Ozarks Environmental and Water Resources Institute (OEWRI)
Missouri State University (MSU)

Mississippi River Basin Healthy Watersheds Initiative (MRBI)
Watershed Assessment for:

Lower Apple Creek Watershed
(HUC-071401070404)

FINAL

Deliverable # 1 – Inventory of the Watershed
Deliverable # 2 – Resource Analysis of the Watershed
Deliverable # 3 –Identification of Conservation Needs

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SCOPE AND OBJECTIVES

In 2009, the U.S. Department of Agriculture through the National Resources Conservation Service (NRCS) began the Mississippi River Basin Healthy Watersheds Initiative (MRBI) to work with landowners to implement voluntary conservation practices designed to reduce nutrients entering the Gulf of Mexico. The goal of the MRBI program is to improve water quality, restore wetlands, and enhance wildlife habitat while ensuring the economic viability of agricultural lands in high-priority watersheds within the Mississippi River Basin (USDA, 2017). Agricultural runoff has persisted as a major contributor to nutrient loads in the Mississippi River Basin that are primarily linked with hypoxia in the Gulf (Burkhart and James, 1999). However, watershed-scale evaluations identifying specific pollution sources and the conservation practices needed to improve water quality are needed to aid field office staff responsible for working with landowners. Therefore, a comprehensive planning effort aimed at prioritizing specific landscapes, crop types, and the conservation practices available is needed to help NRCS field staff implement the MRBI program where it will be the most effective considering limited available resources.

The Missouri State Office of the NRCS contracted the Ozarks Environmental and Water Resources Institute (OEWRI) at Missouri State University (MSU) to perform a watershed assessment study on a 12-digit hydrologic unit code (HUC) watershed, the Lower Apple Creek (071401070404), located within the larger Upper Mississippi-Cape Girardeau watershed in southeast Missouri. Since the potential for groundwater contamination is high due to the area's karst topography, agricultural nonpoint source pollution has been identified as a major concern in the Upper Mississippi-Cape Girardeau watershed (MDNR 2014). Furthermore, a Healthy Watershed Plan developed in 2017 specifically recommends the reduction of stream bank erosion and implementation of agricultural best management practices within the Upper Mississippi-Cape Girardeau watershed (MDNR 2017). Two previous assessments completed for the Upper Apple Creek (071401050401) and Middle Apple Creek (071401050403) watersheds found pasture and cropland to be significant contributors to nonpoint source pollution accounting for up to 80% of nutrient and sediment loads in the watersheds (Reminga et al. 2019). Additionally, the assessments found bank erosion to be a significant contributor to sediment loads with most active bank erosion occurring along the main stem of Apple Creek. This study will complete the assessment of Apple Creek all the way to the Mississippi River.

The purpose of this assessment is to provide NRCS field staff with the necessary information to identify locations within the watershed where soil, slope, and land use practices have the highest pollution potential and to describe conservation practices that can be the most beneficial to improve water quality. The specific objectives of this assessment are to:

(1) Complete a comprehensive inventory of existing data in the watershed including information related to geology, soils, hydrology, climate, land use, and any existing biological or chemical monitoring data available;
(2) Perform a resource assessment of the watershed that includes analysis of the data gathered in the watershed inventory including identification of nonpoint source pollutants, water quality impairments, rainfall-runoff characteristics, and a field-based stream bank conditions assessment;
(3) Provide NRCS staff with information on the resource concerns within the watershed, specific field conditions that contribute that most to the water quality impairment, and what conservation practices should be implemented for the existing conditions to get the most water quality benefit.

DESCRIPTION OF THE WATERSHED

Location, Population, and Demographics

The Lower Apple Creek watershed is located within the larger Upper Mississippi-Cape Girardeau watershed (HUC-8# 07140105) that includes portions of southeast Missouri and southwest Illinois (Figure 1). The Lower Apple Creek (33,898 acres) is one of five watersheds that make up the Apple Creek-Mississippi River Basin (HUC-10# 0714010504). The headwaters of Apple Creek flow from southwest Perry County and northeast Bollinger County into Perry and Cape Girardeau Counties and then east to the confluence of the Mississippi River (Figure 1). The main stem of Apple Creek is along the border between Perry and Cape Girardeau counties. The towns of Frohna and Altenburg, Missouri are located along the northern watershed boundary and Pocahontas is in the southern portion of the watershed (Figure 2).

The Lower Apple Creek watershed is predominately rural and agriculturally focused area of the state, however, the population has grown over the last decade. Between 2010 and 2019, the total population of Perry County has increased 0.9% and Cape Girardeau County has increased 4.2% while the population of the entire state has increased 2.5% over that same time (Table 1). Cape Girardeau County may not be representative of the population living within the Lower Apple Creek watershed since the relatively large City of Cape Girardeau is within the county. Therefore, Perry County demographics will be used to characterize the population living in the watershed. The population of Perry County is predominately white (96.5%), with over half living in unincorporated areas, and a population density of 40 people per square mile. Per capita income is $26,609, with 5.4% of the population working in the agricultural industry, and the poverty rate is 7.4%.

Climate

Southeast Missouri has a warm and temperate continental climate with hot summers and moderate winters (Frankson et al. 2017; Peel, Finlayson, and McMahon, 2007). Over the 30 years from 1991-2020, the average annual rainfall at Jackson, Missouri ranged from 33.2-65.8 inches with an average of 50.4 inches per year (Table 2). The highest monthly rainfall totals (≥5 inches) occur during the spring the months of March, April and May, with generally less precipitation (<4 inches) during the early fall and late winter months (Figure 3A). From 1991 to 2020, average annual temperature ranged from 54.6-60.7°F with an average of 57.7°F (Table 2). Over that period, average monthly temperatures range from about 34°F in January to 80°F in July (Figure 3B). Over the last 30 years, there has been a slight but steady increase in precipitation (Figure 4A). Temperature trends show a minor decline since 1991 but have remained fairly consistent (Figure 4B). Annual temperatures showed a relative decrease in the 5-year moving average around 2003, 2008, 2013 and 2014 (Figure 4B). Solar radiation and evaporation trends are similar to monthly temperature trends for this watershed. From 2001-2020, average daily solar radiation by month ranged from 6.30 MJ/m2 in December up to 21.9 MJ/m2 in June with an average of 14.3 MJ/m2 (Figure 5A). For the same period, monthly average daily estimated evaporation ranged from about 0.03 inches in December to 0.19 inches in June with an average of 0.11 inches over the entire year (Figure 5B).

Geology, Topography, and Geomorphology

The Apple Creek watershed is located on the eastern edge of the Ozark Plateau Province of the Interior Highlands (USDA 2006). The area is characterized by broad, flat to gently rolling dissected plains underlain by Ordovician-age limestone and capped by glacial loess (Nigh and Schroeder, 2002). Elevations for the Lower Apple Creek watershed range from 324.6-748.6 feet (Figure 6). The Lower Apple Creek watershed is defined by relatively flat land in the western half of the watershed contrasted by steep, forested hills in the eastern section. Slope ranges from <3% to >45% percent with a majority of the land having a slope of between 4-15% (Figure 7). The highest slopes (>20%) are generally found along the hillslopes and valley margins of eastern portions of the watershed. Streams in the upper portions of the watershed are relatively steep with gravel bed loads and become less steep moving downstream where the valleys are entrenched into the bluffs near the Mississippi River (Nigh and Schroeder, 2002). Published regional curves have been developed for typical channel morphology analysis of streams in the Ozark Plateaus physiographic regions that can be used as a reference for channel geometry of streams for drainage areas less than 400 mi^2 (USDA, 2018a) (Figure 8).

Landscape and Soils

The Lower Apple Creek watershed is within the western portion of the Central Mississippi Valley Wooded Slopes Major Land Resource Area (MLRA) (USDA 2006). This MLRA includes the dissected hills and floodplains of the Mississippi River and the lower sloped karst plains further west. Loess is the dominant parent material for soils in these watersheds that is thickest near the Mississippi River and thinner moving upstream (Festervand 1986). The majority of soils in the watershed are alfisols which cover over 73% of the watershed (Table 3, Figure 9). Floodplain and valley bottom soils are mostly inceptisols and entisols while ultisols are found in the hillier northeast quarter of the watershed (Figure 9). Roughly two-thirds (68.3%) of the soils in the watershed are classified as hydrologic soil group (HSG) C which indicates moderately high runoff (Table 3, Figure 10) (USDA 2009a). Roughly 25% of the watershed features HSG B soils with relatively low runoff potential including floodplain soils along Flatrock and Shawnee Creeks and the forested hills in the northeast portion of the watershed (Figure 10). Floodplain soils along Apple Creek become more susceptible to runoff ranging from B/D to D soils as the stream nears the Mississippi (Figure 10).

Land Capability Classifications are used to determine the suitability of a soil to grow common field or pasture crops (USDA 2018b). Within the greater Apple Creek watershed, land capability classes range from classes (2-7) with (2) representing very slight to moderate limitations on use, and 7 representing very severe limitations on use that make them generally unsuited to cultivation. Land Capability is distinguished by subclasses of (e) erosion, (w) water, and (s) shallow, droughty, or stony (USDA 2018b). By far the most common capability subclass found in the watershed is 3e-7e (77.2% of the total) which limits plant selection or requires conservation practices due to susceptibility to erosion (Table 3, Figure 11). Lower Apple Creek also has soils with subclass (w) excess water/poor drainage in the floodplains and valley bottoms.

Soils within the watershed have high susceptibility to erosion. Soils were classified by soil erosion K-factor, which predicts the long-term average soil loss from sheet/rill erosion under annual crop systems and conservation practices. The majority of soils in the watershed featured K-Factors between 0.4-0.5 (78.7%) (Table 3, Figure 12). Additionally, of the remaining 21%, 18% feature a K-Factor ranging from 0.3-0.4 (Table 3, Figure 12). T-Factor represents the maximum amount of soil erosion that can occur while maintaining a soil's ability to grow plants (USDA, 2018(b). Around 97% of the watershed has a T-Factor of 4 or 5 tons per acre per year which suggests the watershed is susceptible to erosion, but also has a high soil loss tolerance (Table 3). A complete list of soil series found within the Lower Apple Creek watershed is available in Appendix A.

Hydrology and Drainage Network

Apple Creek begins in southern Perry County along State Highway 51 and flows east to the confluence with the Mississippi River in southeast Perry County and northeast Cape Girardeau County (Figure 2). Major tributaries to Lower Apple Creek include Flatrock Creek and Shawnee

Creek. There is a total of 102.1 miles of mapped streams within the watershed with only 37.8 miles of streams with permanent flow (Table 4). Reservoirs and ponds make up 25.9 acres within the watershed. There are two large wells along the southern border of the Middle Apple Creek watershed in Cape Girardeau County that belong to the Cape Girardeau and Perry Counties Public Water Supply District #1. From 2013-2017 these two wells pumped on average over 40 million gallons of groundwater per year (Table 10).

Land Use and Land Cover

Lower Apple Creek is split almost evenly between forest and agricultural lands. The western half of the watershed is made up of a mix of crop and pasture lands whereas the eastern portion is primarily forested (Figure 13). Agricultural land use is often located in valley bottoms or lower sloped landscapes (Figure 13). Land uses for the watershed were determined using the National Agricultural Statistics Service (NASS) Crop Database from 2016-2020. From 2016-2020, forest made up the highest percentage of land use within the watershed at 42.2%, followed by grass/pasture (23.0%) and cropland (21.0%) (Table 5, Figure 13). Over the last five years, grass/pasture have decreased by 9.4% while forest and cropland have increased by 2.5% and 3.6% respectively. The main crops grown in the watershed are soybeans, corn, and hay (non-alfalfa). Between 2016-2020, soybeans, corn and hay (non-alfalfa) production expanded by 1,585 acres and there was a 799 acre increase in forest land (Table 6). During that same period there was a 3,156 acre decrease in grass and pasture within the watershed. However, other crop types and land uses have remained fairly steady over that time. This suggests that there has been at least some conversion of grassland to cropland within the watershed over the last five years, as well as some grass and pastureland allowed to revert back to forest land.

Previous Work and Other Available Data

TMDLS and Management Plans

There are currently no Total Maximum Daily Loads (TMDLs) or watershed management plans within the larger Apple Creek watershed. However, there was a Healthy Watershed Plan developed for the large Upper Mississippi-Cape Girardeau watershed in conjunction with the Our Missouri Waters initiative by MDNR. This plan was developed by local stakeholders to identify challenges and develop priorities within the watershed (MDNR 2017). This plan outlines several priorities within this larger watershed, but specifically addresses the need to reduce stream bank erosion and utilize agricultural best management practices for cropland and pasturelands. Located upstream of the watershed, sinkholes and losing streams in the Upper Apple Creek and Middle Apple Creek watersheds are connected to the Cinque Hommes Creek through karst connections found using dye tracing methods (Figure 16). Currently, Cinque Hommes Creek is listed on the state 303d list of impaired waters due to *E. Coli* from rural nonpoint sources pollution with a TMDL scheduled to be completed in 2024-2028 (MDNR 2018a, MDNR 2018b). Additionally, there is a TMDL for the Mississippi River for high concentrations of Chlordane and PCBs in fish (MDNR 2006).

<u>Surface and Ground Water Monitoring Stations</u>

There are no United States Geological Survey (USGS) gaging stations in the larger Apple Creek watershed. To be able to predict discharge within the study watershed, 30 nearby USGS gaging stations were used to complete drainage area-based regression equations to estimate discharge from different size watersheds near the study area (Figure 14). A list of the USGS gaging stations can be found in Appendix B. Additionally, there are two wells that monitor groundwater levels located approximately 15 miles south of the watershed near Jackson, Missouri (Jackson, Site Number: 372521089362401) and approximately 25 miles west of the watershed where Perry, Bollinger, and Madison County intersect (National Lead, Site Number: 373559090082901). The Jackson station has been in place since 2007 and the National Lead location has been operational since 1960. Both wells show groundwater levels have steadily increased (Figure 15).

<u>Water Quality Sampling Data</u>

There are a total of six water quality monitoring sites within the larger Apple Creek watershed however there are none located in the Lower Apple Creek watershed. Four of these sites are located along the main stem in the Upper Apple Creek watershed, one is located at Apple Creek Spring in the Middle Apple Creek watershed, and one is located on Indian Creek several miles upstream of its confluence with Apple Creek (Figure 16). Summaries of water quality data from these monitoring locations can be found in previous reports (Reminga et al. 2019). There are three effective permitted point sources within the watershed including two for industrial stormwater and one for sewerage systems (Table 7).

<u>Biological Monitoring Data</u>

There are no biological monitoring stations or samples in Lower Apple Creek. Biological data was collected at the water quality monitoring site located furthest downstream along Apple Creek and upstream of the Lower Apple Creek watershed. The biological data examined at this monitoring station included eight samples of invertebrate biotic data collected between 2000-2013 (Reminga et al. 2019).

Summary

The purpose of this report is to provide the information necessary to describe and study the Lower Apple Creek (HUC-071401070404) watershed located within the larger Upper Mississippi-Cape Girardeau watershed for the Mississippi River Healthy Watershed Initiative

(MRBI). The purpose of the full watershed assessment is to provide NRCS field staff with the necessary information to identify locations within the watershed where soil, slope, and land use practices have the highest pollution potential and to describe conservation practices that can be the most beneficial to improve water quality. Therefore, this first phase of the project provides a general description of the watershed and inventories the data that will be used in subsequent phases of the project. Information collected for the initial phase of the project provides the geographical, physical, hydrological, and water quality attributes of the watershed along with documentation of available data sources (Table 8).

RESOURCE ANALYSIS OF THE WATERSHED

The resource analysis of the watershed will include evaluation of water quality data within the watershed, observed channel conditions from both historical aerial photography and an on-site visual assessment, and water quality modeling results and load reduction analysis. Ultimately these results will help establish what land uses are producing the most pollution and what practices would be the most useful in reducing nutrient and sediment loads within the watershed.

Water Quality Analysis

There are no water quality monitoring stations located within the Lower Apple Creek watershed, and no new data has been collected at established sites upstream. Available water quality data for the Apple Creek watershed is limited to two sites located upstream of the Lower Apple Creek watershed that have been detailed in a previous report. The most complete water quality dataset for nutrients of all the monitoring sites in the watershed is located along the main stem near the outlet of the Upper Apple Creek watershed (Reminga et al. 2019). The other site is located at Apple Creek Spring within the Middle Apple Creek watershed. The average TP concentration at the Apple Creek Spring site was about 2x higher than the average TP concentration in the main stem of Upper Apple Creek. This suggests groundwater may be susceptible to runoff through karst conduits and areas of known sinkholes and losing streams may be important areas to promote conservation practices. This also may indicate the Upper Apple Creek watershed may be receiving less pollution from agricultural runoff compared to the Middle Apple Creek watershed. Nutrient data collected from these two sites was compared to regional reference concentrations and indicates the spring has elevated TP concentrations. However, it is important to note the number of sites and the spatial and temporal distribution of samples in these two watersheds are limited.

Channel Stability and Riparian Corridor Assessment

Aerial Photo Methods

Channel adjustments or human-modifications to streams within the watershed were identified by comparing aerial photography from two different time periods. For this study, aerial photographs from 1996 and 2015 were obtained from the Missouri Spatial Data Information Service (MSDIS) online data server which came pre-rectified (Table 9). Streams channels for each year were digitized to identify and measure changes over time. Both bank lines were digitized for the main stem and larger tributaries. However, since many of these channels were small and some of the channel bank was obstructed by vegetation, the channel centerline was digitized where it could clearly be seen at a scale of 1:1,500 (Martin and Pavlowsky 2011). The error involved in the transformation was quantified using point-to-point error analysis. A total of 10 locations on both sets of aerials were evaluated for the point-to-point errors within the 12-digit HUC watershed boundary. Point-to-point errors ranged from 2.1- 23.8 ft across the watershed with a mean of 11.9 ft (Table 10). Therefore, channel changes had to exceed the average error distance to be considered significant using this method.

Channel Classification

Tributary channels and the main stem of the Lower Apple Creek watershed were further classified by identifying historical channel changes through the interpretation of aerial photos between 1996 and 2015. Channels were first characterized as “modified” or “natural”. Modified channels were then classified as either “channelized” or “dammed/ponded”. Natural channels were classified as “stable” or “active”. Active channels were identified by assessing planform changes since 1996 by overlay analysis of the digitized channel error buffer. This buffer is based on the mean point-to-point error for each watershed to account for biases attributed to rectification (Martin and Pavlowsky 2011). Active reaches were identified as areas where the error buffers did not overlap for at least 100 ft of stream length. If the channel was obstructed by vegetation, or not visible, in both aerials, it was classified as “not visible”. A flow chart was developed to assist in channel classification during aerial photo interpretation (Figure 17).

Channel classification analysis on the Lower Apple Creek watershed shows the majority of streams are stable and the number of active reaches within the watershed is relatively low. Of the total 235.9 stream miles in the watershed, 110.6 miles (46.7%) were stable (Table 11). Only 4.1 miles (1.7%) of streams were classified as active using these methods, with active reaches found predominantly along the main stem and near Apple Creek’s confluence with the Mississippi River (Figure 19). Modified (Channelized or Dammed/Ponded) streams made up a combined 60.0 miles (25.4%) of the total stream network. Of the remaining stream miles, 61.2 miles (26.0%) were not visible on both sets of aerials. Many of the channelized reaches were located along tributaries in agricultural areas. Finally, most dammed/ponded streams were located in either headwater streams or tributaries that were otherwise stable, or not visible. The relatively low percentage of active channels in the watersheds suggests it is possible that channel incision and widening may be a dominant mechanism for adjustment in these streams, and this effect may not be able to be determined through aerial photo analysis at this scale (Simon and Rinaldi 2000).

Riparian Corridor Analysis

The presence of a healthy riparian corridor can provide resistance to erosion during floods and filter runoff water moving from the uplands to the stream (Rosgen 1996, Montgomery and MacDonald 2002, USDA 2003). The riparian corridors for the watershed in this study were evaluated by creating a buffer around the 2015 digitized stream layer and overlaying that layer on the 2015 aerial imagery. A 50 ft buffer was used on first and second order streams and a 100 ft buffer was placed around streams third order and larger (USDA 2014). The area within the buffer was classified into the following: Good, Moderate, and Poor (Figure 18). A “Good” classification represents portions of streams in which adequate riparian tree coverage extends the width of the buffer on both sides of the stream. A “Moderate” class signifies one side of the stream buffer meets the good classification, but the other side does not. Alternatively, the Moderate classification can also indicate a situation where riparian coverage reaches the extent of the buffer, but the tree coverage is sparse. Finally, the “Poor” classification is assigned to portions of the stream where the riparian corridor does not extend to the limits of the buffer on either side of the stream.

Nearly 75% of riparian corridors along streams in the Lower Apple Creek watershed were classified as good or moderate, with the majority of the poor corridors found in the heavily agricultural areas of the watershed. A total of 77.9 stream miles (33%) was classified as having good riparian corridors, 97.4 miles (41%) were moderate, and 60.6 (26%) were classified as poor (Table 12). Good riparian corridors were typically found along the steep, forested headwater streams in the eastern portions of the watershed (Figure 20). In this area the poor corridors were generally confined to the valley bottoms. In contrast, poor and moderate corridors were found along the headwater and main channels draining the agricultural areas of the western half of the watershed. The Shawnee Creek watershed in particular has a high density of streams with poor riparian conditions.

Visual Stream Survey Results

A modified rapid visual stream survey was conducted both upstream and downstream of all public road crossings within the watershed following an established NRCS protocol (USDA 1998). The protocol was modified by only focusing on three physical stream channel indicators, a riparian corridor evaluation, and the presence of manure indicating livestock access to the stream (Appendix C). Based on the assessment, each site receives an overall score between 1 and 10, with <6.0 considered poor, 6.1 – 7.4 fair, 7.5 – 8.9 good, and >9.0 excellent. A total of 80 road crossings were visited for a total of 160 possible observations. However, 11 sites were not evaluated due to either having an established grass waterway or there was only a short reach before a confluence with a larger stream. Therefore, a total of 149 sites were ultimately completed. Of these 149 sites, 55.0% were rated as poor, 26.9% as fair, 13.4% as good, and 4.7% as excellent (Table 13).

The range of channel conditions within crop and pastureland generally follow the level of channel instability, quality of the riparian corridor, and density of canopy cover along the stream. The majority of channels in poor condition within the watershed appeared to have been actively widening with evidence of bank erosion along both banks. Due to the presence of bedrock along the bed, channel widening appears to be how streams adjust to watershed disturbances, and limit incision in most places. This scenario was suggested earlier in this report where limited bank erosion was detected using aerial photography that could not accurately detect channel widening. Additionally, poorly rated streams often also featured underdeveloped riparian zones and limited canopy cover. However, some streams with adequate riparian corridors also showed evidence of channel instability. Poor riparian conditions in croplands or pasture affected by direct livestock access to the stream were associated with some of the lowest stream assessment scores in the watershed. Channel conditions also varied some by location within the watershed. Many of the channels rated as "poor" are located in the central portion of the watershed in lowland agricultural areas (Figure 21). Wooded headwater streams in the eastern half of the watershed tended to be some of the highest scores in the watershed. Examples of the sites evaluated with overall scores can be found in Appendix D.

Rainfall–Runoff Relationship

Annual and monthly runoff rates for the Lower Apple Creek watershed were estimated using equations developed from USGS gaging stations in the region. Monthly runoff rates are important for understanding seasonal variability in runoff and how rainfall-runoff relationships may respond to land management. Additionally, annual runoff rates will be used to help validate the STEPL model hydrology results. A list of the equations used for this analysis of annual and monthly mean discharge values can be found in Appendix E. Mean annual discharge for the watershed is 65.1 ft^3/s and monthly average discharge peaks in the month of April and is lowest in September (Figure 22). Average runoff as a percentage of rainfall for the watershed was 31.6% with monthly mean runoff highest in late winter and early spring and lowest in the late summer and early fall ranging from just over 9% in September to 55% in

February. The remainder of the rainfall is either lost to evapotranspiration or moves through the soil into groundwater storage through infiltration (USDA 2009b). These estimates are supported by the literature where evapotranspiration rates for Missouri range from 60-70% (Sanford and Selnick 2013).

Water Quality Modeling

<u>STEPL Model</u>

Existing water quality loads in the watershed and the influence of best management practices (BMPs) on load reductions were estimated from a predictive model (STEPL). The Spreadsheet Tool for Estimating Pollutant Load (STEPL) uses simple algorithms to calculate nutrient and sediment loads from different land uses and load reductions from implementation of conservation practices on the landscape (Tetra Tech Inc. 2017). Annual nutrient loading was calculated based on the annual runoff volume and pollutant concentrations. The annual sediment load from sheet and rill erosion was calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. Loading reductions resulting from the implementation of conservation practices was computed from known efficiencies. Accuracy is primarily limited by the wide variability in event mean concentrations (EMCs) across watersheds since EMCs are used to calculate annual pollutant loadings.

For this study, each watershed was modeled with inputs following methods outlined in the STEPL user's guide. Model inputs include drainage area, soil hydrologic group, land use, animal numbers, and estimates on septic systems within the watershed. Land use was derived from the 2020 USDA Cropland data layer. Animal numbers were calculated per acre of pasture within the watershed using an animal number ratio of one animal per 2.5 acres of pastureland based on input from local staff. The number of septic systems within each watershed was based on an area ratio of the low intensity developed land use and provided by the STEPL online database. Details about the inputs for each watershed can be found in Appendix F.

Initial annual runoff predicted from the nearby USGS gages was about 45% higher than the modeled STEPL results for the Apple Creek watershed and rainfall-runoff data were adjusted to "calibrate" runoff volume within the model. Using default county based STEPL data the estimated annual runoff volume was 29,693 ac-ft compared to 47,130 ac-ft from the USGS gaging station equation estimate. To update the rainfall in the model the default STEPL rainfall total was adjusted from 46 to 54 inches based on the average 15-year average from nearby rain gaging stations detailed earlier in this report. This improved the modeled annual runoff to around 24% difference compared to the estimate based on local USGS gages. These adjustments show that higher recent rainfall totals in southeast Missouri are likely producing more runoff than in previous years (Pavlowsky et al., 2016). This also occurred during a previous assessment on the Upper and Middle Apple Creek watersheds where gage data from smaller regional streams provided a more accurate local discharge compared to STEPL estimates (Reminga et al., 2019). By using alternate gaging station equation and recent rainfall totals, estimated runoff from the STEPL model was within 11% of estimates from small gages as detailed in the previous assessment. This suggests that the runoff estimate from the STEPL model is producing results that are fairly close to the average observed conditions for the area. Further intensive hydrological analysis of regional gages and rainfall patterns in representative landscapes that would be required to fully understand the differences between the STEPL model and the predicted runoff from nearby gages is beyond the scope of this project.

Lateral stream bank erosion was accounted for by calculating length of actively eroding banks, migration rates from historical aerial photo analysis, and bank heights from a LiDAR digital elevation model (DEM) datasets identified earlier in this report. Annual migration rates were estimated by overlaying the bank lines from each aerial photo year. The areas between the 1996 and 2015 photos that did not overlap were used to create bank erosion polygons. Additionally, a buffer based on the point-to-point error analysis was used around each polygon to account for differences in the photos due to the rectification process. The final area of bank erosion was then divided by the length to calculate a mean width. The mean width was then divided by the number of years between photos to establish an average annual migration rate for each bank erosion polygon. This method identified a total of 140 eroding stream banks in the Lower Apple Creek watershed (Appendix G). Average area weighted eroding bank height was 10.1 ft with an average weighted migration rate of 1.2 ft/yr. These methods can only detect bank erosion due to lateral migration or excessive widening. More accurate bank erosion estimates, and sediment budget assessments are beyond the scope of this study.

Conservation practices have been implemented in the Lower Apple Creek watershed that need to be addressed in the existing load calculations. Estimates of the percentage of cropland with existing conservation practices was calculated based on input from area staff. In this watershed it was estimated that 10% of the cropland already had water and sediment control basins, 15% had cover crops, and 20% were using no-till. These estimates were used to calculate combined efficiencies within the STEPL model's BMP calculator and applied to the watershed. The resulting loads then will reflect a total load that takes these existing conservation practices into account. To assess model accuracy, results were compared to published nutrient and sediment yields from various land uses, as well as to a more sophisticated watershed model (Appendix H). This evaluation suggests that STEPL model results were fairly close, or slightly higher, than the alternative methods referenced, and the higher values can be partially explained by greater rainfall amounts over the last decade.

When assessing model results by sources for this watershed, the majority of the nutrient and sediment load is coming from agricultural nonpoint source pollution. However, streambank erosion is also contributing significantly to the total nutrient and sediment loads. Average yields for the Lower Apple Creek watershed were 9.8 lb/ac/yr for nitrogen, 2.5 lb/ac/yr phosphorus, and 1.8 T/ac/yr of sediment (Table 14). Cropland is the highest contributor of nutrients in the watershed accounting for 59.8% of the nitrogen load and 62.9% of the phosphorus load and the highest land use contributor to sediment load with 53.2% (Table 15). Streambank erosion contributes significantly to the total nutrient and sediment loads accounting for 12.1% of nitrogen, 17.1% phosphorus, and 36.6% of the total sediment load. These results suggest conservation practices aimed at cropland will be the most beneficial at reducing all loads from land use. However, sediment originating from bank erosion is a significant contributor and an effort to reduce bank erosion, particularly along the main stem of Apple Creek, would provide significant benefit to reducing NPS sediment loads.

Load Reduction Analysis

Load reductions for the watershed in this study were modeled with STEPL using established conservation practice efficiencies (Waidler et al. 2009, GSWCC 2013, Tetra Tech 2017). The efficiencies of combined practices were calculated with STEPL's BMP Calculator. A total of seven cropland conservation practice scenarios and eight pastureland scenarios were ultimately modeled. A description of each combined conservation practice scenario with calculated efficiencies can be found in Appendix I. Load reductions of nitrogen, phosphorus, and sediment were modeled based on the percentage of cropland and pastureland within the watershed that were treated. The result is a load reduction matrix for the watershed showing the load reduction for the different percentage of cropland and pastureland treated in 10% increments.

Cropland scenarios start with the use of cover crops as the first level of conservation practices and from there field borders, grassed waterways, grade stabilization, no-till, and water and sediment control basins were added or combined. Land retirement was also used as a scenario to show what would happen if the cropland was taken out of production. For pastureland, conservation practices included in the analysis were forage and biomass planting, alternative water, winter feeding facilities, critical area planting, access control, prescribed grazing, heavy use protection, grade stabilization, and livestock exclusion. Since the pastureland and cropland were modeled separately within each watershed, the combined load reductions can be added together for each watershed for a combined effect.

Load reduction analysis for the Lower Apple Creek watershed shows that the most beneficial conservation practices for the reduction of nutrients and sediment would be achieved on cropland while implementation of conservation practices on pastureland would help increase the total reduction benefit. Based on these reduction estimates, the maximum benefit from implementation of conservation practices on 100% of the crop and pastureland would be nearly a 60% reduction in nutrients and sediment (Tables 16-18). While implementation of conservation practices on 100% of the crop and pastureland in the watershed is very unlikely, the load reduction estimates can be used to track progress over time. For example, if cover crops and no-till were applied to 50% of the 10,862 acres of cropland (5,431 acres) within the watershed, load reduction would be 18.3% for nitrogen, 24.4% for phosphorus, and 22.1% for sediment. Additionally, applying prescribed grazing, alternative water, and heavy use protection to 50% of the 5,751 acres of pastureland (2,876 acres), the reduction for nitrogen would be 6.7%, phosphorus 3.5%, and sediment 2.8%. This combination would result in a total reduction of 25.0% for nitrogen, 27.9% for phosphorus, and 24.9% for sediment. Additionally, if all the cropland within the watershed was taken out of production, the resulting load reduction would be 53.1% for nitrogen, 57.9% phosphorus, and 52.9% sediment. These scenarios indicate cropland conservation practices can achieve the highest reductions of nutrients and sediment, however, by combining cropland and pastureland practices in this watershed these practices can substantially reduce nutrient and sediment loads in the watershed.

Summary

The purpose of this section of the report is to provide results of the resource analysis of the watershed (Deliverable #2) for the Mississippi River Basin Healthy Watersheds Initiative (MRBI) Watershed Assessment for the Lower Apple Creek Watershed (HUC-071401070404) within the larger Upper Mississippi-Cape Girardeau watershed. Agricultural nonpoint source pollution has been identified as a major concern in this region of the state and a Healthy Watershed Plan developed in 2017 specifically recommends reduction of stream bank erosion and implementation of agricultural best management practices within the Upper Mississippi-Cape Girardeau watershed (MDNR 2014, MDNR 2017). Two previous assessments completed for the Upper Apple Creek (071401050401) and Middle Apple Creek (071401050403) watersheds found pasture and cropland to be significant contributors to nonpoint source pollution accounting for up to 80% of nutrient and sediment loads in the watersheds (Reminga et al. 2019).

Both historical aerial photos and a visual stream assessment were used to evaluate potential contributions of streambank erosion to water quality problems within the watershed. Overall, there was very little of the stream network to was classified as active. Further, the majority of actively eroding reaches within the watershed were located along the main stem of the stream suggesting sediment being released though bank erosion is an important component of the total sediment load in the watershed. Due to the small size of the tributary streams within the watershed, overhead vegetation, and photo quality limitations, a complete classification of all the small tributary streams was not possible. Nearly 75% of riparian corridors along streams in the Lower Apple Creek watershed were classified as good or moderate, with the majority of the poor corridors found in the heavily agricultural areas of the watershed. However, visual stream survey results showed bank erosion appears to be prevalent through the process of channel widening that cannot be identified through aerial photo analysis at this scale. Also, these findings suggest that streams are adjusting to some disturbance that is not being mitigated by the presence of a forested riparian corridor at many locations.

Water quality model results show the majority of nutrients and sediment sources in the watershed are from agricultural nonpoint source pollution accounting for nearly 70% of the total load. However, streambank erosion is also contributing significantly to the total nutrient and sediment loads. These results suggest conservation practices aimed at cropland will be the most beneficial at reducing all loads from land use. However, sediment originating from bank erosion is a significant contributor and an effort to reduce bank erosion, particularly along the main stem of Apple Creek, would provide significant benefit to reducing NPS sediment loads. Load reduction analysis for the Lower Apple Creek watershed shows that the most beneficial conservation practices for reduction of nutrients and sediment would be achieved on cropland while implementation of conservation practices on pastureland would help increase the total reduction benefit.

IDENTIFICATION OF CONSERVATION NEEDS

Resource Priorities

For the Lower Apple Creek watershed, the top resource priority identified in this assessment is the reduction of sediment from nonpoint agricultural land use. Agricultural nonpoint source pollution has been identified as a major concern in the Upper Mississippi-Cape Girardeau watershed and basin-scale watershed planning documents recommends implementation of agricultural best management practices to address pollution concerns (MDNR 2014, MDNR 2017). Two previous assessments completed for the Upper Apple Creek (071401050401) and Middle Apple Creek (071401050403) watersheds found pasture and cropland to be significant contributors to nonpoint source pollution accounting for up to 80% of nutrient and sediment loads in the watersheds (Reminga et al. 2019). Therefore, the resource priority for this watershed is basically a continuation of the Middle Apple Creek priorities along with appropriate conservation practices for the area. Load reduction estimates suggest implementation of conservation practices on cropland can have a much higher rate of reduction compared to pastureland practices. Total cropland area for the watershed is 10,862 acres. Furthermore, the trend over the last five years is for more land to be converted to cropland. Therefore, implementing cropland conservation practices will be the most effective in reducing sediment loads as this land use type generates higher pollutant loads and many of the crop practices are more efficient at reducing loads.

Conservation Planning

One of the main goals of this project is to use this assessment to help guide where conservation practices would be the most beneficial to meet water quality goals. This will be accomplished by using a management unit ranking, a susceptible acres classification, and a conservation practice rating system.

Management Units

To better plan for locations to implement conservation practices, the HUC-12 watershed was divided into 10 smaller watersheds, or management units (MU) (Figure 23). MUs will allow field staff to evaluate potential projects based on a system that would rank geographic areas within the watershed. STEPL was used to estimate sediment yields for each management unit with drainage areas ranging from 2,652-3,862 acres (Table 19). The MU with the highest sediment yield (4.44 T/ac/yr) is #10, which includes the main stem of Apple Creek. This is due to bank erosion along the main channel and high banks particularly near the mouth. The 4 MUs with the next highest sediment yields (all <2.0 T/ac/yr) are located along Shawnee Creek, Blue Shawnee Creek that starts near Pocahontas, and the unnamed tributary draining from Frohna. The two MUs with the lowest sediment yield are those in the mostly wooded eastern half of the watershed where agricultural land use is only found along the valley bottoms. Overall, isolating specific areas within the watershed that are potentially generating higher sediment loads will eventually help guide conservation practice implementation strategies.

Susceptible Acres Classification

To identify areas with the most pollution potential within a proposed project, a vulnerable acres ranking system was developed to help field staff isolate problem areas and prioritize projects within the same MU. Four risk classes were used to rank the agricultural land within the watershed based on the resources analysis of the watershed, STEPL modeling, and the VSA. Highest Risk land represents the most critical areas for pollution potential from the landscape and should be prioritized for planning. High Risk are areas that have significant risk as a pollution source, but not as high as the Highest Risk category. The Moderate Risk category could see potential gains from conservation practices but are a lower priority. Low Risk lands have adequate treatment of the landscape. Remaining areas of urban land use and water were classified as "other". A description of each class type is detailed below and summarized in Table 20.

Highest Priority – For these watersheds the highest vulnerability classification for conservation planning was based on cropland and pasture located on high slopes, erodible soils, and soils with high runoff potential. Pastureland on HSG C and D with slopes >6% was placed into the highest category. Also, cropland located on slopes >8% and on erodible soils. Erodible soils were identified using the Erodibility Index (EI) (USDA 2019). The EI is the ratio of potential erodibility (PE) to the soil loss tolerance (T). Soils were classified as highly erodible when EI ≥8. The EI for all of the soil series within the watershed were calculated using a series of equations detailed here.

Equation 1.
Potential Erodibility (PE) is calculated using:

PE = R x K x LS

Where:
R = rainfall and runoff (Wischmeier and Smith 1978)
K = susceptibility of the soil to water erosion (from soil survey)
LS = combined effect of slope length and steepness (See Equation 2 below)

Equation 2.
The LS is calculated as follows:

$$LS = (0.065 + (0.0456 \times S) + (0.006541 \times S^2)) \times (SL \div C)^{NN}$$

Where:
S = slope% (from soil survey)
SL = Slope length (from soil survey)
C = constant 22.1 metric (72.5 English units)
NN = see value below

- If S <1, then NN = 0.2
- If S ≤1 and <3, then NN = 0.3
- If S ≤3 and <5, then NN = 0.4
- If S ≥5, then NN = 0.5

Equation 3.
The EI is calculated as follows:

EI = PE/T

Where:
PE = potential erosion
T = soil loss tolerance (from soil survey)

Within the watershed, 4,467 acres are classified in the highest priority category, or roughly 13.2% of the watershed area (Figure 24).

High Priority – Cropland located on soils with an EI ≥8 and on slopes <8% were placed in the high vulnerability category for conservation planning. Also, pastureland in HSG C or D and slopes ≤6% and pasture located on soils with HSG B and slopes >6% were also included in this category. There is a total of 9,045 acres of high priority acres in the watershed, or about 26.7% of the total drainage area.

Moderate Priority - Land within the moderate priority category would be all remaining crop and pastureland within the watershed. This totals 3,302 acres, or 9.7% of the total area of the watershed.

Low Priority - Low priority acres was defined as all of the forested areas within the watershed. Within the watershed there are 14,781 low priority acres, or 43.6% of the total area.

N/A – This category represents all urban land use and land classified as water or wetlands within the watershed. This represents 2,303 acres, or 6.8% of the total land area.

Conservation Practice Ranking

The final part of the conservation planning portion of this project is to identify the conservation practices that are best suited to help reduce sediment loads in the Lower Apple Creek watershed. For this, each conservation practice, or combination of conservation practices, was ranked based on the highest benefit per acre treated for each watershed. Ranking was based on the percentage of sediment reduction achieved by each practice or combination of practices. Cropland practices make up the top five rankings for the watershed (Table 21). This is a result of cropland having a relatively higher load per acre and cropland conservation practices having relatively high efficiency ratings. Pastureland conservation practices rank in the bottom half of all practices identified in this project because pastureland has a relatively lower sediment load and conservation practices have lower efficiencies compared to conservation practices on cropland. While this analysis suggests treating cropland would ultimately be more efficient in reducing sediment loads, this analysis does not include economic or social aspects that may prohibit or encourage certain practices over others.

SUMMARY - DOCUMENTATION OF RESOURCE AND CONSTITUENT CONCERNS

The purpose of this report is to provide the Missouri State office of the NRCS the results of a watershed assessment study of the Lower Apple Creek (HUC-071401070404) in Perry and Cape Girardeau Counties in Missouri. This assessment supports the Mississippi River Basin Healthy Watersheds Initiative (MRBI) designed to work with landowners to implement voluntary conservation practices to reduce nutrients entering the Gulf of Mexico. The goal of the MRBI program is to improve water quality, restore wetlands, and enhance wildlife habitat while ensuring economic viability of agricultural lands in high-priority watersheds within the Mississippi River Basin (USDA, 2017). Ultimately, this watershed assessment provides NRCS field staff with the necessary information to identify locations within the study watersheds where soil, slope, and land use practices have the highest pollution potential and to describe conservation practices that can be the most beneficial to improve water quality. The assessment included three phases, 1) resource inventory, 2) resource analysis, and 3) identification of resource needs. There are six main conclusions for this assessment:

1) The Lower Apple Creek Watershed is included in the Healthy Watershed Plan developed for the large Upper Mississippi-Cape Girardeau watershed in conjunction with the Our Missouri Waters initiative by the MDNR. This plan was developed by local stakeholders to identify challenges and develop priorities within the watershed (MDNR 2017). This plan outlines several priorities within this larger watershed, but specifically addresses the need to reduce stream bank erosion and utilize agricultural best management practices for cropland and pasturelands. Two previous assessments completed for the Upper Apple Creek (071401050401) and Middle Apple Creek (071401050403) watersheds found pasture and cropland to be significant contributors to nonpoint source pollution accounting for up to 80% of nutrient and sediment loads in the watersheds (Reminga et al. 2019). This study completes the assessment of Apple Creek all the way to the Mississippi River;

2) Historical aerial photo analysis was used to identify potential contributions of streambank erosion to water quality problems within the study watersheds. Overall, there was very little of the stream network that was classified as active. Further, the majority of actively eroding reaches within the watershed were located along the main stem of the stream suggesting sediment being released though bank erosion is an important component of the total sediment load in the watershed. Due to the small size of the tributary streams within the watershed, overhead vegetation, and photo quality limitations, a complete classification of all the small tributary streams was not possible;

3) Nearly 75% of riparian corridors along streams in the Lower Apple Creek watershed were classified as good or moderate, with the majority of the poor corridors found in the heavily agricultural areas of the watershed. However, visual stream survey results showed bank erosion appears to be prevalent through the process of channel widening that cannot be identified through aerial photo analysis at this scale. Also, these findings suggest that streams are adjusting to some disturbance that is not being mitigated by the presence of a forested riparian corridor at many locations;

4) Water quality model results show the majority of nutrients and sediment sources in the watershed are from agricultural nonpoint source pollution accounting for nearly 70% of the total load. However, streambank erosion is also contributing significantly to the total nutrient and sediment loads. These results suggest conservation practices aimed at cropland will be the most beneficial at reducing sediment loads in the watershed. However, sediment originating from bank erosion is a significant contributor and an effort to reduce bank erosion, particularly along the main stem of Apple Creek, would provide significant benefit to reducing NPS sediment loads;

5) For the Lower Apple Creek watershed, the top resource priority identified in this assessment is the reduction of sediment from nonpoint agricultural land use. Load reduction estimates suggest implementation of conservation practices on cropland can have a much higher rate of reduction compared to pastureland practices. Total cropland area for the watershed is 10,862 acres. Furthermore, the trend over the last five years is for more land to be converted to cropland. Therefore, implementing cropland conservation practices will be the most effective in reducing sediment loads as this land use type generates higher pollutant loads and many of the crop practices are more efficient at reducing loads; and

6) Management units, susceptible acres, and conservation practice rankings were all created to help field staff prioritize areas and evaluate potential projects. Management units direct conservation practices to specific areas of the watershed. Susceptible acres within management units can be used to evaluate projects within management units. Finally, conservation practices are ranked in order of effectiveness for cropland and pastureland.

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TABLES

Table 1. Census data from Perry and Cape Girardeau Counties 2010-2019.

Census Category	County		
	Perry	Cape Gir.	Missouri
Population 2010	18,971	75,674	5,988,927
Population 2019*	19,136	78,871	6,137,428
Population Change 2010-2019	165	3,197	148,501
% Change 2010-2019	0.9%	4.2%	2.5%
% White	96.5%	87.5%	82.9%
% Black	0.7%	7.9%	11.8%
% Hispanic	2.5%	2.5%	4.4%
% Other	0.3%	2.1%	0.9%
Population/mi^2	40	136	89
HUC12 Area (mi^2)	53.1	53.1	NA
HUC12 Population Est.	2,124	7,222	NA
Income per capita	$26,609	$28,267	$30,810
% Poverty	7.4%	16.4%	12.9%
% Population working in ag industry**	5.4%	1.6%	1.7%
% Living in Unincorporated Areas	52.1%	27.9%	33.7%

* Estimate

** Includes agriculture, forestry, fishing and hunting, and mining

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Table 2. Annual rainfall and average annual temperature for Jackson, MO (1991-2020).

Year	**Total Rainfall (in)**	**Average Temperature (F°)**
1991	45.8	59.8
1992	36.6	58.0
1993	49.9	57.0
1994	49.0	58.2
1995	46.7	57.6
1996	50.7	56.8
1997	47.2	57.1
1998	52.0	60.7
1999	43.3	59.4
2000	40.2	58.1
2001	49.3	59.0
2002	63.4	58.4
2003	42.6*	56.2*
2004	44.5	58.3
2005	47.8	58.4
2006	62.5	57.4
2007	40.0	58.4
2008	63.5	55.2
2009	60.3	56.2
2010	39.9	57.2
2011	65.8	57.2
2012	33.2	59.9
2013	53.2	55.1
2014	46.9	54.6
2015	60.3	57.3
2016	49.2	58.9
2017	45.4	58.7
2018	54.8	57.3
2019	64.8	56.9
2020	63.8	57.3
n	30	30
Min	33.2	54.6
Mean	50.4	57.6
1991	45.8	59.8

data source: http://mrcc.isws.illinois.edu/CLIMATE/

Missing data were retrieved from nearby stations: *Perryville, MO

Table 3. Watershed soil characteristics summary.

Soil Order	**%**	**Hydrologic Soil Group**	**%**	**Soil Erosion K-Factor**	**%**	**Soil Erosion T-Factor**	**%**	**Land Capability Classification**	**%**
Alfisol	72.6	B	22.6	<0.2	0.0	0	0.6	2w	1.3
Entisol	3.8	B/D	3.3	0.2-0.3	0.3	3	2.4	3w	16.5
Inceptisol	12.9	C	68.3	0.3-0.4	18.0	4	12.4	4w	2.4
Ultisols	10.0	C/D	2.2	0.4-0.5	78.7	5	84.6	5w	0.3
Other	0.7	D	3.0	>0.5	2.7			2e	1.7
		Water	0.6	Other	0.6			3e	18.8
								4e	20.7
								6e	14.4
								7e	23.3
								2s	0.0
								Other	0.6

Table 4. Drainage network summary.

Water Feature	**Length/Area**
Total Streams	102.1 mi
Permanent Flow	37.8 mi
Intermittent Flow	64.3 mi
Waterbodies	
Lakes/Ponds	25.9 ac

Table 5. Generalized crop data classification from 2016-2020.

General Land Use/Land Cover	**Year**					**2016-2020 Average**
	2016	**2017**	**2018**	**2019**	**2020**	
Cropland	19.5%	20.1%	20.8%	21.6%	23.1%	21.0%
Hay and Alfalfa	7.8%	7.1%	7.7%	7.7%	8.9%	7.8%
Grassland/Pasture	26.4%	27.1%	25.6%	18.7%	17.0%	23.0%
Developed	4.0%	4.0%	4.1%	4.5%	4.5%	4.2%
Forest	41.4%	40.6%	40.4%	44.9%	43.9%	42.2%
Water/Wetlands	1.0%	1.2%	1.4%	2.7%	2.7%	1.8%

Table 6. Selected specific crop data from 2016-2020 with five-year total change.

Class Name	**Year**					**2016-2020 Change (acres)**
	2016	**2017**	**2018**	**2019**	**2020**	
Corn	7.3%	6.5%	8.1%	6.6%	8.3%	+340
Soybeans	9.8%	11.3%	11.1%	10.9%	12.2%	+816
Other Hay/Non Alfalfa	8.9%	7.4%	7.4%	6.8%	7.6%	+429
Developed/Open Space	2.3%	2.3%	2.3%	2.9%	2.9%	+203
Deciduous Forest	41.3%	40.6%	40.3%	44.7%	43.7%	+799
Grassland/Pasture	26.4%	27.1%	25.6%	18.7%	17.0%	-3,156

Table 7. Permitted point sources within the watershed.

Site Number	Facility Name	Type	Stream	Waste	Status
1	East Perry Lumber Co.	Storm Water Outfall	Tributary of Apple Creek	Industrial storm water	Effective
2	Beech Manufacturing Inc.	Storm Water Outfall	Tributary of Apple Creek	Industrial storm water	Effective
3	Pocahontas Waste Water Treatment Facility	Outfall	Muddy Shawnee Creek	Sewerage Systems	Effective

Table 8. Data and source summary with web site address.

Data Needed	Source	Agency	Within Watershed	Nearby Watershed	Website
HUC 8 Watershed	National Hydrography Dataset	USGS	x		https://nhd.usgs.gov
HUC 10 Watershed	National Hydrography Dataset	USGS	x		https://nhd.usgs.gov
HUC 12 Watershed	National Hydrography Dataset	USGS	x		https://nhd.usgs.gov
Stream Network	National Hydrography Dataset	USGS	x		https://nhd.usgs.gov
Soils (polygons)	NRCS Geospatial Data Gateway	USDA	x		https://datagateway.nrcs.usda.gov
Soils (attributes)	NRCS Web Soil Survey	USDA	x		https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
Precipitation	Cli-mate	MRCC	x		http://mrcc.isws.illinois.edu/CLIMATE/
Temperature	Cli-mate	MRCC	x		http://mrcc.isws.illinois.edu/CLIMATE/
Solar Radiation	Missouri Climate Center	UMC		x	www.climate.missouri.edu
Evapotranspiration	Missouri Climate Center	UMC		x	www.climate.missouri.edu
Elevation (LiDAR)	MSDIS	UMC	x		http://msdis.missouri.edu/
Geology	MSDIS	UMC	x		http://msdis.missouri.edu/
Land Use/Land Cover	National Agricultural Statistics Service	USDA	x		www.nass.usda.gov
Hydrology	National Water Information System	USGS		x	https://waterdata.usgs.gov/nwis/rt
Groundwater Levels	Groundwater Watch	MDNR		x	https://groundwaterwatch.usgs.gov
Major Water Users	MSDIS	MDNR		x	http://msdis.missouri.edu/
Point Sources	MSDIS	MDNR	x		http://msdis.missouri.edu/
Water Quality	MDNR Water Quality Assessment System	MDNR		x	http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do

HUC = Hydrologic Unit Code
WWTF = Waste Water Treatment Facility
NRCS = National Resource Conservation Service
MSDIS = Missouri Spatial Data Information Service
USGS = United States Geological Survey
USDA = United States Department of Agriculture
MRCC = Midwest Regional Climate Center
UMC = University of Missouri-Columbia
MDNR = Missouri Department of Natural Resources

Table 9. Aerial photography used for channel change analysis.

Photo Year	Source	Type	Resolution (ft)
1996	USGS	Black and White Photo	3.3
2015	USGS	Color High Resolution	0.5

Table 10. Point-to-point (PTP) errors by watershed.

Watershed	Range PTP Error (ft)	Mean PTP Error (ft)
Lower Apple Creek	2.1 – 23.8	11.9

Table 11. Channel classification analysis summary.

Watershed	Total Length (mi)	Channelized	Pond/Dam	Stable	Active	Not Visible
Lower Apple Creek	235.9	39.7 (16.8%)	20.3 (8.6%)	110.6 (46.9%)	4.1 (1.7%)	61.2 (26.0%)

Table 12. Riparian corridor analysis summary.

Watershed	Total Length (mi)	Good	Moderate	Poor
Lower Apple Creek	235.9	78.0 (33.1%)	97.3 (41.2%)	60.6 (25.7%)

Table 13. Visual Stream Assessment survey scores and classification

Watershed	Total Assessments	Poor (< 6.0)	Fair (6.1 - 7.4)	Good (7.5 - 8.9)	Excellent (> 9.0)
Lower Apple Creek	149	82 (55.0%)	40 (26.9%)	20 (13.4%)	7 (4.7%)

Table 14. STEPL model results.

Watershed	Total Ad (ac)	Runoff (ac-ft)	Runoff Yield (ac-ft/ac)	% Rainfall as Runoff	Annual Load			Annual Yield			Mean Concentration		
					N-lb/yr	P-lb/yr	Sed-t/yr	N-lb/ac/yr	P-lb/ac/yr	Sed-t/ac/yr	N-mg/L	P-mg/L	Sed-mg/L
Lower Apple Creek	33,898	36,921	1.1	24.2	332,533	86,112	61,920	9.8	2.5	1.8	3.31	0.86	1,233

Table 15. STEPL results by sources.

Sources	N Load (lb/yr)	%	P Load (lb/yr)	%	Sediment Load (t/yr)	%
Urban	16,735	6.1%	2,586	3.5%	384	0.7%
Cropland	164,484	59.8%	47,0077	62.9%	30,321	53.2%
Pastureland	98,059	14.7%	15,206	5.3%	6,170	2.2%
Forest	19,880	7.2%	8,394	11.2%	4,200	7.4%
Septic	23	<1%	9	<1%	0	0.0%
Streambank	33,351	12.1%	12,840	17.1%	20,845	36.6%
Total	332,533	100.0%	86,112	100.0%	61,920	100.0%

Table 16. Nitrogen load reduction results.

Areas highlighted in gray indicate percentage of land with existing conservation practices.

List of Practices in Deliverable	Nitrogen load reduction by % of land treated									
Cropland	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Cover Crop	0.8	1.6	2.3	3.1	3.9	4.7	5.4	6.2	7.0	7.8
Field Border	3.8	7.6	11.4	15.3	19.1	22.9	26.7	30.5	34.3	38.2
Grassed Waterways	3.8	7.6	11.4	15.3	19.1	22.9	26.7	30.5	34.3	38.2
Grade Stabilization Structure	4.3	8.6	12.8	17.1	21.4	25.7	29.9	34.2	38.5	42.8
Cover Crop and No-Till	3.7	7.3	11.0	14.7	18.3	22.0	25.7	29.4	33.0	36.7
Water and Sediment Control Basin	4.2	8.5	12.7	16.9	21.2	25.4	29.7	33.9	38.1	42.4
Land Retirement	5.3	10.6	15.9	21.2	26.5	31.8	37.1	42.4	47.8	53.1
Pastureland	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Forage and Biomass Planting	0.3	0.6	0.9	1.3	1.6	1.9	2.2	2.5	2.8	3.1
Alternative Water	0.3	0.7	1.0	1.3	1.6	2.0	2.3	2.6	3.0	3.3
Winter Feeding Facilities	0.8	1.6	2.5	3.3	4.1	4.9	5.7	6.5	7.4	8.2
Critical Area Planting	0.5	1.1	1.6	2.1	2.6	3.2	3.7	4.2	4.7	5.3
Access Control	0.7	1.4	2.0	2.7	3.4	4.1	4.8	5.4	6.1	6.8
Prescribed Grazing, Alternative Water, and Heavy Use Protection	1.3	2.7	4.0	5.4	6.7	8.1	9.4	10.7	12.1	13.4
Grade Stabilization Structure	1.7	3.4	5.1	6.8	8.5	10.2	11.9	13.6	15.2	16.9
Livestock Exclusion, Alternative Water, and Heavy Use Protection	1.2	2.3	3.5	4.7	5.9	7.0	8.2	9.4	10.6	11.7

Table 17. Phosphorus load reduction results.

Areas highlighted in gray indicate percentage of land with existing conservation practices

List of Practices in Deliverable	Phosphorus load reduction by % of land treated									
Cropland	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Cover Crop	0.6	1.2	1.8	2.4	3.0	3.5	4.1	4.7	5.3	5.9
Field Border	4.1	8.3	12.4	16.6	20.7	24.9	29.0	33.2	37.3	41.4
Grassed Waterways	4.2	8.4	12.6	16.8	21.0	25.2	29.5	33.7	37.9	42.1
Grade Stabilization Structure	4.7	9.4	14.1	18.8	23.5	28.3	33.0	37.7	42.4	47.1
Cover Crop and No-Till	4.9	9.7	14.6	19.5	24.4	29.2	34.1	39.0	43.9	48.7
Water and Sediment Control Basin	5.2	10.4	15.5	20.7	25.9	31.1	36.3	41.5	46.6	51.8
Land Retirement	5.8	11.6	17.4	23.2	28.9	34.7	40.5	46.3	52.1	57.9
Pastureland	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Forage and Biomass Planting	0.1	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.7
Alternative Water	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
Winter Feeding Facilities	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Critical Area Planting	0.4	0.8	1.2	1.7	2.1	2.5	2.9	3.3	3.7	4.1
Access Control	0.6	1.2	1.8	2.5	3.1	3.7	4.3	4.9	5.5	6.2
Prescribed Grazing, Alternative Water, and Heavy Use Protection	0.7	1.4	2.1	2.8	3.5	4.2	4.9	5.6	6.3	7.0
Grade Stabilization Structure	0.9	1.9	2.8	3.7	4.7	5.6	6.5	7.4	8.4	9.3
Livestock Exclusion, Alternative Water, and Heavy Use Protection	0.8	1.7	2.5	3.4	4.2	5.1	5.9	6.8	7.6	8.4

Table 18. Sediment load reduction results.

Areas highlighted in gray indicate percentage of land with existing conservation practices

List of Practices in Deliverable	Sediment load reduction by % of land treated									
Cropland	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Cover Crop	0.6	1.1	1.7	2.2	2.8	3.3	3.9	4.5	5.0	5.6
Field Border	3.6	7.2	10.9	14.5	18.1	21.7	25.4	29.0	32.6	36.2
Grassed Waterways	3.6	7.2	10.9	14.5	18.1	21.7	25.4	29.0	32.6	36.2
Grade Stabilization Structure	4.2	8.4	12.5	16.7	20.9	25.1	29.3	33.4	37.6	41.8
Cover Crop and No-Till	4.4	8.8	13.3	17.7	22.1	26.5	30.9	35.3	39.8	44.2
Water and Sediment Control Basin	4.8	9.6	14.4	19.2	24.0	28.8	33.5	38.3	43.1	47.9
Land Retirement	5.3	10.6	15.9	21.2	26.5	31.8	37.1	42.3	47.6	52.9
Pastureland	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Forage and Biomass Planting	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alternative Water	0.1	0.3	0.5	0.6	0.8	1.0	1.1	1.3	1.5	1.6
Winter Feeding Facilities	0.3	0.7	1.0	1.4	1.7	2.1	2.4	2.8	3.1	3.5
Critical Area Planting	0.4	0.7	1.1	1.5	1.8	2.2	2.5	2.9	3.3	3.6
Access Control	0.5	1.1	1.6	2.1	2.7	3.2	3.8	4.3	4.8	5.4
Prescribed Grazing, Alternative Water, and Heavy Use Protection	0.6	1.1	1.7	2.2	2.8	3.3	3.9	4.4	5.0	5.5
Grade Stabilization Structure	0.6	1.3	1.9	2.6	3.2	3.9	4.5	5.2	5.8	6.5
Livestock Exclusion, Alternative Water, and Heavy Use Protection	0.7	1.4	2.1	2.7	3.4	4.1	4.8	5.5	6.2	6.9

Table 19. Annual sediment yield ranked by Management Unit.

Watershed ID	Total Ad (ac)	Crop Acres	Pasture Acres	Annual Sed. Yield-t/ac/yr	Priority Rank
10	3,862	1,512	382	4.44	1
1	3,528	737	511	2.45	2
5	2,652	926	641	2.16	3
9	3,282	1,660	687	2.14	4
2	2,866	1,274	771	2.02	5
3	3,573	1,558	814	1.74	6
4	3,553	1,376	833	1.45	7
6	3,545	1,183	776	1.29	8
7	3,308	368	132	1.25	9
8	3,729	294	207	1.05	10

Table 20. Summary of susceptibility classification for the watershed.

Susceptible Acres Rank	**Land Use and Conditions**	**Acres**
Highest	Cropland on soils with EI ≥8 and slope ≥8 Pasture on Hydrologic Soil Group C or D and slope >6%	4,467 (13.2 %)
High	Cropland on soils with EI ≥8 and slope <8% Pasture on Hydrologic Soil Group C or D and slope ≤6% Pasture on Hydrologic Soil Group B and slope >6%	9,045 (26.7 %)
Moderate	Remaining Cropland Remaining Pasture	3,302 (9.7 %)
Low	Forest	14,781 (43.6 %)
N/A	Urban Water and Wetlands	2,303 (6.8 %)

Table 21. Ranked conservation practices by largest sediment load reduction.

Rank	List of Practices in Deliverable
1	CROPLAND - Water and Sediment Control Basin
2	CROPLAND - Cover Crop and No-Till
3	CROPLAND - Grade Stabilization Structure
T-4	CROPLAND - Grassed Waterways
T-4	CROPLAND - Field Border
6	PASTURELAND - Livestock Exclusion, Alternative Water, and Heavy Use Protection
7	PASTURELAND - Grade Stabilization Structure
8	CROPLAND - Cover Crop
9	PASTURELAND - Prescribed Grazing, Alternative Water, and Heavy Use Protection
10	PASTURELAND - Access Control
11	PASTURELAND - Critical Area Planting
12	PASTURELAND - Winter Feeding Facilities
13	PASTURELAND - Alternative Water
14	PASTURELAND - Forage and Biomass Planting

FIGURES

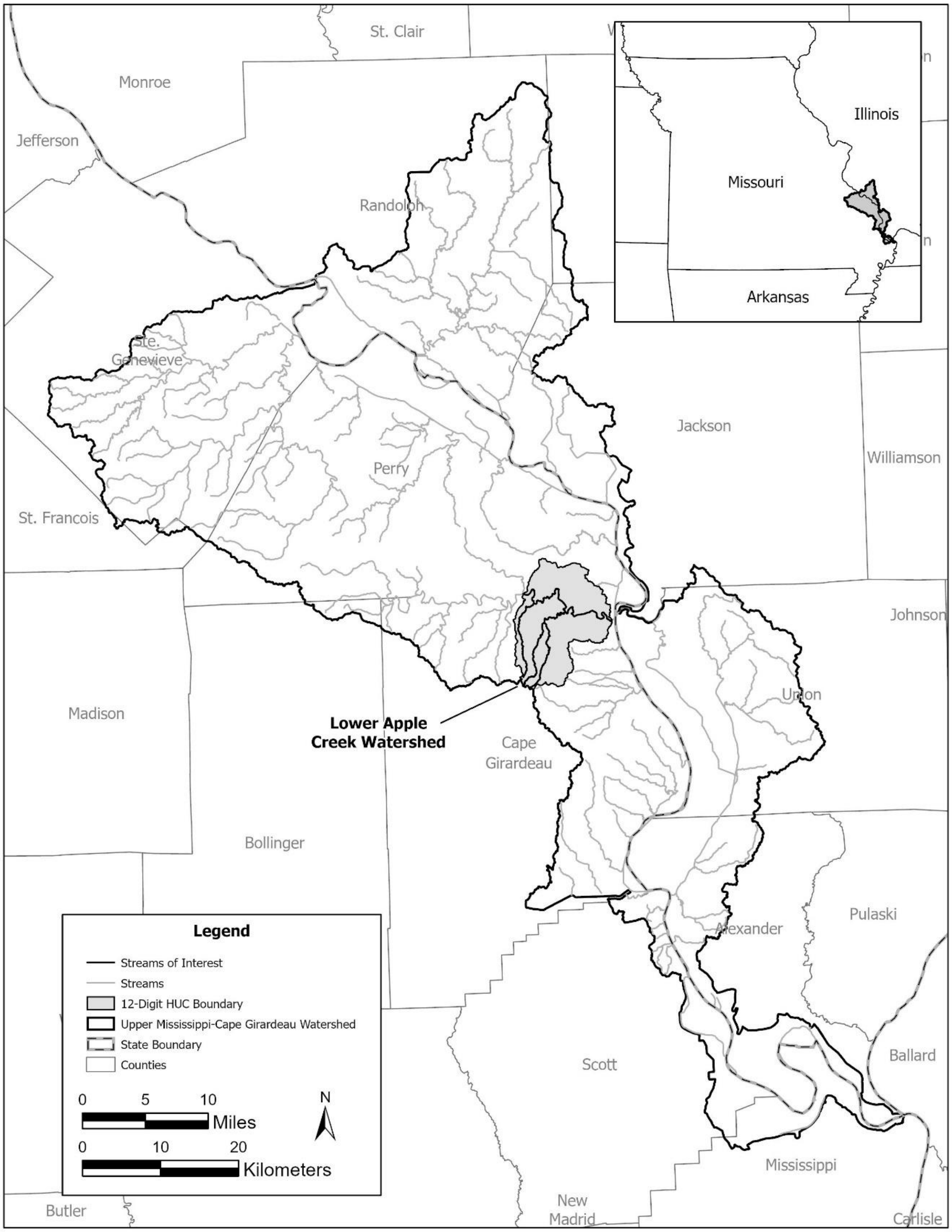


Figure 1. Upper Mississippi-Cape Girardeau Watershed in Southeast Missouri.

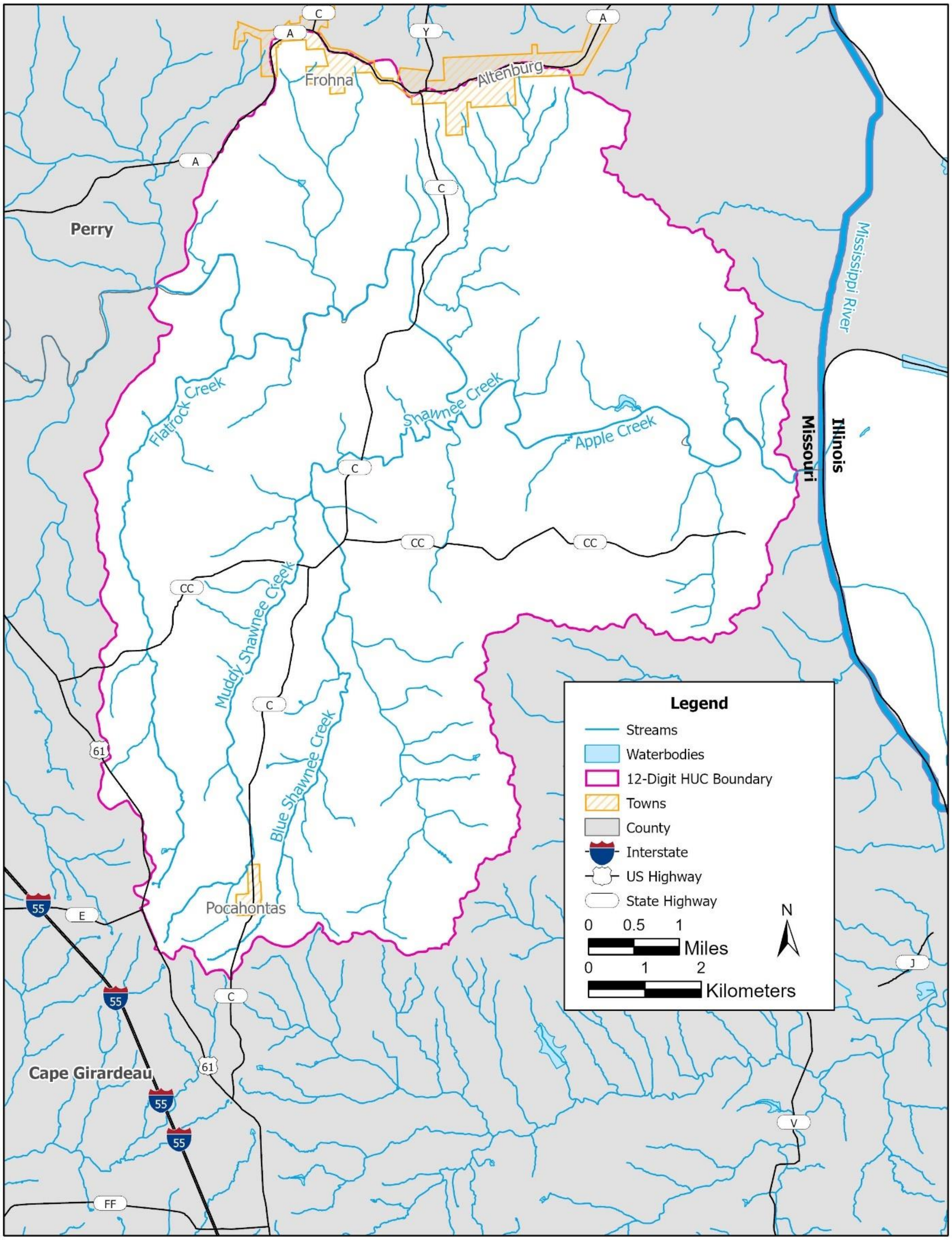


Figure 2. Lower Apple Creek watershed.

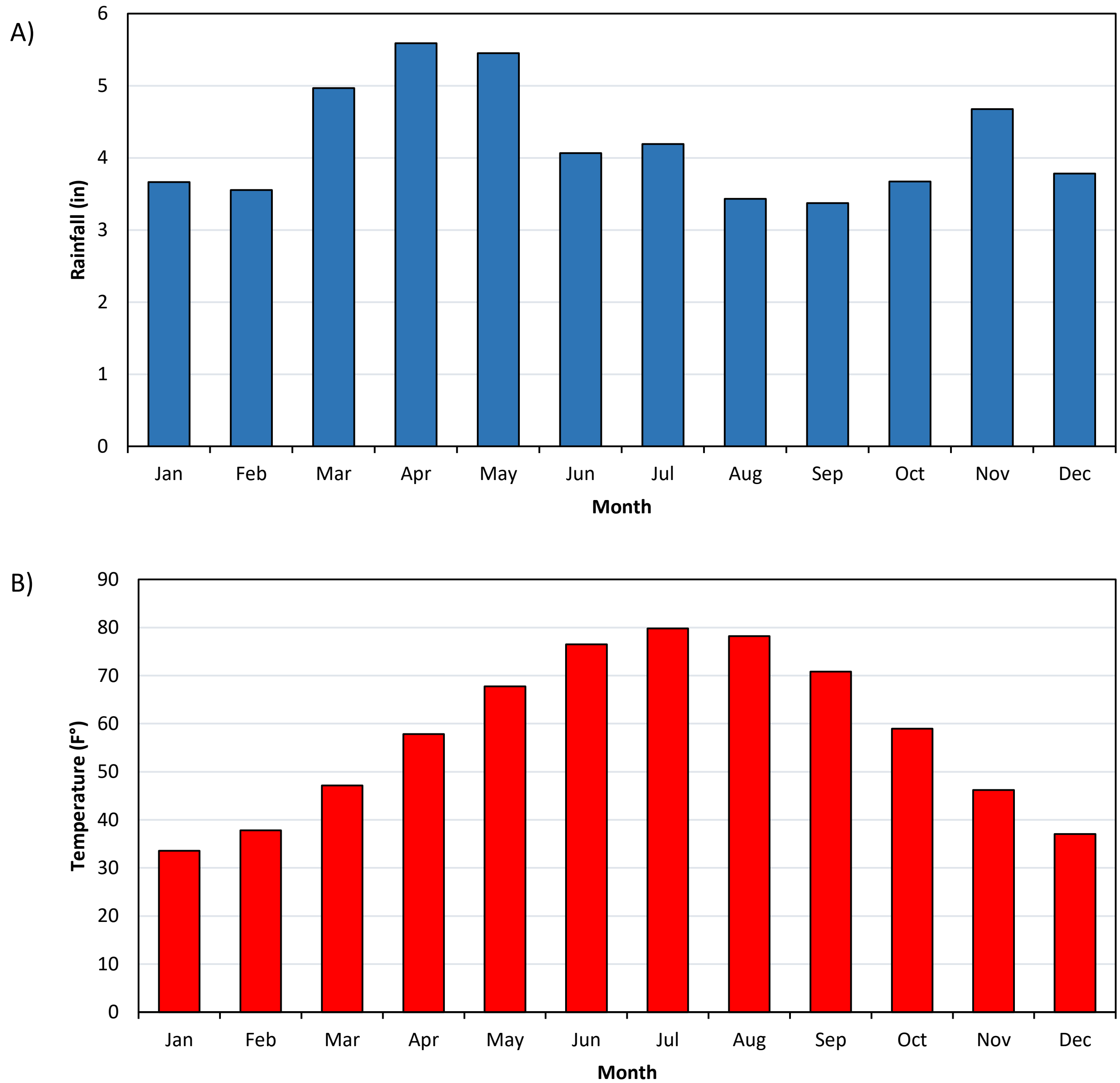
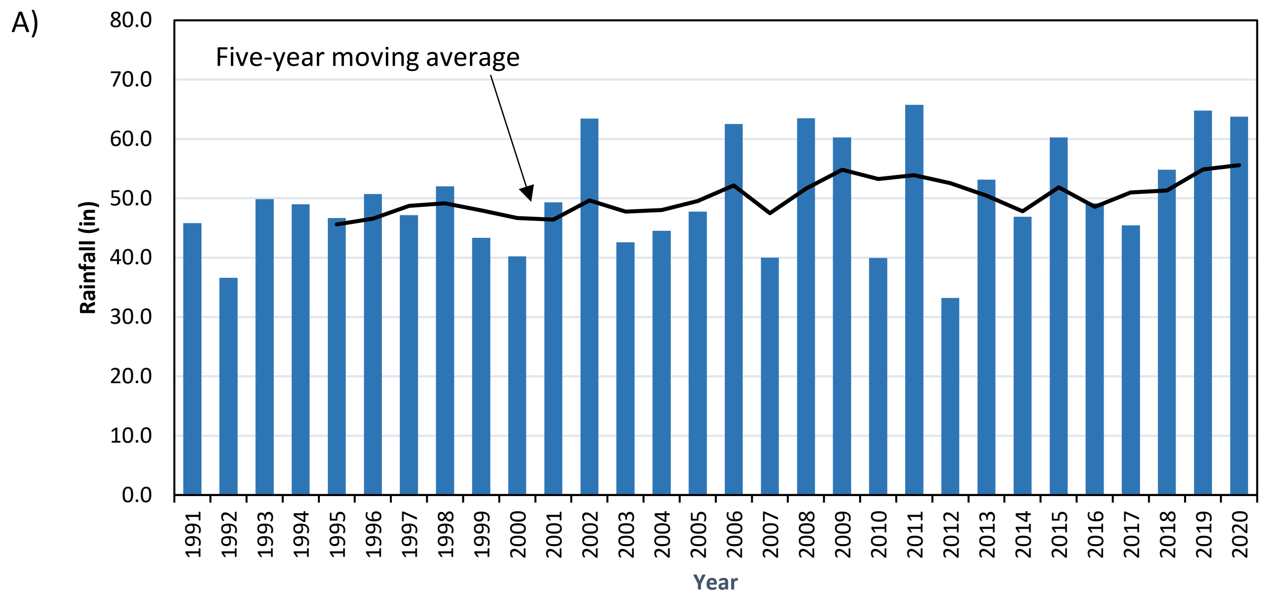


Figure 3. Mean monthly A) rainfall and B) temperature from 1991-2020 for Jackson, MO.



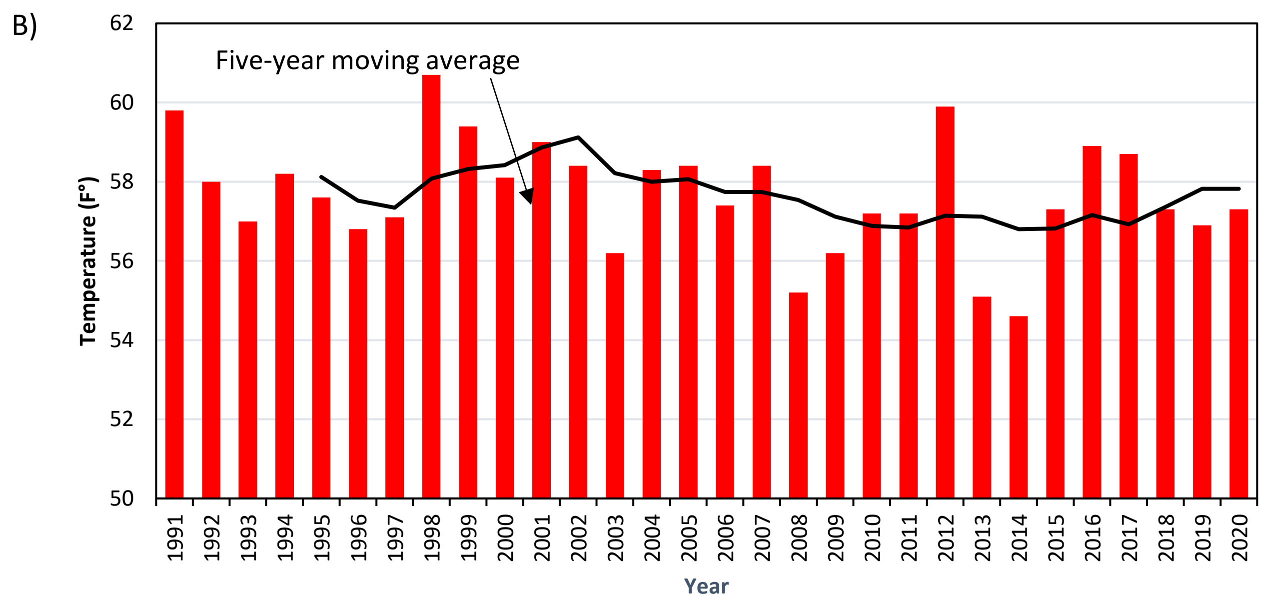


Figure 4. A) Annual total rainfall and B) average annual temperature from 1991-2020 for Jackson, MO.

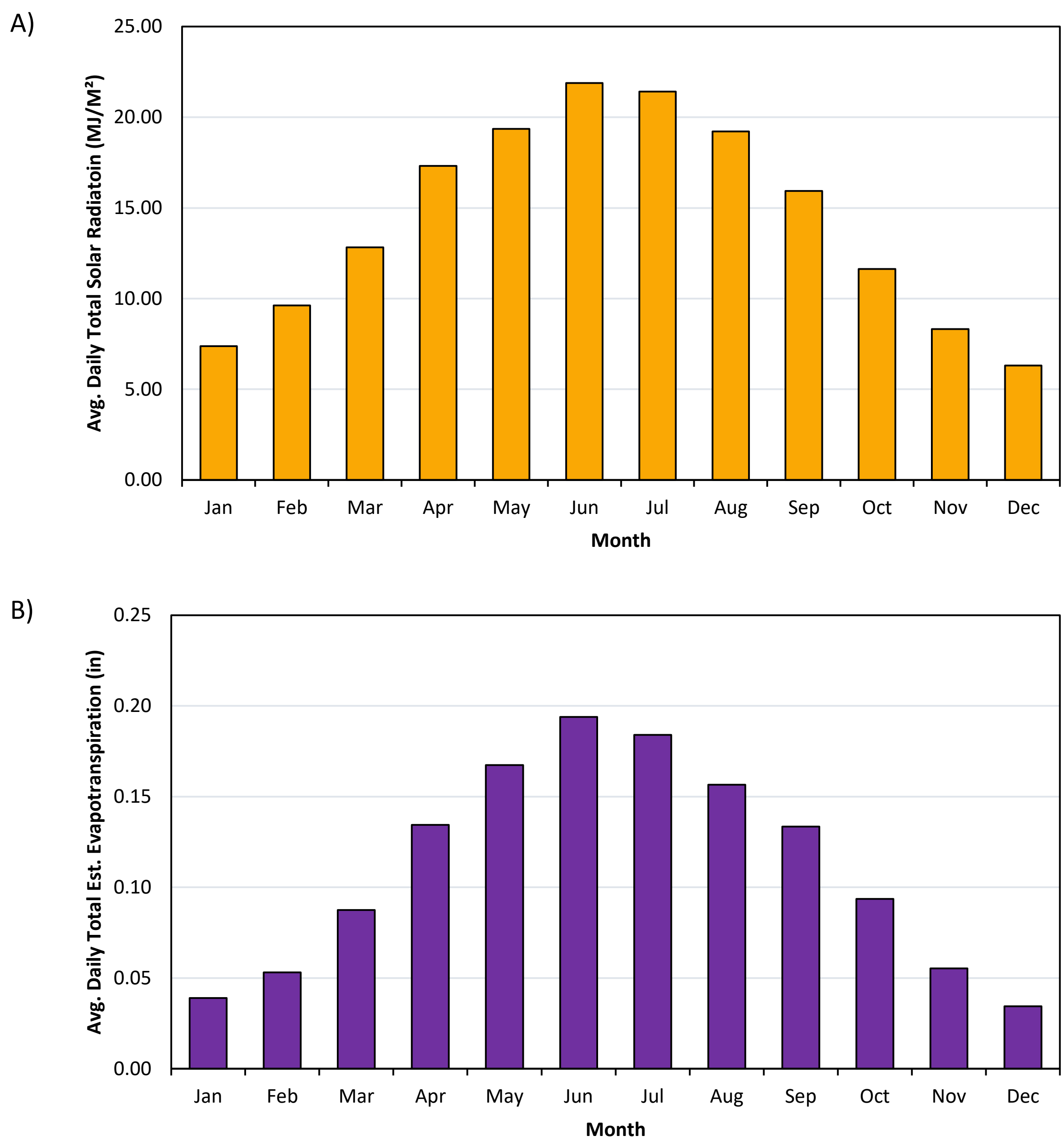


Figure 5. Average daily A) solar radiation (2001-2020) for Delta, Cape Girardeau County MO and B) estimated evaporation (2011-2020) for Portageville, Pemiscot County MO.

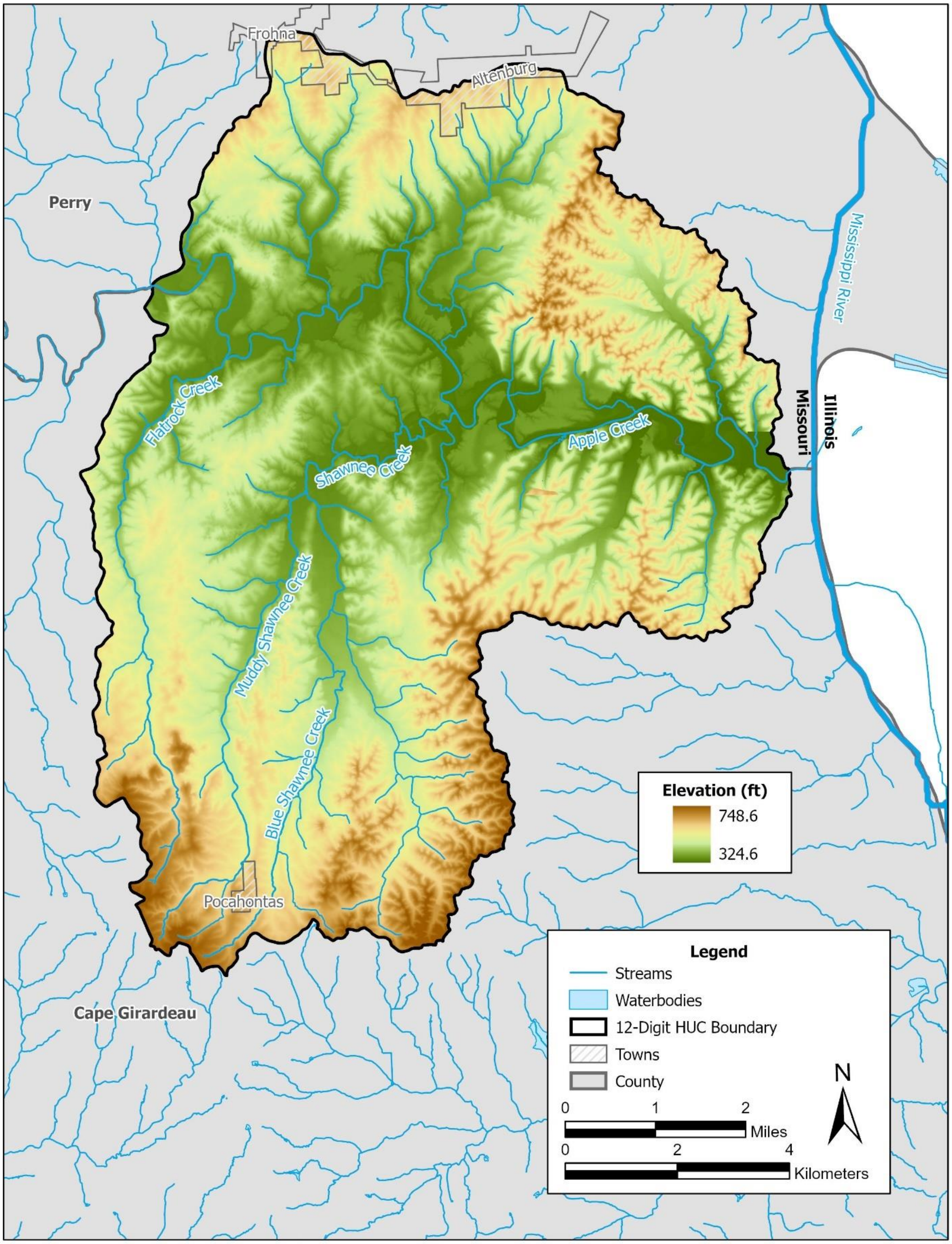


Figure 6. LiDAR elevations within the watershed (ft).

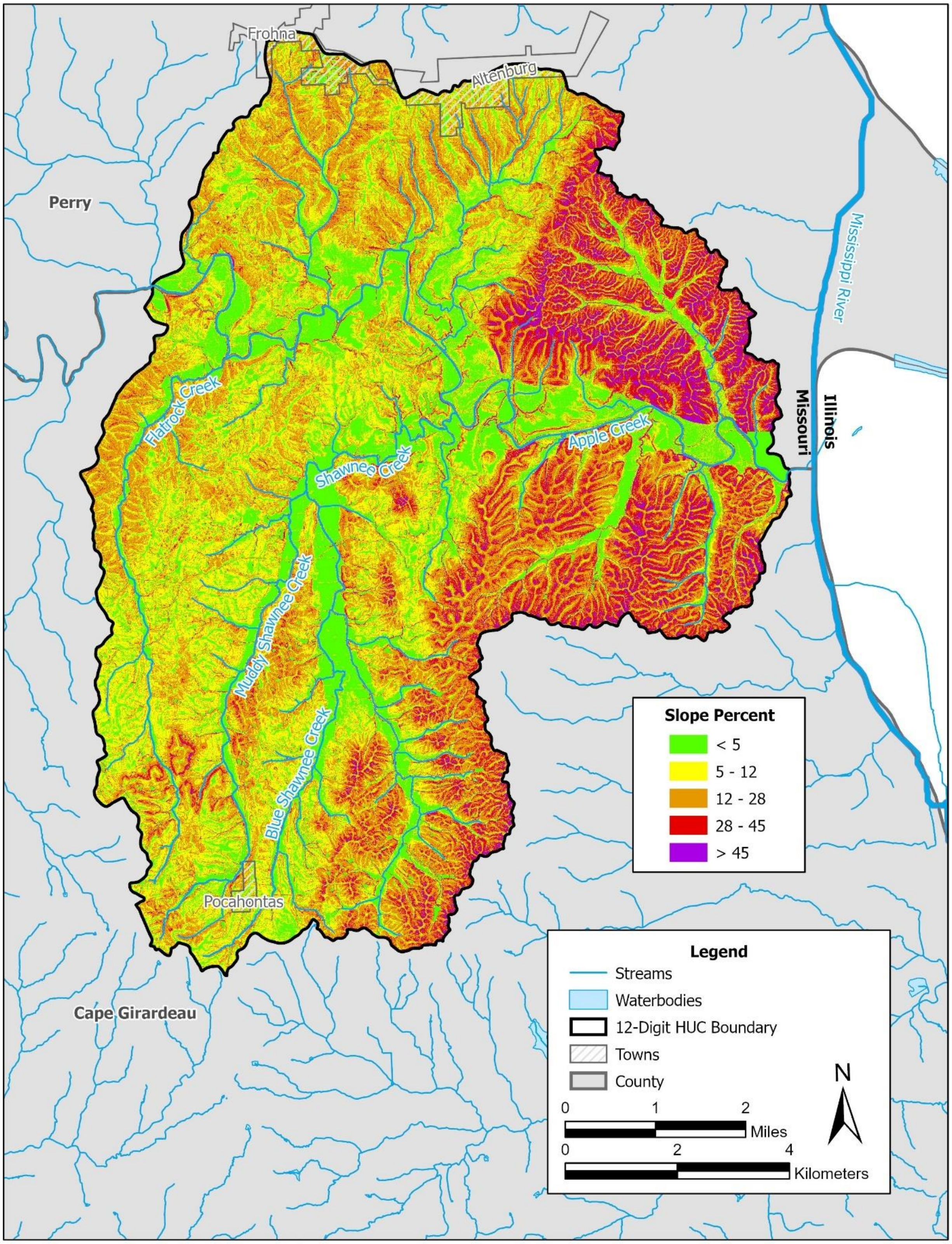


Figure 7. LiDAR based slope classification across the watershed.

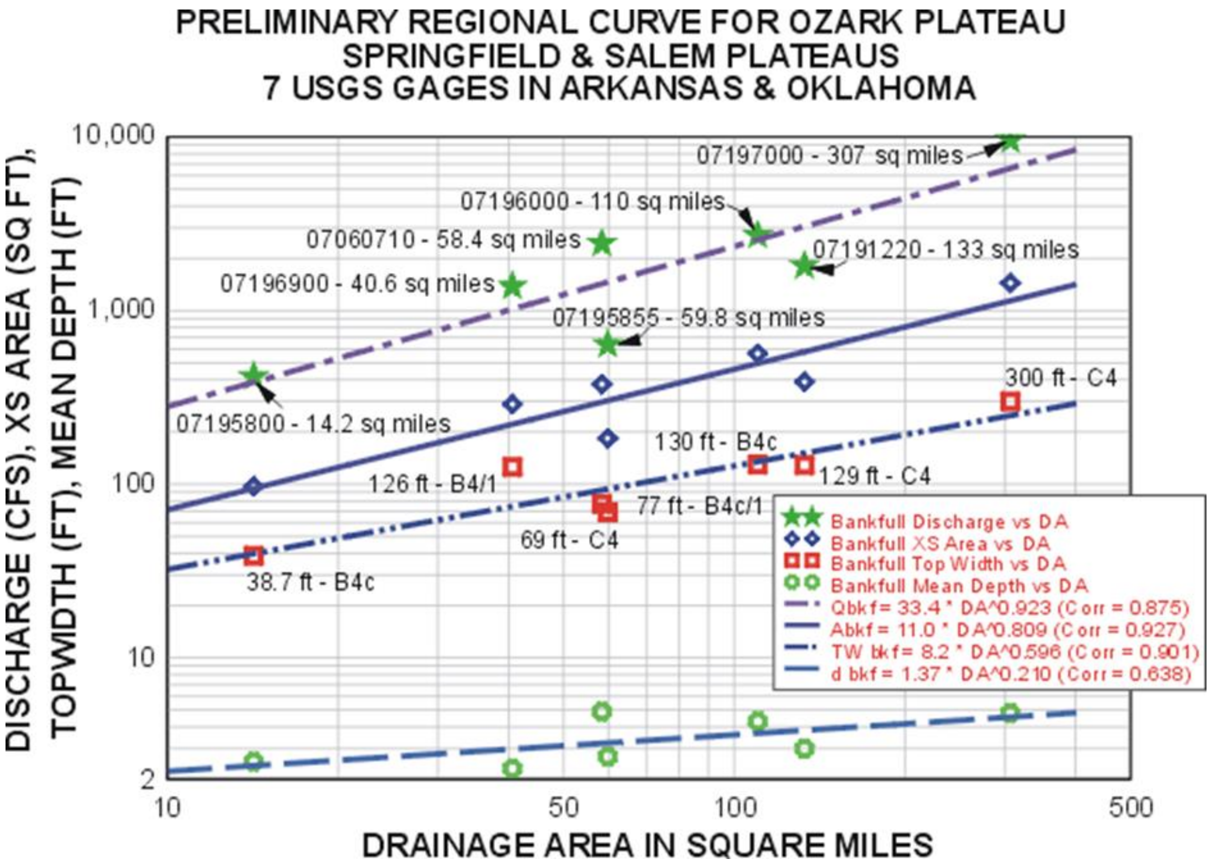


Figure 8. Regional Channel geometry curves for Springfield and Salem Plateaus. Source: NRCS-National Water Management Center.

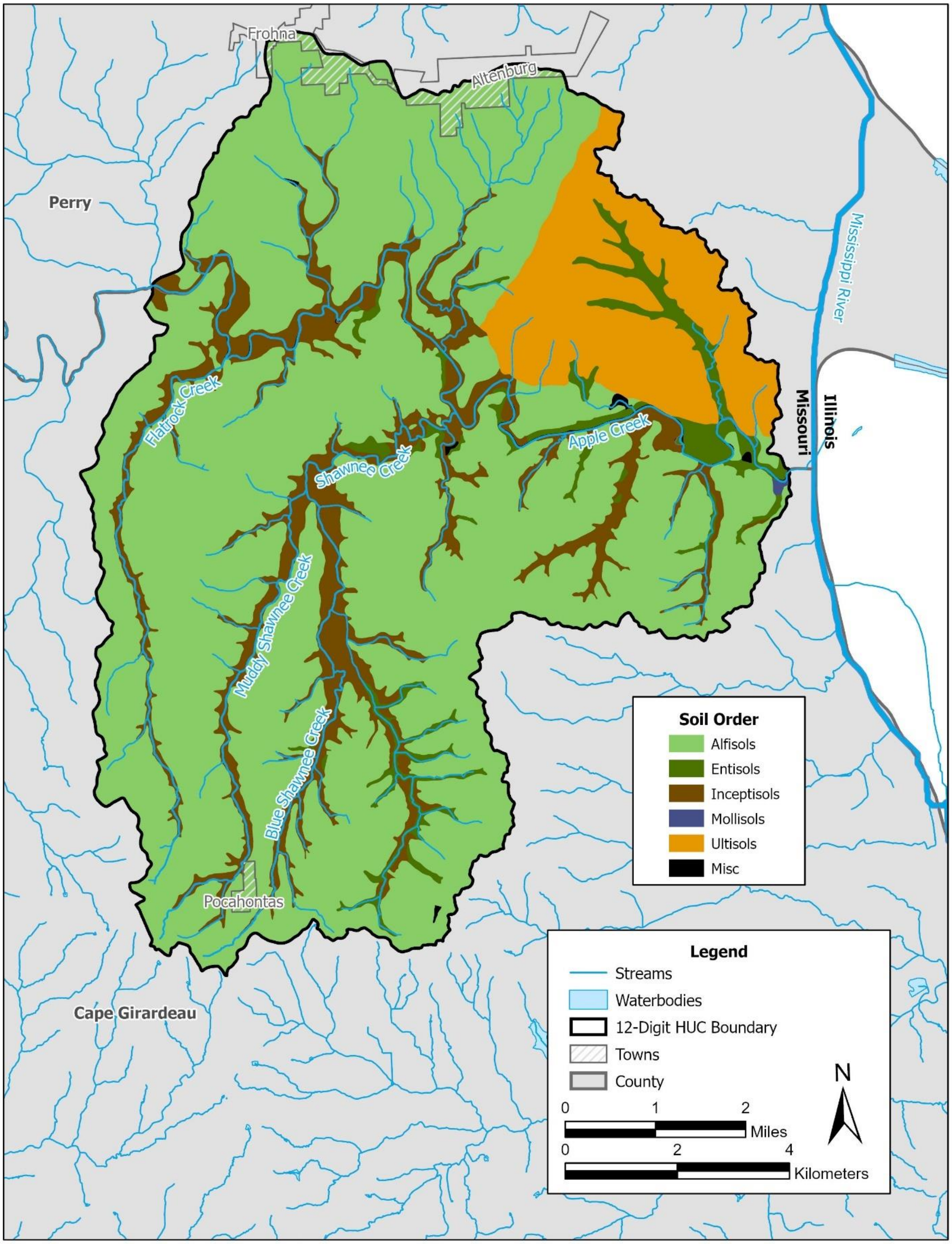


Figure 9. Soil series classified by order.

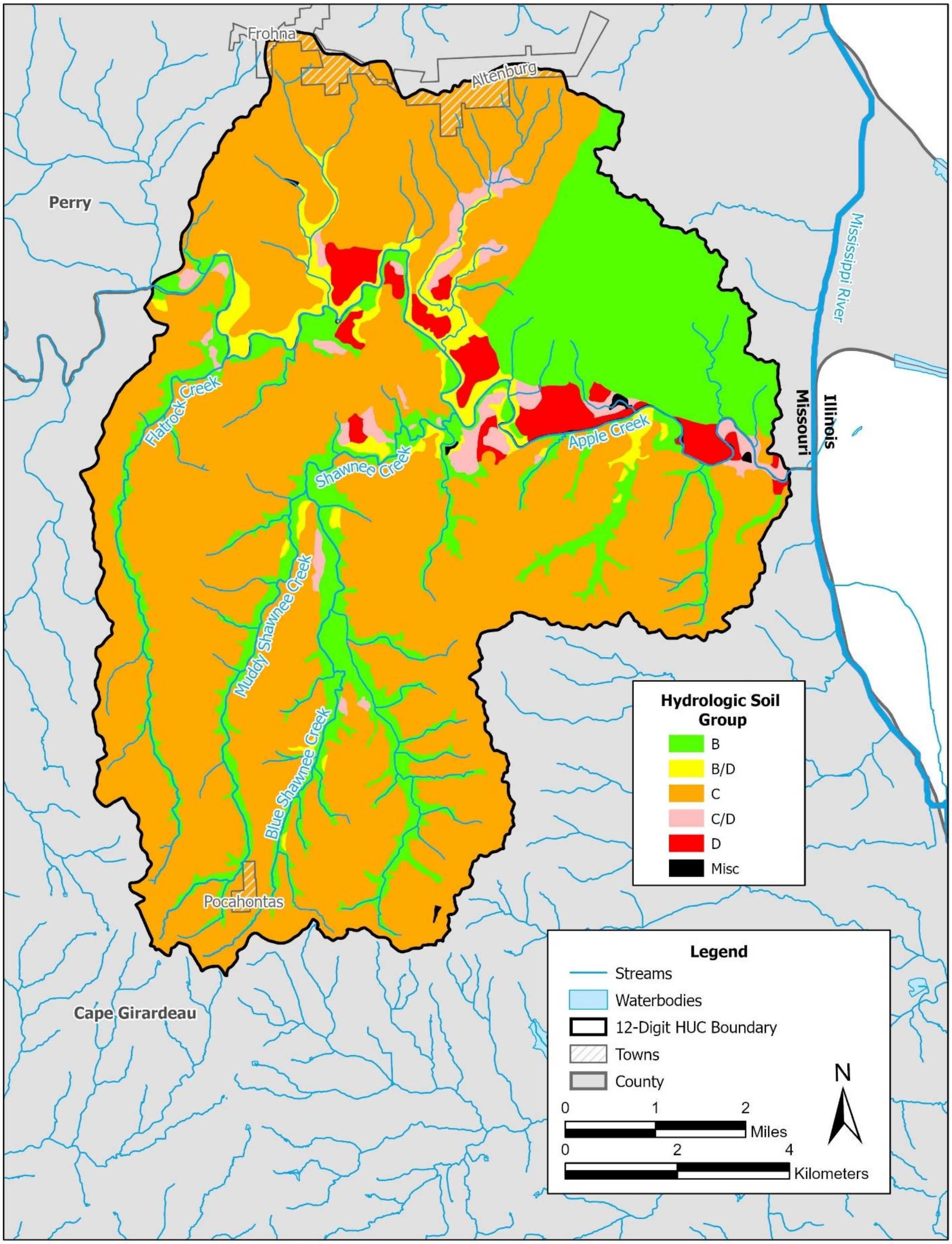


Figure 10. Soil series classified by hydrologic soil group.

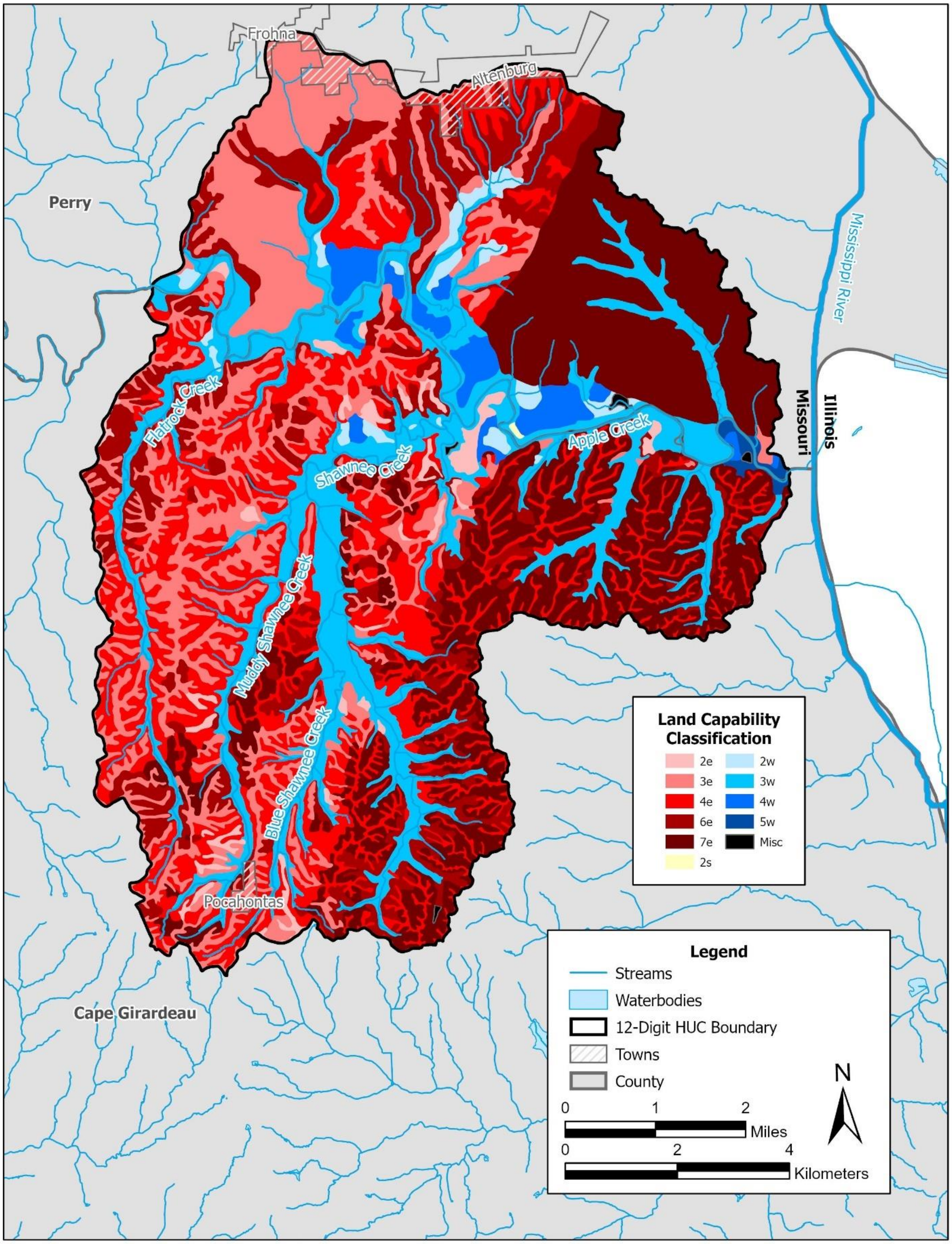


Figure 11. Soil series classified by land capability classification.

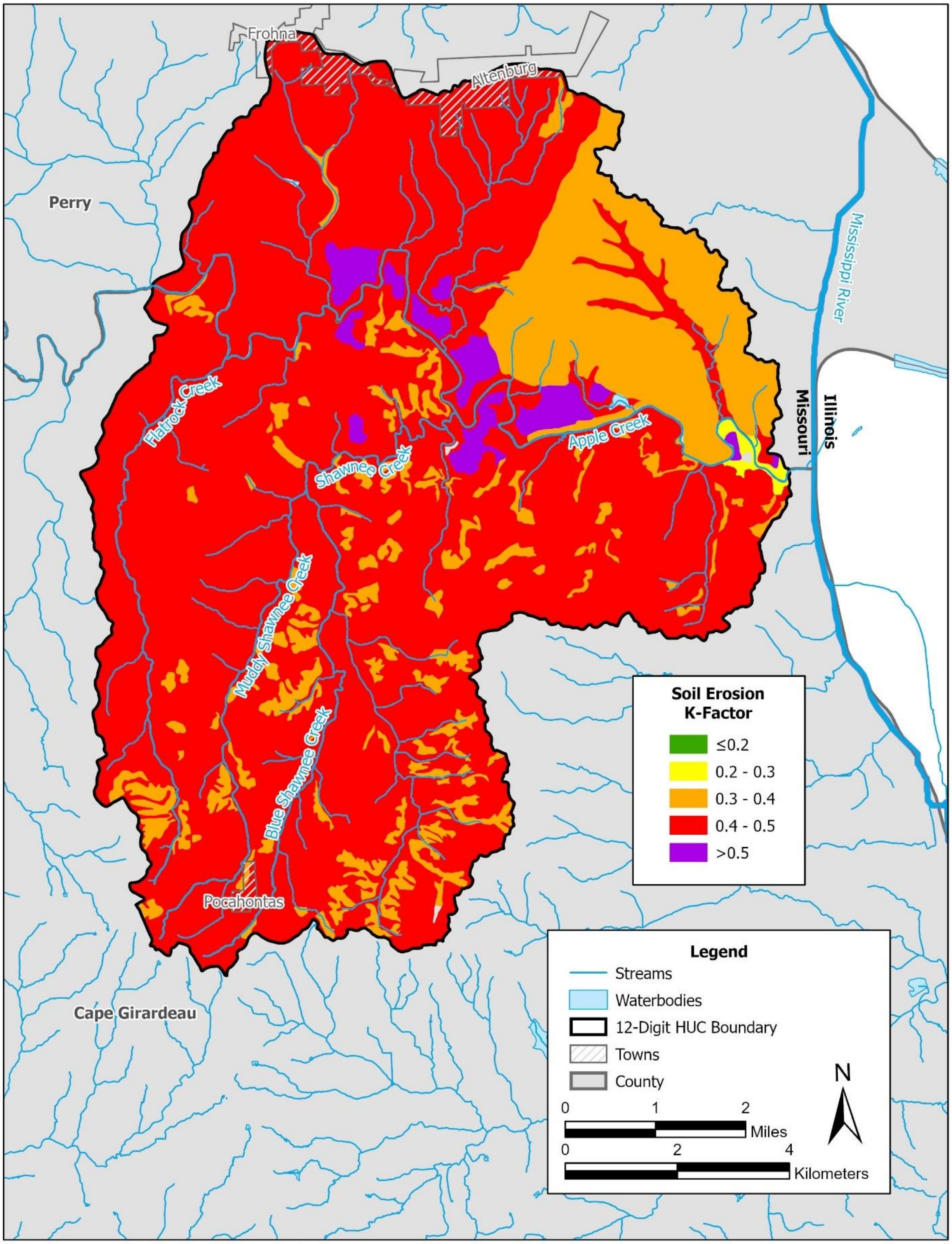


Figure 12. Soil series classified by soil erosion K-factor.

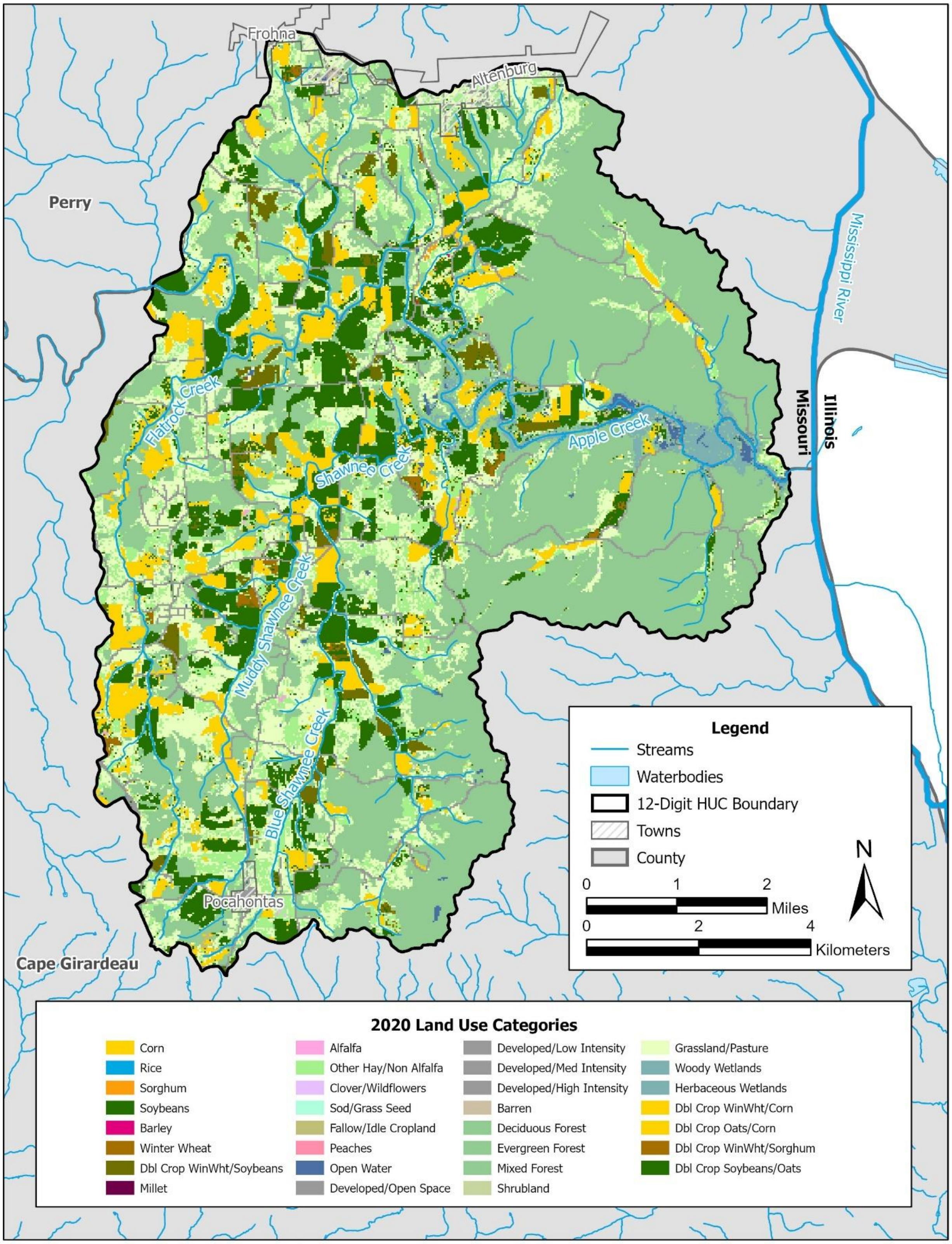


Figure 13. 2020 crop data from the NASS.

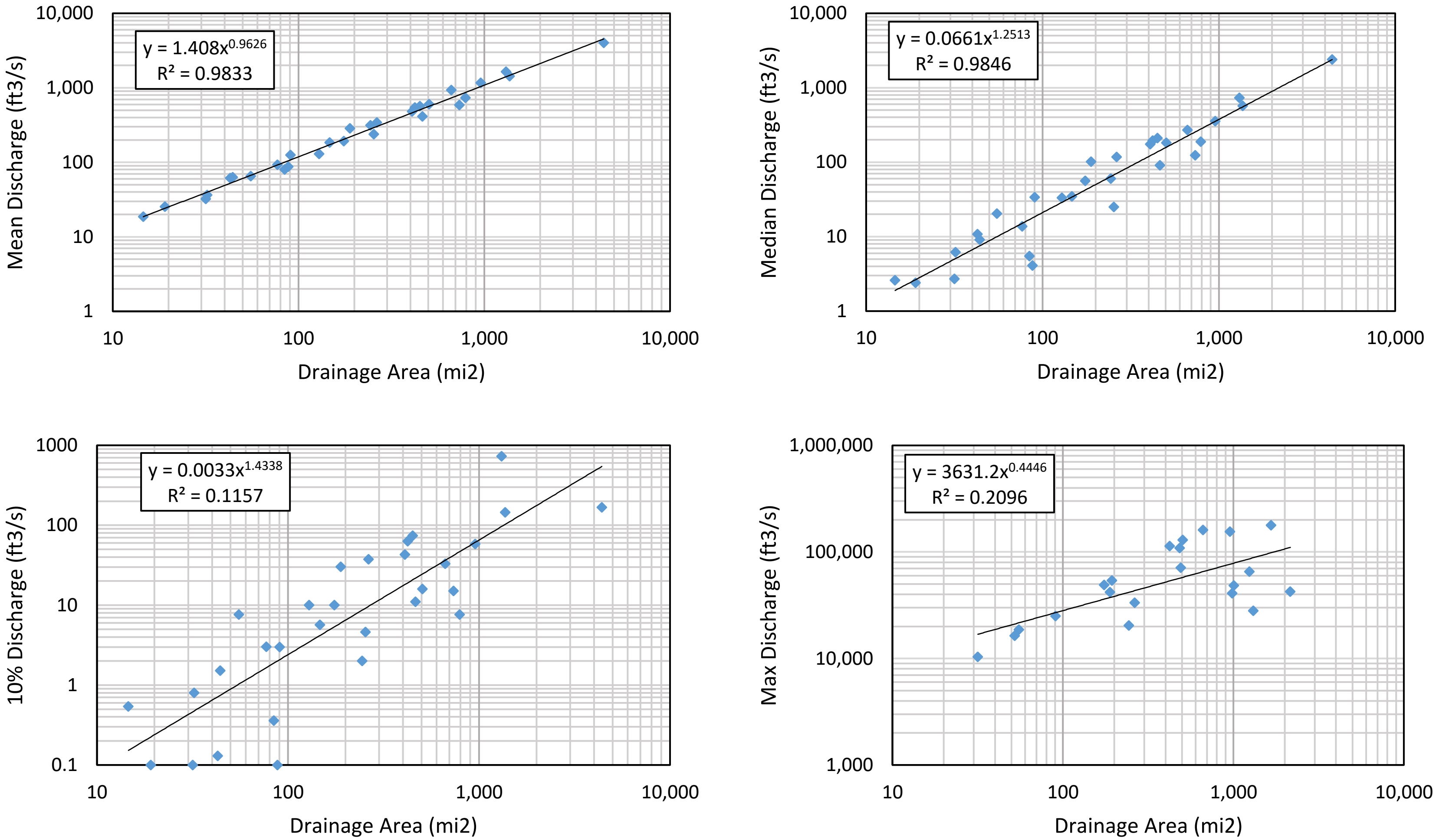


Figure 14. Drainage area and discharge relationships for 30 USGS gaging stations near the study watershed.

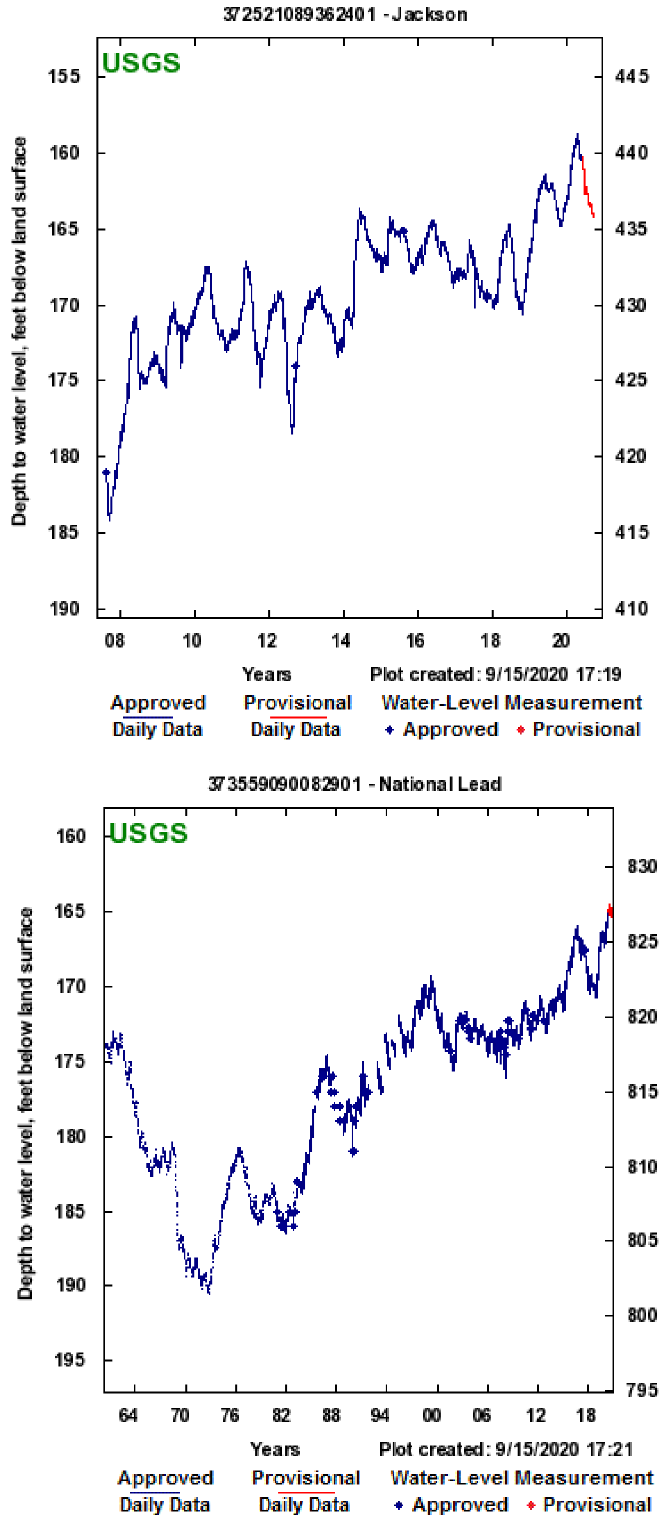


Figure 15. Ground water level change for A) Cape Girardeau County, Missouri (2007-2020) and B) Perry County, Missouri (1960-2020).

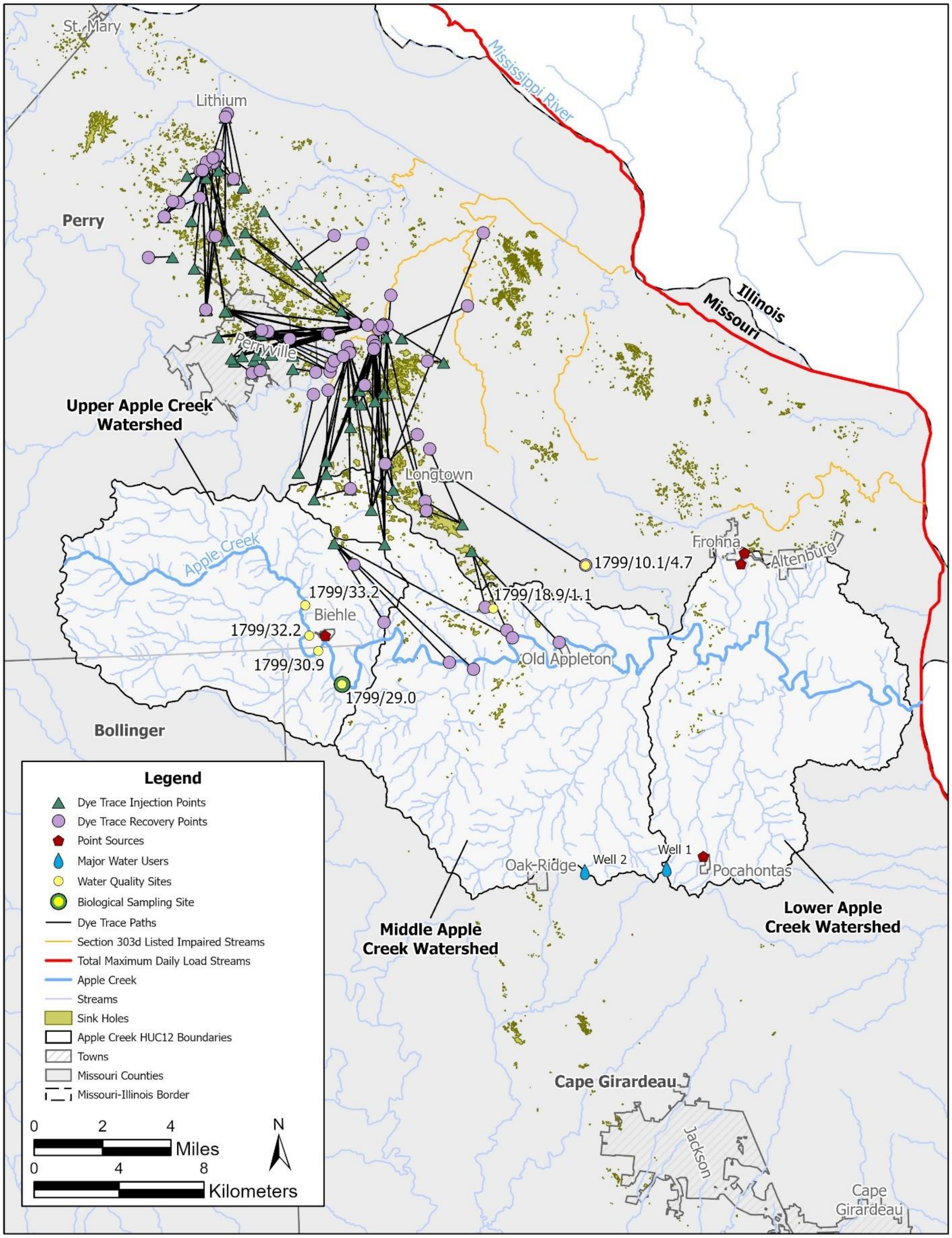


Figure 16. Water quality users, sources and monitoring locations.

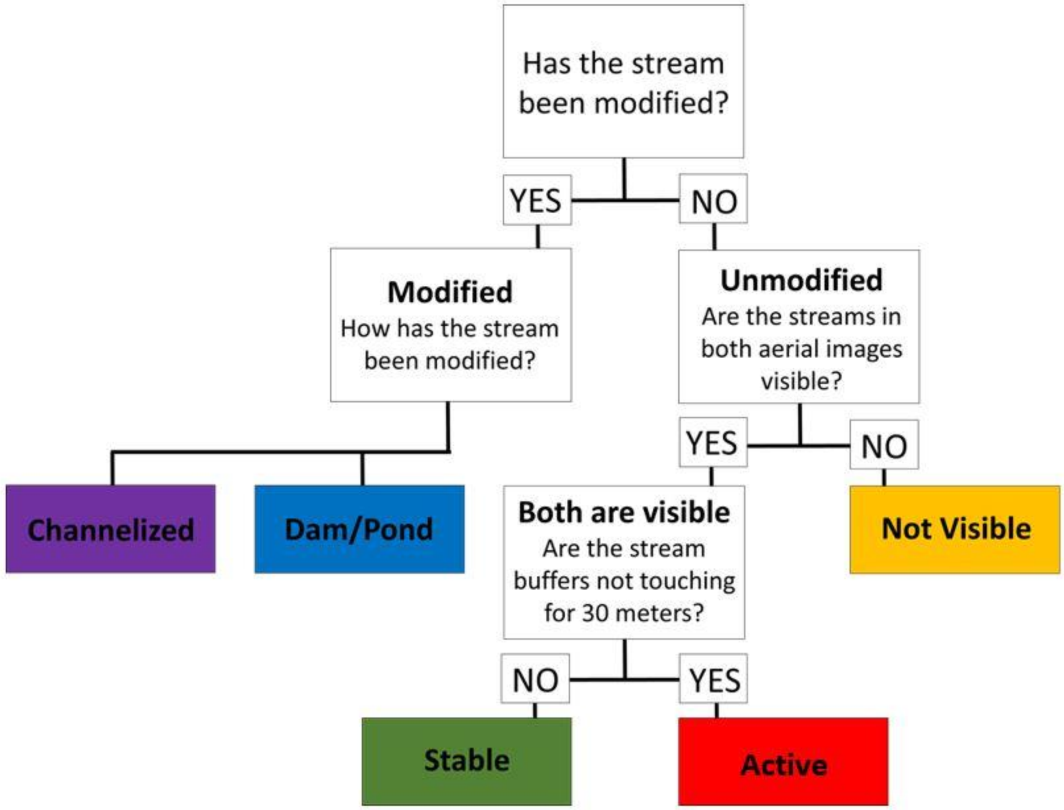


Figure 17. Flow chart showing decision tree for classifying stream channels from aerial photo analysis.

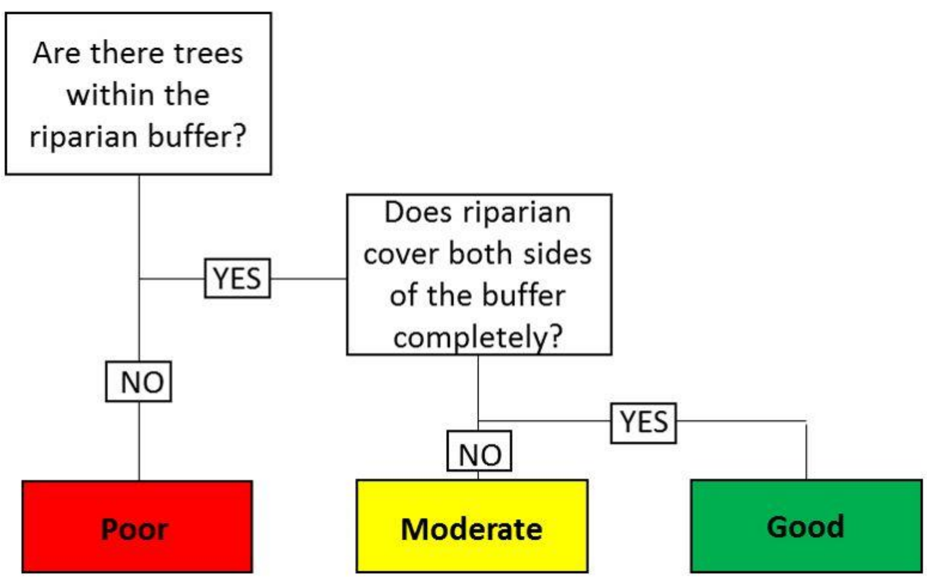


Figure 18. Flow chart showing decision tree for riparian corridor assessment from aerial photo analysis.

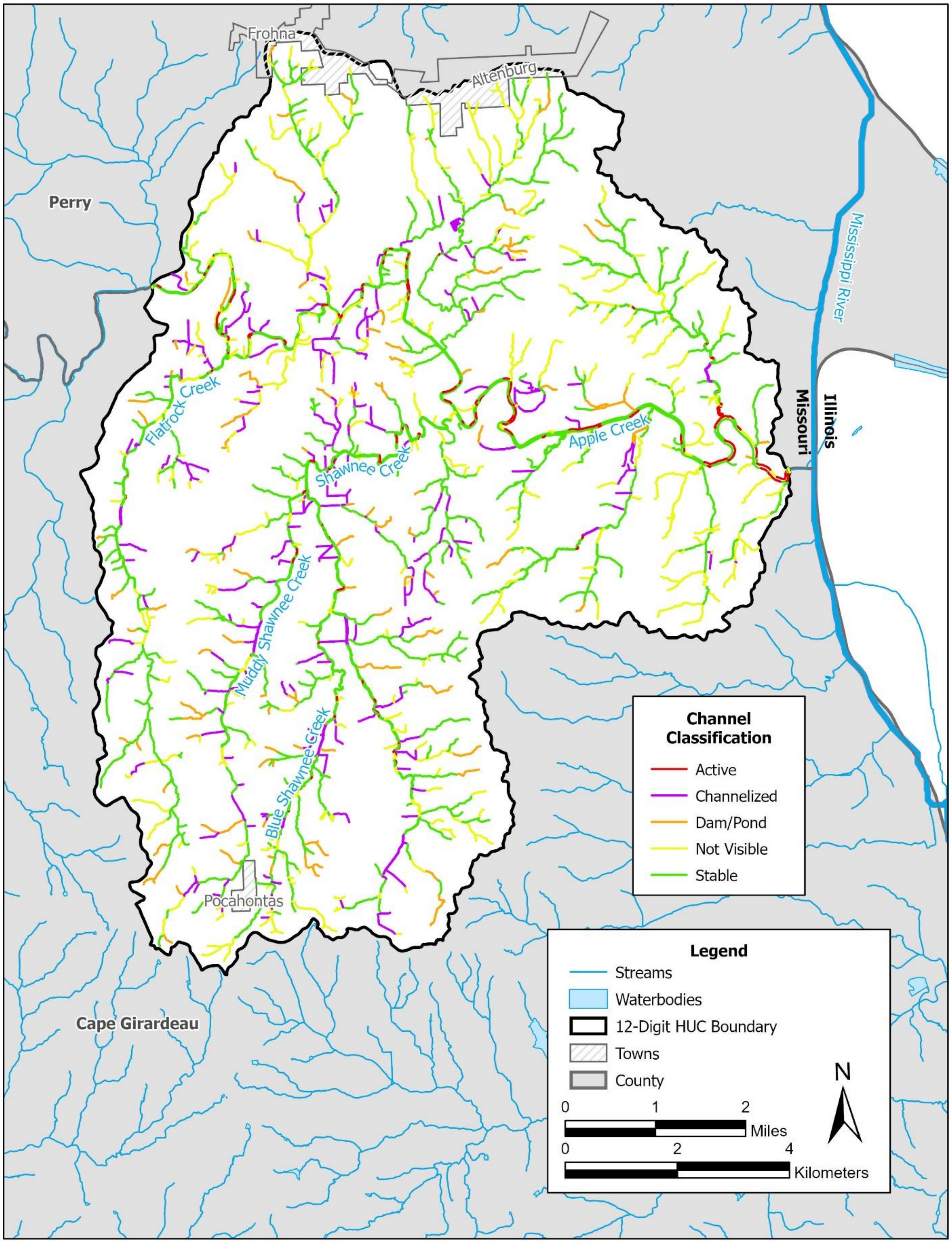


Figure 19. Channel stability classification.

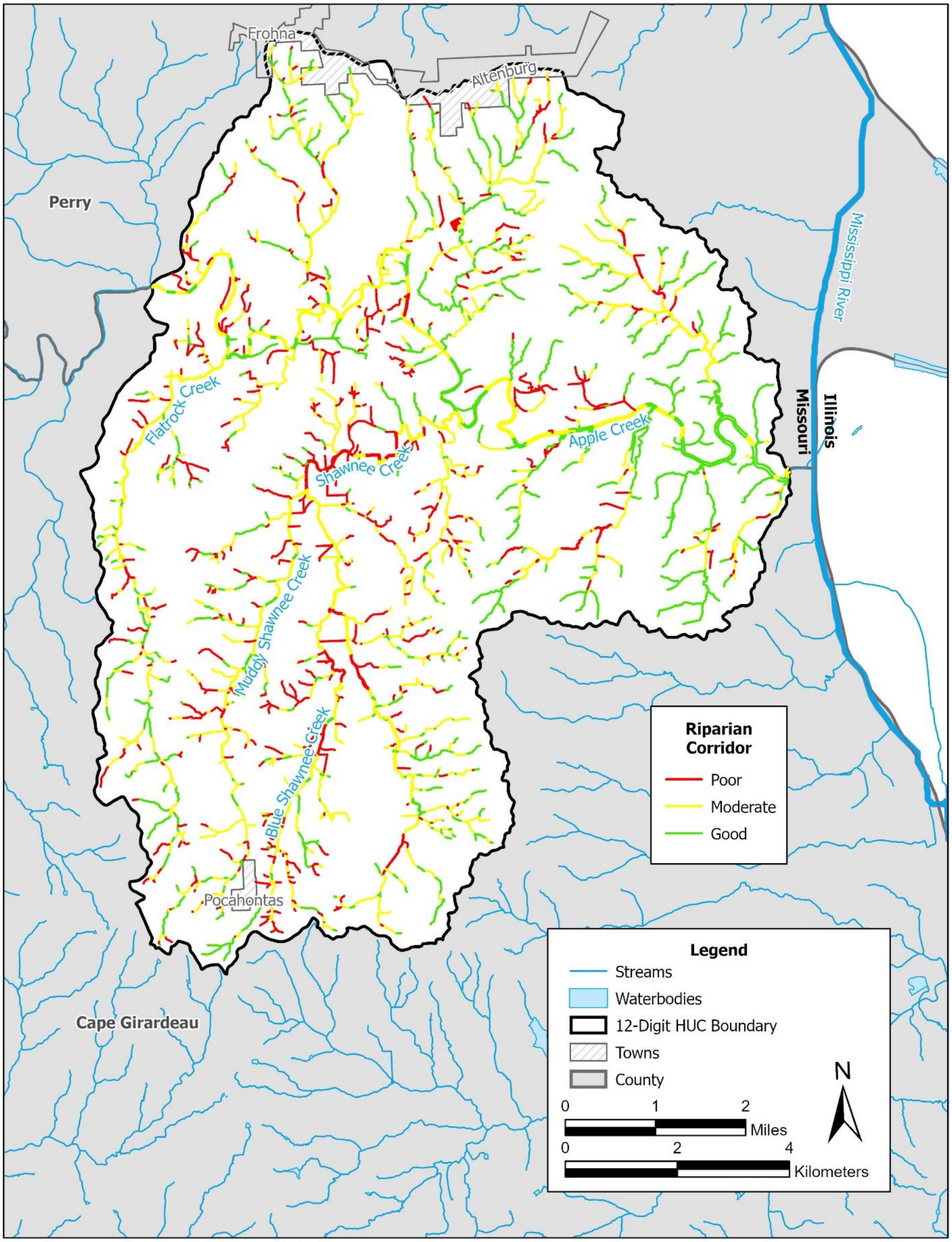


Figure 20. Riparian corridor classification

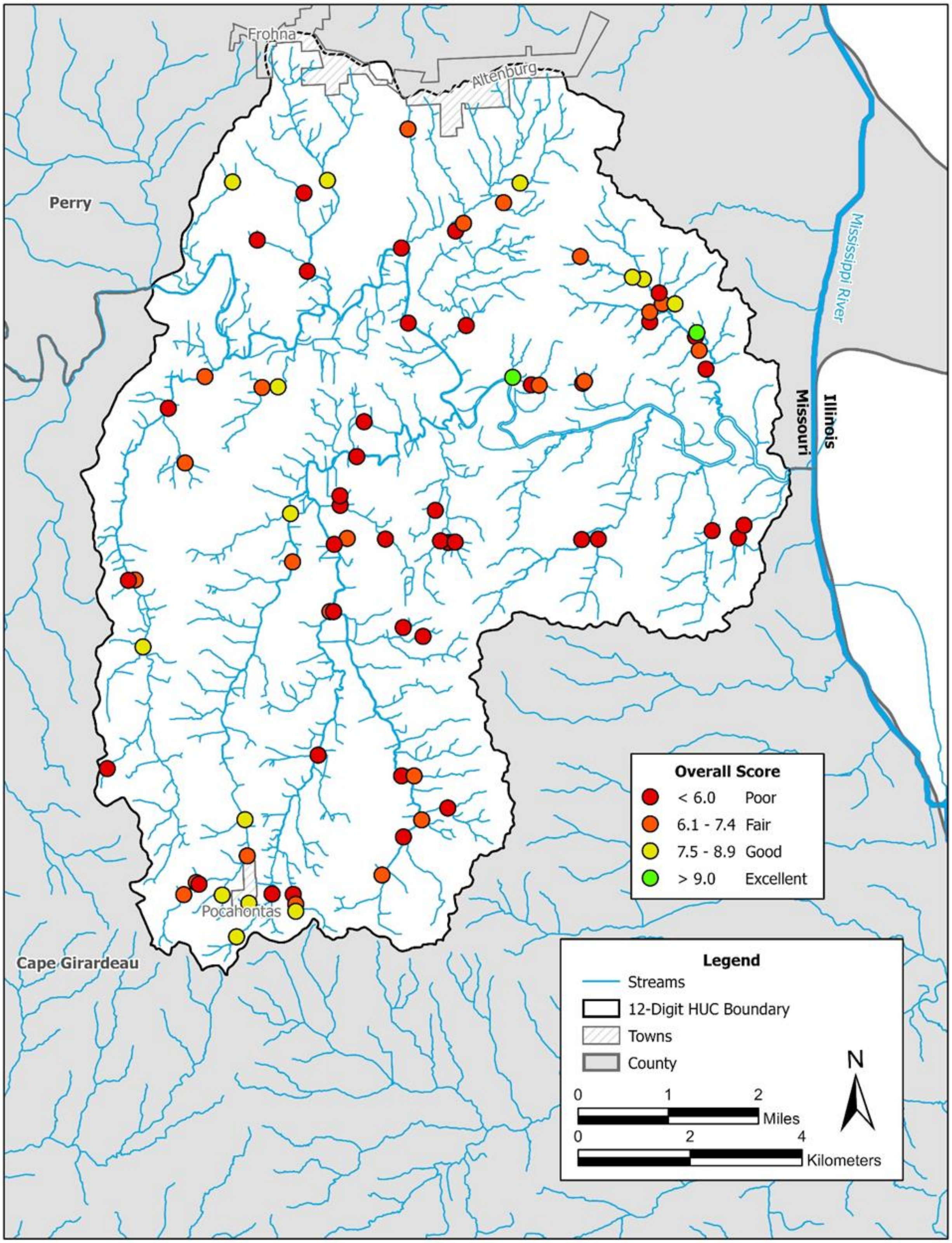
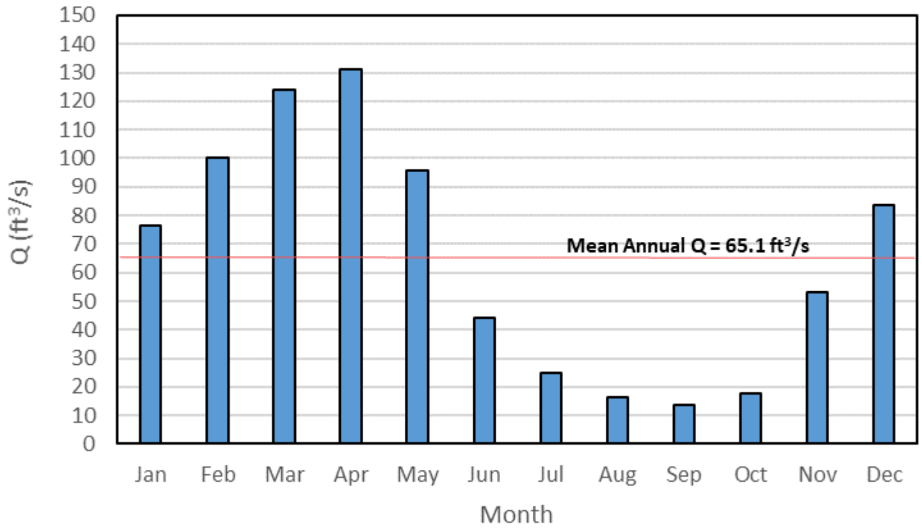


Figure 21. Visual stream assessment results



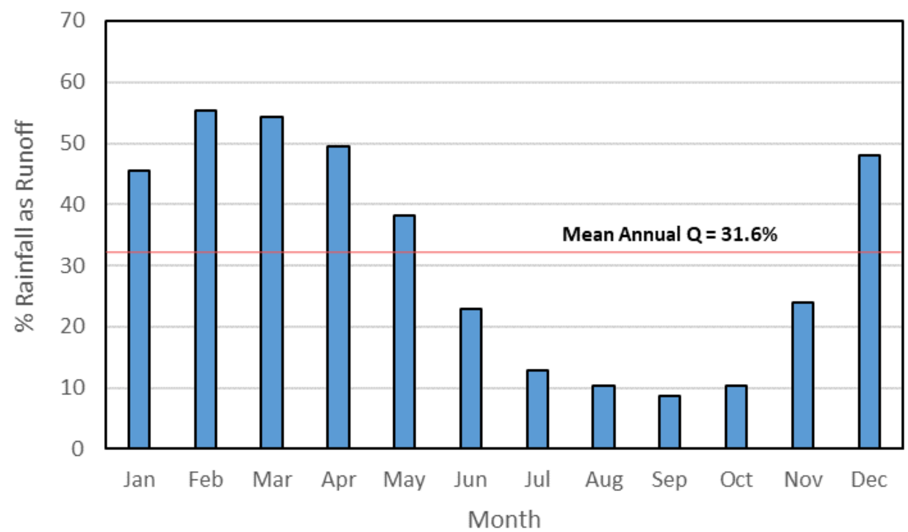


Figure 22. Mean monthly discharge and runoff percentage.

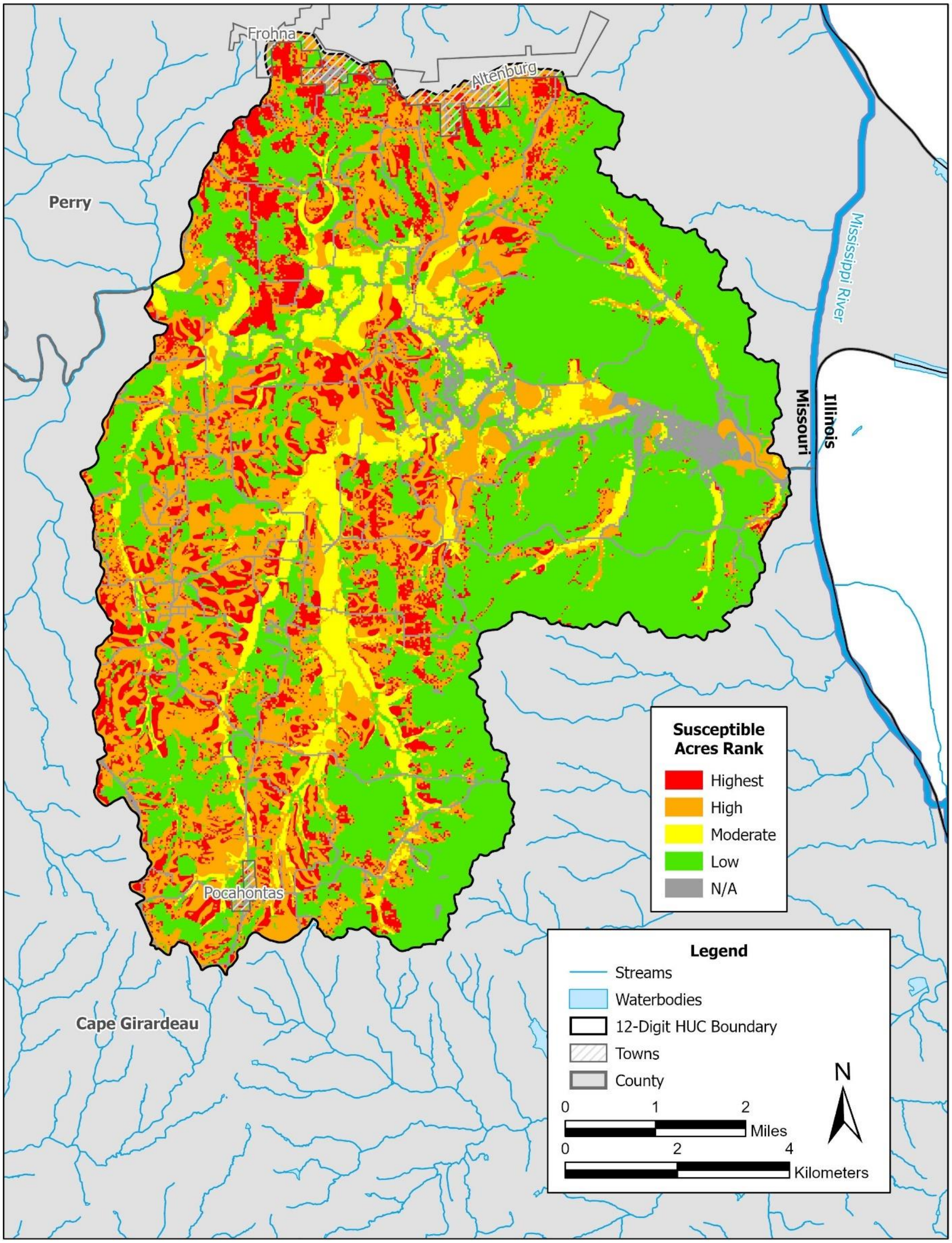


Figure 23. Susceptible acres in the watershed.

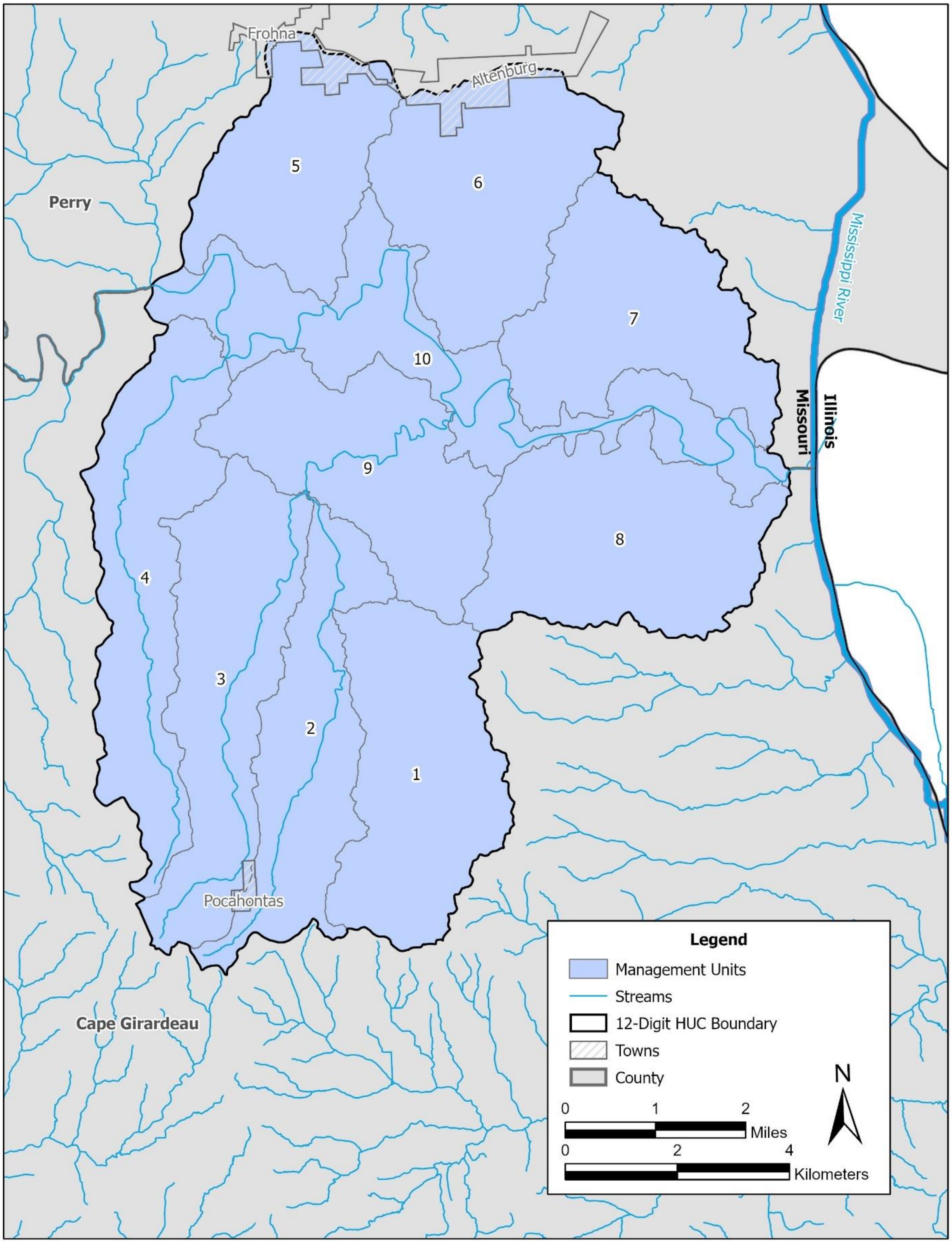


Figure 24. Management units (MUs) in the watershed.

APPENDICES

Appendix A. Soil series data and information for within the watershed.

MU#	Acres	% Area	Series Name	Hydrologic Soil Group	Landform	K Factor	T Factor	Soil Order	Land Capability Classification	Slope % Range
60001	3659	10.8%	Menfro silt loam	C	Upland	0.49	5	Alfisols	3e	7
60003	588	1.7%	Menfro silt loam	C	Upland	0.43	5	Alfisols	4e	11
60024	802	2.4%	Menfro silt loam	C	Upland	0.49	5	Alfisols	3e	5
60077	3390	10.0%	Clarksville-Menfro complex	B	Upland	0.32	4	Ultisols	7e	40
60137	74	0.2%	Iva silt loam	C/D	Upland	0.43	5	Alfisols	2e	3
60164	2359	7.0%	Menfro silt loam	C	Upland	0.37	5	Alfisols	6e	22
60164	78	0.2%	Menfro silt loam	C	Upland	0.37	5	Alfisols	6e	22
60165	394	1.2%	Menfro silt loam	C	Upland	0.43	5	Alfisols	2e	4
60169	5579	16.5%	Menfro silt loam	C	Upland	0.43	5	Alfisols	4e	12
60173	1076	3.2%	Menfro silt loam	C	Upland	0.49	5	Alfisols	3e	8
60177	817	2.4%	Menfro silt loam	C	Upland	0.49	5	Alfisols	3e	25
60179	659	1.9%	Menfro-Bucklick silt loams	C	Upland	0.43	5	Alfisols	6e	17
60179	1764	5.2%	Menfro-Bucklick silt loams	C	Upland	0.43	5	Alfisols	6e	17
60180	322	1.0%	Menfro-Bucklick silt loams	C	Upland	0.43	5	Alfisols	4e	12
60182	207	0.6%	Menfro-Bucklick silt loams	C	Upland	0.43	5	Alfisols	4e	13
60183	321	0.9%	Menfro-Caneyville silt loams	C	Upland	0.43	5	Alfisols	4e	13
60185	4484	13.2%	Menfro-Clarksville complex	C	Upland	0.43	5	Alfisols	7e	40
64001	117	0.3%	Freeburg silt loam	C/D	Stream Terrace	0.43	5	Alfisols	2w	2
64001	324	1.0%	Freeburg silt loam	C/D	Stream Terrace	0.43	5	Alfisols	2w	2
64008	107	0.3%	Freeburg silt loam	C/D	Stream Terrace	0.55	5	Alfisols	2e	2
66000	40	0.1%	Moniteau silt loam	C/D	Floodplain	0.49	5	Alfisols	3w	1
66005	174	0.5%	Deible silt loam	D	Floodplain	0.55	3	Alfisols	4w	1
66005	629	1.9%	Deible silt loam	D	Floodplain	0.55	3	Alfisols	4w	1
66014	2352	6.9%	Haymond silt loam	B	Floodplain	0.43	5	Inceptisols	3w	2
66014	62	0.2%	Haymond silt loam	B	Floodplain	0.43	5	Inceptisols	3w	2
66024	153	0.5%	Wilbur silt loam	B/D	Floodplain	0.43	5	Inceptisols	3w	1
66024	742	2.2%	Wilbur silt loam	B/D	Floodplain	0.43	5	Inceptisols	3w	1
66054	186	0.5%	Wakeland silt loam	B/D	Floodplain	0.43	5	Entisols	3w	1
66087	190	0.6%	Elsah silt loam	B	Floodplain	0.43	4	Entisols	3w	2

MU#	Acres	% Area	Series Name	Hydrologic Soil Group	Landform	K Factor	T Factor	Soil Order	Land Capability Classification	Slope % Range
66087	280	0.8%	Elsah silt loam	B	Floodplain	0.43	4	Entisols	3w	2
66112	185	0.5%	Waldron silty clay	D	Floodplain	0.32	5	Entisols	3w	1
66117	63	0.2%	Waldron silty clay	C/D	Floodplain	0.28	5	Entisols	5w	1
66117	32	0.1%	Waldron silty clay	C/D	Floodplain	0.28	5	Entisols	5w	1
66122	13	0.0%	Darwin silty clay	D	Floodplain	0.24	5	Mollisols	5w	1
67000	232	0.7%	Elsah silt loam	B	Floodplain	0.43	4	Entisols	3w	2
67000	120	0.4%	Elsah silt loam	B	Floodplain	0.43	4	Entisols	3w	2
67001	1010	3.0%	Haymond silt loam	B	Floodplain	0.43	5	Inceptisols	3w	2
67008	49	0.1%	Wilbur silt loam	B/D	Floodplain	0.37	5	Inceptisols	3w	1
75381	8	0.0%	Bearthicket silt loam	B	Floodplain	0.43	5	Alfisols	2s	1
99001	85	0.2%	Water	NA	NA	NA	NA	NA	NA	NA
99001	126	0.4%	Water	NA	NA	NA	NA	NA	NA	NA

Appendix B. USGS gaging stations near the watershed.

USGS Gage ID	Station Name	Stream	Start Year	Years of Record	Ad (mi²)	Elevation (ft)	Flow Exceedence (ft3/s)				
							90%	50%	10%	Max	Mean
7037300	Big Creek at Sam A. Baker State Park, MO	Big Creek	2005	15	189.0	406.2	560.6	102.0	30.1	27,500.0	284.8
5600000	Big Creek near Wetaug, IL	Big Creek	1940	80	32.2	336.9	56.0	6.2	0.8	3,200.0	36.4
5597000	Big Muddy River at Plumfield, IL	Big Muddy River	1908	112	792.0	353.2	1,990.0	189.0	7.6	40,200.0	733.1
7017260	Big River below Desloge, MO	Big River	1988	32	264.0	649.9	697.5	117.5	37.5	29,100.0	342.6
7017610	Big River below Bonne Terre, MO	Big River	2011	9	409.0	628.0	957.0	175.0	42.8	18,600.0	483.6
7017200	Big River at Irondale, MO	Big River	1965	55	175.0	753.3	373.0	56.0	10.0	21,300.0	192.5
3612000	Cache River at Forman, IL	Cache River	1922	98	244.0	308.5	896.0	60.0	2.0	18,600.0	313.7
5595820	Casey Fork at Mount Vernon, IL	Casey Fork	1985	35	76.9	420.0	142.0	13.8	3.0	9,940.0	92.5
7021000	Castor River at Zalma, MO	Castor River	1920	100	423.0	350.5	1,100.0	195.0	63.0	78,000.0	544.1
5597500	Crab Orchard Creek Near Marion, IL	Crab Orchard Creek	1951	69	31.7	415.8	50.0	2.7	0.1	5,610.0	32.4
5593520	Crooked Creek near Hoffman, IL	Crooked Creek	1974	46	254.0	420.2	500.6	25.0	4.6	23,900.0	239.1
3385000	Hayes Creek at Glendale, IL	Hayes Creek	1949	71	19.1	375.1	43.5	2.4	0.1	2,650.0	25.5
3613000	Humphrey Cr at Lacenter, KY	Humphrey Creek	2013	7	44.2	327.4	153.0	9.1	1.5	4,120.0	63.3
5594100	Kaskaskia River near Venedy Station, IL	Kaskaskia River	1969	51	4,393.0	380.1	10,700.0	2,400.0	167.0	58,600.0	4,015.6
5593575	Little Crooked Creek near New Minden, IL	Little Crooked Creek	1967	53	84.3	414.1	142.0	5.5	0.4	8,070.0	80.5
7043500	Little River Ditch No. 1 near Morehouse, MO	Little River Ditch	1945	75	450.0	280.8	1,400.0	211.0	74.0	11,700.0	567.0
7035000	Little St. Francis River at Fredericktown, MO	Little St. Francis River	1939	81	90.5	678.6	259.0	33.9	3.0	13,800.0	125.0
3384450	Lusk Creek near Eddyville, IL	Lusk Creek	1967	53	42.9	360.4	114.0	10.8	0.1	5,660.0	61.5
3611260	Massac Creek near Paducah, KY	Massac Creek	1987	33	14.6	345.5	30.0	2.6	0.5	1,910.0	18.6
5595730	Rayse Creek near Waltonville, IL	Rayse Creek	1979	41	88.0	412.0	138.4	4.1	0.1	8,260.0	87.2
5595200	Richland Creek near Hecker, IL	Richland Creek	1969	51	129.0	375.0	215.0	33.3	10.0	13,300.0	129.7
5594000	Shoal Creek near Breese, IL	Shoal Creek	1909	111	735.0	414.0	1,620.0	124.0	15.0	34,800.0	588.5
5594800	Silver Creek near Freeburg, IL	Silver Creek	1970	50	464.0	381.4	1,170.0	91.3	11.0	15,000.0	413.8
7020550	South Fork Saline Creek near Perryville, MO	South Fork Saline Creek	1998	22	55.3	445.0	111.0	20.4	7.6	4,940.0	65.3
3382100	South Fork Saline River near Carrier Mills, IL	South Fork Saline River	1965	55	147.0	375.6	446.0	34.8	5.7	16,700.0	184.4

USGS Gage ID	Station Name	Stream	Start Year	Years of Record	Ad (mi²)	Elevation (ft)	Flow Exceedence (ft3/s)	USGS Gage ID	Station Name	Stream	Start Year
7036100	St. Francis River near Saco, MO	St. Francis River	1983	37	664.0	472.0	1,870.0	271.0	32.9	88,600.0	933.1
7035800	St. Francis River near Mill Creek, MO	St. Francis River	1987	33	505.0	556.3	1,189.0	182.0	15.9	72,000.0	603.6
7039500	St. Francis River at Wappapello, MO	St. Francis River	1940	80	1,311.0	314.6	4,108.0	731.0	731.0	25,600.0	1,639.4
7037500	St. Francis River near Patterson, MO	St. Francis River	1921	99	956.0	370.5	2,398.0	356.0	58.0	113,000.0	1,168.5
7040000	St. Francis River at Fisk, MO	St. Francis River	1927	93	1,370.0	307.5	3,710.0	570.0	145.0	36,000.0	1,436.1

Appendix C. Score sheet for visual stream survey

Channel Condition:

Natural; no structures, dikes. No evidence of down-cutting or excessive lateral cutting	Evidence of past channel alteration, but with significant recovery of channel and banks. Any dikes or levies are set back to provide access to an adequate flood plain.	Altered channel; <50% of the reach with riprap and/or channelization. Excess aggradation; braided channel. Dikes or levees restrict flood plain width.	Channel is actively downcutting or widening. >50% of the reach with riprap or channelization. Dikes or levees prevent access to the flood plain.
10	7	3	1

Hydrologic Alteration:

Flooding every 1.5 to 2 years. No Dams, No dikes or other structures limiting streams access to the flood plain. Channel is not incised.	Flooding occurs only once every 3 to 5 years; limited channel incision.	Flooding occurs only once every 6 to 10 years: channel deeply incised.	No flooding; channel deeply incised or structures prevent access to flood plain or dam operations prevent flood flows. Flooding occurs on a 1-year rain event or less.
10	7	3	1

Riparian Zone:

Natural Vegetation extends at least two active channel widths on each side.	Natural vegetation extends one active width both sides. Or If less than one width covers entire flood plain.	Natural vegetation extends half of the active channel width on each side.	Natural vegetation extends a third of the active channel width on each side. OR, filtering function moderately compromised.	Natural Vegetation less than 1/3 of active channel width on each side. OR, Lack of regeneration OR, Filtering severely function compromised.
10	8	5	3	1

Bank Stability:

Banks are stable; banks are low (at elevation of flood plain); 33% or more of eroding surface area of banks in outside bends id protected by roots that extend to the base-flow elevation.	Moderately stable; banks are low, less than 33% of eroding surface	Moderately unstable; banks may be low but typically high; outside bends are actively eroding (overhanging vegetation at top of bank, some mature trees falling into stream annually, some slope failures apparent.	Unstable; banks may be low, but typically are high; some straight reaches and inside edges of bends are actively eroding as well as outside bends (overhanging vegetation at top of bare bank, numerous mature trees falling into stream annually, numerous slope failures apparent).
10	7	3	1

Canopy Cover:

> 75% of water surface shaded and upstream 2 to 3 miles generally well shaded.	>50% shaded in reach Or >75% in reach, but upstream 2 to 3 miles poorly shaded.	20 to 50% shaded.	< 20% of water surface in reach shaded.
10	7	3	1

Manure Presence:

	Evidence of livestock access to riparian zone	Occasional manure in stream or waste storage structure located on the flood plain	Extensive amount of manure on banks or in stream. or Untreated human waste discharge pipes present.
	5	3	1

Appendix D. Examples of VSA survey sites.

Site # 17: Upstream

Channel condition	10
Hydrologic alteration	10
Riparian zone	1
Bank stability	3
Canopy cover	1
Manure presence	5

Overall Score 5.0

Site # 17: Downstream

Channel condition	10
Hydrologic alteration	10
Riparian zone	7
Bank stability	7
Canopy cover	7
Manure presence	

Overall Score 8.2

Site # 11: Downstream

Channel condition	1
Hydrologic alteration	3
Riparian zone	3
Bank stability	5
Canopy cover	2

Overall Score 2.8

Site # 14: Upstream

Channel condition	10
Hydrologic alteration	10
Riparian zone	10
Bank stability	10
Canopy cover	8
Manure presence	

Overall Score
9.6

Site # 51: Upstream

Channel condition	10
Hydrologic alteration	10
Riparian zone	10
Bank stability	10
Canopy cover	10
Manure presence	

Overall Score
10

Site # 6: Upstream

Channel condition	1
Hydrologic alteration	1
Riparian zone	7
Bank stability	6
Canopy cover	10
Manure presence	5

Overall Score
5.0

Site # 16: Upstream

Channel condition	1
Hydrologic alteration	1
Riparian zone	1
Bank stability	1
Canopy cover	1
Manure presence	1

Overall Score
1.0

Site # 63: Downstream

Channel condition	1
Hydrologic alteration	7
Riparian zone	5
Bank stability	3
Canopy cover	6
Manure presence	5

Overall Score
4.5

Site # 57: Downstream

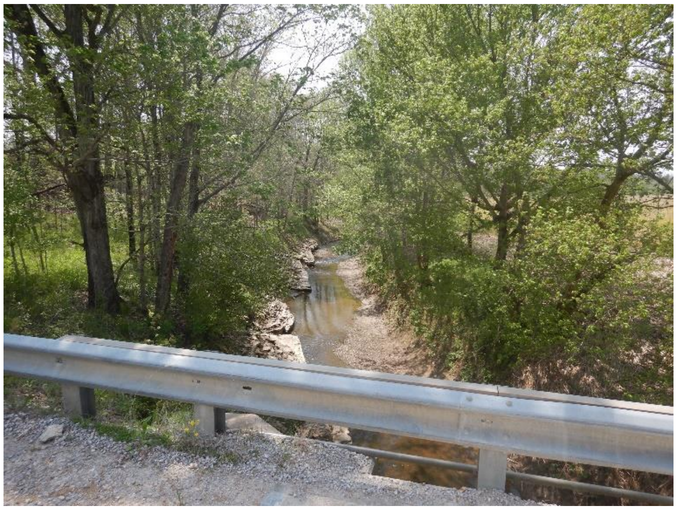
Channel condition	5
Hydrologic alteration	7
Riparian zone	7
Bank stability	5
Canopy cover	8
Manure presence	

Overall Score
6.4

Site # 45: Downstream

Channel condition	7
Hydrologic alteration	5
Riparian zone	7
Bank stability	6
Canopy cover	9
Manure presence	

Overall Score
6.8



Site # 41: Upstream

Channel condition	7
Hydrologic alteration	7
Riparian zone	2
Bank stability	1
Canopy cover	3
Manure presence	1

Overall Score
3.5

Site # 18: Downstream

Channel condition	1
Hydrologic alteration	7
Riparian zone	3
Bank stability	1
Canopy cover	3
Manure presence	3

Overall Score
3.0

Site # 40: Upstream

Channel condition	1
Hydrologic alteration	3
Riparian zone	3
Bank stability	2
Canopy cover	3
Manure presence	

Overall Score
2.4

Site # 69: Upstream

Channel condition	7
Hydrologic alteration	7
Riparian zone	5
Bank stability	7
Canopy cover	8
Manure presence	

Overall Score
6.8

Site # 78: Downstream

Channel condition	3
Hydrologic alteration	5
Riparian zone	5
Bank stability	5
Canopy cover	7
Manure presence	

Overall Score
5.0

Appendix E. Monthly mean discharge equations developed from regional USGS gaging stations

Model	R^2	b_0	b_1	Lower Apple Creek Q (ft^3/s)
Mean Annual Q	0.94	0.01700	0.96748	65.09
Jan Mean Q	0.97	0.01543	1.00476	76.50
Feb Mean Q	0.99	0.02848	0.93463	100.00
March Mean Q	0.97	0.03689	0.92566	123.96
April Mean Q	0.95	0.03695	0.93706	131.31
May Mean Q	0.93	0.01899	1.00844	95.87
June Mean Q	0.99	0.00743	1.04210	44.25
July Mean Q	0.96	0.00585	0.97319	24.83
Aug Mean Q	0.97	0.00269	1.04706	16.40
Sept Mean Q	0.91	0.00371	0.94559	13.75
Oct Mean Q	0.96	0.00419	0.97112	17.62
Nov Mean Q	0.78	0.01804	0.89884	53.12
Dec Mean Q	0.96	0.02539	0.92131	83.52

* Power function equation $y = b_0 (x)^{b1}$
Where: y = mean monthly discharge in ft^3/s
X = drainage area in mi^2

Lower Apple Creek drainage area = 53.0 mi^2

Appendix F. STEPL model inputs

Watershed	Total Ad (ac)	HSG	Land Use (ac)				# of Animals		# Septic Systems
			Urban	Cropland	Pastureland	Forest	Beef Cattle	Swine (Hog)	
Lower Apple Creek	33,898	C	1,512	10,862	5,751	14,867	2,301	385	233

Appendix G. Eroding streambank inputs into STEPL.

Reach ID	Width (ft)	Length (ft)	Area (ft^2)	Height (ft)	Avg. Erosion Rate (ft/yr)
1	14.9	126.1	174.7	9.8	0.8
2	22.2	100.6	207.5	7.2	1.2
3	9.2	179.9	153.4	4.9	0.5
4	10.6	109.2	107.4	5.2	0.6
5	21.1	106.5	208.8	6.6	1.1
6	18.4	99.8	170.7	8.2	1.0
7	19.9	101.8	188.6	7.5	1.0
8	8.8	225.9	185.0	5.2	0.5
9	37.7	250.2	876.0	9.2	2.0
10	24.5	196.8	447.7	6.6	1.3
11	23.0	195.5	417.9	11.5	1.2
12	7.8	209.1	151.8	10.2	0.4
13	25.8	204.9	490.4	9.8	1.4
14	9.3	105.4	91.3	6.9	0.5
15	19.6	198.4	361.1	11.2	1.0
16	16.4	207.3	316.6	13.1	0.9
17	10.9	247.9	250.9	10.8	0.6
18	8.4	159.8	124.9	9.5	0.4
19	22.8	211.0	447.5	10.2	1.2
20	5.1	92.4	44.1	9.8	0.3
21	6.5	114.3	69.0	11.5	0.3
22	8.3	231.4	178.5	4.9	0.4
23	11.1	237.5	244.6	3.9	0.6
24	24.4	505.2	1146.2	8.5	1.3
25	7.4	239.2	164.3	5.2	0.4
26	17.0	275.6	434.0	4.9	0.9
27	16.2	205.1	307.8	9.2	0.9
28	15.6	226.5	328.6	5.9	0.8
29	48.6	260.0	1175.1	8.5	2.6
30	25.6	1003.0	2389.6	6.2	1.3
31	15.7	315.8	461.9	5.9	0.8
32	16.2	223.9	338.0	3.9	0.9
33	11.2	363.2	377.2	9.8	0.6
34	30.9	685.5	1969.2	13.1	1.6
35	11.9	298.2	330.0	10.2	0.6
36	8.1	133.9	100.4	13.1	0.4
37	12.7	230.1	271.5	12.5	0.7
38	8.8	225.0	183.6	9.8	0.5
39	13.0	308.7	372.8	13.1	0.7
40	20.3	462.9	874.3	9.8	1.1

Reach ID	Width (ft)	Length (ft)	Area (ft^2)	Height (ft)	Avg. Erosion Rate (ft/yr)
41	8.3	168.3	129.5	8.2	0.4
42	12.6	171.8	201.5	9.8	0.7
43	15.2	316.1	445.5	8.9	0.8
44	45.4	800.6	3377.2	16.4	2.4
45	18.4	1388.4	2373.7	9.2	1.0
46	28.1	1221.7	3186.6	12.5	1.5
47	9.9	429.9	396.7	8.9	0.5
48	15.5	230.4	331.6	10.2	0.8
49	9.7	223.8	202.3	13.8	0.5
50	8.3	90.9	69.9	13.1	0.4
51	12.9	617.0	739.0	13.1	0.7
52	12.6	522.1	611.2	11.5	0.7
53	13.8	347.8	446.4	13.1	0.7
54	13.9	326.1	422.3	12.8	0.7
55	23.6	447.5	981.2	12.5	1.2
56	24.8	438.2	1011.3	5.6	1.3
57	17.7	1747.1	2870.7	7.5	0.9
58	33.5	721.4	2244.5	11.2	1.8
59	21.2	813.8	1603.2	9.8	1.1
60	10.7	748.6	743.6	6.6	0.6
61	15.1	509.5	713.0	7.5	0.8
62	16.1	173.6	260.0	7.2	0.8
63	7.8	342.2	249.2	7.2	0.4
64	19.7	317.0	579.6	9.2	1.0
65	29.6	235.0	646.3	8.5	1.6
66	12.3	114.5	131.4	3.9	0.6
67	34.2	168.3	534.9	2.0	1.8
68	22.5	161.0	335.9	2.3	1.2
69	19.8	1078.9	1981.8	12.5	1.0
70	6.6	123.0	74.9	7.2	0.3
71	9.6	110.2	98.5	6.2	0.5
72	22.1	89.2	183.3	5.9	1.2
73	10.6	431.8	424.8	6.9	0.6
74	12.2	339.2	384.7	8.2	0.6
75	8.3	531.9	409.0	12.8	0.4
76	7.9	404.5	297.4	13.1	0.4
77	6.4	104.5	62.2	3.0	0.3
78	10.3	123.2	117.8	5.2	0.5
79	6.4	795.4	476.2	8.9	0.3
80	18.6	662.0	1143.2	12.5	1.0
81	6.2	132.4	76.1	9.8	0.3

Reach ID	Width (ft)	Length (ft)	Area (ft^2)	Height (ft)	Avg. Erosion Rate (ft/yr)
82	5.2	89.2	43.0	7.9	0.3
83	9.6	302.9	269.2	11.8	0.5
84	5.4	145.8	72.6	9.8	0.3
85	13.2	295.1	361.7	11.5	0.7
86	22.9	220.2	468.5	8.9	1.2
87	4.8	108.6	48.4	8.9	0.3
88	20.4	260.3	494.2	10.5	1.1
89	5.6	163.6	84.4	8.9	0.3
90	15.2	94.3	133.4	8.2	0.8
91	23.2	294.2	634.4	11.5	1.2
92	11.4	334.5	355.1	13.1	0.6
93	15.9	165.8	245.4	13.8	0.8
94	7.3	131.7	89.8	13.1	0.4
95	9.8	206.6	189.0	14.1	0.5
96	13.5	256.2	321.5	13.5	0.7
97	6.2	692.0	396.7	7.2	0.3
98	11.6	108.4	117.3	8.2	0.6
99	37.3	223.9	776.8	13.8	2.0
100	4.3	130.7	52.6	6.6	0.2
101	15.7	369.2	537.6	13.1	0.8
102	3.5	88.4	28.7	10.2	0.2
103	8.1	158.7	118.9	13.1	0.4
104	2.9	260.6	69.8	13.1	0.2
105	15.2	680.9	963.5	9.8	0.8
106	3.2	360.6	108.1	11.2	0.2
107	6.1	212.1	119.8	13.5	0.3
108	13.9	408.9	528.3	13.8	0.7
109	6.0	184.2	102.5	12.5	0.3
110	7.3	445.9	303.3	13.1	0.4
111	14.2	906.8	1196.0	12.5	0.7
112	6.1	460.6	259.2	10.5	0.3
113	7.6	233.5	164.0	14.8	0.4
114	7.5	245.0	171.6	11.5	0.4
115	7.5	285.3	198.7	9.8	0.4
116	13.8	233.4	298.5	12.5	0.7
117	5.1	167.6	78.6	13.1	0.3
118	8.7	106.9	86.3	12.5	0.5
119	8.7	205.8	167.1	13.1	0.5
120	17.6	244.1	400.1	11.5	0.9
121	7.3	241.5	163.6	11.2	0.4
122	15.2	93.2	132.0	3.3	0.8

Reach ID	Width (ft)	Length (ft)	Area (ft^2)	Height (ft)	Avg. Erosion Rate (ft/yr)
123	8.0	167.6	124.0	7.9	0.4
124	11.3	119.9	126.4	6.9	0.6
125	10.2	110.1	104.7	6.6	0.5
126	14.6	198.9	269.3	9.8	0.8
127	25.2	201.8	473.0	6.6	1.3
128	10.0	230.6	213.2	6.6	0.5
129	15.8	124.5	182.8	9.8	0.8
130	13.3	177.2	218.5	9.8	0.7
131	6.5	153.6	92.6	3.3	0.3
132	10.2	219.0	207.0	9.8	0.5
133	9.2	348.0	296.6	6.6	0.5
134	22.6	297.1	622.7	9.8	1.2
135	51.6	1,018.8	4,884.7	9.8	2.7
136	8.0	187.0	139.4	6.2	0.4
137	5.8	148.8	79.9	3.6	0.3
138	12.6	406.6	474.2	9.8	0.7
139	19.0	155.3	274.6	9.8	1.0
140	17.4	237.6	383.1	6.6	0.9

Appendix H. Evaluation of Model Accuracy

The Spreadsheet Tool for Estimating Pollutant Load (STEPL) uses simple algorithms to calculate nutrient and sediment loads from different land uses, estimates load reductions from implementation of conservation practices on the landscape, and is considered a satisfactory model for watershed planning purpose (Tetra Tech Inc. 2017, USEPA 2008). STEPL uses local rainfall records and the curve number method to produce an annual runoff volume, land use-based nitrogen (N) and phosphorus (P) concentrations to calculate nutrient loads, and the Universal Soil Loss Equation (USLE)-Sediment Delivery Ratio (SDR) to estimate sediment load. Default nutrient concentrations were used for this project that are well within observed values in the literature by land use type (Table 22). The USLE has been used for 80 years all around the world and after recent rigorous review by Alewell et al. (2019) was deemed a good choice for management projects which provides the gross erosion off the landscape while the SDR estimates net erosion. Load reductions then can be calculated by applying various Best Management Practices (BMPs) with known efficiencies (Waidler et al. 2009, GSWCC 2013, Tetra Tech Inc 2017).

Typically, model uncertainty, or accuracy, is evaluated by comparing results to observed values (White et al. 2015). However, when no observed values are available, model output can be validated by comparing values to those found in the literature or by comparing to results of other models (Alewell et al. 2019, USEPA 2008). For this study, STEPL model accuracy will be checked using three separate techniques: 1) annual runoff volume will be compared to regional USGS gaging station records; 2) nutrient and sediment loads will be compared to published Ecoregion specific export coefficients by land use type, and 3) annual loads for each watershed are compared to USGS SPARROW model outputs for the overall HUC-8 watershed. Accuracy and variability of the model compared to each alternative method is discussed below.

Annual Runoff Volume

As stated in the STEPL methods section, estimated annual runoff volume was compared to regression analysis of annual mean discharge from regional USGS gaging stations (Figure 14, Appendix B). Initial estimated annual runoff volume was 29,693 ac-ft compared to 47,130 ac-ft from the USGS gaging station equation estimate. These estimates were compared using relative percent difference (RPD), which is the difference between the two values divided by the average of the two values converted into a percentage. The initial RPD between the models was 45%. To update the rainfall in the model, the default STEPL rainfall total was adjusted from 46 to 54 inches based on the average 15-year average from nearby rain gaging stations detailed earlier in this report. Recent studies have shown an increase in intense rainfall in southeast Missouri over the last decade (Pavlowsky et al. 2016). This increased the annual runoff volume to 36,921 ac-ft and improved the modeled runoff to around 24% RPD compared to the estimate based on local USGS gages. The same discrepancy between the STEPL model runoff and the USGS gaging stations also occurred during a previous assessment work on the Upper and Middle Apple Creek watersheds. In this assessment gage data from smaller regional streams provided a more accurate local discharge compared to STEPL estimates (Reminga et al., 2019). When using this alternate USGS gaging station equation, estimated an annual runoff volume was adjusted to 41,185 ac-ft which improved RPD to 11% of the STEPL volume using the updated rainfall totals. Checking and adjusting hydrology adds confidence to the model output as the runoff estimate from the STEPL model is producing results that are fairly close to the average observed conditions for the area.

Export Coefficient Comparison

Export coefficients (EC) are a pollutant mass loading parameter per unit area coming from a single land use type (USEPA 2008). ECs are obtained from field-based monitoring of these specific land use types and can be found in literature searches. White et al. (2015) published regional ECs for the U.S. in an effort to provide more accurate loading estimates based on similar topography, soils, and climate. This study used a water quality model to generate 45 million simulations across the country that went through an extensive validation and literature comparison process. The result was a dataset that provides median, 10th, and 90th percentile ECs for cropland, grassland, forest, and urban land use by Type III Ecoregion. These data were then used to compare STEPL derived loads from various land use types within the Lower Apple Creek watershed.

Comparative results show that urban and cropland ECs from the STEPL model are generally within the range of the published values while STEPL ECs from pasture and forest land are higher than published values. STEPL ECs were calculated by dividing the total annual load (lbs/yr) by the area (acres) of land within each land use category. Results show that cropland ECs from the STEPL model are within the range of published values for N, P and Sediment (Table 2). Urban ECs from the STEPL model were within the range from P and slightly lower for N and Sediment compared to the published values. However, there is a relatively low percentage of intense urban development within the Lower Apple Creek watershed that is mainly low-density residential. Pastureland and forest land ECs were relatively high compared to published values, but these land uses are generally found on the steep, loess covered slopes within the watershed. While the pasture and forest ECs are higher than the published values for the interior River Valleys and Hills ecoregion, they are within the published ranges of other ecoregions. Therefore the default values were not adjusted.

Annual Yield

Annual yield of the watershed was compared to output from the USGS SPAtially Referenced Regression On Watershed attributes (SPARROW) model for the midwestern U.S. (Robertson and Saad 2019). SPARROW is a hybrid-type model combining physically based simulations of stream flow, N, P, and suspended sediment (SS) with long-term monitoring stations throughout the Midwest. These methods were then applied to small catchments using available data and the model was rigorously evaluated and calibrated to best simulate conditions for the "base year" of 2012. To compare with the STEPL results the individual yields from each catchment (n=40) within the Lower Apple Creek watershed were selected and a drainage area-weighted yield for N, P, and SS were calculated from SPARROW and compared to STEPL modeled yields for the watershed. Results show that STEPL modeled results were 30-70% higher than those from the SPARROW model (Table 3). However, increased runoff, as noted above, can help explain some of the difference between the model results. Regardless, this assessment suggests that the simpler STEPL model results are at least reasonably close to the more sophisticated SPARROW Model results.

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Table 22. Comparison of Published and STEPL Model Nutrient Concentrations by Land Use Type.

Land Use	STEPL Concentrations		EMCs from Literature[1]	
	TP (mg/L)	TN (mg/L)	TP (mg/L)	TN (mg/L)
Cropland	0.3-0.5	1.9-4.4	0.56-3.07	2.68-14.2
Pasture	0.3	4.0	0.18-2.14	1.77-7.61
Forest	0.1	0.2	*0.005*-0.20	0.10-2.60
Urban	0.15-0.5	1.5-3.0	0.16-0.63	0.43-19.4

[1] Literature Cited: Clark et. al (2000); Coulter et. al (2004); Lin (2004)

Table 23. Comparison of Published Ecoregion Specific Export Coefficients to Lower Apple Creek STEPL Model results by Land Use Type.

Land Use	STEPL Values			Literature Values[1] Ecoregion = Interior River Valleys and Hills		
	N (lb/ac/yr)	P (lb/ac/yr)	Sed (t/ac/yr)	N (lb/ac/yr)	P (lb/ac/yr)	Sed (t/ac/yr)
Urban	11.1	1.7	0.25	11.0-40.7	0.63-2.6	0.18-0.83
Cropland	15.1	4.3	2.8	10.5-41.4	0.76-4.04	0.40-6.51
Pastureland	14.7	2.6	1.1	0.93-8.5	0.16-1.6	0-0.37
Forest	1.3	0.56	0.28	1.1-4.4	0.02-0.15	0-0.01

[1] White et al. (2015)

Key:
Green = within the range in the literature
Yellow = below the range in the literature
Red = above the range in the literature

Table 24. Comparison of Catchment Area-Weighted Mean USGS SPARROW Model Yields[1] to STEPL Model results for the Lower Apple Creek Watershed.

Watershed	Yields		
	N (lb/ac/yr)	P (lb/ac/yr)	Sed (t/ac/yr)
Lower Apple Creek HUC12	9.81	2.54	1.55
SPARROW Model	7.20	1.22	1.13
RPD	31%	71%	48%

[1] Robertson and Saad (2019)

Appendix I. Combined conservation practice efficiencies for selected practices

List of Practices	**Combined BMP Efficiencies**		
<u>Cropland</u>	Nitrogen	Phosphorus	Sediment
Cover Crop	0.196	0.070	0.100
Field Borders	0.700	0.700	0.650
Grassed Waterway	0.700	0.750	0.650
Grade Stabilization Structure	0.750	0.750	0.750
Cover Crop and No-Till	0.397	0.709	0.793
Water and Sediment Control Basin	0.550	0.685	0.860
Land Retirement	0.898	0.808	0.950
<u>Pastureland</u>			
Forage and Biomass Planting	0.181	0.150	0.000
Alternative Water	0.133	0.115	0.187
Winter Feeding Facilities	0.350	0.400	0.400
Critical Area Planting	0.175	0.200	0.420
Access Control	0.203	0.304	0.620
Prescribed Grazing, Alternative Water, and Heavy Use Protection	0.581	0.448	0.638
Grade Stabilization Structure	0.750	0.750	0.750
Livestock Exclusion, Alternative Water, and Heavy Use Protection	0.435	0.503	0.794