Delaware River Watershed Restoration and Protection Strategies (WRAPS) Plan

2021

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Delaware River Watershed

K-STATE Research and Extension

Delaware River Watershed
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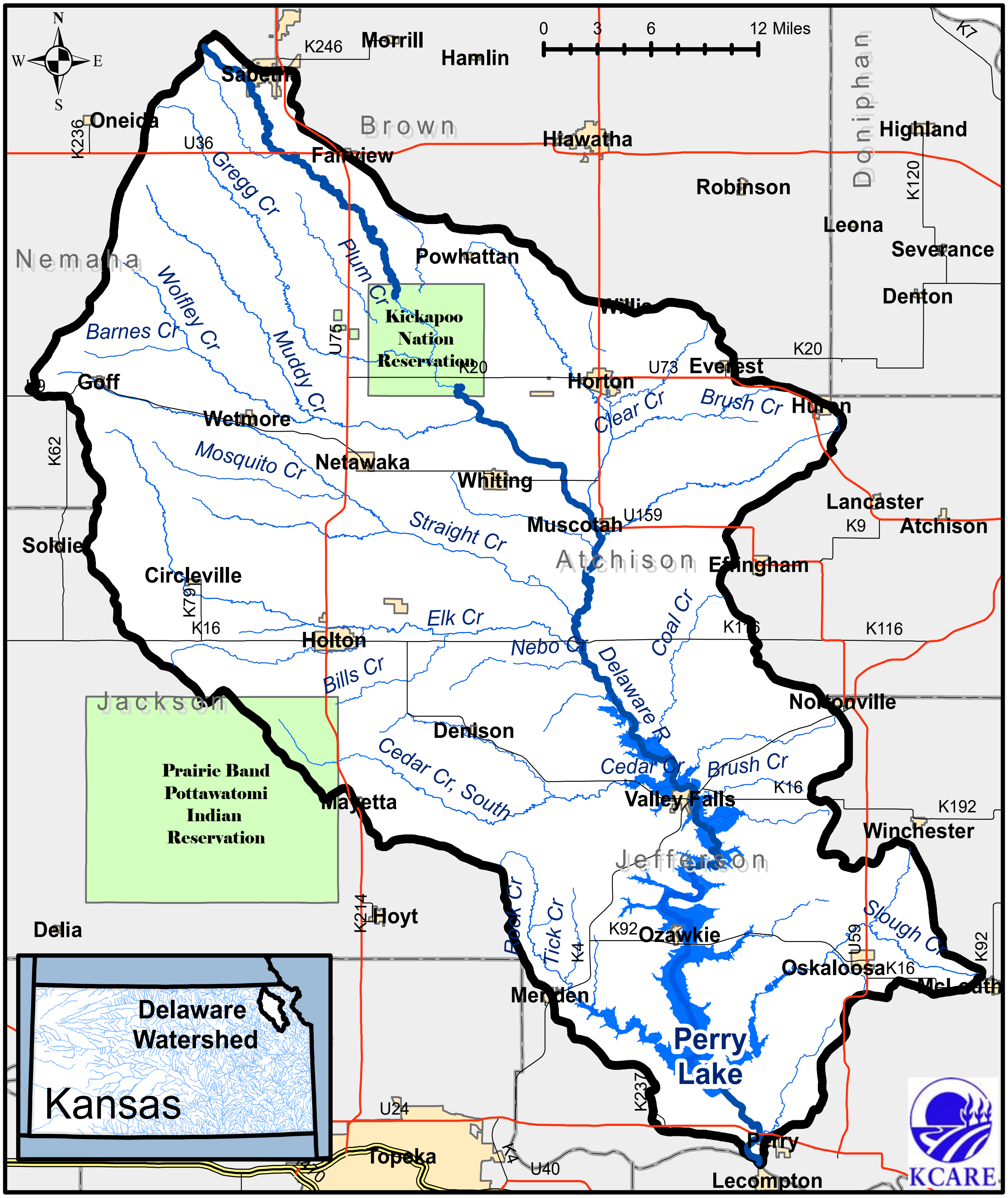

Delaware Watershed
Kansas
Perry Lake
Kickapoo Nation Reservation
Prairie Band Pottawatomi Indian Reservation
0 3 6 12 Miles
N
S
E
W
Brown
Nemaha
Jackson
Atchison
Jefferson
Doniphan
Morrill
Hamlin
Sabetha
Oneida
Fairview
Hiawatha
Highland
Robinson
Leona
Severance
Powhattan
Denton
Willis
Everest
Horton
Huron
Goff
Wetmore
Netawaka
Whiting
Lancaster
Muscotah
Atchison
Effingham
Soldier
Circleville
Holton
Nortonville
Denison
Valley Falls
Mayetta
Winchester
Hoyt
Delia
Ozawkie
Oskaloosa
McLouth
Meriden
Perry
Topeka
Lecompton
Gregg Cr
Plum Cr
Wolfley Cr
Barnes Cr
Muddy Cr
Mosquito Cr
Straight Cr
Clear Cr
Brush Cr
Elk Cr
Nebo Cr
Coal Cr
Bills Cr
Delaware R
Cedar Cr
Cedar Cr, South
Rock Cr
Tick Cr
Slough Cr
K246
U36
K236
U75
K20
U73
K120
K7
K62
U159
K9
K79
K16
K116
K192
K214
K92
K4
U59
K237
U24
U40
KCARE

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Glossary of Terms and Acronyms

Best Management Practices (BMPs): 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 used in photosynthesis, found in algae and other aquatic plants. Can be used for measurement of eutrophication in a water body.

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

***E. coli* bacteria (ECB):** Bacteria normally found in gastrointestinal tracts of animals. Some strains cause diarrheal diseases and are pathogenic to humans.

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

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

Hydrologic Unit Code (HUC): An identification system using numerical digits for watersheds. The smaller the watershed, the more digits a HUC will have.

KDHE: Kansas Department of Health and Environment.

KSRE: Kansas State Research and Extension.

Municipal water system: A water system having at least 10 service connections or regularly serving an average of at least 25 individuals daily at least 60 days out of the year.

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

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

Nitrogen (N): Element essential for plants and animals.

Nonpoint sources (NPS): Any activity not required to have a NPDES permit and results in the release of pollutants to waters of the state. This release may result from precipitation runoff, aerial drift and deposition from the air, or the release of subsurface brine or other contaminated groundwaters to surface waters of the state.

Nutrients: Nitrogen and/or phosphorus in a water source.

Phosphorus (P): Element in water that, in excess, can lead to increased biological activity which may cause eutrophication.

Point sources (PS): Any discernible, confined and discrete conveyance from which pollutants are or could be discharged.

RAC: Regional Advisory Committee.

RC&D: Resource Conservation and Development Region, Inc.

Riparian zone: Areas of interchange between land and water alongside bodies of water.

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.

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

Stakeholder Leadership Team (SLT): Organization of watershed residents, landowners, farmers, ranchers, agency personnel and any other 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 surface water-quality standards which results in failure to support their designated uses.

Total Nitrogen (TN): A chemical measurement of all nitrogen forms in a water sample.

Total Phosphorus (TP): A chemical measurement of all phosphorus forms in a water sample.

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

WRAPS: Watershed Restoration and Protection Strategy.

1. Preface and Plan Update

The purpose of this Watershed Restoration and Protection Strategy (WRAPS) report for the **Delaware River Watershed** is to outline a plan of restoration and protection goals and actions for this watershed's surface waters. Watershed goals can be characterized as either "restoration" or "protection." Watershed *restoration* refers to surface waters that fail to meet water quality standards and for areas of the watershed that need improvement in habitat, land management, or other attributes. Watershed *protection* refers to surface waters currently meeting water quality standards but requiring protection from future degradation.

In the WRAPS process, local communities and government agencies work together toward the common goal of a healthy environment. By working as a WRAPS team, communities can take several steps toward watershed restoration and protection. Local participants, or stakeholders, provide valuable grass-roots leadership, responsibility, and resource management throughout. These community members work together to ensure that their lands' water quality is protected because they have the most at stake. Agencies bring to the table science-based information, communication, and technical and financial assistance. By working as a WRAPS team, communities can take several steps toward watershed restoration and protection. Within the watershed, the team works to build awareness and education, to engage local leadership, and to monitor and evaluate watershed conditions; they also assess, plan and implement the WRAPS process at the local level.

Other crucial objectives for the WRAPS process are to maintain recreational opportunities and biodiversity while protecting the environment from flooding and the negative effects of urbanization and industrial production. Final watershed goals are to provide a sustainable water source for drinking and domestic use while preserving food, fiber, and timber production. The ultimate WRAPS goal is a **restored and protected watershed**: "local hands caring for local lands" in partnership with government agencies to improve the environment for everyone.

This report is intended to serve as an overall strategy to guide WRAPS 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 to restore and protect the water quality and watershed conditions of the Delaware River Watershed.

Plan Update: The original Delaware River WRAPS plan was written and approved in 2007. It was re-written and updated again in 2011. However, targeting and TMDL revisions by the Kansas Department of Health and Environment (KDHE) have resulted in outdated WRAPS plan implementation goals. Therefore, the Delaware River WRAPS plan was last updated and revised in 2021 by Kansas State University staff and KDHE, with the guidance of the Glacial Hills RC&D, Delaware River WRAPS Coordinator, and the SLT.

Note: Tables throughout this plan use rounded figures.

2. Delaware River WRAPS Introduction

This section discusses the importance of a WRAPS plan and describes the key collaborators who strive to make it effective, with a special focus on the Delaware River Watershed's location and stakeholders.

A. What Is a Watershed?

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

B. What Is a Watershed Restoration and Protection Strategy (WRAPS)?

WRAPS is a planning and management framework built to engage local citizen-stakeholders within a particular watershed. It is a process used to **identify** restoration and protection needs, to **establish** management goals for the watershed community, to **create** an action plan to achieve those goals, and to **implement** the action plan.

The acronym "WRAPS" originated from KDHE in response to the 1998 Clean Water Action Plan issued by the Clinton Administration. The Clean Water Action Plan directed the state environmental agency and the state conservationist of every state to complete a "unified watershed assessment." Upon completion of the assessment, states were directed to develop "watershed restoration action strategies" (WRAS).

The state of Kansas contends that restoring damage to a watershed is insufficient because it addresses only part of the need; action to protect water is a necessity, hence the new term WRAPS. Historically, "WRAPS" refers to the development of action plans that address nonpoint source pollution on a watershed basis. WRAPS projects are initiated by watershed stakeholders and receive financial support from KDHE to address Total Maximum Daily Loads (TMDLs) and related water quality concerns.

The WRAPS initiative is intended to address priority issues identified in the basin sections of the Kansas Water Plan through the development and implementation of WRAPS in priority watersheds.

C. Watershed Location

There are 12 river basins in Kansas. The scope of this WRAPS plan will focus on the Delaware River Watershed, located in the northeastern part of the state of Kansas. The Delaware River is a major tributary to the Kansas River and is located in the Kansas-Lower Republican River Basin (**Figure 1**). The Kansas-Lower Republican River basin is part of the larger Missouri

River Basin, which is a sub-watershed of the Mississippi River Basin, the largest watershed in North America.

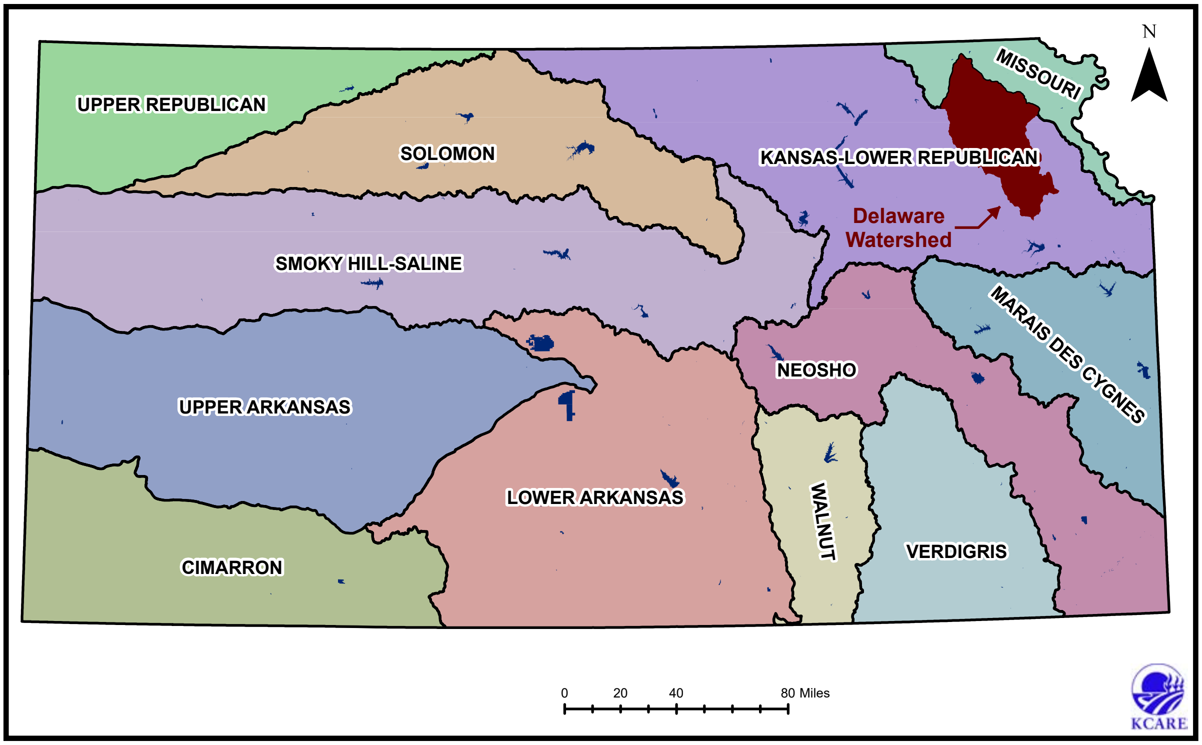


Figure 1. The 12 River Basins of Kansas and the Delaware River Watershed

The Delaware River Watershed is located in northeastern Kansas and overlays portions of five counties. The Delaware River Watershed is located within Atchison, Brown, Jackson, Nemaha, and Jefferson Counties (**Figure 2**).

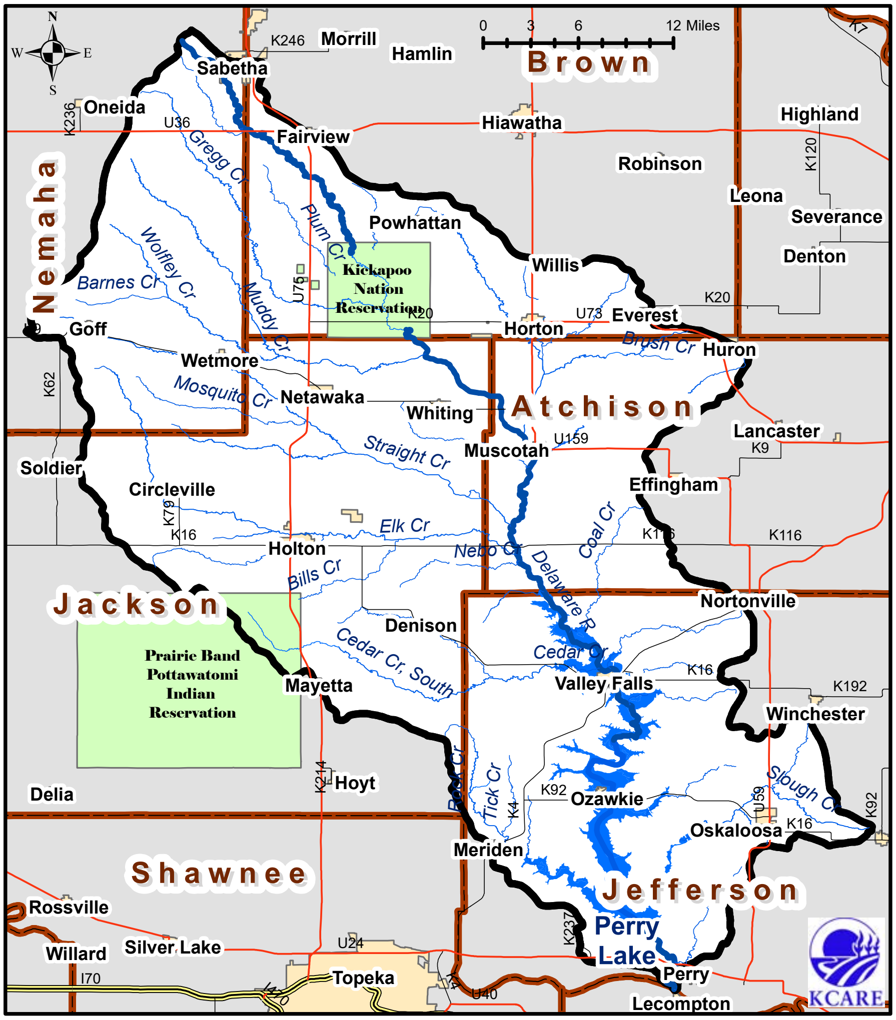


Figure 2. Delaware River Watershed

D. Overview of the Delaware River Watershed

The Delaware River Watershed is the area of land in northeast Kansas that drains to the Delaware River and its tributaries. The Delaware River Watershed covers 734,637 acres, which equates to approximately 1,147 square miles.

The headwaters of the Delaware River begin northwest of the city of Sabetha in Nemaha County. The river flows southeast through Nemaha, Brown, Jackson, Atchison and Jefferson Counties before entering Perry Lake, south of the city of Valley Falls in Jefferson County.

Perry Lake is a federal reservoir operated and maintained by the U.S. Army Corps of Engineers (USACE). The lake is primarily for flood control, recreation and water supply. Outflow from Perry Lake continues south from the reservoir and continues down the Delaware River for approximately four miles to the confluence with the Kansas River, north of the city of Lecompton.

The Perry Lake dam was completed in 1966 and was constructed on the Delaware River to help control flooding downstream in both the Delaware and Kansas Rivers. The dam is 7,750 feet long and rises 95 feet above the stream bed. The formation of the dam and Perry Lake serves to abate flooding for over 1,117 square miles of northeast Kansas.

The Delaware River is the reservoir's primary inflow from the north and outflow to the south. Smaller tributaries include Duck Creek, French Creek and Rock Creek from the west, and Little Slough Creek, Slough Creek and Evans Creek from the east. In 1968, USACE reached a long-term land usage lease with the Kansas Parks and Resources Department, allowing for the development of Perry State Park.

Perry State Park, located along the southwest part of Perry Lake, offers a wide variety of water recreation and outdoor activities, including swimming, boating, camping, fishing, hiking, equestrian trails and bike trails. Perry State Park is roughly 37 square miles. It is comprised of two areas: a 12,500-acre reservoir and an 11,000-acre wildlife area.

This WRAPS plan will focus on the restoration of water quality in the Delaware River Watershed through efforts to improve water quality in Perry Lake and its tributaries.

E. Elevation of the Delaware River Watershed

Elevation determines watershed boundaries. As shown in **Figure 3**, the upper boundary of the Delaware River Watershed has an elevation of 1,320 feet, and the lowest point of the watershed has an elevation of 656 feet.

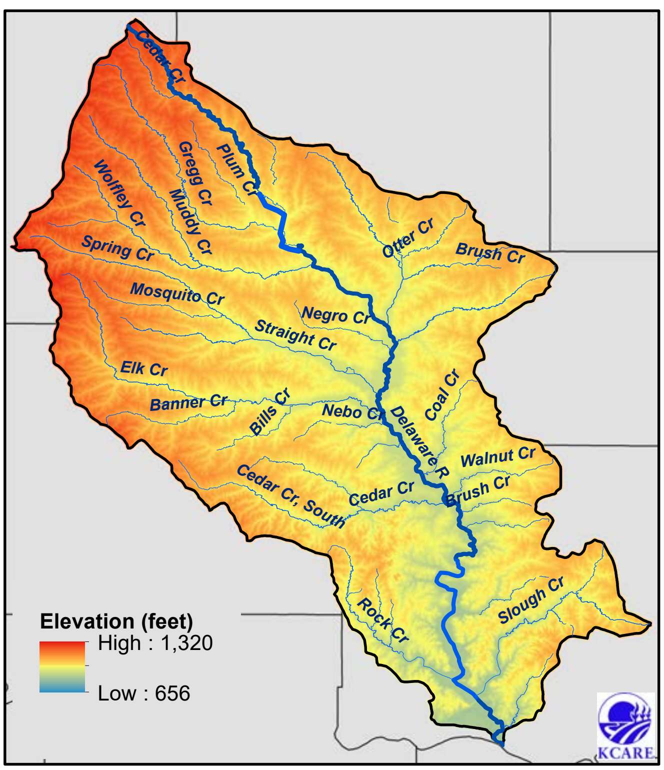


Figure 3. Elevation Relief Map of the Delaware River Watershed

F. What is a Hydrologic Unit Code (HUC)?

HUC is an acronym for **H**ydrologic **U**nit **C**ode; HUCs act as an identification system for watersheds. Each watershed is assigned a unique HUC number, in addition to a common name.

As previously mentioned, the Delaware River Watershed is located in the Kansas-Lower Republican River Basin which is home to seven HUC 8 (meaning an 8-digit identifier code) classifications. The Delaware River Watershed is part of the Delaware River Basin HUC 8, 10270103. The first two numbers in the HUC code refer to the drainage region, the second two digits refer to the drainage sub-region, the third two digits refer to the accounting unit, and the fourth pair of digits is the cataloging unit. For example:

- **10270103**: Region 10, Missouri Region - The drainage within the United States of: (a) the Missouri River Basin, (b) the Saskatchewan River Basin, and (c) several small closed basins. This includes all of Nebraska and parts of Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, North Dakota, South Dakota, and Wyoming (area = 509,547 sq. miles).
- **10270103**: Sub-region drainage of the Kansas River Basin, excluding the Republican and Smoky Hill River Basins. This includes Kansas, Missouri and Nebraska (area = 15,000 sq. miles).
- **10270103**: Accounting unit drainage of the Kansas River Basin, excluding the Big Blue, Republican, and Smoky Hill River Basins in Kansas and Missouri (area = 5,500 sq. miles).
- **10270103**: Cataloging unit drainage of the section of the Delaware River Basin in Kansas (area = 1,150 sq. miles).

As watersheds become smaller, the HUC number becomes larger. HUC 8s can be split into smaller watersheds that are given HUC 10 numbers, and HUC 10 watersheds can be divided into smaller HUC 12 watersheds. The Delaware River Watershed consists of five HUC 10 delineations and can be divided further into 41 HUC 12 delineations (**Figure 4**).

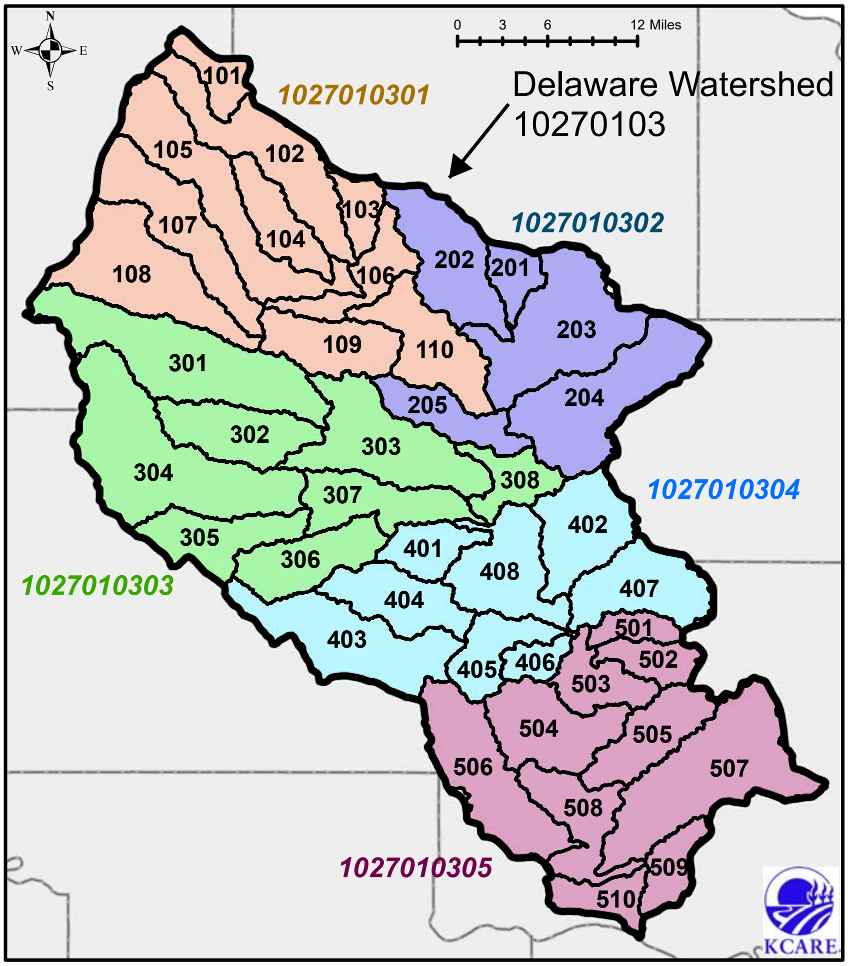


Figure 4. HUC 8, 10 and 12 Delineations in the Delaware River Watershed

For the purpose of simplification, this WRAPS plan will utilize HUC 10 delineations to describe targeted areas for BMP implementation and load reduction goals. These HUC 10s include: **1027010<u>301</u>** (home to 10 HUC 12s), **1027010<u>302</u>** (home to five HUC 12s), **1027010<u>303</u>** (home to eight HUC 12s), **1027010<u>304</u>** (home to eight HUC 12s), and **1027010<u>305</u>** (home to 10 HUC 12s).

Please note that maps throughout this plan will refer to these HUC 10s primarily by their last three digits, as underlined above.

G. Delaware River Watershed WRAPS History

According to the Kansas Unified Watershed Assessment prepared by KDHE and the Natural Resources Conservation Service (NRCS) in 1999, the Delaware River Watershed is rated as a Category I watershed. This means that the watershed needs restoration and protection to sustain water quality. A Category I watershed either does not meet state water quality standards or fails to achieve aquatic system goals related to habitat and ecosystem health. Category I watersheds also are assigned a priority for restoration. The Delaware River Watershed is ranked 3rd out of 92 watersheds in the state for restoration priority.

H. Who Are the Stakeholders?

The Glacial Hills Resource Conservation and Development (RC&D) organization initiated the watershed planning process in 2005 and has continued its support of the project since. Local stakeholders joined the Glacial Hills RC&D to put a WRAPS plan together. Stakeholders are those individuals and groups who live in, own land in, or work in the watershed. They are also the individuals and groups with the greatest influence over pollutant sources, land use, and protection efforts in the area.

The WRAPS process began when local stakeholders gathered to identify water resource protection needs and goals for the development of their WRAPS plan. After months of collaboration and discussion, a large number of stakeholders had become involved. Key water pollutants, best management practices (BMPs), and various educational and outreach strategies were identified to promote water restoration and protection objectives. This information was used to formulate and adopt an approved watershed plan in May 2007. Immediately after this plan was approved, a formal stakeholder leadership team (SLT) was formed and an action plan to implement BMPs to support the plan’s goals and objectives was initiated.

Actions taken as a result of the adoption of the 2007 watershed plan, under the leadership of the SLT and sponsorship of the Glacial Hills RC&D, greatly benefited the watershed. The implementation phase of the Delaware River WRAPS program, which got underway in 2009, resulted in the stabilization of 24,000 linear feet of severely eroding streambanks on the Delaware River above Perry Lake. More than $1.85 million in funding and technical assistance was supplied program from various federal, state and local sources to support the program. These stabilization efforts significantly reduced the sediment load in the Delaware River and sedimentation in Perry Lake, and improved aquatic habitat and water quality.

Delaware River WRAPS was also instrumental in the establishment of a multi-county regional household hazardous waste program in 2008. The program resulted from discussions the Delaware River WRAPS group facilitated between county commissioners, waste departments, KDHE and others in Atchison, Brown, Doniphan and Jackson counties. Delaware River WRAPS also assisted the newly established Northeast Kansas Regional Household Hazardous Waste Program, created to obtain a $105,000 grant and $32,000 in Supplemental Environmental Program funds from KDHE. This funding was sufficient to start and support the regional program through its first year of operation. As a result of these efforts, all counties in the Delaware River Watershed, as well as in Doniphan, located outside the watershed, now offer hazardous waste disposal services to their residents.

An extensive education and outreach effort also was initiated by the Delaware River WRAPS group. These efforts significantly have raised awareness of watershed issues and the importance of protecting watershed resources. Monthly editorials and other information are provided to local newspapers, radio and television outlets in the watershed. The WRAPS group hosts workshops, tours and provides presentations to local groups in the watershed. In addition, a project website (www.delawarewraps.com) was created. Highway road signs informing visitors that they are entering the Delaware River Watershed were posted in 2008. The Delaware River WRAPS group has worked closely with local conservation districts, natural resource organizations, school groups and other entities to raise awareness of watershed issues and to create visibility for the Delaware River WRAPS.

The Delaware River WRAPS Plan was updated and rewritten in 2011 to meet the Environmental Protection Agency's (EPA) 9-Element requirements. The 2021 WRAPS plan revision took place due to targeting and TMDL revisions by KDHE.

I. Goals of the Stakeholder Leadership Team (SLT)

Responsibility for restoration and protection of the watershed rests primarily in the hands of local stakeholders. In cooperation with these local stakeholders, federal and state agencies provide technical and financial assistance for education activities and BMP implementation. The SLT has identified specific goals to achieve watershed improvement; it is believed that implementation of BMPs as well as financial incentives and cost-share programs will, over time, lead to decreases in surface and ground water impairments.

The **watershed goals** of the Delaware River Watershed SLT are to:

- reduce the amount of nutrients flowing into the Delaware River and, ultimately, Perry Lake;
- reduce the amount of sediment entering the Delaware River and, ultimately, Perry Lake;
- protect and restore streambanks along the mainstem of the Delaware River;
- protect and restore water quality throughout the watershed; and
- educate the watershed community about water quality practices and benefits.

Accomplishing these goals will involve both an educational component as well as the implementation of BMPs on cropland, livestock and streambank areas. Efforts will focus on targeted areas in the Delaware River Watershed to achieve the greatest water quality improvement at a minimal cost. Targeted areas will be discussed in **Section 6** of this plan.

The SLT hopes these efforts will protect the productivity of agricultural lands throughout the watershed while improving water quality in local streams and in Perry Lake.

The **main pollutants** for the Delaware River Watershed are nutrients and sediment.

J. Regional Advisory Committee (RAC)

In 2013, the governor of Kansas issued a call to action to develop a 50-Year Vision for incorporation into the Kansas Water Plan. Regional Advisory Committees (RACs) were developed in 2015 to work in concert with the 50-Year Vision. The Delaware River Watershed is part of the **Kansas RAC**.[1] The Kansas RAC has developed five priority goals for the future

[1] Kansas Water Vision, Regional Goal Action Plans Section. http://kwo.ks.gov/docs/default-source/water-vision-water-plan/vision/rpt-vision-regional-goal-action-plans-section.pdf?sfvrsn=4, page 96.

of the Kansas-Lower Republican River Basin; these goals are closely aligned with the WRAPS process and are detailed below.

Kansas RAC Goals:

1. Increase water storage capacity and availability in federal reservoirs. By 2020, purchase all available storage in federal reservoirs to secure an adequate water supply for the region. By 2025, evaluate the ability to raise the conservation pool in each federal reservoir.

   To meet this goal, the Kansas RAC developed the following **Action Steps**:

   - Increase water storage capacity and availability in federal reservoirs. By 2020, purchase all available storage in federal reservoirs to secure an adequate water supply for the region.
     - The Kansas Water Office should conduct an analysis of the impacts of the draw-downs at Milford, Tuttle Creek and Perry reservoirs due to Missouri River navigation support. The results of this study will inform the decision as to whether or not to accelerate the purchase of the remaining storage at the aforementioned reservoirs.
     - Working with Kansas River Water Assurance District, KDHE, the Kansas Department of Wildlife, Parks and Tourism (KDWPT) and other stakeholders, determine the amount of storage necessary within Milford and Perry reservoirs to meet instream purposes through controlled releases.
     - Complete necessary background work to support a request to reallocate storage from water supply to water quality in Milford and Perry reservoirs.
     - Determine amount of additional annual costs for calling into service the remaining water supply storage not needed to meet instream purposes and request full funding. When funding is secured, call into service storage not to be included within reallocation request.
     - Request reallocation of remaining storage from water supply to water quality.
   - By 2025, evaluate the ability to raise the conservation pool in each federal reservoir.
     - Using existing modeling, determine amount of additional yield that can be gained in each reservoir by permanently raising the conservation pool by 1, 2 and 3 feet.
     - Working with Kansas River Water Assurance District, KDHE, KDWPT, the Kansas Department of Agriculture-Department of Water Resources (KDA-DWR) and other stakeholders, begin NEPA evaluation of impacts and benefits at the reservoirs with increased pool level.
     - Work with USACE to determine updated costs of reallocation and purchase of storage.
     - Secure federal funding for reallocation study.
     - Where feasible and appropriate based on cost and impact evaluation, request USACE reallocate storage from flood control to water supply storage.
   - The Kansas Water Office (KWO) shall gather data to determine steps to maintain consistent storage levels at specific reservoirs. As a long-term goal, KWO should incorporate existing studies and information to study the possibility of future dredging

and other measures by the State of Kansas on a more consistent basis to maintain storage.
- As articulated in the "*Basin Restoration Approach: Kansas Lower Republican,"* the Kansas RAC directs the KWO to improve coordination with the USACE on reservoir releases, management plans, and future actions to address water quality and quantity issues.

2. By 2050, explore additional storage possibilities such as construction of multipurpose lakes so that new water sources can be brought online.

   To meet this goal, the Kansas RAC developed the following **Action Steps**:

   - Use the existing Kansas Water Office "*Basin Restoration Approach: Kansas Lower Republican"* as a guide for planning future storage in the region.
   - Maintain an updated inventory of existing reservoir sites not built, along with pertinent data.
   - Contract with a consulting firm to determine the feasibility of building larger reservoir sites based on the "New Site Selection Criteria" from the "*Basin Restoration Approach: Kansas Lower Republican,"* with the addition of the potential sedimentation rate and upstream protection practices.
   - Working with KDA-Department of Conservation (DOC), NRCS and local watershed districts, identify existing watershed structures that are in need of restoration and have potential to be made larger and provide supplemental water supply.
   - Working with KDA-DOC, NRCS and local watershed districts, identify watershed dam sites that were not constructed but could be built to provide supplemental water supply.
   - KWO shall develop criteria to determine whether these sites should be expanded or built based on a broad range of issues.
   - Seek partnership and funding opportunities to rehabilitate existing watershed reservoirs and/or construct new reservoirs that meet the established criteria.

3. Reduce the cumulative sediment rate of federal reservoirs and other water supply lakes by 10% in the Kansas region every 10 years through implementation of watershed best management practices.

   To meet this goal, the Kansas RAC developed the following **Action Steps**:

   - Utilize the Kansas Basin Watershed Management System (KBWM System) to reduce the overall sediment rate by 10% for the entire Kansas basin, not per reservoir, over 10 years.
     - All new funding allocated to meet RAC sedimentation reduction goals will utilize the KBWM System. See the attached document for a description of the KBWM System as well as a process chart illustrating how it functions.
     - KBWM System utilizes and provides for the implementation of BMPs related to the reduction of sediment loading, which include a large range of measures. Approval and recommendation of BMPs for sediment reduction will be determined by the KBWM Interagency Committee (refer to KBWM System description).

- This is accomplished by funding a minimum of $5 million annually to the System specifically for the reduction of sedimentation in the Kansas basin. At this funding rate, the goal is expected to be achieved within 30 years.

- Within five years, all state and federal lands surrounding each reservoir in the watershed must have implemented BMPs as identified through the KBWM System.
- Individual WRAPS plans and conservation district goals must include the concept of reservoir sustainability with the goal of maintaining storage capacity in Kansas Basin reservoirs.
- Reservoir sustainability and reduction of sedimentation must be added as primary goals of the Kansas WRAPS Work Group.
- The KBWM System will allow for the modification or inclusion of additional sedimentation goals as they are developed by RACs.
- Establish programs with local universities to leverage relevant departments for expertise and student resources.
- Existing funding allocations will continue to be distributed and managed as they have been historically with an enhanced focus on communication and coordination among funding providers. This increase in communication and coordination is an anticipated byproduct of the KBWM System.
- Additional funding for sedimentation through the KBWM System is critical to meeting the Kansas RAC Sedimentation Goals.
  - One key element of additional funding will be to secure adequate technical assistance advisors and providers for timely delivery and implementation of recommended BMPs.
  - Additional technical assistance at the state level must be developed, even with the current level of funding. NRCS currently provides technical assistance, but due to current funding and decreased staffing capacity, NRCS cannot always meet the state's implementation schedule. With additional state technical assistance providers, NRCS can dovetail and assist with projects, but projects will move forward in the event NRCS is not available. This encourages collaboration between the two groups and reduces reliance on NRCS.
- Achieving the stated goals requires the broadest participation possible. To effect a science-based solution, it is important that all relevant lands within a specific watershed be analyzed to assess their issues, determine their priority with respect to a defined problem (e.g., sedimentation of reservoirs) and identify and prioritize solutions. This may be a long-term process.
- The Kansas RAC encourages landowners in the Kansas Basin to develop and implement voluntary Comprehensive Conservation Plans for lands in the areas of resource concern.
- Education about the KBWM System and its goals and functions should be included in the Governor's Water Vision Education and Outreach Program.
  - Specific educational and outreach programs, resources and items shall be created, distributed and taught throughout the Kansas Basin focusing on the specific goals of the Kansas Basin.

4. By 2035, reduce per capita water consumption by 10% by 2035 through conservation, education and pricing mechanisms.

To meet this goal, the Kansas RAC developed the following **Action Steps**:

- The Kansas RAC recognizes the need for water conservation in our region varies widely from year to year, season to season, and even throughout the region during any one time period. Regardless of the season or the current availability of water, the Kansas RAC is committed to promoting and supporting wise water use throughout the region.
- Action Plan Section 1: Unaccounted-for Water
  - Whether or not water is in short supply, we should always use it wisely. One of the most significant issues that can and should be addressed with regard to water use is unaccounted-for water (UFW). This is water that public water suppliers have paid to pump, convey and/or treat, and which is unaccounted for due to leakage in the distribution system, failures within the water utility infrastructure, accounting system errors and/or unmetered water distribution. This UFW calculation currently includes a range of unmetered uses, which includes hydrant flushing, tower flushing for maintenance, etc.
  - The Kansas Municipal Water Conservation Plan Guidelines approved by the Kansas Water Authority (KWA) in 2007 currently recommend that a utility implement a water management review when UFW exceeds 20% for a four-month period. The average UFW for all utilities in the region in 2014 was 16.6%. The guidelines for the Kansas Region should raise the bar higher by encouraging utilities to undertake the review at 15% for a four-month period, monitored monthly. The Kansas Water Office (KWO) should ensure technical assistance to conduct those management reviews when necessary, and technical assistance to address acute UFW.
    - Historically, UFW has been difficult to track, as water usage was not metered consistently. By 2017, however, this will change. The KDA-DWR required the installation of a flowmeter or other suitable water measuring device on all non-temporary, non-domestic water uses in 2014, with meter installation required for all water users by the end of 2016 and compliance required by the end of 2017. All public water suppliers currently meter their source of supply; a small number, however, remain that do not meter individual customer water usage. The RAC recommends that all public water suppliers implement customer water metering at the earliest opportunity.
    - The water metering requirement and customer metering will allow for all types of water usage to be tracked and analyzed by 2018. The most important short-term benefit of the installation of water flow meters is that it will allow for appropriate accounting of water usage. This accounting not only allows for the identification of the location and nature of leaks in the system, but the information gathered is critical also to determining the nature of water usage and where conservation measures can be wisely implemented. This information will allow communities and individual users to strategize appropriate water usage and save themselves and/or the community water and money over time.

- Over time, large users should be encouraged to sub-meter which will improve their understanding of the nature of their water consumption and allow for more effective implementation of wise water use measures.
- The KWO should educate communities about the availability of funding for utilities to conduct assessments of distribution and transmission systems and develop a proactive replacement and repair schedule to minimize water loss within the system. Utilities should, where feasible, collaborate with larger utility partners in the area for assistance with assessments. The KWO should also actively educate communities about the availability of funding for investments in infrastructure improvements to minimize water loss for all water utilities in the Kansas Region.

- Action Plan Section 2: Water Conservation Plans
  - The KWO should evaluate current conservation plan guidelines adopted by the KWA in 2007, to ensure they adequately address the Vision and Kansas Region goals and provide assistance in updating plans as necessary.
  - The KWO should work with public water suppliers in the region to ensure that all have an approved water conservation plan consistent with the updated Guidelines approved by the KWA that reflect the Vision and Kansas Region goals.
  - The KWO should work with public water suppliers that have experienced drought vulnerability in the last 10 years to ensure they have robust drought response plans, with meaningful and implementable triggers and responses.
  - The KWO should develop a BMP Conservation Guide for communities, highlighting available resources and success stories. This BMP Conservation Guide shall be updated bi-annually.
  - The Kansas RAC recommends that communities throughout the Kansas Region adopt wise water use in public buildings and on public grounds as identified in the BMP guide.
- Action Plan Section 3: Education
  - The KWO should make use of existing educational resources from federal, state and non-governmental organizations such as the EPA's WaterSense program and WaterSense partners, and materials produced by the American Water Works Association and the Alliance for Water Efficiency.
  - The Kansas RAC supports the mission of the Kansas Water Vision Educational Task Force. Any education efforts should be carried out in collaboration with the Kansas Water Vision Education Program.
  - The Kansas RAC will submit the following recommendations to the Kansas Water Vision Educational Task Force.
    - Develop a strategic, unified messaging campaign tailored to the needs of each region that is executed across the state and through all relevant agencies through coordinated messaging methods.
    - Develop a robust and comprehensive website that will serve as a cornerstone of the education campaign.
    - Establish a shared resource center for water suppliers and major users to connect regionally and share best management practices.
- Action Plan Section 4: Incentive-based conservation practices

- The Kansas RAC will continue to work with stakeholders to research and explore other opportunities to encourage wise use of water in the Kansas Region. The following items are examples of the type of opportunities the RAC will investigate.
- Consider incentive-based conservation practices. Electric utilities use "throughput disincentives" authorized by the Kansas Energy Efficiency Investment Act (KEEIA) to recover revenue lost by conservation measures; something similar might be appropriate for water utilities.
- Establish criteria that encourage Low Impact Development (LID) that focuses on lowering water use in new developments.
  - Direct the KWO to work with cities to adopt LID design criteria with the goal that city ordinances and any other requirements would encourage less water-intensive fixtures, structures and landscape in new developments.
  - Direct the KWO to award and recognize cities and developers who utilize LID that focuses on water conservation.
  - Direct the KWO to proactively promote LID concepts to land developers.
- Work with utilities to incentivize water efficiency via lower connection rates (or other upfront cost saving incentives) for developers, property and business owners using efficient fixtures, xeriscaping, rain catchment/reuse systems, and other conservation measures.
- Offer tax credits for practices that reduce consumption without reducing production.
  - With respect to agricultural water use, provide property tax credits proportionate to water use reduction on irrigated agricultural lands.
  - Consider incentives for recycling of water within an entity or community.
  - Develop a rewards and recognition program for successful Kansas conservation activities to highlight communities, individuals, businesses and industry that implement local conservation BMPs successfully.
  - Create a private "water audit" certification program such as Leadership Energy and Environmental Design (LEED) to identify individuals achieving highly efficient water use and conservation.
  - Promote smart water use in public buildings and on public grounds such as lower volume toilets and reduced lawn watering.
  - Fund K-State Extension programming on low or no water use landscaping.

5. After 2020, reduce duration and frequency of harmful algal blooms disrupting recreation in lakes such that blooms last under a week and do not occur until after Labor Day.

   To meet this goal, the Kansas RAC developed the following **Action Step**:

   - Utilize the Kansas Basin Watershed Management (KBWM) System to reduce the level of nutrients entering the reservoirs and water supply lakes.
     - All new funding allocated to meet RAC nutrient reduction goals will utilize the KBWM System. See the attached document for a description of the KBWM System as well as a process chart illustrating how it functions.
     - KBWM System utilizes and provides for the implementation of BMPs related to the reduction of nutrient loading, which include a large range of measures.

Approval and recommendation of BMPs for nutrient reduction will be determined by the KBWM Interagency Committee (refer to KBWM System description).
    - This is accomplished by a minimum allocation of $1.5 million per year to be directed to BMPs in the Milford Watershed, with a total request of $3 million per year, with the remaining $1.5 million to be distributed throughout the watershed through the KBWM System.
- Within five years, all state and federal lands surrounding each reservoir in the watershed must have implemented best management practices to address harmful algal blooms (HABs) as identified through the KBWM System.
- Individual WRAPS' Plans and local Conservation Districts' goals must include the concept of minimizing nutrient inflow to lakes with the goal of reducing the potential for HABs.
- The reduction of nutrients must be added as a primary focus of the Kansas WRAPS Work Group.
- KWO and KDHE must coordinate with USACE on management of releases during HABs and provide notice to downstream communities of the level of release.
- Ensure that KWO and KS RAC promote the inclusion of lake communities, downstream public water supply systems, and other water users into HAB meetings and discussions.
- Underscore that the preferred methodology is to use BMPs which include a large range of measures which will be vetted through the KBWM System. BMPs should be prioritized to address HABs.
- Recognize that in the near-term, dollars will need to be spent on treatment of the problem in the lakes (e.g., chemical treatment), but the goal is to shift those dollars upstream to prevention of the problem at the source – which is to prevent nutrients from flowing into the lakes.
- The RAC supports ongoing research for identification and remediation of the causes, prevention and treatment of HABs, including potential in-lake technologies.
- Establish programs with universities to leverage relevant departments for expertise and student resources.
- Achieving the stated goals requires the broadest participation possible. To effect a science-based solution, it is important that all relevant lands within a specific watershed be analyzed to assess their issues, determine their priority with respect to a defined problem (e.g., HABs) and identify and prioritize solutions. This may be a long-term process.
- The RAC encourages landowners in the Kansas Basin to develop and implement voluntary Comprehensive Conservation Plans for lands in the areas of resource concern.
- Education about the KBWM System and its goals and functions should be included in the Governor's Water Vision Education and Outreach Program.
- Specific educational and outreach programs, resources and items shall be created, distributed and taught throughout the Kansas Basin focusing on the specific goals of the Kansas Basin including the reduction of HABs.
- Establish a region wide education and communication plan with regard to HABs and include best and worst management practices.

In summary, the Kansas RAC will work in cooperation and coordination with local WRAPS groups, conservation districts, producers and municipalities. Partnerships will implement goals by leveraging existing financial resources and finding new funding sources, implementing new conservation practices, and providing education and awareness of water quality and quantity issues in the watershed.

3. Watershed Review

This watershed review is an in-depth description of the Delaware River Watershed. This section includes descriptions and data about the watershed's land cover and use, special water designations, annual rainfall, aquifers, population, public water supplies and permitted wastewater facilities.

A. Land Cover and Land Uses

Land use activities have a significant impact on the types and quantity of nutrient and sediment pollutants in the Delaware River Watershed. As shown in **Figure 5**, the four major land uses in this watershed are pasture/hay (46%), cropland (24%), deciduous forest (12%), and grassland (9%). Pasture/hay and grassland land uses often can contribute livestock manure to streams and ponds, resulting in nutrient and bacteria runoff, in addition to sediment runoff from cattle trails and gullies in pastures. Cropland (cultivated crops) is the main source of sediment and nutrient runoff from overland flow. Nutrients leach into sediment during runoff events and are deposited in nearby streams and, eventually, the lake. In addition, agricultural cropland 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.

Table 1 lists the remaining land uses in the watershed, including: developed/urban open space (4%), open water (3%), developed, low intensity (1%), woody wetlands (1%), and other (~1%). Properly managed forest/woodland with a good understory does not contribute much sediment or nutrients to this watershed. In fact, forest/woodlands located along rivers and streams provide a good buffer to prevent streambank erosion.

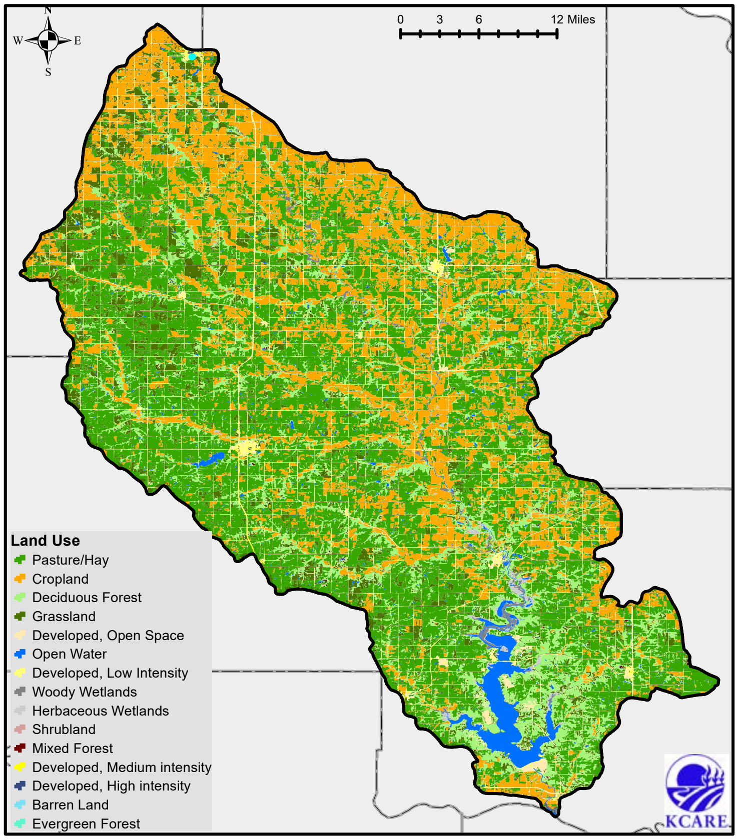


Figure 5. Land Cover and Land Use in the Delaware River Watershed

Table 1. Land Use in the Delaware River Watershed

Land Use in the Delaware River Watershed		
Land Use	**Total Acres**	**% of Watershed**
Pasture/Hay	335,503	46%
Cropland	179,043	24%
Deciduous Forest	91,218	12%
Grassland	63,367	9%
Developed, Open Space	29,589	4%
Open Water	18,602	3%
Developed, Low Intensity	6,315	1%
Woody Wetlands	4,809	1%
Herbaceous Wetlands	2,496	0%
Shrubland	1,445	0%
Mixed Forest	1,006	0%
Developed, Medium Intensity	934	0%
Developed, High Intensity	156	0%
Barren Land	106	0%
Evergreen Forest	47	0%
Total	**734,637**	**100%**

B. Designated Uses

The stream segments and lakes in the Delaware River Watershed have many designated uses according to the Kansas Surface Water Register, which is prepared and maintained by KDHE's Division of Environment, Bureau of Water. Designated uses for the Delaware River Watershed include: aquatic life, contact recreational, domestic water supply, food procurement, groundwater recharge, industrial water supply, irrigation, and livestock water. These "designated uses" are defined and assigned to specific water segments in the Kansas Surface Water Register, 2013, issued by KDHE (**Table 3**).

*Waterbodies in bold will be directly affected by implementation of this 9-element watershed plan. *Asterisks refer to a violation of designated use, and a TMDL has been written.*

Table 2. Designated Water Uses Abbreviation Key

Designated Uses Abbreviation Key			
AL	Aquatic Life	GR	Groundwater Recharge
CR	Contact Recreational	IW	Industrial Water Supply
DS	Domestic Water Supply	IR	Irrigation
FP	Food Procurement	LW	Livestock Water
A	Primary contact recreation stream segment is a designated public swimming area	B	Primary contact recreation stream segment is 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 or accessible by the public under Kansas law	C	Primary contact recreation stream segment is not open to or accessible by the public under Kansas law
E	Expected aquatic life use water	S	Special aquatic life use water
O	Referenced stream segment does not support the indicated designated use	X	Referenced stream segment is assigned the indicated designated use

Table 3. Designated Water Uses in the Delaware River Watershed[2]

Designated Water Uses: Delaware River Watershed - 10270103								
Water Segment Name	**AL**	**CR**	**DS**	**FP**	**GR**	**IW**	**IR**	**LW**
Cedar Creek (Segment 32), Clear Creek, Mission Creek	E	B	X	X	X	X	X	X
Delaware River (Segments 1, 12, 17, and 22)	E*	B*	X	X	X	X	X	X
Coal Creek	E	B	O	X	X	O	X	X
Banner Creek, Bills Creek, Cedar Creek (Segment 37), Grasshopper Creek (Segment 20), Muddy Creek (Segment 26), Slough Creek (Segment 9), Straight Creek, Wolfley Creek	E	b	X	X	X	X	X	X
Delaware River (Segment 23)	E*	b*	X	X	X	X	X	X
Barnes Creek, Little Grasshopper Creek, Mosquito Creek, Nebo Creek	E	b	X	O	X	X	X	X
Brush Creek (Segment 44), Squaw Creek	E	b	O	X	O	O	O	O
Honey Creek	E	b	O	O	O	X	X	X
Negro Creek, Otter Creek	E	b	O	X	X	O	X	X
Brush Creek (Segment 54), Burr Oak Branch, Cedar Creek North and South, Craig Creek, Elk River (Segments 29, 30), Grasshopper Creek (Segment 18), Gregg Creek, Little Slough Creek, Little Wildhorse Creek, Muddy Creek (Segment 25), Rock Creek (Segments 34, 53), Slough Creek (Segment 7), Spring Creek, Walnut Creek	E	C	X	X	X	X	X	X
Delaware River (Segments 13, 14, 15, 21)	E*	C*	X	X	X	X	X	X
Tick Creek	E	C	O	X	O	O	X	X
Catamount Creek, Claywell Creek	E	C	O	X	X	O	X	X
Lake Name:	**AL**	**CR**	**DS**	**FP**	**GR**	**IW**	**IR**	**LW**
Atchison County Park Lake	E	B	X	X	O	X	X	X
Banner Creek Lake	E	A	X	X	O	X	X	X
Elkhorn Lake	E	B	X	X	X	X	X	X
Lake Jayhawk	E	A	X	X	X	X	X	X
Little Lake	E	B	X	X	O	X	X	X
Mission Lake	E	A	X	X	O	X	X	X
Muscotah Marsh	S	a	X	X	X	X	X	X
Nebo State Fishing Lake	E	B	X	X	O	X	X	X
Perry Lake	S*	A*	X*	X*	X*	X*	X*	X*
Perry Wildlife Area Wetlands	E	B	X	X	X	X	X	X
Prairie Lake	E	A	X	X	O	X	X	X
Sabetha Watershed Lake (Niehues)	E	B	X	X	O	X	X	X

[2] Kansas Surface Water Register, 2013. Kansas Department of Health and Environment. https://www.kdheks.gov/befs/download/Current_Kansas_Surface_Register.pdf, pages 7-8 and 54.

C. Special Aquatic Life Use Waters[3]

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 Delaware River Watershed has two areas that are considered to be SALU waters (**Figure 6**):

- Muscotah Marsh, including all wetlands within Sections 15 and 16, Township 6, Range 17 East
- Perry Lake

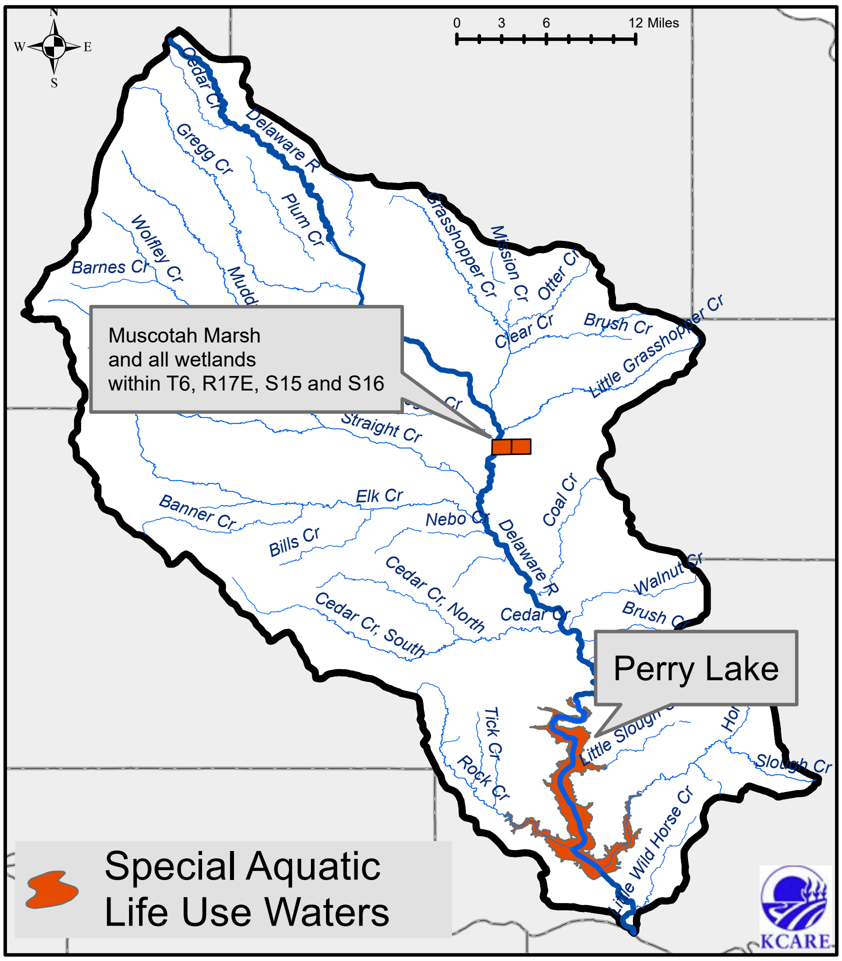


Figure 6. SALU Waters in the Delaware River Watershed

Muscotah Marsh

The Muscotah Marsh is located in Atchison County approximately 1.5 miles south of the town of Muscotah (**Figure 6**) has been designated a SALU water body. It is unique in that it is a raised marsh surrounded by a semi-permanent swampy area. The marsh owes its existence to artesian water coming out of the ground at this location.

[3] KS Surface Water Quality Standards. K.A.R. 28-16-28d(1)(b)(2)(A) For Exceptional State Waters, K.A.R. 28-16-28b(dd). For Outstanding National Resource Waters, K.A.R. 28-16-28b(aaa). https://www.kdheks.gov/nps/resources/specwaterinfo.pdf

Muscotah Marsh is the home to the only population of Slender Walker Snails (*Pomatiopsis lapidaria*) in Kansas. Wetlands and contiguous drainageways in Sections 15 and 16 of Township 6 South, Range 17 East in Atchison County where the marsh is located have been designated as “Critical Habitat” for the snail. Although this species of snail is fairly common in the eastern U.S., only isolated populations can be found in the Plains region. The species is currently listed as endangered in Kansas.

The population of the Slender Walker Snail at Muscotah Marsh is unique not only because it is so isolated and rare in Kansas, but also because the snails are so abundant. Densities of 1,255 individuals per square meter have been described in raised portions of the marsh. This particular snail prefers terrestrial conditions with very high relative humidity, and the raised characteristic of the marsh with stable artesian groundwater flow creates conditions favorable for the snail.

The land where Muscotah Marsh is located is privately owned, and there is potential for adverse impact on the Slender Walker Snail population from changing land use. The snails’ very specific habitat requirements make the species vulnerable to any dewatering of the marsh and water pollution. Dewatering of the marsh could result from groundwater pumping in the surrounding area or changes in area geology that could influence the artesian flow. Increased variability of environmental conditions (e.g., drier conditions and/or lowered humidity) caused by reduced artesian flow would have a devastating effect on the snail population. Groundwater pollution or runoff reaching the marsh also could have a negative impact on the snail population. Since the area is surrounded by agricultural land, nutrients, sediment and agricultural chemicals present the greatest threat to water quality. However, because the marsh receives constant artesian flow, it is unlikely that the area could be drained and converted to another type of land use than what currently exists.

Any adverse conditions imposed on the Muscotah Marsh could impact this single population of the Slender Walker Snail and result in the reduction or total loss of the species in Kansas. The vulnerability of this endangered species warrants close attention by the Kansas Department of Wildlife, Parks and Tourism (KDWPT), Delaware River WRAPS, and other partner agencies. To date, only limited research has been done on Muscotah Marsh and its population of Slender Walker Snails. A recovery plan for the species was developed by the KDWPT in 2003.

Perry Lake

The Perry Lake Reservoir (**Figure 6**) also is designated as a SALU water body. Most federal reservoirs in the state of Kansas are considered SALUs due to the uniqueness of the large expanses of open water and large wetland areas associated with these reservoirs. With over 11,000 acres of open water and large wetlands located at its north end, Perry Lake provides unique support for wildlife, aquatic species and other biota that would not exist otherwise.

Perry Lake is located at the south end of this watershed. Because streams in the basin generally flow southward the lake receives inflow from nearly the entire basin. As a result, Perry Lake directly reflects the effects of land uses in the entire watershed. In many ways it acts as a barometer, signaling watershed and runoff conditions and the impact of water impairments.

Perry Lake has been impacted negatively by sediment and nutrient loading. Sediment from upland erosion, unstable streambanks and stream channel degradation has reduced the lake's water storage capacity, negatively impacted recreation, harmed aquatic life and impaired water quality. The effects of sedimentation are most evident at the north end of the lake where the Delaware River enters the water body. Water depth and open water area are decreasing as the river's heavy sediment load is deposited in the lake.

Nutrient enrichment which causes eutrophication also poses a significant threat to Perry Lake. Eutrophication (which comes from the Greek word "*eutrophic*," meaning richly nourished) is a process in which excessive nutrients are deposited in a lake, causing accelerated algae growth. The resulting algae blooms can release toxins harmful to humans and other animals, can cause taste and odor problems in drinking water, may negatively impact recreation and can have very harmful effects on aquatic species including fish kills.

Perry Lake experienced the most significant algae bloom in its history in July 2011. Heavy nutrient loading from the watershed spawned explosive blue-green algae growth throughout the lake body with heaviest populations noted in the Old Town region on the north and the Rock Creek arm on the west side of the lake. The bloom prompted KDWPT and KDHE to issue a Public Health Warning, advising that conditions in the lake were unsafe for human or animal exposure due to the release of toxins by the blue-green algae. As a result, swimming beaches were closed and other recreational traffic at the lake was reduced significantly.

D. Exceptional State Waters[3]

Exceptional State Waters (ESW) are defined as "any of the surface waters or surface water segments that are of remarkable quality or of significant recreational or ecological value." There are no ESW-listed waters in the Delaware River Watershed.

E. Outstanding National Resource Waters[3]

Outstanding National Resource Waters (ONRW) are defined as "any of the surface waters or surface water segments of extraordinary recreational or ecological significance." The Delaware River Watershed does not contain any ONRW-listed waters.

F. Rainfall and Runoff

Rainfall amounts and duration affect sediment and nutrient runoff during high-intensity rainfall events, most of which occur in late spring and early summer. This is the time frame when cropland is either bare, or crop biomass is small; likewise, grasses are short and do not catch runoff. Both of these situations can lead to pollutants entering the waterways. The Delaware River Watershed averages 37.2 inches of rainfall annually (**Figure 7**). Precipitation data from the cities of Holton, Horton, Oskaloosa and Perry were used to calculate the average annual rainfall in the watershed. As shown in **Figure 8**, the highest levels of precipitation are found in the southern section of the watershed, with the least annual precipitation in the northwest portion.

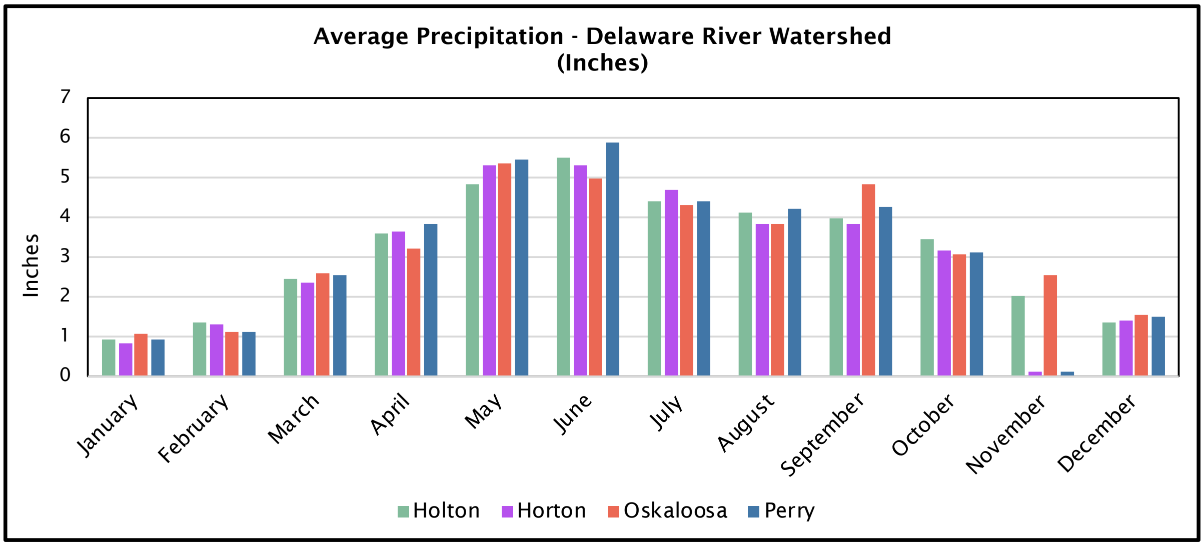


Figure 7. Delaware River Watershed Monthly Average Precipitation[4]

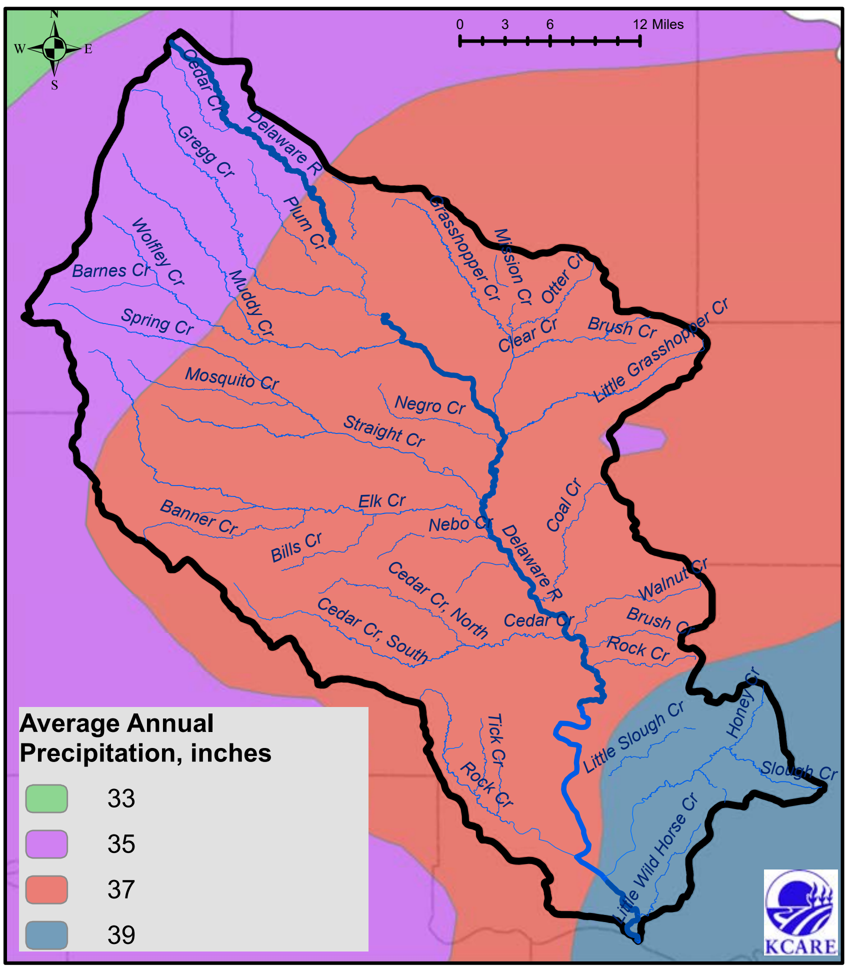


Figure 8. Annual Precipitation in the Delaware River Watershed

[4] U.S. Climate Data. https://USClimatedata.com

G. Population and Wastewater Systems

Most of the Delaware River Watershed is considered below-average population with no major urban areas located in the watershed (**Figure 9**).

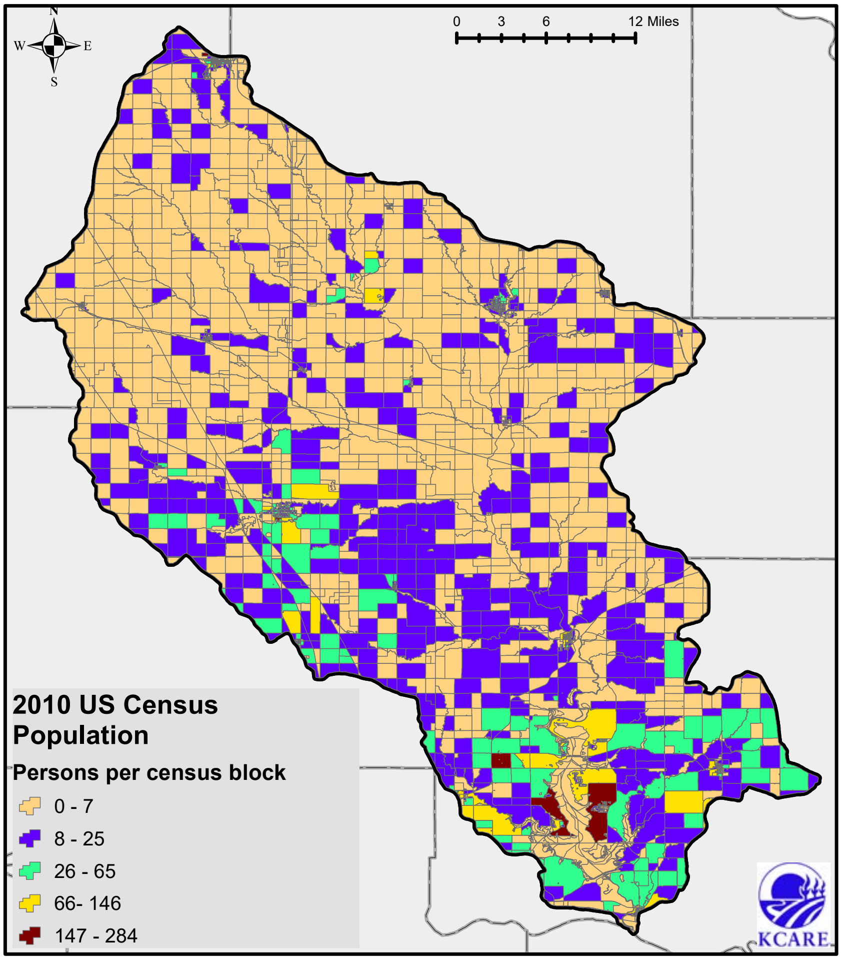


Figure 9. Delaware River Watershed Population Map

The average population density for Kansas, represented as persons per square mile, is 32.9; the average for the Delaware River Watershed is 23.7 persons per square mile (**Table 4**). Using a watershed area of 1,110 square miles (less the 37 square miles of Perry Lake and State Park), the total population for the Delaware River Watershed is estimated to be 26,307 (**Table 5**).

Numbers from 2019 listed in Tables 4 and 5 are estimates from The League of Kansas Municipalities, therefore calculations for current population and wastewater systems in the watershed will utilize 2010 U.S. Census data.

Table 4. Population in the Counties of the Delaware River Watershed

Estimating the Delaware River Watershed Population				
County	**Square Miles**	**2010**	**2019**	**Persons per square mile**
Atchison	434	16924	16193	39.0
Brown	572	9984	9598	17.5
Jackson	658	13462	13280	20.5
Jefferson	557	19,126	18,975	34.3
Nemaha	719	10,178	10,155	14.2
TOTAL	**2,940**	**69,674**	**68,201**	**23.7**

Table 5. Rural and Urban Populations Used to Determine Wastewater Systems

Delaware River Watershed Municipal Population		
Township	**2010**	**2019**
Circleville	170	162
Denison	187	177
Everest	284	275
Fairview (population: 260 ~ 30% in the watershed)	182	174
Goff	126	118
Holton	3,329	3,248
Horton	1,776	1,688
Huron	54	72
Kickapoo Indian Reservation (population in 2006)	1,653	1,653
Mayetta	341	315
Meriden	813	782
Muscotah	176	169
Netawaka	143	138
Oskaloosa	1,113	1,059
Ozawkie	645	621
Perry (population: 929 ~ 50% in the watershed)	465	453
Potawatomi Indian Reservation (population in 2000: 1,238 ~ 20% in the watershed)	990	990
Powhattan	77	75
Sabetha (population: 2,571 ~ 50% in the watershed)	1,286	1,284
Valley Falls	1,192	1,129
Wetmore	368	362
Whiting	187	185
TOTAL URBAN POPULATION	15,557	15,129
TOTAL RURAL POPULATION	10,750	
Delaware River Watershed: TOTAL POPULATION	**26,307**	

The number of wastewater treatment systems is tied directly to population, particularly in rural areas without access to municipal wastewater treatment facilities. The lack of onsite wastewater systems, or systems that are failing or improperly installed, can lead to bacteria and/or other nutrients from untreated sewage leaking or draining into the watershed. Even though all the counties in the watershed have county sanitary codes, there is no way of knowing how many failing or improperly constructed systems exist in the Delaware River Watershed. Using a rural population of roughly 10,750 and an estimated 2.29 people per rural Kansas household, it can be determined that there are approximately 4,694 onsite wastewater treatment systems installed in the watershed with an expected failure rate of roughly 20%, or 939 systems.[5]

H. Aquifers

Portions of two aquifers underlie the Delaware River Watershed: the alluvial aquifer and the Glacial Drift Aquifer (**Figure 10**).

- The **alluvial** aquifer is part of and connected to a river system, consisting of sediment deposited by rivers in the stream valleys. A sign of a healthy and sustainable alluvial system is adequate stream flow. The alluvial aquifer in the Delaware River Watershed lies along and below the Delaware River and Perry Lake. Many additional water segments in the watershed are connected by the alluvial aquifer, including: Elk Creek, Straight Creek, Cedar Creek, Rock Creek, and the lower portions of Gregg, Muddy, Grasshopper, Little Grasshopper and Little Slough Creeks.
- The **Glacial Drift Aquifer** was formed by deposits of rock left by the glacier that covered northeast Kansas 700,000 years ago. These rock deposits of sand and gravel created a porous area that traps and holds water deposits.

[5] Cooperative Extension Service, University of Kentucky, College of Agriculture. http://www2.ca.uky.edu/agcomm/pubs/HENV/HENV502/HENV502.pdf

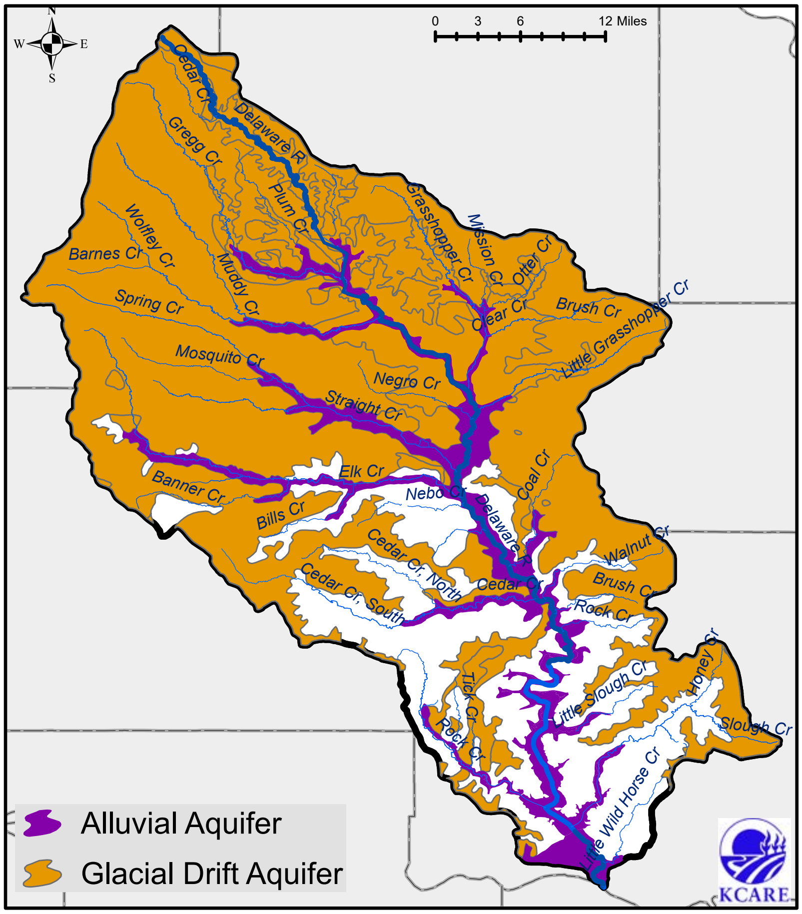


Figure 10. Aquifers in the Delaware River Watershed[6]

I. Public Water Supplies

A Public Water Supply (PWS) is defined as any system that supplies piped water to the public for human consumption, given that the system has at least 10 service connections, or regularly serves an average of 25 or more individuals for at least 60 days out of the year. Municipal water supplies and rural water districts are considered public water supplies.

A PWS utilizes water from either surface water or groundwater sources, or a combination of both. Generally speaking, groundwater sources are less prone to man-made contamination than surface water sources since soil overlying aquifers acts as a protective barrier and filter. However, contaminants able to leach through the soil (or where aquifers are shallow) can have a negative impact on groundwater quality.

Sediment can affect a PWS that derives its water from a surface water supply, by making it difficult to access the water at the intake or to treat the water prior to consumption. Nutrients and bacteria also will affect surface water supplies causing excess treatment costs prior to public consumption.

[6] US Geological Survey, Kansas Geological Survey.

There are 25 public water suppliers within this watershed, as shown in **Table 6**. The majority of people in the Delaware River Watershed receive their water from a PWS, while the rest of the watershed's population depend on private wells.

***Table 6. Delaware River Watershed Public Water Suppliers*[7]**

Public Water Suppliers in the Delaware River Watershed		
Public Water Suppliers	**Population**	**County**
Circleville, City of	161	Jackson
Denison, City of	177	Jackson
Everest, City of	274	Brown
Goff, City of	118	Nemaha
Holton, City of	3,208	Jackson
Horton, City of	1,685	Brown
Jackson County RWD 3	4,376	Jackson
Jefferson County RWD 10	300	Jefferson
Jefferson County RWD 11	483	Jefferson
Jefferson County RWD 3	2,435	Jefferson
Jefferson County RWD 7	1,180	Jefferson
Jefferson County RWD 9	352	Jefferson
Lakeside Village Improvement District	290	Jefferson
Muscotah, City of	167	Atchison
Nemaha County RWD 4	448	Nemaha
Netawaka, City of	137	Jackson
Oskaloosa, City of	1,057	Jefferson
Ozawkie, City of	620	Jefferson
Perry, City of	910	Jefferson
Powhattan, City of	72	Brown
Public Wholesale Watershed 18	1	Jackson
Valley Falls, City of	1,153	Jefferson
Wetmore, City of	366	Nemaha
Whiting, City of	183	Jackson
Willis, City of	38	Brown
Total Population Served	**20,191**	
RWD - Rural Water District		

***Figure 11** appears to have over 25 public water suppliers, and this is due to the fact that many suppliers draw their water supply from multiple sites. The map below reflects each individual KDHE PWS site even though they are considered one source in **Table 6**. For example, the City*

[7] Kansas Department of Health and Environment, April 12, 2021.

of Goff in considered one PWS but draws water from three well sites; those sites are each shown below with a red star.

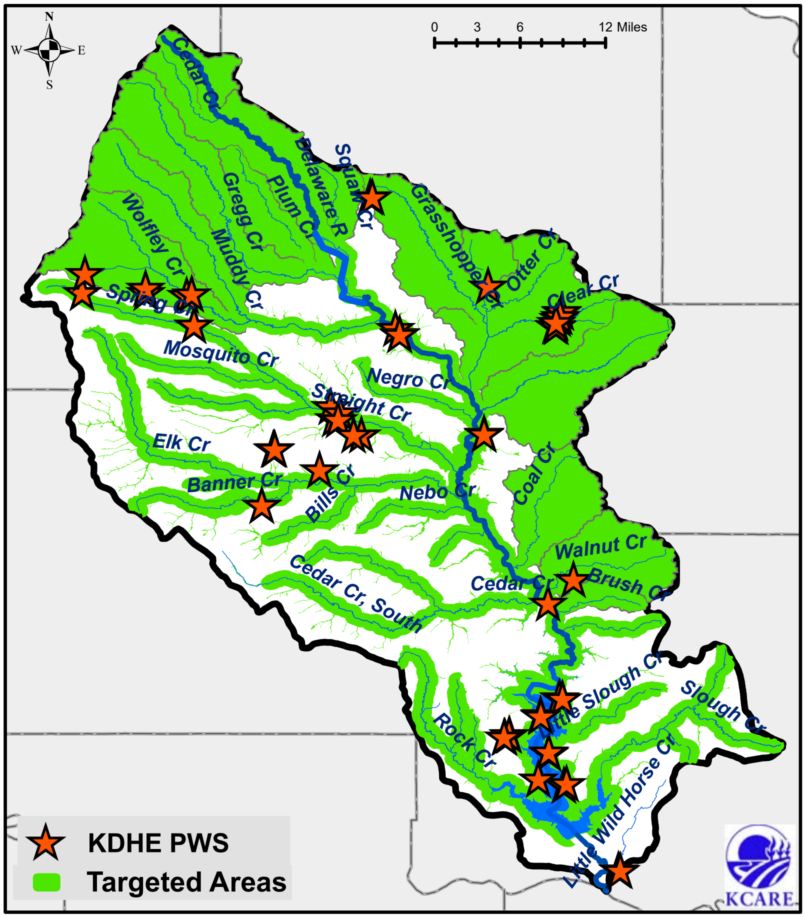


Figure 11. Public Water Suppliers in the Delaware River Watershed

Source water protection

The 1996 amendments to the Safe Drinking Water Act required each state to develop a Source Water Assessment Program (SWAP). Additionally, each state was required to develop a Source Water Assessment (SWA) for each public water supply that treats and distributes raw source water. In Kansas, there are approximately 761 public water supplies requiring SWAs. SWAs include the following: delineation of the source water assessment area, inventory of potential contaminant sources, and susceptibility analysis. The SWA also must be made available to the public. KDHE's Watershed Management Section has implemented the Kansas SWAP plan, and all SWAs are complete[8].

The Safe Drinking Water Act did not require protection planning to be part of the SWAP process. On a voluntary basis, KDHE encourages public water supplies and their surrounding communities to use SWA as the foundation for future protection planning efforts.

[8] Kansas Department of Health and Environment, Source Water Assessment Reports. http://www.kdheks.gov/nps/swap/SWreports.html

The Delaware River Watershed has 25 active PWS sites. Nearly all public water suppliers within the Delaware River Watershed were required to develop a SWAP in 2003. In fact, 18 of the suppliers listed in **Table 6** were required to develop a SWAP, with seven exclusions: the Cities of Circleville, Denison, Goff, Netawaka, Oskaloosa, Powhattan, Willis, and the Public Wholesale Watershed District 18.

J. National Pollutant Discharge Elimination System (NPDES)

National Pollutant Discharge Elimination System (NPDES) permits specify the maximum amount of pollutants allowed to be discharged to surface waters. KDHE permits and regulates wastewater treatment facilities, and these facilities are considered point sources for pollutants. Having these PS located on streams or rivers may impact water quality in the waterways. Municipal wastewater can contain suspended solids, biological pollutants that reduce oxygen in the water column, inorganic compounds, or bacteria. Methods for treating municipal wastewater are similar across the country; wastewater treatment facilities remove solids and organic materials, disinfect water to kill bacteria and viruses, and discharge water to surface waterways.

Industrial point sources also can contribute toxic chemicals or heavy metals to waterways. Treatment of industrial wastewater is specific to the industry and the pollutant discharged. Any pollutant discharge from PS allowed by the state is considered to be wasteload allocation. There are currently 25 permitted NPDES facilities in the Delaware River Watershed (**Table 7**).

***Table 7. NPDES Permitted Facilities in the Delaware River*[9]**

NPDES Permitted Facilities in the Delaware River Watershed			
Facility Name	**Facility Type**	**Description**	**County**
Concrete Supply of Topeka- Holton	Industrial	Waste Stabilization Pond; Overflowing	Jackson
Hamm - Smith #106	Industrial	Mine Pit Dewatering (No Wash)	Jackson
Jefferson County Sewer District #2 - Indian Ridge	Municipal	Waste Stabilization Pond; Overflowing	Jefferson
Everest, City of	Municipal	Waste Stabilization Pond; Overflowing	Brown
Oskaloosa, City of	Municipal	Waste Stabilization Pond; Overflowing	Jefferson
Jefferson County Sewer Dsitrict #6 Lake Shore Estate	Municipal	Waste Stabilization Pond; Overflowing	Jefferson
Jefferson County Sewer District #7 & 8 (Lake Ridge)	Municipal	Waste Stabilization Pond; Overflowing	Jefferson
Netawaka, City of	Municipal	Waste Stabilization Pond; Overflowing	Jackson
Whiting, City of	Municipal	Waste Stabilization Pond; Overflowing	Jackson
Goff, City of	Municipal	Waste Stabilization Pond; Overflowing	Nemaha
Jackson County Rural Water District #3	Industrial	Waste Stabilization Pond; Overflowing	Jackson
Mayetta, City of	Municipal	Waste Stabilization Pond; Overflowing	Jackson
Muscotah, City of	Municipal	Waste Stabilization Pond; Overflowing	Atchison
Valley Falls, City of	Municipal	Waste Stabilization Pond; Overflowing	Jefferson
Wetmore, City of	Municipal	Waste Stabilization Pond; Overflowing	Nemaha
Perry Yacht Club	Commercial	Waste Stabilization Pond; Non-Overflowing	Jefferson
Unified School District #335 Jackson Heights Schools	Municipal	Waste Stabilization Pond; Overflowing	Jackson
Huron, City of	Municipal	Waste Stabilization Pond; Overflowing	Atchison
Powhattan, City of	Municipal	Waste Stabilization Pond; Overflowing	Brown
Banner Creek LLC.	Industrial	Aerated Lagoon	Jackson
Lakewood Hills Improvement District	Municipal	Activated Sludge Extend; Aeration	Jefferson
Holton, City of	Municipal	Activated Sludge Extend; Aeration	Jackson
Horton, City of	Municipal	Bio-Filter Combination	Brown
Sabetha, City of	Municipal	Activated Sludge Extend; Aeration	Nemaha

[9] NPDES Facilities Provided by KDHE on April 13, 2021.

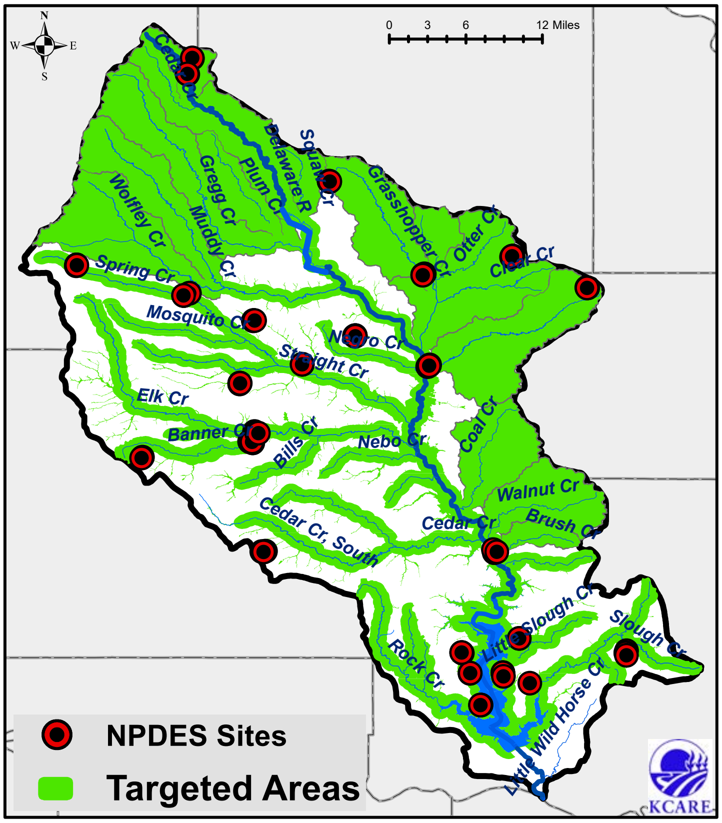


Figure 12. Delaware River Watershed NPDES Sites

K. Livestock Operations in the Delaware River Watershed

1. Confined livestock

Any livestock facility with an animal unit capacity of 300 or more or a facility with a daily discharge, regardless of size, must register with KDHE. Any facility, no matter what animal capacity, is required to register if KDHE investigates them due to a complaint, and the facility is found to have significant pollution potential. Facilities that register with KDHE will be site-inspected for significant pollution potential. If KDHE does not find significant pollution potential at a facility, that facility can be certified if it follows management practices recommended and approved by KDHE. These include, but are not limited to, regular cleaning of stalls, managing manure storage areas, etc.

Facilities having between 300 and 999 animal units are known as Confined Feeding Facilities (CFFs). Any CFFs identified with significant pollution potential must obtain a State of Kansas Livestock Waste Management Permit. Facilities of 1,000 animal units or more, known as Confined Animal Feeding Operations (CAFOs), must obtain an NPDES Livestock Waste Management Permit (Federal). Operations with a daily discharge, such as a dairy operation that generates an outflow from the milking barn on a daily basis, are required to have a permit. See **www.kdheks.gov/feedlots** for more information.

Table 8. Permitted Livestock Facilities in the Delaware River Watershed

Permitted Livestock Facilities	
County	**Quantity of Facilities**
Atchison	24
Brown	12
Jackson	17
Jefferson	2
Nemaha	10
Total	**65**

As shown in Table 8, there are 65 active permitted livestock facilities in the five counties housing the Delaware River Watershed. Permitted facilities are required to have a management plan for containing and utilizing manure and for lot runoff. Livestock waste facilities can be useful tools for managing livestock waste, but waste material must be land-applied from the containment facilities in a manner that does not jeopardize water resources. Within the Delaware River Watershed, producers should apply livestock waste by matching the phosphorus content of the waste with soil test recommendations to avoid over-application of phosphorus in areas prone to runoff.

2. Unconfined livestock

Unconfined areas of animal concentration such as watering areas, loafing areas or feeding areas also can have pollution potential for nutrients, sediment and bacteria if the areas are not managed properly. Management practices for these areas can include alternative water sources, rotational grazing, proper mineral and feed placement, and proper manure application to cropland.

4. Impaired Waters in the Delaware River Watershed

Perry Lake is located on the southern end of the Delaware River Watershed, only a few miles from the confluence of the Delaware River with the Kansas River. Therefore, Perry Lake is a direct reflection of inputs from the watershed and acts as a barometer for water quality impacts from land use throughout the watershed.

Water quality in the Delaware River Watershed is monitored at 26 sites (**Figures 13 and 14**). These sites include six USACE monitoring sites, three U.S. Geological Survey (USGS) real-time stream gaging sites, and 17 permanent and rotational KDHE sampling sites. Seven of these active monitoring sites are in Perry Lake.

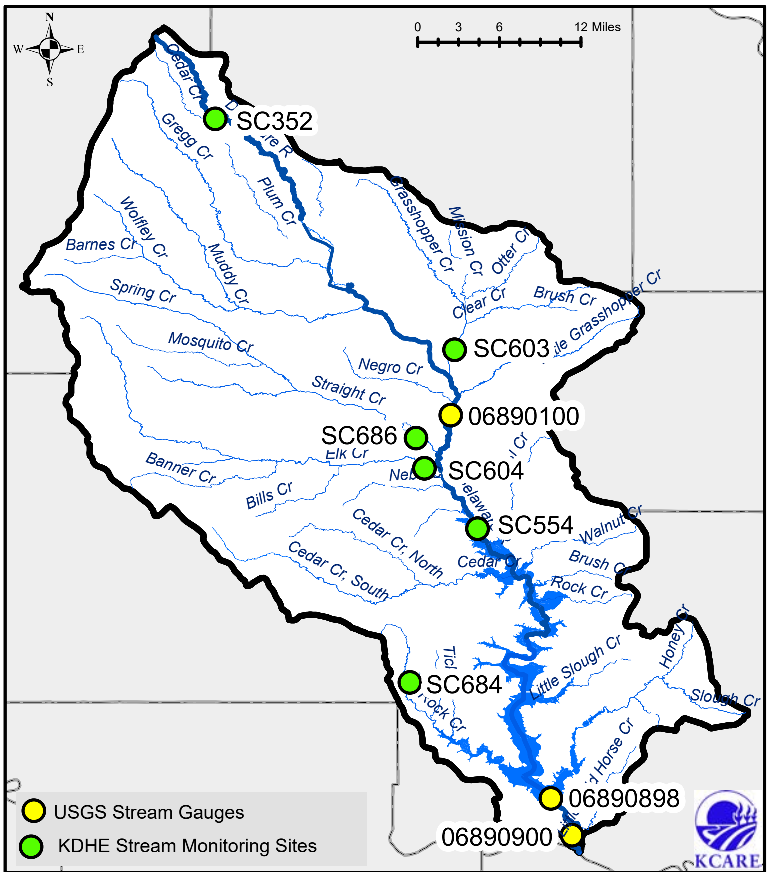


Figure 13. Delaware River Watershed Stream Monitoring Sites

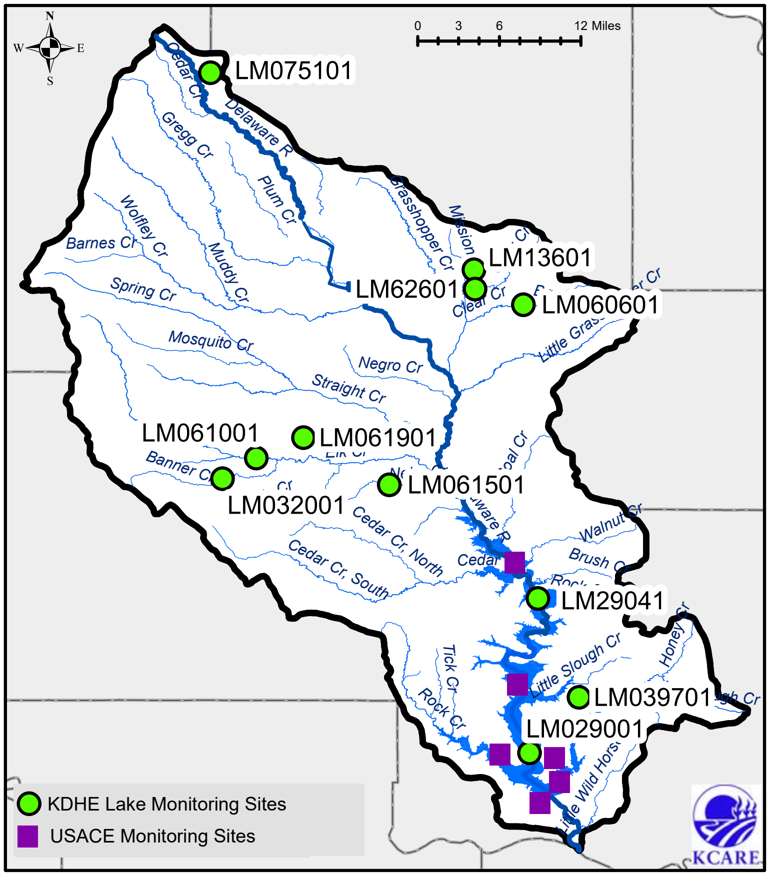


Figure 14. Delaware River Watershed Lake Monitoring Sites

USACE collects water samples at federal reservoirs each year, including Perry Lake. Sites at Perry Lake where USACE collects samples historically have included four in-take locations, one outflow location below the dam (not pictured as it is outside the watershed), and two inflow locations at the Rock Creek arm, and Delaware River, near Valley Falls. Nutrients (nitrogen and phosphorus), pesticides (notably atrazine and alachlor), Secchi depth, chlorophyll *a*, dissolved oxygen, pH, conductivity and temperature are measured.

Since 1999, USGS has conducted studies related to describing hydrology and water quality in the Kansas-Lower Republican River basin. Analysis of continuous real-time water quality monitoring and d sample data has led to the development of statistical models that estimate water quality constituent concentrations, as well as the probability of occurrence for cyanobacteria and associated toxins and taste-and-odor compounds. The data collected throughout these studies are useful for characterizing changes in water quality conditions through time, characterizing potentially harmful cyanobacterial events, and indicating changes in water quality conditions that may affect drinking water treatment processes.

KDHE stream monitoring stations are either permanent or rotational sampling sites. Permanent monitoring sites are sampled continuously, while rotational sites are typically sampled every four years. All sites are sampled for nutrients (nitrogen and phosphorus), metals, ammonia, solid fractions, turbidity, alkalinity, chlorophyll, pH, dissolved oxygen, *E. coli* bacteria and chemicals.

Sample analysis determines if the water contains an unacceptable level of the previously mentioned pollutants.

If analysis determines that any one pollutant exceeds acceptable limits, the water segment then becomes "impaired" by that pollutant and is reported as a 303d-listed impairment. If the water segment affected by the pollutant is in dire need of reduction and is considered "high priority," it is then listed as a Total Maximum Daily Load (TMDL).

A. 303d List of Impaired Waters in the Delaware River Watershed

KDHE develops a "303d list" (**Table 9**) of impaired waters biennially and submits it to EPA. To be included on the 303d list, samples taken by the KDHE monitoring program must show that water quality standards are not met, which also means that the water's designated uses are not met. Each water segment is assigned a category number to describe and report the condition of the segment. These categories include:

- Category 2: Water was previously listed as impaired but now has water quality sufficient to support its designated uses.
- Category 3: There is insufficient data and/or information to make a use support designation.
- Category 4a: A Total Maximum Daily Load (TMDL) has been developed for the waterbody/combination.
- Category 4b: NPDES permits are addressing the impairment, or a watershed plan is addressing an atrazine impairment. This is an alternative to a TMDL.
- Category 5: Data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed. These waterbodies are 303d-listed.

KDHE has identified 12 *303d-listed* waters in the Delaware River Watershed (**Figures 15 and 16)**. Portions of the Delaware River are designated as Category 5, or 303d listed, for biology impairments. Eutrophication and total phosphorus impairments are found in lakes and stream segments as detailed in **Table 9**. Monitoring sites SC352 and SC554 (highlighted in yellow) will be targeted areas for delisting. *All category 4a (TMDL) listings are described in the following "TMDL" section.*

Table 9. 303d-Listed Waters in the Delaware River Watershed[10]

303d List of Impaired Waters				
Water Segment	**Category**	**Impairment**	**Priority**	**Sampling Station**
Atchison County Park Lake	5	Eutrophication Siltation	2023	LM060601
Banner Creek Lake	5	Eutrophication	2023	LM032001
Delaware River at Hwy 36	5	Biology	2023	SC352
Delaware River near Half Mound	5	Biology	2021	SC554
Elk Creek near Larkinburg	5	Total Phosphorus	2023	SC604
Elkhorn Lake	5	Eutrophication	2023	LM061001
Grasshopper Creek near Muscotah	5	Total Phosphorus	2023	SC603
Lake Jayhawk	3	Eutrophication	-	LM039701
Nebo State Fishing Lake	5	Eutrophication	2023	LM061501
Prairie Lake	5	Eutrophication	2022	LM061901
Rock Creek near Rock Creek	3	*E. coli*	-	SC684

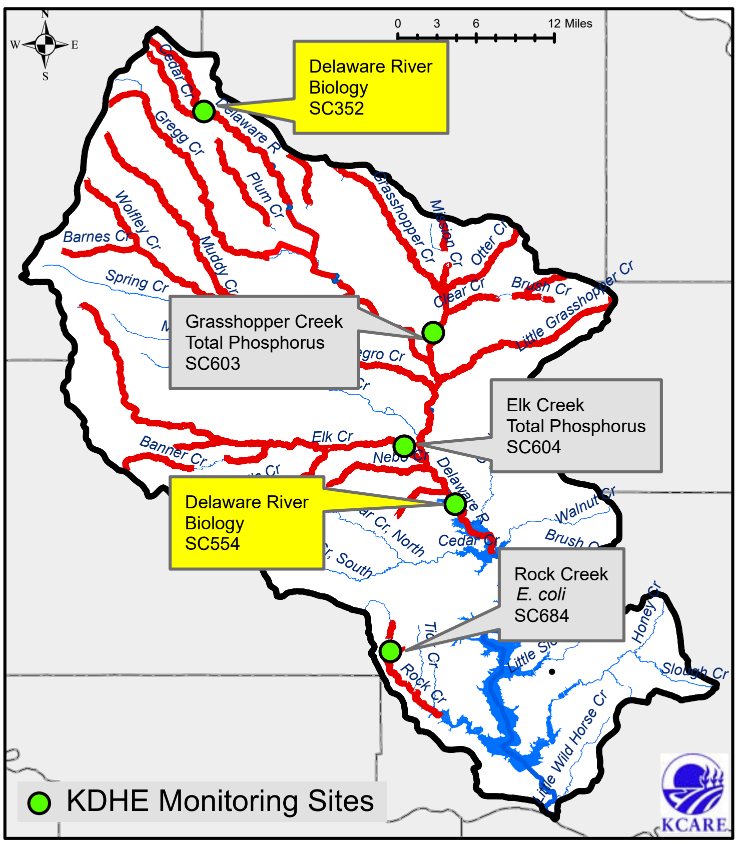


Figure 15. 303d-Listed Stream Waters in the Delaware River Watershed

[10] Kansas Department of Health and Environment, 2021. https://www.kdheks.gov/tmdl/2020/2020_303_d_List_Approved.pdf

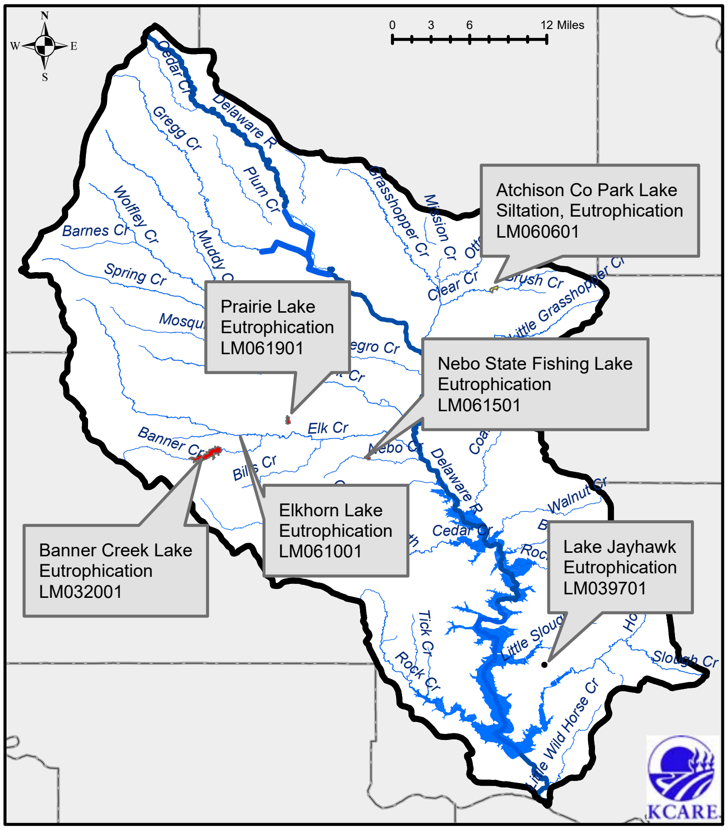


Figure 16. 303d-Listed Lakes in the Delaware River Watershed

B. Total Maximum Daily Loads (TMDL)

1. What is a TMDL?

A 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 its designated uses. TMDLs in Kansas may be established on a watershed basis and may use a pollutant-by-pollutant approach, a biomonitoring approach, or both as appropriate. TMDL establishment means that a draft TMDL has been completed, there has been public notice and comment on the TMDL, public comments have been considered, necessary revisions to the TMDL have been made, and the TMDL has been submitted to EPA for approval. In a TMDL, the desired outcome of the process is indicated, using the current situation as the baseline. Deviations from the water quality standards are documented, and the TMDL states its objective to meet the appropriate water quality standard by quantifying the degree of pollution reduction expected over time.

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 12 Kansas basins every five years on a rotational schedule. The Delaware River Watershed is part of the Kansas-Lower Republican River Basin and was reviewed in 2020; it is scheduled for review again in 2025.

2. Delaware River Watershed TMDLs

To be issued a TMDL, water samples taken during the KDHE monitoring program indicate that water quality standards have not been met. This in turn means that designated uses have not been met.

The Delaware River Watershed has 14 TMDLs (**Table 10**). However, only three of these TMDLs will be targeted by this plan: eutrophication in Perry Lake (monitoring site LM029001), and the total phosphorus and *E. coli* TMDLs in the Delaware River near Half Mound (monitoring site SC554). Half Mound is an unincorporated community located to the east of the Delaware River, north of Valley Falls and west of Nortonville in Jefferson County.

For the purpose of this plan, focus and priority will be given to the highlighted TMDLs in the Delaware River Watershed as listed below. The remaining TMDLs will be impacted positively by BMP implementation targeted to reduce nutrients (nitrogen and phosphorus) in the water.

Table 10. TMDLs in the Delaware River Watershed[11]

TMDLs in the Delaware River Watershed					
Water Segment	**Category**	**Impairment**	**Priority**	**Goal of TMDL**	**Sampling Station**
Delaware River near Half Mound	4a	Total Phosphorus	High	ALUS Index score > 13, Sestonic chlorophyll *a* ≤ 10 µg/L, DO >5 mg/L with saturation < 110%, pH range 6.5 - 8.5	SC554
		E. coli	High	Unmeasurable	
Elk Creek near Larkinburg	4a	*E. coli*	High	-	SC604
Grasshopper Creek near Muscotah	4a	Atrazine	Low	-	SC603
	4a	*E. coli*	High	-	SC603
Little Lake	4a	Eutrophication	Low	-	LM062601
Mission Lake	4a	Atrazine	High	-	LM013601
	4a	Eutrophication	High	-	LM013601
	4a	Siltation	High	-	LM013601
Perry Lake	4a	Eutrophication	High	Summer Chlorophyll *a* ≤ 10 µg/L	LM029001
Perry Wildlife Area Wetlands	4a	Dissolved Oxygen	Low	-	LM029041
	4a	Eutrophication	High	-	LM029041
Sabetha Watershed Lake	4a	Eutrophication	Low	-	LM075101
Straight Creek near Larkinburg	4a	*E. coli*	High	-	SC686

[11] Kansas Department of Health and Environment, 2018. https://www.kdheks.gov/tmdl/2020/2020_303_d_List_Approved.pdf

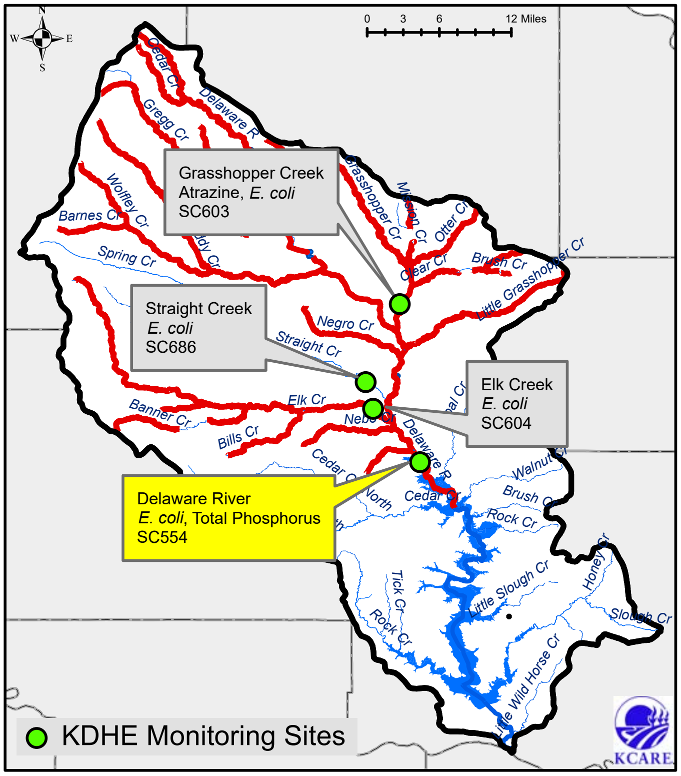


Figure 17. Stream Waters with a TMDL in the Delaware River Watershed

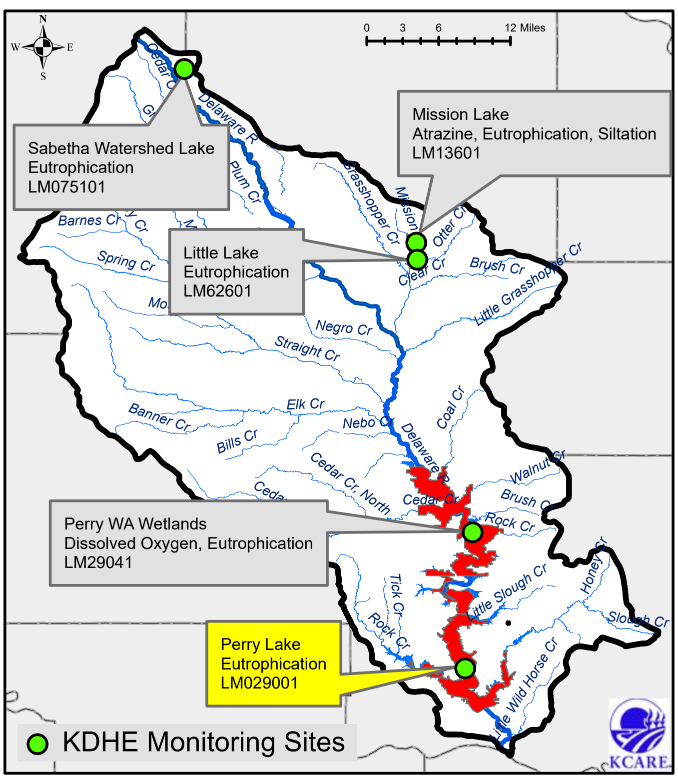


Figure 18. Lake Waters with a TMDL in the Delaware River Watershed

Note: Some of the implemented strategies for addressing the current TMDLs as determined by the SLT and outlined in this plan will have additional benefits by proactively addressing the 303d-listed impairments. The ultimate goal will be to eliminate the need to develop a TMDL for the current 303d-listed impairment.

5. Watershed Impairments to be Addressed

The Delaware River Watershed SLT acknowledges all TMDL and 303d-listed water segments in the watershed. All goals and BMPs will be aimed at protecting the Delaware River Watershed from further degradation (**Table 11**). The SLT will focus this WRAPS plan on four water deficiencies, including three TMDL-listed impairments:

1. **Eutrophication** in Perry Lake (TMDL),
2. **Total phosphorus** in the Delaware River near Half Mound (TMDL),
3. **Sediment** in all riparian areas (Mission Lake is 303d-listed), and
4. ***E. coli*** in the Delaware River near Half Mound (TMDL).

Table 11. Delaware River Watershed TMDL Impairment Loads and Goals

<table>
<tr><th colspan="5">Load Allocations for the Delaware River Watershed</th></tr>
<tr><th colspan="2">Impairment/TMDL</th><th>Current Load</th><th>Allowed Load</th><th>Required Reduction</th></tr>
<tr><td rowspan="2">Eutrophication: Perry Lake</td><td>Nitrogen</td><td>1,291,777 lbs/year</td><td>383,055 lbs/year</td><td>908,722 lbs/year</td></tr>
<tr><td rowspan="2">Phosphorus</td><td rowspan="2">265,788 lbs/year</td><td rowspan="2">76,812 lbs/year</td><td rowspan="2">188,976 lbs/year</td></tr>
<tr><td>Total Phosphorus: Delaware River near Half Mound</td></tr>
<tr><td colspan="2">Sediment: All riparian areas</td><td>1,020,674 tons/year</td><td>735,814 tons/year</td><td>284,860 tons/year</td></tr>
<tr><td colspan="2">E. coli:
Delaware River near Half Mound</td><td colspan="3">Less frequent exceedances or lowered magnitude of exceedances of the nominal E. coli Bacteria (ECB) criterion: 262 Colony Forming Units (CFUs/100 ml) for the sampling stations above Perry Lake.</td></tr>
</table>

This WRAPS plan only addresses the eutrophication TMDL in Perry Lake, and the Delaware River near Half Mound's total phosphorus and *E. coli* TMDLs; however, it should be noted that all 303d and TMDL impairment listings will be affected positively by this WRAPS plan's targeted BMP implementation. Specifically, the 303d-listed biology impairments in the Delaware River at Highway 36 and near Half Mound will be positively impacted by any nutrient load reductions.

A. Eutrophication: Nitrogen and Phosphorus

The Delaware River Watershed has a "high" priority TMDL for the impairment of **eutrophication** in Perry Lake.[12] In addition to Perry Lake's eutrophication TMDL, there are several other areas in the watershed that have been listed for having eutrophication impairments. Although these areas will not be targeted specifically with BMP implementation and load reduction goals, they will be impacted positively by BMP implementation throughout the watershed. These areas include:

- Atchison County Park Lake (303d listed),
- Banner Creek Lake (303d listed),

[12] KDHE, E TMDL for Perry Lake, https://www.kdheks.gov/tmdl/2011/Perry_Eutro_TMDL.pdf

- Elkhorn Lake (303d listed),
- Lake Jayhawk (303d listed),
- Nebo State Fishing Lake (303d listed),
- Prairie Lake (303d listed),
- Little Lake (low-priority TMDL),
- Mission Lake (high-priority TMDL),
- Perry Wetlands Area (low-priority TMDL), and
- Sabetha Watershed Lake (low-priority TMDL).

Perry Lake has been on the TMDL 303d list since 2002 for eutrophication, caused by excess nutrient loading (primarily nitrogen and phosphorus). This creates conditions favorable for algae blooms and aquatic plant growth. All uses in Perry Lake are impaired to a degree by eutrophication. Perry Lake is considered to be in a fully eutrophic state. All uses in the Perry Lake Wildlife Area Wetlands are impaired to a degree by eutrophication, and expected Aquatic Life Support is impaired due to dissolved oxygen deficiencies.

Algal blooms and aquatic plant growth may increase oxygen levels temporarily, but the bloom will die off eventually after nutrients become scarce. During this die-off, there are reduced dissolved oxygen (DO) levels in the water because algal decomposition utilizes the oxygen. This results in an unfavorable habitat for aquatic life. Desirable criteria for healthy water dictate DO rates more than 5 mg/L and biological oxygen demand (BOD) fewer than 3 mg/L.

The impairments in this watershed mainly stem from non-point pollution sources (NPS), meaning that there is not one specific outlet where contaminants enter the water course, but rather multiple sites contribute to the overall pollutant loads. Excess nutrients can originate from manure and fertilizer runoff in rural and urban areas. In the Delaware River Watershed, urbanization, agricultural land use, and small livestock operations all contribute excess nutrients to the watershed system.

1. Sources of the impairment

Nutrient loading can originate in both rural and urban areas and can be caused by both point and nonpoint sources. This plan focuses primarily on agricultural nonpoint source contributions, even though other possible sources will be included as part of the discussion.

Land Use

Land use activities can affect nutrient runoff into streams. For example, fertilizer or manure applied to frozen ground or cropland prior to a rainfall event can be transported easily downstream. Livestock allowed access to streams to drink or loaf will contribute manure directly into the stream. Overgrazed pastures do not provide adequate biomass to trap manure runoff.

Agricultural BMPs designed to help reduce nutrient runoff include the following: implementing cover crops, no-till, minimum tillage, vegetative buffers and riparian areas; creating grassed waterways and grassed terraces; establishing permanent vegetative cover and grazing management plans; providing off-stream watering sites by fencing streams and ponds; relocating pasture feeding sites and feeding pens away from streams; implementing rotational grazing; and placing vegetative filter strips along waterways.

Wastewater treatment facilities

KDHE permits and regulates wastewater treatment facilities. National Pollutant Discharge Elimination System (NPDES) permits specify the maximum amount of pollutants allowed to be discharged to surface waters. There are 25 NPDES facilities in the Delaware River Watershed at the time of this document's publication.

Population

Watershed population can affect nutrient runoff. There are an estimated 4,694 domestic onsite wastewater systems in the Delaware River Watershed, mainly located in rural areas. Although the functional condition of these systems is generally unknown, it is projected that nearly 20% may be failing; onsite wastewater could be an area of possible pollution contribution for evaluation.

Confined Animal Feeding Operations

In Kansas, animal feeding operations (AFOs) with more than 300 animal units (AUs) and fewer than 1,000 AUs must register with KDHE. An AU is an equal standard for all animals based on size and manure production. For example: one AU equals one animal weighing 1,000 pounds. Confined animal feeding operations (CAFOs) are those with more than 999 AUs, and they must be federally permitted. There are 65 certified or permitted AFOs and CAFOs spread throughout this watershed. There are also numerous small livestock farms (below 300 AUs) that contribute to nutrient loads. In addition to livestock-contributed waste, improperly disposed of pet waste also can be a contributor to the nutrient loads, although at a much smaller quantity.

Grazing density

Approximately 55% of the Delaware River Watershed is grassland and pasture/hayland. Grassland in this area of Kansas is a highly productive forage source for beef cattle. Grazing density affects grass cover and potential manure runoff: an overgrazed pasture will not have the needed forage biomass to trap and hold manure during a high rainfall event. Also, allowing cattle to drink and loaf in streams increases the occurrence of nutrients and *E. coli* bacteria in the waterways. Grazing density ranges from 16 to 29.6, with an average of 18.3 cattle per 100 acres across the watershed.[13] This is considered to be medium density when compared with statewide density numbers.

Rainfall and runoff

Rainfall amounts and subsequent runoff affect nutrient runoff from agricultural and urban areas into streams and Perry Lake. The amount and timing of rainfall events affects manure runoff from livestock allowed access to streams, or manure applied before a rainfall or on frozen ground. Therefore, it is important to maintain adequate grass density to slow the runoff of manure over pastures.

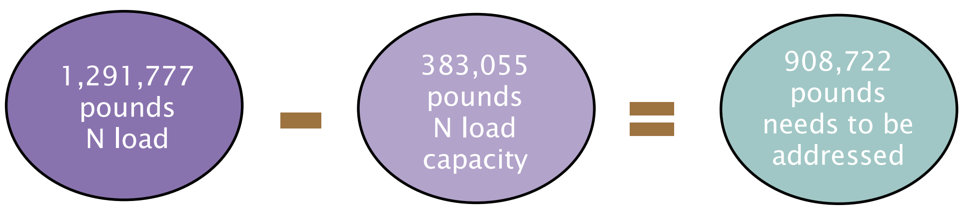
[13] https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Kansas/index.php

2. Pollutant loads

Nitrogen

The current estimated nitrogen (N) load in the Delaware River Watershed is 1,291,777 pounds per year, according to the TMDL section of KDHE.[14] The amount of N in the watershed contributes to the eutrophication TMDLs in Perry Lake, Little Lake, Mission Lake, Perry Wildlife Area Wetlands and Sabetha Watershed Lake, as well as the eutrophication 303d listings in Atchison County Park Lake, Banner Creek Lake, Elkhorn Lake, Lake Jayhawk, Nebo State Fishing Lake (SFL) and Prairie Lake. Increased N levels also are a contributing factor for the DO TMDL in the Perry Wildlife Area Wetlands and the Delaware River 303d listings for biology.

It has been determined that a 70% reduction in N is necessary to meet the Delaware River Watershed's eutrophication TMDL, which equates to a reduction of 908,722 pounds per year. **If all BMPs have been implemented, 1,638,174 pounds of N will have been reduced from the watershed at the end of this 30-year plan.** This exceeds the load reduction goal required to meet the TMDL by roughly 80%.



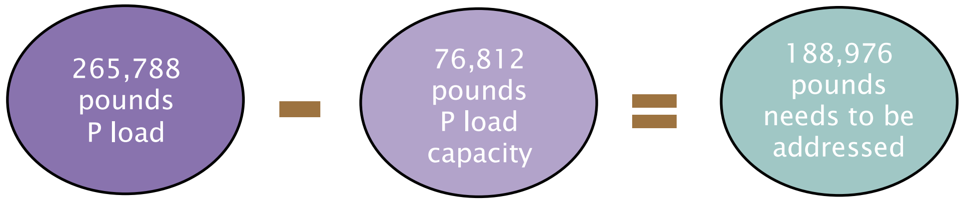
Phosphorus

The current estimated phosphorus (P) load in the Delaware River Watershed is 265,788 pounds per year, according to the TMDL section of KDHE.[15] The amount of P in the watershed contributes to the eutrophication TMDLs in Perry Lake, Little Lake, Mission Lake, Perry Wildlife Area Wetlands and Sabetha Watershed Lake, as well as the 303d listings in Atchison County Park Lake, Banner Creek Lake, Elkhorn Lake, Lake Jayhawk, Nebo State Fishing Lake (SFL) and Prairie Lake.

The high levels of P in the watershed also have resulted in a total phosphorus (TP) TMDL for the Delaware River near Half Mound, as well as two TP 303d-listed areas in Elk Creek near Larkinburg and Grasshopper Creek near Muscotah. Increased P levels also are a contributing factor for the DO TMDL in the Perry Wildlife Area Wetlands and the Delaware River 303d listings for biology.

It has been determined that a 71% reduction in P is necessary to meet the Delaware River Watershed's eutrophication and TP TMDLs, which equates to a reduction of 188,976 pounds per year. **If all BMPs have been implemented, 286,707 pounds of P will have been reduced from the watershed at the end of this 30-year plan.** This exceeds the load reduction required to meet the TMDL by roughly 51%.

[14] Kansas Department of Health and Environment. April 2021.
[15] Kansas Department of Health and Environment. October 2019.



3. What BMPs will be implemented to meet the TMDL?

The SLT identified specific cropland and livestock BMPs which will result in significant nutrient pollutant reductions and are acceptable to watershed residents. Each agricultural BMP such as buffers, cover crops, no-till, permanent vegetation, subsurface fertilizer, terraces and waterways will improve water quality by reducing nutrient runoff and leaching. Implementing off-stream watering systems, vegetative filter strips and rotational grazing, and relocating feeding pens and pasture feeding sites away from streams will all help to reduce nutrient loading from livestock areas. Because nutrients can leach to soil particles, streambank stabilization projects also will take place to aid in reducing sediment runoff and erosion potential, thereby reducing nutrient loading. Specific acreages or projects needing annual implementation have been determined through modeling and economic analysis and have been approved by the SLT (**Table 12**).

Table 12. BMPs to Prevent and/or Reduce Nutrient Runoff and Leaching

BMPs to Reduce Nutrient Loading		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of nutrient contribution from **cropland**	Buffers	1,466 acres
	Cover Crops	2,221 acres
	No-Till	2,221 acres
	Permanent Vegetation	222 acres
	Subsurface Fertilizer	222 acres
	Terraces	2,221 acres
	Waterways	1,333 acres
Prevention of nutrient contribution from **livestock**	Off-stream Watering System	1 project per year
	Relocating Feeding Pens	1 project per year
	Relocate Pasture Feeding Sites	1 project per year
	Rotational Grazing	1 project per year
	Vegetative Filter Strips	1 project per year
Prevention of sediment contribution from **streambanks**	Streambank Stabilization/Restoration Projects	2,393 feet/year

The implementation of cropland BMPs and streambank stabilization projects in support of the eutrophication and TP TMDLs also works to reduce sediment loading, thereby helping to address the watershed's sediment load reduction goal and atrazine TMDL in Mission Lake.

The implementation of livestock BMPs in the watershed and the movement of their feeding sites and alternate watering systems away from the stream will have a positive impact on the E. coli *TMDL.*

The implementation of cropland, livestock and streambank BMPs to address nutrient loading subsequently will improve all biology, DO, E. coli *and TP impairments in the watershed.*

B. Total Phosphorus

The Delaware River Watershed has a "high" priority TMDL for the impairment of **total phosphorus (TP)** in the Delaware River near Half Mound.[16] In addition to this TMDL, there are a few other water segments in the watershed that have been 303d listed for having TP impairments. Although these areas will not be targeted specifically with BMP implementation and load reduction expectations, they will be positively impacted by BMP implementation throughout the watershed. These areas include:

- Elk Creek near Larkinburg, and
- Grasshopper Creek near Muscotah.

The Delaware River's TP TMDL and Perry Lake's eutrophication TMDL will be addressed simultaneously and are combined as one phosphorus load reduction goal in this plan. The cropland, livestock and streambank stabilization BMPs implemented to reduce nutrient and sediment loading will have positive impacts on the TP TMDL in the Delaware River and, ultimately, Perry Lake and the watershed as a whole.

1. Sources of the impairment

Phosphorus loading can originate in both rural and urban areas and can be caused by both point and nonpoint sources. This plan focuses primarily on agricultural nonpoint source contributions, even though other possible sources will be included as part of the discussion.

Land Use

Land use activities can affect phosphorus runoff into streams. For example, fertilizer or manure applied to frozen ground or cropland prior to a rainfall event can be transported easily downstream. Livestock allowed access to streams to drink or loaf will contribute manure directly into the stream. Overgrazed pastures do not provide adequate biomass to trap manure runoff.

Agricultural BMPs designed to help reduce phosphorus runoff include: implementing cover crops, no-till, minimum tillage, vegetative buffers and riparian areas; creating grassed waterways and grassed terraces; establishing permanent vegetative cover and grazing management plans; providing off-stream watering sites by fencing streams and ponds; relocating pasture feeding sites and feeding pens away from streams; implementing rotational grazing; and placing vegetative filter strips along waterways.

[16] KDHE, TP TMDL for the Delaware River, https://www.kdheks.gov/tmdl/2019/Delaware_TP.pdf

Wastewater treatment facilities

KDHE permits and regulates wastewater treatment facilities. National Pollutant Discharge Elimination System (NPDES) permits specify the maximum amount of pollutants allowed to be discharged to surface waters. There are 25 NPDES facilities in the Delaware River Watershed at the time of this document's publication.

Population

Watershed population can affect nutrient (phosphorus) runoff. There are an estimated 4,694 domestic onsite wastewater systems in the Delaware River Watershed, located mainly in rural areas. Although the functional condition of these systems is generally unknown, it is projected that nearly 20% may be failing; onsite wastewater could be an area of possible pollution contribution for evaluation.

Confined Animal Feeding Operations

In Kansas, animal feeding operations (AFOs) with more than 300 animal units (AUs) and fewer than 1,000 AUs must register with KDHE. An AU is an equal standard for all animals based on size and manure production. For example: one AU equals one animal weighing 1,000 pounds. Confined animal feeding operations (CAFOs) are those with more than 999 AUs, and they must be federally permitted. There are 65 certified or permitted AFOs and CAFOs spread throughout this watershed. There are also numerous small livestock farms (below 300 AUs) that contribute to the nutrient loads. In addition to livestock-contributed waste, improperly disposed of pet waste can also be a contributor to the phosphorus loads, although at a much smaller quantity.

Grazing density

Approximately 55% of the Delaware River Watershed is grassland and pasture/hayland. Grassland in this area of Kansas is a highly productive forage source for beef cattle. Grazing density affects grass cover and potential manure runoff: an overgrazed pasture will not have the needed forage biomass to trap and hold manure in a high rainfall event. Also, allowing cattle to drink or loaf in streams increases the occurrence of nutrients, namely phosphorus, and *E. coli* bacteria in the waterway. Grazing density ranges from 16 to 29.6, with an average of 18.3 cattle per 100 acres across the watershed.[17] This is considered to be medium density when compared with statewide density numbers.

Rainfall and runoff

Rainfall amounts and subsequent runoff affect nutrient runoff from agricultural and urban areas into streams and Perry Lake. The amount and timing of rainfall events affects manure runoff from livestock allowed access to streams, or manure applied before a rainfall or on frozen ground. Therefore, it is important to maintain adequate grass density to slow the runoff of manure over pastures.

[17] https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Kansas/index.php

2. Pollutant loads

Delaware River's TP TMDL does not have a specific "pounds per year" quantitative figure as a reference for current load or load reductions. However, the TMDL does include information that indicates the desired endpoints for concentration (**Table 13**).

Table 13. Reductions to Meet TP TMDL

TP Concentration Reductions Necessary to Meet TMDL Endpoints						
	Current Condition TP (mg/L)	Phase I TP Milestone (mg/L)	Phase I Reduction in TP from Current Concentration	Phase II TP Milestone (mg/L)	Phase II Reduction in TP from Current Concentration
Delaware River, near Half Mound	0.215	0.209	3%	0	19%

The endpoints will be evaluated periodically as phosphorus levels decline over time. This TMDL establishes management milestones for phosphorus concentrations that would signal a need to examine the biological conditions of the streams. This TMDL established numeric milestones to achieve the ultimate endpoint to include:

- ALUS Index score > 13,
- Sestonic chlorophyll *a* < 10 μg/L,
- DO > 5 mg/L with saturation < 110%, and
- pH range 6.5 - 8.5.

If the first phase of phosphorus level reduction in the watershed improves water quality but does not attain the biological indicators, a second phase of implementation will commence. Simultaneous achievement of the chlorophyll *a*, DO, oxygen saturation, and pH endpoints will signal phosphorus reductions are addressing the accelerated succession of aquatic biota and the development of objectionable concentrations of algae and algae byproducts, thereby restoring the domestic water supply, aquatic life and contact recreation uses in the river.

Achievement of the biological endpoints indicates that phosphorus loads are within the loading capacity of the stream, that water quality standards are attained, and that full support of the designated uses of the stream have been restored.

Quantitative load reductions in *pounds per year* is not associated with the TP TMDL in the Delaware River near Half Mound. However, this plan will use the same phosphorus load reduction goal of 188,976 pounds per year for both the eutrophication and TP TMDLs. Implementing the necessary BMPs to address the eutrophication TMDL and meeting the desired load reduction goal will result in improved water quality and positively impact the TP TMDL. As indicated for the eutrophication goal, the phosphorus goal will be met and exceeded by 80% by the end of this 30-year plan.

3. What BMPs will be implemented to meet the TMDL?

The Delaware River WRAPS plan will focus simultaneously on both the TP TMDL in the Delaware River near Half Mound, and the eutrophication TMDL in Perry Lake. BMP implementation taking place throughout the Delaware River Watershed will improve water quality regarding both TMDL impairments.

The SLT identified specific cropland and livestock BMPs which will result in significant nutrient pollutant reductions and are acceptable to watershed residents. Each agricultural BMP such as buffers, cover crops, no-till, permanent vegetation, subsurface fertilizer, terraces and waterways will improve water quality by reducing nutrient runoff and leaching. Implementing off-stream watering systems, rotational grazing and vegetative filter strips, and relocating feeding pens and sites away from streams all will help to reduce nutrient loading from livestock areas. Because nutrients can leach to soil particles, streambank stabilization projects also will reduce sediment runoff and erosion potential, thereby reducing nutrient loading. Specific acreages or projects that need annual implementation have been determined through modeling and economic analysis and have been approved by the SLT (**Table 14**).

Table 14. BMPs to Prevent and/or Reduce Phosphorus Loading

BMPs to Reduce Phosphorus Loading		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of nutrient contribution from **cropland**	Buffers	1,466 acres
	Cover Crops	2,221 acres
	No-Till	2,221 acres
	Permanent Vegetation	222 acres
	Subsurface Fertilizer	222 acres
	Terraces	2,221 acres
	Waterways	1,333 acres
Prevention of nutrient contribution from **livestock**	Off-stream Watering System	1 project per year
	Relocating Feeding Pens	1 project per year
	Relocate Pasture Feeding Sites	1 project per year
	Rotational Grazing	1 project per year
	Vegetative Filter Strips	1 project per year
Prevention of sediment contribution from **streambanks**	Streambank Stabilization/Restoration Projects	2,393 feet/year

Again, the implementation of cropland and streambank stabilization BMPs in support of the eutrophication and TP TMDLs also works to reduce sediment loading, thereby positively addressing the watershed's sediment load reduction goal and atrazine TMDL in Mission Lake.

The implementation of livestock BMPs in the watershed and the movement of feeding sites and alternate watering systems away from the stream will have a positive impact on the E. coli *TMDL.*

The implementation of cropland, livestock and streambank BMPs to address nutrient loading subsequently will improve all biology, DO, E. coli *and TP impairments in the watershed.*

C. Sediment

The Delaware River Watershed has a "high" priority TMDL for the impairment of **siltation (sedimentation)** in Mission Lake[18] and a 303d listing in Atchison County Park Lake. Despite these impaired listings, sediment is a personal goal of the Delaware River Watershed's SLT; they wish to target the entire watershed to achieve sediment loss reductions. *BMP implementation and load reductions in this report will refer to sediment and sedimentation, the TMDL will refer to siltation.*

The siltation TMDL can be related to the eutrophication TMDL in the lake due to pollutants, particularly nitrogen and phosphorus, which can be attached to suspended soil particles in the water column. Cropland BMPs implemented to reduce nutrient loading will have positive impacts on the siltation TMDL and 303d listings in both sediment impaired lakes and the watershed as a whole.

Sediment can originate from streambank erosion and streambank sloughing caused by a lack of riparian cover. Sheet and rill erosion from cropping and pasture systems contribute sediment into the ecosystem as well. Once the sediment reaches the lake, it decreases water clarity and can reduce lake volume and storage capacity. This limits public access to the lake's boat ramps and beaches. Also, a decrease in lake storage affects domestic and industrial uses of the lake water. Therefore, reducing erosion is necessary to reduce sediment in Mission Lake and Atchison County Park Lakes as well as all Delaware River Watershed stream segments, including Perry Lake. In addition, nutrient pollutants such as nitrogen and phosphorus can leach to the sediment particles and cause higher than normal concentrations, thus accelerating the eutrophication problem in Perry Lake.

1. Sources of the impairment

Land-based activities affect sediment transported downstream to lakes. Physical components of the terrain, such as slope, propensity to generate runoff and soil type are important in sediment movement. Sediment can originate from a number of sources. One such source is streambank erosion and sloughing of the sides of rivers and streambanks. Others are a lack of riparian cover that causes washing on the banks of streams or rivers, or animal movement, such as livestock regularly crossing streams causing pathways that can erode. Another source of sediment present in the stream is silt. This moves gradually downstream with each high-intensity rainfall event.

[18] KDHE, Siltation TMDL for Mission Lake, https://www.kdheks.gov/tmdl/2011/Mission_Lake_TMDL.pdf

Land use

Land use activities have a significant impact on the types and quantity of sediment transfer in the watershed. Construction projects can leave both disturbed areas of soil and unvegetated roadside ditches that can erode during a rainfall event. In addition, agricultural cropland lacking maintenance from agricultural BMP structures and under conventional tillage practices can have cumulative effects on land transformation through sheet and rill erosion. Sediment transfer also can be caused by degraded pastureland or streambank sloughing. Primary land uses in the areas this WRAPS plan will target for BMP implementation (**Section 6**) are pasture/hay land (46%), cropland (24%), and grassland. Reducing erosion in these areas is necessary for a reduction in sediment.

Agricultural BMPs such as buffers, cover crops, no-till, permanent vegetation, subsurface fertilizer, terraces and waterways, as well as reducing activities within the riparian areas, will reduce erosion and improve water quality.

Soil erosion by wind and/or water

NRCS has established a "T-factor" in evaluating soil erosion. T represents the soil loss tolerance factor. It is defined as the maximum amount of erosion at which soil quality as a medium for plant growth can be maintained. It is assigned to soils without respect to land use or cover and ranges from one ton/acre for shallow soils to five tons/acre for deep soils not as affected by loss of productivity by erosion. T-factors represent the goal for maximum annual soil loss in sustaining the productivity of land use.[19]

Riparian quality

In the targeted areas, the predominant land use in riparian areas is cropland. This is the land that can be most vulnerable to runoff and erosion. An adequately functioning and healthy riparian area will reduce sediment flow from cropland and rangeland. Cropland needs buffer and filter strips adjacent to streams in order to impede sediment flow from fields. Conservation tillage practices, such as no-till, also are effective for slowing the flow of rainwater off of crop fields. The use of permanent grass and vegetative buffers along riparian areas can impede erosion and streambank sloughing. Riparian areas also 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. Restricting livestock movement along streams will prevent livestock from entering streams and degrading the banks.

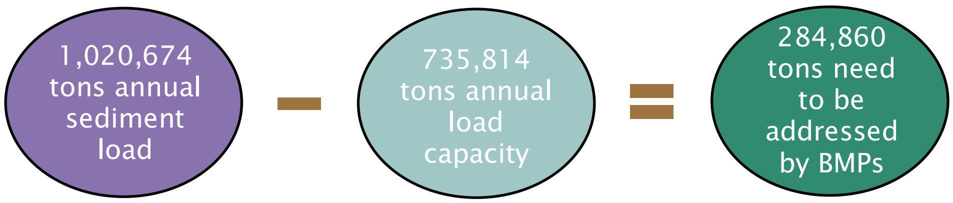
Rainfall and runoff

Rainfall amounts and the subsequent runoff can affect the sediment eroding from both agricultural and urban areas into streams and lakes. In addition, high rainfall events can cause cropland erosion and sloughing of streambanks, adding sediment to streams and rivers that will ultimately flow into the lake.

[19] NRCS T factor. http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/glossary.html

2. Pollutant loads

The current estimated sediment load in the Delaware River Watershed is 1,020,674 tons per year, according to the TMDL section of KDHE. The total load reduction needed to meet the sediment TMDL is 284,860 tons of sediment, a reduction of 28%. **If all BMPs have been implemented by the end of this 30-year WRAPS plan, a reduction of 285,946 tons of sediment will have been achieved.** This meets the sediment load reduction goal.



3. What BMPs will be implemented to meet the TMDL?

The SLT identified specific cropland BMPs which will result in significant sediment (and subsequently nutrient) pollutant reductions and are acceptable to watershed residents. Each agricultural BMP such as buffers, cover crops, no-till, permanent vegetation, subsurface fertilizer, terraces and waterways will improve water quality by reducing nutrient runoff and leaching. Streambank stabilization projects also will take place to reduce sediment runoff and erosion potential. Specific acreages or projects needing annual implementation have been determined through modeling and economic analysis and approved by the SLT, as shown in **Table 15**.

Table 15. BMPs to Prevent or Reduce Sediment Runoff and Erosion

BMPs to Reduce Sediment Runoff		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of sediment contribution from **cropland**	Buffers	1,466 acres
	Cover Crops	2,221 acres
	No-Till	2,221 acres
	Permanent Vegetation	222 acres
	Subsurface Fertilizer	222 acres
	Terraces	2,221 acres
	Waterways	1,333 acres
Prevention of sediment contribution from **streambanks**	Streambank Stabilization/Restoration Projects	2,393 feet/year

The implementation of cropland and streambank stabilization BMPs in support of the sediment load reduction goal also work to reduce nutrients and herbicides from a reduction in nutrient leaching from runoff. This positively affects the watershed's atrazine, biology, DO, eutrophication, and TP impairments.

D. *E. coli*

The Delaware River Watershed has several TMDL and 303d listings for *E. coli* in the Watershed to include:

- Delaware River near Half Mound (high-priority TMDL),
- Elk Creek near Larkinburg (high-priority TMDL),
- Grasshopper Creek near Muscotah (high-priority TMDL),
- Straight Creek near Larkinburg (high-priority TMDL), and
- Rock Creek near Rock Creek (303d listing).

Despite the multiple impaired listings, the high-priority *E. coli* TMDL in the Delaware River near Half Mound[20] is the only one that this WRAPS plan will target for loading reductions. Livestock BMPs implemented in all riparian areas of the watershed should result in reductions of *E. coli* contamination throughout the watershed, thereby improving all impaired water segments listed above.

1. Sources of the impairment

Presence of bacteria in waterways can originate from livestock production area runoff, close proximity of any mammals to water sources, and manure application to agricultural fields. Bacteria are present in livestock manure and can be transported into waterways if livestock have access to streams. Bacteria can originate in both rural and urban areas and can be caused by both point and nonpoint sources. It must be noted that not all bacteria can be attributed to livestock. Wildlife has a contribution to bacteria loads as well. In addition, failing septic systems can be a source of bacteria from humans.

Land Use

Land use activities can affect *E. coli* contributions in streams. For example, manure applied to frozen ground or cropland prior to a rainfall event can be transported easily downstream. Livestock allowed access to streams to drink or to loaf will contribute manure directly into the stream. Overgrazed pastures do not provide adequate biomass to trap manure runoff.

Wastewater treatment facilities

KDHE permits and regulates wastewater treatment facilities. National Pollutant Discharge Elimination System (NPDES) permits specify the maximum amount of pollutants allowed to be discharged to surface waters. There are 25 NPDES facilities in the Delaware River Watershed at the time of this document's publication.

Population

Watershed population can affect *E. coli* bacteria contributions. There are an estimated 4,694 domestic onsite wastewater systems in the Delaware River Watershed, mainly in rural areas. Although the functional condition of these systems is generally unknown, it is projected that nearly 20% may be failing; onsite wastewater could be an area of possible pollution contribution for evaluation.

[20] KDHE, *E. coli* TMDL for the Delaware River, https://www.kdheks.gov/tmdl/klr/DelawareAbvPerry.pdf

Confined Animal Feeding Operations

In Kansas, animal feeding operations (AFOs) with more than 300 animal units (AUs) and fewer than 1,000 AUs must register with KDHE. An AU is an equal standard for all animals based on size and manure production. For example: one AU equals one animal weighing 1,000 pounds. Confined animal feeding operations (CAFOs) are those with more than 999 AUs, and they must be federally permitted. There are 65 certified or permitted AFOs and CAFOs spread throughout this watershed. There are also numerous small livestock farms (below 300 AUs) that contribute to the nutrient loads. In addition to livestock-contributed waste, improperly disposed of pet waste can also be a contributor to the *E. coli* loads, although at a much smaller quantity.

Grazing density

Approximately 55% of the Delaware River Watershed is grassland and pasture/hay land. Grassland in this area of Kansas is a highly productive forage source for beef cattle. Grazing density affects grass cover and potential manure runoff: an overgrazed pasture will not have the needed forage biomass to trap and hold manure in a high rainfall event. Also, allowing cattle to drink and to loaf in streams increases the occurrence of nutrients, specifically phosphorus and *E. coli* bacteria in the waterway. Grazing density ranges from 16 to 29.6, with an average of 18.3 cattle per 100 acres across the watershed.[21] This is considered to be medium density when compared with statewide density numbers.

2. Addressing *E. coli* in the Delaware River Watershed WRAPS plan

There are no quantitative numbers for current load, load allocation and required load reductions for *E. coli*. Since there is not a traditional load allocation made for *E. coli* bacteria, the margin of safety will be framed around the desired endpoints of applicable water quality standards. Therefore, evaluation of achieving the endpoints should use values set 100 counts fewer than the applicable criteria (800 colonies for primary contact recreation; 1,900 colonies for secondary contact recreation) to mark full support of the recreation designated use of the streams in this watershed. By this definition, the margin of safety is 262 colonies per 100 ml and would be represented by a parallel line lying below each seasonal TMDL curve by a distance corresponding to loads associated with 262 colonies per 100 ml. In addition, monitoring data should indicate attainment of the following water quality standards:

- Fewer than 10% of samples taken in spring exceed primary criterion at flows under 300 cubic foot per second (cfs) with no samples exceeding the criterion at flows under 75 cfs.
- Fewer than 10% of samples taken in summer or fall exceed the primary criterion at flows under 300 cfs with no samples exceeding the criterion at flows under 40 cfs.
- Fewer than 10% of samples taken in winter exceed secondary criterion at flows under 300 cfs.

[21] https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Kansas/index.php

3. What BMPs will be implemented to meet the TMDL?

The Delaware River WRAPS plan will focus on the *E. coli* bacteria TMDL in the Delaware River near Half Mound, but only in the sense that it will be impacted positively by all livestock BMP implementation. The SLT identified specific livestock BMPs which will result in significant *E. coli* load reductions and are acceptable to watershed residents. Implementing off-stream watering systems, relocating feeding pens and sites away from streams, rotational grazing, and vegetative filter strips all will help to reduce nutrient loading from livestock areas. Specific projects that need annual implementation have been determined through modeling and economic analysis and have been approved by the SLT (**Table 16**).

Table 16. BMPs to Prevent or Reduce* E. coli *Contributions

BMPs to Reduce *E. coli*		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of *E. coli* contribution from **livestock**	Off-Stream Watering System	1 project per year
	Relocating Feeding Pens	1 project per year
	Relocate Pasture Feeding Sites	1 project per year
	Rotational Grazing	1 project per year
	Vegetative Filter Strips	1 project per year

E. Other Impairment Concerns in the Delaware River Watershed

1. Atrazine

Atrazine is a relatively inexpensive herbicide widely used in corn, sorghum and soybean production. Atrazine enters streams and lakes by way of sediment runoff. It has a slow chemical breakdown, so once atrazine enters the water, it can linger for a long time. Atrazine is one of the most commonly detected herbicides in groundwater and has been connected to health issues in animals and humans, including reproductive system problems in humans. This chemical is lab-created, requires a license for usage and is considered a health threat in contaminated waters.

The Delaware River Watershed has one creek and one lake with **atrazine** TMDLs in place:

- Grasshopper Creek near Muscotah (low priority), and
- Mission Lake (high priority).

Atrazine is not a targeted impairment to be addressed directly by this WRAPS plan, as the plan focuses on high-priority TMDLs in the Delaware River and Perry Lake. However, protection of the watershed and future water quality is of utmost importance. Several of the cropland BMPs that will be implemented in efforts to address nutrient and sediment loading also will serve to reduce atrazine runoff. For example: cover crops, no-till, and the establishment of permanent vegetation certainly will reduce erosion and runoff, which will keep atrazine on the crop field and out of nearby water segments.

2. Biology

There is a direct relation between levels of nutrient loading and biological integrity. Decreased nutrient loads should result in improved aquatic communities and biological metrics indicative of improved water quality. Waters with adequate biology levels tend to sustain a Macroinvertebrate Biotic Index score below 4.5 while maintaining healthy total phosphorus and total nitrogen levels.

Two water segments in the Delaware River Watershed are 303d-listed for having **biology** impairments:

- Delaware River at Highway 36, and
- Delaware River near Half Mound.

Biology TMDLs are not a priority focus in this plan; however, implementing BMPs to address eutrophication and sediment throughout the watershed means that biology in these water segments should be impacted positively. The biology reading of the Delaware River near Half Mound should improve simultaneously with the targeted BMP implementation addressing the TP TMDL in that area.

3. Dissolved oxygen

Excess nutrients often come off crop fields due to sediment leaching during runoff events. Excess nutrients also can originate from failing septic systems, livestock manure, and fertilizer runoff in rural and urban areas. Excess nutrient loading from the watershed creates accelerated rates of eutrophication, followed by decreasing amounts of dissolved oxygen (DO) in the water. This results in an unfavorable habitat for aquatic life. Desirable criteria for healthy water dictate DO rates more than 5 mg/L in 80% of the water column and biological oxygen demand (BOD) fewer than 3 mg/L.

There is one **DO** TMDL in the Delaware River Watershed:

- Perry Wildlife Area Wetlands.

While this plan does not target the DO TMDL impairment specifically, the implementation of nutrient and sediment BMPs will reduce the amount of nutrient loading found in runoff. This will have positive effects on DO rates in the Perry Wildlife Area Wetlands and all other water bodies.

6. Targeted Areas

Implementing BMPs is necessary to improve a watershed's water quality. All crop fields, pastures and feed lots are susceptible to runoff waters to some degree; these can contribute sediment and nutrients to nearby water segments. However, some crop fields, pastures, and feed lots are more susceptible than others, including areas with close proximity to streams, soils more prone to erosion and nutrient leaching, high water flow areas along streams, etc. Areas such as these are considered "high priority" and are targeted for BMP implementation. It has been determined that focusing BMP implementation in high-priority areas offers a greater improvement in water quality since these areas are generally major contributors to non-point source pollution and, ultimately, 303d and TMDL listings.

A. Studies Conducted to Determine Targeted Areas

1. Soil and Water Assessment Tool (SWAT)

The SWAT model is a physically based, deterministic, continuous, watershed-scale simulation model created by the USDA Agricultural Research Service (ARS). It was developed from numerous equations and relationships that 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 functions 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 the amount of manure applied to the pasture or grassland, grazing periods, and amount of biomass consumed or trampled daily by livestock. Septic systems, NPDES discharges, and other point sources are considered combined point sources and applied to inlets of sub-watersheds. These features make SWAT a good tool for assessing rural watersheds in Kansas.

In 2010, the Department of Biological and Agricultural Engineering (BAE) at Kansas State University used SWAT to estimate annual average pollutant loadings for the Delaware River Watershed. Specifically, Kansas State University BAE used the ArcGIS interface of ArcSWAT version 9.2. This version used 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 are determined from the nearest weather station. 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 sub-basin, reservoir, and channel-routing components.

- The sub-basin 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 sub-basin with the Modified Universal Soil Loss Equation (MUSLE). The hydrology model supplies estimates for runoff volume and peak runoff rates. The crop management factor is evaluated as a function of above-ground biomass, surface residue, and the minimum C factor for the crop.
- The reservoir component detains water, sediments and pollutants, and degrades nutrients, pesticides and bacteria during detention. This component was not used during the simulations.
- 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 summarized 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.

The average annual nutrient and sediment loads were calculated for each sub-watershed at the end of the simulation. Based on experience and technical knowledge, the areas or sub-watersheds with the top 20-30% of the highest loads among all areas within the watershed were selected as critical (targeted) areas for cropland and livestock BMP implementation. The SWAT model identified 11 Delaware River HUC 12 sub-watersheds where cropland contributions to nutrient and sediment pollutant loads were the greatest. Most of these sub-watersheds are located in northwestern Atchison, Brown, and Nemaha counties.

The map produced by SWAT is displayed below (**Figure 19**). The darker the color on the map, the greater potential for nutrient and sediment loading. *The map below was sourced from the original 2011 Delaware River Watershed WRAPS Plan; therefore, the map does not align completely with this plan's targeted areas.*

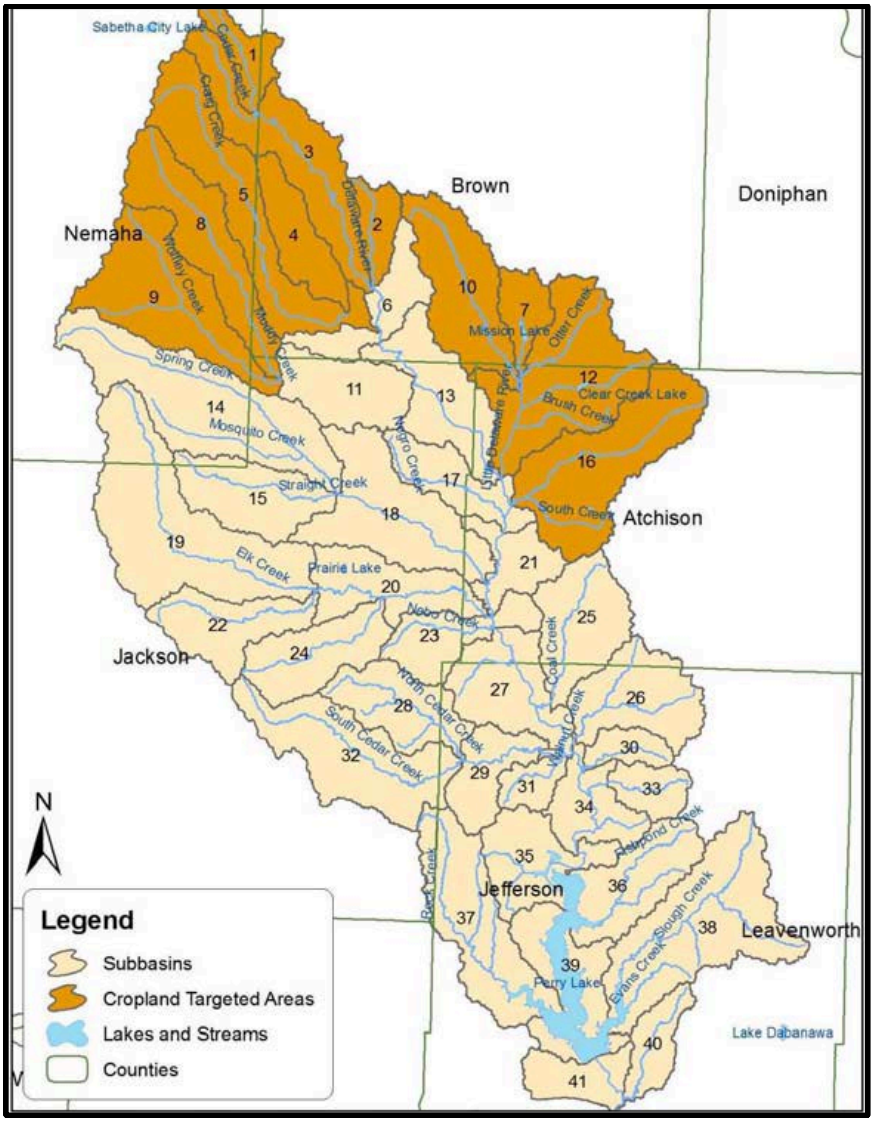


Figure 19. 2010 SWAT Results: High Nutrient and Sediment Loading Potential

2. Cropland/Slope Analysis

Since the SWAT model generated extremely low soil erosion rate estimates, stakeholders involved in targeting decisions requested KDHE to create a cross-referencing tool using observable data to check results of the SWAT model. This method (Cropland/Slope Analysis) factored the percentage of cropland in all HUC 12 sub-watersheds with land slope to estimate soil erosion potential from cropland on a HUC 12 sub-watershed basis. Land slope was used along with total cropland acres because soils' degree of incline (slope) is a significant factor in soil erosion. Generally speaking, the risk of erosion and generation of pollutant-carrying runoff increases as the slope of the land increases. A land slope of 4% or more was used as the slope factor since most fields defined as highly erodible land by USDA in northeast Kansas have a slope of 4% or more.

This Cropland/Slope Analysis identified 14 HUC-12 sub-watersheds having a high percentage of cropland with a land slope of 4% or more. Interestingly, the 11 HUC 12 sub-watersheds identified by Kansas State University SWAT model also were identified by the Cropland/Slope Analysis, lending confidence to the results of the SWAT model. However, three additional HUC 12 sub-watersheds in Atchison and northern Jefferson counties that were not identified by the SWAT model were identified as being significant potential sediment (and subsequently nutrient) contributors by the Cropland/Slope Analysis.

The map produced by Cropland/Slope Analysis is below (**Figure 20**). The darker the color on the map, the greater potential for nutrient and sediment loading. *The map below was sourced from the original 2011 Delaware River Watershed WRAPS Plan; therefore, the map does not completely align with this plan's targeted areas.*

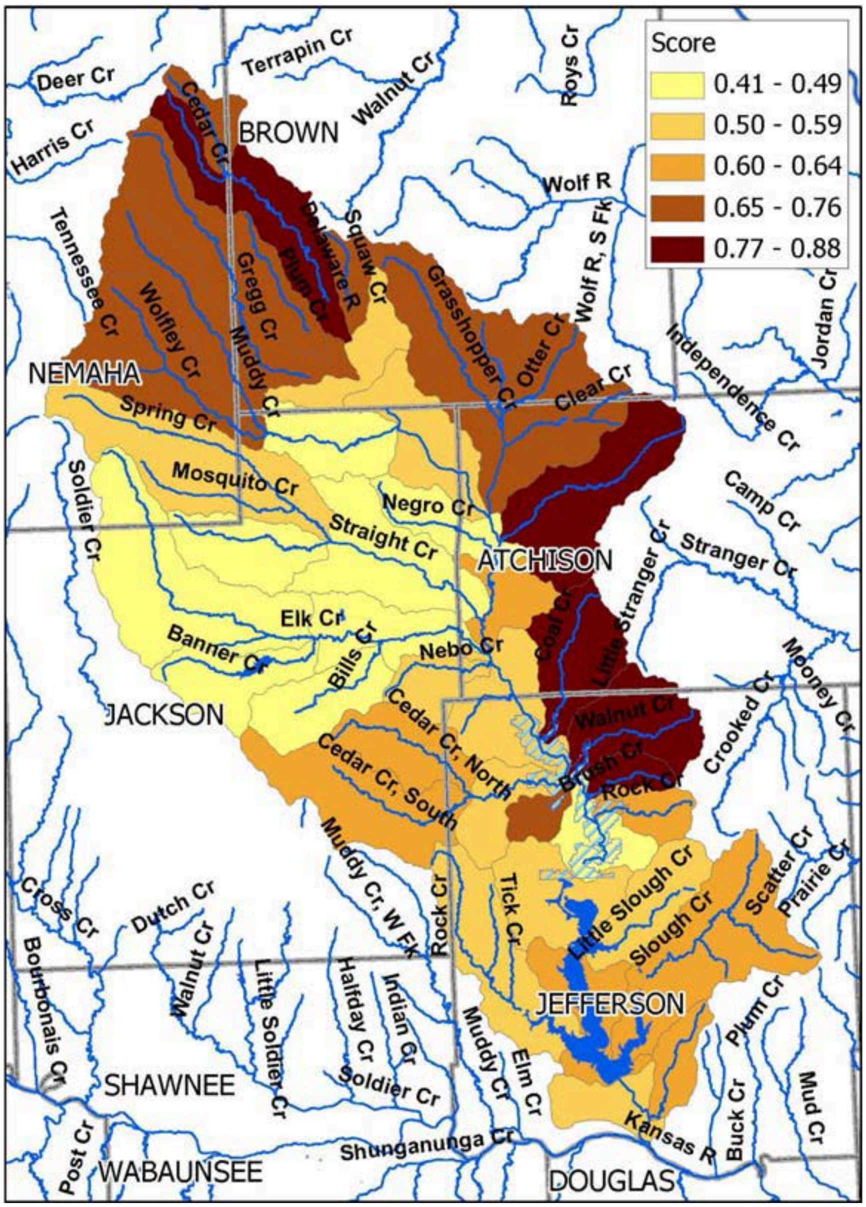


Figure 20. KDHE Cropland/Slope Analysis: High Pollution Potential Areas

3. Aerial assessment

KDHE has analyzed aerial images and determined areas of interest for BMP targeting to include livestock areas near stream segments as well as cropland (**Figure 21**). Specific targeted areas are discussed later in this section of the WRAPS plan.

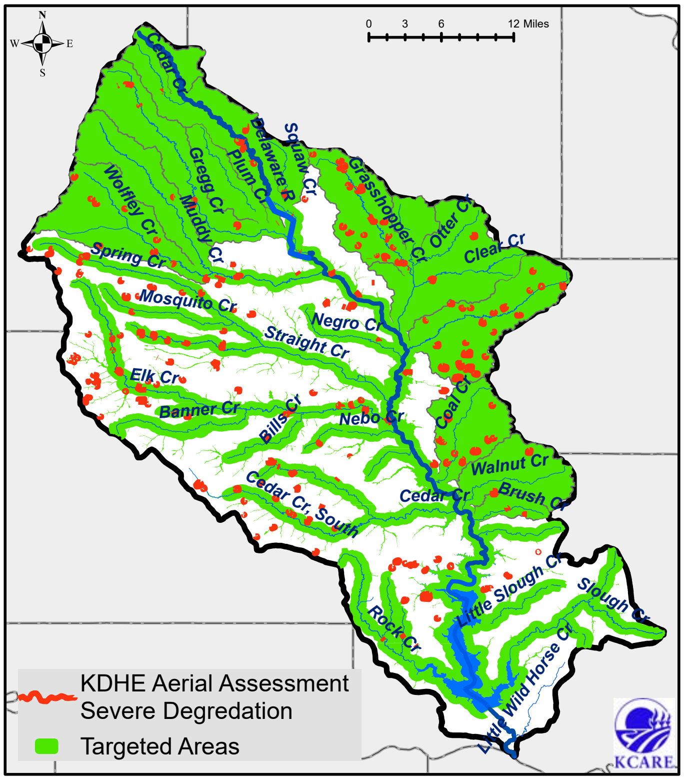


Figure 21. Delaware River Watershed Aerial Assessment[22]

4. Streambank assessment

A variety of information and assessment data were used to target sediment reduction. According to a study conducted in 2007 by USGS, channel-bank (i.e. streambank) sources are the most significant contributors of sediment to Perry Lake. Furthermore, the significance of channel-bank sources increases in importance with distance downstream in the watershed (that is, closer to Perry Lake). Because Perry Lake is one of the highest-priority federal reservoirs in Kansas, reducing the rate of sedimentation is essential to prolonging the longevity and usefulness of this important lake. Stabilizing eroding streambanks on the river closest to the lake will address this need.

In 2008, USACE contracted with Gulf South Research Corporation and The Watershed Institute, Inc. (TWI) to conduct a stream channel morphology and erosion study in the Kansas River Basin. This study focused on streambank erosion sites in selected areas above Perry Lake and on the Delaware River. Data from the study and field observations were

[22] Aerial Assessment figure provided by the Kansas Department of Health and Environment on March 2021.

used to help identify streambank erosion processes and the effects of past channelization on streambank erosion. Significant bank instability was noted in the lower sections of the Delaware River where channelization was practiced most commonly.

Figure 22, produced by TWI, illustrates the impact of *channelization* on the Delaware River near Muscotah. Channelization involves the removing of a stream's natural meanders. Channelization steepens the stream channel grade, removes native riparian vegetation, and shortens the distance water must travel; this causes significant streambank instability, degrades the channel, and increases erosion potential. The yellow line indicates the natural stream channel, and the red line shows the current alignment of the Delaware River. Nearly the entire length of the Delaware River south of Highway K-20 in southern Brown County has been channelized over the years. *The map below was sourced from the original 2011 Delaware River Watershed WRAPS Plan.*

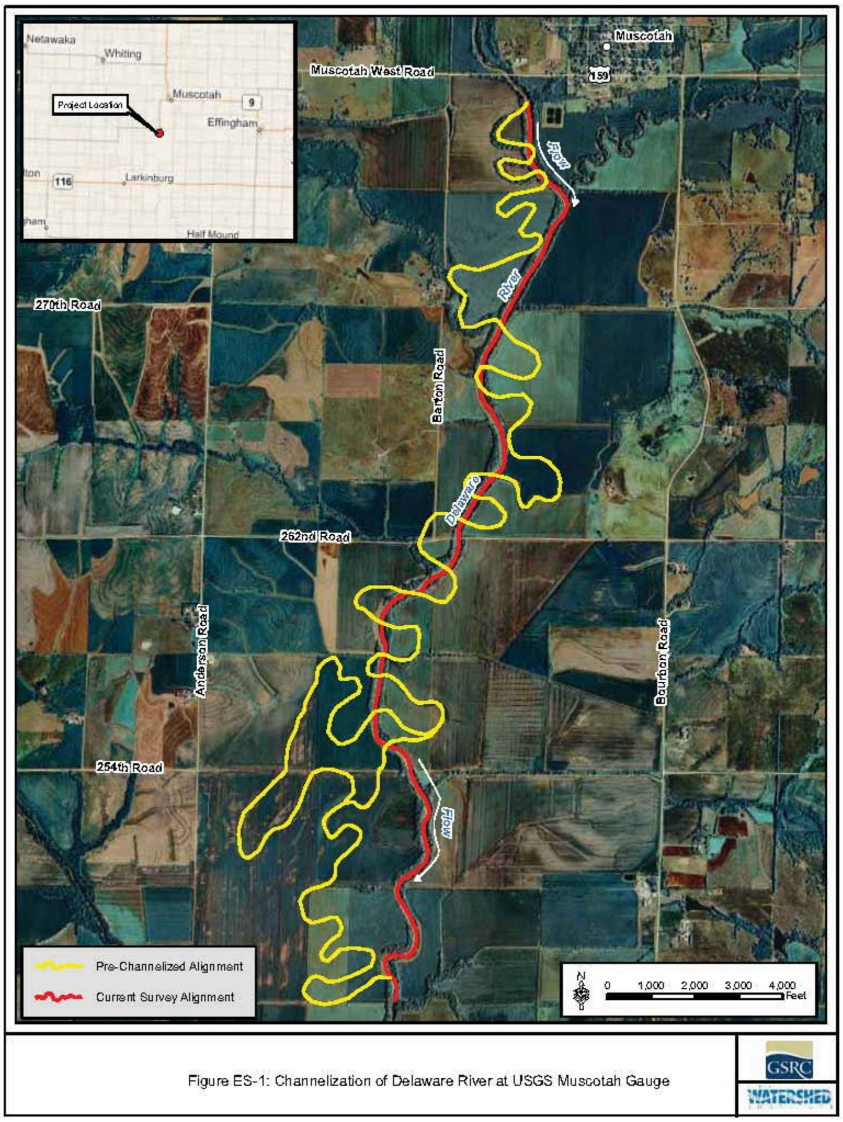


Figure 22. TWI Streambank Assessment Map: Delaware River Near Muscotah

5. Priority revisions in 2021

SWAT and the Cropland/Slope Analysis both illustrate that sediment BMPs primarily are needed in the eastern portions of Nemaha County, throughout the southern portions of Brown County, the western portions of Atchison County, and on into the north-central portion of Jefferson County. Addressing sediment loss also will reduce nutrient pollutant loading.

In 2021, KDHE determined that BMP efforts should be focused on stream proximity, considering that stream segments are the route by which pollutants travel into larger water systems and, ultimately, lakes. By narrowing the focus to riparian corridors, defined as areas one-half mile on either side of the stream or river segment, the Delaware River Watershed SLT can focus on the entire watershed. KDHE believes that focusing cropland and livestock BMP practices in **riparian corridors, which is one-half mile on both sides of water segments**, significantly reduces nutrient and sediment loading.

B. Targeted Areas

It is more economical for watersheds to use specific BMP placement, rather than randomly applying BMPs throughout the watershed. Every watershed has specific locations that contribute a greater pollutant load due to soil type, proximity to streams and land-use practices. By utilizing BMPs in these specific areas, pollutants can be reduced at a more efficient rate.

As previously mentioned, the SWAT model, Cropland/Slope Analysis, KDHE aerial assessment, and the TWI assessment provided data used to determine the targeted areas for this Delaware River Watershed WRAPS plan. Targeting assessment data was presented to, considered, and approved by the SLT and KDHE.

The SLT decided to target the following areas in the Delaware River Watershed for BMP implementation:

1. Cropland areas will be targeted for **nutrients** (nitrogen and phosphorus) and **sediment**. BMP implementation will take place in the following 14 HUC 12s, as well as 39 HUC 12 riparian corridors (**Figure 23** and **Table 17**):
    - 102701030101
    - 102701030102
    - 102701030103
    - 102701030104
    - 102701030105
    - 102701030107
    - 102701030108
    - 102701030201
    - 102701030202
    - 102701030203
    - 102701030204
    - 102701030402
    - 102701030407
    - 102701030501

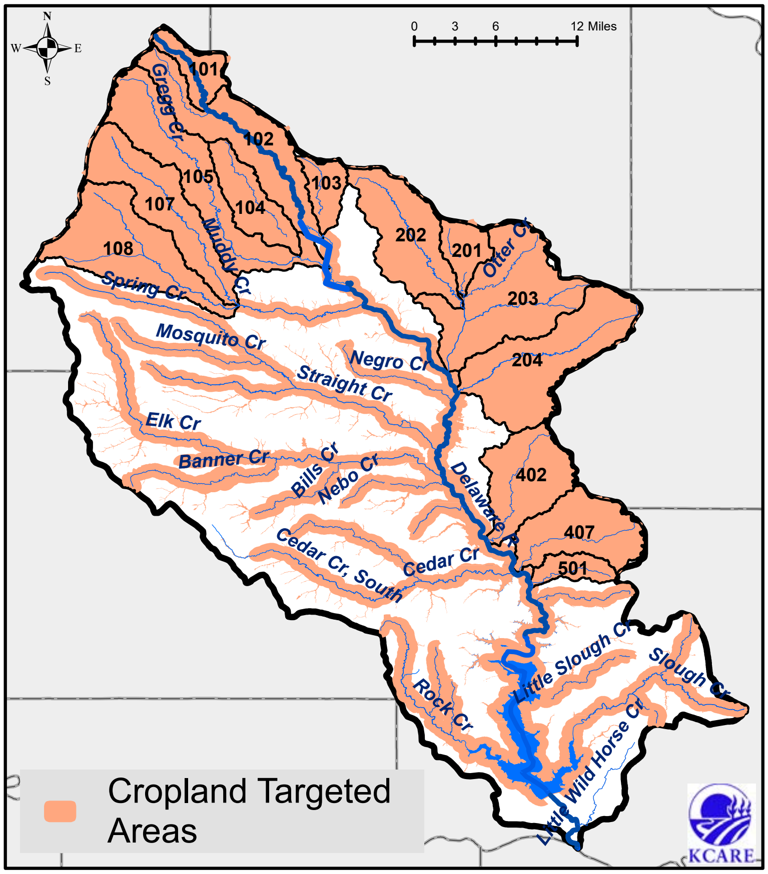


Figure 23. Cropland Targeted Areas in the Delaware River Watershed

2. <u>Livestock areas</u> will be targeted for **nutrients** (with positive effects on *E coli* bacteria). BMP implementation will take place in the riparian corridors of 39 HUC 12s (**Figure 24** and **Table 17**).

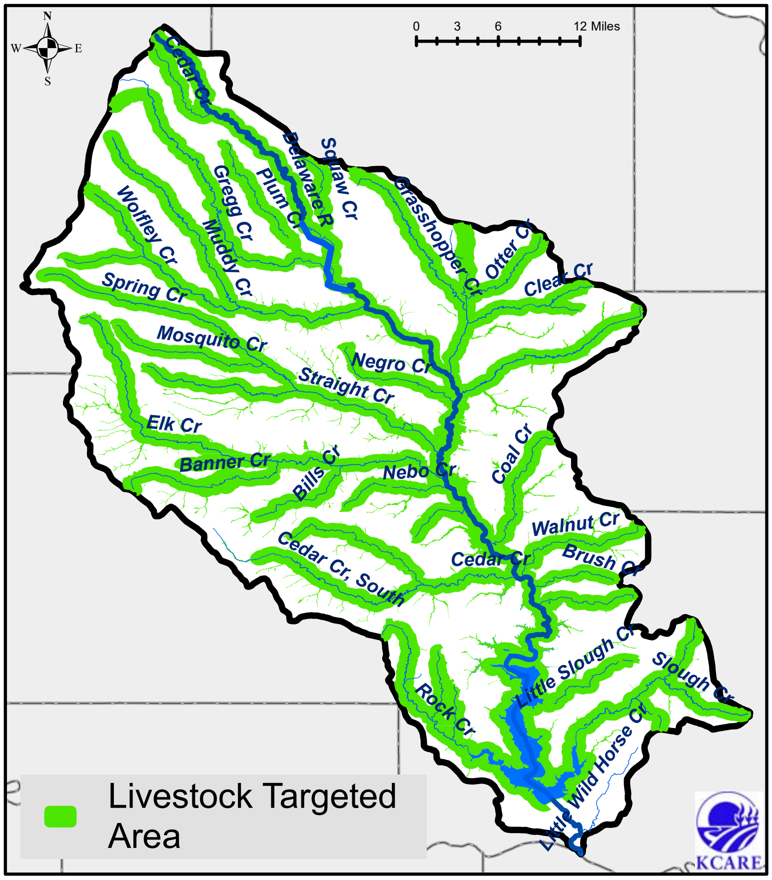


Figure 24. Livestock Targeted Areas in the Delaware River Watershed

3. Streambank areas will be targeted for **nutrients** (nitrogen and phosphorus) and **sediment**. Streambank stabilization projects will take place in 10 HUC 12s (**Figure 25** and **Table 17**):
   - 102701030110
   - 102701030205
   - 102701030308
   - 102701030405 – border only
   - 102701030406 – border only
   - 102701030407 – border only
   - 102701030408
   - 102701030501 – border only
   - 102701030503
   - 102701030504

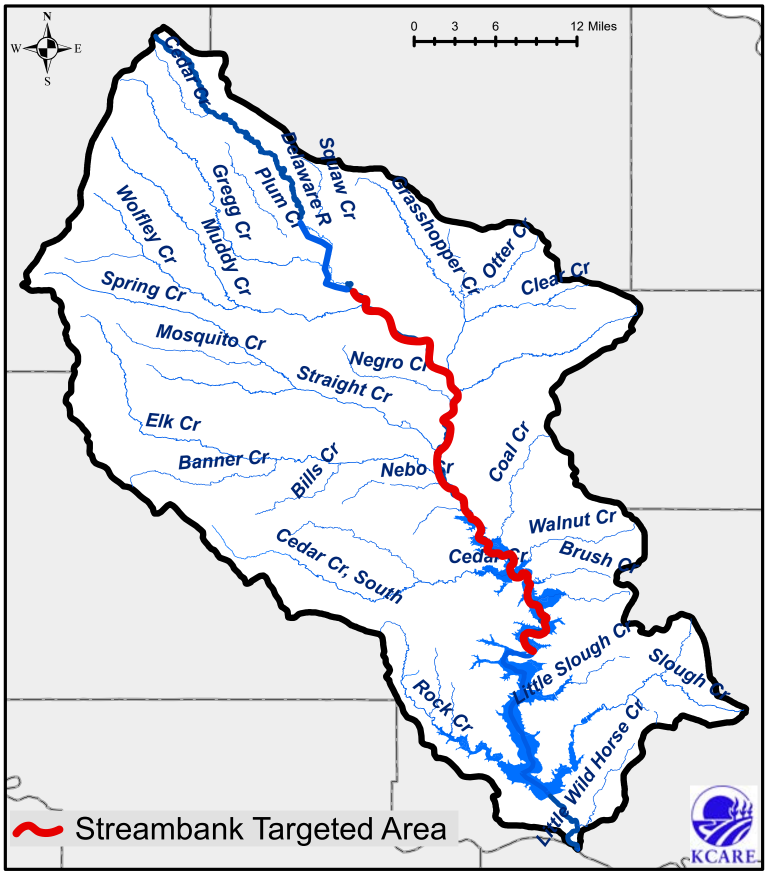


Figure 25. Streambank Targeted Areas in the Delaware River Watershed

Focusing on each of these targeted areas for cropland, livestock, and streambank BMP implementation will have positive impacts on all impaired waters throughout the watershed.

Table 17. Targeted Areas in the Delaware River Watershed

Targeted Areas for BMP Implementation			
HUC 12: 102701030…	Cropland and Livestock BMPs: Riparian Corridors Only	Cropland BMPs: Entire HUC 12	Streambank Stabilization Projects
101	X	X	
102	X	X	
103	X	X	
104	X	X	
105	X	X	
106	X		
107	X	X	
108	X	X	
109	X		
110	X		X
201	X	X	
202	X	X	
203	X	X	
204	X	X	
205	X		X
301	X		
302	X		
303	X		
304	X		
305	X		
306	X		
307	X		
308	X		X
401	X		
402	X	X	
403	X		
404	X		
405	X		X
406	X		X
407	X	X	X
408	X		X
501	X	X	X
502	X		
503	X		X
504	X		X
505	X		
506	X		
507	X		
508	X		
509			
510			

C. Load Reduction Estimate Methodology

Load reductions will be estimated for each pollutant addressed in each area to measure success in meeting TMDL goals.

1. Cropland

Baseline loadings are calculated using the AnnAGNPS model delineated to the HUC 12 watershed scale. BMP load reduction efficiencies are derived from Kansas State University Research and Extension Publication MF-2572.[23] Load reduction estimates are the product of baseline loading and the applicable BMP load reduction efficiencies.

2. Livestock

Baseline nutrient loadings per animal unit are calculated using the Livestock Waste Facilities Handbook[24] and these three publications: *Decreasing Nitrogen and Phosphorus Excretion by Dairy Cattle*[25], *Fertilizing Cropland with Beef Manure*[26], and *Estimating Manure Nutrient Excretion*[27]. Livestock management practice load reduction efficiencies are derived from numerous sources, including Kansas State University Research and Extension Publication MF-2737[28] and MF-2454[29]. Load reduction estimates are the product of baseline loading and the applicable BMP load reduction efficiencies. According to the 2019 Ag Census, stocking rates in the Delaware River Watershed range from 16 to 29.6, with an average of 18.3 cattle per 100 acres.

3. Streambank

The Kansas Alliance for Wetlands and Stream (KAWS) conducted an assessment and identified a total of 69 eroding streambank sites on the main stem of the Delaware River. Eroding sites identified by the assessment represent a total of 43,266 linear feet of eroding streambank. Additional assessments to finely-tune streambank targeting and to derive more accurate streambank erosion estimates may be needed.

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[23] https://www.bookstore.ksre.ksu.edu/pubs/MF2572.pdf
[24] https://www-mwps.sws.iastate.edu/catalog/manure-management/livestock-waste-facilities-handbook
[25] Sudduth, T.Q. and M.J. Loveless. *Decreasing Nitrogen and Phosphorus Excretion by Dairy Cattle.* https://www.clemson.edu/extension/camm/manuals/dairy/dch3b_04.pdf
[26] Schmitt, Michael and George Rehm. *Fertilizing Cropland with Beef Manure.* 2002. University of Minnesota Extension Bulletin.
[27] Koelsch, Rick. *Estimating Manure Nutrient Excretion.* 2007. University of Nebraska Extension Bulletin.
[28] MF-2737 Available at: https://www.bookstore.ksre.ksu.edu/pubs/MF2737.pdf
[29] MF-2454 Available at: https://www.bookstore.ksre.ksu.edu/pubs/MF2454.pdf

7. Implementation

As mentioned in the previous section, BMP implementation in the Delaware River Watershed will take place in throughout the entire watershed. Cropland, livestock, and streambank areas will be targeted in an effort to effectively improve the following TMDL impairments:

- **Eutrophication, *nutrients* (nitrogen and phosphorus):** cropland, livestock, and streambank areas
- **Total Phosphorus (addressed in unison with eutrophication):** cropland, livestock, and streambank areas
- **Siltation:** cropland and streambank areas
- ***E. coli*:** livestock areas

***Cropland BMPs** will reduce sediment and nutrient loading, thereby improving the eutrophication, TP, and siltation TMDLs in the Delaware River Watershed. In addition, these reductions subsequently will work to improve the watershed's non-targeted Atrazine, biology, DO, eutrophication, total phosphorus, and siltation-impaired waters.*

***Livestock BMPs** will reduce both phosphorus and nitrogen nutrient loading, thereby improving the eutrophication, TP and* E. coli *TMDLs. These reductions also will improve the non-targeted biology,* E. coli*, eutrophication, DO and total phosphorus impairment listings throughout the Delaware River Watershed.*

***Streambank stabilization projects** will reduce sediment (and nutrient) loading, thereby improving the eutrophication, TP, and siltation TMDLs in the watershed. Streambank stabilization projects also will serve to positively affect the non-targeted Atrazine, biology, DO, eutrophication, total phosphorus, and siltation-impaired waters.* E. coli *impairments also will be improved if streambank stabilization projects take place in livestock areas.*

A. Nutrient Load Reductions in the Delaware River Watershed

The Delaware River Watershed has "high" TMDL rankings for eutrophication (nitrogen and phosphorus) in Perry Lake and total phosphorus in the Delaware River near Half Mound. The watershed contains three targeted areas for nutrient load reductions: **cropland, livestock and streambank areas**. Adoption and implementation of nutrient BMPs will result in total nutrient load reductions of **1,638,175 pounds of nitrogen** and **286,707 pounds of phosphorus** at the conclusion of this 30-year WRAPS plan. These load reductions will meet and exceed the required reductions to meet both the eutrophication/nutrient (Perry Lake) and total phosphorus (Delaware River near Half Mound) TMDLs.

There are 133,282 cropland acres and 192,652 grassland/pasture/hay acres in the targeted areas for nutrient load reduction in the Delaware River Watershed (**Table 18**). Land use in the nutrient-targeted area does make a difference in the amount of nitrogen and phosphorus entering the water. Cropland is highly susceptible to runoff and erosion during rainfall events, when nutrients can leach to the soil particles and enter nearby water segments. The 46% of grassland/pasture/hay land in the targeted HUC 12s is the reason livestock areas have been added to the nutrient list of targeted areas. Variation in load reductions is due to differences in stocking rates and grazing duration in native grass pastures, cool-season grass pastures and cropland.

Table 18. Land Use in the Nutrient-Targeted Areas

Nutrient-Targeted Area Land Use in the Delaware River Watershed											
Land Use	Acres in Targetd HUC 10: 1027010...									Total Acres	% of Targeted Area
	301		302		303	304		305			
	Riparian Corridor	Upland Acres	Riparian Corridor	Upland Acres	Riparian Corridor	Riparian Corridor	Upland Acres	Riparian Corridor	Upland Acres		
Pasture/Hay	24,657	20,375	15,501	22,556	32,922	5,315	11,974	20,686	865	154,851	37.0%
Cropland	26,823	27,708	16,042	25,371	15,535	7,330	7,897	5,633	943	133,282	31.8%
Deciduous Forest	9,953	3,214	4,518	2,703	10,799	5,130	1,914	18,083	39	56,353	13.4%
Grassland	10,165	11,976	1,498	1,598	4,517	2,805	768	4,443	31	37,801	9.0%
Developed, Open Space	2,619	2,647	2,049	2,269	2,510	1,527	843	3,303	79	17,846	4.3%
Open Water	514	298	609	496	1,299	705	188	2,600	15	6,724	1.6%
Woody Wetlands	1,063	63	378	55	427	515	21	1,574	0	4,096	1.0%
Developed, Low Intensity	528	525	492	433	852	198	39	878	39	3,984	1.0%
Herbaceous Wetlands	26	2	56	17	148	186	7	1,643	6	2,091	0.5%
Shrubland	175	87	67	52	94	116	50	157	0	798	0.2%
Developed, Medium Intensity	28	95	60	21	179	43	1	123	0	550	0.1%
Mixed Forest	51	29	21	11	95	62	34	138	0	441	0.1%
Developed, High Intensity	1	34	14	7	43	0	0	14	0	113	0.0%
Barren Land	1	0	4	0	2	5	0	54	0	66	0.0%
Evergreen Forest	7	1	0	0	2	0	8	2	0	20	0.0%
Totals	**76,611**	**67,054**	**41,309**	**55,589**	**69,424**	**23,937**	**23,744**	**59,331**	**2,017**	**419,016**	**100.0%**

1. Cropland targeted for nutrient reductions in the Delaware River Watershed

a. Targeted cropland areas for nutrient reductions

Cropland BMPs will be implemented to reduce nutrient loading in the Delaware River Watershed to protect local streams, including the Delaware River near Half Mound, and, ultimately, Perry Lake. *Any cropland BMPs implemented in the targeted areas simultaneously will reduce both nutrient and sediment loading.*

As shown in **Figure 26**, cropland BMPs will be implemented along the riparian corridors (one-half mile on each side of a water segment) in the majority of the watershed (39 HUC 12s), as well as upland in the following 14 HUC 12s:

- 102701030101
- 102701030102
- 102701030103
- 102701030104
- 102701030105
- 102701030107
- 102701030108
- 102701030201
- 102701030202
- 102701030203
- 102701030204
- 102701030402
- 102701030407
- 102701030501

Table 17, in Section 6, depicts which HUC 12s are targeted for cropland and livestock BMPs and whether the entire HUC 12 is targeted or only the riparian corridor.

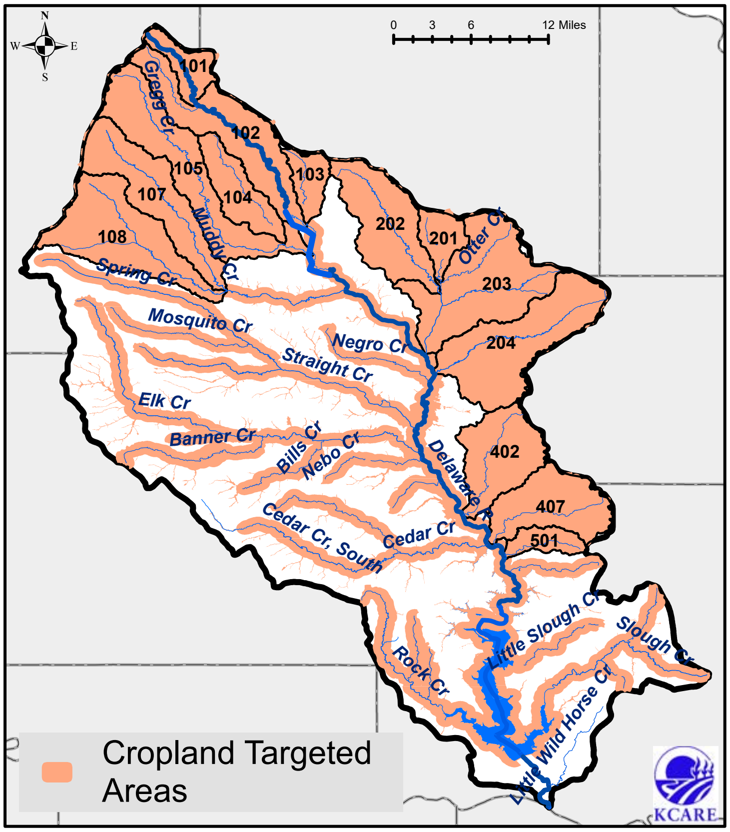

Figure 26. Cropland Targeted Area in the Delaware River Watershed

b. Cropland BMPs for nutrient reductions in the Delaware River Watershed

The following BMPs will be implemented to reduce nutrient loading from crop fields in the targeted areas:

- buffers,
- cover crops,
- no-till,
- permanent vegetation,
- subsurface fertilizer,
- terraces, and
- waterways.

Table 19. Cropland BMPs Needed to Reduce Nutrient Loading

BMPs to Reduce Nutrient Loading		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of nutrient contribution from **cropland**	Buffers	1,466 acres
	Cover Crops	2,221 acres
	No-Till	2,221 acres
	Permanent Vegetation	222 acres
	Subsurface Fertilizer	222 acres
	Terraces	2,221 acres
	Waterways	1,333 acres

Table 20. Adoption Rates for Cropland BMPs to Address Nutrients

Annual Adoption (treated acres), Cropland BMPs								
Year	**Buffers**	**Cover Crop**	**No-Till**	**Permanent Vegetation**	**Subsurface Fertilizer**	**Terraces**	**Waterways**	**Total Adoption**
1	1,466	2,221	2,221	222	222	2,221	1,333	9,907
2	1,466	2,221	2,221	222	222	2,221	1,333	9,907
3	1,466	2,221	2,221	222	222	2,221	1,333	9,907
4	1,466	2,221	2,221	222	222	2,221	1,333	9,907
5	1,466	2,221	2,221	222	222	2,221	1,333	9,907
6	1,466	2,221	2,221	222	222	2,221	1,333	9,907
7	1,466	2,221	2,221	222	222	2,221	1,333	9,907
8	1,466	2,221	2,221	222	222	2,221	1,333	9,907
9	1,466	2,221	2,221	222	222	2,221	1,333	9,907
10	1,466	2,221	2,221	222	222	2,221	1,333	9,907
11	1,466	2,221	2,221	222	222	2,221	1,333	9,907
12	1,466	2,221	2,221	222	222	2,221	1,333	9,907
13	1,466	2,221	2,221	222	222	2,221	1,333	9,907
14	1,466	2,221	2,221	222	222	2,221	1,333	9,907
15	1,466	2,221	2,221	222	222	2,221	1,333	9,907
16	1,466	2,221	2,221	222	222	2,221	1,333	9,907
17	1,466	2,221	2,221	222	222	2,221	1,333	9,907
18	1,466	2,221	2,221	222	222	2,221	1,333	9,907
19	1,466	2,221	2,221	222	222	2,221	1,333	9,907
20	1,466	2,221	2,221	222	222	2,221	1,333	9,907
21	1,466	2,221	2,221	222	222	2,221	1,333	9,907
22	1,466	2,221	2,221	222	222	2,221	1,333	9,907
23	1,466	2,221	2,221	222	222	2,221	1,333	9,907
24	1,466	2,221	2,221	222	222	2,221	1,333	9,907
25	1,466	2,221	2,221	222	222	2,221	1,333	9,907
26	1,466	2,221	2,221	222	222	2,221	1,333	9,907
27	1,466	2,221	2,221	222	222	2,221	1,333	9,907
28	1,466	2,221	2,221	222	222	2,221	1,333	9,907
29	1,466	2,221	2,221	222	222	2,221	1,333	9,907
30	1,466	2,221	2,221	222	222	2,221	1,333	9,907
Total	**43,980**	**66,641**	**66,641**	**6,664**	**6,664**	**66,641**	**39,990**	**297,221**

c. *Nutrient load reductions from cropland BMP implementation*

The implementation of cropland BMPs on 9,907 acres per year in the Delaware River Watershed's targeted areas will result in a nitrogen load reduction of 1,178,856 pounds and a phosphorus reduction of 214,935 pounds at the end of this 30-year WRAPS plan (**Tables 21** and **22**).

Table 21. Cumulative Nitrogen Load Reductions from Cropland BMP Implementation

Annual Nitrogen Reduction (lbs), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	8,448	6,400	6,400	2,432	1,792	7,680	6,144	39,295
2	16,896	12,800	12,800	4,864	3,584	15,360	12,288	78,590
3	25,343	19,200	19,200	7,296	5,376	23,040	18,432	117,886
4	33,791	25,599	25,599	9,728	7,168	30,719	24,576	157,181
5	42,239	31,999	31,999	12,160	8,960	38,399	30,719	196,476
6	50,687	38,399	38,399	14,592	10,752	46,079	36,863	235,771
7	59,135	44,799	44,799	17,024	12,544	53,759	43,007	275,067
8	67,583	51,199	51,199	19,456	14,336	61,439	49,151	314,362
9	76,030	57,599	57,599	21,888	16,128	69,119	55,295	353,657
10	84,478	63,999	63,999	24,320	17,920	76,798	61,439	392,952
11	92,926	70,399	70,399	26,751	19,712	84,478	67,583	432,247
12	101,374	76,798	76,798	29,183	21,504	92,158	73,727	471,543
13	109,822	83,198	83,198	31,615	23,296	99,838	79,870	510,838
14	118,270	89,598	89,598	34,047	25,087	107,518	86,014	550,133
15	126,717	95,998	95,998	36,479	26,879	115,198	92,158	589,428
16	135,165	102,398	102,398	38,911	28,671	122,878	98,302	628,723
17	143,613	108,798	108,798	41,343	30,463	130,557	104,446	668,019
18	152,061	115,198	115,198	43,775	32,255	138,237	110,590	707,314
19	160,509	121,598	121,598	46,207	34,047	145,917	116,734	746,609
20	168,957	127,997	127,997	48,639	35,839	153,597	122,878	785,904
21	177,404	134,397	134,397	51,071	37,631	161,277	129,021	825,200
22	185,852	140,797	140,797	53,503	39,423	168,957	135,165	864,495
23	194,300	147,197	147,197	55,935	41,215	176,636	141,309	903,790
24	202,748	153,597	153,597	58,367	43,007	184,316	147,453	943,085
25	211,196	159,997	159,997	60,799	44,799	191,996	153,597	982,380
26	219,644	166,397	166,397	63,231	46,591	199,676	159,741	1,021,676
27	228,091	172,797	172,797	65,663	48,383	207,356	165,885	1,060,971
28	236,539	179,196	179,196	68,095	50,175	215,036	172,029	1,100,266
29	244,987	185,596	185,596	70,527	51,967	222,716	178,172	1,139,561
30	253,435	191,996	191,996	72,959	53,759	230,395	184,316	1,178,856

Table 22. Cumulative Phosphorus Reductions from Cropland BMP Implementation

Annual Phosphorus Reduction (lbs), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	1,235	1,871	1,497	355	187	1,122	898	7,165
2	2,469	3,741	2,993	711	374	2,245	1,796	14,329
3	3,704	5,612	4,490	1,066	561	3,367	2,694	21,494
4	4,938	7,483	5,986	1,422	748	4,490	3,592	28,658
5	6,173	9,353	7,483	1,777	935	5,612	4,490	35,823
6	7,408	11,224	8,979	2,133	1,122	6,734	5,387	42,987
7	8,642	13,094	10,476	2,488	1,309	7,857	6,285	50,152
8	9,877	14,965	11,972	2,843	1,497	8,979	7,183	57,316
9	11,112	16,836	13,469	3,199	1,684	10,101	8,081	64,481
10	12,346	18,706	14,965	3,554	1,871	11,224	8,979	71,645
11	13,581	20,577	16,462	3,910	2,058	12,346	9,877	78,810
12	14,815	22,448	17,958	4,265	2,245	13,469	10,775	85,974
13	16,050	24,318	19,455	4,620	2,432	14,591	11,673	93,139
14	17,285	26,189	20,951	4,976	2,619	15,713	12,571	100,303
15	18,519	28,059	22,448	5,331	2,806	16,836	13,469	107,468
16	19,754	29,930	23,944	5,687	2,993	17,958	14,366	114,632
17	20,988	31,801	25,441	6,042	3,180	19,080	15,264	121,797
18	22,223	33,671	26,937	6,398	3,367	20,203	16,162	128,961
19	23,458	35,542	28,434	6,753	3,554	21,325	17,060	136,126
20	24,692	37,413	29,930	7,108	3,741	22,448	17,958	143,290
21	25,927	39,283	31,427	7,464	3,928	23,570	18,856	150,455
22	27,162	41,154	32,923	7,819	4,115	24,692	19,754	157,619
23	28,396	43,024	34,420	8,175	4,302	25,815	20,652	164,784
24	29,631	44,895	35,916	8,530	4,490	26,937	21,550	171,948
25	30,865	46,766	37,413	8,885	4,677	28,059	22,448	179,113
26	32,100	48,636	38,909	9,241	4,864	29,182	23,345	186,277
27	33,335	50,507	40,406	9,596	5,051	30,304	24,243	193,442
28	34,569	52,378	41,902	9,952	5,238	31,427	25,141	200,606
29	35,804	54,248	43,399	10,307	5,425	32,549	26,039	207,771
30	37,038	56,119	44,895	10,663	5,612	33,671	26,937	214,935

2. Livestock areas targeted for nutrient reduction in the Delaware River Watershed

a. Targeted livestock areas for nutrient reductions

Livestock area BMPs will be implemented to reduce nutrient loading in the Delaware River Watershed to protect local streams, including the Delaware River near Half Mound, and, ultimately, Perry Lake.

As shown in **Figure 27**, livestock area BMPs will be implemented along the riparian corridors in most of the watershed to include 39 of the 40 HUC 12s in the Delaware River Watershed. *See **Table 17** in Section* 6 *for HUC 12 identifications.*

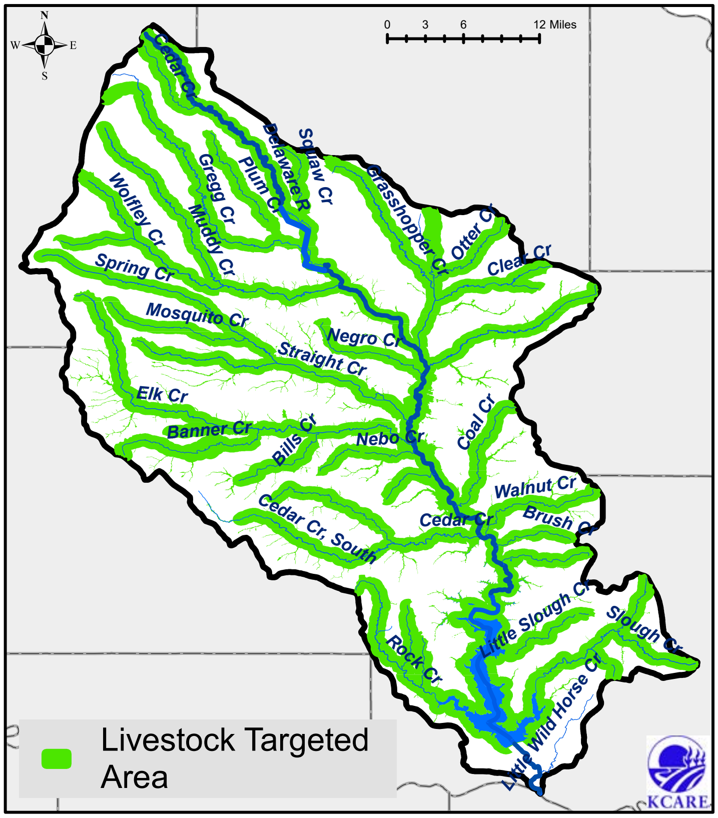

Figure 27. Livestock Targeted Area in the Delaware River Watershed

b. *Livestock area BMPs for nutrient reductions in the Delaware River Watershed*

The following BMPs will be implemented to reduce nutrient loading from livestock in the targeted areas:

- off-stream watering system,
- relocate feeding pens,
- relocate pasture feeding sites,
- rotational grazing, and
- vegetative filter strips.

Table 23. Nutrient BMP Adoption Rates in Livestock Areas

BMPs to Reduce Nutrient Runoff		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of nutrient contribution from **livestock**	Off-stream Watering System	1 project per year
	Relocating Feeding Pens	1 project per year
	Relocate Pasture Feeding Sites	1 project per year
	Rotational Grazing	1 project per year
	Vegetative Filter Strips	1 project per year

Table 24. Adoption Rates for Livestock BMPs to Address Nutrients

Annual Livestock BMP Adoption						
Year	Off-stream Watering System	Relocate Feeding Pens	Relocate Pasture Feeding Site	Rotational Grazing	Vegetative Filter Strip	Projects Per Year
1	1	1	1	1	1	5
2	1	1	1	1	1	5
3	1	1	1	1	1	5
4	1	1	1	1	1	5
5	1	1	1	1	1	5
6	1	1	1	1	1	5
7	1	1	1	1	1	5
8	1	1	1	1	1	5
9	1	1	1	1	1	5
10	1	1	1	1	1	5
11	1	1	1	1	1	5
12	1	1	1	1	1	5
13	1	1	1	1	1	5
14	1	1	1	1	1	5
15	1	1	1	1	1	5
16	1	1	1	1	1	5
17	1	1	1	1	1	5
18	1	1	1	1	1	5
19	1	1	1	1	1	5
20	1	1	1	1	1	5
21	1	1	1	1	1	5
22	1	1	1	1	1	5
23	1	1	1	1	1	5
24	1	1	1	1	1	5
25	1	1	1	1	1	5
26	1	1	1	1	1	5
27	1	1	1	1	1	5
28	1	1	1	1	1	5
29	1	1	1	1	1	5
30	1	1	1	1	1	5
Total	**30**	**30**	**30**	**30**	**30**	**150**

c. *Nutrient load reductions from livestock BMP implementation*

The implementation of five livestock BMP projects per year in the targeted areas will result in a nitrogen load reduction of 105,085 pounds and a phosphorus load reduction of 55,792 pounds at the end of this 30-year WRAPS plan (**Tables 25** and **26**).

Table 25. Cumulative Nitrogen Reductions from Livestock BMP Implementation

Annual Nitrogen Load Reduction (lbs), Livestock BMPs						
Year	Off-stream Watering System	Relocate Feeding Pens	Relocate Pasture Feeding Site	Rotational Grazing	Vegetative Filter Strip	Annual Load Reduction
1	74	1,673	61	22	1,673	3,503
2	148	3,346	122	44	3,346	7,006
3	222	5,019	183	65	5,019	10,508
4	296	6,692	244	87	6,692	14,011
5	370	8,366	305	109	8,366	17,514
6	444	10,039	365	131	10,039	21,017
7	518	11,712	426	152	11,712	24,520
8	592	13,385	487	174	13,385	28,023
9	666	15,058	548	196	15,058	31,525
10	740	16,731	609	218	16,731	35,028
11	813	18,404	670	239	18,404	38,531
12	887	20,077	731	261	20,077	42,034
13	961	21,750	792	283	21,750	45,537
14	1,035	23,424	853	305	23,424	49,040
15	1,109	25,097	914	326	25,097	52,542
16	1,183	26,770	974	348	26,770	56,045
17	1,257	28,443	1,035	370	28,443	59,548
18	1,331	30,116	1,096	392	30,116	63,051
19	1,405	31,789	1,157	413	31,789	66,554
20	1,479	33,462	1,218	435	33,462	70,057
21	1,553	35,135	1,279	457	35,135	73,559
22	1,627	36,808	1,340	479	36,808	77,062
23	1,701	38,482	1,401	500	38,482	80,565
24	1,775	40,155	1,462	522	40,155	84,068
25	1,849	41,828	1,523	544	41,828	87,571
26	1,923	43,501	1,583	566	43,501	91,074
27	1,997	45,174	1,644	587	45,174	94,576
28	2,071	46,847	1,705	609	46,847	98,079
29	2,145	48,520	1,766	631	48,520	101,582
30	2,219	50,193	1,827	653	50,193	105,085

Table 26. Cumulative Phosphorus Reductions from Livestock BMP Implementation

Annual Phosphorus Load Reductions (lbs), Livestock BMPs						
Year	Off-stream Watering System	Relocate Feeding Pens	Relocate Pasture Feeding Site	Rotational Grazing	Vegetative Filter Strip	Annual Load Reduction
1	39	888	32	12	888	1,860
2	79	1,777	65	23	1,777	3,719
3	118	2,665	97	35	2,665	5,579
4	157	3,553	129	46	3,553	7,439
5	196	4,442	162	58	4,442	9,299
6	236	5,330	194	69	5,330	11,158
7	275	6,218	226	81	6,218	13,018
8	314	7,106	259	92	7,106	14,878
9	353	7,995	291	104	7,995	16,738
10	393	8,883	323	115	8,883	18,597
11	432	9,771	356	127	9,771	20,457
12	471	10,660	388	139	10,660	22,317
13	510	11,548	420	150	11,548	24,177
14	550	12,436	453	162	12,436	26,036
15	589	13,325	485	173	13,325	27,896
16	628	14,213	517	185	14,213	29,756
17	667	15,101	550	196	15,101	31,616
18	707	15,989	582	208	15,989	33,475
19	746	16,878	614	219	16,878	35,335
20	785	17,766	647	231	17,766	37,195
21	825	18,654	679	243	18,654	39,055
22	864	19,543	711	254	19,543	40,914
23	903	20,431	744	266	20,431	42,774
24	942	21,319	776	277	21,319	44,634
25	982	22,208	808	289	22,208	46,494
26	1,021	23,096	841	300	23,096	48,353
27	1,060	23,984	873	312	23,984	50,213
28	1,099	24,872	905	323	24,872	52,073
29	1,139	25,761	938	335	25,761	53,933
30	1,178	26,649	970	346	26,649	55,792

3. Streambank areas targeted for nutrient reduction in the Delaware River Watershed

a. Streambank stabilization for nutrient reductions

Streambank stabilization or restoration sites will be used to reduce channel-bank erosion and streambank sloughing during heavy rainfall and high-flow events. This will reduce the amount of sediment entering the Delaware River and, ultimately, Perry Lake. Nutrients tend to leach to soil particles as the soil exits fields and streambanks during runoff events. Therefore, stabilizing streambanks to prevent erosion also will serve to keep nutrients in/on the field and in the riparian area and out of nearby water segments. Reducing erosion also serves to reduce nutrient loading, which leads to improvements to the biology, dissolved oxygen, eutrophication, and total phosphorus water impairments in the Delaware River and, ultimately, Perry Lake.

As shown in **Figure 28**, the Delaware River, north of Perry Lake, will be targeted for streambank stabilization/restoration projects. These streambanks span through 10 HUC 12s to include:

- 102701030110
- 102701030205
- 102701030308
- 102701030405
- 102701030406
- 102701030407
- 102701030408
- 102701030501
- 102701030503
- 102701030504

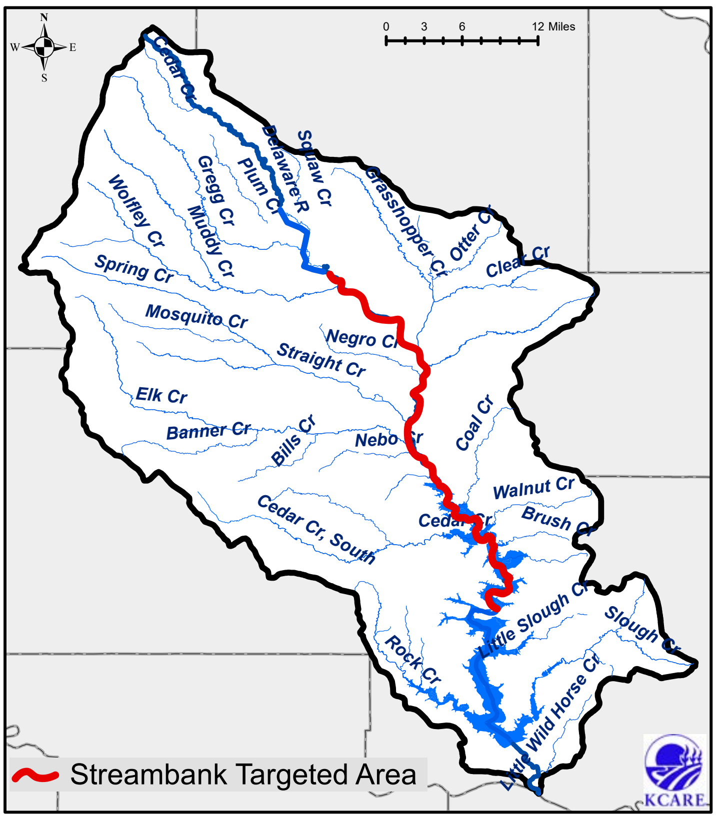

Figure 28. Streambank Targeted Areas in the Delaware River Watershed

b. Streambank stabilization implementation for nutrient reductions in the Delaware River Watershed

The project will stabilize 2,393 feet of streambank annually in the targeted areas for the duration of this 30-year WRAPS plan, for a total of 71,790 linear feet of streambank protected from soil erosion and soil loss.

Table 27. Adoption Rate for Streambank Stabilization to Address Sediment and Nutrients

Annual Adoption (linear feet), Streambank Stabilization		
Year	**Streambank Stabilization (lf)**	**Cumulative Streambank Stabilization (lf)**
1	2,393	2,393
2	2,393	4,786
3	2,393	7,179
4	2,393	9,572
5	2,393	11,965
6	2,393	14,358
7	2,393	16,751
8	2,393	19,144
9	2,393	21,537
10	2,393	23,930
11	2,393	26,323
12	2,393	28,716
13	2,393	31,109
14	2,393	33,502
15	2,393	35,895
16	2,393	38,288
17	2,393	40,681
18	2,393	43,074
19	2,393	45,467
20	2,393	47,860
21	2,393	50,253
22	2,393	52,646
23	2,393	55,039
24	2,393	57,432
25	2,393	59,825
26	2,393	62,218
27	2,393	64,611
28	2,393	67,004
29	2,393	69,397
30	2,393	71,790

c. Nutrient load reductions from streambank BMP implementation

The implementation of 2,393 linear feet of streambank stabilization each project year along the Delaware River will result in a nitrogen load reduction of 354,233 pounds and a phosphorus load reduction of 15,980 pounds at the end of this 30-year WRAPS plan.

Table 28. Nitrogen Load Reduction from Streambank Stabilization

Annual Nitrogen Reduction (lbs), Streambank BMPs			
Year	Streambank Stabilization (linear feet)	Nitrogen Reduction (lbs)	Cumulative Nitrogen Load Reduction (lbs)
1	2,393	11,808	11,808
2	2,393	11,808	23,616
3	2,393	11,808	35,423
4	2,393	11,808	47,231
5	2,393	11,808	59,039
6	2,393	11,808	70,847
7	2,393	11,808	82,654
8	2,393	11,808	94,462
9	2,393	11,808	106,270
10	2,393	11,808	118,078
11	2,393	11,808	129,886
12	2,393	11,808	141,693
13	2,393	11,808	153,501
14	2,393	11,808	165,309
15	2,393	11,808	177,117
16	2,393	11,808	188,924
17	2,393	11,808	200,732
18	2,393	11,808	212,540
19	2,393	11,808	224,348
20	2,393	11,808	236,156
21	2,393	11,808	247,963
22	2,393	11,808	259,771
23	2,393	11,808	271,579
24	2,393	11,808	283,387
25	2,393	11,808	295,194
26	2,393	11,808	307,002
27	2,393	11,808	318,810
28	2,393	11,808	330,618
29	2,393	11,808	342,426
30	2,393	11,808	354,233

Table 29. Phosphorus Load Reduction from Streambank Stabilization

Annual Phosphorus Reduction (lbs), Streambank BMPs			
Year	Streambank Stabilization (linear feet)	Phosphorus Reduction (lbs)	Cumulative Phosphorus Load Reduction (lbs)
1	2,393	533	533
2	2,393	533	1,065
3	2,393	533	1,598
4	2,393	533	2,131
5	2,393	533	2,663
6	2,393	533	3,196
7	2,393	533	3,729
8	2,393	533	4,261
9	2,393	533	4,794
10	2,393	533	5,327
11	2,393	533	5,859
12	2,393	533	6,392
13	2,393	533	6,925
14	2,393	533	7,458
15	2,393	533	7,990
16	2,393	533	8,523
17	2,393	533	9,056
18	2,393	533	9,588
19	2,393	533	10,121
20	2,393	533	10,654
21	2,393	533	11,186
22	2,393	533	11,719
23	2,393	533	12,252
24	2,393	533	12,784
25	2,393	533	13,317
26	2,393	533	13,850
27	2,393	533	14,382
28	2,393	533	14,915
29	2,393	533	15,448
30	2,393	533	15,980

4. Meeting the eutrophication/nutrient TMDL in the Delaware River Watershed

Adoption and implementation of nutrient BMPs in cropland, livestock, and streambank areas will result in a total nitrogen load reduction of 1,638,174 pounds at the conclusion of this 30-year WRAPS plan. The load reduction goal to meet the nutrient TMDL is 908,722 pounds of nitrogen, therefore the implementation of all nutrient BMPs during the 30-year span will exceed the nitrogen reduction goal by roughly 80% (**Table 30**).

Adoption and implementation of these BMPs also will result in a total phosphorus load reduction of 286,707 pounds at the conclusion of this 30-year WRAPS plan. The load reduction goal to meet the nutrient TMDL is 188,976 pounds of phosphorus, therefore the implementation of all nutrient BMPs will exceed the phosphorus reduction goal by 51% (**Table 31**).

The load reductions achieved by this plan will exceed the required reductions to meet both the eutrophication/nutrient TMDL in Perry Lake, and the total phosphorus TMDL in the Delaware River near Half Mound in Year 17 (nitrogen) and Year 20 (phosphorus) of the 30-year Delaware River WRAPS plan (**Tables 32** and **33**).

Table 30. Meeting the Delaware River Watershed Nutrient TMDL: Nitrogen

Meeting the Eutrophication/Nutrient TMDL: Nitrogen		
BMP Category	**Total Load Reduction (pounds)**	**% of Nitrogen TMDL**
Cropland	1,178,856	129.7%
Livestock	105,085	11.6%
Streambank	354,233	39.0%
Total	**1,638,174**	**180.3%**
Nitrogen Reduction Goal: 908,722 pounds		

Table 31. Meeting the Delaware River Watershed Nutrient and Total Phosphorus TMDLs

Meeting the Eutrophication/Nutrient TMDL: Phosphorus		
BMP Category	**Total Load Reduction (pounds)**	**% of Phosphorus TMDL**
Cropland	214,935	113.7%
Livestock	55,792	29.5%
Streambank	15,980	8.5%
Total	**286,707**	**151.7%**
Phosphorus Reduction Goal: 188,976 pounds		

Table 32. Meeting the Nutrient TMDL: Cumulative Nitrogen Reductions by Area

Nitrogen Reduction from Cropland, Livestock and Streambank BMPs					
Year	Cropland Reduction (pounds/year)	Livestock Reduction (pounds/year)	Streambank Reduction (pounds/year)	Total Reduction (pounds/year)	% of TMDL
1	39,295	3,503	11,808	54,606	6.0%
2	78,590	7,006	23,616	109,212	12.0%
3	117,886	10,508	35,423	163,817	18.0%
4	157,181	14,011	47,231	218,423	24.0%
5	196,476	17,514	59,039	273,029	30.0%
6	235,771	21,017	70,847	327,635	36.1%
7	275,067	24,520	82,654	382,241	42.1%
8	314,362	28,023	94,462	436,847	48.1%
9	353,657	31,525	106,270	491,452	54.1%
10	392,952	35,028	118,078	546,058	60.1%
11	432,247	38,531	129,886	600,664	66.1%
12	471,543	42,034	141,693	655,270	72.1%
13	510,838	45,537	153,501	709,876	78.1%
14	550,133	49,040	165,309	764,482	84.1%
15	589,428	52,542	177,117	819,087	90.1%
16	628,723	56,045	188,924	873,692	96.1%
17	668,019	59,548	200,732	928,299	102.2%
18	707,314	63,051	212,540	982,905	108.2%
19	746,609	66,554	224,348	1,037,511	114.2%
20	785,904	70,057	236,156	1,092,117	120.2%
21	825,200	73,559	247,963	1,146,722	126.2%
22	864,495	77,062	259,771	1,201,328	132.2%
23	903,790	80,565	271,579	1,255,934	138.2%
24	943,085	84,068	283,387	1,310,540	144.2%
25	982,380	87,571	295,194	1,365,145	150.2%
26	1,021,676	91,074	307,002	1,419,752	156.2%
27	1,060,971	94,576	318,810	1,474,357	162.2%
28	1,100,266	98,079	330,618	1,528,963	168.3%
29	1,139,561	101,582	342,426	1,583,569	174.3%
30	1,178,856	105,085	354,233	1,638,174	180.3%

Table 33. Meeting the Nutrient TMDL: Cumulative Phosphorus Load Reductions by Area

Phosphorus Reduction from Cropland, Livestock and Streambank BMPs					
Year	Cropland Reduction (pounds/year)	Livestock Reduction (pounds/year)	Streambank Reduction (pounds/year)	Total Reduction (pounds/year)	% of TMDL
1	7,165	1,860	533	9,557	5.1%
2	14,329	3,719	1,065	19,114	10.1%
3	21,494	5,579	1,598	28,671	15.2%
4	28,658	7,439	2,131	38,228	20.2%
5	35,823	9,299	2,663	47,785	25.3%
6	42,987	11,158	3,196	57,342	30.3%
7	50,152	13,018	3,729	66,899	35.4%
8	57,316	14,878	4,261	76,455	40.5%
9	64,481	16,738	4,794	86,013	45.5%
10	71,645	18,597	5,327	95,569	50.6%
11	78,810	20,457	5,859	105,127	55.6%
12	85,974	22,317	6,392	114,683	60.7%
13	93,139	24,177	6,925	124,241	65.7%
14	100,303	26,036	7,458	133,797	70.8%
15	107,468	27,896	7,990	143,354	75.9%
16	114,632	29,756	8,523	152,911	80.9%
17	121,797	31,616	9,056	162,468	86.0%
18	128,961	33,475	9,588	172,025	91.0%
19	136,126	35,335	10,121	181,582	96.1%
20	143,290	37,195	10,654	191,139	101.1%
21	150,455	39,055	11,186	200,696	106.2%
22	157,619	40,914	11,719	210,252	111.3%
23	164,784	42,774	12,252	219,810	116.3%
24	171,948	44,634	12,784	229,366	121.4%
25	179,113	46,494	13,317	238,924	126.4%
26	186,277	48,353	13,850	248,480	131.5%
27	193,442	50,213	14,382	258,038	136.5%
28	200,606	52,073	14,915	267,594	141.6%
29	207,771	53,933	15,448	277,151	146.7%
30	214,935	55,792	15,980	286,708	151.7%

BMPs implemented in cropland, livestock, and streambank areas will reduce both phosphorus and nitrogen nutrient loading, thereby meeting the eutrophication (Perry Lake) and total phosphorus (Delaware River near Half Mound) TMDLs. These BMPs also will serve to positively affect the additional atrazine, biology, dissolved oxygen, E. coli*, eutrophication, siltation and total phosphorus impairments throughout the watershed.*

B. Sediment Load Reductions in the Delaware River Watershed

The Delaware River Watershed has a "high" TMDL ranking for siltation, also referred to as sediment, in Mission Lake, as well as a 303d listing in Atchison County Park Lake. Although these listings are not specific goals or targeted areas in this plan, it is expected that sediment BMP implementation throughout the watershed will impact these impairments in a positive way.

The Delaware River Watershed has two targeted areas for sediment load reductions: **cropland** and **streambank** areas. It is expected that adoption and implementation of sediment BMPs will result in total sediment load reductions of **285,946 tons of sediment** at the conclusion of this 30-year WRAPS plan.

There are 133,282 cropland acres in the targeted areas for sediment load reduction in the Delaware River Watershed (**Table 34**). Land use in the sediment-targeted area does make an impact as cropland is known to be highly susceptible to runoff and erosion during rainfall events. Cropland BMP implementation will take place along riparian corridors in most of the watershed as well as in upland locations in the north and northeastern portions of the watershed. Streambank BMP implementation, also referred to as stabilization or restoration, will take place along the mainstem of the Delaware River, north of Perry Lake.

Any BMPs implemented in the targeted areas simultaneously will reduce both sediment and nutrient loading.

Table 34. Land Use in the Sediment Targeted Areas

Sediment Targeted Area Land Use in the Delaware River Watershed											
Land Use	Acres in Targetd HUC 10: 1027010...									Total Acres	% of Targeted Area
	301		302		303	304		305			
	Riparian Corridor	Upland Acres	Riparian Corridor	Upland Acres	Riparian Corridor	Riparian Corridor	Upland Acres	Riparian Corridor	Upland Acres		
Pasture/Hay	24,657	20,375	15,501	22,556	32,922	5,315	11,974	20,686	865	154,851	37.0%
Cropland	26,823	27,708	16,042	25,371	15,535	7,330	7,897	5,633	943	133,282	31.8%
Deciduous Forest	9,953	3,214	4,518	2,703	10,799	5,130	1,914	18,083	39	56,353	13.4%
Grassland	10,165	11,976	1,498	1,598	4,517	2,805	768	4,443	31	37,801	9.0%
Developed, Open Space	2,619	2,647	2,049	2,269	2,510	1,527	843	3,303	79	17,846	4.3%
Open Water	514	298	609	496	1,299	705	188	2,600	15	6,724	1.6%
Woody Wetlands	1,063	63	378	55	427	515	21	1,574	0	4,096	1.0%
Developed, Low Intensity	528	525	492	433	852	198	39	878	39	3,984	1.0%
Herbaceous Wetlands	26	2	56	17	148	186	7	1,643	6	2,091	0.5%
Shrubland	175	87	67	52	94	116	50	157	0	798	0.2%
Developed, Medium Intensity	28	95	60	21	179	43	1	123	0	550	0.1%
Mixed Forest	51	29	21	11	95	62	34	138	0	441	0.1%
Developed, High Intensity	1	34	14	7	43	0	0	14	0	113	0.0%
Barren Land	1	0	4	0	2	5	0	54	0	66	0.0%
Evergreen Forest	7	1	0	0	2	0	8	2	0	20	0.0%
Totals	**76,611**	**67,054**	**41,309**	**55,589**	**69,424**	**23,937**	**23,744**	**59,331**	**2,017**	**419,016**	**100.0%**

1. Cropland targeted for sediment reductions in the Delaware River Watershed

a. Targeted cropland areas for sediment reductions

Cropland BMPs will be implemented to reduce sediment loading in the Delaware River Watershed to protect local streams and, ultimately, Perry Lake. *Any cropland BMPs implemented in the targeted areas will reduce both nutrient and sediment loading.*

Sediment BMP implementation will be identical to nutrient BMP implementation, using the same BMPs and targeted areas. As shown in **Figure 29**, cropland BMPs will be implemented along the riparian corridors (one-half mile on each side of a water segment) in most of the watershed (39 HUC 12s), as well as upland in the following 14 HUC 12s:

- 102701030101
- 102701030102
- 102701030103
- 102701030104
- 102701030105
- 102701030107
- 102701030108
- 102701030201
- 102701030202
- 102701030203
- 102701030204
- 102701030402
- 102701030407
- 102701030501

Table 17 in Section 6 depicts which HUC 12s are targeted for cropland and streambank BMPs and whether the entire HUC 12 is targeted or just the riparian corridor.

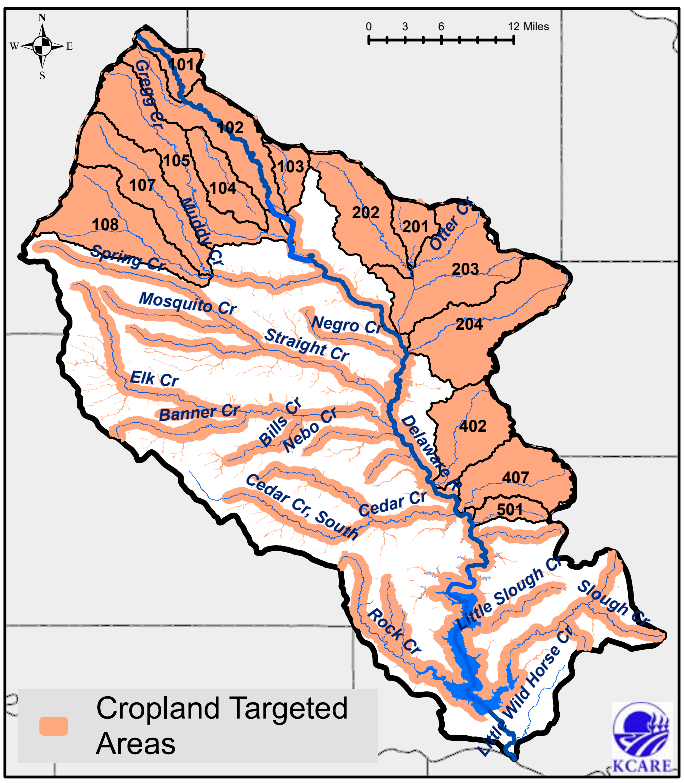

Figure 29. Cropland Targeted Area in the Delaware River Watershed

b. *Cropland BMPs for sediment reductions in the Delaware River Watershed*

The following BMPs will be implemented to reduce sediment (and nutrient) loading from crop fields in the targeted areas:

- buffers,
- cover crops,
- no-till,
- permanent vegetation,
- subsurface fertilizer,
- terraces, and
- waterways.

Table 35. Cropland BMPs Needed to Reduce Sediment Loading

BMPs to Reduce Sediment Runoff		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of sediment contribution from **cropland**	Buffers	1,466 acres
	Cover Crops	2,221 acres
	No-Till	2,221 acres
	Permanent Vegetation	222 acres
	Subsurface Fertilizer	222 acres
	Terraces	2,221 acres
	Waterways	1,333 acres

Table 36. Adoption Rates for Cropland BMPs to Address Sediment

Annual Adoption (treated acres), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Adoption
1	1,466	2,221	2,221	222	222	2,221	1,333	9,907
2	1,466	2,221	2,221	222	222	2,221	1,333	9,907
3	1,466	2,221	2,221	222	222	2,221	1,333	9,907
4	1,466	2,221	2,221	222	222	2,221	1,333	9,907
5	1,466	2,221	2,221	222	222	2,221	1,333	9,907
6	1,466	2,221	2,221	222	222	2,221	1,333	9,907
7	1,466	2,221	2,221	222	222	2,221	1,333	9,907
8	1,466	2,221	2,221	222	222	2,221	1,333	9,907
9	1,466	2,221	2,221	222	222	2,221	1,333	9,907
10	1,466	2,221	2,221	222	222	2,221	1,333	9,907
11	1,466	2,221	2,221	222	222	2,221	1,333	9,907
12	1,466	2,221	2,221	222	222	2,221	1,333	9,907
13	1,466	2,221	2,221	222	222	2,221	1,333	9,907
14	1,466	2,221	2,221	222	222	2,221	1,333	9,907
15	1,466	2,221	2,221	222	222	2,221	1,333	9,907
16	1,466	2,221	2,221	222	222	2,221	1,333	9,907
17	1,466	2,221	2,221	222	222	2,221	1,333	9,907
18	1,466	2,221	2,221	222	222	2,221	1,333	9,907
19	1,466	2,221	2,221	222	222	2,221	1,333	9,907
20	1,466	2,221	2,221	222	222	2,221	1,333	9,907
21	1,466	2,221	2,221	222	222	2,221	1,333	9,907
22	1,466	2,221	2,221	222	222	2,221	1,333	9,907
23	1,466	2,221	2,221	222	222	2,221	1,333	9,907
24	1,466	2,221	2,221	222	222	2,221	1,333	9,907
25	1,466	2,221	2,221	222	222	2,221	1,333	9,907
26	1,466	2,221	2,221	222	222	2,221	1,333	9,907
27	1,466	2,221	2,221	222	222	2,221	1,333	9,907
28	1,466	2,221	2,221	222	222	2,221	1,333	9,907
29	1,466	2,221	2,221	222	222	2,221	1,333	9,907
30	1,466	2,221	2,221	222	222	2,221	1,333	9,907
Total	**43,980**	**66,641**	**66,641**	**6,664**	**6,664**	**66,641**	**39,990**	**297,221**

c. *Sediment load reductions from cropland BMP implementation*

The implementation of cropland BMPs on 9,907 acres per year in the Delaware River Watershed's targeted areas will result in a sediment load reduction of 19,605 tons at the end of this 30-year WRAPS plan (**Table 37**).

Table 37. Cumulative Sediment Load Reductions from Cropland BMP Implementation

Annual Sediment Load Reduction (tons), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	102	124	232	29	0	93	74	653
2	204	247	463	59	0	185	148	1,307
3	306	371	695	88	0	278	222	1,960
4	408	494	927	117	0	371	297	2,614
5	510	618	1,159	147	0	463	371	3,267
6	612	742	1,390	176	0	556	445	3,921
7	714	865	1,622	205	0	649	519	4,574
8	816	989	1,854	235	0	742	593	5,228
9	918	1,112	2,086	264	0	834	667	5,881
10	1,020	1,236	2,317	294	0	927	742	6,535
11	1,122	1,360	2,549	323	0	1,020	816	7,188
12	1,224	1,483	2,781	352	0	1,112	890	7,842
13	1,326	1,607	3,013	382	0	1,205	964	8,495
14	1,427	1,730	3,244	411	0	1,298	1,038	9,149
15	1,529	1,854	3,476	440	0	1,390	1,112	9,802
16	1,631	1,977	3,708	470	0	1,483	1,186	10,456
17	1,733	2,101	3,939	499	0	1,576	1,261	11,109
18	1,835	2,225	4,171	528	0	1,668	1,335	11,763
19	1,937	2,348	4,403	558	0	1,761	1,409	12,416
20	2,039	2,472	4,635	587	0	1,854	1,483	13,070
21	2,141	2,595	4,866	616	0	1,947	1,557	13,723
22	2,243	2,719	5,098	646	0	2,039	1,631	14,377
23	2,345	2,843	5,330	675	0	2,132	1,706	15,030
24	2,447	2,966	5,562	704	0	2,225	1,780	15,684
25	2,549	3,090	5,793	734	0	2,317	1,854	16,337
26	2,651	3,213	6,025	763	0	2,410	1,928	16,991
27	2,753	3,337	6,257	793	0	2,503	2,002	17,644
28	2,855	3,461	6,489	822	0	2,595	2,076	18,298
29	2,957	3,584	6,720	851	0	2,688	2,150	18,951
30	3,059	3,708	6,952	881	0	2,781	2,225	19,605

2. Streambanks targeted for sediment load reduction in the Delaware River Watershed

a. Targeted streambank areas for sediment reductions

Streambank restoration sites will be used to reduce channel-bank erosion and streambank sloughing during heavy rainfall and high-flow events. This will reduce the amount of sediment entering the Delaware River and, ultimately, Perry Lake. The nutrients attached to soil particles that cause biology, dissolved oxygen, eutrophication, and total phosphorus water impairments also will be reduced in the Delaware River, and, ultimately, Perry Lake.

As shown in **Figure 30**, the Delaware River, north of Perry Lake, will be targeted for streambank stabilization/restoration projects. These streambanks span through 10 HUC 12s to include:

- 102701030110
- 102701030205
- 102701030308
- 102701030405
- 102701030406
- 102701030407
- 102701030408
- 102701030501
- 102701030503
- 102701030504

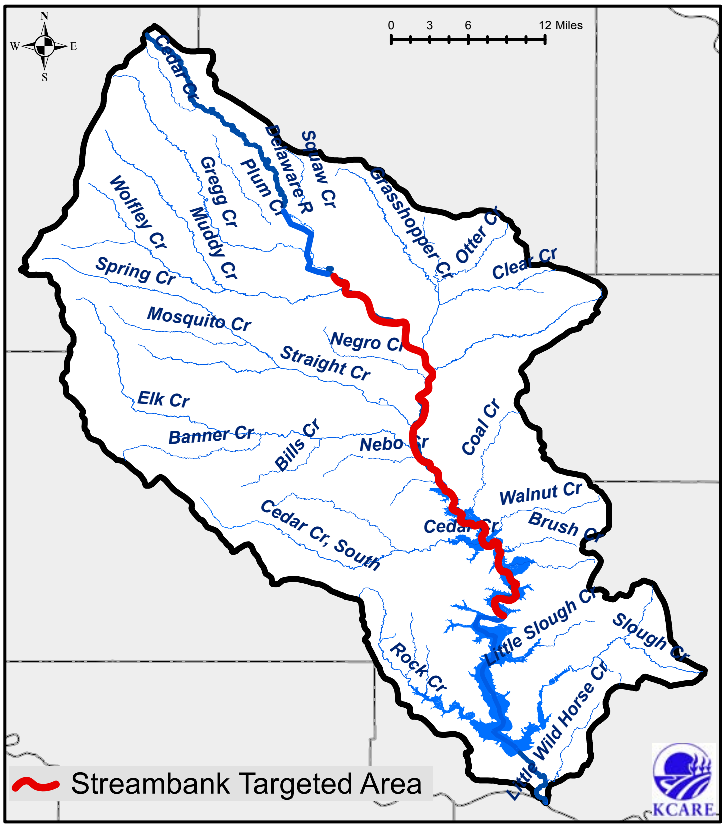

Figure 30. Streambank Stabilization Areas in the Delaware River Watershed

b. Streambank stabilization for sediment reductions in the Delaware River Watershed

The project will stabilize 2,393 linear feet of streambank annually in the targeted areas for the duration of this 30-year WRAPS plan, for a total of 71,790 linear feet of streambank protected from soil erosion and soil loss.

Table 38. Adoption Rate for Streambank Stabilization to Address Sediment and Nutrients

Annual Adoption (linear feet), Streambank Stabilization		
Year	Streambank Stabilization (lf)	Cumulative Streambank Stabilization (lf)
1	2,393	2,393
2	2,393	4,786
3	2,393	7,179
4	2,393	9,572
5	2,393	11,965
6	2,393	14,358
7	2,393	16,751
8	2,393	19,144
9	2,393	21,537
10	2,393	23,930
11	2,393	26,323
12	2,393	28,716
13	2,393	31,109
14	2,393	33,502
15	2,393	35,895
16	2,393	38,288
17	2,393	40,681
18	2,393	43,074
19	2,393	45,467
20	2,393	47,860
21	2,393	50,253
22	2,393	52,646
23	2,393	55,039
24	2,393	57,432
25	2,393	59,825
26	2,393	62,218
27	2,393	64,611
28	2,393	67,004
29	2,393	69,397
30	2,393	71,790

c. *Sediment load reductions from streambank stabilization project implementation*

The implementation of 2,393 linear feet of streambank stabilization each project year along the Delaware River will result in a sediment load reduction of 266,341 tons at the end of this 30-year WRAPS plan.

Table 39. Sediment Load Reduction from Streambank Stabilization

Annual Sediment Reduction (tons), Streambank BMPs			
Year	Streambank Stabilization (linear feet)	Soil Load Reduction (tons)	Cumulative Sediment Reduction (tons)
1	2,393	8,878	8,878
2	2,393	8,878	17,756
3	2,393	8,878	26,634
4	2,393	8,878	35,512
5	2,393	8,878	44,390
6	2,393	8,878	53,268
7	2,393	8,878	62,146
8	2,393	8,878	71,024
9	2,393	8,878	79,902
10	2,393	8,878	88,780
11	2,393	8,878	97,658
12	2,393	8,878	106,536
13	2,393	8,878	115,414
14	2,393	8,878	124,292
15	2,393	8,878	133,170
16	2,393	8,878	142,048
17	2,393	8,878	150,927
18	2,393	8,878	159,805
19	2,393	8,878	168,683
20	2,393	8,878	177,561
21	2,393	8,878	186,439
22	2,393	8,878	195,317
23	2,393	8,878	204,195
24	2,393	8,878	213,073
25	2,393	8,878	221,951
26	2,393	8,878	230,829
27	2,393	8,878	239,707
28	2,393	8,878	248,585
29	2,393	8,878	257,463
30	2,393	8,878	266,341

3. Meeting the sediment goals in the Delaware River Watershed

Adoption and implementation of sediment BMPs in cropland and streambank areas will result in a total sediment load reduction of 285,946 tons at the conclusion of this 30-year WRAPS plan. The sediment load reduction goal in this plan was 284,860 tons, therefore the implementation of all sediment BMPs during the 30-year span will meet the sediment reduction goal in year 30 (**Table 40**).

Table 40. Meeting the Delaware River Watershed Sediment Goal

Meeting the Sediment Goal		
BMP Category	**Total Load Reduction (pounds)**	**% of Sediment Goal**
Cropland	19,605	6.9%
Streambank	266,341	93.5%
Total	**285,946**	**100.4%**
Sediment Reduction Goal: 284,860 tons		

Table 41. Meeting the Sediment Goal: Cumulative Sediment Reductions by Area

Sediment Load Reduction from Cropland and Streambank BMPs				
Year	Cropland Reduction (tons/year)	Streambank Reduction (tons/year)	Total Reduction (tons/year)	% of Sediment Goal
1	653	8,878	9,531	3.3%
2	1,307	17,756	19,063	6.7%
3	1,960	26,634	28,594	10.0%
4	2,614	35,512	38,126	13.4%
5	3,267	44,390	47,657	16.7%
6	3,921	53,268	57,189	20.1%
7	4,574	62,146	66,720	23.4%
8	5,228	71,024	76,252	26.8%
9	5,881	79,902	85,783	30.1%
10	6,535	88,780	95,315	33.5%
11	7,188	97,658	104,846	36.8%
12	7,842	106,536	114,378	40.2%
13	8,495	115,414	123,909	43.5%
14	9,149	124,292	133,441	46.8%
15	9,802	133,170	142,972	50.2%
16	10,456	142,048	152,504	53.5%
17	11,109	150,927	162,036	56.9%
18	11,763	159,805	171,568	60.2%
19	12,416	168,683	181,099	63.6%
20	13,070	177,561	190,631	66.9%
21	13,723	186,439	200,162	70.3%
22	14,377	195,317	209,694	73.6%
23	15,030	204,195	219,225	77.0%
24	15,684	213,073	228,757	80.3%
25	16,337	221,951	238,288	83.7%
26	16,991	230,829	247,820	87.0%
27	17,644	239,707	257,351	90.4%
28	18,298	248,585	266,883	93.7%
29	18,951	257,463	276,414	97.0%
30	19,605	266,341	285,946	100.4%

BMPs implemented in cropland and streambank areas will reduce both sediment and nutrients, thereby positively affecting the atrazine, biology, dissolved oxygen, E. coli*, eutrophication, siltation and total phosphorus impairments throughout the watershed.*

C. *E. coli* Bacteria Reductions in the Delaware River Watershed

Bacteria are often found in water. While *E. coli* bacteria is ranked as a high-priority TMDL in several water segments in the Delaware River Watershed, the focus of this plan is to delist the *E. coli* impairment in the Delaware River near Half Mound. Livestock BMPs designed to reduce nutrient loading will also serve to reduce *E. coli* bacteria in the targeted areas.

1. Targeted livestock areas for *E. coli* reductions

Livestock area BMPs will be implemented to reduce nutrient loading and will simultaneously serve to reduce *E. coli* in the Delaware River Watershed. This will protect the local streams, including the Delaware River near Half Mound.

As shown in **Figure 31**, livestock area BMPs will be implemented along the riparian corridors in most of the watershed to include 39 of the 40 HUC 12s in the Delaware River Watershed. *See **Table 17** in Section* 6 *for HUC 12 identifications.*

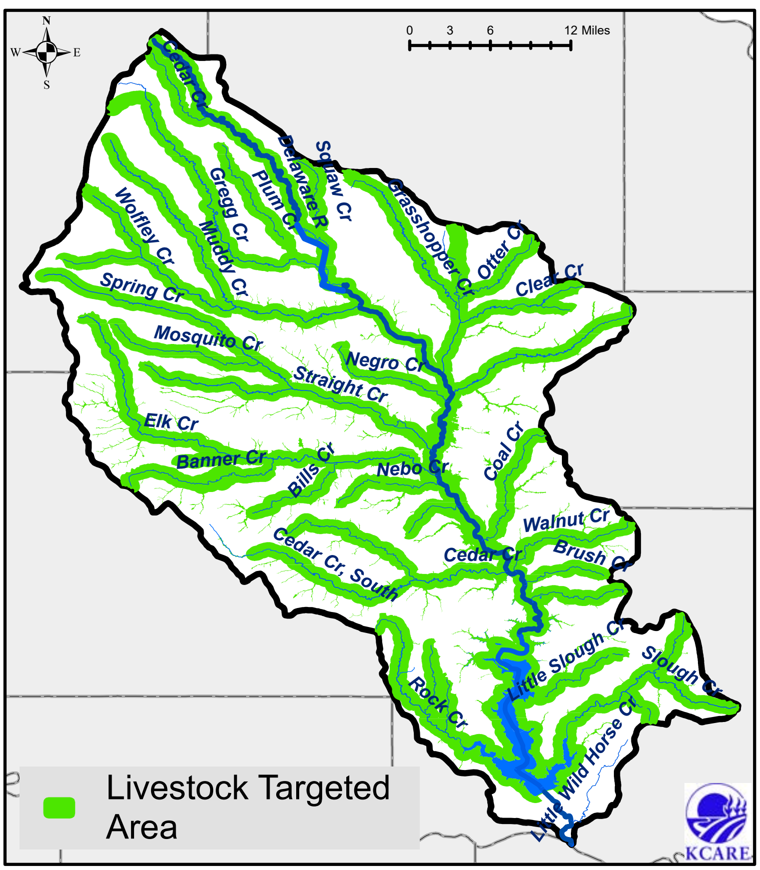

Figure 31. Livestock Targeted Area in the Delaware River Watershed

2. Livestock area BMPs for *E. coli* reductions in the Delaware River Watershed

The following BMPs will be implemented to reduce nutrient loading from crop fields in the targeted areas:

- off-stream watering system,
- relocate feeding pens,
- relocate pasture feeding sites,
- rotational grazing, and
- vegetative filter strips.

Table 42. Nutrient and* E. Coli *BMP Adoption Rates in Livestock Areas

BMPs to Reduce Nutrient Runoff		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of nutrient contribution from **livestock**	Off-stream Watering System	1 project per year
	Relocating Feeding Pens	1 project per year
	Relocate Pasture Feeding Sites	1 project per year
	Rotational Grazing	1 project per year
	Vegetative Filter Strips	1 project per year

***Table 43. Adoption Rates for Livestock BMPs to address* E. coli**

Annual Livestock BMP Adoption						
Year	Off-Stream Watering System	Relocate Feeding Pens	Relocate Pasture Feeding Site	Rotational Grazing	Vegetative Filter Strip	Projects Per Year
1	1	1	1	1	1	5
2	1	1	1	1	1	5
3	1	1	1	1	1	5
4	1	1	1	1	1	5
5	1	1	1	1	1	5
6	1	1	1	1	1	5
7	1	1	1	1	1	5
8	1	1	1	1	1	5
9	1	1	1	1	1	5
10	1	1	1	1	1	5
11	1	1	1	1	1	5
12	1	1	1	1	1	5
13	1	1	1	1	1	5
14	1	1	1	1	1	5
15	1	1	1	1	1	5
16	1	1	1	1	1	5
17	1	1	1	1	1	5
18	1	1	1	1	1	5
19	1	1	1	1	1	5
20	1	1	1	1	1	5
21	1	1	1	1	1	5
22	1	1	1	1	1	5
23	1	1	1	1	1	5
24	1	1	1	1	1	5
25	1	1	1	1	1	5
26	1	1	1	1	1	5
27	1	1	1	1	1	5
28	1	1	1	1	1	5
29	1	1	1	1	1	5
30	1	1	1	1	1	5
Total	**30**	**30**	**30**	**30**	**30**	**150**

3. *E. coli* load reductions from livestock BMP implementation

It is not possible to estimate the current pollutant load for *E. coli* bacteria in the watershed due to several factors. First, environmental factors affect the viability of *E. coli* since it is a living organism. Next, the viability of *E. coli* is affected by variations in initial bacteria loading, ambient temperature, amount of sunlight or UV rays, and a decrease in survivability over time. In addition, *E. coli* concentrations are difficult to model, and the scope of this WRAPS project does not include modeling for *E. coli*. Instead, the SLT has laid out specific BMPs related to livestock management practices to reduce *E. coli* contamination. The implementation of five livestock BMP projects per year addressing nutrients in the targeted areas will no doubt result in less *E. coli* bacteria in the Delaware River Watershed's streams and rivers.

8. Information and Education

The SLT determined which Information and Education (I&E) activities are needed in the Delaware River Watershed. These important activities provide watershed residents with an improved awareness of local watershed issues, leading to increased adoption rates of BMPs. All I&E activities and events are evaluated based on productivity, attendance and achievement of objectives.

A. I&E Activities and Events Scheduled in the Delaware River Watershed

Listed below are the I&E activities and events along with their costs and possible sponsoring agencies. If all listed I&E events and activities take place, the total cost would be **$56,400**. *It is understood that funding from non-WRAPS sources will be required if all these activities are to take place.*

Table 44. I&E: Cropland BMP Education

Cropland BMP Implementation					
BMP	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
Buffers	Landowners and Producers	Field Day	Annual - Summer or Fall	$500	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, Kansas Alliance for Wetlands and Streams, and WRAPS
		Newspaper Article	Annual - 1/year in each Conservation District	No Cost	
		Conservation District and Extension Newsletter	Annual - Summer	No Cost	
		One-on-one consultations with landowners/producers	Annual – Summer	Cost included with Watershed Specialists.	
		Erect roadside signs highlighting riparian buffers	Annual - Ongoing	$100/sign	
Cover Crops	Landowners and Producers	Field Day or tour	Annual - Summer or Fall	No costs, held in conjunction with other cropland field day(s).	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, Kansas Alliance for Wetlands and Streams, and WRAPS
		Field day with soil pit, rainfall simulator, cover crop information shared.	Annual	$1,500	
		One-on-one consultations with crop landowners/producers	Annual - ongoing	Cost included in techncial assistance.	
		Conservation District and Extension Newsletter	Annual - 1/year in each Conservation District	No Cost	

Cropland BMP Implementation, Continued					
BMP	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
No-Till	Landowners and Producers	Demontration project utilizing cover crops in a no-till sytesm	Annual	$300 per project	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, Kansas Alliance for Wetlands and Streams, WRAPS and No-till on th Plains
		Newspaper Article	Annual	No Cost	
		Field day with soil pit, rainfall simulator, cover crop information shared.	Annual	No cost, held in conjunction with cover crop field day.	
		One-on-one consultations with crop landowners/producers	Annual - ongoing	Cost included in techncial assistance.	
		Scholarships to annual No-till Winter Conference	Annual - Winter	$1,500 ($150/person)	
		Conservation District and Extension Newsletter	Annual - 1/year in each Conservation District	No Cost	
Permanent Vegetation	Landowners and Producers	Field Day or tour	Annual - Summer or Fall	No costs, held in conjunction with other cropland field day(s).	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, Kansas Alliance for Wetlands and Streams, and WRAPS
		One-on-one consultations with landowners/producers	Annual - Ongoing	Cost included with Watershed Specialists.	
Subsurface Fertilizer	Landowners and Producers	Field day showing subsurface fertilizer application and equipment.	Annual - Summer	No costs, held in conjunction with other cropland field day(s).	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, Kansas Alliance for Wetlands and Streams, and WRAPS
Terraces	Landowners and Producers	Field Day or tour	Annual - Summer or Fall	No costs, held in conjunction with other cropland field day(s).	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, Kansas Alliance for Wetlands and Streams, and WRAPS
		One-on-one consultations with landowners/producers	Annual - Ongoing	Cost included with Watershed Specialists.	
Waterways	Landowners and Producers	Field Day or tour	Annual - Summer or Fall	No costs, held in conjunction with other cropland field day(s).	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, Kansas Alliance for Wetlands and Streams, and WRAPS
		One-on-one consultations with landowners/producers	Annual - Ongoing	Cost included with Watershed Specialists.	

Table 45. I&E: Livestock BMP Education

Livestock BMP Implementation					
BMP	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
Off-Stream Watering System	Livestock Producers	Demonstration Project	Annual	$5,000 per project	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, Kansas Alliance for Wetlands and Streams, and WRAPS
		One-on-one technical assistance	Annual	No Cost, included with technical assistance from sponsors.	
		Small-group livestock producer meetings	Annual		
		Livestock producer informational email list	Bi-monthly	No Cost	
		Field day or tour	Annual	$1,000 per field day	
		Livestock producer workshop	Annual - Fall or Winter	$500 per workshop	
		Newspaper Article	Biannual	No Cost	
Relocate Feeding Pens	Livestock Producers	Demonstration Project	Annual	$5,000 per project	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, Kansas Alliance for Wetlands and Streams, and WRAPS
		One-on-one technical assistance	Annual	No Cost, included with technical assistance from sponsors.	
		Small-group livestock producer meetings	Annual		
		Livestock producer informational email list	Bi-monthly	No Cost	
		Field day or tour	Annual	$1,000 per field day	
		Livestock producer workshop	Annual - Fall or Winter	$500 per workshop	
		Newspaper Article	Biannual	No Cost	
Relocate Pasture Feeding Sites	Livestock Producers	Demonstration Project	Annual	$500 per project	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, Kansas Alliance for Wetlands and Streams, and WRAPS
		One-on-one technical assistance	Annual	No Cost, included with technical assistance from sponsors.	
		Small-group livestock producer meetings	Annual		
		Livestock producer informational email list	Bi-monthly	No Cost	
		Field day or tour	Annual	$1,000 per field day	
		Livestock producer workshop	Annual - Fall or Winter	$500 per workshop	
		Newspaper Article	Biannual	No Cost	
Rotational Grazing	Livestock Producers	Demonstration Project	Annual	$5,000 per project	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, Kansas Alliance for Wetlands and Streams, and WRAPS
		One-on-one technical assistance	Annual	No Cost, included with technical assistance from sponsors.	
		Small-group livestock producer meetings	Annual		
		Livestock producer informational email list	Bi-monthly	No Cost	
		Field day or tour	Annual	$1,000 per field day	
		Livestock producer workshop	Annual - Fall or Winter	$500 per workshop	
		Newspaper Article	Biannual	No Cost	
Vegetative Filter Strips	Livestock Producers	Demonstration Project	Annual	$500 per project	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, Kansas Alliance for Wetlands and Streams, and WRAPS
		One-on-one technical assistance	Annual	No Cost, included with technical assistance from sponsors.	
		Small-group livestock producer meetings	Annual		
		Livestock producer informational email list	Bi-monthly	No Cost	
		Field day or tour	Annual	$1,000 per field day	
		Livestock producer workshop	Annual - Fall or Winter	$500 per workshop	
		Newspaper Article	Biannual	No Cost	

Table 46. I&E: Streambank BMP Education

Streambank BMP Implementation					
BMP	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
Streambank Stabilization	Landowners in Riparian Areas	One-on-One Technical Assistance for Landowners	Ongoing	Varies by project	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, Kansas Alliance for Wetlands and Streams, and WRAPS
		Field day at a completed streambank project	Annual – late Summer	$2,000	

Table 47. I&E: Delaware River Watershed Resident Education

General / Watershed-Wide Information and Education					
BMP	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
Education Activities Targeting Youth	Students and Educators	2-Day Educator Workshop (graduate credit for attending)	Annual	$3,000 per workshop	WRAPS, KACEE, Area Schools
		Sponsor teachers to attend Ag in the Classroom and other natural resource training events	Annual - Summer	$250 per teacher	Conservaation Districts, Kansas Foundation for Ag in the Classroom
		DVDs and other audio/visual materials with watershed topics	Annual - Ongoing	$250	Conservation Districts, area schools, and WRAPS
		Earth Day	Annual	No Cost	
		Classroom presentations	Annual - Ongoing	No Cost	
		Envirothon and other youth education events	Annual - Spring	$250	Kansas Farm Bureau, Conservation Districts, K-State Research and Extension
		Conservation poster contest	Annual - Winter	No Cost	Conservation Districts and area schools
		Participate in career days	Ongoing	No Cost	Kansas Universities/Colleges, and WRAPS
		Service learning projects with K-12 and college level	Annual - Ongoing	$5,000 per project (college level) No Cost for K-12	

General / Watershed-Wide Information and Education, Continued					
BMP	Target Audience	Information/Education Activity/Event	Time Frame	Estimated Costs	Sponsor/Responsible Agency
Education Activities Targeting Adults	Watershed Residents	Maintain a Delaware River WRAPS Website	Annual - Ongoing	$500	WRAPS
		Watershed Announcements/ Advertisement (television, radio, newspaper, etc.)	Annual - Ongoing	No Cost	WRAPS
		WRAPS Newsletter	Annual - Winter	$5,000	WRAPS
		River Friendly Farms	Annual - Ongoing	$150	Kansas Rural Center
		Media campaign to promote forestry practices	Annual - Ongoing	$600	Kansas Forest Service
		Educational presentations to conservation districts and community groups	Annual - Ongoing	No Cost	WRAPS
		Watershed tour highlighting practices	Annual - Fall	$1,500	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, Kansas Alliance for Wetlands and Streams, and WRAPS
		Referral Program provides information and referral to technical assistance individuals	Annual - Ongoing	$5,000	Jefferson County Health Department, Conservation Districts
		Wastewater Installers Conference	Annual - Ongoing	$1,000	Northeast Kansas Environmental Services
		Abandoned well plugging demonstration	Annual - Summer	$500	Conservation Districts
		Delaware River Watershed and BMP brochures	Annual	$1,000	WRAPS
		Rain barrel/rain garden workshop	Biannual - Spring and late Summer	$1,000	Conservation Districts and WRAPS
		"Urban" BMP field day or tour	Biannual	$500	WRAPS
		Absentee landowner newsletter	Annual	$1,500	WRAPS
Total Cost (per year) for All Information and Education Activities				**$56,400**	

B. Evaluation of Information and Education Activities

All service providers conducting I&E activities funded through the Delaware River Watershed WRAPS will be required to include an evaluation component in their project implementation proposals. Evaluation methods will vary based on the activity. All service providers will be required to submit a brief written evaluation of their I&E activity summarizing the activity's success in achieving the learning objectives, and how the activity contributed to achieving long-term WRAPS goals and/or objectives for pollutant load reductions.

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 or activity, development of a basic logic model identifying long-, medium-, and short-term behavior changes or other expected outcomes 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, usefulness of information, etc.;
- pre- and post-surveys to determine the amount of knowledge gained, anticipated behavior changes, need for further learning, etc.; and
- follow-up interviews (e.g., one-on-one contacts, phone calls, or e-mails) with selected participants to gather more in-depth input regarding the effectiveness of the I&E activity.

9. Cost of Implementing BMPs and Funding Sources

The SLT reviewed all the recommended BMPs listed in this WRAPS plan to address the eutrophication and total phosphorus TMDLS and determined which BMPs will receive implementation funding in each category (cropland, livestock, and streambank areas). An added benefit is that most of the targeted BMPs will have positive impacts on other impairments in the Delaware River Watershed, including the biology and *E. coli* TMDLs, while reducing erosion and sediment loss. Below are expenses before and after cost-share for implementing cropland, livestock, and streambank BMPs. Costs can be shared with any potential funding sources (**Table 55**). Cost derivations are located in the appendix.

A. Cropland BMP Implementation Costs

Table 48. Implementation Costs: Cropland BMP Costs Before Cost-Share

Annual Cost* Before Cost-Share, Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Cost
1	$439,831	$55,534	$22,214	$33,321	$6,664	$111,068	$166,603	$835,234
2	$453,026	$57,200	$22,880	$34,320	$6,864	$114,400	$171,601	$860,291
3	$466,616	$58,916	$23,566	$35,350	$7,070	$117,832	$176,749	$886,100
4	$480,615	$60,684	$24,273	$36,410	$7,282	$121,367	$182,051	$912,683
5	$495,033	$62,504	$25,002	$37,503	$7,501	$125,008	$187,513	$940,063
6	$509,884	$64,379	$25,752	$38,628	$7,726	$128,759	$193,138	$968,265
7	$525,181	$66,311	$26,524	$39,786	$7,957	$132,621	$198,932	$997,313
8	$540,936	$68,300	$27,320	$40,980	$8,196	$136,600	$204,900	$1,027,232
9	$557,164	$70,349	$28,140	$42,209	$8,442	$140,698	$211,047	$1,058,049
10	$573,879	$72,459	$28,984	$43,476	$8,695	$144,919	$217,378	$1,089,791
11	$591,096	$74,633	$29,853	$44,780	$8,956	$149,267	$223,900	$1,122,484
12	$608,828	$76,872	$30,749	$46,123	$9,225	$153,745	$230,617	$1,156,159
13	$627,093	$79,178	$31,671	$47,507	$9,501	$158,357	$237,535	$1,190,844
14	$645,906	$81,554	$32,622	$48,932	$9,786	$163,108	$244,661	$1,226,569
15	$665,283	$84,000	$33,600	$50,400	$10,080	$168,001	$252,001	$1,263,366
16	$685,242	$86,520	$34,608	$51,912	$10,382	$173,041	$259,561	$1,301,267
17	$705,799	$89,116	$35,646	$53,470	$10,694	$178,232	$267,348	$1,340,305
18	$726,973	$91,790	$36,716	$55,074	$11,015	$183,579	$275,369	$1,380,514
19	$748,782	$94,543	$37,817	$56,726	$11,345	$189,086	$283,630	$1,421,930
20	$771,246	$97,379	$38,952	$58,428	$11,686	$194,759	$292,138	$1,464,588
21	$794,383	$100,301	$40,120	$60,181	$12,036	$200,602	$300,903	$1,508,525
22	$818,214	$103,310	$41,324	$61,986	$12,397	$206,620	$309,930	$1,553,781
23	$842,761	$106,409	$42,564	$63,846	$12,769	$212,818	$319,228	$1,600,394
24	$868,044	$109,601	$43,841	$65,761	$13,152	$219,203	$328,804	$1,648,406
25	$894,085	$112,890	$45,156	$67,734	$13,547	$225,779	$338,669	$1,697,858
26	$920,908	$116,276	$46,510	$69,766	$13,953	$232,552	$348,829	$1,748,794
27	$948,535	$119,764	$47,906	$71,859	$14,372	$239,529	$359,293	$1,801,258
28	$976,991	$123,357	$49,343	$74,014	$14,803	$246,715	$370,072	$1,855,296
29	$1,006,301	$127,058	$50,823	$76,235	$15,247	$254,116	$381,174	$1,910,955
30	$1,036,490	$130,870	$52,348	$78,522	$15,704	$261,740	$392,610	$1,968,283
Totals	**$20,925,124**	**$2,642,061**	**$1,056,824**	**$1,585,237**	**$317,047**	**$5,284,122**	**$7,926,183**	**$39,736,598**

**3% Inflation*

Table 49. Implementation Costs: Cropland BMP Costs After Cost-Share

Annual Cost* After Cost-Share, Cropland BMPs								
Year	**Buffers**	**Cover Crop**	**No-Till**	**Permanent Vegetation**	**Subsurface Fertilizer**	**Terraces**	**Waterways**	**Total Cost**
1	$43,983	$11,107	$11,107	$9,996	$2,666	$44,427	$83,301	$206,587
2	$45,303	$11,440	$11,440	$10,296	$2,746	$45,760	$85,800	$212,785
3	$46,662	$11,783	$11,783	$10,605	$2,828	$47,133	$88,374	$219,168
4	$48,061	$12,137	$12,137	$10,923	$2,913	$48,547	$91,026	$225,743
5	$49,503	$12,501	$12,501	$11,251	$3,000	$50,003	$93,756	$232,516
6	$50,988	$12,876	$12,876	$11,588	$3,090	$51,503	$96,569	$239,491
7	$52,518	$13,262	$13,262	$11,936	$3,183	$53,049	$99,466	$246,676
8	$54,094	$13,660	$13,660	$12,294	$3,278	$54,640	$102,450	$254,076
9	$55,716	$14,070	$14,070	$12,663	$3,377	$56,279	$105,524	$261,698
10	$57,388	$14,492	$14,492	$13,043	$3,478	$57,968	$108,689	$269,549
11	$59,110	$14,927	$14,927	$13,434	$3,582	$59,707	$111,950	$277,636
12	$60,883	$15,374	$15,374	$13,837	$3,690	$61,498	$115,308	$285,965
13	$62,709	$15,836	$15,836	$14,252	$3,801	$63,343	$118,768	$294,544
14	$64,591	$16,311	$16,311	$14,680	$3,915	$65,243	$122,331	$303,380
15	$66,528	$16,800	$16,800	$15,120	$4,032	$67,200	$126,001	$312,482
16	$68,524	$17,304	$17,304	$15,574	$4,153	$69,216	$129,781	$321,856
17	$70,580	$17,823	$17,823	$16,041	$4,278	$71,293	$133,674	$331,512
18	$72,697	$18,358	$18,358	$16,522	$4,406	$73,432	$137,684	$341,457
19	$74,878	$18,909	$18,909	$17,018	$4,538	$75,635	$141,815	$351,701
20	$77,125	$19,476	$19,476	$17,528	$4,674	$77,904	$146,069	$362,252
21	$79,438	$20,060	$20,060	$18,054	$4,814	$80,241	$150,451	$373,119
22	$81,821	$20,662	$20,662	$18,596	$4,959	$82,648	$154,965	$384,313
23	$84,276	$21,282	$21,282	$19,154	$5,108	$85,127	$159,614	$395,842
24	$86,804	$21,920	$21,920	$19,728	$5,261	$87,681	$164,402	$407,718
25	$89,409	$22,578	$22,578	$20,320	$5,419	$90,312	$169,334	$419,949
26	$92,091	$23,255	$23,255	$20,930	$5,581	$93,021	$174,414	$432,548
27	$94,853	$23,953	$23,953	$21,558	$5,749	$95,812	$179,647	$445,524
28	$97,699	$24,671	$24,671	$22,204	$5,921	$98,686	$185,036	$458,890
29	$100,630	$25,412	$25,412	$22,870	$6,099	$101,647	$190,587	$472,656
30	$103,649	$26,174	$26,174	$23,557	$6,282	$104,696	$196,305	$486,836
Totals	**$2,092,512**	**$528,412**	**$528,412**	**$475,571**	**$126,819**	**$2,113,649**	**$3,963,092**	**$9,828,467**

**3% Inflation*

B. Livestock BMP Implementation Costs

Table 50. Implementation Costs: Livestock BMPs Before Cost-Share

Annual Cost* Before Cost-Share, Livestock BMPs						
Year	Off-Stream Watering System	Relocate Feeding Pens	Relocate Pasture Feeding Site	Rotational Grazing	Vegetative Filter Strip	Total Cost
1	$3,795	$6,621	$2,203	$7,000	$714	$20,333
2	$3,909	$6,820	$2,269	$7,210	$735	$20,943
3	$4,026	$7,024	$2,337	$7,426	$757	$21,571
4	$4,147	$7,235	$2,407	$7,649	$780	$22,218
5	$4,271	$7,452	$2,479	$7,879	$804	$22,885
6	$4,399	$7,676	$2,554	$8,115	$828	$23,572
7	$4,531	$7,906	$2,630	$8,358	$853	$24,279
8	$4,667	$8,143	$2,709	$8,609	$878	$25,007
9	$4,807	$8,387	$2,791	$8,867	$904	$25,757
10	$4,952	$8,639	$2,874	$9,133	$932	$26,530
11	$5,100	$8,898	$2,961	$9,407	$960	$27,326
12	$5,253	$9,165	$3,049	$9,690	$988	$28,146
13	$5,411	$9,440	$3,141	$9,980	$1,018	$28,990
14	$5,573	$9,723	$3,235	$10,280	$1,049	$29,860
15	$5,740	$10,015	$3,332	$10,588	$1,080	$30,755
16	$5,912	$10,315	$3,432	$10,906	$1,112	$31,678
17	$6,090	$10,625	$3,535	$11,233	$1,146	$32,628
18	$6,273	$10,944	$3,641	$11,570	$1,180	$33,607
19	$6,461	$11,272	$3,750	$11,917	$1,216	$34,616
20	$6,655	$11,610	$3,863	$12,275	$1,252	$35,654
21	$6,854	$11,958	$3,979	$12,643	$1,290	$36,724
22	$7,060	$12,317	$4,098	$13,022	$1,328	$37,825
23	$7,272	$12,687	$4,221	$13,413	$1,368	$38,960
24	$7,490	$13,067	$4,348	$13,815	$1,409	$40,129
25	$7,714	$13,459	$4,478	$14,230	$1,451	$41,333
26	$7,946	$13,863	$4,613	$14,656	$1,495	$42,573
27	$8,184	$14,279	$4,751	$15,096	$1,540	$43,850
28	$8,430	$14,707	$4,893	$15,549	$1,586	$45,165
29	$8,683	$15,148	$5,040	$16,015	$1,634	$46,520
30	$8,943	$15,603	$5,192	$16,496	$1,683	$47,916
Totals	**$180,549**	**$314,997**	**$104,809**	**$333,028**	**$33,969**	**$967,351**

** 3% Inflation*

Table 51. Implementation Costs: Livestock BMPs After Cost-Share

Annual Cost* After Cost-Share, Livestock BMPs						
Year	Off-Stream Watering System	Relocate Feeding Pens	Relocate Pasture Feeding Site	Rotational Grazing	Vegetative Filter Strip	Total Cost
1	$1,898	$3,311	$1,102	$3,500	$357	$10,167
2	$1,954	$3,410	$1,135	$3,605	$368	$10,471
3	$2,013	$3,512	$1,169	$3,713	$379	$10,786
4	$2,073	$3,617	$1,204	$3,825	$390	$11,109
5	$2,136	$3,726	$1,240	$3,939	$402	$11,442
6	$2,200	$3,838	$1,277	$4,057	$414	$11,786
7	$2,266	$3,953	$1,315	$4,179	$426	$12,139
8	$2,334	$4,071	$1,355	$4,305	$439	$12,504
9	$2,404	$4,194	$1,395	$4,434	$452	$12,879
10	$2,476	$4,319	$1,437	$4,567	$466	$13,265
11	$2,550	$4,449	$1,480	$4,704	$480	$13,663
12	$2,627	$4,583	$1,525	$4,845	$494	$14,073
13	$2,705	$4,720	$1,570	$4,990	$509	$14,495
14	$2,787	$4,862	$1,618	$5,140	$524	$14,930
15	$2,870	$5,007	$1,666	$5,294	$540	$15,378
16	$2,956	$5,158	$1,716	$5,453	$556	$15,839
17	$3,045	$5,312	$1,768	$5,616	$573	$16,314
18	$3,136	$5,472	$1,821	$5,785	$590	$16,804
19	$3,230	$5,636	$1,875	$5,959	$608	$17,308
20	$3,327	$5,805	$1,931	$6,137	$626	$17,827
21	$3,427	$5,979	$1,989	$6,321	$645	$18,362
22	$3,530	$6,159	$2,049	$6,511	$664	$18,913
23	$3,636	$6,343	$2,111	$6,706	$684	$19,480
24	$3,745	$6,534	$2,174	$6,908	$705	$20,064
25	$3,857	$6,730	$2,239	$7,115	$726	$20,666
26	$3,973	$6,931	$2,306	$7,328	$747	$21,286
27	$4,092	$7,139	$2,375	$7,548	$770	$21,925
28	$4,215	$7,354	$2,447	$7,775	$793	$22,583
29	$4,341	$7,574	$2,520	$8,008	$817	$23,260
30	$4,472	$7,801	$2,596	$8,248	$841	$23,958
Totals	**$90,274**	**$157,498**	**$52,404**	**$166,514**	**$16,984**	**$483,675**

** 3% Inflation*

C. Streambank Stabilization/Restoration Implementation Costs

Table 52. Implementation Costs: Streambank Stabilization/Restoration

Delaware River Watershed Annual Streambank Stabilization/Restoration Cost		
Year	**Streambank Stabilization (linear feet)**	**Annual Cost***
1	2,393	$231,116
2	2,393	$238,049
3	2,393	$245,191
4	2,393	$252,547
5	2,393	$260,123
6	2,393	$267,927
7	2,393	$275,965
8	2,393	$284,243
9	2,393	$292,771
10	2,393	$301,554
11	2,393	$310,600
12	2,393	$319,919
13	2,393	$329,516
14	2,393	$339,402
15	2,393	$349,584
16	2,393	$360,071
17	2,393	$370,873
18	2,393	$381,999
19	2,393	$393,459
20	2,393	$405,263
21	2,393	$417,421
22	2,393	$429,944
23	2,393	$442,842
24	2,393	$456,127
25	2,393	$469,811
26	2,393	$483,905
27	2,393	$498,423
28	2,393	$513,375
29	2,393	$528,777
30	2,393	$544,640
Totals	**71,790 linear feet**	**$10,995,437**
** 3% Inflation*		

D. Total Costs for BMP Implementation and Education

Table 53. Cost to Implement the Delaware River WRAPS Plan

Total Cost to Implement WRAPS Plan, After Cost-Share					
Year	Cropland	Livestock	Streambank	I&E	Total Cost
1	$206,587	$10,167	$231,116	$56,400	$504,270
2	$212,785	$10,471	$238,049	$58,092	$519,398
3	$219,168	$10,786	$245,191	$59,835	$534,980
4	$225,743	$11,109	$252,547	$61,630	$551,029
5	$232,516	$11,442	$260,123	$63,479	$567,560
6	$239,491	$11,786	$267,927	$65,383	$584,587
7	$246,676	$12,139	$275,965	$67,345	$602,124
8	$254,076	$12,504	$284,243	$69,365	$620,188
9	$261,698	$12,879	$292,771	$71,446	$638,794
10	$269,549	$13,265	$301,554	$73,589	$657,957
11	$277,636	$13,663	$310,600	$75,797	$677,696
12	$285,965	$14,073	$319,919	$78,071	$698,027
13	$294,544	$14,495	$329,516	$80,413	$718,968
14	$303,380	$14,930	$339,402	$82,825	$740,537
15	$312,482	$15,378	$349,584	$85,310	$762,753
16	$321,856	$15,839	$360,071	$87,869	$785,636
17	$331,512	$16,314	$370,873	$90,505	$809,205
18	$341,457	$16,804	$381,999	$93,221	$833,481
19	$351,701	$17,308	$393,459	$96,017	$858,485
20	$362,252	$17,827	$405,263	$98,898	$884,240
21	$373,119	$18,362	$417,421	$101,865	$910,767
22	$384,313	$18,913	$429,944	$104,921	$938,090
23	$395,842	$19,480	$442,842	$108,068	$966,233
24	$407,718	$20,064	$456,127	$111,310	$995,220
25	$419,949	$20,666	$469,811	$114,650	$1,025,076
26	$432,548	$21,286	$483,905	$118,089	$1,055,828
27	$445,524	$21,925	$498,423	$121,632	$1,087,503
28	$458,890	$22,583	$513,375	$125,281	$1,120,128
29	$472,656	$23,260	$528,777	$129,039	$1,153,732
30	$486,836	$23,958	$544,640	$132,910	$1,188,344
Totals	**$9,828,467**	**$483,675**	**$10,995,437**	**$2,683,253**	**$23,990,833**

10. Technical Assistance and Funding Sources

Technical assistance and various funding sources may be required to implement the BMPs and the watershed education programs listed in this WRAPS plan. Possible technical assistance providers and funding sources are presented in **Tables 54** and **55.**

Table 54. Potential Technical Assistance Providers for Plan Implementation

Technical Assistance to Aid in BMP Implementation		
BMPs To Be Implemented		**Technical Assistance**
Cropland	Buffers	Delaware River WRAPS Coordinators, Atchison, Brown, Jackson, Jefferson and Nemaha County Conservation Districts, Farm Service Agency, Kansas Department of Wildlife, Parks and Tourism, Kansas Forest Service, NRCS, River Friendly Farms Technician, Kansas Alliance for Wetlands and Streams (KAWS), and the KSRE Watershed Specialists
	Cover Crops	
	No-Till	
	Permanent Vegetation	
	Subsurface Fertilizer	
	Terraces	
	Waterways	
Livestock	Off-Stream Watering System	
	Relocating Feeding Pens	
	Relocate Pasture Feeding Sites	
	Rotational Grazing	
	Vegetative Filter Strips	
Streambank	Streambank Restoration	

Table 55. Potential Funding Sources for Plan Implementation

Potential BMP Funding Sources	
Potential Funding Sources	**Potential Funding Programs**
United States Department of Agriculture (USDA): Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA)	Environmental Quality Incentives Program (EQIP)
	Conservation Reserve Program (CRP)
	Continuous Conservation Reserve Program (CCRP)
	Wetland Reserve Program (WRP)
	Wildlife Habitat Incentive Program (WHIP)
	Forestland Enhancement Program (FLEP)
	State Acres for Wildlife Enhancement (SAFE)
	Grassland Reserve Program (GRP)
	Farmable Wetlands Program (FWP)
Environmental Protection Agency (EPA) and the Kansas Department of Health and Environment (KDHE)	Section 319 Clean Water Act funds
	State Revolving Fund (SRF)
	American Recovery and Reinvestment Act (ARRA)
	WRAPS Grants
Kansas Department of Wildlife, Parks and Tourism (KDWPT)	Partnering for Wildlife
	Wildlife Habitat Incentive Program (WHIP)
Division of Conservation (DOC)	State Water Resources Cost Share Program (SWRCSP)
	Streambank Restoration funds
	Riparian and Wetland Protection Program (RWPP)
	Governor's Water Quality Buffer Initiative
	Landowner incentive funds for streambank restoration projects
	Conservation Districts Non-point Source Pollution Funds (NPS)
Kansas Forest Service	Rural Forestry Program
	Forestland Enhancement Program (FLEP)
Kansas State University, Research & Extension	Varies
Kansas Rural Center	River Friendly Farms Program
Pheasants Forever, Quail Forever and other private entities	Varies

11. Measurable Milestones

The interim timeframe for all BMP implementation is five years from the date of publication of this report. Targeting and BMP implementation may shift over time in order to achieve TMDLs.

The WRAPS estimated timeframe for reaching the **nitrogen portion of the eutrophication TMDL** in Perry Lake is in year 17 of this 30-year WRAPS plan. The **phosphorus portion of the eutrophication TMDL** in Perry Lake and the **total phosphorus TMDL** in the Delaware River near Half Mound will be met in year 20 of this WRAPS plan. After the nitrogen and phosphorus goals are achieved, the process will become one of protection rather than restoration.

Although there are siltation TMDLs in the Delaware River Watershed, they were not targeted specifically. However, the SLT made sediment reductions a priority to protect the watershed's streams and lakes from further degradation, which will reduce sediment erosion throughout the watershed, including those TMDL- and 303d-listed for siltation. It is estimated that the **siltation goal** in the Delaware River Watershed will be attained in year 30 of this WRAPS plan. After the siltation TMDL is achieved, the process will become one of protection, rather than restoration.

Implementing the BMPs outlined in this plan to achieve the eutrophication TMDL and sediment goal will subsequently reduce sediment and nutrient loading into local stream segments and Perry Lake. The SLT hopes that the implementation of these BMPs will result in the delisting of the eutrophication TMDL in Perry Lake, the total phosphorus TMDL in the Delaware River near Half Mound, as well as other TMDLs and 303d-listed impairments including E. coli *in the Delaware River near Half Mound.*

A. Measurable Milestones for BMP Implementation

Milestones will be determined at the end of every five years by number of acres treated, projects installed, contacts made to watershed residents and water quality parameters. The SLT will examine these criteria to determine if adequate progress has been made on BMP implementations to date. 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 30 years, as stipulated in this WRAPS plan.

Table 56. Delaware Cumulative Cropland BMP Adoption Milestones

Cropland BMP Implementation Milestones (acres)									
	Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Adoption
Short-Term	1	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	2	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	3	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	4	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	5	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	Subtotal	*7,331*	*11,107*	*11,107*	*1,111*	*1,111*	*11,107*	*6,664*	*49,536*
Medium-Term	6	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	7	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	8	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	9	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	10	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	Subtotal	*14,661*	*22,214*	*22,214*	*2,221*	*2,221*	*22,214*	*13,328*	*99,073*
Long-Term	11	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	12	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	13	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	14	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	15	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	16	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	17	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	18	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	19	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	20	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	21	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	22	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	23	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	24	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	25	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	26	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	27	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	28	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	29	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	30	1,466	2,221	2,221	222	222	2,221	1,333	9,907
	Total	**43,983**	**66,641**	**66,641**	**6,664**	**6,664**	**66,641**	**39,985**	**297,219**

Table 57. Delaware Cumulative Livestock BMP Adoption Milestones

Annual Livestock BMP Adoption (projects)							
	Year	Off-Stream Watering System	Relocate Feeding Pens	Relocate Pasture Feeding Site	Rotational Grazing	Vegetative Filter Strip	Total Adoption
Short-Term	1	1	1	1	1	1	5
	2	1	1	1	1	1	5
	3	1	1	1	1	1	5
	4	1	1	1	1	1	5
	5	1	1	1	1	1	5
	Subtotal	*5*	*5*	*5*	*5*	*5*	*25*
Medium-Term	6	1	1	1	1	1	5
	7	1	1	1	1	1	5
	8	1	1	1	1	1	5
	9	1	1	1	1	1	5
	10	1	1	1	1	1	5
	Subtotal	*10*	*10*	*10*	*10*	*10*	*50*
Long-Term	11	1	1	1	1	1	5
	12	1	1	1	1	1	5
	13	1	1	1	1	1	5
	14	1	1	1	1	1	5
	15	1	1	1	1	1	5
	16	1	1	1	1	1	5
	17	1	1	1	1	1	5
	18	1	1	1	1	1	5
	19	1	1	1	1	1	5
	20	1	1	1	1	1	5
	21	1	1	1	1	1	5
	22	1	1	1	1	1	5
	23	1	1	1	1	1	5
	24	1	1	1	1	1	5
	25	1	1	1	1	1	5
	26	1	1	1	1	1	5
	27	1	1	1	1	1	5
	28	1	1	1	1	1	5
	29	1	1	1	1	1	5
	30	1	1	1	1	1	5
	Total	**30**	**30**	**30**	**30**	**30**	**150**

Table 58. Delaware Cumulative Streambank Stabilization Milestones

Streambank Stabilization Milestones (linear feet)		
	Year	Streambank Stabilization (lf)
Short-Term	1	2,393
	2	2,393
	3	2,393
	4	2,393
	5	2,393
	Subtotal	*11,965*
Medium-Term	6	2,393
	7	2,393
	8	2,393
	9	2,393
	10	2,393
	Subtotal	*23,930*
Long-Term	11	2,393
	12	2,393
	13	2,393
	14	2,393
	15	2,393
	16	2,393
	17	2,393
	18	2,393
	19	2,393
	20	2,393
	21	2,393
	22	2,393
	23	2,393
	24	2,393
	25	2,393
	26	2,393
	27	2,393
	28	2,393
	29	2,393
	30	2,393
	Total	**71,790**

B. Benchmarks to Measure Water Quality and Social Progress

The goal of this WRAPS plan is that in the next five- to 30-year time frame, the Delaware River Watershed will see improved water quality throughout the watershed, specifically in the Delaware River near Half Mound, and in Mission and Perry Lakes. To monitor these improvements, measurements taken at Perry Lake are important because the lake is the drainage endpoint of the watershed. Social indicators of success also will be examined by tracking traffic in Mission and Perry Lakes. A good example of a healthy lake ecosystem is frequent visits by the public to enjoy outdoor recreation at the lake and the park.

After reviewing the criteria listed in **Table 59**, the SLT will assess and revise the overall strategy plan for the watershed every five years. New goals will be set and new BMPs will be implemented in order to achieve improved water quality. KDHE TMDL staff, Water Plan staff and the SLT will coordinate every five years to discuss benchmarks and TMDL update plans. Using data obtained by KDHE, USGS, and/or USACE, the following indicator and parameter criteria shall be used to assess progress toward successful implementation to abate pollutant loads.

Table 59. Delaware River Watershed Benchmarks to Measure Progress

Benchmarks to Measure Water Quality Progress		
Impairment Addressed	**Criteria to Measure Water Quality Progress**	**Information Source**
Nutrients	**Perry Lake:** Summer chlorophyll α concentration ≤ 10 μg/L	KDHE
Sediment	**Mission Lake:** Nonalgal Turbidity (NAT) < 1 m^{-1}	KDHE
	Delaware River Watershed: Fewer high-event stream flow rates indicating better retention and slower release of storm water yhroughout the Delaware River Watershed	USGS
Total Phosphorus	**Delaware River Watershed near Half Mound:** ALUS Index > 13 Sestonic Chlorophyll ≤ 10 μg/L Dissolved oxygen concentrations > 5.0 mg/L, with saturation < 110% pH values within the range of 6.5 to 8.5.	KDHE
E. coli	Less frequent exceedances or lowered magnitude of exceedances of the nominal *E. coli* Bacteria (ECB) criterion: 262 Colony Forming Units (CFUs/100 ml) for the sampling stations above Perry Lake.	
Impairment Addressed	**Social Indicators to Measure Water Quality Progress**	**Information Source**
Sediment/ Nutrients/ *E. coli*	Visitor traffic to Perry and Mission Lakes	KDWPT
	Boating traffic in Perry and Mission Lakes	KDWPT
	Trends of quantity and quality of fishing in Perry and Mission Lakes	KDWPT
	Beach closing at Perry and Mission Lakes	KDHE
	Taste and odor issues in public water supply drawn from Delaware River Watershed water segments	KDHE
	Occurrence of algal blooms in Perry and Mission Lakes	KDHE
	Survey of water quality issues to determine whether information and education programs are having an effect on public perception	KSRE
	Number of attendees at tours and field days	KSRE
	Number of acres of BMPs implemented in the targeted areas	NRCS

C. Water Quality Milestones Used to Determine Improvements

The goal of the Delaware River Watershed WRAPS plan is to restore water quality for uses that support aquatic life, primary-contact recreation and public water supply for Perry Lake and the watershed as a whole. This restoration plan specifically addresses the high-priority eutrophication (Perry Lake), total phosphorus, and *E. coli* (Delaware River near Half Mound) TMDLS, as well as the sediment impairments throughout the watershed to include the high-priority TMDL in Mission Lake. In order to reach load reduction goals, a BMP implementation schedule spanning 30 years has been developed. Water quality milestones are established to measure water quality improvements within the watershed due to plan implementation.

The BMPs included in this plan will be implemented along the riparian corridors of cropland and livestock areas throughout the Delaware River Watershed, cropland acres that are upland in the north and northeast portion of the watershed, as well as streambanks along the Delaware River north of Perry Lake. With these targeted areas in place, BMP implementation will result in positive impacts on water quality and impairment listings throughout the watershed, including the Delaware River, Mission Lake, and Perry Lake.

Water quality milestones have been developed for Mission and Perry Lakes and the Delaware River near Half Mound, along with additional indicators of water quality. The purpose of the milestones and indicators is to measure water quality improvements associated with the BMP implementation schedule contained in this plan. These water quality indicators will enable KDHE and the Delaware River WRAPS to measure water quality improvements in the watershed above Perry Lake, which should have direct effects on the water quality in the lake itself.

D. Water Quality Milestones for Perry Lake

As previously stated, to reach the nutrient load reduction goals for Perry Lake a BMP implementation schedule spanning 30 years has been developed, with several water quality milestones and indicators developed for Perry Lake. Water quality measures such as concentrations of total nitrogen, total phosphorus, and chlorophyll *a* measurements will be utilized to determine the effectiveness of the BMPs implemented as part of this plan's outlined nutrient load reduction goals.

Perry Lake is deemed to be fully eutrophic, as its average chlorophyll *a* concentration is 18.8 µg/L with a trophic state index (TSI) of 59.4. Median values based on data from KDHE and USACE from 1996-2009 – including the Carlson Trophic State Indices for Chlorophyll *a* (18.05), Secchi depth (114 centimeters), total nitrogen (900 µg/L), and total phosphorus (68 µg/L) – showed a generally consistent state of fully eutrophic to very eutrophic conditions for the four parameters within Perry Lake.

Long-term water quality goals/milestones for various parameters monitored in Perry Lake have been calculated by KDHE. Nutrient goals for nitrogen and phosphorus are required to meet the eutrophication TMDL in Perry Lake (**Table 60**). BMP implementation for nutrients was targeted in nearly the entire watershed for cropland, livestock and streambank areas. It should be noted that this WRAPS plan addresses phosphorus in a manner that combines the phosphorus reductions required by the eutrophication TMDL and the total phosphorus TMDL in the Delaware River near Half Mound. The milestones listed in **Table 60** for phosphorus are specific to the eutrophication TMDL needs in Perry Lake and do not include the total phosphorus milestones for the Delaware River near Half Mound's TMDL.

While Perry Lake does not have a siltation TMDL or impairment, sediment loading is of concern for the lake. Since Perry Lake sits at the base of the watershed, improvements in chlorophyll *a* and Secchi depth would indicate that watershed-wide sediment BMP implementation has been successful (**Table 61**). BMP implementation for sediment is targeted in nearly the entire watershed for cropland and streambank areas.

Table 60. Water Quality Milestones: Eutrophication in Perry Lake[30]

Water Quality Milestones for Perry Lake: Eutrophication										
Sampling Site	Current Condition	10-Year Goal		Long-Term Goal		Current Condition	10-Year Goal		Long-Term Goal	
	1996 - 2010 Average TN	Improved Condition (2011 - 2021) Average TN	Total Reduction Needed	Improved Condition Average TN	Total Reduction Needed	1996 - 2010 Average TP	Improved Condition (2012 - 2021) Average TP	Total Reduction Needed	Improved Condition Average TP	Total Reduction Needed
	Total Nitrogen (TN) (average of data collected during indicated period), ppb					Total Phosphorus (TP) (average of data collected during indicated period), ppb				
Perry Lake LM029001	0.92	0.75	0.17	0.39	53%	76	60	16	29	47%

Table 61. Water Quality Milestones: Sediment in Perry Lake[31]

Water Quality Milestones for Perry Lake: Sediment								
Sampling Site	Current Condition	10-Year Goal		Long-Term Goal		Current Condition	10-Year Goal	Long-Term Goal
	1996 - 2010 Chlorophyll *a*	Improved Condition (2011 - 2021) Chlorophyll *a*	Total Reduction Needed	Improved Condition Chlorophyll *a*	Total Reduction Needed	1996 - 2010 Secchi Average	Improved Condition (2011 - 2021) Secchi Average	Improved Condition Secchi Average
	Chlorophyll *a* (average of data collected during indicated period), ppb					Secchi (average of data collected during indicated period), meter		
Perry Lake LM029001	17.5	12	5.5	10	7%	1.12	Secchi depth > 1.5	Maintain Secchi depth > 1.0 m

E. Water Quality Milestones for the Delaware River near Half Mound

The Delaware River drains into Perry Lake and has total phosphorus (TP) and *E. coli* TMDLs near Half Mound.

1. Water quality milestones for TP

There are two TP impairments in the Delaware River Watershed: the high-priority TP TMDL in the Delaware River near Half Mound and the 303d-listed Grasshopper Creek near Muscotah. The TP TMDL was rolled into the phosphorus portion of the eutrophication TMDL, to create just one TP goal for the entire watershed. **Table 62** shows the milestones for TP, specific to the Delaware River near Half Mound and Grasshopper Creek near Muscotah, although Grasshopper Creek is not a targeted goal of this WRAPS plan. BMP

[30] Perry Lake Water Quality Milestones provided by KDHE in 2011 for original WRAPS plan.
[31] Perry Lake Water Quality Milestones provided by KDHE in 2011 for original WRAPS plan.

implementation for nutrients was targeted in nearly the entire watershed for cropland, livestock, and streambank areas, therefore it can be assumed that positive impacts have been made in both the Delaware River and in Grasshopper Creek.

Table 62. Water Quality Milestones: Total Phosphorus

Water Quality Milestones for the Delaware River near Half Mound: Total Phosphorus					
Sampling Site	Current Condition	10-Year Goal		Long-Term Goal	
	2000 - 2009 Average TP	Improved Condition (2011 - 2021) Average TP	Total Reduction Needed	Improved Condition Average TP	Total Reduction Needed
	Total Nitrogen (TP) (average of data collected during indicated period), ppb				
Delaware River near Half Mound SC555	205	200	7	0.98	30%
Grasshopper Creek SC063	235	200	35	165	30%

2. Water quality milestones for *E. coli*[32]

The Delaware River near Half Mound has a high-priority *E. coli* TMDL. Livestock areas targeted for nutrient reductions will aid in reducing *E. coli* bacteria in the river. The desired endpoint of this TMDL will be to reduce the percent of samples over the applicable criteria from 29% to fewer than 10% for samples taken at flows below the high flow exclusion over the monitoring period of 2004-2008. This TMDL endpoint meets water quality standards as measured and determined by Kansas Water Quality Assessment protocols. These assessment protocols are similar to those used to cite the stream segments in this watershed as impaired on the Kansas 1998 Section 303d list.

Seasonal variation in endpoints is accounted for by TMDL curves established for each season and will be evaluated based on monitoring data from 2004-2008. Monitoring data plotting below the applicable seasonal TMDL curves will indicate attainment of the water quality standards. As with the overall endpoint, the manner of evaluation of the seasonal endpoints is consistent with the assessment protocols used to establish the case for impairment in these streams.

- Fewer than 10% of samples taken in the spring exceed primary criterion at flows under 300 cfs with no samples exceeding the criterion at flows under 75 cfs.
- Fewer than 10% of samples taken in the summer or fall exceed the primary criterion at flows under 300 cfs with no samples exceeding the criterion at flows under 40 cfs.
- Fewer than 10% of samples taken in the winter exceed secondary criterion at flows under 300 cfs.

[32] Milestones provided by the *E. coli* TMDL: https://www.kdheks.gov/tmdl/klr/DelawareAbvPerry.pdf

These endpoints will be reached as a result of expected, though unspecified, reductions in loading from the various sources in the watershed resulting from implementation of corrective actions and Best Management Practices, as directed by this TMDL. Achievement of the endpoints indicate loads are within the loading capacity of the stream, water quality standards are attained, and full support of the stream's designated uses has been restored.

F. Water Quality Milestones for Mission Lake

Mission Lake has a high-priority siltation TMDL. While it is not the goal of this plan to meet the TMDL in Mission Lake, it is likely to be significantly improved upon as sediment BMPs are implemented throughout the watershed. Reducing sediment loading in the watershed is a goal of this plan as the Delaware River WRAPS SLT has made it a priority for the entire watershed. Cropland and streambank areas will be targeted for BMP implementation in the majority of the watershed.

Mission Lake was dredged in 2010. Future sediment loads must be managed in order to ensure that the lake maintains adequate storage capacity. To meet water quality goals and support designated uses, the lake should not exceed an average sedimentation rate of more than eight acre-feet per year for the next 75 years to ensure that the restored capacity of Mission Lake is protected. In addition to monitoring and maintaining an acceptable sedimentation rate for Mission Lake, **Table 63** includes water quality goals for the Secchi depth measured in Mission Lake.

Table 63. Water Quality Milestones: Sediment in Mission Lake

Water Quality Milestones for Mission Lake: Sediment			
Sampling Site	Current Condition	10-Year Goal	Long-Term Goal
	1989-2009 Secchi (Avg.)	Improved Condition (2011 - 2021) Secchi Average	Improved Condition Secchi Average
	Secchi (average of data collected during indicated period), meter		
Mission Lake LM013601	0.35	0.65	Maintain Secchi Depth >1.0

12. Monitoring Water Quality

KDHE continues to monitor water quality in the Delaware River Watershed by maintaining the monitoring stations located within the watershed. **Figures 32 and 33** illustrate the locations of the monitoring sites within the Delaware River Watershed as well as the BMP-targeted areas identified and discussed in previous sections of this plan.

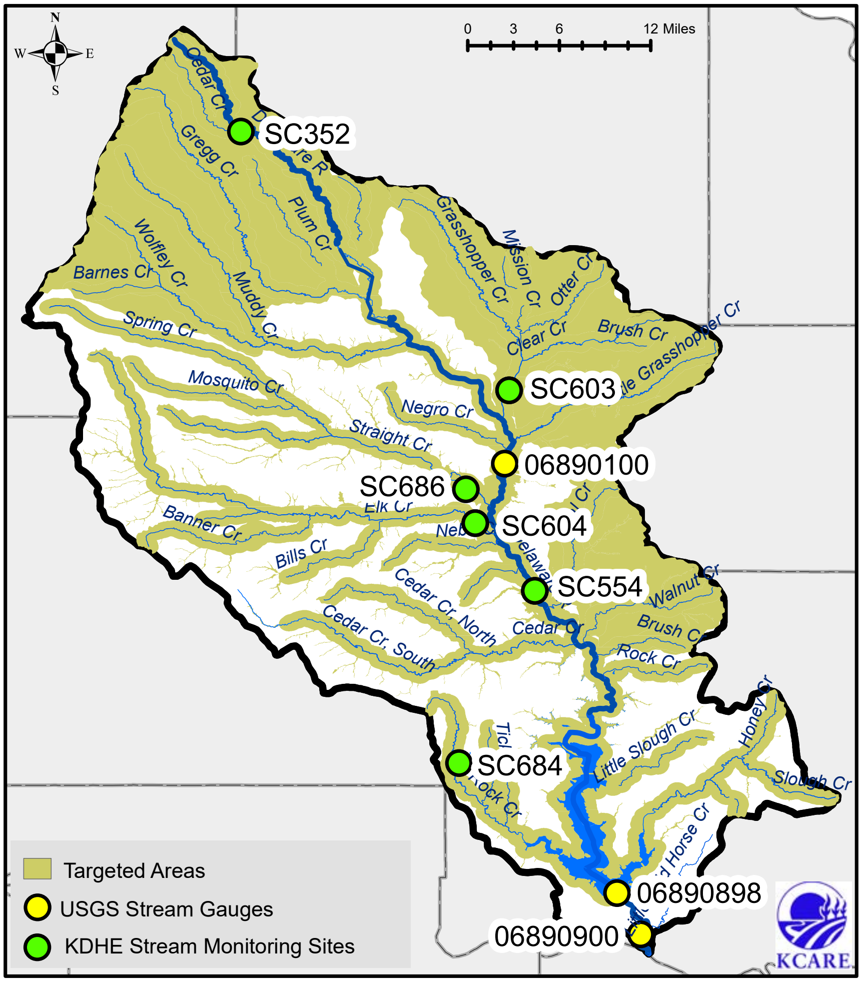

Figure 32. Stream Monitoring Sites and Targeted Areas

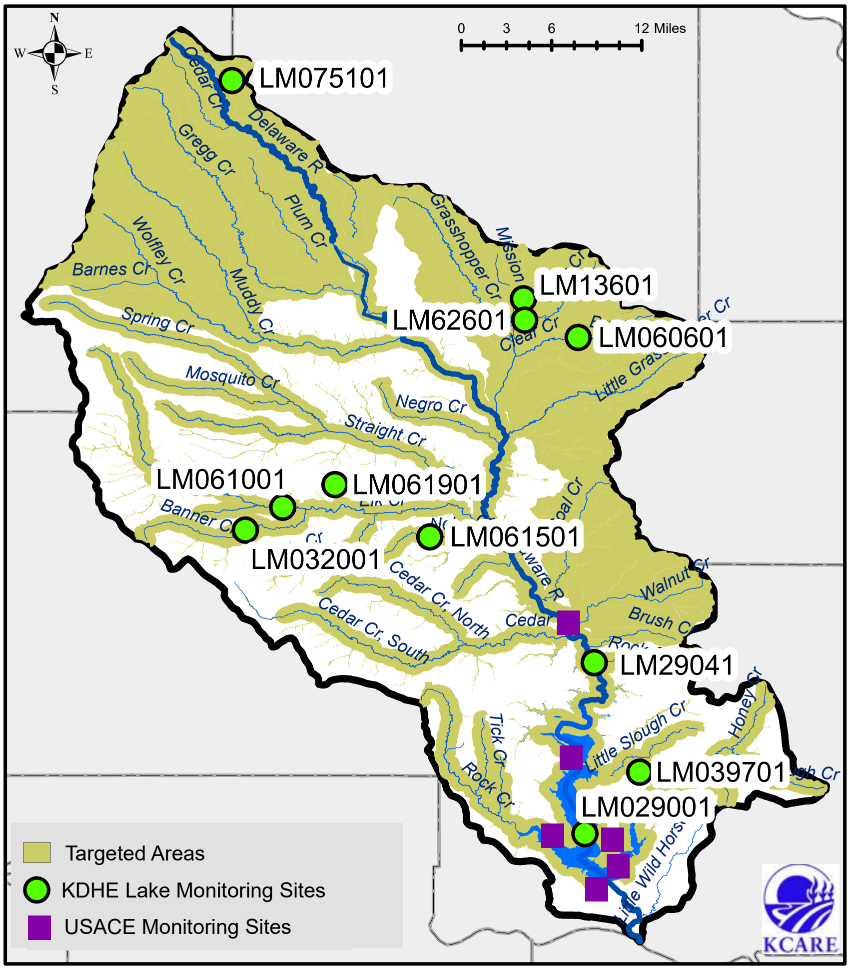

Figure 33. Lake Monitoring Sites and Targeted Areas

KDHE continues to monitor water quality in the Delaware River Watershed by maintaining six stream chemistry stations and 11 lake monitoring stations. Four of the KDHE stream chemistry stations in the watershed will continue to be sampled on a rotational basis every four years. These stations are sampled on a quarterly basis during the sampling year; the next scheduled sampling year for the rotational stations is in 2022. These sites include:

- SC352
- SC554 – rotational
- SC603 – rotational
- SC604
- SC684 – rotational
- SC686 – rotational

The KDHE lake monitoring stations will be sampled every three years with the next sampling year, scheduled for 2024. These sites are located at:

- LM13601
- LM29041

- LM62601
- LM029001
- LM032001
- LM039701
- LM060601
- LM061001
- LM061501
- LM061901
- LM075101

As discussed in Section 4, there are also several USGS and USACE monitoring sites that will contribute water quality data to KDHE and the Delaware River Watershed SLT.

Typically, monitoring takes place May through September. Monitoring sites are sampled for nutrients, bacteria, chemicals, turbidity, alkalinity, DO, pH, ammonia and metals, with the addition of chlorophyll *a* measurements in Perry Lake. The pollutant indicators tested for each site may vary depending on the season at collection time and other factors. Sampling data include temperature, conductivity and Secchi disc depth. The SLT will request that KDHE reviews analyzed data from all monitoring sources on an annual basis, with data collected in the targeted HUC 12s of special interest. Monitoring data will be used to direct the SLT in their evaluation of water quality progress.

Monitoring data in the Delaware River Watershed will be used to determine water quality progress, to track water quality milestones, and to determine the effectiveness of the BMP implementation outlined in this plan. The review schedule for the monitoring data will be tied to the water quality milestones developed for each sub-watershed or drainage area in the Delaware, as well as the frequency of the sampling data.

The BMP implementation schedule and water quality milestones for the Delaware River Watershed extend through a 30-year period from 2021-2051. During that period, KDHE will continue to analyze and to evaluate the collected monitoring data. After the first 10 years of monitoring and BMP implementation, KDHE will evaluate the available water quality data to determine whether the water quality milestones have been achieved. KDHE and the SLT can address any necessary modifications or revisions to the plan based on the data analysis. At the end of this plan in 2051, a determination will be made as to whether the water quality standards have been attained.

In addition to the planned review of the monitoring data and water quality milestones, KDHE and the SLT may revisit this plan in shorter increments. This would allow KDHE and the SLT to evaluate newly available information, incorporate revisions to applicable TMDLs, or address potential water quality indicators that might trigger an immediate review.

13. Review of the WRAPS Plan

In the year 2026, this WRAPS plan will be reviewed and revised according to results from monitoring data. At this time, the SLT will review the criteria listed below, in addition to any other concerns that may occur at this plan's future review.

The SLT will request the following reports on the milestone achievements for nitrogen, phosphorus, and sediment load reductions.

- KDHE reports on current and desired endpoints for water quality in Perry Lake regarding the **eutrophication (E) TMDL**[33]. The desired outcome will be to maintain summer chlorophyll *a* average concentrations below 10 µg/L, with reductions focused on nitrogen and phosphorus. **Nitrogen must be reduced to 383,055 pounds per year**, which is a reduction of 70%. **Phosphorus must be reduced to 76,812 pounds per year**, which is a 71% reduction.
- KDHE reports on current and desired endpoints for water quality in the Delaware River near Half Mound regarding the **total phosphorus (TP)**[34]. The Delaware River's TP TMDL and the Perry Lake E TMDL were rolled into one TP goal, therefore the goal is the same as listed above: **phosphorus must be reduced to 76,812 pounds per year**, a 71% reduction. Other conditions expected in relation to the TP TMDL: ALUS Index > 13, Sestonic Chlorophyll $\leq$ 10 µg/L, dissolved oxygen concentrations > 5.0 mg/L, with saturation < 110%, and pH values within the range of 6.5 to 8.5.
- KDHE reports on current and desired endpoints for water quality in the Delaware River Watershed regarding **siltation impairments**: The WRAPS plan goal is **to reduce sediment loading to 735,814 tons per year** in the watershed, a 28% reduction. The entire watershed was targeted for sediment BMPs, as it was a specific concern of the SLT. However, Mission Lake's siltation TMDL[35] was used to identify milestones for the watershed with the assumption that BMP implementation throughout the Delaware River Watershed would result in improved water quality conditions, including reduced sediment loading in Mission Lake. The sediment entering the lake must be reduced by 80% to achieve a nonalgal turbidity (NAT) value of < 1.0 meter^{-1}.
- KDHE reports on current and desired endpoints for water quality in the Delaware River near Half Mound regarding the ***E. coli* TMDL**. Less frequent exceedances or lowered magnitude of exceedances of the nominal *E. coli* Bacteria (ECB) criterion: 262 Colony Forming Units (CFUs/100 ml) for the sampling stations above Perry Lake.
- KDHE reports concerning revising the watershed TMDLs, including possible nutrient and sediment criteria, revised load allocations, and new wasteload allocations defined for point sources.
- KDHE reports on trends in water quality in Perry Lake and the Delaware River.

[33] KDHE, E TMDL, https://www.kdheks.gov/tmdl/2011/Perry_Eutro_TMDL.pdf
[34] KDHE, TP TMDL, https://www.kdheks.gov/tmdl/2019/Delaware_TP.pdf
[35] KDHE, Siltation TMDL, https://www.kdheks.gov/tmdl/2011/Mission_Lake_TMDL.pdf

In turn, the SLT will provide various reports when necessary. These include:

- progress toward achieving the benchmarks listed in this report;
- progress toward achieving the BMP adoption rates in this report; and
- discussion of necessary adjustments and revisions needed for the targets listed in this plan.

14. Appendix

A. Potential Service Providers

Table 64. Service Provider List

Organization	Programs	Purpose	Technical or Financial Assistance	Phone	Website address
Environmental Protection Agency	Clean Water State Revolving Fund Program	Provides low cost loans to communities for water pollution control activities.	Financial	913-551-7003	www.epa.gov
	Watershed Protection	To conduct holistic strategies for restoring and protecting aquatic resources based on hydrology rather than political boundaries.			
Kansas Alliance for Wetlands and Streams	Streambank Stabilization, Wetland Restoration Cost Share Programs	The Kansas Alliance for Wetlands and Streams (KAWS) organized in 1996 to promote the protection, enhancement, restoration and establishment of wetlands and streams in Kansas.	Technical	785-463-5804 NE Chapter	www.kaws.org
Kansas Department of Agriculture	Watershed structures permitting	Available for watershed districts and multipurpose small lakes development.	Technical and Financial	785-296-2933	www.agriculture.ks.gov
Kansas Department of Health and Environment	Nonpoint Source Pollution Program	Provide funds for projects that will reduce nonpoint source pollution.	Technical and Financial	785-296-5500	www.kdheks.gov
	Livestock waste Municipal waste	Compliance monitoring.			
	State Revolving Loan Fund	Makes low interest loans for projects to improve and protect water quality.			
Kansas Department of Wildlife, Parks and Tourism	Land and Water Conservation Funds	Provides funds to preserve, develop and assure access to outdoor recreation.	Technical Funds	620-672-5911	ksoutdoors.com/Services/Private-Landowner-Assistance
	Conservation Easements for Riparian and Wetland Areas	To provide easements to secure and enhance quality areas in the state.		785-296-2780	
	Wildlife Habitat Improvement Program	To provide limited assistance for development of wildlife habitat.		620-672-5911	
	North American Waterfowl Conservation Act	To provide up to 50 percent cost share for the purchase and/or development of wetlands and wildlife habitat.		620-342-0658	
	MARSH program in coordination with Ducks Unlimited	May provide up to 100 percent of funding for small wetland projects.		620-672-5911	
	Chickadee Checkoff	Projects help with eagles, songbirds, threatened and endangered species, turtles, lizards, butterflies, and stream darters. 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.			
Kansas Forest Service	Conservation Tree Planting Program	Provides low cost trees and shrubs for conservation plantings.	Technical	785-532-3312	www.kansasforests.org
	Riparian and Wetland Protection Program	Work closely with other agencies to promote and assist with establishment of riparian forestland and manage existing stands.		785-532-3310	
Kansas Rural Center	The Heartland Network Clean Water Farms - River Friendly Farms Sustainable Food Systems Project Cost share programs	The Center is committed to economically viable, environmentally sound and socially sustainable rural culture.	Technical and Financial	785-873-3431	www.kansasruralcenter.org

Service Provider List, Continued

Organization	Programs	Purpose	Technical or Financial Assistance	Phone	Website address
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	785-336-3760	www.krwa.net
K-State Research and Extension	Water Quality Programs	Provide programs, expertise and educational materials that relate to minimizing the impact of rural and urban activities on water quality.	Technical	785-532-7108	www.kcare.ksu.edu
	Waste Management Programs				
	Kansas Center for Agricultural Resources and Environment (KCARE)				
	Kansas Local Government Water Quality Planning and Management	Provide guidance to local governments on water protection programs.		785-532-0416	www.ksre.ksu.edu/olg
Kansas Water Office	Public Information and Education	Provide information and education to the public on Kansas Water Resources	Technical and Financial	785-296-3185	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	888-330-5142	www.notill.org
Division of Conservation and Conservation Districts	Water Resources Cost Share Program	Provide cost share assistance to landowners for establishment of water conservation practices.	Technical and Financial	Morris County Conservation District 620-767-5111	agriculture.ks.gov/divisions-programs/division-of-conservation
	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.		Wabaunsee County Conservation District (785) 765-3836	www.kacdnet.org/
	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.			
US Army Corps of Engineers	Planning Assistance to states	Assistance in development of plans for development, utilization and conservation of water and related land resources of drainage.	Technical	816-983-3157	www.usace.army.mil
	Environmental Restoration	Funding assistance for aquatic ecosystem restoration.			
US Fish and and Wildlife	Fish and Wildlife Enhancement Program	Supports field operations which include technical assistance on wetland design.	Technical	785-539-3474	www.fws.gov
	Private Lands Program	Contracts to restore, enhance, or create wetlands.			
USDA Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA)	Conservation Compliance	Primarily for the technical assistance to develop conservation plans on cropland.	Technical and Financial	Morris County Conservation District 620-767-5111	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.		Wabaunsee County Conservation District (785) 765-3836	
	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.			

B. BMP Definitions

1. Cropland BMPs

a. Buffers

- Vegetative buffers are areas of a 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, a one-acre buffer treats 15 acres of cropland, and they have a 50% erosion, 50% nitrogen, and a 50% phosphorus reduction efficiency.

b. Cover crops

- A cover crop is a crop of a specific plant grown primarily for the benefit of the soil rather than the crop yield.
- Cover crops commonly are used to suppress weeds, to manage soil erosion, to help build to improve soil fertility and quality, and to control diseases and pests.
- Cover crops are typically grasses or legumes but may be comprised of other green plants.
- Cover crops can: reduce erosion from wind and water, sequester carbon in plant biomass and soils to increase soil organic matter content, capture and recycle excess nutrients in the soil profile, promote biological nitrogen fixation, increase biodiversity, promote weed suppression, provide supplemental forage, promote soil moisture management, and reduce particulate emissions into the atmosphere.[36]
- Cover crops have a 40% erosion, 25% nitrogen, and a 50% phosphorus reduction efficiency.

c. No-till

- No-till is a management system in which chemicals may be used instead of tillage for weed control and seedbed preparation.
- In no-till, the soil surface is never disturbed, except for planting (or drilling operations in a 100% no-till system); this maintains nutrient levels and aids in preventing nutrients from leaving the field due to runoff events.
- This system has 75% erosion reduction efficiency and 40% phosphorous reduction efficiency.

d. Permanent vegetation

- Establishing permanent vegetation on sites that have or are expected to have high erosion rates, and on sites that have physical, chemical, or biological conditions that prevent the establishment of vegetation using normal practices.
- Establishing permanent vegetation can stabilize areas with existing or expected high rates of soil erosion by water and wind.
- Establishing permanent vegetation can restore degraded sites that cannot be stabilized through normal methods.

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[36] Kansas Department of Health and Environment. http://www.kdheks.gov/nps/downloads/AnnualReport2006.pdf

- Has a reduction efficiency of 95% for erosion, 95% for nitrogen and 95% for phosphorus.

e. *Subsurface fertilizer*

- This method places or injects fertilizer beneath the soil surface.
- Using subsurface fertilizer reduces fertilizer runoff.
- Subsurface fertilizer has a 0% erosion efficiency, 70% nitrogen and 50% phosphorus reduction efficiency.

f. *Terraces*

- Terraces are earth embankments and/or channels constructed across the slope to intercept runoff water and to trap soil.
- They are one of the oldest/most common BMPs.
- Terraces have a 10-year lifespan, with 30% erosion, 30% nitrogen, and a 30% phosphorus reduction efficiency.

g. *Waterways*

- These are defined as a grassed strip used as an outlet to prevent silt and gully formation.
- They also can be used as outlets for water from terraces.
- On average for Kansas fields, a one-acre waterway will treat 10 acres of cropland.
- Grassed waterways have a 10-year lifespan, with 40% erosion, 40% nitrogen, and a 40% phosphorus reduction efficiency.

2. Livestock BMPs

a. *Off-stream watering systems*

- These are watering systems designed so that livestock do not enter a stream or body of water.
- Studies show cattle will drink from tank over a stream or pond 80% of the time.
- These systems have a 10- to 25-year lifespan, with an average phosphorus reduction efficiency of 85% and greater efficiencies for limited stream access.

b. *Relocate feeding sites*

- Relocation of **feeding pen(s)** means to move feedlot or pens away from a stream, waterway, or body of water to increase filtration and waste removal of manure.
- Doing this results in an average of 95% phosphorus reduction efficiency.
- Relocation of **pasture site(s)** means to move feeding sites in a pasture away from a stream, waterway, or body of water to increase the filtration and waste removal (i.e., move bale feeders away from the stream).
- Doing this results in an average of 70% phosphorus reduction efficiency.

c. *Rotational grazing*

- This is defined as a grazing system that rotates livestock within a pasture to spread manure more uniformly and to allow grass adequate rest to regenerate.

- Expenses may involve significant cross-fencing and additional watering sites.
- Rotational grazing has an average of 25% phosphorus reduction efficiency.

d. Vegetative filter strip

- A vegetated area that receives runoff during rainfall from an animal feeding operation is a vegetative filter strip.
- This practice often requires a land area equal to or more than the drainage area (i.e., as large as the feedlot).
- Vegetative filter strips have a 10-year lifespan and require periodic mowing or haying.
- Their average phosphorus reduction efficiency is 50%.

C. Budget Derivations[37]

1. Cropland

Summarized derivation of cropland BMP cost estimates

- Establish buffer: $300 per treated acre with 90% cost-share.
- Cover crops: cost is $25 per treated acre with 68% cost-share.
- No-till: $10 per treated acre with 50% cost-share.
- Establish permanent vegetation: $150 per treated acre with 70% cost-share.
- Subsurface fertilizer: cost is $30 per treated acre with 60% cost-share.
- Terraces: $50 per treated acre with 60% cost-share.
- Waterway: $125 per treated acre with 50% cost-share.

[37] All cost derivations were calculated using rates effective in May 2021.

2. Livestock

Summarized derivation of livestock BMP cost estimates

- Off-stream watering system: $3,795 per unit with 50% cost-share.
- Relocate feeding pens: $6,621 with 50% cost-share. Cost includes fencing, new watering system, concrete, and labor.
- Relocate pasture feeding site: $2,203 with 50% cost-share. Cost includes building ¼ mile of fence, a permeable surface, and labor.
- Rotational grazing: $7,000 with 50% cost share. Cost includes fencing and labor.
- Vegetative filter strip: $714 per unit with 50% cost-share.

3. Streambank

Summarized derivation of streambank BMP cost estimates

A 2009 study conducted by Kansas State University agricultural economists calculated that streambank stabilization costs an average of $96.58 per linear foot, including all engineering and design costs. Sites are extremely variable.

D. 30-year Project Tables by Sub-watershed

Cropland areas will be targeted for nutrients and sediment. BMP implementation will take place in the following 14 HUC 12s, as well as 39 HUC 12 riparian corridors as shown in (**Figure 34**):

- 102701030101
- 102701030102
- 102701030103
- 102701030104
- 102701030105
- 102701030107
- 102701030108
- 102701030201
- 102701030202
- 102701030203
- 102701030204
- 102701030402
- 102701030407
- 102701030501

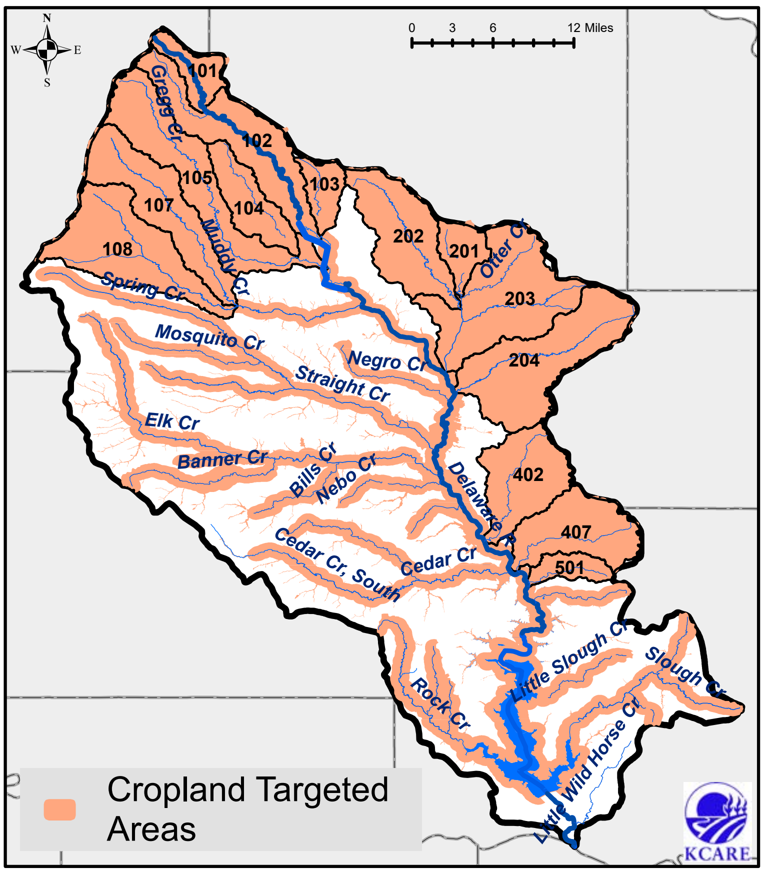

Figure 34. Cropland Targeted Areas (Appendix)

For the purpose of simplification, the appendix tables will utilize HUC 10 delineations to show adoption/implementation rates, load reductions, and costs associated with cropland BMP implementation throughout the Delaware River Watershed. These HUC 10s include: **1027010301** (home to seven targeted HUC 12s), **1027010302** (home to four targeted HUC 12s), **1027010303** (riparian corridors only), **1027010304** (home to two targeted HUC 12s), and **1027010305** (home to one targeted HUC 12).

1. Cropland BMP implementation in the Delaware River Watershed

HUC 10 301 Annual Adoption (treated acres), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Adoption
1	600	909	909	91	91	909	545	4,053
2	600	909	909	91	91	909	545	4,053
3	600	909	909	91	91	909	545	4,053
4	600	909	909	91	91	909	545	4,053
5	600	909	909	91	91	909	545	4,053
6	600	909	909	91	91	909	545	4,053
7	600	909	909	91	91	909	545	4,053
8	600	909	909	91	91	909	545	4,053
9	600	909	909	91	91	909	545	4,053
10	600	909	909	91	91	909	545	4,053
11	600	909	909	91	91	909	545	4,053
12	600	909	909	91	91	909	545	4,053
13	600	909	909	91	91	909	545	4,053
14	600	909	909	91	91	909	545	4,053
15	600	909	909	91	91	909	545	4,053
16	600	909	909	91	91	909	545	4,053
17	600	909	909	91	91	909	545	4,053
18	600	909	909	91	91	909	545	4,053
19	600	909	909	91	91	909	545	4,053
20	600	909	909	91	91	909	545	4,053
21	600	909	909	91	91	909	545	4,053
22	600	909	909	91	91	909	545	4,053
23	600	909	909	91	91	909	545	4,053
24	600	909	909	91	91	909	545	4,053
25	600	909	909	91	91	909	545	4,053
26	600	909	909	91	91	909	545	4,053
27	600	909	909	91	91	909	545	4,053
28	600	909	909	91	91	909	545	4,053
29	600	909	909	91	91	909	545	4,053
30	600	909	909	91	91	909	545	4,053

HUC 10 302 Annual Adoption (treated acres), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Adoption
1	456	690	690	69	69	690	414	3,078
2	456	690	690	69	69	690	414	3,078
3	456	690	690	69	69	690	414	3,078
4	456	690	690	69	69	690	414	3,078
5	456	690	690	69	69	690	414	3,078
6	456	690	690	69	69	690	414	3,078
7	456	690	690	69	69	690	414	3,078
8	456	690	690	69	69	690	414	3,078
9	456	690	690	69	69	690	414	3,078
10	456	690	690	69	69	690	414	3,078
11	456	690	690	69	69	690	414	3,078
12	456	690	690	69	69	690	414	3,078
13	456	690	690	69	69	690	414	3,078
14	456	690	690	69	69	690	414	3,078
15	456	690	690	69	69	690	414	3,078
16	456	690	690	69	69	690	414	3,078
17	456	690	690	69	69	690	414	3,078
18	456	690	690	69	69	690	414	3,078
19	456	690	690	69	69	690	414	3,078
20	456	690	690	69	69	690	414	3,078
21	456	690	690	69	69	690	414	3,078
22	456	690	690	69	69	690	414	3,078
23	456	690	690	69	69	690	414	3,078
24	456	690	690	69	69	690	414	3,078
25	456	690	690	69	69	690	414	3,078
26	456	690	690	69	69	690	414	3,078
27	456	690	690	69	69	690	414	3,078
28	456	690	690	69	69	690	414	3,078
29	456	690	690	69	69	690	414	3,078
30	456	690	690	69	69	690	414	3,078

HUC 10 303 Annual Adoption (treated acres), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Adoption
1	171	259	259	26	26	259	155	1,155
2	171	259	259	26	26	259	155	1,155
3	171	259	259	26	26	259	155	1,155
4	171	259	259	26	26	259	155	1,155
5	171	259	259	26	26	259	155	1,155
6	171	259	259	26	26	259	155	1,155
7	171	259	259	26	26	259	155	1,155
8	171	259	259	26	26	259	155	1,155
9	171	259	259	26	26	259	155	1,155
10	171	259	259	26	26	259	155	1,155
11	171	259	259	26	26	259	155	1,155
12	171	259	259	26	26	259	155	1,155
13	171	259	259	26	26	259	155	1,155
14	171	259	259	26	26	259	155	1,155
15	171	259	259	26	26	259	155	1,155
16	171	259	259	26	26	259	155	1,155
17	171	259	259	26	26	259	155	1,155
18	171	259	259	26	26	259	155	1,155
19	171	259	259	26	26	259	155	1,155
20	171	259	259	26	26	259	155	1,155
21	171	259	259	26	26	259	155	1,155
22	171	259	259	26	26	259	155	1,155
23	171	259	259	26	26	259	155	1,155
24	171	259	259	26	26	259	155	1,155
25	171	259	259	26	26	259	155	1,155
26	171	259	259	26	26	259	155	1,155
27	171	259	259	26	26	259	155	1,155
28	171	259	259	26	26	259	155	1,155
29	171	259	259	26	26	259	155	1,155
30	171	259	259	26	26	259	155	1,155

HUC 10 304 Annual Adoption (treated acres), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Adoption
1	167	254	254	25	25	254	152	1,132
2	167	254	254	25	25	254	152	1,132
3	167	254	254	25	25	254	152	1,132
4	167	254	254	25	25	254	152	1,132
5	167	254	254	25	25	254	152	1,132
6	167	254	254	25	25	254	152	1,132
7	167	254	254	25	25	254	152	1,132
8	167	254	254	25	25	254	152	1,132
9	167	254	254	25	25	254	152	1,132
10	167	254	254	25	25	254	152	1,132
11	167	254	254	25	25	254	152	1,132
12	167	254	254	25	25	254	152	1,132
13	167	254	254	25	25	254	152	1,132
14	167	254	254	25	25	254	152	1,132
15	167	254	254	25	25	254	152	1,132
16	167	254	254	25	25	254	152	1,132
17	167	254	254	25	25	254	152	1,132
18	167	254	254	25	25	254	152	1,132
19	167	254	254	25	25	254	152	1,132
20	167	254	254	25	25	254	152	1,132
21	167	254	254	25	25	254	152	1,132
22	167	254	254	25	25	254	152	1,132
23	167	254	254	25	25	254	152	1,132
24	167	254	254	25	25	254	152	1,132
25	167	254	254	25	25	254	152	1,132
26	167	254	254	25	25	254	152	1,132
27	167	254	254	25	25	254	152	1,132
28	167	254	254	25	25	254	152	1,132
29	167	254	254	25	25	254	152	1,132
30	167	254	254	25	25	254	152	1,132

HUC 10 305 Annual Adoption (treated acres), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Adoption
1	72	110	110	11	11	110	66	489
2	72	110	110	11	11	110	66	489
3	72	110	110	11	11	110	66	489
4	72	110	110	11	11	110	66	489
5	72	110	110	11	11	110	66	489
6	72	110	110	11	11	110	66	489
7	72	110	110	11	11	110	66	489
8	72	110	110	11	11	110	66	489
9	72	110	110	11	11	110	66	489
10	72	110	110	11	11	110	66	489
11	72	110	110	11	11	110	66	489
12	72	110	110	11	11	110	66	489
13	72	110	110	11	11	110	66	489
14	72	110	110	11	11	110	66	489
15	72	110	110	11	11	110	66	489
16	72	110	110	11	11	110	66	489
17	72	110	110	11	11	110	66	489
18	72	110	110	11	11	110	66	489
19	72	110	110	11	11	110	66	489
20	72	110	110	11	11	110	66	489
21	72	110	110	11	11	110	66	489
22	72	110	110	11	11	110	66	489
23	72	110	110	11	11	110	66	489
24	72	110	110	11	11	110	66	489
25	72	110	110	11	11	110	66	489
26	72	110	110	11	11	110	66	489
27	72	110	110	11	11	110	66	489
28	72	110	110	11	11	110	66	489
29	72	110	110	11	11	110	66	489
30	72	110	110	11	11	110	66	489

2. Cropland BMP implementation: Cumulative nitrogen load reductions

HUC 10 301 Annual Nitrogen Reduction (lbs), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	3,978	3,014	3,014	1,145	844	3,616	2,893	18,504
2	7,956	6,027	6,027	2,290	1,688	7,233	5,786	37,008
3	11,934	9,041	9,041	3,436	2,532	10,849	8,679	55,512
4	15,912	12,055	12,055	4,581	3,375	14,466	11,573	74,017
5	19,890	15,069	15,069	5,726	4,219	18,082	14,466	92,521
6	23,869	18,082	18,082	6,871	5,063	21,699	17,359	111,025
7	27,847	21,096	21,096	8,016	5,907	25,315	20,252	129,529
8	31,825	24,110	24,110	9,162	6,751	28,932	23,145	148,033
9	35,803	27,123	27,123	10,307	7,595	32,548	26,038	166,537
10	39,781	30,137	30,137	11,452	8,438	36,164	28,932	185,041
11	43,759	33,151	33,151	12,597	9,282	39,781	31,825	203,545
12	47,737	36,164	36,164	13,742	10,126	43,397	34,718	222,050
13	51,715	39,178	39,178	14,888	10,970	47,014	37,611	240,554
14	55,693	42,192	42,192	16,033	11,814	50,630	40,504	259,058
15	59,671	45,206	45,206	17,178	12,658	54,247	43,397	277,562
16	63,649	48,219	48,219	18,323	13,501	57,863	46,290	296,066
17	67,627	51,233	51,233	19,469	14,345	61,480	49,184	314,570
18	71,606	54,247	54,247	20,614	15,189	65,096	52,077	333,074
19	75,584	57,260	57,260	21,759	16,033	68,712	54,970	351,578
20	79,562	60,274	60,274	22,904	16,877	72,329	57,863	370,083
21	83,540	63,288	63,288	24,049	17,721	75,945	60,756	388,587
22	87,518	66,301	66,301	25,195	18,564	79,562	63,649	407,091
23	91,496	69,315	69,315	26,340	19,408	83,178	66,543	425,595
24	95,474	72,329	72,329	27,485	20,252	86,795	69,436	444,099
25	99,452	75,343	75,343	28,630	21,096	90,411	72,329	462,603
26	103,430	78,356	78,356	29,775	21,940	94,027	75,222	481,107
27	107,408	81,370	81,370	30,921	22,784	97,644	78,115	499,611
28	111,386	84,384	84,384	32,066	23,627	101,260	81,008	518,116
29	115,364	87,397	87,397	33,211	24,471	104,877	83,901	536,620
30	119,343	90,411	90,411	34,356	25,315	108,493	86,795	555,124

HUC 10 302 Annual Nitrogen Reduction (lbs), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	3,675	2,784	2,784	1,058	779	3,340	2,672	17,092
2	7,349	5,567	5,567	2,116	1,559	6,681	5,345	34,184
3	11,024	8,351	8,351	3,173	2,338	10,021	8,017	51,276
4	14,698	11,135	11,135	4,231	3,118	13,362	10,689	68,368
5	18,373	13,919	13,919	5,289	3,897	16,702	13,362	85,460
6	22,047	16,702	16,702	6,347	4,677	20,043	16,034	102,552
7	25,722	19,486	19,486	7,405	5,456	23,383	18,707	119,644
8	29,396	22,270	22,270	8,462	6,236	26,724	21,379	136,736
9	33,071	25,053	25,053	9,520	7,015	30,064	24,051	153,828
10	36,745	27,837	27,837	10,578	7,794	33,405	26,724	170,920
11	40,420	30,621	30,621	11,636	8,574	36,745	29,396	188,012
12	44,094	33,405	33,405	12,694	9,353	40,085	32,068	205,104
13	47,769	36,188	36,188	13,752	10,133	43,426	34,741	222,196
14	51,443	38,972	38,972	14,809	10,912	46,766	37,413	239,288
15	55,118	41,756	41,756	15,867	11,692	50,107	40,085	256,380
16	58,792	44,539	44,539	16,925	12,471	53,447	42,758	273,472
17	62,467	47,323	47,323	17,983	13,250	56,788	45,430	290,564
18	66,141	50,107	50,107	19,041	14,030	60,128	48,103	307,656
19	69,816	52,891	52,891	20,098	14,809	63,469	50,775	324,748
20	73,490	55,674	55,674	21,156	15,589	66,809	53,447	341,840
21	77,165	58,458	58,458	22,214	16,368	70,150	56,120	358,932
22	80,839	61,242	61,242	23,272	17,148	73,490	58,792	376,024
23	84,514	64,025	64,025	24,330	17,927	76,830	61,464	393,116
24	88,188	66,809	66,809	25,387	18,707	80,171	64,137	410,208
25	91,863	69,593	69,593	26,445	19,486	83,511	66,809	427,300
26	95,537	72,377	72,377	27,503	20,265	86,852	69,481	444,392
27	99,212	75,160	75,160	28,561	21,045	90,192	72,154	461,484
28	102,886	77,944	77,944	29,619	21,824	93,533	74,826	478,576
29	106,561	80,728	80,728	30,677	22,604	96,873	77,499	495,668
30	110,235	83,511	83,511	31,734	23,383	100,214	80,171	512,760

HUC 10 303 Annual Nitrogen Reduction (lbs), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	326	247	247	94	69	296	237	1,516
2	652	494	494	188	138	593	474	3,033
3	978	741	741	282	207	889	711	4,549
4	1,304	988	988	375	277	1,185	948	6,066
5	1,630	1,235	1,235	469	346	1,482	1,185	7,582
6	1,956	1,482	1,482	563	415	1,778	1,423	9,098
7	2,282	1,729	1,729	657	484	2,075	1,660	10,615
8	2,608	1,976	1,976	751	553	2,371	1,897	12,131
9	2,934	2,223	2,223	845	622	2,667	2,134	13,647
10	3,260	2,470	2,470	938	692	2,964	2,371	15,164
11	3,586	2,717	2,717	1,032	761	3,260	2,608	16,680
12	3,912	2,964	2,964	1,126	830	3,556	2,845	18,197
13	4,238	3,211	3,211	1,220	899	3,853	3,082	19,713
14	4,564	3,458	3,458	1,314	968	4,149	3,319	21,229
15	4,890	3,705	3,705	1,408	1,037	4,445	3,556	22,746
16	5,216	3,951	3,951	1,502	1,106	4,742	3,793	24,262
17	5,542	4,198	4,198	1,595	1,176	5,038	4,031	25,778
18	5,868	4,445	4,445	1,689	1,245	5,335	4,268	27,295
19	6,194	4,692	4,692	1,783	1,314	5,631	4,505	28,811
20	6,520	4,939	4,939	1,877	1,383	5,927	4,742	30,328
21	6,846	5,186	5,186	1,971	1,452	6,224	4,979	31,844
22	7,172	5,433	5,433	2,065	1,521	6,520	5,216	33,360
23	7,498	5,680	5,680	2,158	1,590	6,816	5,453	34,877
24	7,824	5,927	5,927	2,252	1,660	7,113	5,690	36,393
25	8,150	6,174	6,174	2,346	1,729	7,409	5,927	37,910
26	8,476	6,421	6,421	2,440	1,798	7,705	6,164	39,426
27	8,802	6,668	6,668	2,534	1,867	8,002	6,401	40,942
28	9,128	6,915	6,915	2,628	1,936	8,298	6,638	42,459
29	9,454	7,162	7,162	2,722	2,005	8,594	6,876	43,975
30	9,780	7,409	7,409	2,815	2,075	8,891	7,113	45,491

HUC 10 304 Annual Nitrogen Reduction (lbs), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	336	255	255	97	71	306	244	1,563
2	672	509	509	193	143	611	489	3,126
3	1,008	764	764	290	214	917	733	4,690
4	1,344	1,018	1,018	387	285	1,222	978	6,253
5	1,680	1,273	1,273	484	356	1,528	1,222	7,816
6	2,016	1,528	1,528	580	428	1,833	1,466	9,379
7	2,352	1,782	1,782	677	499	2,139	1,711	10,943
8	2,689	2,037	2,037	774	570	2,444	1,955	12,506
9	3,025	2,291	2,291	871	642	2,750	2,200	14,069
10	3,361	2,546	2,546	967	713	3,055	2,444	15,632
11	3,697	2,801	2,801	1,064	784	3,361	2,689	17,195
12	4,033	3,055	3,055	1,161	855	3,666	2,933	18,759
13	4,369	3,310	3,310	1,258	927	3,972	3,177	20,322
14	4,705	3,564	3,564	1,354	998	4,277	3,422	21,885
15	5,041	3,819	3,819	1,451	1,069	4,583	3,666	23,448
16	5,377	4,074	4,074	1,548	1,141	4,888	3,911	25,011
17	5,713	4,328	4,328	1,645	1,212	5,194	4,155	26,575
18	6,049	4,583	4,583	1,741	1,283	5,499	4,399	28,138
19	6,385	4,837	4,837	1,838	1,354	5,805	4,644	29,701
20	6,721	5,092	5,092	1,935	1,426	6,110	4,888	31,264
21	7,057	5,347	5,347	2,032	1,497	6,416	5,133	32,828
22	7,393	5,601	5,601	2,128	1,568	6,721	5,377	34,391
23	7,730	5,856	5,856	2,225	1,640	7,027	5,621	35,954
24	8,066	6,110	6,110	2,322	1,711	7,332	5,866	37,517
25	8,402	6,365	6,365	2,419	1,782	7,638	6,110	39,080
26	8,738	6,619	6,619	2,515	1,853	7,943	6,355	40,644
27	9,074	6,874	6,874	2,612	1,925	8,249	6,599	42,207
28	9,410	7,129	7,129	2,709	1,996	8,554	6,844	43,770
29	9,746	7,383	7,383	2,806	2,067	8,860	7,088	45,333
30	10,082	7,638	7,638	2,902	2,139	9,165	7,332	46,896

HUC 10 305 Annual Nitrogen Reduction (lbs), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	133	101	101	38	28	121	97	619
2	266	202	202	77	57	242	194	1,239
3	400	303	303	115	85	363	291	1,858
4	533	404	404	153	113	484	387	2,478
5	666	504	504	192	141	605	484	3,097
6	799	605	605	230	170	726	581	3,717
7	932	706	706	268	198	848	678	4,336
8	1,065	807	807	307	226	969	775	4,956
9	1,199	908	908	345	254	1,090	872	5,575
10	1,332	1,009	1,009	383	283	1,211	969	6,195
11	1,465	1,110	1,110	422	311	1,332	1,065	6,814
12	1,598	1,211	1,211	460	339	1,453	1,162	7,434
13	1,731	1,312	1,312	498	367	1,574	1,259	8,053
14	1,865	1,413	1,413	537	396	1,695	1,356	8,673
15	1,998	1,513	1,513	575	424	1,816	1,453	9,292
16	2,131	1,614	1,614	613	452	1,937	1,550	9,912
17	2,264	1,715	1,715	652	480	2,058	1,647	10,531
18	2,397	1,816	1,816	690	509	2,179	1,743	11,151
19	2,530	1,917	1,917	728	537	2,300	1,840	11,770
20	2,664	2,018	2,018	767	565	2,421	1,937	12,390
21	2,797	2,119	2,119	805	593	2,543	2,034	13,009
22	2,930	2,220	2,220	843	622	2,664	2,131	13,629
23	3,063	2,321	2,321	882	650	2,785	2,228	14,248
24	3,196	2,421	2,421	920	678	2,906	2,325	14,868
25	3,330	2,522	2,522	959	706	3,027	2,421	15,487
26	3,463	2,623	2,623	997	735	3,148	2,518	16,107
27	3,596	2,724	2,724	1,035	763	3,269	2,615	16,726
28	3,729	2,825	2,825	1,074	791	3,390	2,712	17,346
29	3,862	2,926	2,926	1,112	819	3,511	2,809	17,965
30	3,995	3,027	3,027	1,150	848	3,632	2,906	18,585

3. Cropland BMP implementation: Cumulative phosphorus load reductions

HUC 10 301 Annual Phosphorus Reduction (lbs), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	744	1,128	902	214	113	677	541	4,319
2	1,488	2,255	1,804	428	226	1,353	1,082	8,637
3	2,233	3,383	2,706	643	338	2,030	1,624	12,956
4	2,977	4,510	3,608	857	451	2,706	2,165	17,274
5	3,721	5,638	4,510	1,071	564	3,383	2,706	21,593
6	4,465	6,765	5,412	1,285	677	4,059	3,247	25,911
7	5,209	7,893	6,314	1,500	789	4,736	3,789	30,230
8	5,954	9,021	7,216	1,714	902	5,412	4,330	34,549
9	6,698	10,148	8,118	1,928	1,015	6,089	4,871	38,867
10	7,442	11,276	9,021	2,142	1,128	6,765	5,412	43,186
11	8,186	12,403	9,923	2,357	1,240	7,442	5,954	47,504
12	8,930	13,531	10,825	2,571	1,353	8,118	6,495	51,823
13	9,675	14,658	11,727	2,785	1,466	8,795	7,036	56,141
14	10,419	15,786	12,629	2,999	1,579	9,472	7,577	60,460
15	11,163	16,913	13,531	3,214	1,691	10,148	8,118	64,779
16	11,907	18,041	14,433	3,428	1,804	10,825	8,660	69,097
17	12,651	19,169	15,335	3,642	1,917	11,501	9,201	73,416
18	13,395	20,296	16,237	3,856	2,030	12,178	9,742	77,734
19	14,140	21,424	17,139	4,071	2,142	12,854	10,283	82,053
20	14,884	22,551	18,041	4,285	2,255	13,531	10,825	86,371
21	15,628	23,679	18,943	4,499	2,368	14,207	11,366	90,690
22	16,372	24,806	19,845	4,713	2,481	14,884	11,907	95,009
23	17,116	25,934	20,747	4,927	2,593	15,560	12,448	99,327
24	17,861	27,062	21,649	5,142	2,706	16,237	12,990	103,646
25	18,605	28,189	22,551	5,356	2,819	16,913	13,531	107,964
26	19,349	29,317	23,453	5,570	2,932	17,590	14,072	112,283
27	20,093	30,444	24,355	5,784	3,044	18,267	14,613	116,601
28	20,837	31,572	25,257	5,999	3,157	18,943	15,154	120,920
29	21,582	32,699	26,160	6,213	3,270	19,620	15,696	125,239
30	22,326	33,827	27,062	6,427	3,383	20,296	16,237	129,557

HUC 10 302 Annual Phosphorus Reduction (lbs), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	323	489	391	93	49	293	235	1,873
2	646	978	783	186	98	587	470	3,746
3	968	1,467	1,174	279	147	880	704	5,620
4	1,291	1,956	1,565	372	196	1,174	939	7,493
5	1,614	2,445	1,956	465	245	1,467	1,174	9,366
6	1,937	2,935	2,348	558	293	1,761	1,409	11,239
7	2,260	3,424	2,739	650	342	2,054	1,643	13,112
8	2,582	3,913	3,130	743	391	2,348	1,878	14,986
9	2,905	4,402	3,521	836	440	2,641	2,113	16,859
10	3,228	4,891	3,913	929	489	2,935	2,348	18,732
11	3,551	5,380	4,304	1,022	538	3,228	2,582	20,605
12	3,874	5,869	4,695	1,115	587	3,521	2,817	22,478
13	4,196	6,358	5,087	1,208	636	3,815	3,052	24,352
14	4,519	6,847	5,478	1,301	685	4,108	3,287	26,225
15	4,842	7,336	5,869	1,394	734	4,402	3,521	28,098
16	5,165	7,825	6,260	1,487	783	4,695	3,756	29,971
17	5,488	8,314	6,652	1,580	831	4,989	3,991	31,844
18	5,810	8,804	7,043	1,673	880	5,282	4,226	33,718
19	6,133	9,293	7,434	1,766	929	5,576	4,460	35,591
20	6,456	9,782	7,825	1,859	978	5,869	4,695	37,464
21	6,779	10,271	8,217	1,951	1,027	6,163	4,930	39,337
22	7,102	10,760	8,608	2,044	1,076	6,456	5,165	41,211
23	7,424	11,249	8,999	2,137	1,125	6,749	5,400	43,084
24	7,747	11,738	9,390	2,230	1,174	7,043	5,634	44,957
25	8,070	12,227	9,782	2,323	1,223	7,336	5,869	46,830
26	8,393	12,716	10,173	2,416	1,272	7,630	6,104	48,703
27	8,716	13,205	10,564	2,509	1,321	7,923	6,339	50,577
28	9,038	13,694	10,956	2,602	1,369	8,217	6,573	52,450
29	9,361	14,184	11,347	2,695	1,418	8,510	6,808	54,323
30	9,684	14,673	11,738	2,788	1,467	8,804	7,043	56,196

HUC 10 303 Annual Phosphorus Reduction (lbs), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	79	120	96	23	12	72	58	459
2	158	240	192	46	24	144	115	919
3	238	360	288	68	36	216	173	1,378
4	317	480	384	91	48	288	230	1,838
5	396	600	480	114	60	360	288	2,297
6	475	720	576	137	72	432	345	2,757
7	554	840	672	160	84	504	403	3,216
8	633	960	768	182	96	576	461	3,675
9	713	1,080	864	205	108	648	518	4,135
10	792	1,200	960	228	120	720	576	4,594
11	871	1,320	1,056	251	132	792	633	5,054
12	950	1,439	1,152	273	144	864	691	5,513
13	1,029	1,559	1,248	296	156	936	749	5,973
14	1,108	1,679	1,344	319	168	1,008	806	6,432
15	1,188	1,799	1,439	342	180	1,080	864	6,891
16	1,267	1,919	1,535	365	192	1,152	921	7,351
17	1,346	2,039	1,631	387	204	1,224	979	7,810
18	1,425	2,159	1,727	410	216	1,296	1,036	8,270
19	1,504	2,279	1,823	433	228	1,367	1,094	8,729
20	1,583	2,399	1,919	456	240	1,439	1,152	9,189
21	1,663	2,519	2,015	479	252	1,511	1,209	9,648
22	1,742	2,639	2,111	501	264	1,583	1,267	10,108
23	1,821	2,759	2,207	524	276	1,655	1,324	10,567
24	1,900	2,879	2,303	547	288	1,727	1,382	11,026
25	1,979	2,999	2,399	570	300	1,799	1,439	11,486
26	2,058	3,119	2,495	593	312	1,871	1,497	11,945
27	2,138	3,239	2,591	615	324	1,943	1,555	12,405
28	2,217	3,359	2,687	638	336	2,015	1,612	12,864
29	2,296	3,479	2,783	661	348	2,087	1,670	13,324
30	2,375	3,599	2,879	684	360	2,159	1,727	13,783

HUC 10 304 Annual Phosphorus Reduction (lbs), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	63	96	77	18	10	57	46	367
2	126	191	153	36	19	115	92	733
3	190	287	230	55	29	172	138	1,100
4	253	383	306	73	38	230	184	1,467
5	316	479	383	91	48	287	230	1,833
6	379	574	459	109	57	345	276	2,200
7	442	670	536	127	67	402	322	2,566
8	505	766	613	146	77	459	368	2,933
9	569	862	689	164	86	517	414	3,300
10	632	957	766	182	96	574	459	3,666
11	695	1,053	842	200	105	632	505	4,033
12	758	1,149	919	218	115	689	551	4,400
13	821	1,244	996	236	124	747	597	4,766
14	885	1,340	1,072	255	134	804	643	5,133
15	948	1,436	1,149	273	144	862	689	5,500
16	1,011	1,532	1,225	291	153	919	735	5,866
17	1,074	1,627	1,302	309	163	976	781	6,233
18	1,137	1,723	1,378	327	172	1,034	827	6,599
19	1,200	1,819	1,455	346	182	1,091	873	6,966
20	1,264	1,915	1,532	364	191	1,149	919	7,333
21	1,327	2,010	1,608	382	201	1,206	965	7,699
22	1,390	2,106	1,685	400	211	1,264	1,011	8,066
23	1,453	2,202	1,761	418	220	1,321	1,057	8,433
24	1,516	2,297	1,838	437	230	1,378	1,103	8,799
25	1,579	2,393	1,915	455	239	1,436	1,149	9,166
26	1,643	2,489	1,991	473	249	1,493	1,195	9,533
27	1,706	2,585	2,068	491	258	1,551	1,241	9,899
28	1,769	2,680	2,144	509	268	1,608	1,287	10,266
29	1,832	2,776	2,221	527	278	1,666	1,333	10,632
30	1,895	2,872	2,297	546	287	1,723	1,378	10,999

HUC 10 305 Annual Phosphorus Reduction (lbs), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	25	38	31	7	4	23	18	147
2	51	77	61	15	8	46	37	293
3	76	115	92	22	11	69	55	440
4	101	153	123	29	15	92	74	587
5	126	191	153	36	19	115	92	733
6	152	230	184	44	23	138	110	880
7	177	268	214	51	27	161	129	1,027
8	202	306	245	58	31	184	147	1,173
9	227	345	276	65	34	207	165	1,320
10	253	383	306	73	38	230	184	1,467
11	278	421	337	80	42	253	202	1,613
12	303	460	368	87	46	276	221	1,760
13	329	498	398	95	50	299	239	1,907
14	354	536	429	102	54	322	257	2,053
15	379	574	460	109	57	345	276	2,200
16	404	613	490	116	61	368	294	2,347
17	430	651	521	124	65	391	312	2,493
18	455	689	551	131	69	414	331	2,640
19	480	728	582	138	73	437	349	2,787
20	505	766	613	146	77	460	368	2,933
21	531	804	643	153	80	483	386	3,080
22	556	842	674	160	84	505	404	3,227
23	581	881	705	167	88	528	423	3,373
24	607	919	735	175	92	551	441	3,520
25	632	957	766	182	96	574	460	3,667
26	657	996	797	189	100	597	478	3,813
27	682	1,034	827	196	103	620	496	3,960
28	708	1,072	858	204	107	643	515	4,107
29	733	1,111	888	211	111	666	533	4,253
30	758	1,149	919	218	115	689	551	4,400

4. Cropland BMP implementation: Cumulative sediment load reductions

HUC 10 301 Annual Sediment Reduction (tons), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	52	63	118	15	0	47	38	332
2	104	126	235	30	0	94	75	664
3	155	188	353	45	0	141	113	996
4	207	251	471	60	0	188	151	1,328
5	259	314	589	75	0	235	188	1,660
6	311	377	706	89	0	283	226	1,992
7	363	439	824	104	0	330	264	2,324
8	414	502	942	119	0	377	301	2,656
9	466	565	1,059	134	0	424	339	2,988
10	518	628	1,177	149	0	471	377	3,320
11	570	691	1,295	164	0	518	414	3,652
12	622	753	1,413	179	0	565	452	3,984
13	673	816	1,530	194	0	612	490	4,316
14	725	879	1,648	209	0	659	527	4,648
15	777	942	1,766	224	0	706	565	4,980
16	829	1,005	1,884	239	0	753	603	5,311
17	881	1,067	2,001	253	0	800	640	5,643
18	932	1,130	2,119	268	0	848	678	5,975
19	984	1,193	2,237	283	0	895	716	6,307
20	1,036	1,256	2,354	298	0	942	753	6,639
21	1,088	1,318	2,472	313	0	989	791	6,971
22	1,140	1,381	2,590	328	0	1,036	829	7,303
23	1,191	1,444	2,708	343	0	1,083	866	7,635
24	1,243	1,507	2,825	358	0	1,130	904	7,967
25	1,295	1,570	2,943	373	0	1,177	942	8,299
26	1,347	1,632	3,061	388	0	1,224	979	8,631
27	1,398	1,695	3,178	403	0	1,271	1,017	8,963
28	1,450	1,758	3,296	418	0	1,318	1,055	9,295
29	1,502	1,821	3,414	432	0	1,366	1,092	9,627
30	1,554	1,884	3,532	447	0	1,413	1,130	9,959

HUC 10 302 Annual Sediment Reduction (tons), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	40	49	91	12	0	36	29	257
2	80	97	182	23	0	73	58	514
3	120	146	274	35	0	109	88	772
4	161	195	365	46	0	146	117	1,029
5	201	243	456	58	0	182	146	1,286
6	241	292	547	69	0	219	175	1,543
7	281	341	638	81	0	255	204	1,801
8	321	389	730	92	0	292	234	2,058
9	361	438	821	104	0	328	263	2,315
10	401	486	912	116	0	365	292	2,572
11	441	535	1,003	127	0	401	321	2,829
12	482	584	1,095	139	0	438	350	3,087
13	522	632	1,186	150	0	474	379	3,344
14	562	681	1,277	162	0	511	409	3,601
15	602	730	1,368	173	0	547	438	3,858
16	642	778	1,459	185	0	584	467	4,115
17	682	827	1,551	196	0	620	496	4,373
18	722	876	1,642	208	0	657	525	4,630
19	763	924	1,733	220	0	693	555	4,887
20	803	973	1,824	231	0	730	584	5,144
21	843	1,022	1,915	243	0	766	613	5,402
22	883	1,070	2,007	254	0	803	642	5,659
23	923	1,119	2,098	266	0	839	671	5,916
24	963	1,168	2,189	277	0	876	701	6,173
25	1,003	1,216	2,280	289	0	912	730	6,430
26	1,043	1,265	2,372	300	0	949	759	6,688
27	1,084	1,313	2,463	312	0	985	788	6,945
28	1,124	1,362	2,554	323	0	1,022	817	7,202
29	1,164	1,411	2,645	335	0	1,058	846	7,459
30	1,204	1,459	2,736	347	0	1,095	876	7,717

HUC 10 303 Annual Sediment Reduction (tons), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	3	3	6	1	0	3	2	18
2	6	7	13	2	0	5	4	35
3	8	10	19	2	0	8	6	53
4	11	13	25	3	0	10	8	71
5	14	17	31	4	0	13	10	89
6	17	20	38	5	0	15	12	106
7	19	23	44	6	0	18	14	124
8	22	27	50	6	0	20	16	142
9	25	30	57	7	0	23	18	160
10	28	34	63	8	0	25	20	177
11	30	37	69	9	0	28	22	195
12	33	40	76	10	0	30	24	213
13	36	44	82	10	0	33	26	231
14	39	47	88	11	0	35	28	248
15	42	50	94	12	0	38	30	266
16	44	54	101	13	0	40	32	284
17	47	57	107	14	0	43	34	302
18	50	60	113	14	0	45	36	319
19	53	64	120	15	0	48	38	337
20	55	67	126	16	0	50	40	355
21	58	70	132	17	0	53	42	373
22	61	74	138	18	0	55	44	390
23	64	77	145	18	0	58	46	408
24	66	81	151	19	0	60	48	426
25	69	84	157	20	0	63	50	444
26	72	87	164	21	0	65	52	461
27	75	91	170	22	0	68	54	479
28	78	94	176	22	0	70	56	497
29	80	97	182	23	0	73	58	515
30	83	101	189	24	0	76	60	532

HUC 10 304 Annual Sediment Reduction (tons), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	5	7	12	2	0	5	4	35
2	11	13	25	3	0	10	8	70
3	16	20	37	5	0	15	12	105
4	22	27	50	6	0	20	16	141
5	27	33	62	8	0	25	20	176
6	33	40	75	9	0	30	24	211
7	38	47	87	11	0	35	28	246
8	44	53	100	13	0	40	32	281
9	49	60	112	14	0	45	36	316
10	55	66	125	16	0	50	40	352
11	60	73	137	17	0	55	44	387
12	66	80	150	19	0	60	48	422
13	71	86	162	21	0	65	52	457
14	77	93	175	22	0	70	56	492
15	82	100	187	24	0	75	60	527
16	88	106	199	25	0	80	64	563
17	93	113	212	27	0	85	68	598
18	99	120	224	28	0	90	72	633
19	104	126	237	30	0	95	76	668
20	110	133	249	32	0	100	80	703
21	115	140	262	33	0	105	84	738
22	121	146	274	35	0	110	88	773
23	126	153	287	36	0	115	92	809
24	132	160	299	38	0	120	96	844
25	137	166	312	39	0	125	100	879
26	143	173	324	41	0	130	104	914
27	148	180	337	43	0	135	108	949
28	154	186	349	44	0	140	112	984
29	159	193	362	46	0	145	116	1,020
30	165	199	374	47	0	150	120	1,055

HUC 10 305 Annual Sediment Reduction (tons), Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Load Reduction
1	2	2	4	1	0	2	1	11
2	4	4	8	1	0	3	3	23
3	5	6	12	2	0	5	4	34
4	7	9	16	2	0	6	5	46
5	9	11	20	3	0	8	6	57
6	11	13	24	3	0	10	8	68
7	12	15	28	4	0	11	9	80
8	14	17	32	4	0	13	10	91
9	16	19	36	5	0	15	12	103
10	18	22	40	5	0	16	13	114
11	20	24	44	6	0	18	14	125
12	21	26	49	6	0	19	16	137
13	23	28	53	7	0	21	17	148
14	25	30	57	7	0	23	18	160
15	27	32	61	8	0	24	19	171
16	28	35	65	8	0	26	21	182
17	30	37	69	9	0	28	22	194
18	32	39	73	9	0	29	23	205
19	34	41	77	10	0	31	25	217
20	36	43	81	10	0	32	26	228
21	37	45	85	11	0	34	27	239
22	39	47	89	11	0	36	28	251
23	41	50	93	12	0	37	30	262
24	43	52	97	12	0	39	31	274
25	44	54	101	13	0	40	32	285
26	46	56	105	13	0	42	34	297
27	48	58	109	14	0	44	35	308
28	50	60	113	14	0	45	36	319
29	52	63	117	15	0	47	38	331
30	53	65	121	15	0	49	39	342

5. Cropland BMP implementation: Costs before cost-share

HUC 10 301 Annual Cost* Before Cost-Share, Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Cost
1	$179,952	$22,721	$9,089	$13,633	$2,727	$45,443	$68,164	$341,728
2	$185,351	$23,403	$9,361	$14,042	$2,808	$46,806	$70,209	$351,979
3	$190,911	$24,105	$9,642	$14,463	$2,893	$48,210	$72,315	$362,539
4	$196,639	$24,828	$9,931	$14,897	$2,979	$49,656	$74,484	$373,415
5	$202,538	$25,573	$10,229	$15,344	$3,069	$51,146	$76,719	$384,617
6	$208,614	$26,340	$10,536	$15,804	$3,161	$52,680	$79,020	$396,156
7	$214,872	$27,130	$10,852	$16,278	$3,256	$54,261	$81,391	$408,041
8	$221,319	$27,944	$11,178	$16,767	$3,353	$55,889	$83,833	$420,282
9	$227,958	$28,783	$11,513	$17,270	$3,454	$57,565	$86,348	$432,890
10	$234,797	$29,646	$11,858	$17,788	$3,558	$59,292	$88,938	$445,877
11	$241,841	$30,535	$12,214	$18,321	$3,664	$61,071	$91,606	$459,253
12	$249,096	$31,452	$12,581	$18,871	$3,774	$62,903	$94,355	$473,031
13	$256,569	$32,395	$12,958	$19,437	$3,887	$64,790	$97,185	$487,222
14	$264,266	$33,367	$13,347	$20,020	$4,004	$66,734	$100,101	$501,839
15	$272,194	$34,368	$13,747	$20,621	$4,124	$68,736	$103,104	$516,894
16	$280,360	$35,399	$14,160	$21,239	$4,248	$70,798	$106,197	$532,400
17	$288,771	$36,461	$14,584	$21,877	$4,375	$72,922	$109,383	$548,372
18	$297,434	$37,555	$15,022	$22,533	$4,507	$75,110	$112,664	$564,824
19	$306,357	$38,681	$15,473	$23,209	$4,642	$77,363	$116,044	$581,768
20	$315,547	$39,842	$15,937	$23,905	$4,781	$79,684	$119,526	$599,221
21	$325,014	$41,037	$16,415	$24,622	$4,924	$82,074	$123,111	$617,198
22	$334,764	$42,268	$16,907	$25,361	$5,072	$84,536	$126,805	$635,714
23	$344,807	$43,536	$17,415	$26,122	$5,224	$87,073	$130,609	$654,785
24	$355,151	$44,842	$17,937	$26,905	$5,381	$89,685	$134,527	$674,429
25	$365,806	$46,188	$18,475	$27,713	$5,543	$92,375	$138,563	$694,662
26	$376,780	$47,573	$19,029	$28,544	$5,709	$95,147	$142,720	$715,502
27	$388,084	$49,000	$19,600	$29,400	$5,880	$98,001	$147,001	$736,967
28	$399,726	$50,470	$20,188	$30,282	$6,056	$100,941	$151,411	$759,076
29	$411,718	$51,985	$20,794	$31,191	$6,238	$103,969	$155,954	$781,848
30	$424,069	$53,544	$21,418	$32,126	$6,425	$107,088	$160,632	$805,303
**3% Inflation*								

HUC 10 302 Annual Cost* Before Cost-Share, Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Cost
1	$136,663	$17,255	$6,902	$10,353	$2,071	$34,511	$51,766	$259,521
2	$140,763	$17,773	$7,109	$10,664	$2,133	$35,546	$53,319	$267,307
3	$144,986	$18,306	$7,323	$10,984	$2,197	$36,613	$54,919	$275,326
4	$149,335	$18,855	$7,542	$11,313	$2,263	$37,711	$56,566	$283,586
5	$153,815	$19,421	$7,768	$11,653	$2,331	$38,842	$58,263	$292,094
6	$158,430	$20,004	$8,002	$12,002	$2,400	$40,008	$60,011	$300,857
7	$163,183	$20,604	$8,242	$12,362	$2,472	$41,208	$61,812	$309,882
8	$168,078	$21,222	$8,489	$12,733	$2,547	$42,444	$63,666	$319,179
9	$173,120	$21,859	$8,743	$13,115	$2,623	$43,717	$65,576	$328,754
10	$178,314	$22,514	$9,006	$13,509	$2,702	$45,029	$67,543	$338,617
11	$183,664	$23,190	$9,276	$13,914	$2,783	$46,380	$69,570	$348,775
12	$189,173	$23,886	$9,554	$14,331	$2,866	$47,771	$71,657	$359,238
13	$194,849	$24,602	$9,841	$14,761	$2,952	$49,204	$73,806	$370,016
14	$200,694	$25,340	$10,136	$15,204	$3,041	$50,680	$76,020	$381,116
15	$206,715	$26,100	$10,440	$15,660	$3,132	$52,201	$78,301	$392,550
16	$212,916	$26,883	$10,753	$16,130	$3,226	$53,767	$80,650	$404,326
17	$219,304	$27,690	$11,076	$16,614	$3,323	$55,380	$83,070	$416,456
18	$225,883	$28,521	$11,408	$17,112	$3,422	$57,041	$85,562	$428,949
19	$232,659	$29,376	$11,750	$17,626	$3,525	$58,752	$88,129	$441,818
20	$239,639	$30,257	$12,103	$18,154	$3,631	$60,515	$90,772	$455,072
21	$246,828	$31,165	$12,466	$18,699	$3,740	$62,330	$93,496	$468,725
22	$254,233	$32,100	$12,840	$19,260	$3,852	$64,200	$96,300	$482,786
23	$261,860	$33,063	$13,225	$19,838	$3,968	$66,126	$99,189	$497,270
24	$269,716	$34,055	$13,622	$20,433	$4,087	$68,110	$102,165	$512,188
25	$277,808	$35,077	$14,031	$21,046	$4,209	$70,153	$105,230	$527,554
26	$286,142	$36,129	$14,452	$21,677	$4,335	$72,258	$108,387	$543,380
27	$294,726	$37,213	$14,885	$22,328	$4,466	$74,426	$111,639	$559,682
28	$303,568	$38,329	$15,332	$22,998	$4,600	$76,659	$114,988	$576,472
29	$312,675	$39,479	$15,792	$23,687	$4,737	$78,958	$118,437	$593,766
30	$322,055	$40,664	$16,265	$24,398	$4,880	$81,327	$121,991	$611,579
**3% Inflation*								

HUC 10 303 Annual Cost* Before Cost-Share, Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Cost
1	$51,266	$6,473	$2,589	$3,884	$777	$12,946	$19,419	$97,353
2	$52,803	$6,667	$2,667	$4,000	$800	$13,334	$20,001	$100,273
3	$54,388	$6,867	$2,747	$4,120	$824	$13,734	$20,601	$103,281
4	$56,019	$7,073	$2,829	$4,244	$849	$14,146	$21,219	$106,380
5	$57,700	$7,285	$2,914	$4,371	$874	$14,571	$21,856	$109,571
6	$59,431	$7,504	$3,002	$4,502	$900	$15,008	$22,512	$112,858
7	$61,214	$7,729	$3,092	$4,637	$927	$15,458	$23,187	$116,244
8	$63,050	$7,961	$3,184	$4,777	$955	$15,922	$23,883	$119,732
9	$64,942	$8,200	$3,280	$4,920	$984	$16,399	$24,599	$123,323
10	$66,890	$8,446	$3,378	$5,067	$1,013	$16,891	$25,337	$127,023
11	$68,897	$8,699	$3,480	$5,219	$1,044	$17,398	$26,097	$130,834
12	$70,963	$8,960	$3,584	$5,376	$1,075	$17,920	$26,880	$134,759
13	$73,092	$9,229	$3,692	$5,537	$1,107	$18,458	$27,686	$138,802
14	$75,285	$9,506	$3,802	$5,703	$1,141	$19,011	$28,517	$142,966
15	$77,544	$9,791	$3,916	$5,875	$1,175	$19,582	$29,373	$147,255
16	$79,870	$10,085	$4,034	$6,051	$1,210	$20,169	$30,254	$151,672
17	$82,266	$10,387	$4,155	$6,232	$1,246	$20,774	$31,161	$156,222
18	$84,734	$10,699	$4,279	$6,419	$1,284	$21,397	$32,096	$160,909
19	$87,276	$11,020	$4,408	$6,612	$1,322	$22,039	$33,059	$165,736
20	$89,894	$11,350	$4,540	$6,810	$1,362	$22,701	$34,051	$170,708
21	$92,591	$11,691	$4,676	$7,014	$1,403	$23,382	$35,072	$175,830
22	$95,369	$12,042	$4,817	$7,225	$1,445	$24,083	$36,125	$181,105
23	$98,230	$12,403	$4,961	$7,442	$1,488	$24,806	$37,208	$186,538
24	$101,177	$12,775	$5,110	$7,665	$1,533	$25,550	$38,325	$192,134
25	$104,212	$13,158	$5,263	$7,895	$1,579	$26,316	$39,474	$197,898
26	$107,339	$13,553	$5,421	$8,132	$1,626	$27,106	$40,659	$203,835
27	$110,559	$13,959	$5,584	$8,376	$1,675	$27,919	$41,878	$209,950
28	$113,875	$14,378	$5,751	$8,627	$1,725	$28,756	$43,135	$216,248
29	$117,292	$14,810	$5,924	$8,886	$1,777	$29,619	$44,429	$222,736
30	$120,811	$15,254	$6,102	$9,152	$1,830	$30,508	$45,762	$229,418

**3% Inflation*

HUC 10 304 Annual Cost* Before Cost-Share, Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Cost
1	$50,249	$6,345	$2,538	$3,807	$761	$12,689	$19,034	$95,423
2	$51,757	$6,535	$2,614	$3,921	$784	$13,070	$19,605	$98,285
3	$53,309	$6,731	$2,692	$4,039	$808	$13,462	$20,193	$101,234
4	$54,909	$6,933	$2,773	$4,160	$832	$13,866	$20,799	$104,271
5	$56,556	$7,141	$2,856	$4,285	$857	$14,282	$21,423	$107,399
6	$58,252	$7,355	$2,942	$4,413	$883	$14,710	$22,065	$110,621
7	$60,000	$7,576	$3,030	$4,545	$909	$15,152	$22,727	$113,939
8	$61,800	$7,803	$3,121	$4,682	$936	$15,606	$23,409	$117,358
9	$63,654	$8,037	$3,215	$4,822	$964	$16,074	$24,111	$120,878
10	$65,564	$8,278	$3,311	$4,967	$993	$16,556	$24,835	$124,505
11	$67,531	$8,527	$3,411	$5,116	$1,023	$17,053	$25,580	$128,240
12	$69,557	$8,782	$3,513	$5,269	$1,054	$17,565	$26,347	$132,087
13	$71,643	$9,046	$3,618	$5,428	$1,086	$18,092	$27,138	$136,050
14	$73,792	$9,317	$3,727	$5,590	$1,118	$18,634	$27,952	$140,131
15	$76,006	$9,597	$3,839	$5,758	$1,152	$19,194	$28,790	$144,335
16	$78,286	$9,885	$3,954	$5,931	$1,186	$19,769	$29,654	$148,665
17	$80,635	$10,181	$4,072	$6,109	$1,222	$20,362	$30,544	$153,125
18	$83,054	$10,487	$4,195	$6,292	$1,258	$20,973	$31,460	$157,719
19	$85,546	$10,801	$4,320	$6,481	$1,296	$21,602	$32,404	$162,450
20	$88,112	$11,125	$4,450	$6,675	$1,335	$22,251	$33,376	$167,324
21	$90,755	$11,459	$4,584	$6,875	$1,375	$22,918	$34,377	$172,344
22	$93,478	$11,803	$4,721	$7,082	$1,416	$23,606	$35,408	$177,514
23	$96,282	$12,157	$4,863	$7,294	$1,459	$24,314	$36,471	$182,839
24	$99,171	$12,522	$5,009	$7,513	$1,503	$25,043	$37,565	$188,325
25	$102,146	$12,897	$5,159	$7,738	$1,548	$25,794	$38,692	$193,974
26	$105,210	$13,284	$5,314	$7,970	$1,594	$26,568	$39,852	$199,794
27	$108,367	$13,683	$5,473	$8,210	$1,642	$27,365	$41,048	$205,787
28	$111,618	$14,093	$5,637	$8,456	$1,691	$28,186	$42,279	$211,961
29	$114,966	$14,516	$5,806	$8,710	$1,742	$29,032	$43,548	$218,320
30	$118,415	$14,951	$5,981	$8,971	$1,794	$29,903	$44,854	$224,869
**3% Inflation*								

HUC 10 305 Annual Cost* Before Cost-Share, Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Cost
1	$21,701	$2,740	$1,096	$1,644	$329	$5,480	$8,220	$41,210
2	$22,352	$2,822	$1,129	$1,693	$339	$5,644	$8,467	$42,446
3	$23,022	$2,907	$1,163	$1,744	$349	$5,814	$8,721	$43,719
4	$23,713	$2,994	$1,198	$1,796	$359	$5,988	$8,982	$45,031
5	$24,424	$3,084	$1,234	$1,850	$370	$6,168	$9,252	$46,382
6	$25,157	$3,177	$1,271	$1,906	$381	$6,353	$9,529	$47,773
7	$25,912	$3,272	$1,309	$1,963	$393	$6,543	$9,815	$49,206
8	$26,689	$3,370	$1,348	$2,022	$404	$6,740	$10,110	$50,683
9	$27,490	$3,471	$1,388	$2,083	$417	$6,942	$10,413	$52,203
10	$28,315	$3,575	$1,430	$2,145	$429	$7,150	$10,725	$53,769
11	$29,164	$3,682	$1,473	$2,209	$442	$7,365	$11,047	$55,382
12	$30,039	$3,793	$1,517	$2,276	$455	$7,586	$11,378	$57,044
13	$30,940	$3,907	$1,563	$2,344	$469	$7,813	$11,720	$58,755
14	$31,868	$4,024	$1,610	$2,414	$483	$8,048	$12,071	$60,518
15	$32,824	$4,144	$1,658	$2,487	$497	$8,289	$12,433	$62,333
16	$33,809	$4,269	$1,708	$2,561	$512	$8,538	$12,806	$64,203
17	$34,823	$4,397	$1,759	$2,638	$528	$8,794	$13,191	$66,129
18	$35,868	$4,529	$1,812	$2,717	$543	$9,058	$13,586	$68,113
19	$36,944	$4,665	$1,866	$2,799	$560	$9,329	$13,994	$70,157
20	$38,052	$4,805	$1,922	$2,883	$577	$9,609	$14,414	$72,261
21	$39,194	$4,949	$1,979	$2,969	$594	$9,897	$14,846	$74,429
22	$40,370	$5,097	$2,039	$3,058	$612	$10,194	$15,292	$76,662
23	$41,581	$5,250	$2,100	$3,150	$630	$10,500	$15,750	$78,962
24	$42,828	$5,408	$2,163	$3,245	$649	$10,815	$16,223	$81,331
25	$44,113	$5,570	$2,228	$3,342	$668	$11,140	$16,710	$83,771
26	$45,437	$5,737	$2,295	$3,442	$688	$11,474	$17,211	$86,284
27	$46,800	$5,909	$2,364	$3,545	$709	$11,818	$17,727	$88,872
28	$48,204	$6,086	$2,435	$3,652	$730	$12,173	$18,259	$91,538
29	$49,650	$6,269	$2,508	$3,761	$752	$12,538	$18,807	$94,285
30	$51,139	$6,457	$2,583	$3,874	$775	$12,914	$19,371	$97,113
3% Inflation								

6. Cropland BMP implementation: Costs after cost-share

HUC 10 301 Annual Cost* After Cost-Share, Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Cost
1	$17,995	$4,544	$4,544	$4,090	$1,091	$18,177	$34,082	$84,523
2	$18,535	$4,681	$4,681	$4,213	$1,123	$18,722	$35,104	$87,059
3	$19,091	$4,821	$4,821	$4,339	$1,157	$19,284	$36,157	$89,671
4	$19,664	$4,966	$4,966	$4,469	$1,192	$19,862	$37,242	$92,361
5	$20,254	$5,115	$5,115	$4,603	$1,228	$20,458	$38,359	$95,131
6	$20,861	$5,268	$5,268	$4,741	$1,264	$21,072	$39,510	$97,985
7	$21,487	$5,426	$5,426	$4,883	$1,302	$21,704	$40,696	$100,925
8	$22,132	$5,589	$5,589	$5,030	$1,341	$22,355	$41,916	$103,953
9	$22,796	$5,757	$5,757	$5,181	$1,382	$23,026	$43,174	$107,071
10	$23,480	$5,929	$5,929	$5,336	$1,423	$23,717	$44,469	$110,283
11	$24,184	$6,107	$6,107	$5,496	$1,466	$24,428	$45,803	$113,592
12	$24,910	$6,290	$6,290	$5,661	$1,510	$25,161	$47,177	$117,000
13	$25,657	$6,479	$6,479	$5,831	$1,555	$25,916	$48,593	$120,510
14	$26,427	$6,673	$6,673	$6,006	$1,602	$26,694	$50,050	$124,125
15	$27,219	$6,874	$6,874	$6,186	$1,650	$27,494	$51,552	$127,849
16	$28,036	$7,080	$7,080	$6,372	$1,699	$28,319	$53,098	$131,684
17	$28,877	$7,292	$7,292	$6,563	$1,750	$29,169	$54,691	$135,635
18	$29,743	$7,511	$7,511	$6,760	$1,803	$30,044	$56,332	$139,704
19	$30,636	$7,736	$7,736	$6,963	$1,857	$30,945	$58,022	$143,895
20	$31,555	$7,968	$7,968	$7,172	$1,912	$31,873	$59,763	$148,212
21	$32,501	$8,207	$8,207	$7,387	$1,970	$32,830	$61,556	$152,658
22	$33,476	$8,454	$8,454	$7,608	$2,029	$33,815	$63,402	$157,238
23	$34,481	$8,707	$8,707	$7,837	$2,090	$34,829	$65,304	$161,955
24	$35,515	$8,968	$8,968	$8,072	$2,152	$35,874	$67,264	$166,814
25	$36,581	$9,238	$9,238	$8,314	$2,217	$36,950	$69,281	$171,818
26	$37,678	$9,515	$9,515	$8,563	$2,284	$38,059	$71,360	$176,972
27	$38,808	$9,800	$9,800	$8,820	$2,352	$39,200	$73,501	$182,282
28	$39,973	$10,094	$10,094	$9,085	$2,423	$40,376	$75,706	$187,750
29	$41,172	$10,397	$10,397	$9,357	$2,495	$41,588	$77,977	$193,383
30	$42,407	$10,709	$10,709	$9,638	$2,570	$42,835	$80,316	$199,184
*3% Inflation								

HUC 10 302 Annual Cost* After Cost-Share, Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Cost
1	$13,666	$3,451	$3,451	$3,106	$828	$13,804	$25,883	$64,190
2	$14,076	$3,555	$3,555	$3,199	$853	$14,218	$26,660	$66,116
3	$14,499	$3,661	$3,661	$3,295	$879	$14,645	$27,459	$68,099
4	$14,934	$3,771	$3,771	$3,394	$905	$15,084	$28,283	$70,142
5	$15,382	$3,884	$3,884	$3,496	$932	$15,537	$29,132	$72,247
6	$15,843	$4,001	$4,001	$3,601	$960	$16,003	$30,006	$74,414
7	$16,318	$4,121	$4,121	$3,709	$989	$16,483	$30,906	$76,646
8	$16,808	$4,244	$4,244	$3,820	$1,019	$16,978	$31,833	$78,946
9	$17,312	$4,372	$4,372	$3,935	$1,049	$17,487	$32,788	$81,314
10	$17,831	$4,503	$4,503	$4,053	$1,081	$18,012	$33,772	$83,754
11	$18,366	$4,638	$4,638	$4,174	$1,113	$18,552	$34,785	$86,266
12	$18,917	$4,777	$4,777	$4,299	$1,147	$19,108	$35,828	$88,854
13	$19,485	$4,920	$4,920	$4,428	$1,181	$19,682	$36,903	$91,520
14	$20,069	$5,068	$5,068	$4,561	$1,216	$20,272	$38,010	$94,265
15	$20,671	$5,220	$5,220	$4,698	$1,253	$20,880	$39,151	$97,093
16	$21,292	$5,377	$5,377	$4,839	$1,290	$21,507	$40,325	$100,006
17	$21,930	$5,538	$5,538	$4,984	$1,329	$22,152	$41,535	$103,006
18	$22,588	$5,704	$5,704	$5,134	$1,369	$22,816	$42,781	$106,097
19	$23,266	$5,875	$5,875	$5,288	$1,410	$23,501	$44,064	$109,279
20	$23,964	$6,051	$6,051	$5,446	$1,452	$24,206	$45,386	$112,558
21	$24,683	$6,233	$6,233	$5,610	$1,496	$24,932	$46,748	$115,935
22	$25,423	$6,420	$6,420	$5,778	$1,541	$25,680	$48,150	$119,413
23	$26,186	$6,613	$6,613	$5,951	$1,587	$26,451	$49,595	$122,995
24	$26,972	$6,811	$6,811	$6,130	$1,635	$27,244	$51,083	$126,685
25	$27,781	$7,015	$7,015	$6,314	$1,684	$28,061	$52,615	$130,485
26	$28,614	$7,226	$7,226	$6,503	$1,734	$28,903	$54,194	$134,400
27	$29,473	$7,443	$7,443	$6,698	$1,786	$29,770	$55,819	$138,432
28	$30,357	$7,666	$7,666	$6,899	$1,840	$30,663	$57,494	$142,585
29	$31,267	$7,896	$7,896	$7,106	$1,895	$31,583	$59,219	$146,862
30	$32,206	$8,133	$8,133	$7,319	$1,952	$32,531	$60,995	$151,268
**3% Inflation*								

HUC 10 303 Annual Cost* After Cost-Share, Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Cost
1	$5,127	$1,295	$1,295	$1,165	$311	$5,178	$9,709	$24,079
2	$5,280	$1,333	$1,333	$1,200	$320	$5,334	$10,001	$24,802
3	$5,439	$1,373	$1,373	$1,236	$330	$5,494	$10,301	$25,546
4	$5,602	$1,415	$1,415	$1,273	$340	$5,659	$10,610	$26,312
5	$5,770	$1,457	$1,457	$1,311	$350	$5,828	$10,928	$27,101
6	$5,943	$1,501	$1,501	$1,351	$360	$6,003	$11,256	$27,914
7	$6,121	$1,546	$1,546	$1,391	$371	$6,183	$11,594	$28,752
8	$6,305	$1,592	$1,592	$1,433	$382	$6,369	$11,941	$29,614
9	$6,494	$1,640	$1,640	$1,476	$394	$6,560	$12,300	$30,503
10	$6,689	$1,689	$1,689	$1,520	$405	$6,757	$12,669	$31,418
11	$6,890	$1,740	$1,740	$1,566	$418	$6,959	$13,049	$32,360
12	$7,096	$1,792	$1,792	$1,613	$430	$7,168	$13,440	$33,331
13	$7,309	$1,846	$1,846	$1,661	$443	$7,383	$13,843	$34,331
14	$7,529	$1,901	$1,901	$1,711	$456	$7,605	$14,259	$35,361
15	$7,754	$1,958	$1,958	$1,762	$470	$7,833	$14,686	$36,422
16	$7,987	$2,017	$2,017	$1,815	$484	$8,068	$15,127	$37,515
17	$8,227	$2,077	$2,077	$1,870	$499	$8,310	$15,581	$38,640
18	$8,473	$2,140	$2,140	$1,926	$514	$8,559	$16,048	$39,799
19	$8,728	$2,204	$2,204	$1,984	$529	$8,816	$16,530	$40,993
20	$8,989	$2,270	$2,270	$2,043	$545	$9,080	$17,025	$42,223
21	$9,259	$2,338	$2,338	$2,104	$561	$9,353	$17,536	$43,490
22	$9,537	$2,408	$2,408	$2,167	$578	$9,633	$18,062	$44,794
23	$9,823	$2,481	$2,481	$2,232	$595	$9,922	$18,604	$46,138
24	$10,118	$2,555	$2,555	$2,299	$613	$10,220	$19,162	$47,522
25	$10,421	$2,632	$2,632	$2,368	$632	$10,526	$19,737	$48,948
26	$10,734	$2,711	$2,711	$2,440	$651	$10,842	$20,329	$50,417
27	$11,056	$2,792	$2,792	$2,513	$670	$11,168	$20,939	$51,929
28	$11,388	$2,876	$2,876	$2,588	$690	$11,503	$21,567	$53,487
29	$11,729	$2,962	$2,962	$2,666	$711	$11,848	$22,214	$55,092
30	$12,081	$3,051	$3,051	$2,746	$732	$12,203	$22,881	$56,744

HUC 10 304 Annual Cost* After Cost-Share, Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Cost
1	$5,025	$1,269	$1,269	$1,142	$305	$5,076	$9,517	$23,602
2	$5,176	$1,307	$1,307	$1,176	$314	$5,228	$9,802	$24,310
3	$5,331	$1,346	$1,346	$1,212	$323	$5,385	$10,096	$25,039
4	$5,491	$1,387	$1,387	$1,248	$333	$5,546	$10,399	$25,790
5	$5,656	$1,428	$1,428	$1,285	$343	$5,713	$10,711	$26,564
6	$5,825	$1,471	$1,471	$1,324	$353	$5,884	$11,033	$27,361
7	$6,000	$1,515	$1,515	$1,364	$364	$6,061	$11,364	$28,182
8	$6,180	$1,561	$1,561	$1,405	$375	$6,242	$11,705	$29,027
9	$6,365	$1,607	$1,607	$1,447	$386	$6,430	$12,056	$29,898
10	$6,556	$1,656	$1,656	$1,490	$397	$6,623	$12,417	$30,795
11	$6,753	$1,705	$1,705	$1,535	$409	$6,821	$12,790	$31,719
12	$6,956	$1,756	$1,756	$1,581	$422	$7,026	$13,174	$32,670
13	$7,164	$1,809	$1,809	$1,628	$434	$7,237	$13,569	$33,651
14	$7,379	$1,863	$1,863	$1,677	$447	$7,454	$13,976	$34,660
15	$7,601	$1,919	$1,919	$1,727	$461	$7,677	$14,395	$35,700
16	$7,829	$1,977	$1,977	$1,779	$474	$7,908	$14,827	$36,771
17	$8,064	$2,036	$2,036	$1,833	$489	$8,145	$15,272	$37,874
18	$8,305	$2,097	$2,097	$1,888	$503	$8,389	$15,730	$39,010
19	$8,555	$2,160	$2,160	$1,944	$518	$8,641	$16,202	$40,181
20	$8,811	$2,225	$2,225	$2,003	$534	$8,900	$16,688	$41,386
21	$9,076	$2,292	$2,292	$2,063	$550	$9,167	$17,189	$42,628
22	$9,348	$2,361	$2,361	$2,125	$567	$9,442	$17,704	$43,906
23	$9,628	$2,431	$2,431	$2,188	$584	$9,726	$18,235	$45,224
24	$9,917	$2,504	$2,504	$2,254	$601	$10,017	$18,782	$46,580
25	$10,215	$2,579	$2,579	$2,322	$619	$10,318	$19,346	$47,978
26	$10,521	$2,657	$2,657	$2,391	$638	$10,627	$19,926	$49,417
27	$10,837	$2,737	$2,737	$2,463	$657	$10,946	$20,524	$50,900
28	$11,162	$2,819	$2,819	$2,537	$676	$11,275	$21,140	$52,427
29	$11,497	$2,903	$2,903	$2,613	$697	$11,613	$21,774	$53,999
30	$11,842	$2,990	$2,990	$2,691	$718	$11,961	$22,427	$55,619

**3% Inflation*

HUC 10 305 Annual Cost* After Cost-Share, Cropland BMPs								
Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Cost
1	$2,170	$548	$548	$493	$132	$2,192	$4,110	$10,193
2	$2,235	$564	$564	$508	$135	$2,258	$4,233	$10,499
3	$2,302	$581	$581	$523	$140	$2,325	$4,360	$10,814
4	$2,371	$599	$599	$539	$144	$2,395	$4,491	$11,138
5	$2,442	$617	$617	$555	$148	$2,467	$4,626	$11,472
6	$2,516	$635	$635	$572	$152	$2,541	$4,765	$11,816
7	$2,591	$654	$654	$589	$157	$2,617	$4,908	$12,171
8	$2,669	$674	$674	$607	$162	$2,696	$5,055	$12,536
9	$2,749	$694	$694	$625	$167	$2,777	$5,206	$12,912
10	$2,831	$715	$715	$644	$172	$2,860	$5,363	$13,299
11	$2,916	$736	$736	$663	$177	$2,946	$5,523	$13,698
12	$3,004	$759	$759	$683	$182	$3,034	$5,689	$14,109
13	$3,094	$781	$781	$703	$188	$3,125	$5,860	$14,532
14	$3,187	$805	$805	$724	$193	$3,219	$6,036	$14,968
15	$3,282	$829	$829	$746	$199	$3,316	$6,217	$15,418
16	$3,381	$854	$854	$768	$205	$3,415	$6,403	$15,880
17	$3,482	$879	$879	$791	$211	$3,518	$6,595	$16,356
18	$3,587	$906	$906	$815	$217	$3,623	$6,793	$16,847
19	$3,694	$933	$933	$840	$224	$3,732	$6,997	$17,353
20	$3,805	$961	$961	$865	$231	$3,844	$7,207	$17,873
21	$3,919	$990	$990	$891	$238	$3,959	$7,423	$18,409
22	$4,037	$1,019	$1,019	$917	$245	$4,078	$7,646	$18,962
23	$4,158	$1,050	$1,050	$945	$252	$4,200	$7,875	$19,530
24	$4,283	$1,082	$1,082	$973	$260	$4,326	$8,111	$20,116
25	$4,411	$1,114	$1,114	$1,003	$267	$4,456	$8,355	$20,720
26	$4,544	$1,147	$1,147	$1,033	$275	$4,590	$8,605	$21,341
27	$4,680	$1,182	$1,182	$1,064	$284	$4,727	$8,864	$21,982
28	$4,820	$1,217	$1,217	$1,096	$292	$4,869	$9,129	$22,641
29	$4,965	$1,254	$1,254	$1,128	$301	$5,015	$9,403	$23,320
30	$5,114	$1,291	$1,291	$1,162	$310	$5,166	$9,685	$24,020
*3% Inflation								

7. Cropland BMP implementation: Milestones

HUC 10 301 Annual Adoption (treated acres), Cropland BMPs									
	Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Adoption
Short-Term	1	600	909	909	91	91	909	545	4,053
	2	600	909	909	91	91	909	545	4,053
	3	600	909	909	91	91	909	545	4,053
	4	600	909	909	91	91	909	545	4,053
	5	600	909	909	91	91	909	545	4,053
	Subtotal	*2,999*	*4,544*	*4,544*	*454*	*454*	*4,544*	*2,727*	*20,267*
Medium-Term	6	600	909	909	91	91	909	545	4,053
	7	600	909	909	91	91	909	545	4,053
	8	600	909	909	91	91	909	545	4,053
	9	600	909	909	91	91	909	545	4,053
	10	600	909	909	91	91	909	545	4,053
	Subtotal	*5,998*	*9,089*	*9,089*	*909*	*909*	*9,089*	*5,453*	*40,535*
Long-Term	11	600	909	909	91	91	909	545	4,053
	12	600	909	909	91	91	909	545	4,053
	13	600	909	909	91	91	909	545	4,053
	14	600	909	909	91	91	909	545	4,053
	15	600	909	909	91	91	909	545	4,053
	16	600	909	909	91	91	909	545	4,053
	17	600	909	909	91	91	909	545	4,053
	18	600	909	909	91	91	909	545	4,053
	19	600	909	909	91	91	909	545	4,053
	20	600	909	909	91	91	909	545	4,053
	21	600	909	909	91	91	909	545	4,053
	22	600	909	909	91	91	909	545	4,053
	23	600	909	909	91	91	909	545	4,053
	24	600	909	909	91	91	909	545	4,053
	25	600	909	909	91	91	909	545	4,053
	26	600	909	909	91	91	909	545	4,053
	27	600	909	909	91	91	909	545	4,053
	28	600	909	909	91	91	909	545	4,053
	29	600	909	909	91	91	909	545	4,053
	30	600	909	909	91	91	909	545	4,053
	Total	**17,995**	**27,266**	**27,266**	**2,727**	**2,727**	**27,266**	**16,359**	**121,604**

HUC 10 302 Annual Adoption (treated acres), Cropland BMPs									
	Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Adoption
Short-Term	1	456	690	690	69	69	690	414	3,078
	2	456	690	690	69	69	690	414	3,078
	3	456	690	690	69	69	690	414	3,078
	4	456	690	690	69	69	690	414	3,078
	5	456	690	690	69	69	690	414	3,078
	Subtotal	*2,278*	*3,451*	*3,451*	*345*	*345*	*3,451*	*2,071*	*15,392*
Medium-Term	6	456	690	690	69	69	690	414	3,078
	7	456	690	690	69	69	690	414	3,078
	8	456	690	690	69	69	690	414	3,078
	9	456	690	690	69	69	690	414	3,078
	10	456	690	690	69	69	690	414	3,078
	Subtotal	*4,555*	*6,902*	*6,902*	*690*	*690*	*6,902*	*4,141*	*30,784*
Long-Term	11	456	690	690	69	69	690	414	3,078
	12	456	690	690	69	69	690	414	3,078
	13	456	690	690	69	69	690	414	3,078
	14	456	690	690	69	69	690	414	3,078
	15	456	690	690	69	69	690	414	3,078
	16	456	690	690	69	69	690	414	3,078
	17	456	690	690	69	69	690	414	3,078
	18	456	690	690	69	69	690	414	3,078
	19	456	690	690	69	69	690	414	3,078
	20	456	690	690	69	69	690	414	3,078
	21	456	690	690	69	69	690	414	3,078
	22	456	690	690	69	69	690	414	3,078
	23	456	690	690	69	69	690	414	3,078
	24	456	690	690	69	69	690	414	3,078
	25	456	690	690	69	69	690	414	3,078
	26	456	690	690	69	69	690	414	3,078
	27	456	690	690	69	69	690	414	3,078
	28	456	690	690	69	69	690	414	3,078
	29	456	690	690	69	69	690	414	3,078
	30	456	690	690	69	69	690	414	3,078
	Total	**13,666**	**20,707**	**20,707**	**2,071**	**2,071**	**20,707**	**12,424**	**92,351**

HUC 10 303 Annual Adoption (treated acres), Cropland BMPs									
	Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Adoption
Short-Term	1	171	259	259	26	26	259	155	1,155
	2	171	259	259	26	26	259	155	1,155
	3	171	259	259	26	26	259	155	1,155
	4	171	259	259	26	26	259	155	1,155
	5	171	259	259	26	26	259	155	1,155
	Subtotal	*854*	*1,295*	*1,295*	*129*	*129*	*1,295*	*777*	*5,774*
Medium-Term	6	171	259	259	26	26	259	155	1,155
	7	171	259	259	26	26	259	155	1,155
	8	171	259	259	26	26	259	155	1,155
	9	171	259	259	26	26	259	155	1,155
	10	171	259	259	26	26	259	155	1,155
	Subtotal	*1,709*	*2,589*	*2,589*	*259*	*259*	*2,589*	*1,554*	*11,548*
Long-Term	11	171	259	259	26	26	259	155	1,155
	12	171	259	259	26	26	259	155	1,155
	13	171	259	259	26	26	259	155	1,155
	14	171	259	259	26	26	259	155	1,155
	15	171	259	259	26	26	259	155	1,155
	16	171	259	259	26	26	259	155	1,155
	17	171	259	259	26	26	259	155	1,155
	18	171	259	259	26	26	259	155	1,155
	19	171	259	259	26	26	259	155	1,155
	20	171	259	259	26	26	259	155	1,155
	21	171	259	259	26	26	259	155	1,155
	22	171	259	259	26	26	259	155	1,155
	23	171	259	259	26	26	259	155	1,155
	24	171	259	259	26	26	259	155	1,155
	25	171	259	259	26	26	259	155	1,155
	26	171	259	259	26	26	259	155	1,155
	27	171	259	259	26	26	259	155	1,155
	28	171	259	259	26	26	259	155	1,155
	29	171	259	259	26	26	259	155	1,155
	30	171	259	259	26	26	259	155	1,155
	Total	**5,127**	**7,768**	**7,768**	**777**	**777**	**7,768**	**4,661**	**34,643**

HUC 10 304 Annual Adoption (treated acres), Cropland BMPs									
	Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Adoption
Short-Term	1	167	254	254	25	25	254	152	1,132
	2	167	254	254	25	25	254	152	1,132
	3	167	254	254	25	25	254	152	1,132
	4	167	254	254	25	25	254	152	1,132
	5	167	254	254	25	25	254	152	1,132
	Subtotal	*837*	*1,269*	*1,269*	*127*	*127*	*1,269*	*761*	*5,659*
Medium-Term	6	167	254	254	25	25	254	152	1,132
	7	167	254	254	25	25	254	152	1,132
	8	167	254	254	25	25	254	152	1,132
	9	167	254	254	25	25	254	152	1,132
	10	167	254	254	25	25	254	152	1,132
	Subtotal	*1,675*	*2,538*	*2,538*	*254*	*254*	*2,538*	*1,523*	*11,319*
Long-Term	11	167	254	254	25	25	254	152	1,132
	12	167	254	254	25	25	254	152	1,132
	13	167	254	254	25	25	254	152	1,132
	14	167	254	254	25	25	254	152	1,132
	15	167	254	254	25	25	254	152	1,132
	16	167	254	254	25	25	254	152	1,132
	17	167	254	254	25	25	254	152	1,132
	18	167	254	254	25	25	254	152	1,132
	19	167	254	254	25	25	254	152	1,132
	20	167	254	254	25	25	254	152	1,132
	21	167	254	254	25	25	254	152	1,132
	22	167	254	254	25	25	254	152	1,132
	23	167	254	254	25	25	254	152	1,132
	24	167	254	254	25	25	254	152	1,132
	25	167	254	254	25	25	254	152	1,132
	26	167	254	254	25	25	254	152	1,132
	27	167	254	254	25	25	254	152	1,132
	28	167	254	254	25	25	254	152	1,132
	29	167	254	254	25	25	254	152	1,132
	30	167	254	254	25	25	254	152	1,132
	Total	**5,025**	**7,614**	**7,614**	**761**	**761**	**7,614**	**4,568**	**33,956**

HUC 10 305 Annual Adoption (treated acres), Cropland BMPs									
	Year	Buffers	Cover Crop	No-Till	Permanent Vegetation	Subsurface Fertilizer	Terraces	Waterways	Total Adoption
Short-Term	1	72	110	110	11	11	110	66	489
	2	72	110	110	11	11	110	66	489
	3	72	110	110	11	11	110	66	489
	4	72	110	110	11	11	110	66	489
	5	72	110	110	11	11	110	66	489
	Subtotal	*362*	*548*	*548*	*55*	*55*	*548*	*329*	*2,444*
Medium-Term	6	72	110	110	11	11	110	66	489
	7	72	110	110	11	11	110	66	489
	8	72	110	110	11	11	110	66	489
	9	72	110	110	11	11	110	66	489
	10	72	110	110	11	11	110	66	489
	Subtotal	*723*	*1,096*	*1,096*	*110*	*110*	*1,096*	*658*	*4,888*
Long-Term	11	72	110	110	11	11	110	66	489
	12	72	110	110	11	11	110	66	489
	13	72	110	110	11	11	110	66	489
	14	72	110	110	11	11	110	66	489
	15	72	110	110	11	11	110	66	489
	16	72	110	110	11	11	110	66	489
	17	72	110	110	11	11	110	66	489
	18	72	110	110	11	11	110	66	489
	19	72	110	110	11	11	110	66	489
	20	72	110	110	11	11	110	66	489
	21	72	110	110	11	11	110	66	489
	22	72	110	110	11	11	110	66	489
	23	72	110	110	11	11	110	66	489
	24	72	110	110	11	11	110	66	489
	25	72	110	110	11	11	110	66	489
	26	72	110	110	11	11	110	66	489
	27	72	110	110	11	11	110	66	489
	28	72	110	110	11	11	110	66	489
	29	72	110	110	11	11	110	66	489
	30	72	110	110	11	11	110	66	489
	Total	**2,170**	**3,288**	**3,288**	**329**	**329**	**3,288**	**1,973**	**14,664**