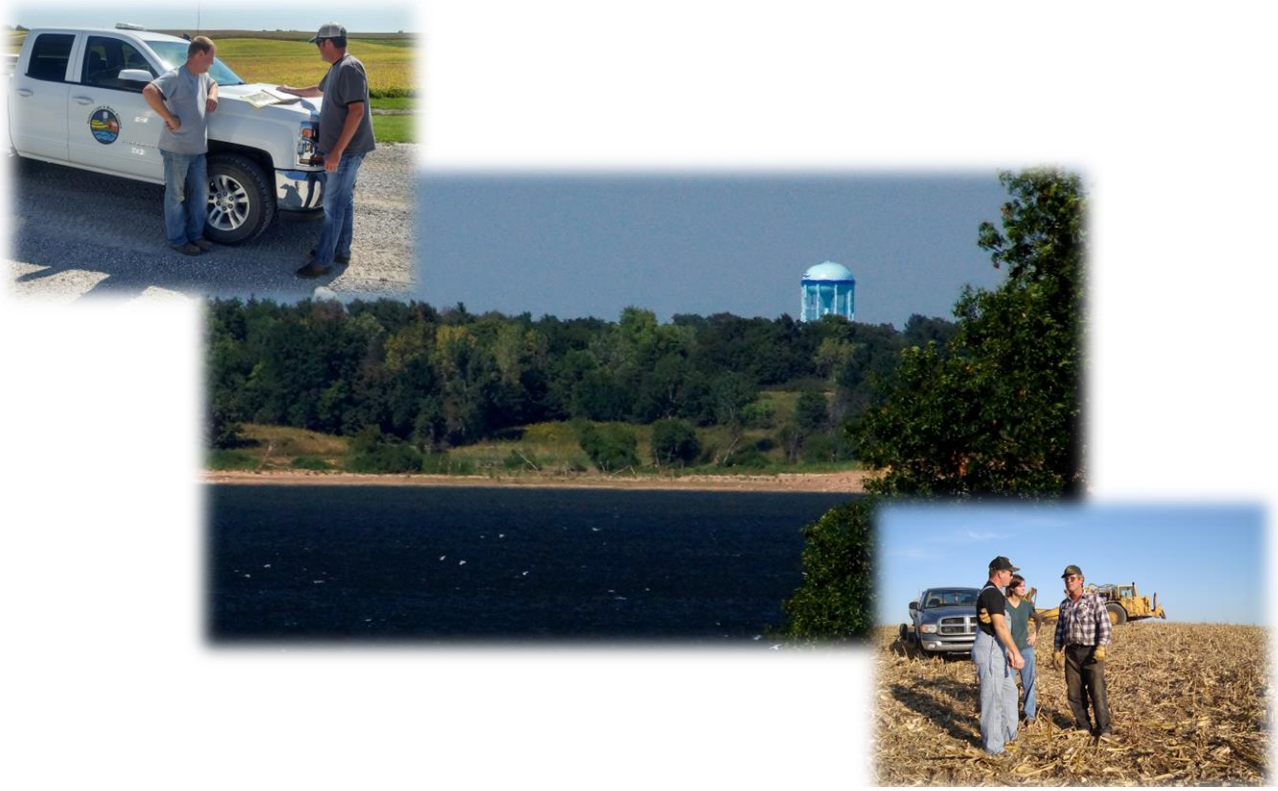
RATHBUN LAKE

WATERSHED MANAGEMENT and

SOURCE WATER PROTECTION PLAN



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EXECUTIVE SUMMARY

Rathbun Lake is located on the Chariton River in south central Iowa. Developed by the US Army Corps of Engineers in the late 1960s, the 11,000-acre lake is the primary source water for Rathbun Regional Water Association (RRWA). RRWA is the largest rural water system in Iowa and one of the largest systems in the United States. Rathbun Lake also provides recreational opportunities for one million visitors annually, flood damage reduction, and fish and wildlife habitat in the lake and on 21,000 acres of adjacent public land. The lake's watershed covers 354,000 acres and is characterized by rolling uplands, integrated drainage, and occasional broad alluvial plains. Land use in the watershed consists of corn and soybeans on close to 50% of the acres with grassland and woodland each on about 20% of the acres. An estimated 800 farms with 400 beef cattle operations are located in the watershed. There are ten communities and approximately 10,000 residents in the watershed, almost all of whom rely on RRWA and the lake for drinking water.

Rathbun Lake's main basin and three of the lake's principal arms, the Chariton Arm, South Fork Arm, and Honey Creek Arm, are included on Iowa's 2022 List of Impaired Waters. The lake's main basin has been identified as impaired since 2012, the Chariton Arm since 2006, South Fork Arm since 2006, and Honey Creek Arm since 2010. Iowa's water quality assessments and impaired waters list determinations have found that Rathbun Lake's ability to support primary contact recreation and aquatic life is impaired by high levels of non-algal turbidity. Sediment that enters the lake from land in its watershed is the major cause of this impairment. In addition, large amounts of sediment-bound phosphorus that are delivered to Rathbun Lake have led to algal turbidity related impairments in the lake. Importantly, excessive algal and non-algal turbidity in Rathbun Lake negatively impact the lake's use as a source water for RRWA.

The Rathbun Land and Water Alliance and its private and public partners have coordinated and supported efforts to protect land and water resources in the Rathbun Lake watershed for the past 25 years. Since 2004, the Alliance with its partners have successfully implemented Protect Rathbun Lake Project activities guided by the original and revised Rathbun Lake Watershed Management Plans. The project's goal is the reduction of sediment and phosphorus loading to the lake. Rathbun Lake protection efforts have focused on the application of structural best management practices (BMP) for land identified as priority. This priority land is the principal source of sediment and associated phosphorus that enters the lake from its watershed. Technical and financial assistance has enabled more than 500 landowners to apply BMPs for priority land to reduce phosphorus and sediment delivery to Rathbun Lake. BMPs have been applied for 36,500 acres, including at least 18,250 acres of priority land, that will reduce annual phosphorus and sediment loading to the lake by an estimated 287,000 pounds and 70,200 tons respectively. In addition, more than 1,500 acres of wetland, riparian, and shoreline areas have been restored and protected that will reduce phosphorus and sediment loads to the lake. Landowner outreach and water quality monitoring activities have been carried out in support of the application of BMPs.

The Water Quality Improvement Plan for Rathbun Lake (WQIP), or Total Maximum Daily Load (TMDL), completed in 2017 and approved in 2019, confirms that algal and non-algal turbidity caused by phosphorus and associated sediment loading are the impairments of greatest concern which impact the lake's recreational, aquatic life, and source water uses. The WQIP provides estimates of phosphorus and sediment loading to the lake from land uses and other sources in its watershed. Importantly, the plan identifies land used primarily for corn and soybean production in the watershed as the principal source of the sediment-bound phosphorus and sediment that enters the lake. The WQIP also establishes load reduction targets for total phosphorus to address the algal and non-algal turbidity impairments in Rathbun Lake. The annual load reduction target for the main basin of Rathbun Lake is 250,800 pounds of phosphorus. Since RRWA's raw water intake is located in the main basin, addressing turbidity impairments in this segment of the lake will most directly improve source water quality as well as benefit recreation and aquatic life.

This Watershed Management and Source Water Protection Plan for Rathbun Lake will guide the watershed and source water protection activities of the Rathbun Land and Water Alliance and its partners over the next 25 years. The plan's goal is to reduce sediment-bound phosphorus and sediment loading to Rathbun Lake. Specifically, the plan will achieve the annual load reduction target of 250,800 pounds of phosphorus for the lake's main basin established in the WQIP. In order to accomplish this target load reduction, the plan proposes to apply BMPs for 44,750 acres of land in the watershed which will reduce annual phosphorus and sediment loads to Rathbun Lake by an estimated 254,400 pounds and 261,000 tons respectively. Plan implementation will focus on the application of structural BMPs for priority land which has proven effective in ongoing Rathbun Lake protection efforts. WQIP-based analysis determined that this priority land consists of 59,115 acres, less than 17% of the watershed, and is the source of 56% of the total annual phosphorus load, an estimated 549,020 pounds, and 72% of the total annual sediment load, an estimated 590,565 tons, to Rathbun Lake. Landowner outreach and water quality monitoring will be conducted to support BMP application. Plan activities will be implemented in five consecutive five-year periods. An investment of $77.6 million in technical and financial assistance will be required to successfully carry out activities during the plan's 25-year timeframe.

RATHBUN REGIONAL WATER ASSOCIATION

Rathbun Regional Water Association (RRWA) is the largest rural water system in Iowa and one of the largest systems in the United States. RRWA provides nine million gallons of potable water daily for residential, agricultural, and business use in 18 counties and 58 communities in Iowa and Missouri. Rathbun Lake is the source of more than eight million gallons per day of untreated raw water to supply RRWA's two water treatment plants. In addition to the potable water produced at RRWA's treatment plants, the Association purchases and distributes drinking water from the Cities of Burlington, Fort Madison, Keokuk, and Mount Pleasant. Map 1 in Appendix A identifies RRWA's Service Territory. Features of RRWA's system are presented in Table 1.

Table 1 Rathbun Regional Water Association System Features

Total Population Served	92,500
Average Daily Potable Water Production	7 million gallons
Peak Daily Potable Water Production	10 million gallons
Average Daily Potable Water Purchase	2 million gallons
Peak Daily Potable Water Purchase	3 million gallons
Untreated Raw Water Intake Daily Capacity	17.5 million gallons
Untreated Raw Water Intake Locations	Principal intake in main basin of Rathbun Lake and secondary intake in Chariton River below outlet of Rathbun Lake
Treatment Plant Daily Capacity	14 million gallons
Treatment Plant Processes	Conventional treatment: oxidation, coagulation, flocculation, sedimentation, filtration, chloramine disinfection
Distribution System Storage Capacity	12 million gallons
Distribution System Components	7,000 miles of water mains 38 elevated water storage tanks 42 booster pump stations
Organizational Structure	Private nonprofit corporation

RATHBUN LAKE AND WATERSHED

Rathbun Lake Features

Rathbun Lake is located on the Chariton River in south central Iowa. The US Army Corps of Engineers (ACOE) developed the lake in the late 1960s. The US ACOE manages Rathbun Lake, lake facilities, and adjacent public land. As stated, Rathbun Lake is the primary source of raw water for RRWA's two water treatment facilities. In addition to being an important source of drinking water for southern Iowa and northern Missouri, the 11,000-acre lake offers recreational opportunities for one million visitors annually and is the home of Iowa's Honey Creek Resort State Park. Rathbun Lake also provides flood damage reduction for 150,000 acres of downstream land, fish and wildlife habitat in the lake and on 21,000 acres of adjacent public land, downstream water quality improvement, storage for supplementing navigational flows, and water for the Iowa Department of Natural Resources (DNR) Rathbun Fish Hatchery.

Watershed Area and Demographics

The Rathbun Lake watershed includes slightly more than 354,000 acres. The six counties in the lake's watershed are Appanoose (52,063 acres, 15% of the watershed), Clarke (15,500 acres, 4% of the watershed), Decatur (7,280 acres, 2% of the watershed), Lucas (90,997 acres, 26% of the watershed), Monroe (6,523 acres, 2% of the watershed) and Wayne (181,697 acres, 51% of the watershed). These six counties are among the least prosperous in Iowa with some of the highest poverty rates and lowest levels of household and farm income in the state. The counties are also some of the least populous in the state, all ranking in the bottom half of Iowa counties by population. Approximately 10,000 people live in the Rathbun Lake watershed. There are ten communities and an estimated 800 farms in the watershed [1]. The majority of farms are family owned and operated. Almost all of the residents, farms, and businesses in the watershed rely on RRWA and Rathbun Lake for their drinking water. Maps 2, 3, and 4 in Appendix A identify features in the Rathbun Lake watershed, including the 12-digit hydrologic units and sub-watersheds. The Rathbun Lake watershed consists of 17 12-digit hydrologic units which range in size from 10,312 acres to 35,031 acres. The watershed also includes 61 sub-watersheds that range in size from 2,590 acres to 16,430 acres.

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[1] Demographic information for the watershed is based on data from the following sources:
Bureau of Economic Analysis, US Department of Commerce, https://www.bea.gov/ .
State Data Center, State Library of Iowa, https://dev.iowadatacenter.org/index.php .

Watershed Geology, Soils, and Climate

The landscape in the Rathbun Lake watershed is characterized by rolling uplands, integrated drainage, and occasional broad alluvial plains. Most soils in the watershed formed in loess, glacial till, or alluvium. A few of the soils formed in colluvium, eolian sand, or shale residuum. The majority of soils in the lake's watershed have characteristics that limit their potential uses. This limitation arises from a prevalence of soils that are highly susceptible to erosion, shallow to root-restrictive zones, excessively wet, and inherently low in fertility. The climate in south central Iowa and the Rathbun Lake watershed is classified as humid continental. Winters are cold and summers are quite hot. The average temperature in the winter is 27 degrees Fahrenheit. The average temperature in the summer is 73 degrees Fahrenheit. Total annual precipitation averages close to 37 inches, of which nearly 70% usually falls in April through September. The average seasonal snowfall is 27 inches. The average length of a growing season is 160 days. [2]

Land Use in the Watershed

Land use information for the Rathbun Lake watershed is presented in Table 2. One of the more significant features of land use in the watershed in terms of potential impacts on water quality in the lake and its tributaries is the trend toward more acres in row crop production. Since 2013, cropland in the watershed has increased by 14%, or an estimated 20,000 acres. At the same time, the acres of grassland and land enrolled in the Conservation Reserve Program (CRP) have each decreased by six percent. Importantly, the conversion of grassland to row crops is often accompanied by the loss of infrastructure require to support the future use of this land for grazing, e.g., removal of pasture fences. Equally important, land previously enrolled in CRP most often becomes a significant source of sediment and phosphorus loading to Rathbun Lake if converted to row crops. In addition to the increase in land used for row crops, there has been a marked reduction in cropland acres farmed using extended rotations that include multiple years of forages. Map 5 in Appendix A presents land use information for the Rathbun Lake watershed.

Table 2 Land Use in the Rathbun Lake Watershed 2020

Acres	Cropland	Land in CRP	Grassland	Woodland	Other
Number	166,265	31,560	79,000	56,335	20,875
(%)	(47%)	(9%)	(22%)	(16%)	(6%)

[2] Geology, soils, and climate information for the watershed is based on data from the following source: Natural Resources Conservation Service, US Department of Agriculture, https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=IA .

In general, cropping patterns in the watershed consist of continuous corn and soybeans on land with slopes of less than nine percent and two to four years of row crops in rotation with four to six years of forages on steeper land. Grassland consists mainly of cool season grasses, most of which receive relatively limited intensive management. Woodland is comprised primarily of oak, hickory, eastern cottonwood, and silver maple. Woodland receives very little to no management.

There are approximately 400 livestock operations in the watershed. Almost all of these are cow-calf operations with a herd size of less than 100 head. These beef cattle operations rely almost exclusively on pasture for grazing and hay production for feed. A small number of livestock operations keep beef cattle in open feedlots for short periods during the year. Sixteen confined feeding operations that raise swine are also located in the watershed. Eight of these confinement operations can have more than 1,000 animal units. None of the confined feeding operations are permitted to discharge. Manure from these confinement facilities is land applied as fertilizer.

There are 13 publicly owned areas in the watershed consisting of more than 24,000 acres. Most notable are the Rathbun Lake Project Area, Honey Creek Resort State Park, Colyn Marsh Area, Bob White State Park, and the Lucas County Greenbelt Complex.

RATHBUN LAKE WATER QUALITY

Iowa's Water Quality Assessments and Impaired Waters List

Rathbun Lake's main basin and three of the lake's principal arms, the Chariton Arm, South Fork Arm, and Honey Creek Arm, are included on Iowa's 2022 List of Impaired Waters (Category 4). Rathbun Lake's main basin has been identified as impaired since 2012, the Chariton Arm of the lake since 2006, the South Fork Arm since 2006, and the Honey Creek Arm since 2010. The lake's ability to support primary contact recreation and aquatic life is impaired by high levels of non-algal turbidity. Sediment that enters the lake from land in its watershed is the major cause of this impairment. In addition, large amounts of sediment-bound phosphorus that are delivered to Rathbun Lake have caused algal turbidity related impairments in the lake. Median trophic state index (TSI) values for Rathbun Lake in 2016, 2018, 2020, and 2022 used in assessing impairment are presented in Tables 3A to 3D. Median TSI values of 65 or greater in the tables below indicate water quality impairment associated with non-algal and algal turbidity.

Table 3A Median TSI Values for Rathbun Lake's Main Basin [a]

Cycle	Secchi Depth TSI	Chlorophyll-a TSI	Total Phosphorus TSI
2016	70	50	63
2018	68	49	63
2020	68	48	65
2022	69	45	66

[a] TSI impairment threshold is 65 and delisting criteria is 63 for Secchi depth and chlorophyll-a

Table 3B Median TSI Values for Rathbun Lake's Chariton Arm [a]

Cycle	Secchi Depth TSI	Chlorophyll-a TSI	Total Phosphorus TSI
2016	79	55	72
2018	79	57	72
2020	74	57	77
2022	76	59	74

[a] TSI impairment threshold is 65 and delisting criteria is 63 for Secchi depth and chlorophyll-a

Table 3C Median TSI Values for Rathbun Lake's South Fork Arm [a]

Cycle	Secchi Depth TSI	Chlorophyll-a TSI	Total Phosphorus TSI
2016	83	63	74
2018	82	64	75
2020	83	62	80
2022	83	62	80

[a] TSI impairment threshold is 65 and delisting criteria is 63 for Secchi depth and chlorophyll-a

Table 3D Median TSI Values for Rathbun Lake's Honey Creek Arm [a]

Cycle	Secchi Depth TSI	Chlorophyll-a TSI	Total Phosphorus TSI
2016	70	57	64
2018	72	61	59
2020	68	60	68
2022	68	60	66

[a] TSI impairment threshold is 65 and delisting criteria is 63 for Secchi depth and chlorophyll-a

The median TSI values presented in the tables above allow several observations to be made regarding water quality impairment in Rathbun Lake. The trend in median Secchi Depth TSI values is stable to decreasing with values above the impairment level for all four lake segments. Median Chlorophyll-a TSI values are below the impairment level in all lake segments and the trend in values varies in the different segments. The trend in median Total Phosphorus TSI values is increasing with values indicative of impairment in all four segments of the lake. These observations support assessing water quality in Rathbun Lake as impaired and threatened by both non-algal and algal turbidity due to excessive sediment and phosphorus loads from land in the lake's watershed. Additionally, median TSI values indicate the level of water quality impairment in Rathbun Lake's main basin is relatively lower than in the lake's Chariton and South Fork arms. This observation is significant given the location of RRWA's principal source water intake in the main basin and the extensive recreational use of this segment of the lake. At the same time, the median TSI values indicate Rathbun Lake's South Fork arm has a relatively higher level of impairment than the other lake segments. This observation aligns with the location of land identified as the source of substantial sediment and phosphorus loads in the southern portion of the Rathbun Lake watershed.

Iowa's 2022 List of Impaired Waters (Category 5) includes 15 additional water bodies and water body segments in the Rathbun Lake watershed. The causes of impairment identified for the water bodies include algal growth, bacteria, low biotic index, and organic enrichment. These water bodies and water body segments include Bob White Lake, Corydon Reservoir, Chariton River, Chariton Creek, Dick Creek, Fivemile Creek, Honey Creek (2), Jackson Creek, Jordan Creek, Ninemile Creek, South Fork Chariton River, Walker Branch, West Jackson Creek, and Wolf Creek. Map 6 and Table 11 in Appendix A identifies water bodies in the Rathbun Lake watershed on Iowa's 2022 List of Impaired Waters (Categories 4 and 5). [3]

Water Quality Monitoring

A cooperative water quality monitoring program in Rathbun Lake and the lake's tributaries has been conducted since 1997. Annual monitoring activities have consisted of at least monthly sample collection and field measurements taken at as many as 20 fixed monitoring sites in Rathbun Lake, its tributaries, and the lake's outlet in the Chariton River. Water quality monitoring efforts during the last 25 years have captured several drought periods and multiple flood events, providing an understanding of phosphorus and sediment loading to Rathbun Lake. Current monitoring activities are focused on the four sites in Rathbun Lake (RA-3, RA-7, RA-8, and RA-25), four sites in the watershed on the main tributaries to the lake (RA-12, RA-15, RA-39, and RA-41), and one site at the lake's outlet in the Chariton River (RA-28). The primary purpose of the

[3] Water quality assessment and impaired waters list information is based on data from the following source: ADBNet, Iowa Department of Natural Resources, https://programs.iowadnr.gov/adbnet .

water quality monitoring program is to provide data required to evaluate Rathbun Lake and water bodies in the lake's watershed as part of Iowa's water quality assessments and impaired waters list determinations. In addition, findings from long-term monitoring in the lake and its tributaries of particular relevance to watershed management and source water protection are the relatively stable trend in water quality parameters over time and the significantly higher loading of phosphorus and sediment associated with heavy rainfall events. Partners in conducting the water quality monitoring program have included the Rathbun Land and Water Alliance, Iowa DNR, US ACOE, Iowa's State Hygienic Laboratory (SHL), and Iowa State University (ISU). Map 7 in Appendix A identifies the locations of water quality monitoring sites in Rathbun Lake, tributaries in the lake's watershed, and the lake's outlet in the Chariton River.

SOURCE WATER QUALITY AND DRINKING WATER

RRWA's use of Rathbun Lake as a source water can be negatively impacted by high levels of algal and non-algal turbidity in the lake caused by excessive phosphorus and sediment loading from its watershed. These source water-related impacts are described below.

Reduced Effectiveness of Water Treatment Processes – High levels of algal and non-algal turbidity in Rathbun Lake can reduce the effectiveness of essential drinking water treatment processes at RRWA. The removal of organic and inorganic substances from highly turbid lake water by oxidation, coagulation, flocculation, and sedimentation can require increased treatment chemical dosages and longer process times. Equally important, the presence of high turbidity in source water from the lake can more rapidly exhaust the adsorption capacity of RRWA's granular activated carbon filters decreasing the time between filter backwashes and shortening the useful life of filter media. In addition, excessive turbidity can reduce the efficiency of disinfection requiring higher rates of chlorination during water treatment and lowering disinfectant residual levels in the water distribution system.

Formation of Disinfection By-Products – Highly turbid conditions in Rathbun Lake can result in elevated levels of particulate and dissolved organic substances in RRWA's source water. These organic substances can react with chlorine used for disinfection during water treatment and in the water distribution system to form by-product chemicals that are suspected carcinogens such as trihalomethanes and haloacetic acids. The effective management of high levels of organic substances to prevent disinfection by-product formation in source water and drinking water can require RRWA to make changes in the oxidation, coagulation, filtration, and disinfection processes including the use of more and different treatment chemicals, implementation of alternative treatment techniques, and adjustments in procedures to achieve, monitor, and maintain adequate disinfection.

Disagreeable Taste, Odor, and Color – The excessive growth and subsequent decay of algae and aquatic vegetation in Rathbun Lake can lead to the formation and release of metabolic and decomposition by-products that create offensive tastes and odors in drinking water. In Rathbun Lake, two compounds in particular, geosmin and methylisoborneal, produced by blue-green algae, or cyanobacteria, have been indicated as the main cause of earthy, musty taste and odor in RRWA's drinking water. Anaerobic conditions at the bottom of Rathbun Lake caused by the microbial decay of dead algal and aquatic plant material can lead to the release of iron and manganese into the water from the sediment. High concentrations of iron and manganese in source water can cause discoloration in drinking water unless effectively addressed during the treatment process. Additionally, the US Environmental Protection Agency (EPA) has developed health advisory levels for manganese in drinking water to protect against potential adverse health effects that may be associated with relatively high concentrations of this mineral. RRWA's management of source water characteristics that cause taste, odor, color, and related health concerns in drinking water can require additional treatment chemicals, alternative treatment techniques, frequent filter backwashes, and increased flushing in the water distribution system.

Toxin and Bacterial Growth Concerns – Excessive phosphorus loads to Rathbun Lake contribute to conditions that lead to cyanobacterial blooms. The metabolism and decay of cyanobacteria can be sources of harmful cyanotoxins. Adverse health effects are associated with the presence of cyanotoxins in drinking water above health advisory levels established by the US EPA. In addition, particulate and dissolved organic substances from algal metabolism and decay in the lake can support the growth of bacteria in the water distribution system if present in treated water. Similarly, high iron and manganese concentrations in the lake associated with the decay of algal and aquatic plant material can also promote the growth of bacteria in the distribution system if not removed during water treatment. This bacterial growth may lead to decreased disinfectant residual levels in the water distribution system. Measures that RRWA implements to address cyanotoxin and bacterial growth concerns include changes in the type, amount, and timing of chemical additions, adjustments in treatment processes, and distribution system flushing.

Quantity and Resiliency Issues – The US ACOE has allocated 15,000 acre-feet (ac-ft) of storage space in Rathbun Lake at normal lake pool elevation of 904 feet above mean sea level for water supply. This allocation takes into consideration the impact on usable storage in Rathbun Lake of sedimentation originally estimated to occur during the lake's first 100 years. A sedimentation survey conducted in 2016 indicated the lake has accumulated sediment at a rate that is more than two times faster than initially estimated. As a result, the US ACOE may determine that it is necessary to designate additional sediment storage space in Rathbun Lake. This reallocation of usable storage in the lake to accommodate future sedimentation could reduce the storage available for water supply. RRWA currently owns 6,680 ac-ft of the allocated 15,000 ac-ft of water

supply storage space in Rathbun Lake. Ownership of this 6,680 ac-ft of water supply storage is projected to provide RRWA with approximately ten months of raw water supply. RRWA is in the process of acquiring the remaining 8,320 ac-ft of water supply storage space from the US ACOE. This additional water supply storage will provide RRWA with approximately 22 months of raw water supply, improving the Association's resiliency for prolonged periods of drought and safeguarding against any loss of allocated water supply storage space due to sedimentation in Rathbun Lake.

High levels of algal and non-algal turbidity caused by excessive phosphorus and sediment loads can increase the complexity and cost of using Rathbun Lake as a source water for RRWA as well as pose potential human health risks and lead to a possible loss of the public's confidence in its drinking water supply.

CAUSES AND SOURCES OF WATER QUALITY IMPAIRMENT

Water Quality Improvement Plan / Total Maximum Daily Load for Rathbun Lake

The Water Quality Improvement Plan for Rathbun Lake (WQIP), or Total Maximum Daily Load (TMDL), was completed by the Iowa DNR in 2017 and approved by the US EPA in 2019 [4]. This Watershed Management and Source Water Protection Plan for Rathbun Lake draws from, builds on, and is an extension of the WQIP. The WQIP includes a comprehensive review and interpretation of water quality data for Rathbun Lake. The plan confirms that excessive algal and non-algal turbidity are the impairments of greatest concern which impact the lake's recreational, aquatic life, and source water uses. The WQIP identifies sediment-bound phosphorus and sediment delivered to Rathbun Lake from its watershed as the main causes of these impairments. According to the plan, sediment-bound phosphorus comprises an estimated 80% and dissolved phosphorus 20% of the total phosphorus load that impacts water quality in the lake. In addition, the plan presents an assessment that estimates phosphorus and sediment loading to Rathbun Lake from land uses and other sources in the lake's watershed. The WQIP develops a phosphorus-based TMDL for the purpose of addressing impairments by both phosphorus and associated sediment. Finally, the plan describes recommended actions to reduce phosphorus and sediment loading that would make progress toward achieving the TMDL for Rathbun Lake.

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[4] Inkenberry, Charles D, "Water Quality Improvement Plan for Rathbun Lake: Appanoose, Clarke, Decatur, Lucas, Monroe, and Wayne Counties in South-Central Iowa," Iowa Department of Natural Resources, 2017, https://www.iowadnr.gov/Environmental-Protection/Water-Quality/Watershed-Improvement/Water-Improvement-Plans/Public-Meetings-Plans

Two key findings of the WQIP assessment related to the sources of water quality impairment in Rathbun Lake that impact watershed management and source water protection planning are:

- The principal source of sediment-bound phosphorus and sediment loading in Rathbun Lake is land in the watershed used primarily for corn and soybean production; and

- A high percentage (75%) of the sediment and associated phosphorus is exported to Rathbun Lake from a relatively small area (20%) of the watershed.

The WQIP assessment of sources of water quality impairment provided the basis for development of a geographic information system (GIS) mapping tool. The mapping tool can be used to estimate phosphorus and associated sediment loading to Rathbun Lake from specific areas of land in the watershed. The mapping tool is based on hydrologic response units (HRU) which are areas in the Rathbun Lake watershed with the same land use, soil type, and slope classification. The HRUs are derived from the Soil and Water Assessment Tool used in the WQIP analysis. The mapping tool can also be used to estimate the impact of best management practices (BMPs) and land use changes on phosphorus and sediment delivery to Rathbun Lake. Development and use of the WQIP-based GIS mapping tool are described in Appendix C.

Priority Land in the Rathbun Lake Watershed

Priority land in the Rathbun Lake watershed is the primary source of sediment and associated phosphorus that impairs water quality in Rathbun Lake. Priority land is almost entirely used for row crop production. The WQIP-based GIS mapping tool was applied to identify and evaluate priority land in the watershed. The tool was also used to develop updated estimates of phosphorus and associated sediment loading to Rathbun Lake from the watershed. In addition, the tool will enable site-specific analysis of sediment and phosphorus load reductions associated with the application of BMPs for priority land. Results from the WQIP-based GIS mapping tool are summarized below and presented in Table 4.

- Annual phosphorus load to Rathbun Lake from land in the watershed is currently estimated at 976,120 pounds.

- Annual sediment load to Rathbun Lake from land in the watershed is currently estimated at 818,270 tons.

- Priority land consists of approximately 59,115 acres which is less than 17% of the 354,000 acres in the Rathbun Lake watershed.

- Priority land delivers at least 4.3 pounds of phosphorus per acre per year and 3.3 tons of sediment per acre per year to Rathbun Lake.

- Annual phosphorus and sediment loads from priority land can exceed an estimated 20 pounds and 10 tons per acre respectively.

- Close to 50% of priority land, an estimated 26,900 acres, has slopes of greater than seven percent which limits the effectiveness of certain in-field BMPs such as terraces.

- Priority land is the source of an estimated 549,020 pounds of the annual phosphorus load to Rathbun Lake which is 56% of the total annual phosphorus load from the watershed.

- Priority land is the source of an estimated 590,565 tons of the annual sediment load to Rathbun Lake which is 72% of the total annual sediment load from the watershed.

Map 8 in Appendix A identifies priority land in the Rathbun Lake watershed.

Table 4 Priority Land in the Rathbun Lake Watershed

Land Classification	Acres	Phosphorus Load (pounds per year)	Sediment Load (tons per year)
Priority Land [a]	59,115 (17%)	549,020 (56%)	590,565 (72%)
Non-Priority Land	294,885 (83%)	427,100 (44%)	227,705 (28%)
Watershed Totals	354,000	976,120	818,270

[a] Annual per acre delivery rates of at least 4.3 pounds of phosphorus and 3.3 tons of sediment

Other Sources of Water Quality Concerns

The WQIP for Rathbun Lake identified all known sources of phosphorus in the lake's watershed. Grassland and streambank erosion were determined to be important sources yet contributed relatively less of the total annual phosphorus load to Rathbun Lake than priority land used for row crop production. Specifically, the WQIP analysis estimated that grassland and streambank erosion contribute approximately 20% respectively of the total annual phosphorus load to Rathbun Lake from the watershed. In addition, the WQIP determined that other nonpoint and point sources in the watershed were minor, accounting for only five percent of the total annual phosphorus load to the lake. These other sources of total phosphorus evaluated in the WQIP included developed areas, woodland, animal feeding operations, septic systems, and wastewater treatment facilities.

RRWA's risk and resilience assessment and emergency preparedness and response plan address potential threats to the utility's major system components. As part of the assessment, RRWA evaluated threats to Rathbun Lake as the source water for the utility's two water treatment plants. This evaluation considered the potential impact on Rathbun Lake from possible threats including droughts, floods, hazardous material releases, intentional acts, and operational failures. Potential point sources of contaminants identified in the Rathbun Lake watershed include 22 animal feeding operations, 38 chemical storage facilities, 46 underground storage tanks, and 11 public and private wastewater systems. Map 9 and Table 12 in Appendix A identify these potential point sources in the Rathbun Lake watershed. The location, size, type, and/or on-site factors including operational requirements and containment measures as well as local and state response capabilities led RRWA to assess these sources as of relatively low potential impact in terms of substantially disrupting the utility's essential operations of treating and distributing drinking water.

PROGRESS PROTECTING RATHBUN LAKE

Rathbun Land and Water Alliance and Partners

The Rathbun Land and Water Alliance and its partners coordinate and support efforts to protect land and water resources in the Rathbun Lake watershed. Alliance members include soil and water conservation districts and county governments in the lake's watershed as well as RRWA. Private, state, and federal partners include: Farm Bureau, CoBank, Southern Iowa Development and Conservation Authority, Iowa DNR, Iowa Department of Agriculture and Land Stewardship's Division of Soil Conservation and Water Quality (IDALS), ISU, USDA Natural Resources Conservation Service (NRCS), US ACOE, and US EPA. The Alliance, established in 1996, is organized as a nonprofit corporation under Iowa Code Chapter 504 and section 501(c)(3) of the US Internal Revenue Code. Representatives of Alliance members and partners who provide expertise for efforts to protect Rathbun Lake are identified in Table 5.

Table 5 Rathbun Land and Water Alliance Technical Advisory Team

Representatives	Organizations	Emails
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Table 5 Rathbun Land and Water Alliance Technical Advisory Team cont.

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Rathbun Lake Watershed Assessment and Planning

In 2002, the Alliance and partners completed a watershed assessment and developed strategies to protect water quality in Rathbun Lake as part of an approved Rathbun Lake watershed management plan. At that time, the Alliance's assessment was one of the most comprehensive analyses of its type for a watershed the size of Rathbun Lake's in Iowa. The assessment identified and prioritized agricultural nonpoint sources of water quality impairment in the lake's watershed. Assessment findings were used by the Alliance and partners to develop the original watershed management plan which included actions that have been carried out through the Protect Rathbun Lake Project. In 2014, the Alliance and its partners revised the original plan with the Protect Rathbun Lake Interim Watershed Management Plan. The interim plan guided application of BMPs in the lake's watershed and implementation of supporting activities including water quality monitoring and landowner outreach during development of the WQIP for Rathbun Lake. This Rathbun Lake Watershed Management and Source Water Protection Plan is based on the results and recommendations presented in the WQIP.

Protect Rathbun Lake Project – Original and Interim Plan Implementation

The overall goal of the Protect Rathbun Lake Project has been the reduction of sediment-bound phosphorus and sediment loading to the lake as put forth in the original and interim Rathbun Lake watershed management plans. The Alliance considered application of BMPs for one-half of the priority land identified in the Rathbun Lake watershed during development of the original management plan, approximately 30,000 acres, to be an achievable and impactful objective in pursuit of this goal. Accomplishment of this objective would reduce annual phosphorus and sediment loads to Rathbun Lake by an estimated 360,000 pounds and 90,000 tons respectively based on original assessment findings.

Protect Rathbun Lake Project activities were initiated in 2004. Since that time, significant progress has been made toward implementation of project activities, achievement of project objectives, and accomplishment of the project's overall goal to reduce the phosphorus and associated sediment delivered to Rathbun Lake from priority land in the watershed. Specifically:

- BMP implementation activities have been carried out in 56 of the 61 targeted sub-watersheds in the Rathbun Lake watershed;
- Project staff have provided assistance to approximately 780 landowners, 550 of whom agreed to apply BMPs for priority land which is a participation rate of 70%;
- BMPs have been applied for 37,500 total acres, including at least 18,750 acres of priority land (62% of the project's original objective) with the remaining acres considered associate priority land which, due to its location, must also be treated to address the priority land;
- BMPs applied will reduce the delivery of phosphorus and associated sediment to Rathbun Lake by an estimated 290,100 pounds and 72,300 tons per year respectively (80% of the project's original objectives);
- More than 1,500 acres of wetland, riparian, and shoreline areas have been restored and protected on private and public land that will benefit water quality in the Rathbun Lake;
- Water quality monitoring, GIS analyses, and landowner outreach have been conducted. These activities supported the application of BMPs to achieve the project's priority land treatment and phosphorus and sediment load reduction objectives; and
- Long-term monitoring data show that water quality in Rathbun Lake has been relatively stable. These results may indicate that the targeted application of BMPs for priority land has helped prevent any significant deterioration in water quality caused by increased phosphorus and sediment loading associated with the expansion of cropland in the watershed.

Factors Supporting Plan Implementation

The Alliance and its partners have determined that the strategy pursued in implementing the original and interim watershed management plans has been successful and should continue in the future. This determination is based on the progress achieved in reducing phosphorus and sediment delivery to Rathbun Lake coupled with relatively stable water quality conditions in the lake in spite of an increase in cropland in the watershed. The Alliance considers the following to be key factors that have supported the effective implementation of the management plans.

- Adequate Financial Resources Success in implementing the watershed management plans has required a substantial and sustained commitment of resources by Alliance members and partners. As an indication of this level of support, more than $23.6 million has been invested by members and partners, including landowners, to install BMPs since 2004.

- Qualified Field Professionals A team of highly qualified field professionals, as is currently in place, has been and will continue to be essential to effective watershed management plan implementation. At this time, professional field staff dedicated to implementing the plan includes two environmental specialists and one technician, all of whom are assisted by personnel with local, state, and federal partners.

- Emphasis on Structural BMPs The Alliance has found that structural BMPs such as terraces and grade stabilization structures combine features which make these practices especially effective at reducing sediment and associated phosphorus delivery to Rathbun Lake. These features are strong levels of landowner interest and adoption, high trapping efficiencies, and consistent performance with little maintenance over long lifespans. In contrast, the Alliance's experience with non-structural BMPs such as no-till and cover crops has been that the application of these practices is affected by such factors as weather, input costs, crop prices, farming operations, and landowner decision-making. While field staff assist landowners with the application of non-structural BMPs, in terms of watershed plan implementation strategy, these practices are currently considered relatively less effective over time compared with structural practices in reducing phosphorus and sediment loading to Rathbun Lake.

- Targeting BMPs for Priority Land Experience implementing the watershed management plans has shown that the targeted application of BMPs for priority land is a cost-effective strategy to reduce phosphorus and sediment loads to Rathbun Lake. The Alliance estimates that the average annual cost for the targeted application of BMPs on priority land is less than $17 per ton of sediment and associated phosphorus reduced. In comparison, the average annual cost for applying BMPs on land not identified as priority is estimated as high as $40 per ton of sediment and associated phosphorus reduced. Given this, the targeting of priority land for BMPs results in a cost to protect water quality in terms of reduced phosphorus and sediment delivery that is less than one-half of the cost of applying BMPs on land without targeting.

- Responsiveness of the "Supershed" Approach The "supershed" approach employed as part of the watershed management plan implementation strategy has allowed the Alliance and partners to carry out activities across the Rathbun Lake watershed in a manner that is highly responsive to opportunities to apply BMPs for priority land. "Supershed" refers to the entire Rathbun Lake watershed without regard to internal sub-watershed boundaries. Specifically, this approach has enabled resources for BMP application to be directed to any area of the watershed in response to such conditions as increases in priority land due to the conversion of land to row crops and changes in land ownership or operation that lead to greater interest in applying BMPs for priority land.

WATERSHED MANAGEMENT AND SOURCE WATER PROTECTION PLAN

General Plan Description

The overall goal of the Rathbun Lake Watershed Management and Source Water Protection Plan is to reduce sediment-bound phosphorus and sediment loading to Rathbun Lake. The plan will guide watershed and source water protection activities for a 25-year timeframe. During this period, the Alliance and its partners will continue to employ the strategy that has proven effective in implementing the original and interim watershed management plans through the Protect Rathbun Lake Project since 2004. This strategy focuses primarily on assisting landowners to achieve the targeted application of structural BMPs for priority land in the Rathbun Lake watershed. The Alliance anticipates that the application of these BMPs for priority land will significantly reduce phosphorus and sediment loading to Rathbun Lake and, as a result, achieve substantial progress toward addressing water quality impairments in the lake.

Expected Load Reductions

The WQIP establishes load reduction targets, or TMDLs, for total phosphorus to address the turbidity impairments in Rathbun Lake. Since most of the phosphorus load to Rathbun Lake is sediment-bound, BMPs will be applied to reduce both of these causes of non-algal and algal turbidity impairments and lessen the possibility of any future chlorophyll-a impairment in the lake. As indicated, RRWA's principal raw water intake is located in the main basin of Rathbun Lake. Addressing turbidity impairments in this segment of the lake will most directly improve source water quality for RRWA. The WQIP annual load reduction target for the main basin of Rathbun Lake is 250,800 pounds of phosphorus. This is 26% of the estimated total annual phosphorus load to the lake. In order to achieve this target load reduction, the Rathbun Lake Watershed Management and Source Water Protection Plan proposes to apply BMPs for 44,750 acres of land in the watershed, including 27,875 acres of priority land with the remaining acres considered associate priority land which, due to its location, must also be treated to address the priority land. These BMPs will reduce annual phosphorus and sediment loads by an estimated 254,400 pounds

and 261,000 tons respectively. Table 6 presents BMP and load reduction information associated with achieving the WQIP total phosphorus load reduction target in Rathbun Lake's main basin.

Table 6 WQIP Total Phosphorus Load Reduction Target – Main Basin of Rathbun Lake

Phosphorus Load Reduction Target	Proposed Acres with BMPs	Phosphorus Load Reduction from BMPs	Sediment Load Reduction from BMPs
250,800 pounds / year	44,750 acres [a]	254,400 pounds / year	261,000 tons / year

[a] 27,875 acres of priority land with the remaining considered associate priority land

Proposed Implementation Measures

The Alliance's implementation strategy for the Rathbun Lake Watershed Management and Source Water Protection Plan emphasizes the application of structural BMPs. These practices include terraces, grade stabilization structures, water and sediment control basins, and sediment basins. As indicated, the Alliance has found that structural BMPs combine features which make these practices highly effective at reducing phosphorus and associated sediment loading to Rathbun Lake. These features include strong levels of landowner adoption, high trapping efficiencies, and consistent performance over a relatively long lifespan. The Alliance's strategy will also include assisting landowners with the conversion of priority land from row crops to grassland by planting forages for hay production and grazing as well as enrolling this land in programs such as the Conservation Reserve Program (CRP). The establishment of forages is an effective alternative on the estimated 26,900 acres of priority land in the watershed that are too steep for in-field structural measures such as terraces.

The Alliance will implement activities of the Rathbun Lake Watershed Management and Source Water Protection Plan in five consecutive five-year periods. These five-year periods will provide adequate time to successfully complete plan activities during a given period while also allowing flexibility to make any modifications needed between periods to ensure continued progress in implementing the plan. During each of the five-year implementation periods of the Rathbun Lake Watershed Management and Source Water Protection Plan, BMPs will be applied for 8,950 acres, including 5,575 acres of priority land with the remaining acres being associate priority land. These BMPs will reduce sediment-bound phosphorus loading to Rathbun Lake by an estimated 50,880 pounds per year. This is 20% of the total phosphorus load reduction target established in the WQIP for the main basin of the lake. The BMPs will also reduce annual sediment loading to Rathbun Lake by an estimated 52,200 tons. This is 20% of the estimated total sediment load reduction associated with achieving the total phosphorus load reduction target for the lake's main basin. Table 7 presents the BMP application and load reduction objectives for each five-year implementation period of the Rathbun Lake Watershed Management and Source Water Protection Plan as well as for the entire 25-year timeframe of the plan.

Table 7 Plan Objectives for BMP Application and Load Reduction

Implementation Period	Date Range	BMP Application	Total Phosphorus Load Reduction Objective	Total Sediment Load Reduction Objective
Period 1	2023 - 2027	8,950 acres [a]	50,880 pounds / year	52,200 tons / year
Period 2	2028 - 2032	8,950 acres [a]	50,880 pounds / year	52,200 tons / year
Period 3	2033 - 2037	8,950 acres [a]	50, 880 pounds / year	52,200 tons / year
Period 4	2038 - 2042	8,950 acres [a]	50, 880 pounds / year	52,200 tons / year
Period 5	2043 - 2047	8,950 acres [a]	50,880 pounds / year	52,200 tons / year
Periods 1 - 5	2023 - 2047	44,750 acres [b]	254,400 pounds / year	261,000 tons / year

[a] 5,575 acres of priority land with the remaining considered associated priority land

[b] 27,875 acres of priority land with the remaining considered associated priority land

The BMPs that will be applied during each of the five-year implementation periods of the Rathbun Lake Watershed Management and Source Water Protection Plan are described below. The Alliance and partners will ensure that applied BMPs comply with NRCS Standards and Specifications (S&S) and are approved by an NRCS engineer or technician, or professional engineer licensed in the State of Iowa, as required. The practices will be maintained by landowners according to approved standards as per agreements with local soil and water conservation districts.

- Terraces (NRCS S&S 600) – Three hundred and fifty thousand (350,000) feet of terraces will be installed to treat a total of 3,500 acres. Practice maintenance period is 20 years.

- Sediment Basins (NRCS S&S 350) – Five (5) sediment basins will be installed to treat a total of 500 acres. Practice maintenance period is 35 years.

- Grade Stabilization Structures (NRCS S&S 410) – Eighty (80) grade stabilization structures will be installed to treat a total of 2,000 acres. Practice maintenance period is 35 years.

- Water and Sediment Control Basins (NRCS S&S 638) – One hundred and eighty (180) water and sediment control basins will be installed to treat a total of 750 acres. Practice maintenance period is 20 years.

- Forage and Biomass Planting (NRCS S&S 512) – Two thousand and two hundred (2,200) acres of priority land in row crops will be converted to grassland. This practice may include enrolling priority land in programs such as CRP. Practice maintenance period is 5 to 10 years.

- Improved Grazing Practices (NRCS S&S 528) - Improved grazing practices will be applied on 600 acres of grassland converted from row crops. Practices will include rotational grazing, fencing, trough or tank, pipeline, and heavy use protection. Fencing will be installed to ensure livestock are excluded or restricted from areas adjacent to water bodies. Improved grazing practices provide infrastructure for the long-term use of land as pasture. As a result, these practices help ensure that land converted to grassland remains in use as pasture. In other words, grassland with improved grazing practices is less likely to be converted back to row crops than grassland without these practices. In terms of water quality protection, the potential long-term reduction in phosphorus and sediment delivery to Rathbun Lake from grassland with improved grazing practices is greater than from grassland without these practices.

The Alliance and its partners will ensure that all permits needed are obtained for BMPs. The construction of sediment basins and grade stabilization structures commonly require permits. These permits can include a Section 404 Permit and Regional General Permit 33 from the US ACOE and a Section 401 Water Quality Certification, Water Storage Permit, Floodplain Construction Permit, and Sovereign Lands Construction Permit from the Iowa DNR.

Technical and Financial Assistance Needs

Implementation of the Rathbun Lake Watershed Management and Source Water Protection Plan over the entire 25-year timeframe will require an investment of $77.6 million in technical and financial resources. The estimated cost of implementing plan activities during each five-year period as well as for the plan's 25-year timeframe is presented in Table 8.

Table 8 Estimated Cost of Technical and Financial Assistance [a]

Implementation Period	Date Range	Estimated Cost
Period 1	2023 - 2027	$10.7 million
Period 2	2028 - 2032	$12.7 million
Period 3	2033 - 2037	$15.1 million
Period 4	2038 - 2042	$17.9 million
Period 5	2043 - 2047	$21.2 million
Periods 1 - 5	2023 - 2047	$77.6 million

[a] Estimated cost includes a 3.5% annual rate of inflation

An estimated $10,701,306 in technical and financial assistance will be required to implement plan activities during the initial five-year period from 2023 to 2027. The principal uses and potential sources of these funds are described below.

- Direct Technical Assistance – An estimated $1,782,232 will be required to support two Environmental Specialists and one Technician. Proposed sources of these funds include $1,463,997 from the Section 319 Program and $318,235 from state partners.

- Terraces – An estimated $3,112,310 will be required to install terraces for 3,500 acres. Proposed sources of these funds include $765,578 from cooperating landowners, $1,985,501 from state and federal partners, and $361,231 in Section 319 Program funds which include a summer construction incentive of $100 per acre for up to 500 acres.

- Sediment Basins – An estimated $471,068 will be required to install sediment basins for 500 acres. Proposed sources of these funds include $42,107 from cooperating landowners, $21,053 from the Alliance, $310,801 from state and federal partners, and $97,107 in Section 319 Program funds which include a summer construction incentive of $100 per acre for up to 500 acres.

- Grade Stabilization Structures – An estimated $2,119,869 will be required to install structures for 2,000 acres. Proposed sources of these funds include $524,967 from cooperating landowners, $1,362,915 from state and federal partners, and $231,987 in Section 319 Program funds which include a summer construction incentive of $100 per acre for up to 200 acres.

- Water and Sediment Control Basins – An estimated $724,612 will be required to install basins for 750 acres. Proposed sources of these funds include $178,653 from cooperating landowners, $463,498 from state and federal partners, and $82,461 in Section 319 Program funds which include a summer construction incentive of $100 per acre for up to 100 acres.

- Forage and Biomass Planting – An estimated $1,684,270 will be required to convert 2,200 acres of priority land to grassland. This estimated amount includes establishment costs of $250 per acre plus one-time per acre incentive payments based on the length of agreed to maintenance period: $300 for 5 years, $450 for 7 years, and $700 for 10 years. Incentive payments may also encourage the enrollment of priority land in programs such as CRP. Proposed sources of these funds include $151,147 from cooperating landowners, $1,364,696 from state and federal partners, and $168,427 in Section 319 Program funds.

- Improved Grazing Practices – An estimated $144,366 will be required to apply improved grazing practices on 600 acres of grassland converted from row crops. Proposed sources of these funds include $72,183 from cooperating landowners and $72,183 from state and federal partners.

- Expert Technical Assistance – An estimated $202,139 for engineering assistance with the design and construction of large sediment basins and grade stabilization structures and for GIS assistance to identify priority land and evaluate BMP effectiveness. Proposed sources of these funds include $86,099 from the Alliance and $116,040 from state and federal partners.

- Water Quality Monitoring – An estimated $261,086 for water quality monitoring activities as described in this plan. Proposed sources of these funds include $29,010 from the Alliance, $58,019 from the Section 319 Program, and $174,057 from federal partner, the US ACOE.

- Information and Education – An estimated $199,354 to implement the outreach activities described in this plan. Proposed sources of these funds include $99,677 from the Alliance and $99,677 from the Section 319 Program.

Table 9 presents a summary of proposed sources of technical and financial assistance required to implement the Rathbun Lake Watershed Management and Source Water Protection Plan during the initial five-year period from 2023 to 2027.

Table 9 Summary of Assistance Needs for Plan Implementation 2023 - 2027

Section 319 Program Partner	Cooperating Landowners	State and Federal Partners	Local Partners	Total Investment
$2,562,906	$1,734,635	$6,167,926	$235,839	$10,701,306

Information and Education

The Rathbun Lake Watershed Management and Source Water Protection Plan will implement the information and education strategy that has proven successful in conducting outreach as a key component of the original and interim watershed management plans. Evidence of the strategy's effectiveness is a landowner participation rate of 70% in terms of the application of BMPs for priority land in the watershed. Features of this outreach strategy are described below.

- Target Audience – Landowners who own and/or farm priority land in the Rathbun Lake watershed are the target audience of the plan's outreach efforts.

- Outreach Activities - Efforts to reach landowners will consist primarily of the following:

  - On-Farm Assistance: One-on-one assistance from highly qualified field staff delivered directly to landowners during visits on their farms has proven to be the most effective form of outreach in achieving the application of BMPs for priority land that will reduce phosphorus and sediment delivery to Rathbun Lake;

  - Recognition Efforts: The Alliance will continue to recognize landowners who excel in their efforts to apply BMPs for priority land in the Rathbun Lake watershed. Similarly, the Alliance will also recognize other individuals and entities for supporting and carrying out activities to protect Rathbun Lake. Recognition activities will include awards, signage, articles in local and state print media, social media postings, and radio interviews; and

  - Complementary Activities: In addition to one-on-one assistance, targeted landowners have indicated that traditional outreach activities are most effective in reaching them including signage, direct mail, newspaper and magazine articles, radio interviews, and meetings and field days. Complementary activities will also consist of maintaining the Alliance's website and the use of social media platforms such as Facebook, Twitter, and YouTube to reach landowners who adopt these forms of communication.

- Outreach Specialist – Implementation of the plan's information and education strategy will include the continued contracting with an outreach specialist. The specialist will be primarily responsible for carrying out the recognition efforts and complementary activities as well as any additional activities such as presentations and displays at local and state events. Importantly, the performance of these activities by the outreach specialist allows field staff to dedicate their time and effort to one-on-one, on-farm assistance to targeted landowners.

- Evaluation – The effectiveness of outreach activities will be evaluated in terms of achieving the level of landowner application of BMPs required to make expected progress toward the plan's load reduction targets for phosphorus and sediment delivered to Rathbun Lake.

Implementation Schedule

The Rathbun Lake Watershed Management and Source Water Protection Plan will be implemented over a 25-year timeframe in five consecutive five-year periods. The plan's implementation schedule for each five-year period is presented in Table 10. Activities described in this plan are proposed to initiate in 2023, and will be an extension of those currently underway in the Protect Rathbun Lake Project. The schedule reflects the implementation strategy successfully employed during the original and interim watershed management plans which emphasizes the application of structural BMPs for priority land in the watershed. In order to coordinate with farming operations, the application of structural BMPs is primarily concentrated during the pre-planting (early spring) and post-harvest (late fall and early winter) periods each year. A summer construction financial incentive is proposed in this plan to lengthen the construction period for these BMPs in an effort to address the challenge that inclement weather can pose for practice application. Assistance to landowners and supporting activities are, for the most part, carried on throughout the year.

Table 10 Rathbun Lake Watershed Management and Source Water Protection Plan's Five-Year Implementation Period Schedule

Major Plan Activities	Y1 Q1	Y1 Q2	Y1 Q3	Y1 Q4	Y2 Q1	Y2 Q2	Y2 Q3	Y2 Q4	Y3 Q1	Y3 Q2	Y3 Q3	Y3 Q4	Y4 Q1	Y4 Q2	Y4 Q3	Y4 Q4	Y5 Q1	Y5 Q2	Y5 Q3	Y5 Q4
Assist landowners plan and apply BMPs	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Install terraces		X	X	X		X	X	X		X	X	X		X	X	X		X	X	X
Install sediment basins		X	X	X		X	X	X		X	X	X		X	X	X		X	X	X
Install grade stabilization structures		X	X	X		X	X	X		X	X	X		X	X	X		X	X	X
Install water/sediment control basins		X	X	X		X	X	X		X	X	X		X	X	X		X	X	X
Priority land conversion		X		X		X		X		X		X		X		X		X		X
Apply improved grazing practices		X	X	X		X	X	X		X	X	X		X	X	X		X	X	X
Engineering and GIS assistance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Conduct water quality monitoring		X	X	X		X	X	X		X	X	X		X	X	X		X	X	X
Perform information/education activities	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Alliance and partner meetings	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Submit work plans and reports	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Plan evaluation and revision					X				X				X				X			

Measurable Milestones and Outcomes

Implementation of the Rathbun Lake Watershed Management and Source Water Protection Plan during the plan's 25-year timeframe will be evaluated in terms of the number and type of BMPs applied as well as the completion of supporting activities. Specific implementation milestones for each of the five consecutive five-year periods of the plan are described below.

- Direct Technical Assistance – A team of professional field staff comprised of two Environmental Specialists and one Technician will be assigned to implement plan activities during each five-year period.

- Terraces - A total of 350,000 feet of terraces will be installed during each five-year period. An average of 70,000 feet of terraces will be installed annually.

- Sediment Basins – A total of five sediment basins will be installed during each five-year period. An average of one sediment basin will be installed annually.

- Grade Stabilization Structures – A total of 80 grade stabilization structures will be installed during each five-year period. An average of 16 structures will be installed annually.

- Water and Sediment Control Basins - A total of 180 water and sediment control basins will be installed during each five-year period. An average of 36 basins will be installed annually.

- Forage and Biomass Planting - A total of 2,200 acres of priority land will be converted from row crops to grassland during each five-year period. This conversion may include enrolling land in programs such as CRP. An average of 440 acres will be converted annually.

- Improved Grazing Practices - Improved grazing practices will be applied on a total of 600 acres of grassland converted from row crop production during each five-year period. Practices will be applied on an average of 120 acres annually.

- Expert Technical Assistance – Engineering assistance to design and construct large sediment basins and grade stabilization structures and GIS assistance to identify priority land and evaluate the effectiveness of BMPs will be performed as needed during each five-year period.

- Water Quality Monitoring - Annual water quality monitoring activities will be conducted as proposed in the plan during each five-year period. Monitoring results will continue to be used as input for Iowa's water quality assessments and impaired waters list determinations.

- Information and Education – Outreach activities will be conducted as proposed in the plan during each five-year period. Principal activities will include one-on-one assistance to targeted landowners and the recognition of landowners and others for their efforts and support. Landowner-preferred complementary activities will also be carried out including signage, direct mail, newspaper and magazine articles, radio interviews, and meetings and field days.

Load Reduction Evaluation

The WQIP annual load reduction target for the main basin of Rathbun Lake is 250,800 pounds of total phosphorus. The proposed application of BMPs during the 25-year timeframe of the Rathbun Lake Watershed Management and Source Water Protection Plan will achieve this target by reducing the annual loads of phosphorus and associated sediment by an estimated 254,400 pounds and 261,000 tons respectively. BMP application during each of the plan's five-year implementation periods will reduce the annual phosphorus load by an estimated 50,880 pounds and the annual sediment load by an estimated 52,200 tons. The WQIP-based GIS Mapping Tool will be used to evaluate the effectiveness of BMPs in reducing phosphorus and sediment loads to Rathbun Lake. Estimated load reductions for the BMPs that will be applied during each of the plan's five consecutive five-year periods are described below.

- Terraces – The installation of 350,000 feet of terraces for 3,500 acres will reduce the annual phosphorus and sediment loads to Rathbun Lake by an estimated 16,800 pounds and 16,800 tons respectively.

- Sediment Basins – The installation of five sediment basins for 500 acres will reduce the annual phosphorus and sediment loads to Rathbun Lake by an estimated 2,400 pounds and 2,400 tons respectively.

- Grade Stabilization Structures – The installation of 80 structures for 2,000 acres will reduce the annual phosphorus and sediment loads to Rathbun Lake by an estimated 9,600 pounds and 9,600 tons respectively.

- Water and Sediment Control Basins – The installation of 180 basins for 750 acres will reduce the annual phosphorus and sediment loads to Rathbun Lake by an estimated 3,600 pounds and 3,600 tons respectively.

- Forage and Biomass Planting – The conversion of 2,200 acres of priority land from row crops to grassland will reduce the annual phosphorus and sediment loads to Rathbun Lake by an estimated 18,480 pounds and 19,800 tons respectively.

The WQIP determined that achievement of the annual load reduction target of 250,800 pounds of total phosphorus with the associated annual reduction in sediment load are estimated to lower the Secchi depth TSI in Rathbun Lake's main basin to a level below impairment due to non-algal turbidity. Specifically, the WQIP load response curve for the lake's main basin estimates a decrease in Secchi depth TSI of approximately two units associated with reducing the annual load of total phosphorus to this segment of the lake by 250,800 pounds. The total phosphorus load reduction objective of 254,400 pounds per year in this plan is, by extension, estimated to lower the Secchi depth TSI for Rathbun Lake's main basin by slightly more than two units. Therefore, the total phosphorus load reduction objective of 50,880 pounds per year for each five-year implementation period of this plan is estimated to lower the Secchi depth TSI in the lake's main basin by approximately 0.4 units. At the same time, the WQIP indicates that achieving the annual load reduction target for total phosphorus is expected to lessen the threat of impairment which could result from an increase in the chlorophyll-a TSI and algal turbidity in Rathbun Lake's main basin. Changes in Secchi depth and chlorophyll-a TSI values as well as in total phosphorus TSI value will be tracked by the Iowa DNR and US ACOE to evaluate the progress of, and identify any modifications that should be made to, efforts to address water quality impairments in the lake as a result of implementing the Rathbun Lake Watershed Management and Source Water Protection Plan.

Alliance members and partners will meet annually in the early spring to conduct this evaluation of plan implementation. Detailed presentations and in-depth review of water quality monitoring data will be carried out during these meetings. Water quality monitoring activities are described on page 31 and in Appendix B. These annual presentations on and review of project progress will allow for an evaluation of trends in Secchi depth, chlorophyll-a, and phosphorus TSI values with technical experts in attendance. Specifically, these trends will be compared with expected decreases in TSI values, particularly in the Secchi depth TSI for Rathbun Lake's main basin, resulting from plan implementation. Additional information used during this evaluation will include the number and type of BMPs applied, estimated annual reductions in phosphorus and sediment loads achieved by BMPs, acres of priority land addressed with BMPs, and changes in the acres of priority land in the watershed. This review will inform any short-term (annual) and longer-term (five-year) modifications required to help ensure progress in addressing water quality impairments in Rathbun Lake resulting from plan implementation. If needed, potential modifications may include increases in financial and technical assistance, enhanced outreach activities, changes in the number and type of BMPs, alternative approaches to targeting priority land, and additional water quality monitoring to direct plan activities. In addition to Alliance members, partners that will participate in this annual evaluation of plan implementation include the Iowa DNR, IDALS, ISU, NRCS, US ACOE, and US EPA.

Water Quality Monitoring

The Rathbun Lake Watershed Management and Source Water Protection Plan includes continued annual water quality monitoring in Rathbun Lake and the lake's tributaries. These monitoring activities during the initial five-year implementation period from 2023 to 2027 will be conducted at four sites in Rathbun Lake (RA-3, RA-7, RA-8, and RA-25), four sites on main tributaries to the lake (RA-12, RA-15, RA-39, and RA-41), and one site at the lake's outlet (RA-28). The Rathbun Lake monitoring sites will provide data for the ongoing assessment of water quality in the four subdivided segments of the lake: Main Basin, Chariton Arm, South Fork Arm, and Honey Creek Arm. The sites on main tributaries to the lake were selected to assess water quality entering Rathbun Lake from four sub-watershed areas that, together with lake sites in the Chariton, South Fork, and Honey Creek Arms, provide monitoring coverage of the entire watershed. Map 7 in Appendix A identifies the locations of these water quality monitoring sites. The US ACOE will continue to conduct monitoring at the lake sites and outlet site. This monitoring is carried out monthly from April through September. The Iowa DNR, Iowa SHL, and Alliance will be responsible for monitoring at the main tributary sites. This monitoring is carried out every two weeks from April through October. The main features of annual water quality monitoring activities are identified in Appendix B. As indicated, the primary purpose of this approach to water quality monitoring is to provide data required to evaluate Rathbun Lake and water bodies in the lake's watershed as part of Iowa's water quality assessments and impaired waters list determinations.

Emergency Response Plan

RRWA updated the Association's risk and resilience assessment in 2020 and revised the utility's emergency preparedness and response plan in 2021. The assessment and plan were completed following guidance from the US EPA to comply with America's Water Infrastructure Act of 2018. RRWA has certified completion of the assessment and plan to the US EPA. The risk and resilience assessment evaluated potential threats to RRWA's major system components. This evaluation identified critical system components and the types of threats that present the greatest relative risk to these components in terms of substantially disrupting the utility's ability to treat and distribute drinking water. RRWA used results from the assessment to develop an emergency preparedness and response plan that includes mitigation and response actions for high-risk threats to the utility's critical system components. As part of the assessment, RRWA evaluated threats to Rathbun Lake as the source water for the utility's two water treatment plants. This evaluation considered the potential impact on the lake from possible threats including droughts, floods, hazardous material releases, intentional acts, and operational failures. As a result of assessment findings, RRWA included actions in the Association's emergency preparedness and response plan that will help mitigate and respond to identified threats that have the potential to affect Rathbun Lake as the utility's source water. RRWA's risk and resilience assessment and emergency preparedness and response plan can be made available for review on request.

Emergency Response Plan Affidavit

The Safe Drinking Water Act amendments of 1986 and 1996 established the concept of wellhead protection, and subsequently the Source Water Protection Program. The program is currently overseen by the Iowa Department of Natural Resources (DNR) and attempts to prevent potential contaminants from entering source waters and prepare for situations in which drinking water may be impaired through contamination, power outage, and treatment or distribution system interruptions. In order to ensure a public water supply's preparedness in such events, a Contingency/Emergency Plan has been required in every approved Source Water Protection Plan (SWPP) or Wellhead Protection Plan (WHPP). Due to recent and growing concerns over water system security and due to many systems having previously prepared such a plan under the provisions of the 2002 Bioterrorism Act, the DNR is now allowing an affidavit in lieu of including a completed Contingency/Emergency Plan within the submitted SWPP/WHPP. Although public water supplies do not need to send DNR completed plans, each must have an accessible and up-to-date plan in case a catastrophic event occurs within their system. It is necessary for the completed water supply Contingency/Emergency Plan to contain the following information, at a minimum:

- Contact information for the city's mayor, city clerk, and water/ operator.
- Contact information for the city's power company, a professional electrician, a professional plumber, and an equipment repair company.
- System's critical users must be identified and a plan for immediate notification must be created. (i.e., hospitals, nursing homes, schools, etc.).
- Contact information for local media, including newspaper, radio, and television.
- Contact information for a certified laboratory, local emergency contacts, state and local public health departments, and the National Guard.
- Contact information for the DNR's 24-hour emergency contact and the local DNR field office.

I, Martin Braster, representing Rathbun Regional Water Association, certify that a Contingency / Emergency Plan has been created for our public water supply system and that this information can be presented to the DNR upon request.

Martin Braster	3/17/23
Signature	Date

REFERENCES

ADBNet. Iowa Department of Natural Resources. https://programs.iowadnr.gov/adbnet .

Bureau of Economic Analysis. United States Department of Commerce. https://www.bea.gov/ .

Facility Explorer. Iowa Department of Natural Resources. https://facilityexplorer.iowadnr.gov/FacilityExplorer/ .

FYRA Engineering. "Technical Memorandum: Rathbun Priority Land Mapping and Water Quality Modeling." 2019.

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Iowa Geospatial Data. Iowa Department of Natural Resources. https://geodata.iowa.gov/ .

Natural Resources Conservation Service. United States Department of Agriculture. https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=IA .

State Data Center. State Library of Iowa. https://dev.iowadatacenter.org/index.php .

APPENDIX A – Plan Maps

The Rathbun Lake Watershed Management and Source Water Protection Plan is accompanied by the maps listed below.

- Map 1 – Rathbun Regional Water Association: Service Territory
- Map 2 - Rathbun Lake Watershed: General Features
- Map 3 - Rathbun Lake Watershed: 12-Digit Hydrologic Units
- Map 4 - Rathbun Lake Watershed: Sub-Watersheds
- Map 5 - Rathbun Lake Watershed: 2020 Land Use
- Map 6 - Rathbun Lake Watershed: 2022 Impaired Waters
- Map 7 - Rathbun Lake Watershed: Water Quality Monitoring Sites
- Map 8 - Rathbun Lake Watershed: Priority Land
- Map 9 - Rathbun Lake Watershed: Potential Point Sources

Map 1
Rathbun Regional Water Association Service Territory

Legend

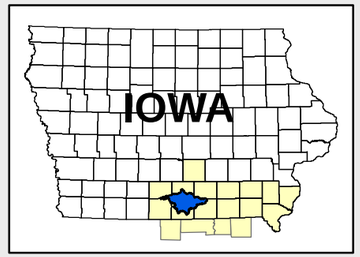
- RRWA Water Tower
- RRWA Distribution Booster
- RRWA Service Area Boundaries
- Iowa Primary Roads
- Missouri Primary Roads
- Rathbun Lake

Incorporated City/Town (Current RRWA Status)

- RRWA Bulk
- RRWA Franchise
- None

RRWA System Boundaries

- Rathbun System (Missouri is Bulk Service)
- Burlington System
- Ft. Madison System
- Mt. Pleasant System
- Keokuk System



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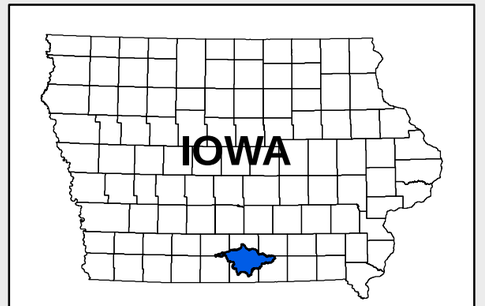
Protect Rathbun Lake Watershed Management and Source Water Protection Plan

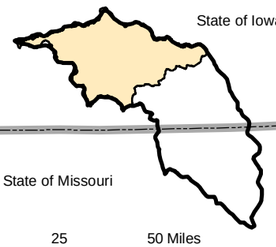
Source: Rathbun Regional Water Association
Iowa DNR NRGIS
ESRI Data and Maps
USDA Data

Map 2
Rathbun Lake Watershed
General Features



Chariton
Russell
Lucas County
Derby
Clarke County
Weldon
Monroe County
Le Roy
Decatur County
Humeston
Millerton
Appanoose County
Rathbun Lake
Wayne County
Corydon
Promise City
Allerton
Chariton River
Chariton Creek
Honey Creek
Wolf Creek
Lost Branch
Brush Creek
Goodwater Creek
Walker Branch
Catfish Branch
Jordan Creek
Nhemile Creek
S Fork Walker Branch
S Fork Chariton River
Wildcat Creek
Dick Creek
Cris Creek
W Jackson Creek
Jackson Creek
65

Upper Chariton River Watershed
HUC 10280201



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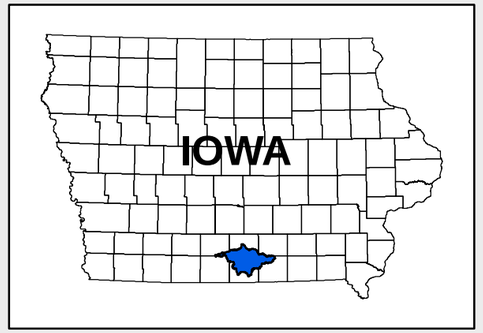
Legend

- RRWA Intake
- County Boundary
- Rathbun Lake Watershed Boundary
- Railroads (Local)
- Highway
- Major Road
- Perennial Stream
- Intermittent Stream

Source: Rathbun Regional Water Association
Iowa DNR NRGIS
ESRI Data and Maps
USDA Data

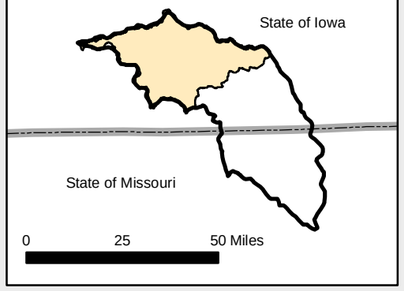
Protect Rathbun Lake
Watershed Management and
Source Water Protection Plan

Map 3
Rathbun Lake Watershed
12-Digit Hydrologic Units



Chariton
West Lake-Chariton River
102802010206
Russell
Honey Creek
Hamilton Creek-Chariton River
102802010203
Chariton River
Lucas County
Derby
Chariton Creek
102802010201
Chariton Creek
Clarke County
Weldon
65
Lost Branch-Chariton River
102802010207
Honey Creek-Chariton River
102802010208
Wolf Creek
Lost Branch
Wolf Creek
102802010205
Monroe County
Honey Creek
Brush Creek
Headwaters Wolf Creek
102802010204
Wolf Creek
Brush Creek-Chariton River
102802010202
Goodwater Creek
Le Roy
Lake Rathbun-Chariton River
102802010209
Decatur County
Humeston
Brush Creek
Appanoose County
Rathbun Lake
Millerton
Jordan Creek
Jordan Creek
102802010106
Walker Branch
Catfish Branch
Walker Branch
102802010107
Ninemile Creek
102802010101
Ninemile Creek
S Fork Walker Branch
S Fork Chariton River
Middle South Fork Chariton River
102802010105
Wayne County
Lower South Fork Chariton River
102802010108
Wildcat Creek
Carls Creek
Dick Creek
Upper South Fork Chariton River
102802010102
Corydon
Promise City
W Jackson Creek
W Jackson Creek
West Jackson Creek
102802010103
Jackson Creek
Allerton
Jackson Creek
102802010104

Upper Chariton River Watershed
HUC 10280201



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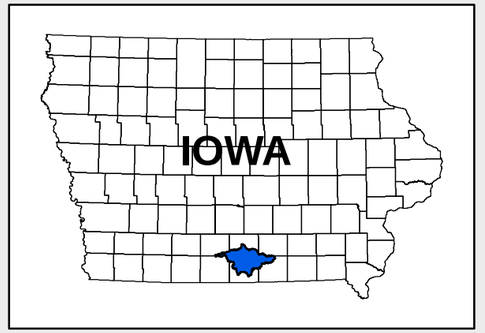
Protect Rathbun Lake Watershed Management and Source Water Protection Plan

Legend

- 12-Digit Hydrologic Units
- County Boundary
- Rathbun Lake Watershed Boundary
- Highway
- Major Road
- Railroads (Local)
- Perennial Stream
- Intermittent Stream

Source: Rathbun Regional Water Association
Iowa DNR NRGIS
ESRI Data and Maps
USDA Data

Map 4
Rathbun Lake Watershed
Rathbun Lake Sub-Watersheds



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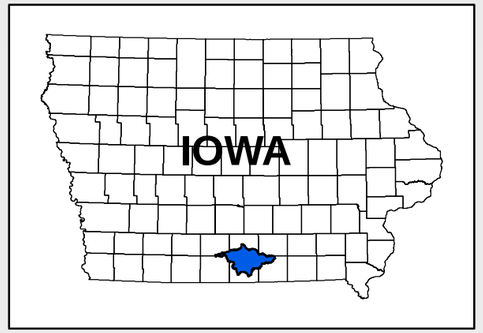
Protect Rathbun Lake Watershed Management and Source Water Protection Plan

Legend

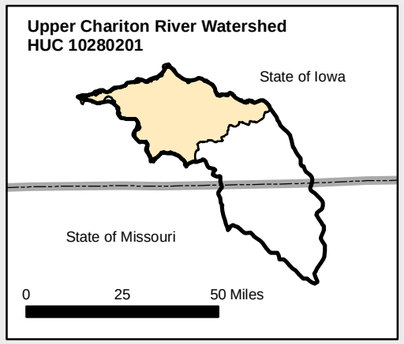
- Rathbun Lake Sub-Watersheds
- County Boundary
- Rathbun Lake Watershed Boundary
- Railroads (Local)
- Highway
- Major Road
- Perennial Stream
- Intermittent Stream

Source: Rathbun Regional Water Association
Iowa DNR NRGIS
ESRI Data and Maps
USDA Data

Map 5
Rathbun Lake Watershed
2020 Land Use



Chariton
Russell
Lucas County
Derby
Clarke County
Weldon
Monroe County
Le Roy
Decatur County
Humeston
Millerton
Appanoose County
Rathbun Lake
Wayne County
Corydon
Promise City
Allerton
65
Chariton River
Chariton Creek
Honey Creek
Wolf Creek
Lost Branch
Brush Creek
Goodwater Creek
Jordan Creek
Walker Branch
Catfish Branch
Ninemile Creek
S Fork Walker Branch
S Fork Chariton River
Wildcat Creek
Dick Creek
Cars Creek
W Jackson Creek
Jackson Creek



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Protect Rathbun Lake Watershed Management and Source Water Protection Plan

Legend

- County Boundary
- Rathbun Lake Watershed Boundary
- Highway
- Major Road
- Railroads (Local)
- Perennial Stream
- Intermittent Stream

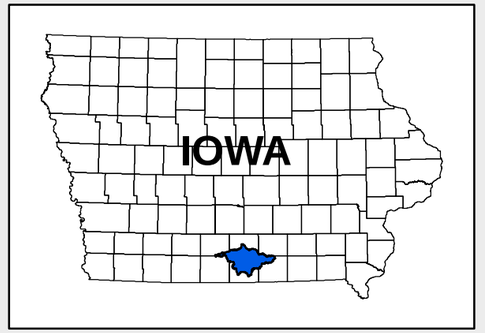
Land Use

- Cropland--Corn and Soybeans (148,652 acres)
- Cropland-- Extended Rotation (17,612 acres)
- Grassland (110,560 acres)*
- Woodland (56,335 acres)
- Urban and Developed Areas (4,647 acres)
- Water (16,229 acres)

*Includes 31,560 acres in CRP

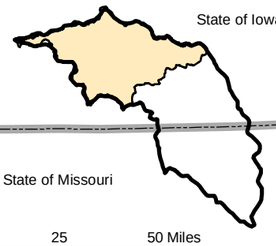
Source: Rathbun Regional Water Association
Iowa DNR NRGIS
ESRI Data and Maps
USDA Data

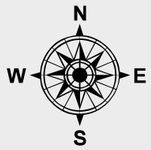
Map 6
Rathbun Lake Watershed
2022 Impaired Waters



Chariton
Russell
Lucas County
Derby
Clarke County
Weldon
Le Roy
Decatur County
Humeston
Millerton
Wayne County
Monroe County
Appanoose County
Promise City
Corydon
Allerton
Chariton River
Chariton Creek
Honey Creek
Wolf Creek
Lost Branch
Brush Creek
Goodwater Creek
Walker Branch
Jordan Creek
Catfish Branch
Whemile Creek
S Fork Walker Branch
S Fork Chariton River
Wildcat Creek
Dick Creek
Cars Creek
W Jackson Creek
Jackson Creek
65
Rathbun Lake Chariton Arm
Rathbun Lake Honey Creek Arm
Rathbun Lake Main Basin
Rathbun Lake South Fork Chariton Arm
Corydon Reservoir
Bob White Lake

Upper Chariton River Watershed
HUC 10280201





0 2.5 5 10 Miles

Legend

- Impaired Lakes Iowa 2022
- Impaired Streams Iowa 2022
- County Boundary
- Rathbun Lake Watershed Boundary
- Highway
- Major Road
- Railroads (Local)
- Perennial Stream
- Intermittent Stream

Source: Rathbun Regional Water Association
Iowa DNR NRGIS
ESRI Data and Maps
USDA Data

Protect Rathbun Lake Watershed Management and Source Water Protection Plan

Table 11 Rathbun Lake Watershed: 2022 Impaired Waters on Map 6 [3]

Waterbody	ID	Size	Impaired Use [a]	Impairment
Rathbun Reservoir – Main Basin	1309	6,330 acres	A1	Turbidity
Rathbun Reservoir – Chariton Arm	2028	1,860 acres	A1 BWW1	Turbidity Turbidity
Rathbun Reservoir – South Fork Arm	2027	1,660 acres	A1 BWW1	Turbidity Turbidity
Rathbun Reservoir – Honey Creek Arm	2030	700 acres	A1	Turbidity
Bob White Lake	1338	89 acres	A1	Turbidity
Corydon Reservoir	1331	50 acres	C	Pesticides: Atrazine
Chariton River	1310	18.9 miles	A1 BWW2	Bacteria: Indicator Bacteria - E. coli Biological: Low Fish IBI
Chariton River	1311	28.9 miles	A1 BWW2	Bacteria: Indicator Bacteria - E. coli Biological: Low Fish and Invert IBIs
Chariton River	1312	13.3 miles	A1	Bacteria: Indicator Bacteria - E. coli
Chariton Creek	1313	19.0 miles	A1	Bacteria: Indicator Bacteria - E.coli

[a] Impaired Use: A1 – Recreation: Primary Contact; A2 – Recreation: Secondary Contact; BWW1 – Aquatic Life: Warm Water Type 1; BWW2 – Aquatic Life: Warm Water Type 2; C – Drinking Water

[3] Water quality assessment and impaired waters list information is based on data from the following source: ADBNet, Iowa Department of Natural Resources, https://programs.iowadnr.gov/adbnet .

Table 11 Rathbun Lake Watershed: 2022 Impaired Waters on Map 6 cont. [3]

Waterbody	ID	Size	Impaired Use [a]	Impairment
Dick Creek	1336	1.7 miles	BWW2	Biological: Low Fish and Invert IBIs
Fivemile Creek	1341	4.8 miles	A1	Bacteria: Indicator Bacteria - E. coli
Honey Creek	2019	5.3 miles	A1	Bacteria: Indicator Bacteria - E. coli
Honey Creek	1337	4.6 miles	A2	Bacteria: Indicator Bacteria - E. coli
Jackson Creek	1332	12.0 miles	A1 BWW2	Bacteria: Indicator Bacteria - E. coli Biological: Low Fish and Invert IBIs
Jordan Creek	1330	4.4 miles	A1 BWW2	Bacteria: Indicator Bacteria - E. coli Biological: Low Fish and Invert IBIs
Ninemile Creek	1335	2.6 miles	A1 BWW2	Bacteria: Indicator Bacteria - E. coli Biological: Low Fish IBI
South Fork Chariton River	1327	18.3 miles	A1 BWW2	Bacteria: Indicator Bacteria - E. coli Biological: Low Fish IBI
South Fork Chariton River	1328	10.9 miles	A1 BWW2	Bacteria: Indicator Bacteria - E. coli Biological: Low Fish and Invert IBIs

[a] Impaired Use: A1 – Recreation: Primary Contact; A2 – Recreation: Secondary Contact; BWW1 – Aquatic Life: Warm Water Type 1; BWW2 – Aquatic Life: Warm Water Type 2; C – Drinking Water

[3] Water quality assessment and impaired waters list information is based on data from the following source: ADBNet, Iowa Department of Natural Resources, https://programs.iowadnr.gov/adbnet .

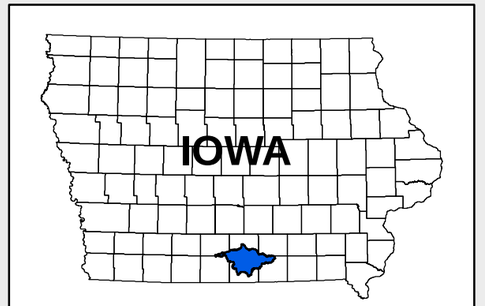
Table 11 Rathbun Lake Watershed: 2022 Impaired Waters on Map 6 cont. [3]

Waterbody	ID	Size	Impaired Use [a]	Impairment
Walker Branch	1329	2.1 miles	A1	Bacteria: Indicator Bacteria - E. coli
West Jackson Creek	1333	9.7 miles	BWW2	Biological: Low Invert IBI
Wolf Creek	1339	16.9 miles	A1 BWW2	Bacteria: Indicator Bacteria - E. coli Biological: Low Fish and Invert IBIs

[a] Impaired Use: A1 – Recreation: Primary Contact; A2 – Recreation: Secondary Contact; BWW1 – Aquatic Life: Warm Water Type 1; BWW2 – Aquatic Life: Warm Water Type 2; C – Drinking Water

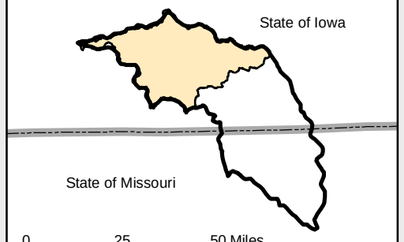
[3] Water quality assessment and impaired waters list information is based on data from the following source: ADBNet, Iowa Department of Natural Resources, https://programs.iowadnr.gov/adbnet .

Map 7
Rathbun Lake Watershed
Water Quality Monitoring Sites



Chariton
RA-15
Russell
Honey Creek
Lucas County
RA-41
RA-40
Wolf Creek
Lost Branch
Chariton River
Monroe County
Honey Creek
RA-43
Chariton Creek
Clarke County
RA-33
RA-32
Derby
Brush Creek
65
RA-42
RA-44
Weldon
Wolf Creek
Goodwater Creek
RA-7
Le Roy
Decatur County
Humeston
Brush Creek
Walker Branch
RA-25
RA-34
Rathbun Lake
RA-3
Millerton
Jordan Creek
Appanoose County
RA-8
Wayne County
S Fork Walker Branch
RA-38
RA-28
Nineveh Creek
S Fork Chariton River
RA-36
RA-37
RA-12
Sandy Branch
Wildcat Creek
Dick Creek
RA-35
Cedar Creek
Corydon
RA-39
Promise City
W Jackson Creek
Jackson Creek
Allerton

Upper Chariton River Watershed
HUC 10280201



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Legend

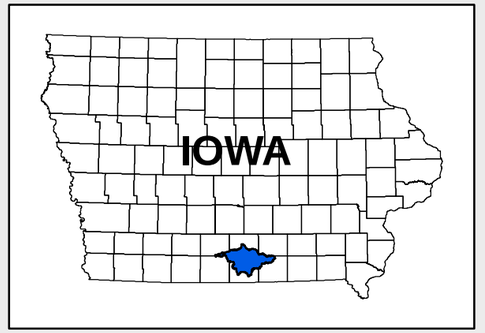
- Watershed Monitoring Sites
- Lake Monitoring Sites
- County Boundary
- Rathbun Lake Watershed Boundary
- Highway
- Major Road
- Railroads (Local)
- Perennial Stream
- Intermittent Stream

Source: Rathbun Regional Water Association
Iowa DNR NRGIS
ESRI Data and Maps
USDA Data

Rathbun Land & Water Alliance
www.riwa.org

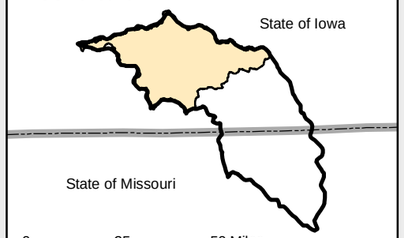
Protect Rathbun Lake Watershed Management and Source Water Protection Plan

Map 8
Rathbun Lake Watershed
Priority Land



Chariton
Russell
Lucas County
Derby
Clarke County
Weldon
Monroe County
Le Roy
Decatur County
Humeston
Millerton
Appanoose County
Rathbun Lake
Wayne County
Corydon
Promise City
Allerton
65
Chariton River
Honey Creek
Wolf Creek
Lost Branch
Goodwater Creek
Brush Creek
Walker Branch
Cattle Entrance
Jordan Creek
Ninemile Creek
S Fork Chariton River
S Fork Walker Branch
Wildcat Creek
Dick Creek
Carls Creek
W Jackson Creek
Jackson Creek

Upper Chariton River Watershed
HUC 10280201



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W
E
S

0 2.5 5 10 Miles

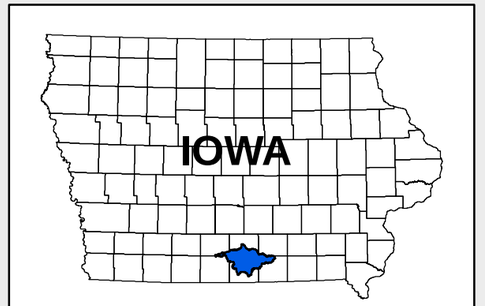
Legend

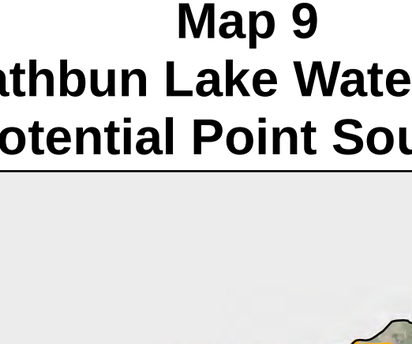
- County Boundary
- Rathbun Lake Watershed Boundary
- Highway
- Major Road
- Railroads (Local)
- Perennial Stream
- Intermittent Stream
- Priority Land (59,115 acres)
- Non-Priority Land (294,885 acres)

Source: Rathbun Regional Water Association
Iowa DNR NRGIS
ESRI Data and Maps
USDA Data

Protect Rathbun Lake Watershed Management and Source Water Protection Plan

Map 9
Rathbun Lake Watershed
Potential Point Sources





Clarke County
Lucas County
Monroe County
Decatur County
Wayne County
Appanoose County
Rathbun Lake
Weldon
Le Roy
Humeston
Millerton
Derby
Chariton
Russell
Corydon
Promise City
Allerton
Chariton River
Chariton Creek
Brush Creek
Wolf Creek
Lost Branch
Honey Creek
Goodwater Creek
Jordan Creek
Walker Branch
Cattail Branch
Nimamis Creek
S Fork Chariton River
S Fork Walker Branch
Wildcat Creek
Dick Creek
W Jackson Creek
Jackson Creek
Critz Creek

0 2.5 5 10 Miles

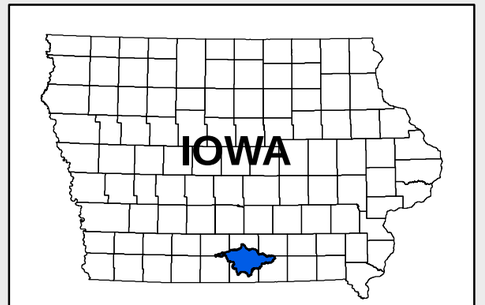
Protect Rathbun Lake Watershed Management and Source Water Protection Plan

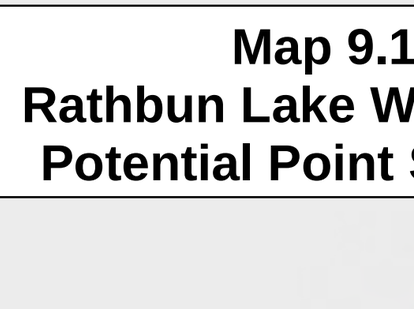
Legend

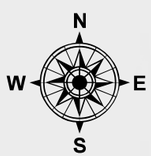
- Animal Feeding Operations (22)
- Chemical Storage Facilities (38)
- Underground Storage Tanks (46)
- Wastewater Systems (11)
- County Boundary
- Rathbun Lake Watershed Boundary
- Highway
- Major Road
- Railroads (Local)
- Perennial Stream
- Intermittent Stream

Source: Rathbun Regional Water Association
Iowa DNR NRGIS
ESRI Data and Maps
USDA Data

Map 9.1
Rathbun Lake Watershed
Potential Point Sources







0 0.5 1 Miles

40 39 36 72 81 38 34 35 33 32 68 70 78 31 84 71 67 73 77 83

S23 23 Chariton Muni Chariton Court Main Russell 14

Legend

- Animal Feeding Operations (22)
- Chemical Storage Facilities (38)
- Underground Storage Tanks (46)
- Wastewater Systems (11)
- County Boundary
- Rathbun Lake Watershed Boundary
- Highway
- Major Road
- Railroads (Local)
- Perennial Stream
- Intermittent Stream

Source: Rathbun Regional Water Association
Iowa DNR NRGIS
ESRI Data and Maps
USDA Data

Protect Rathbun Lake Watershed Management and Source Water Protection Plan

Map 9.2
Rathbun Lake Watershed
Potential Point Sources

Wildcat Creek

IOWA

Upper Chariton River Watershed
HUC 10280201

State of Iowa

State of Missouri

0 25 50 Miles

58 48 49 105 90 44 102 43 103 88 99 95 46 47 116 Jefferson Corydon 92 93 94 91 106 114

Washington

14 2 40

W Jackson Creek

N W E S

0 0.5 1 Miles

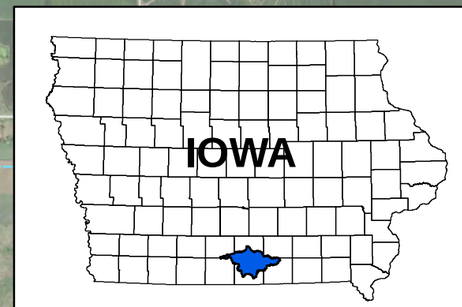
Protect Rathbun Lake Watershed Management and Source Water Protection Plan

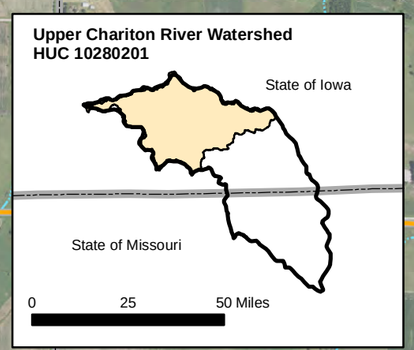
Legend

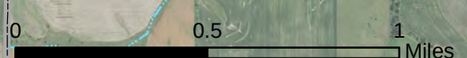
- Animal Feeding Operations (22)
- Chemical Storage Facilities (38)
- Underground Storage Tanks (46)
- Wastewater Systems (11)
- County Boundary
- Rathbun Lake Watershed Boundary
- Highway
- Major Road
- Railroads (Local)
- Perennial Stream
- Intermittent Stream

Source: Rathbun Regional Water Association
Iowa DNR NRGIS
ESRI Data and Maps
USDA Data

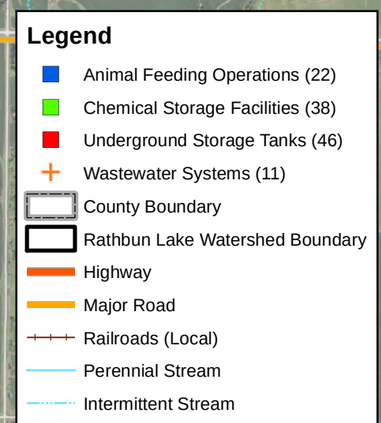
Map 9.3
Rathbun Lake Watershed
Potential Point Sources







Protect Rathbun Lake Watershed Management and Source Water Protection Plan



Source: Rathbun Regional Water Association
Iowa DNR NRGIS
ESRI Data and Maps
USDA Data

115
59
104
53
56
41
42
54
52
Humeston
100
89
98
87
57
60
97
101
22
J22
Guy Porter
Front
65

Table 12 Rathbun Lake Watershed: Potential Point Sources on Map 9 [5]

Map ID	Type	Name	County
1	Animal Feeding Operation	Iowa Quality Farms	Clarke
2	Animal Feeding Operation	Davis #1	Lucas
3	Animal Feeding Operation	Derby Sow Farm S034	Lucas
4	Animal Feeding Operation	Elmore	Lucas
5	Animal Feeding Operation	Hunter Brothers, Inc.	Lucas
6	Animal Feeding Operation	ISU McNay Research and Demonstration Farm	Lucas
7	Animal Feeding Operation	John Curran Feedlot	Lucas
8	Animal Feeding Operation	Last Chance Sow Farm	Lucas
9	Animal Feeding Operation	Lucas Gilt Development Unit	Lucas
10	Animal Feeding Operation	MMA Fat Pig	Lucas
11	Animal Feeding Operation	Murrays	Lucas
12	Animal Feeding Operation	Patrick Evans	Lucas
13	Animal Feeding Operation	Travis Swartz	Lucas
14	Animal Feeding Operation	Wayne Finisher Farm	Lucas
15	Animal Feeding Operation	Crown A Pork Finisher	Wayne
16	Animal Feeding Operation	Double A Pork	Wayne
17	Animal Feeding Operation	Ewing Family Farms, LLC	Wayne
18	Animal Feeding Operation	Mark Brown	Wayne
19	Animal Feeding Operation	Paul Alexander	Wayne
20	Animal Feeding Operation	Richard D. Morr Feedlot	Wayne
21	Animal Feeding Operation	Rodney Evitt	Wayne
22	Animal Feeding Operation	Tom Watkins	Wayne
23	Chemical Storage Facility	Delaware North at Honey Creek Resort	Appanoose
24	Chemical Storage Facility	L & W Quarries, Shop	Appanoose
25	Chemical Storage Facility	L & W Quarries, Shop	Appanoose
26	Chemical Storage Facility	L & W Quarries, Walnut City # 5	Appanoose
27	Chemical Storage Facility	Rathbun Lake Marina	Appanoose
28	Chemical Storage Facility	Sport Wade Inc	Clarke

[5] Potential point source information for the watershed is based on data from the following sources:
Facility Explorer, Iowa Department of Natural Resources, https://facilityexplorer.iowadnr.gov/FacilityExplorer/ .
Iowa Geospatial Data, Iowa Department of Natural Resources, https://geodata.iowa.gov/ .

Table 12 Rathbun Lake Watershed: Potential Point Sources on Map 9 cont. [5]

Map ID	Type	Name	County
29	Chemical Storage Facility	Sport Wade Inc	Clarke
30	Chemical Storage Facility	Agriland FS, Inc - Weldon	Decatur
31	Chemical Storage Facility	Corydon Oil Co dba Southern Iowa Oil	Lucas
32	Chemical Storage Facility	Hy-Vee Distribution Center	Lucas
33	Chemical Storage Facility	Hy-Vee Distribution Center	Lucas
34	Chemical Storage Facility	Hy-Vee Distribution Center	Lucas
35	Chemical Storage Facility	Hy-Vee Grocery Distribution Center	Lucas
36	Chemical Storage Facility	Hy-Vee Perishable Distribution Center	Lucas
37	Chemical Storage Facility	Russell 901 Auction	Lucas
38	Chemical Storage Facility	South Central Coop	Lucas
39	Chemical Storage Facility	South Central Coop	Lucas
40	Chemical Storage Facility	United Farmers' Cooperative - Chariton	Lucas
41	Chemical Storage Facility	Agriland FS, Inc - Humeston	Wayne
42	Chemical Storage Facility	Agriland FS, Inc - Humeston	Wayne
43	Chemical Storage Facility	Corydon Oil Co dba Southern IA Oil	Wayne
44	Chemical Storage Facility	Corydon Oil Co dba Southern IA Oil	Wayne
45	Chemical Storage Facility	DairiConcepts, LP	Wayne
46	Chemical Storage Facility	East Penn Manufacturing	Wayne
47	Chemical Storage Facility	East Penn Manufacturing	Wayne
48	Chemical Storage Facility	Ferrellgas	Wayne
49	Chemical Storage Facility	Ferrellgas	Wayne
50	Chemical Storage Facility	MFA Agri Service - Corydon	Wayne
51	Chemical Storage Facility	MFA Agri Service - Corydon	Wayne
52	Chemical Storage Facility	MFA Oil Company #10013	Wayne
53	Chemical Storage Facility	MFA Oil Company #10013	Wayne
54	Chemical Storage Facility	MFA Oil Company #10013	Wayne
55	Chemical Storage Facility	MFA Oil Company #10013	Wayne
56	Chemical Storage Facility	MFA Oil Company #10013	Wayne

[5] Potential point source information for the watershed is based on data from the following sources:
Facility Explorer, Iowa Department of Natural Resources, https://facilityexplorer.iowadnr.gov/FacilityExplorer/ .
Iowa Geospatial Data, Iowa Department of Natural Resources, https://geodata.iowa.gov/ .

Table 12 Rathbun Lake Watershed: Potential Point Sources on Map 9 cont. [5]

Map ID	Type	Name	County
57	Chemical Storage Facility	South Central Coop	Wayne
58	Chemical Storage Facility	US Cellular - Corydon	Wayne
59	Chemical Storage Facility	US Cellular - Humeston	Wayne
60	Chemical Storage Facility	United Farmers' Cooperative - Humeston	Wayne
61	Underground Storage Tank	AT&T Communications	Appanoose
62	Underground Storage Tank	Bridgeview Bait & Tackle	Appanoose
63	Underground Storage Tank	Lake Rathbun Boat & Storage	Appanoose
64	Underground Storage Tank	Southfork Marina	Appanoose
65	Underground Storage Tank	The Litehouse Corporation	Appanoose
66	Underground Storage Tank	Sport Wade, Inc	Clarke
67	Underground Storage Tank	Casey's General Store 22	Lucas
68	Underground Storage Tank	Central Sales Co, Inc.	Lucas
69	Underground Storage Tank	Chariton Maintenance Garage	Lucas
70	Underground Storage Tank	Chariton Municipal Airport	Lucas
71	Underground Storage Tank	Coastal Mart #1002	Lucas
72	Underground Storage Tank	Lucas County Shop	Lucas
73	Underground Storage Tank	Iowa Southern Utilities Company	Lucas
74	Underground Storage Tank	Derby Farm	Lucas
75	Underground Storage Tank	Derby Supply Corp	Lucas
76	Underground Storage Tank	Former Service Station	Lucas
77	Underground Storage Tank	Graves and Sons	Lucas
78	Underground Storage Tank	Iowa Department of Transportation	Lucas
79	Underground Storage Tank	Iowa State University	Lucas
80	Underground Storage Tank	Johnson Machine Works, Inc.	Lucas
81	Underground Storage Tank	Joint City/County Fuel	Lucas
82	Underground Storage Tank	Lucas County Engineer	Lucas
83	Underground Storage Tank	South Lift Station	Lucas
84	Underground Storage Tank	Trenary Sales, Inc.	Lucas

[5] Potential point source information for the watershed is based on data from the following sources:
Facility Explorer, Iowa Department of Natural Resources, https://facilityexplorer.iowadnr.gov/FacilityExplorer/ .
Iowa Geospatial Data, Iowa Department of Natural Resources, https://geodata.iowa.gov/ .

Table 12 Rathbun Lake Watershed: Potential Point Sources on Map 9 cont. [5]

Map ID	Type	Name	County
85	Underground Storage Tank	J&L Marine (formerly)	Monroe
86	Underground Storage Tank	Bob White State Park	Wayne
87	Underground Storage Tank	Casey's General Store 1125	Wayne
88	Underground Storage Tank	Casey's General Store 2315	Wayne
89	Underground Storage Tank	City Of Humeston	Wayne
90	Underground Storage Tank	Coates Property	Wayne
91	Underground Storage Tank	Corydon BP	Wayne
92	Underground Storage Tank	Corydon Conoco	Wayne
93	Underground Storage Tank	Corydon Oil Company	Wayne
94	Underground Storage Tank	D and K Standard	Wayne
95	Underground Storage Tank	Eldon & Shirley Spidle	Wayne
96	Underground Storage Tank	First Stop	Wayne
97	Underground Storage Tank	Mormon Trail Community School	Wayne
98	Underground Storage Tank	Richard Oil Company	Wayne
99	Underground Storage Tank	Rod's Auto, Inc.	Wayne
100	Underground Storage Tank	Street Town & Country, Inc	Wayne
101	Underground Storage Tank	Street Town & Country, Inc	Wayne
102	Underground Storage Tank	Unknown	Wayne
103	Underground Storage Tank	Unknown	Wayne
104	Underground Storage Tank	Vandell Automotive	Wayne
105	Underground Storage Tank	Wayne County Engineer	Wayne
106	Underground Storage Tank	Wayne County Hospital	Wayne
107	Wastewater System	Honey Creek State Park	Appanoose
108	Wastewater System	Parkside Knolls Homeowners' Association	Appanoose
109	Wastewater System	Southfork Marina	Appanoose
110	Wastewater System	City of Derby	Lucas
111	Wastewater System	City of Russell	Lucas
112	Wastewater System	Iowa DOT Maintenance Garage - Chariton	Lucas

[5] Potential point source information for the watershed is based on data from the following sources:
Facility Explorer, Iowa Department of Natural Resources, https://facilityexplorer.iowadnr.gov/FacilityExplorer/ .
Iowa Geospatial Data, Iowa Department of Natural Resources, https://geodata.iowa.gov/ .

Table 12 Rathbun Lake Watershed: Potential Point Sources on Map 9 [5]

Map ID	Type	Name	County
113	Wastewater System	City of Allerton	Wayne
114	Wastewater System	City of Corydon	Wayne
115	Wastewater System	City of Humeston	Wayne
116	Wastewater System	East Penn Manufacturing Company	Wayne
117	Wastewater System	Indian Ridge Homeowners' Association	Wayne

[5] Potential point source information for the watershed is based on data from the following sources:
Facility Explorer, Iowa Department of Natural Resources, https://facilityexplorer.iowadnr.gov/FacilityExplorer/ .
Iowa Geospatial Data, Iowa Department of Natural Resources, https://geodata.iowa.gov/ .

APPENDIX B – Water Quality Monitoring Activities

Rathbun Lake and Chariton River Outlet Monitoring

Locations: Sites RA-3, RA-7, RA-8, and RA-25 in Rathbun Lake and Site RA-28 at the lake's outlet in the Chariton River; Please refer to Map 7 in Appendix A

12-Digit HUC Coverage: RA-7 (102802010208 and 102802010207); RA-8 (102802010108 and 102802010107); RA-3 and RA-25 (102802010209)

Frequency: Monthly from April – September

Parameters: Annual ambient monitoring: total nitrogen, total phosphorus, chlorophyll-a, total suspended solids, turbidity, Secchi depth, temperature, dissolved oxygen, pH, salinity, and conductivity; Triennial intensive monitoring: total nitrogen, total phosphorus, chlorophyll-a, phytoplankton, total suspended solids, turbidity, Secchi depth, temperature, dissolved oxygen, pH, salinity, conductivity, herbicides (atrazine, alachlor, metolachlor, cyanazine, metribuzin, simazine), metals (arsenic, copper, iron, lead, manganese, mercury, cadmium, chromium, nickel, zinc), organic carbon, chloride, sulfate, and alkalinity

Partner: US Army Corps of Engineers conducts monitoring in Rathbun Lake and at the lake's Chariton River outlet

Rathbun Lake Watershed Tributary Monitoring

Locations: Sites RA-12, RA-15, RA-39, and RA-41 on main tributaries to Rathbun Lake; Please refer to Map 7 in Appendix A

12-Digit HUC Coverage: RA-12 (102802010106, 102802010105, 102802010102, and 102802010101); RA-15 (102802010206, 102802010203, 102802010202, and 102802010201); RA-39 (102802010104 and 102802010103); and RA-41 (102802010205 and 102802010204)

Frequency: Every two weeks from April - October

Parameters: Total phosphorus, orthophosphate, total suspended solids, total dissolved solids, ammonia, total kjeldahl nitrogen, and nitrate + nitrite nitrogen

Partners: Iowa Department of Natural Resources, Iowa's State Hygienic Lab, and Rathbun Land and Water Alliance conduct monitoring in the Rathbun Lake watershed tributaries

APPENDIX C – WQIP-Based GIS Mapping Tool

Development and use of the WQIP-based GIS mapping tool are described in the accompanying Technical Memorandum: Rathbun Priority Land Mapping and Water Quality Modeling.

Technical Memorandum

To: Rathbun Land & Water Alliance
c/o Marty Braster
From: FYRA Engineering
Re: Priority Land Map and Model/Tool Development Methodology
Date: 9 December 2019

1 INTRODUCTION

FYRA Engineering is providing four deliverables to the Rathbun Land & Water Alliance (RLWA):

- A comprehensive coverage of the entire watershed to Rathbun Lake, including Priority Land, non-priority land, and attributes that define each,
- A Microsoft Excel spreadsheet that includes the same information as the shapefile coverage,
- A second Microsoft Excel spreadsheet that includes data manipulations (equations and Pivot Tables) necessary to develop the Priority Land shapefile and spreadsheet, and
- this Technical Memorandum, which documents the methodology used to develop the Priority Land coverage and a step-by-step process for updating Priority Lands as land use changes and/or conservation practices are implemented.

The purposes of these deliverables are to (i) provide RLWA with a tool to connect future watershed management efforts in the Rathbun Lake Watershed to the Total Maximum Daily Load (TMDL) developed by the Iowa Department of Natural Resources (DNR) and approved by the U.S. Environmental Protection Agency (EPA), and (ii) track incremental and cumulative progress towards watershed and water quality goals, as measured by estimates of annual sediment and phosphorus yields.

The basis of the mapping tool and spreadsheet model is the Soil & Water Assessment Tool (SWAT) model output utilized in the TMDL. This model is comprised of thousands of unique combinations of land uses, soil types, and slopes, which are overlaid and then summarizes as hydrologic response units (HRUs) (Figure 1). Due to limitations of the SWAT model and computer computational time, HRUs require a filtering process that limits the number of distinct HRUs within a model. As a result, some spatial resolution was lost. Additionally, updating and re-running the original TMDL SWAT model is tedious, requires specialized expertise (familiarity with the model), and is further complicated by an ever-changing SWAT model code that frequently renders older versions obsolete. For these reasons, the deliverables provided to RLWA (the updated Priority Land shapefile and accompanying spreadsheets) were developed using:

- detailed attribute data that connects each polygon to the TMDL SWAT model HRU from which it is drawn,
- mean sediment yield based on the TMDL SWAT model, and
- mean phosphorus yield based on the TMDL SWAT model.

This tool and the corresponding information will be used and updated annually by RLWA staff and partners to quantify land use changes and sediment and phosphorus annual loading rates. This tool predicts annual sediment and phosphorus yields that leave the priority lands and enter surface water. They do not account for any processing or lag effects that may occur along the tributary streams to the lake; however, it is reasonable to assume that any pollutant loads entering surface water will eventually impact Rathbun Lake. This is consistent with prior planning and implementation protocols by RLWA. Another simplifying step in tool development was the synthesis of 4,330 SWAT model HRUs and over 110,000 GIS polygons into a smaller number of defining features in the Priority Land tool (shapefile and spreadsheet). The methodology utilized to develop these features is described within this Technical Memorandum.

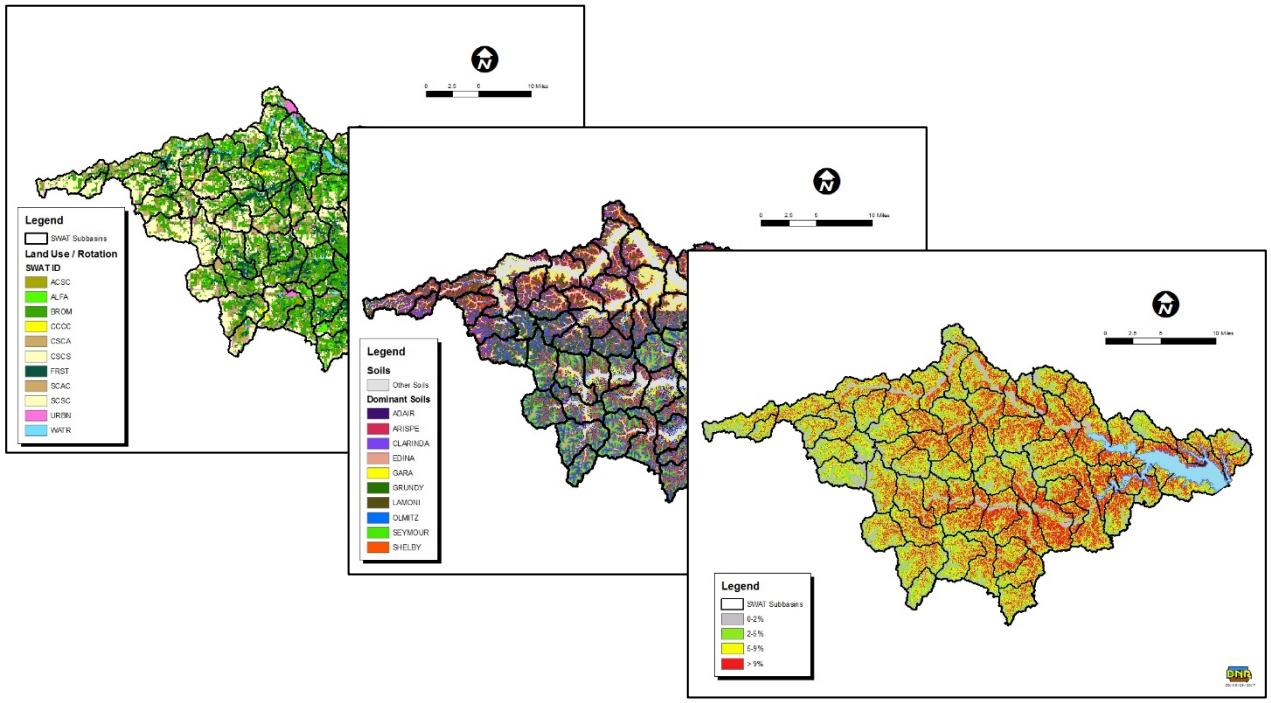


Figure 1 – Land Use, Soil Types, and Slope Classifications for HRU and Priority Land Mapping

2 METHODOLOGY

2.1 Priority Land and Non-Priority Land Mapping

Land Use

One of the first steps in the process was to develop a new polygon shapefile of unique combinations of land use, soil types, and slope classifications in the watershed (Figure 1). This was done using the same criteria/classifications as utilized in the TMDL. Table 1 reports the land use categories from the SWAT model and GIS coverage, a description, and the synthesis of land uses into like groups for the priority land hydrologic response units (PLHRUs).

Table 1 - Priority Land HRU Categories

SWAT Land Use	Description	PLHRU Land Use[1]
WATR	Water, wetland, quarry pit, etc.	WATR
FRST	Timber, shrub	FRST
BROM	Pasture, other grassland	BROM
ALFA	Hay, alfalfa	ALFA
SCSC	Soybean-corn rotation	CROP
CSCS	Corn-soybean rotation	CROP
CCCC	Continuous corn	CROP
CSCA	Corn, soybeans, and alfalfa/hay in extended rotation (may include alfalfa hay or small grains)	EROT
SCAC	Soybeans, corn, and alfalfa/hay in extended rotation (may include alfalfa hay or small grains)	EROT
ACSC	Alfalfa/hay, corn, and soybeans in extended rotation (may include alfalfa hay or small grains)	EROT
URBN	Developed (roads, towns, etc.)	URBN

[1]Priority Land Hydrologic Response Units in the new Priority Land Tool.

As shown in Table 1, all conventional row crop rotations were grouped into a CROP category, whereas extended rotations (those including small grains and/or hay) were grouped as EROT. All others were left the same as in the TMDL SWAT model and report. This was necessary to synthesize over 110,000 polygons into a manageable number of categories with relatively homogeneous annual loading rates for PLHRU modeling.

Soil Types

Soil types were aggregated in similar fashion as land uses. Sediment and phosphorus yields obtained from the TMDL SWAT model were evaluated for trends in yields across soil types, controlling for slope and land use. Several soil characteristics were assessed to determine which soil parameters were the key drivers of sediment and phosphorus. Based on that evaluation, soils were grouped according to the Universal Soil Loss Equation (USLE) K-factor, which is a quantitative indicator of soil erodibility. K-factors range from zero (for water features and other areas where erosion is not applicable) to 0.43 for the most erodible soils in the watershed. K factors of 0.32 and 0.37 are the most prevalent in terms of spatial area/extents. Table 2 reports the major soils types in the watershed along with some defining characteristics, as reported in Appendix D of the TMDL. The soils were grouped by the USLE K-Factor to develop the PLHRUs.

Table 2 – Prevalent Soil Types and Respective Characteristics

Soil Type	Watershed Area (%)	Texture	Drainage Class	USLE K-Factor[1]
Clarinda	12.8	Silty clay loam	Poorly drained	0.37
Seymour	11.6	Silt loam	Somewhat poorly drained	0.37
Shelby	11.4	Clay loam	Well drained	0.32
Grundy	10.2	Silt loam	Somewhat poorly drained	0.37
Arispe	7.7	Silty clay loam	Somewhat poorly drained	0.37
Olmitz	6.4	Loam	Moderately well drained	0.24
Gara	6.3	Loam	Well drained	0.28
Adair	6.1	Clay loam	Somewhat poorly drained	0.32
Edina	5.1	Silt loam	Very poorly drained	0.37
All others	Varies	Varies	Varies	Varies

[1]USLE K-factor = soil erodibility. For PLHRU modeling, soils were categorized by this parameter.

Slope

Slopes are grouped according to HRU and polygon average slopes, which are categorized into the classifications reported in Table 3. This approach is identical to the methodology described in Appendix D of the TMDL for the TMDL SWAT model.

Table 3 – Slope Classifications Used for Priority Land HRUs

Slope (%)	Description	Watershed Area (%)
0-2	Level and nearly level	19.3
2-5	Gently sloping	29.1
5-9	Moderately sloping	26.2
>9	Strongly sloping to very steep	25.4

2.2 New PLHRU Definition

Using the Land Use, Soil, and Slope categories developed to align the TMDL SWAT model HRUs with a high-resolution priority land GIS coverage, the new PLHRUs were defined. The PLHRUs and their respective annual sediment and phosphorus yields are distinct for each HUC-10 watershed (S. Fork-Chariton vs. Wolf Creek-Chariton) because the TMDL model was calibrated using USGS stream gaging and Iowa DNR water quality monitoring locations in each HUC-10. As a result, sediment and phosphorus yields from PLHRUs with the same attributes will be unique to each HUC-10 watershed.

Many of the distinct PLHRUs defined using this process align directly with TMDL model HRUs and their respective sediment and phosphorus yields. In these cases, the SWAT model HRUs and their and yields were evaluated, and an average annual sediment and phosphorus yield was assigned to each unique PLHRU. The process of translating the TMDL SWAT model output to the desired PLHRUs is illustrated in Figure 2. The PLHRU below is from the S. Fork watershed and includes all land in an extended rotation (EROT) with soils having a USLE K-factor of 0.37 and a slope between 2% and 5%. The statistics and histogram indicate that the modeled HRUs in this category have annual sediment loading rates that are normally distributed, with an average yield of 3.35 tons/ac/yr and a relatively small standard deviation (Std Dev) and coefficient of variation (CV). The average sediment and phosphorus yields will be used for this PLHRU in future watershed planning efforts (loading-rate based prioritization, targeted implementation of practices, and calculation of load reductions). The same process was followed for all other PLHRUs.

PLHRU - EROT/K37/2-5

Landuse	Soil	Slope
SCSA	EDINA	2-5%
SCAC	CLARINDA	
ACSC	SEYMORE	

	Sed (ton/ac/yr)	P (lb/ac/yr)
Average	3.35	5.24
Std Dev	0.66	0.80
CV	0.20	0.15
Median	3.40	5.33

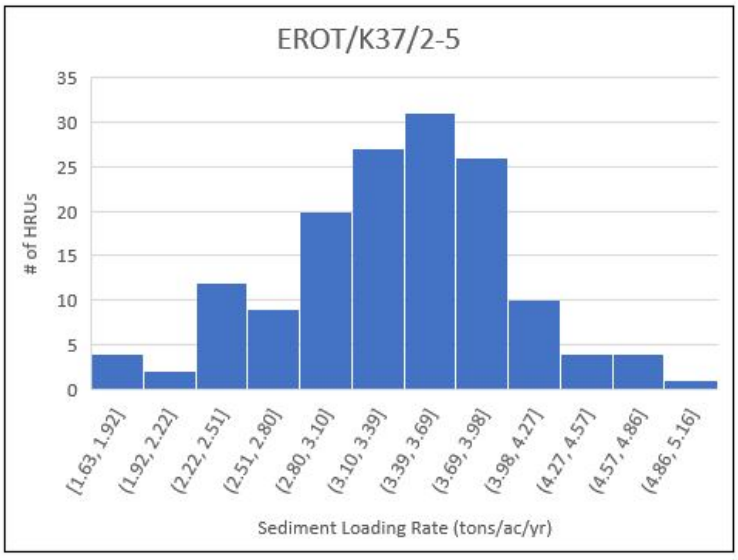


Figure 2 – Translation of SWAT Model HRUs to GIS-Based PLHRUs

2.3 Multiple Regression Analysis

The GIS polygon coverage has a higher spatial resolution than the TMDL SWAT model; therefore, some PLHRUs do not have a direct equivalent HRU from the SWAT model. To apply losses (yields) from the SWAT model to the GIS polygons in such cases, a multiple regression analysis was performed to fill in the missing sediment and phosphorus yields and provide complete coverage of yield estimates for all GIS polygons (PLHRUs). A multiple regression equation was developed for each pollutant yield (sediment and phosphorus) within the different land use categories (FRST, BROM, ALFA, CROP, EROT, and URBN). Sediment and phosphorus loss rates from water (WATR) land uses were assumed to be zero. The multiple regression equations use soil K values and slope as independent variables and sediment (or phosphorus) yield as the dependent variable. The regression approach results in a predictive equation used to estimate annual sediment and phosphorus yields for PLHRUs that have no direct equivalent HRU in the TMDL SWAT model. The basic form of this equation is provided below.

$$y = c_0 + c_1 x_1 + c_2 x_2$$

where y is the annual sediment or phosphorus yield, c_0, c_1, and c_2 are regression coefficients, x_1 is the soil K-factor (0, 24, 28, 32, 37, or 43), and x_2 is the low end of the slope classification (0, 2, 5, or 9).

The annual sediment and phosphorus yield for each unique PLHRU is provided as Appendix A to this Technical Memorandum and is included in the attribute table and spreadsheet deliverables, which contain the GIS polygons (PLRHRUs) in the watershed. The sediment yields are illustrated in Figure 3 and phosphorus yields are shown in Figure 4.

2.4 Priority Land Classification and Ranking

After the TMDL model sediment and phosphorus yields were applied to the GIS polygon coverage, PLHRUs in the coverage were sorted in order of annual sediment yield. The highest annual sediment yields comprising approximately 20% of the watershed area were classified as "Priority Land." These Priority Lands are targeted by the RLWA for implementation of watershed/water quality improvement (i.e., conservation) practices. The RLWA and its partners have been implementing practices for two decades, and their experience has shown that 20% of the watershed is a manageable and appropriately-sized focus area. This approach is also consistent with EPA watershed management guidance, which recognizes that it is targeting limited resources to high priority areas is more effective and economical than spreading efforts across an entire watershed. Although the Priority Land only includes 20% of the watershed, it is responsible for 73% of the sediment loss and 52% of the phosphorus loss from the PLHRUs.

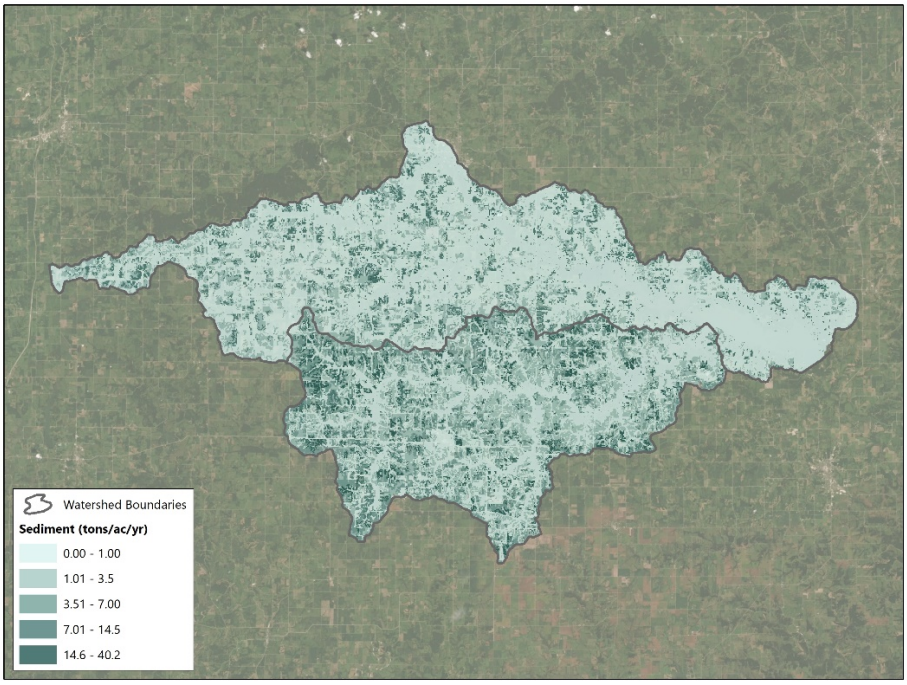


Figure 3 – Annual Sediment Yield Map of PLHRUs

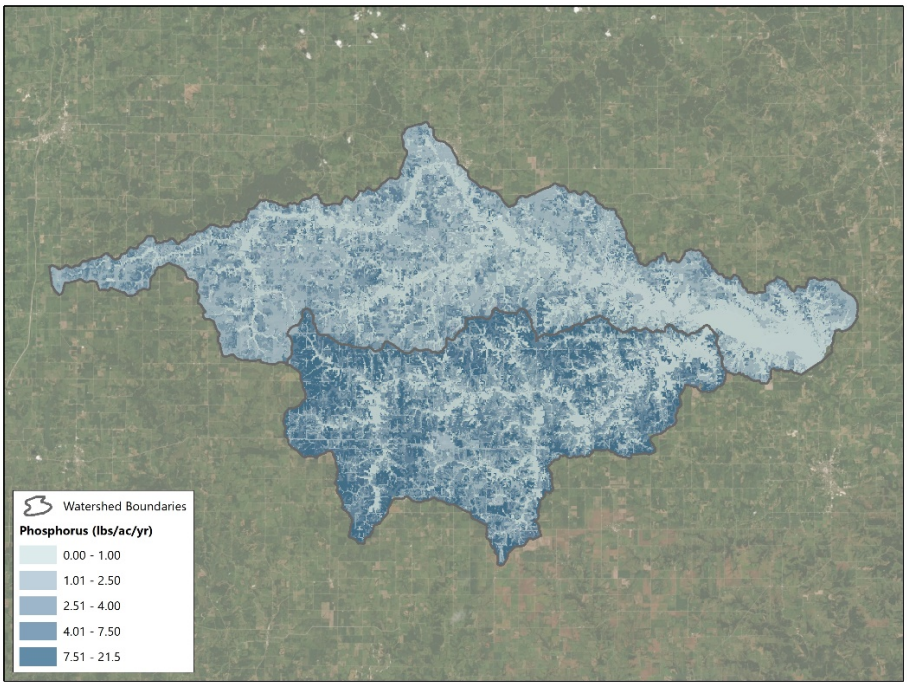


Figure 4 – Annual Phosphorus Yield Map of PLHRUs

The RLWA and its partners have been implementing conservation practices on Priority Land for nearly 2 decades. As a result, over 20,000 acres of Priority Land have already been treated with conservation practices. The drainage area to these practices was delineated to distinguish treated Priority Land from untreated Priority Land so that future efforts will focus on those areas not previously treated. Table 4 summarizes untreated Priority Land acres and the portion of annual sediment and phosphorus yield emanating from each category.

Table 4 – Summary of Untreated Priority Land Classification

Sediment Yield (tons/ac/yr)	Ranking	Area (acres)	% of Priority Land	% of Priority Land Sediment Load	% of Priority Land Phosphorus Load
>10	High Priority	9,572	21.8	46.1	36.0
5 - 9.9	Medium Priority	22,378	51.0	42.9	48.7
2.4 - 4.9	Low Priority	11,908	27.2	11.0	15.4

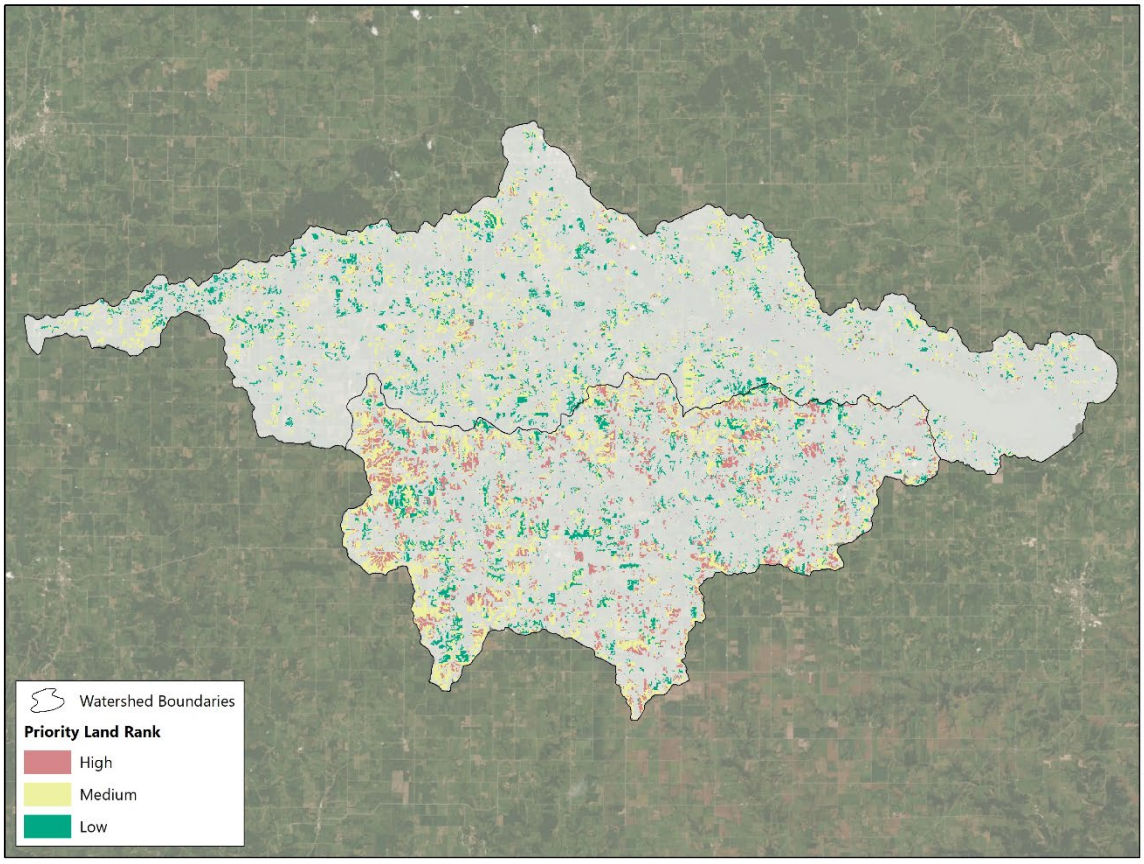


Figure 5 – Map of Priority Land and Ranking

2.5 Summary Statistics

Table 5 summarizes watershed and annual loading data, with focus towards the remaining (untreated) Priority Land. This demonstrates the importance of targeting implementation and supports RLWA's approach to Priority Land identification, classification, and conservation. The data in Table 5 are analogous to results in both Chapter 4 of the TMDL, and also Table E-9 of Appendix E. The total annual sediment and phosphorus loads differ from Table E-9 for two reasons:

- As Section 4.2 of the TMDL states: *"Although the numeric TMDLs were developed based on 2008-2013 conditions, the 12-year period (2002-2013) may provide better baseline information for long-term planning and implementation. All information provided in this Section of the WQIP is therefore based on 2002-2013 conditions."* Information used in this current effort, like Chapter 4 of the TMDL, utilized the longer period of record than the calibration period per Appendix E of the TMDL.
- Due to the higher spatial resolution of the PLHRUs created in this effort, results will differ slightly from SWAT model HRU output, but this variation is insignificant in the context of overall annual loads, watershed planning, and pollutant load tracking.

The information in Table 5 has profound significance for watershed management efforts. For example, note that Untreated, High Priority Land is classified on only 9,572 acres (2.7%) of the watershed area; however, it is responsible for 167,212 tons (21.8%) of sediment and 129,197 lbs (11.8%) of the overall annual phosphorus load. The watershed total area in Table 5 differs slightly from the TMDL watershed area because the SWAT model delineation, publicly available USGS shapefile, and other spatial data will have slightly different pixel resolutions, which can lead to negligible adjustments in the watershed boundary. These differences are inconsequential and small compared to the degree of uncertainty when determining any watershed boundary.

Table 5 – Summary of Watershed and Priority Land Data

Land Classification	Area (acres)	Sediment Load (tons/yr)	Phosphorus Load (lbs/yr)
Non-Priority	282,477	203,574	519,184
Priority	69,870	563,706	573,388
WATERSHED TOTALS	**352,347**	**767,280**	**1,092,572**
Untreated High Priority	9,572	167,212	129,197
Untreated Medium Priority	22,378	155,645	174,965
Untreated Low Priority	11,908	39,788	55,213
PRIORITY (UNTREATED) TOTALS	**43,858**	**362,645**	**359,376**

3 SUMMARY & NEXT STEPS

3.1 Summary of Deliverables

This Technical Memorandum, which documents the methodology used to develop the following:

- A GIS map/coverage of Priority Land
- Priority Land Rankings (High, Medium, and Low)
- Average annual sediment and phosphorus loss yields for each GIS polygon (PLHRU) in the Rathbun Lake Watershed (also see Appendix A)
- Definition of fields (column headings) in the Priority Land tool (Appendix B)
- Procedure for updating the Priority Land tool annually based on implementation of conservation practices and/or land use changes (Section 3.2 below)

Deliverables submitted to RLWA in conjunction with this Technical Memorandum include:

- ESRI shapefile of Priority Land
- Microsoft Excel spreadsheet that includes the data and calculations.

3.2 Updating Priority Land and Pollutant Loads

The RLWA plans to update the Priority Land tool annually based on implementation of conservation practices (BMPs) and potential land uses changes observed in the watershed. This update could be performed in a number of ways, including use of automated tools within the ESRI GIS platform. However, a simple approach is described below with the understanding that after several years of using this tool, an automated feature/process may be developed based on lessons learned and opportunities for increased efficiency.

Step 1 –Priority Land Field Assessment

Each year, Rathbun Watershed Coordinators will conduct field assessments to document land use changes and construction/adoption of agricultural conservation practices. These assessments will be incorporated into the shapefiles described per Step 2, as follows:

Step 2 – Develop/Maintain New Conservation Practice Shapefiles

Two additional ESRI shapefiles will be develop/maintained by RLWA personnel: (i) a shapefile that includes the new conservation practices implemented, and (ii) a shapefile that includes a drainage area polygon delineated for all land draining to each new conservation practice.

Step 3 – Update Priority Land Polygons (PLHRUs)

The Priority Land polygon shapefile delivered with this project, and new conservation practice shapefile, and the BMP drainage area shapefile will be added to an ESRI ArcMap project. The drainage area can be delineated directly in the "PLHRU_Final" shapefile using the "Cut Polygons" tool within the

shapefile "Editor" menu. This will create a duplicate row in the attribute table for each new polygon (i.e., for all Priority Land polygons within the BMP drainage area boundary). The "Snapping" tool may be used to trace the BMP drainage area polygon to minimize the extra work of performing a second delineation within the PLHRU shapefile.

Step 4 –Priority Land Polygon (PLHRUs) Attribute Cleanup

- If the Cut Polygons tool was used to create new polygons in the PLHRU shapefile (through subdivision of existing PLHRU polygons), the newly created polygons will be clones of the original polygon, with duplicate information copied into the new rows of the attribute table. Using the "Editor" menu, the polygon attribute data can be updated manually (typed) directly in the attribute table. Attribute fields (see Appendix B) that will require editing/updating include:
    - Acres – update the area of each new/modified polygon boundary
    - PL_LU – update only if a land use change was documented in the assessment
    - Treated – Value of "1" indicates polygon is treated, "0" indicates not treated
    - Current – "Yes" indicates polygon is untreated (still Priority Land), "No" indicates polygon is treated with BMP and no longer Priority Land
    - CurrentRnk – Indicates priority level of untreated (current) Priority Land (blank indicates treated)
- If desired, the following columns could be added:
    - SBMP_Prcnt = The sediment load reduction efficiency of the BMP(s) treating a PLHRU
    - NewSed = The post-BMP sediment yield (lbs/ac/yr)
        - Calculated by multiplying original PLHRU yield by SBMP%
    - PBMP_Prcnt = The phosphorus load reduction efficiency of the BMP(s) treating a PLHRU
        - Calculated by multiplying original PLHRU yield by PBMP%
    - NewP = The post-BMP sediment yield (lbs/ac/yr)

NOTE: If land use of the PLHRU changes due to either conservation or management, Steps 1 through 4 will be completed, similar to the procedure for inclusion of BMPs. To update the information in the spreadsheet and shapefile, the new PLHRU ID (for example, CROP/K32/5-9) and corresponding annual sediment and phosphorus yields from Appendix A should be entered for the affect PLHRU polygon (rather than applying a BMP reduction efficiency).

APPENDIX A – PLHRU ANNUAL SEDIMENT & PHOSPHORUS YIELDS

South Fork Watershed		
PLHRU	Sed (tons/ac)	P (lbs/ac)
ALFA/K0/0-2	0.00	0.00
ALFA/K0/2-5	0.00	0.00
ALFA/K0/5-9	0.00	0.23
ALFA/K0/9-9999	0.00	0.19
ALFA/K24/0-2	0.10	0.73
ALFA/K24/2-5	0.16	0.79
ALFA/K24/5-9	0.30	0.88
ALFA/K24/9-9999	0.38	0.72
ALFA/K28/0-2	0.05	0.95
ALFA/K28/2-5	0.17	1.05
ALFA/K28/5-9	0.43	1.25
ALFA/K28/9-9999	0.52	1.15
ALFA/K32/0-2	0.10	1.13
ALFA/K32/2-5	0.11	1.05
ALFA/K32/5-9	0.42	1.29
ALFA/K32/9-9999	0.58	1.29
ALFA/K37/0-2	0.09	1.25
ALFA/K37/2-5	0.37	1.61
ALFA/K37/5-9	0.85	2.14
ALFA/K37/9-9999	1.71	2.98
ALFA/K43/0-2	0.37	1.68
ALFA/K43/2-5	0.54	1.80
ALFA/K43/5-9	0.80	2.00
ALFA/K43/9-9999	1.14	2.26
BROM/K0/0-2	0.00	0.00
BROM/K0/2-5	0.00	0.00
BROM/K0/5-9	0.00	0.00
BROM/K0/9-9999	0.00	0.00
BROM/K24/0-2	0.10	0.40
BROM/K24/2-5	0.27	1.28
BROM/K24/5-9	0.61	1.60
BROM/K24/9-9999	0.86	1.59
BROM/K28/0-2	0.10	0.88
BROM/K28/2-5	0.10	1.34
BROM/K28/5-9	0.56	2.04
BROM/K28/9-9999	1.27	2.55
BROM/K32/0-2	0.10	1.77

Chariton (Wolf Creek) Watershed		
PLHRU	Sed (tons/ac)	P (lbs/ac)
ALFA/K0/0-2	0.00	0.00
ALFA/K0/2-5	0.00	0.00
ALFA/K0/5-9	0.00	0.00
ALFA/K0/9-9999	0.03	0.00
ALFA/K24/2-5	0.01	0.22
ALFA/K24/5-9	0.09	0.35
ALFA/K24/9-9999	0.22	0.43
ALFA/K28/0-2	0.03	0.44
ALFA/K28/2-5	0.03	0.48
ALFA/K28/5-9	0.11	0.69
ALFA/K28/9-9999	0.25	0.75
ALFA/K32/0-2	0.03	0.64
ALFA/K32/2-5	0.04	0.75
ALFA/K32/5-9	0.10	0.63
ALFA/K32/9-9999	0.20	0.63
ALFA/K37/0-2	0.02	0.93
ALFA/K37/2-5	0.08	0.91
ALFA/K37/5-9	0.20	0.99
ALFA/K37/9-9999	0.47	1.15
ALFA/K43/5-9	0.25	1.30
BROM/K0/0-2	0.59	0.59
BROM/K0/2-5	0.00	0.59
BROM/K0/5-9	0.17	0.44
BROM/K0/9-9999	0.46	0.67
BROM/K24/0-2	0.00	0.37
BROM/K24/2-5	0.05	0.41
BROM/K24/5-9	0.13	0.50
BROM/K24/9-9999	0.46	0.72
BROM/K28/0-2	0.03	0.80
BROM/K28/2-5	0.06	0.58
BROM/K28/5-9	0.26	1.18
BROM/K28/9-9999	0.60	1.47
BROM/K32/0-2	0.02	0.75
BROM/K32/2-5	0.10	0.82
BROM/K32/5-9	0.22	0.92
BROM/K32/9-9999	0.46	1.02
BROM/K37/0-2	0.05	1.30

South Fork Watershed		
PLHRU	Sed (tons/ac)	P (lbs/ac)
BROM/K32/2-5	0.48	2.24
BROM/K32/5-9	1.15	2.71
BROM/K32/9-9999	1.48	2.85
BROM/K37/0-2	0.13	2.18
BROM/K37/2-5	0.86	3.15
BROM/K37/5-9	1.99	4.37
BROM/K37/9-9999	4.65	6.53
BROM/K43/0-2	1.44	4.24
BROM/K43/2-5	1.98	4.71
BROM/K43/5-9	2.78	5.41
BROM/K43/9-9999	3.85	6.35
CROP/K0/0-2[1]	0.00	0.00
CROP/K0/2-5[1]	0.00	0.00
CROP/K0/5-9[1]	0.00	0.00
CROP/K0/9-9999[1]	0.00	0.00
CROP/K24/0-2	2.00	1.00
CROP/K24/2-5	2.00	2.42
CROP/K24/5-9	5.03	6.40
CROP/K24/9-9999	16.50	11.70
CROP/K28/0-2	0.73	2.58
CROP/K28/2-5	0.54	4.50
CROP/K28/5-9	9.43	9.26
CROP/K28/9-9999	20.63	14.02
CROP/K32/0-2	2.00	3.93
CROP/K32/2-5	4.71	7.02
CROP/K32/5-9	10.31	10.18
CROP/K32/9-9999	16.40	12.59
CROP/K37/0-2	1.53	4.19
CROP/K37/2-5	6.76	9.37
CROP/K37/5-9	18.64	15.19
CROP/K37/9-9999	40.19	19.94
CROP/K43/2-5	15.97	12.28
CROP/K43/5-9	24.57	16.26
CROP/K43/9-9999	36.05	21.55
EROT/K0/0-2[1]	0.00	0.00
EROT/K0/2-5[1]	0.00	0.00
EROT/K0/5-9[1]	0.00	0.00
EROT/K0/9-9999[1]	0.00	0.00
EROT/K24/0-2	0.50	1.00

Chariton (Wolf Creek) Watershed		
PLHRU	Sed (tons/ac)	P (lbs/ac)
BROM/K37/2-5	0.23	1.50
BROM/K37/5-9	0.58	1.83
BROM/K37/9-9999	1.39	2.44
BROM/K43/2-5	0.25	1.27
BROM/K43/5-9	0.47	1.44
BROM/K43/9-9999	0.76	1.68
CROP/K0/0-2	0.00	3.35
CROP/K0/2-5	1.54	4.10
CROP/K0/5-9	5.01	6.19
CROP/K0/9-9999	9.64	8.98
CROP/K24/0-2	0.50	2.31
CROP/K24/2-5	2.31	3.70
CROP/K24/5-9	5.78	5.79
CROP/K24/9-9999	10.41	8.58
CROP/K28/0-2	0.30	1.80
CROP/K28/2-5	2.43	3.64
CROP/K28/5-9	5.91	5.73
CROP/K28/9-9999	10.54	8.51
CROP/K32/0-2	0.19	1.51
CROP/K32/2-5	2.56	3.57
CROP/K32/5-9	3.32	4.28
CROP/K32/9-9999	7.37	6.53
CROP/K37/0-2	0.64	2.35
CROP/K37/2-5	2.33	3.83
CROP/K37/5-9	7.05	6.85
CROP/K37/9-9999	15.23	10.27
CROP/K43/0-2	0.60	2.00
CROP/K43/2-5	2.91	3.39
CROP/K43/5-9	6.39	5.48
CROP/K43/9-9999	11.02	8.27
EROT/K0/0-2[1]	0.00	0.00
EROT/K0/2-5[1]	0.00	0.00
EROT/K0/5-9[1]	0.00	0.00
EROT/K0/9-9999[1]	0.00	0.09
EROT/K24/0-2	0.10	0.98
EROT/K24/2-5	0.28	1.18
EROT/K24/5-9	0.74	1.63
EROT/K24/9-9999	1.50	2.00
EROT/K28/0-2	0.10	1.03

South Fork Watershed		
PLHRU	Sed (tons/ac)	P (lbs/ac)
EROT/K24/2-5	1.05	1.99
EROT/K24/5-9	2.25	3.13
EROT/K24/9-9999	3.22	3.86
EROT/K28/0-2	0.53	2.03
EROT/K28/2-5	1.60	2.98
EROT/K28/5-9	2.70	3.11
EROT/K28/9-9999	6.03	5.77
EROT/K32/0-2	0.06	2.35
EROT/K32/2-5	1.79	3.52
EROT/K32/5-9	4.22	4.95
EROT/K32/9-9999	5.85	5.84
EROT/K37/0-2	0.86	2.75
EROT/K37/2-5	3.59	5.63
EROT/K37/5-9	8.92	9.35
EROT/K37/9-9999	17.53	13.19
EROT/K43/2-5	3.20	5.31
EROT/K43/5-9	7.17	7.85
EROT/K43/9-9999	14.45	11.77
FRST/K0/0-2	0.00	0.00
FRST/K0/2-5	0.00	0.00
FRST/K0/5-9	0.00	0.00
FRST/K0/9-9999	0.00	0.00
FRST/K24/0-2	0.01	0.23
FRST/K24/2-5	0.01	0.18
FRST/K24/5-9	0.03	0.17
FRST/K24/9-9999	0.03	0.11
FRST/K28/0-2	0.00	0.31
FRST/K28/2-5	0.02	0.32
FRST/K28/5-9	0.05	0.28
FRST/K28/9-9999	0.06	0.21
FRST/K32/0-2	0.01	0.34
FRST/K32/2-5	0.03	0.33
FRST/K32/5-9	0.05	0.29
FRST/K32/9-9999	0.07	0.24
FRST/K37/0-2	0.01	0.38
FRST/K37/2-5	0.04	0.38
FRST/K37/5-9	0.09	0.38
FRST/K37/9-9999	0.14	0.37
FRST/K43/0-2	0.06	0.51

Chariton (Wolf Creek) Watershed		
PLHRU	Sed (tons/ac)	P (lbs/ac)
EROT/K28/2-5	0.61	1.94
EROT/K28/5-9	1.29	2.31
EROT/K28/9-9999	3.30	3.32
EROT/K32/0-2	0.14	1.47
EROT/K32/2-5	0.41	1.58
EROT/K32/5-9	1.03	1.77
EROT/K32/9-9999	2.31	2.57
EROT/K37/0-2	0.31	1.62
EROT/K37/2-5	0.96	2.12
EROT/K37/5-9	2.51	3.28
EROT/K37/9-9999	5.00	4.87
FRST/K0/0-2	0.00	0.00
FRST/K0/2-5	0.00	0.00
FRST/K0/5-9	0.00	0.00
FRST/K0/9-9999	0.00	0.00
FRST/K24/0-2	0.00	0.08
FRST/K24/2-5	0.00	0.08
FRST/K24/5-9	0.00	0.09
FRST/K24/9-9999	0.02	0.09
FRST/K28/0-2	0.00	0.17
FRST/K28/2-5	0.00	0.16
FRST/K28/5-9	0.01	0.18
FRST/K28/9-9999	0.03	0.20
FRST/K32/0-2	0.00	0.12
FRST/K32/2-5	0.00	0.13
FRST/K32/5-9	0.01	0.18
FRST/K32/9-9999	0.04	0.20
FRST/K37/0-2	0.01	0.24
FRST/K37/2-5	0.01	0.29
FRST/K37/5-9	0.02	0.26
FRST/K37/9-9999	0.05	0.27
FRST/K43/0-2	0.01	0.31
FRST/K43/2-5	0.02	0.32
FRST/K43/5-9	0.03	0.33
FRST/K43/9-9999	0.05	0.35
URBN/K0/0-2	0.03	0.25
URBN/K0/2-5	0.06	0.50
URBN/K0/5-9	0.08	0.57
URBN/K0/9-9999	0.12	0.65

South Fork Watershed		
PLHRU	Sed (tons/ac)	P (lbs/ac)
FRST/K43/2-5	0.08	0.49
FRST/K43/5-9	0.10	0.46
FRST/K43/9-9999	0.14	0.42
URBN/K0/0-2	0.11	0.73
URBN/K0/2-5	0.06	1.24
URBN/K0/5-9	0.08	1.27
URBN/K0/9-9999	0.10	1.17
URBN/K24/0-2	0.11	1.83
URBN/K24/2-5	0.15	2.01
URBN/K24/5-9	0.20	2.08
URBN/K24/9-9999	0.34	2.31
URBN/K28/0-2	0.09	2.02
URBN/K28/2-5	0.13	2.09
URBN/K28/5-9	0.27	2.32
URBN/K28/9-9999	0.28	2.21
URBN/K32/0-2	0.14	2.11
URBN/K32/2-5	0.30	2.70
URBN/K32/5-9	0.23	2.19
URBN/K32/9-9999	0.26	2.10
URBN/K37/0-2	0.08	2.00
URBN/K37/2-5	0.13	2.11
URBN/K37/5-9	0.25	2.31
URBN/K37/9-9999	0.48	2.84
URBN/K43/0-2	0.18	2.49
URBN/K43/2-5	0.22	2.56
URBN/K43/5-9	0.28	2.67
URBN/K43/9-9999	0.37	2.81
WATR/K0/0-2	0.00	0.00
WATR/K0/2-5	0.00	0.00
WATR/K0/5-9	0.00	0.00
WATR/K0/9-9999	0.00	0.00
WATR/K24/0-2	0.00	0.00
WATR/K24/2-5	0.00	0.00
WATR/K24/5-9	0.00	0.00
WATR/K24/9-9999	0.00	0.00
WATR/K28/0-2	0.00	0.00
WATR/K28/2-5	0.00	0.00
WATR/K28/5-9	0.00	0.00
WATR/K28/9-9999	0.00	0.00

Chariton (Wolf Creek) Watershed		
PLHRU	Sed (tons/ac)	P (lbs/ac)
URBN/K24/0-2	0.06	1.28
URBN/K24/2-5	0.09	1.53
URBN/K24/5-9	0.13	1.63
URBN/K24/9-9999	0.14	1.47
URBN/K28/0-2	0.06	1.42
URBN/K28/2-5	0.08	1.46
URBN/K28/5-9	0.09	1.72
URBN/K28/9-9999	0.12	1.65
URBN/K32/0-2	0.06	1.55
URBN/K32/2-5	0.10	1.74
URBN/K32/5-9	0.09	1.61
URBN/K32/9-9999	0.13	1.58
URBN/K37/0-2	0.06	1.61
URBN/K37/2-5	0.07	1.65
URBN/K37/5-9	0.10	1.72
URBN/K37/9-9999	0.19	1.82
URBN/K43/2-5	0.09	1.97
URBN/K43/5-9	0.12	2.03
URBN/K43/9-9999	0.15	2.12
WATR/K0/0-2	0.00	0.00
WATR/K0/2-5	0.00	0.00
WATR/K0/5-9	0.00	0.00
WATR/K0/9-9999	0.00	0.00
WATR/K24/0-2	0.00	0.00
WATR/K24/2-5	0.00	0.00
WATR/K24/5-9	0.00	0.00
WATR/K24/9-9999	0.00	0.00
WATR/K28/0-2	0.00	0.00
WATR/K28/2-5	0.00	0.00
WATR/K28/5-9	0.00	0.00
WATR/K28/9-9999	0.00	0.00
WATR/K32/0-2	0.00	0.00
WATR/K32/2-5	0.00	0.00
WATR/K32/5-9	0.00	0.00
WATR/K32/9-9999	0.00	0.00
WATR/K37/0-2	0.00	0.00
WATR/K37/2-5	0.00	0.00
WATR/K37/5-9	0.00	0.00
WATR/K37/9-9999	0.00	0.00

South Fork Watershed		
PLHRU	**Sed (tons/ac)**	**P (lbs/ac)**
WATR/K32/0-2	0.00	0.00
WATR/K32/2-5	0.00	0.00
WATR/K32/5-9	0.00	0.00
WATR/K32/9-9999	0.00	0.00
WATR/K37/0-2	0.00	0.00
WATR/K37/2-5	0.00	0.00
WATR/K37/5-9	0.00	0.00
WATR/K37/9-9999	0.00	0.00
WATR/K43/2-5	0.00	0.00
WATR/K43/5-9	0.00	0.00
WATR/K43/9-9999	0.00	0.00

Chariton (Wolf Creek) Watershed		
PLHRU	**Sed (tons/ac)**	**P (lbs/ac)**
WATR/K43/2-5	0.00	0.00
WATR/K43/5-9	0.00	0.00
WATR/K43/9-9999	0.00	0.00

[1]Multiple regression analysis was used to assign missing yield values and assumed all areas with USLE K-factors of zero (K0) would have a yield of 0. Most K0 polygons are water or other non-erodible surfaces.

APPENDIX B – PRIORITY LAND FIELD DEFINITION KEY/LEGEND

Field Heading	Description/Explanation
SoilName	Soil type from SSURGO database and TMDL SWAT model
Slope	Slope classification (range) from TMDL SWAT model
HRU	Hydrologic Response Unit. Unique combination of land use/soil/slope from TMDL SWAT model
HUC_10	USGS Hydrologic Unit 10-Digit Code
HUC_10_NAME	USGS HUC-10 Name
Kfactor	USLE Soil K-factor (soil erodibility factor)
PLSOIL	Code assigned to soil types by USLE Kfactor for Priority Land HRUs
SWAT_LU	Land use category from TMDL SWAT model
PL_LU	Land use category assigned to Priority Land HRUs
PLHRU	Priority Land polygon identifiers assigned using land use, soil Kfactor, and slope classification
Sed	Sediment loss rate (yield) to surface water from PLHRU (tons/acre/year)
P	Phosphorus loss rate (yield) to surface water from PLHRU (lbs/acre/year)
Priority_L	1 = is Priority Land as indicated by top 20% of lands with highest sediment yield (0= not PL)
PL_Rank	Indicates High, Medium, or Low Priority Land based on sediment yield
Treated	1 = Treated with prior BMPs and not currently Priority Land (0 = Not treated and still PL)
Current	Yes = untreated Priority Land, No= Not currently Priority Land
CurrentRnk	Indicates priority level of untreated (current) Priority Land (blank indicates treated)
Acres	Area in acres
SBMP_Prcnt	Percent reduction by the added BMP
NewSed	New sediment loss rate (yield) to surface water after BMP implementation
PBMP_Prcnt	Percent reduction by the added BMP
NewP	New phosphorus loss rate (yield) to surface water after BMP implementation