# Cottonwood Watershed – 9 Element Watershed Plan Summary

Impairments to be addressed:

Mud Creek (Bacteria)

Cottonwood River South (Bacteria, Sulfate)

Clear Creek (Sulfate)

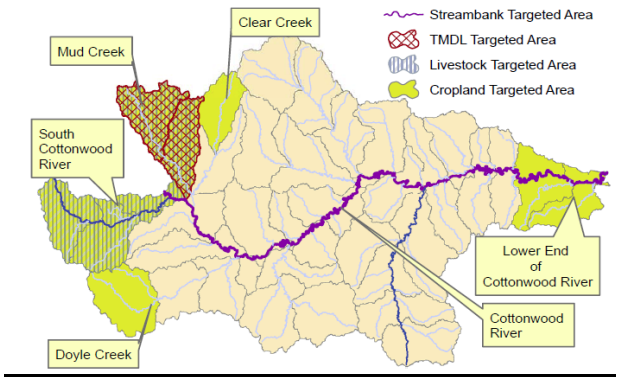
Doyle (Sulfate)

Mud Creek near Marion (Sulfate, Atrazine)

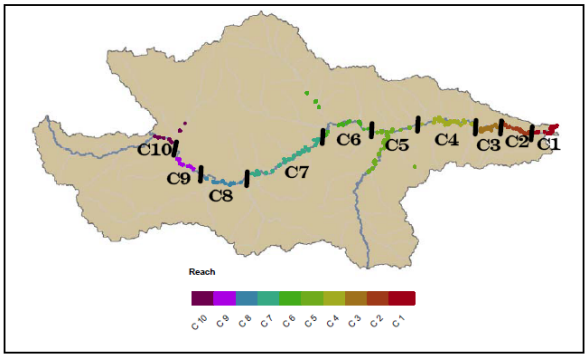
South Cottonwood River near Canada (TP)

Cottonwood River near Emporia (TP, Biology)

Prioritized Critical Areas for Targeting BMPs

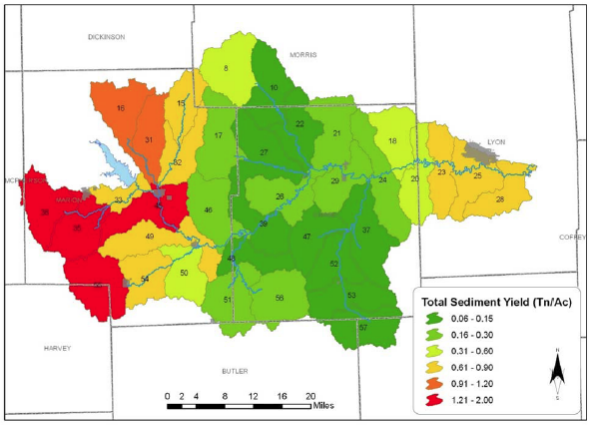


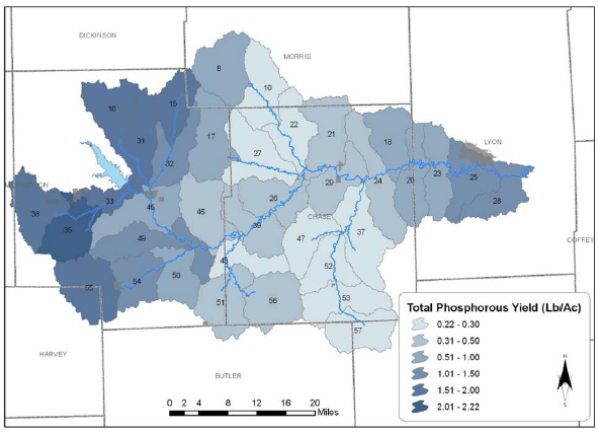

Streambank targeted areas




Targeting considerations:

- Livestock targeted areas were chosen by identifying the impaired water for bacteria and landowner knowledge.
- Cropland BMP Targeted areas were identified through SWAT (Soil and Water Assessment Tool) modeling to determine where high levels of phosphorous and sediment where coming from within the Cottonwood watershed.
- Streambank targeted areas were determined through a riparian and stream channel assessment conducted by the Kansas Water Office. This assessment identified "hot spots" along the Cottonwood River.
- High priority targeted areas were determined by where the high priority TDLS are located in the watershed.



# Cottonwood Watershed – 9 Element Watershed Plan Summary

## 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

- Grasses Waterways
- No-till cultivation practice
- Vegetative Buffers
- Terraces
- Conservation crop rotation
- Establish permanent vegetation

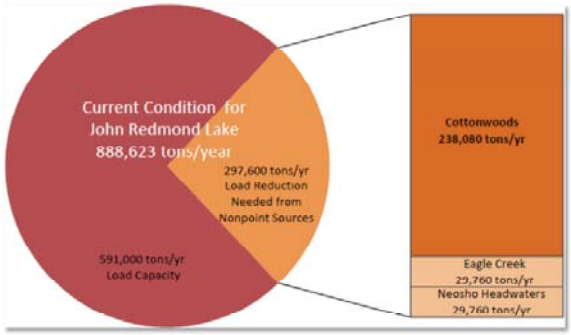
Livestock BMPs

- Vegetative filter strips
- Fence off streams
- Relocate psture feeding sites
- Off strem watering sites
- Rotational grazing

**Sediment Reduction:**

Required load reduction for Cottonwood from Nonpoint Sources (80% of Total load for John Redmond)

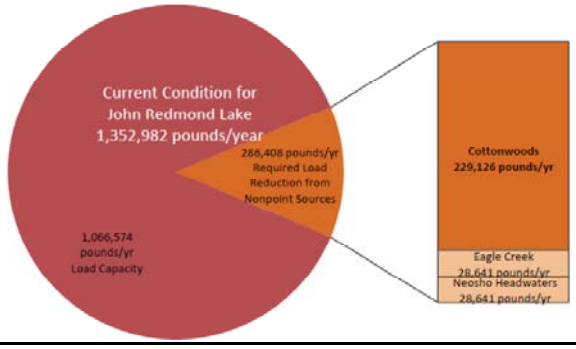
| John Redmond Sediment TMDL | |
|---|---|
| Sediment Current Condition (tons) | 888,623 |
| Less Total Silt Load Capacity (tons) | 591,000 |
| **Required Load Reduction from Nonpoint Sources (tons) for John Redmond Reservoir** | **297,600** |
| | |
| **Required Annual Load by Watersheds (tons/yr) to meet TMDL** | |
| Neosho Headwaters (10% of total load reduction) | 29,760 |
| Eagle Creek (10% of total load reduction) | 29,760 |
| **Required Load Reduction for Cottonwood Watershed from Nonpoint Sources (80% of Total Load for John Redmond Reservoir)** | **238,080** |
| **Total Load Reduction for John Redmond Reservoir** | **297,600** |

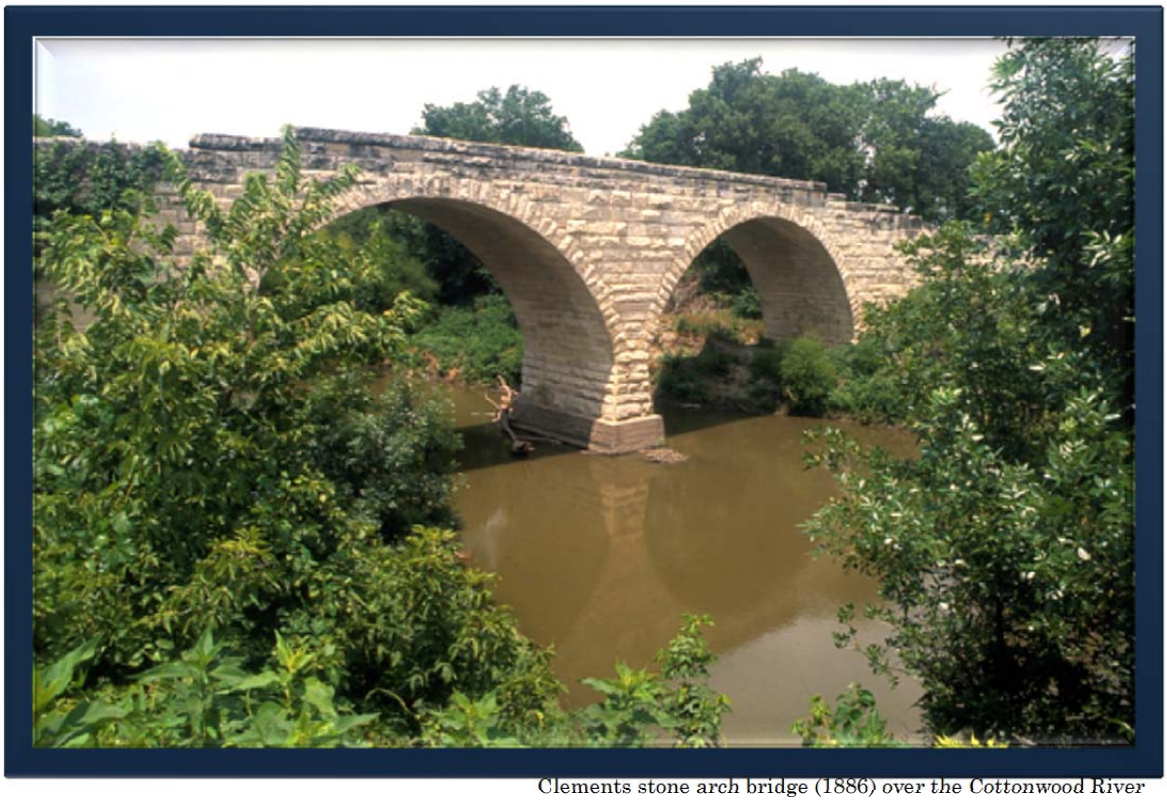



**Phosphorus Reducation:**

Required load reduxtion for Cottonwood from nonpoint sources (80% total load for John Redmond Reservoir)

| John Redmond Phosphorous TMDL | |
|---|---|
| Total P Current Condition (lbs) | 1,352,982 |
| less Total P Load Capacity (lbs) | 1,066,574 |
| **Required Load Reduction from Nonpoint Sources (lbs)** | **286,408** |
| | |
| **Required Annual Load by Watersheds (lbs/yr) to meet TMDL** | |
| Neosho Headwaters (10% of total load reduction) | 28,641 |
| Eagle Creek (10% of total load reduction) | 28,641 |
| **Required Load Reduction for Cottonwood Watershed from Nonpoint Sources (80% of Total Load for John Redmond Reservoir)** | **229,126** |
| **Total Load Reduction for John Redmond Reservoir** | **286,408** |





Clements stone arch bridge (1886) over the Cottonwood River
Photo courtesy of Kansas Geological Survey

# COTTONWOOD RIVER

## Watershed Restoration and Protection Strategy

## Upper and Lower Cottonwood Watershed

Final Draft Plan July 18, 2011

*Funding for the development of this plan was provided through an EPA 319 grant 2007-0028 from the Kansas Department of Health and Environment.*

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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:** 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 Cottonwood 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 Cottonwood River Watershed.

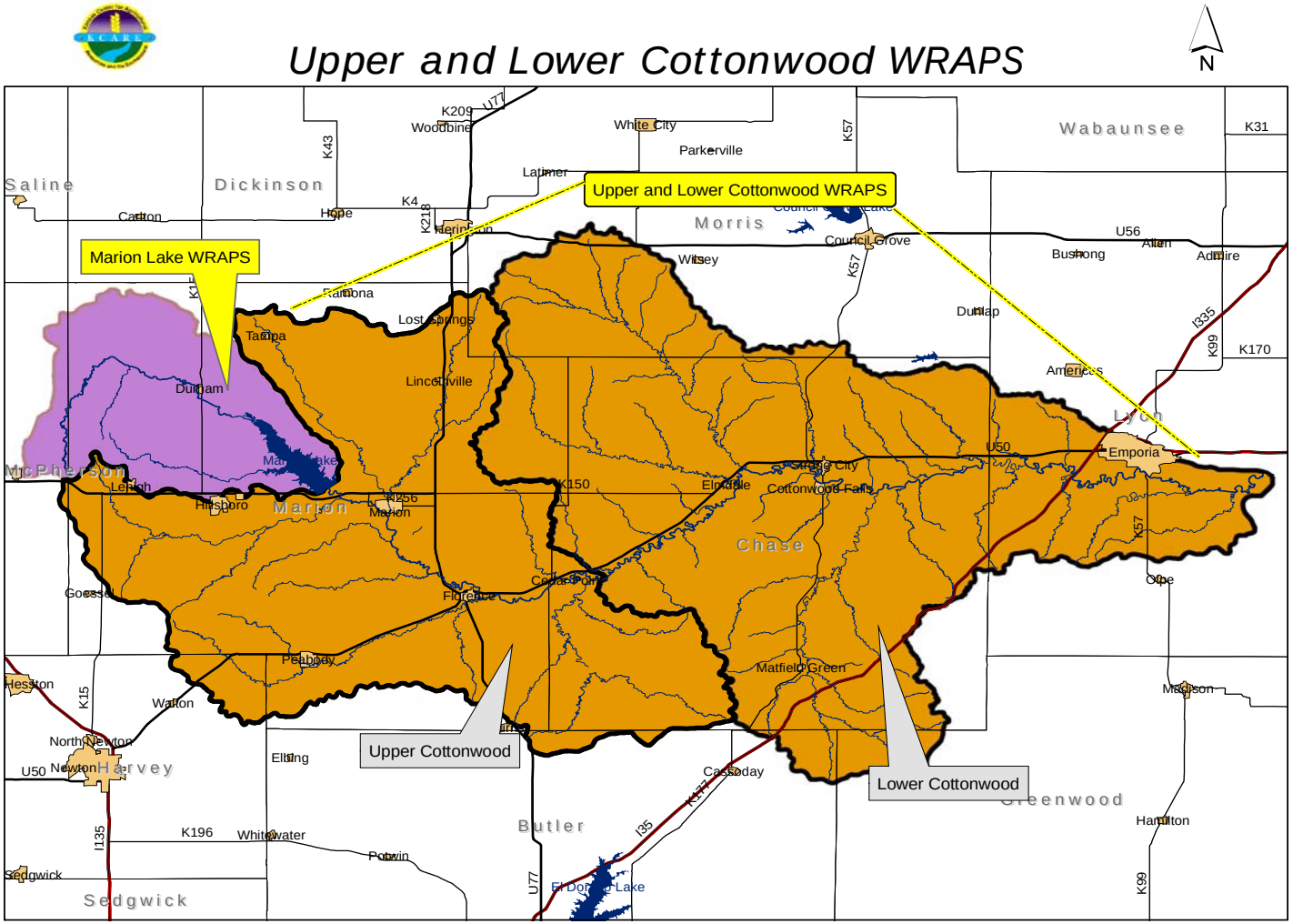
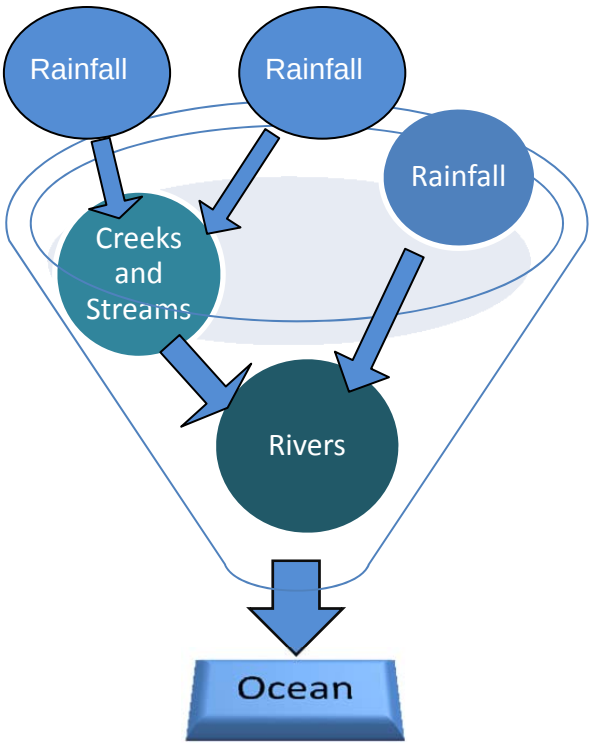



**Figure 1. Map of the Upper and Lower Cottonwood Watersheds.**

# 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.

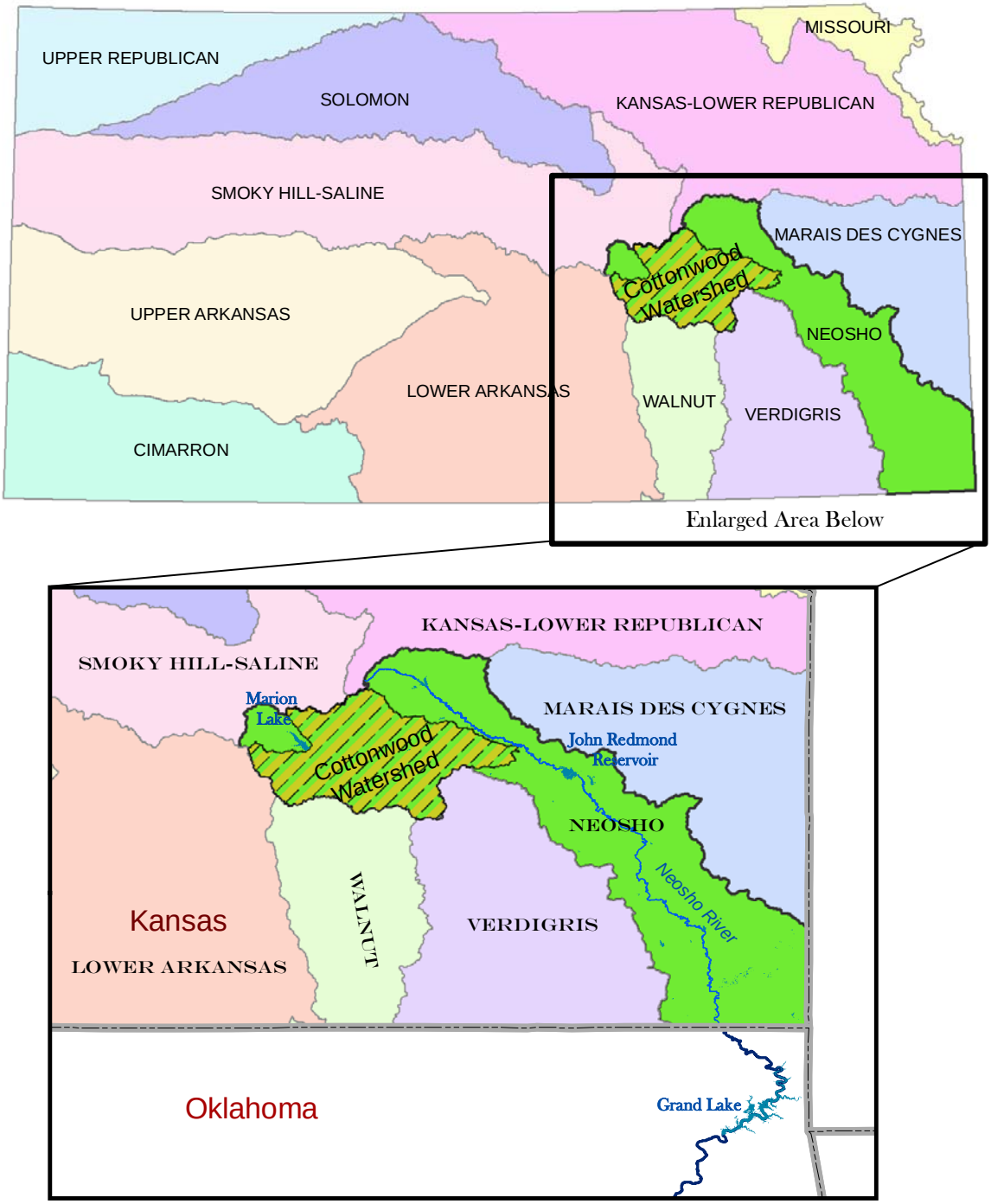



Elevation determines the watershed boundaries. The upper boundary of the Cottonwood Watershed has an elevation of 677 meters (2,221 feet) and the lowest point of the watershed, which is the confluence of the Cottonwood and Neosho Rivers, has an elevation of 200 meters (656 feet) above sea level.

## 2.2 Where is the Cottonwood Watershed?

The Cottonwood Watershed WRAPS project covers the area that drains the Cottonwood River and its tributaries from the dam at Marion Lake to the confluence of the Cottonwood and Neosho Rivers. One other WRAPS project is currently underway in the Cottonwood Watershed. It is the Marion Lake WRAPS which involves the drainage of Marion Lake. The area of the Marion Lake WRAPS is not included in the Cottonwood WRAPS. Refer to the illustration in Figure 1, page 11.

There are twelve river basins located in Kansas. The Cottonwood Watershed is a portion of the Neosho Basin.



## 2.3 Why is the Cottonwood Watershed Important?

The Neosho Basin drains the Neosho River and its tributaries into Oklahoma where it flows into the Arkansas River, through Arkansas to the Mississippi River and ultimately empties into the Gulf of Mexico. There are several dams constructed along the Cottonwood and Neosho Rivers. Marion Lake, as mentioned previously is located on the headwaters of the Cottonwood River. John Redmond Reservoir is located on the Neosho River. Grand Lake is located on the Neosho River in Oklahoma.

Grand Lake, located in northeast Oklahoma, was impounded in 1940. It contains 46,500 surface acres and is a major recreational reservoir. Three major rivers flow into Grand Lake:

- the Neosho River from Kansas,
- the Spring River from Missouri, and
- the Elk River from Missouri.

Grand Lake is a surface water supply to many communities in the area. It is also a major recreational economic resource for Oklahoma. The Neosho Basin comprises 57 percent of the total Grand Lake Watershed; therefore, it is of key importance to the overall environmental health of Grand Lake.

Grand Lake has elevated levels of phosphorus and nitrogen. This can cause algal blooms in the lake and low levels of dissolved oxygen which will be discussed later in this report. Both of these incidents will negatively impact aquatic life. According to the Grand Lake Watershed Alliance Foundation (GLWAF), the Neosho River basin can contribute phosphorus, nitrogen, sediment and bacteria into Grand Lake. Spring River may contribute to the phosphorus, nitrogen and bacteria levels, but also carries heavy metals from abandoned mining areas. Elk River is similar to the Neosho River in that it can contribute phosphorus, nitrogen, bacteria and sediment. Therefore, the water quality of Grand Lake depends on the water quality of the rivers entering it. Since the bulk of the watershed of Grand Lake lies in Kansas, it is important for the Cottonwood and the other Neosho Basin watersheds to reduce pollutants exiting their watersheds. A 30 percent reduction target has been assigned by KDHE to the outflow of each watershed in Kansas.

Grand Lake is expected to receive TMDLs in 2012. At this time, responsibilities for pollutants in the lake will be distributed to the incoming rivers. Therefore, the Neosho River Basin could receive a significant portion of the pollutant load. At that time, the SLTs for the Cottonwood Watershed will need to reevaluate the BMPs (definition below) and load reductions that are outlined later in this plan for needed corrections and alterations.

**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.

## 2.4 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 Cottonwood Watershed WRAPS project is composed of 2 HUC8s (meaning an 8 digit identifier code): the Upper Cottonwood and the Lower Cottonwood. The Upper Cottonwood HUC number is 11070202 and the Lower Cottonwood HUC number is 11070203. 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:

**11**070203 = Region drainage of the Arkansas, Red and White River basins
11**07**0203 = Subregion drainage of the Neosho and Verdigris Rivers in Arkansas, Kansas, Missouri and Oklahoma
1107**02**03 = Accounting unit drainage of the Neosho River basin in Arkansas, Kansas, Missouri and Oklahoma
110702**02** = Cataloging units drainage of the section of the Cottonwood River named the Upper Cottonwood
110702**03** = Cataloging units drainage of the section of the Cottonwood River named the Lower Cottonwood

As watersheds become smaller, the HUC number will become larger. HUC 8s are further divided into smaller watersheds with HUC 10 and HUC 12 delineations. The Cottonwood Watershed is divided into thirty five HUC 12 delineations.

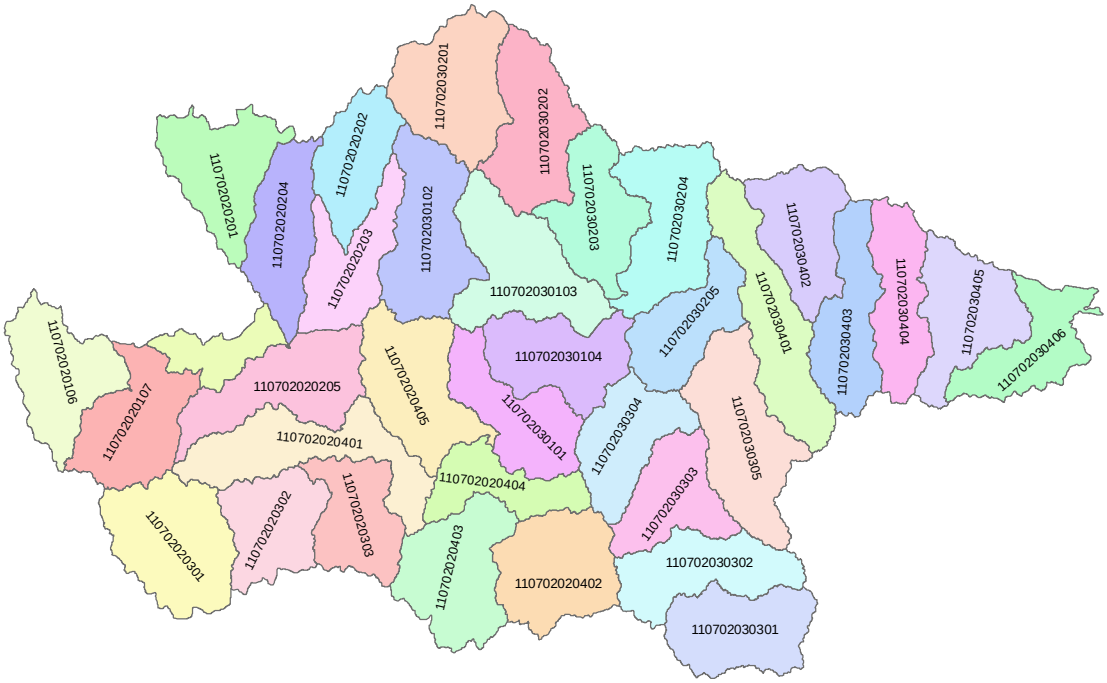



**Figure 2. HUC 12 Delineations in the Cottonwood Watershed.**

# 3.0 Watershed History

## 3.1 Stakeholder Leadership Team (SLT) History

The SLT was formed out of concern for the Cottonwood River and flooding events that occur along the river. Due to the size of the watershed, it was decided that two SLTs would serve the WRAPS process better than one. One group is from the Upper Cottonwood and meets in Hillsboro and Marion. The other group is from the Lower Cottonwood and meets in Cottonwood Falls. The SLTs began meeting in August of 2009. Although two different SLTs have been formed, there is one set of water quality issues and goals for the watershed.

The Cottonwood SLTs have representation from several watershed districts within the basin. The primary purpose of these taxing entities is to construct and maintain watershed structures to control flooding.

Even though there is one set of water quality issues, the SLT from the Lower portion of the watershed has desired that a greater focus be placed on flooding. The SLT hopes to slow the rate of flooding in the Cottonwood River and subsequent erosion by improving conditions in the watershed. New conservation practices will include those implemented in cropland, along streambanks and in livestock areas in addition to their desire to construct more retention structures. Watershed-wide benefits will be an improvement of water quality, an increase in yields in agricultural production and an increase in the health of wildlife and natural ecosystems. Benefits will also apply to downstream Reservoirs: John Redmond and Grand Lake. However, EPA 319 and State Water Plan funds cannot be spent on structural practices such as watershed retention structures so a complete evaluation of increased adoption, costs, and load reductions (which will be discussed later in this report) stemming from new structures is not included in this plan. The SLT does recognize that the installation of new watershed structures in the future could have a positive effect on sediment and nutrient loadings in the Cottonwood River.

In summary, there are 57 completed watershed structures and 60 planned structures within the Cottonwood Watershed. Their average retention is 520 acre-feet and average drainage area is 1,792 acres (2.8 square miles). As noted in the following map, watershed structures are generally placed on intermittent streams. For load reduction purposes, they function similar to a large pond, reducing sediment and nutrients by an average of 50 percent.

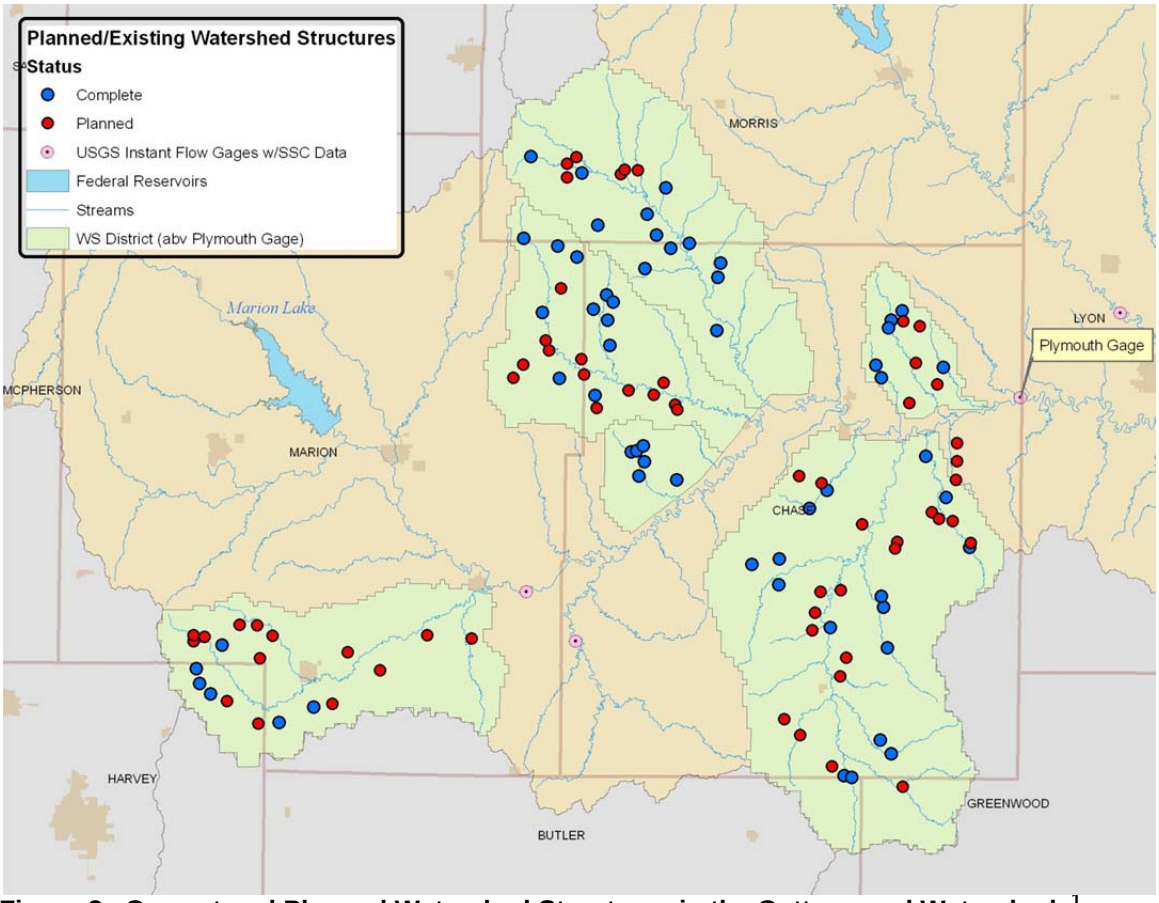



**Figure 3. Current and Planned Watershed Structures in the Cottonwood Watershed.** [1]

## 3.2 Overview

The Upper and Lower Cottonwood Watersheds are designated as Category I watersheds indicating that they are 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 Upper Cottonwood is ranked thirty-sixth in priority and the Lower Cottonwood is ranked forty-third out of ninety-two watersheds state wide.

## 3.3 Issues and Goals of the Upper and Lower SLTs

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 SLTs have set their priority issues as (in no particular order):

1. Flooding along the Cottonwood River.
2. Streambank erosion.
3. Riparian area degradation.
4. Erosion on cropland and livestock areas.
5. Bacteria and nutrient runoff from livestock operations.
6. Sediment and nutrient runoff from cropland.

The Watershed goals as set by the SLTs are (in no particular order):

1. Achieve high-priority Total Maximum Daily Loads (TMDLs) in the watershed.
2. Protect public drinking water supplies.
3. Preserve productivity of agricultural lands.
4. Minimize impacts of flooding along the Cottonwood River by utilizing the BMPs listed in this WRAPS 9 Element Plan.
5. Protect recreational uses on rivers, streams and lakes.
6. Protect aquatic life in rivers, streams and lakes.

**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 these 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.**

# 4.0 Watershed Review

## 4.1 Land Cover/Land Uses

The Lower Cottonwood Watershed covers 609,280 acres and the Upper Cottonwood covers 476,093 (excluding Marion Lake watershed). The entire watershed covers 1,085,373 acres. It is overwhelmingly grassland (68%). This area is part of the Flint Hills ecosystem which is part of the Tallgrass Prairie. Much of the grassland is used to summer stocker calves from May to June. Heavier than normal stocking rates are used for this short period of time. Grassland can contribute fecal coliform bacteria (FCB) from livestock access to streams and ponds. Erosion can occur from pathways made by livestock in creeks or gullies in pastures. Cropland is the second most prominent land use at 26 percent. Cropland can contribute nutrients from fertilizer runoff and sediment from bare crop ground that erodes during heavy rainfall events. The rest of the land uses (6%) in the watershed are urban, woodlands, water and other.

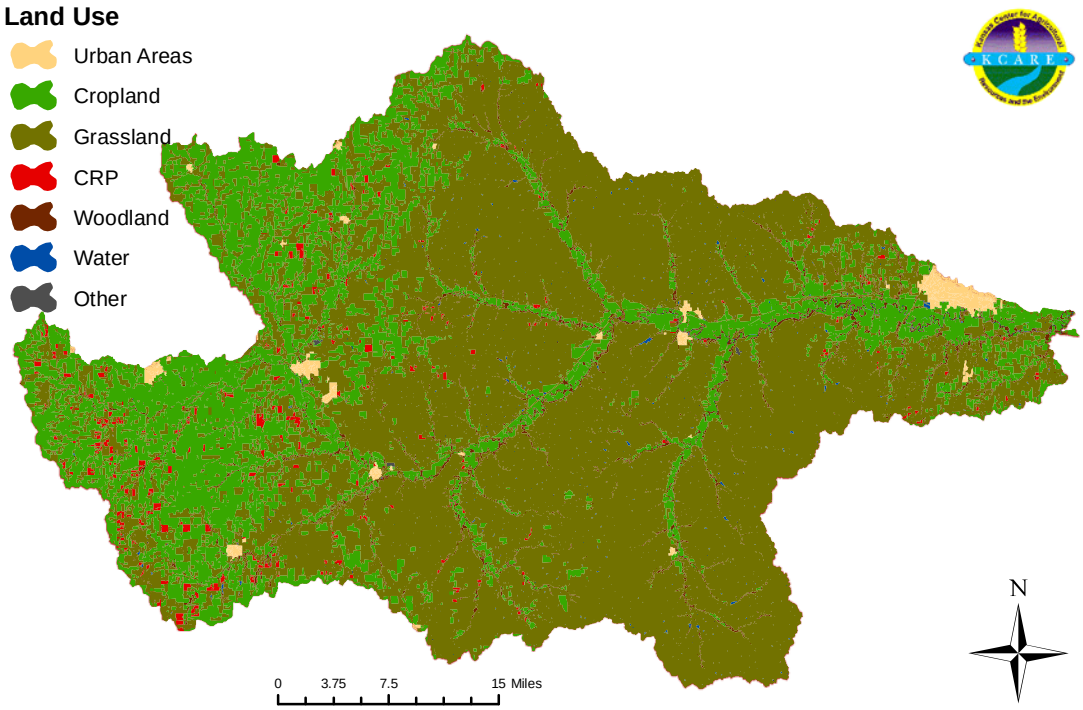



**Figure 3. Land Use of the Cottonwood Watershed.** [3]

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

| Land Use | *Acres* | *Percentage* |
|---|---|---|
| Grassland | 741,037 | 68.27 |
| Cropland | 282,245 | 26.00 |
| Woodland | 34,012 | 3.13 |
| Urban Areas | 11,785 | 1.09 |
| CRP | 11,492 | 1.06 |
| Water | 4,518 | 0.42 |
| Other | 284 | 0.03 |
| ***Total*** | **1,085,373** | **100.00** |

## 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. If the designated uses of a water body are not being met, the Water Quality Standard for that water body is not being met and therefore, it is impaired.

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

| Designated Uses Table | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Stream or Lake Name** | **AL** | **CR** | **DS** | **FP** | **GR** | **IW** | **IR** | **LW** |
| Bruno Cr | E | | | X | | | | |
| Buck Cr, Camp Cr, Corn Cr, Gannon Cr, Little Cedar Cr Seg 11, Picket Cr, Spring Cr | E | | | | | | | |
| Marion Co L, Chase Co SFL | E | A | X | X | O | X | X | X |
| Palmer Cr, | E | a | X | X | X | X | X | X |
| Bills Cr, Beaver Cr, Cannonball Cr, Coyne Br, Dodd Cr, French Cr, Gould Cr, Mile and a Half Cr, Phenus Cr, Schaffer Cr, School Cr, Sharpes Cr, Silver Cr, Stout Run, Stibby Cr | E | b | | | | | | |
| Buckeye Cr, Coal Cr | E | b | | X | | | | |
| Bull Cr, Moon Cr | E | b | O | O | X | O | O | X |
| Clear Cr , Cottonwood R seg 1 | E | B | X | X | X | X | X | X |
| Clear Cr E B, Perry Cr, Stony Br | E | b | O | X | O | O | X | X |
| Clear Cr Seg 5, Cottonwood R S, Spring Br, Diamond Cr, Prather Cr, | E | b | X | X | X | X | X | X |
| Dry Cr, Kirk Cr, | E | b | O | O | X | O | O | O |
| Fox Cr | E | B | | X | | | | X |
| French Cr | E | b | X | X | | | | |
| Holmes Cr, Mulvane Cr, | E | b | X | O | X | X | X | X |
| Antelope Cr | E | C | O | X | X | O | X | X |

| Designated Uses Table, cont. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Stream or Lake Name** | **AL** | **CR** | **DS** | **FP** | **GR** | **IW** | **IR** | **LW** |
| Coon Cr, Turkey Cr, Crocker Cr, Mercer Cr, | E | C | | | | | | |
| Cottonwood R seg 2,3,7,8, Cottonwood R N, Doyle Cr, Unnamed Stream | E | C | X | X | X | X | X | X |
| Spring Cr seg 28 | E | C | O | O | O | O | X | X |
| Little Cedar Cr seg 45 | S | | | | | | | |
| Collette Cr | S | b | | | | | | |
| Cottonwood R S Fk seg 10 | S | b | X | X | X | X | X | X |
| Cottonwood R seg 2,4,6, Peter Pan L | S | B | X | X | X | X | X | X |
| Jacob Cr, | S | b | | X | | | | |
| Catlin Cr, Spring Cr seg 29, Bloody Cr, Middle Cr, Peyton Cr, Rock Cr | S | C | | X | | | | |
| Cottonwood R seg 1, Cottonwood R S Fk seg 9, Six Mile Cr | S | C | X | X | X | X | X | X |
| Mud Cr | S | C | X | X | | | | |

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
a=Secondary contact recreation lakes that are by law or written permission of the landowner open to and accessible by the public
B=Primary contact recreation lakes that are by law or written permission of the landowner open to and accessible by the public
b=Secondary contact recreation stream segment is not open to and accessible by the public under Kansas law
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
Blank=Capacity of the referenced stream segment to support the indicated designated use has not been determined by use attainability analysis

## 4.3 Special Aquatic Life Use Waters 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 Cottonwood River Watershed has a special aquatic life use designation for Mud Creek, Six Mile Creek, Middle Creek,

Collett Creek, Bloody Creek, Jacob Creek, Spring Creek, Catlin Creek, Little Cedar Creek and the lower portion of the Cottonwood River. **Exceptional State Waters (ESW)** are waters that are defined as "any of the surface waters or surface water segments that are of remarkable quality or of significant recreational or ecological value". Cedar Creek and the Cottonwood River, South Fork are designated as both ESW and SALU waters.

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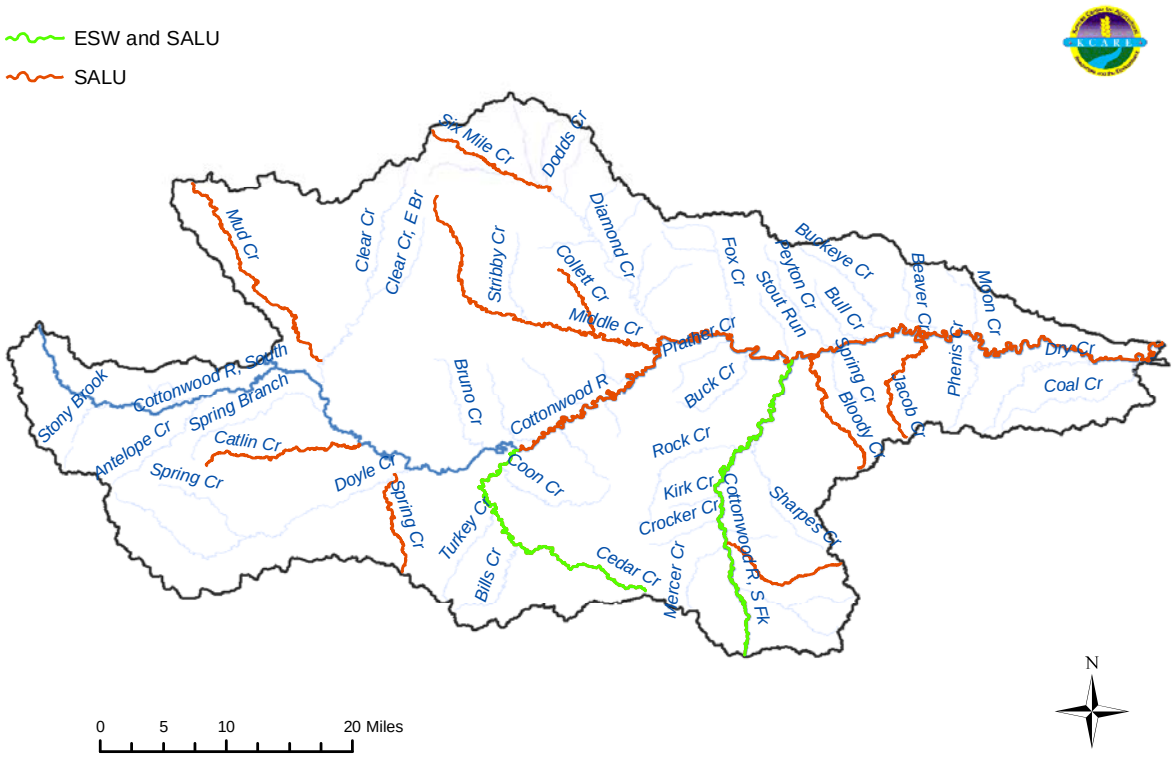



**Figure 4. SALU Waters and ESW in the Watershed.** [6]

The SALU waters and ESW 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 *E. coli* bacteria from livestock are some of the potential pollutants.

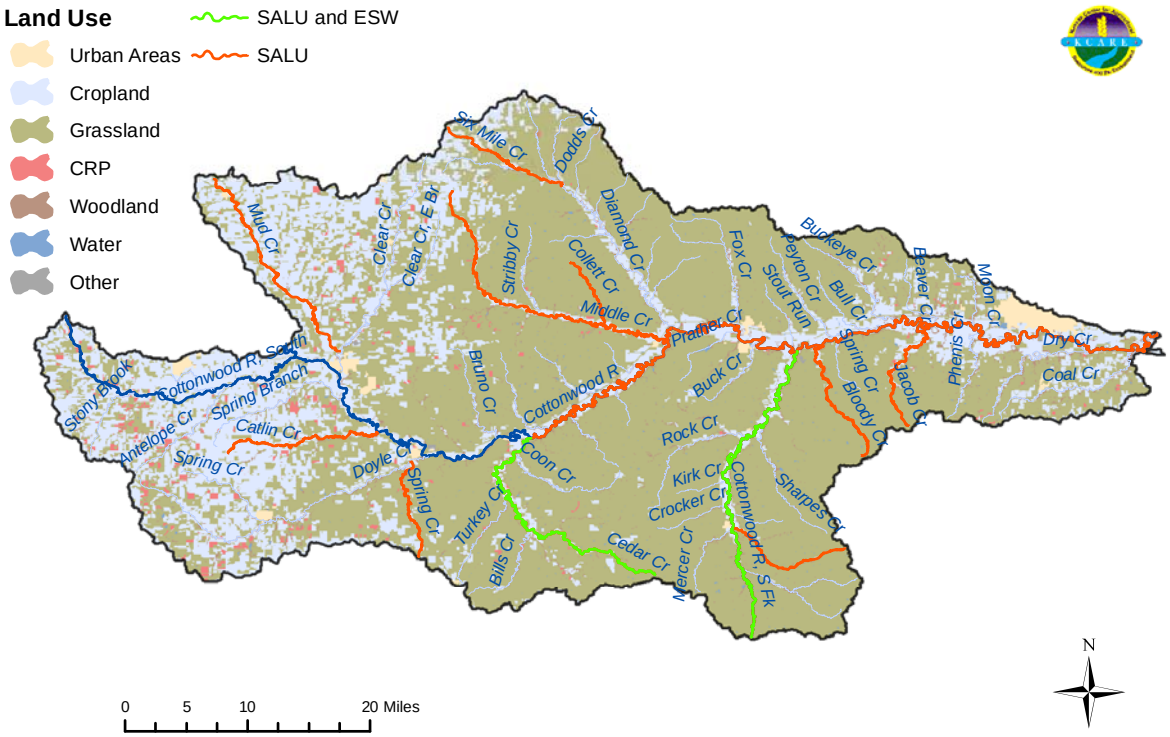



**Figure 5. SALU and ESW with Land Cover.**[7]

## 4.4 Rainfall and Runoff

Rainfall rates and duration will affect sediment runoff and nutrient runoff during high rainfall events. The Cottonwood Watershed averages 34 inches of rainfall yearly. Most high intensity rainfall events will occur in late spring and early summer.

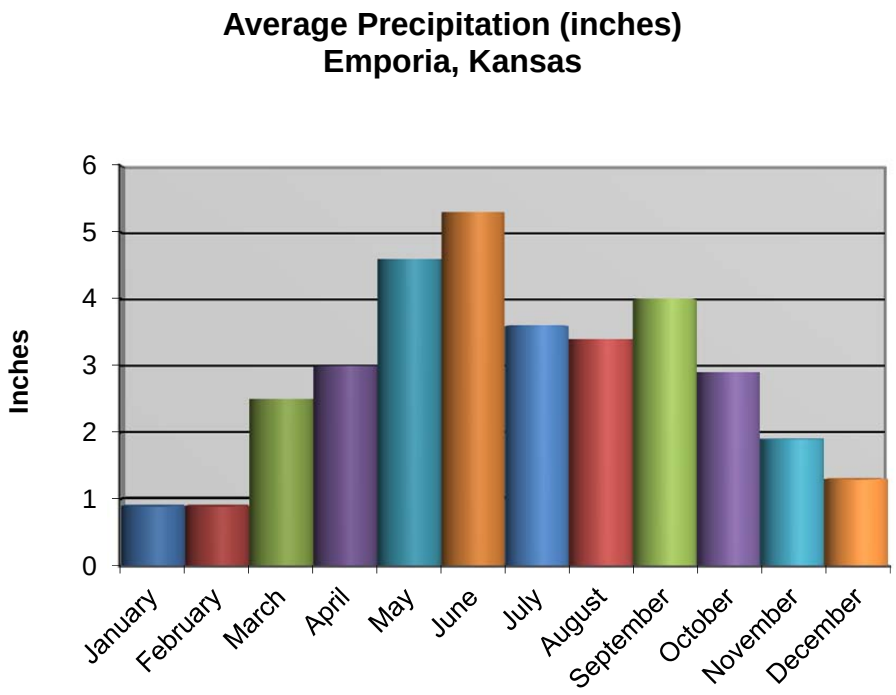



**Figure 6. Average Precipitation by Month.** [8]

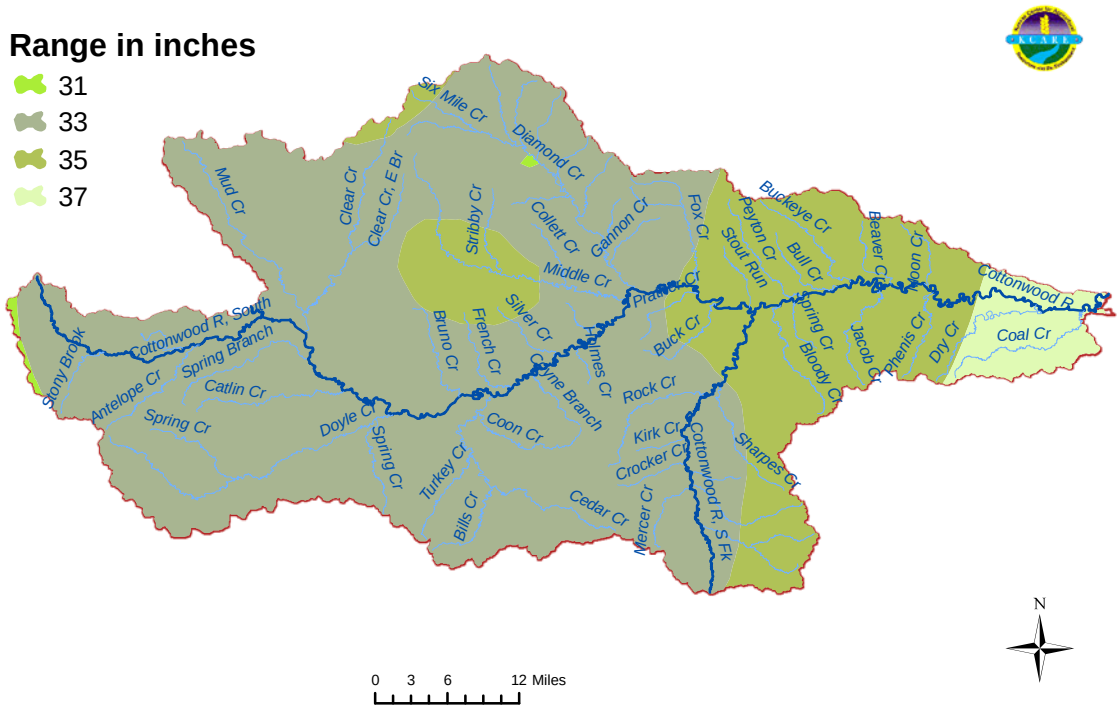



**Figure 7. Average yearly Precipitation in the Watershed.** [9]

## 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 *E.coli* bacteria or nutrients to the watershed through leakage or drainage of untreated sewage. 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. It is estimated 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 | Persons per square mile | Population Change (2000 to 2008), % |
|---|---|---|---|
| Chase | 2,798 | 3.9 | -7.7 |
| Lyon (minus City of Emporia) | 9,734 | 13.9 | -1.0 |
| City of Emporia | 26,188 | | -2.3 |
| Marion | 12,100 | 14.2 | -9.4 |
| Morris | 5,994 | 8.8 | -1.8 |
| **Total for Watershed without Emporia** | **30,626** | **Average: 10.2** | **Average: -5.0** |
| **Total for Watershed** | **Total: 56,814** | **Average: 19.8** | **Average: -3.8** |

Most of the watershed would be considered low population. The only major urban area is the city of Emporia. The Kansas average population density represented as persons per square mile is 32.9, whereas, the average for the watershed is 10.2.

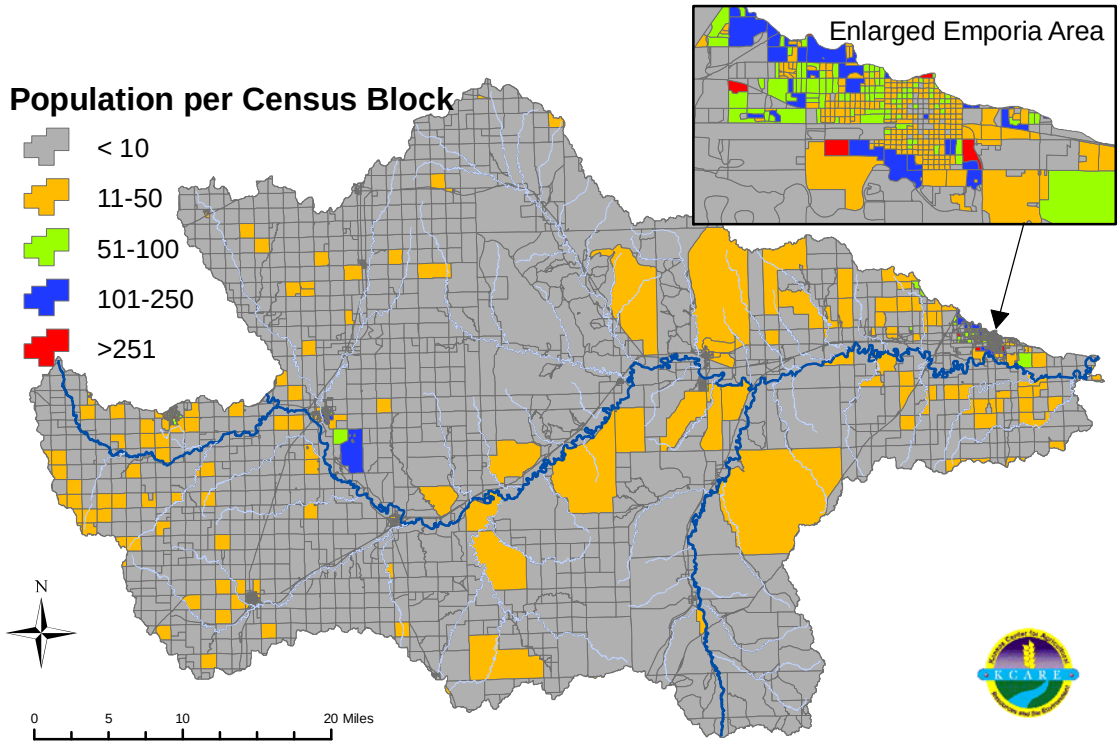



**Figure 8. Census Count, 2000.** [12]

## 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 Cottonwood River has an alluvial aquifer that lies along and below the river. Creeks that have alluvial aquifers are Mud, Clear, Turkey, Cedar, Middle, Diamond and the South Fork of the Cottonwood River.
- Dakota Aquifer - The Dakota aquifer extends from southwestern Kansas to the Arctic Circle. In recent years, the Dakota aquifer has been used for irrigation purposes in southwest and in north-central Kansas (Cloud, Republic and Washington counties) and continues to present time. The Dakota aquifer also provides water for municipal, industrial, and stock water supplies. The Cottonwood Watershed has a small portion of the Dakota Aquifer in its upper reaches.

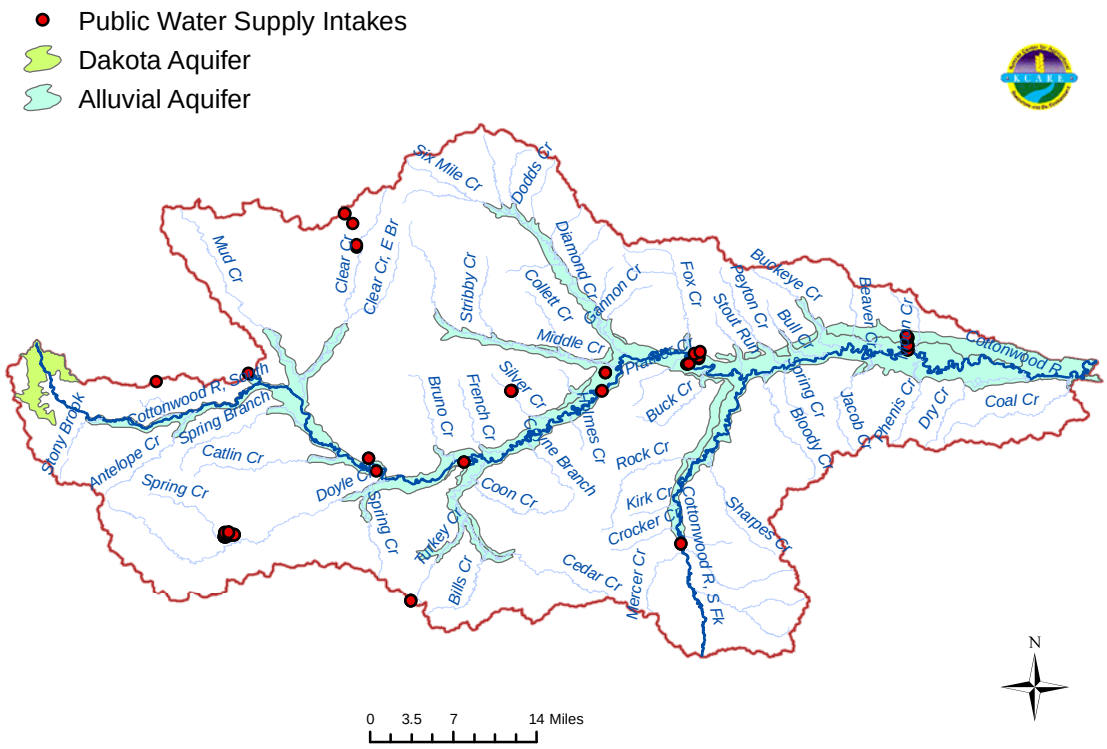



**Figure 9. Aquifers in the Watershed.** [13]

## 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 *E. coli* bacteria will also affect surface water supplies causing excess cost in treatment prior to public consumption. The table below lists the PWS in the Cottonwood Watershed.

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

| Municipality | Source | Serves (Secondary Users) | Purchase From | County | Population Served |
|---|---|---|---|---|---|
| **Cedar Point** | Groundwater | | | Chase | 30 |
| **Centre USD 397** | Groundwater | | | Marion | |
| **Cottonwood Falls** | Groundwater | | | Chase | 966 |
| **Elmdale** | Groundwater | | | | 52 |
| **Florence** | Groundwater | | | Marion | 600 |
| **Hillsboro** | Groundwater | Peabody (treatment only) | | | 2,300 |
| **Matfield Green** | Groundwater | | | Chase | 73 |
| **Peabody** | Groundwater | | | | 1,203 |
| **Strong City** | Groundwater | | | Chase | 533 |

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 waste water can contain suspended solids, biological pollutants that reduce oxygen in the water column, inorganic compounds or bacteria. Waste water will be treated to remove solids and organic materials, disinfected to kill bacteria and viruses, and discharged to surface water. Treatment of municipal waste water is similar across the country. Industrial point sources can contribute toxic chemicals or heavy metals. Treatment of industrial waste water 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 | Owner | Description | City | County |
|---|---|---|---|---|
| Associated Milk Prod. Inc | Private | Condensed and Evaporated Milk | Hillsboro | Marion |
| City of Hillsboro | Public | Sewerage Systems | Hillsboro | Marion |
| Peabody Wastewater Treatment | Public | Sewerage Systems | Peabody | Marion |
| Martin Marietta-hett Quarry | Private | Crushed and Broken Limestone | Marion County | Marion |
| Martin Marietta –Sunflower Quarry | Private | Crushed and Broken Limestone | Marion County | Marion |
| City of Lincolnville Wastewater Treatment Plant | Public | Sewerage System | Lincolnville | Marion |
| Unruh Catering Groundwater Rem | Private | | Peabody | Marion |
| Martin Marietta Aggre-Marion | Private | Crushed and Broken Limestone | Marion | Marion |
| IBP Incorporated | Private | Meat Packing Plants | Emporia | Lyon |
| City of Strong City | Public | Sewerage Systems | Strong City | Chase |
| Kansas Turnpike Authority Mat | State | Inspection and Fixed Facilities | Matfield Green | Chase |
| Modine Manufacturing Company | Private | Motor Vehicle Parts and Accessor | Emporia | Lyon |
| Didde Web Press Corp. | Private | Commercial Printing, Nec | Emporia | Lyon |
| Cottonwood Falls Wastewater Treatment Plant | Public | | Cottonwoo d Falls | Chase |
| Thunderbird Estates | Private | Operator of Res Mobile Home Sites | Emporia | Lyon |

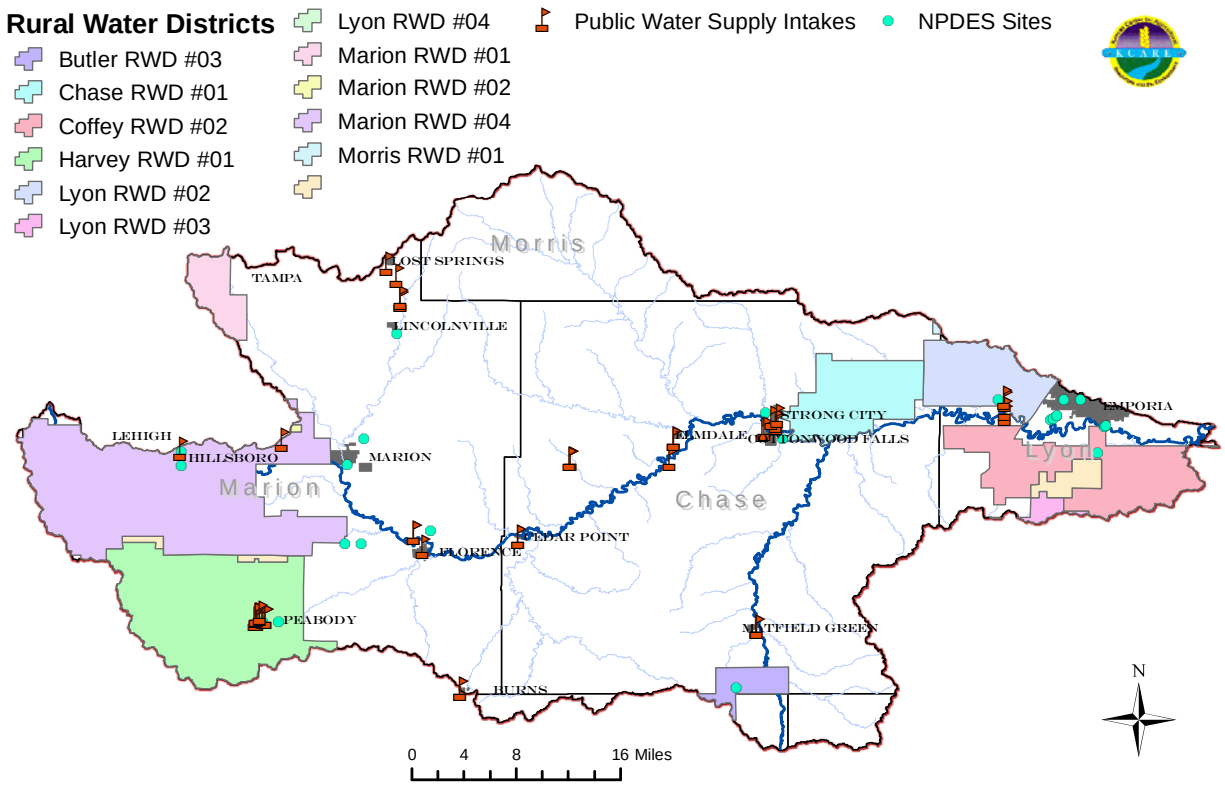



**Figure 10. Rural Water Districts, Public Water Supply Diversion Points and NPDES Wastewater Treatment Plants (WTP).** [17]

## 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 Neosho Basin.

**Table 6. TMDLs Review Schedule for the Neosho Basin.** [19]

| Year Ending in September | Implementation Period | Possible TMDLs to Revise | TMDLs to Evaluate |
|---|---|---|---|
| 2013 | 2014-2023 | 2002, 2004, 2005 | 2002, 2004, 2005 |
| 2018 | 2019-2028 | 2000, 2004, 2005, 2008 | 2000, 2004, 2005, 2008 |

Pursuant to EPA, water bodies are assigned "categories" depending on their impairment status. [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.

**Table 7. TMDLs in the Watershed.** [21] The shaded lines indicate high, medium or low priortities. The **bold** impairments indicate ones that are included in the Targeted Areas. John Redmond Lake TMDLs are included, even though they are not geographically in the watershed, to emphasize the effect the Cottonwood Watershed has on water quality in the Lake.

| Water Segment | TMDL Pollutant | End Goal of TMDL | Priority | Sampling Station |
|---|---|---|---|---|
| **Upper Cottonwood** | | | | |
| **High Priority** | | | | |
| **Mud Creek** | **FCB** | **< 2,000 colonies FCB / 100 ml water** | **High** | **SC691** |
| **Medium Priority** | | | | |
| Marion County Lake | Dissolved Oxygen | DO > 5mg/l | Medium | LM01201 |

| Water Segment | TMDL Pollutant | End Goal of TMDL | Priority | Sampling Station |
|---|---|---|---|---|
| **Upper Cottonwood, cont.** | | | | |
| **Medium Priority** | | | | |
| Marion County Lake | Eutrophication | Summer chlorophyll a concentrations < 12ug/L Total N concentration < 0.62 mg/L | Medium | LM01201 |
| **Cottonwood River South** | **FCB** | **< 2,000 colonies FCB / 100 ml water** | **Medium** | **SC635** |
| **Low Priority** | | | | |
| **Cottonwood River South** | **Sulfate** | **250 mg/l at outlet of the watershed** | **Low** | **SC635** |
| **Clear Creek** | | | | **SC690** |
| **Doyle Creek** | | | | **SC120** |
| **Lower Cottonwood** | | | | |
| **Water Segment** | **TMDL Pollutant** | **End Goal of TMDL** | **Priority** | **Sampling Station** |
| **Medium Priority** | | | | |
| Fox Creek | Biology | MBI > 4.5 | Medium | SC718 |
| Palmer Creek | | | | SC719 |
| South Fork Cottonwood River | | | | SC582 |
| Cottonwood River | FCB | < 2,000 colonies FCB / 100 ml water | Medium | SC627 |
| Cottonwood River | FCB | < 2,000 colonies FCB / 100 ml water | Medium | SC275 |
| Diamond Creek | Cottonwood River | < 2,000 colonies FCB / 100 ml water | Medium | SC625 |
| Cottonwood River | Sulfate | | Low | SC627 SC275 |
| **John Redmond Lake** | | | | |
| **Water Segment** | **TMDL Pollutant** | **End Goal of TMDL** | **Priority** | **Sampling Station** |
| **Medium Priority** | | | | |
| John Redmond Lake | Siltation | Secchi disc depth > 0.8m Target storage capacity 65,000acre/ft for 2014 | Medium | LM026001 |
| John Redmond Lake | Eutrophication | Summer chlorophyll a concentrations < 12ug/L Total N concentration < 0.62 mg/L | Medium | LM026001 |

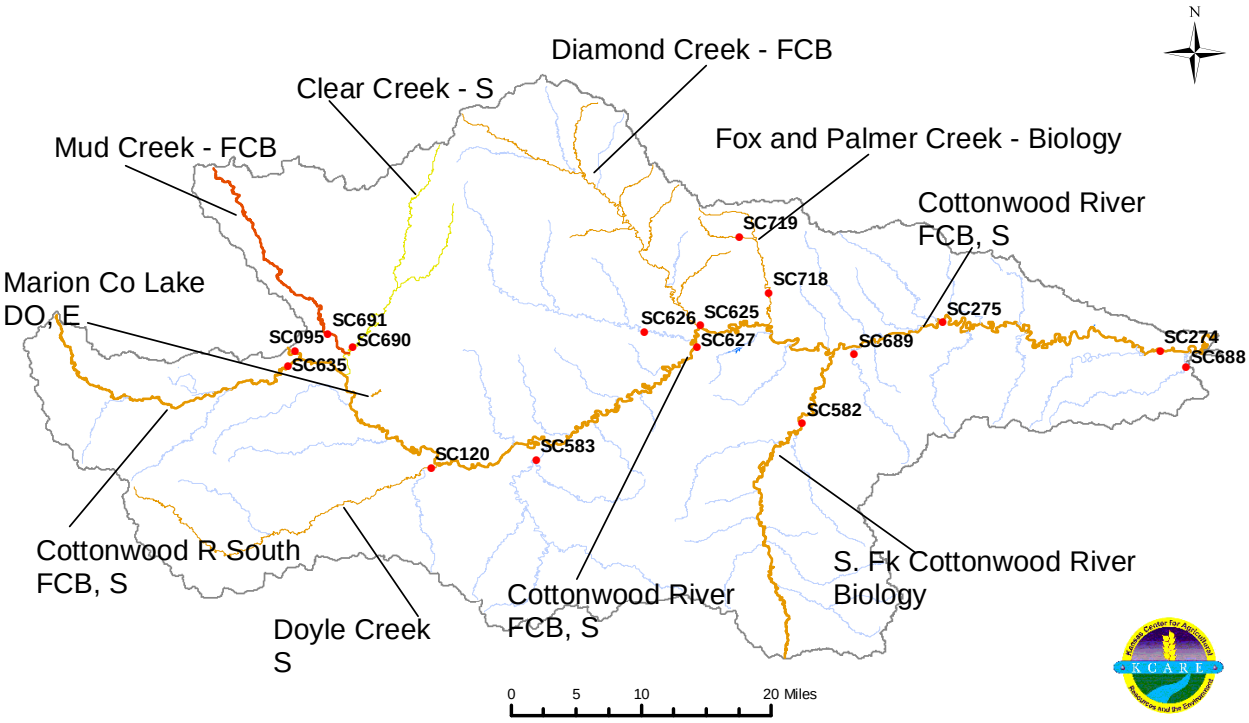



**Figure 11. TMDLs in the Watershed.** [22] Red color indicates high priority TMDL, orange color indicates medium priority TMDL and yellow color indicates low priority TMDL.

## 4.9 303d Listings in the Watershed

The Cottonwood Watershed has numerous 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 Cottonwood Watershed is scheduled for 2013. 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 Cottonwood Watershed.** [23] The impairments in **bold** print indicate ones that are included in the Targeted Areas.

| Category | Water Segment | Impairment | Priority | Sampling Station |
|---|---|---|---|---|
| **Low Priority** | | | | |
| **5 – Waters needing TMDL** | **Mud Creek near Marion** | **Atrazine, Sulfate** | **Low** | **SC691** |
| 5 – Waters needing TMDL | Cedar Creek near Cedar Point | Copper, Zinc | Low | SC583 |

| Category | Water Segment | Impairment | Priority | Sampling Station |
|---|---|---|---|---|
| **Low Priority, cont.** | | | | |
| **5 – Waters needing TMDL** | **South Cottonwood River near Canada** | **Total Phosphorus** | **Low** | **SC635** |
| 5 – Waters needing TMDL | Cottonwood River near Elmdale | Atrazine | Low | SC627 |
| **5 – Waters needing TMDL** | **Cottonwood River near Emporia** | **Biology, Total Phosphorus** | **Low** | **SC274** |
| 5 – Waters needing TMDL | Bloody Creek near Saffordville | Sulfate | Low | SC689 |
| 5 – Waters needing TMDL | Cottonwood River near Plymouth | Total Suspended Solids | Low | SC275 |
| **Category** | **Water Segment** | **Impairment** | **Comment** | **Sampling Station** |
| 3 – Waters that need more data | Doyle Creek | Ammonia, Dissolved Oxygen, FCB | NPDES Permit Lagoon Study Pending | NPDES51705 |
| 3 – Waters that need more data | Clear Creek near Marion | Atrazine | Recent trends indicate concern | SC690 |
| 3 – Waters that need more data | Cottonwood River | FCB | Disinfection compliance needs improvement | NPDES46728 |

**Table 9. 2010 303d Delisted Waters.** [24]

| Category | Water Segment | Impairment | Comment | Sampling Station |
|---|---|---|---|---|
| 2 – Waters now compliant | South Cottonwood River near Canada | Mercury | No longer impaired | SC635 |
| 2 – Waters now compliant | North Cottonwood River near Durham | Zinc | No longer impaired | SC636 |
| 2 – Waters now compliant | Cottonwood River near Emporia | Chlordane | Fish consumption advisory withdrawn | SC274 |
| | | E. coli bacteria | Adequate water quality | |
| | | FCB | Went Cat 2 *E. coli* bacteria in 2008 | |
| 2 – Waters now compliant | Middle Creek near Elmdale | Lead | Cat 2 – Unstable flow analysis | SC626 |

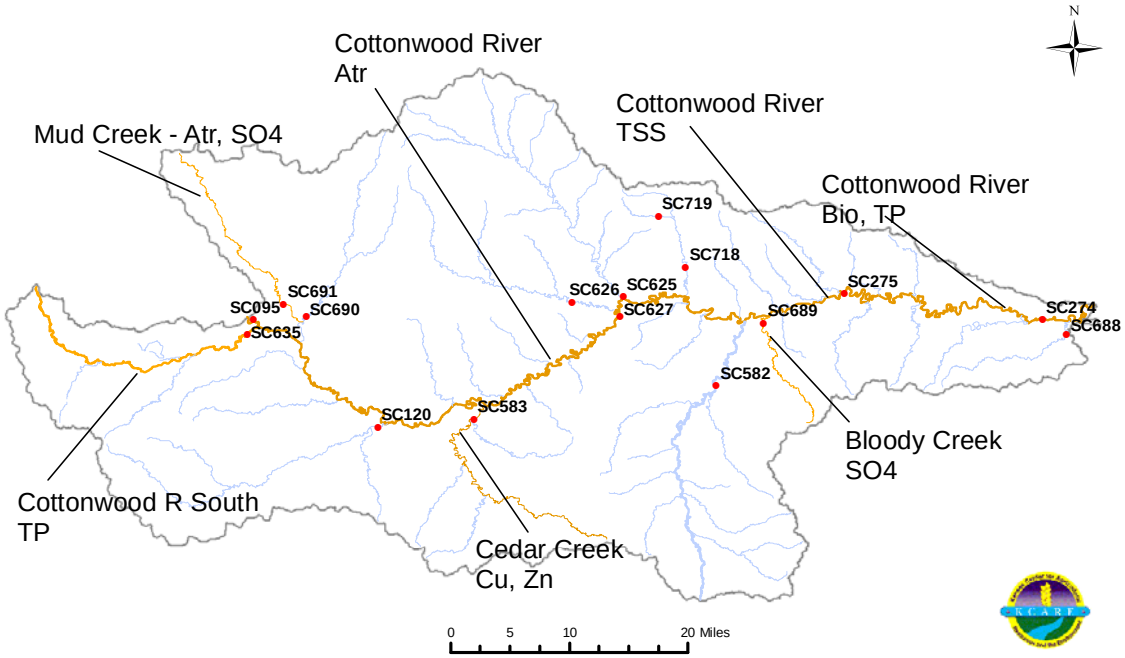



**Figure 12. 303d Listings in the Watershed.** [23] **O**range color indicates low priority TMDL.

## 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, Confined Animal Feeding Operations (CAFOs) or other regulated sites. Point sources are regulated and are not covered by this WRAPS project. 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.

Three sub watersheds that drain into John Redmond Lake that have been given a pollutant load responsibility: Cottonwood, Neosho Headwaters and Eagle Creek. KDHE has determined by analyzing river and creek samples the degree to which each of the sub watersheds contribute to the pollutant load in the Reservoir. Cottonwood Watershed (the Cottonwood River from Marion Lake to its confluence with the Neosho River) is attributed for 80% of the impairment allocation. Eagle Creek Watershed (Eagle Creek headwaters to its confluence with the Neosho River) is attributed for 10% of the impairment allocation.

Neosho Headwaters is attributed with a responsibility of 10% of the total load allocations.

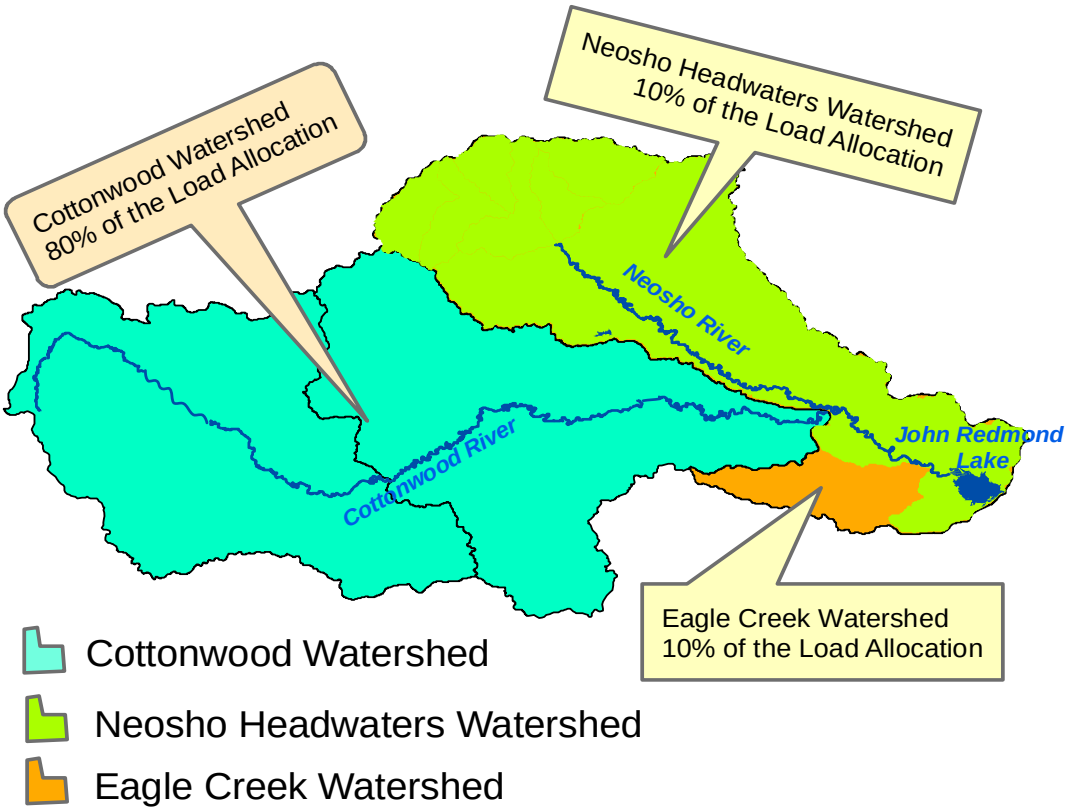



**Figure 13. Load Responsibilities Assigned in Neosho Headwaters, Eagle Creek and Cottonwood Watersheds.**

Load allocations for the Cottonwood Watershed as determined as 80 percent of the total pollutant loads are:

1) **Sediment nonpoint source load allocation = 472,800 tons/year**
2) **Total Phosphorus nonpoint source load allocation = 853,259 lbs/year**

### 4.10.1 Sediment

KDHE has set a load reduction goal for siltation for John Redmond Reservoir originating from nonpoint sources. This amount is 297,600 tons per year. It is derived from subtracting the total silt load capacity from the silt current condition. This is the amount that the Neosho Headwaters, Eagle Creek and the Cottonwood Watersheds will need to remove through BMP installations and conservation practices. In addition to naming a load reduction for John Redmond

Reservoir, KDHE has determined that the Cottonwood Watershed is responsible for 80% of the load reduction or 238,080 tons of sediment into John Redmond Reservoir.

**Table 10. Sediment Load Reductions for Cottonwood Watershed.** [26]

| **John Redmond Sediment TMDL** | |
|---|---|
| Sediment Current Condition (tons) | 888,623 |
| Less Total Silt Load Capacity (tons) | 591,000 |
| **Required Load Reduction from Nonpoint Sources (tons) for John Redmond Reservoir** | **297,600** |
| | |
| **Required Annual Load by Watersheds (tons/yr) to meet TMDL** | |
| Neosho Headwaters (10% of total load reduction) | 29,760 |
| Eagle Creek (10% of total load reduction) | 29,760 |
| **Required Load Reduction for Cottonwood Watershed from Nonpoint Sources (80% of Total Load for John Redmond Reservoir)** | **238,080** |
| **Total Load Reduction for John Redmond Reservoir** | **297,600** |

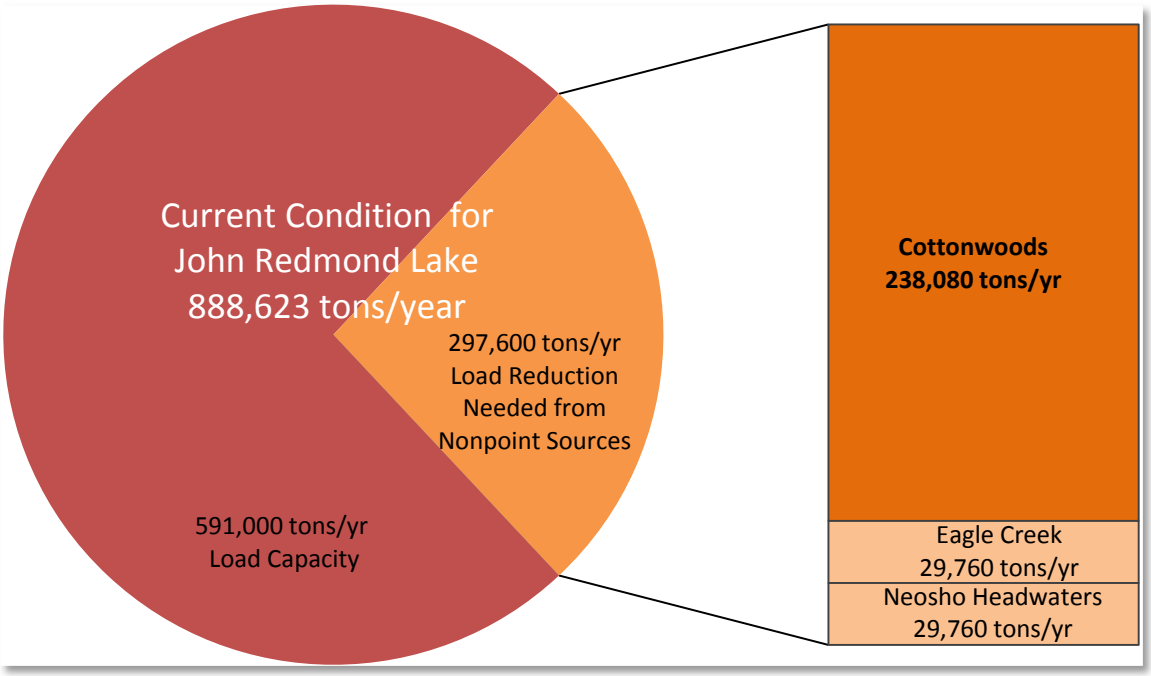



**Figure 14. Sediment Load Allocations for Cottonwood, Eagle Creek and Neosho Headwaters Watersheds.**

### 4.10.2 Phosphorus

The same principal has been applied to phosphorus loads. KDHE has set a load reduction goal for phosphorus in John Redmond Reservoir originating from

nonpoint sources. This amount is 286,408 pounds per year. It is derived from subtracting the total phosphorus load capacity from the current condition of phosphorus concentration in the reservoir. This is the amount that the Neosho Headwaters, Eagle Creek and the Cottonwood Watersheds will need to remove through BMP installations and conservation practices. In addition to naming a load reduction for the reservoir, KDHE has determined that the Cottonwood Watershed is responsible for 80% of the load reduction or 229,126 pounds of phosphorus.

**Table 11. Phosphorus Load Reductions for the Cottonwood Watershed.** [27]

| **John Redmond Phosphorous TMDL** | |
|---|---|
| Total P Current Condition (lbs) | 1,352,982 |
| less Total P Load Capacity (lbs) | 1,066,574 |
| **Required Load Reduction from Nonpoint Sources (lbs)** | **286,408** |
| | |
| **Required Annual Load by Watersheds (lbs/yr) to meet TMDL** | |
| Neosho Headwaters (10% of total load reduction) | 28,641 |
| Eagle Creek (10% of total load reduction) | 28,641 |
| **Required Load Reduction for Cottonwood Watershed from Nonpoint Sources (80% of Total Load for John Redmond Reservoir)** | **229,126** |
| **Total Load Reduction for John Redmond Reservoir** | **286,408** |

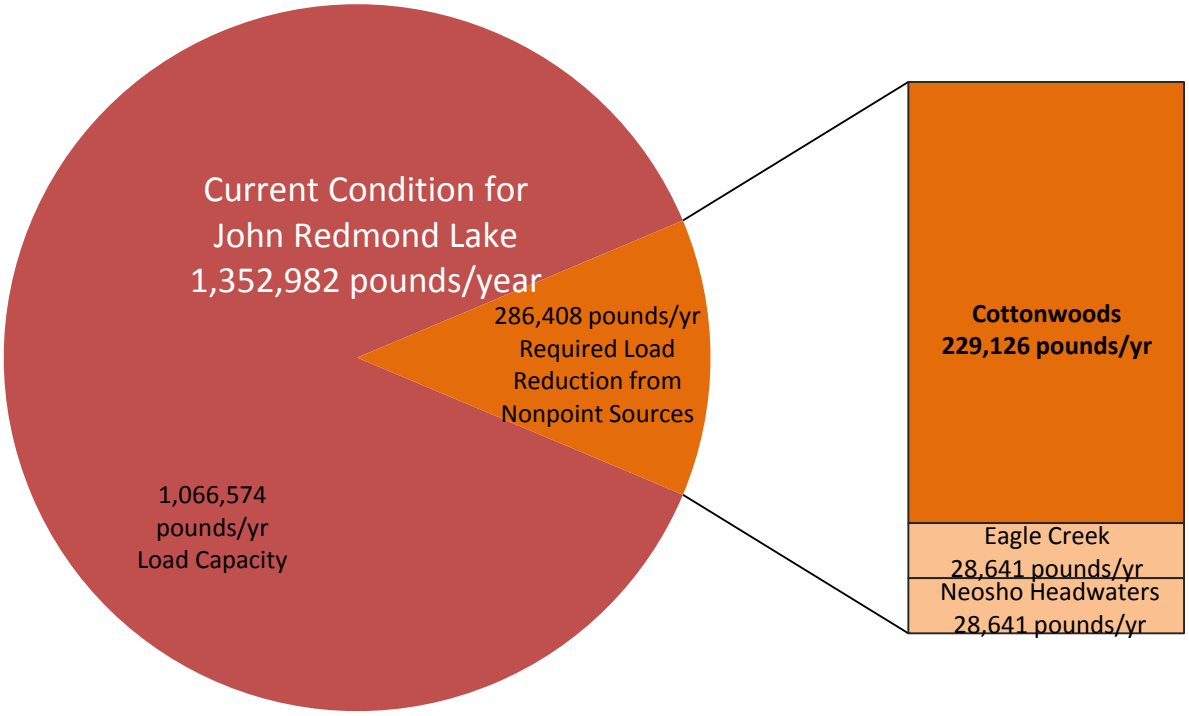



**Figure 15. Phosphorus Load Reductions for Cottonwood, Eagle Creek and Neosho Headwaters Watersheds.**

# 5.0 Critical and Targeted Areas, and Load Reduction Methodology

## 5.1 Critical Areas

In the Cottonwood 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. [28] Two 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,
2. Sub watersheds with high priority TMDLs

## 5.2 Targeted Areas

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, 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 four different areas:

1. Cropland areas will be targeted for sediment and nutrients (phosphorus),
2. Livestock areas will be targeted for nutrients (phosphorus) and *E. coli* bacteria,
3. High priority TMDL areas will be targeted for *E. coli* bacteria, and
4. Streambank areas will be targeted for sediment and nutrients (phosphorus).

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 12. Overlapping Targeted Areas for Cropland, Livestock, Streambank and High Priority TMDLs.**

| Targeted Areas | Cropland Sediment | Livestock Nutrients | Streambank | High Priority TMDLs |
|---|---|---|---|---|
| Mud Creek | X | X | | X |
| Clear Creek | X | | | |
| Cottonwood River | X | | X | |
| South Cottonwood River | X | X | | |
| Doyle Creek | | X | | X |
| Lightning Creek | X | | | |
| Lower End of Cottonwood River | X | | | |

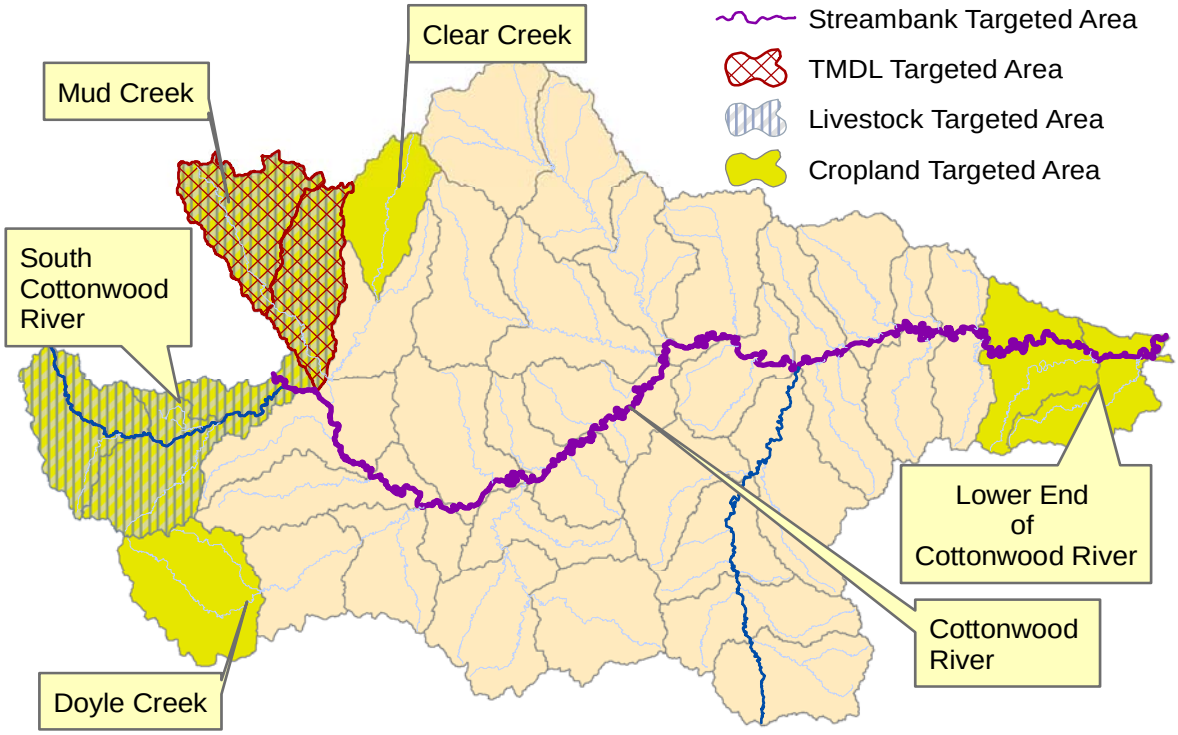



**Figure 16. Targeted Areas for High Priority TMDLs, Livestock, Cropland and Streambanks.**

### 5.2.1 Cropland Targeted Areas

The Cropland Targeted Area of this project was determined by the Soil and Water Assessment Tool (SWAT) as having the potential to runoff sediment (overland origin), and nutrients and is to be used for the determination of BMP placement.

SWAT was used as an assessment tool by Kansas State University Department of Biological and Agricultural Engineering to estimate annual average pollutant loadings such as nutrients and sediment coming from the land into the stream.

At the end of simulation runs the average annual loads are calculated for each sub watershed. Some areas have higher average annual loads than the others. Based on experience and technical knowledge, the areas or sub watershed with the top 20 to 30 percent of the highest loads among all areas within the watershed are selected as targeted areas for cropland and livestock BMPs implementation.

The SWAT model was developed by USDA-ARS from numerous equations and relationships that have evolved from years of runoff and erosion research in combination with other models used to estimate pollutant loads from animal feedlots, fertilizer and agrochemical applications, etc. The SWAT model has been tested for a wide range of regions, conditions, practices, and time scales. Evaluation of monthly and annual streamflow and pollutant outputs indicate SWAT functioned well in a wide range of watersheds. The model directly accounts for many types of common agricultural conservation practices, including terraces and small ponds; management practices, including fertilizer applications; and common landscape features, including grass waterways. The model incorporates various grazing management practices by specifying amount of manure applied to the pasture or grassland, grazing periods, and amount of biomass consumed or trampled daily by the livestock. Septic systems, NPDES discharges, and other point-sources are considered as combined point-sources and applied to inlets of sub watersheds. These features made SWAT a good tool for assessing rural watersheds in Kansas.

The SWAT model is a physically based, deterministic, continuous, watershed-scale simulation model developed by the USDA Agricultural Research Service. ArcGIS interface of ArcSWAT version 9.2 was used. It uses spatially distributed data on topography, soils, land cover, land management, and weather to predict water, sediment, nutrient, and pesticide yields. A modeled watershed is divided spatially into sub watersheds using digital elevation data according to the drainage area specified by the user. Sub watersheds are modeled as having non-uniform slope, uniform climatic conditions determined from the nearest weather station, and they are further subdivided into lumped, non-spatial hydrologic response units (HRUs) consisting of all areas within the sub watershed having similar soil, land use, and slope characteristics. The use of HRUs allows slope, soil, and land-use heterogeneity to be simulated within each sub watershed, but ignores pollutant attenuation between the source area and stream and limits spatial representation of wetlands, buffers, and other BMPs within a sub watershed.

The model includes subbasin, reservoir, and channel routing components.

1. The subbasin component simulates runoff and erosion processes, soil water movement, evapotranspiration, crop growth and yield, soil nutrient and carbon cycling, and pesticide and bacteria degradation and transport. It allows simulation of a wide array of agricultural structures and practices, including tillage, fertilizer and manure application, subsurface drainage,

irrigation, ponds and wetlands, and edge-of-field buffers. Sediment yield is estimated for each subbasin with the Modified Universal Soil Loss Equation (MUSLE). The hydrology model supplies estimates of runoff volume and peak runoff rates. The crop management factor is evaluated as a function of above ground biomass, residue on the surface, and the minimum C factor for the crop that is the crop provided in the database.

2. The reservoir component detains water, sediments, and pollutants, and degrades nutrients, pesticides and bacteria during detention. This component was not used during the simulations.
3. The channel component routes flows, settles and entrains sediment, and degrades nutrients, pesticides and bacteria during transport. SWAT produces daily results for every sub watershed outlet, each of which can be summed to provide daily, monthly, and annual load estimates. The sediment deposition component is based on fall velocity, and the sediment degradation component is based on Bagnold's stream power concepts. Bed degradation is adjusted by the USLE soil erodibility and cover factors of the channel and the floodplain. This component was utilized in the simulations but not used in determining the critical areas.

Data for the Cottonwood Watershed SWAT model were collected from a variety of reliable online and printed data sources and knowledgeable agency personnel within the watershed. Input data and their online sources are:

1. 30 meters DEM (USGS National Elevation Dataset)
2. 30m NLCD 2001 Land Cover data layer (USDA-NRCS)
3. STATSGO soil dataset (USDA-NRCS)
4. NCDC NOAA daily weather data (NOAA National Climatic Data Center)
5. Point sources (KDHE on county basis)
6. Septic tanks (US Census)
7. Crop rotations (local knowledge)
8. Grazing management practices (local knowledge)

The maps produced by the modeling are displayed below. It is noted that the darker or brighter the color on the map, the higher the pollutant load potential. The watersheds in the western end of the watershed show the greatest potential for erosion, phosphorus and nitrogen runoff. The Cropland Targeted Area was determined as a composite of sediment, nitrogen and phosphorus. As stated earlier, this model accounts for land use, soil type, slope, and current conservation practices.

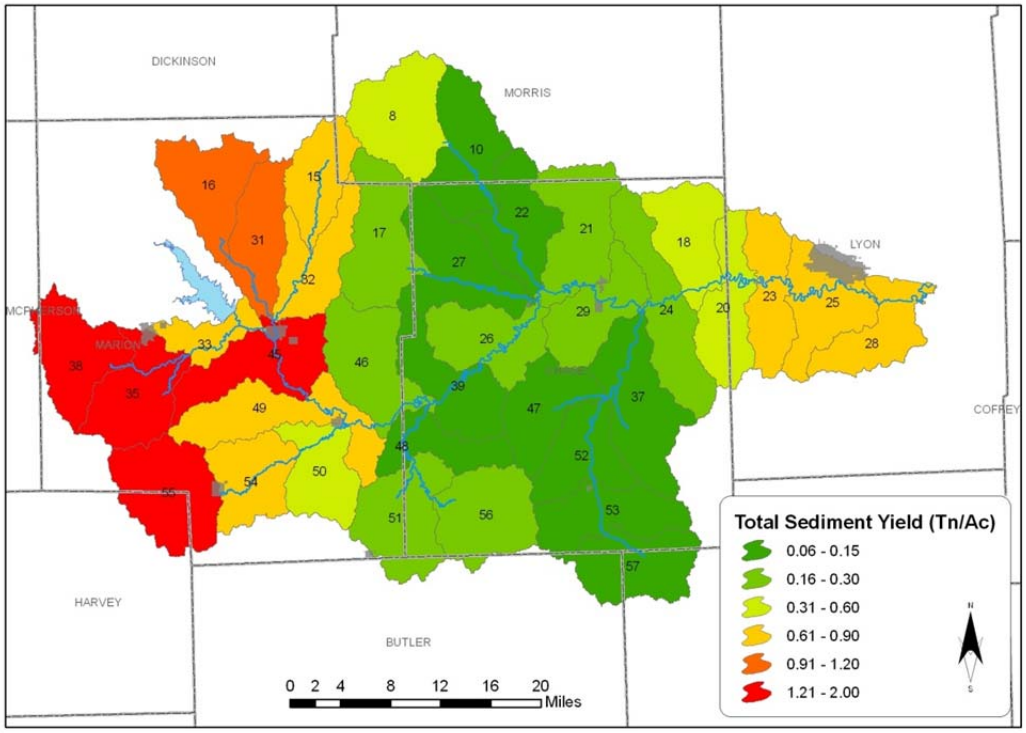



**Figure 17. Total Sediment Load, tons/acre as Determined by SWAT.**

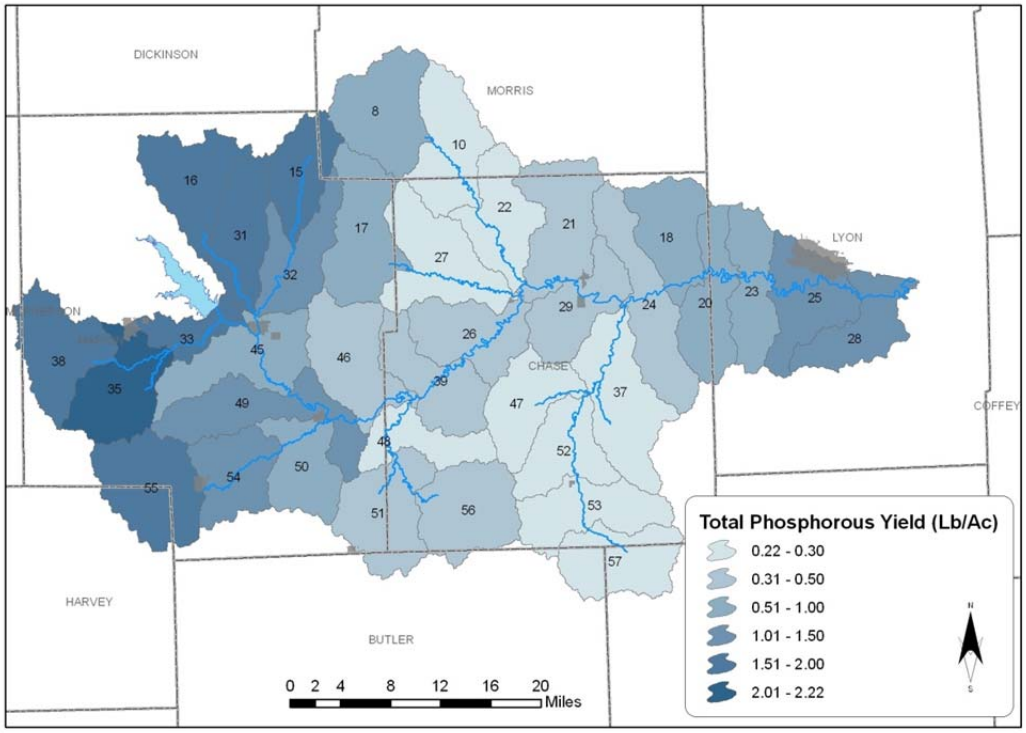



**Figure 18. Total Phosphorus Load, pounds/acre as Determined by SWAT.**

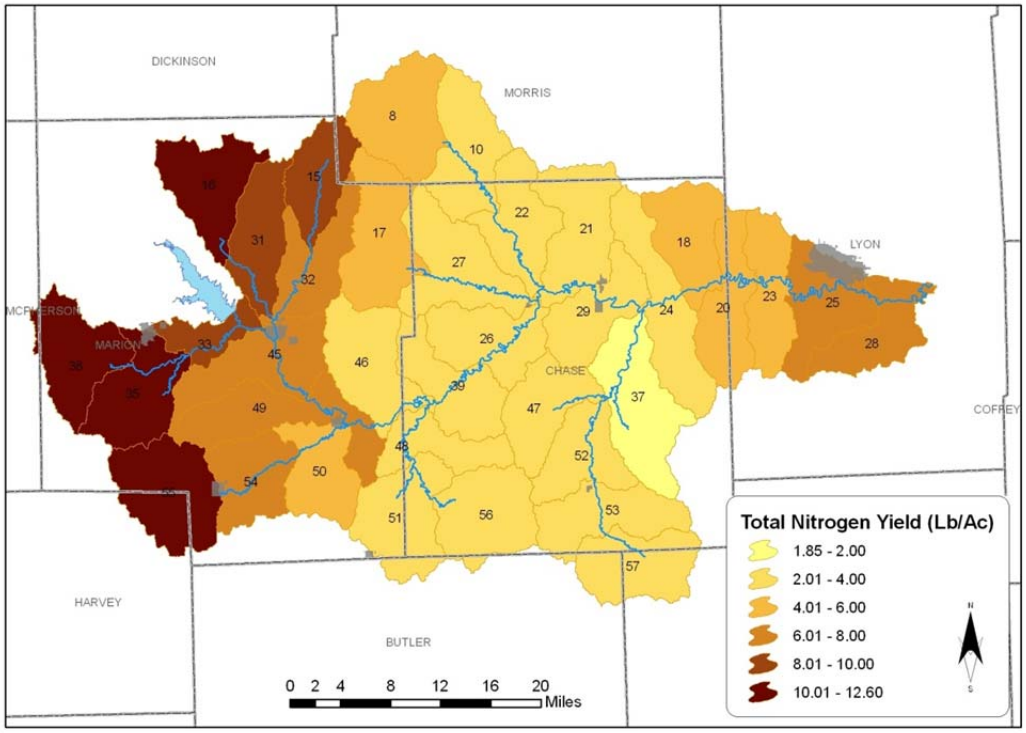



**Figure 19. Total Nitrogen Load, pounds/acre as Determined by SWAT.**

After locating initial sediment targeted areas, the area was groundtruthed. Groundtruthing is a method used to determine what BMPs are currently being utilized in the targeted areas. It involves conducting windshield surveys throughout the targeted areas identified by the watershed models to determine which BMPs are currently installed. These surveys are conducted by local agency personnel and members of the stakeholder leadership team that are familiar with the area and its land use history. Groundtruthing provides the current adoption rate of BMPs, pictures of the targeted areas, and may bring forth additional water quality concerns not captured by watershed modeling. Below is a map of the areas that were groundtruthed in the watershed.

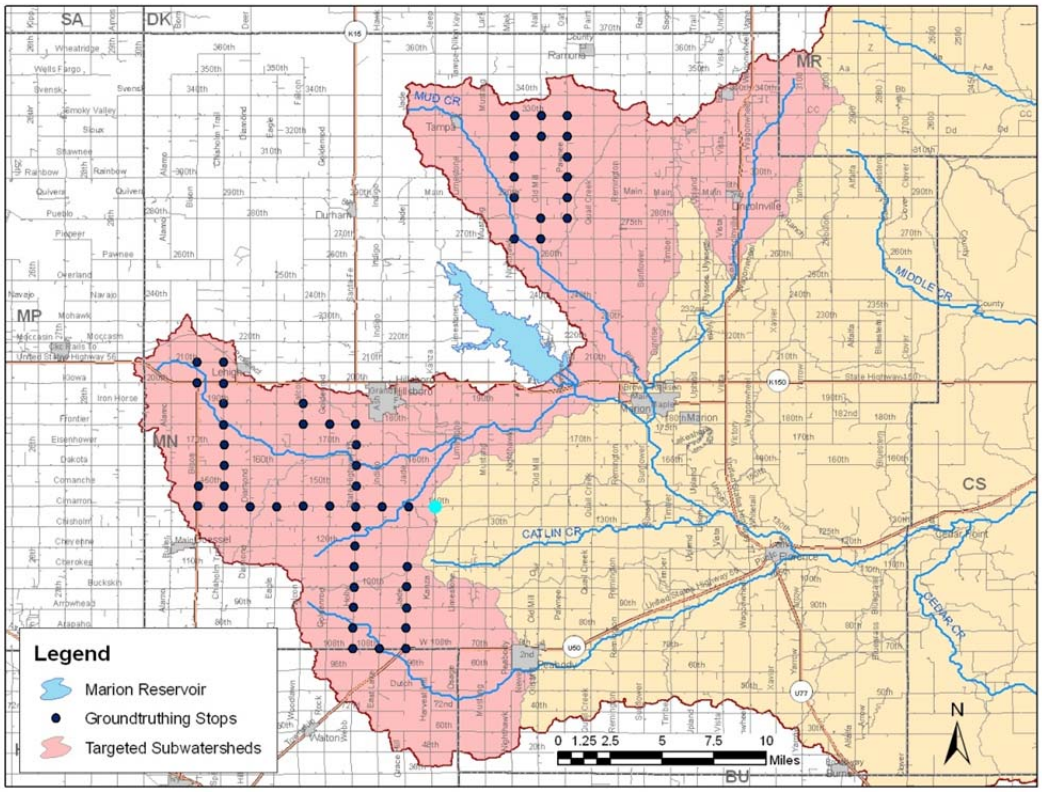



**Figure 20. Groundtruthing Areas in the Watershed.**

In 2009, the groundtruthing was conducted in two counties of the targeted area: Marion and Lyon. Current adoption rates are provided below for five BMPs in Marion County and four BMPs in Lyon County.

**Marion County**

- Conservation Crop Rotation – current adoption rate not able to determine
- Grassed waterways – current adoption rate of 38 percent
- No-till cultivation – current adoption rate of 29 percent
- Vegetative buffer strips – current adoption rate of 0 percent
- Grassed terraces – current adoption rate of 25 percent
- Permanent vegetation – current adoption rate of 9 percent

**Lyon County**

- Conservation Crop Rotation – current adoption rate not able to determine
- No-till cultivation – current adoption rate of 8 percent
- Vegetative buffer strips – current adoption rate of 0 percent
- Permanent vegetation – current adoption rate of 0 percent

The SWAT model was revised using the groundtruthing information. This allows the SWAT model to develop a more accurate determination of appropriate targeted areas. The SWAT model then determined number of acres needed to be implemented for each BMP to meet load reductions. Based on SLT opinion of

landowner and producer acceptability, the BMPs that will be implemented for this watershed are:

- Conservation crop rotation
- Grassed waterways
- No-till
- Vegetative buffers
- Terraces
- Establish permanent vegetation

The SWAT model has delineated the targeted area into subbasins. (HUCs will be labeled with the last three digits of the HUC number.) The HUC 12s that are included in these subbasins are:

- 110702020106
- 110702020107
- 110702020108
- 110702020201
- 110702020202
- 110702020204
- 110702020301
- 110702030405
- 110702030406

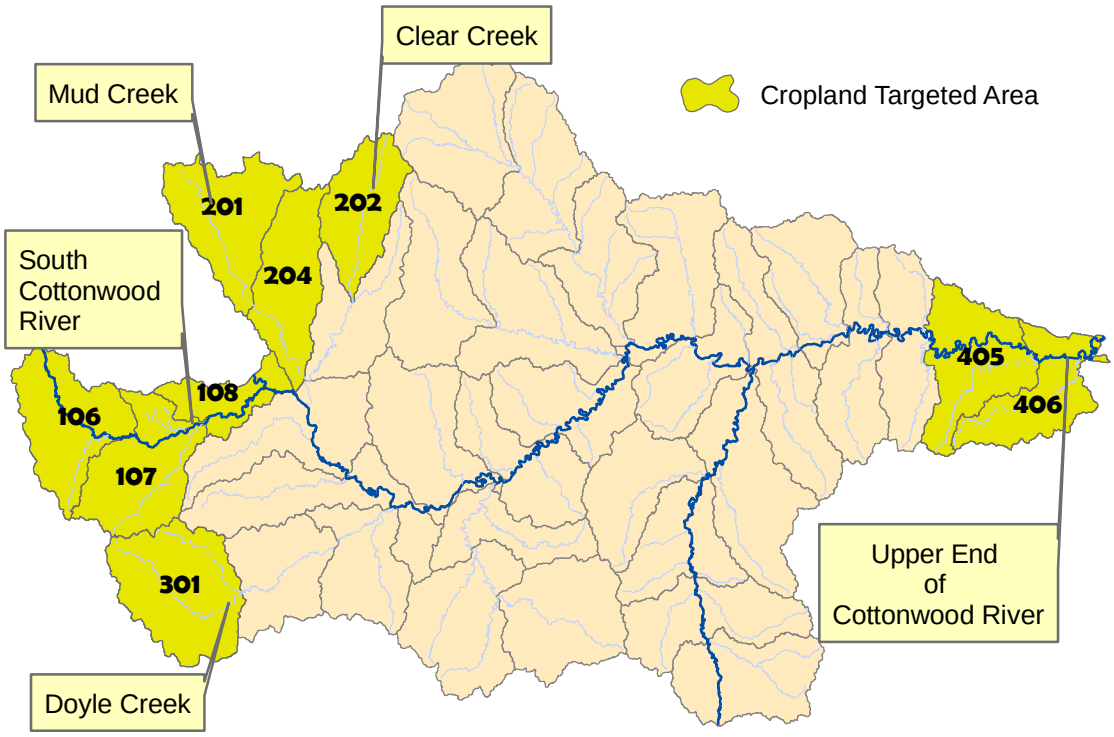



**Figure 21. Cropland Targeted Area.**

**Table 13. Land Use by Subbasin for Cropland Targeted Area as Determined by SWAT.**

| Land Use Breakdown (acres) | | | | | | |
|---|---|---|---|---|---|---|
| **Sub- basin** | **Pasture or Hay** | **Percent Pasture or Hay** | **Cultivated** | **Percent Cultivated** | **Percent Other Land Uses** | **Total Acres in Subbasin** |
| **106** | 14,044 | 60.3 | 5,518 | 23.7 | 16.0 | 23,273 |
| **107** | 15,005 | 47.1 | 12,563 | 39.4 | 13.5 | 31883 |
| **108** | 4,403 | 32.2 | 7,091 | 51.9 | 15.9 | 13,665 |
| **201** | 13,706 | 44.3 | 14,377 | 46.5 | 9.2 | 30,918 |
| **202** | 19,115 | 58.3 | 9,972 | 30.4 | 11.3 | 32,767 |
| **204** | 11,289 | 66.7 | 3,583 | 21.2 | 12.1 | 16,934 |
| **301** | 9,492 | 28.4 | 20,688 | 61.9 | 9.7 | 33,423 |
| **405** | 14,447 | 46.6 | 7,730 | 25.0 | 28.4 | 30,974 |
| **406** | 14,154 | 56.7 | 7,457 | 29.9 | 13.4 | 24,942 |
| **Total** | 136,455 | 57.1 | 69,104 | 28.9 | 14.0 | 238,779 |

### 5.2.2 Livestock Targeted Area

Mud Creek has a high priority TMDL for FCB. For this reason it is in the targeted area for livestock. The livestock targeted areas were determined by examining monitoring site information for elevated nutrient concentrations along with SLT input and were approved by the SLT. A presentation of common livestock BMPs to reduce phosphorous and bacteria runoff from livestock facilities was given to the SLT. Livestock producers within these areas as well as local agency personnel familiar with these areas then discussed which BMPs were needed in the area. The top five livestock BMPs were selected by need, cost-effectiveness, and producer acceptability. Adoption rate goals were set for the next 40 years based on their overall need and what can be feasibly adopted.

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

- Establish vegetative filter strips,
- Fence off streams,
- Move pasture feeding sites,
- Install off stream watering systems, and
- Implement rotational grazing systems.

The Livestock Targeted Area is seen in the following map and includes the HUC 12s (HUCs will be labeled with the last three digits of the HUC number.):

- 110702020106
- 110702020107
- 110702020108
- 110702020201

- 110702020204

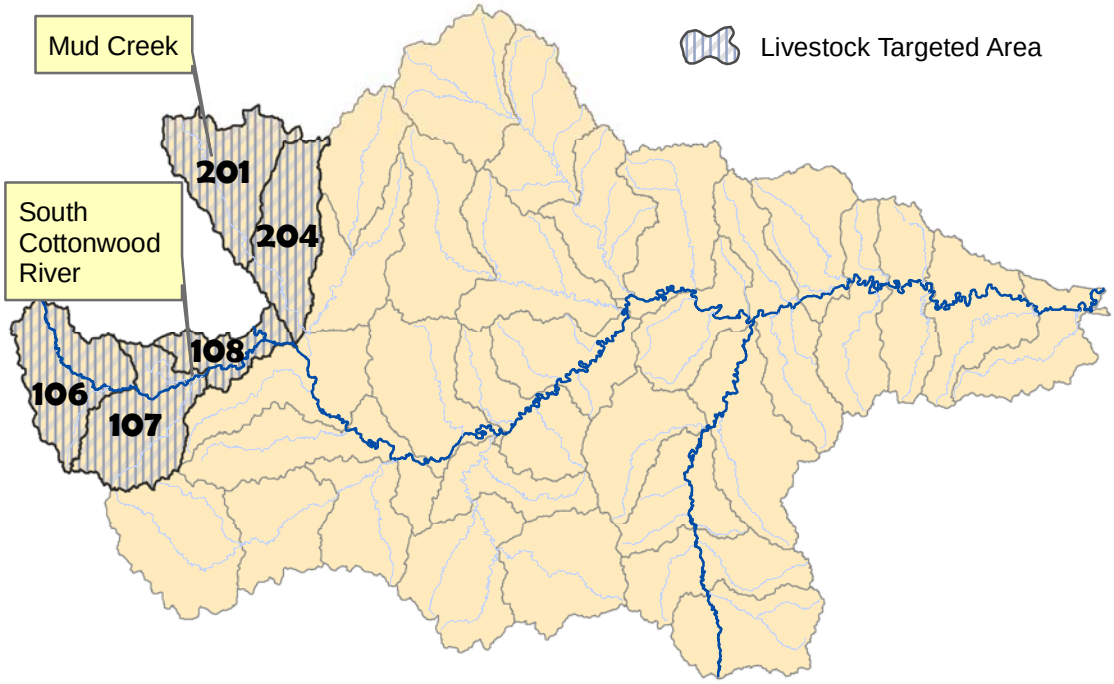



**Figure 22. Livestock Targeted Area.**

**Table 14. Land Use by Subbasin for Livestock Targeted Area as Determined by SWAT.**

| Landuse Breakdown (acres) | | | | | | |
|---|---|---|---|---|---|---|
| **Subbasin** | **Pasture or Hay** | **Percent Pasture or Hay** | **Cultivated** | **Percent Cultivated** | **Percent Other Land Uses** | **Total** |
| **201** | 13,706 | 44.3 | 14,377 | 46.5 | 9.2 | 30,918 |
| **204** | 11,289 | 66.7 | 3,583 | 21.2 | 12.1 | 16,934 |
| **106** | 14,044 | 60.3 | 5,518 | 23.7 | 16.0 | 23,273 |
| **107** | 15,005 | 47.1 | 12,563 | 39.4 | 13.5 | 31883 |
| **108** | 4,403 | 32.2 | 7,091 | 51.9 | 15.9 | 13,665 |
| **Total** | 58,447 | 50.1 | 43,132 | 37.0 | 12.9 | 116,673 |

### 5.2.3 Streambank Targeted Area

A study funded by the Kansas Water Office has been completed to determine the reaches of the Cottonwood River that need riparian and streambank stabilization. This assessment along the main channel of the Cottonwood River determined the targeted area for streambank restoration. Unless a future need arises, there should be no need for another streambank assessment.

The Cottonwood River was divided into ten “reach” areas each containing numerous sites of degradable streambanks. The following map shows the location of each Reach Area. Cottonwood River segments are labeled as C1 through C10. Reach numbers N1 through N9 are targeted areas that lie along the Neosho River and have been addressed in the Neosho Headwaters WRAPS project.

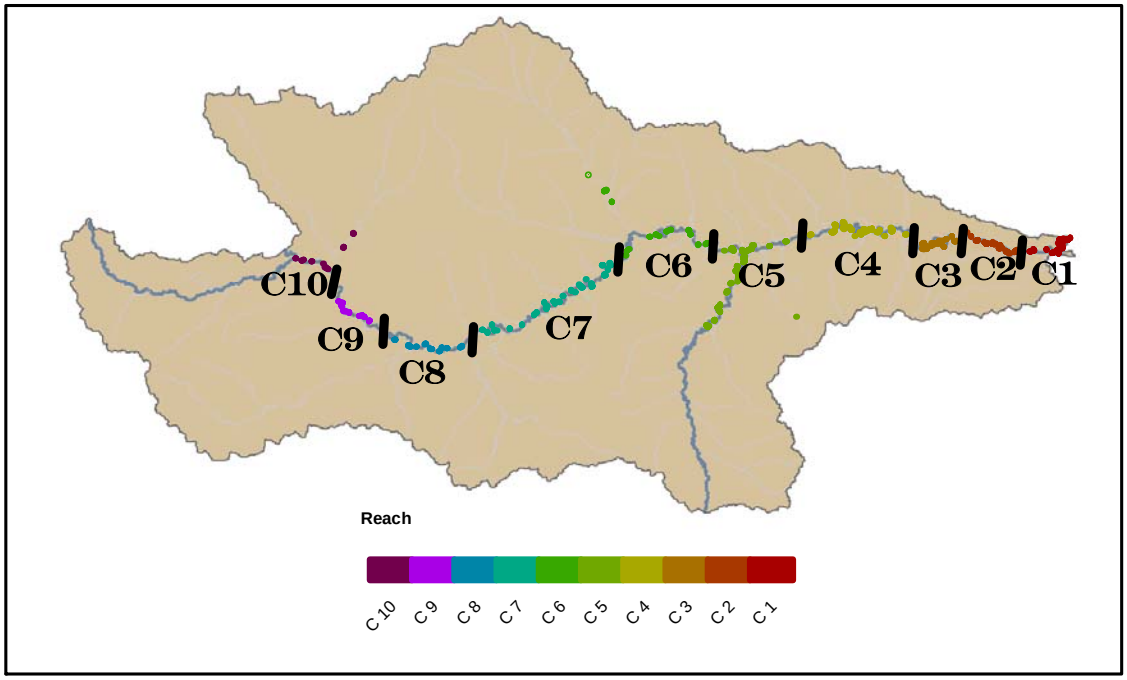



**Figure 23. Targeted Areas for Streambank Stabilization along the Cottonwood River (C1 through C10).**

It has been decided that the restoration projects will begin with Reach C1 and all streambank projects will be completed in this Reach Area before new projects are begun in the subsequent Reach Areas.

**Table 15. Summary of Cottonwood River Streambank Hotspots.**

| Reach | Number of Sites | Total Erosion (tons/year) | Total Length (feet/year) | Tons Sediment /Foot/Year |
|---|---|---|---|---|
| C1 | 18 | 26,541 | 9,402 | 2.82 |
| C2 | 16 | 31,977 | 12,311 | 2.60 |
| C3 | 22 | 13,918 | 8,014 | 1.74 |
| C4 | 27 | 26,341 | 13,468 | 1.96 |
| C5 | 10 | 7,095 | 4,916 | 1.44 |
| C6 | 12 | 5,064 | 3,302 | 1.53 |
| C7 | 32 | 17,652 | 10,503 | 1.68 |
| C8 | 14 | 10,303 | 5,179 | 1.99 |
| C9 | 11 | 11,591 | 4,253 | 2.73 |
| C10 | 7 | 4,948 | 2,335 | 2.12 |

| Cottonwood River Hotspots, cont. | | | | |
|---|---|---|---|---|
| Reach | Number of Sites | Total Erosion (tons/year) | Total Length (feet/year) | Tons Sediment /Foot/Year |
| Total | 169 | 155,429 | 73,683 | |

### 5.2.4 High Priority TMDL Targeted Area

The High Priority TMDL Targeted Area is driven from a high priority TMDL in the watershed. Mud Creek has a high priority TMDL for FCB. FCB will be discussed later in this report.

The BMPs that will be implemented for the High Priority Targeted Area are contained in the Livestock Targeted Area BMPs. This is due to geographic overlap of the two targeted areas.

The high priority TMDL area is delineated into two subbasins. (HUCs will be labeled with the last three digits of the HUC number.) The HUC 12s that are included in these subbasins are:

- 110702020201
- 110702020204

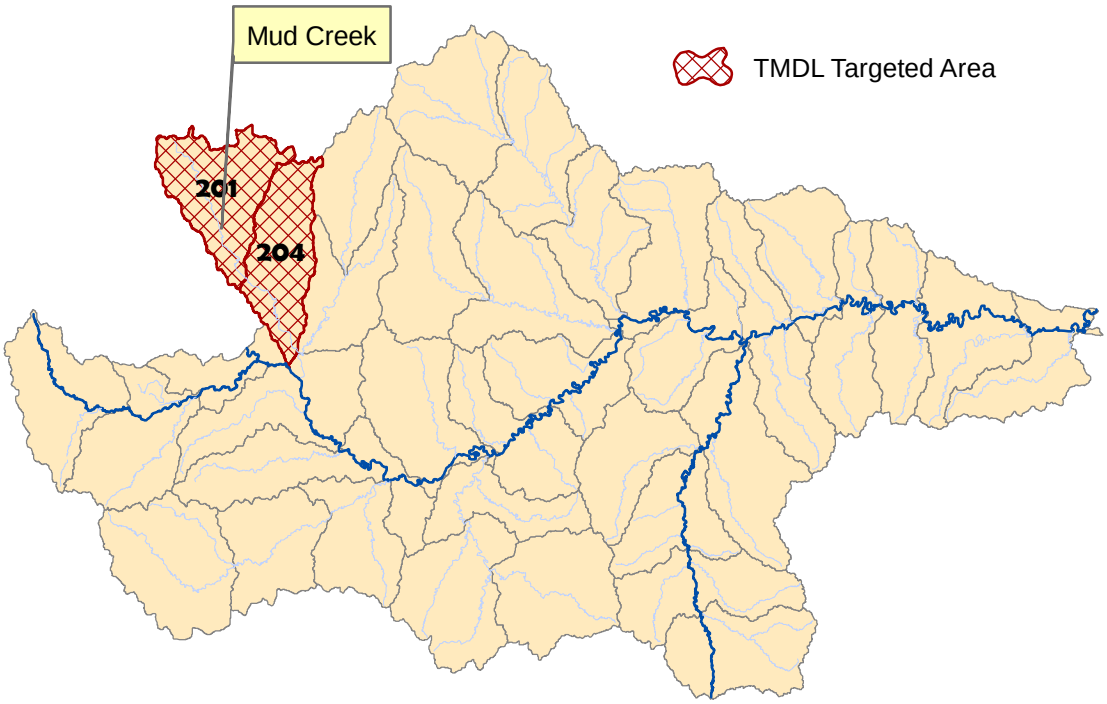



**Figure 24. TMDL Targeted Area.**

**Table 16. Land Use for High Priority TMDL Targeted Area as Determined by SWAT.**

| Landuse Breakdown (acres) | | | | | | |
|---|---|---|---|---|---|---|
| **Subbasin** | **Pasture or Hay** | **Percent Pasture or Hay** | **Cultivated** | **Percent Cultivated** | **Percent Other Land Uses** | **Total** |
| **201** | 13,706 | 44.3 | 14,377 | 46.5 | 9.2 | 30,918 |
| **204** | 11,289 | 66.7 | 3,583 | 21.2 | 12.1 | 16,934 |
| **Total** | 24,995 | | 17,960 | | | 47,852 |

## 5.3 Load Reduction Estimate Methodology

### 5.3.1 Cropland

Baseline loadings (natural runoff rates) are calculated using the SWAT 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. [29] Load reduction estimates are the product of baseline loading and the applicable BMP load reduction efficiencies.

### 5.3.2 Livestock

Baseline nutrient loadings (natural runoff rates) per animal unit are calculated using the Livestock Waste Facilities Handbook.[30] Livestock management practice load reduction efficiencies are derived from numerous sources including K-State Research and Extension Publication MF-2737 and MF-2454.[31] Load reduction estimates are the product of baseline loading and the applicable BMP load reduction efficiencies.

### 5.3.3 Streambank

A 2009 study of thirteen Neosho River restoration sites conducted by the KSU Agricultural Economists calculated the cost of stabilizing these sites at $710,011.38 or an average of $41.66 per linear foot, including all engineering and design costs. All load reductions and costs assume a properly engineered streambank restoration with the addition of a 66 foot riparian buffer.

**NOTE:** The SLT of the Cottonwood 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, and**
    b. **Streambank erosion**
2. **Nutrients and *E. coli* bacteria**
    a. **Livestock (nutrients and *E. coli* bacteria),**
    b. **Cropland (nutrients and *E. coli* bacteria), and**
    c. **High Priority TMDL (*E. coli* bacteria)**

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 Cottonwood Watershed. However, John Redmond Reservoir has a TMDL for **siltation (sedimentation)**. Since the Cottonwood Watershed is one of three watersheds eventually draining into John Redmond Reservoir, KDHE has used a reduction goal for the reservoir and divided responsibility for meeting the reduction goal between the three watersheds. It was determined that the Cottonwood Watershed would take responsibility for eighty percent of the reduction goal. Even though there is no sediment TMDL, there is a listing on the 303d list for TSS on the Cottonwood River near Plymouth. It is hoped that intervening BMPs that will be incorporated in the watershed will prevent the need of developing a TMDL at this location.

Silt or sediment accumulation in lakes and wetlands 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. In addition to the problem of sediment loading in lakes, pollutants can be attached to the suspended soil particles in the water column causing additional impairments. 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 best management practices (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.

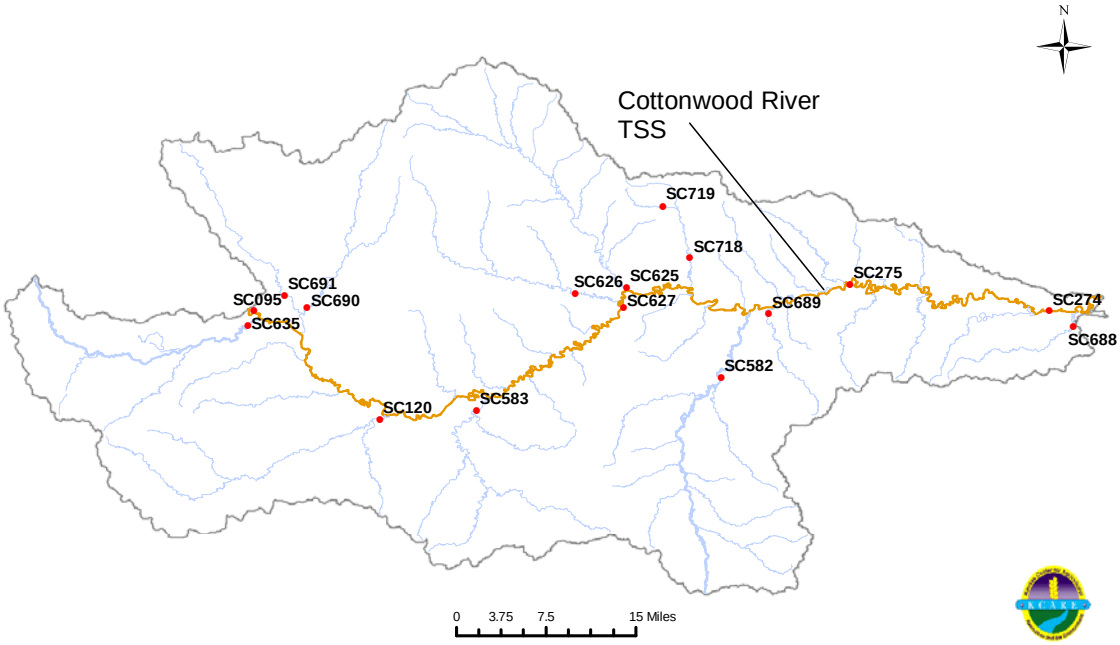



**Figure 25. 303d Listing for Siltation in the Cottonwood Watershed.** [20] Orange color indicates low priority at SC275.

Physical components of the terrain are important in sediment movement, such as:

- Slope of the land, propensity to generate runoff and soil type
- Streambank erosion and sloughing 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.

Activities performed on the land affects sediment that is transported downstream to the lakes. 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

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

- Conservation Crop Rotation
- Grassed Waterways
- No-Till
- Vegetative Buffers
- Terraces
- Permanent vegetation to replace crops

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):

**Cropland Erosion**

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

**Streambank Degradation**

- Riparian quality
- Precipitation distribution

### 6.1.1 Cropland Erosion

Cropland BMPs have been assigned by the SLT. The targeted areas for cropland are located in the extreme western portion of the watershed and the extreme eastern portion of the watershed. 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 watershed are grasslands (68%), cropland (26%), woodlands (3%), and all other (3%). According to SWAT calculations, the primary land uses in the cropland targeted area of the watershed are grassland (57%), cropland (29%) and all other (14%). Table 13, page 48 provides the breakout acreages.

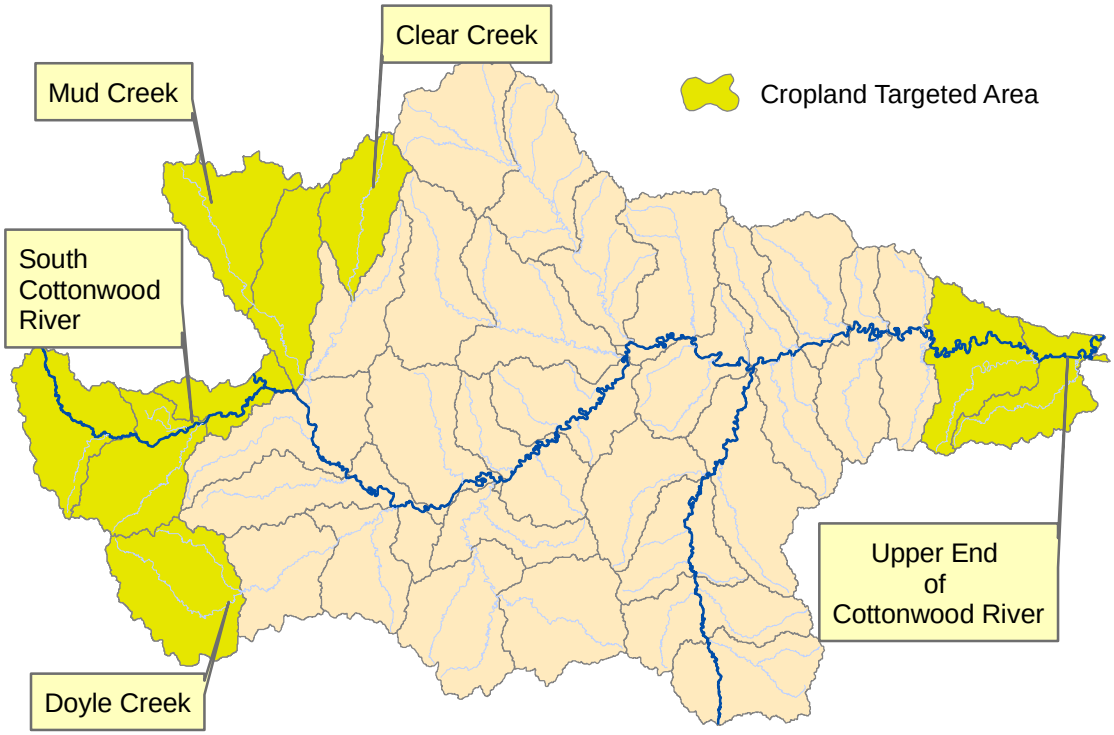



**Figure 26. Targeted Area for Cropland as Determined by SWAT.**

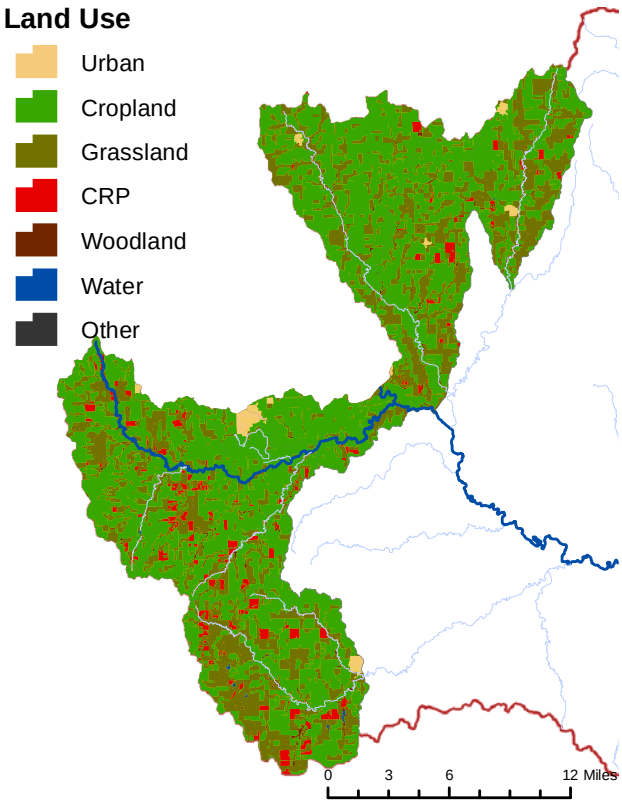



**Figure 27. Land Cover in the Western Portion of the Cropland Targeted Area.** [4]

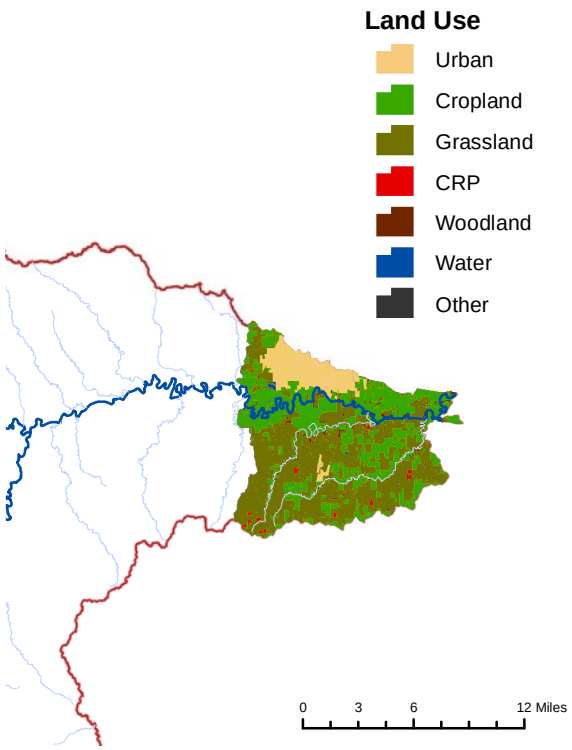



**Figure 28. Land Cover of the Eastern Portion of the Cropland Targeted Area.** [4]

### *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. [32]

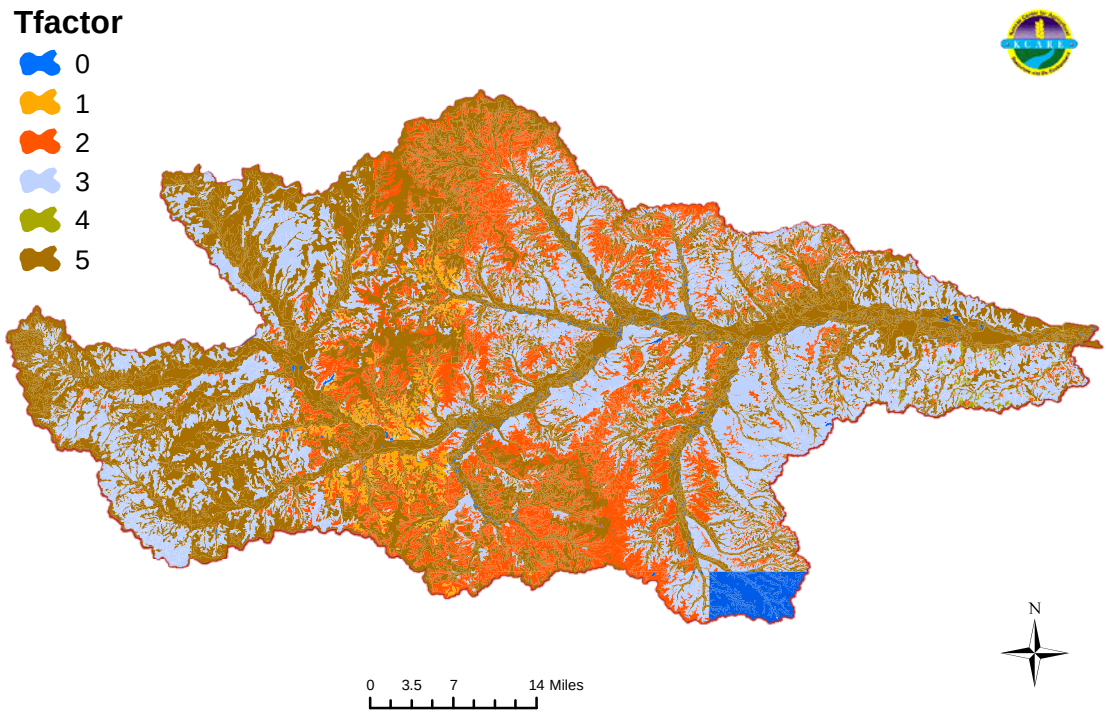



**Figure 29. T Factor in the Watershed, tons/acre.** [33]

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 17. T Factor in the Watershed, tons/acre.** [33]

| T Factor | Acres | Percent of Watershed |
|---|---|---|
| 0 | 20,804 | 1.8 |
| 1 | 16,871 | 1.5 |
| 2 | 219,872 | 19.4 |
| 3 | 308,705 | 27.3 |
| 4 | 2,256 | 0.2 |
| 5 | 564,272 | 49.8 |

#### *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.

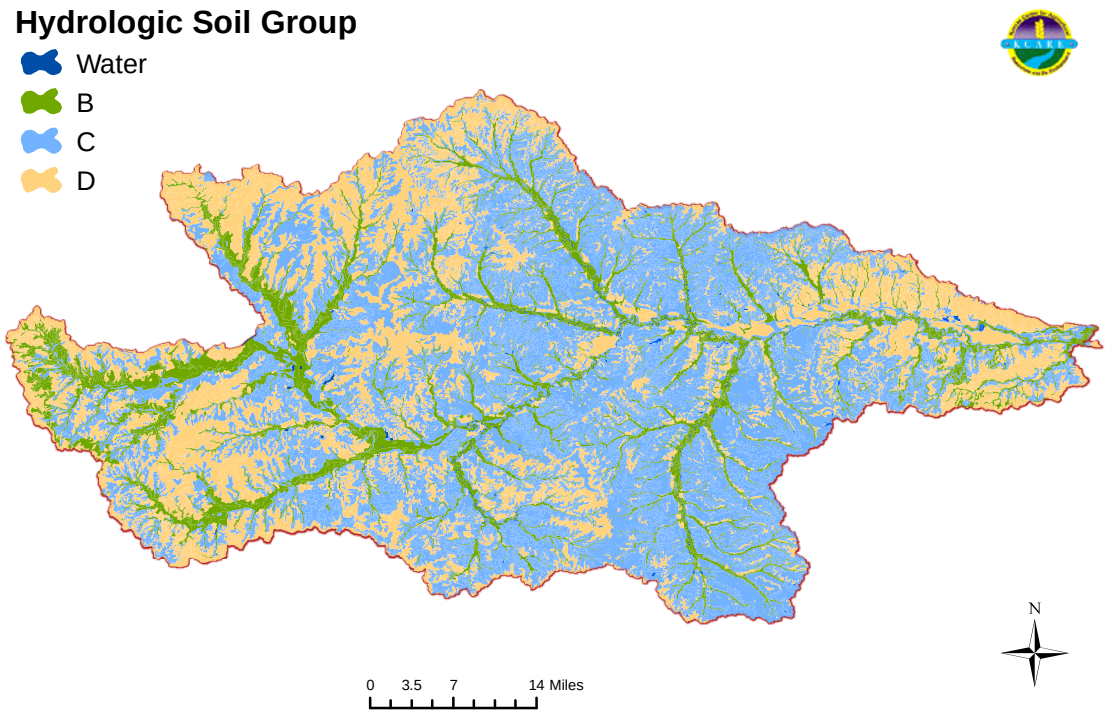



**Figure 30. Hydrologic Soil Groups of the Watershed.** [33]

Almost half of the watershed (51 percent) is characterized as soil group C. Thirty three percent are categorized as soil group D, which is the soil group with the highest potential for runoff. Conservation practices and BMP installations will help to protect this fragile soil.

**Table 18. Hydrologic Soil Groups of the Watershed.** [33]

| Hydrologic Soil Group | Definition | Acres of Watershed in HSG | Percentage of Watershed in HSG |
|---|---|---|---|
| **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 |
| **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. | 161,545 | 14.3 |
| **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. | 586,573 | 51.8 |

| HSG of the Watershed, cont. | | | |
|---|---|---|---|
| **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 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. | 377,991 | 33.4 |
| **Other** | Water, dams, pits, sewage lagoons | 6,675 | 0.6 |

### 6.1.2 Streambank Erosion

Sediment can originate from streambank erosion and sloughing 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.

#### *6.1.2.A Riparian Quality*

An adequately functioning and healthy riparian area will reduce sediment flow from cropland and rangeland. Riparian areas can be vulnerable to runoff and erosion from livestock induced activities in pastureland and overland flow from bare soil on cropland. Buffers and filter strips along with additional forested riparian areas can be used to impede erosion and streambank sloughing. Livestock restriction along the stream will prevent livestock from entering the stream and degrading the banks. Cropland needs buffer and filter strips adjacent to the stream in order to impede the flow of sediment off of fields. Conservation tillage practices are also effective for slowing the flow of rain water off of crop fields.

This WRAPS project has targeted the Cottonwood River for streambank stabilization projects. According to the USDA/NRCS GIS mapping data, approximately fifty three percent of the 100 foot buffer area along the river is at least 51 percent forested. Forty-one percent is considered to be barren. Four percent is cropland and two percent is pasture and urban areas.

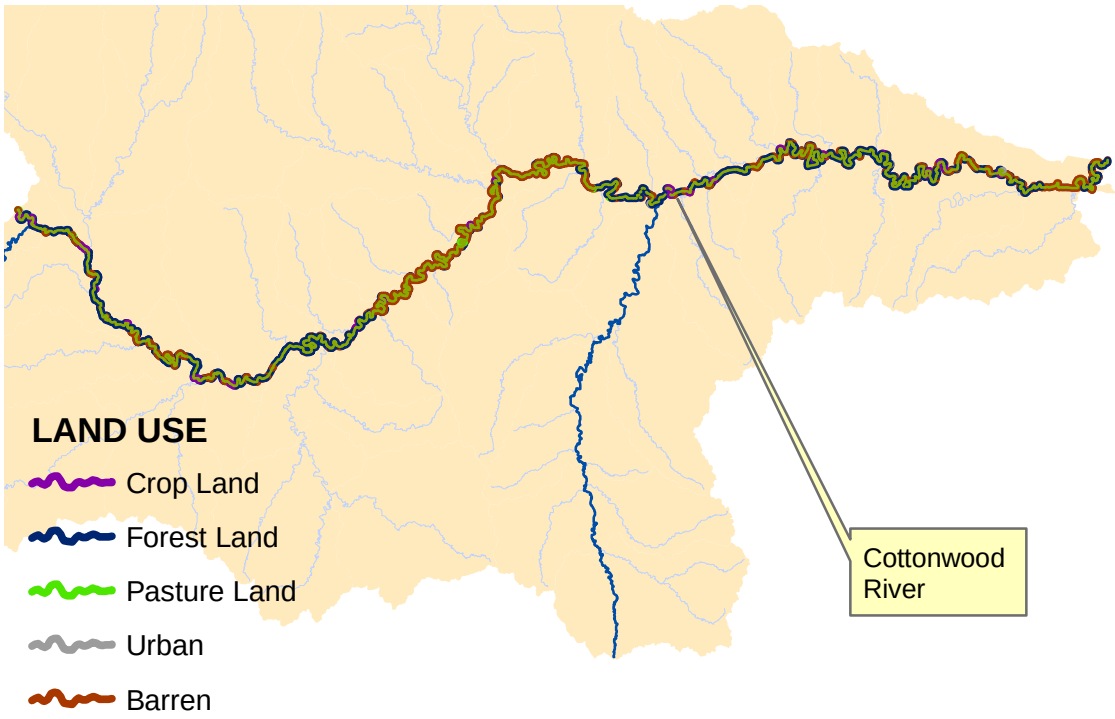



**Figure 31. Land Use Within a 100 Ft. Buffer Along the Streambank Targeted Area.** [34]

#### *6.1.2.B Rainfall and Runoff*

Rainfall amounts and subsequent runoff can affect sediment delivery from agricultural areas and urban areas into streams and the Cottonwood River. High water flows in the River will cause swirling and under cutting of the river banks with subsequent sloughing. Sloughing of stream and river banks is a major contributor of sediment downstream.

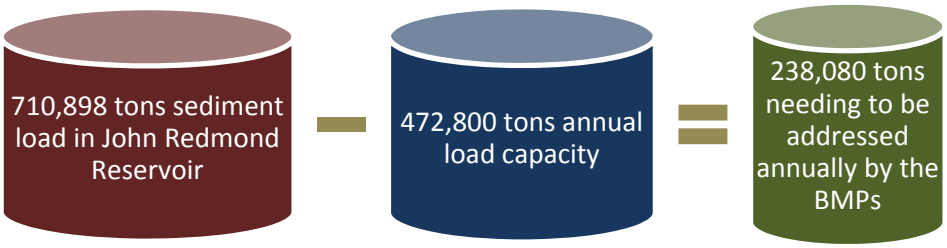
In cropland, high rainfall events can cause sheet and rill erosion. High intensity rainfall events (rainfall rates that overwhelm soil adsorptive capacity) usually occur in late spring and early summer. Extended duration of rainfall events that causes soil saturation and subsequent runoff also usually occurs in late spring and early summer. For these reasons it is important to utilize conservation practices such as no-till that provide a “cover” on bare soil during the spring and into the summer.

See Figures 5 and 6.

### 6.1.3 Sediment BMPs with Acres or Projects Needed

The current estimated sediment load from nonpoint sources entering John Redmond Reservoir is 297,600 tons per year according to the TMDL section of KDHE. **The total annual load reduction allocated to Cottonwood Watershed**

**needed to meet the 89 percent sediment TMDL for John Redmond Reservoir is 238,080 tons**. 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 and streambank targeted areas.** Cropland BMPs that will be implemented to address nutrient/phosphorus runoff are included in this section. An added bonus is that the cropland and streambank BMPs aimed at sediment reduction will also have 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 and economic analysis and approved by the SLT.

**Table 19. BMPs and Acres or Projects Needed to Reduce Sediment Contribution in John Redmond Reservoir by 238,080 tons and Address the Sediment Listing on the 303d List on the Cottonwood River.**

| Protection Measures | Best Management Practices and Other Actions | Total Acres or Projects Needed to be Implemented Over a Forty Year Period |
|---|---|---|
| 1.0 Prevention of sediment (TSS) contribution from **cropland** | 1.1 Conservation Crop Rotations | 12,111 acres |
| | 1.2 Grassed Waterways | 42,303 acres |
| | 1.3 No-Till | 57,486 acres |
| | 1.4 Vegetative Buffers | 45,364 acres |
| | 1.5 Terraces | 10,576 acres |
| | 1.6 Establish Permanent Vegetation | 12,111 acres |
| 2. Prevention of sediment (TSS) contribution from **streambank** erosion | Streambank Restoration | Repair 73,683 feet of eroding streambank |

### 6.1.4 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 20. Estimated Sediment Load Reductions for Implemented BMPs on Cropland Aimed at Reducing Sediment Contribution in John Redmond Reservoir by 238,080 tons and Addressing the Cottonwood River Sediment Listing on the 303d List.**

| Annual Soil Erosion Reduction (tons), Cropland BMPs | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
| 1 | 175 | 515 | 1,576 | 700 | 193 | 666 | 3,825 |
| 2 | 350 | 1,029 | 3,153 | 1,401 | 386 | 1,331 | 7,650 |
| 3 | 525 | 1,544 | 4,729 | 2,101 | 579 | 1,997 | 11,475 |
| 4 | 701 | 2,059 | 6,305 | 2,801 | 772 | 2,662 | 15,300 |
| 5 | 876 | 2,573 | 7,881 | 3,502 | 965 | 3,328 | 19,125 |
| 6 | 1,051 | 3,088 | 9,458 | 4,202 | 1,158 | 3,993 | 22,949 |
| 7 | 1,226 | 3,602 | 11,034 | 4,903 | 1,351 | 4,659 | 26,774 |
| 8 | 1,401 | 4,117 | 12,610 | 5,603 | 1,544 | 5,324 | 30,599 |
| 9 | 1,576 | 4,632 | 14,187 | 6,303 | 1,737 | 5,990 | 34,424 |
| 10 | 1,751 | 5,146 | 15,763 | 7,004 | 1,930 | 6,655 | 38,249 |
| 11 | 1,926 | 5,661 | 17,339 | 7,704 | 2,123 | 7,321 | 42,074 |
| 12 | 2,102 | 6,176 | 18,915 | 8,404 | 2,316 | 7,986 | 45,899 |
| 13 | 2,277 | 6,690 | 20,492 | 9,105 | 2,509 | 8,652 | 49,724 |
| 14 | 2,452 | 7,205 | 22,068 | 9,805 | 2,702 | 9,317 | 53,549 |
| 15 | 2,627 | 7,720 | 23,644 | 10,505 | 2,895 | 9,983 | 57,374 |
| 16 | 2,802 | 8,234 | 25,220 | 11,206 | 3,088 | 10,648 | 61,199 |
| 17 | 2,977 | 8,749 | 26,797 | 11,906 | 3,281 | 11,314 | 65,024 |
| 18 | 3,152 | 9,263 | 28,373 | 12,606 | 3,474 | 11,979 | 68,848 |
| 19 | 3,328 | 9,778 | 29,949 | 13,307 | 3,667 | 12,645 | 72,673 |
| 20 | 3,503 | 10,293 | 31,526 | 14,007 | 3,860 | 13,310 | 76,498 |
| 21 | 3,503 | 10,807 | 32,490 | 14,651 | 3,860 | 13,310 | 78,621 |
| 22 | 3,503 | 11,322 | 33,455 | 15,294 | 3,860 | 13,310 | 80,744 |
| 23 | 3,503 | 11,837 | 34,420 | 15,937 | 3,860 | 13,310 | 82,867 |
| 24 | 3,503 | 12,351 | 35,385 | 16,580 | 3,860 | 13,310 | 84,990 |
| 25 | 3,503 | 12,866 | 36,350 | 17,224 | 3,860 | 13,310 | 87,113 |
| 26 | 3,503 | 13,380 | 37,315 | 17,867 | 3,860 | 13,310 | 89,235 |
| 27 | 3,503 | 13,895 | 38,280 | 18,510 | 3,860 | 13,310 | 91,358 |
| 28 | 3,503 | 14,410 | 39,245 | 19,154 | 3,860 | 13,310 | 93,481 |
| 29 | 3,503 | 14,924 | 40,210 | 19,797 | 3,860 | 13,310 | 95,604 |
| 30 | 3,503 | 15,439 | 41,175 | 20,440 | 3,860 | 13,310 | 97,727 |
| 31 | 3,503 | 15,954 | 42,140 | 21,083 | 3,860 | 13,310 | 99,850 |
| 32 | 3,503 | 16,468 | 43,105 | 21,727 | 3,860 | 13,310 | 101,973 |
| 33 | 3,503 | 16,983 | 44,070 | 22,370 | 3,860 | 13,310 | 104,096 |
| 34 | 3,503 | 17,498 | 45,035 | 23,013 | 3,860 | 13,310 | 106,218 |
| 35 | 3,503 | 18,012 | 46,000 | 23,657 | 3,860 | 13,310 | 108,341 |

| Annual Soil Erosion Reduction (tons), Cropland BMPs, cont. | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
| 36 | 3,503 | 18,527 | 46,965 | 24,300 | 3,860 | 13,310 | 110,464 |
| 37 | 3,503 | 19,041 | 47,930 | 24,943 | 3,860 | 13,310 | 112,587 |
| 38 | 3,503 | 19,556 | 48,894 | 25,586 | 3,860 | 13,310 | 114,710 |
| 39 | 3,503 | 20,071 | 49,859 | 26,230 | 3,860 | 13,310 | 116,833 |
| 40 | 3,503 | 20,585 | 50,824 | 26,873 | 3,860 | 13,310 | 118,956 |

The table below demonstrates the streambank load reductions attained by implementing streambank restoration projects.

**Table 21. Estimated Sediment Load Reductions for Implemented Streambanks Restoration Projects Aimed at Reducing Sediment Contribution in John Redmond Reservoir by 238,080 tons and Addressing the Cottonwood River Sediment Listing on the 303d List.**

| Annual Erosion Reduction (tons), Streambank BMPs | | | |
|---|---|---|---|
| Year | Streambank Stabilization (feet) | Soil Load Reduction (tons) | Cumulative Erosion Reduction (tons) |
| 1 | 1,842 | 3,887 | 3,887 |
| 2 | 1,842 | 3,887 | 7,774 |
| 3 | 1,842 | 3,887 | 11,660 |
| 4 | 1,842 | 3,887 | 15,547 |
| 5 | 1,842 | 3,887 | 19,434 |
| 6 | 1,842 | 3,887 | 23,321 |
| 7 | 1,842 | 3,887 | 27,207 |
| 8 | 1,842 | 3,887 | 31,094 |
| 9 | 1,842 | 3,887 | 34,981 |
| 10 | 1,842 | 3,887 | 38,868 |
| 11 | 1,842 | 3,887 | 42,755 |
| 12 | 1,842 | 3,887 | 46,641 |
| 13 | 1,842 | 3,887 | 50,528 |
| 14 | 1,842 | 3,887 | 54,415 |
| 15 | 1,842 | 3,887 | 58,302 |
| 16 | 1,842 | 3,887 | 62,188 |
| 17 | 1,842 | 3,887 | 66,075 |
| 18 | 1,842 | 3,887 | 69,962 |
| 19 | 1,842 | 3,887 | 73,849 |
| 20 | 1,842 | 3,887 | 77,736 |
| 21 | 1,842 | 3,887 | 81,622 |
| 22 | 1,842 | 3,887 | 85,509 |

| Annual Erosion Reduction (tons), Streambank BMPs, cont. | | | |
|---|---|---|---|
| Year | Streambank Stabilization (feet) | Soil Load Reduction (tons) | Cumulative Erosion Reduction (tons) |
| 23 | 1,842 | 3,887 | 89,396 |
| 24 | 1,842 | 3,887 | 93,283 |
| 25 | 1,842 | 3,887 | 97,169 |
| 26 | 1,842 | 3,887 | 101,056 |
| 27 | 1,842 | 3,887 | 104,943 |
| 28 | 1,842 | 3,887 | 108,830 |
| 29 | 1,842 | 3,887 | 112,717 |
| 30 | 1,842 | 3,887 | 116,603 |
| 31 | 1,842 | 3,887 | 120,490 |
| 32 | 1,842 | 3,887 | 124,377 |
| 33 | 1,842 | 3,887 | 128,264 |
| 34 | 1,842 | 3,887 | 132,150 |
| 35 | 1,842 | 3,887 | 136,037 |
| 36 | 1,842 | 3,887 | 139,924 |
| 37 | 1,842 | 3,887 | 143,811 |
| 38 | 1,842 | 3,887 | 147,698 |
| 39 | 1,842 | 3,887 | 151,584 |
| 40 | 1,842 | 3,887 | 155,471 |

The table below shows the combined load reduction for sediment that is attained by implementing all cropland BMPs and streambank restoration projects annually. The percent of TMDL achievement is illustrated in the right column. It will require thirty-four years to meet the sediment reduction goal in John Redmond Reservoir if all BMPs are implemented. The life of the WRAPS plan is forty years due to the objective of meeting the phosphorus reduction goal. After thirty-four years, the sediment portion of this plan will switch from being "restoration" to "protection" of the watershed.

**Table 22. Combined Cropland and Streambank Load Reductions Aimed at Reducing Sediment Contribution in John Redmond Reservoir by 238,080 tons and Addressing the Cottonwood River Sediment Listing on the 303d List.**

| Combined Annual Erosion Reduction (tons) | | | | |
|---|---|---|---|---|
| Year | Streambank Reduction (tons) | Cropland Reduction (tons) | Total Reduction (tons) | % of TMDL |
| 1 | 3,887 | 3,825 | 7,712 | **3%** |
| 2 | 7,774 | 7,650 | 15,423 | **6%** |
| 3 | 11,660 | 11,475 | 23,135 | **10%** |
| 4 | 15,547 | 15,300 | 30,847 | **13%** |

| Combined Annual Erosion Reduction (tons), cont. | | | | |
|---|---|---|---|---|
| **Year** | **Streambank Reduction (tons)** | **Cropland Reduction (tons)** | **Total Reduction (tons)** | **% of TMDL** |
| 5 | 19,434 | 19,125 | 38,558 | **16%** |
| 6 | 23,321 | 22,949 | 46,270 | **19%** |
| 7 | 27,207 | 26,774 | 53,982 | **23%** |
| 8 | 31,094 | 30,599 | 61,694 | **26%** |
| 9 | 34,981 | 34,424 | 69,405 | **29%** |
| 10 | 38,868 | 38,249 | 77,117 | **32%** |
| 11 | 42,755 | 42,074 | 84,829 | **36%** |
| 12 | 46,641 | 45,899 | 92,540 | **39%** |
| 13 | 50,528 | 49,724 | 100,252 | **42%** |
| 14 | 54,415 | 53,549 | 107,964 | **45%** |
| 15 | 58,302 | 57,374 | 115,675 | **49%** |
| 16 | 62,188 | 61,199 | 123,387 | **52%** |
| 17 | 66,075 | 65,024 | 131,099 | **55%** |
| 18 | 69,962 | 68,848 | 138,810 | **58%** |
| 19 | 73,849 | 72,673 | 146,522 | **62%** |
| 20 | 77,736 | 76,498 | 154,234 | **65%** |
| 21 | 81,622 | 78,621 | 160,243 | **67%** |
| 22 | 85,509 | 80,744 | 166,253 | **70%** |
| 23 | 89,396 | 82,867 | 172,263 | **72%** |
| 24 | 93,283 | 84,990 | 178,272 | **75%** |
| 25 | 97,169 | 87,113 | 184,282 | **77%** |
| 26 | 101,056 | 89,235 | 190,292 | **80%** |
| 27 | 104,943 | 91,358 | 196,301 | **82%** |
| 28 | 108,830 | 93,481 | 202,311 | **85%** |
| 29 | 112,717 | 95,604 | 208,321 | **88%** |
| 30 | 116,603 | 97,727 | 214,330 | **90%** |
| 31 | 120,490 | 99,850 | 220,340 | **93%** |
| 32 | 124,377 | 101,973 | 226, 350 | **95%** |
| 33 | 128,264 | 104,096 | 232,359 | **98%** |
| 34 | 132,150 | 106,218 | 238,369 | **100%** |
| 35 | 136,037 | 108,341 | 244,378 | **103%** |
| 36 | 139,924 | 110,464 | 250,388 | **105%** |
| 37 | 143,811 | 112,587 | 256,398 | **108%** |
| 38 | 147,698 | 114,710 | 262,407 | **110%** |
| 39 | 151,584 | 116,833 | 268,417 | **113%** |
| 40 | 155,471 | 118,956 | 274,427 | **115%** |
| *Sediment TMDL 238,080 Tons* | | | | |

Sediment Reduction Goal is Met

**Table 23. Sediment Load Reduction at the End of Forty Years by Category Aimed at Reducing Sediment Contribution in John Redmond Reservoir by 238,080 tons and Addressing the Cottonwood River Sediment Listing on the 303d List.**

| Best Management Practice Category | Total Load Reduction (tons) | % of Sediment TMDL |
|---|---|---|
| Cropland | 118,956 | 50% |
| Streambank | 155,471 | 65% |
| **Total** | **274,427** | **115%** |
| **Sediment Goal 238,080 Tons** | | |

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

## 6.2 Nutrients

### 6.2.1 Livestock Related Impairments

Livestock can cause certain pollutants in the water. *E. coli* bacteria are present in livestock manure and can be transported into waterways if livestock have access to streams. Nutrients, primarily phosphorus, are also present in manure. Soluble phosphorus can easily be transported in runoff from fields where livestock gather. Other nutrient issues can arise from fertilizers applied to non-native pastures. Nitrogen and phosphorus can originate from fertilizer runoff caused by either excess application or a rainfall event immediately after application. ***It must be noted that not all E. coli bacteria can be attributed to livestock. Wildlife has a contribution to E. coli bacteria loads. In addition, failing septic systems can be a source of E. coli bacteria from humans. However, for this WRAPS process, targeting will be for livestock. A similar notation is that 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. Similarly, for this WRAPS process, targeting will be for agricultural practices.***

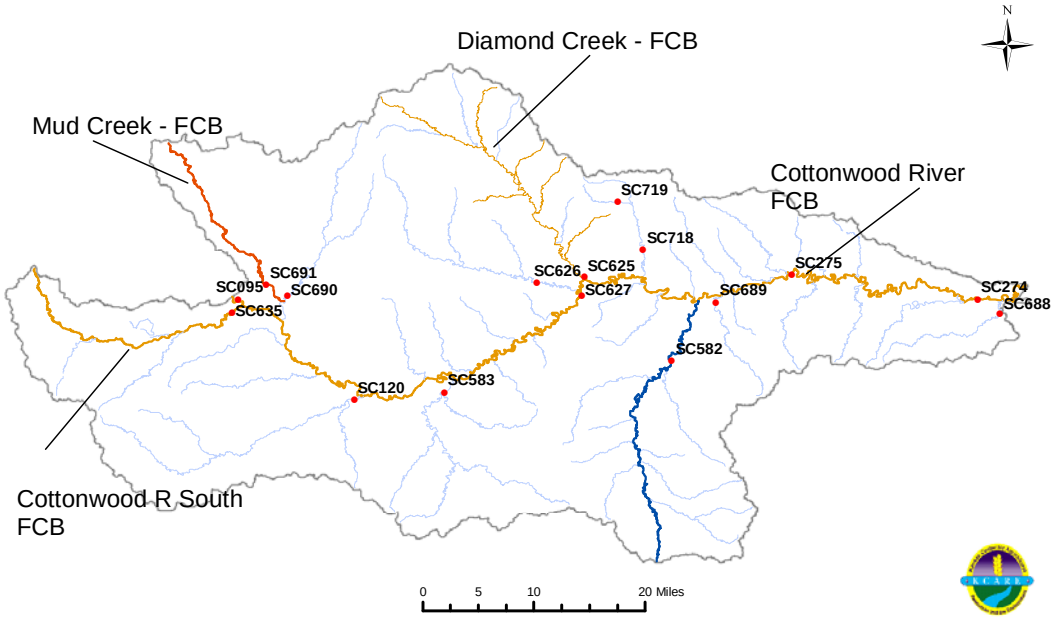



**Figure 32. FCB Impairments in the Watershed.**

As mentioned earlier in this report, targeting has been assigned for livestock related pollutants. It includes the Mud Creek watershed which is the only high priority FCB TMDL area in the watershed. The South Cottonwood River, the

Cottonwood River and Diamond Creek have medium priorities for FCB. The drainage areas of Mud Creek and the South Cottonwood River have been designated as targeted areas for BMP placement.

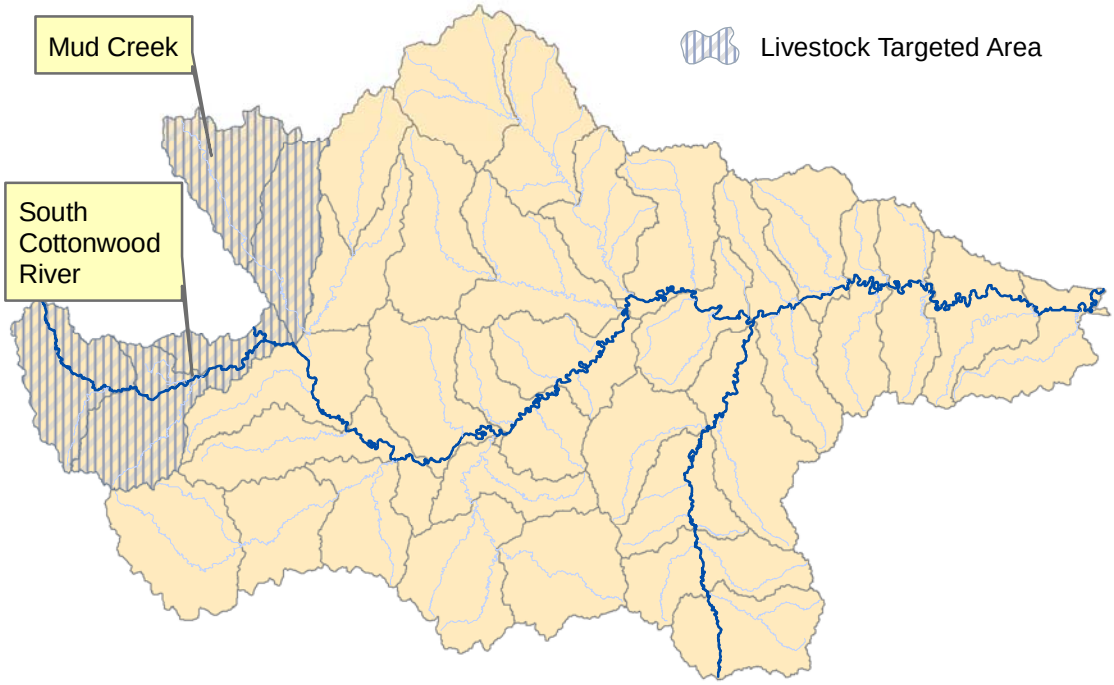



**Figure 33. Targeted Areas for Livestock BMPs in the Watershed.**

### *6.2.1.A. Manure Runoff from Fields and Livestock Operations*

Mud Creek is listed with a TMDL for **FCB**. FCB are a broad spectrum of bacteria species which includes ***E. coli* bacteria.** 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 *E. coli* bacteria as it is a more reliable indicator of human health risk. Consequently, the new methodology for assessing *E. coli* bacteria 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 *E. coli* bacteria in waterways can originate from

- improper manure disposal from livestock production areas,
- failing septic systems,

- close proximity of any mammals to water sources, and
- manure application during adverse weather events to agricultural fields.

*E. coli* bacteria can originate in both rural and urban areas. It can be caused by both point and nonpoint sources.

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 prevention of *E. coli* bacteria 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 for addressing *E. coli* bacteria in Mud Creek and South Cottonwood River targeted areas.

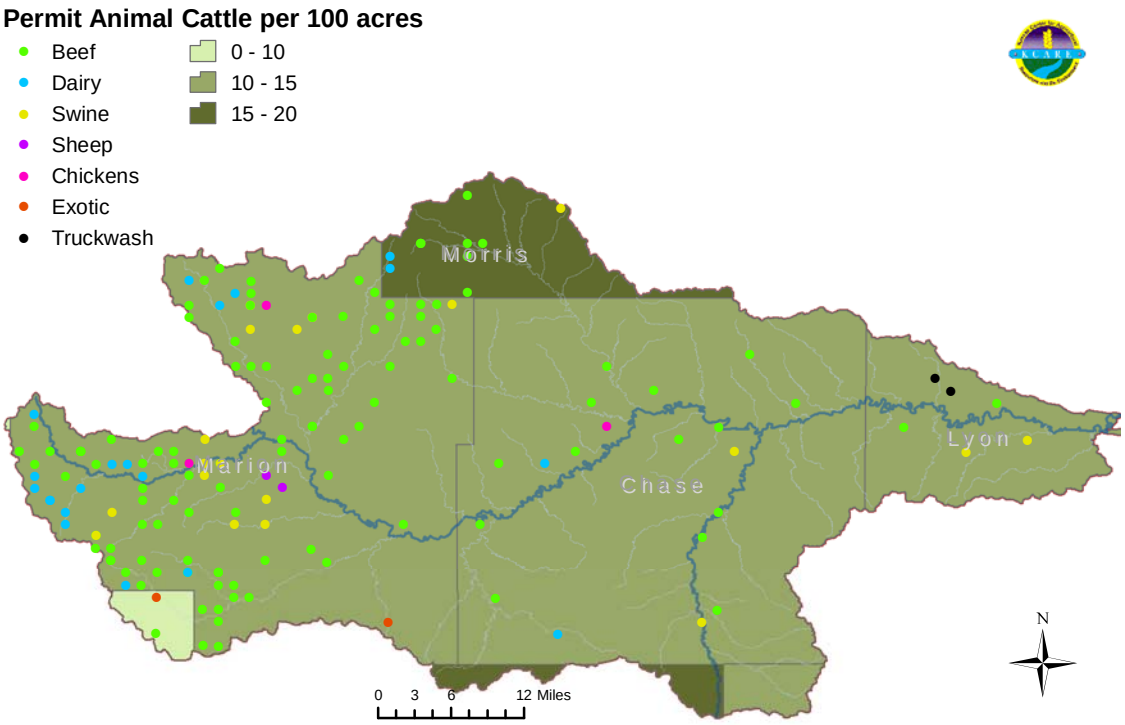



**Figure 34. Confined Animal Feeding Operations and Grazing Density in the Watershed.** [35]

### *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 *E. coli* bacteria in the waterways. The primary land uses in the livestock targeted area of the watershed are grassland (50%) and cropland (37%).

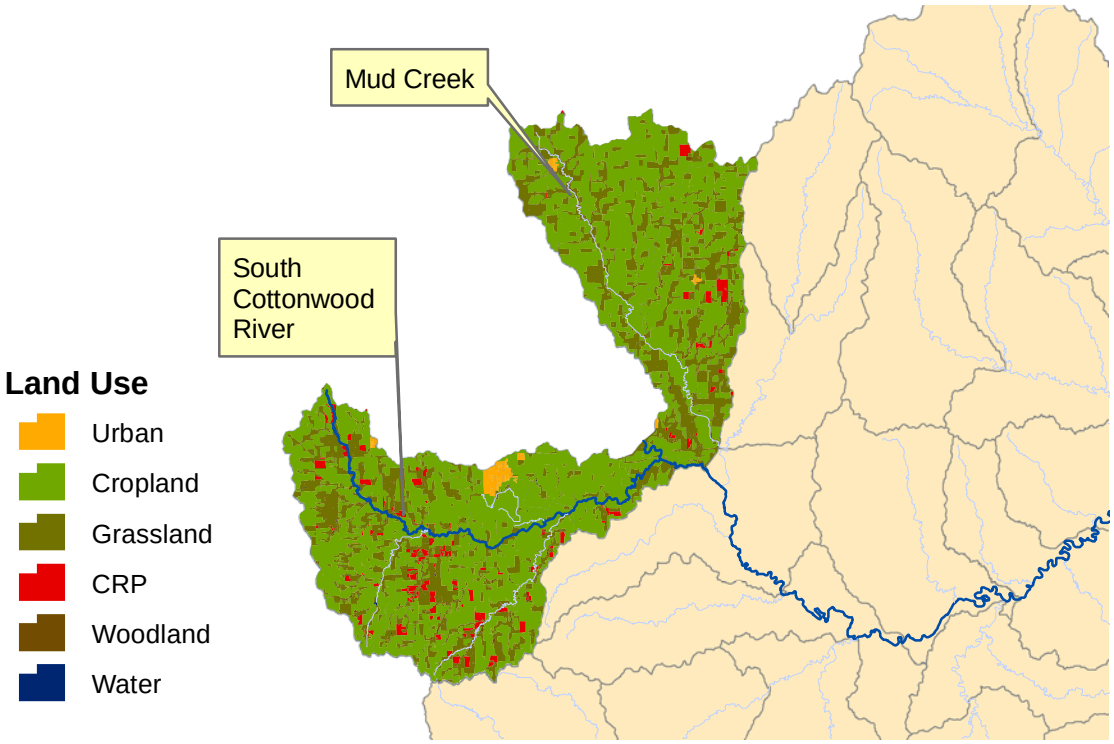



**Figure 35. Land Cover of the Livestock Targeted Area of the Watershed.** [36]

### *6.2.1.C Rainfall and Runoff*

Rainfall amounts and subsequent runoff along with flooding outside the stream channel can affect *E. coli* bacteria 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 *E. coli* bacteria 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.

See Figures 5 and 6.

### 6.2.2 Cropland Related Nutrient Pollutants

Marion County Lake, Fox Creek, Palmer Creek and the South Fork of the Cottonwood River have TMDLs for nutrient related impairments. However, these waterbodies are not contained in the targeting areas. Listings on the 303d list that are included in one of the targeted areas are the South Cottonwood River and the Cottonwood River near Emporia. In order to be able to measure improvements in water quality, nutrients will be measured as phosphorus or Total Phosphorus (TP). Targeting for phosphorus will be the watersheds of the South Cottonwood River and the Cottonwood River near Emporia; however, reduction of manure and phosphorus in these areas will have a positive effect on water quality downstream in John Redmond Reservoir. John Redmond Reservoir has a TMDL for eutrophication.

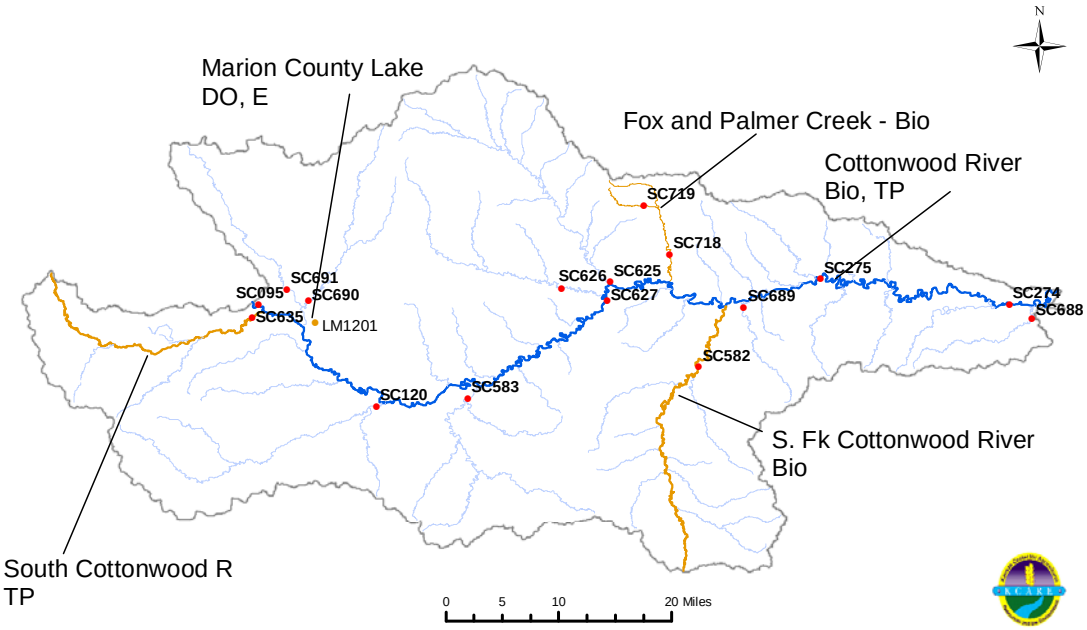



**Figure 36. Nutrient Related TMDLs and 303d Listings in the Cottonwood Watershed.** [37]

Eutrophication (E) is a natural process that occurs when a water body receives excess nutrients. These excess nutrients, primarily nitrogen and phosphorus, create optimum conditions that are favorable for algal blooms and plant growth. Marion County Lake has a TMDL for E. 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. Marion County Lake also has a TMDL for low dissolved oxygen (DO). Desirable criteria for a healthy water profile include DO rates greater than 5 milligrams per liter and biological oxygen demand (BOD) less than 3.5 milligrams per liter. 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.

Excess nutrients can originate from failing septic systems, manure runoff and fertilizer runoff in rural and urban areas. A TMDL for Biology (Bio) is another indicator of nutrient related impairments.

An excess in nutrients can be caused by any land practice that will contribute to nitrogen or phosphorus 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.

Activities performed on the land affects nutrient loading in the lakes of 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.

#### *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 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 Cottonwood Watershed consists of approximately twenty-six percent of the land use. Cropland in the watershed consists of mainly wheat, soybeans, corn and sorghum. 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 and consist of one percent of the land use.

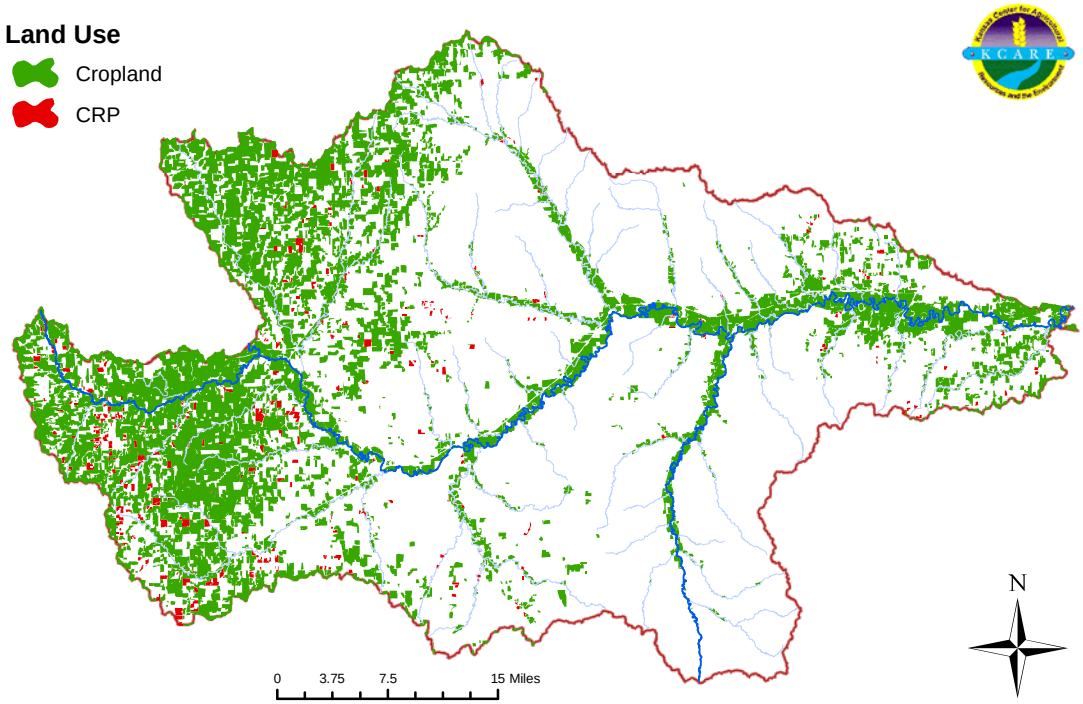



**Figure 37. Cropland and CRP in the Watershed.** [3]

Crops grown in the watershed will have an effect on nutrient runoff. Different crops have different nutrient requirements. The main crop grown in the watershed is wheat. 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. Wheat is a moderate user of nitrogen, as is sorghum. Corn, which is eleven percent of the crops in the watershed, is a heavy user of nitrogen fertilizer in order to support the large amount of biomass produced. Soybeans are a legume and as such, do not require nitrogen fertilizer. 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.

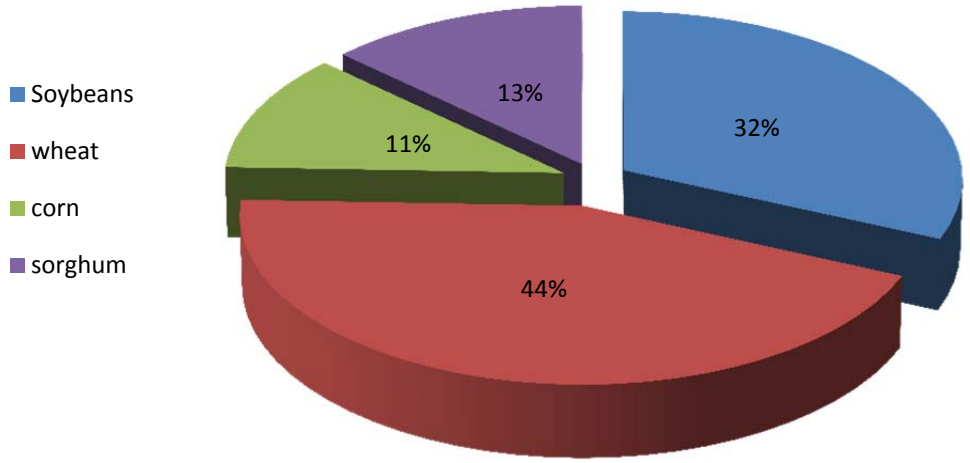



**Figure 38. Farm Crops in the Watershed.** [38]

#### *6.2.2.B Confined Animal Feeding Operations*

The watershed contains numerous CAFOs. (This data is derived from KDHE, 2003. It may be dated and subject to change). Number of and location of CAFOs is important in nutrient reduction because of the manure that is generated and must be disposed of by the CAFOs. Most farmers haul manure to cropland and incorporate it to be used as fertilizer for the crops. However, due to hauling costs, fields close to the feedlot tend to receive more manure over the course of time than fields that are at a more distant location. These close fields will have a higher concentration of soil phosphorus and therefore, a higher incidence of runoff potential as phosphorus can be attached to the soil particles. Prevention of erosion is a part of reduction of phosphorus in surface water. Refer to Section 6.3.1.A for additional information.

#### *6.2.2.C Rainfall and Runoff*

Rainfall amounts and subsequent runoff can affect nutrient runoff from agricultural areas. Manure runoff from livestock that are allowed access to stream or manure applied before a rainfall or on frozen ground is affected by the amount and timing of rainfall events. Manure management is a part of reduction of phosphorus in surface water. Refer to Section 6.2.1.C for additional information.

### 6.2.3 Streambank Related Phosphorus Pollutant

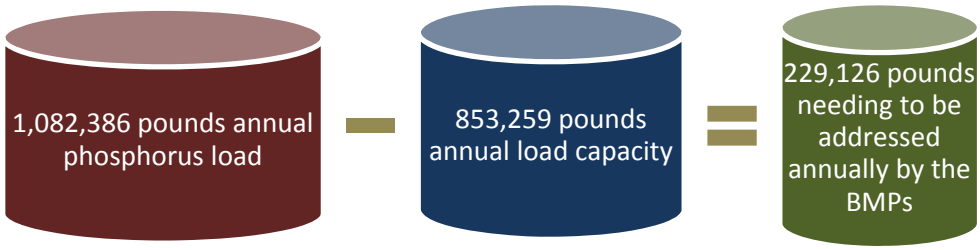
Stable streambanks are important to reduction in phosphorus in the waterways of the watershed. Soil that is lost from the streambanks can have attached

phosphorus particles. This soil will then gradually release the phosphorus as it travels downstream.

The SLT of the Cottonwood Watershed would like to stabilize 1,842 feet of streambank per year along the Cottonwood River. In addition to these major stabilization projects, all smaller streams and creeks need good riparian areas along their banks. This will prevent upstream erosion that also contributes to the sediment and phosphorus loading downstream. All livestock related BMPs that the SLT has agreed upon will be beneficial to soil loss and ultimately also help reduce phosphorus concentrations in John Redmond Reservoir.

### 6.2.4 Phosphorus BMPs with Projects Needed

The current estimated phosphorus load from nonpoint sources entering John Redmond Reservoir is 1,352,982 pounds per year according to the TMDL section of KDHE. This load originates from The Cottonwood Watershed allotment of the total load is eighty percent or 1,082,386 pounds. 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 Cottonwood Watershed needed to meet the 80 percent of phosphorus reduction goal for John Redmond Reservoir with implemented BMPs is 229,126 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 streambank targeted areas. All these BMPs will simultaneously have a positive effect on reduction of *E. coli* bacteria 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.

**Table 24. BMPs and Number of Projects to be Installed as Determined by the SLT Aimed at Meeting the 229,126 Pound Phosphorus Reduction Goal in John Redmond Reservoir.**

| Protection Measures | Best Management Practices and Other Actions | Total Acres or Projects Needed to be Implemented Over a Forty Year Period |
|---|---|---|
| 1. Prevention of phosphorus (TP) contribution from **cropland** | 1.1 Conservation Crop Rotations | 12,111 acres |
| | 1.2 Grassed Waterways | 42,303 acres |
| | 1.3 No-Till | 57,486 acres |
| | 1.4 Vegetative Buffers | 45,364 acres |
| | 1.5 Terraces | 10,576 acres |
| | 1.6 Establish Permanent Vegetation | 12,111 acres |
| 2. Prevention of phosphorus (TP) contribution from **livestock** erosion | 2.1 Vegetative Filter Strip | 80 acres |
| | 2.2 Fence Off Streams | 20, ½ mile sections |
| | 2.3 Move Pasture Feeding Sites | 120 sites |
| | 2.4 Off Stream Watering Systems | 120 systems |
| | 2.5 Rotational Grazing | 40 systems |
| 3. Prevention of phosphorus (TP) contribution from **streambank** erosion | Streambank Restoration | Repair 73,683 feet of eroding streambank |

### 6.2.5 Phosphorus Load Reductions

The table below lists the cropland BMPs installed with the associated phosphorus load reductions.

**Table 25. Estimated Phosphorus Load Reductions for Installed BMPs for Cropland Aimed at Meeting the 229,126 Pound Phosphorus Reduction Goal in John Redmond Reservoir.**

| Annual Phosphorous Reduction (lbs), Cropland BMPs | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
| 1 | 267 | 787 | 1,281 | 1,067 | 295 | 1,014 | 4,712 |
| 2 | 534 | 1,574 | 2,562 | 2,135 | 590 | 2,028 | 9,423 |
| 3 | 801 | 2,361 | 3,843 | 3,202 | 885 | 3,042 | 14,135 |
| 4 | 1,068 | 3,148 | 5,124 | 4,269 | 1,180 | 4,057 | 18,846 |
| 5 | 1,334 | 3,935 | 6,405 | 5,336 | 1,476 | 5,071 | 23,558 |
| 6 | 1,601 | 4,722 | 7,687 | 6,404 | 1,771 | 6,085 | 28,269 |
| 7 | 1,868 | 5,509 | 8,968 | 7,471 | 2,066 | 7,099 | 32,981 |
| 8 | 2,135 | 6,296 | 10,249 | 8,538 | 2,361 | 8,113 | 37,692 |
| 9 | 2,402 | 7,083 | 11,530 | 9,605 | 2,656 | 9,127 | 42,404 |
| 10 | 2,669 | 7,870 | 12,811 | 10,673 | 2,951 | 10,142 | 47,115 |

| Annual Phosphorous Reduction (lbs), Cropland BMPs, cont. | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
| 11 | 2,936 | 8,657 | 14,092 | 11,740 | 3,246 | 11,156 | 51,827 |
| 12 | 3,203 | 9,444 | 15,373 | 12,807 | 3,541 | 12,170 | 56,538 |
| 13 | 3,470 | 10,231 | 16,654 | 13,874 | 3,837 | 13,184 | 61,250 |
| 14 | 3,736 | 11,018 | 17,935 | 14,942 | 4,132 | 14,198 | 65,961 |
| 15 | 4,003 | 11,805 | 19,216 | 16,009 | 4,427 | 15,212 | 70,673 |
| 16 | 4,270 | 12,592 | 20,497 | 17,076 | 4,722 | 16,227 | 75,384 |
| 17 | 4,537 | 13,379 | 21,779 | 18,143 | 5,017 | 17,241 | 80,096 |
| 18 | 4,804 | 14,166 | 23,060 | 19,211 | 5,312 | 18,255 | 84,807 |
| 19 | 5,071 | 14,953 | 24,341 | 20,278 | 5,607 | 19,269 | 89,519 |
| 20 | 5,338 | 15,740 | 25,622 | 21,345 | 5,902 | 20,283 | 94,230 |
| 21 | 5,338 | 16,527 | 26,409 | 22,329 | 5,902 | 20,283 | 96,788 |
| 22 | 5,338 | 17,314 | 27,196 | 23,313 | 5,902 | 20,283 | 99,346 |
| 23 | 5,338 | 18,101 | 27,983 | 24,296 | 5,902 | 20,283 | 101,903 |
| 24 | 5,338 | 18,888 | 28,770 | 25,280 | 5,902 | 20,283 | 104,461 |
| 25 | 5,338 | 19,675 | 29,557 | 26,264 | 5,902 | 20,283 | 107,019 |
| 26 | 5,338 | 20,462 | 30,344 | 27,248 | 5,902 | 20,283 | 109,577 |
| 27 | 5,338 | 21,249 | 31,131 | 28,231 | 5,902 | 20,283 | 112,134 |
| 28 | 5,338 | 22,036 | 31,918 | 29,215 | 5,902 | 20,283 | 114,692 |
| 29 | 5,338 | 22,823 | 32,705 | 30,199 | 5,902 | 20,283 | 117,250 |
| 30 | 5,338 | 23,610 | 33,492 | 31,183 | 5,902 | 20,283 | 119,808 |
| 31 | 5,338 | 24,397 | 34,279 | 32,166 | 5,902 | 20,283 | 122,365 |
| 32 | 5,338 | 25,184 | 35,066 | 33,150 | 5,902 | 20,283 | 124,923 |
| 33 | 5,338 | 25,971 | 35,853 | 34,134 | 5,902 | 20,283 | 127,481 |
| 34 | 5,338 | 26,758 | 36,640 | 35,118 | 5,902 | 20,283 | 130,038 |
| 35 | 5,338 | 27,545 | 37,427 | 36,101 | 5,902 | 20,283 | 132,596 |
| 36 | 5,338 | 28,332 | 38,214 | 37,085 | 5,902 | 20,283 | 135,154 |
| 37 | 5,338 | 29,119 | 39,001 | 38,069 | 5,902 | 20,283 | 137,712 |
| 38 | 5,338 | 29,906 | 39,788 | 39,053 | 5,902 | 20,283 | 140,269 |
| 39 | 5,338 | 30,693 | 40,575 | 40,036 | 5,902 | 20,283 | 142,827 |
| 40 | 5,338 | 31,480 | 41,362 | 41,020 | 5,902 | 20,283 | 145,385 |

The table below demonstrates the phosphorus reduction attained by implementing the livestock BMPs.

**Table 26. Estimated Phosphorus Load Reductions for Installed BMPs for Livestock Aimed at Meeting the 229,126 Pound Phosphorus Reduction Goal in John Redmond Reservoir.**

| Annual Phosphorous Load Reductions (lbs) | | | | | | |
|---|---|---|---|---|---|---|
| Year | Vegetative Filter Strip | Fenced Off Streams | Relocate Pasture Feeding Site | Off Stream Watering System | Rotational Grazing | Annual Load Reduction |
| 1 | 1,276 | 90 | 229 | 229 | 140 | 1,964 |
| 2 | 2,552 | 90 | 459 | 459 | 280 | 3,839 |
| 3 | 3,827 | 180 | 688 | 688 | 420 | 5,803 |
| 4 | 5,103 | 180 | 917 | 917 | 560 | 7,677 |
| 5 | 6,379 | 270 | 1,147 | 1,147 | 700 | 9,642 |
| 6 | 7,655 | 270 | 1,376 | 1,376 | 840 | 11,516 |
| 7 | 8,930 | 360 | 1,605 | 1,605 | 980 | 13,481 |
| 8 | 10,206 | 360 | 1,834 | 1,834 | 1,120 | 15,355 |
| 9 | 11,482 | 450 | 2,064 | 2,064 | 1,260 | 17,319 |
| 10 | 12,758 | 450 | 2,293 | 2,293 | 1,400 | 19,194 |
| 11 | 14,033 | 540 | 2,522 | 2,522 | 1,540 | 21,158 |
| 12 | 15,309 | 540 | 2,752 | 2,752 | 1,680 | 23,032 |
| 13 | 16,585 | 630 | 2,981 | 2,981 | 1,820 | 24,997 |
| 14 | 17,861 | 630 | 3,210 | 3,210 | 1,960 | 26,871 |
| 15 | 19,136 | 720 | 3,440 | 3,440 | 2,100 | 28,836 |
| 16 | 20,412 | 720 | 3,669 | 3,669 | 2,240 | 30,710 |
| 17 | 21,688 | 810 | 3,898 | 3,898 | 2,380 | 32,674 |
| 18 | 22,964 | 810 | 4,128 | 4,128 | 2,520 | 34,549 |
| 19 | 24,239 | 900 | 4,357 | 4,357 | 2,660 | 36,513 |
| 20 | 25,515 | 900 | 4,586 | 4,586 | 2,800 | 38,387 |
| 21 | 26,791 | 990 | 4,816 | 4,816 | 2,940 | 40,352 |
| 22 | 28,067 | 990 | 5,045 | 5,045 | 3,080 | 42,226 |
| 23 | 29,342 | 1,080 | 5,274 | 5,274 | 3,220 | 44,191 |
| 24 | 30,618 | 1,080 | 5,503 | 5,503 | 3,360 | 46,065 |
| 25 | 31,894 | 1,170 | 5,733 | 5,733 | 3,500 | 48,029 |
| 26 | 33,170 | 1,170 | 5,962 | 5,962 | 3,640 | 49,904 |
| 27 | 34,445 | 1,260 | 6,191 | 6,191 | 3,780 | 51,868 |
| 28 | 35,721 | 1,260 | 6,421 | 6,421 | 3,920 | 53,742 |
| 29 | 36,997 | 1,350 | 6,650 | 6,650 | 4,060 | 55,707 |
| 30 | 38,273 | 1,350 | 6,879 | 6,879 | 4,200 | 57,581 |
| 31 | 39,548 | 1,440 | 7,109 | 7,109 | 4,340 | 59,546 |
| 32 | 40,824 | 1,440 | 7,338 | 7,338 | 4,480 | 61,420 |
| 33 | 42,100 | 1,530 | 7,567 | 7,567 | 4,620 | 63,384 |
| 34 | 43,376 | 1,530 | 7,797 | 7,797 | 4,760 | 65,259 |
| 35 | 44,651 | 1,620 | 8,026 | 8,026 | 4,900 | 67,223 |
| 36 | 45,927 | 1,620 | 8,255 | 8,255 | 5,040 | 69,097 |

| Annual Phosphorous Load Reductions (lbs), cont. | | | | | | |
|---|---|---|---|---|---|---|
| Year | Vegetative Filter Strip | Fenced Off Streams | Relocate Pasture Feeding Site | Off Stream Watering System | Rotational Grazing | Annual Load Reduction |
| 37 | 47,203 | 1,710 | 8,485 | 8,485 | 5,180 | 71,062 |
| 38 | 48,479 | 1,710 | 8,714 | 8,714 | 5,320 | 72,936 |
| 39 | 49,754 | 1,800 | 8,943 | 8,943 | 5,460 | 74,901 |
| 40 | 51,030 | 1,800 | 9,172 | 9,172 | 5,600 | 76,775 |

The table below demonstrates the streambank load reductions attained by stabilizing sites along the Cottonwood River.

**Table 27. Estimated Phosphorus Load Reductions for Streambank Restoration Aimed at Meeting the 229,126 Pound Phosphorus Reduction Goal in John Redmond Reservoir.**

| Annual Phosphorous Load Reductions (lbs) | | | |
|---|---|---|---|
| Year | Streambank Stabilization (feet) | Phosphorous Reduction (lbs) | Cumulative P Load Reduction (lbs) |
| 1 | 1,842 | 233 | 233 |
| 2 | 1,842 | 233 | 466 |
| 3 | 1,842 | 233 | 700 |
| 4 | 1,842 | 233 | 933 |
| 5 | 1,842 | 233 | 1,166 |
| 6 | 1,842 | 233 | 1,399 |
| 7 | 1,842 | 233 | 1,632 |
| 8 | 1,842 | 233 | 1,866 |
| 9 | 1,842 | 233 | 2,099 |
| 10 | 1,842 | 233 | 2,332 |
| 11 | 1,842 | 233 | 2,565 |
| 12 | 1,842 | 233 | 2,798 |
| 13 | 1,842 | 233 | 3,032 |
| 14 | 1,842 | 233 | 3,265 |
| 15 | 1,842 | 233 | 3,498 |
| 16 | 1,842 | 233 | 3,731 |
| 17 | 1,842 | 233 | 3,965 |
| 18 | 1,842 | 233 | 4,198 |
| 19 | 1,842 | 233 | 4,431 |
| 20 | 1,842 | 233 | 4,664 |
| 21 | 1,842 | 233 | 4,897 |
| 22 | 1,842 | 233 | 5,131 |
| 23 | 1,842 | 233 | 5,364 |
| 24 | 1,842 | 233 | 5,597 |
| 25 | 1,842 | 233 | 5,830 |
| 26 | 1,842 | 233 | 6,063 |

| Annual Phosphorous Load Reductions (lbs), cont. | | | |
|---|---|---|---|
| Year | Streambank Stabilization (feet) | Phosphorous Reduction (lbs) | Cumulative P Load Reduction (lbs) |
| 27 | 1,842 | 233 | 6,297 |
| 28 | 1,842 | 233 | 6,530 |
| 29 | 1,842 | 233 | 6,763 |
| 30 | 1,842 | 233 | 6,996 |
| 31 | 1,842 | 233 | 7,229 |
| 32 | 1,842 | 233 | 7,463 |
| 33 | 1,842 | 233 | 7,696 |
| 34 | 1,842 | 233 | 7,929 |
| 35 | 1,842 | 233 | 8,162 |
| 36 | 1,842 | 233 | 8,395 |
| 37 | 1,842 | 233 | 8,629 |
| 38 | 1,842 | 233 | 8,862 |
| 39 | 1,842 | 233 | 9,095 |
| 40 | 1,842 | 233 | 9,328 |

The table below shows the combined load reduction for phosphorus that is attained by implementing all cropland, livestock and streambank BMPs annually. The percent of TMDL achievement is illustrated in the right column. The timeframe for attaining the TMDL is forty years

**Table 28. Estimated Total Phosphorus Load Reductions for All Implemented BMPs Aimed at Meeting the 229,126 Pound Phosphorus Reduction Goal in John Redmond Reservoir.**

| Annual Phosphorous Load Reductions (lbs) | | | | | |
|---|---|---|---|---|---|
| Year | Streambank Reduction (lbs) | Cropland Reduction (lbs) | Livestock Reduction (lbs) | Total Reduction (lbs) | % of TMDL |
| 1 | 233 | 4,712 | 1,964 | 6,909 | 3% |
| 2 | 466 | 9,423 | 3,839 | 13,728 | 6% |
| 3 | 700 | 14,135 | 5,803 | 20,637 | 9% |
| 4 | 933 | 18,846 | 7,677 | 27,456 | 12% |
| 5 | 1,166 | 23,558 | 9,642 | 34,365 | 15% |
| 6 | 1,399 | 28,269 | 11,516 | 41,185 | 18% |
| 7 | 1,632 | 32,981 | 13,481 | 48,094 | 21% |
| 8 | 1,866 | 37,692 | 15,355 | 54,913 | 24% |
| 9 | 2,099 | 42,404 | 17,319 | 61,822 | 27% |
| 10 | 2,332 | 47,115 | 19,194 | 68,641 | 30% |
| 11 | 2,565 | 51,827 | 21,158 | 75,550 | 33% |
| 12 | 2,798 | 56,538 | 23,032 | 82,369 | 36% |
| 13 | 3,032 | 61,250 | 24,997 | 89,278 | 39% |

| Annual Phosphorous Load Reductions (lbs), cont. | | | | | |
|---|---|---|---|---|---|
| **Year** | **Streambank Reduction (lbs)** | **Cropland Reduction (lbs)** | **Livestock Reduction (lbs)** | **Total Reduction (lbs)** | **% of TMDL** |
| 14 | 3,265 | 65,961 | 26,871 | 96,097 | 42% |
| 15 | 3,498 | 70,673 | 28,836 | 103,006 | 45% |
| 16 | 3,731 | 75,384 | 30,710 | 109,826 | 48% |
| 17 | 3,965 | 80,096 | 32,674 | 116,735 | 51% |
| 18 | 4,198 | 84,807 | 34,549 | 123,554 | 54% |
| 19 | 4,431 | 89,519 | 36,513 | 130,463 | 57% |
| 20 | 4,664 | 94,230 | 38,387 | 137,282 | 60% |
| 21 | 4,897 | 96,788 | 40,352 | 142,037 | 62% |
| 22 | 5,131 | 99,346 | 42,226 | 146,702 | 64% |
| 23 | 5,364 | 101,903 | 44,191 | 151,458 | 66% |
| 24 | 5,597 | 104,461 | 46,065 | 156,123 | 68% |
| 25 | 5,830 | 107,019 | 48,029 | 160,878 | 70% |
| 26 | 6,063 | 109,577 | 49,904 | 165,544 | 72% |
| 27 | 6,297 | 112,134 | 51,868 | 170,299 | 74% |
| 28 | 6,530 | 114,692 | 53,742 | 174,964 | 76% |
| 29 | 6,763 | 117,250 | 55,707 | 179,720 | 78% |
| 30 | 6,996 | 119,808 | 57,581 | 184,385 | 80% |
| 31 | 7,229 | 122,365 | 59,546 | 189,140 | 83% |
| 32 | 7,463 | 124,923 | 61,420 | 193,806 | 85% |
| 33 | 7,696 | 127,481 | 63,384 | 198,561 | 87% |
| 34 | 7,929 | 130,038 | 65,259 | 203,226 | 89% |
| 35 | 8,162 | 132,596 | 67,223 | 207,981 | 91% |
| 36 | 8,395 | 135,154 | 69,097 | 212,647 | 93% |
| 37 | 8,629 | 137,712 | 71,062 | 217,402 | 95% |
| 38 | 8,862 | 140,269 | 72,936 | 222,067 | 97% |
| 39 | 9,095 | 142,827 | 74,901 | 226,823 | 99% |
| 40 | 9,328 | 145,385 | 76,775 | 231,488 | 101% |
| ***Phosphorous TMDL: 229,126 Pounds*** | | | | | |

Phosphorus Reduction Goal is Met

**Table 29. Phosphorus Load Reduction in Forty Years by Category Aimed at Meeting the 229,126 Pound Phosphorus Reduction Goal in John Redmond Reservoir.**

| Best Management Practice Category | Total Load Reduction (pounds) | Percent of Phosphorous TMDL |
|---|---|---|
| Cropland | 145,385 | 63% |
| Livestock | 76,775 | 34% |
| Streambank | 9,328 | 4% |
| **Total** | **231,488** | **101%** |

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

# 7.0 Information and Education in Support of BMPs

## 7.1 Information and Education Activities and Events

**Table 30. Information and Education Activities and Events as Requested by the SLT in Support of Meeting the TMDLs.**

| Cropland BMP Implementation | | | | | |
|---|---|---|---|---|---|
| **BMP** | **Target Audience** | **Activity/Event Technical Assistance** | **Time Frame** | **Estimated Costs** | **Sponsor/ Responsible Agency** |
| **Conservation Crop Rotation** | Farmers in cropland targeted areas | One-on-one technical assistance for producers to implement BMPs in the targeted area. | Annual | No cost | Conservation Districts<br>NRCS |
| | | Workshop/Field Day | Annual, Spring | Included in above | Conservation Districts<br>K-State Extension<br>Flint Hills RC&D |
| **Grassed Waterways** | Farmers in cropland targeted areas | One-on-one technical assistance for producers to implement BMPs in the targeted area. | Annual | No cost | Conservation Districts<br>NRCS |
| **No-Till** | Farmers in cropland targeted areas | Scholarships for producers to attend No-Till on the Plains Annual Conference | Annual, Winter | 5 per year, $150 per scholarship | No-Till on the Plains |
| | | Workshop/Field Day | Annual, Spring | Included in above | Conservation Districts<br>K-State Extension<br>Flint Hills RC&D |
| | | One-on-one technical assistance for producers to implement BMPs in the targeted area | Annual | No cost | Conservation District<br>NRCS |

| Cropland BMP Implementation, cont. | | | | | |
|---|---|---|---|---|---|
| **BMP** | **Target Audience** | **Activity/Event Technical Assistance** | **Time Frame** | **Estimated Costs** | **Sponsor/ Responsible Agency** |
| **Vegetative Buffers** | Farmers in cropland targeted areas | Workshop/field day | Annual - spring | $5,000 | K-State Extension<br>Conservation Districts<br>Flint Hills RC&D |
| | | One-on-one technical assistance | Annual - ongoing | No cost | Conservation Districts<br>NRCS |
| | | Workshop/Field Day | Annual, Spring | Included in above | Conservation Districts<br>K-State Extension<br>Flint Hills RC&D |
| | | Forestry Field Day | Annual | $3,000 | Kansas Forest Service |
| | | One-on-one technical assistance for producers to implement BMPs in the targeted area | Annual | No cost | Conservation Districts<br>NRCS |
| | | One-on-one technical assistance for riparian tree planting | Annual, Ongoing | Included in above | Kansas Forest Service |
| **Terraces** | Farmers in cropland targeted areas | One-on-one technical assistance for producers to implement BMPs in the targeted area | Annual | No cost | Conservation Districts<br>NRCS |
| | | Workshop/Field Day | Annual, Spring | Included in above | Conservation Districts<br>K-State Extension<br>Flint Hills RC&D |
| **Permanent Vegetation** | Farmers in cropland targeted areas | Workshop/Field day | Annual, Spring | $2,000 | Conservation Districts<br>K-State Extension<br>Flint Hills RC&D |
| | | Forestry field day | Annual | $3,000 | Kansas Forest Service |

| Livestock BMP Implementation | | | | | |
|---|---|---|---|---|---|
| **BMP** | **Target Audience** | **Activity/Event Technical Assistance** | **Time Frame** | **Estimated Costs** | **Sponsor/ Responsible Agency** |
| **Vegetative Filter Strips** | Producers in livestock targeted areas | Tour/Field Day | Annual, Summer | Included in above | Kansas Rural Center<br>K-State Extension<br>Conservation Districts<br>NRCS |
| | | One-on-one technical assistance for producers to implement BMPs in the targeted area | Annual, Ongoing | Included in above | Conservation Districts<br>NRCS |
| **Fenced Off Streams** | Producers in livestock targeted areas | One-on-one technical assistance | Annual | $10,000 | Conservation Districts<br>NRCS<br>K-State Extension |
| | | Tour/Field Day | Annual, Summer | $2,500 | Kansas Rural Center<br>K-State Extension<br>Conservation Districts<br>NRCS |

| Livestock BMP Implementation, cont. | | | | | |
|---|---|---|---|---|---|
| **BMP** | **Target Audience** | **Activity/Event Technical Assistance** | **Time Frame** | **Estimated Costs** | **Sponsor/ Responsible Agency** |
| **Relocate Pasture Feeding Sites** | Producers in livestock targeted areas | Tour/Field Day | Annual, Summer | $5,000 | Kansas Rural Center<br>K-State Extension<br>Conservation Districts<br>NRCS |
| | | Scholarships to Grazing Schools and Workshops | Annual, Winter | 5 per year, $50 per scholarships | Kansas Rural Center<br>K-State Extension<br>Kansas Grazer's Association |
| | | One-on-one technical assistance for producers to implement BMPs in the targeted area | Annual, Ongoing | $17,500 | K-State Extension<br>Conservation Districts<br>NRCS |
| | | One-on-one technical assistance to remove livestock from riparian area | Annual, Ongoing | $4,000 | Kansas Forest Service |
| **Off-Stream Watering Systems** | Producers in livestock targeted areas | Tour/Field Day | Annual, Summer | Included in above | Kansas Rural Center<br>K-State Extension<br>Conservation Districts<br>NRCS |
| | | Scholarships to Grazing Schools and Workshops | Annual, Winter | Included in above | Kansas Rural Center<br>K-State Extension<br>Kansas Grazer's Association |
| | | One-on-one technical assistance for producers to implement BMPs in the targeted area | Annual, Ongoing | Included in above | K-State Extension<br>Conservation Districts<br>NRCS |

| Livestock BMP Implementation, cont. | | | | | |
|---|---|---|---|---|---|
| **BMP** | **Target Audience** | **Activity/Event Technical Assistance** | **Time Frame** | **Estimated Costs** | **Sponsor/ Responsible Agency** |
| **Rotational Grazing** | Producers in livestock targeted areas | Tour/Field Day | Annual - summer | $2,500 | Kansas Rural Center<br>K-State Extension<br>Conservation Districts<br>NRCS |
| | | One-on-one technical assistance | Annual | $10,000 | Kansas Rural Center<br>K-State Extension |
| **Streambank BMP Implementation** | | | | | |
| **BMP** | **Target Audience** | **Activity/Event Technical Assistance** | **Time Frame** | **Estimated Costs** | **Sponsor/ Responsible Agency** |
| **Streambank Stabilization** | Farmers/Landowners | Workshop/Field Day | Annual, Spring | Included in Above | Conservation Districts<br>KSRE<br>FH RC&D<br>TWI<br>KAWS |
| | Farmers/Landowners | Forestry Field Day | Annual | $3,000 | Kansas Forest Service |
| | Farmers/Landowners | One-on-one technical assistance for producers to implement BMPs in the targeted area. | Annual | No Cost | Conservation Districts<br>NRCS |
| | Farmers/Landowners | One-on-one technical assistance for riparian tree planting | Annual, ongoing | Included above | Kansas Forest Service |

| General / Watershed Wide Information and Education | | | | | |
|---|---|---|---|---|---|
| **BMP** | **Target Audience** | **Activity/Event Technical Assistance** | **Time Frame** | **Estimated Costs** | **Sponsor/ Responsible Agency** |
| **Educational Activities Targeting Youth** | Educators, K-12 Students | Envirothon | Annual | No cost | Conservation Districts<br>KACEE |
| | | Day on the Farm | Annual | No cost | Conservation Districts<br>KACEE |
| | | Poster, essay, and speech contests | Annual | No cost | Conservation Districts<br>KACEE |
| | | Water Festival | Annual | $5,000 | Conservation Districts<br>K-State Extension<br>Flint Hills RC&D<br>KACEE |
| **Educational Activities Targeting Adults** | Watershed residents | BMP Auction | Annual | $10,000 | K-State Extension<br>Conservation Districts<br>KACEE |
| | | River Friendly Farms | Annual | $20,000 | Kansas Rural Center |
| | | Healthy Ecosystems – Healthy Communities | Annual, Ongoing | $17,500 | Kansas PRIDE |
| **Total Cost per Year** | | | | **$118,000** | |

## 7.2 Evaluation of Information and Education Activities

All service providers conducting Information and Education (I&E) activities funded through the Cottonwood 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.

# 8.0 Costs of Implementing BMPs and Possible Funding Sources

The SLT has reviewed all the recommended BMPs listed in the Section 5 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 streambank). 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**

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%.

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.

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.

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.

**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.

Fence Off Streams: 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%.

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.

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 31. 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 | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
| 1 | $23,616 | $169,211 | $141,140 | $80,708 | $53,936 | $90,830 | $559,441 |
| 2 | $24,324 | $174,288 | $145,374 | $83,129 | $55,554 | $93,555 | $576,224 |
| 3 | $25,054 | $179,516 | $149,735 | $85,623 | $57,221 | $96,362 | $593,511 |
| 4 | $25,806 | $184,902 | $154,227 | $88,192 | $58,937 | $99,253 | $611,317 |
| 5 | $26,580 | $190,449 | $158,854 | $90,838 | $60,706 | $102,230 | $629,656 |
| 6 | $27,377 | $196,162 | $163,620 | $93,563 | $62,527 | $105,297 | $648,546 |
| 7 | $28,199 | $202,047 | $168,528 | $96,370 | $64,402 | $108,456 | $668,002 |
| 8 | $29,045 | $208,108 | $173,584 | $99,261 | $66,335 | $111,710 | $688,042 |

| Annual Cost* Before Cost-Share, Cropland BMPs, cont. | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
| 9 | $29,916 | $214,352 | $178,792 | $102,238 | $68,325 | $115,061 | $708,683 |
| 10 | $30,813 | $220,782 | $184,155 | $105,306 | $70,374 | $118,513 | $729,944 |
| 11 | $31,738 | $227,406 | $189,680 | $108,465 | $72,486 | $122,068 | $751,842 |
| 12 | $32,690 | $234,228 | $195,371 | $111,719 | $74,660 | $125,730 | $774,397 |
| 13 | $33,671 | $241,255 | $201,232 | $115,070 | $76,900 | $129,502 | $797,629 |
| 14 | $34,681 | $248,492 | $207,269 | $118,522 | $79,207 | $133,387 | $821,558 |
| 15 | $35,721 | $255,947 | $213,487 | $122,078 | $81,583 | $137,389 | $846,205 |
| 16 | $36,793 | $263,626 | $219,891 | $125,740 | $84,031 | $141,511 | $871,591 |
| 17 | $37,897 | $271,534 | $226,488 | $129,513 | $86,552 | $145,756 | $897,739 |
| 18 | $39,033 | $279,680 | $233,283 | $133,398 | $89,148 | $150,129 | $924,671 |
| 19 | $40,204 | $288,071 | $240,281 | $137,400 | $91,823 | $154,632 | $952,411 |
| 20 | $41,411 | $296,713 | $247,490 | $141,522 | $94,577 | $159,271 | $980,984 |
| 21 | $0 | $305,614 | $148,395 | $127,339 | $0 | $0 | $581,348 |
| 22 | $0 | $314,783 | $152,847 | $131,159 | $0 | $0 | $598,789 |
| 23 | $0 | $324,226 | $157,432 | $135,094 | $0 | $0 | $616,752 |
| 24 | $0 | $333,953 | $162,155 | $139,147 | $0 | $0 | $635,255 |
| 25 | $0 | $343,972 | $167,020 | $143,321 | $0 | $0 | $654,313 |
| 26 | $0 | $354,291 | $172,030 | $147,621 | $0 | $0 | $673,942 |
| 27 | $0 | $364,919 | $177,191 | $152,050 | $0 | $0 | $694,160 |
| 28 | $0 | $375,867 | $182,507 | $156,611 | $0 | $0 | $714,985 |
| 29 | $0 | $387,143 | $187,982 | $161,310 | $0 | $0 | $736,435 |
| 30 | $0 | $398,757 | $193,622 | $166,149 | $0 | $0 | $758,528 |
| 31 | $0 | $410,720 | $199,430 | $171,133 | $0 | $0 | $781,284 |
| 32 | $0 | $423,042 | $205,413 | $176,267 | $0 | $0 | $804,722 |
| 33 | $0 | $435,733 | $211,576 | $181,555 | $0 | $0 | $828,864 |
| 34 | $0 | $448,805 | $217,923 | $187,002 | $0 | $0 | $853,730 |
| 35 | $0 | $462,269 | $224,460 | $192,612 | $0 | $0 | $879,342 |
| 36 | $0 | $476,137 | $231,194 | $198,390 | $0 | $0 | $905,722 |
| 37 | $0 | $490,421 | $238,130 | $204,342 | $0 | $0 | $932,893 |
| 38 | $0 | $505,134 | $245,274 | $210,472 | $0 | $0 | $960,880 |
| 39 | $0 | $520,288 | $252,632 | $216,787 | $0 | $0 | $989,707 |
| 40 | $0 | $535,896 | $260,211 | $223,290 | $0 | $0 | $1,019,398 |
| **3% Inflation* | | | | | | | |

**Table 32. 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 | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
| 1 | $23,616 | $84,606 | $86,095 | $8,071 | $26,968 | $45,415 | $274,771 |
| 2 | $24,324 | $87,144 | $88,678 | $8,313 | $27,777 | $46,778 | $283,014 |
| 3 | $25,054 | $89,758 | $91,338 | $8,562 | $28,610 | $48,181 | $291,504 |
| 4 | $25,806 | $92,451 | $94,079 | $8,819 | $29,469 | $49,626 | $300,249 |
| 5 | $26,580 | $95,224 | $96,901 | $9,084 | $30,353 | $51,115 | $309,257 |
| 6 | $27,377 | $98,081 | $99,808 | $9,356 | $31,263 | $52,649 | $318,535 |
| 7 | $28,199 | $101,024 | $102,802 | $9,637 | $32,201 | $54,228 | $328,091 |
| 8 | $29,045 | $104,054 | $105,886 | $9,926 | $33,167 | $55,855 | $337,933 |
| 9 | $29,916 | $107,176 | $109,063 | $10,224 | $34,162 | $57,531 | $348,071 |
| 10 | $30,813 | $110,391 | $112,335 | $10,531 | $35,187 | $59,256 | $358,513 |
| 11 | $31,738 | $113,703 | $115,705 | $10,846 | $36,243 | $61,034 | $369,269 |
| 12 | $32,690 | $117,114 | $119,176 | $11,172 | $37,330 | $62,865 | $380,347 |
| 13 | $33,671 | $120,627 | $122,751 | $11,507 | $38,450 | $64,751 | $391,757 |
| 14 | $34,681 | $124,246 | $126,434 | $11,852 | $39,603 | $66,694 | $403,510 |
| 15 | $35,721 | $127,974 | $130,227 | $12,208 | $40,792 | $68,694 | $415,615 |
| 16 | $36,793 | $131,813 | $134,134 | $12,574 | $42,015 | $70,755 | $428,084 |
| 17 | $37,897 | $135,767 | $138,158 | $12,951 | $43,276 | $72,878 | $440,926 |
| 18 | $39,033 | $139,840 | $142,302 | $13,340 | $44,574 | $75,064 | $454,154 |
| 19 | $40,204 | $144,035 | $146,571 | $13,740 | $45,911 | $77,316 | $467,779 |
| 20 | $41,411 | $148,356 | $150,969 | $14,152 | $47,289 | $79,636 | $481,812 |
| 21 | $0 | $152,807 | $90,521 | $12,734 | $0 | $0 | $256,062 |
| 22 | $0 | $157,391 | $93,236 | $13,116 | $0 | $0 | $263,744 |
| 23 | $0 | $162,113 | $96,034 | $13,509 | $0 | $0 | $271,656 |
| 24 | $0 | $166,976 | $98,915 | $13,915 | $0 | $0 | $279,806 |
| 25 | $0 | $171,986 | $101,882 | $14,332 | $0 | $0 | $288,200 |
| 26 | $0 | $177,145 | $104,938 | $14,762 | $0 | $0 | $296,846 |
| 27 | $0 | $182,460 | $108,087 | $15,205 | $0 | $0 | $305,751 |
| 28 | $0 | $187,933 | $111,329 | $15,661 | $0 | $0 | $314,924 |
| 29 | $0 | $193,571 | $114,669 | $16,131 | $0 | $0 | $324,372 |
| 30 | $0 | $199,379 | $118,109 | $16,615 | $0 | $0 | $334,103 |
| 31 | $0 | $205,360 | $121,652 | $17,113 | $0 | $0 | $344,126 |
| 32 | $0 | $211,521 | $125,302 | $17,627 | $0 | $0 | $354,450 |
| 33 | $0 | $217,866 | $129,061 | $18,156 | $0 | $0 | $365,083 |
| 34 | $0 | $224,402 | $132,933 | $18,700 | $0 | $0 | $376,036 |
| 35 | $0 | $231,134 | $136,921 | $19,261 | $0 | $0 | $387,317 |

| Annual Cost* After Cost-Share, Cropland BMPs, cont. | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
| 36 | $0 | $238,069 | $141,029 | $19,839 | $0 | $0 | $398,936 |
| 37 | $0 | $245,211 | $145,259 | $20,434 | $0 | $0 | $410,904 |
| 38 | $0 | $252,567 | $149,617 | $21,047 | $0 | $0 | $423,231 |
| 39 | $0 | $260,144 | $154,106 | $21,679 | $0 | $0 | $435,928 |
| 40 | $0 | $267,948 | $158,729 | $22,329 | $0 | $0 | $449,006 |
| **3% Inflation* | | | | | | | |

**Table 33. Annual Costs Before Cost Share in the Livestock Targeted Area.** Sub watershed costs are provided in the Appendix. Expressed in 2010 dollar amounts.

| Livestock BMPs, Annual Cost Before Cost-Share | | | | | | |
|---|---|---|---|---|---|---|
| Year | Vegetative Filter Strip | Fenced Off Streams | Relocate Pasture Feeding Site | Off Stream Watering System | Rotational Grazing | Annual Cost |
| 1 | $1,428 | $4,106 | $6,609 | $11,385 | $7,000 | **$30,528** |
| 2 | $1,471 | $0 | $6,807 | $11,727 | $7,210 | **$27,215** |
| 3 | $1,515 | $4,356 | $7,011 | $12,078 | $7,426 | **$32,387** |
| 4 | $1,560 | $0 | $7,222 | $12,441 | $7,649 | **$28,872** |
| 5 | $1,607 | $4,621 | $7,438 | $12,814 | $7,879 | **$34,360** |
| 6 | $1,655 | $0 | $7,662 | $13,198 | $8,115 | **$30,630** |
| 7 | $1,705 | $4,903 | $7,891 | $13,594 | $8,358 | **$36,452** |
| 8 | $1,756 | $0 | $8,128 | $14,002 | $8,609 | **$32,496** |
| 9 | $1,809 | $5,201 | $8,372 | $14,422 | $8,867 | **$38,672** |
| 10 | $1,863 | $0 | $8,623 | $14,855 | $9,133 | **$34,475** |
| 11 | $1,919 | $5,518 | $8,882 | $15,300 | $9,407 | **$41,027** |
| 12 | $1,977 | $0 | $9,148 | $15,760 | $9,690 | **$36,574** |
| 13 | $2,036 | $5,854 | $9,423 | $16,232 | $9,980 | **$43,526** |
| 14 | $2,097 | $0 | $9,706 | $16,719 | $10,280 | **$38,802** |
| 15 | $2,160 | $6,211 | $9,997 | $17,221 | $10,588 | **$46,176** |
| 16 | $2,225 | $0 | $10,297 | $17,737 | $10,906 | **$41,165** |
| 17 | $2,292 | $6,589 | $10,606 | $18,270 | $11,233 | **$48,988** |
| 18 | $2,360 | $0 | $10,924 | $18,818 | $11,570 | **$43,672** |
| 19 | $2,431 | $6,990 | $11,251 | $19,382 | $11,917 | **$51,972** |
| 20 | $2,504 | $0 | $11,589 | $19,964 | $12,275 | **$46,331** |
| 21 | $2,579 | $7,416 | $11,937 | $20,563 | $12,643 | **$55,137** |
| 22 | $2,657 | $0 | $12,295 | $21,179 | $13,022 | **$49,153** |
| 23 | $2,736 | $7,868 | $12,664 | $21,815 | $13,413 | **$58,495** |
| 24 | $2,818 | $0 | $13,043 | $22,469 | $13,815 | **$52,146** |
| 25 | $2,903 | $8,347 | $13,435 | $23,143 | $14,230 | **$62,057** |

| Livestock BMPs, Annual Cost Before Cost-Share, cont. | | | | | | |
|---|---|---|---|---|---|---|
| Year | Vegetative Filter Strip | Fenced Off Streams | Relocate Pasture Feeding Site | Off Stream Watering System | Rotational Grazing | Annual Cost |
| 26 | $2,990 | $0 | $13,838 | $23,838 | $14,656 | **$55,322** |
| 27 | $3,080 | $8,855 | $14,253 | $24,553 | $15,096 | **$65,836** |
| 28 | $3,172 | $0 | $14,680 | $25,289 | $15,549 | **$58,691** |
| 29 | $3,267 | $9,394 | $15,121 | $26,048 | $16,015 | **$69,846** |
| 30 | $3,365 | $0 | $15,575 | $26,829 | $16,496 | **$62,265** |
| 31 | $3,466 | $9,966 | $16,042 | $27,634 | $16,991 | **$74,099** |
| 32 | $3,570 | $0 | $16,523 | $28,463 | $17,501 | **$66,057** |
| 33 | $3,677 | $10,573 | $17,019 | $29,317 | $18,026 | **$78,612** |
| 34 | $3,788 | $0 | $17,529 | $30,197 | $18,566 | **$70,080** |
| 35 | $3,901 | $11,217 | $18,055 | $31,103 | $19,123 | **$83,400** |
| 36 | $4,018 | $0 | $18,597 | $32,036 | $19,697 | **$74,348** |
| 37 | $4,139 | $11,900 | $19,155 | $32,997 | $20,288 | **$88,479** |
| 38 | $4,263 | $0 | $19,729 | $33,987 | $20,897 | **$78,876** |
| 39 | $4,391 | $12,625 | $20,321 | $35,006 | $21,523 | **$93,867** |
| 40 | $4,523 | $0 | $20,931 | $36,057 | $22,169 | **$83,679** |
| **3% Inflation* | | | | | | |

**Table 34. Annual Costs After Cost Share in the Livestock Targeted Area.** Sub watershed costs are provided in the Appendix. Expressed in 2010 dollar amounts.

| Livestock BMPs, Annual Cost After Cost-Share | | | | | | |
|---|---|---|---|---|---|---|
| Year | Vegetative Filter Strip | Fenced Off Streams | Relocate Pasture Feeding Site | Off Stream Watering System | Rotational Grazing | Annual Cost |
| 1 | $714 | $2,053 | $3,305 | $5,693 | $3,500 | **$15,264** |
| 2 | $735 | $0 | $3,404 | $5,863 | $3,605 | **$13,607** |
| 3 | $757 | $2,178 | $3,506 | $6,039 | $3,713 | **$16,194** |
| 4 | $780 | $0 | $3,611 | $6,220 | $3,825 | **$14,436** |
| 5 | $804 | $2,311 | $3,719 | $6,407 | $3,939 | **$17,180** |
| 6 | $828 | $0 | $3,831 | $6,599 | $4,057 | **$15,315** |
| 7 | $853 | $2,451 | $3,946 | $6,797 | $4,179 | **$18,226** |
| 8 | $878 | $0 | $4,064 | $7,001 | $4,305 | **$16,248** |
| 9 | $904 | $2,601 | $4,186 | $7,211 | $4,434 | **$19,336** |
| 10 | $932 | $0 | $4,312 | $7,427 | $4,567 | **$17,237** |
| 11 | $960 | $2,759 | $4,441 | $7,650 | $4,704 | **$20,514** |
| 12 | $988 | $0 | $4,574 | $7,880 | $4,845 | **$18,287** |
| 13 | $1,018 | $2,927 | $4,711 | $8,116 | $4,990 | **$21,763** |
| 14 | $1,049 | $0 | $4,853 | $8,360 | $5,140 | **$19,401** |

| Livestock BMPs, Annual Cost After Cost-Share, cont. | | | | | | |
|---|---|---|---|---|---|---|
| Year | Vegetative Filter Strip | Fenced Off Streams | Relocate Pasture Feeding Site | Off Stream Watering System | Rotational Grazing | Annual Cost |
| 15 | $1,080 | $3,105 | $4,998 | $8,610 | $5,294 | **$23,088** |
| 16 | $1,112 | $0 | $5,148 | $8,869 | $5,453 | **$20,582** |
| 17 | $1,146 | $3,294 | $5,303 | $9,135 | $5,616 | **$24,494** |
| 18 | $1,180 | $0 | $5,462 | $9,409 | $5,785 | **$21,836** |
| 19 | $1,216 | $3,495 | $5,626 | $9,691 | $5,959 | **$25,986** |
| 20 | $1,252 | $0 | $5,794 | $9,982 | $6,137 | **$23,166** |
| 21 | $1,290 | $3,708 | $5,968 | $10,281 | $6,321 | **$27,568** |
| 22 | $1,328 | $0 | $6,147 | $10,590 | $6,511 | **$24,576** |
| 23 | $1,368 | $3,934 | $6,332 | $10,907 | $6,706 | **$29,247** |
| 24 | $1,409 | $0 | $6,522 | $11,235 | $6,908 | **$26,073** |
| 25 | $1,451 | $4,173 | $6,717 | $11,572 | $7,115 | **$31,029** |
| 26 | $1,495 | $0 | $6,919 | $11,919 | $7,328 | **$27,661** |
| 27 | $1,540 | $4,427 | $7,126 | $12,276 | $7,548 | **$32,918** |
| 28 | $1,586 | $0 | $7,340 | $12,645 | $7,775 | **$29,345** |
| 29 | $1,634 | $4,697 | $7,560 | $13,024 | $8,008 | **$34,923** |
| 30 | $1,683 | $0 | $7,787 | $13,415 | $8,248 | **$31,133** |
| 31 | $1,733 | $4,983 | $8,021 | $13,817 | $8,495 | **$37,050** |
| 32 | $1,785 | $0 | $8,262 | $14,232 | $8,750 | **$33,029** |
| 33 | $1,839 | $5,287 | $8,509 | $14,659 | $9,013 | **$39,306** |
| 34 | $1,894 | $0 | $8,765 | $15,098 | $9,283 | **$35,040** |
| 35 | $1,951 | $5,609 | $9,028 | $15,551 | $9,562 | **$41,700** |
| 36 | $2,009 | $0 | $9,298 | $16,018 | $9,849 | **$37,174** |
| 37 | $2,069 | $5,950 | $9,577 | $16,498 | $10,144 | **$44,239** |
| 38 | $2,131 | $0 | $9,865 | $16,993 | $10,448 | **$39,438** |
| 39 | $2,195 | $6,313 | $10,161 | $17,503 | $10,762 | **$46,933** |
| 40 | $2,261 | $0 | $10,465 | $18,028 | $11,085 | **$41,840** |
| **3% Inflation* | | | | | | |

**Table 35. Annual Costs of Streambank Stabilization Projects in the Streambank Targeted Area.** Expressed in 2010 dollar amounts.

| Cottonwood River Annual Streambank Load Reductions and Cost | | | | | | |
|---|---|---|---|---|---|---|
| Year | Streambank Stabilization (feet) | Soil Load Reduction (tons) | Cumulative Erosion Reduction (tons) | Phosphorous Reduction (lbs) | Cumulative P Load Reduction (lbs) | Cost* |
| 1 | 1,842 | 3,887 | 3,887 | 233 | 233 | $177,908 |
| 2 | 1,842 | 3,887 | 7,774 | 233 | 466 | $183,245 |
| 3 | 1,842 | 3,887 | 11,660 | 233 | 700 | $188,742 |

| Cottonwood River Annual Streambank Load Reductions and Cost, cont. | | | | | | |
|---|---|---|---|---|---|---|
| Year | Streambank Stabilization (feet) | Soil Load Reduction (tons) | Cumulative Erosion Reduction (tons) | Phosphorous Reduction (lbs) | Cumulative P Load Reduction (lbs) | Cost* |
| 4 | 1,842 | 3,887 | 15,547 | 233 | 933 | $194,404 |
| 5 | 1,842 | 3,887 | 19,434 | 233 | 1,166 | $200,237 |
| 6 | 1,842 | 3,887 | 23,321 | 233 | 1,399 | $206,244 |
| 7 | 1,842 | 3,887 | 27,207 | 233 | 1,632 | $212,431 |
| 8 | 1,842 | 3,887 | 31,094 | 233 | 1,866 | $218,804 |
| 9 | 1,842 | 3,887 | 34,981 | 233 | 2,099 | $225,368 |
| 10 | 1,842 | 3,887 | 38,868 | 233 | 2,332 | $232,129 |
| 11 | 1,842 | 3,887 | 42,755 | 233 | 2,565 | $239,093 |
| 12 | 1,842 | 3,887 | 46,641 | 233 | 2,798 | $246,266 |
| 13 | 1,842 | 3,887 | 50,528 | 233 | 3,032 | $253,654 |
| 14 | 1,842 | 3,887 | 54,415 | 233 | 3,265 | $261,263 |
| 15 | 1,842 | 3,887 | 58,302 | 233 | 3,498 | $269,101 |
| 16 | 1,842 | 3,887 | 62,188 | 233 | 3,731 | $277,174 |
| 17 | 1,842 | 3,887 | 66,075 | 233 | 3,965 | $285,489 |
| 18 | 1,842 | 3,887 | 69,962 | 233 | 4,198 | $294,054 |
| 19 | 1,842 | 3,887 | 73,849 | 233 | 4,431 | $302,876 |
| 20 | 1,842 | 3,887 | 77,736 | 233 | 4,664 | $311,962 |
| 21 | 1,842 | 3,887 | 81,622 | 233 | 4,897 | $321,321 |
| 22 | 1,842 | 3,887 | 85,509 | 233 | 5,131 | $330,961 |
| 23 | 1,842 | 3,887 | 89,396 | 233 | 5,364 | $340,889 |
| 24 | 1,842 | 3,887 | 93,283 | 233 | 5,597 | $351,116 |
| 25 | 1,842 | 3,887 | 97,169 | 233 | 5,830 | $361,650 |
| 26 | 1,842 | 3,887 | 101,056 | 233 | 6,063 | $372,499 |
| 27 | 1,842 | 3,887 | 104,943 | 233 | 6,297 | $383,674 |
| 28 | 1,842 | 3,887 | 108,830 | 233 | 6,530 | $395,184 |
| 29 | 1,842 | 3,887 | 112,717 | 233 | 6,763 | $407,040 |
| 30 | 1,842 | 3,887 | 116,603 | 233 | 6,996 | $419,251 |
| 31 | 1,842 | 3,887 | 120,490 | 233 | 7,229 | $431,828 |
| 32 | 1,842 | 3,887 | 124,377 | 233 | 7,463 | $444,783 |
| 33 | 1,842 | 3,887 | 128,264 | 233 | 7,696 | $458,127 |
| 34 | 1,842 | 3,887 | 132,150 | 233 | 7,929 | $471,871 |
| 35 | 1,842 | 3,887 | 136,037 | 233 | 8,162 | $486,027 |
| 36 | 1,842 | 3,887 | 139,924 | 233 | 8,395 | $500,608 |
| 37 | 1,842 | 3,887 | 143,811 | 233 | 8,629 | $515,626 |
| 38 | 1,842 | 3,887 | 147,698 | 233 | 8,862 | $531,095 |
| 39 | 1,842 | 3,887 | 151,584 | 233 | 9,095 | $547,027 |

| Cottonwood River Annual Streambank Load Reductions and Cost, cont. | | | | | | |
|---|---|---|---|---|---|---|
| Year | Streambank Stabilization (feet) | Soil Load Reduction (tons) | Cumulative Erosion Reduction (tons) | Phosphorous Reduction (lbs) | Cumulative P Load Reduction (lbs) | Cost* |
| 40 | 1,842 | 3,887 | 155,471 | 233 | 9,328 | $563,438 |
| *3% Inflation | | | | | | |

**Table 36. Technical Assistance Needed to Implement BMPs.**

| BMP | | Personnel Needed to Implement BMP | |
|---|---|---|---|
| | | ***Technical Assistance*** | ***Projected Annual Cost*** |
| Cropland | 1. Conservation Crop Rotation | KRC River Friendly Farms Technician | NRCS District Conservationist No Charge<br><br>Conservation District Soil Technician No Charge<br><br>SCC Buffer Technician No Charge<br><br>KRC River Friendly Farms Technician $20,000<br><br>Kansas State Forester No Charge<br><br>Watershed Coordinator and Grant Manager $45,000 |
| | 2. Grassed Waterways | SCC Buffer Technician<br>KRC River Friendly Farms Technician | |
| | 3. No-Till | SCC Buffer Technician<br>WRAPS Coordinator<br>KRC River Friendly Farms Technician | |
| | 4. Buffers | SCC Buffer Technician<br>KRC River Friendly Farms Technician | |
| | 5. Terraces | SCC Buffer Technician<br>KRC River Friendly Farms Technician | |
| | 5. Establish Permanent Vegetation | KRC River Friendly Farms Technician | |
| Livestock | 1. Vegetative filter strips | SCC Buffer Technician<br>KRC River Friendly Farms Technician<br>Watershed Specialist | |
| | 2. Fence off streams | KRC River Friendly Farms Technician<br>Watershed Specialist | |
| | 3. Relocate pasture feeding sites | KRC River Friendly Farms Technician<br>Watershed Specialist | |
| | 4. Establish off stream watering systems | KRC River Friendly Farms Technician<br>Watershed Specialist | |
| | 5. Rotational grazing | KRC River Friendly Farms Technician<br>Watershed Specialist | |
| Streambank | 1. Stabilization | SCC Buffer Technician<br>WRAPS Coordinator<br>KRC River Friendly Farms Technician | |
| | Total | | $65,000 |

**Table 37. Total Costs After Cost Share for BMPs I&E and Technical Support if All BMPs and I&E Projects are Implemented.** Expressed in 2010 dollar amounts.

| Annual Cost of Cropland, Livestock, Streambank BMPs, I&E, and Technical Assistance adjusted for Cost Share | | | | | | |
|---|---|---|---|---|---|---|
| | BMPs Implemented | | | I&E and Technical Assistance | | |
| Year | Cropland | Livestock | Streambank | I&E | Technical Assistance | Total |
| 1 | $274,771 | $15,264 | $177,908 | $118,000 | $65,000 | $650,943 |
| 2 | $283,014 | $13,607 | $183,245 | $121,540 | $66,950 | $668,356 |
| 3 | $291,504 | $16,194 | $188,742 | $125,186 | $68,959 | $690,585 |
| 4 | $300,249 | $14,436 | $194,404 | $128,942 | $71,027 | $709,058 |
| 5 | $309,257 | $17,180 | $200,237 | $132,810 | $73,158 | $732,642 |
| 6 | $318,535 | $15,315 | $206,244 | $136,794 | $75,353 | $752,241 |
| 7 | $328,091 | $18,226 | $212,431 | $140,898 | $77,613 | $777,259 |
| 8 | $337,933 | $16,248 | $218,804 | $145,125 | $79,942 | $798,052 |
| 9 | $348,071 | $19,336 | $225,368 | $149,479 | $82,340 | $824,594 |
| 10 | $358,513 | $17,237 | $232,129 | $153,963 | $84,810 | $846,652 |
| 11 | $369,269 | $20,514 | $239,093 | $158,582 | $87,355 | $874,813 |
| 12 | $380,347 | $18,287 | $246,266 | $163,340 | $89,975 | $898,215 |
| 13 | $391,757 | $21,763 | $253,654 | $168,240 | $92,674 | $928,088 |
| 14 | $403,510 | $19,401 | $261,263 | $173,287 | $95,455 | $952,916 |
| 15 | $415,615 | $23,088 | $269,101 | $178,486 | $98,318 | $984,608 |
| 16 | $428,084 | $20,582 | $277,174 | $183,840 | $101,268 | $1,010,948 |
| 17 | $440,926 | $24,494 | $285,489 | $189,355 | $104,306 | $1,044,570 |
| 18 | $454,154 | $21,836 | $294,054 | $195,036 | $107,435 | $1,072,515 |
| 19 | $467,779 | $25,986 | $302,876 | $200,887 | $110,658 | $1,108,186 |
| 20 | $481,812 | $23,166 | $311,962 | $206,914 | $113,978 | $1,137,832 |
| 21 | $256,062 | $27,568 | $321,321 | $213,121 | $117,397 | $935,469 |
| 22 | $263,744 | $24,576 | $330,961 | $219,515 | $120,919 | $959,715 |
| 23 | $271,656 | $29,247 | $340,889 | $226,100 | $124,547 | $992,439 |
| 24 | $279,806 | $26,073 | $351,116 | $232,883 | $128,283 | $1,018,161 |
| 25 | $288,200 | $31,029 | $361,650 | $239,870 | $132,132 | $1,052,881 |
| 26 | $296,846 | $27,661 | $372,499 | $247,066 | $136,096 | $1,080,168 |
| 27 | $305,751 | $32,918 | $383,674 | $254,478 | $140,178 | $1,116,999 |
| 28 | $314,924 | $29,345 | $395,184 | $262,112 | $144,384 | $1,145,949 |
| 29 | $324,372 | $34,923 | $407,040 | $269,975 | $148,715 | $1,185,025 |
| 30 | $334,103 | $31,133 | $419,251 | $278,075 | $153,177 | $1,215,739 |
| 31 | $344,126 | $37,050 | $431,828 | $286,417 | $157,772 | $1,257,193 |
| 32 | $354,450 | $33,029 | $444,783 | $295,009 | $162,505 | $1,289,776 |
| 33 | $365,083 | $39,306 | $458,127 | $303,860 | $167,380 | $1,333,756 |

| Annual Cost of Cropland, Livestock, Streambank BMPs, I&E, and Technical Assistance adjusted for Cost Share, cont. | | | | | | |
|---|---|---|---|---|---|---|
| | BMPs Implemented | | | I&E and Technical Assistance | | |
| Year | Cropland | Livestock | Streambank | I&E | Technical Assistance | Total |
| 34 | $376,036 | $35,040 | $471,871 | $312,976 | $172,402 | $1,368,325 |
| 35 | $387,317 | $41,700 | $486,027 | $322,365 | $177,574 | $1,414,983 |
| 36 | $398,936 | $37,174 | $500,608 | $332,036 | $182,901 | $1,451,655 |
| 37 | $410,904 | $44,239 | $515,626 | $341,997 | $188,388 | $1,501,154 |
| 38 | $423,231 | $39,438 | $531,095 | $352,257 | $194,040 | $1,540,061 |
| 39 | $435,928 | $46,933 | $547,027 | $362,824 | $199,861 | $1,592,573 |
| 40 | $449,006 | $41,840 | $563,438 | $373,709 | $205,857 | $1,633,850 |
| **3% Inflation* | | | | | | |

## 8.2 Potential Funding Sources

**Table 38. Potential BMP Funding Sources.**

| Potential Funding Sources | Potential Funding Programs |
|---|---|
| Natural Resources Conservation Service | Environmental Quality Incentives Program (EQIP)<br><br>Wetland Reserve Program (WRP)<br><br>Conservation Reserve Program (CRP)<br><br>Wildlife Habitat Incentive Program (WHIP)<br><br>Cooperative Conservation Partnership Initiative (CCPI)<br><br>State Acres for Wildlife Enhancement (SAFE)<br><br>Grassland Reserve Program (GRP)<br><br>Farmable Wetlands Program (FWP) |
| EPA/KDHE | 319 Funding Grants<br>KDHE WRAPS Funding<br>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 | |

| Potential Funding Sources, cont. | |
|---|---|
| **Potential Funding Sources** | **Potential Funding Programs** |
| US Fish and Wildlife | |
| National Wild Turkey Federation | |
| Quail Unlimited | |
| Ducks Unlimited | |

**Table 39. Service Providers for BMP Implementation. ***

| BMP | | Services Needed to Implement BMP | | Service Provider ** |
|---|---|---|---|---|
| | | ***Technical Assistance*** | ***Information and Education*** | |
| Cropland | 1. Conservation Crop Rotation | Development of management plan | BMP workshops, tours, field days | NRCS<br>KRC<br>SCC<br>No-Till on the Plains<br>KSRE<br>CD<br>RC&D<br>KDWP<br>KFS |
| | 2. Waterways | Design, cost share and maintenance | BMP workshops, tours, field days | |
| | 3. No-till | Design, cost share and maintenance | BMP workshops, tours, field days | |
| | 4. Buffers | Development of management plan | BMP workshops | |
| | 5. Terraces | Design, cost share and maintenance | BMP workshops, field days, tours | |
| | 6. Establish Permanent Vegetation | Development of management plan | BMP workshops, field days, tours | |
| Livestock | 1. Vegetative filter strips | Design, cost share and maintenance | BMP workshops, field days, tours | KSRE<br>NRCS<br>SCC<br>KRC<br>CD<br>RC&D<br>KDWP |
| | 2. Fence off streams | Design, cost share and maintenance | BMP workshops, field days, tours | |
| | 3. Relocate pasture feeding sites | Design, cost share and maintenance | BMP workshops, field days, tours | |
| | 4. Establish off stream watering systems | Design, cost share and maintenance | BMP workshops, field days, tours | |
| | 5. Rotational grazing | Design, cost share and maintenance | BMP workshops, field days, tours | |
| Streambank | Streambank restoration | Design, cost share and maintenance | BMP workshops, field days, tours | KAWS<br>NRCS<br>KFS<br>KSRE<br>CD<br>RC&D |
| ***** 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 2015. In 2013, the SLT will request a review of data by KDHE for the Neosho Basin. It is this 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 forty years from the date of publication of this report. Sediment and phosphorus reductions in the water column will not be noticeable by the year 2015 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 2020. They will examine BMP placement and implementation in 2015 and every subsequent five years after.

**Table 41. Review Schedule for Pollutants and BMPs.**

| Review Year | Sediment | Phosphorus | BMP Placement |
|---|---|---|---|
| 2015 | | | X |
| 2020 | X | X | X |
| 2025 | X | X | X |
| 2030 | X | X | X |
| 2035 | X | X | X |
| 2040 | X | X | X |
| 2045 | X | X | X |
| 2050 | 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 TMDL** will be attained at year thirty four of the plan. After the sediment TMDL is achieved, the process will become one of protection instead of restoration.
- The WRAPS estimate timeframe for the **phosphorus TMDL** will be the full forty years of the plan. At this time, if all BMPs have been implemented, the TMDL should be met.

# 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 40. Short, Medium and Long Term Goals for BMP Cropland Adoption Rates.** Sub watershed adoption rates are provided in the Appendix.

| Annual Adoption (treated acres) Rates for Cropland BMPs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Adoption |
| Short-Term | 1 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 2 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 3 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 4 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 5 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | *Total* | *3,028* | *5,288* | *9,084* | *6,053* | *2,644* | *3,028* | *29,124* |
| Medium-Term | 6 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 7 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 8 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 9 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 10 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | *Total* | *6,055* | *10,576* | *18,167* | *12,106* | *5,288* | *6,055* | *58,248* |
| Long-Term | 11 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 12 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 13 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 14 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 15 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 16 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 17 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 18 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 19 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 20 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 5,825 |
| | 21 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 22 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 23 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 24 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 25 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 26 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 27 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 28 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 29 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 30 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 31 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |

| Annual Adoption (treated acres) Rates for Cropland BMPs, cont. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Adoption |
| Long Term | 32 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 33 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 34 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 35 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 36 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 37 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 38 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 39 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | 40 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 3,173 |
| | ***Total*** | ***12,111*** | ***42,303*** | ***57,486*** | ***45,364*** | ***10,576*** | ***12,111*** | ***179,949*** |

**Table 41. Short, Medium and Long Term Goals for BMP Livestock Adoption Rates.**

| Annual Livestock BMP Adoption Rates | | | | | | |
|---|---|---|---|---|---|---|
| | Year | Vegetative Filter Strip | Fenced Off Streams | Relocate Pasture Feeding Site | Off Stream Watering System | Rotational Grazing |
| Short-Term | 1 | 2 | 1 | 3 | 3 | 1 |
| | 2 | 2 | | 3 | 3 | 1 |
| | 3 | 2 | 1 | 3 | 3 | 1 |
| | 4 | 2 | | 3 | 3 | 1 |
| | 5 | 2 | 1 | 3 | 3 | 1 |
| | *Total* | *10* | *3* | *15* | *15* | *5* |
| Medium-Term | 6 | 2 | | 3 | 3 | 1 |
| | 7 | 2 | 1 | 3 | 3 | 1 |
| | 8 | 2 | | 3 | 3 | 1 |
| | 9 | 2 | 1 | 3 | 3 | 1 |
| | 10 | 2 | | 3 | 3 | 1 |
| | *Total* | *20* | *5* | *30* | *30* | *10* |
| Long-Term | 11 | 2 | 1 | 3 | 3 | 1 |
| | 12 | 2 | | 3 | 3 | 1 |
| | 13 | 2 | 1 | 3 | 3 | 1 |
| | 14 | 2 | | 3 | 3 | 1 |
| | 15 | 2 | 1 | 3 | 3 | 1 |
| | 16 | 2 | | 3 | 3 | 1 |
| | 17 | 2 | 1 | 3 | 3 | 1 |
| | 18 | 2 | | 3 | 3 | 1 |
| | 19 | 2 | 1 | 3 | 3 | 1 |
| | 20 | 2 | | 3 | 3 | 1 |

| Annual Livestock BMP Adoption Rates, cont. | | | | | | |
|---|---|---|---|---|---|---|
| | Year | Vegetative Filter Strip | Fenced Off Streams | Relocate Pasture Feeding Site | Off Stream Watering System | Rotational Grazing |
| Long Term | 21 | 2 | 1 | 3 | 3 | 1 |
| | 22 | 2 | | 3 | 3 | 1 |
| | 23 | 2 | 1 | 3 | 3 | 1 |
| | 24 | 2 | | 3 | 3 | 1 |
| | 25 | 2 | 1 | 3 | 3 | 1 |
| | 26 | 2 | | 3 | 3 | 1 |
| | 27 | 2 | 1 | 3 | 3 | 1 |
| | 28 | 2 | | 3 | 3 | 1 |
| | 29 | 2 | 1 | 3 | 3 | 1 |
| | 30 | 2 | | 3 | 3 | 1 |
| | 31 | 2 | 1 | 3 | 3 | 1 |
| | 32 | 2 | | 3 | 3 | 1 |
| | 33 | 2 | 1 | 3 | 3 | 1 |
| | 34 | 2 | | 3 | 3 | 1 |
| | 35 | 2 | 1 | 3 | 3 | 1 |
| | 36 | 2 | | 3 | 3 | 1 |
| | 37 | 2 | 1 | 3 | 3 | 1 |
| | 38 | 2 | | 3 | 3 | 1 |
| | 39 | 2 | 1 | 3 | 3 | 1 |
| | 40 | 2 | | 3 | 3 | 1 |
| | ***Total*** | ***80*** | ***20*** | ***120*** | ***120*** | ***40*** |

**Table 42. Short, Medium and Long Term Goals for Information and Education Adoption Rates.**

| | Year | Workshops, Tours and Field Days | One on One Technical Assistance | Scholarships for Conference Attendees | Educational Events | Educational Activities | Water Festival | BMP Auction | Contacts made by Tech Assistance |
|---|---|---|---|---|---|---|---|---|---|
| Short Term | 1 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 2 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 3 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 4 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 5 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | | 35 | 50 | 50 | 15 | 10 | 5 | 5 | 1,250 |

| I&E Goals, cont. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Year | Workshops, Tours and Field Days | One on One Technical Assistance | Scholarships for Conference Attendees | Educational Events | Educational Activities | Water Festival | BMP Auction | Contacts made by Tech Assistance |
| Medium Term | 6 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 7 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 8 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 9 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 10 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | | 70 | 100 | 100 | 30 | 20 | 10 | 10 | 2,500 |
| Long Term | 11 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 12 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 13 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 14 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 15 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 16 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 17 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 18 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 19 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 20 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 21 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 22 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 23 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 24 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 25 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 26 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 27 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 28 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 29 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 30 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 31 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 32 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 33 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 34 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |

| I&E Goals, cont. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Year | Workshops, Tours and Field Days | One on One Technical Assistance | Scholarships for Conference Attendees | Educational Events | Educational Activities | Water Festival | BMP Auction | Contacts made by Tech Assistance |
| Long Term | 35 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 36 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 37 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 38 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 39 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | 40 | 7 | 10 | 10 | 3 | 2 | 1 | 1 | 250 |
| | *Total* | *280* | *400* | *400* | *120* | *80* | *40* | *40* | *10,000* |

## 10.2 Benchmarks to Measure Water Quality and Social Progress

Over a forty year time frame, this WRAPS project hopes to improve water quality throughout the watershed and in John Redmond Reservoir. Measurements taken at John Redmond Reservoir are important because it is the drainage endpoint of the watershed. Any water quality improvements will be observed by conducting tests in the reservoir. Social indicators will also be examined by tracking traffic in John Redmond Reservoir Park. An example of a healthy lake ecosystem is frequent visits by the public to enjoy the outdoor recreation of the reservoir and park. After reviewing the criteria listed in the table below, the SLT will assess and revise the overall strategy plan for the watershed. 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, KSU or the Tulsa District, US Army Corps of Engineers, the following indicator and parameter criteria shall be used to assess progress in successful implementation to abate pollutant loads.

**Table 45. Benchmarks to Measure Water Quality Progress.**

| Impairment Addressed | Criteria to Measure Water Quality Progress | Information Source |
|---|---|---|
| Sediment | Number of acres of buffers, grassed waterways and terraces installed in the Cropland Targeted Area indicating that there would be a reduction in sediment into John Redmond Reservoir | NRCS |

| Benchmarks, cont. | | |
|---|---|---|
| **Impairment Addressed** | **Criteria to Measure Water Quality Progress** | **Information Source** |
| Sediment, cont. | Secchi Disc depth in John Redmond Reservoir > 0.5 meters | KDHE |
| | Target storage in John Redmond Reservoir 65,000 acre feet in 2014 | COE |
| | Reduction in streambank and farmland loss along the Cottonwood River | KWO |
| | Reduced number of gullies on upland cropland and rangeland areas | NRCS |
| | Fewer high event stream flow rates entering John Redmond Reservoir indicating better retention and slower release of storm water in the upper end of the watershed and in the vicinity of Emporia | USGS |
| Nutrients | No algal blooms are reported as the reservoir clarity improves | KDHE |
| | Summer Chlorophyll a concentrations in John Redmond Reservoir < 12 ug/l | KDHE |
| | No nuisance blooms on the Cottonwood River or its shoreline | KDHE |
| | Total Nitrogen concentration in John Redmond Reservoir < 0.62 mg.L | KDHE |
| | Continued availability of use of surface water sources for public water supply | KDHE/DWR |
| *E. coli* bacteria | Number of livestock that have been relocated from close proximity to a stream indicating that there would be a reduction in *E. coli* bacteria into John Redmond Reservoir | Watershed Specialist |
| | No violations of bacteria criteria on primary recreation on the Cottonwood River | KDHE |
| | Reduced incidence of high bacteria during wet weather on Mud Creek | KDHE |
| **Impairment Addressed** | **Social Indicators to Measure Water Quality Progress** | **Information Source** |
| Sediment<br>Nutrients<br>*E. coli* bacteria | Visitor traffic to John Redmond Reservoir | KDWP |
| | Boating traffic in John Redmond Reservoir | KDWP |
| | Trends of quantity and quality of fishing in John Redmond Reservoir and along the Cottonwood River | KDWP |
| | Economic indicators indicating effect of John Redmond Reservoir's impact on local businesses | Coffey County Economic Development |
| | Improved crop yields for farms along the Cottonwood River | KSRE |
| | Survey of water quality issues to determine whether information and education programs are having an effect on public perception | KSRE |
| | Number of attendees at workshops and field days | KSRE |
| | BMP adoptability rates | NRCS |

## 10.3 Phosphorus and Sediment Milestones

At the end of five years, the SLT will be able to examine water quality data for phosphorus (eutrophication determination) and suspended solids (sediment determination) to determine if progress has been made in improving water quality in the priority sub watersheds in the upper and lower portions of the Cottonwood River watershed, as well as along the river itself. It is estimated that it will require five years to see progress of phosphorus and sediment reduction after BMP implementation in the critical areas within those priority sub watersheds. KDHE has outlined water quality milestones for total phosphorus and total suspended solids. These goals are presented below for the upper and lower portions of the Cottonwood watershed.

### 10.3.1 Short Term Water Quality Milestones

#### *10.3.1.A Phosphorus and Sediment*

**Table 43. Reduction Needed for TP and TSS.**

| | Current Condition (2000-2010) Median TP | Improved Condition (2011 – 2015) Median TP | Reduction Needed | Current Condition (2000-2010) 75% TSS | Improved Condition (2011 – 2015) 75% TSS | Reduction Needed |
|---|---|---|---|---|---|---|
| **Sampling Site** | **Total Phosphorus (median of data collected during indicated period), ppb** | | | **Total Suspended Solids (upper quartile of data collected during indicated period), ppm** | | |
| **UPPER COTTONWOOD** | | | | | | |
| **Doyle Creek** | 70 ppb | 66 ppb | 6% | 22 ppm | 13 ppm | 41% |
| **South Cottonwood River** | 246 ppb | 211 ppb | 14% | 33 ppm | 30 ppm | 9% |
| **Mud Creek** | 165 ppb | 128 ppb | 22% | 35 ppm | 28 ppm | 20% |
| **Clear Creek** | 98 ppb | 93 ppb | 5% | 43 ppm | 37 ppm | 14% |
| **Cottonwood River at Elmdale** | 154 ppb | 140 ppb | 9% | 97 ppm | 72 ppm | 26% |
| **Cottonwood River at Plymouth** | 144 ppb | 130 ppb | 10% | 78 ppm | 70 ppm | 10% |
| **LOWER COTTONWOOD** | | | | | | |
| **Cottonwood River at Emporia** | 487 ppb | 370 ppb | 24% | 83 ppm | 70 ppm | 16% |

### *10.3.1.B E. coli Bacteria on Mud Creek*

A TMDL addressing excessive bacteria on Mud Creek was developed and approved in December, 2002. At the time, the bacteria indicator was FCB and the desired endpoint was 900 colonies per 100 ml during the primary recreation season of April through October. During the off-season between November and March, the criterion rose to 2000 colonies per 100 ml.

In 2003, the water quality standards for bacteria and recreation were changed. *E coli* bacteria became the indicator, Mud Creek was designated for Primary "C" recreation and, thus, the criterion was changed to 427 colonies per 100 ml for April through October and 3843 colonies per 100 ml during the winter. The criterion is assessed as a geometric mean of five samples taken within a 30-day period.

In 2007, Mud Creek was sampled intensively in the manner prescribed by the water quality standards. On four occasions of differing weather and flow conditions, the creek was sampled five (once six times) times within a 3-4 week period. The geometric mean of the samples was computed for each sampling occasion and the creek exceeded the primary recreation season criteria twice, violating the water quality standards. Numerous individual samples exceeded the nominal value of the criterion (427 counts), and even when discounting the weight of any individual sample, persistently high bacteria levels have been present.

KDHE now utilizes the routine (bimonthly to quarterly) sampling of bacteria to gage the likelihood of bacteria levels exceeding the criterion. The individual samples from routine monitoring were combined with the intensive collections of 2007 (April through October only). An index was computed as the natural logarithm of the sample value divided by the natural logarithm of the criterion (427). An index value of one or less indicated meeting the face value of the water quality standard for bacteria. A cumulative frequency curve was drawn for the index values. The desired endpoint is for the majority (> 90%) of the curve to lie below one.

As can be seen by the index profile for Mud Creek below, while two-thirds of the samples are below the criterion, the frequency of excursions over the criterion is too high. Therefore, the milestone for Mud Creek bacteria over the next five years will be a reduction in the index profile below the current profile line. The future profile may not yet meet the desired line, but it should begin to approach it with an increasing number of samples with E coli bacteria counts less than 427 during April through October.

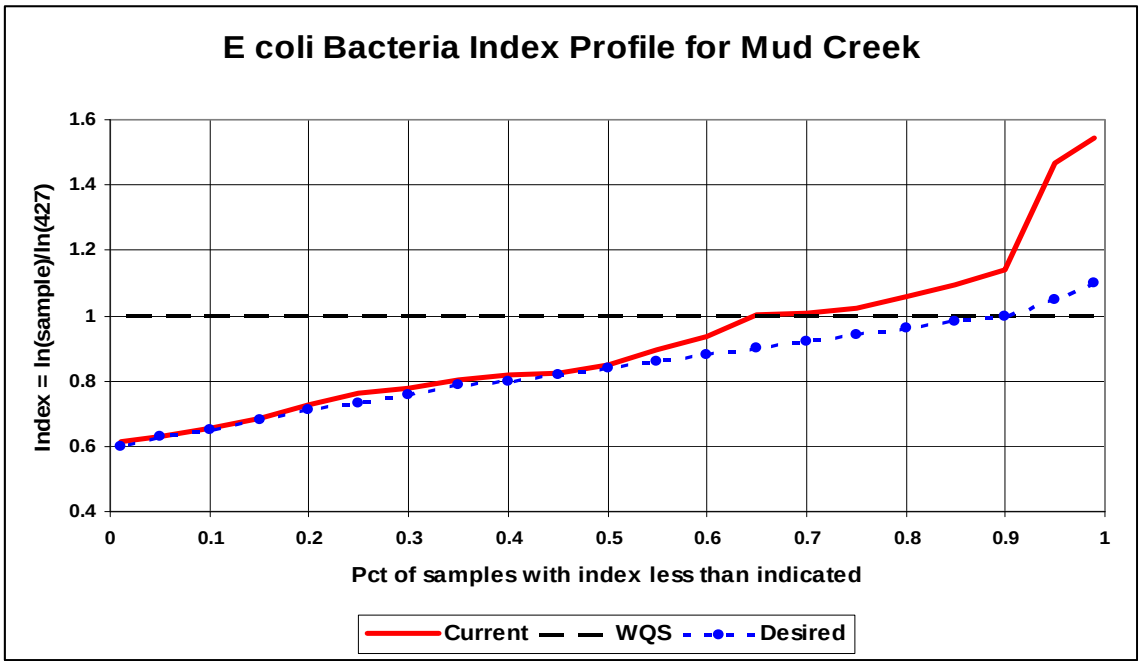



**Figure 39. *E. coli* Bacteria Index for Mud Creek.**

### 10.3.2 Mid Term Water Quality Milestones

The expectation of midterm water quality milestones is that the improved water quality from the short term milestones would continue to trend toward improvement over the midterm life of the plan.

### 10.3.3 Long Term Water Quality Milestones

The long-term water quality goal associated with the bacteria impairment in Mud Creek is the achievement of an ECB index below one for 90 percent of the samples based on the Primary Contact Recreation C Index, which is based on 427 cfus (colony forming units)/100 ml of water. The goal is to reduce both the magnitude and frequency of the bacteria impairment in order to meet the water quality standards for Mud Creek.

Long term water quality milestones at the end of the plan will constitute that the water quality standards for all waterways will be met, and therefore, the 30 percent reduction goals for phosphorus and sediment will be accomplished.

If phosphorus and TSS milestones are met by 2050, with an anticipation that the FCB TMDL in Mud Creek will be met, then...

the Water Quality Standards will be met for John Redmond Lake and Mud Creek, and...

John Redmond Lake and Mud Creek will meet their full designated uses.

### 10.3.4 BMP Implementation Milestones from 2010 to 2050

The SLT will review the number of acres, projects or contacts made in the watershed at the end of five, ten and forty years (2050). 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 forty year period.

**Table 44. BMP Implementation Milestones from 2010 to 2050.**

| Cumulative Total | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cropland, acres | | | | | | Livestock, number of projects | | | | | Information and Education, number | |
| Year | Conservation Crop Rotation | Grassed Waterways | No-Till | Buffers | Terraces | Permanent Vegetation | Vegetative Filter Strip | Fence off Stream | Relocate Pasture Feeding Site | Off Stream Watering System | Rotational Grazing | Workshops and Field Days | Contacts made |
| 2011 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2012 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2013 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2014 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2015 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| **Total** | **3,030** | **5,290** | **9,085** | **6,055** | **2,645** | **3,030** | ***10*** | ***3*** | ***15*** | ***15*** | ***5*** | ***35*** | ***1,250*** |
| 2016 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2017 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2018 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2019 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2020 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | | 3 | 3 | 1 | 7 | 250 |
| ***Total*** | **6,060** | **10,580** | **18,170** | **12,110** | **5,290** | **6,060** | ***20*** | ***5*** | ***30*** | ***30*** | ***10*** | ***70*** | ***2,500*** |

| Cumulative Total, cont. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cropland, acres | | | | | | Livestock, number of projects | | | | | Information and Education, number | |
| Year | Conservation Crop Rotation | Grassed Waterways | No-Till | Buffers | Terraces | Permanent Vegetation | Vegetative Filter Strip | Fence off Stream | Relocate Pasture Feeding Site | Off Stream Watering System | Rotational Grazing | Workshops and Field Days | Contacts made |
| 2021 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2022 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2023 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2024 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2025 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2026 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2027 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2028 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2029 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2030 | 606 | 1,058 | 1,817 | 1,211 | 529 | 606 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2031 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2032 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2033 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2034 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2035 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2036 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2037 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2038 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2039 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2040 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | | 3 | 3 | 1 | 7 | 250 |

| Cumulative Total, cont. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cropland, acres | | | | | | Livestock, number of projects | | | | | Information and Education, number | |
| Year | Conservation Crop Rotation | Grassed Waterways | No-Till | Buffers | Terraces | Permanent Vegetation | Vegetative Filter Strip | Fence off Stream | Relocate Pasture Feeding Site | Off Stream Watering System | Rotational Grazing | Workshops and Field Days | Contacts made |
| 2041 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2042 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2043 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2044 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2045 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2046 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2047 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2048 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | | 3 | 3 | 1 | 7 | 250 |
| 2049 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | 1 | 3 | 3 | 1 | 7 | 250 |
| 2050 | 0 | 1,058 | 1,058 | 1,058 | 0 | 0 | 2 | | 3 | 3 | 1 | 7 | 250 |
| ***Total*** | **12,120** | **42,320** | **57,500** | **45,380** | **10,580** | **12,120** | ***80*** | ***20*** | ***120*** | ***120*** | ***40*** | ***280*** | ***10,000*** |

# 11.0 Monitoring Water Quality Progress

The KDHE sampling data will be reviewed by the SLT every year. 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 on a yearly basis.

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. All sampling sites will be continued into the future. Each site is tested for nutrients, metals, ammonia, solid fractions, turbidity, alkalinity, pH, dissolved oxygen, *E. coli* bacteria 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.

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 rainfall events in the upper reaches of the watershed have been slowed by BMPs such as no-till.

The COE has three sampling sites in John Redmond Reservoir and one site immediately below the dam. Reservoirs are sampled on a rotational basis around the Tulsa District. Since there are 36 projects in the District, John Redmond Reservoir was last sampled in 1997. Samples taken are analyzed for temperature, dissolved oxygen, alkalinity, hardness, pH, conductivity, total dissolved solids, chloride, sulfate, turbidity, total suspended solids, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, total Kjeldahl nitrogen, total phosphorus, iron, copper, zinc, manganese, cadmium, chromium, mercury, arsenic, lead, nickel and selenium. This data will be of interest to the SLT when analyzing the effectiveness of BMP placement.

Much of the evaluative information can be obtained through the existing networks and sampling plans of KDHE, USGS and the Tulsa District, COE. Public engagement can be obtained through observations of reservoir clarity, ease of boating and the physical appearance of the reservoir. Some communications with the COE will supplement any information on the conditions in the Cottonwood River drainage and in John Redmond Reservoir.

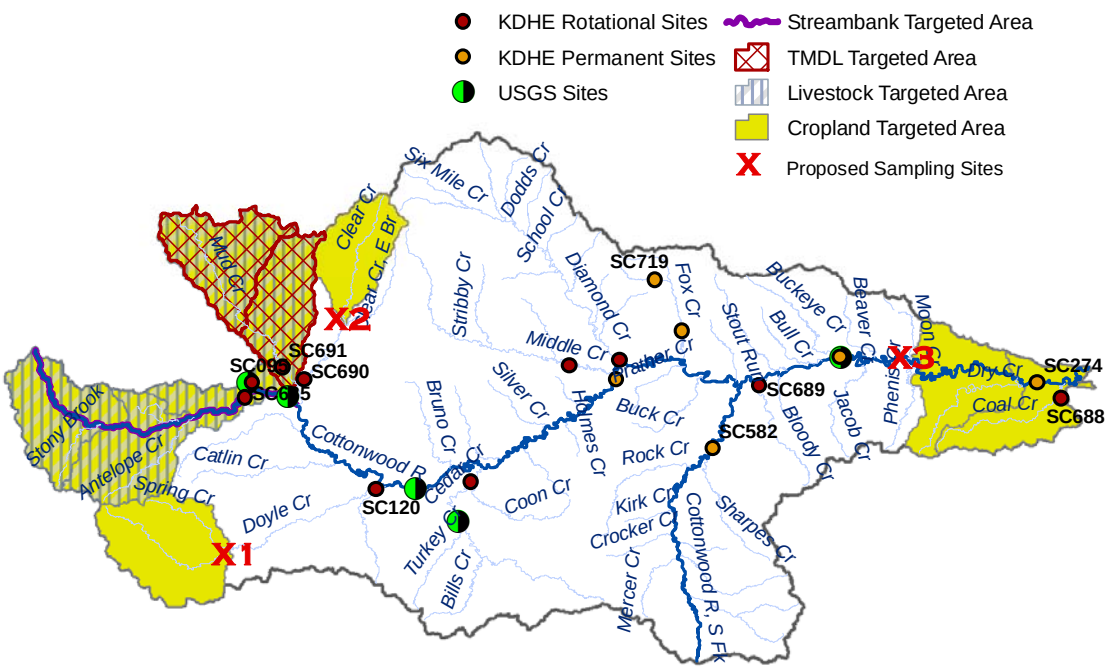



**Figure 40. Monitoring Sites in the Watershed with Proposed Sites.** [39]

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. KDHE will be requested to provide additional monitoring sites needing to be installed. The cost and implementation of these sites will be dependent on funding.

**Table 45. 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 | 691 | Sediment, Phosphorus | Mud Creek | Turbidity, TSS, pH, DO, Phosphorus, Nitrogen |
| KDHE | 095 | Sediment, Phosphorus | Cottonwood River | Turbidity, TSS, pH, DO, Phosphorus, Nitrogen |
| KDHE | 635 | Sediment, Phosphorus | South Cottonwood River | Turbidity, TSS, pH, DO, Phosphorus, Nitrogen |
| KDHE | 274 | Sediment, Phosphorus | Cottonwood River | Turbidity, TSS, pH, DO, Phosphorus, Nitrogen |

| Cropland Targeted Area, cont. | | | | |
|---|---|---|---|---|
| **Agency** | **Site Number or Name** | **Pollutant Target** | **River, Stream or Lake** | **Sampling Tests Needed** |
| KDHE | 688 | Sediment, Phosphorus | Coal Creek | Turbidity, TSS, pH, DO, Phosphorus, Nitrogen |
| KDHE | Proposed Site **X1** (refer to map above) | Sediment, Phosphorus | Doyle Creek | Turbidity, TSS, pH, DO, Phosphorus, Nitrogen |
| KDHE | Proposed Site **X2** (refer to map above) | Sediment, Phosphorus | Clear Creek | Turbidity, TSS, pH, DO, Phosphorus, Nitrogen |
| KDHE | Proposed Site **X3** (refer to map above) | Sediment, Phosphorus | Cottonwood River | Turbidity, TSS, pH, DO, Phosphorus, Nitrogen |
| **Livestock Targeted Area** | | | | |
| **Agency** | **Site Number or Name** | **Pollutant Target** | **River, Stream or Lake** | **Sampling Tests Needed** |
| KDHE | 691 | Phosphorus | Mud Creek | pH, DO, Phosphorus, Nitrogen |
| KDHE | 095 | Phosphorus | Cottonwood River | pH, DO, Phosphorus, Nitrogen |
| KDHE | 635 | Phosphorus | South Cottonwood River | pH, DO, Phosphorus, Nitrogen |
| **Streambank Targeted Area** | | | | |
| **Agency** | **Site Number or Name** | **Pollutant Target** | **River, Stream or Lake** | **Sampling Tests Needed** |
| KDHE | 627 | Sediment, Phosphorus | Cottonwood River | Turbidity, TSS, pH, DO, Phosphorus, Nitrogen |
| KDHE | 275 | Sediment, Phosphorus | Cottonwood River | Turbidity, TSS, pH, DO, Phosphorus, Nitrogen |
| KDHE | 274 | Sediment, Phosphorus | Cottonwood River | Turbidity, TSS, pH, DO, Phosphorus, Nitrogen |
| KDHE | 095 | Sediment, Phosphorus | Cottonwood River below Marion Lake Dam | Turbidity, TSS, pH, DO, Phosphorus, Nitrogen |

| High Priority TMDL Targeted Area | | | | |
|---|---|---|---|---|
| **Agency** | **Site Number or Name** | **Pollutant Target** | **River, Stream or Lake** | **Sampling Tests Needed** |
| KDHE | 691 | *E. coli* bacteria | Mud Creek | *E. coli* bacteria |

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 and the sites in John Redmond Reservoir will benefit all 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 sites691, 095 and 635 for sediment and nutrient determination for the upper section of the targeted area. The lower section of the targeted area can utilize KDHE sampling sites 274 and 688. Portions of the upper section of the cropland targeted area could benefit with additional monitoring on streams directly exiting the targeted area:
    - Site X1 - Doyle Creek as it exits the targeted area.
    - Site X2 – Clear Creek as it exits the targeted area.
    - Site X3 – Cottonwood River as it enters the targeted area.
- The *Livestock Targeted Area* can utilize the same existing sampling sites as the cropland monitoring sites. These are site numbers 691, 095 and 635. These sampling sites should be sufficient since it drains the entire targeted area.
- The *Streambank Targeted Area* can utilize sampling site numbers 627, 275, 274, and 095.
- The High Priority Targeted Area will utilize KDHE site number 691 on Mud Creek to test for *E. coli* bacteria.

Analysis of the data generated will be used to determine effectiveness of implemented BMPs. If the SLT decides at some point in the future that more data is required, they can discuss this with KDHE. All KDHE and COE data from John Redmond Reservoir 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 accumulated by their sites on a yearly basis. 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 Cottonwood Watershed is 2013 and 2018. 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 2015

In the year 2015, the plan will be reviewed and revised according to results acquired from monitoring data. 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 2015 milestone for sediment should be based on the 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 2015 milestone for phosphorus should be based on the phosphorus concentration in the watershed.
3. The SLT will request a report from KDHE concerning the revisions of the TMDLs from 2013.
4. The SLT will request a report from KDHE, COE and Kansas Department of Wildlife and Parks on trends in water quality in John Redmond Reservoir.
5. The SLT will report on progress towards achieving the adoption rates listed in Section 9.1 of this report.
6. The SLT will report on progress towards achieving the benchmarks listed in Section 9.2 of this report.
7. The SLT will report on progress towards achieving the BMP implementations in Section 9.3 of this report.
8. The SLT will discuss impairments on the 303d list and the possibility of addressing these impairments prior to them being listed as TMDLs.
9. The SLT will discuss the effect of implementing BMPs aimed at specific TMDLs on the impairments listed on the 303d list.
10. The SLT will discuss necessary adjustments and revisions needed in the targets listed in this plan.

# 13.0 Appendix

## 13.1 Service Providers

**Table 46. Potential Service Provider Listing.**

| Organization | Programs | Purpose | Technical or Financial Assistance | Website address |
|---|---|---|---|---|
| **Environmental Protection Agency** | Clean Water State Revolving Fund Program<br><br>Watershed Protection | Provides low cost loans to communities for water pollution control activities.<br><br>To conduct holistic strategies for restoring and protecting aquatic resources based on hydrology rather than political boundaries. | Financial | www.epa.gov |
| **Flint Hills 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/ |
| **Kansas Alliance for Wetlands and Streams** | Streambank Stabilization<br>Wetland Restoration<br>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 |

| Organization | Programs and Technical Assistance | Purpose | Technical or Financial Assistance | Website address |
|---|---|---|---|---|
| **Kansas Association for Conservation and Environmental Education** | Project Learning Tree<br>WILD & WILD Aquatic WET<br>Leopold Education Project | Promotes and provides effective, non-biased and science-based environmental education to all Kansas. | Technical | www.kacee.org |
| **Kansas Dept. of Agriculture** | Watershed structures permitting. | Available for watershed districts and multipurpose small lakes development. | Technical and Financial | www.accesskansas.org/kda |
| **Kansas Dept. of Health and Environment** | **Nonpoint Source Pollution Program**<br>Municipal and livestock waste<br><br>Livestock waste<br>Municipal waste<br><br>State Revolving Loan Fund | Provide funds for projects that will reduce nonpoint source pollution.<br><br>Compliance monitoring.<br><br>Makes low interest loans for projects to improve and protect water quality. | Technical and Financial | www.kdheks.ks.us |

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

| Organization | Programs and Technical Assistance | Purpose | Technical or Financial Assistance | Website address |
|---|---|---|---|---|
| **Kansas Forest Service** | Conservation Tree Planting Program<br><br>Riparian and Wetland Protection Program | Provides low cost trees and shrubs for conservation plantings.<br><br>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<br>Clean Water Farms-River Friendly Farms<br>Sustainable Food Systems Project<br>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<br><br>Kansas Center for Agricultural Resources and Environment (KCARE)<br><br>Kansas Environmental Leadership Program (KELP)<br><br>Kansas Local Government Water Quality Planning and Management<br><br>Rangeland and Natural Area Services (RNAS)<br><br>WaterLINK<br><br>Kansas Pride: Healthy Ecosystems/Healthy Communities<br><br>Citizen Science | Provide programs, expertise and educational materials that relate to minimizing the impact of rural and urban activities on water quality.<br><br>Educational program to develop leadership for improved water quality.<br><br>Provide guidance to local governments on water protection programs.<br><br>Reduce non-point source pollution emanating from Kansas grasslands.<br><br>Service-learning projects available to college and university faculty and community watersheds in Kansas.<br><br>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.<br><br>Education combined with volunteer soil and water testing for enhanced natural resource stewardship. | Technical | www.ksre.ksu.edu |

| 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 |

| Organization | Programs and Technical Assistance | Purpose | Technical or Financial Assistance | Website address |
|---|---|---|---|---|
| **Division of Conservation and Conservation Districts** | Water Resources Cost Share | Provide cost share assistance to landowners for establishment of water conservation practices. | Technical and Financial | www.ksda.gov/doc/<br><br>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<br><br>Environmental Restoration | Assistance in development of plans for development, utilization and conservation of water and related land resources of drainage<br><br>Funding assistance for aquatic ecosystem restoration. | Technical | www.usace.army.mil |
| **US Fish and Wildlife Service** | Fish and Wildlife Enhancement Program<br><br>Private Lands Program | Supports field operations which include technical assistance on wetland design.<br><br>Contracts to restore, enhance, or create wetlands. | Technical | www.fws.gov |
| **US Geological Survey** | National Streamflow Information Program<br><br>Water Cooperative Program | Provide streamflow data<br><br>Provide cooperative studies and water-quality information | Technical | ks.water.usgs.gov<br><br>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 | Primarily for the technical assistance to develop conservation plans on cropland. | Technical and Financial | www.ks.nrcs.usda.gov |
| | Conservation Operations | To provide technical assistance on private land for development and application of Resource Management Plans. | | |
| | Watershed Planning and Operations | Primarily focused on high priority areas where agricultural improvements will meet water quality objectives. | | |
| | Wetland Reserve Program | Cost share and easements to restore wetlands. | | |
| | Wildlife Habitat Incentives Program | Cost share to establish wildlife habitat which includes wetlands and riparian areas. | | |
| | Grassland Reserve Program, EQIP, and Conservation Reserve Program | Improve and protect rangeland resources with cost-sharing practices, rental agreements, and easement purchases. | | |

## 13.2 BMP Definitions

***** (reduction explanations are provided on pages 40-41)***

**Cropland**

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.

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.

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

Nutrient Management Plan
-Managing the amount, source, placement, form and timing of the application of nutrients and soil amendments.
-Intensive soil testing
-25% erosion and 25% P reduction efficiency.
-WRAPS groups and KSU Ag Economists have decided $7.30 an acre for 10 years is an adequate payment to entice producers to convert, 50% cost-share is available from NRCS.

Subsurface Fertilizer Application
-Placing or injecting fertilizer beneath the soil surface.
-Reduces fertilizer runoff.
-0% soil and 50% P reduction efficiency.
-$3.50 an acre for 10 years, no cost-share.
-WRAPS groups and KSU Ag Economists have decided $3.50 an acre for 10 years is an adequate payment to entice producers to convert, 50% cost-share is 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 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.

Pond
-Water impoundment made by constructing an earthen dam.

-Traps sediment and nutrients from leaving edge of pasture.
-Provides source of water.
-50% P Reduction.
-Approximately $12,000

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.

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.

## 13.3 Sub Watershed Tables

### 13.3.1 Load Reduction Rates by Sub Watershed

**Table 47. Sediment Reduction Rates by Sub Watershed.**

**Sub Watershed #15 Annual Soil Erosion Reduction (tons), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 12 | 37 | 104 | 46 | 14 | 44 | 257 |
| 2 | 23 | 74 | 208 | 93 | 28 | 88 | 514 |
| 3 | 35 | 111 | 312 | 139 | 42 | 132 | 770 |
| 4 | 46 | 148 | 416 | 185 | 56 | 176 | 1,027 |
| 5 | 58 | 185 | 520 | 231 | 69 | 220 | 1,284 |
| 6 | 69 | 222 | 625 | 278 | 83 | 264 | 1,541 |
| 7 | 81 | 259 | 729 | 324 | 97 | 308 | 1,797 |
| 8 | 93 | 296 | 833 | 370 | 111 | 352 | 2,054 |
| 9 | 104 | 333 | 937 | 416 | 125 | 396 | 2,311 |
| 10 | 116 | 370 | 1,041 | 463 | 139 | 440 | 2,568 |
| 11 | 127 | 407 | 1,145 | 509 | 153 | 483 | 2,824 |
| 12 | 139 | 444 | 1,249 | 555 | 167 | 527 | 3,081 |
| 13 | 150 | 481 | 1,353 | 601 | 180 | 571 | 3,338 |
| 14 | 162 | 518 | 1,457 | 648 | 194 | 615 | 3,595 |
| 15 | 173 | 555 | 1,561 | 694 | 208 | 659 | 3,852 |
| 16 | 185 | 592 | 1,666 | 740 | 222 | 703 | 4,108 |
| 17 | 197 | 629 | 1,770 | 786 | 236 | 747 | 4,365 |
| 18 | 208 | 666 | 1,874 | 833 | 250 | 791 | 4,622 |
| 19 | 220 | 703 | 1,978 | 879 | 264 | 835 | 4,879 |
| 20 | 231 | 740 | 2,082 | 925 | 278 | 879 | 5,135 |
| 21 | 231 | 777 | 2,151 | 972 | 278 | 879 | 5,288 |
| 22 | 231 | 814 | 2,221 | 1,018 | 278 | 879 | 5,441 |
| 23 | 231 | 851 | 2,290 | 1,064 | 278 | 879 | 5,593 |
| 24 | 231 | 888 | 2,359 | 1,110 | 278 | 879 | 5,746 |
| 25 | 231 | 925 | 2,429 | 1,157 | 278 | 879 | 5,899 |
| 26 | 231 | 962 | 2,498 | 1,203 | 278 | 879 | 6,051 |
| 27 | 231 | 999 | 2,568 | 1,249 | 278 | 879 | 6,204 |
| 28 | 231 | 1,036 | 2,637 | 1,295 | 278 | 879 | 6,357 |
| 29 | 231 | 1,073 | 2,706 | 1,342 | 278 | 879 | 6,509 |
| 30 | 231 | 1,110 | 2,776 | 1,388 | 278 | 879 | 6,662 |
| 31 | 231 | 1,147 | 2,845 | 1,434 | 278 | 879 | 6,815 |
| 32 | 231 | 1,184 | 2,915 | 1,480 | 278 | 879 | 6,967 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 33 | 231 | 1,221 | 2,984 | 1,527 | 278 | 879 | 7,120 |
| 34 | 231 | 1,258 | 3,053 | 1,573 | 278 | 879 | 7,273 |
| 35 | 231 | 1,295 | 3,123 | 1,619 | 278 | 879 | 7,425 |
| 36 | 231 | 1,332 | 3,192 | 1,666 | 278 | 879 | 7,578 |
| 37 | 231 | 1,369 | 3,262 | 1,712 | 278 | 879 | 7,731 |
| 38 | 231 | 1,406 | 3,331 | 1,758 | 278 | 879 | 7,883 |
| 39 | 231 | 1,443 | 3,400 | 1,804 | 278 | 879 | 8,036 |
| 40 | 231 | 1,480 | 3,470 | 1,851 | 278 | 879 | 8,189 |

**Sub Watershed #16 Annual Soil Erosion Reduction (tons), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 26 | 84 | 237 | 105 | 32 | 100 | 584 |
| 2 | 53 | 168 | 474 | 211 | 63 | 200 | 1,169 |
| 3 | 79 | 253 | 711 | 316 | 95 | 300 | 1,753 |
| 4 | 105 | 337 | 948 | 421 | 126 | 400 | 2,338 |
| 5 | 132 | 421 | 1,185 | 527 | 158 | 500 | 2,922 |
| 6 | 158 | 505 | 1,422 | 632 | 190 | 600 | 3,507 |
| 7 | 184 | 590 | 1,659 | 737 | 221 | 700 | 4,091 |
| 8 | 211 | 674 | 1,895 | 842 | 253 | 800 | 4,675 |
| 9 | 237 | 758 | 2,132 | 948 | 284 | 900 | 5,260 |
| 10 | 263 | 842 | 2,369 | 1,053 | 316 | 1,000 | 5,844 |
| 11 | 290 | 927 | 2,606 | 1,158 | 347 | 1,100 | 6,429 |
| 12 | 316 | 1,011 | 2,843 | 1,264 | 379 | 1,200 | 7,013 |
| 13 | 342 | 1,095 | 3,080 | 1,369 | 411 | 1,300 | 7,598 |
| 14 | 369 | 1,179 | 3,317 | 1,474 | 442 | 1,401 | 8,182 |
| 15 | 395 | 1,264 | 3,554 | 1,580 | 474 | 1,501 | 8,766 |
| 16 | 421 | 1,348 | 3,791 | 1,685 | 505 | 1,601 | 9,351 |
| 17 | 448 | 1,432 | 4,028 | 1,790 | 537 | 1,701 | 9,935 |
| 18 | 474 | 1,516 | 4,265 | 1,895 | 569 | 1,801 | 10,520 |
| 19 | 500 | 1,601 | 4,502 | 2,001 | 600 | 1,901 | 11,104 |
| 20 | 527 | 1,685 | 4,739 | 2,106 | 632 | 2,001 | 11,689 |
| 21 | 527 | 1,769 | 4,897 | 2,211 | 632 | 2,001 | 12,036 |
| 22 | 527 | 1,853 | 5,055 | 2,317 | 632 | 2,001 | 12,384 |
| 23 | 527 | 1,938 | 5,212 | 2,422 | 632 | 2,001 | 12,731 |
| 24 | 527 | 2,022 | 5,370 | 2,527 | 632 | 2,001 | 13,079 |
| 25 | 527 | 2,106 | 5,528 | 2,633 | 632 | 2,001 | 13,426 |
| 26 | 527 | 2,190 | 5,686 | 2,738 | 632 | 2,001 | 13,774 |
| 27 | 527 | 2,275 | 5,844 | 2,843 | 632 | 2,001 | 14,121 |
| 28 | 527 | 2,359 | 6,002 | 2,948 | 632 | 2,001 | 14,469 |
| 29 | 527 | 2,443 | 6,160 | 3,054 | 632 | 2,001 | 14,816 |
| 30 | 527 | 2,527 | 6,318 | 3,159 | 632 | 2,001 | 15,164 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 31 | 527 | 2,612 | 6,476 | 3,264 | 632 | 2,001 | 15,511 |
| 32 | 527 | 2,696 | 6,634 | 3,370 | 632 | 2,001 | 15,859 |
| 33 | 527 | 2,780 | 6,792 | 3,475 | 632 | 2,001 | 16,206 |
| 34 | 527 | 2,864 | 6,950 | 3,580 | 632 | 2,001 | 16,554 |
| 35 | 527 | 2,948 | 7,108 | 3,686 | 632 | 2,001 | 16,901 |
| 36 | 527 | 3,033 | 7,266 | 3,791 | 632 | 2,001 | 17,249 |
| 37 | 527 | 3,117 | 7,424 | 3,896 | 632 | 2,001 | 17,596 |
| 38 | 527 | 3,201 | 7,582 | 4,002 | 632 | 2,001 | 17,944 |
| 39 | 527 | 3,285 | 7,740 | 4,107 | 632 | 2,001 | 18,291 |
| 40 | 527 | 3,370 | 7,898 | 4,212 | 632 | 2,001 | 18,639 |

**Sub Watershed #25 Annual Soil Erosion Reduction (tons), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 7 | 0 | 65 | 29 | 0 | 28 | 129 |
| 2 | 15 | 0 | 131 | 58 | 0 | 55 | 259 |
| 3 | 22 | 0 | 196 | 87 | 0 | 83 | 388 |
| 4 | 29 | 0 | 262 | 116 | 0 | 110 | 517 |
| 5 | 36 | 0 | 327 | 145 | 0 | 138 | 647 |
| 6 | 44 | 0 | 392 | 174 | 0 | 166 | 776 |
| 7 | 51 | 0 | 458 | 203 | 0 | 193 | 905 |
| 8 | 58 | 0 | 523 | 233 | 0 | 221 | 1,035 |
| 9 | 65 | 0 | 588 | 262 | 0 | 248 | 1,164 |
| 10 | 73 | 0 | 654 | 291 | 0 | 276 | 1,293 |
| 11 | 80 | 0 | 719 | 320 | 0 | 304 | 1,422 |
| 12 | 87 | 0 | 785 | 349 | 0 | 331 | 1,552 |
| 13 | 94 | 0 | 850 | 378 | 0 | 359 | 1,681 |
| 14 | 102 | 0 | 915 | 407 | 0 | 386 | 1,810 |
| 15 | 109 | 0 | 981 | 436 | 0 | 414 | 1,940 |
| 16 | 116 | 0 | 1,046 | 465 | 0 | 442 | 2,069 |
| 17 | 123 | 0 | 1,112 | 494 | 0 | 469 | 2,198 |
| 18 | 131 | 0 | 1,177 | 523 | 0 | 497 | 2,328 |
| 19 | 138 | 0 | 1,242 | 552 | 0 | 524 | 2,457 |
| 20 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 21 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 22 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 23 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 24 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 25 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 26 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 27 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 28 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 29 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 30 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 31 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 32 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 33 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 34 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 35 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 36 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 37 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 38 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 39 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |
| 40 | 145 | 0 | 1,308 | 581 | 0 | 552 | 2,586 |

**Sub Watershed #28 Annual Soil Erosion Reduction (tons), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 7 | 0 | 63 | 28 | 0 | 27 | 125 |
| 2 | 14 | 0 | 127 | 56 | 0 | 54 | 251 |
| 3 | 21 | 0 | 190 | 84 | 0 | 80 | 376 |
| 4 | 28 | 0 | 254 | 112 | 0 | 107 | 501 |
| 5 | 35 | 0 | 317 | 140 | 0 | 134 | 627 |
| 6 | 42 | 0 | 381 | 168 | 0 | 161 | 752 |
| 7 | 49 | 0 | 444 | 196 | 0 | 188 | 877 |
| 8 | 56 | 0 | 508 | 224 | 0 | 214 | 1,003 |
| 9 | 63 | 0 | 571 | 252 | 0 | 241 | 1,128 |
| 10 | 71 | 0 | 635 | 280 | 0 | 268 | 1,253 |
| 11 | 78 | 0 | 698 | 308 | 0 | 295 | 1,379 |
| 12 | 85 | 0 | 762 | 336 | 0 | 321 | 1,504 |
| 13 | 92 | 0 | 825 | 364 | 0 | 348 | 1,629 |
| 14 | 99 | 0 | 889 | 392 | 0 | 375 | 1,754 |
| 15 | 106 | 0 | 952 | 420 | 0 | 402 | 1,880 |
| 16 | 113 | 0 | 1,016 | 448 | 0 | 429 | 2,005 |
| 17 | 120 | 0 | 1,079 | 476 | 0 | 455 | 2,130 |
| 18 | 127 | 0 | 1,143 | 504 | 0 | 482 | 2,256 |
| 19 | 134 | 0 | 1,206 | 532 | 0 | 509 | 2,381 |
| 20 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 21 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 22 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 23 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 24 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 25 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 26 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 27 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 28 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 29 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 30 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 31 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 32 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 33 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 34 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 35 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 36 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 37 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 38 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 39 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |
| 40 | 141 | 0 | 1,270 | 560 | 0 | 536 | 2,506 |

**Sub Watershed #31 Annual Soil Erosion Reduction (tons), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 18 | 58 | 164 | 73 | 22 | 69 | 405 |
| 2 | 36 | 117 | 328 | 146 | 44 | 139 | 809 |
| 3 | 55 | 175 | 492 | 219 | 66 | 208 | 1,214 |
| 4 | 73 | 233 | 656 | 292 | 87 | 277 | 1,618 |
| 5 | 91 | 292 | 820 | 364 | 109 | 346 | 2,023 |
| 6 | 109 | 350 | 984 | 437 | 131 | 416 | 2,427 |
| 7 | 128 | 408 | 1,148 | 510 | 153 | 485 | 2,832 |
| 8 | 146 | 467 | 1,312 | 583 | 175 | 554 | 3,237 |
| 9 | 164 | 525 | 1,476 | 656 | 197 | 623 | 3,641 |
| 10 | 182 | 583 | 1,640 | 729 | 219 | 693 | 4,046 |
| 11 | 200 | 641 | 1,804 | 802 | 241 | 762 | 4,450 |
| 12 | 219 | 700 | 1,968 | 875 | 262 | 831 | 4,855 |
| 13 | 237 | 758 | 2,132 | 948 | 284 | 900 | 5,259 |
| 14 | 255 | 816 | 2,296 | 1,021 | 306 | 970 | 5,664 |
| 15 | 273 | 875 | 2,460 | 1,093 | 328 | 1,039 | 6,069 |
| 16 | 292 | 933 | 2,624 | 1,166 | 350 | 1,108 | 6,473 |
| 17 | 310 | 991 | 2,788 | 1,239 | 372 | 1,177 | 6,878 |
| 18 | 328 | 1,050 | 2,952 | 1,312 | 394 | 1,247 | 7,282 |
| 19 | 346 | 1,108 | 3,116 | 1,385 | 416 | 1,316 | 7,687 |
| 20 | 364 | 1,166 | 3,280 | 1,458 | 437 | 1,385 | 8,091 |
| 21 | 364 | 1,225 | 3,390 | 1,531 | 437 | 1,385 | 8,332 |
| 22 | 364 | 1,283 | 3,499 | 1,604 | 437 | 1,385 | 8,572 |
| 23 | 364 | 1,341 | 3,608 | 1,677 | 437 | 1,385 | 8,813 |
| 24 | 364 | 1,400 | 3,718 | 1,749 | 437 | 1,385 | 9,054 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 25 | 364 | 1,458 | 3,827 | 1,822 | 437 | 1,385 | 9,294 |
| 26 | 364 | 1,516 | 3,936 | 1,895 | 437 | 1,385 | 9,535 |
| 27 | 364 | 1,575 | 4,046 | 1,968 | 437 | 1,385 | 9,775 |
| 28 | 364 | 1,633 | 4,155 | 2,041 | 437 | 1,385 | 10,016 |
| 29 | 364 | 1,691 | 4,264 | 2,114 | 437 | 1,385 | 10,256 |
| 30 | 364 | 1,749 | 4,374 | 2,187 | 437 | 1,385 | 10,497 |
| 31 | 364 | 1,808 | 4,483 | 2,260 | 437 | 1,385 | 10,737 |
| 32 | 364 | 1,866 | 4,592 | 2,333 | 437 | 1,385 | 10,978 |
| 33 | 364 | 1,924 | 4,702 | 2,406 | 437 | 1,385 | 11,219 |
| 34 | 364 | 1,983 | 4,811 | 2,478 | 437 | 1,385 | 11,459 |
| 35 | 364 | 2,041 | 4,920 | 2,551 | 437 | 1,385 | 11,700 |
| 36 | 364 | 2,099 | 5,030 | 2,624 | 437 | 1,385 | 11,940 |
| 37 | 364 | 2,158 | 5,139 | 2,697 | 437 | 1,385 | 12,181 |
| 38 | 364 | 2,216 | 5,248 | 2,770 | 437 | 1,385 | 12,421 |
| 39 | 364 | 2,274 | 5,358 | 2,843 | 437 | 1,385 | 12,662 |
| 40 | 364 | 2,333 | 5,467 | 2,916 | 437 | 1,385 | 12,902 |

**Sub Watershed #33 Annual Soil Erosion Reduction (tons), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 10 | 31 | 88 | 39 | 12 | 37 | 218 |
| 2 | 20 | 63 | 177 | 79 | 24 | 75 | 436 |
| 3 | 29 | 94 | 265 | 118 | 35 | 112 | 654 |
| 4 | 39 | 126 | 353 | 157 | 47 | 149 | 872 |
| 5 | 49 | 157 | 442 | 196 | 59 | 186 | 1,090 |
| 6 | 59 | 188 | 530 | 236 | 71 | 224 | 1,307 |
| 7 | 69 | 220 | 618 | 275 | 82 | 261 | 1,525 |
| 8 | 79 | 251 | 707 | 314 | 94 | 298 | 1,743 |
| 9 | 88 | 283 | 795 | 353 | 106 | 336 | 1,961 |
| 10 | 98 | 314 | 883 | 393 | 118 | 373 | 2,179 |
| 11 | 108 | 346 | 972 | 432 | 130 | 410 | 2,397 |
| 12 | 118 | 377 | 1,060 | 471 | 141 | 448 | 2,615 |
| 13 | 128 | 408 | 1,148 | 510 | 153 | 485 | 2,833 |
| 14 | 137 | 440 | 1,237 | 550 | 165 | 522 | 3,051 |
| 15 | 147 | 471 | 1,325 | 589 | 177 | 559 | 3,269 |
| 16 | 157 | 503 | 1,413 | 628 | 188 | 597 | 3,487 |
| 17 | 167 | 534 | 1,502 | 667 | 200 | 634 | 3,704 |
| 18 | 177 | 565 | 1,590 | 707 | 212 | 671 | 3,922 |
| 19 | 186 | 597 | 1,678 | 746 | 224 | 709 | 4,140 |
| 20 | 196 | 628 | 1,767 | 785 | 236 | 746 | 4,358 |
| 21 | 196 | 660 | 1,826 | 825 | 236 | 746 | 4,488 |
| 22 | 196 | 691 | 1,885 | 864 | 236 | 746 | 4,617 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 23 | 196 | 722 | 1,943 | 903 | 236 | 746 | 4,747 |
| 24 | 196 | 754 | 2,002 | 942 | 236 | 746 | 4,876 |
| 25 | 196 | 785 | 2,061 | 982 | 236 | 746 | 5,006 |
| 26 | 196 | 817 | 2,120 | 1,021 | 236 | 746 | 5,136 |
| 27 | 196 | 848 | 2,179 | 1,060 | 236 | 746 | 5,265 |
| 28 | 196 | 879 | 2,238 | 1,099 | 236 | 746 | 5,395 |
| 29 | 196 | 911 | 2,297 | 1,139 | 236 | 746 | 5,524 |
| 30 | 196 | 942 | 2,356 | 1,178 | 236 | 746 | 5,654 |
| 31 | 196 | 974 | 2,415 | 1,217 | 236 | 746 | 5,783 |
| 32 | 196 | 1,005 | 2,474 | 1,256 | 236 | 746 | 5,913 |
| 33 | 196 | 1,037 | 2,532 | 1,296 | 236 | 746 | 6,042 |
| 34 | 196 | 1,068 | 2,591 | 1,335 | 236 | 746 | 6,172 |
| 35 | 196 | 1,099 | 2,650 | 1,374 | 236 | 746 | 6,302 |
| 36 | 196 | 1,131 | 2,709 | 1,413 | 236 | 746 | 6,431 |
| 37 | 196 | 1,162 | 2,768 | 1,453 | 236 | 746 | 6,561 |
| 38 | 196 | 1,194 | 2,827 | 1,492 | 236 | 746 | 6,690 |
| 39 | 196 | 1,225 | 2,886 | 1,531 | 236 | 746 | 6,820 |
| 40 | 196 | 1,256 | 2,945 | 1,571 | 236 | 746 | 6,949 |

**Sub Watershed #35 Annual Soil Erosion Reduction (tons), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 35 | 112 | 316 | 140 | 42 | 133 | 779 |
| 2 | 70 | 224 | 631 | 281 | 84 | 267 | 1,557 |
| 3 | 105 | 337 | 947 | 421 | 126 | 400 | 2,336 |
| 4 | 140 | 449 | 1,262 | 561 | 168 | 533 | 3,114 |
| 5 | 175 | 561 | 1,578 | 701 | 210 | 666 | 3,893 |
| 6 | 210 | 673 | 1,894 | 842 | 252 | 800 | 4,671 |
| 7 | 245 | 786 | 2,209 | 982 | 295 | 933 | 5,450 |
| 8 | 281 | 898 | 2,525 | 1,122 | 337 | 1,066 | 6,228 |
| 9 | 316 | 1,010 | 2,841 | 1,262 | 379 | 1,199 | 7,007 |
| 10 | 351 | 1,122 | 3,156 | 1,403 | 421 | 1,333 | 7,785 |
| 11 | 386 | 1,234 | 3,472 | 1,543 | 463 | 1,466 | 8,564 |
| 12 | 421 | 1,347 | 3,787 | 1,683 | 505 | 1,599 | 9,342 |
| 13 | 456 | 1,459 | 4,103 | 1,824 | 547 | 1,732 | 10,121 |
| 14 | 491 | 1,571 | 4,419 | 1,964 | 589 | 1,866 | 10,899 |
| 15 | 526 | 1,683 | 4,734 | 2,104 | 631 | 1,999 | 11,678 |
| 16 | 561 | 1,795 | 5,050 | 2,244 | 673 | 2,132 | 12,456 |
| 17 | 596 | 1,908 | 5,365 | 2,385 | 715 | 2,265 | 13,235 |
| 18 | 631 | 2,020 | 5,681 | 2,525 | 757 | 2,399 | 14,013 |
| 19 | 666 | 2,132 | 5,997 | 2,665 | 800 | 2,532 | 14,792 |
| 20 | 701 | 2,244 | 6,312 | 2,805 | 842 | 2,665 | 15,570 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 21 | 701 | 2,357 | 6,523 | 2,946 | 842 | 2,665 | 16,033 |
| 22 | 701 | 2,469 | 6,733 | 3,086 | 842 | 2,665 | 16,496 |
| 23 | 701 | 2,581 | 6,943 | 3,226 | 842 | 2,665 | 16,959 |
| 24 | 701 | 2,693 | 7,154 | 3,367 | 842 | 2,665 | 17,422 |
| 25 | 701 | 2,805 | 7,364 | 3,507 | 842 | 2,665 | 17,885 |
| 26 | 701 | 2,918 | 7,575 | 3,647 | 842 | 2,665 | 18,348 |
| 27 | 701 | 3,030 | 7,785 | 3,787 | 842 | 2,665 | 18,810 |
| 28 | 701 | 3,142 | 7,996 | 3,928 | 842 | 2,665 | 19,273 |
| 29 | 701 | 3,254 | 8,206 | 4,068 | 842 | 2,665 | 19,736 |
| 30 | 701 | 3,367 | 8,416 | 4,208 | 842 | 2,665 | 20,199 |
| 31 | 701 | 3,479 | 8,627 | 4,348 | 842 | 2,665 | 20,662 |
| 32 | 701 | 3,591 | 8,837 | 4,489 | 842 | 2,665 | 21,125 |
| 33 | 701 | 3,703 | 9,048 | 4,629 | 842 | 2,665 | 21,588 |
| 34 | 701 | 3,815 | 9,258 | 4,769 | 842 | 2,665 | 22,051 |
| 35 | 701 | 3,928 | 9,468 | 4,910 | 842 | 2,665 | 22,514 |
| 36 | 701 | 4,040 | 9,679 | 5,050 | 842 | 2,665 | 22,977 |
| 37 | 701 | 4,152 | 9,889 | 5,190 | 842 | 2,665 | 23,439 |
| 38 | 701 | 4,264 | 10,100 | 5,330 | 842 | 2,665 | 23,902 |
| 39 | 701 | 4,376 | 10,310 | 5,471 | 842 | 2,665 | 24,365 |
| 40 | 701 | 4,489 | 10,520 | 5,611 | 842 | 2,665 | 24,828 |

**Sub Watershed #38 Annual Soil Erosion Reduction (tons), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 30 | 96 | 271 | 120 | 36 | 114 | 668 |
| 2 | 60 | 193 | 542 | 241 | 72 | 229 | 1,336 |
| 3 | 90 | 289 | 813 | 361 | 108 | 343 | 2,004 |
| 4 | 120 | 385 | 1,083 | 481 | 144 | 457 | 2,672 |
| 5 | 150 | 481 | 1,354 | 602 | 181 | 572 | 3,340 |
| 6 | 181 | 578 | 1,625 | 722 | 217 | 686 | 4,008 |
| 7 | 211 | 674 | 1,896 | 843 | 253 | 800 | 4,676 |
| 8 | 241 | 770 | 2,167 | 963 | 289 | 915 | 5,345 |
| 9 | 271 | 867 | 2,438 | 1,083 | 325 | 1,029 | 6,013 |
| 10 | 301 | 963 | 2,708 | 1,204 | 361 | 1,144 | 6,681 |
| 11 | 331 | 1,059 | 2,979 | 1,324 | 397 | 1,258 | 7,349 |
| 12 | 361 | 1,156 | 3,250 | 1,444 | 433 | 1,372 | 8,017 |
| 13 | 391 | 1,252 | 3,521 | 1,565 | 469 | 1,487 | 8,685 |
| 14 | 421 | 1,348 | 3,792 | 1,685 | 506 | 1,601 | 9,353 |
| 15 | 451 | 1,444 | 4,063 | 1,806 | 542 | 1,715 | 10,021 |
| 16 | 481 | 1,541 | 4,333 | 1,926 | 578 | 1,830 | 10,689 |
| 17 | 512 | 1,637 | 4,604 | 2,046 | 614 | 1,944 | 11,357 |
| 18 | 542 | 1,733 | 4,875 | 2,167 | 650 | 2,058 | 12,025 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 19 | 572 | 1,830 | 5,146 | 2,287 | 686 | 2,173 | 12,693 |
| 20 | 602 | 1,926 | 5,417 | 2,407 | 722 | 2,287 | 13,361 |
| 21 | 602 | 2,022 | 5,597 | 2,528 | 722 | 2,287 | 13,759 |
| 22 | 602 | 2,119 | 5,778 | 2,648 | 722 | 2,287 | 14,156 |
| 23 | 602 | 2,215 | 5,958 | 2,769 | 722 | 2,287 | 14,553 |
| 24 | 602 | 2,311 | 6,139 | 2,889 | 722 | 2,287 | 14,950 |
| 25 | 602 | 2,407 | 6,320 | 3,009 | 722 | 2,287 | 15,347 |
| 26 | 602 | 2,504 | 6,500 | 3,130 | 722 | 2,287 | 15,745 |
| 27 | 602 | 2,600 | 6,681 | 3,250 | 722 | 2,287 | 16,142 |
| 28 | 602 | 2,696 | 6,861 | 3,370 | 722 | 2,287 | 16,539 |
| 29 | 602 | 2,793 | 7,042 | 3,491 | 722 | 2,287 | 16,936 |
| 30 | 602 | 2,889 | 7,222 | 3,611 | 722 | 2,287 | 17,334 |
| 31 | 602 | 2,985 | 7,403 | 3,732 | 722 | 2,287 | 17,731 |
| 32 | 602 | 3,082 | 7,583 | 3,852 | 722 | 2,287 | 18,128 |
| 33 | 602 | 3,178 | 7,764 | 3,972 | 722 | 2,287 | 18,525 |
| 34 | 602 | 3,274 | 7,945 | 4,093 | 722 | 2,287 | 18,922 |
| 35 | 602 | 3,370 | 8,125 | 4,213 | 722 | 2,287 | 19,320 |
| 36 | 602 | 3,467 | 8,306 | 4,333 | 722 | 2,287 | 19,717 |
| 37 | 602 | 3,563 | 8,486 | 4,454 | 722 | 2,287 | 20,114 |
| 38 | 602 | 3,659 | 8,667 | 4,574 | 722 | 2,287 | 20,511 |
| 39 | 602 | 3,756 | 8,847 | 4,695 | 722 | 2,287 | 20,909 |
| 40 | 602 | 3,852 | 9,028 | 4,815 | 722 | 2,287 | 21,306 |

**Sub Watershed #55 Annual Soil Erosion Reduction (tons), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 30 | 95 | 268 | 119 | 36 | 113 | 660 |
| 2 | 59 | 190 | 535 | 238 | 71 | 226 | 1,320 |
| 3 | 89 | 285 | 803 | 357 | 107 | 339 | 1,980 |
| 4 | 119 | 381 | 1,070 | 476 | 143 | 452 | 2,640 |
| 5 | 149 | 476 | 1,338 | 595 | 178 | 565 | 3,300 |
| 6 | 178 | 571 | 1,605 | 714 | 214 | 678 | 3,960 |
| 7 | 208 | 666 | 1,873 | 832 | 250 | 791 | 4,620 |
| 8 | 238 | 761 | 2,141 | 951 | 285 | 904 | 5,280 |
| 9 | 268 | 856 | 2,408 | 1,070 | 321 | 1,017 | 5,940 |
| 10 | 297 | 951 | 2,676 | 1,189 | 357 | 1,130 | 6,600 |
| 11 | 327 | 1,047 | 2,943 | 1,308 | 392 | 1,243 | 7,260 |
| 12 | 357 | 1,142 | 3,211 | 1,427 | 428 | 1,356 | 7,920 |
| 13 | 387 | 1,237 | 3,479 | 1,546 | 464 | 1,469 | 8,580 |
| 14 | 416 | 1,332 | 3,746 | 1,665 | 499 | 1,582 | 9,240 |
| 15 | 446 | 1,427 | 4,014 | 1,784 | 535 | 1,695 | 9,900 |
| 16 | 476 | 1,522 | 4,281 | 1,903 | 571 | 1,808 | 10,560 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 17 | 505 | 1,617 | 4,549 | 2,022 | 607 | 1,921 | 11,220 |
| 18 | 535 | 1,713 | 4,816 | 2,141 | 642 | 2,034 | 11,881 |
| 19 | 565 | 1,808 | 5,084 | 2,260 | 678 | 2,147 | 12,541 |
| 20 | 595 | 1,903 | 5,352 | 2,378 | 714 | 2,260 | 13,201 |
| 21 | 595 | 1,998 | 5,530 | 2,497 | 714 | 2,260 | 13,593 |
| 22 | 595 | 2,093 | 5,708 | 2,616 | 714 | 2,260 | 13,985 |
| 23 | 595 | 2,188 | 5,887 | 2,735 | 714 | 2,260 | 14,378 |
| 24 | 595 | 2,283 | 6,065 | 2,854 | 714 | 2,260 | 14,770 |
| 25 | 595 | 2,378 | 6,244 | 2,973 | 714 | 2,260 | 15,163 |
| 26 | 595 | 2,474 | 6,422 | 3,092 | 714 | 2,260 | 15,555 |
| 27 | 595 | 2,569 | 6,600 | 3,211 | 714 | 2,260 | 15,948 |
| 28 | 595 | 2,664 | 6,779 | 3,330 | 714 | 2,260 | 16,340 |
| 29 | 595 | 2,759 | 6,957 | 3,449 | 714 | 2,260 | 16,733 |
| 30 | 595 | 2,854 | 7,135 | 3,568 | 714 | 2,260 | 17,125 |
| 31 | 595 | 2,949 | 7,314 | 3,687 | 714 | 2,260 | 17,518 |
| 32 | 595 | 3,044 | 7,492 | 3,806 | 714 | 2,260 | 17,910 |
| 33 | 595 | 3,140 | 7,671 | 3,924 | 714 | 2,260 | 18,302 |
| 34 | 595 | 3,235 | 7,849 | 4,043 | 714 | 2,260 | 18,695 |
| 35 | 595 | 3,330 | 8,027 | 4,162 | 714 | 2,260 | 19,087 |
| 36 | 595 | 3,425 | 8,206 | 4,281 | 714 | 2,260 | 19,480 |
| 37 | 595 | 3,520 | 8,384 | 4,400 | 714 | 2,260 | 19,872 |
| 38 | 595 | 3,615 | 8,563 | 4,519 | 714 | 2,260 | 20,265 |
| 39 | 595 | 3,710 | 8,741 | 4,638 | 714 | 2,260 | 20,657 |
| 40 | 595 | 3,806 | 8,919 | 4,757 | 714 | 2,260 | 21,050 |

**Table 48. Phosphorus Reduction Rates by Sub Watershed.**

**Sub Watershed #15 Annual Phosphorous Reduction (lbs), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 19 | 62 | 93 | 77 | 23 | 73 | 347 |
| 2 | 39 | 123 | 185 | 154 | 46 | 147 | 694 |
| 3 | 58 | 185 | 278 | 231 | 69 | 220 | 1,041 |
| 4 | 77 | 247 | 370 | 308 | 93 | 293 | 1,388 |
| 5 | 96 | 308 | 463 | 386 | 116 | 366 | 1,735 |
| 6 | 116 | 370 | 555 | 463 | 139 | 440 | 2,082 |
| 7 | 135 | 432 | 648 | 540 | 162 | 513 | 2,429 |
| 8 | 154 | 493 | 740 | 617 | 185 | 586 | 2,776 |
| 9 | 173 | 555 | 833 | 694 | 208 | 659 | 3,123 |
| 10 | 193 | 617 | 925 | 771 | 231 | 733 | 3,470 |
| 11 | 212 | 679 | 1,018 | 848 | 254 | 806 | 3,817 |
| 12 | 231 | 740 | 1,110 | 925 | 278 | 879 | 4,164 |
| 13 | 251 | 802 | 1,203 | 1,002 | 301 | 952 | 4,511 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 14 | 270 | 864 | 1,295 | 1,080 | 324 | 1,026 | 4,858 |
| 15 | 289 | 925 | 1,388 | 1,157 | 347 | 1,099 | 5,205 |
| 16 | 308 | 987 | 1,480 | 1,234 | 370 | 1,172 | 5,552 |
| 17 | 328 | 1,049 | 1,573 | 1,311 | 393 | 1,245 | 5,899 |
| 18 | 347 | 1,110 | 1,666 | 1,388 | 416 | 1,319 | 6,246 |
| 19 | 366 | 1,172 | 1,758 | 1,465 | 440 | 1,392 | 6,593 |
| 20 | 386 | 1,234 | 1,851 | 1,542 | 463 | 1,465 | 6,940 |
| 21 | 386 | 1,295 | 1,912 | 1,619 | 463 | 1,465 | 7,140 |
| 22 | 386 | 1,357 | 1,974 | 1,696 | 463 | 1,465 | 7,341 |
| 23 | 386 | 1,419 | 2,036 | 1,773 | 463 | 1,465 | 7,541 |
| 24 | 386 | 1,480 | 2,097 | 1,851 | 463 | 1,465 | 7,742 |
| 25 | 386 | 1,542 | 2,159 | 1,928 | 463 | 1,465 | 7,942 |
| 26 | 386 | 1,604 | 2,221 | 2,005 | 463 | 1,465 | 8,143 |
| 27 | 386 | 1,666 | 2,282 | 2,082 | 463 | 1,465 | 8,343 |
| 28 | 386 | 1,727 | 2,344 | 2,159 | 463 | 1,465 | 8,544 |
| 29 | 386 | 1,789 | 2,406 | 2,236 | 463 | 1,465 | 8,744 |
| 30 | 386 | 1,851 | 2,467 | 2,313 | 463 | 1,465 | 8,944 |
| 31 | 386 | 1,912 | 2,529 | 2,390 | 463 | 1,465 | 9,145 |
| 32 | 386 | 1,974 | 2,591 | 2,467 | 463 | 1,465 | 9,345 |
| 33 | 386 | 2,036 | 2,652 | 2,545 | 463 | 1,465 | 9,546 |
| 34 | 386 | 2,097 | 2,714 | 2,622 | 463 | 1,465 | 9,746 |
| 35 | 386 | 2,159 | 2,776 | 2,699 | 463 | 1,465 | 9,947 |
| 36 | 386 | 2,221 | 2,838 | 2,776 | 463 | 1,465 | 10,147 |
| 37 | 386 | 2,282 | 2,899 | 2,853 | 463 | 1,465 | 10,348 |
| 38 | 386 | 2,344 | 2,961 | 2,930 | 463 | 1,465 | 10,548 |
| 39 | 386 | 2,406 | 3,023 | 3,007 | 463 | 1,465 | 10,749 |
| 40 | 386 | 2,467 | 3,084 | 3,084 | 463 | 1,465 | 10,949 |

**Sub Watershed #16 Annual Phosphorous Reduction (lbs), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 48 | 153 | 230 | 191 | 57 | 182 | 862 |
| 2 | 96 | 306 | 460 | 383 | 115 | 364 | 1,723 |
| 3 | 144 | 460 | 689 | 574 | 172 | 546 | 2,585 |
| 4 | 191 | 613 | 919 | 766 | 230 | 728 | 3,446 |
| 5 | 239 | 766 | 1,149 | 957 | 287 | 909 | 4,308 |
| 6 | 287 | 919 | 1,379 | 1,149 | 345 | 1,091 | 5,169 |
| 7 | 335 | 1,072 | 1,608 | 1,340 | 402 | 1,273 | 6,031 |
| 8 | 383 | 1,225 | 1,838 | 1,532 | 460 | 1,455 | 6,893 |
| 9 | 431 | 1,379 | 2,068 | 1,723 | 517 | 1,637 | 7,754 |
| 10 | 479 | 1,532 | 2,298 | 1,915 | 574 | 1,819 | 8,616 |
| 11 | 527 | 1,685 | 2,527 | 2,106 | 632 | 2,001 | 9,477 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12 | 574 | 1,838 | 2,757 | 2,298 | 689 | 2,183 | 10,339 |
| 13 | 622 | 1,991 | 2,987 | 2,489 | 747 | 2,365 | 11,200 |
| 14 | 670 | 2,144 | 3,217 | 2,680 | 804 | 2,546 | 12,062 |
| 15 | 718 | 2,298 | 3,446 | 2,872 | 862 | 2,728 | 12,924 |
| 16 | 766 | 2,451 | 3,676 | 3,063 | 919 | 2,910 | 13,785 |
| 17 | 814 | 2,604 | 3,906 | 3,255 | 976 | 3,092 | 14,647 |
| 18 | 862 | 2,757 | 4,136 | 3,446 | 1,034 | 3,274 | 15,508 |
| 19 | 909 | 2,910 | 4,365 | 3,638 | 1,091 | 3,456 | 16,370 |
| 20 | 957 | 3,063 | 4,595 | 3,829 | 1,149 | 3,638 | 17,231 |
| 21 | 957 | 3,217 | 4,748 | 4,021 | 1,149 | 3,638 | 17,729 |
| 22 | 957 | 3,370 | 4,901 | 4,212 | 1,149 | 3,638 | 18,227 |
| 23 | 957 | 3,523 | 5,055 | 4,404 | 1,149 | 3,638 | 18,725 |
| 24 | 957 | 3,676 | 5,208 | 4,595 | 1,149 | 3,638 | 19,223 |
| 25 | 957 | 3,829 | 5,361 | 4,787 | 1,149 | 3,638 | 19,720 |
| 26 | 957 | 3,982 | 5,514 | 4,978 | 1,149 | 3,638 | 20,218 |
| 27 | 957 | 4,136 | 5,667 | 5,169 | 1,149 | 3,638 | 20,716 |
| 28 | 957 | 4,289 | 5,820 | 5,361 | 1,149 | 3,638 | 21,214 |
| 29 | 957 | 4,442 | 5,974 | 5,552 | 1,149 | 3,638 | 21,712 |
| 30 | 957 | 4,595 | 6,127 | 5,744 | 1,149 | 3,638 | 22,209 |
| 31 | 957 | 4,748 | 6,280 | 5,935 | 1,149 | 3,638 | 22,707 |
| 32 | 957 | 4,901 | 6,433 | 6,127 | 1,149 | 3,638 | 23,205 |
| 33 | 957 | 5,055 | 6,586 | 6,318 | 1,149 | 3,638 | 23,703 |
| 34 | 957 | 5,208 | 6,739 | 6,510 | 1,149 | 3,638 | 24,201 |
| 35 | 957 | 5,361 | 6,893 | 6,701 | 1,149 | 3,638 | 24,698 |
| 36 | 957 | 5,514 | 7,046 | 6,893 | 1,149 | 3,638 | 25,196 |
| 37 | 957 | 5,667 | 7,199 | 7,084 | 1,149 | 3,638 | 25,694 |
| 38 | 957 | 5,820 | 7,352 | 7,275 | 1,149 | 3,638 | 26,192 |
| 39 | 957 | 5,974 | 7,505 | 7,467 | 1,149 | 3,638 | 26,690 |
| 40 | 957 | 6,127 | 7,658 | 7,658 | 1,149 | 3,638 | 27,187 |

**Sub Watershed #25 Annual Phosphorous Reduction (lbs), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 10 | 0 | 50 | 42 | 0 | 39 | 141 |
| 2 | 21 | 0 | 100 | 83 | 0 | 79 | 282 |
| 3 | 31 | 0 | 149 | 125 | 0 | 118 | 423 |
| 4 | 42 | 0 | 199 | 166 | 0 | 158 | 565 |
| 5 | 52 | 0 | 249 | 208 | 0 | 197 | 706 |
| 6 | 62 | 0 | 299 | 249 | 0 | 237 | 847 |
| 7 | 73 | 0 | 349 | 291 | 0 | 276 | 988 |
| 8 | 83 | 0 | 399 | 332 | 0 | 315 | 1,129 |
| 9 | 93 | 0 | 448 | 374 | 0 | 355 | 1,270 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10 | 104 | 0 | 498 | 415 | 0 | 394 | 1,411 |
| 11 | 114 | 0 | 548 | 457 | 0 | 434 | 1,553 |
| 12 | 125 | 0 | 598 | 498 | 0 | 473 | 1,694 |
| 13 | 135 | 0 | 648 | 540 | 0 | 513 | 1,835 |
| 14 | 145 | 0 | 697 | 581 | 0 | 552 | 1,976 |
| 15 | 156 | 0 | 747 | 623 | 0 | 591 | 2,117 |
| 16 | 166 | 0 | 797 | 664 | 0 | 631 | 2,258 |
| 17 | 176 | 0 | 847 | 706 | 0 | 670 | 2,399 |
| 18 | 187 | 0 | 897 | 747 | 0 | 710 | 2,541 |
| 19 | 197 | 0 | 947 | 789 | 0 | 749 | 2,682 |
| 20 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 21 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 22 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 23 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 24 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 25 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 26 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 27 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 28 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 29 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 30 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 31 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 32 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 33 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 34 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 35 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 36 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 37 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 38 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 39 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |
| 40 | 208 | 0 | 996 | 831 | 0 | 789 | 2,823 |

**Sub Watershed #28 Annual Phosphorous Reduction (lbs), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 11 | 0 | 51 | 42 | 0 | 40 | 144 |
| 2 | 21 | 0 | 102 | 84 | 0 | 80 | 287 |
| 3 | 32 | 0 | 152 | 126 | 0 | 121 | 431 |
| 4 | 42 | 0 | 203 | 168 | 0 | 161 | 574 |
| 5 | 53 | 0 | 254 | 210 | 0 | 201 | 718 |
| 6 | 63 | 0 | 305 | 252 | 0 | 241 | 861 |
| 7 | 74 | 0 | 355 | 294 | 0 | 281 | 1,005 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8 | 85 | 0 | 406 | 336 | 0 | 321 | 1,148 |
| 9 | 95 | 0 | 457 | 378 | 0 | 362 | 1,292 |
| 10 | 106 | 0 | 508 | 420 | 0 | 402 | 1,435 |
| 11 | 116 | 0 | 559 | 462 | 0 | 442 | 1,579 |
| 12 | 127 | 0 | 609 | 504 | 0 | 482 | 1,723 |
| 13 | 137 | 0 | 660 | 546 | 0 | 522 | 1,866 |
| 14 | 148 | 0 | 711 | 588 | 0 | 563 | 2,010 |
| 15 | 159 | 0 | 762 | 630 | 0 | 603 | 2,153 |
| 16 | 169 | 0 | 813 | 672 | 0 | 643 | 2,297 |
| 17 | 180 | 0 | 863 | 714 | 0 | 683 | 2,440 |
| 18 | 190 | 0 | 914 | 756 | 0 | 723 | 2,584 |
| 19 | 201 | 0 | 965 | 798 | 0 | 764 | 2,727 |
| 20 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 21 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 22 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 23 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 24 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 25 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 26 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 27 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 28 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 29 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 30 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 31 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 32 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 33 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 34 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 35 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 36 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 37 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 38 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 39 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |
| 40 | 212 | 0 | 1,016 | 840 | 0 | 804 | 2,871 |

**Sub Watershed #31 Annual Phosphorous Reduction (lbs), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 31 | 99 | 149 | 124 | 37 | 118 | 558 |
| 2 | 62 | 198 | 297 | 248 | 74 | 235 | 1,115 |
| 3 | 93 | 297 | 446 | 372 | 112 | 353 | 1,673 |
| 4 | 124 | 397 | 595 | 496 | 149 | 471 | 2,231 |
| 5 | 155 | 496 | 744 | 620 | 186 | 589 | 2,788 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6 | 186 | 595 | 892 | 744 | 223 | 706 | 3,346 |
| 7 | 217 | 694 | 1,041 | 867 | 260 | 824 | 3,904 |
| 8 | 248 | 793 | 1,190 | 991 | 297 | 942 | 4,461 |
| 9 | 279 | 892 | 1,338 | 1,115 | 335 | 1,060 | 5,019 |
| 10 | 310 | 991 | 1,487 | 1,239 | 372 | 1,177 | 5,576 |
| 11 | 341 | 1,091 | 1,636 | 1,363 | 409 | 1,295 | 6,134 |
| 12 | 372 | 1,190 | 1,784 | 1,487 | 446 | 1,413 | 6,692 |
| 13 | 403 | 1,289 | 1,933 | 1,611 | 483 | 1,530 | 7,249 |
| 14 | 434 | 1,388 | 2,082 | 1,735 | 520 | 1,648 | 7,807 |
| 15 | 465 | 1,487 | 2,231 | 1,859 | 558 | 1,766 | 8,365 |
| 16 | 496 | 1,586 | 2,379 | 1,983 | 595 | 1,884 | 8,922 |
| 17 | 527 | 1,685 | 2,528 | 2,107 | 632 | 2,001 | 9,480 |
| 18 | 558 | 1,784 | 2,677 | 2,231 | 669 | 2,119 | 10,038 |
| 19 | 589 | 1,884 | 2,825 | 2,355 | 706 | 2,237 | 10,595 |
| 20 | 620 | 1,983 | 2,974 | 2,478 | 744 | 2,355 | 11,153 |
| 21 | 620 | 2,082 | 3,073 | 2,602 | 744 | 2,355 | 11,475 |
| 22 | 620 | 2,181 | 3,172 | 2,726 | 744 | 2,355 | 11,797 |
| 23 | 620 | 2,280 | 3,272 | 2,850 | 744 | 2,355 | 12,120 |
| 24 | 620 | 2,379 | 3,371 | 2,974 | 744 | 2,355 | 12,442 |
| 25 | 620 | 2,478 | 3,470 | 3,098 | 744 | 2,355 | 12,764 |
| 26 | 620 | 2,578 | 3,569 | 3,222 | 744 | 2,355 | 13,086 |
| 27 | 620 | 2,677 | 3,668 | 3,346 | 744 | 2,355 | 13,408 |
| 28 | 620 | 2,776 | 3,767 | 3,470 | 744 | 2,355 | 13,731 |
| 29 | 620 | 2,875 | 3,866 | 3,594 | 744 | 2,355 | 14,053 |
| 30 | 620 | 2,974 | 3,965 | 3,718 | 744 | 2,355 | 14,375 |
| 31 | 620 | 3,073 | 4,065 | 3,842 | 744 | 2,355 | 14,697 |
| 32 | 620 | 3,172 | 4,164 | 3,965 | 744 | 2,355 | 15,019 |
| 33 | 620 | 3,272 | 4,263 | 4,089 | 744 | 2,355 | 15,341 |
| 34 | 620 | 3,371 | 4,362 | 4,213 | 744 | 2,355 | 15,664 |
| 35 | 620 | 3,470 | 4,461 | 4,337 | 744 | 2,355 | 15,986 |
| 36 | 620 | 3,569 | 4,560 | 4,461 | 744 | 2,355 | 16,308 |
| 37 | 620 | 3,668 | 4,659 | 4,585 | 744 | 2,355 | 16,630 |
| 38 | 620 | 3,767 | 4,759 | 4,709 | 744 | 2,355 | 16,952 |
| 39 | 620 | 3,866 | 4,858 | 4,833 | 744 | 2,355 | 17,275 |
| 40 | 620 | 3,965 | 4,957 | 4,957 | 744 | 2,355 | 17,597 |

**Sub Watershed #33 Annual Phosphorous Reduction (lbs), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 17 | 56 | 84 | 70 | 21 | 66 | 314 |
| 2 | 35 | 112 | 168 | 140 | 42 | 133 | 628 |
| 3 | 52 | 168 | 251 | 209 | 63 | 199 | 942 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 | 70 | 223 | 335 | 279 | 84 | 265 | 1,256 |
| 5 | 87 | 279 | 419 | 349 | 105 | 332 | 1,571 |
| 6 | 105 | 335 | 503 | 419 | 126 | 398 | 1,885 |
| 7 | 122 | 391 | 586 | 489 | 147 | 464 | 2,199 |
| 8 | 140 | 447 | 670 | 558 | 168 | 530 | 2,513 |
| 9 | 157 | 503 | 754 | 628 | 188 | 597 | 2,827 |
| 10 | 175 | 558 | 838 | 698 | 209 | 663 | 3,141 |
| 11 | 192 | 614 | 921 | 768 | 230 | 729 | 3,455 |
| 12 | 209 | 670 | 1,005 | 838 | 251 | 796 | 3,769 |
| 13 | 227 | 726 | 1,089 | 907 | 272 | 862 | 4,083 |
| 14 | 244 | 782 | 1,173 | 977 | 293 | 928 | 4,397 |
| 15 | 262 | 838 | 1,256 | 1,047 | 314 | 995 | 4,712 |
| 16 | 279 | 893 | 1,340 | 1,117 | 335 | 1,061 | 5,026 |
| 17 | 297 | 949 | 1,424 | 1,187 | 356 | 1,127 | 5,340 |
| 18 | 314 | 1,005 | 1,508 | 1,256 | 377 | 1,194 | 5,654 |
| 19 | 332 | 1,061 | 1,591 | 1,326 | 398 | 1,260 | 5,968 |
| 20 | 349 | 1,117 | 1,675 | 1,396 | 419 | 1,326 | 6,282 |
| 21 | 349 | 1,173 | 1,731 | 1,466 | 419 | 1,326 | 6,463 |
| 22 | 349 | 1,228 | 1,787 | 1,536 | 419 | 1,326 | 6,645 |
| 23 | 349 | 1,284 | 1,843 | 1,605 | 419 | 1,326 | 6,826 |
| 24 | 349 | 1,340 | 1,899 | 1,675 | 419 | 1,326 | 7,008 |
| 25 | 349 | 1,396 | 1,954 | 1,745 | 419 | 1,326 | 7,189 |
| 26 | 349 | 1,452 | 2,010 | 1,815 | 419 | 1,326 | 7,371 |
| 27 | 349 | 1,508 | 2,066 | 1,885 | 419 | 1,326 | 7,552 |
| 28 | 349 | 1,564 | 2,122 | 1,954 | 419 | 1,326 | 7,734 |
| 29 | 349 | 1,619 | 2,178 | 2,024 | 419 | 1,326 | 7,915 |
| 30 | 349 | 1,675 | 2,234 | 2,094 | 419 | 1,326 | 8,097 |
| 31 | 349 | 1,731 | 2,289 | 2,164 | 419 | 1,326 | 8,278 |
| 32 | 349 | 1,787 | 2,345 | 2,234 | 419 | 1,326 | 8,460 |
| 33 | 349 | 1,843 | 2,401 | 2,303 | 419 | 1,326 | 8,641 |
| 34 | 349 | 1,899 | 2,457 | 2,373 | 419 | 1,326 | 8,823 |
| 35 | 349 | 1,954 | 2,513 | 2,443 | 419 | 1,326 | 9,004 |
| 36 | 349 | 2,010 | 2,569 | 2,513 | 419 | 1,326 | 9,186 |
| 37 | 349 | 2,066 | 2,624 | 2,583 | 419 | 1,326 | 9,367 |
| 38 | 349 | 2,122 | 2,680 | 2,652 | 419 | 1,326 | 9,549 |
| 39 | 349 | 2,178 | 2,736 | 2,722 | 419 | 1,326 | 9,730 |
| 40 | 349 | 2,234 | 2,792 | 2,792 | 419 | 1,326 | 9,912 |

**Sub Watershed #35 Annual Phosphorous Reduction (lbs), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 48 | 154 | 231 | 193 | 58 | 183 | 868 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 | 96 | 309 | 463 | 386 | 116 | 366 | 1,736 |
| 3 | 145 | 463 | 694 | 579 | 174 | 550 | 2,604 |
| 4 | 193 | 617 | 926 | 771 | 231 | 733 | 3,472 |
| 5 | 241 | 771 | 1,157 | 964 | 289 | 916 | 4,340 |
| 6 | 289 | 926 | 1,389 | 1,157 | 347 | 1,099 | 5,208 |
| 7 | 338 | 1,080 | 1,620 | 1,350 | 405 | 1,283 | 6,076 |
| 8 | 386 | 1,234 | 1,852 | 1,543 | 463 | 1,466 | 6,943 |
| 9 | 434 | 1,389 | 2,083 | 1,736 | 521 | 1,649 | 7,811 |
| 10 | 482 | 1,543 | 2,314 | 1,929 | 579 | 1,832 | 8,679 |
| 11 | 530 | 1,697 | 2,546 | 2,122 | 636 | 2,016 | 9,547 |
| 12 | 579 | 1,852 | 2,777 | 2,314 | 694 | 2,199 | 10,415 |
| 13 | 627 | 2,006 | 3,009 | 2,507 | 752 | 2,382 | 11,283 |
| 14 | 675 | 2,160 | 3,240 | 2,700 | 810 | 2,565 | 12,151 |
| 15 | 723 | 2,314 | 3,472 | 2,893 | 868 | 2,748 | 13,019 |
| 16 | 771 | 2,469 | 3,703 | 3,086 | 926 | 2,932 | 13,887 |
| 17 | 820 | 2,623 | 3,935 | 3,279 | 984 | 3,115 | 14,755 |
| 18 | 868 | 2,777 | 4,166 | 3,472 | 1,042 | 3,298 | 15,623 |
| 19 | 916 | 2,932 | 4,398 | 3,665 | 1,099 | 3,481 | 16,491 |
| 20 | 964 | 3,086 | 4,629 | 3,857 | 1,157 | 3,665 | 17,359 |
| 21 | 964 | 3,240 | 4,783 | 4,050 | 1,157 | 3,665 | 17,860 |
| 22 | 964 | 3,395 | 4,938 | 4,243 | 1,157 | 3,665 | 18,362 |
| 23 | 964 | 3,549 | 5,092 | 4,436 | 1,157 | 3,665 | 18,863 |
| 24 | 964 | 3,703 | 5,246 | 4,629 | 1,157 | 3,665 | 19,365 |
| 25 | 964 | 3,857 | 5,400 | 4,822 | 1,157 | 3,665 | 19,866 |
| 26 | 964 | 4,012 | 5,555 | 5,015 | 1,157 | 3,665 | 20,367 |
| 27 | 964 | 4,166 | 5,709 | 5,208 | 1,157 | 3,665 | 20,869 |
| 28 | 964 | 4,320 | 5,863 | 5,400 | 1,157 | 3,665 | 21,370 |
| 29 | 964 | 4,475 | 6,018 | 5,593 | 1,157 | 3,665 | 21,872 |
| 30 | 964 | 4,629 | 6,172 | 5,786 | 1,157 | 3,665 | 22,373 |
| 31 | 964 | 4,783 | 6,326 | 5,979 | 1,157 | 3,665 | 22,875 |
| 32 | 964 | 4,938 | 6,481 | 6,172 | 1,157 | 3,665 | 23,376 |
| 33 | 964 | 5,092 | 6,635 | 6,365 | 1,157 | 3,665 | 23,878 |
| 34 | 964 | 5,246 | 6,789 | 6,558 | 1,157 | 3,665 | 24,379 |
| 35 | 964 | 5,400 | 6,943 | 6,751 | 1,157 | 3,665 | 24,881 |
| 36 | 964 | 5,555 | 7,098 | 6,943 | 1,157 | 3,665 | 25,382 |
| 37 | 964 | 5,709 | 7,252 | 7,136 | 1,157 | 3,665 | 25,884 |
| 38 | 964 | 5,863 | 7,406 | 7,329 | 1,157 | 3,665 | 26,385 |
| 39 | 964 | 6,018 | 7,561 | 7,522 | 1,157 | 3,665 | 26,887 |
| 40 | 964 | 6,172 | 7,715 | 7,715 | 1,157 | 3,665 | 27,388 |

**Sub Watershed #38 Annual Phosphorous Reduction (lbs), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 39 | 124 | 186 | 155 | 46 | 147 | 696 |
| 2 | 77 | 248 | 371 | 310 | 93 | 294 | 1,393 |
| 3 | 116 | 371 | 557 | 464 | 139 | 441 | 2,089 |
| 4 | 155 | 495 | 743 | 619 | 186 | 588 | 2,786 |
| 5 | 193 | 619 | 929 | 774 | 232 | 735 | 3,482 |
| 6 | 232 | 743 | 1,114 | 929 | 279 | 882 | 4,179 |
| 7 | 271 | 867 | 1,300 | 1,083 | 325 | 1,029 | 4,875 |
| 8 | 310 | 990 | 1,486 | 1,238 | 371 | 1,176 | 5,572 |
| 9 | 348 | 1,114 | 1,671 | 1,393 | 418 | 1,323 | 6,268 |
| 10 | 387 | 1,238 | 1,857 | 1,548 | 464 | 1,470 | 6,964 |
| 11 | 426 | 1,362 | 2,043 | 1,702 | 511 | 1,617 | 7,661 |
| 12 | 464 | 1,486 | 2,229 | 1,857 | 557 | 1,764 | 8,357 |
| 13 | 503 | 1,610 | 2,414 | 2,012 | 604 | 1,911 | 9,054 |
| 14 | 542 | 1,733 | 2,600 | 2,167 | 650 | 2,058 | 9,750 |
| 15 | 580 | 1,857 | 2,786 | 2,321 | 696 | 2,205 | 10,447 |
| 16 | 619 | 1,981 | 2,971 | 2,476 | 743 | 2,352 | 11,143 |
| 17 | 658 | 2,105 | 3,157 | 2,631 | 789 | 2,499 | 11,839 |
| 18 | 696 | 2,229 | 3,343 | 2,786 | 836 | 2,646 | 12,536 |
| 19 | 735 | 2,352 | 3,529 | 2,941 | 882 | 2,793 | 13,232 |
| 20 | 774 | 2,476 | 3,714 | 3,095 | 929 | 2,941 | 13,929 |
| 21 | 774 | 2,600 | 3,838 | 3,250 | 929 | 2,941 | 14,331 |
| 22 | 774 | 2,724 | 3,962 | 3,405 | 929 | 2,941 | 14,734 |
| 23 | 774 | 2,848 | 4,086 | 3,560 | 929 | 2,941 | 15,136 |
| 24 | 774 | 2,971 | 4,210 | 3,714 | 929 | 2,941 | 15,538 |
| 25 | 774 | 3,095 | 4,333 | 3,869 | 929 | 2,941 | 15,941 |
| 26 | 774 | 3,219 | 4,457 | 4,024 | 929 | 2,941 | 16,343 |
| 27 | 774 | 3,343 | 4,581 | 4,179 | 929 | 2,941 | 16,745 |
| 28 | 774 | 3,467 | 4,705 | 4,333 | 929 | 2,941 | 17,148 |
| 29 | 774 | 3,591 | 4,829 | 4,488 | 929 | 2,941 | 17,550 |
| 30 | 774 | 3,714 | 4,952 | 4,643 | 929 | 2,941 | 17,953 |
| 31 | 774 | 3,838 | 5,076 | 4,798 | 929 | 2,941 | 18,355 |
| 32 | 774 | 3,962 | 5,200 | 4,952 | 929 | 2,941 | 18,757 |
| 33 | 774 | 4,086 | 5,324 | 5,107 | 929 | 2,941 | 19,160 |
| 34 | 774 | 4,210 | 5,448 | 5,262 | 929 | 2,941 | 19,562 |
| 35 | 774 | 4,333 | 5,572 | 5,417 | 929 | 2,941 | 19,965 |
| 36 | 774 | 4,457 | 5,695 | 5,572 | 929 | 2,941 | 20,367 |
| 37 | 774 | 4,581 | 5,819 | 5,726 | 929 | 2,941 | 20,769 |
| 38 | 774 | 4,705 | 5,943 | 5,881 | 929 | 2,941 | 21,172 |
| 39 | 774 | 4,829 | 6,067 | 6,036 | 929 | 2,941 | 21,574 |
| 40 | 774 | 4,952 | 6,191 | 6,191 | 929 | 2,941 | 21,976 |

**Sub Watershed #55 Annual Phosphorous Reduction (lbs), Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Load Reduction |
|---|---|---|---|---|---|---|---|
| 1 | 43 | 139 | 209 | 174 | 52 | 165 | 782 |
| 2 | 87 | 278 | 417 | 348 | 104 | 330 | 1,564 |
| 3 | 130 | 417 | 626 | 521 | 156 | 495 | 2,346 |
| 4 | 174 | 556 | 834 | 695 | 209 | 660 | 3,129 |
| 5 | 217 | 695 | 1,043 | 869 | 261 | 826 | 3,911 |
| 6 | 261 | 834 | 1,251 | 1,043 | 313 | 991 | 4,693 |
| 7 | 304 | 973 | 1,460 | 1,217 | 365 | 1,156 | 5,475 |
| 8 | 348 | 1,112 | 1,669 | 1,390 | 417 | 1,321 | 6,257 |
| 9 | 391 | 1,251 | 1,877 | 1,564 | 469 | 1,486 | 7,039 |
| 10 | 435 | 1,390 | 2,086 | 1,738 | 521 | 1,651 | 7,822 |
| 11 | 478 | 1,530 | 2,294 | 1,912 | 574 | 1,816 | 8,604 |
| 12 | 521 | 1,669 | 2,503 | 2,086 | 626 | 1,981 | 9,386 |
| 13 | 565 | 1,808 | 2,711 | 2,260 | 678 | 2,147 | 10,168 |
| 14 | 608 | 1,947 | 2,920 | 2,433 | 730 | 2,312 | 10,950 |
| 15 | 652 | 2,086 | 3,129 | 2,607 | 782 | 2,477 | 11,732 |
| 16 | 695 | 2,225 | 3,337 | 2,781 | 834 | 2,642 | 12,514 |
| 17 | 739 | 2,364 | 3,546 | 2,955 | 886 | 2,807 | 13,297 |
| 18 | 782 | 2,503 | 3,754 | 3,129 | 939 | 2,972 | 14,079 |
| 19 | 826 | 2,642 | 3,963 | 3,302 | 991 | 3,137 | 14,861 |
| 20 | 869 | 2,781 | 4,171 | 3,476 | 1,043 | 3,302 | 15,643 |
| 21 | 869 | 2,920 | 4,311 | 3,650 | 1,043 | 3,302 | 16,095 |
| 22 | 869 | 3,059 | 4,450 | 3,824 | 1,043 | 3,302 | 16,547 |
| 23 | 869 | 3,198 | 4,589 | 3,998 | 1,043 | 3,302 | 16,999 |
| 24 | 869 | 3,337 | 4,728 | 4,171 | 1,043 | 3,302 | 17,451 |
| 25 | 869 | 3,476 | 4,867 | 4,345 | 1,043 | 3,302 | 17,903 |
| 26 | 869 | 3,615 | 5,006 | 4,519 | 1,043 | 3,302 | 18,355 |
| 27 | 869 | 3,754 | 5,145 | 4,693 | 1,043 | 3,302 | 18,806 |
| 28 | 869 | 3,893 | 5,284 | 4,867 | 1,043 | 3,302 | 19,258 |
| 29 | 869 | 4,032 | 5,423 | 5,041 | 1,043 | 3,302 | 19,710 |
| 30 | 869 | 4,171 | 5,562 | 5,214 | 1,043 | 3,302 | 20,162 |
| 31 | 869 | 4,311 | 5,701 | 5,388 | 1,043 | 3,302 | 20,614 |
| 32 | 869 | 4,450 | 5,840 | 5,562 | 1,043 | 3,302 | 21,066 |
| 33 | 869 | 4,589 | 5,979 | 5,736 | 1,043 | 3,302 | 21,518 |
| 34 | 869 | 4,728 | 6,118 | 5,910 | 1,043 | 3,302 | 21,970 |
| 35 | 869 | 4,867 | 6,257 | 6,083 | 1,043 | 3,302 | 22,422 |
| 36 | 869 | 5,006 | 6,396 | 6,257 | 1,043 | 3,302 | 22,874 |
| 37 | 869 | 5,145 | 6,535 | 6,431 | 1,043 | 3,302 | 23,326 |
| 38 | 869 | 5,284 | 6,674 | 6,605 | 1,043 | 3,302 | 23,777 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 39 | 869 | 5,423 | 6,813 | 6,779 | 1,043 | 3,302 | 24,229 |
| 40 | 869 | 5,562 | 6,952 | 6,952 | 1,043 | 3,302 | 24,681 |

### 13.3.2 Adoption Rates by Sub Watershed

**Table 49. Short, Medium and Long Term Goals by Sub Watershed.**

**Sub Watershed #15 Annual Adoption (treated acres), Cropland BMPs**

| | Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Adoption |
|---|---|---|---|---|---|---|---|---|
| Short-Term | 1 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 2 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 3 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 4 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 5 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | *Total* | *257* | *514* | *771* | *514* | *257* | *257* | *2,570* |
| Medium-Term | 6 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 7 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 8 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 9 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 10 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | *Total* | *514* | *1,028* | *1,542* | *1,028* | *514* | *514* | *5,141* |
| Long-Term | 11 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 12 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 13 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 14 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 15 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 16 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 17 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 18 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 19 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 20 | 51 | 103 | 154 | 103 | 51 | 51 | 514 |
| | 21 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 22 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 23 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 24 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 25 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 26 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 27 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 28 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 29 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 30 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 31 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 32 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 33 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 34 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 35 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 36 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 37 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 38 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 39 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | 40 | 0 | 103 | 103 | 103 | 0 | 0 | 308 |
| | *Total* | *1,028* | *4,112* | *5,141* | *4,112* | *1,028* | *1,028* | *16,450* |

**Sub Watershed #16 Annual Adoption (treated acres), Cropland BMPs**

| | Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Adoption |
|---|---|---|---|---|---|---|---|---|
| **Short-Term** | 1 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 2 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 3 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 4 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 5 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | *Total* | *479* | *957* | *1,436* | *957* | *479* | *479* | *4,787* |
| **Medium-Term** | 6 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 7 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 8 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 9 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 10 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | *Total* | *957* | *1,915* | *2,872* | *1,915* | *957* | *957* | *9,573* |
| **Long-Term** | 11 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 12 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 13 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 14 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 15 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 16 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 17 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 18 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 19 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 20 | 96 | 191 | 287 | 191 | 96 | 96 | 957 |
| | 21 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 22 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 23 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 24 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 25 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 26 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 27 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 28 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 29 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 30 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 31 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 32 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 33 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 34 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 35 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 36 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 37 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 38 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 39 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | 40 | 0 | 191 | 191 | 191 | 0 | 0 | 574 |
| | *Total* | *1,915* | *7,658* | *9,573* | *7,658* | *1,915* | *1,915* | *30,634* |

**Sub Watershed #25 Annual Adoption (treated acres), Cropland BMPs**

| | Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Adoption |
|---|---|---|---|---|---|---|---|---|
| **Short-Term** | 1 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 2 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 3 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 4 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 5 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | *Total* | *208* | *0* | *623* | *415* | *0* | *208* | *1,453* |
| **Medium-Term** | 6 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 7 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 8 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 9 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 10 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | *Total* | *415* | *0* | *1,246* | *831* | *0* | *415* | *2,906* |
| **Long-Term** | 11 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 12 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 13 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 14 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 15 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 16 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 17 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 18 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 19 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 20 | 42 | 0 | 125 | 83 | 0 | 42 | 291 |
| | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | *Total* | *830* | *0* | *2,491* | *1,661* | *0* | *830* | *5,812* |

**Sub Watershed #28 Annual Adoption (treated acres), Cropland BMPs**

| | Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Adoption |
|---|---|---|---|---|---|---|---|---|
| **Short-Term** | 1 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 2 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 3 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 4 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 5 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | *Total* | *176* | *0* | *529* | *350* | *0* | *176* | *1,232* |
| **Medium-Term** | 6 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 7 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 8 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 9 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 10 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | *Total* | *353* | *0* | *1,058* | *700* | *0* | *353* | *2,463* |
| **Long-Term** | 11 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 12 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 13 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 14 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 15 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 16 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 17 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 18 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 19 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 20 | 35 | 0 | 106 | 70 | 0 | 35 | 246 |
| | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | *Total* | *705* | *0* | *2,116* | *1,400* | *0* | *705* | *4,926* |

**Sub Watershed #31 Annual Adoption (treated acres), Cropland BMPs**

| | Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Adoption |
|---|---|---|---|---|---|---|---|---|
| **Short-Term** | 1 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 2 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 3 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 4 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 5 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | *Total* | *364* | *729* | *1,093* | *729* | *364* | *364* | *3,645* |
| **Medium-Term** | 6 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 7 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 8 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 9 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 10 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | *Total* | *729* | *1,458* | *2,187* | *1,458* | *729* | *729* | *7,290* |
| **Long-Term** | 11 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 12 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 13 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 14 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 15 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 16 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 17 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 18 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 19 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 20 | 73 | 146 | 219 | 146 | 73 | 73 | 729 |
| | 21 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 22 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 23 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 24 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 25 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 26 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 27 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 28 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 29 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 30 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 31 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 32 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 33 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 34 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 35 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 36 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 37 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 38 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 39 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | 40 | 0 | 146 | 146 | 146 | 0 | 0 | 437 |
| | *Total* | *1,458* | *5,832* | *7,290* | *5,832* | *1,458* | *1,458* | *23,326* |

**Sub Watershed #33 Annual Adoption (treated acres), Cropland BMPs**

| | Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Adoption |
|---|---|---|---|---|---|---|---|---|
| **Short-Term** | 1 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 2 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 3 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 4 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 5 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | *Total* | *218* | *436* | *654* | *436* | *218* | *218* | *2,181* |
| **Medium-Term** | 6 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 7 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 8 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 9 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 10 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | *Total* | *436* | *873* | *1,309* | *873* | *436* | *436* | *4,363* |
| **Long-Term** | 11 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 12 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 13 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 14 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 15 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 16 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 17 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 18 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 19 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 20 | 44 | 87 | 131 | 87 | 44 | 44 | 436 |
| | 21 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 22 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 23 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 24 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 25 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 26 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 27 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 28 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 29 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 30 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 31 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 32 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 33 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 34 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 35 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 36 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 37 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 38 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 39 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | 40 | 0 | 87 | 87 | 87 | 0 | 0 | 262 |
| | *Total* | *873* | *3,490* | *4,363* | *3,490* | *873* | *873* | *13,960* |

**Sub Watershed #35 Annual Adoption (treated acres), Cropland BMPs**

| | Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Adoption |
|---|---|---|---|---|---|---|---|---|
| Short-Term | 1 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 2 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 3 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 4 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 5 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | *Total* | *438* | *877* | *1,315* | *877* | *438* | *438* | *4,384* |
| Medium-Term | 6 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 7 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 8 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 9 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 10 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | *Total* | *877* | *1,753* | *2,630* | *1,753* | *877* | *877* | *8,767* |
| Long-Term | 11 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 12 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 13 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 14 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 15 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 16 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 17 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 18 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 19 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 20 | 88 | 175 | 263 | 175 | 88 | 88 | 877 |
| | 21 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 22 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 23 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 24 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 25 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 26 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 27 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 28 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 29 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 30 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 31 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 32 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 33 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 34 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 35 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 36 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 37 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 38 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 39 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | 40 | 0 | 175 | 175 | 175 | 0 | 0 | 526 |
| | *Total* | *1,753* | *7,014* | *8,767* | *7,014* | *1,753* | *1,753* | *28,054* |

**Sub Watershed #38 Annual Adoption (treated acres), Cropland BMPs**

| | Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Adoption |
|---|---|---|---|---|---|---|---|---|
| **Short-Term** | 1 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 2 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 3 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 4 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 5 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | *Total* | *430* | *860* | *1,290* | *860* | *430* | *430* | *4,299* |
| **Medium-Term** | 6 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 7 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 8 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 9 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 10 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | *Total* | *860* | *1,720* | *2,579* | *1,720* | *860* | *860* | *8,598* |
| **Long-Term** | 11 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 12 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 13 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 14 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 15 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 16 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 17 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 18 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 19 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 20 | 86 | 172 | 258 | 172 | 86 | 86 | 860 |
| | 21 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 22 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 23 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 24 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 25 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 26 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 27 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 28 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 29 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 30 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 31 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 32 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 33 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 34 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 35 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 36 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 37 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 38 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 39 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | 40 | 0 | 172 | 172 | 172 | 0 | 0 | 516 |
| | *Total* | *1,720* | *6,878* | *8,598* | *6,878* | *1,720* | *1,720* | *27,514* |

**Sub Watershed #55 Annual Adoption (treated acres), Cropland BMPs**

| | Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Adoption |
|---|---|---|---|---|---|---|---|---|
| **Short-Term** | 1 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 2 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 3 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 4 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 5 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | *Total* | *457* | *915* | *1,372* | *915* | *457* | *457* | *4,574* |
| **Medium-Term** | 6 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 7 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 8 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 9 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 10 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | *Total* | *915* | *1,830* | *2,744* | *1,830* | *915* | *915* | *9,148* |
| **Long-Term** | 11 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 12 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 13 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 14 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 15 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 16 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 17 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 18 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 19 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 20 | 91 | 183 | 274 | 183 | 91 | 91 | 915 |
| | 21 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 22 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 23 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 24 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 25 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 26 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 27 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 28 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 29 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 30 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 31 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 32 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 33 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 34 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 35 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 36 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 37 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 38 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 39 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | 40 | 0 | 183 | 183 | 183 | 0 | 0 | 549 |
| | *Total* | *1,830* | *7,318* | *9,148* | *7,318* | *1,830* | *1,830* | *29,274* |

### 13.3.3 Costs by Sub Watershed

**Table 50. Costs Before Cost Share by Sub Watershed.**

**Sub Watershed #15 Annual Cost* Before Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $2,005 | $16,450 | $11,981 | $6,854 | $5,243 | $7,711 | $50,243 |
| 2 | $2,065 | $16,943 | $12,340 | $7,060 | $5,401 | $7,942 | $51,751 |
| 3 | $2,127 | $17,451 | $12,711 | $7,271 | $5,563 | $8,180 | $53,303 |
| 4 | $2,191 | $17,975 | $13,092 | $7,490 | $5,730 | $8,426 | $54,902 |
| 5 | $2,256 | $18,514 | $13,485 | $7,714 | $5,901 | $8,679 | $56,549 |
| 6 | $2,324 | $19,070 | $13,889 | $7,946 | $6,078 | $8,939 | $58,246 |
| 7 | $2,394 | $19,642 | $14,306 | $8,184 | $6,261 | $9,207 | $59,993 |
| 8 | $2,466 | $20,231 | $14,735 | $8,430 | $6,449 | $9,483 | $61,793 |
| 9 | $2,540 | $20,838 | $15,177 | $8,682 | $6,642 | $9,768 | $63,647 |
| 10 | $2,616 | $21,463 | $15,632 | $8,943 | $6,841 | $10,061 | $65,556 |
| 11 | $2,694 | $22,107 | $16,101 | $9,211 | $7,047 | $10,363 | $67,523 |
| 12 | $2,775 | $22,770 | $16,584 | $9,488 | $7,258 | $10,673 | $69,549 |
| 13 | $2,858 | $23,453 | $17,082 | $9,772 | $7,476 | $10,994 | $71,635 |
| 14 | $2,944 | $24,157 | $17,594 | $10,065 | $7,700 | $11,323 | $73,784 |
| 15 | $3,032 | $24,881 | $18,122 | $10,367 | $7,931 | $11,663 | $75,998 |
| 16 | $3,123 | $25,628 | $18,666 | $10,678 | $8,169 | $12,013 | $78,278 |
| 17 | $3,217 | $26,397 | $19,226 | $10,999 | $8,414 | $12,373 | $80,626 |
| 18 | $3,314 | $27,189 | $19,803 | $11,329 | $8,666 | $12,745 | $83,045 |
| 19 | $3,413 | $28,004 | $20,397 | $11,668 | $8,926 | $13,127 | $85,536 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | $3,515 | $28,844 | $21,009 | $12,019 | $9,194 | $13,521 | $88,102 |
| 21 | $0 | $29,710 | $14,426 | $12,379 | $0 | $0 | $56,515 |
| 22 | $0 | $30,601 | $14,859 | $12,750 | $0 | $0 | $58,210 |
| 23 | $0 | $31,519 | $15,305 | $13,133 | $0 | $0 | $59,957 |
| 24 | $0 | $32,465 | $15,764 | $13,527 | $0 | $0 | $61,755 |
| 25 | $0 | $33,439 | $16,237 | $13,933 | $0 | $0 | $63,608 |
| 26 | $0 | $34,442 | $16,724 | $14,351 | $0 | $0 | $65,516 |
| 27 | $0 | $35,475 | $17,225 | $14,781 | $0 | $0 | $67,482 |
| 28 | $0 | $36,539 | $17,742 | $15,225 | $0 | $0 | $69,506 |
| 29 | $0 | $37,635 | $18,274 | $15,681 | $0 | $0 | $71,591 |
| 30 | $0 | $38,765 | $18,823 | $16,152 | $0 | $0 | $73,739 |
| 31 | $0 | $39,927 | $19,387 | $16,636 | $0 | $0 | $75,951 |
| 32 | $0 | $41,125 | $19,969 | $17,136 | $0 | $0 | $78,230 |
| 33 | $0 | $42,359 | $20,568 | $17,650 | $0 | $0 | $80,577 |
| 34 | $0 | $43,630 | $21,185 | $18,179 | $0 | $0 | $82,994 |
| 35 | $0 | $44,939 | $21,821 | $18,724 | $0 | $0 | $85,484 |
| 36 | $0 | $46,287 | $22,475 | $19,286 | $0 | $0 | $88,048 |
| 37 | $0 | $47,676 | $23,149 | $19,865 | $0 | $0 | $90,690 |
| 38 | $0 | $49,106 | $23,844 | $20,461 | $0 | $0 | $93,410 |
| 39 | $0 | $50,579 | $24,559 | $21,075 | $0 | $0 | $96,213 |
| 40 | $0 | $52,096 | $25,296 | $21,707 | $0 | $0 | $99,099 |

**3% Inflation*

**Sub Watershed #16 Annual Cost* Before Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $3,733 | $30,634 | $22,312 | $12,764 | $9,764 | $14,360 | $93,567 |
| 2 | $3,845 | $31,553 | $22,981 | $13,147 | $10,057 | $14,790 | $96,374 |
| 3 | $3,961 | $32,499 | $23,671 | $13,541 | $10,359 | $15,234 | $99,265 |
| 4 | $4,080 | $33,474 | $24,381 | $13,948 | $10,670 | $15,691 | $102,243 |
| 5 | $4,202 | $34,478 | $25,112 | $14,366 | $10,990 | $16,162 | $105,310 |
| 6 | $4,328 | $35,513 | $25,865 | $14,797 | $11,320 | $16,647 | $108,470 |
| 7 | $4,458 | $36,578 | $26,641 | $15,241 | $11,659 | $17,146 | $111,724 |
| 8 | $4,592 | $37,675 | $27,441 | $15,698 | $12,009 | $17,660 | $115,075 |
| 9 | $4,729 | $38,806 | $28,264 | $16,169 | $12,369 | $18,190 | $118,528 |
| 10 | $4,871 | $39,970 | $29,112 | $16,654 | $12,740 | $18,736 | $122,083 |
| 11 | $5,017 | $41,169 | $29,985 | $17,154 | $13,123 | $19,298 | $125,746 |
| 12 | $5,168 | $42,404 | $30,885 | $17,668 | $13,516 | $19,877 | $129,518 |
| 13 | $5,323 | $43,676 | $31,811 | $18,198 | $13,922 | $20,473 | $133,404 |
| 14 | $5,483 | $44,986 | $32,766 | $18,744 | $14,339 | $21,087 | $137,406 |
| 15 | $5,647 | $46,336 | $33,749 | $19,307 | $14,770 | $21,720 | $141,528 |
| 16 | $5,817 | $47,726 | $34,761 | $19,886 | $15,213 | $22,372 | $145,774 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 17 | $5,991 | $49,158 | $35,804 | $20,482 | $15,669 | $23,043 | $150,147 |
| 18 | $6,171 | $50,633 | $36,878 | $21,097 | $16,139 | $23,734 | $154,652 |
| 19 | $6,356 | $52,152 | $37,984 | $21,730 | $16,623 | $24,446 | $159,291 |
| 20 | $6,547 | $53,716 | $39,124 | $22,382 | $17,122 | $25,179 | $164,070 |
| 21 | $0 | $55,328 | $26,865 | $23,053 | $0 | $0 | $105,246 |
| 22 | $0 | $56,988 | $27,671 | $23,745 | $0 | $0 | $108,403 |
| 23 | $0 | $58,697 | $28,501 | $24,457 | $0 | $0 | $111,655 |
| 24 | $0 | $60,458 | $29,356 | $25,191 | $0 | $0 | $115,005 |
| 25 | $0 | $62,272 | $30,237 | $25,947 | $0 | $0 | $118,455 |
| 26 | $0 | $64,140 | $31,144 | $26,725 | $0 | $0 | $122,009 |
| 27 | $0 | $66,064 | $32,078 | $27,527 | $0 | $0 | $125,669 |
| 28 | $0 | $68,046 | $33,041 | $28,353 | $0 | $0 | $129,439 |
| 29 | $0 | $70,087 | $34,032 | $29,203 | $0 | $0 | $133,322 |
| 30 | $0 | $72,190 | $35,053 | $30,079 | $0 | $0 | $137,322 |
| 31 | $0 | $74,356 | $36,104 | $30,982 | $0 | $0 | $141,442 |
| 32 | $0 | $76,586 | $37,188 | $31,911 | $0 | $0 | $145,685 |
| 33 | $0 | $78,884 | $38,303 | $32,868 | $0 | $0 | $150,056 |
| 34 | $0 | $81,251 | $39,452 | $33,854 | $0 | $0 | $154,557 |
| 35 | $0 | $83,688 | $40,636 | $34,870 | $0 | $0 | $159,194 |
| 36 | $0 | $86,199 | $41,855 | $35,916 | $0 | $0 | $163,970 |
| 37 | $0 | $88,785 | $43,111 | $36,994 | $0 | $0 | $168,889 |
| 38 | $0 | $91,448 | $44,404 | $38,103 | $0 | $0 | $173,956 |
| 39 | $0 | $94,192 | $45,736 | $39,247 | $0 | $0 | $179,174 |
| 40 | $0 | $97,017 | $47,108 | $40,424 | $0 | $0 | $184,549 |

**3% Inflation*

**Sub Watershed #25 Annual Cost* Before Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $1,619 | $0 | $9,676 | $5,537 | $0 | $6,225 | $23,056 |
| 2 | $1,667 | $0 | $9,967 | $5,703 | $0 | $6,412 | $23,748 |
| 3 | $1,717 | $0 | $10,266 | $5,874 | $0 | $6,604 | $24,461 |
| 4 | $1,769 | $0 | $10,574 | $6,050 | $0 | $6,802 | $25,194 |
| 5 | $1,822 | $0 | $10,891 | $6,232 | $0 | $7,006 | $25,950 |
| 6 | $1,876 | $0 | $11,217 | $6,419 | $0 | $7,216 | $26,729 |
| 7 | $1,933 | $0 | $11,554 | $6,611 | $0 | $7,433 | $27,531 |
| 8 | $1,991 | $0 | $11,901 | $6,809 | $0 | $7,656 | $28,357 |
| 9 | $2,050 | $0 | $12,258 | $7,014 | $0 | $7,886 | $29,207 |
| 10 | $2,112 | $0 | $12,625 | $7,224 | $0 | $8,122 | $30,083 |
| 11 | $2,175 | $0 | $13,004 | $7,441 | $0 | $8,366 | $30,986 |
| 12 | $2,240 | $0 | $13,394 | $7,664 | $0 | $8,617 | $31,916 |
| 13 | $2,308 | $0 | $13,796 | $7,894 | $0 | $8,875 | $32,873 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 14 | $2,377 | $0 | $14,210 | $8,131 | $0 | $9,142 | $33,859 |
| 15 | $2,448 | $0 | $14,636 | $8,375 | $0 | $9,416 | $34,875 |
| 16 | $2,522 | $0 | $15,075 | $8,626 | $0 | $9,698 | $35,921 |
| 17 | $2,597 | $0 | $15,528 | $8,885 | $0 | $9,989 | $36,999 |
| 18 | $2,675 | $0 | $15,993 | $9,151 | $0 | $10,289 | $38,109 |
| 19 | $2,755 | $0 | $16,473 | $9,426 | $0 | $10,598 | $39,252 |
| 20 | $2,838 | $0 | $16,967 | $9,709 | $0 | $10,916 | $40,430 |
| 21 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 22 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 23 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 24 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 25 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 26 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 27 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 28 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 29 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 30 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 31 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 32 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 33 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 34 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 35 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 36 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 37 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 38 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 39 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 40 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |

**3% Inflation*

**Sub Watershed #28 Annual Cost* Before Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $1,375 | $0 | $8,220 | $4,667 | $0 | $5,288 | $19,549 |
| 2 | $1,416 | $0 | $8,466 | $4,807 | $0 | $5,446 | $20,135 |
| 3 | $1,458 | $0 | $8,720 | $4,951 | $0 | $5,610 | $20,739 |
| 4 | $1,502 | $0 | $8,982 | $5,099 | $0 | $5,778 | $21,361 |
| 5 | $1,547 | $0 | $9,251 | $5,252 | $0 | $5,951 | $22,002 |
| 6 | $1,594 | $0 | $9,529 | $5,410 | $0 | $6,130 | $22,662 |
| 7 | $1,642 | $0 | $9,815 | $5,572 | $0 | $6,314 | $23,342 |
| 8 | $1,691 | $0 | $10,109 | $5,739 | $0 | $6,503 | $24,042 |
| 9 | $1,741 | $0 | $10,412 | $5,912 | $0 | $6,698 | $24,763 |
| 10 | $1,794 | $0 | $10,725 | $6,089 | $0 | $6,899 | $25,506 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 11 | $1,848 | $0 | $11,046 | $6,272 | $0 | $7,106 | $26,272 |
| 12 | $1,903 | $0 | $11,378 | $6,460 | $0 | $7,319 | $27,060 |
| 13 | $1,960 | $0 | $11,719 | $6,654 | $0 | $7,539 | $27,872 |
| 14 | $2,019 | $0 | $12,071 | $6,853 | $0 | $7,765 | $28,708 |
| 15 | $2,079 | $0 | $12,433 | $7,059 | $0 | $7,998 | $29,569 |
| 16 | $2,142 | $0 | $12,806 | $7,271 | $0 | $8,238 | $30,456 |
| 17 | $2,206 | $0 | $13,190 | $7,489 | $0 | $8,485 | $31,370 |
| 18 | $2,272 | $0 | $13,586 | $7,713 | $0 | $8,739 | $32,311 |
| 19 | $2,340 | $0 | $13,993 | $7,945 | $0 | $9,002 | $33,280 |
| 20 | $2,411 | $0 | $14,413 | $8,183 | $0 | $9,272 | $34,278 |
| 21 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 22 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 23 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 24 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 25 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 26 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 27 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 28 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 29 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 30 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 31 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 32 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 33 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 34 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 35 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 36 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 37 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 38 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 39 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 40 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |

**3% Inflation*

**Sub Watershed #31 Annual Cost* Before Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $2,843 | $23,326 | $16,990 | $9,719 | $7,435 | $10,934 | $71,248 |
| 2 | $2,928 | $24,026 | $17,499 | $10,011 | $7,658 | $11,262 | $73,385 |
| 3 | $3,016 | $24,747 | $18,024 | $10,311 | $7,888 | $11,600 | $75,587 |
| 4 | $3,107 | $25,489 | $18,565 | $10,621 | $8,125 | $11,948 | $77,854 |
| 5 | $3,200 | $26,254 | $19,122 | $10,939 | $8,368 | $12,307 | $80,190 |
| 6 | $3,296 | $27,042 | $19,696 | $11,267 | $8,620 | $12,676 | $82,596 |
| 7 | $3,395 | $27,853 | $20,287 | $11,605 | $8,878 | $13,056 | $85,074 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8 | $3,496 | $28,689 | $20,895 | $11,954 | $9,144 | $13,448 | $87,626 |
| 9 | $3,601 | $29,549 | $21,522 | $12,312 | $9,419 | $13,851 | $90,255 |
| 10 | $3,709 | $30,436 | $22,168 | $12,682 | $9,701 | $14,267 | $92,962 |
| 11 | $3,821 | $31,349 | $22,833 | $13,062 | $9,992 | $14,695 | $95,751 |
| 12 | $3,935 | $32,289 | $23,518 | $13,454 | $10,292 | $15,136 | $98,624 |
| 13 | $4,053 | $33,258 | $24,223 | $13,857 | $10,601 | $15,590 | $101,582 |
| 14 | $4,175 | $34,256 | $24,950 | $14,273 | $10,919 | $16,057 | $104,630 |
| 15 | $4,300 | $35,283 | $25,698 | $14,701 | $11,247 | $16,539 | $107,769 |
| 16 | $4,429 | $36,342 | $26,469 | $15,142 | $11,584 | $17,035 | $111,002 |
| 17 | $4,562 | $37,432 | $27,263 | $15,597 | $11,931 | $17,546 | $114,332 |
| 18 | $4,699 | $38,555 | $28,081 | $16,065 | $12,289 | $18,073 | $117,762 |
| 19 | $4,840 | $39,712 | $28,924 | $16,547 | $12,658 | $18,615 | $121,295 |
| 20 | $4,985 | $40,903 | $29,791 | $17,043 | $13,038 | $19,173 | $124,933 |
| 21 | $0 | $42,130 | $20,457 | $17,554 | $0 | $0 | $80,141 |
| 22 | $0 | $43,394 | $21,070 | $18,081 | $0 | $0 | $82,545 |
| 23 | $0 | $44,696 | $21,703 | $18,623 | $0 | $0 | $85,022 |
| 24 | $0 | $46,037 | $22,354 | $19,182 | $0 | $0 | $87,572 |
| 25 | $0 | $47,418 | $23,024 | $19,757 | $0 | $0 | $90,199 |
| 26 | $0 | $48,840 | $23,715 | $20,350 | $0 | $0 | $92,905 |
| 27 | $0 | $50,306 | $24,426 | $20,961 | $0 | $0 | $95,693 |
| 28 | $0 | $51,815 | $25,159 | $21,589 | $0 | $0 | $98,563 |
| 29 | $0 | $53,369 | $25,914 | $22,237 | $0 | $0 | $101,520 |
| 30 | $0 | $54,970 | $26,691 | $22,904 | $0 | $0 | $104,566 |
| 31 | $0 | $56,619 | $27,492 | $23,591 | $0 | $0 | $107,703 |
| 32 | $0 | $58,318 | $28,317 | $24,299 | $0 | $0 | $110,934 |
| 33 | $0 | $60,067 | $29,166 | $25,028 | $0 | $0 | $114,262 |
| 34 | $0 | $61,869 | $30,041 | $25,779 | $0 | $0 | $117,690 |
| 35 | $0 | $63,726 | $30,943 | $26,552 | $0 | $0 | $121,221 |
| 36 | $0 | $65,637 | $31,871 | $27,349 | $0 | $0 | $124,857 |
| 37 | $0 | $67,606 | $32,827 | $28,169 | $0 | $0 | $128,603 |
| 38 | $0 | $69,635 | $33,812 | $29,014 | $0 | $0 | $132,461 |
| 39 | $0 | $71,724 | $34,826 | $29,885 | $0 | $0 | $136,435 |
| 40 | $0 | $73,875 | $35,871 | $30,781 | $0 | $0 | $140,528 |

**3% Inflation*

**Sub Watershed #33 Annual Cost* Before Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $1,701 | $13,960 | $10,168 | $5,817 | $4,450 | $6,544 | $42,639 |
| 2 | $1,752 | $14,379 | $10,473 | $5,991 | $4,583 | $6,740 | $43,918 |
| 3 | $1,805 | $14,810 | $10,787 | $6,171 | $4,721 | $6,942 | $45,236 |
| 4 | $1,859 | $15,254 | $11,110 | $6,356 | $4,862 | $7,151 | $46,593 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | $1,915 | $15,712 | $11,444 | $6,547 | $5,008 | $7,365 | $47,991 |
| 6 | $1,972 | $16,183 | $11,787 | $6,743 | $5,158 | $7,586 | $49,431 |
| 7 | $2,032 | $16,669 | $12,141 | $6,945 | $5,313 | $7,814 | $50,913 |
| 8 | $2,092 | $17,169 | $12,505 | $7,154 | $5,473 | $8,048 | $52,441 |
| 9 | $2,155 | $17,684 | $12,880 | $7,368 | $5,637 | $8,289 | $54,014 |
| 10 | $2,220 | $18,215 | $13,267 | $7,589 | $5,806 | $8,538 | $55,635 |
| 11 | $2,287 | $18,761 | $13,665 | $7,817 | $5,980 | $8,794 | $57,304 |
| 12 | $2,355 | $19,324 | $14,074 | $8,052 | $6,159 | $9,058 | $59,023 |
| 13 | $2,426 | $19,904 | $14,497 | $8,293 | $6,344 | $9,330 | $60,793 |
| 14 | $2,499 | $20,501 | $14,932 | $8,542 | $6,535 | $9,610 | $62,617 |
| 15 | $2,573 | $21,116 | $15,380 | $8,798 | $6,731 | $9,898 | $64,496 |
| 16 | $2,651 | $21,749 | $15,841 | $9,062 | $6,933 | $10,195 | $66,431 |
| 17 | $2,730 | $22,402 | $16,316 | $9,334 | $7,141 | $10,501 | $68,423 |
| 18 | $2,812 | $23,074 | $16,806 | $9,614 | $7,355 | $10,816 | $70,476 |
| 19 | $2,896 | $23,766 | $17,310 | $9,902 | $7,575 | $11,140 | $72,590 |
| 20 | $2,983 | $24,479 | $17,829 | $10,200 | $7,803 | $11,475 | $74,768 |
| 21 | $0 | $25,213 | $12,243 | $10,506 | $0 | $0 | $47,961 |
| 22 | $0 | $25,970 | $12,610 | $10,821 | $0 | $0 | $49,400 |
| 23 | $0 | $26,749 | $12,988 | $11,145 | $0 | $0 | $50,882 |
| 24 | $0 | $27,551 | $13,378 | $11,480 | $0 | $0 | $52,409 |
| 25 | $0 | $28,378 | $13,779 | $11,824 | $0 | $0 | $53,981 |
| 26 | $0 | $29,229 | $14,193 | $12,179 | $0 | $0 | $55,601 |
| 27 | $0 | $30,106 | $14,618 | $12,544 | $0 | $0 | $57,269 |
| 28 | $0 | $31,009 | $15,057 | $12,920 | $0 | $0 | $58,987 |
| 29 | $0 | $31,939 | $15,509 | $13,308 | $0 | $0 | $60,756 |
| 30 | $0 | $32,898 | $15,974 | $13,707 | $0 | $0 | $62,579 |
| 31 | $0 | $33,885 | $16,453 | $14,119 | $0 | $0 | $64,456 |
| 32 | $0 | $34,901 | $16,947 | $14,542 | $0 | $0 | $66,390 |
| 33 | $0 | $35,948 | $17,455 | $14,978 | $0 | $0 | $68,382 |
| 34 | $0 | $37,027 | $17,979 | $15,428 | $0 | $0 | $70,433 |
| 35 | $0 | $38,137 | $18,518 | $15,891 | $0 | $0 | $72,546 |
| 36 | $0 | $39,282 | $19,074 | $16,367 | $0 | $0 | $74,722 |
| 37 | $0 | $40,460 | $19,646 | $16,858 | $0 | $0 | $76,964 |
| 38 | $0 | $41,674 | $20,235 | $17,364 | $0 | $0 | $79,273 |
| 39 | $0 | $42,924 | $20,842 | $17,885 | $0 | $0 | $81,651 |
| 40 | $0 | $44,212 | $21,468 | $18,422 | $0 | $0 | $84,101 |

**3% Inflation*

**Sub Watershed #35 Annual Cost* Before Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $3,419 | $28,054 | $20,433 | $11,689 | $8,942 | $13,151 | $85,689 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 | $3,522 | $28,896 | $21,046 | $12,040 | $9,211 | $13,545 | $88,260 |
| 3 | $3,627 | $29,763 | $21,678 | $12,401 | $9,487 | $13,951 | $90,907 |
| 4 | $3,736 | $30,656 | $22,328 | $12,773 | $9,772 | $14,370 | $93,635 |
| 5 | $3,848 | $31,575 | $22,998 | $13,156 | $10,065 | $14,801 | $96,444 |
| 6 | $3,964 | $32,523 | $23,688 | $13,551 | $10,367 | $15,245 | $99,337 |
| 7 | $4,083 | $33,498 | $24,398 | $13,958 | $10,678 | $15,702 | $102,317 |
| 8 | $4,205 | $34,503 | $25,130 | $14,376 | $10,998 | $16,173 | $105,387 |
| 9 | $4,331 | $35,538 | $25,884 | $14,808 | $11,328 | $16,659 | $108,548 |
| 10 | $4,461 | $36,605 | $26,661 | $15,252 | $11,668 | $17,158 | $111,805 |
| 11 | $4,595 | $37,703 | $27,461 | $15,709 | $12,018 | $17,673 | $115,159 |
| 12 | $4,733 | $38,834 | $28,284 | $16,181 | $12,378 | $18,203 | $118,614 |
| 13 | $4,875 | $39,999 | $29,133 | $16,666 | $12,750 | $18,749 | $122,172 |
| 14 | $5,021 | $41,199 | $30,007 | $17,166 | $13,132 | $19,312 | $125,837 |
| 15 | $5,172 | $42,435 | $30,907 | $17,681 | $13,526 | $19,891 | $129,612 |
| 16 | $5,327 | $43,708 | $31,834 | $18,212 | $13,932 | $20,488 | $133,501 |
| 17 | $5,487 | $45,019 | $32,789 | $18,758 | $14,350 | $21,103 | $137,506 |
| 18 | $5,651 | $46,370 | $33,773 | $19,321 | $14,780 | $21,736 | $141,631 |
| 19 | $5,821 | $47,761 | $34,786 | $19,900 | $15,224 | $22,388 | $145,880 |
| 20 | $5,995 | $49,194 | $35,830 | $20,497 | $15,680 | $23,059 | $150,256 |
| 21 | $0 | $50,669 | $24,603 | $21,112 | $0 | $0 | $96,385 |
| 22 | $0 | $52,189 | $25,341 | $21,746 | $0 | $0 | $99,276 |
| 23 | $0 | $53,755 | $26,101 | $22,398 | $0 | $0 | $102,255 |
| 24 | $0 | $55,368 | $26,885 | $23,070 | $0 | $0 | $105,322 |
| 25 | $0 | $57,029 | $27,691 | $23,762 | $0 | $0 | $108,482 |
| 26 | $0 | $58,740 | $28,522 | $24,475 | $0 | $0 | $111,736 |
| 27 | $0 | $60,502 | $29,377 | $25,209 | $0 | $0 | $115,088 |
| 28 | $0 | $62,317 | $30,259 | $25,965 | $0 | $0 | $118,541 |
| 29 | $0 | $64,186 | $31,167 | $26,744 | $0 | $0 | $122,097 |
| 30 | $0 | $66,112 | $32,102 | $27,547 | $0 | $0 | $125,760 |
| 31 | $0 | $68,095 | $33,065 | $28,373 | $0 | $0 | $129,533 |
| 32 | $0 | $70,138 | $34,057 | $29,224 | $0 | $0 | $133,419 |
| 33 | $0 | $72,242 | $35,078 | $30,101 | $0 | $0 | $137,422 |
| 34 | $0 | $74,410 | $36,131 | $31,004 | $0 | $0 | $141,544 |
| 35 | $0 | $76,642 | $37,214 | $31,934 | $0 | $0 | $145,791 |
| 36 | $0 | $78,941 | $38,331 | $32,892 | $0 | $0 | $150,164 |
| 37 | $0 | $81,309 | $39,481 | $33,879 | $0 | $0 | $154,669 |
| 38 | $0 | $83,749 | $40,665 | $34,895 | $0 | $0 | $159,309 |
| 39 | $0 | $86,261 | $41,885 | $35,942 | $0 | $0 | $164,089 |
| 40 | $0 | $88,849 | $43,142 | $37,020 | $0 | $0 | $169,011 |

**3% Inflation*

**Sub Watershed #38 Annual Cost* Before Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $3,353 | $27,514 | $20,039 | $11,464 | $8,770 | $12,897 | $84,037 |
| 2 | $3,454 | $28,339 | $20,641 | $11,808 | $9,033 | $13,284 | $86,558 |
| 3 | $3,557 | $29,189 | $21,260 | $12,162 | $9,304 | $13,682 | $89,155 |
| 4 | $3,664 | $30,065 | $21,898 | $12,527 | $9,583 | $14,093 | $91,830 |
| 5 | $3,774 | $30,967 | $22,554 | $12,903 | $9,871 | $14,516 | $94,585 |
| 6 | $3,887 | $31,896 | $23,231 | $13,290 | $10,167 | $14,951 | $97,422 |
| 7 | $4,004 | $32,853 | $23,928 | $13,689 | $10,472 | $15,400 | $100,345 |
| 8 | $4,124 | $33,838 | $24,646 | $14,099 | $10,786 | $15,862 | $103,355 |
| 9 | $4,248 | $34,853 | $25,385 | $14,522 | $11,110 | $16,338 | $106,456 |
| 10 | $4,375 | $35,899 | $26,147 | $14,958 | $11,443 | $16,828 | $109,649 |
| 11 | $4,506 | $36,976 | $26,931 | $15,407 | $11,786 | $17,332 | $112,939 |
| 12 | $4,642 | $38,085 | $27,739 | $15,869 | $12,140 | $17,852 | $116,327 |
| 13 | $4,781 | $39,228 | $28,571 | $16,345 | $12,504 | $18,388 | $119,817 |
| 14 | $4,924 | $40,405 | $29,428 | $16,835 | $12,879 | $18,940 | $123,411 |
| 15 | $5,072 | $41,617 | $30,311 | $17,340 | $13,265 | $19,508 | $127,114 |
| 16 | $5,224 | $42,865 | $31,221 | $17,861 | $13,663 | $20,093 | $130,927 |
| 17 | $5,381 | $44,151 | $32,157 | $18,396 | $14,073 | $20,696 | $134,855 |
| 18 | $5,542 | $45,476 | $33,122 | $18,948 | $14,495 | $21,317 | $138,901 |
| 19 | $5,709 | $46,840 | $34,116 | $19,517 | $14,930 | $21,956 | $143,068 |
| 20 | $5,880 | $48,245 | $35,139 | $20,102 | $15,378 | $22,615 | $147,360 |
| 21 | $0 | $49,693 | $24,129 | $20,705 | $0 | $0 | $94,527 |
| 22 | $0 | $51,183 | $24,853 | $21,326 | $0 | $0 | $97,363 |
| 23 | $0 | $52,719 | $25,598 | $21,966 | $0 | $0 | $100,283 |
| 24 | $0 | $54,300 | $26,366 | $22,625 | $0 | $0 | $103,292 |
| 25 | $0 | $55,929 | $27,157 | $23,304 | $0 | $0 | $106,391 |
| 26 | $0 | $57,607 | $27,972 | $24,003 | $0 | $0 | $109,582 |
| 27 | $0 | $59,336 | $28,811 | $24,723 | $0 | $0 | $112,870 |
| 28 | $0 | $61,116 | $29,675 | $25,465 | $0 | $0 | $116,256 |
| 29 | $0 | $62,949 | $30,566 | $26,229 | $0 | $0 | $119,744 |
| 30 | $0 | $64,838 | $31,483 | $27,016 | $0 | $0 | $123,336 |
| 31 | $0 | $66,783 | $32,427 | $27,826 | $0 | $0 | $127,036 |
| 32 | $0 | $68,786 | $33,400 | $28,661 | $0 | $0 | $130,847 |
| 33 | $0 | $70,850 | $34,402 | $29,521 | $0 | $0 | $134,773 |
| 34 | $0 | $72,975 | $35,434 | $30,406 | $0 | $0 | $138,816 |
| 35 | $0 | $75,165 | $36,497 | $31,319 | $0 | $0 | $142,980 |
| 36 | $0 | $77,419 | $37,592 | $32,258 | $0 | $0 | $147,270 |
| 37 | $0 | $79,742 | $38,720 | $33,226 | $0 | $0 | $151,688 |
| 38 | $0 | $82,134 | $39,881 | $34,223 | $0 | $0 | $156,238 |
| 39 | $0 | $84,598 | $41,078 | $35,249 | $0 | $0 | $160,925 |
| 40 | $0 | $87,136 | $42,310 | $36,307 | $0 | $0 | $165,753 |

**3% Inflation*

**Sub Watershed #55 Annual Cost* Before Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $3,568 | $29,274 | $21,321 | $12,197 | $9,331 | $13,722 | $89,413 |
| 2 | $3,675 | $30,152 | $21,961 | $12,563 | $9,611 | $14,134 | $92,095 |
| 3 | $3,785 | $31,056 | $22,620 | $12,940 | $9,899 | $14,558 | $94,858 |
| 4 | $3,899 | $31,988 | $23,298 | $13,328 | $10,196 | $14,994 | $97,704 |
| 5 | $4,016 | $32,948 | $23,997 | $13,728 | $10,502 | $15,444 | $100,635 |
| 6 | $4,136 | $33,936 | $24,717 | $14,140 | $10,817 | $15,908 | $103,654 |
| 7 | $4,260 | $34,954 | $25,459 | $14,564 | $11,142 | $16,385 | $106,764 |
| 8 | $4,388 | $36,003 | $26,222 | $15,001 | $11,476 | $16,876 | $109,967 |
| 9 | $4,519 | $37,083 | $27,009 | $15,451 | $11,820 | $17,383 | $113,266 |
| 10 | $4,655 | $38,195 | $27,819 | $15,915 | $12,175 | $17,904 | $116,663 |
| 11 | $4,795 | $39,341 | $28,654 | $16,392 | $12,540 | $18,441 | $120,163 |
| 12 | $4,939 | $40,522 | $29,514 | $16,884 | $12,916 | $18,994 | $123,768 |
| 13 | $5,087 | $41,737 | $30,399 | $17,390 | $13,304 | $19,564 | $127,481 |
| 14 | $5,239 | $42,989 | $31,311 | $17,912 | $13,703 | $20,151 | $131,306 |
| 15 | $5,396 | $44,279 | $32,250 | $18,450 | $14,114 | $20,756 | $135,245 |
| 16 | $5,558 | $45,607 | $33,218 | $19,003 | $14,537 | $21,378 | $139,302 |
| 17 | $5,725 | $46,976 | $34,214 | $19,573 | $14,973 | $22,020 | $143,481 |
| 18 | $5,897 | $48,385 | $35,241 | $20,160 | $15,423 | $22,680 | $147,786 |
| 19 | $6,074 | $49,836 | $36,298 | $20,765 | $15,885 | $23,361 | $152,219 |
| 20 | $6,256 | $51,331 | $37,387 | $21,388 | $16,362 | $24,062 | $156,786 |
| 21 | $0 | $52,871 | $25,672 | $22,030 | $0 | $0 | $100,573 |
| 22 | $0 | $54,458 | $26,443 | $22,691 | $0 | $0 | $103,591 |
| 23 | $0 | $56,091 | $27,236 | $23,371 | $0 | $0 | $106,698 |
| 24 | $0 | $57,774 | $28,053 | $24,072 | $0 | $0 | $109,899 |
| 25 | $0 | $59,507 | $28,894 | $24,795 | $0 | $0 | $113,196 |
| 26 | $0 | $61,292 | $29,761 | $25,539 | $0 | $0 | $116,592 |
| 27 | $0 | $63,131 | $30,654 | $26,305 | $0 | $0 | $120,090 |
| 28 | $0 | $65,025 | $31,574 | $27,094 | $0 | $0 | $123,693 |
| 29 | $0 | $66,976 | $32,521 | $27,907 | $0 | $0 | $127,403 |
| 30 | $0 | $68,985 | $33,497 | $28,744 | $0 | $0 | $131,226 |
| 31 | $0 | $71,055 | $34,502 | $29,606 | $0 | $0 | $135,162 |
| 32 | $0 | $73,186 | $35,537 | $30,494 | $0 | $0 | $139,217 |
| 33 | $0 | $75,382 | $36,603 | $31,409 | $0 | $0 | $143,394 |
| 34 | $0 | $77,643 | $37,701 | $32,351 | $0 | $0 | $147,696 |
| 35 | $0 | $79,973 | $38,832 | $33,322 | $0 | $0 | $152,126 |
| 36 | $0 | $82,372 | $39,997 | $34,322 | $0 | $0 | $156,690 |
| 37 | $0 | $84,843 | $41,197 | $35,351 | $0 | $0 | $161,391 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 38 | $0 | $87,388 | $42,432 | $36,412 | $0 | $0 | $166,233 |
| 39 | $0 | $90,010 | $43,705 | $37,504 | $0 | $0 | $171,220 |
| 40 | $0 | $92,710 | $45,017 | $38,629 | $0 | $0 | $176,356 |

**3% Inflation*

**Table 51. Costs by BMP After Cost Share.**

**Sub Watershed #15 Annual Cost* After Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $2,005 | $8,225 | $7,308 | $685 | $2,622 | $3,855 | $24,700 |
| 2 | $2,065 | $8,472 | $7,528 | $706 | $2,700 | $3,971 | $25,441 |
| 3 | $2,127 | $8,726 | $7,753 | $727 | $2,781 | $4,090 | $26,205 |
| 4 | $2,191 | $8,987 | $7,986 | $749 | $2,865 | $4,213 | $26,991 |
| 5 | $2,256 | $9,257 | $8,226 | $771 | $2,951 | $4,339 | $27,801 |
| 6 | $2,324 | $9,535 | $8,472 | $795 | $3,039 | $4,469 | $28,635 |
| 7 | $2,394 | $9,821 | $8,727 | $818 | $3,130 | $4,604 | $29,494 |
| 8 | $2,466 | $10,115 | $8,988 | $843 | $3,224 | $4,742 | $30,378 |
| 9 | $2,540 | $10,419 | $9,258 | $868 | $3,321 | $4,884 | $31,290 |
| 10 | $2,616 | $10,731 | $9,536 | $894 | $3,421 | $5,030 | $32,228 |
| 11 | $2,694 | $11,053 | $9,822 | $921 | $3,523 | $5,181 | $33,195 |
| 12 | $2,775 | $11,385 | $10,117 | $949 | $3,629 | $5,337 | $34,191 |
| 13 | $2,858 | $11,727 | $10,420 | $977 | $3,738 | $5,497 | $35,217 |
| 14 | $2,944 | $12,078 | $10,733 | $1,007 | $3,850 | $5,662 | $36,273 |
| 15 | $3,032 | $12,441 | $11,055 | $1,037 | $3,965 | $5,832 | $37,362 |
| 16 | $3,123 | $12,814 | $11,386 | $1,068 | $4,084 | $6,007 | $38,482 |
| 17 | $3,217 | $13,198 | $11,728 | $1,100 | $4,207 | $6,187 | $39,637 |
| 18 | $3,314 | $13,594 | $12,080 | $1,133 | $4,333 | $6,372 | $40,826 |
| 19 | $3,413 | $14,002 | $12,442 | $1,167 | $4,463 | $6,564 | $42,051 |
| 20 | $3,515 | $14,422 | $12,815 | $1,202 | $4,597 | $6,760 | $43,312 |
| 21 | $0 | $14,855 | $8,800 | $1,238 | $0 | $0 | $24,893 |
| 22 | $0 | $15,301 | $9,064 | $1,275 | $0 | $0 | $25,639 |
| 23 | $0 | $15,760 | $9,336 | $1,313 | $0 | $0 | $26,409 |
| 24 | $0 | $16,232 | $9,616 | $1,353 | $0 | $0 | $27,201 |
| 25 | $0 | $16,719 | $9,904 | $1,393 | $0 | $0 | $28,017 |
| 26 | $0 | $17,221 | $10,201 | $1,435 | $0 | $0 | $28,857 |
| 27 | $0 | $17,738 | $10,507 | $1,478 | $0 | $0 | $29,723 |
| 28 | $0 | $18,270 | $10,823 | $1,522 | $0 | $0 | $30,615 |
| 29 | $0 | $18,818 | $11,147 | $1,568 | $0 | $0 | $31,533 |
| 30 | $0 | $19,382 | $11,482 | $1,615 | $0 | $0 | $32,479 |
| 31 | $0 | $19,964 | $11,826 | $1,664 | $0 | $0 | $33,454 |
| 32 | $0 | $20,563 | $12,181 | $1,714 | $0 | $0 | $34,457 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 33 | $0 | $21,180 | $12,546 | $1,765 | $0 | $0 | $35,491 |
| 34 | $0 | $21,815 | $12,923 | $1,818 | $0 | $0 | $36,556 |
| 35 | $0 | $22,469 | $13,311 | $1,872 | $0 | $0 | $37,652 |
| 36 | $0 | $23,143 | $13,710 | $1,929 | $0 | $0 | $38,782 |
| 37 | $0 | $23,838 | $14,121 | $1,986 | $0 | $0 | $39,945 |
| 38 | $0 | $24,553 | $14,545 | $2,046 | $0 | $0 | $41,144 |
| 39 | $0 | $25,289 | $14,981 | $2,107 | $0 | $0 | $42,378 |
| 40 | $0 | $26,048 | $15,431 | $2,171 | $0 | $0 | $43,649 |

**3% Inflation*

**Sub Watershed #16 Annual Cost* After Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $3,733 | $15,317 | $13,610 | $1,276 | $4,882 | $7,180 | $45,999 |
| 2 | $3,845 | $15,776 | $14,018 | $1,315 | $5,029 | $7,395 | $47,379 |
| 3 | $3,961 | $16,250 | $14,439 | $1,354 | $5,180 | $7,617 | $48,800 |
| 4 | $4,080 | $16,737 | $14,872 | $1,395 | $5,335 | $7,846 | $50,264 |
| 5 | $4,202 | $17,239 | $15,318 | $1,437 | $5,495 | $8,081 | $51,772 |
| 6 | $4,328 | $17,756 | $15,778 | $1,480 | $5,660 | $8,323 | $53,325 |
| 7 | $4,458 | $18,289 | $16,251 | $1,524 | $5,830 | $8,573 | $54,925 |
| 8 | $4,592 | $18,838 | $16,739 | $1,570 | $6,005 | $8,830 | $56,573 |
| 9 | $4,729 | $19,403 | $17,241 | $1,617 | $6,185 | $9,095 | $58,270 |
| 10 | $4,871 | $19,985 | $17,758 | $1,665 | $6,370 | $9,368 | $60,018 |
| 11 | $5,017 | $20,584 | $18,291 | $1,715 | $6,561 | $9,649 | $61,819 |
| 12 | $5,168 | $21,202 | $18,840 | $1,767 | $6,758 | $9,938 | $63,673 |
| 13 | $5,323 | $21,838 | $19,405 | $1,820 | $6,961 | $10,237 | $65,583 |
| 14 | $5,483 | $22,493 | $19,987 | $1,874 | $7,170 | $10,544 | $67,551 |
| 15 | $5,647 | $23,168 | $20,587 | $1,931 | $7,385 | $10,860 | $69,577 |
| 16 | $5,817 | $23,863 | $21,204 | $1,989 | $7,606 | $11,186 | $71,665 |
| 17 | $5,991 | $24,579 | $21,840 | $2,048 | $7,835 | $11,521 | $73,815 |
| 18 | $6,171 | $25,316 | $22,496 | $2,110 | $8,070 | $11,867 | $76,029 |
| 19 | $6,356 | $26,076 | $23,170 | $2,173 | $8,312 | $12,223 | $78,310 |
| 20 | $6,547 | $26,858 | $23,866 | $2,238 | $8,561 | $12,590 | $80,659 |
| 21 | $0 | $27,664 | $16,388 | $2,305 | $0 | $0 | $46,357 |
| 22 | $0 | $28,494 | $16,879 | $2,374 | $0 | $0 | $47,748 |
| 23 | $0 | $29,349 | $17,386 | $2,446 | $0 | $0 | $49,180 |
| 24 | $0 | $30,229 | $17,907 | $2,519 | $0 | $0 | $50,655 |
| 25 | $0 | $31,136 | $18,444 | $2,595 | $0 | $0 | $52,175 |
| 26 | $0 | $32,070 | $18,998 | $2,672 | $0 | $0 | $53,740 |
| 27 | $0 | $33,032 | $19,568 | $2,753 | $0 | $0 | $55,352 |
| 28 | $0 | $34,023 | $20,155 | $2,835 | $0 | $0 | $57,013 |
| 29 | $0 | $35,044 | $20,759 | $2,920 | $0 | $0 | $58,723 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 30 | $0 | $36,095 | $21,382 | $3,008 | $0 | $0 | $60,485 |
| 31 | $0 | $37,178 | $22,024 | $3,098 | $0 | $0 | $62,300 |
| 32 | $0 | $38,293 | $22,684 | $3,191 | $0 | $0 | $64,169 |
| 33 | $0 | $39,442 | $23,365 | $3,287 | $0 | $0 | $66,094 |
| 34 | $0 | $40,625 | $24,066 | $3,385 | $0 | $0 | $68,077 |
| 35 | $0 | $41,844 | $24,788 | $3,487 | $0 | $0 | $70,119 |
| 36 | $0 | $43,099 | $25,531 | $3,592 | $0 | $0 | $72,222 |
| 37 | $0 | $44,392 | $26,297 | $3,699 | $0 | $0 | $74,389 |
| 38 | $0 | $45,724 | $27,086 | $3,810 | $0 | $0 | $76,621 |
| 39 | $0 | $47,096 | $27,899 | $3,925 | $0 | $0 | $78,919 |
| 40 | $0 | $48,509 | $28,736 | $4,042 | $0 | $0 | $81,287 |

**3% Inflation*

**Sub Watershed #25 Annual Cost* After Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $1,619 | $0 | $5,903 | $554 | $0 | $3,113 | $11,187 |
| 2 | $1,667 | $0 | $6,080 | $570 | $0 | $3,206 | $11,523 |
| 3 | $1,717 | $0 | $6,262 | $587 | $0 | $3,302 | $11,869 |
| 4 | $1,769 | $0 | $6,450 | $605 | $0 | $3,401 | $12,225 |
| 5 | $1,822 | $0 | $6,643 | $623 | $0 | $3,503 | $12,591 |
| 6 | $1,876 | $0 | $6,843 | $642 | $0 | $3,608 | $12,969 |
| 7 | $1,933 | $0 | $7,048 | $661 | $0 | $3,716 | $13,358 |
| 8 | $1,991 | $0 | $7,259 | $681 | $0 | $3,828 | $13,759 |
| 9 | $2,050 | $0 | $7,477 | $701 | $0 | $3,943 | $14,172 |
| 10 | $2,112 | $0 | $7,701 | $722 | $0 | $4,061 | $14,597 |
| 11 | $2,175 | $0 | $7,933 | $744 | $0 | $4,183 | $15,035 |
| 12 | $2,240 | $0 | $8,170 | $766 | $0 | $4,308 | $15,486 |
| 13 | $2,308 | $0 | $8,416 | $789 | $0 | $4,438 | $15,950 |
| 14 | $2,377 | $0 | $8,668 | $813 | $0 | $4,571 | $16,429 |
| 15 | $2,448 | $0 | $8,928 | $837 | $0 | $4,708 | $16,922 |
| 16 | $2,522 | $0 | $9,196 | $863 | $0 | $4,849 | $17,429 |
| 17 | $2,597 | $0 | $9,472 | $888 | $0 | $4,995 | $17,952 |
| 18 | $2,675 | $0 | $9,756 | $915 | $0 | $5,144 | $18,491 |
| 19 | $2,755 | $0 | $10,049 | $943 | $0 | $5,299 | $19,045 |
| 20 | $2,838 | $0 | $10,350 | $971 | $0 | $5,458 | $19,617 |
| 21 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 22 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 23 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 24 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 25 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 26 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 27 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 28 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 29 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 30 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 31 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 32 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 33 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 34 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 35 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 36 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 37 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 38 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 39 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 40 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |

**3% Inflation*

**Sub Watershed #28 Annual Cost* After Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $1,375 | $0 | $5,014 | $467 | $0 | $2,644 | $9,499 |
| 2 | $1,416 | $0 | $5,164 | $481 | $0 | $2,723 | $9,784 |
| 3 | $1,458 | $0 | $5,319 | $495 | $0 | $2,805 | $10,078 |
| 4 | $1,502 | $0 | $5,479 | $510 | $0 | $2,889 | $10,380 |
| 5 | $1,547 | $0 | $5,643 | $525 | $0 | $2,976 | $10,691 |
| 6 | $1,594 | $0 | $5,813 | $541 | $0 | $3,065 | $11,012 |
| 7 | $1,642 | $0 | $5,987 | $557 | $0 | $3,157 | $11,342 |
| 8 | $1,691 | $0 | $6,167 | $574 | $0 | $3,251 | $11,683 |
| 9 | $1,741 | $0 | $6,352 | $591 | $0 | $3,349 | $12,033 |
| 10 | $1,794 | $0 | $6,542 | $609 | $0 | $3,449 | $12,394 |
| 11 | $1,848 | $0 | $6,738 | $627 | $0 | $3,553 | $12,766 |
| 12 | $1,903 | $0 | $6,940 | $646 | $0 | $3,660 | $13,149 |
| 13 | $1,960 | $0 | $7,149 | $665 | $0 | $3,769 | $13,543 |
| 14 | $2,019 | $0 | $7,363 | $685 | $0 | $3,882 | $13,950 |
| 15 | $2,079 | $0 | $7,584 | $706 | $0 | $3,999 | $14,368 |
| 16 | $2,142 | $0 | $7,812 | $727 | $0 | $4,119 | $14,799 |
| 17 | $2,206 | $0 | $8,046 | $749 | $0 | $4,242 | $15,243 |
| 18 | $2,272 | $0 | $8,287 | $771 | $0 | $4,370 | $15,701 |
| 19 | $2,340 | $0 | $8,536 | $794 | $0 | $4,501 | $16,172 |
| 20 | $2,411 | $0 | $8,792 | $818 | $0 | $4,636 | $16,657 |
| 21 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 22 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 23 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 24 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 25 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 26 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 27 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 28 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 29 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 30 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 31 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 32 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 33 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 34 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 35 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 36 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 37 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 38 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 39 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| 40 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |

**3% Inflation*

**Sub Watershed #31 Annual Cost* After Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $2,843 | $11,663 | $10,364 | $972 | $3,718 | $5,467 | $35,026 |
| 2 | $2,928 | $12,013 | $10,675 | $1,001 | $3,829 | $5,631 | $36,077 |
| 3 | $3,016 | $12,373 | $10,995 | $1,031 | $3,944 | $5,800 | $37,160 |
| 4 | $3,107 | $12,745 | $11,325 | $1,062 | $4,062 | $5,974 | $38,274 |
| 5 | $3,200 | $13,127 | $11,664 | $1,094 | $4,184 | $6,153 | $39,423 |
| 6 | $3,296 | $13,521 | $12,014 | $1,127 | $4,310 | $6,338 | $40,605 |
| 7 | $3,395 | $13,926 | $12,375 | $1,161 | $4,439 | $6,528 | $41,823 |
| 8 | $3,496 | $14,344 | $12,746 | $1,195 | $4,572 | $6,724 | $43,078 |
| 9 | $3,601 | $14,775 | $13,128 | $1,231 | $4,709 | $6,926 | $44,371 |
| 10 | $3,709 | $15,218 | $13,522 | $1,268 | $4,851 | $7,133 | $45,702 |
| 11 | $3,821 | $15,674 | $13,928 | $1,306 | $4,996 | $7,347 | $47,073 |
| 12 | $3,935 | $16,145 | $14,346 | $1,345 | $5,146 | $7,568 | $48,485 |
| 13 | $4,053 | $16,629 | $14,776 | $1,386 | $5,300 | $7,795 | $49,939 |
| 14 | $4,175 | $17,128 | $15,219 | $1,427 | $5,459 | $8,029 | $51,438 |
| 15 | $4,300 | $17,642 | $15,676 | $1,470 | $5,623 | $8,270 | $52,981 |
| 16 | $4,429 | $18,171 | $16,146 | $1,514 | $5,792 | $8,518 | $54,570 |
| 17 | $4,562 | $18,716 | $16,631 | $1,560 | $5,966 | $8,773 | $56,207 |
| 18 | $4,699 | $19,277 | $17,130 | $1,606 | $6,145 | $9,036 | $57,893 |
| 19 | $4,840 | $19,856 | $17,643 | $1,655 | $6,329 | $9,307 | $59,630 |
| 20 | $4,985 | $20,451 | $18,173 | $1,704 | $6,519 | $9,587 | $61,419 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 21 | $0 | $21,065 | $12,479 | $1,755 | $0 | $0 | $35,299 |
| 22 | $0 | $21,697 | $12,853 | $1,808 | $0 | $0 | $36,358 |
| 23 | $0 | $22,348 | $13,239 | $1,862 | $0 | $0 | $37,449 |
| 24 | $0 | $23,018 | $13,636 | $1,918 | $0 | $0 | $38,572 |
| 25 | $0 | $23,709 | $14,045 | $1,976 | $0 | $0 | $39,729 |
| 26 | $0 | $24,420 | $14,466 | $2,035 | $0 | $0 | $40,921 |
| 27 | $0 | $25,153 | $14,900 | $2,096 | $0 | $0 | $42,149 |
| 28 | $0 | $25,907 | $15,347 | $2,159 | $0 | $0 | $43,413 |
| 29 | $0 | $26,685 | $15,808 | $2,224 | $0 | $0 | $44,716 |
| 30 | $0 | $27,485 | $16,282 | $2,290 | $0 | $0 | $46,057 |
| 31 | $0 | $28,310 | $16,770 | $2,359 | $0 | $0 | $47,439 |
| 32 | $0 | $29,159 | $17,273 | $2,430 | $0 | $0 | $48,862 |
| 33 | $0 | $30,034 | $17,792 | $2,503 | $0 | $0 | $50,328 |
| 34 | $0 | $30,935 | $18,325 | $2,578 | $0 | $0 | $51,838 |
| 35 | $0 | $31,863 | $18,875 | $2,655 | $0 | $0 | $53,393 |
| 36 | $0 | $32,819 | $19,441 | $2,735 | $0 | $0 | $54,995 |
| 37 | $0 | $33,803 | $20,025 | $2,817 | $0 | $0 | $56,645 |
| 38 | $0 | $34,817 | $20,625 | $2,901 | $0 | $0 | $58,344 |
| 39 | $0 | $35,862 | $21,244 | $2,988 | $0 | $0 | $60,094 |
| 40 | $0 | $36,938 | $21,881 | $3,078 | $0 | $0 | $61,897 |

**3% Inflation*

**Sub Watershed #33 Annual Cost* After Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $1,701 | $6,980 | $6,202 | $582 | $2,225 | $3,272 | $20,962 |
| 2 | $1,752 | $7,189 | $6,388 | $599 | $2,292 | $3,370 | $21,591 |
| 3 | $1,805 | $7,405 | $6,580 | $617 | $2,360 | $3,471 | $22,239 |
| 4 | $1,859 | $7,627 | $6,777 | $636 | $2,431 | $3,575 | $22,906 |
| 5 | $1,915 | $7,856 | $6,981 | $655 | $2,504 | $3,683 | $23,593 |
| 6 | $1,972 | $8,092 | $7,190 | $674 | $2,579 | $3,793 | $24,301 |
| 7 | $2,032 | $8,334 | $7,406 | $695 | $2,657 | $3,907 | $25,030 |
| 8 | $2,092 | $8,585 | $7,628 | $715 | $2,736 | $4,024 | $25,781 |
| 9 | $2,155 | $8,842 | $7,857 | $737 | $2,818 | $4,145 | $26,554 |
| 10 | $2,220 | $9,107 | $8,093 | $759 | $2,903 | $4,269 | $27,351 |
| 11 | $2,287 | $9,381 | $8,335 | $782 | $2,990 | $4,397 | $28,171 |
| 12 | $2,355 | $9,662 | $8,585 | $805 | $3,080 | $4,529 | $29,016 |
| 13 | $2,426 | $9,952 | $8,843 | $829 | $3,172 | $4,665 | $29,887 |
| 14 | $2,499 | $10,250 | $9,108 | $854 | $3,267 | $4,805 | $30,784 |
| 15 | $2,573 | $10,558 | $9,382 | $880 | $3,365 | $4,949 | $31,707 |
| 16 | $2,651 | $10,875 | $9,663 | $906 | $3,466 | $5,097 | $32,658 |
| 17 | $2,730 | $11,201 | $9,953 | $933 | $3,570 | $5,250 | $33,638 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 18 | $2,812 | $11,537 | $10,251 | $961 | $3,677 | $5,408 | $34,647 |
| 19 | $2,896 | $11,883 | $10,559 | $990 | $3,788 | $5,570 | $35,687 |
| 20 | $2,983 | $12,239 | $10,876 | $1,020 | $3,901 | $5,737 | $36,757 |
| 21 | $0 | $12,607 | $7,468 | $1,051 | $0 | $0 | $21,125 |
| 22 | $0 | $12,985 | $7,692 | $1,082 | $0 | $0 | $21,759 |
| 23 | $0 | $13,374 | $7,923 | $1,115 | $0 | $0 | $22,412 |
| 24 | $0 | $13,776 | $8,160 | $1,148 | $0 | $0 | $23,084 |
| 25 | $0 | $14,189 | $8,405 | $1,182 | $0 | $0 | $23,777 |
| 26 | $0 | $14,615 | $8,657 | $1,218 | $0 | $0 | $24,490 |
| 27 | $0 | $15,053 | $8,917 | $1,254 | $0 | $0 | $25,225 |
| 28 | $0 | $15,505 | $9,185 | $1,292 | $0 | $0 | $25,981 |
| 29 | $0 | $15,970 | $9,460 | $1,331 | $0 | $0 | $26,761 |
| 30 | $0 | $16,449 | $9,744 | $1,371 | $0 | $0 | $27,564 |
| 31 | $0 | $16,942 | $10,036 | $1,412 | $0 | $0 | $28,391 |
| 32 | $0 | $17,451 | $10,337 | $1,454 | $0 | $0 | $29,242 |
| 33 | $0 | $17,974 | $10,648 | $1,498 | $0 | $0 | $30,120 |
| 34 | $0 | $18,513 | $10,967 | $1,543 | $0 | $0 | $31,023 |
| 35 | $0 | $19,069 | $11,296 | $1,589 | $0 | $0 | $31,954 |
| 36 | $0 | $19,641 | $11,635 | $1,637 | $0 | $0 | $32,912 |
| 37 | $0 | $20,230 | $11,984 | $1,686 | $0 | $0 | $33,900 |
| 38 | $0 | $20,837 | $12,343 | $1,736 | $0 | $0 | $34,917 |
| 39 | $0 | $21,462 | $12,714 | $1,788 | $0 | $0 | $35,964 |
| 40 | $0 | $22,106 | $13,095 | $1,842 | $0 | $0 | $37,043 |

**3% Inflation*

**Sub Watershed #35 Annual Cost* After Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $3,419 | $14,027 | $12,464 | $1,169 | $4,471 | $6,575 | $42,126 |
| 2 | $3,522 | $14,448 | $12,838 | $1,204 | $4,605 | $6,773 | $43,390 |
| 3 | $3,627 | $14,881 | $13,223 | $1,240 | $4,743 | $6,976 | $44,691 |
| 4 | $3,736 | $15,328 | $13,620 | $1,277 | $4,886 | $7,185 | $46,032 |
| 5 | $3,848 | $15,788 | $14,029 | $1,316 | $5,032 | $7,401 | $47,413 |
| 6 | $3,964 | $16,261 | $14,450 | $1,355 | $5,183 | $7,623 | $48,836 |
| 7 | $4,083 | $16,749 | $14,883 | $1,396 | $5,339 | $7,851 | $50,301 |
| 8 | $4,205 | $17,252 | $15,329 | $1,438 | $5,499 | $8,087 | $51,810 |
| 9 | $4,331 | $17,769 | $15,789 | $1,481 | $5,664 | $8,329 | $53,364 |
| 10 | $4,461 | $18,302 | $16,263 | $1,525 | $5,834 | $8,579 | $54,965 |
| 11 | $4,595 | $18,851 | $16,751 | $1,571 | $6,009 | $8,837 | $56,614 |
| 12 | $4,733 | $19,417 | $17,253 | $1,618 | $6,189 | $9,102 | $58,312 |
| 13 | $4,875 | $19,999 | $17,771 | $1,667 | $6,375 | $9,375 | $60,062 |
| 14 | $5,021 | $20,599 | $18,304 | $1,717 | $6,566 | $9,656 | $61,863 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 15 | $5,172 | $21,217 | $18,853 | $1,768 | $6,763 | $9,946 | $63,719 |
| 16 | $5,327 | $21,854 | $19,419 | $1,821 | $6,966 | $10,244 | $65,631 |
| 17 | $5,487 | $22,510 | $20,002 | $1,876 | $7,175 | $10,551 | $67,600 |
| 18 | $5,651 | $23,185 | $20,602 | $1,932 | $7,390 | $10,868 | $69,628 |
| 19 | $5,821 | $23,880 | $21,220 | $1,990 | $7,612 | $11,194 | $71,717 |
| 20 | $5,995 | $24,597 | $21,856 | $2,050 | $7,840 | $11,530 | $73,868 |
| 21 | $0 | $25,335 | $15,008 | $2,111 | $0 | $0 | $42,454 |
| 22 | $0 | $26,095 | $15,458 | $2,175 | $0 | $0 | $43,727 |
| 23 | $0 | $26,878 | $15,922 | $2,240 | $0 | $0 | $45,039 |
| 24 | $0 | $27,684 | $16,400 | $2,307 | $0 | $0 | $46,390 |
| 25 | $0 | $28,514 | $16,892 | $2,376 | $0 | $0 | $47,782 |
| 26 | $0 | $29,370 | $17,398 | $2,447 | $0 | $0 | $49,216 |
| 27 | $0 | $30,251 | $17,920 | $2,521 | $0 | $0 | $50,692 |
| 28 | $0 | $31,158 | $18,458 | $2,597 | $0 | $0 | $52,213 |
| 29 | $0 | $32,093 | $19,012 | $2,674 | $0 | $0 | $53,779 |
| 30 | $0 | $33,056 | $19,582 | $2,755 | $0 | $0 | $55,393 |
| 31 | $0 | $34,048 | $20,169 | $2,837 | $0 | $0 | $57,054 |
| 32 | $0 | $35,069 | $20,774 | $2,922 | $0 | $0 | $58,766 |
| 33 | $0 | $36,121 | $21,398 | $3,010 | $0 | $0 | $60,529 |
| 34 | $0 | $37,205 | $22,040 | $3,100 | $0 | $0 | $62,345 |
| 35 | $0 | $38,321 | $22,701 | $3,193 | $0 | $0 | $64,215 |
| 36 | $0 | $39,471 | $23,382 | $3,289 | $0 | $0 | $66,142 |
| 37 | $0 | $40,655 | $24,083 | $3,388 | $0 | $0 | $68,126 |
| 38 | $0 | $41,874 | $24,806 | $3,490 | $0 | $0 | $70,170 |
| 39 | $0 | $43,131 | $25,550 | $3,594 | $0 | $0 | $72,275 |
| 40 | $0 | $44,425 | $26,316 | $3,702 | $0 | $0 | $74,443 |

**3% Inflation*

**Sub Watershed #38 Annual Cost* After Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $3,353 | $13,757 | $12,224 | $1,146 | $4,385 | $6,449 | $41,314 |
| 2 | $3,454 | $14,170 | $12,591 | $1,181 | $4,517 | $6,642 | $42,553 |
| 3 | $3,557 | $14,595 | $12,968 | $1,216 | $4,652 | $6,841 | $43,830 |
| 4 | $3,664 | $15,032 | $13,358 | $1,253 | $4,792 | $7,046 | $45,145 |
| 5 | $3,774 | $15,483 | $13,758 | $1,290 | $4,935 | $7,258 | $46,499 |
| 6 | $3,887 | $15,948 | $14,171 | $1,329 | $5,083 | $7,476 | $47,894 |
| 7 | $4,004 | $16,426 | $14,596 | $1,369 | $5,236 | $7,700 | $49,331 |
| 8 | $4,124 | $16,919 | $15,034 | $1,410 | $5,393 | $7,931 | $50,811 |
| 9 | $4,248 | $17,427 | $15,485 | $1,452 | $5,555 | $8,169 | $52,335 |
| 10 | $4,375 | $17,950 | $15,950 | $1,496 | $5,721 | $8,414 | $53,905 |
| 11 | $4,506 | $18,488 | $16,428 | $1,541 | $5,893 | $8,666 | $55,522 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12 | $4,642 | $19,043 | $16,921 | $1,587 | $6,070 | $8,926 | $57,188 |
| 13 | $4,781 | $19,614 | $17,429 | $1,634 | $6,252 | $9,194 | $58,904 |
| 14 | $4,924 | $20,202 | $17,951 | $1,684 | $6,439 | $9,470 | $60,671 |
| 15 | $5,072 | $20,808 | $18,490 | $1,734 | $6,633 | $9,754 | $62,491 |
| 16 | $5,224 | $21,433 | $19,045 | $1,786 | $6,832 | $10,047 | $64,366 |
| 17 | $5,381 | $22,076 | $19,616 | $1,840 | $7,037 | $10,348 | $66,297 |
| 18 | $5,542 | $22,738 | $20,204 | $1,895 | $7,248 | $10,658 | $68,286 |
| 19 | $5,709 | $23,420 | $20,811 | $1,952 | $7,465 | $10,978 | $70,334 |
| 20 | $5,880 | $24,123 | $21,435 | $2,010 | $7,689 | $11,307 | $72,444 |
| 21 | $0 | $24,846 | $14,719 | $2,071 | $0 | $0 | $41,635 |
| 22 | $0 | $25,592 | $15,160 | $2,133 | $0 | $0 | $42,885 |
| 23 | $0 | $26,359 | $15,615 | $2,197 | $0 | $0 | $44,171 |
| 24 | $0 | $27,150 | $16,083 | $2,263 | $0 | $0 | $45,496 |
| 25 | $0 | $27,965 | $16,566 | $2,330 | $0 | $0 | $46,861 |
| 26 | $0 | $28,804 | $17,063 | $2,400 | $0 | $0 | $48,267 |
| 27 | $0 | $29,668 | $17,575 | $2,472 | $0 | $0 | $49,715 |
| 28 | $0 | $30,558 | $18,102 | $2,546 | $0 | $0 | $51,206 |
| 29 | $0 | $31,475 | $18,645 | $2,623 | $0 | $0 | $52,743 |
| 30 | $0 | $32,419 | $19,204 | $2,702 | $0 | $0 | $54,325 |
| 31 | $0 | $33,391 | $19,781 | $2,783 | $0 | $0 | $55,955 |
| 32 | $0 | $34,393 | $20,374 | $2,866 | $0 | $0 | $57,633 |
| 33 | $0 | $35,425 | $20,985 | $2,952 | $0 | $0 | $59,362 |
| 34 | $0 | $36,488 | $21,615 | $3,041 | $0 | $0 | $61,143 |
| 35 | $0 | $37,582 | $22,263 | $3,132 | $0 | $0 | $62,977 |
| 36 | $0 | $38,710 | $22,931 | $3,226 | $0 | $0 | $64,867 |
| 37 | $0 | $39,871 | $23,619 | $3,323 | $0 | $0 | $66,813 |
| 38 | $0 | $41,067 | $24,328 | $3,422 | $0 | $0 | $68,817 |
| 39 | $0 | $42,299 | $25,057 | $3,525 | $0 | $0 | $70,882 |
| 40 | $0 | $43,568 | $25,809 | $3,631 | $0 | $0 | $73,008 |

**3% Inflation*

**Sub Watershed #55 Annual Cost* After Cost-Share, Cropland BMPs**

| Year | Conservation Crop Rotations | Grassed Waterways | No-Till | Vegetative Buffers | Terraces | Permanent Vegetation | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | $3,568 | $14,637 | $13,006 | $1,220 | $4,665 | $6,861 | $43,957 |
| 2 | $3,675 | $15,076 | $13,396 | $1,256 | $4,805 | $7,067 | $45,275 |
| 3 | $3,785 | $15,528 | $13,798 | $1,294 | $4,950 | $7,279 | $46,634 |
| 4 | $3,899 | $15,994 | $14,212 | $1,333 | $5,098 | $7,497 | $48,033 |
| 5 | $4,016 | $16,474 | $14,638 | $1,373 | $5,251 | $7,722 | $49,474 |
| 6 | $4,136 | $16,968 | $15,077 | $1,414 | $5,409 | $7,954 | $50,958 |
| 7 | $4,260 | $17,477 | $15,530 | $1,456 | $5,571 | $8,192 | $52,487 |
| 8 | $4,388 | $18,001 | $15,996 | $1,500 | $5,738 | $8,438 | $54,061 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9 | $4,519 | $18,541 | $16,476 | $1,545 | $5,910 | $8,691 | $55,683 |
| 10 | $4,655 | $19,098 | $16,970 | $1,591 | $6,087 | $8,952 | $57,354 |
| 11 | $4,795 | $19,671 | $17,479 | $1,639 | $6,270 | $9,221 | $59,074 |
| 12 | $4,939 | $20,261 | $18,003 | $1,688 | $6,458 | $9,497 | $60,846 |
| 13 | $5,087 | $20,869 | $18,543 | $1,739 | $6,652 | $9,782 | $62,672 |
| 14 | $5,239 | $21,495 | $19,100 | $1,791 | $6,851 | $10,076 | $64,552 |
| 15 | $5,396 | $22,139 | $19,673 | $1,845 | $7,057 | $10,378 | $66,488 |
| 16 | $5,558 | $22,804 | $20,263 | $1,900 | $7,269 | $10,689 | $68,483 |
| 17 | $5,725 | $23,488 | $20,871 | $1,957 | $7,487 | $11,010 | $70,538 |
| 18 | $5,897 | $24,192 | $21,497 | $2,016 | $7,711 | $11,340 | $72,654 |
| 19 | $6,074 | $24,918 | $22,142 | $2,077 | $7,943 | $11,680 | $74,833 |
| 20 | $6,256 | $25,666 | $22,806 | $2,139 | $8,181 | $12,031 | $77,078 |
| 21 | $0 | $26,436 | $15,660 | $2,203 | $0 | $0 | $44,299 |
| 22 | $0 | $27,229 | $16,130 | $2,269 | $0 | $0 | $45,628 |
| 23 | $0 | $28,046 | $16,614 | $2,337 | $0 | $0 | $46,997 |
| 24 | $0 | $28,887 | $17,112 | $2,407 | $0 | $0 | $48,406 |
| 25 | $0 | $29,754 | $17,626 | $2,479 | $0 | $0 | $49,859 |
| 26 | $0 | $30,646 | $18,154 | $2,554 | $0 | $0 | $51,354 |
| 27 | $0 | $31,566 | $18,699 | $2,630 | $0 | $0 | $52,895 |
| 28 | $0 | $32,513 | $19,260 | $2,709 | $0 | $0 | $54,482 |
| 29 | $0 | $33,488 | $19,838 | $2,791 | $0 | $0 | $56,116 |
| 30 | $0 | $34,493 | $20,433 | $2,874 | $0 | $0 | $57,800 |
| 31 | $0 | $35,527 | $21,046 | $2,961 | $0 | $0 | $59,534 |
| 32 | $0 | $36,593 | $21,677 | $3,049 | $0 | $0 | $61,320 |
| 33 | $0 | $37,691 | $22,328 | $3,141 | $0 | $0 | $63,159 |
| 34 | $0 | $38,822 | $22,997 | $3,235 | $0 | $0 | $65,054 |
| 35 | $0 | $39,986 | $23,687 | $3,332 | $0 | $0 | $67,006 |
| 36 | $0 | $41,186 | $24,398 | $3,432 | $0 | $0 | $69,016 |
| 37 | $0 | $42,422 | $25,130 | $3,535 | $0 | $0 | $71,087 |
| 38 | $0 | $43,694 | $25,884 | $3,641 | $0 | $0 | $73,219 |
| 39 | $0 | $45,005 | $26,660 | $3,750 | $0 | $0 | $75,416 |
| 40 | $0 | $46,355 | $27,460 | $3,863 | $0 | $0 | $77,678 |

**3% Inflation*

## 13.4 Kansas Water Office Cottonwood Watershed Structure Model

**Watershed Detention Structure Reductions to Sediment Yield and Flood Frequency for the Cottonwood River near Plymouth, Kansas**

**Executive Summary**
The Kansas Water Office has developed a model to analyze the impact of enhanced detention storage in the Cottonwood River basin. The model evaluates the changes to the mean annual sediment yield and flood frequency for the flows recorded on the Cottonwood River near Plymouth from 1990 through 2009 by temporarily storing a portion of the historic flows in an artificial detention pool. The overall size of the artificial detention pool in the model is user specified. The user specified volume is conceptualized within the model by adding or removing watershed structures within the Cottonwood basin. Each watershed structure has the same physical properties established by reviewing and averaging the properties of all the planned structures in the basin. KWO modeled total detention volumes ranging from 10,000 to 200,000 acre-feet for this report.

In order gain appreciable reductions to sediment yields and flood frequencies on the Cottonwood River the evacuation time of the 'typical' watershed structure detention pool had to be increased significantly over the standard design evacuation rate for those 'typical' watershed structures.

Model results indicate sediment yield reductions limit out for very large detention volumes in the basin near 24% below the mean annual sediment yield for the last 20 years. Reductions to mean annual sediment yields are generally linear as total detention volumes increase. Flood frequency reductions of about 88% can be achieved with very large detention volume values. The reductions to the flood frequency are not linear but S-shaped. Initial flood frequency reductions are relatively large for the smaller detention volumes, the reduction rate declines for the medium sized detention volumes and then increases again for the largest detention volumes simulated.

Sediment yield and flood frequency reductions for the total detention volume of currently planned watershed structures in watershed districts located above the Cottonwood River near Plymouth were also calculated. The 31,155 acre-feet of detention storage of those planned structures would reduce the mean annual sediment yield at Plymouth by 4.3% and the flood flows were reduced by 20% during the modeled period (1990 – 2009).

**Introduction**
The KWO has developed an artificial detention pool model in response two issues on the Cottonwood River;

1. the impact of enhancing detention pool volumes on the flood frequency on the Cottonwood River
2. improving the estimated impact on mean annual sediment yield from additional watershed structures in the Cottonwood River drainage area,

The first issue is associated with a request made by the Cottonwood watershed reduction and protection strategies (WRAPS) stakeholder leadership team about flood frequency reduction and the second issue is a KWO initiative to improve upon previous sediment yield reduction estimates. Both issues are strictly related to watershed structure detention volume impacts on the Cottonwood River.

The computer model routes 1990 – 2009 runoff flows from within the Cottonwood River basin below Marion Reservoir through a user-specified artificial detention pool to analyze the impact on flow rates and sediment yields on the Cottonwood River near Plymouth, Kansas. The numbers of days equaling or exceeding historic flood flows are compared to the modeled flows to determine

the reduction to flood flow frequency. The modeled flows are also utilized to create mean annual flow exceedence curves to compare to the historic mean annual flow exceedence curves. The change to those exceedence curves is used to calculate the changes to mean annual sediment yields on the Cottonwood River associated with enhanced flow detention.

**Methodology**

Figure 1 locates existing and planned watershed structures within watershed districts, USGS flow gaging stations and the sub watersheds of those stations and the estimated mean sediment yield for streams on the Kansas Surface Water Register in the Cottonwood basin. Figure 2 shows 1990 – 2009 flow volumes for the four sub watersheds (depicted by the matching colors in Figure 1).

Gaged average daily flows (1990 – 2009) on the Cottonwood River below Marion Reservoir (07179795) were subtracted from the average daily gaged flows recorded at the Cottonwood River near Plymouth (07182250) on a two day lag. The two day lag was selected based upon the reported travel time in the Marion Reservoir Water Control Manual (1996, page A-19) between Marion Reservoir and the gage near Plymouth. This adjusted flow at Plymouth represents the flow contributed from the drainage area above Plymouth and below Marion Reservoir where the enhancements to detention storage would be located.

If the artificial detention pool was available to temporarily store all adjusted flows at Plymouth, then the model would function by routing all adjusted flows through the artificial detention pool in the model. In reality, this would not be the case unless the detention pool was created on the Cottonwood River near Plymouth gage site. The KWO model assumes the artificial detention pool is comprised of a set of 'typical' watershed structures impounding much smaller drainages. The 'typical' structures were defined by calculating the average detention volume of the 60 planned (but not built) structures located in the watershed districts above the Plymouth gage site (Figure 1). The average detention volume was just under 520 acre-feet for the planned structures. The average drainage area was just over 2.8 square miles. Changes to the artificial detention pool volume within the model add or remove 'typical' watershed structures proportional to the size of the total artificial volume change.

The fraction of the total area controlled by the 'typical' watershed structures determines the fraction of the adjusted Plymouth flows available for potential detention pool storage. Since most of the 60 planned watershed structures above Plymouth are located on intermittent streams, the flows generated from

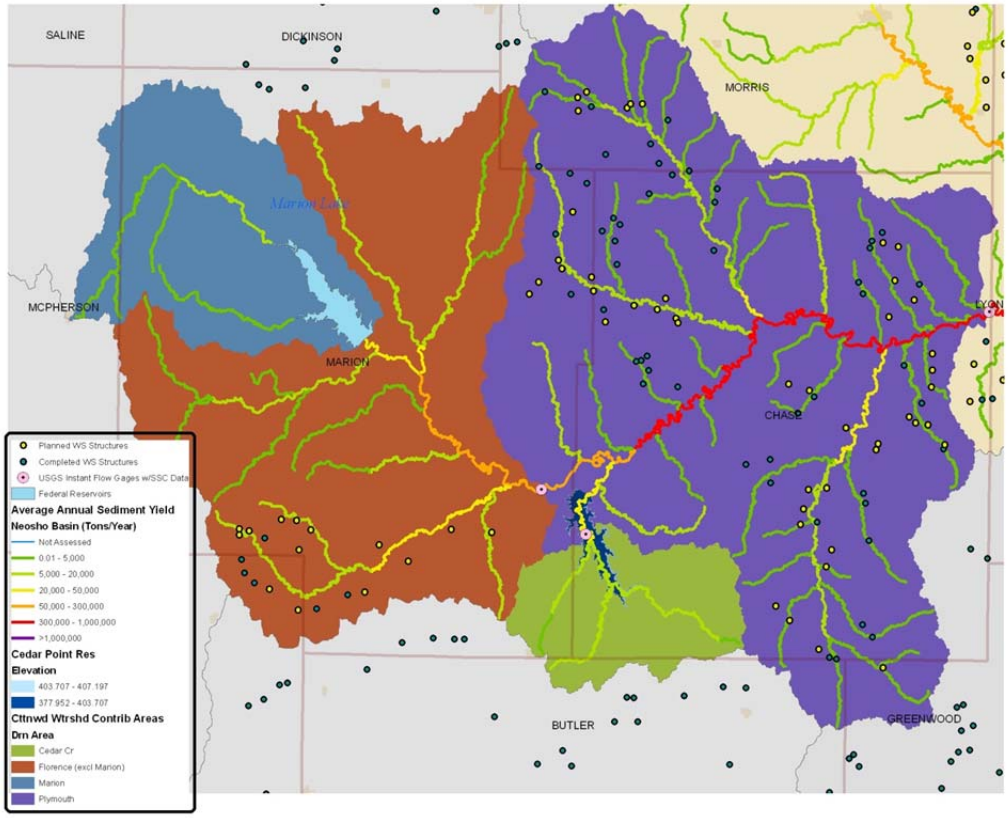



**Figure 1**: Flow gages, completed and planned watershed structures and estimated sediment yield for the Cottonwood basin.

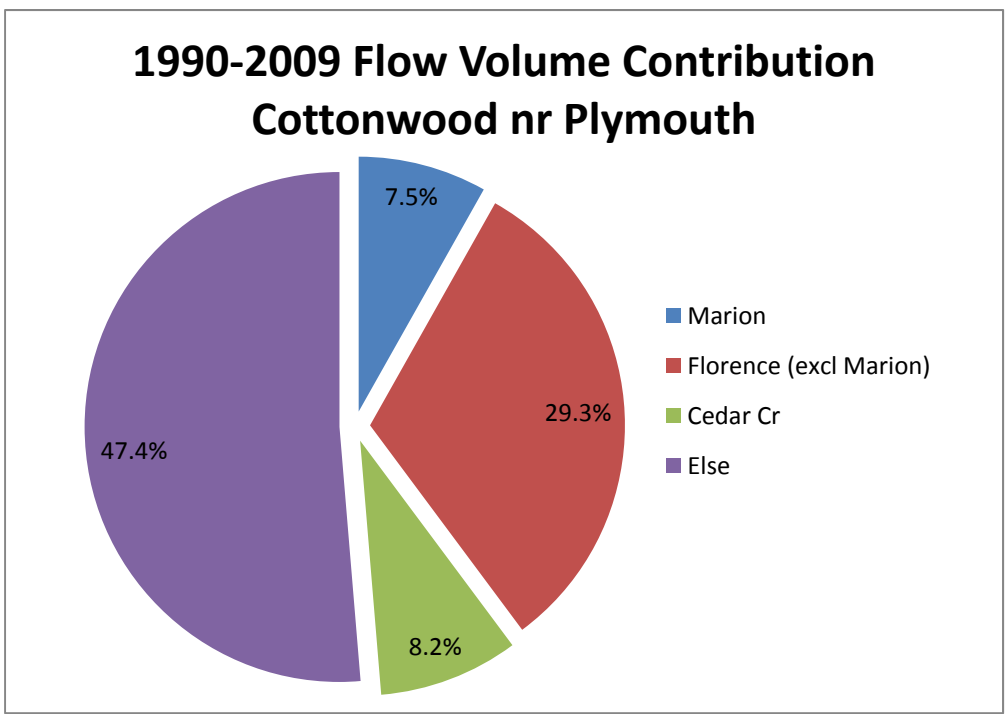



**Figure 2**: Volumetric flow comparison of sub watersheds within the Cottonwood R. subbasin (1990-2009)

perennial streams (conceptualized as baseflows for this model) in the watershed would not be available for detention pool storage. The model assumes that flows less than the adjusted median flow at Plymouth (~ 230 cfs) are baseflows and flows greater than that median flow are created during wetter periods. The runoff events creating wetter periods cause flow within the intermittent streams upon which the 'typical' watershed structures would be located and are available for detention pool storage with the model. As an example, if the controlled drainage area of additional watershed structures was 10% of the total drainage area at Plymouth (1,507.5 square miles, excluding the Marion Reservoir drainage area), then 10% of the flows that exceed the maximum baseflow (230 cfs) are available to store in the artificial detention pool within the model.

The KWO model runs on a daily time step. Once the runoff proportioned to the drainage area controlled by the modeled watershed structures is skimmed into the artificial detention pool, it becomes available for release. If the entire detention pool volume becomes filled, all flows are bypassed through the artificial detention pool until storage space is eventually created by releases. The last calculation at the end of each time step adds the Marion releases (from two days earlier) to the artificial detention pool modified flows at Plymouth.

Detention pool releases are governed by the 'typical' watershed structures concept used in the model. Standard design for watershed structures is to completely evacuate the detention pool within 5 days of fill. A pipe size of 24 inches meets this standard design criterion; however no improvements to sediment yield or flood frequency were notes with this design. Therefore, two smaller pipe size options were reviewed in the model; a 12 inch pipe and an 18 inch pipe. Both options were used to drain the detention pool in each of the 'typical' structures. The 18 inches pipe option took 13 days to completely drain the detention pool of the 'typical' structure, while the 12 inch pipe took 30 days.

As previously noted, the 'typical' structure had a detention volume of almost 520 acre-feet. The average depth of the 60 planned watershed structures when full is 12 feet. A table (Table 1, below) was created for various intervals in the hypothetical 12 foot detention pool and the releases associated with those intervals were determined by comparing several discharge calculation methods. When comparing discharge calculation methods, the lower discharge values were selected to create the discharge rating curves. At heights less than 2 feet above the riser, discharges were calculated using either the standard weir formula or standard orifice formula. The standard weir formula is:

$$Q = C_w L(2gh)^{3/2}$$

where,
Q = weir flow discharge (cfs)
Cw = dimensionless weir discharge coefficient
L = effective weir length (ft)
g = acceleration due to gravity (32.2 ft/s$^2$)
h = water depth above crest

The standard orifice formula is:

$$Q=cA(2gh)^{0.5}$$

where,
Q= the orifice flow discharge (cfs)
c = 0.6 (a dimensionless discharge coefficient)
A = cross-sectional area of 12 or 18 inch pipe
g = gravity (32.2 ft/sec^2)
h = head on the orifice

At heights greater than 2 feet above the riser, discharges were calculated using either the standard orifice formula or pipe-full computations. The artificial pool is sized to the user specified volume and the *number* of 'typical' structures is scaled to that volume. Releases are governed based upon the release rating curve in Table 1 and the head in the detention pool storage. Releases made in the model are scaled from the number of 'typical' structures associated with the artificial detention volume.

| | Standpipe Diameter (ft) | |
|---|---|---|
| | 1.5 | 1 |
| Head (ft) | Discharge (cfs) | |
| 12 | 29.5 | 12.0 |
| 11 | 28.2 | 11.7 |
| 10 | 26.9 | 11.5 |
| 9 | 25.5 | 11.3 |
| 8 | 24.1 | 10.7 |
| 7 | 22.5 | 10.0 |
| 6 | 20.8 | 9.3 |
| 5 | 19.0 | 8.5 |
| 4 | 17.0 | 7.6 |
| 3 | 14.7 | 6.6 |
| 2 | 12.0 | 5.3 |
| 1.5 | 8.8 | 4.6 |
| 1.35 | 8.4 | 4.4 |
| 1.2 | 7.9 | 4.1 |
| 1.05 | 7.4 | 3.9 |
| 0.9 | 6.9 | 3.6 |
| 0.75 | 6.2 | 3.3 |
| 0.6 | 5.4 | 2.9 |
| 0.45 | 4.4 | 2.5 |
| 0.3 | 2.8 | 1.8 |
| 0.15 | 1.1 | 0.7 |
| 0 | 0.0 | 0.0 |

**Table 1**: Discharge Rating Curves for Modeled Typical Watershed Structure

The model summarizes and compares the number of days that flood flows are equaled or exceeded at Plymouth to the historic (1990-2009) observed number of flood days. Flood flows at Plymouth are flows equaling or exceeding 13,300 cfs (http://waterdata.usgs.gov/nwisweb/local/nwis_host/dkslwr/local/site_text/ratings/07182250.1.rdb accessed on May 20, 2010).
The method of developing mean annual sediment yield estimates for the Neosho basin was described in a previous KWO report (KWO, 2009a) and included a sediment yield estimate for the Plymouth on the Cottonwood River. Those yields were created based upon the method described in Sedimentation Engineering (Vanoni, 2006) for estimating long-term sediment yields by flow duration-sediment rating curves.

Previous studies and analysis of the stream system sediment loading pattern in the Cottonwood basin indicated that most of the sediment load is generated from the stream banks of the Cottonwood River rather than from primary tributaries or the land surface in the basin (TWI 2007; KWO 2009a and Sheshukov 2010). Therefore, the KWO detention model assumes no change to the current sediment rating curve at Plymouth. The change to the sediment yield at Plymouth occurs because storage in the artificial detention pool changes the flow exceedence curve at Plymouth. Since most of the mean annual sediment yield is generated during high flow events, the storage of a portion of those high flows in detention pools reduces the magnitude of those

large runoff events and changes the mean annual flow exceedence curve at Plymouth. It is this change to mean annual flow exceedence that reduces the sediment yield at Plymouth.

Any reductions to the sediment yield on primary tributaries to the Cottonwood River due to enhanced detention structure storage are not included in this KWO flow detention model. Even though the primary source of sediment at Plymouth is from the stream banks of the Cottonwood River, it should be noted that sediment yield reductions can also be expected on the primary tributaries as a result of enhanced detention. The method of calculating the expected tributary sediment yield reductions was described in a previous KWO report (KWO, 2009b). That method related mean annual sediment yield on primary tributaries to the Cottonwood and Neosho Rivers to the uncontrolled drainage area in them. The regression relation indicated that as the uncontrolled drainage area of a watershed decreased, so did the mean annual sediment yield. Therefore, as structures are added within a tributary watershed to the Cottonwood River, the mean annual sediment yield should decline in that watershed. Unlike the main stem sediment yield that is primarily affected by changes to the flow exceedence gained from enhanced detention flow storage, the tributary yield reduction should be affected by both an anticipated change to the sediment rating curve and the change to flow exceedences on the primary tributary.

The KWO flow detention model includes estimates for the construction cost of watershed structures based upon reported construction costs of structures completed within the last 20 years and the drainage area of those impoundments (KWO, 2009b). Using the drainage area of the 'typical' watershed structure developed for the KWO detention model (2.8 square miles) the estimated construction cost of the 'typical' watershed structure was estimated at $168,000. As the size of the artificial detention pool is increased or decreased, the model adds or removes the number of watershed structures and adjusts the total estimated construction cost for the number of 'typical' structures needed to create the overall size of the specified artificial detention pool.

Total mitigation costs are also included in the KWO detention model using the same 'typical' structure estimation method. Ten completed watershed structures in the Neosho basin, having physical properties most similar to the 'typical' watershed structure used in the model, were reviewed for length of stream inundated by the principal pool, dam width covering the primary stream impounded and the type of stream covered by the dam and inundated by impoundment at the principal pool. The estimated mitigation cost for the 'typical' structure used in the KWO detention model for the Cottonwood basin is $433,000. Like the construction cost estimate, as the size of the artificial detention pool is increased or decreased, the model adds or removes the number of watershed structures and adjusts the total estimated mitigation cost for the number of 'typical' structures needed to create the overall size of the specified artificial detention pool.

**Results**

Although two different pipe sizes were initially reviewed to create detention discharge rating curves, the 12 inch pipe option was significantly better than the 18 inch option in sediment yield and flood flow frequency reductions in this model. For the 18 inch pipe scenario the detention pool never completely filled during the simulation period (a condition that would force any excess detention flows over the emergency spillway). For the 12 inch pipe scenario, there were only 5 days during the simulation in which the artificial detention pool was complete filled (2 days in 1993 and 3 days in 1998). Since the discharge rating curve for the 12 inch pipe detained stored flows longer by releasing stored water more slowly than the 18 inch pipe option, high flows were generally lower at the Plymouth gage site. The results presented in the text of this report relate only the 12 inch pipe scenario; however, the 18 inch pipe scenario has been included in the graphs and tables of this report for comparison purposes.

The difficulty with longer detention times for watershed structures is that the detention pool inundation duration becomes sufficiently long to drown terrestrial plants in the inundation zone. The standard design evacuation rate of less than 5 days for watershed structures enhances the survivability of terrestrial plants in the inundation zone.

Eleven different artificial detention pool sizes were created to generate the results of this report (Table 2). The total artificial pool size varied from 10,000 to 200,000 acre-feet of storage. The 10,000 acre-foot detention pool controls about 3.6% of the contributing area to the Plymouth gage site on the Cottonwood River (excluding Marion Reservoir's drainage area). The 200,000 acre-foot pool controls about 71.7% of the contributing area at Plymouth which would cover much of the drainage contribution of the intermittent streams in the modeled area. Mean annual sediment yield reductions ranged from less than 1.5% of the current estimated mean annual sediment yield for the 10,000 acre-foot artificial detention pool, to nearly a 25% reduction for the 200,000 acre-foot pool. Flood exceedence frequencies at Plymouth were reduced from historic frequencies by 12% for the 10,000 acre-foot artificial detention pool and 88% for the 200,000 acre-foot pool. Total cost estimates (construction plus mitigation) ranged from about $11.5 million for the 10,000 acre-foot pool to $231.5 million for the 200,000 acre-foot detention pool scenario.

| | 12" Pipe for Typical WS Structures | | | | 18" Pipe for Typical WS Structures | | | | |
|---|---|---|---|---|---|---|---|---|---|
| WS Detention Pool Vol (af) | WS Mod Mean Annual Sed Yld (Plymouth ) T/Yr | Main Stem % Reduction | Plymouth (Main Stem) Sed Redn (T/Yr) | # Days Flood Flows | WS Mod Mean Annual Sed Yld (Plymouth ) T/Yr | Main Stem % Reduction | Plymouth (Main Stem) Sed Redn (T/Yr) | # Days Flood Flows | Constr + Mitigatn Cost ($) |
| 0 | 719,224 | 0.00 | 0 | 59 | 719,224 | 0.00 | 0 | 59 | |
| 10000 | 708,883 | 1.44 | 10,341 | 52 | 715,509 | 0.52 | 3,715 | 54 | 11,574,498 |
| 20000 | 698,970 | 2.82 | 20,254 | 48 | 711,824 | 1.03 | 7,400 | 52 | 23,148,995 |
| 30000 | 689,144 | 4.18 | 30,080 | 47 | 707,935 | 1.57 | 11,289 | 49 | 34,723,493 |
| 31155 | 688,007 | 4.34 | 31,217 | 47 | 707,495 | 1.63 | 11,729 | 49 | 36,060,347 |
| 40000 | 679,196 | 5.57 | 40,028 | 45 | 704,103 | 2.10 | 15,121 | 48 | 46,297,990 |
| 50000 | 669,485 | 6.92 | 49,739 | 43 | 700,405 | 2.62 | 18,819 | 48 | 57,872,488 |
| 56450 | 663,469 | 7.75 | 55,755 | 41 | 698,163 | 2.93 | 21,061 | 46 | 65,338,039 |
| 75000 | 646,554 | 10.10 | 72,670 | 33 | 691,794 | 3.81 | 27,430 | 44 | 86,808,732 |
| 87605 | 635,120 | 11.69 | 84,104 | 31 | 687,015 | 4.48 | 32,209 | 43 | 101,398,386 |
| 125000 | 603,185 | 16.13 | 116,039 | 18 | 673,900 | 6.30 | 45,324 | 34 | 144,681,220 |
| 200000 | 549,290 | 23.63 | 169,934 | 7 | 650,390 | 9.57 | 68,834 | 23 | 231,489,952 |

**Table 2**: KWO detention model results

Sediment yield reductions for the eleven different artificial detention pool sized model followed a roughly linear pattern. The slope of the trend in detention volume by mean annual sediment yield declines slightly for the largest artificial detention pool volume scenarios (Figure 3).

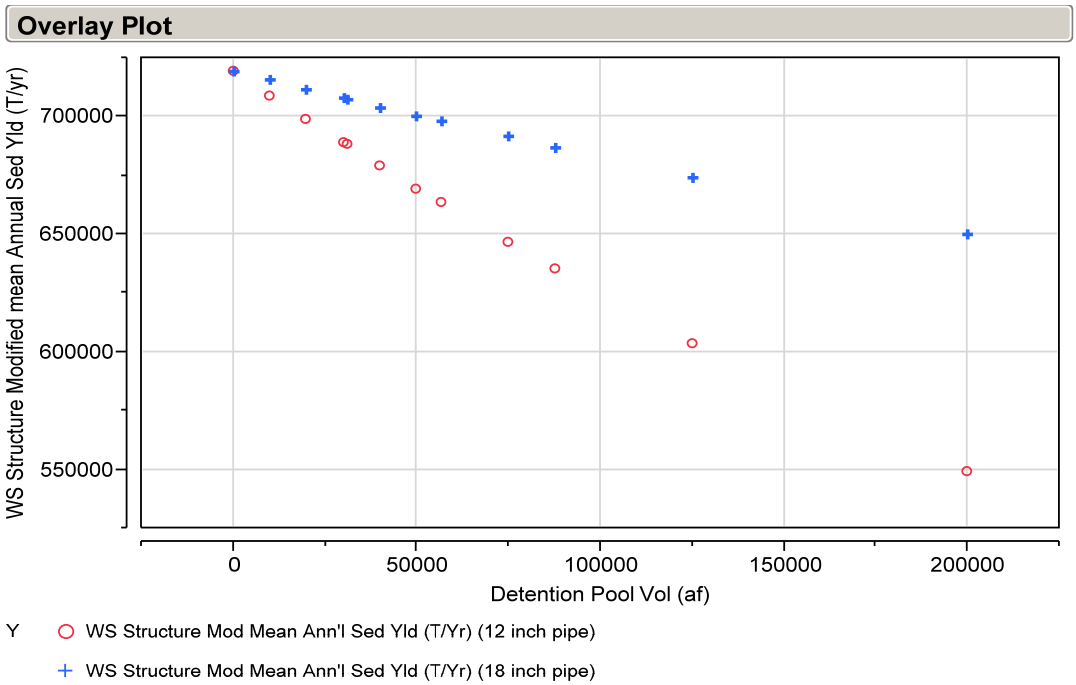



**Figure 3**: Reduction to mean annual sediment yield for various sized artificial detention pool

Flood frequency reductions by detention pool volumes followed an S-shaped curve. The relative reduction to the number of days that equaled or exceeded flood flows at Plymouth is greatest for small detention volumes. The slope of the trend flattens out across the medium sized artificial detention volumes, and then increases again for the largest detention volumes (Figure 4).

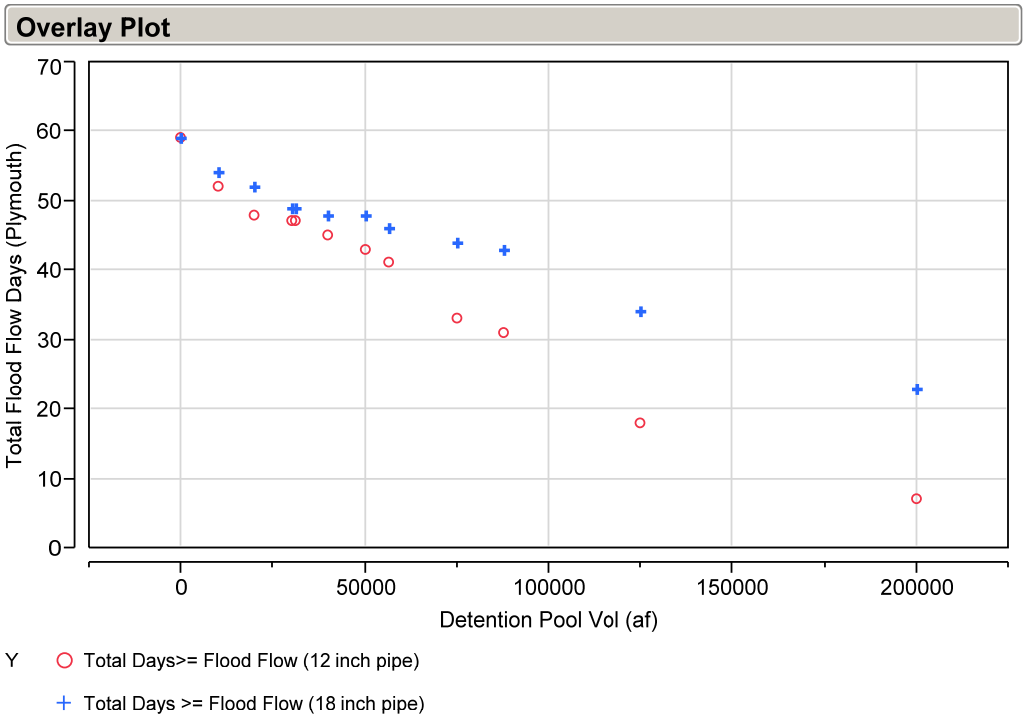



**Figure 4:** Change in the number of flood days for various sized detention pools

**References Cited**

Kansas Water Office, 2009a, Mean Annual Sediment Yield Estimation for the Neosho Basin, available online: http://www.kwo.org/Reports%20%26%20Publications/EstimatingMeanAnnualSedimentYield_092209_cbg.pdf, accessed June 7, 2010.

Kansas Water Office, 2009b, Reservoir Road Map Vol III, p. 88-90. Available online: http://www.kwo.org/ReservoirRoadmap/Rpt_Reservoir_Roadmap_Volume_III.pdf accessed June 7, 2010.

Sheshukov, A. Y, et al, Kansas State University, 2010, (Draft Report) Modeling of John Redmond Watershed with Soil and Water Assessment Tool (SWAT) (reference will be updated and hyperlinked when final report is received in June 2010).

The Watershed Institute 2007, Enchanced Riparian Area/Stream Channel Assessment for John Redmond Feasibility Study; available online: http://www.kwo.org/Reports%20%26%20Publications/RiparianReport/Rpt_EnhancedRiparianAreaStreamChannelAssessment_Intro.pdf, accessed June 7, 2010.

Vanoni, V.I., editor, 2006, Sedimentation Engineering, American Society of Civil Engineers, p.277-2

# 14.0 Bibliography

[1] Map prepared by the Kansas Water Office.

[2] Kansas Unified Watershed Assessment 1999. Kansas Department of Health and Environment and the United States Department of Agriculture Natural Resources Conservation Service. http://www.kdheks.gov/nps/resources/uwa.pdf

[3] Kansas Applied Remote Sensing Program,2005. Kansas Geospatial Community Commons

[4] Calculated from Kansas Applied Remote Sensing Program, 2005. Kansas Land Cover Patterns, Kansas Geospatial Community Commons

[5] Kansas Surface Water Register, 2009. Kansas Department of Health and Environment. http://www.kdheks.gov/befs/download/Current_Kansas_Surface_Register.pdf

[6] Kansas Department of Health and Environment. List of exceptional state waters (ESW), special aquatic life use waters (SALU) and outstanding national resource waters (ONRW). 2007. http://www.kdheks.gov/nps/resources/specwaterinfo.pdf . Kansas Applied Remote Sensing Program,2005. Kansas Geospatial Community Commons

[7] Kansas Department of Health and Environment. List of exceptional state waters (ESW), special aquatic life use waters (SALU) and outstanding national resource waters (ONRW). 2007. http://www.kdheks.gov/nps/resources/specwaterinfo.pdf

[8] Rainfall data records. http://countrystudies.us/united-states/weather/kansas/manhattan.htm

[9] USDA/NRCS National Water and Climactic Center.

[10] EPA estimates "10 to 20 % of onsite wastewater systems malfunction each year". http://cfpub.epa.gov/owm/septic/septic.cfm?page_id=265 The KSU technical team used best professional guess to claim the number of failing septic systems to be 10%.

[11] US Census Bureau, 2008. http://quickfacts.census.gov/qfd/states/2008.html

[12] Kansas Geospatial Commons. US Census Bureau. Tiger 2000 Census Blocks. http://www.kansasgis.org/catalog/catalog.cfm

[13] Kansas Geospatial Community Commons. http://www.kansasgis.org/catalog/catalog.cfm

[14] Kansas Water Office. 2009.

[15] Internet source. http://www.pollutionissues.com/Pl-Re/Point-Source.html

[16] *Permitted Point Source Facilities*: BASINS. Online reference information available at: *http://www.epa.gov/waterscience/basins/index.htm*

[17] Kansas Geospatial Community Commons. Kansas Department of Health and Environment. Rural Water Districts, 2006, Public Water Supply, 1994. These sites include those that are currently in use and those that have been functional in the past. NPDES Treatment Facilities, 1994. http://www.kansasgis.org/catalog/catalog.cfm

[18] Kansas Department of Health and Environment. The Basics of TMDLs. http://www.kdheks.gov/tmdl/basic.htm#tmdl

[19] Kansas Department of Health and Environment. Kansas TMDL Development Cycle. 2009. http://www.kdheks.gov/tmdl/download/Kansas_TMDL_Development_Cycle.pdf

[20] Kansas Department of Health and Environment. 2010 303d list. http://www.kdheks.gov/tmdl/

[21] Kansas Department of Health and Environment, 2010.

[22] Kansas Geospatial Community Commons. http://www.kansasgis.org/catalog/catalog.cfm

[23] Kansas Department of Health and Environment, 2010. http://www.kdheks.gov/tmdl/download/2010_303d_List.pdf

[24] Kansas Department of Health and Environment. 2010. http://www.kdheks.gov/tmdl/download/2010_303_d_Delistings.pdf

[25] Provided by KDHE TMDL Watershed Management Section, November 2009.

[26] Determined by KDHE TMDL Watershed Management Section, November, 2009.

[27] Provided by KDHE TMDL Watershed Management Section, November 2009.

[28] EPA website. http://water.epa.gov/type/watersheds/datait/watershedcentral/goal4.cfm

[29] Available at: http://www.oznet.ksu.edu/library/h20ql2/mf2572.pdf

[30] Available at: http://www.mwps.org/index.cfm?fuseaction=c_Categories.viewCategory&catID=719

[31] MF-2737 Available at: http://www.oznet.ksu.edu/library/h20ql2/mf2737.pdf
MF-2454 Available at: http://www.oznet.ksu.edu/library/ageng2/mf2454.pdf

[32] NRCS T factor. http://www.nrcs.usda.gov/technical/NRI/2007/nri07erosion.html

[33] Kansas Geospatial Commons. US Department of Agriculture Natural Resources Conservation Service. SSURGO. http://www.kansasgis.org/catalog/catalog.cfm

[34] Kansas Geospatial Community Commons. USDA/NRCS data base. http://www.kansasgis.org/catalog/catalog.cfm

[35] CAFO data provided by Kansas Department of Health and Environment, 2003. Grazing density obtained from US Department of Agriculture National Agricultural Statistics Service, 2002. http://nationalatlas.gov/atlasftp.html?openChapters=chpagri#chpagri

[36] Kansas Applied Remote Sensing Program, 2005. Kansas Geospatial Community Commons.

[37] Kansas Geospatial Commons. Kansas Department of Health and Environment, 2010.

[38] Total farm crops in the counties of the watershed by percentage. 2007 Census of Agriculture, USDA NASS. www.agcensus.usda.gov

[39] Kansas Department of Health and Environment. 2009. Environmental Lake Monitoring Sites 1994. USGS Realtime streamflow stations, 2004. http://www-atlas.usgs.gov/atlasftp.html#realstx