Marmaton – 9 Element Watershed Plan Summary

<u>Impairments to be addressed:</u>

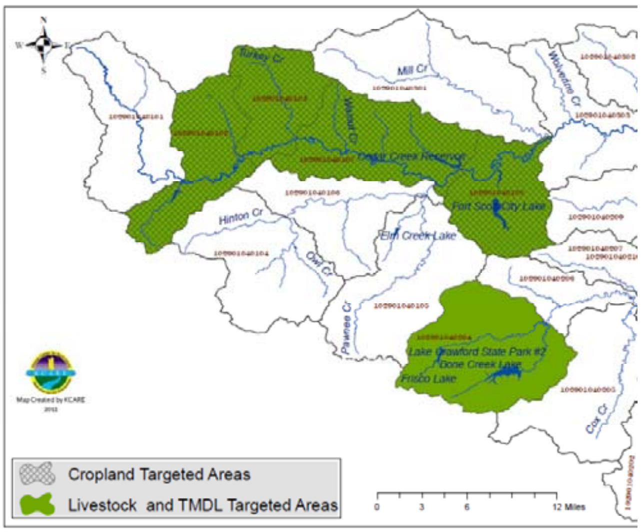
Marmaton River (DO, Biology)

Lake Crawford (EU)

Rock Creek (EU)

Rock Creek Lake (DO)

<u>Prioritized Critical Areas for Targeting BMPs</u>



<u>Targeting considerations:</u>

- Cropland targeted areas were determined by AnnAgNPS (Agricultural Non-Point Source Pollution Model Version 5.00). The AnnAgNPA model shows areas in the watershed that have the most potential for sediment runoff.
- Livestock/ High Priority TMDL targeted areas were chosen based on water quality data provided by KDHE's monitoring network. Monitoring data showed areas with elevated nutrient and bacteria levels that were therefore targeted for livestock BMP implementation.

Table 14. Marmaton AnnAGNPS Model summary for Cropland Erosion and Nutrient Rates.
[31] Cropland Targeted Areas in Bold Print.

		Total Runoff			Average Per Acre Runoff					
HUC 12	Cropland Acres	Sed (tons)	Nit (lbs)	Phos (lbs)	Sed (tons)	Nit (lbs)	Phos (lbs)	Sed Rank	Nit Rank	Phos Rank
102901040202	2,005	236	4,408	593	0.118	2.199	0.296	1	4	2
102901040108	**3,919**	**452**	**8,141**	**1,188**	**0.115**	**2.077**	**0.303**	**2**	**7**	**1**
102901040210	5,814	603	11,095	1,697	0.104	1.908	0.292	3	9	3
102901040103	**6,191**	**447**	**16,833**	**1,587**	**0.072**	**2.719**	**0.256**	**4**	**2**	**4**
102901040102	**5,125**	**353**	**8,335**	**904**	**0.069**	**1.626**	**0.176**	**5**	**10**	**8**
102901040107	**8,253**	**535**	**17,455**	**1,603**	**0.065**	**2.115**	**0.194**	**6**	**5**	**6**
102901040104	10,966	575	37,930	2,130	0.052	3.459	0.194	7	1	5
102901040106	5,961	292	11,721	964	0.049	1.966	0.162	8	8	9
102901040105	6,118	285	16,431	1,148	0.047	2.686	0.188	9	3	7
102901040101	12,869	487	27,154	1,548	0.038	2.11	0.12	10	6	10

Best Management Practices and Load Reduction Goals

Best Management Practices (BMPs) to address phosphorus and sediment in the watershed where chosen by the SLT based on local acceptance/adoptability and the amount of load reduction gained per dollar spent.

Cropland BMPs

- Establish permanent vegetation
- Install grassed waterways
- Implement no-till cropping
- Install vegetative buffers
- Establish conservation crop rotation
- Install terraces

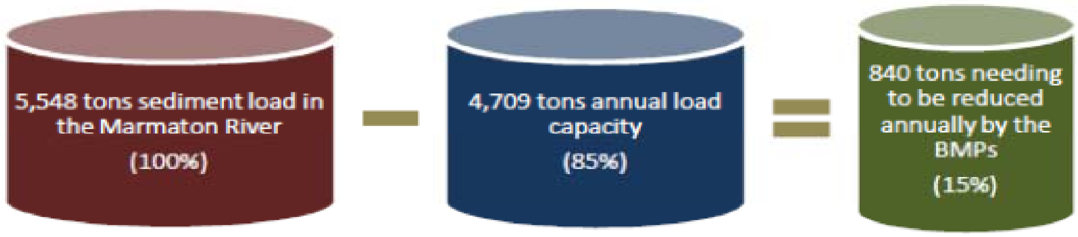
Livestock BMPs

- Establish Vegetative filter strips
- Relocate feeding pens
- Relocate pasture feeding sites
- Install off strem watering sites
- Strategic fencing of streams and ponds
- Implement Rotational grazing

Marmaton – 9 Element Watershed Plan Summary

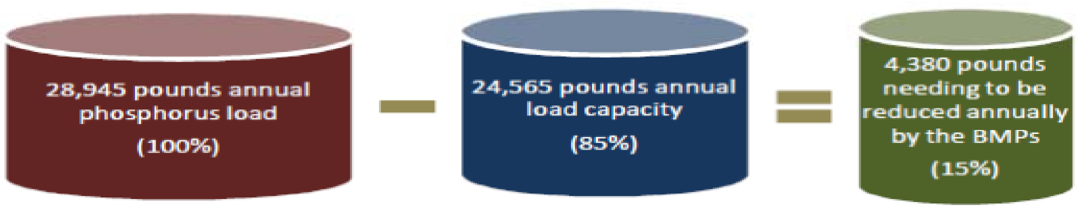
Sediment Reduction:

Required load reduction for the Marmaton River from nonpoint sources as related to the Biology TMDL.

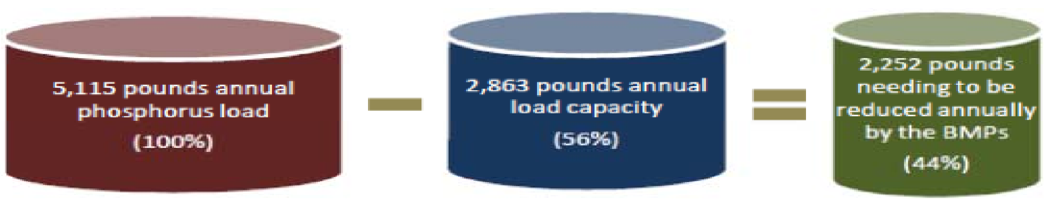


Phosphorus Reductions:

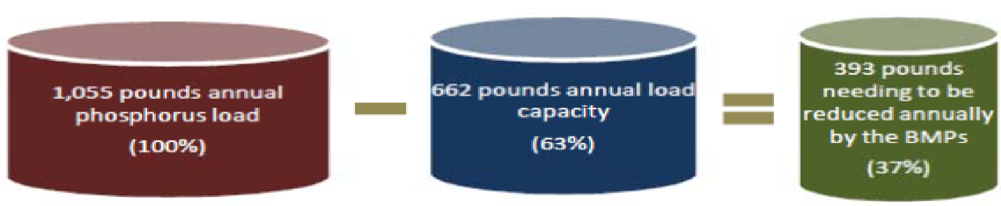
Required load reduction for the Marmaton River from nonpoint sources related to the Biology TMDL.



Required load reduction for Rock Creek Lake from nonpoint sources related to the Eutrophication TMDL.



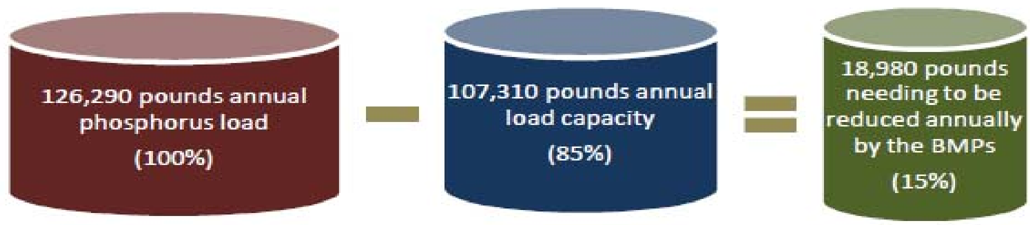
Required load reduction for Crawford Lake from nonpoint sources related to the Eutrophication TMDL.



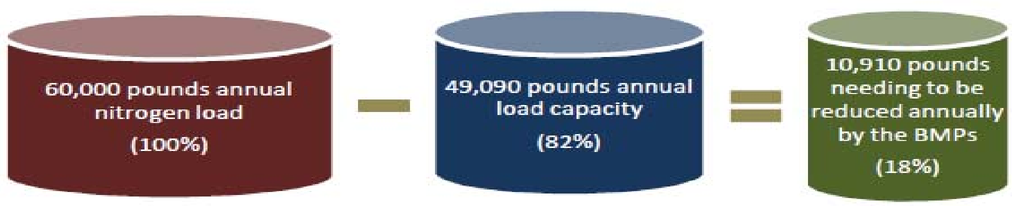
Marmaton – 9 Element Watershed Plan Summary

Nitrogen Reductions:

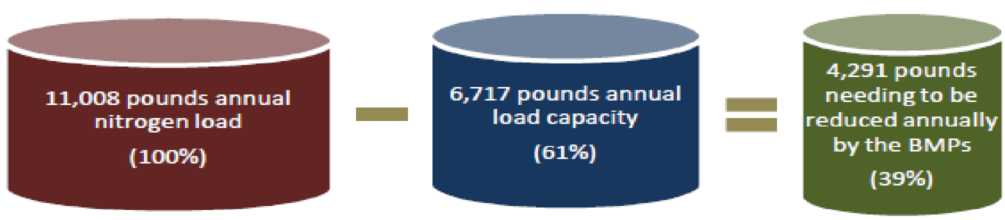
Required load reduction for Marmaton River from nonpoint sources related to the Biology TMDL.



Required load reduction for Rock Creek Lake from nonpoint sources related to the Eutrophication TMDL.



Required load reduction for Crawford Lake from nonpoint sources related to the Eutrophication TMDL.



Bourbon County State Fishing Lake
Photo courtesy of Herschel George

MARMATON

Watershed Restoration and Protection Strategy

Marmaton Watershed

Final Draft Plan November 2, 2011

Funding for the development of this plan was provided through an EPA 319 grant from the Kansas Department of Health and Environment.

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Stakeholder Leadership Team

Name	Affiliation (title)	City
Bob Love, Chairman	Marmaton Joint Watershed District No. 102 (treasurer), Fort Scott/Bourbon County Riverfront Authority (director), MdC Livestock Grant Review Committee (board member), BB Co. Farm Bureau's Natural and Environmental Resources Committee member), landowner	Hiattville
Jingles Endicott, Vice-Chairman	Bourbon County Commissioner, landowner, conservation district (advisor), retired manager of Bourbon County RWD C2	Fort Scott
Randy Nelson, Secretary/Treasurer	KDWP (Manager, Farlington Fish Hatchery; State Aquaculture Coordinator/Fish Trade Coordinator; landowner)	Farlington
Dean Mann	Fort Scott/Bourbon County Riverfront Authority (chairman), civic club rep., conservation district (advisor), landowner	Fort Scott
Brad Blythe	Marmaton Joint Watershed District No. 102 (board member), conservation district (advisor), landowner	Uniontown
Rollin Wiley	Bone Creek PWWSD (board member), landowner	Farlington
Matt Powe	NRCS (Supervisory District Conservationist)	Iola

Kansas Department of Health and Environment Project Officer
Matt Unruh, Watershed Management Section

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Glossary of Terms

Best Management Practices (BMP): Environmental protection practices used to control pollutants, such as sediment or nutrients, from common agricultural or urban land use activities.

Biological Oxygen Demand (BOD): Measure of the amount of oxygen removed from aquatic environments by aerobic microorganisms for their metabolic requirements.

Biota: Plant and animal life of a particular region.

Chlorophyll a: Common pigment found in algae and other aquatic plants that is used in photosynthesis

Dissolved Oxygen (DO): Amount of oxygen dissolved in water.

E. coli bacteria (ECB): Bacteria normally found in gastrointestinal tracts of animals. Some strains cause diarrheal diseases.

Eutrophication (E): Excess of mineral and organic nutrients that promote a proliferation of plant life in lakes and ponds.

Fecal coliform bacteria (FCB): Bacteria that originate in the intestines of all warm-blooded animals.

Municipal Water System: Water system that serves at least 25 people or has more than 15 service connections.

National Pollutant Discharge Elimination System (NPDES) Permit: Required by Federal law for all point source discharges into waters.

Nitrates: Final product of ammonia's biochemical oxidation. Primary source of nitrogen for plants. Originates from manure and fertilizers.

Nitrogen(N or TN): Element that is essential for plants and animals. TN or total nitrogen is a chemical measurement of all nitrogen forms in a water sample.

Nonpoint Sources (NPS): Sources of pollutants from a disperse area, such as urban areas or agricultural areas

Nutrients: Nitrogen and phosphorus in water source.

Phosphorus (P or TP): Element in water that, in excess, can lead to increased biological activity in water. TP or total phosphorus is a chemical measurement of all phosphorus forms in a water sample.

Point Sources (PS): Pollutants originating from a single localized source, such as industrial sites, sewerage systems, and confined animal facilities

Riparian Zone: Margin of vegetation within approximately 100 feet of waterway.

Sedimentation: Deposition of slit, clay or sand in slow moving waters.

Secchi Disk: Circular plate 10-12" in diameter with alternating black and white quarters used to measure water clarity by measuring the depth at which it can be seen.

Stakeholder Leadership Team (SLT): Organization of watershed residents, landowners, farmers, ranchers, agency personnel and all persons with an interest in water quality.

Total Maximum Daily Load (TMDL); Maximum amount of pollutant that a specific body of water can receive without violating the surface water-quality standards, resulting in failure to support their designated uses

Total Suspended Solids (TSS): Measure of the suspended organic and inorganic solids in water. Used as an indicator of sediment or silt.

Water Quality Standard (WQS): Mandated in the Clean Water Act. Defines goals for a waterbody by designating its uses, setting criteria to protect those uses and establishing provisions to protect waterbodies from pollutants.

1.0 Preface

The purpose of this Watershed Restoration and Protection Strategy (WRAPS) report for the Marmaton Watershed is to outline a plan of restoration and protection goals and actions for the surface waters of the watershed. Watershed goals are characterized as “restoration” or “protection”. Watershed restoration is for surface waters that do not meet Kansas water quality standards, and for areas of the watershed that need improvement in habitat, land management, or other attributes. Watershed protection is needed for surface waters that currently meet water quality standards, but are in need of protection from future degradation.

The WRAPS development process involves local communities and governmental agencies working together toward the common goal of a healthy environment. Local participants or stakeholders provide valuable grass roots leadership, responsibility and management of resources in the process. They have the most “at stake” in ensuring the water quality existing on their land is protected. Agencies bring science-based information, communication, and technical and financial assistance to the table. Together, several steps can be taken towards watershed restoration and protection. These steps involve building awareness and education, engaging local leadership, monitoring and evaluation of watershed conditions, in addition to assessment, planning, and implementation of the WRAPS process at the local level. Final goals for the watershed at the end of the WRAPS process are to provide a sustainable water source for drinking and domestic use while preserving food, fiber, timber and industrial production. Other crucial objectives are to maintain recreational opportunities and biodiversity while protecting the environment from flooding, and negative effects of urbanization and industrial production. The ultimate goal is watershed restoration and protection that will be “locally led and driven” in conjunction with government agencies in order to better the environment for everyone.

This report is intended to serve as an overall strategy to guide watershed restoration and protection efforts by individuals, local, state, and federal agencies and organizations. At the end of the WRAPS process, the Stakeholder Leadership Team (SLT) will have the capability, capacity and confidence to make decisions that will restore and protect the water quality and watershed conditions of the Marmaton Watershed.

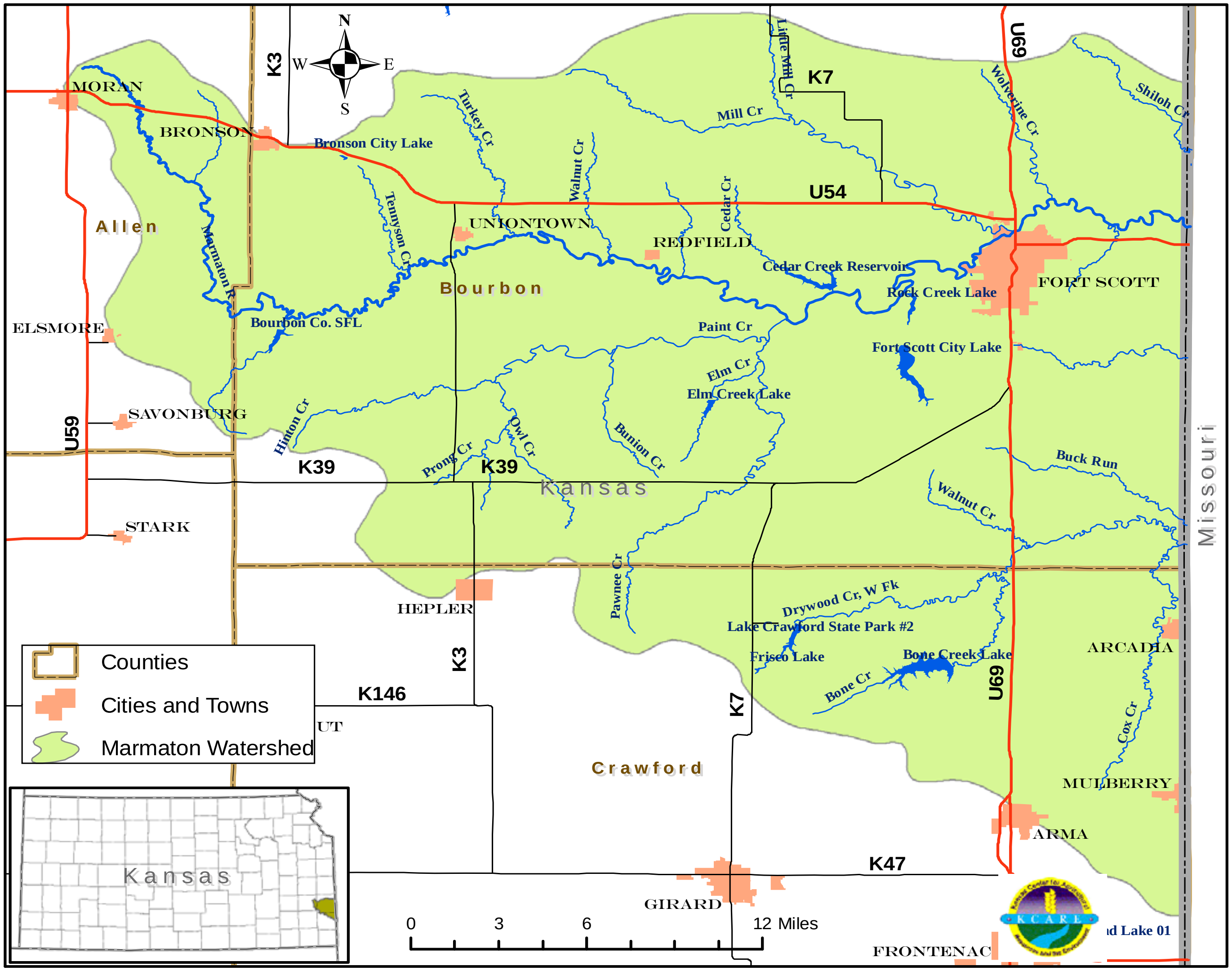
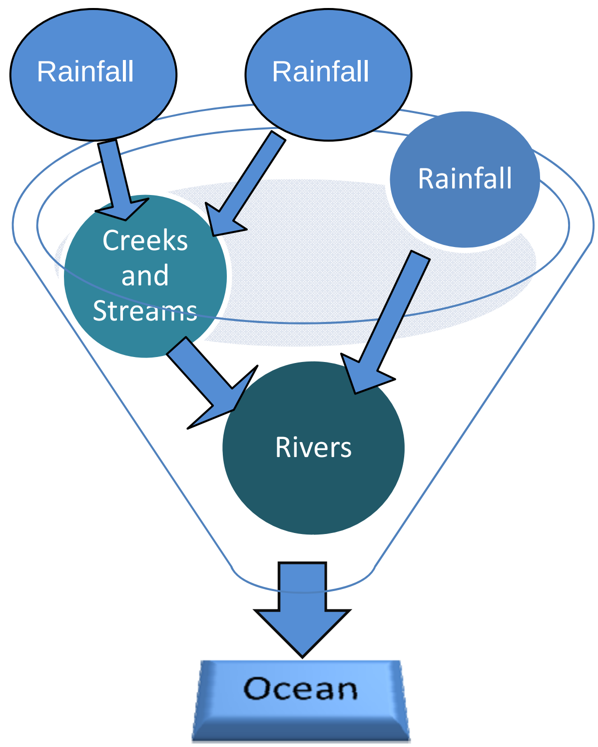


Figure 1. Map of the Marmaton Watershed

2.0 Background Information

2.1 What is a Watershed?

A watershed is an area of land that catches precipitation and funnels it to a particular creek, stream, and river and so on, until the water drains into an ocean. A watershed has distinct elevation boundaries that do not follow political “lines” such as county, state and international borders. Watersheds come in all shapes and sizes, with some only covering an area of a few acres while others are thousands of square miles across.



Elevation determines the watershed boundaries. The upper boundary of the Marmaton Watershed has an elevation of 677 meters (2,221 feet) and the lowest point of the watershed has an elevation of 200 meters (656 feet) above sea level.

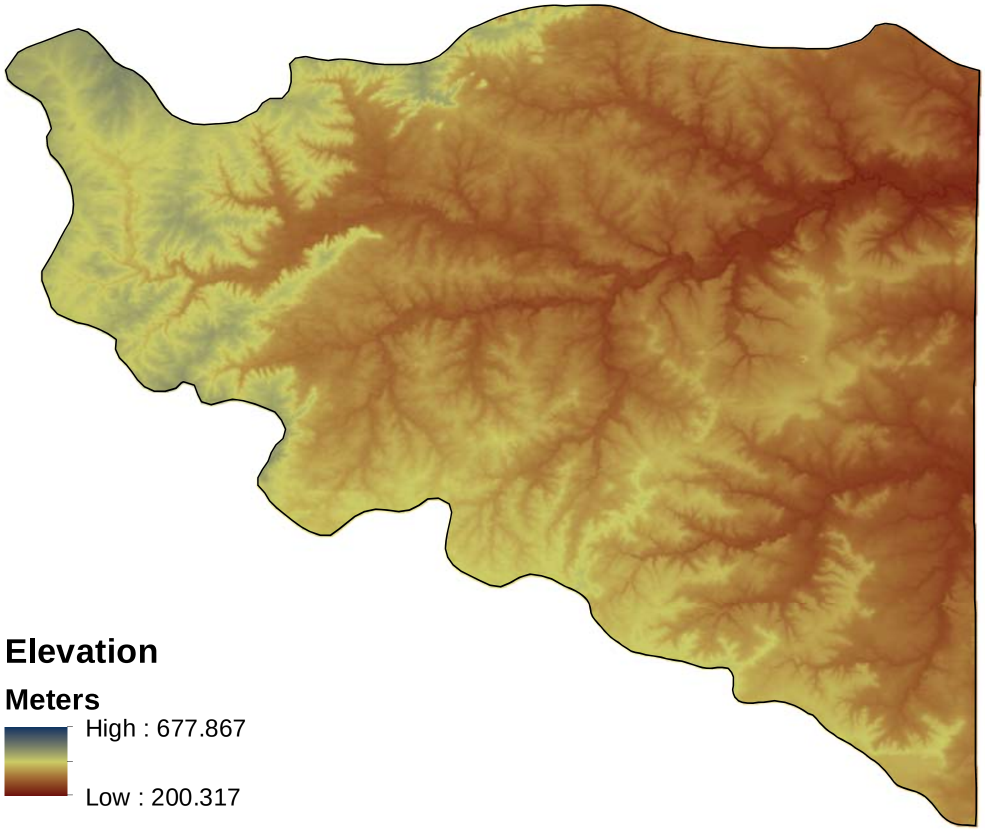


Figure 2. Relief Map of the Marmaton Watershed. [1]

2.2 Where is the Marmaton Watershed?

There are twelve river basins located in Kansas. The Marmaton Watershed is located in the Marais des Cygnes Basin.

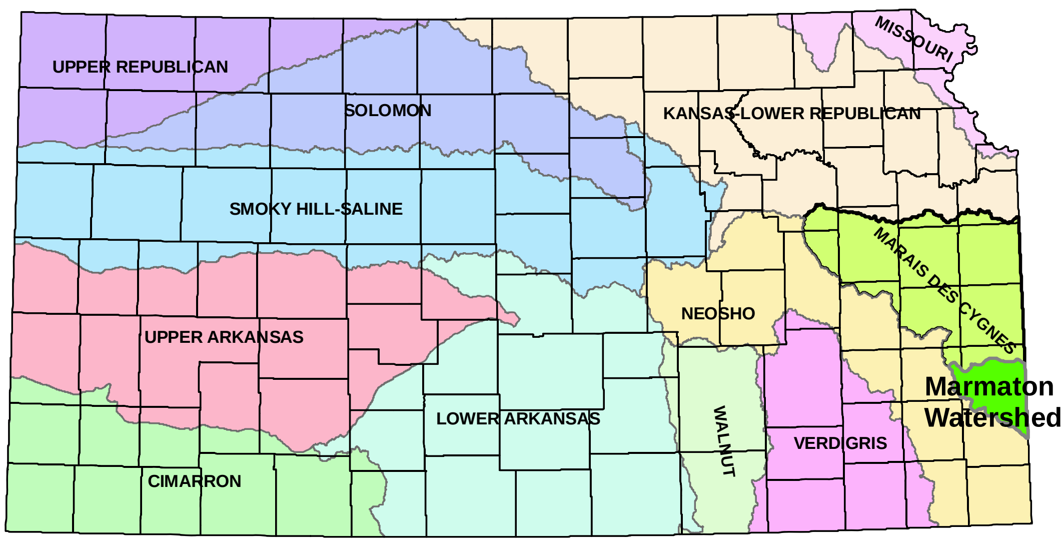


Figure 3. Twelve Basins with Marmaton Watershed Highlighted

The Marais des Cygnes Basin drains the Marmaton River, the Little Osage River, and the Marais des Cygnes River. In Missouri, the Marmaton River flows into the Little Osage and the confluence of the Little Osage and the Marais des Cygnes creates the Osage River. This river eventually flows into the Missouri River in eastern Missouri. It is impounded twice to form the Harry S. Truman Reservoir and the Lake of the Ozarks.

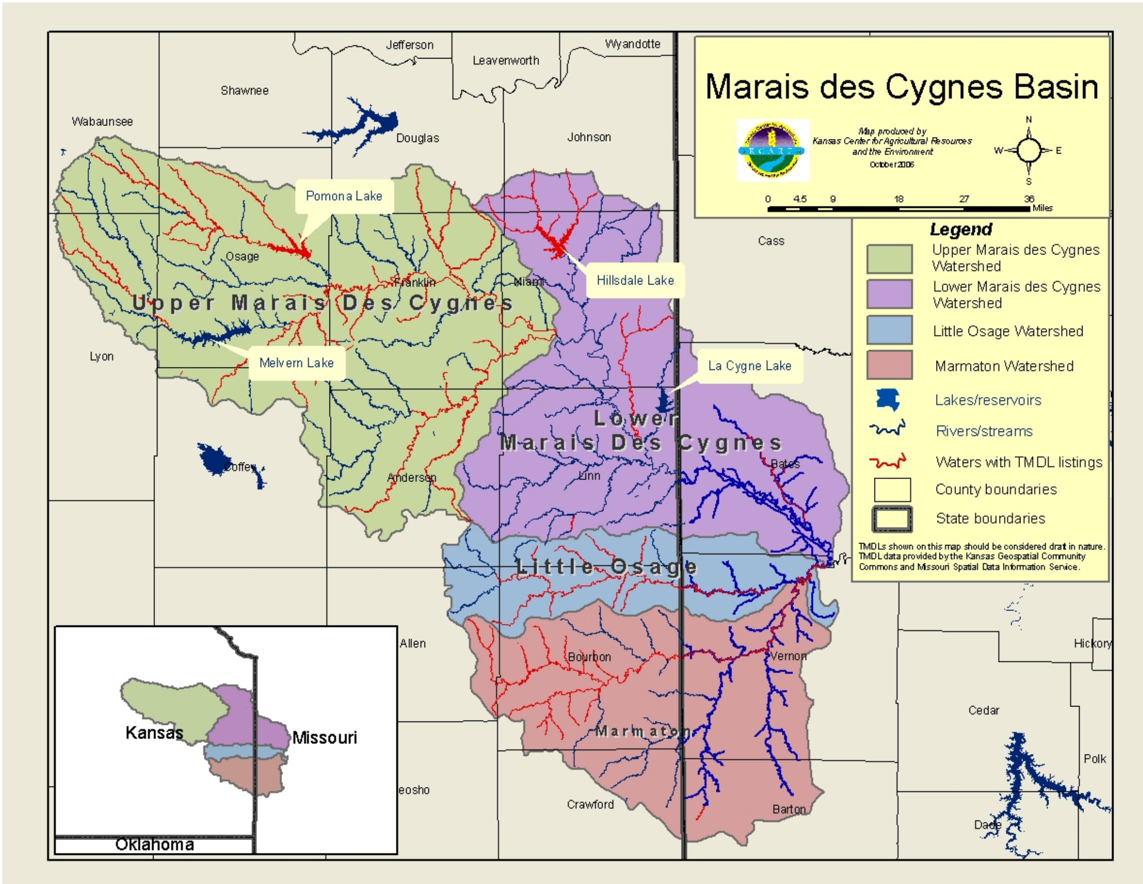


Figure 4. Watersheds of the Marais des Cygnes Basin.

The entire Marmaton Watershed drains the Marmaton River and its tributaries in Kansas and Missouri. However, this WRAPS process will focus only on the portion of the Marmaton Watershed that exists in Kansas.

2.3 What is a HUC?

HUC is an acronym for **H**ydrologic **U**nit **C**odes. HUCs are an identification system for watersheds. Each watershed has a unique HUC number in addition to a common name. The Marmaton Watershed WRAPS project is composed of the HUC8 (meaning an 8 digit identifier code) numbered 10290104. The first 2 numbers in the code refer to the drainage region, the second 2 digits refer to the drainage subregion, the third 2 digits refer to the accounting unit and the fourth set of digits is the cataloging unit. For example:

10290104 = Region drainage of the Missouri River, the Saskatchewan River and several small closed basins (Area = 509,547 sq. miles)
10**29**0104 = Subregion drainage of the Gasconade and Osage Rivers in Kansas and Missouri (Area = 18,400 sq. miles)
1029**01**04 = Accounting unit drainage of the Osage River basin in Kansas and Missouri (Area = 14,800 sq. miles)
102901**04** = Cataloging units drainage of the section of the Marmaton River (Area = 1,080 sq. miles)

As watersheds become smaller, the HUC number will become larger. HUC 8s are further divided into smaller watersheds with HUC 10 delineations and HUC 12s are HUC 10 watersheds that have been even further divided into smaller watersheds. The Marmaton Watershed is divided into eighteen HUC 12 delineations.

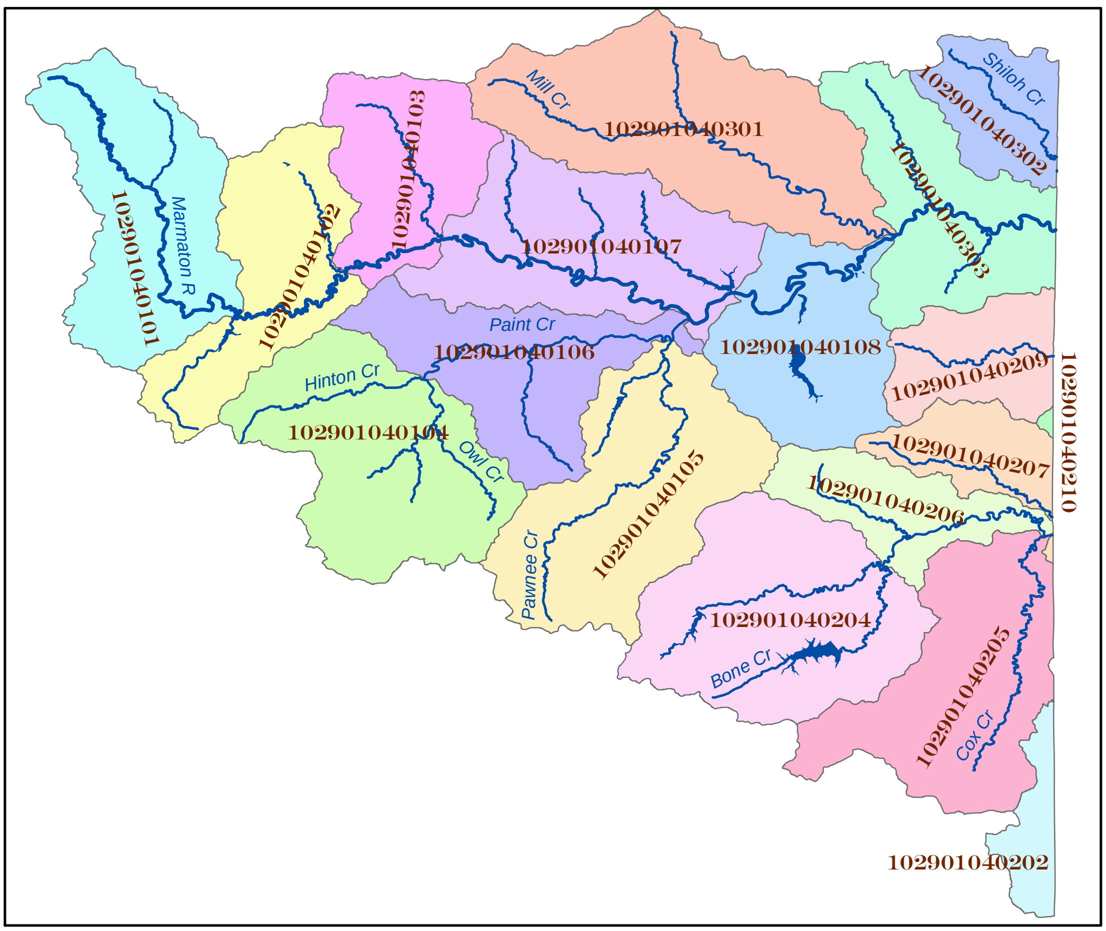


Figure 5. HUC 12 Delineations in the Marmaton Watershed

3.0 Watershed History

3.1 Stakeholder Leadership Team (SLT) History

In 2006, a group of concerned watershed stakeholders came together to discuss applying for a Kansas WRAPS Program Development Phase Grant. In order to apply for the grant, a sponsor was needed. The Marmaton Watershed Joint District No. 102 took the lead to sponsor the project. The Marmaton Watershed District has in the past focused its efforts solely on flood damage reduction, but it realized that to properly manage a watershed, multiple issues must be considered. The Marmaton Watershed District thus determined to take a holistic approach to characterizing, planning, and managing the watershed. By taking a holistic approach to characterizing the watershed, the Watershed District will gain a better understanding of how the watershed responds to change and will be able to make informed, environmentally-responsible planning and management decisions. To this end, the Marmaton Watershed District applied for a development phase grant through the WRAPS Program and was awarded the grant in 2007.

After the grant was awarded, a group of stakeholders met monthly during the fall and winter of 2007 to develop informational materials (such as a brochure, presentation, and survey) to use for spreading the word about the on-going project. Informational presentations were given throughout the watershed to inform as well as gain interested stakeholders. On March 12, 2008, Marmaton WRAPS held its first stakeholder meeting. Thirty-one stakeholders were in attendance. At this meeting, the stakeholder leadership team was formed, as well as stakeholder committees.

As one of the main goals of the WRAPS development phase process is to provide information and education, Marmaton WRAPS continued to give informational presentations as the opportunity arose. Along with its informational presentations, Marmaton WRAPS developed an informational web-site, fact sheets, and held demonstration projects and field days throughout its development phase project.

Marmaton WRAPS held its first field day and demonstration on September 18, 2008. The field day was entitled, “Calm Cattle, Cow Chips and Clean Water”. The attendance totaled 144 producers/stakeholders. The field day included tours and discussions of utilizing tall fescue in non-confined cattle feeding sites, livestock water quality using riparian fences/riparian zone protection, and low stress handling of cattle using a “Bud Box”. The tour ended with a demonstration of the construction and installation of a livestock tire tank waterer and a hamburger feed. Two smaller-scale tire tank waterer installation demonstrations took place the following December and June. Marmaton WRAPS also ended its development phase with a demonstration project. Marmaton WRAPS worked with a local producer and the conservation district to relocate a feeding site where cattle had access to the back-up water supply lake for the City of Fort Scott. The project included the installation of a waterer, new feeding site, and fencing to keep cattle from the lake.

Marmaton WRAPS has also received funding for its project from the three local water utilities: City of Fort Scott, Bourbon Consolidated Rural Water District No. 2, and Bone Creek PWWSD No. 11.

Marmaton WRAPS has worked to bridge the gap in communication between Kansas and Missouri and has continually invited Missouri regulators to its quarterly stakeholder meetings. A representative from the Missouri Department of Conservation frequents the meetings. Marmaton WRAPS also went to Sedalia, MO, in February 2009, to give an informational presentation to representatives from Missouri DNR and Missouri Dept. of Conservation about the Marmaton WRAPS project and to answer any questions they may have.

Marmaton WRAPS was awarded an assessment phase grant in 2008. The major goals of Marmaton WRAPS in the assessment phase were to install a water quality and quantity monitoring network and to have modeling done on the watershed in order to better be able to identify targeted and problem areas for implementation. Marmaton WRAPS has installed a network of eleven water level samplers and six automated water quality/flow samplers. The full monitoring network was installed by March 2010. During the spring/summer/fall of 2010, volunteers collected grab samples at eight sites weekly, with the addition of four more sites when a precipitation event of one inch or more occurred. The monitoring has continued at the pace of once per month during the winter.

Marmaton WRAPS has also worked with KAWS/KSU during its assessment phase to perform a riparian area/streambank assessment. Riparian areas in need of protection or restoration were identified, as well as sites in need of streambank stabilization.

During the assessment phase, Marmaton WRAPS has worked with KDHE/EPA on AnnAGNPS (Agricultural Non-Point Source Model Version 5.00) modeling for the watershed. Marmaton WRAPS has a partial dataset for the watershed that it is working with EPA to calibrate. EPA is also to be modeling the rest of the Marmaton WRAPS watershed in order to have a complete set of results from AnnAGNPS. Marmaton WRAPS wishes to have the results in order to share with producers when discussing possible BMP implementation.

In its original assessment grant, Marmaton WRAPS had entered into an agreement with KSU to perform hydrological modeling for the watershed; however, the modeler with whom Marmaton WRAPS had agreed to work with left KSU. The money originally specified for this modeling has been re-designated for a BMP cost-share/incentive program and the writing of the EPA 9 element plan. WRAPS funds will be used to piggyback state or federal programs for buffers and terraces for the cost-share/incentive program. Buffers will include a onetime cost-share of $10 per acre, while terraces will increase the current available cost-share rate 10 percent. Part of the cost-share/incentive program will include an information and education portion for buffers.

Marmaton WRAPS is working with KSU to develop its 9 element plan. Targeted areas and BMP practices and implementation rates have been selected.

Marmaton WRAPS continues to hold informational meetings for its stakeholders on a quarterly basis.

3.2 Overview

The Marmaton Watershed is designated as Category I watershed indicating that it is in need of restoration as defined by the Kansas Unified Watershed Assessment 1999 submitted by the Kansas Department of Health and Environment (KDHE) and the United States Department of Agriculture (USDA)[2]. A Category I watershed does not meet state water quality standards or fails to achieve aquatic system goals related to habitat and ecosystem health. Category I watersheds are also assigned a priority for restoration. The Marmaton is ranked seventeenth in priority out of ninety-two watersheds state wide.

3.3 Issues and Goals of the SLT

The charge of the SLTs has been to create a plan of restoration and protection measures for the watershed. During the time period that they have been meeting, they have had speakers and discussions to review and study watershed issues and concerns. The SLT then set **priority watershed issues and concerns.**

The SLT has set their priority issues as (in no particular order):

1. Cropland erosion and nutrient runoff,
2. Streambank erosion, and
3. Flooding.

This watershed plan primarily addresses Goal 1. Goals 2, 3 and 4 will be addressed indirectly through improvements in water quality. The Watershed goals as set by the SLT are (in no particular order):

1. Restore poor water quality (achieve TMDLs) in:
    a. Marmaton River
    b. Lake Crawford
    c. Rock Creek Lake
    d. Bourbon County State Fishing Lake
    e. Bronson City Lake

2. Protect public drinking water supplies in:
    a. Fort Scott City Lake
    b. Bone Creek
    c. Cedar Creek
3. Protect recreational uses at:
    a. Bourbon County State Fishing Lake
    b. Fort Scott City Lake
    c. Lake Crawford
    d. Rock Creek Lake
    e. Bone Creek Lake
    f. Elm Creek
4. Restore and protect streambanks and riparian areas along the Marmaton River

What is a Total Maximum Daily Load (TMDL)?

Every state assigns ***designated uses*** for each water body. These designated uses provide for:

- healthy aquatic life,
- safe contact recreation (swimming and boating),
- safe drinking water,
- safe food procurement, and
- adequate ground, irrigation, industrial, and livestock water usage.

Not meeting these uses indicates a failure to meet the Kansas ***Water Quality Standard*** (WQS). When this happens, a ***TMDL*** is developed. TMDL is a regulatory term derived from the US Clean Water Act. The TMDL will set a maximum amount of pollutant that can be discharged into a waterbody while still providing for its designated uses. It is an assessment tool that helps to identify pollutant impairments and determine the amount of pollutant in the water.

TMDLs consist of 3 parts: wasteload allocation (WLA) from point sources, load allocation (LA) from nonpoint sources, and a built in margin of safety (MOS). In this WRAPS report, we will address the LA from nonpoint sources.

The purpose of this WRAPS plan is to address the issues and concerns of the SLT, to address and mitigate current TMDLs in the watershed and to proactively improve conditions so that the impairments on the current 303d list will not reach the stage of TMDL development.

NOTE: In this report, the term BMP (Best Management Practice) will be used frequently. A BMP is defined as an environmental protection practice used to control pollutants, such as sediment or nutrients, from common agricultural or urban land use activities. Common agricultural BMPs are buffer strips, terraces, grassed waterways, utilizing no-till or minimum tillage, conservation crop rotation and nutrient management plans. Definitions of each of these BMPs are found in the appendix of this report.

4.0 Watershed Review

4.1 Land Cover/Land Uses

The Marmaton Watershed covers 386,586 acres. It is overwhelmingly grassland (64 percent). Grassland can contribute nutrients from livestock manure if the livestock have access to streams and ponds. Erosion can occur from pathways made by livestock in creeks or gullies in pastures. Woodland is the second most prominent land use at 17 percent. Properly managed woodland with a good understory does not contribute much sediment or nutrients to the watershed. Woodland located along rivers and streams provides a good buffer to prevent streambank erosion. Cropland is the third highest land use at 13 percent. Cropland can contribute nutrients from fertilizer runoff and sediment from bare crop ground that erodes during heavy rainfall events. CRP consists of 4 percent of the watershed. The goal of this land use is to stabilize the land and minimize any sediment or nutrient contributions to the watershed. The rest of the land uses (2 percent) include urban, water and other.

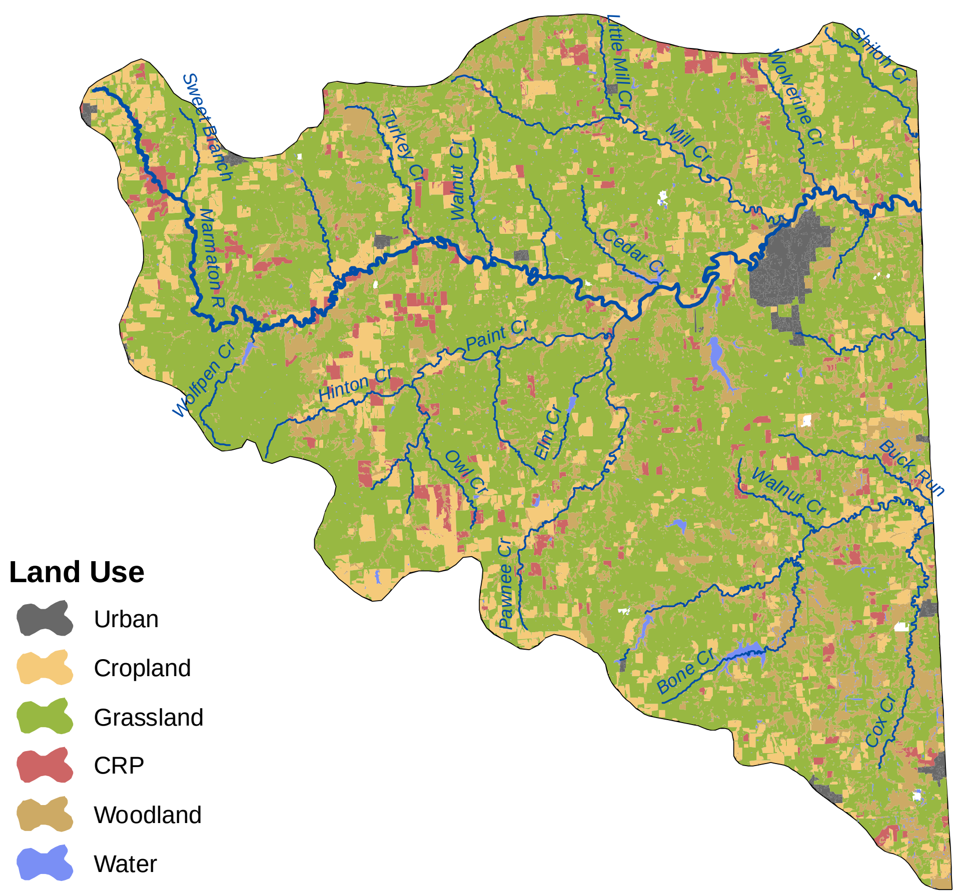


Figure 6. Land Use of the Marmaton Watershed. [3]

Table 1. Land Use in the Watershed. [4]

Land Use	Acres	Percentage
Marmaton Watershed		
Grassland	245,620	**63.5**
Woodland	65,016	**16.8**
Cropland	51,966	**13.4**
CRP	13,442	**3.5**
Urban	6,526	**1.7**
Water	3,595	**0.9**
Other	413	**0.1**
Total	**386,577**	**100.0**

4.2 Designated Uses

Surface waters in this watershed are generally used for aquatic life support (fish), human health purposes, domestic water supply, recreation (fishing, boating, swimming), groundwater recharge, industrial water supply, irrigation and livestock watering. These are commonly referred to as "designated uses" as stated in the Kansas Surface Water Register, 2009, issued by KDHE.

Table 2. Designated Water Uses for the Marmaton Watershed. [5]

Designated Uses Table								
Stream or Lake Name	**AL**	**CR**	**DS**	**FP**	**GR**	**IW**	**IR**	**LW**
Bone Cr, Cedar Cr, Elm Cr, Lath Br,	E	b	X	O	X	X	X	X
Buck Run,	E	C	X	O	X	X	X	X
Bunion Cr, Paint Cr, Tennyson Cr,	E	C	X	X	X	X	X	X
Cox, Cr,	E	C	O	O	X	O	X	X
Drywood Cr Moores Br, Drywood Cr W Fk seg 19, Hinton Cr, Walnut Cr Seg 47,	E	C	X	O	X	X	X	X
Drywood Cr W Fk seg 323, Gunn Park E Lake, Gunn Park W Lake, Rock Cr Lake	E	B	X	X	X	X	X	X
Little Mill Cr,	E	C	O	O	O	O	X	X
Marmaton R Seg 5, 11, 12, Mill Cr, Pawnee Cr,	S	C	X	X	X	X	X	X
Marmaton R Seg 7, 8, Cedar Cr Res	S	B	X	X	X	X	X	X
Owl Cr, Walnut Cr Seg 32,	E	b	O	X	O	O	O	X
Prong Cr,	E	b	O	O	O	O	O	O
Robinson Br, Shiloh Cr, Wolfpen Cr,	E	b	O	O	O	O	X	X
Sweet Br, Turkey Cr,	E	b	X	X	X	X	X	X
Wolverine Cr	E	C	O	O	X	X	X	X
Bone Cr Lake, Bourbon Co SFL, Bronson City Lake, Frisco Lake	E	B	X	X	O	X	X	X
Elm Cr Lake, Lake Crawford State Park #2, Fort Scott City	E	A	X	X	O	X	X	X

Lake								

AL = Aquatic Life Support
CR = Contact Recreation Use
DS = Domestic Water Supply
FP = Food Procurement
GR = Groundwater Recharge
IW = Industrial Water Supply
IR = Irrigation Water Supply
LW = Livestock Water Supply
A=Primary contact recreation lakes that have a posted public swimming area
b=Secondary contact recreation stream segment is not open to and accessible by the public under Kansas law
B=Primary contact recreation lakes that are by law or written permission of he landowner open to and accessible by the public
C=Primary contact recreation lakes that are not open to and accessible by the public under Kansas law
S=Special aquatic life use water
E = Expected aquatic life use water
X = Referenced stream segment is assigned the indicated designated use
O = Referenced stream segment does not support the indicated beneficial use

4.3 Special Aquatic Life Use and Exceptional State Waters

Special Aquatic Life Use (SALU) waters are defined as "surface waters that contain combinations of habitat types and indigenous biota not found commonly in the state, or surface waters that contain representative populations of threatened or endangered species". The Marmaton Watershed has a special aquatic life use designation for the Marmaton River. **Exceptional State Waters (ESW)** are defined as "any of the surface waters or surface water segments that are of remarkable quality or of significant recreational or ecological value". There are no ESW in this watershed.

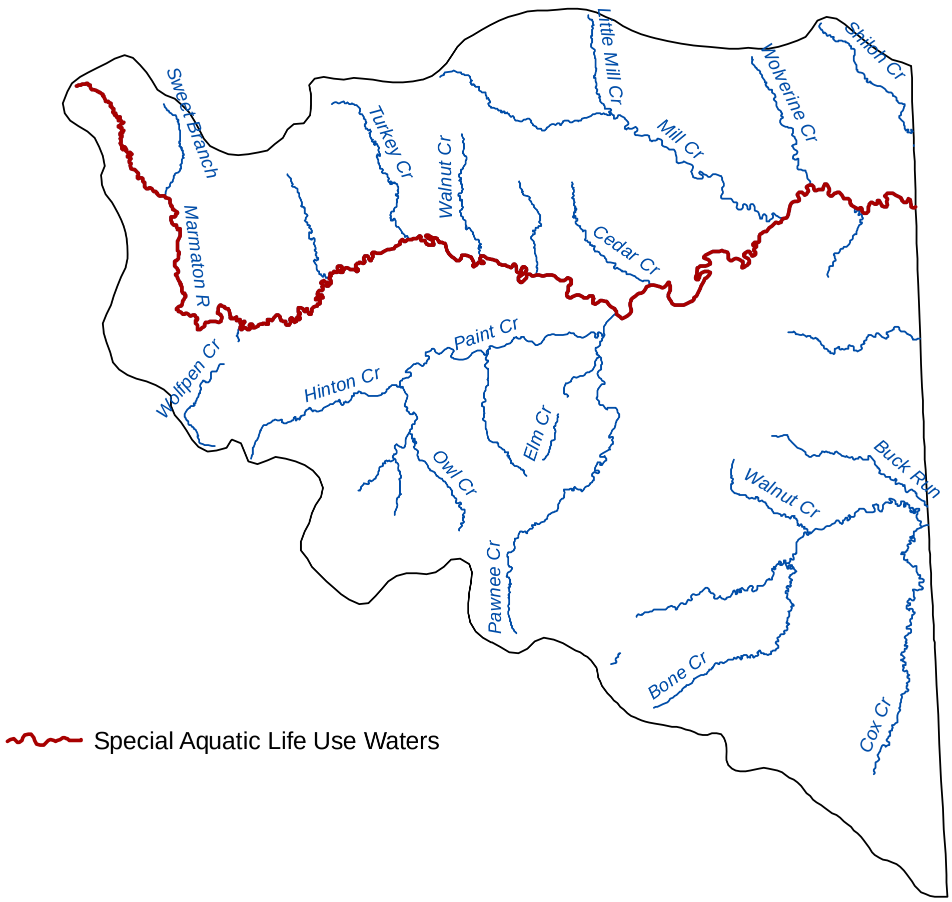


Figure 7. SALU Waters in the Watershed. [6]

The SALU waters are located in areas that are primarily surrounded by grassland; however, cropland lies adjacent to the river in the flat floodplains. Pollutants that might threaten the health of these waters would be from cropland. Sediment from ephemeral gullies, nutrients from fertilizer and applied manure and fecal coliform bacteria from livestock are some of the potential pollutants.

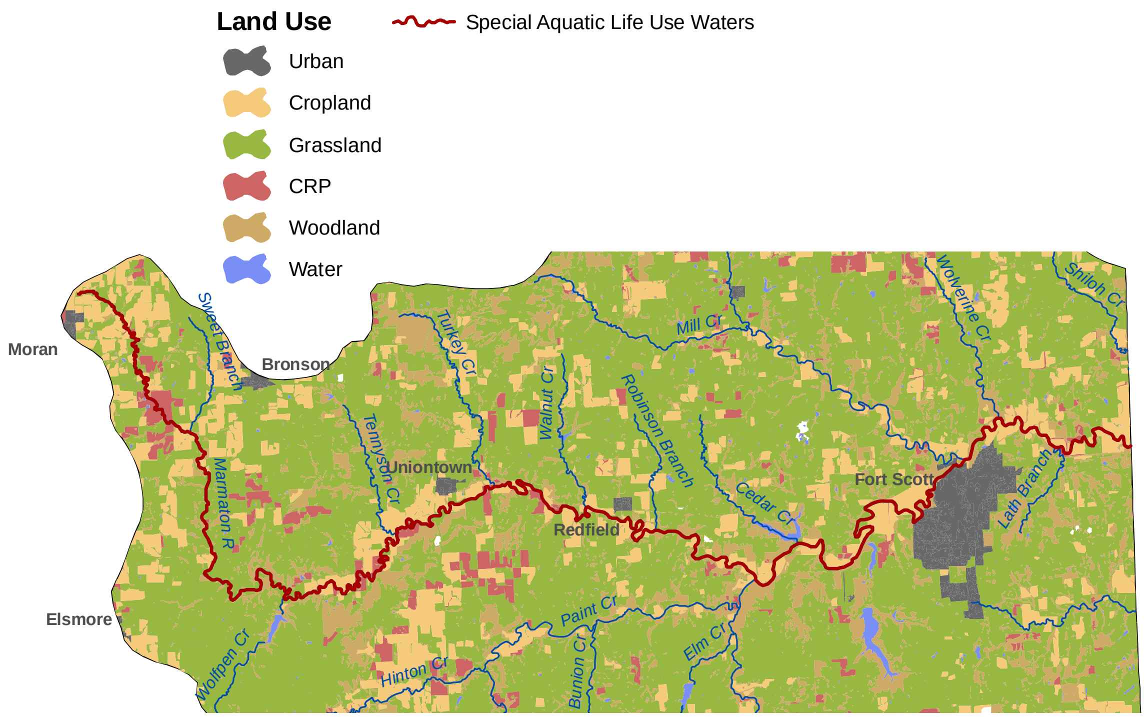


Figure 8. SALU with Land Cover. [7]

4.4 Rainfall and Runoff

Rainfall rates and duration will affect sediment and nutrient runoff during high rainfall events. The Marmaton Watershed averages 42 inches of rainfall yearly. Most high intensity rainfall events will occur in late spring and early summer. This is the time when crop ground is either bare or crop biomass is small. Also, grassland is short and does not catch runoff. Both of these situations can lead to pollutants entering the waterways.

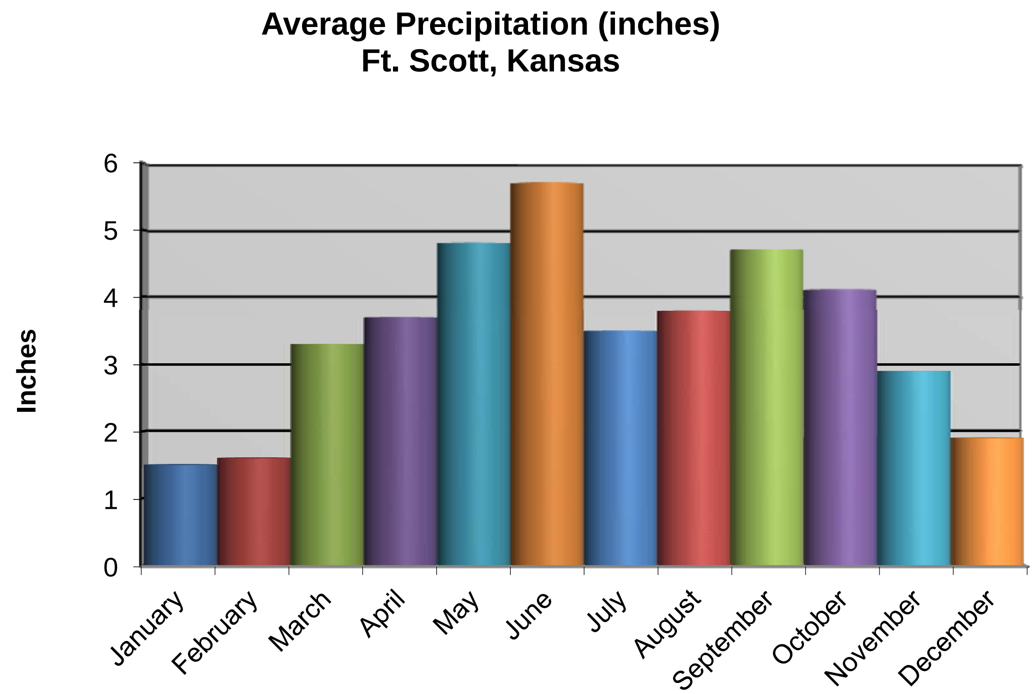


Figure 9. Average Precipitation by Month. [8]

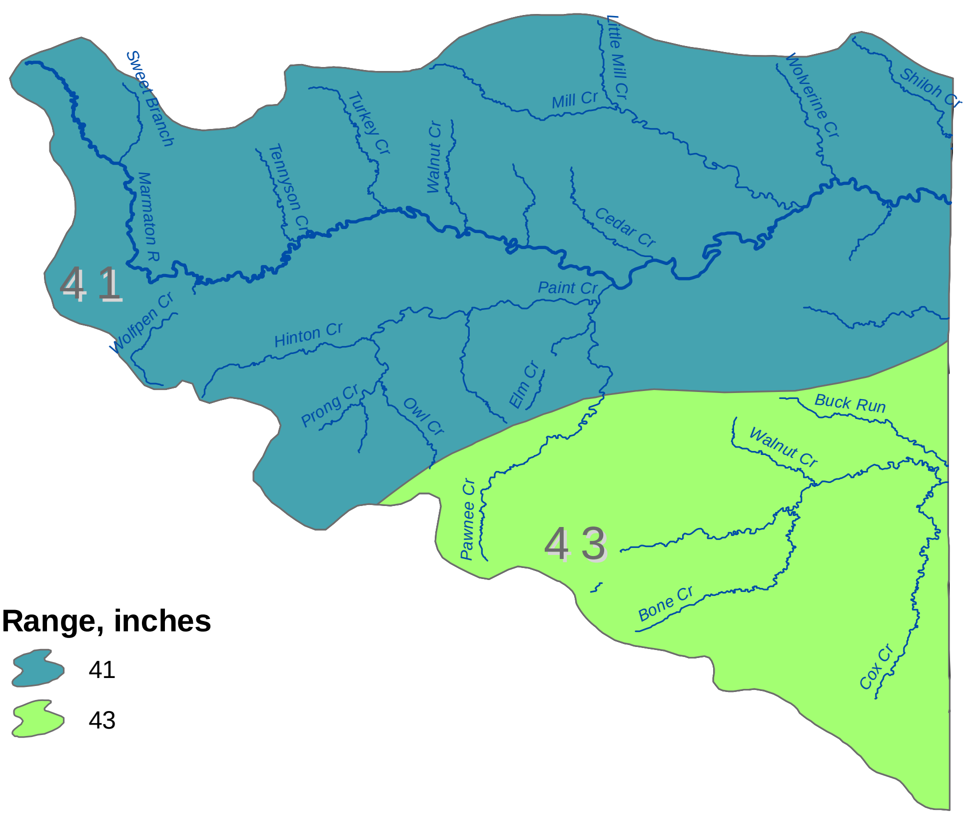


Figure 10. Average Yearly Precipitation in the Watershed. [9]

4.5 Population and Wastewater Systems

The number of wastewater treatment systems is directly tied to population, particularly in rural areas that do not have access to municipal wastewater treatment facilities. Failing, improperly installed or lack of an onsite wastewater system can contribute Fecal Coliform Bacteria (FCB) or nutrients to the watershed through leakage or drainage of untreated sewage. Even though all the counties in the watershed have County Sanitarian Codes, there is no way of knowing how many failing or improperly constructed systems exist in the watershed. Thousands of onsite wastewater systems may exist in this watershed and the functional condition of these systems is generally unknown. However, best guess would be that ten percent of wastewater systems in the watershed are failing or insufficient. [10] Therefore, the exact number of systems is directly tied to population.

Table 3. Population in the Major Counties of the Watershed. [11]

County	Population, 2009	Persons per square mile, 2009	Population Change (2000 to 2009), %
Allen	13,203	28.6	-8.2
Bourbon	14,884	24.1	-3.2
Crawford (minus City of Pittsburg)	19,635	33.1	1.1
City of Pittsburg	19,243		2.1
Total for Watershed without Pittsburg	**47,722**	**Average: 28.6**	**Average: -3.4**

Most of the watershed would be considered near average population. The only major urban area is the city of Fort Scott. The Kansas average population density represented as persons per square mile is 32.9, whereas, the average for the watershed is 28.6.

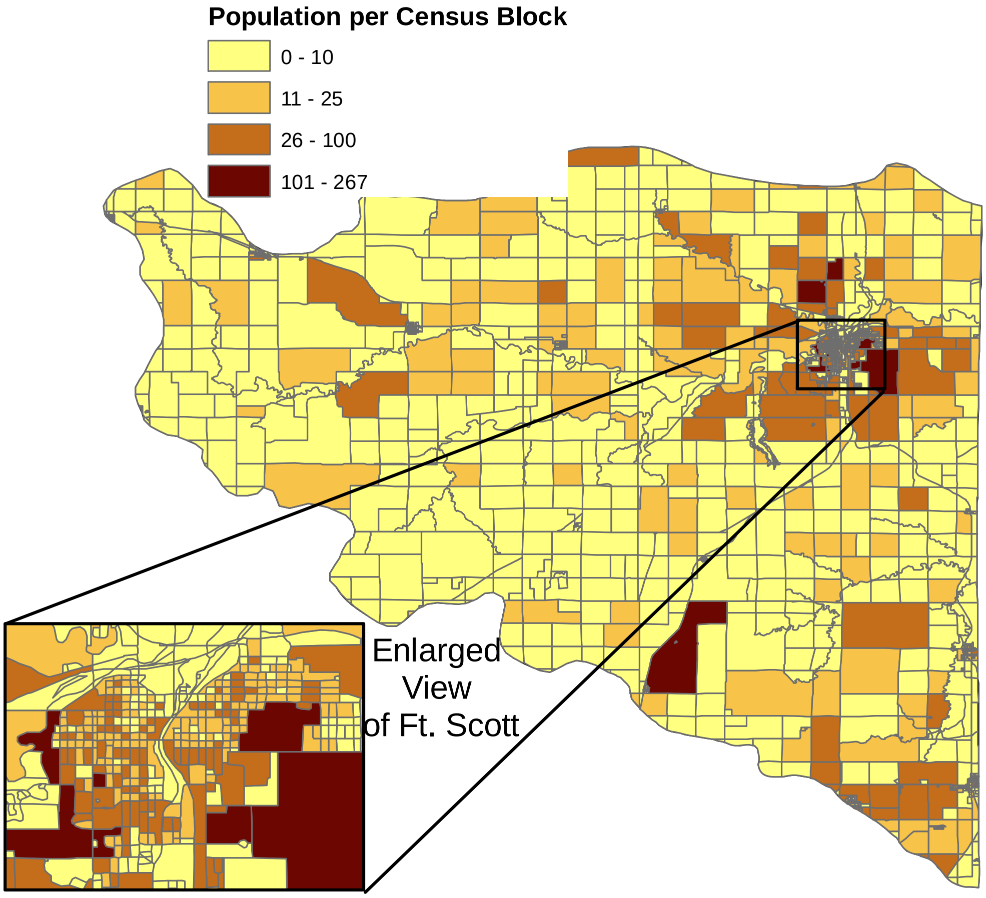


Figure 11. Census Count, 2000. [12]

4.6 Aquifers

Two aquifers underlie the watershed:

- Alluvial Aquifer - An alluvial aquifer is a part of and connected to a river system and consists of sediments deposited by rivers in the stream valleys. The Marmaton River has an alluvial aquifer that lies along and below the river in the lower section. Creeks that have alluvial aquifers are Paint Creek and Pawnee Creek.
- Ozark Aquifer - The Ozark Aquifer extends from southeastern Kansas and eastern Oklahoma east to St. Louis and south into Arkansas. It is mainly comprised of limestone and dolomite. Historically, water from this aquifer is very hard. The Ozark Aquifer underlies the entire Marmaton Watershed.

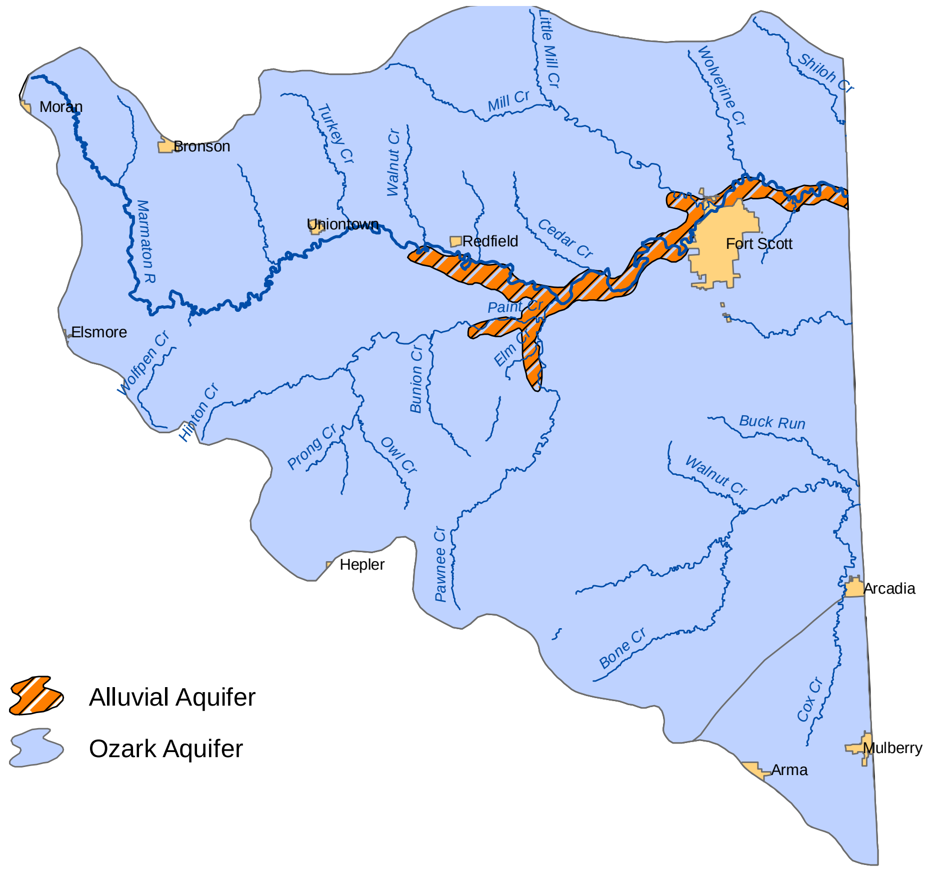


Figure 12. Aquifers in the Watershed. [13]

4.7 Public Water Supply (PWS) and National Pollutant Discharge Elimination System (NPDES)

A Public Water Supply (PWS) that derives its water from a surface water supply can be affected by sediment – either in difficulty at the intake in accessing the water or in treatment of the water prior to consumption. Nutrients and FCB will also affect surface water supplies causing excess cost in treatment prior to public consumption. The table below lists the PWS in the Marmaton Watershed.

Table 4. Public Water Supplies in the Marmaton Watershed [14]

Municipality	Source	County	Population Served
Bourbon County Consolidated RWD No. 2	City of Ft. Scott	Bourbon	6,544
Bronson & Bourbon County RWD No. 4	Tennyson Creek Trib 1	Bourbon	360
Fort Scott	Marmaton River	Bourbon	8,370
Fort Scott	Rock Creek (Marmaton)	Bourbon	
PWWSD No. 11	Bone Creek (Marmaton)	Crawford	10,000

Uniontown	Marmaton River	Bourbon	280
City of Mulberry	Groundwater	Crawford	590
Crawford County RWD No. 3	Marmaton River	Crawford	250
City of Arcadia	Ozark aquifer	Crawford	395

Wastewater treatment facilities are permitted and regulated through KDHE. National Pollutant Discharge Elimination System (NPDES) permits specify the maximum amount of pollutants allowed to be discharged to surface waters. Having these point sources located on streams or rivers may impact water quality in the waterways. For example, municipal wastewater can contain suspended solids, biological pollutants that reduce oxygen in the water column, inorganic compounds or bacteria. Wastewater will be treated to remove solids and organic materials, disinfected to kill bacteria and viruses, and discharged to surface water. Treatment of municipal wastewater is similar across the country. Industrial point sources can contribute toxic chemicals or heavy metals. Treatment of industrial wastewater is specific to the industry and pollutant discharged. [15] Any pollutant discharge from point sources that is allowed by the state is considered to be Wasteload Allocation.

Table 5. Permitted Point Source Facilities. [16] Municipalities that have both NPDES and PWS sites are highlighted in tan.

Facility Name	Facility City	NPDES No.	County
Bronson	Bronson	KS0045942	Bourbon
Uniontown	Uniontown	KS0046051	Bourbon
Moran Municipal	Moran	KS0047490	Allen
Fort Scott	Fort Scott	KS0095923	Bourbon
KOA Kampground	Fort Scott	KS0079111	Bourbon
Arcadia	Arcadia	KS0080683	Crawford
Maple Ridge Park	Fort Scott	KS0081094	Bourbon
Mulberry	Mulberry	KS0087467	Crawford
Redfield, City of	Redfield	KS0091197	Bourbon
Crawford County Sewer District #4	Farlington	KS0096741	Crawford
Midwest Minerals – Quarry 11	Fort Scott	KS0081655	Bourbon
Midwest Minerals - #9 Uniontown Quarry	Uniontown	KS0090221	Bourbon
Nelson Quarries – Fort Scott Quarry	Fort Scott	KS0096458	Bourbon
Nelson Quarries – Ft Scott South	Fort Scott	KS0093009	Bourbon
Nelson Quarries – Renard and Camerlink	Fort Scott	KS0092991	Bourbon
O'Brien Redimix – Ft Scott Plant	Fort Scott	KSG110096	Bourbon
Phoenix Coal Co – Garland Mine #2	Garland	KS0098515	Bourbon
Phoenix Coal Co, Inc	Garland	KS0092932	Bourbon

Midwest Minerals - #4 Farlington Quarry	Farlington	KS0115533	Crawford
Mulberry Limestone – Mulberry Quarry	Mulberry	KS0096008	Crawford
Mulberry Limestone – Englevale Quarry	Arma	KS0095991	Crawford
Public Wholesale Dist #11 – Bone Creek	Farlington	KS0097101	Crawford

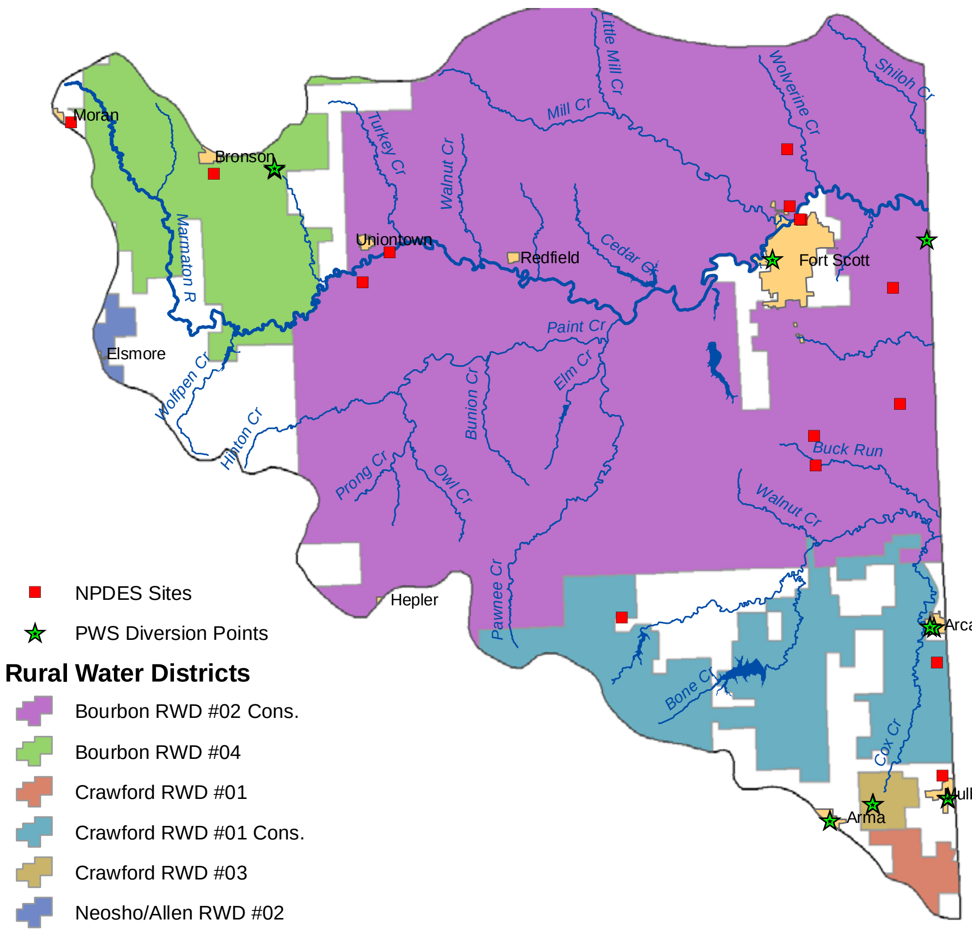


Figure 13. Rural Water Districts, Public Water Supply Diversion Points and NPDES Wastewater Treatment Plants (WTP). [17]

4.8 Total Maximum Daily Loads in the Watershed

A Total Maximum Daily Load (TMDL) designation sets the maximum amount of pollutant that a specific body of water can receive without violating the surface water-quality standards, resulting in failure to support their designated uses. TMDLs provide a tool to target and reduce point and nonpoint pollution sources. TMDLs established by Kansas may be done on a watershed basis and may use a pollutant-by-pollutant approach or a biomonitoring approach or both as appropriate. TMDL establishment means a draft TMDL has been completed, there has been public notice and comment on the TMDL, there has been consideration of the public comment, any necessary revisions to the TMDL have been made, and the TMDL has been submitted to EPA for approval. The desired outcome of the TMDL process is indicated, using the current situation as the baseline. Deviations from the water quality standards will be documented. The TMDL will state its objective in meeting the appropriate water quality standard by quantifying the degree of pollution reduction expected over time. Interim objectives will also be defined for midpoints in the implementation process. [18] In summary, TMDLs provide a tool to target and reduce point and nonpoint pollution sources. The goal of the WRAPS process is to address high priority TMDLs.

KDHE reviews TMDLs assigned in each of the twelve basins of Kansas every five years on a rotational schedule. The table below includes the review schedule for the Marais des Cygnes Basin.

Table 6. TMDLs Review Schedule for the Marais des Cygnes Basin. [19]

Year Ending in September	Implementation Period	Possible TMDLs to Revise	TMDLs to Evaluate
2012	2013-2022	2001	2001
2017	2018-2027	2001, 2007	2001, 2007

Pollutants are assigned "categories" depending on stage of TMDL development: [20]

- Category 5 – Waters needing TMDLs
- Category 4a – Waters that have TMDLs developed for them and remain impaired
- Category 4b – NPDES permits addressed impairment or watershed planning is addressing atrazine problem
- Category 4c – Pollution (typically insufficient hydrology) is causing impairment
- Category 3 – Waters that are indeterminate and need more data or information
- Category 2 – Waters that are now compliant with certain water quality standards
- Category 1 – All designated uses are supported, no use is threatened

TMDLs in the watershed are listed in the table below. Not all of the contributing area noted within the Marmaton River DO TMDL is noted as having nonpoint source pollution contributions to low DO conditions. With that in mind, this TMDL stands to benefit from implementation activities but might not necessarily be directly addressed through implementation of watershed plan.

Table 7. TMDLs in the Watershed. [21] The shaded lines indicate high, medium or low priorities. The **bold** impairments indicate ones that will be directly affected by this WRAPS plan.

Water Segment	TMDL Pollutant	End Goal of TMDL	Priority	Sampling Station
High Priority				
Marmaton River	**Dissolved Oxygen**	**BOD < 2.9mg/l under critical conditions, no excursions < 5mg/l DO > 5mg/l**	**High**	**SC208, SC559**
Marmaton River	**Biology**	**MBI < 4.5**	**High**	**SC208**
Lake Crawford	**Eutrophication**	**Summer Chlorophyll *a* < 12ug/l**	**High**	**LM011101**
Rock Creek Lake	**Eutrophication**	**Summer Chlorophyll *a* <10ug/l**	**High**	**LM045201**
Medium Priority				
Bourbon County SFL	Eutrophication, Dissolved Oxygen, pH	Summer chlorophyll *a* < 12ug/l pH > 6.5 and < 8.5 Dissolved oxygen > 5mg/l	Medium	LM013301
Bronson City Lake	Eutrophication	Summer chlorophyll *a* < 20ug/l	Medium	LM046201
Low Priority				
Drywood Creek W. Fork	Dissolved Oxygen	DO > 5mg/l	Low	SC617
Elm Creek Lake	Eutrophication	Summer chlorophyll a =/< 12ug/l	Low	SM044801

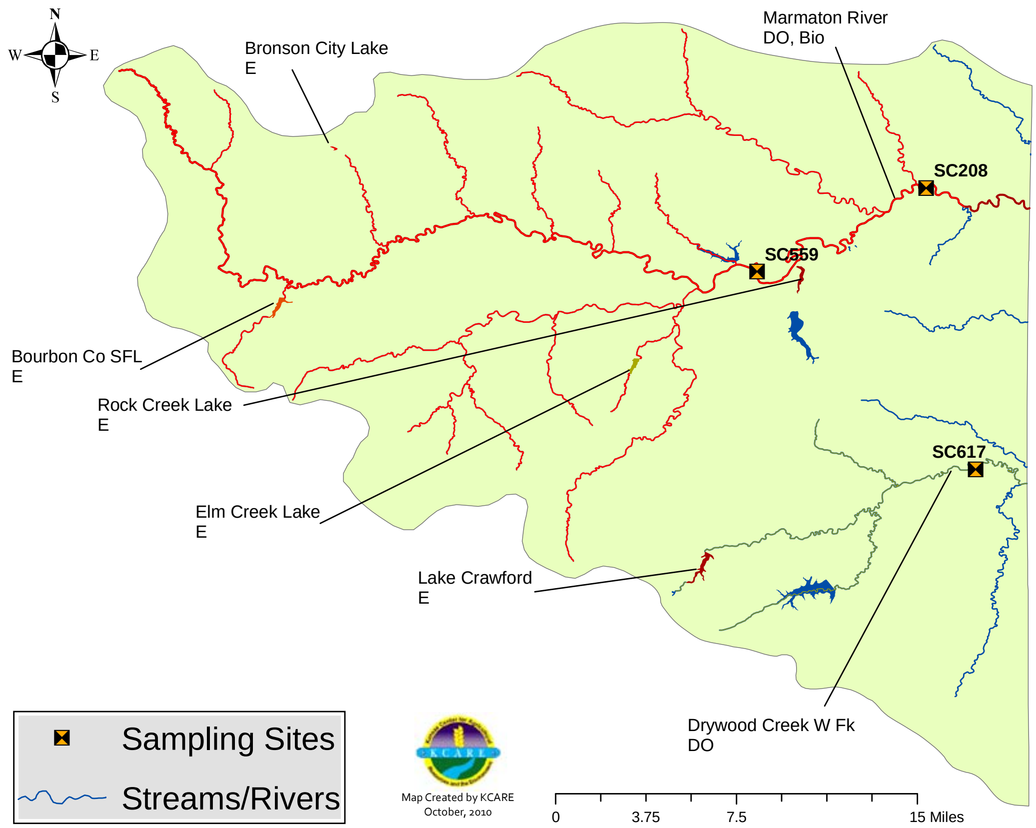


Figure 14. TMDLs in the Watershed. [22]

4.9 303d Listings in the Watershed

The Marmaton Watershed has new listings on the 2010 “303d list”. A 303d list of impaired waters is developed biennially and submitted by KDHE to EPA. To be included on the 303d list, samples taken during the KDHE monitoring program must show that water quality standards are not being met. This in turn means that designated uses are not met. TMDL development and revision for waters of the Marmaton Watershed is scheduled for 2012. TMDLs will be developed over the subsequent two years for “high” priority impairments. Priorities are set by work schedule and TMDL development timeframe rather than severity of pollutant. If it will be greater than two years until the pollutant can be assessed, the priority will be listed as “low”.

Table 8. 2010 303d List of Impaired Waters in the Marmaton Watershed. [23] The impairments in **bold** print indicate ones that will be positively affected or directly affected by this WRAPS plan.

Category	Water Segment	Impairment	Priority	Sampling Station

Low Priority				
5 – Waters needing TMDL	**Rock Creek Lake**	**Dissolved Oxygen**	**Low**	**LM45201**
Category	**Water Segment**	**Impairment**	**Comment**	**Sampling Station**
3 – Waters that need more data	Marmaton River	Biology	Small sample size	SC559
3 – Waters that need more data	Gunn Park East Lake	Eutrophication	Only 1 sample since 1990	LM065401
3 – Waters that need more data	Gunn Park West Lake	Eutrophication	Only 1 sample since 1990	LM065501

Table 9. 2010 303d Delisted Waters in the Marmaton Watershed. [24]

Category	Water Segment	Impairment	Comment	Sampling Station
2 – Waters now compliant	Marmaton River	Ammonia	No longer impaired	NPDES52116
2 – Waters now compliant	Marmaton River	Fecal coliform bacteria	No longer impaired	NPDES52116
2 – Waters now compliant	Marmaton River	Zinc	No longer impaired	SC208

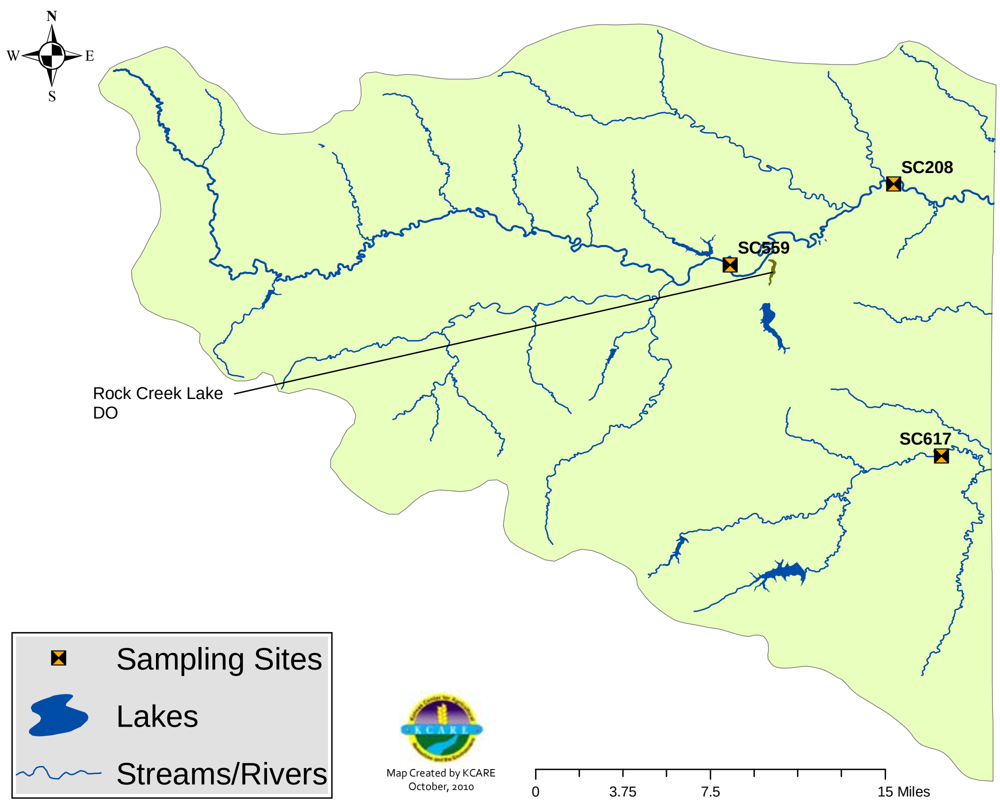


Figure 15. Category 5 303d Listings in the Watershed. [23]

4.10 Load Allocations [25]

TMDL loading is based on several factors. A total load is derived from the TMDL. Part of this total load is wasteload allocation. This portion comes from point sources in the watershed: NPDES facilities, CAFOs or other regulated sites. Some TMDLs will have a natural or background load allocation, which might be atmospheric deposition or natural mineral content in the waters. After removing all the point source and natural contributions, the amount of load left is the TMDL Load Allocation. This is the amount that originates from nonpoint sources (pollutants originating from diffuse areas, such as agricultural or urban areas that have no specific point of discharge) and is the amount that this WRAPS project is directed to address. All BMPs derived by the SLT will be directed at this Load Allocation by nonpoint sources.

4.10.1 Load Reductions to Meet the Biology TMDL on the Marmaton River

KDHE has set a required load reduction goal for phosphorus, nitrogen and sediment for the Marmaton River Bio TMDL originating from nonpoint sources. It is derived from subtracting the TMDL from the current loading in the river. This is the amount that the Marmaton Watershed will need to remove through BMP installations, conservation practices and streambank restorations.

Table 10. Load Reductions to Meet Biology TMDL on Marmaton River. [26]

	Annual Loading		
	Phosphorus (lbs)	**Nitrogen (lbs)**	**Sediment (tons)**
Current Condition	28,945	126,290	5,548
Less TMDL	24,565	107,310	4,709
Required Load Reduction from Nonpoint Sources	**4,380**	**18,980**	**840**

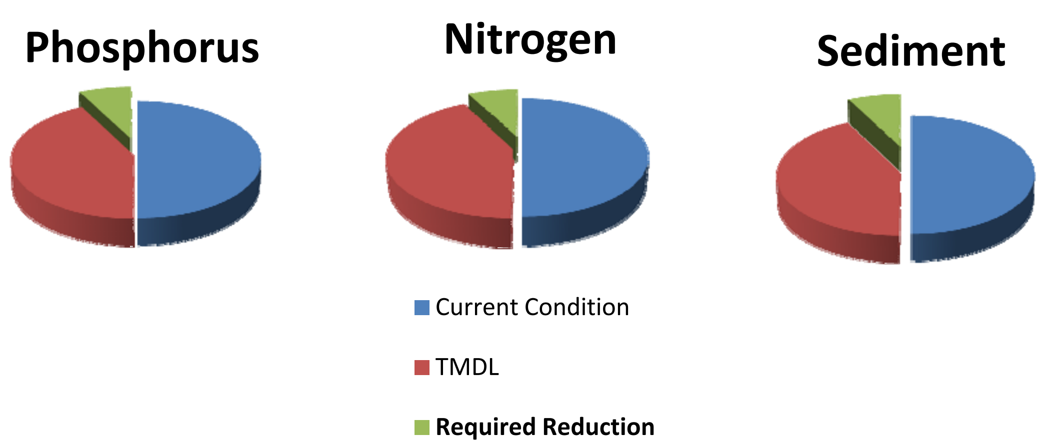


Figure 16. Load Allocations for Marmaton River Watershed.

4.10.2 Load Reductions to Meet Eutrophication TMDL for Lake Crawford

KDHE has set a required load reduction goal for phosphorus and nitrogen for Lake Crawford originating from nonpoint sources. It is derived from subtracting the TMDL from the current loading in the lake. This is the amount that the Lake Crawford watershed will need to remove through BMP installations and conservation practices.

Table 11. Load Reductions to Meet Eutrophication TMDL for Lake Crawford. [27]

	Annual Loading	
	Phosphorus (lbs)	Nitrogen (lbs)
Current Condition	1,055	11,008
Less TMDL	662	6,717
Required Load Reduction from Nonpoint Sources	**393**	**4,291**

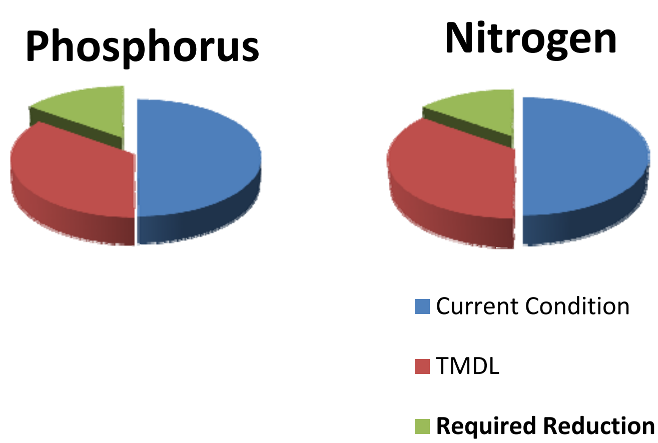


Figure 17. Load Allocations for Lake Crawford.

4.10.3 Load Reductions to Meet Eutrophication TMDL for Rock Creek Lake

KDHE has set a required load reduction goal for phosphorus and nitrogen for Rock Creek Lake originating from nonpoint sources. It is derived from subtracting the TMDL from the current loading in the lake. This is the amount that the Rock Creek Lake watershed will need to remove through BMP installations and conservation practices.

Table 12. Load Reductions to Meet Eutrophication TMDL for Rock Creek Lake. [28]

	Annual Loading	
	Phosphorus (lbs)	**Nitrogen (lbs)**
Current Condition	5,115	60,000
Less TMDL	2,863	49,090
Required Load Reduction from Nonpoint Sources	**2,252**	**10,910**

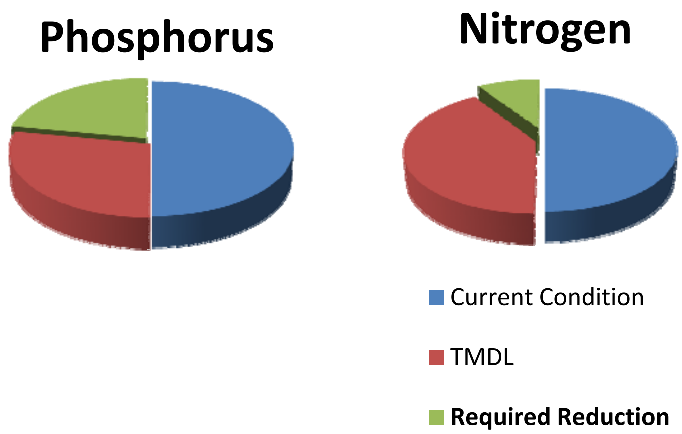


Figure 20. Load Allocations for Rock Creek Lake.

5.0 Critical and Targeted Areas, and Load Reduction Methodology

5.1 Critical Areas

In the Marmaton Watershed, "Critical Areas" have been identified as areas that need to be protected or restored, such as areas that have TMDLs, emerging pollutant threats, on the 303d list or contain a public water supply. Critical areas are defined by EPA as geographic areas that are critical to implement management practices in order to achieve load reductions. [29] Four areas have been identified as Critical Areas in this WRAPS:

1. Sub watersheds that have been identified by Watershed Assessment Tools as a potential source of pollutants (as identified in Section 5.2 below),
2. Sub watersheds with high priority TMDLs
3. Sub watersheds that contain lakes that are public water supplies and/or provide public recreation.
4. Sub watersheds that have assessments that have been reviewed by the SLT. The final report for both of these assessments is contained in the appendix of this report.
    1. *Kansas Alliance of Wetlands and Streams (KAWS) Streambank Assessment.* This assessment determined that 250 acres of riparian areas are in need of restoration. Buffer BMPs that are included in this WRAPS plan will help to address these riparian areas. One site is considered a high priority that needs a streambank stabilization project. However, WRAPS funding will not be used for specific streambank stabilization projects.
    2. *Kansas State University Bio and Agricultural Engineering Department Paired Watershed Monitoring Assessment.* This project studied the effects of the watersheds on low dissolved oxygen in the streams.

5.2 Targeted Areas

"Targeted Areas" are those specific areas in the Critical Areas that require BMP placement in order to meet load reductions. The Targeted Areas that have been identified in this WRAPS are:

1. Cropland areas targeted for sediment and nutrient runoff
2. Livestock areas targeted for nutrients and E. *coli* bacteria (ECB) runoff
3. High Priority TMDL area targeted for nutrient runoff

There is significant overlap in these targeted areas which is to the benefit of water quality in that applying BMPs for one pollutant will also positively affect other pollutants. Detailed discussion of each Targeted Area follows in the next sections of this report.

Table 13. Overlapping Targeted Areas for Cropland, Livestock and High Priority TMDLs.

Targeted Areas	Cropland Sediment	Cropland Nutrients	Livestock Nutrients	High Priority TMDLs
Marmaton River	X	X	X	X
Lake Crawford			X	X
Rock Creek Lake	X	X	X	X
Bourbon County SFL	X	X	X	X
Bronson City Lake	X	X	X	X

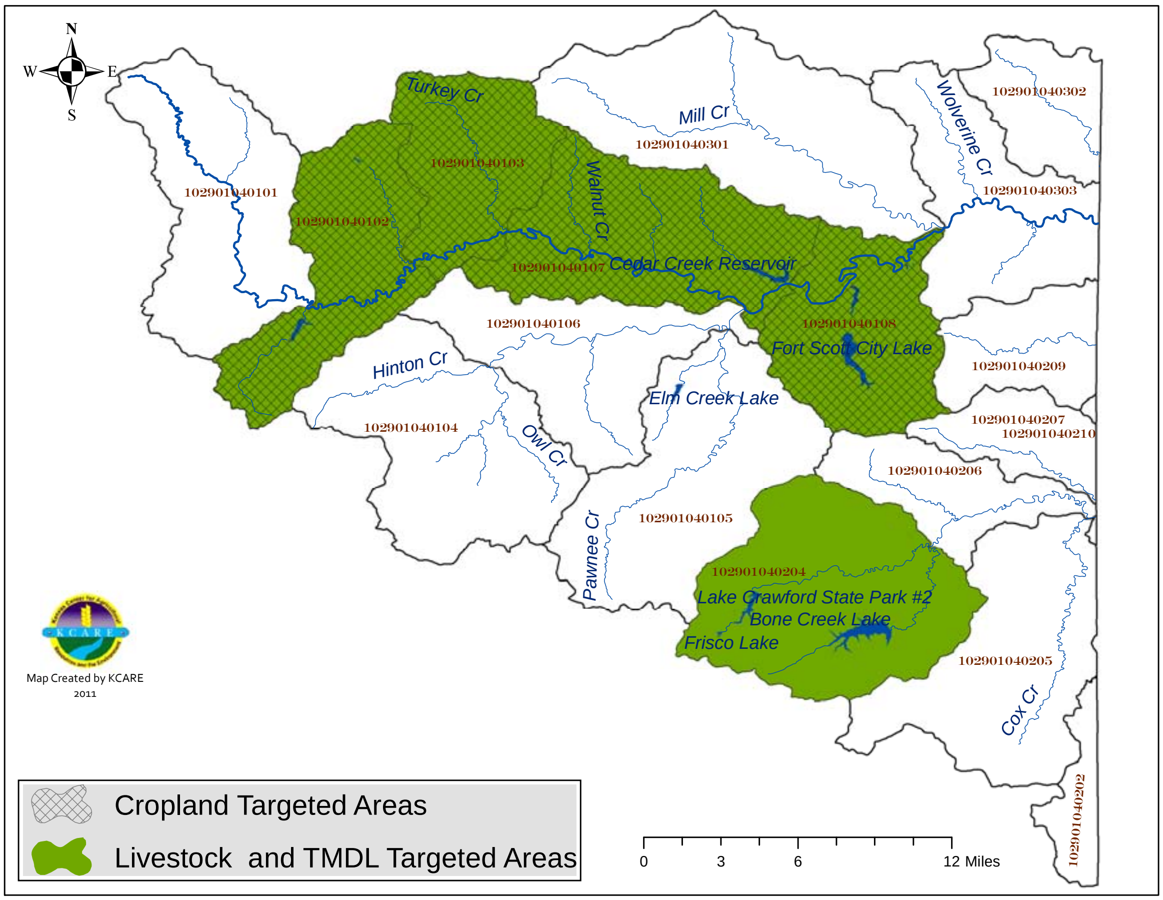


Figure 18. Targeted Areas for Cropland, Livestock and High Priority TMDLs.

In every watershed, there are specific locations that contribute a greater pollutant load due to soil type, proximity to a stream and land use practices. By focusing BMPs in these areas; pollutants can be reduced at a more efficient rate. Through research at the University of Wisconsin, it has been shown that there is a "bigger bang for the buck" with streamlining BMP placement in contrast to a "shotgun" approach of applying BMPs in a random nature throughout the watershed. Therefore, the SLT has targeted areas in the watershed to focus BMP placement for sediment and nutrient runoff. Targeting for this watershed will be accomplished in three different areas:

1. Cropland areas will be targeted for sediment and nutrients (phosphorus and nitrogen),
2. Livestock areas will be targeted for fecal coliform bacteria and nutrients (phosphorus and nitrogen), and
3. High priority TMDL areas will be targeted for nutrients (phosphorus and nitrogen)

5.2.1 Cropland Targeted Areas

The Cropland Targeted Area of this project was determined by the AnnAgNPS (Agricultural Non-Point Source Pollution Model Version 5.00) modeling tool as having the potential to runoff sediment (overland origin), and nutrients and is to be used for the determination of BMP placement.

The AgNPS (Agricultural Non-Point Source Pollution Model) is described as follows by NRCS: [30]

"AGNPS is a tool for use in evaluating the effect of management decisions impacting a watershed system. The AGNPS system is a direct update of the AGNPS 98 & 2001 system of modules containing many enhancements.

The term "AGNPS" now refers to the system of modeling components instead of the single event AGNPS, which was discontinued in the mid-1990's. These enhancements have been included to improve the capability of the program and to automate many of the input data preparation steps needed for use with large watershed systems.

New to AnnAGNPS Version 5.00, the model includes enhanced ephemeral gully feature, automated calibration features for many of the pollutants, capabilities to enter in an unlimited number of climate stations with any naming convention needed, actual or potential evapotranspiration for every climate station can now be defined in any climate file, and many more input and output options. The AGNPS interface has been better integrated with the components needed to develop AnnAGNPS datasets, including the development of automated procedures for the creation of ephemeral gully input data. The capabilities of RUSLE, used by USDA-NRCS to evaluate the degree of erosion on agricultural fields and to guide development of conservation plans to control erosion, have been incorporated into AnnAGNPS. The capability of importing RUSLE2 databases into AnnAGNPS is also available. This provides a watershed scale aspect to conservation planning. The channel network evolution models, CCHE1D, and the stream corridor model CONCEPTS, have been developed for analysis of reaches within a stream network for integration with AnnAGNPS, for watersheds that require a more comprehensive evaluation of the stream system, when channel evolution, erosion, or in-stream structures produce problems that the simplified channel system of AnnAGNPS is not designed for. An updated output processor now provides convenient compilation of loadings at any point in the watershed on an event, monthly or annual basis. The output processor includes options to determine the flow associated with a runoff hydrograph distributed across days, as well as associated with individual events.

The input programs include: (1) a GIS-assisted computer program (TOPAZ with *an interface to AGNPS) to develop terrain-following cells with all the needed hydrologic & hydraulic parameters that can be calculated from readily available DEM's. Included are procedures to associated management, soils, and climate shape files with the derived AnnAGNPS cells. Additional features of the GIS interface provide ephemeral gully input information required by AnnAGNPS to describe the location of gully mouths and the associated input information for each gully; and (2) an Input Editor to initialize, complete, and/or revise the input data. Options are now available in the Input Editor to export and import files in a comma-delimited format for many of the data sections. This provides a convenient approach to developing input data sections in spreadsheet programs and then importing those into the Input Editor.*

AnnAGNPS includes up-to-date technology (e.g., ephemeral gullies, RUSLE & pesticides) as well as the daily features necessary for continuous simulation in a watershed.

Outputs related to soluble & attached nutrients (nitrogen, phosphorus, & organic carbon) and any number of pesticides are provided. Water and sediment yield by particle size class and source are calculated. A field pond water & sediment loading routine is included for rice/crawfish ponds that can be rotated with other land uses. Nutrient concentrations from feedlots and other point sources are modeled. Individual feedlot potential ratings can also be derived using the model. The application of CCHE1D for stream networks and CONCEPTS for stream corridors include more detailed science for the channel hydraulics, morphology, and transport of sediments and contaminants."

Table 14. Marmaton AnnAGNPS Model summary for Cropland Erosion and Nutrient Rates.
[31] Cropland Targeted Areas in Bold Print.

		Total Runoff			Average Per Acre Runoff					
HUC 12	Cropland Acres	Sed (tons)	Nit (lbs)	Phos (lbs)	Sed (tons)	Nit (lbs)	Phos (lbs)	Sed Rank	Nit Rank	Phos Rank
102901040202	2,005	236	4,408	593	0.118	2.199	0.296	1	4	2
102901040108	**3,919**	**452**	**8,141**	**1,188**	**0.115**	**2.077**	**0.303**	**2**	**7**	**1**
102901040210	5,814	603	11,095	1,697	0.104	1.908	0.292	3	9	3
102901040103	**6,191**	**447**	**16,833**	**1,587**	**0.072**	**2.719**	**0.256**	**4**	**2**	**4**
102901040102	**5,125**	**353**	**8,335**	**904**	**0.069**	**1.626**	**0.176**	**5**	**10**	**8**
102901040107	**8,253**	**535**	**17,455**	**1,603**	**0.065**	**2.115**	**0.194**	**6**	**5**	**6**
102901040104	10,966	575	37,930	2,130	0.052	3.459	0.194	7	1	5
102901040106	5,961	292	11,721	964	0.049	1.966	0.162	8	8	9
102901040105	6,118	285	16,431	1,148	0.047	2.686	0.188	9	3	7
102901040101	12,869	487	27,154	1,548	0.038	2.11	0.12	10	6	10

The AnnAGNPS model results were presented to the SLT. After discussion by the SLT, HUC 12 Targeted Areas were selected. The Targeted Areas reflect those that are on the Marmaton River and rank highest in sediment loss. Even though 102901040202 ranked high in sediment loss, it was not chosen due to its geographic distance from the river. HUC 102901040210 also ranked high in sediment loss, but was not chosen since the vast majority of the HUC lies in Missouri not Kansas.

After determining the Targeted Areas, the SLT selected BMPs that they felt would be beneficial to improving water quality and, using their knowledge of the watershed, would be acceptable to producers and landowners. The BMPs that will be implemented in the Cropland Targeted Area for this watershed are:

- Establish permanent vegetation
- Install grassed waterways
- Implement no-till cropping
- Install vegetative buffers
- Establish conservation crop rotation
- Install terraces

The HUC 12s that are included in the Targeted Area are:

- 102901040102
- 102901040103
- 102901040107
- 102901040108

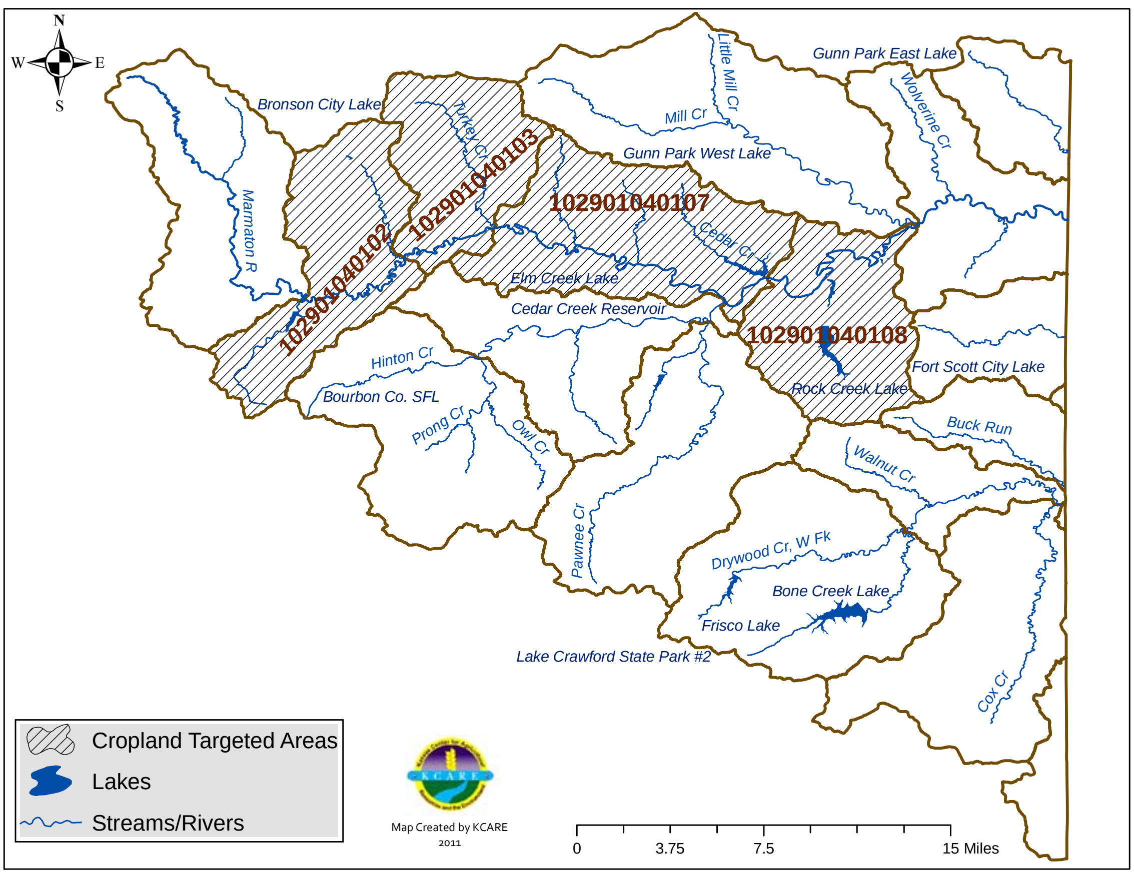


Figure 19. Cropland Targeted Area.

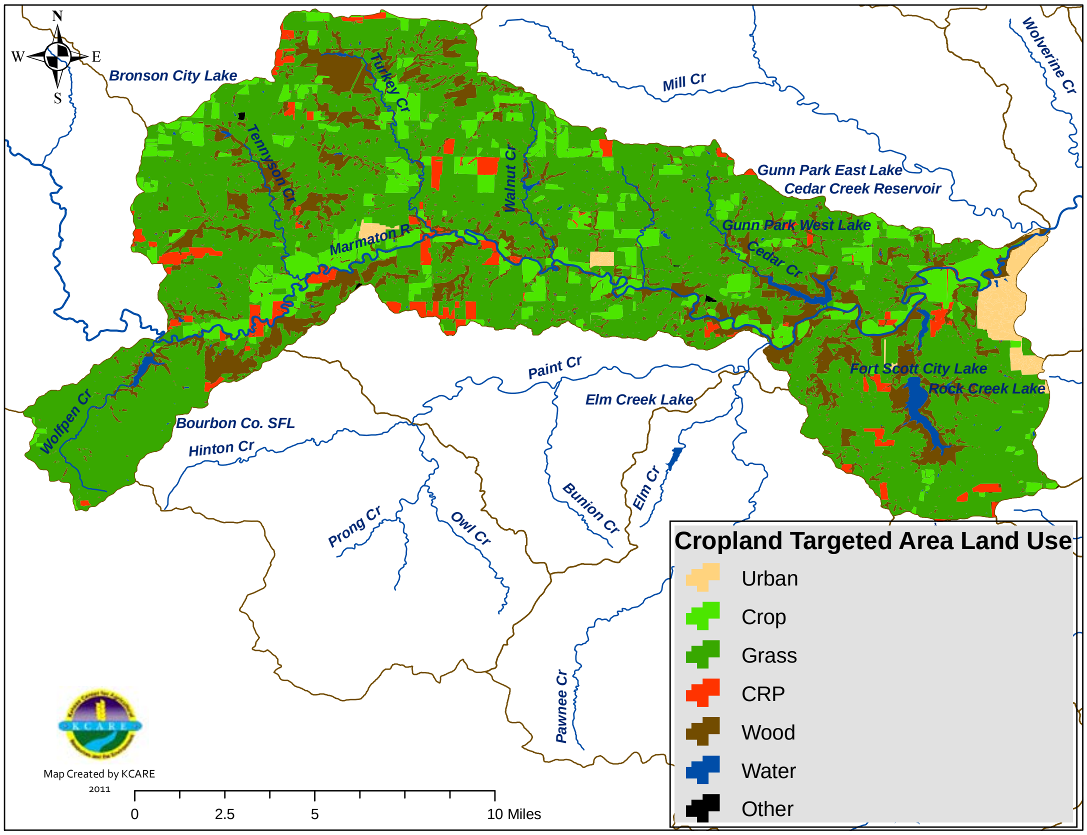


Figure 20. Land Use in the Cropland Targeted Area. [32]

Table 15. Land Use for Cropland Targeted Area. [32]

Land Use	*Acres*	*Percentage*
Grassland	61,615	65.9%
Woodland	14,951	16.0%
Cropland	11,098	11.9%
CRP	2,968	3.2%
Water	1,010	1.1%
Urban Openland	716	0.8%
Residential	599	0.6%
Urban Woodland	327	0.3%
Commercial/industrial	145	0.2%
Other	49	0.1%
Urban Water	17	0.0%
Total	**93,495**	**100.0%**

5.2.2 Livestock Targeted Area and High Priority TMDL Targeted Area

The Livestock Targeted Area and the High Priority TMDL Targeted Area cover the same geographic regions; therefore, they will be addressed together. These areas are targeted based on water quality data provided by KDHE's monitoring network. These data show elevated nutrients. Both areas will be targeted for nutrients and the Livestock Targeted Area will additionally be targeted for ECB. BMPs will be the same for both Targeted Areas as the BMPs that address nutrients will also address ECB.

Based on SLT opinion of landowner and producer acceptability, the BMPs that will be implemented for this watershed are:

- Establish vegetative filter strips
- Relocate feeding pens
- Relocate pasture feeding sites
- Install off stream watering systems
- Strategic fencing of streams and ponds
- Implement rotational grazing systems

This area is seen in the map below and includes the following HUC 12s:

- 102901040102
- 102901040103
- 102901040107
- 102901040108
- 102901040204 which contains the Lake Crawford Watershed

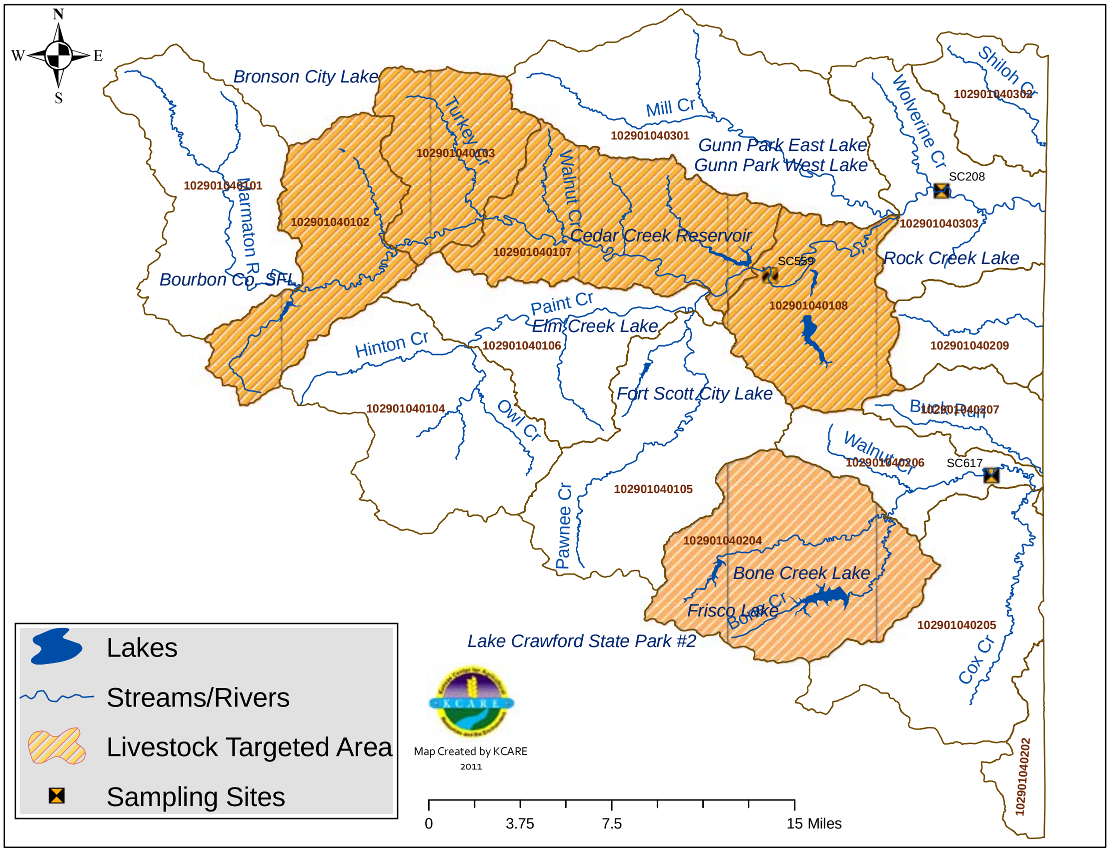


Figure 21. Livestock/High Priority Targeted Area.

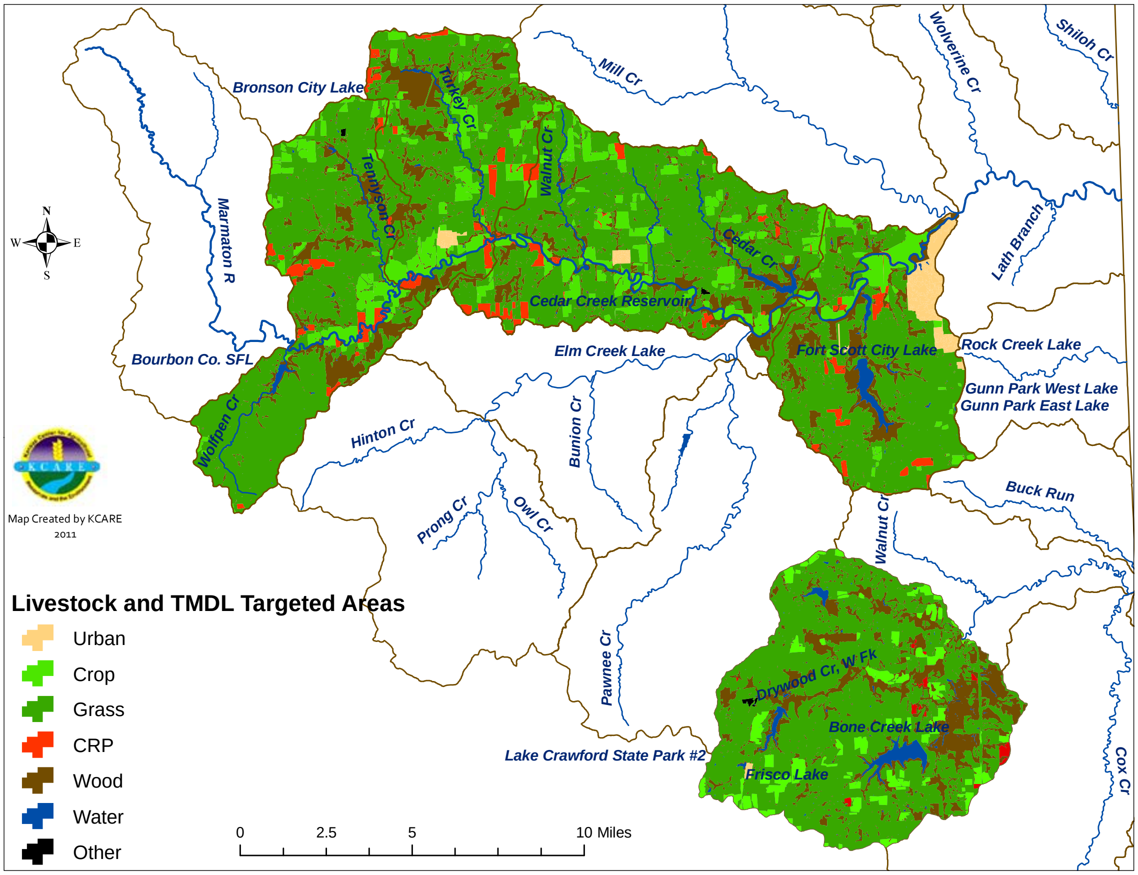


Figure 22. Land Use in the Livestock and TMDL Targeted Areas. [32]

Table 16. Land Use for the Livestock Targeted Area and the High Priority TMDL Targeted Area. [32]

Land Use	*Acres*	*Percentage*
Grassland	84,664	66.2%
Woodland	22,149	17.3%
Cropland	14,081	11.0%
CRP	3,190	2.5%
Water	1,929	1.5%
Urban Openland	735	0.6%
Residential	634	0.5%
Urban Woodland	330	0.3%
Commercial/industrial	145	0.1%
Other	90	0.1%
Urban Water	17	0.0%
Total	**127,965**	**100.0%**

5.2 Load Reduction Estimate Methodology

5.2.1 Cropland

Baseline loadings are calculated using the AnnAGNPS model delineated to the HUC 12 watershed scale. Best management practice (BMP) load reduction efficiencies are derived from K-State Research and Extension Publication MF-2572. [33] Load reduction estimates are the product of baseline loading and the applicable BMP load reduction efficiencies.

5.2.2 Livestock

Baseline nutrient loadings per animal unit are calculated using the Livestock Waste Facilities Handbook.[34] Livestock management practice load reduction efficiencies are derived from numerous sources including K-State Research and Extension Publication MF-2737 and MF-2454.[35] Load reduction estimates are the product of baseline loading and the applicable BMP load reduction efficiencies.

NOTE: The SLT of the Marmaton Watershed has determined that the focus of this WRAPS process will be on two key concerns of the watershed listed in order of importance:

1. **Sedimentation**
    a. **Cropland erosion**
2. **Nutrients and ECB**
    a. **Livestock (nutrients and ECB),**
    b. **Cropland (nutrients),**
    c. **High Priority TMDL (nutrients)**

All goals and best management practices will be aimed at restoring water quality or protecting the watershed from further degradation. The following sections in this report will address these concerns.

6.0 Impairments Addressed by the SLT

6.1 Sediment

There are no TMDLs for **sediment** in the Marmaton Watershed. However, the Biology TMDL on the Marmaton River has a sediment component due to the biological impairment being a function of many different factors. This is not the same as a sedimentation TMDL for a lake, but there is a sedimentation component of the Marmaton River Biology TMDL which could be addressed through reduction of sediment and erosion from overland runoff as well as failing streambanks. For example, pollutants, particularly phosphorus, can be attached to the suspended soil particles in the water column. Even though there is no sediment TMDL, the SLT hopes that the sediment BMPs that will be incorporated in the watershed will prevent the need of developing a TMDL in the future and addressing the Biology TMDL in the Marmaton River.

Sediment that originates in this watershed will eventually accumulate in lakes and wetlands downstream. This reduces reservoir volume and therefore, limits public access to the lakes because of inaccessibility to boat ramps, beaches and the water side. Also, a decrease in storage in the lake affects domestic and industrial uses of the lake water. Sediment can originate from streambank erosion and sloughing of the sides of the river and stream due to erosion and a lack of riparian cover. Sheet and rill erosion from cropping and pasture systems contributes sediment in the ecosystem. Therefore, reducing erosion is necessary for accomplishing a reduction in sediment. Agricultural BMPs such as no-till, conservation tillage, grass buffer strips around cropland, terraces, grassed waterways and reducing activities within the riparian areas will reduce erosion and improve water quality. These are some of the BMPs that will be the focus of this WRAPS plan.

Physical components and activities performed on the land affects sediment movement. Some are:

- Slope of the land, propensity to generate runoff and soil type
- Streambank erosion and sloughing or undercutting of the sides of the river and stream bank. A lack of riparian cover can cause washing on the banks of streams or rivers and enhance erosion.
- Animal movement, such as livestock that regularly cross the stream or follow trails in pastures, can cause pathways that will erode.
- Silt that is present in the stream from past activities and is gradually moving downstream with each high intensity rainfall event.

Agricultural BMPs that will help reduce sediment deposition in waterways are (in no particular order, many other BMPs exist):

- No-till
- Minimum tillage
- Vegetative buffers and riparian areas
- Grassed waterways
- Grassed terraces
- Wetland creation
- Establishing permanent vegetative cover
- Farming on the contour
- Conservation crop rotation

Cropland BMPs that have been selected by the SLT based on projected acceptability by landowners, cost effectiveness and pollutant load reduction effectiveness are:

- Establish permanent vegetation on cropland
- Install grassed waterways
- Implement no-till cultivation
- Establish vegetative buffers
- Establish conservation crop rotations
- Install terraces

This section will review several potential sources or environmental actions that have the potential of increasing sediment in the waters. They are (in no particular order of importance):

<u>Cropland Erosion</u>

- Land use
- T-factor or soil loss
- Hydrologic soil groups

6.1.1 Cropland Erosion

Cropland BMPs have been assigned by the SLT. The Targeted Areas for cropland are located along the Marmaton River. This is the area that contains the most potential for sediment runoff as determined by the AnnAGNPS model. Causes of erosion are discussed in more detail in the rest of this section.

6.1.1.A Land Use

Land use activities have a significant impact on the types and quantity of sediment transfer in the watershed. Construction projects in the watershed and in communities can leave disturbed areas of soil and unvegetated roadside ditches that can wash in a rainfall event. In addition, agricultural cropland that is under conventional tillage practices as well as a lack of maintenance of agricultural BMP structures can have cumulative effects on land transformation through sheet and rill erosion. The primary land uses in the Cropland Targeted Area are grasslands (65.9%), woodland (16%), cropland (11.9%) and all other (6.3%).

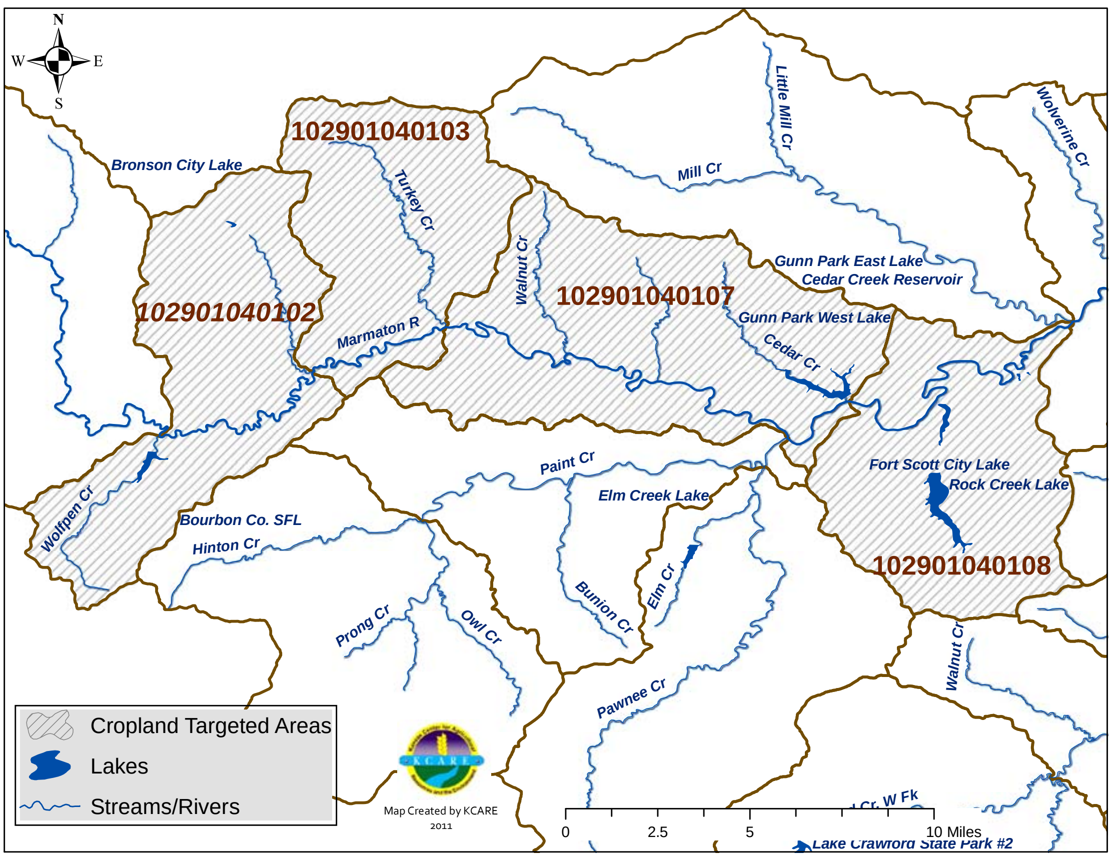


Figure 23. Targeted Area for Cropland as Determined by AnnAGNPS.

Table 17. Land Use in the Cropland Targeted Area, 2005. [4]

Land Use	*Acres*	*Percentage*

Grassland	61,615	65.9
Woodland	14,951	16.0
Cropland	11,098	11.9
CRP	2,968	3.2
Water	1,010	1.1
Urban Openland	716	0.8
Residential	599	0.6
Urban Woodland	327	0.3
Commercial	145	0.2
Other	49	0.1
Urban Water	17	0.0
Total	**93,495**	**100.0%**

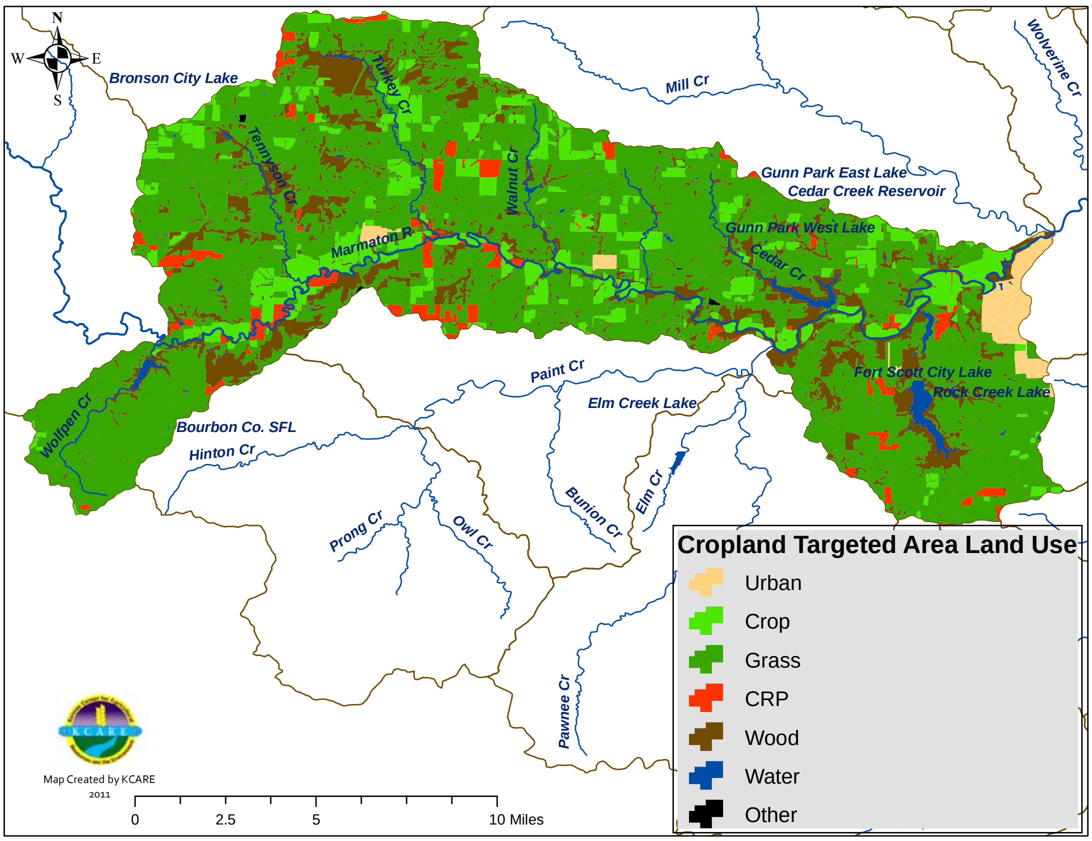


Figure 24. Cropland Targeted Area Land Use. [4]

6.1.1.B Soil Erosion Caused by Wind and/or Water

NRCS has established a "T factor" in evaluating soil erosion. T is the soil loss tolerance factor. It is defined as the maximum rate of annual soil loss that will permit crop productivity to be sustained economically and indefinitely on a given soil. It is assigned to soils without respect to land use or cover and ranges from 1 ton per acre for shallow soils to 5 tons per acre for deep soils that are not as affected by loss of productivity by erosion. T factor represents the goal for maximum annual soil loss in sustaining productivity of the land use. Erosion is considered to be greater than T if either the water (sheet and rill) erosion or the wind erosion rate exceeds the soil loss tolerance rate. [36]

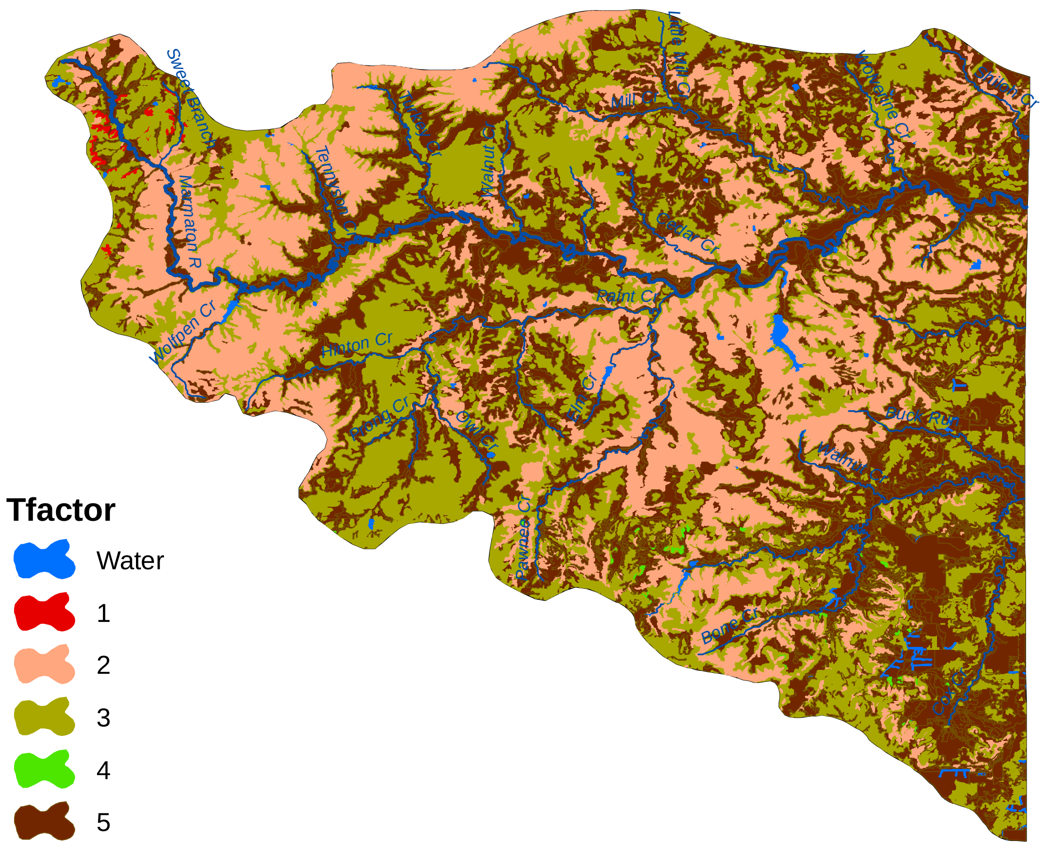


Figure 25. T Factor in the Watershed. [37]

The primary percentage ranking T Factor for this watershed is 5, which constitutes the deepest soils. This demonstrates the need for conservation practices in the watershed to protect against soil erosion.

Table 18. T Factor in the Watershed. [37]

T Factor	Acres	Percent of Watershed
5	156,398	40.5
3	121,749	31.5
2	105,529	27.3
0	1,911	0.5
1	565	0.1
4	412	0.1

6.1.1.C Soil Erosion Influenced by Soil Type and Runoff Potential

Soil type has an influence on runoff potential and erosion throughout the watershed. Soils are classified into four hydrologic soil groups (HSG). The soils within each of these groups have the same runoff potential after a rainfall event if the same conditions exist, such as plant cover or storm intensity. Soils are categorized into four groups: A, B, C and D.

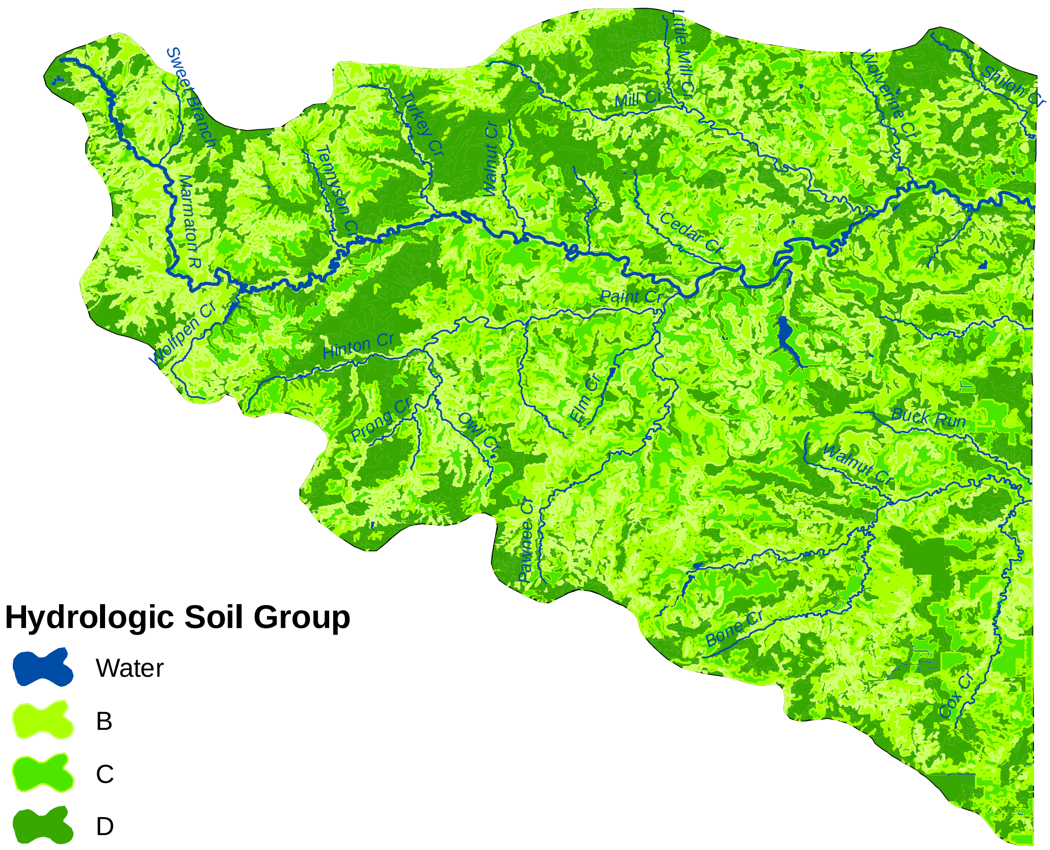


Figure 26. Hydrologic Soil Groups of the Watershed. [37]

One third of the watershed (38 percent) is characterized as soil group D, which is the soil group with the highest potential for runoff. Thirty two percent are categorized as soil group C and twenty eight percent is soil group B. Conservation practices and BMP installations are vital to help to protect this fragile soil.

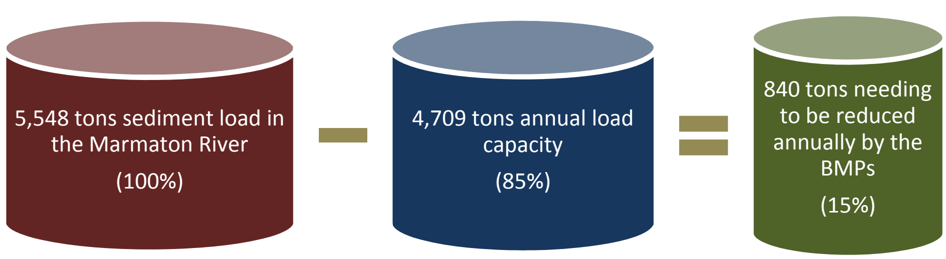
Table 19. Hydrologic Soil Groups of the Watershed. [37]

Hydrologic Soil Group	Definition	Acres of Watershed in HSG	Percentage of Watershed in HSG
D	Soils with high runoff potential. Soils having very slow infiltration rates even when thoroughly wetted and consisting chiefly of clay soils with a	148,435	38.4

	high swelling potential, soils with a permanent high water table, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious material.		
C	Soils having slow infiltration rates even when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine textures.	125,294	32.4
B	Soils having moderate infiltration rates even when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well drained to sell drained soils with moderately fine to moderately coarse textures.	110,924	28.7
Other	Water, dams, pits, sewage lagoons	1,911	0.5
A	Soils with low runoff potential. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep well drained to excessively well-drained sands or gravels.	0	0

6.1.2 Sediment BMPs with Acres or Projects Needed

The current estimated sediment load from nonpoint sources in the Marmaton River is 5,548 tons per year according to the TMDL section of KDHE. KDHE has determined that there should be a 15 percent sediment reduction in the Marmaton River to meet the Marmaton River Biology TMDL. **The total annual load reduction allocated to Marmaton Watershed needed to meet the sediment portion of the Biology TMDL is 840 tons of sediment**. This is the amount of sediment that needs to be removed from the watershed and is the target of the BMP installations that will be placed in the watershed. These BMPs have been determined as feasible and approved by the SLT.



The SLT has laid out specific BMPs that they have determined will be acceptable to watershed residents as listed below. **These BMPs will be implemented in the Cropland Targeted Area.** An added bonus of implementing cropland BMPs aimed at sediment reduction is a positive effect on nutrient/phosphorus runoff (will be discussed in the next section). Specific acreages or projects that need to be implemented per year have been determined through modeling, cost-effectiveness and producer acceptability and approved by the SLT. All BMPs are considered independent projects and stand alone in their load reductions.

Table 20. BMPs and Acres or Projects Needed to Reduce Sediment Contribution in the Marmaton River Biology TMDL.

Protection Measures	Best Management Practices and Other Actions	Total Treated Acres Needed to be Implemented Annually
Prevention of sediment (TSS) contribution from **cropland**	1. Establish Permanent Vegetation	35 acres
	2. Grassed Waterways	87 acres
	3. No-Till	87 acres
	4. Vegetative Buffers	87 acres
	5. Conservation Crop Rotation	87 acres
	6 Terraces	87 acres

6.1.3 Sediment Load Reductions

The table below lists the cropland BMPs and acres implemented with the associated load reductions attained by implementing all of these BMPs.

Table 21. Estimated Sediment Load Reductions for Implemented BMPs on Cropland Aimed at Reducing Sediment Contribution in the Marmaton River Biology TMDL.

Cropland BMPs Annual Soil Erosion Reduction (tons)							
Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotation	Terraces	Total Load Reduction
1	7.5	7.9	14.7	9.8	4.9	5.9	**50.7**
2	14.9	15.7	29.5	19.7	9.8	11.8	**101.4**
3	22.4	23.6	44.2	29.5	14.7	17.7	**152.1**
4	29.9	31.4	59.0	39.3	19.7	23.6	**202.8**
5	37.3	39.3	73.7	49.1	24.6	29.5	**253.5**
6	44.8	47.2	88.4	59.0	29.5	35.4	**304.2**
7	52.3	55.0	103.2	68.8	34.4	41.3	**354.9**
8	59.7	62.9	117.9	78.6	39.3	47.2	**405.6**
9	67.2	70.7	132.6	88.4	44.2	53.1	**456.3**
10	74.7	78.6	147.4	98.3	49.1	59.0	**507.0**
11	82.1	86.5	162.1	108.1	54.0	64.8	**557.7**
12	89.6	94.3	176.9	117.9	59.0	70.7	**608.4**
13	97.1	102.2	191.6	127.7	63.9	76.6	**659.1**
14	104.5	110.0	206.3	137.6	68.8	82.5	**709.8**
15	112.0	117.9	221.1	147.4	73.7	88.4	**760.5**
16	119.5	125.8	235.8	157.2	78.6	94.3	**811.2**
17	126.9	133.6	250.5	167.0	83.5	100.2	**861.9**
18	134.4	141.5	265.3	176.9	88.4	106.1	**912.6**
19	141.9	149.3	280.0	186.7	93.3	112.0	**963.3**
20	149.3	157.2	294.8	196.5	98.3	117.9	**1,014.0**

The percent of sediment reduction achievement is illustrated in the right column. It will require seventeen years to meet the sediment reduction goal in the Marmaton River if all BMPs are implemented. The life of the WRAPS plan is twenty years. After seventeen years, the sediment portion of this plan will switch from being "restoration" to "protection" of the watershed.

Table 22. Percentage of Sediment Load Reductions for Implemented BMPs on Cropland Aimed at Reducing Sediment Contribution in the Marmaton River Biology TMDL.

Year	Cropland Reduction (tons)	% of TMDL
1	51	6%
2	101	12%
3	152	18%
4	203	24%
5	253	30%
6	304	36%
7	355	42%
8	406	48%
9	456	54%
10	507	60%
11	558	66%
12	608	72%
13	659	78%
14	710	84%
15	760	91%
16	811	97%
17	862	103%
18	913	109%
19	963	115%
20	1,014	121%
Load Reduction to meet Sediment TMDL:		**840**

Sediment component of Biology TMDL has been met

Table 23. Sediment Load Reduction at the End of Twenty Years Aimed at Reducing Sediment Contribution in the Marmaton River Biology TMDL.

Best Management Practice Category	Total Load Reduction (tons)	% of Sediment TMDL
Cropland	1,014	121%
Sediment Goal 840 Tons		

Refer to Section 8, "Costs of BMP Implementation" for specific BMP costs in order to meet the TMDL.

6.2 Nutrients

An excess of nutrients in water bodies can cause water impairments that are detrimental to aquatic life and water quality. The terminology “nutrients” primarily encompasses phosphorus and nitrogen as the two main contributors. An excess in nutrients can be caused by any land practice that will contribute to nutrients in surface waters. Examples are (but not limited to):

- Fertilizer runoff from agricultural and urban lands,
- Manure runoff from domestic livestock and wildlife in close proximity to streams and rivers,
- Failing septic systems, and
- Phosphorus recycling from lake sediment.

Not all phosphorus and nitrogen contributions can be attributed to agricultural practices. Excess fertilization of lawns, golf courses and urban areas can easily transport nitrogen and phosphorus downstream. However, for this WRAPS process, targeting will be for cropland and livestock practices.

The impairments that are caused by excess nutrients are:

- **Eutrophication (E).** E is a natural process that occurs when a water body receives excess nutrients. These excess nutrients create optimum conditions that are favorable for algal blooms and plant growth. Lake Crawford and Rock Creek Lake have high priority TMDLs for E. Bourbon County State Fishing Lake, Bronson City Lake, and Elm Creek Lake also have TMDLs for E. Listings on the 303d list for E are Gunn Park East Lake and Gunn Park West Lake.
- **Dissolved oxygen (DO).** Proliferation of algae and subsequent decomposition depletes available dissolved oxygen in the water profile. This lack of oxygen is devastating for aquatic species and can lead to fish kills. The Marmaton River has a high priority TMDL for low DO. Bourbon County State Fishing Lake and Drywood Creek West Fork also have TMDLs for low DO. Desirable criteria for a healthy water profile include DO rates greater than 5 milligrams per liter.
- **Biology (Bio).** TMDLs for Bio can be caused by a grouping of biological related factors contained in the bullets below. The Marmaton River has a high priority TMDL for Bio at the segment of the river that is covered by sampling site SC208 which is located near Ft. Scott. The Marmaton River is also listed on the 303d listing for the segment at SC559 which is located immediately downstream of the confluence of the Marmaton River and Cedar Creek.
    - **Biological Oxygen Demand (BOD).** BOD is a measure of the amount of oxygen removed in water while stabilizing biodegradable organic matter. It can be used to indicate organic pollution levels. Desired criteria would be less than 3.5 milligrams per liter.

- **Macroinvertebrate Biotic Index (MBI).** MBI rates the nutrient and oxygen demanding pollution tolerance of large taxonomic groups. Higher values indicate greater pollution tolerances. MBI indexes should be below 4.5 to support aquatic life.
- **% Ephemeroptera, Plecoptera, and Trichoptera (EPT)**. The EPT is the proportion of aquatic taxa present within a stream belonging to pollution intolerant orders: EPT are mayflies, stoneflies and caddisflies. A higher percentage of total taxa comprising these three groups indicate less pollutant stress and better water quality. EPS taxa should be 58 percent or greater for full support of aquatic species.

Activities performed on the land affects nutrient loading in the watershed. Land use in this watershed is primarily agricultural related; therefore, agricultural BMPs are necessary for reducing nitrogen and phosphorus. Some examples of nitrogen and phosphorus BMPs include:

- Soil sampling and appropriate fertilizer recommendations,
- Minimum and no-till farming practices,
- Filter and buffer strips installed along waterways,
- Reduce contact to streams from domestic livestock,
- Develop nutrient management plans for manure management, and
- Replace failing septic systems.

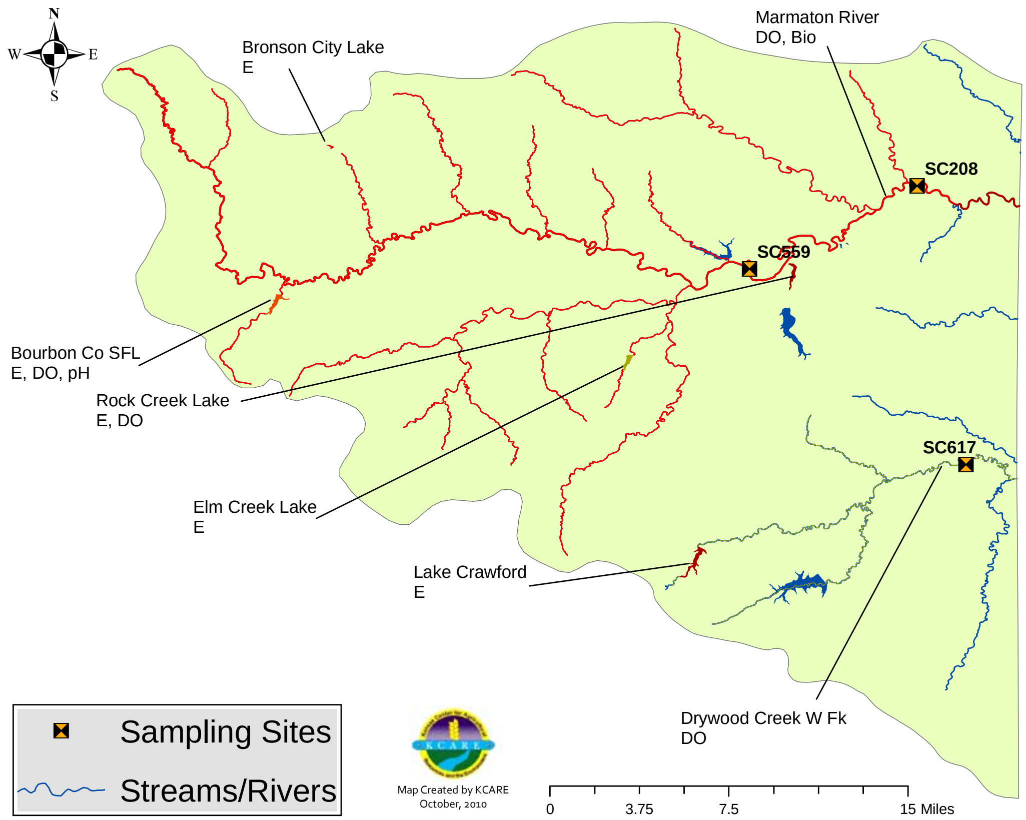


Figure 27. Nutrient Related TMDLs and 303d Listings.

6.2.1 Livestock Related Impairments

Livestock can contribute to nutrients in surface water through manure runoff. Soluble phosphorus can easily be transported in runoff from fields where livestock gather. Preventing manure runoff into streams is important in avoiding elevated phosphorus concentrations. A few BMPs that can assist are restricting cattle access to streams, maintaining adequate buffer areas, providing an alternate watering system and managing optimal grass cover.

In addition to nutrients in manure, **ECB** are present in livestock manure and can be transported into waterways if livestock have access to streams or manure is allowed to run off into a stream. There are no current ECB impairments within the watershed. ECB improvements are anticipated to occur as a result of the livestock related BMPs which are addressing nutrient water quality issues.

As mentioned earlier in this report, the Livestock Targeted Area and the High Priority TMDL Targeted Area cover the same geographic region. This area will be targeted for nutrients and ECB. The Cropland Targeted Area will also be targeted for nutrients, in addition to the sediment BMPs that have been mentioned in the previous section of this report. Other nutrient issues can arise from fertilizers applied to non-native pastures used for livestock grazing. Nitrogen and phosphorus can originate from fertilizer runoff caused by either excess application or a rainfall event immediately after application.

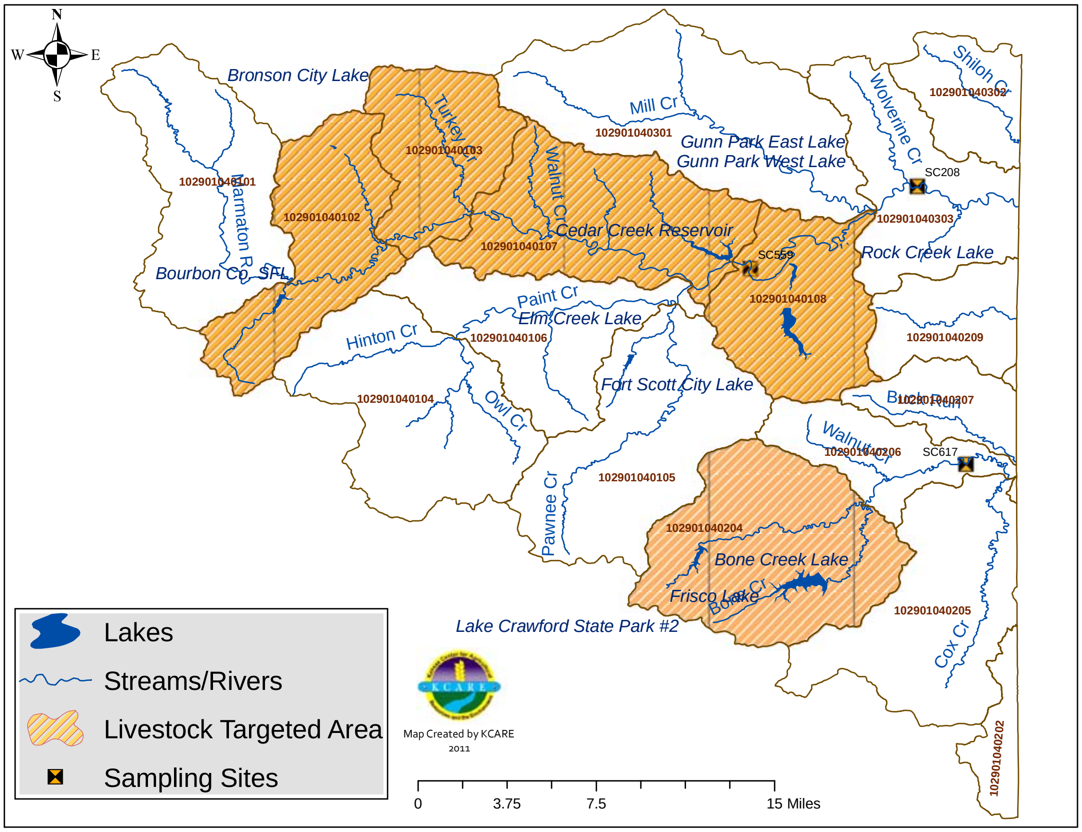


Figure 28. Targeted Areas for Livestock BMPs in the Watershed.

6.2.1.A. Manure Runoff from Fields and Livestock Operations

It must be noted that not all ECB can be attributed to livestock. Wildlife has a contribution to ECB loads. In addition, failing septic systems can be a source of ECB bacteria from humans. However, for this WRAPS process, targeting will be for livestock.

There are no TMDLs for **FCB** or **ECB** at this time in the watershed. Even though there is not a TMDL at this time, the SLT feels that because of the number of livestock in the watershed, they would like to address this subject in conjunction with the nutrient impairments aimed at livestock.

FCB are a broad spectrum of bacteria species which includes ECB**.** Since FCB is present in the digestive tract of all warm blooded animals including humans and animals (domestic and wild), its presence in water indicates that the water has been in contact with human or animal waste. FCB is not itself harmful to humans, but its presence indicates that disease causing organisms, or pathogens, may also be present. A few of these are Giardia, Hepatitis, and Cryptosporidium. In the past, KDHE has measured FCB as an indicator of pathogen impairment and in determination of issuance of a TMDL. Currently, however, KDHE is transitioning to the use of ECB as it is a more reliable indicator of human health risk. Consequently, the new methodology for assessing ECB levels in water bodies requires the average of five samples taken over a month's time to exceed the criteria level. This is much more stringent than the former FCB methodology which required a single exceedance to indicate impairment. Presence of ECB in waterways can originate from

- improper manure disposal from livestock production areas,
- close proximity of any mammals to water sources, and
- manure application during adverse weather events to agricultural fields.

ECB can originate in both rural and urban areas. It can be caused by both point and nonpoint sources. In this report, the BMPs will address rural areas that are the source of nonpoint pollution.

In Kansas, animal feeding operations (AFOs) with greater than 300 animal units must register with KDHE. Confined animal feeding operations (CAFOs), those with more than 999 animal units, must be permitted with EPA. An animal unit or AU is an equal standard for all animals based on size and manure production. For example: 1 AU= 1,000 pounds of live animal weight (steer = 1 AU, dairy cow = 1.4 AU, swine = 0.4 AU). The watershed contains several CAFOs. (This data is derived from KDHE, 2003. It may be dated and subject to change). CAFOs are not allowed to release manure from the operation. However, they are allowed to spread manure on cropland fields for distribution. If this application is followed by a rainfall event or the manure is applied on frozen ground, it can run off into the stream. Smaller operations are not regulated by the state. Many of these operations are located along streams because of historic preferences by early settlers. Movement of feeding sites away from the streams and providing alternate watering sites is logistically important to the prevention of ECB entering the stream. Grazing density is an important factor in manure runoff due to the common practice of cattle loafing in ponds and streams during the hot summer months and frequently defecating directly into the water source. Also, overgrazed pastures do not retain manure as well as moderately grazed pastures. This allows for runoff to a greater extent. Manure management is a key component in the WRAPS plan.

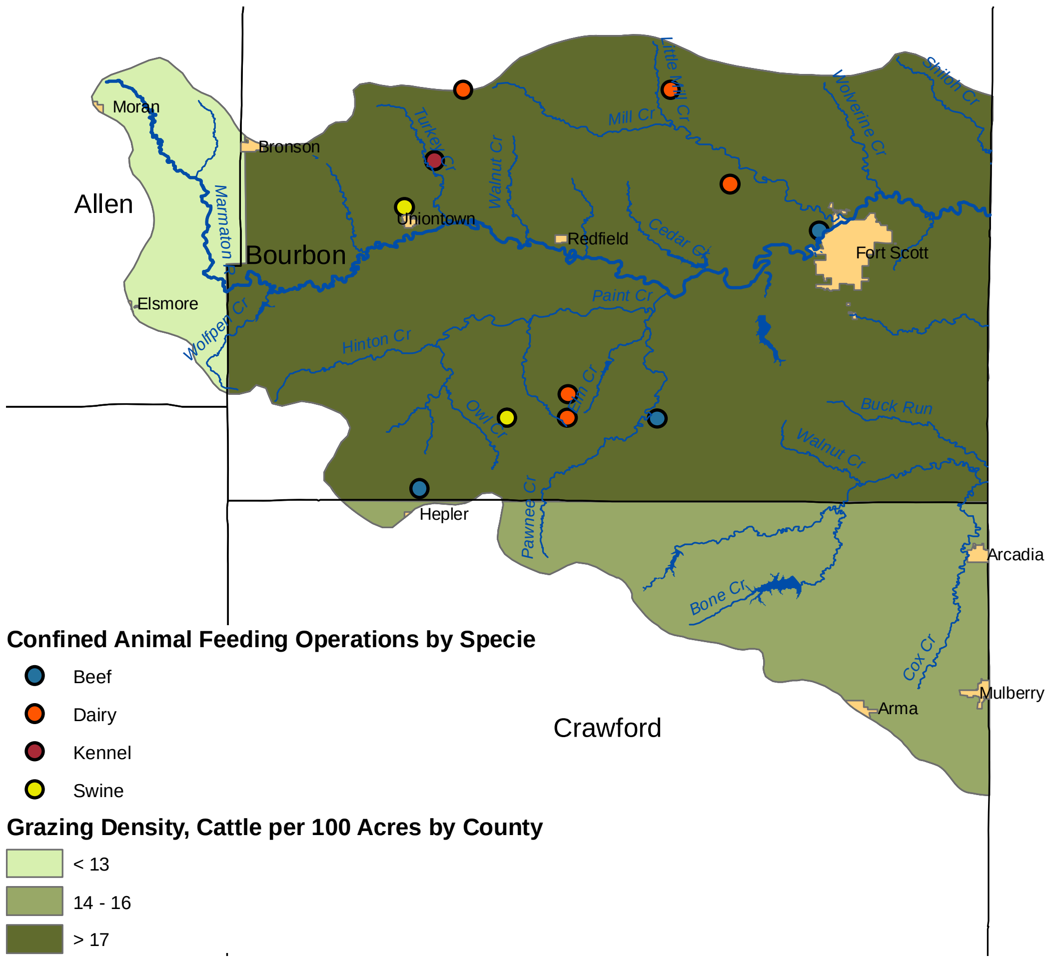


Figure 29. Confined Animal Feeding Operations and Grazing Density in the Watershed. [38]

6.2.1.B Land Use

Land use activities have a significant impact on the types and quantity of livestock related nonpoint source pollutants in the watershed. Agricultural activities and lack of maintenance of agricultural structures can have cumulative effects on land transformation. Manure runoff from grasslands close to waterways can add to ECB in the waterways. The primary land uses in the livestock targeted area of the watershed are grassland (66%) and woodland (16%).

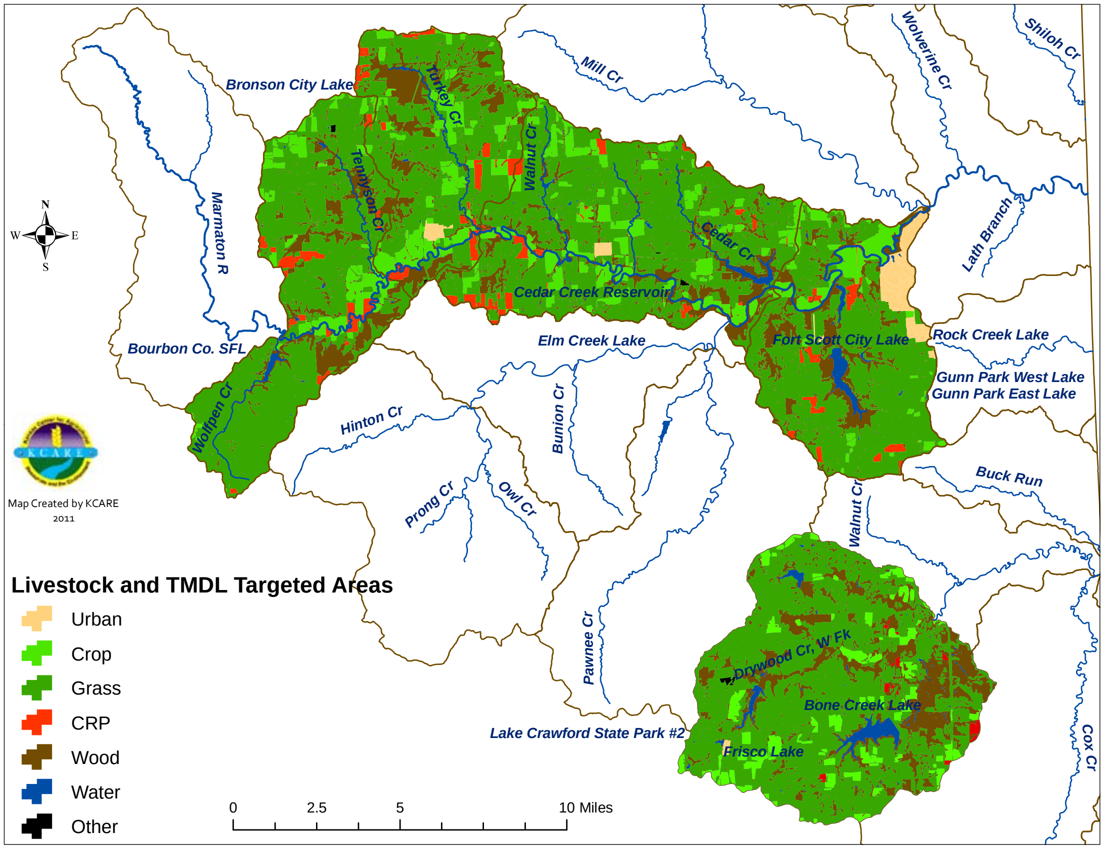


Figure 30. Land Cover of the Livestock Targeted Area of the Watershed. [39]

6.2.1.C Rainfall and Runoff

Rainfall amounts and subsequent runoff along with flooding outside the stream channel can affect ECB concentrations in the streams and rivers. Manure in streams can originate from livestock that are allowed access to wade or loaf directly in the stream. Manure from cropland can originate from fields where the manure that has been applied either before a rainfall event or on frozen ground. Manure and livestock management is important in preventing ECB or phosphorus runoff from the targeted area. Rainfall in this watershed occurs primarily in the late spring and early summer. This occurs when grass is short and runoff potential is greatest.

6.2.2 Cropland Related Nutrient Pollutants

The Marmaton River, Bronson City Lake, Bourbon County State Fishing Lake, Rock Creek Lake, Lake Crawford and Drywood Creek West Fork have TMDLs for nutrient related impairments. The Marmaton River, Bronson City Lake, Bourbon County State Fishing Lake, Rock Creek Lake and Lake Crawford are contained in the Livestock Targeted Area. One listing on the 303d list that has cropland related nutrient impairments is Rock Creek Lake. It is included in the Targeted Area. In order to be able to be able to measure improvements in water quality, nutrients will be measured as phosphorus or Total Phosphorus (TP).

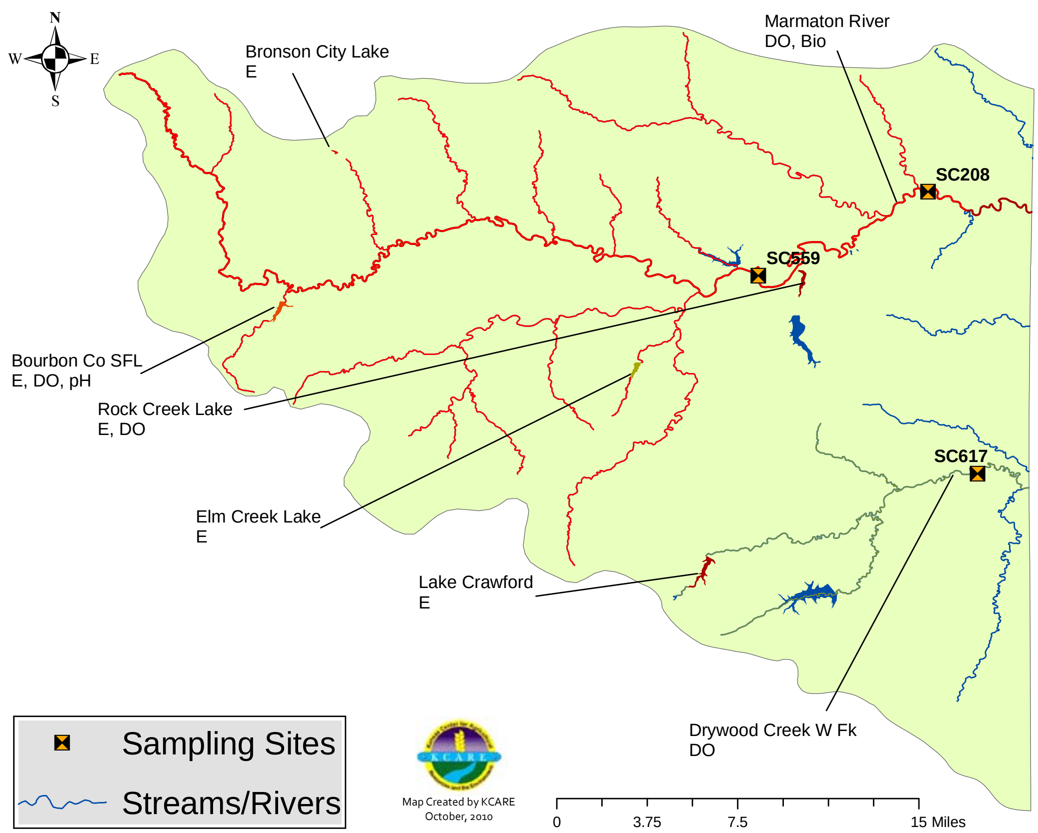


Figure 31. Nutrient Related TMDLs and 303d Listings in the Marmaton Watershed. [40]

6.2.2.A Land Uses

Land use activities have a significant impact on the types and quantity of nutrient runoff in the watershed. Agricultural cropland in the watershed primarily lies along and adjacent to the river and tributaries. If this cropland is under conventional tillage practices and/or lacks maintenance of agricultural BMP structures, there can be an increase in runoff which will carry nitrogen and phosphorus into streams and lakes. Cropland in the Marmaton Watershed consists of approximately thirteen percent of the land use. Cropland in the watershed consists of mainly wheat, soybeans, corn and sorghum.

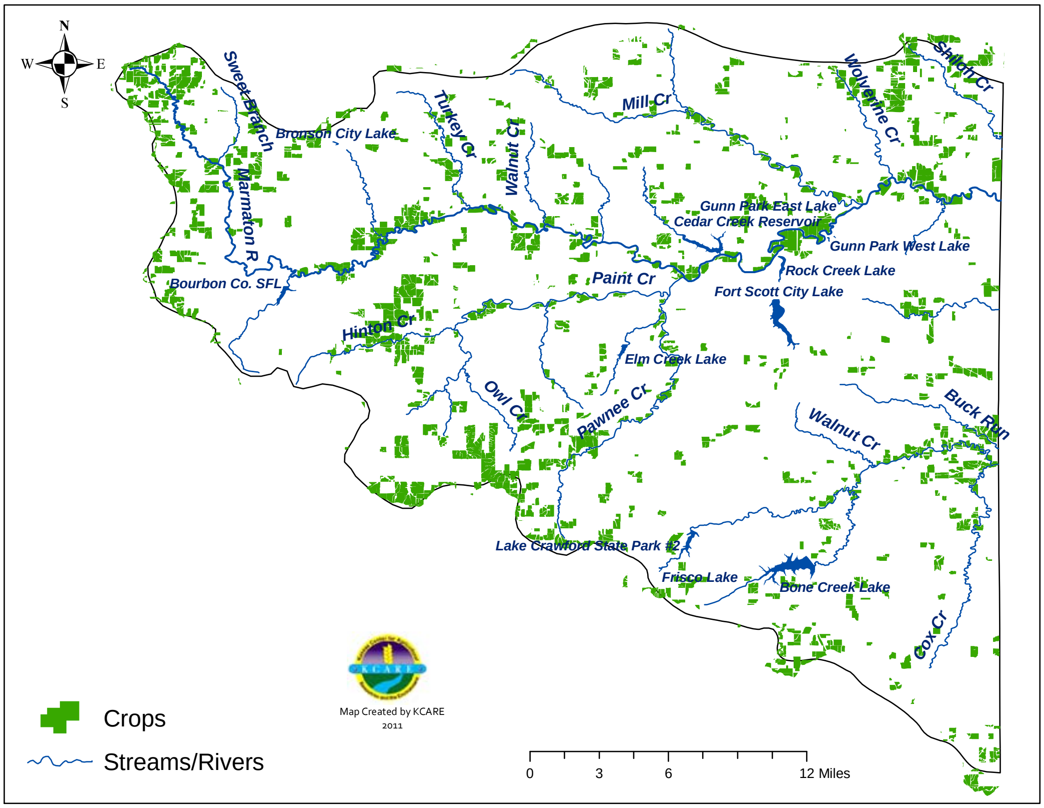


Figure 32. Cropland in the Watershed. [41]

According to FSA records from 2009[41], 52,405 acres were planted to crops in the watershed. The type of crop grown will have an effect on nutrient runoff since different crops have different nutrient requirements. The main crop grown in the watershed was soybeans (twenty percent of all farmable land, which includes crops and trees). Soybeans are a legume and as such, do not require nitrogen fertilizer. Corn, which is five percent of the harvested land in the watershed, is a heavy user of nitrogen fertilizer in order to support the large amount of biomass produced. Wheat (four percent) is a moderate user of nitrogen, as is sorghum. Some farms apply nitrogen in the fall as anhydrous ammonia. This is usually dependent on whether the crop will be used for winter grazing of stocker calves. Nitrogen may also be applied in the spring. All farm ground should be soil tested for the proper amount of phosphorus available in the soil and phosphorus fertilizer should be applied only when needed. It should be applied at planting time and incorporated into the soil where it will attach to soil particles and prevent runoff.

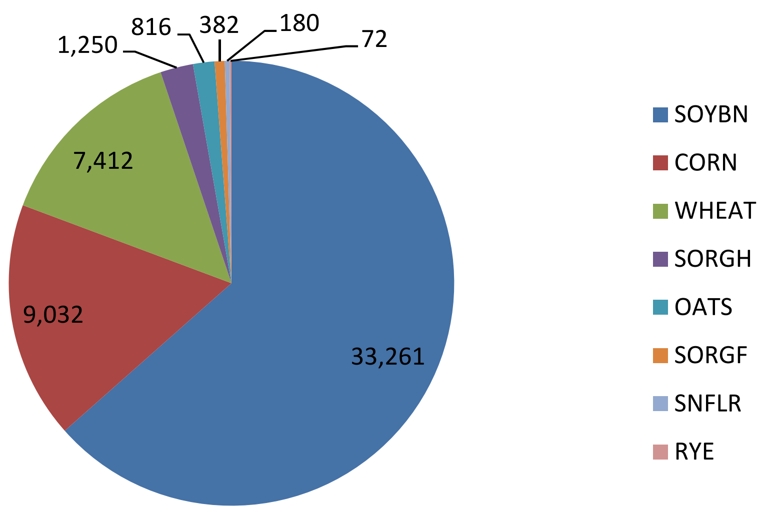


Figure 33. Farm Crops in the Watershed, in acres. [41]

6.2.2.B CRP

CRP (Conservation Reserve Program) land is marginal farm ground that has been removed from production and planted to grass cover. The owner of the land receives a government payment as incentive for allowing the land to be removed from production. This is the best way to stop runoff of nutrients as well as sediment through erosion. CRP lands are scattered throughout the watershed. According to FSA in 2009[41], CRP comprised 9.7 percent of the farmable land in the watershed.

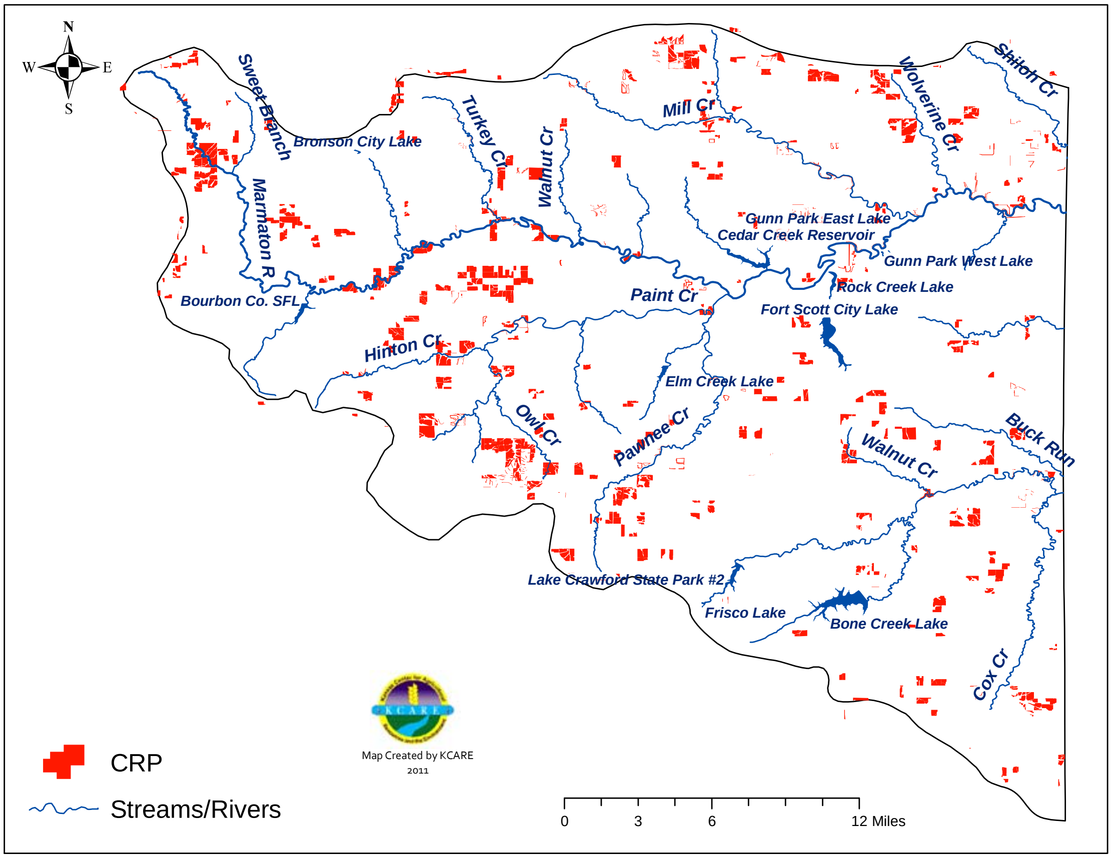


Figure 34. CRP in the Watershed. [41]

6.2.2.C Rainfall and Runoff

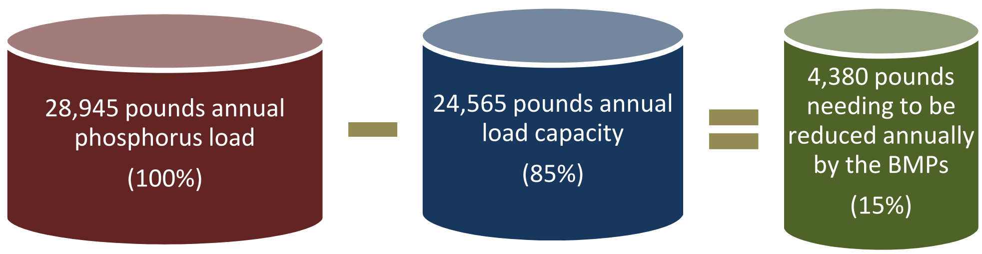
Rainfall amounts and subsequent runoff can affect nutrient runoff from agricultural areas. Fertilizer runoff from crop fields if applied prior to a rainfall event or on frozen ground can contribute to elevated phosphorus water concentrations.

6.2.2.D Riparian and Cropland Buffer Areas

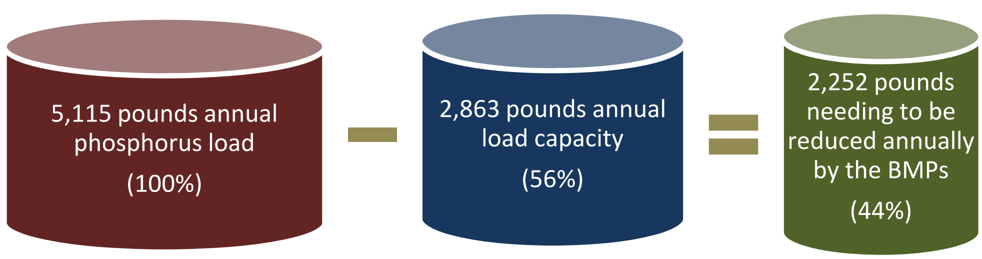
Stable streambank riparian areas or buffers are important to reduction in phosphorus in the waterways of the watershed. Soil that is lost from the streambanks can have attached phosphorus particles. This soil will then gradually release the phosphorus as it travels downstream. An adequate buffer area along streams and the river with grass and tree cover will protect the banks during events of flooding. The roots of the grass and trees will stabilize the land and catch soil that washes through the buffer area.

6.2.3 Phosphorus BMPs with Projects Needed

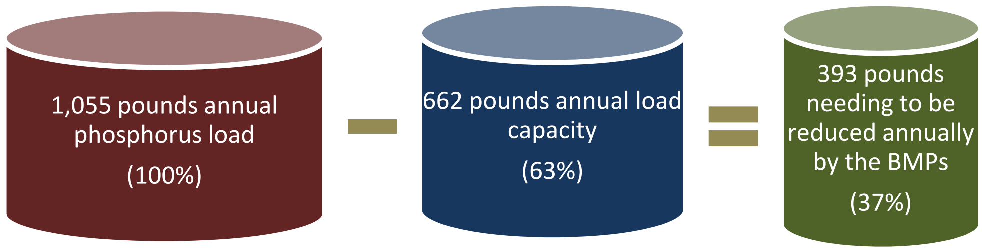
The current estimated phosphorus load from nonpoint sources in the Marmaton River is 28,945 pounds per year according to the TMDL section of KDHE. This has been determined by KDHE as a result of sampling data obtained in the watershed. After subtracting the annual load capacity, t**he total annual load reduction needed to meet the phosphorus portion of the Marmaton River Bio TMDL with implemented BMPs is 4,380 pounds of phosphorus**. This is the amount of phosphorus that needs to be removed from the watershed and is the target of the BMP installations that will be placed in the watershed. These BMPs have been determined as feasible and approved by the SLT.



The current estimated phosphorus load from nonpoint sources in the Rock Creek Lake Watershed is 5,115 pounds per year according to the TMDL section of KDHE. This has been determined by KDHE as a result of sampling data obtained in the watershed. After subtracting the annual load capacity, t**he total annual load reduction allocated to the Rock Creek Lake Watershed needed to meet the phosphorus portion of the Eutrophication TMDL with implemented BMPs is 2,252 pounds of phosphorus**. This is the amount of phosphorus that needs to be removed from the watershed and is the target of the BMP installations that will be placed in the watershed. These BMPs have been determined as feasible and approved by the SLT.



The current estimated phosphorus load from nonpoint sources in the Lake Crawford is 1,055 pounds per year according to the TMDL section of KDHE. This has been determined by KDHE as a result of sampling data obtained in the watershed. After subtracting the annual load capacity, t**he total annual load reduction allocated to the Lake Crawford Watershed needed to meet the phosphorus portion of the Eutrophication TMDL with implemented BMPs is 393 pounds of phosphorus**. This is the amount of phosphorus that needs to be removed from the watershed and is the target of the BMP installations that will be placed in the watershed. These BMPs have been determined as feasible and approved by the SLT.



The SLT has laid out specific BMPs that they have determined will be acceptable to watershed residents as listed below. **These BMPs will be implemented in the Cropland, Livestock and High Priority TMDL targeted areas. All these BMPs will simultaneously have a positive effect on reduction of ECB and sediment impairments.** Specific acreages or projects that need to be implemented per year have been determined modeling, cost-effectiveness and producer acceptability and approved by the SLT. All BMPs are considered independent projects and stand alone in their load reductions.

Table 24. BMPs and Number of Projects to be Installed as Determined by the SLT Aimed at Meeting the Phosphorus Portion of the *Bio TMDL in the Marmaton River, Lake Crawford E TMDL and Rock Creek Lake E TMDL.*

Protection Measures	Best Management Practices and Other Actions	Total Treated Acres or Projects Needed to be Implemented
1. Prevention of phosphorus (TP) contribution from **cropland** in the Marmaton River Portion of the Targeted Area	1.1 Establish Permanent Vegetation	35 acres annually
	1.2 Grassed Waterways	87 acres annually
	1.3 No-Till	87 acres annually
	1.4 Vegetative Buffers	87 acres annually
	1.5 Conservation Crop Rotation	87 acres annually
	1.6 Terraces	87 acres annually
2. Prevention of phosphorus (TP) contribution from **livestock** erosion the Marmaton River Portion of the Targeted Area	2.1 Vegetative Filter Strip	0.4 acres annually
	2.2 Relocate Feeding Pens	8 projects in 20 years
	2.3 Relocate Pasture Feeding Sites	1 project annually
	2.4 Off Stream Watering Systems	1 project annually
	2.5 Fence Off Streams/Ponds	1 project annually
	2.6 Rotational Grazing	1 project biennially
3. Prevention of phosphorus (TP) contribution from **cropland** in the Rock Creek Lake Watershed	3.1 Establish Permanent Vegetation	13 acres annually
	3.2 Grassed Waterways	31 acres annually
	3.3 No-Till	31 acres annually
	3.4 Vegetative Buffers	31 acres annually
	3.5 Conservation Crop Rotation	31 acres annually
	3.6 Terraces	31 acres annually

4. Prevention of phosphorus (TP) contribution from **livestock** erosion in Rock Creek Lake Watershed	4.1 Vegetative Filter Strip	0.1 acres annually
	4.2 Relocate Feeding Pens	2 projects in 10 years
	4.3 Relocate Pasture Feeding Sites	2 projects in 10 years
	4.4 Off Stream Watering Systems	2 projects in 10 years
	4.5 Fence Off Streams/Ponds	2 projects in 10 years
	4.6 Rotational Grazing	1 project in 10 years
5. Prevention of phosphorus (TP) contribution from **livestock** erosion in the Lake Crawford Watershed	5.1 Vegetative Filter Strip	1 project every 10 years
	5.2 Relocate Feeding Sites	1 project every 10 years
	5.3 Relocate Pasture Feeding Sites	2 projects every 10 years
	5.4 Off Stream Watering Systems	2 projects every 10 years
	5.5 Fence Off Streams/Ponds	1 project every 10 years
	5.6 Rotational Grazing	1 project every 10 years

6.2.4 Phosphorus Load Reductions

The tables below demonstrate the installed BMPs with the associated phosphorus load reductions.

Table 25. Estimated Phosphorus Load Reductions in the Cropland Targeted Area for All Implemented BMPs Aimed at Meeting the Phosphorus Portion of the *Bio TMDL in the Marmaton River.*

Annual Phosphorous Reduction (pounds), Cropland BMPs							
Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	21	22	22	27	14	16	**121**
2	41	43	43	54	27	33	**242**
3	62	65	65	81	41	49	**363**
4	83	87	87	109	54	65	**484**
5	103	109	109	136	68	81	**605**
6	124	130	130	163	81	98	**726**
7	144	152	152	190	95	114	**848**
8	165	174	174	217	109	130	**969**
9	186	195	195	244	122	147	**1,090**
10	206	217	217	271	136	163	**1,211**
11	227	239	239	299	149	179	**1,332**
12	248	261	261	326	163	195	**1,453**
13	268	282	282	353	176	212	**1,574**
14	289	304	304	380	190	228	**1,695**
15	309	326	326	407	204	244	**1,816**
16	330	347	347	434	217	261	**1,937**

17	351	369	369	462	231	277	**2,058**
18	371	391	391	489	244	293	**2,179**
19	392	413	413	516	258	309	**2,301**
20	413	434	434	543	271	326	**2,422**

Table 26. Estimated Phosphorus Load Reductions in the Livestock Targeted Area for All Implemented BMPs Aimed at Meeting the Phosphorus Portion of the *Bio TMDL in the Marmaton River.*

Marmaton River Annual Phosphorous Load Reduction, pounds							
Year	Vege-tative Filter Strip	Relocate Feeding Pens	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams/ Ponds	Rotational Grazing	Total
1	340	0	60	60	70	0	530
2	680	0	60	119	140	60	1,059
3	1,021	1,276	119	119	210	60	2,805
4	1,361	1,276	179	179	210	119	3,324
5	1,701	2,552	239	239	281	119	5,130
6	2,041	2,552	298	298	351	119	5,659
7	2,381	3,827	358	358	421	119	7,465
8	2,722	3,827	417	358	491	179	7,994
9	3,062	5,103	477	417	491	179	9,730
10	3,402	5,103	477	477	561	239	10,259
11	3,827	6,379	537	537	631	239	12,150
12	4,253	6,379	596	596	702	298	12,824
13	4,678	7,655	656	656	772	298	14,714
14	5,103	7,655	716	716	842	358	15,389
15	5,528	8,930	775	775	912	358	17,279
16	5,954	8,930	835	835	982	417	17,954
17	6,379	10,206	895	895	1,052	417	19,844
18	6,804	10,206	954	954	1,123	477	20,518
19	7,229	11,482	1,014	1,014	1,193	477	22,409
20	7,655	11,482	1,074	1,074	1,263	537	23,083

Table 27. Estimated Phosphorus Load Reductions in the Cropland Targeted Area for All Implemented BMPs Aimed at Meeting the *E TMDL in Rock Creek Lake*.

Annual Phosphorous Reduction (pounds), Cropland BMPs							
Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	7	8	8	10	5	6	**43**
2	15	15	15	19	10	12	**86**

3	22	23	23	29	14	17	**128**
4	29	31	31	38	19	23	**171**
5	36	38	38	48	24	29	**214**
6	44	46	46	58	29	35	**257**
7	51	54	54	67	34	40	**299**
8	58	61	61	77	38	46	**342**
9	66	69	69	86	43	52	**385**
10	73	77	77	96	48	58	**428**
11	80	84	84	105	53	63	**470**
12	87	92	92	115	58	69	**513**
13	95	100	100	125	62	75	**556**
14	102	107	107	134	67	81	**599**
15	109	115	115	144	72	86	**641**
16	117	123	123	153	77	92	**684**
17	124	130	130	163	81	98	**727**
18	131	138	138	173	86	104	**770**
19	138	146	146	182	91	109	**812**
20	146	153	153	192	96	115	**855**

Load reductions that will be needed for livestock BMPs will be attained in ten years.

Table 28. Estimated Phosphorus Load Reductions in the Livestock Targeted Area for All Implemented BMPs Aimed at Meeting the *E TMDL in Rock Creek Lake*.

Rock Creek Lake Annual Phosphorous Load Reduction, pounds							
Year	Vege-tative Filter Strip	Relocate Feeding Pens	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams/ Ponds	Rotational Grazing	Total
1	85	1,276	0	0	0	0	**1,361**
2	170	1,276	60	0	0	0	**1,505**
3	255	1,276	60	60	0	0	**1,650**
4	340	1,276	60	60	70	0	**1,805**
5	425	2,552	60	60	70	0	**3,166**
6	510	2,552	60	60	70	60	**3,311**
7	595	2,552	60	60	70	60	**3,396**
8	680	2,552	60	119	70	60	**3,541**
9	765	2,552	60	119	140	60	**3,696**
10	851	2,552	119	119	140	60	**3,841**

The BMPs that will be installed in the Lake Crawford Watershed will be minimal due to the size of the watershed. It is anticipated that one project per BMP will be installed in ten years.

Table 29. Estimated Total Phosphorus Load Reductions in the Livestock Targeted Area Aimed at Meeting E TMDL in the Lake Crawford.

Lake Crawford Annual Phosphorous Load Reduction, pounds							
Years	Vege-tative Filter Strip	Relocate Feeding Pens	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams/Ponds	Rotational Grazing	Total
1-10	851	1,276	119	119	70	60	**2,495**

The tables below demonstrate the combined load reduction for phosphorus that is attained by implementing all cropland and livestock BMPs annually. The percent of TMDL achievement is illustrated in the right column. The timeframe for attaining the phosphorus portion of the Marmaton River Bio TMDL is three years. The life of the WRAPS plan is twenty years. After three years, the phosphorus portion of this plan will switch from being “restoration” to “protection” in the Marmaton River Watershed.

Table 30. Combined Phosphorus Load Reduction Aimed at Meeting the Phosphorus Portion of the *Bio TMDL in the Marmaton River*.

Year	Cropland Reduction (lbs)	Livestock Reduction (lbs)	Total Reduction (lbs)	% of Required Reduction
1	121	1,890	2,012	46%
2	242	2,565	2,807	64%
3	363	4,455	4,818	110%
4	484	5,130	5,614	128%
5	605	7,020	7,625	174%
6	726	7,694	8,421	192%
7	848	9,585	10,432	238%
8	969	10,259	11,228	256%
9	1,090	12,150	13,239	302%
10	1,211	15,319	16,530	377%
11	1,332	17,209	18,541	423%
12	1,453	17,884	19,337	441%
13	1,574	19,774	21,348	487%
14	1,695	20,449	22,144	506%
15	1,816	22,339	24,155	551%
16	1,937	23,013	24,951	570%
17	2,058	24,904	26,962	616%

Phosphorus portion of the Marmaton River Bio TMDL has been met

18	2,179	25,578	27,758	634%
19	2,301	27,469	29,769	680%
20	2,422	28,143	30,564	698%
Load Reduction to meet Phosphorous TMDL:			**4,380**	

Table 31. Phosphorus Load Reduction in Twenty Years by Category Aimed at Meeting the Phosphorus Portion of the *Bio TMDL in the Marmaton River*.

Best Management Practice Category	Total Load Reduction (pounds)	% of Phosphorus Required Reduction
Cropland	2,422	55%
Livestock	28,143	643%
Total	**30,564**	**698%**

The timeframe for attaining the phosphorus portion of Rock Creek Lake E TMDL is five years. The life of the WRAPS plan is twenty years. After five years, the phosphorus portion of this plan will switch from being "restoration" to "protection" in the Rock Creek Lake Watershed.

Table 32. Combined Phosphorus Load Reduction Aimed at Meeting the Phosphorus Portion of the *E TMDL in Rock Creek Lake.*

Year	Cropland Reduction (lbs)	Livestock Reduction (lbs)	Total Reduction (lbs)	% of Required Reduction
1	43	1,361	1,404	**62%**
2	86	1,505	1,591	**71%**
3	128	1,650	1,778	**79%**
4	171	1,805	1,976	**88%**
5	214	3,166	3,380	**150%**
6	257	3,311	3,567	**158%**
7	299	3,396	3,695	**164%**
8	342	3,541	3,883	**172%**
9	385	3,696	4,081	**181%**
10	428	3,841	4,268	**190%**
11	470	3,841	4,311	**191%**
12	513	3,841	4,354	**193%**
13	556	3,841	4,396	**195%**
14	599	3,841	4,439	**197%**
15	641	3,841	4,482	**199%**
16	684	3,841	4,525	**201%**
17	727	3,841	4,567	**203%**
18	770	3,841	4,610	**205%**
19	812	3,841	4,653	**207%**
20	855	3,841	4,696	**209%**

Phosphorus portion of the Rock Creek Lake E TMDL has been met

Load Reduction to meet EU TMDL:	**2,252**

Table 33. Phosphorus Load Reduction in Twenty Years by Category Aimed at Meeting the Phosphorus Portion of the *E TMDL in Rock Creek Lake*.

Best Management Practice Category	Total Load Reduction (pounds)	% of Phosphorous Required Reduction
Cropland	855	39%
Livestock	3,841	170%
Total	**4,696**	**208%**

The timeframe for attaining the phosphorus portion of Lake Crawford E TMDL is two years. However, since only one project is needed for each BMP during the ten year time period, the required reduction of phosphorus may not occur in the early years. If so, the percent of required reduction may not reach full attainment until later in the ten year time period.

Table 34. Phosphorus Load Reduction Aimed at Meeting the Phosphorus Portion of the *E TMDL in Lake Crawford.*

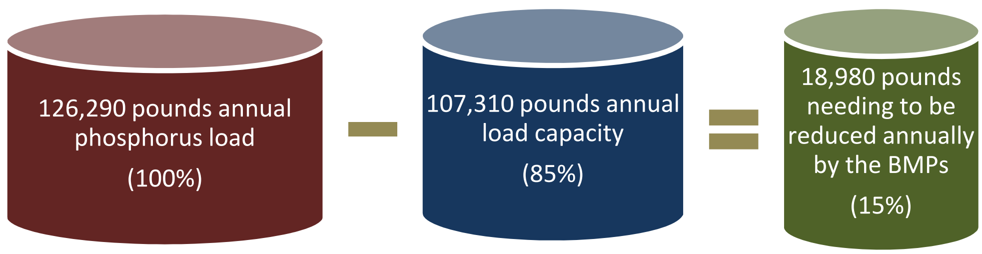
Year	Livestock Reduction (lbs)	% of Required Reduction
1	249	63%
2	499	127%
3	748	190%
4	998	254%
5	1,247	317%
6	1,497	381%
7	1,746	444%
8	1,996	508%
9	2,245	571%
10	2,495	635%
Load Reduction to Meet E TMDL: 393 pounds		

Phosphorus portion of Lake Crawford E TMDL has been met

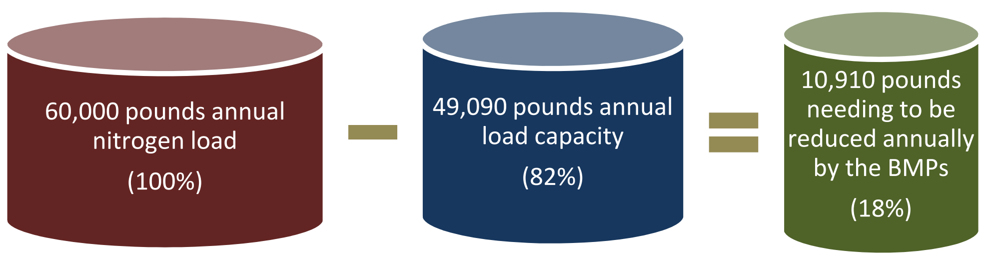
6.2.5 Nitrogen Load Reductions

Nitrogen has been included in this plan because of its relationship as a nutrient pollutant contributor to low DO. Nitrogen in manure or fertilizer is converted by specific bacteria to ammonia, then to nitrite, then to nitrate. Nitrate is the most common form of nitrogen that is utilized by plants. However, it is also extremely soluble and mobile in water. Since nitrate can originate in surface waters from animal manure and chemical fertilizer runoff, it is important to decrease runoff from cropland and livestock areas. All BMPs that have been assigned to phosphorus reduction will also have a positive impact on nitrogen reduction in the watershed.

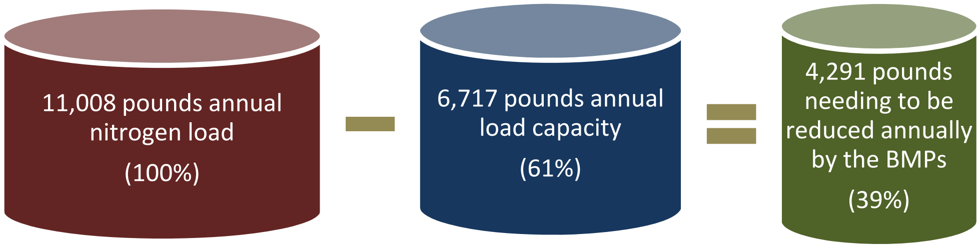
The current estimated total nitrogen load in the Marmaton River is 126,290 pounds per year according to the TMDL section of KDHE. This has been determined by KDHE as a result of sampling data obtained in the watershed. After subtracting the annual load capacity, t**he total annual load reduction allocated to the nitrogen portion of the Marmaton River Bio TMDL with implemented BMPs is 18,980 pounds of nitrogen**. This is the amount of nitrogen that needs to be removed from the watershed and is the target of the BMP installations that will be placed in the watershed. These BMPs have been determined as feasible and approved by the SLT.



The current estimated total nitrogen load in Rock Creek Lake is 60,000 pounds per year according to the TMDL section of KDHE. This has been determined by KDHE as a result of sampling data obtained in the watershed. After subtracting the annual load capacity, t**he total annual load reduction allocated to Rock Creek Lake Watershed needed to meet the nitrogen portion of the E TMDL with implemented BMPs is 10,910 pounds of nitrogen**. This is the amount of nitrogen that needs to be removed from the watershed and is the target of the BMP installations that will be placed in the watershed. These BMPs have been determined as feasible and approved by the SLT.



The current estimated total nitrogen load in the Lake Crawford is 11,008 pounds per year according to the TMDL section of KDHE. This has been determined by KDHE as a result of sampling data obtained in the watershed. After subtracting the annual load capacity, t**he total annual load reduction allocated to the Lake Crawford**



Watershed needed to meet the nitrogen portion of the E TMDL with implemented BMPs is 4,291 pounds of nitrogen. This is the amount of nitrogen that needs to be removed from the watershed and is the target of the BMP installations that will be placed in the watershed. These BMPs have been determined as feasible and approved by the SLT.

The SLT has laid out specific BMPs that they have determined will be acceptable to watershed residents as listed below. **These BMPs will be implemented in the Cropland, Livestock and High Priority TMDL targeted areas. All these BMPs will simultaneously have a positive effect on reduction of phosphorus, ECB and sediment impairments.** Specific acreages or projects that need to be implemented per year have been determined through modeling and economic analysis and approved by the SLT. All BMPs are considered independent projects and stand alone in their load reductions. BMPs and acreages or projects can be found in Table 24, page 72.

The tables below list the cropland BMPs installed with the associated nitrogen load reductions.

Table 35. Estimated Nitrogen Load Reductions for All Implemented BMPs in the Cropland Targeted Area Aimed at Meeting the Nitrogen Portion of the *Bio TMDL in the Marmaton River.*

Annual Nitrogen Reduction (pounds), Cropland BMPs							
Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	160	168	105	105	105	126	**770**
2	320	337	210	210	210	253	**1,540**
3	480	505	316	316	316	379	**2,311**
4	640	673	421	421	421	505	**3,081**
5	800	842	526	526	526	631	**3,851**
6	960	1,010	631	631	631	758	**4,621**
7	1,120	1,178	737	737	737	884	**5,392**

8	1,279	1,347	842	842	842	1,010	**6,162**
9	1,439	1,515	947	947	947	1,136	**6,932**
10	1,599	1,684	1,052	1,052	1,052	1,263	**7,702**
11	1,759	1,852	1,157	1,157	1,157	1,389	**8,472**
12	1,919	2,020	1,263	1,263	1,263	1,515	**9,243**
13	2,079	2,189	1,368	1,368	1,368	1,641	**10,013**
14	2,239	2,357	1,473	1,473	1,473	1,768	**10,783**
15	2,399	2,525	1,578	1,578	1,578	1,894	**11,553**
16	2,559	2,694	1,684	1,684	1,684	2,020	**12,324**
17	2,719	2,862	1,789	1,789	1,789	2,147	**13,094**
18	2,879	3,030	1,894	1,894	1,894	2,273	**13,864**
19	3,039	3,199	1,999	1,999	1,999	2,399	**14,634**
20	3,199	3,367	2,104	2,104	2,104	2,525	**15,404**

Table 36. Estimated Nitrogen Load Reductions in the Livestock Targeted Area for All Implemented BMPs Aimed at Meeting the Nitrogen Portion of the *Bio TMDL in the Marmaton River.*

Marmaton River/Rock Creek Annual Nitrogen Load Reduction							
Year	**Vegetative Filter Strip**	**Relocate Feeding Site**	**Relocate Pasture Feeding Site**	**Off-Stream Watering System**	**Fence out Streams/ Ponds**	**Rotational Grazing**	**Total**
1	641	0	112	112	132	0	998
2	1,282	0	112	225	264	112	1,995
3	1,922	2,403	225	225	396	112	5,283
4	2,563	2,403	337	337	396	225	6,261
5	3,204	2,403	449	449	529	225	7,259
6	3,845	2,403	562	562	661	225	8,256
7	4,485	4,806	674	674	793	225	11,657
8	5,126	4,806	786	674	925	337	12,654
9	5,767	7,209	899	786	925	337	15,923
10	6,408	7,209	899	899	1,057	449	16,920
11	7,209	9,612	1,011	1,011	1,189	449	20,481
12	8,010	9,612	1,123	1,123	1,322	562	21,751
13	8,811	12,014	1,236	1,236	1,454	562	25,312
14	9,612	12,014	1,348	1,348	1,586	674	26,582
15	10,412	14,417	1,460	1,460	1,718	674	30,142
16	11,213	14,417	1,573	1,573	1,850	786	31,413
17	12,014	16,820	1,685	1,685	1,982	786	34,973
18	12,815	16,820	1,797	1,797	2,115	899	36,243
19	13,616	19,223	1,910	1,910	2,247	899	39,804
20	14,417	19,223	2,022	2,022	2,379	1,011	41,074

Table 37. Estimated Nitrogen Load Reductions in the Cropland Targeted Area for All Implemented BMPs Aimed at Meeting the *E TMDL in Rock Creek Lake*.

Annual Nitrogen Reduction (pounds), Cropland BMPs							
Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	48	50	32	32	32	38	**231**
2	96	101	63	63	63	76	**461**
3	144	151	95	95	95	113	**692**
4	192	202	126	126	126	151	**923**
5	239	252	158	158	158	189	**1,153**
6	287	302	189	189	189	227	**1,384**
7	335	353	221	221	221	265	**1,614**
8	383	403	252	252	252	302	**1,845**
9	431	454	284	284	284	340	**2,076**
10	479	504	315	315	315	378	**2,306**
11	527	555	347	347	347	416	**2,537**
12	575	605	378	378	378	454	**2,768**
13	623	655	410	410	410	492	**2,998**
14	671	706	441	441	441	529	**3,229**
15	718	756	473	473	473	567	**3,460**
16	766	807	504	504	504	605	**3,690**
17	814	857	536	536	536	643	**3,921**
18	862	907	567	567	567	681	**4,152**
19	910	958	599	599	599	718	**4,382**
20	958	1,008	630	630	630	756	**4,613**

Load reductions that will be needed for livestock BMPs will be attained in ten years.

Table 38. Estimated Nitrogen Load Reductions in the Livestock Targeted Area for All Implemented BMPs Aimed at Meeting the *E TMDL in Rock Creek Lake*.

Rock Creek Lake Annual Phosphorous Load Reduction, pounds							
Year	Vege-tative Filter Strip	Relocate Feeding Pens	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams/ Ponds	Rotational Grazing	Total
1	160	2,403	0	0	0	0	2,563
2	320	2,403	112	0	0	0	2,836
3	481	2,403	112	112	0	0	3,108
4	641	2,403	112	112	132	0	3,400
5	801	4,806	112	112	132	0	5,964

6	961	4,806	112	112	132	112	6,236
7	1,121	4,806	112	112	132	112	6,396
8	1,282	4,806	112	225	132	112	6,669
9	1,442	4,806	112	225	264	112	6,961
10	1,602	4,806	225	225	264	112	7,234

The BMPs that will be installed in the Lake Crawford Watershed will be minimal due to the size of the watershed. It is anticipated that one project per BMP will be installed in the first ten years.

Table 39. Estimated Nitrogen Load Reductions in the Livestock Targeted Area Aimed at Meeting *E TMDL in the Lake Crawford Watershed*.

Lake Crawford Annual Nitrogen Load Reduction							
Years	Vege-tative Filter Strip	Relocate Feeding Pens	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams/Ponds	Rotational Grazing	Total
1-10	1,602	2,403	225	225	132	112	**4,699**

The table below shows the combined load reduction for nitrogen that is attained by implementing all cropland and livestock BMPs annually. The nitrogen TMDL is a component of the Biology TMDL in the Marmaton River. The percent of TMDL achievement is illustrated in the right column. The timeframe for attaining the TMDL is four years. The life of the WRAPS plan is twenty years. After four years, the nitrogen portion of this plan will switch from being “restoration” to “protection” of the watershed.

Table 40. Combined Nitrogen Load Reduction Aimed at Meeting the Nitrogen Portion of the *Bio TMDL in the Marmaton River*.

Year	Cropland Reduction (lbs)	Livestock Reduction (lbs)	Total Reduction (lbs)	% of TMDL
1	770	5,184	5,955	31%
2	1,540	10,369	11,909	63%
3	2,311	15,553	17,864	94%
4	3,081	20,738	23,819	125%
5	3,851	25,922	29,773	157%
6	4,621	31,107	35,728	188%
7	5,392	36,291	41,683	220%
8	6,162	41,476	47,637	251%
9	6,932	46,660	53,592	282%
10	7,702	51,845	59,547	314%
11	8,472	57,029	65,501	345%
12	9,243	62,213	71,456	376%

Nitrogen reduction towards meeting the Bio TMDL have been met

13	10,013	67,398	77,411	408%
14	10,783	72,582	83,365	439%
15	11,553	77,767	89,320	471%
16	12,324	82,951	95,275	502%
17	13,094	88,136	101,229	533%
18	13,864	93,320	107,184	565%
19	14,634	98,505	113,139	596%
20	15,404	103,689	119,093	**627%**
Load Reduction to meet Nitrogen TMDL: 18,980 lbs				

Table 41. Nitrogen Load Reduction in Twenty Years by Category Aimed at the Nitrogen Portion of the *Bio TMDL in the Marmaton River*.

Best Management Practice Category	Total Load Reduction (pounds)	Percent of Phosphorous TMDL
Cropland	15,404	81%
Livestock	103,689	546%
Total	**119,093**	**627%**

The timeframe for attaining the nitrogen portion of Rock Creek Lake E TMDL is 16 years. The life of the WRAPS plan is twenty years. After 16 years, the phosphorus portion of this plan will switch from being “restoration” to “protection” in the Rock Creek Lake Watershed.

Table 42. Combined Nitrogen Load Reduction Aimed at Meeting the Nitrogen Portion of the *E TMDL in Rock Creek Lake*.

Year	Cropland Reduction (lbs)	Livestock Reduction (lbs)	Total Reduction (lbs)	% of Required Reduction
1	231	2,563	2,794	26%
2	461	2,836	3,297	30%
3	692	3,108	3,800	35%
4	923	3,400	4,323	40%
5	1,153	5,964	7,117	65%
6	1,384	6,236	7,620	70%
7	1,614	6,396	8,011	73%
8	1,845	6,669	8,514	78%
9	2,076	6,961	9,037	83%
10	2,306	7,234	9,540	87%
11	2,537	7,234	9,771	90%
12	2,768	7,234	10,001	92%
13	2,998	7,234	10,232	94%
14	3,229	7,234	10,463	96%
15	3,460	7,234	10,693	98%

16	3,690	7,234	10,924	100%
17	3,921	7,234	11,155	102%
18	4,152	7,234	11,385	104%
19	4,382	7,234	11,616	106%
20	4,613	7,234	11,847	109%
Load Reduction to meet Nitrogen TMDL: 10,910 lbs				

Nitrogen reduction towards meeting the E TMDL have been met

Table 43. Nitrogen Load Reduction in Twenty Years by Category Aimed at Meeting the Nitrogen Portion of the *E TMDL in Rock Creek Lake*.

Best Management Practice Category	Total Load Reduction (pounds)	% of Phosphorous Required Reduction
Cropland	4,613	42%
Livestock	7,234	66%
Total	**11,847**	**108%**

The timeframe for attaining the nitrogen portion of Lake Crawford E TMDL is ten years.

Table 44. Nitrogen Load Reduction Aimed at Meeting the Nitrogen Portion of the *E TMDL in Lake Crawford.*

Year	Livestock Reduction (lbs)	% of Required Reduction
1	470	11%
2	940	22%
3	1,410	33%
4	1,879	44%
5	2,349	55%
6	2,819	66%
7	3,289	77%
8	3,759	88%
9	4,229	99%
10	4,699	109%
Load Reduction to Meet E TMDL: pounds		

Nitrogen reduction towards meeting the E TMDL have been met

Refer to Section 8, "Costs of BMP Implementation" for specific BMP costs in order to meet the TMDL.

7.0 Information and Education (I&E) in Support of BMPs

7.1 I&E Activities and Events

The SLT has determined which I&E activities will be needed in the watershed. These activities are important in providing the residents of the watershed with a higher awareness of watershed issues. This will lead to an increase in adoption rates of BMPs. I&E projects will be emphasized in the Targeted Areas, but open to the entire watershed. Even though open to the entire watershed, special attention will be paid to residents of the Targeted Areas with supplemental postcards, mailings and contacts.

Table 32. I&E Activities and Events as Requested by the SLT in Support of Meeting the TMDLs.

BMP	Target Audience	I&E Activity/Event	Time Frame	Estimated Cost	Sponsor/Responsible Agency
Livestock BMP Implementation					
Relocate Pasture Feeding Sites	Livestock Producers	Help in determining site, design, O&M info	Annual	Cost included in TA for Watershed Specialist	Watershed Specialist
		Help in determining site, design, O&M info	Annual	No charge	NRCS/CD/KSU Extension/KRC
		Informational meeting/brochures/news articles	As needed on annual basis	$1,000	Watershed Specialist/Coordinator/NRCS/CD/KSU Extension/KRC/SLT
		Demonstration Project	Annual or Every Other Year	$5,000 per demo	Watershed specialist/Coordinator/KSU Extension/NRCS/CD/KRC
		Tour/Field Day	Annual or Every Other Year	$1,000	Watershed specialist/Coordinator/KSU Extension/NRCS/CD/KRC/SLT

Off-stream Watering Systems	Livestock Producers	Help designing site and waterer, installation and O&M help as needed	Annual	Cost included in TA for Watershed Specialist	Watershed Specialist
		Demonstration Project	Annual or Every Other Year	$5,000 per demo	Watershed specialist/Coordinator/KSU Extension/NRCS/CD/KRC
		Informational meeting/brochures/news articles	As needed on annual basis	$1,000	Watershed Specialist/Coordinator/NRCS/CD/KSU Extension/KRC/SLT
		Tour/Field Day	Annual or Every Other Year	$1,000	Watershed specialist/Coordinator/KSU Extension/NRCS/CD/KRC/SLT
Relocate Feeding Pens	Livestock Producers	Help in determining site, design, and O&M	Annual	Cost included in TA for Watershed Specialist and KRC	Watershed Specialist/KRC/KSU Extension
		Informational meeting/brochures/news articles	As needed on annual basis	$1,000	Watershed Specialist/Coordinator/NRCS/CD/KSU Extension/KRC/SLT
		Tour/Field Day	Annual or Every Other Year	$1,000	Watershed specialist/Coordinator/KSU Extension/NRCS/CD/KRC/SLT
Vegetative Filter Strips	Livestock Producers	Help with identifying site, O&M, and design/layout	Annual	Cost included in TA for Buffer Coordinator and Watershed Specialist	Buffer Coordinator/CD/NRCS/Watershed Specialist
		Field Day/Tour	Annual or Every Other Year	$1,000 per field day	Buffer Coordinator/CD/NRCS/Watershed Specialist/Coordinator/KSU Extension/SLT
		Informational meeting/brochures/news articles	As needed on annual basis	$1,000	Watershed Specialist/Coordinator/NRCS/CD/KSU Extension/KRC/SLT
Fence Out Streams/Ponds	Livestock Producers	Informational meeting/brochures/news	As needed on annual basis	$1,000	Watershed Specialist/Coordinator/NRCS/CD/KSU

		articles			Extension/SLT/KRC
		Tour/Field Day	Annual or Every Other Year	$1,000 per tour	Watershed Specialist/Coordinator/CD/SLT/KRC/KSU Extension/NRCS
		Help with identifying site, O&M, and design/layout	Annual	Cost included in TA for Watershed Specialist and KRC	Buffer Coordinator/CD/NRCS/Watershed Specialist/KRC
Rotational Grazing	Livestock Producers	Informational meeting/brochures/news articles	As needed on annual basis	$1,000	Watershed Specialist/Coordinator/NRCS/KRC/KSU Extension/SLT
		Tour/Field Day	Annual or Every Other Year	$1,000 per tour	Watershed Specialist/Coordinator/NRCS/KRC/KSU Extension/CD/SLT
		Help with identifying site, O&M, and design/layout	Annual	Cost included in TA for Watershed Specialist and KRC	CD/NRCS/Watershed Specialist/KRC/KSU Extension
		Demonstration	Annual or Every Other Year	$3,000	Watershed Specialist/Coordinator/ NRCS/KRC/KSU Extension/CD/SLT
Cropland BMP Implementation					
Permanent Vegetation	Landowners and/or Operators	Informational meeting/brochures/news articles	As needed on annual basis	$1,000	Watershed Specialist/Coordinator/KSU Extension/NRCS/CD/SLT/Buffer Coordination
		Tour	Annual or Every Other Year	$1,000	Watershed Specialist/Coordinator/KSU Extension/NRCS/CD/SLT/Buffer Coordination
		Help with site selection, planning, and maintenance	Annual	Cost included in TA for Buffer Coordinator	Buffer Coordinator
Grassed Waterways	Landowners and/or Operators	Tour	Annual or Every Other Year	$1,000 per tour	NRCS/CD/Coordinator/KSU Extension/Watershed Specialist/SLT/Buffer Coordination
		Help with planning, implantation, and maintenance	Annual	No Charge	NRCS

		Help with planning, implantation, and maintenance	Annual	Cost included in TA for Buffer Coordinator	Buffer Coordinator
No-Till	Landowners and/or Operators	Informational Meeting	Annual	$5,000 per meeting	No-till on the Plains/SLT/Buffer Coordination/Watershed Specialist
		Information meetings/brochures/news articles	As needed on annual basis	$1,000	Watershed Specialist/Coordinator/KSU Extension/NRCS/CD/SLT/Buffer Coordinator
		Help with planning and implementation	Annual	Cost included in TA for Watershed Specialist	Watershed Specialist
		Help with planning and implementation	Annual	Cost included in TA for Buffer Coordinator	Buffer Coordinator
		Tour/Field Day	Every Other Year	$3,000	Watershed Specialist/Coordinator/KSU Extension/NRCS/CD/SLT/Buffer Coordination/No-till on the Plains/SLT/Farm Bureau
		Help with planning and implementation	Annual	No Charge	NRCS and KSU Extension
Vegetative Buffers	Landowners and/or Operators	Demonstration Project	Annual	$5,000 per demo	Buffer Coordinator/Watershed Specialist/Coordinator/CD/NRCS, KFS
		Tour/Field Day	Annual or Every Other Year	$1,000 per tour	Buffer Coordinator/Watershed Specialist/Coordinator/CD/NRCS/KSU Extension/SLT, KFS
		Informational meetings/brochures/news articles	As needed on annual basis	$1,000	Watershed Specialist/Coordinator/KSU Extension/NRCS/CD/SLT/Buffer Coordination, KFS
		Help with planning, implantation, and maintenance	Annual	Cost included in TA for Buffer Coordinator	Buffer Coordinator, KFS
		Help with planning, implantation, and	Annual	Cost included in TA for Watershed Specialist	Watershed Specialist, KFS

		maintenance			
Conservation Crop Rotation	Landowners and/or Operators	Informational meeting/brochures/news articles	As needed on annual basis	$1,000	Watershed Specialist/Coordinator/KSU Extension/NRCS/CD/SLT/Buffer Coordinator
		Help with planning and implantation	Annual	No charge	NRCS/KSU Extension/CD
		Help with planning and implantation	Annual	Cost included in TA for Buffer Coordinator	Buffer Coordinator
Terraces	Landowners and/or Operators	Informational meeting/brochures/news articles	As needed on annual basis	$1,000	Watershed Specialist/Coordinator/KSU Extension/NRCS/CD/SLT/Buffer Coordination
		Help with planning, implantation, and maintenance	Annual	Cost included in TA for Buffer Coordinator	Buffer Coordinator
		Help with planning, implantation, and maintenance	Annual	Cost included in TA for Watershed Specialist	Watershed Specialist
		Help with planning and implantation	Annual	No charge	NRCS/KSU Extension/CD
		Tour/Field Day	Every 2 or 3 years	$1,000	Watershed Specialist/Coordinator/KSU Extension/NRCS/CD/SLT/Buffer Coordination
General / Watershed Wide I&E					
Educational Activities Targeting Youth	Educators, K-12 Students	Poster, essay, and speech contests	Annual	$400	Conservation District
		BMP/Farm Tour	Annual	$5,000	NRCS/KSU Extension/CD/SLT/Watershed Specialist/Coordinator
		Educational meeting, tour, and FFA activity support	Annual	$5,000	NRCS/KSU Extension/CD/Watershed Specialist/Coordinator
Educational Activities	Watershed residents	Presentations to groups and civic clubs	Annual	$500	Watershed Specialist/Coordinator/SLT

Targeting Adults		Newsletters	Annual	$1,000	KSU Extension/CD/FSA
		BMP Tour	Annual	$5,000	Watershed Specialist/Coordinator/NRCS/CD/KSU Extension/FFA Advisor/SLT
		Streambank Stabilization Informational Meeting	Once every 3 years	$10,000	KAWS/SCC/NRCS/CD
		Timber and Forest Management Informational Meeting	Once every 3 years	$5,000	KS Forest Service/Ecotone Forestry/KSU Extension
		Pasture/Grassland/Brush Control Management Informational Meeting	Once every 3 years	$5,000	KSU Extension/NRCS/CD/SLT/Watershed Specialist
			Total	**$83,900**	

7.2 Evaluation of I&E Activities

All service providers conducting I&E activities funded through the Marmaton WRAPS will be required to include an evaluation component in their project proposals and PIPs. The evaluation methods will vary based on the activity.

At a minimum, all I&E projects must include participant learning objectives as the basis for the overall evaluation. Depending on the scope of the project, development of a basic logic model identifying long-term, medium-term, and short-term behavior changes or other outcomes that are expected to result from the I&E activity may be required.

Specific evaluation tools or methods may include (but are not limited to):

- Feedback forms allowing participants to provide rankings of the content, presenters, useful of information, etc.
- Pre and post surveys to determine amount of knowledge gained, anticipated behavior changes, need for further learning, etc.
- Follow up interviews (one-on-one contacts, phone calls, e-mails) with selected participants to gather more in-depth input regarding the effectiveness of the I&E activity.

All service providers will be required to submit a brief written evaluation of their I&E activity, summarizing how successful the activity was in achieving the learning objectives, and how the activity contributed to achieving the long-term WRAPS goals and/or objectives for pollutant load reductions.

7.3 Future Assessment Needs

Below is a listing of assessment needs developed by the SLT.

Table 45. Future Assessment Needs as Determined by the SLT.

Assessment Project Description	Technical Assistance Needs	Time Frame	Estimated Costs	Sponsor/ Service Provider(s)
Continuation of paired watershed monitoring	Water quality sampling, monitoring of samplers, analysis of data, report findings	Annual	$10,000	Watershed Specialist/KSU-KCARE/ Watershed Monitoring Specialist/stakeholder volunteers
Continuation of water quality monitoring throughout the watershed	Sampler upkeep, water quality sampling, analysis of data, report findings	Annual	$30,000	KSU KCARE/Watershed Monitoring Specialist/Watershed Specialist
Aquatic habitat sampling	Perform aquatic habitat sampling and report results	Every two years	$40,000	KDWP
Installation and monitoring of new sites based on targeted areas from BMP installation	Sampler installation, water quality monitoring, analysis of data, report findings	Annual	$40,000	Watershed Specialist/KSU KCARE/ Watershed Monitoring Specialist
Increased monitoring from KDHE TMDL group	Increased water quality sampling and analysis, report findings	Annual	$20,000	KDHE
Streamflow monitoring for flooding	Equipment installation, technical assistance, data analysis, report findings	Annual	$10,000	Agricultural Engineering Associates, Inc./KSU/ NRCS/ Watershed Specialist
Watershed modeling	To identify high priority/target areas for BMP implementation	Every 3 to 5 years	$100,000	EPA/KDHE/KSU/USGS
On-the-spot water quality sampling and testing for educational/hot spot identification purposes	Water test kit and quick test equipment	Annual	$2,000	Coordinator/Watershed Specialist/SLT/NRCS/KSU Extension
Stream assessment	Technical assistance and equipment for performing assessments	Every 2 or 3 years	$20,000	Kansas Forest Service/KAWS/Ecotone Forestry/Watershed Specialist/SLT/Coordinator
Range, Pasture, and Cropland assessment	Technical assistance and equipment for performing assessments	Annual	$10,000	KFS/KSU Extension/NRCS/Watershed Specialist/Buffer Coordinator
Total Assessment Costs (multiple year projects averaged by year for annual cost)			**$177,000**	

8.0 Costs of Implementing BMPs and Possible Funding Sources

The SLT has reviewed all the recommended BMPs listed in the Section 6 of this report for each individual impairment. It has been determined by the SLT that specific BMPs will be the target of implementation funding for each category (cropland, livestock and high priority TMDLs). Most of the BMPs that are targeted will be advantageous to more than one impairment, thus being more efficient.

Summarized Derivation of Cropland BMP Cost Estimates

Establish Permanent Vegetation: The cost of $150 an acre was calculated based on K-State Research and Extension estimates of the cost of planting and maintaining native grass.

Grassed Waterway: $2,200 per acre was arrived at using average cost of installation figures from the conservation districts within the watershed and updated costs of brome grass seeding from Josh Roe.

No-Till: After being presented with information from K-State Research and Extension (Craig Smith and Josh Roe) on the costs and benefits of no-till, the SLT decided that a fair price to entice a producer to adopt no-till would be to pay them $10 per acre for 10 years, or a net present value of $77.69 per acre upfront assuming the NRCS discount rate of 4.75%.

Vegetative Buffer Strips: The cost of $1,000 per acre was arrived at using average cost of installation figures from the conservation districts within the watershed and cost estimates from the KSU Vegetative Buffer Tool developed by Craig Smith.

Conservation Crop Rotation: After being presented with information from K-State Research and Extension (Josh Roe) on the costs and benefits of conservation crop rotations, the SLT decided that a fair price to entice a producer to adopt a conservation crop rotation would be to pay them $5 an acre for 10 years, or a net present value of $38.84 per acre up front assuming the NRCS discount rate of 4.75%.

Terraces: In consulting with numerous conservation districts it was determined by Josh Roe that the average cost of building a terrace at this point in time is $1.25 per foot.

Summarized Derivation of Livestock BMP Cost Estimates
Vegetative Filter Strip: The cost of $714 an acre was calculated by Josh Roe and Mike Christian figuring the average filter strip in the watershed will require four hours of bulldozer work at $125 an hour plus the cost of seeding one acre in permanent vegetation estimated by Josh Roe.

Relocate Feeding Pens:
-Feeding Pens- Move feedlot or pens away from a stream, waterway, or body of water to increase filtration and waste removal of manure. Highly variable in price, average of $6,600 per unit (1 unit equals 1 acre, 100 AU pen).
-Pasture- Move feeding site that is in a pasture away from a stream, waterway, or body of water to increase the filtration and waste removal (e.g. move bale feeders away from stream). Highly variable in price, average of $2,203 per unit (1 unit equals 1 acre, 100 AU pen).
-Average P reduction: 30-80%

Relocated Pasture Feeding Site: The cost of moving a pasture feeding site of $2,203 was calculated by Josh Roe figuring the cost of building ¼ mile of fence, a permeable surface, and labor.

Off-Stream Watering System: The average cost of installing an alternative watering system of $3,500 was estimated by Herschel George, Marais des Cygnes Watershed Specialist, who has installed numerous systems and has detailed average cost estimates.

Fence Off Streams/Ponds: The average cost of ½ mile of fence at $4,106 was determined by current fencing and labor prices, assuming the fence has a 20 year life, and taking the net present value of future repairs at the NRCS discount rate of 4.75%.

Rotational Grazing: The average cost of implementing a rotational grazing system for $7,000 was estimated by Herschel George, Marais des Cygnes Watershed Specialist who has installed numerous systems and has detailed average cost estimates. More complex systems that require significant cross fencing and buried water lines will come with a much higher price.

8.1 Costs of Implementing BMPs and Information and Education

Table 46. Estimated Costs Before Cost Share for Cropland Implemented BMPs in the Cropland Targeted Area. Individual sub watershed costs are provided in the Appendix. Expressed in 2010 dollar amounts.

Annual Cost* Before Cost-Share, Cropland BMPs							
Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Cost
1	$5,232	$13,952	$6,775	$5,814	$3,401	$8,895	**$44,068**
2	$5,389	$14,371	$6,978	$5,988	$3,503	$9,161	**$45,390**

3	$5,551	$14,802	$7,187	$6,168	$3,608	$9,436	**$46,752**
4	$5,717	$15,246	$7,403	$6,353	$3,716	$9,719	**$48,155**
5	$5,889	$15,704	$7,625	$6,543	$3,828	$10,011	**$49,599**
6	$6,065	$16,175	$7,854	$6,739	$3,943	$10,311	**$51,087**
7	$6,247	$16,660	$8,089	$6,942	$4,061	$10,621	**$52,620**
8	$6,435	$17,160	$8,332	$7,150	$4,183	$10,939	**$54,199**
9	$6,628	$17,674	$8,582	$7,364	$4,308	$11,267	**$55,824**
10	$6,827	$18,205	$8,840	$7,585	$4,437	$11,606	**$57,499**
11	$7,032	$18,751	$9,105	$7,813	$4,571	$11,954	**$59,224**
12	$7,243	$19,313	$9,378	$8,047	$4,708	$12,312	**$61,001**
13	$7,460	$19,893	$9,659	$8,289	$4,849	$12,682	**$62,831**
14	$7,684	$20,490	$9,949	$8,537	$4,994	$13,062	**$64,716**
15	$7,914	$21,104	$10,247	$8,793	$5,144	$13,454	**$66,657**
16	$8,152	$21,737	$10,555	$9,057	$5,298	$13,858	**$68,657**
17	$8,396	$22,390	$10,872	$9,329	$5,457	$14,273	**$70,717**
18	$8,648	$23,061	$11,198	$9,609	$5,621	$14,702	**$72,838**
19	$8,907	$23,753	$11,534	$9,897	$5,790	$15,143	**$75,023**
20	$9,175	$24,466	$11,880	$10,194	$5,963	$15,597	**$77,274**
**3% Inflation*							

Table 47. Estimated Costs Before Cost Share for Cropland Implemented BMPs in the Rock Creek Lake Watershed. Expressed in 2010 dollar amounts.

Annual Cost* Before Cost-Share, Cropland BMPs							
Year	**Permanent Vegetation**	**Grassed Waterways**	**No-Till**	**Vegetative Buffers**	**Conservation Crop Rotations**	**Terraces**	**Total Cost**
1	$1,886	$5,029	$2,442	$2,095	$1,226	$3,206	**$15,883**
2	$1,942	$5,180	$2,515	$2,158	$1,263	$3,302	**$16,360**
3	$2,001	$5,335	$2,591	$2,223	$1,300	$3,401	**$16,851**
4	$2,061	$5,495	$2,668	$2,290	$1,339	$3,503	**$17,356**
5	$2,122	$5,660	$2,748	$2,358	$1,380	$3,608	**$17,877**
6	$2,186	$5,830	$2,831	$2,429	$1,421	$3,716	**$18,413**
7	$2,252	$6,005	$2,916	$2,502	$1,464	$3,828	**$18,966**
8	$2,319	$6,185	$3,003	$2,577	$1,508	$3,943	**$19,535**
9	$2,389	$6,370	$3,093	$2,654	$1,553	$4,061	**$20,121**
10	$2,461	$6,561	$3,186	$2,734	$1,599	$4,183	**$20,724**
11	$2,534	$6,758	$3,282	$2,816	$1,647	$4,308	**$21,346**
12	$2,610	$6,961	$3,380	$2,900	$1,697	$4,438	**$21,986**
13	$2,689	$7,170	$3,481	$2,987	$1,748	$4,571	**$22,646**
14	$2,769	$7,385	$3,586	$3,077	$1,800	$4,708	**$23,325**
15	$2,852	$7,607	$3,693	$3,169	$1,854	$4,849	**$24,025**

16	$2,938	$7,835	$3,804	$3,264	$1,910	$4,995	**$24,746**
17	$3,026	$8,070	$3,918	$3,362	$1,967	$5,144	**$25,488**
18	$3,117	$8,312	$4,036	$3,463	$2,026	$5,299	**$26,253**
19	$3,210	$8,561	$4,157	$3,567	$2,087	$5,458	**$27,040**
20	$3,307	$8,818	$4,282	$3,674	$2,149	$5,621	**$27,852**
**3% Inflation*							

Table 48. Estimated Costs After Cost Share for Cropland Implemented BMPs in the Cropland Targeted Area. Individual sub watershed costs are provided in the Appendix. Expressed in 2010 dollar amounts.

Annual Cost* After Cost-Share, Cropland BMPs							
Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Cost
1	$2,616	$6,976	$4,133	$581	$3,401	$4,447	**$22,154**
2	$2,695	$7,185	$4,257	$599	$3,503	$4,581	**$22,819**
3	$2,775	$7,401	$4,384	$617	$3,608	$4,718	**$23,504**
4	$2,859	$7,623	$4,516	$635	$3,716	$4,860	**$24,209**
5	$2,944	$7,852	$4,651	$654	$3,828	$5,006	**$24,935**
6	$3,033	$8,087	$4,791	$674	$3,943	$5,156	**$25,683**
7	$3,124	$8,330	$4,935	$694	$4,061	$5,310	**$26,454**
8	$3,217	$8,580	$5,083	$715	$4,183	$5,470	**$27,247**
9	$3,314	$8,837	$5,235	$736	$4,308	$5,634	**$28,065**
10	$3,413	$9,102	$5,392	$759	$4,437	$5,803	**$28,907**
11	$3,516	$9,375	$5,554	$781	$4,571	$5,977	**$29,774**
12	$3,621	$9,657	$5,720	$805	$4,708	$6,156	**$30,667**
13	$3,730	$9,946	$5,892	$829	$4,849	$6,341	**$31,587**
14	$3,842	$10,245	$6,069	$854	$4,994	$6,531	**$32,535**
15	$3,957	$10,552	$6,251	$879	$5,144	$6,727	**$33,511**
16	$4,076	$10,869	$6,438	$906	$5,298	$6,929	**$34,516**
17	$4,198	$11,195	$6,632	$933	$5,457	$7,137	**$35,551**
18	$4,324	$11,531	$6,831	$961	$5,621	$7,351	**$36,618**
19	$4,454	$11,877	$7,035	$990	$5,790	$7,571	**$37,716**
20	$4,587	$12,233	$7,247	$1,019	$5,963	$7,798	**$38,848**
**3% Inflation*							

Table 49. Estimated Costs After Cost Share for Cropland Implemented BMPs in the Rock Creek Lake Watershed. Expressed in 2010 dollar amounts.

Annual Cost* Before Cost-Share, Cropland BMPs							
Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Cost

1	$943	$2,514	$1,489	$210	$1,226	$1,603	**$7,985**
2	$971	$2,590	$1,534	$216	$1,263	$1,651	**$8,225**
3	$1,000	$2,668	$1,580	$222	$1,300	$1,701	**$8,471**
4	$1,030	$2,748	$1,628	$229	$1,339	$1,752	**$8,725**
5	$1,061	$2,830	$1,676	$236	$1,380	$1,804	**$8,987**
6	$1,093	$2,915	$1,727	$243	$1,421	$1,858	**$9,257**
7	$1,126	$3,002	$1,779	$250	$1,464	$1,914	**$9,535**
8	$1,160	$3,092	$1,832	$258	$1,508	$1,971	**$9,821**
9	$1,194	$3,185	$1,887	$265	$1,553	$2,031	**$10,115**
10	$1,230	$3,281	$1,943	$273	$1,599	$2,091	**$10,419**
11	$1,267	$3,379	$2,002	$282	$1,647	$2,154	**$10,731**
12	$1,305	$3,481	$2,062	$290	$1,697	$2,219	**$11,053**
13	$1,344	$3,585	$2,124	$299	$1,748	$2,285	**$11,385**
14	$1,385	$3,692	$2,187	$308	$1,800	$2,354	**$11,726**
15	$1,426	$3,803	$2,253	$317	$1,854	$2,425	**$12,078**
16	$1,469	$3,917	$2,321	$326	$1,910	$2,497	**$12,440**
17	$1,513	$4,035	$2,390	$336	$1,967	$2,572	**$12,814**
18	$1,558	$4,156	$2,462	$346	$2,026	$2,649	**$13,198**
19	$1,605	$4,281	$2,536	$357	$2,087	$2,729	**$13,594**
20	$1,653	$4,409	$2,612	$367	$2,149	$2,811	**$14,002**
**3% Inflation*							

Table 50. Annual Costs Before Cost Share in the Livestock Targeted Area Aimed at Meeting the Phosphorus and Nitrogen Portion of the Bio TMDL in the Marmaton River. Sub watershed costs are provided in the Appendix. Expressed in 2010 dollar amounts.

Livestock BMPs, Annual Cost Before Cost-Share							
Year	Vegetative Filter Strip	Relocate Feeding Pens	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams/ Ponds	Rotational Grazing	Total
1	$286	$0	$2,203	$3,795	$4,106	$0	$10,390
2	$294	$0	$0	$3,909	$4,229	$7,210	$15,642
3	$303	$7,024	$2,337	$0	$4,356	$0	$14,020
4	$312	$0	$2,407	$4,147	$0	$7,649	$14,515
5	$321	$0	$2,479	$4,271	$4,621	$0	$11,694
6	$331	$0	$2,554	$4,399	$4,760	$0	$12,044
7	$341	$7,906	$2,630	$4,531	$4,903	$0	$20,312
8	$351	$0	$2,709	$0	$5,050	$8,609	$16,720
9	$362	$8,387	$2,791	$4,807	$0	$0	$16,347
10	$373	$0	$0	$4,952	$5,357	$9,133	$19,815
11	$480	$8,898	$2,961	$5,100	$5,518	$0	$22,957
12	$494	$0	$3,049	$5,253	$5,684	$9,690	$24,170

13	$509	$9,440	$3,141	$5,411	$5,854	$0	$24,355
14	$524	$0	$3,235	$5,573	$6,030	$10,280	$25,642
15	$540	$10,015	$3,332	$5,740	$6,211	$0	$25,838
16	$556	$0	$3,432	$5,912	$6,397	$10,906	$27,204
17	$573	$10,625	$3,535	$6,090	$6,589	$0	$27,412
18	$590	$0	$3,641	$6,273	$6,787	$11,570	$28,860
19	$608	$11,272	$3,750	$6,461	$6,990	$0	$29,081
20	$626	$0	$3,863	$6,655	$7,200	$12,275	$30,618
**3% Inflation*							

Table 51. Annual Costs Before Cost Share in the Livestock Targeted Area Aimed at Meeting the Phosphorus and Nitrogen Portion of the E TMDL in Rock Creek Lake. Expressed in 2010 dollar amounts.

Livestock BMPs, Annual Cost Before Cost-Share							
Year	Vegetative Filter Strip	Relocate Feeding Pens	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams/ Ponds	Rotational Grazing	Total
1	$71	$6,621	$0	$0	$0	$0	$6,692
2	$74	$0	$2,269	$0	$0	$0	$2,343
3	$76	$0	$0	$4,026	$0	$0	$4,102
4	$78	$0	$0	$0	$4,487	$0	$4,565
5	$80	$7,452	$0	$0	$0	$0	$7,532
6	$83	$0	$0	$0	$0	$8,115	$8,198
7	$85	$0	$0	$0	$0	$0	$85
8	$88	$0	$0	$4,667	$0	$0	$4,755
9	$90	$0	$0	$0	$5,201	$0	$5,292
10	$93	$0	$2,874	$0	$0	$0	$2,968
**3% Inflation*							

Table 52. Annual Costs Before Cost Share in the Lake Crawford Livestock Targeted Area. This reflects the installation of one practice in ten years. Expressed in 2010 dollar amounts.

Lake Crawford Annual Cost Before Cost-Share							
Years	Vegetative Filter Strip	Relocate Feeding Site	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams/Ponds	Rotational Grazing	Total
1-10	$714	$6,621	$2,203	$3,795	$4,106	$7,000	**$24,439**
**3% Inflation*							

Table 53. Annual Costs After Cost Share in the Livestock Targeted Area Aimed at Meeting the Phosphorus and Nitrogen Portion of the Bio TMDL in the Marmaton River. Sub watershed costs are provided in the Appendix. Expressed in 2010 dollar amounts

Livestock BMPs, Annual Cost After Cost-Share

Year	Vegetative Filter Strip	Relocate Feeding Site	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams/ Ponds	Rotational Grazing	Total
1	$143	$0	$1,102	$1,898	$2,053	$0	$5,195
2	$147	$0	$0	$1,954	$2,115	$3,605	$7,821
3	$151	$3,512	$1,169	$0	$2,178	$0	$7,010
4	$156	$0	$1,204	$2,073	$0	$3,825	$7,258
5	$161	$0	$1,240	$2,136	$2,311	$0	$5,847
6	$166	$0	$1,277	$2,200	$2,380	$0	$6,022
7	$171	$3,953	$1,315	$2,266	$2,451	$0	$10,156
8	$176	$0	$1,355	$0	$2,525	$4,305	$8,360
9	$181	$4,194	$1,395	$2,404	$0	$0	$8,174
10	$186	$0	$0	$2,476	$2,679	$4,567	$9,908
11	$240	$4,449	$1,480	$2,550	$2,759	$0	$11,478
12	$247	$0	$1,525	$2,627	$2,842	$4,845	$12,085
13	$254	$4,720	$1,570	$2,705	$2,927	$0	$12,177
14	$262	$0	$1,618	$2,787	$3,015	$5,140	$12,821
15	$270	$5,007	$1,666	$2,870	$3,105	$0	$12,919
16	$278	$0	$1,716	$2,956	$3,199	$5,453	$13,602
17	$286	$5,312	$1,768	$3,045	$3,294	$0	$13,706
18	$295	$0	$1,821	$3,136	$3,393	$5,785	$14,430
19	$304	$5,636	$1,875	$3,230	$3,495	$0	$14,540
20	$313	$0	$1,931	$3,327	$3,600	$6,137	$15,309
*3% Inflation							

Table 54. Annual Costs After Cost Share in the Livestock Targeted Area Aimed at Meeting the Phosphorus and Nitrogen Portion of the E TMDL in Rock Creek Lake. Expressed in 2010 dollar amounts.

Livestock BMPs, Annual Cost After Cost-Share							
Year	Vegetative Filter Strip	Relocate Feeding Site	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams/ Ponds	Rotational Grazing	Total
1	$36	$3,311	$0	$0	$0	$0	$3,346
2	$37	$0	$1,135	$0	$0	$0	$1,171
3	$38	$0	$0	$2,013	$0	$0	$2,051
4	$39	$0	$0	$0	$2,243	$0	$2,282
5	$40	$3,726	$0	$0	$0	$0	$3,766
6	$41	$0	$0	$0	$0	$4,057	$4,099
7	$43	$0	$0	$0	$0	$0	$43
8	$44	$0	$0	$2,334	$0	$0	$2,378

9	$45	$0	$0	$0	$2,601	$0	$2,646
10	$47	$0	$1,437	$0	$0	$0	$1,484
**3% Inflation*							

Table 55. Annual Costs After Cost Share in the Lake Crawford Livestock Targeted Area. This reflects the installation of one practice in ten years. Expressed in 2010 dollar amounts.

Lake Crawford Annual Cost* After Cost-Share							
Years	**Vegetative Filter Strip**	**Relocate Feeding Site**	**Relocate Pasture Feeding Site**	**Off-Stream Watering System**	**Fence out Streams/Ponds**	**Rotational Grazing**	**Total**
1-10	$357	$3,311	$1,102	$1,898	$2,053	$3,500	$12,220
**3% Inflation*							

Table 56. Technical Assistance Needed to Implement BMPs.

<table>
<tr><th colspan="2" rowspan="2">BMP</th><th colspan="2">Personnel Needed to Implement BMP</th></tr>
<tr><th>Technical Assistance</th><th>Projected Annual Cost</th></tr>
<tr><td rowspan="6">Cropland</td><td>1. Establish Permanent Vegetation</td><td rowspan="2">SCC Buffer Coordinator
Conservation District
NRCS
KSU Extension
KRC River Friendly Farms Technician
Watershed Specialist
Watershed Coordinator
SLT</td><td rowspan="7">SCC Buffer Technician
$15,000

WRAPS Coordinator
$30,000

KRC River Friendly Farms Technician
$10,000

Watershed Specialist
$50,000

NRCS District Conservationist
No Charge

Conservation District Soil Technician
No Charge

KSU Extension
No Charge

No-Till on the Plains
(included in tour/field day cost)</td></tr>
<tr><td>2. Grassed Waterways</td></tr>
<tr><td>3. No-Till</td><td>No-Till on the Plains
SCC Buffer Coordinator
Conservation District
NRCS
KSU Extension
KRC River Friendly Farms Technician
Watershed Specialist
Watershed Coordinator
SLT
Farm Bureau</td></tr>
<tr><td>4. Buffers</td><td rowspan="3">SCC Buffer Coordinator
Conservation District
NRCS
KSU Extension
KRC River Friendly Farms Technician
Watershed Specialist
Watershed Coordinator
SLT</td></tr>
<tr><td>5. Conservation Crop Rotation</td></tr>
<tr><td>5. Terraces</td></tr>
<tr><td>Livestock</td><td>1. Vegetative filter strips</td><td>SCC Buffer Coordinator
Conservation District
NRCS
KSU Extension
KRC River Friendly Farms Technician
Watershed Specialist
Watershed Coordinator</td></tr>
</table>

		SLT	SLT No Charge
	2. Relocate feeding pens	Conservation District NRCS KSU Extension KRC River Friendly Farms Technician Watershed Specialist Watershed Coordinator SLT	
	3. Relocate pasture feeding sites		
	4. Establish off stream watering systems		
	5. Fence out streams/ponds		
	6. Rotational grazing		
Total			$105,000

Table 57. Total Costs for BMPs I&E, Assessments and Technical Support if All BMPs and I&E Projects are Implemented.

Annual Cost of Cropland, Livestock, I&E, and Technical Assistance adjusted for Cost Share						
	BMPs Implemented		I&E and Technical Assistance			
Year	Cropland	Livestock	I&E	Monitoring/ Assessment	Technical Assistance	Total
1	$22,154	$9,763	$83,900	$177,000	$105,000	**$397,817**
2	$22,819	$10,251	$86,417	$182,310	$108,150	**$409,947**
3	$23,504	$10,358	$89,010	$187,779	$111,395	**$422,045**
4	$24,209	$10,875	$91,680	$193,413	$114,736	**$434,913**
5	$24,935	$10,988	$94,430	$199,215	$118,178	**$447,747**
6	$25,683	$11,538	$97,263	$205,192	$121,724	**$461,399**
7	$26,454	$11,657	$100,181	$211,347	$125,375	**$475,015**
8	$27,247	$12,240	$103,186	$217,688	$129,137	**$489,498**
9	$28,065	$12,367	$106,282	$224,218	$133,011	**$503,943**
10	$28,907	$12,986	$109,470	$230,945	$137,001	**$519,310**
11	$29,774	$11,478	$112,755	$237,873	$141,111	**$532,991**
12	$30,667	$12,085	$116,137	$245,009	$145,345	**$549,243**
13	$31,587	$12,177	$119,621	$252,360	$149,705	**$565,450**
14	$32,535	$12,821	$123,210	$259,930	$154,196	**$582,692**
15	$33,511	$12,919	$126,906	$267,728	$158,822	**$599,887**
16	$34,516	$13,602	$130,713	$275,760	$163,587	**$618,178**
17	$35,551	$13,706	$134,635	$284,033	$168,494	**$636,419**
18	$36,618	$14,430	$138,674	$292,554	$173,549	**$655,825**
19	$37,716	$14,540	$142,834	$301,331	$178,755	**$675,176**
20	$38,848	$15,309	$147,119	$310,371	$385,394	**$695,765**
3% inflation						

8.2 Potential Funding Sources

Table 58. Potential BMP Funding Sources.

Potential Funding Sources	Potential Funding Programs
Natural Resources Conservation Service	Environmental Quality Incentives Program (EQIP) Wetland Reserve Program (WRP) Conservation Reserve Program (CRP) Wildlife Habitat Incentive Program (WHIP) Cooperative Conservation Partnership Initiative (CCPI) State Acres for Wildlife Enhancement (SAFE) Grassland Reserve Program (GRP) Farmable Wetlands Program (FWP)
EPA/KDHE	319 Funding Grants KDHE WRAPS Funding Clean Water Neighbor Grants
Kansas Alliance for Wetlands and Streams	
State Conservation Commission	State Cost Share
Conservation Districts	
No-Till on the Plains	
Kansas Forest Service	
US Fish and Wildlife	
National Wild Turkey Federation	
Quail Unlimited	
Ducks Unlimited	

Table 59. Service Providers for BMP Implementation. *

BMP		Services Needed to Implement BMP		Service Provider **
		Technical Assistance	*Information and Education*	
Cropland	1. Establish Permanent Vegetation 2. Grassed Waterways 3. No-Till 4. Buffers	Site selection, planning, implementation, maintenance	BMP workshops, tours, field days, brochures, news articles	NRCS KRC SCC No-Till on the Plains KSRE CD KDWP

	5. Conservation Crop Rotation			KFS
	5. Terraces			
Livestock	1. Vegetative filter strips	Site selection, planning, implementation, maintenance	BMP workshops, field days, tours	KSRE NRCS SCC KRC CD RC&D KDWP
	2. Relocate feeding pens			
	3. Relocate pasture feeding sites			
	4. Establish off stream watering systems			
	5. Fence out streams/ponds			
	6. Rotational grazing			
***** See Appendix for service provider directory***				

** All service providers are responsible for evaluation of the installed or implemented BMPs and/or other services provided and will report to SLT for completion approval.*

9.0 Timeframe

The plan will be reviewed every five years starting in 2016. In 2012, the SLT will request a review of data by KDHE for the Marais des Cygnes Basin. 2012 is the year that the TMDLs will officially be reviewed for additions or revisions. The timeframe of this document for BMP implementation to meet both sediment and phosphorus TMDLs would be twenty years from the date of publication of this report. Sediment, phosphorus and nitrogen reductions in the water column will not be noticeable by the year 2016 due to a lag time from implementation of BMPs and resulting improvements in water quality. Therefore, the SLT will review sediment and phosphorus concentrations in year 2021. They will examine BMP placement and implementation in 2016 and every subsequent five years after.

Table 60. Review Schedule for Pollutants and BMPs.

Review Year	Sediment	Phosphorus	Nitrogen	BMP Placement
2016				X
2021	X	X	X	X
2026	X	X	X	X
2031	X	X	X	X

The interim timeframe for all BMP implementation would be ten years from the date of publication of this report. Targeting and BMP implementation might shift over time in order to achieve TMDLs.

- Timeframe for reaching the **sediment portion of the Marmaton River Biology TMDL** will be attained at year seventeen of the plan. After the sediment goal is achieved, the process will become one of protection instead of restoration.
- Timeframe for reaching the **phosphorus portion of the Marmaton River Biology TMDL** will be year three of the plan. After the phosphorus goal is achieved, the process will become one of protection instead of restoration.
- Timeframe for reaching the **phosphorus portion of the Rock Creek Lake E TMDL** will be year five of the plan. After the phosphorus goal is achieved, the process will become one of protection instead of restoration.
- Timeframe for reaching the **phosphorus portion of the Lake Crawford E TMDL** will be year two of the plan. After the phosphorus goal is achieved, the process will become one of protection instead of restoration.
- Timeframe for reaching the **nitrogen portion of the Marmaton River Biology TMDL** will be year four of the plan. After the nitrogen goal is achieved, the process will become one of protection instead of restoration.
- Timeframe for reaching the **nitrogen portion of the Rock Creek Lake E TMDL** will be year 16 of the plan. After the nitrogen goal is achieved, the process will become one of protection instead of restoration.

- Timeframe for reaching the **nitrogen portion of the Lake Crawford E TMDL** will be year ten of the plan. After the nitrogen goal is achieved, the process will become one of protection instead of restoration.

10.0 Measureable Milestones

10.1 Adoption Rates for BMP Implementation

Milestones will be determined by number of acres treated, projects installed, contacts made to residents of the watershed and water quality parameters at the end of every five years. The SLT will examine these criteria to determine if adequate progress has been made from the current BMP implementations. If they determine that adequate progress has not been made, they will readjust the implementation projects in order to achieve the TMDL by the end of ten years. Below are tables outlining the expected adoption rates of BMPs in order to attain impairment reduction goals.

Table 61. Short, Medium and Long Term Goals for BMP Cropland Adoption Rates in the Cropland Targeted Area. Sub watershed adoption rates are provided in the Appendix.

Annual Adoption (treated acres) Rates for Cropland BMPs								
	Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Adoption
Short-Term	1	35	87	87	87	87	87	471
	2	35	87	87	87	87	87	471
	3	35	87	87	87	87	87	471
	4	35	87	87	87	87	87	471
	5	35	87	87	87	87	87	471
	Total	*174*	*436*	*436*	*436*	*436*	*436*	*2,354*
Medium-Term	6	35	87	87	87	87	87	471
	7	35	87	87	87	87	87	471
	8	35	87	87	87	87	87	471
	9	35	87	87	87	87	87	471
	10	35	87	87	87	87	87	471
	Total	*349*	*872*	*872*	*872*	*872*	*872*	*4,709*
Long-Term	11	35	87	87	87	87	87	471
	12	35	87	87	87	87	87	471
	13	35	87	87	87	87	87	471
	14	35	87	87	87	87	87	471
	15	35	87	87	87	87	87	471
	16	35	87	87	87	87	87	471

	17	35	87	87	87	87	87	471
	18	35	87	87	87	87	87	471
	19	35	87	87	87	87	87	471
	20	35	87	87	87	87	87	471
	Total	*698*	*1,744*	*1,744*	*1,744*	*1,744*	*1,744*	*9,418*

Table 62. Short, Medium and Long Term Goals for BMP Cropland Adoption Rates in the Rock Creek lake Watershed.

Annual Adoption (treated acres) Rates for Cropland BMPs								
	Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Adoption
Short-Term	1	13	31	31	31	31	31	170
	2	13	31	31	31	31	31	170
	3	13	31	31	31	31	31	170
	4	13	31	31	31	31	31	170
	5	13	31	31	31	31	31	170
	Total	*65*	*155*	*155*	*155*	*155*	*155*	*850*
Medium-Term	6	13	31	31	31	31	31	170
	7	13	31	31	31	31	31	170
	8	13	31	31	31	31	31	170
	9	13	31	31	31	31	31	170
	10	13	31	31	31	31	31	170
	Total	*130*	*310*	*310*	*310*	*310*	*310*	*1,700*
Long-Term	11	13	31	31	31	31	31	170
	12	13	31	31	31	31	31	170
	13	13	31	31	31	31	31	170
	14	13	31	31	31	31	31	170
	15	13	31	31	31	31	31	170
	16	13	31	31	31	31	31	170
	17	13	31	31	31	31	31	170
	18	13	31	31	31	31	31	170
	19	13	31	31	31	31	31	170
	20	13	31	31	31	31	31	170
	Total	*260*	*620*	*620*	*620*	*620*	*620*	*3,400*

Table 63. Short, Medium and Long Term Goals for BMP Livestock Adoption Rates in the Marmaton River Watershed.

Annual Livestock BMP Adoption Rates							
	Year	Vegetative Filter Strips	Relocate Feeding Pens	Relocate Pasture Feeding Site	Off Stream Watering System	Fence Out Streams/ Ponds	Rotational Grazing
		Acres	Projects				

Short-Term	1	0.4	0	1	1	1	0
	2	0.4	0	0	1	1	1
	3	0.4	1	1	0	1	0
	4	0.4	0	1	1	0	1
	5	0.4	0	1	1	1	0
	Total	*2*	*1*	*4*	*4*	*4*	*2*
Medium-Term	6	0.4	0	1	1	1	0
	7	0.4	1	1	1	1	0
	8	0.4	0	1	0	1	1
	9	0.4	1	1	1	0	0
	10	0.4	0	0	1	1	1
	Total	*4*	*3*	*8*	*8*	*8*	*4*
Long-Term	11	0.5	1	1	1	1	0
	12	0.5	0	1	1	1	1
	13	0.5	1	1	1	1	0
	14	0.5	0	1	1	1	1
	15	0.5	1	1	1	1	0
	16	0.5	0	1	1	1	1
	17	0.5	1	1	1	1	0
	18	0.5	0	1	1	1	1
	19	0.5	1	1	1	1	0
	20	0.5	0	1	1	1	1
	Total	***9***	***8***	***18***	***18***	***18***	***9***

Table 64. Short, Medium and Long Term Goals for BMP Livestock Adoption Rates in the Rock Creek Lake Watershed.

Annual Livestock BMP Adoption Rates							
	Year	**Vegetative Filter Strips**	**Relocate Feeding Pens**	**Relocate Pasture Feeding Site**	**Off Stream Watering System**	**Fence Out Streams/ Ponds**	**Rotational Grazing**
		Acres	**Projects**				
Short-Term	1	0.1	1	0	0	0	0
	2	0.1	0	1	0	0	0
	3	0.1	0	0	1	0	0
	4	0.1	0	0	0	1	0
	5	0.1	1	0	0	0	0
	Total	*.5*	*2*	*1*	*1*	*1*	*0*
Medium-Term	6	0.1	0	0	0	0	1
	7	0.1	0	0	0	0	0
	8	0.1	0	0	1	0	0
	9	0.1	0	0	0	1	0
	10	0.1	0	1	0	0	0

	Total	1	2	2	2	2	1

Table 65. BMP Livestock Adoption Rates for Lake Crawford Watershed. This reflects the installation of one practice in ten years.

Lake Crawford Annual Livestock BMP Adoption						
Years	Vegetative Filter Strip	Relocate Feeding Site	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams/ Ponds	Rotational Grazing
1-10	1	1	2	2	1	1

Table 66. Short, Medium and Long Term Goals for Watershed Wide Information and Education Adoption Rates.

	Year	Demo Projects	Informational Meetings/ Workshops	Tours and Field Days	Brochures, Newsletter Inserts	BMP Assistance with One on One Meetings	Educational Events	Contacts made by Tech Assistance
Short Term	1	4	15	13	11	20	2	250
	2	4	15	13	11	20	2	250
	3	4	15	13	11	20	2	250
	4	4	15	13	11	20	2	250
	5	4	15	13	11	20	2	250
	Total	***20***	***75***	***65***	***55***	***100***	***10***	***1,250***
Medium Term	6	4	15	13	11	20	2	250
	7	4	15	13	11	20	2	250
	8	4	15	13	11	20	2	250
	9	4	15	13	11	20	2	250
	10	4	15	13	11	20	2	250
Total		***40***	***150***	***130***	***110***	***200***	***20***	***2,500***
Long Term	11	4	15	13	11	20	2	250
	12	4	15	13	11	20	2	250
	13	4	15	13	11	20	2	250
	14	4	15	13	11	20	2	250
	15	4	15	13	11	20	2	250
	16	4	15	13	11	20	2	250
	17	4	15	13	11	20	2	250
	18	4	15	13	11	20	2	250
	19	4	15	13	11	20	2	250

	20	4	15	13	11	20	2	250
Total		***80***	***300***	***260***	***220***	***400***	***40***	***5,000***

Table 67. Short, Medium and Long Term Goals for Assessment Adoption Rates.

	Year	Monitoring Projects	Stream Sampling Projects	New Sampling Site Projects	Modeling Projects	Assessment Projects
Short Term	1	4	2	1	1	2
	2	4	2	1	1	2
	3	4	2	1	1	2
	4	4	2	1	1	2
	5	4	2	1	1	2
Total		***20***	***10***	***5***	***5***	***10***
Medium Term	6	4	2	1	1	2
	7	4	2	1	1	2
	8	4	2	1	1	2
	9	4	2	1	1	2
	10	4	2	1	1	2
Total		***40***	***20***	***10***	***10***	***20***
Long Term	11	4	2	1	1	2
	12	4	2	1	1	2
	13	4	2	1	1	2
	14	4	2	1	1	2
	15	4	2	1	1	2
	16	4	2	1	1	2
	17	4	2	1	1	2
	18	4	2	1	1	2
	19	4	2	1	1	2
	20	4	2	1	1	2
Total		***80***	***40***	***20***	***20***	***40***

10.2 Benchmarks to Measure Water Quality and Social Progress

Over a twenty year time frame, this WRAPS project hopes to improve water quality in the Marmaton River and throughout the watershed. Social indicators will also be examined by tracking traffic in parks throughout the watershed. An example of a healthy ecosystem is frequent visits by the public to enjoy the outdoor recreation of the reservoirs and parks. After reviewing the criteria listed in the table below, the SLT will assess and revise the overall strategy plan for the watershed. The milestones will be utilized in determining what specific revisions are needed. If milestones are not attained, the SLT will revise the plan strategy. New goals will be set and new BMPs will be implemented in order to achieve improved water quality. Coordination with KDHE TMDL staff, Water Plan staff and the SLT will be held every five years to discuss benchmarks and TMDL update plans. Using data obtained by KDHE, NRCS, KSU and USGS, the following indicator and parameter criteria shall be used to assess progress in successful implementation to abate pollutant loads.

Table 68. Benchmarks to Measure Waters Quality Progress.

Impairment Addressed	Criteria to Measure Water Quality Progress	Information Source
Sediment	Fewer high event stream flow rates indicating better retention and slower release of storm water in the upper end of the watershed	USGS
Nutrients	**Marmaton River:** Maintain BOD concentrations < 2.4 mg/l DO > 5mg/l Average MBI <4.5	KDHE
	Lake Crawford: Summer Chlorophyll *a* concentrations < 12 ug/l	KDHE
	Rock Creek Lake: Summer Chlorophyll *a* concentrations < 10 ug/l	KDHE
	Bourbon County State Fishing Lake: Summer Chlorophyll *a* concentrations < 12 ug/l pH between 6.5 and 8.5 DO concentrations >5.0mg/l	KDHE
	Bronson City Lake: Summer Chlorophyll *a* concentrations < 20 ug/l	KDHE
	No taste or odor issues at the City of Ft. Scott	City of Ft. Scott
Impairment Addressed	**Social Indicators to Measure Water Quality Progress**	**Information Source**
Sediment Nutrients ECB	Visitor traffic to watershed lakes and reservoirs	KDWP
	Boating traffic in watershed lakes and reservoirs	KDWP
	Trends of quantity and quality of fishing in watershed lakes and reservoirs	KDWP
	Economic indicators indicating effect of watershed lakes and reservoirs' impact on local businesses	County Economic Development Organizations
	Survey of water quality issues to determine whether information and education programs are having an effect on public perception	KSRE
	Number of attendees at tours and field days	KSRE
	BMP adoptability rates	NRCS

10.3 Water Quality Milestones Used to Determine Improvements [42]

The goals of the Marmaton watershed plan will be to restore water quality for uses supportive of aquatic life, primary contact recreation and public water supply for the Marmaton River, Rock Creek Lake and Lake Crawford. The plan will specifically address high priority eutrophication TMDLs for both Rock Creek Lake and Lake Crawford, and a high priority biology TMDL in the Marmaton River. The restoration plan includes BMP implementation schedules spanning a period of twenty years.

A timeframe of ten years has been utilized for the water quality milestones for a few reasons. Firstly, the ten year timeframe for water quality milestones can be directly compared to the baseline data – which in most cases has been developed utilizing a ten-year period of record. Further, it is anticipated that it will require ten years to see progress from the BMP implementation outlined in the plan. Short-term (5-year) and long-term (20 year) goals were not included due to the fact that the TMDLs being addressed by the plan are scheduled to be reviewed in 2012. At that time, the water quality milestones will be reviewed by KDHE and revised as necessary. See following tables.

Table 69. Water Quality Milestones for the Marmaton River.

	Current Condition (2000 - 2010) Median TP	Improved Condition (2011 - 2021) Median TP	Reduction Needed	Current Condition (1980 - 2010) *% EPT > 50	Improved Condition (2011 - 2021) *% EPT > 50	Current Condition (1980 - 2010) *MBI (Avg) < 4.5	Improved Condition (2011 - 2021) *MBI (Avg) < 4.5
Sampling Sites	**Total Phosphorus (median of data collected during indicated period), ppb**			***Percent of Samples % EPT > 50 (data collected during indicated period)**		***Percent of Samples MBI < 4.5 (data collected during indicated period)**	
Marmaton River (Lower) SC208	131	98	**33**	55%	**Maintain at least 50% of samples % EPT > 50 and no sample with % EPT < 30**	35%	**At least 50% of samples MBI < 4.5 and no sample with MBI > 5**
Marmaton River (Middle) SC559	70	53	**17**	20%	**At least 50% of samples % EPT > 50 and no sample with % EPT < 30**	**Maintain Average MBI < 4.5 and no sample with MBI > 5**	

	Current Condition (2000 - 2010) *DO < 5 mg/L	Improved Condition (2011 - 2021) *DO < 5 mg/L	Reduction Needed	Current Condition (2000 - 2010) Average TSS	Improved Condition (2011 - 2021) Average TSS	Reduction Needed	Current Condition (2000 - 2010) Chlorophyll	Improved Condition (2011 - 2021) Chlorophyll
Sampling Sites	***Percent of Samples DO < 5 mg/L (data collected during indicated period)**			**TSS (average of data collected during indicated period), ppm**			**Chlorophyll (average of data collected during indicated period), ppb**	
Marmaton River (Lower) SC208	23%	15%	**8%**	34	25	**7**		
Marmaton River (Middle) SC559	17%	10%	**7%**	16	**Maintain Average TSS < 16**		2.65	**Maintain Avg Chlorophyll <= 2.65**

Table 70. Water Quality Milestones for Lake Crawford.

	Current Condition (1990 - 2010) Average TP	Improved Condition (2011 - 2021) Average TP	Reduction Needed	Current Condition (1990 - 2010) Chlorophyll a	Improved Condition (2011 - 2021) Chlorophyll a	Reduction Needed	Current Condition (1990 - 2010) Secchi (Avg)	Improved Condition (2011 - 2021) Secchi (Avg)
Sampling Sites	**Total Phosphorus (median of data collected during indicated period), ppb**			**Chlorophyll a (average of data collected during indicated period), ppb**			**Secchi (average of data collected during indicated period), m**	
Lake Crawford LM011101	51	40	**11**	16	12	**4**	1.46	**Secchi depth > 1.5**

Table 71. Water Quality Milestones for Rock Creek Lake.

	Current Condition (1990 - 2010) Average TP	Improved Condition (2011 - 2021) Average TP	Reduction Needed	Current Condition (1990 - 2010) Chlorophyll a	Improved Condition (2011 - 2021) Chlorophyll a	Reduction Needed	Current Condition (1990 - 2010) Secchi (Avg)	Improved Condition (2011 - 2021) Secchi (Avg)
Sampling Sites	**Total Phosphorus (median of data collected during indicated period), ppb**			**Chlorophyll a (average of data collected during indicated period), ppb**			**Secchi (average of data collected during indicated period), m**	
Rock Creek Lake LM045201	56	40	**16**	17	10	**7**	0.64	**Secchi depth > 1.0**

10.4 BMP Implementation Milestones from 2011 to 2030

The SLT will review the number of acres, projects or contacts made in the watershed at the end of five, ten and twenty years (2030). At the end of each period, the SLT will have the option to reassess the goals and alter BMP implementations as they determine is best. Below is the outline of BMP implementations over a twenty year period. Cumulative BMP Implementation Milestones from 2011 to 2030.

Table 72. Cumulative BMP Implementation Milestones from 2011 to 2030 for Cropland BMPs In the Cropland Targeted Area.

Cumulative Totals						
Cropland, treated acres						
Year	**Permanent Vegetation**	**Grassed Waterways**	**No-Till**	**Buffers**	**Conservation Crop Rotation**	**Terraces**
2011	35	87	87	87	87	87
2012	70	174	174	174	174	174
2013	105	261	261	261	261	261
2014	140	348	348	348	348	348
2015	175	435	435	435	435	435
2016	210	522	522	522	522	522
2017	245	609	609	609	609	609
2018	280	696	696	696	696	696
2019	315	783	783	783	783	783
2020	350	870	870	870	870	870
2021	385	957	957	957	957	957
2022	420	1044	1044	1044	1044	1044
2023	455	1131	1131	1131	1131	1131
2024	490	1218	1218	1218	1218	1218
2025	525	1305	1305	1305	1305	1305
2026	560	1392	1392	1392	1392	1392
2027	595	1479	1479	1479	1479	1479
2028	630	1566	1566	1566	1566	1566
2029	665	1653	1653	1653	1653	1653
2030	700	1740	1740	1740	1740	1740

Table 73. Cumulative BMP Implementation Milestones from 2011 to 2030 for Cropland BMPs In the Rock Creek Lake Watershed.

Cumulative Totals						
Cropland, treated acres						
Year	Permanent Vegetation	Grassed Waterways	No-Till	Buffers	Conservation Crop Rotation	Terraces
2011	13	31	31	31	31	31
2012	25	63	63	63	63	63
2013	38	94	94	94	94	94
2014	50	126	126	126	126	126
2015	63	157	157	157	157	157
2016	75	189	189	189	189	189
2017	88	220	220	220	220	220
2018	101	251	251	251	251	251
2019	113	283	283	283	283	283
2020	126	314	314	314	314	314
2021	138	346	346	346	346	346
2022	151	377	377	377	377	377
2023	163	409	409	409	409	409
2024	176	440	440	440	440	440
2025	189	471	471	471	471	471
2026	201	503	503	503	503	503
2027	214	534	534	534	534	534
2028	226	566	566	566	566	566
2029	239	597	597	597	597	597
2030	251	629	629	629	629	629

Table 74. Cumulative BMP Implementation Milestones from 2011 to 2030 for Livestock BMPs in the Marmaton River Watershed.

Cumulative Totals						
	Livestock, number of projects					
Year	Vegetative Filter Strip, acres	Relocate Feeding Pens	Relocate Pasture Feeding Site	Off Stream Watering System	Fence off Stream/ Ponds	Rotational Grazing
2011	0.4	0	1	1	1	0
2012	0.8	0	1	2	2	1
2013	1.2	1	2	2	3	1
2014	1.6	1	3	3	3	2

2015	2	1	4	4	4	2
2016	2.4	1	5	5	5	2
2017	2.8	2	6	6	6	2
2018	3.2	2	7	6	7	3
2019	3.6	3	8	7	7	3
2020	4	3	8	8	8	4
2021	4.5	4	9	9	9	4
2022	5	4	10	10	10	5
2023	5.5	5	11	11	11	5
2024	6	5	12	12	12	6
2025	6.5	6	13	13	13	6
2026	7	6	14	14	14	7
2027	7.5	7	15	15	15	7
2028	8	7	16	16	16	8
2029	8.5	8	17	17	17	8
2030	9	8	18	18	18	9

Table 75. Cumulative BMP Implementation Milestones from 2011 to 2020 for Livestock BMPs in the Rock Creek Lake Watershed.

Cumulative Totals						
	Livestock, number of projects					
Year	Vegetative Filter Strip, acres	Relocate Feeding Pens	Relocate Pasture Feeding Site	Off Stream Watering System	Fence off Stream/ Ponds	Rotational Grazing
2011	0.1	1	0	0	0	0
2012	0.2	1	1	0	0	0
2013	0.3	1	1	1	0	0
2014	0.4	1	1	1	1	0
2015	0.5	2	1	1	1	0
2016	0.6	2	1	1	1	1
2017	0.7	2	1	1	1	1
2018	0.8	2	1	2	1	1
2019	0.9	2	1	2	2	1
2020	1	2	2	2	2	1

Table 76. Cumulative BMP Implementation Milestones from 2011 to 2020 for Livestock BMPs in the Lake Crawford Watershed.

Cumulative Totals						
	Livestock, number of projects					
Year	Vegetative Filter Strip, acres	Relocate Feeding Pens	Relocate Pasture Feeding Site	Off Stream Watering System	Fence off Stream/ Ponds	Rotational Grazing

2011 through 2020	1	1	2	2	1	1

Table 77. Cumulative I&E Implementation Milestones from 2011 to 2030 for I&E Watershed Wide.

	Cumulative Totals		
	Information and Education, number		
Year	**Workshops and Field Days**	**Monitoring and Assessments**	**Contacts made**
2011	28	10	250
2012	56	20	500
2013	84	30	750
2014	112	40	1,000
2015	140	50	1,250
2016	168	60	1,500
2017	196	70	1,750
2018	224	80	2,000
2019	252	90	2,250
2020	280	100	2,500
2021	308	110	2,750
2022	336	120	3,000
2023	364	130	3,250
2024	392	140	3,500
2025	420	150	3,750
2026	448	160	4,000
2027	476	170	4,250
2028	504	180	4,500
2029	532	190	4,750
2030	560	200	5,000

If phosphorus and TSS milestones are met by 2031, then...

the Water Quality Standards will be met for the Marmaton River, Lake Crawford and Rock Creek Lake, and...

the Marmaton River, Lake Crawford, and Rock Creek Lake will meet their full designated uses.

11.0 Monitoring Water Quality Progress

The KDHE sampling data will be reviewed by the SLT as available. Data collected in the Targeted Areas will be of special interest. A composite review of BMPs implemented and monitoring data will be analyzed for effects resulting from the BMPs. The SLT will also ask KDHE to review analyzed data from all monitoring sources as available.

KDHE has ongoing monitoring sites in the watershed. There are two types of monitoring sites utilized by KDHE: permanent and rotational. Permanent sites are continuously sampled, whereas rotational sites are only sampled every fourth year. There are three stream sampling sites currently in the watershed and only one (SC208) on the Marmaton River is a permanent site. All sampling sites will be continued into the future. Each site is tested for nutrients, metals, ammonia, solid fractions, turbidity, alkalinity, pH, dissolved oxygen, ECB and chemicals. Not all sites are tested for these pollutant indicators at each collection time. This is dependent upon the anticipated pollutant concern as well as other factors. There are ten lake monitoring sites in the watershed.

Stream flow data is collected by the USGS and will be available for SLT review. At publication time of this report, depending on the sampling site, up to six different parameters are sampled: water temperature, specific conductance, gage height, discharge, precipitation and turbidity. Samples are automatically taken every 15 minutes. Reviewing this data will indicate whether runoff events in the upper reaches of the watershed have been slowed by BMPs such as no-till.

The COE does not have any sampling sites in the watershed.

Much of the evaluative information can be obtained through the existing networks and sampling plans of KDHE, USGS and KSU. Public engagement can be obtained through observations of reservoir or lake clarity, ease of boating and the physical appearance of the reservoir or lake.

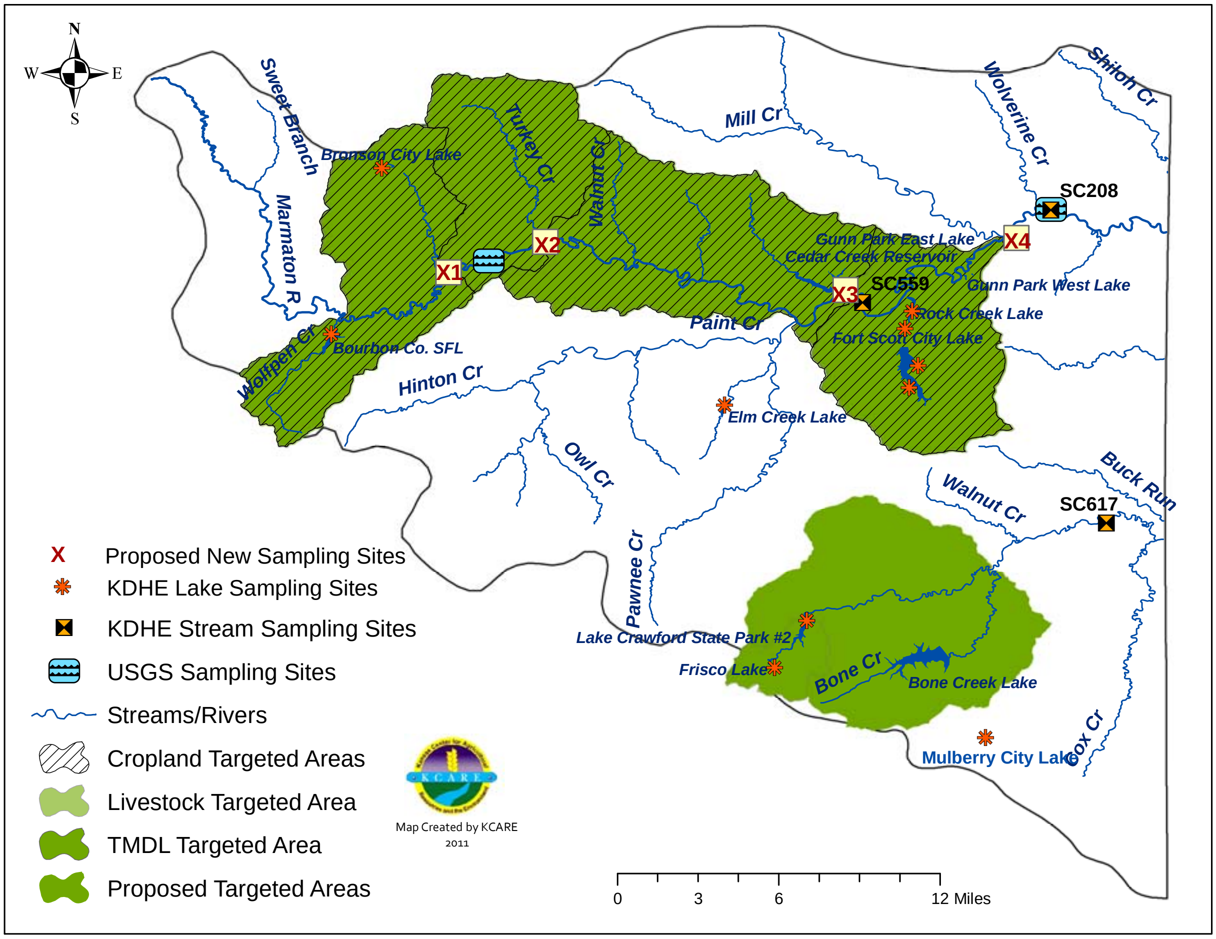


Figure 35. Monitoring Sites in the Watershed with Proposed Sites. [43]

Monitoring data will be used to direct the SLT in their evaluation of water quality progress. KDHE will be requested to provide any additional monitoring sites that need to be installed. The table below indicates which current monitoring sites data will be used by the SLT in determination of effectiveness of BMP implementation.

Table 78. Monitoring Sites and Tests Needed to Direct the SLT in Water Quality Evaluations.

Cropland Targeted Area				
Agency	**Site Number or Name**	**Pollutant Target**	**River, Stream or Lake**	**Sampling Tests Needed**
KDHE	208	Sediment, Phosphorus	Marmaton River	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	559	Sediment, Phosphorus	Marmaton River	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	Proposed Site	Sediment,	Marmaton River	Turbidity, TSS,

	X1 (refer to map above)	Phosphorus	(end of HUC 102901040102)	pH, DO, Phosphorus, Nitrogen
KDHE	Proposed Site X2 (refer to map above)	Sediment, Phosphorus	Marmaton River (end of HUC 102901040103)	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	Proposed Site X3 (refer to map above)	Sediment, Phosphorus	Marmaton River (end of HUC 102901040107)	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	Proposed Site X4 (refer to map above)	Sediment, Phosphorus	Marmaton River (end of HUC 102901040108)	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
Livestock Targeted Area				
Agency	**Site Number or Name**	**Pollutant Target**	**River, Stream or Lake**	**Sampling Tests Needed**
KDHE	208	Phosphorus, Nitrogen, ECB	Marmaton River	pH, DO, Phosphorus, Nitrogen, ECB
KDHE	559	Phosphorus, Nitrogen, ECB	Marmaton River	pH, DO, Phosphorus, Nitrogen, ECB
KDHE	Proposed Site X1 (refer to map above)	Phosphorus, Nitrogen, ECB	Marmaton River (end of HUC 102901040102)	pH, DO, Phosphorus, Nitrogen, ECB
KDHE	Proposed Site X2 (refer to map above)	Phosphorus, Nitrogen, ECB	Marmaton River (end of HUC 102901040103)	pH, DO, Phosphorus, Nitrogen, ECB
KDHE	Proposed Site X3 (refer to map above)	Phosphorus, Nitrogen, ECB	Marmaton River (end of HUC 102901040107)	pH, DO, Phosphorus, Nitrogen, ECB
KDHE	Proposed Site X4 (refer to map above)	Phosphorus, Nitrogen, ECB	Marmaton River (end of HUC 102901040108)	pH, DO, Phosphorus, Nitrogen, ECB
KDHE	LM11101	Phosphorus, Nitrogen, ECB	Lake Crawford	pH, DO, Phosphorus, Nitrogen, ECB
High Priority TMDL Targeted Area				
Agency	**Site Number or Name**	**Pollutant Target**	**River, Stream or Lake**	**Sampling Tests Needed**
KDHE	208	Phosphorus, Nitrogen	Marmaton River	pH, DO, Phosphorus, Nitrogen
KDHE	559	Phosphorus, Nitrogen	Marmaton River	pH, DO, Phosphorus, Nitrogen
KDHE	Proposed Site X1 (refer to map above)	Phosphorus, Nitrogen	Marmaton River (end of HUC 102901040102)	pH, DO, Phosphorus, Nitrogen
KDHE	Proposed Site X2 (refer to map above)	Phosphorus, Nitrogen	Marmaton River (end of HUC 102901040103)	pH, DO, Phosphorus, Nitrogen
KDHE	Proposed Site	Phosphorus,	Marmaton River	pH, DO,

	X3 (refer to map above)	Nitrogen	(end of HUC 102901040107)	Phosphorus, Nitrogen
KDHE	Proposed Site **X4** (refer to map above)	Phosphorus, Nitrogen	Marmaton River (end of HUC 102901040108)	pH, DO, Phosphorus, Nitrogen
KDHE	LM11101	Phosphorus, Nitrogen	Lake Crawford	pH, DO, Phosphorus, Nitrogen

Monitoring site data that is being generated at this time will be helpful to the SLT. Many of the existing monitoring sites will benefit multiple Targeted Areas.

Below is a summary of site placement (existing and proposed) to support BMP evaluation in the targeted areas:

- The *Cropland Targeted Area* can utilize KDHE sampling sites 208 and 559 for sediment determination for the lower section of the targeted area. Additional monitoring could be added at the endpoint of each HUC 12 in order to determine changes in each HUC. These would be:
  - Site X1 – Marmaton River as it exits the HUC. 102901040102.
  - Site X2 – Marmaton River as it exits the HUC. 102901040103.
  - Site X3 – Marmaton River as it exits the HUC. 102901040107.
  - Site X4 - Marmaton River as it exits the HUC. 102901040108.
- The *Livestock Targeted Area* can utilize the same existing sampling sites as the cropland monitoring sites. These are site numbers 208 and 559. Additional lake monitoring site in Lake Crawford (LM11101) would be utilized. Additional monitoring could be added at the endpoint of each HUC 12 in order to determine changes in each HUC. These would be:
  - Site X1 – Marmaton River as it exits the HUC. 102901040102.
  - Site X2 – Marmaton River as it exits the HUC. 102901040103.
  - Site X3 – Marmaton River as it exits the HUC. 102901040107.
  - Site X4 - Marmaton River as it exits the HUC. 102901040108.
- The *High Priority Targeted Area* will utilize the same sampling sites as the Livestock Targeted Area. These are site numbers 208 and 559. Additional lake monitoring site in Lake Crawford (LM11101) would be utilized. Additional monitoring could be added at the endpoint of each HUC 12 in order to determine changes in each HUC. These would be:
  - Site X1 – Marmaton River as it exits the HUC. 102901040102.
  - Site X2 – Marmaton River as it exits the HUC. 102901040103.
  - Site X3 – Marmaton River as it exits the HUC. 102901040107.
  - Site X4 - Marmaton River as it exits the HUC. 102901040108.

Analysis of the data generated will be used to determine effectiveness of implemented BMPs. The SLT would like to add future sampling sites as funding allows. These are listed in Section 7 of this report. All KDHE and KSU data will be shared with the SLT and can then be passed on to the watershed residents by way of the information and education efforts discussed previously.

Monitoring data will be used to direct the SLT in their evaluation of water quality progress. KDHE will be requested to meet with the SLT to review the monitoring data trends accumulated by their sites as available. However, the overall strategy and alterations of the WRAPS plan will be discussed with KDHE immediately after each update of the 303d list and subsequent TMDL designation. The upcoming years for this in the Marmaton Watershed is 2012 and 2017. At this time, the plan can be altered or modified in order to meet the water quality goals as assigned by the SLT in the beginning of the WRAPS process.

12.0 Review of the Watershed Plan in 2016

This plan will begin in 2011. In the year 2016, the plan will be reviewed and revised according to results acquired from monitoring data and TMDL revision. At this time, the SLT will review the following criteria in addition to any other concerns that may occur at that time:

1. The SLT will ask KDHE for a report on the milestone achievements in **sediment** load reductions. The 2016 milestone for sediment should be based on the available data at the time in the trend of total suspended solids concentration in the watershed.
2. The SLT will request from KDHE a report on the milestone achievements in **phosphorus** load reductions. The 2016 milestone for phosphorus should be based on the available data at the time in the trend of phosphorus concentration in the watershed.
3. The SLT will request from KDHE a report on the milestone achievements in **nitrogen** load reductions. The 2016 milestone for nitrogen should be based on the available data at the time in the trend of nitrogen concentration in the watershed.
4. The SLT will request a report from KDHE concerning the revisions of the TMDLs from 2012.
5. The SLT will request a report from KDHE and Kansas Department of Wildlife and Parks on trends in water quality in watershed lakes and reservoirs.
6. The SLT will report on progress towards achieving the adoption rates listed in Section 10.1 of this report.
7. The SLT will report on progress towards achieving the benchmarks listed in Section 10.2 of this report.
8. The SLT will report on progress towards achieving the milestones in Section 10.3 of this report.
9. The SLT will discuss impairments on the 303d list and the possibility of addressing these impairments prior to them being listed as TMDLs.
10. The SLT will discuss the effect of implementing BMPs aimed at specific TMDLs on the impairments listed on the 303d list.
11. The SLT will discuss necessary adjustments and revisions needed in the targets listed in this plan.

13.0 Appendix

13.1 Service Providers

Table 79. Potential Service Provider Listing.

Organization	Programs	Purpose	Technical or Financial Assistance	Website address
Environmental Protection Agency	Clean Water State Revolving Fund Program Watershed Protection	Provides low cost loans to communities for water pollution control activities. To conduct holistic strategies for restoring and protecting aquatic resources based on hydrology rather than political boundaries.	Financial	www.epa.gov
Kansas Alliance for Wetlands and Streams	Streambank Stabilization Wetland Restoration Cost share programs	The Kansas Alliance for Wetlands and Streams (KAWS) organized in 1996 to promote the protection, enhancement, restoration and establishment wetlands and streams in Kansas.	Technical	www.kaws.org
Kansas Dept. of Agriculture	Watershed structures permitting.	Available for watershed districts and multipurpose small lakes development.	Technical and Financial	www.accesskansas.org/kda

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Website address
Kansas Dept. of Health and Environment	**Nonpoint Source Pollution Program** Municipal and livestock waste Livestock waste Municipal waste State Revolving Loan Fund	Provide funds for projects that will reduce nonpoint source pollution. Compliance monitoring. Makes low interest loans for projects to improve and protect water quality.	Technical and Financial	www.kdheks.gov

Kansas Department of Wildlife and Parks	Land and Water Conservation Funds Conservation Easements for Riparian and Wetland Areas Wildlife Habitat Improvement Program North American Waterfowl Conservation Act MARSH program in coordination with Ducks Unlimited Chickadee Checkoff Walk In Hunting Program F.I.S.H. Program	Provides funds to preserve develop and assure access to outdoor recreation. To provide easements to secure and enhance quality areas in the state. To provide limited assistance for development of wildlife habitat. To provide up to 50 percent cost share for the purchase and/or development of wetlands and wildlife habitat. May provide up to 100 percent of funding for small wetland projects. Projects help with all nongame species. Funding is an optional donation line item on the KS Income Tax form. Landowners receive a payment incentive to allow public hunting on their property. Landowners receive a payment incentive to allow public fishing access to their ponds and streams.	Technical and Financial	www.kdwp.state.ks.us/

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Website address
Kansas Forest Service	Conservation Tree Planting Program Riparian and Wetland Protection Program	Provides low cost trees and shrubs for conservation plantings. Work closely with other agencies to promote and assist with establishment of riparian forestland and manage existing stands.	Technical	www.kansasforests.org
Kansas Rural Center	The Heartland Network Clean Water Farms-River Friendly Farms Sustainable Food Systems Project Cost share programs	The Center is committed to economically viable, environmentally sound and socially sustainable rural culture.	Technical and Financial	www.kansasruralcenter.org
Kansas Rural Water Association	Technical assistance for Water Systems with Source Water Protection Planning.	Provide education, technical assistance and leadership to public water and wastewater utilities to enhance the public health and to sustain Kansas' communities	Technical	www.krwa.net

Kansas State Research and Extension	Water Quality Programs, Waste Management Programs Kansas Center for Agricultural Resources and Environment (KCARE) Kansas Environmental Leadership Program (KELP) Kansas Local Government Water Quality Planning and Management Rangeland and Natural Area Services (RNAS) WaterLINK Kansas Pride: Healthy Ecosystems/Healthy Communities Citizen Science	Provide programs, expertise and educational materials that relate to minimizing the impact of rural and urban activities on water quality. Educational program to develop leadership for improved water quality. Provide guidance to local governments on water protection programs. Reduce non-point source pollution emanating from Kansas grasslands. Service-learning projects available to college and university faculty and community watersheds in Kansas. Help citizens appraise their local natural resources and develop short and long term plans and activities to protect, sustain and restore their resources for the future. Education combined with volunteer soil and water testing for enhanced natural resource stewardship.	Technical	www.kcare.ksu.edu www.ksu.edu/kelp www.ksu.edu/olg www.k-state.edu/waterlink/ www.kansasprideprogram.ksu.edu/healthyecosystems/ www.ksu.edu/kswater/

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Website address
Kansas Water Office	Public Information and Education	Provide information and education to the public on Kansas Water Resources	Technical and Financial	www.kwo.org
No-Till on the Plains	Field days, seasonal meetings, tours and technical consulting.	Provide information and assistance concerning continuous no-till farming practices.	Technical	www.notill.org
Pittsburg State University	Provide water quality monitoring and analysis.	Water quality monitoring	Technical	www.pittstate.edu
See-Kan RC&D	Natural resource development and protection.	Plan and implement projects and programs that improve environmental quality of life.	Technical	www.ks.nrcs.usda.gov

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Website address
State Conservation Commission and Conservation Districts	Water Resources Cost Share	Provide cost share assistance to landowners for establishment of water conservation practices.	Technical and Financial	www.accesskansas.org/kscc www.kacdnet.org
	Nonpoint Source Pollution Control Fund	Provides financial assistance for nonpoint pollution control projects which help restore water quality.		
	Riparian and Wetland Protection Program	Funds to assist with wetland and riparian development and enhancement.		
	Stream Rehabilitation Program	Assist with streams that have been adversely altered by channel modifications.		
	Kansas Water Quality Buffer Initiative	Compliments Conservation Reserve Program by offering additional financial incentives for grass filters and riparian forest buffers.		
	Watershed district and multipurpose lakes	Programs are available for watershed district and multipurpose small lakes.		

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Website address
US Army Corps of Engineers	Planning Assistance to States Environmental Restoration	Assistance in development of plans for development, utilization and conservation of water and related land resources of drainage Funding assistance for aquatic ecosystem restoration.	Technical	www.usace.army.mil
US Fish and Wildlife Service	Fish and Wildlife Enhancement Program Private Lands Program	Supports field operations which include technical assistance on wetland design. Contracts to restore, enhance, or create wetlands.	Technical	www.fws.gov
US Geological Survey	National Streamflow Information Program Water Cooperative Program	Provide streamflow data Provide cooperative studies and water-quality information	Technical	ks.water.usgs.gov Nrtwq.usgs.gov

Organization	**Programs and Technical Assistance**	**Purpose**	Technical or Financial Assistance	**Website address**
USDA-Natural Resources Conservation Service and Farm Service Agency	Conservation Compliance Conservation Operations Watershed Planning and Operations Wetland Reserve Program Wildlife Habitat Incentives Program Grassland Reserve Program, EQIP, and Conservation Reserve Program	Primarily for the technical assistance to develop conservation plans on cropland. To provide technical assistance on private land for development and application of Resource Management Plans. Primarily focused on high priority areas where agricultural improvements will meet water quality objectives. Cost share and easements to restore wetlands. Cost share to establish wildlife habitat which includes wetlands and riparian areas. Improve and protect rangeland resources with cost-sharing practices, rental agreements, and easement purchases.	Technical and Financial	www.ks.nrcs.usda.gov

13.2 BMP Definitions

(Reduction explanations are provided on pages 88-89)

Cropland

Establish Permanent Vegetation
The cost of $150 an acre was calculated based on K-State Research and Extension estimates of the cost of planting and maintaining native grass.

Grassed Waterway
-Grassed strip used as an outlet to prevent silt and gully formation.
-Can also be used as outlets for water from terraces.
-On average for Kansas fields, 1 acre waterway will treat 10 acres of cropland.
-40% erosion reduction efficiency, 40% phosphorous reduction efficiency.
-$800 an acre, 50% cost-share available from NRCS.

No-Till
-A management system in which chemicals may be used for weed control and seedbed preparation.
-The soil surface is never disturbed except for planting or drilling operations in a 100% no-till system.
-75% erosion reduction efficiency, 40% phosphorous reduction efficiency.
-WRAPS groups and KSU Ag Economists have decided $10 an acre for 10 years is an adequate payment to entice producers to convert, 50% cost-share available from NRCS.

Vegetative Buffer
-Area of field maintained in permanent vegetation to help reduce nutrient and sediment loss from agricultural fields, improve runoff water quality, and provide habitat for wildlife.
-On average for Kansas fields, 1 acre buffer treats 15 acres of cropland.
-50% erosion reduction efficiency, 50% phosphorous reduction efficiency
-Approx. $1,000/acre, 90% cost-share available from NRCS.

Conservation Crop Rotation
-Growing various crops on the same piece of land in a planned rotation.
-High residue crops (corn) with low residue crops (wheat, soybeans).
-Low residue crops in succession may encourage erosion.
-25% Erosion Reduction Efficiency, 25% phosphorous reduction efficiency
-WRAPS groups and KSU Ag Economists have decided $5 an acre for 10 years is an adequate payment to entice producers to convert.

Terraces
-Earth embankment and/or channel constructed across the slope to intercept runoff water and trap soil.

-One of the oldest/most common BMPs
-30% Erosion Reduction Efficiency, 30% phosphorous reduction efficiency
-$1.02 per linear foot, 50% cost-share available from NRCS

Livestock

Vegetative Filter Strip
-A vegetated area that receives runoff during rainfall from an animal feeding operation.
-Often require a land area equal to or greater than the drainage area (needs to be as large as the feedlot).
-10 year lifespan, requires periodic mowing or haying, average P reduction: 50%.
-$714 an acre

Relocate Feeding Pens
Feeding Pens- Move feedlot or pens away from a stream, waterway, or body of water to increase filtration and waste removal of manure. Highly variable in price, average of $6,600 per unit (1 unit equals 1 acre, 100 AU pen).
-Pasture- Move feeding site that is in a pasture away from a stream, waterway, or body of water to increase the filtration and waste removal (eg. move bale feeders away from stream). Highly variable in price, average of $2,203 per unit (1 unit equals 1 acre, 100 AU pen).
-Average P reduction: 30-80%

Relocate Feeding Sites
-Feedlot- Move feedlot or pens away from a stream, waterway, or body of water to increase filtration and waste removal of manure. Highly variable in price, average of $6,600 per unit.
-Pasture- Move feeding site that is in a pasture away from a stream, waterway, or body of water to increase the filtration and waste removal (eg. move bale feeders away from stream). Highly variable in price, average of $2,203 per unit.
-Average P reduction: 30-80%

Alternative (Off-Stream) Watering System
-Watering system so that livestock do not enter stream or body of water.
-Studies show cattle will drink from tank over a stream or pond 80% of the time.
-10-25 year lifespan, average P reduction: 30-98% with greater efficiencies for limited stream access.
-$3,795 installed for solar system, including present value of maintenance costs.

Stream Fencing
-Fencing out streams and ponds to prevent livestock from entering.
-95% P Reduction.
-25 year life expectancy.
-Approximately $4,106 per ¼ mile of fence, including labor, materials, and maintenance.

Rotational Grazing

-Rotating livestock within a pasture to spread manure more uniformly and allow grass to regenerate.

-May involve significant cross fencing and additional watering sites.

-50-75% P Reduction.

-Approximately $7,000 with complex systems significantly more expensive.

13.3 Sub Watershed Tables

Load reductions, adoption rates and costs by individual sub watersheds are provided for the Cropland Targeted Area only. Livestock projects are minimal and as such the SLT has determined that projects can be installed in any area of the Livestock Targeted Area. Therefore, these sub watersheds are not listed in this section.

13.3.1 Load Reduction Rates by Sub Watershed

Table 80. Sediment Reduction Rates by Sub Watershed.

Sub-Watershed #2 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	0.7	0.7	1.3	0.9	0.4	0.5	**5**
2	1	1	3	2	1	1	**9**
3	2	2	4	3	1	2	**14**
4	3	3	5	4	2	2	**18**
5	3	4	7	4	2	3	**23**
6	4	4	8	5	3	3	**28**
7	5	5	9	6	3	4	**32**
8	5	6	11	7	4	4	**37**
9	6	6	12	8	4	5	**41**
10	7	7	13	9	4	5	**46**
11	7	8	15	10	5	6	**51**
12	8	9	16	11	5	6	**55**
13	9	9	17	12	6	7	**60**
14	9	10	19	12	6	7	**64**
15	10	11	20	13	7	8	**69**
16	11	11	21	14	7	9	**74**
17	12	12	23	15	8	9	**78**
18	12	13	24	16	8	10	**83**
19	13	14	25	17	8	10	**87**
20	14	14	27	18	9	11	**92**

Sub-Watershed #3 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	2.6	2.7	5.1	3.4	1.7	2.0	**18**

2	5	5	10	7	3	4	**35**
3	8	8	15	10	5	6	**53**
4	10	11	20	14	7	8	**70**
5	13	14	26	17	9	10	**88**
6	16	16	31	20	10	12	**106**
7	18	19	36	24	12	14	**123**
8	21	22	41	27	14	16	**141**
9	23	25	46	31	15	18	**158**
10	26	27	51	34	17	20	**176**
11	29	30	56	38	19	23	**194**
12	31	33	61	41	20	25	**211**
13	34	35	67	44	22	27	**229**
14	36	38	72	48	24	29	**247**
15	39	41	77	51	26	31	**264**
16	41	44	82	55	27	33	**282**
17	44	46	87	58	29	35	**299**
18	47	49	92	61	31	37	**317**
19	49	52	97	65	32	39	**335**
20	52	55	102	68	34	41	**352**

Sub-Watershed #7 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	1.2	1.3	2.4	1.6	0.8	1.0	**8**
2	2	3	5	3	2	2	**16**
3	4	4	7	5	2	3	**25**
4	5	5	10	6	3	4	**33**
5	6	6	12	8	4	5	**41**
6	7	8	14	10	5	6	**49**
7	8	9	17	11	6	7	**58**
8	10	10	19	13	6	8	**66**
9	11	11	22	14	7	9	**74**
10	12	13	24	16	8	10	**82**
11	13	14	26	18	9	11	**90**
12	15	15	29	19	10	11	**99**
13	16	17	31	21	10	12	**107**
14	17	18	33	22	11	13	**115**
15	18	19	36	24	12	14	**123**
16	19	20	38	25	13	15	**132**
17	21	22	41	27	14	16	**140**
18	22	23	43	29	14	17	**148**
19	23	24	45	30	15	18	**156**

20	24	25	48	32	16	19	**164**

Sub-Watershed #8 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	3.0	3.1	5.9	3.9	2.0	2.4	**20**
2	6	6	12	8	4	5	**41**
3	9	9	18	12	6	7	**61**
4	12	13	24	16	8	9	**81**
5	15	16	29	20	10	12	**101**
6	18	19	35	24	12	14	**122**
7	21	22	41	28	14	17	**142**
8	24	25	47	31	16	19	**162**
9	27	28	53	35	18	21	**182**
10	30	31	59	39	20	24	**203**
11	33	35	65	43	22	26	**223**
12	36	38	71	47	24	28	**243**
13	39	41	77	51	26	31	**264**
14	42	44	83	55	28	33	**284**
15	45	47	88	59	29	35	**304**
16	48	50	94	63	31	38	**324**
17	51	53	100	67	33	40	**345**
18	54	57	106	71	35	42	**365**
19	57	60	112	75	37	45	**385**
20	60	63	118	79	39	47	**405**

Table 81. Phosphorus and Phosphorus Reduction Rates by Sub Watershed.

Sub-Watershed #2 Annual Phosphorous Reduction (pounds), Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	2	2	2	2	1	1	**9**
2	3	3	3	4	2	2	**18**
3	5	5	5	6	3	4	**27**
4	6	6	6	8	4	5	**36**
5	8	8	8	10	5	6	**45**
6	9	10	10	12	6	7	**54**
7	11	11	11	14	7	9	**63**
8	12	13	13	16	8	10	**72**
9	14	15	15	18	9	11	**81**
10	15	16	16	20	10	12	**90**
11	17	18	18	22	11	13	**99**

12	18	19	19	24	12	15	**108**
13	20	21	21	26	13	16	**117**
14	22	23	23	28	14	17	**126**
15	23	24	24	30	15	18	**135**
16	25	26	26	32	16	19	**145**
17	26	28	28	34	17	21	**154**
18	28	29	29	36	18	22	**163**
19	29	31	31	38	19	23	**172**
20	31	32	32	41	20	24	**181**

Sub-Watershed #3 Annual Phosphorous Reduction (pounds), Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	9	9	9	11	6	7	**50**
2	17	18	18	22	11	13	**100**
3	26	27	27	34	17	20	**150**
4	34	36	36	45	22	27	**200**
5	43	45	45	56	28	34	**250**
6	51	54	54	67	34	40	**300**
7	60	63	63	78	39	47	**350**
8	68	72	72	90	45	54	**400**
9	77	81	81	101	50	61	**450**
10	85	90	90	112	56	67	**500**
11	94	99	99	123	62	74	**550**
12	102	108	108	135	67	81	**600**
13	111	117	117	146	73	87	**650**
14	119	126	126	157	78	94	**700**
15	128	135	135	168	84	101	**750**
16	136	144	144	179	90	108	**800**
17	145	152	152	191	95	114	**850**
18	153	161	161	202	101	121	**900**
19	162	170	170	213	107	128	**950**
20	170	179	179	224	112	135	**1,000**

Sub-Watershed #7 Annual Phosphorous Reduction (pounds), Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	3	3	3	4	2	3	**19**
2	7	7	7	9	4	5	**39**
3	10	10	10	13	6	8	**58**
4	13	14	14	17	9	10	**77**

5	16	17	17	22	11	13	**96**
6	20	21	21	26	13	16	**116**
7	23	24	24	30	15	18	**135**
8	26	28	28	35	17	21	**154**
9	30	31	31	39	19	23	**174**
10	33	35	35	43	22	26	**193**
11	36	38	38	48	24	29	**212**
12	39	42	42	52	26	31	**231**
13	43	45	45	56	28	34	**251**
14	46	48	48	61	30	36	**270**
15	49	52	52	65	32	39	**289**
16	53	55	55	69	35	42	**309**
17	56	59	59	74	37	44	**328**
18	59	62	62	78	39	47	**347**
19	62	66	66	82	41	49	**366**
20	66	69	69	86	43	52	**386**

Sub-Watershed #8 Annual Phosphorous Reduction (pounds), Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	7	8	8	10	5	6	**43**
2	15	15	15	19	10	12	**86**
3	22	23	23	29	14	17	**128**
4	29	31	31	38	19	23	**171**
5	36	38	38	48	24	29	**214**
6	44	46	46	58	29	35	**257**
7	51	54	54	67	34	40	**299**
8	58	61	61	77	38	46	**342**
9	66	69	69	86	43	52	**385**
10	73	77	77	96	48	58	**428**
11	80	84	84	105	53	63	**470**
12	87	92	92	115	58	69	**513**
13	95	100	100	125	62	75	**556**
14	102	107	107	134	67	81	**599**
15	109	115	115	144	72	86	**641**
16	117	123	123	153	77	92	**684**
17	124	130	130	163	81	98	**727**
18	131	138	138	173	86	104	**770**
19	138	146	146	182	91	109	**812**
20	146	153	153	192	96	115	**855**

Sub-Watershed #2 Annual Nitrogen Reduction (pounds), Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	14	14	9	9	9	11	**66**
2	27	29	18	18	18	21	**131**
3	41	43	27	27	27	32	**197**
4	54	57	36	36	36	43	**262**
5	68	72	45	45	45	54	**328**
6	82	86	54	54	54	64	**393**
7	95	100	63	63	63	75	**459**
8	109	115	72	72	72	86	**524**
9	122	129	81	81	81	97	**590**
10	136	143	90	90	90	107	**655**
11	150	158	98	98	98	118	**721**
12	163	172	107	107	107	129	**786**
13	177	186	116	116	116	140	**852**
14	190	200	125	125	125	150	**917**
15	204	215	134	134	134	161	**983**
16	218	229	143	143	143	172	**1,048**
17	231	243	152	152	152	183	**1,114**
18	245	258	161	161	161	193	**1,179**
19	258	272	170	170	170	204	**1,245**
20	272	286	179	179	179	215	**1,310**

Sub-Watershed #3 Annual Nitrogen Reduction (pounds), Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	75	79	49	49	49	59	**362**
2	150	158	99	99	99	119	**723**
3	225	237	148	148	148	178	**1,085**
4	300	316	198	198	198	237	**1,446**
5	375	395	247	247	247	296	**1,808**
6	451	474	296	296	296	356	**2,170**
7	526	553	346	346	346	415	**2,531**
8	601	632	395	395	395	474	**2,893**
9	676	711	445	445	445	534	**3,254**
10	751	790	494	494	494	593	**3,616**
11	826	869	543	543	543	652	**3,978**
12	901	948	593	593	593	711	**4,339**
13	976	1,028	642	642	642	771	**4,701**
14	1,051	1,107	692	692	692	830	**5,063**
15	1,126	1,186	741	741	741	889	**5,424**

16	1,201	1,265	790	790	790	948	**5,786**
17	1,276	1,344	840	840	840	1,008	**6,147**
18	1,352	1,423	889	889	889	1,067	**6,509**
19	1,427	1,502	939	939	939	1,126	**6,871**
20	1,502	1,581	988	988	988	1,186	**7,232**

Sub-Watershed #7 Annual Nitrogen Reduction (pounds), Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	23	25	15	15	15	18	**112**
2	47	49	31	31	31	37	**225**
3	70	74	46	46	46	55	**337**
4	93	98	61	61	61	74	**450**
5	117	123	77	77	77	92	**562**
6	140	147	92	92	92	111	**675**
7	163	172	108	108	108	129	**787**
8	187	197	123	123	123	147	**900**
9	210	221	138	138	138	166	**1,012**
10	234	246	154	154	154	184	**1,125**
11	257	270	169	169	169	203	**1,237**
12	280	295	184	184	184	221	**1,349**
13	304	320	200	200	200	240	**1,462**
14	327	344	215	215	215	258	**1,574**
15	350	369	230	230	230	277	**1,687**
16	374	393	246	246	246	295	**1,799**
17	397	418	261	261	261	313	**1,912**
18	420	442	277	277	277	332	**2,024**
19	444	467	292	292	292	350	**2,137**
20	467	492	307	307	307	369	**2,249**

Sub-Watershed #8 Annual Nitrogen Reduction (pounds), Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Load Reduction
1	48	50	32	32	32	38	**231**
2	96	101	63	63	63	76	**461**
3	144	151	95	95	95	113	**692**
4	192	202	126	126	126	151	**923**
5	239	252	158	158	158	189	**1,153**
6	287	302	189	189	189	227	**1,384**
7	335	353	221	221	221	265	**1,614**
8	383	403	252	252	252	302	**1,845**

9	431	454	284	284	284	340	**2,076**
10	479	504	315	315	315	378	**2,306**
11	527	555	347	347	347	416	**2,537**
12	575	605	378	378	378	454	**2,768**
13	623	655	410	410	410	492	**2,998**
14	671	706	441	441	441	529	**3,229**
15	718	756	473	473	473	567	**3,460**
16	766	807	504	504	504	605	**3,690**
17	814	857	536	536	536	643	**3,921**
18	862	907	567	567	567	681	**4,152**
19	910	958	599	599	599	718	**4,382**
20	958	1,008	630	630	630	756	**4,613**

13.3.2 Adoption Rates by Sub Watershed

Table 82. Short, Medium and Long Term Goals by Sub Watershed.

Sub-Watershed #2 Annual Adoption (treated acres), Cropland BMPs

	Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Adoption
Short-Term	1	3	8	8	8	8	8	44
	2	3	8	8	8	8	8	44
	3	3	8	8	8	8	8	44
	4	3	8	8	8	8	8	44
	5	3	8	8	8	8	8	44
	Total	*16*	*41*	*41*	*41*	*41*	*41*	*219*
Medium-Term	6	3	8	8	8	8	8	44
	7	3	8	8	8	8	8	44
	8	3	8	8	8	8	8	44
	9	3	8	8	8	8	8	44
	10	3	8	8	8	8	8	44
	Total	*32*	*81*	*81*	*81*	*81*	*81*	*437*
Long-Term	11	3	8	8	8	8	8	44
	12	3	8	8	8	8	8	44
	13	3	8	8	8	8	8	44
	14	3	8	8	8	8	8	44
	15	3	8	8	8	8	8	44
	16	3	8	8	8	8	8	44
	17	3	8	8	8	8	8	44
	18	3	8	8	8	8	8	44
	19	3	8	8	8	8	8	44
	20	3	8	8	8	8	8	44

	Total	*65*	*162*	*162*	*162*	*162*	*162*	*875*

Sub-Watershed #3 Annual Adoption (treated acres), Cropland BMPs

	Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Adoption
Short-Term	1	13	33	33	33	33	33	176
	2	13	33	33	33	33	33	176
	3	13	33	33	33	33	33	176
	4	13	33	33	33	33	33	176
	5	13	33	33	33	33	33	176
	Total	*65*	*163*	*163*	*163*	*163*	*163*	*878*
Medium-Term	6	13	33	33	33	33	33	176
	7	13	33	33	33	33	33	176
	8	13	33	33	33	33	33	176
	9	13	33	33	33	33	33	176
	10	13	33	33	33	33	33	176
	Total	*130*	*325*	*325*	*325*	*325*	*325*	*1,755*
Long-Term	11	13	33	33	33	33	33	176
	12	13	33	33	33	33	33	176
	13	13	33	33	33	33	33	176
	14	13	33	33	33	33	33	176
	15	13	33	33	33	33	33	176
	16	13	33	33	33	33	33	176
	17	13	33	33	33	33	33	176
	18	13	33	33	33	33	33	176
	19	13	33	33	33	33	33	176
	20	13	33	33	33	33	33	176
	Total	*260*	*650*	*650*	*650*	*650*	*650*	*3,510*

Sub-Watershed #7 Annual Adoption (treated acres), Cropland BMPs

	Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Adoption
Short-Term	1	6	15	15	15	15	15	82
	2	6	15	15	15	15	15	82
	3	6	15	15	15	15	15	82
	4	6	15	15	15	15	15	82
	5	6	15	15	15	15	15	82
	Total	*30*	*76*	*76*	*76*	*76*	*76*	*410*
Medium-Term	6	6	15	15	15	15	15	82
	7	6	15	15	15	15	15	82
	8	6	15	15	15	15	15	82
	9	6	15	15	15	15	15	82

	10	6	15	15	15	15	15	82
	Total	*61*	*152*	*152*	*152*	*152*	*152*	*819*
Long-Term	11	6	15	15	15	15	15	82
	12	6	15	15	15	15	15	82
	13	6	15	15	15	15	15	82
	14	6	15	15	15	15	15	82
	15	6	15	15	15	15	15	82
	16	6	15	15	15	15	15	82
	17	6	15	15	15	15	15	82
	18	6	15	15	15	15	15	82
	19	6	15	15	15	15	15	82
	20	6	15	15	15	15	15	82
	Total	*121*	*303*	*303*	*303*	*303*	*303*	*1,639*

Sub-Watershed #8 Annual Adoption (treated acres), Cropland BMPs

	Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Adoption
Short-Term	1	13	31	31	31	31	31	170
	2	13	31	31	31	31	31	170
	3	13	31	31	31	31	31	170
	4	13	31	31	31	31	31	170
	5	13	31	31	31	31	31	170
	Total	*63*	*157*	*157*	*157*	*157*	*157*	*849*
Medium-Term	6	13	31	31	31	31	31	170
	7	13	31	31	31	31	31	170
	8	13	31	31	31	31	31	170
	9	13	31	31	31	31	31	170
	10	13	31	31	31	31	31	170
	Total	*126*	*314*	*314*	*314*	*314*	*314*	*1,697*
Long-Term	11	13	31	31	31	31	31	170
	12	13	31	31	31	31	31	170
	13	13	31	31	31	31	31	170
	14	13	31	31	31	31	31	170
	15	13	31	31	31	31	31	170
	16	13	31	31	31	31	31	170
	17	13	31	31	31	31	31	170
	18	13	31	31	31	31	31	170
	19	13	31	31	31	31	31	170
	20	13	31	31	31	31	31	170
	Total	*251*	*629*	*629*	*629*	*629*	*629*	*3,394*

13.3.3 Costs by Sub Watershed

Table 83. Costs Before Cost Share by Sub Watershed.

Sub-Watershed #2 Annual Cost* Before Cost-Share, Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Cost
1	$486	$1,296	$629	$540	$316	$826	**$4,093**
2	$501	$1,335	$648	$556	$325	$851	**$4,216**
3	$516	$1,375	$668	$573	$335	$877	**$4,343**
4	$531	$1,416	$688	$590	$345	$903	**$4,473**
5	$547	$1,459	$708	$608	$356	$930	**$4,607**
6	$563	$1,502	$730	$626	$366	$958	**$4,745**
7	$580	$1,547	$751	$645	$377	$987	**$4,888**
8	$598	$1,594	$774	$664	$389	$1,016	**$5,034**
9	$616	$1,642	$797	$684	$400	$1,047	**$5,185**
10	$634	$1,691	$821	$705	$412	$1,078	**$5,341**
11	$653	$1,742	$846	$726	$425	$1,110	**$5,501**
12	$673	$1,794	$871	$747	$437	$1,144	**$5,666**
13	$693	$1,848	$897	$770	$450	$1,178	**$5,836**
14	$714	$1,903	$924	$793	$464	$1,213	**$6,011**
15	$735	$1,960	$952	$817	$478	$1,250	**$6,192**
16	$757	$2,019	$980	$841	$492	$1,287	**$6,377**
17	$780	$2,080	$1,010	$867	$507	$1,326	**$6,569**
18	$803	$2,142	$1,040	$893	$522	$1,366	**$6,766**
19	$827	$2,206	$1,071	$919	$538	$1,407	**$6,969**
20	$852	$2,273	$1,103	$947	$554	$1,449	**$7,178**

**3% Inflation*

Sub-Watershed #3 Annual Cost* Before Cost-Share, Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Cost
1	$1,950	$5,200	$2,525	$2,167	$1,268	$3,315	**$16,424**
2	$2,009	$5,356	$2,601	$2,232	$1,306	$3,414	**$16,917**
3	$2,069	$5,517	$2,679	$2,299	$1,345	$3,517	**$17,424**
4	$2,131	$5,682	$2,759	$2,368	$1,385	$3,622	**$17,947**
5	$2,195	$5,853	$2,842	$2,439	$1,427	$3,731	**$18,485**
6	$2,261	$6,028	$2,927	$2,512	$1,469	$3,843	**$19,040**
7	$2,328	$6,209	$3,015	$2,587	$1,513	$3,958	**$19,611**
8	$2,398	$6,395	$3,105	$2,665	$1,559	$4,077	**$20,200**
9	$2,470	$6,587	$3,198	$2,745	$1,606	$4,199	**$20,806**

10	$2,544	$6,785	$3,294	$2,827	$1,654	$4,325	**$21,430**
11	$2,621	$6,988	$3,393	$2,912	$1,703	$4,455	**$22,073**
12	$2,699	$7,198	$3,495	$2,999	$1,755	$4,589	**$22,735**
13	$2,780	$7,414	$3,600	$3,089	$1,807	$4,726	**$23,417**
14	$2,864	$7,636	$3,708	$3,182	$1,861	$4,868	**$24,119**
15	$2,950	$7,865	$3,819	$3,277	$1,917	$5,014	**$24,843**
16	$3,038	$8,101	$3,934	$3,376	$1,975	$5,165	**$25,588**
17	$3,129	$8,344	$4,052	$3,477	$2,034	$5,320	**$26,356**
18	$3,223	$8,595	$4,173	$3,581	$2,095	$5,479	**$27,147**
19	$3,320	$8,853	$4,299	$3,689	$2,158	$5,644	**$27,961**
20	$3,419	$9,118	$4,427	$3,799	$2,223	$5,813	**$28,800**

**3% Inflation*

Sub-Watershed #7 Annual Cost* Before Cost-Share, Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Cost
1	$910	$2,428	$1,179	$1,012	$592	$1,548	**$7,668**
2	$938	$2,500	$1,214	$1,042	$609	$1,594	**$7,898**
3	$966	$2,575	$1,251	$1,073	$628	$1,642	**$8,134**
4	$995	$2,653	$1,288	$1,105	$647	$1,691	**$8,379**
5	$1,025	$2,732	$1,327	$1,138	$666	$1,742	**$8,630**
6	$1,055	$2,814	$1,366	$1,173	$686	$1,794	**$8,889**
7	$1,087	$2,899	$1,407	$1,208	$707	$1,848	**$9,155**
8	$1,120	$2,986	$1,450	$1,244	$728	$1,903	**$9,430**
9	$1,153	$3,075	$1,493	$1,281	$750	$1,960	**$9,713**
10	$1,188	$3,167	$1,538	$1,320	$772	$2,019	**$10,004**
11	$1,223	$3,262	$1,584	$1,359	$795	$2,080	**$10,305**
12	$1,260	$3,360	$1,632	$1,400	$819	$2,142	**$10,614**
13	$1,298	$3,461	$1,681	$1,442	$844	$2,207	**$10,932**
14	$1,337	$3,565	$1,731	$1,485	$869	$2,273	**$11,260**
15	$1,377	$3,672	$1,783	$1,530	$895	$2,341	**$11,598**
16	$1,418	$3,782	$1,836	$1,576	$922	$2,411	**$11,946**
17	$1,461	$3,896	$1,892	$1,623	$950	$2,483	**$12,304**
18	$1,505	$4,012	$1,948	$1,672	$978	$2,558	**$12,673**
19	$1,550	$4,133	$2,007	$1,722	$1,007	$2,635	**$13,053**
20	$1,596	$4,257	$2,067	$1,774	$1,038	$2,714	**$13,445**

**3% Inflation*

Sub-Watershed #8 Annual Cost* Before Cost-Share, Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Cost
1	$1,886	$5,029	$2,442	$2,095	$1,226	$3,206	**$15,883**
2	$1,942	$5,180	$2,515	$2,158	$1,263	$3,302	**$16,360**
3	$2,001	$5,335	$2,591	$2,223	$1,300	$3,401	**$16,851**
4	$2,061	$5,495	$2,668	$2,290	$1,339	$3,503	**$17,356**
5	$2,122	$5,660	$2,748	$2,358	$1,380	$3,608	**$17,877**
6	$2,186	$5,830	$2,831	$2,429	$1,421	$3,716	**$18,413**
7	$2,252	$6,005	$2,916	$2,502	$1,464	$3,828	**$18,966**
8	$2,319	$6,185	$3,003	$2,577	$1,508	$3,943	**$19,535**
9	$2,389	$6,370	$3,093	$2,654	$1,553	$4,061	**$20,121**
10	$2,461	$6,561	$3,186	$2,734	$1,599	$4,183	**$20,724**
11	$2,534	$6,758	$3,282	$2,816	$1,647	$4,308	**$21,346**
12	$2,610	$6,961	$3,380	$2,900	$1,697	$4,438	**$21,986**
13	$2,689	$7,170	$3,481	$2,987	$1,748	$4,571	**$22,646**
14	$2,769	$7,385	$3,586	$3,077	$1,800	$4,708	**$23,325**
15	$2,852	$7,607	$3,693	$3,169	$1,854	$4,849	**$24,025**
16	$2,938	$7,835	$3,804	$3,264	$1,910	$4,995	**$24,746**
17	$3,026	$8,070	$3,918	$3,362	$1,967	$5,144	**$25,488**
18	$3,117	$8,312	$4,036	$3,463	$2,026	$5,299	**$26,253**
19	$3,210	$8,561	$4,157	$3,567	$2,087	$5,458	**$27,040**
20	$3,307	$8,818	$4,282	$3,674	$2,149	$5,621	**$27,852**

**3% Inflation*

Table 84. Costs by BMP After Cost Share.

Sub-Watershed #2 Annual Cost* After Cost-Share, Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Cost
1	$243	$648	$384	$54	$316	$413	**$2,058**
2	$250	$667	$395	$56	$325	$425	**$2,120**
3	$258	$687	$407	$57	$335	$438	**$2,183**
4	$266	$708	$419	$59	$345	$451	**$2,249**
5	$273	$729	$432	$61	$356	$465	**$2,316**
6	$282	$751	$445	$63	$366	$479	**$2,386**
7	$290	$774	$458	$64	$377	$493	**$2,457**
8	$299	$797	$472	$66	$389	$508	**$2,531**
9	$308	$821	$486	$68	$400	$523	**$2,607**
10	$317	$845	$501	$70	$412	$539	**$2,685**
11	$327	$871	$516	$73	$425	$555	**$2,766**
12	$336	$897	$531	$75	$437	$572	**$2,849**

13	$346	$924	$547	$77	$450	$589	**$2,934**
14	$357	$952	$564	$79	$464	$607	**$3,022**
15	$368	$980	$581	$82	$478	$625	**$3,113**
16	$379	$1,010	$598	$84	$492	$644	**$3,206**
17	$390	$1,040	$616	$87	$507	$663	**$3,302**
18	$402	$1,071	$634	$89	$522	$683	**$3,401**
19	$414	$1,103	$654	$92	$538	$703	**$3,503**
20	$426	$1,136	$673	$95	$554	$724	**$3,608**

**3% Inflation*

Sub-Watershed #3 Annual Cost* After Cost-Share, Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Cost
1	$975	$2,600	$1,540	$217	$1,268	$1,658	**$8,257**
2	$1,004	$2,678	$1,586	$223	$1,306	$1,707	**$8,505**
3	$1,034	$2,758	$1,634	$230	$1,345	$1,758	**$8,760**
4	$1,065	$2,841	$1,683	$237	$1,385	$1,811	**$9,023**
5	$1,097	$2,926	$1,734	$244	$1,427	$1,866	**$9,293**
6	$1,130	$3,014	$1,786	$251	$1,469	$1,921	**$9,572**
7	$1,164	$3,105	$1,839	$259	$1,513	$1,979	**$9,859**
8	$1,199	$3,198	$1,894	$266	$1,559	$2,039	**$10,155**
9	$1,235	$3,294	$1,951	$274	$1,606	$2,100	**$10,460**
10	$1,272	$3,392	$2,010	$283	$1,654	$2,163	**$10,773**
11	$1,310	$3,494	$2,070	$291	$1,703	$2,228	**$11,097**
12	$1,350	$3,599	$2,132	$300	$1,755	$2,294	**$11,429**
13	$1,390	$3,707	$2,196	$309	$1,807	$2,363	**$11,772**
14	$1,432	$3,818	$2,262	$318	$1,861	$2,434	**$12,125**
15	$1,475	$3,933	$2,330	$328	$1,917	$2,507	**$12,489**
16	$1,519	$4,051	$2,400	$338	$1,975	$2,582	**$12,864**
17	$1,565	$4,172	$2,472	$348	$2,034	$2,660	**$13,250**
18	$1,612	$4,297	$2,546	$358	$2,095	$2,740	**$13,647**
19	$1,660	$4,426	$2,622	$369	$2,158	$2,822	**$14,057**
20	$1,710	$4,559	$2,701	$380	$2,223	$2,906	**$14,478**

**3% Inflation*

Sub-Watershed #7 Annual Cost* After Cost-Share, Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Cost
1	$455	$1,214	$719	$101	$592	$774	**$3,855**
2	$469	$1,250	$741	$104	$609	$797	**$3,970**

3	$483	$1,288	$763	$107	$628	$821	**$4,089**
4	$497	$1,326	$786	$111	$647	$846	**$4,212**
5	$512	$1,366	$809	$114	$666	$871	**$4,338**
6	$528	$1,407	$834	$117	$686	$897	**$4,469**
7	$544	$1,449	$859	$121	$707	$924	**$4,603**
8	$560	$1,493	$884	$124	$728	$952	**$4,741**
9	$577	$1,538	$911	$128	$750	$980	**$4,883**
10	$594	$1,584	$938	$132	$772	$1,010	**$5,029**
11	$612	$1,631	$966	$136	$795	$1,040	**$5,180**
12	$630	$1,680	$995	$140	$819	$1,071	**$5,336**
13	$649	$1,731	$1,025	$144	$844	$1,103	**$5,496**
14	$668	$1,783	$1,056	$149	$869	$1,136	**$5,661**
15	$688	$1,836	$1,088	$153	$895	$1,170	**$5,831**
16	$709	$1,891	$1,120	$158	$922	$1,206	**$6,005**
17	$730	$1,948	$1,154	$162	$950	$1,242	**$6,186**
18	$752	$2,006	$1,188	$167	$978	$1,279	**$6,371**
19	$775	$2,066	$1,224	$172	$1,007	$1,317	**$6,562**
20	$798	$2,128	$1,261	$177	$1,038	$1,357	**$6,759**

**3% Inflation*

Sub-Watershed #8 Annual Cost* After Cost-Share, Cropland BMPs

Year	Permanent Vegetation	Grassed Waterways	No-Till	Vegetative Buffers	Conservation Crop Rotations	Terraces	Total Cost
1	$943	$2,514	$1,489	$210	$1,226	$1,603	**$7,985**
2	$971	$2,590	$1,534	$216	$1,263	$1,651	**$8,225**
3	$1,000	$2,668	$1,580	$222	$1,300	$1,701	**$8,471**
4	$1,030	$2,748	$1,628	$229	$1,339	$1,752	**$8,725**
5	$1,061	$2,830	$1,676	$236	$1,380	$1,804	**$8,987**
6	$1,093	$2,915	$1,727	$243	$1,421	$1,858	**$9,257**
7	$1,126	$3,002	$1,779	$250	$1,464	$1,914	**$9,535**
8	$1,160	$3,092	$1,832	$258	$1,508	$1,971	**$9,821**
9	$1,194	$3,185	$1,887	$265	$1,553	$2,031	**$10,115**
10	$1,230	$3,281	$1,943	$273	$1,599	$2,091	**$10,419**
11	$1,267	$3,379	$2,002	$282	$1,647	$2,154	**$10,731**
12	$1,305	$3,481	$2,062	$290	$1,697	$2,219	**$11,053**
13	$1,344	$3,585	$2,124	$299	$1,748	$2,285	**$11,385**
14	$1,385	$3,692	$2,187	$308	$1,800	$2,354	**$11,726**
15	$1,426	$3,803	$2,253	$317	$1,854	$2,425	**$12,078**
16	$1,469	$3,917	$2,321	$326	$1,910	$2,497	**$12,440**
17	$1,513	$4,035	$2,390	$336	$1,967	$2,572	**$12,814**
18	$1,558	$4,156	$2,462	$346	$2,026	$2,649	**$13,198**

19	$1,605	$4,281	$2,536	$357	$2,087	$2,729	**$13,594**
20	$1,653	$4,409	$2,612	$367	$2,149	$2,811	**$14,002**

**3% Inflation*

13.4 Assessment Studies

Level 1 Assessment of the main stem of the Marmaton River and parts of Mill Creek, Drywood Creek, Bone Creek, and Paint Creek

April, 2010

Assessment and report completed by the Kansas Alliance for Wetlands and Streams, Blue Earth and the Geographic Information Systems Spatial Analysis Laboratory (GISSAL) for the Marmaton Watershed Restoration and Planning Strategy (WRAPS).

The Kansas Department of Health and environment has provided financial assistance to this project through EPA Section 319 Non Point Source Pollution Control Grant #C9007405 13 & #C9007405 15 and Kansas Water Plan Funds.

Summary of Major Water Quality Issues for Marmaton Watershed

According to the Kansas Unified Watershed Assessment FFY 1999 (KDHE and USDA-NRCS, 1998), the Marmaton River Watershed (HUC-8 = 10290104) was ranked seventeenth (17th) in priority for watershed restoration throughout the State. Approximately 62 % of the total miles of surface water in the watershed were indicated as impaired and not meeting their designated uses. The Watershed Conditions Report (KDHE, 2000) completed for the Marmaton Watershed by KDHE indicated that of those stream segments sampled, 44% need Total Maximum Daily Loads (TMDLs). The primary pollutant concerns for the watersheds' streams and rivers included dissolved oxygen (DO) levels (80% of streams sampled impaired), eutrophication (~18% impaired), ammonia (~8% impaired), and nutrients (~18 % impaired).

Focus of the Assessment

Results of the assessment effort to identify sites for BMP implementation in the Marmaton watershed are described herein. Much of this work is based on analysis and interpretation of aerial photographs and geographical informational system (GIS) data at medium resolution (i.e., ranging from 1mx1m to 30mx30m pixel size) in an attempt to identify potential sites for BMP implementation. Field verification of sites identified in the assessment was completed by a Kansas Alliance for Wetlands and Stream representative. Although subjectivity is inherent in the assessment approach, verification of sites on the ground was used to validate results and identify potential problems or misidentifications.

Scope of Level 1 Watershed Assessment

Assessment Area

The scope of work for Level 1 watershed assessment for the Marmaton system was undertaken at two geographic scales:

- The entire HUC-8 **watershed** west of the Missouri State line to include parts of Crawford, Bourbon and Allen Counties (figure 1).

- A **riparian region** extending from the center line of the chosen river channels (the main stem of the Marmaton and parts of the following streams: Mill Creek, Drywood Creek, Bone Creek, and Paint Creek – see Figure 1) as depicted by the National Hydrological Dataset (NHD) Flowline data. A GIS buffer operation was then performed on the aforementioned stream segments of the NHD Flowline dataset to 100ft to define this **riparian region**.

Assessment Activities

The **watershed level** was used to evaluate:

1) Land use throughout the watershed using several land cover datasets, including estimates of acreages for both a full range of land use classifications and a generalized land use classification scheme.

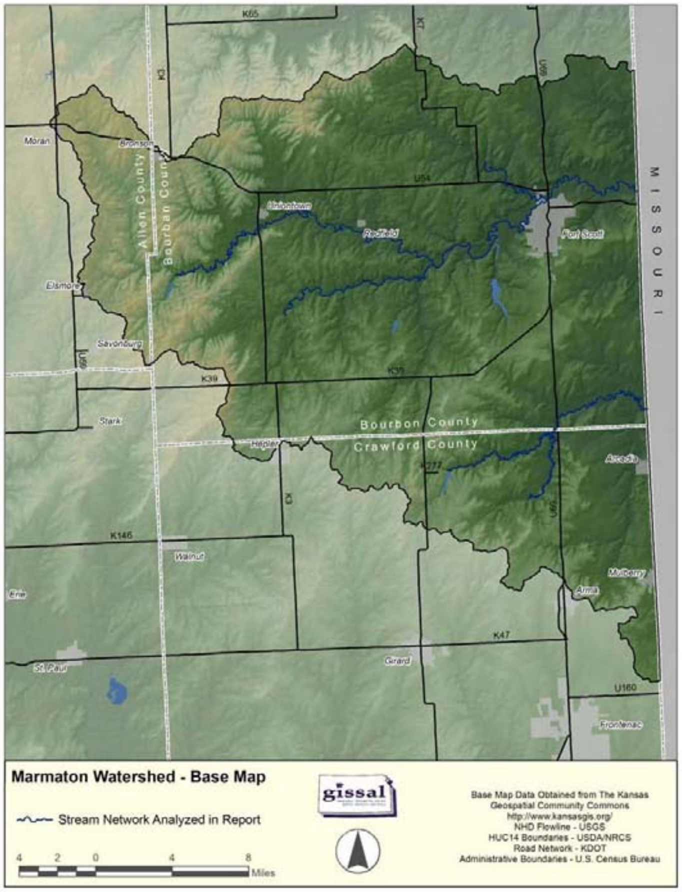


Figure 1. Marmaton River Watershed

2) Land use changes over two time periods (1992-2001 and 1990-2005), including estimates of acreages.

The **riparian region** was used to evaluate:

1) Land use along the aforementioned stream segments using several land cover datasets, including estimates of acreages for both a full range of land use classifications and a generalized land use classification scheme.

2) The identification of major stream bank erosion sites for rehabilitation and stabilization utilizing aerial photography and ancillary GIS datatsets, including estimates of linear extent in feet.

3) The approximation of riparian areas in need of protection and restoration utilizing the 2006 LANDFIRE Existing Vegetation Cover, including estimates of acreage for restoration and protection and applicable maps.

Field verification of major stream bank erosion sites and areas in need of protection restoration identified in the analysis period utilizing aerial photography was undertaken on April 8th, 12th and May 3rd, 2010 by KAWS representative, C. Douglas Bex. Field stream bank assessment procedures and field notes/observation for each site are included as Appendix C, and are summarized in the results section of this report.

Methods

Summary of Assessment Methodologies

Land Use Analysis

Evaluation of **watershed level** and **riparian region** land use for Rock Creek utilized several raster datasets available publically from the Kansas Geospatial Community Commons (www.kansisgis.org), the Multi-Resolution Land Characteristics Consortium (MRLC) (www.mrlc.gov), the Kansas Applied Remote Sensing (KARS) Program (www.kars.ku.edu), and the U.S. Department of Agriculture, National Agricultural Statistics Service (www.nass.usda.gov). The following datasets were analyzed at the watershed level:

- 1992 National Land Cover Dataset (MRLC)
- 2001 National Land Cover Dataset (MRLC)
- NLCD 1992-2001 Retrofit Change Product (MRLC)
- 1990 Kansas Land Cover Patterns (KARS)
- 2005 Kansas Land Cover Patterns (KARS), Level I
- Kansas Applied Remote Sensing (KARS) Program Kansas GAP Land Cover Map
- 2009 National Agricultural Statistics Service (USDA) Cropland Data Layer

For the **watershed level** analysis, all land cover datasets were clipped utilizing the Marmaton HUC-8 delineation from the Natural Resource Conservation Service (USDA) and land use data was extracted. Subsequently, these clipped datasets were reclassified to present generalized land use categories to better allow for comparison across datasets.

Watershed Level land cover change
Land cover change for the Marmaton watershed was determined utilizing the NLCD 1992-2001 retrofit Change Product (MRLC) and a derived dataset created from the two Kansas Land Cover Patterns datasets. For the latter, a Spatial Analyst Tool, Combinatorial XOr, was run to combine the values for each individual pixel in the two (1990 and 2005) Level I land cover datasets. Each resulting code was then re-interpreted to represent a change from one land cover class to another.

Evaluation of land use within the chosen **riparian region** of the Maramton system followed the same approach to that of the watershed level analysis, except that the riparian region was defined as an area within a buffer distance extending from the center line of the river channel, as defined by the NHD Flowline, perpendicular up both the right and left banks. The chosen NHD Flowline data for the Marmaton system was buffered utilizing ArcMap Analysis Tools to a distance of 100 feet. Utilizing this buffered stream layer as the clip feature, each land use data set was then clipped. From these clipped land use datasets, land use information was subsequently extracted and presented in both its detailed form and a generalized form to better allow for comparison across datasets.

In addition to the available raster datasets, the 1991 Natural Resource and Conservation Service's (USDA) Riparian Inventory data was evaluated within the **riparian region**. This vector dataset represents a 100ft buffer around all hydrologic features except sewage lagoons.

Within this 100 foot buffer, land use was determined by interpreting 1:12,000 Digital Orthophotograph Quarter Quadrangles ground conditions in 1991. Due to the classification scheme adopted in the Riparian Inventory, this dataset does not lend itself to be easily compared with other raster model land use data sets, but is a reliable and accurate depiction of riparian conditions in 1991 due to the methodology of heads-up digitizing directly from the Digital Orthophotograph imagery.

Identification of potential eroding streambanks for rehabilitation and stabilization

Visual inspection of 2008 USDA-FSA NAIP color composite aerial photography, and additional historical imagery available through Google Earth, along with ancillary GIS datasets was used to identify major sites of potential streambank erosion occurring along the riparian region. Aerial photography was examined a quarter section at a time to identify indicators of potential bank erosion.

Indicators of potential streambank erosion sites included the following: minimal or no significant riparian vegetation (especially mature trees), and the outside bank of tight meander bends. Particular attention was paid to those areas meeting both criteria, especially those areas where cropland occurred in close proximity to the bank with little or no vegetative buffer between it and the stream network. Streambank sites that met these criteria and were greater than 500 feet in length, or were otherwise considered significant, were marked and stored in a linear vector dataset.

Identification of riparian areas in need of protection or restoration

Land use information was extracted from the 2006 USGS/U.S. Forest Service (USFS)/The Nature Conservancy (TNC) LANDFIRE Existing Vegetation Cover Dataset for the riparian region. Land use classes were subsequently classified into three categories:

- Riparian areas in need of restoration
- Riparian areas in need of management
- Riparian areas in need of protection

LANDFIRE is an interagency project shared between the United Stages Geological Survey (USGS), United States Forest Service (USFS) and The Nature Conservancy (TNC) to map vegetation, fire and fuel characteristics in the U.S. The LANDFIRE project has resulted in some 20+ data sets that focus on fire behavior, fire regimes, vegetation and fire effects. For this particular analysis, the LANDFIRE Existing Vegetation Cover dataset that characterizes the average percent cover of existing vegetation, with a resolution of 30 meter grid cells, was utilized.

Each cell captured within the riparian region along the analyzed stream segments were classified into one of the aforementioned categories. Riparian areas in need of restoration were developed and cultivated lands. Riparian areas in need of management were cells classified as either Pasture/Hay, that were sparsely forested (<40% cover), that had shrub cover of less than 40% and cells with a herbaceous cover of less than 60%. Areas in need of protection were cells classified as containing a forest cover greater than 40%.

Results

Historical Land Cover and Departure Index

Two datasets available from LANDFIRE, an interagency project shared between the United Stages Geological Survey (USGS), United States Forest Service (USFS) and The Nature Conservancy (TNC) to map vegetation, fire and fuel characteristics in the U.S., provide some insight into the historical nature of land cover in the Marmaton watershed, as well as provide some indication of how much vegetation has departed from historical conditions. The first, the LANDFIRE Biophysical Settings layer "represents the vegetation that may have been dominant on the landscape prior to Euro-American settlement and is based on both the current biophysical environment and an approximation of the historical disturbance regime" (LANDFIRE). This data suggests that the upland areas of the Marmaton watershed may have been dominated by a mix of Big Bluestem, Little Bluestem, and Indiangrass prairie, with the south and west facing slopes harboring a mix of White Oak, Red Oak and Sugar Maple. The lower reaches of riparian areas, as suggested by the data, would have been dominated by a floodplain forest of American Sycamore and Silver Maple, while woodlands containing a mix of Sugar Maple, Beech and Basswood might have been scattered throughout the watershed (figure 2).

The second LANDFIRE dataset, Forest Regime Condition Class (FRCC), is an attempt to characterize the departure between current natural vegetative conditions and simulated historical reference conditions. Fire regime condition classes are defined as Low (0-33), Medium (34-66), and High (67-100), based upon an index of 0-100. Agricultural lands were excluded from the final classification scheme. Given that agriculture is a predominant land use within the watershed, much of the watershed is characterized as such. However, generally speaking the eastern, and especially southeastern, portions of the watershed have seen the greatest vegetative departure from simulated historical conditions. The data also suggests large pockets of low vegetation departure in the central and upper western portions of the watershed (figure 3).

Both of these datasets were developed to support landscape-scale fire, ecosystem, and fuel assessments at the National level, so this should be taken into account when interpreting the data. The purpose of their use here is to lend a broad historical context for the watershed as a whole.

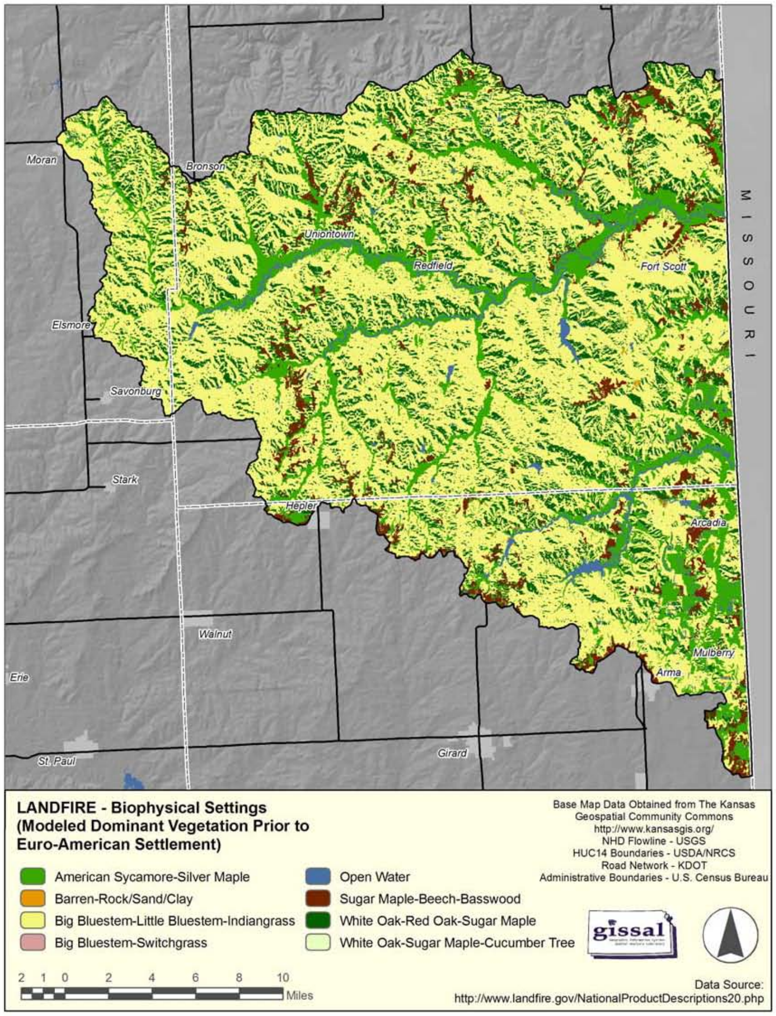

Moran
Bronson
Uniontown
Redfield
Fort Scott
MISSOURI
Elsmore
Savonburg
Stark
Hepler
Arcadia
Walnut
Erie
Mulberry
Arma
St. Paul
Girard
LANDFIRE - Biophysical Settings
(Modeled Dominant Vegetation Prior to
Euro-American Settlement)
American Sycamore-Silver Maple
Barren-Rock/Sand/Clay
Big Bluestem-Little Bluestem-Indiangrass
Big Bluestem-Switchgrass
Open Water
Sugar Maple-Beech-Basswood
White Oak-Red Oak-Sugar Maple
White Oak-Sugar Maple-Cucumber Tree
Base Map Data Obtained from The Kansas
Geospatial Community Commons
http://www.kansasgis.org/
NHD Flowline - USGS
HUC14 Boundaries - USDA/NRCS
Road Network - KDOT
Administrative Boundaries - U.S. Census Bureau
gissal
2 1 0 2 4 6 8 10
Miles
Data Source:
http://www.landfire.gov/NationalProductDescriptions20.php

Figure 2

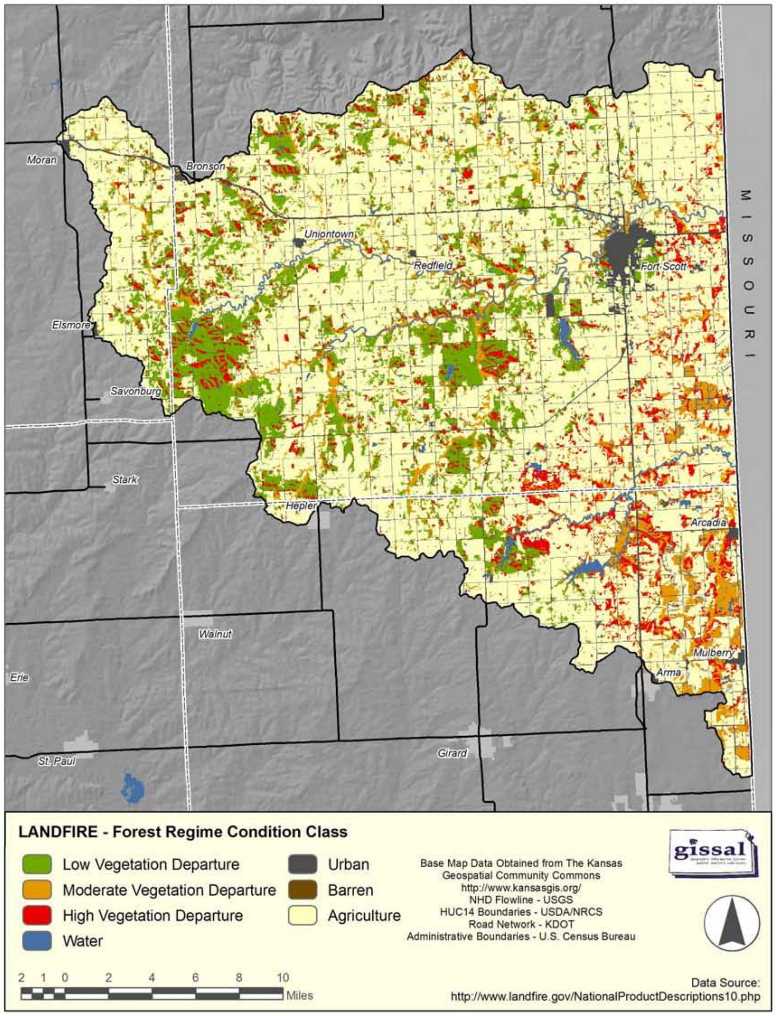

Moran
Bronson
Uniontown
Redfield
Fort Scott
Elsmore
Savonburg
Stark
Hepler
Arcadia
Walnut
Erie
Mulberry
Arma
St. Paul
Girard
M I S S O U R I
LANDFIRE - Forest Regime Condition Class
Low Vegetation Departure
Moderate Vegetation Departure
High Vegetation Departure
Water
Urban
Barren
Agriculture
Base Map Data Obtained from The Kansas
Geospatial Community Commons
http://www.kansasgis.org/
NHD Flowline - USGS
HUC14 Boundaries - USDA/NRCS
Road Network - KDOT
Administrative Boundaries - U.S. Census Bureau
2 1 0 2 4 6 8 10
Miles
Data Source:
http://www.landfire.gov/NationalProductDescriptions10.php

Figure 3

Watershed Level Land Cover Analysis

A total of eight land cover data sets were evaluated for the Marmaton watershed - six "static" datasets, as well as two land cover change datasets. Links to GIS metadata are included in Appendix A. The results from this analysis are presented in Tables 1 through 3 and Figure 4. Watershed level maps of land cover can be found in Appendix B.

Land use within the Marmaton watershed was largely comprised of grassland, cultivated land and forested lands according to all the GIS datasets analyzed. Smaller areas of developed land, water, shrubland and wetlands comprised the reminder of the watershed.

Analysis of the Kansas Applied Remote Sensing (KARS) Program's Kansas Land Cover Patterns (KLCP) data from 1990 and 2005 (Table 2, Table 3, and Figure 4) indicates a marked increase in grasslands, about a 40% increase in forest cover, and a substantial (about 2/3rds) loss of cultivated lands throughout the watershed. Overall, such changes in land cover patterns suggest an overall improvement in land cover conditions (a move away from agriculture to more natural cover types). However the 1990 data did not adequately account for developed lands, so changes in developed acreages are not easily discerned. While useful to some degree, caution should be applied before comparing datasets (one year to the next) due to changes in technology, methodologies, land use definitions and inherent accuracies associated with the two individual datasets at each end of the time scale, even though both datasets were developed by KARS.

A direct comparison of the two NLCD datatsets is plagued with issues and is not recommended (i.e. do not compare the two NLCD pie charts shown in Figure 4). New developments in mapping methodology, new sources of input data and changes in the class definitions will confound any direct comparison between the 1992 and 2001 product. As such, the Multi-Resolution Land Characteristics Consortium (MRLC) developed a 1991/2001 retrofit land cover change product to offer users a more accurate direct change analysis. The results of which can be found in Table 3. This dataset suggests a rather more static land cover than the KARS dataset would suggest, with the vast majority of the watershed exhibiting little or no change, although loss of agricultural land cover and some loss of forest cover seem to be more prevalent, albeit at very small scales when considered across the entire watershed.

Crops cultivated in the watershed in 2009 were primarily soybeans (20,067 acres), corn (5,862 acres), and a double cropping of winter wheat and soybeans (3,396 acres) according to the 2009 National Agricultural Statistics Service Cropland Data layer (Table 1). Other minor crops cultivated included winter wheat and sorghum. This dataset is primarily used by the USDA for estimating acreages to the Agricultural Statistics Board for the state's major commodities.

KARS GAP Analysis data, utilizing imagery from the early to mid 1990s, indicates again that grassland (native and non-native) is the predominant land cover in the watershed (174,000+ acres (45%)), however, GAP data suggests a much larger forest cover (35%) than all other land cover datasets, with cultivated lands (17%) making up the majority of the remaining land cover within the watershed. The primary benefit of the GAP Analysis data layer is its detailed classification of land cover (43 classes across Kansas). Of the forest land identified by GAP, the largest component was Post Oak-Blackjack Oak Forest (~35%), with smaller pockets of Mixed Oak Floodplain Forest (9%) and Oak-Hickory Forest (7%). Of the grassland identified by the GAP analysis, Tallgrass prairie (48%) and non-Native grasslands (41%) made up the majority, while smaller areas of Conservation Reserve Program (CRP) lands and low or wet prairie comprised the remainder (Figure 5).

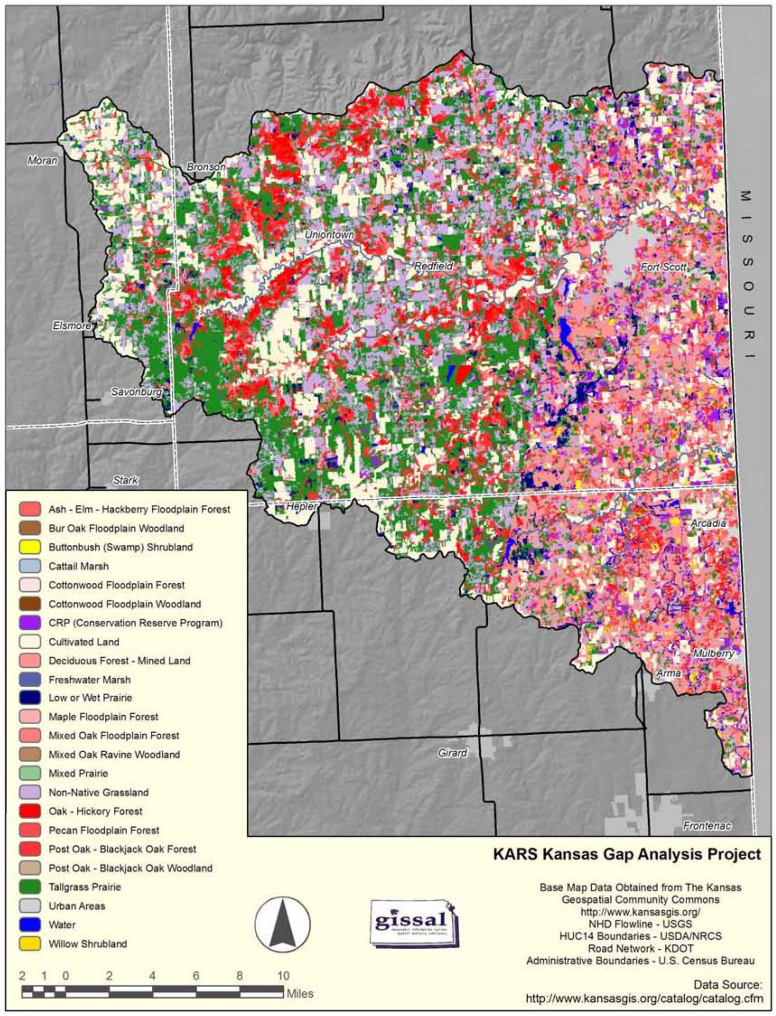


Figure 4

NLCD1992

Land Cover	Acres
Open Water	5,235
Low Intensity Residential	1,383
High Intensity Residential	1,391
Commercial/Industrial/Transportation	1,593
Bare Rock/Sand/Clay	25
Quarries/Strip Mines/Gravel Pits	561
Transitional	10
Deciduous Forest	56,895
Evergreen Forest	2,990
Mixed Forest	7,575
Shrubland	2,270
Grasslands/Herbaceous	52,399
Pasture/Hay	140,304
Row Crops	113,200
Small Grains	684
Urban/Recreational Grasses	592
Woody Wetlands	5,842
Emergent Herbaceous Wetlands	4,941
TOTAL	**397,888**

NLCD 2001

Land Cover	Acres
Open Water	4,919
Developed, Open Space	15,462
Developed, Low Intensity	3,948
Developed, Medium Intensity	756
Developed, High Intensity	182
Barren Land	337
Deciduous Forest	54,003
Evergreen Forest	77
Mixed Forest	2,103
Shrub/Scrub	291
Grassland/Herbaceous	39,888
Pasture/Hay	204,611
Cultivated Crops	57,687
Woody Wetlands	4,320
Emergent Herbaceous Wetlands	294
TOTAL	**388,879**

KLCP 2005 - Level 1

Land Cover	Acres
Commercial Industrial	929
Residential	2,925
Urban Openland	1,992
Urban Woodland	560
Urban Water	43
Cropland	53,614
Grassland	245,841
Conservation Reserve Program (CRP)	13,316
Woodland	65,459
Water	3,867
Other	420
TOTAL	**388,966**

GAP

Land Cover	Acres
Oak - Hickory Forest	9,503
Post Oak - Blackjack Oak Forest	48,050
Pecan Floodplain Forest	2,131
Ash - Elm - Hackberry Floodplain Forest	5,171
Cottonwood Floodplain Forest	999
Mixed Oak Floodplain Forest	12,077
Bur Oak Floodplain Woodland	295
Mixed Oak Ravine Woodland	7
Post Oak - Blackjack Oak Woodland	5,748
Cottonwood Floodplain Woodland	309
Willow Shrubland	784
Buttonbush (Swamp) Shrubland	1,561
Tallgrass Prairie	82,950
Mixed Prairie	878
Low or Wet Prairie	8,731
Freshwater Marsh	57
Cattail Marsh	1,168
Non-Native Grassland	71,622
CRP (Conservation Reserve Program)	10,222
Cultivated Land	66,128
Deciduous Forest - Mined Land	51,735
Maple Floodplain Forest	844
Urban Areas	3,696
Water	4,282
TOTAL	**388,947**

2009 NASS

Class Name	Acres
Corn	5,862
Sorghum	498
Soybeans	20,067
Sunflowers	39
Winter Wheat	969
W. Wht./Soy. Dbl. Crop	3,396
Rye	6
Oats	156
Millet	1
Alfalfa	158
Other Crops	86
Clover/Wildflowers	81
Seed/Sod Grass	177
Fallow/Idle Cropland	77
Pasture/Grass	30,387
Woodland	2
Other Tree Nuts	1
Wetlands	46
NLCD - Open Water	4,017
NLCD - Developed/Open Space	18,597
NLCD - Developed/Low Intensity	4,026
NLCD - Developed/Medium Intensit	666
NLCD - Developed/High Intensity	151
NLCD - Barren	143
NLCD - Deciduous Forest	57,679
NLCD - Evergreen Forest	12
NLCD - Mixed Forest	852
NLCD - Shrubland	23
NLCD - Pasture/Hay	235,927
NLCD - Woody Wetlands	4,826
NLCD - Herbaceous Wetlands	15
TOTAL	**388,944**

Table 1 Watershed Level Land Use – Full Classification

NLCD 1992

Land Cover	Acres
Developed Areas	4,262
Forest	65,908
Grassland	188,364
Cultivated Land	111,915
Shrubland	2,215
Barren	586
Water	5,104
TOTAL	**378,355**

NLCD 2001

Land Cover	Acres
Developed Areas	20,186
Forest	55,737
Grassland	242,556
Cultivated Land	57,229
Shrubland	289
Barren	335
Water	4,880
TOTAL	**381,211**

2009 NASS

Land Cover	Acres
Developed Areas	23,440
Forest	58,545
Grassland	266,395
Cultivated Land	31,492
Shrubland	23
Wetlands	4,888
Barren	143
Water	4,017
TOTAL	**388,944**

KLCP 1990

Land Cover	Acres
Forest	47,368
Grassland	184,983
Cultivated Land	149,257
Water	3,162
Other	622
TOTAL	**385,393**

KLCP 2005

Land Cover	Acres
Developed Areas	5,846
Forest	66,019
Grassland	259,156
Cultivated Land	53,614
Water	3,911
Other	420
TOTAL	**388,966**

GAP

Land Cover	Acres
Developed Areas	3,696
Forest	137,652
Grassland	174,404
Cultivated Land	66,128
Wetland	2,787
Water	4,282
TOTAL	**388,947**

Table 2 Watershed Level Land Use – Generalized Classification

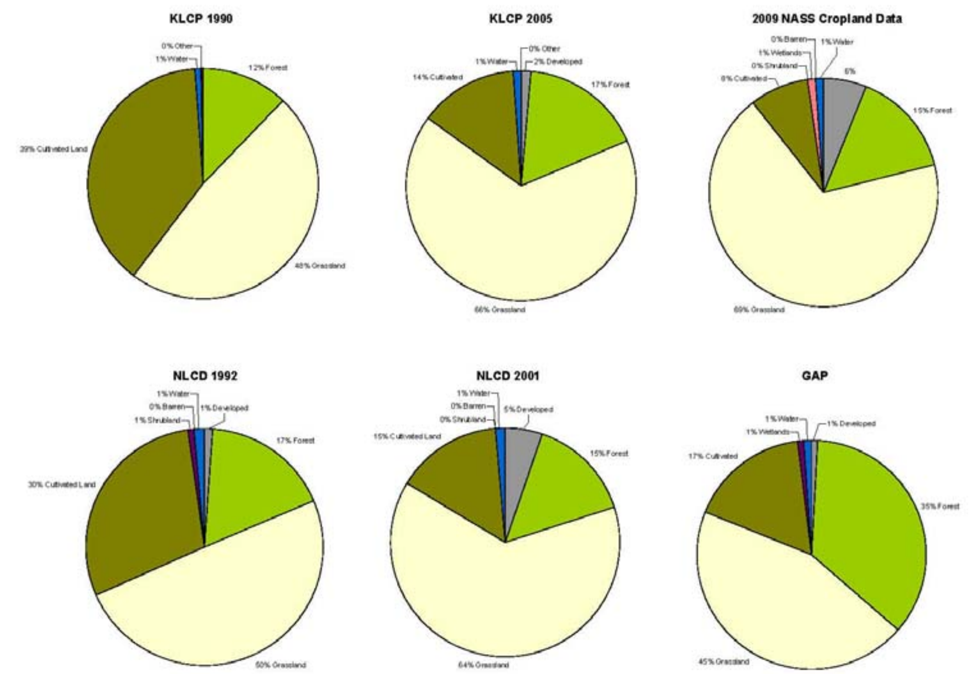


Figure 5. Land Use in the Marmaton Watershed

KLCP Change (1990-2005)	
Land Cover (Change)	Acres
Cultivated-Developed	1,057
Cultivated-Forest	6,959
Cultivated-Grassland	96,653
Cultivated-Other	41
Cultivated-Water	526
Developed-Cultivated	10
Developed-Forest	117
Developed-Grassland	41
Developed-Water	6
Forest-Cultivated	986
Forest-Developed	193
Forest-Grassland	9,254
Forest-Other	59
Forest-Water	1,054
Grassland-Cultivated	8,513
Grassland-Developed	1,193
Grassland-Forest	22,129
Grassland-Other	271
Grassland-Water	883
Other-Cultivated	53
Other-Developed	24
Other-Forest	90
Other-Grassland	385
Other-Water	27
Water-Cultivated	23
Water-Developed	18
Water-Forest	888
Water-Grassland	810
Water-Other	6
Unchanged: Cultivated	44,022
Unchanged: Developed	3,360
Unchanged: Forest	35,822
Unchanged: Grassland	151,994
Unchanged: Other	43
Unchanged: Water	1,416
TOTAL	388,926

NLCD Change (1992-2001)	
Land Cover (Change)	Acres
Agriculture to Barren	135
Agriculture to Forest	51
Agriculture to Grassland/Shrub	53
Agriculture to Open Water	975
Agriculture to Urban	270
Agriculture to Wetlands	83
Forest to Agriculture	656
Forest to Barren	12
Forest to Grassland/Shrub	233
Forest to Open Water	305
Forest to Urban	67
Forest to Wetlands	22
Open Water to Agriculture	54
Open Water to Forest	8
Open Water to Wetlands	29
Urban to Agriculture	70
Urban to Open Water	3
Urban to Wetlands	10
Wetlands to Agriculture	35
Wetlands to Barren	20
Wetlands to Forest	8
Wetlands to Grassland/Shrub	10
Wetlands to Open Water	2
Wetlands to Urban	26
Unchanged: Open Water	3,730
Unchanged: Urban	20,032
Unchanged: Barren	185
Unchanged: Forest	56,073
Unchanged: Grassland/Shrub	39,905
Unchanged: Agriculture	261,431
Unchanged: Wetlands	4,471
TOTAL	388,964

Table 3 Watershed Level Land Cover Change

Riparian Region Land Cover Analysis

A total of eight land cover data sets were evaluated for the riparian regions of the Marmaton River, Mill Creek, Drywood Creek, Bone Creek and Paint Creek. - six "static" datasets, as well as two land cover change datasets. Links to GIS metadata are included in Appendix A. The results from this analysis are presented in Tables 4 through 6 and Figure 6.

Land use within the riparian region of the analyzed streams was largely comprised of forest, grassland, and in some cases (the two NLCD datasets and Cropland data) wetland, accounting for as much as a one-fifth to one-quarter of the riparian region. Cultivated land made up for the majority of the remaining areas within the riparian region, and in one case (the 1990 Kansas Land Cover Dataset) as much as a quarter of the riparian region. The data generally suggests a healthy riparian region with limited cultivated land immediately adjacent to the river channel. This is especially apparent along the lower reaches of the stream network when viewed against the 2008 NAIP imagery.

Comparison of the two KARS datasets suggests an increase in forested areas within the riparian region and equivalent loss of cultivated land immediately adjacent to the channel, with a similar acreage of grasslands in the riparian region in 2005 as there was in 1990. The proportional loss of cultivated land along the river channel seems to be similar to that seen throughout the watershed as a whole (approximately a $2/3^{rd}$ loss), although the loss of grassland along the riparian region also suggest that the overall increase in grasslands seen throughout the watershed, as exhibited by the two KARS datasets, has occurred in the upland portions of the watershed, away from streams and their tributaries. Again, while useful to some degree, caution should be applied before comparing datasets (one year to the next) due to changes in technology, methodologies, land use definitions and inherent accuracies associated with the two individual datasets at each end of the time scale, even though both datasets were developed by KARS.

As noted in the watershed level analysis, direct comparison of the two NLCD datasets is plagued with problems, and as such no direct comparison of the two pie charts should be undertaken. The retrofit NLCD Change data set developed by the MRLC suggests next to no change throughout the riparian region (Table 6).

Overall estimates of cultivated land use in the riparian region varied from 27 acres to 295 acres (1-24%), the high end being estimated by the 1990 KLCP. The 2009 NASS Cropland Data Layer (Table 4), incidentally the dataset that estimates the lowest amount of cultivated land within the riparian region, indicates that Soybeans (21 acres) and Corn (5 acres) are the crops being grown along the cultivated floodplains or terraces adjacent to the stream network, albeit in small amounts.

GAP Analysis (Tables 4 and 5) indicates that those areas within the riparian region that are forested (2011 acres, or 87% of the riparian region), some 50% are comprised of a mixed Oak Floodplain forest, while the remaining 50% are a mix of primarily Ash-Elm-Hackberry, Cottonwood Floodplain forest, Pecan Floodplain forest. Some 295 acres contain a general deciduous forest category assigned to mined land. The remainder of the riparian region identified by GAP Analysis included cultivated land (8%), non-native grassland (2%) and a small amount (<1%, or 22 acres) of Tall grass prairie.

NLCD1992

Land Cover	Acres
Open Water	245.1
Low Intensity Residential	2.2
High Intensity Residential	0.2
Commercial/Industrial	4.7
Quarries/Strip Mines/Gravel Pits	0.2
Deciduous Forest	772.4
Evergreen Forest	38.3
Mixed Forest	145.7
Shrubland	8.5
Grasslands	28.5
Pasture/Hay	224.0
Row Crops	294.2
Small Grains	0.4
Urban/Recreational Grasses	0.7
Woody Wetlands	542.0
Emergent Herbaceous Wetlands	5.3
TOTAL	**2312.2**

NLCD 2001

Land Cover	Acres
Open Water	87.2
Developed, Open Space	34.8
Developed, Low Intensity	8.1
Developed, Medium Density	1.9
Deciduous Forest	1167.6
Mixed Forest	56.0
Grassland	39.1
Pasture/Hay	228.0
Cultivated Crops	310.5
Woody Wetlands	371.7
Emergent Herbaceous Wetlands	6.7
TOTAL	**2311.6**

GAP

Land Cover	Acres
Oak - Hickory Forest	48.3
Post Oak - Blackjack Oak Forest	73.2
Pecan Floodplain Forest	102.1
Ash - Elm - Hackberry Floodplain Forest	238.2
Cottonwood Floodplain Forest	122.3
Mixed Oak Floodplain Forest	1017.9
Bur Oak Floodplain Forest	1.6
Post Oak - Blackjack Oak Woodland	28.5
Cottonwood Floodplain Woodland	3.1
Willow Shrubland	1.3
Buttonbush (Swamp) Shrubland	0.7
Tallgrass Prairie	22.0
Low or Wet Prairie	2.4
Cattail Marsh	1.6
Non-Native Grassland	48.9
CRP (Conservation Reserve Program)	8.2
Cultivated Land	191.0
Deciduous Forest - Mined Land	295.3
Maple Floodplain Forest	79.8
Urban Areas	8.2
Water	17.1
TOTAL	**2311.8**

KLCP2005

Land Cover	Acres
Urban Commercial/Industrial	2.4
Urban Residential	0.4
Urabn Openland	6.0
Urban Woodland	14.2
Cropland	184.6
Grassland	150.6
Conservation Reserve Program (CRP)	30.7
Woodland	1904.6
Water	19.8
TOTAL	**2313.4**

2009 NAAS

Class Name	Acres
Corn	5.4
Soybeans	20.9
W. Wht./Soy. Dbl. Crop	1.5
Pasture/Grass	16.3
NLCD - Open Water	20.1
NLCD - Developed/Open Space	44.9
NLCD - Developed/Low Intensity	10.8
NLCD - Deciduous Forest	1418.9
NLCD - Mixed Forest	3.9
NLCD - Pasture/Hay	290.6
NLCD - Woody Wetlands	491.3
NLCD - Herbaceous Wetlands	2.3
TOTAL	**2327.1**

NRCS 1991 Riparian Inventory

Land Use	Acres
Crop Land	1.0
Crop/Tree Mix	252.4
Forest Land	1646.5
Pasture/Tree Mix	18.3
Shrub/Scrub Land	9.5
Urban Land	1.9
Urban/Tree Mix	4.0
Water	371.7
TOTAL	**2305.1**

Table 4 Riparian Region Land Use – Full Classification

NLCD 1992

Land Cover	Acres
Developed Land	7.1
Forest	956.3
Grassland	252.4
Cultivated Land	295.3
Wetland	547.3
Barren	0.2
Water	245.1
TOTAL	**2303.8**

NLCD 2001

Land Cover	Acres
Developed Land	44.9
Forest	1223.5
Grassland	267.1
Cultivated Land	310.5
Wetland	378.4
Water	87.2
TOTAL	**2311.6**

2009 NASS

Land Cover	Acres
Developed Land	55.8
Forest	1422.8
Grassland	306.9
Cultivated Land	27.9
Wetlands	493.6
Water	20.1
TOTAL	**2327.1**

KLCP 1990

Land Cover	Acres
Forest	1541.9
Grassland	189.5
Cultivated Land	565.3
Water	5.3
Residential	5.1
Commercial Industrial	4.2
TOTAL	**2311.3**

KLCP 2005

Land Cover	Acres
Developed Land	8.9
Forest	1918.8
Grassland	181.3
Cultivated Land	184.6
Water	19.8
TOTAL	**2313.4**

GAP

Land Cover	Acres
Developed Land	8.2
Forest	2011.6
Grassland	81.6
Cultivated Land	191.0
Wetland	2.2
Water	17.1
TOTAL	**2311.8**

Table 5 Riparian Region Land Use – Generalized Classification

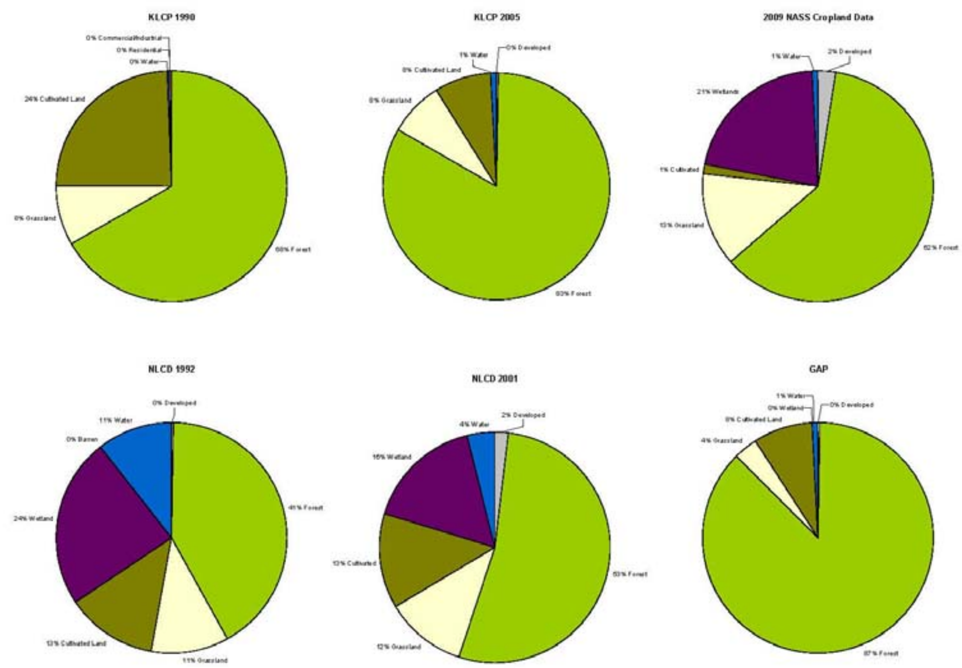


Figure 6. Land Use in the Riparian Region of stream analyzed

KLCP Change	
Land Cover (Change)	**Acres**
Cultivated-Forest	390.3
Cultivated-Grassland	26.2
Cultivated-Water	1.6
Developed-Forest	2.2
Forest-Cultivated	70.1
Forest-Developed	3.8
Forest-Grassland	61.2
Forest-Water	15.1
Grassland-Cultivated	19.8
Grassland-Developed	1.1
Grassland-Forest	128.3
Grassland-Water	2.9
Water-Forest	4.9
Water-Grassland	0.2
Unchanged: Cultivated	94.7
Unchanged: Developed	0.2
Unchanged: Forest	1375.3
Unchanged: Grassland	36.7
Unchanged: Water	0.2
TOTAL	**2234.8**

NLCD Change	
Land Cover (Change)	**Acres**
Forest to Open Water	2.0
Forest to Urban	1.1
Forest to Grassland/Shrub	1.8
Forest to Agriculture	2.2
Agriculture to Open Water	2.0
Agriculture to Forest	3.6
Agriculture to Wetlands	0.7
Unchanged: Open Water	136.6
Unchanged: Urban	54.3
Unchanged: Forest	1300.8
Unchanged: Grassland/Shrub	26.0
Unchanged: Agricultuure	404.3
Unchanged: Wetlands	376.3
TOTAL	**2311.6**

Table 6 Riparian Region Land Cover Change

The 1991 NRCS Riparian Inventory (Figure 7 and Table 7) indicated that within 100 feet of the center line of the streams analyzed 72% of the area was forested, while a further 11% fell within an area classified as Crop/Tree mix. Given the source of this data (heads-up digitizing off of orthophoto quads), this dataset represents probably the most accurate indication of riparian conditions as they existed in 1991, and seems to suggest a healthy riparian corridor in 1991. Areas within the 100 foot riparian region exhibiting either a cropland and/or crop-tree mix would suggest these areas reflect significant departures from historical (pre-settlement) riparian conditions and represent areas where bank stability may have been significantly undermined by the removal of deep rooted perennial vegetative cover. However, in the case of the stream areas analyzed for this report, these areas, at least in 1991, were small.

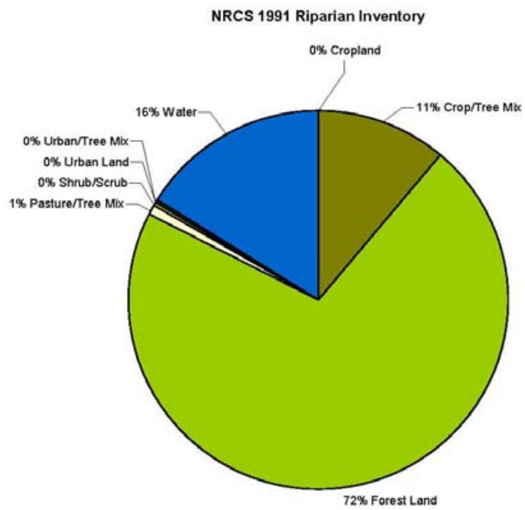


Figure 7 NRCS Riparian Inventory for streams analyzed

NRCS 1991 Riparian Inventory

Land Use	Acres
Crop Land	1.0
Crop/Tree Mix	252.4
Forest Land	1646.5
Pasture/Tree Mix	18.3
Shrub/Scrub Land	9.5
Urban Land	1.9
Urban/Tree Mix	4.0
Water	371.7
TOTAL	**2305.1**

Table 7 Riparian Inventory for streams analyzed

Identification of potential eroding streambanks for rehabilitation and stabilization

A total of seventy (69) potential streambank erosion sites were identified for potential rehabilitation or stabilization within the riparian region of the assessed stream network. Over 51,000 linear feet of streambanks were associated with these sites, ranging from 304 feet to 3,500 feet (Table 8). The mean size of the streambank erosion site was 743 feet. Sites tended to be located on either the outside of tight meander bends or in areas where steep banks were left unprotected along side cultivated land and/or grassland. Potential streambank erosion sites were evaluated during field verification and assigned an individual code (1-10, see Table 9) based upon the severity of conditions found in the field. The results of this evaluation are summarized in Table 10, and extended field notes can be found in Appendix C. Only four of 69 potential stream bank erosion sites were not evaluated in the field due to access, and one additional site was identified based upon discussion with the landowner. The locations of potential stream bank erosion sites can be found in figures 9 through 17. In addition, the locations of the top 3 categories of sites (17 sites in total) are identified in figure 18. A full size index sheet showing the location of all nine map extents can be found in Appendix D.

Streambank Erosion Sites	
Count	70
Minimum	304
Maximum	3,660
Sum	51,275
Mean	743
Standard Deviation	461

Table 8 Streambank erosion sites and Basic statistics

Rank	Description
1	Near vertical banks, almost no trees, head cuts from fields, evidence of sloughing, possible infrastructure damage.
2	Steep banks, very few trees, < 10' wide, potential infrastructure impact, adjacent cropland lacks conservation measures or over grazed pasture land with cattle in stream.
3	Steep bank at point of hit, < 15' wide, overgrazed, adjacent land with surface runoff.
4	Sloped bank, riparian ban of trees 15-20' wide, mature and young trees, evidence of regeneration of young trees on bank slope, maybe some grassed buffers.
5	These sites usually had a 15'-25' riparian band of mature and young trees, many had native grass buffers adjacent to trees. Presence of stream benches and slight slope of banks. Some sites had rock substrate or were on the upper end of the stream with a majority of the drainage coming from rangeland.
6	These sites had wide riparian buffers 25'-40'. Presence of grass buffers along cropfields or adjacent land seeded to grass or pasture. On many sites, landowner had already fenced cattle out of the riparian zone.
7	No sites were assigned this number, although some may have approached with wide 40'-60'riparian buffers with mature and young trees and rocky substrate.
8-10	These sites would not even be considered for any restoration efforts due to limited funding and not required.

Table 9. Condition Ranking used to evaluate Potential Stream Bank Erosion Sites

Condition Rank	Number of Sites	Total Stream Length (ft.)
1	1	809
2	2	4,239
3	14	12,529
4	33	21,749
5	14	8,799
6	1	635
Not Evaluated	*4*	*2,515*
Sum	***69***	***51,275***

Table 10. Summary of Stream Bank Erosion Sites


Osage
United States Highway 69
235th
Noble
225th
265th
Native
Marmaton River
Muskot
Bourbon
Mill Creek
Parkinson
Maple
Locust
Fort Scott
Limestone
MO
1-01
1-02
1-03
1-04
1-05
Map: 1
Potential Stream Bank Stabilization Sites
Potential Stream Bank Stabilization Sites for Main Stem Marmaton, Mill Creek, Drywood Creek, Bone Creek, and Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
0 0.1 0.2 0.4 0.6 0.8 1 Miles
Missouri
BB
CR
gissal

Figure 9


Poplar
Overbrook
Overbrook
180th
170th
195th
Osage
2-01
2-02
Bourbon
United States Highway 54
190th
205th
Native
215th
United States Highway 69
225th
185th
195th
Mill Creek
Marmaton River
Maple
Fort Scott
180th
190th
Locust
Map: 2
Potential Stream Bank Stabilization Sites
Potential Stream Bank Stabilization Sites for
Main Stem Marmaton, Mill Creek,
Drywood Creek, Bone Creek, and
Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
Miles
0 0.1 0.2 0.4 0.6 0.8 1
Missouri
gissal

Figure 10


Maple
Locust
Locust
Limestone
Bourbon
Katy
Cedar Creek Lake
Kansas
160th
Juniper
Jayhawk
Ironwood
Marmaton River
Fort Scott
3-04
205th
187th
Map: 3
Potential Stream Bank Stabilization Sites
Potential Stream Bank Stabilization Sites for
Main Stem Marmaton, Mill Creek,
Drywood Creek, Bone Creek, and
Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
Miles
0 0.1 0.2 0.4 0.6 0.8 1
Missouri

Figure 11


Marmaton River
Paint Creek
Bourbon
Kansas
Jayhawk
Indian
Hickory
Hackberry
Kay
160th
4-01
4-03
4-04
4-05
Map: 4
Potential Stream Bank Stabilization Sites
Potential Stream Bank Stabilization Sites for
Main Stem Marmaton, Mill Creek,
Drywood Creek, Bone Creek, and
Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
0 0.1 0.2 0.4 0.6 0.8 1 Miles
Missouri
gissal

Figure 12


Jayhawk
100th
90th
Indian
115th
112th
Paint Creek
4-01
80th
5-05
5-06
5-08
5-07
5-03
Hickory
110th
5-02
Kansas State Highway 3
5-01
Hackberry
B o u r b o n
120th
Grand
Grand
95th
Map: 5
Potential Stream Bank Stabilization Sites
Missouri
Potential Stream Bank Stabilization Sites for
Main Stem Marmaton, Mill Creek,
Drywood Creek, Bone Creek, and
Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
0 0.1 0.2 0.4 0.6 0.8 1 Miles
gissal

Figure 13

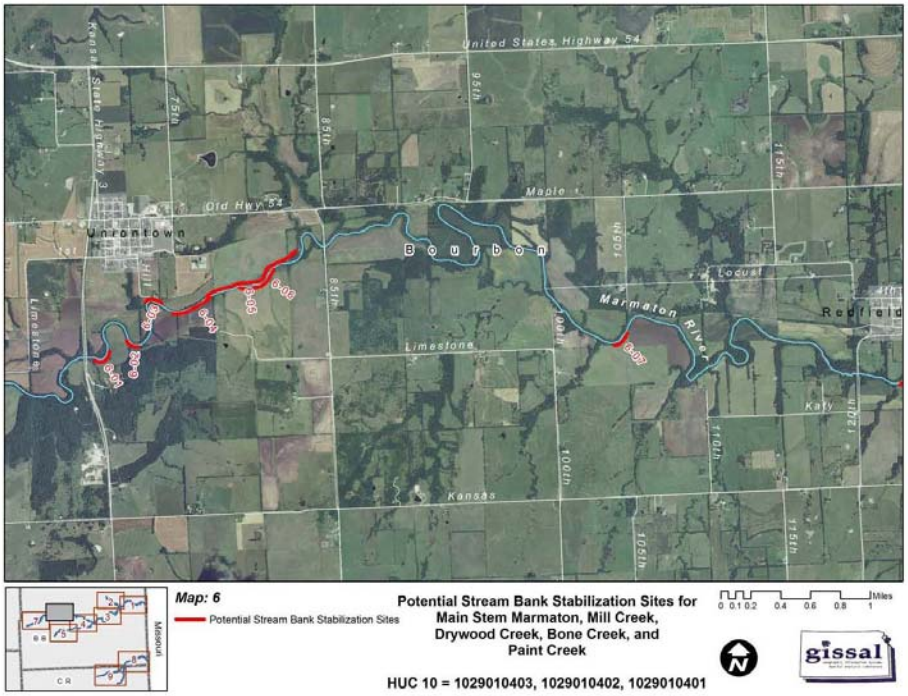

United States Highway 54
Kansas State Highway 3
Old Hwy 54
Maple
Uniontown
Bourbon
Marmaton River
Locust
Redfield
Limestone
Katy
Kansas
75th
85th
95th
100th
105th
110th
115th
120th
Map: 6
Potential Stream Bank Stabilization Sites
Potential Stream Bank Stabilization Sites for Main Stem Marmaton, Mill Creek, Drywood Creek, Bone Creek, and Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
0 0.1 0.2 0.4 0.6 0.8 1 Miles
Missouri
gissal

Figure 14

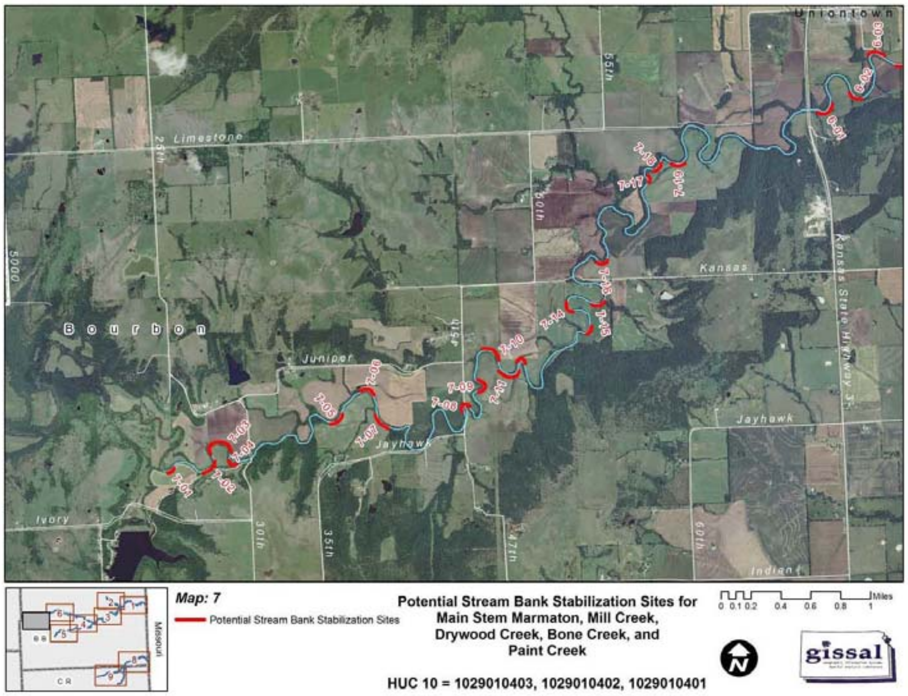

Uniontown
Limestone
Kansas
Bourbon
Juniper
Jayhawk
Ivory
Indian
Kansas State Highway 3
Map: 7
Potential Stream Bank Stabilization Sites
Potential Stream Bank Stabilization Sites for
Main Stem Marmaton, Mill Creek,
Drywood Creek, Bone Creek, and
Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
Miles
Missouri

Figure 15

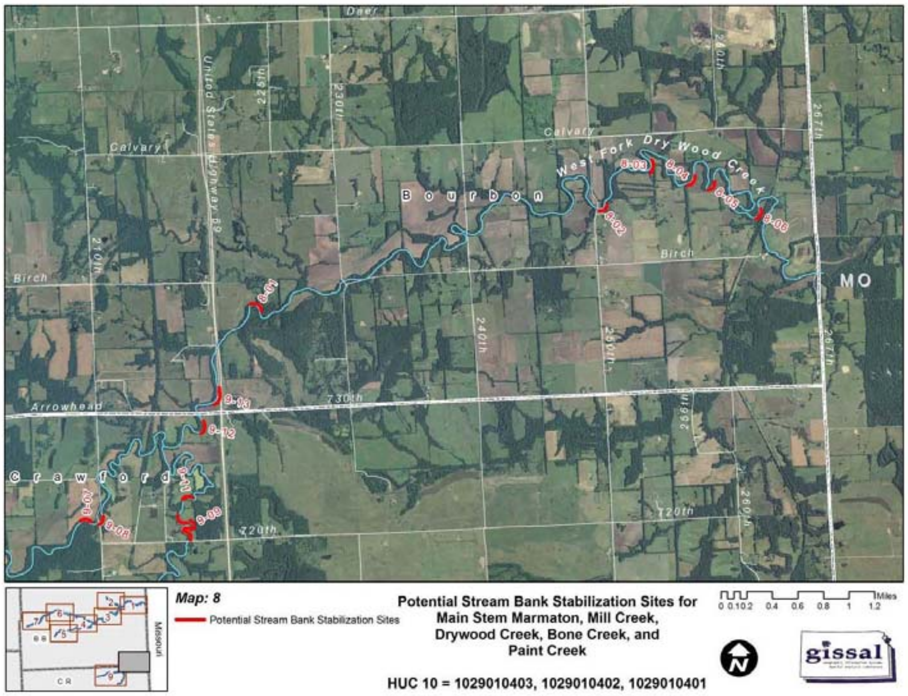

Map: 8
Potential Stream Bank Stabilization Sites
Potential Stream Bank Stabilization Sites for Main Stem Marmaton, Mill Creek, Drywood Creek, Bone Creek, and Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
Miles
0 0.1 0.2 0.4 0.6 0.8 1 1.2
West Fork Dry Wood Creek
Bourbon
Crawford
MO
Missouri
Calvary
Birch
Arrowhead
Deer
United States Highway 69
720th
730th
240th
gissal

Figure 16

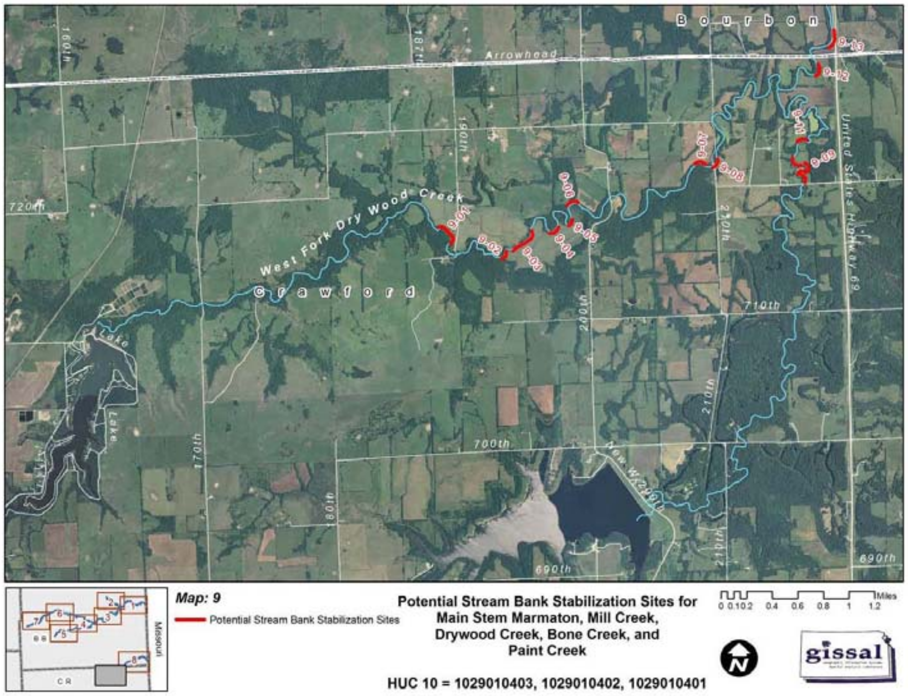

Bourbon
Arrowhead
West Fork Dry Wood Creek
Crawford
United States Highway 69
710th
700th
690th
720th
Map: 9
Potential Stream Bank Stabilization Sites
Potential Stream Bank Stabilization Sites for
Main Stem Marmaton, Mill Creek,
Drywood Creek, Bone Creek, and
Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
Miles
0 0.1 0.2 0.4 0.6 0.8 1 1.2
Missouri
gissal

Figure 17

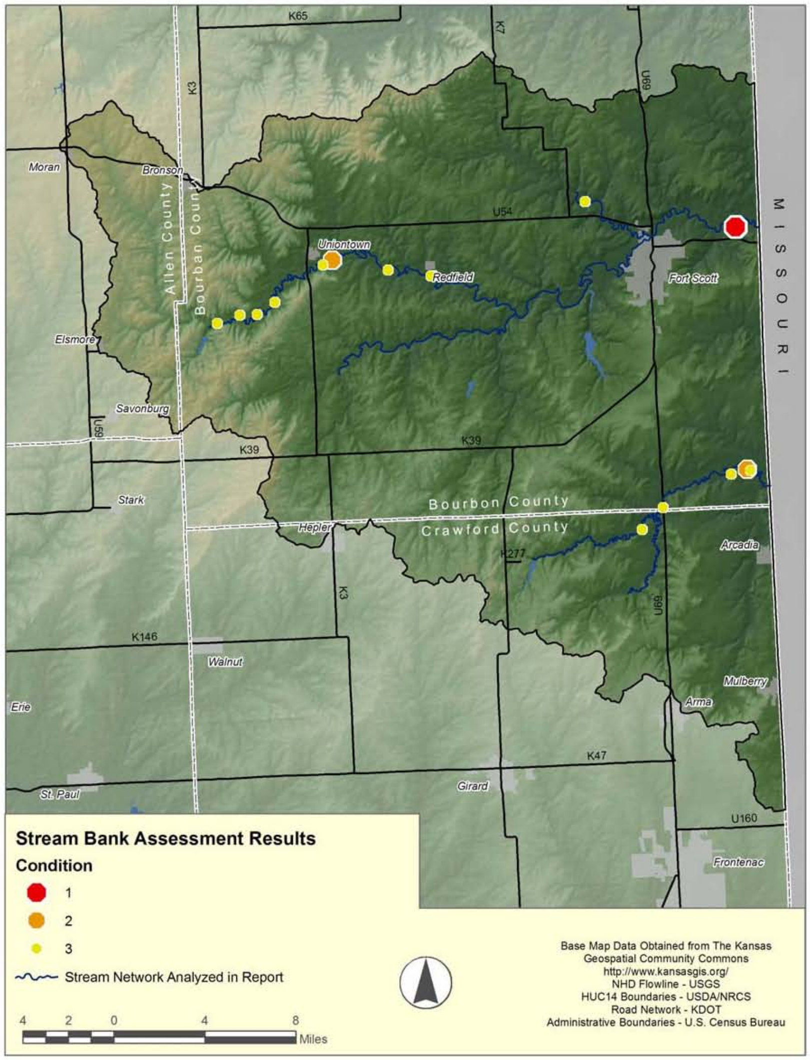

K65
K7
U69
K3
Moran
Bronson
Allen County
Bourban County
U54
Uniontown
Redfield
Fort Scott
MISSOURI
Elsmore
Savonburg
U59
K39
K39
Stark
Bourbon County
Crawford County
Hepler
K277
Arcadia
K3
U69
K146
Walnut
Erie
Mulberry
Arma
K47
St. Paul
Girard
U160
Frontenac
Stream Bank Assessment Results
Condition
1
2
3
Stream Network Analyzed in Report
4 2 0 4 8
Miles
Base Map Data Obtained from The Kansas
Geospatial Community Commons
http://www.kansasgis.org/
NHD Flowline - USGS
HUC14 Boundaries - USDA/NRCS
Road Network - KDOT
Administrative Boundaries - U.S. Census Bureau

Figure 18

Identification of riparian areas in need of protection or restoration

The LANDFIRE existing vegetation cover dataset classifies the percentage of vegetation cover for 30m x30m pixels nationwide, and is a more recent dataset than many land cover data sets available today. This particular dataset is useful in classifying riparian land use, especially in identifying forest stands, which may help stabilize streambanks, and those areas that might be characterized as poor vegetative cover, providing inadequate protection along riparian zones and streambanks.

Results of the land use riparian analysis indicated 252 acres (11%) in need of restoration and 1583 acres (68%) in need of protection (Figure 19 and Table 11) in the riparian region of the stream network analyzed. The remaining land area was considered in need of management since it primarily consisted of pasture/hay (154 acres, or 6.7%) and tree cover of less than 40% (125 acres, or 5.4%). Riparian areas classified as in need of management were considered to be in a more transitory state. The state of the riparian vegetation and its ability to stabilize and protect streambanks while maintaining a proper functioning riparian and stream system could not be evaluated remotely, and may require further on the ground surveys to better understand riparian conditions. Problematic in all the riparian analysis performed is the moderate resolution of the data (30m x30m pixels) and the mixed land use that characterizes many riparian areas. These two issues can result in some misclassification errors. Further on-the-ground evaluation will help in evaluating the riparian region. Maps showing riparian areas classified as either in need of restoration, protection or management can be found in Appendix E.

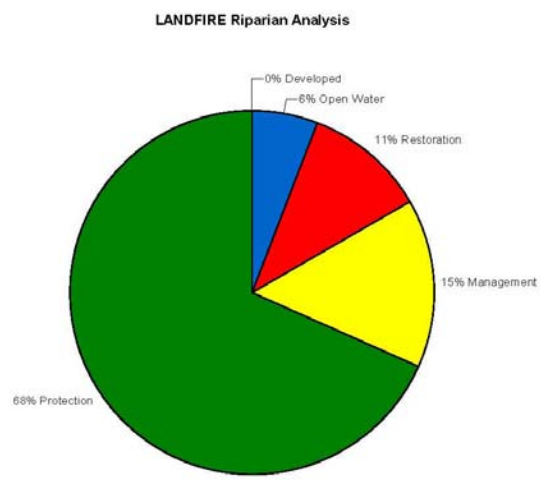


Figure 19 LANDFIRE riparian analysis – areas in need of Restoration, Management and Protection

LANDFIRE Riparian Analysis

Description	Acres
Developed	1.8
Open Water	134.8
Restoration	252.0
Management	341.6
Protection	1583.2
TOTAL	**2311.6**

LANDFIRE Riparian Analysis

Description	Acres	%
RESTORATION	**253.8**	**11**
Developed, Open Space	39.4	1.7
Developed, Low Intensity	8.2	0.4
Developed, Medium Intensity	1.8	0.1
Cultivated Crops	204.4	8.8
MANAGEMENT	**341.6**	**14.8**
Pasture/Hay	154.6	6.7
Tree Cover >=10 and<20%	11.3	0.5
Tree Cover >=20 and <30%	31.6	1.4
Tree Cover >=30 and <40%	82.7	3.6
Shrub Cover >=20 and <30%	0.2	0.0
Shrub Cover >=30 and <40%	8.2	0.4
Herb Cover >=30 and <40%	21.8	0.9
Herb Cover >=40 and <50%	24.5	1.1
Herb Cover >=50 and <60%	6.7	0.3
PROTECTION	**1583.2**	**68.4**
Tree Cover >=40 and <50%	114.5	5.0
Tree Cover >=50 and <60%	163.0	5.6
Tree Cover >=60 and <70%	196.2	6.8
Tree Cover >=70 and <80%	275.5	9.5
Tree Cover >=80 and <90%	528.4	18.2
Tree Cover >=90 and <=100%	305.6	10.5
OPEN WATER	**134.8**	**5.8**
Open Water	134.8	5.8
TOTAL	**2313.4**	**100**

Table 11. Riparian areas in need of restoration, protection and management

References:

Kansas Department of Health and Environment (2000) A Watershed Conditions Report For the State of Kansas HUC 10290101 (Marmaton) Watershed, Topeka, KS

Appendix A

MetaData

2009 USDA National Agriuclutural Statistics Service (NASS) Cropland Data Layer:
http://www.nass.usda.gov/research/Cropland/metadata/metadata_ks09.htm

2009 NLCD 1992-2001 Retrofit Change Product: http://www.mrlc.gov/changeproduct.php &
http://pubs.usgs.gov/of/2008/1379/

2008 U.S. Department of Agriculture (USDA) Farm Service Agency (FSA) National Agriculture Imagery Program (NAIP) Color-composite Imagery:
http://www.kansasgis.org/catalog/catalog.cfm

2006 U.S. Geological Survey (USGS), U.S. Forest Service, The Nature Conservancy:
LANDFIRE Biophysical Settings:
http://landfire.cr.usgs.gov/distmeta/servlet/gov.usgs.edc.MetaBuilder?TYPE=html&DATASET=F0B

2006 U.S. Geological Survey (USGS), U.S. Forest Service, The Nature Conservancy:
LANDFIRE Fire Regime Condition Class (FRCC):
http://landfire.cr.usgs.gov/distmeta/servlet/gov.usgs.edc.MetaBuilder?TYPE=html&DATASET=F0Y

2006 U.S. Geological Survey (USGS), U.S. Forest Service, The Nature Conservancy:
LANDFIRE Existing Vegetation Cover:
http://landfire.cr.usgs.gov/distmeta/servlet/gov.usgs.edc.MetaBuilder?TYPE=HTML&DATASET=F0G

2005 Kansas Land Cover Patterns – Level I: http://kars.ku.edu/research/2005-kansas-land-cover-patterns-level-i/

2001 National Land Cover Dataset (NLCD): http://www.mrlc.gov/nlcd.php

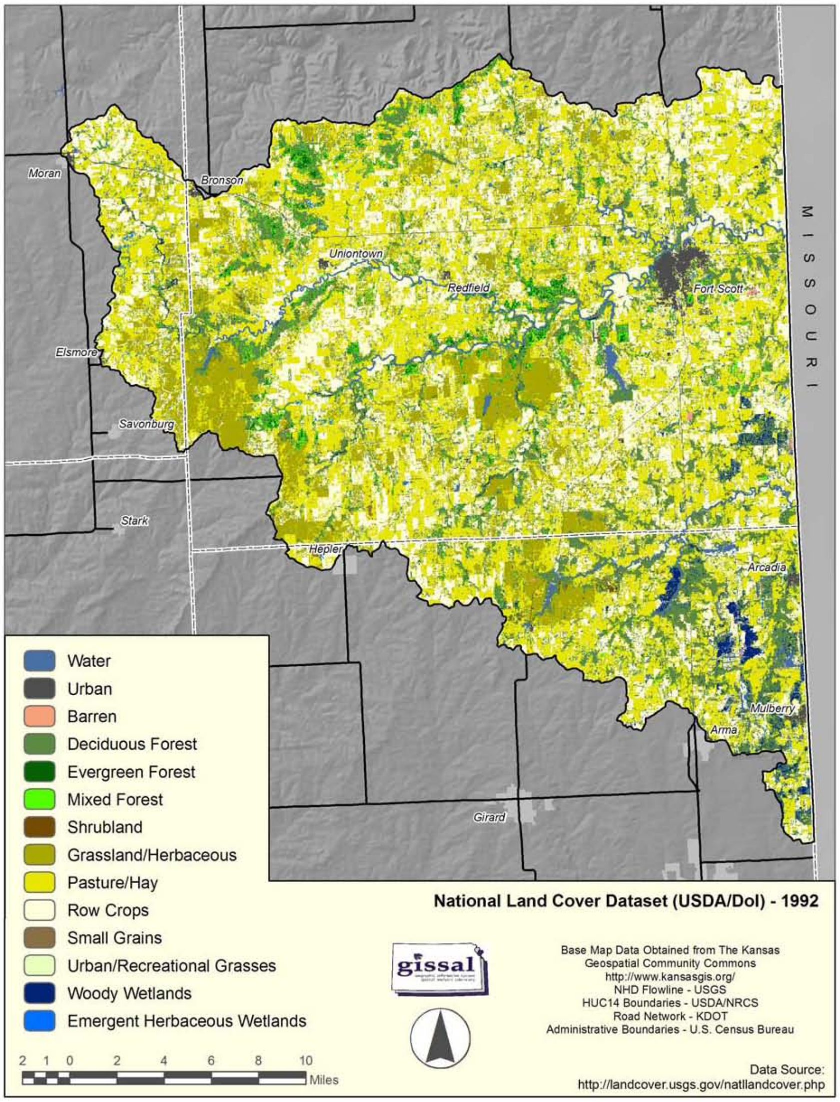
1992 National Land Cover Dataset (NLCD): http://landcover.usgs.gov/accuracy/index.php

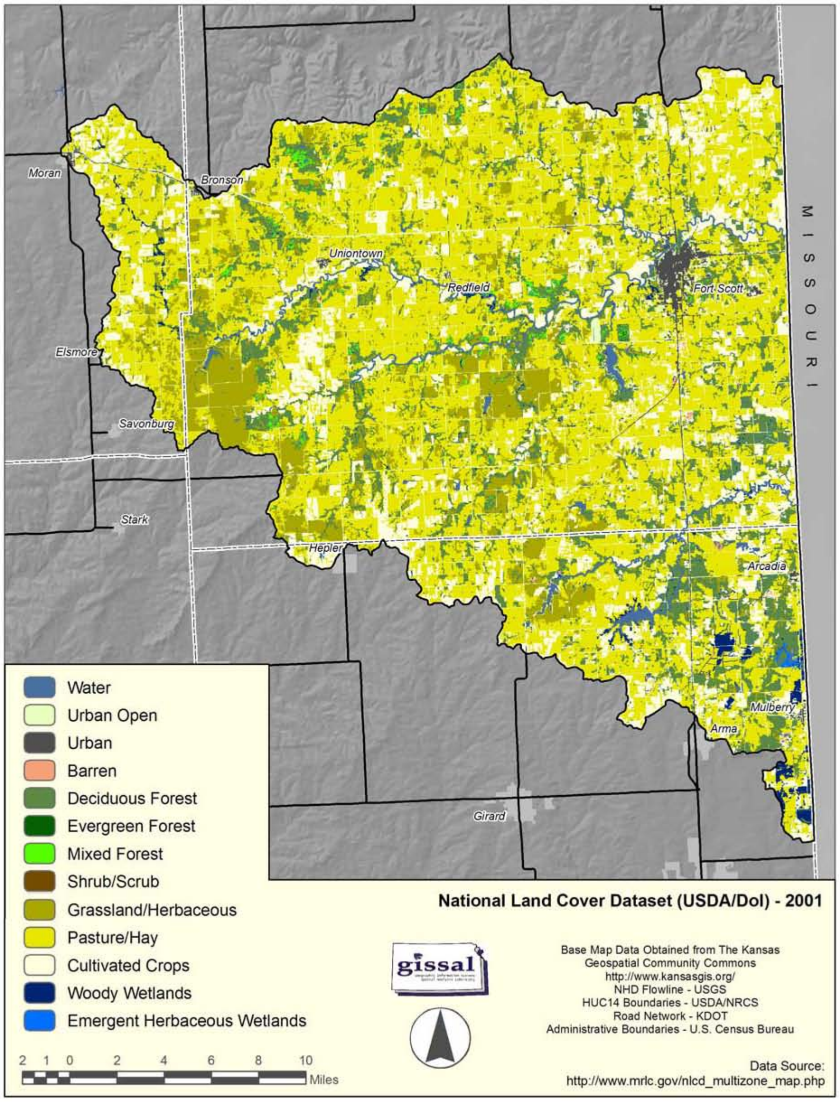
1990 Kansas Land Cover Patterns: http://kars.ku.edu/research/2005-kansas-land-cover-patterns-level-i/

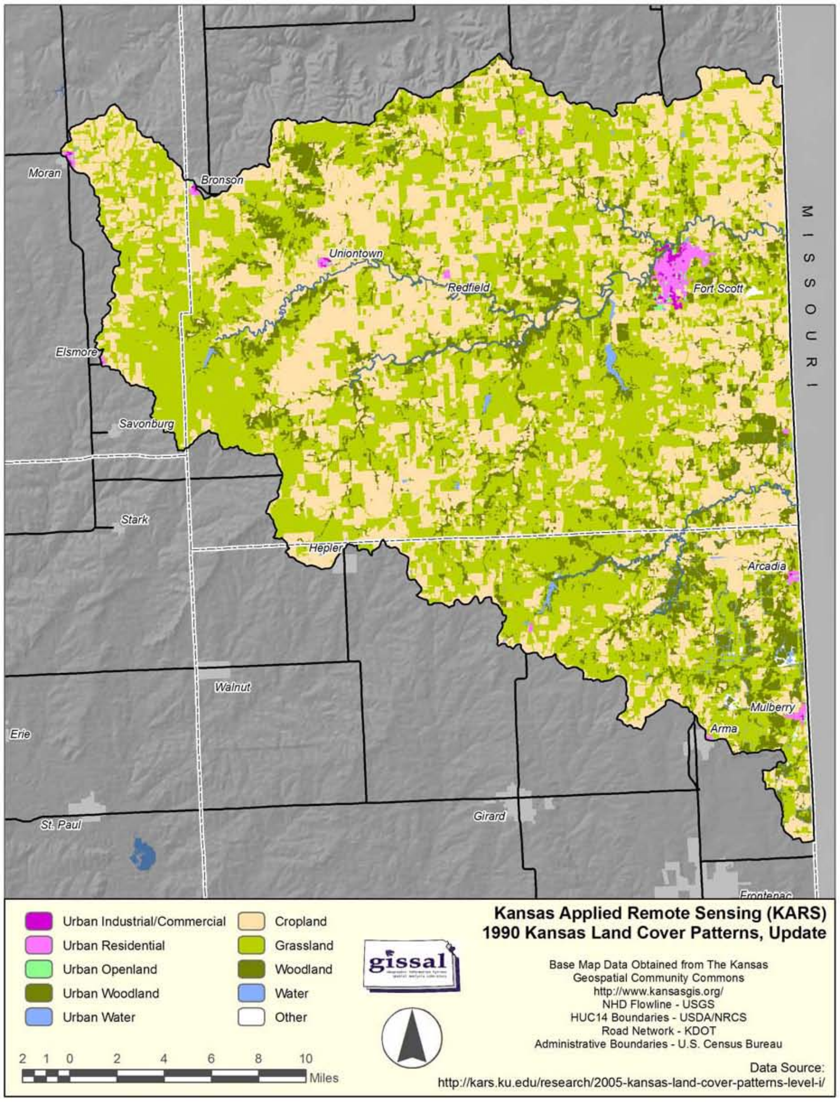
Kansas Applied Remote Sensing (KARS) Program GAP Analysis Land Cover Database:
http://www.kansasgis.org/catalog/viewmeta.cfm?ds=GAP%20Analysis%20Program%20%28GAP%29%20Raster

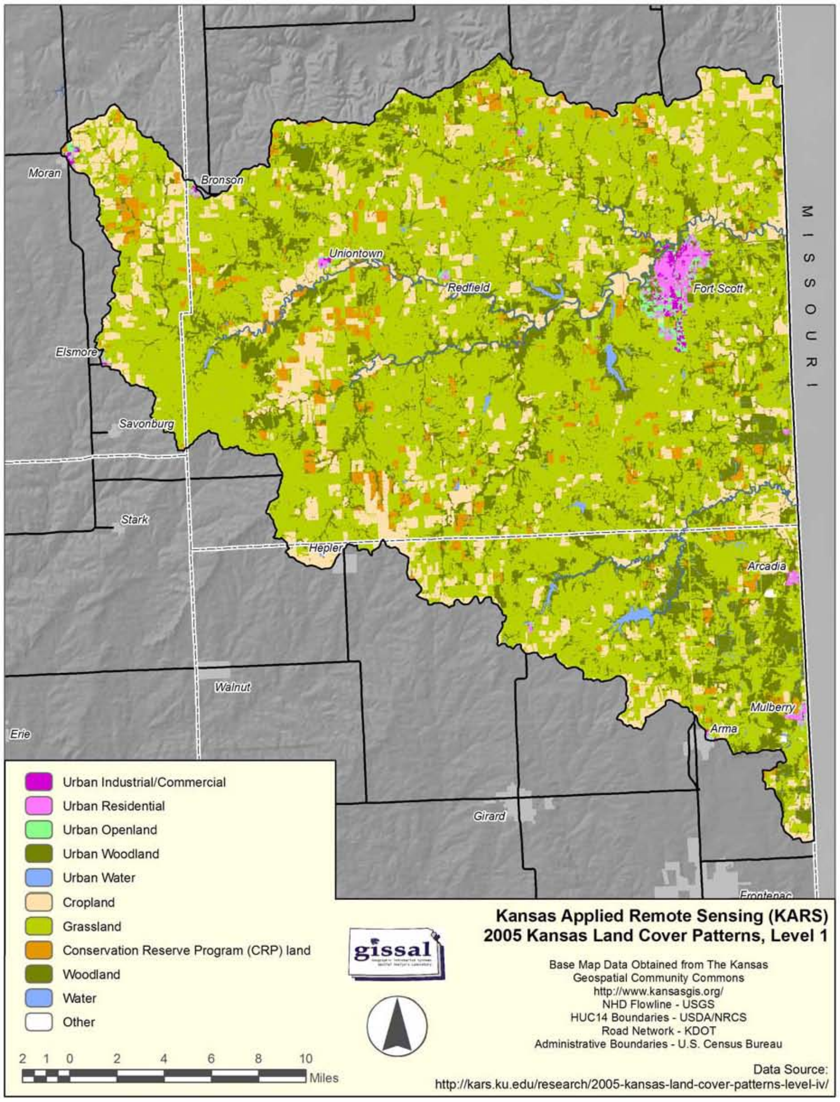
Appendix B

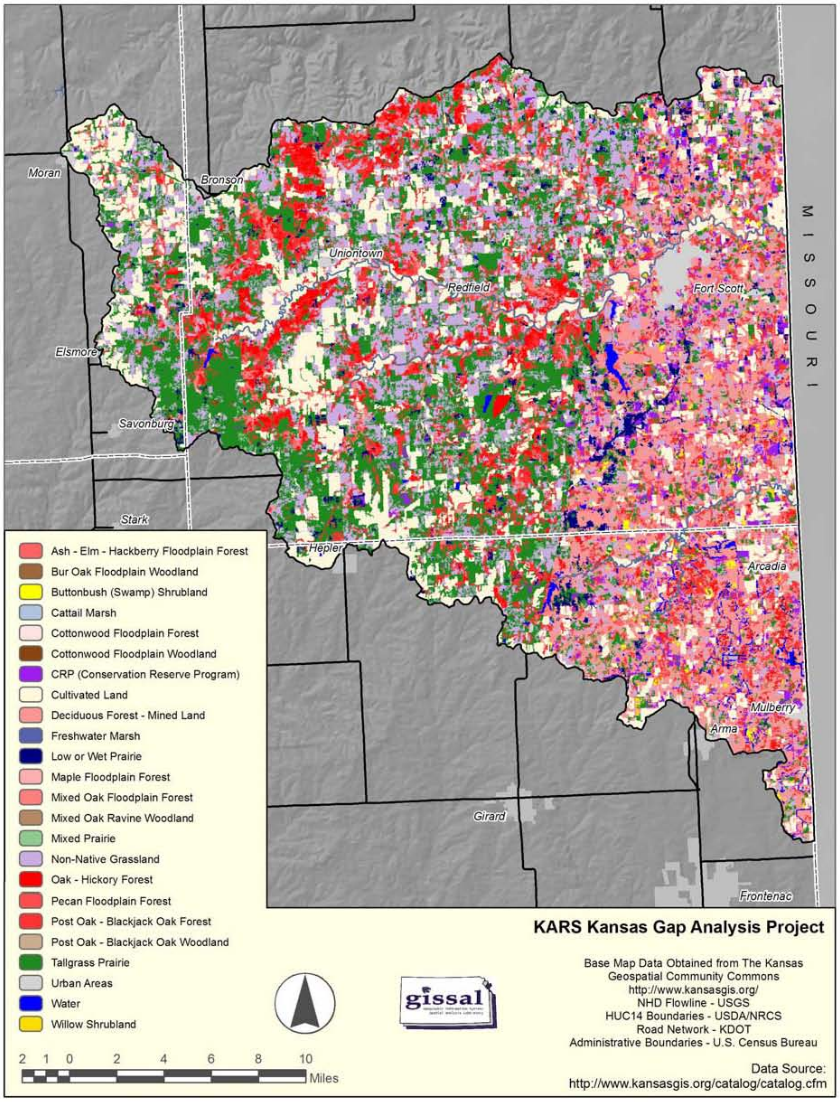
Land Use Maps – Marmaton River Watershed



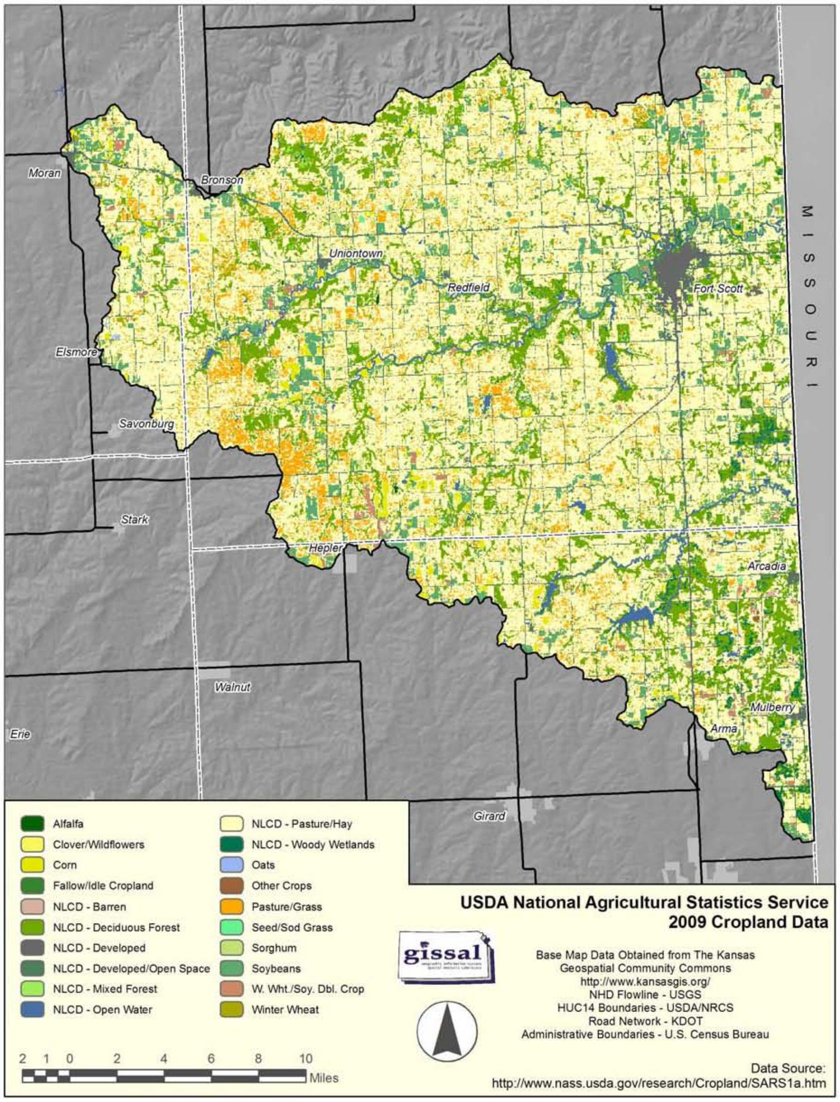

Moran
Bronson
Uniontown
Redfield
Fort Scott
M I S S O U R I
Elsmore
Savonburg
Stark
Hepler
Arcadia
Mulberry
Arma
Girard
Water
Urban Open
Urban
Barren
Deciduous Forest
Evergreen Forest
Mixed Forest
Shrub/Scrub
Grassland/Herbaceous
Pasture/Hay
Cultivated Crops
Woody Wetlands
Emergent Herbaceous Wetlands
2 1 0 2 4 6 8 10
Miles
National Land Cover Dataset (USDA/DoI) - 2001
gissal
Base Map Data Obtained from The Kansas
Geospatial Community Commons
http://www.kansasgis.org/
NHD Flowline - USGS
HUC14 Boundaries - USDA/NRCS
Road Network - KDOT
Administrative Boundaries - U.S. Census Bureau
Data Source:
http://www.mrlc.gov/nlcd_multizone_map.php


Moran
Bronson
Uniontown
Redfield
Fort Scott
Elsmore
Savonburg
Stark
Hepler
Arcadia
Walnut
Erie
Mulberry
Arma
St. Paul
Girard
Frontenac
MISSOURI
Urban Industrial/Commercial
Urban Residential
Urban Openland
Urban Woodland
Urban Water
Cropland
Grassland
Woodland
Water
Other
gissal
Kansas Applied Remote Sensing (KARS)
1990 Kansas Land Cover Patterns, Update
Base Map Data Obtained from The Kansas
Geospatial Community Commons
http://www.kansasgis.org/
NHD Flowline - USGS
HUC14 Boundaries - USDA/NRCS
Road Network - KDOT
Administrative Boundaries - U.S. Census Bureau
2 1 0 2 4 6 8 10
Miles
Data Source:
http://kars.ku.edu/research/2005-kansas-land-cover-patterns-level-i/


Moran
Bronson
Uniontown
Redfield
Fort Scott
Elsmore
Savonburg
Stark
Hepler
Arcadia
Walnut
Erie
Mulberry
Arma
Girard
Frontenac
MISSOURI
Urban Industrial/Commercial
Urban Residential
Urban Openland
Urban Woodland
Urban Water
Cropland
Grassland
Conservation Reserve Program (CRP) land
Woodland
Water
Other
2 1 0 2 4 6 8 10
Miles
gissal
Kansas Applied Remote Sensing (KARS)
2005 Kansas Land Cover Patterns, Level 1
Base Map Data Obtained from The Kansas
Geospatial Community Commons
http://www.kansasgis.org/
NHD Flowline - USGS
HUC14 Boundaries - USDA/NRCS
Road Network - KDOT
Administrative Boundaries - U.S. Census Bureau
Data Source:
http://kars.ku.edu/research/2005-kansas-land-cover-patterns-level-iv/



Moran
Bronson
Uniontown
Redfield
Fort Scott
M I S S O U R I
Elsmore
Savonburg
Stark
Hepler
Arcadia
Mulberry
Arma
Girard
Frontenac
Ash - Elm - Hackberry Floodplain Forest
Bur Oak Floodplain Woodland
Buttonbush (Swamp) Shrubland
Cattail Marsh
Cottonwood Floodplain Forest
Cottonwood Floodplain Woodland
CRP (Conservation Reserve Program)
Cultivated Land
Deciduous Forest - Mined Land
Freshwater Marsh
Low or Wet Prairie
Maple Floodplain Forest
Mixed Oak Floodplain Forest
Mixed Oak Ravine Woodland
Mixed Prairie
Non-Native Grassland
Oak - Hickory Forest
Pecan Floodplain Forest
Post Oak - Blackjack Oak Forest
Post Oak - Blackjack Oak Woodland
Tallgrass Prairie
Urban Areas
Water
Willow Shrubland
2 1 0 2 4 6 8 10
Miles
KARS Kansas Gap Analysis Project
gissal
Base Map Data Obtained from The Kansas
Geospatial Community Commons
http://www.kansasgis.org/
NHD Flowline - USGS
HUC14 Boundaries - USDA/NRCS
Road Network - KDOT
Administrative Boundaries - U.S. Census Bureau
Data Source:
http://www.kansasgis.org/catalog/catalog.cfm


Moran
Bronson
Uniontown
Redfield
Fort Scott
MISSOURI
Elsmore
Savonburg
Stark
Hepler
Arcadia
Walnut
Erie
Mulberry
Arma
Girard
Alfalfa
Clover/Wildflowers
Corn
Fallow/Idle Cropland
NLCD - Barren
NLCD - Deciduous Forest
NLCD - Developed
NLCD - Developed/Open Space
NLCD - Mixed Forest
NLCD - Open Water
NLCD - Pasture/Hay
NLCD - Woody Wetlands
Oats
Other Crops
Pasture/Grass
Seed/Sod Grass
Sorghum
Soybeans
W. Wht./Soy. Dbl. Crop
Winter Wheat
USDA National Agricultural Statistics Service
2009 Cropland Data
gissal
Base Map Data Obtained from The Kansas
Geospatial Community Commons
http://www.kansasgis.org/
NHD Flowline - USGS
HUC14 Boundaries - USDA/NRCS
Road Network - KDOT
Administrative Boundaries - U.S. Census Bureau
2 1 0 2 4 6 8 10
Miles
Data Source:
http://www.nass.usda.gov/research/Cropland/SARS1a.htm

APPENDIX C
MARMATON STREAMBANK ASSESSMENT PROCEDURES

Ground truthing was completed by visual field observation, talking to landowners and FSA 2009 crop layers. Actual access to all sites was limited, due to private landowner control and locating all landowners by contractor. Kansas Alliance for Wetlands and Streams (KAWS) Level 1 GIS Assessment utilizing various land cover data sets and layers identified 70 potential sites of potential streambank erosion. Almost of the sites were on outside bends of the river, with a few along straight channels where stream flow increased. Four (4) potential sites were not evaluated due to lack of contact with landowner or inaccessible from road way. One additional site was identified as a potential in discussion with the landowner. That site is listed as 1-A on Map 3.

KAWS Level 1 Assessment produced 9 maps covering the Marmaton River, Paint Creek, West and East Branches of Drywood Creek. Sites were identified by red bands and points of concern. Potential sites were not numbered. The contractor assigned a numerical number of one (1) starting on the upstream sites and labeling each site in numerical order, going downstream until all sites were numbered. For example Map 1 had a total of five (5) sites identified. The first site on the upstream side was labeled 1-1 the last site downstream was labeled 1-5. Each Map Number would utilize the same procedure. Map 7 had the most sites with seventeen (17).

KAWS did not identify overall length of each proposed sites; however these lines are to scale so a rough estimate could be determined by measurement.

A condition rating was assigned by the field observer to determine a priority for potential restoration of sites that were rated by the observer to have the most erosion. The field observer used a rating numerical rating of 1-10. Condition rating is the following: one (1) being the worst and ten (10) being the best. No scientific protocol was followed other that field observer's experience with streambank sites. Factors influencing the field observer's rating were the following: width of riparian buffers, mature and young trees present, native grassed buffers, adjacent land, crop or grass, streambed and bank materials, infrastructure in peril, bank height and slope. The following is a general guideline to numerical ratings:

1 –Near vertical banks, almost no trees, head cuts from fields, evidence of sloughing, possible infrastructure damage
2- Steep banks, very few trees, < 10' wide, potential infrastructure impact, adjacent cropland lacks conservation measures or over grazed pasture land with cattle in stream
3 – Steep bank at point of hit, < 15' wide, overgrazed, adjacent land with surface runoff
4- Sloped bank, riparian ban of trees 15-20' wide, mature and young trees, evidence of regeneration of young trees on bank slope, maybe some grassed buffers. Most sites were in this category
5- These sites usually had a 15'-25' riparian band of mature and young trees, many had native grass buffers adjacent to trees. Presence of stream benches and slight slope of banks. Some sites had rock substrate or were on the upper end of the stream with a majority of the drainage coming from rangeland

6-These sites had wide riparian buffers 25'-40'. Presence of grass buffers along cropfields or adjacent land seeded to grass or pasture. On many sites, landowner had already fenced cattle out of the riparian zone.
7- No sites were assigned this number, although some may have approached with wide 40'-60'riparian buffers with mature and young trees and rocky substrate.
8-10- These sites would not even be considered for any restoration efforts due to limited funding and not required.

The field observer had previously conducted a similar stream assessment on the Fall River drainage. Evidence of stream damage on the Fall River system appeared to be more dramatic as compared to the Marmaton system. No doubt slope and soil type would be a factor. The field assessment indicated a lot of young trees being regenerated on the sloping banks. This regeneration helps hold the banks from sloughing in future flood events. Fertile soil and adequate rainfall also assists tree regeneration. The abundance of native grass buffers along streams has helped stabilize head cuts from surface runoff.

The field observer identified the following sites as priority for consideration:

Site	Condition/Priority
1-4	1*
6-5	2
8-4	2
15 sites	3

* Site North and east of Ft. Scott Map 1-4 Condition 1

Marmaton Field Assessment Ground Truthing Report
Completed on April 8, 12, and May 13, 2010
C. Douglas Bex, KAWS

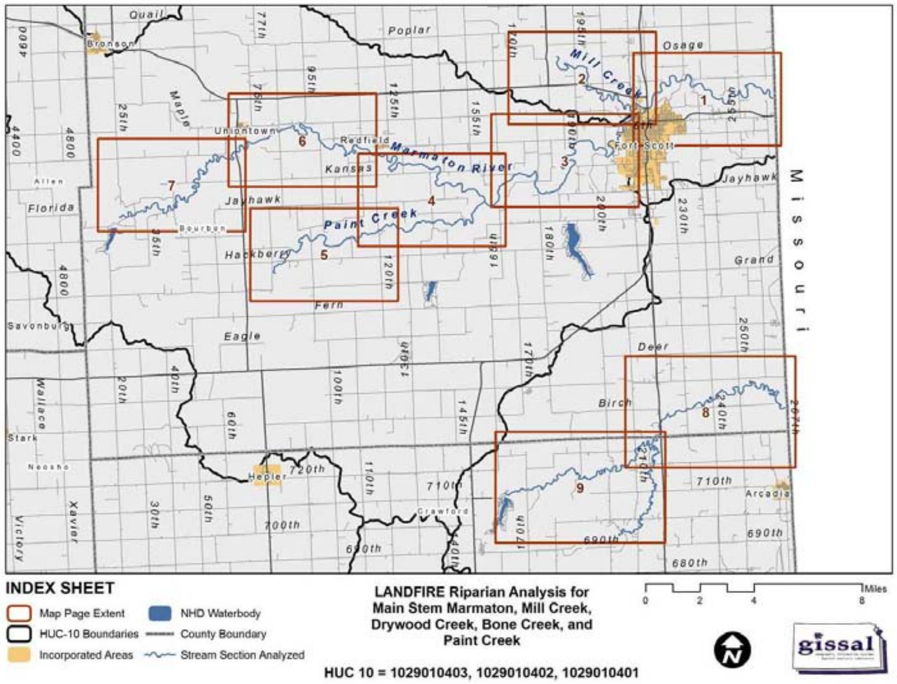
Map#	Site #	Length (ft.)	Stream Name	Condition/Priority	Field Note/Observations
1	1	635	Marmaton	6	Crop field on south, narrow riparian band, young tree growth
1	2	975	Marmaton	5	Tall mature trees, high bank, narrow band of trees, buffer
1	3	496	Marmaton	4	Tall mature trees, young trees, high bank, buffer. Picture # 3
1	4	809	Marmaton	1	Severe erosion on east bank, almost no trees, some rock, high bank
1	5	781	Marmaton	4	Grass land adjacent, narrow band of trees, Pictures # 4& 5
2	1	483	Marmaton	5	Grass land adjacent, buffer of native grass, narrow band of trees
2	2	1403	Marmaton	3	Cropland adjacent, some damage to narrow tree border, buffer
3	1	707	Marmaton	5	Grass land adjacent, narrow band of trees
3	2	557	Marmaton	4	Grass & some cropland adjacent, narrow band of trees
3	3	1086	Marmaton	5	Narrow levee on west side, grass land adjacent on south
3	4	628	Marmaton	4	Narrow tree band, some damage around boat ramp at the stream curve City doing mowing for stream access
4	1	499	Paint	4	Grass land/crop field adjacent, few trees
4	2	510	Marmaton	3	Grass land adjacent, narrow band of trees, mature and young, stream shallow
4	3	1527	Marmaton	3	Grass land adjacent, few trees, erosion at power line crossing
4	4	851	Marmaton	4	Grass land/cropfield adjacent, narrow band of trees
4	5	790	Marmaton	5	ATV driving area on south??, narrow band of mature and young trees
5	1	771	Paint	4	Thin riparian buffer, cropfield on east, low water road crossing
5	2	712	Paint	5	Thin riparian buffer, grass buffer on north, mixture of mature & young trees
5	3	540	Paint	5	Thin riparian buffer,cropfield on east, grass buffer strip
5	4	682	Paint	4	Grassland adjacent, rocky banks, mature and young trees
5	5	897	Paint	4	Grassland adjacent, pasture grazed, high banks, mature and young trees
5	6	681	Paint	4	Grass land adjacent, cattle fenced out of riparian zone, rocky high banks, mature and young trees
5	7	907	Paint	4	Grass land adjacent, pasture grazed, rocky high banks, mature and young trees
5	8	707	Paint	4	Grass land adjacent, cattle fenced out of riparian zone, rocky high banks, mature and young trees
6	1	736	Marmaton	5	Thin riparian buffer, mature and young trees
6	2	529	Marmaton	5	Thin riparian buffer, mature and young trees, some slight erosion
6	3	642	Marmaton	4	Mature and young trees, grass land adjacent
6	4	1498	Marmaton	3	Cropfield on south, grass buffer, thin riparian trees

Map #	Site #	Length (ft.)	Stream Name	Condition/Priority	Field Note/Observations
6	5	3660	Marmaton	2	Cropfield on north, grass buffer, very few trees, steep banks
6	6	1526	Marmaton	3	Grass buffer and some CRP adjacent, few trees, high banks, irrigation intake
6	7	680	Marmaton	3	Grass land on south, some erosion on hit point
7	1	331	Marmaton	4	Grass land on south thin riparian buffer, mature and young trees
7	2	650	Marmaton	4	Grass land on south thin riparian buffer, mature and young trees
7	3	1257	Marmaton	3	Cropfield on north, high banks,mature and young trees,but thin band
7	4	377	Marmaton	4	Thin riparian band of trees, base of steep hill road
7	5	589	Marmaton	4	Grass land on south, mature and young trees, grass buffer on tip of site
7	6	592	Marmaton	3	Cropfield on north, erosion on hit point
7	7	689	Marmaton	4	Grass land on south, thin riparian buffer with mature & young trees
7	8	514	Marmaton	4	Low water road crossing cropfield on west, buffer with mature & young trees
7	9	732	Marmaton	3	Native grass field buffer, almost no trees
7	10	806	Marmaton	4	Native grass field buffer, thin riparian buffer a few mature & young trees
7	11	918	Marmaton	4	Native grass field buffer, thin riparian buffer a few mature & young trees
7	12	452	Marmaton	4	Native grass buffer on both north & south, few mature & young trees
7	13	383	Marmaton	4	Native grass cropfield adjacent to stream, few mature & young trees
7	14	500	Marmaton	4	Native grass buffer very few trees
7	15	508	Marmaton	3	Almost no riparian tree buffer
7	16	453	Marmaton	5	Thin riparian tree buffer 20-30' wide, mature and young trees
7	17	304	Marmaton	5	Thin riparian tree buffer 20-30' wide, mature and young trees
7	18	402	Marmaton	5	Thin riparian tree buffer 20-30' wide, mature and young trees
7	19	515	Marmaton	4	Native grass/johnson grass buffer, few trees
8	1	685	W. Fork Drywood	4	Grassland adjacent,small section eroded, narrow riparian tree buffer
8	2	494	W. Fork Drywood	3	Grassland adjacent, erosion on hit point, LO said moved 30' in 20 years
8	3	567	W. Fork Drywood	5	Cropfield on south, narrow riparian band of trees, mature and young
8	4	579	W. Fork Drywood	2	Cropfield on south, LO said is cutting into field,will help, narrow band of trees
8	5	516	W. Fork Drywood	3	Cropfield on south, cutting on hit point, narrow band of trees
8	6	515	W. Fork Drywood	5	Railroad rightaway on east, small brush and some stabiliztion by railroad
9	1	1081	W. Fork Drywood	4	Grass land adjacent, cattle fenced out of riparian zone
9	2	436	W. Fork Drywood		Did not evaluate
9	3	1255	W. Fork Drywood		Did not evaluate
9	4	492	W. Fork Drywood		Did not evaluate
9	5	332	W. Fork Drywood		Did not evaluate
9	6	522	W. Fork Drywood	4	Grass land adjacent, tree row has head cut, but ample riparian buffer
9	7	510	W. Fork Drywood	4	Narrow band of trees, mature & young, cropland adjacent
9	8	447	W. Fork Drywood	3	Grass land adjacent, some erosion at hit point near county bridge

Map #	Site #	Length (ft.)	Stream Name	Condition/Priority	Field Note/Observations
9	9	1483	E. Fork Drywood	4	Narrow band of trees, mature & young, grass land on south
9	10	582	E. Fork Drywood	4	Grass land on east, narrow band of trees
9	11	484	E. Fork Drywood	4	Grass land on north, narrow band of trees, mature & young
9	12	579	W. Fork Drywood	4	Grass land on east, narrow band of trees, mature & young
9	13	839	W. Fork Drywood	3	Adjacent to US 69, erosion along rightaway, KDOT has stabilized in places
3	1-A		Marmaton	3	Landowner identified as a problem, not identified on GIS assessment

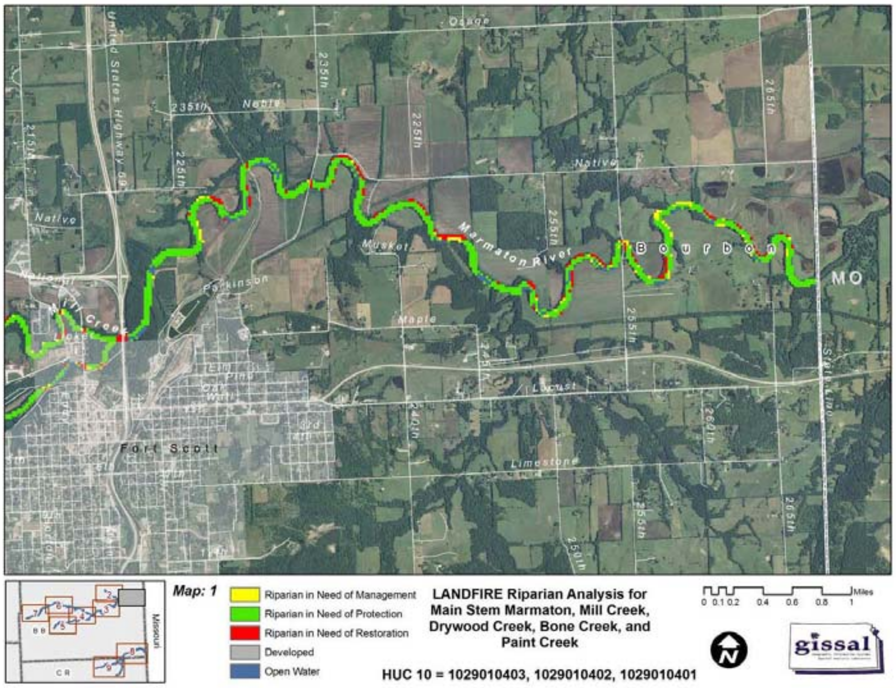
APPENDIX D

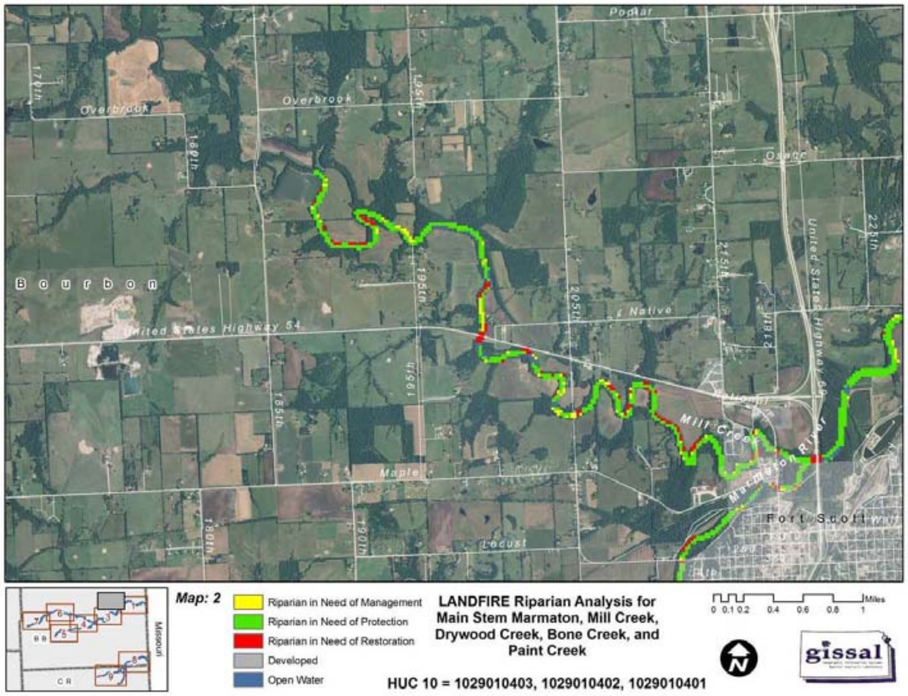
Riparian Analysis Map Index Sheet

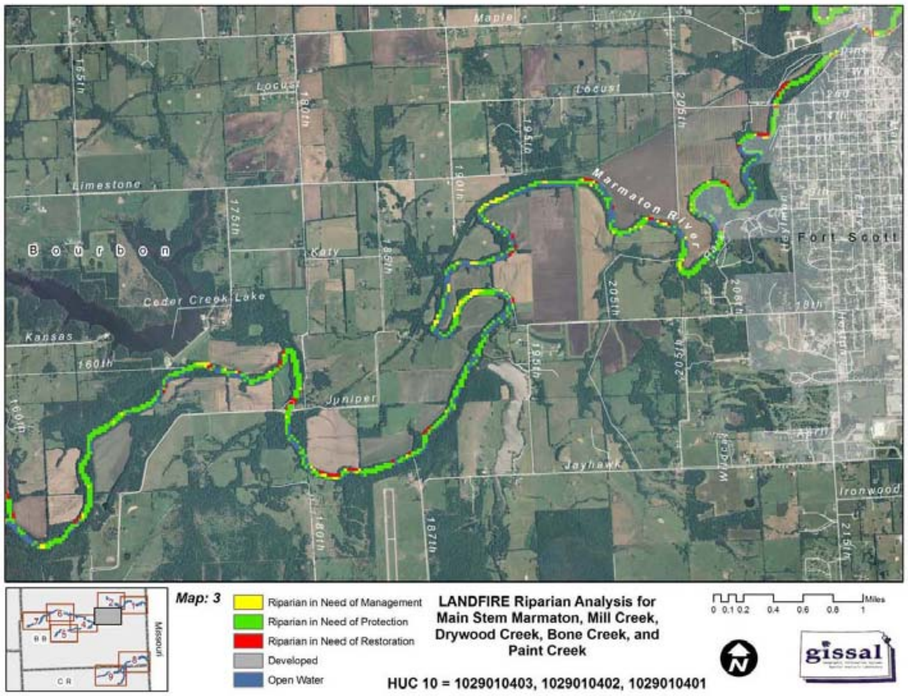


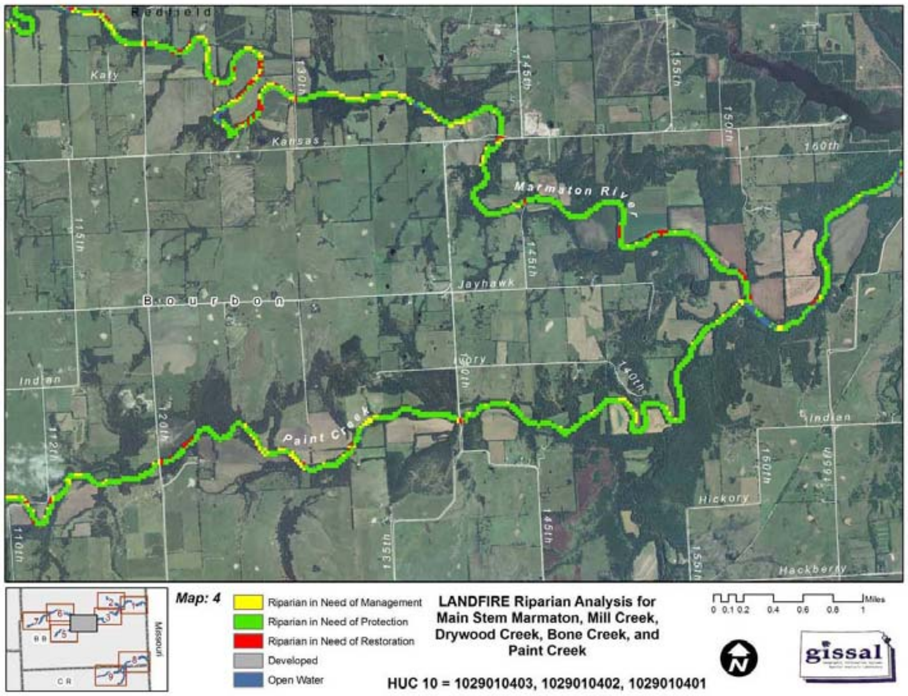
APPENDIX E

Areas in Need of Protection and Restoration – Supporting Maps

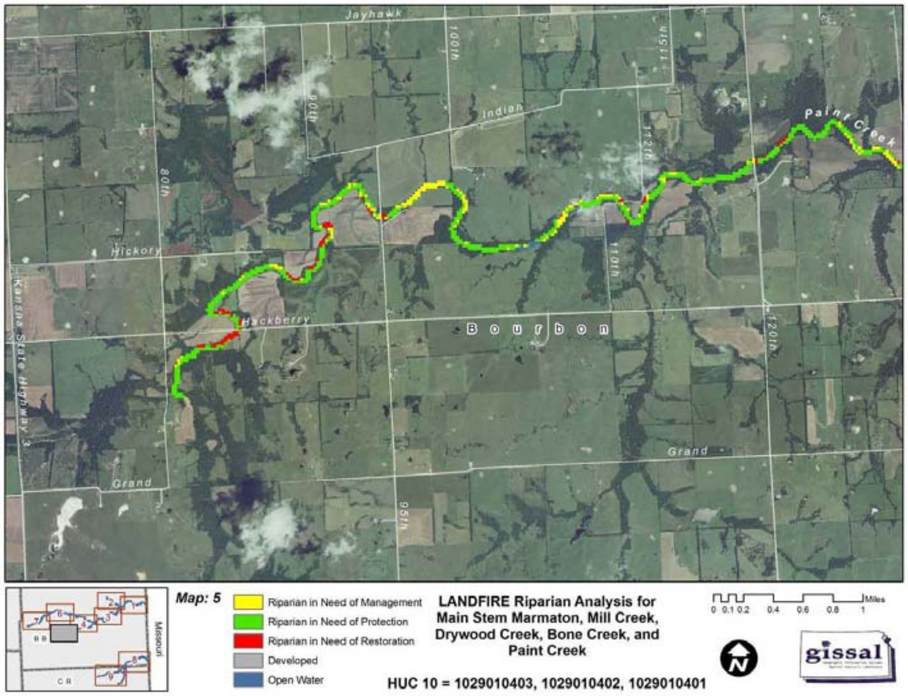


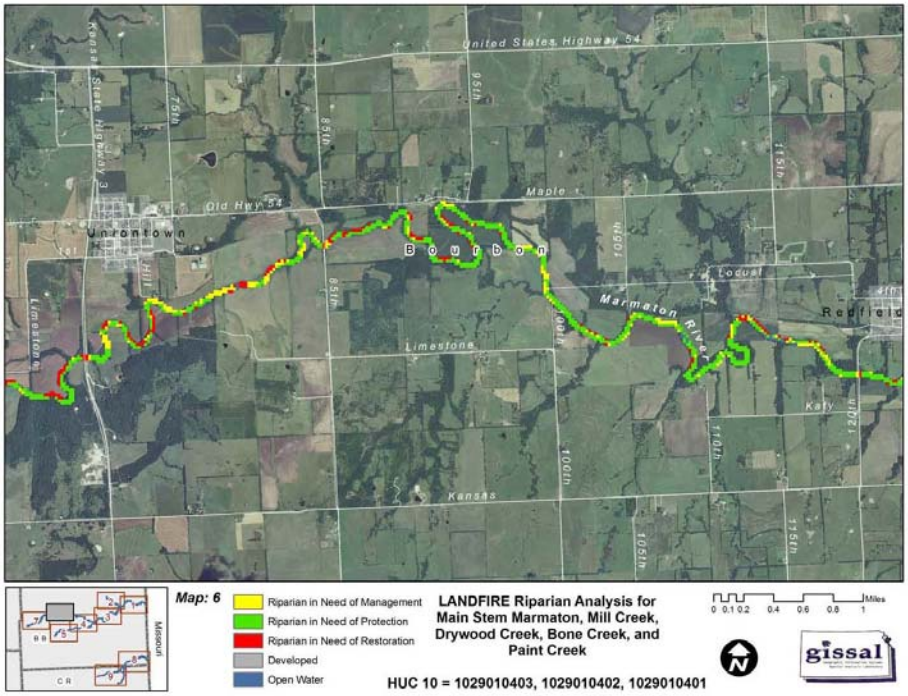

Poplar
Overbrook
Overbrook
Osage
Bourbon
United States Highway 54
Native
United States Highway 69
Mill Creek
Marmaton River
Maple
Locust
Fort Scott
Map: 2
Riparian in Need of Management
Riparian in Need of Protection
Riparian in Need of Restoration
Developed
Open Water
LANDFIRE Riparian Analysis for Main Stem Marmaton, Mill Creek, Drywood Creek, Bone Creek, and Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
0 0.1 0.2 0.4 0.6 0.8 1 Miles
Missouri
gissal


Maple
Locust
Limestone
Bourbon
Katy
Cedar Creek Lake
Kansas
160th
Juniper
Marmaton River
Fort Scott
Jayhawk
Ironwood
Missouri
Map: 3
Riparian in Need of Management
Riparian in Need of Protection
Riparian in Need of Restoration
Developed
Open Water
LANDFIRE Riparian Analysis for Main Stem Marmaton, Mill Creek, Drywood Creek, Bone Creek, and Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
0 0.1 0.2 0.4 0.6 0.8 1 Miles
gissal



Marmaton River
Paint Creek
Bourbon
Kansas
Jayhawk
Indian
Hickory
Hackberry
160th
Map: 4
Riparian in Need of Management
Riparian in Need of Protection
Riparian in Need of Restoration
Developed
Open Water
LANDFIRE Riparian Analysis for Main Stem Marmaton, Mill Creek, Drywood Creek, Bone Creek, and Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
0 0.1 0.2 0.4 0.6 0.8 1 Miles
Missouri
gissal


Jayhawk
100th
115th
Indian
Paint Creek
80th
Hickory
Hackberry
Bourbon
110th
120th
Kansas State Highway 3
Grand
Grand
95th
Missouri
Map: 5
Riparian in Need of Management
Riparian in Need of Protection
Riparian in Need of Restoration
Developed
Open Water
LANDFIRE Riparian Analysis for
Main Stem Marmaton, Mill Creek,
Drywood Creek, Bone Creek, and
Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
0 0.1 0.2 0.4 0.6 0.8 1 Miles
N
gissal


United States Highway 54
Kansas State Highway 3
75th
85th
95th
Old Hwy 54
Maple
Uniontown
Bourbon
Locust
Marmaton River
Redfield
Limestone
Katy
100th
105th
110th
115th
120th
Kansas
Missouri
Map: 6
Riparian in Need of Management
Riparian in Need of Protection
Riparian in Need of Restoration
Developed
Open Water
LANDFIRE Riparian Analysis for
Main Stem Marmaton, Mill Creek,
Drywood Creek, Bone Creek, and
Paint Creek
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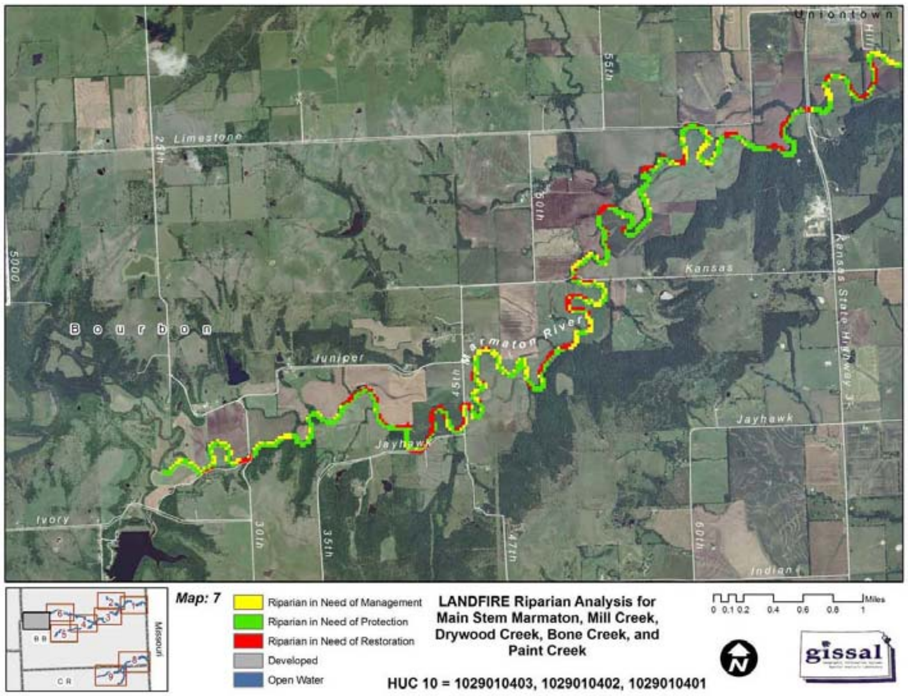
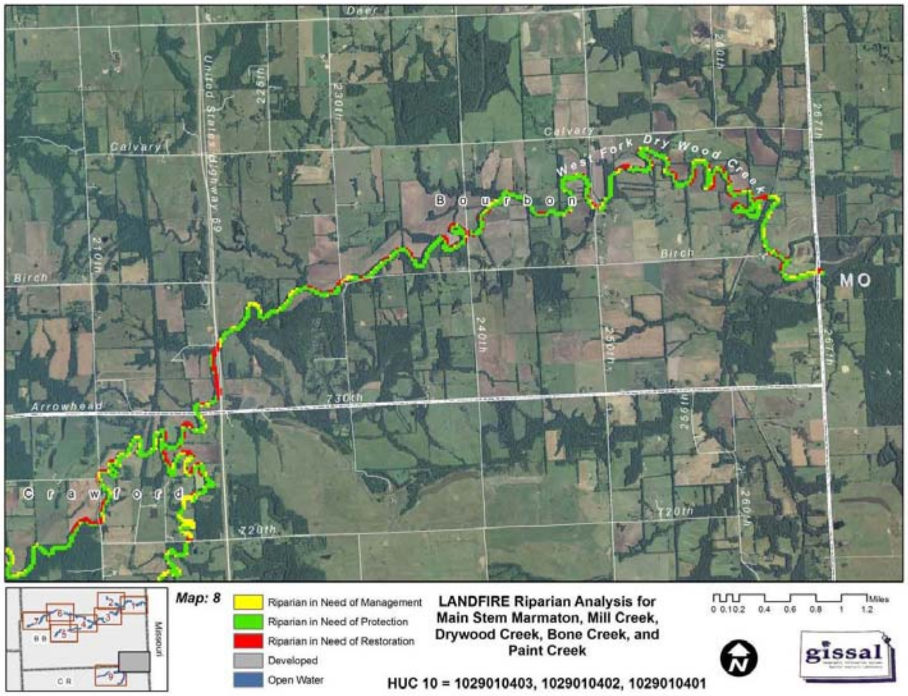
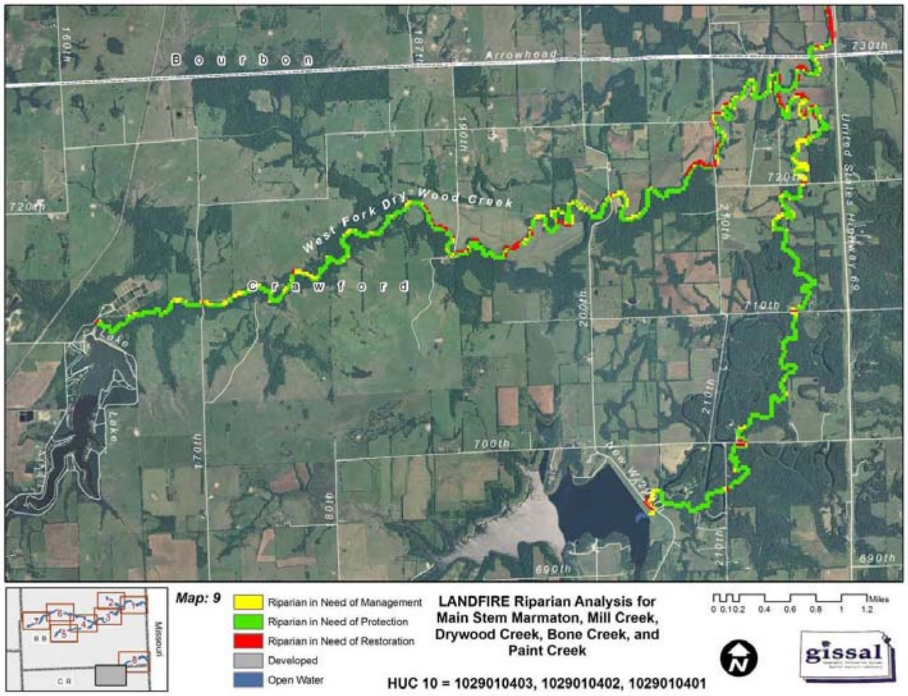
Miles
gissal


Uniontown
Limestone
25th
55th
60th
5000
Bourbon
Kansas
Kansas State Highway 3
Marmaton River
Juniper
15th
Jayhawk
Jayhawk
Ivory
30th
35th
47th
60th
Indian
Map: 7
Riparian in Need of Management
Riparian in Need of Protection
Riparian in Need of Restoration
Developed
Open Water
LANDFIRE Riparian Analysis for Main Stem Marmaton, Mill Creek, Drywood Creek, Bone Creek, and Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
0 0.1 0.2 0.4 0.6 0.8 1 Miles
Missouri
BB
CR
gissal


Map: 8
Riparian in Need of Management
Riparian in Need of Protection
Riparian in Need of Restoration
Developed
Open Water
LANDFIRE Riparian Analysis for Main Stem Marmaton, Mill Creek, Drywood Creek, Bone Creek, and Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
Miles
West Fork Dry Wood Creek
Bourbon
Crawford
MO
Calvary
Birch
Arrowhead
730th
720th
United States Highway 69
Missouri
gissal


Bourbon
Arrowhead
730th
720th
West Fork Dry Wood Creek
Crawford
United States Highway 69
710th
700th
690th
160th
170th
180th
187th
190th
200th
210th
Map: 9
Riparian in Need of Management
Riparian in Need of Protection
Riparian in Need of Restoration
Developed
Open Water
LANDFIRE Riparian Analysis for
Main Stem Marmaton, Mill Creek,
Drywood Creek, Bone Creek, and
Paint Creek
HUC 10 = 1029010403, 1029010402, 1029010401
Miles
0 0.1 0.2 0.4 0.6 0.8 1 1.2
Missouri
gissal

Marmaton Watershed Report 2009

Report Written for

Marmaton Watershed Restoration and Protection Strategy

Report Written by

Philip L. Barnes PhD
Biological and Agricultural Engineering
Kansas State University

Introduction

"Eutrophication" is the enrichment of surface waters with plant nutrients. While eutrophication occurs naturally, it is normally associated with anthropogenic sources of nutrients. The "trophic status" of reservoirs is the central concept in reservoir management. It describes the relationship between nutrient status of a reservoir and the growth of organic matter in the reservoir. Eutrophication is the process of change from one trophic state to a higher trophic state by the addition of nutrients. Land use above a water body is a major factor in eutrophication state.

Although both nitrogen and phosphorus contribute to eutrophication, classification of trophic status usually focuses on that nutrient which is limiting. In the majority of cases, phosphorus is the limiting nutrient. While the effects of eutrophication such as algal blooms are readily visible, the process of eutrophication is complex and its measurement difficult.

Problems of restoration of eutrophic lakes

Eutrophic and hypertrophic reservoirs tend to be shallow and suffer from high rates of nutrient loadings from point and non-point sources. In areas of rich soils such as the prairies, reservoir bottom sediments are comprised of nutrient-enriched soil particles eroded from surrounding soils. The association of phosphorus with sediment is a serious problem in the restoration of shallow, enriched reservoirs. Phosphorus-enriched particles settle to the bottom of the reservoir and form a large pool of nutrients in the bottom sediments that is readily available to rooted aquatic plants and which is released from bottom sediments under conditions of anoxia into the overlying water column and which is quickly utilized by the aquatic plants or algae. This phosphorus pool, known as the "internal load" of phosphorus, can greatly offset any measures taken by watershed management to control reservoir eutrophication by control of external phosphorus sources from the watershed. Historically, dredging of bottom sediments was considered the only means of remediating nutrient-rich reservoir sediments; however, modern technology now provides alternative and more cost-effective methods of controlling internal loads of phosphorus by oxygenation and by chemically treating sediments in situ to immobilize the phosphorus.

Methods and Materials

<u>Surface Water</u>

Water quality samples were collected at five locations including primary watershed tributaries flowing into Marmaton River, during 2009 (Figure 1). The watershed district and Kansas State University were unable to get a right-of-way on KDOT easements on Mill Creek during 2009. Samples in the winter months of March, October, November, and December will be taken once during the month. During the rest of the sampling year samples will be taken weekly or on a runoff event. Flow depths and

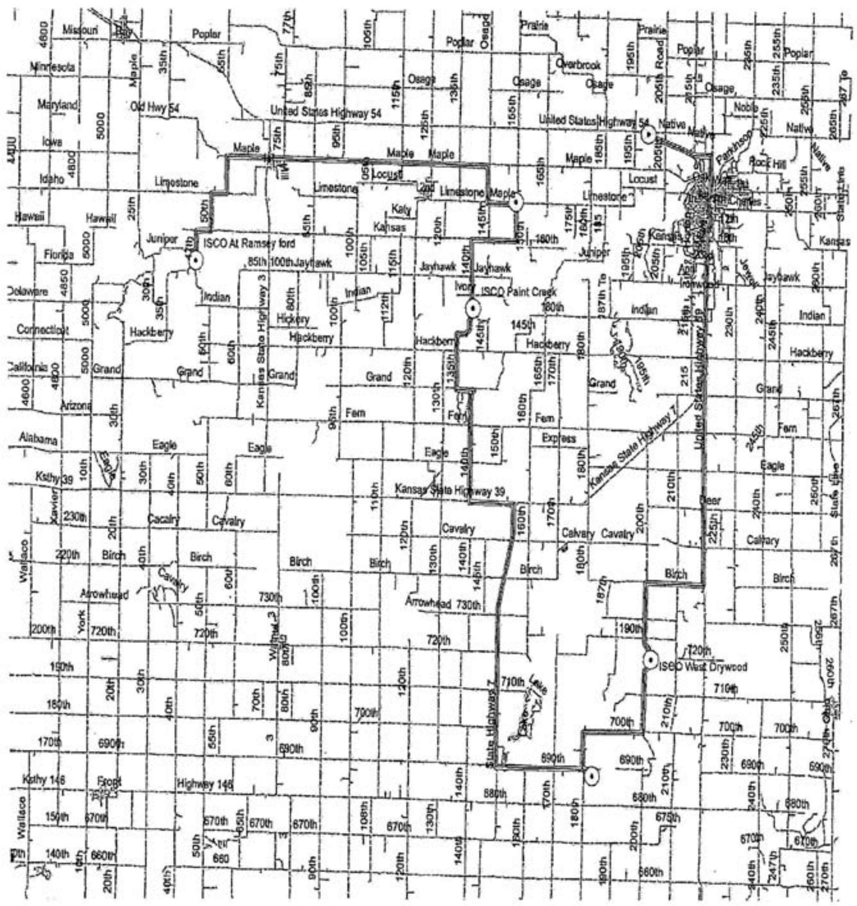


Figure 1. Marmaton route to monitoring locations.

samples were collected using an automated sampler, (Bone Creek sampler shown on front cover). This data will be used to calculate flowrate and flow volumes at sampling collection. The sites are located in figure 1 are described in table 1.

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The water samples will be analyzed for total suspended solids, total nitrogen and phosphorus. When these contaminant concentrations are multiplied by the flow volume, the load of a particular contaminant can be determined. These loads will be assessed over time to examine if the source of the contaminant is derived from an erosion source or potentially by application of fertilizer or manure. Once these loads are assessed then the study can investigate the watershed for potential sources of that contamination.

1. Stream Flow (Ward and Elliot, 1995)

Flow in a stream is a function of many factors including precipitation, surface runoff, interflow; the cross sectional geometry and bed slope of the channel, the bed and

Table 1. Monitoring site location description and coordinates for Marmaton watershed.

Site Number	Site Location	Sample Type	Site Coordinates
1	Mill Creek (Not Installed)	Isco Event	Lat 37 51.744 Lon 94 44.542
1	Mill Creek	Grab	Lat 37 51.741 Lon 94 44.566
2	Lower West Drywood Creek	Isco Event	Lat 37 39.512 Lon 94 44.200
2	Lower West Drywood Creek	Grab	Lat 37 39.501 Lon 94 44.197
3	Bone Creek	Isco Event	Lat 37 36.757 Lon 94 46.338
3	Bone Creek	Grab	Lat 37 36.760 Lon 94 46.347
4	Upper West Drywood Creek	Grab	Lat 37 38.912 Lon 94 47.719
5	Paint Creek	Isco Event	Lat 37 47.575 Lon 94 51.039
5	Paint Creek	Grab	Lat 37 47.558 Lon 94 51.039
6	Cedar Creek	Isco Event	Lat 37 50.078 Lon 94 49.463
6	Cedar Creek	Grab	Lat 37 50.060 Lon 94 49.473
7	Upper Marmaton River	Isco Event	Lat 37 48.509 Lon 95 01.148
7	Upper Marmaton	Grab	Lat 37 48.489 Lon 95 01.155

side slope roughness; meandering, obstructions, and changes in shape; hydraulic control structures and impoundments; and sediment transport and channel stability. Generally, flow in streams and impoundments are classified as open-channel flow because the surface of the flow is open to the atmosphere. Stream flow can be classified several ways. For example, it can be turbulent in steep rocky areas or following severe storm events. Typically, stream flow is tranquil and is considered to be a steady uniform flow. The calculated stream flows for this study assume this condition where the stream depth does not change during the flow measurement and the same depth at every section along the stream.

The stream flow is:

$$q = va \tag{1}$$

where: q = stream flow (ft^3/sec),
v = average stream velocity (ft/sec), and
a = cross-sectional area of flow (ft^2).

For uniform flow in a stream, the average stream velocity, v, can be estimated by Manning's equation.

$$v = \frac{1.5}{n} R^{2/3} S^{1/2} \tag{2}$$

where: v = average stream velocity (ft/sec),
n = Manning's roughness coefficient of the stream channel,
R = hydraulic radius (a/p, p = wetted perimeter), and
S = channel bed slope (ft/ft).

Flow measurement and sample collection for this study was made at road crossings at bridges or culverts using an ISCO stage recorder. The cross sectional area and hydraulic parameters needed to estimate stream flow through these structures were measured.

2. Total Suspended Solids Parameter

Total suspended solids (TSS) include all particles suspended in which will not pass through a filter. Nonpoint sources of suspended solids are typically associated with soil erosion in surface runoff and stream bank erosion.

As levels of TSS increase, a stream begins to lose its ability to support a diversity of aquatic life. Suspended solids absorb hear from sunlight, which increases water temperature and subsequently decreases levels of dissolved oxygen.

TSS can also destroy fish habitat because suspended solids settle to the bottom and can eventually blanket the riverbed. Suspended solids can smother the eggs of fish and aquatic insects, and can suffocate newly hatched insect larvae. Suspended solids can also harm fish directly by clogging gills, reducing growth rates, and lowering resistance to disease. Changes to the aquatic environment may result in diminished food sources, and increased difficulties in finding food. Natural movements and migrations of aquatic populations may be disrupted.

The procedure used in this study to measure the total suspended solids parameter is described the Standard Methods for the Examination of Water and Wastewater Method 209C (1985). Total suspended solid concentrations less than 20 mg/l are considered to be clear. Water with TSS levels between 20 and 80 mg/l tend to appear cloudy, while TSS levels greater than 150 mg/l appear to be dirty and are considered impaired.

3. Total Nitrogen and Phosphorus Parameter

The growth of aquatic plants is stimulated principally by nutrients such as nitrogen and phosphorus. Nutrient-stimulated plant production is of most concern in lakes, because primary production in flowing water is thought to be controlled by physical factors, such as light penetration, timing of flow, and type of substrate available, instead of by nutrients (McCabe et al., 1985).

Generally, phosphorus (as orthophosphate) is the limiting nutrient in freshwater aquatic systems. That is, if all phosphorus is used, plant growth will cease, no matter how much nitrogen is available. The natural background levels of total phosphorus are generally less than 0.03 mg/l. The natural levels of orthophosphate usually range from 0.005 to 0.05 mg/l (Dunne and Leopold, 1978).

Many bodies of freshwater are currently experiencing influxes of nitrogen and phosphorus from outside sources. The increasing concentration of available phosphorus allows plants to assimilate more nitrogen before the phosphorus is depleted. Thus, if sufficient phosphorus is available, elevated concentrations of nitrates will lead to algal blooms. Although levels of 0.08 to 0.10 mg/l orthophosphate may trigger periodic blooms, long-term eutrophication will usually be prevented if total phosphorus levels and orthophosphate levels are below 0.5 mg/l and 0.05 mg/l, respectively (Dunne and Leopold, 1978).

Water samples from this study will be analyzed for total phosphorus at the Kansas State University Soil Testing Laboratory, Manhattan, Kansas. The technique used involves sample digestion with a Potassium Persulfate Reagent in an autoclave and then analyzed using a Technicon AutoAnalyzer 11 (Hosomi and Sudo, 1986).

Results and Discussion

Rain gages were placed near Uniontown and Fort Scott, Kansas. Figure 2 and 3 shows the comparison rainfall for these locations. This is a point measurement but gives a fair representation of the rainfall patterns that fell in the Marmaton watershed. Figure 3 shows the USGS average daily stream flow at Uniontown and Fort Scott.

Figure 2. Uniontown 2009 Rainfall

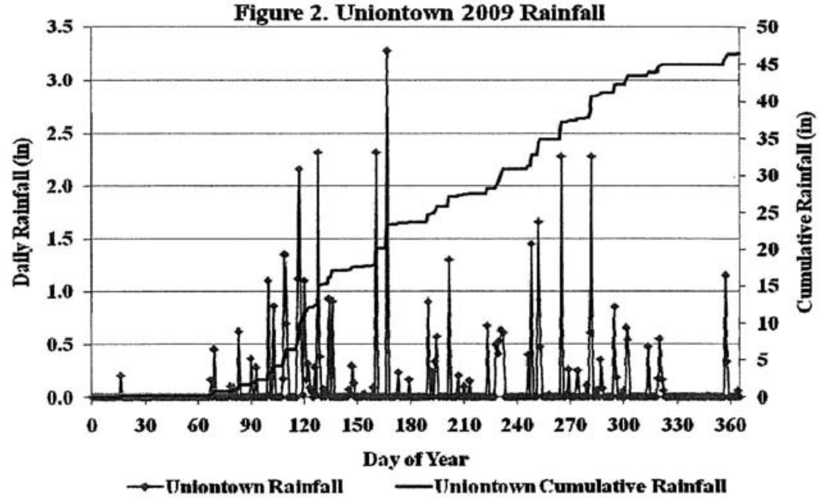
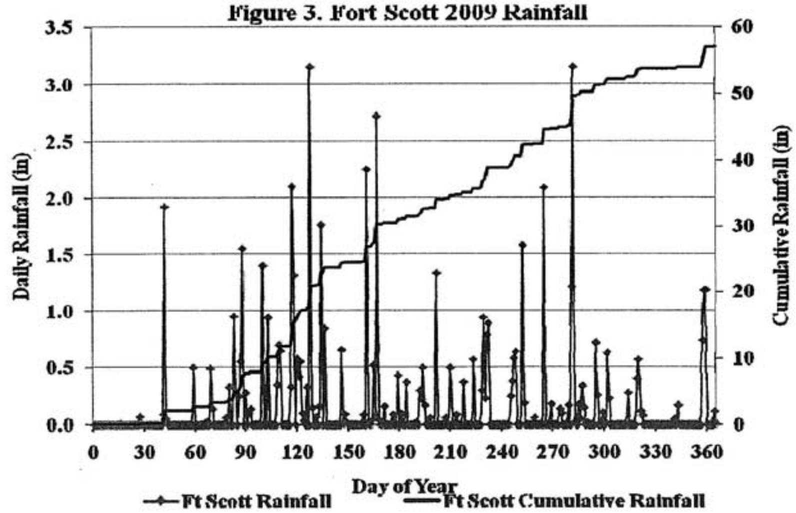
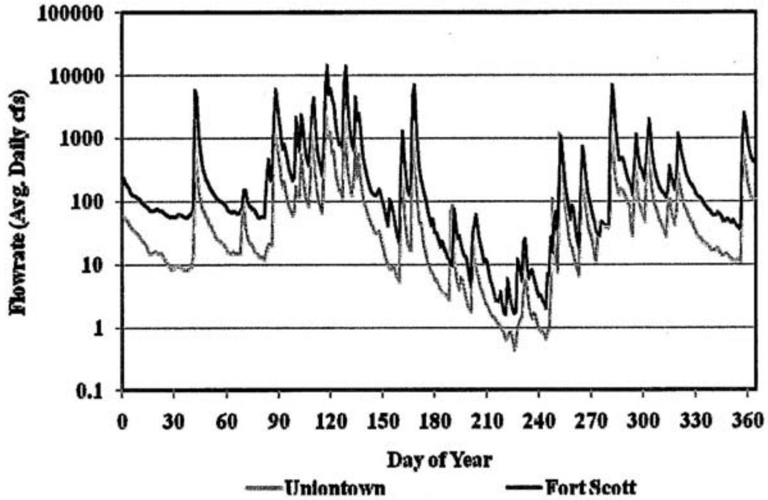


Figure 3. Fort Scott 2009 Rainfall



135

Figure 4. Uniontown and Fort Scott USGS 2009 Gaged Flowrates



Total Suspended Sediment Inflow

Figure 5, 6, 7, 8, and 9 show the suspended sediment concentration for each stream reach.

Figure 5. Drywood Creek TSS Concentration 2009

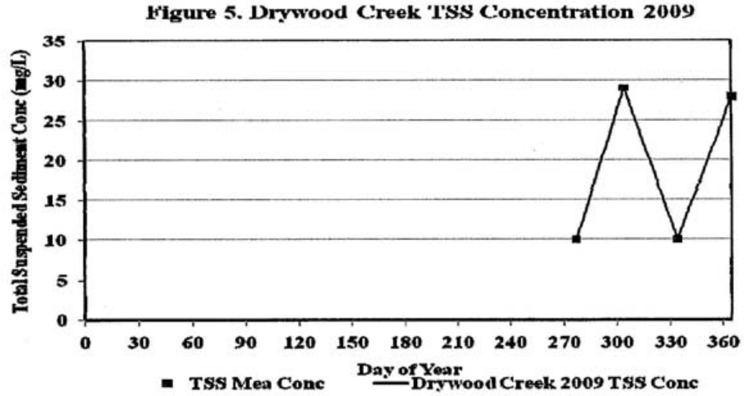


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Figure 6. Bone Creek 2009 TSS Conc

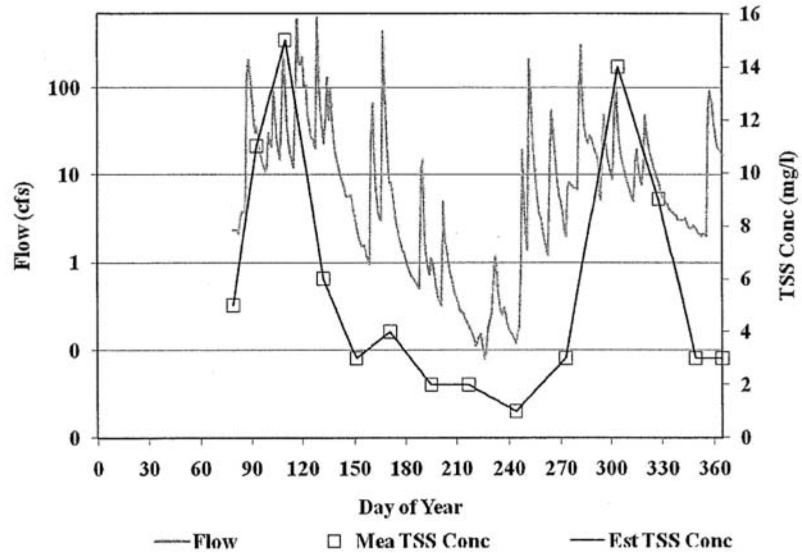
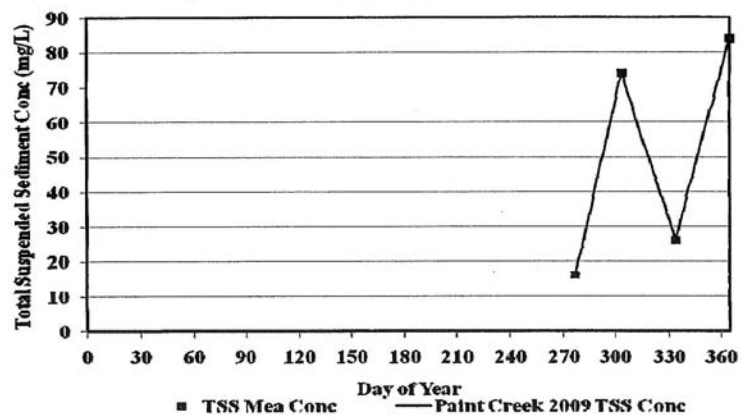


Figure 7. Paint Creek TSS Concentration 2009



137

Figure 8. Cedar Creek TSS Concentration 2009

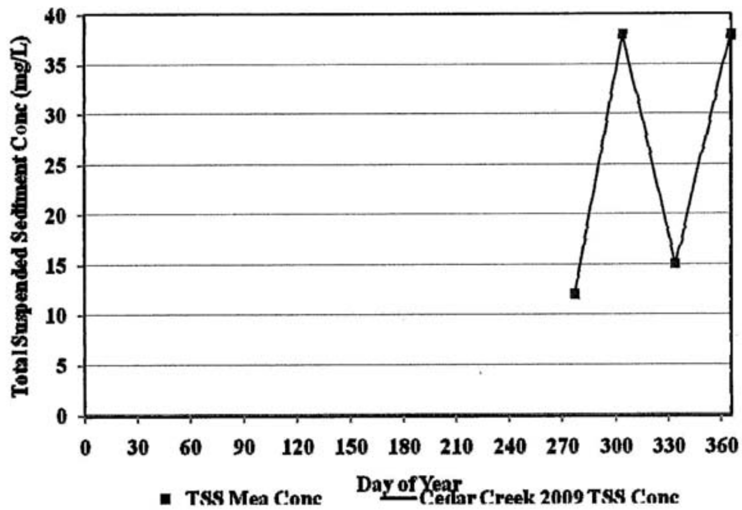
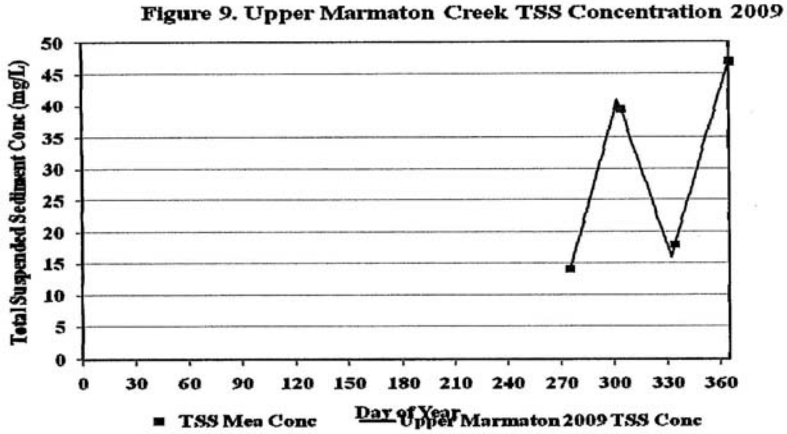


Figure 9. Upper Marmaton Creek TSS Concentration 2009



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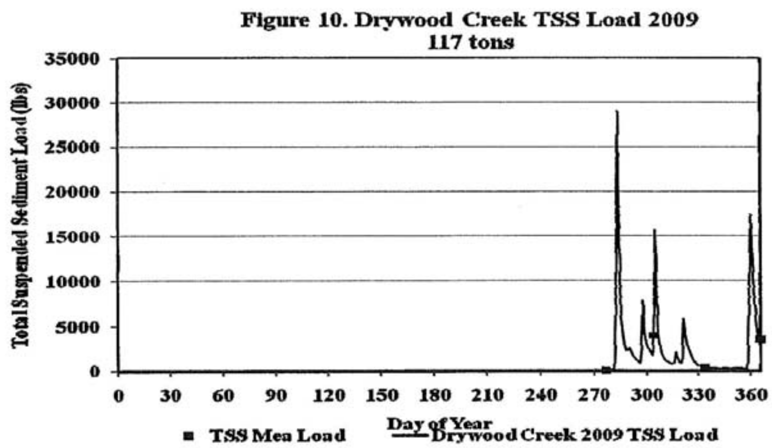
If these concentrations are multiplied by the flow and a conversion factor then the weight of sediment can be calculated. These values are shown in figures 10, 11, 12, 13, and 14 for the stream reaches



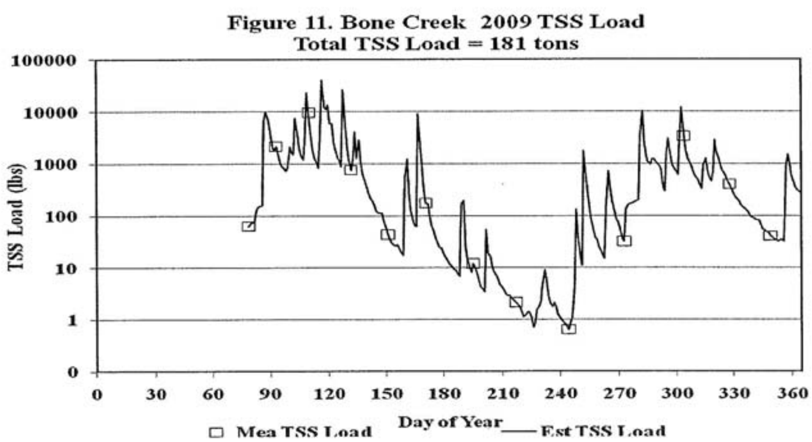


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Figure 12. Paint Creek TSS Load 2009
1190 tons

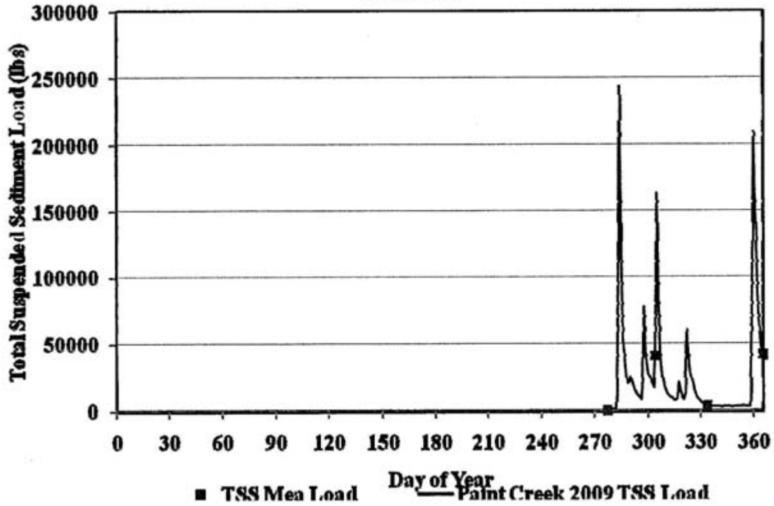

Figure 13. Cedar Creek TSS Load 2009
48.6 tons

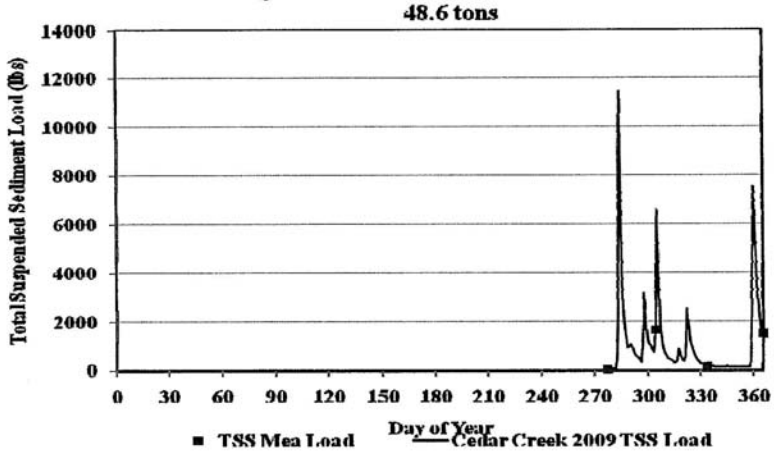

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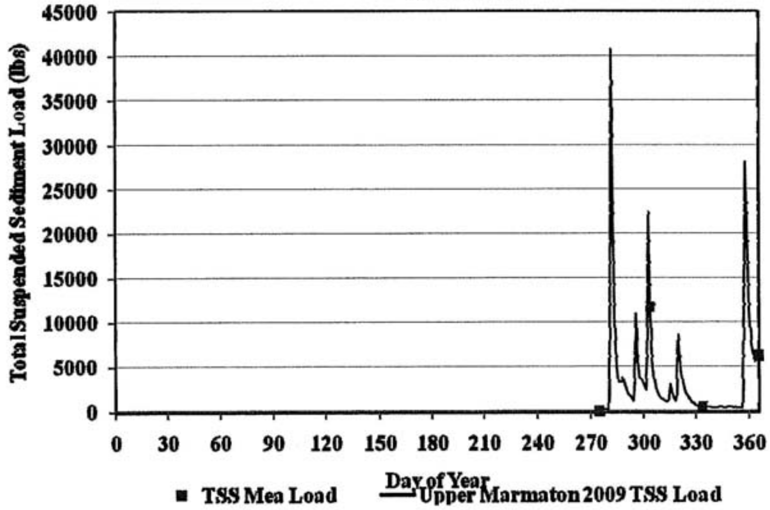
Figure 14. Upper Marmaton Creek TSS Load 2009
178.2 tons



Total Nitrogen and Phosphorus Inflow

There are several pathways for nitrogen and phosphorus to enter stream reaches. Measuring total products doesn't delineate the different forms that these nutrients may take in the water but is an excellent measure of the total contribution to the reservoir. The inflow concentrations of total nitrogen and phosphorus are shown in figures 15 through 24. The nitrogen and phosphorus loads are shown in figures 25 through 34.

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Figure 15. Drywood Creek TN Concentration 2009

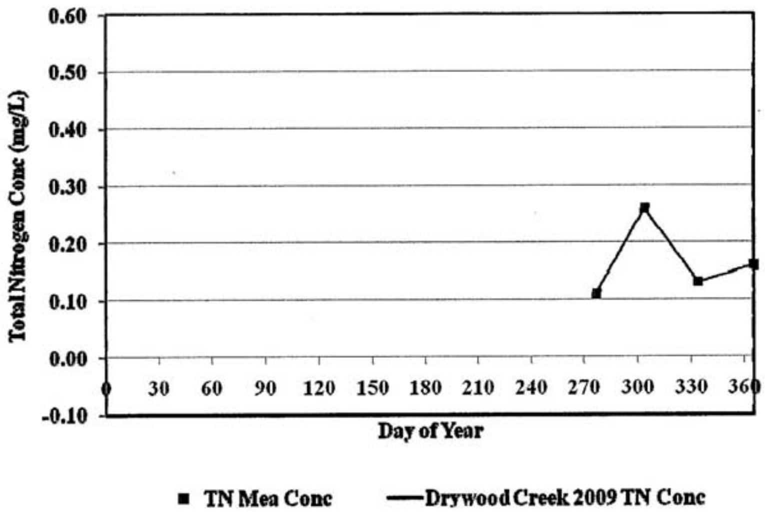
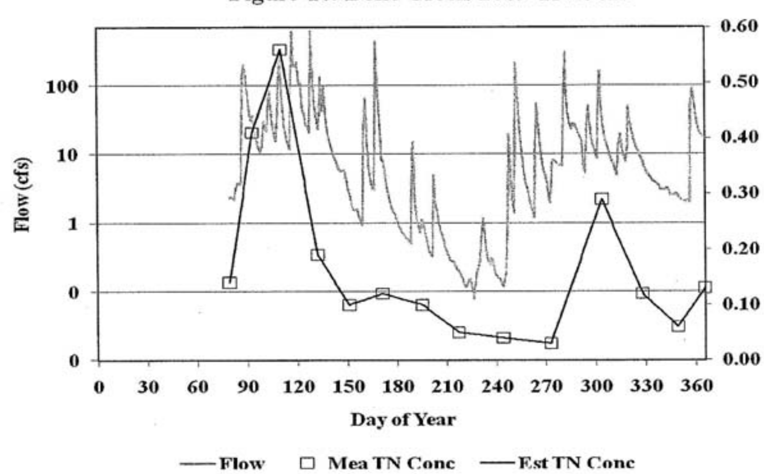


Figure 16. Bone Creek 2009 TN Conc



142

Figure 17. Paint Creek TN Concentration 2009

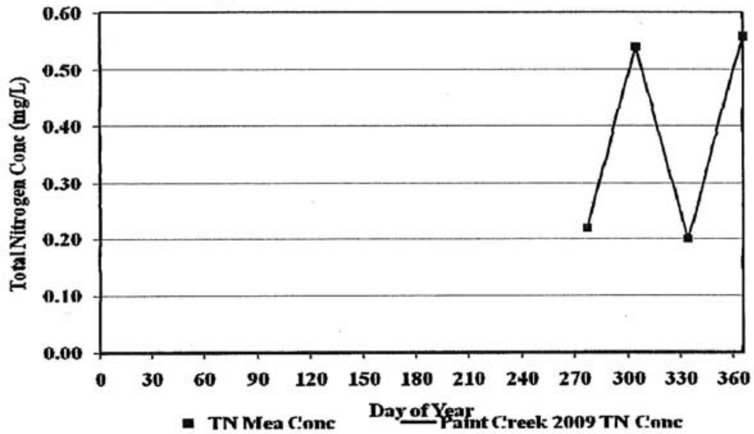
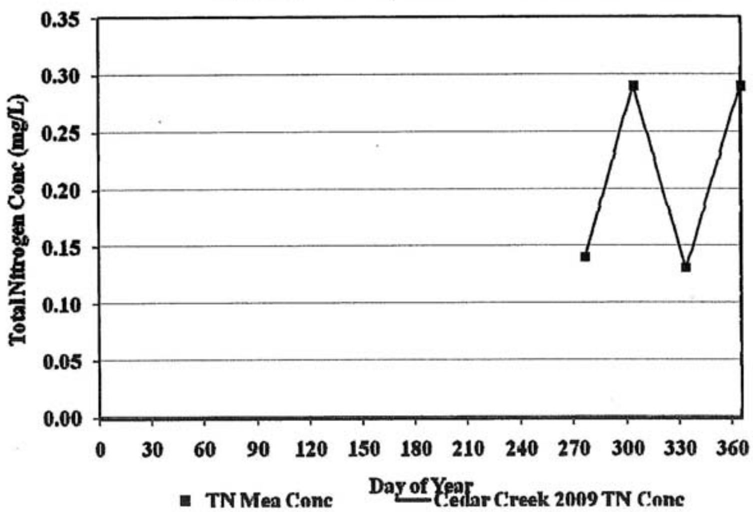


Figure 18. Cedar Creek TN Concentration 2009



143

Figure 19. Upper Marmaton TN Concentration 2009

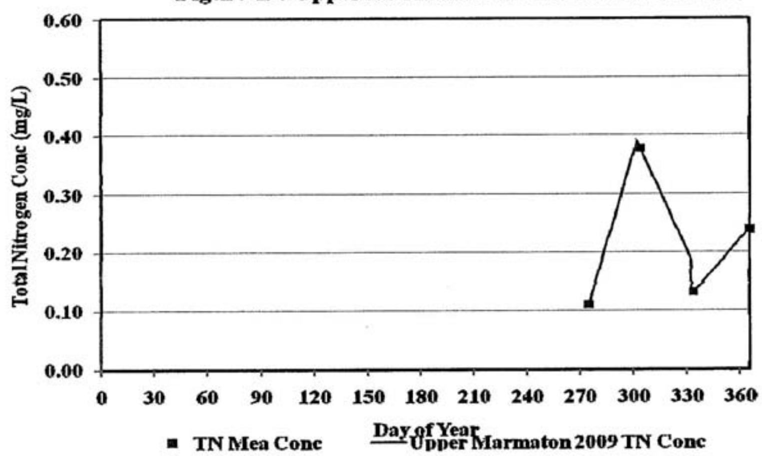
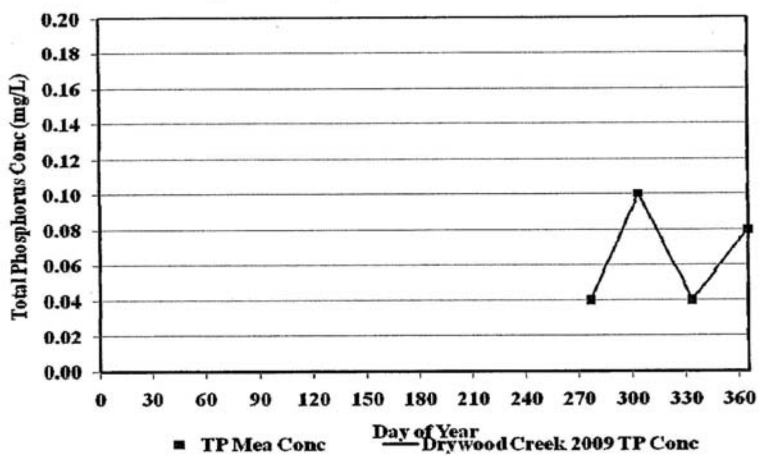


Figure 20. Drywood Creek TP Concentration 2009



144

Figure 21. Bone Creek 2009 TP Conc

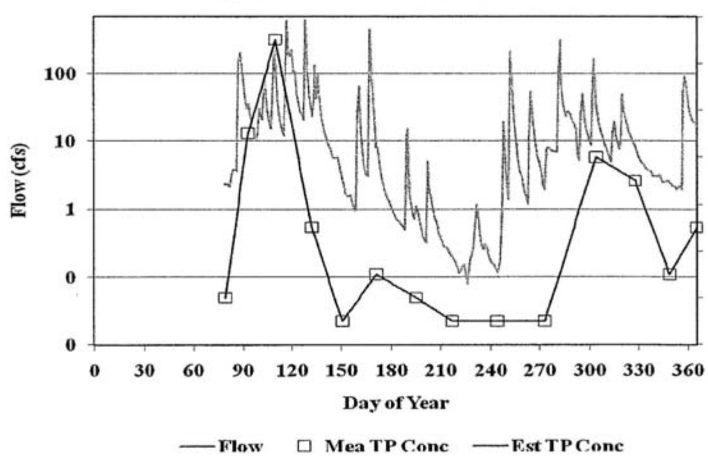


Figure 22. Paint Creek TP Concentration 2009

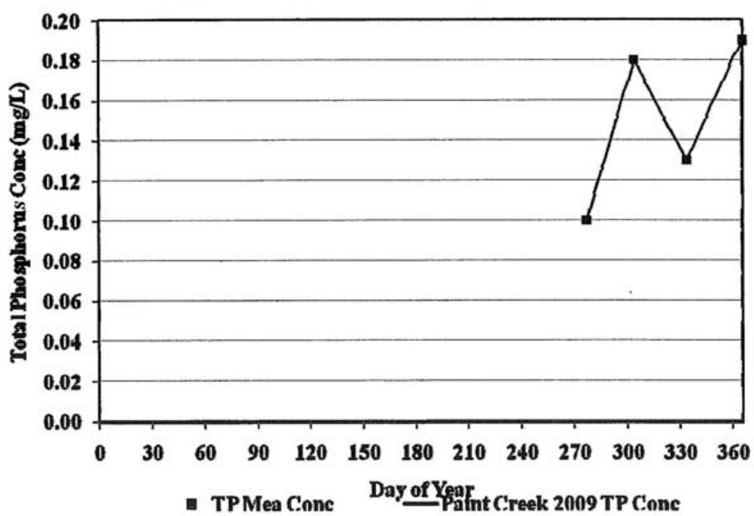


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Figure 23. Cedar Creek TP Concentration 2009

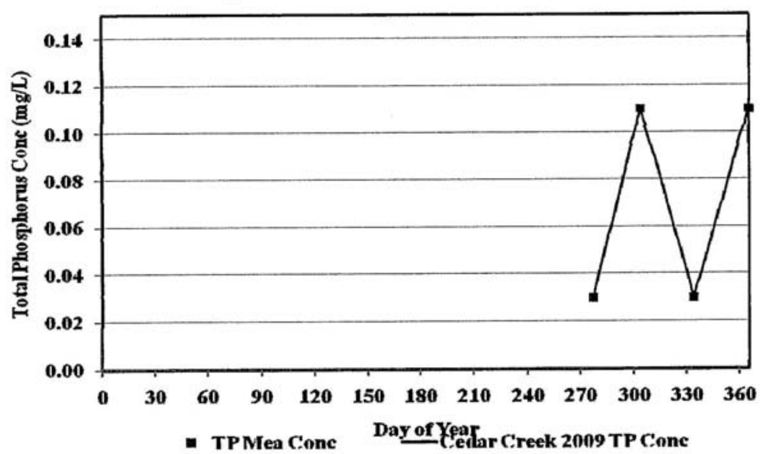
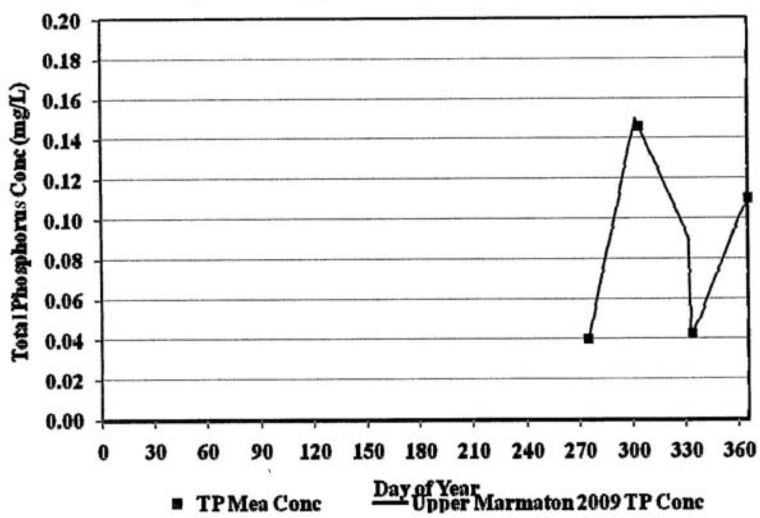


Figure 24. Upper Marmaton TP Concentration 2009



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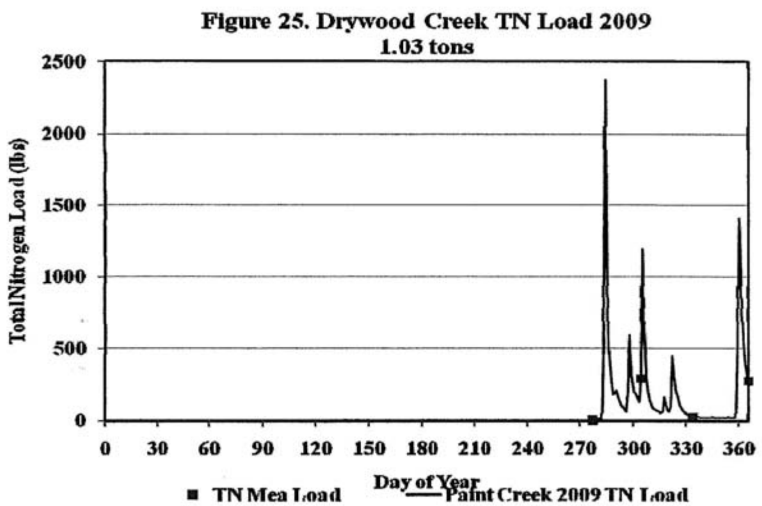
Figure 25. Drywood Creek TN Load 2009
1.03 tons
Total Nitrogen Load (lbs)
2500
2000
1500
1000
500
0
0 30 60 90 120 150 180 210 240 270 300 330 360
Day of Year
TN Mea Load
Paint Creek 2009 TN Load

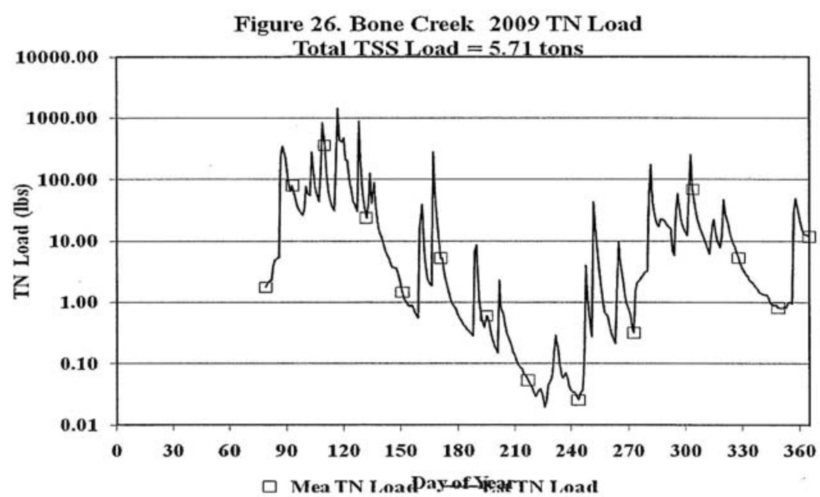
Figure 26. Bone Creek 2009 TN Load
Total TSS Load = 5.71 tons
TN Load (lbs)
10000.00
1000.00
100.00
10.00
1.00
0.10
0.01
0 30 60 90 120 150 180 210 240 270 300 330 360
Day of Year
Mea TN Load

147

Figure 27. Paint Creek TN Load 2009
9.22 tons

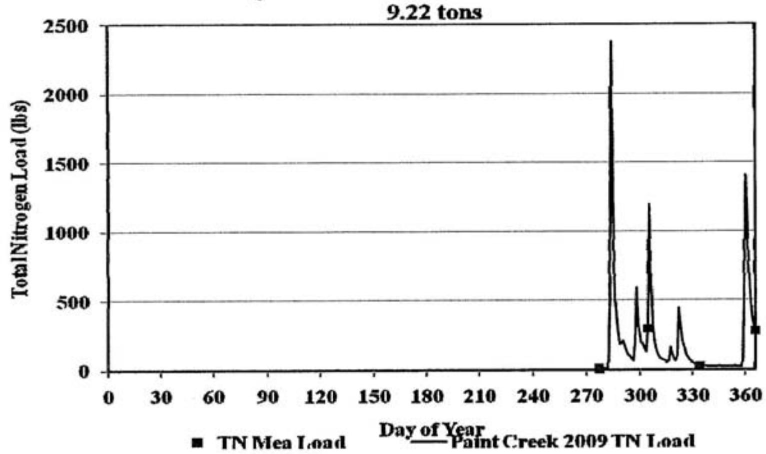

Figure 28. Cedar Creek TN Load 2009
0.40 tons

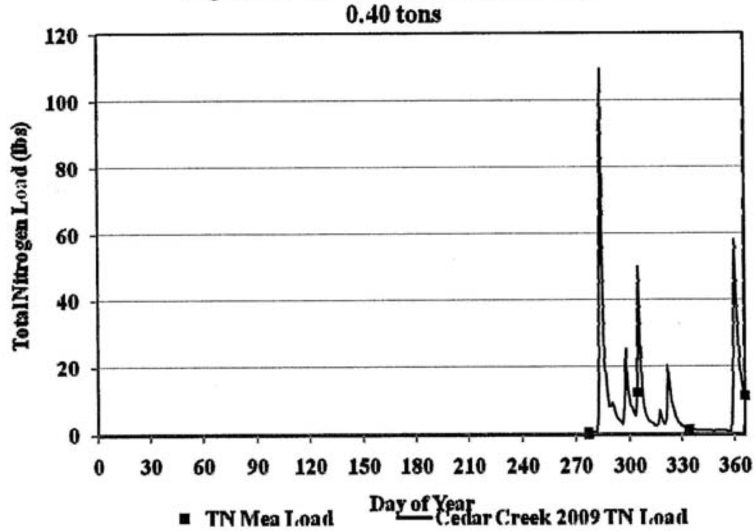

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Figure 29. Upper Marmaton TN Load 2009
1.45 tons

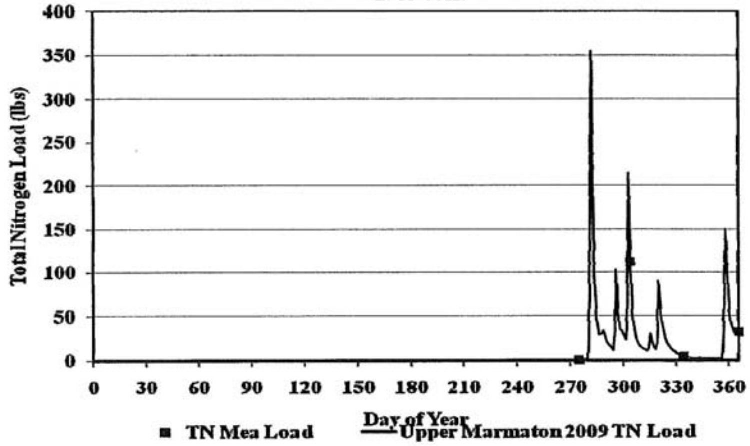

Figure 30. Drywood Creek TP Load 2009
0.40 tons

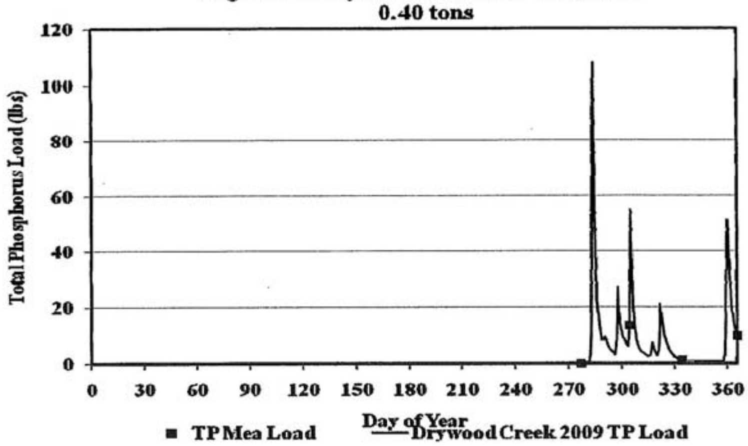

Figure 31. Bone Creek 2009 TP Load
Total TSS Load = 1.41 tons

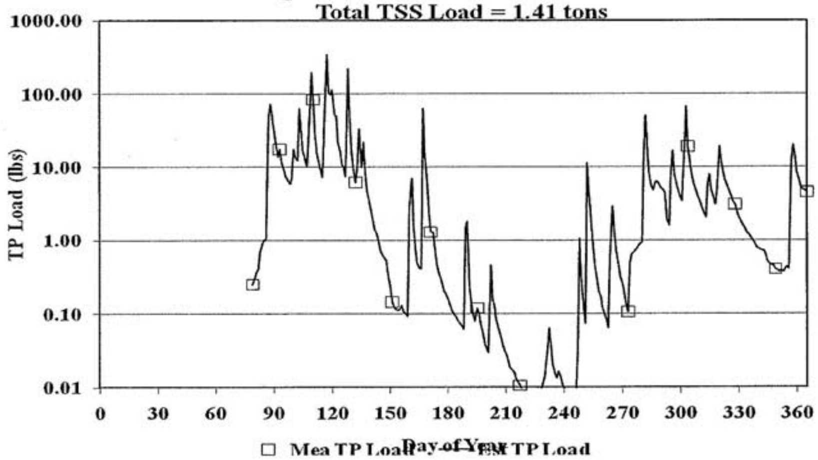

Figure 32. Paint Creek TP Load 2009
3.51 tons

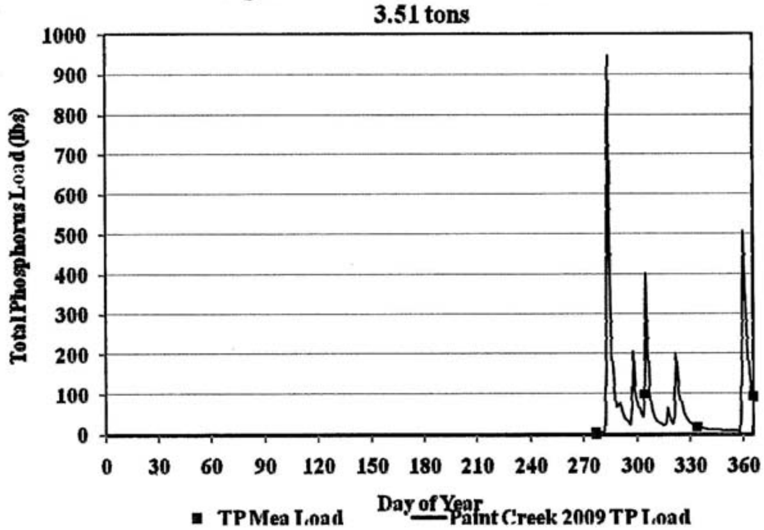

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Figure 33. Cedar Creek TP Load 2009
0.13 tons

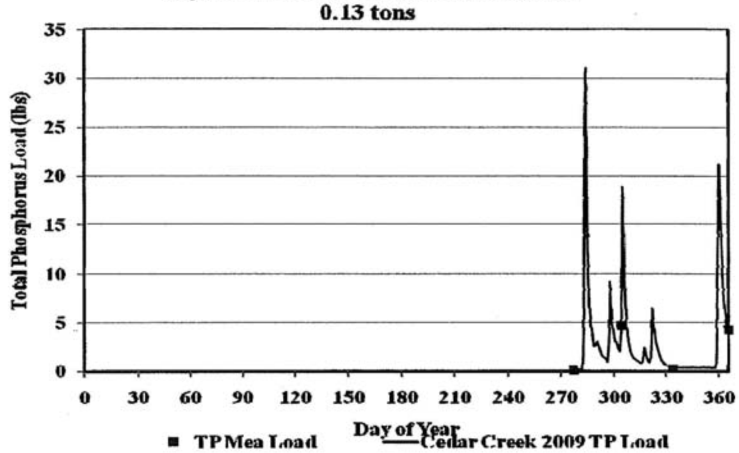
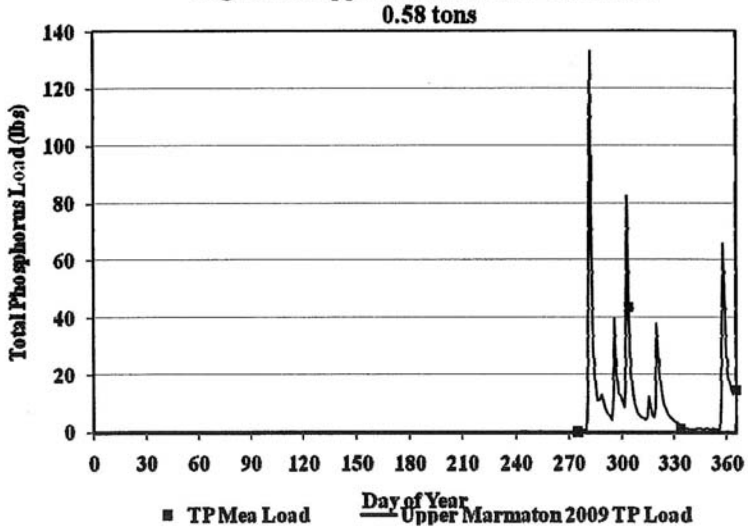


Figure 34. Upper Marmaton TP Load 2009
0.58 tons



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Conclusions

Suspended sediment flowing in these stream reaches is the primary carrier of nutrients. During 2009, there was much time spent installing the Isco samplers and calibrating the cross sections. Several times during this period there was limited flow through the cross sections.

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