The Upper Little Sac River Watershed Management Plan

By: The Watershed Committee of the Ozarks

March 2020

"U.S. Environmental Protection Agency Region 7, through the Missouri Department of Natural Resources, has provided partial funding for this project under Section 319 of the Clean Water Act," Little Sac #G14-NPS-02

Disclaimer

The Upper Little Sac River Watershed Management Plan has been written as clearly as possible to help stakeholders understand and use this information to make future watershed management decisions. It is a non-regulatory document that portrays the watershed and its water quality, actions presently being taken to maintain water quality, and what actions are needed to improve water quality. All Best Management Practices (BMPs) suggested to stakeholders are purely voluntary in their implementation. It is the residents in the Little Sac River Watershed who are able to improve water quality. The water can only be clean as long as people maintain the soil and land in the watershed.

This plan is intended to be dynamic. One set of plans made at this time may not meet the challenges that arise in the future. If major changes occur in the watershed or the water quality of the Little Sac River, the plan should be revised as deemed necessary. Otherwise, it should be re-visited every 5 years to evaluate the effectiveness of the management measures and the public's perception of the water quality in the watershed.

Nine critical elements, as suggested by the Environmental Protection Agency (EPA) and the Missouri Department of Natural Resources (MODNR), are also included to ensure a successful watershed management plan. Comments and concerns were recorded from citizen meetings within the watershed and then adapted to the nine critical elements. This approach satisfies both regulatory purposes and public concerns about the watershed. The nine elements also act as a framework for the management plan.

These basic elements are listed as follows:

a) Identify the sources that will need to be controlled to reduce pollution levels.
b) An estimate of the load reductions expected from the management measures.
c) Describe the management measures needed to achieve the pollution reductions.
d) Estimate the amounts of technical and financial assistance needed.
e) An Information and education component.
f) Schedule or timeline for implementing the nonpoint source management measures.
g) Description of the interim measurable milestones.
h) Set of criteria to be used to determine if load reductions are being achieved
i) Monitoring component to evaluates the effectiveness of the implemented measures.

For a description of each of the nine elements see Appendix H.
For any questions, comments, or concerns about this plan or the Little Sac River Watershed, contact the Watershed Committee of Committee of the Ozarks by phone at 417-866-1127 or visit our Watershed Committee of the Ozarks website.

Table of Contents

Disclaimer 2
Contents 3
List of Figures 5
Executive Summary 6
Watershed Management Plan Introduction 6
Purpose of the Plan 6
History of the Watershed Committee of the Ozarks 7
History of Greene County Soil and Water Conservation District (SWCD) 7
History within the Little Sac River Watershed 7
Overview of the Little Sac River Watershed 8
Soils, Climate, and Geologic Characteristics 9
Hydrologic Setting 9
Land Use 9
The Little Sac River: A River Level View 10
Historic Issues in the Little Sac River Watershed 12
Northwest Wastewater Treatment Plant 12
Springfield Sanitary Landfill 13
Springfield Stormwater Engineering and Water Quality 13
Springfield-Greene County Integrated Plan for the Environment 15
Describing the Little Sac River Watershed with Maps 16
List of Existing Water Quality Information and Data 23
Little Sac Water Quality Data 23
Little Sac River Watershed Related Projects 23
Thesis Work in the Little Sac River Watershed 24
Sac River Basin Water Quality Data Gap Analysis Summary 26
The Little Sac Fish Index and Biotic Integrity 27
Sources of Impairment and Pollutant Load Reductions 28
Impairments: 303(d) List 28
Quantified Pollutant Load Attributed to Each Source of Impairment 29

Remaining Load 29
Load Reduction Goal 29
Modeling and Critical Area Identification 30
Bacteria Source Tracking 34
Critical/Priority Areas Maps 36
Completed Watershed BMPs 42
Public Engagement 43
Recommended Management Measures 44
Reduction Action 1: Reduce Bacteria Pollution in the Watershed 44
Stream Corridor Improvement and Protection 44
Soil Health and Restoration 44
Remediate and Improve Failing Onsite Wastewater Management Systems 45
Reduction Action 2: Reduce Sediment Erosion in the Watershed 45
Promote Prescribed Rotational Grazing Management and Solar Watering 45
Reduction Action 3: Reduce Stormwater Runoff in the Watershed 45
Tree Planting 45
Rainwater Collection 45
Reduce Impervious Surface Area 46
Reduction Action 4: Increase Watershed Education and Awareness 46
Promote BMPs to Citizens and Landowners in Upper Little Sac River Watershed 46
Groundwater Monitoring Program 46
Watershed Center Educational Efforts 47
Promote Septic Tank Education 47
Promote Education about preventing spread of Hydrilla 47
Recommended Management Measures Implementation 48
Financial and Technical Assistance 51
Evaluating the Plan 53

List of Figures

Figure 1 - Little Sac River Watershed 8
Figure 2 - Between Highway O and Hackney Bridge 10
Figure 3 - Below Hackney Bridge 10
Figure 4 - Spring White Bass Season 11
Figure 5 - Longear Sunfish....11
Figure 6 - Carp fishing on fly rod 11
Figure 7 - Little Sac River Native Mussels 11
Figure 8 - Ephemeroptera Mayfly....11
Figure 9 - Little Sac River between Farm Road 44 Bridge and Highway BB 11
Figure 10 - Below Greene County Farm Road 125 12
Figure 11 – The Upper Little Sac River Watershed 16
Figure 12- TMDL Listed Stream Map with major point sources identified 17
Figure 13- Springs Map 18
Figure 14-Sinkhole Map 19
Figure 15-Soil Suitability Map....20
Figure 16-Public Lands Map 21
Figure 17- Land Use/Land Cover 2005 Map....22
Figure 18-Average E.coli levels in the Little Sac Watershed-Sac River Data Gap Analysis 27
Figure 19-Bacteria Load Duration Curve....33
Figure 20-Land Use Map and Bacteria Source Tracking sample locations 35
Figure 21-Critical Areas for BMP Implementation....36
Figure 22-Visual Assessment Map 37
Figure 23-Critical Areas defined in the Load Duration Curve Report 38
Figure 24-Tier One subbasins for implementation....39
Figure 25-Tier Two subbasins for implementation 40
Figure 26-Tier Three subbasins for implementation 41

List of Tables

Table 1-BMP Scenarios in SWAT Model....31
Table 2-Percent pollutant reductions for each scenario in SWAT Model....31
Table 3-Group Specific Bacteria Contamination Table 33
Table 4-Soil and Water District BMP's Completed 2009 to 2019 41
Table 5-Urban BMP's Completed 2009 to 2019....41
Table 6-Management Measures and Implementation Schedule....47
Table 7-Cost Estimates based on 700 acres of BMP Treatment per year 53

Executive Summary

The Little Sac River had a 27-mile reach listed on the Missouri 303(d) list for E. coli in 1998 and Pea Ridge Creek was listed in 2019 for unknown pollutant and Fellows Lake was listed in 2012 for atmospheric depositional mercury. The sources of the impairment are primarily nonpoint source pollution. Many local partners in the community work together to address these sources of pollution. Water quality data helps to analyze, address and plan for the future health of the watershed by creating a targeted list of recommended best management practices to reduce these sources of pollution. This document provides a culmination of all the water quality information for the Upper Little Sac River and the conclusions of the planning process.

Watershed Management Plan Introduction

Purpose of the Plan

WCO Mission Statement: *"The mission of the Watershed Committee of the Ozarks is to sustain and improve the water resources of Springfield and Greene County through education and effective management of the region's watersheds."*

A Watershed Management Plan for the Little Sac River Watershed (HUC 1029010604) is necessary to guide stakeholders within the watershed as they seek to improve the water quality of the Little Sac River. This plan addresses the upper, or southern, portion of the Little Sac River Watershed (HUC 1029010604). In the future, the lower, or northern, portion of the watershed (HUC 1029010605) will be addressed. The original plan was written in 2009; this document is the updated version of that plan. The Watershed Committee of the Ozarks (WCO) believes that updating this watershed management plan for the Little Sac River Watershed will help to protect and to improve water quality in the rivers and streams as well as in Fellows, McDaniel, and Stockton lakes, by identifying pollutant sources, offering guidance for implementing better management practices, setting reasonable goals, and developing a timeline for implementation. An updated management plan will also help current and future monitoring evaluation programs to determine the success of implemented projects/programs.

Development of a watershed management plan increases the success of future projects and addresses issues related to the current Total Maximum Daily Load (TMDL) for the Little Sac River. This plan helps determine where future efforts should be focused and fulfills specific grant application requirements for securing future and potential cost-share funds to implement Best Management Practices (BMPs).

The primary focus areas for the plan relate to addressing the TMDL for the Little Sac River and the need to protect drinking water/source water. The current TMDL for the Little Sac River is focused on the bacteria levels within the river. To follow the approved TMDL, many of the management measures in the watershed plan are focused on reducing the bacteria/E. coli present in the river. The management measures also address other water quality issues such as education, stormwater runoff, nutrients, and sediment. The load reductions for pollutants not causing the impairment will be addressed in the appendices.

History of the Watershed Committee of the Ozarks

The WCO began 34 years ago when Springfield Mayor Harry Strawn, sent a memo to the Chair of the Board of Public Utilities, N. L. "Mac" McCartney. The memo began: "With your concurrence, I have appointed an ad hoc task force to develop a program for the protection of surface and subsurface watersheds which supply Springfield and the surrounding area with drinking water." It was a prophetic statement and a visionary approach. Development was encroaching into the drinking watersheds and officials were worried about whether public policies and programs would effectively protect their precious drinking water resources.

In November 1983, the Task Force issued its report and recommendations, many of which are pertinent and instructive even today. One recommendation centered on the need for a permanent body whose primary purpose would be oversight and protection of public drinking water sources. From this recommendation, the Watershed Management Coordinating Committee was established. In 1989, the organization became a non-profit corporation and changed its name to Watershed Committee of the Ozarks. The WCO adopted a six-member board, comprised of three citizen appointees representing the respective sponsors and three at-large positions.

History of Greene County Soil and Water Conservation District (SWCD)

In the 1930s, Americans realized how devastating soil erosion could be as the Dust Bowl swept across the nation, relocating an estimated 300 million tons of soil. Legislation began to take shape to better manage and conserve our nation's soil. In 1935, Congress set up the Soil Conservation Service as an agency under the Department of Agriculture. In 1937, the Standard State Soil Conservation law was developed. This act provided for the organization of soil conservation districts as governmental subdivisions of the state in order to carry on projects for erosion control.

Then, in 1943, Missouri's General Assembly passed Senate Bill 80, the Soil Districts Law, which ultimately became Chapter 278 of the Missouri Revised Statutes. Gradually over the next 49 years counties across Missouri have been forming local soil and water conservation districts.

The Greene County Soil and Water Conservation District was formed in 1969. The district is locally led by farmers who live within the county and are elected by other farmers in the county to serve four-year terms.

The cost-share program provides financial incentives to landowners for up to 75 percent of the cost for installation of soil conservation practices that prevent or control excessive erosion and runoff. Soil and water conservation districts also provide technical support with the design, implementation and maintenance of practices. By promoting good farming techniques that help keep soil on the fields and our waters clean, the Greene County Soil and Water Conservation District is working with landowners to conserve and protect farmland in the State of Missouri.

A 1/10th of 1% parks, soils, and water sales tax was passed by Missouri voters in 1984 to fund state parks and soil and water conservation efforts. It is estimated that more than 148 million tons of soil have been saved since the start of the sales tax, but millions of tons of soil still wash away every year on cultivated cropland in Missouri. Much of this tax has been used to assist agricultural landowners through voluntary programs that are developed by the SWCD By promoting good farming techniques that help keep soil on the fields and our waters clean, each soil and water conservation district is helping protect the water quality and conserving the productivity of our working lands.

Both the WCO and the Greene County SWCD helped to implement past management measures in the Little Sac River Watershed. During the Little Sac Restoration Project (2001–2005), a previous 319-project in the Little Sac River Watershed, the WCO partnered with the Greene County SWCD, Natural Resources Conservation Service (NRCS), and Missouri Department of Conservation (MDC) professionals to aid in the installation of conservation practices with landowners in the watershed. The projects completed are as follows: five riparian restoration sites, five management intensive grazing systems, six alternative watering systems, and one animal waste containment system.

Overview of the Little Sac River Watershed

The Little Sac River begins at the north edge of Springfield and Strafford to form Fellows Lake and McDaniel Lake. On its journey north into Stockton Lake, the Little Sac's 41.5-mile channel gains flow through springs and its major tributaries: Slagle Creek, North Dry Sac, South Dry Sac, and Asher Creek. The 390-square mile watershed encompasses the towns of Willard, Walnut Grove, and Morrisville. This watershed has a diverse landscape that changes from very urbanized/high-density population in the upper, southern part of the watershed to rural agricultural land in the middle two-thirds and recreational areas surrounding Stockton Lake. The three lakes (Stockton, Fellows, and McDaniel) are public drinking water sources for Springfield and Greene County residents. The lakes also annually provide recreation, fishing, and hunting opportunities for thousands of users.

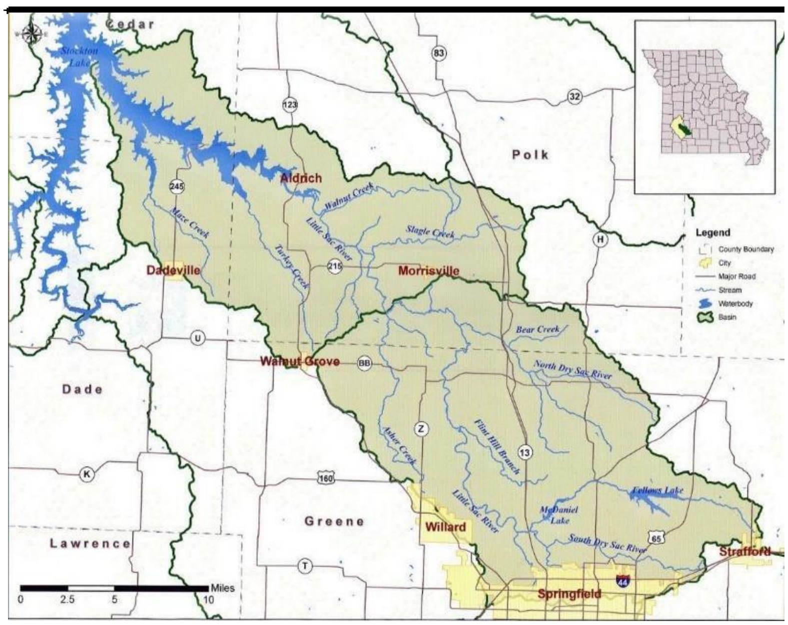

Figure 1 - Little Sac River Watershed

Soils, Climate, and Geologic Characteristics

The Little Sac River Watershed originates in Eldon-Pembroke, Peridge-Wilderness-Goss-Pembroke, and Needleye-Viraton-Wilderness soil associations. It then flows through Peridge-Wilderness-Goss-Pembroke soils. The lower reach flows through Hartville-Ashton-Cedar gap-Nolin bottomland soils until it is inundated by the Stockton Reservoir. Two impoundments near the headwaters of the Little Sac River Watershed (Fellows Lake and McDaniel Lake) cause a rapid descent to Hartville-Ashton-Cedar gap-Nolin bottomland soils. In general, the soils are moderately deep to very deep, moderately well-drained to well-drained, and medium- to fine-textured.

The watershed is characterized by a temperate climate with warm, humid summers and cool, wet winters. The National Oceanic and Atmospheric Administration (NOAA) operates a climatological station at the Springfield-Branson Regional Airport, located in the northwestern part of the city of Springfield. The average temperature range as measured at the airport is 67–90° Fahrenheit (F) during the summer and 20–42°F during the winter. The average annual precipitation is between 40–42 inches (in) of rainfall and 17 in of snowfall in Springfield. The annual runoff from precipitation ranges from 8–10 in. Elevations in the watershed range from 270 m (885 ft) at the watershed outlet, to 455 m (1490 ft) at the southeastern boundary. The major part of the watershed consists of rolling plains. On the east side, broad upland areas divide the Little Sac River Watershed from the Pomme de Terre watershed.

Hydrologic Setting

The Ozarks, including the Little Sac River Watershed, are well-known for their karst geology characterized by numerous sinkholes, caves, bedrock fractures, and streams-both losing and on the surface. The karst developments typical of the Springfield plateau aquifer are mostly located in the southern, more urban and suburban portions of the Little Sac River Watershed.

Two aquifers lie under the Little Sac River Watershed. The Ozark aquifer is high-yielding, deeply confined, and generally of very good quality. It provides municipal, agricultural, and industrial water. The Springfield plateau aquifer is an unconfined, shallow aquifer ranging from near the surface to down 200–300 ft and is recharged by precipitation. The shallow aquifer was generally of fairly good quality and was a major drinking water resource until the mid-1950s. Karst geologic conditions in the Springfield area make the shallow aquifer vulnerable to contamination. Contamination of this aquifer has prompted stricter regulations for wells; now, this aquifer requires wells to be further cased out and drilled into the deeper aquifers. Most of the domestic water is now pumped from the deep Ozark aquifer, but the Springfield plateau aquifer still provides agricultural and industrial water.

Land Use

The Upper Little Sac River Watershed is located in the Ozark Border Area. This area is part of the northeast and central farming forest region. Feed grains and hay are the main crops. Summer droughts and steep slopes limit the use of the land for crop production. Shallow wells, small creeks, or springs are often used for livestock needs. Deep wells supply drinking water and water for high-volume uses. This area supports oak-hickory forests. The grassland supports a combination of introduced and tall native prairie grasses consisting mainly of Indian grass, little bluestem, big bluestem, and switchgrass.

Introduced grasses include fescue, annual crab grasses, and Kentucky bluegrass. The pastures are mostly in fescue grass over-seeded with red clover.

The watershed consists mostly of grassland (67%) and forests (30%). The grassland designation includes hay, pasture, and land enrolled in the Conservation Reserve Program (CRP). Hay and CRP land, which are sometimes considered cropland, behave more like grassland in terms of runoff, erosion, and nutrient loads and have been left in this class. Urban areas comprise 2.4% of the watershed. A high water quality contamination potential exists due to the high urban population density and the number of impervious surfaces. Estimates have been made indicating that the most urbanized portion of this watershed has about 25% imperviousness.

The Little Sac River: A River Level View

The upper part of the Little Sac River starts near Strafford. It flows through Fellows Lake and McDaniel Lake before joining with the South Dry Sac. This is where the river begins to hold enough water to float a canoe. Shortly after the confluence of the Dry Sac River, the Little Sac River receives the effluent of the Northwest Wastewater Treatment Plant (NWWTP). This discharge has raised concerns in the past about downstream water quality and conditions. However, the river below this discharge point remains relatively healthy and has some outstanding natural attributes. The development of this management plan allows us to gain a more detailed understanding of these attributes and provides a means for future water quality improvements throughout the watershed.

Figure 2 - Between Highway O and Hackney Bridge

The Little Sac River is a different type of stream than most others. Its unique location places it halfway between the clear waters of the Ozarks and the turbid waters of western and north Missouri. The upper half is characterized by coarse gravel, cobble, and boulders. The lower section is characterized by turbid water, large woody debris, and mud. Same stream—yet the end looks nothing like the beginning. This stream is just as scenic as its nearby cousins, Pomme de Terre and the Niangua. It has its share of bluffs, rock ledges, small waterfalls, fast chutes of white water, and fish, too. The Little Sac River has an abundance of common carp, bass, and a variety of sunfish in the rocky areas. The lower Little Sac River is influenced by Stockton Lake and many species swim up the river to spawn, such as white bass, walleye, and catfish.

Figure 3 - Below Hackney Bridge

Though carp may not be the best fish to put on the dinner table, they are a wary fish to approach and are strong fighters once caught. Carp are a challenge to any angler looking for a great sporting opportunity.

Figure 4 - Spring White Bass Season

Figure 5 - Longear Sunfish

Figure 6 - Carp fishing on fly rod

Figure 7 - Little Sac River Native Mussels

Figure 8- Ephemeroptera Mayfly

Figure 9 - Little Sac River between Farm Road 44 Bridge and Highway BB

There is also plenty of wildlife present in the water. Native mussels, mayflies, red ear sliders, northern water snakes, great blue herons, yellow crowned night herons, green herons, barred owls, whitetail deer, beavers, otters, mink, wood ducks, and many other water-loving wildlife live on the banks of the Little Sac River.

Even though the Little Sac River receives effluent from a wastewater treatment plant, and is partially an urban stream, one should not write it off. It is a great place to enjoy wildlife and the characteristic scenery of the Ozarks.

Historic Issues in the Little Sac River Watershed

Historically, there have been concerns among the downstream landowners, primarily agricultural producers, that the real water quality impairments in the Little Sac River arise from the urban area at the top of the watershed—primarily the Springfield Landfill and the NWWTP. Below are descriptions of the efforts of the City of Springfield to protect and preserve the water quality of the Little Sac River.

Figure 10 - Below Greene County Farm Road 125

Northwest Wastewater Treatment Plant

The City of Springfield is committed to the protection of the water quality of the Little Sac River, as evidenced by investments in improvements at their NWWTP. In 2008, $21,279,000 was spent on improvements to increase the peak flow capacity of the plant from 12 million gallons per day to 22 million gallons per day, while treating an average daily flow of 6 million gallons per day. It is expected that the expansion will meet the needs of the ever-growing area estimated over the next 5 to 10 years. In addition, facilities for the treatment/removal of phosphorus and nitrates were added—a voluntary measure on the part of the City of Springfield. These pollutant loads are addressed in the National Pollutant Discharge Elimination System (NPDES) permit. No regulations currently exist or are in process to designate the Little Sac River as an area to be covered by stricter nutrient management regulations. The plant has also begun year-round disinfection using UV equipment, which provides the benefit of higher quality effluent without the use of chlorine.

To learn more, visit the Northwest Wastewater Treatment Plant's website.

Springfield Sanitary Landfill

The Solid Waste Management Division staff continue to make improvements to the stormwater management and compliance practices used at the Springfield Sanitary Landfill (SSLF). The SSLF staff are continuously re-vegetating disturbed soil and using other stormwater management practices to reduce erosion and prevent suspended solids from leaving the property. The stormwater is regularly monitored and reported to ensure compliance with all applicable state and federal regulations. To learn more visit, visit the Springfield Sanitary Landfill website.

Springfield Stormwater Engineering and Water Quality

The City of Springfield Stormwater Engineering and Water Quality division has taken many steps toward protecting the water quality of the Little Sac River. Current improvement projects in the Little Sac River Watershed area within the city include:

- **Dickerson Park Zoo:** BMPs to address runoff from animal exhibits and to stabilize lake bank erosion.
- **Doling Park:** Lake improvements to address bank erosion and water quality.
- **Regional Detention Basin Plan/Implementation:** Projects to control flooding, to reduce erosion, and to improve water quality.
- **Urban Stream Monitoring:** Monitoring is conducted to characterize effects of stormwater runoff on urban streams. In the Little Sac River Watershed, several years of monitoring data have been collected on Pea Ridge Creek, Spring Branch, and Grandview Branch.
- **Stormwater Design Criteria:** To protect the city's drinking water source, water quality requirements have been in place since 1999 for all new developments in the South Dry Sac Watershed. Recent revisions to the design criteria have expanded water quality requirements city-wide and include significant redevelopments, such as the North Town Mall Wal-Mart Supercenter, which is located in the Little Sac River Watershed. Designs emphasize natural channel protection, green engineering, low-impact development and new stream buffer requirements.

- **Water Quality Standards:** Springfield City Council officially adopted the water quality standards in December 2017.
- **Industrial and High-Risk Runoff:** The City of Springfield conducts stormwater monitoring and inspections of industries and other high-risk facilities for pollution prevention.
- **Land Disturbance Program:** In fall 2008, the City of Springfield implemented a land disturbance permit program for erosion and sediment control on sites 1 acre or larger, including stormwater pollution prevention plan review, inspection, and enforcement.
- **Public Education/Outreach:** The City of Springfield, in partnership with the WCO, James River Basin Partnership, and others, is continually expanding its public education/outreach efforts through a variety of programs and projects, including:
    - **Yard Ethic Program:** Began in 2000 as Show-Me Yard and Neighbors program to promote environmentally friendly yard care to homeowners/professionals through educational workshops held throughout the year. In 2018, the program was revitalized and renamed the program Yard Ethic. The Yard Ethic program provides information and yard certification for residential yards to encourage practices that protect water quality including native plants, soil testing, rain barrels, rain gardens, tree planting, and composting.
    - **Rain Garden Demonstration Projects:** 15 rain garden demonstration projects have been completed throughout Springfield.
    - **Rain Barrel Rebate Program:** 1,781 rain barrel rebates have been provided to Greene County residents since 2007.
    - **Storm Drain Manhole Cover Design Contest:** Winning design with Upstream Starts Here, Protect Our Waterways is now standard for all new storm drain manhole covers.
    - **The Clean Pavement Initiative** encourages pavement sealant choices that are more protective of water quality through providing information and recognition for property owners.
    - **The City's educational efforts** also currently include radio ads on a variety of water quality messages, informational materials in the Neighborhood News publication, social media posts, tabling at community events, and speakers and tours for schools and other groups.

Springfield-Greene County Integrated Plan for the Environment

In 2014, the City of Springfield, Greene County, and City Utilities created a citizen environmental priorities task force comprised of 30 community leaders of various backgrounds and groups to prioritize environmental needs and investments based on effective solutions to address the most pressing problems. The outcome of that process created an overall priorities list with "Clean and healthy drinking water supply" listed as a top tier 1 priority. Below is a section from the recommendations section of the environmental task force report.

"During the process, members of the Environment Priorities Task Force were shown the big-picture issues associated with overall environmental protection and developed a new paradigm that few people have the opportunity to witness. From this, the Task Force developed a vision statement, goals, policy statements, and identified priorities to guide Springfield, Greene County, and City Utilities in their Integrated Planning work. The recommendations are listed below.

The recommendations of the task force are being carried out by the City, Greene County and City Utilities of Springfield as well as various community members that served on the committee. A follow-up report about the progress since the initial report from 2015 is currently being worked on. The City of Springfield and Greene County have hired HDR a local consulting firm to analyze all the local data collected to create an SROI (sustainable return on investment) model. The SROI model will yield information to help answer the question if you had one dollar to spend in the community which environmental practices (land, air and water) would provide the largest benefit for the community.

Vision Statement:
The environmental vision for Springfield-Greene County is as follows: Our community is committed to clean water, air, and land through responsible stewardship of our natural and economic resources for ourselves and future generations.

Goals:

- The environmental goals for Springfield-Greene County are listed below:
- Protect and improve human health and the environment.
- Protect our watersheds so that people can use them for drinking water supply, fishing, swimming, boating, and wading.
- Sustain the quality of the environment for future generations.
- Protect air, water, and land resources as they support high quality food production.
- Protect the environment to attract/retain business and maintain our high quality of life.
- Maintain compliance with environmental regulations"

The entire Integrated Plan for the Environment Environmental Priorities Task Force Report can be found at this link: https://springfieldintegratedplan.com/wp-content/uploads/2018/05/epTaskForceFinalReport020615.pdf

Describing the Little Sac River Watershed with Maps

Each of the following maps are used to provide a general description of the watershed. They describe the physical features of the land area, give general information, and help in illustrating the watershed. The watershed depicted is based on WBID 1381 for the Little Sac River, which extends to Stockton Lake about midway into the Walnut Creek-Little Sac River 12-digit HUC. For this reason, the watershed boundaries delineated cover a slightly larger area than the USGS HUC boundaries. As such, the following maps depicting the watershed will be based on this larger watershed boundary.

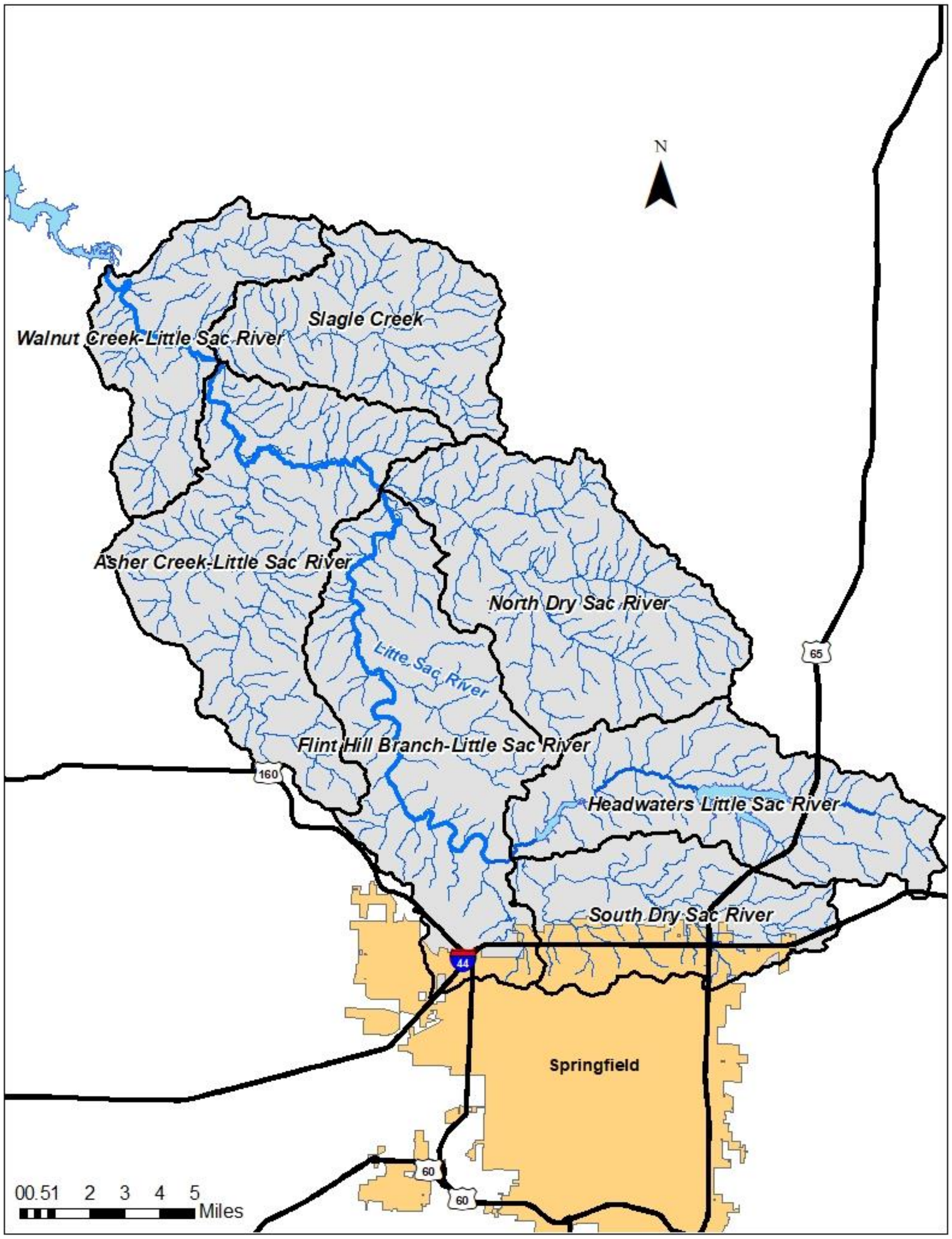

Figure 11 – The Upper Little Sac River Watershed.

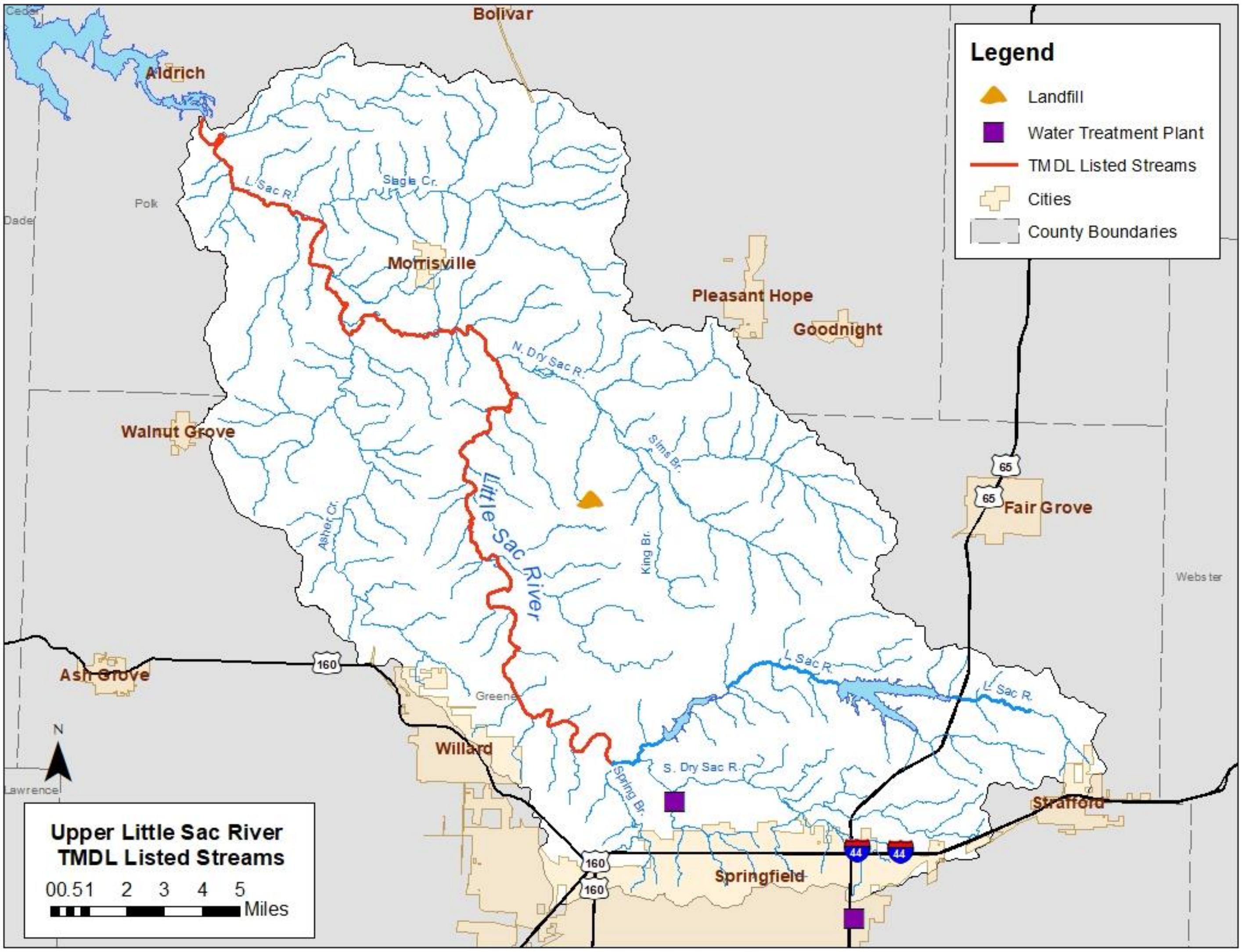

Figure 12 – TMDL Listed Stream Map with major point sources identified

The map in figure 11 displays the Upper Little Sac Watershed in proximity to Springfield, MO and highlights the section of the Little Sac River that is listed on the 303d list for bacteria. The map also displays the location of the Springfield Sanitary Landfill and the Northwest Wastewater Treatment Plant.

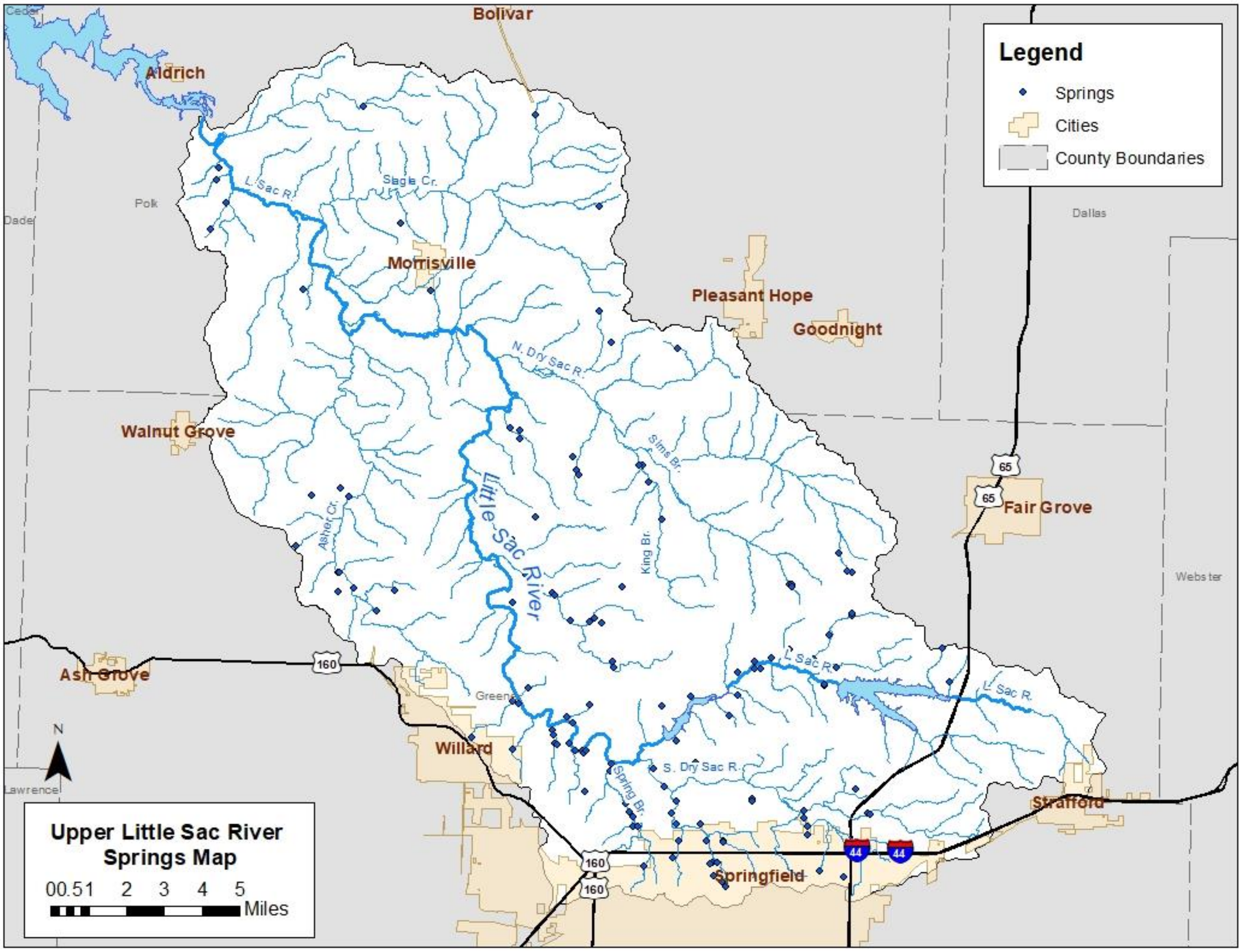

Figure 13 - Springs Map

The map in figure 12 displays the springs in the Upper Little Sac Watershed. Numerous springs are present in the watershed which conveys the highly karst terrain present in the watershed. Springs can be a potential conduit for transferring pollutants. The groundwater and surface water in this watershed are highly connected.

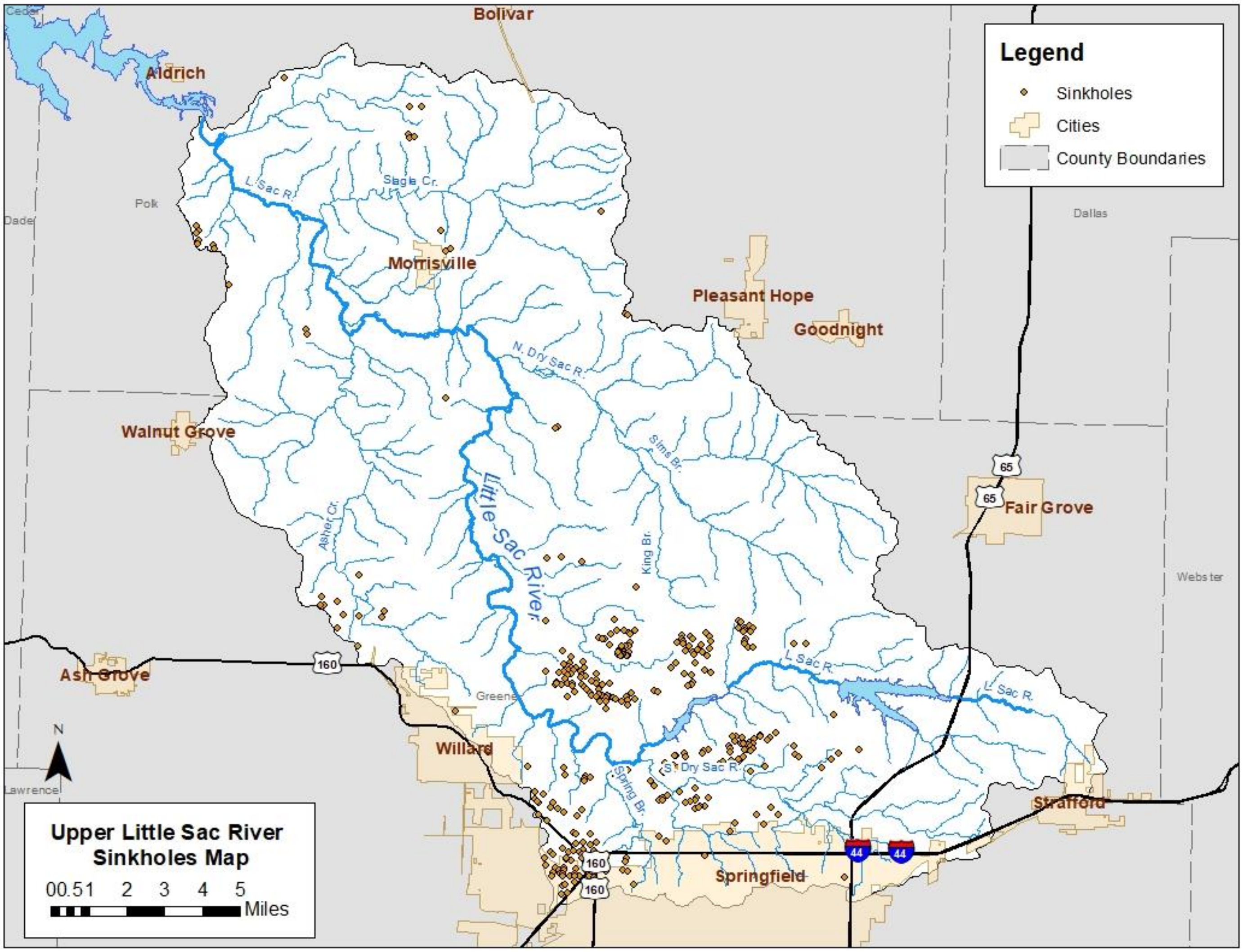

Figure 14 - Sinkhole Map

The map in figure 13 displays the sinkholes present in the Upper Little Sac Watershed. This is also a karst feature that provides a lot of connection with surface runoff in the watershed which relates to how potential pollutants can travel. There is a possibility that potentially more sinkholes exist in the watershed that have not been discovered or mapped.

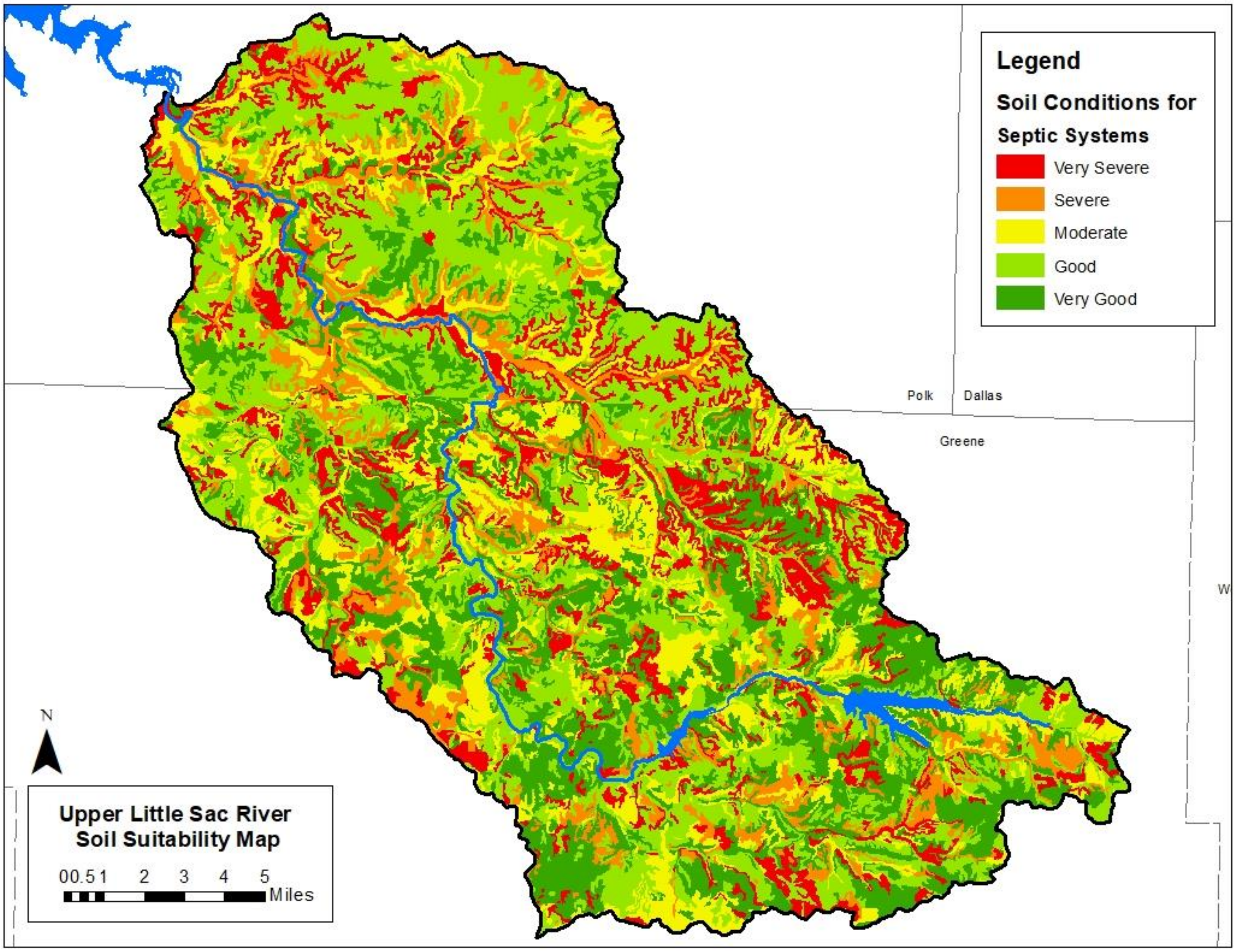

Figure 15 - Soil Suitability Map

The map in figure 14 displays the soil suitability in the watershed as it relates to onsite wastewater treatment. A large portion of the residents in the watershed are in rural areas with limited access to public sewer, therefore onsite wastewater (septic systems) are prevalent in the watershed. The soil suitability for treatment of septic systems is important for water quality because 80% of the treatment of wastewater occurs in the soil. Soils listed as very severe and severe are thin and rocky soils that cannot adequately treat wastewater unless additional treatment is added which can be expensive and cost prohibited for landowners. Also, a failing septic system might not always surface and the improperly treated wastewater can flow underground without the landowner knowing until the septic system is inspected. Failing or improperly installed septic systems are a known water quality problem in the watershed.

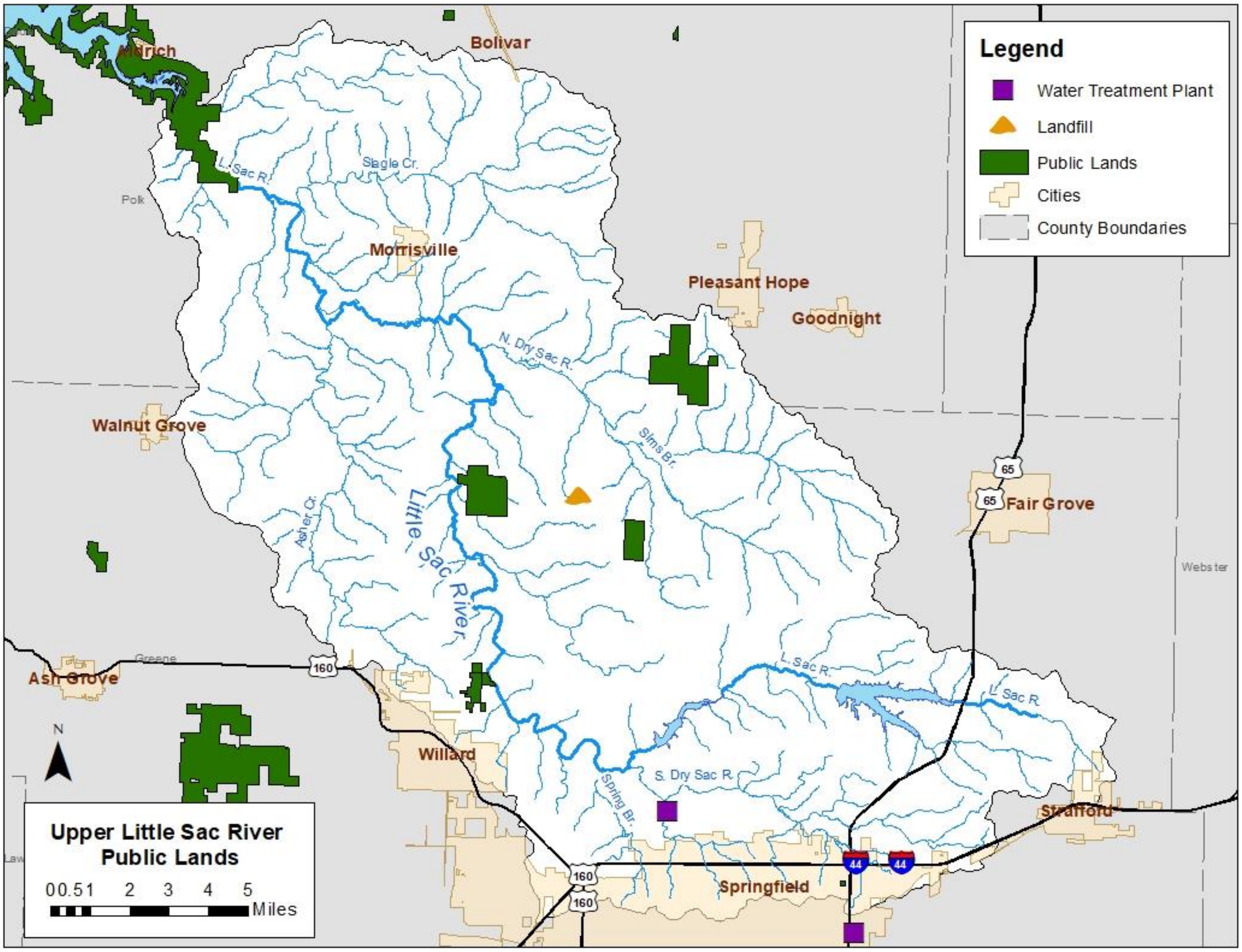

Figure 16 - Public Lands Map

The map in figure 15 displays the public land in the watershed. There are very limited public lands in the watershed meaning most of the watershed is privately owned. This is important for water quality because there is no control over what land practices occur.

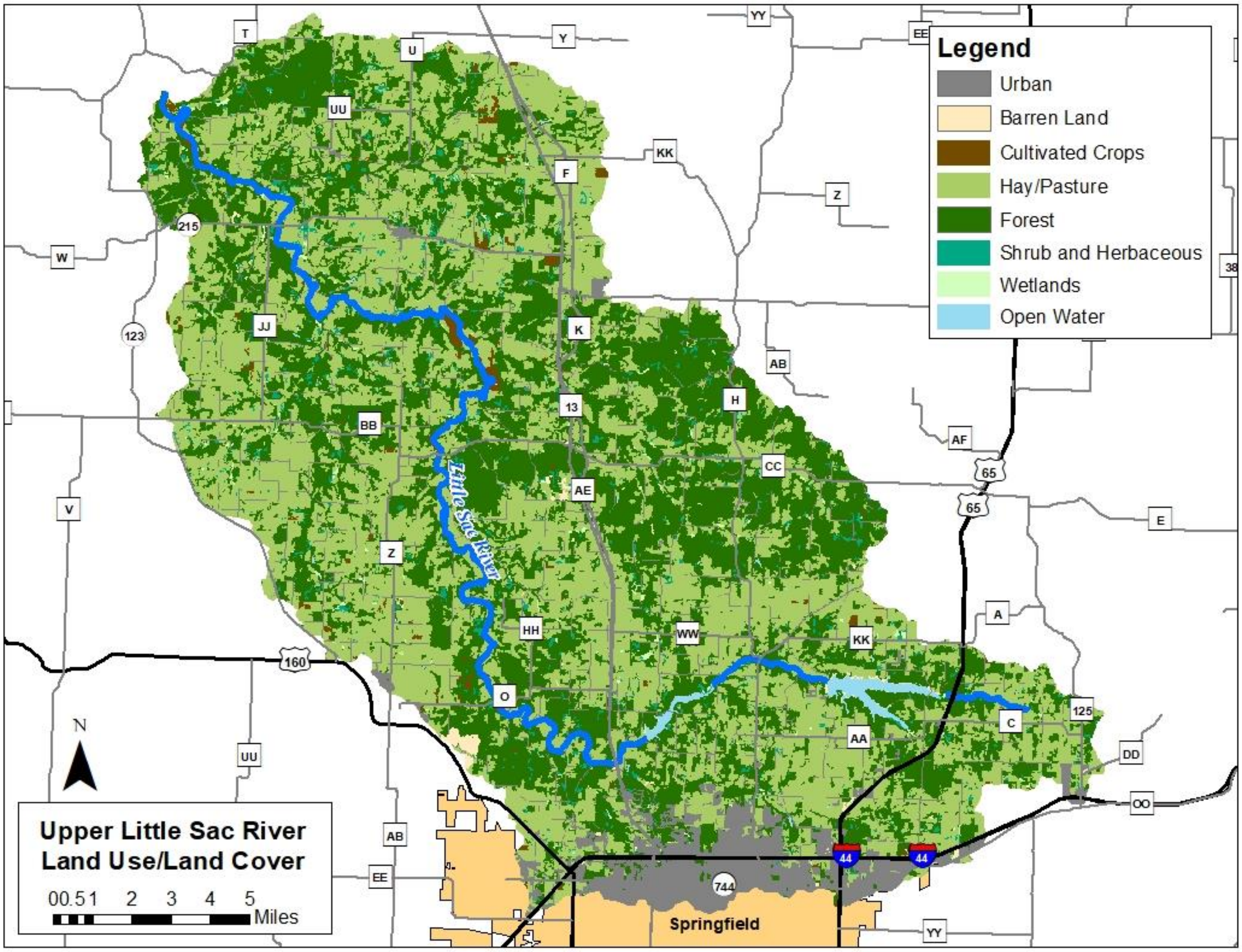

Figure 17 – Land Use/Land Cover Map

The map in figure 16 displays the land use and land coverage for the watershed. Understanding the land use in the watershed is important to understanding potential water quality challenges including potential sources of pollution. As the map displays, the northern tip of the watershed is impervious/urban and the majority of the watershed is grassland/pasture. Grassland and pasture can have a higher infiltration however depending on the soil health some pastures might have very low infiltration rates.

List of Existing Water Quality Information and Data

The Little Sac River Watershed is the primary source of the public drinking water for Springfield. Since this watershed provides drinking water, water quality is a priority. For this reason, many studies relative to water quality have been completed. As of 2019, this is the current list of known water quality research in the watershed. It will be updated as needed when new or undiscovered data or research is revealed.

Little Sac Water Quality Data

- WCO: WQM Field Data (2003–2008)
- Stream Team: Biological/Visual/Chemical (1995–2006)
- Waste Water Treatment Plant: Online Graphs of Effluent (2004–2006)
- City of Springfield: 2002–2007 Stormwater data (Pea Ridge and S. Dry Sac)
- MODNR: L. Sac (CU, USGS, MODNR, SPFDPW, FAPRI) (1984–2006)
- Data Gap Analysis (Sac River): (MODNR, CU, WCO, SPW, USGS, FAPRI)
- Little Sac River Priority Watershed 2013 Sampling Summary Report (Missouri Department of Conservation)
- Little Sac Restoration Grant Water Quality Data and Bacteria Source Tracking (CU, OEWRI-MSU, WCO) (2014–2017)
- Soil and Water Assessment Tool (SWAT) simulated flow and bacteria in Little Sac River Watershed: BMPs Assessment (OEWRI) (2018)
- Bacteria Source Tracking to Support Watershed Planning, Little Sac River Southwest Missouri (OEWRI) (2018)

Little Sac River Watershed Related Projects

- Little Sac River Restoration and Improvement Project (April 2014 to November 2019)
  - Summary statement: 319 BMP projects that occurred during 319 grant
- Sac River Healthy Watershed Plan (May 2015 to October 2016)
  - Summary statement: The goal of this project was to gather local input and identify water resource priorities through community meetings. Community meeting were held to reach citizens living and working in the Sac River watershed, asking them to voluntarily serve on an advisory committee to identify and develop resources to achieve those priorities.
- Sac River Data Gap Analysis (March 2008)
  - Summary statement: Mapped all water quality data for the Sac and Little Sac Rivers. They found that E. coli exceeded safe levels in two of the six monitoring stations. Formation of a monitoring network, standardized sampling, and central database of water quality data were the recommendations of this project.
- Little Sac River TMDL, FAPRI (June 2006)
  - Summary statement: Bacterial source tracking data showed that the highest loads came from unknown sources, geese, and humans. Base flow loading is suggested to be from springs. Suggestions are to monitor springs further, to address the contamination of the springs, and to address stormwater issues in the urban areas.
- Little Sac River Watershed Restoration Project Final Report, WCO (November 2005)
  - Summary statement: Shows data of stream monitoring on the Little Sac and discusses BMPs cost-share projects that took place during this 319-grant project.

- Little Sac River Watershed Bacteria Source Tracking, FAPRI-UMC (May 2005)
  - Summary statement: Water quality data showing that two sites on the Little Sac River did not meet the whole-body contact water quality criteria during the sampling period. It was also found that significant differences between base flow and storm flow bacteria loading occurred.
- Water Quality in the Little Sac River near Springfield, USGS (1999–2001)
  - Summary statement: Study on the bacteria in the Little Sac River. Compares the upstream of the NWWTP to below the treatment plant.
- Watershed Restoration Action Strategy (WRAS) (2000)
  - Summary statement: Very similar to this WMP. Gives general descriptions of the watershed, water quality concerns, and strategies to address the concerns. It also outlines the implementation and funding needs of the strategies.
- Identification of sources of nutrients and fecal coliform bacterial contamination in the Little Sac River, Greene, and Polk Counties, Missouri, USGS, MODNR, WCO (1999)
  - Summary statement: A study to identify contaminates in the Little Sac River.
- Fellows Lake and McDaniel Lake Watershed Protection Project, WCO (1998)
  - Summary statement: A 319-grant Project that implemented BMPs, education, and monitoring in the Little Sac River Watershed.
- Water Quality in the Ozark Plateau, USGS (1992–1995)
  - Summary statement: A broad look at water quality and issues facing Ozark streams. Includes information on bacteria, nutrients, riparian, chemical, sediment, and fish data of Ozark streams.
- Drinking Water & Urbanization: Water Issues in the Fulbright Spring Recharge Area, Southwest Missouri State Dept. of Geology and Planning (1999)
  - Summary statement: An Assessment of the baseline conditions in the Fulbright Spring recharge area.
- Sac River Watershed Inventory and Assessment, MDC Online
  - Summary statement: General description of the Sac River Watershed. Includes geography, wildlife, and aquatics.

Thesis Work in the Little Sac River Watershed

- Priority Assessment of Low Water Stream Crossings within the Range of the Niangua Darter: MDC, USFWS (2008)
- Complementary population dynamics of exotic and native Daphnia in North American reservoir communities: Missouri State University (MSU) (2006)
- Channel Geomorphology and Restoration Guidelines for Springfield Plateau Streams, South Dry Sac Watershed, Southwest Missouri State University: John M. Horton (May 2003)
- Invasibility of a reservoir to exotic Daphnia lumholtzi; experimental assessment of diet selection and life history responses to cyanobacteria: MSU (2003)
- Competition between native and exotic Daphnia: MSU (2001)
- Blue-green algae and the seasonal succession of Daphnia: MSU (2001)
- Effects of the Exotic Cladoceran Daphnia lumhltzi (SARS) on the Growth Rate and Prey Selection of Bluegill Sunfish (Lepomis Machochirus Rafinsque): MSU (1998)
- Competition between native and exotic Daphnia: MSU (1998)
- The Central Stoneroller, Campostoma anomalum, as an Indicator of Heavy Metal Contamination

Using

- Otolith Age and Growth Analysis: MSU (1996)
- The Effects of Landfill Leachate on the Behavior, Feeding Rate, and Growth Rate of the Freshwater Prosobranch Snail: MSU (1992)

Sac River Basin Water Quality Data Gap Analysis Summary

In March of 2008, the Southwest Missouri Water Quality Improvement Project funded the completion of the Sac River Basin Water Quality Data Gap Analysis. Below is the executive summary of that project.

"Rapid growth and expansion in southwest Missouri is threatening the water resources this region's population, agriculture, and tourism industry so heavily depend upon. In response to this threat, several watershed groups in southwest Missouri collaborated to secure federal funding for water protection efforts in this region. Because of this effort, the Environmental Resources Coalition (ERC) received a U.S. EPA grant to develop and manage the Southwest Missouri Water Quality Improvement Project (WQIP), a multi-year, multi-stakeholder effort to address water quality issues in this region. WQIP was tasked with assembling, evaluating, and interpreting existing water quality for several major basins in southwest Missouri. The Sac River Basin is the subject of this report.

The Sac River Basin is 1,969 square miles and includes the north edge of Springfield along the southern boundary. Major tributaries of the Sac River include the Little Sac River, Turnback, Sons, Horse, Cedar, Coon, Turkey, Brush, and Bear Creeks. Water quality regulatory concerns in the basin include a bacteria TMDL on the Little Sac River, the impairment of Stockton Branch for volatile suspended solids, and the impairment of Brush Creek for low dissolved oxygen.

Water quality data from the Sac River Basin were compiled from multiple collection entities including the MODNR, U.S. Army Corps of Engineers-Kansas City District, City Utilities of Springfield, City of Springfield Public Works, FAPRI at the University of Missouri, Murphy Family Farms, and the U.S. Geological Survey. The data were analyzed with relation to total phosphorus, total nitrogen, nitrate plus nitrite as nitrogen, sestonic chlorophyll-a, E. coli, and fecal coliform. Phosphorus and nitrogen levels were notably elevated in the Sac River above Walnut Grove and in Brush and Turnback Creeks. Significant levels of nitrogen were also observed in the Horse Creek watershed where there is a large concentration of swine operations. Fecal coliform geometric means exceeded Missouri's water quality criterion at two of the six stations on the Little Sac River; however, E. coli geometric means did not exceed criterion.

Based on a data gap analysis of the existing water quality data in the Sac River Basin, several recommendations were made for WQIP. Formation of a monitoring coordinating board could benefit all the stakeholder entities in WQIP by standardizing sampling designs, quality assurance programs, metadata requirements, and by developing a centralized database to facilitate the sharing of water quality data. Current and historical water quality data are insufficient to address the goals of WQIP; therefore, a new comprehensive water quality monitoring network needs to be designed. Further data analysis and potential special stormwater studies are also recommended to better understand nonpoint source loading issues. WQIP stakeholders are encouraged to participate in the development of regional stream nutrient criteria through stakeholder involvement and further water quality studies. Finally, efforts should be made to incorporate additional existing water quality data into the WQIP database that were not populated at the time of creation."

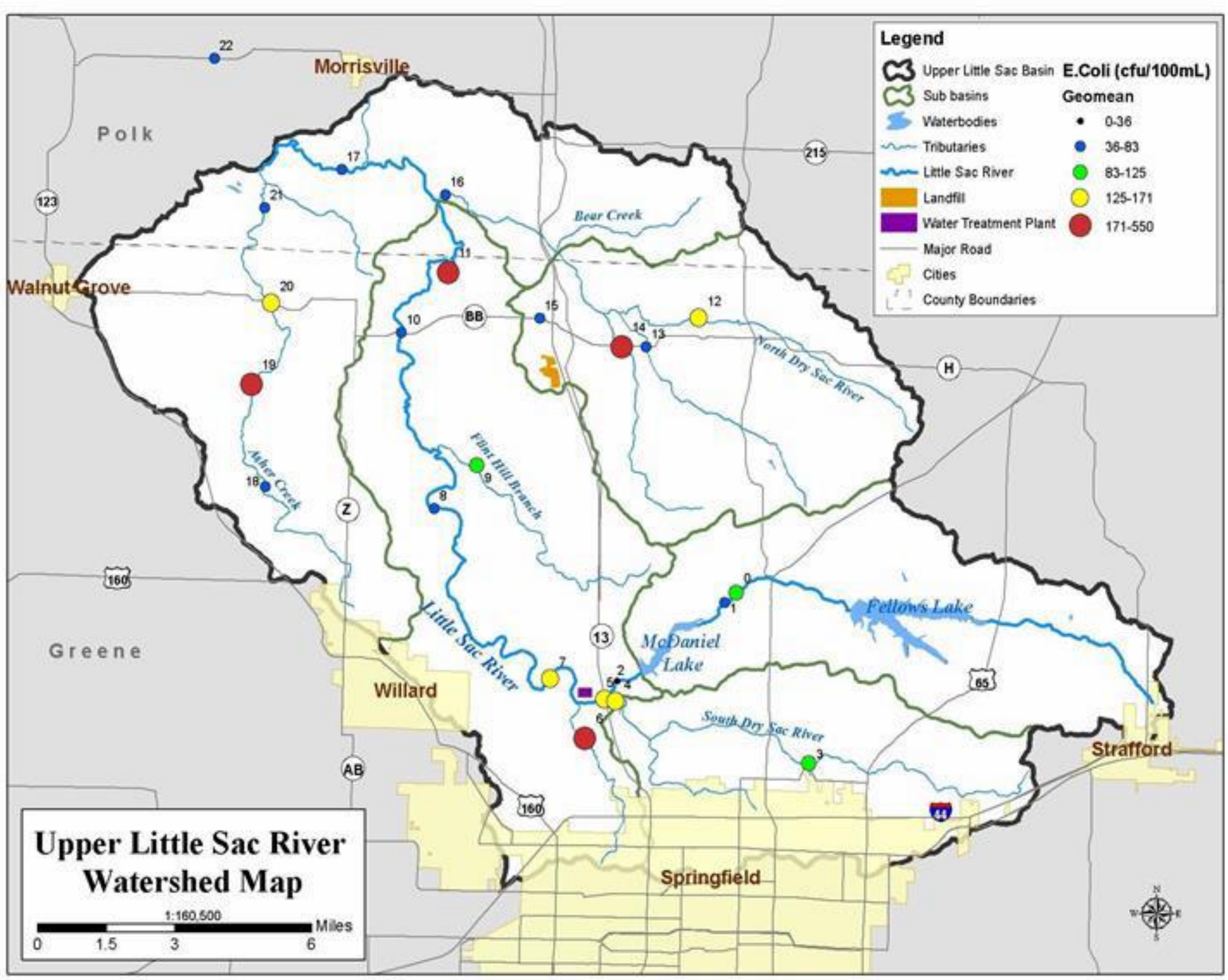

Figure 18- Average E. coli levels in the Little Sac watershed-Sac River Data Gap Analysis

The E. coli data used in 2008 Data Gap Analysis shows hot-spots of contamination are within the upper watershed. These hot spots labeled yellow and red are over the limits for bacteria. These hot spots in the watershed are potential areas of concern and would be good locations where new management efforts and further research could focus as displayed in figure 17. Missouri Water Quality Standards require that E.coli count during the recreational season April to October shall not exceed a geometric mean of 126 counts/100mL of water. The sites that are identified in the map with the yellow and red symbol have geomeans that exceed that standard. The location description of the sample sites are listed on the following page. As this map was taken from the previous Data Gap Analysis, the watershed is shown at the HUC 11 level.

Sample Site Locations for the Sac R. Data Gap Analysis map on previous page

ID	Site Description
0	L. Sac R. at Farm Road 68
1	L. Sac R. at Farm Road 159
2	L. Sac R. near. Springfield
3	South Dry Sac at Valley Water Mill
4	South Dry Sac River below. Springfield
5	Little Sac River-State Hwy 13
6	Spring Branch
7	L. Sac R. 1 mile below Springfield North West Waste Water Treatment Plant at Farm Road 125 ***
8	Little Sac River-Farm Road 54
9	Flint Hill Branch- Farm Road 117
10	L. Sac R. above. Walnut Grove, Hwy BB
11	Tributary of Little Sac River Farm Road 115
12	North Dry Sac River- Farm Road 163
13	Sims Branch- State Hwy CC
14	King Branch. at CC
15	Tributary to tributary. to North Dry Sac River at BB
16	North Dry Sac River at Sod Farm
17	Little Sac River- 111th Rd
18	Asher Creek- West Farm Road 52
19	Asher Creek- N Farm Road 81
20	Asher Creek- State Hwy BB
21	Asher Creek near L. Sac R. Confluence
22	Little Sac River near Morrisville

*** The only sample site used in 2006 TMDL for the upper Little Sac River Watershed.

The Little Sac Fish Index and Biotic Integrity

Below is the Executive Summary from the Little Sac River Priority Watershed 2013 Sampling Summary Report which measures and summarizes the aquatic and biotic diversity by the Missouri Department of Conservation Fisheries Division-Southwest Region. The entire report can be found in Appendix F.

"The Little Sac River Priority Watershed is located in Greene and Polk counties, Missouri, within the Ozark/Osage Ecological Drainage Unit (EDU). Nine sites were sampled within the Little Sac watershed during the summer field season of 2013 in an effort to establish baseline aquatic community data, determine Index of Biotic Integrity (IBI) and Stream Condition Index (SCI) scores, compare the list of species collected to historic samples and targeted species predicted to occur within the watershed, and collect baseline habitat data. The fish communities and physical habitats were sampled according to Resource Assessment and Monitoring (RAM) protocol and fish Index of Biotic Integrity (IBI) scores were calculated. In addition to fish samples, macroinvertebrate surveys were conducted to calculate Stream Condition Index (SCI) scores for all stream reaches sampled. A total of forty-two fish species were collected from nine sites in the Little Sac River watershed. Of the 63 fish species previously observed from historic collections in the Little Sac watershed, 40 were observed in the 2013 samples. Additionally, two species observed in the 2013 samples were never documented in the watershed according to the WIA or RSD-IAD data. Two sites of the nine sites sampled in the Little Sac River watershed (LSR01 and LSR02) were designated as "highly impaired". The other seven sites sampled in the watershed were designated as "not impaired" based fish IBI scores. One hundred and seventy-three different macroinvertebrate taxa were collected from sites in the Little Sac watershed. Macroinvertebrate data showed similar results as the IBI data, as seven of the nine sites in the Little Sac watershed scored high in the Stream Condition Index, designating those reaches as "fully biologically supporting". The few high stress level factors that do exist in the watershed, calculated by the Human Stress Index, include the high percent of land used for agriculture and the number of stream crossings in the drainage. These potential threats should be addressed by engaging conservation partners and other stakeholders in the watershed to promote best management practices on agricultural land and by working with county road districts to install crossings that facilitate fish passage when stream crossings are scheduled for replacement

Sources of Impairment and Pollutant Load Reductions

Impairments: 303(d) List

The Little Sac River had a 27-mile reach listed on the Missouri 303(d) list for E. coli in 1998 and 2002 (see Upper Little Sac Watershed Map Figure 10 on page 56). Pea Ridge Creek was listed in 2019 for unknown pollutant and Fellows Lake was listed in 2012 for atmospheric depositional mercury. The sources of the impairment are both point and nonpoint source pollution. The Little Sac River TMDL listed that the point source pollution was the City of Springfield's NWWTP. Since the TMDL report, the treatment plant has undergone major renovation. After the Little Sac River Watershed TMDL was approved in 2006, the NWWTP began disinfecting the effluent water year-round. Now the main contribution of impairment is presumably from nonpoint sources in the watershed. These sources will be addressed in the recommended measures section of this watershed management plan.

Since the Little Sac River Watershed is very large and has both urban and rural areas, it was decided that the area should be divided into upper and lower watershed plans. The upper or southern half of the Little Sac River Watershed's (HUC #1029010604) will be addressed first in this plan. The lower watershed (HUC 1029010605) or northern half will be completed at a later date.

> *It is important to note that this plan is ever-changing and dynamic, just as the river and its watershed. One set of plans made at this time may not meet the challenges that arise in the future. If major changes are seen in the watershed or seen in the water quality of the Little Sac River, then the plan should be modified as deemed necessary to reflect any changes. Otherwise, the plan should be re-visited every 5 years to evaluate the effectiveness of the management measures and adapted to meet stakeholder concerns.

The Little Sac River was designated impaired in 1998 and has remained on the list due to E. coli concentrations that exceed the water quality standard for whole body contact codified in state water law. The Little Sac River Watershed Fecal Coliform TMDL was approved by MODNR in June 2006. The TMDL is for fecal coliforms, which is no longer used in assessing water quality standards. Missouri's current water quality standards designate the Little Sac River to be used for Whole Body Contact Recreation Category A. For protection of Category A waters, Missouri Water Quality Standards require that E.coli count during the recreational season April to October shall not exceed a geometric mean of 126 counts/100mL of water. A list of potential sources of impairment was derived by the TMDL stakeholder committee and listed livestock, horses, septic tanks, wildlife, permitted facilities, and storm runoff from urban areas as potential sources of bacteria. DNA source tracking was conducted in 2006 by UMC and evaluated by Food and Agricultural Policy Research Institute (FAPRI) to examine these sources; modeling was used to estimate the loading percentages of the Little Sac River. This was conducted at two monitoring locations.

Below is a section from the 2006 FAPRI TMDL study:
DNA analyses of these samples showed that the hosts of these bacteria colonies include the following sources present in the watershed: cattle, sewage, geese, and horses.

- At Farm Road 129, 15% of the bacteria was attributed to geese, 16% to sewage, 9% to cattle, 7% to horses, and 2% to septic.
- At Farm Road 215, 27% of the bacteria were attributed to geese, 13% to sewage, 14% to cattle, 10% to horses, and 2% to septic.

- More than half (51%) of the fecal coliform at Farm Road 129 and 34% at Road 215 could not be identified with our database. Only 3% of the bacteria identified as coming from sewage can be attributed to the NWWTP treated effluent, implying that there are other sources of sewage.

At base flow, the loadings potentially come from contamination of the springs or from direct input to streams (illegal discharges, cattle in streams, or wildlife). While there are some data about these springs, the information is not as thorough as what would be needed to build an accurate model of the watershed hydrology.

The Little Sac River crosses under the Farm Road 129 and Hwy 215 bridges. This is where the water samples were collected for the 2006 Little Sac TMDL. They are on opposite ends of the Little Sac River Watershed. This is good for a broad look at the contaminants but having sample sites at opposite ends of a long river segment does not allow for identifying specific areas of contamination with high bacteria loads.

Quantified Pollutant Load Attributed to Each Source of Impairment

The Little Sac River Watershed TMDL gives quantified load percentages for each source during different flow conditions at both Farm Road 129 and Farm Road 215. It is relevant to note that over 50% of the load is unknown at Farm Road 215.

*NOTE: The Northwest Wastewater Treatment Plant currently disinfects effluent all year long. For more information, visit the NWWTP website.

Remaining Load

According to the TMDL, 12% of the E. coli load at Farm Road 129 could already be removed from the watershed with the upgrade to the treatment plant, reducing the E.coli load significantly. Based on data at Farm Road 129, this means there is 37% of the identified and 52% unknown daily E. coli loading remaining in the watershed.

Load Reduction Goal

The Little Sac River Watershed TMDL lists the following as load reduction goals for the Little Sac River:

- A TMDL for each site was determined based on the simulated flows and the water quality standard of 200 colonies/100 ml. Model results show that the average daily load at Farm Road 129 needs to be reduced by 70% to 90% to meet the whole body contact fecal coliform criteria throughout all flow conditions.

These percentages are based on two sampling sites in the watershed with 52% of the loading at Farm Road 129 unknown. This might indicate the need for further research to isolate the actual sources of bacteria into the stream. The TMDL further suggested that springs are the main contributor to bacterial loading during base flow. Based on these findings, the springs recharge areas near bacteria hot-spots should be investigated for potential pollution sources. DNA studies and dye traces should be performed in the recharge areas of springs near these hot-spots to better determine the loading sources. Once identified, these source locations can be addressed according to the management practices proposed within this watershed plan.

It should be noted that since the TMDL was written the Northwest Treatment plant added facilities for the treatment/removal of phosphorus and nitrates were added—a voluntary measure on the part of the City of Springfield. They also have begun year-round disinfection using UV equipment, which provides the benefit of higher quality effluent without the use of chlorine. To learn more, visit the Northwest Wastewater Treatment Plant's website

There are also nutrient and sediment erosion concerns in the watershed. Areas in the watershed with little or no riparian corridor are more prone to sediment erosion which causes concern for high nutrient and bacteria for the drinking water supply and recreation uses in the watershed. Excess nutrients and sediment erosion in the watershed can cause algae blooms which can cause taste and odor issues for drinking water.

Modeling and Critical Area Identification

In 2018, Ozarks Environmental Water Resources Institute (OEWRI) at Missouri State University conducted the Little Sac Watershed Soil and Water Assessment Tool (SWAT) analysis and Bacteria Source Tracking. The SWAT model was generated in part with the ArcSWAT software utilizing local water quality data and parameters as input. The entire report including all modeling parameters and data inputs can be found in Appendix D.

The scenarios for the best management measures used for the SWAT model were selected by the Little Sac Stream Restoration Project steering committee. The steering committee is made up of local water quality professionals and community partners that are very familiar with the watershed. Based on years of experience and data on BMP performance the steering committee selected the management measures are the practices most likely be successful in reducing the bacteria load in the watershed to the water quality standards while also being the most achievable to accomplish.

A total of four BMP scenarios were selected by the committee. The first scenario simulated the influence of soil conservation practices on bacteria loading in pasture areas. The following grazing management practices were included in this scenario as selected from the Missouri Soil and Water Conservation Districts' Cost Share Handbook: Permanent Vegetative Cover Enhancement (DSP-02), Grazing System Water Development (DSP 3.1), Grazing System Water Distribution (DSP 3.2), Grazing System Fence (DSP 3.3), Grazing System Lime (DSP 3.4), and Grazing System Seed (DSP 3.5). Descriptions of these are available on the MoDNR website. The second scenario simulated the effects of vegetative buffers in pasture areas by adding vegetative filter strips (VFS) with a width of 15m to all hay and pasture related hydrologic response units. Scenario three simulated the effects of implementing VFS with a width of 10m to urban areas. Scenario four modeled the effects of implementing the first three scenarios simultaneously within the watershed. The BMP's selected for the SWAT model are summarized in Table 1.

Below is the conclusions section from the OEWRI SWAT Simulated Flow and Bacteria in Little Sac Watershed Report:

"The purpose of this modeling effort was to use SWAT to simulate long-term natural (e.g. climate) and human (e.g. land use) impacts to flow and E. coli loading in Little Sac Watershed to support a broader watershed planning project being conducted by the WCO. The current work updated previous modeling efforts and best management practices (BMP) plans were evaluated using present watershed conditions. Results provide critically needed science-based information (i.e. data) to assist management and planning efforts focused on mitigating problems associated with excessive E. coli presence in Little Sac Watershed (LSW).

Results from BMP scenario modeling evaluated percent reductions of E. coli from multiple BMPs including: 1) practices to improve soil health in pasture areas, 2) planting vegetative stream buffers in pasture areas, 3) planting vegetative stream buffers in urban areas, and 4) all aforementioned BMPs. While the greatest percent reductions of E. coli were associated with the all BMPs scenario, the greatest percent reduction of E. coli associated with a single BMP was BMP scenario #2 (VFS in pasture areas). Additionally, while percent reductions associated with scenario #3 (VFS in urban areas) were 0 % for many sub-basins, percent reductions ranged from 16 to 44 % in the urbanized sub-basins 21-24 where the urban 10 m VFSs were applied. Soil conservation practices in pasture areas (BMP scenario #1) resulted in less percent reduction in E. coli in comparison to the other BMP scenarios; however, soil conservation practices remain an attractive choice for managers who need to conserve valuable soil and water resources. Ultimately, VFSs have been shown by other published works to capture excessive agricultural and urban surface runoff thereby mitigating water quality problems associated with increased pollutant delivery to streams. Thus, results from this modeling effort in combination with previous published works show the benefits of applying VFSs in combination with soil conservation practices to reduce E. coli loading in Little Sac Watershed.

A lack of observed spring flow and bacteria data was a limitation in the current modeling effort. Future work should focus on obtaining continuous spring flow data and associated recharge areas in Little Sac Watershed. There is also a great need to monitor the water quality of the larger springs in the southern urbanized area of Little Sac Watershed. Additionally, there is need to quantify estimates of true water quality loadings (e.g. suspended sediment, nutrients, and bacteria) at the Morrisville USGS gage where flow has been continuously monitored for decades, yet the true export of total pollutant loading remains unknown. Such monitoring efforts remain a rich avenue for future work with management implications for conserving water resources in LSW. Understanding source contributions (e.g. springs, point sources, nonpoint sources) of pollutants exported from the stream network of LSW is integral to securing valuable water resources in Stockton, Fellows, and McDaniel reservoirs."

Table 1-BMP Scenarios in SWAT Model

Table generated by OEWRI of modeling scenarios used to test the effects of BMPs on SWAT simulated bacteria loading in Little Sac River Watershed, Missouri

Scenario	**Brief Description**	**Area Applied**
1	BMPs to conserve soil health in pasture areas	Pasture
2	15 m vegetative buffer in pasture areas	Pasture
3	10 m vegetative buffer in urban areas	Urban
4	All BMPs included	Pasture and urban

Table 2-Percent pollutant reductions for each scenario in SWAT Model

Table generated by OEWRI of percent reductions of Escherichia coli (E. coli) from BMPs scenarios in Little Sac River Watershed, Missouri. Load reductions for the other pollutants will be achieved in addition to the E. coli reduction, but do not address the impairment. While all the below scenarios were modeled, Scenario 4 has been selected for implementation. The load reductions listed in this table for Scenario 4 are the loads that will be achieved by implementing this plan

Scenario	Streamflow	Sediment	Total Nitrogen	Total Phosphorous	E30. coli
1	1	2	2	3	7
2	1	15	12	21	30
3	0	0	3	12	6
4	2	24	15	34	34

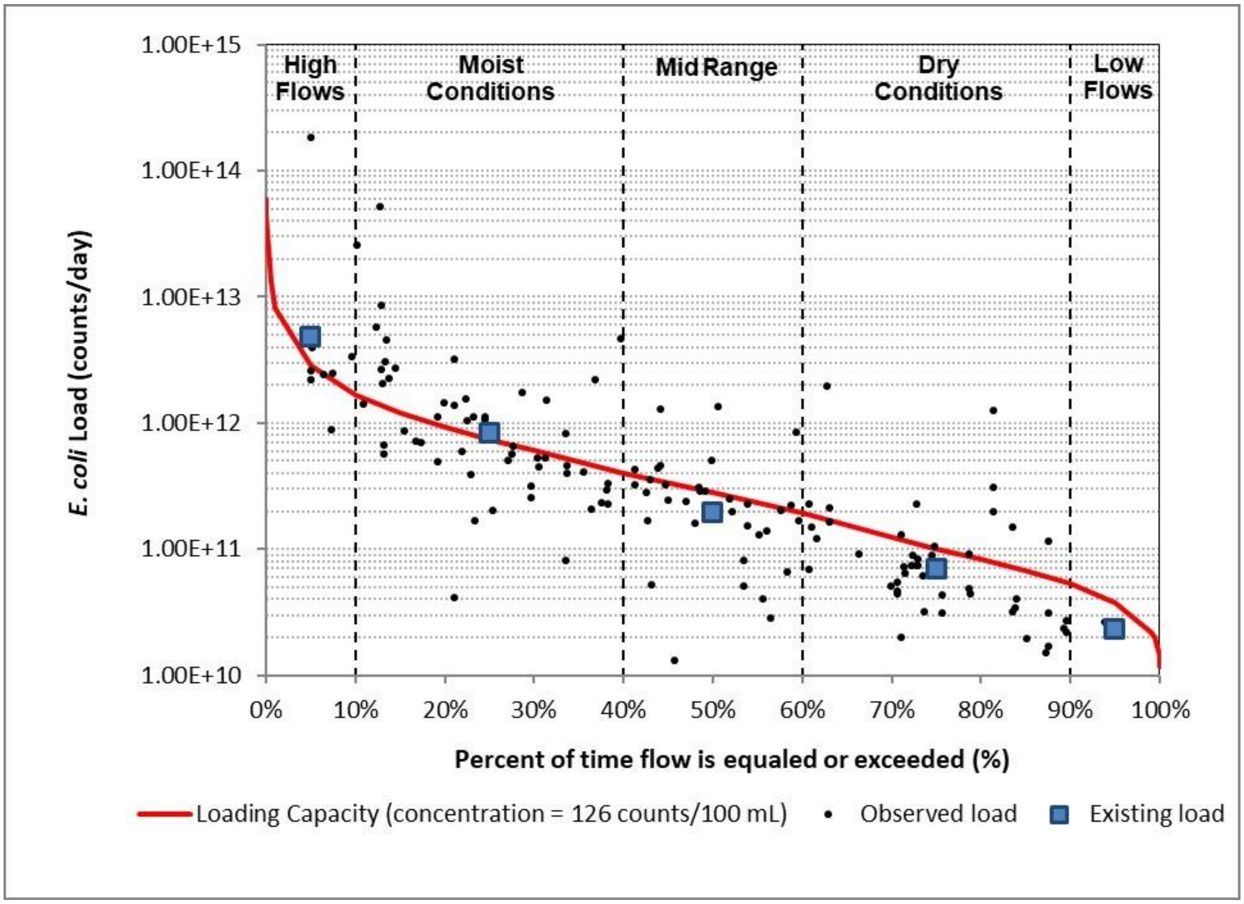

Figure 19- Bacteria Load Duration Curve created by Missouri Department of Natural Resources

The Bacteria Load Duration Curve and Reduction Estimates for the Little Sac River Water Body 1381 Polk and Greene Counties was created by Missouri Department of Natural Resources which helps to provide information on the load of bacteria in relation to the flow conditions. Figure 18 displays this load duration curve which yields bacteria loads exceeding water quality standard during moist conditions and high flows. This relationship helps communicate excess bacteria loads are entering the river through stormwater runoff. The report also determined the percent needed reduction of bacteria is a reduction of 12 percent during moist conditions and 41 percent during high flows. The entire report can be found in Appendix G.

Based on the SWAT model, the maximum reduction in E. coli that can be achieved through implementation of the identified BMP's is 34%, which does not achieve the 41% reduction necessary during high flows to achieve water quality standards as shown by the load duration curve. Due to the large reductions necessary to achieve water quality standards, the goal of this plan will instead be to emphasize management measures aimed at reducing E. coli loads to achieve a long-term trend in water quality improvement. The goal of this plan is to achieve the 34% reduction of E. coli as was determined feasible by the SWAT model. While there is no impairment for sediment or nutrients, implementation of this plan will also serve to reduce total load of those pollutants as stated in Table 2.

The load duration report also identifies segments of tributary streams that are critical areas to reduce bacteria loads. The BMP's identified in the SWAT model will be implemented in the critical and priority areas in the watershed which are identified and discussed beginning on page 36.

Bacteria Source Tracking

Bacteria source tracking was originally conducted in the Little Sac River Watershed in 2006 for the TMDL Little Sac FAPRI study. In 2017, bacteria source tracking was analyzed again in the watershed at five sites, the bacteria source tracking data was collected once in September and then again in October. These samples were collected as part of the Little Sac Restoration and Improvement Project to help identify the potential sources of bacteria contributing to the watershed. This information is useful in reducing bacteria loads in the watershed by identifying type of bacteria sources in certain locations of the watershed. Locations in the watershed with bovine bacteria present would be a prime location to target pasture improvement BMPs and locations with human bacteria present would be a location to focus on urban BMPs. This type of information could be utilized to focus future placement of BMP's for future funding. It also provides good baseline data for the watershed, especially if more large-scale animal operations begin to develop in the watershed.

The results of this study found four out of five sites with positive markers for at least one of the bacteria sources of human, bovine, and geese. (Table 3). No presence of chicken or dog markers were found at any of the five sampling sites. The complete bacteria source tracking report and sampling results can be found in Appendix E, Bacteria Source Tracking to Support Watershed Planning, Little Sac River, Southwest Missouri. The entire "Bacteria Source Tracking to Support Watershed Planning, Little Sac River, Southwest Missouri" report can be found in Appendix E.

Table 3- Group Specific Bacterial Contamination Table generated by OEWRI of Bacteria Source Tracking Results

Copies per 1,000 mL of water. Non-detect (-). Duplicate samples in yellow.

Sample	Human	Bovine	Goose	Chicken	Dog
September 22nd					
PR_102	1,149	–	2,561	–	–
LS_068	–	4,122	–	–	–
LS_129	–	–	3,296	–	–
AC_560	–	5,187	–	–	–
LS_215-A	–	–	–	–	–
LS215-B	–	–	–	–	–
October 6th					
PR_102	855	–	1,392	–	–
LS_068-A	–	6,577	–	–	–
LS_068-B	–	6,769	–	–	–
LS_129	–	–	1,428	–	–
AC_560	–	2,650	–	–	–
LS_215	–	–	–	–	–

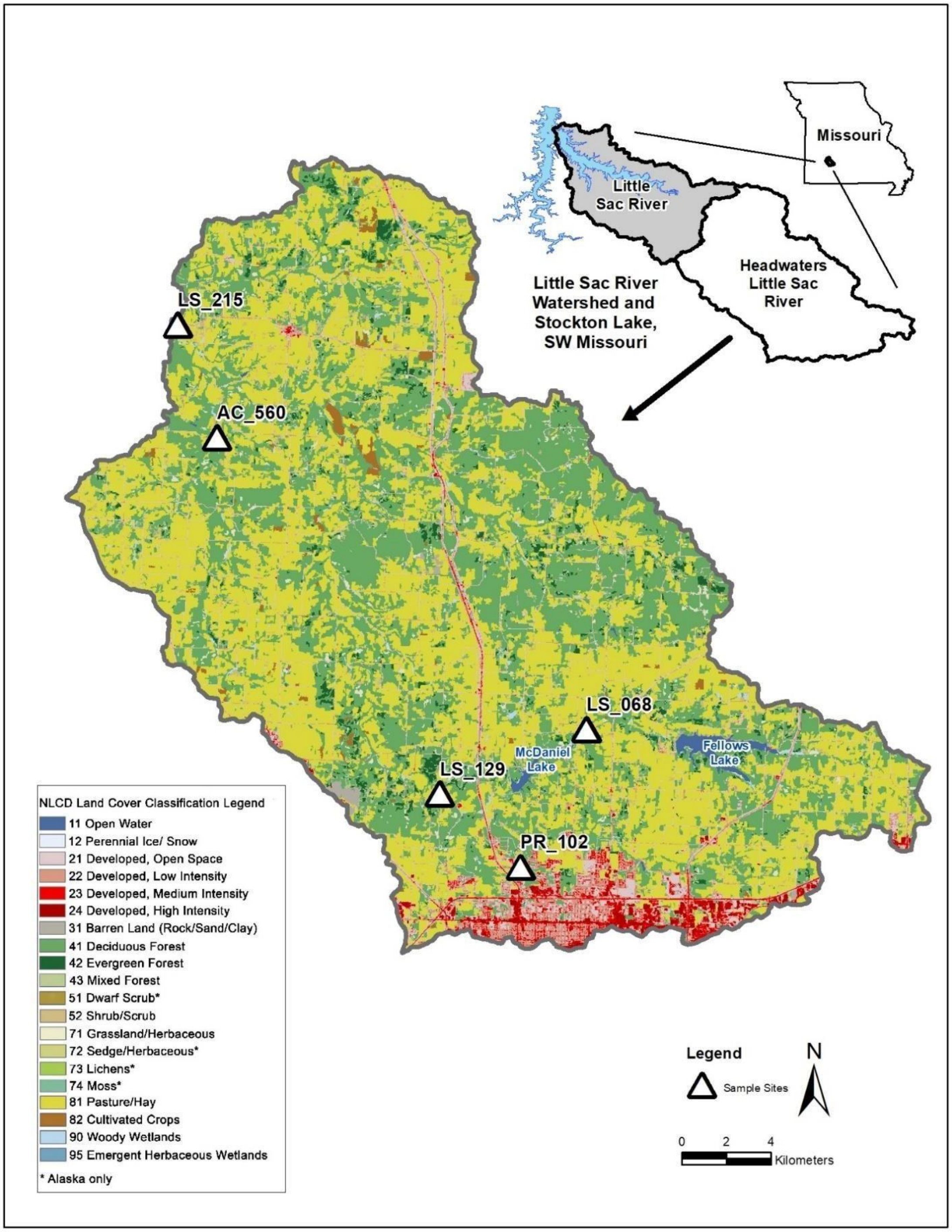

Figure 20 – Land Use Map and Bacteria Source Tracking sample locations

The map above was generated by OEWRI as part of the bacteria source tracking study and land cover classifications for the watershed. The map displays the locations sampled for the bacteria source tracking study. The map also displays a larger geographic area for the headwaters of the Little Sac due to the SWAT modeling software that was utilized. Due to this the watershed boundary will be different in maps yielded in the technical reports.

Critical/Priority Areas Maps

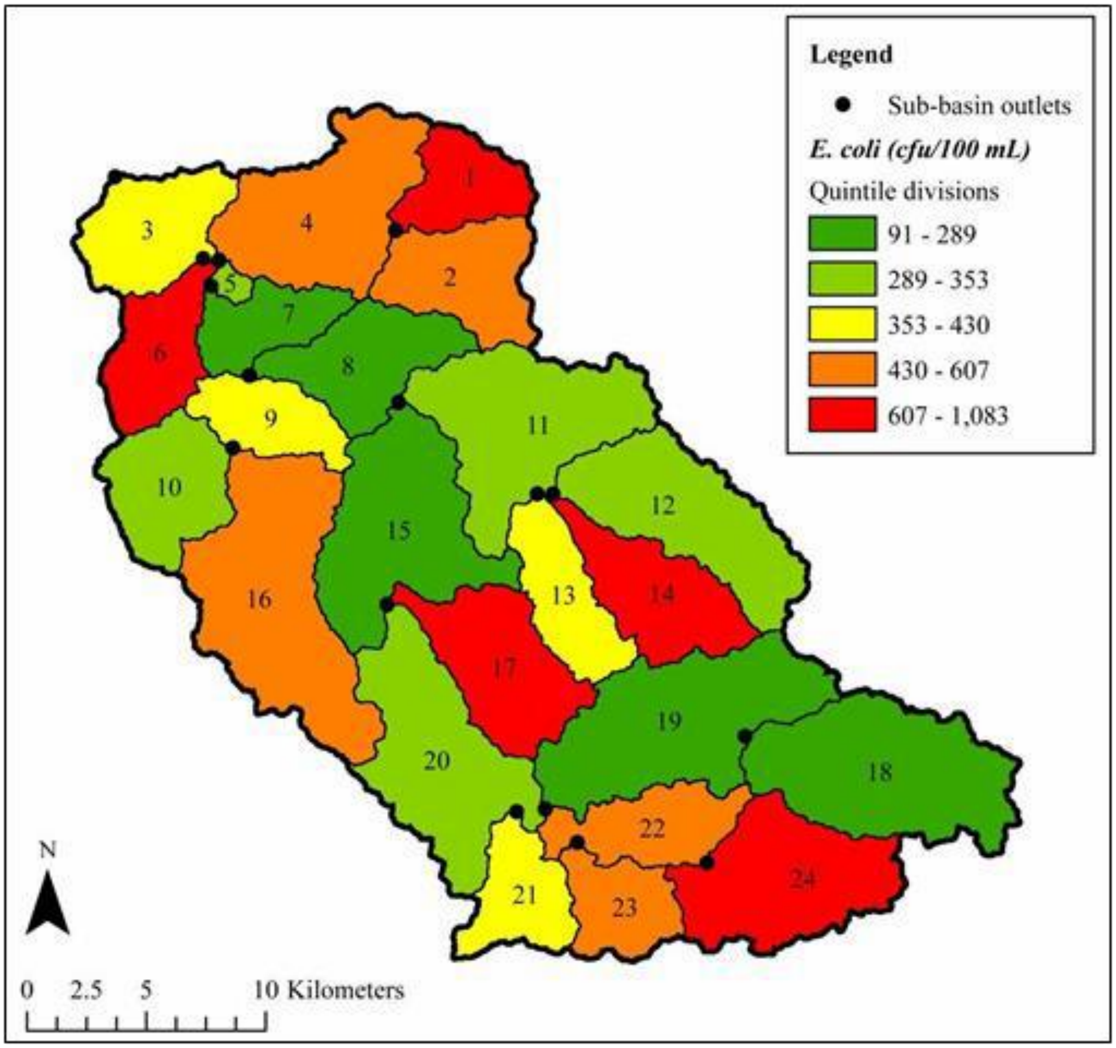

Figure 21 – Critical Areas for BMP Implementation

This map was generated by OEWRI, displaying simulated annual average daily Escherichia (E.coli) export during the study in the Little Sac River watershed. Based on the results of the model the following subwatersheds with the high daily E.coli exports marked as orange and red in the map are listed as high priority for BMP implementation. The highest priority watershed are labeled as subwatersheds 1, 6, 17, 14, and 24. It should be noted that according to water quality standards no single sample should exceed 235 cfu/100mL E.coli and only five subwatersheds labeled in the map as 7, 8, 15, 18 and 19 are below that bacteria level however these are daily exports which yield much higher bacteria loads than a single sample.

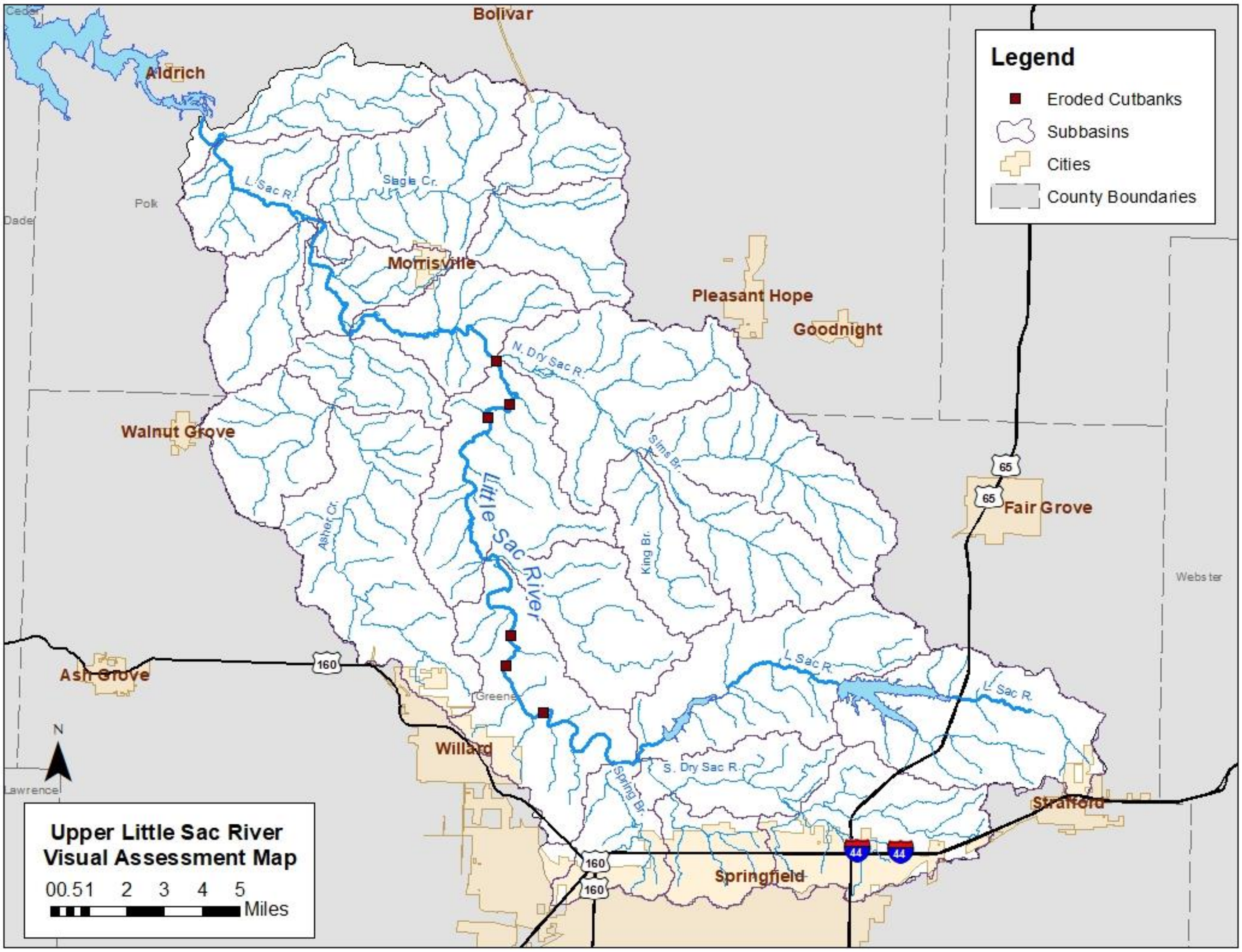

Figure 22 - Visual Assessment Map

Sites located on this map are from the Visual Assessment in June of 2009. Each location is of an eroded bank that needs more assessment and attention. They were marked with a GPS unit from the river. In 2017, these locations were reassessed and still are actively eroding. These locations along the Little Sac River are critical for streambank stabilization or improvement BMP's.

Figure 23 – Critical Areas Defined in Load Duration Curve Report

The load duration curve report generated by Missouri Department of Natural Resources (DNR) highlights segments of tributaries in the subwatershed that are critical areas for BMP implementation. The stream segments highlighted in red display critical areas for buffer implementation. The brown and green portions of the watershed display critical areas for the implementation of agricultural BMPs and the grey portions of the watershed display critical areas for the implementation of urban BMPs. These critical areas have then been further separated into three tiers for implementation based on the critical areas identified by the SWAT model. In figures 24-26 the subwatersheds that correlate to the priority subwatersheds from the SWAT analysis are shown. The BMP's in the critical areas in tier one will be installed in years 1 to 3. The BMP's in the critical areas in tier two will be installed in years 3 to 6. The BMPs in the critical areas in tier three will be installed in years 6 to 20. However, it should be noted that BMP installation is entirely dependent on landowner willingness, participation and financial contribution. The entire "Bacteria Load Duration Curve and Reduction Estimates, Little Sac River Water Body 1381, Polk and Greene counties" report, including enlarged photos of the critical areas, can be found in Appendix G.

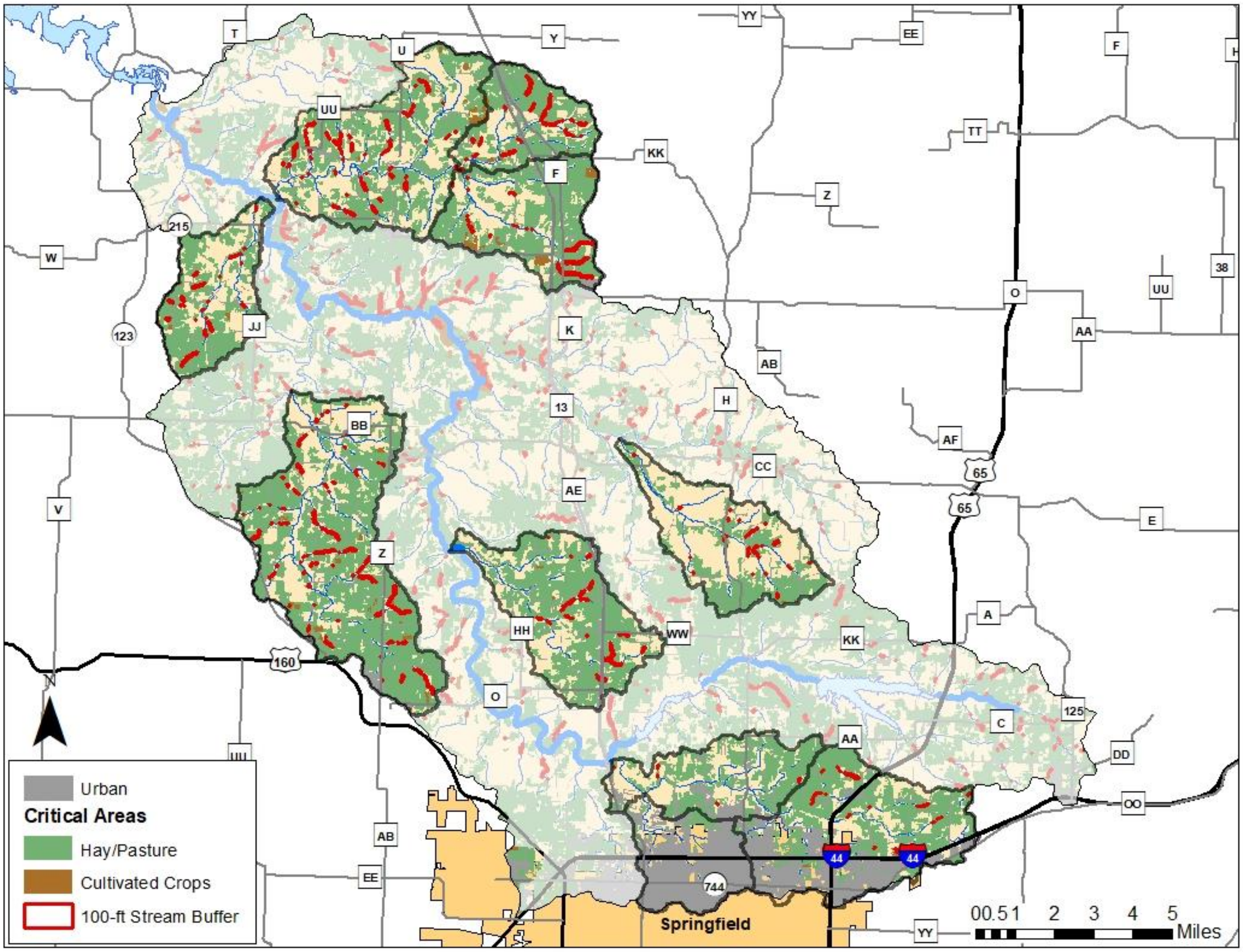

Figure 24 - Tier one subbasins for implementation

This map overlaps the critical areas defined by the SWAT model with the critical areas defined in the Load Duration Curve Report. The subbasins from Figure 21 with E. coli export greater than 430 cfu/100mL (the orange and red subbasins) will be targeted first for implementation. These are the areas of the map that are *not* covered with the white mask. Critical areas within the teir one subbasins are those that were identified in Figure 23.

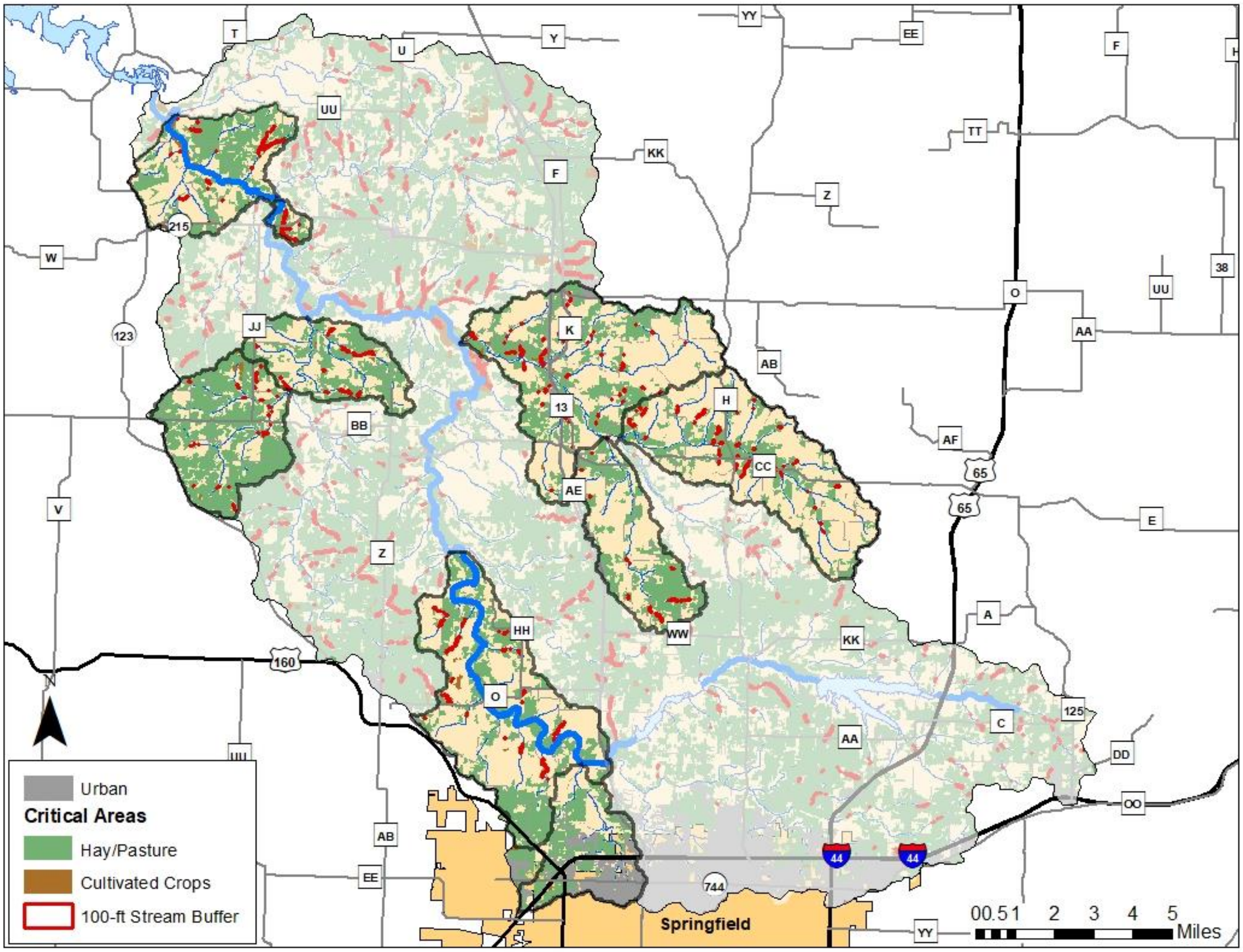

Figure 25 - Tier two subbasins for implementation

This map depicts the tier two subbasins for implementation overlaid on the Critical Area Map developed for the Load Duration Curve Report. The subbasins from Figure 21 with E. coli export between 289-430 cfu/100mL (the yellow and light green subbasins) will be targeted during years 3-6 of implementation. These are the areas of the map that are *not* covered with the white mask. Critical areas within the teir two subbasins are those that were identified in Figure 23.

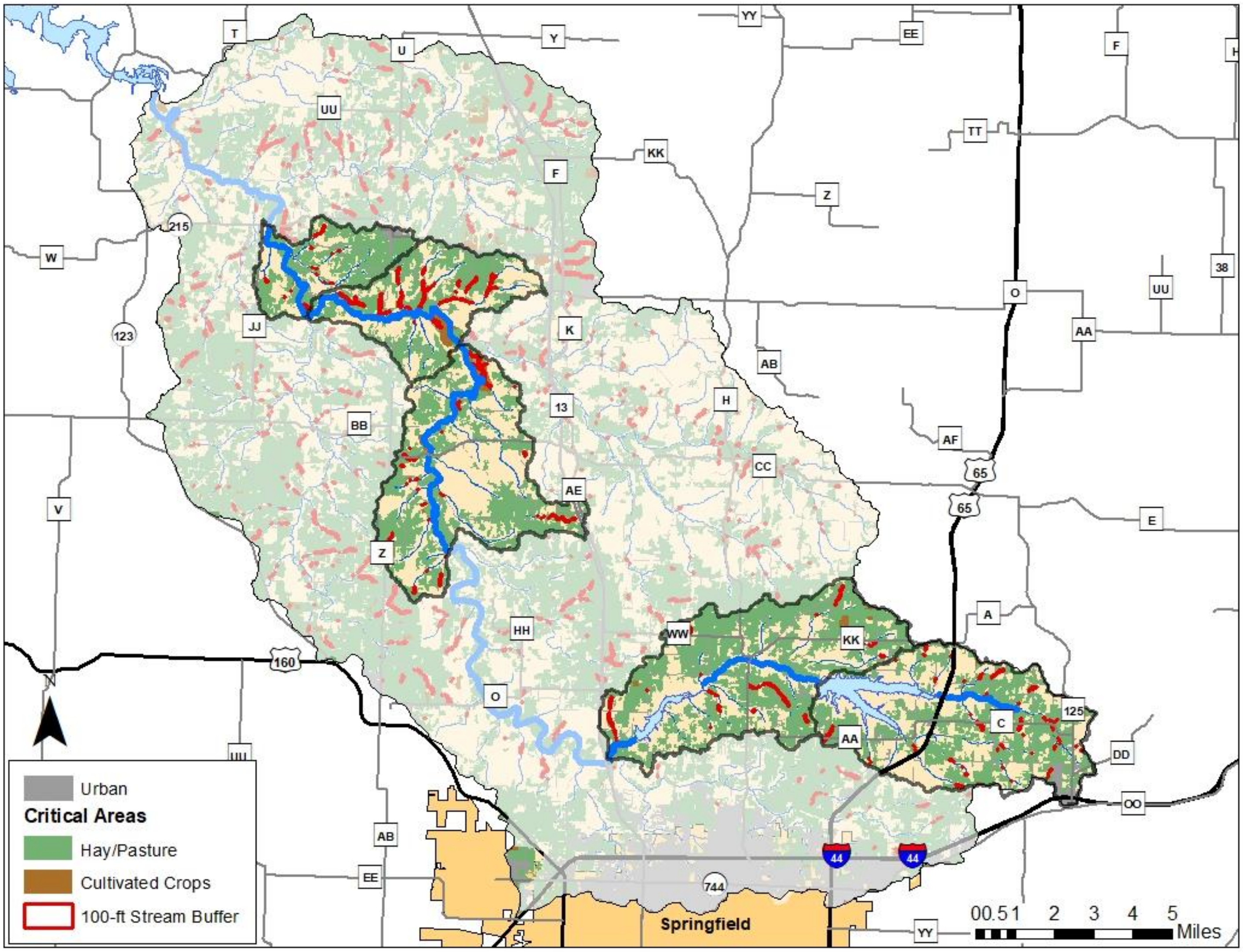

Figure 26 – Tier three subbasins for implementation

This map depicts the tier three subbasins for implementation overlaid on the Critical Area Map developed for the Load Duration Curve Report. The subbasins from Figure 21 with E. coli export between 91-289 cfu/100mL (the dark green subbasins) will be targeted after 6 years of implementation. These are the areas of the map that are *not* covered with the white mask. Critical areas within the tier three subbasins are those that were identified in Figure 23.

Completed Watershed BMPs

The Greene County Soil and Water District and Missouri Department of Natural Resources records how many acres (ac) of BMPs are completed each year. Tables 4 and 5 summarize the total acres and types of agricultural and urban BMP's that have been completed since the last watershed management plan was approved in 2009. It should be noted that the BMP's listed are for the entire Little Sac watershed. The data in Table 4 was provided by the Missouri Department of Natural Resources.

Table 4- Soil and Water District BMP's Completed 2009 to 2019

Little Sac River BMP Data 2009 to 2019					
Agricultral BMPs		*Amount Served*		*Cost-share*	*Tons of Soil Saved*
DSL 1	Seeding	174.4	ac	$ 18,060.67	5191.5
DSL 2	Inter-seeding	43.4	ac	$ 3,610.79	815.5
DSP 2	Inter-seeding	126.9	ac	$ 6,630.44	
LW DEV/Dst.	Livestock water	1002	ac	$ 171,339.76	
DWP-03	Sod Waterway	1.8	ac	$ 4,915.71	350
DSP 3	Grazing system	2031.5	ac	$ 161,537.61	
N391	Riparian Buffer	392	ac	$ 22,125.54	
WQ10	Stream Protection	86.87	ac	$ 88,076.05	
N340	Cover Crop	149.8	ac	$ 4,696.50	
N590	Nutrient mgmt.	424.8	ac	$ 10,009.00	
N595	Pest mgmt.	326.2	ac	$ 3,690.00	
N472	Use Exclusion	97.2	ac	$ 27,670.86	
DFR 5	Woodland Exclusion	16.5	ac	$ 1,269.36	
N574	Spring development	5	ea	$ 8,644.17	
N312 Beef	Animal Waste	66	au	$ 27,874.15	
N312 Dairy	Animal Waste	162	au	$ 27,198.21	
N351	Well plugging	4	ea	$ 1,600.00	

Table 5- Urban BMP's Completed 2009 to 2019

Completed BMPs	*Type of BMPs*	*Pollutants Addressed*	*Year Completed*	*Funding Source*
Doling Wetland/Rain Garden	Wetland and rain garden	Nutrients and bacteria	2012	Big Urbie Grant
Robberson Elementary Courtyard	Gravel infiltration swales and native plants	Nutrients and bacteria	2014	Big Urbie Grant
Dicken Rainwater Collection	Rainwater harvesting	Water quantity	2015	Big Urbie Grant

Grasspave at Watershed Center	Groundwater infiltration	Nutrients and bacteria	2012	Big Urbie Grant
Asher Creek Projects	Septic tank remediation's	Nutrients and bacteria	2013	Asher Creek Grant
Water Quality Improvement Project	Septic tank remediation's	Nutrients and bacteria	2012	WQIP
Rainwater Harvesting at Watershed Center	Rainwater harvesting	Water quantity	2012	Donations/Grants
Little Sac Stream Longitudinal Peak Stone Toe Protection Stream Stabilization	Streambank stabilization, erosion control and native plantings	Nutrients and bacteria	2017	Little Sac Restoration Grant
Dickerson Park Zoo Stormwater Improvements	Extended detention basins, rain gardens, and lake bank stabilization	Nutrients, bacteria, sediment	2011	City funds
Rain Barrel Rebate Program (Approximately 70 rebates for 4000 gallons)	Rainwater harvesting	Water quantity	2009–2017	City funds
Flood Property Acquisition Program	Removal of impervious surface (0.04 ac)	Water quantity	2013	City funds

Public Engagement

In an effort to engage members from all aforementioned areas within the watershed, informational community meetings were hosted in three different geographic locations throughout the watershed in 2015 and 2016. To reach people that live and work in the watershed, informational flyers and press releases were submitted to the local media to help publicize the community meetings. Local community leaders and regional groups in the watershed were notified of meetings by phone and email, including the Missouri Farm Bureau, soil and water districts, city clerks, mayors' offices, local Stream Teams, Lakes of Missouri Volunteer Program, local newspapers and media stations, U.S. Army Corps of Engineers, Missouri Department of Conservation, county commissioners, state representatives, local green teams, and Watershed Committee of the Ozarks' comprehensive contact list.

Community meetings were held on November 17 in Stockton, December 15 in Greenfield, and January 12 in Willard, with a total of 142 meeting participants. Of those participants, sixty-six completed and submitted surveys during the meetings with most couples submitting one survey together. All information provided through the survey was shared by email with all the meeting attendees that submitted contact information. The survey asked participants if they were interested in voluntarily serving on the Sac River Watershed Advisory Committee (WAC). The only requirement to serve as a WAC member was to be a resident or property owner in the Sac River Watershed. Thirty-four survey respondents expressed interest in serving on the WAC. Those that expressed interest were contacted, asked if they owned property the Sac River Watershed, and if they would like to serve on the committee. Twenty-four of those respondents committed to serving on the WAC. The WAC also received a summary of the community survey results. The outcome from the facilitated meeting and the volunteer advisory committee process was an agreed upon list of problems and solutions for the watershed can be found in Appendix A.

In 2017, questionnaires were given to watershed partners that have collaborated on watershed projects and education over several years to collect their input and opinions. Questions were about primary challenges, water quality problems, and BMPs that should be implemented in the watershed in the next five, ten and twenty years. The complete questionnaire can be found in Appendix B. Then they were asked what improvements they have seen in the watershed since 2009 when the last Upper Little Sac River Watershed Management Plan was approved. The summary results from those surveys is in the Appendix C.

Local community partnerships have historically played an important role in the improvements in the watershed. Past and improvements heading into the future. Partners have helped bring grant funding to the community by helping provide local matching dollars necessary to receive water quality improvement grant funding. Partners also play a vital part in watershed planning for the community.

Recommended Management Measures

Reduction Action 1: Reduce Bacteria Pollution in the Watershed

Stream Corridor Improvement and Protection

The SWAT model identified vegetative buffers in pasture areas of 15 m, approximately 50 ft to have the greatest percent reduction for bacteria and nutrients. Planting, improving, or restoring vegetative buffers, which can also be referred to as stream corridor improvements, can greatly improve watershed health.

Erosion in stream zones leads to the loss of productive farmland and an increase in downstream siltation, which is harmful to wildlife and water quality. Riverside lands often contain the richest soils in the Ozarks, which have taken thousands of years to form. The best way to preserve these soils is to leave a healthy, vegetated buffer along streams. Trees tend to be the best at holding soil and should not be removed for at least 50–100ft back from the streambank. Where active bank cutting is occurring, methods such as willow staking, or revetments can often be used to reduce erosion. Technical advice for these methods can be provided through the MDC. In cases of severe erosion, in-channel stabilization practices may also be necessary in addition to riparian improvements. See Appendix I for a list of approved practices to address E. coli.

Leaving vegetation along stream zones or creating new buffers can benefit landowners. Soil erosion is minimal in well-vegetated areas. Buffers filter runoff from fields or pastures, improving stream water quality. Forested buffers also provide benefits such as firewood, saw timber, nuts and berries, wildlife habitats, improved fishing, clean swimming holes, and reduced flood damage.

Soil Health and Restoration

Poor and compacted soil has low to no infiltration capacity and functions as an impervious surface. Bringing stormwater into contact with healthy soils, mulch, or compost increases infiltration capacity and treatment of stormwater, providing a relatively inexpensive means for reducing pollution. Opportunities will be sought to improve soil structure to facilitate infiltration and treatment capacity, particularly in priority areas. Specific load reductions will not be calculated, but a reduction will be assumed based on increased infiltration and treatment.

Remediate and Improve Failing Onsite Wastewater Management Systems

Onsite Wastewater Treatment Systems (OWTS), commonly known as septic systems, like houses and cars, require periodic maintenance. This is especially true in the Ozarks, where soils are often thin and rocky and may allow partially treated sewage to leak directly into groundwater supplies. Although this problem is being addressed today with better site evaluations and designs, there are thousands of OWTS systems already in use in the Ozarks. Owners of these systems may claim to have never had problems, even though no maintenance has not been done in many years. It is these very systems that may in fact be contributing to the unseen pollution in groundwater. Failing systems closest to the creek or waterbody could receive a larger amount of reimbursement for their pumpout or installation of a new system.

Reduction Action 2: Reduce Sediment Erosion in the Watershed

Promote Prescribed Rotational Grazing Management and Solar Watering

In managed grazing, pastures are divided into sections, or paddocks, which are grazed one at a time. Livestock are grazed only long enough to eat the desired amount of the most nutritious forage, then the paddock is rested and allowed to regrow. Providing livestock with alternative watering source means you can exclude livestock from the stream corridor called livestock inclusion. With this method, animal performance and herd health are usually improved, because cattle spend less time in wet areas and are drinking water less susceptible to contamination. Streamside vegetation stays healthier, reducing erosion and improving water quality. Animal waste is a fertilizer and should be distributed more evenly over the entire grazing area, rather than becoming a water pollutant.

Providing clean water to livestock increases productivity and improves animal health. Where electricity is not readily available, water can be pumped from the stream using solar power, from a shallow well, or from spring into stock tanks at a planned location away from the stream. Wells, pipelines, spring developments, and ponds are alternatives to consider. Advantages of alternative watering systems include: cleaner, disease-free water; reduced parasite load; movable tanks for improved grazing distribution, adequate quantity of water; improved livestock production; and a reduction in long-term electricity costs by using solar power.

Reduction Action 3: Reduce Stormwater Runoff in the Watershed

Tree Planting

Tree planting and vegetative cover re-establishment will be emphasized in riparian corridors and priority areas currently lacking healthy vegetative cover. A tree value calculator website suggests that a 25% increase in urban forest canopy will result in an 11% decrease in stormwater runoff. Trees as BMPs are also desirable to the public. Knowledge and appreciation of tree benefits, especially for cooling and oxygen replenishment, in urban settings is low. Trees provide multiple benefits for both air and water quality; they also serve as tools to disconnect impervious surfaces. Tree planting is an ideal way to involve volunteers and the public in restoration efforts. However, the actual stormwater and pollutant reduction attained by trees is highly variable, depending on the tree species, age, location, land-use in the drainage area, and other factors. Rather than using a specific per-tree estimate of these reductions, it is assumed that trees and other vegetation, especially in riparian corridors, will reduce sediment in runoff by preventing erosion; large areas of forest cover will uptake significant amounts of stormwater and nutrients. Thus, in conjunction with other water quality BMPs, healthy vegetative cover will help achieve water quality goals.

Rainwater Collection

There are two significant reasons to harvest rainwater—it's free and it's beneficial to water quality. There are no legal restrictions in Missouri on collecting as much rainwater as desired. The collection area (usually a roof) is typically very close to the site of end use, reducing the length and therefore the costs of pipes to get water from source to point of use. Rainwater harvesting systems are simple to design and construct, relatively easy to maintain, and the water collected is of sufficient quality for most outdoor uses with little to no treatment. Capturing rainwater were it falls help reduce flooding and runoff. Reducing runoff is important to improve water quality.

The most commonly seen rainwater harvesting system in southwest Missouri is the simple rain barrel, which is gaining in popularity for home landscape and garden watering needs. Harvested rainwater is very good for this purpose. It is usually of nearly neutral pH (unless it is acid rain), free from disinfection byproducts such as chlorinated organics, and low in salts and minerals. Setting up rain barrels allows homeowners to gain experience with using harvested rainwater. More widespread use of rain barrels should increase public support for rainwater harvesting in general and could motivate citizens to amend local codes and regulations to allow for larger and wider-spread applications of harvested rainwater in the future.

Reduce Impervious Surface Area

Reducing the amount of impervious surface area in the watershed will help increase reduce flooding issues in the community. Allowing the water to slow down, spread out over the surface and soak into the ground helping to recharge our aquifers. Replacing impervious surfaces such as concrete with BMP's such as pervious concrete pavers and, increasing native vegetation can help reduce stormwater runoff.

Reduction Action 4: Increase Watershed Education and Awareness

Promote BMPs to Citizens and Landowners in Upper Little Sac River Watershed

Promote landowner and citizen education about urban and rural BMPs through the WCO website, newsletters, social media, trainings, workshops, and monthly public watershed meetings. Because nonpoint source reduction measures are primarily voluntary in nature, engaging and building relationships with citizens, landowners, businesses, government and community organizations in the watershed is essential to successfully decrease nonpoint source pollution. Building these relationships and partnerships is key to having lasting positive impact on local water quality. The Watershed Committee of the Ozarks is founded on collaboration and it is an vital part of completing successful education and projects in the watershed.

Groundwater Monitoring Program

The Little Sac River Watershed has karst topography, which yields hundreds of springs throughout the watershed. Springs gather flow from relatively large land areas, which can concentrate the effects of pollution and human activity to a single point. Therefore, springs are sensitive indicators and efficient, inexpensive sites (compared to monitoring wells) for monitoring the health of shallow groundwater. It is very important that we know what is happening to this shallow groundwater—because it can affect the deeper groundwater that most rural wells tap for their drinking water supplies.

A volunteer-based quarterly sampling program called Adopt-A-Spring began at WCO in 2000 as part of a section 319-mini-grant with the MODNR. Over the years, volunteer numbers have severely declined. Reestablishing and restoring a spring sampling program at WCO would increase the amount of bacteria and water quality data being collected at local springs in the watershed. This program will gather baseline groundwater information and locate springs with consistently high bacteria levels and other water quality parameters, targeting those sub-watersheds for future efforts.

Watershed Center Educational Efforts

The Watershed Center is the home base of the WCO, and the heart of our mission's educational focus. The beautiful site, Valley Water Mill Park, is a microcosm of the Ozarks with streams, springs, a lake, caves, sinkholes, and diverse types of habitats. Educational interpretive signs are located around the site to help visitors learn about water as they visit the site. The dream to create this special place was made possible by Watershed staff members, board members, sponsors, and partners. We are grateful for their support and for the support of the community. At the Watershed Center, we strive to provide age-appropriate, place-based education about our water resources.

Many school groups, professional groups, and community groups take educational field trips or workshops at the site. The Watershed Center employs an education and outreach coordinator to help such groups plan an educational experience at the Watershed Center. In 2017, a total of 11,131 people participated in a Watershed Committee educational program, tour, or field trip. These educational experiences help the City of Springfield meet their educational federal stormwater mandates and are also of great value to the community.

Promote Septic Tank Education

The Springfield region of Missouri has seen high growth rates in the last decade. Much of this growth has occurred south of the city and in unincorporated areas. Many of these areas rely on well water and on-site septic systems to service business and household needs. The area known as the Springfield Plateau has a unique suite of soils, topography, and hydrology. These features present a distinctive potential for groundwater contamination.

The Onsite Wastewater Training Center at WCO is a demonstration site for new and innovative stormwater controls. It can be compared to more traditional designs which would benefit builders, as well as city perimeters and planners. Educational features that can incorporate watershed and groundwater protection would naturally involve the importance of septic and stormwater in preventing nonpoint source pollution.

Promote Education about preventing spread of Hydrilla

Hydrilla is a federally listed noxious weed that can be detrimental to our aquatic resources. It is native to the Indian sub-continent and was first observed in the United States in the early 1950s, more than likely from the aquarium trade. Hydrilla can quickly spread throughout freshwater systems including ponds, lakes, reservoirs, and even streams. Hydrilla displaces the local aquatic plant community, interferes with boating and fishing, clogs water intake systems, and adversely changes the dynamics of fish populations. In places that have hydrilla, pond owners and lake managers are faced with expensive control measures.

In short, this plant is not only detrimental to small ponds and lakes, but it will harm Missouri's economy through hindering fishing and other recreational uses at our larger impoundments if allowed to spread.

One of the main routes for spread outside of the immediate area is via a plant fragment hitching a ride on something such as boat trailer, within a boat's live well, or even in a bait bucket. To help reduce the spread of hydrilla, education in the drinking watershed is important to reduce the risk of hydrilla spreading. Education should focus on thoroughly cleaning all fishing gear after each trip and not transporting plants or fish to another waterbody. There have been a lot of local cooperative efforts lead by the Missouri Department of Conservation to eradicate hydrilla from the Little Sac Watershed which have yielded much success. Those cooperative efforts should continue until hydrilla is completely removed from all waterbodies in the Little Sac Watershed.

Recommended Management Measures Implementation

Springfield uses ground and surface water for its drinking water sources. This drinking water comes from different sub-watersheds. Each sub-watershed has different characteristics and requires different management strategies to address and maintain the quality and quantity of drinking water in the area. Within the Little Sac River Watershed, the highly urban area in Springfield transition into the rural, agricultural areas to the north. In this transition zone, urban sprawl is occurring and needs proper conservation and growth management practices. For these reasons, the management measures currently ongoing and planned in the watershed are divided into the Urban and Rural BMPs tables below. The management measures listed in the tables and reduction action goals is a culmination of measures recommended by local community professionals, watershed studies and local citizens based on years of previous work in the watershed combined with survey results to target reduce nonpoint source pollution in the Little Sac Watershed.

Table 6-Management Measure and Implementation Schedule

Goal	Management Measures (milestones)	Milestone Quantity	Critical Area Location	Load Reductions	Assisting agencies	Monitoring/ Evaluation Criteria
Reduction Action 1: Reduce Bacteria Pollution in the Watershed 37% E.coli reduction <u>Priority Subbasins:</u> Tier 1: Years 1-3 Tier 2: Years 3-6 Tier 3: Years 6 - 20	Stream Corridor Improvement and Protection (*See conservation practice list in Appendix I for eligible BMP*s)	700 ac. of BMP treatment per year	All priority subbasins Riparian corridor in hay/pasture and urban areas	% reduction	WCO/Greene County SWCD / Private Landowners	Monitor use and follow up through field check and modeling water quality and loading
	Soil Health and Restoration (*See conservation practice list in Appendix I for eligible BMP*s)	# of acres per year	All priority subbasins hay/pasture	% nutrients, sediment	WCO/Greene County SWCD / Private Landowners	Evaluate water quality and loading in targeted sub-basins through modeling
	Riparian Habitat Improvement	25 systems acres per year	All priority subbasins hay/pasture	% nutrients, sediment, bacteria	WCO/Greene County SWCD/ Private Landowners	Monitor surface water quality before and after remediation of system
	Nutrient Management	50 acres/year	All priority subbasins hay/pasture	% Nutrients	WCO/Greene County SWCD/Private Landowners	Monitor surface water quality before and after remediation of system
	Septic Systems Remediation Project (install/repair, maintain)	Priority houses closest to the stream. (within one mile) 25 systems	Urban area subbasin	% Bacteria, phosphorus	WCO/Greene County SWCD/Private landowners	Visually monitoring and # completed
	Water Protection for Well, Sinkholes, Caves & Springs	Impervious area reduced by 5 acres in 10 years (2026)	All priority subbasins	% nutrients, sediment, bacteria	Greene county Resource Management	Monitor use and follow up through field check and modeling
Reduction Action 2: Reduce Sediment Erosion in the Watershed (agr.)	Sheet/Rill Erosion Prevention	40 acres/year	All priority subbasins	Nutrients, sediment	Greene County SWCD	Monitor use and follow up through field check and modeling

	Forage Management	200 acres/year	Priority Subbasins hay/pasture	Nutrients, bacteria, sediment, runoff volume	Greene County SWCD	Monitor use and follow up through field check and calculate pollutants load by modeling
Reduction Action 3: Reduce Stormwater Runoff in the Watershed (Urban) 6 % E.coli reduction Priority Subbasins: Tier 1: Years 1-3 Tier 2: Years 3-6 Tier 3: Years 6 - 20	Zoo Storm water BMPs (*See conservation practice list in Appendix I for eligible BMPs*)	Approx. 500 feet of lakeshore stabilization and BMPs for approx. 1.5 acres of animal exhibits	Urban area subbasin	Runoff volume, sediment, bacteria, nutrients	City of Springfield Storm Water Services	Monitor use and follow up through field check and modeling
	Detention Basin Retrofits	Ongoing property acquisition as Available. 10 basins	Urban area subbasin	sediment	City of Springfield Storm Water Services	Follow-up site visits and field monitoring. Calculate increased stormwater detention from BMP
	Doling Park Lake Improvements (*See conservation practice list in Appendix I for eligible BMPs*)	Approx. 500 feet of lakeshore stabilization; waterfowl deterrent measures; 400 feet of channel improvements	Urban area Subbasin	Sediment, bacteria, nutrients	City of Springfield Storm Water Services	Monitor use and follow up through field check and modeling
	Conduct Stormwater inspections of industrial/high risk operations	Average 5 inspections annually	Urban area Subbasin	Heavy metals, oil, sediment, others	City of Springfield Storm Water Services	Follow up site visits and field monitoring
	Implement water quality requirements for new developments & significant redevelopments using Flood Control and Water Quality Protection Manual adopted 2017	# Per development and redevelopment	All priority subbasins	sediment, nutrient, others	City of Springfield Storm Water Services & Greene County Resource Management	Follow up site visits and field monitoring

	Implement Land Disturbance/ Site Grading Permit Program	Help to secure sustainable funding for at least one community within 5 years	All priority subbasins	sediment	City of Springfield Storm Water Services/ Greene County Resource Management	Follow up site visits and field monitoring
Reduction Action 4: Increase Watershed Education and Awareness	Public Education and Outreach programs in watershed	20 presentations, 15 community events, 5,000 handouts, various other projects annually - SSWS see element #5 – ongoing during 20 year plan period	All priority subbasins	Nutrients, pesticides, household chemicals, sediment, runoff volume	City of Springfield Storm Water Services and WCO	Surveys, landowner contact, BMPs requests
	Little Sac Agricultural Demonstration Farm Educational Workshops	two per year once installed	All priority subbasin	Pollution Prevention with Prescribed Rotational Grazing Management	WCO/Greene County SWCD	Landowners surveys at each event
	Implement Floodplain Development and Planning Program	Per Planned Development	All subbasins	Nutrients, sediment, bacteria	Greene County Resource Management	# of plans and project implemented
	Specific Contamination Source & Springs Source Tracking Research	1 graduate research project at the 4 areas of critical priority	All subbasins	Bacteria source tracking	City of Springfield, Greene County, and other interested parties	# of projects completed

Financial and Technical Assistance

This section provides information on financial and technical assistance for the BMPs that are recommended to reduce bacteria levels in the Upper Little Sac River Watershed. Responsible entities will be responsible for making sure the BMPs are included in new and existing development. The costs of the required individual practices will be borne by developers as part of the normal development process. The cost of stream corridor improvement and protection such as restoring or establishing vegetative buffers will be borne by the private property owner and grant funding if available can assist with cost share. The cost to conserve soil health in pastures, increase prescribed rotational grazing and install solar watering will be borne by the landowner however some cost share funding is available through farm bill programs and grants depending on fund availability. Funding for watershed planning, BMPs maintenance, remediating failing septic systems, tree planting, rainwater collection, reducing impervious surface area, floodplain and sinkhole acquisition, and other ongoing water-quality-focused activities will need to be sought by the responsible entities. Other potential funding sources include Capital Improvements Sales Tax, Parks and Waterways Sales Tax, Section 319-Grants, 604(b) Water Quality Planning Grants, Soil and Water Conservation Cost Share Assistance, Conservation Reserve Program (CRP), Conservation Easement Program (NRCS), Environmental Quality Incentives Program (EQIP), Conservation Stewardship Program, Springfield Community Foundation Grants, LAD Grants, USDA Sustainable Urban Agriculture grants, and, most importantly, local stormwater funding sources such as stormwater utilities, development impact fees, or tax-supported stormwater programs.

The Watershed Committee of the Ozarks (WCO) is sponsored by City Utilities, City of Springfield and Greene County. The sponsor support allows WCO to provide essential educational efforts to give citizens information and experiences which improve their understanding of local water resources and encourage the stewardship of those resources. Participants range of audiences from children to professionals. Both our projects and educational efforts help our community meet federally mandated requirements.

Table 7 below provides cost estimates for the BMPs that were modeled in the 2018 SWAT Report which can be found in the appendix. Based on the size of the watershed and the average amount of acres treated each year by the soil and water district, it was estimated that an average of 700 acres could be treated each year. The estimated unit cost was based on past projects that have been completed in the watershed combined with researching unit cost estimates for each BMP.

When comparing the economic and environmental benefits to the implementation costs the BMP's used in the model the greatest water quality improvement in bacteria load reduction is scenario 4 when all three BMP are utilized which is reflected in the tables 2 on page 31 which reveals a 34 percent reduction of E.coli. If funding is available this is the best management scenario that would be selected for the watershed to implement in the critical areas defined. This scenario combined with the recommended BMP's measures in tablewould achieve the needed bacteria reduction goal of 41 percent as defined in the load duration curve. The greatest environmental impact with one BMP is scenario 2 an applied BMP of 15m vegetative buffer in the pasture. The second greatest environmental impact is scenario 3 an applied 10 m vegetative buffer in urban areas. Soil health improvements in scenario 1 is the most economically feasible however it has the lowest bacteria load reduction of 7%. Despite this low quantifiable bacteria reduction, it soil health is critical to improving the water quality in the watershed especially as part of overall healthy land management. Pasture and urban riparian corridor improvements BMP's yielded the greater quantifiable improvements in the model and likewise yielded the greatest cost estimates.

Table 7-Cost Estimates based on 700 acres of BMP Treatment per year					
BMPs Type	*Unit Cost*	*Total Cost (5 Years)*	*Total Cost (10 Years)*	*Total Cost (15 Years)*	*Total Cost (20 Years)*
Scenario 1: BMPs to conserve soil health in pasture areas	$40 per acre	$140,000	$280,000	$420,000	$560,000
Scenario 2: 15 m vegetative buffer in pasture areas	$110 per acre or $2,000 per river mile	$385,000	$770,000	$1,155,000	$1,540,000
Scenario 3: 10 m vegetative buffer in urban areas	$305 per acre or $5,000 per river mile	$1,076,500	$2,135,000	$3,229,500	$4,270,000
Scenario 4: Total of all BMP types combined	**$455 per acre**	**$1,601,500**	**$3,185,000**	**$4,804,500**	**$6,370,000**

Evaluating the Plan

If funding is available, adaptive management measures will consist of revaluating the watershed data by collecting more monitoring data including a second collection of bacteria source tracking at the same sites in the watershed. If funding is available, it would be helpful to add a gaging station in the watershed. Yearly cooperative groundwater monitoring data collected at local area springs collected in partnership with City Utilities of Springfield and Watershed Committee of the Ozarks can also be used as a baseline to track if water quality is maintaining or improving. Long term monitoring of BMP's will be done based on water quality data collected by partners including City Utilities of Springfield, City of Springfield, Greene County and Missouri Department of Natural Resources. See Appendix J for Missouri's Water Quality Monitoring strategy

The quantity and descriptions of the BMP's in tables 6 and 7will be utilized as evaluation criteria to measure if the goals for each BMP has been meet and if the responsible parties have completed the project. This evaluation will be performed each year to measure the progress and success of the projects installed in the watershed. Load reductions will also be modeled for each BMP implemented as a part of this plan, and these load reductions will be reported on an annual basis.

Within 5 years of the beginning of implementation of the Upper Little Sac River Watershed-based Plan elements, partners and stakeholders will evaluate the progress made toward achievement of the BMPs implementation schedule and water quality goals. If water quality goals are not on pace to be met within the first five-year increment, partners will discuss the feasibility of increasing the pace of installation of BMPs. If modeling and/or monitoring indicates that water quality goals will most likely not be met through further implementation, water quality partners will discuss revising strategies toward the achievement of plan goals. WCO will have primary responsibility for the updating process, including contact with all major stakeholders, and gathering data and input.

References

Aley, T. and K.C. Thompson, 2002. A Study of Septic Field Performance and Recharge Area Delineations for Twelve Spring Systems Greene County, Missouri. Ozarks Underground Laboratory.

Baffaut, C. (2006) Total Maximum Daily Load for Little Sac River Watershed. FAPRI-UMC Report #07-05. Food and Agricultural Policy Research Institute (FAPRI), University of Missouri. Missouri Department of Natural Resources Water Protection Program.

Bair, Brain. Stream Restoration Cost Estimates: Streambank stabilization, streambank fencing, nuisance species control, riparian zone management. USDA Forest Service Gillford-Pinchot National Forest Carson, WA.

Brookshire, C. N., 1997. Missouri Water Quality Assessment, Water Resources Report No. 47, Missouri State Water Plan Series III, Missouri Department of Natural Resources.

City of Springfield Missouri, 2016. Clean Water Services Website. Statistics Average Effluent Water Quality. Site visited May, 2017.
https://www.springfieldmo.gov/248/Statistics

Greene County Soil and Water Conservation District in Partnership with the Watershed Committee of the Ozarks and Missouri Department of Natural Resources. Little Sac River Watershed Management Plan Covering the Fellows-McDaniel and Fulbright Watersheds. 2009.

MEC, 2007. Southwest Missouri Water Quality Improvement Project (WQIP) Sac River Basin Water Quality Gap Analysis. MEC Water Resources and Ozarks Environmental and Water Resources Institute at Missouri State University. Prepared for the Environmental Resources Coalition.

Ozarks Environmental and Water Resources Institute (OEWRI) (2018) Ozarks Environmental and Water Resources Institute, Missouri State University.

United States Census Bureau, 2018. Population Distribution and Change: 2000 to 2010
https://www.census.gov/prod/cen2010/briefs/c2010br-01.pdf

United States Department of Agriculture, Natural Resources Conservation Service.

United States Geological Survey. National Water Information System: Web Interface, USGS Water Resources.
March 2017 http://nwis.waterdata.usgs.gov/mo/nwis/

United States Geological Survey. Water Quality in the Little Sac River Basin near Springfield, Missouri, 1999–
2001. Water-Resources Investigations Report 02-4154

United States Environmental Protection Agency (USEPA), 2012. Recreational Water Quality Criteria, Office of Water EPA-820-F-12-061.

Watershed Committee of the Ozarks (WCO) (2016) Sac River Healthy Watershed Plan. October

2016.

Watershed Committee of the Ozarks (WCO) (2009) Little Sac Watershed Management Plan. Prepared by the Watershed Committee of the Ozarks in Cooperation with the Greene County Soil and Water District.

Woods, D., 2014. Little Sac River Priority Watershed 2013 Sampling Summary Report. Missouri Department of Conservation Fisheries Division-Southwest Region.

Appendix H.

Minimum Elements of a Watershed-based Plan

Although many different elements may be included in a watershed plan, EPA has identified nine minimum elements that are critical for achieving improvements in water quality. In general, EPA requires that nine-element watershed-based plans (WBPs) be developed prior to implementing project(s) funded with § 319 watershed project funding. In many cases, state and local groups have already developed watershed plans and strategies for their rivers, lakes, streams, wetlands, estuaries, and coastal waters that address some or all of the nine elements. EPA encourages states to use these plans and strategies, where appropriate, as building blocks for developing and implementing WBPs. If these existing plans contain all nine elements listed below, they can be used to fulfill the WBP requirement for watershed projects. If the existing plans do not address all nine elements or do not include the entire watershed planning area, they can still provide valuable components to inform, develop, and update WBPs.

For example, some watershed management plans contain information on hydrology, topography, soils, climate, land uses, water quality problems, and management practices needed to address water quality problems but lack the quantitative analysis of current pollutant loads or expected load reductions from proposed management practices. In this case, the WBP developer could incorporate such existing information into the plan to help fulfill the nine WBP elements. If separate documents contain information that help meet the nine WBP elements listed below but are too lengthy to be included in the WBP, they can be summarized and referenced in the appropriate sections of the plan, as long as the information is readily available.

Nine Elements of Watershed-based Plans (WBPs)

The nine elements, as well as short explanations of how each element fits in the context of the broader WBP, are provided below. Although they are listed as *a* through *i*, they do not necessarily take place sequentially. For example, element *d* asks for a description of the technical and financial assistance that will be needed to implement the WBP, but this can be done only after you have addressed elements *e* and *i*.

The level of detail needed to address the nine elements of WBPs will vary in proportion to the homogeneity or similarity of land use types and variety and complexity of pollution sources. For example, densely developed urban and suburban watersheds often have multiples sources of pollution from historic and current activities (Superfund sites, point sources, solid waste disposal, leakage from road salt storage, oil handling, stormwater-caused erosion, road maintenance, etc.) in addition to some agricultural activities. Plans will be more complex than in predominantly rural settings in these cases. For this reason, plans for urban and suburban watersheds may need to be developed and implemented at a smaller scale than watersheds with agricultural lands of a similar character.

Element a. Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan. Sources that need to be controlled should be identified at the significant subcategory level along with estimates of the extent to which they are present in the watershed (e.g., X number of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).

What does this mean?
Your WBP source assessment should encompass the watershed of the impaired waterbody(ies) throughout the watershed, and include map(s) of the watershed that locates the major cause(s) and source(s) of impairment in the planning area. To address these impairments, you will set goals to meet (or exceed) the appropriate water quality standards for pollutant(s) that threaten or impair the physical, chemical, or biological integrity of the watershed covered in the plan.

This element will usually include an accounting of the significant point and nonpoint sources in addition to the natural background levels that make up the pollutant loads causing problems in the watershed. If a TMDL or TMDLs exist for the waters under consideration, this element may be adequately addressed in those documents. If not, you will need to conduct a similar analysis (which may involve mapping, modeling, monitoring, and field assessments) to make the link between the sources of pollution and the extent to which they cause the water to exceed relevant water quality standards.

Element b. An estimate of the load reductions expected from management measures.

What does this mean?
On the basis of the existing source loads estimated for element *a*, you will similarly determine the reductions needed to meet water quality standards. After identifying the various management measures that will help to reduce the pollutant loads (see element *c* below), you will estimate the load reductions expected as a result of implementing these management measures, recognizing the difficulty in precisely predicting the performance of management measures over time.

Estimates should be provided at the same level as that required in the scale and scope described in element *a* (e.g., the total load reduction expected for dairy cattle feedlots, row crops, eroded streambanks, or implementation of a specific stormwater management practice). For waters for which TMDLs have been approved or are being developed, the plan should identify and incorporate the TMDLs; the plan needs to be designed to achieve the applicable load reductions in the TMDLs. Applicable loads for downstream waters should be included so that water delivered to a downstream or adjacent segment does not exceed the water quality standards for the pollutant of concern at the water segment boundary. The estimate should account for reductions in pollutant loads from point and nonpoint sources identified in the TMDL as necessary to attain the applicable water quality standards.

Element c. A description of the nonpoint source management measures that will need to be implemented to achieve load reductions in element b, and a description of the critical areas in which those measures will be needed to implement this plan.

What does this mean?
The plan should describe the management measures that need to be implemented to achieve the load reductions estimated under element *b*, as well as to achieve any additional pollution prevention goals outlined in the watershed plan (e.g., habitat conservation and protection). Pollutant loads will vary even within land use types, so the plan should also identify the critical areas17 in which those measures will be needed to implement the plan. This description should be detailed enough to guide needed implementation activities throughout the watershed and can be greatly enhanced by developing an accompanying map with priority areas and practices. Thought should also be given to the possible use of measures that protect important habitats (e.g. wetlands, vegetated buffers, and forest corridors) and other non-polluting areas of the watershed. In this way, waterbodies would not continue to degrade in some areas of the watershed while other parts are being restored.

Element d. Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.

What does this mean?
You should estimate the financial and technical assistance needed to implement the entire plan. This includes implementation and long-term operation and maintenance of management measures, information/education (I/E) activities, monitoring, and evaluation activities. You should also document which relevant authorities might play a role in implementing the plan. Plan sponsors should consider the use of federal, state, local, and private funds or resources that might be available to assist in implementing the plan. Shortfalls between needs and available resources should be identified and addressed in the plan.

Element e. An information and education component used to enhance public understanding of the plan and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.

What does this mean?
The plan should include an I/E component that identifies the education and outreach activities or actions that will be used to implement the plan. These I/E activities may support the adoption and long-term operation and maintenance of management practices and support stakeholder involvement efforts.

Element f. Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.

What does this mean?
You should include a schedule for implementing the management measures outlined in your watershed plan. The schedule should reflect the milestones you develop in *g* and you should begin implementation as soon as possible. Conducting baseline monitoring and outreach for

implementing water quality projects are examples of activities that can start right away. It is important that schedules not be "shelved" for lack of funds or program authorities; instead they should identify steps towards obtaining needed funds as feasible.

Element g. A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

What does this mean?
The WBP should include interim, measurable implementation milestones to measure progress in implementing the management measures. These milestones will be used to track implementation of the management measures, such as whether they are being implemented according to the schedule outlined in element *f*, whereas element *h* (see below) will develop criteria to measure the effectiveness of the management measures by, for example, documenting improvements in water quality. For example, a watershed plan may include milestones for a problem pesticide found at high levels in a stream. An initial milestone may be a 30% reduction in measured stream concentrations of that pesticide after 5 years and 50 percent of the users in the watershed have implemented Integrated Pest Management (IPM). The next milestone could be a 40% reduction after 7 years, when 80% of pesticide users are using IPM. The final goal, which achieves the water quality standard for that stream, may require a 50% reduction in 10 years. Having these waypoints lets the watershed managers know if they are on track to meet their goals, or if they need to re-evaluate treatment levels or timelines.

Element h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.

What does this mean?
As projects are implemented in the watershed, you will need water quality benchmarks to track progress towards attaining water quality standards. The *criteria* in element *h* (not to be confused with *water quality criteria* in state regulations) are the benchmarks or waypoints to measure against through monitoring. These interim targets can be direct measurements (e.g., fecal coliform concentrations, nutrient loads) or indirect indicators of load reduction (e.g., number of beach closings). These criteria should reflect the time it takes to implement pollution control measures, as well as the time needed for water quality indicators to respond, including lag times (e.g., water quality response as it is influenced by ground water sources that move slowly or the extra time it takes for sediment bound pollutants to break down, degrade or otherwise be isolated from the water column). Appendix B of these guidelines, "Measures and Indicators of Progress and Success," although intended as measures for program success, may provide some examples that may be useful. You should also indicate how you will determine whether the WBP needs to be revised if interim targets are not met. These revisions could involve changing management practices, updating the loading analyses, and reassessing the time it takes for pollution concentrations to respond to treatment.

***Element i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under element* h.**

What does this mean?
The WBP should include a monitoring component to determine whether progress is being made toward attaining or maintaining the applicable water quality standards for the waterbody(ies) addressed in the plan. The monitoring program should be fully integrated with the established schedule and interim milestone criteria identified above. The monitoring component should be designed to assess progress in achieving loading reductions and meeting water quality standards. Watershed-scale monitoring can be used to measure the effects of multiple programs, projects, and trends over time. Instream monitoring does not have to be conducted for individual BMPs unless that type of monitoring is particularly relevant to the project.

For more detailed information on developing watershed-based plans, please see *A Handbook for Developing Watershed Plans to Restore and Protect Our Waters*, U.S. EPA, EPA 841-B-08-002 March 2008, (water.epa.gov/polwaste/nps/handbook_index.cfm). Other resources for watershed planning are available on the Watershed Central website - including the Watershed Central Wiki and Plan Builder tool at (water.epa.gov/type/watersheds/datait/watershedcentral/index.cfm).

Appendix I.

Missouri Soil and Water Conservation Program		Practice Mode of Action*			Pollutants Addressed			
Resource Concerns and Associated Cost-Share Practices		Avoid	Control	Trap	Sediment	Nutrients	E. coli	Pesticide
SWCP Cost-Share #	Sheet/Rill and Gully Erosion	Sheet/Rill and Gully Erosion						
DSL-01	Permanent Vegetative Cover Establishment	x	x	x	x	x	x	x
DSL-02	Permanent Vegetative Cover Improvement	x	x	x	x	x	x	x
DSL-04	Terrace System		x	x	x	x		x
DSL-44	Terrace System with Tile		x		x	x		
DSL-05	Diversion		x		x	x		x
DSL-11	Permanent Vegetative Cover - Critical Area	x	x	x	x	x		x
DSL-111	Permanent Vegetative Cover - Critical Area: Confined Animal Feedlot	x	x	x	x	x	x	
DSL-15	No-Till System	x	x	x	x	x		x
DWC-01	Water Impoundment Reservoir		x	x	x	x		x
DWP-01	Sediment Retention, Erosion or Water Control Structure		x	x	x	x		x
DWP-03	Sod Waterway	x	x	x	x	x		x
N332	Contour Buffer Strips	x	x	x	x	x		x
N340	Cover Crop	x	x	x	x	x	x	x
N380	Windbreak/Shelterbelt Establishment	x	x	x	x	x		x
N410	Drop Pipe		x	x	x	x		
N585	Contour Stripcropping		x	x	x	x	x	x
Cost-Share #	Grazing Management	Grazing Management						
DSP-02	Permanent Vegetative Cover Enhancement	x	x	x	x	x	x	
DSP 3.1	Grazing System Water Development		x		x	x	x	
DSP 3.2	Grazing System Water Distribution		x		x	x	x	
DSP 3.3	Grazing System Fence	x	x		x	x	x	
DSP 3.4	Grazing System Lime		x			x		

DSP 3.5	Grazing System Seed	x	x	x	x	x	x	
	-							
Cost-Share #	Irrigation Management	Irrigation Management						
N430	Irrigation Water Conveyance		x		x	x		x
N442	Irrigation System, Sprinkler	x			x	x		x
N443	Irrigation System, Surface and Subsurface		x		x	x		x
N447	Irrigation System, Tail Water Recovery		x		x	x		x
N554	Drainage Water Management		x	x	x	x		x
N587	Structure for Water Control		x	x	x	x		x
	-							
Cost-Share #	Animal Waste Management	Animal Waste Management						
N312	Beef Waste Management System	x	x			x	x	
N312	Dairy Waste Management System	x	x			x	x	
N312	Poultry Waste Management	x	x			x	x	
N312	Swine Waste Management	x	x			x	x	
N316	Incinerator	x	x			x	x	
N317	Composting Facility	x	x			x	x	
Cost-Share #	Nutrient and Pest Management	Nutrient and Pest Management						
N590	Nutrient Management	x	x		x	x	(x)	
N595	Pest Management	x	x					x
Cost-Share #	Sensitive Areas	Sensitive Areas						
C650	Streambank Stabilization		x	x	x	x	x	
DSP-31	Sinkhole Improvement		x	x	x	x	x	x
BDSP-31	Buffer Sinkhole Improvement		x	x	x	x	x	x
N351	Well Decommissioning	x			x	x	x	x

N380	Windbreak/Shelterbelt Establishment	x	x	x	x	x		x
N386	Field Border		x	x	x	x	x	x
N391	Riparian Forest Buffer		x	x	x	x		
N393	Filter Strip		x	x	x	x	x	x
N574	Spring Development	x			x	x	x	
N725	Sinkhole Treatment	x	x	x	x	x	x	x
WQ10	Stream Protection	x	x	x	x	x	x	x
Cost-Share #	[Woodland Erosion]	Woodland Erosion						
C100	Timber Harvest Plan	x			x	x		
DFR-04	Forest Plantation	x			x	x		
N472	Livestock Exclusion	x			x	x	x	
N655	Restoration of Skid Trails, Logging Roads, Stream Crossings and Log Landings		x	x	x	x		
	Resource Concern and Associated Cost-Share Practices	**Avoid**	**Control**	**Trap**	**Sediment**	**Nutrients**	**E. coli**	**Pesticide**
Note: The above table is meant to provide examples of the most commonly accepted practices employed in Missouri. It is not meant to preclude other practices that that may be appropriate to specific projects or site conditions.		**Practice Mode of Action***			**Pollutants Addressed**			

**Additional information can be found at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1187023.pdf*

(x) count if management plan is for animal waste

Common Urban Land Management Practices	Practice Mode of Action			Pollutants Addressed			
	Avoid	Control	Trap	Sediment	Nutrients	E. coli	Pesticide
Urban	**Urban**						
Bioswale		x	x	x	x	x	
Detention basin		x	x	x	x	x	
Fertilizer management	x	x			x		
Enhanced infiltration (soil amendment)	x	x	x	x	x		
Irrigation management	x	x			x	x	x
Low impact landscaping	x			x	x		x
Pest management							x
Porous pavement		x	x		x	x	x
Rain garden		x	x	x	x	x	x
Rain water harvesting	x	x		x	x	x	
Other	**Other**						
Alum application		x	x		x		
Filter/buffer strip		x	x	x	x	x	x
Grade stabilization structure		x		x			
Grass seeding	x	x		x	x		
Habitat improvement	x	x		x	x	x	
On-site wastewater system upgrade		x			x	x	
Riparian restoration	x	x	x	x	x	x	x
Sediment control basin		x	x	x	x	x	
Sediment removal		x		x	x		
Shoreline stabilization		x		x	x		
Stream bank stabilization		x		x	x	x	
Water diversion	x	x		x	x		
Water retention basin		x	x	x	x	x	x
Well decommissioning	x				x	x	x

Wetland Restoration/Construction		x	x	x	x	x	x
Practice Facilitation	**Practice Facilitation**						
Conservation consultant							
Crop production deferment	x	x		x	x		x
Common Practices	**Avoid**	**Control**	**Trap**	**Sediment**	**Nutrients**	**E. coli**	**Pesticide**
	Practice Mode of Action			**Pollutants Addressed**			

** Note: The above table is meant to provide examples of the most commonly accepted practices employed in Nebraska. It is not meant to preclude other practices that that may be appropriate to specific projects or site conditions.*

Appendix J.

Missouri's Water Quality Monitoring Strategy

Missouri's objectives reflect the needs of the Clean Water Act (CWA), the Safe Drinking Water Act, and other water management activities. Water quality monitoring provides the data to characterize waters and identify changes or trends in water quality over time. The collection of monitoring data enables Missouri to identify existing or emerging water quality problems, and determine whether current pollution control measures are effective in complying with the regulations. The CWA requires each state to monitor and assess the health of all waters and report their findings every two years to the EPA. The list of data and findings are discussed in a 305(b) Integrated Report (also known as the 305(b) report or water quality report) and is available from the Missouri Department of Natural Resources website at URL: http://dnr.mo.gov/env/wpp/waterquality/303d/303d.htm.

Monitoring Objectives

Missouri's overall objective of a monitoring program is to provide sufficient data to allow a water quality assessment of all waters of the state where data is available in both quantity and quality. The specific objectives for Missouri's monitoring program are described A Proposal for A Water Quality Monitoring Strategy for Missouri.

Assessing Water Quality Conditions

For assessing present conditions, more recent data are preferable; however, older data may be used to assess present conditions if the data remains representative of present conditions.

- If the department uses data older than seven years to make a Section 303(d) list decision a written justification for the use of such data will be provided.

- If a water body has not been listed previously and all data indicating an impairment is older than 7 years, then the water body shall be placed into the 303(d) Listing Category 2B or 3B and prioritized for future sampling.

- A second consideration is the age of the data relative to significant events that may have an effect on water quality. Data collected prior to the initiation, closure, or significant change in a wastewater discharge, or prior to a large spill event or the reclamation of a mining or hazardous waste site, for example, may not be representative of present conditions. Such data would not be used to assess present conditions even if it was less than seven years old. Such "pre-event" data can be used to determine changes in water quality before and after the event or to show water quality trends.

Core Water Quality Indicators

The table below describes MoDNR's core and supplemental indictors utilized by the state for the determination of water quality decision needs. The process includes assessing water quality standards attainments and designated use support, identifying needed changes to water quality standards, describing causes and sources of impairments, developing water quality-based source controls, and assessing whether physical, chemical and biological integrity are supported. Details of the department's assessment methods and processes are described in Methodology for the Development of the Section 303(d)

List and Missouri Water Quality (305(b)) Integrated Report. Reference the MoDNR website: http://www.dnr.mo.gov/env/wpp/waterquality/index.html for additional information.

Details of Proposed Core and Supplemental Indicators

	Protection of Aquatic Life	Recreation	Drinking Water Supply	Fish and Shellfish Consumption
Core Indicators	• Quantitative Sampling of Aq. Invertebrates • Quantitative Sampling of Fish • Qualitative Sampling of Invertebrates and Fish • Habitat Assessment • Flow • Water Temperature • Dissolved Oxygen • pH • Conductivity • Sulfate • Chloride • TKN, NH^3N,NO^2+NO^3N • Total P • Diss. Al,Cd,Cu,Fe,Pb,Zn	• Fecal Coliform/E. coli • Total N, Total P **For lakes only:** • Secchi depth • Chlorophyll • VSS • NVSS	• Diss. As,Cd,Cu,Pb,Zn • NO^2+NO^3N • Dissolved Solids **For lakes only:** • Chlorophyll • VSS • NVSS • Total N, Total P	• Pesticides • PCBs • Hg,Pb • Dioxins • Dibenzo Furans
Supplemental Indicators	• Diss. Co, Ni, Cr, Th • Bioassay toxicity • Pesticides	• Hazardous chemicals	• Taste and odor causing substances • Diss. Fe, Mn	• Heavy metals, PAHs

Quality Assurance

MoDNR has an EPA approved quality assurance (QA) management program in place and describes the processes to be followed for all MoDNR environmental monitoring activities. All internal water quality monitoring completed by the department’s Division of Environmental Quality must be done under a QAPP with the MoDNR Environmental Services Program laboratory and approved by the MoDNR QA manager. Environmental monitoring contracted to those outside of the department requires the contractor to also develop a QAPP that must be reviewed and approved by MoDNR. Data generated in the absence of an MoDNR approved QAPP may be used if the department determines the data is scientifically defensible after making a review of the quality assurance procedures used by the data generator. This review includes 1) names of all persons involved in the monitoring program, their duties and a description of training and work related experience; 2) all written procedures, standard operation procedures, or QAPPs pertaining to the monitoring effort; 3) a description of all the field methods used, brand names and model number of any equipment and description of calibration and maintenance procedures; and 4) a description of laboratory analytical methods.