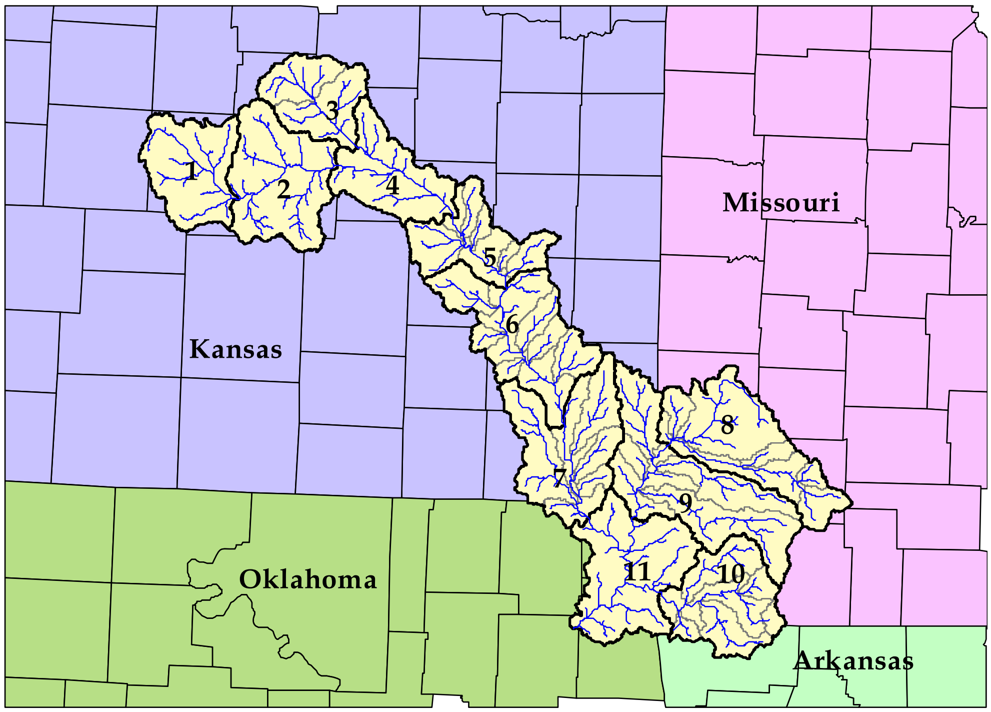
GRAND LAKE WATERSHED PLAN

For Improving Water Quality Throughout the Grand Lake Watershed



Prepared by:

Grand Lake O' the Cherokees Watershed Alliance Foundation, Inc.

November, 18 2008

"It's All About the Water!"

GRAND LAKE WATERSHED PLAN - 2008

Table of Contents

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ACRONYMS AND ABBREVIATIONS USED IN THIS DOCUMENT

BMP	Best Management Practice
BOD	Biological Oxygen Demand
DO	Dissolved Oxygen
CAFO	Confined Animal Feeding Operation
Cd	Cadmium
cfs	Cubic feet per second
CERCLA	Comprehensive Environmental Response, Compensation & Liability Act
EPA	US Environmental Protection Agency
ERWIA	Elk River Watershed Improvement Association
FSWC	Four State Watershed Collaborative
GLWAF	Grand Lake O' the Cherokees Watershed Alliance Foundation
GRDA	Grand River Dam Authority
IPI	Improvement Potential Index
KDHE	Kansas Department of Health and Environment
KWO	Kansas Water Office
MoDNR	Missouri Department of Natural Resources
N	Nitrogen
NPS	Nonpoint Source
OCC	Oklahoma Conservation Commission
ODEQ	Oklahoma Department of Environmental Quality
OWRB	Oklahoma Water Resources Board
P	Phosphorus
Pb	Lead
PS	Point Source
SLT	Stakeholder Leadership Team
TMDL	Total Maximum Daily Load
USDA	US Department of Agriculture
USACE	US Army Corps of Engineers
USGS	US Geological Survey
WP	Watershed Plan
WQS	Water Quality Standards
WRAPS	Watershed Restoration and Protection Strategy
WWTP	Wastewater Treatment Plant
Zn	Zinc

EXECUTIVE SUMMARY

The purpose of this Watershed Plan (WP) is to provide an initial assessment and overall strategic plan for the Grand Lake O' The Cherokees 10,298 square mile watershed. A strategic water quality approach is necessary because the watershed is located within the four states of Arkansas, Kansas, Missouri and Oklahoma. It also traverses two separate Environmental Protection Agency Regions, includes numerous Tribal areas, and has many county and local governments within its boundaries.

Impaired waters caused by nutrient (most notably phosphorous) pollution are widespread throughout the Grand Lake watershed. Each of the three major watershed rivers (Neosho River, Spring River, and Elk River) has nutrient impairment and each flows into Grand Lake and other reservoirs.

The Neosho River Subwatershed has three federal reservoirs (Marion Reservoir, Council Grove, and John Redmond), each negatively impacted by nutrients. A 2005 algae bloom occurred on Marion Reservoir that resulted in the beaches being closed and communities prevented from using lake water as their water supply. Beach closings at Marion have occurred in subsequent years. Also, Grand Lake O' The Cherokees is a nutrient rich lake that is receiving an elevated and excess amount of nutrients.

Toxic algal bloom in Marion Reservoir in the headwaters of the Grand Lake Watershed (photo courtesy of Gerard A. Clyde, Jr., US Army Corps of Engineers, Tulsa District).

Nutrients are carried throughout the watershed attached to sediment particles or as organic waste (which may also contain bacteria and pathogens). These issues are linked and well documented throughout the watershed:

> The Neosho River Subwatershed priority impairments include: (1) nutrients (evidenced by low dissolved oxygen/eutrophication), (2) sediment (silt), and (3) bacteria. Sources for these high priority impairments are: agriculture fields, stream banks, pasture, permitted sites, including municipal waste water treatment plant point source discharges, and septic systems. Identified causes include soil erosion, lack of riparian buffers, overgrazing, and failing septic systems.
>
> The Spring River Subwatershed priority impairments include: (1) heavy metals, (2) nutrients (evidenced by low dissolved oxygen in Kansas), and (3) bacteria. The causes of impairment stem from acid mine seepage, soil and bank erosion, animal stream access, and failed septic systems.
>
> The Elk River Subwatershed priority impairments include: (1) nutrients, (2) bacteria, and (3) sediment. The causes of impairment are agricultural activity, failed septic systems, pasture erosion, and permitted sites, specifically municipal waste water treatment plant point source discharges.
>
> The Lake O' The Cherokees Subwatershed, about 888 square miles located mostly in northeast Oklahoma, priority impairments include: (1) nutrients, (2) bacteria, and (3) heavy metals. The sources of impairment stem from livestock, land application of manure, agricultural activity, septic systems, mine waste, and wastewater lagoon discharges.

Reducing total watershed-wide nutrient (phosphorus) pollution requires a strategic collective solution. Pollution risks stemming from elevated nutrient levels will only increase from population increases and other sources unless a four-state coordinated effort is implemented.

This WP advances three priority initiatives each designed to address a strategic problem throughout the watershed:

1. Conduct watershed-wide targeting studies, including sediment and nutrient modeling and stream bank stability studies.
2. Establish signage that designates the watershed boundaries to include the boundaries of subwatersheds
3. Fund four full-time Foundation Executive Vice-president positions to assist in organizing and developing citizen-based groups and to assist in developing individually tailored subwatershed plans.

Watershed-wide targeting studies (modeling and streambank stability) will identify the best locations to establish cost-effective nutrient/sediment reduction projects. These studies will provide important information to citizen groups and water quality related state agencies for developing localized improvement projects.

A large portion of the watershed lacks individual WPs for rivers and their tributaries. This condition represents a major deterrent to successfully improving water quality. Preparing and implementing individual WPs within each of its three major rivers and their tributaries is an essential step necessary to achieve improved water quality.

Strategically, the Grand Lake Watershed has an insufficient number of citizen-based stakeholder groups established. This condition is slowing efforts to prepare and implement localized watershed improvement plans. Measures designed to establish additional active stakeholder groups are given a high priority in this WP.

Steps to improve citizen ownership of their watershed are important. Installing signage throughout the total watershed showing the watershed boundaries is a project advanced in this WP. Also, the newly formed citizen-based non-profit Grand Lake O' The Cherokees Watershed Alliance Foundation intends to establish a full-time Foundation position in each of the four watershed states to assist in organizing and supporting citizen-based organizations.

Increased water pollution pressures from population growth are occurring within the Spring River, Elk River and Lake of the Cherokees sub-watersheds. Each of these sub-watersheds warrant a higher priority in the development of citizen-based organizations and locally targeted river and stream WPs. This WP also advances a proposal that additional nutrient/metal monitoring sites be established in both the Spring River and Elk River sub-watersheds.

Heavy metals, a high priority issue in parts of the watershed, are being managed primarily through a separate process. However, since some heavy metals are transported through sediment erosion, projects aimed at reducing nutrients/sediment will also reduce heavy metal pollution.

The non-profit corporation Grand Lake O' The Cherokees Watershed Alliance Foundation Inc. was formed in late 2007. Its Board of Directors is comprised of citizens from each of the four watershed states. The objectives of this Foundation include:

- Providing private funding to supplement governmental funding
- Assisting in the support and organization of citizen-based organizations
- Funding a full time Foundation staff to work within the watershed
- Supporting a strong public education outreach program
- Assisting with identification and solution of water quality related issues
- Energizing citizens and watershed stakeholders in shaping the watershed
- Interfacing with local, state, Tribal, and federal agencies

The watershed presently has insufficient citizen-based stakeholder organizational infrastructure that is essential to achieve improved water quality. A large portion of the watershed lacks individual subwatershed plans tailored for specific rivers and streams. Consequently, material improvements in water quality during the next ten years do not look promising unless the following occur:

- Organizing and supporting citizen-based stakeholder organizations must receive a high priority for the next five years. This is an imperative strategic element requiring focus by citizens, community leaders, and governmental leaders.
- Citizen-based stakeholder organizations and additional funds are required to prepare subwatershed plans tailored for specific streams.
- A higher priority for funding water quality improvement projects implemented by citizen-based organizations with support from local, state, federal and tribal government is necessary.
- Private funds must be made available to support these water quality improvement efforts.

Degradation of water quality is a real risk within the watershed. Increased pollution risks are expected unless drastic steps are taken and higher priorities are established. One strategic objective is to stop the projected decline in water quality. Clearly, the nutrient rich watershed will continue to affect the four major reservoirs (Marion, Council Grove, John Redmond, and Grand Lake) and the major rivers (Neosho, Spring, and Elk) unless a watershed-wide collective and coordinated effort is adopted and implemented.

PREFACE

The purpose of this Watershed Plan (WP) is to serve as the first general strategic assessment and analysis of the total Grand Lake O' The Cherokees watershed. This large watershed is about 10,298 square miles located in parts of the four states Arkansas, Kansas, Missouri and Oklahoma.

The organizational format follows the nine elements recommended in the United States Environmental Protection Agency (EPA) *Handbook for Developing Watershed Plans to Restore and Protect our Waters* (2008). It is noted the sheer size and complexity of the watershed warrants a more strategic presentation rather than the detail appropriate for a smaller watershed.

The Grand Lake watershed is diverse and complex. This is due not only to its size but also to the separate local, state, federal and tribal governmental jurisdictional boundaries. The impact of mining districts in Missouri, Kansas, and Oklahoma, including the Tar Creek EPA Superfund site (located in the southern portion of the watershed), also compound these water quality issues.

The water quality assessment in this report is organized into four sections corresponding to the four major subwatersheds of the Grand Lake Watershed (Figure 1).

> (1) The Neosho River Subwatershed drains from Kansas into Oklahoma and comprises about 5,830 miles or about 57% in the Kansas portion of the watershed. There are three federal reservoirs in this watershed: Marion, Council Grove, and John Redmond.
>
> (2) The Spring River Subwatershed is located in southwest Missouri, southeast Kansas, and northeast Oklahoma. About 2,577 square miles of the total Spring River watershed or about 25% is located in southwest Missouri, and southeast Kansas. There are no reservoirs on the Spring River.
>
> (3) The Elk River Subwatershed is located in parts of Arkansas, Missouri and Oklahoma and includes about 1,037 square miles, or about 10% of the watershed.
>
> (4) The Lake O' the Cherokees Subwatershed includes the land draining into the Neosho River from about the Kansas border to its convergence with the Spring River in northeast Oklahoma into the Grand River. This subwatershed also includes the land areas around other minor streams draining into the Grand Lake O' the Cherokee reservoir. This subwatershed is about 888 square miles or 8% of the total Grand Lake watershed. Grand Lake covers 46,500 surface acres and holds 1,572,000 acre-feet of water.

Review and analysis of Total Maximum Daily Loads (TMDL) for bodies of water in the watershed served as the analytical foundation for this WP. The methodology used also included a review of published reports and other relevant information. The analysis focused on bodies of water that have been declared impaired by respective state governments.

There have been water quality improvement programs instituted within the watershed, but not pursuant to an overall comprehensive strategic WP. One essential step to achieve improved water quality is to have a strategic WP for the total watershed. This is because the Grand Lake Watershed is so large and complex (with the four states involved having different water quality standards, different methods and different priorities).

In 2007 a non-profit organization, Grand Lake Watershed Alliance Foundation Inc. (GLWAF), was formed to provide a citizen-based focus on the total watershed. The makeup of its Board of Directors includes citizens from each of the four watershed states. This Foundation intends to work closely with other citizen-based organizations within the watershed in order to improve education, communication and coordination among the various watershed stakeholders and governmental entities.

The GLWAF has developed this WP to provide an initial overall watershed strategic assessment. This plan expands upon the 2004 WP developed by the Oklahoma Conservation Commission. There are clear and definitive future actions presented that will advance improvements in water quality. The overall focus of this WP is weighted more heavily on non-point source conditions due to the nature of the watershed and its pollution contributing factors. However, it is recognized that point-sources such as wastewater treatment plants are significant contributors of nutrients/phosphorus and other pollutants and must be addressed by the state and federal agencies that regulate these permitted sites, in conjunction with the Foundation's plans and actions.

This WP has been developed as a dynamic document subject to revision and update as appropriate. It can serve as a framework and reference for more detailed and comprehensive WPs tailored for specific subwatershed streams and bodies of water.

This WP also presents key important steps: further developing subwatershed stakeholder groups, improving watershed wide education efforts, supporting citizen-based watershed groups, assisting in developing subwatershed plans, and generating private and public funding to support water quality improvement efforts.

To reflect the increasing importance of citizen-based watershed groups in shaping and achieving water quality improvements, a portion of this report presents a discussion of these key groups within the watershed and corresponding plans to increase their presence and involvement within the watershed.

This WP confirms the watershed is facing increased water quality risks from population increase and other pollution pressures. This WP for the Grand Lake watershed also points to the present risks associated with sediment, nutrients, and bacteria that are a common pollution threat throughout the watershed. In addition, there are portions of the watershed where heavy metals pose a major concern.

Watershed planning is an emerging process. A considerable portion of the watershed geographical area does not have a WP that is applicable to specific rivers and their tributary streams. This WP also presents the status of watershed planning.

There were many individual and organizational participants in the preparation of this WP. However, the efforts of four individuals are appropriately recognized: Dr. Kevin Gustavson, Oklahoma Conservation Commission; Foundation Board member Dr. Jim Triplett, Pittsburg State University; Foundation Board member Drew Holt, Executive Director Elk River Watershed Improvement Association; and Foundation Committee member Terry Hallauer, Oklahoma Department of Environmental Quality.

INTRODUCTION

The Nonpoint Source Program and Grants Guidelines for States and Territories for 2004 and Beyond requires a *Watershed Plan* to be completed prior to implementation of watershed projects using federal money authorized by the Clean Water Act. The guidance defines the 9 key components to be addressed in a watershed-based plan. These components include: 1) identification of sources and causes that will need to be controlled to achieve load reductions, 2) estimate of load reductions expected from the management measures described, 3) a description of the management measures that will need to be implemented to achieve load reductions, 4) an estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources or authorities who will bear responsibility, 5) an information/education component that will be used to enhance public understanding of the project and encourage early participation in the overall program, 6) a schedule for implementing the management measures identified in this plan that is reasonably expeditious, 7) a description of interim, measurable milestones for determining whether control actions are being implemented, 8) a set of criteria that can be used to determine whether load reductions are being achieved over time and substantial progress is being made or whether the Watershed Plan or Total Maximum Daily Load (TMDL) needs to be revised, and 9) a monitoring component to evaluate the effectiveness of the implementation efforts over time.

In the US Environmental Protection Agency's (EPA) supplemental guidance "Handbook for Developing Watershed Plans to Restore and Protect our Waters" (2008), it is noted that the detail expected in addressing the above guidelines decreases with larger watersheds, as the challenges of documenting each stream mile becomes a daunting task for these large watersheds. As the Grand Lake Watershed covers a large portion of 4 states, the intent of this document is to provide an overall framework for addressing water quality issues watershed-wide and to support the development and implementation of subwatershed plans led by local stakeholder initiatives.

In order for the watershed plan to become an integral part of the entire watershed restoration program, it must be amenable to revision and update. The Grand Lake Watershed Plan has been developed as a dynamic document that will be revised to incorporate the latest information, address new strategies, and define new partnerships among watershed stakeholders. It is anticipated that at least biannual revisions may be necessary and that the responsibility for such revisions will rest primarily with the Grand Lake O' the Cherokees Watershed Alliance Foundation (GLWAF). It is understood that the water quality goals set forth in this watershed plan, as well as the technical approach to address the goals, may not be comprehensive, so they may be expanded in the future. Federal and state funding allocations for future water quality projects designed to address the Grand Lake Watershed problems should not be based solely upon their inclusion in this watershed plan; rather, the plan should be considered a focal point for initial planning and strategy development.

Watershed Characterization

Hydrology: Grand Lake Watershed comprises over 10,000 square miles and spans parts of four states: Kansas, Missouri, Oklahoma, and Arkansas (Figure 1). The watershed is elongate, oriented northwest-southeast, and drains predominantly southward. The watershed is comprised of 3 major river systems (Figure 1): the Neosho, Spring, and Elk Rivers. All 3 rivers converge in Oklahoma in the upper portion of Grand Lake, the terminal reservoir of the watershed. The Neosho River drains approximately 5800 sq. miles in Kansas and provides about half of the inflow to Grand Lake with a discharge of 5,491 cfs. The Spring River drains about 2500 square miles in Missouri and Kansas with a discharge of 3,417 cfs which is about thirty two percent of the inflow to Grand Lake. The Elk River drains about 900 square miles in Missouri and Arkansas with a discharge of 1,299 cfs to provide about twelve percent of Grand's hydraulic budget. Water from the watershed continues down the Grand River through two other reservoirs before entering the Arkansas River near Muskogee, OK, and flowing through Arkansas toward the Mississippi River.

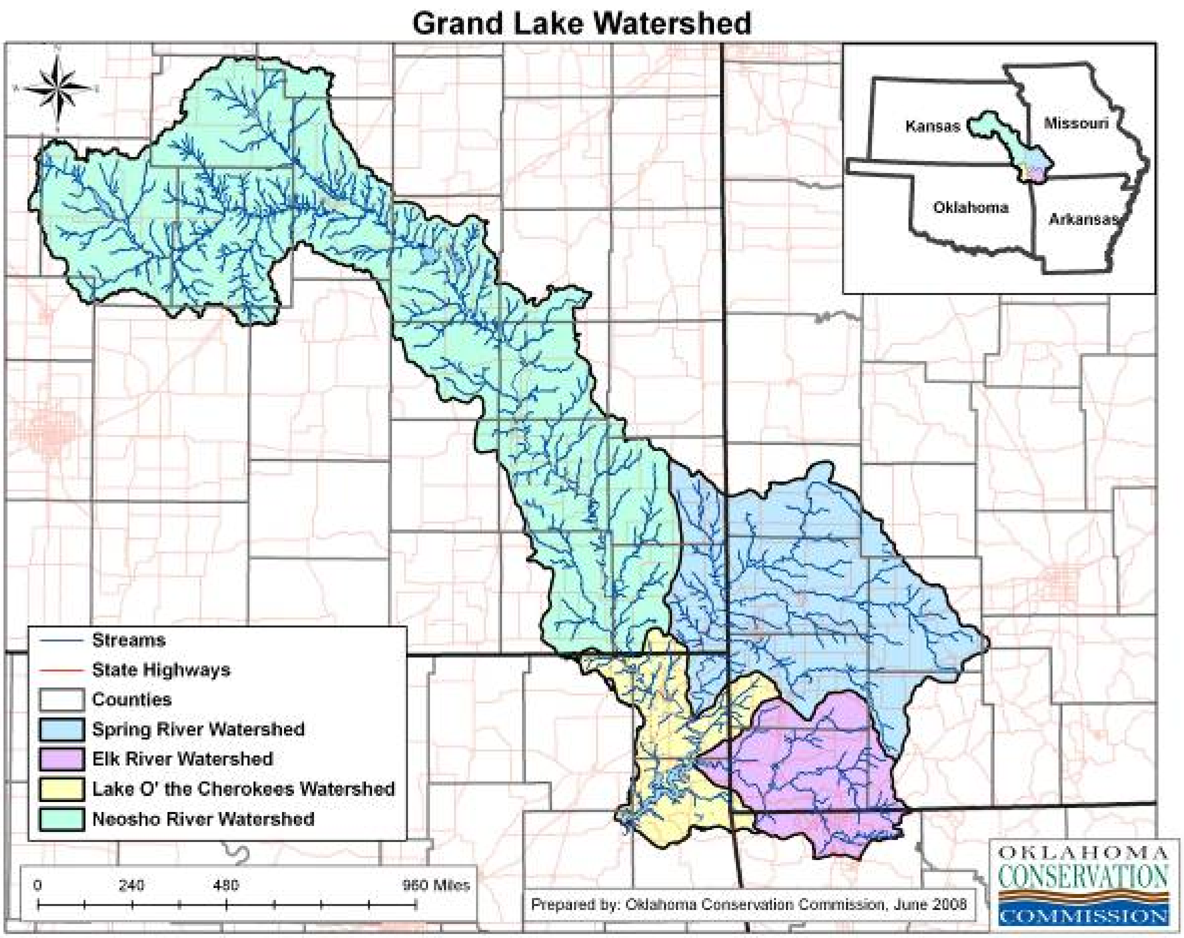

Figure 1: Location of Grand Lake Watershed and its four major divisions corresponding to the 3 major river basins and an area around Grand Lake O' the Cherokees.

There are four major reservoirs in the Grand Lake Watershed. In addition to Grand Lake, these include John Redmond and Council Grove Reservoirs (also on the Neosho River) and Marion Lake (on the Cottonwood) in Kansas. The storage capacity of John Redmond is now about 44,400 acre-feet, Council Grove is about 36,700 acre-feet, and Marion Lake is about 75,100 acre-feet. Grand Lake has a storage capacity of about 1,672,000 acre-feet. Based on the annual volume of water transported by the Neosho River (1,698,000 acre feet at Parsons, KS), water from the Neosho alone is sufficient to "refill" the volume of Grand Lake on an annual basis.

Climate and Precipitation: The Grand Lake Watershed has a continental climate characterized by mild winters and hot summers. Average high temperatures are in the 40's (Fahrenheit) during the coldest winter months and are typically close to 90 degrees Fahrenheit over July and August.

Average annual rainfall in the area increases from the northwest to the southeast: from about 33 inches per year in Lehigh, KS up to about 47 inches per year in Bentonville, Arkansas. Average rainfall throughout the watershed is lowest in the winter months (averaging 0.5 to 2.5 inches per month) and peaks in the spring months (typically over 5 inches in May throughout the watershed). The farther southwest in the watershed, the greater tendency to have another, less pronounced peak in rainfall in early Fall (typically 5 inches in September).

The region is known for its localized, torrential rain storms and its resulting "flashy" stream flows. April, May, and June bring a third of the annual rainfall and about 60% of flooding to the Spring River Watershed with similar patterns elsewhere in the watershed (MoDNR Spring River TMDL, Aber).

High summer temperatures lead to high evapotranspiration (evaporation from the surface plus transpiration of water vapor through vegetation) during the summer months. In the Spring River Watershed, about 75% of the annual rainfall is lost to evapotranspiration with the rest available for streamflow and groundwater recharge (MoDNR Spring River TMDL).

The region experiences over 10 inches of snow on average in portions of the watershed and regular freezing and thawing between the months of November and March. Frost and snows occur as early as September and as late as April.

Ecoregions: Ecoregions are delineated across the United States to help identify areas of common ecological and environmental identity. The Grand Lake Watershed is mostly comprised of 3 level III ecoregions with a fourth making up the extreme northwestern fringe of the watershed. Ecoregion descriptions for this section are taken from the updated level III ecoregion maps (Woods et al. 2004, Woods et al. 2005, Chapman et al. 2001, Chapman et al. 2002).

The extreme northwestern fringe of the Grand Lake Watershed is within the Central Great Plains ecoregion. This ecoregion consists of undulating to hilly topography, originally covered in native tallgrass prairie, much of which has been converted to cropland. Pastureland and cropland are the major land uses with winter wheat the dominant crop (the easternmost region for this crop). Soils are sandy over sandstone bedrock and silty overlying windblown silt deposits.

Much of the upper northwestern portion of the Grand Lake Watershed (most of the land upstream of John Redmond Reservoir) lies in the Flint Hills ecoregion. The rolling hills of this ecoregion are underlain by shale and cherty limestone bedrock. Rocky soils have resulted from the concentration of weathering resistant chert (flint) as the softer Permian limestone weathered over time. These soils are difficult to plow, resulting in limited cropland agriculture. Some cropland, however, has developed in the valleys along the edge of the Flint Hills. This ecoregion contains the largest intact tallgrass prairie that remains in the Great Plains and is mostly used for range and pasture land.

The central portion of the Grand Lake Watershed is part of the Central Irregular Plains ecoregion. This ecoregion is comprised of a band of tallgrass prairie. The topography of this ecoregion is broken by limestone and sandstone cuestas, buttes, hills, and nearby level areas underlain by shale. Fire and grazing is required to maintain the grasslands. In its absence, woody plants such as red cedar, sumac, blackberries, and persimmons will invade the grasslands. This ecoregion supports a variety of land uses from pastureland to cropland to woodland. In addition, oil and gas exploration and coal and limestone mining operations are common in this region.

The southeastern portion of the Grand Lake Watershed is in the Ozark Highlands ecoregion, including the bulk of the Spring River, Elk River, and Lake O' the Cherokees subwatersheds. The Ozark Highlands ecoregion is a karst-rich area characterized by soluble bedrock creating open cavities in the rock (Figure 2). Compared to adjacent ecoregions, this region has more irregular physiography and is generally more forested. The majority of this dissected limestone plateau is predominantly an oak-hickory forest, but stands of oak and pine are also common. Less than one fourth of the core of this region has been cleared for pasture and cropland, but half or more of the periphery, while not as agricultural as bordering ecoregions, is in cropland or pasture.

Figure 2: A cave typical of karst-rich areas in the Ozark Highlands.

Geohydrology and Soils: The Flint Hills portion of the watershed has 3 main types of soils: rocky soils of residual chert on hilltops, silt and clay soils in modern valley floodplains, and older silt and clay soils from windblown deposits found on nearly level uplands. Bedrock structures exert a strong control on stream patterns. Dissolvable bedrock also gives rise to karst features in areas including sinkholes, caves, and springs. This area of surplus water gives rise to perennial spring-fed streams, many of which are deeply entrenched flowing off of the uplands. Groundwater, typically high in dissolved solids, is abundant and generally flows westward with the dip of bedrock. (Aber, Aber)

Geohydrology of the Central Irregular Plains portion of the watershed is characterized by soils derived from shale, sandstone, and limestone. In some nearly level areas, clay pan soils occur. On limestone slopes, exposed limestone slabs and gravels occur. Major streams have low gradients, meander considerably, and develop wide valleys except on areas of very hard rocks. Groundwater in the Central Irregular Plains tends to be saline and is more likely to be anoxic, as opposed to fresh, oxygenated groundwater generally found in the Ozark Highlands.

The Ozark highlands are composed of Springfield plateaus largely underlain by highly soluble and fractured limestone and chert of the Mississippi Boone Formation. Caves, sinkholes, and underground drainage occur, heavily influencing surface water availability, water temperature, and the potential for surface and groundwater pollution. Clear, cold, 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. Losing streams are common, which allows water to flow directly into the groundwater system through streambeds. During the summer dry period, springs and groundwater recharge sustain stream flows. Springs are a natural resurgence of groundwater, usually on a hillside or the valley floor. Soils are often cherty and have developed from carbonate rocks or interbedded chert, sandstone, and shale.

Natural Vegetation: Potential natural vegetation of the Flint Hills and Central Great Plains in the Grand Lake Watershed is native tallgrass prairie. Much of the native prairie remains in the Flint Hills region due to the poor suitability of the soils for agriculture. Typical vegetation includes tall grasses such as big bluestem and indiangrass with many flowering perennials including coneflowers, prairie rosinweed, lead plant, and others. Occasional fires and managed grazing help preserve these native species.

Potential natural vegetation in the Central Irregular Plains consists of bluestem prairie and oak-hickory forest mosaic. Tall grasses such as big and little bluestem, indiangrass, and switchgrass are dominant species on shales. These are interspersed with a diverse and abundant community of wildflowers. Thin gravelly soils of limestone scarps are populated with a dry prairie of short and tall grasses such as side oats grama, hairy grama, and prickly pear. Dry, open forests on hilltops and in level limestone are composed of post and blackjack oaks and black hickory. Floodplains support elm, spotted oak, pin oak, hackberry, cottonwood, black willow, and sycamore. Poorly drained sites are populated by sedge thickets, willow, and buttonbush.

Potential natural vegetation in the Ozark Highlands is mostly oak-hickory forest. Open forest composed of numerous tree species dominates rugged areas, while pasture and hayland are more common on level areas. Some areas of steep, cherty escarpments and shallow soils derived from limestone support shortleaf pine communities while cool, dry sites on north-facing slopes and in ravines support a closed forest of sugar maple, white oak, chinquapin oak, mockernut hickory, bitternut hickory, and shade-tolerant shrubs. Ridgetops and south-facing slopes are often grassland while floodplains are often an open forest of maples, elms, river birch, sycamore, and cottonwood. Grass and Eastern redcedar are found on shallow, droughty soils especially over dolomite.

Demographics: According to the 2000 census, the population of the Grand Lake Watershed is roughly 500,000 people, about half of which live in Missouri. Population in the region has experienced continued growth over the last half century, especially in NW Arkansas, SW Missouri, and NE Oklahoma. From 1990 to 2000, population in the three Missouri counties within the Elk River Watershed grew an average of 23.3 percent (MoDNR 2004 - Elk River TMDL). Figure 3 clearly shows that despite the larger area, the population in Kansas is very sparse compared to the rest of the watershed.

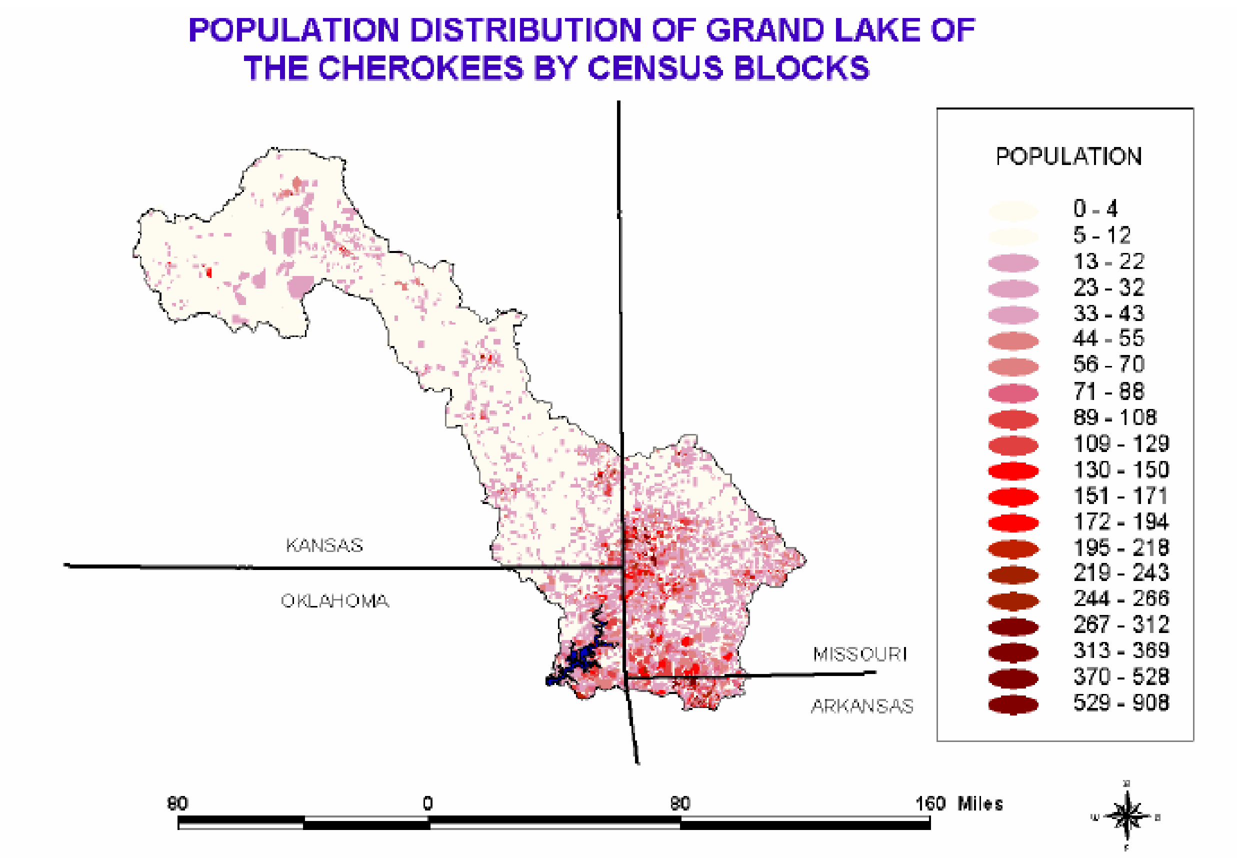

Figure 3: Population concentration map of Grand Lake Watershed (from Oklahoma Water Resources Board 2003).

Land Use: Overall land use in the watershed is 36% planted pasture, 21% natural grassland (which may be grazed), 20% cropland, 14% forest, 6% developed (mostly low intensity or open space such as residential lawns, parks, and golf courses), with the remaining 3% mostly divided between open water and wetlands (Figure 3).

Land use patterns coincide remarkably with ecoregion descriptions (Figure 4). The upper northwestern fringe is mostly cropland and grassland of the Central Great Plains. The Flint Hills Region in the northwest is predominantly grassland. The Irregular Central Plains is a mixture of cropland, pastureland, and grassland. The southeastern part of the watershed, in the Ozark Highlands, is forest and pastureland with cattle and poultry operations prevalent.

The major agricultural industry throughout the watershed is cattle production. Rowcrops produced in the watershed include corn, soybeans, wheat, or sorghum. Poultry operations are most prevalent in the Ozark Highland portion of the watershed to the southeast. In addition to agriculture, land use is becoming increasingly urban and suburban as small cities grow and lakeshore property is developed.

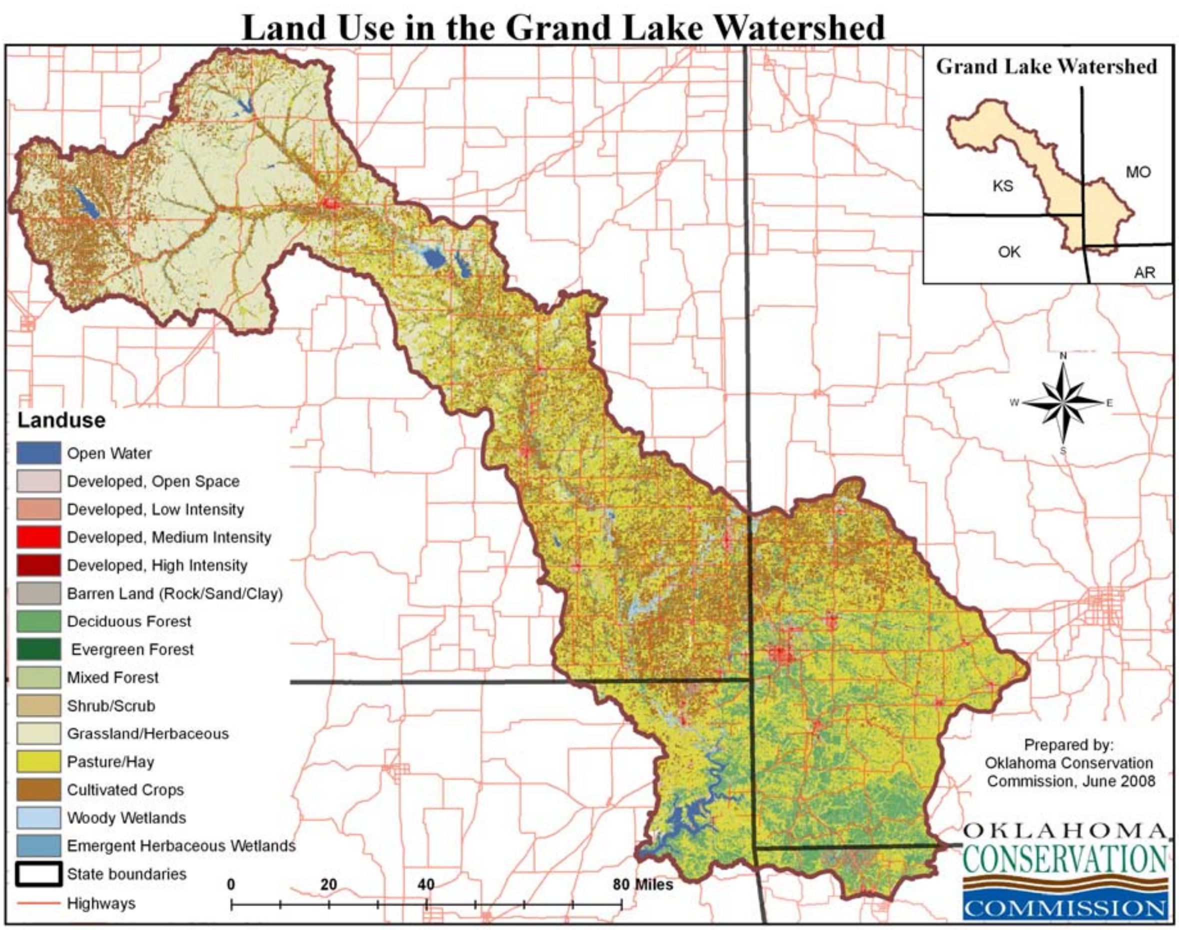

Figure 4: Land use classification for Grand Lake Watershed.

GENERAL IMPAIRMENTS, SOURCES AND CAUSES OF POLLUTION

Process for Determining Impaired Waters

Every state is required by the federal government to set water quality standards, monitor waters of the state, and list all water bodies that do not meet state standards on a 303(d) impaired waters list (named after the section of the Clean Water Act that mandates the process).

Water quality standards are based on the designated uses of the water body. Each state has its own set of designated uses (See Table 1) and associated water quality standards for each use. Water bodies that do not meet the water quality standards for its designated uses are considered "impaired". Not all uses apply to each water body, so water quality standards may be more stringent in some water bodies than in others.

Once the water is listed as impaired, the state has a timeline to develop a Total Maximum Daily Load (TMDL) for the impairment. The TMDL sets how much of a particular pollutant can be in the water and still meet water quality standards (with a margin of safety) and must address how the state plans to meet that goal.

Table 1: Designated uses for water bodies in the States of Grand Lake Watershed

ARKANSAS	KANSAS	MISSOURI	OKLAHOMA
Extraordinary Resource Waters	Aquatic Life	Aquatic Life & Human Health	Emergency Water Supply
Ecologically Sensitive Waterbody	Agriculture	Cold Water Fishery	Public & Private Water Supply
Natural & Scenic Waterways	Domestic Water Supply	Cool Water Fishery	Fish & Wildlife Propagation
Fisheries (fishable)	Food Procurement	Irrigation	Agriculture
Primary Contact Recreation (swimmable)	Groundwater Recharge	Livestock & Wildlife Watering	Recreation
Secondary Contact Recreation (wadable)	Industrial Water Supply	Whole Body Contact Recreation	Navigation
Domestic Water Supply	Recreation	Boating & Canoeing	Aesthetics
Industrial Water Supply		Drinking Water Supply	
Agricultural Water Supply		Industrial Process & Cooling Water	
		Storm & Flood Storage Attenuation	
		Habitat By Resident & Migratory Wildlife Species	
		Waters Having Recreational, Cultural, Educational, Scientific & Aesthetic Values	

Common Impairments in Grand Lake Watershed

Described below are described some of the most common impairments in the Grand Lake Watershed, according to TMDL documents, government reports, and stakeholder input, with an explanation of some impacts of those impairments.

Nutrients / Low dissolved oxygen (DO) / Eutrophication: Low dissolved oxygen can threaten the lives and health of many aquatic species (and humans) and is often the result of eutrophication. Eutrophication results from nutrient-enriched water. Nutrients cause abundant growth and decay of algae and associated feeding organisms. Ultimately, eutrophication results in fluctuating dissolved oxygen (DO) levels in the water that sometimes reach critically low levels for aquatic species survival. Low dissolved oxygen, therefore, is often related to nutrient levels. In fact, the recommended solution for low DO in TMDLs for the watershed is to decrease nutrient loads of phosphorus and nitrogen. These impairments typically lead to poor tasting drinking water, poor ecological quality, fish kills, and unsightly conditions. In extreme cases, algal blooms produce toxins that are a human health threat and which make water unfit for recreation or as a drinking water supply.

Many lakes and streams in the Grand Lake Watershed are impaired by nutrients or nutrient-related issues, including all four of the major reservoirs: Grand Lake, John Redmond Reservoir, Marion Reservoir, and Council Grove Reservoir.

Extreme impairments have been documented in the Grand Lake Watershed. Marion Reservoir, in the upper reaches of the watershed has had enormous algal blooms starting in 2003. These algal blooms have emerged over the course of a few days from previously clear water. Poor taste and odor of the water made it unfit for consumption, forcing communities to haul water from other locations to meet the needs of the local citizens. Testing showed that algal toxins were present in the water, even after treatment. (Marion County Conservation District, 2006)

Sediment / Silt: Sediments are particles of gravel, sand, silt, and clay that can be picked up by flowing water on the landscape and carried downstream. Silt is a sediment size between sand and clay (about the size of grains of flour) that stays suspended in water fairly easily. Sediment is problematic, particularly in reservoirs, for a number of reasons. First, suspended sediment causes water to be turbid (or cloudy) which impedes light penetration into the water column that is necessary for aquatic life. Sediment also fills in reservoirs, decreasing their volume and use as a drinking water source, flood control structure, and recreational facility. In streams, sediment abrades fish gills and fins, and fills in spaces in open gravel where fish lay eggs and aquatic insects live. In addition, much of the phosphorus (as well as pesticides) entering reservoirs is attached to silt particles, therefore sediment contributes to nutrient and other related impairments described above. Sediment from parts of the watershed can also contain heavy metals and contribute to the metals impairment described below (Juracek 2006).

Sediment is impacting many lakes and streams in the Grand Lake Watershed. Sediment is particularly a concern in John Redmond Reservoir and Council Grove Lake where it is reducing the water storage capacity of the lakes. In the first 30 years of their existence, John Redmond Reservoir and Council Grove Reservoir lost over 30% and 22% respectively of their storage capacity to sediment infill (Kansas Department of Health and Environment, John Redmond 2003 and Council Grove 2002 Siltation TMDLs). These rates were faster than the design estimate, indicating that the lifetime of the reservoirs are impacted by high sediment inflow from upstream land use practices. Sediment is also considered a threat to Grand Lake as they bring in heavy metals and decrease water clarity (Oklahoma Office of the Secretary of the Environment 2004, 2005).

Bacteria: Bacteria impairments are potentially hazardous for contact recreation in the impaired waters. High levels of fecal coliform bacteria indicate high levels of human and/or animal fecal material in the waters. Many types of bacteria are harmless, but high levels of animal waste bacteria increase the likelihood of associated harmful bacteria or pathogens in the water that may lead to illness.

Bacteria impairments are found throughout the watershed, primarily in rivers and creeks.

Heavy metals: Heavy metal impairments, including lead, zinc, and cadmium, are hazardous for drinking water, recreational waters, and for wildlife. Heavy metals in high concentrations can be acutely toxic. At lower concentrations, heavy metals bioaccumulate in human and fish tissue, leading to chronic health problems in humans, especially developmental problems in young children. The bioaccumulation problem is especially apparent when the non-fillet portions of fish are consumed because the metals that concentrate in the fatty portions of the fish will then build up in the fatty tissue of the humans or other fish that eat them.

Although not as uniformly spread throughout the watershed, heavy metals impairments are a major concern where they are found. Heavy metals are of particular concern in the Tri-State border region of Kansas, Oklahoma, and Missouri where past heavy metal mining operations has left a myriad of clean-up problems.

Sources and Causes of Pollution

Pollution sources are the origin for pollutants of concern. They come in two main categories: point and nonpoint sources. Point sources of pollution include discharges that are emitted from factories, plants, municipalities (such as stormdrains), or large scale animal operations where pollutants may be concentrated into a small area and discharged to local water bodies through pipes or channels (distinct "points"). Nonpoint sources (NPS) of pollution are those that wash off landscape areas and enter all along a water body rather than from distinct points.

Point source (PS) pollution was generally considered the greatest source of pollution to waterbodies when the US Clean Water Act was developed in the 1970's. Point sources are generally more easily managed by a permitting system, run by state governments, that determines the maximum amount of pollution allowed by each source. Regulating point sources has been effective in cleaning up our nations waters to the extent that many impairments are now predominantly caused by nonpoint sources. Nonpoint sources are more difficult to manage through regulation and permitting, so a cooperative watershed management process has developed, primarily since the 1990's, to create workable solutions through collaboration and cost-share programs to make water quality and land stewardship improvements on a watershed scale.

Causes of pollution are the reasons those sources may become problematic. It is less of a problem for water quality to have a source of pollution if it is prevented or inhibited from reaching a water body. There may be a number of reasons why a particular source of pollution may be problematic and these causes may vary from site to site.

For this document, sources and causes of pollution in the Grand Lake Watershed were determined initially through consultation with stakeholder groups and through water quality reports including TMDL documents.

Throughout the Grand Lake Watershed, there are common sources and causes of pollution. Although the following sources and causes are prevalent in the watershed, the scope and priority of each source and cause varies according to local conditions, concentrations, and stakeholder concerns, many of which are being or will be handled in greater detail through watershed planning on a more local basis. General prioritizations will also be addressed on the subwatershed level in the next section of this document.

Pasture – livestock and domestic animal operations: Pasture land is the most prevalent land use in the Grand Lake watershed (36% of the total watershed area, with another 21% in grassland, some of which is used for grazing). Livestock, grazing in pastures (Figure 5), contribute manure containing fecal bacteria and nutrients onto land surfaces, making it possible for both pollutants to enter surface water when it rains. In addition, livestock often have direct access to waterbodies and may provide a concentrated source of fecal loading directly into streams. This access to streams also contributes sediment loading to streams as the animals trample riparian vegetation and deteriorate bank stability, making these areas susceptible to erosion. Livestock were found to be the primary sources of fecal bacteria in a study conducted in Delaware County (USGS 2005) and in studies in the Upper Shoal Creek Watershed in Missouri (Food and Agricultural Policy Research Institute, 2004).

In addition to cattle production, there are significant areas of other livestock and domestic animals in the watershed including poultry, horses, alpaca, pigs, and dog operations. These operations, although less common than cattle operations, have similar pollution causes. In some cases the fecal contributions from these animals are too great to keep onsite: dog operations, though unregulated, often apply excrement to nearby fields in order to keep their operations sanitary (MoDNR, 2003, Shoal Creek TMDL).

Figure 5: Litter from poultry houses (shown in background) is typically spread on nearby pastures to increase forage production.

Application of poultry litter or other fertilizer to pastures allows increased forage production and, thereby, allows greater numbers of livestock to be produced per acre. Poultry litter contains much more phosphorus than nitrogen in its nutrient balance. Plants, however, need nitrogen in greater proportions than phosphorus. Nitrogen is also more mobile in soils and is therefore more necessary to be added to the soil to maximize forage production. As a result, the use of poultry litter and other similar fertilizers commonly lead to build up of phosphorus in soils as more and more is applied to increase nitrogen levels. If the soil erodes during rain events, this can be a significant source of nutrient loading to local waterbodies, especially phosphorus. This is especially the case when the land is freshly fertilized in the Spring just as typically high rainfall events occur with relative frequency in the watershed.

Agricultural fields: Cultivated crops make up close to 20% of the land use in the watershed. The practice is more prevalent in the middle portion of the watershed and is almost absent in the extreme southeast and in the Flint Hills region of Kansas where soils are poor. Typical impairments related to these areas are sediment (from erosion) and low dissolved oxygen (related to nutrients attached to eroded sediments). Soil exposed when a field is plowed or harvested is susceptible to erosion. Local streams are more susceptible when streamside vegetation is removed so that nothing stands between a barren landscape and the water. Overfertilization of the soils can result in excessive nutrients entering waterbodies.

Modeling of an adjacent watershed, the Verdigris River Watershed in Kansas and Oklahoma, showed that rowcrops, although a relatively small percentage of the land use, were the most significant source of sediment and nutrients to the watershed: taking up less than 11% of the overall land use, rowcrops contributed 86% of the sediment, 55% of total nitrogen, and 69% of total phosphorus loading to local waters (USACE, 2006).

Pesticides are also commonly used on agricultural fields. Pesticides can drift directly into waterbodies by wind during application. Pesticides also attach to soil particles and are washed into water bodies through soil erosion.

Ore-bearing bedrock and mine tailings: Ore-bearing bedrock, especially prevalent in the Spring River Watershed, drew extensive mining operations to parts of the watershed from the mid-1800's to the mid-1900's. These rocks contain moderately high concentrations of lead (Pb), zinc (Zn), cadmium (Cd), and other heavy metals that can be highly toxic, produce a number of health impairments, and tend to bioaccumulate in animal flesh with continued exposure. As a result of these mining operations, large amounts of mine tailings (or waste rock, locally referred to as "chat") were extracted from the ground and piled on the surface (Figure 6). Water flowing through ore-bearing rock at the surface, tailings, and abandoned mines below the surface leach heavy metals from the rocks and into local water bodies (Figure 6). In addition, rocks and tailings exposed at the surface wash into local streams by overland erosion and become transported downstream in the form of metal-bearing stream deposits. A US Geological Survey study around Empire Lake, a small reservoir in Cherokee County Kansas, showed that mining sediments transported in streams are accumulating in the lake and are present in nearby river floodplains. These sediments contain heavy metal concentrations that far exceed the background soil conditions in the area (Juracek, 2006).

Problems with heavy metals are severe enough to have resulted in the listing of several Superfund sites in the Tri-State Mining District within Grand Lake Watershed, including Superfund sites located in Jasper and Newton Counties in SW Missouri, the Cherokee County Superfund Site in SE Kansas, and the Tar Creek Superfund Site in NE Oklahoma (See Appendix

A). Established by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, U.S. Code Title 42, Chapter 103), Superfund establishes a US Environmental Protection Agency National Priority List for hazardous waste sites and comprises a legal and financial system of handling these sites in the United States.

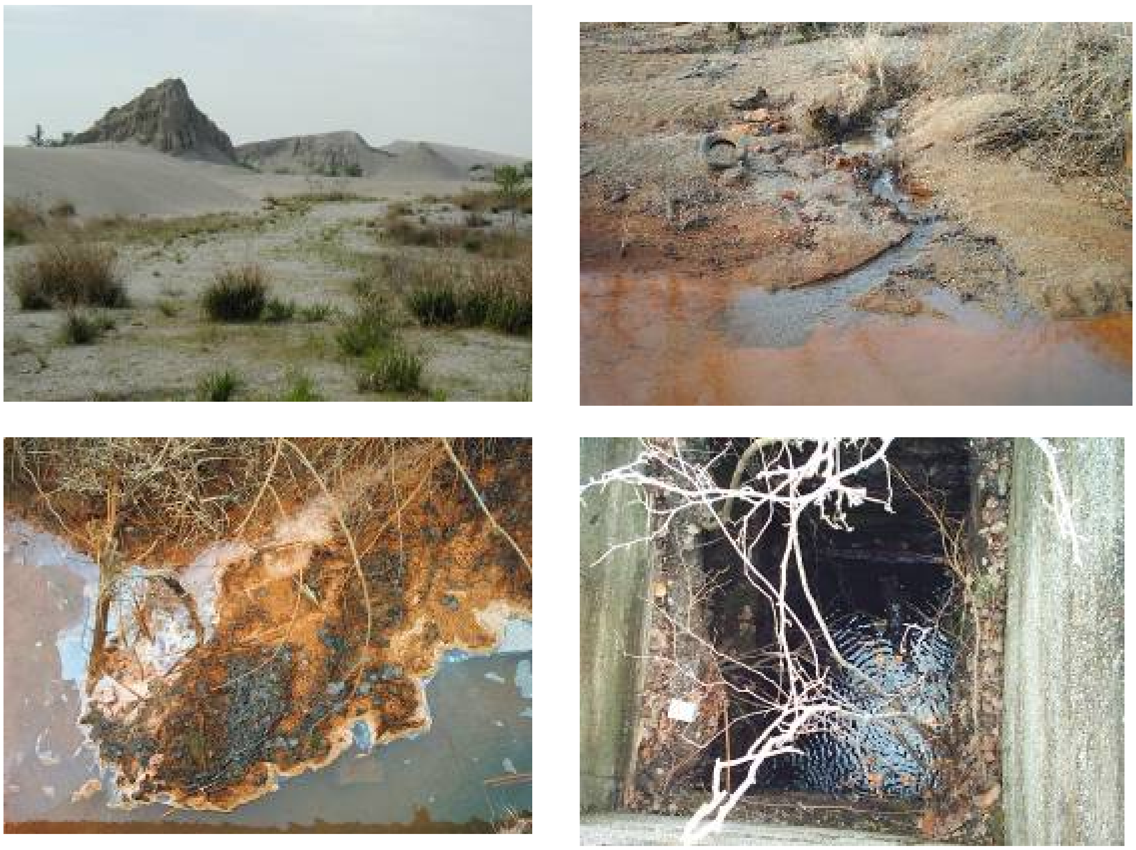

Figure 6: The historical mining industry in the Tri-State Mining District of the Grand Lake Watershed left a host of environmental problems including large piles of metal-bearing mining tailings, and metals contamination in surface water, ground water, and soils. (Photos courtesy of USGS, 2003)

Septic systems: Failing septic systems can contribute to pathogen and nutrient problems in both groundwater and surface waters if leakage or illicit discharge occurs. Improper function of septic systems can especially occur if the systems are poorly maintained or poorly sited or sized in particular soils. Any loading of bacteria into the groundwater can enter surface water through seeps or springs, especially in the southeastern portion of the watershed where common caves and karst bedrock enable rapid movement of subsurface flow.

Urban areas: Urban and suburban areas make up 6% of the watershed (more concentrated in the southern portion of the watershed). High nutrient concentrations stem from overfertilization of residential, commercial, or recreational lawns. Fertilizers are often used more freely on smaller urban lawns than on farms because the cost of fertilizing a small plot is much less than covering large areas, and the sum of many small lawns can have a significant cumulative effect on water quality. Sediment erosion is prevalent where protective vegetation is stripped on construction sites. Concentrated runoff from impervious surfaces contributes to soil erosion. High volumes of runoff from these impervious surfaces also contributes to streambank erosion as the streams fill more quickly and more frequently with rushing water. Runoff from roadway and parking lots also introduce other pollutants such as salt, oil and other fluids that leak from cars, trash, and grease from restaurants (Figure 7). Pesticides and herbicides used on residential, commercial, and recreational lawns and gardens can also wash into streams through soil erosion or wind drift during application (Figure 7). Although these areas take up less space than some other uses, urban pollutants can be particularly concentrated. In addition, future growth is expected that will present future challenges for water quality from these sources.

Figure 7: Lawns and impervious surfaces of urban and suburban areas contribute a range of pollutants to local water bodies.

Streambanks: Much of the landscape throughout the watershed has been altered from pre-settlement days. Converting grasslands and forest to cropland, pasture, or urban/suburban areas all contribute to increased runoff over the land surface during storms and cause flow in streams to increase faster than in pre-settlement times, contributing to accelerated streambank erosion. Straightening of streams from their often meandering pattern may decrease the likelihood of flooding in the adjacent property as floodwaters pass more quickly by, but the increased velocity of the water can increase streambank erosion. In addition, vegetation along the streams has been removed in many places to increase animal access to streams or to allow larger areas for growing crops. The removal of this native vegetation from streambanks weakens the banks and makes them more susceptible to erosion from high flows in the streams (Figure 8). The banks of the Neosho River in Kansas have had significant streambank erosion issues (USGS 1999, KDHE 1995).

Wildlife: Wild animals which have direct access to streams include deer, feral hogs, raccoons, other small mammals, and avian species. These animals contribute fecal bacteria and nutrients to waterbodies in the watershed, but at much smaller rates than livestock, domestic animals, and humans, according to a DNA tracking study in Missouri (Food and Agricultural Policy Research Institute, 2004).

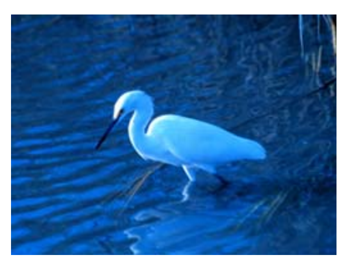

Figure 8: A break in woody vegetation along Honey Creek, OK, has resulted in severe streambank erosion.

Permitted sites: Point sources of pollution include discharges from pipes (points), rather than generally from landscape areas. These sources are typically permitted by state agencies, which means that pollution levels are monitored and mandated not to exceed certain levels. The permitted sites of particular concern in the Grand Lake Watershed are Waste Water Treatment Plants (WWTP) and Confined Animal Feeding Operations (CAFO). WWTPs collect waste water from communities, partially treat the water, and discharge the water into local water bodies. Some CAFOs, have nondischarging permits that require waste management systems to prevent waste from leaving the site uncontrolled in most weather conditions. In Kansas, CAFOs are required to manage all waste runoff in storms up to the 25 year, 24 hour rain fall event (Kansas Department of Health and the Environment 2002, French Creek TMDL). Other permitted point sources include car wash facilities, dry cleaning facilities, warehouses, food processing plants, mining operations, hotels, and other similar operations. Although each type of these sites are regulated for a number of pollutants, many are not limited at all for nutrients such as phosphorus or nitrogen. Although point sources are not the primary concern of this watershed management plan, the importance of handling these sources for the overall health of the watershed cannot be ignored.

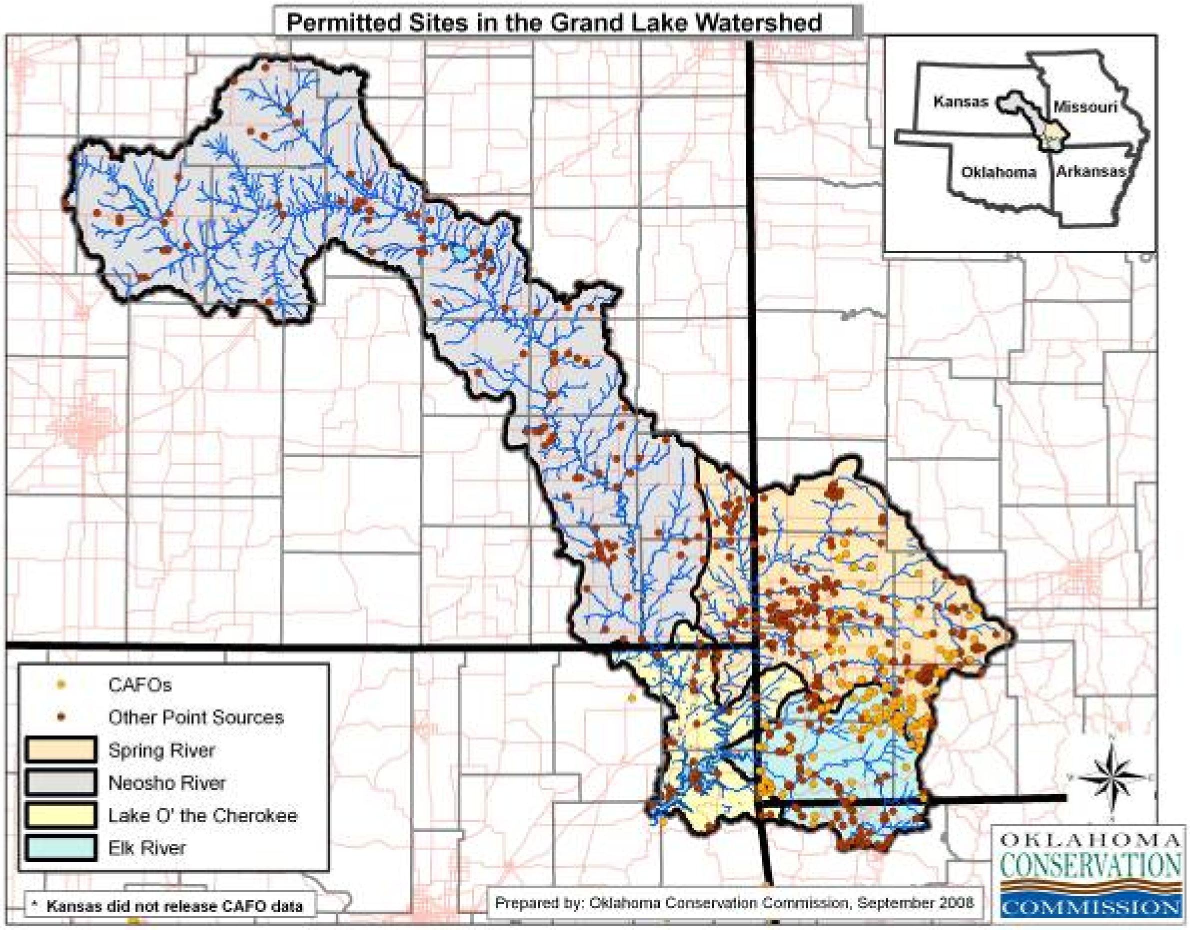

Figure 9: Map of permitted sites in Grand Lake Watershed.

Additional Reports and Studies Documenting Problems

There have been numerous scientific studies and government reports related to the water quality of the Grand Lake Watershed (too numerous to cover in this watershed plan). Some more general studies are worth highlighting that identify water quality issues on a broad scale.

In 1996, the Oklahoma Conservation Commission and Oklahoma State University conducted a crude modeling of phosphorus loads in the watershed by subwatershed as a precursor to watershed planning. The effort suggested that the greatest impact of phosphorus reaching Grand Lake was from the Spring River Watershed, and recommended the formation of an advisory group to develop or guide the development of a watershed plan (Dutnell et al 1996).

The 2004 Kansas Department of Health and the Environment (KDHE) "Surface Water Nutrient Reduction Plan" responds to the US Environmental Protection Agency's (EPA) call for states to handle nutrient-related pollution. Rather than quickly adopting nutrient criteria for surface water, the plan calls for a 30% reduction in nutrients through point and nonpoint sources to meet the goal. The target is the same adopted by Minnesota and Wisconsin, other states in the

Mississippi River Basin, based on estimates by the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force of necessary reductions to potentially eliminate dead zones in the Gulf of Mexico resulting from excessive nutrient delivery to the Gulf. This document indicates that counties in eastern Kansas, including some portions of the Grand Lake Watershed, should be targeted because they contribute the largest nutrient loads in the State.

In 2007, the US Geological Survey published a study of Elk River Watershed in cooperation with the Missouri Department of Natural Resources. The study concluded that local streams had significant increases in nutrients (especially phosphorus) compared to data collected prior to 1985 (Smith et al 2007).

The Oklahoma Office of the Secretary of the Environment (2004, 2005) released the *Comprehensive Study of the Grand Lake Watershed* initial and final reports that document nutrients as the top water quality concern in the watershed impacting Grand Lake. Secondary concerns for Grand Lake were sediments bearing heavy metals and decreasing water clarity.

Other studies further document the heavy metal problems in the watershed. The Oklahoma Department of Environmental Quality released a 2003 and a follow-up 2007 report “Fish Tissue Metals Analysis in the Tri-State Mining Area” that indicates that fish in that area have elevated heavy metals in their flesh that correspond to elevated level of heavy metals in stream sediment (ODEQ 2003, 2007). A US Geological Survey study around Empire Lake, a small reservoir in Cherokee County Kansas, showed that mining sediments transported in streams are accumulating in the lake and are present in nearby river floodplains. These sediments contain heavy metal concentration that far exceed the background soil conditions in the area (Juracek, 2006).

PRIORITY IMPAIRMENTS, SOURCES, CAUSES, LOAD REDUCTIONS AND MANAGEMENT MEASURES FOR SUBWATERSHEDS

Watershed characteristics including land use, soils, and populations vary in significant ways in different portions of the Grand Lake Watershed. Despite common sources and causes of pollution, the relative importance or impact of these factors vary for the separate subwatersheds. To better represent the different priorities throughout the watershed, the Grand Lake Watershed Alliance Foundations (GLWAF) decided that priorities for sources, causes, and load reductions required to meet water quality standards were best presented within the framework of the 4 major subwatersheds: Neosho River, Spring River, Elk River, and Lake O’ the Cherokees Watersheds.

Priority impairments, sources, causes and load reductions were largely determined on the basis of TMDL documents produced in the watershed to handle impaired waters, and other local water quality reports, documents, and studies. The TMDL documents include scientific data and public input to determine the amount of impairment, the sources and causes of those impairments, the necessary load reductions to meet water quality standards, and a relative prioritization of addressing each impairment (See Appendix B for a summary of all TMDLs in the Grand Lake Watershed). These documents include the necessary load reductions to meet water quality standards, prioritizations, and recommended strategies to meet them, so they are well suited to meet part of the EPA's 9 elements for watershed plans (listed above). This information was assembled and prioritized by the GLWAF watershed plan committee and the GLWAF board, represented by stakeholders from all 4 states, and with input from local watershed groups and from state and federal agencies with jurisdiction in the 4 states of the watershed.

Note: all completed TMDLs are listed in the references at the end of this document. The list of TMDLs is extensive (over 60 documents) and an attempt to reference each one in the text of this document would be burdensome for the reader. To reference the TMDL from which the information reported in the following sections is derived, look up the reference based on the state, waterbody name, and impairment. In addition, Appendix B is a comprehensive summary of all completed and approved TMDLs in the Grand Lake Watershed including a listing of sources, causes, necessary load reductions (where available), and recommended solutions for meeting standards.

Neosho River Watershed

The Neosho River Watershed (Figure 10) terminates in extreme southeastern Kansas, draining an area that extends northwestward in an elongate pattern encompassing 5,830 square miles, by far the largest subdivision of the Grand Lake Watershed for the purpose of this document. Significant tributaries include Cottonwood and Lightning Rivers. This subwatershed contains a number of significant reservoirs including Marion Lake, Council Grove Lake, and John Redmond Reservoir. Land use in the Neosho River Watershed (Figure 10) is 36% natural grasslands (which may be grazed), 26% planted pasture, 24% cropland, 5% forest, and 5% developed (mostly low intensity or open space), close to 2% wetlands and over 1% open water.

Priority Impairments: Priority impairments are based on the number of impaired water bodies (see tables below), the relative priority given those segments in TMDL documents, and stakeholder impressions and experience with these issues in the watershed.

The highest priority impairments for the Neosho River Watershed are:

1) Nutrients (evidenced by Low dissolved oxygen (DO) / Eutrophication)
2) Sediment (Silt)
3) Bacteria

This above list is consistent with the Neosho River Basin High Priority TMDLs in a document approved by the Neosho Basin Advisory Committee in Kansas in June 2008. That document on "Watershed Restoration and Protection" indicates that the top TMDL concerns in the watershed are DO/eutrophication, silt, and bacteria. The above list was presented to the Neosho Basin Advisory Committee at their June 2008 meeting in Burlington, KS without objection. Representatives of all of the subwatershed groups currently existing or under development in the Kansas portion of the Grand Lake Watershed were also present at that June 2008 meeting.

Bacteria was considered a lower priority than nutrients and sediment because most of the high priority bacteria impairments have been controlled by a permitting process. Sediment only impairs 4 water bodies, but they are all lakes, indicating upstream sources of those problems.

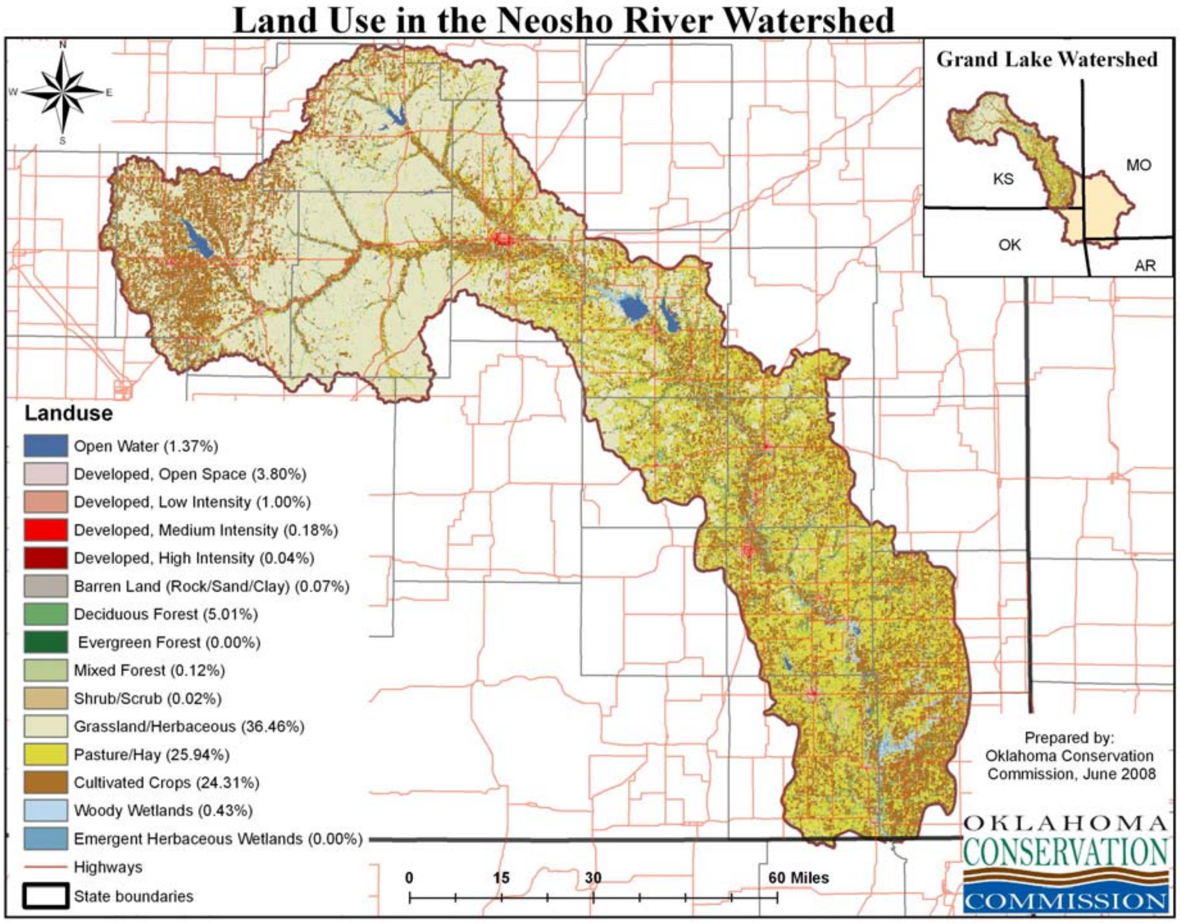

Figure 10: Map of land use in the Neosho River Subwatershed of the Grand Lake Watershed.

Other impairments (details in Appendix B) in the Neosho River Watershed considered <u>lower</u> priority include (all low priority unless otherwise indicated):

1) Biology (poor diversity in streams) – 2 segments medium priority
2) Copper – agricultural uses – 8 segments
3) Mercury – battery recycling, etc – 1 segment
4) DO from cattails – 1 minor wetland area
5) Chlordane (banned pesticide) – 1 segment
6) pH (few violations) – 2 segments (dealt with if nutrient issue is dealt with)
7) Sulfate – Mined Land Lakes (9) and wetland (1)
8) Sulfate (natural from bedrock) – 1 stream segment
9) Methane – 4 segments (high priority, but addressed with permits)
10) Urban Eutrophication II (Phosphorus and Nitrogen) – 1 pond

Water bodies listed as impaired in the Neosho River Watershed without TMDLs developed:

1) Zinc – 53 segments
2) Atrazine (a pesticide) – 7 segments

Priority Sources and Causes: Sources for the high priority impairments of the Neosho River Watershed were identified in TMDL documents and confirmed by stakeholder input as agricultural fields, streambanks, pastures, permitted sites, and septic systems. Causes of impairments are erosion (soil from cropland, pastures, and streambanks), lack of riparian buffers on cropland and pastures, exposed soil on cropland and pastures, animal stream access, overgrazing, and failing septic systems. Problems with permitted sites were to be addressed under a permit review process.

Load reductions: Desired load reductions are as determined in TMDL documents as those needed to meet state water quality criteria. Load reductions were calculated and presented for most impaired stream segments for low DO / Eutrophication and Silt, but none were calculated for fecal coliform bacteria, as shown in the tables below.

Nutrients (Low DO / Eutrophication) - Neosho

WATERBODY	P LOAD REDUCTION	N LOAD REDUCTION	POINT SOURCES?	PRIORITY
Allen/Dows Creek	x	x	x	High
Altamont City Lake	92.4%	0%	None	Low
Bachelor Creek	x	x	x	Medium
Bartlett City Lake	50%	0%	None	Low
Canville Creek	x	x	x	High
Chanute/SF City Lake	89.3%	50%	None	Medium
Cherry Creek	x	x	x	High
Council Grove Lake	94%	58%	WWTP not problem	High
Doyle Creek	x	x	Addressed w/ permit	High
Eagle Creek	x	x	x	High
French Creek	x	x	x	Medium
Gridley City Lake	54.4%	0%	None	Medium
John Redmond Lake	21.2%	60%	WWTP P-22.8% red	Medium
Labette Creek	x	x	x	High
Marion County Lake	21.4%	0%	None	Medium
Marion Lake	75%	x	3 WWTP	High
Neosho County SFL	97.8%	64%	None	Medium
Neosho WMA	77.8%	78%	None	Medium
Olpe City Lake	48%	32%	None	High
Parsons Lake	81%	0%	WWTP not problem	Medium
Turkey Creek	x	x	x	High

x – no information P – phosphorus N - nitrogen

Sediment (Silt / Silt and Lead) - Neosho

WATERBODY	SILT LOAD REDUCTION	LEAD LOAD REDUCTION	POINT SOURCES?	PRIORITY
Bartlett City Lake	61%	None – tied to silt	None	Medium
Council Grove Lake	48%	n/a	WWTP 0% red.	High
John Redmond Lake	Need detailed analysis	n/a	x	Medium
Olpe City Lake	54%	n/a	None	High

x – no information

Fecal Coliform Bacteria - Neosho

WATERBODY	LOAD REDUCTION	ADDRESSED WITH PERMIT?	PRIORITY
Allen/Dows Creek	x	x	Medium
Big Creek	x	x	Medium
Cottonwood River	x	Yes	High
Cottonwood River, South	x	x	Medium
Deer Creek	x	x	Medium
Doyle Creek	x	Yes	High
Labette Creek	x	Yes	High
Little Turkey	x	Yes	High
Mud River	x	x	Medium
Neosho River	x	x	High
Owl Creek	x	x	Medium
Turkey Creek	x	x	Medium

x – no information

Critical Areas: Critical areas for implementation are defined for this document as areas contributing to the impaired segments above. Further refinement of critical area delineation is best done through a targeting effort as 1) proposed watershed-wide later in this document and 2) as is being conducted, or likely to be initiated, on a local level by some Watershed Restoration Protection Strategy (WRAPS) groups, which are local citizen-based watershed planning groups in Kansas.

Management measures: Although the specifics are best handled on a local basis with local stakeholder involvement, TMDL documents recommended a number of solutions, also generally agreed upon by stakeholders, to improve water quality in the impaired segments:

1. Implement soil sampling to recommend appropriate fertilizer applications on cropland: use application rates of chemical fertilizers according to labels.
2. Maintain conservation tillage and contour farming to minimize cropland erosion.
3. Install grass buffer strips along streams.
4. Reduce activities within riparian areas.
5. Restore riparian vegetation along target stream segments.
6. Implement nutrient management plans to manage manure application to land.
7. Renew state and federal permits and inspect permitted facilities for permit compliance.
8. Install pasture management practices, including proper stock density on grasslands.
9. Install proper manure and livestock waste storage.
10. Remove winter feeding sites in proximity to streams.
11. Proper on-site waste system operations in proximity to targeted streams.

Spring River Watershed

The Spring River Watershed (Figure 11) is located in extreme southeastern Kansas, extreme northeastern Oklahoma and a larger area in southwestern Missouri that encompasses 2,577 square miles. Significant tributaries include Upper and Lower Shoal Creek, Turkey Creek, and

Center Creek. Land use in the Spring River Watershed (Figure 11) is 50% planted pasture, 1% natural grassland (which may be grazed), 20% cropland, 18% forest, 8% developed (mostly low intensity or open space), 2% wetlands, and less than 1% open water.

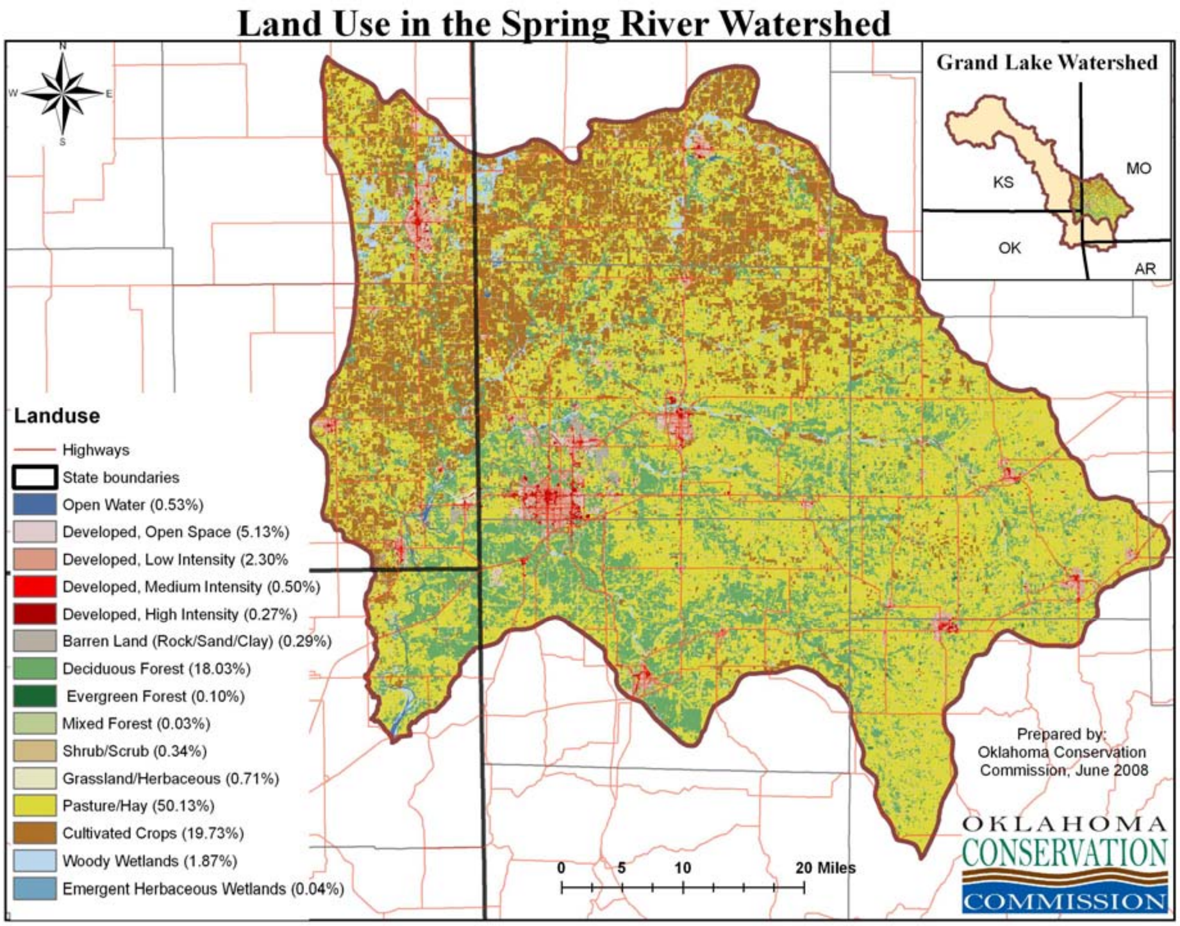

Figure 11: Map of land use in the Spring River Subwatershed of the Grand Lake Watershed.

Priority Impairments: Priority impairments are based on the number of impaired water bodies (see tables below), the relative priority given those segments in TMDL documents, and stakeholder impressions and experience with these issues in the watershed.

The highest priority impairments for the Spring River Watershed are:

1) Heavy metals – many segments throughout Spring River Watershed
2) Nutrients (evidenced by Low DO in Kansas)
3) Bacteria – 13.5 miles along Shoal Creek

This above list is consistent with the Neosho River Basin High Priority TMDLs in a document approved by the Neosho Basin Advisory Committee in Kansas in June 2008. That document on “Watershed Restoration and Protection” indicates that the top TMDL concern in the Spring River watershed is heavy metals. Other concerns were not highlighted in this document as a high priority in Kansas. This list was presented to the Neosho Basin Advisory Committee at the June 2008 meeting without objection.

Other impairments in the Spring River Watershed considered lower priority include (all low priority unless otherwise indicated):

1) Eutrophication/pH (nutrients) – urban lawn overfertilization – 2 lakes
2) Fecal Coliform Bacteria, KS - High priority (addressed with permit) – 1 segment
3) Chlordane (banned pesticide) – 1 segment
4) Sulfate – related to strip mining areas – 1 segment
5) Ammonia, BOD, Suspended Solids, MO – High priority (addressed with permit) – 1 segment
6) Sediment (Missouri) – Cropland erosion – 1 segment (Low priority)

Water bodies listed as impaired in the Spring River Watershed without TMDLs developed:

1) turbidity – 1 segment
2) zinc – 1 segment
3) cadmium – 1 segment

Priority Sources and Causes: Sources for the high priority impairments of the Spring River Watershed were identified in TMDL documents and confirmed by stakeholder input as mining tailings (on land and in streambeds), agricultural fields, streambanks, pastures, permitted sites, and septic systems. Causes of impairments are erosion (soil, animal waste, and streambanks), acid mine seepage, animal stream access, and failing septic systems. Problems with permitted sites were to be addressed under a permit review process.

Load reductions: Desired load reductions are as determined in TMDL documents as those needed to meet state water quality criteria. Load reductions were calculated and presented for most impaired stream segments for metals, low DO / eutrophication, and bacteria, as shown in the tables below.

Heavy Metals - Spring

WATERBODY	LOAD REDUCTION	PRIORITY
Spring River, various branches	Up to 99.3%	High
Turkey Creek	50%	Medium
Center Creek	~10%	Medium

Nutrients (evidenced by Low DO in Kansas) - Spring

WATERBODY	P LOAD REDUCTION	N LOAD REDUCTION	POINT SOURCES?	PRIORITY
Shawnee Creek	x	x	Addressed w/ permit	High
Lamar Lake	65%	x	None	Medium

x – no information P – phosphorus N - nitrogen

Fecal Coliform Bacteria - Spring

WATERBODY	LOAD REDUCTION	ADDRESSED WITH PERMIT?	PRIORITY
Cow Creek	x	Yes	High
Shoal Creek	85% High Flows 53% Moderate Flows 72% Low Flows	x	Medium

x – no information

Critical Areas: Critical areas for implementation are defined for this document as areas contributing to the impaired segments above. Further refinement of critical area delineation is best done through a targeting effort as 1) proposed watershed-wide later in this document and 2) local stakeholder input as is being conducted, or likely to be initiated, on a local level by some watershed groups in this watershed.

Management measures: Although the specifics are best handled on a local basis with local stakeholder involvement, TMDL documents recommended a number of solutions, also generally agreed upon by stakeholders, to improve water quality in the impaired segments:

Management measures in Kansas:

1. Reduce metal loads from tributaries that contribute to the impaired condition seen on the Spring River at Baxter Springs
2. Remove contaminated sediments from the channel bed at selected locations.
3. Install filter strips along edge of agricultural fields.
4. Reduce activities within riparian areas.
5. Restore riparian vegetation along target stream segments.
6. Use application rates of chemical fertilizers according to labels.
7. Renew state and federal permits and inspect permitted facilities for permit compliance.
8. Install proper manure and livestock waste storage.
9. Proper on-site waste system operations in proximity to targeted streams.

Management measures in Missouri:

1. Reevaluate point source permits and require Zn monitoring
2. Continue abandoned mine cleanup including replacing residential soils, installing pipe for delivery of water, closing mine shafts, burying mine waste below highways, etc.
3. Poultry litter application education.
4. Feasibility study of transporting litter out of the watershed.
5. Pump septic systems every 3 yrs, replace some along with public education
6. Possible local ordinances to handle septic system problems.
7. Fence riparian areas, alternative watering sites, rotational grazing, add shade away from streams for cattle, varied diets to lower fescue toxicity.

8) Filter Strips on fields w/ litter application 30 ft for 50% reduction, 40 ft for 66% reduction of bacteria.
9) Shoal Creek Bacterial Goal: remove 50-100% cattle from streams, stop all septic leaks, reduce runoff 66%

Superfund Activities:
A number of remedial actions related to heavy metals are ongoing or have already taken place in the multiple Superfund sites in the Spring River portion of the Grand Lake Watershed including plugging of abandoned wells and mine shafts, surface water diversions, soil remediation, and even public relocation in the Tar Creek Superfund Site (See Appendix A). Any work regarding the Superfund Sites of the Tri-State Mining District must be coordinated with all federal and state regulatory agencies with legal jurisdiction over this area.

Elk River Watershed

The Elk River Watershed (Figure 12) is located in the southwestern corner of Missouri, northwestern corner of Arkansas, and northeastern corner of Oklahoma and encompasses 1,037 square miles. The Elk River is formed where two creeks, Big Sugar Creek and Little Sugar Creek, come together in Pineville, MO. Other tributaries include Indian Creek, Buffalo Creek, and Patterson Creek. Land use in the watershed (Figure 12) is 47% forest, 42% planted pasture, 2% natural grassland (which may be grazed), 7% developed (mostly low intensity or open space), nearly 2% wetlands and under 1% open water and cropland.

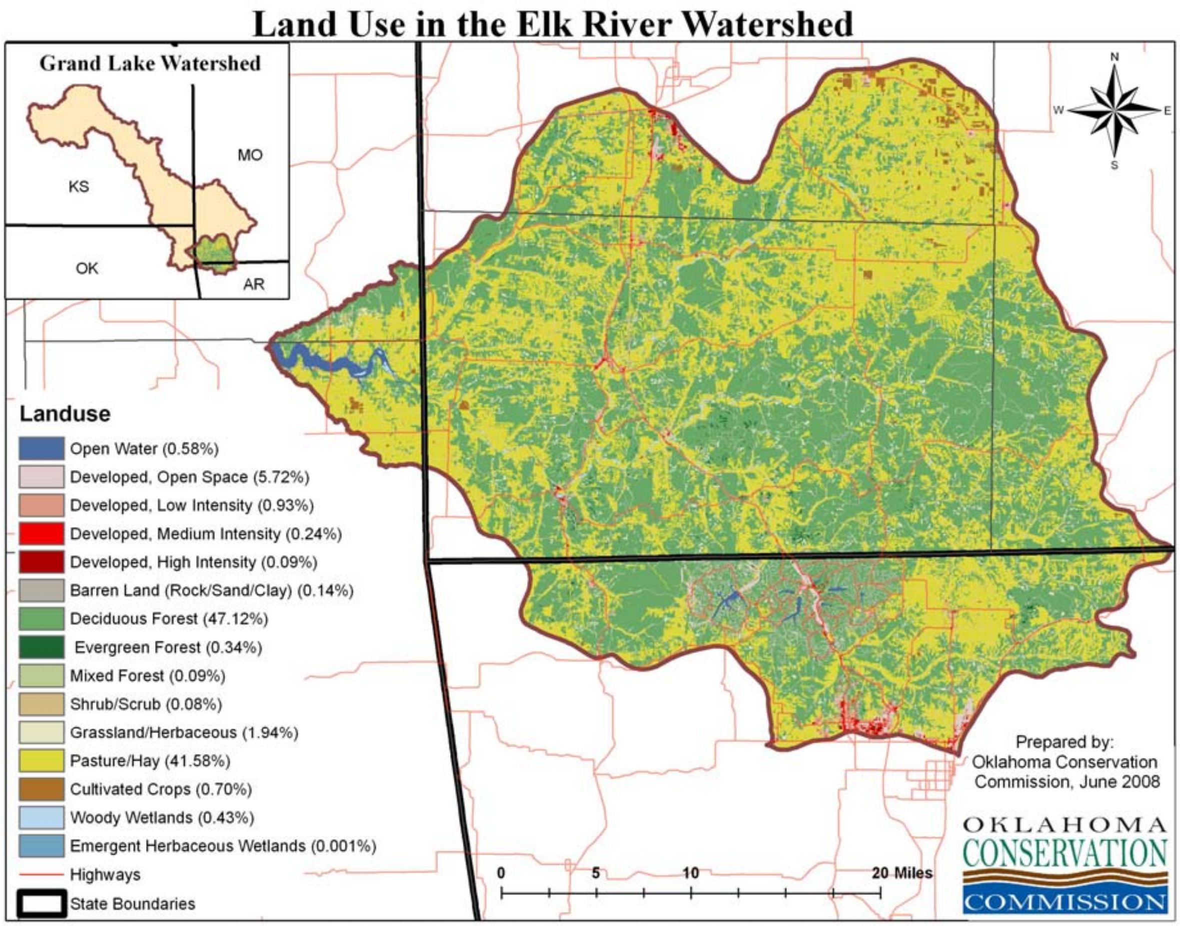

Figure 12: Map of land use in the Elk River Subwatershed of the Grand Lake Watershed.

Priority Impairments: Priority impairments are based on the number of impaired water bodies (see tables below), the relative priority given those segments in TMDL documents, and stakeholder impressions and experience with these issues in the watershed.

The highest priority impairments for the Elk River Watershed are:

1) Nutrients – based on TMDL in Missouri
2) Bacteria – based on one impairment in OK and local concerns in Missouri
3) Sediment – based on local concerns in Missouri

Priority Sources and Causes: Sources for the high priority impairments of the Elk River Watershed were identified in TMDL documents and confirmed by stakeholder input as permitted sites, grazing animals, fertilizer and litter application, and septic systems. Causes of impairments are lack of nutrient limits on permitted sites (such as waste water treatment plants), animal stream access, pasture erosion, over-application of fertilizer/litter and failing septic systems. Problems with permitted sites were to be addressed under a permit review process.

Load reductions: Desired load reductions are as determined in TMDL documents as those needed to meet state water quality criteria. Load reductions were calculated and presented for most impaired stream segments for nutrients and bacteria, as shown below.

Nutrients – Elk River Watershed

WATERBODY	P LOAD REDUCTION	N LOAD REDUCTION	POINT SOURCES?	PRIORITY
11 stream segments in MO	64% (low flows)	42% (low flows)	60% of problem	Medium

P – phosphorus N - nitrogen

Target: 0.06 mg/L Phosphorus and 1mg/L Nitrogen concentrations (the monitored condition before eutrophication problems). Point sources: WWTP and poultry processing plants)

Bacteria – Elk River Watershed

WATERBODY	FC INS	EC INS	EC GEO	ENT INS	ENT GEO	PRIORITY
Elk River, OK				78%	52%	?

FC – Fecal coliform; EC – E. coli; ENT – Enterococci; INS – instantaneous; GEO – geometric mean

Critical Areas: Critical areas for implementation are defined for this document as areas contributing to the impaired segments above. Further refinement of critical area delineation is best done through a targeting effort as 1) proposed watershed-wide later in this document and 2) local stakeholder input as is being conducted, or likely to be initiated, on a local level by some watershed groups in this watershed.

Management measures: Although the specifics are best handled on a local basis with local stakeholder involvement, TMDL documents recommended a number of solutions, also generally agreed upon by stakeholders, to improve water quality in the impaired segments:

Management measures in Oklahoma:
NONE listed in TMDL.

Management measures in Missouri:

1. Phosphorus limits for larger, expanding, and new point source dischargers of monthly avg. 1 mg/L (1.5 mg/L daily). Nitrogen limits 25.5 mg/L monthly average.
2. Voluntary agricultural management practices (not specified).
3. Management plans to deal with NPS pollution.

Lake O' the Cherokees Watershed

The Lake O' the Cherokees Watershed (Figure 13) is located in extreme northeastern Oklahoma with small sections that protrude into Kansas, Missouri, and Arkansas, encompassing 888 square miles. The Oklahoma portions of the Each of the other major subwatersheds drain into the Lake O' the Cherokee Watershed. The Oklahoma portion of the Neosho River is included in this subwatershed. Other significant tributaries include Honey Creek, Horse Creek, Drowning Creek, and Tar Creek. Grand Lake is the terminal water body for this subwatershed and the Grand Lake Watershed as a whole.

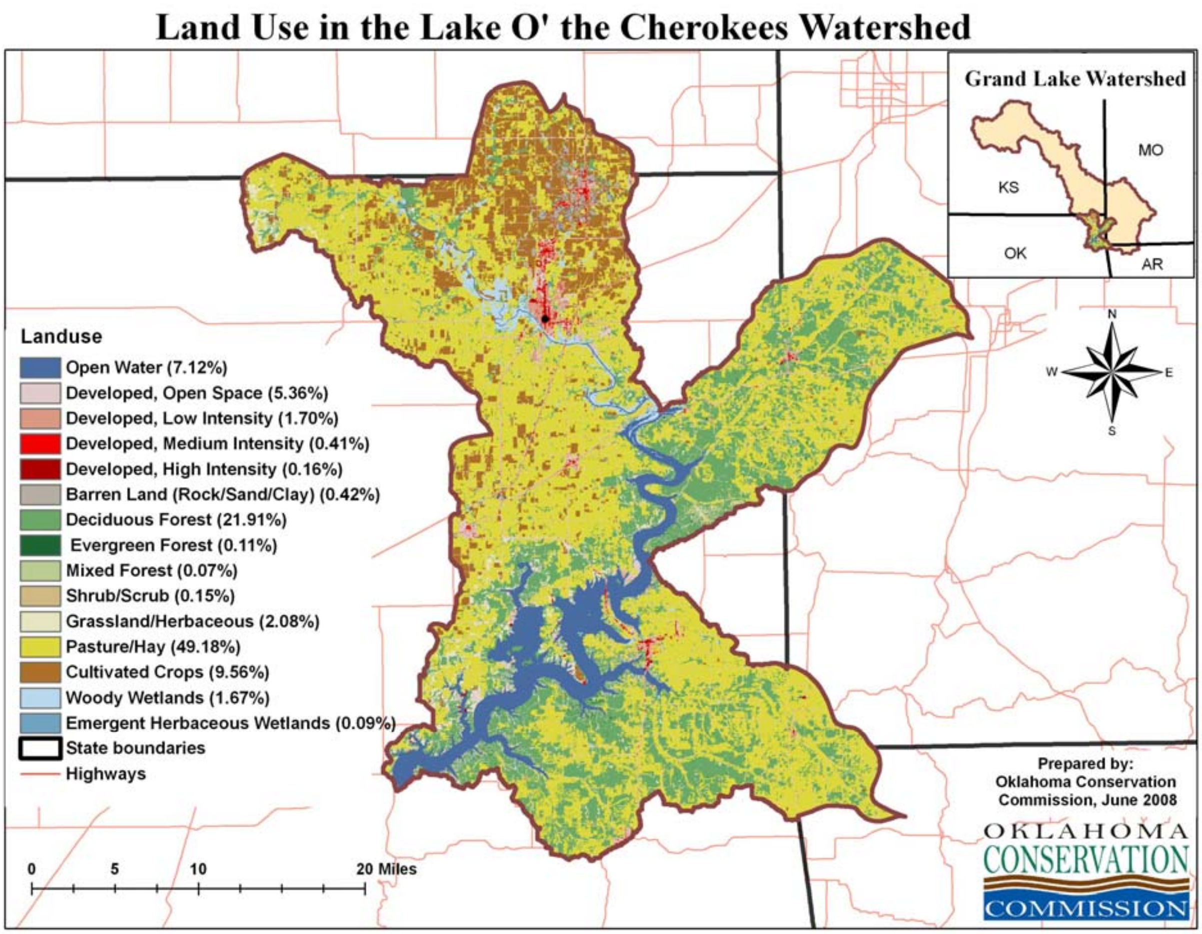

Figure 13: Map of land use in the Lake O' the Cherokees Subwatershed of the Grand Lake Watershed.

Land use in the Lake O' the Cherokees Watershed (Figure 13) is 49% planted pasture, 2% natural grassland (which may be grazed), 22% forest, 10% cropland, and 8% developed (mostly low intensity or open space), 7% open water, and nearly 2% wetlands.

Priority Impairments: Priority impairments are based on the number of impaired water bodies (see tables below), the relative priority given those segments in TMDL documents, and stakeholder impressions and experience with these issues in the watershed.

The highest priority impairments for the Lake O' the Cherokees Watershed are:

1) Nutrients (evidenced by Low DO/organic enrichment/ammonia) – based on 9 impairments in OK (no TMDLs developed).
2) Bacteria – based on 11 segments impaired in OK
3) Heavy metals (Zn, Pb, Cd) – based on 1 impairment in KS (Tar Creek) and stakeholder concerns (no TMDL developed).

Nutrients and bacteria have comparable number of impairments, but recent reports from the Oklahoma Office of the Secretary of the Environment (2004, 2005) document evidence that Grand Lake is becoming increasingly threatened by nutrient enrichment and document nutrients as the greatest threat to Grand Lake water quality. In addition, nutrient impairments in the lake itself suggest a larger impact than the comparable number of local stream segments impaired for bacteria. These considerations led to the conclusion that nutrients are a bigger overall concern for this subwatershed than bacteria, although bacteria are still considered a significant threat to water quality.

Water bodies listed as impaired in the Lake O' the Cherokees Watershed without TMDLs developed:

1) Organic enrichment/Low DO – 8 segments
2) Chlorides – 2 segments
3) Total Dissolved Solids – 1 segment
4) Sulfates – 2 segments
5) Ammonia – 1 segment
6) pH – 1 segment
7) Turbidity – 3 segments

Priority Sources and Causes: Sources for the high priority impairments of the Lake O' the Cherokees Watershed were identified in TMDL documents and confirmed by stakeholder input as livestock, land application, agricultural activities, septic systems, domestic animals, mine waste and a wastewater lagoon. Causes of impairments are animal stream access, overgrazing, erosion (fields and streambanks), failing septic systems, mine waste runoff and lagoon discharges.

Load reductions: Desired load reductions are as determined in TMDL documents as those needed to meet state water quality criteria. Load reductions were calculated and presented for most impaired segments for bacteria, as shown below.

Bacteria – Lake O' the Cherokees Watershed

WATERBODY	FC INS	EC INS	EC GEO	ENT INS	ENT GEO	PRIORITY
Drowning Creek	28%			56%	47%	?
Horse Creek	86%					?
Fly Creek	49%			84%	77%	?
Little Horse Creek	49%	59%	53%			?
Cave Springs Branch	47%	59%	53%			?
Honey Creek	28%			99%	90%	?
Sycamore Creek				3%	26%	?
Tar Creek				84%	80%	?
Cow Creek	60%					?
Fourmile Creek	55%					?
Russell Creek	49%					?

FC – Fecal coliform; EC – E. coli; ENT – Enterococci; INS – instantaneous; GEO – geometric mean

Critical Areas: Critical areas for implementation are defined for this document as areas contributing to the impaired segments above. Further refinement of critical area delineation is best done through a targeting effort as 1) proposed watershed-wide later in this document and 2) local stakeholder input as is being conducted, or likely to be initiated, on a local level by some watershed groups in this watershed.

A limited targeting effort was carried out as part of the Grand Lake Watershed Implementation Project (Oklahoma portion only) headed by Oklahoma Conservation Commission (OCC). The targeting for phosphorus indicated which subwatersheds of the Lake O' the Cherokees Watershed and vicinity that contribute the greatest percentage of phosphorus (Figure 14). These areas can be targeted for future implementation projects to reduce nutrients in this area around Grand Lake. (Oklahoma Conservation Commission 2008)

The targeting effort proposed as a part of this watershed plan will be specific to the field rather than general areas as shown in Figure 14.

Management measures: Although the specifics are best handled on a local basis with local stakeholder involvement, TMDL documents recommended a number of solutions, also generally agreed upon by stakeholders, to improve water quality in the impaired segments:

Management measures in Oklahoma:
Although there are no recommendations in the published TMDL for bacteria, a suite of agricultural practices are recommended for phosphorus and sediment in Oklahoma Conservation Commission (2008) document "Grand Lake Watershed Implementation Recommended Suite of Practices":

1. Riparian Area Establishment and Management
2. Buffer Strip Establishment and Streambank Protection
3. Animal Waste Practices and Structures
4. Pasture Establishment and Management
5. Proper Waste Utilization (Poultry Waste Producers)
6. Heavy Use Areas
7. Rural Waste Septic Systems (Human Waste)

Management measures in Kansas:

1. Where needed, create/restore riparian vegetation along target stream segments.
2. Install grass buffer strips where needed along streams.
3. Explore and enhance opportunities for mined land area reclamation projects.
4. Load allocations for permitted wastewater lagoon.

Superfund Activities:

A number of remedial actions related to heavy metals are ongoing or have already taken place in the multiple Superfund sites in the Lake O' the Cherokees portion of the Grand Lake Watershed including plugging of abandoned wells and mine shafts, surface water diversions, soil remediation, and even public relocation in the Tar Creek Superfund Site (See Appendix A). Any work regarding the Superfund Sites of the Tri-State Mining District must be coordinated with all federal and state regulatory agencies with legal jurisdiction over this area.

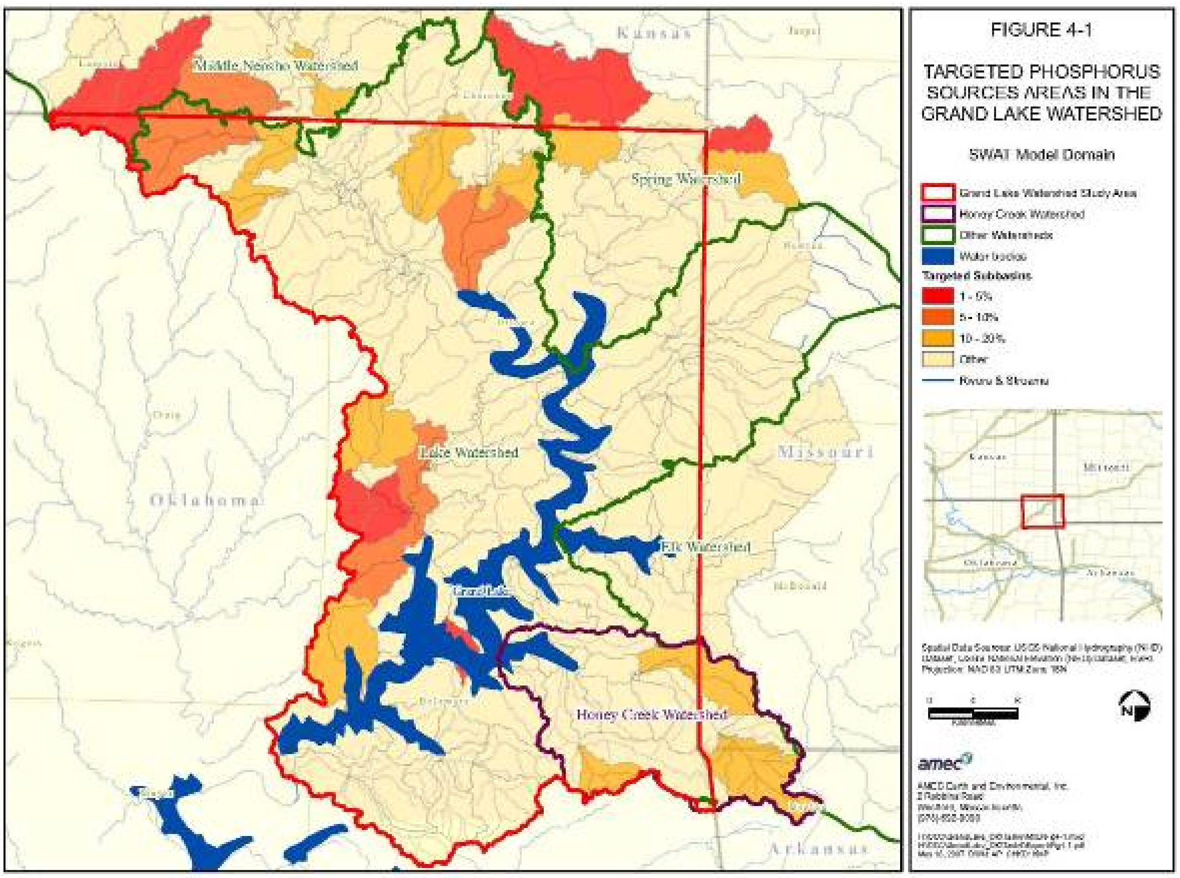

Figure 14: Subwatersheds of the Lake O' the Cherokees Watershed and vicinity with the greatest percentage contribution of phosphorus in the area around Grand Lake (darker color indicates greater contribution of phosphorus). (From Oklahoma Conservation Commission 2008)

SUBWATERSHED PLANNING

Establishing subwatershed plans for lakes and streams is essential for the successful management of water quality improvements within the Grand Lake watershed. The development and implementation of local and regional watershed plans is also linked to engaging local citizens and stakeholders in their portions of the watershed.

The Grand Lake watershed, when viewed in its totality, is characterized as being in an emerging phase of subwatershed planning. A vast majority of the watershed is without benefit of an established subwatershed plan. This means many streams presently lack a watershed approach necessary to coordinate and direct water quality improvements.

Many subwatershed plans should adopt improvement projects that will also address strategic water quality improvement needs. For example, the overall Grand Lake watershed presently is experiencing issues associated with excess nutrients and sediment. Any ultimate watershed strategy to improve nutrient/sediment water pollution is directly dependent upon implementing local and regional projects that target and effectively address these nutrient/sediment issues.

A summary of the status of subwatershed plans follows:

Neosho River Subwatershed Plans: Both the Marion Reservoir Watershed (Marion County Conservation District and Marion Reservoir WRAPS 2006) and the Council Grove Reservoir (Twin Lakes WRAPS 2006) have watershed plans.

Stakeholder organizations, or WRAPS (Watershed Restoration and Protection Strategy), within the Neosho River watershed are in various formative stages and one objective for each of these emerging organizations is to prepare a watershed plan for a specific stream and/or area.

Spring River Subwatershed Plans: A Kansas WRAPS stakeholder group has been organized on the Kansas portion of the Spring River. The Spring River WRAPS organization's objectives include education and outreach strategies, greater stakeholder involvement, developing a watershed plan for the Kansas portion of the Spring River and coordinating with citizen-based watershed organizations, especially for the Spring River watershed in Missouri.

Presently, there are no formal watershed plans that have been adopted that cover~~ing~~ any part of the Spring River itself either in Missouri, Kansas, or Oklahoma. The (upper) Shoal Creek Watershed Improvement Group is completing a watershed management plan and already implementing water quality improvements to address known sources contributing to water quality contamination identified by a TMDL for excess fecal coliform. In addition, the Environmental Task Force of Jasper and Newton Counties is sponsoring the (lower) Shoal Creek Watershed Partnership in completing a Watershed Restoration Action Strategy for lower portion of the Shoal Creek watershed.

Elk River Subwatershed Plans: The Elk River Watershed Improvement Association (ERWIA) has a 319 Subgrant agreement to develop five subwatershed management plans, implement specific water quality improvement and demonstration projects and expand public education and outreach strategies. ERWIA continues to coordinate with neighboring states and citizen-based organizations in the development of watershed plans.

Lake O' the Cherokees Subwatershed Plans: In 2004, the Oklahoma Conservation Commission published the Grand Lake Watershed Plan for the Oklahoma portion of the Grand Lake Watershed that focused on phosphorus reduction in the area immediately around Grand Lake. The implementation efforts focused on water quality and nutrient management education programs, trainings, and demonstration sites for residential, commercial and municipal audiences. In 2005, the Honey Creek Watershed Plan resulted primarily in implementing agricultural practices and developing a demonstration farm with examples of the array of management practices available for cost-share. (Oklahoma Conservation Commission 2004, 2005)

CITIZEN-BASED WATERSHED GROUPS

The Grand Lake Watershed has significant gaps where there are no citizen watershed groups or where organizations are just emerging. Creating additional citizen-based stakeholder groups within the watershed must be a priority for the overall water quality improvement strategy. Supporting and fostering growth of recently formed citizen groups is also a top priority.

Successful citizen-based groups represent a key underpinning necessary to achieve water quality improvement. These groups serve as the core for these essential watershed management functions:

- Education and public outreach
- Shaping the future of the watershed
- Energizing water quality improvement efforts
- Providing stakeholders an active voice in their watershed
- Assisting in preparing subwatershed plans
- Causing voluntarily induced water quality improvements

Generally the Neosho River Subwatershed in Kansas and the Elk River Subwatershed are more advanced in gaining citizen-based group involvement in their watershed. The Spring River Subwatershed has a limited scope of operating citizen-based groups and represents a significant gap within the Grand Lake Watershed. Significantly, however, a citizen stakeholder group has recently been formed on the Kansas portion of the Spring River. The Oklahoma portion of the Grand Lake Watershed is also without a local citizen-based group to assist in water quality improvements for portions of the Spring River, Neosho River, Grand River and Grand Lake. Appendix C lists the current citizen-based watershed groups within the Grand Lake Watershed. Appendix D specifies the geographic extent of all current citizen-based watershed groups in Kansas based on Hydrologic Unit Codes.

Neosho River Subwatershed

Local stakeholders within the Kansas Neosho River watershed participate in watershed management through Watershed Restoration and Protection Strategy groups (WRAPS). The current development stage for each WRAPS organization varies. WRAPS groups operating above each of the three federal reservoirs are more developed and have been functioning for several years. However, WRAPS organizational stakeholder efforts from below the John Redmond Reservoir to the Kansas/Oklahoma border are emerging.

Information provided by the Kansas Department of Health and Environment Watershed Management Section describes the Neosho Headwaters to be in the Assessment and Planning phase and there is a functioning Stakeholder Leadership Team (SLT). This SLT team is addressing sediment and other water quality issues.

The Upper Neosho River WRAPS project, covering the area directly below John Redmond Reservoir, is in the planning phase with a functioning SLT. Modeling options and economic analysis are in progress for this project.

The Middle Neosho River WRAPS project is in the planning phase. This area basically covers the area from the Upper Neosho to the Kansas/Oklahoma state line. This WRAPS project does have a SLT in place. The types of modeling and assessment considerations are in progress.

Two WRAPS projects on the Upper and Lower Cottonwood are in the development, assessment and planning phase. Two WRAPS projects for Marion Reservoir watershed and for the Twin Lakes project (AKA Council Grove watershed) are in the implementation phase. Both of these projects have active SLTs in place. The Eagle Creek WRAPS project, located immediately above John Redmond Reservoir, is currently in the implementation phase.

The Kansas Water Office (KWO) is helping with efforts in the Neosho Headwaters with two supporting projects (more information on the projects below is available at www.kwo.org):

Logjam Study, Sediment Monitoring, and Subwatershed Assessment: KWO is contracting to conduct a study of a logjam that has developed over more than 20 years at the inflow to John Redmond Reservoir, near the Jacob's Creek landing boat ramp. This logjam is largely a result of sedimentation at John Redmond where the Neosho River slows to form the reservoir. Input of large woody material from the watershed has resulted in accumulation of this material over about a 2.5 mile reach, blocking access to the river. Possible options to restore access to the river have been evaluated and recommendations as to the most cost effective solution have been provided and are under consideration. In addition, the USGS has installed several continuous monitoring stations in the watershed to gain a better understanding of sediment delivery dynamics to the reservoir. Efforts are underway to assess subwatersheds within the basin to prioritize areas for streambank stabilization and riparian area improvement.

Feasibility Study: KWO is participating in a Feasibility Study with the Tulsa District Corps of Engineers in the Neosho Headwaters (above John Redmond Reservoir). This study will provide information to the WRAPS project stakeholders as they develop their WRAPS plan. Specific objectives of the study include:

a. Preserve storage in John Redmond Reservoir for flood control, water supply, and other authorized purposes.
b. Revitalize John Redmond Reservoir for flood control, water supply, and other authorized purposes.
c. Reduce watershed contributions of sediment and harmful chemicals, such as phosphorus, into John Redmond Reservoir.
d. Restore riparian habitat (including native grass buffer zones) that improves the value and function of the ecosystem.
e. Restore wetlands that improve the value and function of the ecosystem.
f. Restore aquatic riverine habitat that improves the value and function of the ecosystem.
g. Preserve riparian habitat (including native grass buffer zones) essential to the value and function of restored habitat above.
h. Preserve wetlands essential to the value and function of restored habitat above.
i. Preserve aquatic habitat essential to the value and function of restored habitat above.
j. Protect public resources, utilities, including power, water, transportation, from the impacts of flooding, bank erosion, and channel changes.
k. Protect wetland and grasslands from invasive plant species.

Elk River Subwatershed

The Elk River Watershed Improvement Association (ERWIA) is an active citizen-based non-profit organization with active stakeholder involvement in the Elk River watershed. The ERWIA was formed in 2003 and its Board of Directors has a broad stakeholder mix. The Elk River watershed includes Buffalo, Big Sugar, Indian and Little Sugar Creeks, as well as the main stem of the Elk River to the Elk River Arm of Grand Lake. The ERWIA includes portions of six counties in Arkansas, Missouri and Oklahoma.

Spring River Subwatershed

There is a large gap on the Missouri portion of the Spring River watershed. A considerable portion of this watershed does not have functioning citizen-based groups involved in watershed management; however, portions of the Spring River watershed have active groups.

The Shoal Creek Watershed Improvement Group (SCWIG) is active in a 150 square mile portion of upper Shoal Creek watershed. In addition the Environmental Task Force of Jasper and Newton Counties has established the Shoal Creek Watershed Partnership for the remaining portion of lower Shoal Creek.

A Kansas WRAPS citizen group has been organized on the Kansas portion of the Spring River. This is an emerging organization that intends to link with the Missouri portions of the Spring River watershed. Some effort has been occurring to engage local stakeholders in watershed planning for the North Fork of the Spring River and the main stem of the Spring River watersheds, but have yet to result in formation of citizen-based groups. This is a priority area for the Foundation to address significant gaps in citizen-based groups to achieve water quality improvement objectives.

Lake O' the Cherokees Subwatershed

No active citizen-based group that has the purpose of planning and implementing a watershed plan is present in this subwatershed.

Grand Lake O' the Cherokees Watershed Alliance Foundation, Inc.

The Grand Lake Watershed Alliance Foundation Inc. (GLWAF) is a non-profit corporation formed in 2007. It focuses on preserving, protecting, and improving water quality within the total Grand Lake Watershed. Stakeholders from each of the four watershed states serve as members of the Foundation Board of Directors.

The Foundation is working with other watershed citizen-based groups to support their efforts to include public education, projects, programs and other actions designed to improve water quality. Importantly, the Foundation will assist in forming other watershed citizen-based groups and will partner with them.

The Foundation recognizes the watershed has a vast range of stakeholders. GLWAF, together with other similar citizen-based groups, will provide stakeholders a means and method for stakeholders to participate in their watershed. A Foundation Stakeholder Advisory Committee also provides an opportunity for stakeholders to participate in improving water quality.

One of the Foundation objectives is to have a full-time Foundation Vice President established and located in each of the four watershed states. These Vice Presidents will work with other citizen-based organizations as well as interface with local, state, federal and tribal organizations. Each Vice President also will be responsible for assisting in the development of localized citizen-based groups for subwatersheds.

Private funding will be needed to supplement public funding for the many programs and projects necessary for water quality stabilization and improvement. An essential Foundation objective is to secure private funds to support water quality improvement.

The Foundation also will host periodic coordinating and information sharing seminars with watershed state agencies, tribal governments, and federal agencies. In addition, the Foundation will host, at least annually, a seminar involving all citizen-based groups within the watershed.

Also, the Foundation will host at least semiannual watershed planning sessions attended by water quality agencies from each of the four watershed states. These sessions will focus on watershed planning and implementation; coordination of programs, monitoring efforts and trends, and activities; exchanging relevant information; and other assessment activities necessary for arresting and improving water quality.

A critical Foundation objective is to establish an effective educational outreach program. The educational outreach program will include:

1. Assisting in developing a Watershed Signage Program
2. Preparing and publishing educational pamphlets
3. Preparing and distribution of watershed and subwatershed videos
4. Developing a Grand Lake Watershed Health Index
5. Developing and publish watershed and subwatershed Fact Sheets
6. Establishing a Public Speaking program
7. Establishing a Public Education section of Foundation web site
8. Publishing periodic Foundation Newsletters
9. Hosting an Annual Meeting for Watershed Groups
10. Supporting other Citizen Group Education programs

Other important Foundation objectives include:

1. Assisting in the identification and recommending solutions to matters that affect water quality.
2. Assisting in improving water quality monitoring within the watershed
3. Publishing a Foundation Strategic Plan
4. Developing the Foundation and obtaining sufficient funding and staffing to achieve positive and sustained impacts on water quality.

WATERSHED-WIDE MANAGEMENT STRATEGIES

The Need for a Watershed-Wide Strategy

Local Support: Specific strategies to implement pollution prevention practices on the ground are best conducted on a local basis, addressing specific concerns of local people. However, local groups often lack the necessary funding or support to make significant inroads on solving pollution problems. A watershed-wide support network can help local groups combine efforts where helpful, such as outreach and education, and can help provide technical or monetary support where needed. A combined watershed-wide effort can also help leverage support of local issues by highlighting their collective impact on a regional level.

Reservoir vs. Stream Pollution: The impact of pollution is different in moving water than in the still water of reservoirs. Conditions that cause impairments of these standing water bodies can arise from upstream conditions that do not manifest themselves as problems in flowing water. In other words, a lake or reservoir could be impaired even though none of the streams feeding the lake are considered impaired. This means that additional efforts to reduce pollution may be necessary in officially unimpaired subwatersheds to provide necessary benefits downstream. This complication is normally particularly difficult to handle when the downstream waterbody is in a different state than the upstream waters.

Conflicting Impairment Designations: Other complications arise when waters that are impaired in one state are not considered impaired in the downstream state, or vice versa. These complications may arise more from a change in the water quality standards from one state to the next rather than a change in the actual condition of the water body. These changes may arise either from a change in designated use of the water body from one state to the next or a change in water quality standards of that use based on a different state's criteria. For example, water quality standards for the same use, such as "recreation", may differ in each state. Similar changes in impairment status can occur within one state as the designated use of the water body changes without a decided change in water quality.

All of the above complications underscore the need for a comprehensive watershed plan and ongoing cooperative planning to help ensure that local improvement efforts contribute to the overall good of the Grand Lake Watershed.

Management Strategies for Grand Lake Watershed

Continue Development of Grand Lake Watershed Alliance Foundation (GLWAF):
GLWAF is a citizens-based, officially recognized 501(c)(3) nonprofit organization with representation from all four states of the Grand Lake Watershed. GLWAF is organized to represent the stakeholders in the total watershed as well as work with local citizen-based organizations.

GLWAF has an active board, a set of bylaws, and several active committees, including the Watershed Plan Committee. GLWAF is taking steps to increase its membership and solidify its organizational structure. This will enable the Foundation to hire support staff to help further the efforts of the organization. In addition, the Foundation is working to complete a more specific Strategic Plan, built upon this watershed plan. Once fully established, GLWAF will be better able to generate private and public funds that will benefit local watershed implementation efforts and raise awareness of and foster solutions for water quality problems in the Grand Lake Watershed.

Help Develop and Support Local Watershed Groups: Local stakeholder involvement is key for successful watershed management and water quality improvements. Local watershed groups are developing in many parts of the Grand Lake Watershed, but other areas lack concerted efforts to develop watershed groups. GLWAF will help foster local watershed groups so that eventually the entire watershed can be represented by local groups. All current and future watershed groups can benefit from financial, organizational, and technical support from GLWAF.

Conduct watershed-wide modeling: A critical element of the management strategy is to help ensure that implementation money is spent in areas where it can make the biggest impact on improving water quality. In order to get the biggest bang for the buck, it is essential to identify and quantify all pollutant sources in the basin, including both nonpoint and point sources. Computer models can use data (soil type, topography, land use practices, climate, etc.) to determine current pollutant loading throughout the watershed. Modeling can also determine the load reductions expected with a change in management practices, thereby ensuring that the most effective practices are recommended for consideration by local adopters.

Some modeling has been initiated in portions of the Grand Lake Watershed, but watershed-wide modeling is important for a number of reasons. First, one set of modeling results will produce a document covering the entire watershed that GLWAF can take to potential funding sources. Those funding sources can be confident that the money provided will go to areas that will make a meaningful impact on water quality and that the efforts are not fragmented. Second, the modeling results will be beneficial to local watershed groups that are attempting to develop a management plan for their subwatershed, especially where there is no plan to conduct such models. The results of the modeling study will allow local groups to meet many of EPA's 9 elements to develop those plans. Third, the modeling results will aid in development of local watershed groups where none exist. Modeling results can be used to energize citizens to form watershed planning groups. Fourth, one set of modeling results, using identical methodology for the entire watershed, will ensure appropriate comparisons will be made from one part of the watershed to another. Finally, the results of the watershed-wide modeling will be used to update this Grand Lake Watershed Management Plan to thoroughly address EPA's 9 elements for successful watershed planning (see below).

The proposed modeling effort will focus on nutrient (phosphorus) and sediment loads in the watershed, including upland, instream and reservoir processes. Watershed-wide, the top concerns are nutrients, sediment, bacteria, and heavy metals. Although these 4 concerns represent distinctive impairments, the sources and causes are often interrelated. For example, heavy metals can be transported with sediment and bacteria may be associated with organic material rich in nutrients. As a result, modeling that focuses on nutrient and sediment issues will not only lead to improvements for those specific impairments, but will lead to a reduction of bacteria and heavy metals as well.

At this point, heavy metals and bacteria are not intended to be directly addressed by watershed-wide modeling. However, a local WRAPS group in Kansas is planning to develop modeling for heavy metal pollution reduction in the Spring River Watershed where those issues are the number one concern. Those and other local modeling efforts that enhance our understanding of the watershed will be supported and encouraged.

Streambank Stability Study: A watershed-wide streambank stability study must be initiated. Streambank erosion is a significant issue throughout the watershed. It is responsible for large amounts of sediment and nutrient pollution downstream and the loss of land along streams. This study would identify key areas to implement bank or channel improvements. Streambank stability studies may take place as a part of some WRAPS projects in Kansas. Although this study is needed watershed-wide, the cost of this study may necessitate a phased implementation.

Data Gap Anaylsis: As part of the watershed-wide modeling project, all existing relevant data will be compiled. As an extension of that project, a data gap analysis will be conducted to determine what kinds of additional data are needed to be collected to further our understanding of the Grand Lake Watershed system.

Website Linking Water Quality Information: A significant amount of data and reports on Grand Lake Watershed are already available online. Developing a website based on Grand Lake Watershed with links to available water quality information would aid citizens and citizen-based groups in finding relevant information on the watershed.

Analyze Point Source Discharge Regulations and State Water Quality Standards: In order to begin dealing with interstate inconsistencies in water quality measures, GLWAF intends to begin compiling and analyzing information and data on point source discharge regulations and state water quality standards. This is a starting point for establishing options for handling conflicting regulations and standards. The results of the modeling effort and continued development of TMDLs will aid in the analysis of these issues.

Regular Meetings of State Water-related Agencies and GLWAF: GLWAF has commitments from several state agencies to meet on a regular basis to address interstate water issues relevant to Grand Lake Watershed and to increase communication about water quality improvement efforts and monitoring in the respective states, including addressing a four state monitoring plan elaborated upon in the "Monitoring" section of this documents.

Update Grand Lake Watershed Plan: This watershed plan will be updated to include the results of the watershed-wide modeling effort and increased input from developed and developing local watershed groups.

INFORMATION AND EDUCATION STRATEGIES

Watershed-wide signage: In order to promote awareness of watersheds and specific watershed boundaries and names, GLWAF will kick-off a watershed-wide signage initiative. Watershed signage helps citizens identify themselves as a stakeholder in Grand Lake Watershed and enhances their ability to understand the impact their actions may have on local and downstream waters. GLWAF intends to work with local watershed groups to develop the plan for watershed signage design and implementation. The first step is to develop a pilot project in each subwatershed for locals to develop an action plan.

Develop Grand Lake Watershed Health Index: In order to publicize and help the public track improvements (or declines) in the watershed, a Watershed Health Index (akin to the Chesapeake Bay Foundation's Health Index) will be developed and publicized. A health index will use monitoring data and watershed statistics (such as % streambanks with vegetative buffer) to indicate the relative progress of planning and implementation efforts. The numeric scale, to be updated and publicized annually, will be a simple tool to aid the public in understanding the state of the watershed.

Help promote regional workshops, conferences, and events: A number of regional workshops and conferences provide valuable information for a variety of audiences, including local officials, land managers, etc. From topics ranging from low impact development to lawn management to agricultural practices, there are numerous events held in or near the Grand Lake Watershed that can be promoted rather than developed from scratch. GLWAF will support (when funds are available) and promote these events throughout the watershed.

Annual Water Meeting for Watershed Groups: Each year GLWAF will organize a gathering of local stakeholder groups to meet and discuss watershed issues. Groups will have the opportunity to update each other on progress, challenges, and initiatives within each subwatershed ranging from water quality improvements to successful outreach events to practices implemented. Most importantly, the annual event should instill a sense of community among stakeholders throughout the watershed. The annual meeting will be held in different parts of the watershed each year.

Quarterly Newsletter: GLWAF will produce a quarterly newsletter to members and member organizations to increase communication about initiatives throughout the watershed. The newsletter can serve to keep watershed groups informed of events, initiatives, and opportunities throughout the watershed and to aid in communication across the watershed.

Watershed and Subwatershed Educational Videos: Educational videos can be used to promote the understanding of watersheds, pollution sources and causes, and ways to make a difference. Produced videos can be used in classrooms, access cable channels, and public venues such as visitor centers and nature centers, to promote watershed education. Educational videos should be produced for the entire watershed as well as more locally focused videos directed toward narrower audiences for each of the 3 major subwatersheds.

Watershed and Subwatershed Fact Sheets: Fact sheets can be used to inform the public about watershed statistics including land use, population, and impaired waters. Fact sheets can be available at watershed events, meetings, and public venues to promote understanding of watershed issues. Fact sheets should be produced for the entire watershed as well as more locally focused subwatersheds.

MONITORING

Current State of Monitoring in Subwatersheds

In general, the Kansas portion of the Neosho River Subwatershed has broader geographical monitoring coverage than either the Spring River or Elk River Subwatersheds outside Kansas. Establishing additional monitoring sites are necessary in these other areas, in particular in the Spring River Subwatershed.

Neosho River Subwatershed: The Kansas Department Health and Environment (KDHE) is the responsible state agency for monitoring of Kansas water quality. According to KDHE, the Neosho River Subwatershed contains a large portion of the state's surface water. Consequently, this watershed receives an elevated level of monitoring priority and attention.

An important element of the KDHE monitoring program is the use of targeted water chemistry sites within the Kansas portion of the watershed. The location of each chemistry site is shown on a website map (http://www.kdheks.gov/befs/water_quality_disclaimer.htm). Each site displays summary data and a site photograph. KDHE reports 54 targeted stream monitoring locations established within the Neosho River watershed and 21 sites established that monitor public owned (or public accessible) lakes and wetlands.

KDHE is currently developing 23 targeted stream biological monitoring sites within the watershed each having a similar data summary and photograph presentation. In addition, 17 stream fish tissue-monitoring sites are scheduled for the watershed (KDHE works with the Kansas Department of Wildlife on fish tissue matters).

KDHE uses a probabilistic monitoring network to augment the targeted monitoring stream programs. This involves using a random sample site selection process and then application of physical/chemical, biological, and fish tissue sampling procedures.

According to KDHE, historical analysis of water quality trends has focused on heavy metals in streams and the trophic conditions of impounded waters. KDHE does have a historical database that could be used to provide further trend analysis of nutrients and phosphorous.

Spring River Subwatershed: The Missouri Department of Natural Resources (MoDNR) is the Missouri state agency that monitors water quality on the Spring River and its tributary streams. There are five fixed monitoring sites on the Spring River and its streams. One of the sites is monitored for nutrients only. Four of the sites are monitored for nutrients, trace metals, and ions.

KDHE also has four fixed monitoring sites on the Spring River and its streams in Kansas. Two of these sites are located on the Spring River and two sites are located on tributary streams.

Elk River Subwatershed: The U.S. Geological Survey (USGS), in cooperation with MoDNR, recently concluded a study of water and streambed sediment quality in the upper Elk River watershed in southwestern Missouri and northwestern Arkansas (U.S. Geological Survey Water and Streambed-Sediment Quality in the Upper Elk River Basin, Missouri and Arkansas, 2004–06).

There are presently five fixed water monitoring gages operating in the Elk River watershed. These gage sites include:

- Elk River at Tiff City
- Buffalo Creek at Tiff City
- Indian Creek at Lanagan
- Big Sugar Creek at Powell
- Little Sugar Creek at Pineville

These five fixed water monitoring gages measure the following parameters: gage height, discharge and precipitation; and, one of them (Little Sugar Creek gage) also measures the following water quality parameters: temperature, specific conductance, dissolved oxygen, pH, turbidity and dissolved oxygen.

Through its cooperative water resources program in the Elk River watershed for 2009, the MoDNR and USGS will be conducting additional water quality monitoring for the following parameters:

- Nutrients (12 times/year)
- Trace metals and major ions (4 times/year)
- Total residue (8 times/year)

The GLWAF urges continuation of comprehensive water resources monitoring in the Elk River watershed, especially for nutrients, beyond 2009 and budgets $26,000 per site for helping MoDNR and USGS continue monitoring, including monthly sampling for nutrients.

Lake O' the Cherokees Subwatershed: The Missouri Department of Natural Resources has a fixed monitoring site on the Cave Springs Branch located on the Missouri-Oklahoma state line which drains to Honey Creek where there is another fixed monitoring site before merging with the Honey Creek arm of Grand Lake. The Cave Springs site is monitored for nutrients as well as pH, dissolved oxygen and other water quality parameters.

In Oklahoma, water quality monitoring responsibility is divided among several state agencies. The Oklahoma Conservation Commission (OCC) is responsible for monitoring streams wetlands and waters to determine the nonpoint source pollution impact. Other state and agencies supplement OCC water quality monitoring efforts. The Oklahoma Department of Environmental Quality performs point source monitoring and enforcement. It also monitors for TMDL development plus special projects monitoring.

The Oklahoma Water Resources Board (OWRB) is the Oklahoma state agency responsible for monitoring water quality in Grand Lake. The Grand River Dam Authority also conducts water monitoring on the lake.

A citizen-based volunteer monitoring program was established in 1992 on Grand Lake as part of the Oklahoma Water Resources Board Water Watch Program. This monitoring program includes partnerships with three Tribal governments who also participate. Trained and OWRB certified volunteer monitors conduct periodic water sampling at both in water and near shoreline monitoring sites. There are about 45 monitoring sites on Grand Lake and on the Neosho River, Spring River, and Elk River. The test results are reported to the OWRB who retains both the Water Watch collected data and the data collected by OWRB.

A new state-of-the art water quality research laboratory is scheduled to be completed by the Grand River Dam Authority (GRDA) in mid-2009 and will be located on the shores of Grand Lake. This lab will be part of the GRDA Ecosystems & Education Center which will facilitate easy access to Grand Lake for research scientists and will provide unique public education and teaching opportunities. The GRDA lab is expected to support research activities throughout the total Grand Lake watershed. The GRDA also will be monitoring water quality in Grand Lake and will be able to support monitoring efforts elsewhere within the watershed.

Grand Lake, therefore, has historical water quality data from 1992 forward that provides baseline data and also provides a basis for trend analysis. This historical data includes: Dissolved Oxygen, pH, Secchi Disk depths, Orthophosphate, Nitrate Nitrogen and Ammonia Nitrogen. Grand Lake Water Watch Inc., the non-profit parent volunteer monitoring organization, added periodic testing for bacteria in the lake samples sent to OWRB for testing. What is lacking for Grand Lake is a study and analysis of the significant amount of historical data collected by the various agencies and the Water Watch Program.

Monitoring and Data Management Strategies

The widespread occurrence of nutrients/phosphorous is a significant issue and is a high priority water quality concern within the entire watershed. This problem warrants a strategic focus to monitor nutrients and sediment. Currently there are strategic gaps in nutrient monitoring sites and a lack of adequate geographical coverage.

Local subwatershed plans will require project-specific monitoring programs that are designed specifically to track the progress of local water quality improvement projects. However, there are important strategic monitoring aspects applicable to the total Grand Lake watershed.

New and Existing Monitoring Sites: Existing monitoring sites should be continued. Other sites where discharge monitoring is currently underway should be augmented with nutrient and, in some cases, metal monitoring. Finally, where data gaps exist, new sites should be added that monitor discharge, nutrients, metals, and other parameters. Specifically, sites monitored in the Elk River Subwatershed that are currently funded through the first part of 2009 should be maintained in perpetuity in order to track improvements in the watershed. Parts of the Spring River Subwatershed, in particular, would be a good target for new monitoring sites.

Four State Monitoring Plan: The Grand Lake O' The Cherokees Watershed Alliance Foundation Inc. intends to host a four-state effort to craft an overall coordinated watershed nutrient/sediment monitoring plan. This monitoring plan will use existing data collection efforts, but also will fill gaps necessary to obtain adequate strategic geographical coverage. This approach will insure a coordinated and strategic water quality monitoring plan is functioning within the watershed.

Trend Analysis of Water Quality Data: There are instances when scarce resources have been used to collect monitoring data, but the data are not fully subjected to historical trend analysis or further interpretation. Limited budgets and resource allocation decisions contribute to this situation. Additional funding could provide a more thorough analysis of existing data to provide further relevant information that can aid watershed management choices and decisions.

Data Clearing House: No data clearing house for the water quality monitoring data and information exists. Instead, the repository of data and information can be found in many locations and within many different organizations. At the same time, some monitoring information, but not all, is available on web sites. The cost of establishing and operating a data-clearing house for the total watershed may not be warranted based upon cost/benefit criteria. A data clearing house concept should further explored in the future.

Website Linking Water Quality Data: The Grand Lake Watershed Alliance Foundation Inc. intends to establish a web-based site that links all of the websites that publish watershed and water quality data. This website would serve as a one stop web directory that lists an inventory of all the locations having watershed and water quality data and information with an Internet link to each.

Grand Lake Watershed Health Index: The Grand Lake watershed will greatly benefit by having a simple index number that would convey to the public an easy to understand state of the watershed. Therefore, the Grand Lake Watershed Alliance Foundation intends to publish a watershed ***Health Index***. This Index number would be similar in nature to one published by the Chesapeake Bay Foundation and by organizations in other watersheds. Citizens and stakeholders can use the ***Health Index*** as an easy to understand number to chart any improvement, stagnation, or regression in watershed and water quality conditions.

IMPLEMENTATION SCHEDULE AND INTERIM MILESTONES

Short Term Tasks (complete in first 2 years)

- Further development of Grand Lake Watershed Alliance Foundation
- Complete modeling of watershed
- Initiate streambank stability study
- Implement watershed signage:
  pilot project in each major subwatershed plus action plan to complete
- Help develop 3 new watershed groups, one in Spring River Subwatershed
- Develop Grand Lake Watershed Health Index
- Complete data gap analysis
- Promote 10+ local & regional workshops/events to engage stakeholders
- Hold annual meeting for watershed groups
- Assemble and tabulate various water quality standards from each state
- Review and analyze all point source permits in the watershed
- Develop watershed educational video for entire watershed
- Develop watershed and subwatershed fact sheets and distribute
- Develop water quality data linkage website
- Establish three fixed monitoring sites in Spring River system - nutrients, metals & total residue
- Establish three fixed monitoring sites in Elk River system for nutrients & metals

Medium Term Tasks (complete in 2- 5 years)

- Signage throughout watershed
- Help establish watershed groups throughout the watershed
- Support completion of 4 subwatershed plans
- Publicize Grand Lake Watershed Health Index
- Update watershed plan – using modeling results
- Complete Strategic Plan of the Foundation
- Analyze water quality standard variances between states, work on solutions
- Develop action plan for establishing appropriate point source discharge rates for nutrients throughout the watershed (based on needs documented in TMDLs and the watershed modeling effort).
- Develop subwatershed educational videos
- Distribute educational videos and fact sheets to 5+ schools in each state
- Establish 2 additional fixed monitoring sites in Spring River system (Total of 5)
- Establish 1 additional fixed monitoring site in Elk River system (Total of 4)

Long Term Tasks (complete in 5+ years)

- Subwatershed groups throughout the watershed
- Subwatershed plans throughout the watershed
- Implement action plan to improve water quality from point sources
- Determine and implement corrective solutions for conflicting water quality standards on a watershed basis
- Expand plans to cover entire Grand River Basin to the confluence with Arkansas River
- Continue monitoring to demonstrate success of plan implementation.

TECHNICAL AND FINANCIAL ASSISTANCE

The top priority projects of the Grand Lake Watershed plan are 1) conduct watershed-wide targeting studies (modeling and streambank stability), 2) further develop the Grand Lake Watershed Alliance Foundation (GLWAF), and 3) initiate watershed-wide signage pilot projects.

Watershed-wide targeting studies (modeling and streambank stability) will clearly define areas of the watershed to concentrate implementation projects in the future. Watershed targeting is essential to determine where scarce financial resources can best be spent to achieve maximum pollution reduction. Potential nutrient reduction projects, such as bank stabilization, are costly. Therefore, cost effective projects along with their location must be identified and prioritized within the watershed. The streambank stability study is necessary to supplement the modeling efforts, because modeling does not adequately address the streambank stability issues.

The GLWAF will assist with the formation and support to citizen-based groups by funding the staffing of four Foundation Vice-presidents positions within each of the four watershed states. Their job will also include assisting in preparing subwatershed plans and interfacing with local private and governmental entities. The Foundation intends to establish a grant writer/facilitator to assist local citizen-based groups in obtaining the financial resources that are necessary to reduce pollutants.

Watershed signage helps citizens identify themselves as a stakeholder in Grand Lake Watershed and enhances their ability to understand the impact their actions may have on local and downstream waters. By initiating pilot projects in each of the four states, local citizens will take responsibility for their own portion of the watershed. In addition, this project will enable GLWAF to immediately forge a positive relationship with local watershed groups.

The tables below tabulate the financial assistance needed to carry out all of the immediate tasks recommended in the Grand Lake Watershed Plan. The primary responsible party is GLWAF. Technical assistance has and will continue to be provided by two main groups:

State and federal agencies: Several agencies have assigned staff to participate in GLWAF committees and have agreed to meet separately 2-4 times a year with GLWAF to address water issues in Grand Lake Watershed. In addition to technical support, agency support of GLWAF activities are considered financial contributions (personnel time and travel expenses) and are included as costs in the tables below.

Four State Watershed Collaborative (FSWC): A group of university professors, university extension professionals, and state agency professionals from the four Grand Lake Watershed states have formed to provide technical assistance to watershed groups in the Grand Lake Watershed.

TOP PRIORITY TASKS	FUNDS NEEDED	RESPONSIBLE PARTY
Watershed-wide modeling	$600,000	GLWAF, FSWC
Streambank stability study	$850,000 – $4,500,000 (depending on scope)	GLWAF, FSWC
Develop GLWAF 1. Staff stipend and benefits a. 4 Vice Presidents – one for each state b. Grant writer/facilitator (self-supporting after 2 yrs) c. Administrative assistant c. President (lower priority) 2. Travel reimbursement (board meetings, committee meetings, local watershed meetings, etc.) 3. Office supplies and operation 4. Office space and utilities 5. Develop / support local watershed groups	Total: $410,000/yr $240,000/yr $60,000/yr (2 yrs only) $22,000/yr $60,000/yr $60,000/yr $30,000/yr $30,000/yr $0, included above	GLWAF
Watershed-wide signage pilot projects	$100,000	GLWAF, watershed groups

Total cost over 4 years: $3,558,000 – $7,208,000

OTHER TASKS	FUNDS NEEDED	RESPONSIBLE PARTY
DATA ANALYSIS 1. Data gap analysis 2. Website linking water quality data 3. Analyze point source discharge regulations and State water quality standards 4. Trend analysis of water quality data 4. Regular meetings of State water-related agencies and GLWAF	 $108,000 $4,800 $680,000 $500,000 $4,000/yr	 GLWAF, FSWC GLWAF GLWAF, State Agencies GLWAF, State Agencies GLWAF, State Agencies
EDUCATION AND OUTREACH 1. Develop Grand Lake Watershed Health Index 2. Annual meeting for watershed groups 3. Quarterly newsletter printing and mailing 4. Watershed & subwatershed education videos 5. Watershed and subwatershed fact sheets 6. Help promote regional workshops, conferences, and events	 $75,000 $10,000/yr $10,000/yr $40,000 $10,000 $0	GLWAF, FSWC
MONITORING 1. Spring River Watershed monitoring sites a. First 3 sites b. Additional 2 sites (after 2 yrs) 2. Elk River Watershed monitoring sites a. Add parameters to 3 sites b. Additional site (after 2 yrs)	Total: $780,000 $78,000/yr $52,000/yr $78,000/yr $26,000/yr	 GLWAF GLWAF
Update Grand Lake Watershed Plan (after 2+ yrs)	$500,000	GLWAF, State Agencies

Total Cost over 4 years: $2,793,800

CRITERIA TO MEASURE PROGRESS

Criteria to measure progress of watershed plans are generally linked to the actual water quality improvements expected in the watershed. The Grand Lake Watershed Plan is a large scale plan. On such a large scale, one can only expect longer term criteria to appropriately measure water quality progress. This expectation is amplified by the fact that sources of pollution may be cut off in the short term, but the pollutants may still work their way through the watershed for decades to come.

Shorter term water quality criteria are expected to be determined by local groups in local areas as part of subwatershed plans. Shorter term milestones for progress on action items in this watershed plan are included in a previous section of the document.

Ultimate Goals

1) Remove waters of Grand Lake Watershed (eventually also the entire Grand River Watershed) from state impairment lists.

2) Determine corrective solutions for conflicting water quality standards and regulations on a watershed basis.

3) Prevent development of toxic algae blooms in reservoirs of Grand Lake Watershed.

Initial Goals

1) Reduce nutrients, sediment, and bacteria loading by 10% in 10 years (specific load reduction numbers will be determined after watershed modeling is complete).

2) Removal of 5% impaired waters of the Grand Lake Watershed from state impairment lists in 10 years (based available funding and local implementation) – priority given to top impairment concerns: sediment, nutrients, bacteria, and heavy metals.

Corrective actions

If the above initial goals are not reached, the watershed plan will be reevaluated to address shortcomings or reassessed to set more realistic goals. The initial goals are not endpoints and new goals will be set as the first ones are attained.

CONCLUSIONS

The watershed presently has insufficient citizen-based stakeholder organizational infrastructure that is essential to achieve improved water quality. A large portion of the watershed lacks individual subwatershed plans tailored for specific rivers and streams. Consequently, material improvements in water quality during the next ten years do not look promising unless the following occur:

- Organizing and supporting citizen-based stakeholder organizations must receive a high priority for the next five years. This is an imperative strategic element requiring focus by citizens, community leaders, and governmental leaders.
- Citizen-based stakeholder organizations and additional funds are required to prepare subwatershed plans tailored for specific streams.
- A higher priority for funding water quality improvement projects implemented by citizen-based organizations with support from local, state, federal and tribal government is necessary.
- Private funds must be made available to support these water quality improvement efforts.

Degradation of water quality is a real risk within the watershed. Increased pollution risks are expected unless drastic steps are taken and higher priorities are established. One strategic objective is to stop the projected decline in water quality. Clearly, the nutrient rich watershed will continue to affect the four major reservoirs (Marion, Council Grove, John Redmond, and Grand Lake) and the major rivers (Neosho, Spring, and Elk) unless a watershed-wide collective and coordinated effort is adopted and implemented.

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APPENDIX A: TAR CREEK SUPERFUND SITE BACKGROUND

The Tar Creek Superfund Site is located in far northeastern Oklahoma near the Oklahoma/Kansas border in Ottawa County. The Site generally consists of a forty square-mile area; however, it is part of the larger Tri-State Mining District that includes areas of Kansas and Missouri. The Site includes portions of five communities: Picher, Cardin, Quapaw, North Miami, and Commerce and affects a total population of roughly 30,000 residents. A substantial amount of the land in the mining area is owned by the Quapaw Tribe and its members held in trust by the U.S. Department of Interior.

Beginning in the early 1900s and continuing to some degree as late as the 1970s, the Site was extensively mined for lead and zinc ore. Most mines had their own mill, and Oklahoma mills in many cases served as central mills for mines operating in Kansas and Missouri. Milling the lead and zinc ore resulted in a concentrate of the original mined material. The milling process, however, also resulted in mine tailings that were originally considered an unmarketable waste product. Typically, the mine tailings were disposed of by collecting in piles or in flotation tailings ponds. Some piles are as high as 200 feet and contain elevated levels of lead and other heavy metals. The chat has been sold and marketed as a construction product, similar to limestone gravel, for many years. Chat piles are either owned privately or held in trust by the U.S. Department of Interior for members of the Quapaw Tribe.

The U.S. Geological Survey and the U.S. Army Corps of Engineers have estimated that the Site generally contains 75 million tons of chat piles and an additional amount of tailings in flotation ponds that has yet to be quantified. The Environmental Protection Agency and Oklahoma state agencies have determined that the mining and milling of lead and zinc ore left miles of underground tunnels, open mine shafts, and drill holes. The Environmental Protection Agency (EPA) listed the Tar Creek Superfund Site on the National Priorities List in 1983 making it subject to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, 42 U.S.C. §9601 et seq.). CERCLA listing, also known as Superfund listing, establishes procedures under that law for clean up of a listed site and reimbursement for such clean up by collecting from responsible parties. In 1984, the EPA began work on its first Operable Unit (OU1) in the Site. Each OU is a portion of a remedial response, and the clean up of a Superfund site can be divided into a number of OUs. OUs may be organized by geographical portions of a site or specific site problems to be remediated. Since its listing in 1983, EPA has designated four different OUs within the Site. The first OU was designated to address surface water contamination in Tar Creek from discharge of mine water and the threat of contamination of the Roubidoux Aquifer beneath the Site from open abandoned wells. The EPA conducted work from 1984 to 1986 to build dikes, plug eighty-three abandoned wells, and divert surface water around abandoned mines and collapsed mine shafts. The result of the work of OU1 was mixed. Surface water quality was not significantly improved. The diking and diversion remedial action was at best only partially effective, and there was insufficient data to evaluate the effectiveness of the well plugging operations. Concentrations of most constituents in the mine water discharges decreased; however, that may have occurred naturally, and the volume of the mine water discharged to Tar Creek was not significantly impacted by the remedial action. Some well plugging continues and the Oklahoma Department of Environmental Quality (ODEQ) continues water monitoring. EPA and ODEQ expenditures totaled just under $10 million for the OU1 work.

The second designated OU occurred in 1995. It began as a result of information obtained from the Indian Health Service (IHS) concerning the concentration levels of lead in the blood of Indian children living in the area. IHS indicated that approximately 35 percent of the Indian children tested showed concentrations of lead in their blood that exceeded the level considered elevated by the Centers for Disease Control and Prevention. Subsequent countywide testing showed that more than 30 percent of children had elevated blood lead levels. EPA found that tailings were located throughout residential properties in the Site. EPA cited that chat was commonly moved to use for fill and to cover driveways, alleyways, roadbeds, yards and home playgrounds. EPA also found that the foundations of area homes and business where local children regularly played were built on chat. In response, the EPA began sampling area soils and subsequently began the yard remediation activities that occurred from 1995 and are scheduled to conclude in 2003. EPA reports that more than 2,000 residential properties, day cares, schools, parks, and business properties in the five-city mining area have been remediated through this work. The EPA reports it has spent more than $100 million to complete this work. Testing has shown a reduction in the percentage of children with elevated blood lead levels. This reduction has been attributed to a combination of the remediation and extensive public education campaigns on the dangers of lead and how to reduce exposures.

The third designated OU began in 1989 and ended in 1999. Pursuant to the request of the Quapaw Tribe, EPA investigated the abandoned Eagle Picher Industries mining laboratory located in Cardin. EPA disposed of 120 deteriorating containers of lead recovering chemicals at the laboratory. EPA estimated the cost of the OU3 work at $55,000.

The fourth OU has only recently been designated. The EPA and U.S. Department of Justice are negotiating a proposed legal consent order and statement of work concerning the remedial investigation and feasibility study (RI/FS) with Department of Interior, Blue Tee Mining Company, and Gold Fields Mining Company. These entities are three of the potentially responsible parties (PRP) involved in the Tar Creek Superfund Site. Although the RI/FS uses terms like “study,” this is not simply another evaluation or study of the Site with no resulting action. An RI/FS is the first necessary action to identify the nature and extent of contamination and evaluate options for clean up. The RI/FS becomes the basis that establishes site remedies. The selected remedy for OU4 was issued in July 2008 and includes voluntary relocation, phased consolidation, chat sales and on-site disposal as presented in the proposed plan, July 30, 2007, with some modifications based on public comment.

APPENDIX B: SUMMARY OF TMDLs FOR GRAND LAKE WATERSHED

The following identifies pollutants causing impairment in Grand Lake Watershed water bodies, their sources and causes, solutions, and necessary load reductions to become unimpaired based on TMDL evaluations developed by state agencies and organized by subwatershed and relative priority. Note: all TMDL references are listed in the Reference section of this watershed plan.

Neosho River Watershed TMDLs

Low DO (Sediment causing low DO), Eutrophication (nutrients)

Source: agricultural fields, stream banks, grasslands, permitted sites (CAFO, WWTP)
Cause: erosion, (at high flows CAFO, WWTP not problem), animal stream access, lack riparian buffer.
Priority: HIGH – 10 segments, MEDIUM – 9 segments, LOW – 2 segments
Solution: 1. Implement soil sampling to recommend appropriate fertilizer applications on cropland. 2. Maintain conservation tillage and contour farming to minimize cropland erosion. 3. Install grass buffer strips along streams. 4. Reduce activities within riparian areas. 5. Implement nutrient management plans to manage manure application to land. 6. Filter strips on edge of agricultural fields 7. Restore riparian vegetation along target stream segments 8. Renew state and federal permits 9. Install proper manure and livestock waste storage 10. Proper on-site waste system operations in proximity to targeted streams 11. Labeled application rates of chemical fertilizers.

- Allen/Dows Creek → HIGH Priority
- Eagle Creek → HIGH Priority
- French Creek → MED Priority (no recommended actions) – attributed to low flow
- Doyle Creek → HIGH Priority (addressed with NPDES permit)
- Bachelor Creek → MED Priority
- Canville Creek → HIGH Priority
- Cherry Creek → HIGH Priority
- Labette Creek → HIGH Priority
- Marion County Lake → Load Reduction: P (21.4%) N(0%) (no point sources) MED Priority
- Marion Lake → Load Reduction: P (75%) (3 WWTP undetermined) HIGH Priority
- Gridley City Lake → Load Reduction: P (54.4%) N(0%) (no point sources) MED Priority
- Council Grove Lake → Load Reduction: P (94%) N(58%) (WWTP less than 1% contribution – no load reduction) HIGH Priority
- John Redmond Lake → Load Reduction: P (21.2%) N(60%) (WWTP P-22.8%) MED Priority
- Olpe City Lake → Load Reduction: P (48%) N(32%) (no point sources) HIGH Priority
- Turkey Creek → HIGH Priority
- Altamont City Lake → Load Reduction: P (92.4%) N(0%) (no point sources) LOW Priority
- Bartlett City Lake→ Load Reduction: P (50%) N(0%) (no point sources) LOW Priority
- Neosho County SFL→ Load Reduction: P (97.8%) N(64%) (no point sources) MED Priority
- Neosho WMA→ Load Reduction: P (77.8%) N(78%) (no point sources) MED Priority
- Parsons Lake→ Load Reduction: P (81%) N(0%) (no red. for 1 WWTP) MED Priority
- Chanute/SF City Lake → Load Reduction: P (89.3%) N(50%) (no point sources) MED Priority

Silt / Silt and Lead (one segment w/ lead in soil)

Source: Cropland, very minor WWTP contribution **Cause:** Exposed soil
Priority: HIGH – 2 lakes, MEDIUM – 1 lake and 1 stream segment (silt and lead)
Solution: 1. conservation tillage and contour farming, 2. grass buffer strips 3. Reduce riparian activities

Council Grove Lake → Load Reduction: 48% (WWTP 0% reduction) HIGH Priority
John Redmond Lake → Load Reduction: more detailed assessment needed MED Priority
Olpe City Lake → Load Reduction: 54% (no point sources) HIGH Priority

Fecal Coliform Bacteria

Point Sources: WWT lagoon, CAFO sites **NPS:** septic systems, smaller livestock operations
Load Reduction: zero permitted from lagoon/CAFO during low flows.
Priority: HIGH – 5 segments (4 addressed with permits), MEDIUM – 8 segments
Solution: 1. Renew state and federal permits and inspect permitted facilities for permit compliance. 2. Install proper manure and livestock waste storage. 3. Install grass buffer strips along tributaries. 4. Install pasture management practices, including proper stock density on grasslands. 5. Remove winter feeding sites in proximity to streams. 6. Reduce livestock use of riparian areas. 7. Insure proper on-site waste system operations in proximity to main streams.

Allen/Dows Creek: → MED Priority
Neosho River → HIGH Priority
Cottonwood River, South → MED Priority (although no recommended action)
Cottonwood River → MOD Priority (although no recommended action)
Mud River → MOD Priority (although no recommended action)
Doyle Creek → HIGH Priority (addressed with NPDES permit)
Big Creek → MED Priority
Deer Creek → MED Priority
Turkey Creek → MED Priority
Owl Creek → MED Priority
Little Turkey Creek → HIGH Priority (addressed with NPDES permit)
Cottonwood River → HIGH Priority (addressed with NPDES permit)
Labette Creek → HIGH Priority (addressed with NPDES permit)

Biology (poor diversity in streams)

Source: livestock waste, crop fertilization (minor) **Cause:** runoff to streams
Priority: MEDIUM priority – 2 segments
Solution: Follow the action plan for Tallgrass Prairie National Reserve; mussel data collection / reintroduction, Assess land use outside of the Tallgrass Prairie National Preserve.

Fox Creek → MED priority
South Fork Cottonwood River → MED Priority

Silt and Lead

Source: Cropland **Cause:** Exposed soil (lead attached to the soil)
Solution: 1. Maintain conservation tillage and contour farming to minimize cropland erosion. 2. Install grass buffer strips along streams. 3. Reduce activities within riparian areas.

Neosho WMA → Load Reduction: Silt - 61% (no point sources) MED Priority
Lead – no load reduction specified (assumed tied to silt problem) – MED Priority

Eutrophication II (Phosphorus and Nitrogen)

Source: Urban lawns **Cause:** Overfertilization
Recommended solutions: Various urban best management practices (not specified)
Jones Park Pond → Load Reduction: P (30%) LOW Priority

Copper

Source: Copper sulfate used for treatment and nutrition of livestock, treatment of orchard diseases, and removal of nuisance aquatic vegetation such as fungi and algae (minor amounts possible naturally in soil or from urban/road areas (1% of watershed)).
Cause: soil erosion
Solution: filter strips, grasses waterways, education on $CuSO4$ use, investigate Stormwater sources
Allen Creek → Load Reduction: 87% LOW Priority
Eagle Creek → Load Reduction: 93% LOW Priority
Neosho River (Parkerville) → Load Reduction: 72% LOW Priority
North Cottonwood River → Load Reduction: 31.5% LOW Priority
Big Creek → Load Reduction: 86% LOW Priority
Owl Creek → Load Reduction: 86-91% LOW Priority
Neosho River → Load Reduction: 76% LOW Priority
Flat Rock Creek → Load reduction: 82% LOW Priority

Mercury

Source: battery recycling plant, coal burning power plants (outside watershed), trace amount from soils
Cause: discharges from plant, atmospheric deposition
Solution: Monitor anthropogenic contributions of mercury loading.
South Cottonwood River → load reduction: 79.1% LOW Priority

DO

Source: Cattails
Cause: Dense canopy causing high oxygen demand (in a wetland with small input)
Solution: Minimize any additional anthropogenic BOD sources
Minded Land WA Unit #42→ Load Reduction: P (0%) (no point sources) LOW Priority

Chlordane

Source: Found in fish tissue → bioaccumulation of banned chemical **Cause:** sediment erosion?
Solution: banned product TMDL = 0 → uphold fish advisory
Cottonwood River → LOW Priority

pH (few violations)

Source: Neosho - Undetermined **Cause:** Neosho - Undetermined
Solution: None, unless monitoring shows continued problems (Neosho)
Neosho River → LOW priority
Chanute/SF City Lake (nutrient enrichment cause) → MED Priority (address nutrients in separate TMDL)

Sulfate
Source: Pyrite in bedrock and tailings **Cause:** Mining exposed bedrock and tailings to water
Solution: Minimize anthropogenic oriented contributions of loading of sulfate.
Mined Land Lakes (9) and wetland (1) → LOW Priority No specified load reductions, concentrations not to exceed 900 mg/L.

Sulfate
Source: Natural Bedrock (gypsum) **Cause:** Dissolving bedrock
Solution: 1. Monitor any anthropogenic contributions of sulfate loading
2. Establish alternative background criterion. 3. Assess likelihood of river being used for domestic uses.
Cottonwood River → LOW Priority

NH3
Doyle Creek → HIGH Priority (addressed with NPDES permit)
Owl Creek → HIGH Priority (addressed with NPDES permit)
Little Turkey Creek → HIGH Priority (addressed with NPDES permit)
Labette Creek → HIGH Priority (addressed with NPDES permit)

Water bodies listed as impaired (KS) w/o TMDLs developed:
Zinc – 5 in Neosho Headwaters, 7 in Upper Cottonwood, 33 in Upper Neosho, 8 Middle Neosho
Atrazine – 7 in Middle Neosho

Spring River Watershed TMDLs

Zn, Pb, Cu, Cd, Biology, (KS)
Source: Mining tailings on land and in stream substrate **Cause:** Erosion of mine waste
Solution: Reduce metal loads on tributaries, remove contaminated sediments from streambeds
Priority: HIGH – throughout Spring R. system (Load reductions: up to 99.3% needed, esp. high flow)

Zinc (Missouri)
Source: Tri-State Mining waste, point source (some?) **Cause:** Acid mine seepage, soil erosion
Solution: 1) Reevaluate permits / require Zn monitoring 2) abandoned mine cleanup
Priority: MEDIUM – 2 segments (Load Reduction: ~50% in Turkey Cr. & ~10% in Center Cr.)

DO: Sediment causing low DO, (KS)
Source: agricultural fields, stream banks, permitted sites (CAFO, WWTP), septic systems, livestock
Cause: erosion (high flow discharge at CAFO, WWTP not considered problematic).
Solution: Renew permits, Cropland and Livestock BMPs, proper septic systems near streams.
Priority: HIGH – 1 segment (Shawnee Creek)

Nutrients, (Missouri)
Source: Agricultural fields **Cause:** Soil erosion
Solution: Reactivate Source Water Protection Plan; Sediment & animal waste reduction practices
Priority: MEDIUM – Lamar Lake (Load Reduction: Phosphorus 65%)

Bacteria (Missouri)
Source: from DNA testing: cattle, human waste, poultry waste during high flow (runoff events), other domestic animal operations (horse, dog (66 puppy farms), and pig).
Cause: 1) cattle stream access, 2) poultry (etc.) litter erosion (Spring season) 3) failed septic systems.
Solution: 1) Remove cattle from streams, 2) Poultry litter education and possible transport, 3) 319 project, 4) Replace/maintain septic systems.
Shoal Cr → MED Priority (Load reductions: 85% high flows, 53% mod. Flows, 72% low flows)
Goal: remove 50-100% cattle from streams, stop all septic leaks, reduce runoff 66%
TMDL suggest 100% cattle removal a low probability.

Eutrophication/pH (nutrients), (KS)
Source: Urban lawns/gardens **Cause:** overfertilization
Solution: Urban management practices (not specified)
Pittsburg College Lake → Load Reduction: P (55.8%) N(0%) (no point sources) LOW Priority
Plater's Lake→ Load Reduction: P (26.5%) N(0%) (no point sources) LOW Priority

Fecal Coliform Bacteria, (KS)
Cow Creek → HIGH Priority (addressed with NPDES permit)

Chlordane
Source: Found in fish tissue → bioaccumulated from past use of banned chemical
Cause: sediment erosion?
Solution: banned product TMDL = 0 → uphold fish advisory
Cow Creek → LOW Priority

Sulfate
Source: Pyrite in bedrock and mining tailings.
Cause: Pyrite exposed to oxidation due to mining operations
Solution: 1. Monitor any anthropogenic contributions of sulfate loading to river. 2. Minimize irrigation return flows 3. Reclaim strip mining areas
Cow Creek → LOW Priority

Ammonia, Biological Oxygen Demand, Suspended Solids
Source: Wastewaters Treatment Plant
Cause: Mechanical problems, high BOD flows from food processing plants
Solution: Upgrade plant. COMPLETED IN LATE 90's.
Clear Creek → HIGH Priority (although apparently solved)

Sediment
Source: Agricultural fields **Cause:** Erosion during storms
Solution: None provided. Conducting further assessment, including biological assessment of streams to determine true impact. The analysis showed biological impact as well.
N. Fork Spring River → LOW Priority (Load reduction up to 94%, depending on flow)

Water bodies listed as impaired w/o developed TMDLs:
Turbidity (1); Zinc (1); Cadmium (1)

Lake O' the Cherokees Watershed TMDLs

Bacteria (OK)
Sources: livestock (by far largest), land application, agricultural activities, septic systems, domestic animals, wildlife, (no problems from WWTPs or point sources in OK except for minor contributor in Tar Creek Watershed (no CAFOs in OK study area)).
Causes: not specific (presumed cattle access to stream, soil erosion, poorly functioning septics)
Solution: none given (separate process) → however, livestock and cropland BMPs
Priority: not specified (presumed high) - 12 segments
Load reductions: variable (up to 99.7% - see table below)

WATERBODY	FC INS	EC INS	EC GEO	ENT INS	ENT GEO
Drowning Creek	28%			56%	47%
Horse Creek	86%				
Fly Creek	49%			84%	77%
Little Horse Creek	49%	59%	53%		
Cave Springs Branch	47%	59%	53%		
Honey Creek	28%			99%	90%
Sycamore Creek				3%	26%
Tar Creek				84%	80%
Cow Creek	60%				
Fourmile Creek	55%				
Russell Creek	49%				
Elk River				78%	52%

FC – Fecal coliform; EC – E. coli; ENT – Enterococci; INS – instantaneous; GEO – geometric mean

Zn, Pb, Cd (KS)
Sources: Mine waste and wastewater lagoon **Causes:** Mine waste runoff and lagoon discharges
Solution: 1. Create/restore riparian vegetation 2. Grass buffer strips 3. Mined land reclamation. 4. Load allocations for permitted wastewater lagoon.
Priority: MEDIUM – 1 segment (Tar Creek (KS))

Water bodies listed as impaired (OK) w/o developed TMDLs:
Organic enrichment/Low DO (8); Ammonia (1); Chlorides (2); TDS (1); Sulfates (2); Turbidity (3); pH (1)

Elk River Watershed TMDLs

Nutrients (Nitrogen and Phosphorus)
Sources: Point sources (WWTP, poultry processing), septic systems, fertilizer and litter application, grazing animals, wildlife, urban areas
Causes: no nutrient limits for point sources in past, failing septic systems, overapplication of fertilizer, animal access to streams, pasture erosion, unsustainable numbers of livestock.
Solution: 1) Phosphorus limits for larger, expanding, and new point source dischargers, 2) Voluntary agricultural BMPs, 3) Management plans to deal with NPS pollution.
Priority: MEDIUM – 11 stream segments (Load reductions variable with flow (60% problem point sources))

Bacteria (one segment listed in OK, see Lake O' the Cherokees Watershed above)

APPENDIX C: DIRECTORY OF CITIZEN-BASED WATERSHED GROUPS IN GRAND LAKE WATERSHED

Grand Lake O' the Cherokees Watershed

Grand Lake O' the Cherokees Watershed Alliance Foundation Inc.
PO Box 451185, Grove, OK 74345-1185

Neosho River Subwatershed

1. Twin Lakes WRAPS
   Flint Hills RC&D, (620) 767-5111

2. Marion Reservoir WRAPS
   Marion County Conservation District (620) 364-3149

3. Upper Neosho River WRAPS
   Kansas State University (785) 532-2911 & (785) 532-7832

4. Middle Neosho River WRAPS
   Kansas State University (785) 532-2911 & (785) 532-7832

5. Neosho Headwaters WRAPS
   Kansas State University (785) 532-2911 & (785) 532-7832

6. Eagle Creek WRAPS
   Coffey County Conservation District, (620) 364-3149

Spring River Subwatershed

1. Kansas Spring River WRAPS
   See-Kan RC&D, (620) 431-6180

2. Upper Shoal Creek: Shoal Creek Watershed Improvement Group
   Rt 2 Box 230-A, Purdy, MO 65734

3. Lower Shoal Creek: Environmental Task Force of Jasper & Newton Counties
   1 S. Main, Suite 102, Webb City, Missouri 64870

Elk River Subwatershed

Elk River Watershed Improvement Association
P. O. Box 6, Pineville, MO 64856

Lake O' the Cherokees Subwatershed

Grand Lake Water Watch, Inc.
9630 U.S. Highway 59 N, Grove, OK 74344

APPENDIX D: GEOGRAPHIC EXTENT OF KANSAS WRAPS GROUPS IN GRAND LAKE WATERSHED BY HYDROLOGIC UNIT CODE

Hydrologic Unit Codes (HUC) are labels for watershed subdivisions as part of a classification system for the United States. Essentially, the fewer digits in the code, the larger the watershed. One HUC 8 (8 digits) can be divided into several HUC 10s (10 digits) which can be divided into several HUC 12s (12 digits), and so on. For more information on HUCs, visit http://water.usgs.gov/GIS/huc.html.

The Kansas WRAPS groups are organized by HUC areas as shown below:

Spring River WRAPS:
1 HUC (8) 11070207

Middle Neosho WRAPS:
1 HUC (8) 11070205

Upper Neosho WRAPS:
1 HUC (8) 11070204

Neosho Headwaters WRAPS:
1 HUC (8) 11070201

Eagle Creek WRAPS:
3 HUC (12) 1107020104 -04, 1107020104-03, 1107020104-05

Twin Lakes WRAPS:
1 HUC (10) 1107020101

Marion Lake WRAPS:
1 HUC (10) 1107020201