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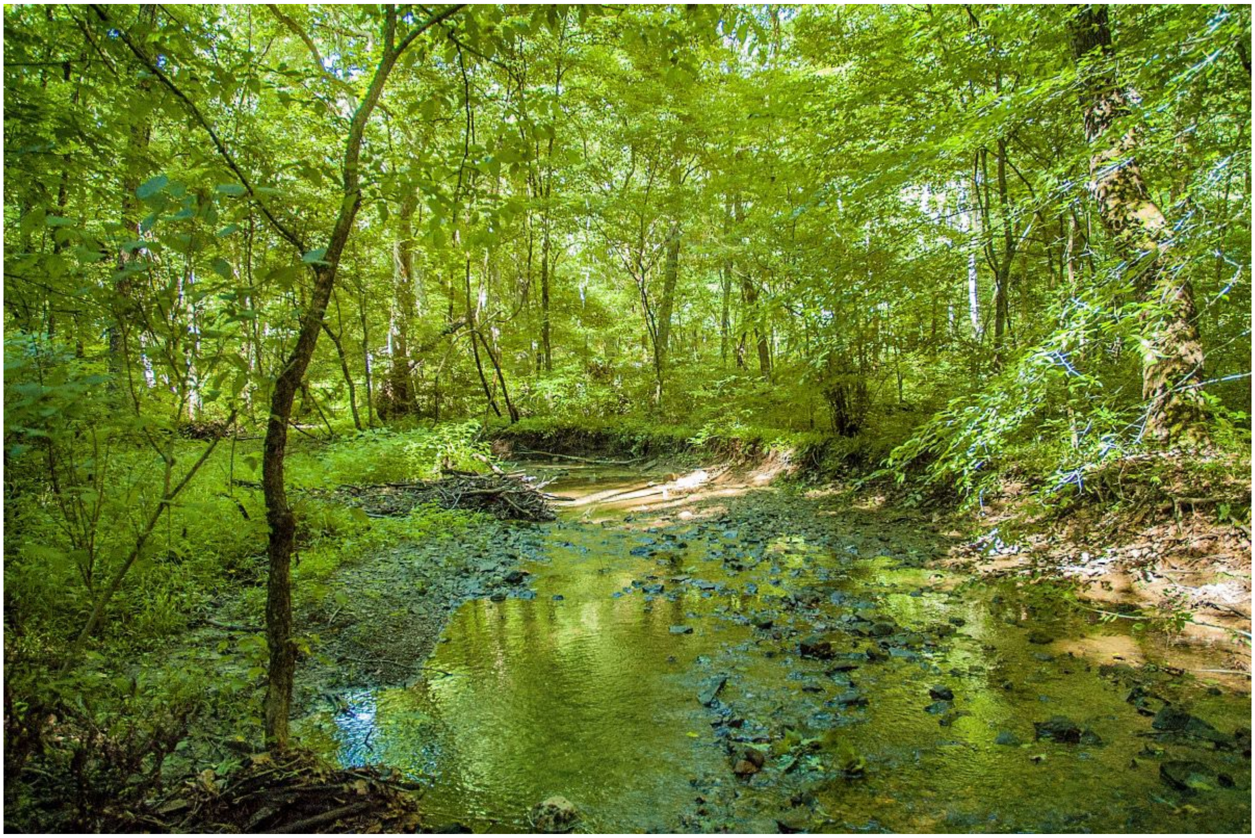
LOWER SALT CREEK WATERSHED MANAGEMENT PLAN

JACKSON, LAWRENCE AND MONROE COUNTIES, INDIANA

20 DECEMBER 2022



A PROJECT OF THE
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LOWER SALT CREEK WATERSHED MANAGEMENT PLAN

LAWRENCE AND MONROE COUNTIES, INDIANA

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JACKSON, LAWRENCE AND MONROE COUNTIES, INDIANA

1.0 WATERSHED INTRODUCTION

1.1 Watershed Community Initiative

A watershed is the land area that drains to a common point, such as a location on a river. All of the water that falls on a watershed will move across the landscape collecting in low spots and drainageways until it moves into the waterbody of choice. All activities that take place in a watershed can impact the water quality of the river that drains it. What we do on the land, such as constructing new buildings, fertilizing lawns, or growing crops, affects the water and the ecosystem that lives in it. A healthy watershed is vital for a healthy river, and a healthy river can enhance the community and helps maintain a healthy local economy. Watershed planning is especially important in that it will help communities and individuals determine how best to preserve water functions, prevent water quality impairment, and produce long-term economic, environmental, and political health.

The Lower Salt Creek Watershed starts downstream of Lake Monroe and drains 638 square miles in total. The watershed covers 203 square miles and includes drainage from Bloomington, Oolitic and Bedford as well as portions of the Hoosier National Forest. The watershed includes one 10-digit hydrologic unit code (HUC): 0512020808. The Lower Salt Creek Watershed is comprised of three major basins: Salt Creek downstream of Lake Monroe; Clear Creek from First Street in Bloomington south through Monroe and Lawrence Counties and Little Salt Creek, Knob Creek and other tributaries draining the eastern portion of the basin. Clear Creek, Little Salt Creek, Knob Creek and other tributaries join Salt Creek upstream of Bedford. Salt Creek continues south and west through Lawrence County where it meets the East Fork White River east of Englewood. The East Fork White River flows south and west to join with the White River near Worthington draining 772,476 acres (1,206 square miles; Figure 1).

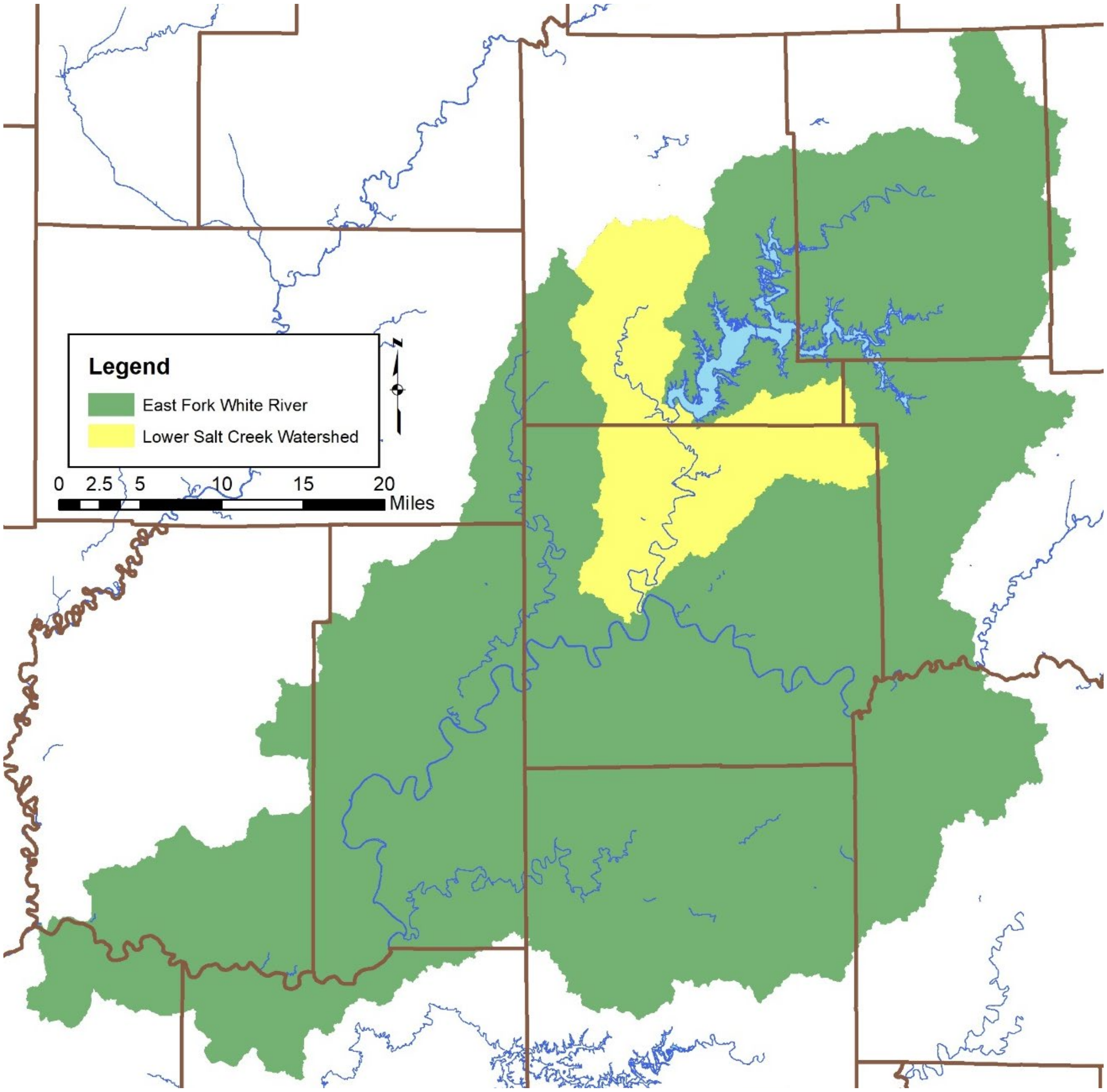

Figure 1. The East Fork White River Basin highlighting the Lower Salt Creek Watershed.

1.2 Project History

In 2016, IDEM initiated a Total Maximum Daily Load (TMDL) study of the Lower Salt Creek Watershed. Local interest from Jackson, Lawrence and Monroe county, City of Bloomington and Bedford and local landowners led to IDEM selecting the Lower Salt Creek Watershed for a TMDL/Watershed characterization study. The Lower Salt Creek Project launched in early 2021 as a result from a Section 205j grant awarded to develop the Lower Salt Creek Watershed Management Plan. The Lower Salt Creek Watershed includes portions of Bloomington and Bedford, Oolitic, Avoca, Harrodsburg, Coneyville, Bartlettsville, Fayettville and Coxton. The watershed includes a variety of land uses including agricultural, forest and natural areas, including nature preserves and national forest, as well as urban and urbanizing land uses. The Clear Creek drainage is a mix of urban and forested land, while the Little Salt Creek and Knob Creek drainages are almost entirely forested with some residential and agricultural land. Salt Creek includes a mix of agricultural, forested and urban/urbanizing land uses. Much of the watershed is covered by highly erodible soils. The presence of karst, high number of quarries and history of legacy pollution contamination associated with Superfund and Resource Conservation and Recovery Act (RCRA) sites are also of concern in the Lower Salt Creek Watershed.

Based on these concerns, the Lawrence County SWCD approached community groups and individuals throughout the watershed that might be interested in working with them to assess and improve water quality within Lower Salt Creek Creek and its tributaries. Identified potential stakeholders include: Lawrence and Monroe County SWCD and NRCS staff; Monroe County, City of Bloomington, City of Bedford and Indiana University MS4s; Indiana DNR; Indiana State Department of Agriculture; Lawrence and Monroe County surveyors, parks departments and Purdue Extension; Hoosier National Forest hydrologists and biologists; local landowners, educators and more. This group formed a Steering Committee (Table 1), conducted windshield surveys of the watershed, and held several meetings open to the public in order to generate input in the development of a watershed management plan for Lower Salt Creek Watershed.

1.3 Stakeholder Involvement

Development of a watershed management plan requires input from interested citizens, local government leaders, and water resource professionals. These individuals are required to not only buy into the project and the process but must also become an integral part of identifying the solution(s) which will result in improved water quality. The Lower Salt Creek Project involved stakeholders in the watershed management planning process through a series of public meetings and education and outreach events including windshield surveys, workshops, field days and youth-focused education events.

1.3.1 Steering Committee

Individuals representing the towns and counties within the watershed, environmental groups, natural resource professionals, agricultural and commercial representatives, and private citizens comprised the steering committee. The steering committee has met quarterly to develop the WMP starting in February 2021. Table 1 identifies the steering committee members and their affiliation.

Table 1. Lower Salt Creek Watershed steering committee members and their affiliation.

Individual	Organization(s) Represented
Misti Adams	City of Bedford MS4
Steve Cotter, Rebecca Swift	City of Bloomington Parks
James Hall	City of Bloomington Utilities
David Parkhurst	City of Bloomington Environmental Commission
Maggie Sullivan	Friends of Lake Monroe
Ryan McDuffee	General Motors
Dave Kittaka	Indiana DNR
Michael Dorsett	Indiana University MS4
Don Ryan, Laura Fribley	Indiana State Department of Agriculture
Matt Colchin	Landowner
Charles Sproul	Landowner

Individual	Organization(s) Represented
Curt McBride	Landowner, Lawrence County SWCD
Evan Smith, Whitney Baldwin	Lawrence County NRCS
Ophelia Davis	Lawrence County Purdue Extension
Corey Allen	Lawrence County Surveyor
Hannah Martin	Lawrence and Monroe County SWCD
Amanda Robbins, Stephanie Baker	Lawrence County SWCD
Lynnette Murphy	Monroe County Health Department, MS4
Ryan Kasper-Cushman	Monroe County Health Department
Kelsey Thetonia	Monroe County MS4
Cara Bergschneider, Allison Shoaf	Monroe County NRCS
Amy Thompson	Monroe County Purdue Extension
Martha Miller, Ryan Conway	Monroe County SWCD
Chad Menke	US Forest Service

1.3.2 Public Meetings

Public participation is necessary for the long-term success of any watershed planning and subsequent implementation effort. One component of public participation for this project was public meetings and listening sessions. Due to the pandemic, a series of listening sessions were swapped for the in person public meeting to start the project. These sessions occurred in February 2021 and were used to introduce the project, develop a concerns list and allow individuals to provide their thoughts on potential projects that will be targeted in future implementation efforts. The purpose of the public meetings was to provide information on the overall planning effort and its progress; solicit stakeholder input, opinions, and participation; create opportunities for the public to recommend programs, policies, and projects to improve water quality; and build support for future phases of the project.

The public meetings/listening sessions were advertised through press releases distributed to local newspapers in the watershed and via the project website and emails sent to local landowners and conservation partners. The meetings/listening sessions were also advertised through word of mouth as staff from the Soil and Water Conservation District put together mailings that advertised the events.

The first public meeting occurred on March 9, 2021 in a virtual, drop-in, listening session format. In total 22 individuals attended the virtual public meeting. Attendees shared their interest in the Lower Salt Creek Watershed and assisted in developing the concerns list. Options for future engagement opportunities and details about upcoming aspects of the project were also shared.

The second meeting occurred on October 3, 2022 as two drop in meetings with the morning meeting held at the Lawrence SWCD office and the afternoon meeting held at the Monroe SWCD office. The meetings included an overall project update, review of project goals and future timelines and focused on gathering feedback on critical areas, practices selected for implementation and the likelihood of meeting project goals gathered.

1.4 Public Input

Throughout the planning process, project stakeholders, the steering committee, and the general public listed concerns for the Lower Salt Creek Watershed including Salt Creek, its tributaries, and its watershed. Public and committee meetings were the primary mechanism of soliciting individual concerns. All comments were recorded and included as part of the concern documentation and prioritization process. Concerns voiced throughout the process are listed in Table 2. Similar stakeholder concerns were grouped roughly by topic and condensed by the committee. The order of concern listing does not reflect any prioritization by watershed stakeholders.

Table 2. Stakeholder concerns identified during public input sessions, steering committee meetings and via the watershed inventory process. Note: The order of concern listing does not reflect any prioritization by watershed stakeholders.

Stakeholder Concerns
Karst topography and sinkholes – potential for contamination
Sinkholes should be buffered to protect groundwater-surface water connection
Sinking Creek ends in a terminal sinkhole – this portion of the watershed is particularly sensitive
Protection of lands 15% sloped or more is needed (Monroe has this already)
Highly erodible land impacts
Streambank erosion
Sedimentation
Flooding is concern – floodplain management/flood protection needed.
Flooding/floodwater downstream of Lake Monroe and south of Bloomington are of high concern.
Fish consumption advisories, options for remediation/ removal from category 5 list
Streams listed on impaired waterbodies list – *E. coli* and impaired biotic communities
Elevated E. coli levels
Septic system density
Septic use and maintenance should be regulated
Failing septic systems
Sanitary sewer overflows or illicit discharge
Wastewater treatment plant impacts
Nutrients, sediment from agricultural runoff
Manure applied to farm ground
Livestock access
Algal blooms
Urban streams – options for naturalization, daylighting or remediation
Urbanizing areas -urban sprawl, development impacts
Stormwater runoff
Leaking underground storage tanks – downtown Bloomington
PCB contamination/ remediation
Legacy pollutants– downtown Bloomington, GM, Superfund sites (potential removal from NPL), Bedford, creosote treatment plants along Clear Creek
Trash in public areas
Wetlands need to be protected /wetland loss should be limited
Forest management

Maintain forest canopy cover
Improve forest composition to improve water quality
Culverted stream crossings negatively impact biological communities
Quarries negatively impact land use and water quality, impact natural land use and result in tracking materials onto paved surfaces
Pesticides and fertilizers
Lack of public awareness
Need to develop and instill a sense of place
Watershed restoration is underfunded
Unified group for watershed activities and implementation is needed
Lack of cohesive governance and regulations can inhibit current and future efforts

2.0 WATERSHED INVENTORY I: WATERSHED DESCRIPTION

2.1 Watershed Location

The Lower Salt Creek Watershed (HUC 0512020808) is part of the East Fork White River Watershed and covers portions of Lawrence and Monroe counties (Figure 1). The Lower Salt Creek Watershed includes all the land that enters Clear Creek, Salt Creek, Little Salt Creek, Knob Creek and their 130,255 acre drainage. Lower Salt Creek starts at the Lake Monroe tailwaters carrying water south and west through Lawrence County gathering drainage from Clear Creek, Little Salt Creek, Knob Creek, Pleasant Run and other streams. Salt Creek meets the East Fork White River east of Englewood. The East Fork White River flows south and west to join with the White River near Worthington.

2.2 Subwatersheds

In total, seven 12-digit Hydrologic Unit Codes are contained within the Lower Salt Creek Watershed (Figure 2, Table 3). Each of these drainages will be discussed in further detail under *Watershed Inventory II*.

Table 3. 12-digit Hydrologic Unit Code (HUC) watersheds in the Lower Salt Creek Watershed.

Subwatershed Name	Hydrologic Unit Code	Area (acres)	Percent of Watershed
Jackson Creek-Clear Creek	051202080801	16,068.3	12.3%
May Creek-Clear Creek	051202080802	19,185.7	14.7%
Little Clear Creek-Clear Creek	051202080803	13,271.0	10.2%
Hunter Creek-Little Salt Creek	051202080804	18,987.1	14.6%
Knob Creek-Little Salt Creek	051202080805	15,427.3	11.8%
Wolf Creek-Salt Creek	051202080806	25,229.0	19.4%
Goose Creek-Salt Creek	051202080807	22,085.7	17.0%
	Entire Watershed	**130,254.2**	

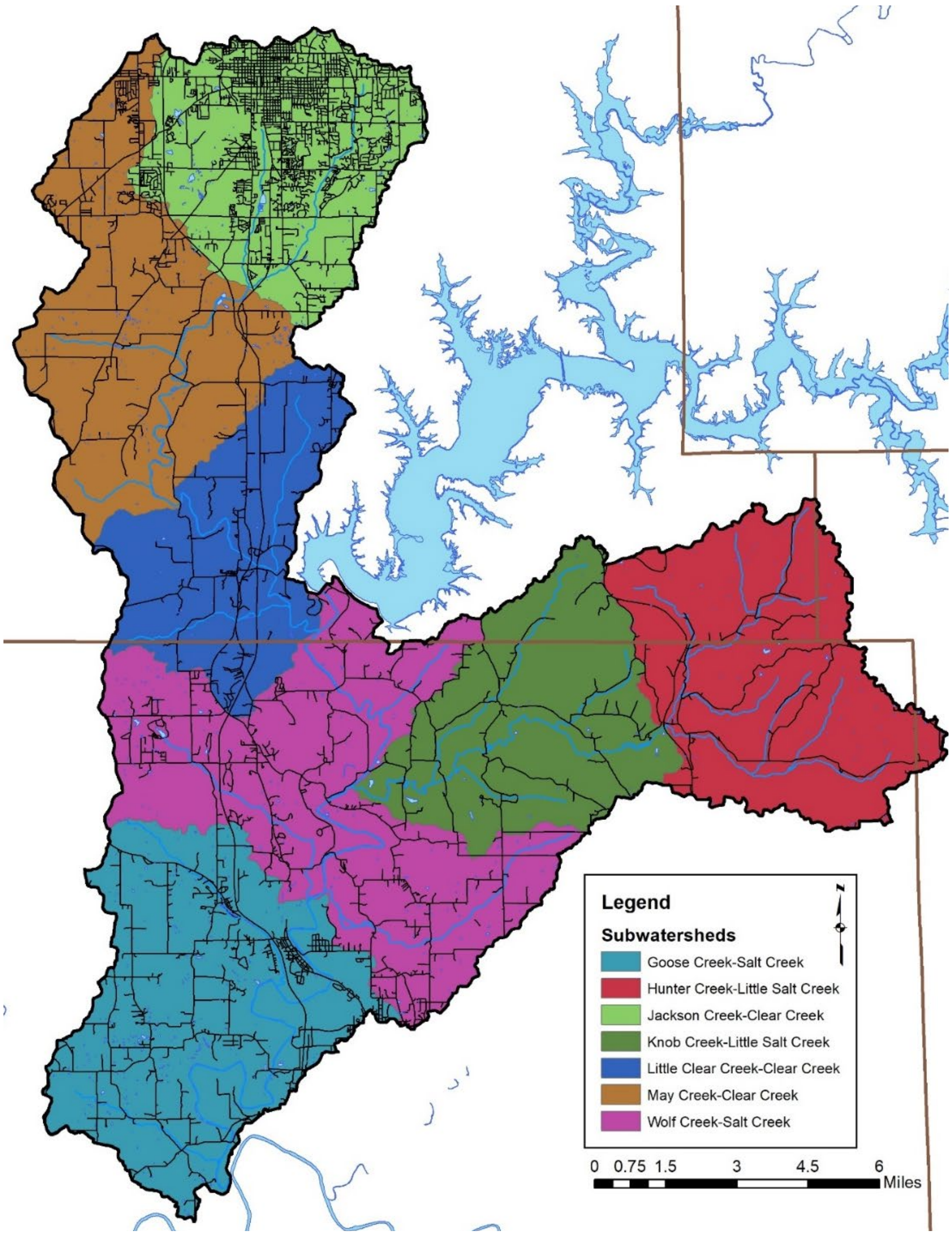

Figure 2. 12-digit subwatersheds in the Lower Salt Creek Watershed.

2.3 Climate

In general, Indiana has a temperate climate with warm summers and cool or cold winters. Climate in the Lower Salt Creek Watershed is no different than the rest of the state. There are four seasons throughout the year. The average temperatures measure approximately 73.4°F in the summer, while low temperatures measure near freezing (33°F) in the winter. The growing season typically extends from April through September. On average, 52 inches of precipitation occurs within the watershed per year; approximately 62% of this precipitation falls during the 205 day growing season. Rainfall intensity and timing affect watershed response to precipitation. This information is important in evaluating the effects of storm water on the Lower Salt Creek watershed. Using data from the Bloomington Climate Station (USC00120784), 74% percent of the measurable precipitation events were very low intensity (less than 0.2 inches), while 0.04% percent of the measurable precipitation events were greater than one inch.

2.4 Geology and Topography

Bedrock deposits within much of the Lower Salt Creek Watershed are from the Mississippian age with the extreme western edge of the watershed covered by Pennsylvanian age rocks (Raccoon Group). Mississippian bedrock generally consists of limestone and clays, while Pennsylvanian bedrock is typically shale, siltstone, and limestone (Hill et al., 1982). Borden Group bedrock covers most of the eastern portion of the Lower Salt Creek Watershed with Blue River Group and Sanders Group deposits covering much of the western portion of the watershed. Minor areas of Raccoon Group and West Baden Group also lie along the western edge of the watershed (Figure 3). The Borden Group is dominated by siltstones, sandstones and shale, while the Raccoon Creek Group consists mostly of sandstone and shale with coal, limestone, and mudstone intermixed. The Blue River, West Baden and Sanders groups consist mostly of shallow limestone. Much of the Lower Salt Creek Watershed is covered by glacial drift measuring from 0 to 200 feet in thickness with deeper drift filling preglacial drainageways. Two distinct glacial stages are represented by the watershed's till and drift deposits. The most recent Wisconsinan drift was deposited by the Ontario-Erie Lobe of the Wisconsinan glacier (Wayne, 1963). Sand and gravel deposits found along all major and many minor streams originate from the Wisconsinan outwash. Lacustrine deposits found in the watershed's headwaters originate from the Illinoian till (Figure 4). Sand and gravel are readily available resources along watershed stream floodplains.

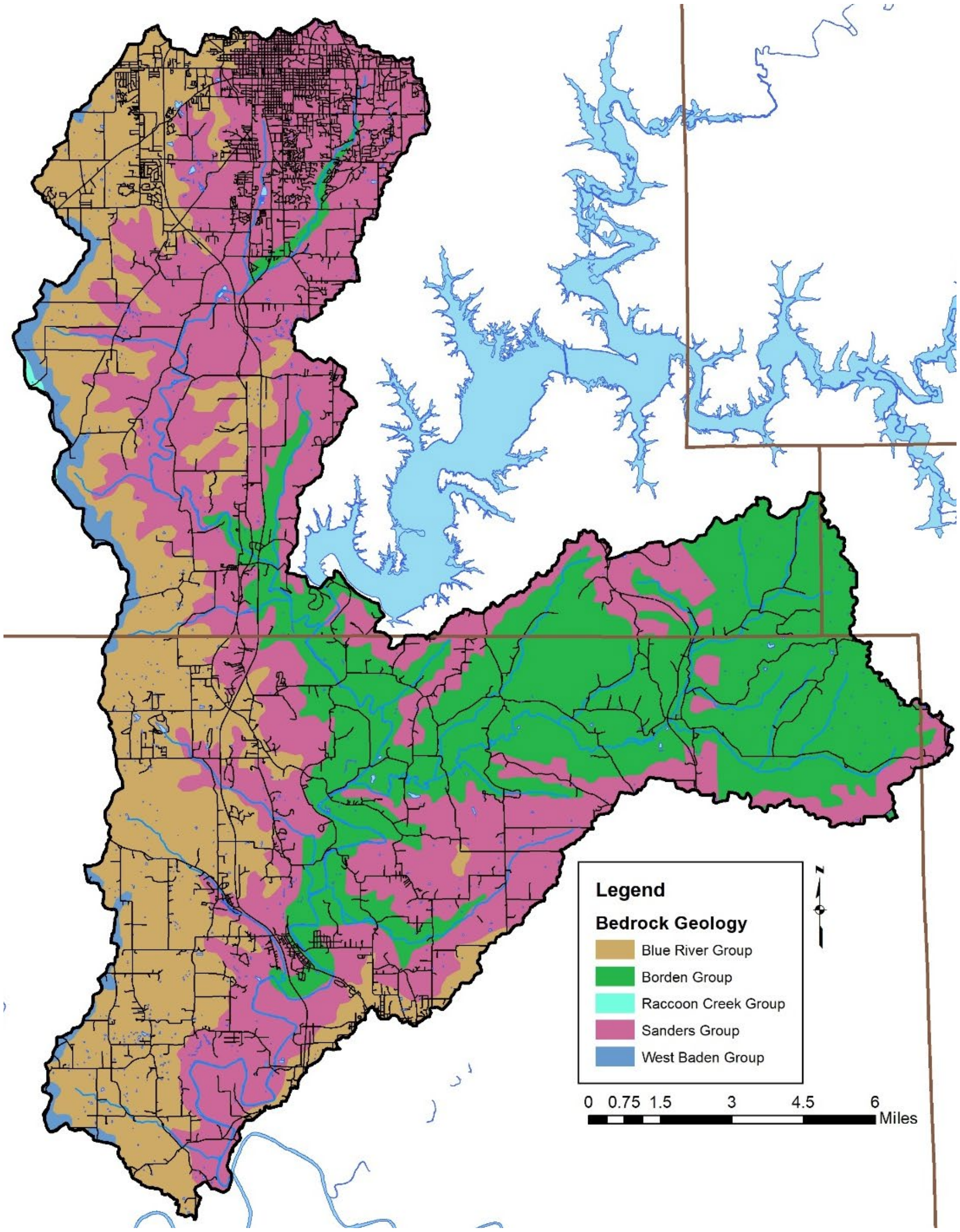

Figure 3. Bedrock in the Lower Salt Creek Watershed.

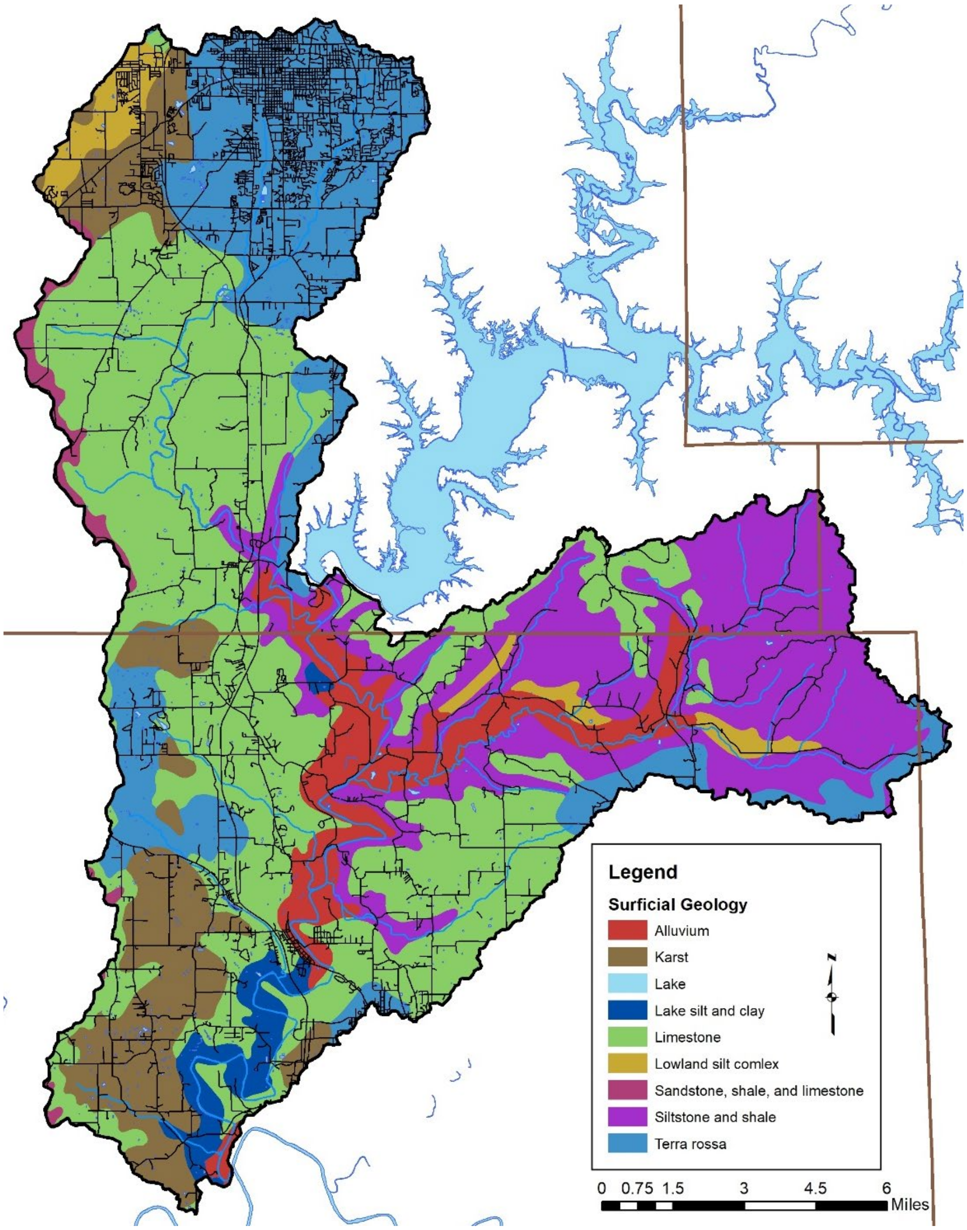

Figure 4. Surficial geology throughout the Lower Salt Creek Watershed.

More than 13% of the watershed (17,511 acres) is covered by karst sinkholes and springs. Karst topography is especially prevalent in the western portion of the watershed west of the SR 37 corridor. Karst forms when carbonate rocks, including limestone and dolostone, lie beneath the surface. As rainwater moves through and into the groundwater system, the limestone is slowly dissolved and sinkholes and caves as well as other karst characteristics form. These features are sensitive as water flows directly into them rather than being filtered by soil and bedrock (IGS, not dated). There are fewer perennial stream miles in the southwestern portion of the Lower Salt Creek Watershed due to this karst topography. Because surface water can reach underground aquifers without filtering through soil and bedrock, water quality is very sensitive in karst topography. The steering committee noted this potential for contamination and highlight karst areas including sinkholes and springs as one of their concerns. There are 1,833 karst sinkholes and 36 karst springs in the Lower Salt Creek Watershed (Figure 5). This is an ever-changing number of sinkholes which form daily in karst regions. Karst sinkholes are extremely sensitive and should be protected to avoid contamination to water sources. Karst caves are typically common in karst areas, nearly 90 karst caves covering more than 17,230 acres are mapped in the Lower Salt Creek Watershed.

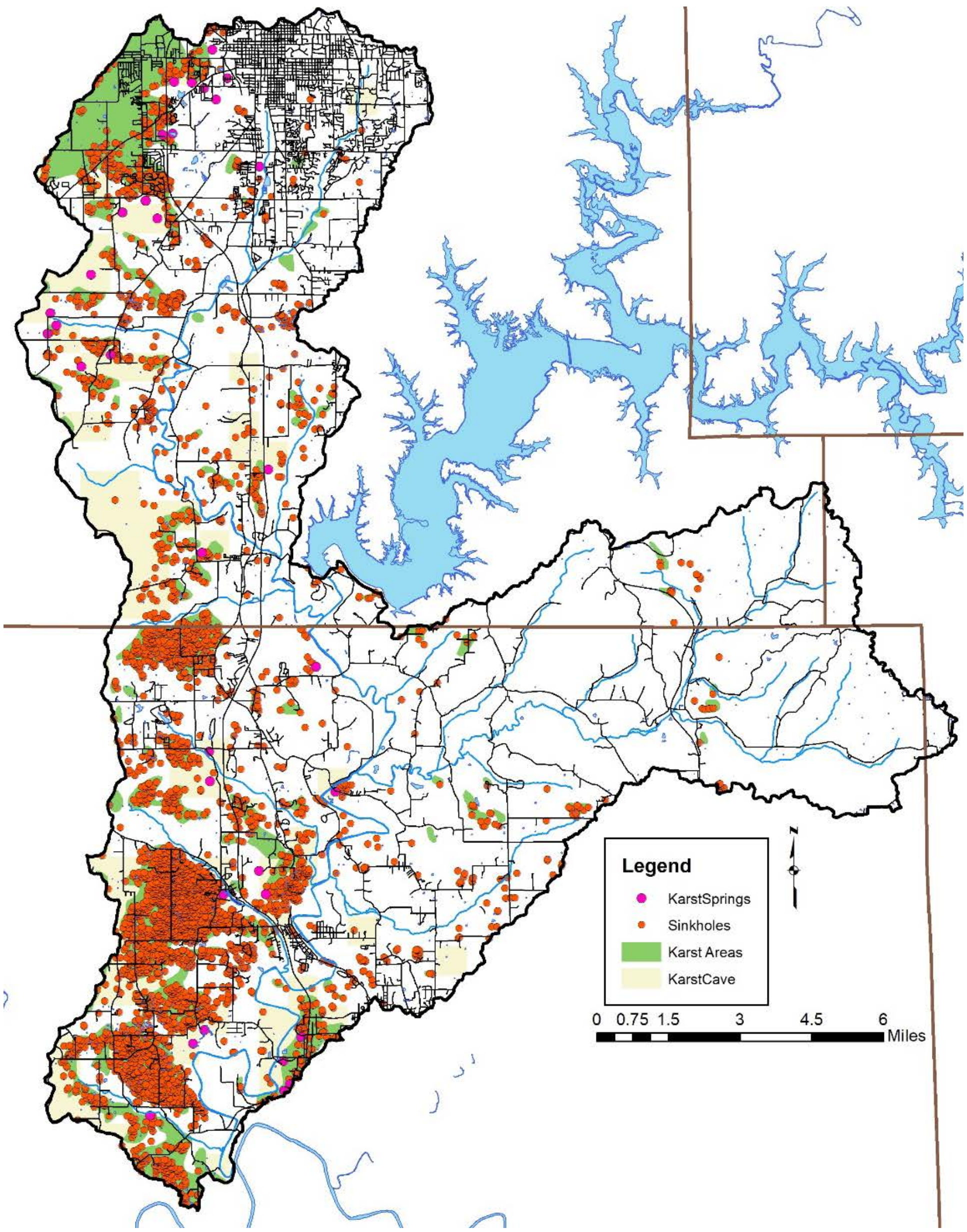

Figure 5. Karst sinkholes, springs and caves in the Lower Salt Creek Watershed.

The topography of the Lower Salt Creek Watershed ranges from flat rolling agricultural fields to undulating hills and valleys to steeply sloped forest land (Figure 6). The landscape changes from steeply sloped to rolling terrain in the Clear Creek drainage (northern part of the watershed) to gently rolling terrain and relatively flat plains along Salt Creek to steep valleys in the eastern portion of the watershed (Hoosier National Forest). The Lower Salt Creek Watershed elevation is highest measuring 911 feet mean sea level (msl) at the in Hoosier National Forest in the eastern portion of the watershed and west of Bloomington in the northern portion of the watershed. Steep valleys surround many of the Lower Salt Creek Watershed streams. The lowest elevation (434 feet msl) occurs near the intersection of Lower Salt Creek with the East Fork White River.

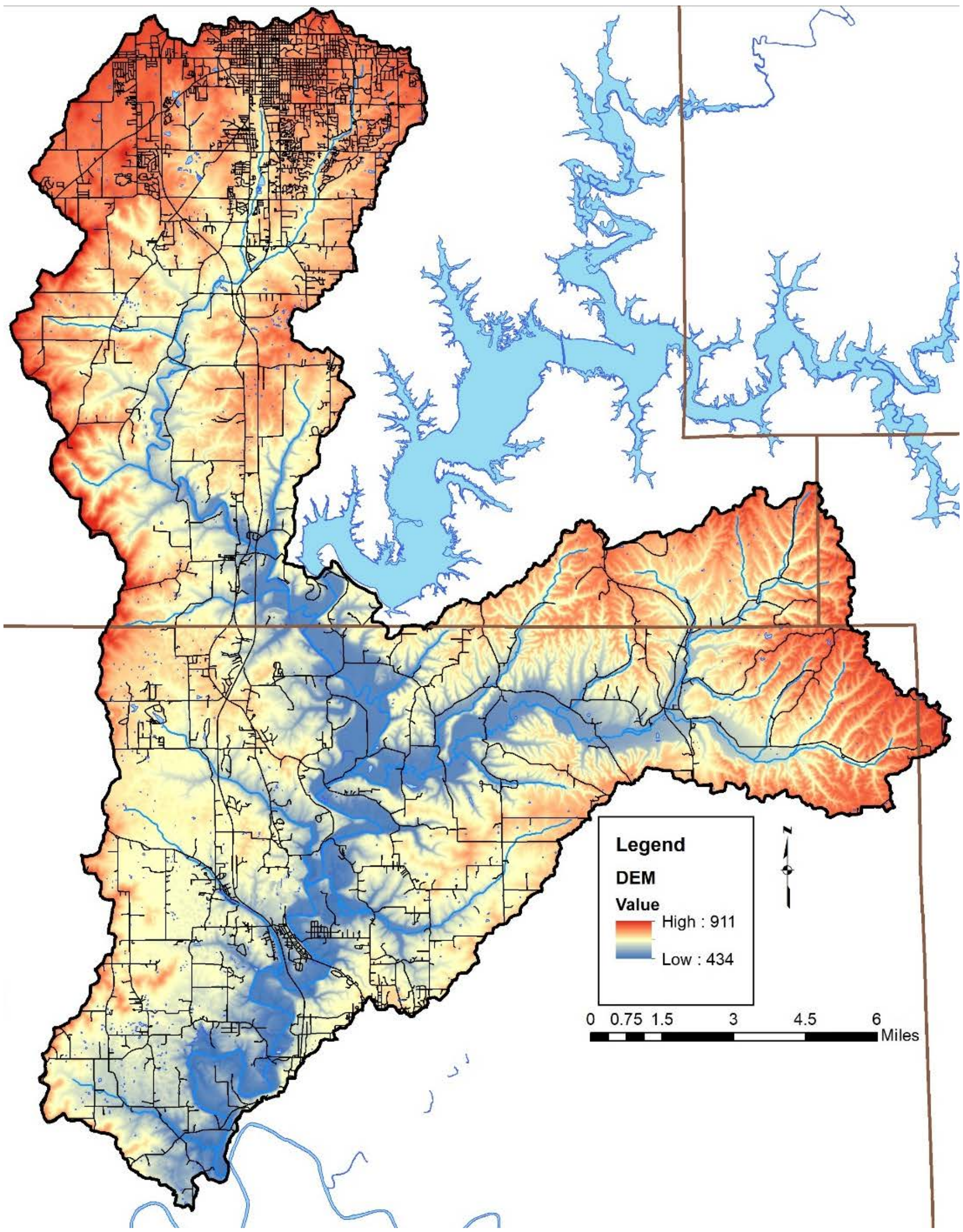

Figure 6. Surface elevation in the Lower Salt Creek Watershed.

2.5 Soil Characteristics

There are hundreds of different soil types located within the Lower Salt Creek Watershed. These soil types are delineated by their unique characteristics. The types are then arranged by relief, soil type, drainage pattern, and position within the landscape into soil associations. These associations provide the overall characteristics across the landscape. Soil associations are not used at the individual field level for decision making. Rather, the individual soil types are used for field-by-field management decisions. Some specific soil characteristics of interest, including septic limitations and soil erodibility, for watershed and water quality management are detailed below.

2.5.1 Hydrologic Soil Group

The hydrologic soil group classification is a means for categorizing soils by similar infiltration and runoff characteristics during periods of prolonged wetting. The vast majority of the Lower Salt Creek Watershed is covered by well-drained soils from materials weathered from shale, siltstone and limestone. These moderately deep to deep soils are found on moderately sloping to steeply sloped land. Within floodplains, somewhat poorly drained to well-drained soils are located within river deposits on nearly level land. Soils are classified by the NRCS into four hydrologic soil groups based on the soil's runoff potential (Table 4). The majority of the watershed is covered by category B soils (48%) followed by category C soils (43%), category D soils (6%), and category A soils (3%). Soils in the western portion of the Lower Salt Creek Watershed are mostly category B soils, while soils in the northern and eastern portions of the Lower Salt Creek Watershed are comprised of mostly C soils (Figure 7). Category B soils are moderately deep and well drained, while Category C soils are finer and allow for slower infiltration. D soils are found on the western edge of the Clear Creek drainage and immediately downstream of Lake Monroe. In these areas, D soils are slow infiltration soils where flooding can regularly occur. This means that regular flooding is likely not typical in much of this watershed but could potentially occur on occasion and transport pollutants across the landscape.

Table 4. Hydrologic soil group summary.

Hydrologic Soil Group	Description
A	Soils with high infiltrations rates. Usually deep, well drained sands or gravels. Little runoff.
B	Soils with moderate infiltration rates. Usually moderately deep, moderately well drained soils.
C	Soils with slow infiltration rates. Soils with finer textures and slow water movement.
D	Soils with very slow infiltration rates. Soils with high clay content and poor drainage. High amounts of runoff.

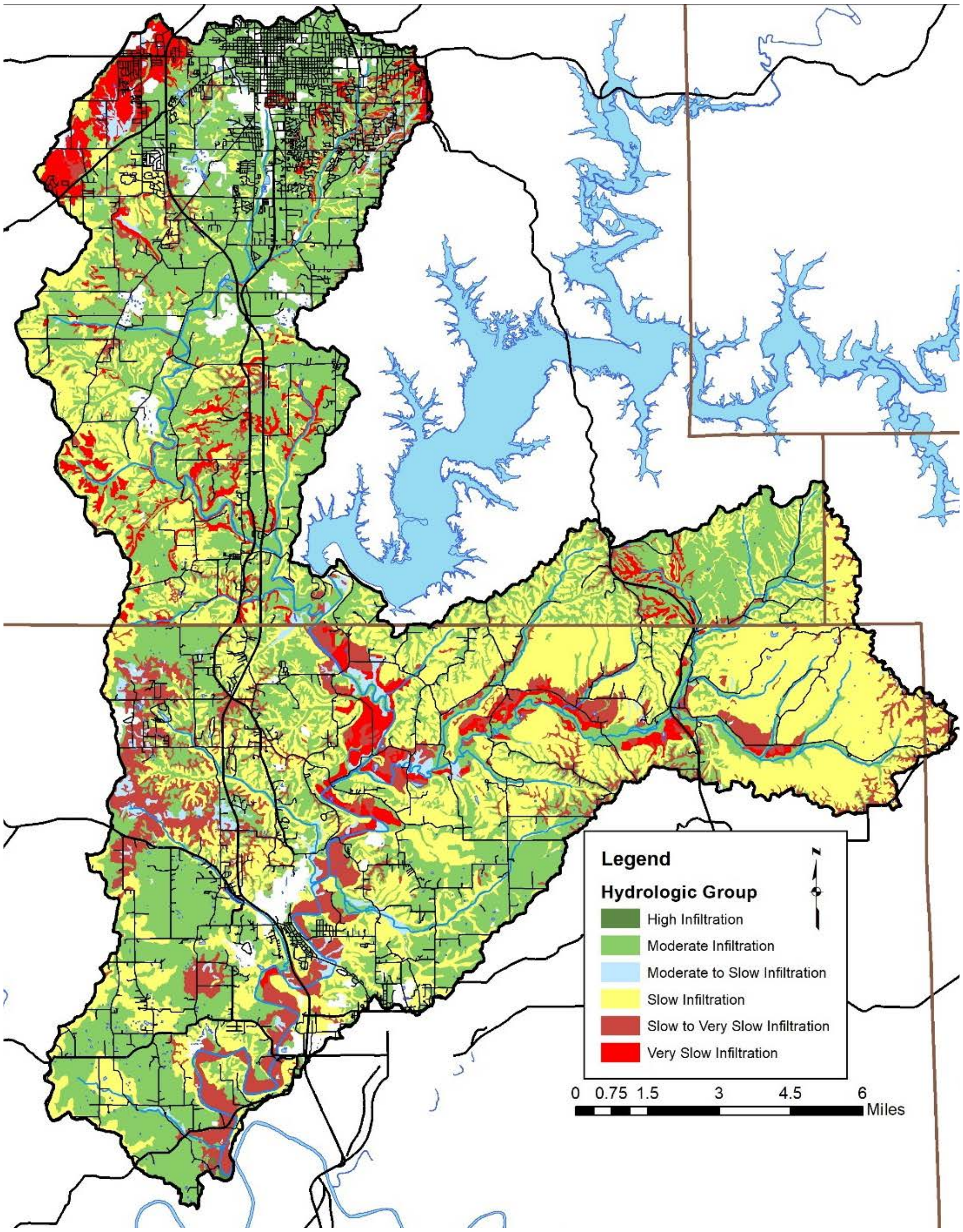

Figure 7. Hydrologic Soil Groups in the Lower Salt Creek Watershed.

2.5.2 Soil Erodibility

Soils that move from the landscape to adjacent waterbodies result in degraded water quality, limited recreational use, and impaired aquatic habitat and health. Soils carry attached nutrients and pesticides, which can result in impaired water quality by increasing plant and algae growth or even killing aquatic life. The ability and/or likelihood for soils to move from the landscape to waterbodies are rated by the Natural Resources Conservation Service (NRCS). The NRCS uses soil texture and slope to classify soils into those that are considered highly erodible, potentially highly erodible, and not highly erodible. The classification is based on an erodibility index which is determined by dividing the potential average annual rate of erosion by the soil unit's soil loss T value or tolerance value. The T value is the maximum annual rate of erosion that can occur for a particular soil type without causing a decline in long-term productivity.

Watershed stakeholders are concerned about soil erosion. As detailed above, soils which have high erodibility index values are those that are located on steep slopes and are easily moved by wind, water, or land uses. Figure 8 details locations of highly erodible land within the Lower Salt Creek Watershed. Highly erodible soils cover 96% of the watershed or 125,166 acres. Highly erodible soils are found throughout the watershed with no discernable pattern of location.

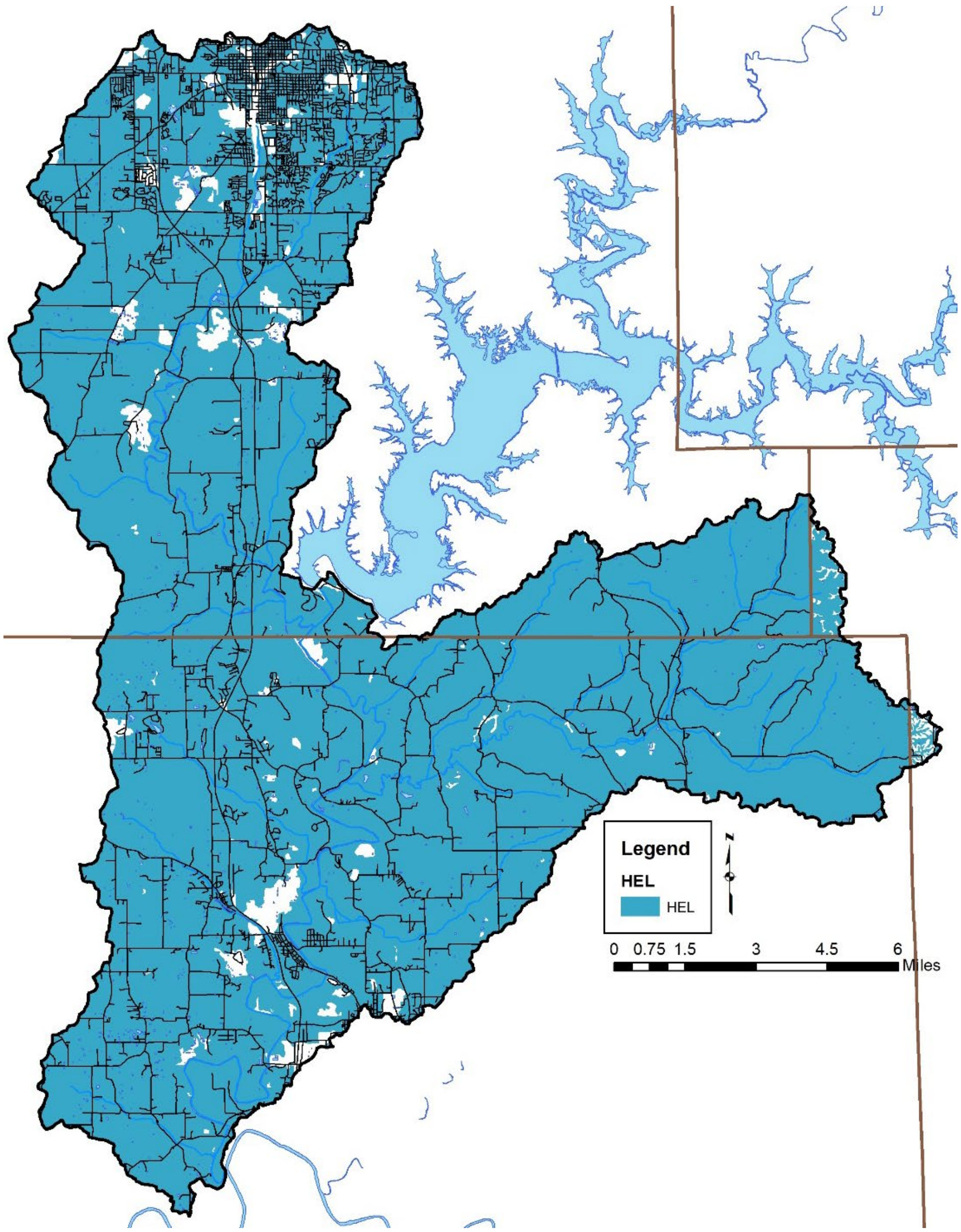

Figure 8. Highly erodible land in the Lower Salt Creek Watershed.

2.5.3 Hydric Soils

Hydric soils are those which remain saturated for a sufficient period of time to generate a series of chemical, biological, and physical processes. The oxidation and reduction of iron in the soil, or "redox", causes color changes characteristic of prolonged fluctuations in the water table. After undergoing these processes, the soils maintain the resultant characteristics even after draining or use modification occurs. Watershed stakeholders are concerned about the conversion of wetlands into agricultural and urban land uses. Approximately 12,226 acres (9.4%) of the watershed was covered by hydric soils (Figure 9). Hydric soils are sporadically located throughout the watershed with most occurring in the Salt Creek floodplain. As these soils are considered to have developed under wetland conditions, they are a good indicator of historic wetland locations and therefore will be revisited in the land use section.

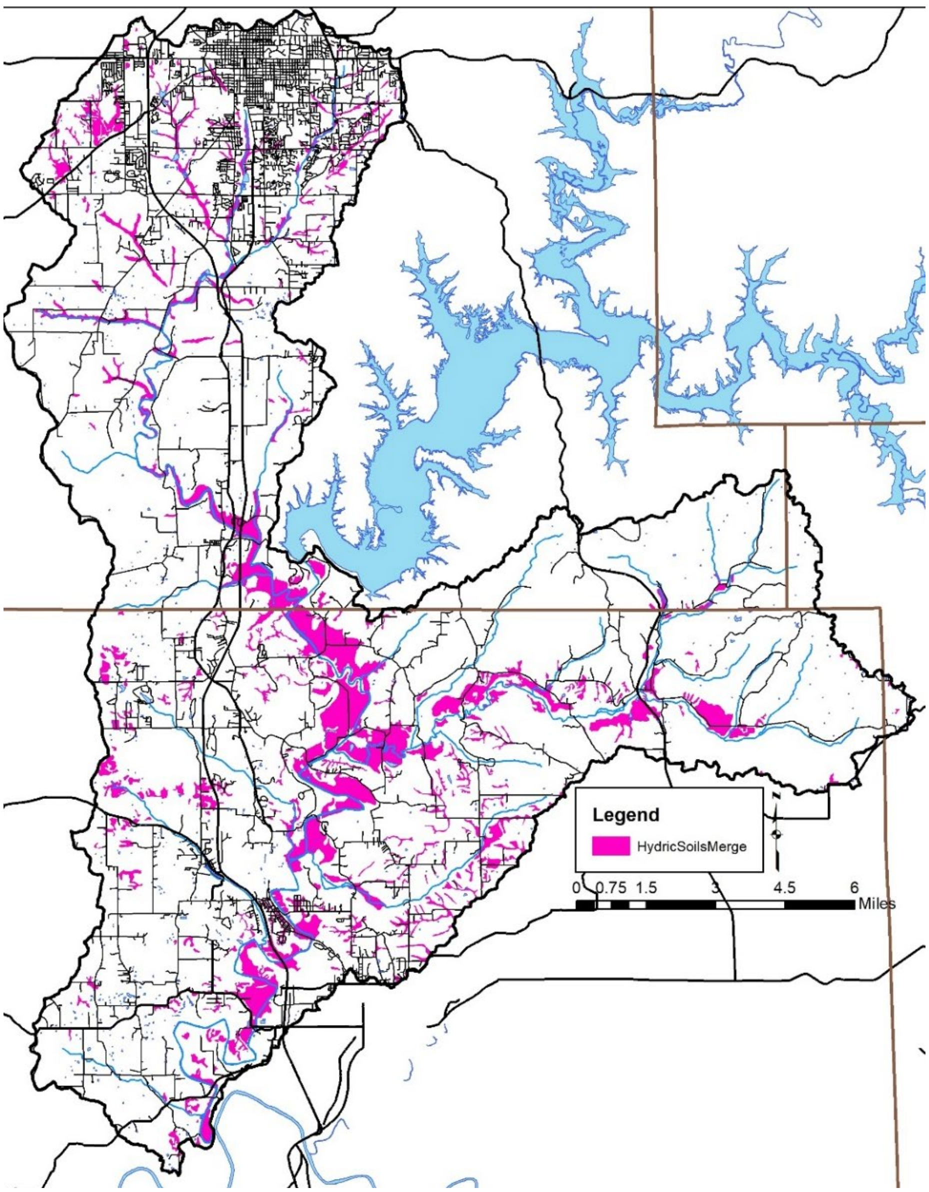

Figure 9. Hydric soils in the Lower Salt Creek Watershed.

2.5.4 Tile-Drained Soils

Soils drained by tile drains cover 5,517 acres or 4% of the Lower Salt Creek Watershed as estimated utilizing methods details in Sugg, 2007. This method of drainage is widely used in row crop agricultural settings within the watershed and has become even more intensively used within the last ten years. This results in altered hydrology, allowing the water to drain from the landscape more quickly to improve conditions for farming, but also potentially exacerbating downstream flooding and incising streams which cuts them off from their natural floodplains. In these areas, materials such as nutrients applied to agricultural soils are directly transported downstream, bypassing natural features such as filter strips that might otherwise filter out or assimilate nutrients. As the demands of production on each acre of land increases more tile is put in, typically in a network or series as extensive as 30 to 50 foot spacing between tiles. Impacts to stream water quality can be reduced by the use of tile control structures and drainage water management. A majority of tile-drained soils are located in Lower Salt Creek headwaters including areas west of Bloomington and along the mainstem of Salt Creek and Little Salt Creek in Lawrence County and northern and eastern Monroe County (Figure 10). Most of these areas are relatively flat where drainage augmentation is required to move water from agricultural fields in order to produce row crops. In these areas, materials applied to agricultural soils are directly transported to downstream waterbodies.

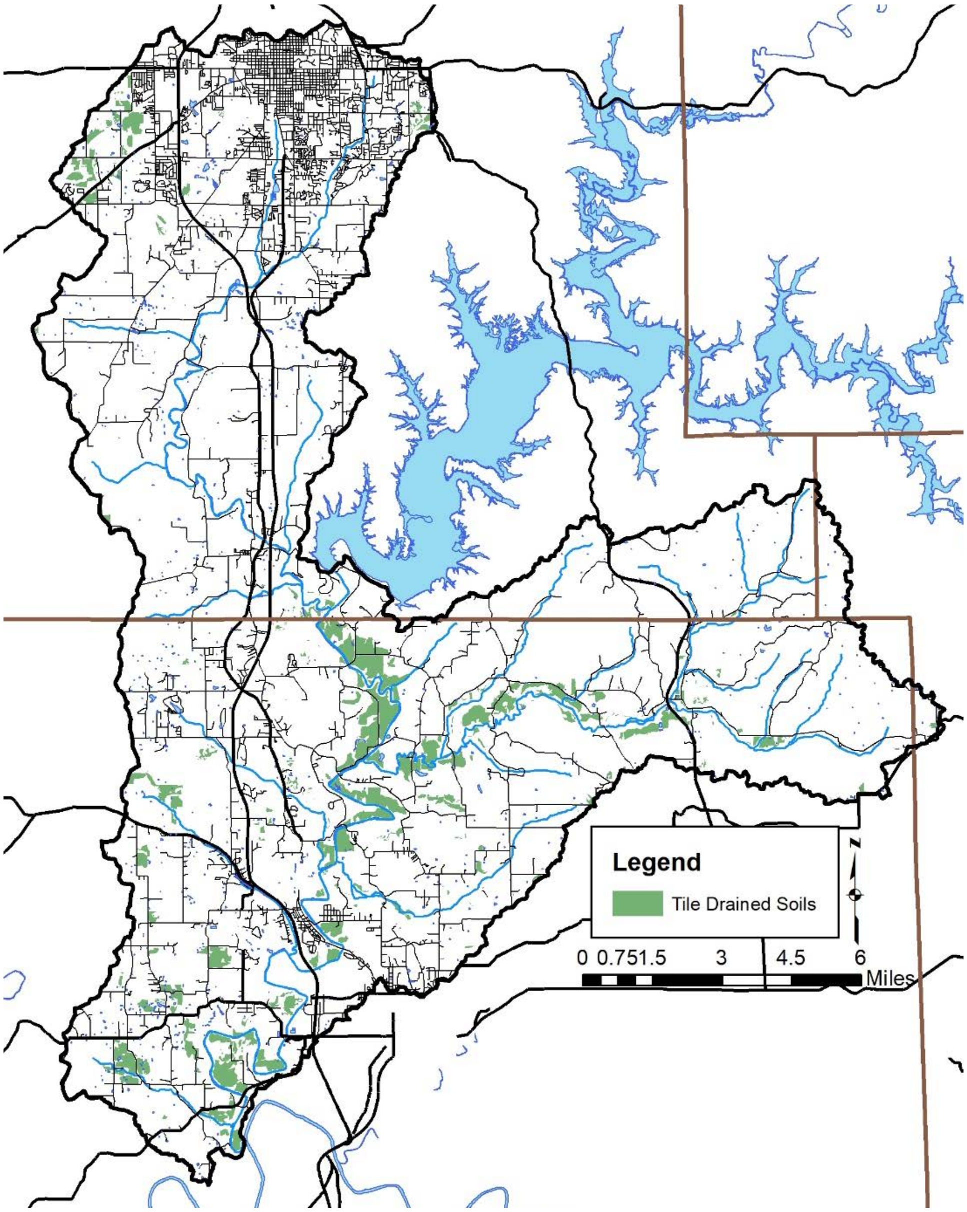

Figure 10. Tile-drained soils in the Lower Salt Creek Watershed.

2.6 Wastewater Treatment

2.6.1 Soil Septic Tank Suitability

Throughout Indiana, households depend upon septic tank absorption fields in order to treat wastewater. Seven soil characteristics, including position in the landscape, soil texture, slope, soil structure, soil consistency, depth to limiting layers, and depth to seasonal high water table, are utilized to determine suitability for on-site septic treatment. Septic tanks require soil characteristics that allow for gradual movement of wastewater from the surface into the groundwater. A variety of characteristics limit the ability for soils to adequately treat wastewater. High water tables, shallow soils, compact till, and coarse soils all limit soils abilities in their use as septic tank absorption fields. Specific system modifications are necessary to adequately address soil limitation; however, in some cases, soils are too poor for treatment and therefore prove inadequate for use in septic tank absorption fields.

Until 1990, residential homes located on 10 acres or more and occurring at least 1,000 feet from a neighboring residence were not required to comply with any septic system regulations. In 1990, a new septic code corrected this loophole. Current regulations address these issues and require that individual septic systems be examined for functionality. Additionally, newly constructed systems cannot be placed within the 100-year floodplain and systems installed at existing homes must be placed above the 100-year flood elevation. However, many residences grandfathered into this code throughout the state have not upgraded or installed fully functioning systems (Krenz and Lee, 2005). In these cases, septic effluent discharges into field tiles or open ditches and waterways and will likely continue to do so due to the high cost of repairing or modernizing systems ($4,000 to $15,000; ISDH, 2001). Lee et al. (2005) estimates that 76,650 gallons of untreated wastewater per system is expelled in the state of Indiana annually. The true impact of these systems on the water quality in the watershed cannot be determined without a complete survey of systems.

The NRCS ranks each soil series in terms of its limitations for use as a septic tank absorption field. Each soil series is placed in one of three categories: severely limited, moderately limited, and slightly limited. Some soils are also unranked. Severe or very limited limitations delineate areas whose soil properties present serious restrictions to the successful operation of a septic tank tile disposal field. Using soils with a severe limitation increases the probability of the system's failure and increases the costs of installation and maintenance. Areas designated as having moderate or somewhat limited limitations have soil qualities which present some drawbacks to the successful operation of a septic system; correcting these restrictions will increase the system's installation and maintenance costs. Slight limitations delineate locations whose soil properties present no known complications to the successful operation of a septic tank tile disposal field. Use of soils that are rated moderately or severely limited generally require special design, planning, and/or maintenance to overcome limitations and ensure proper function.

Watershed stakeholders are concerned about the lack of maintenance associated with septic tanks, the use of soils that are not suited for septic treatment, and the presence of straight pipe systems within the watershed. These concerns are exacerbated by the fact that severely limited soils cover essentially the entire watershed (Figure 11). Nearly 88,077 acres or 68% of the watershed is covered by soils that are considered very limited for use in septic tank absorption fields. Nearly 37,696 (29%) acres are somewhat limited meaning that these soils are generally suitable for septic systems. The remaining 4,480 acres (3.4%) not rated for septic usage as it is not generally industry standard to install a septic system in these geographic locations.

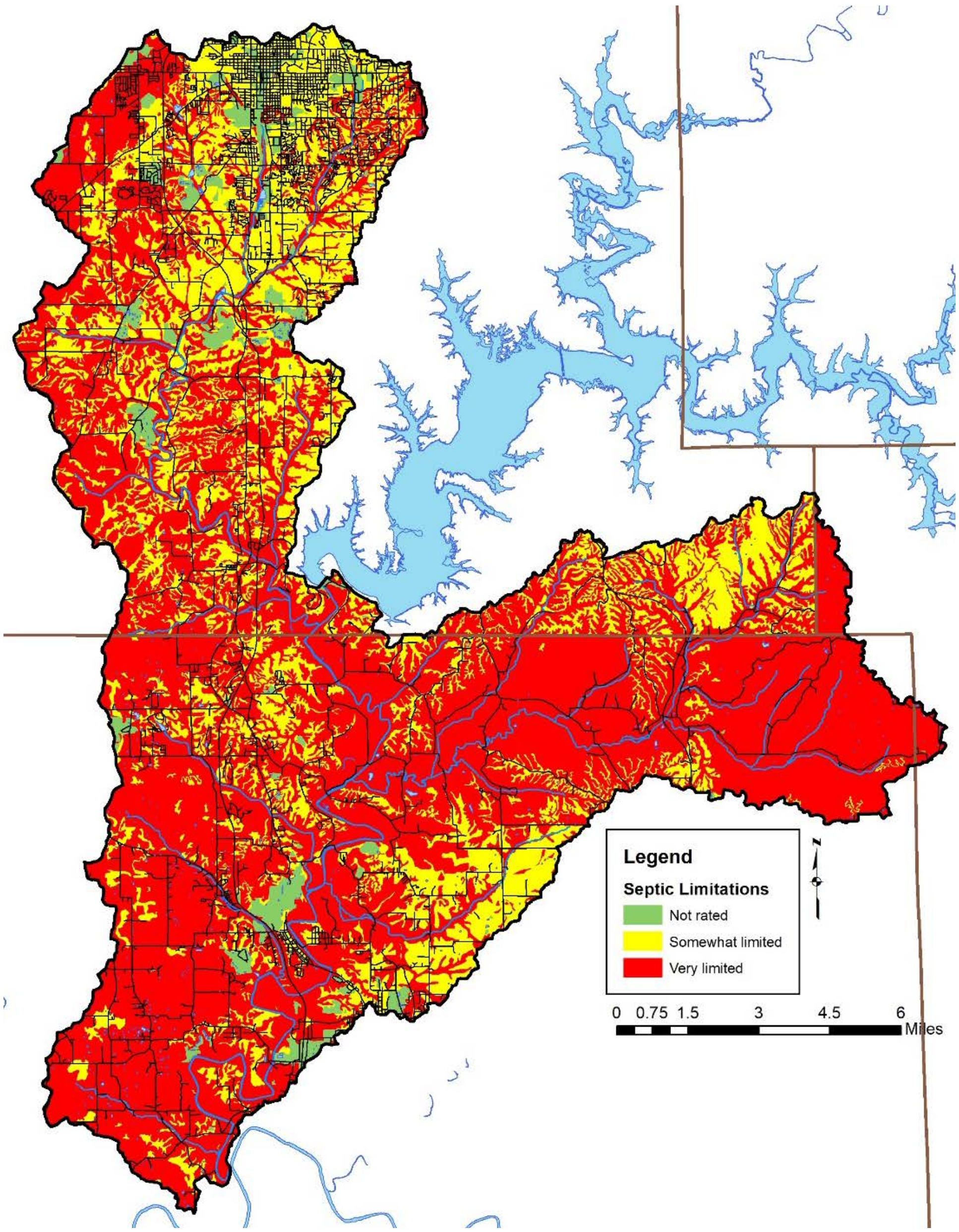

Figure 11. Suitability of soils for septic tank usage in the Lower Salt Creek Watershed.

Septic systems that are properly designed and maintained should not serve as a source of contamination to surface waters. However, septic systems do fail for a variety of reasons. Common soil-type limitations which contribute to failure are: seasonal high water tables, compact glacial till, bedrock, coarse sand and gravel outwash and fragipan. When these septic systems fail via surface breakouts or due to inadequate soil filtration there can be adverse effects to surface waters due to E. coli, nitrate, and total phosphorus (Horsely and Witten, 1996). Septic systems contain all the water discharged from homes and business and can be significant sources of pathogens and nutrients.

A comprehensive database of septic systems within the Lower Salt Creek Watershed is not available. However, the Monroe County Health Department maintains a list of septic discharge complaint properties (Figure 12). In total, 58 properties within the Lower Salt Creek Watershed are listed. Additionally, 41 lift stations and 12 campgrounds with holding tanks are present in the Lower Salt Creek Watershed. To cover the entire Lower Salt Creek Watershed and based on the IDEM TMDL for the Lower Salt Creek Watershed, the rural population of the watershed was calculated to obtain a general representation of the number of systems. It is assumed that the numbers of septic systems in the subwatersheds are directly proportional to rural household density. Based on IDEM's estimates, more than 39,900 individuals live in rural residences within the Lower Salt Creek Watershed. Those located on Group C and D soils have slow infiltration rates with finer textures and slow water movement and are of higher concern for septic system maintenance issues.

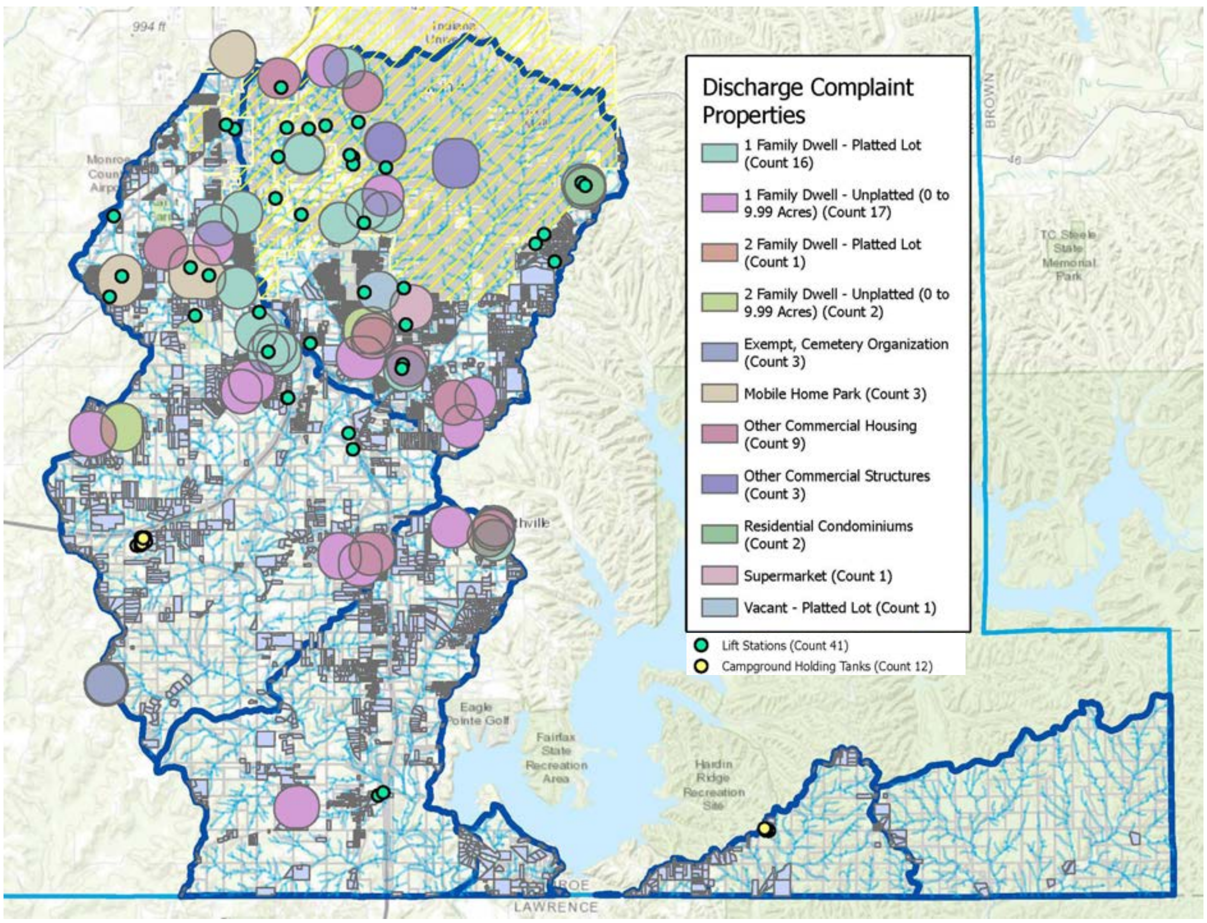

Figure 12. Potential wastewater sources in the Lower Salt Creek Watershed.
Source: Monroe County Health Department.

2.6.2 Wastewater Treatment

Several facilities which treat wastewater and are permitted to discharge the treated effluent are located within the watershed. These facilities are regulated by National Pollution Discharge Elimination System (NPDES) permits. These include several wastewater treatment plants ranging in size from small, local plants to larger, publicly-owned facilities, and school facilities. In total, 11 NPDES-regulated facilities are located within the watershed (Figure 13). Wastewater treatment plant septage sludge is applied to approximately 890 acres of the Lower Salt Creek Watershed (**Figure 14**). Table 5 details the NPDES facility name, activity, and permit number. More detailed information for each wastewater facility is discussed below.

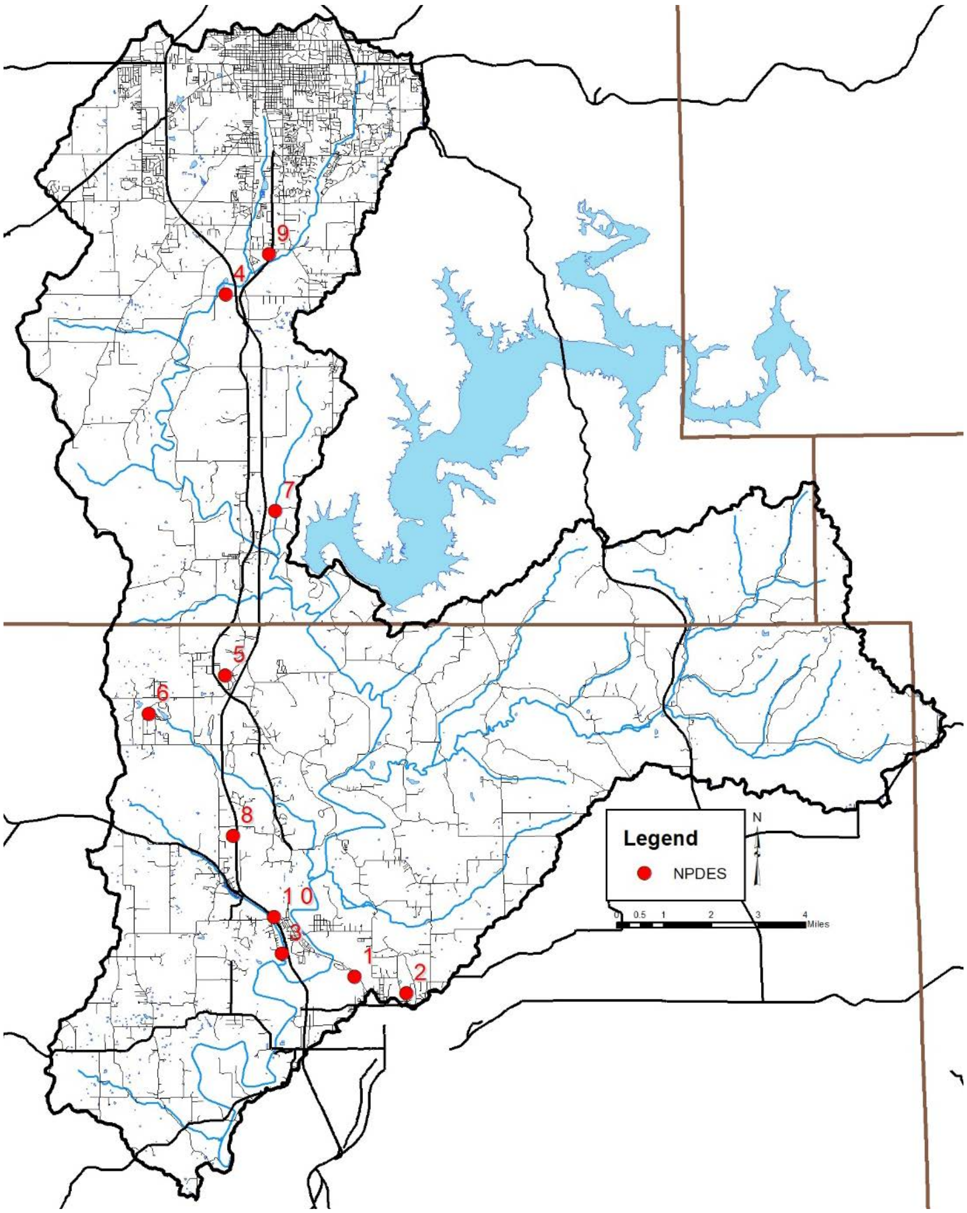

Figure 13. NPDES-regulated facilities in the Lower Salt Creek Watershed.

Table 5. NPDES-regulated facility information.

Map ID	NPDES ID	Facility Name	Volume (MGD)
1	IN0001368	INDIANA LIMESTONE MCMILLAN MIL	0.09
2	IN0003573	G.M. CORP., POWERTRAIN DIV.	0.35
3	IN0023981	OOLITIC MUNICIPAL STP	0.18
4	IN0035718	BLOOMINGTON S (DILLMAN ROAD)	15
5	IN0038920	BRIARWOOD SUBDIVISION	0.037
6	IN0042617	CAMP INDI-CO-SO	0.01
7	IN0045187	SOUTH CENTRAL RSD CASLON WWTP	0.30
8	IN0053741	NEEDMORE ELEMENTARY SCHOOL	0.01
9	ING080065	KIEL BROS. OIL CO., INC.	0.00
10	ING490057	INDIANA LIMESTONE, JOYNER MILL	0.00
11	IN0062154	PEDIGO BAY WWTP	0.022

2.6.3 Municipal Wastewater Treatment

In the relatively urban Lower Salt Creek Watershed, there are eight wastewater treatment facilities located within and discharging to Salt Creek or a tributary including Bloomington's Dillman Road WWTP, South Central RSD Caslon WWTP, Briarwood subdivision, Crest Golf Community WWTP, Oolitic WWTP and Camp Indi-co-so as well as the Needmore Elementary School and four corporate dischargers (Figure 14). None of these facilities possess combined sewer overflows.

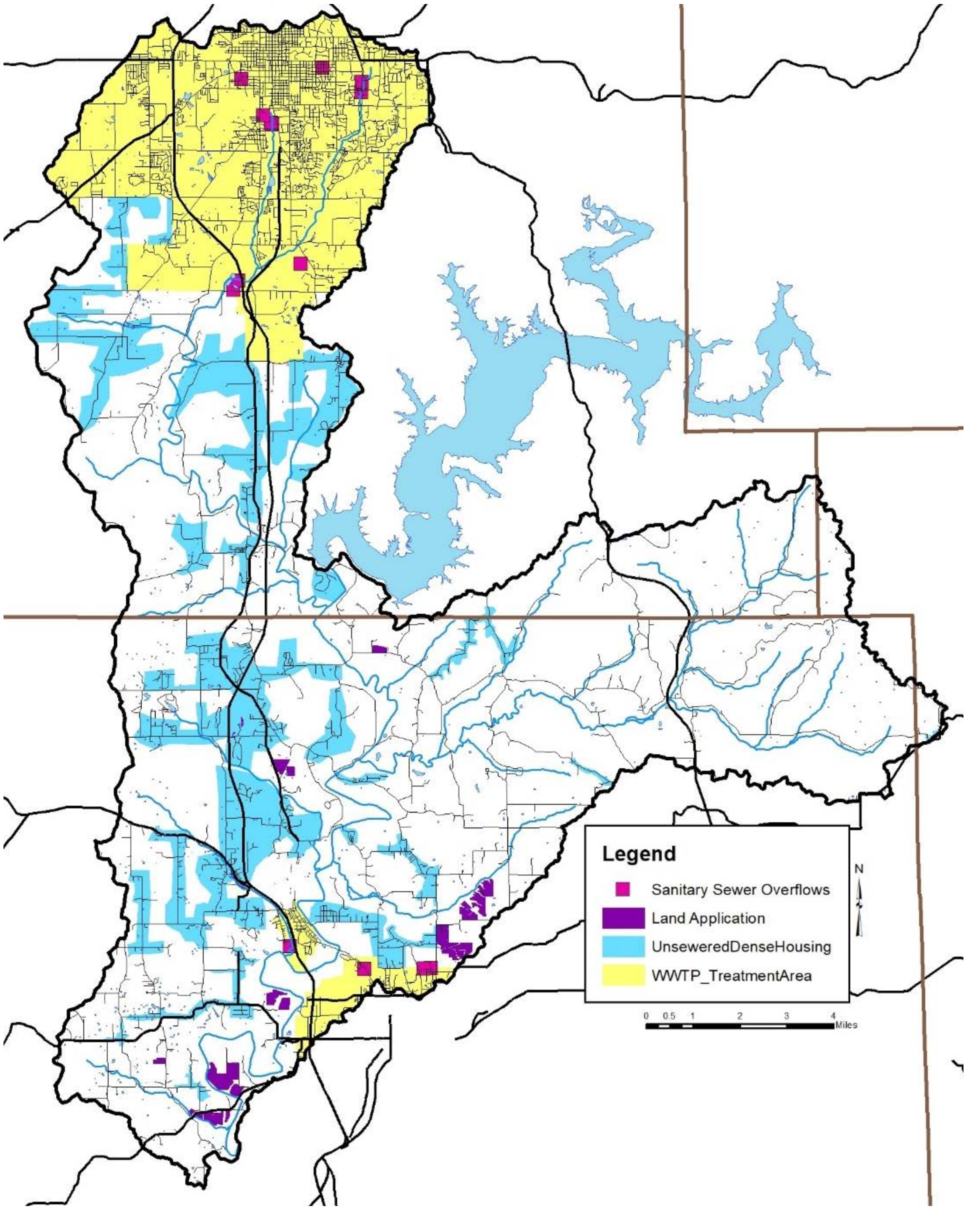

Figure 14. Wastewater treatment plant service areas, sanitary sewer overflow locations and dense unsewered housing within the Lower Salt Creek Watershed.

The Town of Oolitic currently operates a Class I, 0.35 MGD extended aeration treatment facility (Publicly Owned Treatment Works) consisting of an influent splitter box, two bar screens, two activated sludge treatment units with anoxic zones, two secondary clarifiers, ultraviolet light disinfection, and an effluent flow meter. Bio-solids are stored in an aerobic digester prior to disposal. The collection system is comprised of 100% separate sanitary sewers by design with one Sanitary Sewer Overflow (SSO).

The City of Bloomington (Dillman Road) currently operates a Class IV, 15.0 MGD (million gallons per day) wastewater treatment facility (Publicly Owned Treatment Works) with a peak design flow of 30.0 MGD. Flow equalization is accomplished via a 43-million-gallon capacity flow equalization basin with four floating aeration units. Flows to the equalization basin are controlled by a plant pump station. Return of flows to the plant are controlled by a drain using an electronic flow control valve with a flow meter. The facility also has influent and effluent flow measurement, two aerated rectangular grit chambers, two mechanically cleaned bar screens, six single-stage aeration units with step feed capability and coarse bubble diffusers, six circular center feed secondary clarifiers, four mixed media filters, a backwash tank, phosphorus removal equipment, and sodium hypochlorite disinfection and sodium bisulfite dechlorination. Solids handling includes two aerobic digesters, two gravity belt thickeners, two belt filter presses, seventeen sludge drying beds, one covered storage pad, a sludge monofill, and two solids storage lagoons. The collection system is comprised of 100% separate sanitary sewers by design with eleven Sanitary Sewer Overflow (SSO) points.

Briarwood Subdivision currently operates a Class I, 0.037 MGD extended aeration treatment facility (Publicly Owned Treatment Works) consisting of an aeration tank, an effluent clarifier, an ultraviolet light disinfection unit, post aeration, and an effluent flow meter. Final solids are hauled off-site by a licensed contractor. The collection system is comprised of 100% separate sanitary sewers by design with no overflow or bypass points.

Camp Indi-Co-So currently operates a Class I, 0.010 MGD extended aeration treatment facility (Semipublic facility) with a bar screen, aerobic digestion, settling, effluent chlorination, a terminal lagoon, and an effluent flow meter. The collection system is comprised of 100% separate sanitary sewers by design with no overflow or bypass points.

The South Central Regional Sewer District currently operates the Caslon Wastewater Treatment Plant (Semipublic facility), a Class II, 0.3 MGD extended aeration treatment facility consisting of three package type extended aeration units with a 1.0 million gallon equalization basin, post aeration, ultraviolet light disinfection, and effluent flow measurement. The collection system is comprised of 100% separate sanitary sewers by design with no overflow or bypass points.

Needmore Elementary School operates a Class I, 0.009 MGD extended aeration package treatment facility consisting of a bar screen, a 6,000-gallon flow equalization basin, a 12,000 gallon aeration basin, a 900 gallon sludge holding tank, a 1,500 gallon secondary clarifier tank, ultraviolet lights and intensity meter, a flow meter, two 9,000 gallon polishing tanks and a lift station to Outfall 001. The collection system is comprised of 100% separate sanitary sewers by design with no overflow or bypass points.

Stone Crest Golf Community Wastewater Treatment Plants currently operates a Class I, 0.04 MGD extended aeration treatment facility (Semipublic facility) consisting of a flow equalization tank, a comminutor, a sludge holding tank, an aeration basin, two secondary clarifiers, ultraviolet light disinfection, post aeration, and a flow meter. Final solids are hauled off-site by a contract hauler. The collection system is comprised of 100% separate sanitary sewers by design with no overflow or bypass points.

The Pedigo Bay Wastewater Treatment Plant operates a Class I, 0.022 MGD extended aeration package-type treatment facility consisting of a surge tank, an aeration chamber, clarifiers, a sludge holding tank and return system, ultraviolet light disinfection, and post aeration which drains from the watershed into Lake Monroe. Biosolids are hauled off site. The collection system is comprised of 100%

separate sanitary sewers by design, with no overflow or bypass points. Pedigo Bay is not included in Figure 13 as it is located upstream of the Lower Salt Creek watershed and discharges into Lake Monroe.

Table 6 details permit compliance issues for wastewater treatment plants in the Lower Salt Creek Watershed. As noted in the sanitary sewer overflow section below, the City of Bloomington, Town of Oolitic and City of Bedford are working with IDEM to address on-going compliance issues.

Table 6. Permit compliance notes for wastewater treatment plans in the Lower Salt Creek Watershed.

Facility	Compliance Issues	Parameter
Oolitic WWTP/STP	No violation	--
Bloomington S. Dillman Road	In violation	Chlorine (monthly and daily average, 2016, 2019) TSS (weekly average, 2016, 2019)
Briarwood Subdivision WWTP	Potential violation	Ammonia (weekly average, 2013)
Camp Indi-Co-So	No violation	--
South Central RSD Caslon	Potential violation	TSS (monthly average, 2015)
Needmore Elementary School	No violation	--
Stone Crest Golf Community WWTP	In violation	E. coli (daily, 2017) Ammonia (weekly and monthly average, 2012-Present) Chlorine (daily and monthly average, 2012-Present) TSS (weekly average, 2016, 2020)
Pedigo Bay WWTP	No violation	--

2.6.4 Sanitary Sewer Overflows

According to U.S. EPA, sanitary sewer systems collect and transport domestic, commercial, and industrial wastewater and limited amounts of stormwater and infiltrated ground water to treatment facilities for appropriate treatment. Sanitary sewers are different than combined sewers, which are designed to collect large volumes of stormwater in addition to sewage and industrial wastewater. Occasionally, sanitary sewers will release raw sewage resulting in a sanitary sewer overflow (SSO). EPA estimates there are at least 23,000 to 75,000 SSOs per year in the United States.

SSOs are unintentional and illegal discharges of raw sewage from municipal sanitary sewers. SSOs discharge *E. coli* to waterbodies and may occur due to:

- Severe weather resulting in excessive runoff of storm water into sewer lines
- Blockages
- Improper operation and maintenance
- Malfunction of lift stations
- Electrical power failures
- Vandalism

Overflows in the sanitary sewer system or in a sanitary portion of a combined sewer system are expressly prohibited from discharging at any time. Should any release from the sanitary sewer system occur, the permittee is required to notify the IDEM Compliance Data Section within 24 hours (oral) and within 5 days (written). There are three SSO systems in the Lower Salt Creek Watershed – the City of Bloomington's Dillman Road wastewater treatment plant, the Town of Oolitic Wastewater Treatment Plant and a portion of the City of Bedford wastewater treatment plant (Figure 14;Table 7).

Table 7. Sanitary sewer overflows in the Lower Salt Creek Watershed.

Facility Name	Permit Number	Type	Outfall Number
Bloomington-Dillman Road WWTP	IN0035718	Man hole	004
Bloomington-Dillman Road WWTP	IN0035718	Man hole	014
Bloomington-Dillman Road WWTP	IN0035718	Man hole	019
Bloomington-Dillman Road WWTP	IN0035718	Man hole	064
Bloomington-Dillman Road WWTP	IN0035718	Man hole	068
Bloomington-Dillman Road WWTP	IN0035718	Man hole	069
Bloomington-Dillman Road WWTP	IN0035718	Man hole	072
Bloomington-Dillman Road WWTP	IN0035718	Man hole	073
Bloomington-Dillman Road WWTP	IN0035718	Man hole	035
Bloomington-Dillman Road WWTP	IN0035718	Man hole	002
Bloomington-Dillman Road WWTP	IN0035718	Man hole	066
Bedford WWTP	IN0025623	Lift station	002
Bedford WWTP	IN0025623	Lift station	008
Bedford WWTP	IN0025623	Lift station	009
Oolitic WWTP	IN0023984	Lift station	002

City of Bloomington-Dillman Road Wastewater Treatment Plant

The City of Bloomington transports wastewater to the City of Bloomington-Dillman Road WWTP. The collection system is comprised of 100% separate sanitary sewers by design with eleven SSO points. The SSO locations have been identified and prohibited in the facility's permit. The City developed an Agreed Order in 2005 which aims in part to address the system's SSOs. According to the Agreed Order, the SSO Elimination Plan will identify corrective actions necessary to eliminate sanitary sewer overflows from the wastewater collection system and create a schedule for the completion of such actions. The SSO Elimination Plan scope includes:

- Attending meetings with the City of Bloomington Utilities (CBU) and IDEM to discuss the proposed Project Plan that will become the basis for the development of the SSO Elimination Plan
- Reviewing and summarizing previous relevant studies and sewer work performed to date for inclusion into the Plan, in addition to summarizing the historical SSO data and showing trends versus precipitation
- Using hydraulic sewer modeling software to estimate collection system hydraulic capacity. Tabulating wet weather SSO frequency, duration, and estimated volume for multiple levels of control

- Meeting with CBU staff to prepare an agenda to set and meet goals for public participation
- Coordinating with CBU's financial and rate consultant regarding financing for corrective action projects
- Preparing a draft report summarizing findings and recommendations

City of Bedford Wastewater Treatment Plant

The collection system is comprised of 100% separate sanitary sewers by design with nineteen SSO points. While this facility and main outfall are located outside of the Lower Salt Creek watershed, three of the SSO points fall within the watershed. In 2014 the City of Bedford developed a Sewer Master Plan that aims at addressing SSOs. The proposed projects are divided between two major sewersheds referred to as the Westside System and the Eastside System. According to the Sewer Master Plan, when considering SSO, stormwater and unsewered area issues collectively, the financial capability analysis demonstrates that Bedford will be in the "High Burden" category. Therefore, Bedford has put a plan together that would take approximately 20 years to complete based on EPA guidance for high burden communities. This plan allows for phased construction of the SSO improvements. The City of Bedford intends to continue the existing monitoring effort that has provided good information with regard to the magnitude of the SSO volumes. The City of Bedford will also be expanding the monitoring program to include newly discovered overflows to better understand the behavior of the system during wet weather.

The Eastside System will include four phases as will the Westside System.

2.6.5 Unsewered Areas

Approximately 2,860 acres of unsewered areas were identified within the watershed (Figure 14). Areas that have at least 25 houses within a square mile outside of the sanitary district boundaries were classified as dense, unsewered areas.

2.7 Hydrology

Watershed streams, reservoirs, legal drains, floodplains, wetlands, storm drains, groundwater, subsurface conveyances, and manmade drainage channels all contribute to the watershed's hydrology. Each component moves water into, out of, or through the system. Their contributions will be covered in further detail in subsequent sections.

2.7.1 Watershed Streams

The Lower Salt Creek Watershed contains approximately 659 miles of perennial streams, regulated drains, tile drains, underground pipes and artificial channels in the Lower Salt Creek Watershed (Figure 15). Of these, approximately 25.6 miles are regulated drains, 37.7 miles are pipes and 123 miles are tile drains. Clear Creek, Campus River and their tributaries have been significantly modified and flow as underground streams in pipes through Indiana University and Bloomington. The majority of streams in the Lower Salt Creek Watershed are not regulated. It should be noted that regulated drains are maintained by the county surveyor's office and all of the regulated drains within the watershed have both a regular maintenance fund and a regular maintenance schedule. Maintenance practices can include dredging with large construction equipment to maintain flow, debris removal, and vegetation management both within the regulated drain and the riparian zone. As these waterbodies are subject to periodic cleaning, it is important to work with the county surveyor to establish priorities for these waterbodies in terms of water quality improvement and erosion control. Each time a ditch is cleaned out or maintained, this action increases the amount of sediment going downstream towards the mainstem of Lower Salt Creek.

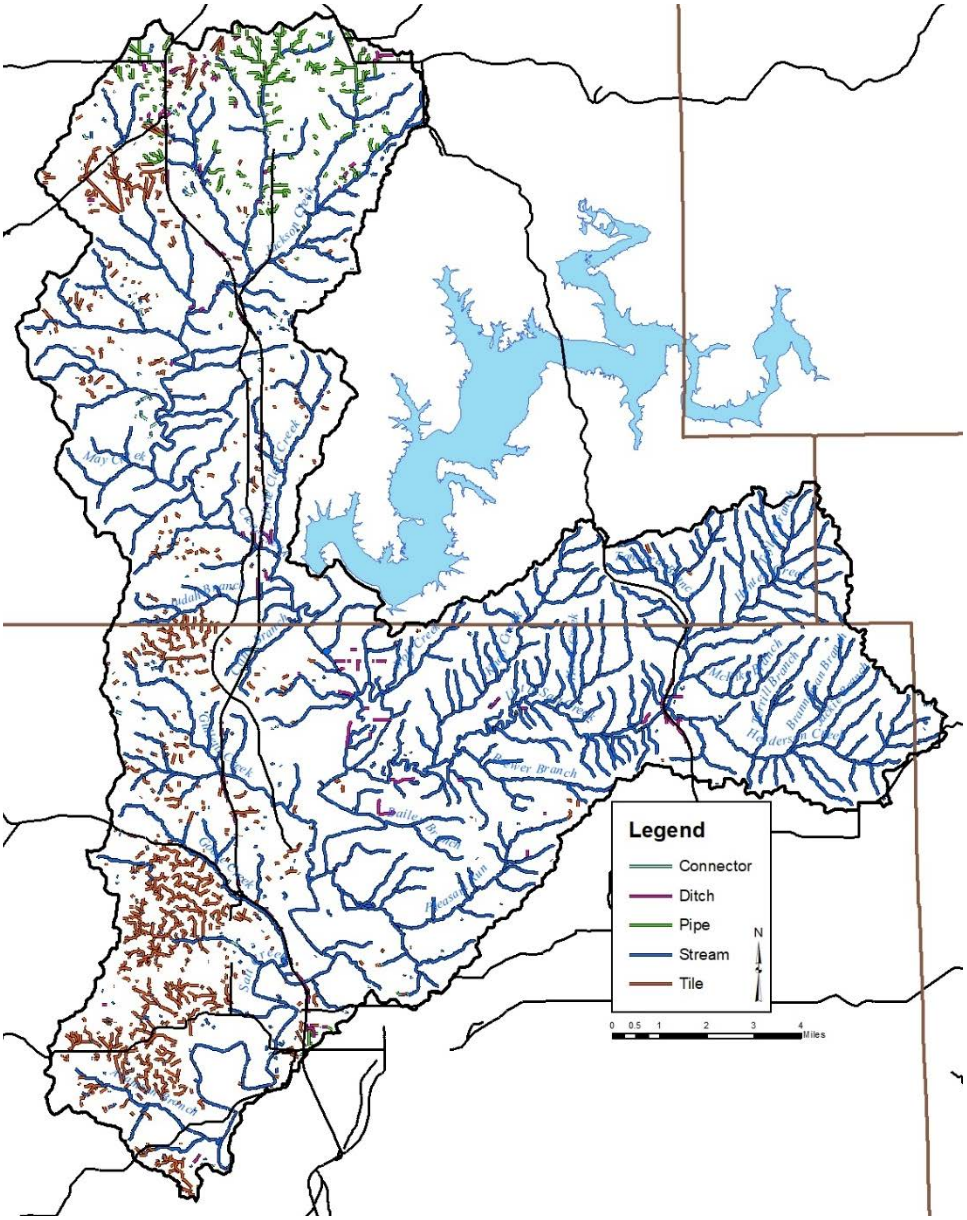

Figure 15. Waterbodies by type in the Lower Salt Creek Watershed.

Salt Creek flows 26.4 miles from the tailwaters of Lake Monroe to its confluence with the East Fork-White River. The major tributaries to Lower Salt Creek include Clear Creek, Little Salt Creek, Gulletts Creek, Pleasant Run, Knob Creek, Henderson Creek, Goose Creek, Jackson Creek, Little Clear Creek, Hunter Creek, Judah Branch, Adamson Branch, Brewer Branch, McPike Branch, Terrill Branch and Wolf Creek (Table 8). Lower Salt Creek from the tailwaters to the mouth is used for recreational kayaking and canoeing as well as fishing, swimming, and aesthetic enjoyment. Several tributaries to Lower Salt

Creek Creek are also used for canoeing, kayaking, fishing and aesthetic enjoyment. Stakeholders are concerned with maintaining the recreational value of the creeks and have some concerns because portions of the watershed have been designated as impaired by IDEM for *E. coli*, nutrients, impaired biotic communities, mercury and PCBs. Salt Creek and Clear Creek are both designated as non-consumption streams due to historic PCB contamination.

Table 8. Streams in the Lower Salt Creek watershed.

Stream Name	Length (mi)	Stream Name	Length (mi)
Mose Ray Branch	1.6	Judah Branch	4.4
Howe Creek	2.1	Hunter Creek	4.9
Bailey Branch	2.2	Little Clear Creek	5.3
Taylor Branch	2.4	Jackson Creek	6.1
Jackie Branch	2.4	Goose Creek	6.5
Tanyard Branch	2.5	Henderson Creek	7.5
May Creek	2.6	Knob Creek	7.8
Clifty Branch	2.6	Pleasant Run	7.9
Wolf Creek	3.0	Gulletts Creek	8.6
Brannaman Branch	3.4	Little Salt Creek	15.5
Terrill Branch	3.5	Clear Creek	19.6
McPike Branch	3.8	Salt Creek	26.4
Brewer Branch	4.3	Unnamed tributary	502.6
Adamson Branch	4.4		

2.7.2 Lakes, Ponds and Impoundments

Nearly 1000 small lakes and ponds dot the Lower Salt Creek Watershed landscape. In total, lakes cover nearly 374 acres of the Lower Salt Creek Watershed. The largest of these, Weimer Lake, Twin Lakes, Tower Blackwell Lake, Jay Pond, Hunter Creek Pond and Geiger Ridge Pond measure 5 acres or less. In total two dam structures create Weimer Lake and Camp Indi-Co-So's lake, which range in size from 2.2 to just over 4.7 acres (Figure 16). These provide local swimming holes, recreational boating options, and localized fishing as well as providing water storage and retention to assist with flooding. Two additional, in channel dams are located on Goose Creek at the Old Avoca State Fish Hatchery. The DNR recently transferred ownership to Marshall Township in Lawrence County. The Avoca Spring Dam was used as a water supply for fish hatchery operations. Currently, the Goose Creek Dam is not functional but does allow passage of aquatic life at all water levels. The Avoca Spring Dam impounds spring water and overflows into a manmade channel approximately 100 yards to the confluence of Goose Creek. Many are located in tributary headwaters and offer some water retention; however, most are insignificant in size or water quality impact. The Avoca Fish Hatchery dams are considered lowhead dams. There is an additional lowhead dam located on Henderson Creek. Stakeholders noted concern of this dam and the continued hazard and fish passage impacts it has.

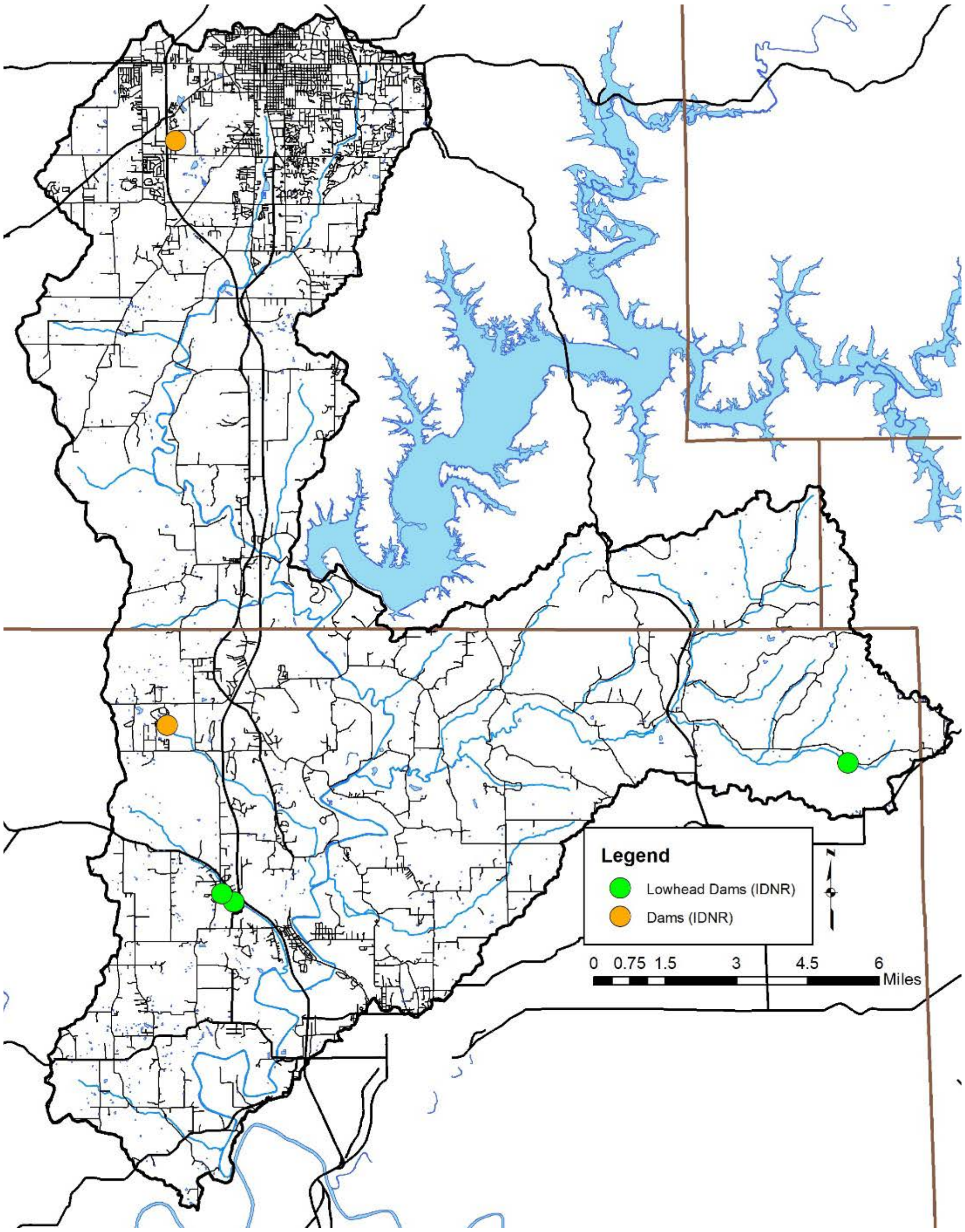

Figure 16. Lakes and dams including lowhead dams located in the Lower Salt Creek Watershed.

2.7.3 Floodplains

Flooding is a common hazard that can affect a local area or an entire river basin. Increased imperviousness, encroachment on the floodplain, deforestation, stream obstruction, tiling, or failure of a flood control structure all are mechanisms by which flooding occurs. Impacts of flooding include property and inventory damage, utility damage and service disruption, bridge or road impasses, streambank erosion and riparian vegetation loss, water quality degradation, and channel or riparian area modification.

Floodplains are lands adjacent to streams, rivers, and other waterbodies that provide temporary storage for water. These systems act as nurseries for wildlife, offer green space for humans and wildlife, improve water quality, and buffer the waterbody from adjacent land uses. Local stakeholders are concerned about impacts to floodplains from development, lack of landowner maintenance, and soil erosion and deposition within the floodplain.

Figure 17 details the locations of floodplains within the Lower Salt Creek Watershed. Narrow floodplains lie adjacent to Jackson Creek, Clear Creek, Little Salt Creek, Pleasant Run and several Clear Creek unnamed tributaries. The widest floodplain lies adjacent to Salt Creek from the Lake Monroe tailwaters to the confluence with the East Fork White River. Approximately 9% (12,257.8 acres) of the Lower Salt Creek Watershed lies within the 100-year floodplain (Figure 17). This 100-year floodplain is composed of three regions:

- Zone A is the area inundated during a 100-year flood event for which no base flood elevations (BFE) have been established. A majority of the Lower Salt Creek Watershed floodplain is in Zone A or nearly 11,278 acres (8.7% of the watershed).
- Zone AE is the area inundated during a 100-year flood event for which BFEs have been determined. The chance of flooding in Zone AE is the same as the chance of flooding in Zone A; however, floodplain boundaries in Zone A are approximated, while those in Zone AE are based on detailed hydraulic models which allows Zone AE floodplains to be more accurate. Nearly 960 acres (0.74%) of the Lower Salt Creek Watershed floodplain is in Zone AE.
- Zone X includes areas outside the 100-year and 500-year floodplains which have a 1% chance of flooding to a depth of one foot of water. No BFEs are available for these areas and no flood insurance is required.

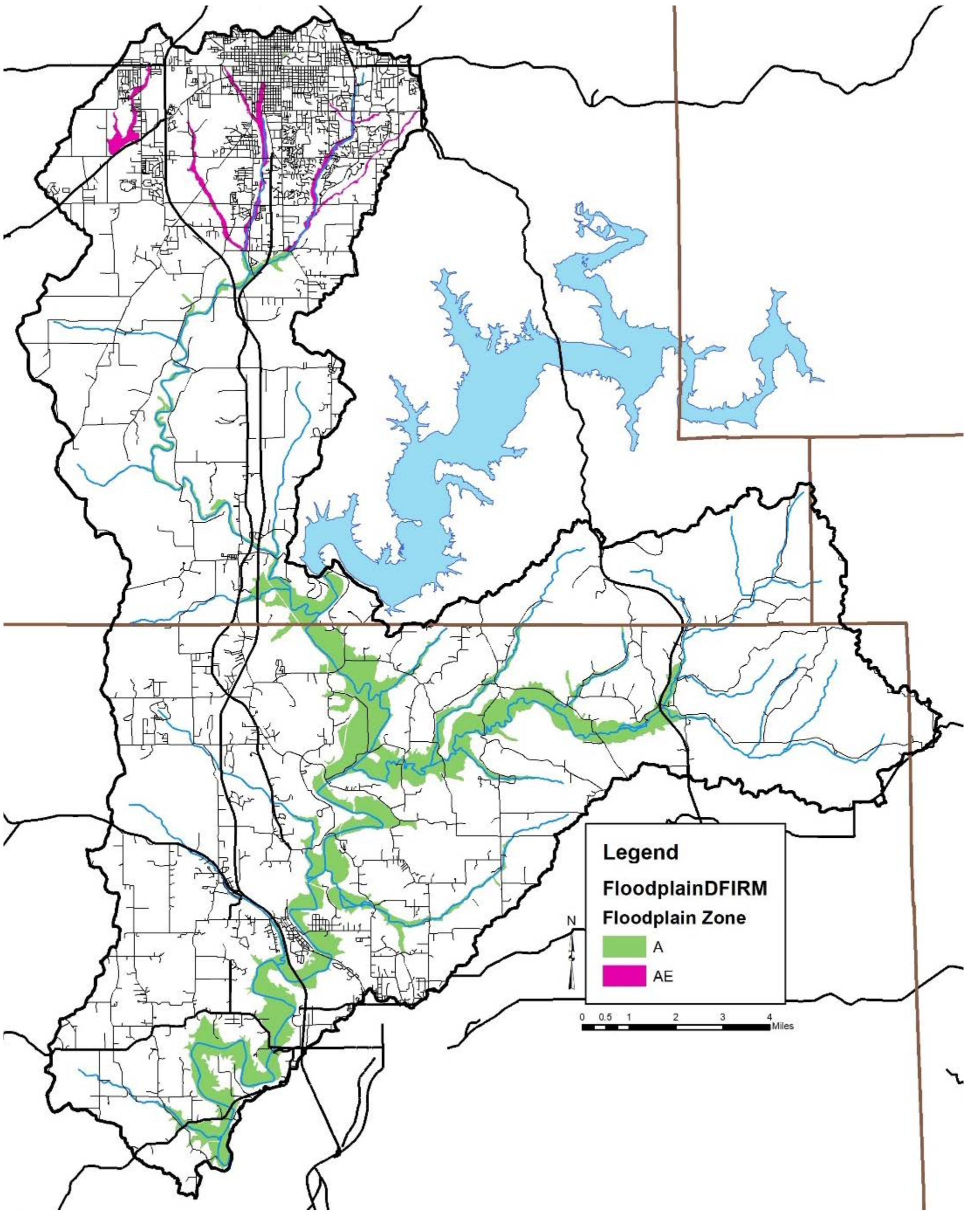

Figure 17. Floodplain locations within the Lower Salt Creek Watershed.

2.7.4 Wetlands

Approximately 25% of Indiana was covered by wetlands prior to European settlement (IDEM, 2007). Overall, 85% of wetlands have been lost resulting in Indiana ranking fourth in the nation in terms of percentage of wetland loss. Wetlands provide numerous valuable functions that are necessary for the health of a watershed and waterbodies. Wetlands play critical roles in protecting water quality, moderating water quantity, and providing habitat. Wetland vegetation adjacent to waterways stabilizes shorelines and streambanks, prevents erosion, and limits sediment transport to waterbodies. Additionally, wetlands have the capacity to increase stormwater detention capacity, increase stormwater attenuation, and moderate low water levels or flow volumes by allowing groundwater to slowly seep back into waterbodies. These benefits help to reduce flooding and erosion. Wetlands also serve as high quality natural areas providing breeding grounds for a variety of wildlife. They are typically diverse ecosystems which can provide recreational opportunities such as fishing, hiking, boating, and bird watching. It should be noted that natural wetlands are regulated through the IDEM and the U.S. Army Corps of Engineers while USDA has jurisdiction over wetlands on agricultural fields. Any modification to wetlands requires permits from these agencies.

Wetlands cover only 58.3 acres, or 1.7%, of the watershed. When hydric soil coverage is used as an estimate of historic wetland coverage, it becomes apparent that more than 82% of wetlands have been modified or lost over time. This represents more than 10,000 acres of wetland loss within the Lower Salt Creek Watershed. As commodity prices continue to go up and down, area land values remain high and as a result, individuals are spending a great deal of money to drain small natural wetlands in their fields in order to be able to farm that additional couple acres of land as it is cheaper to tile it than to buy ground already in production.

Figure 18 shows the current extent of wetlands within the Lower Salt Creek Watershed. Wetlands displayed in Figure 18 results from compilation efforts by the U.S. Fish and Wildlife Service as part of the National Wetland Inventory (NWI). The NWI was not intended to map specific wetland boundaries that would compare exactly with boundaries derived from ground surveys. As such, NWI boundaries are not exact and should be considered to be estimates of wetland coverage. Using this map will help us to identify which portions of the watershed would make ideal candidates for wetland restoration efforts which would reduce the amount of sediment and nutrients reaching the creek, as well as helping to restore the natural hydrology of the area which could help to reduce flooding impacts locally.

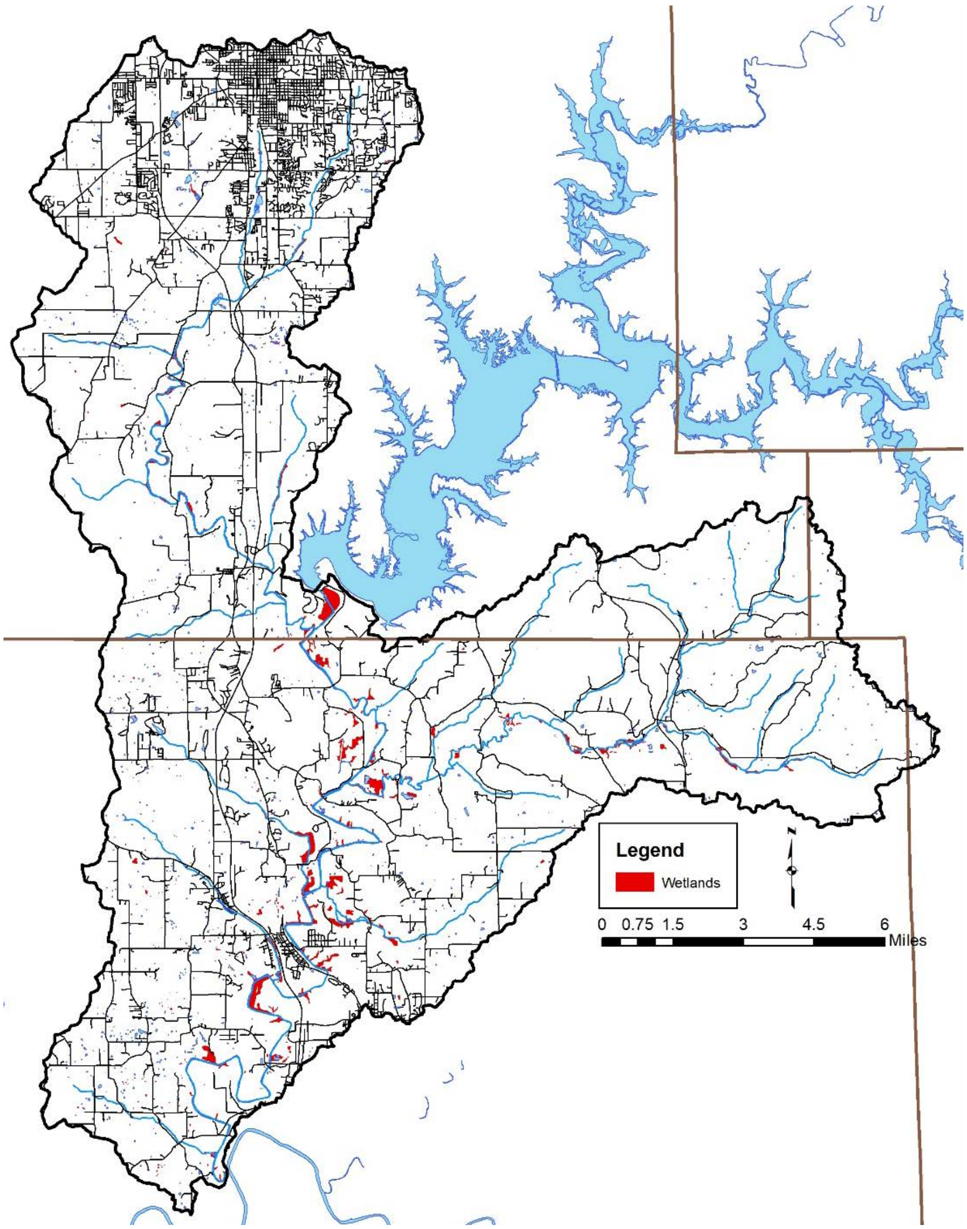

Figure 18. Wetland locations within the Lower Salt Creek Watershed. Source: USFWS, 2017.

2.7.5 Stormwater and Storm Drains

Under natural conditions, the majority of precipitation is allowed to infiltrate the soil and recharge groundwater resources. The volume of infiltration and groundwater recharge diminishes as development increases. To handle the large volume of precipitation falling in urban areas, stormwater systems have been constructed. Storm drain systems are present in most urban areas throughout the watershed. There are four municipal separate storm sewer systems (MS4) in the Lower Salt Creek Watershed. MS4s are defined as a conveyance or system of conveyances owned by a state, city, town, or other public entity that discharges to waters of the United States and is designed or used for collecting or conveying storm water. Regulated conveyance systems include roads with drains, municipal streets, catch basins, curbs, gutters, storm drains, piping, channels, ditches, tunnels and conduits. It does not include CSOs and publicly owned treatment works. Figure 19 details the MS4 boundaries for the Monroe County, Indiana University Bloomington, City of Bloomington and City of Bedford MS4s as well as the area that Monroe County identifies as their urbanizing zone (13,002 acres). It should be noted that the Monroe County urbanizing zone is managed by a regulatory ordinance but is not part of the Monroe County MS4. The management of this zoning code is guided by the urbanizing area plan (MKSK, 2015). Monroe County and MKSK created the Monroe County urbanizing Area Plan in 2014 to fulfill a recommendation from the County Comprehensive Plan. Additional details about this plan are documented in subsequent sections of this document. More than 24,713 acres of the Lower Salt Creek Watershed are located in one of the four designated MS4s. Construction Stormwater General Permit plan review and monthly inspections are handled by Monroe County, Bloomington and Bedford MS4 staff. Any inspections and enforcement is handled on a case-by-case basis.

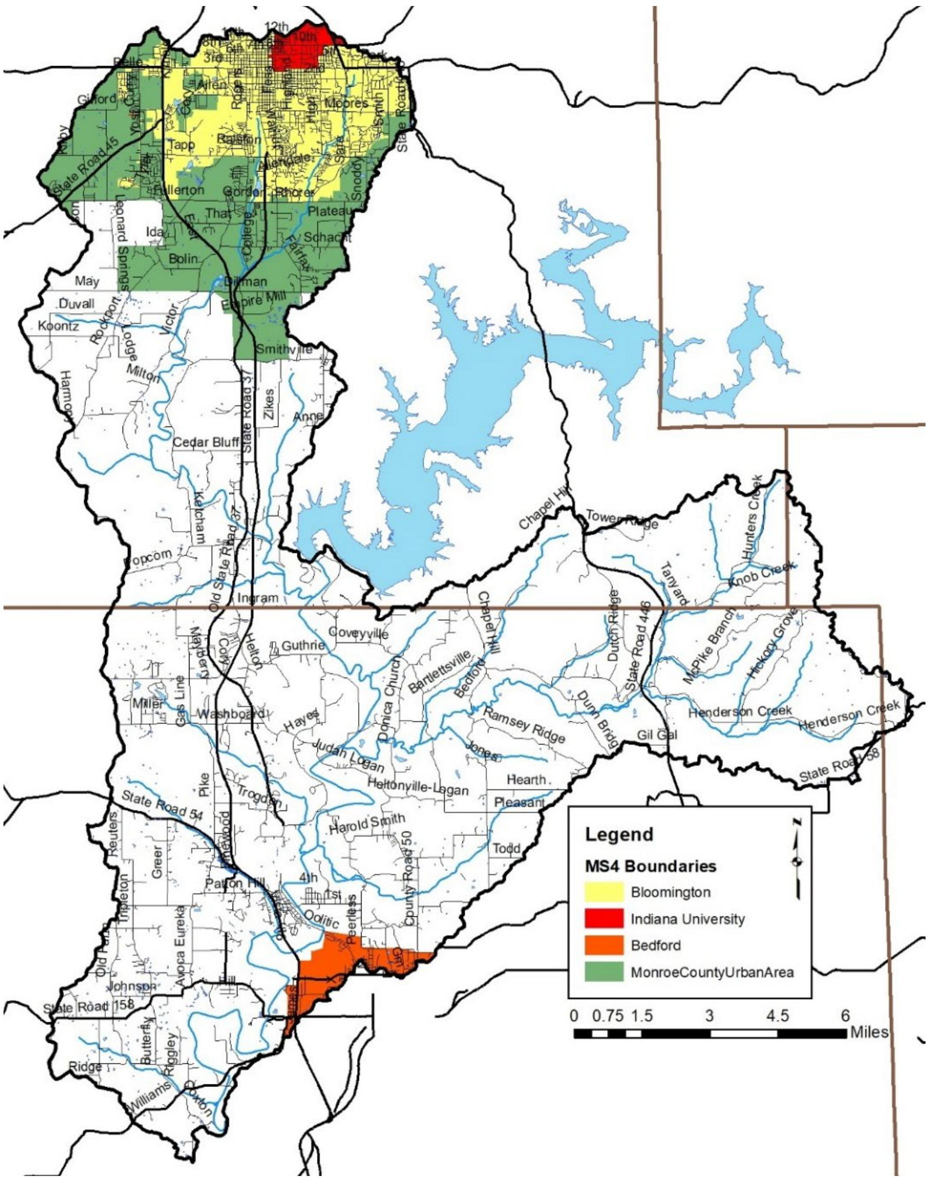

Figure 19. MS4 boundaries for Bedford, Bloomington, Monroe County and Indiana University and the Monroe County urbanizing boundary located within the Lower Salt Creek Watershed.

Table 9. MS4 communities in the Lower Salt Creek Watershed.

MS4 Community	Permit ID	Area (acres)
Monroe County	INR040089	13,322.19
IU Bloomington	INR040123	954
Bloomington	INR040136	8,904.23
Bedford	INR0400027	1,532.89

2.7.6 Wellfields/Groundwater Sensitivity

Recharge to the bedrock aquifer occurs at bedrock outcrops where precipitation enters the aquifer directly or indirectly via unconsolidated deposits. Table 10 lists wellhead protection areas within and adjacent to the Lower Salt Creek Watershed. Potential pollution from construction, sewage outfalls or overflows, illegal dumping, agriculture, and storm water runoff must be avoided or controlled due to the recharge of these aquifers from runoff and river water. The sensitivity to surface contamination is shown in Figure 20. Most of the Lower Salt Creek Watershed aquifer sensitivity rates as low or very low (<4.3 inches/year; 56%); however, 24% of the watershed rates as medium sensitivity (4.3-6.1 inches/year) while 17% rates as high sensitivity (>9.1 inches/year). In these areas, which cover much of Monroe County outside of Bloomington and the Lower Salt Creek Watershed northeast of Bedford, groundwater protections should occur as possible. Watershed stakeholders noted the preponderance of karst topography and the easy access to groundwater in these areas of the watershed and identified groundwater protection as a need in the Lower Salt Creek Watershed.

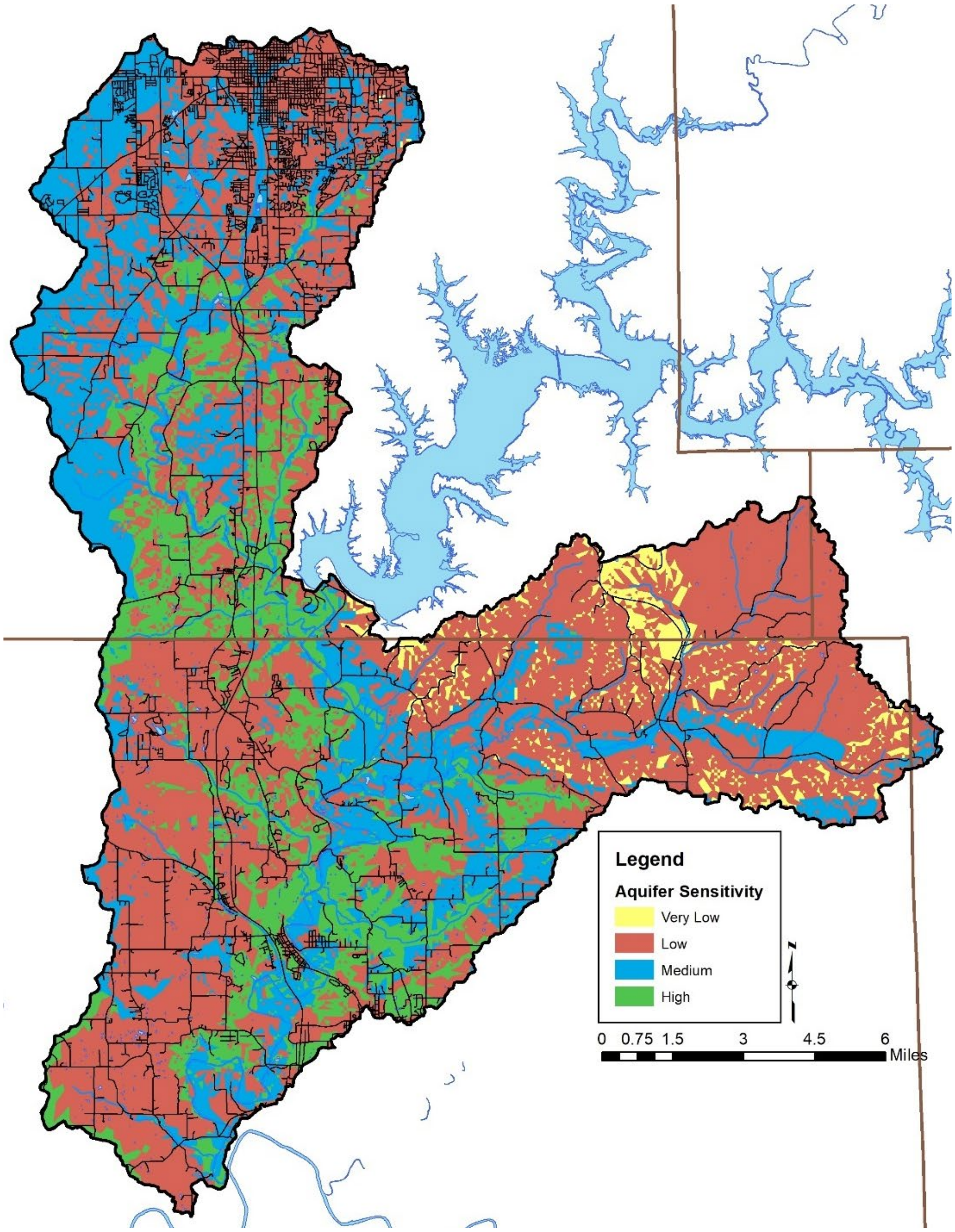

Figure 20. Aquifer sensitivity within the Lower Salt Creek Watershed. Source: IGS, 2015.

Table 10. Wellhead protection areas in and adjacent to the Lower Salt Creek Watershed.

County	PWSID	System name	Population
Lawrence	5247004	North Lawrence Water Authority	13,300
Lawrence	5247006	Blue Springs Campground	51

2.8 Natural History

Geology, climate, geographic location, and soils all factor into shaping the native flora and fauna which occurs in a particular area. Categorization of these floral and faunal communities has been completed by a number of ecologists since the earliest efforts by Coulter in 1886. Since this time, Petty and Jackson (1966) identified regional communities; Homoya et al. (1985) classified Indiana into natural regions, while Omernik and Gallant (1988) categorized Indiana into ecoregions.

2.8.1 Natural and Ecoregion Descriptions

According to Homoya et al.'s (1985) classification of natural regions in Indiana, the Lower Salt Creek Watershed lies within two regions: the Shawnee Hills Natural Region and the Highland Rim Natural Region (Figure 21). The Shawnee Hills natural region is covered by Pennsylvanian and Mississippian bedrock outcrops which form distinct cliffs and rock houses. Much of this region is driftless, rugged and generally sparsely populated. The Shawnee Hills natural Region covers the western edge of the Lower Salt Creek Watershed including much of the area west of SR 37. All of the Shawnee Hills natural region is part of the Escarpment Section. The Highland Rim Natural Region is comprised of Mississippian bedrock with outcrops of Pennsylvanian bedrock. The natural region is unglaciated. Cliffs, rugged hills, and large expanses of karst topography cover the Highland Rim Natural Region. Historically, this natural region was forested with barrens and glades intermixed with gravel wash communities in small areas. The Lower Salt Creek Watershed is comprised of the Mitchell Karst Plain and Brown County Hills Sections.

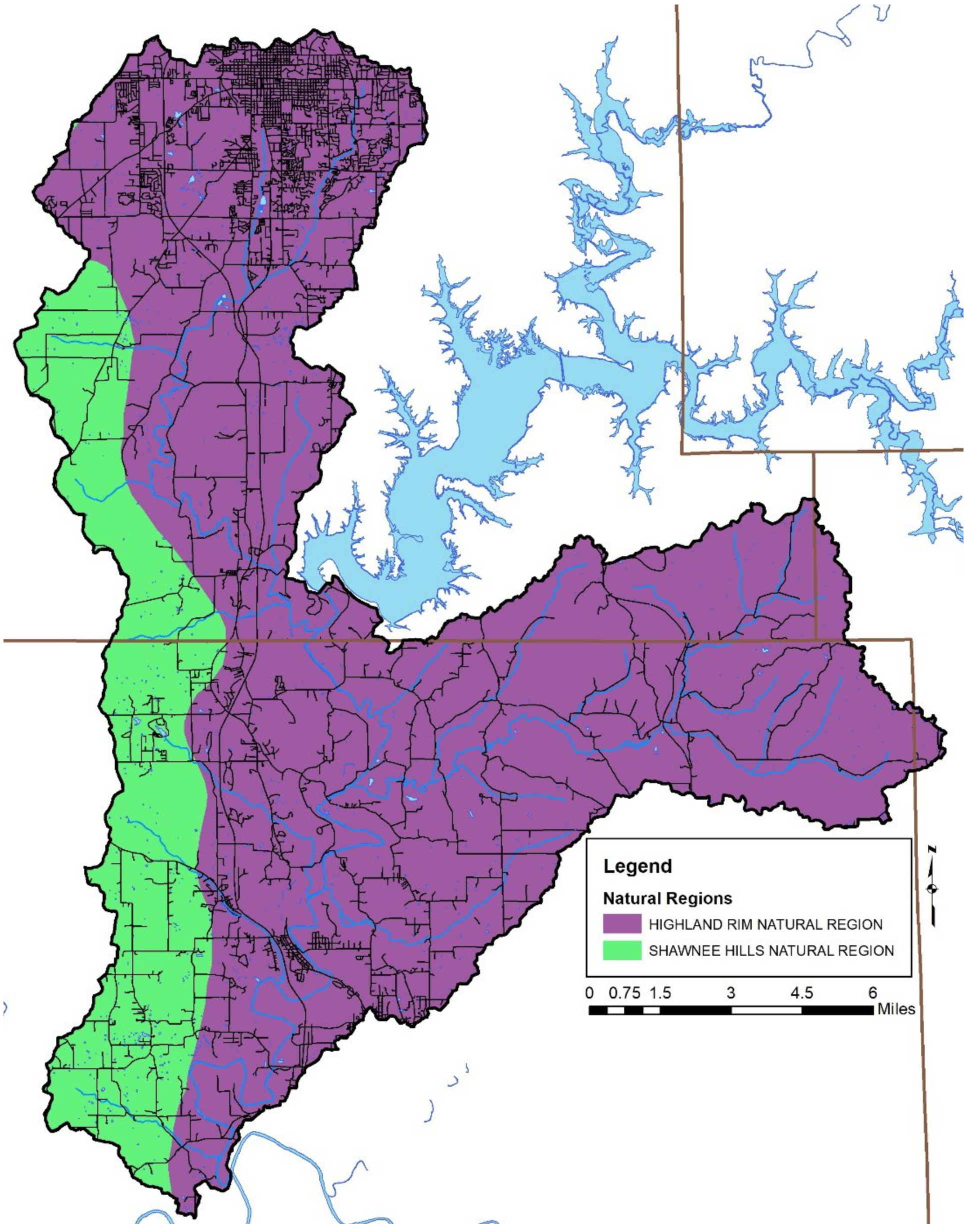

Figure 21. Natural regions in the Lower Salt Creek Watershed.

The Lower Salt Creek Watershed is mostly covered by the Mitchell Plain Ecoregion with the Knobs Norman Upland covering much of the eastern portion of the watershed and the Crawford-Mammoth Cave Uplands covering the extreme western edge of the watershed (Figure 22). The Mitchell Plain is a karst area in Indiana of relatively low relief. Soils in the Mitchell Plain are leached and largely developed from loess and limestone and is dominated by forests, karst wetland communities and limestone glades. The Crawford-Mammoth Cave Uplands ecoregion is heavily dissected by medium to high gradient streams and is more rugged and wooded. Oak forest communities are found on well-drained upper slopes, mixed forests and specialized plant communities dominate the sandstone-limestone cliff, while agricultural land occurs in wider valleys. The Knobs Norman Upland ecoregion is mostly forested and is characterized by dissected high hills and knobs, narrow valleys, and medium to high gradient streams. The silt loam soils were derived from loess, siltstone, shale, or sandstone. Originally, oak-hickory forests grew on the uplands and beech forests were found in the valleys. Today, chestnut oak has replaced American chestnut on the well-drained upper slopes; Virginia pine grows on the southern uplands.

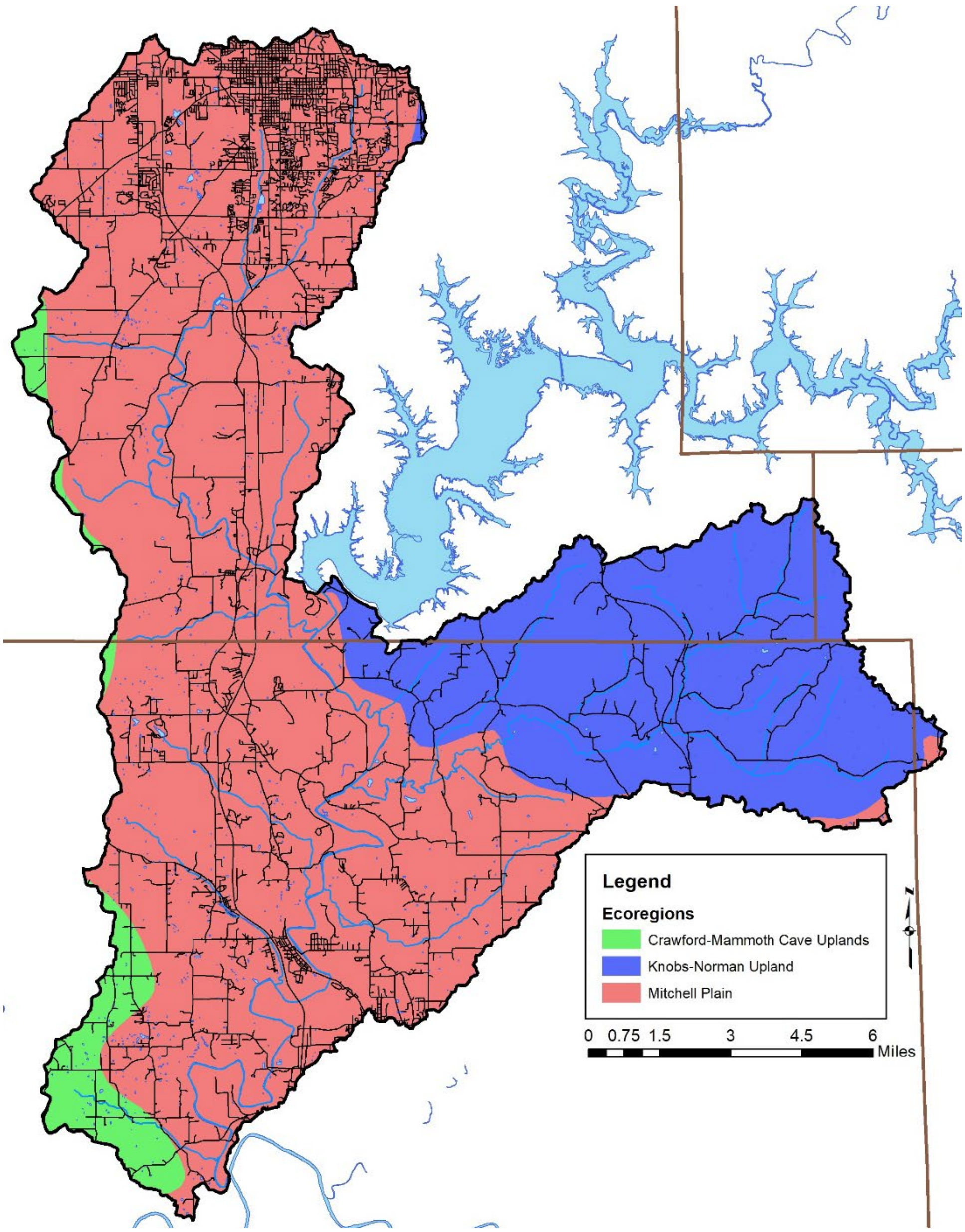

Figure 22. Level 4 eco-regions in the Lower Salt Creek Watershed.

2.8.2 Wildlife Populations and Pets

Individuals are concerned about local wildlife and pet populations, the impact that these have on pathogen levels, and the impact that changing land uses could have on these populations. These will be quantified in subsequent sections. With these concerns in mind, wildlife density can be estimated from a variety of sources. The Indiana Department of Natural Resources (IDNR) is tasked with managing wildlife populations throughout the state. In order to complete this task, the IDNR must have an idea of the population density within specific areas, counties, or regions. The most recent survey of wildlife populations for which data are publicly available occurred in 2005. Those densities are shown in Table 11 with deer, squirrels and turkey being the most common wildlife present within the region. It should be noted that these numbers could both underestimate and overestimate populations within the watershed. Densities are recorded based on animal observations per 1000 hours of overall observation. If observations areas are not equally spread throughout the region, over or underestimates of the populations could occur. Likewise, animals are not likely equally distributed throughout the region; therefore, the regional density may again over or underestimate the true density of the animal in question. Nonetheless, these estimates provide the best guess at wildlife densities. Wildlife waste will be an issue in the more natural, forested or wetland portions of the watershed.

Table 11. Surrogate estimates of wildlife density in the IDNR southwest region, which includes the Lower Salt Creek Watershed.

Animal	2005 Population Observation (per 1000 hours of observation)
Beaver	0.4
Bobcat	1.2
Bobwhite	38.6
Coyote	43.4
Deer	806.3
Fox squirrel	572
Gray fox	1.2
Gray squirrel	156.3
Grouse	4
Domestic cat	12.3
Muskrat	0.8
Opossum	14.7
Rabbit	19.9
Raccoon	41.8
Red fox	3.6
Skunk	7.6
Turkey	255.8

Source: Plowman, 2006.

Pet populations can affect pathogen levels similar to the impacts provided by wildlife. While a count of pets for the Lower Salt Creek Watershed was not completed, dog and cat populations were estimated for the watershed as part of the Lower Salt Creek TMDL (IDEM, 2016). IDEM used statistics reported in the 2012 U.S. Pet Ownership & Demographics Sourcebook. Specifically, the Sourcebook reports that on average 36.5 percent of households own dogs and 30.4 percent of households own cats. Typically, the average number of pets per household is 1.6 dogs and 2.1 cats. However, pets are likely only a significant source of E. coli in population centers including Oolitic, Bedford and Bloomington. The estimated number of domestic pets in the Lower Salt Creek Watershed is based on the average number of pets per household multiplied by the population of the watershed resulting in a suggested population of 62,903 cats and 47,926 dogs. Pet waste issues are more predominant in the urban areas noted above but are also present at any residential parcel.

2.8.3 Endangered Species

The Indiana Natural Heritage Data Center, part of the Indiana Department of Natural Resources, Division of Nature Preserves, maintains a database documenting the presence of endangered, threatened, or rare species; high quality natural communities; and natural areas in Indiana. The database originated as a tool to document the presence of special species and significant natural areas and to assist with management of said species and areas where high quality ecosystems are present. The database is populated using individual observations which serve as historical documentation or as sightings occur; no systematic surveys occur to maintain the database.

The state of Indiana uses the following definitions to list species:

- *Endangered*: Any species whose prospects for survival or recruitment with the state are in immediate jeopardy and are in danger of disappearing from the state. This includes all species classified as endangered by the federal government which occur in Indiana. Plants currently known to occur on five or fewer sites in the state are considered endangered.
- *Threatened*: Any species likely to become endangered within the foreseeable future. This includes all species classified as threatened by the federal government which occur in Indiana. Plants currently known to occur on six to ten sites in the state are considered threatened.
- *Rare*: Plants and insects currently known to occur on eleven to twenty sites.

In total, 191 observations of listed species and/or high quality natural communities occurred within the Lower Salt Creek Watershed (Figure 23; Davis, personal communication). These observations include 20 invertebrates, 24 vascular plants, 23 vertebrate animals including 4 bat species, 11 birds, 1 turtle and 2 snake species as well as 5 terrestrial high quality natural communities and two geologic features (waterfalls). State endangered species include the Cave Beetle, Hidden Springs Snail, Jordan's groundwater isopod, Monroe cave ground beetle, Northern Casemaker Caddisfly, Springtail, American chestnut, Appalachian quillwort, gray beardtongue, Illinois pinweed, narrow-leaved puccoon, sharp-scaled manna-grass, Allegheny Woodrat, Barn Owl, Cerulean Warbler, Henslow's sparrow, Indiana Bat, little brown myotis, Loggerhead Shrike, Northern Long Eared Bat, timber rattlesnake, Tricolored Bat and Upland Sandpiper. State threatened species include Agapetus Caddisfly, Spatterdock Darner, black-fruit mountain-ricegrass, butternut, cypress-knee sedge, ostrich fern, roundleaf water-hyssop, roundleaf water-hyssop, trailing arbutus, trailing arbutus and weakstalk bulrush. State rare species include: Hilly Springtail and Troglobitic Crayfish. These species are found in high quality natural areas identified in the Lower Salt Creek Watershed as well as in streams, forests and caves throughout the watershed. The Aquatic Cave, Highland Rim Dry-mesic Upland Forest, Limestone Cliff and Sinkhole Swamp rate as high quality terrestrial communities. Two waterfalls rate as geologic features. Appendix A includes the database results for the Lower Salt Creek Watershed, as well as county-wide listings for Lawrence and Monroe Counties.

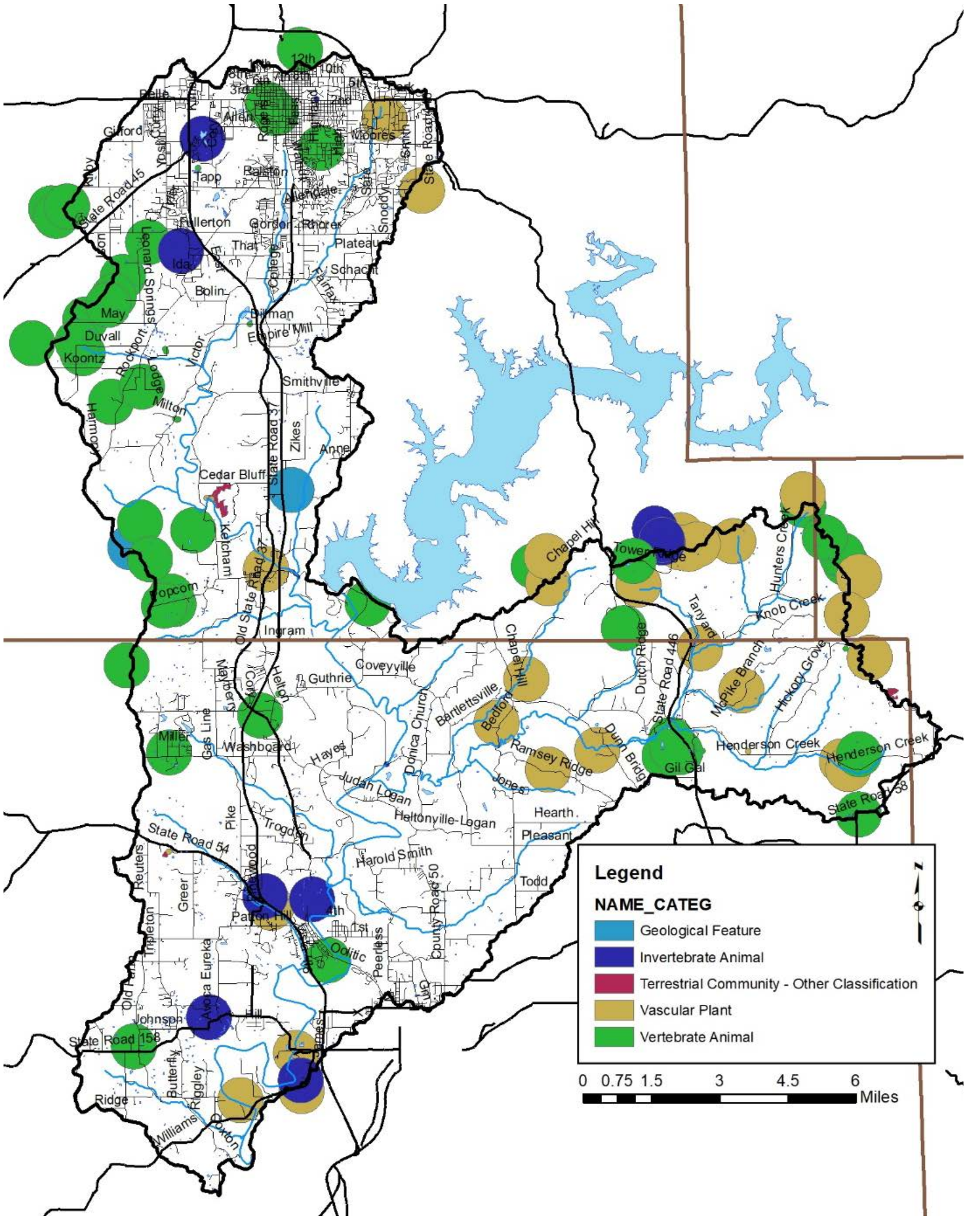

Figure 23. Locations of special species and high quality natural areas observed in the Lower Salt Creek Watershed. Source: Davis, 2021.

2.8.4 Recreational Resources and Significant Natural Areas

A variety of recreational opportunities and natural areas exist within the Lower Salt Creek Watershed. Recreational opportunities include parks, fish and wildlife areas, nature preserves, fairgrounds, golf courses, race tracks, and school grounds (

Table 12, Figure 24). There are several significant natural areas located within the Lower Salt Creek Watershed. The Indiana DNR, The Nature Conservancy, Sycamore Land Trust, Monroe County and Bloomington Park Boards, U.S. Forest Service and U.S. Army Corps of Engineers maintain, preserve and protect these properties. Switchyard Park, Leonard Springs Nature Park and Cedar Bluff Nature Preserve provide access to Clear Creek; Avoca State Fish Hatchery provides access to Goose Creek, Monroe Lake provides access to Salt Creek; and U.S. Forest Service Property provides access to Henderson Creek, Knob Creek, Little Salt Creek, Hunter Creek, Brannaman Branch, Terrill Branch and other streams. Additional recreational opportunities exist at various schools, golf complexes and recreational facilities.

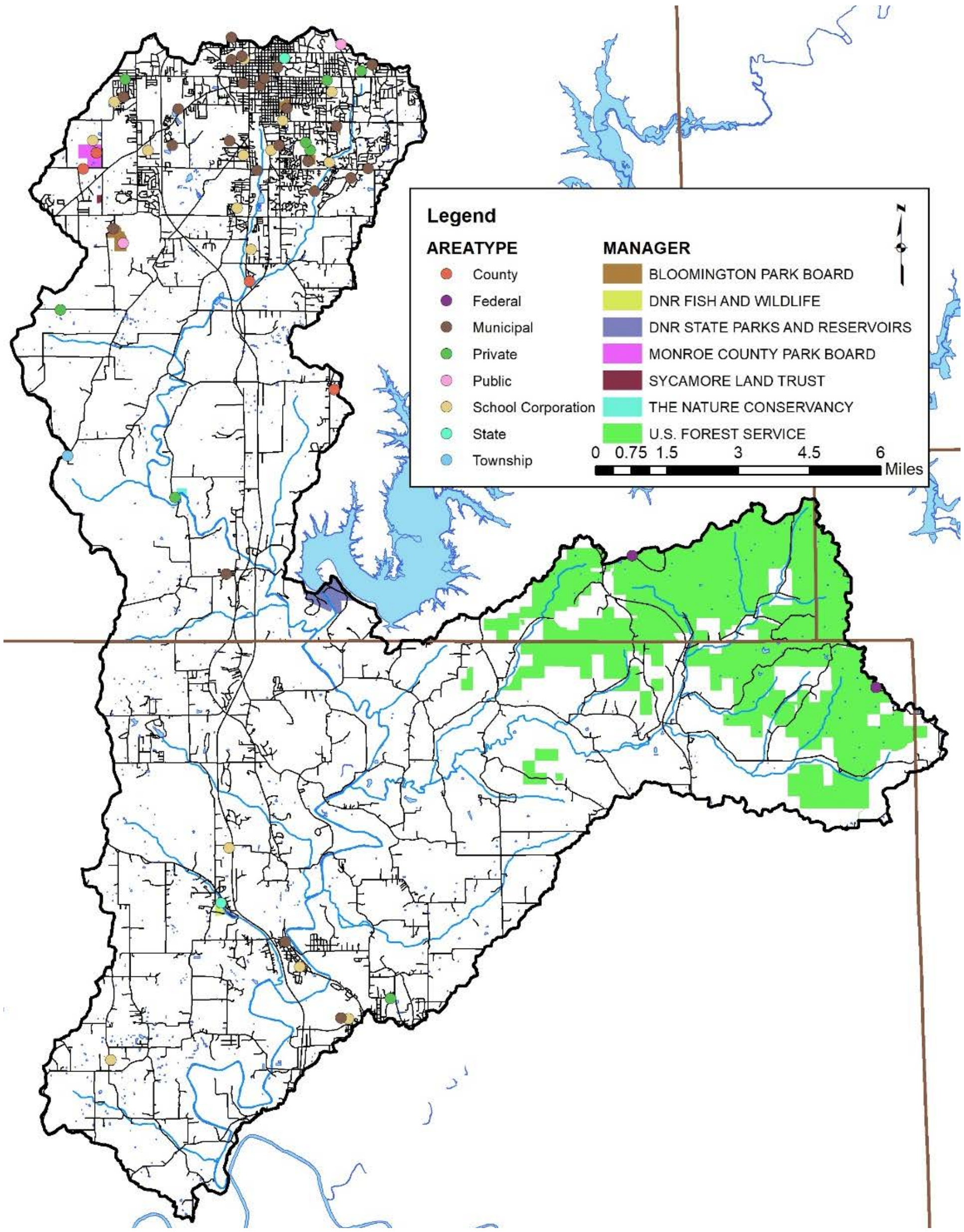

Figure 24. Recreational opportunities and natural areas in the Lower Salt Creek Watershed.

Table 12. Natural areas in the Lower Salt Creek Watershed

Natural Area	County	Organization	Access
Avoca State Fish Hatchery	Lawrence	IDNR	Restricted
Bryan Park	Monroe	Bloomington Park Board	Open
Cedar Bluffs Nature Preserve	Monroe	IDNR/TNC	Open
County Farm/Karst Park	Monroe	Monroe County Park Board	Open
Hoosier National Forest	Lawrence	USFS	Open
Leonard Springs Park	Monroe	Bloomington Park Board	Open
Monroe Lake	Monroe	IDNR/USACE	Open
Park Ridge West Park	Monroe	Bloomington Park Board	Open
Park Square Park	Monroe	Bloomington Park Board	Open
Southeast Park	Monroe	Bloomington Park Board	Open
Switchyard Park	Monroe	Bloomington Park Board	Open
Wayne's Woods	Monroe	Sycamore Land Trust	Restricted
Winslow Sports Complex and Trail	Monroe	Bloomington Park Board	Open

2.9 Land Use

Water quality is greatly influenced by land use both past and present. Different land uses contribute different contaminants to surface waters. As water flows across agricultural lands it can pick up pesticides, fertilizers, nutrients, sediment, pathogens, and manure, to name a few. However, when water flows across parking lots or from roof tops it not only picks up motor oil, grease, transmission fluid, sediment, and nutrients, but it reaches a waterbody faster than water flowing over natural or agricultural land. Hard or impervious surfaces present in parking lots or on rooftops create a barrier between surface and groundwater. This barrier limits the infiltration of surface water into the groundwater system resulting in increased rates of transport from the point of impact on the land to the nearest waterbody.

2.9.1 Current Land Use

Today, the majority of the Lower Salt Creek Watershed is covered by deciduous forest (48%; Table 13, Figure 25). Nearly 25% of the watershed is mapped in pasture land, while developed open space and low, medium and high density developed land covers 14% of the watershed. Row crop agriculture covers nearly 7% of the watershed. Grassland, open water, and wetlands cover the remaining 6% of the watershed.

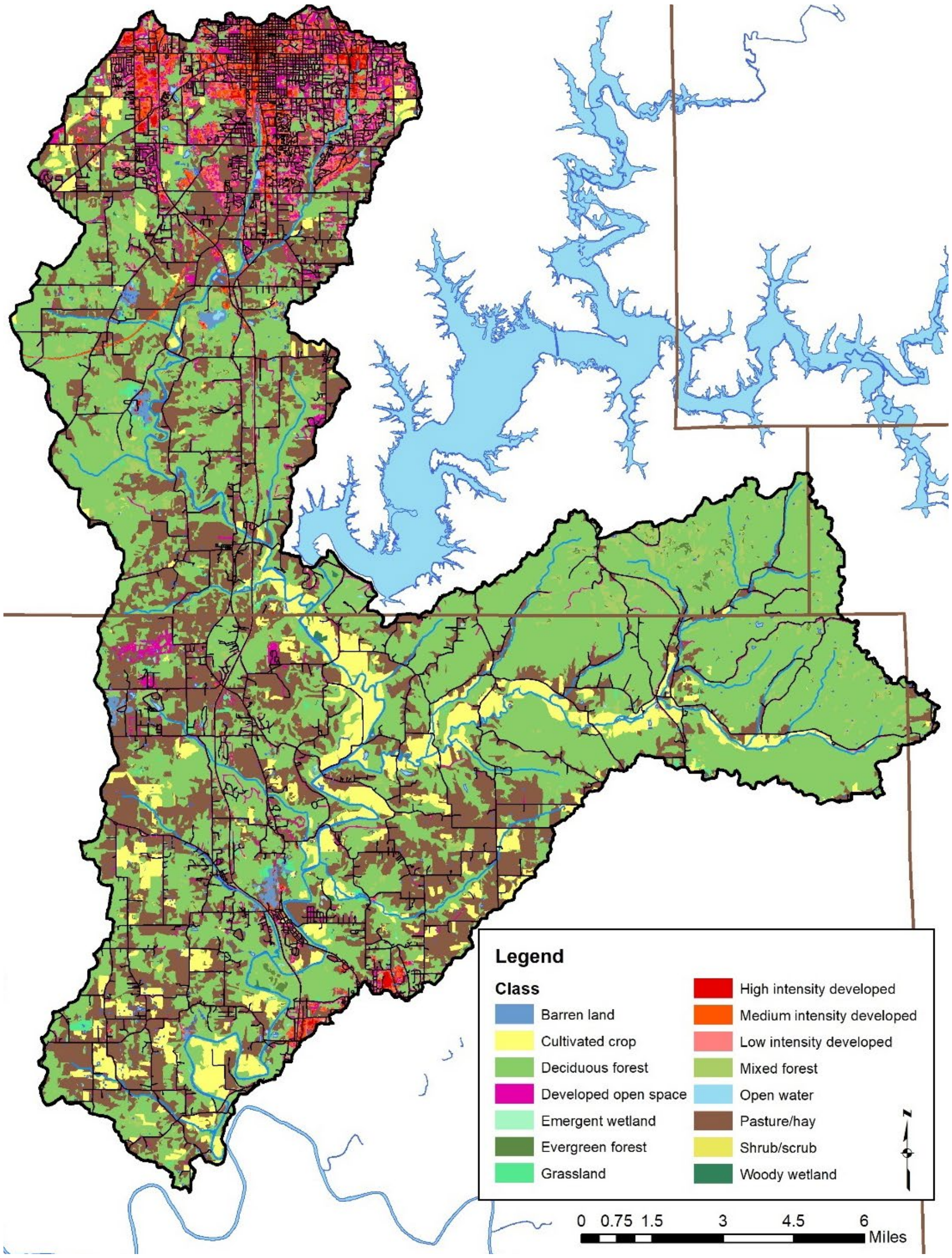

Figure 25. Land use in the Lower Salt Creek Watershed. Source: NLCD, 2016.

Table 13. Detailed land use in the Lower Salt Creek Watershed.

Classification	Area (acres)	Percent of Watershed
Deciduous forest	62,658.1	48.1%
Pasture/hay	32,189.4	24.7%
Developed open space	9,930.7	7.6%
Cultivated crop	9,601.8	7.4%
Mixed forest	5,374.4	4.1%
Low intensity developed	4,664.9	3.6%
Medium intensity developed	2,499.4	1.9%
Grassland	1,050.4	0.8%
High intensity developed	846.5	0.6%
Barren land	682.8	0.5%
Evergreen forest	285.7	0.2%
Open water	215.9	0.2%
Shrub/scrub	171.3	0.1%
Woody wetland	147.9	0.1%
Emergent wetland	33.2	0.0%
Entire Watershed	130,352.3	100.0%

Source: USGS, 2016

2.9.2 Agricultural Land Use

Individuals are concerned about the impact of agricultural practices on water quality. Specifically, the volume of exposed soil entering adjacent waterbodies, the prevalence of tiled fields and thus the transport of chemicals into waterbodies, the use of agricultural chemicals, and the volume of manure applied via small animal farms and through confined animal feeding operations are concerning to local residents. Each of these issues will be discussed in further detail below.

Tillage Transect

Tillage transect information data for Lawrence and Monroe Counties was compiled for 2019 (Table 14; ISDA, 2019A-C). As reported by ISDA, members of Indiana's Conservation Partnership (ICP) conduct a field survey of tillage methods. A tillage transect is an on-the-ground survey that identifies the types of tillage systems farmers are using and long-term trends of conservation tillage adoption using GPS technology, plus a statistically reliable model for estimating farm management and related annual trends. Table 14 provides the number of acres and percent of acres on which conservation tillage was utilized for each county by corn and soybeans.

Table 14. Conservation tillage data as identified by county tillage transect data for corn and soybeans (ISDA, 2019).

County	Corn (acres)	Corn (%)	Soybeans (acres)	Soybeans (%)
Lawrence	10,266	65%	22,149	89%
Monroe	2,532	44%	3,897	55%

Agricultural Chemical Usage

Agricultural pesticides and fertilizers are commonly applied to row crops in Indiana. These chemicals can be carried into adjacent waterbodies through surface runoff and via tile drainage. This is especially an issue if a storm occurs prior to the chemicals being broken down and used by the crops.

Data for chemical usage on an individual county or watershed level are not currently collected. Rather, data is collected for the state as a whole in two forms. First, the National Agricultural Statistics Survey (NASS) collects information on chemical usage, number of applications per year, type of chemical applied, and the application rate. These data were last collected in 2006 (NASS, 2006). Additionally, NASS collects farmland data for the number of acres in agricultural production by type (i.e. corn, soybeans, grains) by county (NASS, 2019). These data indicate that corn (23,200 acres planted in Lawrence and Monroe counties) and soybeans (19,300 acres planted in Lawrence and Monroe counties) are the two primary crops grown in the watershed.

Nitrogen is more typically applied to corn than to soybeans. Soybeans have symbiotic bacteria on their roots that act as nitrogen fixers, which means that they pull the nitrogen that they need from the atmosphere then convert it into a form which they can use. Corn does not fix nitrogen; therefore nitrogen needs to be applied. Nitrogen is typically applied twice in Indiana – once at or before planting and a second time when corn reaches approximately one foot in height (NASS, 2007). Fall application of nitrogen also occurs and is particularly problematic. Agricultural data indicate that corn receives 98% of the nitrogen applied in the state and 87% of the phosphorus. For these reasons, nutrient calculations were only completed for corn as applications to soybeans are likely negligible. Based on these data, it is estimated that 1,710 tons of nitrogen and 846 tons of phosphorus are applied annually within the counties in which the Lower Salt Creek Watershed is located (Table 15).

Table 15. Agricultural nutrient usage for corn in the Lower Salt Creek Watershed counties.

Nutrient	Acres of Corn	% of Area Applied	Applications (#/year)	Rate/Application (lb/acre)	Total Applied/Year (tons)
Nitrogen	23,200	100	2.2	67	1,710
Phosphorus	23,200	93	1.4	56	846

Source: NASS, 2007; NASS, 2019

Pesticides are also used on crops grown in Indiana. The Office of the Indiana State Chemist indicates that the two predominant herbicide active ingredients applied are atrazine and glyphosate. Atrazine is most commonly applied as a corn herbicide, while glyphosate is used on both corn and soybean fields as an herbicide. NASS indicates that in 2005, an average of 1.24 pounds of atrazine and 0.6 pounds of glyphosate were applied per acre of corn, and 0.73 pounds of glyphosate were applied per acre of soybeans (NASS, 2006). Using these rates, we estimated that a little over 14 tons of atrazine and approximately 14 tons of glyphosate are applied to cropland in the Lower Salt Creek Watershed counties annually (Table 16).

Table 16. Agricultural herbicide usage in the Lower Salt Creek Watershed counties.

Crop	Acres	Application Rate (lb/acre)	Total Applied (lbs)	Total Applied/Year (tons)
Corn (Atrazine)	23,200	1.24	28,768	14.4
Corn (Glyphosate)	23,200	0.60	13,920	6.9
Soybeans (Glyphosate)	19,300	0.73	14,089	7.1

Source: NASS, 2006; NASS, 2019

Confined Feeding Operations and Hobby Farms

A mixture of small, unregulated and larger, regulated livestock operations (confined feeding operations) is found within the Lower Salt Creek Watershed. Small farms are those which house less than 300 animals, while larger farms that house large numbers of animals for longer than 45 days per year are regulated by IDEM. These regulations are based on the number and type of animals present. IDEM requires permit applications which document animal housing, manure storage and disposal, and nutrient management plans for farms which maintain 300 or more cows, 600 or more hogs, or 30,000 or more fowl. These facilities are considered confined feeding operations (CFO). There is one active confined feeding operation located in the watershed (Figure 26). The facility is permitted to house up to 68,000 turkeys. In total, 168 small, unregulated animal farms containing more than 2,500 animals were identified during the windshield survey, which is most likely an underestimate of the actual number. These small "mini farms" contain small numbers of cattle, horses, bison, sheep, or goats, which could be sources of nutrients and *E. coli* as these animals exist on small acreage lots with limited ground cover. In total, approximately 70,500 animals per year are housed in CFOs and on unregulated farms in the watershed, generating approximately 59,316 tons of manure per year spread over the watershed. This volume of manure contains approximately 1,930,990 pounds of nitrogen, 1,659,200 pounds of phosphorus and 1.54×10^{16} col of E. coli.

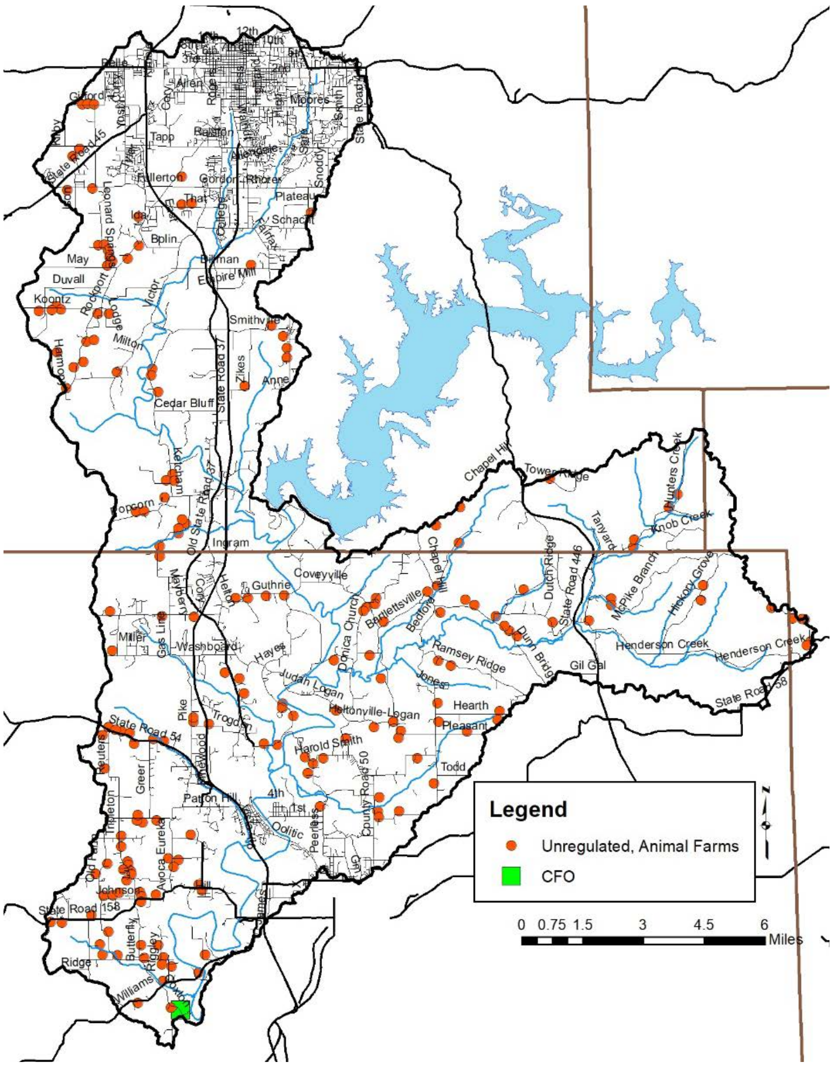

Figure 26. Confined feeding operation and unregulated animal farm locations within the Lower Salt Creek Watershed.

2.9.3 Natural Land Use

Natural land uses including forest, wetlands, and open water cover approximately 54% of the watershed. Approximately 68,318 acres or 52% of the watershed is covered by trees. Forest cover occurs adjacent to waterbodies throughout the watershed. The largest volume of forest cover occurs in the eastern portion of the watershed, most of which is owned and managed by the U.S. Forest Service and in southern Monroe County. In total, more than 25% of the watershed is 75% or more covered by forest canopy (Figure 27). Many forested tracts are contiguous and large lengths of the watershed streams contain intact riparian buffers.

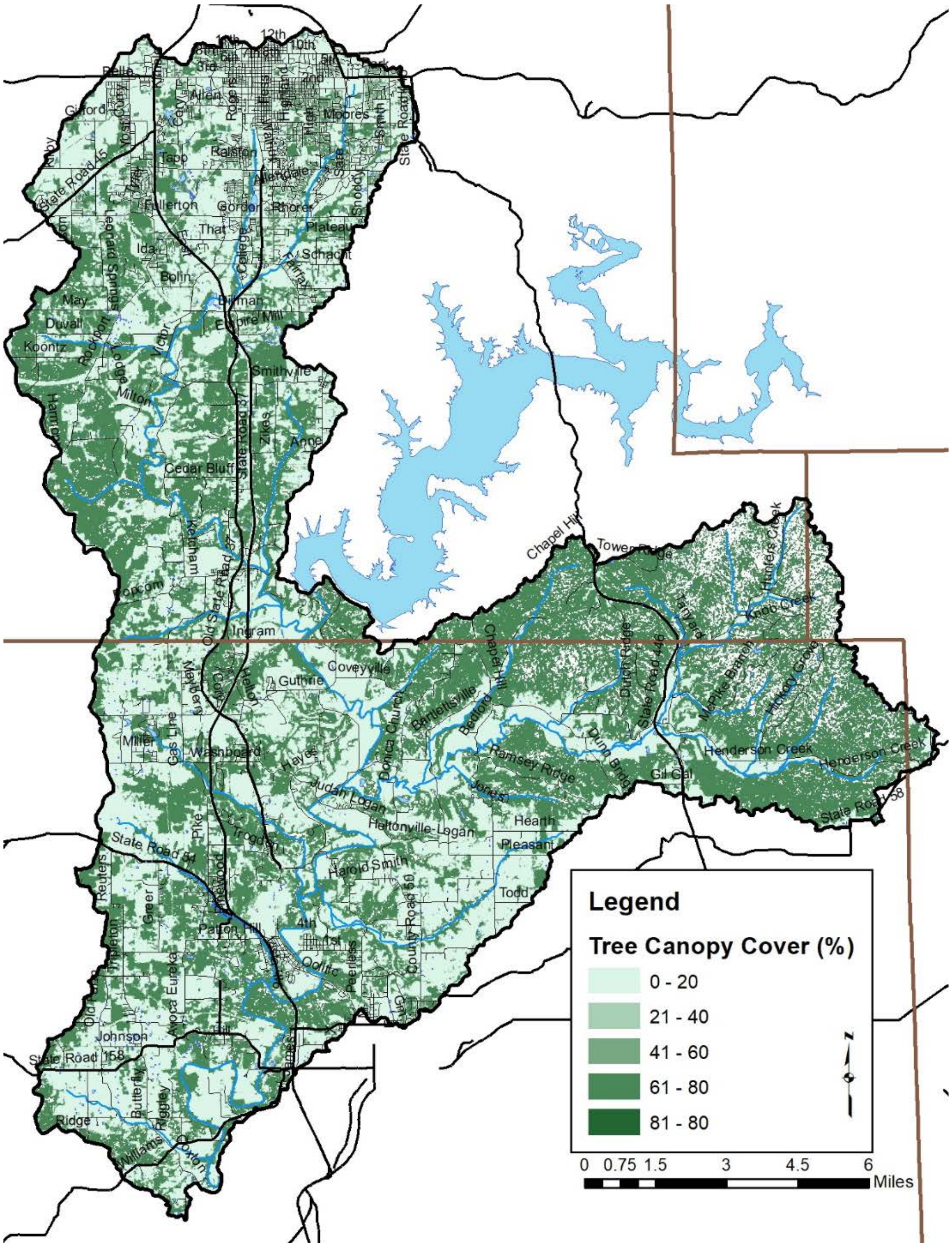

Figure 27. Forest canopy cover in the Lower Salt Creek Watershed.

2.9.4 Urban Land Use

Urban land uses cover approximately 18,625 acres or nearly 14% of the watershed (Table 13). Most developed areas are associated with the Cities of Bloomington and Bedford and the Town of Oolitic as well as unincorporated Monroe County. There are some significant issues related to the MS4 communities and the Monroe County Urbanizing Area including the continued need to manage development through Indiana's Construction Stormwater General Permit program and addressing construction and sprawl activities. Especially troublesome are issues related to failing septic systems, impervious surfaces, flooding, and stormwater runoff that allow untreated sewage and stormwater to flow into the watershed during heavy rain events.

Urban Chemical Use

At least three golf courses including the Bloomington Country Club, Stone Crest Golf Community and Taylors Par 3, are located in the Lower Salt Creek Watershed. Regularly applied fertilizer is likely common on these golf courses as well as lawns in the three MS4 communities and Monroe County's urbanizing area and on turf management areas in City of Bloomington, City of Bedford, Indiana University and Monroe and Lawrence County parks. Urban pesticide and herbicide use has not been quantified for the Lower Salt Creek Watershed. However, studies of nitrogen sources in urban landscapes throughout the United States have found that nitrogen-based fertilizer typically represents the dominant nitrogen source to urban areas. For example, 53% of N inputs into a suburban neighborhood in Baltimore, MD, were estimated to be from lawn fertilizer (Law et al. 2004). Similarly, 37%–59% of total nitrogen inputs into urban watersheds in St. Paul, MN, were from household lawn fertilizer (Hobbie et al. 2017). Although fertilizer may be the major nitrogen input into urban watersheds, that does not necessarily mean it is having the largest environmental effect. Although a large amount of nitrogen enters urban watersheds as fertilizer nitrogen, only a small fraction of this fertilizer moves through the landscape as either leaching or runoff. A large proportion of the fertilizer nitrogen is incorporated into plant biomass or soil organic matter pools, with the latter accumulating in the system for years to decades (Raciti et al. 2011). Results from an experiment performed at the University of Florida found little leaching of nitrate through the soil under turfgrass plots regardless of fertilizer application rates (Trenholm et al. 2012), but these results were from ideal experimental conditions. It is less clear how much N is lost from lawns in "real-world conditions." Additionally, a study of nitrogen runoff from residential communities in the Tampa Bay region found that the contribution of nitrogen-based fertilizer to nitrogen in stormwater runoff was highly variable, ranging from <1%–39% of total nitrogen in runoff (Yang and Toor 2017).

2.9.5 Impervious Surfaces

Impervious surfaces are hard surfaces which limit surface water from infiltrating into the land surface to become groundwater thereby creating high overland flow rates. Hard surfaces include concrete, asphalt, compacted soils, rooftops, and buildings or structures. In developed areas, land which was once permeable has been covered by hard, impervious surfaces. This results in rain which once absorbed into the soil running off of rooftops and over pavement to enter the stream with not only higher velocity but also higher quantities of pollutants.

Overall, the watershed is covered by low levels of impervious surfaces. However, high impervious densities are present in Bloomington, Bedford and Oolitic and along roads throughout the watershed. Estimates indicate that 7,118 acres (5%) of the watershed are 25% or more covered by hard surfaces. In some areas of the watershed, including the Cities of Bloomington and Bedford and Town of Oolitic, individual drainages have much higher impervious coverage (Figure 28). Elvidge et al. (2004) indicated that streams in watersheds with greater than 10% impervious surfaces clearly exhibited degradation. The Center for Watershed Protection (CWP) identified similar impacts from impervious surface density on water quality. The CWP study indicates that stream ecology degradation begins with only 10% impervious cover in a watershed. Higher impervious surface coverage results in further impairments including water quality problems, increased bacteria concentrations, higher levels of toxic chemicals, high temperatures, and lower dissolved oxygen concentrations (CWP, 2003).

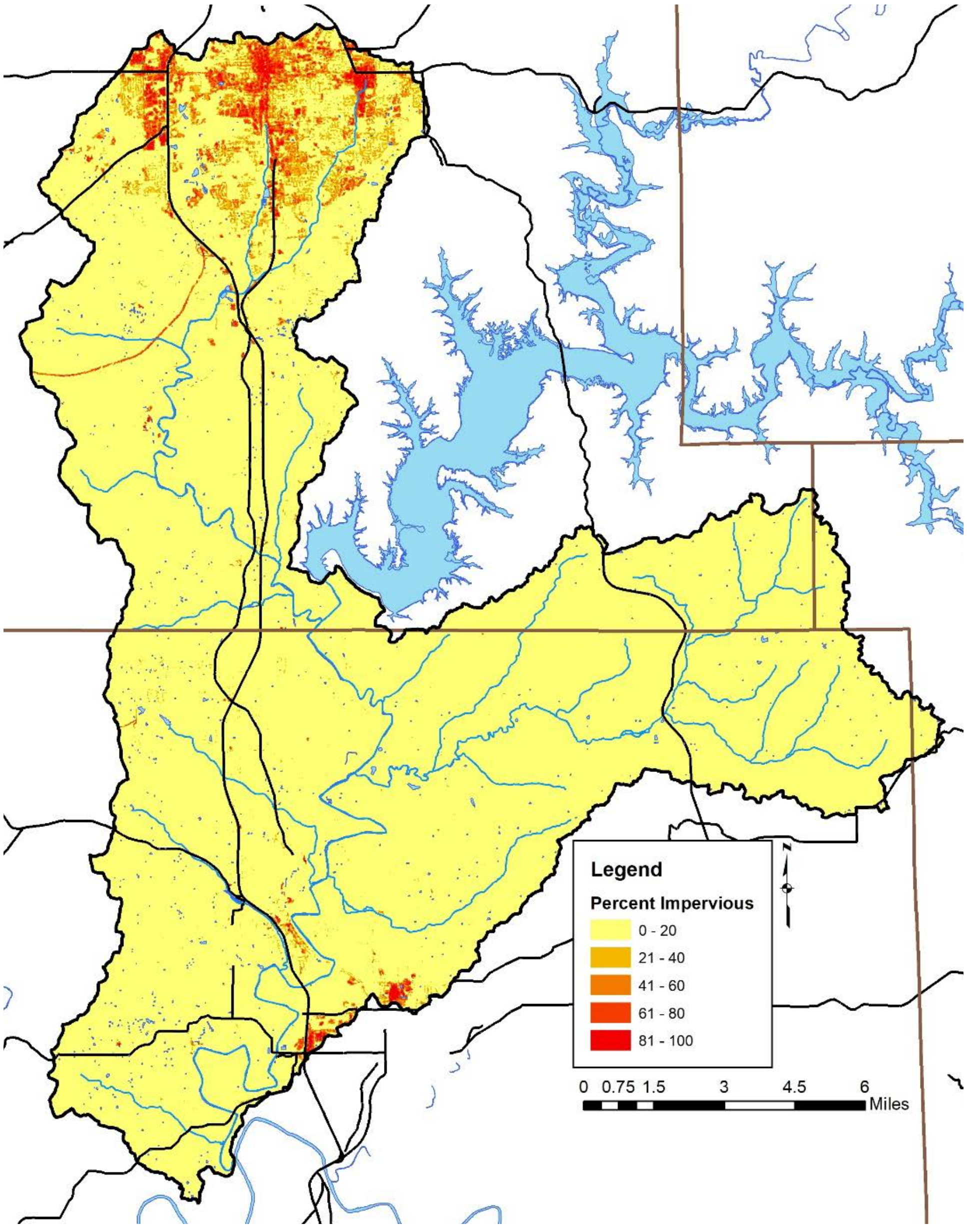

Figure 28. Impervious cover in the Lower Salt Creek Watershed.

2.9.6 Legacy Pollutant Remediation Sites

Remediation sites including industrial waste, leaking underground storage tanks (LUST), open dumps, Superfund sites and brownfields are present throughout the Lower Salt Creek Watershed (Figure 29; Table 17). Most of these sites are located within the developed areas of the watershed including the City of Bloomington, City of Bedford and Town of Oolitic. Urban areas in the Lower Salt Creek Watershed are also home to legacy pollutants from four Superfund sites including Winston Thomas, Illinois Central

Spring Water Treatment Facility and Abb Power T&D Company. In total, 22 industrial waste sites (RCRA), 189 LUST facilities, five voluntary remediation project (VRP) locations, two solid waste sites, four Superfund sites and 14 brownfields are present within the watershed.

Table 17. Industrial waste facilities in the Lower Salt Creek Watershed. Data derived from IDEM GIS shapefiles – blank lines in this table originate from the data layer and are unavailable.

Program ID	Facility Name	Program
4000005	Habitat for Humanity Lindbergh & Oolitic	Brownfield
4010029	McDoel Switch Yard/Bloomington Greenway	Brownfield
4020024	Old SIRA Office Building	Brownfield
4040001	One Call Communications Property (F)	Brownfield
4050015	Ed Greene Property	Brownfield
4060002	BLOOMINGTON TIRE CO	Brownfield
4060045	Brownfields III, LLC	Brownfield
4070709	GE Bloomington Vacant Land Parcel	Brownfield
4080102	ROYAL DOG	Brownfield
4080405	Big O Properties	Brownfield
4080506	Walnut Street Lofts	Brownfield
4960005	RCI, Inc.	Brownfield
4980016	Gas Station (F)	Brownfield
4980072	Josephine Brown Trust Property	Brownfield
000006932208		RCRA
IN0001314145		RCRA
IND000803726	GEA BLOOMINGTON PROD OPER LLC	RCRA
IND000815431	INDIANA UNIVERSITY-BLOOMINGTON	RCRA
IND003938701	OTIS ELEVATOR COMPANY INC	RCRA
IND006036099	GM POWERTRAIN-BEDFORD FACILITY	RCRA
IND006036099	GM POWERTRAIN-BEDFORD FACILITY	RCRA
IND016210361		RCRA
IND042823948		RCRA
IND044073922	CARLISLE BRAKING SYSTEM	RCRA
IND061032678		RCRA
IND072072952	HOOSIER PAINT & BODY SHOP	RCRA
IND082293143		RCRA
IND107239071	IMPERIAL LUMBER KILNS INC	RCRA
IND984875799	JERDEN INDUSTRIES INC	RCRA
IND984876805	METROPOLITAN PRINTING SERVICE	RCRA
IND984876938	HERALD TIMES INC	RCRA
IND984877381		RCRA
IND984890889		RCRA
IND985048537	MOTOR SERVICE INC	RCRA

Program ID	Facility Name	Program
IND985084953	BLOOMINGTON FORD INC	RCRA
INR000100172	CIRCLE-PROSCO INC	RCRA
6000410	INDIANA GAS/BLOOMINGTON MGP	VRP
6970604	BANK ONE INDIANA	VRP
6970403	INDIANA CREOSOTING	VRP
6990904	FORMER RCI	VRP
6000616	JOHNSON OIL BULK PLANT	VRP

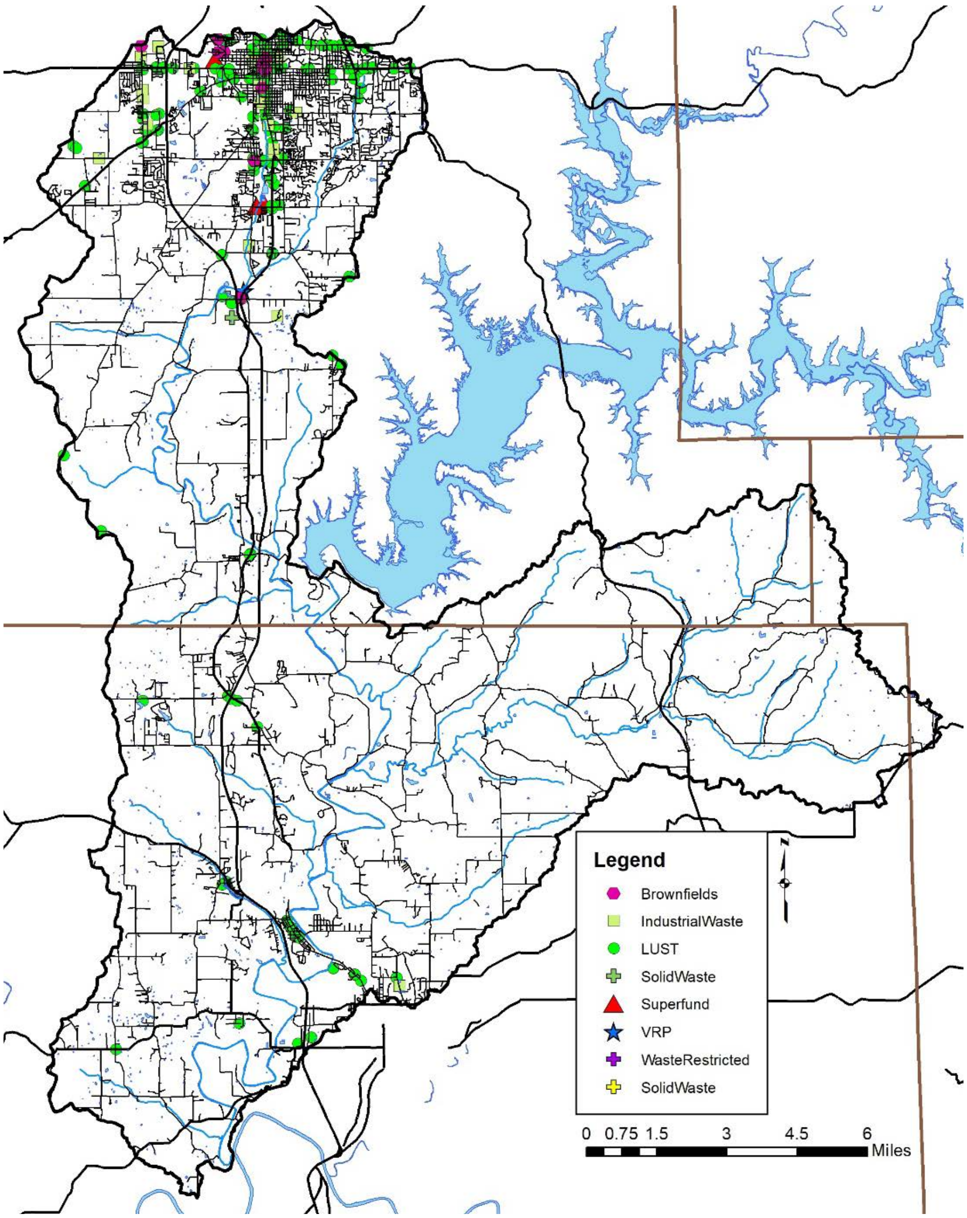

Figure 29. Industrial remediation and waste sites within the Lower Salt Creek Watershed.

Legacy pollutants are those substances whose use has been banned or severely restricted by the EPA. Because of their slow rate of decomposition, these substances frequently remain at elevated levels in the environment for many years after their widespread use has ended. No additional loading of legacy pollutants is allowed or expected due to the EPA restrictions. Gradual declines in environmental legacy pollutant concentrations occur as a result of natural attenuation processes. Legacy pollutants primarily include PCBs in Bloomington and Bedford; however, additional organic and inorganic chemicals have been detected at several of these locations. Based on the presence of these legacy pollutants, the Indiana State Department of Health designates three streams as Rule 5 streams which restricts fish consumption from these waterbodies including Clear Creek in Monroe County, Salt Creek in Monroe and Lawrence Counties and Pleasant Run in Lawrence County.

The General Motors RCRA site includes more than 5 miles of Pleasant Run Creek and Bailey Branch north of Bedford. As part of cleanup efforts, GM removed nearly 6,000 tons of PCB-contaminated sediment (GM Authority, 2011). These efforts result from the agreement signed between EPA and GM in 2001 to address PCB contamination issues. As of June 2019, many of the clean activities were complete; however, ongoing monitoring of seeps, springs and constructed wells continue to ensure that any additional contamination be identified (WBIW, 2019). Based on collected data, which will be summarized in subsequent sections of this report, General Motors will continue their monitoring efforts and reduce public outreach on the remediation effort to a single annual meeting.

Historically, seven sites were investigated for PCB contamination all of which have undergone some form of remediation via Superfund, RCRA or VRP (Delavore et al, 2011). The EPA continues overseeing work at two Superfund sites in Bloomington in the Lower Salt Creek Watershed including Lemon Lane Landfill and Bennett's Stone Quarry/Landfill. These sites are part of a group of sites contaminated by PCB waste from the former Westinghouse Electric Corporation plant (now CBS Corporation). Groundwater from Lemon Lane Landfill flows to the headwaters of Clear Creek. All material with PCB concentrations greater than 50 ppm were removed and a wastewater treatment plant installed to treat PCBs flowing from Illinois Central Spring to Clear Creek. Nearly 55,000 tons of material was removed from Bennett's stone quarry/landfill; however, these removal efforts did not remediate PCB contamination to groundwater leaving the site flowing to Stout Creek. Subsequent installation of a wastewater treatment plant to treat groundwater from Bennett's stone quarry was installed and will continue in operation until PCB levels measure less than 0.3 ppm in seeps and springs draining to Stout Creek.

The Indiana Creosoting property, owned by CSX Transportation, is contaminated by semivolatile organic compounds, benzene, toluene, ethylbenzene, xylenes, arsenic and lead (Delavore et al., 2011). As of 2011, 11,500 cubic yards of material as well as two underground storage tanks were removed from the site and a creek liner and interceptor trench installed along 170 feet of Clear Creek to mitigate the flow of creosote to Clear Creek. As of 2011, CSX was in the process of developing remediation work plans to mitigate the site through the volunteer remediation program.

The Indiana Gas-Bloomington Manufactured Gas Plant, owned by Vectron, is contaminated with benzene and polyaromatic hydrocarbons (Delavore et al., 2011). As of 2011, Vectron was in the process of developing remediation work plans to reduce contaminant levels to comply with VRP tier II standards.

The Bloomington McDoel Rail Site, now Switchyard Park, was contaminated with various petroleum hydrocarbons and metals including arsenic and lead. These materials leached into soils while the site adjacent to Clear Creek was active resulting in subsequent remediation in advance of converting this area to Switchyard Park (Delavore et al., 2011).

Additional sites including the Reclamation Contractors Inc Facility and Johnson Oil-Bulk Plant, have been remediated. However, restrictions on their use for residential purposes continue.

Leaking underground storage tanks are a matter of particular concern because their underground location means that even small spills are capable of contaminating groundwater. The issue of ground water contamination means that LUSTs not only cause harm to the general environment but also pose a health risk in areas where groundwater supplies are used as a source of public drinking water. According to IDEM's LUST database, 11 of Bloomington's 112 documented LUST sites have active LUST incidents and are currently undergoing either study or remediation (Delavore et al., 2011). The remaining 101 Bloomington LUST sites have been assigned other IDEM designations such as closed, indicating that no-further-action status has been granted, or MNA, indicating that monitored natural attenuation has been approved as a method of corrective action.

2.10 Population Trends

The Lower Salt Creek Watershed is a mix of relatively sparsely populated areas and urban centers in general. The City of Bloomington, City of Bedford and Town of Oolitic house the highest density populations. Table 18 details the population of each county in the Lower Salt Creek Watershed. These data indicate that all three counties are growing – this is especially true for Monroe County where the City of Bloomington continues to grow. The steering committee identified that increasing urban sprawl and development can be sources of pollutants including sediment, nutrients and pathogens.

Table 18. Population data for counties in the Lower Salt Creek Watershed.

County	1990	2000	2010
Monroe	108,978	120,563	137,974
Lawrence	37,730	41,335	42,376
Jackson	42,836	45,922	46,134

Tracking population changes within a watershed is challenging as data is published by counties and townships rather than watershed boundaries. Changes in watershed population and the associated land use changes and infrastructure impacts were noted by watershed stakeholders. Estimated populations in the Lower Salt Creek Watershed indicate that 37% of the population is rural residents while 63% of the population reside in urban locations. Table 19 displays estimated populations for the portion of each county located within the watershed (US Census data, 2010).

Table 19. Estimated watershed demographics for the Lower Salt Creek Watershed.

County	2010 Population	Total Estimated Watershed Population	Total Estimated Watershed Urban Population	Total Estimated Watershed Rural Population	Percent of Total Watershed Population
Monroe	137,974	82,532	56,684	25,848	87%
Jackson	42,376	60	0	60	<1%
Lawrence	46,134	12,105	2,531	9,574	13%
Total	**226,484**	**94,697**	**59,215**	**35,482**	**100%**

2.11 Planning Efforts in the Watershed

Multiple plans have encompassed portions of the Lower Salt Creek Watershed or areas which it drains or outlets into. Planning efforts include Lawrence and Monroe SWCD Master Plans, Lawrence and Monroe county-wide master plans, Bloomington Environmental Action Plan, and more. Plans are listed in chronological order.

City of Bloomington Environmental Resource Inventory (COBERI, 2003)

The primary purpose of the COBERI was to collect and analyze information on Bloomington's natural environment in an effort to help prioritize areas for future management and/or preservation. It laid the foundation for all subsequent natural resource planning efforts in the City of Bloomington. The COBERI identified several themes present in natural resources including:

- Bloomington is shaped by several major environmental features that harbor diverse and sensitive natural areas.
- Bloomington is home to many unique and sensitive ecological communities that also extend beyond its political boundaries.
- The natural resources in Bloomington are interconnected in a complex network of systems that requires constant monitoring.

Specifically, the COBERI identified highly sensitive locations throughout the city including those areas where special habitats, unique topography, karst geology or floodplains or high quality water bodies were located.

Bedford Comprehensive Plan (2010)

The comprehensive plan for Bedford directs the future physical development of the community. It addresses the use of land to accommodate future activities, the improvement of the infrastructure (roads and utilities) to sustain development, the provision of community and recreation facilities to meet the needs of its residents, and the preservation of natural and historic amenities to protect the heritage of the community. Environmental related goals in the plan include:

- Preserve and enhance environmentally sensitive areas.
- Preserve or reuse land that has been affected by the Limestone Industry.
- Protect the White River as the source of drinking water and a place for recreation.
- Protect and conserve groundwater quantity and quality.
- Protect naturally occurring plant and animal species.
- Reduce human health hazards related to environmental factors.
- Encourage development in areas that are not subjected to flooding.

Indiana University Campus Master Plan (2010)

The Indiana University Bloomington Campus Master Plan has multiple key themes, one of which is to "Embrace the Jordan River". The Jordan River is Bloomington's most prominent natural feature. It is desired that future development should embrace the river's natural scenic quality and accentuate its environmental setting. The riparian corridor recommendations include:

- Establish a 50-ft buffer on each side of the stream.
- Plant trees to establish a consistent canopy.
- Regrade stream banks within the buffer zones to reduce erosion.
- Stabilize the toe of slope using stone and bioengineering techniques.
- Construct new wetlands and plant with appropriate native plants.
- Create a lower channel with check dams to improve low flow conditions.
- Create access points and overlook areas.
- Implement corridor management and landscape plan for all streams/springs on campus.

Bloomington Switchyard Park Master Plan (2012)

From 2005-2009, the City of Bloomington acquired 58 acres of former railroad yard on the south side of the city known as the switchyard. The park master plan included an inventory and assessment of existing conditions, analysis of opportunities and constraints, a design workshop and development of the preliminary and final master plan. Key elements of the master plan include:

- The comprehensive restoration of the Clear Creek Corridor, including erosion control, invasive species removal, enhancement of wetland areas, and restoration of habitat.
- Environmental remediation to include capping of soils to isolate existing soil pollutants.
- Utilize stormwater management techniques, such as permeable pavers, bioswales, etc. to reduce and cleanse stormwater runoff.

Specifically, the Switchyard Park Master Plan identifies the following water quality or habitat improvement projects:

- Stream daylighting to restore natural systems and provide stormwater mitigation.
- Relocating a segment of Clear Creek to follow a more natural stream channel alignment.
- Invasive species removal and reforestation to improve natural habitat and stream health.
- Removal, remediation and replacement of contaminated soils within the floodplain to a depth of 12 inches.
- Conservation of riparian trees along Clear Creek and along the old railway that runs along the west end of the property.
- Streambank stabilization in four high priority areas. Stabilization should include grading, erosion control fabric, seeding or live staking, tree and shrub planting and the placement of limestone to replace the instable areas.
- Preservation of existing pool and riffle structures in Clear Creek.
- Restoration of native species including seeding with native grasses, sedges and forbs; planting native shrubs; planting of native trees in the Clear Creek floodplain and riparian corridor and planting native wetland species in wetland areas.
- Installation of stormwater BMPs around and the use of pervious concrete or pavers in current and future parking lots.

Indiana University Sustainability Master Plan (2012)
Building on the Campus Sustainability Report, the Campus Master Plan focuses on sustainable planning principles. Recommendations are grouped under several broad sustainable planning principles:

- Adopt environmentally sensitive land use practices including increasing the campus area dedicated to quality woodland, stream, and meadow habitat.
- Move toward a carbon-neutral campus which may involve strategies to lead to a significant reduction in greenhouse gas emissions up to 80 percent by the year 2050.
- Ensure a range of transportation options
- Identify land use changes to consolidate diverse campus uses within easy walking distance and reorganize critical routes through campus.
- Plan for innovative sustainable buildings and landscapes.
- Establish standards of sustainable design to guide new development.

Monroe County Comprehensive Plan (2012)
A key goal in this plan is to enhance protection of Monroe County's existing natural resources and open spaces while discouraging development activities that jeopardize the prosperity, integrity, and sustainability of the natural environment and associated recreational opportunities which make the community unique. Two water quality related goals in this plan include:

- Identify and evaluate the interrelated components of the local watersheds.
- Protect and restore the natural function of the components of the local watersheds.

To accomplish these goals, Monroe County will focus to:

- Protect significant natural features by increasing the amount of significant natural features permanently protected.
- Improve the integrity of local watersheds by improving water quality and quantity for all uses and establish a storm water utility.
- Protect economically significant natural resources including, but not limited to; farmland, forestland, mineral deposits, lakes, groundwater and surface-water and other bodies of water based on local, state and federal data contained in the Natural Features Inventory.
- Avoid future conflict with Vulnerable Land and natural features as the expansion of future infrastructure occurs.
- Restore damaged eco-systems beneficial to the community.
- Promote water conservation through improved site design standards.
- Avoid whenever feasible new development on slopes 15% or greater throughout the County.
- Establish riparian buffers on both sides of perennial or intermittent streams.
- Exclude karst features, floodway and slopes greater than 15% from the acreage used to calculate subdivision density in Urban areas.
- As part of the planning approval process, establish standards in the zoning and subdivision ordinances for avoiding disturbance of sensitive geological features.
- As part of the planning approval process, establish standards in the zoning and subdivision ordinances that require soils suitable to the permitted property use.
- Define a maintenance standard for tree buffering, preservation and coverage in new subdivisions and continue to encourage planting native tree species for residential, commercial and industrial development.

- Require protection of verified Endangered Species habitats.
- Establish standards in the zoning and subdivision ordinances that preserves topsoil and minimizes cut and fill in areas proposed for development.
- Establish a process for regular on-site inspections of erosion, sediment, and other pollution control practices throughout the development process.
- Require erosion and sediment control measures that maintain off-site run-off during construction and post-development at pre-development conditions.
- Create a storm water utility to manage and fund water run-off control structures.
- Require all subdivision proposals to provide adequate access to open space.
- Establish clear limits for site grading that will: minimize the impact of building footprints, maintain existing topsoil on site, and protect development area topography, existing vegetation and habitat.
- Establish protective buffers around existing wetlands and encourage the restoration of wetlands and watershed components as part of development approvals.
- Encourage the use of pervious surfaces in parking lots and sidewalks to enhance stormwater management when not in conflict with local, state and federal standards.
- Enable alternative renewable, sustainable energy sources for domestic use.
- Enable environmentally friendly soil management programs.
- Implement a Lake Lemon Watershed Protection Area and develop a plan to restore damaged ecosystems around the lake, improve the quality of watershed run-off, and protect the lake
- Increase sanctions for violations of protected slopes, karst features, and floodways.
- Create an Environmental Review Committee made up of citizens with technical expertise on environmental systems to provide a review of development proposals and report on concerns or mitigation recommendations.

Jordan River Restoration (2012)
The IU Bloomington Sustainability Task Force drafted the Jordan River Master Plan Feasibility Study. The project proposes the following restoration projects:

- Address streambank erosion at the bridge leaving the Indiana Memorial Union near Woodlawn/7Th street. Heavy infrastructure and trees are being eroded in this area.
- The bridge is broken causing safety issues in addition to erosion north of Bryan House.
- Areas of erosion east of the Indiana Memorial Union/Rockwall and hill erosion behind the chapel are high profile and threatening a historic structure.
- Wetland restoration areas were identified including the forested wetland north of the Musical Arts Center, the palustrine wetland north of Wright Education Building and the open wetland east of Campus View.

Bloomington Environmental Action Plan (2013)
The Bloomington Environmental Action Plan was developed to combat environmental degradation and climate change which are challenges facing the world. The plan states that Bloomington must grow more resilient in the face of an already changing climate. The goal of the BEAP is to achieve a 17 percent greenhouse gas emission reduction from a 2014 baseline by 2020 while enhancing the natural environment. Objectives that involve water quality include:

- Increase tree canopy coverage in Bloomington by 40% by 2020. The BEAP noted that this may require changes to codes and policies, expansion of public and private outreach programs and tree protection guidelines.
- Promote biodiversity by protecting, enhancing and expanding native wildlife habitat areas and the use of native plants within the City of Bloomington. This was slated to include resolutions noticing the native plant life and habitat as city assets, creating pocket parks to promote wildlife mobility, identifying and creating policies to protect sensitive areas, controlling invasive species in public parks and providing education to residents about invasive species management.
- Reducing energy consumption and nonpoint source pollution by implementing green infrastructure BMPs including the adoption of at least one green infrastructure technique in each city facility, updating erosion control ordinances, adopting a city green infrastructure policy to manage stormwater, promoting permeable pavement for new construction and in repair/replacement projects and applying for grants to offer financial incentives for rain gardens to residents.
- Provide Bloomington residents with educational resources about why they should conserve water.
- Fix or replace 20 miles of clay drinking water transmission piping.
- Reduce GHG emissions from Bloomington's WWTPs through the installation of an anaerobic digester if deemed feasible.

Lawrence County SWCD Plan of Business (2014)
The Lawrence County SWCD Business Plan highlights seven critical natural resources issues for Lawrence County: 1) cropland management, 2) forestry management, 3) pasture management, 4) urban, 5) water quality, 6) invasive species, and 7) wildlife. The following are some of the goals highlighted for completion by 2018:

- Increase cover crop acres by 2000 acres over 2013 plantings.
- Promote the number of individuals enrolled in the Classified Forests and Wildlands program by 5%.
- Promoting forage and biomass plantings by 140 acres.
- Increase stormwater and MS4 awareness by hosting one stormwater workshop.
- Use filter strips along streams and rivers to increase by 5000 additional feet.
- Increase early detection rapid response of invasive species by increasing information about invasive species.
- Assist landowners with wildlife management goals by increasing the annual distribution of wildlife food plot seed for upland birds by 2%.

Additional on-going efforts target promoting nutrient management plans, fertilizer and soil health workshops, continued marketing through website, etc. and continued identification of partnership opportunities.

Bloomington Parks and Recreation Department Master Plan (2015)
In 2015, the Bloomington Parks and Recreation Department developed the Master Plan (2016-2020) to provide guidance and direction to civic leaders and residents about decisions that affect the needs, distribution, relationships, and trajectory of park-land, recreation facilities, recreation programs, and

other services within the Bloomington community. Bloomington Parks and Recreation manage multiple parks including Winslow Woods, Olcott, Wapahani Mountain Bike Sports Park, RCA, Switchyard Park and Bryan Park; three nature preserves in the Lower Salt Creek Watershed: Brown's Woods, Latimer Woods and Leonard Springs and multiuse trails including Clear Creek, Bloomington Rail, B-Line and Jackson Creek. Several goals identified in the plan lend themselves to the Lower Salt Creek Watershed plan including:

- Expanding departmental trail systems to improve connectivity to other active design assets.
- Continuing to provide and promote high quality programs, events and recreational opportunities.
- Being responsive to development and redevelopment opportunities that enhance the park system.

Lake Monroe Master Plan (2015)
This is the strategic land-use management document that guides the comprehensive management, development and use for recreation, natural resources and cultural resources that are efficient and cost-effective throughout the life of the Monroe Lake Project. The plan identifies the need to continue to provide flood control for downstream communities and agricultural interests while continuing to provide low water augmentation for the Lower Salt Creek Watershed as Lower Salt Creek provides habitat for plant and animal life and aids in flood control and helps to mitigate flooding in below-dam receiving waters.

Monroe County Urbanizing Area Plan (2015)
The Monroe County Urbanizing Area Plan was initiated in 2014 to fulfill the recommendations of the County Comprehensive Plan for a more detailed land use plan to guide growth and development for the land surrounding the City of Bloomington. The Urbanizing Area Plan is the key policy guide for land use and development in the 36-square-mile area of unincorporated land immediately surrounding the City of Bloomington. Two objectives – encourage agriculture and promote green infrastructure – tie most closely to the Lower Salt Creek Watershed Plan. The strategies include:

- Conserve and protect open space networks and natural systems.
- Integrate sustainable design practices into roadways to create "green streets".
- Encourage low impact development techniques such as biofiltration, pervious pavements, and green roofs.
- Adopt policies to preserve existing agricultural land.

Additional areas of concern in the urbanizing area include:

- Utilities expansion – portions of the urbanizing area are located within City of Bloomington utilities. However, the Bloomington Grown Policies Plan limits expansion into the full area which could result in dense housing development in areas without utility access.
- Stormwater management – a key site development consideration for any new development in the urbanizing area will include the protection of surface water quality which will require stormwater management.

Monroe County Long Range Stormwater Improvement Plan (2016)
Monroe County Government recognized the need to develop a county-wide comprehensive stormwater improvement plan to provide an accounting of known stormwater drainage issues, along

with a plan for identifying, prioritizing and implementing sustainable solutions and providing a guideline for future improvements. The Stormwater Management Board has expressed the desire for a County wide strategy that allows for budgeting and implementation of prioritized projects over a 20-year period with flexibility to adjust solutions based on continual, ongoing and iterative feedback and input from residents. The Long-Range Stormwater Improvement Plan:

- Identifies and analyzes the existing drainage deficiencies throughout the County.
- Provides a range of drainage concepts for the repair, retrofit, and enhancement of existing facilities and construction of future facilities.
- Establishes criteria for selecting and prioritizing drainage projects.
- Combines the demands of flood risk reduction with ecosystem enhancements and considers development and rural land uses in providing an effective plan.
- Included active participation and involvement of a diverse set of key stakeholders; including the public, County staff, community organizations, and County Commissioners.
- Outlines potential funding sources for stormwater project.

Bloomington Habitat Connectivity Plan (BHCP, 2017)

The City of Bloomington Environmental Commission created the Bloomington Habitat Connectivity Plan to strengthen biodiversity and improve habitat connectivity through conservation, enhancement, and expansion of green space and habitat in Bloomington. The five recommendations to the city include:

- Conserve habitat before, during, and after development.
- Prioritize the habitat potential and permanent habitat connectivity of an area when making land use decisions.
- Connect isolated areas of habitat by producing greenspace corridors.
- Enhance habitat quality in stable areas by planting native species and removing invasives.
- Inform Bloomington residents of the ecological benefits of habitat connectivity and encourage citizen involvement in habitat restoration.

The BHCP identified three critical areas of essential greenspace that must be protected or enhanced to conserve high quality habitat in Bloomington and Monroe County. Two of these areas, Clear Creek and Jackson Creek, are located within the Lower Salt Creek Watershed. Protection will include the following:

- Mandate greenspace and habitat conservation before development occurs. The BHCP notes that this is especially important in the Clear Creek drainage as the southwest side of Bloomington is developing/redeveloping at a rapid rate. To prevent habitat loss that could result in development of sensitive natural features like karst, wetland and mature woodlands, protective measures must be enacted. The CBHP suggests that Bloomington require the conservation of greenspace before or as part of development activities.
- Preservation of environmentally sensitive areas including the State Road 37/Tapp Road critical sub area 3 development area is equally important. The Bloomington Growth Policies Plan identified this area as an area where the preservation of environmentally valuable and sensitive lands should occur. This area includes karst features such as sinkholes, steep slopes, riparian buffers and stream headwaters. The development of this area could have severe implications for the future of Jackson Creek and Bloomington as a whole.

- Connection of isolated corridors could occur through preservation and expansion of the green corridor northeast of Twin Lakes Sports Park and southwest/northeast of Butler Park and Crestmont Park.
- The use of green infrastructure must be increased through Bloomington as part of any efforts to mitigate stormwater impacts.

Monroe County SWCD Long Range Plan (2018)
The Monroe County SWCD Long Range Plan (2019 – 2023) highlights five critical natural resources issues for Monroe County: 1) soil health, 2) erosion, 3) invasive plants, 4) land use and 5) water appreciation. The Monroe County SWCD highlights the need to host cover crop and soil health workshops, partner with the County Stormwater Utilities concerning a contractor's workshop, partner with McIRIS on a field day about invasive plants, promote urban conservation, partner/participate in the Lake Shore Clean Up at Lake Monroe and Lake Griffy and more.

Monroe County Parks and Recreation Department Master Plan (2018)
Monroe County Parks & Recreation, which operates five parks and one greenway, has created this system-wide master plan for parks and recreation in order to assess current conditions, identify community needs and interests, and balance these with opportunity, sustainability, financial plans, and the actions required to implement the plan. It is noted that:

- Flatwoods Park has intermittent streams used for water quality studies.
- Jackson Creek Park preserves the riparian corridor of Clear Creek.
- Ferguson Nature Park has generous wooded riparian buffers along Muddy Fork and Beanblossom Creek.

Additionally, the Monroe County Parks Department offers Environmental Education Programs that include water quality.

City of Bloomington Climate Action Plan (2021)
The Bloomington Climate Action Plan is intended as a living plan rather than a static document. The City of Bloomington notes that as a living plan, the 2030 emission reduction goal should be seen as a guiding constant to achieve emissions reductions. However, recognition should be given that the initial implementation actions may not yet fully achieve plan goals. Intermittent plan progress measurements and adjustments will be necessary to identify additional actions that may be necessary to reach the CAP goal, as well as any adjustments to implementation targets that may be needed to meet the greenhouse gas reduction goal by 2030. Four goals in the plan address water and wastewater targets and four goals address greenspace and ecosystems. These include the following:

- Decrease potable water consumption by 3% of 2018 values.
- Maintain source and drinking water quality through climate related challenges.
- Reduce energy use associated with treating and transporting water and wastewater by 10% of 2018 values.
- Mitigate flood hazards and impacts.
- Increase quantity and quality of greenspaces within the community.
- Increase quantity and quality of climate adaptive native habitats.
- Increase citywide tree canopy coverage by 3% of 2018 values.
- Reduce stormwater and micro heat island impacts.

Lake Monroe Watershed Management Plan (2022)
Lake Monroe is the largest lake in Indiana, providing drinking water for over 130,000 people and generating over $40 million annually in recreational spending. Friends of Lake Monroe worked for three years to develop the 2022 Lake Monroe Watershed Management Plan. The 2022 Management Plan is available to the public at libraries in Monroe, Brown, and Jackson Counties, as well as online at https://friendsoflakemonroe.org/watershed-plan/ (FOLM, 2022). The watershed plan identifies the top threats to water quality in Lake Monroe and provides an action plan to address those threats over the next 20 years. These include harmful algal blooms which impact recreation and drinking water treatment in Lake Monroe; nutrients which impact algal blooms; sediment which carries nutrients into the lake and accumulates in the lake; fecal contamination from humans and animals which was found to be widespread; the need for best management practices for livestock to reduce nutrient and bacteria inputs; septic system maintenance and repair which can reduce nutrient and bacteria inputs; streambank and shoreline stabilization. Protecting water quality in Lake Monroe will require reducing phosphorus, nitrogen, sediment, and E. coli loads entering the lake from the watershed over the next 20 years. The action plan includes:

- Increasing the adoption of best management practices on agricultural and forested land.
- Expanding riparian buffer along streams.
- Maintaining and repairing septic systems.
- Encouraging green boating practices and "leave no trace" principles.
- Stabilizing key sections of shoreline and streambanks.
- Protecting and restoring floodplains, especially along the three main tributaries (South Fork, Middle Fork, and North Fork Salt Creek).
- Reducing the amount of littering in the watershed.
- Promoting collaboration between different governmental bodies in the watershed.
- Monitoring water quality to evaluate impacts.

2.12 Watershed Summary: Parameter Relationships

Several relationships among watershed parameters become apparent when watershed-wide data are examined. These relationships are discussed here in general, while relationships within specific subwatersheds are discussed in more detail in subsequent sections.

2.12.1 Topography, Soils, Septic Suitability, Hydrology and Karst Geology

Much of the topography and terrain characteristics within the Lower Salt Creek Watershed have a direct correlation to water quality. Approximately 96% of the Lower Salt Creek Watershed is mapped in highly erodible lands. Highly erodible lands are very susceptible to erosion. Nutrients, such as phosphorus, and sediment erode easily when these soils are not covered. Sediments and nutrients that reach Lower Salt Creek waterbodies are likely to degrade water quality. Highly erodible lands that are used for animal production or are located on cropland are more susceptible to soil erosion.

Topography within the watershed is relatively steep with nearly 13% of the watershed covered by karst. Steepness of the terrain in this area likely made it very difficult to remove timber, making this portion of the watershed one of the most heavily forested areas today. Protecting and restoring the forested riparian buffer in this area will be important to reducing streambank erosion and in-stream sediment levels. Additionally, buffering karst areas will be necessary to limit negative impacts to the aquifer.

2.12.2 Development, Population Centers and Legacy Pollutants

Much of the watershed's population is located within incorporated areas, including Bedford, Bloomington and Oolitic but continues to extend along the SR 37 corridor. Unsewered, dense housing areas are located throughout the watershed with small subdivisions and roadside housing developments occurring throughout the watershed. This is a concern because adequate filtration may not occur and this water may easily reach water sources and groundwater. With a lack of natural filtration of septic fields to groundwater, degradation of water quality is likely if septic systems are not maintained. Septic maintenance is a concern of Lower Salt Creek Watershed stakeholders with nearly 60 septic complaint areas identified by the Monroe County Health Department. The highest impervious surface densities and highest number of NPDES-regulated facilities occur within these urban population centers and are home to the most urban development issues including brownfields, leaking underground storage tanks (LUST), industrial waste sites and legacy pollutants. The concentration of urban pollution issues suggests that within these areas, urban solutions are required to control water quality pollution and improve conditions within the Lower Salt Creek Watershed.

2.12.3 High Quality Habitat and ETR Species

Many high quality communities occur throughout the Lower Salt Creek Watershed. Several of these are preserved for future generations by the U.S. Forest Service, Bloomington and Bedford Parks and Recreation, The Nature Conservancy, Monroe County Park and Recreation and others. The high quality natural regions, heavy forest cover and steep topography associated with Lower Salt Creek Watershed streams' riparian areas provide unique habitats which house several endangered, threatened or rare communities and species. The topography, bedrock and soils in this area support spectacular ravines and mature forest habitats that provide rare habitat that is home to many species of wildlife, fish, and plants. The topography here made this area less suitable for farming and so more of the natural community and habitat has been preserved here. Many of the endangered, threatened and rare species and high quality natural communities in the watershed are found along this stretch of the stream corridor, making this an important area to focus habitat preservation and restoration efforts.

3.0 <u>WATERSHED INVENTORY II-A: WATER QUALITY AND WATERSHED ASSESSMENT</u>

In order to better understand the watershed, an inventory and assessment of the watershed and existing water quality studies conducted within the watershed is necessary. Examining previous efforts allowed the project participants to determine if sufficient data was available or if additional data needed to be collected in order to characterize water quality problems. Once the water quality data assessment occurred, the watershed was then characterized to determine potential sources of any water quality issues identified by the data review. Subsequently, pollutant sources could then be tied to stakeholder concerns and collected data could be used to estimate pollutant loads from each identified source location. The following sections detail the water quality and watershed assessment efforts on both the broad, watershed-wide scale and in a focused manner looking at each subwatershed within the Lower Salt Creek Watershed.

3.1 Water Quality Targets

Many of the historic water quality assessments occurred using different techniques or goals. Several sites were sampled only one time and for a limited number of parameters. Monitoring committee members were reluctant to draw too many conclusions based on a single sampling event. Nonetheless, the available data are detailed below and compared in general with water quality targets. In order to compare the results of these assessments, the monitoring committee identified a standard suite of parameters and parameter benchmarks. Table 20 details the selected parameters and the benchmark utilized to evaluate collected water quality data.

Table 20. Water quality benchmarks used to assess water quality from historic and current water quality assessments.

Parameter	Water Quality Benchmark	Source
Dissolved oxygen	>4 mg/L or <12 mg/L	Indiana Administrative Code
pH	>6 or <9	Indiana Administrative Code
Temperature	Monthly standard	Indiana Administrative Code
Conductivity	<1050 μmhos/cm	Indiana Administrative Code
E. coli	<235 colonies/100 mL	Indiana Administrative Code
Nitrate-nitrogen	<1 mg/L	Dodds et al. (1998)
Ammonia-nitrogen	Varies by pH/temp	Indiana Administrative Code
Total Kjeldahl nitrogen	2.18 mg/L	USEPA (2000)
Total phosphorus	<0.08 mg/L	Dodds et al. (1998)
Orthophosphorus	<0.005 mg/L	Dunne and Leopold (1978)
Total suspended solids	<15 mg/L	Waters (1995)
Turbidity	<6.36 NTU	USEPA (2000)
Qualitative Habitat Evaluation Index	>51 points	IDEM (2008)
Index of Biotic Integrity	>36 points	IDEM (2008)
Macroinvertebrate Index of Biotic Integrity	>2.2 points (old) >36 points (new)	IDEM (2008)

3.2 Historic Water Quality Sampling Efforts

A variety of water quality assessment projects have been completed within the Lower Salt Creek Watershed (Figure 30). Statewide assessments and listings include the impaired waterbodies assessment and fish consumption advisories. Additionally, the U.S. Fish and Wildlife Service (USFWS), U.S. Environmental Protection Agency (USEPA), U.S. Army Corps of Engineers (USACE) and U.S. Geological Survey (USGS), Indiana Department of Environmental Management (IDEM), Indiana Department of Natural Resources (IDNR), Indiana University, Indiana Geological Survey, Monroe County, General Motors and Friends of Lake Monroe have all completed assessments within the watershed. Additionally, volunteer-based sampling of water quality through the Hoosier Riverwatch program also provide water quality data with which the watershed can be characterized. A summary of each assessment methodology and general results are discussed below. Specific data results are detailed within subwatershed discussions in subsequent sections.

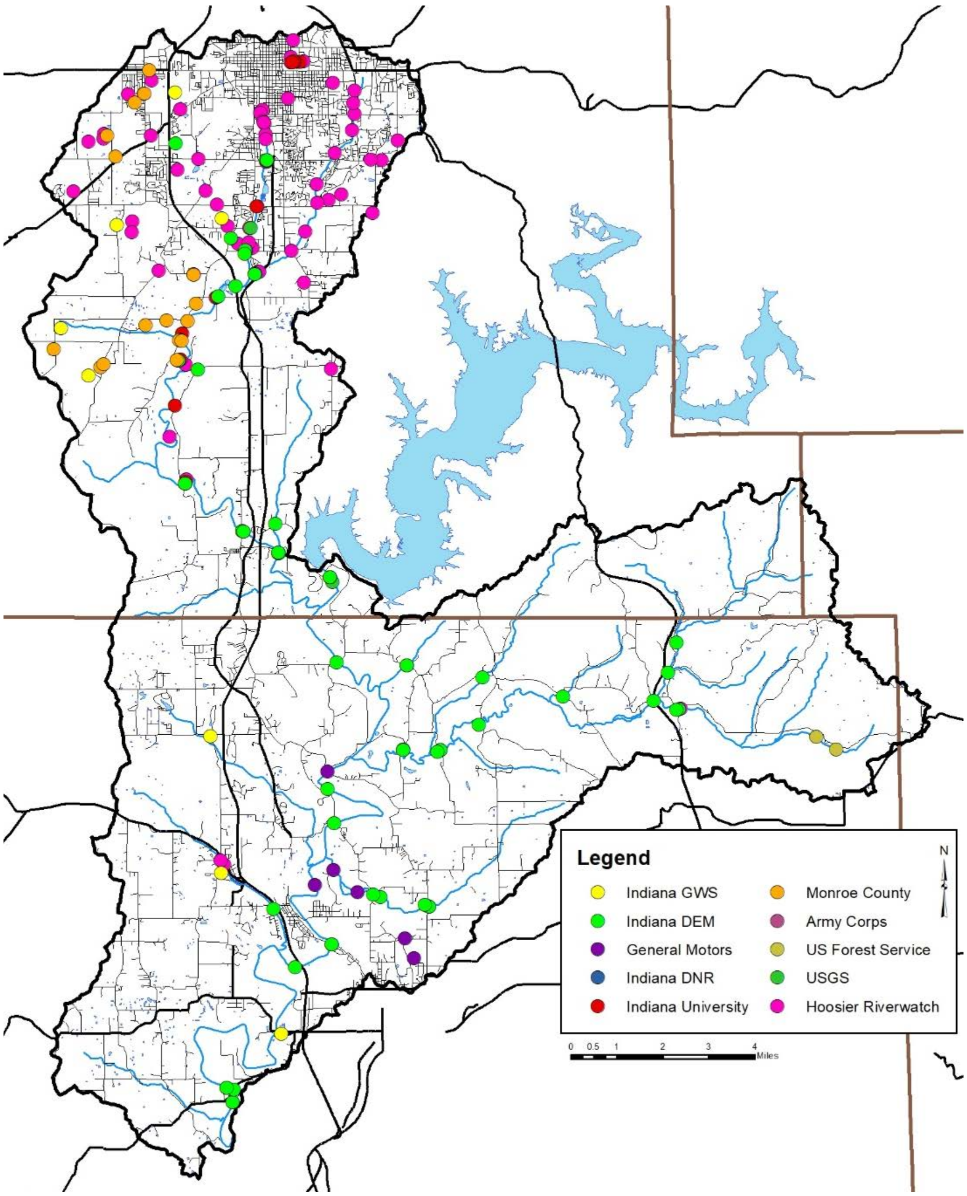

Figure 30. Historic water quality assessment locations.

3.2.1 Impaired Waterbodies (303(d) List)

The impaired waterbodies, or 303(d), list is prepared biannually by the Indiana Department of Environmental Management. Waterbodies are included on the list if water quality assessments indicate that they do not meet their designated use. In total, 55 stream segments within the Lower Salt Creek Watershed are included on the list of impaired waterbodies (IDEM, 2018). Table 21 details the listings in the watershed, while Figure 31 maps the segments and their locations within the watershed. Waterbodies are listed as impaired for *E. coli* (175 miles), nutrients (9.1 miles), impaired biotic communities (72.5 miles), dissolved oxygen (6.1 miles), mercury in fish tissue (21.5 miles) and PCBs in fish tissue (82.5 miles). It should be noted that the development of the Lower Salt Creek TMDL moves E. coli impairments to category 4 or removes them from the Indiana impaired waterbodies list.

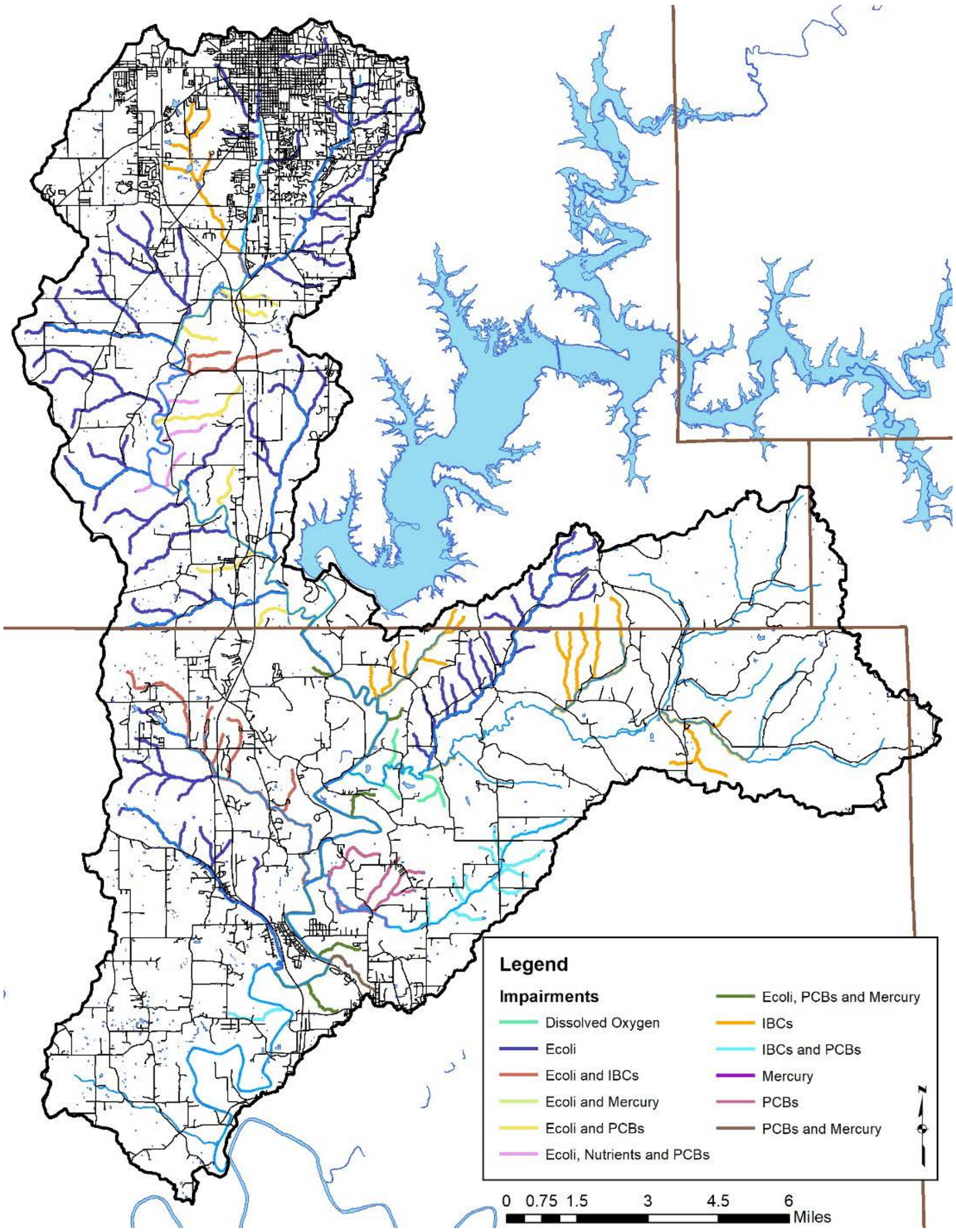

Figure 31. Impaired waterbody locations in the Lower Salt Creek Watershed. Source: IDEM, 2018.

Table 21. Impaired waterbodies on the Lower Salt Creek Watershed 2018 IDEM 303(d) list. E. coli listings are considered Category 4 listings, while all other listings are considered Category 5 listings.

Waterbody Name	Assessment Unit	Impairment	Miles
CLEAR CREEK	INW0881_01	E. coli	0.32
CLEAR CREEK	INW0881_01A	E. coli	1.36
CLEAR CREEK	INW0881_02	E. coli	0.47
CLEAR CREEK	INW0881_03	E. coli, IBC, PCBs	3.11
CLEAR CREEK	INW0881_04	E. coli, IBC	0.59
CLEAR CREEK - UNNAMED TRIBUTARY	INW0881_T1001	E. coli	1.66
CLEAR CREEK - UNNAMED TRIBUTARY	INW0881_T1002	E. coli	0.82
CLEAR CREEK - UNNAMED TRIBUTARY	INW0881_T1003	E. coli	1.35
JACKSON CREEK - UNNAMED TRIBUTARY	INW0881_T1005	E. coli	5.31
JACKSON CREEK - UNNAMED TRIBUTARY	INW0881_T1006	E. coli	2.54
JACKSON CREEK - UNNAMED TRIBUTARY	INW0881_T1007	E. coli	1.40
JACKSON CREEK	INW0881_T1008	E. coli	6.37
JACKSON CREEK	INW0881_T1009	E. coli, IBC	2.29
CLEAR CREEK - UNNAMED TRIBUTARY	INW0881_T1010	IBC	6.74
CLEAR CREEK	INW0882_02	E. coli, PCBs	5.88
CLEAR CREEK	INW0882_03	E. coli, PCBs, nutrients	9.12
CLEAR CREEK - UNNAMED TRIBUTARY	INW0882_T1001	E. coli	7.05
CLEAR CREEK - UNNAMED TRIBUTARY	INW0882_T1003	E. coli	7.47
CLEAR CREEK - UNNAMED TRIBUTARY	INW0882_T1004	E. coli, IBC	3.58
CLEAR CREEK - UNNAMED TRIBUTARY	INW0882_T1005	E. coli	6.52
MAY CREEK	INW0882_T1006	E. coli	4.79
CLEAR CREEK - UNNAMED TRIBUTARY	INW0882_T1007	E. coli, PCBs	2.51
CLEAR CREEK	INW0883_01	E. coli, PCBs	6.29
CLEAR CREEK	INW0883_02	E. coli, PCBs	3.52
CLEAR CREEK - UNNAMED TRIBUTARY	INW0883_T1001	E. coli	1.83
CLEAR CREEK - UNNAMED TRIBUTARY	INW0883_T1002	E. coli	3.17
CLEAR CREEK - UNNAMED TRIBUTARY	INW0883_T1003	E. coli	2.67
LITTLE CLEAR CREEK	INW0883_T1004	E. coli	9.43
JUDAH BRANCH	INW0883_T1005	E. coli	6.18
HENDERSON CREEK	INW0884_T1010	IBC	5.50
LITTLE SALT CREEK	INW0885_02	DO	6.09
LITTLE SALT CREEK	INW0885_05	IBC	0.77
LITTLE SALT CREEK - UNNAMED TRIBUTARY	INW0885_T1001	IBC	9.81
KNOB CREEK	INW0885_T1007	E. coli	6.24
KNOB CREEK	INW0885_T1008	E. coli	8.10

Waterbody Name	Assessment Unit	Impairment	Miles
KNOB CREEK	INW0885_T1009	E. coli	7.54
SALT CREEK	INW0886_01	E. coli, Mercury	1.21
SALT CREEK	INW0886_02	E. coli, PCBs, Mercury	6.33
SALT CREEK	INW0886_03	E. coli, PCBs, Mercury	5.54
SALT CREEK	INW0886_04	E. coli, PCBs, Mercury	0.33
WOLF CREEK	INW0886_T1004	IBC	6.69
GULLETTS CREEK	INW0886_T1009	E. coli, IBC	12.46
GULLETT CREEK - UNNAMED TRIBUTARY	INW0886_T1010	E. coli	1.47
GULLETT CREEK - UNNAMED TRIBUTARY	INW0886_T1011	E. coli	5.39
PLEASANT RUN	INW0886_T1012	PCBs	8.65
PLEASANT RUN	INW0886_T1013	IBC, PCBs	11.59
SALT CREEK	INW0887_02	E. coli, PCBs, Mercury	3.81
SALT CREEK	INW0887_03	E. coli, PCBs, Mercury	2.69
SALT CREEK	INW0887_04	IBC, PCBs, Mercury	10.62
SALT CREEK	INW0887_05	IBC, PCBs, Mercury	1.01
GOOSE CREEK	INW0887_T1006	E. coli	7.71
GOOSE CREEK	INW0887_T1007	E. coli	1.67
SALT CREEK - UNNAMED TRIBUTARY	INW0887_T1009	PCBs, Mercury	1.47
WEIMER LAKE	INW08P1111_00	Mercury	0.11

3.2.2 Fish Consumption Advisory (FCA)

Three state agencies collaborate annually to compile the Indiana Fish Consumption Advisory (FCA). The Indiana Department of Natural Resources, Indiana Department of Environmental Management, and Indiana State Department of Health have worked together since 1972 on this effort. Samples are collected through IDEM's rotating basin assessment for bottom feeding, mid-water column feeding, and top feeding fish. Fish tissue samples are then analyzed for heavy metals, PCBs, and pesticides. Advisories listings by the ISDH are as follows:

- Level 3 – limit consumption to one meal per month for adults with pregnant or breastfeeding women, women who plan to have children, and children under 15 consuming zero volume of these fish.
- Level 4 – limit consumption to one meal every 2 months for adults with women and children detailed above having zero consumption.
- Level 5 – zero consumption or do not eat.

Further, sensitive populations are defined as females under 50 except those no longer able to become pregnant, males under 15 or people with compromised immune systems, while general populations are defined as males over the age of 15 and women over the age of 50 or who are no longer capable of becoming pregnant.

Based on these listings, the following conclusions can be drawn:

- Consumption of any fish from Clear Creek should be limited to one meal per month for general and sensitive populations.
- Consumption of any fish from Salt Creek from the Lake Monroe tailwaters to the confluence with the East Fork White River in Monroe and Lawrence Counties should not occur.
- Consumption of fish from Pleasant Run should be limited to no more than one meal per month for group 3 individuals for general and sensitive populations with the following exceptions: bullhead species should be limited to one meal per week and largemouth bass and sunfish species should be limited to one meal per month for general and sensitive populations.
- For those in the sensitive population in Monroe and Lawrence Counties, bullhead species up to 11 inches should be limited to one meal per month while those over 11 inches should be limited to six meals per year; carpsucker, crappie, largemouth bass, rock bass, smallmouth bass, spotted bass, sunfish and white sucker species should be limited to one meal per month; flathead catfish under 20 inches should be limited to six meals per year, while those over 20 inches should not be consumed; and redhorse species up to 12 inches should be limited to one meal per month, while those over 12 inches should be limited to six meals per year.
- For the general population in Monroe and Lawrence Counties, bullhead species under 11 inches should be limited to one meal per month, while those over 11 inches should be limited to six meals per year; redhorse species up to 12 inches should be limited to one meal per month and those over 12 inches should be limited to six meals per year; flathead catfish up to 20 inches should be limited to six meals per year and those over 20 inches should not be eaten; carpsucker, crappie, largemouth bass, smallmouth bass, spotted bass, sunfish and white sucker should be limited to on meal per month; spotted sucker should be limited to one meal per year; and rock bass should be limited to one meal per week.
- Additionally, statewide limitations are as follows: buffalo species up to 23 inches should be limited to one meal per week and those over 23 inches should be limited to one meal per month; bullhead species should be limited to one meal per week, channel catfish up to 20 inches should be limited to one meal per week, 20-30 inch channel catfish should be limited to one meal per month and those over 30 inches should not be consumed; freshwater drum up to 15 inches should be limited to one meal per week and those over 15 inches should be limited to one meal per month; northern pike over 30 inches should be limited to one meal per week and those over 30 inches should be limited to one meal per month; sauger under 14 inches should be limited one meal per week and over 14 inches should be limited to one meal per month; silver carp over 24 inches should be limited to one meal per month; spotted bass under 10 inches should be limited to one meal per week and over 10 inches should be limited to one meal per month; sunfish should be limited to one meal per week; walleye up to 19 inches should be limited to one meal per week while those over 19 inches should be limited to one meal per month; white, striped or hybrid bass up to 12 inches should be limited to one meal per week and those over 12 inches should be limited to one meal per month.

3.2.3 U.S. Forest Service (2011; 2015-2017)

The USFS completed its Watershed Condition Framework in 2011 (USFS, 2011a and b). The framework is a comprehensive approach to proactively implement integrated restoration for priority watersheds located on national forest and grasslands. Specifically, the framework created a mechanism to improve the way the USFS approaches watershed restoration by targeting and implementing projects in watersheds which have been identified as restoration priorities. The framework provides a consistent way to evaluate conditions at the national and forest level using the core national watershed condition indicators and attributes (Figure 32).

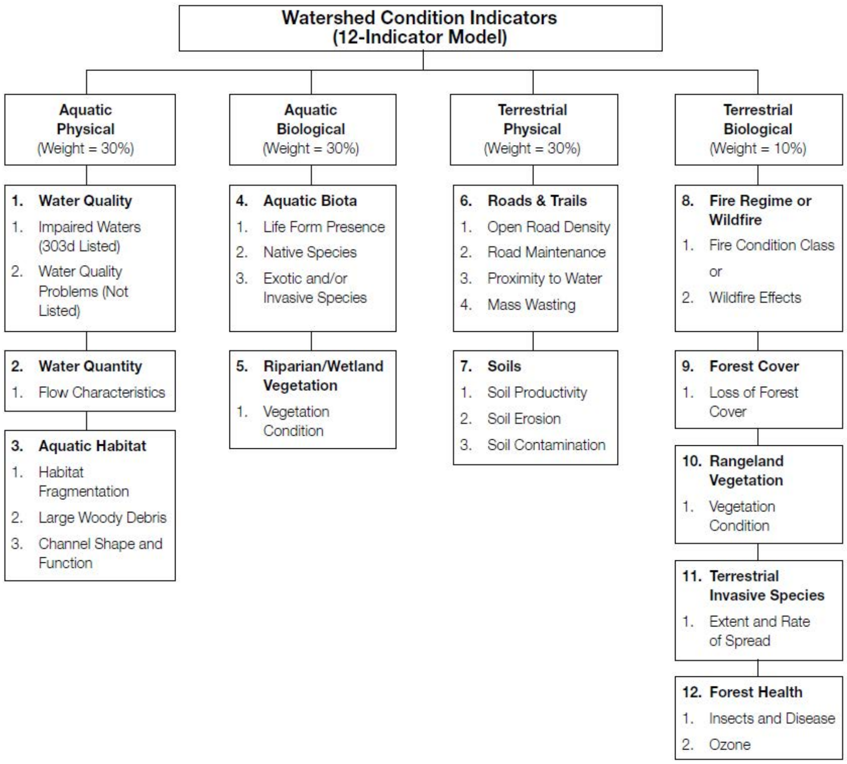

Figure 32. Watershed condition indicators model.

Based on 2011 framework assessment of the Hunter Creek-Little Salt Creek and Knob Creek-Little Salt Creek subwatersheds, the following conclusions can be drawn:

- Aquatic biota, water quantity, forest cover, terrestrial invasive species and riparian condition rate as good for both subwatersheds.
- Water quality and forest health rate as fair for both subwatersheds.
- Aquatic habitat, soil condition, fire condition rate as poor for both subwatersheds.
- Road and trail conditions rate as fair for Knob Creek-Little Salt Creek and poor for Hunter Creek-Little Salt Creek.
- Overall, both subwatersheds rate as "functioning at risk" using the framework assessment.

Additionally, U.S. Forest Service personnel completed fish community assessments at four locations along Henderson Creek above and below the lowhead dam (Kring, personal communication). Based on the fish community assessments, the following conclusions can be drawn:

- The fish community above the lowhead dam is limited with IBI scores ranges from 18 to 24 both immediately above the dam and below the dam. Overall, these sites rated as very poor.
- Conditions improve downstream of the lowhead dam with scores ranged from 34 to 38 and rating poor to fair.

3.2.4 U.S. Army Corps of Engineers (1999-2020)

The Army Corps of Engineers samples the Lake Monroe tailwaters immediately downstream of Lake Monroe or at the uppermost undammed location of Salt Creek in the Lower Salt Creek Watershed on a monthly basis during the growing season. Based on the water chemistry assessments, the following conclusions can be drawn:

- Dissolved oxygen concentrations exceeded target concentrations in 6% of samples collected.
- Total phosphorus concentrations exceeded target concentrations in 32% of samples collected.
- Orthophosphorus samples exceeded target concentrations in 43% of samples collected.
- Nitrate-nitrogen concentrations exceeded target concentrations in 6% of samples collected.
- Turbidity exceeded target concentrations in 61% of samples collected.

3.2.5 U.S. Geological Survey Assessments (1989-2014)

Between 1992 and 2009, the U.S. Geological Survey (USGS) sampled water chemistry at seven locations in the Lower Salt Creek Watershed. Based on the water chemistry assessments, the following conclusions can be drawn:

- Total phosphorus concentrations exceeded target concentrations in 32% of samples collected in the Lower Salt Creek Watershed.
- Nitrate-nitrogen concentrations exceeded target concentrations in 20% of samples collected in the Lower Salt Creek Watershed.
- Total suspended solids concentrations exceeded target concentrations in 10% of samples collected in the Lower Salt Creek Watershed.

3.2.6 IDEM Rotational Basin Assessments (1991-2021)

IDEM sampled water chemistry, macroinvertebrates, fish and habitat at several locations in the Lower Salt Creek Watershed via their rotational basin, watershed assessment, and source ID assessment programs between 1991 and 2020. Additionally, one site on Salt Creek at Oolitic is sampled monthly as part of IDEM's fixed station monitoring program from 1991 through 2020. A few of the assessments which occurred via various IDEM assessment programs included a single sample event with most assessments including five sample events and a few assessments including up to 12 events. Based on the water chemistry assessments, the following conclusions can be drawn:

- *E. coli* concentrations exceeded the state standard in 32% of samples collected in the Lower Salt Creek Watershed.
- Nitrate-nitrogen concentrations exceeded target concentrations in 22% of samples collected in the Lower Salt Creek Watershed.
- Total phosphorus concentrations exceeded the recommended criteria in 22% of samples collected in the Lower Salt Creek Watershed.
- Total suspended solids concentrations exceeded the recommended criteria in 27% of samples collected in the Lower Salt Creek Watershed.
- Turbidity levels routinely exceed the recommended standard in 79% of samples collected in the Lower Salt Creek Watershed.

Based on the fish and macroinvertebrate community and habitat assessments, the following conclusions can be drawn:

- Macroinvertebrate community assessments indicate that Lower Salt Creek and its tributaries rate as moderately impaired to slightly impaired using the kick net sampling procedure. Nearly half of the sites sampled using the multimetric habitat approach rate as impaired scoring 36 points or less.

- Fish community assessments indicate that Lower Salt Creek and its tributaries rate as very poor (16) to excellent (56). Salt Creek at Old SR 450 and Gulletts Creek at Peerless Road rated as very poor, while Wolf Creek at CR 825 North, the Tributary to Little Salt Creek at Heltonville Bartlettsville Road, Henderson Creek at Humpback Ridge Road and Little Clear Creek at Monroe Dam Road rated as poor. Clear Creek at Ketcham Road and Gore Road rated as excellent.
- Habitat assessments completed along Lower Salt Creek and its tributaries indicate that habitat is generally fully supporting for aquatic life uses with QHEI scores ranging from 36 to 88 during fish community assessments and from 30 to 87 during macroinvertebrates. During fish assessment, only six sites rated QHEI scores which indicate they are not fully supporting of their aquatic life use designation. These include Little Salt Creek at Judah Legend and Bat Hollow Road, Gulletts Creek at Peerless Road, Salt Creek at Guthrie Road and Peerless Road and Wolf Creek at CR 825 North. In total, 13 sites rated as not fully supporting of their aquatic life use designation during macroinvertebrate sampling. These include Salt Creek at Peerless Road, Guthrie Road and Old SR 450; Little Salt Creek at Bat Hollow Road, Old SR 450 and Judah Legan Road; Wolf Creek at CR 825 North and Guthrie Road; Gulletts Creek at Peerless Road; Knob Creek at Bat Hollow Road; and Clear Creek at Country Club Drive.

3.2.7 Lower Salt Creek TMDL (IDEM, 2018)

IDEM collected water quality data from Lower Salt Creek and its tributaries in 1992, 1995, 1997, 2000, 2001, 2002, 2007 and 2012.These data were combined with targeted water quality data collected November 2015 through October 2016. These data indicate that 19 of 27 sample sites exceeded the state geometric mean standard for E. coli (125 col/100 ml). Further, these data indicate that a 47-94% reduction in E. coli is needed to meet state water quality standards. IDEM identified a number of potential sources of E. coli in the Lower Salt Creek Watershed including wastewater treatment plants, Municipal Separate Storm Sewer Systems (MS4s), Sanitary Sewer Overflows, pet waste, unregulated stormwater runoff, agriculture runoff, direct deposition or field runoff from livestock, wildlife direct deposits, leaking or failing septic systems and illegal straight pipe systems. IDEM detailed critical conditions for each of the Lower Salt Creek subwatersheds (Table 22). Data collected by IDEM and used for TMDL calculation generate the following conclusions:

- A 90-98% reduction in E. coli is required in the Jackson Creek Subwatershed.
- A 47-98% reduction in E. coli is required in the May Creek Subwatershed.
- A 57-87% reduction in E. coli is required in the Little Clear Creek Subwatershed.
- An 8-37% reduction in E. coli is required in the Hunter Creek Subwatershed.
- A 58-82% reduction in E. coli is needed in the Knob Creek Subwatershed.
- A 70-93% reduction in E. coli is needed in the Wolf Creek Subwatershed.
- An 82-89% reduction in E. coli is needed in the Goose Creek Subwatershed.

Table 22. Critical conditions for E. coli in the Lower Salt Creek Watershed as detailed by IDEM (2018).

Parameter	Subwatershed (HUC)	Critical Condition				
		High (0%-10%)	Moist (10%-40%)	Mid-Range (40%-60%)	Dry (60%-90%)	Low (90%-100%)
E. coli	Jackson Creek (051202080801)	--	90%	90%	98%	--
	May Creek (051202080802)	--	47%	90%	98%	--
	Little Clear Creek (051202080803)	--	57%	83%	87%	--
	Hunter Creek (051202080804)	--	8%	NA	37%	--
	Knob Creek (051202080805)	--	74%	58%	82%	--
	Wolf Creek (051202080806)	--	84%	70%	93%	--
	Goose Creek (051202080807)	--	89%	NA	82%	--

Note: -- = No Data Collected in Flow Regime NA= No reduction needed

Prior to water quality sample collection for the TMDL, several impaired waterbodies listings were already in place for the Lower Salt Creek Watershed. This included two assessment units listed as impaired for E. coli, 12 assessment units listed as impaired for fish tissue impairments including PCBs or mercury, and three assessment units cited for impaired biotic communities. Based on data collected from November 2015 to October 2016, 43 assessment units are listed as impaired for E. coli. IDEM developed waste load allocations (WLA) for each NPDES wastewater treatment facility (Table 23) and each of the MS4 communities in the Lower Salt Creek Watershed (Table 24).

Table 23. Individual waste load allocation for NPDES facilities in the Lower Salt Creek Watershed.

Subwatershed	Facility Name	Permit Number	AUID	Design Flow (MGD)	E.coli WLA (count/day)
May Creek	Bloomington S. Dillman Rd. WWTP	IN0035718	INW0882_01	15	1.33E+11
Little Clear Creek	South Central RSD Caslon WWTP	IN0045187	INW0883_T1004	0.3	2.67E+09
	Briarwood Subdivision WWTP	IN0038920	INW0883_T1006	0.037	3.29E+08
Wolf Creek	Pedigo Bay WWTP	IN0062154	INW0886_01	0.022	1.96E+08
	Camp INDI CO SO	IN0042617	INW0886_T1010	0.010	8.89E+07
	Stone Crest Golf Community WWTP	IN0061093	INW0886_T1009	0.04	3.56E+08
Goose Creek	Oolitic WWTP	IN0023981	INW0887_T1001	0.35	3.11E+09
	Needmore Elementary School	IN0053741	INW0887_T1001	0.009	8.00E+07

Table 24. Individual waste load allocations for the MS4 communities in the Lower Salt Creek Watershed.

Subwatershed	MS4 Community	Permit ID	Area in Drainage (Acres)	Percentage of Subwatershed	High Flow Regime WLA	Moist Flow Regime WLA
Jackson Creek	Monroe County	INR040089	6325.25	39.36%	5.85E+11	1.04E+11
	IU Bloomington	INR040123	954.38	5.94%	8.82E+10	1.58E+10
	Bloomington	INR040136	8,657.22	53.88%	8.00E+11	1.43E+11
May Creek	Bloomington	INR040136	347.01	1.81%	3.14E+10	5.61E+09
	Monroe County	INR040089	6,996.94	36.47%	6.33E+11	1.13E+11
Little Clear Creek	NA	NA	NA	NA	NA	NA
Hunter Creek	NA	NA	NA	NA	NA	NA
Knob Creek	NA	NA	NA	NA	NA	NA
Wolf Creek	Bedford	INR040027	315.78	1.25%	4.73E+10	8.45E+09
Goose Creek	Bedford	INR040027	1,217.11	5.51%	1.12E+11	2.00E+10

IDEM recommended addressing the following contributing sources:

- Wastewater treatment plants
- Sanitary sewer overflows
- Regulated stormwater sources (MS4s)
- Illicitly connected straight pipe septic systems
- Cropland
- Pastures and livestock operations
- Confined feeding operations
- Streambank erosion
- On-site wastewater treatment systems especially failing septic systems or those in disrepair
- Wildlife and domestic pets
- Urban nonpoint source runoff

Table 25 details potential contributing E. coli sources by flow condition (duration curve zone). These can be used to identify sources of E. coli for each subwatershed.

Table 25. Relationship between load duration curve zones and contributing sources identified in the Lower Salt Creek Watershed.

Contributing Source Area	Duration Curve Zone				
	High (0%-10%)	Moist (10%-40%)	Mid-Range (40%-60%)	Dry (60%-90%)	Low (90%-100%)
Wastewater treatment plants			L	M	H
Livestock direct access to streams			L	M	H
Wildlife direct access to streams			L	M	H
Pasture management	H	H	M		
On-site wastewater systems/Unsewered areas	L	M	H	H	H
Riparian buffer areas	H	H	M	M	
Storm water: Impervious	H	H	H		
Storm water: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M	L	
Bank erosion	H	M	L		

3.2.8 Indiana DNR (2004)

In 2004, the Indiana DNR assessed the fish community and habitat of Clear Creek at three stations approximately five river miles apart (Kittaka and Schoenung, 2006). In total, 1,513 fish representing 29 species were collected. Based on the community assessment, the following conclusions can be drawn:
Field measurements, including temperature, dissolved oxygen, pH, conductivity, and turbidity, fall within target concentrations for all samples collected.
Game species, including smallmouth bass, rock bass, spotted bass and largemouth bass comprised 7% of the fish collected.
All stations rated as good for fish community (IBI scores 48 to 54) and all habitat assessments indicate Clear Creek is meeting its aquatic life use designation at these stations (QHEI scores 57.6 to 80.25).

3.2.9 Indiana Geological and Water Survey (2019-2020)

The Indiana Geological and Water Survey completed a one-time, low-flow sampling of 100 karst springs in an effort to characterize the groundwater component of springs (Branam, personal communication). Eight of the springs sampled are located in the Lower Salt Creek Watershed. Based on the water chemistry assessments conducted, the following conclusions can be drawn:

- Conductivity measured below state standards for all springs except Salt Creek Spring.
- Nitrate-nitrogen concentrations were generally low with only Avoca Spring exceeding target concentrations.
- Total phosphorus concentrations were elevated with seven of eight springs (88%) exceeding target concentrations. Only Chambers Spring contained total phosphorus concentrations below the target concentration.
- E. coli concentrations generally measured low with five springs, Avoca Spring, Bailey Spring, Goode's Cave Spring, Chambers Spring and Nudist Cave Spring, measuring below 100 MPN/100 ml. Only one spring, Stoney Springs West, measured above the state standard.
- While E. coli concentrations measured low, total coliform concentrations were elevated in three springs, Stoney Springs West, Chambers Spring and Salt Creek Spring, with all three measuring above the Minnesota TMDL limit. Note Indiana does not have a total coliform standard.

3.2.10 Indiana University (1993-2021)

Multiple efforts to assess water quality in Campus River (formerly Jordan River), Clear Creek, the Lake Monroe tailwater on Salt Creek and other local waterbodies occurred via Indiana University students, faculty and staff. Each assessment will be detailed below and conclusions drawn, as possible, based on the quality of the data collected.

Clear Creek Assessment (2008)

From January 2008 through November 2008, a graduate student collected a combination of grab samples and continuous data from one site on Clear Creek (Gardner and Royer, 2010 and Royer and Gardner, 2009). Based on the water chemistry assessments conducted, the following conclusions can be drawn:

- Chloride concentrations measured in Clear Creek during the 2008 sampling period ranged from 19 to 102 mg/L during non-winter sampling events and from 221 to 2100 mg/L during winter sampling events. Baseline chloride concentrations were higher in Clear Creek than at other sites monitored during the study.
- Nitrate-nitrogen concentrations measured as high as 2.3 mg/L with a mean concentration of 1.2 mg/L.
- Conductivity measurements were elevated with concentrations as high as 3,564 mS/cm measured during the sampling period.

Campus River (Jordan River) Sustainability Assessment (2008)

In 2008, the School of Public and Environmental Affairs Lake and Watershed (E545) class worked in concert with the Indiana University Task Force on Campus Sustainability to assess conditions within Campus River (then Jordan River). Class members conducted assessments along six 100-meter sections of the river including assessing instream habitat using the QHEI, mapping erosion and other areas of concern and suggesting potential solutions to address problems identified (Altinay et al, 2008; Arnold et al, 2008; Bosecker et al, 2008; Corbin et al, 2008; Guse et al, 2008; Menigat et al., 2008; Olin et al, 2008). Based on their assessments, the following conclusions can be drawn:

- Streambank erosion, bank undercutting and sloughing are common along the Jordan River with issues identified near Dunn Meadow, near the Indiana Memorial Union, near 7th Street, along most bridges over the Jordan River and at the Jordan Avenue Parking Garage. Some of the erosion is negatively impacting structures such as the admission building and Jordan Avenue parking garage. While streambank stabilization is the predominant recommendation, other suggestions include re-meandering the stream, widening the floodplain or resloping streambanks.
- Heavy foot traffic and mowing to the edge of the stream negatively impacts vegetation along the Jordan River. The prevalence of turf and/or invasive species such as English ivy and winter creeper were noted at multiple locations with the suggestion to revegetate with native plants or restrict access to the bank of the river. Additionally, compaction due to foot and vehicular traffic were also noted as concerns.
- Stormwater negatively impacts the river. Issues identified include the prevalence of stormwater pipes, stormwater pipes acting as instream barriers and increased discharge during storm events as well as flooding in areas including the Jordan Avenue bridge, the area upstream of the concrete block dam originally constructed to protect a high voltage substation and prevent spring flooding in Dunn Meadow, the bridge near the new Ashton complex where undersized

culverts within the bridge prevent the flow of stormwater through this area and at the footbridge path near Hilltop Garden Center where culverts have collapsed beneath the bridge.
- Finally, trash was noted as a concern along the length of the Jordan River.

Campus River (Jordan River) Water Quality Assessment (2015-2016)

In 2015 and 2016, a student assessed water quality in Campus River from September 2015 through October 2016 as part of an honors thesis (Brown and Royer, 2016). As part of the projects, samples were collected roughly weekly at four sample sites. Based on the water chemistry assessments conducted at two locations on Campus River, the following conclusions can be drawn:

- Conductivity concentrations were generally elevated ranging from 750 mS/cm to nearly 3000 mS/cm during the 2015-2016 sample period. In total, 79% of samples exceeded conductivity standards. A visible increase in conductivity occurred from December through February. This can likely be attributed to the prevalence of salt used on Indiana University streets, sidewalks and parking lots.
- Under base flow conditions, turbidity in Campus River typically measures below 10 NTU during the 2015-2016 sample period. However, during storm events, turbidity levels in Campus River increase as is expected for this urban stream. In total, 14% of sampled exceeded turbidity targets.
- Soluble reactive phosphorus samples were collected twice during the 2015-2016 study period. All samples measured below the target for SRP.
- Total phosphorus samples were collected once during the 2015-2016 study period. All samples exceeded target concentrations for total phosphorus.

Campus River Chloride Assessment (2018-2021)

A student assessed water quality in Campus River from September 2018 through November 2020 with additional grab samples and storm samples collected in February and March 2021 in an effort to better understand the impacts of road salt runoff on the Campus River (Bules and Royer, 2021). As part of the projects, samples were collected roughly weekly at four sample sites. Based on the water chemistry assessments conducted at two locations on Campus River, the following conclusions can be drawn:

- Chloride concentrations measured above the Indiana acute limit twice and the EPA acute limit two or three times at each Campus River sample site during the 2018-2021 sampling period with concentrations reaching 2,800 mg/L (Bules and Royer, 2021).

Campus River Assessment (2021)

In 2021, the O'Neill School of Public and Environmental Affairs Stream Ecology class assessed two segments of Campus River – upstream and downstream. Based on the water quality assessments conducted in the two reaches of Campus River, the following conclusions can be drawn:

- Nutrient samples including nitrate-nitrogen, ammonia-nitrogen, total Kjeldahl nitrogen and dissolved and total phosphorus all measured within target concentrations.
- Dissolved oxygen concentrations were elevated at the downstream site with one of six samples measuring above the state standard (16% exceeded targets).
- All of the upstream and downstream samples contained elevated conductivity measurements with concentrations measuring as high as nearly double the state standard. 100% of samples exceeded conductivity targets.

- Turbidity levels were elevated at the upstream site with two of the five samples (40%) exceeding targets. Concentrations measured more than 20 times target turbidities at the upstream station.

Indiana University Limnology Class – Clear Creek (1993-Present)
Indiana University Limnology students collected and analyzed water quality samples from four to seven locations along Clear Creek from 1993 to present. Data from 1993 through 2018 are presented below. It should be noted that these samples are collected and analyzed by students learning to collect and analyze samples. Their collection techniques should be considered solid; however, their laboratory analysis techniques are those of students. These data should be considered of lower quality than data collected by professionals. Sampling occurred annually in October. Based on the water chemistry assessment, the following conclusions can be drawn:

- Temperature, pH, conductivity and dissolved oxygen generally measured within state standards or water quality targets. None of the conductivity or temperature samples exceeded targets. However, 2% of pH and 6% of dissolved oxygen concentrations measured above state standards. For pH, all samples were collected during 2012 at downstream sampling locations. Dissolved oxygen sample collection also occurred at downstream locations but in various years.
- Turbidity concentrations were relatively low in Clear Creek sites with only 12% of samples exceeding water quality targets. All of the samples which exceeded targets were collected during three sampling events (1996, 2001, 2002) which are considered high flow events.
- Total Kjeldahl nitrogen concentrations measured below water quality targets during all sampling events with the exception of sample collected in 2016. These data look suspect and have been removed from the sample analysis.
- Nitrate-nitrogen concentrations were elevated with 73% of samples exceeding water quality targets. Generally, the upper Clear Creek sites (5, 6 and 7) generally measured lower than downstream sites (8, 9, 10, 11, 13).
- Soluble reactive and total phosphorus concentration were elevated in Clear Creek samples with 77% of soluble and 72% of total phosphorus samples exceeding target concentrations. In general, the upper Clear Creek sites (5, 6 and 7) generally measured lower than downstream sites (8, 9, 10, 11, 13).

Lake Monroe Watershed Management Plan – Salt Creek (2020-2021)
The Indiana Clean Lakes Program collected, and the City of Bloomington Utilities analyzed water quality samples at the Lake Monroe tailwaters as part of the Friends of Lake Monroe sponsored Lake Monroe Watershed Management Plan (FOLM, 2022). Sampling occurred May 22, 2020 to April 18, 2021. Based on the water chemistry assessment, the following conclusions can be drawn:

- Nitrate-nitrogen, ammonia-nitrogen, soluble reactive phosphorus, total Kjeldahl nitrogen and total suspended solids measured relatively low with none of the collected samples exceeding target concentrations.
- Total phosphorus concentrations were also relatively low with only one of the 12 samples exceeding target concentrations.

3.2.11 Monroe County (1997-2007)

Multiple efforts to assess water quality in local waterbodies occurred via Monroe County planning, highway and stormwater department staff. Each assessment will be detailed below and conclusions drawn, as possible, based on the quality of the data collected.

Bloomington/Monroe County Urban Nonpoint Source Water Pollution Assessment (1997)

In September 1997, the City of Bloomington Planning Department and Monroe County Planning Department contracted with Commonwealth Biomonitoring to complete the urban nonpoint source pollution assessment. In total, Commonwealth monitored macroinvertebrate communities twice, assessed habitat once and collected water chemistry samples twice at 25 sites throughout Monroe County. Of these, 12 are in the Lower Salt Creek Watershed. Additionally, local staff collected stormwater samples at 21 sites. Based on assessments completed in 1997, the following conclusions can be drawn:

- Riparian habitat was good on many area streams, biological diversity was below potential with IBI scores for Jackson Creek at Rhorer Road, College Mall Road, Rogers/Winslow Road and Rogers Road and Clear Creek at Miller Drive, Country Club Drive and Adams/Allen Streets; Jordan Creek rating as severely impaired. Jordan Creek at Indiana Ave and West Fork Clear Creek at Victor Pike rated as moderately impaired, while the East Fork Jackson Creek at Rhorer Road and the West Fork Clear Creek at Wiemer Road and Tapp Road rated as slightly impaired during the fall assessments. Spring assessments mimic these results with three sites rating as severely impaired, eight sites rating as moderately impaired and one site rating as slightly impaired.
- All dissolved oxygen, pH, conductivity, TSS and temperatures measured below state standards or water quality targets.
- Clear Creek and Jackson Creek had indications of toxic substances, sedimentation, excessive nutrient loading, and sewage related problems. Two Clear Creek sample sites contained E. coli concentrations which measured more than seven times the state standard.
- Nitrate, total phosphorus, pH and alkalinity concentrations all increased in Clear Creek downstream of the Dillman Road wastewater treatment plant.
- Sedimentation problems were also noted in West Fork Clear Creek with riparian habitat damage, sedimentation and excess nutrients and algal growth observed during sampling.
- Jackson Creek was described as having excellent potential for greenspace corridors and natural resources for the community. However, impairments including riparian habitat damage, the presence of toxic substances, elevated sedimentation, high nutrient concentrations and E. coli concentrations measuring above the state standard are present. Habitat and macroinvertebrate IBI scores indicate water impairments with the fish IBI rating as poor.
- Clear Creek was noted as having riparian habitat damage including channelization, removal of riparian vegetation and development too close to the channel, sedimentation problems, eutrophication problems and likely sewage inputs. West Fork Clear Creek also possessed riparian habitat damage, fresh sediment from construction and excess algae. Jackson Creek possessed riparian habitat damage near Childs School and College Park Mall Road, indication of toxic substances at times, sedimentation and eutrophication problems and likely sewage sources.
- Commonwealth Biomonitoring (1997) noted the lack of pollution intolerant species in the urban streams of Monroe County when compared to the ambient stream background chemistry

would indicate that the limiting factor on pollution intolerant species survival is related to acute pollution from episodic storm events and habitat degradation from alteration and sedimentation rather than intolerable ambient water quality conditions.

Baseline Characterization (2002)

Monroe County initiated baseline characterization efforts in 2002 using guidance provided to MS4 communities (Monroe County, 2002). The baseline characterization includes: 1) a review of existing land use, 2) assessment of structural and nonstructural stormwater BMPS, 3) identification of observation or monitoring locations, 4) identification of sensitive areas, 5) review of available water quality data, 6) identification of areas of impairment or problems and 7) recommendations for BMP placement within the MS4 area. The baseline characterization efforts identified the following:

- Clear Creek receives runoff from about two-thirds of Bloomington including Indiana University. It is the single stream that receives most of the nonpoint source pollution from Bloomington, including runoff from the major commercial areas on the west and east sides of town, the highest traffic areas, and much of the industry on the west side. Within Bloomington, much of the course of Clear Creek and its tributaries is enclosed in old storm sewers or is channelized within stone walls and may receive illicit discharges in these reaches. Runoff from the Illinois Railroad Spring (Lemon Lane landfill) drains to the creek. Like many landfills in the area, Lemon Lane received PCB laden waste.
- Sinking Creek is a terminal sinkhole located in the northwest quadrant of the intersection of State Road 45 and Curry Pike. Sinking Creek flows from the north to the south through a highly urbanized watershed encompassing commercial, industrial, and residential areas along Curry Pike (including older residential areas such as Highland Village and Westwood Estates). The City of Bloomington Utilities has been active in lining leaky sanitary sewers in this area. Sinking Creek "sinks" in the terminal sinkhole area, and the runoff comes out in any number of springs (depending on the rate of flow) in the area of Leonard and Shirley Springs. This area was once the site of one of Bloomington's early and ill-fated water supply lakes and is a now a city park occupied by beavers and traversed by a stream that feeds into Clear Creek.
- The Baseline Environmental Quality Index (2001) completed for Monroe County noted that eroding streambanks and sediment carried by runoff is a major source of stream sediment loads. Riparian habitat restoration would improve the water quality and aquatic communities of the region's streams by reducing the inflow of sediment. Riparian habitat restoration and filter strips would also reduce the flow of nutrients into the streams. Adherence to erosion control measures in developing areas and construction sites would also reduce sediment inflow. Storm water system improvements may also reduce the runoff of toxic chemicals from the City's streets.

The characterization also identifies the following planning policies which guide development in Monroe County:

- Chapter 829 of the Monroe County Zoning Ordinance provides for the substantial protection of karst features including limits on land disturbance within such areas, the provision of buffer areas, extraordinary erosion control measures in such areas and recently the required installation of water quality protection measures including infiltration basins.
- Chapter 816 of the Monroe County Zoning Ordinance establishes erosion control standards for construction activities within Monroe County. All construction activities, (other than individual

single-family residences, and development proposals are required to plan for and implement erosion control measures. The County works in concert with the Indiana Department of Natural Resources and the Monroe County Soil and Water Conservation District to inspect and enforce the provisions of the Ordinance.

In 2007, the Monroe County Planning Department completed a watershed characterization of Sinking Creek and its watershed (Arazan and Bruce, 2007). The assessment included sampling Sinking Creek at five locations under baseline and storm flow conditions in April and May 2007 using Hoosier Riverwatch sampling and analysis methods. Based on the water quality assessments, the following conclusions can be drawn:

- The headwaters site rated as poor using the Pollution Tolerance Index under both base and storm flow sampling conditions.
- The middle reaches of Sinking Creek rated Pollution Tolerance Indices that measured lower following a storm event than that measured under base flow conditions.

I-69 Turbidity Assessment (2012)

In 2012, the Monroe County Planning Department conducted turbidity sampling to assess the impacts of I-69 construction on regional streams. In total, 9 stream sites were assessed following a rain event. Based on the water quality assessment, the following conclusions can be drawn:

- Turbidity exceeded water quality targets in 100% of sampled collected. Concentrations ranged from 13 to 160 NTU.

3.2.12 General Motors (2001-2002)

In 2001, General Motors conducted a baseline stream investigation for Pleasant Run and Salt Creek. Storm event sample collection occurred in 2002. Samples were collected in the upper portion of Pleasant Run, Gulletts Creek, an unnamed tributary to Salt Creek and on Salt Creek up and downstream of the confluence with Pleasant Run. Surface water chemistry, stream sediment and aquatic biology were assessed at each station. Based on the water chemistry assessments, the following conclusions can be drawn:

- PCBs were found in all media – surface water samples, sediment samples and fish and crayfish tissue – but were not found in water samples collected at upper Pleasant Run, Gullets Creek or Salt Creek stations.
- PCB concentrations were generally similar under base and storm flow conditions in surface water chemistry samples.
- Total Kjeldahl nitrogen, ammonia and total suspended solids concentrations measured below detection limits in all base flow samples. This is as expected as samples were collected under low flow conditions.
- Total Kjeldahl nitrogen concentrations exceeded targets in 10% of samples collected under storm flow conditions. Total suspended solids, ammonia, and pH samples all measured under target concentrations under storm flow conditions.

3.2.13 Hoosier Riverwatch Sampling (2001-2021)

From 2001 to present, volunteers trained through the Hoosier Riverwatch program assessed 62 sites in the Lower Salt Creek Watershed. Volunteers monitored stream stage, flow rate, and discharge; collected water chemistry samples for analysis using HACH test kits; assessed instream habitat using the Citizen's QHEI; and surveyed the stream's macroinvertebrate community. Using the chemical data, the Water Quality Index (WQI) was calculated. Volunteers calculated a Pollution Tolerance Index (PTI) using the biological data. Based on these data, the following conclusions can be drawn:

- Dissolved oxygen concentrations typically measured within the state standard with concentrations ranging from 0.1 to 14 mg/L. Low dissolved oxygen levels were observed in the Jordan River (Campus River) and Sinking Creek). High dissolved oxygen concentrations were observed in Clear Creek, West Fork Jackson Creek, Jordan River (Campus River) and Goose Creek.
- When measured, E. coli concentrations were elevated in 37% of samples. Concentrations above the state standard ranged from 250 to 10,000 col/100 ml.
- Nitrate concentrations ranged from 0 to 44 mg/L with 38% of samples exceeding the water quality target. Clear Creek at Dillman Road, at Ketchum Road and in Railyard Park and the Jordan River (Campus River) generally possessed the highest nitrate concentrations.
- Orthophosphorus concentrations were elevated in 28% of samples. There is no pattern to sites with elevated orthophosphorus concentrations.
- Turbidity levels were elevated across all sample sites with 62% of samples exceeding the transparency which indicates poor water quality (29 cm).
- The pollution tolerance index ranged from 2 to 41 indicating the Lower Salt Creek Watershed streams rate as poor to excellent depending on flow regimes at the time of sampling.

3.3 <u>Watershed Inventory Assessment</u>

3.3.1 Watershed Inventory Methodologies

Volunteers completed windshield surveys throughout the Lower Salt Creek Watershed in spring 2021. Volunteers conducted surveys by driving all accessible roads throughout the watershed. Large maps with aerial photographs, road and stream names, and public property labels were provided to each volunteer group. Volunteers recorded observations on the provided maps and data sheets, documented field conditions with photographs, and provided all notes to the Project Coordinator for review. The windshield surveys were also used to confirm GIS map layer data throughout the watershed. Items targeted during the surveys included, but were not limited to the following:

- Aerial land use category
- Field or gully erosion
- Pasture locations and condition
- Livestock access and impact to streams
- Buffer condition and width
- Bank erosion or head-cutting
- Logjams located within the stream
- Dumping areas or areas where trash or debris accumulate
- Small, unregulated farms
- Environmental site confirmation (NPDES, CFO, open dump, Superfund, etc.)

3.3.2 Watershed Inventory Results

All accessible road-stream crossings were inventoried. A majority of issues identified fall into five categories: stream buffers limited in width or lacking altogether, areas of livestock access, streambank erosion, dumping areas, and unregulated farms. Figure 33 details locations throughout the Lower Salt Creek Watershed where riparian area problems were identified. Much of the watershed is not visible from the road and additional assessments will be on-going; therefore, those identified in Figure 33 should not be considered exhaustive. Nearly 1.5 miles of streams possessed limited buffers, nearly 90 miles of streambank were eroded, and livestock had access to nearly 1.5 miles of streams. Note that these data are preliminary and additional inventory efforts will augment this map as the project moves forward.

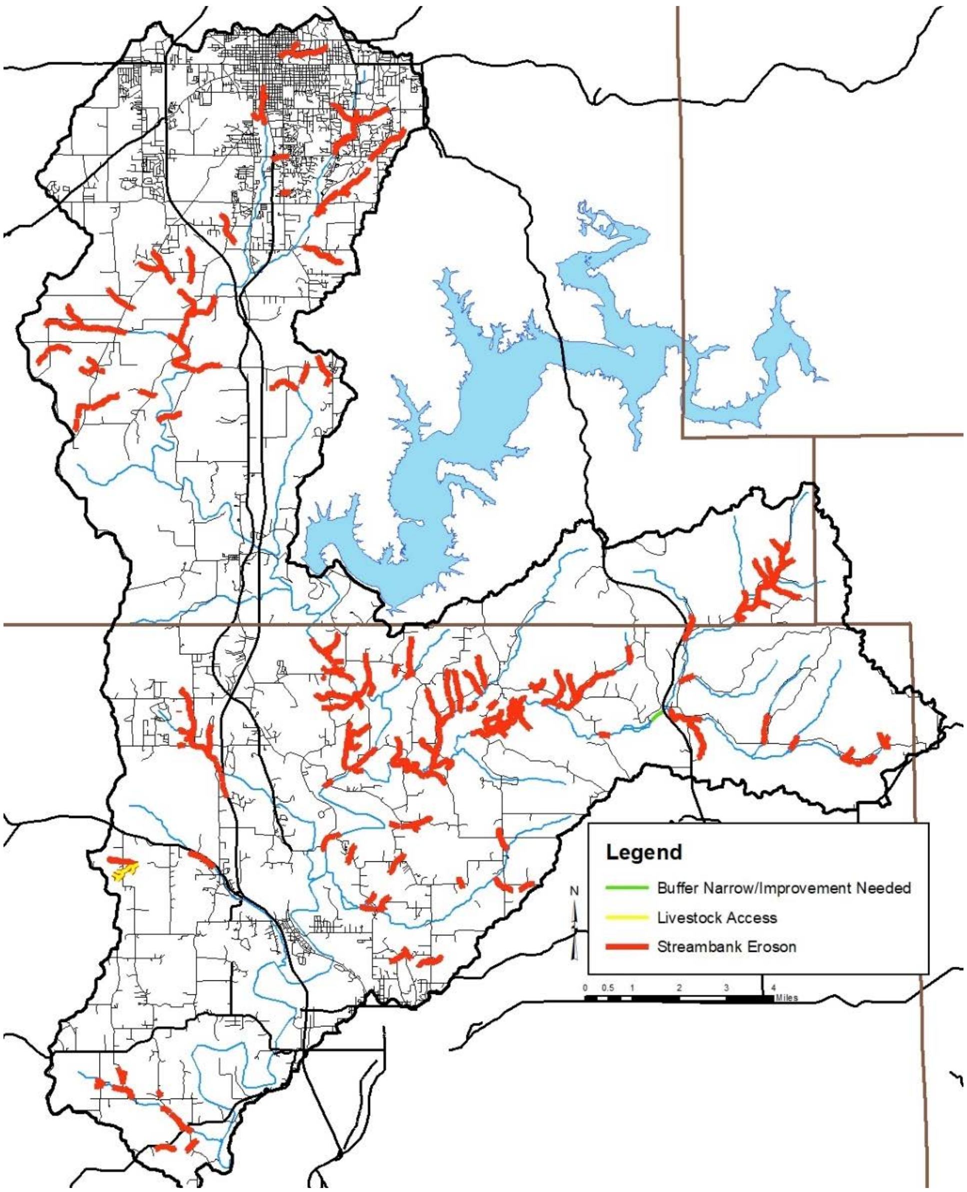

Figure 33. Stream-related watershed concerns identified during watershed inventory efforts.

4.0 <u>WATERSHED INVENTORY II-B: SUBWATERSHED DISCUSSIONS</u>

To gather more specific, localized data, the Lower Salt Creek Watershed was divided into seven (7) subwatersheds with each subwatershed reflecting one 12-digit Hydrologic Unit Code (HUC; Figure 34).

These subwatersheds reflect specific tributary drainages and similar land uses and hydrology. Land uses, point and non-point watershed concern areas, and historic water quality sampling locations and results are discussed in detail below for each subwatershed.

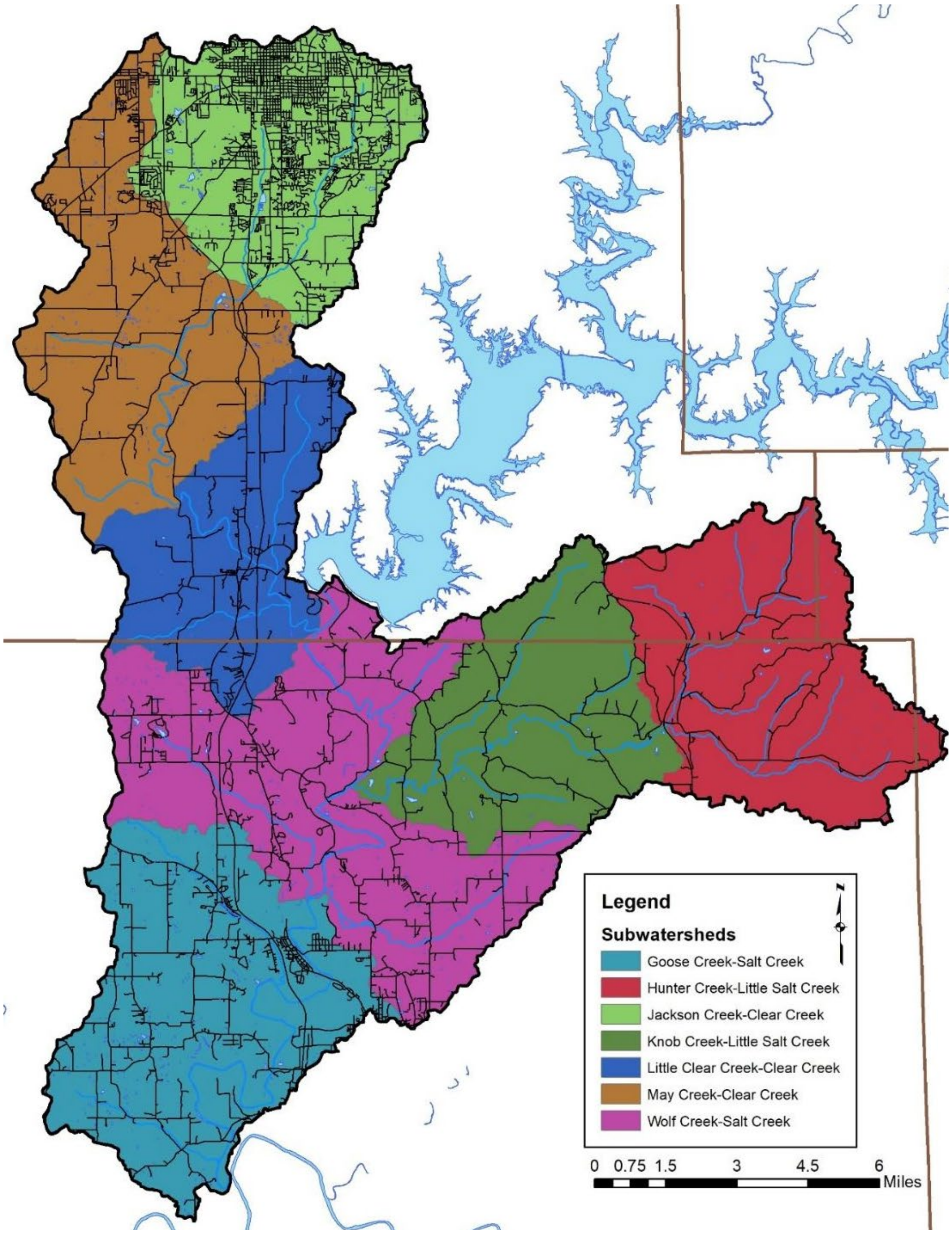

Figure 34. 12-digit Hydrologic Unit Codes Subwatersheds in the Lower Salt Creek Watershed.

4.1 Jackson Creek-Clear Creek Subwatershed

The Jackson Creek-Clear Creek Subwatershed is the northernmost subwatershed of the Lower Salt Creek Watershed and encompasses the majority of the City of Bloomington and much of Indiana University. The Jackson Creek-Clear Creek Subwatershed lies entirely within Monroe County (Figure 35). It encompasses one 12-digit HUC watershed: 051202080801. This subwatershed drains 16,068 acres or 25 square miles and accounts for 12.3% of the total watershed area. There are 34 miles of stream. IDEM has classified 34 miles of stream as impaired for *E. coli*, 10.43 miles of stream as impaired for impaired biotic communities, and 5.68 miles of stream as impaired for polychlorinated biphenyl (PCB; Figure 37).

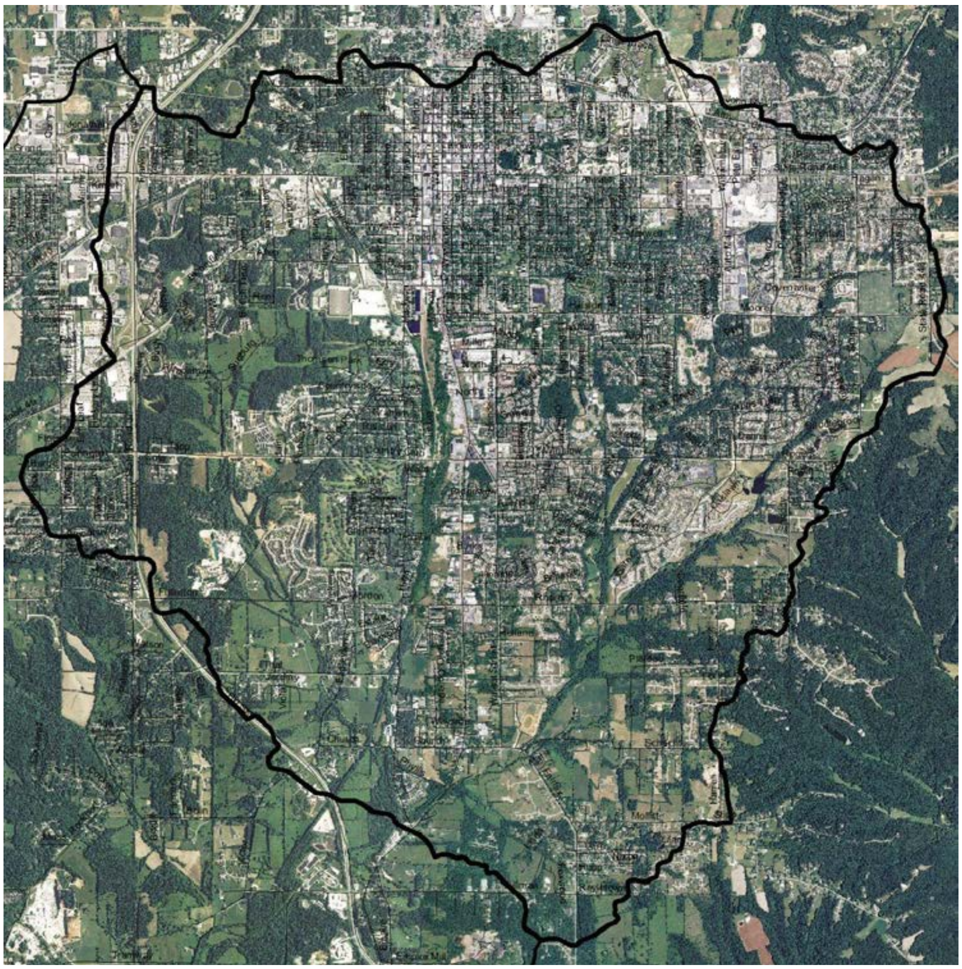

Figure 35. Jackson Creek-Clear Creek Subwatershed.

4.1.1 Soils

There are no hydric soils located in the subwatershed; wetlands currently cover 0.6% (100.6 acres) of the subwatershed. Highly erodible soils are prevalent throughout the subwatershed covering 14,548 acres or 90.5% of the subwatershed. Over a quarter of the subwatershed, 27.6% (4,431 acres), has soils which are very limited for septic use. According to the Lower Salt Creek TMDL, maintenance and inspection of septic systems is important to ensure proper function and capacity. In total, 1,310.1 acres of karst, or sinkholes, appear throughout the subwatershed.

4.1.2 Land Use

Urban land use dominates the Jackson Creek-Clear Creek subwatershed at 57.5% (9,235.4 acres), with the City of Bloomington, Monroe County urbanizing area and Interstate 69 accounting for the majority of urban land uses. Agricultural land use and forested land use co-dominate the remaining half of the subwatershed with 20.3% (3,256.7 acres) in agricultural land uses, including row crop and pasture and 21.6% (3,468.3 acres) in forested land use. Wetlands, open water, and grassland cover just over 100 acres, or 0.6%, of the subwatershed.

4.1.3 Point Source Water Quality Issues

There are several potential sources of water pollution in the subwatershed. There are 140 leaking underground storage tanks located primarily within the City of Bloomington (Figure 36). There is one NPDES-permitted facility (Kiel Brothers Oil Co., INC.), four Superfund sites, four Voluntary Remediation Program sites, twelve brownfields and thirteen industrial waste facilities located within the Jackson Creek-Clear Creek Subwatershed. Two industrial stormwater facilities, Fell Iron and Metal, Inc. and JBs Salvage Incorporated West Side Auto Parts, are located in the Jackson Creek-Clear Creek Subwatershed. Additionally, three MS4 communities: Monroe County, Indiana University Bloomington and the City of Bloomington are located in the Jackson Creek-Clear Creek Subwatershed. It should be noted that the Superfund sites are slated for delisting – this section will be updated if or when delisting occurs. There are no open dumps or corrective action sites in the subwatershed.

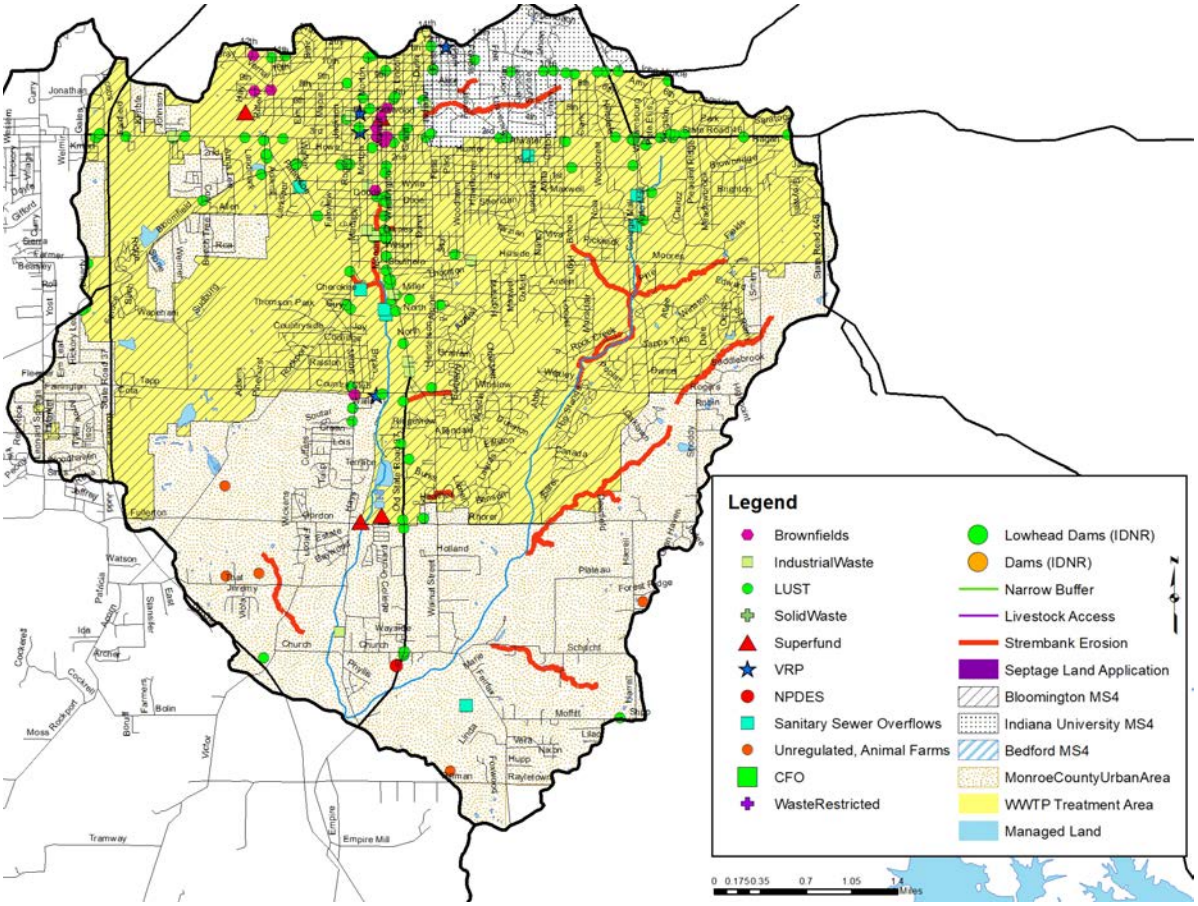

Figure 36. Point and non-point sources of pollution and suggested solutions in the Jackson Creek-Clear Creek Subwatershed.

4.1.4 Non-Point Source Water Quality Issues

Urban land uses are the predominant land use in the Jackson Creek-Clear Creek subwatershed. However, a small number of small animal operations and pastures are also present (Figure 36). Sixteen unregulated animal operations housing more than 47 cows, horses, and goats were identified during the windshield survey. In total, manure from small animal operations total over 778 tons per year, which contains almost 583 pounds of nitrogen, almost 329 pounds of phosphorus and 2.07E+13 col of E. coli. IDEM notes an animal density of 18.48 animals/square mile. This is lower than the median for other Lower Salt Creek subwatersheds. Livestock do not have access to the Jackson Creek-Clear Creek Subwatershed streams based on observations during the windshield survey. No active confined feeding operations are located within the Jackson Creek-Clear Creek subwatershed. Streambank erosion is a concern in the subwatershed. Approximately 11.8 miles of streambank erosion were identified within the subwatershed.

4.1.5 IDEM TMDL Assessment

IDEM created and evaluated load duration curves and precipitation graph with consideration of watershed characteristics which allowed IDEM to identify potential nonpoint sources that could be contributing to elevated E. coli concentrations. Many of these sources could also be considered sources of nutrient and sediment concentrations within the Jackson Creek-Clear Creek Subwatershed. Based on the water quality duration curves, IDEM concluded that the majority of sources of E. coli in the Jackson Creek-Clear Creek Subwatershed are nonpoint sources that could include urban stormwater, small animal operations, wildlife, pasture animals with direct access to streams, straight pipes, and leaking/failing septic systems. IDEM indicates that achieving necessary load reductions for E. coli impairments in the Jackson Creek-Clear Creek Subwatershed should focus on BMPs that have an impact throughout moist, mid-range, and dry flow regimes. These include septic system outreach and education, proper pet waste disposal, fencing and livestock exclusion systems, alternative livestock watering systems, comprehensive nutrient management planning, and vegetated filter strips.

Table 26. Flow regime TMDL analysis for E. coli in the Jackson Creek-Clear Creek Subwatershed.

Flow Regine TMDL analysis for *E. coli* (MPN/day)					
Allocation Category Duration Level	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL= LA+WLA+MOS	**1.75E+12**	**3.12E+11**	**1.14E+11**	**2.85E+10**	**9.10E+09**
Upstream Drainage	N/A	N/A	N/A	N/A	N/A
LA	1.22E+10	2.17E+09	9.73E+10	2.42E+10	7.74E+09
Monroe Co. MS4 WLA	5.85E+11	1.04E+11	N/A	N/A	N/A
IU Bloomington MS4 WLA	9.E+10	2.E+10	N/A	N/A	N/A
City of Bloomington MS4 WLA	8.00E+11	1.43E+11	N/A	N/A	N/A
Total WLA	1.47E+12	2.63E+11	N/A	N/A	N/A
MOS (10%)	1.75E+11	3.12E+10	1.14E+10	2.85E+09	9.10E+08
Future Growth (5%)	8.74E+10	1.56E+10	5.72E+09	1.43E+09	4.55E+08

4.1.6 Water Quality Assessment

Waterbodies within the Jackson Creek-Clear Creek subwatershed have been sampled at 73 locations (Figure 37). Assessments include collection of water chemistry and biology data by IDEM (8 sites on Clear Creek, Jackson Creek and a Clear Creek tributary), by USGS (1 site), by the Indiana Geological and Water Survey (2 spring sites), Indiana University limnology students (2 sites) and Hoosier Riverwatch Volunteers (53 sites). No stream gages are in the Jackson Creek-Clear Creek subwatershed.

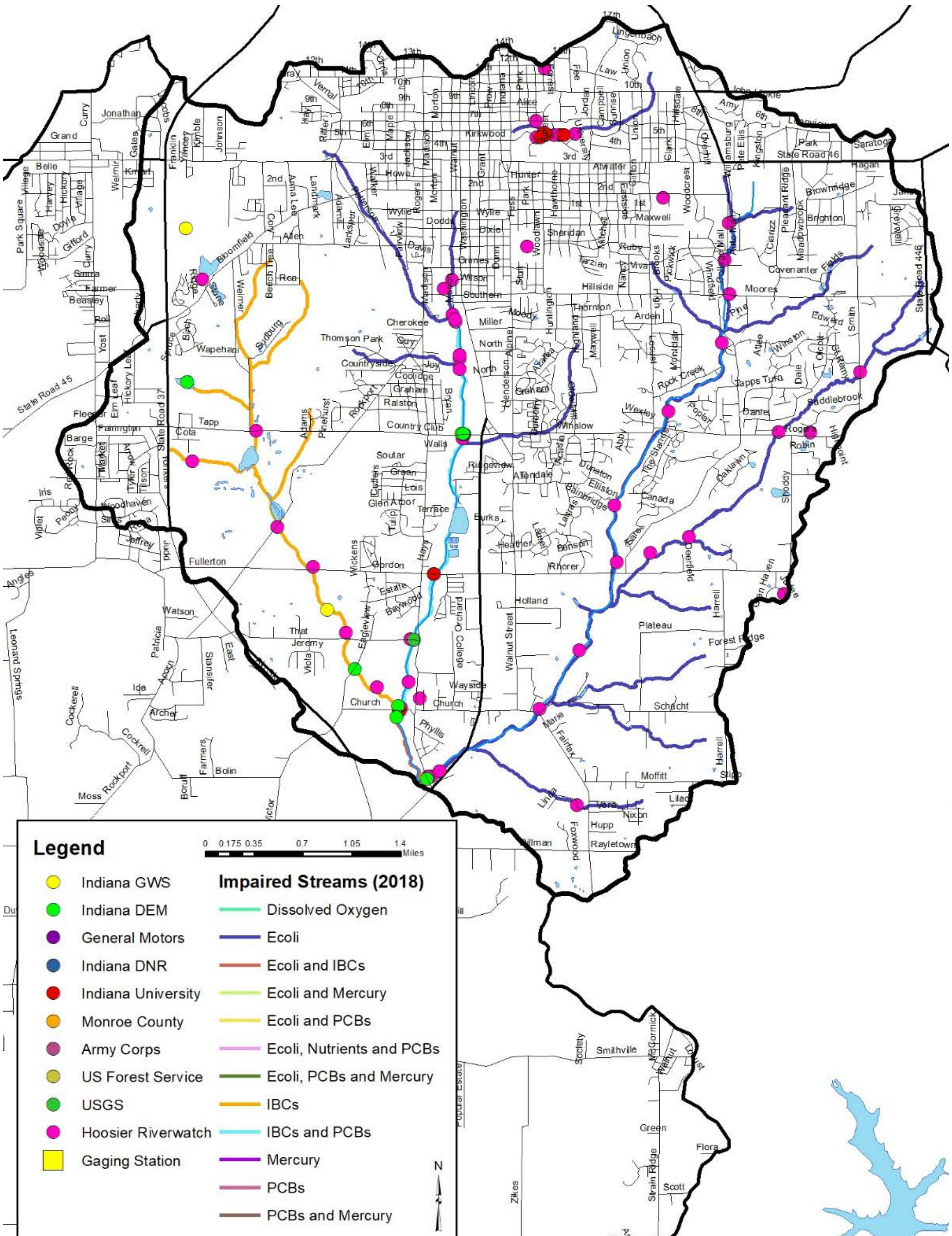

Figure 37. Locations of historic water quality data collection and impairments in the Jackson Creek-Clear Creek Subwatershed.

Table 27 details Tier 1 data – those collected by IDEM, IDNR, IGWS, USGS, USFS, USACE, Indiana University researchers, Monroe County or General Motors. As shown in the table, conductivity samples exceed state standards (1050 μmhos/cm) in 66% of samples collected. E. coli samples exceed state grab sample standards (235 col/100 ml) in 51% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 27% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 13% of samples. Total suspended solids exceed water quality targets (15 mg/L) in 8% of samples, while turbidity levels exceed water quality targets (6.36 NTU) in 24% of samples.

Table 27. Jackson Creek-Clear Creek Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	192	2,909	151	230	66%
DO	5.59	13.6	1	148	1%
E. coli	29.4	19,863	24	35	69%
Ammonia-Nitrogen	0.037	158	0	28	0%
Nitrate-Nitrogen	0.1	1.6	7	26	27%
Dissolved Phosphorus	0.001	0.014	0	10	0%
pH	7.49	8.15	0	45	0%
Temperature	1.5	24.1	0	184	0%
TKN	0.3	1.68	0	26	0%
Total Phosphorus	0.006	0.224	4	30	13%
Total Suspended Solids	6	19	2	24	8%
Turbidity	0.71	312	31	130	24%

Tier II data – those collected by Indiana University student groups or classes learning to analyze laboratory data as well as Hoosier Riverwatch volunteer collected data are detailed in Table 28. E.coli concentrations exceed state standards in 46% of collected samples. Nitrate concentrations exceed water quality targets (1 mg/L) in 38% of samples. Dissolved phosphorus concentrations exceed water quality targets in 45% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 14% of samples. Turbidity exceeds water quality targets in 11% of samples while transparency exceeds targets in 62% of samples.

Table 28. Jackson Creek-Clear Creek Subwatershed Tier II historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Ammonia	0.001	0.194	0	28	0%
BOD	0	45	1	108	1%
Conductivity	238	910	0	15	0%
Dissolved Oxygen	0	14	11	321	3%
E. coli	0	10,000.5	17	37	46%
Nitrate	0	44	115	301	38%
Dissolved Phosphorus	0	5	98	218	45%
pH	3	10	9	320	3%
Temperature	0	28	0	0	--
TKN	0.173	1.355	0	5	0%
Total Nitrogen	0.059	0.059	0	1	0%
Total Phosphorus	0.013	0.15	4	28	14%
Turbidity	0.59	29	3	28	11%
Transparency (cm)	4	118.33	164	266	62%

Biological monitoring was conducted by IDEM at 10 sites with 6 sites assessed for macroinvertebrates, 4 sites assessed for fish and 10 sites assessed for habitat. Indiana University stream ecology students assessed habitat at 7 sites and macroinvertebrate and fish communities at 2 sites. Habitat scores ranged from 30 to 77 with 35% of sites scoring below the state target (51). Fish community assessments rated very poor to good with 33% of assessments not meeting their aquatic life use designation. Macroinvertebrate assessments rated moderately impaired to slightly impaired using the kick sampling method with 33% of sites not meeting their aquatic life use designation and from 16 to 38 with 66% of multihabitat samples not meeting their aquatic life use designation (Table 29).

Table 29. Jackson Creek-Clear Creek Subwatershed biological assessment data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Habitat (QHEI)	30	77	6	17	35%
Fish (IBI)	16	52	2	6	33%
Macroinvertebrates (mIBI, Kick)	2.2	4.8	1	3	33%
Macroinvertebrates (mIBI, Multi Habitat)	16	38	3	5	66%

4.2 May Creek - Clear Creek Subwatershed

The May Creek-Clear Creek Subwatershed forms the western boundary of the Lower Salt Creek Watershed, including the western edge of City of Bloomington and lies within Monroe County (Figure 38). It encompasses one 12-digit HUC watershed: 051202080802. This subwatershed drains 19,185.7 acres but has a total drainage of 55 square miles. The May Creek-Clear Creek Subwatershed accounts for 14.73% of the total watershed area. There are 50 miles of stream. IDEM has classified 46.89 miles of stream as impaired for *E. coli*, 17.49 miles of stream as impaired for polychlorinated biphenyl (PCB), 9.12 miles of stream as impaired for nutrients, and 3.58 miles of stream as impaired for biotic communities (Figure 40).

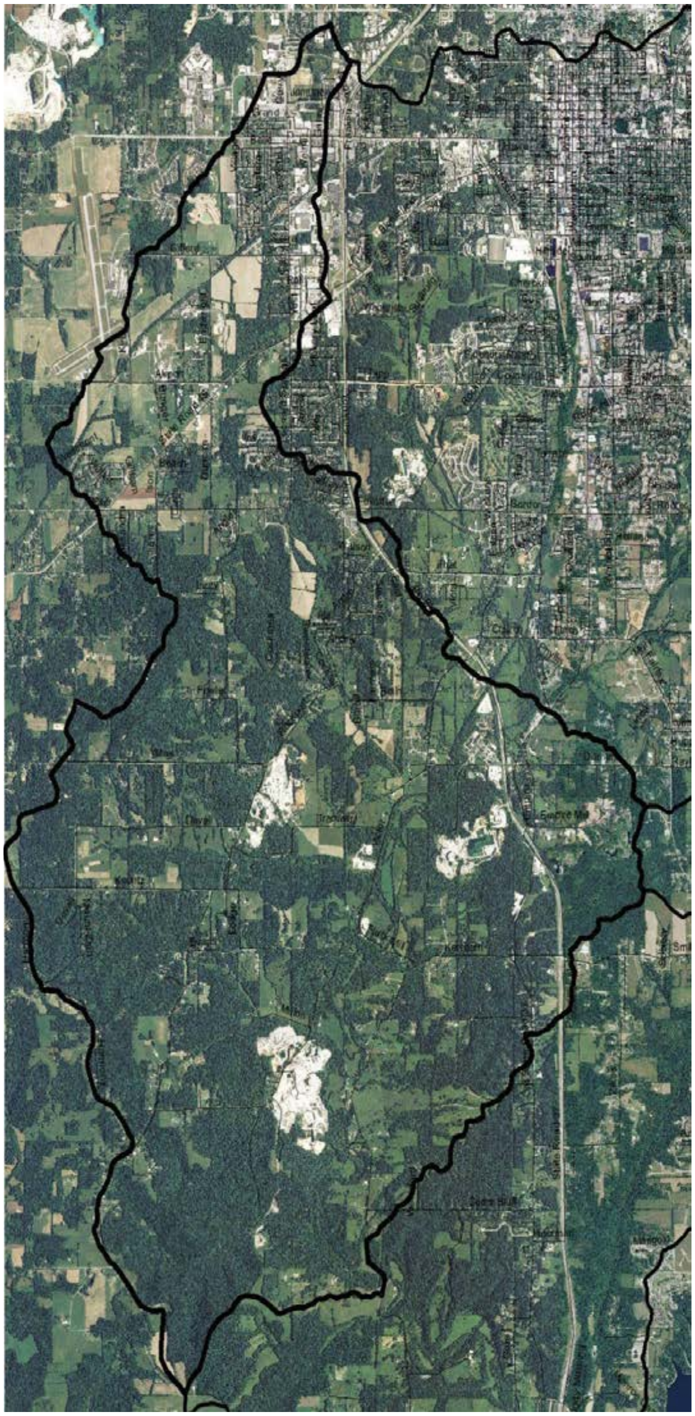

Figure 38. May Creek-Clear Creek Subwatershed.

4.2.1 Soils

Hydric soils cover 5.1 acres or <0.1% of the subwatershed. Wetlands currently cover 2.1% (394.4 acres) of the subwatershed. Highly erodible soils nearly cover the entire subwatershed (94.3%) or 18,089.3 acres. In total, 11,808.6 acres or 61.5% of the subwatershed is identified as very limited for septic use. The majority of the May Creek-Clear Creek Subwatershed is rural indicating many homes utilize on-site septic systems. Based on the soil septic suitability, maintenance and inspection of septic systems is important to ensure proper function and capacity. More than 4,309 acres of karst, or sinkholes, appear throughout the subwatershed.

4.2.2 Land Use

Forested land use dominates May Creek-Clear Creek Subwatershed covering 55.7% (10,682.1 acres). Agricultural land use covers 27.1% (5,205.1 acres) including row crop and pasture. Wetlands, open water, and grassland cover 394.4 acres or 2.1%, of the subwatershed. The City of Bloomington and urbanized areas of the county surrounding the city, along with State Road 37, account for much of the urban land use within the subwatershed. In total, 2.604.3 acres or 13.6% of the subwatershed are in urban land uses.

4.2.3 Point Source Water Quality Issues

There are a number of potential point sources of water pollution in the subwatershed (Figure 39). There are 24 leaking underground storage tanks sites, two brownfields, eight industrial waste facilities, two solid waste facilities, and one waste restricted location. There is one NPDES-permitted facility (City of Bloomington Dillman Road), two MS4 communities, Monroe County and City of Bloomington, and one voluntary remediation site. The Dillman Road wastewater treatment plant is a high-capacity wastewater treatment plant which contributes approximately 87% of Clear Creek's flow during periods of low instream flows.

4.2.4 Non-Point Source Water Quality Issues

Forested land uses are the predominant land use in the May Creek-Clear Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. In total, 32 unregulated animal operations housing more than 266 cows, horses, and goats were identified during the windshield survey (Figure 39). Animals produce more than 6,440 tons of manure annually which contains more than 5,213 pounds nitrogen, 2,809 pounds of phosphorus and more than 2.52E+14 colonies of E. coli. Based on windshield survey observations, livestock do not appear to have access to the May Creek-Clear Creek Subwatershed streams. No active confined feeding operations are located within the subwatershed. IDEM estimates an animal density of 18.48 animals/square mile. However, streambank erosion is a concern in the subwatershed. Approximately 14.4 miles of streambank erosion were identified within the subwatershed.

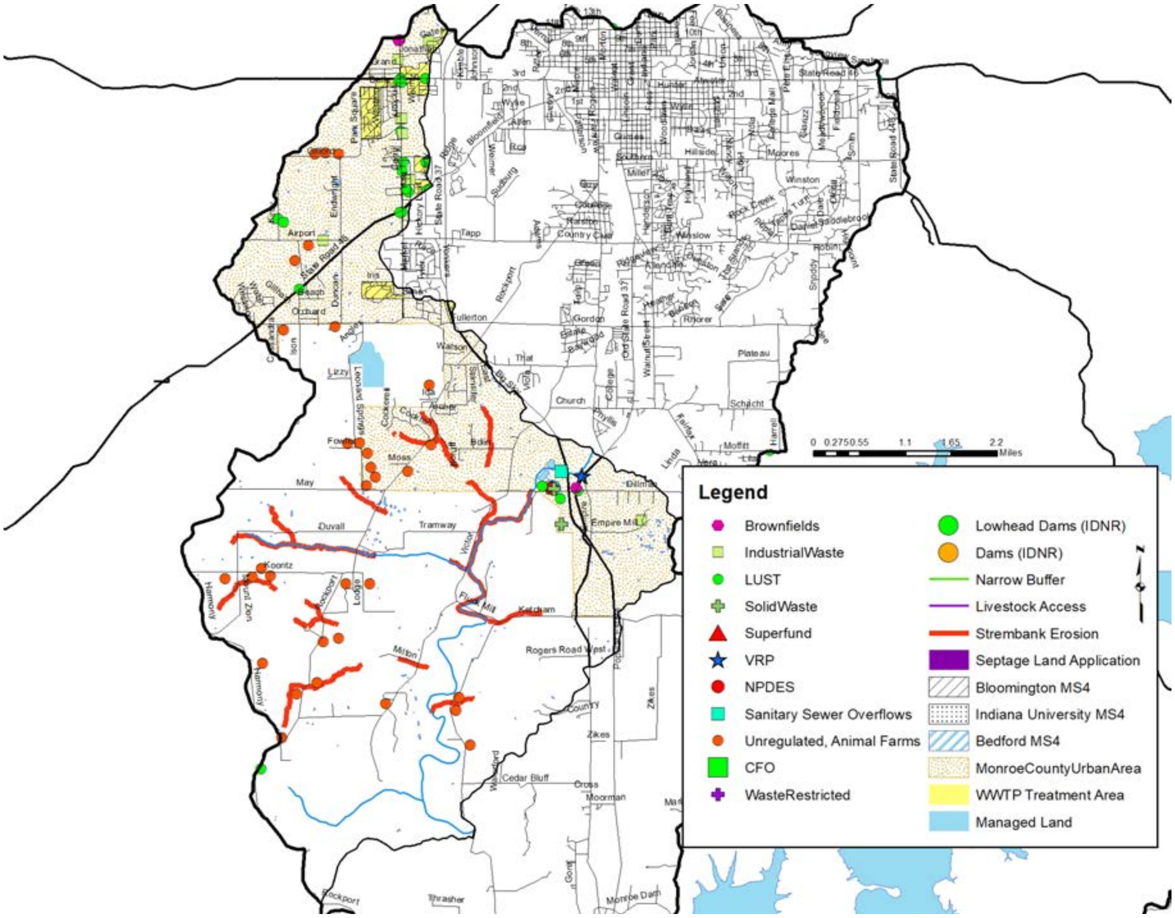

Figure 39. Point and non-point sources of pollution and suggested solutions in the May Creek-Clear Creek Subwatershed.

4.2.5 IDEM TMDL Assessment

IDEM created and evaluated load duration curves and precipitation graph with consideration of watershed characteristics which allowed IDEM to identify potential nonpoint sources that could be contributing to elevated E. coli concentrations. Many of these sources could also be considered sources of nutrient and sediment concentrations within the May Creek-Clear Creek Subwatershed. Based on the water quality duration curves, IDEM concluded that the majority of sources of E. coli in the May Creek-Clear Creek Subwatershed are nonpoint sources that could include wildlife, pasture animals with direct access to streams, urban stormwater, straight pipes, and leaking and failing septic systems. IDEM indicates that achieving necessary load reductions for E. coli impairments in the May Creek-Clear Creek Subwatershed should focus on BMPs that have an impact throughout moist, mid-range, and dry flow regimes. These include septic system outreach and education, stormwater reduction, fencing and livestock exclusion systems, alternative livestock watering systems, comprehensive nutrient management planning, and vegetated filter strips.

Table 30. Flow regime TMDL analysis for E. coli in the May Creek-Clear Creek Subwatershed.

Flow Regime TMDL analysis for *E. coli* (MPN/day)					
Allocation Category Duration Level	**High** 5%	**Moist** 25%	**Mid-range** 50%	**Dry** 75%	**Low** 95%
TMDL= LA+WLA+MOS	**3.92E+12**	**8.10E+11**	**3.82E+11**	**1.95E+11**	**1.53E+11**
City of Bloomington MS4 WLA	3.14E+10	5.61E+09	N/A	N/A	N/A
Bloomington S. Dillman Rd. WWTP WLA	1.33E+11	1.33E+11	1.33E+11	1.33E+11	1.33E+11
Total WLA	7.98E+11	2.52E+11	1.33E+11	1.33E+11	1.33E+11
MOS (10%)	2.04E+11	3.65E+10	1.34E+10	3.33E+09	1.06E+09
Future Growth (5%)	1.02E+11	1.82E+10	6.69E+09	1.67E+09	5.32E+08
Allocation Category Duration Level	**High** 5%	**Moist** 25%	**Mid-range** 50%	**Dry** 75%	**Low** 95%
TMDL= LA+WLA+MOS	**3.92E+12**	**8.10E+11**	**3.82E+11**	**1.95E+11**	**1.53E+11**
Upstream Drainage Input (Jackson Creek)	1.75E+12	3.12E+11	1.14E+11	2.85E+10	9.10E+09
LA	1.07E+12	1.91E+11	1.14E+11	2.83E+10	9.04E+09
Monroe County MS4 WLA	6.33E+11	1.13E+11	N/A	N/A	N/A

4.2.6 Water Quality Assessment

Waterbodies within the May Creek-Clear Creek subwatershed have been sampled at 46 locations (Figure 40). Assessments include collection of water chemistry data by IDEM (6 sites on Clear Creek and a tributary to Clear Creek), by Monroe County (16 sites including Sinking Creek), by Indiana DNR (1 site), Indiana Geological and Water Survey (4 spring sites), by Indiana University limnology students (4 sites) and by Hoosier Riverwatch volunteers (15 sites). No stream gages are in the May Creek-Clear Creek subwatershed.

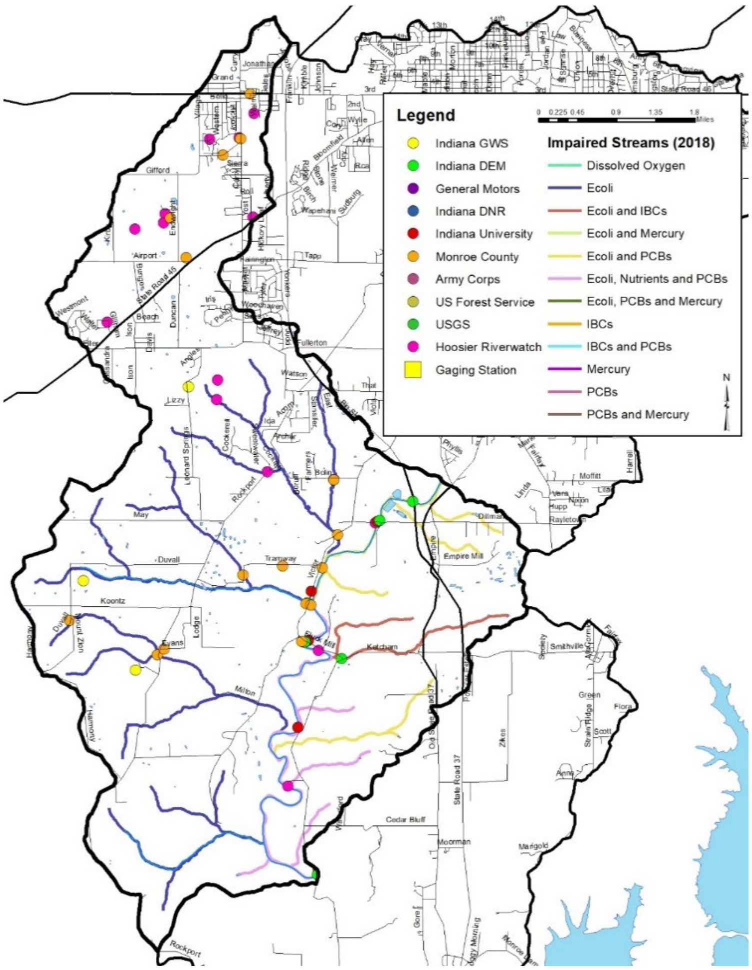

Figure 40. Locations of historic water quality data collection and impairments in the May Creek-Little Clear Creek Subwatershed.

Table 31 details Tier 1 data – those collected by IDEM, IDNR, IGWS, USGS, USFS, USACE, Indiana University researchers, Monroe County or General Motors. As shown in the table, conductivity samples do not exceed state standards (1050 µmhos/cm) in any samples collected. E. coli samples exceed state grab sample standards (235 col/100 ml) in 37% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 20% of samples, while total Kjeldahl nitrogen concentrations do not exceed water quality targets (2.18 mg/L) in any collected samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 10% of samples. Total suspended solids do not exceed water quality targets (15 mg/L), while turbidity levels exceed water quality targets (6.36 NTU) in 56% of samples.

Table 31. May Creek-Clear Creek Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	218	856	0	58	0%
DO	0	13.47	3	58	5%
E. coli	0	17,329	17	52	37%
Ammonia-Nitrogen	0	0	0	36	0%
Nitrate-Nitrogen	0.2	9.7	8	40	20%
Dissolved Phosphorus	--	--	--	--	--
pH	7.28	8.27	0	55	0%
Temperature	--	--	--	--	--
TKN	0.3	0.86	0	37	0%
Total Phosphorus	0.005	0.38	4	40	10%
Total Suspended Solids	6	12	0	37	0%
Turbidity	1.63	347	35	63	56%

Tier II data – those collected by Indiana University student groups or classes learning to analyze laboratory data as well as Hoosier Riverwatch volunteer collected data are detailed in Table 32. pH levels exceed the upper state standard (9) in 1% of samples. Nitrate concentrations exceed water quality targets (1 mg/L) in 75% of samples. Total Kjeldahl nitrogen concentrations exceed water quality targets (2.18 mg/L) in 20% of samples. Soluble reactive phosphorus concentrations exceed water quality targets in 72% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 70% of samples. Turbidity exceeds water quality targets in 13% of samples.

Table 32. May Creek-Clear Creek Subwatershed Tier II historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Ammonia	0.001	0.337	0	85	0%
Conductivity	300	781	0	41	0%
Dissolved Oxygen	6.0	19.2	4	83	5%
Nitrate	0.062	17.584	64	85	75%
pH	6.3	10.3	1	85	1%
Soluble Reactive Phosphorus	0.005	2.959	63	88	72%
Temperature	7.8	23.5	0	86	0%
TKN	0.139	10.675	3	15	20%
Total Nitrogen	0.021	0.187	0	4	0%
Total Phosphorus	0.004	8.639	59	84	70%
Turbidity	0.054	26	11	88	13%

IDEM assessed the biological community at 10 sites including 5 sites assessed for macroinvertebrates, 4 sites assessed for fish and 10 sites assessed for habitat. Indiana DNR assessed fish communities and habitat at one site. Habitat scores ranged from 43 to 76 with 90% of sites scoring below the state target

(51). Fish community assessments rated fair to good-excellent with all assessments meeting the aquatic life use designation. Macroinvertebrate assessments rated slightly impaired to not impaired using the kick sampling method with all sites meeting their aquatic life use designation and scoring 32 using the multihabitat samples with 100% of sites not meeting their aquatic life use designation (Table 33).

Table 33. May Creek-Clear Creek Subwatershed biological assessment data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Habitat (QHEI)	43	76	9	10	90%
Fish (IBI)	36	54	0	6	0%
Macroinvertebrates (mIBI, Kick)	4.2	6.0	0	6	0%
Macroinvertebrates (mIBI, Multi Habitat)	32	32	1	1	100%

4.3 Little Clear Creek - Clear Creek Subwatershed

The Little Clear Creek-Clear Creek Subwatershed is in the center of the Lower Salt Creek Watershed and lies within Monroe and Lawrence Counties (Figure 41). It encompasses one 12-digit HUC watershed: 051202080803. This subwatershed drains 13,271 acres and accounts for 10.19% of the total watershed area. In total, the Little Clear Creek-Clear Creek Subwatershed drains 76 square miles. There are 36 miles of stream. IDEM has classified 33.05 miles of stream as impaired for *E. coli* (Figure 43).

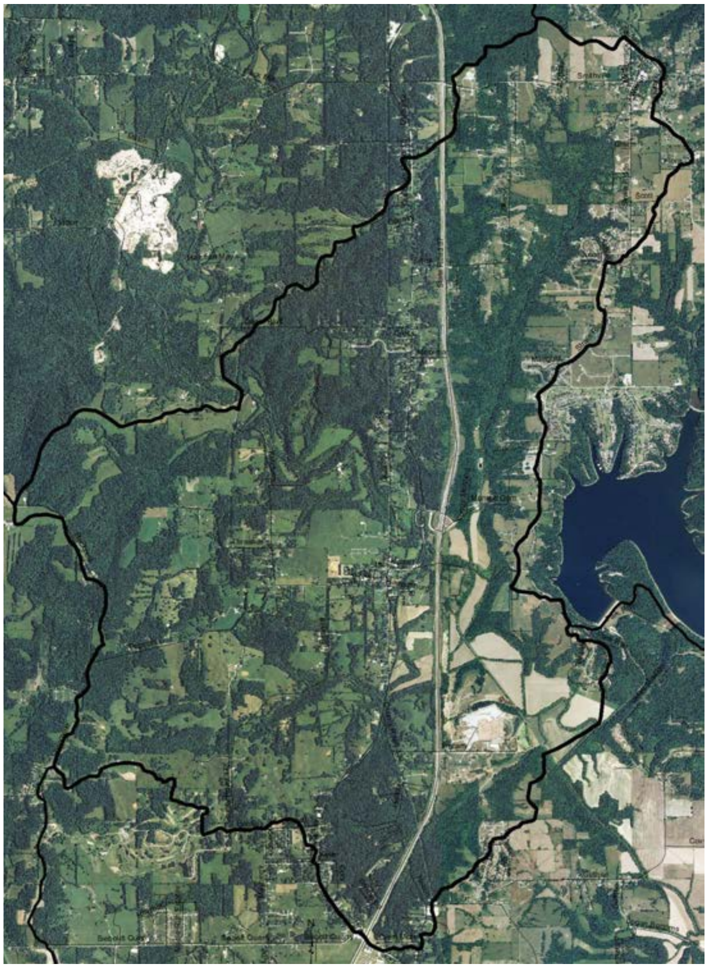

Figure 41. Little Clear Creek-Clear Creek Subwatershed.

4.3.1 Soils

Hydric soils cover 29.5 acres or 0.2% of the subwatershed. Wetlands currently cover 1.2% (159.2 acres) of the subwatershed. Highly erodible soils nearly cover 99.6% of the subwatershed with 13,215.6 acres. In total, 8,600.7 acres or 27.6% of the subwatershed is identified as very limited for septic use. Maintenance and inspections of septic systems in the Little Clear Creek-Clear Creek Subwatershed is important to ensure proper function and capacity. Nearly 1,652 acres of karst, or sinkholes, appear throughout the subwatershed.

4.3.2 Land Use

Forested and agricultural land uses co-dominate the Little Clear Creek-Clear Creek Subwatershed with 51.5% (6,835.0 acres) in forested land use and 40.1% (5320.8 acres) in agricultural land uses including row crop and pasture. Wetlands, open water, and grassland cover 159.2 acres, or 1.2%, of the subwatershed. The unincorporated community of Harrodsburg and State Road 37 account for much of the urban land use within the subwatershed. In total, 950.6 acres or 7.2% of the subwatershed are in urban land uses.

4.3.3 Point Source Water Quality Issues

There are few potential point sources of water pollution in the subwatershed (Figure 42). There are three leaking underground storage tanks (LUST) and two NPDES-permitted locations, Briarwood Subdivision WWTP and South Central RSD Caslon WWTP (Figure 42). Monroe County is the only MS4 in the Little Clear Creek-Clear Creek Subwatershed. There are no open dumps, brownfields, corrective action sites, voluntary remediation sites, or industrial waste facilities located within the Little Clear Creek-Clear Creek Subwatershed.

4.3.4 Non-Point Source Water Quality Issues

Agricultural and forested land uses are the predominant land uses in the Little Clear Creek-Clear Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Surveyors observed 17 unregulated animal operations housing more than 227 cows and horses during the windshield survey (Figure 42). Animals produce more than 4,366 tons of manure annually which contains more than 2,432 pounds nitrogen, 1,208 pounds of phosphorus and more than 1.27E+14 colonies of E. coli. Based on windshield survey observations, livestock do not have access to Little Clear Creek-Clear Creek Subwatershed streams. No active confined feeding operations are located within the Little Clear Creek - Clear Creek Subwatershed. IDEM identified and animal density of 20.97 animals/square mile. Streambank erosion is a concern in the subwatershed. Approximately 2.1 miles (3.7%) of streambank erosion were identified within the subwatershed.

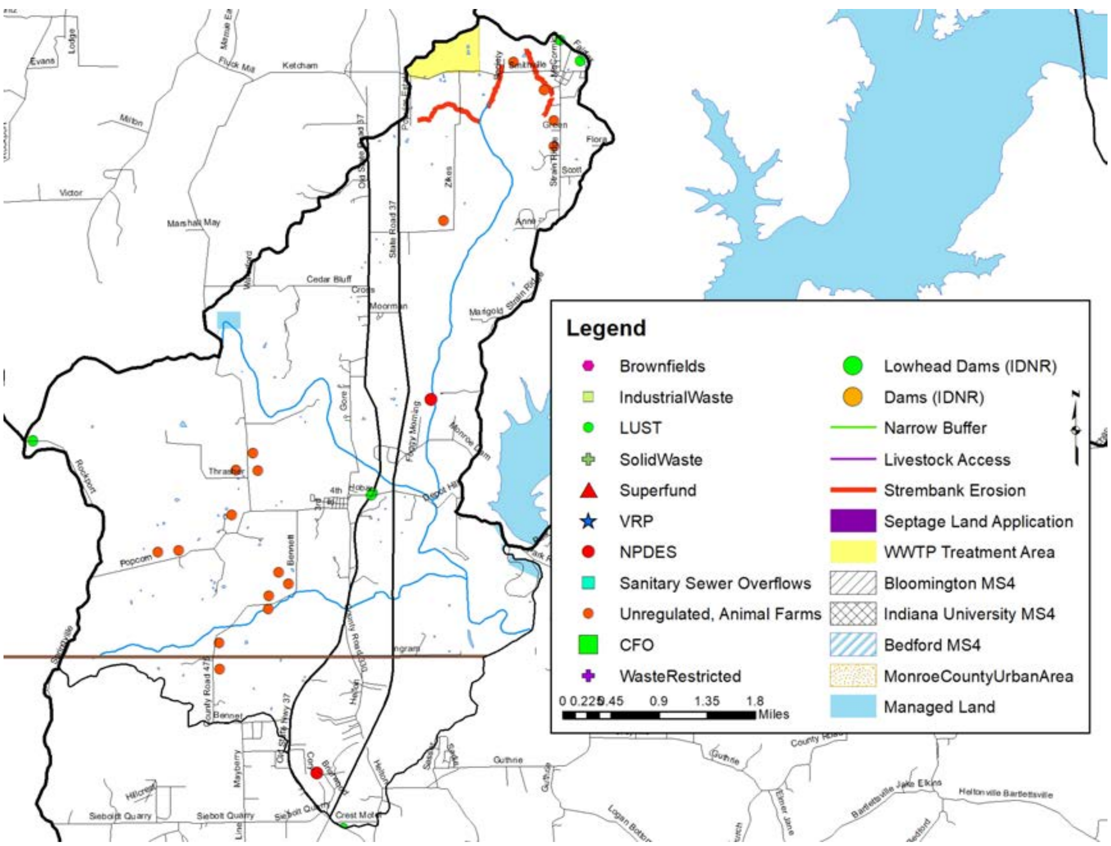

Figure 42. Point and non-point sources of pollution and suggested solutions in the Little Clear Creek-Clear Creek Subwatershed.

4.3.5 IDEM TMDL Assessment

IDEM created and evaluated load duration curves and precipitation graph with consideration of watershed characteristics which allowed IDEM to identify potential nonpoint sources that could be contributing to elevated E. coli concentrations. Many of these sources could also be considered sources of nutrient and sediment concentrations within the Little Clear Creek-Clear Creek Subwatershed. Based on the water quality duration curves, IDEM concluded that the majority of sources of E. coli in the Little Clear Creek-Clear Creek Subwatershed are nonpoint sources that could include wildlife, pasture animals with direct access to streams, straight pipes, and leaking and failing septic systems. IDEM indicates that achieving necessary load reductions for E. coli impairments in the Little Clear Creek-Clear Creek Subwatershed should focus on BMPs that have an impact throughout moist, mid-range, and dry flow regimes. These include septic system outreach and education, stormwater reduction, fencing and livestock exclusion systems, alternative livestock watering systems, comprehensive nutrient management planning, and vegetated filter strips.

Table 34. Flow regime TMDL analysis for E. coli in the Little Clear Creek-Clear Creek Subwatershed.

Allocation Category Duration Level	High 5%	Moist 25%	Mid-Range 50%	Dry 75%	Low 95%
TMDL= LA+WLA+MOS	**5.36E+12**	**1.07E+12**	**4.79E+11**	**2.22E+11**	**1.64E+11**
Upstream Drainage Input (May Creek)	3.92E+12	8.10E+11	3.82E+11	1.95E+11	1.53E+11
LA	1.22E+12	2.18E+11	7.96E+10	1.95E+10	5.91E+09
South Central RSD Caslon WWTP WLA	2.67E+09	2.67E+09	2.67E+09	2.67E+09	2.67E+09
Briarwood Subdivision WWTP WLA	3.29E+08	3.29E+08	3.29E+08	3.29E+08	3.29E+08
Total WLA	**3.00E+09**	**3.00E+09**	**3.00E+09**	**3.00E+09**	**3.00E+09**
MOS (10%)	1.44E+11	2.60E+10	9.71E+09	2.64E+09	1.05E+09
Future Growth (5%)	7.20E+10	1.30E+10	4.86E+09	1.32E+09	5.24E+08

4.3.6 Water Quality Assessment

Waterbodies within the Little Clear Creek-Clear Creek subwatershed have been sampled at 14 locations (Figure 43). Assessments include collection of water chemistry data by IDEM (7 sites on Clear Creek and Little Clear Creek), by Indiana DNR (2 sites), by Indiana University limnology students (2 sites) and by Hoosier Riverwatch volunteers (3 sites). No stream gages are in the Little Clear Creek-Clear Creek subwatershed.

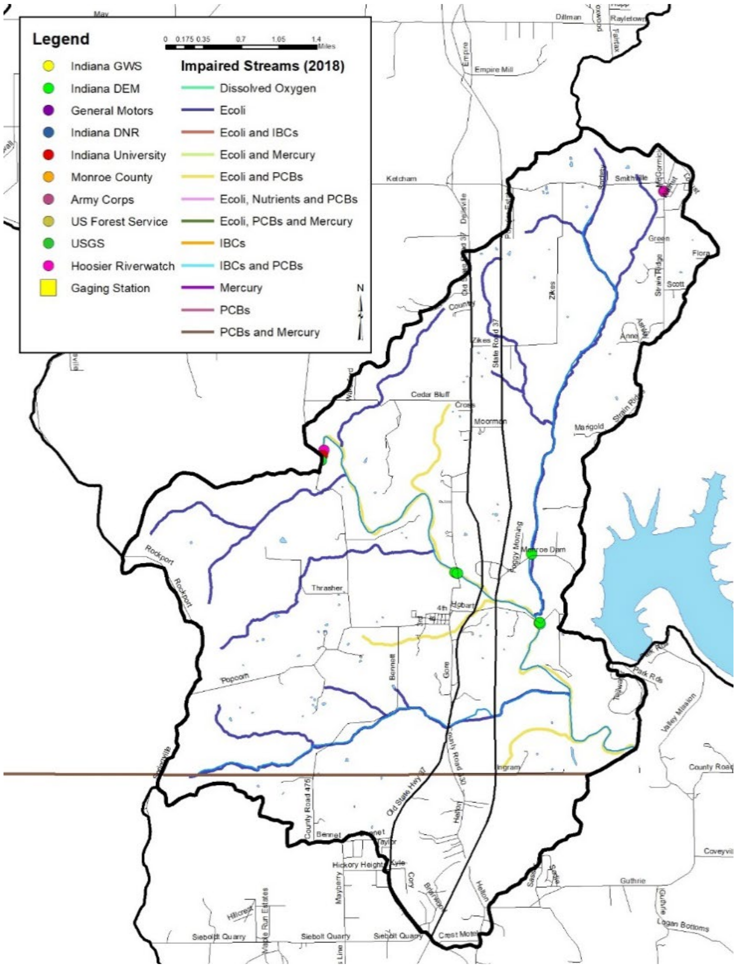

Figure 43. Locations of historic water quality data collection and impairments in the Little Clear-Clear Creek Subwatershed.

Table 35 details Tier 1 data – those collected by IDEM, IDNR, IGWS, USGS, USFS, USACE, Indiana University researchers, Monroe County or General Motors. As shown in the table, conductivity samples do not exceed state standards (1050 µmhos/cm). E. coli samples exceed state grab sample standards (235 col/100 ml) in 33% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 75% of samples, while total Kjeldahl nitrogen concentrations do not exceed water quality targets (2.18 mg/L). Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 61% of samples. Total suspended solids exceed water quality targets (15 mg/L) in 4% of samples, while turbidity levels exceed water quality targets (6.36 NTU) in 49% of samples.

Table 35. Little Clear Creek-Clear Creek Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	307	753	0	82	0%
DO	6.57	13.58	7	82	9%
E. coli	10	5,172	20	75	33%
Ammonia-Nitrogen	0.1	0.446	0	50	0%
Nitrate-Nitrogen	0.2	13	43	57	75%
Dissolved Phosphorus	--	--	--	--	--
pH	7.17	8.48	0	82	0%
Temperature	--	--	--	--	--
TKN	0.22	1.2	0	57	0%
Total Phosphorus	0.005	0.693	35	57	61%
Total Suspended Solids	4	25	2	57	4%
Turbidity	2.92	191	40	81	49%

Tier II data – those collected by Indiana University student groups or classes learning to analyze laboratory data as well as Hoosier Riverwatch volunteer collected data are detailed in Table 36. Dissolved oxygen concentrations measure above the upper state standard (12 mg/L) in 3% of samples. pH levels exceed the upper pH state standard (9) in 3% of samples. Nitrate concentrations exceed water quality targets (1 mg/L) in 100% of samples. Total Kjeldahl nitrogen concentrations exceed water quality targets in 22% of samples, while total nitrogen samples exceed water quality targets in 33% of samples. Soluble reactive phosphorus concentrations exceed water quality targets in 95% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 91% of samples. Turbidity exceeds water quality targets in 8% of samples.

Table 36. Little Clear Creek-Clear Creek Subwatershed Tier II historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Ammonia	0.001	1.618	0	58	0%
Conductivity	370	750	0	29	0%
Dissolved Oxygen	5.4	13.2	2	59	3%
Nitrate	1.319	16.428	56	56	100%
pH	6.2	10.1	2	59	3%
Soluble Reactive Phosphorus	0.044	1.376	56	59	95%
Temperature	9.0	18.3	0	59	0%
TKN	0.347	8.096	2	9	22%
Total Nitrogen	0.061	8.096	1	3	33%
Total Phosphorus	0.034	7.87	49	54	91%
Turbidity	0.7	22	5	59	8%

IDEM assessed the biological community at 11 sites including 5 sites assessed for macroinvertebrates, 6 sites assessed for fish and 11 sites assessed for habitat. Indiana DNR assessed fish communities and habitat at two sites. Habitat scores ranged from 36 to 88 with 23% of sites scoring below the state target (51). Fish community assessments rated poor to good-excellent with 12% of assessments not meeting the state aquatic life use designation. Macroinvertebrate assessments rated moderately impaired using the kick sampling method with 100% of sites not meeting their aquatic life use designation and from 24 to 44 with 50% of multihabitat samples not meeting their aquatic life use designation (Table 37).

Table 37. Little Clear Creek-Clear Creek Subwatershed biological assessment data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Habitat (QHEI)	36	88	3	13	23%
Fish (IBI)	26	56	1	8	12%
Macroinvertebrates (mIBI, Kick)	2.2	2.2	1	1	100%
Macroinvertebrates (mIBI, Multi Habitat)	24	44	2	4	50%

4.4 Hunter Creek-Little Salt Creek Subwatershed

The Hunter Creek-Little Salt Creek Subwatershed is in the eastern boundary of the Lower Salt Creek Watershed and lies within Jackson, Monroe and Lawrence Counties (Figure 44). It encompasses one 12-digit HUC watershed: 051202080804. This subwatershed drains 18,987.1 acres or 29.7 square miles, and accounts for 14.58% of the total watershed area. There are 101.5 miles of stream. IDEM has classified 5.5 miles of stream as impaired for impaired biotic communities (Figure 46).

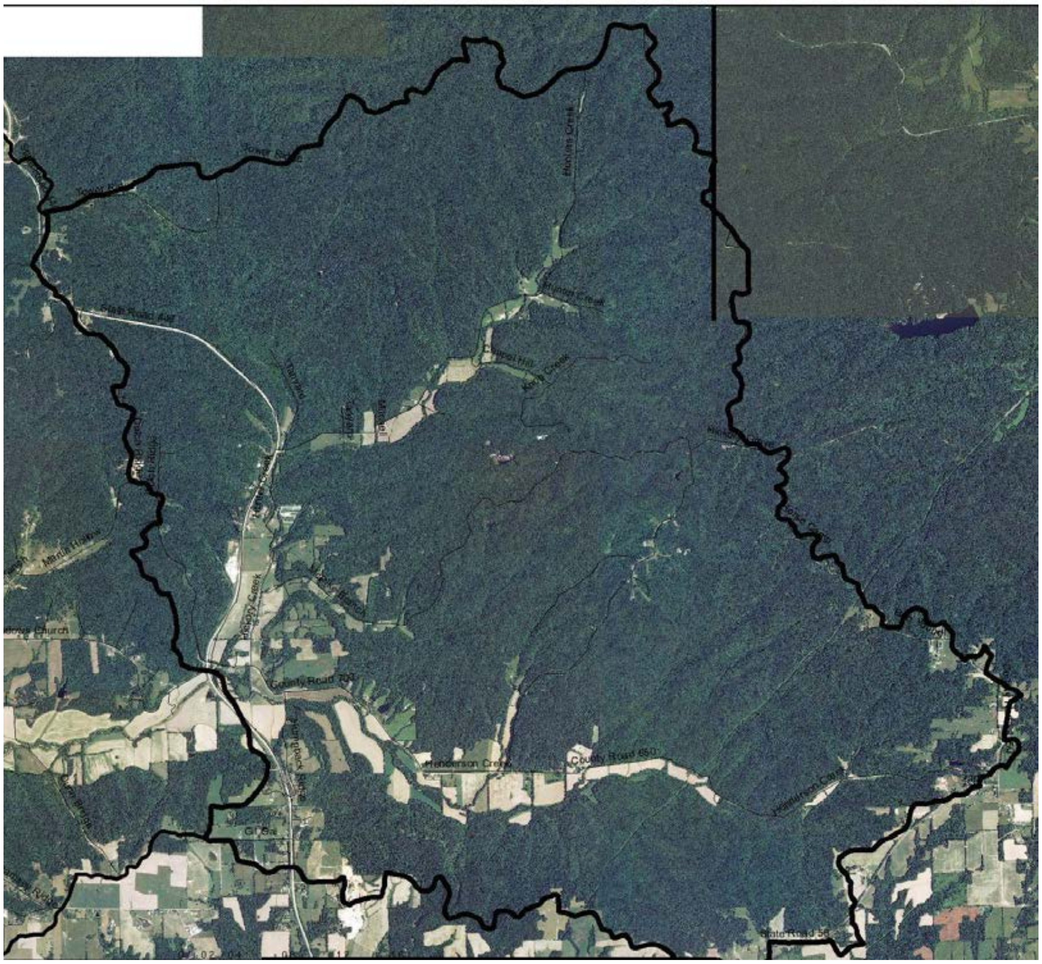

Figure 44. Hunter Creek-Little Salt Creek Subwatershed.

4.4.1 Soils

There are no hydric soils located within the subwatershed. Wetlands currently cover 0.4% (65.8 acres) of the subwatershed. Highly erodible soils nearly cover the entire subwatershed with 18,657.1 acres or 98.3%. More than 15,123 acres (79.6%) of the subwatershed are identified as very limited for septic use. Homes in the Hunter Creek-Little Salt Creek Subwatershed are mostly rural using on-site septic systems. Maintenance and inspection of septic systems in this area are important to ensure proper function and capacity. In total, 173.1 acres of karst, or sinkholes, appear throughout the subwatershed.

4.4.2 Land Use

Forested land use dominates the Hunter Creek-Little Salt Creek Subwatershed with 87.5% (16,621.9 acres) in forested land use which lies within Hoosier National Forest. Agricultural land uses, including row crop and pasture, account for 8.5% (1,606.2 acres). Wetlands, open water, and grassland cover 98.5 acres or 0.5%, of the subwatershed. There is very little urban area in this subwatershed. In total, 668.1 acres or 3.5% of the subwatershed are in urban land uses.

4.4.3 Point Source Water Quality Issues

There are no point sources of water pollution in the subwatershed (Figure 45). No open dumps, NPDES-permitted locations, Superfund sites, LUST locations, corrective action sites, or voluntary remediation sites are located within the Hunter Creek-Little Salt Creek Subwatershed.

4.4.4 Non-Point Source Water Quality Issues

Forested land uses are the predominant land use in the Hunter Creek-Little Salt Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. In total, 16 unregulated animal operations housing more than 103 cows, horses, and goats were identified during the windshield survey. In total, manure from small animal operations total over 1,933 tons per year, which contains almost 1,194 pounds of nitrogen, almost 642 pounds of phosphorus and 5.23E+13 colonies of E. coli. Based on windshield survey observations, livestock do not appear to have access to the subwatershed streams. No active confined feeding operations are located within the Hunter Creek-Little Salt Creek Subwatershed. Streambank erosion is a concern in the subwatershed. Approximately 12.1 miles (11.9%) of streambank erosion were identified within the subwatershed. Additionally, due to the forested cover, a significant presence of wildlife is expected to use the stream corridor.

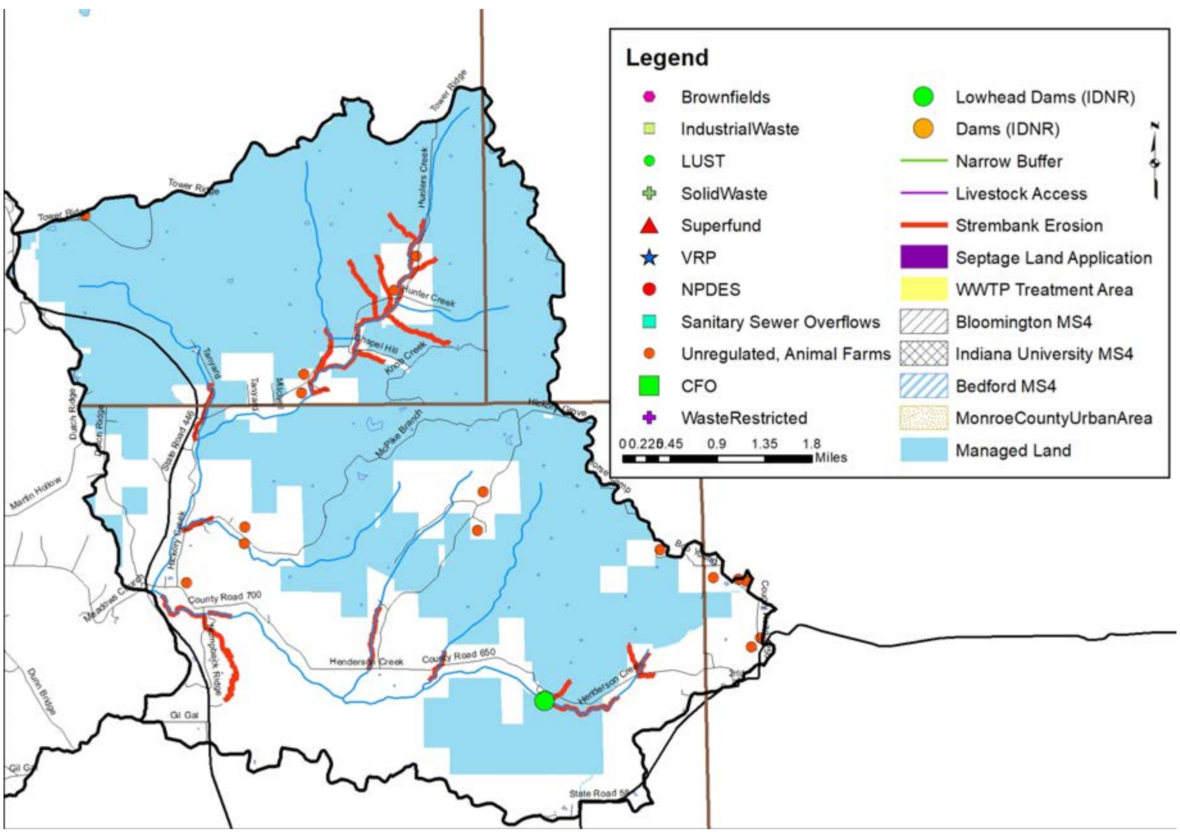

Figure 45. Point and non-point sources of pollution and suggested solutions in the Hunter Creek - Little Salt Creek Subwatershed.

4.4.5 IDEM TMDL Assessment

IDEM created and evaluated load duration curves and precipitation graph with consideration of watershed characteristics which allowed IDEM to identify potential nonpoint sources that could be contributing to elevated E. coli concentrations. Many of these sources could also be considered sources of nutrient and sediment concentrations within the Hunter Creek- Salt Creek Subwatershed. Based on the water quality duration curves, IDEM concluded that no reduction for E. coli is necessary in the Hunter Creek-Little Salt Creek Watershed.

Table 38. Flow regime TMDL analysis for E. coli in the Hunter Creek- Salt Creek Subwatershed.

Allocation Category Duration Level	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL= LA+WLA+MOS	**2.04E+12**	**3.65E+11**	**1.34E+11**	**3.33E+10**	**1.06E+10**
Upstream Drainage	N/A	N/A	N/A	N/A	N/A
LA	1.74E+12	3.10E+11	1.14E+11	2.83E+10	9.04E+09
Total WLA	N/A	N/A	N/A	N/A	N/A
MOS (10%)	2.04E+11	3.65E+10	1.34E+10	3.33E+09	1.06E+09
Future Growth (5%)	1.02E+11	1.82E+10	6.69E+09	1.67E+09	5.32E+08

4.4.6 Water Quality Assessment

Waterbodies within the Hunter Creek-Salt Creek have been sampled at 8 locations (Figure 46). Assessments include collection of water chemistry data by IDEM (5 sites on Little Salt Creek and Henderson Creek), by the U.S. Forest Service (2 sites) and by Hoosier Riverwatch volunteers (1 site). No stream gages are in the Hunter Creek-Little Salt Creek subwatershed.

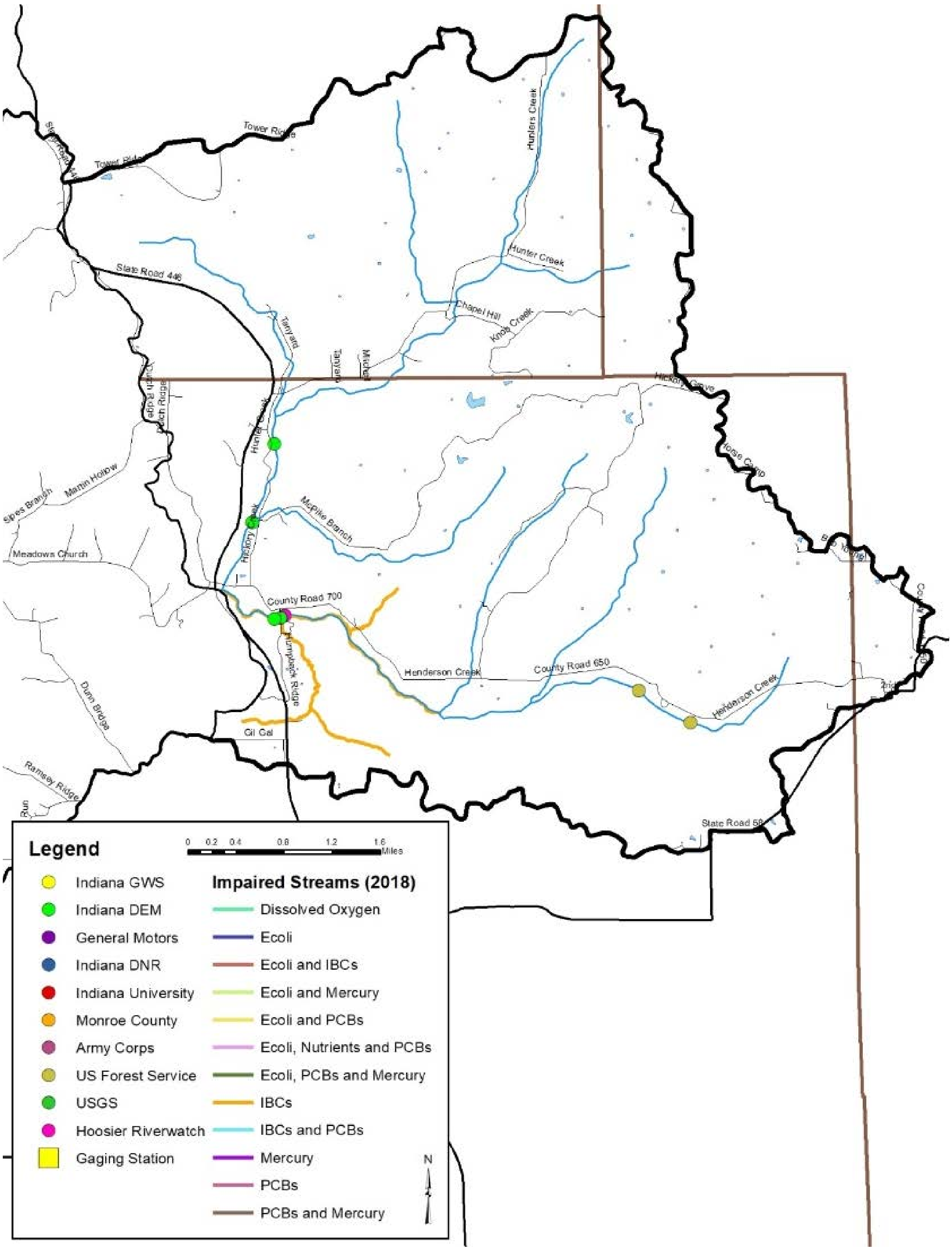

Figure 46. Locations of historic water quality data collection and impairments in the Hunter Creek-Salt Creek Subwatershed.

Table 39 details Tier 1 data – those collected by IDEM, IDNR, IGWS, USGS, USFS, USACE, Indiana University researchers, Monroe County or General Motors. As shown in the table, conductivity samples do not exceed state standards (1050 µmhos/cm). E. coli samples exceed state grab sample standards (235 col/100 ml) in 22% of samples collected. Nitrate-nitrogen and total Kjeldahl nitrogen concentrations do not exceed water quality targets (1 mg/L and 2.18 mg/L, respectively). Total phosphorus concentrations do not exceed water quality targets (0.08 mg/L). Similarly, total suspended solids do not exceed water quality targets (15 mg/L), while turbidity levels exceed water quality targets (6.36 NTU) in 15% of samples.

Table 39. Hunter Creek-Little Salt Creek Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	157	327	0	35	0%
DO	5.38	11.69	0	35	0%
E. coli	29.2	488.4	6	27	22%
Ammonia-Nitrogen	0.1	0.1	0	24	0%
Nitrate-Nitrogen	0.1	0.6	0	25	0%
Dissolved Phosphorus	--	--	--	--	--
pH	7.25	8.58	0	35	0%
Temperature	--	--	--	--	--
TKN	0.48	0.48	0	25	0%
Total Phosphorus	0.004	0.043	0	25	0%
Total Suspended Solids	4	6	0	25	0%
Turbidity	1.07	35	5	34	15%

Tier II data – those collected by Indiana University student groups or classes learning to analyze laboratory data as well as Hoosier Riverwatch volunteer collected data are detailed in Table 40. Nitrate concentrations exceed water quality targets (1 mg/L) in 100% of samples. Ortho P (Hoosier Riverwatch) concentrations exceed water quality targets in 100% of samples.

Table 40. Hunter Creek-Little Salt Creek Subwatershed Tier II historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Dissolved Oxygen	6	6	0	1	0%
Nitrate	2	2	1	1	100%
Ortho P	1	1	1	1	100%
pH	7	7	0	1	0%
Temperature	25	25.00	0	1	0%
Turbidity	60	60	0	1	0%

IDEM assessed the biological community at 11 sites including 7 sites assessed for macroinvertebrates, 3 sites assessed for fish and 10 sites assessed for habitat. The U.S. Forest Service assessed fish and habitat at four sites. Habitat scores ranged from 59 to 82 all sites scoring above the state target (51). Fish community assessments rated very poor to fair with 50% of assessments not meeting the state aquatic life use designation. Macroinvertebrate assessments rated moderately impaired to slightly impaired using the kick sampling method with 50% of sites not meeting their aquatic life use designation and from 16 to 38 with 57% of multihabitat samples not meeting their aquatic life use designation (Table 41).

Table 41. Hunter Creek-Little Salt Creek Subwatershed biological assessment data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Habitat (QHEI)	59	82	0	10	0%
Fish (IBI)	18	42	6	12	50%
Macroinvertebrates (mIBI, Kick)	3.2	4.8	1	2	50%
Macroinvertebrates (mIBI, Multi Habitat)	16	38	4	7	57%

4.5 Knob Creek-Little Salt Creek Subwatershed

The Knob Creek-Little Salt Creek Subwatershed forms the eastern boundary of the Lower Salt Creek Watershed and draining portions of Monroe and Lawrence Counties (Figure 47). It encompasses one 12-digit HUC watershed: 051202080805. This subwatershed drains 15,427.30 acres and accounts for 11.84% of the total watershed area. The Knob Creek-Little Salt Creek Subwatershed drains 55 square miles. There are 91.4 miles of stream. IDEM has classified 21.88 miles of stream as impaired for *E. coli*, 10.58 miles of stream as impaired for impaired biotic communities, and 6.09 miles of stream as impaired for DO (Figure 49).

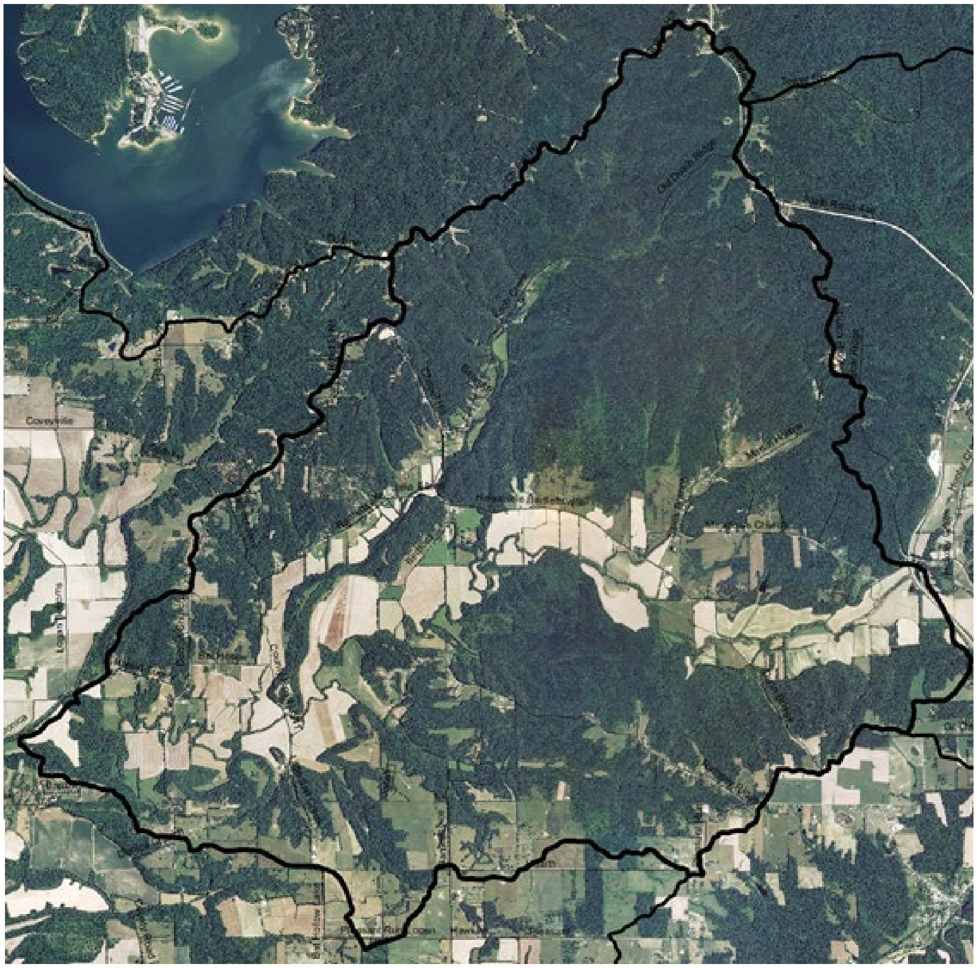

Figure 47. Knob Creek-Little Salt Creek Subwatershed.

4.5.1 Soils

Hydric soils cover 118.1 acres (0.8%) of the subwatershed. Wetlands currently cover 0.4% (65.8 acres) of the subwatershed. Highly erodible soils nearly 99.3% the subwatershed with 15,320.3 acres. In total, 13,100.2 acres (84.9%) of the subwatershed are identified as very limited for septic use. Maintenance and inspections of septic systems in the area is important to ensure proper function and capacity. In total, 261.9 acres of karst, or sinkholes, appear throughout the subwatershed.

4.5.2 Land Use

Forested land use dominates the Knob Creek-Little Salt Creek Subwatershed with 69.1% (10,657.4 acres) in forested land use with Hoosier National Forest covering much of the subwatershed. An additional 26.8% of the watershed (4,128.8 acres) is in agricultural land uses, including row crop and pasture. Wetlands, open water, and grassland cover 65.8 acres, or 0.4%, of the subwatershed. In total, 586.4 acres or 3.8% of the subwatershed are in urban land uses.

4.5.3 Point Source Water Quality Issues

There are no NPDES-permitted facilities, open dumps, brownfields, corrective action sites, voluntary remediation sites or industrial waste facilities located within the Knob Creek-Little Salt Creek Subwatershed (Figure 48).

4.5.4 Non-Point Source Water Quality Issues

Forested land use is the predominant land use in the Knob Creek - Little Salt Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present (Figure 48). In total, 26 unregulated animal operations housing more than 280 cows, horses, sheep and goats were identified during the windshield survey. In total, manure from small animal operations total over 5,719 tons per year, which contains almost 3,075 pounds of nitrogen, almost 1,557 pounds of phosphorus and 2.07E+14 colonies of E. coli. Livestock do not appear to have access to the subwatershed streams based on windshield survey observations. No active confined feeding operations are located within the Knob Creek-Little Salt Creek Subwatershed. With 70% of the land being forested, an even greater presence of wildlife is expected, many of which will utilize the stream corridor. IDEM calculated an animal density of 33.07 animals/square mile. This is higher than the median for Lower Salt Creek Subwatersheds. Streambank erosion and lack of buffers are a concern in the subwatershed. Approximately 0.6 miles of insufficient stream buffers and 20.6 miles of streambank erosion were identified within the subwatershed.

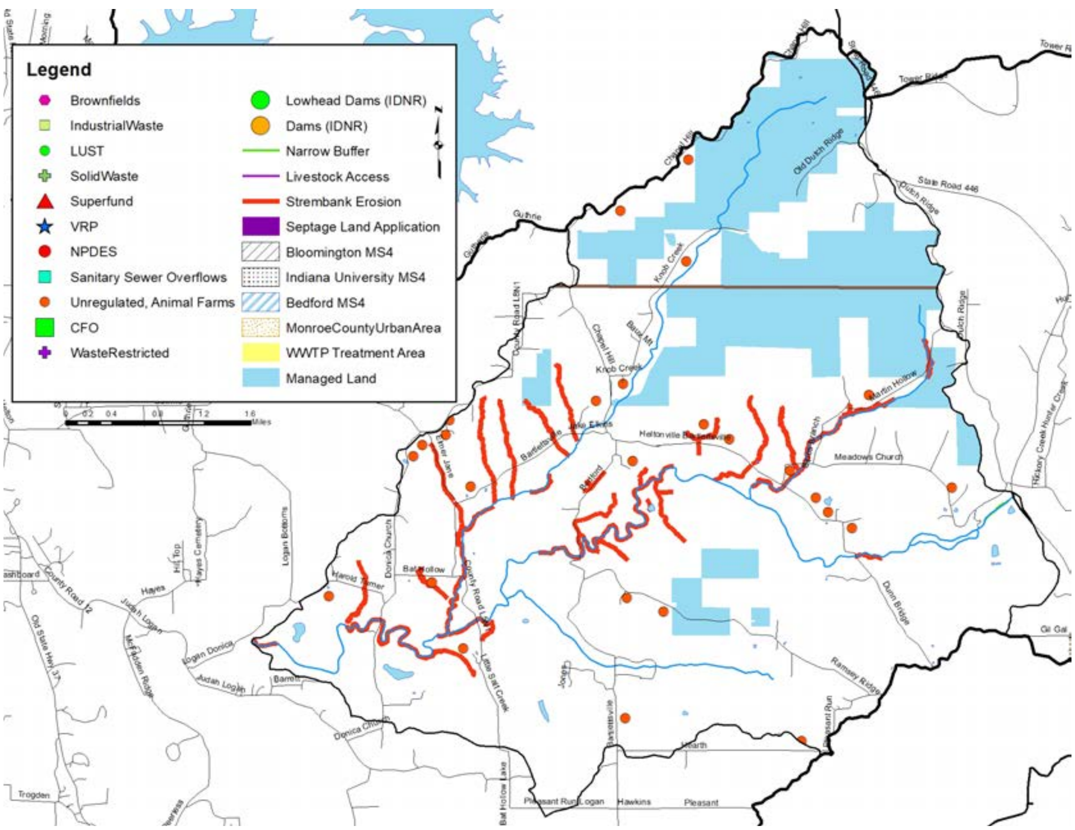

Figure 48. Point and non-point sources of pollution and suggested solutions in the Knob Creek-Little Salt Creek Subwatershed.

4.5.5 IDEM TMDL Assessment

IDEM created and evaluated load duration curves and precipitation graph with consideration of watershed characteristics which allowed IDEM to identify potential nonpoint sources that could be contributing to elevated E. coli concentrations. Many of these sources could also be considered sources of nutrient and sediment concentrations within the Knob Creek-Little Salt Creek Subwatershed. Based on the water quality duration curves, IDEM concluded that the majority of sources of E. coli in the Knob Creek-Little Salt Creek Subwatershed are nonpoint sources that could include wildlife, pasture animals with direct access to streams, straight pipes, and leaking and failing septic systems. IDEM indicates that achieving necessary load reductions for E. coli impairments in the Knob Creek-Little Salt Creek Subwatershed should focus on BMPs that have an impact throughout moist, mid-range, and dry flow regimes. These include septic system outreach and education, fencing and livestock exclusion systems, alternative livestock watering systems, comprehensive nutrient management planning, and vegetated filter strips.

Table 42. Flow regime TMDL analysis for E. coli in the Knob Creek-Little Salt Creek Subwatershed.

Allocation Category Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL= LA+WLA+MOS	**3.71E+12**	**6.63E+11**	**2.43E+11**	**6.05E+10**	**1.93E+10**
Upstream Drainage Input (Hunter Creek)	2.04E+12	3.65E+11	1.34E+11	3.33E+10	1.06E+10
LA	1.42E+12	2.53E+11	9.27E+10	2.31E+10	7.37E+09
WLA	N/A	N/A	N/A	N/A	N/A
MOS (10%)	1.67E+11	2.98E+10	1.09E+10	2.72E+09	8.68E+08
FG (5%)	8.33E+10	1.49E+10	5.45E+09	1.36E+09	4.34E+08

4.5.6 Water Quality Assessment

Waterbodies within the Knob Creek-Little Salt Creek subwatershed have been sampled at 10 locations (Figure 49). Assessments include collection of water chemistry data by IDEM (9 sites on Little Salt Creek, Knob Creek and a tributary to Little Salt Creek) and USGS (1 site). No stream gages are in the Knob Creek-Little Salt Creek subwatershed.

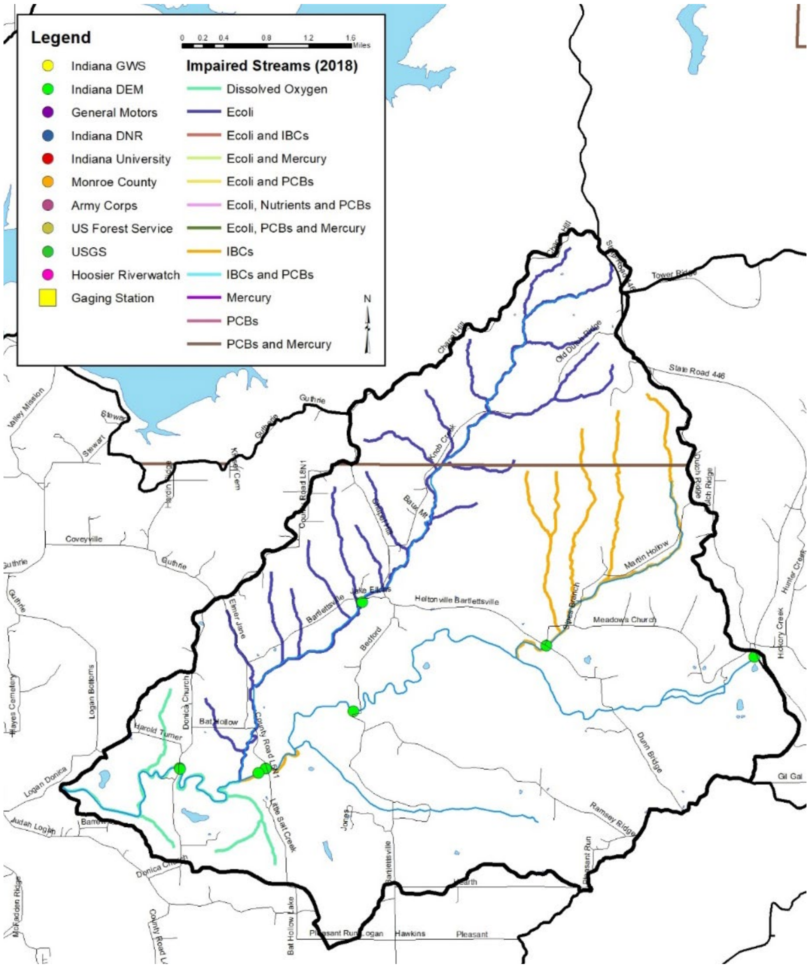

Figure 49. Locations of historic water quality data collection and impairments in the Knob Creek-Little Salt Creek Subwatershed.

Table 43 details Tier 1 data – those collected by IDEM, IDNR, IGWS, USGS, USFS, USACE, Indiana University researchers, Monroe County or General Motors. As shown in the table, conductivity samples exceed state standards (1050 μmhos/cm) in 1% of samples collected. E. coli samples exceed state grab sample standards (235 col/100 ml) in 42% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 2% of samples, while total Kjeldahl nitrogen concentrations do not exceed water quality targets (2.18 mg/L). Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 6% of samples. Total suspended solids do not exceed water quality targets (15 mg/L), while turbidity levels exceed water quality targets (6.36 NTU) in 68% of samples.

Table 43. Knob Creek-Little Salt Creek Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	114	1,439	1	82	1%
DO	1.52	13.84	16	82	20%
E. coli	15.6	2,419.6	26	62	42%
Ammonia-Nitrogen	0.56	0.56	0	46	0%
Nitrate-Nitrogen	0.02	1.3	1	53	2%
Dissolved Phosphorus	--	--	--	--	--
pH	6.79	8.32	0	82	0%
Temperature	--	--	--	--	--
TKN	0.2	1.4	0	52	0%
Total Phosphorus	0.004	0.14	3	52	6%
Total Suspended Solids	4	15	0	53	0%
Turbidity	1.13	36.6	54	79	68%

IDEM assessed the biological community at 13 sites including five sites assessed for macroinvertebrates, eight sites assessed for fish and 13 sites assessed for habitat. Habitat scores ranged from 36 to 88 with 12% of sites scoring below the state target (51). Fish community assessments rated poor to good-excellent with 33% of assessments not meeting the state aquatic life use designation. Macroinvertebrate assessments rated moderately impaired using the kick sampling method with 100% of sites not meeting their aquatic life use designation and from 24 to 44 with 50% of multihabitat samples not meeting their aquatic life use designation (Table 44).

Table 44. Knob Creek-Little Salt Creek Subwatershed biological assessment data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Habitat (QHEI)	36	88	3	13	23%
Fish (IBI)	26	56	1	8	12%
Macroinvertebrates (mIBI, Kick)	2.2	2.2	1	1	100%
Macroinvertebrates (mIBI, Multi Habitat)	24	44	2	4	50%

4.6 Wolf Creek - Salt Creek Subwatershed

The Wolf Creek-Salt Creek Subwatershed forms the headwaters of the Lower Salt Creek Watershed receiving all of the drainage from the Lake Monroe Watershed (Figure 50). It encompasses one 12-digit HUC watershed: 051202080806. This subwatershed drains 25,229 acres and accounts for 19.37% of the total watershed area. However, total drainage to this subwatershed is 601 square miles. There are 81 miles of stream. IDEM has classified 32.77 miles of stream as impaired for E. coli, 32.49 miles of stream as impaired for polychlorinated biphenyl (PCB) and 30.74 miles of stream as impaired for impaired biotic communities (Figure 52).

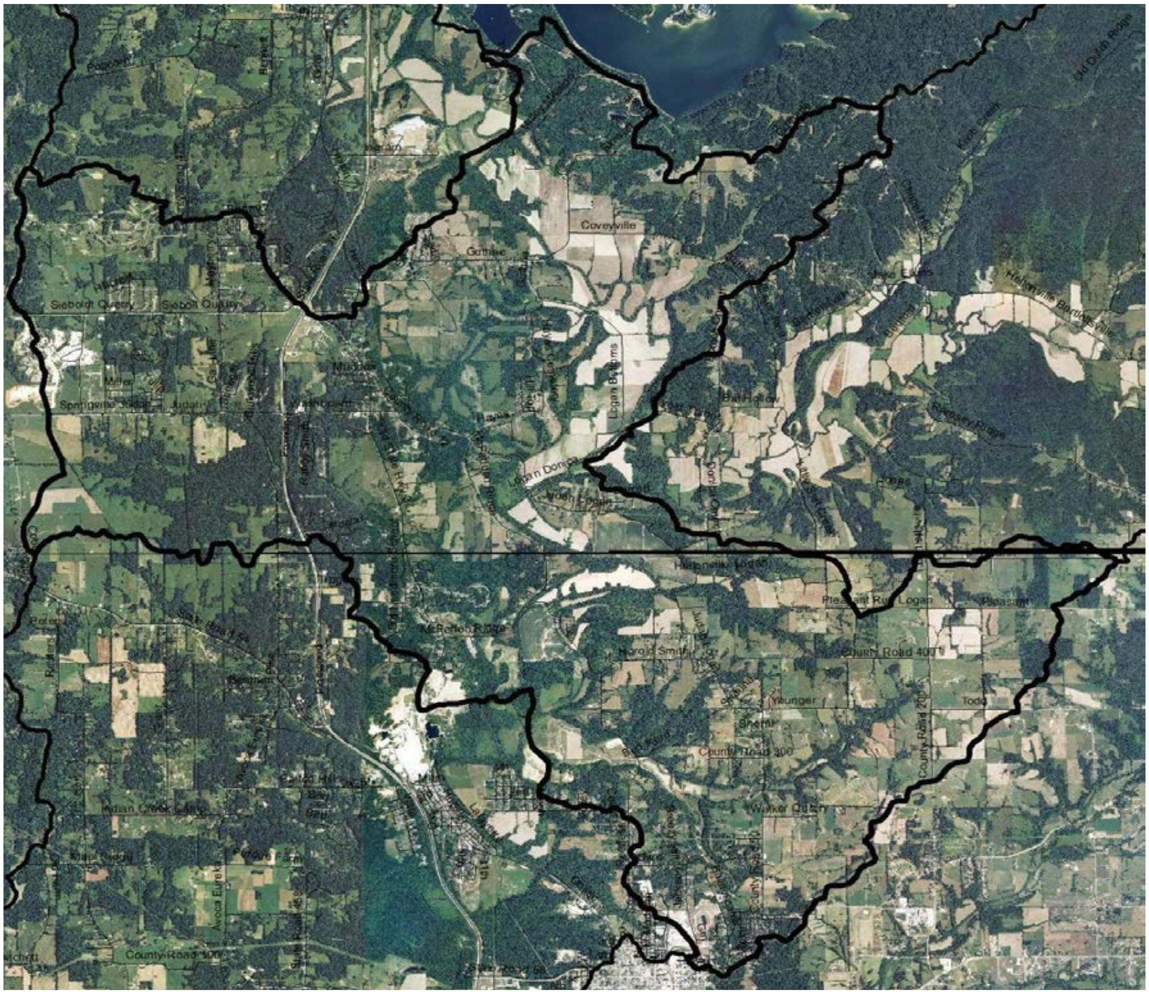

Figure 50. Wolf Creek-Salt Creek Subwatershed.

4.6.1 Soils

Hydric soils cover 230.0 acres (0.9%) of the subwatershed, indicating that only a small portion of the subwatershed was historically wetlands. Wetlands currently cover 1.7% (420.4 acres) of the subwatershed. Highly erodible soils nearly cover the entire subwatershed (96.8%), respectively. In total, 16,813.8 miles (66.6%) of the subwatershed are identified as very limited for septic use. The majority of the Wolf Creek-Salt Creek Subwatershed is rural indicating homes pump to an on-site wastewater system. Maintenance and inspection of these septic systems are important to ensure proper function and capacity. In total,2,099 acres of karst, or sinkholes, appear throughout the subwatershed.

4.6.2 Land Use

Agricultural land use dominates the Wolf Creek - Salt Creek Subwatershed with 49.2% (12,415.9 acres) in agricultural land uses, including row crop and pasture and 40.9% (10,317.2 acres) in forested land use. Wetlands, open water, and grassland cover 420.4 acres, or 1.7%, of the subwatershed. In total, 1,933.7 acres or 7.7% of the subwatershed are in urban land uses.

4.6.3 Point Source Water Quality Issues

There are a number of potential point sources of water pollution in the subwatershed. There are six LUST sites located in the subwatershed (Figure 51), one NPDES permitted location, Stone Crest Golf Community WWTP, one RCRA site, General Motors Corporation Powertrain Division, one MS4 community, the City of Bedford, and one industrial waste facility. No open dumps, brownfields, corrective action sites, or voluntary remediation sites are located within the Wolf Creek-Salt Creek Subwatershed.

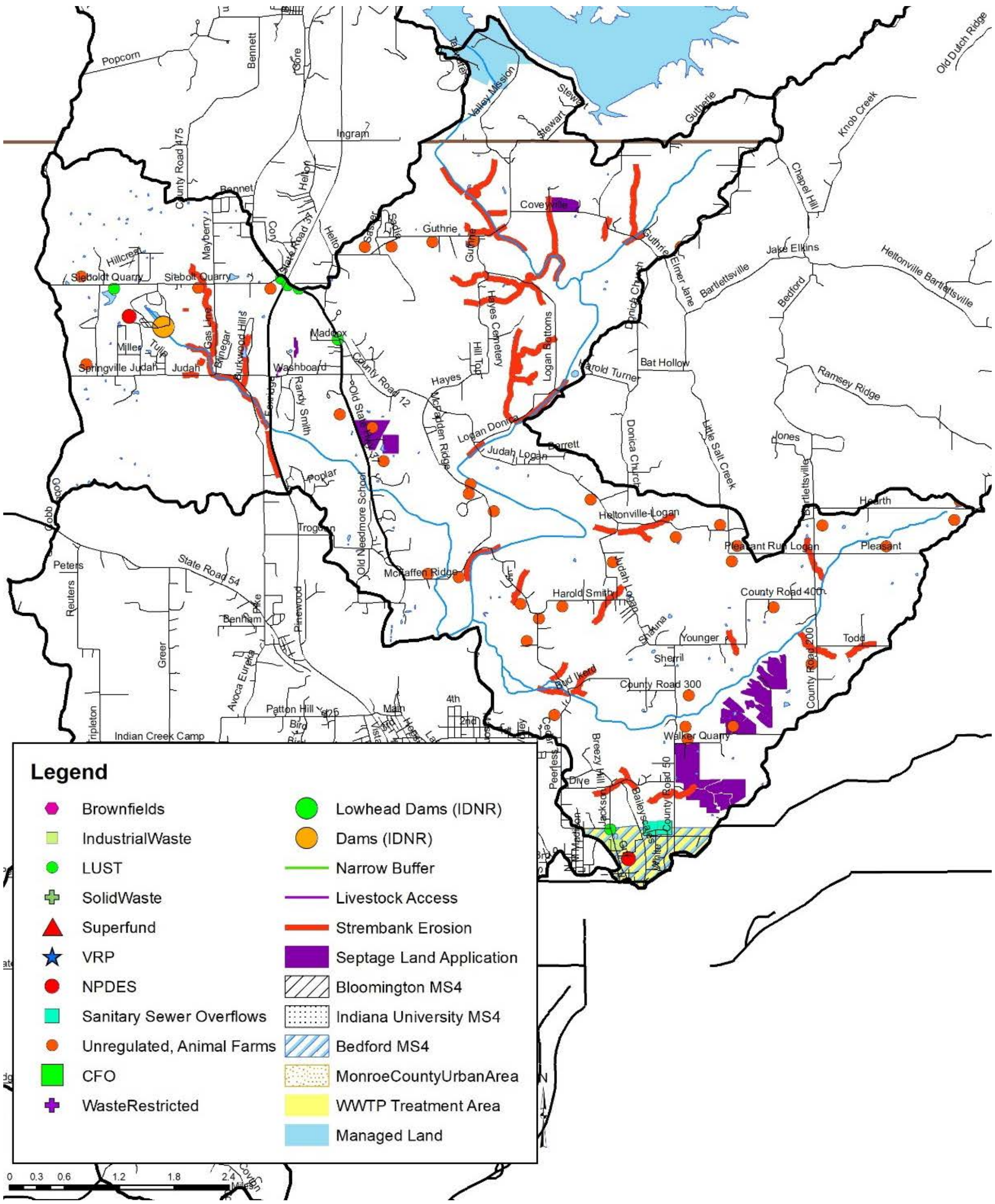

Figure 51. Point and non-point sources of pollution and suggested solutions in the Wolf Creek-Salt Creek Subwatershed.

4.6.4 Non-Point Source Water Quality Issues

Agricultural and forested land uses are the predominant land use in the Wolf Creek-Salt Creek Subwatershed. Additionally, 36 unregulated animal operations housing more than 903 cows, horses, and goats were identified during the windshield survey. In total, manure from small animal operations total over 19,510 tons per year, which contains almost 9,475 pounds of nitrogen, almost 4,694 pounds of phosphorus and 5.58E+14 colonies of E. coli. Based on windshield survey observations, livestock do not have access to Wolf Creek-Salt Creek Subwatershed streams. No active confined feeding operations are located within the Wolf Creek-Salt Creek Subwatershed. IDEM calculated an animal density of 35.31 animals/square mile which is higher than the median for Lower Salt Creek subwatersheds. Streambank erosion is a concern in the subwatershed. Approximately 22.9 miles (20.6%) of streambank erosion were identified within the subwatershed.

4.6.5 IDEM TMDL Assessment

IDEM created and evaluated load duration curves and precipitation graph with consideration of watershed characteristics which allowed IDEM to identify potential nonpoint sources that could be contributing to elevated E. coli concentrations. Many of these sources could also be considered sources of nutrient and sediment concentrations within the Wolf Creek-Salt Creek Subwatershed. Based on the water quality duration curves, IDEM concluded that the majority of sources of E. coli in the Wolf Creek-Salt Creek Subwatershed are nonpoint sources that could include small animal operations, wildlife, pasture animals with direct access to streams, straight pipes, leaking and failing septic systems, and some urban stormwater. IDEM indicates that achieving necessary load reductions for E. coli impairments in the Wolf Creek-Salt Creek Subwatershed should focus on BMPs that have an impact throughout moist, mid-range, and dry flow regimes. These include septic system outreach and education, fencing and livestock exclusion systems, alternative livestock watering systems, comprehensive nutrient management planning, and vegetated filter strips.

Table 45. Flow regime TMDL analysis for E. coli in the Wolf Creek-Salt Creek Subwatershed.

Allocation Category Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL= LA+WLA+MOS	**4.17E+13**	**7.56E+12**	**2.86E+12**	**8.15E+11**	**3.53E+11**
Upstream Drainage Input (Little Clear Creek, Knob Creek, Lake Monroe)	3.89E+13	7.06E+12	2.67E+12	7.69E+11	3.38E+11
LA	2.33E+12	4.17E+11	1.55E+11	3.85E+10	1.22E+10
Pedigo Bay WWTP	1.96E+08	1.96E+08	1.96E+08	1.96E+08	1.96E+08
Stone Crest Golf Community WWTP	3.56E+08	3.56E+08	3.56E+08	3.56E+08	3.56E+08
Camp INDI CO SO WWTP	8.89E+07	8.89E+07	8.89E+07	8.89E+07	8.89E+07
City of Bedford MS4	2.96E+10	5.29E+09	N/A	N/A	N/A
Total WLA	3.02E+10	5.93E+09	6.40E+08	6.40E+08	6.40E+08
MOS (10%)	2.78E+11	4.98E+10	1.83E+10	4.60E+09	1.51E+09
FG (5%)	1.39E+11	2.49E+10	9.14E+09	2.30E+09	7.56E+08

4.6.6 Water Quality Assessment

Waterbodies within the Wolf Creek-Salt Creek subwatershed have been sampled at 20 locations (Figure 52). Assessments include collection of water chemistry data by IDEM (10 sites including sites on Pleasant Run, Salt Creek and Wolf Creek), USGS (1 site), US Army Corps of Engineers (1 site), Indiana University on behalf of Friends of Lake Monroe (1 site), General Motors (6 sites) and Indiana Geological and Water Survey (1 spring site). The USGS operates a stream gage on Salt Creek immediately downstream of the Lake Monroe outlet in the Wolf Creek-Salt Creek subwatershed.

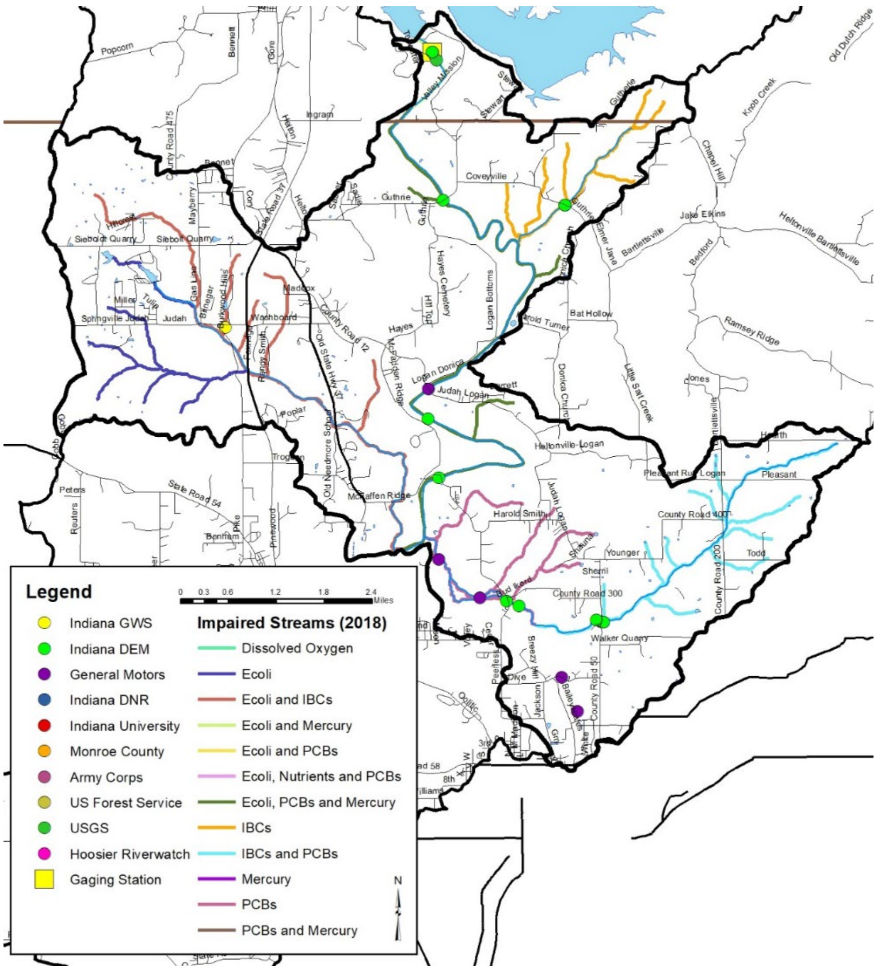

Figure 52. Locations of historic water quality data collection and impairments in the Wolf Creek-Salt Creek Subwatershed.

Table 46 details Tier 1 data – those collected by IDEM, IDNR, IGWS, USGS, USFS, USACE, Indiana University researchers, Monroe County or General Motors. As shown in the table, conductivity samples exceed state standards (1050 μmhos/cm) in 2% of samples collected. E. coli samples exceed state grab sample standards (235 col/100 ml) in 21% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 15% of samples, while total Kjeldahl nitrogen concentrations exceed water quality targets (2.18 mg/L) in 1% of samples. Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 12% of samples. Total suspended solids exceed water quality targets (15 mg/L) in 12% of samples, while turbidity levels exceed water quality targets (6.36 NTU) in 62% of samples.

Table 46. Wolf Creek-Salt Creek Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	67	1,399	3	146	2%
DO	3.24	18.13	14	257	5%
E. coli	0	4,352	14	67	21%
Ammonia-Nitrogen	0.01	1.0	0	101	0%
Nitrate-Nitrogen	0.008	3.0	12	79	15%
Dissolved Phosphorus	6.44	9.1	2	157	1%
pH	0.002	0.105	2	26	8%
Temperature	3.4	25.5	--	9	0%
TKN	0.26	3.0	1	88	1%
Total Phosphorus	0.005	0.167	9	76	12%
Total Suspended Solids	1	50	9	74	12%
Turbidity	1.66	331	80	130	62%

IDEM assessed the biological community at 22 sites including 14 sites assessed for macroinvertebrates, 8 sites assessed for fish and 22 sites assessed for habitat. Habitat scores ranged from 36 to 68 with 31% of sites scoring below the state target (51). Fish community assessments rated very poor to fair with 38% of assessments not meeting the state aquatic life use designation. Macroinvertebrate assessments rated moderately impaired to slightly impaired using the kick sampling method with 75% of sites not meeting their aquatic life use designation and from 28 to 40 with 40% of multihabitat samples not meeting their aquatic life use designation (Table 47).

Table 47. Wolf Creek-Salt Creek Subwatershed biological assessment data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Habitat (QHEI)	36	68	7	22	31%
Fish (IBI)	16	44	3	8	38%
Macroinvertebrates (mIBI, Kick)	2.2	4.4	3	4	75%
Macroinvertebrates (mIBI, Multi Habitat)	28	40	4	10	40%

4.7 <u>Goose Creek-Salt Creek Subwatershed</u>

The Goose Creek-Salt Creek Subwatershed forms the southern boundary of the Lower Salt Creek Watershed (Figure 53). It encompasses one 12-digit HUC watershed: 051202080807. This subwatershed drains 22,085.70 acres and accounts for 16.96% of the total watershed area. In total, the Goose Creek-Salt Creek Subwatershed drains 636 square miles. There are 42 miles of stream. IDEM has classified

19.56 miles of stream as impaired for polychlorinated biphenyl (PCB), 15.86 miles of stream impaired for E. coli, and 11.61 miles of stream impaired for impaired biotic communities (Figure 55).

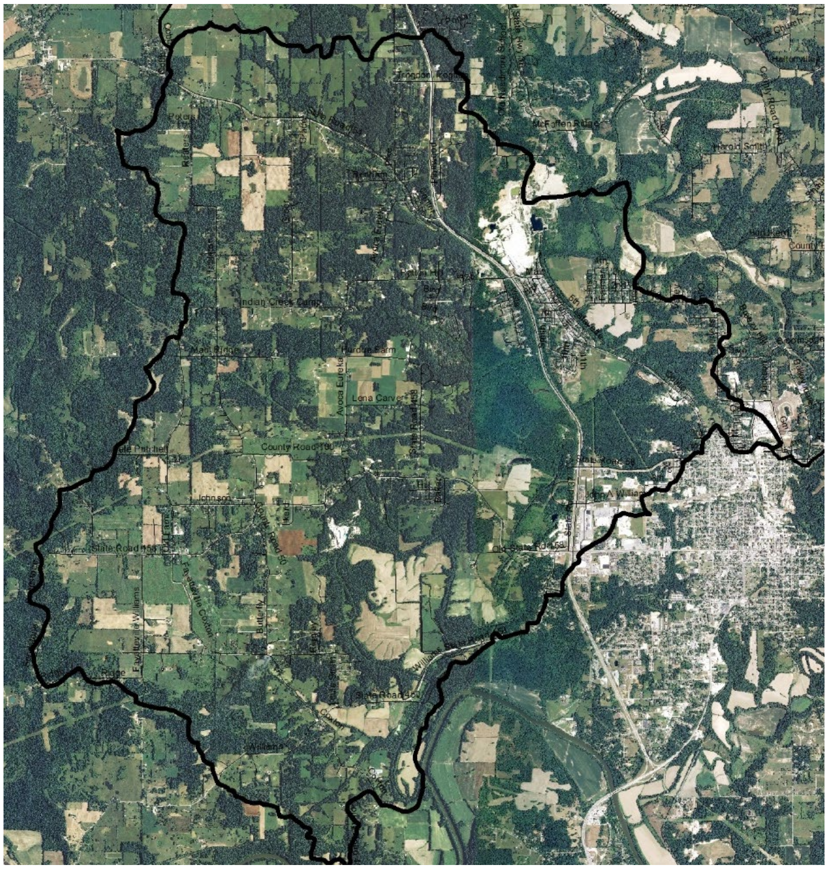

Figure 53. Goose Creek - Salt Creek Subwatershed.

4.7.1 Soils

Hydric soils cover 36.1 acres (0.2%) of the subwatershed. Wetlands currently cover 1.7% (379.8 acres) of the subwatershed. Highly erodible soils nearly cover the entire subwatershed (94.7%%). In total, 18,199.9 acres (82.4%) of the subwatershed are identified as very limited for septic use. The majority of the subwatershed is rural, indicating homes pump to on-site septic systems. Based on the septic suitability of the soil, the majority of the subwatershed is very limited. Therefore, maintenance and inspections of septic systems in the area are important to ensure proper function and capacity. More than 7,704 acres or 34% of the watershed is in karst.

4.7.2 Land Use

Agricultural and forested land uses co-dominate the Goose Creek-Salt Creek Subwatershed with 44.6% (9,857.6 acres) in agricultural land uses, including row crop and pasture and 44.1% (9,736.1 acres) in forested land use. Wetlands, open water, and grassland cover 379.8 acres, or 1.7%, of the subwatershed. Bedford, Avoca, Oolitic and other small towns within the Indiana 37 corridor are present in the Goose Creek-Salt Creek Subwatershed. In total, 1,963.0 acres or 8.9% of the subwatershed are in urban land uses.

4.7.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are 16 leaking underground storage tank sites (Figure 54) and two NPDES-permitted facilities in the subwatershed, the Oolitic Municipal STP and Needmore Elementary School. The City of Bedford is a regulated MS4 community and occupies 5.51% of the subwatershed by land area. There are no open dumps, brownfields, corrective action sites, voluntary remediation sites, or industrial waste facilities located within the Goose Creek-Salt Creek.

4.7.4 Non-Point Source Water Quality Issues

Agricultural and forested land uses are the predominant land uses in the Goose Creek-Salt Creek subwatershed. Nearly 60 unregulated animal operations housing more than 682 cows, horses, goats, bison and sheep were identified during the windshield survey. Livestock have access to 1.1 miles of Goose Creek-Salt Creek streams. There is one active CFO which houses turkeys located within the Goose Creek-Salt Creek Subwatershed. In total, manure from small animal operations and the CFO total over 13,985 tons per year, which contains almost 7,300 pounds of nitrogen, almost 3,660 pounds of phosphorus and 4.80E+14 colonies of E. coli. The subwatershed has a total animal density of 36.08 animals/square mile, the highest amount of all of the subwatersheds in Lower Salt Creek. Streambank erosion is a concern in the subwatershed. Approximately 6.1 miles (4.8%) of streambank erosion were identified within the subwatershed.

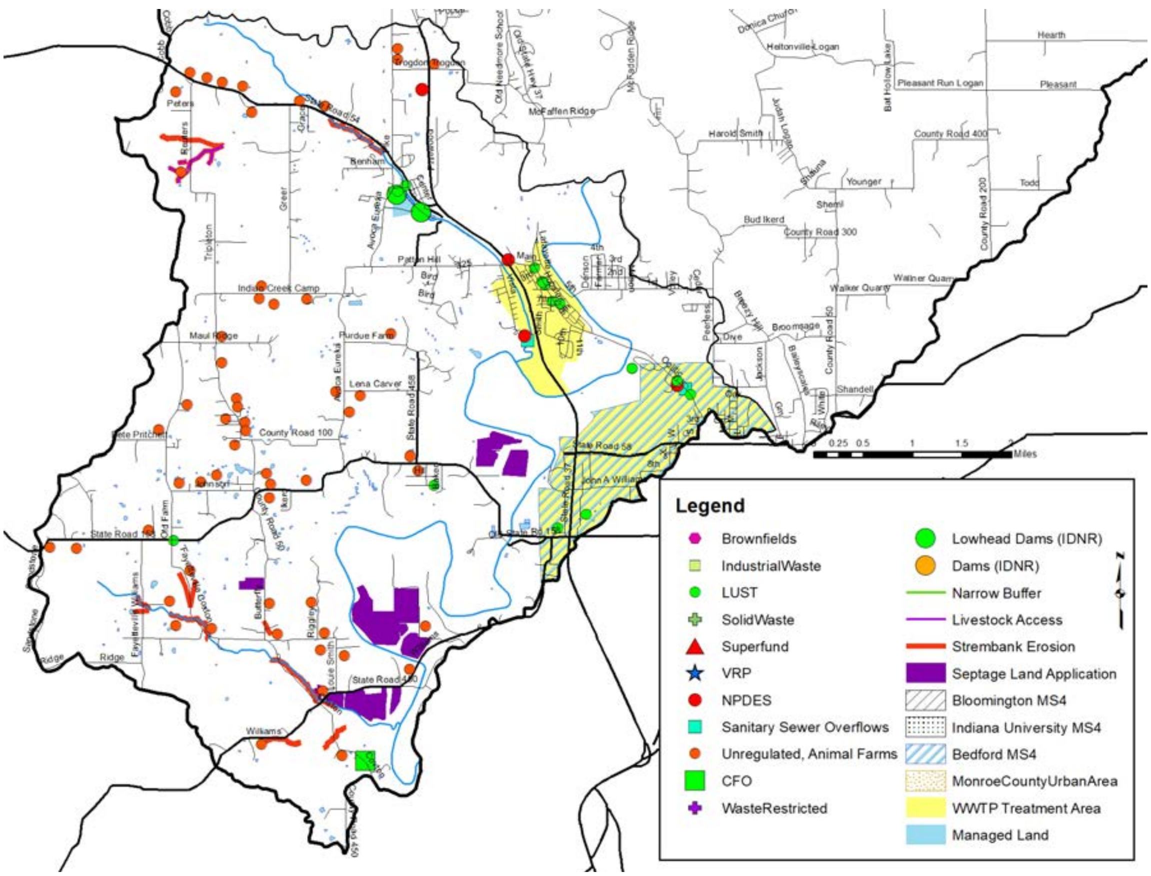

Figure 54. Point and non-point sources of pollution and suggested solutions in the Goose Creek-Salt Creek Subwatershed.

4.7.5 IDEM TMDL Assessment

IDEM created and evaluated load duration curves and precipitation graph with consideration of watershed characteristics which allowed IDEM to identify potential nonpoint sources that could be contributing to elevated E. coli concentrations. Many of these sources could also be considered sources of nutrient and sediment concentrations within the Goose Creek-Salt Creek Subwatershed. Based on the water quality duration curves, IDEM concluded that the majority of sources of E. coli in the Goose Creek-Salt Creek Subwatershed are nonpoint sources that could include small animal operations, wildlife, pasture animals with direct access to streams, straight pipes, leaking and failing septic systems, and some urban stormwater. IDEM indicates that achieving necessary load reductions for E. coli impairments in the Goose Creek-Salt Creek Subwatershed should focus on BMPs that have an impact throughout moist, mid-range, and dry flow regimes. These include fencing and livestock exclusion systems, alternative livestock watering systems, comprehensive nutrient management planning, vegetated filter strips, and septic system outreach and education.

Table 48. Flow regime TMDL analysis for E. coli in the Goose Creek-Salt Creek Subwatershed.

Allocation Category Duration Interval	High 5%	Moist 25%	Mid-range 50%	Dry 75%	Low 95%
TMDL= LA+WLA+MOS	**4.40E+13**	**7.99E+12**	**3.02E+12**	**8.57E+11**	**3.69E+11**
Upstream Drainage Input (Wolf Creek)	4.17E+13	7.56E+12	2.86E+12	8.15E+11	3.53E+11
LA	1.92E+12	3.42E+11	1.32E+11	3.26E+10	1.01E+10
Oolitic WWTP	3.11E+09	3.11E+09	3.11E+09	3.11E+09	3.11E+09
Needmore Elementary School WWTP	8.00E+07	8.00E+07	8.00E+07	8.00E+07	8.00E+07
City of Bedford MS4	1.12E+11	2.00E+10	N/A	N/A	N/A
Total WLA	1.15E+11	2.31E+10	3.19E+09	3.19E+09	3.19E+09
MOS (10%)	2.39E+11	4.30E+10	1.60E+10	4.21E+09	1.56E+09
FG (5%)	1.20E+11	2.15E+10	7.98E+09	2.11E+09	7.81E+08

4.7.6 Water Quality Assessment

Waterbodies within the Goose Creek-Salt Creek subwatershed have been sampled at 14 locations (Figure 55). Assessments include collection of water chemistry data by IDEM (7 sites including Goose Creek and Salt Creek), General Motors (1 site), USGS (2 sites), Indiana Geological and Water Survey (2 spring sites) and Hoosier Riverwatch volunteers (2 sites). The only IDEM fixed monitoring station in the Lower Salt Creek Watershed is located in the Goose Creek-Salt Creek subwatershed. No stream gages are in the Goose Creek-Salt Creek subwatershed.

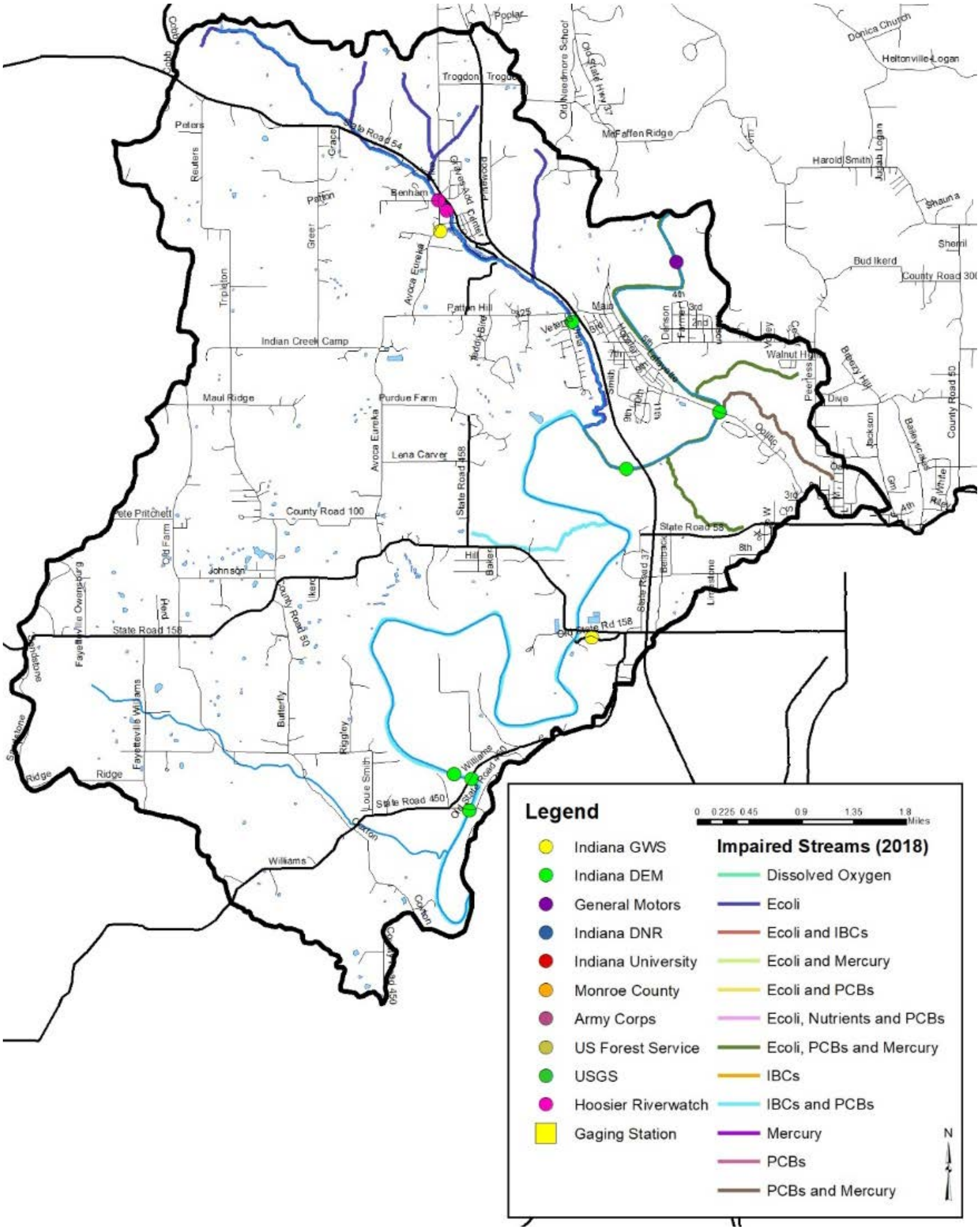

Figure 55. Locations of historic water quality data collection and impairments in the Goose Creek-Salt Creek Subwatershed.

Table 49 details Tier 1 data – those collected by IDEM, IDNR, IGWS, USGS, USFS, USACE, Indiana University researchers, Monroe County or General Motors. As shown in the table, conductivity samples do not exceed state standards (1050 µmhos/cm). Dissolved oxygen concentrations measure both above the upper state standard (12 mg/L) and below the lower state standard (5 mg/L) in 17% of samples collected. E. coli samples exceed state grab sample standards (235 col/100 ml) in 21% of samples collected. Nitrate-nitrogen concentrations exceed water quality targets (1 mg/L) in 36% of samples, while total Kjeldahl nitrogen concentrations do not exceed water quality targets (2.18 mg/L). Total phosphorus concentrations exceed water quality targets (0.08 mg/L) in 24% of samples. Total suspended solids exceed water quality targets (15 mg/L) in 40% of samples, while turbidity levels exceed water quality targets (6.36 NTU) in 87% of samples.

Table 49. Goose Creek-Salt Creek Subwatershed historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Conductivity	0.8	1032	0	412	0%
DO	1.98	14.8	70	413	17%
E. coli	10	17,000	30	153	21%
Ammonia-Nitrogen	0.02	0.4	0	384	0%
Nitrate-Nitrogen	0.1	8.9	142	394	36%
Dissolved Phosphorus	--	--	--	--	--
pH	6.5	8.6	0	664	0%
Temperature	--	--	--	--	--
TKN	0.18	1.5	0	331	0%
Total Phosphorus	0.007	0.56	96	395	24%
Total Suspended Solids	4	600	156	391	40%
Turbidity	1.5	159	309	354	87%

Tier II data – those collected by Indiana University student groups or classes learning to analyze laboratory data as well as Hoosier Riverwatch volunteer collected data are detailed in Table 50. Nitrate concentrations exceed water quality targets (1 mg/L) in 33% of samples. Ortho P concentration exceed water quality targets in 100% of samples.

Table 50. Goose Creek-Salt Creek Subwatershed Tier II historic water quality data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
BOD	1	3	0	2	0%
Dissolved Oxygen	8	12	0	3	0%
Nitrate	1	2	1	3	33%
Ortho P	1	1	1	1	100%
pH	8	9	0	2	0%
Temperature	12	21.50	0	3	0%
Turbidity	0	15	0	3	0%

IDEM assessed the biological community at 8 sites including 3 sites assessed for macroinvertebrates, 3 sites assessed for fish and 8 sites assessed for habitat. Habitat scores ranged from 35 to 70 with 25% of sites scoring below the state target (51). Fish community assessments rated very poor to fair with 33% of assessments not meeting the aquatic life use designation. Macroinvertebrate assessments rated 18 to 40 with 33% of multihabitat samples not meeting their aquatic life use designation (Table 51).

Table 51. Goose Creek-Salt Creek Subwatershed biological assessment data summary.

Parameter	Minimum	Maximum	Number Exceeding Target	Number of Samples	Percent Exceeding
Habitat (QHEI)	35	70	2	8	25%
Fish (IBI)	18	40	1	3	33%
Macroinvertebrates (mIBI, Kick)	--	--	--	--	--
Macroinvertebrates (mIBI, Multi Habitat)	18	40	1	3	33%

5.0 WATERSHED INVENTORY III: WATERSHED INVENTORY SUMMARY

Several important factors and relationships become apparent when the Lower Salt Creek Watershed is observed both as a whole and in part. Many of these were discussed in the individual subwatershed discussions above. An overall summary of water quality impairments and a review of stakeholder concerns and any data which support these concerns are included below.

5.1 Water Quality Summary

Several water quality impairments were identified during the watershed inventory process, based on Tier 1 historic data collected by the USFWS, USEPA, USACE, USGS, IDEM, IDNR, Indiana University, Indiana Geological Survey, Monroe County, General Motors and Friends of Lake Monroe and Tier 2 data collected by Indiana University Limnology class and Hoosier Riverwatch volunteers. These include elevated nitrate-nitrogen, total phosphorus, total suspended solids, conductivity, turbidity, and *E. coli* concentrations, as well as dissolved oxygen concentrations outside of target ranges. Additionally, IDEM lists more than 70 miles of watershed streams for impaired biotic communities.

Based on historic data, Table 52 summarizes Tier 1 sample data which historically measured outside of target values in the Lower Salt Creek Watershed, while Table 53 summarizes Tier 2 sample data. Elevated nitrate-nitrogen concentrations were observed in all subwatersheds except Hunter Creek-Little Salt Creek with concentrations exceeding targets during 15 to 75% of Tier 1 samples. Tier 2 data indicated elevated nitrate-nitrogen in a majority of samples collected in the May Creek-Clear Creek, Little Clear Creek-Clear Creek and Hunter Creek-Little Salt Creek subwatersheds. Elevated total phosphorus concentrations were observed in all subwatersheds except Hunter Creek-Little Salt Creek with concentrations exceeding total phosphorus targets during 6 to 51% of Tier 1 samples. Dissolved phosphorus (orthophosphorus) concentrations were elevated in a majority of samples collected in Hunter Creek-Little Salt Creek, Little Clear Creek-Clear Creek and May Creek-Clear Creek subwatersheds. Elevated total suspended solids concentrations were observed in the Little Clear Creek-Clear Creek, Jackson Creek-Clear Creek, Wolf Creek-Salt Creek and Goose Creek-Salt Creek subwatersheds exceeding targets in 4 to 40% of Tier 1 samples. Turbidity concentrations exceeded targets in 15 to 87% of Tier 1 by subwatershed. Tier 2 turbidity data indicate low levels of exceedance in Little Clear Creek-Clear Creek, May Creek-Clear Creek and Jackson Creek-Clear Creek. *E. coli* concentrations that exceeded the state grab sample standard were measured at in all subwatersheds with between 21 and 69% of Tier 1 samples exceeding state standards. Tier 2 data reflect similar concerns with E. coli concentrations exceeding state standards in 46% of samples collected with all collection occurring in Jackson Creek-Clear Creek.

Table 52 highlights those locations within the Lower Salt Creek Watershed where concentrations of these parameters measured higher than the target concentrations or those locations where impaired waterbodies were identified by IDEM. Sample sites are mapped for each parameter only if 50% or more of samples collected at those sites were outside the target values. Table 52 summarizes Tier 1 sample data which historically measured outside of target values in the Lower Salt Creek Watershed, while Table 53 summarizes Tier 2 sample data. Elevated nitrate-nitrogen concentrations were observed in all subwatersheds except Hunter Creek-Little Salt Creek with concentrations exceeding targets during 15 to 75% of Tier 1 samples. Tier 2 data indicated elevated nitrate-nitrogen in a majority of samples collected in the May Creek-Clear Creek, Little Clear Creek-Clear Creek and Hunter Creek-Little Salt Creek subwatersheds. Elevated total phosphorus concentrations were observed in all subwatersheds except Hunter Creek-Little Salt Creek with concentrations exceeding total phosphorus targets during 6 to 51% of Tier 1 samples. Dissolved phosphorus (orthophosphorus) concentrations were elevated in a majority of samples collected in Hunter Creek-Little Salt Creek, Little Clear Creek-Clear Creek and May Creek-Clear Creek subwatersheds. Elevated total suspended solids concentrations were observed in the Little Clear Creek-Clear Creek, Jackson Creek-Clear Creek, Wolf Creek-Salt Creek and Goose Creek-Salt Creek subwatersheds exceeding targets in 4 to 40% of Tier 1 samples. Turbidity concentrations exceeded targets in 15 to 87% of Tier 1 by subwatershed. Tier 2 turbidity data indicate low levels of exceedance in Little Clear Creek-Clear Creek, May Creek-Clear Creek and Jackson Creek-Clear Creek. *E. coli* concentrations that exceeded the state grab sample standard were measured at in all subwatersheds with between 21 and 69% of Tier 1 samples exceeding state standards. Tier 2 data reflect similar concerns with E. coli concentrations exceeding state standards in 46% of samples collected with all collection occurring in Jackson Creek-Clear Creek.

Table 52 and Table 53 summarize where historic samples were outside the target values and are grouped by subwatershed. Figure 56 shows the locations of historical sites that that exceeded target values. Table 52 summarizes Tier 1 sample data which historically measured outside of target values in the Lower Salt Creek Watershed, while Table 53 summarizes Tier 2 sample data. Elevated nitrate-nitrogen concentrations were observed in all subwatersheds except Hunter Creek-Little Salt Creek with concentrations exceeding targets during 15 to 75% of Tier 1 samples. Tier 2 data indicated elevated nitrate-nitrogen in a majority of samples collected in the May Creek-Clear Creek, Little Clear Creek-Clear Creek and Hunter Creek-Little Salt Creek subwatersheds. Elevated total phosphorus concentrations were observed in all subwatersheds except Hunter Creek-Little Salt Creek with concentrations exceeding total phosphorus targets during 6 to 51% of Tier 1 samples. Dissolved phosphorus (orthophosphorus) concentrations were elevated in a majority of samples collected in Hunter Creek-Little Salt Creek, Little Clear Creek-Clear Creek and May Creek-Clear Creek subwatersheds. Elevated total suspended solids concentrations were observed in the Little Clear Creek-Clear Creek, Jackson Creek-Clear Creek, Wolf Creek-Salt Creek and Goose Creek-Salt Creek subwatersheds exceeding targets in 4 to 40% of Tier 1 samples. Turbidity concentrations exceeded targets in 15 to 87% of Tier 1 by subwatershed. Tier 2 turbidity data indicate low levels of exceedance in Little Clear Creek-Clear Creek, May Creek-Clear Creek and Jackson Creek-Clear Creek. *E. coli* concentrations that exceeded the state grab sample standard were measured at in all subwatersheds with between 21 and 69% of Tier 1 samples exceeding state standards. Tier 2 data reflect similar concerns with E. coli concentrations exceeding state standards in 46% of samples collected with all collection occurring in Jackson Creek-Clear Creek.

Table 52. Percent of Tier 1 samples historically collected in Lower Salt Creek Subwatersheds which measured outside target values.

Subwatershed Name	Cond	DO	pH	Turb	Nitrate	TP	TSS	*E. coli*
Jackson Creek-Clear Creek	66%	1%	0%	24%	27%	13%	8%	69%
May Creek-Clear Creek	0%	5%	0%	56%	20%	10%	0%	37%
Little Clear Creek-Clear Creek	0%	9%	0%	49%	75%	61%	4%	33%
Hunter Creek-Little Salt Creek	0%	0%	0%	15%	0%	0%	0%	22%
Knob Creek-Little Salt Creek	1%	20%	0%	68%	2%	6%	0%	42%
Wolf Creek-Salt Creek	2%	5%	8%	62%	15%	12%	12%	21%
Goose Creek-Salt Creek	0%	17%	0%	87%	36%	24%	40%	21%

Table 53. Percent of Tier 2 samples historically collected in Lower Salt Creek Subwatersheds which measured outside target values.

Subwatershed Name	DO	Turb	Nitrate	TKN	OrthoP	TP	*E. coli*
Jackson Creek-Clear Creek	4%	11%	38%	0%	45%	14%	46%
May Creek-Clear Creek	5%	13%	75%	20%	72%	70%	N/A
Little Clear Creek-Clear Creek	3%	8%	100%	22%	95%	91%	N/A
Hunter Creek-Little Salt Creek	0%	0%	100%	N/A	100%	N/A	N/A
Knob Creek-Little Salt Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wolf Creek-Salt Creek	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Goose Creek-Salt Creek	0%	0%	33%	N/A	100%	N/A	N/A

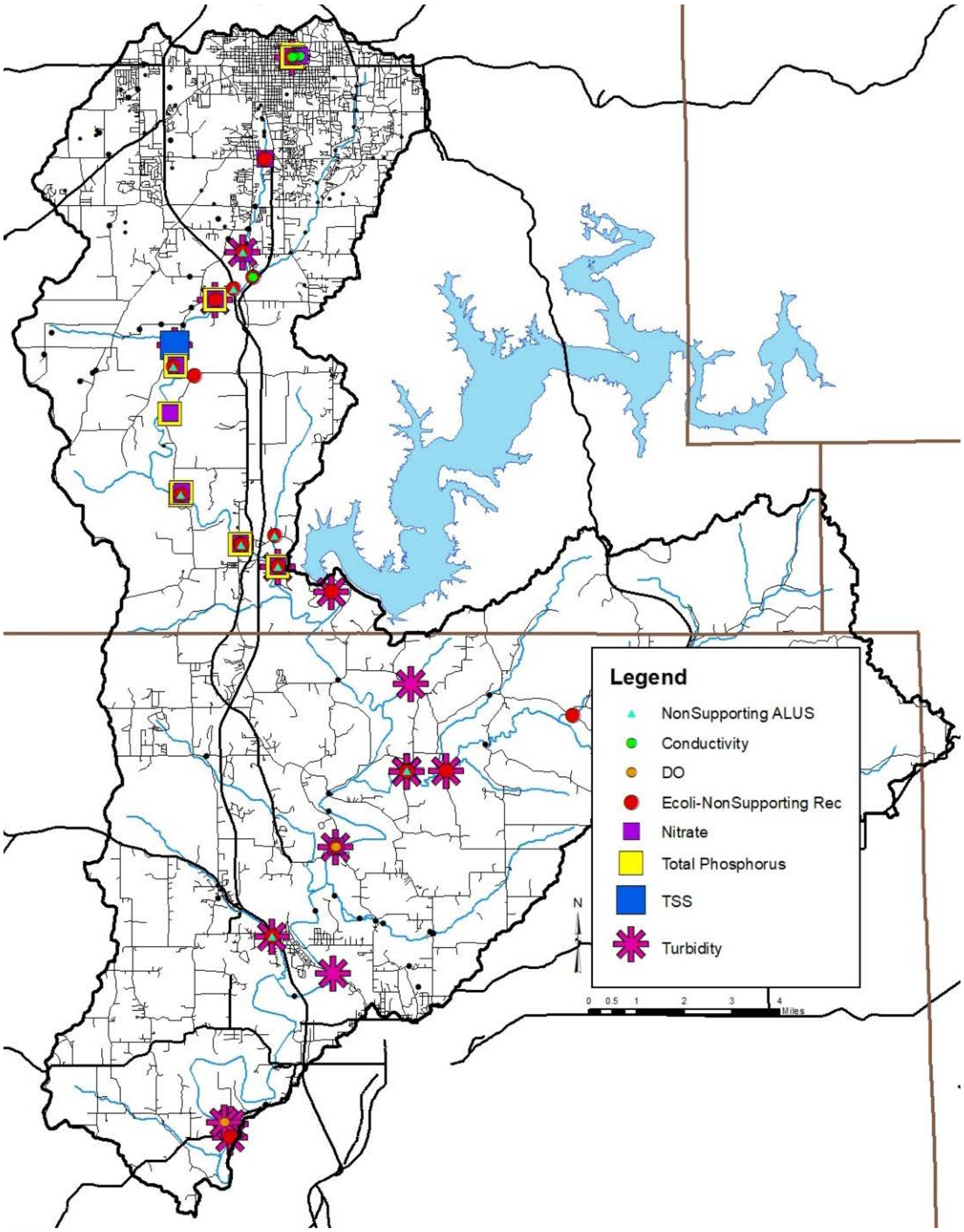

Figure 56. Lower Salt Creek Watershed historical sampling sites that exceed target values.

5.2 Stakeholder Concern Analysis

All identified concerns generated both from stakeholder input and through water quality and watershed inventory efforts are detailed in Table 54. This list represents a work in progress and additional concerns may be added as the steering and monitoring committees work through data analysis. The steering committee rated each concern as to whether it is supported by watershed-based data, what evidence does or does not support the concern, whether the concern is quantifiable, whether it is in the scope of the watershed management plan, and if it is something on which the committee wants to focus. Nearly all concerns were quantifiable, and many were rated as being within the scope and items on which the committee wants to focus.

Following a review of the stakeholder concerns, the steering committee determined the following concerns identified by the public to be outside of this project's approach: wastewater treatment plant impacts. Additionally, the fish consumption advisories, septic system density, septic use and maintenance, failing septic systems, algal blooms, if occurring, PCB contamination and remediation efforts, legacy pollutant remediation were identified as inside the scope, but the committee will focus on these through educational efforts only.

Table 54. Analysis of stakeholder concerns identified in the Lower Salt Creek Watershed.

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Karst topography and sinkholes – potential for contamination	Yes	Nearly 17,500 acres of the watershed (13%) is covered by karst sinkholes and springs.	Yes	No	Yes
Sinkholes should be buffered to protect groundwater-surface water connection	Yes	Karst areas are particularly sensitive to surface water impacts as materials flow directly into karst sinkholes and springs without being filtered by soil or bedrock. The Monroe County Zoning Ordinance provided substantial protection for karst features including limits on land disturbance, buffering, erosion control measures and more.	Yes	No	Yes
Sinking Creek ends in a terminal sinkhole – this portion of the watershed is particularly sensitive	Yes	Sinking Creek is a terminal sinkhole. This area is rated as sensitive by Monroe County (2007).	yes	No	Yes
Protection of lands 15% sloped or more is needed (Monroe has this already)	Yes	The Monroe County comprehensive plan notes the need to avoid development of 15% or more steeply sloped lands. State code may protect septic system install on 15% slope	Yes	No	Yes

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Highly erodible land impacts	Yes	Nearly 96% of the watershed is mapped in highly erodible lands.	Yes	No	Yes
Streambank erosion	Yes	Approximately 25% of streambanks were identified as eroding (90 miles) during the windshield survey. The BEQI noted that riparian habitat restoration and the adherence to erosion control measures/planting filter strips would improve urban streams in the watershed.	Yes	No	Yes
Sedimentation	Yes	More than 59% of TSS samples and more than 64% of turbidity samples exceed water quality target values.	Yes	No	Yes
Flooding is concern – floodplain management/flood protection needed.	Yes	Approximately 9% of the watershed is located within the 100 year floodplain.	Yes	No	Yes
Flooding/floodwater downstream of Lake Monroe and south of Bloomington are of high concern.	yes	Anecdotal information indicates that flooding occurs relatively regularly in the Clear Creek drainage south of the City of Bloomington.	Yes	No	Yes
Fish consumption advisories, options for remediation/ removal from category 5 list	Yes	The consumption of any fish from Clear Creek should be limited to one/month and from Salt Creek from the Lake Monroe tailwaters to the confluence with the East Fork White River should not occur. Consumption of fish from Pleasant Run should be limited to no more than one/month in group 3 individuals. Several other fish species limitations are also present for Lower Salt Creek streams.	Yes – IDEM plans to survey below Lake Monroe & Clear Creek	No	Yes - education
Streams listed on impaired waterbodies list – *E. coli* and impaired biotic communities	Yes	Waterbodies are listed as impaired for *E. coli* (175 miles), nutrients (9.1 miles), impaired biotic communities (72.5 miles), dissolved oxygen (6.1 miles), mercury (21.5 miles) and PCBs (82.5 miles) in fish tissue.	Yes	No	Yes

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Elevated E. coli levels	Yes	38% of E. coli samples exceed state standards. The Lower Salt Creek TMDL indicates a 47-94% reduction in E. coli is needed to meet state standards throughout the watershed. The Lower Salt Creek TMDL identified a number of potential sources of E. including wastewater treatment plants, Municipal Separate Storm Sewer Systems (MS4s), Sanitary Sewer Overflows, pet waste, unregulated stormwater runoff, agriculture runoff, direct deposition or field runoff from livestock, wildlife direct deposits, leaking or failing septic systems and illegal straight pipe systems.	Yes	No	Yes
Septic system density	Yes	Nearly 68% of soils in the watershed are considered very limited for septic tank absorption fields. IDEM notes more than 39,900 individual rural residences in the watershed. Monroe County's septic discharge complaint database includes 58 properties. The Lower Salt Creek TMDL identified leaking or failing septic systems and illegal straight pipe systems as sources of E. coli.	Yes	No	Education
Septic use and maintenance should be regulated	Regulated under state code		Yes	No	Education
Failing septic systems	Yes		Yes	No	Education
Sanitary sewer overflows or illicit discharge	Yes	14 SSOs are located in the watershed: 3 in the Bedford system, 1 in the Oolitic system and 11 in the Bloomington system	Yes	No	Education for non MS4s areas

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Wastewater treatment plant impacts	Yes	11 wastewater treatment plants discharge to a watershed waterbody. Both the Bedford and Bloomington WWTPs have approved SSO elimination plans. The Lower Salt Creek TMDL notes that wastewater treatment plants and sanitary sewer overflows are a source of E. coli	Yes	Already regulate; Outside scope	Education
Nutrients, sediment from agricultural runoff	yes	Pastureland covers 25% of the watershed, row crop agriculture covers 7% of the watershed. In tier 1 samples, 55% of nitrate-nitrogen, 54% of total phosphorus, 59% of total suspended solids and 64% of turbidity samples collected exceed water quality targets. In tier 2 samples, 53% of nitrate-nitrogen, 70% of soluble and 67% of total phosphorus, 11% of turbidity and 46% of E. coli sample exceed water quality targets. The Lower Salt Creek TMDL identified agriculture runoff as a source of E. coli. 55-89% of soybeans and 44-65% of corn is farmed using conservation tillage methods.	No; not directly	No	Yes
Livestock access	Yes	More than 1 mile of areas where livestock have access to watershed streams was documented during the windshield survey. This is likely an underestimate.	Yes	No	yes
Algal blooms	No	Anecdotal information indicates algal blooms occur in the mainstem of Salt Creek between Lake Monroe and the East Fork White River outlet.	No not with current data	If occurring, then no	Education – what to look for

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Manure applied to farm ground	Yes	The watershed is home to one CFO which is permitted to house 68,000 turkeys. The CFO and the 2500 animals observed on small, unregulated farms produce 59,316 tons of manure annually which accounts for 1,930,990 pounds of nitrogen, 1,659,200 pounds of phosphorus and 1.54×10^{16} col of E. coli. The Lower Salt Creek TMDL identified direct deposition or field runoff from livestock as a source of E. coli.	Yes	No	Yes
Urban streams – options for naturalization, daylighting or remediation	Yes	The BEQI noted that riparian habitat restoration and the adherence to erosion control measures in developing areas would improve urban streams in the watershed. The Jordan River Restoration Plan Feasibility study and IU Campus Master Plan notes the need to establish buffers, plant trees, regrade stream banks, stabilize stream banks and create instream check dams in Campus River. The Switchyard Park Master Plan identifies opportunities for streambank stabilization, tree planting, invasive species removal, native species planting, pool-riffle restoration and/or daylighting Clear Creek and its tributaries.	Yes	No	Yes
Urbanizing areas - urban sprawl, development impacts	Yes	More than 24,700 acres of the watershed are located in a designated MS4 (Monroe County, IU Bloomington, Bloomington, Bedford). An additional 13,000 acres are located in the Monroe County Urbanizing Zone.	Yes	No	Yes

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Leaking underground storage tanks – downtown Bloomington	Yes	Nearly 190 LUST facilities are located in the watershed. Most are located within Bloomington and Bedford and along SR 37, Interstate 69 and other state highways.	Yes	No	Yes
Stormwater runoff	Yes	14% of the watershed is in urban land uses. The BEQI noted that eroding streambanks and sediment carried in stormwater runoff is a major source of sediment and nutrients. The Lower Salt Creek TMDL notes that unregulated stormwater runoff is a source of E. coli.	Yes	No	Yes
Trash in public areas	Yes	Anecdotal information and observations during the windshield survey indicate trash is a common problem in public and non public areas in the watershed.	Yes	No	Yes
Wetlands need to be protected /wetland loss should be limited	Yes	Wetlands and open water cover 6% of the watershed. Hydric soils cover approximately 9.5% of the watershed indicating wetland loss has occurred in the watershed.	Yes	No	Yes
PCB contamination/ remediation	Yes	Seven sites have been investigated for PCB contamination in the watershed. More than 5,000 tons of PCB laden sediment was removed from the General Motors RCRA site. This site impacts Pleasant Run Creek and Bailey Branch north of Bedford. Remediation is considered complete. Monitoring is on-going. More than 55,000 tons of materials was removed from Bennett's stone quarry and Lemon Lane Landfill. Remediation is nearing completion and monitoring will continue.	Yes	No	Yes, Education only

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Legacy pollutants–downtown Bloomington, GM, Superfund sites (potential removal from NPL), Bedford, creosote treatment plants along Clear Creek	Yes	More than 23 industrial waste sites, 189 LUST facilities, 5 voluntary remediation sites, 2 solid waste sites and 5 brownfields are located within the watershed. The Indiana Creosoting property is contaminated by semivolatile organic compounds, benzene, toluene, ethylbenzene, xylenes, arsenic and lead. As of 2011, 11,500 cubic yards of material have been remediated. The Indiana Gas-Bloomington Manufactured Gas Plant, owned by Vectron, is contaminated with benzene and polyaromatic hydrocarbons. The Bloomington McDoel Rail Site, now Switchyard Park, was contaminated with various petroleum hydrocarbons and metals including arsenic and lead. Remediation of this site occurred as part of Switchyard Park development. Additional sites including the Reclamation Contractors Inc Facility and Johnson Oil-Bulk Plant, have been remediated.	Yes	No	Education only
Quarries negatively impact land use and water quality, impact natural land use and result in tracking materials onto paved surfaces	Yes	In total, 10 quarries are located within the Lower Salt Creek Watershed. All quarries present in the watershed have active NPDES permits and are currently in compliance with these permits. Observations include land use modifications, increased turbidity which likely includes sediment and nutrient impacts, and reduced stream habitat.	Yes	No	Yes

<table>
<tr><th>Concern</th><th>Supported by our data?</th><th>Evidence</th><th>Able to Quantify?</th><th>Outside Scope?</th><th>Group wants to focus on?</th></tr>
<tr><td>Culverted stream crossings negatively impact biological communities</td><td>Yes</td><td>USFS staff identified two perched culverts which are in the process of being remediated.</td><td>Yes</td><td>No</td><td>Yes</td></tr>
<tr><td>Forest management</td><td rowspan="3">Yes</td><td rowspan="3">Forested land covers 48% of the watershed. In total, 25% of the watershed is 75% or more covered by forest canopy.

The US Forest Service owns nearly 15,000 aces in the watershed. Based on the USFS Watershed Condition Framework completed in 2011, aquatic biota, water quantity, forest cover, terrestrial invasive species and riparian conditions in the two watershed basins rate as good, while water quality and forest health rate as fair. Aquatic habitat, soil condition, fire condition rate as poor. Both subwatersheds are considered as functioning at risk.</td><td rowspan="3">Yes</td><td rowspan="3">No</td><td rowspan="3">Yes</td></tr>
<tr><td>Maintain forest canopy cover</td></tr>
<tr><td>Improve forest composition to improve water quality</td></tr>
<tr><td>Pesticides and fertilizers</td><td>Yes</td><td>Agricultural pesticide data estimated from NASS and local crop data indicate 14.4 tons of atrazine and 14 tons of glyphosate are applied annually.

Urban pesticide and herbicide use have not been quantified but anecdotal evidence indicates both are used on commercial and residential properties throughout the watershed.</td><td>Yes</td><td>No</td><td>Yes</td></tr>
<tr><td>Lack of public awareness</td><td>Yes</td><td rowspan="2">Anecdotal information suggests that education of the public is needed to increase awareness of water quality protection needs and solutions and to better connect them to their local community and natural resources.</td><td>Yes</td><td>No</td><td>Yes</td></tr>
<tr><td>Need to develop and instill a sense of place</td><td>Yes</td><td>Yes</td><td>No</td><td>Yes</td></tr>
<tr><td>Lack of cohesive governance and regulations can inhibit current and future efforts</td><td>Yes</td><td>Local regulations are key to protecting and improving the Lower Salt Creek Watershed. The watershed covers three counties which manage and regulate in differing fashions.</td><td>Yes</td><td>No</td><td>Yes</td></tr>
</table>

<table>
<tr><th>Concern</th><th>Supported by our data?</th><th>Evidence</th><th>Able to Quantify?</th><th>Outside Scope?</th><th>Group wants to focus on?</th></tr>
<tr><td>Watershed restoration is underfunded</td><td>Yes</td><td rowspan="2">There is no sole source of funding for watershed education or implementation activities. Coordinating these efforts will make both education and funding more cohesive and targeted likely resulting in a more stable source of both funding and engagement.</td><td>Yes</td><td>No</td><td>Yes</td></tr>
<tr><td>Unified group for watershed activities and implementation is needed</td><td>Yes</td><td>Yes</td><td>No</td><td>Yes</td></tr>
</table>

6.0 PROBLEM AND CAUSE IDENTIFICATION

After evaluation of stakeholder concerns and completion of the watershed inventory, watershed problems can be summarized as shown in Table 55. Problems represent the condition that exists due to a particular concern or group of concerns. Table 56 details potential causes of problems identified in Table 55.

Table 55. Problems identified for the Lower Salt Creek watershed based on stakeholder and inventory concerns.

Concern(s)	Problem
• Protection of lands 15% sloped or more is needed (Monroe has this already) • Highly erodible land impacts • Streambank erosion • Sedimentation • Streams listed on impaired waterbodies list – IBC • Sediment from agricultural runoff • Urbanizing areas -urban sprawl, development impacts • Stormwater runoff • Wetlands need to be protected /wetland loss should be limited • Stream crossing improvement needed • Livestock access • Karst topography and sinkholes – potential for contamination • Sinkholes should be buffered to protect groundwater-surface water connection • Sinking Creek ends in a terminal sinkhole – this portion of the watershed is particularly sensitive • Forest management • Maintain forest canopy cover • Improve forest composition to improve water quality • Quarries – land use and water quality impacts (water reuse on site; NPDES permits); loss of natural land use; tracking of materials onto paved surfaces	Sediment: area streams are cloudy/turbid

Concern(s)	Problem
• Protection of lands 15% sloped or more is needed • Streams listed on impaired waterbodies list – nutrients, dissolved oxygen, IBC • Septic system density • Septic use and maintenance should be regulated • Failing septic systems • Sanitary sewer overflows or illicit discharge • Nutrients from agricultural runoff • Manure applied to farm ground • Livestock access • Algal blooms • Urbanizing areas -urban sprawl, development impacts • Stormwater runoff • Wetlands need to be protected /wetland loss should be limited • Stream crossing improvement needed • Karst topography and sinkholes – potential for contamination • Sinkholes should be buffered to protect groundwater-surface water connection • Sinking Creek ends in a terminal sinkhole – this portion of the watershed is particularly sensitive • Forest management • Maintain forest canopy cover • Improve forest composition to improve water quality • Quarries – land use and water quality impacts (water reuse on site; NPDES permits); loss of natural land use; tracking of materials onto paved surfaces	Nutrients (phosphorus and nitrogen): Area streams have nutrient levels exceeding the target set by this project

<table>
<tr><th>Concern(s)</th><th>Problem</th></tr>
<tr><td>Streams listed on impaired waterbodies list – E. coli
Elevated E. coli levels
Septic system density
Septic use and maintenance should be regulated
Failing septic systems
Sanitary sewer overflows or illicit discharge
Nutrients, sediment from agricultural runoff
Manure applied to farm ground
Livestock access
Urbanizing areas -urban sprawl, development impacts
Stormwater runoff
Karst topography and sinkholes – potential for contamination
Sinkholes should be buffered to protect groundwater-surface water connection
Sinking Creek ends in a terminal sinkhole – this portion of the watershed is particularly sensitive</td><td>E. coli: Area streams are impaired for recreational contact by IDEM’s 303(d) list</td></tr>
<tr><td>Flooding is concern – floodplain management/flood protection needed.
Flooding/floodwater downstream of Lake Monroe and south of Bloomington are of high concern
Urban streams – options for naturalization, daylighting or remediation</td><td>Flooding, loss of natural floodplain/natural habitat in urban settings</td></tr>
<tr><td>Pesticides and fertilizers
Trash in public areas</td><td>Inorganic pollution (trash, chemicals) negatively impact Lower Salt Creek and its watershed</td></tr>
<tr><td>Watershed restoration is underfunded</td><td rowspan="3">No effort to educate local officials, foundations, and other funding sources on the importance of watershed protection
Lack of public awareness of watershed issues
Lack of unified government strategy about watershed management</td></tr>
<tr><td>A unified group for the entire watershed does not exist</td></tr>
<tr><td>Lack of cohesive regulations and governance makes implementation challenging.</td></tr>
</table>

Concern(s)	Problem
Lack of public awareness of watershed issues/how to address them including algal blooms; sanitary sewer overflows/illicit discharge, failing septic systems, density and maintenance; legacy pollutant issues; fish consumption advisories; leaking underground storage tanks; wastewater treatment plan impacts and PCB contamination/remediation while instilling a sense of place.	Focused cohesive education and outreach activities and promotion of activities is needed to build public awareness and create a sense of place.

Table 56. Potential causes of identified problems in the Lower Salt Creek watershed.

Problem	Potential Cause(s)
Sediment: area streams are cloudy/turbid	Suspended Sediment concentration levels exceed the target set by this project
Nutrients: Area streams have nutrient levels exceeding the target set by this project	Nutrient levels exceed the target set by this project
E. coli: Area streams are impaired for recreational contact by IDEM's 303(d) list	E. coli levels exceed the water quality standard
Flooding, loss of natural floodplain/natural habitat in urban settings	Periodic flooding of streams causes property damage, increased stream bank erosion and lateral stream movement. Modification of stream channels, especially in urban environments, limits the connectivity between streams and floodplains.
Inorganic pollution (trash, chemicals) negatively impact Lower Salt Creek and its watershed	Trash and inorganic pollution are negatively impacting Lower Salt Creek and its tributaries.
• No effort to educate local officials, foundations, and other funding sources on the importance of watershed protection • Lack of public awareness of watershed issues • Lack of unified government strategy about watershed management	Unified approach, time and interest are lacking; limited perceived benefit
Focused cohesive education and outreach activities and promotion of activities is needed to build public awareness and create a sense of place.	Interest and benefits are lacking.

7.0 SOURCE IDENTIFICATION AND LOAD CALCULATION

7.1 Source Identification: Key Pollutants of Concern

Nonpoint pollution sources are varied, yet common throughout almost any watershed. Several earlier sections of this document identify potential sources of the pollutants of concern in the Lower Salt Creek Watershed. These and other potential sources of these causes are discussed in further detail in subsequent sections. A summary of potential sources identified in the Lower Salt Creek Watershed for each of our concerns is listed below:

Sediment:
- Conventional tillage cropping practice
- Karst topography
- Streambank and bed erosion
- Poor riparian buffers
- Poor forest management
- Gully or ephemeral erosion
- Cropped floodplains
- Livestock access to streams
- Altered hydrology (ditching and draining, altered stream courses)
- Development impacts (diffuse, disorganized, lack of proper stabilization technique use)
- Invasive species impacts to land cover/soil stability
- Stormwater from municipal sources (MS4s)

Nutrients (Nitrogen and Phosphorus):
- Conventional tillage cropping practice
- Karst topography
- Wastewater treatment discharges
- Agricultural fertilizer
- Poor riparian buffers
- Poor forest management
- Streambank and bed erosion
- Animal waste (livestock in streams, poor manure management, domestic and wildlife runoff)
- Confined feeding operations
- Human waste (failing septic systems, sanitary sewer overflows, inadequately treated wastewater)
- Development impacts (diffuse, disorganized, lack of proper stabilization technique use)
- Invasive species impacts to land cover/soil stability
- Stormwater from municipal sources (MS4s)

E. coli:
- Human waste (failing septic systems, sanitary sewer overflows, inadequately treated wastewater)
- Animal waste (livestock in streams, poor manure management, domestic and wildlife runoff)

7.1.1 Potential Sources of Pollution

The steering committee used GIS data, water quality data, watershed inventory observations and anecdotal information as available to evaluate the potential sources of nonpoint pollution in the Lower Salt Creek Watershed. Appendix B contains tables detailing each potential source within each subwatershed. Table 57 through Table 63 summarizes the magnitude of potential sources of pollution for each problem identified in the Lower Salt Creek Watershed. Several sources listed above are not included below as specific data for each concern is not available: conventional tillage by subwatershed; gully or ephemeral erosion (none identified during the watershed inventory but likely present); poor forest management (not assessed); animal waste (domestic and wildlife runoff numbers not identified on the subwatershed level); cropped floodplains (they occur but density and distribution was not mapped); development impacts; invasive species (a list was developed but the volume was not assessed).

Table 57. Potential sources causing sediment problems.

Problems:	Area streams are cloudy and turbid.
Potential Causes:	Suspended sediments and/or turbidity exceed target values set by this project.
Potential Sources:	• 90 miles of stream lack adequate stabilization, with the highest percent of stream miles lacking stabilization found in Jackson Creek-Clear Creek (35%), May Creek-Clear Creek (29%), Wolf Creek-Salt Creek (28%) and Knob Creek-Little Salt Creek (27%) subwatersheds. • Only one livestock access area (1.1 miles of streams) was observed in the Goose Creek-Salt Creek Subwatershed. This does not mean livestock do not have access but rather they were not observed during the windshield survey. • 1.1 miles of stream lack adequate buffers with this observation occurring in the Knob Creek-Little Salt Creek Watershed. • 11-44% of soybean fields and 35-66% of corn fields are under conventional tillage. • Nearly 2,500 animals were observed on unregulated animal operations throughout the watershed. The highest density of animals was identified in the Wolf Creek-Salt Creek (900), Goose Creek-Salt Creek (680) and Knob Creek-Little Salt Creek (290) subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading. • 17,511 acres of the Lower Salt Creek Watershed is located on karst land. Karst predominates in the Goose Creek-Salt Creek (35%) and May Creek-Clear Creek (22%) and Little Clear Creek-Clear Creek (12%) subwatersheds. • 125,167 acres of highly erodible soils occur within the watershed. The highest density of HES occurs in Little Clear Creek-Clear Creek (99%), Hunter Creek-Little Salt Creek (98%), Wolf Creek-Salt Creek (97%), Goose Creek-Salt Creek (94%) and May Creek-Clear Creek (94%) subwatersheds. • The City of Bloomington, City of Bedford, Monroe County and Indiana University MS4 lies partially within the Lower Salt Creek Watershed. • There are three SSO systems in the Lower Salt Creek Watershed – the City of Bloomington's Dillman Road wastewater treatment plant, the Town of Oolitic Wastewater Treatment Plant and a portion of the City of Bedford wastewater treatment plant. • Nearly 14 tons of atrazine and glyphosate are applied on fields in Lower Salt Creek counties.

Table 58. Potential sources causing nutrient problems.

Problems:	Nutrient concentrations threaten the health of Lower Salt Creek and its tributaries.
Potential Causes:	Nutrient concentrations exceed target values set by this project.
Potential Sources:	• 90 miles of stream lack adequate stabilization, with the highest percent of stream miles lacking stabilization found in Jackson Creek-Clear Creek (35%), May Creek-Clear Creek (29%), Wolf Creek-Salt Creek (28%) and Knob Creek-Little Salt Creek (27%) subwatersheds. • Only one livestock access area (1.1 miles of streams) was observed in the Goose Creek-Salt Creek Subwatershed. This does not mean livestock do not have access but rather they were not observed during the windshield survey. • 1.1 miles of stream lack adequate buffers with this observation occurring in the Knob Creek-Little Salt Creek Watershed. • 11-44% of soybean fields and 35-66% of corn fields are under conventional tillage. • Nearly 2,500 animals were observed on unregulated animal operations throughout the watershed. The highest density of animals was identified in the Wolf Creek-Salt Creek (900), Goose Creek-Salt Creek (680) and Knob Creek-Little Salt Creek (290) subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading. • One confined feeding operation which is permitted to house up to 68,000 turkeys is located in the watershed. • Manure from confined feeding operations and small animal operations is applied across the Lower Salt Creek Watershed with more than 53,229 tons produced annually. More than 29,272 lb of N and 14,899 lb of P are delivered annually with this manure. • 17,511 acres of the Lower Salt Creek Watershed is located on karst land. Karst predominates in the Goose Creek-Salt Creek (35%) and May Creek-Clear Creek (22%) and Little Clear Creek-Clear Creek (12%) subwatersheds. • 125,167 acres of highly erodible soils occur within the watershed. The highest density of HES occurs in Little Clear Creek-Clear Creek (99%), Hunter Creek-Little Salt Creek (98%), Wolf Creek-Salt Creek (97%), Goose Creek-Salt Creek (94%) and May Creek-Clear Creek (94%) subwatersheds. • The City of Bloomington, City of Bedford, Monroe County and Indiana University MS4 lies partially within the Lower Salt Creek Watershed. • There are three SSO systems in the Lower Salt Creek Watershed – the City of Bloomington's Dillman Road wastewater treatment plant, the Town of Oolitic Wastewater Treatment Plant and a portion of the City of Bedford wastewater treatment plant.

Table 59. Potential sources causing *E. coli* problems.

Problems:	Area streams are listed by IDEM as impaired for recreational contact.
Potential Causes:	*E. coli* concentrations exceed target values and the state standard.
Potential Sources:	• Only one livestock access area (1.1 miles of streams) was observed in the Goose Creek-Salt Creek Subwatershed. This does not mean livestock do not have access but rather they were not observed during the windshield survey. • Nearly 2,500 animals were observed on unregulated animal operations throughout the watershed. The highest density of animals was identified in the Wolf Creek-Salt Creek (900), Goose Creek-Salt Creek (680) and Knob Creek-Little Salt Creek (290) subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading. • Manure from confined feeding operations and small animal operations is applied across the Lower Salt Creek Watershed with more than 53,229 tons produced annually. More than 1.70x10E15 colonies of E. coli are delivered annually with this manure. • Failing septic systems contribute *E. coli* to the system within the rural portion of the watershed and in areas of dense unsewered housing. • The City of Bloomington, City of Bedford, Monroe County and Indiana University MS4 lies partially within the Lower Salt Creek Watershed.

Table 60. Potential sources causing flooding problems.

Problems:	Flooding, loss of natural floodplain/natural habitat in urban settings
Potential Causes:	Periodic flooding of streams causes property damage, increased stream bank erosion and lateral stream movement. Modification of stream channels, especially in urban environments, limits the connectivity between streams and floodplains.
Potential Sources:	Riparian habitat alterations; disconnection and development of the floodplain; ditching, draining and tiling; stormwater runoff

Table 61. Potential sources causing inorganic pollution problems.

Problems:	Inorganic pollution (trash, chemicals) negatively impacts Lower Salt Creek and its watershed
Potential Causes:	Trash and inorganic pollution are negatively impacting Lower Salt Creek and its tributaries.
Potential Sources:	N/A

Table 62. Potential sources causing education and sense of place problems.

Problems:	Focused cohesive education and outreach activities and promotion of activities is needed to build public awareness and create a sense of place.
Potential Causes:	Interest and benefits are lacking.
Potential Sources:	N/A

Table 63. Potential sources causing watershed funding and cohesion problems.

Problems:	• Watershed restoration is underfunded • A unified group for the entire watershed does not exist • Lack of cohesive regulations and governance makes implementation challenging.
Potential Causes:	Unified approach, time and interest are lacking; limited perceived benefit
Potential Sources:	N/A

7.2 Load Estimates

Nonpoint source pollution is generated from diffuse sources found on public and private lands. The USEPA notes that sources of nonpoint source pollution include stormwater runoff, construction activities, solid waste disposal, atmospheric deposition, streambank erosion, and more. Inventory data in Table 57 to Table 63 identify potential sources of nonpoint pollution within the watershed. These tables – generated using GIS, water quality data, windshield surveys, local knowledge, and other sources of data – are useful for generally identifying water quality problems. Two methods could be used to understand the loading of nutrients, sediment, and pathogens in waterbodies in the Lower Salt Creek Watershed: 1) measured results from the monitoring regime completed by IDEM during their 2015 assessment for the Lower Salt Creek TMDL or from Salt Creek at Oolitic fixed station data and 2) modeled results. Each method can estimate both the current load and the reduction in load needed to reach target concentrations. These methods each present advantages and disadvantages for understanding the loading in this watershed in particular. The steering committee considered the monitoring data to draft long term goals and critical areas. The fixed station data were used to calculate final goals and set long term goals, short term goals, and critical areas.

Results from monitoring data can be used to estimate loads of nonpoint source pollution. Concentrations of nutrients, sediments, and pathogens taken at sampling sites can be combined with flow data to estimate the current loads in those waterbodies. Target loads for those waterbodies can also be calculated using available flow data. As noted above, water quality data collection was not part of the current project. Data collected by IDEM as part of their 2015 targeted monitoring for development of the Lower Salt Creek TMDL or IDEM samples collected from Salt Creek monthly at Oolitic as part of their fixed station monitoring program were two options for calculating current loading rates. Load duration curves were created for each of these basins; however, once the steering committee set watershed-wide goals, the steering committee opted to use the fixed station data which 1) represents water quality throughout the watershed as it is the most downstream subwatershed and is reasonably close to the watershed outlet and 2) will continue to be collected by IDEM and can be used to monitor changes in all parameters annually once IDEM makes those data available. It should be noted that IDEM does not collect E. coli as part of its fixed station monitoring program. IDEM collected *E. coli* five times over 30 days during the 2015 IDEM targeted monitoring to calculate necessary E. coli reductions for each subwatershed. These data and calculations were used as the baseline for necessary E. coli reductions in the Lower Salt Creek Watershed.

7.2.1 Current Load Estimates

To calculate watershed-wide loading rates, the steering committee opted to use data from the Salt Creek fixed station and create load duration curves to estimate loading rates and necessary load reductions. This method uses approximate flow data from a surrogate flow gage to estimate flow within the Salt Creek Watershed. IDEM used the Lick Creek at Paoli (USGS 03373610) to approximate the flow in Lower Salt Creek. The Lick Creek watershed was chosen as a surrogate due to its proximity to the Lower Salt Creek watershed and its similar hydrologic characteristics. Both watersheds are located in the south-central portion of the state and the centers of each watershed are approximately 30 miles from one another. The watershed drainage from Lick Creek was scaled to approximate drainage for Lower Salt Creek. Data collected from the IDEM fixed station at Oolitic was used for nitrate-nitrogen, total phosphorus and total suspended solids load calculations. IDEM collects data at this fixed station monthly for these parameters. The scaled instream flow data were combined with IDEM fixed station grab sample data were used to create load duration curves. These curves represent the current loading rate for each parameter for the entire watershed.

7.2.2 Load Duration Curves Load Reductions

Load duration curves allows for comparison of instream loading with stream flow so that conditions of concern can be identified. The load duration curves present the flow characteristics for the entire Lower Salt Creek drainage from June 2021 to May 2022. Data used for the curves were calculated by scaling flow measured at Lick Creek stream gage near Paoli, Indiana to approximate flow in Lower Salt Creek at Oolitic and used the monthly data collected by IDEM (June 2021 to May 2022) as part of their fixed station monitoring network.

observed flow (cfs)) x (conversion factor) x (target concentration or state criteria) = total load /day

The individual load duration curves, also known as the allowable load curves, are displayed below (Figure 57). In the graphs, the total daily load of each contaminant sample result (points) is plotted against the "percent time flow is exceeded" for the day of sampling (curve). Those points above the curve exceed the state criterion or target concentration. Values on a load duration curve can be grouped by hydrologic condition to help identify possible sources and conditions that result in the material being present in the system under those flow conditions. Most often, the flow ranges fall in High (0 to 10), Moist (10-40), Mid-Range (40-60), Dry (60-90), and Low (90-100). Exceedances falling in the moist range (10-40) are typically associated surface runoff or stormwater loads, while exceedances associated with the dry zone are most often associated with dry conditions. These exceedances are suggested to result from point sources that are the most likely source. The curves shown in Figure 57 represent the current loading rate for each parameter calculated for the Lower Salt Creek drainage.

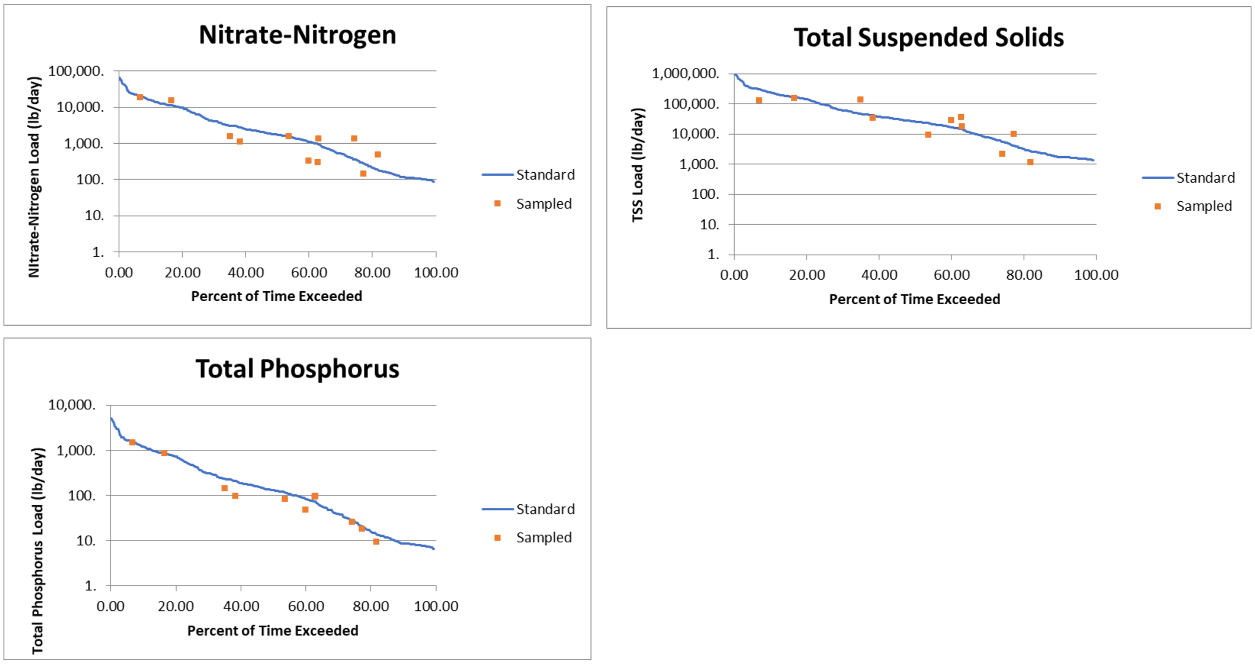

Figure 57. Nitrate-Nitrogen, total phosphorus and total suspended solids load duration curves for Lower Salt Creek using stream flow measured at Lick Creek near Paoli.

7.2.3 Load Reductions

As discussed in Section 3.1 the steering committee selected water quality benchmarks for nitrate-nitrogen, total phosphorus, and total suspended solids that will significantly improve water quality in Lower Salt Creek (Table 20). Target loads needed to meet these benchmarks were calculated for the entire watershed for each parameter. IDEM fixed station data was used to calculate annual loading rates and load reductions. The current loading rate was calculated using the load duration curves detailed above. Concentration data collected monthly at the fixed station was multiplied by the representative days between sampling events (typically 30 days) and then by the average flow during that period of time. Load reduction targets were initially calculated using the water quality targets selected by the steering committee for each parameter (Table 20). After review, it was determined that lower target values were necessary. With this in mind, the steering committee reduced nitrate-nitrogen concentrations by half from 1.0 mg/L to 0.5 mg/L, total phosphorus concentrations by half from 0.8 mg/L to 0.04 mg/L and total suspended solids by one-third from 15 mg/L to 10 mg/L. These targets were multiplied by the same scaled average continuous flow data used to calculate current loading rates and the number of days between sampling events. All calculations are in lb/year and are shown as percent of the current load (Table 64). Appendix C details the load duration curve and load reduction calculations.

Table 64. Estimated load reductions needed to meet water quality target concentrations in the Lower Salt Creek Watershed.

	Current Load (lb/year)	Reduction Needed (lb/year)	Target Load (lb/year)	Percent Reduction
Nitrate-nitrogen	1,488,256	1,169,134	319,122	79%
Total phosphorus	67,728	42,198	25,530	62%
Total suspended solids	15,439,267	9,056,821	6,382,446	59%

Additionally, the Lower Salt Creek *E. coli* TMDL was used to confirm *E. coli* reductions needed in the Lower Salt Creek Watershed. The required *E. coli* load reduction was determined using the TMDL for each 12-digit HUC within the Lower Salt Creek Watershed (IDEM, 2019). The TMDL states that between a 0 and 98% reduction in *E. coli* geometric mean concentration (MPN/100 mL) is needed in order to achieve the state water quality standard (Table 65). Under moist conditions (10-40% of flows), 47-90% reductions in E. coli concentration are required to meet geometric mean sample state standards (125 MPN/100 ml). Under mid-range concentrations (40-60% of instream flows), 58-90% reductions are required to meet E. coli geometric mean concentration state standards (125 MPN/100 ml) for all subwatershed except Hunter Creek-Little Salt Creek and Goose Creek-Salt Creek, where reductions are not needed. Under dry conditions (60-90% of instream flows), 37-98% reductions in E. coli concentration are required to meet E. coli geometric mean concentration state standards (125 MPN/100 ml).

Table 65. Estimated *E. coli* load allocations (MPN/100 ml) and E. coli loading reductions needed to meet water quality target concentrations in the Lower Salt Creek Watershed under various flow conditions.

Subwatershed	High Flow Conditions (0-10%)	Moist Flow Conditions (10-40%)	Mid-Range Flow Conditions (40-60%)	Dry Flow Conditions (60-90%)	Low Flow Conditions (90-10-0%)
Jackson Creek-Clear Creek	--	90%	90%	98%	--
	1.75E+12	3.12E+11	1.14E+11	2.85E+10	9.10E+09
May Creek-Clear Creek	--	47%	90%	98%	--
	3.93E+12	8.10E+11	3.82E+11	1.95E+11	1.53E+11
Little Clear Creek-Clear Creek	--	57%	83%	87%	--
	5.36E+12	1.07E+12	4.79E+11	2.22E+11	1.64E+11
Hunter Creek-Little Salt Creek	--	8%	NA	37%	--
	2.04E+12	3.65E+12	1.34E+11	3.33E+10	1.06E+10
Knob Creek-Little Salt Creek	--	74%	58%	82%	--
	3.71E+12	6.63E+11	2.43E+11	6.05E+10	1.93E+10
Wolf Creek-Salt Creek	--	84%	70%	93%	--
	4.17E+13	7.56E+12	2.86E+12	8.15E+11	3.53E+11
Goose Creek-Salt Creek	--	89%	NA	82%	--
	4.40E+13	7.69E+12	3.02E+12	8.57E+11	3.69E+11

8.0 CRITICAL AND PRIORITY AREA DETERMINATION

Critical areas are defined as the areas where sources of water quality problems occur in the highest densities and where restoration measures can improve water quality. These areas indicate locations where best management practices should be targeted to address nonpoint sources of pollution. Priority areas are those areas of the watershed where high quality habitat is found, and the aquatic biological community is classified as good or excellent. Best management practices to protect the higher quality conditions should be targeted to these areas.

There are several options for defining critical areas. These include 1) using a list of potential sources developed for each parameter of concern on a subwatershed or watershed-wide basis; 2) ranking subwatersheds based on these parameters or a portion of these parameters, such as miles of impaired streams or acreage of karst topography; or 3) utilizing source identification to prioritize across the watershed based on the most significant sources or data available. The steering committee discussed all of these options and working in small groups reviewed data for each subwatershed with the goal of listing potential sources for each concern noted above (nutrients, sediment, E. coli). However, once review was complete, the committee noted that the overall impact area might be too limited to reach individuals within the Lower Salt Creek Watershed. The steering committee reviewed options for ranking each subwatershed based on one set of parameters regardless of concern noted above (nutrients, sediment, E. coli). While this resulted in better cohesion throughout the watershed, the committee determined that the coverage 1) would not sufficiently cover the watershed as a whole, 2) would be too limiting to meet load reduction targets and 3) would not allow for sufficient reach to individuals and entities throughout the watershed where the greatest need and highest benefit could occur. With this in mind, the steering committee decided a source-based approach would be used to define Lower Salt Creek Watershed critical areas.

Several potential sources of pollution were reviewed as options for defining critical areas in the Lower Salt Creek Watershed. These included:

1. Using individual data such as karst coverage, highly erodible land coverage, agricultural land across the watershed or within the floodplain, areas of streambank erosion or livestock access, septic soil limitations and more.

2. Using E. coli impairment by miles impaired as the main critical area. E. coli represents the major impairment for the watershed and the committee noted that efforts to reduce E. coli sources would likely result in a reduction in sediment and nutrient concentrations as well. However, through further discussion, the steering committee determined that addressing the main sources of E. coli may not sufficiently address sources of nutrients and sediment. Thus, the committee determined that using E. coli impairment by stream mile may not provide adequate watershed coverage or address all concerns noted by stakeholders.

3. Using land use as the predominant determinant for source identification. The rural and agriculture working group noted that implementation on pasture and row crop would likely yield the biggest impact for dollars spent. This working group identified the need to work both on mapped row crop and pastureland as well as working with backyard gardeners, small crop production areas or those with single digit animals including chickens, cattle, pigs and horses.

> The urban working group identified several options for prioritizing urban land use including using areas mapped in urban land cover including residential, commercial and industrial; considering MS4 boundaries and using these as well as the Monroe County urbanizing area boundary as it represents the area of fastest growth within Monroe County. As Section 319 funds cannot be used to address MS4 compliance, the Lower Salt Creek steering committee recognizes that furure Section 319 funds will not be used to address compliance issues within MS4 areas now or in the future.

The steering committee identified agricultural land use, row crop and pastureland, and urban land use, MS4 boundaries and the Monroe County urbanizing area, as their critical areas. However, they noted that these would leave out the impacts from small farms located across the Lower Salt Creek Watershed. To address these impacts, the committee will use the USDA definition of small farms: an operation with gross cash farm income under $250,000. Within that group are commercial and noncommercial farms. USDA classifies these operations as farms so long as they have enough land or livestock to generate $1,000, whether or not actual sales reach that level. Most of these operations are better described as rural residences; the households on these farms – and on many other small farms – rely heavily on off-farm income.

Figure 58 details the critical areas prioritized by the Lower Salt Creek steering committee including agricultural land use (row crop and pasture), urban land use (MS4 and Monroe County urbanizing area) and USDA-defined small farms. Agricultural row crow and pastureland cover 32% of the Lower Salt Creek Watershed. Urban acreage as represented by the MS4 communities and Monroe County urbanizing area cover 14% of the Lower Salt Creek Watershed. Combined, critical areas cover 66,505 acres or 46% of the watershed. Address points outside of these two land uses are used to show the location of potential USDA-defined small farms. Note that these points are oversized to show on the map. Figure 58 shows the approximate locations of critical areas in the Lower Salt Creek Watershed. This map should be considered a starting point rather than the definitive map for agricultural land uses or USDA-defined small farms – the MS4 and urbanizing boundaries are set by local definition and are considered the highest priority urban land areas. Further investigation will be needed to identify specific locations where problems are occurring and where solutions can be implemented. While some specific sources of streambank erosion, narrow buffers and livestock access to streams were identified, karst land uses, highly erodible soils and septic limitations are mapped, the field condition may be different than areas identified through desktop and windshield survey efforts.

Lower Salt Creek Watershed critical areas are defined based on pollutant sources. The steering committee reviewed historic Tier 1 and Tier 2 data (Table 52 and Table 53) and identified areas which should be targeted as being of higher concern or more critical due to observed water quality data. These include Goose Creek-Salt Creek, Jackson Creek-Clear Creek and Little Clear Creek-Clear Creek subwatersheds. These priority subwatersheds are shown in Figure 58. These three subwatersheds and additional concerns identified by the steering committee will be used to target implementation within the project's critical areas when landowner interest outpaces available funds. The steering committee identified a few high priority concerns which will be used for targeting purposes. The rating of each concern will be determined during cost share program development and additional items may be added to further refine how each concern area be used to target hot spots or problem areas identified within the Lower Salt Creek Watershed. A rating system will be developed prior to cost share program implementation – the rating system will assign a weighted score to each potential project based on its location in a priority subwatershed as well as the following concerns:

- Ensuring that highly erodible soils areas are protected or covered.
- Ensuring that karst areas are protected or covered.
- Targeting livestock restriction, streambank erosion and buffer strip installation in areas where erosion, livestock access and/or narrow buffers were identified during plan development.
- Working with producers to reduce the impacts from manure production within the Lower Salt Creek Watershed.
- Improving septic system installation and maintenance practices with a focus on education and outreach opportunities and identification of options for future funding for priority areas.

After setting initial goals, the steering committee reviewed the likelihood of meeting water quality targets based on these critical areas. Based on the projected likelihood of successful implementation within these areas, the Lower Salt Creek steering committee did not see a reason to adjust their critical areas. Additionally, the committee did not elect to select additional areas in which to work as the project continues through its lifetime. Much of the remaining land is in forested land use with either federal oversite or where local, state and federal funds are currently sufficient to address concerns on privately-owned forested land. The committee noted the need to continue education and outreach to forest landowners, forest users including individuals using horse trails or camping in the National Forest and those who day hike or camp as well.

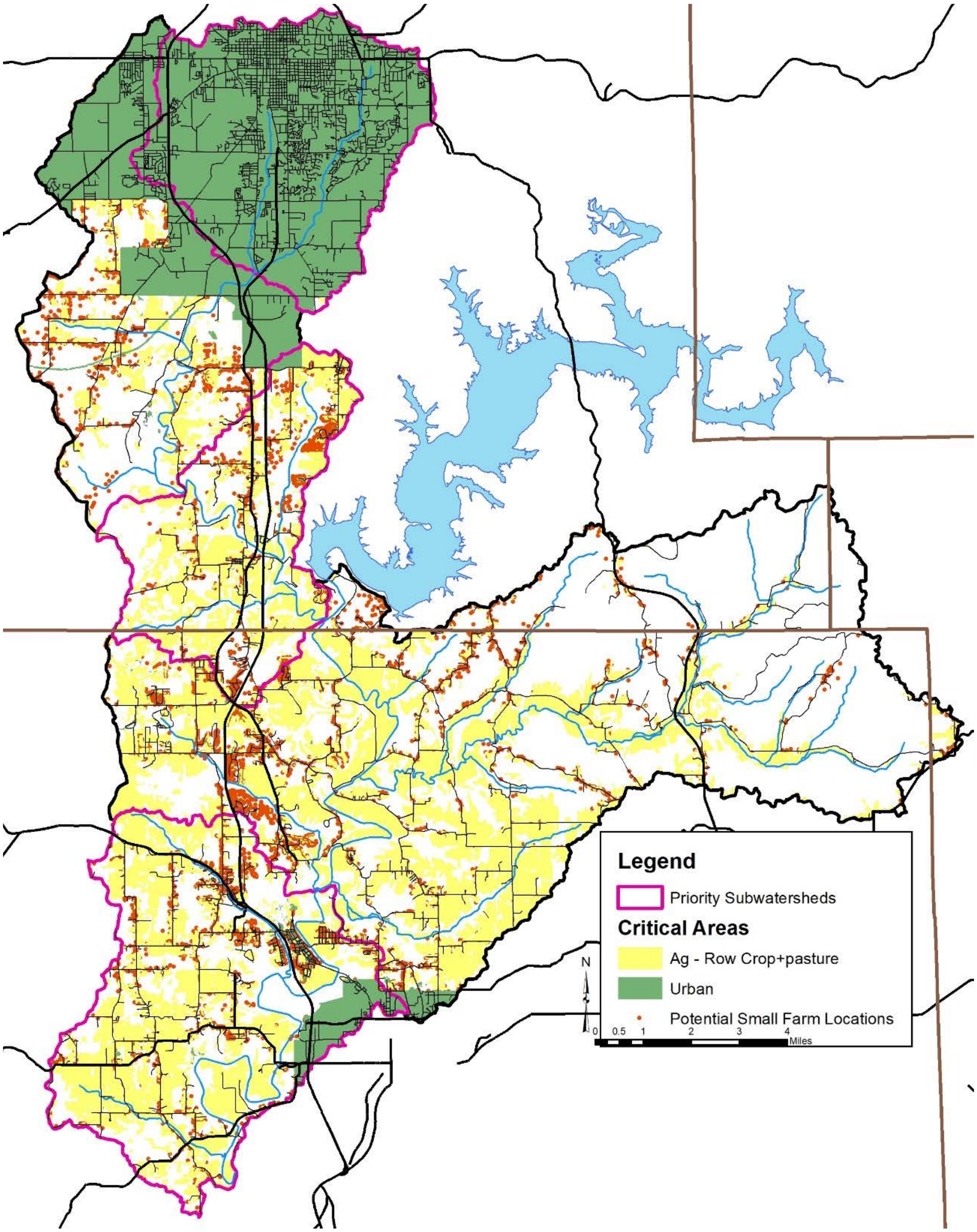

Figure 58. Lower Salt Creek critical areas.

8.1 Critical Acre Determination

To be eligible for Mississippi River Basin Initiative (MRBI) Funding, the Lower Salt Creek Watershed steering committee considered options for targeting all agricultural acreage within the watershed rather than limiting implementation efforts to specific 12-digit HUC subwatersheds. Table 66 details critical acres by subwatershed based on the criteria selected for nutrient, sediment and *E. coli* critical areas. For purposes of MRBI implementation, these acres within each of the prioritized critical areas identified in Figure 59 will be targeted for implementation on a subwatershed by subwatershed basis. The steering committee will target hot spots or problem areas identified within each subwatershed including but not limit to 1) ensuring that all highly erodible soils and karst areas are protected or covered; 2) targeting livestock restriction, streambank erosion and buffer strip installation in areas where erosion, livestock access and/or narrow buffers were identified; and 3) working with producers to reduce the impacts from manure production within the Lower Salt Creek Watershed (Figure 59). Lower Salt Creek Watershed stakeholders identified the need for soils with septic limitation to be targeted for septic treatment; however, this is not an MRBI targeted practice and is therefore not included in Table 66. Note that manure application acres have not been mapped as these application areas are only identified as potential areas for manure application for each permitted confined feeding operation.

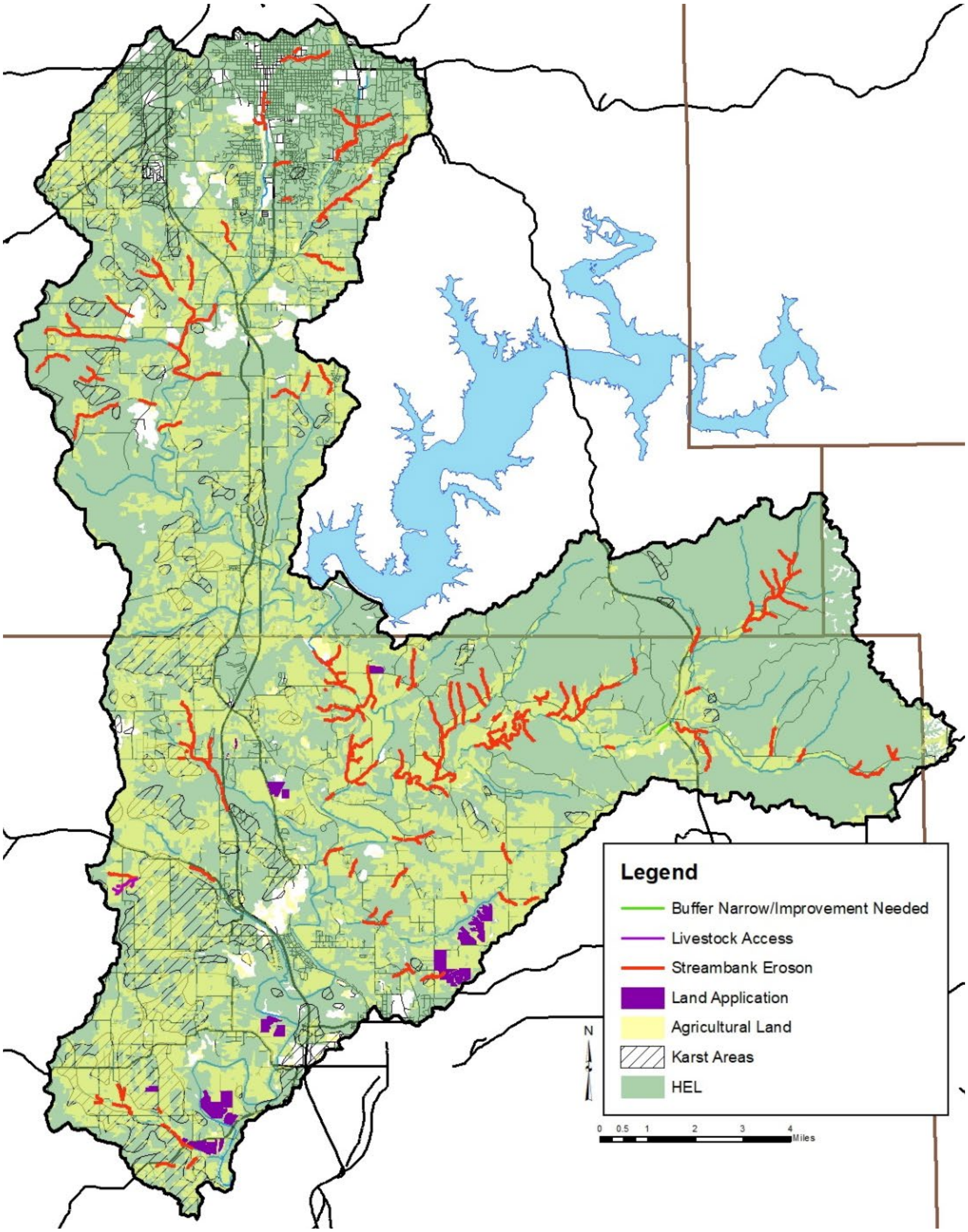

Figure 59. Critical acres in the Lower Salt Creek Watershed.

Table 66. Critical acres by subwatershed in the Lower Salt Creek Watershed.

Subwatershed Name	HUC	HEL (acres)	Karst (acres)	Row Crop (acres)	Pasture (acres)
Jackson Creek-Clear Creek	051202080801	14,548.8	1,310.2	3,256.7	2,998.4
May Creek-Clear Creek	051202080802	18,089.3	4,309.8	5,205.1	4,491.1
Little Clear Creek-Clear Creek	051202080803	13,215.6	1,651.8	5,320.8	4,846.4
Hunter Creek-Little Salt Creek	051202080804	18,657.1	173.1	1,606.2	1,012.2
Knob Creek-Little Salt Creek	051202080805	15,320.3	261.9	4,128.8	2,260.1
Wolf Creek-Salt Creek	051202080806	24,412.5	2,099.6	12,415.9	9,264.8
Goose Creek-Salt Creek	051202080807	20,923.1	7,704.7	9,857.6	7,316.4
TOTALS		125,166.7	17,511.0	41,791.2	32,189.4

Subwatershed Name	Forest (acres)	Manure estimate (tons)	Livestock Access (miles)	Streambank Erosion (miles)	Narrow Buffer (miles)	Municipal Sludge App (acres)
Jackson Creek-Clear Creek	3,468.3	778.0	0.0	11.8	0.0	0.0
May Creek-Clear Creek	10,682.1	6,438.0	0.0	14.4	0.0	0.0
Little Clear Creek-Clear Creek	6,835.0	4,866.0	0.0	2.1	0.0	0.0
Hunter Creek-Little Salt Creek	16,621.9	1,933.0	0.0	12.1	0.0	0.0
Knob Creek-Little Salt Creek	10,657.4	5,719.0	0.0	20.6	0.6	0.0
Wolf Creek-Salt Creek	10,317.2	19,510.0	0.0	22.9	0.0	480.3
Goose Creek-Salt Creek	9,736.1	13,985.0	1.1	6.1	0.0	410.3
TOTALS	68,318	53,229.0	1.1	90.0	0.6	890.6

8.2 Current Level of Treatment

Based on data from the Indiana Conservation Partnership, more than 1,575 acres of best management practices including but not limited to cover crops, conservation cover, fencing, firebreak installation, forage and biomass planting, residue tillage, water facility and heavy use protection area construction and more have been implemented over the last 5 years in the Lower Salt Creek Watershed. Table 67 details practices by acre.

Table 67. Practices installed from 2017-2021 in the Lower Salt Creek Watershed based on Indiana Conservation Partner data in acres, feet*, square feet or units&.**

	Jackson Creek-Clear Creek	May Creek-Clear Creek	Little Clear Creek-Clear Creek	Hunter Creek-Little Salt Creek	Knob Creek-Little Salt Creek	Wolf Creek-Salt Creek	Goose Creek-Salt Creek
Access Road*			0.09	0.03	0.15	1,855.3	150.1
Conservation Cover			1		64	18.6	
Cover Crop		156.5	271.2	76.6	56.7	1,573.6	1,447.1
CREP CP 21 Filter Strips				3.76	6.6	0.5	
CREP CP 22 Riparian Buffer	6.87		2.7				
Critical Area Planting		1.5					
Early Successional Habitat Dev/Mgmt.					64.4	9.1	
Fence*					2892	8501	
Firebreak			815				
Forage and Biomass Planting		11	213.1	97.8	183.3	1081.1	152
Heavy Use Area Protection**		10,280	5,401	7,041	4,682	36,359	7,890
Pollinator Habitat	1	0.5					
Prescribed Grazing			29.1				
Residue and Tillage Mgmt.		77.5					
Spring Development						0.1	
Tree/Shrub Establishment	20		3			4	
Upland Wildlife Habitat Mgmt.					119.5	26.3	
Watering Facility&		4			1	10	

9.0 GOAL SETTING

Based on watershed inventory efforts; stakeholder input for concerns, problems, and sources; and watershed loading information, the following goals and strategies were developed.

9.1 Goal Statements

The steering committee wrote goals for each parameter or area of concern based on a goal of meeting the target concentrations identified by the committee. Goals utilize fixed station water chemistry data collected monthly by the IDEM at Salt Creek at Oolitic (nitrate-nitrogen, total phosphorus, total suspended solids) and using E. coli load allocations calculated as part of IDEM's Lower Salt Creek TMDL (IDEM, 2018). Flow data from the USGS Lick Creek stream gage near Paoli was utilized for calculating loading rates for the Lower Salt Creek Watershed. These flows were scaled to the Lower Salt Creek drainage area to calculate loading rates. The committee reviewed loading rate calculations and the associated required number of BMPs to meet these loading rate reductions during their July and September 2022 steering committee meetings and determined that while the goals were lofty, they were feasible with sufficient funding and a targeted implementation effort. These calculations also allowed the committee to determine if interim goals (short or medium) term would be included in their final watershed management plan. Interim goals were developed by scaling the 30-year goals to 10-year phases with the first 10 years (2023-2032) deemed short term, the second 10 years (2033-2042) deemed medium term and the final 10 years (2043-2052) deemed long term goals.

Reduce Nutrient Loading

Based on fixed station water quality data summarized for Lower Salt Creek at Oolitic, the committee set the following goals for nitrate-nitrogen and total phosphorus: Reduce total phosphorus inputs from 67,728 pounds per year to 25,530 pounds per year (62% reduction) and nitrate-nitrogen from 1,488,256 pounds per year to 319,122 pounds per year (79% reduction) in Lower Salt Creek in 30 years (Table 68 and Table 69).

Short term goal: Reduce total phosphorus inputs from 67,728 pounds per year to 53,662 pounds per year (21% reduction) and nitrate-nitrogen from 1,488,256 pounds per year to 1,098,545 pounds per year (26% reduction) in Lower Salt Creek in 10 years (2032).

Medium term goal: Reduce total phosphorus inputs from 53,662 pounds per year to 39,956 pounds per year (21% reduction) and nitrate-nitrogen from 1,098,545 pounds per year to 708,834 pounds per year (26% reduction) in Lower Salt Creek in 10 years (2042).

Long term goal: Reduce total phosphorus inputs from 39,956 pounds per year to 25,530 pounds per year (21% reduction) and nitrate-nitrogen from 708,834 pounds per year to 319,122 pounds per year (26% reduction) in Lower Salt Creek in 10 years (2052).

Table 68. Nitrate-nitrogen short, medium, and long-term goal calculations for prioritized critical areas in Lower Salt Creek.

Goal Timeframe	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (10 years)	1,488,256.0	389,711.2	1,098,544.8	26%
Medium Term (20 years)	1,098,544.8	389,711.2	708,833.5	35%
Long Term (30 years)	708,833.5	389,711.2	319,122.3	55%

Table 69. Total phosphorus short, medium, and long-term goal calculations for prioritized critical areas in Lower Salt Creek.

Goal Timeframe	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (10 years)	67,727.7	14,066.0	53,661.7	21%
Medium Term (20 years)	53,661.7	14,066.0	39,595.7	26%
Long Term (30 years)	39,595.8	14,066.0	25,529.8	36%

Reduce Sediment Loading
Based on collected water quality data summarized for Lower Salt Creek, the committee set the following goal for total suspended solids: Reduce total suspended solids inputs from 15,439,267 pounds per year to 6,382,446 pounds per year (59% reduction) in Lower Salt Creek in 30 years (Table 70).

Short term goal: Reduce total suspended solids inputs from 15,439,267 pounds per year to 12,420,327 pounds per year (20% reduction) in Lower Salt Creek in 10 years (2032).

Medium term goal: Reduce total suspended solids inputs from 12,420,327 pounds per year to 9,401,387 pounds per year (20% reduction) in Lower Salt Creek in 10 years (2042).

Long term goal: Reduce total suspended solids inputs from 9,401,387 pounds per year to 6,3882,442 pounds per year (20% reduction) in Lower Salt Creek in 10 years (2052).

Table 70. Total suspended solids short, medium, and long-term goal calculations for prioritized critical areas in Lower Salt Creek.

Goal Timeframe	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (10 years)	15,439,267.3	3,018,940.4	12,420,326.9	20%
Medium Term (20 years)	12,420,326.9	3,018,940.4	9,401,386.5	24%
Long Term (30 years)	9,401,386.5	3,018,940.4	6,382,446.1	32%

Reduce *E. coli* Loading
Based on collected water quality data summarized for Lower Salt Creek, the committee set the following goal for *E. coli*: Reduce *E. coli* inputs so that they do not exceed the state standard in Lower Salt Creek and meet load allocations as detailed in the Lower Salt Creek TMDL within 30 years (IDEM, 2018; Table 65). Based on E. coli load allocations calculated as part of the Lower Salt Creek TMDL (IDEM, 2018), E. coli load reductions for 37-98% are needed under dry flow conditions, 58-90% reductions are needed in all but the Hunter Creek-Little Salt Creek and Goose Creek-Salt Creek subwatersheds under mid-range flow conditions and 47-90% reductions are needed under moist flow conditions. The steering committee chose not to set interim goals for E. coli.

Increase Public Awareness and Education
Increase the current level of outreach to engage a 50% increase of individuals in the watershed within 30 years. Baseline data will be gathered in year one of project implementation and will include the current reach of the Monroe and Lawrence SWCDs and City of Bloomington, City of Bedford, Monroe County and Indiana University Bloomington MS4s reach. Engagement should include an effort to educate local officials, foundations and other potential funders; engage with the local community to increase public awareness for watershed issues and work to overcome the issues created by the Lower Salt Creek Watershed covering multiple governmental boundaries (county, city, MS4, university, etc). This focused, cohesive education and outreach effort will result in an increase in public awareness with the goal of building a sense of place.

Address Inorganic Pollution
The steering committee identified the need to reduce the use of pesticides and fertilizers especially on urban lands and reduce impacts of trash in public areas and along Lower Salt Creek watersheds. The Lower Salt Creek steering committee set a goal of improving education and outreach around inorganic pollution with the goal of a 10% increase in awareness about inorganic pollution in 30 years. Baseline trash data will be gathered in year one of project implementation and will include current annual measurements of trash removed during clean up events hosted or completed by Monroe and Lawrence SWCDs and City of Bloomington, City of Bedford, Monroe County and Indiana University Bloomington MS4s and parks departments. Urban pesticide and herbicide impact awareness baselines will be established in year one of project implementation using an MS4-mailed survey.

Flooding and Loss of Natural Habitat/Floodplain
Based on water quality and quantity data, habitat quality data and other local anecdotal information, the Lower Salt Creek steering committee set the following goal: Identify and remove key log jams to reduce flooding and lateral stream movement, improve instream habitat and restore floodplains and riparian buffer where practical. High profile locations will be targeted in the short term (10 years) to provide examples for individuals to use on private lands with the long-term goal of all areas impacted by flooding and floodplain impacts addressed in the long term (30 years).

The next steps for the project include starting implementation of the Lower Salt Creek Watershed Management Plan. The Lawrence County SWCD in partnership with the project steering committee and other regional partners are in the process of submitting an implementation-focused grant application. If funded, this grant would provide funds for a cost-share program to install BMPs, promotion of the cost-share program, and an education and outreach program. If the grant is awarded, the steering committee will develop a cost-share program that will include steps to meeting the goals and management strategies of this plan. The anticipated cost-share program will use a ranking system to fund applications that will have the most impact in improving water quality. Factors such as location within watershed (priority areas), distance from streams, number of resource concerns addressed, and number of practices planned will be considered as part of the ranking process to further prioritize BMPs. It is anticipated that implementation efforts will target high priority critical areas and focus on the implementation of short-term goals.

10.0 IMPROVEMENT MEASURE SELECTION

A wide variety of practices are available for on-the-ground implementation to reduce sediment, nutrient, and *E. coli* loading within the Lower Salt Creek Watershed. A list of potential best management practices was reviewed by the project steering committee. From this list, the practices which were deemed most appropriate to remediate the sources of pollution in the watershed and most likely to successfully meet loading reduction targets were identified. It should be noted that no practice list is exhaustive and that additional techniques may be both possible and necessary to reach water quality goals.

10.1 Best Management Practices Descriptions

A list of potential BMPs were reviewed by the Lower Salt Creek Watershed steering committee. Committee members reviewed potential practices taking into account the identified resource concerns, watershed land uses, and Lower Salt Creek Watershed Project goals. From the potential practice list, the most appropriate BMPs to remediate sources of pollution and address resource concerns in the Lower Salt Creek Watershed was developed. This practice list is not exhaustive and new and emerging technologies and techniques should be considered as possible and necessary options to meet water quality targets within the Lower Salt Creek Watershed. A combination of practices detailed below aimed at avoiding, controlling and trapping nutrients and sediment and the implementation of a conservation system could be necessary to make lasting, measurable changes in Lower Salt Creek water quality. Selected practices are appropriate for all critical areas since they predominantly contain agriculture land use and pasture, and crop resource concerns were identified in all subwatersheds. Several urban practices were also identified. These should be targeted at residential and commercial areas throughout the watershed including Bloomington, Bedford and small towns and developing areas present throughout the watershed. Selected practices with descriptions are listed below. Potential best management practices include the following:

Access Control
Alternate Watering System
Bioreactor
Bioretention
Brush Management
Composting Facility
Conservation Tillage: Residue and Tillage Management, No till/Strip till/Direct Seed
Conservation Cover
Cover Crop
Critical Area Seeding
Curb Openings/Curbless Design
Dam removal
Diversion structures
Drainage Water Management
Drivable Grass
Fencing
Field Border or Filter Strip
Flow Splitter
Forage and Biomass Planting
Forest Management Plan
FSI, Forest Trails and Landing
Grade Stabilization Structure
Grassed Waterway
Green Roof
Greenways and Trails
Habitat Corridor Identification and Improvement
Heavy Use Area Protection
Herbaceous Weed Control
Infrastructure Retrofits
Lined Waterway or Outlet
Livestock Pipeline
Mulching
Nutrient and/or Pest Management Plans
Pervious Pavement
Pollinator Planting
Prescribed Grazing
Pumping Plant
Rain Barrel
Rain Garden
Roof and Cover
Roof Runoff Structure
Education: Septic System Care and Maintenance
Soil testing - Consider soil characteristics to minimize runoff
Streambank Stabilization
Subsurface Drain (Agricultural)
Tree Box Filter
Threatened and Endangered Species Protection
Treatment Vault
Tree/Shrub Establishment
Tree Pruning
Underground outlet
Upland Wildlife Habitat
Education: University fertilization recs.
Vegetated Swale
Waste Utilization
Water and Sediment Control Basin
Wetland Creation, Enhancement, Restoration

Access Control
Access control involves the temporary or permanent exclusion of animals, people, vehicles, and/or equipment from an area. Access control is used to achieve and maintain desired resource conditions by monitoring and managing the intensity of use by animals, people, vehicles, and/or equipment in coordination with the application schedule of practices, measures and activities specified in the conservation plan.

Alternate Watering Systems/Fencing/Livestock Pipeline
Fencing livestock out of stream systems allows for the restoration of the stream channel. Alternative watering systems provide an alternate location for livestock to seek water rather than using a surface water source. This removes the negative impacts of livestock access to streams including direct deposit of manure and bank erosion and destabilization, while improving the health of livestock by providing a clean water source and better footing while drinking. This results in less *E. coli*, phosphorus, nitrogen, and sediment entering a surface waterbody. Alternative watering systems may include pump systems or gravity systems connected to a well or running pipe from a pond or spring.

Bioreactors
Bioreactors use bacteria to digest organic materials including manure, remnant plant material, and woody debris. Bioreactors typically generate energy, water, and fertilizer. Bioreactors use a series of tanks and treatment processes to separate cellulose-based materials from oils and gases. Materials are then broken down into carbon dioxide or methane gas and ethanol.

Bioretention
Bioretention practices use biofiltration or bioinfiltration to filter runoff by storing it in shallow depressions. Bioretention uses plant uptake and soil permeability mechanisms in a variety of manners typically in combination. Potential practices include sand beds, pea gravel overflow structures, organic mulch layers, plant materials, gravel underdrains, and an overflow system to promote infiltration. Bioinfiltration can also be used to treat runoff from parking lots, roads, driveways and other areas in the urban environment. Bioretention should not be used in highly urbanized areas rather, it should be used in areas where on-site storage space is available.

Brush Management
Brush management refers to the management or removal of woody (non-herbaceous or succulent) plants including those that are invasive and noxious. This can be applied on all lands except active cropland where the removal, reduction, or manipulation of woody plants is desired. This practice does not apply to removal of woody vegetation by prescribed fire.

Composting Facility
A composting facility is a structure to facilitate the controlled anaerobic decomposition of manure or other organic material by microorganisms into a biologically stable organic material that is suitable for use as a soil amendment. It can reduce the pollution potential and improve the handling characteristics of organic waste solids and produce a soil amendment that adds organic matter and beneficial organisms, provides slow-release plant-available nutrients, and improves soil conditions (FOTG Code 317, NRCS, 2011).

Conservation Tillage (No-till)

Conservation tillage refers to several different tillage methods or systems that leave at least 30% of the soil covered with crop residue after planting (Holdren et al., 2001). Tillage methods encompassed by conservation tillage include no-till, mulch-till, ridge-till, and strip till. The purpose of conservation tillage is to reduce sheet and rill erosion, maintain or improve soil organic matter content, conserve soil moisture, increase available moisture, reduce plant damage, and provide habitat and cover for wildlife. The remaining crop residue helps reduce soil erosion and runoff volume.

Several researchers have demonstrated the benefits of conservation tillage in reducing pollutant loading to streams and lakes. A comprehensive comparison of tillage systems showed that no-till results in 70% less herbicide runoff, 93% less erosion, and 69% less water runoff volume when compared to conventional tillage (Conservation Technology Information Center, 2000). Reductions in pesticide loading have also been reported (Olem and Flock, 1990).

Cover Crops/Critical Area Seeding/Conservation Cover

Cover crops include legumes, such as clover, hairy vetch, field peas, alfalfa, and soybean, and non-legumes, such as rye, oats, wheat, radishes, turnips, and buckwheat which are planted prior to or following crop harvest. Cover crops typically grow for one season to one year and are typically grown in non-cropping seasons. Cover crops are used to improve soil quality and future crop harvest by improving soil tilth, reducing wind and water erosion, increasing available nitrogen, suppressing weed cover, and encouraging beneficial insect growth. Cover crops, conservation cover and critical area seeding reduce phosphorus transport by reducing soil erosion and runoff. Both wind and water erosion move soil particles that have phosphorus attached. Sediment that reaches water bodies may release phosphorus into the water. Runoff water can wash soluble phosphorus from the surface soil and crop residue and carry it off the field. The vegetation recovers plant-available nutrients in the soil and recycles them through the plant biomass for succeeding crops.

Curb Openings/Curbless Design

An essential element of green infrastructure project design is ensuring the stormwater enters the system and is captured. In urban environments where curbs are prevalent, stormwater flow accumulates as it moves along the curbed edges of roadways. Adding curb cuts allows this concentrated flow to spill into green infrastructure practices. To capture stormwater runoff from curbed roads, curb cuts are added at intervals along a raised curb, resulting in areas of concentrated flow. This practice is commonly used in urban bioretention cells, stormwater curb extensions, stormwater planters and urban tree trenches. Three key criteria should be considered when designing curb cuts: placement, grading and size/angle of opening.

In contrast, stormwater drains off curbless roadways under sheet flow conditions to the lowest area. In areas without curbs and gutters, practices are designed to capture runoff via sheet flow across pavement and other surfaces. Establishing sheet flow conditions allows for an even distribution of runoff into the feature. Moreover, in conditions of low-velocity sheet flow, pretreatment such as a pea gravel apron installed between the impervious area and the practice can help capture suspended sediment. Green infrastructure practices that capture sheet flow from curbless streets and parking lots often include a band of concrete edging that lies flush with the stormwater feature and the street/parking lot surface. Because of concrete's fine-grain composition, it is easier to use concrete than asphalt to achieve the necessary flat slope that will direct sheet flow into the stormwater feature. Sidewalks can be designed with slight in slopes or out slopes to direct sheet flow into green infrastructure practices, but the sidewalks must also comply with local codes and ordinances and meet the slope requirements outlined in the Americans with Disabilities Act.

Dam Removal

Low-head dams are man-made structures in rivers that pool upstream water for various reasons. Low-head dams, normally produce vertical water surface drops of one to 15 feet. Low-head dams alter natural habitat and impair how a stream behaves. Adverse effects of low-head dams include the following:

- Low-head dams block the upstream movement of fish and other species, impacting their reproductive cycle.
- They change free-flowing river habitat and turn it into pond-like habitat, an environment where fish adapted to free-flowing conditions do not fare well. This leads to substantial decreases in the types of fish in a dammed river.
- Water quality is impaired by low-head dams. Dams create conditions favorable to algal growth by slowing water and trapping sediment and nutrients. This can significantly deplete the oxygen in the water behind a dam, leading to fish kills.

Diversion Structures

A diversion structure is a channel generally constructed across the slope with a supporting ridge on the lower side. This practice may be applied to support various purposes including breaking up concentrations of water on long slopes, on undulating land surfaces, and on land that is generally considered too flat or irregular for terracing. Diverting water away from farmsteads, agricultural waste systems, and other improvements. Collecting or directing water for storage, water- spreading or water-harvesting systems. Protecting terrace systems by diverting water from the top terrace where topography, land use, or land ownership prevents terracing the land above. Intercept surface and shallow subsurface flow. Reducing runoff damages from upland runoff. Reducing erosion and runoff on urban or developing areas and at construction or mining sites. Diverting water away from active gullies or critically eroding areas. Supplementing water management on conservation cropping or strip cropping systems. Diversion structures can be applied to all land uses where surface runoff water control and/or management are needed and where soils and topography are such that the diversion can be constructed, and a suitable outlet is available or can be provided.

Drainage Water Management/Subirrigation

Subsurface tile drainage is an essential water management practice on highly productive fields. As a result of tile drainage, nitrate carried in drainage water enters adjacent surface waterbodies. Drainage water management is necessary to reduce nitrate loads entering adjacent surface waterbodies from tile drainage networks. Drainage water management uses water control structures within lateral drains to vary the depth of tile outlets. Typically, the outlet is raised after harvest to limit outflow from the tile and reduce nitrate transport to adjacent waterbodies; lowered in the spring and fall to allow tile water to flow freely from the field to adjacent waterbodies; and raised in the summer to help store water making it available for crops (Frankenberger et al., 2006). Drainage water management can be used in concert with a suite of other conservation practices including subirrigation, cover crops and conservation tillage to promote a systems approach and be better stewards of water quantity.

Drivable Grass

Drivable grass is a permeable, flexible and plantable concrete pavement system that is environmentally friendly, aesthetically pleasing, and an alternative to poured concrete, asphalt and interlocking concrete pavers. Drivable grass is designed with an engineered polymer grid, which allows the product to be flexible and conform to irregular ground surface contours along pre-defined linear grooves, while providing the intended structural support.

Drivable grass facilitates the growth of a continuous root system below the product in the bedding course, promoting healthy turf while minimizing moisture evaporation. The distinctive thin profile and bearing properties of drivable grass enable superior root penetration into the underlying bedding course, establishing a cohesive root zone below the mats.

This unique product, whether planted or non-planted, is a solution for multiple applications of low impact development strategies ranging from commercial parking lots to drainage swales and practical DIY applications. Drivable grass is a great solution for many existing and emerging government regulations, codes and requirements. Contractors, specifiers, local and state municipalities can incorporate drivable grass on their projects to enhance water quality, mitigate stormwater runoff, increase greenspace, and reduce heat island effects.

Field Border/Buffer Strip/Filter Strip

Installing natural buffers or filters along major and minor drainages in the watershed helps reduce the nutrient and sediment loads reaching surface waterbodies. Buffers provide many benefits including restoring hydrologic connectivity, reducing nutrient and sediment transport, improving recreational opportunities and aesthetics, and providing wildlife habitat. Sediment, phosphorus, nitrogen, and *E. coli* are at least partly removed from water passing through a naturally vegetated buffer. The percentage of pollutants removed depends on the pollutant load, the type of vegetation, the amount of runoff, and the character of the buffer area. The most effective buffer width can vary along the length of a channel. Adjacent land uses, topography, runoff velocity, and soil and vegetation types are all factors used to determine the optimum buffer width.

Many researchers have verified the effectiveness of filter strips in removing sediment from runoff with reductions ranging from 56-97% (Arora et al., 1996; Mickelson and Baker, 1993; Schmitt et al., 1999; Lee et al, 2000; Lee et al., 2003). Most of the reduction in sediment load occurs within the first 15 feet of installed buffer. Smaller additional amounts of sediment are retained and infiltration is increased by increasing the width of the strip (Dillaha et al., 1989). Filter strips have been found to reduce sediment-bound nutrients like total phosphorus but to a lesser extent than they reduce sediment load itself. Phosphorus predominately associates with finer particles like silt and clay that remain suspended longer and are more likely to reach the strip's outfall (Hayes et al., 1984). Filter strips are least effective at reducing dissolved nutrients like those of nitrate and phosphorus, and atrazine and alachlor, although reductions of dissolved phosphorus, atrazine, and alachlor of up to 50% have been documented (Conservation Technology Information Center, 2000). Simpkins et al. (2003) demonstrated 20-93% nitrate-nitrogen removal in multispecies riparian buffers. Short groundwater flow paths, long residence times, and contact with fine-textured sediments favorably increased nitrate-nitrogen removal rates. Additionally, up to 60% of pathogens contained in runoff may be effectively removed. Computer modeling also indicates that over the long run (30 years), filter strips significantly reduce amounts of pollutants entering waterways.

Filter strips should be designed as permanent plantings to treat runoff and should not be considered part of the annual rotation of adjacent cropland. Filter strips should receive only sheet flow and should be installed on stable banks. A mixture of grasses, forbs, and herbaceous plants should be used. In more permanent plantings, shrubs and trees should be intermingled to form a stable riparian community.

Flow Splitter
A flow splitter is an engineered structure used to divide flow into two or more parts and divert these parts to different places. The design of a flow splitter uses specifically designed structures, pipes, orifices, and weirs set at specific elevations to control the direction of flow. An illustration of a simple type of flow splitter is provided in the accompanying figure. Typically, when managing storm water flows, a flow splitter is used to direct initial storm water flows to an off-line BMP. The splitter is placed at an elevation coordinated with the elevation of the treatment BMP, so that the elevation of water in the BMP governs the elevation in the flow splitter. Storm water flows to the BMP until it reaches a pre-determined elevation. Once storm water reaches that elevation, a weir (or other hydraulic feature) directs additional flow to an alternative outlet. This simple type of flow splitter works on hydraulic principles and requires no mechanical components or instrumentation.

Forage and Biomass Planting
Forage and biomass plantings establish adapted and/or compatible species, varieties, or cultivars of herbaceous species suitable for pasture, hay or biomass production. Plantings occur to improve or maintain livestock nutrition and/or health; provide or increase forage supply during periods of low forage production; reduce soil erosion; improve soil and water quality; produce feedstock for biofuel or energy production.

Forest Management
Establishing woody plants by planting seedling or cuttings, direct seeding, or natural regeneration. The purpose of this practice is to establish woody plants for: forest products such as timber, pulpwood, etc.; wildlife habitat; long-term erosion control and improvement of water quality; treating waste; storing carbon in biomass; reduce energy use; develop renewable energy systems; improving or restoring natural diversity; and enhancing aesthetics.

Forest or Timber Stand Improvement
Forest or Timber Stand Improvement is used to remove undesirable trees and provide resources for the desirable trees that are left. With these resources (space, light, water, and nutrients) freed up, the desirable or crop trees are allowed increase their growth rate.

Forest Trails and Landings
Forest trails and landings are installed and/or maintained for infrequent access to conduct management activities such as forest stand improvement, pruning, fire suppression, or harvest of forest products.

The conservation objective is to allow suitable access while minimizing on-site and off-site damage to other natural resources.

Grade Stabilization
A grade stabilization structure is used to stabilize and control soil erosion in natural and artificial channels. It can prevent the formation or advance of gullies, enhance environmental quality, and reduce pollution hazards. Special attention is given to maintaining or improving habitat for fish and wildlife.

Grassed Waterway
Grassed waterways are natural or constructed channels established for transport of concentrated flow at safe velocities using adequate channel dimensions and proper vegetation. They are generally broad and shallow by design to move surface water across farmland without causing soil erosion. Grassed waterways are used as outlets to prevent rill and gully formation. The vegetative cover slows the water flow, minimizing channel surface erosion. When properly constructed, grassed waterways can safely transport large water flows downslope. These waterways can also be used as outlets for water released from contoured and terraced systems and from diverted channels. The amount of precipitation that runs off the soil surface rather than infiltrating down into the soil profile is increased by tillage and other farming activities that increase soil compaction and decrease soil organic matter and macro-pore content. For these reasons, the establishment or refurbishing of a grassed waterway should, when possible, be coupled with other practices that aim to increase the rate of water infiltration into the soil. This BMP can reduce sediment concentrations of nearby waterbodies and pollutants in runoff. The vegetation improves the soil aeration and water quality due to its nutrient removal through plant uptake and absorption by soil. The waterways can also provide wildlife corridors and allows more land to be natural areas.

Green Roof
A green roof system is an extension of the existing roof which involves, at a minimum, high quality waterproofing, root repellent system, drainage system, filter cloth, a lightweight growing medium, and plants.

Green roof systems may be modular, with drainage layers, filter cloth, growing media, and plants already prepared in movable, often interlocking grids, or loose laid/built-up whereby each component of the system may be installed separately. Green roof development involves the creation of "contained" green space on top of a human-made structure. This green space could be below, at, or above grade, but in all cases, it exists separate from the ground.

Green roofs can provide a wide range of public and private benefits and have been successfully installed in countries around the world. Green roofs provide a variety of environmental benefits to aesthetic improvements, waste diversion, moderation of the heat island effect, improved air quality, and stormwater benefits. Some of the water benefits include; water is stored by the substrate and then taken up by the plants from where it is returned to the atmosphere through transpiration and evaporation, in summer, green roofs can retain 70-90% of the precipitation that falls on them, in winter, green roofs can retain between 25-40% of the precipitation that falls on them, green roofs not only retain rainwater, but also moderate the temperature of the water and act as natural filters for any of the water that happens to run off, and green roofs reduce the amount of stormwater runoff and also delay the time at which runoff occurs, resulting in decreased stress on sewer systems at peak flow periods.

Greenways and Trails

Greenways can provide a large number of functions and benefits to nature and the public. For plants and animals, greenways provide habitat, a buffer from development, and a corridor for migration. Greenways located along streams include riparian buffers that protect water quality by filtering sediments and nutrients from surface runoff and stabilizing streambanks. By buffering the stream from adjacent developed land use, riparian greenways offset some of the impacts associated with increased impervious surface in a watershed. Maintaining a good riparian buffer can mitigate the negative impacts of approximately 5% additional impervious surface in the watershed.

Habitat Corridor Identification and Improvement

Protection of habitat corridors requires a multi-phase program including identification of appropriate habitat corridors, development of a corridor management plan, and creation of an improvement plan. Most long-term corridor protection will require land transfer into protected status. There are several options for land transfer ranging from donation to fee simple land purchase. Donations can be solicited and encouraged through incentive programs. Outright purchase of property offers a secondary option and is frequently the least complicated and most permanent protection technique but is also the costliest. A conservation easement is a less expensive technique than outright purchase that does not require the transfer of land ownership but rather a transfer of use rights. Conservation easements might be attractive to property owners who do not want to sell their land at the present time but would support perpetual protection from further development. Conservation easements can be donated or purchased.

Several techniques can be used for protecting natural areas and open space in both public and private ownership. The first step in the process is to identify and prioritize properties for protection. The highest priority natural areas should be permanently protected by the ownership or under the management of public agencies or private organizations dedicated to land conservation. Other open space can be protected using conservation design development techniques and is more likely to be managed by homeowner associations.

Heavy Use Area Protection (HUAP)

HUAP is used to stabilize a ground surface that is frequently used by people, animals, or vehicles and to protect water quality.

Herbaceous Weed Control

Herbaceous weed control is the removal or control of herbaceous weeds including invasive, noxious and prohibited plants. This practice can be used to enhance accessibility, quantity, and/or quality of forage and/or browse. Restore or release native or create desired plant communities and wildlife habitats consistent with the site potential. Protect soils and control erosion and reduce fine fuel loads and wildfire hazard.

Infrastructure Retrofits

Typical stormwater infrastructure includes pipe and storm drains, or hard infrastructure, to convey water away from hard surfaces and into the stormwater system. Retrofitting these structures to implement low impact development techniques, use green practices, and introduce plants and filters to reduce sediment and nutrient concentrations contained in stormwater.

Livestock Restriction/Prescribed (Rotational) Grazing/Lined Waterway or Outlet

Livestock that have unrestricted access to a stream or wetland have the potential to degrade the waterbody's water quality and biotic integrity. Livestock can deliver nutrients and pathogens directly to a waterbody through defecation. Livestock also degrade stream ecosystems indirectly. Trampling and removal of vegetation through grazing of riparian zones can weaken banks and increase the potential for bank erosion. Trampling can also compact soils in a wetland or riparian zone decreasing the area's ability to infiltrate water runoff. Removal of vegetation in a wetland or riparian zone also limits the area's ability to filter pollutants in runoff. The degradation of a waterbody's water quality and habitat typically results in the impairment of the biota living in the waterbody.

Restoring areas impacted by livestock grazing often involves several steps. First, the livestock in these areas should be restricted from the wetland or stream to which they currently have access. If necessary, an alternate source of water should be created for the livestock. Second, the wetland or riparian zone where the livestock have grazed should be restored. This may include stabilizing or reconstructing the banks using bioengineering techniques. Minimally, it involves installing filter strips along banks or wetland edge and replanting any denuded areas. Finally, if possible, drainage from the land where the livestock are pastured should be directed to flow through a constructed wetland to reduce pollutant loading, particularly nitrate-nitrogen loading, to the adjacent waterbody. Complete restoration of aquatic areas impacted by livestock will help reduce pollutant loading, particularly nitrate-nitrogen, sediment, and pathogens.

A livestock exclusion system is a system of permanent fencing (board, barbed, etc) installed to exclude livestock from streams and areas not intended for grazing. This will reduce erosion, sediment, and nutrient loading, and improve the quality of surface water. Landowners can additionally section off the pastureland and move the animals from one paddock to the next, ensuring adequate vegetation growth for nutrient removal. Using this system of rotational grazing no one piece of land gets overgrazed and ensures a high-quality food for the livestock and adequate ground cover for nutrient and sediment retention. Education and outreach programs focusing on rotational grazing and exclusionary fencing are important in the success of this BMP.

Mulching

Mulching is the application of plant residues to the land surface. This can help conserve soil moisture, moderate soil temperature, provide erosion control, facilitate the establishment of vegetative cover, improve soil quality, and reduce airborne particulates. This practice can be used alone or in combination with other practices.

Nutrient/Pest Management Planning including Variable Rate Application and Waste Storage Facility

Nutrient management is the management of the amount, source, placement, form, and timing of the application of plant nutrients and soil amendments to minimize the transport of applied nutrients into surface water or groundwater and can be in commercial/non-manure fertilizer or manure-based fertilizers. Nutrient management seeks to supply adequate nutrients for optimum crop yield and quantity, while also helping to sustain the physical, biological, and chemical properties of the soil. A nutrient budget for nitrogen, phosphorus, and potassium is developed considering all potential sources of nutrients including, but not limited to, animal manure, commercial fertilizer, crop residue, and legume credits. Realistic yields are based on soil productivity information, potential yield, or historical yield data based on a 5-year average. Nutrient management plans specify the form, source, amount, timing, and method of application of nutrients on each field in order to achieve realistic production levels while minimizing transport of nutrients to surface and/or groundwater.

Pervious Pavement

Pervious pavement comes in many forms including porous pavement and modular block pavement. Both types of pervious pavement can be installed on most any travel surface with a slope of 5% or less. Pervious pavement has the approximate strength characteristics of traditional pavement with the ability to percolate water into the groundwater system. The pavement reduces sediment and nutrient transmission into the groundwater as water moves through the pores in the pavement. When installed, porous pavement includes a stone layer, filter fabric, and a filter layer covered by porous pavement. Correctly mixed porous pavement eliminates fine aggregates found in typical pavements. Porous asphalt is a type of porous pavement which includes a mix of Portland cement, coarse aggregates, and water that results in the formation of interconnected voids.

Modular pavement consists of individual blocks made of pervious material such as sand, gravel, or sod interspersed with strong structural material such as concrete. The blocks are typically placed on a sand or gravel base and designed to provide a load-bearing surface that is adequate to support personal vehicles, while allowing infiltration of surface water into the underlying soils. They usually are used in low-volume traffic areas such as overflow parking lots and lightly used access roads. An alternative to pervious and modular pavement for parking areas is a geotextile material installed as a framework to provide structural strength. Filled with sand and sodded, it provides a completely grassed parking area.

Pollinator Planting

Pollinator plantings focus on selecting plants and providing recommendations on plants which will enhance pollinator populations throughout the growing season. These wildflowers, trees, shrubs, and grasses are an integral part of the conservation practices that landowners and farmers.

Prescribed Grazing

This practice where grazing and/or browsing animals are managed on a prescribed schedule. Removal of herbage by the grazing animals is in accordance with production limitations, plant sensitivities and management goals. Frequency of defoliations and season of grazing is based on the rate of growth and physiological condition of the plants. Duration and intensity of grazing is based on desired plant health and expected productivity of the forage species to meet management objectives. In all cases enough vegetation is left to prevent accelerated soil erosion. Application of this practice will manipulate the intensity, frequency, duration, and season of grazing to: Improve water infiltration, maintain or improve riparian and upland area vegetation, protect stream banks from erosion, manage for deposition of fecal material way from water bodies and promote ecological and economically stable plant communities which meet landowner objectives.

Pumping Plant

Pumping plants are used to pressurize and transfer water from a surface or underground source to irrigated land, wetland, livestock watering facility or reservoir or move wastewater or other liquid byproducts. The pumping plant includes one or more pumps, power units, plumping tanks and an energy source.

Rain Barrel

A rain barrel is a container that collects and stores rainwater from your rooftop (via your home's disconnected downspouts) for later use on your lawn, garden, or other outdoor uses. Rainwater stored in rain barrels can be useful for watering landscapes, gardens, lawns, and trees. Rain is a naturally soft water and devoid of minerals, chlorine, fluoride, and other chemicals. In addition, rain barrels help to reduce peak volume and velocity of stormwater runoff to streams and storm sewer systems. Although rain barrels don't specifically reduce nutrient or sediment loading to waterbodies, their presence can reduce the first flush of water reaching storm drains. This impact is great especially in portions of the watershed where combined sewers are still in operation. Although a high percentage of urban residents indicated a general knowledge of rain barrels, only 3% of survey respondents indicate that they have installed a rain barrel. Furthermore, 75% of respondents indicate a willingness to consider installing a rain barrel.

Rain Garden

Rain gardens are small-scale bioretention systems that can be used as landscape features and small-scale stormwater management systems for single-family homes, townhouse units, some small commercial development, and to treat parking lot or building runoff. Rain gardens provide a landscape feature for the site and reduce the need for irrigation and can be used to provide stormwater depression storage and treatment near the point of generation. These systems can be integrated into the stormwater management system since the components can be optimized to maximize depression storage, pretreatment of the stormwater runoff, promote evapotranspiration, and facilitate groundwater recharge. The combination of these benefits can result in decreased flooding due to a decrease in the peak flow and total volume of runoff generated by a storm event. Additionally, rain gardens can be designed to provide a significant improvement in the quality of the stormwater runoff.

Roofs and Cover

A roofs and covers system consists of a rigid, semirigid, or flexible manufactured membrane, composite material, or roof structure placed over a waste management facility or an agrichemical handling facility. Roofs and cover are used in areas where precipitation should be excluded from contaminated areas, such as animal feeding and management areas, facilities for waste storage, animal mortality, composting, waste transfer or waste treatment, and agrichemical handling. Additionally, roofs and cover can be used for biotreatment of emissions using a porous cover on a wastewater storage facility is needed to improve air quality, limit odors, and moderate the net effect of greenhouse gas emissions or where a cover is needed to exclude precipitation from a wastewater storage facility. Auxiliary elements of the cover will also capture and manage biogas emissions, improve air quality, limit odors, and reduce the net effect of greenhouse gas emissions.

Roof Runoff Structure

A roof runoff structure is made of various components that will collect, control and convey precipitation runoff from a roof. Roof runoff structures are used to protect surface water by excluding roof runoff from contaminated areas, protecting foundations from water damage or soil erosion from excess water runoff, increase infiltration of runoff water or capture water for other uses. Oftentimes, roof runoff from precipitation is collected or captured for other uses such as livestock water, irrigation or evaporative cooling systems.

Septic System Care and Maintenance

Septic, or on-site waste disposal systems, are the primary means of sanitary flow treatment outside of incorporated areas including most of the small towns and unincorporated areas in the Lower Salt Creek Watershed. Because of the prohibitive cost of providing centralized sewer systems to many areas, septic tank systems will remain the primary means of treatment into the future. Annual maintenance of septic systems is crucial for their operation, particularly the annual removal of accumulated sludge. The cost of replacing failed septic tanks is about $5,000-$15,000 per unit based on industry standards.

Property owners are responsible for their septic systems under the regulation of the County Health Department. When septic systems fail, untreated sanitary flows are discharged into open watercourses that pollute the water and pose a potential public health risk. Septic systems discharging to the ground surface are a risk to public health directly through body contact or contamination of drinking water sources. Additionally, septic systems can contribute significant amounts of nitrogen and phosphorus to the watershed. Therefore, it is imperative for homeowners not to ignore septic failures. If plumbing fixtures back up or will not drain, the system is failing. Funding for this practice is limited. Our efforts will include developing an education plan for homeowners in the watershed and hosting a series of septic system care and maintenance workshops.

Soil testing - Consider soil characteristics to minimize runoff

Soil testing can be used to determine nutrient levels in the soil, determine pH levels and thus, lime needs; provides a decision-making tool to determine what nutrients to apply, how much, and when. Regular soil testing and the application of fertilizers at or below university fertilizer recommendations provides the potential for higher yielding, high quality crops with more targeted fertilizer use.

Streambank Stabilization

Streambank stabilization or stream restoration techniques are used to improve stream conditions so they more closely mimic natural conditions. The most feasible restoration options return many of the stream's natural functions (flood storage, nutrient removal, etc.) without restoring the stream completely to its original condition. However, even a partial restoration of this type is extremely expensive, takes quite a bit of land to accomplish, and is likely unrealistic as a large-scale strategy in this watershed. Our efforts will focus primarily on two-stage ditch construction, which is a cheaper way to incorporate a small floodplain into the ditch itself in the form of benches on either side of the main channel that allow for increased capacity in the ditch resulting in slower moving water along the banks resulting in reduced bank slumping and failure. Restoration and stabilization options are limited by available floodplain, modifications to natural flows, and development structure locations. Reestablishment of riparian buffers, restoration of stream channels, stabilization of eroding stream banks, installation of riffle-pool complexes, and general maintenance can all improve stream function while reducing sediment and nutrient transport into and within the system.

Subsurface Drain
A subsurface drain is a conduit, such as corrugated plastic tubing, tile, or pipe, installed beneath the ground surface to collect and/or convey drainage water. Subsurface drains are used to improve the environment for crops, reduce erosion, improve water quality, regulate water tables, collect groundwater for beneficial uses, or to remove salts and other contaminants from the soil profile.

Subsurface drainage is used in areas having a high-water table where the benefits of lowering the water level are worth the expense. The practice also applies to areas that will benefit from controlling ground water and/or surface runoff. The soil must meet certain suitability requirements and an adequate outlet must be available to assure the drain will function properly.
The operation and maintenance of a subsurface drainage system includes periodic inspection and prompt repair of system components (e.g. structures for water control, underground outlets, vents, drain outlets, trash and rodent guards). In cold climates, winterization protection from freezing conditions will be necessary.

T&E Species Protection (Habitat Improvement)
Threatened and endangered species are those plant and animal species whose survival is in peril. Federally and state listed species identified within Lower Salt Creek Watershed are highlighted in the Watershed Inventory. Threatened species are those that are likely to become endangered in the foreseeable future. Federally endangered species are those that are in danger of extinction throughout all or a significant portion of their range. A state-endangered species is any species that is in danger of extinction as a breeding species in Indiana.

Protecting threatened and endangered species requires consideration of their habitat including food, water, and nesting and roosting living space for animals and preferred substrate for plants and mussels. Corridors for species movement are also necessary for long-term protection of these species. Protection of habitat can include providing clean water and available food but likely requires protection of the physical living space and associated corridor. Conservation management plans should be developed for each species, if they are not already in place. Such plans should consider habitat needs including purchase or protection of adjacent properties to current habitat locations, hydrologic needs, pollution reduction, outside impacts, and other techniques necessary to protect threatened and endangered species.

Treatment Vault
Treatment vaults are a subsurface flow-through structure that physically separates sediment, trash, leaf litter, debris and other particulate pollutants from stormwater via various separation or settling techniques. This includes mechanical separation devices such as hydrodynamic separators, flow separation vaults, and gross solid retention devices. No volume reduction occurs due to impervious base. These may be a confined space but not always. Accumulation of material at the base of BMP can be observed and measured via manhole access.

Tree Box Filters

Tree box filters are a proprietary biotreatment device that is designed to mimic natural systems such as bioretention areas by incorporating plants, soil, and microbes. Tree box filters are installed at curb level and consist of an open bottom concrete barrel filled with a porous soil media, an underdrain in crushed gravel, and a tree. Tree box filters are highly adaptable solutions that can be used in all types of development and in all types of soils but are especially applicable to ultra-urban areas.

Tree Pruning

Tree pruning is the removal of all or part of selected branches, leaders or roots from trees and shrubs. This practice has many benefits and purposes. Some of them include improving the appearance of trees or shrubs, e.g., ornamental plants and Christmas trees, Improving the quality of wood products, Improve the production of plant products, e.g., nuts, fruits, boughs and tips. Reducing fire and/or safety hazards. Improving the growth and vigor of understory plants. Adjusting the foliage and branching density or rooting length for other specific intents, such as wind and snow control, noise abatement, access control, and visual screens and managing competition. Improves health and vigor of woody plants e.g. disease, insect and injury management.

Tree/Shrub Establishment/Reforestation and site prep including Invasive Control

Reforestation is the establishment of forests, usually accomplished through the planting of tree seedlings. It is important to match the species being planted to the site chosen for reforestation. Control of competing vegetation and invasive plants is often necessary to ensure establishment and survival of planted trees. This is usually done through mowing and/or herbicide application. Reforestation can provide many benefits to the landscape. Increasing the amount of forest through tree planting provides more habitat for forest dependent species, improves water quality by reducing erosion, decreases nutrient loading and lowers floodwater velocity.

Underground Outlet

An Underground Outlet is a conduit installed beneath the surface of the ground to convey runoff to a suitable outlet. This practice is commonly used in concert with grassed waterway installation, lined waterway or outlet, subsurface drain, roof runoff structure or diversion.

Upland Wildlife Habitat

Upland Wildlife Habitat Management provides for management of upland habitats and connectivity within the landscape for wildlife. This practice is used to treat upland wildlife habitat concerns identified during the conservation planning process that enable movement, or provide shelter, cover, food in proper amounts, locations and times to sustain wild animals that inhabit uplands during a portion of their life cycle.

Vegetated Swale

Vegetated swales are used in agricultural areas and are often considered landscape features. Swales are graded to be linear with a shallow, open channel of a trapezoidal or parabolic shape. Vegetation which is water tolerant is planted within the channel which promotes the slowing of water flow through the system. Swales reduce sediment and nutrients as water moves through the swale and water infiltrates into the groundwater.

Waste Utilization
Large volumes of manure are generated by small, unregulated animal operations located throughout the Lower Salt Creek watershed. Many entities have manure management plans in place and are currently using these plans to manage the volume of manure produced on their facility. Manure management planning includes consideration of the volume and type of manure produced annually, crop rotations by field, the volume of manure and nutrients needed for each crop, field slope, soil type, and manure collection, transportation, storage, and distribution methods. Manure management planning uses similar techniques to nutrient management planning with regards to nutrient budgets. Specific technical practices that can be included in manure management planning can include waste storage facilities and waste utilization.

Animal waste is a major source of pollution to waterbodies. To protect the health of aquatic ecosystems and meet water quality standards, manure must be safely managed. Good management of manure keeps livestock healthy, returns nutrients to the soil, improves pastures and gardens, and protects the environment, specifically water quality. Poor manure management may lead to sick livestock, unsanitary and unhealthy conditions for humans and other organisms, and increased insect and parasite populations. Proper management of animal waste can be done by implementing BMPs, through safe storage, by application as a fertilizer, and through composting. Proper manure management can effectively reduce E. coli concentrations, nutrient levels and sedimentation. Manure management can also be addressed in education and outreach to encourage farmers to participate in this BMP.

Water and Sediment Control Basin
A water and sediment control basin is an earthen embankment constructed across the slope of a minor watercourse to form a sediment trap and water detention basin with a stable outlet. This practice can reduce watercourse and gully erosion, trap sediment, and reduce downstream runoff. It is particularly applicable where watercourse or gully erosion is a problem and where sheet and rill erosion is controlled by other conservation practices. It can help in areas where sediment in runoff is severe, though it needs to be placed where adequate outlets can be provided.

Wetland Creation, Enhancement or Restoration
Visual observation and historical records indicate at least a portion of the Lower Salt Creek Watershed has been altered to increase its drainage capacity. Riser tiles in low spots on the landscape and tile outlets along the waterways in the watershed confirm the fact that the landscape has been hydrologically altered. This hydrological alteration and subsequent loss of wetlands has implications for the watershed's water quality. Wetlands serve a vital role in storing water and recharging the groundwater. When wetlands are drained with tiles, the stormwater reaching these wetlands is directed immediately to nearby ditches and streams. This increases the peak flow velocities and volumes in the ditch. The increase in flow velocities and volumes can in turn lead to increased stream bed and bank erosion, ultimately increasing sediment delivery to downstream water bodies. Wetlands also serve as nutrient sinks at times. The loss of wetlands can increase pollutant loads reaching nearby streams and downstream waterbodies.

Restoring wetlands in the watershed could return many of the functions that were lost when these wetlands were drained. Through this process, a historic wetland site is restored to its historic status.

These restored systems store nutrients, sediment, and *E. coli* while also increasing water storage and reducing flooding. Wetlands also provide additional habitat, stormwater mitigation, and recreational opportunities.

10.2 Best Management Practice Selection and Load Reduction Calculations

Table 71 details selected agricultural and urban best management practices and reflect those parameters which NRCS eFOTG, if appropriate, indicate can be utilized to impact each parameter. The critical area and the selected best management practices are based on subwatershed characteristics and available water quality data. Table 72 outlines suggested BMPs, estimated load reduction for nutrients and sediment (if available), and the target volume (area, length) and cost of each practice based on target volume. The steering committee identified BMPs that would be of interest to local producers, while the project coordinator calculated volume of BMPs necessary to meet project goals.

Table 71. Suggested Best Management Practices to address Lower Salt Creek critical areas. Note BMPs were selected by the steering committee.

Practice	Nutrients	Sediment	Pathogens
Access Control	X	X	X
Alternate Watering System	X	X	X
Bioreactor	X		
Bioretention – Rain Garden, Bioswale	X	X	X
Brush Management			
Composting Facility	X		X
Conservation Cover	X	X	X
Conservation Tillage	X	X	X
Cover Crop	X	X	X
Critical Area Seeding	X	X	
Curb Openings/Curbless Design	X	X	
Dam removal	X	X	
Diversion structures	X	X	
Drainage Water Management	X	X	
Drivable Grass	X	X	X
Fencing	X	X	X
Field Border or Filter Strip	X	X	X
Flow Splitter	X	X	X
Forage and Biomass Planting	X	X	X
Forest Management Plan	X	X	
FSI, Forest Trails and Landing	X	X	
Grade Stabilization Structure	X	X	
Grassed Waterway	X	X	X
Green Roof	X		
Greenways and Trails	X	X	
Habitat Corridor Identification and Improvement			X
Heavy Use Area Protection	X	X	X
Herbaceous Weed Control	X	X	

Practice	Nutrients	Sediment	Pathogens
Infrastructure Retrofits	X	X	X
Lined Waterway or Outlet	X	X	X
Livestock Pipeline	X	X	X
Mulching	X	X	X
Nutrient and/or Pest Management Plans	X		
Pervious Pavement	X	X	
Pollinator Planting	X	X	X
Prescribed Grazing	X	X	X
Pumping Plant	X	X	X
Rain Barrel	X	X	
Roofs and Cover	X	X	X
Roof Runoff Structure	X	X	X
Education: Septic System Care and Maintenance	X		X
Soil testing	X	X	X
Streambank Stabilization	X	X	
Subsurface Drain (Agricultural)	X	X	X
Threatened and Endangered Species Protection	X	X	
Treatment Vault	X		X
Tree Box Filter	X	X	
Tree Pruning	X	X	
Tree/Shrub Establishment	X	X	
Underground outlet	X	X	
Upland Wildlife Habitat	X	X	X
Vegetated Swale	X	X	
Waste Utilization	X		X
Water and Sediment Control Basin	X	X	
Wetland Creation, Enhancement, Restoration	X	X	X

The Region V model was used to estimate the approximate load reductions for BMPs unless otherwise noted (Appendix D). BMPs with dashes (-) do not have load reductions available using the Region V Model or other identifiable source. The target volumes of BMPs proposed to be installed are not required to be implemented as the quantities suggest. These targets are simply guidelines for achieving goals. Load reductions solely using this model meet the project targets for nitrogen, phosphorus and sediment goals for short, medium, and long-term goals. If the volume of practices specific in Table 72 is met, then the target loading rates detailed in Table 68 to Table 70 will be achieved. The Region V model does not provide estimated reductions for all suggested BMPs; these load reductions cannot be included in the calculations. The Lower Salt Creek steering committee set goals for each parameter, then selected best management practices which they can utilize to meet those goals. Best management practices were then phased to three 10-year terms (short, medium and long) with each phase of the goal being met by the same annual volume of best management practices. This results in the same number of best management practices targeted in each phase and the same cost for each best management practice within each phase. Table 73 details cost estimates by phase.

Table 72. Suggested Best Management Practices, target volumes to meet short, medium and long-term goals and their estimated load reduction by unit.

Suggested BMPs:	Lifetime Target (30 years)	Short Term (10 Year) Targets	Medium Term (20 Year) Targets	Long Term (30 Year) Targets	Unit	Nitrogen (lb/year)	Phosphorus (lb/year)	Sediment (t/year)
Conservation Cover (327) and Pollinator planting (420)	1,000	333	333	333	acre	23	11	10
Cover Crop (340)	9,600	3,200	3,200	3,200	acre	15	7	7
Critical Area Planting (342)	1,000	333	333	333	acre	15	7	7
Diversions (362)	30	10	10	10	units	0.4	0.2	0.2
Filter Strip (393)	1,000	333	333	333	acre	24	12	10
Forage and Biomass Planting (512)	30,000	10,000	10,000	10,000	acre	23	11	10
Grade Stabilization Structure (410)	30	10	10	10	unit	69.9	34.9	30.4
Grassed Waterway (412), Underground outlet (620), Mulching (484)	2,500	833	833	833	acre	232.9	116.4	101.3
Heavy Use Area Protection (561)	30,000	10,000	10,000	10,000	Ft^2	0.0014463	0.000712	0.000941
Livestock Restriction (Alt Watering System, Access Control)	5,280	1,760	1,760	1,760	feet	2.8	0.83	7.52
Nutrient/Pest Management (590)^	9,600	3,200	3,200	3,200	Acre	4.16	6.24	-
Prescribed Grazing (528)	30,000	10,000	10,000	10,000	acre	17	9	8
Residue and Tillage Management (329)	9,600	3,200	3,200	3,200	acres	21	10	11
Roof runoff structure (558)	300	100	100	100	units	-	-	-
Streambank Stabilization**	46,000	15,333	15,333	15,333	feet	0	0.83	14
Tree/shrub Establishment (612)	2,500	833	833	833	acre	10	5	5
Water and Sediment Control Basin (638)	60	20	20	20	unit	129.8	64.9	56.4
Urban BMPs (bioretention, rain barrel, rain garden, pervious pavement, treatments vaults, green roof)*	300	100	100	100	unit	0.5	0.2	0.2

^Assumes all nutrient management is non-manure based. Increase to 6.24 lb/ac/yr for N and 8.77 lb/ac/yr P for manure-based nutrient management.
**Assumes average width of 5 feet.
*Assumes average bioretention reduction – estimates could be higher or lower depending on the BMP selected and practice installed.

Table 73. Estimated cost for selected Best Management Practices to meet short, medium, and long-term goals.

Suggested BMPs:	Estimated Per Unit Cost	Unit	Short-term Estimated Cost	Medium-term Estimated Cost	Long-term Estimated Cost
Conservation Cover (327) and Pollinator planting (420)	$75	acre	$25,000	$25,000	$25,000
Cover Crop (340)	$25	acre	$80,008	$80,008	$80,008
Critical Area Planting (342)	$650	acre	$216,667	$216,667	$216,667
Diversions (362)	$90	units	$900	$900	$900
Filter Strip (393)	$75	acre	$25,000	$25,000	$25,000
Forage and Biomass Planting (512)	$75	acre	$750,000	$750,000	$750,000
Grade Stabilization Structure (410)	$2,500	unit	$25,000	$25,000	$25,000
Grassed Waterway (412), Underground outlet (620), Mulching (484)	$5,000	acre	$4,166,667	$4,166,667	$4,166,667
Heavy Use Area Protection (561)	$3	Ft^2	$30,000	$30,000	$30,000
Livestock Restriction (Alt Watering System, Access Control)	$1,000	feet	$1,760,000	$1,760,000	$1,760,000
Nutrient/Pest Management (590)	$4.00	Acre	$12,801	$12,801	$12,801
Prescribed Grazing (528)	$15.00	acre	$150,000	$150,000	$150,000
Residue and Tillage Management (329)	$15	acres	$48,005	$48,005	$48,005
Roof runoff structure (558)	$7	units	$700	$700	$700
Streambank Stabilization	$1,000	feet	$15,333,333	$15,333,333	$15,333,333
Tree/shrub Establishment (612)	$450	acre	$375,000	$375,000	$375,000
Water and Sediment Control Basin (638)	$2,500	unit	$50,000	$50,000	$50,000
Urban BMPs (bioretention, rain barrel, rain garden, pervious pavement, treatments vaults, green roof)	varies	unit	$83,333	$83,333	$83,333

10.3 Action Register

All activities to be completed as part of the Lower Salt Creek Watershed management plan are identified in Table 74. The goals set by the steering committee are listed below. Each objective in the action register corresponds to one or more goals and reflects the estimated amount of each BMP that will be needed in order to achieve the target load reductions. Nutrient and sediment removal efficiencies were not available for all BMPs, so the estimated number of BMPs needed was calculated based only on those BMPs that had load reduction estimates. For those BMPs that did not have associated load reduction estimates, the objective was developed with an amount of each BMP that the steering committee determined to be reasonably achievable. Therefore, if all the BMPs listed in all objectives are implemented, the total load reductions achieved will far exceed the load reductions needed to meet the water quality benchmarks.

Table 74. Action Register.

Goals	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
Nutrients, Sediment, *E. coli*	Coordinate on-the-ground cost-share program starting in 2023.	Landowners, agricultural producers (livestock and row crop)	Develop a cost-share program (2023).	$25,000 annually staffing	PP/TA: NRCS, SWCD, ISDA, Purdue Extension, Ag suppliers, USFS, DNR, FSA, MS4
			Implement cost-share program (2023-2053).		
			Identify and apply for potential funding sources to augment cost-share program including MRBI, RCPP, LARE, CWA and others. Once received, implement cost-share program per program guidance.		
Nutrients, Sediment, *E. coli*	Promote and fund conservation practices which emphasize livestock management, soil health, forest management and target urban BMP implementation (2023-2053).	Landowners, agricultural producers, municipalities, developers, plan commissions	Meet short term, medium term and long-term BMP targets (Table 72).	$2.3 million annually BMP implementation	PP/TA: NRCS, SWCD, ISDA, Purdue Extension, Ag suppliers, USFS, DNR, FSA, MS4, MCIRIS, KIC, Karst Conservancy
			Increase adoption of conservation plans and nutrient (including manure management) plans.		
			Increase adoption of forest management plans on private land.		
			Work with the USFS to identify funding to target forest management practices on federally owned lands.		
			Work with MS4 communities to ensure that urban BMPs are implemented on new construction and retrofits are included as possible on lands already developed.		
			Achieve short-term load reductions: 26% reduction in nitrate loading 21% reduction in total phosphorus loading and 20% reduction in total suspended solids loading.		
			Achieve medium-term load reductions: 35% reduction in nitrate loading, 26% reduction in total phosphorus loading and 24% reduction in total suspended solids loading.		
			Achieve long-term load reductions: 55% reduction in nitrate loading, 36% reduction in total phosphorus loading and 32% reduction in total suspended solids loading.		

Goals	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
Education; E. coli	Work with contractors and Health Depts to increase septic system maintenance and installation awareness (2023-2033).	Landowners, renters, municipalities	Produce and distribute septic maintenance brochure at local events, field days, city festivals and county fairs.	$5,000 annually	PP/TA: Purdue Extension, SWCDs, contractors, WWTP, Health Departments
			Offer cost-share incentives to producers proving voluntary septic maintenance.		
			Explore options for future septic system maintenance or upgrade assistance funding.		
Education (inorganic pollution)	Work with local entities to establish an inorganic pollution education program (2023-2033).	Schools, clubs, urban landowners, NGOs	Continue to promote trash pick up, annual clean up events and identify new opportunities (adopt a road, community corrections clean up events, student engagement) to reduce trash pollution.	$2,000 annually	PP: Farm bureau, MS4s, NGOs, schools, parks and rec, FOLM TA: MS4, SWCDs, parks and rec
			Establish an annual reporting mechanism to determine how much trash was saved from entering and removed from Lower Salt Creek streams.		
Flooding; Nutrients, Sediment, *E. coli*	Reduce peak flows from urban sources (2023-2030)	Landowners, developers, City of Bloomington, Indiana University, City of Bedford, Monroe County, Highway Dept	Work with the City of Bloomington to implement their Climate Action Plan which focuses on a) mitigating flood hazards and impacts and b) reducing stormwater impacts by 2030.	See plans for established budgets.	PP: City and county councils, Bloomington sustainability PP/TA: MS4s, SWCDs, cities, counties, contractors TA: IDEM, Karst conservancy
			Work with MS4 communities (Bedford, Bloomington, Monroe County, Indiana University) to implement their minimum control measures.		
			Coordinate efforts with the Bedford, Monroe County Comprehensive Plans; Indiana University Campus and Sustainability Master Plans.		
			Identify individual residents who can serve as ambassadors for residential BMP implementation, identify funding opportunities and implement a residential BMP demonstration program.		

Goals	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
	Protect and restore floodplains and stream buffers (2023-2053).	Landowners, producers, cities, counties, MS4s	Develop and implement a floodplain maintenance and reforestation program targeting urban and row crop agricultural areas.	$15,000 annually	PP/TA: DNR, USFS, NRCS, FSA, SWCD, consulting foresters, city foresters, plan commission PP: Sycamore Land Trust, private contractors, karst conservancy
			Identify high quality riparian lands and their owners.		
			Work with riparian landowners to protect high quality riparian lands via conservation easements, reforestation and/or restoration.		
			Conserve and protect open space networks and implement stormwater management and low impact development as noted in the Monroe County Urbanizing Area Plan and the Monroe County Long Range Stormwater Improvement Plan.		
Education (sense of place)	Create a cohesive education and outreach program focused on increasing public awareness and building a sense of place and watershed connectivity (2023-2033).	Schools, clubs, NGOs, urban landowners, City of Bloomington	Identify opportunities to highlight where you live, where your water flows, connection from Bloomington to Bedford.	$5,000 annually	PP: Farm bureau, MS4s, NGOs, schools, parks&rec, FOLM TA: MS4s, SWCD, parks&rec
			Implement sense of place and watershed connectivity education programming.		
			Promote local natural areas which provide access to Lower Salt Creek and its tributaries. Highlight options to engage with or get out onto water.		
			Once PCB delisting occurs, promote local fishing and recreation opportunities.		

Goals	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
Flooding; Nutrients, Sediment, *E. coli*	Increase storage and filtration (2023-2030).	Landowners, producers, cities, counties, MS4s	Increase tree canopy cover across the watershed by 2030.	$10,000 annually	PP/TA: DNR, USFS, NRCS, FSA, SWCD, consulting foresters, city foresters, plan commission PP: Sycamore Land Trust, private contractors, karst conservancy
			Work with the City of Bloomington to meet their Environmental Action Plan goal of 40% tree cover.		
Education	Educate Lower Salt Creek Project stakeholders about soil erosion, increase awareness about applicable BMPs, inorganic pollution and cost share opportunities (2023-2053).	Schools, producers, landowners, city/county councils	Develop an education plan targeting each practice identified above by 2023.	$25,000 annually	PP/TA: SWCDs, NRCS, Purdue extension, schools, Health Departments, SICIM, parks & rec, DNR, USFS, FSA, NRCS, karst conservancy PP: GM outreach coordinator, Friends of the Milwaukee Trail
			Create mechanism to promote each practice using methods including but not limited to press releases; workshops; field days; stream clean up; float trip; stream, field or pasture walk; website creation; local events; county fair booth; educational booth; and public mtgs.		
			Develop funding mechanism for education efforts.		
			The education program should include educational efforts which includes but is not limited to the following: all practices identified by the steering committee and noted in tables above; septic system use, maintenance and care; high quality natural areas; wetland protection and preservation and general stream processes.		
			Continue to maintain a project-based website and social media to promote events, cost share fund availability and build project awareness.		

Goals	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
Education (sense of place; public awareness)	Work with partners to identify and promote hands-on opportunities to improve natural areas and habitat within the Lower Salt Creek Watershed (2023-2053).	Landowners, developers, City of Bloomington, Indiana University, Bedford, Highway Department	Identify partner organizations which host field days, workdays, and clean-up events.	$5,000 annually	PP: City council, county council, Bloomington sustainability PP/TA: MS4s, SWCDs, cities, counties, contractors TA: IDEM, Karst conservancy
			Annually, identify partner work days for river clean-up, float trip, invasive species control, low-head dam safety education, septic system maintenance and education, trash removal, illegal dumping or habitat restoration opportunities and promote throughout the watershed.		
Nutrients, Sediment, *E. coli*	Monitor annual loading rates using IDEM fixed station data and consider options for delisting streams currently on IDEM's 303(d) list for E. coli and nutrients (2023-2053).	State agencies, SWCD, MS4s	Establish a USGS gaging station to coincide with IDEM's fixed monitoring station (Lower Salt Creek at Oolitic)	$55,000 per gaging station per year	PP/TA: USGS, IDEM, IDNR, Indiana University
			Collect E. coli samples no less than monthly concurrent with IDEM fixed station monitoring at Lower Salt Creek.		
			Every 10 years complete geometric mean E. coli monitoring (5 samples collected over 30 days) at the outlets of each Lower Salt Creek 12-digit HUC.		
Flooding, Nutrients, Sediment	Improve water quality and habitat to obtain passing mIBI, IBI, and QHEI scores and delist streams currently on IDEM's 303(d) list for IBC (2023-2053).	State agencies, SWCD, MS4s	Implement BMPs noted above targeting sediment, nutrients and E. coli reductions, flood mitigation, forest management and riparian habitat improvement.	$10,000 per assessment	PP/TA: USGS, IDEM, IDNR, Indiana University
			Implement the Bloomington Habitat Connectivity Plan to conserve and protect habitat before, during and after development and enhance habitat quality and improve habitat conservation.		
			Monitor fish and macroinvertebrate populations every five years and habitat annually.		

11.0 FUTURE ACTIVITIES

The next steps for the project include starting implementation of the Lower Salt Creek Watershed Management Plan. The Lawrence County SWCD in partnership with the project steering committee and other regional partners are in the process of submitting an implementation-focused grant application. If funded, this grant would provide funds for a cost-share program to install BMPs, promotion of the cost-share program, and an education and outreach program. If the grant is awarded, the steering committee will develop a cost-share program that will include steps to meeting the goals and management strategies of this plan. The anticipated cost-share program will use a ranking system to fund applications that will have the most impact in improving water quality. Factors such as location within watershed (priority areas), distance from streams, number of resource concerns addressed, and number of practices planned will be considered as part of the ranking process to further prioritize BMPs. It is anticipated that implementation efforts will target high priority critical areas and focus on the implementation of short-term goals.

11.1 Tracking Effectiveness

Implementation of policies, programs, and practices will improve water quality and watershed conditions within the Lower Salt Creek Watershed, helping reach goal statements by 2053. For each practice identified, an annual target for the acres or number of each BMP implemented is included in Table 72. Measurement of the success of implementation is a necessary part of any watershed project (Table 75). Both social indicator and water quality data will be used to measure observable changes following implementation. In order to track the project's progress of reaching goals and improving water quality, information and data will need to be continually collected during implementation.

Table 75. Strategies for and indicators of tracking goals and effectiveness of implementation.

Tracking Strategy	Frequency	Total Estimated Cost (Staff Time Included)	Partners/Technical Assistance
BMP Count	Continuous	$5,000	SWCDs, NRCS, ISDA, MS4
BMP Load Reductions	Continuous	$5,000	SWCDs, NRCS, ISDA, MS4
Attendance at Workshops/Field Days	Yearly	$500/workshop	N/A
Post Workshop Surveys for Effectiveness	Yearly	$250/workshop	SWCD, NRCS, Purdue Extension
Number of Educational Programs/students reached	Yearly	$250/program	N/A
Windshield Surveys	Every 4-5 years	$2,500 annually	SWCDs, Committee, ISDA
Tillage/Cover Crop Transects	Yearly	$20,000 in SWCD and ISDA staff time	SWCDs, NRCS, ISDA Staff
Number of educational publications/press releases	Yearly	$500/release	SWCD
IDEM Probabilistic Monitoring	Every 9 years	N/A (IDEM provides staff and funding)	IDEM

The tracking strategies illustrated in Table 75 will be used to document changes and aid in the plan re-evaluation. Activities to be completed as part of this watershed management plan are identified in the action register in Table 74. Table 76 identifies the annual target for the number or acres of BMPs to be installed during each implementation phase. Work completed towards each goal/objective documented will include scheduled and completed activities, numbers of individuals attending or efforts completed toward each objective, and load calculations for each goal, objective, and strategy. Overall, project progress will be tracked by measurable items such as workshops held, BMPs installed, meetings held, number of attendees, etc. Load reductions will be calculated for each BMP installed. These values and associated project details including BMP type, location, dimensions, load reductions, and more will be tracked over time and documented on the Indiana State Department of Agriculture Conservation Tracking sheet. Individual landowner contacts and information will be tracked for both identified and installed BMPs. The Lawrence County SWCD will be responsible for keeping the mentioned records.

Table 76. Annual targets for each best management practice.

Suggested BMPs:	Annual BMP Targets
Conservation Cover (327) and Pollinator planting (420)	33
Cover Crop (340)	320
Critical Area Planting (342)	33
Diversions (362)	1
Filter Strip (393)	33
Forage and Biomass Planting (512)	1,000
Grade Stabilization Structure (410)	1
Grassed Waterway (412), Underground outlet (620), Mulching (484)	83
Heavy Use Area Protection (561)	1,000
Livestock Restriction (Alt Watering System, Access Control)	176
Nutrient/Pest Management (590)	320
Prescribed Grazing (528)	1,000
Residue and Tillage Management (329)	320
Roof runoff structure (558)	10
Streambank Stabilization	1,533
Tree/shrub Establishment (612)	83
Water and Sediment Control Basin (638)	2
Urban BMPs (bioretention, rain barrel, rain garden, pervious pavement, treatments vaults, green roof)	10

11.2 Indicators of Success

Water quality, social, and administrative indicators will be used to monitor progress towards successful achievement of the short term, medium term and long term goals and will serve as a feedback mechanism to adapt and tailor future education and outreach efforts. Pre and post event surveys will occur at each educational event. The information collected from each survey and/or event will be used to inform future education and outreach strategies creating an adaptive education strategy as implementation of the watershed management plan moves forward. Water quality indicators will include monitoring total phosphorus, nitrate-nitrogen, total suspended solids and E. coli. Monitoring will occur as part of the Hoosier Riverwatch volunteer program, at a minimum. If local laboratory partners will continue to analyze collected samples as an in-kind service, laboratory data will be utilized as an indicator for each parameter. Administrative indicators will be listed with each strategy included in the action register.

Reduce Nutrient Loading

- Water Quality Indicator: Nitrate-nitrogen and total phosphorus will be measured monthly at the Salt Creek IDEM fixed station at Oolitic, Indiana. After five years of implementation, water quality samples will show a decreasing trend, with more samples annually meeting the target level for nitrate-nitrogen of 1.0 mg/L and for total phosphorus of 0.08 mg/L. Additionally, a loading rate reduction will be measured with the loading rate calculated for 2021 fixed station data.
- Administrative Indicator: The number of BMPs that can reduce nitrate-nitrogen total phosphorus will be tracked annually. The total number of acreage will be compared against annual targets identified in Table 76. Individual load reductions calculated for each BMP will be reviewed to determine if cumulative loading rates for nitrate-nitrogen and phosphorus are sufficient to meet the target reductions.

Reduce Sediment Loading

- Water Quality Indicator: Total suspended solids will be measured monthly at the Salt Creek IDEM fixed station at Oolitic, Indiana. After five years of implementation, water quality samples will show a decreasing trend, with more samples annually meeting the target level for total suspended solids.
- Administrative Indicator: The number of BMPs that can reduce total suspended solids will be tracked annually. The total number of acreage will be compared against annual targets identified in Table 76. Individual load reductions calculated for each BMP will be reviewed to determine if the cumulative loading rate for total suspended solids is sufficient to meet the target reduction.

Reduce *E. coli* Loading

- Water Quality Indicator: *E. coli* will be measured five times during 30 days during the growing season in year 5 of implementation. After five years of implementation, water quality samples will show a decreasing trend, with more samples annually meeting the state standard.
- Administrative Indicator: The number of BMPs that can reduce *E. coli* will be tracked annually. The total number of acreage will be compared against annual targets identified in Table 76.

Increase Public Awareness and Participation

- Administrative Indicator: The number of events and the number of people who attend education and outreach events will be tracked. The percent of targeted households reached will increase annually.
- Social Indicator: Pre and post surveys of attendees will be conducted at workshops to determine changes in individuals' knowledge of the topic as a result of attending the workshop. It would be expected that 75% of workshop attendees would have a better understanding of the topic after the workshop.

Address Inorganic Pollution

- Administrative Indicator: The number of events and the number of people who attend education and outreach events focused on inorganic pollution will be tracked. The percent of targeted households reached will increase annually.
- Social Indicator: Pre and post surveys of attendees will be conducted at workshops to determine changes in individuals' knowledge of the topic as a result of attending the workshop. It would be expected that 75% of workshop attendees would have a better understanding of the topic after the workshop.

Flooding and Loss of Natural Habitat/Floodplain

- Administrative Indicator: The number of logjams removed, linear feet of streambank erosion improved, linear feet of stream buffer addressed, acres of floodplain restored or reconnected, total number of annual flood events will be tracked. After five years of implementation, the total number of practices installed, flood duration and intensity will be reviewed and compared with data collected during the current study.

11.3 NEPA Concerns and Compliance

The National Environmental Policy Act (NEPA) was signed into law in 1970. The law requires federal agencies to assess the environmental impacts of their proposed actions prior to making decisions. This law also applies to watershed planning activities. As part of the planning process the NRCS is required to evaluate the individual and cumulative effects of proposed actions. Any project that has significant environmental impacts must be evaluated with an Environmental Assessment (EA) or Environmental Impact Statement (EIS) unless the activities are eligible under a categorical exclusion or already covered by an existing EA or EIS. The NRCS utilizes a planning process that incorporates an evaluation of potential environmental impacts using an Environmental Evaluation Worksheet. There are several NRCS conservation practices and activities that fall under a categorical exclusion. A categorical exclusion is a category of actions that do not normally create a significant individual or cumulative effects on the human environment. There are 21 NRCS approved conservation or restoration categorical exclusions identified in GM190 §410.6. These categorical exemptions include practices that reduce soil erosion, involve planting vegetation and restoring areas to natural ecological systems.

This watershed plan calls for conservation practices that control soil erosion and runoff from agricultural fields and structural practices to address runoff and waste management issues. Many of these practices are covered by either a categorical exclusion or may be included in an existing environmental assessment. A list of practices likely to be used to implement the plan is listed in Table 71 and Table 72.

Prior to practice implementation with USDA NRCS assistance, an NRCS CPA 52 Environmental Evaluation form will be completed for each practice. Using this form, each planned practice and practices system will be evaluated to determine if it meets the criteria of categorical exclusions and any existing Environmental assessments. Any adverse impacts from practices will first try to be avoided then minimized or mitigated as necessary. If resource concerns are found, NRCS will contact the agency with responsibility for the resource. Agencies will include but are not limited to US Fish and Wildlife Service and the State Historic Preservation Office. It is not anticipated that the practices planned for the Lower Salt Creek Watershed will require an Environmental Assessment or an Environmental Impact Statement.

12.0 OUTREACH PLAN

Based on steering committee knowledge, a multi-tiered strategy will be required to fully implement the Lower Salt Creek Watershed Management Plan. The plan will use targeted outreach to agricultural producers which will encourage the adoption of conservation practices to avoid, control and trap nutrients and sediment. Additional associated landowners will receive information about the project with the goal of raising awareness and informing the local community. For the targeted producers, outreach methods will include but not be limited to the following:

- Targeted landowner and producer mailings to announce the program and encourage the adoption of conservation practices. Mailings will occur no less than once but may occur annually, as needed.
- Practice specific field days and workshops. No less than 2 workshops or field days will occur annually.
- Newsletters. The Lower Salt Creek steering committee will work with partners to distribute information on a quarterly basis within partner newsletters including SWCD, county extension, FSA, and others.
- Post information at public locations such as farm and garden centers.
- Work with regional CCAs to provide information about the program.
- Maintain a project website which will be used to promote project events, announce fund availability and detail funding deadlines.
- Social media posts will occur on project social media no less than monthly and will be shared across partner social media as well.
- Radio announcements (PSAs) and news releases will occur no less than quarterly to local media.
- Additional options such as billboards, videos, tabling at community events, and others will be considered by the technical committee.

The following partners will be engaged as part of the outreach efforts:

- Natural resources conservation service (NRCS) conservationists provide technical assistance and expertise, coordinate conservation planning and distribute financial assistance for local producers. The Lawrence and Monroe County service centers provide assistance for Lower Salt Creek Watershed.
- Lawrence and Monroe County SWCD offices assist producers with conservation choices via farm planning assistance as well as targeted education and outreach.
- Indiana State Department of Agricultural staff provides technical assistance and expertise with conservation practice design and assessment.
- The Lower Salt Creek Watershed Project will provide education and outreach assistance and assist with program promotion.

12.1 Adapting Strategies in the Future

Due to the uncertainty of the watershed management planning, an adaptive management strategy will be implemented to improve the project's success. While much thought and expertise has been put into the planning process, not all scenarios can be foreseen. Oftentimes there are changes such as a shift in community attitude/behavior, changes in resource concerns, development of new information or accomplishing a goal sooner or later than expected. By implementing an adaptive management strategy, the Lower Salt Creek Project Steering Committee can adjust the watershed management plan to ensure project success. A four-step adaptive management strategy has been outlined for the Lower Salt Creek Watershed Project and can be found below.

Step 1: Planning The planning process used to develop the Lower Salt Creek WMP follows the IDEM 2009 Watershed Management Checklist. The project coordinator worked in concert with and was guided by the Lower Salt Creek Project Steering Committee to develop the WMP using knowledge of the watershed, inputs from stakeholders, new data from water monitoring and windshield surveys, and historical data. This plan includes goals, action register, and schedule outlining how and when to achieve the defined goals.

Step 2: Implementation The action register and schedule will be implemented to achieve the goals of the Lower Salt Creek Watershed Project objectives and goals. Partnering agencies such as NRCS, SWCD, ISDA, and IDEM will carry out the implementation. Implementation will include a cost-share program and education events targeting both for youth and adults. Practices implemented through the cost-share program will follow the NRCS Field Office Technical Guide (FOTG) Practice Standards or other technical standards as detailed in the cost-share program, once developed. The cost-share program will include but will not be limited to practices such as cover crops, watering facilities, fencing, conservation buffers, grassed waterways, and nutrient and pest management plans. Cost-share funding will be implemented in priority areas, addressing high priority areas before the medium priority area. A ranking system will be used to prioritize applications that will have the greatest impact on water quality improvement.

Step 3: Evaluate & Learn Evaluations of indicators identified above and in Table 75 will occur often to check the progress being made toward the project goals. The steering committee will annually review progress and determine if the project is on track to meet interim and project end goals outlined in the Action Plan (Table 74) and goals. Factors evaluated will include but will not be limited to numbers of BMPs installed, calculated/estimated load reductions of installed BMPs, number of individuals reach through outreach, etc. The evaluations will be conducted by the Lower Salt Creek Project Steering Committee. The group will then provide recommendations that will improve project success. Progress against the watershed management plan will be reviewed no less than every two years (i.e. 2021, 2023, etc).

Step 4: Alter Strategy The project's implementation and management strategy will be adjusted to improve the project's success. If progress is not made proportionate to the time into the project (i.e. at the end of year 3, approximately 30% (3/10) of 10 year goals should be met), the steering committee will have the opportunity to alter their strategy in order to meet the goals of the project. Adjustments will be based off of recommendations from the Evaluate and Learn step. Once the adjustments are agreed upon by the steering committee, the project will revert back to Implementation (Step 2) to continue with the Adaptive Management strategy (steps 2-4) until all goals have been met or all conservation opportunities have been exhausted.

The Lower Salt Creek Project coordinated by the Lawrence County SWCD, are responsible for maintaining records for the project including tracking plan successes and failures and any necessary watershed management plan revisions. The plan will be re-evaluated at the end of Year 5 and every 5 years after that.

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List of special species and high quality natural areas observed in the Lower Salt Creek Watershed. Source: Davis, 2021.

Common Name	Scientific Name	State Rank	Last Observation	Type
Allegheny Woodrat	Neotoma magister	SE	1982	Vertebrate Animal
American Badger	Taxidea taxus	SSC	1983-08-15	Vertebrate Animal
American Badger	Taxidea taxus	SSC	NO DATE	Vertebrate Animal
American Badger	Taxidea taxus	SSC	1989-08-16	Vertebrate Animal
American Burying Beetle	Nicrophorus americanus	SX	1906	Invertebrate Animal
American chestnut	Castanea dentata	SE	1990	Vascular Plant
American chestnut	Castanea dentata	SE	1990	Vascular Plant
American chestnut	Castanea dentata	SE	1990	Vascular Plant
American ginseng	Panax quinquefolius	WL	1990	Vascular Plant
American ginseng	Panax quinquefolius	WL	1990	Vascular Plant
American ginseng	Panax quinquefolius	WL	1990	Vascular Plant
American ginseng	Panax quinquefolius	WL	1990	Vascular Plant
American ginseng	Panax quinquefolius	WL	1990	Vascular Plant
American ginseng	Panax quinquefolius	WL	1990	Vascular Plant
American ginseng	Panax quinquefolius	WL	1990	Vascular Plant
An Agapetus Caddisfly	Agapetus gelbae	ST	1946-04-25	Invertebrate Animal
An Agapetus Caddisfly	Agapetus gelbae	ST	1946-04-25	Invertebrate Animal
Appalachian quillwort	Isoetes engelmannii	SE	1979-06	Vascular Plant
Aquatic Cave	Primary - cave aquatic	SG	1990-07-12	Terrestrial Community - Other Classification
bald eagle	Haliaeetus leucocephalus		2009-03-31	Vertebrate Animal
bald eagle	Haliaeetus leucocephalus		2020-03-31	Vertebrate Animal
Barn Owl	Tyto alba	SE	2002-07-22	Vertebrate Animal
Barr's Commensal Cave Ostracod	Sagittocythere barri	WL	1971-07-17	Invertebrate Animal
Barr's Commensal Cave Ostracod	Sagittocythere barri	WL	1969-04-10	Invertebrate Animal
Barr's Commensal Cave Ostracod	Sagittocythere barri	WL	1969-09-26	Invertebrate Animal

Common Name	Scientific Name	State Rank	Last Observation	Type
Black-and-white Warbler	Mniotilta varia	SSC	1988-SU	Vertebrate Animal
Black-and-white Warbler	Mniotilta varia	SSC	1988	Vertebrate Animal
Black-and-white Warbler	Mniotilta varia	SSC	1988	Vertebrate Animal
Black-and-white Warbler	Mniotilta varia	SSC	1989	Vertebrate Animal
Black-and-white Warbler	Mniotilta varia	SSC	1989	Vertebrate Animal
black-fruit mountain-ricegrass	Patis racemosa	ST	1982-07-19	Vascular Plant
Bollman's Cave Milliped	Conotyla bollmani	WL	2005	Invertebrate Animal
Bollman's Cave Milliped	Conotyla bollmani	WL	2000-08-20	Invertebrate Animal
Broad-winged Hawk	Buteo platypterus	SSC	1993-SU	Vertebrate Animal
Broad-winged Hawk	Buteo platypterus	SSC	1986-05-29	Vertebrate Animal
Broad-winged Hawk	Buteo platypterus	SSC	1986-06-29	Vertebrate Animal
butternut	Juglans cinerea	ST	1990	Vascular Plant
Cave Beetle	Pseudanophthalmus shilohensis	SE	1957	Invertebrate Animal
Cerulean Warbler	Setophaga cerulea	SE	1993-SU	Vertebrate Animal
cypress-knee sedge	Carex decomposita	ST	1935-06	Vascular Plant
Deam's two-seeded mercury	Acalypha deamii	WL	1999-08-31	Vascular Plant
eastern pygmy shrew	Sorex hoyi	SSC	1983	Vertebrate Animal
Eastern red bat	Lasiurus borealis	SSC	2016-06-13	Vertebrate Animal
Eastern red bat	Lasiurus borealis	SSC	2016-06-16	Vertebrate Animal
Eastern red bat	Lasiurus borealis	SSC	2004-07-15	Vertebrate Animal
Eastern red bat	Lasiurus borealis	SSC	2016-06-16	Vertebrate Animal
Eastern red bat	Lasiurus borealis	SSC	2004-07-18	Vertebrate Animal
forked bluecurl	Trichostema dichotomum	WL	1934-09	Vascular Plant
golden alexanders	Zizia aptera	WL	1979	Vascular Plant
golden seal	Hydrastis canadensis	WL	1990	Vascular Plant
golden seal	Hydrastis canadensis	WL	1990	Vascular Plant
golden seal	Hydrastis canadensis	WL	1990	Vascular Plant
golden seal	Hydrastis canadensis	WL	1990	Vascular Plant

Common Name	Scientific Name	State Rank	Last Observation	Type
golden seal	Hydrastis canadensis	WL	1990	Vascular Plant
golden seal	Hydrastis canadensis	WL	1990	Vascular Plant
golden seal	Hydrastis canadensis	WL	1990	Vascular Plant
golden seal	Hydrastis canadensis	WL	1990	Vascular Plant
golden seal	Hydrastis canadensis	WL	1990	Vascular Plant
grassleaf ladies'-tresses	Spiranthes vernalis	WL	1990-07	Vascular Plant
gray beardtongue	Penstemon canescens	SE	1935-06-08	Vascular Plant
gray beardtongue	Penstemon canescens	SE	1935-06-08	Vascular Plant
Henslow's sparrow	Centronyx henslowii	SE	1994-06-07	Vertebrate Animal
Hidden Springs Snail	Fontigens cryptica	SE	2005	Invertebrate Animal
Highland Rim Dry-mesic Upland Forest	Forest - upland dry-mesic Highland Rim	SG	NO DATE	Terrestrial Community - Other Classification
Highland Rim Dry-mesic Upland Forest	Forest - upland dry-mesic Highland Rim	SG	1988-05-18	Terrestrial Community - Other Classification
Hilly Springtail	Pseudosinella collina	SR	2005	Invertebrate Animal
Hooded Warbler	Setophaga citrina	SSC	2001-07-05	Vertebrate Animal
Hooded Warbler	Setophaga citrina	SSC	1989	Vertebrate Animal
Hooded Warbler	Setophaga citrina	SSC	1989-SP	Vertebrate Animal
Humped Springtail	Hypogastrura gibbosus	WL	2000-09-09	Invertebrate Animal
Illinois pinweed	Lechea racemulosa	SE	1935-07-21	Vascular Plant
Illinois woodsorrel	Oxalis illinoensis	WL	1990	Vascular Plant
Indiana Bat	Myotis sodalis	SE	2010-06-09	Vertebrate Animal
Indiana Bat	Myotis sodalis	SE	2016-06-15	Vertebrate Animal
Indiana Bat	Myotis sodalis	SE	2004-10-07	Vertebrate Animal
Indiana Bat	Myotis sodalis	SE	2012-05-15	Vertebrate Animal
Indiana Bat	Myotis sodalis	SE	2012-02-19	Vertebrate Animal
Indiana Bat	Myotis sodalis	SE	2018-02-10	Vertebrate Animal
Indiana Bat	Myotis sodalis	SE	2004-10-01	Vertebrate Animal
Indiana Bat	Myotis sodalis	SE	2004-09-09	Vertebrate Animal

Common Name	Scientific Name	State Rank	Last Observation	Type
Indiana Bat	Myotis sodalis	SE	2009-01-24	Vertebrate Animal
Indiana Cave Amphipod	Crangonyx indianensis	WL	2005	Invertebrate Animal
Jordan's groundwater isopod	Caecidotea jordani	SE	1961-02	Invertebrate Animal
Kidneyshell	Ptychobranchus fasciolaris	SSC	2010-08-11	Invertebrate Animal
large yellow lady's-slipper	Cypripedium parviflorum var. pubescens	WL	2002-05-05	Vascular Plant
Limestone Cliff	Primary - cliff limestone	SG	1983-07	Terrestrial Community - Other Classification
little brown myotis	Myotis lucifugus	SE	2004-07-15	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2004-07-15	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2004-07-15	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2004-06-03	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2004-06-11	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2004-09-23	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2004-10-07	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2005-04-20	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2004-12-26	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2004-10-01	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2005-01-13	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2004-09-29	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2004-09-27	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2004-09-28	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2009-01-24	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2018-01-25	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2016-02-03	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2005-09-09	Vertebrate Animal
little brown myotis	Myotis lucifugus	SE	2005-09-27	Vertebrate Animal
Little Spectaclecase	Villosa lienosa	SSC	2009-08-17	Invertebrate Animal
Loggerhead Shrike	Lanius ludovicianus	SE	1953	Vertebrate Animal

Common Name	Scientific Name	State Rank	Last Observation	Type
Monroe cave ground beetle	Pseudanophthalmus shilohensis mayfieldensis	SE	2005	Invertebrate Animal
narrow-leaved puccoon	Lithospermum incisum	SE	1921-04-26	Vascular Plant
Northern Casemaker Caddisfly	Goera stylata	SE	1947-05-28	Invertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2004-07-12	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2004-06-03	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2004-07-16	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2004-06-11	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2004-10-08	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2004-09-23	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2004-10-07	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2005-04-21	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2005-04-10	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2004-09-30	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2004-09-10	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2004-09-21	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2004-09-29	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2005-01-31	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2005-09-09	Vertebrate Animal
Northern Long Eared Bat	Myotis septentrionalis	SE	2005-09-27	Vertebrate Animal
ostrich fern	Matteuccia struthiopteris	ST	1934-09-07	Vascular Plant
Packard's Cave Amphipod	Crangonyx packardi	WL	2005	Invertebrate Animal
panic-grass	Dichanthelium mattamuskeetense	SX	1941-06	Vascular Plant
roundleaf water-hyssop	Bacopa rotundifolia	ST	1935-06-30	Vascular Plant
roundleaf water-hyssop	Bacopa rotundifolia	ST	1934-07-14	Vascular Plant
Rove beetle	Atheta annexa	WL	2000-09-09	Invertebrate Animal
sharp-scaled manna-grass	Glyceria acutiflora	SE	1935-06-30	Vascular Plant
Sharp-shinned Hawk	Accipiter striatus	SSC	1986-05-05	Vertebrate Animal

Common Name	Scientific Name	State Rank	Last Observation	Type
Sharp-shinned Hawk	Accipiter striatus	SSC	1989-SU	Vertebrate Animal
Sinkhole Swamp	Wetland - swamp sinkhole	SG	1983-09	Terrestrial Community - Other Classification
Smoky Shrew	Sorex fumeus	SSC	1983	Vertebrate Animal
Spatterdock Darner	Rhionaeschna mutata	ST	1998-05-18	Invertebrate Animal
Springtail	Isotoma anglicana	WL	2002-05-25	Invertebrate Animal
Springtail	Arrhopalites bimus	SE	1966	Invertebrate Animal
Springtail	Sinella alata	WL	2005	Invertebrate Animal
Springtail	Sinella alata	WL	2000-08-20	Invertebrate Animal
timber rattlesnake	Crotalus horridus	SE	NO DATE	Vertebrate Animal
trailing arbutus	Epigaea repens	ST	1921-06-10	Vascular Plant
trailing arbutus	Epigaea repens	ST	1990	Vascular Plant
trailing arbutus	Epigaea repens	ST	1981-04-15	Vascular Plant
Tricolored Bat	Perimyotis subflavus	SE	2004-07-14	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2004-07-15	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2004-07-15	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2004-06-03	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2004-07-17	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2005-04-25	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2005-01-18	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2004-10-07	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2005-04-21	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2004-09-03	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2004-09-08	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2004-10-10	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2005-01-13	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2005-01-12	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2004-09-26	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2005-02-13	Vertebrate Animal

Common Name	Scientific Name	State Rank	Last Observation	Type
Tricolored Bat	Perimyotis subflavus	SE	2005-02-19	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2005-02-05	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2004-10-09	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2009-01-24	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2018-01-25	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2018-02-10	Vertebrate Animal
Tricolored Bat	Perimyotis subflavus	SE	2005-09-09	Vertebrate Animal
Troglobitic Crayfish	Orconectes inermis inermis	WL	1967	Invertebrate Animal
Troglobitic Crayfish	Orconectes inermis inermis	WL	1896-07	Invertebrate Animal
Troglobitic Crayfish	Orconectes inermis inermis	WL	1975	Invertebrate Animal
Troglobitic Crayfish	Orconectes inermis inermis	WL	1971	Invertebrate Animal
Troglobitic Crayfish	Orconectes inermis testii	SR	2005	Invertebrate Animal
Troglobitic Crayfish	Orconectes inermis testii	SR	1975	Invertebrate Animal
Troglobitic Crayfish	Orconectes inermis testii	SR	1972	Invertebrate Animal
Troglobitic Crayfish	Orconectes inermis testii	SR	1972	Invertebrate Animal
Troglobitic Crayfish	Orconectes inermis testii	SR	1961	Invertebrate Animal
Troglobitic Crayfish	Orconectes inermis testii	SR	1897	Invertebrate Animal
Troglobitic Crayfish	Orconectes inermis testii	SR	1975	Invertebrate Animal
Upland Sandpiper	Bartramia longicauda	SE	1953-05	Vertebrate Animal
Water Fall and Cascade	Geomorphic - Nonglacial Erosional Feature - Water Fall and Cascade		2009-03-09	Geological Feature
Water Fall and Cascade	Geomorphic - Nonglacial Erosional Feature - Water Fall and Cascade		2009-02-17	Geological Feature
weakstalk bulrush	Schoenoplectiella purshiana	ST	1999-09-02	Vascular Plant
weakstalk bulrush	Schoenoplectiella purshiana	ST	1999-09-02	Vascular Plant
western ribbon snake	Thamnophis proximus proximus	SSC	NO DATE	Vertebrate Animal
woodland box turtle	Terrapene carolina carolina	SSC	2011-03-03	Vertebrate Animal
woodland box turtle	Terrapene carolina carolina	SSC	2011-03-16	Vertebrate Animal
woodland box turtle	Terrapene carolina carolina	SSC	2011-05-24	Vertebrate Animal

Common Name	Scientific Name	State Rank	Last Observation	Type
worm-eating warbler	Helmitheros vermivorus	SSC	1992-06-11	Vertebrate Animal
worm-eating warbler	Helmitheros vermivorus	SSC	1989	Vertebrate Animal

Subwatershed Name	Jackson Creek- Clear Creek	May Creek- Clear Creek	Little Clear Creek- Clear Creek	Hunter Creek- Little Salt Creek	Knob Creek- Little Salt Creek	Wolf Creek- Salt Creek	Goose Creek- Salt Creek	**TOTALS**
HUC	051202080801	051202080802	051202080803	051202080804	051202080805	051202080806	051202080807	
Area (acres)	16,068.3	19,185.7	13,271.0	18,987.1	15,427.3	25,229.0	22,085.7	130,254.1
% of Watershed	12%	15%	10%	15%	12%	19%	17%	100%
Stream (miles)	34.0	50.0	36.0	34.2	77.0	81.0	42.0	354
Impaired ECOLI 4A (miles)	34.00	46.89	33.05	0.00	21.88	32.77	15.86	184
Impaired Nutr 5A (miles)	0.00	9.12	0.00	0.00	0.00	0.00	0.00	9
Impaired PCBs 5B (miles)	5.68	17.49	9.77	0.00	0.00	32.49	19.56	85
Impaired biotic comm (miles)	10.43	3.58	0.00	5.50	10.58	30.74	11.61	72
Impaired DO (miles)	0.00	0.00	0.00	0.00	6.09	0.01	0.00	6
HEL (acres)	14,548.8	18,089.3	13,215.6	18,657.1	15,320.3	24,412.5	20,923.1	125,167
HEL (%)	90.5%	94.3%	99.6%	98.3%	99.3%	96.8%	94.7%	96%
Hydric (acres)	0.0	5.1	29.5	0.0	118.1	230.0	36.1	419
Hydric (%)	0.0%	0.0%	0.2%	0.0%	0.8%	0.9%	0.2%	0%
Septic-VeryLimited	4,431.0	11,808.6	8,600.7	15,123.0	13,100.2	16,813.8	18,199.9	88,077.3
Septic-VL (%)	27.6%	61.5%	64.8%	79.6%	84.9%	66.6%	82.4%	68%
Floodplain (acres)	895	665	772	231	2,912	3,573	3,190	12,238.3
Floodplain (%)	6%	3%	6%	1%	19%	14%	14%	9%
CFO (animals	0	0	0	0	0	0	68,000	
Hobby Farm (animals)	47	266	227	103	280	903	682	2,508
Manure estimate (tons)	778	6,438	4,866	1,933	5,719	19,510	13,985	53,229
Manure N estimate (lb)	583	5,213	2,432	1,194	3,075	9,475	7,300	29,272
Manure P estimate (lb)	329	2,809	1,208	642	1,557	4,694	3,660	14,899
Manure Ecoli Estimate (col)	2.07E+13	2.52E+14	1.27E+14	5.23E+13	2.07E+14	5.58E+14	4.80E+14	1.70E+15
Municipal Sludge App (acres)	0	0	0	0	0	480.2965	410.3055	891
Karst (acres)	1,310.2	4,309.8	1,651.8	173.1	261.9	2,099.6	7,704.7	17,511
Karts (%)	8%	22%	12%	1%	2%	8%	35%	13%
Livestock Access (miles)	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1
Livestock Access (%)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.6%	0.3%
Streambank Erosion (miles)	11.8	14.4	2.1	12.1	20.6	22.9	6.1	90
Streambank Erosion (%)	34.7%	28.8%	5.8%	35.4%	26.8%	28.3%	14.5%	25.4%
Narrow Buffer (miles)	0.0	0.0	0.0	0.0	0.6	0.0	0.0	1
Narrow Buffer (%)	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.2%
Subwatershed Name	Jackson Creek- Clear Creek	May Creek- Clear Creek	Little Clear Creek- Clear Creek	Hunter Creek- Little Salt Creek	Knob Creek- Little Salt Creek	Wolf Creek- Salt Creek	Goose Creek- Salt Creek	**TOTALS**
HUC	051202080801	051202080802	051202080803	051202080804	051202080805	051202080806	051202080807	

Land Use (acres)								
Ag - Row +Pasture	3,256.7	5,205.1	5,320.8	1,606.2	4,128.8	12,415.9	9,857.6	41,791
Forest	3,468.3	10,682.1	6,835.0	16,621.9	10,657.4	10,317.2	9,736.1	68,318
Wetland + Open water + grass	100.6	394.4	159.2	98.5	65.8	420.4	379.8	1,619
Urban	9,235.4	2,604.3	950.6	668.1	586.4	1,933.7	1,963.0	17,942
Land Use (%)								
Ag - Row +Pasture	20.3%	27.1%	40.1%	8.5%	26.8%	49.2%	44.6%	32%
Forest	21.6%	55.7%	51.5%	87.5%	69.1%	40.9%	44.1%	53%
Wetland + Open water + grass	0.6%	2.1%	1.2%	0.5%	0.4%	1.7%	1.7%	1%
Urban	57.5%	13.6%	7.2%	3.5%	3.8%	7.7%	8.9%	14%
LUST	140	24	3	0	0	6	16	189
NPDES	1	1	2	0	0	2	4	10
NPDES SSO	1	2	2	0	0	1	2	8
Superfund	4	0	0	0	0	0	0	4
VRP	4	1	0	0	0	0	0	5
Brownfields	12	2	0	0	0	0	0	14
Industrial Waste	13	8	0	0	0	1	0	22
Solid Waste	0	2	0	0	0	0	0	2
Waste Restricted	0	1	0	0	0	0	0	1

Subwatershed Name	Jackson Creek-Clear Creek	May Creek- Clear Creek	Little Clear Creek- Clear Creek	Hunter Creek-Little Salt Creek	Knob Creek-Little Salt Creek	Wolf Creek- Salt Creek	Goose Creek-Salt Creek	**TOTALS**
HUC	051202080801	051202080802	051202080803	051202080804	051202080805	051202080806	051202080807	
Historic Water Quality Samples Exceeding Targets								
Conductivity	66%	0%	0%	0%	1%	2%	0%	
Dissolved Oxygen	1%	5%	9%	0%	20%	5%	17%	
E. coli	69%	37%	33%	22%	42%	21%	21%	
Nitrate-Nitrogen	27%	20%	75%	0%	2%	15%	36%	
pH	0%	0%	0%	0%	0%	1%	0%	
Soluble phosphorus	0%	0%	0%	0%	0%	8%	0%	
Total Kjeldahl Nitrogen	0%	0%	0%	0%	0%	1%	0%	
Total Phosphorus	13%	10%	61%	0%	6%	12%	24%	
Total Suspended Solids	8%	0%	4%	0%	0%	12%	40%	
Turbidity	24%	56%	49%	15%	68%	62%	87%	
Tier 2 WQ Data								
Dissolved Oxygen	4%	5%	5%	0%	--	--	0%	
E. coli	46%	--	--	--	--	--	--	
Nitrate	38%	75%	100%	100%	--	--	33%	
Ortho P	45%	72%	95%	100%	--	--	100%	
Total Kjeldahl Nitrogen	0%	20%	22%	--	--	--	--	
Total Phosphorus	14%	70%	91%	--	--	--	--	
Turbidity	11%	13%	100%	0%	--	--	0%	

Date	DailyDischarge	Rank	PercentExceeded	NO_3 Load	TP Load	TSS Load
3/7/2022	5,791.36	1	0.27	15607.72	1248.62	312154.41
2/17/2022	4,311.17	2	0.55	11618.59	929.49	232371.87
9/22/2021	4,267.86	3	0.82	11501.88	920.15	230037.69
7/16/2021	4,199.83	4	1.10	11318.54	905.48	226370.73
6/19/2021	4,130.54	5	1.37	11131.81	890.54	222636.16
10/25/2021	3,558.26	6	1.64	9589.52	767.16	191790.46
6/13/2021	2,709.98	7	1.92	7303.40	584.27	146067.99
10/15/2021	2,707.38	8	2.19	7296.39	583.71	145927.89
7/1/2021	2,580.69	9	2.47	6954.95	556.40	139098.95
4/25/2022	2,200.61	10	2.74	5930.64	474.45	118612.71
2/22/2022	2,107.71	11	3.01	5680.28	454.42	113605.66
10/24/2021	2,004.06	12	3.29	5400.93	432.07	108018.67
3/23/2022	1,979.39	13	3.56	5334.45	426.76	106689.00
4/14/2022	1,741.12	14	3.84	4692.31	375.38	93846.12
4/13/2022	1,601.94	15	4.11	4317.23	345.38	86344.69
12/28/2021	1,579.86	16	4.38	4257.72	340.62	85154.45
7/8/2021	1,540.20	17	4.66	4150.83	332.07	83016.59
7/17/2021	1,405.62	18	4.93	3788.14	303.05	75762.90
2/18/2022	1,315.41	19	5.21	3545.04	283.60	70900.83
7/11/2021	1,249.49	20	5.48	3367.39	269.39	67347.77
3/22/2022	1,247.04	21	5.75	3360.78	268.86	67215.59
12/18/2021	1,217.50	22	6.03	3281.17	262.49	65623.33
6/3/2021	1,167.43	23	6.30	3146.21	251.70	62924.28
9/23/2021	1,063.99	24	6.58	2867.45	229.40	57348.92
12/29/2021	953.62	25	6.85	2570.01	205.60	51400.16
10/16/2021	912.28	26	7.12	2458.60	196.69	49171.96
12/11/2021	882.28	27	7.40	2377.74	190.22	47554.73
6/30/2021	879.55	28	7.67	2370.40	189.63	47407.99
3/8/2022	844.45	29	7.95	2275.80	182.06	45515.97
1/1/2022	824.99	30	8.22	2223.35	177.87	44467.05
1/9/2022	811.16	31	8.49	2186.07	174.89	43721.42
5/27/2022	782.68	32	8.77	2109.32	168.75	42186.47
10/30/2021	760.45	33	9.04	2049.42	163.95	40988.31
1/2/2022	748.87	34	9.32	2018.20	161.46	40363.95
3/19/2022	745.09	35	9.59	2008.03	160.64	40160.51
2/23/2022	734.77	36	9.86	1980.22	158.42	39604.37
3/24/2022	710.17	37	10.14	1913.91	153.11	38278.16
7/9/2021	698.15	38	10.41	1881.51	150.52	37630.18
6/20/2021	689.38	39	10.68	1857.87	148.63	37157.50
10/26/2021	687.60	40	10.96	1853.09	148.25	37061.86
4/26/2022	664.84	41	11.23	1791.75	143.34	35835.08
8/25/2021	655.97	42	11.51	1767.83	141.43	35356.61
7/2/2021	620.09	43	11.78	1671.15	133.69	33422.93
2/25/2022	594.25	44	12.05	1601.49	128.12	32029.85
2/2/2022	589.44	45	12.33	1588.54	127.08	31770.72
5/20/2022	582.66	46	12.60	1570.27	125.62	31405.49
4/15/2022	549.30	47	12.88	1480.37	118.43	29607.34
12/6/2021	543.91	48	13.15	1465.84	117.27	29316.79
7/18/2021	538.28	49	13.42	1450.67	116.05	29013.44
12/19/2021	530.15	50	13.70	1428.74	114.30	28574.87
10/29/2021	487.70	51	13.97	1314.35	105.15	26286.98

Date	DailyDischarge	Rank	PercentExceeded	NO3 Load	TP Load	TSS Load
9/24/2021	487.09	52	14.25	1312.70	105.02	26254.08
2/24/2022	484.04	53	14.52	1304.48	104.36	26089.62
2/19/2022	483.65	54	14.79	1303.45	104.28	26068.91
3/9/2022	474.86	55	15.07	1279.75	102.38	25595.01
7/15/2021	474.84	56	15.34	1279.69	102.38	25593.79
5/6/2022	471.81	57	15.62	1271.53	101.72	25430.54
5/26/2022	452.68	58	15.89	1219.98	97.60	24399.53
6/14/2021	446.55	59	16.16	1203.46	96.28	24069.14
6/4/2021	443.09	60	16.44	1194.14	95.53	23882.74
10/7/2021	442.46	61	16.71	1192.43	95.39	23848.63
2/3/2022	435.22	62	16.99	1172.93	93.83	23458.61
3/25/2022	434.22	63	17.26	1170.22	93.62	23404.40
5/28/2022	429.62	64	17.53	1157.83	92.63	23156.66
7/12/2021	426.65	65	17.81	1149.82	91.99	22996.46
12/16/2021	405.65	66	18.08	1093.21	87.46	21864.27
12/30/2021	399.35	67	18.36	1076.24	86.10	21524.80
10/28/2021	392.72	68	18.63	1058.39	84.67	21167.85
3/26/2022	392.18	69	18.90	1056.93	84.55	21138.61
12/17/2021	386.36	70	19.18	1041.25	83.30	20824.91
2/12/2022	378.60	71	19.45	1020.32	81.63	20406.44
10/17/2021	377.12	72	19.73	1016.33	81.31	20326.65
7/13/2021	371.70	73	20.00	1001.74	80.14	20034.87
6/2/2021	363.22	74	20.27	978.88	78.31	19577.54
11/18/2021	360.29	75	20.55	970.98	77.68	19419.65
9/20/2021	360.26	76	20.82	970.91	77.67	19418.13
1/3/2022	355.49	77	21.10	958.04	76.64	19160.77
10/27/2021	354.87	78	21.37	956.36	76.51	19127.27
4/16/2022	351.57	79	21.64	947.47	75.80	18949.40
9/21/2021	351.52	80	21.92	947.35	75.79	18946.97
10/31/2021	350.91	81	22.19	945.70	75.66	18914.07
4/27/2022	348.30	82	22.47	938.67	75.09	18773.37
4/12/2022	342.67	83	22.74	923.50	73.88	18470.02
3/10/2022	326.09	84	23.01	878.82	70.31	17576.43
4/18/2022	324.77	85	23.29	875.26	70.02	17505.16
3/20/2022	323.21	86	23.56	871.05	69.68	17421.10
2/26/2022	320.06	87	23.84	862.56	69.00	17251.15
5/7/2022	316.11	88	24.11	851.93	68.15	17038.57
9/5/2021	314.19	89	24.38	846.75	67.74	16935.01
12/27/2021	313.00	90	24.66	843.52	67.48	16870.45
7/19/2021	312.62	91	24.93	842.52	67.40	16850.34
12/12/2021	312.52	92	25.21	842.24	67.38	16844.86
4/6/2022	310.41	93	25.48	836.56	66.92	16731.14
12/25/2021	305.55	94	25.75	823.45	65.88	16469.09
12/20/2021	304.33	95	26.03	820.16	65.61	16403.24
6/21/2021	295.24	96	26.30	795.68	63.65	15913.50
9/15/2021	294.61	97	26.58	793.97	63.52	15879.45
1/10/2022	292.91	98	26.85	789.40	63.15	15788.02
2/20/2022	291.81	99	27.12	786.42	62.91	15728.33
12/26/2021	287.69	100	27.40	775.33	62.03	15506.61
12/31/2021	284.31	101	27.67	766.22	61.30	15324.48
7/10/2021	281.54	102	27.95	758.76	60.70	15175.24

Date	DailyDischarge	Rank	PercentExceeded	NO3 Load	TP Load	TSS Load
3/27/2022	280.51	103	28.22	755.98	60.48	15119.69
9/25/2021	277.57	104	28.49	748.04	59.84	14960.83
7/3/2021	273.63	105	28.77	737.44	59.00	14748.85
7/14/2021	272.71	106	29.04	734.94	58.80	14698.90
4/21/2022	272.28	107	29.32	733.79	58.70	14675.75
5/3/2022	269.93	108	29.59	727.45	58.20	14549.05
5/5/2022	266.60	109	29.86	718.50	57.48	14369.97
3/18/2022	265.61	110	30.14	715.83	57.27	14316.55
3/11/2022	264.17	111	30.41	711.95	56.96	14239.01
2/10/2022	260.59	112	30.68	702.30	56.18	14045.91
9/4/2021	259.05	113	30.96	698.13	55.85	13962.58
2/11/2022	255.44	114	31.23	688.41	55.07	13768.15
4/7/2022	253.77	115	31.51	683.91	54.71	13678.28
2/27/2022	250.91	116	31.78	676.19	54.10	13523.89
4/19/2022	249.73	117	32.05	673.03	53.84	13460.54
1/4/2022	248.08	118	32.33	668.58	53.49	13371.61
10/18/2021	248.04	119	32.60	668.46	53.48	13369.17
5/1/2022	241.26	120	32.88	650.18	52.01	13003.69
4/28/2022	235.66	121	33.15	635.11	50.81	12702.17
4/11/2022	235.39	122	33.42	634.37	50.75	12687.46
6/9/2021	231.75	123	33.70	624.57	49.97	12491.42
2/21/2022	222.11	124	33.97	598.59	47.89	11971.83
11/25/2021	221.28	125	34.25	596.36	47.71	11927.18
4/17/2022	220.89	126	34.52	595.30	47.62	11906.04
12/21/2021	219.56	127	34.79	591.71	47.34	11834.16
12/7/2021	219.07	128	35.07	590.40	47.23	11807.97
7/20/2021	212.18	129	35.34	571.82	45.75	11436.40
11/21/2021	208.01	130	35.62	560.59	44.85	11211.88
3/21/2022	206.86	131	35.89	557.48	44.60	11149.50
3/31/2022	206.62	132	36.16	556.85	44.55	11136.97
11/1/2021	206.11	133	36.44	555.47	44.44	11109.30
6/22/2021	205.62	134	36.71	554.16	44.33	11083.11
6/5/2021	204.52	135	36.99	551.17	44.09	11023.41
3/28/2022	203.00	136	37.26	547.09	43.77	10941.79
4/8/2022	202.37	137	37.53	545.40	43.63	10907.97
3/12/2022	197.11	138	37.81	531.22	42.50	10624.43
12/13/2021	196.80	139	38.08	530.37	42.43	10607.38
6/15/2021	195.26	140	38.36	526.23	42.10	10524.54
4/20/2022	188.66	141	38.63	508.44	40.68	10168.80
5/29/2022	187.98	142	38.90	506.61	40.53	10132.26
2/28/2022	187.04	143	39.18	504.08	40.33	10081.70
5/18/2022	185.35	144	39.45	499.51	39.96	9990.15
4/9/2022	184.98	145	39.73	498.51	39.88	9970.23
4/22/2022	184.87	146	40.00	498.24	39.86	9964.75
3/29/2022	183.64	147	40.27	494.92	39.59	9898.35
5/8/2022	183.00	148	40.55	493.18	39.45	9863.63
3/1/2022	181.04	149	40.82	487.91	39.03	9758.25
4/1/2022	179.88	150	41.10	484.78	38.78	9695.53
1/5/2022	179.87	151	41.37	484.75	38.78	9694.90
6/10/2021	178.84	152	41.64	481.97	38.56	9639.47
11/22/2021	177.89	153	41.92	479.42	38.35	9588.30

Date	DailyDischarge	Rank	PercentExceeded	NO_3 Load	TP Load	TSS Load
4/29/2022	177.64	154	42.19	478.75	38.30	9574.90
8/31/2021	176.57	155	42.47	475.86	38.07	9517.16
11/26/2021	173.73	156	42.74	468.21	37.46	9364.15
8/26/2021	172.28	157	43.01	464.31	37.14	9286.12
5/19/2022	171.75	158	43.29	462.86	37.03	9257.24
5/4/2022	170.73	159	43.56	460.11	36.81	9202.12
10/14/2021	170.48	160	43.84	459.45	36.76	9189.02
2/16/2022	167.99	161	44.11	452.74	36.22	9054.71
12/22/2021	166.83	162	44.38	449.60	35.97	8991.97
4/30/2022	166.59	163	44.66	448.96	35.92	8979.18
7/21/2021	164.32	164	44.93	442.84	35.43	8856.74
7/4/2021	162.44	165	45.21	437.78	35.02	8755.62
3/13/2022	162.10	166	45.48	436.87	34.95	8737.35
5/21/2022	158.98	167	45.75	428.46	34.28	8569.23
11/19/2021	157.10	168	46.03	423.38	33.87	8467.51
3/30/2022	155.74	169	46.30	419.72	33.58	8394.48
10/19/2021	154.41	170	46.58	416.13	33.29	8322.53
4/23/2022	153.42	171	46.85	413.48	33.08	8269.54
9/26/2021	152.96	172	47.12	412.23	32.98	8244.57
6/28/2021	152.60	173	47.40	411.25	32.90	8224.95
12/8/2021	147.26	174	47.67	396.88	31.75	7937.56
10/8/2021	146.71	175	47.95	395.39	31.63	7907.72
11/2/2021	146.36	176	48.22	394.44	31.56	7888.83
4/10/2022	145.92	177	48.49	393.25	31.46	7865.08
3/14/2022	144.02	178	48.77	388.14	31.05	7762.74
4/2/2022	142.83	179	49.04	384.93	30.79	7698.57
6/23/2021	142.43	180	49.32	383.84	30.71	7676.86
6/29/2021	139.78	181	49.59	376.70	30.14	7534.02
12/14/2021	138.00	182	49.86	371.90	29.75	7438.08
8/30/2021	137.60	183	50.14	370.84	29.67	7416.76
1/6/2022	136.81	184	50.41	368.71	29.50	7374.12
2/6/2022	136.70	185	50.68	368.40	29.47	7368.03
4/5/2022	136.35	186	50.96	367.47	29.40	7349.49
7/22/2021	135.64	187	51.23	365.54	29.24	7310.77
1/12/2022	133.76	188	51.51	360.48	28.84	7209.65
5/2/2022	133.22	189	51.78	359.03	28.72	7180.66
6/24/2021	129.49	190	52.05	348.99	27.92	6979.71
10/23/2021	129.35	191	52.33	348.59	27.89	6971.79
12/2/2021	129.21	192	52.60	348.21	27.86	6964.18
11/12/2021	128.12	193	52.88	345.28	27.62	6905.52
6/6/2021	126.94	194	53.15	342.10	27.37	6841.92
6/7/2021	126.14	195	53.42	339.96	27.20	6799.16
4/3/2022	126.08	196	53.70	339.77	27.18	6795.45
11/3/2021	123.69	197	53.97	333.35	26.67	6666.92
6/12/2021	123.28	198	54.25	332.25	26.58	6644.99
12/23/2021	123.27	199	54.52	332.22	26.58	6644.38
5/9/2022	122.65	200	54.79	330.55	26.44	6610.94
3/2/2022	122.64	201	55.07	330.51	26.44	6610.27
12/15/2021	121.62	202	55.34	327.77	26.22	6555.33
6/16/2021	121.47	203	55.62	327.36	26.19	6547.29
4/24/2022	118.45	204	55.89	319.21	25.54	6384.22

Date	DailyDischarge	Rank	PercentExceeded	NO_3 Load	TP Load	TSS Load
5/30/2022	118.15	205	56.16	318.40	25.47	6368.02
4/4/2022	117.99	206	56.44	317.97	25.44	6359.47
3/6/2022	117.29	207	56.71	316.09	25.29	6321.79
10/20/2021	116.55	208	56.99	314.09	25.13	6281.83
3/15/2022	116.37	209	57.26	313.61	25.09	6272.20
11/27/2021	116.19	210	57.53	313.12	25.05	6262.40
12/1/2021	115.76	211	57.81	311.97	24.96	6239.31
1/13/2022	115.43	212	58.08	311.08	24.89	6221.65
7/5/2021	114.44	213	58.36	308.41	24.67	6168.17
2/7/2022	111.85	214	58.63	301.45	24.12	6028.92
10/22/2021	110.59	215	58.90	298.03	23.84	5960.63
3/16/2022	110.06	216	59.18	296.62	23.73	5932.49
5/22/2022	109.22	217	59.45	294.35	23.55	5886.99
12/9/2021	109.15	218	59.73	294.17	23.53	5883.34
6/25/2021	108.63	219	60.00	292.75	23.42	5855.01
3/3/2022	107.98	220	60.27	291.00	23.28	5819.93
12/10/2021	107.63	221	60.55	290.06	23.20	5801.10
11/23/2021	106.13	222	60.82	286.03	22.88	5720.52
1/8/2022	105.29	223	61.10	283.76	22.70	5675.14
10/12/2021	105.26	224	61.37	283.67	22.69	5673.43
6/8/2021	104.99	225	61.64	282.96	22.64	5659.18
12/24/2021	104.64	226	61.92	282.02	22.56	5640.35
1/14/2022	103.88	227	62.19	279.97	22.40	5599.36
11/4/2021	103.29	228	62.47	278.36	22.27	5567.20
5/10/2022	102.30	229	62.74	275.69	22.06	5513.90
10/9/2021	101.45	230	63.01	273.41	21.87	5468.15
3/17/2022	99.31	231	63.29	267.64	21.41	5352.85
11/15/2021	96.76	232	63.56	260.76	20.86	5215.18
6/11/2021	95.63	233	63.84	257.73	20.62	5154.57
6/17/2021	95.03	234	64.11	256.11	20.49	5122.23
9/14/2021	93.42	235	64.38	251.78	20.14	5035.55
3/4/2022	93.38	236	64.66	251.65	20.13	5033.05
9/27/2021	92.46	237	64.93	249.17	19.93	4983.35
2/13/2022	91.68	238	65.21	247.07	19.77	4941.38
1/15/2022	91.65	239	65.48	247.00	19.76	4940.04
10/21/2021	91.24	240	65.75	245.88	19.67	4917.68
11/20/2021	90.79	241	66.03	244.67	19.57	4893.44
10/4/2021	88.79	242	66.30	239.30	19.14	4785.99
11/28/2021	88.71	243	66.58	239.08	19.13	4781.54
12/3/2021	88.70	244	66.85	239.05	19.12	4781.00
7/23/2021	88.24	245	67.12	237.81	19.03	4756.26
11/17/2021	87.52	246	67.40	235.88	18.87	4717.52
6/26/2021	86.27	247	67.67	232.49	18.60	4649.79
10/11/2021	84.95	248	67.95	228.93	18.31	4578.58
11/5/2021	84.21	249	68.22	226.95	18.16	4538.93
11/24/2021	83.53	250	68.49	225.12	18.01	4502.38
11/14/2021	83.08	251	68.77	223.91	17.91	4478.20
7/6/2021	82.96	252	69.04	223.58	17.89	4471.68
5/31/2022	81.69	253	69.32	220.16	17.61	4403.15
5/11/2022	78.42	254	69.59	211.35	16.91	4226.99
3/5/2022	77.86	255	69.86	209.84	16.79	4196.78

Date	DailyDischarge	Rank	PercentExceeded	NO3 Load	TP Load	TSS Load
11/29/2021	77.45	256	70.14	208.74	16.70	4174.73
9/6/2021	75.59	257	70.41	203.72	16.30	4074.34
10/3/2021	74.66	258	70.68	201.20	16.10	4024.03
11/13/2021	74.54	259	70.96	200.87	16.07	4017.45
8/27/2021	73.48	260	71.23	198.03	15.84	3960.68
10/2/2021	73.46	261	71.51	197.97	15.84	3959.40
9/1/2021	73.38	262	71.78	197.77	15.82	3955.38
11/6/2021	73.33	263	72.05	197.62	15.81	3952.46
6/18/2021	73.32	264	72.33	197.61	15.81	3952.21
5/25/2022	73.18	265	72.60	197.23	15.78	3944.66
5/23/2022	73.06	266	72.88	196.90	15.75	3938.02
5/15/2022	72.93	267	73.15	196.55	15.72	3930.96
1/25/2022	72.36	268	73.42	195.02	15.60	3900.38
7/7/2021	71.79	269	73.70	193.47	15.48	3869.31
7/24/2021	71.67	270	73.97	193.16	15.45	3863.22
7/30/2021	71.62	271	74.25	193.02	15.44	3860.48
10/6/2021	71.59	272	74.52	192.93	15.43	3858.65
12/5/2021	70.64	273	74.79	190.36	15.23	3807.24
11/11/2021	70.40	274	75.07	189.72	15.18	3794.45
10/13/2021	70.38	275	75.34	189.68	15.17	3793.66
11/16/2021	69.27	276	75.62	186.69	14.93	3733.72
9/29/2021	69.22	277	75.89	186.54	14.92	3730.80
1/24/2022	68.08	278	76.16	183.47	14.68	3669.40
5/12/2022	67.96	279	76.44	183.15	14.65	3663.00
12/4/2021	66.67	280	76.71	179.68	14.37	3593.62
9/28/2021	66.49	281	76.99	179.19	14.34	3583.81
6/27/2021	65.75	282	77.26	177.21	14.18	3544.16
5/16/2022	65.61	283	77.53	176.82	14.15	3536.30
11/30/2021	65.41	284	77.81	176.27	14.10	3525.46
8/29/2021	65.13	285	78.08	175.53	14.04	3510.66
11/7/2021	64.20	286	78.36	173.03	13.84	3460.59
10/10/2021	63.28	287	78.63	170.55	13.64	3411.00
1/19/2022	61.63	288	78.90	166.09	13.29	3321.70
7/25/2021	60.74	289	79.18	163.69	13.10	3273.83
5/14/2022	59.96	290	79.45	161.59	12.93	3231.86
9/16/2021	59.84	291	79.73	161.26	12.90	3225.16
1/23/2022	59.51	292	80.00	160.37	12.83	3207.43
5/13/2022	58.50	293	80.27	157.65	12.61	3153.04
1/26/2022	57.45	294	80.55	154.82	12.39	3096.33
1/20/2022	55.30	295	80.82	149.04	11.92	2980.90
5/24/2022	55.14	296	81.10	148.60	11.89	2972.06
11/8/2021	54.49	297	81.37	146.85	11.75	2937.10
11/9/2021	51.66	298	81.64	139.23	11.14	2784.70
7/26/2021	50.93	299	81.92	137.26	10.98	2745.22
1/7/2022	50.93	300	82.19	137.25	10.98	2745.05
1/18/2022	49.68	301	82.47	133.90	10.71	2677.92
1/22/2022	49.04	302	82.74	132.16	10.57	2643.13
2/9/2022	48.96	303	83.01	131.94	10.56	2638.87
5/17/2022	48.63	304	83.29	131.05	10.48	2620.90
1/27/2022	47.61	305	83.56	128.32	10.27	2566.44
9/30/2021	47.19	306	83.84	127.18	10.17	2543.60

Date	DailyDischarge	Rank	PercentExceeded	NO_3 Load	TP Load	TSS Load
11/10/2021	47.08	307	84.11	126.87	10.15	2537.45
10/5/2021	46.50	308	84.38	125.31	10.03	2506.26
1/28/2022	45.66	309	84.66	123.06	9.84	2461.18
7/27/2021	45.61	310	84.93	122.92	9.83	2458.32
6/1/2021	45.27	311	85.21	122.00	9.76	2440.05
1/11/2022	44.37	312	85.48	119.58	9.57	2391.69
7/29/2021	44.15	313	85.75	118.99	9.52	2379.81
2/1/2022	42.93	314	86.03	115.69	9.25	2313.72
7/31/2021	42.02	315	86.30	113.23	9.06	2264.68
10/1/2021	38.71	316	86.58	104.32	8.35	2086.45
7/28/2021	38.66	317	86.85	104.18	8.33	2083.59
8/19/2021	38.48	318	87.12	103.71	8.30	2074.15
1/16/2022	38.36	319	87.40	103.38	8.27	2067.51
9/7/2021	38.00	320	87.67	102.40	8.19	2048.08
2/15/2022	37.99	321	87.95	102.37	8.19	2047.47
1/21/2022	37.75	322	88.22	101.75	8.14	2034.98
8/28/2021	35.94	323	88.49	96.86	7.75	1937.27
1/29/2022	34.23	324	88.77	92.25	7.38	1844.93
8/1/2021	33.02	325	89.04	88.98	7.12	1779.69
9/18/2021	33.00	326	89.32	88.93	7.11	1778.60
1/30/2022	32.66	327	89.59	88.01	7.04	1760.14
1/31/2022	31.61	328	89.86	85.19	6.82	1703.89
9/2/2021	30.47	329	90.14	82.12	6.57	1642.46
9/8/2021	28.90	330	90.41	77.88	6.23	1557.60
2/5/2022	28.74	331	90.68	77.46	6.20	1549.14
9/17/2021	28.16	332	90.96	75.90	6.07	1518.07
8/2/2021	27.63	333	91.23	74.47	5.96	1489.44
8/3/2021	25.29	334	91.51	68.16	5.45	1363.17
8/4/2021	23.22	335	91.78	62.58	5.01	1251.52
9/9/2021	22.11	336	92.05	59.60	4.77	1191.94
8/5/2021	21.74	337	92.33	58.58	4.69	1171.60
2/4/2022	21.48	338	92.60	57.89	4.63	1157.77
9/3/2021	21.32	339	92.88	57.47	4.60	1149.31
8/20/2021	20.58	340	93.15	55.46	4.44	1109.16
8/15/2021	20.35	341	93.42	54.84	4.39	1096.80
8/6/2021	19.63	342	93.70	52.92	4.23	1058.30
9/19/2021	18.28	343	93.97	49.26	3.94	985.27
9/10/2021	18.00	344	94.25	48.52	3.88	970.46
8/7/2021	17.94	345	94.52	48.35	3.87	967.05
2/8/2022	17.33	346	94.79	46.70	3.74	934.03
8/9/2021	17.19	347	95.07	46.34	3.71	926.73
8/10/2021	16.86	348	95.34	45.44	3.64	908.82
2/14/2022	16.81	349	95.62	45.31	3.63	906.26
8/13/2021	16.54	350	95.89	44.57	3.57	891.40
8/8/2021	16.50	351	96.16	44.47	3.56	889.39
8/11/2021	16.39	352	96.44	44.16	3.53	883.30
8/14/2021	16.11	353	96.71	43.40	3.47	868.07
8/16/2021	15.58	354	96.99	41.99	3.36	839.81
9/11/2021	15.39	355	97.26	41.47	3.32	829.33
8/12/2021	15.26	356	97.53	41.13	3.29	822.63
9/13/2021	14.99	357	97.81	40.40	3.23	808.01

Date	DailyDischarge	Rank	PercentExceeded	NO3 Load	TP Load	TSS Load
1/17/2022	14.98	358	98.08	40.37	3.23	807.40
8/21/2021	14.82	359	98.36	39.94	3.20	798.87
8/17/2021	14.10	360	98.63	37.99	3.04	759.83
8/18/2021	13.49	361	98.90	36.37	2.91	727.36
9/12/2021	13.05	362	99.18	35.17	2.81	703.42
8/22/2021	13.05	363	99.45	35.17	2.81	703.30
8/23/2021	11.27	364	99.73	30.38	2.43	607.55
8/24/2021	10.24	365	100.00	27.59	2.21	551.81
TOTAL NUMBER OF DAYS FOR PERIOD		364				

Target Concentration	0.50	0.04	10.00
Conversion Factor	5.39	5.39	5.39

Date	Flow	Nitrate	TP	TSS	% Flow Exceed
6/2/21	363.22	2.3	0.16	45	20.27
7/7/21	71.79	0.2	0.039	72	73.70
8/11/21	16.39	0.3	0.062	47	96.44
9/27/21	92.46	1.1	0.056	15	64.93
10/25/21	3558.26	2.2	0.09	15	1.64
11/22/21	177.89	1.3	0.059	15	41.92
12/20/21	304.33	0.6	0.038	15	26.03
1/12/22	133.76	0.3	0.04	25	51.51
2/28/22	187.04	1	0.028	10	39.18
3/30/22	155.74	0.6	0.04	24	46.30
4/18/22	324.77	0.8	0.036	15	23.29
5/4/22	170.73	0.4	0.046	29	43.56
5/30/2022					
	Conversion Factor	5.39	5.39	5.39	

NO3 Act Load	TP Act Load	TSS Act Load	Ann Load Proxy Range
4502.833808	313.2406127	88098.92233	35
77.38622583	15.09031404	27859.0413	35
26.49895298	5.476450282	4151.502633	47
548.1682703	27.90674831	7475.021868	28
42193.90096	1726.11413	287685.6884	28
1246.479609	56.57099766	14382.45703	28
984.1946138	62.33232554	24604.86534	23
216.2896403	28.83861871	18024.13669	47
1008.169944	28.22875843	10081.69944	30
503.6685608	33.57790405	20146.74243	19
1400.412681	63.01857064	26257.73777	16

	NO3 Ann Load	TP Ann Load	TSS Ann Load
	157599.1833	10963.42145	3083462.282
	2708.517904	528.1609913	975066.4454
	1245.45079	257.3931633	195120.6238
	15348.71157	781.3889526	209300.6123
	1181429.227	48331.19565	8055199.275
	34901.42906	1583.987934	402708.7969
	22636.47612	1433.643487	565911.9029
	10165.6131	1355.415079	847134.4246
	30245.09832	846.8627529	302450.9832
	9569.702656	637.980177	382788.1062
	22406.60289	1008.29713	420123.8042
TOTAL	1,488,256.0	67,727.7	15,439,267.3
TARGET	319,122.3	25,529.8	6,382,446.1

Suggested BMPs	Eligible Area	BMP Targets	Unit
Conservation Cover (327) and Pollinator planting (420)	9,601.0	1,000	acre
Cover Crop (340)	9,601.0	9,601	acre
Critical Area Planting (342)	5,280.0	1,000	acre
Diversions (362)	all	30	units
Filter Strip (393)	5,280.0	1,000	acre
Forage and Biomass Planting (512)	32,189.0	30,000	acre
Grade Stabilization Structure (410)	all	30	unit
Grassed Waterway (412), Underground outlet (620), Mulching (484)	3,226.0	2,500	acre
Heavy Use Area Protection (561)	all	30,000	Ft2
Livestock Restriction (Alt Watering System, Access Control)	5,280.0	5,280	feet
Nutrient/Pest Management (590)^	9,601.0	9,601	Acre
Prescribed Grazing (528)	32,189.0	30,000	acre
Residue and Tillage Management (329)	9,601.0	9,601	acres
Roof runoff structure (558)		300	
Streambank Stabilization**	473,400.0	46,000	feet
Tree/shrub Establishment (612)	5,280.0	2,500	acre
Water and Sediment Control Basin (638)		60	unit

Suggested Urban BMPs
Bioretention
Bioswale
Green roof
Pervious pavement
Rain barrel
Rain garden
Treatment Vaults

Suggested BMPs	Total N Reduction	Total P Reducation	Total S Reduction
Conservation Cover (327) and Pollinator planting (420)	23,000	11,000	36,010
Cover Crop (340)	144,015	67,207	345,732
Critical Area Planting (342)	23,000	11,000	10,000
Diversions (362)			
Filter Strip (393)	24,000	12,000	58,510
Forage and Biomass Planting (512)	690,000	330,000	300,000
Grade Stabilization Structure (410)	2,097	1,047	912
Grassed Waterway (412), Underground outlet (620), Mulching (484)	582,250	291,000	253,250
Heavy Use Area Protection (561)	43	21	28
Livestock Restriction (Alt Watering System, Access Control)	14,784	4,382	356,506
Nutrient/Pest Management (590)^	39,940	59,910	
Prescribed Grazing (528)	510,000	270,000	684,300
Residue and Tillage Management (329)	201,621	96,010	648,260
Roof runoff structure (558)			
Streambank Stabilization**	0	38,180	3,105,920
Tree/shrub Establishment (612)	25,000	12,500	112,525
Water and Sediment Control Basin (638)	7,788	3,894	3,384
Suggested Urban BMPs			
Bioretention			
Bioswale			
Green roof			
Pervious pavement			
Rain barrel			
Rain garden			
Treatment Vaults			
TOTAL	2,287,539	1,208,152	5,915,336
Current	1,488,256.01	67,727.75	15,439,267.26
Target	638,244.6	51,059.6	9,573,669.1
Reduction	850,011.41	16,668.18	5,865,598.15

+/- Reduction Target	-1,437,527.1	-1,191,483.8	-49,738.2

Suggested BMPs	Estimated Cost per Unit	Total Estimated Cost
Conservation Cover (327) and Pollinator planting (420)	75	$75,000
Cover Crop (340)	25	$240,025
Critical Area Planting (342)	$650	$650,000
Diversions (362)		$90
Filter Strip (393)	75	$75,000
Forage and Biomass Planting (512)	75	$2,250,000
Grade Stabilization Structure (410)	$2,500	$75,000
Grassed Waterway (412), Underground outlet (620), Mulching (484)	$5,000	$12,500,000
Heavy Use Area Protection (561)	3	$90,000
Livestock Restriction (Alt Watering System, Access Control)	$1,000	$5,280,000
Nutrient/Pest Management (590)^	$4.00	$38,404
Prescribed Grazing (528)	$15.00	$450,000
Residue and Tillage Management (329)	$15	$144,015
Roof runoff structure (558)	$7	$2,100
Streambank Stabilization**	$1,000	$46,000,000
Tree/shrub Establishment (612)	$450	$1,125,000
Water and Sediment Control Basin (638)	$2,500	$150,000
		250000
Suggested Urban BMPs		$69,394,634
Bioretention		$2,313,154.47
Bioswale		
Green roof		
Pervious pavement		
Rain barrel		
Rain garden		
Treatment Vaults		
TOTAL		$69,142,444.00