonstrated long-term stewardship in conservation practices, in continuing conservation treatment that will protect soil and water quality with options to improve wildlife habitat, improve air quality, participate in watershed-wide stewardship programs, and improve nutrient and pest management activities.		USDA	TBA

	PROGRAMS / ACTIVITIES (Con't)	CONTACT	Start Date	End Date	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
14.	**An Ecoregion Approach to Recovery of the Oazrk Big-eared Bat and Other Federally-listed Karst Species, Phase I and Phase II (ODWC)**	ODWC	2007	NA	Protect important cave and forest habitat used by the Ozark Big-eared Bat and other karst-dependent species. The property in Oklahoma is owned and managed by the ODWC as the Ozark Plateau Wildlife Management Area.			
15.	**The Partners for Fish and Wildlife Program** (USFWS)	John Aldrich (USFWS)	2007	NA	Work cooperatively with private landowners to protect and enhance fish and wildlife resources. Where possible, this program will continue to be used to protect cave sites from human disturbance and restore and enhance foraging habitat through financial and technical assistance.			
16.	**Continuous-Water Quality Monitoring in the Spavinaw-Eucha River Basin, Northeastern, OK** (COT)	Scott Strong (USGS)	July 2008	On-going	Using real-time water-quality monitoring probes in the Eucha-Spavinaw basin, develop regression equations relating general water properties (Ph, specific conductance, DO, temperature, chlorophyll, and turbidity) to chemical constituents from samples collected in the basin that can be used to provide real-time constituent concentrations and loads, via Internet.		USGS (~50%) TMUA (~50%) Total	$250K/yr
17.	**Estimation of Nutrient Loads in the Eucha-Spavinaw Basin, Northeastern, Oklahoma.** (USGS)	Bill Andrews (USGS)	July 1 2008	On-going	Compile and update TN and TP concentrations for calendar years '02-'10 at 5 sites above Lake Eucha in the Eucha-Spavinaw Basin: ● summary stats of TP & TN conc.s ● determine base-flow & runoff days ● use LOADEST to estimate daily TN & TP loads for the eight-year period and then calculate(1) total, base flow,& runoff (r.o.) mean annual constituent loads; (2) total, base-flow, and r.o. mean annual constituent yields; (3) total, base-flow, and r.o. seasonal constituent loads; and (4) mean flow-weighted conc.s.	Scientific Investigations Report 2011-5172 "Nutrient Concentrations, Loads, and Yields in the Eucha-Spavinaw Basin, Arkansas and Oklahoma, 2002-2010 is completed. Available at http://pubs.usgs.gov/sir/2011/5172/SIR11-5172.pdf	USGS TMUA	
18.	**Illinois River Sub-Basin and Eucha-Spavinaw Watershed Initiative Project** (USDA-NRCS-OK)	Michael Ramming (NRCS), Jay, OK	Jan 2011	Dec 2018	Provides cost-share assistance to agriculture producers for installation of conservation measures that improve soil, water, and grazing land quality in the Spavinaw Creek Watershed. Assistance is available for a broad array of "on farm/ranch" conservation practices relating to water quality and riparian restoration.		NRCS	NRCS-AR $3 million NRCS-OK $725,000

	PROGRAMS / ACTIVITIES (Con't)	CONTACT	Start Date	End Date	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
19.	**Arkansas Poultry Registration Program** (ANRC)	Gail Sparks Benton Co. ANRC	Jan 2009	On-going	A statewide program to register poultry (farmers with 2,500 plus birds) for the purpose of monitoring litter generation and usage. Information from this program will be for education purposes to help protect local water quality. Registration cost is $10.00. Deadline for registering poultry operations is March 31 of each year. First offense for failure to register before the deadline is a written notice of noncompliance. The 2nd offense is a fine up to $50, and a 3rd offenses can be fined up to $500.			
20.	**Ozark Plateau Karst-Dependent Species Conservation Initiative –Healthy Forest Reserve Program Project (OPKDS)**	Richard Zetterberg (NRCS)	2009	On-going	Protect, enhance, and restore forested areas in the Ozark Plateau of northeastern OK. Primary objectives are to improve forest ecosystems around cave openings that provide foraging and roosting habitat and travel corridors for the endangered Ozark Big-eared Bat and Gray Bat. Also, OPKDS will target protection of these areas and promote conservation activities to protect and improve water quality. Most restoration work will be 10 yr contracts.	To date, NRCS has closed on 5 easements – three permanent on 875.29 acres; and two 30-yr easements on 1501.45 acres. NRCS has enrolled an additional 4,453.4 acres that they are actively working on the conservation easement acquisitions.	USDA	Over 2009-2011, NRCS has received and obligated over $4.5.
21.	**Regional Conservation Partnership Program (RCPP)**	Gary O'Neill (NRCS)	2014	2020	Combines the authorities of 4 former conservation programs (CCPI, AWEP, Chesapeake Bay WP, Great Lakes Basin Progr). Promotes coordinat. betw NRCS and its partners to deliver conservation assistance to producers and landowners thru partnership agreements, program (nat'l, state, or critical area) contracts, or easements agreements.		USDA	$400 million available (Jan 2015) nationally
22.	**Agricultural Conservation Easement Program (ACEP)**	Gary O'Neill (NRCS)	2014	2020	Combines the authorities of 4 former conservation programs WRP, GRP,FRPP). Provides financial and technical assistance to help conserve ag lands and wetlands for tribes, state/local govt.s and NGOs. NRCS pays 100% of the permanent easement value and 75-100% of the restoration costs.		USDA	

	PAST PROJECTS / PRORAMS	LEAD PI	START DATE	END DATE	DESCRIPTION	FUNDING SOURCE	TOTAL COST
1.	**Risk to Water Quality – Soils of Eastern Oklahoma: Percolate Concentrations of Nitrogen and Phosphorus in Poultry Litter-Applied-Soils of Eastern Oklahoma.** (OSU)	Ray West (OSU)	1990	1992	Examine the effect of various poultry litter application rates have on nitrogen and phosphorus concentrations in soil percolates for establishing application rates (greenhouse and field study) https://shareok.org/handle/11244/13602	USDA – NRCS	$25,000
2.	**Phase I Clean Lakes Project** (OCC)	OCC	1992	Feb 1997	Ecological conditions of lakes; evaluation of mgt. options. http://www.okcc.state.ok.us/WQ/WQ_reports/REPORT031.pdf	Fed (EPA) TMUA	$ 42,857 $ 100,000
3.	**Spav/Eucha Lakes Limnological Study** (Montgomery Watson)	Montgomery Watson	1995	Jul 1996	Ecological conditions of lakes; evaluation of mgt. options.	TMUA	--
4.	**Water Quality Evaluation of the Eucha/Spavinaw Lake System** (OSU)	Bill Marshal	1997	1998	Examine the probability distributions of soil test phosphorus data and develop a non-parametric method to determine the number of observations required to estimate basin-scale soil test phosphorus http://storm.okstate.edu/eucha/modeling/marshall_thesis.pdf	OSU	--
5.	**Water Quality Evaluation of the Eucha/Spavinaw Lake System** (OWRB)	OWRB	1997	Feb 2002	Lake ecosystem conditions; Phosphorus quantity the lakes can accept; Possible lake treatment techniques. http://www.owrb.ok.gov/studies/reports/eucha-spav/eucha-spav.php	TMUA	$ 185,604
6.	**Analysis of Taste & Odor Occurrences Attributed to the Spav/Eucha Raw Water Supply System** (Montgomery Watson)	Montgomery Watson	1998	Apr 1999	Summarize discussions and recommendations toward minimizing taste and odor episodes	TMUA	--
7.	**Determining Limiting Nutrients in Lake Eucha Tributaries** (OSU)	Valerie Keyworth (OSU)	1998	2000	Determine the limiting nutrient in 7 streams in the Lake Eucha Basin. Assess the Lotic Ecosystem Trophic Status Index (LETSI) in the 7 streams. Characterize seasonal effects on the limiting nutrients. http://storm.okstate.edu/eucha/stream/keyworth_thesis.pdf	OSU	--
8.	**Alternative Poultry Litter Management in the Eucha/Spavinaw Watershed: Part I – Raw Litter Export** (FORM)	FORM	1998	Nov 2000	Cost of, obstacles, and mechanisms for removing litter from watershed	TMUA 1998 TMUA 1998	$ 78,106 70,436
9.	**Sediment-Phosphorus Chemistry in Ozark Plateau Streams in Northeast Oklahoma** (OSU)	Valerie Keyworth (OSU)	1998	Dec 2000	Characterize water chemistry in 4 Lake Eucha tribs. Evaluate, characterize, and determine amount of easily exchangeable P and NH_4-N in sediments and the partitioning of these nutrients between the water column and benthic sediments. Evaluate water column EPCo and its relationship to the benthic sediment P concentrations. Compare sediment nutrient attributes between 4 tribs. Compare biotic vs. abiotic sinks of P. Characterize benthic sediment particle size distribution and OM content. Evaluate relationship of the sediment particle size distribution with sediment buffering capacity. Evaluate effects of seasonal variability within a stream. Investigate trends among various parameters and significant correlations.. http://storm.okstate.edu/eucha/stream/popova_thesis.pdf	OSU	--
10.	**Alternative Poultry Litter Management in the Eucha/Spavinaw Watershed: Part II – Processed Litter Options** (FORM)	FORM	1998	Apr 2001	Cost of, obstacles, and mechanisms for removing litter from watershed.	TMUA	$ 86,353
11.	**Modeling Phosphorous Loading for the Lake Eucha Basin** (OSU)	Dan Storm (OSU)	1998	2001	Source and volume of phosphorus (P) entering Lake Eucha; Predicts average run-off volume, sediment load, and dissolved and sediment-bound P load. https://www.researchgate.net/publication/251768533_Modeling_Phosphorous_Loading_for_the_Lake_Eucha_Basin	TMUA	$ 112,687

	PAST PROJECTS / PRORAMS	LEAD PI	START DATE	END DATE	DESCRIPTION	FUNDING SOURCE	TOTAL COST
12.	**Assessment of In-Stream Nutrient Dynamics Within the Lake Eucha Basin** (OSU)	B. Haggard (OSU)	1998	2001	How phosphorus cycles in the stream; the impact of treatment plant discharge. http://storm.okstate.edu/eucha/stream/haggard_dissertation.pdf	TMUA	$121,333
13.	**Lake Eucha Watershed Implementation Project** (OCC)	Dan Butler (OCC)	1998	2005	Demonstrate the benefits of NPS implementation on the water resources of the Spavinaw Creek Watershed.	EPA 319	$1,032,663
14.	**USDA-NRCS-OK: Eucha/Spavinaw Environmental Quality Incentives Program (EQIP) Local Emphasis Area** (NRCS)	Eric Daniels (NRCS), Jay, OK	1998	2007	Provides cost-share assistance to agriculture producers for installation of conservation measures that improve soil, water, and grazing land quality in the Spavinaw Creek Watershed. Assistance is available for a broad array of "on farm/ranch" conservation practices relating to water quality and riparian restoration. Interested producers may apply at the local NRCS/ Conservation district office.	USDA/ NRCS	$ 650,000 through 2005. Projected $100,000/yr.
15.	**Freshwater Sample Analysis for Eucha, Spavinaw, and Yahola Reservoirs** (City of Tulsa)	Ray West Roy Foster (COT)	(1998) 2000	Jan 2011	Identify and enumerate (cell density/biovolume) lake phytoplankton.	TMUA	~ $ 20,160/yr
16.	**Watershed Restoration Action Strategy (WRAS) for the Eucha/Spavinaw Watershed COT & INCOG**	COT & INCOG	May 1999	Jun 1999	A plan for restoring a watershed, and contains 6 essential components (1. public outreach methods; 2. monit./eval activities; 3. clearly defined wq problems; 4 specified action plan and wq goals; 5. implementation schedule; and 6. funding needs based upon EPA guidance. The WRAS is amenable to revision and update. http://www.deq.state.ok.us/WQDnew/pubs/eucha_watershed_wras_final.pdf	--	$ 00.00
17.	**Septic Tank Assessment for Eucha/Spavinaw Watershed (ODEQ)**	ODEQ	Mar 2000 (Map & Lat/Lng	Dec 2001 (Part of TMDL Draft)	Map(Ark not included) and spreadsheet of septic tank locations in the Eucha/Spavinaw watershed. http://www.deq.state.ok.us/	--	--
18.	**Phosphorus Index for Pastures Phase I and Phase 2** (USDA-ARS)	USDA-ARS (AR)	Apr 2001 Phasel	Oct 2001 Phase I&II	Determine what factors are most important in controlling phosphorus (P) runoff from pastures and to develop a risk assessment tool (P-Index) to predict where problems may occur.	TMUA	$ 104,626
19	**Evaluating Cost Effective Technologies to Reduce Phosphorus Loading to Surface Waters for the Ozark Regions** (OSU)	Dan Storm (OSU)	2001	June 2003	Estimate P loading using SWAT & determine sources & their relative contribution. Evaluate & determine cost effectiveP abatement technologies and BMPs on a site-specific basis using high-level spatial detail. http://ojs.library.okstate.edu/osu/index.php/OWRRI/article/view/39	Fed State	NA
20.	**A Demonstration of Process Technology for Converting Poultry Waste to Energy and Chemical Products, Delaware Country, Oklahoma ("Stamper Project") (OCC)**	Ken Stamper (Production Specialties, Inc.) Jerry Latty of Cherokee Hills (RC&D) will manage project	2001	2010	Phase I: Demonstrate that poultry waste can economically be converted to liquid fertilizer and ultimately electricity such that excess P can be shipped out of nutrient sensitive watersheds. Initial phase of project will allow removal of approximately 10,000 T litter in 6 months from Eucha/Spav WS. Phase II: Expand the processing capabilities of Phase I to approx. 100,000 T poultry waste/yr.	State (AR) FY03 319 Poultry Intg State (OK) FY02 319 Poultry Intg OCAS Grant Total	$ 100,000 $ 300,000 $ 126,000 $ 50,000 $ 500,000 $ 123,684 $ 185,000 $1,385,000
21.	**Stream Nutrient Retention Efficiency in an Enriched System (USDA-ARS)**	Brian Haggard (USDA-ARS)	Jan 2002		Quantify impact of Decatur's WWTP's effluent discharge on stream nutrient retention efficiency. http://docplayer.net/4876400-Nutrient-retention-in-a-point-source-enriched-stream.html	--	--

	PAST PROJECTS / PRORAMS	LEAD PI	START DATE	END DATE	DESCRIPTION	FUNDING SOURCE	TOTAL COST
22.	**A Nutrient Management Decision Support System for the Eucha Basin (DSS Project)** (USDA-ARS, UA, OSU)	Marty Matlock (UA)	Sep 2002	Aug 2006	Develop a watershed nutrient decision support system (DSS) for developing comprehensive watershed nutrient management strategies for both agricultural and urban landscapes. http://slideplayer.com/slide/5227232/	USDA	$ 686,000
23.	**Conservation Technical Assistance (CTA) Environmental Quality Incentives Program (EQIP) cost share assistance & incentive payments for conservation practices (USDA-NRCS-AR)**	Fred Reed/ Steven Davied	2003	2004	CTA: Assist with conservation practice application. EQIP: Help customers with cost share to implement conservation practices.	USDA FY 2003 FY 2004	$ 173,000 for E/S $ 503,000 for E/S
24.	**GIS Database Development and Watershed Modeling in Arkansas Priority Watersheds (ASWCC) (UA)**	Indrajeet Chaubey (UA)	Jul 2003	Jul 2004	Develop GIS database. Obtain base-line sediment data from modeling Arkansas priority watersheds.	EPA 319	$ 118,634
25.	**Phytoplankton and Periphyton Nutrient Limitation Bioassays at Lake Eucha (Part of DSS Project) (USDA-ARS, UA**	Brian Haggard & Ray Avery (USDA-ARS)	Aug 2003	Aug 2005	Determine whether N and/or P are limiting algal growth using phytoplankton enclosures & periphytometers with N&P enrichment treatments. http://elibrary.asabe.org/abstract.asp?aid=16205&t=2&redir=&redirType=	USDA	---
26.	**ASWCC: Demonstration of On-Farm Litter Combustion (UA)**	Tom Costello (UA)	Aug 2003	Aug 2005	Demonstrate the use of poultry litter to generate heat for poultry houses. Target and focus is primarily Illinois and White River watersheds, but could include Eucha/Spav WS.	EPA 319	$ 250,000
27.	**CE-QUAL-W2 Modeling of Lake Eucha (Part of DSS Project) (USDA-ARS, UA)**	B. Haggard & R. Avery (USDA-ARS)	Dec 2003	May 2005	Calibrate CE-QUAL-W2 water model for Lake Eucha using existing lake & stream data collected by the COT & USGS. http://search.proquest.com/docview/304897688	USDA	---
28.	**ASWCC & UA: Feasibility Assessment of Establishing the Ozark Poultry Litter Bank (UA)**	H.L. Goodwin (UA)	Oct 2003	Sep 2005	Determine economic feasibility of establishing a poultry litter bank and determine what the poultry litter price would be. Includes Eucha/Spavinaw, Illinois River, Beaver, Lower Neosho, and Elk River watersheds.	EPA 319	$ 200,000
29.	**ASWCC: Urban Nutrient Management of Illinois River Landscape. Includes the Eucha/Spav Watershed (CCD)**	Washington CCD	Jul 2003	Oct 2006	Develop nutrient management plans (NMPs) for urban lawns.	EPA 319	$ 58,261
30.	**Spavinaw Creek Watershed Implementation Project (OCC)**	Dan Butler (OCC)	2003	2008	Demonstrate the benefits of NPS implementation on the water resources of the Spavinaw Creek Watershed. The following funds were spent on this project:	State (OK) EPA 319 Total	$1,107,893.40 $1,661,840.10 $2,769,733.50
30.A.	**Nonpoint Source Education Program for Producers in Spavinaw Creek Watershed (part of Spavinaw Creek Project) (OSU & OCC)**	Mike Smolen (OSU)	2004	2007	Establish a demonstration farm on Brush Creek to educate producers and others in the Spavinaw Creek Watershed about the practical considerations of grazing BMPs, utilization of soil test P, riparian management, and recordkeeping for protecting water quality and enhancing natural resource values.	-----	$ 288,968†
30.B.	**Utilize Oklahoma Water Watch volunteers to collect chlorophyll-a samples in addition to routine OWW parameters to assist in determining impacts from eutrophication in Eucha Lake (part of Spavinaw Creek Project) (OWRB)**	Lynda Williamson (OWRB)	2004	2007	Support Oklahoma Water Watch Activities and train volunteers to collect additional parameters include chlorophyll-a sampling in Lake Eucha.	-----	$ 25,624†

	Cost-share Funds	Participant's Share	Total
05	252,462.71	150,507.59	402,970.30
06	321,908.94	239,092.56	561,001.50
07	574,371.65	389,600.15	963,971.80

	PAST PROJECTS / PRORAMS	LEAD PI	START DATE	END DATE	DESCRIPTION	FUNDING SOURCE	TOTAL COST
30.C.	**Soil Sampling Technique and Nutrient Variability Demonstration in a Nutrient Limited Watershed (part of Spavinaw Creek Project)** (OSU)	Hailin Zhang & Mike Smolen	2004	2008	Demonstrate proper soil sampling protocol and teach tech. professionals & producers how variation in the natural system or changes to the protocol affect soil test results. Id. soil nutria. variability for eastern OK pasture system through intensive soil sampling & disseminate better sampling techniques to producers.	-----	$ 47,337†
30.D.	**Poultry Litter Transport from The Illinois River Watershed (Oklahoma) to Non-Nutrient Limited Watersheds. Includes Eucha/Spav.** (OCC)	Dan Butler (OCC)	Apr 2004	Jun 2007	Transfer litter from the Oklahoma portion of the watershed to non-Nutrient Sensitive Areas. Includes Eucha/Spavinaw watershed.	State Federal Total	$ 200,000 $ 300,000 $ 500,000†
31.	**OCC Litter Transfer Program (OCC)**	Shanon Phillips (OCC)	Apr 2004	2008	Transfer litter from the Oklahoma portion of the watershed to non-Nutrient Sensitive Areas. Includes Eucha/Spavinaw watershed.	State Federal Total	$ 200,000 $ 300,000 $ 500,000
32.	**Poultry Litter Transport from The Illinois River Watershed (Oklahoma) to Non-Nutrient Limited Watersheds. Includes Eucha/Spav (OCC)**	Dan Butler (OCC)	Apr 2004	Jun 2007	Transfer litter from the Oklahoma portion of the watershed to non-Nutrient Sensitive Areas. Includes Eucha/Spavinaw watershed.	State Federal Total	$ 200,000 $ 300,000 $ 500,000
33.	**Monitoring Edge-of-Field Phosphorus Loss to Validate a P Loss Index for the Spavinaw Creek Watershed** (OSU & USDA-ARS)	Dan Storm (OSU)	May 2004	May 2007	Validate OK/AR P loss index.	EPA 319 OSU 40% (In-kind)	$ 555,632
34.	**Poultry Litter Transport from Nutrient Surplus Watersheds in Northwest Arkansas** (ASWCC & BMPs Inc)	Sheri Herron (BMPs Inc.)	2004	2006	Provide the method(s) for the export of litter from contract grower operats within the Eucha/Spav and Illinois river (ES/IR) watershed in northwest Arkansas (NWA) to row crop, pasture, forage, grass and forest lands of Arkansas outside the surplus nutr. watersheds as defined by ASWCC. Reduce the potential for water quality impacts resulting from continued litter application within the NWA area.	EPA 319	$ 1,600,000
35.	**TMDL Development for Lakes Eucha and Spavinaw in Oklahom** (ODEQ)	Mark Derich-weiler (ODEQ)	Sep 2004	Dec 2009	Assign waste loads to sources using EFDC watershed model. https://www.deq.state.ok.us/wqdnew/tmdl/eucha_spavinaw/eucha_lk_spavinaw_%20ck_%20final_tmdl_2009-09-01.pdf	--	--
36.	**Concentrated Animal Feeding Operations (CAFOs): Water Utility Issues and Regulatory Controls" (AwwaRF)**	Ryan Ulrich (AwwaRF)	Jun 2004	May 2007	Develop an understanding of the potential and known impacts of CAFOs-derived contaminants on drinking water supply and potential control strategies that could be implemented to protect drinking water supply.	AwwaRF	$5,700 (Approx
37.	**Determination of Water Soluble Estrogen Levels in the Spavinaw-Eucha Watershed (TU)**	Brigid DeCoursey (TU)	June 2004	Aug 2004	Determine water soluble levels of 17-beta-estradiol from Eucha/Spavinaw watershed broiler litter.	TMUA	$4,944
38.	**Cattle Exclusion from Streams for Water Quality in the Eucha Spavinaw Watershed (BMPs Inc.)**	Sheri Heron (BMPs Inc.)	Oct 2004	Oct 2006	Establish fencing along stream corridors; alternative cattle watering sources; establish vegetative buffers; measure sediment loads; educational demonstrations	Fed	$ 60,000
39.	**Best Management Practices to Sustain Agricultural Production and Water Quality (UA) (USDA)**	Tommy Daniel (UA)	Oct 2004	Jun 2009	Develop and test methods for converting surplus manure into value-added fertilizers, and to evaluate the effects of conservation tillage on runoff water quality in the Arkansas Delta. A provisional patent was granted for the process of making a value added fertilizer from broiler litter and municipal biosolids.	State (AR) Federal Total	$ 5,263 $ 100,000 $ 105,263
40.	**ASWCC & UA: GIS Database Development and Watershed Modeling in Arkansas Priority Watersheds (2nd Phase) (UA)**	Indrajeet Chaubey (UA)	Jul 2004	Jul 2005	Develop model scenarios using base-line data collected from initial phase of the project.	EPA 319	$ 107,240
41.	**ASWCC & UA: SWAT Model of Illinois River Watershed (for nutrients (UA)**	Indrajeet Chaubey (UA)	Jul 2004	Jul 2005	Calibrate SWAT Model (i.e. calibrate P transport, monthly flow and P transport conditions).	EPA 319	$ 50,693

	PAST PROJECTS / PRORAMS	LEAD PI	START DATE	END DATE	DESCRIPTION	FUNDING SOURCE	TOTAL COST
42.	**Integrated Strategy Pilot for Compliance with New NPDES CAFO Permits at CAFOs in Oklahoma** (ODAFF)	Norma Aldridge (ODAFF)	2004	NA	Identify new CAFOs and assist owners/operators to comply with federal permitting requirements.	State	--
43.	**Evaluation of the Effect of Conservation Practices on Water Quality, Environment, and Socio-economics in the Spavinaw Watershed, Northeast Oklahoma** (OSU)	Dan Storm (OSU)	2004		Evaluate the effects of various conservation practices on water quality, soil quality, environment, and socio-economics. For the evaluation (1) develop a watershed conservation assessment system, (2) identify best cost/benefits of conservation practice on different topographic form of watershed, and (3) develop a database containing information on water, soil and environmental quality, and socio-economics variation in the watershed.	USDA	--
44.	**Conservation Technical Assistance (CTA)/ Environmental Quality Incentives Program (EQIP) cost share assistance & incentive payments for conservation practices. (USDA-NRCS-AR)**	Fred Reed/ Steven Davied (USDA-NRCS-AR)	2004	NA	CTA: Assist with conservation practice application. EQIP: Help customers with cost share to implement conservation practices.	USDA FY 2003 FY 2004	$ 173,000 for E/S $ 503,000 for E/S
45.	**Optimal Selection of Management Practices in Phosphorus Abatement: Using GIS and Economic Methodology in the Modeling of a Watershed (OSU)**	Brian Adam (OSU)	2004	2006	Evaluate the economic efficiency of a set of policies designed to remedy phosphorus (P) pollution problems in the Eucha/Spavinaw Watershed. Using a basin-level mathematical programming model, simultaneously determine the (1) optimal location of processing facilities for the quantity of poultry litter to be converted to energy, (2) quantity of litter to be transported from poultry houses to locations within and out of the watershed, and (3) best management practices for applying poultry litter in each HRU within the watershed so that the total cost of meeting specific P emission targets is minimized. http://ojs.library.okstate.edu/osu/index.php/OWRRI/article/view/48		
46.	**Illinois River Cost-Share Program. Includes Eucha/Spav WS (ASWCC)**	Benton CCD	Jul 2004	Sep 2007	Develop nutrient management plans and provide cost share for implementing BMPs.	EPA 319	$ 580,128
47.	**USDA-NRCS-OK: Environmental Quality Incentives Program (EQIP) Manure Transfer Incentives (NRCS)**	Eric Daniels (NRCS), Jay, OK	2004	2007	Provides cost-share assistance to agriculture producers for transfer of animal waste from nutrient limited and scenic river watersheds. The program is available statewide to producers willing to receive and apply the waste outside the watersheds. Interested producers may apply at the local NRCS/Conservation district office.	USDA FY2004	$ 700,000 statewide through 2005. Projected $500,000/yr
48.	**Spavinaw and Eucha Lakes, Oklahoma Ecosystem Restoration Study (USACE) (SAIC)**	Tom Daues (SAIC) Cynthia Kitchens (USACE)	2004	Fall 2010	Investigate the aquatic ecosystems restoration alternatives within the Spavinaw/Eucha Lakes, formulate a variety of alternatives to restore the aquatic ecosystems, and identify other concerns or needs specific to the lakes to formulate a recommenced plan of action or non-action.	Federal (50%) TMUA (50%) TMUA Total	$608,000 $ 60,000 $ 668,000
49.	**OCC Litter Transfer Program (OCC)**	Shanon Phillips (OCC)	Apr 2004		Transfer litter from the Oklahoma portion of the watershed to non-Nutrient Sensitive Areas. Includes Eucha/Spavinaw watershed.	State Federal Total	$ 200,000 $ 300,000 $ 500,000
50.	**Multivariate Analysis of Paired Watersheds to Evaluate Best Management Practices on Stream Water Quality in Northeastern Oklahoma (OSU)**	Andrew Lyon (OSU)	2005	2006	Quantify reductions in Beaty Creek P loads resulting from Ag BMPs implementation and poultry litter export Results of this paired watershed study design will demonstrate the difference between the pre-emplementation and post-implementation P levels and therefore the overall success of the implemented BMPs and reduction in poultry litter application.		

	PAST PROJECTS / PRORAMS	LEAD PI	START DATE	END DATE	DESCRIPTION	FUNDING SOURCE	TOTAL COST
51.	**Historical, Ecological, and Geochemical Analysis of Lakes Eucha and Spavinaw (Univ. of Tulsa)**	Bert Fisher (Univ. of Tulsa)	2005	2006	Investigate historic changes in land use and land cover through aerial photos and other remote sensing data, historic water quality changes from water testing in the basin, and changes in sediment loads and sources using sediment cores. This information will be linked in a predictive model to investigate catastrophic shifts in the water nutrient levels and whether there are significant lag-times between land use changes and shifts in water quality		
52.	**Recovery Land Acquisition Grants Program (ODWC) (USFWS)**	Julianne Hoagland (ODWC)	2005	2006	A Section 6 Nontraditional grant program to acquire habitat for endangered and threatened species in approved recovery plans for private lands. In FY 2005, funds were awarded to purchase tracts in both OK & AR to provide foraging habitat, movement corridors, and roost sites for populations of Ozark big-eared bat, gray bat, and Indiana. Additionally, these acquisitions should result in increased protection of the Ozark cavefish.	Congress	FYO5 $405,190
53.	**Neuro Network Analysis of Causative Relationships for Geosmin Production (OSU)**	Michelle Lay (OSU)	2006	2008	Evaluate numerous water quality parameters and establish relationships regarding geosmin production in Lake Eucha and Spavinaw Lake.		
54.	**Eucha/Spavinaw Watershed Riparian Protection Initiative** (Land Legacy & TMUA)	Robert Gregory (Land Legacy)	Sep 2007	Dec 2010	A 3-year conservation easement initiative in the Eucha/Spavianw watershed to target key watershed properties, develop an outreach and education program, acquire (through either purchase and/or donation) from landowners, conservation easements, and monitor conditions to effectively document progress.	Federal (EPA) $600,000 Non-Federal (TMUA) $1,250,000	$1,850,000
55.	**Investigation of the Potential Occurrence of Organic Wastewater Compounds in Water Supplies and Treated Wastewater in Tulsa, Oklahoma**	Bill Andrews (USGS)	Sep 2008	Aug 2009	Evaluate the occurrence of OWCs in surface water used as sources of drinking water for the City of Tulsa (COT). Eight water samples to be analyzed for a wide range of OWCs will be collected over the course of one year at intakes of 2 COT drinking-water treatment plants.	USGS $20,000 TMUA $32,245	$52,245
56.	**Modeling the Lake Eucha Basin with SWAT 2000** (USDA-ARS)	USDA-ARS	2008	2010	A new model including more water quality and flow data, recent land cover data derived from Landsat TM+ imagery, high resolution (Next generation weather radar) NEXRAD precipitation data, and soil test phosphorus for both pastures and row crops. Model is used for estimating phosphorus loads in the basin. The Soil and Water Assessment Tool (SWAT) 2000 model was calibrated for flow at three gages and for phosphorus loads at eight locations. Phosphorus loads were estimated using the US Geologic Survey (USGS) program LOADEST2 using observed water quality measurements, and streamflow estimates provided by both the City of Tulsa and the USGS. The SWAT model predicts that the application of poultry litter and elevated soil test phosphorus in the basin is responsible for 49% of the current annual phosphorus load to the lakes. http://asae.frymulti.com/abstract.asp?aid=15611&t=2		
57.	**Eucha Spavinaw Watershed Implementation**	OCC	2008 2009	2010 2012	Implement and track agricultural BMPs Implement and track agricultural BMPs Combination Final Report submitted December 2012	State and EPA §319	2008: State: $455,989 Fed: $960,156 2009: State: $156,797 Fed:$235,197

	PAST PROJECTS / PRORAMS	LEAD PI	START DATE	END DATE	DESCRIPTION	FUNDING SOURCE	TOTAL COST
58.	**Source Water Assessment:** **Eucha/Spavinaw Watershed** **Hudson Watershed** **Verdigris River Basin** (TMUA)	Ray West (TMUA)	2011 Oct	2012 May	Determine the relative susceptibility of Tulsa's source water to contamination from Synthetic Organic Contaminants (SOCs) and to make source water protection recommendations.	TMUA	
59.	**Clean Water State Revolving Fund Loan Program (OWRB)**	OWRB (LL)	2009	2012	Infrastructure upgrades and riparian conservation easements.		
60.	**Illinois River Cost-Share Program. Includes Eucha/Spav WS** (ASWCC)	Benton CCD	Jul 2004	2012	Develop nutrient management plans and provide cost share for implementing BMPs.	Fed (319)	
61.	**Spavinaw Creek Bsin, Oklahoma and Arkansas Feasibility Cost Study with Eucha-Spavinaw CE-QUAL W2 Model Development Project** (USACE)	USACE	2004	2010	Develop hydrodynamic and water quality model of L. Eucha, Spavinaw L, and Spavinaw Cr between the two lakes. Calibrate model to field date and develop/run modeling scenarios to improve water quality	TMUA	
62.	**Reducing the impacts of nonpoint source pollution through the establishment of floating wetlands in Eucha Lake** (OWRB)	Paul Koenig (OWRB)	2011	2013	Establish 6,400 ft2 of floating wetland islands within the riverine zone of Lake Eucha. The intent is to reduce phosphorus loads to the lake while providing habitat for aquatic organisms and other wildlife. Project involves thousands of plants representing some 30 species planted on floating wetland islands. Data collection is a cooperative effort with the City of Tulsa by sampling lake water quality, nutrient content of floating island generated sediment, and experimental mesocosms. Habitat use noted by staff includes serving as an otter feeding station in the winter and young-of-the-year (bass and bluegill) fish refuge.	State Fed (319) Total	$157,143 $235,715 $392,858
63.	**Lake Eucha SWAT Model (OSU)**	Dan Storm (OSU)	2011	2014	Update previous SWAT model		
64.	**Eucha/Spavinaw and Illinois River Watershed Implementation Extension Project (OCC) Phases I and II**	Shanon Phillips (OCC)	2008	2015	Implement and track agricultural BMPs	State (OK) Fed (319)	>$3.5 M
65.	**Watershed Based Plan Support for the Illinois river and Spavinaw Creek Basins**	Dan Storm (OSU)	2014	2016	Tasks include: • Identify, obtain, and seamlessly integrate data specifically gathered and analyzed by the Eucha/Spaninaw Watershed Management Team for the purpose of developing litter plans and CNMPs. • Develop a digital land use data layer using recent 30m resolution Landsat TM imagery for the Illinois River and Lake Eucha/Spavinaw watersheds • Locate and quantify "Legacy P" in the watersheds to aid in the development of P load reduction strategies for watershed based plans • Calibrate SWAT models for IRW and E/S watersheds.Use poultry house density and county-level STP to characterize subbasin litter application rates and STP – such information/tools can be used to evaluate various managing changes and conservation practices required to meet numeric WQSs in the watersheds • Using SWAT model predictions, develop P load allocations to aid in the development of P load reduction strategies for the watershed based plans.		

Appendix B –

Verdigris River Basin Projects and Programs

Verdigris River Basin Projects and Programs

December 2017

Oologah Lake owner: USACE
Oologah Lake operator: USACE
Storage contractees: City of Tulsa/TMUA (effective since Feb. 1985); PSO; City of Claremore; City of Collinsville; Town of Chelsea; Washington Co. RWD#3; Rogers Co. RWD #1;
Flood pool responsibility: USACE

	CURRENT PROJECTS	LEAD PI	START DATE	END DATE	*DESCRIPTION*	STATUS	FUNDING SOURCE	TOTAL COST
1.	Verdigris Basin Planning - Coordination with WRAPS (KWO)	Rob Reschke (KWO)	NA	NA	Coordinate basin planning activities with locally sponsored WRAPS projects to identify watershed needs and goals, and develop cost effective strategies for implementation through existing programs.	WRAPS are being developed for the entire basin within the state of Kansas. The area above Fall River Reservoir has a final WRAPS plan. The Middle Verdigris Basin project has an approved WRAPS plan. The watershed above Toronto Reservoir has an approved plan. Fall River and Toronto WRAPS were not funded in 2012 due to reductions in state and federal funds. It is hoped that the Leadership Teams will continue to meet to guide implementation from other funding sources. Stakeholder leadership teams above Big Hill, and Elk City reservoirs have not yet been established. Initial meetings have been held in these areas to identify stakeholders and issues. KWO &/or KDA will provide the USACE's Oologah Watershed Assessment report to the conservation districts in the Verdigris R. Basin below the 4 fed reservoirs as a tool that may help assist future water quality activities. The Kansas Geological Survey annual Field Tour included several stops in the Verdigris basin including a streambank restoration project. The "Reservoir Roadmap for the Verdigris Basin" has been completed. This report is a comprehensive assessment of the condition of the watershed as it influences reservoir sedimentation. Roadmap for the Verdigris Basin is available on the KWO website.	EPA 319 Funds; EPA 319/State Water Plan WRAPS funds	
1.A.	Upper Fall River WRAPS (KDHE/KAWS)	Bob Culbertson (Fall River & Toronto WRAPS / KAWS)	NA	NA	Identify watershed needs and goals, develop cost effective strategies and put them into action.	Bob Culbertson is the new Upper Fall River WRAPS coordinator. The Upper Fall River WRAPS received "support funding" (i.e.enough funding to hire a part time coordinator to leverage other state and federal resources to install BMPs) of $6,000 to install BMPs as outlined in KDHE-approved 9 element plan. Project implementation ongoing.	EPA 319 Funds; EPA 319/State Water Plan WRAPS funds	

	CURRENT PROJECTS (Con't)	LEAD PI	START DATE	END DATE	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
1.B.	Toronto WRAPS (KDHE / KAWS)	Bob Culbertson (Fall River & Toronto WRAPS / KAWS)	NA	NA	Identify watershed needs and goals, develop cost effective strategies and put them into action. Implementation project.	Bob Culbertson is the new Upper Fall River WRAPS coordinator. The project continues installing BMPs as outlined in KDHE-approved 9 element plan. KAWS is the sponsoring organization. The SLT is now well established and implementation is ongoing.	EPA 319/State Water Plan WRAPS funds	
2.	Pond and Riparian Area Water Monitoring Project Greenwood County (Greenwood Co.)	(KDHE)	NA	NA	The goal of this project is to determine the impact of fencing livestock from ponds and riparian areas. Project objectives include: 1. Implement a water monitoring for two fenced ponds; 2. Implement a vegetative survey, before and after fencing, to determine plant species for correlating to water quality; 3. Disseminate results with a workshop, brochure and/or news article.			
3.	Implementing the KAWS "Save Money and Time" publication for livestock producers	Tim Christian (KAWS)	NA	NA	The Fall River watershed is one of two watersheds chosen to work directly with landowners to implement practices recommended in this publication. Barriers to implementation will be identified and used to overcome resistance to changing practices.	This publication has been printed and widely distributed.	EPA	
4.	Responses to Climate Change (USACE)	Lilly Douglas (USACE)	Oct 1 2011	NA	Key result of the program is to identify a multi-organization process to characterize climate change impacts to reservoir yield and associated drought contingency planning that can be repeated in the future as climate science advances.	Description (con't) The project would utilize existing data from the USACE's Oologah Watershed SWAT Model and the Oologah lake response model.		
5.	3-Dimensional Hydrodynamic and Water Quality Model of Lake Oologah Task 2 Data Collection, Inventory, and Processing for Watershed and Lake Models (ODEQ)	Joe Long (ODEQ)	2015	2017	Develop linked HSPF watershed model and EFDC lake model to calculate a TMDL.	Draft TMDL report has been released for review.		

	PROGRAMS	LEADER / CONTACT	START DATE	END DATE	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
1.	Conservation Technical Assistance (CTA) / Environmental Quality Incentives Program (EQIP) cost share assistance & incentive payments for conservation practices. (USDA-NRCS-OK)		NA	On-going	CTA: Assist with conservation practice application. EQIP: Help customers with cost share to implement conservation practices.			
2.	Kansas Watershed Districts	Herb Graves	NA	On-going	Watershed Districts can be formed to address rural flooding concerns. There are several in the Verdigris Basin.			
3.	Conservation Technical Assistance (CTA) / Environmental Quality Incentives Program (EQIP) cost share assistance & incentive payments for conservation practices. (USDA-NRCS-KS)		NA	On-going	CTA: Assist with conservation practice application. EQIP: Help customers with cost share to implement conservation practices.			
4.	Kansas County Conservation Districts	Greg Foley	NA	On-going	Nonpoint Source Pollution Control Plans – provides cost share assistance from State Water Plan fund to implement conservation and pollution management practices on the land. Water Resources Cost Share Programs – provides cost share assistance to address public water supply, reduce soil erosion and improve or protect water quality. Riparian and Wetland Program – Conservation Districts prepare Riparian and Wetland Plans and are then eligible for cost share assistance to develop and restore wetland and riparian areas.			
5.	Kansas Resource Conservation and Development Councils	Varies	NA	On-going	Among their many responsibilities, RC&D councils are involved in various environmental programs including grant management for EPA 319 watershed protection and planning projects.			
6.	Kansas Alliance for Wetlands and Streams – KAWS	Jeff Neel		On-going	Local chapters of KAWS are organized throughout the basin. Personnel work with landowners to install wetlands, stabilize streambanks, and improve riparian areas.	Ongoing.		
7.	KDHE Bureau of Environmental Remediation	Gary Blackburn (KDHE)	On-going	On-going	State Water Plan funds are used to remediate contaminated sites within the basin.	Ongoing.		
8.	Kansas Corporation Commission Well Plugging Program (Kansas Corp Commission)	Steve Korf & Bob Jenkins (KCC)	1996		Plugging of abandoned oil and gas wells.	1,493 oil wells have been plugged in the Verdigris Basin since 1996. Approximately 550 wells statewide were plugged in 2005. Ninety percent of these are in eastern KS, with a fair number in the Verdigris.		~$4,500,000

	PROGRAMS (Con't)	LEADER / CONTACT	START DATE	END DATE	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
9.	Beneficial Use Monitoring Program (BUMP) (OWRB)	Bill Cauthron (OWRB)	On-going	On-going	Monitor river, streams, and lakes to document beneficial use impairments, detect water quality trends, provide needed information for the OWQS development and refinement process and to facilitate the prioritization of pollution control activities.	2016 BUMP report is available at http://www.owrb.ok.gov/quality/monitoring/bump/pdf_bump/Current/Lakes/BUMPLakesReport.pdf		
10.	Monitoring and Establishment of Ambient Water Quality Baseline (KDHE)	Tom Stiles (KDHE)	On-going	On-going	Baseline monitor Kansas waterbodies by KDHE to evaluate progress in meeting TMDLs.	Results are in the Kansas Integrated Water Quality Assessment 2014 at http://www.kdheks.gov/befs/download/Kansas_Integrated_Report_2014.pdf		
11.	NPDES Stormwater Program	Rance Walker (KDHE)	1999	On-going	Of cities in the Verdigris Basin, Coffeyville is subject to Phase II Permitted Municipal Separate Storm Sewer System.			
12.	State Water Plan Contamination Remediation Program	Doug Doubek (KDHE)		On-going	Evaluate, monitor, and remediate contaminated ground or surface water sites and contamination source areas where the responsible party is unknown or is unable or unwilling to undertake the necessary action. Sites are recommended based on environmental and health concerns, community priorities, partnership opportunities, and lack of alternative funding choices. The program also provides funding to supply alternate water sources as an emergency response action to residences with contaminated drinking water sources.	2008 update: Altoona Smelter: KDHE has identified a PRP for the Altoona Smelter site, in Altoona, Wilson Co. The site was transferred to the State Cooperative Unit. Group A and C Refineries: Site is located in Caney, Montgomery Co.; Cherryvale, Montgomery Co.; Longton, Elk Co.; Niotaze, Chautauqua Co.. Potential Contamination is refinery waste including polynuclear aromatic hydrocarbons. Status: Investigation. Phase I FFRAs were completed in 2006 & 2007. Phase II assessment activities were recommended at several of the former refineries. Kanotex Refinery (Former) – Caney. A Phase II FFRA was not conducted in 2008. The site will be evaluated for possible assessment activities in 2009. Sunflower Refinery – Niotaze. Phase II field activities were conducted in Aug 2008. Superior Refinery – Longton. A Phase II FFRA was not conducted in 2008. The site will be evaluated for possible assessment activities in 2009. Uncle Sam Oil Refinery (Former) – Cherryvale. Phase II activities were conducted in Aug & Sep.		

	PROGRAMS (Con't)	LEADER / CONTACT	START DATE	END DATE	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
13.	Stream Assessment and Monitoring Program (KDHE & Kansas Dept. of Wildlife Parks & Tourism)	Mark Van Scoyoc (KDWPT)	1975	On-going	Document t current range and distribution of stream species. Other objectives include the establishment of recent baseline data on stream fishes and macroinvertebrates to enhance stream management decisions and help assess overall conditions of Kansas streams.	2013 survey ended in August.		
14.	Surface water quality monitoring (USGS-OK)	Scott Strong (USGS)	NA	On-going	Current USGS surface-water stations in the Verdigris Basin: 07171000 VERDIGRIS R NR LENAPAH 07174400 CANEY R ABOVE COON C AT BARTLESVILLE NR RAMONA , OK 07175500 CANEY R NR RAMONA, OK 07169800 ELK R AT ELK FALLS, KS 07170990 VERDIGRIS R AT COFFEYVILLE, KS 07170500 VERDIGRIS R AT INDEPENDENT, KS		DOE & Cooperators	

	PROGRAMS (Con't)	LEADER / CONTACT	START DATE	END DATE	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
15.	Virdigris Watershed District Water Appropriations				1. Verdigris River Upper Verdigris WJD # 24 PO Box 79 Madison KS 66860 #45,920 39 reservoirs Cedar Creek WJD # 56 20310 1300 Rd Chanute KS 66720-5503 #47,089 7 reservoirs Walnut West WD # 72 1819 E River St Eureka KS 67045 #44,498 1 reservoir #45,465 10 reservoirs #45,945 2 reservoirs Cedar Creek WJD # 97 105 N State STE B Yates Center KS 66783 #46,897 3 reservoirs Tri Creek WD # 100 700 N 31st St Parsons KS 67357 #44,546 2 reservoirs #46,253 4 reservoirs			

	PROGRAMS (Con't)	LEADER / CONTACT	START DATE	END DATE	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
					2. Fall River Fall River WJD # 21 1829 E River Eureka KS 67045 12,663 & 42,976 (Otis Creek Reservoir, City of Eureka) divert water from the impoundment under one point of diversion of File # 45,466 #44,599 1 reservoir #45,466 28 reservoirs #46,383 1 reservoir #46,384 1 reservoir Otter Creek WJD # 83 1829 E River Eureka KS 67045 #44,463 1 reservoir #45,464 2 reservoirs #46,311 1 reservoir			
					3. Elk River Grant-Shanghai WD # 14 801 Rd 10 Sedan KS 67361 #46,873 7 reservoirs (existing reservoirs pending final approval) Elk River WD # 47 715 N Main Moline KS 67353 #46,217 1 reservoir #46,759 47 reservoirs Duck Creek WJD # 59 3311 250 Rd Fredonia KS 66736 #46,975 4 reservoirs (existing reservoirs pending final approval)			

	PROGRAMS (Con't)	LEADER / CONTACT	START DATE	END DATE	DESCRIPTION	STATUS	FUNDING SOURCE	TOTAL COST
					4. Caney River Bee Creek WJD # 15 109 E Taylor Caney KS 67333 #47,092 8 reservoirs (existing reservoirs pending final approval) Big Caney WJD # 31 Box 46 Cedar Vale KS 67024 #46,860 32 reservoirs Twin Caney WJD # 34 PO Box 328 Sedan KS 67361 #47,066 27 reservoirs			

	PROPOSED PROJECTS / PRORAMS	**LEAD PI**	START DATE	END DATE	DESCRIPTION	**STATUS**	**FUNDING SOURCE**	TOTAL COST
	None at this time							

	PAST PROJECTS / PRORAMS	LEAD PI	START DATE	END DATE	DESCRIPTION	SUMMARY	FUNDING SOURCE	TOTAL COST
1.	An Evaluation of Settling, Densities and Growth of Zebra Mussels in Lynn Lane Reservoir and Lake Oologah (OSU)	Joe Bidwell (OSU)	Fall 2005	Fall 2007	Determine densities and size distributions of existing adult zebra mussels (ZM), and densities and settling rates of ZM larvae, in Oologah Lake and Lynn Lane Reservoir. Characterize temporal trends in select water chemistry variables at both systems. Evaluate physical and chemical control technologies for ZM under conditions relevant to Oklahoma.	Final report submitted Nov 2007.	TMUA	$49,999
2.	Well Plugging Project (EPA / OK Corp Comm / OERB)	Chris Ruhl (EPA) Steve Sowers (OERB)	2000	2006	Locate and plug idle and abandoned oil wells and restore the well sites to as near natural conditions as possible to prevent surface water pollution. Most of the work encompasses an area 3 to 5 miles wide and 11 miles long funning in the north/south direction east of Lake Oologah. The project covers about 25,000 acres. According to OK Corp Comm, this project was the largest oil well-plugging project in the U.S.	OK Corp. Commission plugged 300 abandoned wells at a cost of $500,000. EPA plugged just over 1,000 wells at a cost of $8.5 million. OERB surface-restored 226 sites at a cost of $300,000.	Oil Spill Liability Contingency Fund OK Corp Commission (OK Well Plugging Program)	$9,300,000
3.	**Source Water Assessment: Eucha/Spavinaw Watershed Hudson Watershed** Verdigris River Basin (TMUA)	Ray West (TMUA)	2011	2012 May	Determine the relative susceptibility of Tulsa's source water to contamination from Synthetic Organic Contaminants (SOC)s and to make source water protection recommendations.	The Watershed Protection Areas (WPA) for Oologah Lake were determined to have a relatively low susceptibility to SOCs.Only one regulated SOC was found in Zone B (areas within 1-mile of lakes or streams) within Oologah Lake WPA. Recommendations; Source water protection should begin with sampling Oologah L intake to determine the possibility of occurrence for Alachlor, aldicarb sulfoxide, Atrazine, 2,4-D, glyphosate, Pichloram, and PCBs.	TMUA (in-house)	
4.	Oologah Lake Watershed Watershed Study Verdigris River Basin, Oklahoma and Kansas (USACE& COT)	Steve Nolen (USACE)	2003	2013	Evaluate environmental restoration measures by assessing linked watershed and lake models (SWAT & CE-QUAL-W2) to improve water quality and reduce flood damages within the Verdigris River Basin, Oklahoma and Kansas.	Final Oologah Lake Watershed Assessment Study report has been submitted to the City of Tulsa. The assessment was conducted to identify potential causes of and solutions to impairment issues arising from the uncontrolled portions of the watershed. KWO has received this report.	TMUA 50% Federal 50%	~$4,600,000
5.	Oklahoma-Kansas Stakeholder Group	Patricia Newell (Corps) Troy Krenzel (SEE-KAN RC&D)	Spring 2008	2010	A multi-state (KS & OK) group interested in improving water quality in the Verdigris River Basin.	The Oologah Lake Watershed Assessment was completed (Spring 2012).		