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

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

Mozingo Creek Watershed (HUC-102400130303)

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

Final Report

Prepared by:
Marc R. Owen, M.S., Assistant Director, OEWRI
Sierra Casagrand, Graduate Assistant, OEWRI
Tyler Pursley, Graduate Assistant, OEWRI
Robert T. Pavlowsky, Ph.D., Director, OEWRI

Completed for:
Steve G. Hefner, Natural Resources Specialist
Natural Resources Conservation Service
United States Department of Agriculture
Parkade Center, Suite 250
601 Business Loop 70 West
Columbia, MO 65203-2546
Office: 573-876-9399

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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 for the Mozingo Creek watershed located in Nodaway County in northwest Missouri. The project area is a 12-digit hydrologic unit code (HUC-12 # 102400130303) watershed that is within the One Hundred and Two River watershed. The watershed is located east of the City of Maryville and includes Mozingo Creek and the water supply reservoir Mozingo Lake built by the NRCS in 1996 (MDNR 2002). Mozingo Lake is listed on the 303d list of impaired waters for chlorophyll A and mercury in fish tissue (MDNR 2020). Increased runoff from agricultural land use has been identified as a major factor in water quality degradation in the Platte River Watershed causing increased upland erosion rates, stream bank erosion, and delivery of excess nutrients to streams and reservoirs (Bayless and Travnichek 2001). In 2014, the Mozingo Lake Recreation Park Master Plan specifically states the need for a watershed management plan to reduce pollutants entering the lake from the upstream contributing area (RDG 2014).

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 based on analysis of the data gathered in the watershed inventory that includes 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 the 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 Mozingo Creek watershed is located within the larger One Hundred and Two River watershed (HUC-8#10240013) of northwest Missouri (Figure 1). Mozingo Creek (17,954 acres) is one of four 12-digit HUC watersheds within the Upper One Hundred and Two River watershed (HUC-10 #1024001303). Mozingo Creek flows from northeast Nodaway County generally south-southwest to the confluence of One Hundred and Two River southeast of the City of Maryville (population of 11,971) (Figure 2). The dam at Mozingo Lake (1,006 acres) is located in the southern half of the watershed approximately 0.5 miles east of Maryville. The One Hundred and Two River is a major tributary to the Platte River approximately 24 miles downstream of the Mozingo Creek confluence.

Even though the Mozingo Creek watershed is near the City of Maryville, the area has a low population density, and the total population has declined over the last decade. Between 2010 and 2019, the total population of Nodaway County has decreased 5.5% while the population of the entire state has increased 2.5% over that same time (Table 1). The population of Nodaway County is predominately white (94%), with 34% living in unincorporated areas, and a population density of 25 persons per square mile. Per capita income is $22,915, which is well below the state average of $30,810. Also, 4.6% of the population is working in the agricultural industry. Finally, the poverty rate is 17.8% which is also higher than the state average of 12.9%.

Climate

Over the past 30 years from 1991-2020, the average rainfall at Maryville, Missouri ranged from 23.0-63.5 inches with an average of 38.0 inches per year (Table 2). The highest monthly rainfall totals (>5 inches) occur in the summer months of May and July, with generally less precipitation (<2 inches) during the late fall and winter months (Figure 2A). From 1991 to 2020, average annual temperatures ranged from 48.7-54.8°F with an average of 51.4°F (Table 2). Over that period, average monthly temperatures ranged from 24.6°F in January to 76.1°F in July (Figure 3B). From 1991 to 2003, average annual precipitation decreased from about 40 inches per year to less than 30 inches per year (Figure 4A). However, since 2003 average annual precipitation has generally increased back to about 40 inches per year. Average annual temperature has slowly, but steadily increased for the last 30 years from less than 51°F to over 52°F (Figure 4B).

Solar radiation and evapotranspiration data were collected from Corning in Atchison County, and from Albany in Gentry County, as data was not available for Maryville. From 2000-2020, average daily solar radiation by month ranged from about 6.2 MJ/m2 in December up to around 19.7 MJ/m2 in May with an average of 14.3 MJ/m2 (Figure 5A). From 2014 to 2020, monthly average daily estimated evaporation ranged from around 0.025 inches per day in December to about 0.19 inches per day in June with an average of 0.1 inches per day over the entire year (Figure 5B).

Geology, Topography, and Geomorphology

The underlying geology of the watershed consists of loess and glacial till over Pennsylvanian age shale, siltstone, sandstone, and limestone of the Wabaunsee, Shawnee, and Douglas Group (Miller and Vandike, 1997, Starbuck 2017). Thickness of glacial till over the surficial bedrock varies locally ranging from a few feet to over 300 feet deep covered by a mantle of loess that can be up to 14 feet thick (Zimmerman 1986). Elevations within the watershed range from around 1,226 ft near State Route E in northern Nodaway County to about 948 ft near the confluence with One Hundred and Two River (Figure 6). Slopes derived from digital elevation models shows the uplands in the northern portion of the watershed and the broad valley bottoms have slopes generally less than 5% (Figure 7). Downslope of the uplands the land becomes steeper along the side slopes and stream valleys and generally the watershed is increasing steeper from north-to-south. Streams naturally have low slopes and are sinuous, and as a result have been channelized throughout the area (Nigh and Schroeder, 2002). Habitat conditions in streams of the Platte River are generally poor due to altered channel conditions, siltation, and poor riparian corridors (Bayless and Travnichek 2001). The NRCS has not developed regional hydraulic geometry curves this region.

Landscape and Soils

The Mozingo Creek watershed is located within the Nodaway Loess Prairie Hills Land Type Association (LTA), Loess Hills Subsection, Central Dissected Till Plains Ecological Section of Missouri (Nigh and Schroeder 2002). The Ecological Section covers the glaciated portions of the state north of the Missouri River. Historically, this LTA was covered by native prairie with trees only being found along the valley bottoms. This has been replaced by extensive row crops and pastureland. The most abundant soil order in the watershed is mollisols (93.1%), with small areas of alfisols (1.2%) and entisols (0.9%) near the confluence (Figure 8). Soils in the watershed generally exhibit moderate-moderately low infiltration rates, with approximately 92% of soils in the watershed being either type C (slow) or C/D (slow/very slow) in the Hydrologic Soil Group classification (Table 3, Figure 9) (USDA 2009). The USDA Land Capability Classification was also used to classify and describe suitability to grow field crops (USDA 2018). Land Capability within the watershed is dominated by class 3e, meaning erosion (e) is the major limiting factor, accounting for approximately 85% of land in the watershed (Figure 10). The majority of the soils within the watershed have K-factors less than 0.4 (92.1%) and are found throughout the watershed (Figure 11). Soils with a K-factor greater than 0.4 cover about 3.2% of the watershed and are found predominantly downstream and around Mozingo Lake. A complete list of soil series found within the watershed is available in Appendix A.

Hydrology and Drainage Network

The headwaters of Mozingo Creek are located about 4 miles south of the Iowa state line and flow south to the confluence of the One Hundred and Two River in eastern Randolph County (Figure 1). Mozingo Creek is the only "named" stream within the watershed and the creek was dammed in 1994 to form Mozingo Lake, which at the time was the largest NRCS reservoir in the State (MDNR 2002). There are a total of 90.4 miles of mapped streams within the watershed (Table 4). According to the National Hydrological Dataset (NHD), around 14.4 miles are perennial streams, 56.2 miles are intermittent streams, and 19.8 miles are artificial flow paths. There are around 1,132 acres of ponds and lakes within the NHD database, with the largest being Mozingo Lake at 1,006 acres. There are no mapped major groundwater usage wells within the watershed reporting to MDNR. However, the City of Maryville processes approximately 2.5 million gallons of water per day from Mozingo Lake (City of Maryville 2021).

Land Use and Land Cover

Land use for the watersheds was determined using the 2016-2020 National Agricultural Statistics Service (NASS) Crop Database. Crop classes were combined to look at the overall representation of land use in the watershed. In general, the Mozingo Creek watershed is an agricultural watershed with grass/pasture (39.4%) the largest land use category in the watershed followed by row crops (30.5%) (Table 5). While the highest land use percentage in the watershed is grass/pasture, there has been a decrease of about 1,081 acres since 2016 (Table 6). The majority of the land in row crops is located in the upper watershed above Mozingo Lake and the most common crops are soybeans (19%) and corn (13%) (Figure 12). However, the crop type has shifted some over the last five years as corn has decreased by about 300 acres and soybeans has increased by about 700 acres since 2016.

Previous Work and Other Available Data

TMDLs and Management Plans

Currently, there are no Total Maximum Daily Loads (TMDL) for streams within the watershed in this study. However, Mozingo Lake is on the 303(d) impaired streams and lakes list for chlorophyll-a (W) from a nonpoint source and for mercury in fish tissue from atmospheric deposition (MDNR 2020). Right now, the impairments are considered low priority and a TMDL is not planned to be completed in the next 10 years. Furthermore, sections of the Platte River below Mozingo Creek are listed on the 303d list for E. Coli contamination by rural nonpoint sources. The Mozingo Lake Recreation Park Master Plan was completed in 2014 by the City of Maryville and various consultants (RDG 2014). While the majority of the plan focuses on the infrastructure of the park land surrounding the lake, one recommendation was to create a watershed management plan for the lake to help protect water quality into the future. The recommendation is for the watershed management plan to reduce pollution from entering the lake by implementation of best management practices (BMPs) in the watershed and require appropriate BMPs on new development.

Surface and Ground Water Monitoring Stations

There are no United States Geological Survey (USGS) gaging stations within the watershed. The closest gaging station near Maryville, MO is approximately 4 miles upstream of the Mozingo Creek and One Hundred and Two River confluence (USGS Gaging Station #6819500). To be able to predict discharge within the study watershed, 28 nearby USGS gaging stations were used to complete drainage area-based regression equations to be able to estimate discharge from different size watersheds within the study area (Figure 13). A list of the USGS gaging stations can be found in Appendix B. Additionally, there are no groundwater monitoring stations within the study watershed. The closest groundwater monitoring site is located approximately 12 miles north of Maryville near Hopkins, Missouri (Site Number: 403301094492301) that has data going back to 2007. Data from this station shows that the local water table can fluctuate about 5-6 feet over any given year, but the general trend has been a decrease in the water table since 2007 (Figure 14). If resources became available to install continuous monitoring stations within the watershed, one could be located on Mozingo Creek downstream of the dam on 280th street (UTM Zone15N meters, N: 4,464,290.352, E: 348,073.986).

Water Quality Sampling Data

There is one water quality monitoring site within the watershed. Site 7402/0.1 is located on Mozingo Lake near the dam (Figure 15). This site has between 27 and 83 samples collected to analyze nutrients, sediment, and chlorophyll-a from 1999-2018 (Table 7). Only limited water quality data is available at six sampling sites on the One Hundred and Two River west of the

Mozingo Creek watershed, but these sites are located upstream of the Mozingo Creek confluence. These six sites have 2-5 samples collected and analyzed for nutrients in 2007. There are two permitted point sources within the Mozingo Creek watershed classified as outfall pipes for domestic (sanitary) wastewater (Table 8). There are no permitted confined animal feeding operations (CAFOs) mapped in the watershed.

Biological Monitoring Data

Biological monitoring data available within the watershed is limited to fish tissue samples collected to test metal toxicity in channel catfish and largemouth bass. However, various fish, mussel, and macroinvertebrate studies have been performed in the Platte River watershed for over a century (Bayless and Travnichek 2001). These studies indicate a loss of diversity and an increase in the density of pollution tolerant species across the watershed. Channelization and agricultural land use have been identified as the reason for the decline in aquatic resources in the Platte River watershed. Channelization, for example, was reported to cause a 90% decrease in harvestable fish in the watershed. These data suggest water quality and habitat improvements are needed to reverse these trends.

Summary

The purpose of this report is to provide the information necessary to describe and study a HUC-12 watershed within the One Hundred and Two River watershed for the Mississippi River Basin Healthy Watersheds Initiative (MRBI), Mozingo Creek (HUC #102400130303). The watershed is located east of the City of Maryville and includes Mozingo Creek and the water supply reservoir Mozingo Lake that is listed on the 303d list of impaired waters for chlorophyll A and mercury in fish tissue (MDNR 2020). Increased runoff from agricultural land use has been identified as a major factor in water quality degradation in the Platte River Watershed causing increased upland erosion rates, stream bank erosion, and delivery of excess nutrients to streams (Bayless and Travnichek 2001). 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 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 9).

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

Summary statistics for nutrients, chlorophyll-a, and sediment samples were used to evaluate water quality by looking at both the range of mean concentrations and variability among sites. All water quality data was downloaded from the MDNR Water Quality Assessment System website. Data was only available at one site within the Mozingo Creek watershed located at the dam of Mozingo Lake. Limited data is also available at six sites along the One Hundred and Two River upstream of the confluence with Mozingo Creek. Total phosphorus (TP) and total nitrogen (TN) were available for all sites; however, total suspended solids (TSS) and chlorophyll-a (Chl-a) were only available at the Mozingo Lake site (7402/0.1).

Available data from the dam at Mozingo Lake shows TP and TN concentrations are currently below the State of Missouri screening levels, but Chl-a concentrations fluctuated drastically over the last decade and are currently approaching the screening level. Criteria for listing a lake in the Plains region of Missouri as “impaired for excess nutrients” is based on Chl-a geometric mean concentration of 30 ug/L over a three-year period (MDNR 2019). However, there are “screening levels” set at 0.049 mg/L TP, 0.843 mg/L TN, and 18.0 ug/L for Chl-a. A site that exceeds the screening level must also have documented eutrophic impacts to be considered impaired. From 2003 to 2018 the site located near the Mozingo Lake dam had an annual Chl-a geomean that ranged from 6.9 ug/L in 2014 to over 33 ug/L in 2005 and 2006 with an overall geomean concentration of 16.0 ug/L (Table 10, Figure 16). Using a three-year moving average, Chl-a concentrations peaked from 2005-2007 with levels near the impairment threshold. After 2007 levels decreased dramatically from 2008-2014 to well below the screening level concentration. However, since 2015, concentrations have increased every year to near the screening level of 20 ug/L.

Similar to Chl-a, nutrient concentrations decreased drastically in 2008 and the recent trend shows a gradual increase approaching the State’s screening level. Analysis of the annual geomean shows TP concentrations ranged from 0.020 mg/L in 2008 to 0.049 mg/L in 2015 with an overall geomean of 0.032 mg/L (Figure 16). The three-year moving average line shows a slight decrease to 2010, and then a gradual increase since that time. Annual geomean TN concentrations ranged from 0.12 mg/L in 2008 to 1.13 mg/L in 2005. From 2005-2007, TN concentration exceeded the screening threshold, but also decreased drastically in 2008. But similar to TP, the three-year moving average shows concentrations have gradually increased since that time to back near the screening level. The similarities in the trends of TP, TN, and Chl-a concentrations at Mozingo Lake suggests the gradual increase in nutrients is at least partially responsible for the increased Chl-a concentrations since 2008 and that the water quality in the lake is trending towards the impairment category over the last several years. However, these data also suggest efforts to reduce nutrients entering the lake can decrease Chl-a concentrations dramatically.

There are no available water quality data for streams within Mozingo Creek Watershed and only a few along the One Hundred and Two River that is from 2007. Average TP and TN concentrations for streams upstream of the confluence with Mozingo Creek were relatively high for the region. However, five of the six sites are downstream of the Maryville Wastewater Treatment Facility (WTF) which is likely contributing to the high values. The site at 342/61.9 is upstream of the WWTF and has a mean TP concentration of 0.180 mg/L and average TN concentration of 0.74 mg/L (Table 10). Ambient water quality criteria suggested reference conditions for these streams are 3.26 mg/L TN and 0.118 mg/L TP based on the 25th percentile value for streams within the Corn Belt and Northern Great Plains Ecoregion VI (Table 11, USEPA 2000). Although there are only a few samples available, water quality data from the One Hundred and Two River Watershed near the Mozingo Lake Watershed has mean TP concentrations that exceed the reference condition while TN concentrations are much lower than the reference condition. Water quality conditions for streams within the Mozino Creek Watershed are likely similar to those nearby and conservation practices that can reduce phosphorus and sediment in runoff could be an important component in improving and protecting water quality.

Channel Stability and Riparian Corridor Assessment

<u>Aerial Photo Methods</u>

Aerial photographs from 1997 and 2015 were obtained from the Missouri Spatial Data Information Service (MSDIS) online data server pre-rectified (Table 12). Differences between the two photos due to transformation errors were quantified using point-to-point error analysis. A total of 10 locations on both sets of aerials were evaluated within the HUC-12 watershed boundary. Point-to-point errors ranged from 4.23-9.19 ft for a mean of 7.02 ft (Table 13). Stream 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 the tributary channels were small and the channel bank was obstructed by vegetation in some places, the channel centerline was digitized where it could clearly be seen at a scale of 1:1,500 (Martin and

Pavlowsky 2011). Digitized lines representing the channel position from each year were then compared to identify areas of change and to quantify lateral migration rates.

<u>Channel Classification</u>

Tributary channels and the main stem of Mozingo Creek within the watershed were further classified by identifying historical channel changes by interpretation of the 1997 and 2015 aerial photos. Channels were first characterized as modified or natural. Modified channels were further classified as either "channelized" or "ponded". Natural channels were then classified as either "stable" or "active". Active channels were identified by assessing planform changes since 1997 by overlay analysis of the digitized channel using an error buffer which is based off the 7.02 ft mean point-to-point error to account for biases attributed to rectification (Martin and Pavlowsky 2011). Active reaches were identified as areas where the buffers between the two sets of digitized lines did not overlap for at least 100 ft to account for rectification errors. 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 results show most of the tributaries were not visible. Of the 125.2 miles of evaluated channels within the watershed using this method, 53.4 (42.7) miles were classified as not visible, 28.4 (22.7) miles were stable, 21.6 (17.3%) miles were channelized, 17.9 (14.3%) miles were dams/ponds, and 3.8 (3.0%) miles were active (Table 14). The areas of the channel that were classified as not visible was mainly due to the obstruction of vegetation in the aerial photographs. Most of the dams/ponds are found on branches of Mozingo Lake while channelized reaches are found upstream of the lake where most of the crop land is located, however, there is some channelization right below the Mozingo Lake dam (Figure 19).

<u>Riparian Corridor Analysis</u>

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). Riparian corridors for the Mozingo Creek watershed were evaluated by creating a buffer around the 2015 digitized stream layer and overlaying that layer on the 2015 aerial photo. 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.

Most of the riparian corridors along streams in the Mozingo Creek watershed classified as moderate but are not concentrated to a specific area of the watershed. Within the Mozingo Creek watershed, 58.1 (46%) miles are considered moderate, 42.3 (34%) miles are poor, and 24.8 (20%) miles are good (Table 15). Almost the entire length of Mozingo Creek has moderate riparian corridors with other sections of moderate riparian corridors found throughout (Figure 20). Poor riparian corridors are most found on the upstream section of tributaries and is commonly found upstream of the lake although can be found in a few areas downstream of the lake. Poor riparian corridors upstream of the lake correspond with the location of channelized reaches and cropland in the watershed. Good riparian corridors are scattered throughout the watershed and are not focused in a specific area.

Visual Stream Survey Results

A modified rapid visual stream survey was conducted on both upstream and downstream portions of all public road crossings within the watershed following an established NRCS protocol (USDA 1998). The protocol was modified by only focusing on five physical stream channel indicators, 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 55 crossings were examined for a total of 110 possible observations. Of these 110 sites, 48% were rated as poor, 13% as fair, 9% as good, and 30% as excellent (Table 16). The majority of the poor ratings were due to levees/channelization, active incision, active widening as bank erosion occurred on both sides of the stream, and presence of livestock (Appendix D). This visual survey captured information from both pasture and row crops land uses but was limited in some places due to excessive vegetation and canopy cover.

The main channel of Mozingo Creek both upstream and downstream of the lake generally had poor scores in the VSA assessment (Figure 21). This was mainly due to levees restricting access to the floodplain, active incision/widening, and thin/poor riparian conditions at many sites the survey was conducted. Incision and widening are well known geomorphic processes that occur in the loess region of the Midwest in response to channelization and levee construction (Simon and Rinaldi 2000). Channelization and levee construction increases stream power locally causing headward channel erosion and incision releasing sediment downstream. While many of the smaller, steeper streams draining off the divides also show signs of incision, generally these streams had an adequate riparian corridor and often drained to one or more ponds prior to entering the main stem.

Rainfall–Runoff Relationship

Annual and monthly runoff rates for the Mozingo Creek watershed were estimated using equations developed from 27 USGS gaging stations in the region. Monthly runoff rates are important for understanding the seasonal variability and how rainfall-runoff relationships correspond to land management and annual runoff rates will be used to help validate the STEPL model hydrology results. A list of the equations used for the analysis of monthly mean discharge values can be found in Appendix E. Mean annual discharge for the Mozingo Creek watershed is 24.1 ft3/s and total runoff percent was 30.7% (Figure 22). Average monthly discharge peaks in the month of May and is the lowest in January. Monthly mean runoff as a percentage of rainfall is highest in the winter and early spring, and lowest in the summer ranging from 16.8% in August to nearly 50.4% in February. The remainder of the rainfall is either lost to evapotranspiration or moved through the soil into groundwater storage through infiltration (USDA, 2009). These estimates are comparable with existing literature that show 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 were estimated using 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 17 of conservation practices (Tetra Tech, Inc 2017). Annual nutrient loading was calculated based on the annual runoff volume and established land use specific 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. 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, the 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 Crop database. Animal numbers were estimated at 2,000 beef cattle within the watershed based on input from local staff. The number of septic systems within the watershed was based 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.

Lateral stream bank erosion was accounted for by calculating the 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 1997 and 2015 photos that do not overlap were considered the bank erosion polygons. Additionally, a 7.02 ft error buffer was used to account for the difference in photos. The 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 62 eroding stream banks in the Mozingo Creek watershed (Appendix G). Total eroding bank length for the Mozingo Creek watershed is 589 ft, average volume-weighted bank height is 8.4 ft, and average volume-weighted migration rate is 0.9 ft/yr.

Model results estimated average yields for the Mozingo Creek watershed were 6.10 lb/ac/yr for nitrogen, 1.13 lb/ac/yr phosphorus, and 0.58 T/ac/yr of sediment (Table 17). Runoff rates were 0.92 ac-ft/ac/yr and the percentage of rainfall as runoff was 29.2% for the watershed. Modeled percent runoff is relatively close to the estimated percentage of rainfall as runoff from the USGS gaging station equation estimate, which was 30.7% for the watershed. The relative agreement of these two methods adds confidence to the STEPL modeled runoff results. Further, there as already conservation practices implemented on cropland within the watershed with 32.5% having terraces, 6.4% cover crops, and 14.4% no-till. These were taken into account for the existing loads.

When assessing model results by sources for the Mozingo Creek watershed, the majority of the phosphorus and sediment load is from cropland while the highest nitrogen source is from pasture. Model results show cropland accounts for 49.2% of the phosphorus load and 54.5% of the sediment load (Table 18). Pasture was the next highest contributor of phosphorus with 37.0% of the phosphorus load and 21.9% of the sediment load. When combining pasture and cropland model results, agricultural nonpoint sources contribute 90.1% of the nitrogen, 86.2% of the phosphorus, and 76.3% of the sediment load in the watershed. Streambank erosion also contributes substantially to the sediment load at 21.6% based on the methods used for this study. However, visual stream assessments performed in the watershed identified possible incision and some widening in streams surveyed for this project. These processes are not able to be identified using multiple-year aerial photos for streams of this size. Nevertheless, these results suggest any effort to reduce nutrients from leaving the watersheds should include both cropland and pastureland conservation practices.

<u>Load Reduction Analysis</u>

Load reductions for the watershed were modeled in STEPL using established conservation practice efficiencies. The efficiencies of combined conservation practices were calculated with STEPL's BMP Calculator. A total of twelve cropland conservation practices scenarios and eight pastureland conservation practices scenarios were modeled. A description of each combined conservation practices scenario with calculated efficiencies can be found in Appendix H. Load reductions of nitrogen, phosphorus, and sediment for watershed 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 terraces, no-till, and nutrient management are added and/or combined. Also, grass waterways, filter strips, and water and sediment control basins were added as stand-alone practices. Land retirement was also used as a scenario to show what would happen if the land was taken out of production. For pastureland, the first level conservation practice was livestock exclusion and alternative water. From there, grade stabilization structure, prescribed grazing, and water and sediment control basins were added and combined.

Load reduction analysis indicates substantial nutrient and sediment reduction can be achieved in the watershed through the implementation of both cropland and pastureland conservation practices (Waidler et al. 2009, GSWCC 2013, Tetra Tech 2017). For instance, the most intensely managed scenario combines cover crops, no till, terraces, and nutrient management. If that scenario was applied to 50% of the 6,923 acres of cropland (3,462 acres) within the watershed, load reduction would be 18.8% for nitrogen, 28.1% for phosphorus, and 30.2% for sediment (Tables 19-21). In contrast, applying the most intensely managed scenario to 50% of the 6,255 acres of pastureland (3,128 acres), which is prescribed grazing, grade stabilization structure, and water and sediment control basin, the reduction would be only 17.7% for nitrogen, 10.2% for phosphorus, and 7.3% for sediment. An important part of the load reduction modeling is the benefit of multiple practices applied to cropland within the watershed. For instance, an estimated 30% of the cropland has existing terraces, adding cover crops, no-till, and nutrient management to that same land can more than double the reduction of nutrients and sediment. Additionally, if all the cropland within the watershed was taken out of production and the land retired, the resulting load reduction would be 44.9% for nitrogen, 57.9% phosphorus, and 65.6% for sediment.

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 Mozingo Creek Watershed (HUC-102400130303). Available data from the dam at Mozingo Lake shows TP and TN concentrations are currently below the State of Missouri screening levels, but Chl-a concentrations fluctuated drastically over the last decade and are currently approaching the screening level. The three-year moving average for Chl-a concentrations peaked from 2005-2007 with levels near the impairment threshold. After 2007 levels decreased dramatically from 2008-2014 to well below the screening level concentration. However, since 2015 concentrations have increased every year to near the screening level of 20 ug/L. Similar to Chl-a, nutrient concentrations decreased drastically in 2008 and the recent trend shows a gradual increase approaching the State's screening level. The similarities in the trends of TP, TN, and Chl-a concentrations at Mozingo Lake suggests the gradual increase in nutrients is at least partially responsible for the increased Chl-a concentrations since 2008 and that the water quality in the lake is trending towards the impairment category over the last several years. However, these data also suggest efforts to reduce nutrients entering the lake can decrease Chl-a concentrations dramatically.

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. While the majority of the small tributaries were not visible, most of the dams/ponds are found on branches of Mozingo Lake while channelized reaches are found upstream of the lake where much of the cropland is located. Most of the riparian corridors along streams in the Mozingo Creek watershed classified as moderate but are not concentrated to a specific area of the watershed. This visual survey captured information from both pasture and row crops land uses but was limited in some places due to excessive vegetation and canopy cover. The main channel of Mozingo Creek both upstream and downstream of the lake generally had poor scores in the VSA assessment (Figure 21). This was mainly due to levees restricting access to the floodplain, active incision/widening, and thin/poor riparian conditions at many sites the survey was conducted. Many of the smaller, steeper streams draining off the divides also show signs of incision, generally these streams had an adequate riparian corridor and often drained to one or more ponds prior to entering the main stem.

When assessing model results by sources for the Mozingo Creek watershed, the majority of the phosphorus and sediment load is from cropland while the highest nitrogen source is from pasture. When combining pasture and cropland model results, agricultural nonpoint sources contribute 90.1% of the nitrogen, 86.2% of the phosphorus, and 76.3% of the sediment load in the watershed. Streambank erosion also contributes substantially to the sediment load at 21.6% based on the methods used for this study. Nevertheless, these results suggest any effort to reduce nutrients from leaving the watersheds should include both cropland and pastureland conservation practices. Load reduction analysis indicates substantial nutrient and sediment reduction can be achieved in the watershed through the implementation of both cropland and pastureland conservation practices. An important part of the load reduction modeling is the benefit of multiple practices applied to cropland within the watershed. For instance, an estimated 30% of the cropland has existing terraces, adding cover crops, no-till, and nutrient management to that same land can more than double the reduction of nutrients and sediment.

IDENTIFICATION OF CONSERVATION NEEDS

Resource Priorities

For the Mozingo Creek watershed, the top resource priority identified in this assessment is the reduction of sediment from nonpoint agricultural land use. Increased runoff from agricultural land use has been identified as a major factor in water quality degradation in the larger Platte River Watershed from increased upland erosion rates, stream bank erosion, and delivery of excess nutrients to streams and reservoirs (Bayless and Travnichek 2001). Further, in 2014, the Mozingo Lake Recreation Park Master Plan specifically states the need for a watershed management plan to reduce pollutants entering the lake from the upstream contributing area (RDG 2014). 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 6,923 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.

<u>Management Units</u>

To better plan for locations to implement conservation practices, the HUC-12 watershed was divided into 7 smaller watersheds, or management units (MUs) (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 2,160-3,457 acres (Table 22). MUs will be ranked in two ways. First, they will be ranked by location in relationship to Mozingo Lake. MUs located upstream of the dam are a higher priority than the MUs located downstream. The MU with the highest sediment yield (1.85 T/ac/yr) is #6, which is upstream of Mozingo Lake. The MU with the next highest sediment yield is #7, which is located just upstream of #6. These two MUs have high sediment yields due to having greater than half the land use within the drainage area dedicated to crops.

MU #5 is also located upstream of Mozingo Lake, but since the percentage of cropland is significantly lower than the upstream MUs, it ranks third. Due to the sediment yields and location, MUs 5, 6, and 7 are classified as high priority for conservation practices. The two MUs downstream of the dam have similar sediment yields to #5 but are lower in the ranking due to being downstream of the lake. Finally, MUs 3 and 4, located around the lake, have relatively low agricultural land uses and low sediment yields. As a result, they are classified in the moderate category. 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 susceptible 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 areas 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 23.

Highest Priority – For this watershed the highest susceptibility classification for conservation planning was based on cropland and pasture located within 500 ft of a mapped stream. Within the watershed, 6,578 acres are classified in the highest priority category, or roughly 36.6% of the watershed area (Figure 24).

High Priority – Cropland and pasture located between 500-1,000 ft of a mapped stream were placed in high vulnerability category for conservation planning. There is a total of 4,906 acres of high priority acres in the watershed, or about 27.3% 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 1,906 acres, or 10.9% 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 2,426 low priority acres, or 13.5% 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 2,078 acres, or 11.6% 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 Mozingo 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 ten rankings for the watershed (Table 24). 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 Mozingo Creek watershed (HUC-102400130303) in Nodaway County 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 eight main conclusions for this assessment:

1) The watershed is located east of the City of Maryville and includes the water supply reservoir Mozingo Lake built by the NRCS in 1996. Mozingo Lake is listed on the 303d list of impaired waters for chlorophyll A and mercury in fish tissue. Increased runoff from agricultural land use

has been identified as a major factor in water quality degradation in the larger Platte River Watershed causing increased upland erosion rates, stream bank erosion, and delivery of excess nutrients to streams and reservoirs;

2) Available water quality data from the dam at Mozingo Lake shows TP and TN concentrations are currently below the State of Missouri screening levels, but Chl-a concentrations fluctuated drastically over the last decade and are currently approaching the screening level. The three-year moving average for Chl-a concentrations peaked from 2005-2007 with levels near the impairment threshold. After 2007, levels decreased dramatically from 2008-2014 to well below the screening level concentration. However, since 2015 concentrations have increased every year to near the screening level of 20 ug/L. Similar to Chl-a, nutrient concentrations decreased drastically in 2008 and the recent trend shows a gradual increase approaching the State's screening level;

3) The similarities in the trends of TP, TN, and Chl-a concentrations at Mozingo Lake suggests the gradual increase in nutrients is at least partially responsible for the increased Chl-a concentrations since 2008 and that the water quality in the lake is trending towards the impairment category over the last several years. However, these data also suggest efforts to reduce nutrients entering the lake can decrease Chl-a concentrations dramatically;

4) Both historical aerial photos were used to evaluate potential contributions of streambank erosion to water quality problems and classify the riparian corridor along stream channels within the watershed. While the majority of the small tributaries were not visible, most of the dams/ponds are found on branches of Mozingo Lake while channelized reaches are found upstream of the lake where much of the cropland is located. Most of the riparian corridors along streams in the Mozingo Creek watershed classified as moderate but are not concentrated to a specific area of the watershed;

5) A field-based visual survey was able to provide information from both pasture and row crops land uses but was limited in some places due to excessive vegetation and canopy cover. The main channel of Mozingo Creek both upstream and downstream of the lake generally had poor scores in the VSA assessment. This was mainly due to levees restricting access to the floodplain, active incision/widening, and thin/poor riparian conditions at many sites the survey was conducted. Many of the smaller, steeper streams draining off the divides also show signs of incision, generally these streams had an adequate riparian corridor and often drained to one or more ponds prior to entering the main stem;

6) When assessing water quality model results by sources for the Mozingo Creek watershed, the majority of the phosphorus and sediment load is from cropland while the highest nitrogen source is from pasture. When combining pasture and cropland model results, agricultural nonpoint sources contribute 90.1% of the nitrogen, 86.2% of the phosphorus, and 76.3% of the sediment load in the watershed. Streambank erosion also contributes substantially to the sediment load at 21.6% based on the methods used for this study. Nevertheless, these results suggest any effort to reduce nutrients from leaving the watersheds should include both cropland and pastureland conservation practices.

7) For the Mozingo Creek watershed, the top resource priority identified in this assessment is the reduction of sediment from nonpoint agricultural land use. Load reduction analysis indicates substantial nutrient and sediment reduction can be achieved in the watershed through the implementation of both cropland and pastureland conservation practices. An important part of the load reduction modeling is the benefit of multiple practices applied to cropland within the watershed. For instance, an estimated 30% of the cropland has existing terraces, adding cover crops, no-till, and nutrient management to that same land can more than double the reduction of nutrients and sediment; and

8) 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 Nodaway County 2010-2019.

Census Category	Nodaway County	Missouri
Population 2010	23,373	5,988,927
Population 2019*	22,092	6,137,428
Population Change 2010-2019	-1,281	148,501
% Change 2010-2019	-5.5%	2.5%
% White	94.0%	82.9%
% Black	3.0%	11.8%
% Hispanic	1.8%	4.4%
% Other	1.2%	0.9%
Population/mi^2	25	89
HUC12 Area (mi^2)	28.1	NA
HUC12 Population Est.	703	NA
Income per capita	$22,915	$30,810
% Poverty	17.8%	12.9%
% Population working in ag industry**	4.6%	1.7%
% Living in Unincorporated Areas	34.0%	33.7%

* Estimate

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

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

Year	Annual Total Rainfall (in)	Average Annual Temperature (F°)
1991*	39.8	52.0
1992*	38.8	51.3
1993	63.5	49.4
1994	30.8	51.0
1995	36.2	50.6
1996	39.8	48.7
1997	35.0	50.3
1998	46.1	53.6
1999	30.1	52.6
2000	32.0	51.4
2001	36.7	52.0
2002	23.0	52.0
2003	25.2	51.4
2004	36.4	51.5
2005	35.5	52.3
2006	37.9	53.2
2007	42.0	51.8
2008	39.3	49.2
2009	47.6	49.4
2010	39.6	50.8
2011	34.7	51.3
2012*	29.5	54.8
2013*	27.1	49.0
2014	44.3	48.8
2015	53.7	52.6
2016	38.2	54.1
2017	37.6	53.5
2018	34.5	51.2
2019	51.0	50.7
2020*	33.6	52.0
n	30	30
Min	23.0	48.7
Mean	38.0	51.4
Max	63.5	54.8

*Data supplemented for some months from Conception, MO

Data source: http//mrcc/isws.illinois.edu/CLI-MATE

Table 3. Watershed soil characteristics summary

Soil Order	%	Hydrologic Soil Group	%	Soil Erosion K-Factor	%	Soil Erosion T-Factor	%	Land Capability Classification	%
Alfisols	1.2%	B	1.1%	<0.2	5.7%	3	0.8%	2e	19.5%
Entisols	0.9%	C	67.3%	0.2-0.3	54.5%	5	94.4%	2w	8.7%
Mollisols	93.1%	C/D	24.9%	0.3-0.4	31.8%	Other	4.8%	3e	64.6%
Other	4.8%	D	1.9%	0.4-0.5	3.2%			3w	0.3%
		Other	4.8%	>0.5	0.0%			4e	0.9%
				Other	4.8%			6e	1.2%
								Other	4.8%

Table 4. Drainage network summary

Water Feature	**Length/Area**
<u>Total Streams</u>	<u>90.4 mi</u>
Permanent Flow	14.4 mi
Intermittent Flow	56.2 mi
Artificial Path	19.8 mi
<u>Waterbodies</u>	
Lakes/Ponds	1,132 ac

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

General Land Use/Land Cover	Year					2016-2020 Average (%)
	2016	2017	2018	2019	2020	
Crop	29.9%	29.7%	30.3%	30.5%	32.2%	30.5
Alfalfa and Other Hay	5.6%	4.7%	6.5%	6.8%	7.3%	6.2
Grass/Pasture	41.4%	42.7%	39.8%	37.8%	35.4%	39.4
Water and Wetlands	6.0%	5.9%	6.3%	6.4%	6.3%	6.2
Developed	5.8%	5.8%	5.8%	5.2%	5.2%	5.6
Forest	11.3%	11.2%	11.2%	13.2%	13.5%	12.1

Table 6. Specific crop data from 2016-2020 with change in acres.

Class Name	Year					Change 2016-2020 (acres)
	2016	2017	2018	2019	2020	
Soybeans	15.1%	16.8%	16.7%	16.8%	19.0%	+700
Corn	14.2%	12.8%	13.4%	12.9%	12.5%	-301
Other Hay/Non-Alfalfa	5.5%	4.7%	6.4%	6.8%	7.2%	+310
Grassland/Pasture	41.4%	42.3%	39.8%	37.3%	35.4%	-1,081
Deciduous Forest	11.1%	11.1%	11.0%	12.8%	13.2%	+375

Table 7. Water quality monitoring sites with nutrient, sediment, and chlorophyll-a data summary.

Site ID	TP (n)	TP Start	TP End	TP Mean (mg/L)	TN (n)	TN Start	TN End	TN Mean (mg/L)	TSS (n)	TSS Start	TSS End	TSS Mean (mg/L)	Chl-a (n)	Chl-a Start	Chl-a End	Chl-a Mean (ug/L)
7402/0.1	83	6/2/1999	9/12/2018	0.03	78	6/2/1999	9/12/2018	0.78	27	10/22/2002	9/12/2018	4.97	55	6/2/2003	9/12/2018	20.0
342/57.8	5	7/18/2007	9/6/2007	0.22	5	7/18/2007	9/6/2007	0.74	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
342/59.8	4	7/18/2007	9/6/2007	0.35	4	7/18/2007	9/6/2007	1.38	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
342/59.9	2	7/18/2007	9/6/2007	1.83	2	7/18/2007	9/6/2007	6.08	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
342/60.8	4	7/18/2007	9/5/2007	0.14	4	7/18/2007	9/5/2007	0.55	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
342/60.9	3	7/18/2007	9/5/2007	4.57	3	7/18/2007	9/5/2007	12.86	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
342/61.9	4	7/18/2007	9/5/2007	0.18	4	7/18/2007	9/5/2007	0.74	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

n= sample number
TP = total phosphorus
TN = total nitrogen
TSS = total suspended sediment
N/A = not available

Table 8. Permitted point sources within the watershed.

Site Number	Facility Name	Type	Stream	Waste	Status
1	Countryside View Subdivision	Outfall Pipe	Unnamed Tributary to Mozingo Creek	Domestic (Sanitary) Wastewater	Effective
2	Mozingo Lake Recreation	Outfall Pipe	Unnamed Tributary to Mozingo Creek	Domestic (Sanitary) Wastewater	Effective

Table 9. 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		https://apps5.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 10. Summary of water quality data for the Mozingo Creek watershed

Site ID	TP (mg/L)						TN (mg/L)						TSS (mg/L)						Chl-a (ug/L)					
	n	min	mean	max	stdev	cv%	n	min	mean	max	stdev	cv%	n	min	mean	max	stdev	cv%	n	min	mean	max	stdev	cv%
7402/0.1	83	0	0.03	0.06	0.01	33.3	78	0.01	0.78	2.00	0.3	38.1	27	0	4.97	9.67	2.92	58.8	55	0	20.04	52	12.08	60.3
342/57.8	5	0.18	0.22	0.3	0.06	27.3	5	0.45	0.74	1.25	0.4	54.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
342/59.8	4	0.2	0.35	0.57	0.18	51.4	4	0.5	1.38	2.53	1.0	75.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
342/59.9	2	1.18	1.83	2.48	0.92	50.3	2	2.56	6.08	9.6	5.0	81.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
342/60.8	4	0.01	0.14	0.23	0.09	64.3	4	0.03	0.55	1.02	0.4	76.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
342/60.9	3	4.4	4.57	4.9	0.29	6.3	3	5.28	12.86	15.3	6.7	52.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
342/61.9	4	0.13	0.18	0.23	0.06	33.3	4	0.33	0.74	1.17	0.4	59.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 11. Ambient water quality criteria recommendations for total nitrogen (TN) and total phosphorus (TP), Ecoregion VI, ecoregion 47 (USEPA 2000)

Parameter	25th Percentile	Range
TN (mg/L)	3.26	1.65-10.06
TP (mg/L)	0.118	0.011-1.720

Table 12. Aerial photography used for channel change analysis.

Photo Year	Source	Type	Resolution (ft)
1997	USGS	Black and White Photo	3.3
2015	USGS	Color High Resolution	0.5

Table 13. Point-to-point (PTP) errors by watershed.

Watershed	Range PTP Error (ft)	Mean PTP Error (ft)
Mozingo	4.23-9.19	7.02

Table 14. Channel classification.

Watershed	Total Length (mi)	Channelized	Dam/Pond	Stable	Active	Not Visible
Mozingo	125.2	21.6 17.3%	17.9 14.3%	28.4 22.7%	3.8 3.0%	53.4 42.7%

Table 15. Riparian corridor classification.

Watershed	Total Length (mi)	Good	Moderate	Poor
Mozingo	125.2	24.8 20%	58.1 46%	42.3 34%

Table 16. VSA survey results.

Watershed	Total Assessments	Poor (< 6.0)	Fair (6.1 - 7.4)	Good (7.5 - 8.9)	Excellent (> 9.0)
Mozingo Creek	110	53 48%	14 13%	10 9%	33 30%

Table 17. STEPL model results.

Watershed ID	Total Ad (ac)	Runoff (ac-ft)	Runoff Yield (ac-ft/ac)	% Rainfall as Runoff	Annual Load			Annual Yield			Mean Concentrations		
					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
Mozingo	17,954	16,598	0.92	29.2	109,578	20,270	10,436	6.10	1.13	0.58	2.43	0.45	462

Table 18. STEPL results by sources.

Sources	**N Load (lb/yr)**	**%**	**P Load (lb/yr)**	**%**	**Sediment Load (t/yr)**	**%**
Urban	6,249	5.7%	965	4.8%	143	1.4%
Cropland	41,245	37.6%	9,982	49.2%	5,683	54.5%
Pastureland	57,520	52.5%	7,494	37.0%	2,283	21.9%
Forest	849	0.8%	398	2.0%	73	0.7%
Septic	11	0.0%	4	0.0%	0	0.0%
Streambank	3,704	3.4%	1,426	7.0%	2,254	21.6%
Total	109,578	100%	20,270	100%	10,436	100%

Table 19. 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	0.7	1.4	2.1	2.8	3.5	4.2	4.9	5.7	6.4	7.1
Terrace	1.6	3.2	4.8	6.4	8.0	9.6	11.2	12.8	14.4	16.0
Cover Crop and Terrace	2.1	4.2	6.3	8.4	10.5	12.6	14.7	16.7	18.8	20.9
Cover Crop and No-Till	2.9	5.9	8.8	11.8	14.7	17.6	20.6	23.5	26.5	29.4
Cover Crop, No-Till, Nutrient Management	3.3	6.6	9.8	13.1	16.4	19.7	23.0	26.3	29.5	32.8
Water and Sediment Control Basin	3.5	6.9	10.4	13.9	17.3	20.8	24.2	27.7	31.2	34.6
No-Till and Terrace	3.2	6.4	9.6	12.9	16.1	19.3	22.5	25.7	28.9	32.2
Cover Crop, No-Till, and Terrace	3.5	7.0	10.5	14.0	17.5	21.0	24.5	28.0	31.5	35.0
Cover Crop, No-Till, Terrace, and Nutrient Management	3.8	7.5	11.3	15.0	18.8	22.6	26.3	30.1	33.8	37.6
Grassed Waterway	3.3	6.5	9.8	13.1	16.4	19.6	22.6	26.2	29.4	32.7
Filter Strips	3.4	6.8	10.2	13.6	17.1	20.5	23.9	27.3	30.7	34.1
Land Retirement	4.5	9.0	13.5	18.0	22.5	27.0	31.5	35.9	40.4	44.9
Pastureland	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Livestock Exclusion and Alternative Water	1.1	2.2	3.3	4.4	5.5	6.6	7.7	8.8	9.9	11.0
Grade Stabilization Structure	2.8	5.7	8.5	11.3	14.2	17.0	19.8	22.7	25.5	28.3
Livestock Exclusion, Alternative Water, and Prescribed Grazing	2.3	4.7	7.0	9.4	11.7	14.1	16.4	18.8	21.1	23.5
Grade Stabilization Structure and Prescribed Grazing	3.2	6.4	9.6	12.8	16.0	19.3	22.5	25.7	28.9	32.1
Water and Sediment Control Basin	2.2	4.5	6.7	9.0	11.2	13.5	15.7	18.0	20.2	22.5
Livestock Exclusion, Alternative Water, Prescribed Grazing, and Forest Buffer	3.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0
Grade Stabilization Structure and Sediment Control Basin	3.4	6.8	10.2	13.6	17.0	20.4	23.8	27.2	30.6	33.9
Grade Stabilization Structure, Water and Sediment Control Basin, and Prescribed Grazing	3.5	7.1	10.6	14.2	17.7	21.3	24.8	28.4	31.9	35.5

Table 20. 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									
<u>Cropland</u>	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Cover Crop	0.6	1.2	1.8	2.3	2.9	3.5	4.1	4.7	5.3	5.8
Terrace	2.4	4.8	7.1	9.5	11.9	14.3	16.7	19.1	21.4	23.4
Cover Crop and Terrace	2.7	5.5	8.2	11.0	13.7	16.5	19.2	21.9	24.7	27.4
Cover Crop and No-Till	4.9	9.8	14.7	19.6	24.5	29.3	34.2	39.1	44.0	48.9
Cover Crop, No-Till, Nutrient Management	5.2	10.3	15.5	20.7	25.9	31.0	36.2	41.4	46.5	51.7
Water and Sediment Control Basin	5.2	10.3	15.5	20.6	25.8	31.0	36.1	41.3	46.5	51.6
No-Till and Terrace	5.3	10.7	16.0	21.4	26.7	32.0	37.4	42.7	48.0	53.4
Cover Crop, No-Till, and Terrace	5.4	10.9	16.3	21.7	27.2	32.6	38.0	43.4	48.9	54.3
Cover Crop, No-Till, Terrace, and Nutrient Management	5.6	11.2	16.9	22.5	28.1	33.7	39.4	45.0	50.6	56.2
Grassed Waterway	4.3	8.6	12.9	17.2	21.5	25.8	30.1	34.4	38.7	43.0
Filter Strips	4.7	9.4	14.0	18.7	23.4	28.1	32.7	37.4	42.1	46.8
Land Retirement	5.8	11.6	17.4	13.2	28.9	34.7	40.5	46.3	52.1	57.9
<u>Pastureland</u>	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Livestock Exclusion and Alternative Water	0.6	1.2	1.9	2.5	3.1	3.7	4.4	5.0	5.6	6.2
Grade Stabilization Structure	1.6	3.2	4.8	6.4	8.0	9.6	11.2	12.8	14.4	16.0
Livestock Exclusion, Alternative Water, and Prescribed Grazing	1.4	2.8	4.2	5.6	7.0	8.3	9.7	11.1	12.5	13.9
Grade Stabilization Structure and Prescribed Grazing	1.8	3.5	5.3	7.0	8.8	10.5	12.3	14.0	15.8	17.5
Water and Sediment Control Basin	1.6	3.3	4.9	6.6	8.2	9.8	11.5	13.1	14.8	16.4
Livestock Exclusion, Alternative Water, Prescribed Grazing, and Forest Buffer	1.7	3.4	5.2	6.9	8.6	10.3	12.0	13.7	15.5	17.2
Grade Stabilization Structure and Sediment Control Basin	2.0	4.0	6.0	8.1	10.1	12.1	14.1	16.1	18.1	20.1
Grade Stabilization Structure, Water and Sediment Control Basin, and Prescribed Grazing	2.0	4.1	6.1	8.2	10.2	12.3	14.3	16.4	18.4	20.5

Table 21. 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	0.7	1.4	2.1	2.8	3.5	4.1	4.8	5.5	6.2	6.9
Terrace	2.8	5.5	8.3	11.0	13.8	16.6	19.3	22.1	24.9	27.6
Cover Crop and Terrace	3.2	6.4	9.5	12.7	15.9	19.1	22.2	25.4	28.6	31.8
Cover Crop and No-Till	5.5	11.0	16.4	21.9	27.4	32.9	38.3	43.8	49.3	54.8
Cover Crop, No-Till, Nutrient Management	5.5	11.0	16.4	21.9	27.4	32.9	38.3	43.8	49.3	54.8
Water and Sediment Control Basin	5.9	11.9	17.8	23.8	29.7	35.6	41.6	47.5	53.5	59.4
No-Till and Terrace	6.0	11.9	17.9	23.8	29.8	35.7	41.7	47.6	53.6	59.5
Cover Crop, No-Till, and Terrace	6.0	12.1	18.1	24.2	30.2	36.3	42.3	48.4	54.4	60.5
Cover Crop, No-Till, Terrace, and Nutrient Management	6.0	12.1	18.1	24.2	30.2	36.3	42.3	48.4	54.4	60.5
Grassed Waterway	4.5	9.0	13.5	18.0	22.4	26.9	31.4	35.9	40.4	44.9
Filter Strips	5.2	10.4	15.5	20.7	25.9	31.1	36.3	41.4	46.6	51.8
Land Retirement	6.6	13.1	19.7	26.2	32.8	39.4	45.9	52.5	59.0	65.6
Pastureland	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Livestock Exclusion and Alternative Water	0.3	0.6	0.8	1.1	1.4	1.7	1.9	2.2	2.5	2.8
Grade Stabilization Structure	1.1	2.2	3.3	4.5	5.6	6.7	7.8	8.9	10.0	11.1
Livestock Exclusion, Alternative Water, and Prescribed Grazing	1.2	2.4	3.5	4.7	5.9	7.1	8.3	9.4	10.6	11.8
Grade Stabilization Structure and Prescribed Grazing	1.2	2.5	3.7	5.0	6.2	7.4	8.7	9.9	11.1	12.4
Water and Sediment Control Basin	1.3	2.6	3.8	5.1	6.4	7.7	8.9	10.2	11.5	12.8
Livestock Exclusion, Alternative Water, Prescribed Grazing, and Forest Buffer	1.3	2.7	4.0	5.4	6.7	8.1	9.4	10.7	12.1	13.4
Grade Stabilization Structure and Sediment Control Basin	1.4	2.9	4.3	5.7	7.2	8.6	10.0	11.5	12.9	14.3
Grade Stabilization Structure, Water and Sediment Control Basin, and Prescribed Grazing	1.5	2.9	4.4	5.8	7.3	8.7	10.2	11.6	13.1	14.5

Table 22. Annual sediment yield ranked by Management Unit.

Watershed ID	Total Ad (ac)	Crop Acres	Pasture Acres	Annual Sed. Yield-t/ac/yr	Priority Rank	Priority Class
6	2,404.2	1,498.2	680.0	1.85	1	High
7	2,160.2	1,410.6	543.5	1.75	2	High
5	3,457.3	1,613.4	1,190.9	1.11	3	High
4	2,677.7	578.3	1,191.1	0.74	4	Moderate
3	2,400.0	394.1	711.9	0.61	5	Moderate
2	2,571.5	793.1	1,296.5	1.12	6	Low
1	2,278.7	810.6	731.1	1.12	7	Low

Table 23. Summary of susceptibility classification for the study watershed.

Susceptible Acres Rank	Land Use and Conditions	Acres
Highest	Cropland or Pasture within 500 ft of a stream	6,578 (36.6 %)
High	Cropland or Pasture 500 - 1,000 ft of a stream	4,906 (27.3 %)
Moderate	Crop and Pasture > 1,000 ft from a stream	1,965 (10.9 %)
Low	Forest	2,426 (13.5 %)
N/A	Urban Water and Wetlands	2,078 (11.6 %)

Table 24. Ranked conservation practices by largest sediment load reduction.

Rank	List of Practices in Deliverable	Land Use Type
T-1	Cover Crop, No-Till, and Terrace	Cropland
T-1	Cover Crop, No-Till, Terrace, and Nutrient Management	Cropland
3	No-Till and Terrace	Cropland
4	Water and Sediment Control Basin	Cropland
T-5	Cover Crop and No-Till	Cropland
T-5	Cover Crop, No-Till, Nutrient Management	Cropland
7	Filter Strips	Cropland
8	Grassed Waterway	Cropland
9	Cover Crop and Terrace	Cropland
10	Terrace	Cropland
11	Grade Stabilization Structure, Sediment Control Basin, and Prescribed Grazing	Pasture
12	Grade Stabilization Structure and Sediment Control Basin	Pasture
13	Livestock Exclusion, Alternative Water, Prescribed Grazing, and Forest Buffer	Pasture
14	Water and Sediment Control Basin	Pasture
15	Grade Stabilization Structure and Prescribed Grazing	Pasture
16	Livestock Exclusion, Alternative Water, and Prescribed Grazing	Pasture
17	Grade Stabilization Structure	Pasture
18	Cover Crop	Cropland
19	Livestock Exclusion and Alternative Water	Pasture

FIGURES

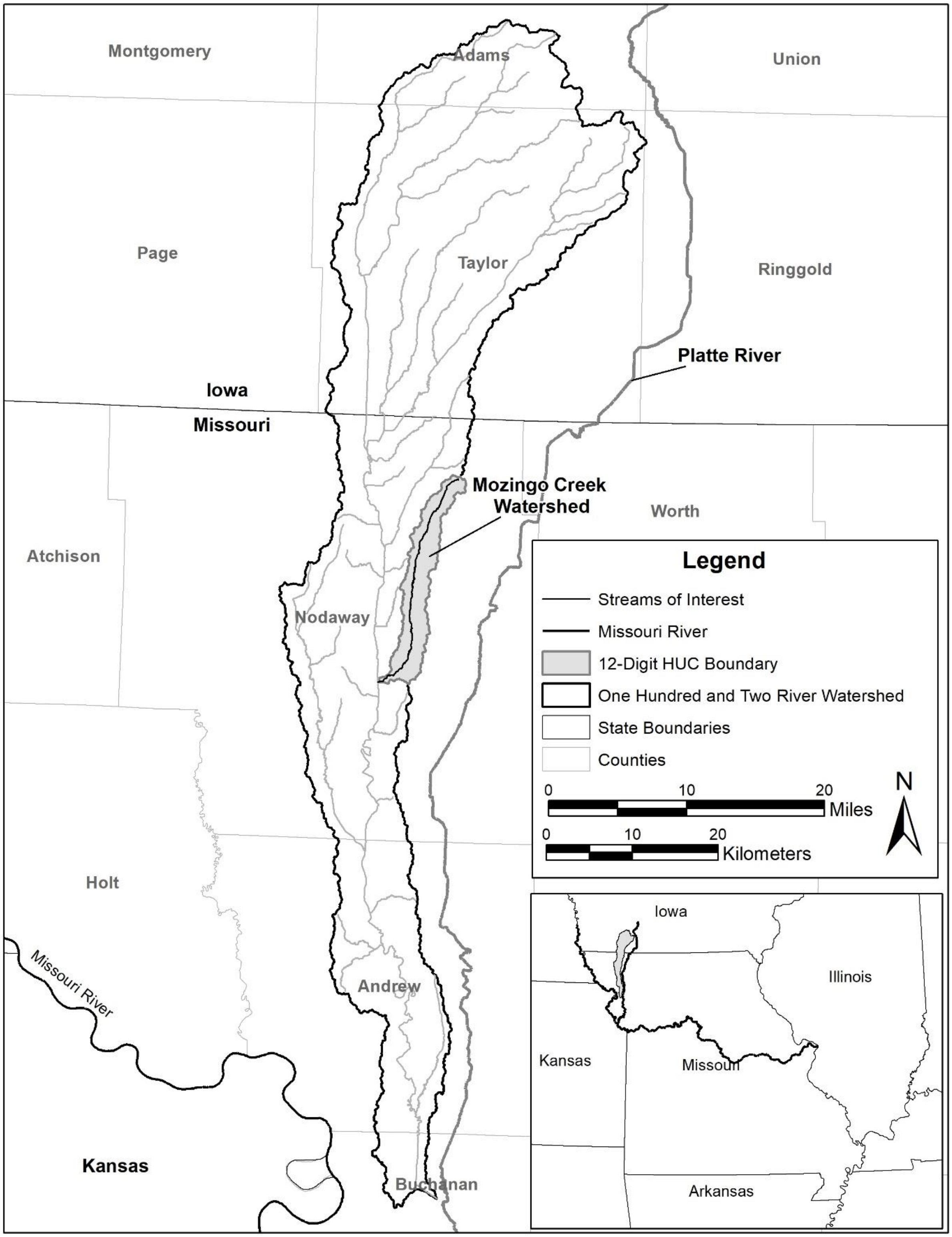


Figure 1. One Hundred and Two watershed in northwest Missouri.

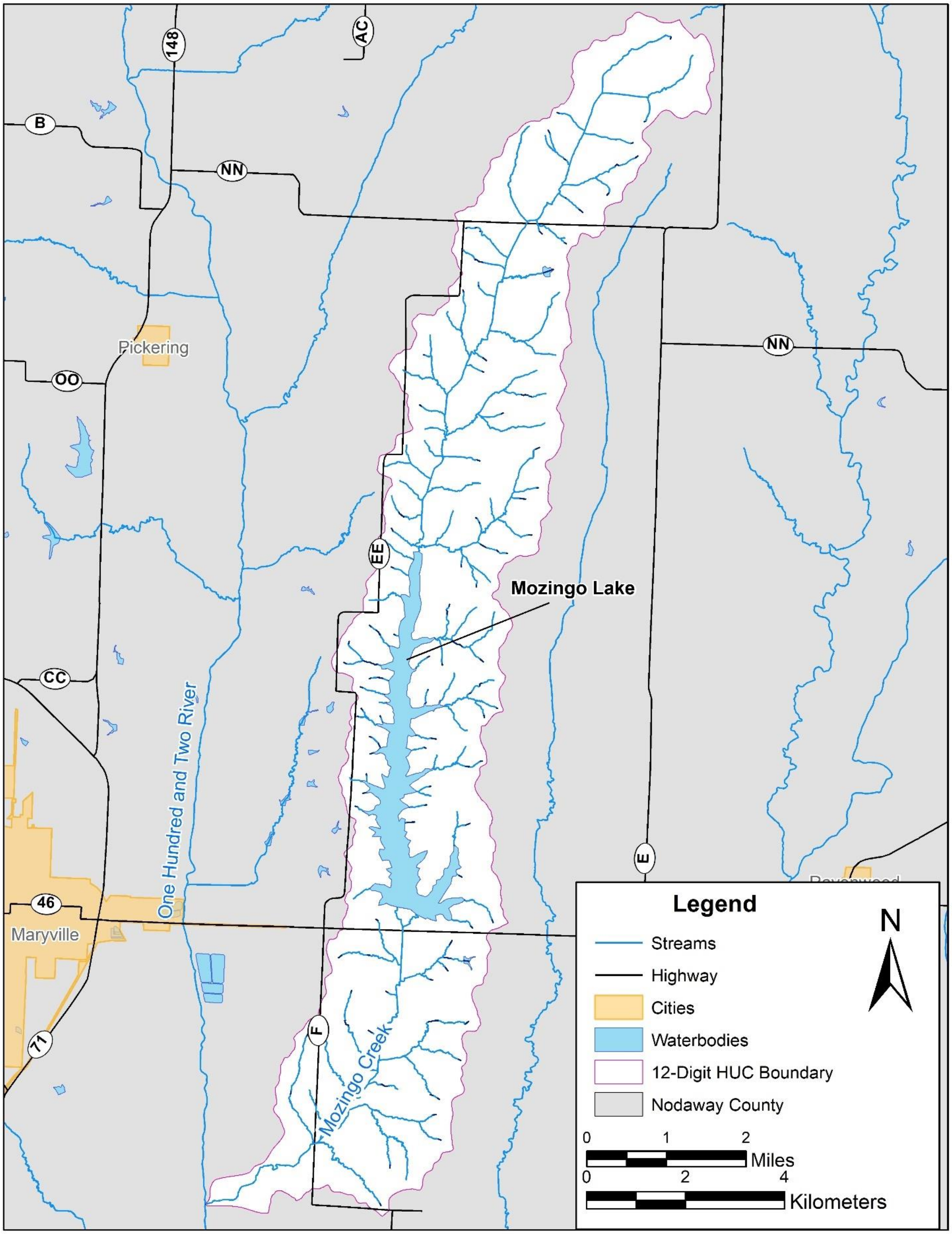
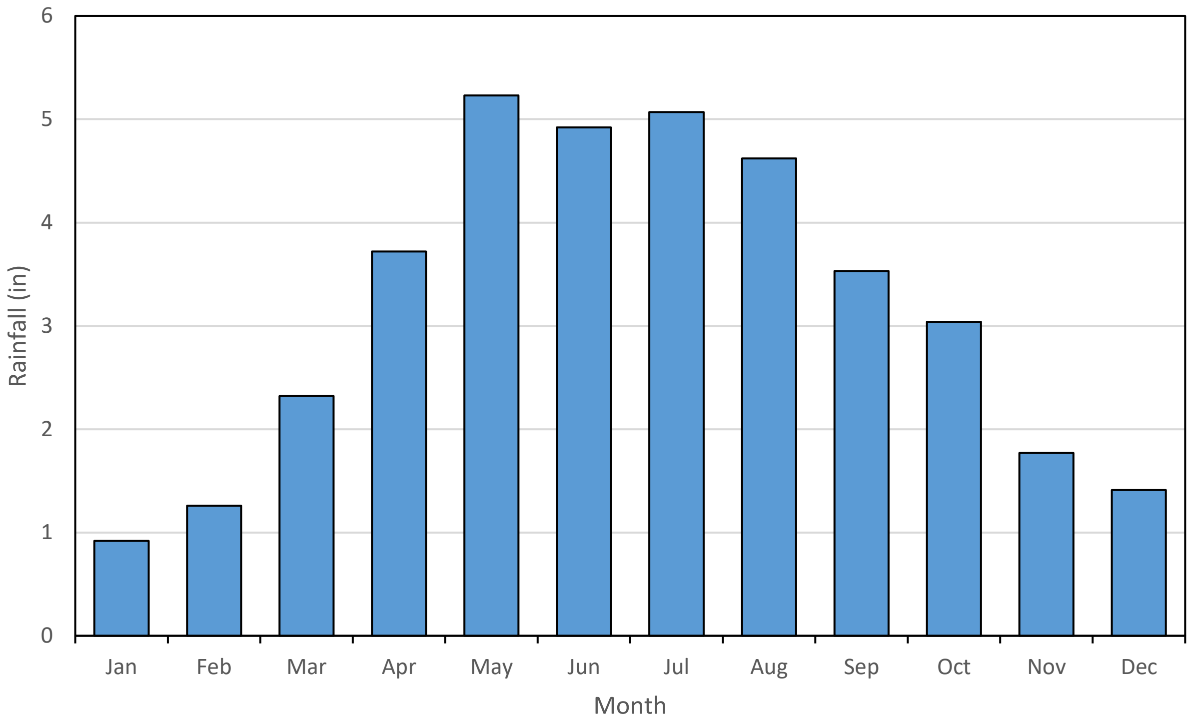


Figure 2. Mozingo Creek watershed.

A)



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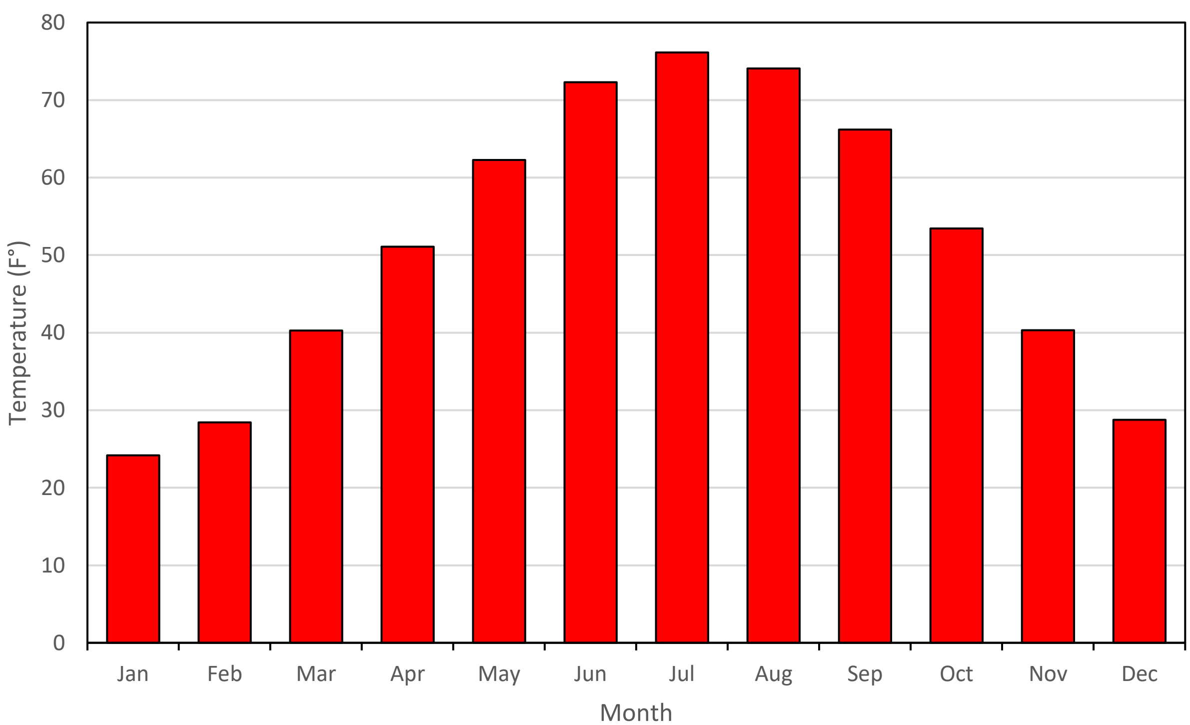

Figure 3. Mean monthly A) rainfall and B) temperature from 1991-2020 for Maryville, MO.

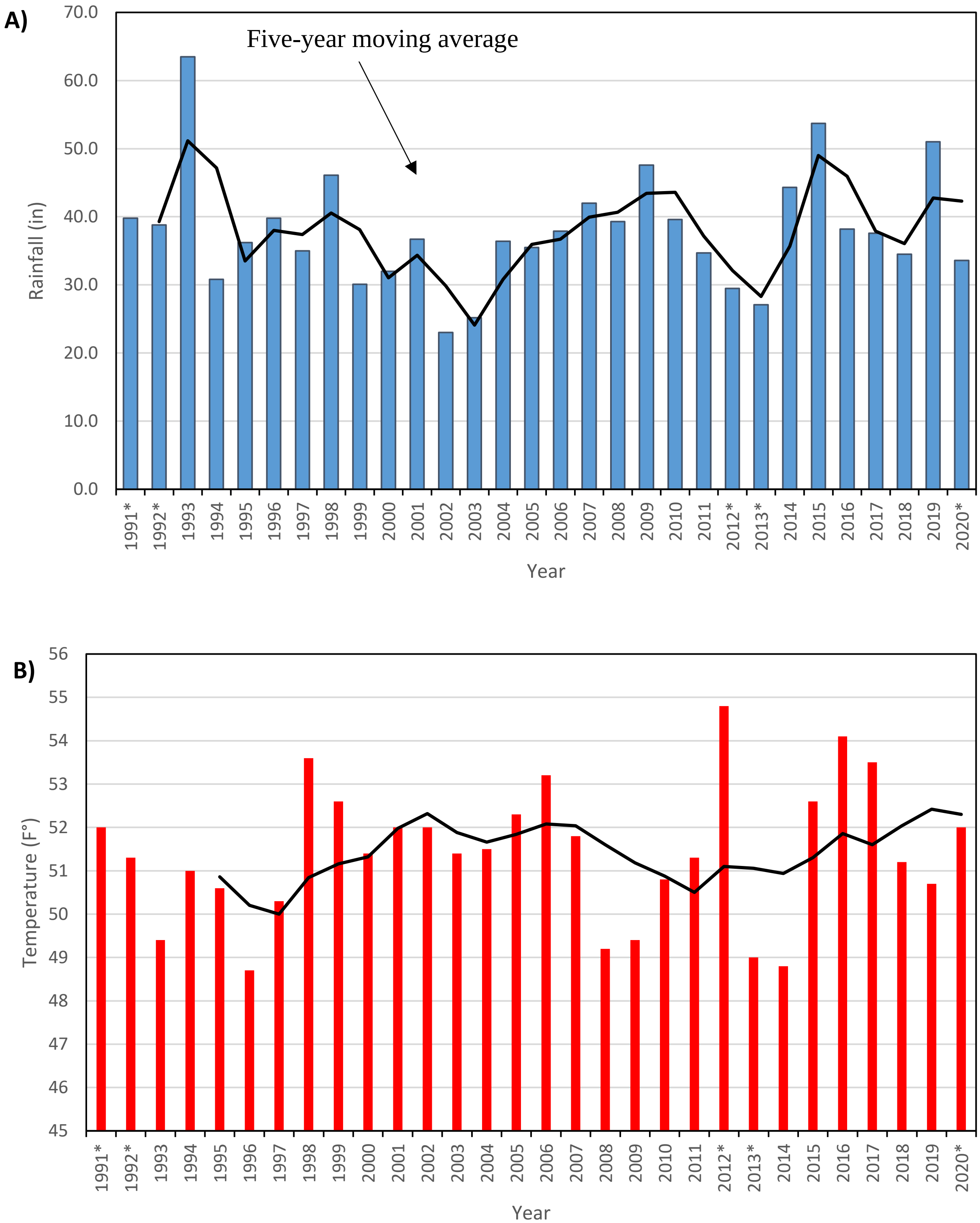

Figure 4. A) Annual total rainfall and B) average annual temperature from 1991-2020 for Maryville, MO.

*Data supplemented for some months from Conception, MO

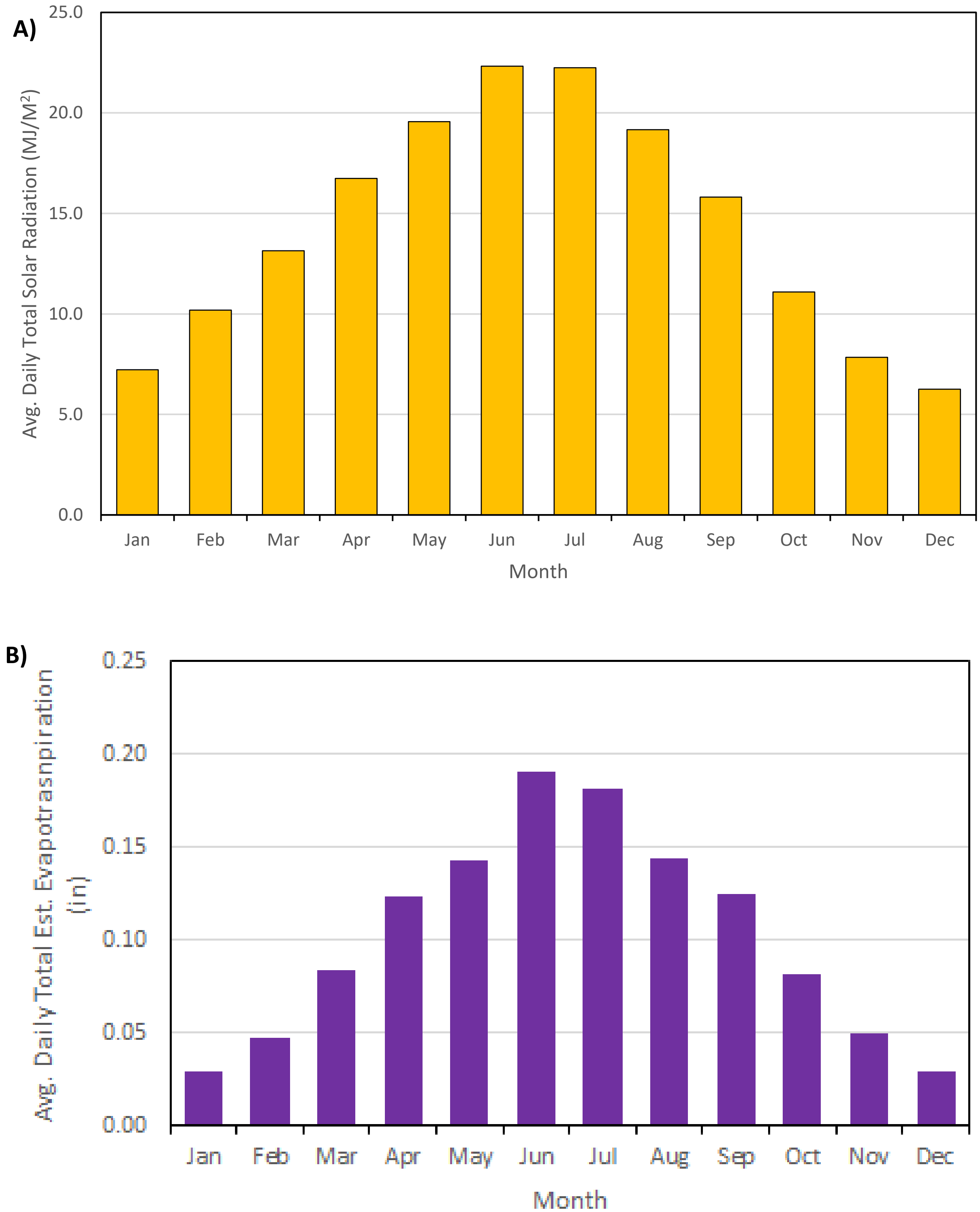

Figure 5. Average daily A) solar radiation (2000-2020) for Corning, Atchison County, MO and B) estimated evapotranspiration (2014-2020) for Albany, Gentry County, MO.

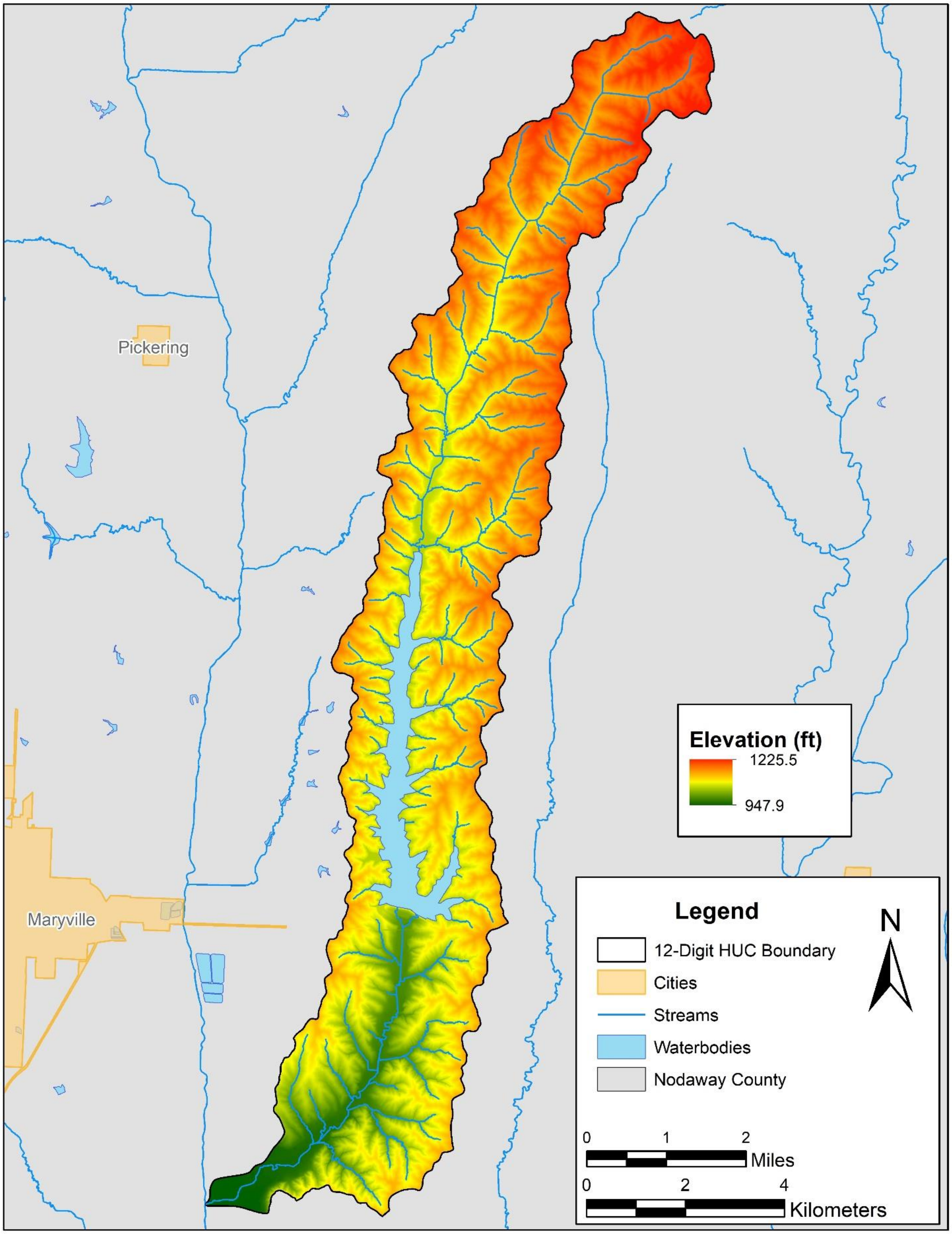

Figure 6. LiDAR elevations within the watershed (ft).

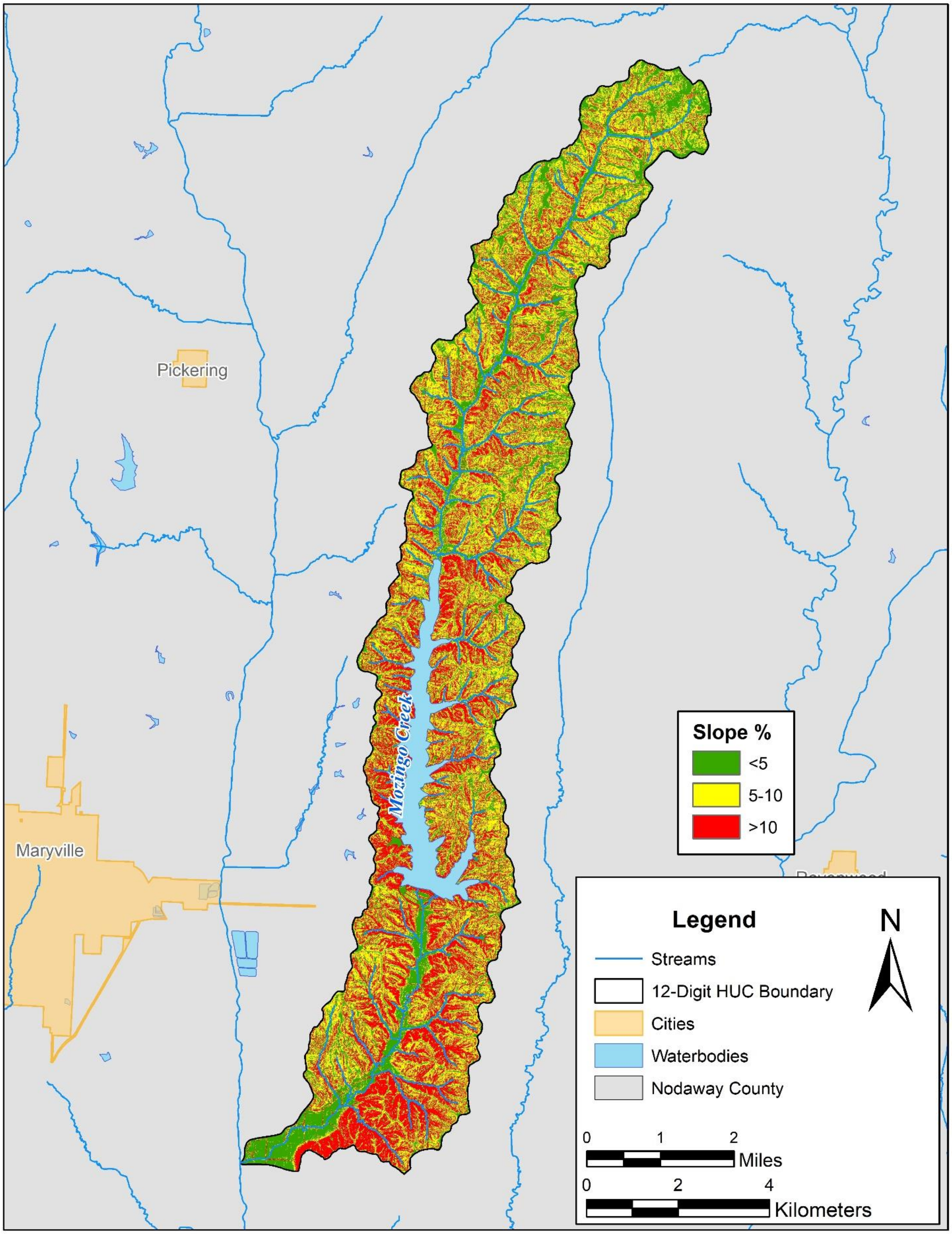

Figure 7. LiDAR based slope classification across the watershed.

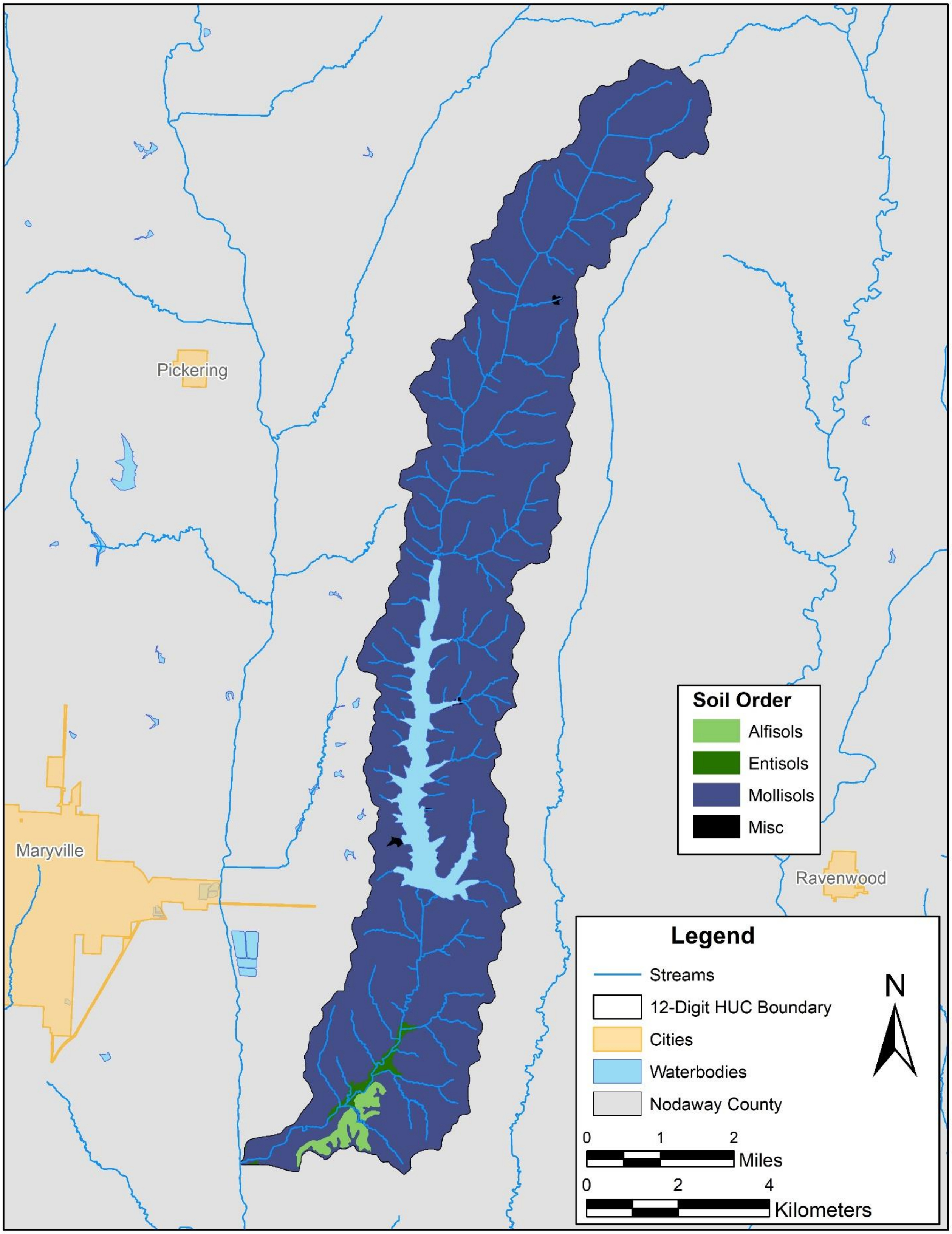

Figure 8. Soil series classified by order.

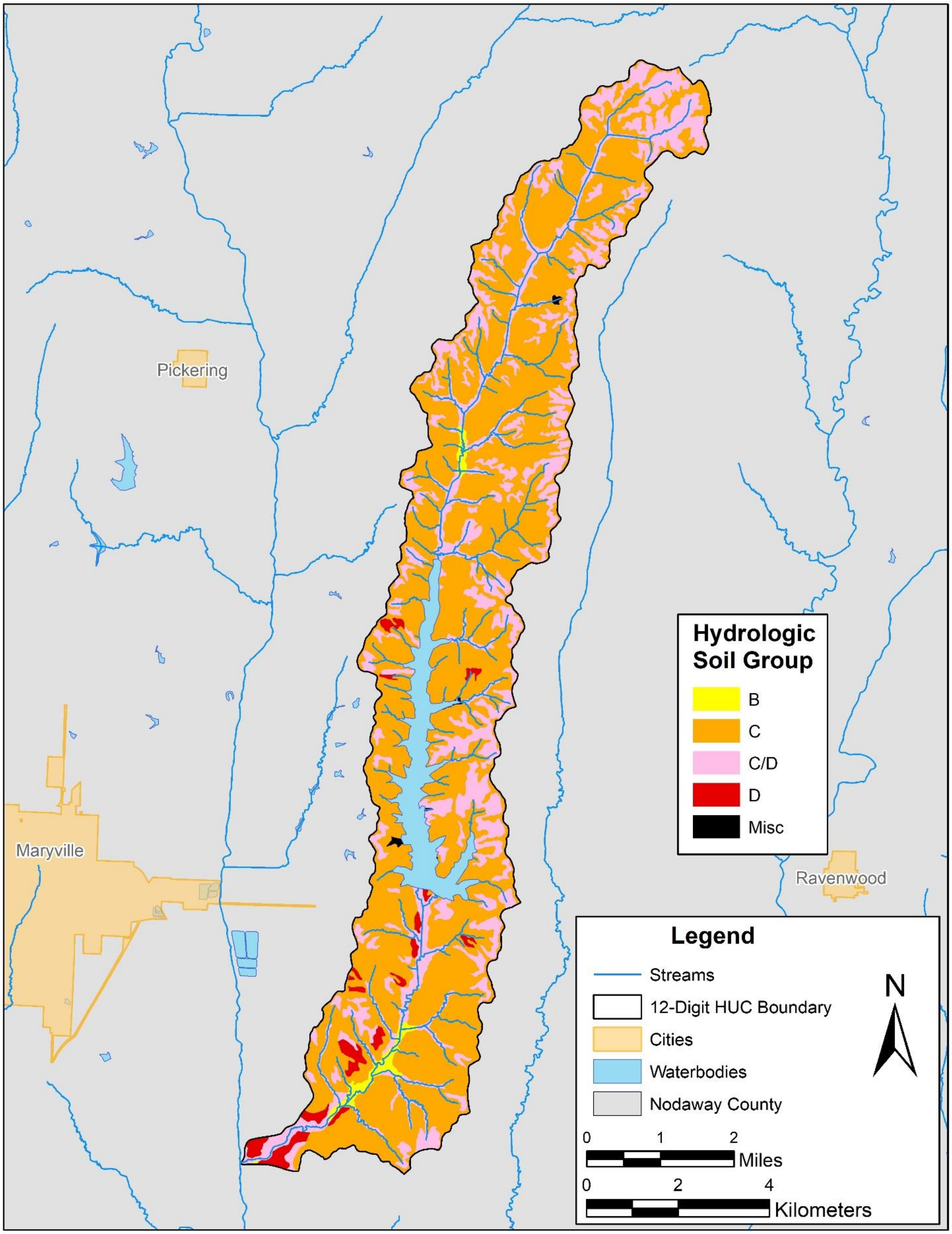

Figure 9. Soil series classified by hydrologic soil group.

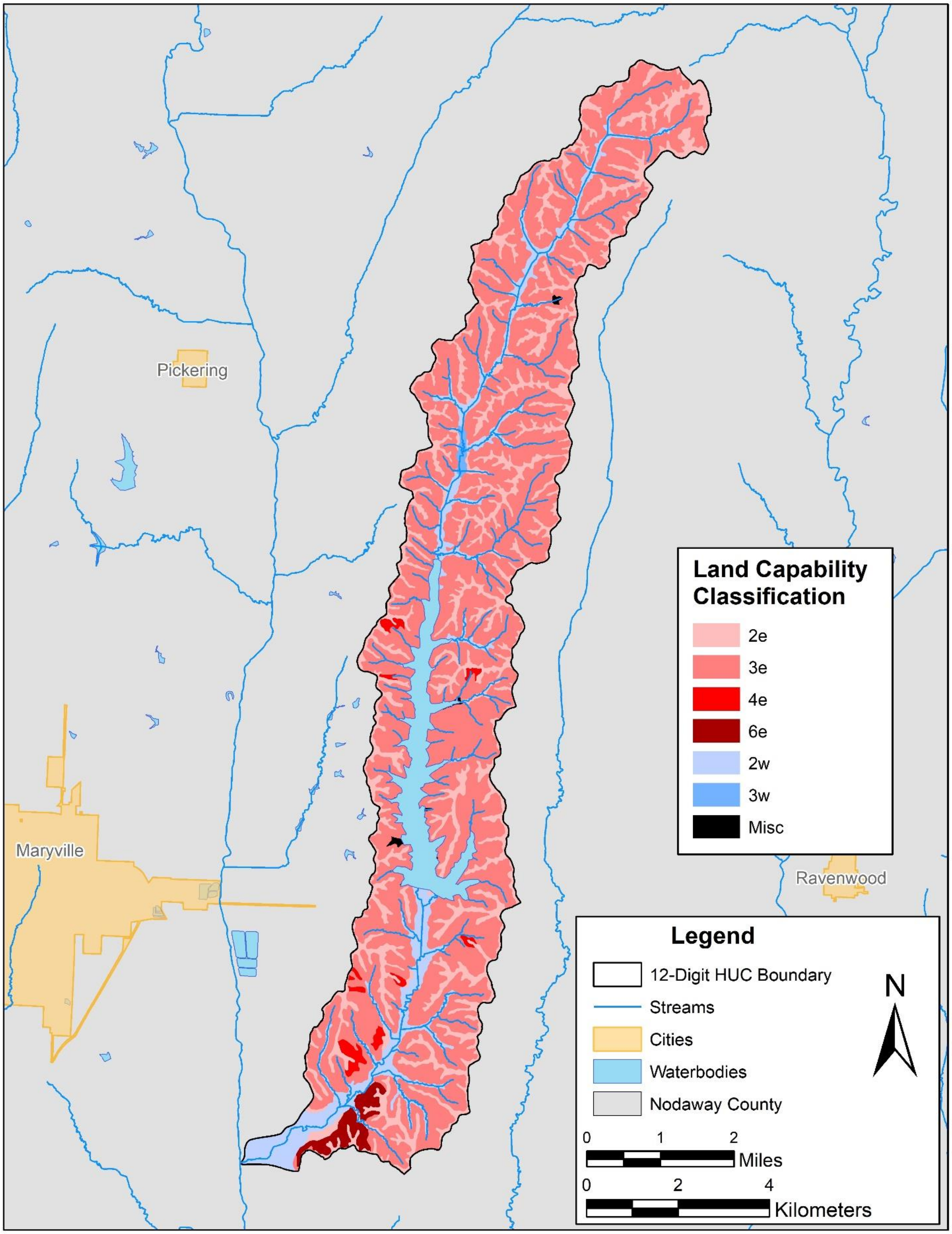

Figure 10. Soil series classified by land capability classification.

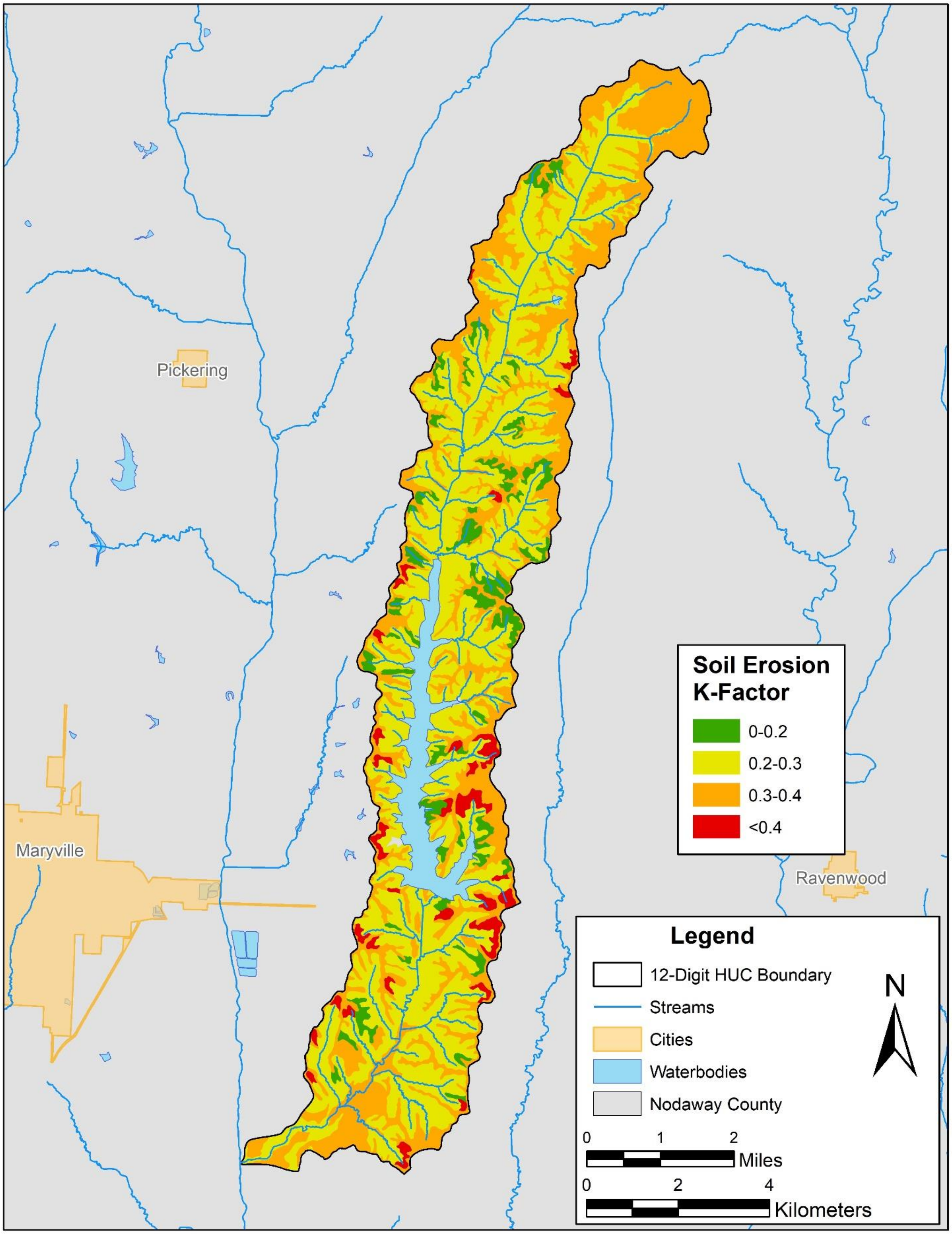

Figure 11. Soil series classified by soil erosion K-factor.

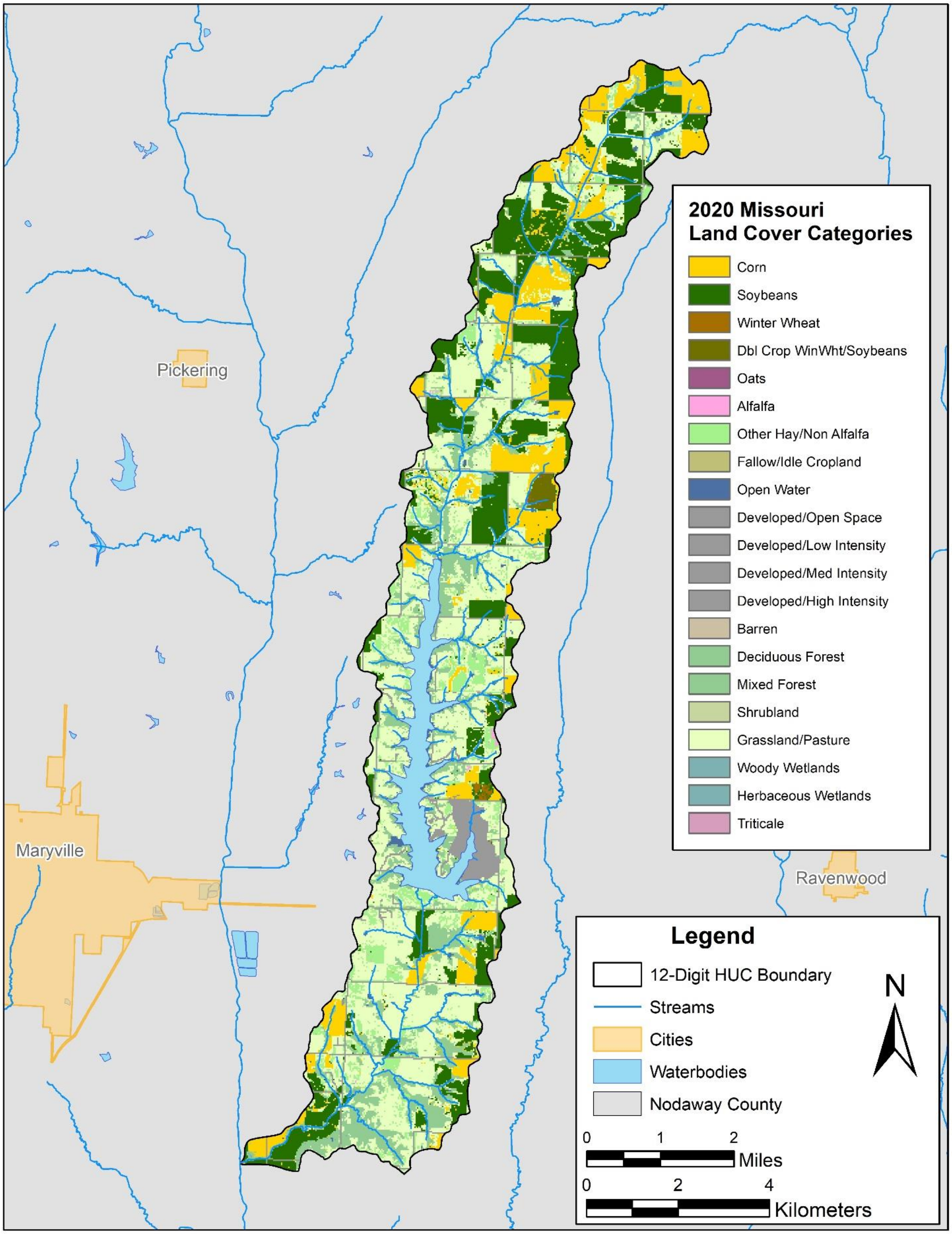

Figure 12. 2020 crop data from the NASS.

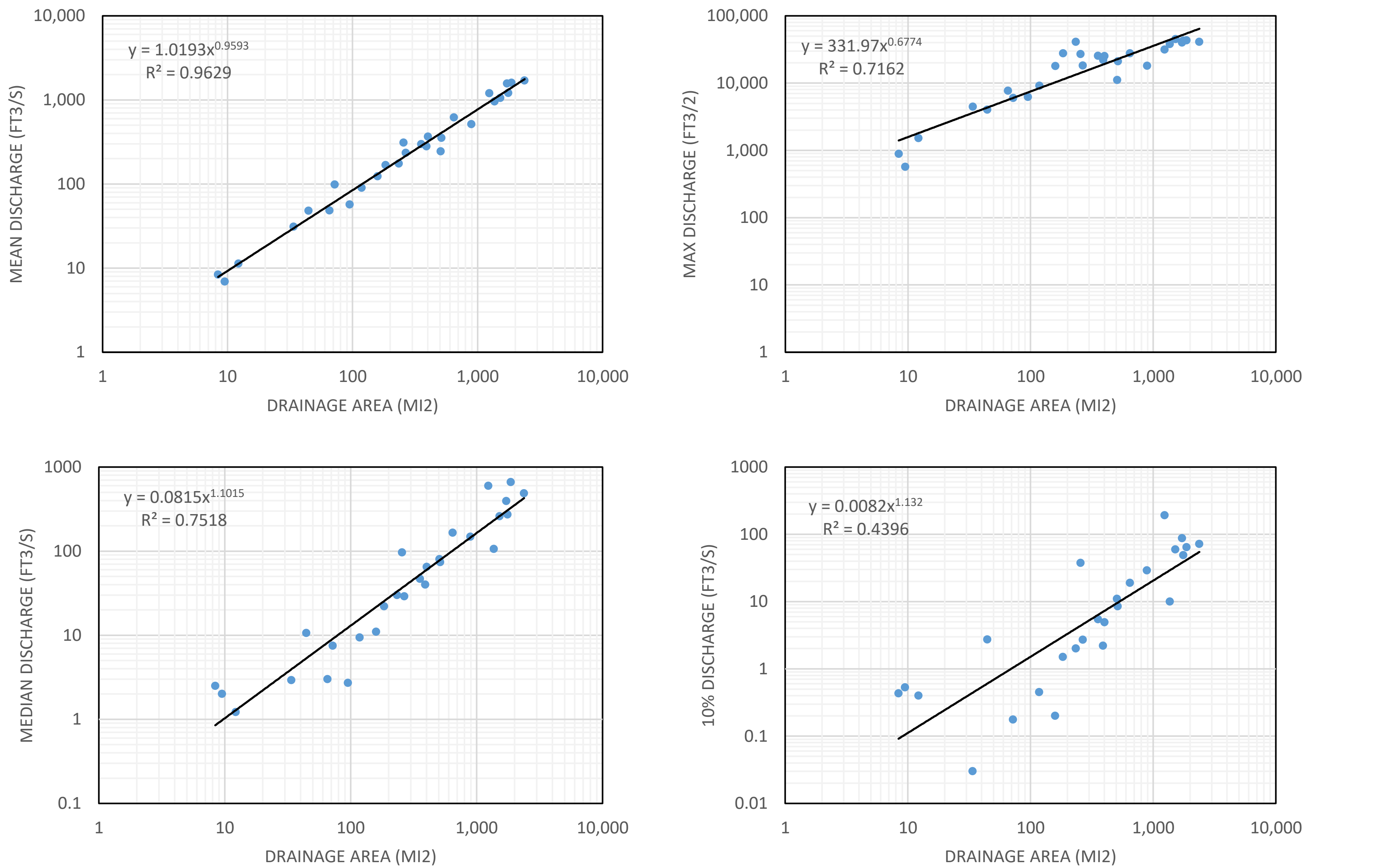

Figure 13. Drainage area and discharge relationships for 28 USGS gaging stations near the study watershed.

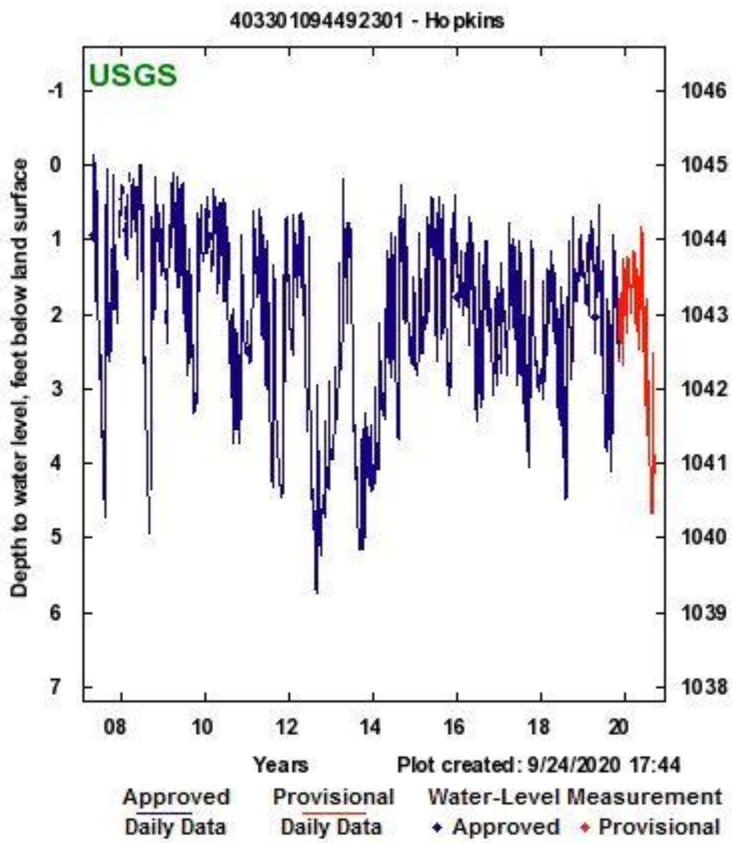

Figure 14. Groundwater level change for Maryville, Missouri (2007-2020).

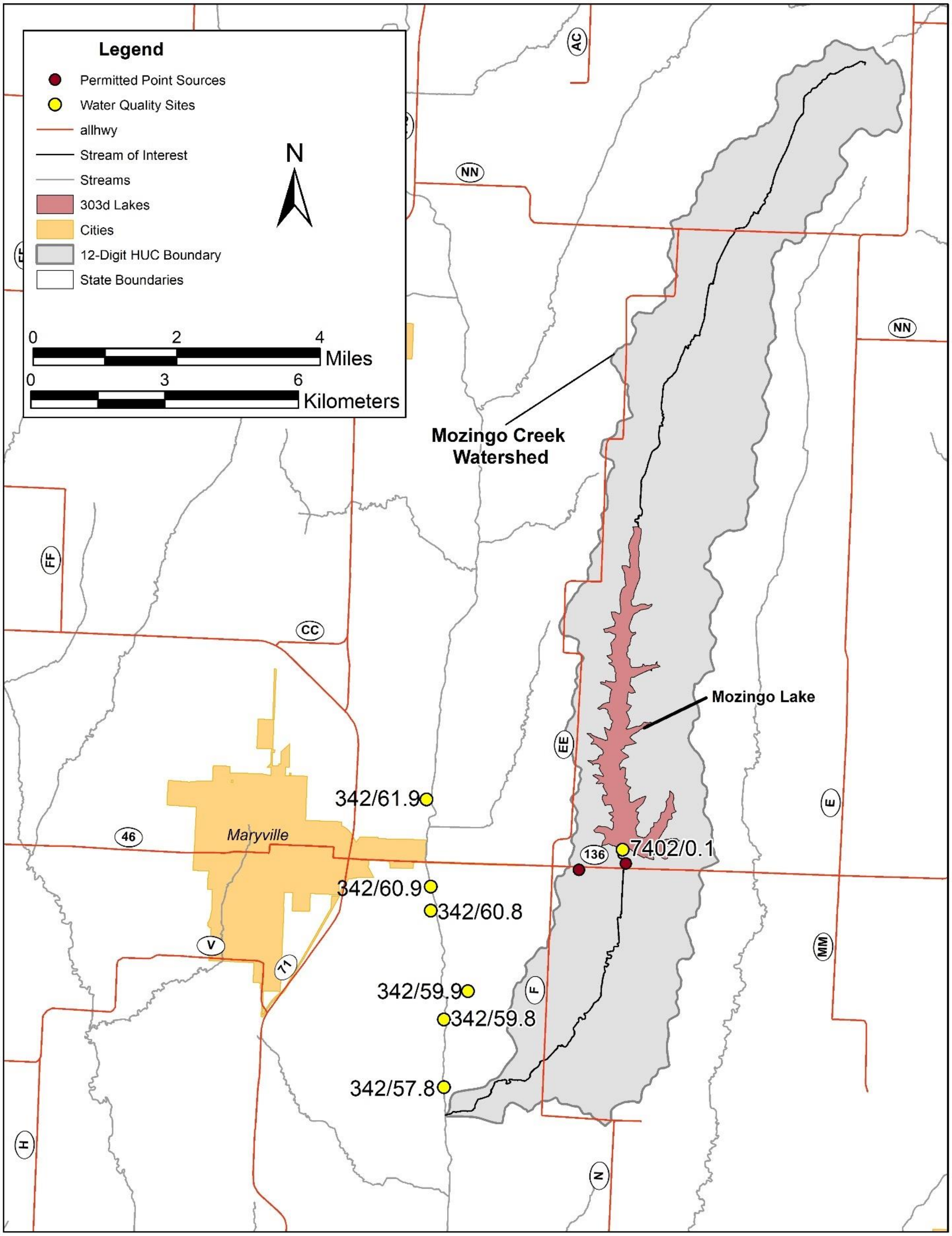

Figure 15. Water quality monitoring station locations.

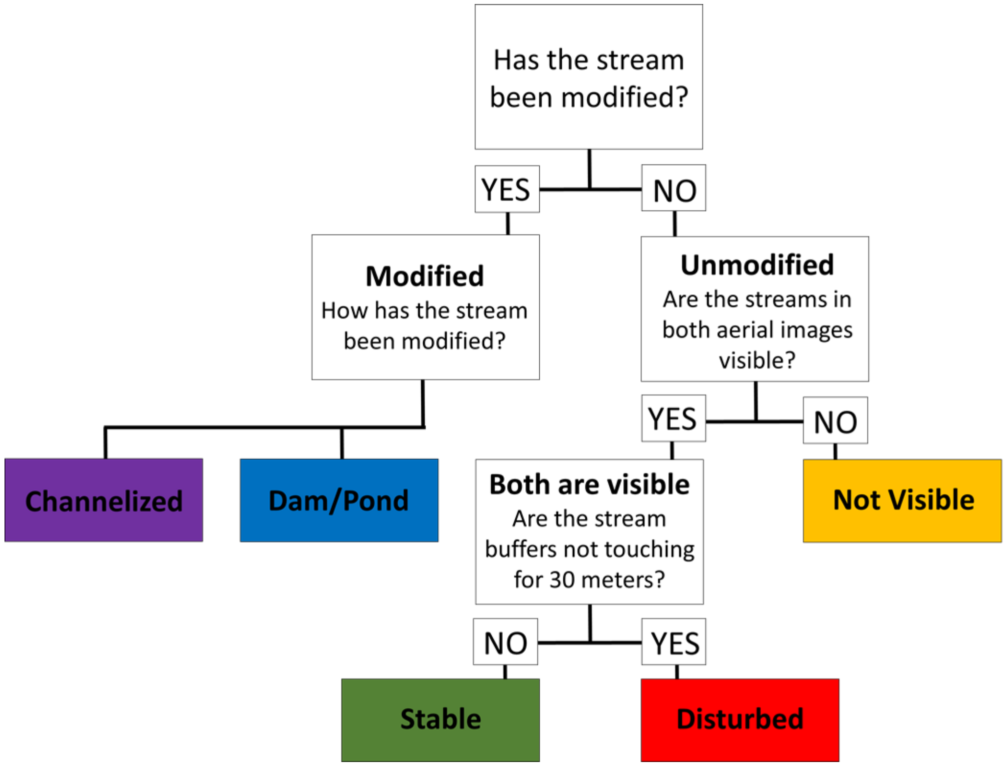

Figure 16. Flow chart showing decision tree for classifying stream channels from aerial photo analysis.

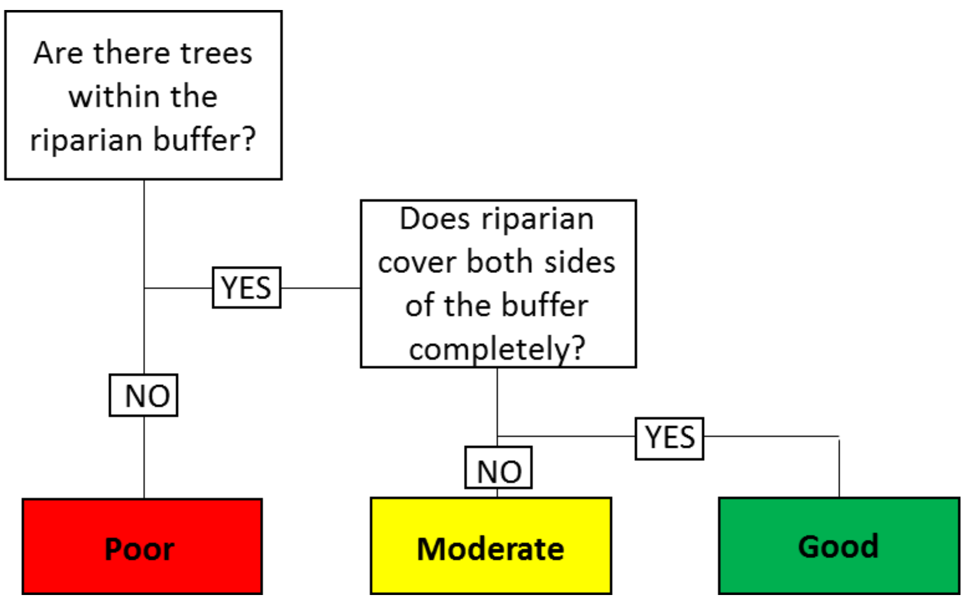

Figure 17. Flow chart showing decision tree for riparian corridor assessment from aerial photo analysis.

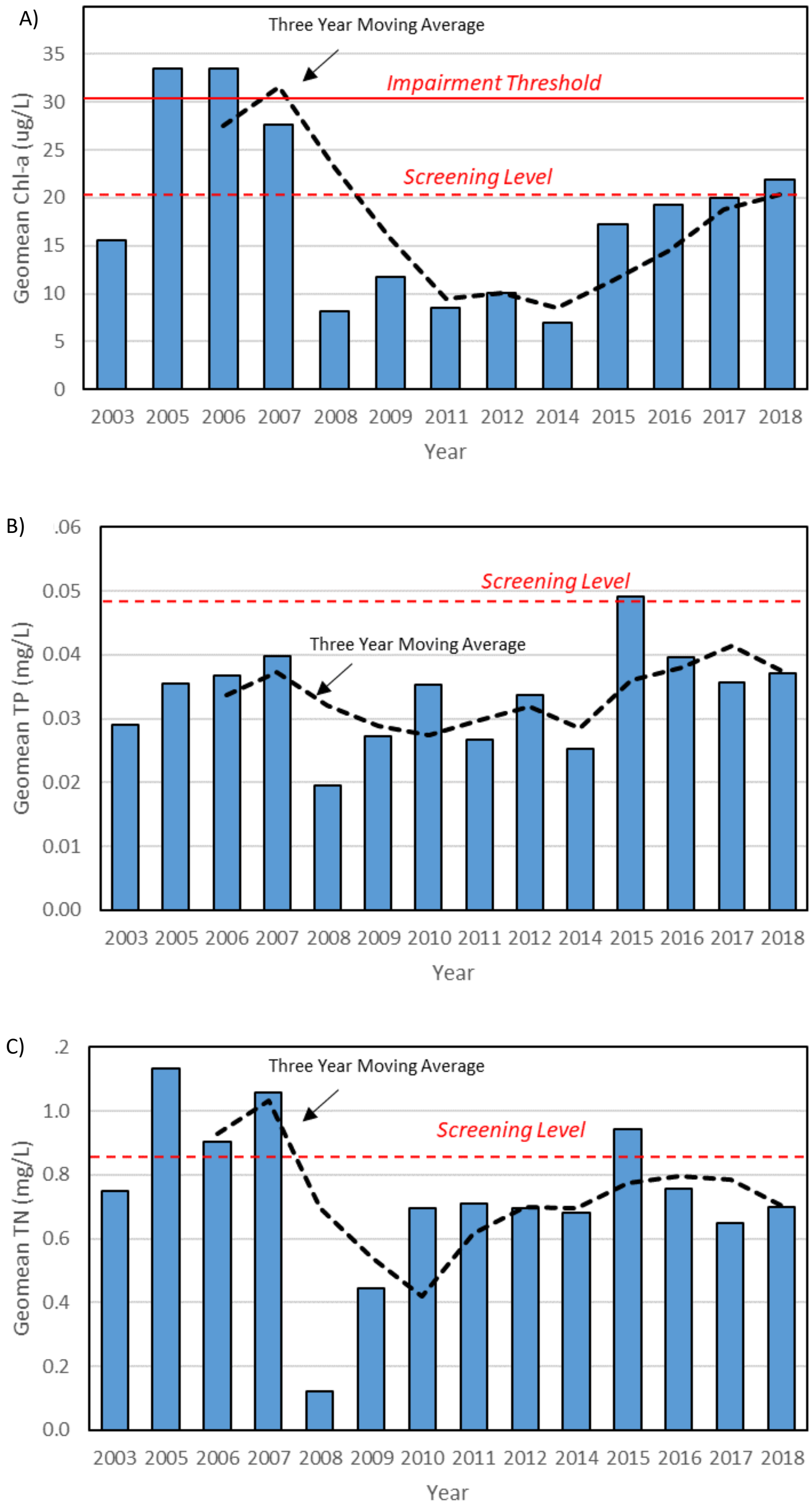

Figure 18. Annual Geometric Mean for A) Chl-a, B) TP and C) TN from 2003-2018 for Mozingo Lake.

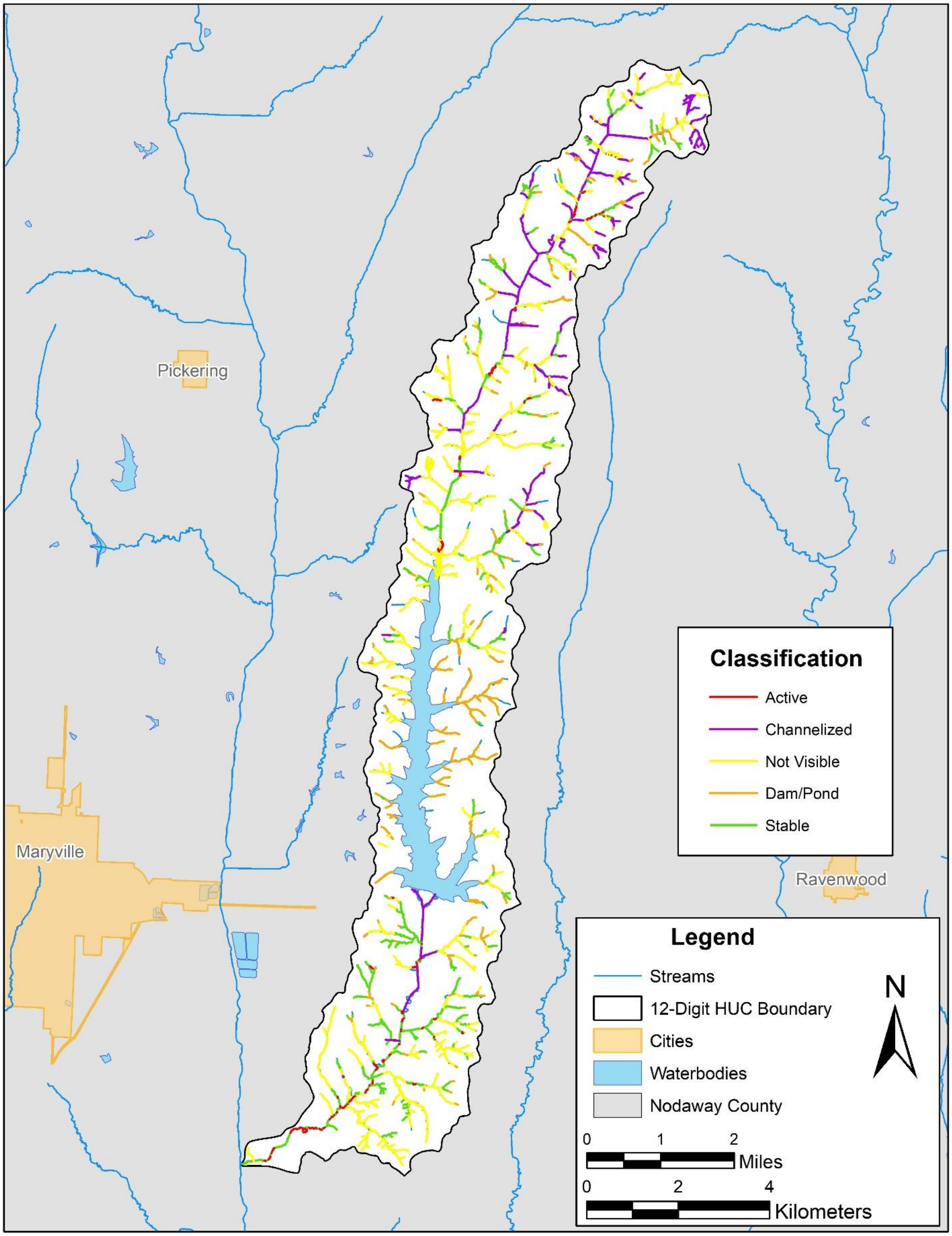

Figure 19. Channel stability classification.

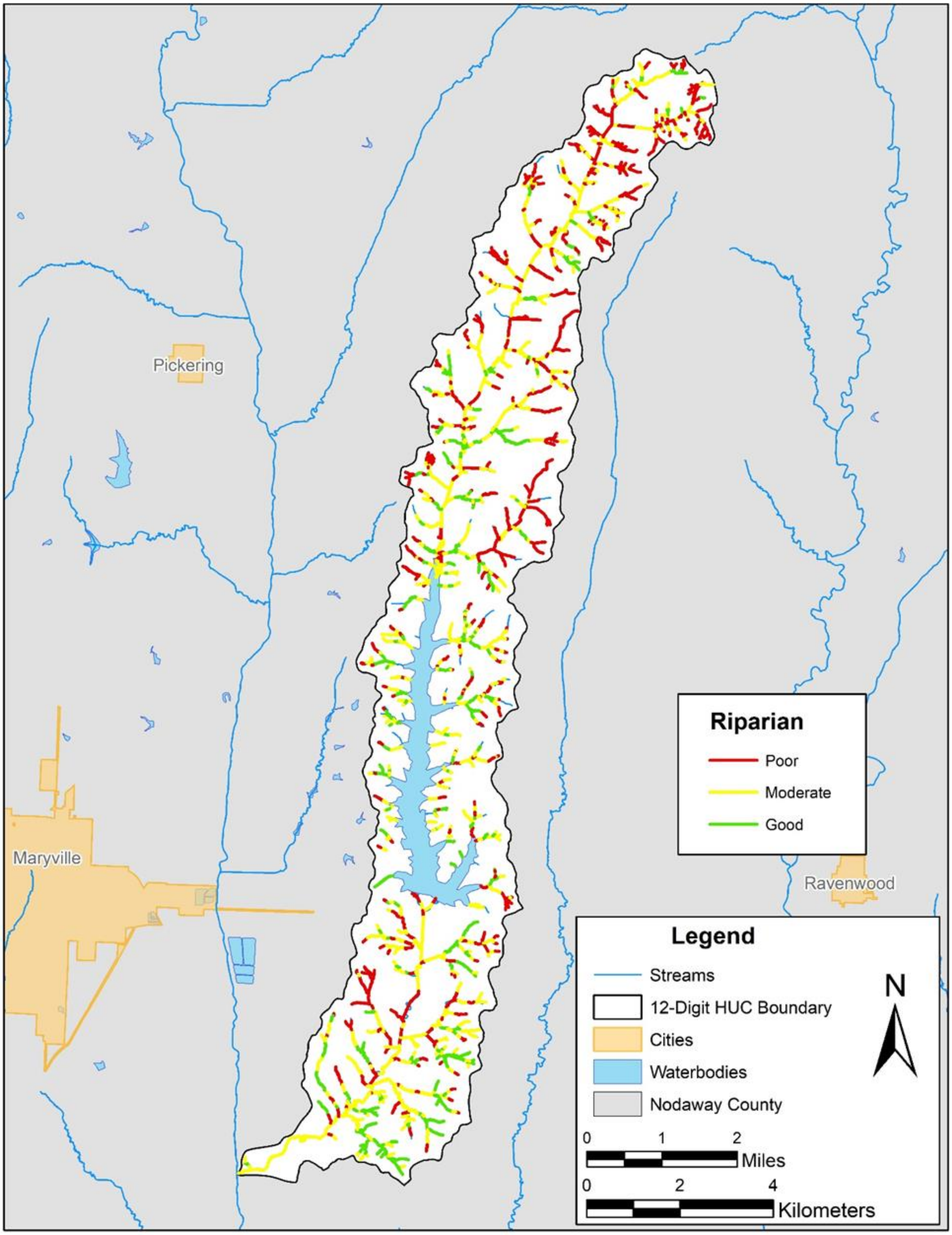

Figure 20. Riparian corridor classification.

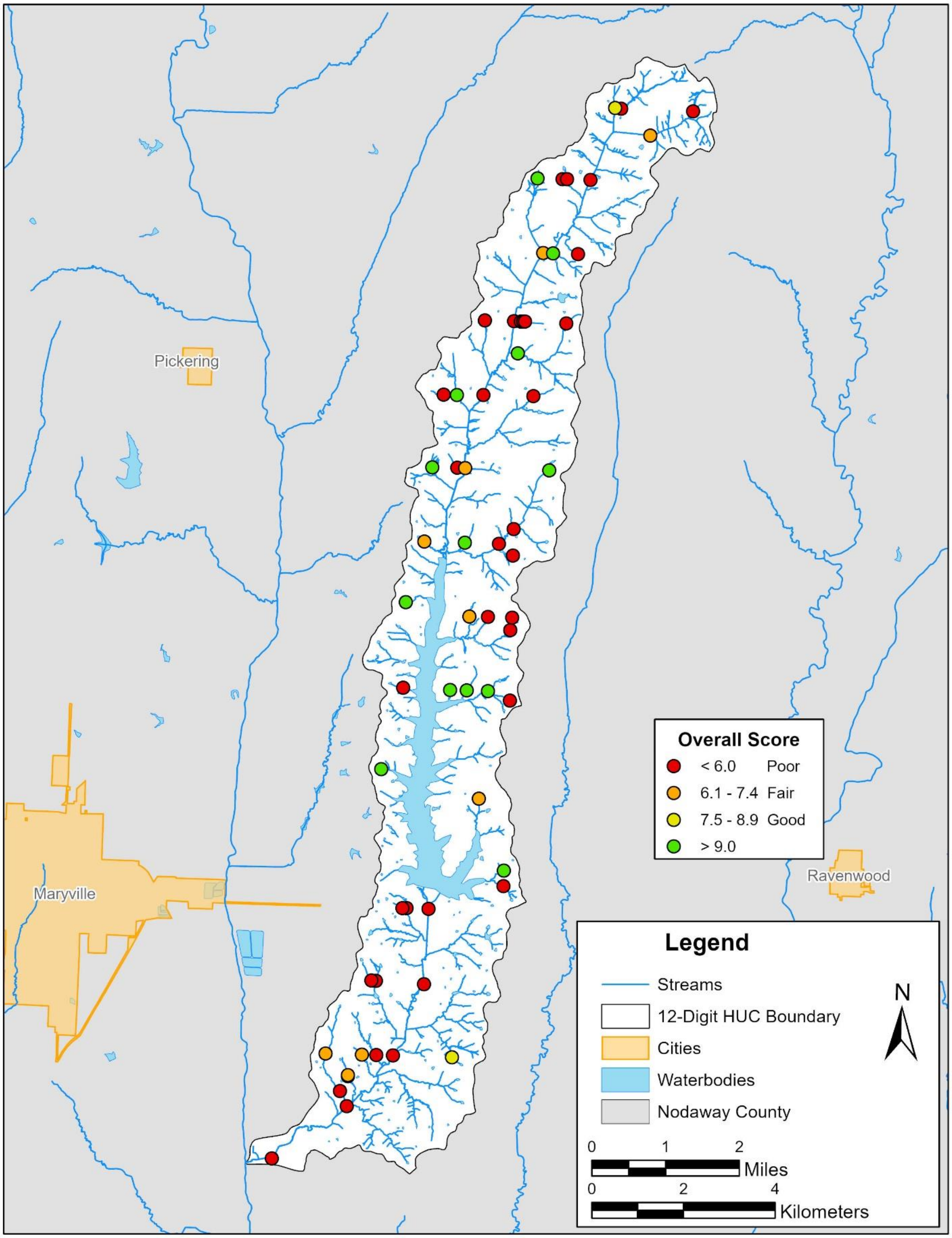

Figure 21. VSA Results.

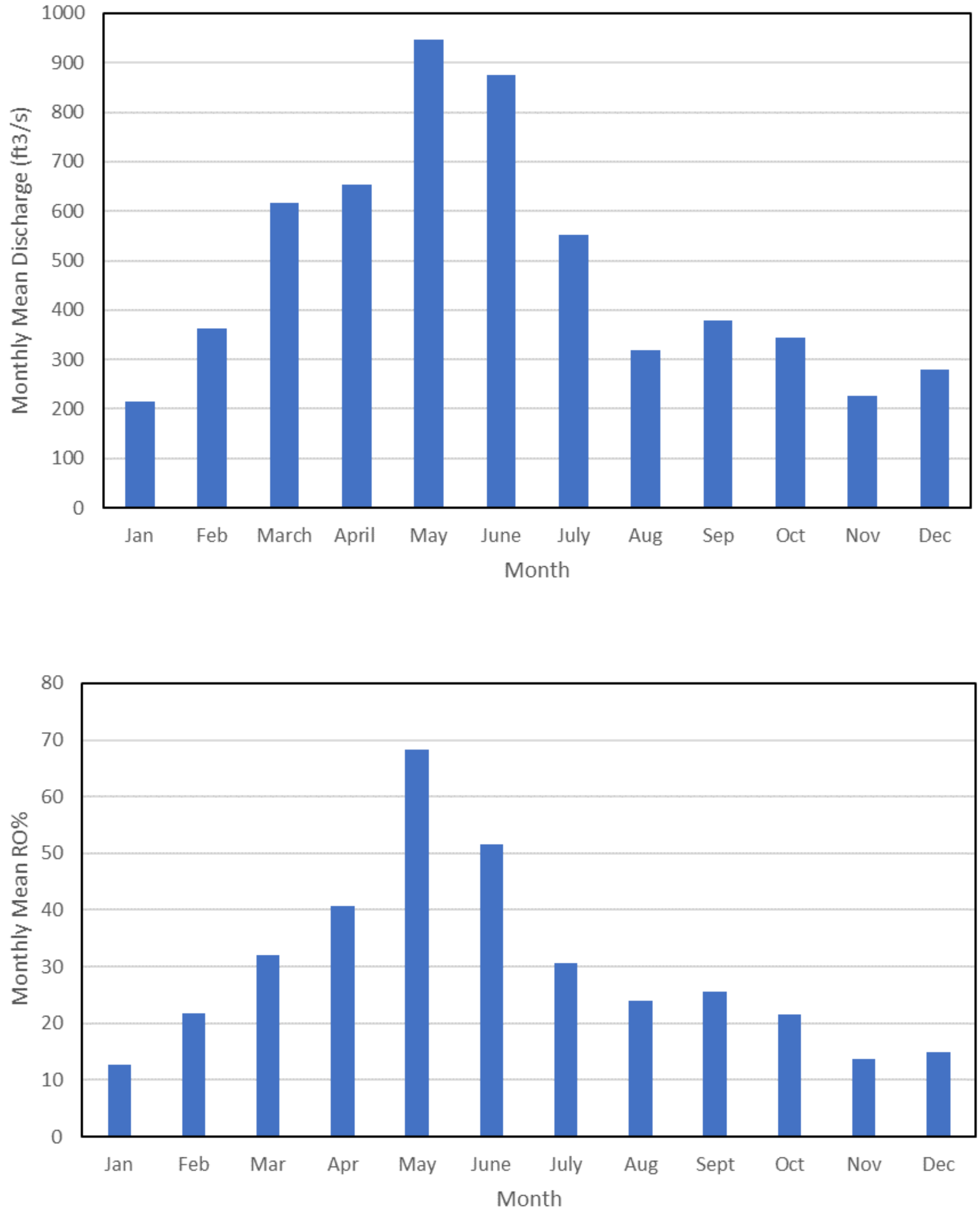

Figure 22. Mean monthly discharge and runoff percentage.

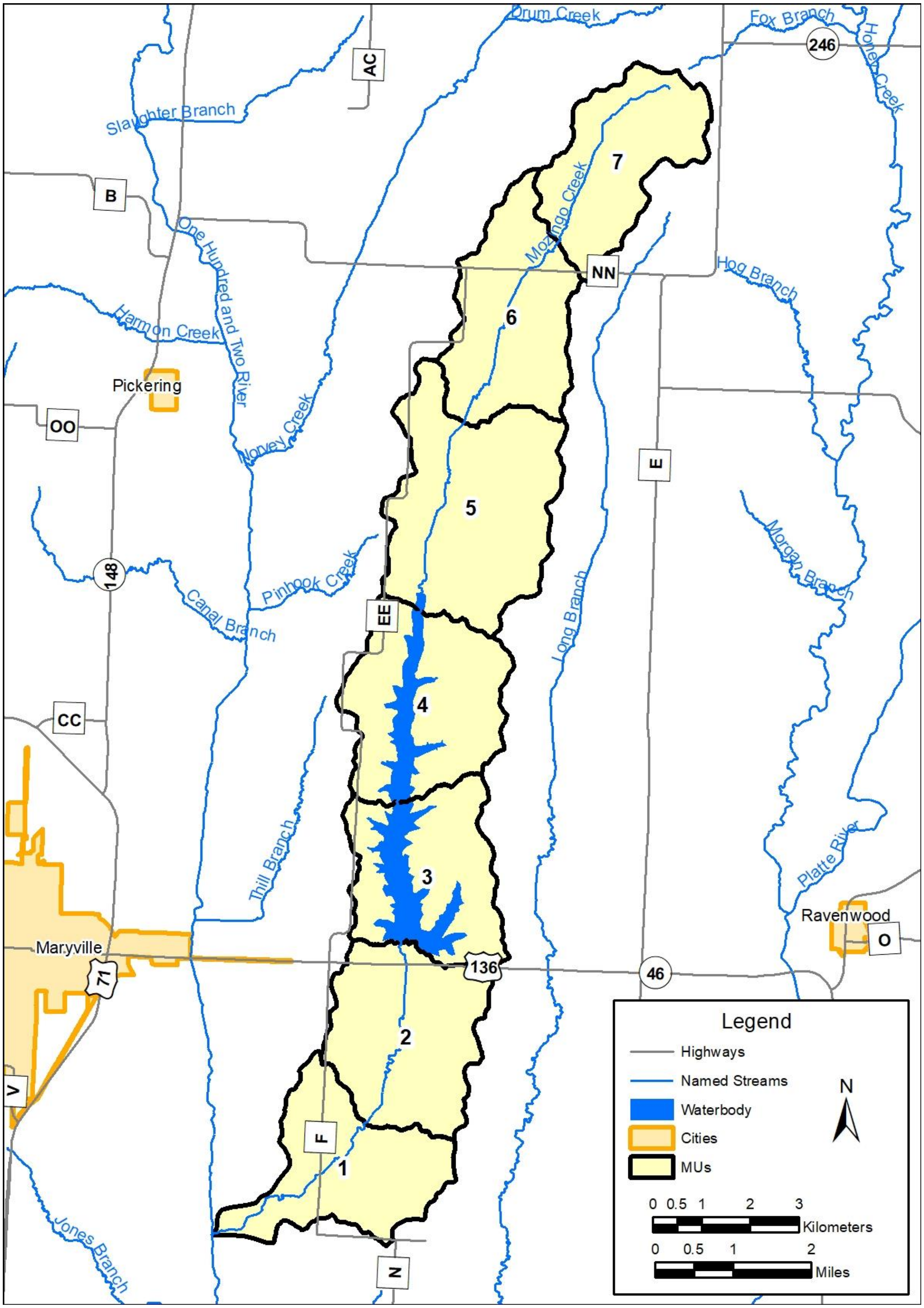

Figure 23. Management units (MUs) in the watershed.

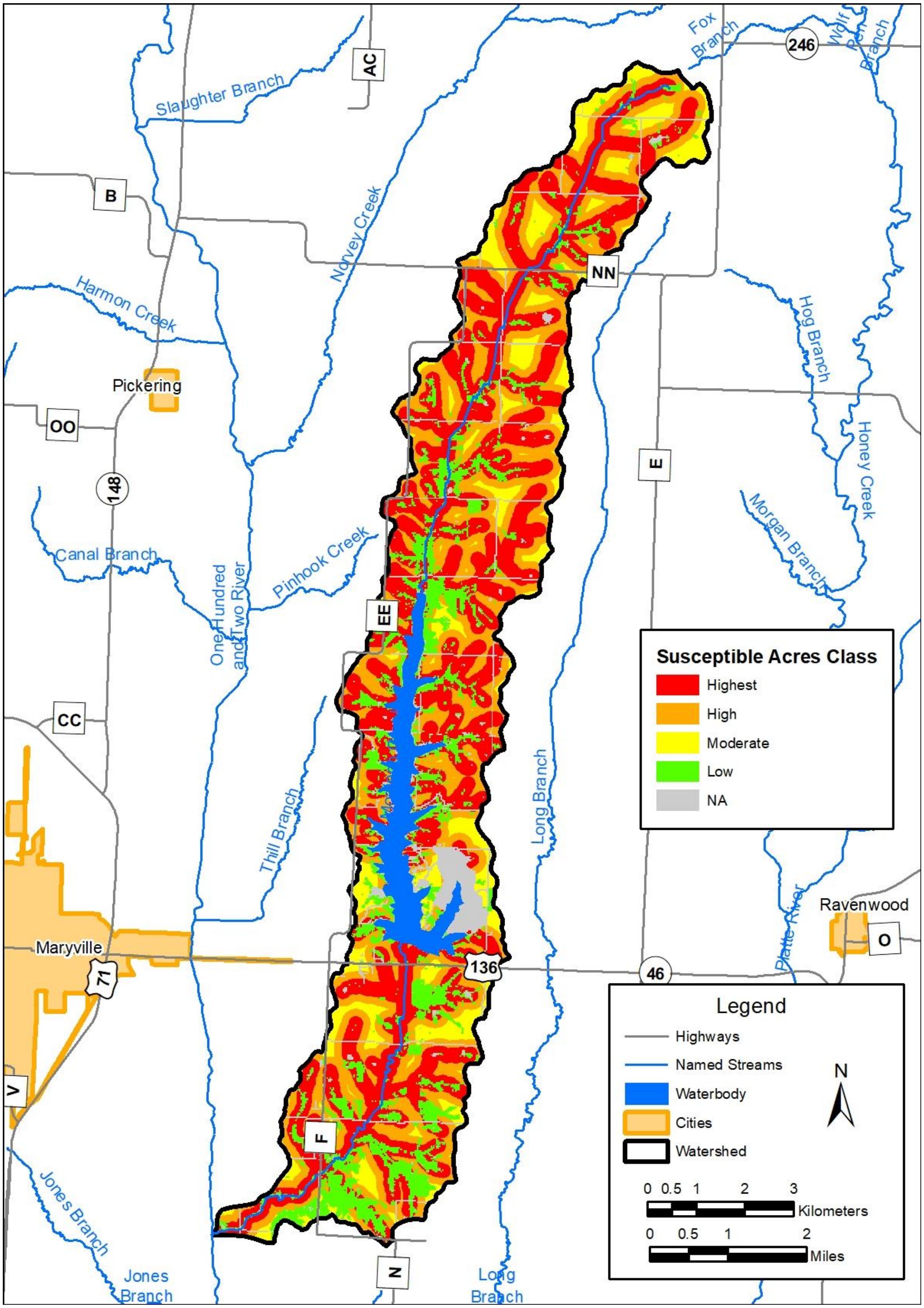

Figure 24. Susceptible acres in the watershed.

APPENDICES

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

MU#	Acres	% Area	Series Name	Hydrologic Soil Group	Landform	K Factor	T Factor	Soil Order	Land Capability Classification	Slope % Range
10029	1,546.60	8.60%	Higginsville silty clay loam	C/D	Uplands	0.32	5	Mollisols	3e	7
13539	47.6	0.30%	Kennebec silt loam	B	Floodplain	0.28	5	Mollisols	3w	1
13563	153	0.90%	Nodaway silt loam	B	Floodplain	0.32	5	Entisols	2w	1
13611	807.3	4.50%	Colo silty clay loam	C/D	Floodplain	0.28	5	Mollisols	2w	1
13627	423.4	2.40%	Colo, frequently flooded-Judson silty clay loams	C/D	Floodplain	0.28	5	Mollisols	2w	1
20001	16.5	0.10%	Macksburg silty clay loam	C/D	Uplands	0.43	5	Mollisols	2e	4
20005	1,024.30	5.70%	Lamoni clay loam	C/D	Uplands	0.17	5	Mollisols	3e	7
20006	3,309.40	18.40%	Sharpsburg silty clay loam	C	Uplands	0.37	5	Mollisols	2e	4
20008	57.2	0.30%	Sharpsburg silty clay loam	C	Uplands	0.37	5	Mollisols	3e	7
20010	227.1	1.30%	Shelby loam	C	Uplands	0.28	5	Mollisols	3e	7
20011	0.3	0.00%	Shelby clay loam	C	Uplands	0.28	5	Mollisols	4e	13
20012	2,717.80	15.10%	Shelby clay loam	C	Uplands	0.28	5	Mollisols	3e	7
20013	244.8	1.40%	Shelby loam	C	Uplands	0.28	5	Mollisols	3e	12
20014	5,216.60	29.10%	Shelby clay loam	C	Uplands	0.28	5	Mollisols	3e	12
20016	222.9	1.20%	Gara loam	C	Uplands	0.32	5	Alfisols	6e	16
30120	555.7	3.10%	Lagonda silty clay loam	C/D	Uplands	0.43	5	Mollisols	3e	7
30135	163.5	0.90%	Lamoni clay loam	D	Uplands	0.32	3	Mollisols	4e	12
30160	91.5	0.50%	Olmitz loam	C	Uplands	0.24	5	Mollisols	2e	4
30242	89.3	0.50%	Olmitz-Ely-Zook complex	C/D	Uplands	0.32	5	Mollisols	2e	4
36050	177	1.00%	Zook silty clay loam	D	Floodplain	0.32	5	Mollisols	2w	1
99001	862.4	4.80%	Water	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Appendix B. USGS gaging stations near the watershed.

USGS Gage ID	Station Name	Start Year	Years of Record	Ad (mi2)	90%	50%	10%	Max	Mean
6813000	Tarkio River at Fairfax, MO	1922	98	508	500.0	80.0	11.0	11,100	243.8
6817500	Nodaway River near Burlington Junction, MO	2015	5	1,240	2,280	597.0	191.0	31,500	1,204
6817700	Nodaway River near Graham, MO	1995	25	1,520	1,850	259.0	59.5	44,900	1,053
6820410	One Hundred Two River near Bolckow, MO	2008	12	647	1,100	165.0	19.0	27,700	618.4
6819500	One Hundred and Two River at Maryville, MO	2001	19	515	629.2	74.0	8.5	21,000	352.6
6821190	Platte River at Sharps Station, MO	1994	26	2,380	3,502	488.0	71.8	41,200	1,704
6820500	Platte River near Agency, MO	1994	26	1,760	2,300	273.0	49.0	42,900	1,211
6893557	Brush Creek at Ward Parkway in Kansas City, MO	1998	22	12.2	20.7	1.2	0.4	1,520	11.3
6821150	Little Platte River at Smithville, MO	1965	55	234	326.0	30.0	2.0	41,000	175.1
6893578	Blue River at Stadium Drive in Kansas City, MO	2002	18	256	566.2	96.4	37.4	27,100	310.7
6893620	Rock Creek at Kentucky Road in Independence, MO	2005	15	9.5	11.8	2.0	0.5	570	6.9
6821080	Little Platte River near Plattsburg, MO	1999	21	65.4	44.5	3.0	0.0	7,730	48.6
6896400	East Fork Grand River at Albany, MO	2007	13	401	663.0	65.0	4.9	25,200	366.1
6893970	Spring Branch Ck at Holke Rd in Independence, MO	2005	15	8.4	14.6	2.5	0.4	884	8.4
6894200	Fishing River above Mosby, MO	2007	13	44.4	70.1	10.6	2.7	4,010	48.2
6894000	Little Blue River near Lake City, MO	1948	72	184	202.0	22.0	1.5	27,700	167.8
6896900	Grand River near Pattonsburg, MO	2014	6	1,720	3,211	394.0	87.6	39,900	1,563
6897000	East Fork Big Creek near Bethany, MO	1934	86	95	79.0	27.0	0.0	6,200	57.3
6895000	Crooked River near Richmond, MO	1948	72	159	154.0	11.0	0.2	17,900	123.8
6899700	Shoal Creek near Braymer, MO	1957	63	391	432.2	40.0	2.2	22,000	280.7
6898100	Thompson River at Mount Moriah, MO	1960	60	891	1,350	148.0	29.0	18,100	515.7
6900050	Medicine Creek near Laredo, MO	2000	20	355	459.2	46.7	5.4	25,500	298.1
6899900	Medicine Creek at Lucerne, MO	2010	10	118	113.0	9.4	0.5	9,100	90.0
6901205	East Locust Creek near Boynton, MO	2013	7	33.8	42.4	2.9	0.03	4,460	31.1
6906000	Mussel Fork near Musselfork, MO	1948	72	267	349.0	29.0	2.7	18,300	234.5
6904650	Spring Creek at Stahl, MO	2017	3	72.1	197.2	7.5	0.2	6,000	98.4
6905500	Chariton River near Prairie Hill, MO	1990	30	1,870	3,002	660.0	64.0	43,200	1,599.6
6904500	Chariton River at Novinger, MO	1930	90	1,370	1,740	106.0	10.0	38,100	958.9

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 # 55: Downstream

Channel condition	5
Hydrologic alteration	7
Riparian zone	8
Bank stability	6
Canopy cover	8
Manure presence	

Overall Score 6.8

Site # 14: Downstream

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

Overall Score 1.7

Site # 60: Upstream

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

Overall Score 2.6

Site # 29: Upstream

Channel condition	10
Hydrologic alteration	10
Riparian zone	8
Bank stability	9
Canopy cover	8
Manure presence	

Overall Score
9.0

Site # 2: Downstream

Channel condition	1
Hydrologic alteration	2
Riparian zone	7
Bank stability	3
Canopy cover	10
Manure presence	

Overall Score
4.6

Site # 59: Upstream

Channel condition	9
Hydrologic alteration	10
Riparian zone	5
Bank stability	10
Canopy cover	8
Manure presence	

Overall Score
8.4

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

Model	R2	b_0	b_1	Mozingo Creek Q (ft3/s)
Mean Annual Q	0.96	0.957096	0.967539	24.1
Jan Mean Q	0.97	0.373948	0.98657	10.0
Feb Mean Q	0.97	0.637939	0.986504	17.1
March Mean Q	0.98	0.813273	1.029544	25.2
April Mean Q	0.97	0.813273	1.029544	25.2
May Mean Q	0.96	2.519997	0.917041	53.6
June Mean Q	0.98	1.496296	0.989454	40.5
July Mean Q	0.95	0.925339	0.976422	24.0
Aug Mean Q	0.91	0.989061	0.884608	18.9
Sept Mean Q	0.97	0.863017	0.943226	20.0
Oct Mean Q	0.96	0.694805	0.959359	17.0
Nov Mean Q	0.96	0.422512	0.972173	10.8
Dec Mean Q	0.96	0.415563	1.002645	11.8

*Power Function equation $y=b_0(X)^{b_1}$

Where: y= mean monthly discharge in ft^3/s

X= drainage area in mi^2

Mozingo Creek drainage area 28.0 mi^2

Appendix F. STEPL model inputs

Watershed	Total Ad (ac)	HSG	Land Use (Acres)					Beef Cattle	# of Septic
			Urban	Crop	Pasture	Forest	Water		
Mozingo Creek	17,956	C	885	6,923	6,255	2,345	1,547	2,000	75

Appendix G. Eroding streambank inputs into STEPL.

Length (ft)	Height (ft)	Area (ft2)	Mean Width (ft)	Average Erosion Rate (ft/yr)
113	13.8	1,297	11.5	0.64
151	12.1	802	5.3	0.30
133	12.5	1,003	7.5	0.42
268	11.2	3,179	11.9	0.66
160	11.8	1,428	8.9	0.50
123	11.8	1,001	8.1	0.45
116	10.2	1,250	10.7	0.60
195	11.8	1,738	8.9	0.50
118	11.2	929	7.8	0.44
104	3.9	1,422	13.6	0.76
176	11.5	945	5.4	0.30
270	12.1	4,505	16.7	0.93
109	11.8	596	5.5	0.30
118	11.8	662	5.6	0.31
156	11.8	1,350	8.6	0.48
128	9.2	1,443	11.3	0.63
291	13.5	2,861	9.8	0.55
172	12.5	1,017	5.9	0.33
258	13.1	2,282	8.8	0.49
151	13.1	1,485	9.9	0.55
261	15.7	1,318	5.1	0.28
124	13.1	867	7.0	0.39
175	6.6	2,850	16.3	0.90
126	11.8	336	2.7	0.15
216	7.5	1,599	7.4	0.41
121	4.6	4,941	40.7	2.27
173	8.2	786	4.5	0.25
111	11.8	353	3.2	0.18
101	13.1	329	3.3	0.18
116	10.2	1,250	10.8	0.60
168	12.5	860	5.1	0.28
105	1.6	3,840	36.7	2.03
139	1.6	489	3.5	0.20
146	14.4	898	6.2	0.34
137	15.4	2,825	20.6	1.15
184	5.2	2,555	13.9	0.77
200	5.6	4,099	20.5	1.14
151	5.9	2,176	14.5	0.80

Length (ft)	Height (ft)	Area (ft2)	Mean Width (ft)	Average Erosion Rate (ft/yr)
465	6.6	5,923	12.7	0.71
129	6.6	1,285	10.0	0.55
121	6.2	655	5.4	0.30
112	6.9	655	5.8	0.32
239	9.5	3,325	13.9	0.77
158	10.5	908	5.7	0.32
111	9.8	614	5.5	0.31
132	6.2	451	3.4	0.19
385	11.5	4,084	10.6	0.59
242	6.6	4,886	20.2	1.12
150	6.9	2,400	16.0	0.89
124	3.3	2,983	24.2	1.34
115	13.1	1,446	12.5	0.70
104	9.8	1,255	12.0	0.67
187	9.8	1,658	8.9	0.49
285	9.8	2,175	7.6	0.42
165	12.1	2,073	12.6	0.70
150	3.3	5,718	38.2	2.12
220	1.6	6,321	28.7	1.60
178	4.6	920	5.2	0.29
116	5.2	716	6.2	0.34
229	11.8	2,629	11.5	0.64
154	12.1	1,387	9.0	0.50
219	9.8	1,400	6.4	0.36

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 purposes (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 1). 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-12 watershed. Accuracy and variability of the model compared to each alternative method is discussed below.

<u>Annual Runoff Volume</u>

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). The relative agreement of these two methods adds confidence to the STEPL modeled runoff results. Estimated annual runoff volume was 16,598 ac-ft compared to 18,082 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 RPD between the models was 8.6%. Checking hydrology adds confidence to the model output as the runoff estimate from the STEPL model is producing results that are 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 Mozingo 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 for P, N, and Sediment compared to the published values. 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 Western Corn Belt ecoregion, they are within the published ranges of other nearby ecoregions, such as the Central Irregular Plains. 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=6) within the Mozingo 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 18-57% higher than those from the SPARROW model (Table 3). Results at the watershed level are somewhat misleading for this project since the reservoir intercepts the majority of the runoff from the watershed capturing much of the nutrients and sediment. STEPL does not model lake processes and the main point of this assessment is to decrease the nutrients and sediment to Mozingo Lake. The drainage-area weighted comparison to the STEPL model results does partially resolve this problem as it better reflects what is moving off the landscape and not taking the lake into account. However, this comparison does suggest that the simpler STEPL model results are at least reasonably close to the more sophisticated SPARROW Model results.

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TABLES

Table 25. 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 26. Comparison of Published Ecoregion Specific Export Coefficients to Mozingo Creek STEPL Model results by Land Use Type.

Land Use	STEPL Values			Literature Values[1] Ecoregion = Western Corn Belt		
	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	6.18-30.3	0.42-1.68	0.09-0.36
Cropland	15.1	4.3	2.8	5.97-35.6	0.47-3.20	0.17-1.68
Pastureland	14.7	2.6	1.1	0.50-5.17	0.04-0.61	0-0.06
Forest	1.3	0.56	0.28	0.47-2.51	0.007-0.07	0-0.004

[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 27. Comparison of Catchment Area-Weighted Mean USGS SPARROW Model Yields[1] to STEPL Model results for the Mozingo Creek Watershed.

Watershed	Yields		
	N (lb/ac/yr)	P (lb/ac/yr)	Sed (t/ac/yr)
Mozingo Creek HUC12	6.10	1.13	0.58
SPARROW Model	4.66	0.63	0.49
RPD	27%	57%	18%

[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
Terrace	0.253	0.308	0.400
Cover Crop and Terrace	0.399	0.356	0.460
Cover Crop and No-Till	0.397	0.709	0.793
Cover Crop, No-Till, Nutrient Management	0.546	0.872	0.793
Water and Sediment Control Basin	0.550	0.685	0.860
No-Till and Terrace	0.440	0.783	0.862
Cover Crop, No-Till, and Terrace	0.550	0.799	0.876
Cover Crop, No-Till, Terrace, and Nutrient Management	0.661	0.911	0.876
Grassed Waterway	0.700	0.750	0.650
Filter Strips	0.650	0.700	0.750
Land Retirement	0.898	0.808	0.950
<u>Pastureland</u>			
Livestock Exclusion and Alternative Water	0.309	0.384	0.187
Grade Stabilization Structure	0.750	0.750	0.750
Livestock Exclusion, Alternative Water, and Prescribed Grazing	0.591	0.524	0.794
Grade Stabilization Structure and Prescribed Grazing	0.852	0.807	0.833
Water and Sediment Control Basin	0.550	0.685	0.860
Livestock Exclusion, Alternative Water, Prescribed Grazing, and Forest Buffer	0.776	0.714	0.904
Grade Stabilization Structure and Sediment Control Basin	0.887	0.921	0.965
Grade Stabilization Structure, Water and Sediment Control Basin, and Prescribed Grazing	0.933	0.939	0.977