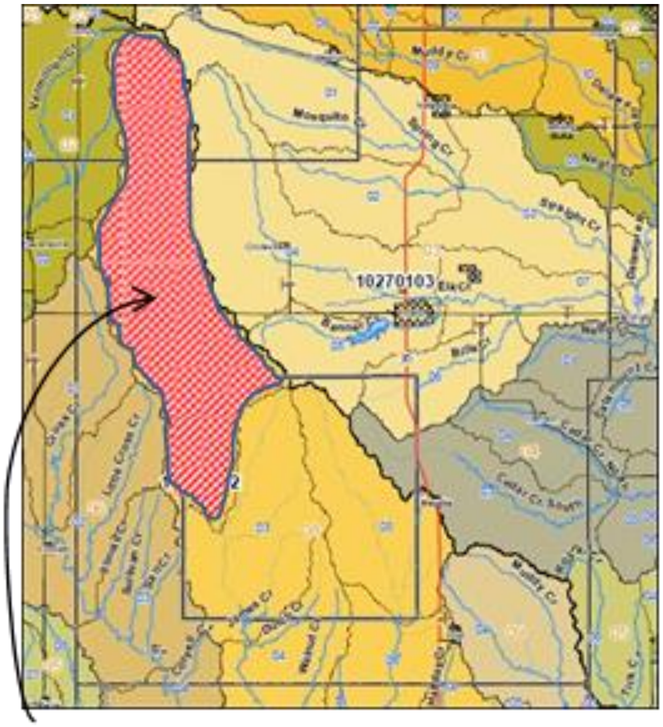
PBPN 9 Critical Element Plan Overview

WATER QUALITYIMPAIRMENTS DIRECTLY ADDRESSED



Upper Soldier Creek Focus Area, Jackson County

Upper Soldier Creek near Delia – Aquatic Life/Total Suspended Solids (High)

Upper Soldier Creek above and below the Prairie Band Potawatomi Nation Reservation is listed as Partially Supporting for Aquatic Life due to sediment, and a TMDL has been designated that includes the Walnut Creek, James Creek, and Dutch Creek tributaries. Aquatic life is impaired due to sediment, which greatly influences biological activity as sediment loads are correlated with nutrient, pesticide, and fecal coliform bacteria.

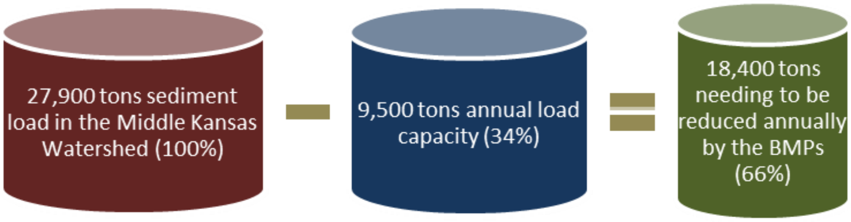
Tribal lands lie outside the jurisdiction and oversight of the Kansas Department of Health and Environment, and this TMDL is referenced as a guideline only for the Tribe's water quality planning and nonpoint source management efforts.

BEST MANAGEMENT PRACTICES AND REDUCTION GOALS

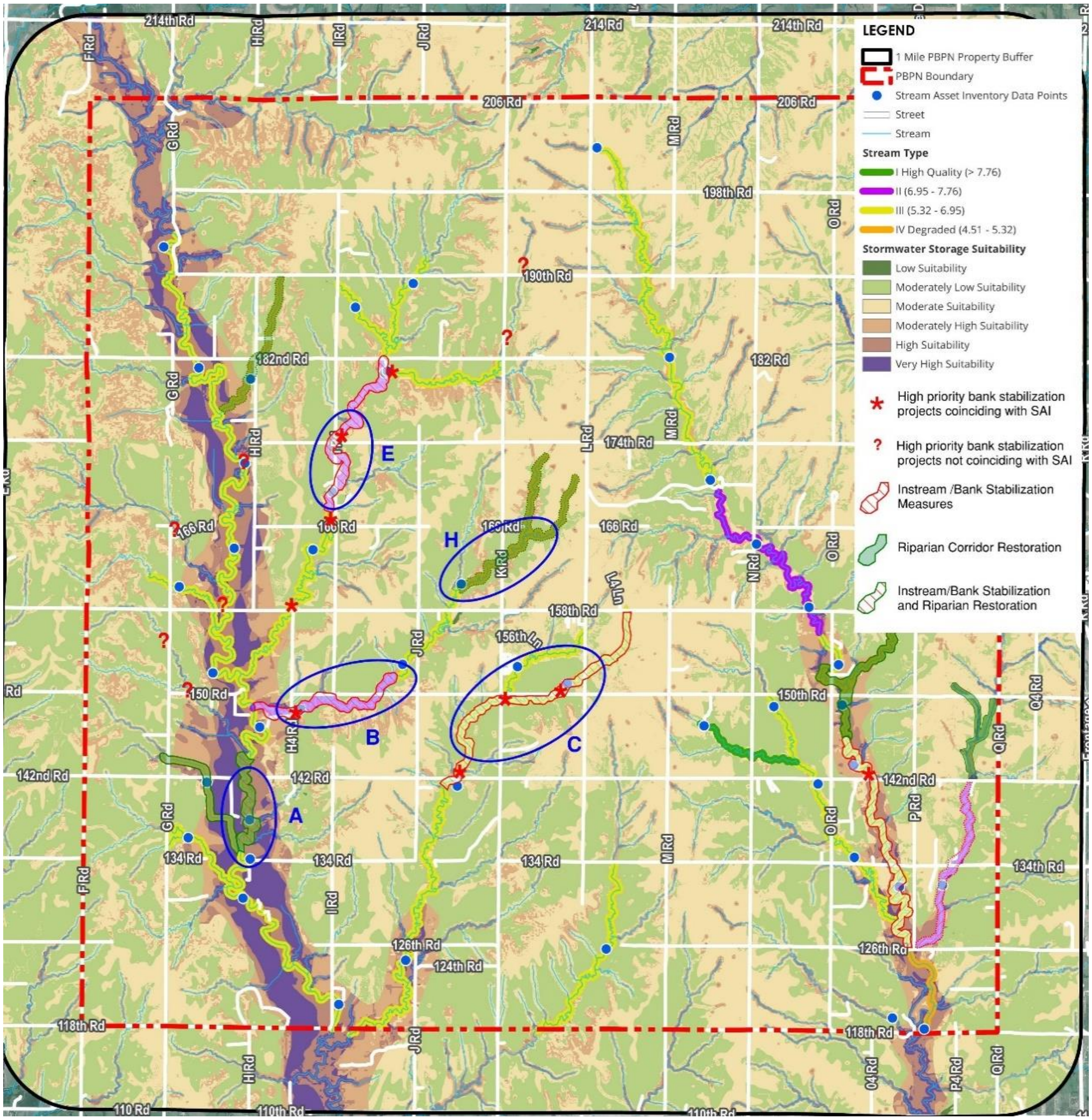
The current estimated sediment load from nonpoint sources in the Upper Soldier Creek watershed is 27,900 tpy according to KDHE (KAWS, 2011). KDHE's proposed load reduction endpoint to meet the TMDL is 18,400 tons of sediment per year. BMPs implemented by the Nation on Tribal land and in partnership with non-tribal landowners where possible will address sediment originating on the Reservation, and will contribute to overall sediment load reductions, which will help partners and neighboring communities meet the desired endpoint.

Because agricultural land uses make up most of the Reservation's area, agricultural BMPs are proposed to meet the pollutant reduction targets:

- Riparian buffers
- Stream stabilization
- No-till and regenerative agriculture
- Information & education



On non-tribal land not subject to the Nation's jurisdiction, the Tribe will partner with the Cooperative Extension Service, Jackson County Conservation District, Natural Resources Conservation Service, and other Middle Kansas WRAPS partners to enlist landowners to participate in this effort. Potential load reduction estimates presented below are good faith estimates of potential partnerships, based on current agricultural trends.



Proposed riparian corridor restoration and/or streambank stabilization areas

The Nation proposes a 20-year implementation program to implement the BMPs.

	Current Condition Average TSS Runoff Condition	10-Year Goal		20-Year Goal	
		Improved Condition Average TSS	Total Reduction Desired	Improved Condition Average TSS	Total Reduction Desired
Soldier Creek SC101 (Delia)	232 mg/l	200 mg/l	**25%**	168 mg/l	**50%**

Reductions in total phosphorus (TP), total nitrogen (TN), and bacteria should be proportional to TSS reductions. In addition, PBPN will make improvements toward the following desired endpoints: an average EPT count of 48% or greater and MBI values approaching 4.5 after 20 years.

PRAIRIE BAND POTAWATOMI NATION
9 CRITICAL ELEMENT PLAN

SOLDIER CREEK WATERSHED
JUNE 2024 – FINAL

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LIST OF ACRONYMS

BMP	Best Management Practice
CAFO	Confined Animal Feeding Operation
CFS	Cubic Feet per Second
GIS	Geographic Information System
HUC	Hydrologic Unit Code
I&E	Information and Education
KDHE	Kansas Department of Health and Environment
LA	Load Allocation
LC	Load Capacity
MS4	Municipal Separate Storm Sewer Systems
NPS	Non-point Source
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources and Conservation Service
O&M	Operations and Maintenance
PBPN	Prairie Band Potawatomi Nation
PEP	Planning and Environmental Protection
POTW	Publicly owned Treatment Works
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USGS	United States Geological Survey

WIRE	Wichita Initiative to Renew the Environment
WLA	Waste Load Allocation

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1.0 PREFACE

The Prairie Band Potawatomi Nation (PBPN) considers water to be one of their most important natural and cultural resources. Protection of aquatic resources and their associated terrestrial resources has biological, cultural, and economic benefits due to the significance of fish and wildlife consumption. Management of natural resources (both aquatic and terrestrial) within the Reservation is reflected within several of the Tribe's management plans and land use planning documents. This plan provides guidance to staff and Tribal leadership to make sound management decisions that will protect and enhance water quality on the Reservation and downstream in the Soldier Creek watershed. A watershed or ecosystem management plan uses an integrated approach that incorporates both the natural and human environment. The underlying tenet of this type of planning effort is a very humanistic view of resource management, blending the needs of people and environmental values.

The purpose of this 9 Element Plan is to outline an aspirational but achievable plan to protect and restore the Reservation's aquatic resources and, in the process, protect and enhance its terrestrial natural resources, cultural resources, and community values. In doing so, the Nation will take additional steps to develop its long-range goals and objectives for greater Tribal regulation of its sovereign water resources, while enhancing water resources throughout the Soldier Creek watershed and Kaw (Kansas) River receiving waters for our watershed partners and neighboring communities.

This plan is intended to serve as the overall guide for successful implementation of watershed protection and restoration efforts by the Nation and stakeholders, including Tribal agencies, agricultural enterprises, and Tribal and non-tribal landowners, leading to the achievement of our stated goals and objectives.

The Prairie Band Potawatomi Nation Reservation and Community was established in Northeast Kansas by treaty in 1846, with its government offices located at 16281 Q Road, Mayetta, Kansa (Figure 1). The closest major cities are the City of Topeka, Kansas, which is 20 miles south, and the City of Kansas City, Missouri, 80 miles to the southeast. Smaller communities bordering the Reservation include the towns of Mayetta, Hoyt, Delia, and Holton, Kansas.

Figure 1 - Study Area Location in Jackson County, KS (map source: World Atlas)

2.0 VISION AND GOALS

During preparation of PBPN's Land and Water Management Plan (PBPN 2021), the planning team conducted a visioning session with PBPN staff to help create a vision and goals and priorities related to protection and management of natural resources:

> *The future landscape will sustain, protect, and improve the diversity of ecosystems found within the Reservation, using an integrated resource management approach that protects and promotes a culture and history of water and land that honors and respects the Tribe's historical roots within the Great Lakes region.*

The planning team asked several questions of staff to better understand what natural resources are found within the Reservation, what problems and opportunities exist, and how these resources relate to the people who call the Reservation home. Goals and objectives supporting water management practices included:

- Adopt water policies that are adaptable and resilient to climate change.
- Create a Land and Water Management Council in charge of managing natural resources and implementing best management practices (BMPs).
- Develop a water supply that is controlled and managed by the PBPN.
- Implement technology and other cooperative practices that conserve water and save money. For example, low flow fixtures, rainwater harvesting, and a grey water system for the casino and golf course.

Resource management that includes the greater PBPN community and its partners:

- Bring program development together and highlight areas of overlap.
- Identify project partnership opportunities.
- Educate the greater community of both tribal and non-tribal landowners.

According to the Kansas Surface Water Register (KDHE 2021), the rivers and streams in this area of Kansas are generally used to support aquatic life, recreation, food procurement, groundwater recharge, industrial water supply, irrigation water supply, livestock water supply, and domestic water supply.

2.1 WATERSHED MANAGEMENT PROGRAM

In 2006, the Planning and Environmental Protection (PEP) Department obtained Treatment as a State (TAS) status from the EPA, to initiate their water quality program. The program primarily addresses nonpoint source pollutants and management, as point sources do not contribute significantly to pollutant loadings as discussed later in the document. Over the years, the program has expanded to include a Clean Water Act (CWA) 319 Tribal Non-Point Source Pollution Control Program and a Wetland Program. PEP staff have been actively monitoring surface and groundwater to develop a baseline for water quality standards and a watershed plan within the Reservation. Surface water monitoring is conducted at five sites along Big Soldier, Little Soldier, and Big Elm Creeks. Additionally, eight monitoring wells are located throughout the Reservation. PEP staff monitor several environmental microbiological, inorganic, and organic chemical indicators, including but not limited to Escherichia coli, dissolved oxygen, pH, temperature, turbidity, total nitrogen, total phosphorous, total suspended solids, metals, pesticides, volatiles, and herbicides.

This plan will continue to guide the Nation' as it addresses its water quality concerns. It will also help PBPN consider whether to apply for expanded TAS status to designate uses for the Reservation's streams, adopt Water Quality Standards, and develop TMDLs.

2.2 WATER QUALITY IMPAIRMENTS

Upper Soldier Creek above and below the PBPN Reservation is listed as Partially Supporting for Aquatic Life due to sediment, and a TMDL has been designated that includes the Walnut Creek, James Creek, and Dutch Creek tributaries. Little Soldier Creek is not listed as impaired for any pollutants. Aquatic life is impaired within these stream reaches due to sediment. Biological activity is greatly influenced by suspended sediment, as sediment loads are correlated with nutrient, pesticide, and fecal coliform bacteria loading within the stream system. (Kansas Alliance for Wetlands and Streams [KAWS], 2011). Tribal lands lie outside the jurisdiction and oversight of the Kansas Department of Health and Environment, and this TMDL is referenced as a guideline only for the Tribe's water quality planning and nonpoint source management efforts.

Upper Soldier Creek is also listed as impaired for Aquatic Life on the 2022 Section 303(d) list due to Atrazine. TMDL development may be scheduled during the 2025 planning period. Lower Soldier Creek, downstream of the Reservation, is also listed as impaired for E. Coli bacteria, and a TMDL may also be scheduled during the 2025 planning period (KDHE 2022). See Table 1, below.

TABLE 1: SECTION 303(d) IMPAIRMENTS - 2022

Category	Stream/Lake	Impaired use	Impairment	Station	Counties	Body type	Priority
*5	Soldier Creek Near Delia	Aquatic life	Total Suspended Solids	SC101	NM, JA	Watershed	2023
4a	Soldier Creek near Circleville	Aquatic life	Biology	SC299	JA, NM	Watershed	High
4a	Soldier Creek Near Delia	Aquatic life	Biology	SC 101	NM, JA	Watershed	High
5	Soldier Creek Near Topeka	Aquatic life	Atrazine	SC239	JA, SN	Watershed	2025
5	Soldier Creek Near Delia	Aquatic life	Atrazine	SC101	NM, JA	Watershed	2023
5	Soldier Creek Near Topeka	Recreation	*Escherichia coli*	SC239	JA, SN	Watershed	2025

* NOTE: TSS taken off 303(d) list (KDHE, 2022)
Category 4a: A Total Maximum Daily Load (TMDL) has been developed.
Category 5: Available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed.

Section 305(b) of the Clean Water Act requires PBPN- PEP Water Program to develop and submit an annual Water Quality Assessment Report. PBPN-PEP CWA-106 Program has submitted EPA approved Tribal Assessment Reports (TAR) from 2006 to 2023 to fulfill statutory requirements. Data and usage of those reports supported graduate student (Boyd 2019) efforts."

An assessment of the Reservation's water quality impacts on cultural and natural resources was completed in 2019 by a University of Kansas graduate student (Boyd 2019). Boyd based his assessment on the PBPN's past water quality studies, along with years of data from water-quality remediation and enhancement sampling and monitoring projects. The assessment noted that two categories of pollution pose a significant risk to water quality within the Reservation: nonpoint source pollution from agricultural land use within and around the Reservation, and point source pollution from septic systems, sewage lagoons, and injection wells upstream of the Reservation boundaries.

A stream channel stability assessment was completed in 2020 (WRS 2020a), which helps to understand streambank erosion as another pollutant source. The assessment generally followed an established geomorphic screening method from the Kansas City regional chapter of the American Public Works Association (APWA), which is applicable for streams within the Reservation. A field team comprised of engineers and PEP staff gathered data at 36 locations along streams representing approximately 22 miles of stream length in the Soldier Creek watershed. The team then used the data to rank the stability of each adjacent stream reach. Where field data were not collected, the project engineers used geographic information system data along with adjacent stream reach field results to either interpolate or extrapolate stream conditions as appropriate. Additional potential future sampling locations were also identified (Figure 2), which may be assessed by PEP staff in the future to help confirm the rankings assigned in this study. Those additional sites are noted with green dots on the map in Figure 2.

Using this method, stream reach stability was ranked as "good," "fair," or "poor." The project engineers also used these data to identify stream restoration priorities, which were further evaluated and screened through a preliminary cost-benefit analysis based on typical costs per linear foot for rural stream restoration in the area (WRS 2020a). Project prioritization was based on cost, length of reach, and severity of degradation. Refer to the 2020 Stream System Assessment Report in Appendix B for the prioritized list of capital improvement projects. Based on the APWA method utilized for the channel stability assessment, approximately 50 percent of the length of Big Soldier Creek is in fair condition and 50 percent is in poor condition. Little Soldier Creek exhibits approximately 75 percent fair condition and 25 percent poor condition along its length through the Reservation boundaries. The difference between the two is likely due to Big Soldier Creek having higher flows, resulting in significantly greater degradation than in Little Soldier Creek. Stream reaches within the Reservation ranked only "fair" or "poor" because of widespread impacts from past and present land uses (Figure 2).

The assessment also provided a risk analysis of stream reaches, to guide future interventions to improve stream stability. Basic facts considered in the risk analysis included:

- Big Soldier and Little Soldier Creeks are actively eroding and adjusting to changes in land use and climate.
- Land within the Reservation may continue to develop and change with time.

- Land upstream of the Reservation boundary in tributary watersheds to Big Soldier Creek will likely continue to develop outside of the PBPN's control. Such development would affect erosion rates of Big Soldier Creek.

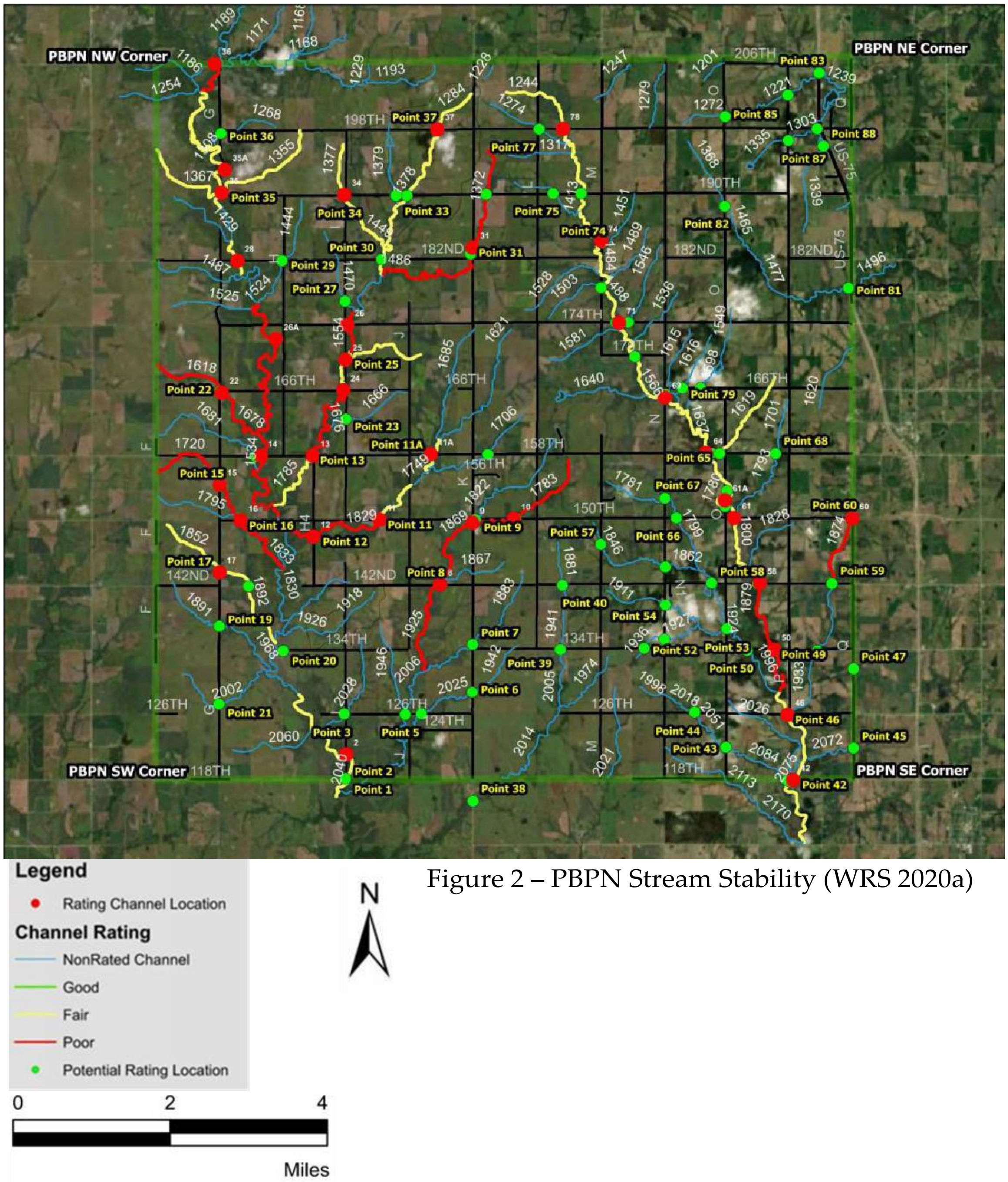

Figure 2 – PBPN Stream Stability (WRS 2020a)

As a result of the risk analysis, the engineers recommended that as future development takes place, the PBPN should be careful to maintain vegetated stream buffers adjacent to Big and Little Soldier Creeks and other tributaries. Those buffers would reduce the risk of actively eroding streams that could affect public safety, private property, and natural resources (WRS 2020a).

2.3 ENVIRONMENTAL JUSTICE FOCUS

In September 2021, EPA's national Nonpoint Source (NPS) program issued a memorandum recognizing the importance of integrating environmental justice (EJ) considerations into the Clean Water Act (CWA) §319 grant program to help ensure that disadvantaged communities (DACs) equitably enjoy the benefits of cleaner water. EPA's EJ call for action led to an enthusiastic response from the CWA §319 community. Many states have committed address barriers and increase equity, including but not limited to waiving non-federal match for sub-recipients, revising sub-award application criteria to prioritize projects in DACs, and supporting communities as they begin to implement watershed plans (USEPA 2022).

In September 2022 EPA issued a follow-up memorandum that outlines specific elements related to Tribal programs and requirements, including:

- Allowing states to direct CWA §319 funds to support watershed plan development and capacity building in DACs.
- Granting an exception to the 2013 CWA §319 guidelines that allows states to award CWA §319 watershed project funds to CWA §319-eligible Tribes to implement project(s) consistent with an up-to-date, EPA-approved Tribal NPS management program plan, which EPA will now consider as an acceptable alternative to a nine-element plan.
- Requiring grantees to discuss efforts to advance environmental justice in their annual reports to EPA.
- Increasing §319 investments to DACs to 40 percent nationally.
- Better supporting Tribal programs through the above initiatives, as well as increased Tribal grant funding, higher project funding caps, enhanced collaboration with partners to provide technical support, and continued work to address key Tribal challenges.

As a DAC and a Tribal Nation, PBPN will work collaboratively with EPA and the State of Kansas as these initiatives unfold to ensure that it is fully participating and is positioned to maximize program benefits. It will also collaborate with partners and neighboring communities to help leverage benefits for other DACs within the Middle Kansas Watershed.

3.0 WATERSHED REVIEW

3.1 SURFACE WATER

The Middle Kansas watershed (HUC 10270102) comprises an area of land approximately 2,180 square miles (1,365,615 acres) in size that drains a portion of northeastern Kansas. HUCs (Hydrologic Unit Codes) are an identification system for watersheds. Each watershed has a defined HUC number in addition to a common name. The larger the HUC number, the smaller the watershed area. Thus, HUC 8s can further be split into smaller watersheds and are given HUC 10 numbers. HUC 10s can be further divided into smaller HUC 12 watersheds. Figure 3 shows the Middle and Upper Kansas HUC 8s and 10s, which are within the Watershed Restoration and Protection Strategy (WRAPS) project area (KAWS 2011).

The Middle Kansas Watershed includes parts of 10 counties including Douglas, Geary, Jackson, Jefferson, Nemaha, Morris, Pottawatomie, Riley, Shawnee, and Wabaunsee Counties. The Upper Kansas Watershed includes portions of four counties including Morris, Geary, Riley, and Wabaunsee.

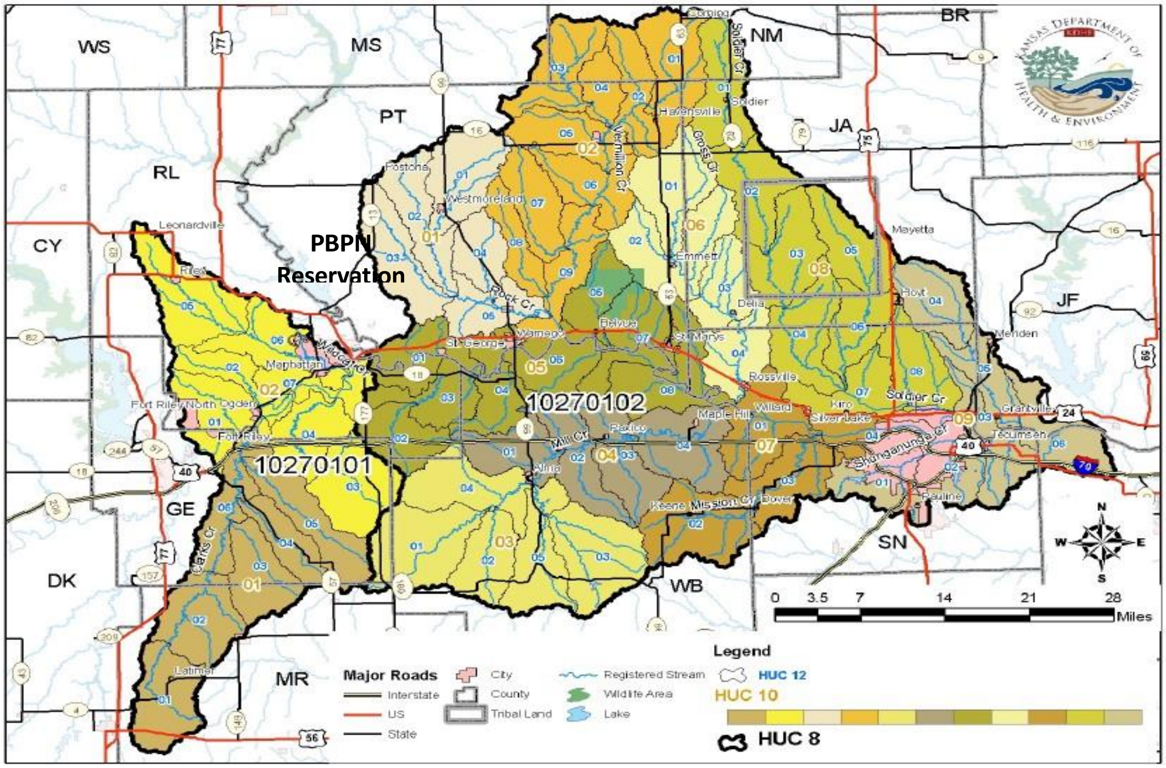

Figure 3 – Watersheds with the PBPN Reservation Boundary (KAWS 2011)

The primary surface waters within the Reservation are in the Soldier Creek watershed (HUC 1027010208), which encompasses Big Soldier and Little Soldier Creek sub-watersheds (Figure 4). The Delaware River watershed, which crosses through the northeastern corner of the Reservation and includes Banner, South Cedar, and Bills Creek sub-watersheds, is not included in this study. Streams within the Soldier Creek watershed generally flow south and east. Big Soldier Creek watershed located in the western side of the Reservation (HUC 102701020802, 102701020803, 102701020804), drains approximately 60% of the Reservation. Little Soldier Creek (HUC 102701020805) in the central and eastern side, drains approximately 30% of the Reservation.

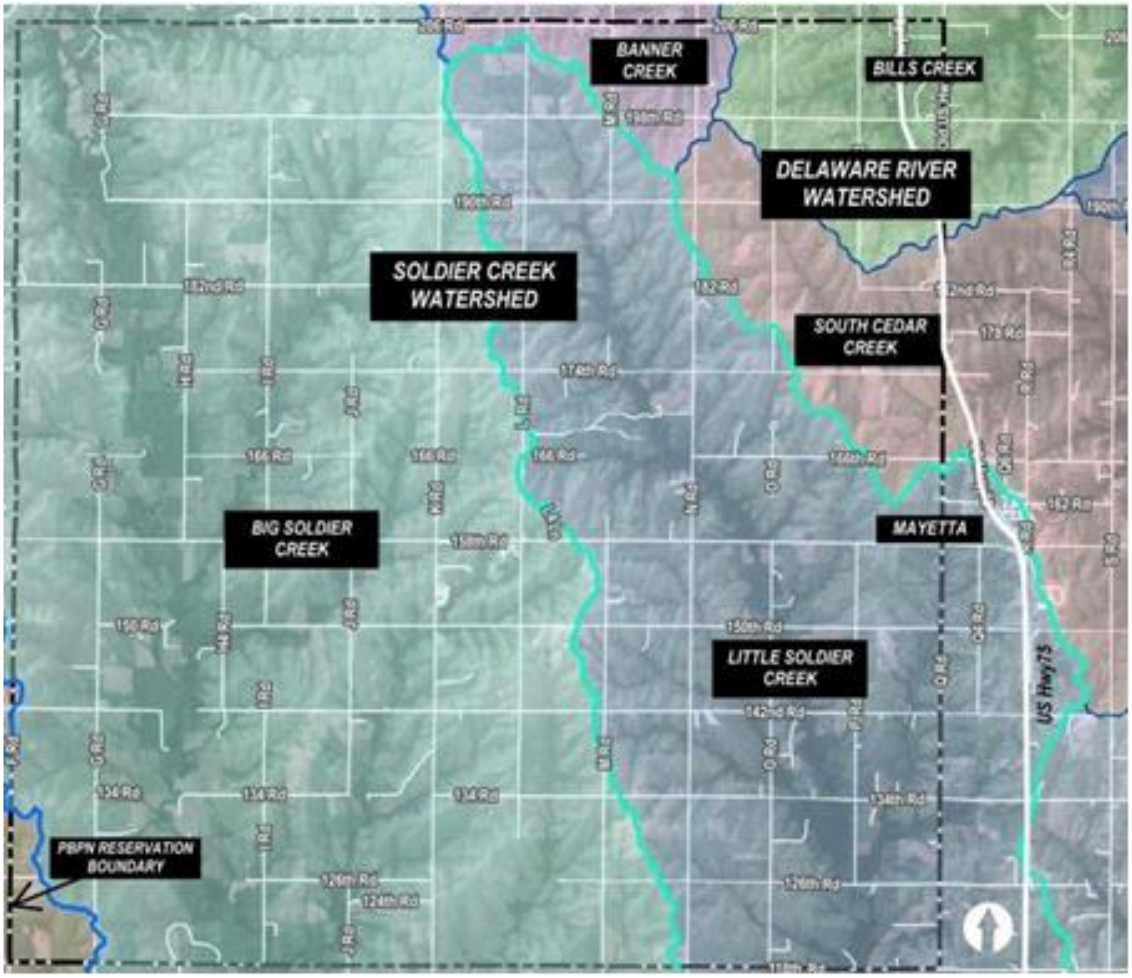

Figure 4 – Watersheds within the PBPN Reservation Boundary

3.2 GROUNDWATER

Groundwater studies of Jackson County were initiated by the USGS as early as 1949, to study the presence of groundwater to meet present and future water supply demands (USGS 1953). According to this study, nearly all the population in rural areas of the county depended on domestic wells for their water supply. These wells are fed by groundwater from five primary regions in Jackson County. In addition to the 1954 study, PBPN provided well data that was used to determine location, depth, and yield within the Reservation (WRS 2020b).

The review of USGS studies indicated that the quality of groundwater is highly variable, and that components found in the groundwater include dissolved solids, iron, fluoride, nitrate, and sulfate. Based on this information, neither the quantity nor the quality of groundwater is sufficient for long-term sustainable use by the Tribe (WRS 2020b). Given the limitations for use of groundwater, most drinking water on the Reservation is purchased from Rural Water District #3 in Jackson County, Kansas. The primary source of drinking water is from the Banner Creek Reservoir, which is located outside of the northeastern boundary of the Reservation, in the Delaware River watershed.

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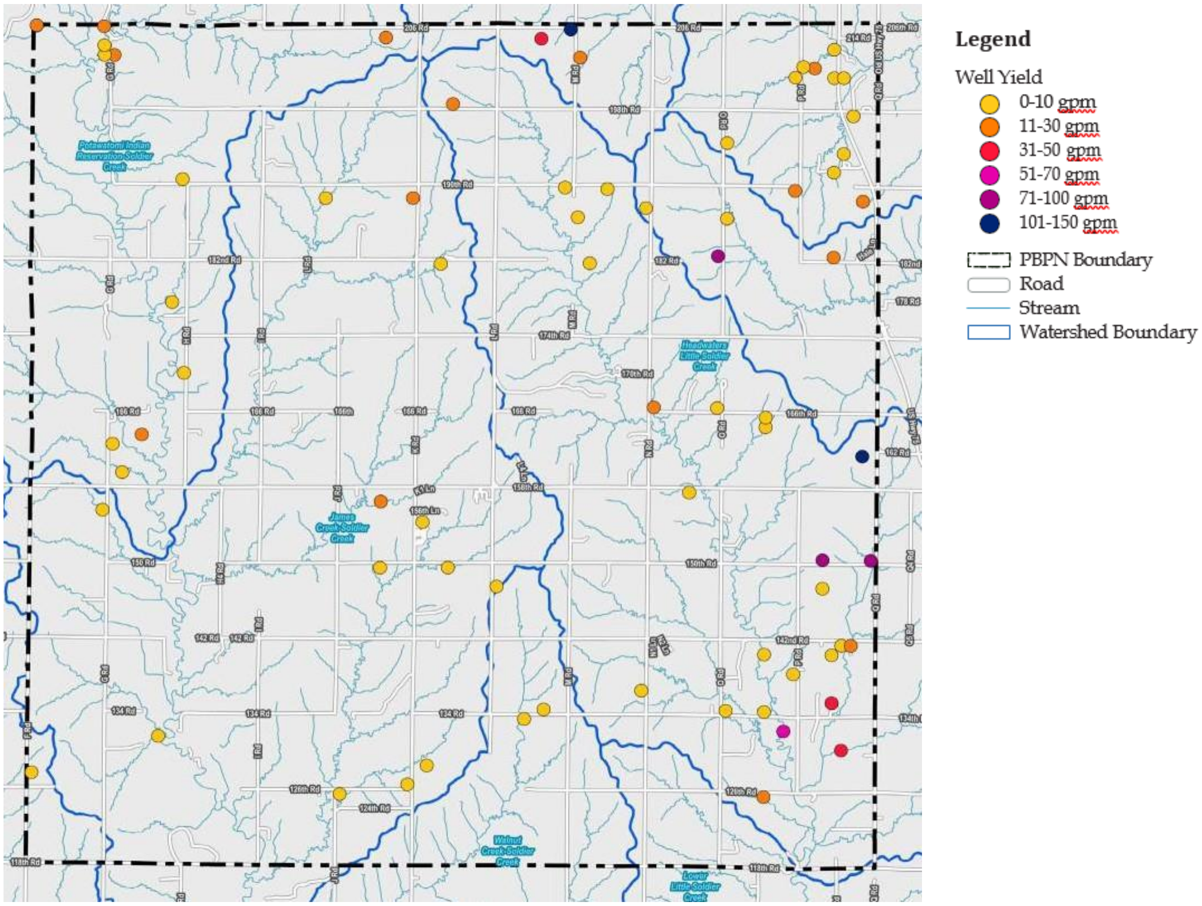

Figure 5 – Location and capacity of water supply wells

A total of 94 wells were reported (Figure 5), of which 76 have reported yield, 11 have no reported yield, and 7 have been plugged. Approximately 66% of the wells reporting yields had between 0 and 10 gallons per minute (gpm). Two wells reporting 150 gpm were drilled to a depth of 140 feet and are located due west of 162nd Rd along the eastern edge of the Reservation, and near the intersection of M and 206th Rd along the northern boundary of the Reservation. Three wells reporting 100 gpm were drilled to depths ranging from 75 to 100 feet deep. The maximum yield of 150 gpm from well records equates to approximately 242 acre- feet of water yield in one year if those wells were to run continuously (WRS 2020a).

3.3 LAND COVER/LAND USES

The Reservation is 121 square miles, or 77,440 acres, in size. Land ownership within the Reservation is divided into the following five categories:

- Tribal Trust – land that is held in legal title by the federal government (the Bureau of Indian Affairs, BIA) but, the beneficial interest lies with the PBPN.
- Tribal Fee – land owned by the PBPN but not yet placed into trust with the BIA.
- Tribal Allotment – land that is held in legal title by the BIA but, the beneficial interest lies with individual tribal members and the PBPN.
- Individual Allotment – land that is owned in fee title by the BIA but, the beneficial interest lies with individual tribal members.
- Non-tribal/Private – land that is owned and controlled by non-tribal members and that is not held in trust.

Currently, 46.2 percent of the Reservation is in various forms of tribal ownership or trust, and 53.8 percent is in non-tribal ownership. The patchwork mix of land ownership creates additional challenges for management of natural resources within the Reservation. The PBPN Reservation lies within three distinct ecoregions (Figure 6). The eastern portion is within the Western Corn Belt Plains; the western portion is within the Flint Hills; and the southern edge is within the Central Irregular Plains (US EPA 2020). Soils are predominantly silty clay loams throughout, with rocky soils in the Flint Hills portion of the Reservation. Vegetation within these ecoregions historically transitioned from oak/hickory forests in the east to tallgrass prairie in the west. The Flint Hills has the unique distinction of having the largest remaining intact tallgrass prairie in the Great Plains region. Presently, vegetative communities are a mix of native grasslands, cool season pasture, agricultural crop fields, and wooded riparian corridors along streams.

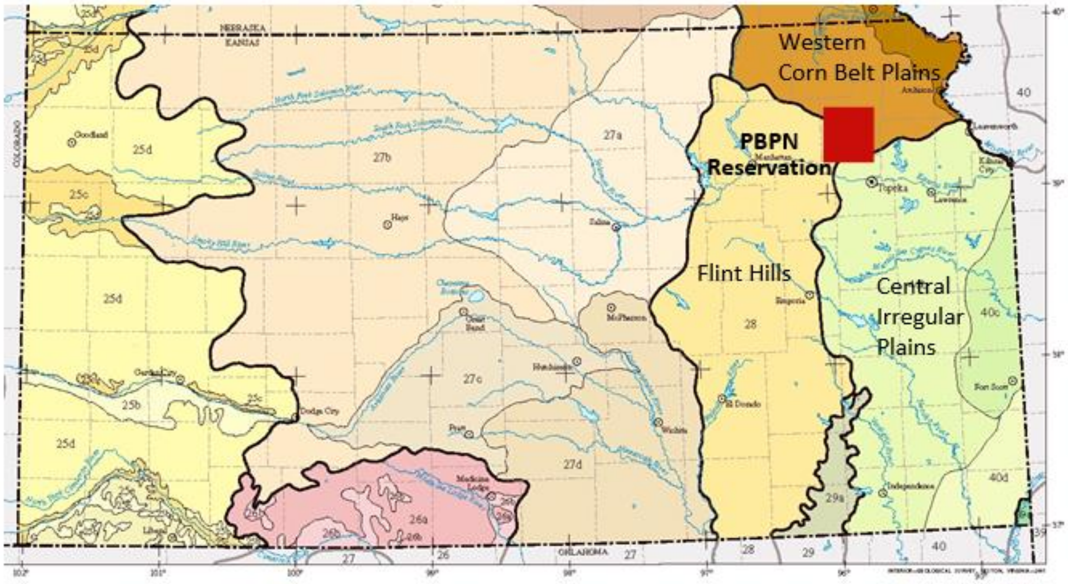

Figure 6 – PBPN Ecoregions

This is consistent with the Kansas Department of Health and Environment's (KDHE) Kansas- Lower Republican Basin Total Maximum Daily Load (TMDL) study (KDHE 2007), which used Kansas GAP data. The difference is most likely attributable to the differences in the GIS datasets. The KDHE Study focused on the Middle Kansas Subbasin in Shawnee, Jackson, and Nemaha Counties, comparing land cover within and outside of the Reservation boundaries for the Soldier Creek watershed. The study noted a slightly higher percentage of non-native grassland than native prairie, which is consistent with the brome dominated grasslands present throughout Jackson County.

The KDHE Study also compared land cover within a 100-foot buffer of streams within the Reservation boundaries and noted that woodland cover is significantly higher within the stream corridors, followed by native prairie (Figure 7). Field assessments for streams confirmed that most of the woodland vegetation present is within riparian (streamside) corridors.

Figure 7 – Land cover mapping of the PBPN Reservation

As noted above, several potential non-point pollutant sources are associated with land use identified in the Upper Soldier Creek watershed. In rural areas, agricultural practices may have a significant effect on surface water quality. Run-off from small livestock feeding or watering stations located in proximity to streams and drainage areas contributing to stream flow are a source of sediment, bacterial and nutrient loading. Overstocking of grazing areas may also contribute to these impairments. Cropland may contribute to nutrient and sediment loading, depending on management practices.

Stream channels may contribute significant proportions of total sediment load due to stream bank erosion. Stream bank erosion contributes nitrogen and phosphorous to surface waters and is estimated to have a disproportionate impact on phosphorous loads because of the adsorption of phosphorus to soil particles, which are released when stream bank failures release sediment into streams.

Rural residences in the watershed rely on septic or lagoon systems for treatment of domestic wastewater. Failing on-site wastewater systems are a potential source of both nutrients and bacteria.

3.4 DESIGNATED USES

Designated uses for the streams in this watershed include primary contact recreation, domestic water supply, food procurement, groundwater recharge, irrigation, and livestock watering. In the future, PBPN may designate uses for its water resources as noted previously.

3.5 SPECIAL AQUATIC LIFE USE WATERS

According to the Kansas Surface Water Register (KDHE 2021), no surface waters within the Upper Soldier Creek or Little Soldier Creek watersheds are designated as special aquatic life use waters. A review of the U.S. Fish and Wildlife Service (USFWS) Information, Planning and Conservation System (IPaC) indicated only one terrestrial species (Northern Long-eared Bat, *Myotis septentrionalis*) may inhabit the Reservation that is considered threatened, endangered, or a candidate species. No critical designated habitats are located within the Reservation boundaries (USFWS 2020).

Kansas Department of Wildlife and Parks (KDWP) also maintains data by county on threatened and endangered (T&E) species at the state and federal level (KDWP 2020). Similarly, only the Least Tern (*Sternula antillarum*) has a critical habitat designation in Kansas, but none within Reservation boundaries.

3.6 PUBLIC WATER SUPPLY (PWS) AND WASTEWATER MANAGEMENT

3.6.1 PWS

According to the Jackson County RWD-3 annual meeting, published in the Holton Recorder, volume 149, issue 29, April 11, 2016, RWD-3 provides all the water to the PBPN, including the hotel and casino. RWD-3 purchases wholesale water from Public Wholesale Water District No. 18 (PWD-18), which comes from the Banner Creek Reservoir (WRS 2020c).

3.6.2 WASTEWATER MANAGEMENT

Three wastewater treatment plants operate on the Reservation. The K Road facility (KS0096202) is located on the eastern side of the K Road government complex between 150th and 158th Roads and discharges into an unnamed tributary of James Creek. The system consists of activated sludge mechanical treatment, an influent lift station, aeration tanks, clarifiers, aerated sludge digester, and an ultraviolet disinfection system. It has a design capacity of 60,000 gallons per day (gpd), but typically treats about 30,000 gpd. The facility treats the government facilities complex and three small housing complexes, totaling about 900 persons (USEPA 2018a).

The Q Road wastewater treatment facility (KS0096199) discharges into an unnamed tributary of Big Elm Creek, a tributary to Little Soldier Creek. The Q Road facility serves the Tribal government complex using a continuous discharging, Cromaglass® Batch Treatment System with an extended aeration system, a sedimentation/clarifier tank, and a final chlorination/dechlorination tank. The facility's design capacity is 15,000 gallons of wastewater per day but currently treats about 5,000 gallons per week (USEPA 2018b).

The Prairie Band Casino Complex treatment facility (KS0093777) discharges into Big Elm Creek, a tributary to Little Soldier Creek. The casino complex facility consists of a 3-cell lagoon system and an activated sludge mechanical treatment plant that treats domestic wastewater from the hotel, spa, casino, a convenience store, and an RV park with 75 sanitary hook-up stations. The lagoon system has been bypassed with the construction of a direct discharge line, which allows the mechanical plant to discharge directly to Big Elm Creek. The mechanical plant has a design flow of 125,000 gpd. Based on data from the discharge monitoring reports from March 2013 to December 2017, the average effluent flow is 68,300 gpd (USEPA 2019).

Sludge from the wastewater treatment facilities is aerobically digested and periodically withdrawn from the holding tanks, put through the filter press, and then composted by the Tribe at the Tribe's composting facility. The lagoon casino complex system currently functions as a retention basin for stormwater and for diversion of wastewater from the mechanical plant during repairs or emergency situations. The lagoon can discharge, if necessary, as long as the discharge meets the facility’s effluent permit requirements (USEPA 2018b).

The remainder of the households on the Reservation are served by residential septic systems. Tribal planning and zoning regulations restrict new septic systems to 5-acre lots or larger. Indian Health Service staff in Holton assist with review of proposed septic system designs.

3.7 303(d) LISTINGS IN THE WATERSHED

According to the 2022 Integrated Water Quality Assessment Report (KDHE 2022), Upper Soldier Creek is included on the 2022 Section 303(d) list as impaired for Aquatic Life due to Biological impairment. TMDL development may be scheduled for Atrazine during the 2025 planning period. Lower Soldier Creek, downstream of the Reservation, is also listed as impaired for E. *coli* bacteria, and a TMDL may also be scheduled during the 2025 planning period.

3.8 TOTAL MAXIMUM DAILY LOADS IN THE WATERSHED

A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards. Exceeding the TMDL typically results in failure to support a designated use for the specific water body. The TMDL allocates the allowable load to point sources (Waste Load Allocation or WLA) and nonpoint sources (Load Allocation or LA) which include both anthropogenic and natural background sources of the pollutant. The process of developing TMDLs determines:

1. The pollutants causing water quality impairments.
2. The degree of deviation away from applicable water quality standards.
3. The levels of pollution reduction needed to achieve water quality standards.
4. Corrective actions, including load allocations, to be implemented among point and nonpoint sources in the watershed affecting the water quality limited water body.

5. The monitoring and evaluation strategies needed to assess the impact of corrective actions in achieving TMDLs and water quality standards.
6. Provisions for future revision of TMDLs based on those evaluations.

In summary, TMDLs provide the basis for targeting and addressing point and nonpoint source pollution sources. The objective is to address high priority TMDLs within the specified watershed. KDHE reviews TMDLs on a 5-year rotational basis. The current TMDLs for Upper Soldier Creek were developed in 2007.

KDHE is scheduled to develop additional TMDLs for Lower Soldier Creek downstream of the Reservation and for the Kansas River. The proposed TMDLs include TSS, atrazine, and E. *coli* bacteria. The anticipated publication date is 2023. The water quality BMPs proposed for the PBPN Reservation would directly benefit concentrations of these pollutants in these receiving waters, as described below.

3.9 TMDL LOAD ALLOCATIONS

As noted previously, a high-priority TMDL for Biology and Sediment has been designated for Soldier Creek above and below the PBPN Reservation, including the Walnut Creek, James Creek, and Dutch Creek tributaries. Little Soldier Creek is not listed as impaired for any pollutants. Aquatic life is impaired within these stream reaches due to sediment. Biological activity is greatly influenced by suspended sediment, as sediment loads are correlated with nutrient, pesticide, and fecal coliform bacteria loading within the stream system. As Tribal lands lie outside the jurisdiction and oversight of the Kansas Department of Health and Environment (KDHE 2007), this TMDL is used as a reference only for the Tribe's water quality planning efforts.

TMDL load allocations identify allowable loads for point, nonpoint, and background sources and is based on several factors. Each pollutant source and its relative contribution to the water quality impairment are determined. Total load is derived from the TMDL. For point sources, National Pollutant Discharge Elimination System (NPDES) facilities, confined animal feeding operations (CAFOs) or other regulated facilities, WLAs are based on NPDES permits which consider the type of wastewater and treatment, volume of discharged effluent, degree of compliance with existing permits, potential for future growth and expected flow conditions over which they are expected to provide protection. Nonpoint source LAs are the load remaining after removal of point source and natural contributions to the total load and reflect the load originating from agricultural and urban areas that have no specific point of discharge. This plan addresses nonpoint sources.

Percent EPT taxa, TSS concentrations, and Macroinvertebrate Biotic Index (MBI) are analyzed to address the sediment/biological impact impairment. The EPT index is the proportion of aquatic taxa present within a stream belonging to pollution intolerant orders; *Ephemeroptera, Plecoptera* and *Trichoptera* (mayflies, stoneflies, and caddisflies). Higher percentages of total taxa comprising these three groups indicate less pollutant stress and better water quality. Typically, these macroinvertebrates utilize a coarse substrate in the stream for habitat. Elevated amounts of suspended solids deposited on the substrate limits substrate utility by these clean water indicator species. Biological monitoring metrics were used to assess compliance with KDHE standards for water quality. MBI values less than, or equal to, 4.5 are considered fully supporting, values greater than, or equal to, 5.4 are considered non-supporting, and intervening values are designated as partially supporting. EPT abundance standards establish full support levels greater than, or equal to, 48%, non-supporting at levels below, or equal to, 30%, and partially supporting for intervening values (KDHE 2007).

MBI values over the period of record used to develop the TMDL averaged 4.83, partially supporting. EPT abundances over the period of record averaged 46%, also partially supporting. TSS ranges included fairly elevated levels and averaged 232 milligrams per liter (mg/l), with a median concentration of 70 mg/l. KDHE (2007) estimates that targeting moderate to high flow events may have the greatest impact on TSS levels.

The Soldier Creek TMDL (KDHE 2007) specifies the following desired endpoints: an average EPT count of 48% or greater over the 2006–2011-timeframe, MBI values approaching 4.5, and average TSS levels below 100 mg/l over 2006-2011 at Delia for flows less than 1,000 cubic feet per second (cfs). These endpoints would indicate full support of the aquatic life use in the stream reach and attainment of the narrative water quality standard for TSS. Sediment loads are also correlated with nutrient loading and fecal coliform loading: at concentrations below 100mg/l of TSS, phosphorus, nitrogen oxide compounds, and fecal coliform levels are observed to be low.

The sole NPDES discharger outside of the Reservation, the City of Soldier (KS0081035, M-KS70-OO01) employs a three-cell lagoon system and its permit limits the amount of suspended solids it may discharge to a monthly average of 80 mg/l. Adherence to this limit will not cause impairment to stream or its biology. Based on the assessment of sources, point sources do not contribute to water quality impairment relative to sediment impacts on stream biology. At this point, the wasteload allocations (WLA) will be a maintenance of TSS loadings from point sources with average monthly TSS concentrations maintained below 80 mg/l, leading to in-stream concentrations below 100 mg/l at flows below 1 cfs. Soldier Creek's WLA is 12.7 pounds (lbs.)/day (USEPA 2007).

The K Road wastewater treatment complex permitted discharge limits for TSS are even lower at a monthly average of 30 mg/l and a weekly average of 45 mg/l. The treatment facility's average treated discharge of 30,000 gpd represents less than 0.054% of the average stream discharge of 101 cfs (65 million gpd) and does not significantly add to TSS loads in Soldier Creek. According to USEPA (2007), its WLA would be 7.5 lbs. of TSS per day, but it does not have the jurisdiction to implement this WLA.

Table 2 below, from the 2007 TMDL document, provides WLAs and LAs for various flow conditions.

TABLE 2: WASTELOAD ALLOCATIONS, LOAD ALLOCATIONS, AND LOAD CAPACITIES FOR TSS IN SOLDIER CREEK

Flow Exceedance	Flow	Wasteload Allocation (WLA)	Load Allocation (LA)	Load Capacity (LC)
90%	2 cfs	20.2 lbs./day	1,060 lbs./day	1,080 lbs./day
75%	9 cfs	20.2 lbs./day	4,840 lbs./day	4,860 lbs./day
50%	30 cfs	20.2 lbs./day	16,180 lbs./day	16,200 lbs./day
25%	80 cfs	20.2 lbs./day	43,180 lbs./day	43,200 lbs./day
10%	200 cfs	20.2 lbs./day	107,980 lbs./day	108,000 lbs./day

Source: (USEPA, 2007)

Flow Exceedance is the percentage of a typical year where flow exceeds the given rate. The Middle Kansas WRAPS 9 Element Plan (KAWS 2011) reported that KDHE's TMDL section estimated the sediment load from nonpoint sources in the Soldier Creek Watershed (Figure 8 at right) Middle Kansas Watershed to be 27,900 tons per year. The LA for the Middle Kansas Watershed needed to meet the sediment TMDL was 18,400 tons of sediment (Figure 9, below). This is the amount of sediment that needs to be removed from the watershed and is the target of the BMP installations that will need to be placed in the watershed.

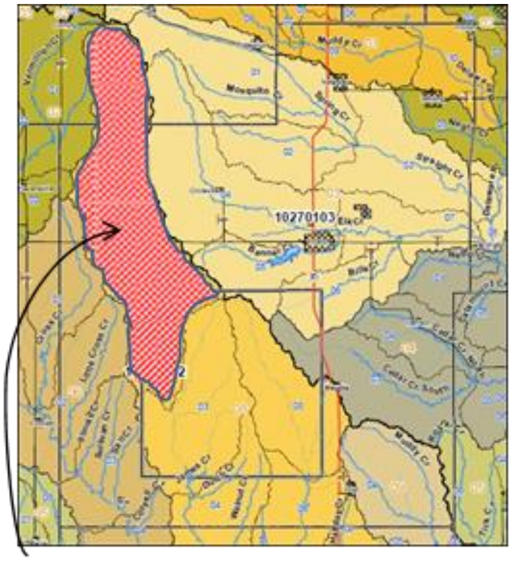

Figure 8 – Upper Soldier Creek Focus Area in Jackson County (KAWS, 2011)

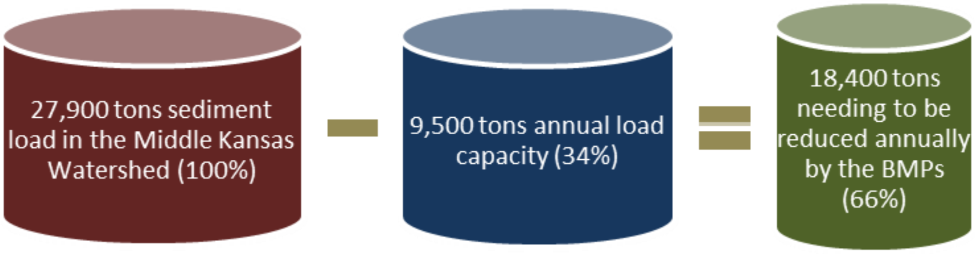

Figure 9 – Watershed Sediment Load and Reduction Estimates (KAWS, 2011)

4.0 WATER QUALITY MODELING

Modelers from Kansas State University (K-State) employed the Soil and Water Assessment Tool (SWAT) model to develop a current conditions model and pollutant load estimates, and to estimate load reductions from several BMPs. K-State modelers have employed SWAT to develop several 9 Element Plans across the state of Kansas.

SWAT is a runoff-based model that estimates watershed hydrology using the SCS Curve Number method, and runoff-based sediment loadings using the Modified Uniform Soil Loss Equation (MUSLE). SWAT generates total annual pollutant load estimates in tons for sediment; and in kilograms for total nitrogen (TN) and total phosphorus (TP). K-State used the Delia stream gauge (SC101) to:

- Calibrate the hydrologic volumes based on USGS data from 2003 to 2011
- Validate the model using data from 2012 to 2019
- Calibrate pollutant loads for TSS, TN, and TP using KDHE's monitoring data

Evaluating bacteria loads is notoriously difficult. The model was not calibrated for bacteria; therefore, for this study the model was used to estimate potential relative percent reductions in E. *coli* bacteria as value-added information.

The SWAT model also allows the user to estimate potential load reductions for various BMPs that reduce surface erosion and pollutant transport. No mapping exists for application of BMPs on the Reservation, so the planning team aggregated general estimates from Tribal staff and the Bureau of Indian Affairs (BIA) to determine the current extent of BMP application across both Tribal and non-tribal agricultural lands, which were integrated into the existing conditions model.

The SWAT model results generally agreed with KDHE's estimated load allocations from Upper Soldier Creek. As noted previously, for the 2011 WRAPS 9 Element Plan KDHE estimated the typical annual sediment load for the Upper Soldier Creek watershed, which lies mostly upstream of the Reservation. The SWAT model estimated the total sediment load from Upper Soldier Creek and the sediment contribution to Soldier Creek from the Reservation, yielding a total load about 30% greater than KDHE's estimates for Upper Soldier Creek alone, which is proportional to the additional land area that K-State modeled.

The SWAT model produces general estimates of streambank erosion and resulting sediment loads using simplified stream power relationships. To better estimate potential sediment load reduction contribution from bank erosion, and potential load reductions from proposed stabilization, the K-State modeling team evaluated the WRS stream stability assessment discussed in Section 2.2. The team used the WRS data and published literature to develop bank loss estimates, and empirical studies of streambank erosion and sediment entrainment from watersheds in vicinity of the Reservation to develop more detailed sediment load estimates (Moore, 2022; Attachment 1).

Based on this assessment, the SWAT model results are suitable for screening and preliminary planning purposes, to estimate relative effectiveness of BMPs to meet required load reduction targets for sediment and to provide general estimates of other pollutant load reductions.

4.1 LOAD REDUCTION ESTIMATES

The modeling team used SWAT to estimate load reductions from various management practices, with the exception of streambank stabilization as noted above. The model estimates load reductions based on changes in runoff volume and integrated performance data where available. For new or novel BMPs, the modeler can adjust hydrologic, input, and output parameters to simulate anticipated BMP performance derived from other sources. The following section describes the impairments addressed with various BMPs and how they were estimated.

5.0 IMPAIRMENTS ADDRESSED BY THE TRIBE

Based on the analysis described in previous sections, the Tribe will focus primarily on reducing sediment loads in the Soldier Creek watershed to support Aquatic Life. These efforts will produce significant secondary benefits by reducing nutrient concentrations, particularly TP, which contribute to the Aquatic Life impairment. Agricultural practices will also directly and indirectly reduce Atrazine and bacteria concentrations, which will help neighboring communities and watershed partners address those impairments in anticipation of future TMDLs for those pollutants, or if the Nation should develop its own WQS and TMDLs in the future.

As noted above, the current estimated sediment load from nonpoint sources in the Upper Soldier Creek watershed is 27,900 tpy according to KDHE (KAWS, 2011). KDHE's proposed load reduction endpoint to meet the TMDL is 18,400 tons of sediment per year. BMPs implemented by the Nation on Tribal land and in partnership with non-tribal landowners where possible will address sediment originating on the Reservation, and will contribute to overall sediment load reductions, which will help partners and neighboring communities meet the desired endpoint.

Because agricultural land uses make up most of the Reservation's area, agricultural BMPs are proposed to meet the pollutant reduction targets. On non-tribal land not subject to the Nation's jurisdiction, the Tribe will partner with the Cooperative Extension Service, Jackson County Conservation District, Natural Resources Conservation Service, and other Middle Kansas WRAPS partners to enlist landowners to participate in this effort. Potential load reduction estimates presented below are good faith estimates of potential partnerships, based on current agricultural trends.

To address the impairments that the SLT has selected, the planning team evaluated the assumed pollutant sources and identified corresponding BMPs that could be successfully implemented to address these sources. Three primary BMPs were identified based on past and current Tribal experience and initiatives, conversations with partner organizations and local practitioners, and the project team's considerable relevant experience and professional judgment.

The Nation proposes a 20-year implementation program to implement the BMPs described below.

Riparian Buffers

Riparian buffers are proposed along stream corridors adjacent to cropland where currently absent. Restored buffers of up to 150 feet in width are proposed with a mix of native grasses, forbs, trees, and shrubs to restore healthy riparian corridors where possible. The riparian buffer restoration concepts were developed and refined based upon information provided through extensive riparian corridor habitat assessment and modeling. Several different riparian buffer configurations will be implemented depending on site-specific conditions, as described in Appendix B. Proposed locations are illustrated on Figure 10, below (PBPN, 2021).

Stream Stabilization

Stream stabilization is proposed as noted on Figure 10, below, to address previously identified unstable stream reaches. The primary strategy will be to install grade stabilization throughout to prevent incision in the target stream reaches in the Soldier Creek watershed, which should significantly reduce stream erosion and sediment entrainment. Additional bioengineering practices such as in-stream structures (rock vanes and weirs), toe stabilization, revetments, flood terracing and bank reshaping, and native vegetation will be strategically employed over subsequent years to further redirect erosive flows, provide adequate conveyance and floodplain storage, and naturally reinforce unstable streambanks. Measures for stream restoration and in-stream habitat concepts were refined based upon stream stability assessments, hydraulic modeling, and aquatic habitat assessment and modeling as described in Appendix B (PBPN, 2021).

Figure 10 - Proposed areas for riparian corridor restoration and/or streambank stabilization measures (PBPN, 2021).

<u>No-Till Farming and Regenerative Agriculture</u>

While fairly limited in area compared to pastureland, conventional cropland throughout the Reservation occupies relatively level floodplains and adjacent terraces along stream corridors and are more prone to erosion because of a relative lack of vegetative cover. Because of their proximity to streams and greater erosive potential, cropland contributes a disproportionate pollutant load to the watershed. A holistic package of no-till and regenerative agriculture practices (See Appendix C) including cover crops and soil health measures will be implemented on Tribally owned and operated land, and no-till and regenerative agriculture requirements will be integrated into lease agreements for land leased to non-tribal farmers. The Tribe will work cooperatively with partners to encourage non-tribal landowners to adopt the practices on cropland that they farm or lease as well.

5.1 BIG SOLDIER CREEK WATERSHED

Table 3 illustrates proposed and potential agricultural BMPs evaluated for the Soldier Creek watershed. The implementation schedule assumes that riparian buffers and in-stream grade stabilization on Tribal lands will be implemented in the first 5 years in collaboration with the U.S. Army Corps of Engineers. Additional riparian buffers on Tribal land will be implemented over the subsequent 15 years. The Tribe will work to implement agricultural practices on Tribal land and will collaborate with its partners to encourage adoption of riparian buffers and regenerative agricultural practices on non-tribal owned lands over the entire 20-year planning period. Information and Education (I&E) practices are described in Section 6.0.

TABLE 3: ANNUAL BMP IMPLEMENTATION
SOLDIER CREEK WATERSHED

Year	Riparian Buffers on Tribal Cropland) (Acres)	Riparian Buffers on 25% of Non-Tribal Cropland (Acres)	No Till + Regenerative Agriculture on Tribal Cropland (Acres)	No Till + Regenerative Agriculture on 25% of Non-Tribal Cropland (Acres)	Stream Stabilization (Miles)
1	18.40	0	265	90	0.41
2	18.40	0	265	90	0.41
3	18.40	0	265	90	0.41
4	18.40	0	265	90	0.41
5	18.40	0	265	90	0.41
6	0.00	10.4	265	90	0.0
7	0.00	10.4	265	90	0.0
8	0.00	10.4	265	90	0.0
9	0.00	10.4	265	90	0.0
10	0.00	10.4	265	90	0.0
11	0.00	10.4	265	90	0.7
12	0.00	10.4	265	90	0.7
13	0.00	10.4	265	90	0.7
14	0.00	10.4	265	90	0.7
15	0.00	10.4	265	90	0.7
16	0.00	10.4	265	90	0.7
17	0.00	10.4	265	90	0.7
18	0.00	10.4	265	90	0.7
19	0.00	10.4	265	90	0.7
20	0.00	10.4	265	45	0.7
Total	**95.0**	**156**	**5300**	**1755**	**9.2**

Table 3 is an illustration contingent upon securing needed staffing, funding, outreach, and partnership assistance. Additionally, the schedule assumes that riparian buffers and in-stream grade stabilization on Tribal lands will be implemented in the first 5 years in collaboration with (and funding from) the U.S. Army Corps of Engineers. See Section 7.2 for details.

Table 4 presents the estimated sediment load reductions for the 20-year implementation period, based on a combination of SWAT modeling and streambank load reduction estimates as previously described.

TABLE 4: ADDITIVE ANNUAL SEDIMENT LOAD REDUCTIONS
SOLDIER CREEK WATERSHED

Year	Riparian Buffer Filter Strips on Tribal Cropland) (Tons)	Riparian Buffer Filter Strips on 25% of Non-Tribal Cropland (Tons)	No Till + Regenerative Agriculture on Tribal Cropland (Tons)	No Till + Regenerative Agriculture on 25% of Non-Tribal Cropland (Tons)	Stream Stabili-zation (Tons)	Cumulative Annual Load Reduction (Tons)
1	487	0	84	49	309	930
2	974	0	169	99	618	1859
3	1460	0	253	148	928	2789
4	1947	0	338	197	1237	3719
5	2434	0	422	246	1546	4649
6	2434	91	507	296	1546	4873
7	2434	181	591	345	1546	5098
8	2434	272	676	394	1546	5322
9	2434	363	760	443	1546	5546
10	2434	454	845	493	1546	5771
11	2434	544	929	542	1701	6150
12	2434	635	1013	591	1855	6529
13	2434	726	1098	641	2010	6908
14	2434	816	1182	690	2164	7287
15	2434	907	1267	739	2319	7666
16	2434	998	1351	788	2474	8045
17	2434	1089	1436	838	2628	8424
18	2434	1179	1520	887	2783	8803
19	2434	1270	1605	936	2937	9182
20	2434	1361	1689	986	3092	9561

Table 4 is an illustration contingent upon securing needed staffing, funding, outreach, and partnership assistance. See Section 7.2 for details.

5.2 LITTLE SOLDIER CREEK WATERSHED

Although Little Soldier Creek is not listed as water quality impaired, BMPs, I&E and O&M efforts will positively affect the bacteria and Atrazine impairments in the Lower Soldier Creek and Kansas River watersheds near Topeka. The Nation will work with Tribal and non-tribal landowners in a similar fashion to implement BMPs throughout the watershed.

Additional implementation strategies for the Little Soldier Creek watershed include the following:

- Riparian buffers on Tribal land
- Riparian buffers on nontribal land
- No-till and regenerative agriculture on Tribal land
- No-till and regenerative agriculture on nontribal land
- Wetland restoration

I&E activities are ongoing and will increase in the future, as the Nation works with the Middle Kansas WRAPS to coordinate BMP implementation throughout the watershed. Although the extent of existing agricultural BMPs is unknown, successful outreach efforts undertaken by WRAPS partners in the Middle Kansas watershed and elsewhere should continue during the 20-year program period, with coordination and cooperation the Nation. Other approved WRAPS projects assume a 40-percent adoption rate for agricultural BMPs over a 20-year program period, so the 25-percent estimate in this plan is conservative.

6.0 INFORMATION AND EDUCTATION

6.1 ACTIVITIES AND EVENTS

Successful pollution reduction and prevention programs require voluntary cooperation and compliance from Tribal Members, staff and departments, stakeholders, and other landowners in the watershed. Education to explain the benefits of compliance is essential for success. Education efforts are accordingly designed to promote understanding of water quality problems, requirements, and best management practices. The PBPN PEP will continue to develop educational materials designed for Tribal members and landowners, agricultural leaseholders, Tribal staff from relevant departments and affiliated corporations, non-tribal landowners, and other stakeholders as appropriate. Outreach activities will include online and print educational and technical assistance materials, presentations to Tribal and affiliated staff, and tours of Tribal holdings to demonstrate BMPs and restoration projects. For example, PEP publishes a quarterly newsletter that is the most effective outreach tool to provide information to all Reservation residents. The Prairie Band Potawatomi Newspaper and website are useful outreach tools, providing public notices and publishing PEP articles. Finally, in conjunction with its ongoing resilience planning efforts, PEP plans to work Tribal members of all ages to develop citizen science programs to crowdsource data gathering while educating the community and strengthening its base of scientific and Traditional Ecological Knowledge.

Tribal Departments and Prairie Band, LLC

Training will be developed and provided to Tribal staff from departments whose operations have the potential to impact water quality and who will be instrumental in implementing the water quality program. Staff training will cover water quality issues, permit requirements, general Section 319 program activities, and BMP implementation described in this plan. Training will include but not be limited to the Road & Bridge Department, Land Management (including the Buffalo Management Program), Land Office, Building Maintenance & Construction, and Prairie Band LLC subsidiaries Prairie Band Ag and Prairie Band Construction.

Tribal and Non-tribal Landowners

The proposed water quality program includes I&E and operations and maintenance (O&M) activities in addition to the structural and nonstructural BMPs described in the previous section. The Nation will focus I&E and O&M efforts on other Tribally owned and operated lands such as rangeland and pastures, including those occupied by the buffalo herds. While grazing lands constitute most of the Reservation's land area, they are much less prone to erosion because of the prevalence of continuous vegetative cover, including significant deep-rooted native prairie species. O&M practices such as rotational grazing, cattle (and buffalo) fencing, alternative water supplies, riparian buffer enhancement, and planting of native hay species contributed relatively little to the load reduction estimates identified by the SWAT model and therefore were excluded from the quantitative estimates. Regardless, they are particularly important for proper landscape management and pollution prevention efforts and will be incorporated into management plans for Tribally owned, operated, and leased lands.

PEP will provide I&E materials to Tribal landowners as it works to implement these practices. It will also provide I&E materials and will work cooperatively with partners to encourage nontribal landowners to adopt similar BMP and O&M practices on their crop, range, and pasture lands.

Demonstration Projects

PEP will work with other Tribal departments and LLC subsidiaries to develop demonstration sites where it can implement and showcase BMPs for staff training and outreach to Tribal landowners, agricultural leaseholders, nontribal landowners, and the public. PEP anticipates implementing pilot projects at Prairie Peoples Park to develop internal staff capacity and train new staff and educate the general public. PEP will work with Land Management and Prairie Band Ag to create regenerative agriculture demonstration sites on Tribally operated cropland and pastureland. Demonstration projects will be monitored for cost, environmental performance, and cost-effectiveness, and the lessons learned will be used for continuous process improvement efforts and shared with Tribal and nontribal landowners, stakeholders, and partners.

Stakeholder Coordination

In addition to Tribal initiatives, the Prairie Band Potawatomi Nation will work cooperatively with other Tribal, federal, state, and local governments, and other stakeholder groups such as local watershed associations. Current and ongoing involvement with Middle Kansas Watershed Restoration and Protection Strategy will provide networking, resources, and educational opportunities for environmental staff. A watershed- based approach shall be incorporated into PBPN nonpoint source management plan. Table 4 summarizes information and education targeting implementation, operation, and maintenance of planned BMPs.

Citizen Science Programs

Citizen science is defined as involving the public in scientific research, data collection, and identification of environmental issues and/or approaches to address those issues. Web-based platforms like iNaturalist, FieldScope and River Source make citizen science accessible to anyone and everyone who is interested in getting outdoors and involved.

TABLE 5: INFORMATION AND EDUCATION IN SUPPORT OF PUBLIC AWARENESS AND PARTICIPATION

I&E Practice	Description	Existing	Planned	Target Audience	Partnerships
Septic System Education and Enforcement	Proper septic system operation, maintenance, and repair; eventual replacement	Web site, water bill inserts, inspections, and enforcement	Increased outreach, multimedia advertising	Rural and suburban property owners w/o POTW connection	Jackson County Health Department, Jackson County Extension
Agricultural BMP Education	Planning, design, installation of agricultural BMPs; cost/benefit and cost-share programs	Brochures, web sites, speakers	Multimedia advertising; workshops; training; volunteer installations of each agricultural BMP type	Tribal agricultural operations/ non-tribal agricultural producers	Jackson County Extension / Conservation District, NRCS, Middle Kansas WRAPS
Earth Day Activities	General watershed awareness	Earth Day booth with presentation	Earth Day Booth with Presentation	Public and elementary/ secondary schools, elders	Newspaper, Education Department, Elder Center
Riparian Buffer and Streambank Stabilization	Planning, design, and implementation of stream protection and restoration	Bank stabilization, riparian and prairie buffer installations	Prairie Peoples Park demonstration sites	Tribal and LLC staff, Tribal and nontribal landowners, general public	Tribal departments, Prairie Band LLC,
Citizen Science Programs	Programs to educate the public and gather data on watershed and ecological health	Not Applicable	To Be Determined (TBD)	General public, youth, elders	TBD (Education, Elder Center, Language and Cultural Department)

Notes:

BMP	Best Management Practice
NRCS	Natural Resources Conservation Service
POTW	Publicly Owned Treatment Works

6.2 PROGRAM EVALUATION

Information and Education activities funded through the PBPN will include a program evaluation component designed to assess program effectiveness. Evaluation methods may vary from program to program but will, at a minimum, include participant learning objectives and estimate outcomes relative to behavior changes and BMP adoption rates expected to result from the information and education activities. Written evaluations of program activities will include participation rates and demonstrating successful delivery of learning objectives and progress toward achieving program goals and objectives.

7.0 IMPLEMENTATION

7.1 COSTS OF IMPLEMENTING BMPS

The total estimated cost for addressing impairments outlined in Section 5.0 is based on a 20-year implementation program, broken into three phases (Years 1 – 5, 6-10, and 11-20) based on potential funding. The total estimated cost is $35,520,000 in 2022 dollars.

TABLE 6: SUMMARY OF ESTIMATED PROGRAM COSTS

Year	Staff& Admin. / 1.5 New FTE	I&E	Riparian Buffer Filter Strips on Tribal Cropland	Riparian Buffer Filter Strips on 25% of Non-Tribal Cropland	No Till + Regenerative Agriculture on Tribal Cropland	No Till + Regenerative Agriculture on 25% of Non-Tribal Cropland	Stream Stabili-zation	TOTAL
1	$150,000	$50,000	$195,000	$163,000	$16,000	$5,400	$1,200,000	$1,780,000
2	$150,000	$50,000	$195,000	$163,000	$16,000	$5,400	$1,200,000	$1,780,000
3	$150,000	$50,000	$195,000	$163,000	$16,000	$5,400	$1,200,000	$1,780,000
4	$150,000	$50,000	$195,000	$163,000	$16,000	$5,400	$1,200,000	$1,780,000
5	$150,000	$50,000	$195,000	$163,000	$16,000	$5,400	$1,200,000	$1,780,000
6	$150,000	$50,000		$163,000	$16,000	$5,400		$380,000
7	$150,000	$50,000		$163,000	$16,000	$5,400		$380,000
8	$150,000	$50,000		$163,000	$16,000	$5,400		$380,000
9	$150,000	$50,000		$163,000	$16,000	$5,400		$380,000
10	$150,000	$50,000		$163,000	$16,000	$5,400		$380,000
11	$150,000	$50,000		$163,000	$16,000	$5,400	$2,100,000	$2,480,000
12	$150,000	$50,000		$163,000	$16,000	$5,400	$2,100,000	$2,480,000
13	$150,000	$50,000		$163,000	$16,000	$5,400	$2,100,000	$2,480,000
14	$150,000	$50,000		$163,000	$16,000	$5,400	$2,100,000	$2,480,000
15	$150,000	$50,000		$163,000	$16,000	$5,400	$2,100,000	$2,480,000
16	$150,000	$50,000		$163,000	$16,000	$5,400	$2,100,000	$2,480,000
17	$150,000	$50,000		$163,000	$16,000	$5,400	$2,100,000	$2,480,000
18	$150,000	$50,000		$163,000	$16,000	$5,400	$2,100,000	$2,480,000
19	$150,000	$50,000		$163,000	$16,000	$5,400	$2,100,000	$2,480,000
20	$150,000	$50,000		$81,500	$16,000	$2,700	$2,100,000	$2,400,000
TOTAL	**$3,000,000**	**$1,000,000**	**$975,000**	**$3,178,500**	**$320,000**	**$105,300**	**$27,000,000**	**$35,520,000**

Table 6 is an illustration contingent upon securing needed staffing, funding, outreach, and partnership assistance. Additionally, the schedule assumes that riparian buffers and in-stream grade stabilization on

Tribal lands will be implemented in the first 5 years in collaboration with (and funding from) the U.S. Army Corps of Engineers. See Section 7.2 for details.

Estimated costs are general and are based on the following sources:

- Costs for riparian buffer restoration, grade stabilization, and streambank stabilization came from a feasibility for a USACE ecosystem restoration project. The project is eligible for Federal funding for approximately 61 acres of riparian corridor restoration and 2 miles of grade stabilization. A 15% escalation factor was applied to the opinions of probable cost from early 2021. Not eligible for Federal funding are about 34 acres of riparian restoration, and other streambank stabilization costs for 7.2 miles of additional restoration area.
- Operations & Maintenance costs are also derived from the USACE study.
- Costs to convert farmland to no-till and implement regenerative agriculture practices were provided by K-State Research & Extension based on their actual project costs from across the state.
- Implementation costs include program administration and annual, targeted I&E. The estimate in Table 6 assumes 1.0 to 1.5 additional, full-time equivalent (FTE) staff will be needed to administer the program (about $150,000 per year). The program administrator will be housed in PEP with additional staff support from the General Manager of Tribal Operations (GM) and other departments as noted below. Additional dedicated I&E funding (estimated at $50,000/year) would be used for program-specific education and technical assistance.

7.2 POTENTIAL FUNDING SOURCES

Grant money and matching funds for program implementation could potentially be obtained from a variety of sources. The PBPN Planning and Environmental Protection (PEP) Division will administer the program and grant funds in conjunction with the General Manager of Tribal Operations and staff support from the other Tribal departments, including Lands Management, and Prairie Band LLC where applicable. Funding for the added staff and administration will be solicited from a variety of sources. Administration and overhead funding will be requested where allowable, and other dedicated capacity-building or environmental justice grant funds will be sought to make up the difference.

The estimated project costs presented in Table 6 above assume that matching funds will be solicited from the following sources. Actual program implementation will depend on funding availability and success in securing available funding. See Table 7 below for a breakdown of estimated costs after accounting for potential funding sources.

- **USACE**: PBPN assumes that installation of riparian buffers and grade stabilization in Phase I (years 1–5) would be funded by the USACE through a cost-share agreement. If the Tribe and USACE are able to successfully negotiate a cost share agreement, approximately $6.0 Million in Federal funding would be provided by USACE. PBPN would contribute land, in-kind services, and some cash toward its matching share.

- **US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA) Cost Share Programs**: PBPN anticipates using some or all of the following Federal programs to provide matching funds for typical agricultural BMPs (cover crops, no-till, and other regenerative practices) on Tribal and nontribal land. Currently the Land Management Department participates in the following US Department of Agriculture cost share programs:
  - Environmental Quality Improvement Program (EQIP)
  - Conservation Reserve Program (CRP)

  Other USDA programs that could provide funding in the future include those below. In particular, the proposed riparian buffers are more robust than standard grassed filter strips and may require other sources of matching funds such as the Forestland Enhancement Program.
  - Continuous Conservation Reserve Program
  - 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)

- **EPA Section 319 Grants:** Pilot projects and targeted education and monitoring may be funded through the EPA, based on funding.
  - PBPN anticipates that additional funding will be available for the initial 5-year period at a minimum to address EJ and CAS; See Section 3.3 above for details.
- **Kansas WRAPS Grants**: State funding for cooperative projects may also be available through the EJ initiative as described in Section 3.3.
- **State Cost Share Programs:** The Division of Conservation (DOC), Kansas Department of Agriculture administers four voluntary cost-share programs that may be used to fund BMPs on nontribal lands:
  - Water Resources Cost-Share Program
  - Non-Point Source Pollution Control Program
  - Riparian and Wetland Protection Program
  - Sediment & Nutrient Reduction Initiative
- **Bipartisan Infrastructure Law and Inflation Reduction Act:** The Tribe will continue to explore new funding opportunities for water resources, natural resources, infrastructure (including streambank stabilization), climate resilience, and Tribal development and assistance that could be used to fund capacity-building (including additional staff and administration funding), BMPs, infrastructure improvements, and I&E activities proposed in this plan.

TABLE 7: OVERVIEW OF ESTIMATED PROGRAM COSTS AFTER COST SHARE

Year	Staff & Admin. / 1.5 New FTE	I&E	Riparian Buffers on Tribal Cropland[a]	Riparian Buffers on 25% of Non-Tribal Cropland[b]	No Till + Regenerative Agriculture on Tribal & Nontribal Cropland[c]	No Till + Regenerative Agriculture on 25% of Non-Tribal Cropland[c]	Stream Stabili-zation[a]	TOTAL
1	$150,000	$50,000	$19,500	$163,000	$4,800	$1,620	$120,000	$508,920
2	$150,000	$50,000	$19,500	$163,000	$4,800	$1,620	$120,000	$508,920
3	$150,000	$50,000	$19,500	$163,000	$4,800	$1,620	$120,000	$508,920
4	$150,000	$50,000	$19,500	$163,000	$4,800	$1,620	$120,000	$508,920
5	$150,000	$50,000	$19,500	$163,000	$4,800	$1,620	$120,000	$508,920
6	$150,000	$50,000		$163,000	$4,800	$1,620		$369,420
7	$150,000	$50,000		$163,000	$4,800	$1,620		$369,420
8	$150,000	$50,000		$163,000	$4,800	$1,620		$369,420
9	$150,000	$50,000		$163,000	$4,800	$1,620		$369,420
10	$150,000	$50,000		$163,000	$4,800	$1,620		$369,420
11	$150,000	$50,000		$163,000	$4,800	$1,620	$2,100,000	$2,469,420
12	$150,000	$50,000		$163,000	$4,800	$1,620	$2,100,000	$2,469,420
13	$150,000	$50,000		$163,000	$4,800	$1,620	$2,100,000	$2,469,420
14	$150,000	$50,000		$163,000	$4,800	$1,620	$2,100,000	$2,469,420
15	$150,000	$50,000		$163,000	$4,800	$1,620	$2,100,000	$2,469,420
16	$150,000	$50,000		$163,000	$4,800	$1,620	$2,100,000	$2,469,420
17	$150,000	$50,000		$163,000	$4,800	$1,620	$2,100,000	$2,469,420
18	$150,000	$50,000		$163,000	$4,800	$1,620	$2,100,000	$2,469,420
19	$150,000	$50,000		$163,000	$4,800	$1,620	$2,100,000	$2,469,420
20	$150,000	$50,000		$81,500	$4,800	$1,620	$2,100,000	$2,387,920
TOTAL	**$3,000,000**	**$1,000,000**	**$97,500**	**$3,178,500**	**$96,000**	**$32,400**	**$21,600,000**	**$29,004,900**

Notes:

a. Riparian buffers and in-stream grade stabilization on Tribal lands in the first 5 years are contingent upon collaboration with (and funding from) the U.S. Army Corps of Engineers, which would cover about 90% of the total cost. See Section 7.2 for details.

b Costs are shown for 150-foot wide wooded/mixed vegetation riparian buffers rather than typical NRCS EQIP prairie buffer strips, which will require exploration of other USDA or other funding programs.

c Assumes 70% cost share from USDA/NRCS EQIP and CRP conservation programs.

8.0 TIMEFRAME

As previously noted, based on the information currently available, meeting the required load reductions will likely be a physically, socially, technically, and financially challenging undertaking.

Because of the anticipated difficulty, the Nation proposes a 20-year implementation plan, broken into three phases (Years 1 – 5, 6-10, and 11-20) based on potential funding as described in Section 7. Activities during the initial 5-year period center on implementation of the USACE ecosystem restoration project, and efforts to begin conversion of Tribal and non-tribal cropland to no-till and regenerative agriculture practices. The proposed implementation strategies for years 6 – 10 and 11 – 20 will be implemented as specific opportunities and funding are identified. Finally, additional monitoring and study of both pollutant sources and BMP effectiveness will improve the community's understanding of the watershed's needs and the most effective means of improving watershed health. The approach will be revised periodically (on a 5-year basis) as described in Section 11. With each revision, the remainder of the implementation program and schedule will be adapted as the cost-effectiveness of various approaches is better understood.

9.0 MEASURABLE MILESTONES

9.1 WATER QUALITY MILESTONES FOR SOLDIER CREEK – BIOLOGICAL SEDIMENT TMDL

As previously stated, this plan estimates that it will take 20 years to implement the planned BMPs, which should reduce Soldier Creek sediment loads by 33 to 50%. The table below includes 10- and 20-year water quality goals related to the high priority biological sediment TMDL for Upper Soldier Creek. The TMDL focuses on average concentrations during the runoff condition, which is defined in the TMDL as flows greater than the median flow condition. The TMDL establishes relationships between sediment concentrations relative to flow conditions. Therefore, the current condition for high flow concentrations has been established with the 90th percentile concentration at sampling site SC101 from 2000-2007. These current conditions have been utilized to develop water quality milestones for total suspended solids (TSS), as indicated in the table below.

TABLE 8: WATER QUALITY MILESTONES FOR SOLDIER CREEK

	Current Condition* Average TSS Runoff Condition	10-Year Goal		20-Year Goal	
		Improved Condition Average TSS	Total Reduction Desired	Improved Condition Average TSS	Total Reduction Desired
Soldier Creek SC101 (Delia)	232 mg/l	200 mg/l	**25%**	168 mg/l	**50%**

Reductions in total phosphorus (TP), total nitrogen (TN), and bacteria should be proportional to TSS reductions. In addition, PBPN will make improvements toward the following desired endpoints: an average EPT count of 48% or greater and MBI values approaching 4.5 after 20 years.

9.2 ADDITIONAL WATER QUALITY INDICATORS

The proposed BMPs should result in similar relative load reductions for Total Nitrogen and Total Phosphorus of 25% over 10 years and 50% over 20 years. Bacteria should also see proportional load reductions.

In addition to the monitoring data, the Nation can utilize other water quality indicators. Such indicators may include excessive turbidity and sedimentation, anecdotal information from citizens (skin rash outbreaks, fish kills, nuisance odors), and stream team monitoring results, all of which can be used to assess short-term deviations from water quality standards.

9.3 MONITORING WATER QUALITY PROGRESS

KDHE continues to monitor water quality in the Upper Soldier Creek Watershed by maintaining the monitoring stations located within the watershed. The map on page 30 shows the KDHE monitoring stations located in streams and lakes. KDHE utilizes a Stream Biological Monitoring Program and Stream Probabilistic Monitoring Program to determine if Kansas WQS and Designated Uses are being met. Stream chemistry and stream biological monitoring programs have traditionally employed a targeted monitoring design, with stations positioned strategically at locations that capture runoff from a large portion of the state's land area, bracket potential contamination sources (*e.g.*, upstream and downstream of large wastewater treatment plants), monitor interstate waters, and describe and track long term trends. The KDHE Stream Probabilistic Monitoring Program visits randomly selected sites and collects a variety of data to support a statewide assessment of rivers and streams. It also maintains and monitors a network of reference sites, which are used to establish thresholds for indices of aquatic life support. Targeted monitoring continues to serve as the primary basis for CWA section 303(d) list development, total maximum daily load (TMDL) formulation, and National Pollutant Discharge Elimination System (NPDES) permit review and certification. The sites are sampled for nutrients, E. Coli bacteria, chemicals, turbidity, alkalinity, dissolved oxygen, pH, ammonia, and metals. The pollutant indicators assessed for each site may vary depending on the season at collection time and other factors.

9.4 EVALUATION OF MONITORING DATA

Monitoring data in Upper Soldier Creek will be used to determine water quality progress, track water quality milestones, and to determine the effectiveness of the BMP implementation outlined in the plan. The schedule of review for the monitoring data will be tied to the water quality milestones that have been developed for each watershed, as well as the frequency of the sampling data.

The BMP implementation schedules, and water quality milestones will extend through a 20-year period as described above. Throughout the plan period, the Tribe's Section 106 program, alongside KDHE, will continue to analyze and evaluate the monitoring data collected upstream and downstream of the Reservation. KDHE and USGS have designated monitoring locations upstream and downstream of PBPN Reservation. As this plan builds upon the 2011 Middle Kansas Watershed Restoration and Protection Strategy 9 Element Plan, and because PBPN does not have its own water quality standards, historical and current data collected by KDHE and USGS will be used to determine upstream and downstream water quality conditions.

Significant additional resources, time, and staff are necessary if PBPN is to operate an effective and mature water program that includes planning, monitoring, assessment, standards development, and other operations similar to the State of Kansas. PBPN-PEP typically operates all current water programs with 1.5 FTEs (full-time equivalent employees), and when task saturation occurs, tasks must be prioritized accordingly. The PBPN-PEP Water Program was initially designed to develop a baseline set of water quality indicators. The collection and analysis of baseline data takes decades to develop into a thorough water quality program. If additional funding and staff are secured and obtained, PBPN can begin to develop and implement a water quality standards program that parallels the State of Kansas.

Until then, PEP staff will work with the State to integrate aspects of their monitoring programs into PEP's water quality monitoring program. For instance, the following is needed to operate a WQS similar to the State: Water chemistry and biological metrics are used as indicators of a water body's capacity to meet its designated uses. The State of Kansas utilizes a suboptimal aquatic macroinvertebrate community metric to demonstrate non-support for biology for streams. This process is important to understand for the determination of 303(d) listing purposes. Big Soldier creek is currently listed as impaired for Biology. Biological metrics are used for diagnostic purposes such as:

- MBI- Macroinvertebrate index
- KBI – Kansas Biotic Index
- EPT index Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)
- % EPT
- Total Taxa
- EPA rapid habitat assessment protocol
- HDI- Habitat Diversity Index

In order for Kansas Tribal water programs to develop to this level will require significant resources, development, and time. The metrics listed above are required for Section 303(d) listing and current CWA-106 tribal programs do not have the staff required to fully function at this level. This is only one aspect of a full WQS program that needs to be considered by tribal administration and management before considering TAS for WQS.

Once funding is secured for BMP implementation, and after the first five years of monitoring and BMP implementation, the Nation will work with KDHE to evaluate the available water quality data to determine whether the water quality milestones have been achieved. KDHE and the Nation can cooperatively address needed modifications or revisions to the plan based on the data analysis.

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

10.0 MONITORING WATER QUALITY PROGRESS

10.1 EXISTING MONITORING NETWORK

Active water quality monitoring stations in the Soldier Creek watershed include two KDHE Bureau of Water permanent water quality monitoring stations and four USGS gauging stations. The KDHE monitoring sites are permanent sites and are anticipated to be continued into the future.

Figure 11 illustrates the active KDHE and USGS monitoring sites.

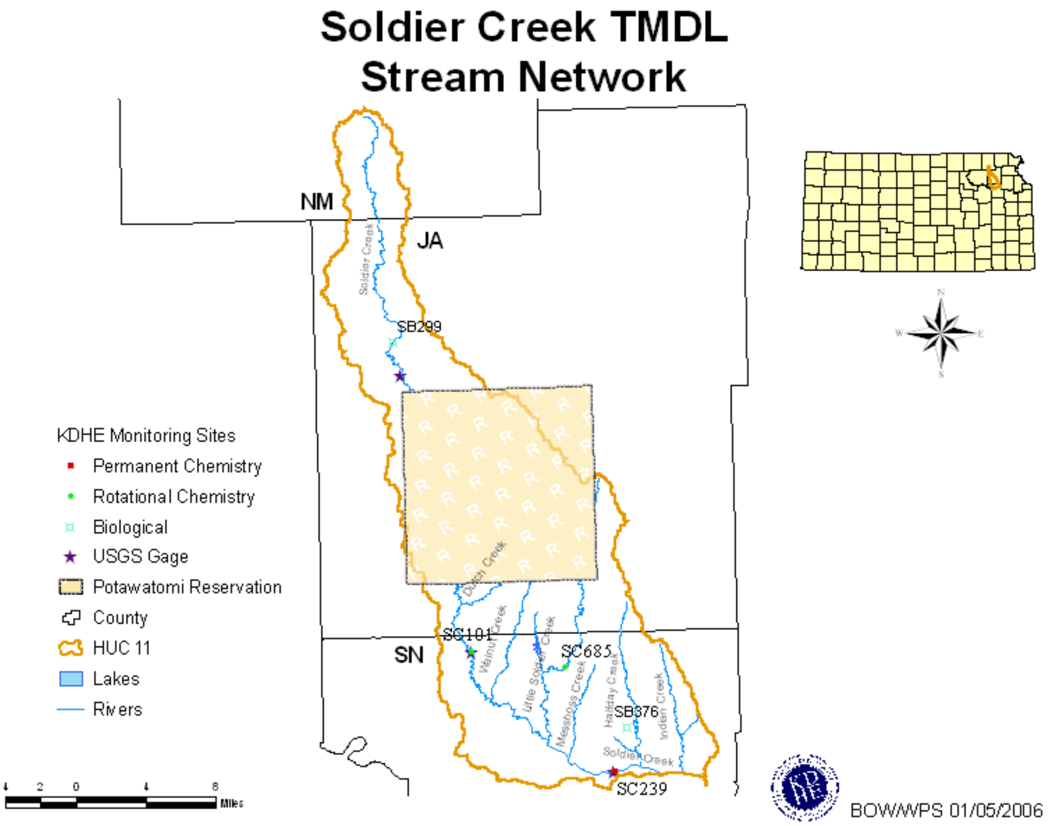

Figure 11 - KDHE and USGS Monitoring Sites (KAWS, 2011)

Streams within the Soldier Creek Watershed are affected by water quality problems common to surface water in the Great Plains agricultural region. During the rainy months of the year, there is an increase in bacteria, pesticides/herbicides, sediment, and nutrient loading into streams within Reservation boundaries. Monitoring of pollutants is important to understanding the health of the 193 miles of streams flowing within the boundaries of the Reservation. The quality and quantity of water needs to be maintained at a level that poses no danger to human health and protects environmental resources on the Reservation and for downstream communities. Therefore, monitoring is critical to maintaining, preserving, and protecting these valuable water resources.

From June 1996 to August 2006, PBPN and USGS collected, analyzed, and summarized surface and groundwater water quality as part of a cooperative study. Since then, PBPN developed a Quality Assurance Program Plan to sample ambient waters (surface and groundwater) within the PBPN Reservation, with the intention to begin developing a water quality baseline for PBPN water resources. PBPN monitoring of surface water is conducted at 5 sites along Big Soldier, Little Soldier, and Big Elm Creek. Groundwater is monitored by the Tribe's 106 CWA Program through 8 monitoring well sites located throughout the Reservation. The map in Figure 12 shows the locations of the water quality monitoring sites within the Reservation. All surface water samples are analyzed for physical properties, dissolved solids, major ions, nutrients, trace elements, pesticides, fecal indicator bacteria, suspended sediment concentration, and total suspended solids. All ground water samples are analyzed for physical properties, dissolved solids, major ions, nutrients, trace elements, pesticides, and fecal indicator bacteria (PBPN 2022a, 2022b). PBPN-PEP'S Water Program developed a Surface Water Quality Criteria as a measure to gauge water quality within the Reservation boundaries - see Table 9, below. Surface water monitoring, under an EPA approved QAPP, began during the year 2011. Since then, PEP data set has been used to gauge water quality over time. By using the Surface Water Quality Criteria, PEP can determine if numeric criteria for designated uses are being met by standards set forth by Federal and State standards.

Goals and objectives for the program were established within a number of the Nation's other plans including the Water Quality Management, Wetlands Conservation, and Wildlife Management plans. Long-term goals for water quality include:

- Protecting and enhancing the quality of waters and wetlands of the Reservation for the benefit of current and future generations.
- Attaining a level of water quality that allows for fishing and swimming in all surface waters within the Reservation, by controlling all point and nonpoint pollution sources within and outside of the Reservation.
- Preventing adverse effects to human health and the environment by ensuring that groundwater quality is protected through the control of potential sources of contamination within the Reservation.

TABLE 9: PRAIRIE BAND POTAWATOMI NATION SURFACE WATER QUALITY CRITERIA

DEVELOPED SEPTEMBER 30, 2010

PARAMETER	UNITS	WATER USE Aquatic Life	WATER USE Contact Recreation (Swimming)	WATER USE Domestic Water Supply[7]
Dissolved Oxygen	mg/L	≥5 mg/L[1]	-	-
pH	Units	6.5 – 8.5 [1]	-	-
Temperature	˚ Celsius	32 [1] (working on seasonal temperature values for Tribal waters)	-	-
Turbidity	FNU (~ NTU)	4.1 NTU [2]	-	-
Total Dissolved Solids (calcium, magnesium, sodium, potassium, anions bicarbonate, sulfate, and chloride)	mg/L	-	-	5003
E. Coli	MPN/100mL	-	1264 (assessing 75% CI of 235 until have enough data for geometric mean)	-
Nitrate + Nitrite Nitrogen	mg/L	-	-	105
Nitrite Nitrogen	mg/L	-	-	13
Total Nitrogen	mg/L	0.96	-	-
Total Phosphorous	mg/L	0.0756	-	-
Arsenic	mg/L	-	-	0.0101
Atrazine	ug/L	3.01	-	3.01
Alachlor	ug/L	-	-	2.01

[1] Kansas Water Quality Standards

[2] Aquatic Life Recommendations for Ecoregion IV

[3] National Secondary Drinking Water Regulations

[4] EPA's Ambient Water Quality Criteria for Bacteria – 1986; EPA440/5-84-002

[5] EPA's National Recommended Water Quality Criteria

[6] EPA's Regional Technical Advisory Group recommended criteria

[7] Kansas Implementation Procedures: Surface Water Quality Standards as defined under K.A.R. 28-15-11 (cc).

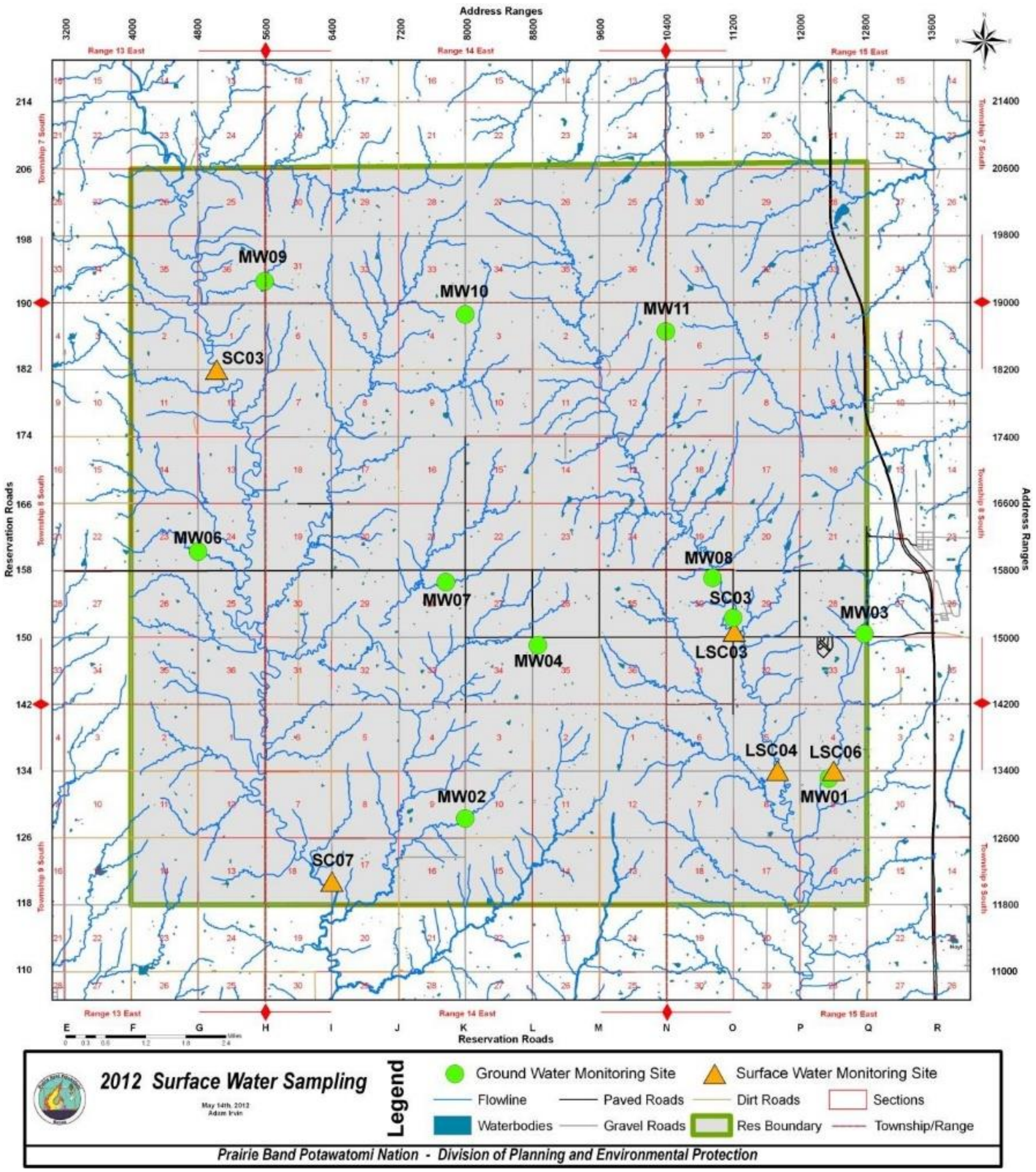

Figure 12 – Location of Water Quality Monitoring Sites within the Reservation

This 9 Critical Element plan provides several elements and objectives to meet the above goals, from collecting baseline data, identifying impaired waters and sources of impairment, and protecting and restoring riparian corridors, to describing the information and education needed to enhance public understanding and encourage participation in the program. See Table 10 below for detailed objectives for the program.

Table 10: PBPN MONITORING OBJECTIVES

MONITORING OBJECTIVES	
Program Area	**Objectives**
Surface Water Quality for creeks	1. Assess whether water quality criteria are being met. 2. Establish a baseline of water quality condition. 3. Periodically reassess the baseline water quality to look for changes (status and trends).
Ground Water Quality, Monitoring Wells	1. Assess whether water quality criteria are being met. 2. Establish a baseline of water quality condition. 3. Periodically reassess the baseline water quality to look for changes (status and trends).
Physical & biological monitoring -creeks	Collect and assess physical and biological data for creeks, Benthic macroinvertebrate data used to assess water quality condition/status. Sampling occurs during the open water season (April – November) within the aquatic stage of the life cycle of the macroinvertebrates.
Wetlands National Condition Wetland Assessment methodology	1. Develop inventory and map 2. Evaluate the ecological integrity of wetlands and the risk posed by stressors affecting the broader environment. 3. Assess wetland condition.
Non-point Source	1. Identify water needing restoration. 2. Determine the effectiveness of individual NPA projects in meeting water quality criteria. 3. Evaluate cumulative watershed impacts from best management practices (BMP) installation.
Emergency Monitoring	Determination of causation of fish kills, impacts of oil/chemical spills, flooding impacts and harmful algal blooms.
BPN Water Quality Lab @ Earthship	IDEXX COLILERT® Quanti-Tray®/2000 TEST METHOD FOR THE SIMULTANEOUS DETECTION OF TOTAL COLIFORMS AND *E. COLI* IN AMBIENT WATER. Standard Method 9223-B

In addition to the above objectives, the 106 Water Quality Monitoring Strategy plan includes monitoring designs, water quality indicators and parameters, and the quality assurance parameters. The monitoring program is evaluated on an annual basis to determine if the current monitoring design is effectively meeting the Nation's environmental priorities, determine if goals have been accomplished, and identify resource needs and any emerging issues that could lead to a shift in Tribal priorities.

CWA Section 106 Sampling Report for 2021

Since 2013, wetland and CWA-319 activities have been incorporated into the PBPN water program. In addition to sampling site data, PEP staff have been using the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS), which is a unique, non-profit, community-based network of volunteers who work together to measure and map precipitation events, to engage the greater community in collecting local data on precipitation and evapotranspiration. The data, while valuable for informing local monitoring, also provides researchers and others with data that can be used at a regional or national level.

Water quality is adversely affected by land use and further compounded by extreme climatic events. Therefore, measures to mitigate streambank erosion and associated pollutants will need to be implemented throughout the Reservation, with the goal of pollution control and prevention. A number of recommendations have been made to improve the watershed and avoid further impacts due to land use. Recommendations include stream protection and restoration with an emphasis on protecting higher quality stream reaches, riparian buffer restoration on tribal and non-tribal lands, fencing livestock out of streams, and providing alternative water supplies for livestock. Long-term stability initiatives and adopt-a-stream programs could be implemented with community participation, and education programs could be implemented with the aim of f keeping streams clean. The more tribal members are involved, the better these water resources will be protected and enhanced for current and future generations.

10.2 SUPPLEMENTAL MONITORING

Additional monitoring may be provided through citizen science programs as noted in Section 6.0. The nature and extent of these programs has yet to be determined.

11.0 REVIEW OF THE WATERSHED PLAN – 2033

The Nation will evaluate implementation results during years 1 through 5 to determine which strategies have provided the greatest benefit, and which are most cost-effective effective. During this phase of the program, the Nation will also monitor lessons learned by other regional WRAPS groups, state and national research on BMP effectiveness and cost, and emerging I&E strategies; as well as local, state, and federal funding availability. The Nine Critical Element Plan will be updated based on these findings. The Nation will develop a revised, detailed implementation plan for years 6 through 10 and will adjust the longer-term implementation strategies and forecasts as appropriate. The Nation will review the program again after year 10 and will adjust the strategies and forecasts for years 11 through 20 if needed.

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APPENDIX A – MOORE, 2022

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Technical Memorandum

To: Scott Schulte, Ad Astra Collaborative, LLC

From: Trisha Moore, Kansas State University, Biological & Agricultural Engineering

Subject: Streambank restoration and stabilization sediment load reductions for PBPN

Date: November 14, 2022

1.0 Overview

This memo summarizes available stream assessment data collected for streams within the Prairie Band Pottawatomie Nation Reservation area (Section 2) and presents a method by which to estimate sediment loads generated by streambank erosion along these reaches (Section 3). Potential sediment load reductions that could be achieved through planned restoration and/or bank stabilization projects within these reaches are then discussed (Section 4).

2.0 Existing stream assessment information

The general health and stability of stream channel and riparian systems within the Prairie Band Pottawatomie Nation (PBPN) reservation area have been assessed through at least two independent stream assessment studies. In one, Watershed Resources Solutions (2020) assessed geomorphic stability at sites along Big and Little Soldier Creeks. Data collected through this effort was used to classify reaches as “good”, “fair”, or “poor” in terms of channel stability. As depicted in Figure 1, reaches surveyed in Soldier Creek were distributed relatively evenly between “Fair” and “Poor,” while in Little Soldier Creek, the majority of reaches were classified as “Fair” (75%) and the remainder “Poor” (25%). While this assessment is qualitative in nature, it provides the most comprehensive description of streambank stability in the Reservation area.

In addition to the channel stability assessment, a stream asset inventory (SAI) was conducted in 2019 along many of the same reaches assessed by WRS (2020) as described in Ad Astra Collaborative (2020). Briefly, the SAI assessment included indicators of geomorphic stability, terrestrial and aquatic habitat quality, and water quality. These indicators were then used to classify each reach as one of five categories ranging from “exceptionally high quality (Type I) to exceptionally low quality (Type V). The majority of streams were classified as “average quality” (Type III, 75%), while the next highest category of “relatively low quality” (Type IV) applied to 14% of surveyed reaches (Figure 2). Although the SAI incorporates additional measures of stream health, it is worth noting that “average” and “relatively low quality” reaches identified through the SAI generally align with reaches identified as having “Fair” or “Poor” channel stability by WRS (2020), respectively. Thus, the SAI assessment helps to corroborate qualitative rankings produced through the channel stability assessment.

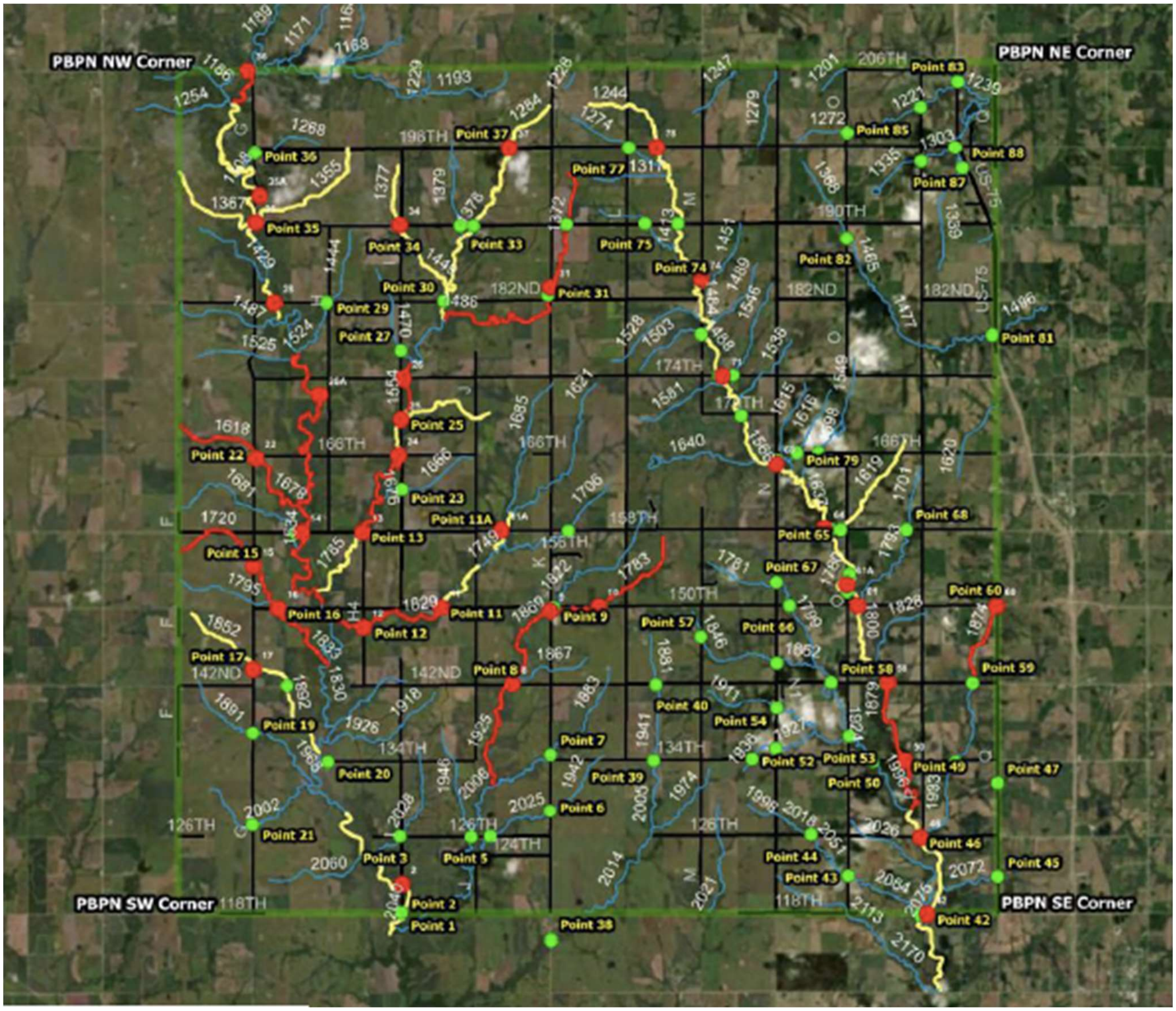


Figure 1. Results of stream stability assessment by Water Resources Solutions in which streams throughout the PBPN Reservation area were classified as “Good,” “Fair,” or “Poor,” condition, corresponding to green, yellow and red highlighted reaches in the figure. Figure reproduced from WRS, 2020.

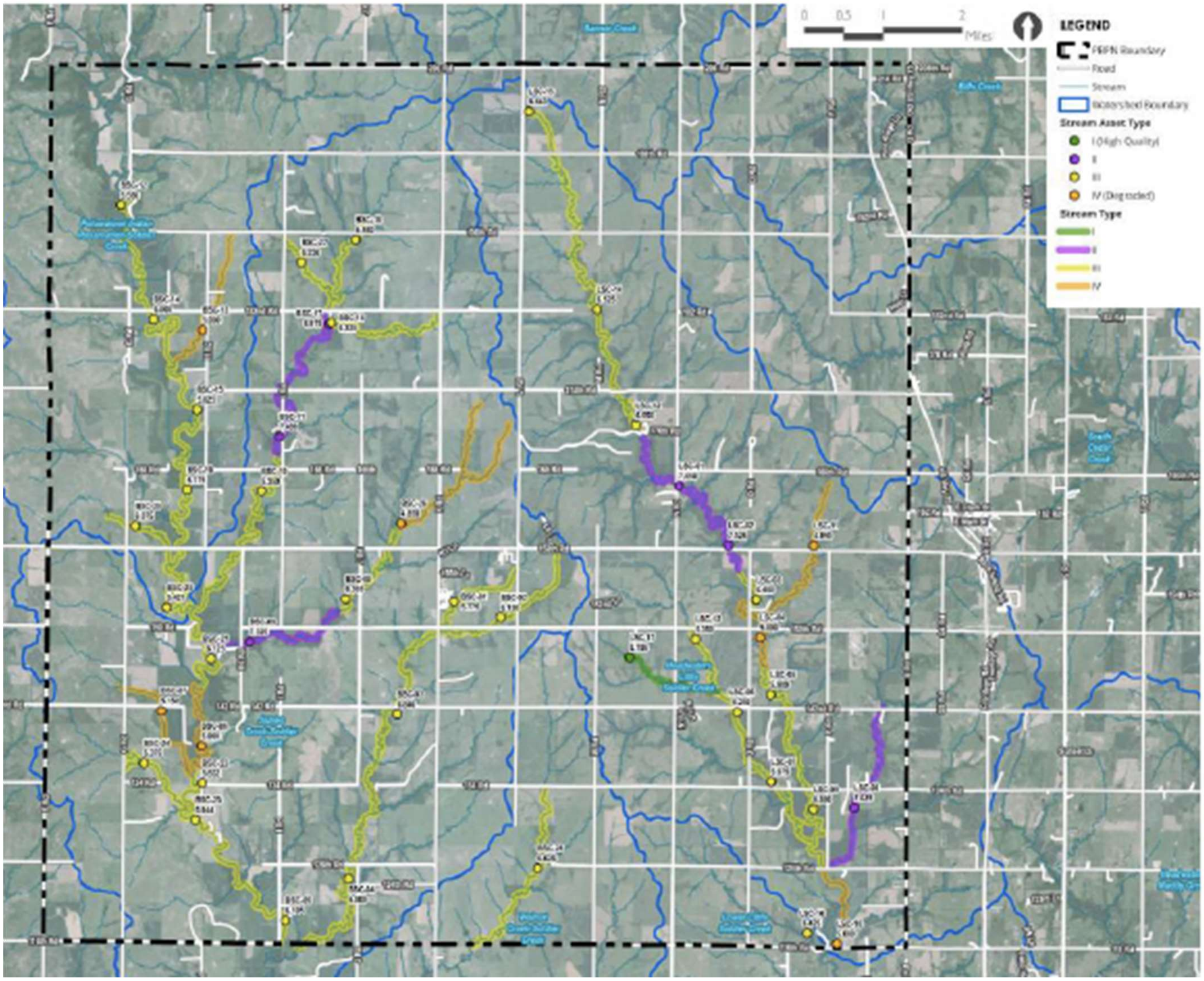


Figure 2. Results of the Stream Asset Inventory (SAI) conducted by Ad Astra Collaborative in which indicators of stream stability and overall riparian health were assessed. Indicator ratings were used to assign stream reaches to categories of Type 1 (green), II (purple), III (yellow), or IV (orange) corresponding to “exceptionally high quality,” “high quality,” “average,” and “low quality.”

3.0 Developing quantitative estimates of streambank erosion

The SAI and channel stability assessment established benchmark conditions for geomorphic stability and broader riparian system health across the Prairie Band Pottawatomie Nation Reservation. These prior assessments also serve as a basis for more quantitative estimates of streambank erosion and associated sediment loads, as well as the potential to reduce such loads through restoration and other measures to stabilize stream channels. Several methods were considered to obtain quantitative estimates of current sediment loads due to channel erosion. For example, time series of aerial imagery or digital elevation models have been used to estimate rates of lateral bank erosion (e.g., KWO, n.d.; Layzell et al., 2022). In the case of Soldier and Little Soldier Creeks, riparian vegetation obscured bank edges (and in some cases the entire channel) in available aerial imagery and high resolution DEMs (e.g., 1 m scale) as needed to reliably detect channel degradation were only available for one year. Therefore neither of these options was pursued. As an alternative, bank erosion measurements and resulting models developed by Sass and Keane (2012) for streams in the Western Cornbelt Ecoregion of northeast Kansas were explored. Sass and Keane (2012) employed stream assessment methods described by Rosgen (1996) to conduct field measurements of geomorphic features in the Black Vermillion Watershed of northeast Kansas and then classify assessed reaches by stream type. They then created a Bank Assessment for Non-Point Consequences of Sediment (BANCS) model, also described by Rosgen (1996), in which indicators related to the susceptibility of a bank to lateral erosion (known as the Bank Erosion Hazard Index, or BEHI) and relative magnitude of applied fluvial shear stresses (known as Near Bank Stress, or NBS) are related to lateral bank retreat rates measured in the field. The resulting bank erosion prediction curve (Figure 3) can be applied to other streams in the same or similar ecoregions that are characterized by similar climate, native vegetation and/or cropping systems, soils, and underlying geology – all of which play an important role in shaping geomorphic processes such as channel erosion.

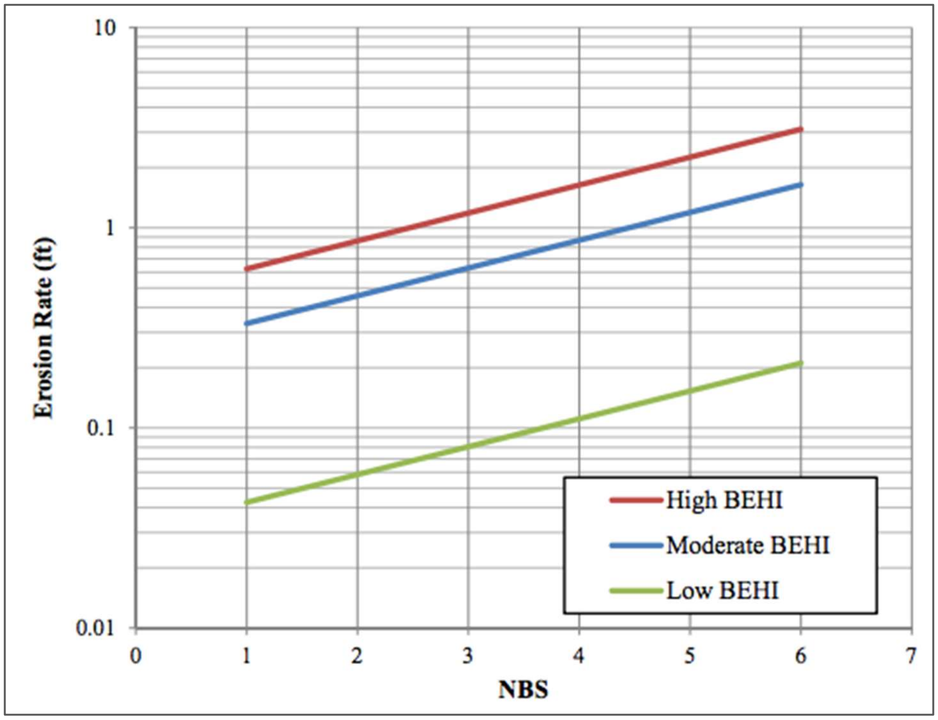
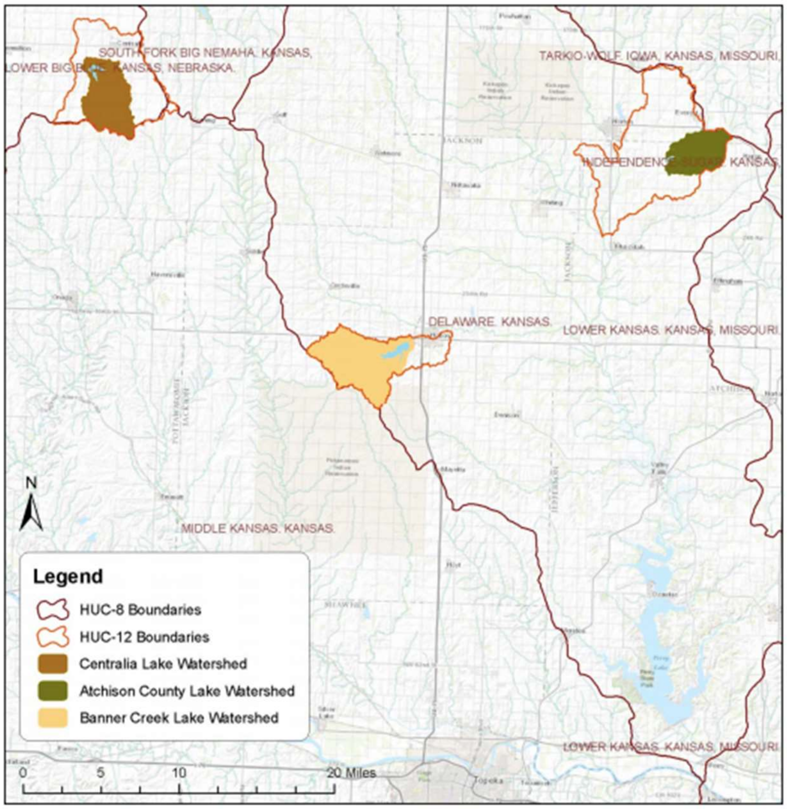


Figure 3. BANCS model developed by Sass and Keane (2012) for streams in the Western Cornbelt Region and applied by Emmert (2013) to streams in three watersheds near to Soldier and Little Soldier Creeks. Figure reproduced from Sass and Keane (2012).

The BEHI-NBS curves developed by Sass and Keane were applied in watersheds near to Soldier and Little Soldier Creeks by The Watershed Institute (TWI; Emmert, 2013) as part of an in-depth study of sediment transport and fate in the watersheds draining to Atchison Lake, Banner Creek Lake, and Cedar Creek Lake (Figure 4). As with much of the area within the PBPN Reservation, the Atchison, Banner Creek and Centralia Lake watersheds all lie within the Western Corn Belt ecoregion, meaning that they share similar climate, land cover (corn-soybean crop rotations; cool and warm season pasture/grassland), soils (predominantly silt loams) and underlying geology.

Furthermore, the drainage areas of streams surveyed as part of the TWI study fall in a range (up to 10 square miles) that coincides with the majority of stream reaches identified for riparian corridor restoration and/or placement of in-stream structures to promote geomorphic stability (Figure 5). Reaches along the mainstem of Soldier Creek are the exception to this generalization, as drainage areas to those reaches are an order of magnitude larger. An additional similarity across these riparian systems is that the majority of stream channels are relatively narrow and deep with limited floodplain access.

Figure 4. Watersheds to which BANCS model created by Sass and Keane (2012; Figure 3) were applied by Emmert (2013), including Centralia Lake (brown), Atchison County Lake (green), and Banner Creek Lake (yellow). Geomorphic relationships between drainage area and bankfull height as surveyed and presented by Emmert (2013) for these watersheds was used to estimate bank heights used in estimates of streambank sediment loads. The PBPN reservation area lies just outside of the Banner Creek Lake watershed as indicated by light shaded region in the map. Figure reproduced from Emmert (2013).



As seen in the BEHI-NBS bank erosion model developed by Sass and Keane (2012) and as applied to stream reaches in the TWI study (Emmert, 2013), stream banks with “high” bank erosion potential were predicted to experience lateral bank retreat rates of approximately 0.8 feet per year. By comparison, lateral bank retreat rates predicted for banks with "moderate" erosion potential were lower, ranging from 0.4 to 0.9 feet per year as dependent on relative magnitude of applied shear stresses (i.e., NBS value).

Proper application of the BANCS bank erosion model developed by Sass and Keane to streams in the PBPN Reservation area would require completing BEHI and NBS assessments on study banks within stream reaches of interest (e.g., reaches identified for streambank restoration and stabilization). This assessment is beyond the scope of this study; however, we can use results of the prior SAI and bank stability assessment to approximate BEHI classification and, with this, a range of potential lateral bank retreat rates. Correlations between these assessments were defined as outlined in Table 1.

Figure 5. Proposed areas for riparian corridor restoration and/or streambank stabilization measures. Figure reproduced from AAC (2020).

Table 1. Assumed Bank Erosion Hazard Index (BEHI) rating and associated lateral bank erosion rate for reach conditions classified for streams on PBPN Tribal lands in the Channel Stability Assessment (WRS, 2020) and Stream Asset Inventory (AAC, 2020).

Channel Stability Assessment (WRS, 2020)	**SAI (AAC, 2020)**	**BEHI**	**Estimated lateral bank erosion rate**[1]
Poor	Relatively low quality	High	1.1 ft/yr
Fair	Average quality	Moderate	0.6 ft/yr
Good	Relatively high quality	Low	0.08 ft/yr

[1] from BANCS model developed by Sass and Keane (2012) and demonstrated for Atchison, Banner Creek and Cedar Lake Watersheds by Emmert (2013). In all cases, a moderate NBS rating was assumed.

Sediment loads associated with lateral retreat rates were then estimated as [Eqn. 1]:

$$\text{Sediment load (lb/year)} = \text{lateral retreat rate (ft/year)} \times \text{bank height (ft)} \times \text{reach length (ft)} * \text{sediment density (lb/ft}^3\text{)}$$

This approximation has several limitations. These limitations are discussed in brief for each of the variables used to estimate streambank sediment loads in Equation 1 in the following sections.

Lateral retreat rate. The value selected for the lateral retreat rate (last column of Table 1) assumes a “moderate” near bank stress value to be representative of the reach. As indicated in Figure 3, actual bank erosion rates are expected to increase as near bank stress increases. Determining NBS for PBPN streams would require specific field measurements and was beyond the scope of this study, so a moderate range (i.e., NBS value of 3 in Figure 3) was assumed to be representative of the PBPN reaches. This assumption introduces additional uncertainty to that inherent in the BANCS model.

Bank height. Without direct field measurements of bank height for streams, two methods were considered to estimate. The first was to estimate bank height using available 1-m resolution LiDAR elevation data (2018) by extracting elevations along stream cross-sections measured at the top, middle, and end of each reach for which riparian restoration and/or in-stream structures for stability were indicated by AAC (2020). One limitation of this method is that the LiDAR data do not extend below the water surface of the stream; thus the actual height represented is the distance between the top of the bank and the stream water surface on the day LiDAR data were collected. Bank heights are also expected to vary along the reach, which may not be captured accurately by the average of three measurements as used here. The other method considered was to use geomorphic relationships between drainage area and bank height established by Emmert (2013) for streams in the Atchison, Banner Creek, and Centralia Lake watersheds described previously. While such bank geometry relationships are commonly applied to estimate bank heights in unmeasured stream systems within similar ecoregions and hydrophysical controls, there is a high degree of variability in the relationships that can be explained by watershed-specific factors (e.g., as shown in data presented by Emmert, 2013). Given the limitations of each, a combined approach was adopted. First, relationships between bank height and watershed drainage area derived from data presented by Emmert et al. (2012) were used to calculate a bank height for each of the PBPN stream reaches for which stream restoration and/or stabilization has been considered. Watershed drainage areas for each reach were determined by linking PBPN stream restoration/stabilization spatial data with reach characteristic data compiled as part of the National Hydrography Dataset Plus, which includes total catchment drainage area (Moore, 2019). Calculated heights were then checked against cross-section elevations extracted manually from LiDAR elevation data at selected points along the reach. Calculated bank heights were generally within the range estimated from LiDAR elevations for banks with moderate to high bank erosion potentials (i.e., “Fair” to “Poor” condition in the WRS, 2020 stream stability assessment) but were high for stream segments with low bank erosion potential (i.e., “Good” rating in the WRS assessment). In such cases, adjustments were made to bank height estimates using best judgment. It was noted that the WRS (2020) stream stability assessment included bank height as a criteria. If measured bank heights from this assessment are available, the uncertainty in this variable could be reduced.

Reach length. Reach lengths were taken as is from the shapefile specifying candidate reaches for stream restoration and/or stabilization within the PBPN reservation area. These reach lengths also corresponded with stream segments delineated in the NHD-Plus dataset and the lengths given therein. Because these values come from remotely-sensed NHD they may not reflect field measurements for reach length. We note though that there is uncertainty even in field measurements of reach length and that the NHD data are widely accepted for stream assessments. We would also emphasize here that all stream variables described here are extrapolated over the reach scale as defined by the reach length. In other words, the reach length represents the spatial scale over which bank erosion calculations and associated input variables are assessed.

Sediment density. Sediment density is intended to represent the bulk density of bank materials. Here, we assume a bulk density of 90 lb/ft^3 (1.45 g/cm^3), which falls in the range expected for silt loam materials. Likewise, soil texture and density is expected to vary with depth and along the length of each reach while we assume a constant bulk density. Even with these simplifications and limitations, the uncertainty associated with variation in streambank material density is likely much less than that associated with reach bank height and annual retreat rates described previously.

Streambank erosion rates and estimates of streambank-derived sediment load. A summary of estimated bank erosion rates is presented in Table 2. The mean rate across all stream reaches identified for restoration and/or stabilization was 0.27 tons/year/linear foot. As expected, rates associated with banks in the “Poor” stability category (Table 2). These values fall in line with rates observed in the Banner Creek and Centralia Watersheds by Emmert (2013).

Table 2. Estimated sediment eroded from streambanks as calculated from Equation 1.

Bank condition[1]	**Estimated bank erosion rate (tons/yr/linear foot)**		
	Mean	Min	Max
Good	2.6E-3	1.0E-3	5E-3
Fair	0.15	0.08	0.22
Poor	0.58	0.27	1.17

[1] Bank condition as characterized by WRS (2020). See Table 1 for corresponding lateral bank erosion rate estimates.

Sediment eroded from the bank does not all entrain and become part of the suspended sediment load. A portion is likely to be deposited in point bars (or mid-channel bars in the case of non-equilibrium) in meandering alluvial streams such as Soldier Creek and Little Soldier Creek. There is great uncertainty in the portion of bank sediment losses that will ultimately become part of the annual sediment load exported from the watershed. For the purposes here, we use stream sediment budgets developed from a multi-year field monitoring project in the Cottonwood River, an alluvial channel in Chase County Kansas in the Flint Hills Ecoregion (in which westernmost areas of the Soldier Creek watershed also fall), along with modeling data from Emmert (2013) in the Atchison, Banner Creek and Centralia watersheds described previously. In these studies, the ratio of estimated bank erosion (tons bank erosion/yr) to suspended sediment yield (tons sediment yield/yr) ranged from 5% to 65% of moderate bank erosion rates and 2% to 19% of high bank erosion rates. Variation in this ratio was strongly correlated to drainage area, with higher rates of apparent entrainment in smaller watersheds. Based on these previous studies and conditions observed in Soldier Creek, **conversion factors ranging from 5% for reaches along the mainstem of Soldier Creek** (with drainage areas exceeding 50 mi^2) **and 9% to 22% for smaller tributaries** with drainage areas of up to 25 mi^2. In addition to reach drainage area, these ratios reflect the relative distribution of banks with “moderate” versus “high” bank erosion rates reported in the 2020 WRS study (25/75 in Soldier Creek and 50/50 in Little Soldier as summarized in Section 2.0). These conversion factors are intended to provide an estimate of the contribution of streambank erosion from reaches of interest to observed sediment yields from Soldier Creek (at Delia) and Little Soldier Creek (at the southern PBPN reservation border), respectively, and are summarized in Table 4.

4.0 Sediment load mitigation by streambank restoration and/or stabilization.

Sediment loads generated by streambank erosion as presented in Section 3.0 provide estimates for current conditions. The potential to mitigate for streambank sediment contributions via riparian restoration and/or in-stream structures to enhance channel stability was estimated by applying a sediment load reduction efficiency factor as presented in [Eqn. 2]:

Sediment load reduction (tons/year/foot) = sediment load (tons/year/foot) x % sediment retention effectiveness

For this calculation, the sediment load from Equation 1 was multiplied by the bank erosion-to-load conversion factor to obtain a sediment load derived from streambanks. This load was then multiplied by a factor representing the effectiveness of restoration/stabilization practices in reducing reach-scale sediment loads. Literature values suggest a conservative value of 50% can be adopted for this efficiency factor (Scheuler and Stack, 2014) but that values upwards of 75% could actually be achieved (Thompson, et al., 2018). Resulting sediment loads and retention rates for potential stream restoration and/or stabilization projects are summarized in Table 3 and depicted in Figure 6 with the assumption of a 50% sediment reduction effectiveness factor.

In interpreting these values, we again raise some of the limitations of this method. The sediment reduction factor does not take into consideration differences in different measures (e.g., stabilization alone compared to a more comprehensive channel and riparian system restoration) and, rather, assigns a constant value of 50%. In addition, this approach does not account for system-scale changes. For example, restoring floodplain vegetation and connection in lower order streams may have positive downstream effects with respect to sediment load reductions that are not reflected by this analysis. If an effect greater than 50% reduction on sediment load delivery is expected, then the values in Table 3 can be adjusted accordingly. Streambank erosion estimates and associated load reductions were aggregated on the reach basis (reaches were assigned as illustrated in Figure 6) and area presented in Table 4. Total sediment losses from selected streambanks were estimated at over 8,000 tons per year. Assuming restoration strategies are 50% effective for reducing associated sediment loads, implementing the set of stream projects could reduce watershed sediment loads by over 4,000 tons per year.

Table 3. Estimated sediment load reductions achieved by stream restoration and/or stabilization for stream reaches identified in Figure 6. These values represent a 50% sediment load reduction efficiency of stream restoration/stabilization systems.

Bank condition[1]	**Estimated sediment load reduction (tons/yr/linear foot)**		
	Mean	Min	Max
Good	2.9E-04	1.1E-04	5.5E-04
Fair	6.8E-03	3.6E-03	9.9E-03
Poor	2.6E-02	1.3E-02	5.3E-02

[1]Bank condition as characterized by WRS (2020). See Table 1 for corresponding lateral bank erosion rate estimates.

Table 4. Estimated sediment loads associated with streambank erosion and load reduction through potential streambank restoration and/or stabilization projects. Refer to Figure 6 for reach designations.

Reach ID	**Stream**	**Est. Sediment load (tons/yr)**	**Streambank length (miles)**	**% of eroded bank material exported**	**Sediment load attributed to bank erosion (tons/yr)**	**Est. Load reduction through restoration / stabilization (tons/yr)**
1	Tributary to Soldier Creek	12,329	4.94	9%	1,110	555
2	Tributary to Crow Creek	1,220	2.54	9%	110	55
3	Tributary to Crow Creek	550	1.22	9%	50	25
4	Tributary to Crow Creek	220	0.66	9%	20	10
5	Crow Creek	640	0.69	9%	58	29
6	Crow Creek	870	0.37	9%	78	39
7	Tributary to Crow Creek	30	1.17	22%	7	3
8	Crow Creek	2,650	0.62	9%	239	119
9	Tributary to Crow Creek	50	0.38	22%	11	6
10	Tributary to Crow Creek	10,420	1.77	9%	938	469
11	Crow Creek	12,660	2.44	9%	1,139	570
12	Crow Creek	1,570	0.42	9%	141	71
13	South Branch Soldier Creek	114	1.34	22%	25	13
14	South Branch Soldier Creek	97	1.32	22%	21	11
15	South Branch Soldier Creek	3,600	3.52	9%	324	162
16	South Branch Soldier Creek	10,208	3.95	9%	919	459
17	James Creek	4	0.15	22%	1	0
18	James Creek	10,185	1.97	9%	917	458

19	Tributary to Soldier Creek	3,590	1.84	9%	323	162
20	Soldier Creek	43,200	2.26	5%	2,160	1,080
Total		**114,207**	**34**		**8,589**	**4,294**

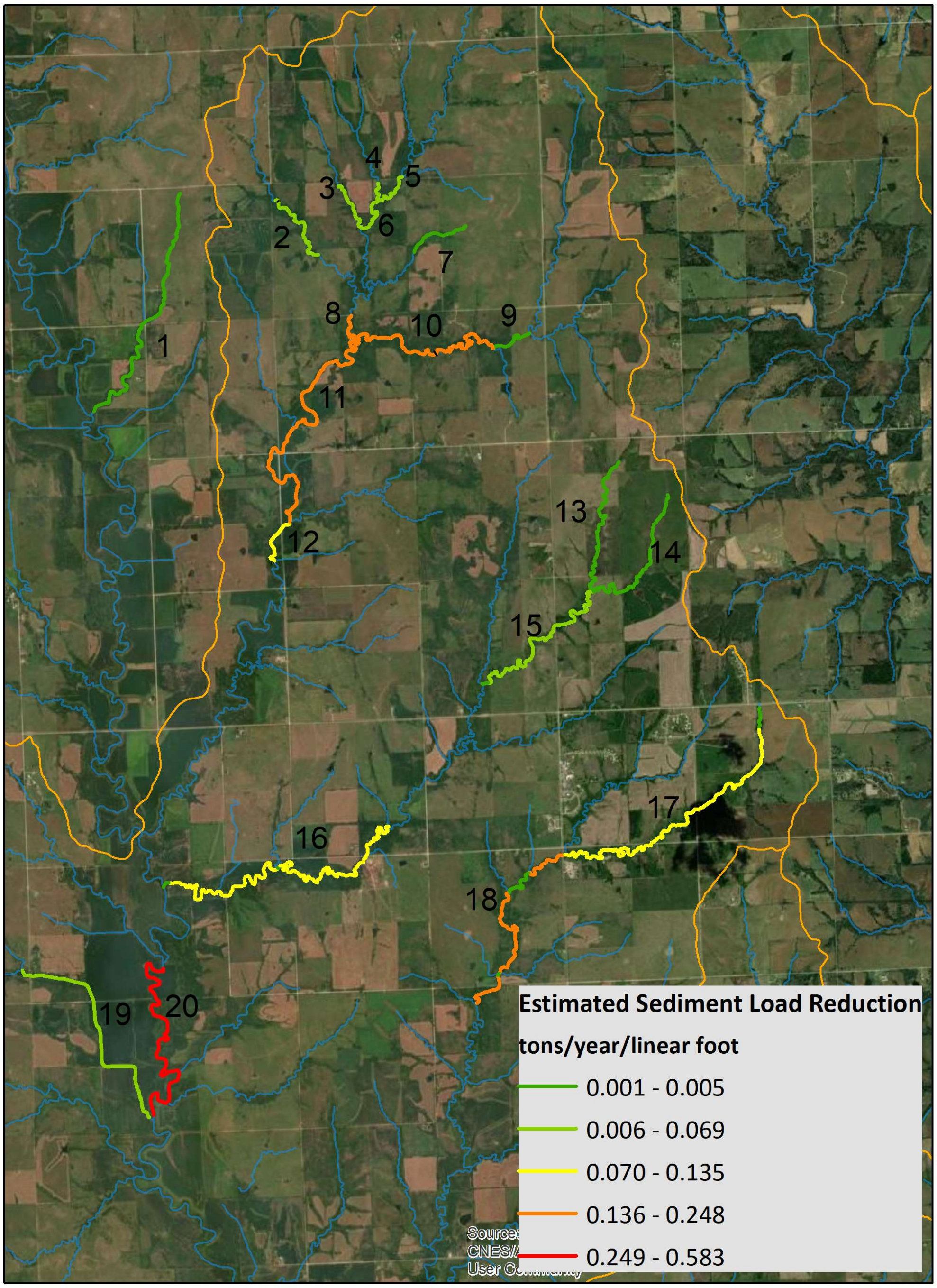


Figure 6. Estimated sediment load reductions (in tons sediment per year per linear foot of streambank) for stream reaches identified as potential stream restoration and/or channel stabilization projects (Figure 5).

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APPENDIX B – RIPARIAN BUFFER AND STREAM STABILIZATION MEASURES

Riparian Corridor Restoration Measures

Riparian corridor restoration concepts were developed and refined based upon information provided through extensive riparian corridor habitat assessment and modeling (PBPN, 2021). Several different riparian buffer configurations will be implemented depending on site-specific conditions, as follows.

Wooded Buffer

In areas where little to no wooded riparian corridor vegetation exists and the adjoining land use is crop fields, the recommended 150-foot buffer consists of native trees, shrubs, and associated understory vegetation (Figure 1).

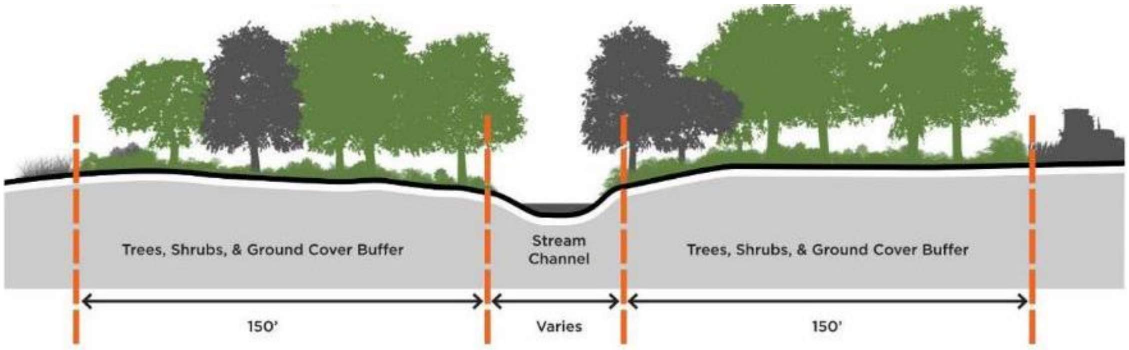


Figure 1. Typical Cross Section of Wooded Buffer.

Mixed Buffer

In areas where there wooded riparian corridor already exists and the adjoining land use is livestock pasture or cool season hay meadow, the recommended 150-foot buffer includes an inner zone of 100 feet of trees and shrubs adjacent to the stream and an outer zone of 50 feet of native warm-season grasses or native prairie (Figure 2).

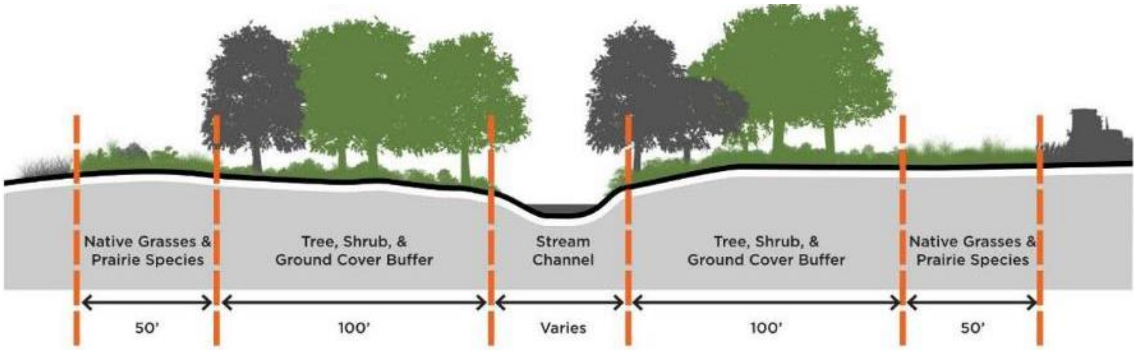


Figure 2. Typical Cross Section of a Mixed Buffer of Woods with a Prairie Border.

In areas where little to no wooded riparian corridor vegetation exists and where the adjoining land use is native prairie pasture or prairie hay meadow, the recommended 150-foot buffer includes an inner zone of 50 feet of trees and shrubs to protect bank stability, and an outer zone of 100 feet of native warm-season grasses or native prairie (Figure 3).

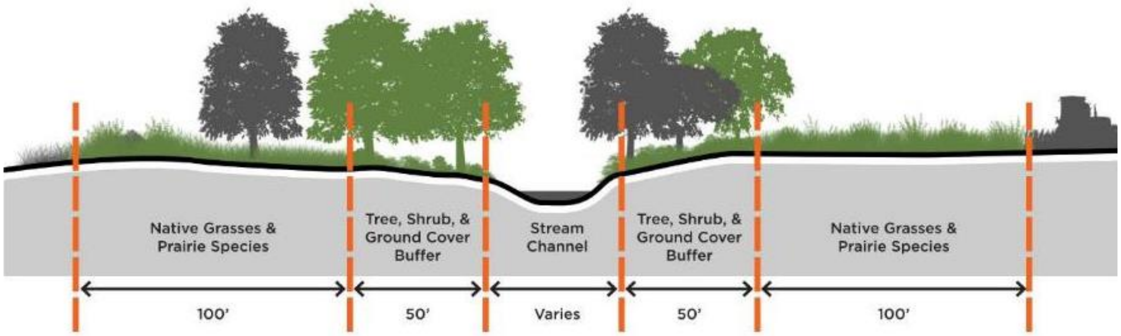


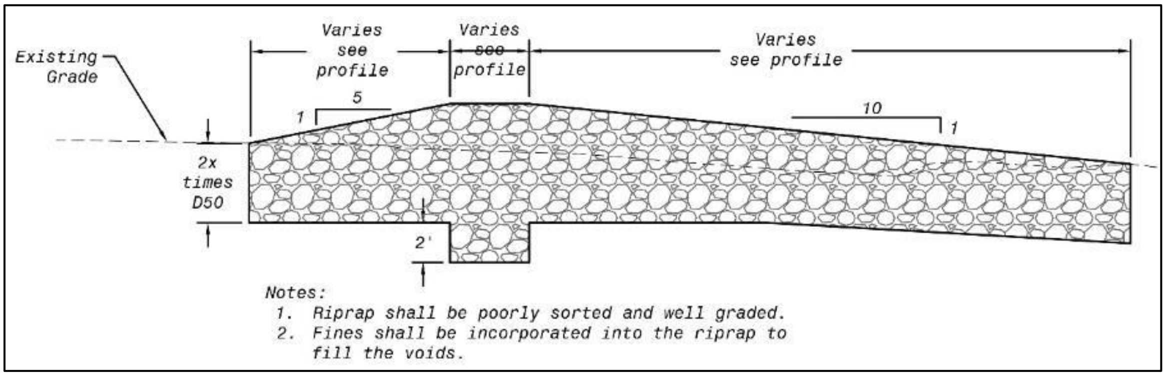
Figure 3. Typical Cross Section of Mixed Buffer of Narrow Woods with a Wide Prairie Border.

Channel Restoration Measures

Measures for stream restoration and in-stream habitat concepts were refined based upon stream stability assessments, hydraulic modeling, and aquatic habitat assessment and modeling (PBPN, 2021).

Grade Control

Grade controls are riprap structures used to stabilize the bed of a stream by reducing the stream slope, thus reducing the flow velocities. The existing change in elevation along the channel is made up by the grade controls. A typical grade control will have a one- to two-foot drop in elevation along the grade control from the crest to the existing channel bed elevation (Figure 4). This structure flattens the channel slope between grade controls, thus reducing the flow velocities. Velocities are higher at the crest grade control, but riprap placed below the crest is sized appropriately to resist erosive forces.



Notes:
1. Riprap shall be poorly sorted and well graded.
2. Fines shall be incorporated into the riprap to fill the voids.

Figure 4. Typical Cross Section of a Rock Grade Control Structure.

Longitudinal Peaked Stone Toe Protection

Longitudinal peaked stone toe protection is riprap placed along the toe of a stream bank on the outside of meanders to provide erosion protection. The height of the toe protection is typically set at or near the depth of the stream forming flow or bankfull flow. The stream forming flow is typically between the 1-year and 2-year storm events and coincides with indicators, such as scour lines, lower limit of woody vegetation, and bar height (Figure 5). Rock keys set into the bank perpendicular to the stone toe protection may be needed to prevent flanking during larger storm events. The slope above the protection is regraded and restored with native vegetation.

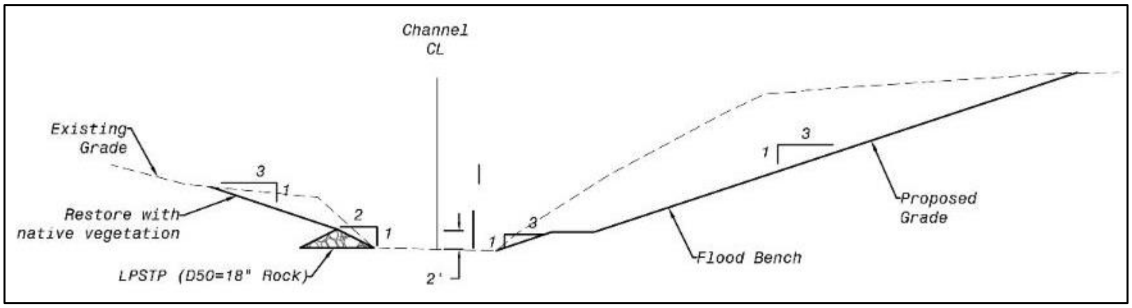


Figure 5. Typical Cross Section of a LPSTP Structure and Flood Bench.

Flood Bench

A flood bench is created by regrading overly steep stream banks of inside meander bends to create a benched area that increases the flow area within the channel. The added flow area will reduce velocities within the channel and reduce erosion. The height of the flood bench is typically set at or near the depth of the stream forming flow or bankfull flow (Figure 5). The stream forming flow is typically between the 1-year and 2-year storm events and coincides with indicators such as scour lines, lower limit of woody vegetation, and bar height. The flood bench can be planted with native vegetation, which increases the roughness and further reduces velocities within the channel.

The areas designated for the toe protection and flood bench include streambank grading to a 3:1 slope and revegetation with native trees, shrubs, and herbaceous plants.

APPENDIX C – EPA TECHNICL ASSISTANCE – REGENERATIVE AGRICULTURE

September 2022

Technical Support for Prairie Band Potawatomi Nation's CWA 319 Nine Element-Based Planning

Note

This document was prepared by a team of individuals from a variety of organizations (university, federal, tribal, consulting). It represents a consensus of views of its authors and the guidance of elders, teachers, etc. for the Prairie Band Potawatomi Nation.

Introduction

Much of modern U.S. agriculture operates on an industrial scale—relying on large fossil fuel inputs, corporate organization, and a host of chemical fertilizers, herbicides, and pesticides to produce abundant crops. However, this linear approach to food production has resulted in extensive monocultures, loss of biological diversity and soil quality, an enormous environmental footprint (water/air pollution and greenhouse gas emissions), and an increasing vulnerability to drought, flood, and supply-chain disruptions (LaCanne and Lundgren 2018; Newton et al. 2020; Gordon et al. 2022). Regenerative agriculture (RA) is an alternative to contemporary industrial farming that is suggested to have lower, or even net positive, environmental and/or social impacts. It is not a single, specific practice, but encompasses an interrelated variety of sustainable agriculture techniques pursued with a goal of restoring natural watershed functions.

Activity 1: Research and Define Regenerative Agriculture

Definition of Regenerative Agriculture

The concept of RA came into circulation in the 1980s as part of the organic farming movement (Harwood 1983; Rodale 1983; Savory 1983), although RA does not necessarily always conform to organic standards. There is no universally accepted definition of RA. Generally, RA is farming and ranching in harmony with nature, incorporating a broad view of agriculture in the context of soil and nutrient cycles and ecosystem services like carbon sinks, water recharge, and biodiversity. The holistic principles behind RA are intended to restore soil and ecosystem health; provide healthy food; address inequity by promoting rural economic development and greater financial security from diversified revenue streams, and by building networks of diverse growers who build community; and leave the land, waters, and climate in better condition for future generations (NRDC 2021).

In a recent review, Newton et al. (2020) identified two broad classes of RA definitions:

- **Process-based**, for example, protect/cover the soil, integrate livestock and crop systems, and reduce tillage.
- **Outcome-based**, for example, improve ecosystem health, increase biodiversity, improve water quality, and increase carbon sequestration.

Giller et al. (2021) identified the principal outcome-based components of RA (Figure 1. Key components of RA (Giller et al. 2021).). The diagram highlights several key desired outcomes of RA that are common to most definitions:

- Restoration of soil health
- Reversal of biodiversity loss
- Enhanced local and regional self-reliance

- Improved sustainability of agriculture and food systems
- Mitigation of climate change

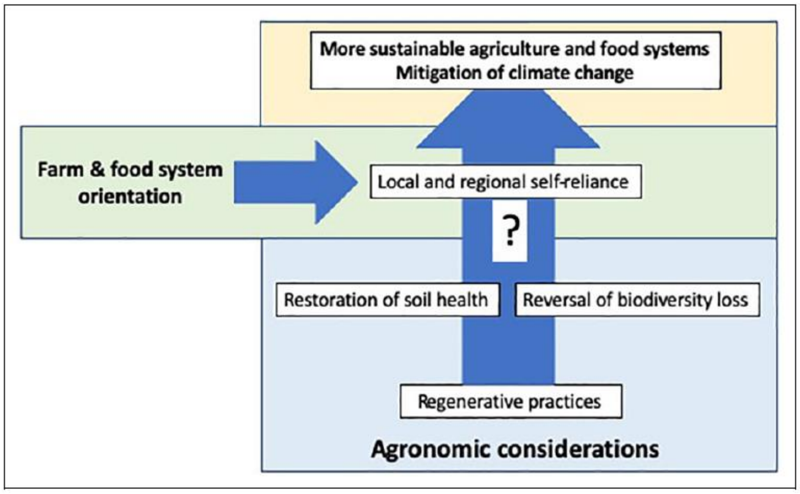


Figure 1. Key components of RA (Giller et al. 2021).

The Chesapeake Bay Foundation (2022) defines RA as holistic farming systems that improve water and air quality, enhance ecosystem biodiversity, produce quality food, and store carbon to help mitigate the effects of climate change. These farming systems are designed to work in harmony with nature, while maintaining and improving economic viability.

From these published analyses, we propose a definition of RA appropriate to the goals of the Prairie Band Potawatomi Nation.

Draft Definition of Regenerative Agriculture for Prairie Band Potawatomi Nation

Regenerative agriculture is a set of principles and practices intended to restore soil and ecosystem health, while providing healthy food and designed to leave the land, waters, and climate in better condition for future generations. Improvement of water and air quality, promotion of biodiversity, mitigation of climate change, and support for sustainable and equitable communities are key elements of regenerative agriculture.

Characteristics and Principles of Regenerative Agriculture

Much has been written about important principles of RA, some at a fairly philosophical level (Gordon et al. 2022). However, in a practical vein, several key ideas have been discussed. For example, foundational principles of RA are suggested to include (Lal 2020):

- Conservation agriculture
- Integration of crop and livestock production
- Restoration of soil health, including carbon sequestration
- Reversal of biodiversity loss

Several important characteristics of RA have been identified as follows (NRDC 2021):

- Views agriculture as a connective, dynamic network, not a linear supply chain.
- Recognizes and supports ecosystem services such as water quantity/quality regulation and carbon sequestration.
- Respects soil and soil health as the foundation of agriculture.
- Defines agricultural success as more than maximizing yield or farm size, but includes consideration of community values, feeding people, and keeping money cycling within the community.
- Strives to reduce reliance on synthetic inputs.
- Strives to maintain the connection between animal and crop production by recycling manure nutrients and producing animal feed locally.
- Strives to reduce social, economic, and ethnic inequities in agriculture.

The Chesapeake Bay Foundation (2022) identified the top five principles of RA:

1. **Minimize the physical, biological, and chemical disturbance of the soil.** For example, regenerative farmers often minimize tilling their land, or forgo tilling all together. They also seek to reduce or eliminate the use of chemicals, such as pesticides and chemical fertilizers.

2. **Keep the soil covered with vegetation or natural material.** Instead of tilling the land, regenerative practices include mulching, planting cover crops (crops that are not sold, but provide other benefits, such as soil improvement, water retention, weed suppression, and erosion prevention), and keeping the land as permanent pasture.

3. **Increase plant diversity.** Diversity helps build healthy soils to better trap water and nutrients, can provide other sources of revenue for the farm, and can benefit pollinators and wildlife. Regenerative farms may vary crop rotations, plant multiple species of cover crops together, grow diverse forage in pastures, and maintain permanent vegetation (conservation cover) in some areas of the farm.

4. **Keep living roots in the soil as much as possible.** Roots stabilize the soil and continually cycle water and nutrients so these valuable resources do not wash away. Regenerative farms can do this by planting cover crop seeds in the same fields as their primary crops, prior to harvest, to ensure the fields are never bare (a technique called overseeding); planting their primary crops directly into fields where cover crops are already growing (called planting “green” into cover crops); or converting cropland to pastures.

5. **Integrate animals into the farm as much as possible.** Livestock manure can add valuable nutrients to the soil, reducing the need for fertilizers, and permanent pastures can trap large amounts of carbon and water, reducing farm emissions and polluted runoff. Practices include rotational grazing—moving livestock frequently between grass pastures to allow plants time to regenerate—or grazing cover crops.

Considerations for Implementing Regenerative Agriculture

Transitioning to a regenerative approach will require outreach, education, technical assistance, and some attention to the basic principles of social marketing. Agricultural producers are by nature somewhat conservative in their views, especially regarding broad changes in farm practices. In addition, the introduction of new concepts and terminology can present an initial barrier to even discussing alternative approaches.

However, leveraging existing farm sector conservation policies, programs, and practices can provide an entry point for discussing and promoting key regenerative practices. For example, the USDA NRCS soil health program, which is more than ten years old, has a solid record of economic, conservation, and public success, and is a foundational element of RA. Initiatives that promote crop diversification, water quality protection, and erosion prevention / sediment control are also widely known, accepted, and supportive of the regenerative approach. Outreach, educational, and promotional programs should be developed that focus on these gateway policy and programmatic opportunities as part of any effort to introduce producers to the broader realm of regenerative practices and gradually increase their adoption.

Besides agriculture-specific policies and programs, other connections exist within public agency missions and networks that could also be leveraged to promote—or at least consider—regenerative practices. For example, federal agencies beyond EPA (e.g., the U.S. Army Corps of Engineers [USACE] and the Federal Emergency Management Administration [FEMA]) have been embracing more holistic approaches to their missions that intersect with some RA considerations. USACE maintains civil works, environmental, and sustainability missions that have direct or secondary applications to farmland (e.g., the “Growing Green” sustainability initiative, assessing and integrating natural resource laws, values, and sound environmental practices as part of the Corps’ environmental mission). FEMA is promoting a more proactive approach to natural hazard reduction through its “Building Resilient Infrastructure and Communities” (BRIC) program, which fully embraces “nature-based solutions” that address flooding and other hazards. These missions may come into sharper focus when projects addressing rural flooding, wetland protection, streambank stabilization/restoration, runoff infiltration, forest protection, and other projects are discussed.

Activity 2: Regenerative Agriculture Practices

Giller et al. (2021) indicate that many practices promoted as regenerative (including crop residue retention, cover cropping, and reduced tillage) are central to the canon of 'good agricultural practices', while others are debated and at best niche approaches (e.g., permaculture, holistic grazing). Many of the practices identified as supporting RA are already used widely in the USDA-NRCS suite of best management practices (BMPs). Lal (2020) identified basic practices of RA as the intersection of groups of practices in four areas: conservation agriculture, integration of crop and livestock agriculture, restoration of soil health, and reversal of biodiversity loss (Figure 2).

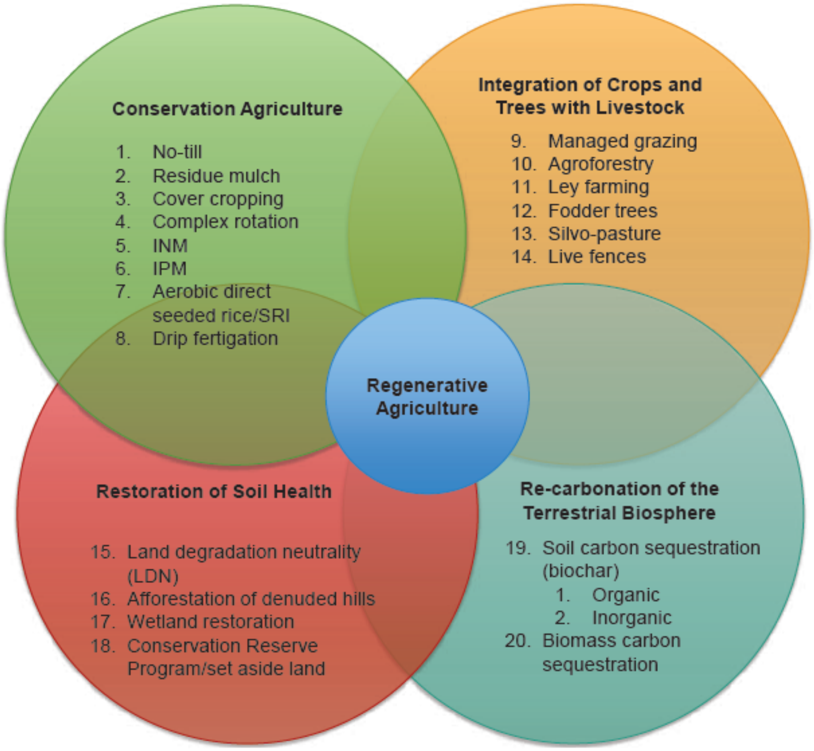


Figure 2. Basic tenets of RA designed to draw carbon dioxide from the atmosphere. Specific packages of practices depend on site-specific biophysical environments and the human dimensions. INM = integrated nutrient management. IPM = integrated pest management. SRI = system of rice intensification (Lal 2020).

Giller et al. (2021) listed several practices contributing to important RA principles. See Table 1.

Table 1. Examples of Practices Contributing to RA Principles (Giller et al. 2021)

Principles	Practices
Minimize tillage	Zero-till, reduced tillage, conservation agriculture, controlled traffic
Maintain soil cover	Mulch, cover crops, permaculture
Build soil C	Biochar, compost, green manures, animal manures
Sequester Carbon	Agroforestry, silvopasture, tree crops
Relying more on biological nutrient cycles	Animal manures, compost, compost tea, green manures and cover crops, maintain living roots in soil, inoculation of soils and composts, reduce reliance on mineral fertilizers, organic agriculture, permaculture
Foster plant diversity	Diverse crop rotations, multi-species cover crops, agroforesty
Integrate livestock	Rotational grazing, holistic [Savory] grazing, pasture cropping, silvopasture

Principles	**Practices**
Avoid pesticides	Diverse crop rotations, multi-species cover crops, agroforestry
Encouraging water percolation	Biochar, compost, green manures, animal manures, holistic [Savory] grazing

The NRDC (2021) and The Chesapeake Bay Foundation (2022) also identify familiar conservation practices as key RA practices:

- Cover cropping
- Diversifying crops through conservation crop rotation
- Management intensive/rotational grazing
- Reduced tillage/no-till
- Converting cropland to pasture/permanent cover
- Agroforestry/silvopasture
- Riparian buffers
- Streamside fencing
- Nutrient management
- Composting
- Reduced chemical inputs

Table 2 summarizes USDA-NRCS conservation practices (with practice codes) that are candidates for RA practices.

Table 2. Common USDA-NRCS Conservation Practices Contributing to RA (USDA NRCS 2022)

Water Quality	**Animal Waste Management**	**Soil Health**
327 Conservation cover	313 Waste storage facility	328 Crop rotation
328 Crop rotation	316 Animal mortality facility	329 Conservation tillage-No-till
329 Conservation tillage-No-till	317 Composting facility	345 Conservation tillage-Mulch till
345 Conservation tillage-Mulch till	359 Waste treatment lagoon	346 Conservation tillage-Ridge till
346 Conservation tillage-Ridge till	365/366 Anaerobic digestor	330 Contour farming
332 Contour buffer strip		332 Contour buffer strip
340 Cover crop		340 Cover crop
342 Critical area planting		350 Sediment basin
390 Riparian herbaceous cover		391 Riparian forest buffer
391 Riparian forest buffer		512 Forage & biomass planting
393 Filter strip		590 Nutrient management
528 Prescribed grazing		612 Tree and shrub establishment
561 Heavy use area protection		638 Water & sediment control basin
580 Streambank & shoreline protection		
590 Nutrient management		
635 Vegetated treatment area		
657 Wetland restoration		
658 Wetland creation		
659 Wetland enhancement		

Activity 3: Quantified Watershed Management Benefits

Reported benefits of RA to watershed management include reduction of runoff and flooding, improvements in water quality, improvements in soil health/quality, and enhancement of ecosystem services provided by agriculture. Unfortunately, in many cases—especially for soil health and ecosystem services—these benefits have not been extensively quantified. A summary of available information is provided in the following sub sections.

Runoff and Flooding

An analysis published by the Union of Concerned Scientists (UCS) (Basche 2017) reported on approaches to build resilience to drought and flood in agricultural landscape in the face of climate change and historical alterations of the landscape and hydrology by intensive agriculture. The report documents that increasing soil infiltration capacity through improved agricultural management is key to reducing both flood and drought impacts from agriculture. The report compiled results from more than 150 field-scale experiments around the world looking at measures including no-till, more diverse crop rotations, use of cover crops between cash crop seasons, improved livestock grazing, and incorporation of perennial crops (all practices that can be considered part of RA) to document these methods' ability to improve soil health and increase resilience to droughts and floods. Figure 3 and Figure 4 summarize the results of the study with significant improvement in infiltration and runoff management observed at the field scale:

- 70% of experiments showed an increase in water infiltration when any of these practices were used, whereas grazing existing cropland tends to reduce infiltration.
- Continuous living soil cover is the best strategy for improving water infiltration. This cover, which keeps living roots in the soil all year, can be achieved by introducing perennials or cover crops, or by improving grazing practices.
- Perennial crop systems, such as permanent hayland and grazing/rangeland, are optimal for managing the effects of heavy rains. In 28% of the studies analyzed, the experimental practices increased infiltration enough to absorb a heavy rain event of 1 in/hr.
- Significant improvements to some soil properties were widely reported:
    - Cover crops and perennials increase porosity by an average of 8% compared to practices that leave the soil bare for portions of the year
    - Continuous cover systems make an average of 9% more water available to plants than do annual crop systems.

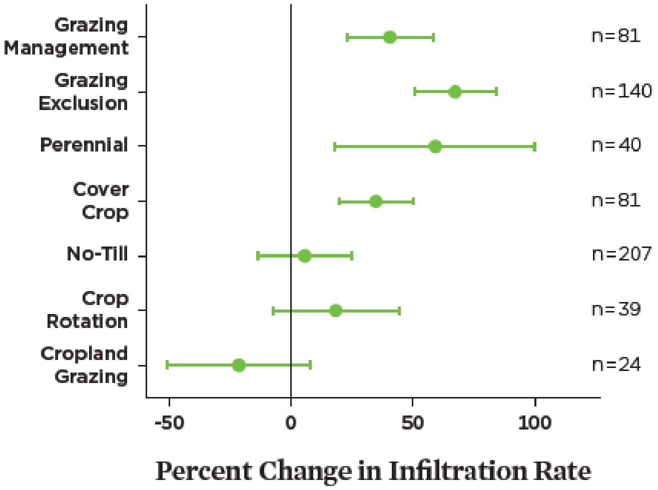


Figure 3. Water infiltration improves with alternative crop and soil practices. Our analysis of experiments involving various soil management practices produced ranges of the rate of water entering and moving through soil. As this figure shows, the greatest increases resulted from continuous living cover practices and changes to grazing management. Estimated ranges show average changes from conventional practices. The "n" numbers show the number of experiments included in each category (Basche 2017).

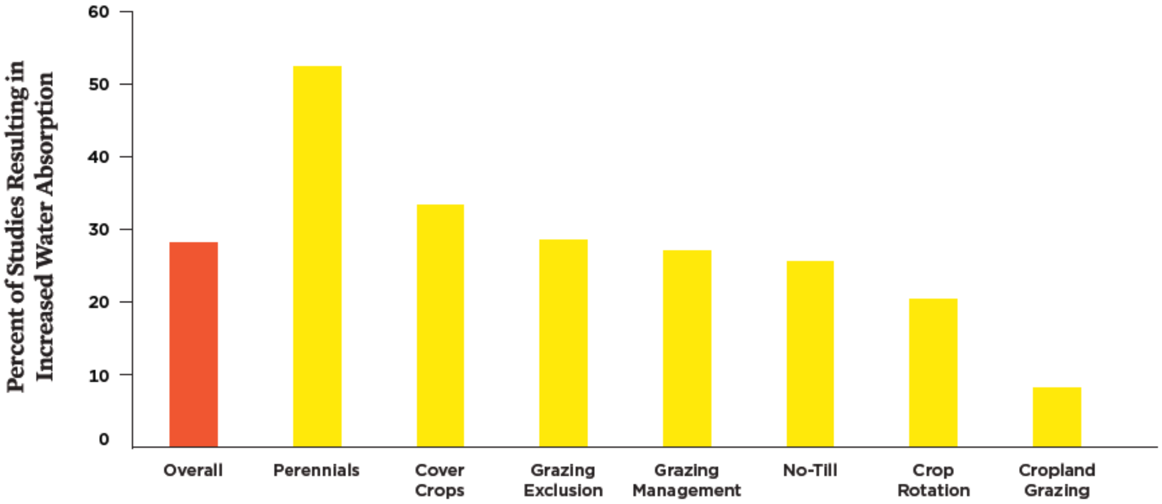


Figure 4. Alternative crop and soil practices can improve water absorption during heavy rainfall. The first bar shows the overall percentage of experimental alternatives that were able to increase the absorption of rainfall by more than one inch. The other bars show the percentage of experiments within each category that improved absorption of rainfall by the same amount (Basche 2017).

The UCS analysis also used a regional water-balance model to extrapolate field-level changes to basin scale, using Iowa as a case-study. The modeling showed significant effects on hydrology at the watershed level in simulations of three historical Midwest flooding events:

1993 flooding

- Up to 10% less runoff in eastern Iowa/Mississippi River region
- Up to 26% less runoff in other affected watersheds

  - 20% reduction in flood frequency if crop changes implemented on highly erodible cropland

2008 flooding

  - Up to 7% less runoff in Cedar Rapids IA region
  - 17% reduction in flood frequency if crop changes implemented on less-profitable croplands

2011 flooding

  - Up to 19% runoff in Cedar Rapids IA region
  - 13% reduction in flood frequency if crop changes implemented on highly erodible croplands

Note that the authors define flood frequency here as the number of months of the given major long-duration flood event during which streams or rivers reach the critical flood inundation stage.

The report further found that even under projected higher temperatures and wetter conditions associated with climate change, BMPs could yield the following:

- 7–11% more water available for crop use
- Runoff reductions ranging from 9 to 15%

In a global review of field-scale studies, DeLonge and Basche (2018) reported that a variety of grazing management approaches (including adding complexity to grazing patterns, reducing stocking rates or extended rest from grazing) increased soil infiltration rates 52–67%.

More recently, Antolini et al. (2020) used modeling of watershed hydrology, flood frequency, and flood damages to conclude that watershed-scale implementation of agricultural BMPs could provide significant benefits of flood loss reduction in addition to water quality improvements. All BMPs simulated (including cover crops, constructed wetlands in watershed headwaters, and nutrient management) at least modestly reduced peak stream discharge and economic loss from flooding. Restored wetlands and application of cover crops (both RA practices) were the most effective BMPs in reducing peak discharge and flooding losses in four Iowa watersheds (see Figure 5 and Figure 6 below).

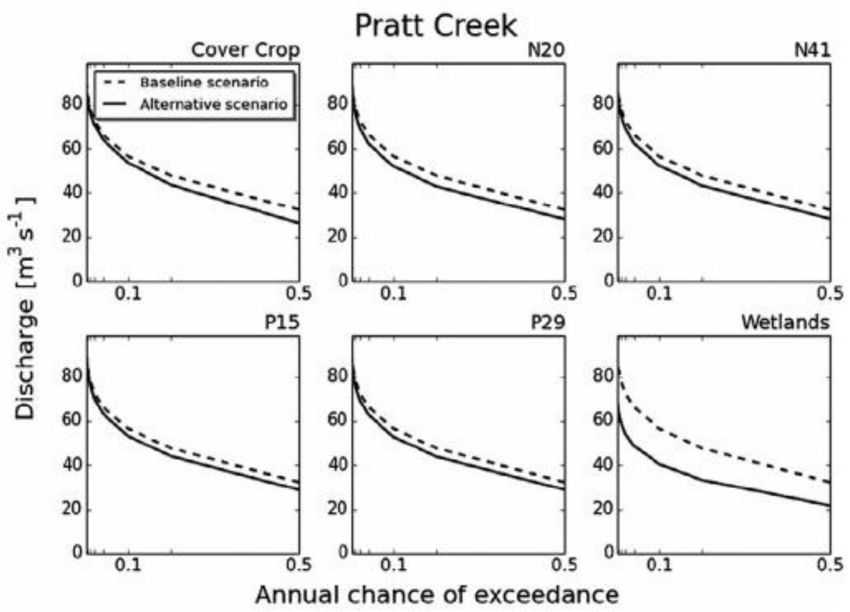


Figure 5. Frequency–discharge relationship for Pratt Creek watershed in baseline and alternative scenarios. N20/41 and P15/20 refer to sets of BMPs designed to reduce nitrogen and phosphorus loads by specified percentages and include cover crops and nutrient management (Antolini et al. 2020).

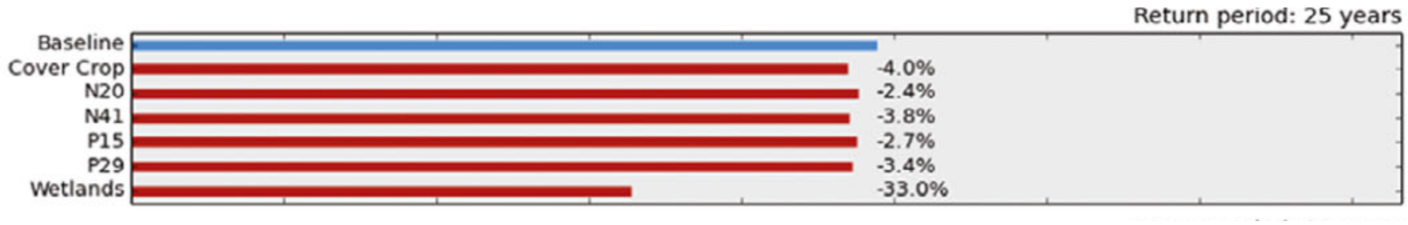


Figure 6. Estimated flood losses (million $) for a 25 year return period in the Wolf Creek watershed. Percentages represent relative difference from Baseline scenario (Antolini et al. 2020).

The authors included both agricultural (crop) flood losses and urban flood damages using both hydrologic and FEMA flood loss models. Results suggested that although estimated flood loss reductions were modest in the agricultural portion of the watershed, loss reductions were more substantial when urban centers or other high-value assets are located downstream.

Water Quality

Water quality benefits of common water quality-directed BMPs are well-reported (although highly variable with uncertainties in most settings). For example,

Table 3 shows BMP efficiencies for nitrogen, phosphorus, and sediment for a number of RA-component practices in support of modeling pollution dynamics in the Chesapeake Bay.

Table 3. Range of N, P, and TSS Reductions Attributed to BMPs in Various Physiographic Regions of the Chesapeake Bay Watershed (Chesapeake Bay Program 2018)

Practice	N	P	TSS
Ag land retirement - alternative crops	12–57 lb/ac		237–1,712 lb/ac
Ag land retirement - pasture conversion	4–49 lb/ac		235–799 lb/ac
Nutrient management	0–15%		0–20%
Low-residue tillage	2–5%	6–9%	18%
Conservation tillage	4–10%	2–60%	41%
High-residue tillage	12–15%	11–74%	79%
Cover crop	9–45%	0–15%	0–20%
Cover crop - commodity	4–15%	0	0
Barnyard runoff control/loafing lot mgt	20%	20%	40%
Mgt Intensive Grazing	9–11%	24%	30%
Forest buffer	19–65%	30–45%	40–60%
Grass buffer	13–46%	30–45%	40– 60%
Wetland restoration	42%	40%	31%

Table 4 shows research-based efficiency values for RA-supporting practices from the *USEPA Spreadsheet Tool for Estimating Pollutant Loads* (STEPL). The values are used to estimate the potential effectiveness of BMP implementation scenarios.

Table 4. Default BMP Efficiencies from STEPL

Land Use	BMP & Efficiency	N	P	Sediment
Cropland	Bioreactor	45%		
Cropland	Buffer - Forest (100ft wide)	48%	47%	59%
Cropland	Buffer - Grass (35ft wide)	34%	44%	53%
Cropland	Conservation Tillage 1 (30-59% Residue)	15%	36%	40%
Cropland	Conservation Tillage 2 ($\geq$ 60% Residue)	25%	69%	77%
Cropland	Contour Farming	28%	40%	34%
Cropland	Controlled Drainage	39%	35%	
Cropland	Cover Crop 1 (Group A Commodity) (High Till only for Sediment)	1%		
Cropland	Cover Crop 2 (Group A Traditional Normal Planting Time) (High Till only for TP and Sediment)	20%	7%	10%
Cropland	Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)	20%	15%	20%
Cropland	Land Retirement	90%	81%	95%
Cropland	Nutrient Management 1 (Determined Rate)	15%	45%	
Cropland	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	25%	56%	
Cropland	Streambank Stabilization and Fencing	75%	75%	75%
Cropland	Terrace	25%	31%	40%
Cropland	Two-Stage Ditch	12%	28%	
Pastureland	30m Buffer with Optimal Grazing	36%	65%	

Land Use	BMP & Efficiency	N	P	Sediment
Pastureland	Alternative Water Supply	13%	12%	19%
Pastureland	Critical Area Planting	18%	20%	42%
Pastureland	Forest Buffer (minimum 35 feet wide)	45%	40%	53%
Pastureland	Grass Buffer (minimum 35 feet wide)	87%	77%	65%
Pastureland	Grazing Land Management (Rotational Grazing with Fenced Areas)	43%	26%	
Pastureland	Heavy Use Area Protection	18%	19%	33%
Pastureland	Litter Storage and Management	14%	14%	0%
Pastureland	Livestock Exclusion Fencing	20%	30%	62%
Pastureland	Multiple Practices	25%	21%	22%
Pastureland	Pasture and Hayland Planting (Forage Planting)	18%	15%	
Pastureland	Prescribed Grazing	41%	23%	33%
Pastureland	Streambank Protection w/o Fencing	15%	22%	58%
Pastureland	Streambank Stabilization and Fencing	75%	75%	75%
Pastureland	Use Exclusion	39%	4%	59%
Pastureland	Winter Feeding Facility	35%	40%	40%

Activity 4: Financial Costs and Benefits of Regenerative Agriculture

Costs of implementing traditional agricultural BMPs are variable by locale but can be generally estimated using USDA-NRCS cost-share experience. Table 5 below shows the range of cost-share rates offered by KS NRCS under the Environmental Quality Incentives Program (EQIP). The range of cost-share rates is often large because of varying intensities or characteristics of practices and situation requirements. Note also that these figures represent only the NRCS share of the cost of implementation, which is typically ~60–75% of total implementation cost.

Table 5. Range of Unit Costs for Selected Kansas NRCS Conservation Practices Under EQIP Cost-share, FY2022$

NRCS Code	Conservation Practice	EQIP Cost range/unit
116	Soil health management plan	$1,250–$2,400/plan
327	Conservation cover	$85–$620/ac
328	Conservation crop rotation	$8–$118/ac
329	Residue & tillage mgt - no-till	$14–$32/ac
330	Contour farming	$5–$7/ac
332	Contour buffer strip	$171–$1,355/ac
338	Prescribed burning	$7–$19/ac
340	Cover crop	$42–$427/ac
342	Critical area planting	$154–$776/ac
345	Residue & tillage mgt - reduced till	$11–$25/ac
350	Sediment basin	$2–$3/yd^3
390	Riparian herbaceous cover	$79–$2,298/ac
391	Riparian forest buffer	$134–$4,477/ac
393	Filter strip	$92–$361/ac
512	Pasture and hayland planting	$34–$195/ac

NRCS Code	Conservation Practice	EQIP Cost range/unit
528	Prescribed grazing	\$5–\$27/ac
561	Heavy use area protection	\$10–\$338/yd^3
590	Nutrient management	\$5–\$48/ac
612	Tree and shrub establishment	\$214–\$1,009/ac
635	Vegetated treatment area	\$756–\$10,323/ac
638	Water and sediment control basin	\$2–\$4/yd^3
657	Wetland restoration	\$3–\$1,012/ac
658	Wetland creation	\$2–\$4/yd^3
		\$1,983–\$2,975/ac
659	Wetland enhancement	\$8–\$406/ac

Source: https://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=NRCSEPRD1854466&ext=pdf

Systematic analysis of financial benefits or benefit-cost ratio of agricultural BMPs is a complex topic. Although there have been numerous efforts to quantify costs and benefits reported at a variety of scales, the results tend to be both highly site-specific and highly uncertain. There are many reasons for this uncertainty:

- Implementation of BMPs in a watershed—either in the real world or a modeling environment—is highly variable, often essentially random and rarely optimized from a cost or effectiveness standpoint.
- Effectiveness of BMPs for water quality is variable and uncertain and depends strongly on initial conditions, weather, management by the producer, and maintenance; BMP effectiveness for soil health and ecosystem services is even less well-understood.
- Financial returns (positive or negative) from BMPs are not well-documented and have been discussed from a variety of perspectives.
    - In some cases, such as impairment of a drinking water source, benefits can be reasonably quantified by projecting savings in water treatment costs after reduction of pollutant concentrations.
    - On-farm benefits have been assessed through changes in yield or production costs, but benefits off the farm are more challenging to quantify.
    - Some researchers have successfully quantified the cost-effectiveness of a BMP, e.g., for sediment reduction, but have not evaluated the monetary benefits of the sediment saved, either from a water quality or soil quality perspective.
    - Economic studies of large watershed projects have often used a contingent valuation approach to quantify benefits, wherein watershed residents are surveyed to assess their willingness to pay for water quality, recreation, etc. as a surrogate to direct valuation of improvements in water quality.
    - Benefit-cost analyses, especially those conducted in large watersheds, have often been conducted entirely in a modeling environment.
    - Benefit-cost analyses often focus exclusively on on-farm financial balance and do not account well for off-site or ecosystem service benefits.
- Assessments of the monetary value of some benefits of RA at a broad or ecosystem scale tend to result in very general approximations and, in some cases, extravagant or unproven claims.

A broadly-applicable formula or framework for quantifying financial costs and benefits of a watershed program of BMP implementation does not appear to exist although the issue has been the subject of considerable site-specific research. Published results have been quite variable. Although some studies have identified positive benefit-cost balances, others have suggested that implementation costs for at least some practices outweigh benefits to water quality. While an in-depth review of the literature on this subject is beyond the scope of this effort, a few examples will illustrate the character of the issue and highlight some important considerations in assessing BMP benefits and costs.

Veith et al. (2004) used modeling and a genetic algorithm in a Virginia watershed to determine if cost−effectiveness of BMP scenarios could be improved through optimization rather than targeting. The optimization procedure searched for the combination of site−specific practices that met pollution reduction requirements, and then continued searching for the BMP combination that minimized cost. All three optimization plans identified BMP placement scenarios having lower cost than the targeting strategy solution for equivalent sediment reduction. The targeting strategy reduced average annual sediment loss compared to the baseline at a cost of $42/kg/ha sediment reduction, whereas the optimization plan with the same BMP choices achieved the same sediment reduction at a cost of $36/kg/ha.

More recently, Getahun and Keefer (2016) used an integrated modeling system to identify optimum scenarios of BMPs such as nutrient management, constructed wetlands and filter strips that provide downstream water quality improvements in Illinois watersheds. The modeling system coupled SWAT for simulating watershed responses and impacts of BMPs and *Archived Micro-Genetic Algorithm* (AMGA2) for generating optimal pollution reduction strategies at a watershed scale. Study results indicated that nutrient management was the best alternative practice to provide water quality benefits with annual nitrate-N loss reduction of 14.9% and cost savings of $6.42 /kg N/ha. In contrast, constructed wetlands and filter strips were found to incur implementation costs of $10.89/kg N/ha and $1.74/kg N/ha, respectively, including associated land revenue losses. The effectiveness of the filter strips was very limited because of extensive tile drainage in the study watersheds.

Mussell et al. (2011) examined the agronomic and environmental effectiveness and the economic efficiency of BMPs used to protect groundwater resources by reducing the amount of nitrogen (N) potentially available to leach into groundwater in Ontario, Canada. Five BMP scenarios were compared to determine: (i) their potential effectiveness in reducing the amount of N available to leach from agricultural fields into groundwater and (ii) their relative potential for ensuring groundwater obtained in the future at a production well will meet the drinking water standard for NO_3-N (10 mg/L). Finally, the economic costs associated with the alternative BMPs were assessed. Economic costs of the BMP scenarios generally ranged between $45–$129/ha/yr, with a subset of BMP scenarios generating a benefit (net reduction in costs) and others a much higher cost. The BMP scenarios that focused on removal of manure (i.e., not applying manure to corn crops) and improved management decisions based on results from a soil N test generated net benefits. The BMP scenario that focused on both removing manure and removing corn (i.e., eliminating corn crop) from the crop rotation tended to incur the highest costs.

Monte Carlo simulation was used to examine the on-farm economics from adoption of BMPs on four Alberta, Canada cropping farms (Trautman et al. 2012). Adoption of shelterbelts, buffer strips, residue management, and the addition of annual and perennial forages, field peas, and oats in crop rotations were included as BMPs that contribute positively to Ecological Goods and Service production from agriculture. Results suggested positive on-farm benefits associated with perennial forage and field pea BMPs. The overall conclusion of this study was that cropping-related BMPs have limited potential for providing direct net benefits to crop producers. BMPs that involved removal of land from production (e.g., shelterbelts, buffer strips) were also costly for producers. Furthermore, BMPs that changed crop rotations in ways that did not involve adding marketable crops (e.g., green manure) or that did not provide yield benefits or significant cost savings for subsequent crops (e.g., oats), also represented a net cost to producers. The opportunities for direct net benefits arose from adoption of BMPs that involved incorporating marketable crops into rotations that also provided potential nitrogen and/or yield benefits to subsequent crops.

Roth et al. (2018) quantified the environmental and N cycling benefits observed from cover cropping and determined the potential of those benefits to offset the costs of cover crop implementation. The authors determined that valuing the impact of cover cropping on subsurface drainage N loading, soil erosion, and cover crop residue N mineralization has the potential to recover an average of 61% of the costs associated with cover crop implementation. More specifically, the average composition of recovered costs was 34% from reductions in N loading to subsurface drainage, 57% from the tile-adjusted mineralization of N from the cover crop biomass, and 9% from the estimated reduction in erosion.

Zhou et al. (2009) investigated the effectiveness and benefit-cost ratio of conservation management practices on sediment reduction under a corn–soybean rotation in Iowa. Baseline management practices consisted of tillage with a moldboard plow with a row cropped system of corn and soybeans. Annual sediment yield from this site was estimated using the Water Erosion Prediction Project (WEPP) model for three tillage systems (chisel plow, disk tillage, and no-till) as well as three conservation structures (grassed waterways, filter strips, and terraces). Without supplemental conservation measures, predicted sediment yield was 22.5, 17.7, and 3.3 t/ha/yr from chisel plow, disk tillage, and no-tillage, respectively. Supplemental conservation measures in addition to tillage (i.e., grassed waterways, filter strips, and terraces) had the most impact on sediment yield reduction when used in conjunction with chisel plow management and the smallest impact with the no-tillage system. The value of lost soil resulting from soil erosion ranged between $10.9 and $137.3/ha/yr for the simulated scenarios when a soil value of $5.5/t was considered. When factoring in the value of soil, no-till was the most efficient practice with the highest net benefit of $94.5/ha/yr. The authors concluded that the no-till system would be the most efficient practice in the study area when the soil value of $6.1/t was considered. Due to greater sediment yield during the soil erosion process, grassed waterways, filter strips, and terraces were more effective in reducing sediment yield with chisel plow or disk tillage than with no-till systems. Erosion control structures reduced the costs related to soil erosion, but also took a certain proportion of land out of production and brought additional expenses due to establishment and continued maintenance.

Yang et al. (2010) used the SWAT model to evaluate the efficacy of flow diversion terraces (FDT) in abating sediment yield at the outlet of a New Brunswick, Canada watershed. The authors found that average annual sediment yield decreased exponentially with increased proportion of watershed land under FDT protection. When the proportion of FDT-protected areas was low, sediment reductions caused by FDT increased sharply with increasing use of FDT. Similarly, marginal sediment yield abatement costs ($/t sediment reduction) increased exponentially with increasing proportion of FDT-protected area. The results indicated that increasing land protection with FDT from 6 to 50% would result in a reduction of about 2.1 t/ha/yr and costs of sediment reduction increased from $7 to $12/t. Increasing FDT-protected cropland from 50 to 100%, an additional sediment reduction of about 0.9 t/ha/yr would occur and the costs would increase from $12 to $53/t of sediment yield reduction. Unfortunately, the authors did not cite a monetary value for sediment saved, so a benefit-cost ratio cannot be evaluated.

Bracmort et al. (2004) conducted a cost-benefit analysis on a large watershed management project in Indiana that installed hundreds of BMPs in the mid-1970s; the Black Creek Project. Conservation practices included field borders, grade stabilization structures, grassed waterways, and parallel terraces. Water quality improvement for sediment and phosphorus reduction due to BMP implementation was estimated in 2000 dollars using off-site benefit estimates, fertilizer nutrient costs and water quality trading values. The benefits received from the BMPs did not outweigh the costs for implementing and maintaining the BMPs.

Several studies, especially cases of multiple BMP implementation programs in large watersheds, have used a contingent valuation procedure to estimate environmental benefits. In this procedure, watershed residents are surveyed to determine their willingness to pay for “clean water,” “improved recreation,” or similar perceived benefits. The resulting value is then compared to the cost of BMP implementation to estimate a benefit-cost ratio.

Eisen-Hecht and Kramer (2002) performed a benefit-cost analysis of maintaining water quality in the Catawba River Basin (North and South Carolina), estimating economic benefits based on a survey of respondents’ willingness to pay for water quality protection. The results placed an estimated total economic benefit of $340.1 million. The total management plan cost (estimated by a model) was calculated to be $244.8 million. The resulting benefit-cost ratio indicated that the potential benefits of the management plan would outweigh costs by more than $95 million.

An analysis by Borisova et al. (2008) examined a Virginia TMDL written to address bacteria and aquatic-life-use impairments. BMPs for grazing land protection, stream protection, riparian buffers, pasture management, loafing lot management, and cover crops were included. The researchers estimated benefits using a contingent valuation survey of local residents. Costs were based on the number and type of BMPs necessary to achieve TMDL pollution reduction goals. BMPs were quantified using watershed-scale water quality simulation models. Based on the authors’ projections, the costs to achieve TMDL induced pollution reduction goals exceeded the estimated benefits, with benefit-cost ratios ranging between 0.1 and 0.3.

In a case study in a Quebec, Canada agricultural watershed, Salvano et al. (2006) evaluated two scenarios using an integrated, economic hydrological, modeling framework: (i) a base-case scenario assuming application of all available manure; and (ii) an on-farm nutrient management scenario based on meeting phosphorus crop requirements with manure and treating any manure surpluses. For one of the subwatersheds evaluated, the benefit-cost ratio was close to one although only various recreational benefits were accounted for in the evaluation. A sensitivity analysis revealed that variations of 37.5%, -22.5%, and -20% for significant increases in estimated monetary benefits, decreases in on-farm manure treatment costs, and decreases in average probabilities of exceeding the targeted water quality standards would be necessary to obtain a benefit-cost ratio greater than one. The authors contended that if a more holistic set of benefits were accounted for, a benefit-cost ratio greater than or equal to one would have resulted, illustrating the importance of valuing environmental goods and services associated with water quality improvements when assessing implementation of agricultural management plans.

In a study intended to include such broad environmental values, Thomsen et al. (2010) assessed the costs and benefits of agricultural BMPs for Lake Winnipeg (Manitoba, Canada) in physical and economic terms, with an emphasis on the co-benefits in terms of ecological goods and services. The authors included BMPs for nutrient management, crop rotation, conservation tillage, vegetated filter strips, and surface water control structures in the analysis. Assessment of benefits followed Environment Canada's classification of *Ecological Goods and Services* (EGS), which includes:

Goods
- Food
- Fuel
- Drinking water
- Wood and fiber

Regulating services
- Climate regulation
- Water purification
- Erosion control
- Waste Treatment

Supporting services
- Soil formation
- Nutrient cycling
- Photosynthesis
- Pollination

Cultural services
- Aesthetic
- Recreation
- Education
- Heritage
- Spiritual

The authors concluded that the selected BMPs have the potential to reduce the annual export of P from Manitoba agriculture by approximately 10%, or just under 100 t of the annual 1,200 t P load to Lake Winnipeg that Manitoba agriculture is understood to contribute. Cost-benefit ratios including EGS values or indicators for these BMPs range from 0.8 to 6.3. In other terms, relative to the estimated cost of treating outflow to the Red River by the City of Winnipeg of $164,697/t of P removed, the cost of reducing P exports from agricultural sources in Manitoba using the BMPs ranges from $0 (net benefit) to $765,125/t of P.

A key insight of this research is that the variability and uncertainty of the biophysical potential to reduce P exports to Lake Winnipeg from Manitoba agricultural sources is the greatest determinant of the viability of the BMPs from a benefit-cost and EGS perspective. Best estimates of the physical capacity or potential of agricultural BMPs have a wide range, extending nearly an order of magnitude—from a reduction to an increase in P export. Unit costs and prices including EGS values are relatively small factors in comparison to the range of biophysical uncertainty and variability.

There have been few benefit-cost analyses specifically focused on RA, and the few reported results have been conflicting.

LaCanne and Lundgren (2018) evaluated the relative effects of RA and conventional corn production systems in the U.S. Northern Plains on pest management, soil conservation, and farm profitability and productivity. Regenerative farming systems provided greater ecosystem services and profitability for farmers than an input-intensive model of corn production. Pests were 10-fold more abundant in insecticide-treated corn fields than on insecticide-free regenerative farms, indicating that farmers who proactively design pest-resilient food systems outperform farmers that react to pests chemically. Regenerative fields had 29% lower grain production but 78% higher profits over traditional corn production systems. Profit was positively correlated with the particulate organic matter of the soil, not yield. These conclusions are illustrated in Figure 7 below.

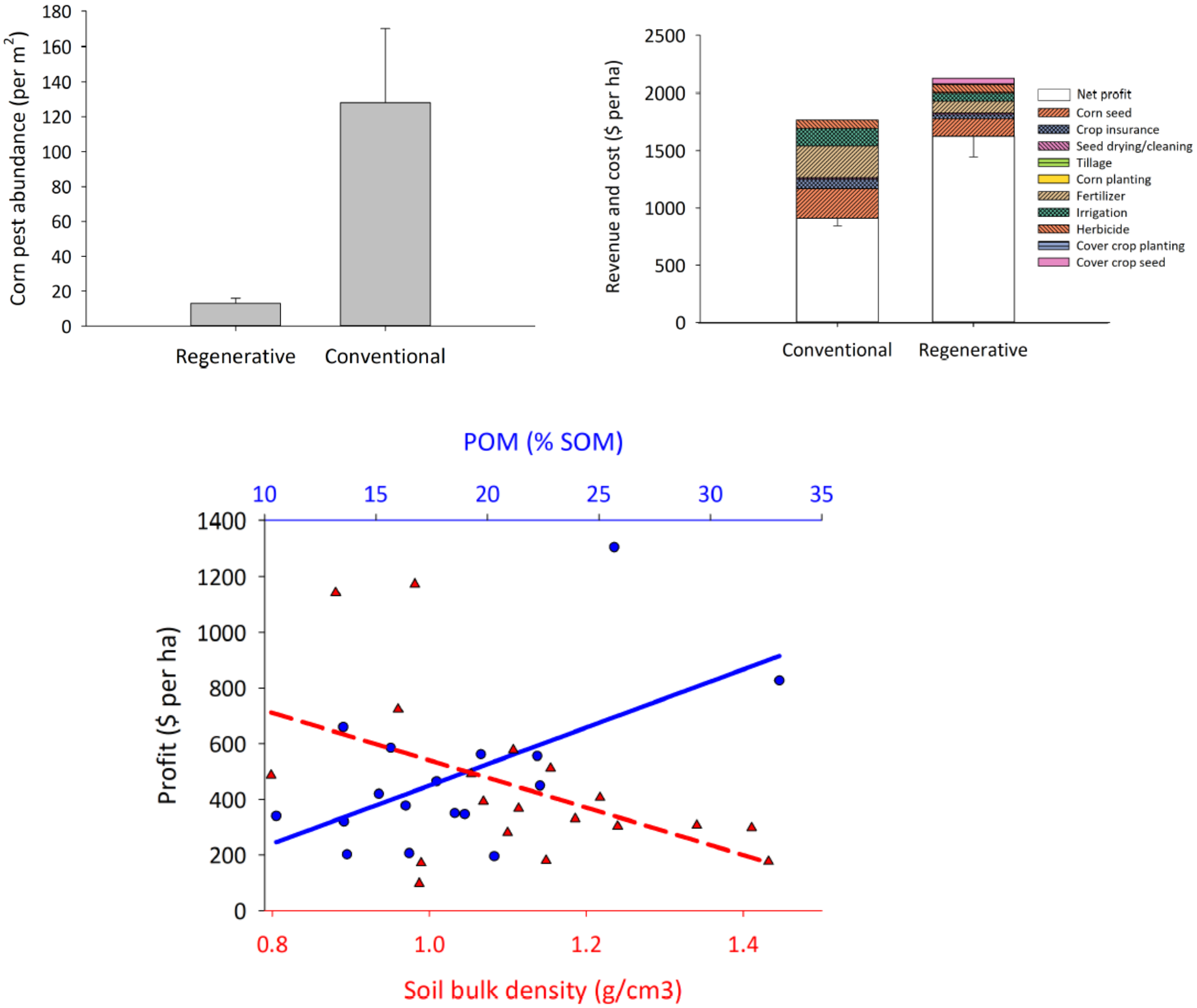


Figure 7. Corn fields with high particulate organic matter and low bulk density in the soil have greater profits. Corn fields were managed under either conventional or regenerative systems, and profits was calculated using direct costs and revenues for each field and excludes any overhead and indirect expenses (LaCanne and Lundgren 2018).

The Chesapeake Bay Foundation (2022) reported (without extensive documentation of their analytical methods) that improved soil health can lead to higher crop yields, better forage quality for animals, and reduced risk due to increased resiliency to pests, drought, or floods. Cost savings from reduced use of livestock feed, synthetic fertilizers, herbicides, insecticides, and antibiotics can also have a positive impact on farm profitability. For example, the CBF reported analyses suggesting that an investment of $57 billion in RA practices would yield a projected return of $1.9 trillion through savings on costly inputs like synthetic fertilizers and pesticides and increased farm profits. The CBF also cites data that show that farms in the Bay watershed that converted conventional farmland to rotationally grazed pasture found an average reduction of 42% for net greenhouse gas emissions along with average pollution reductions of 63%, 67%, and 47% for nitrogen, phosphorus, and sediment, respectively. Additional studies showed that if the Bay states meet their commitment of implementing 190,500 acres of forest buffers by 2025, it would remove more than 173,000 metric tons of carbon dioxide annually—equivalent to the annual emissions of more than 37,600 passenger vehicles.

In contrast, a recent study in Australia reported that RA generated considerably lower economic returns than did conventional agriculture. Francis (2020) published an analytical comparison of profitability and imputed whole farm profit between a group of Australian producers practicing RA and a group not practicing RA. Over a decade, the RA group of producers generated operating returns of 1.66%, compared to 4.22% for the non-RA group. The average cumulative whole farm profits of the non-RA group were ~ AUS$4.0 million, compared to ~ AUS$1.6 million for the RA group. The author concluded that assuming the same farm asset value between groups, the cost of foregone profits of RA compared with non-RA farming system is ~ AUS$2.5 million over the decade 2007–2016. The most plausible explanation for the difference in farm profitability is the difference in production per unit area. It is important to note that this study focused exclusively on direct farm income and profitability and did not account for off-site environmental or ecosystem service benefits.

Activity 5: Additional Benefits of Regenerative Agriculture

Grazing Management

As noted earlier, integration of crop and livestock production is a key component of RA. Well-managed livestock production can use locally-produced feed and judicious land application of animal wastes can increase crop production, build soil quality, and reduce the need to purchase and import chemical fertilizers. Under some circumstances, grazing can maintain and enhance the quality of the rangeland. However, poor grazing management can degrade vegetation and soils, increase soil loss, and exert negative water quality impacts, for example, through runoff or direct encroachment of animals into waterways. Thus, it is ***management*** that is the key concern for integrating grazing with RA. Adaptive multi-paddock grazing management is an example of an approach for grazing lands (Teague and Barnes 2017). In general, the method is to use multiple paddocks per herd with short grazing periods, long recovery periods, and adaptively changing recovery periods, residual biomass, animal numbers and other management elements as conditions change.

In the past, livestock grazing was an integral component of the prairie system. Knapp et al. (1999) reported that bison historically played a keystone role in the tallgrass prairies ecosystem, much as fire is now recognized as an essential part of tallgrass prairie management. Bison and fire act similarly by reducing the accumulatioin of detritus in the tallgrass system; it is primarily the blanketing effect of the accumulation of dead plant material above ground that limits productivity in undisturbed tallgrass prairie. Bison grazing reduces above-ground standing dead biomass, but more than this, the unique spatial and temporal complexities of bison grazing activities are critical to the successful maintanance of biotic diversity in this grassland. The authors argued that reintroducing ungulate grazing and fire is critical to conserving and restoring the biotic integrity of tallgrass prairie.

Reports of the benefits of managed or regenerative grazing range from the nearly evangelical to the purely empirical; universal agreement does not exist for either the parameters or the benefits of regenerative grazing. One widely promoted system of grazing management is the *Savory Grazing Method* or *Holistic Resource Management* (Savory 1983). According to its proponents, Holistic Management has the ability to regenerate grasslands from an ecological, economic, and social perspective, and while regenerating Earth’s desertifying global grasslands and addressing climate change by sequestering carbon in grassland soils. *Holistic Planned Grazing* accounts for the needs of land, plants, animals, and people. The process aims to strategically mimic nature and is built on thorough planning and constant monitoring and adjustment. Ecological, environmental, and human factors that influence the grazing plan are charted. This facilitates healthy ecosystem process, including water cycles, mineral cycle, community dynamics, and energy flow. Moisture and minerals are carried down into the soil by insects and other organisms. As the herd grazes, dung, urine, and old plant material are trampled into the soil. Monitoring provides a clear picture of where livestock need to be and when, and this determines how the manager plans their moves.

Embracing the concepts of *Holistic Resource Management*, Franzluebbers et al. (2012) examined managed grazing and specified some characteristics of robust and resilient grazing lands:

- Forage production and quality that can sustain an optimized stock of grazing animals throughout the year or through a particularly important grazing season for producers’ profit.
- Sufficient residual forage mass that can support rapid forage regrowth when growing conditions are good and sustain plant health when growing conditions are not good to sustain long-term productivity.
- Sufficient botanical biodiversity to take advantage of different environmental growing conditions throughout the year and to provide habitat for a diversity of soil microorganisms, beneficial insects, small game, and birds.
- Gradual accumulation of soil organic matter from the balanced input and outputs of carbon exchange from forage and animal excreta to support a multitude of environmental indices related to water cycling, nutrient cycling, and biodiversity.
- Maintenance of protective plant cover over the land to avoid nutrient losses to the atmosphere and to surface and groundwater sources.

The authors argue that well-managed pasture-based farming systems provide society-wide environmental services while offering productivity and profit to individual producers. Small-scale farms are supplying local communities with food and aesthetic, yet functional, landscapes. While some barriers to greater adoption of well-managed pasture-based farming systems are real, surveys suggest that many barriers are perceived and could be overcome with education. Potential barriers include:

- Debt load: concerns about reduced production per head, investment infrastructure, and ability to service debt, especially for those already heavily invested in confinement production systems.
- Land availability: concern about whether there will be enough land to meet feeding requirements.

- Measures of success: concern about production per head, rather than overall profitability per head or unit of land area.
- Practicality and lifestyle: concerns about logistics and physical farm layout, lack of time and/or labor to move livestock, and how daily demands would fit into management and lifestyle.

The authors suggest that changes in agricultural policy could provide needed financial and technical support for transitioning to pasture-based farming systems and that education efforts could improve focus on farm net profitability, rather than per head production.

Recently, Spratt et al. (2021) published a glowing discussion of regenerative grazing, defining it as an agricultural practice that uses soil health and adaptive livestock management principles to improve farm profitability, human and ecosystem health, and food system resiliency. Applicable in both annual and perennial forage systems, such grazing builds on ecological principles and the relationship between grasslands and ruminants. It is based on long-standing Indigenous land stewardship of native prairie and savanna. Regenerative grazing typically maintains rest-rotation cycles: short periods of dense grazing followed by long forage rest periods to support vegetative recovery. The authors claim that regenerative grazing can:

- Address issues of racial inequity
- Improve soil structure and function
- Increase farm financial resilience
- Produce significant ecosystem services
- Improve animal health and welfare
- Improve farm and community profitability

According to the authors, RA and grazing can help solve some of our most urgent environmental challenges: the devastations of a shifting climate, poor water quality, rural community contraction, racial inequities, the financial struggle of the farm next door, and declining soil health. Furthermore, the authors state that the benefits of regenerative grazing continue to be undervalued and under-incentivized by actors ranging from federal and state governments to lenders, private sector agribusinesses, and universities.

However, the concept of holistic grazing management—especially in the form promoted by the Savory Institute—is not universally accepted. Briske et al. (2013) published a frank commentary asserting that the claims of the Savory Grazing Method are unfounded and expressing concern that these claims have the potential to undermine proven practical approaches to rangeland management and restoration that are supported by a global community of practitioners and scientists. The authors present data and arguments to refute Savory's claims that:

- All nonforested lands on the planet are degraded.
- Rangelands can store all fossil fuel carbon in the atmosphere.
- Intensive grazing is necessary to prevent rangeland degradation.

In a somewhat more temperate analysis, Nordborg (2016) published a critical review of the Savory grazing method, responding to claims that holistic grazing increases plant production and the soil's ability to infiltrate and retain water, stops land degradation, sequesters enormous quantities of carbon from the atmosphere, and improves living and profitability for producers. The author concluded that:

- Peer-reviewed studies that show positive benefits of holistic grazing are few and limited in time, number of study sites, and collected data. Results are partially inconclusive and reported effects are small in most cases.
- To date, no review study has been able to demonstrate that holistic grazing is superior to conventional or continuous grazing.
- Some claims concerning holistic grazing are directly at odds with scientific knowledge.
- Improved grazing management can improve conditions on many degraded lands. Based on this review, holistic grazing could be an example of good grazing management, but nothing suggests that it is better than other well-managed grazing methods.
- The total carbon storage potential in pastures does not exceed 0.8 t C/ha/yr, or 27 billion t of C globally, according to an estimate in this report based on very optimistic assumptions. This 27 billion t of C corresponds to less than 5% of the emissions of carbon since the beginning of the industrial revolution. Thus, holistic grazing cannot reverse climate change.

Nordborg concludes that to date, no review study has confirmed that holistic grazing is superior to conventional or continuous grazing. One possible reason is that the effects of the holistic framework for decision-making have not been appropriately accounted for in these studies. The claimed benefits of holistic grazing thus appear to be exaggerated and/or lack broad scientific support. In the end, holistic grazing could be an example of good grazing management, but nothing suggests that it is better than other well-managed grazing methods.

Teague and Barnes (2017) have criticized conventional research into holistic managed grazing, suggesting that most such studies have examined rigidly applied treatments and have been conducted at spatial and temporal scales too small to incorporate diversity and adaptive management. It may be that in real-world application, flexibility and adaptive management are key elements to improved grazing management.

Setting aside extravagant arguments and scientific disagreement, there is considerable empirical evidence that well-managed grazing can have environmental benefits. Teague et al. (2008) stated that the benefits of multi-paddock rotational grazing on commercial livestock enterprises have been evident for many years in many countries. Consistent with producer experience, published data from small paddock trials on both temporal and spatial aspects of grazing management indicates the potential for significantly higher production under multi-paddock rotational grazing relative to continuous grazing and conservative stocking. The authors attributed the lack of experimental evidence for these benefits to the notion that researchers have not managed trials to answer practical questions such as: how good is this management option, where is it successful, and what does it take to make it work as well as possible? In contrast, successful ranchers manage strategically to achieve the best possible profitability and ecosystem health. They use basic knowledge of plant physiology and ecology generated by research within an adaptive, goal-oriented management approach to successfully implement planned grazing management. The authors summarized that the combination of published research and ranchers' experience have indicated that the following management factors are the keys to achieving desired goals:

1. Planned grazing and financial planning to reduce costs, improve work efficiency and enhance profitability and environmental goals.
2. Adjusting animal numbers or having a buffer area available so that animal numbers match forage availability in wet and dry years.

3. Grazing grasses and forbs moderately and for short periods during the growing season to allow adequate recovery.
4. Timing grazing to mitigate detrimental effects of defoliation at critical points in the life cycle of preferred species inter- and intra-annually.
5. Where significant regrowth is likely, grazing the area again before the forage has matured too much.
6. Using fire to smudge patch-grazing imprints and manage livestock distribution.
7. Using multiple livestock species. In all these areas, management is the key to success.

Rotz et al. (2009) conducted an assessment of environmental impacts of four management scenarios by simulating a 250 ac Pennsylvania dairy farm: (i) a confinement fed herd producing 22,000 lbs of milk per cow per year; (ii) a confinement fed herd producing 18,500 lbs; (iii) a confinement fed herd with summer grazing producing 18,500 lbs; and (iv) a seasonal herd maintained outdoors producing 13,000 lbs. Converting 75 acres of cropland to perennial grassland reduced erosion 24% and sediment-bound and soluble P runoff by 23% and 11%, respectively. Conversion to all perennial grassland reduced erosion 87% with sediment-bound and soluble P losses reduced 80 and 23%. Ammonia volatilization was reduced about 30% through grazing, but nitrate leaching loss increased up to 65%. Grazing systems reduced the net greenhouse gas emission by 8 to 14% and the C footprint by 9 to 20%. Including C sequestration further reduced the C footprint of an all grassland farm up to 80% during the transition from cropland. For approximately 25 years following the conversion of rotated cropland to permanent perennial grassland, C sequestration can greatly reduce net greenhouse gas emission and the C footprint of dairy production systems. See Table 6.

Table 6. Annual Environmental Impacts of Four Dairy Production Systems on a Simulated 250-acre Farm in Central Pennsylvania (Rotz et al. 2009)

	Confinement all year		**Confined, summer grazing**	**Outdoors all year**
	High	**Moderate**	**Moderate**	**Low**
Erosion sediment loss (lb/acre)	2,500	1,900	1,900	330
Sediment-bound P (lb)	296	229	232	59
Soluble P runoff (lb)	57	51	44	44
Soil P accumulation (depletion) (lb/acre)	(3.2)	(1.5)	(2.9)	2.2
Nitrate N leaching (lb/acre)	19.5	16.1	21.5	32.3
Nitrate N in shallow groundwater (ppm)	8.3	6.5	8.4	8.1
Ammonia N volatilization (lb/acre)	55.2	53.3	40.4	39.1

Park et al. (2017) conducted a study to quantify runoff, sediment, and nutrient losses under traditional continuous and adaptive multi-paddock (MP) grazing management practices in a rangeland-dominated watershed in north Texas using the Agricultural Policy/Environmental Extender (APEX) model. Both ranch- and watershed-scale results indicated a strong influence of the grazing practice on runoff and water quality. When the grazing management was changed from the baseline MP to heavy continuous (HC) at one of the study ranches, the simulated 34-year average annual surface runoff, sediment, TN and TP losses increased by 148%, 142%, 144%, and 158%, respectively. At the watershed-scale, changing grazing management from a baseline HC to adaptive MP reduced the average annual surface runoff, sediment, TN, and TP loads at the watershed outlet by 39%, 34%, 33%, and 31%, respectively (Figure 8). In addition, implementation of adaptive MP grazing reduced streamflow during the high flow conditions that have ≤ 10% exceedance probability, by about 20%, and hence reduced the chances of flooding downstream of the watershed. Adaptive MP grazing was therefore found to be an effective conservation practice on grazing lands for enhancing water conservation and protecting water quality.

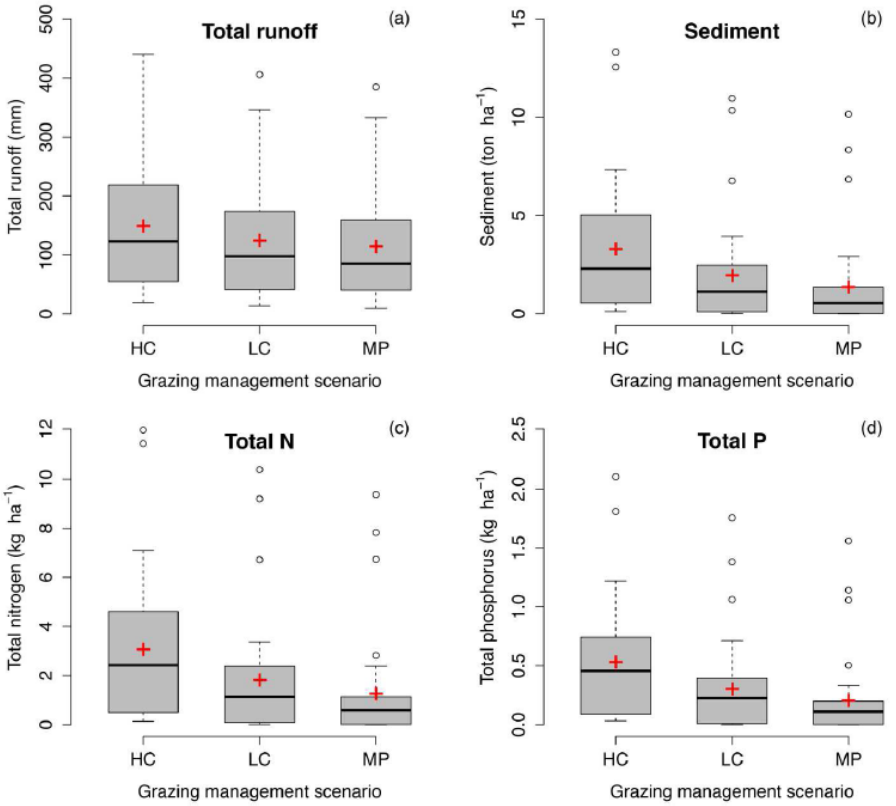


Figure 8. Box-and-whisker plots of the simulated average (1980–2013) annual (a) total runoff, (b)sediment, (c) total nitrogen and (d) total phosphorus losses under the heavy continuous (HC), light continuous (LC) and adaptive multi-paddock (MP) grazing scenarios at the Pittman Ranch. Red cross points indicate average values for each bar (Park et al. 2017).

Finally, some research has confirmed that rotational grazing, specifically adaptive multi-paddock (AMP) grazing that utilizes short-duration rotational grazing at high stocking densities, can increase soil C stocks in grassland ecosystems. Recently, Mosier et al. (2021) conducted a large-scale on-farm study on five adjacent pairs of AMP and conventional grazing (CG) grasslands covering a spectrum of southeast United States grazing lands. The authors quantified soil C and nitrogen (N) stocks and their distribution among soil organic matter (SOM) physical fractions characterized by contrasting mechanisms of formation and persistence in soils. Findings showed that the AMP grazing sites had on average 13% (i.e., 9 Mg C/ha) more soil C and 9% (i.e., 1 Mg N/ha) more soil N compared to the CG sites over a 1 m depth. Additionally, the stocks' difference was mostly in the mineral-associated organic matter fraction in the A-horizon, suggesting long-term persistence of soil C in AMP grazing farms. The higher N stocks and lower 15N abundance of AMP soils also point to higher N retention in these systems. These findings provide evidence that AMP grazing is a management strategy to sequester C in the soil and retain N in the system, thus contributing to climate change mitigation.

Teague and Barnes (2017) stated that multiple-paddock grazing does indeed provide tangible and substantive advantages over continuous grazing, *if* it is well planned and adaptively managed. However, the core is complexity and creativity, not paddocks *per se*: more paddocks *facilitate* adaptive management. It is a key to sustaining resources and regenerating ecosystem services from grazing lands to improve farmer incomes.

Soil Health

Although data reported on the effects of RA on soil health are less extensive, results point to important improvements in soil health under RA practices.

Xu et al. (2019) evaluated changes in Florida mineral soil properties associated with two regenerative farming practices: horse bedding application + cover cropping versus cover cropping alone. Results indicated a significant reduction in soil bulk density (BD) and a significant increase in maximum water holding capacity (MWHC) for both practices (Figure 9). Cation exchange capacity (CEC) and active carbon (C) increased significantly after 1.5 years. Horse bedding application with cover cropping increased soil organic matter (OM) by 4% and led to a significant increase in plant-available soil P. Horse bedding application as an organic amendment in conjunction with cover cropping provided an enhanced soil health effect compared to cover cropping alone. Significant reduction in soil BD and increase in MWHC are preferred from a soil health point of view because they are more favorable for plant growth. Increases in CEC improve soil ability to retain nutrients.

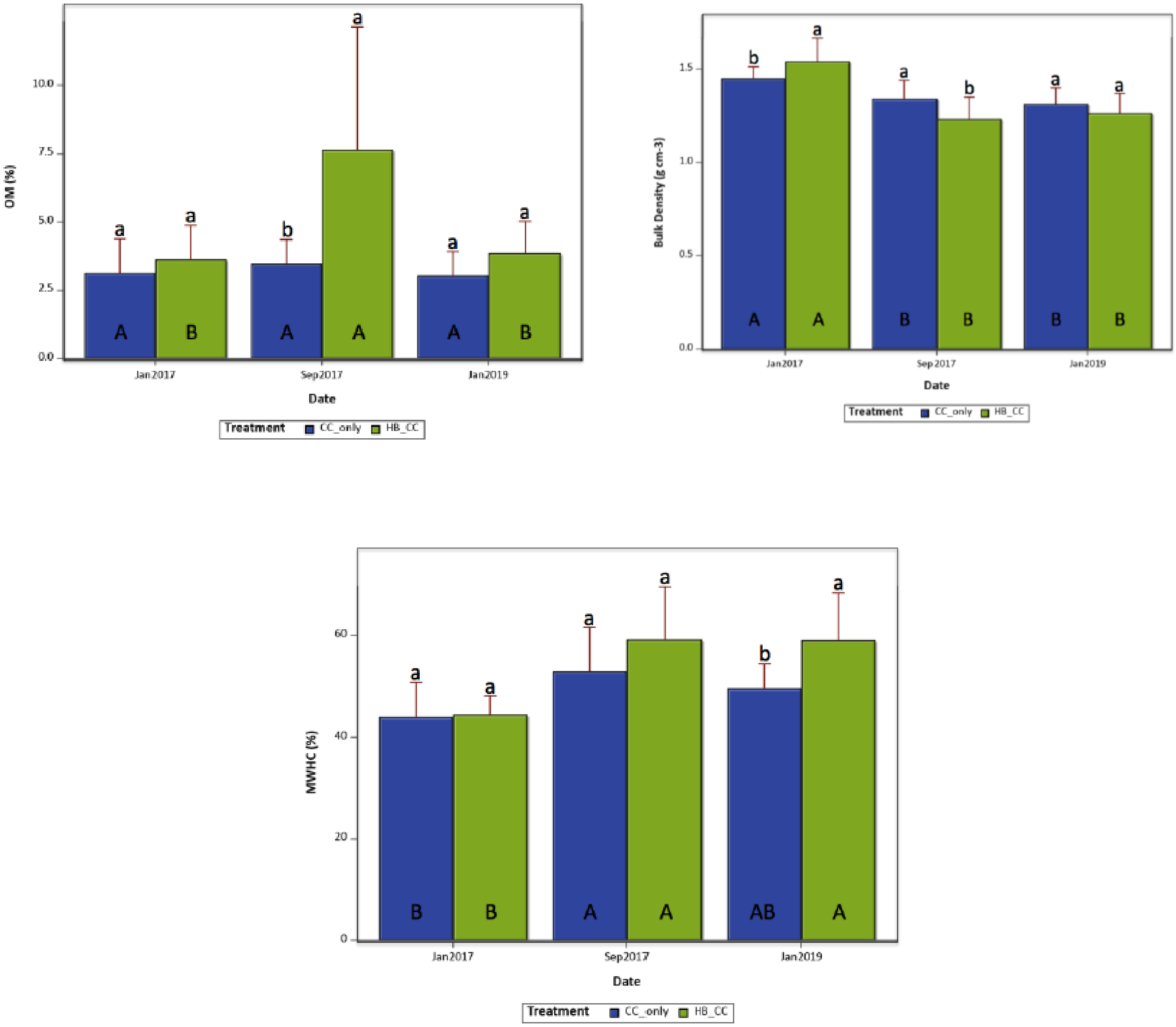


Figure 9. HB_CC = Horse bedding application with cover cropping, CC-only = Cover cropping only. Means followed by different lower case letters within same time are significantly different (p <0.05). Means for the same treatment with different upper case letters for different sampling time are significantly different (p <0.05) (Xu et al. 2019).

Bhadha et al. (2021) conducted a study to determine the effects of cover cropping practices on ten Florida farms on soil health, assessed by measurements of BD, MWHC, OM, active C, CEC, N, P, and K and reported mixed results. Individual farm results showed that effects of cover cropping on soil health were site-specific because of variations in cover crop species, soil types, climates, cropping systems, and farm management. Three farms showed decrease in BD (-1.4 to -5.8%) after first year, while 5 farms showed an increase (+3.4 to +10.3%). Five farms showed an increase in OM (+6.7 to +16.5) and five farms showed an increase in MWHC (+1.7 to +21.3%), while four showed a decrease. Across all farms, the authors concluded that cover cropping was a promising option because compared to fallow, soil

OM, BD, MWHC, and soil protein showed significant increase in the second year. They observed a 2% increase in soil OM after 1 year of CC. Similarly, reduced BD and increased MWHC improved soil quality. The most positive effect was on soil protein level, a measure of the bioavailable N pool in soil for microbial communities. The increase in soil protein indicated that cover crops assisted in optimizing N cycling in soils that slowly release available N for subsequent crops over time, reducing losses of soluble N.

Conservation agricultural systems using cover crops and no-till (NT) or reduced tillage were shown to be effective in improving soil health conditions across a diversity of soil types in the southeastern United States (NC, SC, PA, and VA) (Farmaha et al. 2022) (Table 7). Both recent research station literature and on-farm trial data in the region suggested significant improvement in soil organic C and N fractions and inorganic nutrients with adoption of NT and cover cropping. Evidence was strong for soil health improvement with adoption of NT compared with inversion tillage, and evidence was good but not universal across physiographic regions or soil properties for soil health improvement with addition of cover crops to the NT system.

- There was significant improvement in soil organic C and N and inorganic nutrients with no-till and cover crops.
- Soil health improved with adoption of no-till compared with inversion tillage.
- There was weak evidence for soil health improvement with multi-species cover crops compared to single species.

Table 7. Effects of Conservation Tillage and Cover Crop (cc) on Soil Health Characteristics (0-10 cm depth) across Physiographic Regions in Southeastern United States (Farmaha et al. 2022)

	Inversion/ no CC	Conservation till/ no CC	Conservation till/single-species CC
Total Organic C (g/kg)	14.3	20.4	21.4
Total N (g/kg)	0.97	1.68	1.86
Soil test biological activity (mg/kg/3 d)	138	244	281
Net N mineralization (mg/kg/24 d)	39	70	85
Mehlich3 P (g/m^3)	158	210	222
Mehlich3 K (g/m^3)	159	228	235

Montgomery et al. (2022) linked RA, soil health, and the quality of agricultural products at eight pairs of regenerative and conventional farms across the United States (NC, PA, OH, IA, TN, KS, ND, and MT). Measurements from paired farms indicated differences in soil health and crop nutrient density between fields worked with conventional (synthetically-fertilized and herbicide treated) or regenerative practices for 5–10 years. Specifically, regenerative farms that combined no-till, cover crops, and diverse rotations produced crops with higher soil OM levels, soil health scores, and levels of certain vitamins, minerals, and phytochemicals (e.g., Figure 10). In addition, crops from two regenerative no-till vegetable farms, one in CA and the other in CT, had higher levels of phytochemicals than values reported previously from supermarkets. Moreover, a comparison of wheat from adjacent regenerative and conventional no-till fields in northern OR found a higher density of mineral micronutrients in the regenerative crop. Finally, a comparison of the unsaturated fatty acid profile of beef and pork raised on one of the regenerative farms to a regional health-promoting brand and conventional meat from local supermarkets, found higher levels of omega-3 fats and a more health-beneficial ratio of omega-6 to omega-3 fats. Together these comparisons offer preliminary support for the conclusion that regenerative soil-building farming practices can enhance the nutritional profile of conventionally grown plant and animal foods.

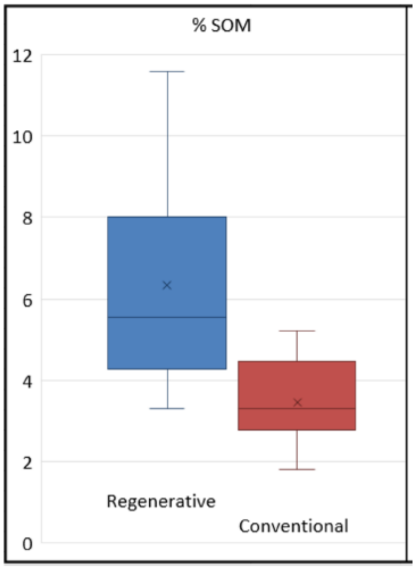


Figure 10. Distributions of soil % organic matter for regenerative (blue) and conventional (red) farms (Montgomery et al. 2022)

The authors concluded that RA practices combining no-till, cover crops, and diverse rotations can increase topsoil organic matter and enhance soil health after less than a decade of full adoption. Moreover, the roughly doubled soil OM measured on average for the regenerative farms is large enough to substantially contribute toward reversing the roughly 50% historical decline in soil organic matter reported previously as typical for American cropland in general. The results suggest the potential for RA that build soil health to enhance the nutritional profile of crops and livestock, and thereby influence human health and risk of chronic diseases.

Ecosystem Services

Beyond water quality and soil health improvements, broader benefits have been attributed to RA practices (mainly cover crops), although the specific benefits have not been extensively quantified.

In a literature review, Scholberg et al. (2010) concluded that cover crops can contribute to carbon sequestration, especially in no-tillage systems, whereas such benefits may be minimal for frequently tilled sandy soils. Due to the presence of a natural soil cover, cover crops reduce erosion while enhancing the retention and availability of both nutrients and water. Moreover, cover-crop-based systems provide a renewable N source and can also be instrumental in weed suppression and pest management in organic production systems. The authors provided an overview of the primary and secondary effects of cover cropping on different agroecological services (Figure 11):

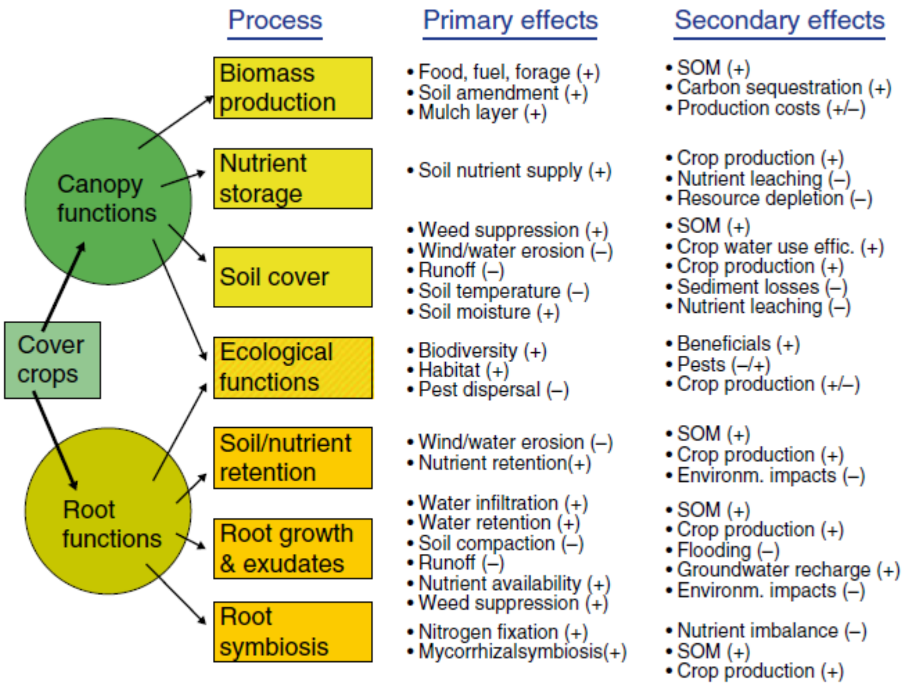


Figure 11. Schematic overview of cover crops and corresponding primary and secondary effects on different agroecological services. SOM: soil organic matter (Scholberg et al. 2010).

Schipanski et al. (2014) used quantitative models and semi-quantitative literature-based estimates to develop a framework to analyze the temporal dynamics of 11 ecosystem services and two economic metrics when cover crops were introduced into a 3-year soybean-wheat-corn rotation in a typical Mid-Atlantic climate. The authors estimated that cover crops could increase 8 of 11 ecosystem services without negatively influencing crop yields (Figure 12).

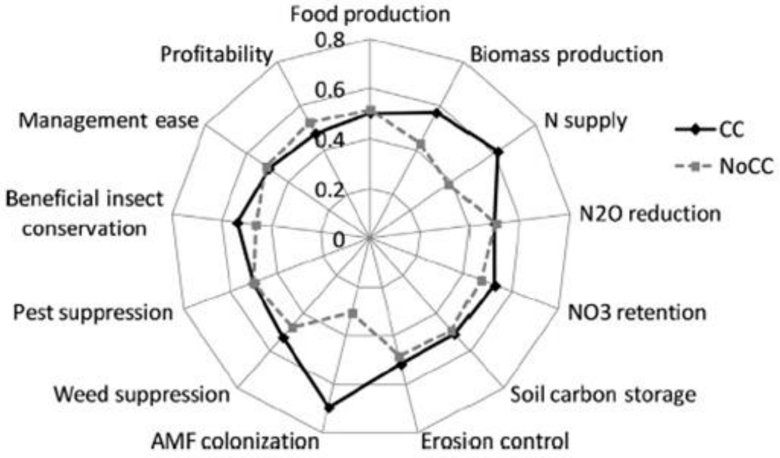


Figure 12. Normalized values for 11 ecosystem services and two economic with cover crops (CC) and without cover crops (NoCC) simulated with the Cycles model (source: Schipanski et al. 2014). Note: Arbuscular mycorrhizal fungi (AMF) colonization represents an integrated measure of supporting ecosystem services. AMF play an important role in plant acquisition of phosphorous and may increase plant uptake of N and zinc, pest resistance, and drought tolerance (Schipanski et al. 2014).

The authors also modeled the effects of cover cropping on long-term soil carbon accumulation – see Figure 13.

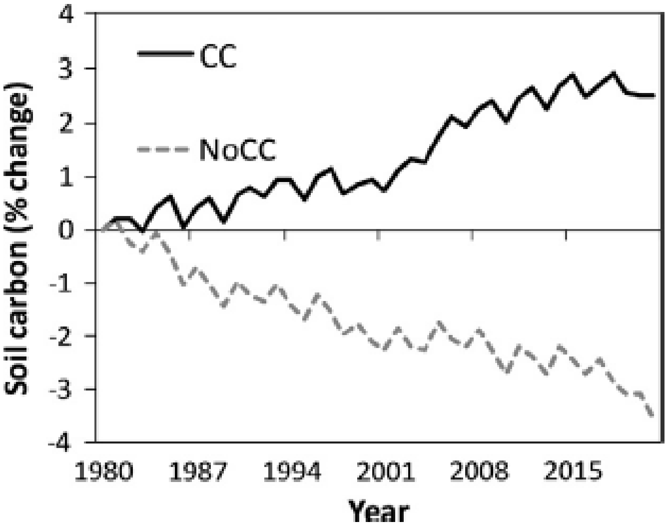


Figure 13. Relative changes in soil profile carbon over 40 years for soybean-wheat-corn rotations with cover crops (CC) and without cover crops (NoCC) simulated with the Cycles model (Schipanski et al. 2014).

In a literature review, Daryanto et al. (2018) quantitatively synthesized different ecosystem services provided by cover crops: erosion control, water quality regulation, soil moisture retention, accumulation of soil organic matter and microbial biomass, greenhouse gas (GHG) emission, weed and pest control, as well as yield of the subsequent cash crop. Compared against fallow, results showed that cover crops provided beneficial ecosystem services in most cases, except for an increase in GHG emission and in pest (nematode) incidence (Table 8). The authors attributed the reported increases in GHG emissions from cover crops to increased microbial decomposition of cover crop residue, while noting that the limited data available on this topic may have skewed results. More importantly, there was generally an increase in cash crop yield with cover cropping, likely due to improvement in various soil processes. The authors summarized data from 377 studies/sites across the world to evaluate efficiencies of cover cropping as ratio of measured parameter for cover crops/fallow:

Table 8. **Mean Changes in Selected Soil Parameters vs. Fallow Reported from Cover Crop Studies (Daryanto et al. 2018)**

Parameter	Change	Parameter	Change	Parameter	Change
Soil loss	-75%	Soil residual avail. P	+8%	Microbial biomass P	+26%
Water loss	-18%	Soil organic C	+8%	Weed biomass	-5%
Bulk density	-1%	Soil TN stock	+2%	Nematode abundance	+29%
NO_3-N loss	-47%	Soil TP concentration	+4%	GHG emissions	+48%
Diss. P loss	+5%	Microbial biomass C	+64%	Successive cash crop yield	+15-29%
Soil residual NO_3-N	-21%	Microbial biomass N	+79%		

In a qualitative sense, NRDC (2021) listed these broad benefits of RA:

Ecological Benefits

- Improvements in soil health and fertility—the foundation of healthy water, nutrients, and carbon cycling—as evidenced by healthier crops, increased yields, improved soil test results, and vibrant microbial communities.
- Biodiversity on land, in the air, and in the water (following improved biodiversity in the soil), including richer plant, bird, and insect populations.
- Reduced soil erosion.
- Reductions in water pollution—including contributions to harmful algal blooms—due to fewer chemical inputs.
- Improvements to water-holding capacity in the soil.

Personal and Regional Economic Benefits

- Cost savings from reduced use of antibiotics and chemical fertilizers, herbicides, and pesticides.
- Greater financial security from diversified revenue streams.
- The promotion of rural economic development with local employment and healthier food choices.

Community Benefits

- Networks of growers who exchange information, learn from one another, and build community.
- On-farm/on-ranch visits and networks of farmers' markets that help farmers and ranchers build stronger relationships between consumers and their food.

Mental **and Physical Health Benefits**

- Many RA farmers and ranchers report feeling joy through their professions.
- The health of farmers, farmworkers, and downstream communities all benefit from reduced use of and exposure to harmful chemicals.

Other benefits of RA generally discussed (CBF 2022) include:

- Improved soil health, mitigation of climate change
- Increased climate resilience through better water absorption, flood resistance, drought tolerance
- Reduced fossil fuel use
- Reduced greenhouse gas emissions
- Increased food production
- Preserved agricultural land
- Protected and restored natural ecosystems

The Science for Nature and People Partnership (SNAPP) and The Nature Conservancy (TNC) have established a web site "AgEvidence: the impact of agricultural practices on crops and the environment" that synthesizes published scientific data on the impacts of RA on environmental quality (SNAPP and TNC 2022). The web site includes data from 364 studies from the U.S. corn belt on the effects of conservation practices such as cover crops, nutrient management, and tillage on environmental outcomes including water quality, soil nutrients, and climate mitigation (measured as changes in C and N emissions and C storage in soils). While the contents of the site are too detailed to summarize here, one of the site's syntheses of the impacts of cover crops on water quality is illustrated in Figure 14. It is recommended that those interested in applications of RA practices for the Prairie Band Potawatomi Nation consult this database directly.

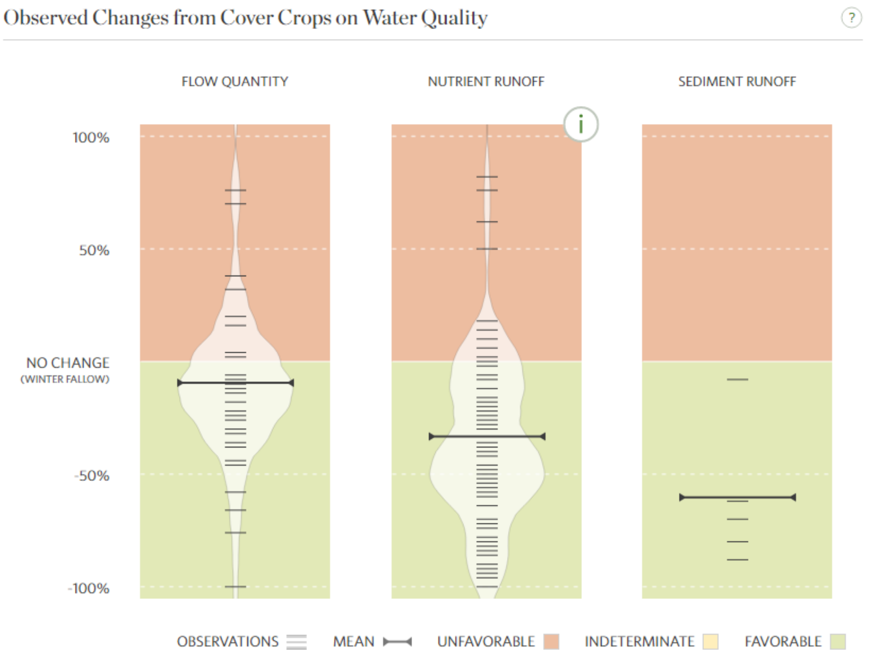


Figure 14. Synthesis of observed effects of cover cropping on water quantity and quality in the U.S. corn belt from the AgEvidence web site (https://www.agevidence.org) (SNAPP and TNC 2022).

Activity 6: Potential Locations for RA Practices

The Importance of Prioritization

After water quality problems and their causes have been identified, the focus of watershed planning should move to selecting the right RA practices (see Activities 2 and 3) and siting these practices in the right places to meet water quality goals. It is widely recognized that a small area of a watershed can generate a disproportionate amount of pollutant load (e.g., Sharpley et al. 1994, Daniel et al. 1994, Heathwaite et al. 2000, Walter et al. 2000, Srinivasan et al. 2002). In Pennsylvania for example, Pionke et al. (2000) reported that 90% of annual watershed P loss came from less than 10% of the watershed area. In a New York watershed, the 10% of the watershed in hydrologically sensitive areas generated 20% of the annual runoff (Walter et al. 2000). Such areas should be prioritized for practice implementation for water quality improvement.

Critical Source Areas

These priority watershed areas—referred to as Critical Source Areas (CSAs)—are typically defined as areas where significant sources of pollutants (e.g., sediment, phosphorus, pathogens) coincide with hydrologic transport mechanisms (e.g., surface runoff, infiltration) that can mobilize and carry the pollutants to receiving waters. Because it is rarely feasible to apply practices to all eligible watershed land, it is crucial to implement practices in major CSAs where they will be most effective. Research has shown that watershed management strategies to reduce phosphorus export could be more cost-effective, than in the typical *ad hoc* approach, if treatments are prioritized to CSAs (Sharpley 1999, Pionke et al. 2000, Yang and Weersink 2004, Gburek et al. 2000a,b). For example, in a SWAT simulation, Winchell et al. (2011) reported that targeted implementation of reduced phosphorus applications, cover crops, and conservation crop rotations in a Vermont watershed resulted in an approximately two-fold increase in P load reduction compared to random implementation on the same number of watershed acres.

Identifying CSAs

Identification of CSAs in a watershed is a challenging endeavor. While areas of significant pollutant sources (e.g., highly erodible soil, bare cropland, land receiving manure or fertilizer, fields of excessive soil test phosphorus levels) can be identified relatively easily, hydrologically-active areas are highly site-specific, are dependent on the prevailing runoff generation process, and vary with storm intensity/duration and season. CSAs can be identified using a range of tools from visual inspection to watershed modeling. In small, localized areas, on-site inspections through windshield surveys or streamwalks can identify significant source areas. A Vermont project used streamwalks to identify riparian pastures and streambanks that needed restoration and livestock exclusion (Meals 2001). The knowledge and expertise of local residents and conservation professionals (e.g., USDA-NRCS staff) can be highly useful. At the site scale, identification of source and transport pathways (e.g., through LiDAR or detailed drainage plans) can locate measures that could effectively interrupt transport or delivery of nonpoint source (NPS) pollutants. Tools like the Phosphorus Index, soil test data on phosphorus, or data concerning land management can help identify high risk source areas. Techniques like topographic analysis can help define transport pathways in regions characterized by Variable Source Area (VSA) hydrology. VSA hydrology is the concept that runoff-generating areas in a landscape vary in location and size over time, depending on time of year, rainfall, topography, soils, vegetation, and other factors.

Common approaches to CSA identification at the watershed scale include:

- Use of water quality data from a synoptic survey to identify high-contributing sub-basins.
- Application of historical or project hydrogeologic data to understand ground water systems.
- Application of literature-based loading coefficients and land use data to prioritize sub-basins by pollutant load contributions.
- Use of the RUSLE to map erosion risk as a surrogate for NPS pollutant runoff risk.
- Mapping factors like soils, slope, land use, animal density, and proximity to water in a GIS overlay to identify high-risk source areas.
- Use of watershed simulation models like SWAT to identify CSAs at multiple scales.

Some approaches to CSA identification reported in the recent literature include:

- McDowell and Srinivasan (2009) reported that hydrologic analysis in grazed headwater catchments in New Zealand showed that compacted areas like gateways, lanes, tracks, and troughs that produce infiltration-excess runoff lose a disproportionately large amount of phosphorus and sediment to streams during even small events.

- Buchanan et al. (2013) combined the Phosphorus Index with VSA analysis (process of identifying runoff contributing areas in the context of VSA hydrology) to incorporate the concept of hydrologic connectivity to the stream network to identify CSAs.

- Winchell et al. (2015) combined a high-resolution SWAT model with the Topographic Index (Beven and Kirkby 1979, Easton et al. 2008) to identify sub-field scale CSAs for phosphorus loss in a Vermont watershed. Numerous other researchers have reported on using SWAT or other models to identify CSAs, including Niraula et al. 2013, Giri et al. 2016, Imani et al. 2019, and Djodjic and Marnensten 2019.

- Based on comprehensive watershed and water quality analysis, McCarty et al. (2018) proposed four risk indicators to improve the identification of CSAs in an Arkansas watershed: subwatersheds that have < 50% forested area within the drainage area, < 50% forested area in the riparian buffer zone, > 0.9 poultry houses/km^2, and a stream density > 50 m/ha.

- Reany et al. (2019) evaluated and compared three different approaches to identifying CSAs in a UK watershed (including a custom designed smartphone app, a desktop GIS system, and a terrain analysis model) and advocated the use of a multi-tiered, multi-evidence approach to CSA identification.

- Rudra et al. (2020) reviewed potential methods and challenges in identifying CSAs in Canada ranging from simple index-based methods to complex hydrologic models and recommended development of a toolbox that includes a variety of methods to identify CSAs.

It should be emphasized that the foregoing discussion of CSAs is presented entirely in the context of water quality management, that is the reduction of NPS pollutant generation and delivery to receiving waters. The criteria and parameters of CSA identification for the other goals of RA will be significantly different. The existence of hydrologic transport pathways, for example, will be considerably less important in locating priority areas for implementation of RA practices designed to improve soil quality, increase agricultural productivity, or to serve other goals at the field scale.

For selecting locations for RA practices, several approaches might be applied:

- Identify areas of special soil quality concern (e.g., low organic matter, high compaction, excessive soil loss) or agricultural management concerns (e.g., poor pasture quality, low grazing capacity, degraded streambanks) as priorities for implementation of appropriate RA practices.
- Identify a few areas of concern to receive RA practices as long-term demonstration sites to promote and encourage widespread adoption.
- Identify a few innovative and cooperative landowners to implement RA practices as demonstrations.
- Offer support for RA practice implementation on an open, voluntary basis across the entire project area.

All of these approaches could be done largely based on local knowledge, without complex modeling or technology. Just as implementation of conventional practices for water quality goals requires monitoring and evaluation to document effectiveness, implementation of RA practices should include long term monitoring both to document effectiveness on local conditions and to demonstrate success to other potential adopters.

Identification of CSAs in the Prairie Band Potawatomi Nation Reservation

As a demonstration, Tetra Tech used the Model My Watershed on-line tool to assess potential approaches to identifying CSAs for runoff/water quality in the Soldier Creek watershed within the Prairie Band Potawatomi Nation Reservation. Tetra Tech reviewed several soil, land use and water quality model parameters in an effort to identify CSAs: hydrologic soil group, soil erodibility factor, land use categories, catchment-scale pollutant loading rates, and in-stream water quality (by catchment) in selected drainage areas of the reservation. This process is intended as a demonstration of a possible approach to identify CSAs in the reservation. A more complete evaluation conducted at a finer resolution (e.g., field level) may be required to truly prioritize practice siting.

The subsections below present a series of maps that can, therefore be used as a simple, high level screening tool for identifying and prioritizing potential CSAs. There are other considerations when identifying the highest priority CSAs and selecting specific management practices, such as catchment-level assessments, proximity to waterbodies, availability of land, willingness of landowner participation, and operation and maintenance considerations.

Soils

Soil characteristics together with land use and slope are often assessed to help identify CSAs within a watershed. In the Prairie Band Potawatomi Nation Reservation, soils are mainly Hydrologic Soil Group (HSG) C and D soils. These HSGs are considered areas to have slow to very slow infiltration, which may contribute high volumes of runoff. The soil erodibility factor (K-factor) used in the RUSLE erosion model can indicate areas prone to high erosion and soil loss. K-factor values typically range from 0.02 to 0.69. Maps of these factors within portions of the Soldier Creek watershed are illustrated in Figures 15 and 16. As indicated in these figures, soils in the reservation area are predominantly considered slow infiltration and erodible, with the majority of the reservation covered by soil with a K-factor greater than 0.3. These soil characteristics are relatively homogeneous across the reservation and to offer limited utility in identifying areas of especially high potential runoff and/or pollutant loss.

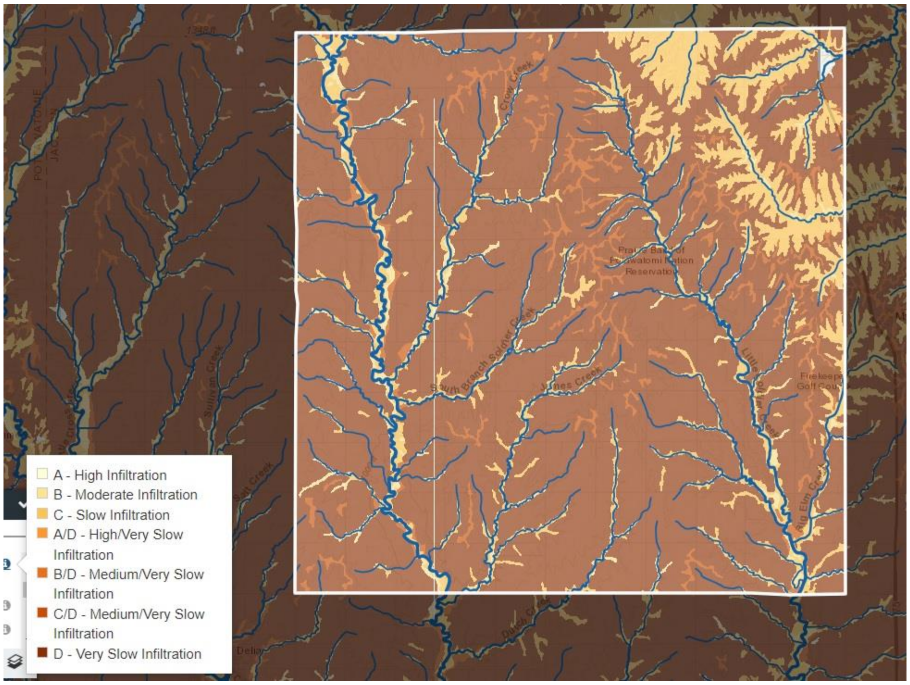


Figure 15. Map of Hydrologic Soil Group (HSG) classification in a portion of the Soldier Creek Watershed within the Prairie Band Potawatomi Nation Reservation. Group C and D soils represent soils prone to generating high runoff.

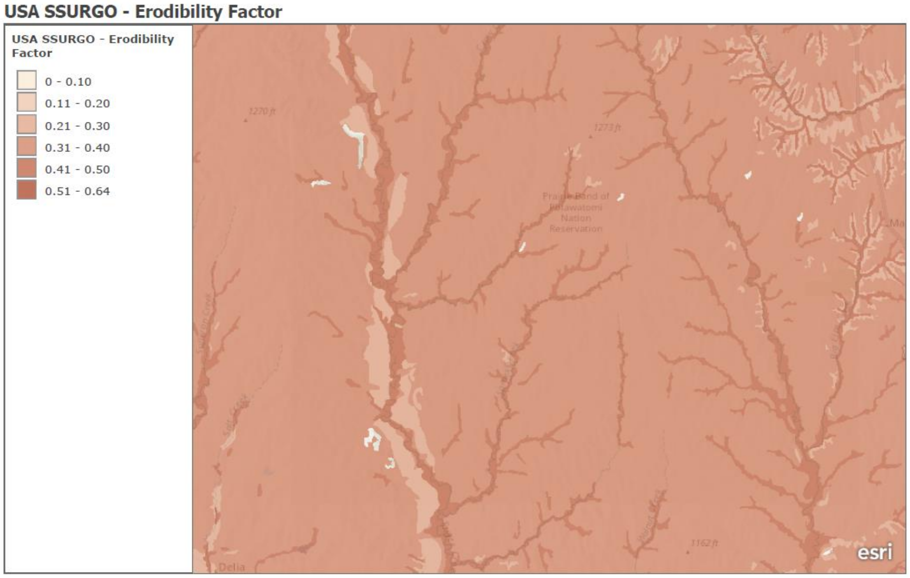


Figure 16. Map soil erodibility factors in a portion of the Soldier Creek Watershed within the Prairie Band Potawatomi Nation Reservation. The soil erodibility factor quantifies the susceptibility of soils to erosion and is a key input to the RUSLE and other erosion models.

Land Use

Land use is often used as an indicator of NPS pollution potential, regardless of specific condition or management in individual parcels. Row crop land, for example, tends to contribute higher levels of sediment, nutrients, and other pollutants than permanent grassland. Thus, agricultural land use distribution may be useful in identifying potential CSAs. The spatial distribution of different land use types in the reservation is displayed in Figure 17.

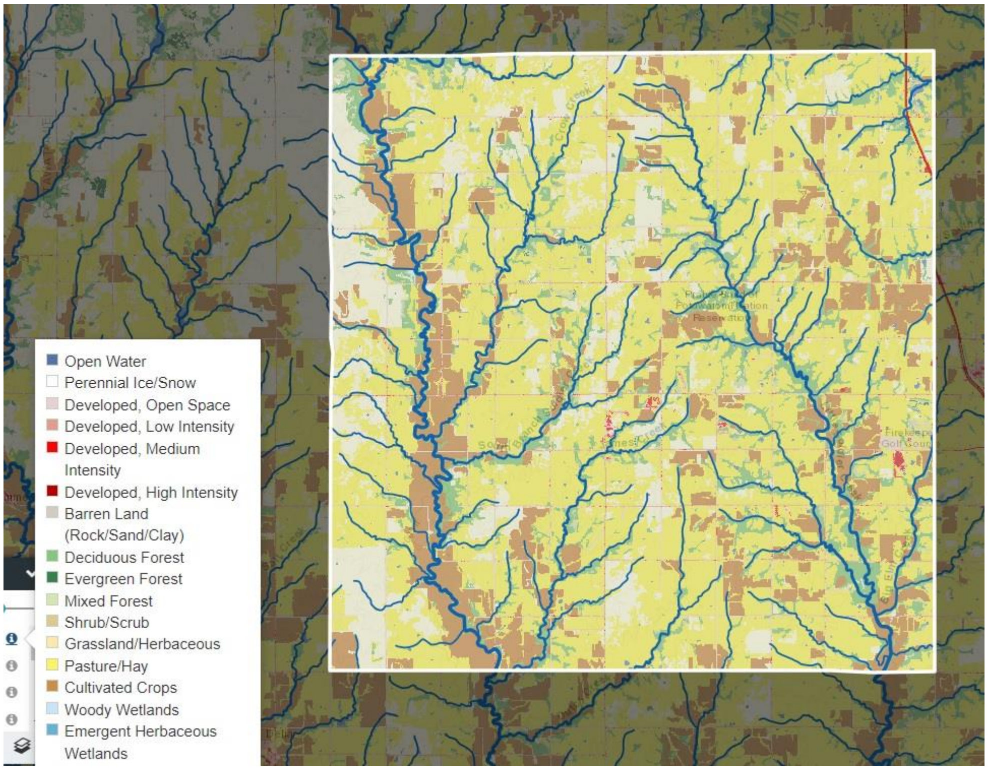


Figure 17. Map of land use classifications in a portion of the Soldier Creek Watershed within the Prairie Band Potawatomi Nation Reservation.

Clearly, implementation of practices (whether for water quality or soil health) designed for row crop land should be focused on areas of cultivated crops. Cultivated cropland is concentrated along the main channel of Soldier Creek to the west, while more widely distributed in the Little Soldier Creek drainage area. Because proximity to surface water is often a driver of pollutant delivery by surface runoff, the riparian row crop land along Soldier Creek on the western side of reservation should be prioritized for practice implementation.

Water Quality

Another approach to identifying CSAs for siting RA practices is to consider ambient water quality (either in runoff or in-stream), for example from modeling or synoptic sampling of relevant water quality constituents at the catchment scale. Areas of particularly high concentrations of sediment or nutrients, for example, may indicate a need for land treatment within a drainage area. The spatial distributions of catchment scale loading rates and in-stream concentrations of sediment, phosphorus, and nitrogen for selected areas in the Prairie Band Potawatomi Nation Reservation (James Creek-Soldier Creek HUC-12, Potawatomie Indian Reservation-Soldier Creek HUC-12, and Headwaters Little Soldier Creek HUC-12) are displayed in Figures 18 through 26.

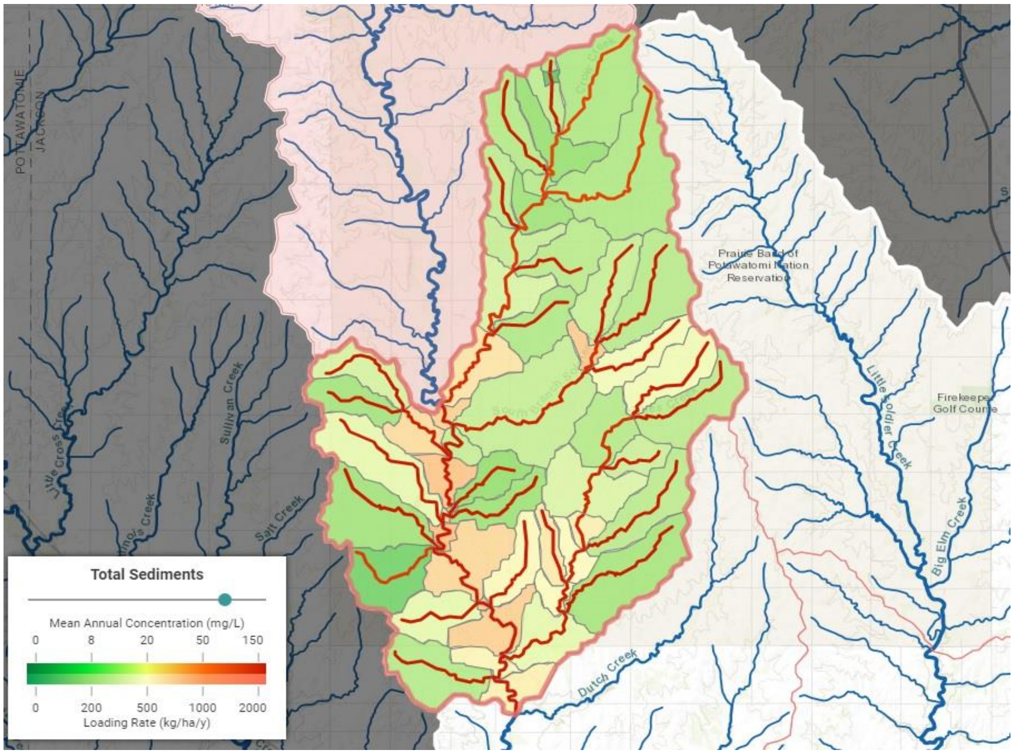


Figure 18. Map of in-stream sediment concentrations and loading rates from catchments in the James Creek-Soldier Creek HUC-12.

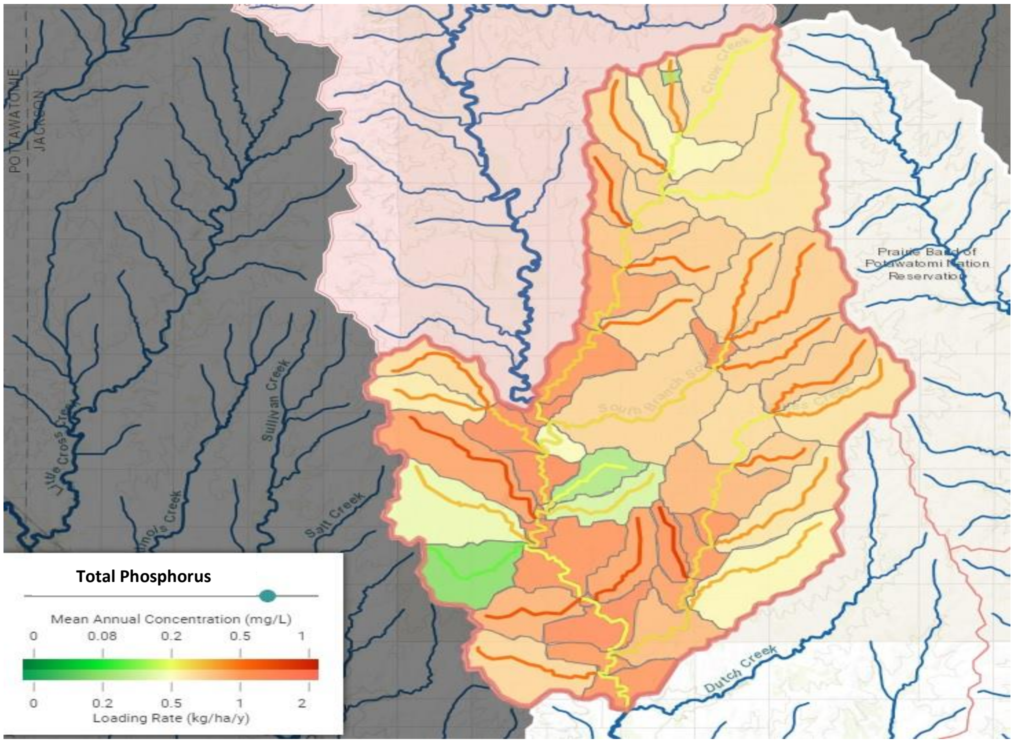


Figure 19. Map of in-stream phosphorus concentrations and loading rates from catchments in the James Creek-Soldier Creek HUC-12.

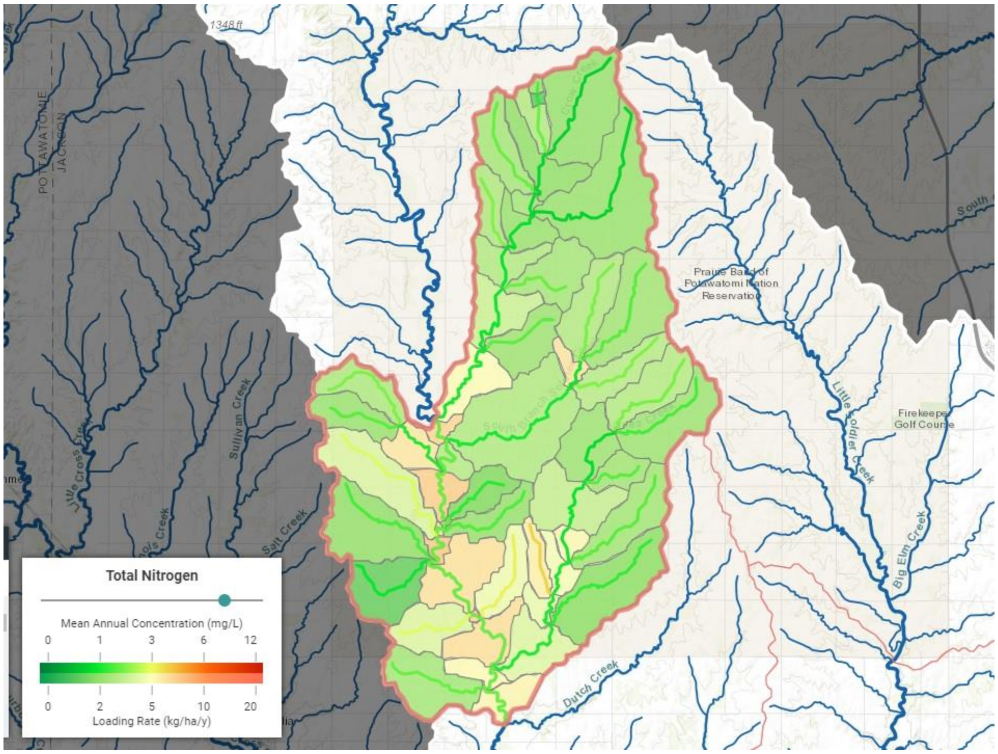


Figure 20. Map of in-stream nitrogen concentrations and loading rates from catchments in the James Creek-Soldier Creek HUC-12.

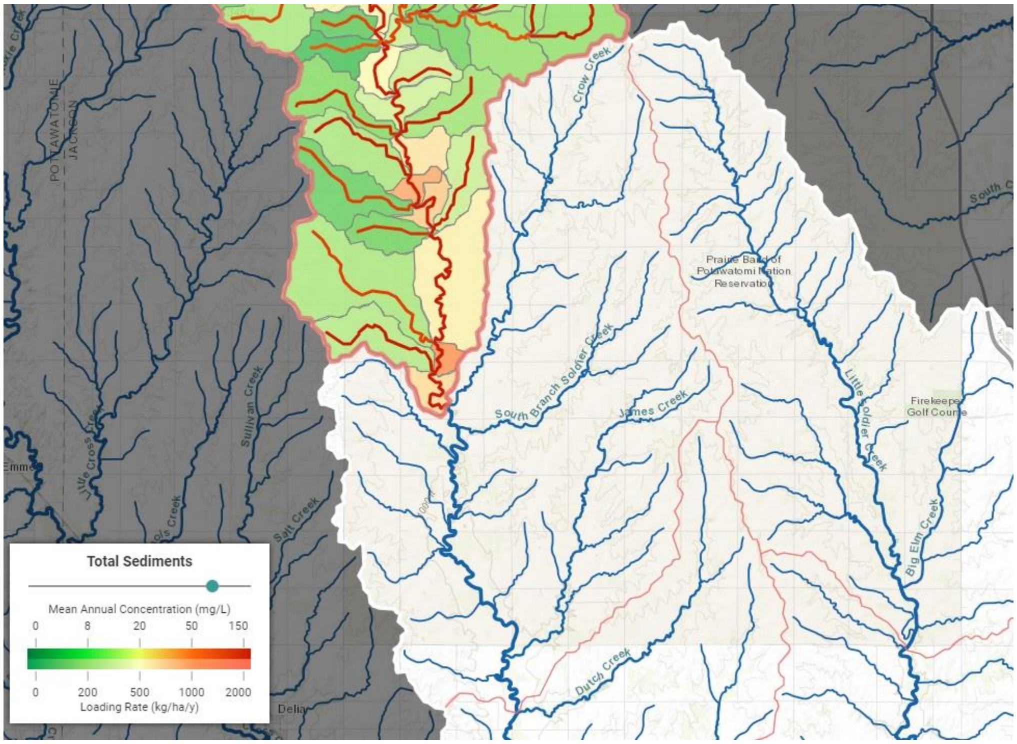


Figure 21. Map of in-stream sediment concentrations and loading rates from catchments in the Potawatomie Indian Reservation-Soldier Creek HUC-12.

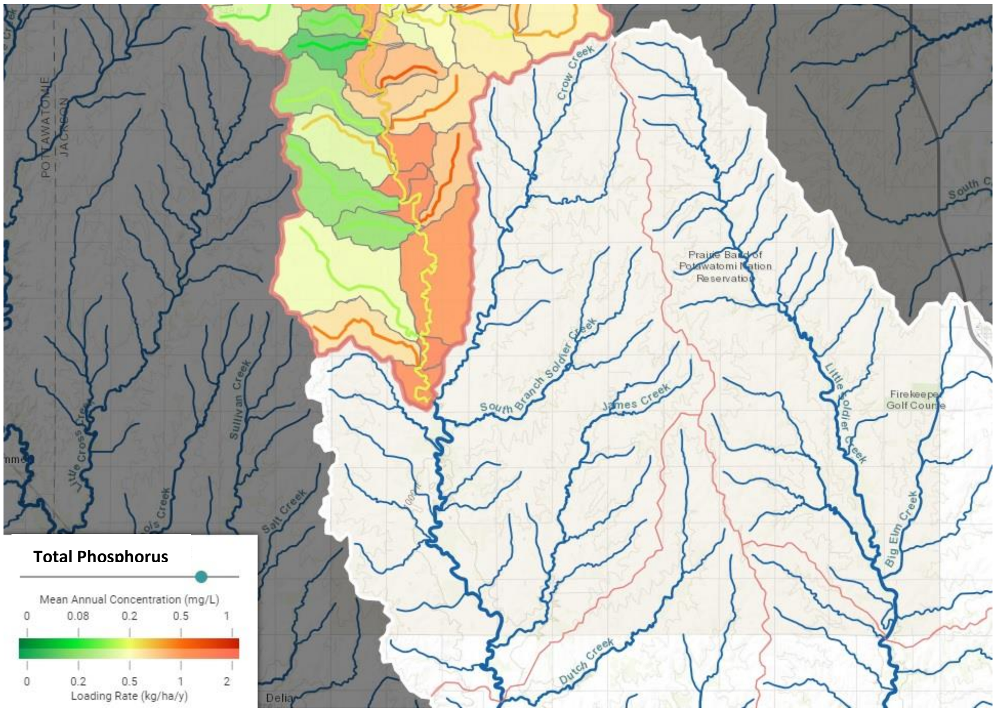


Figure 22. Map of in-stream phosphorus concentrations and loading rates from catchments in the Potawatomie Indian Reservation-Soldier Creek HUC-12.

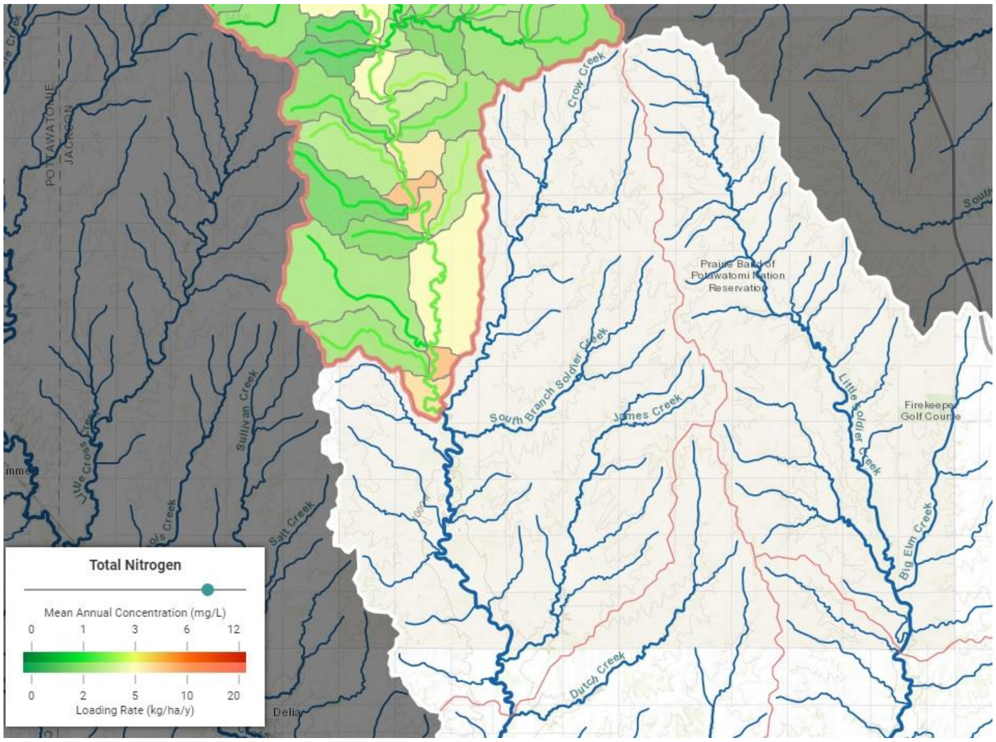


Figure 23. Map of in-stream nitrogen concentrations and loading rates from catchments in the Potawatomie Indian Reservation-Soldier Creek HUC-12.

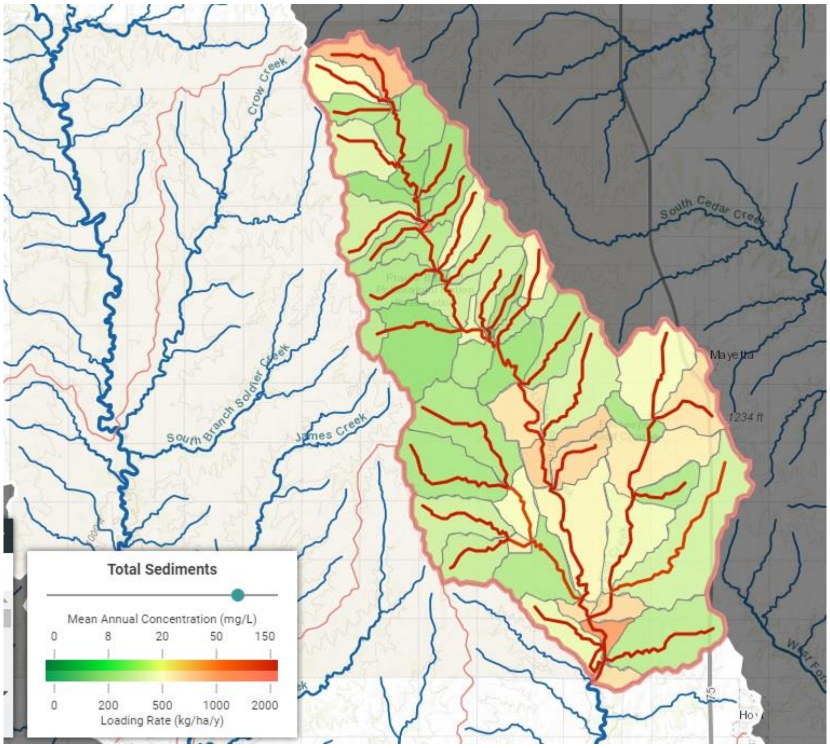


Figure 24. Map of in-stream sediment concentrations and loading rates from catchments in the Headwaters Little Soldier Creek HUC-12.

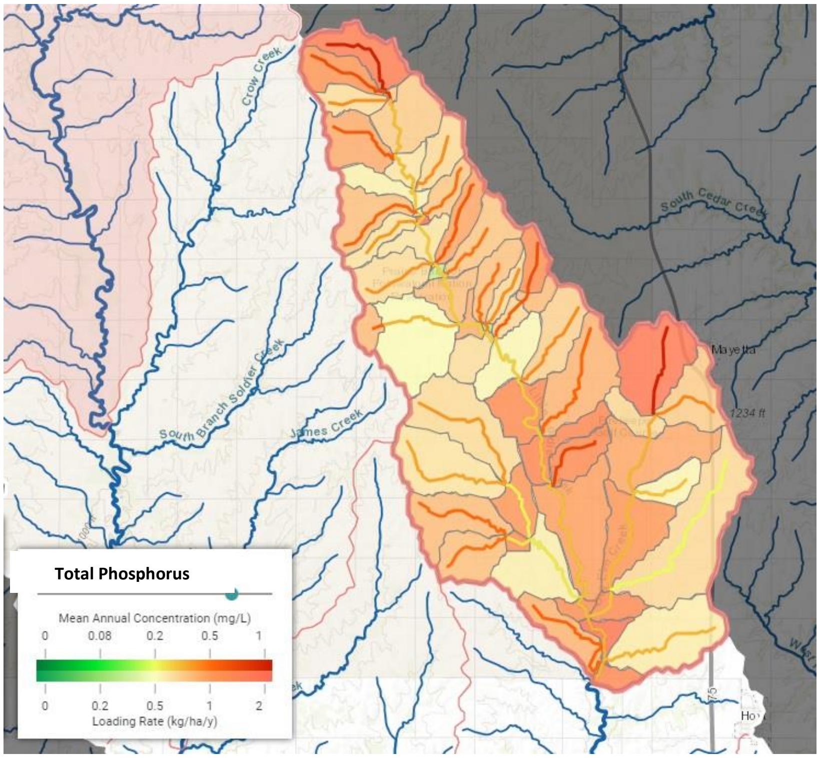


Figure 25. Map of in-stream phosphorus concentrations and loading rates from catchments in the Headwaters Little Soldier Creek HUC-12.

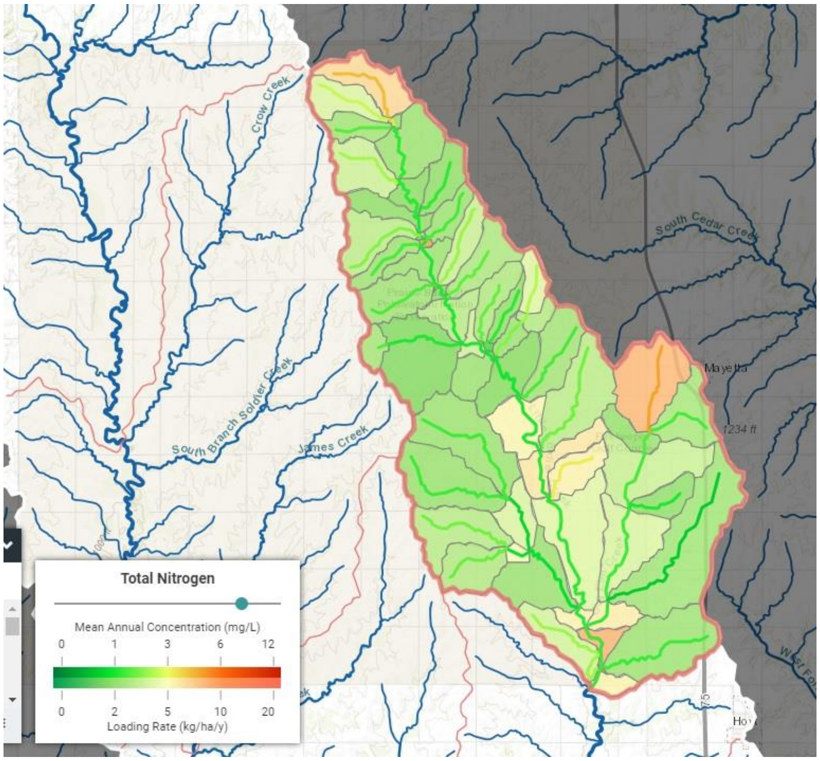


Figure 26. Map of in-stream nitrogen concentrations and loading rates from catchments in the Headwaters Little Soldier Creek HUC-12.

The modeling data suggest that, in general, the highest loading rates for all pollutants are evident in the same set of catchments across the three HUC-12s. This information can help to prioritize the HUC-12 catchment areas for RA practice implementation. For example:

- Spatially, sediment loading rates appear to be highest in catchments along the main stem of Soldier Creek (James Creek-Soldier Creek HUC-12 and Potawatomie Indian Reservation-Soldier Creek HUC-12). Loading rates appear to be higher in downstream catchments of the HUC-12s. In-stream concentrations are generally high across the reservation.
- Highest phosphorus loading rates are evident in catchments along the main stems of Soldier Creek and Little Soldier Creek (including some of its tributary catchments). In-stream phosphorus concentrations vary across the reservation, but are considered to be above natural background levels in many catchments.
- Catchments with highest nitrogen loading rates also appear to be along the main stems of Soldier Creek and Little Soldier Creek. In-stream nitrogen concentrations vary across the reservation, but are considered to be above natural background levels in many catchments.

This catchment-scale spatial information is based on outputs from Model My Watershed and should be considered concurrently with soil, land use, and other available data.

Summary

The spatial and modeling data reviewed suggest that areas of cropland along the main channel of Soldier Creek and its tributaries represent the highest risk areas for pollutant loading. Because stream proximity is generally an important driver of pollutant contribution to waterways, RA practices should be prioritized to riparian lands, where indicated. Note that RA practice application to cropland or grazing lands for the purposes of improving soil quality or forage quality/production should be prioritized according to field-scale needs wherever possible, not always proximity to water.

Note that RA practice siting and prioritization can differ by pollutant focus, willingness of stakeholders to adopt practices, and management goals (e.g., water quality vs. soil health); thus, a variety of recommendations may be needed depending on implementation planning objectives. RA practices that focus on reducing sediment and phosphorus from agricultural sources could be implemented in priority locations to provide the most benefit in meeting overall water quality goals. To pursue these objectives on tribal lands, the Prairie Band Potawatomi Nation Reservation could encourage and promote the following RA practices in priority locations:

- Cover crops
- Conservation crop rotations, emphasizing periods of continuous vegetation cover
- Reduced tillage, no-till, or residue management
- Riparian buffers, including livestock exclusion from water courses
- Streambank stabilization where needed
- Managed grazing, including adaptive multi-paddock systems
- Other management practices designed to protect water quality and promote soil and vegetation quality as needed

Information from local sources, site level assessment, or localized testing and analysis will be needed to inform RA practice implementation planning. The Prairie Band Potawatomi Nation could conduct regular water, soil, and crop monitoring to assess the progress of regenerative management and help adjust agricultural management as needed. Examples of such monitoring include:

- Chemical and biological monitoring of surface and ground waters to assess changes in water quality, sediment/nutrient loads, and stream biological health.
- Soil testing to assess changes in organic matter, infiltration capacity, and other measures of soil quality.
- Crop monitoring to track crop yields and quality and quality of pasture vegetation.

Note that monitoring must be carefully designed in order to provide a reliable basis for assessing change and progress toward management goals.

Caveats

- While there is abundant documentation of the effectiveness of conventional BMPs on water quality, there is comparatively scant data available on the effectiveness of such BMPs on soil health, direct benefits of soil health for water quality, and many of the claims for the broad benefits of RA.
- Much of the discussion of the benefits of RA has occurred outside of peer-reviewed scientific literature and is therefore subject to significant uncertainty.
- Consideration of the benefit-cost balance of RA must include accounting for environmental and ecosystem-level benefits, not just on-farm profitability.
- RA represents a long-term commitment; most research studies are relatively short-term (e.g., 1-3 years) and cannot be expected to reveal the full effects of sustained RA management.

- RA is not necessarily dependent on or defined by organic farming. Many RA practices can be accomplished outside of organic farming constraints.
- RA is more than a set of agronomic practices; principles of RA are integrally linked to the human community, supporting local food systems, social equity, cultural traditions, and environmental quality. While benefits of some of these features are difficult to quantify, their existence should be valued.
- Teague and Barnes (2017) and others have criticized conventional research into holistic managed grazing, suggesting that most grazing studies, for the sake of scientific rigor, examined rigidly applied treatments, precluding adaptive management, and what they collectively show is that without goal-oriented, creative and adaptive management, all forms of grazing management ('systems') are limited in their effectiveness. The overwhelming majority of those studies also were conducted at scales too small to incorporate diversity and unevenness of grazing (the process by which degradation occurs), collectively showing that small paddocks tend to be more evenly grazed.

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QA Statement

To support the development of Activities 1 to 6 for Technical Support for Prairie Band Potawatomi Nation's CWA 319 Nine Element-Based Planning, several quality control checks were performed during development of this deliverable, including reviews of data transfers from literature as well as editorial reviews. All identified errors were corrected before finalizing the deliverable.