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Project Manager: Josh Brosmer

BIG WALNUT CREEK WATERSHED MANAGEMENT PLAN
BOONE, HENDRICKS AND PUTNAM COUNTIES, INDIANA

A PROJECT OF THE
BIG WALNUT WATERSHED ALLIANCE
C/O PUTNAM COUNTY SOIL AND WATER CONSERVATION DISTRICT
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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 Big Walnut Creek Watershed includes all the land that enters Big Walnut Creek from its 270,768 acre (423 square mile) drainage. The watershed includes four 12-digit hydrologic unit codes (HUCs) including 0512020301, 0512020302, 051202020303, and 051202020304. The Big Walnut Creek Watershed is comprised of two major branches: Big Walnut Creek and Deer Creek. Big Walnut Creek starts in Boone County immediately south of Lebanon and flows southwesterly through northwest Hendricks County into Putnam County. Deer Creek drains the area south and east of Greencastle flowing west to join with Little Deer Creek joining Mill Creek immediately south of US Highway 70. The stream continues westerly through Putnam County where it meets Big Walnut Creek to form the Eel River. Mill Creek carries water from Cagles Mill (Cataract) Lake. The Eel River flows south and west to join with the White River near Worthington draining 772,476 acres (1,206 square miles; Figure 1).

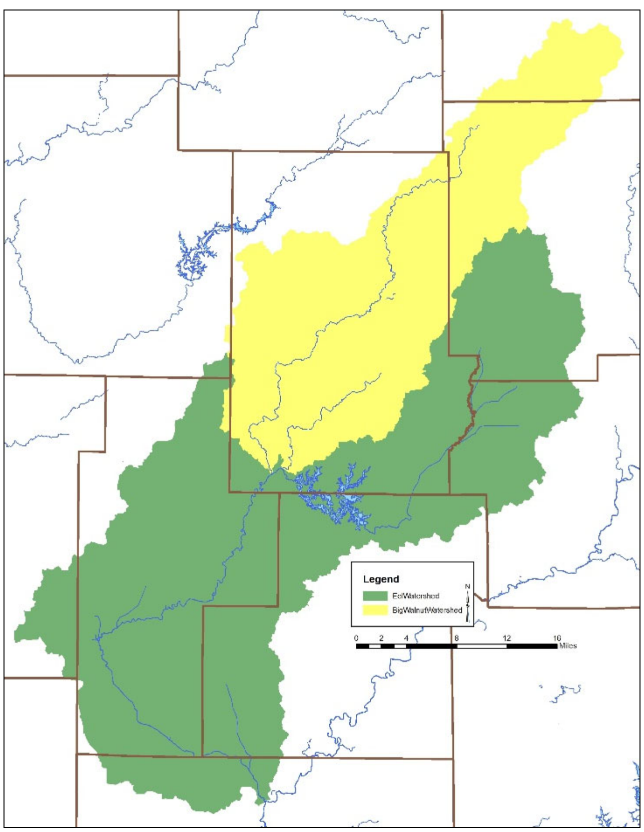

Figure 1. The Eel River Watershed highlighting the Big Walnut Creek Drainage.

1.2 Project History

The Big Walnut Watershed Alliance was formed in 2006 as a result from a Section 319 grant awarded to develop the Big Walnut Creek Watershed Management Plan. The plan was completed in 2009 and a subsequent implementation grant was awarded from Section 319 funds. Utilizing these funds, projects targeting sediment were implemented from 2009 to 2012 resulting in more than 22,446,000 tons of sediment being kept out of Big Walnut Creek. Both the phosphorus and sediment goals developed as part of the planning process were met during this implementation process. Concurrently, the Indiana Department of Environmental Management (IDEM) utilized Section 319 funds and partnered with other state and federal partners, including the Putnam SWCD Upper Eel River Manure Management project, the Sycamore Trails RC&D Upper Eel River Manure Management program, Sycamore Trails RC&D Big Walnut-Deer Creek conservation buffer project and the Owen County SWCDs CORE 4 initiative, to support numerous watershed restoration projects from 1999 through 2007. As a result of the 2007 IDEM water quality assessment, IDEM identified a 96% reduction in E. coli the East Fork Big Walnut and an 82% reduction in E. coli in the West Fork Big Walnut and subsequently removed six segments of Big Walnut Creek from the 2010 impaired waters list (EPA, 2009). Since the last grant, the Big Walnut Watershed Alliance continues to meet on a regular basis promoting water quality awareness, watershed tours and canoe trips to highlight water quality.

The Big Walnut Creek Watershed includes the City of Greencastle and the towns of Barnard, Bainbridge, Fillmore, Jamestown, Lizton, Groveland, Morton, Manhattan, Mt. Meridian, North Salem, and Heritage and Glenn Flint Lakes. These communities are scattered evenly throughout the watershed. The watershed includes a variety of land uses including agricultural, forest and natural areas, including nature preserves, as well as urban and urbanizing land uses. The northern headwaters are almost exclusively in row crop agricutural production with pastureland and forests increasing as the watershed moves south. The southern portion of the watershed is heavily forested with pastureland and row crops scattered thoughout the southern drainage. The change in glacial pattern from glaciated in the northern portion of the watershed to unglaciated near the confluence with Mill Creek results in steep, highly erodible hills and valleys which contribute to water quality issues, especially during storm flow conditions.

The Big Walnut Watershed Alliance has continued to observe changes in the watershed through the completion of watershed inventories and landowner meetings. A 2015 windshield survey identified livestock access to watershed tributaries as a continued concern. Tributary *E. coli* concentrations are elevated beyond the state standard and sediment loads are elevated throughout the watershed. Two thirds of the corn and half of the soybeans in Putnam County are planted to no till but with increased agricultural production, the changes in land use from forested to row crop agriculture continues to negatively impact Big Walnut Creek. Additionally, observable changes in land use continue to impact water quality, including increased construction, growth in incorporated urban areas, migration of populations from incorporated areas to more rural portions of the watershed, recreational land use changes which result in additional stream access points and groundwater withdrawal and wellfield recharge. Based on these changes, the Big Walnut Watershed Alliance approached community groups and individuals throughout the watershed that might be interested in working with them to assess and improve water quality within Big Walnut Creek and its tributaries and update the previous watershed management plan. Identified potential stakeholders include: City of Greencastle; Boone, Hendricks and Putnam County Soil and Water Conservation Districts, Clear Creek Conservancy District, Little Walnut Creek Conservancy District, Indiana State Department of Agriculture, Purdue Extension Putnam County, and the Natural Resources Conservation Service. 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 the Big Walnut Creek Watershed. All of these efforts were guided by the following mission and vision developed by public participants and committee members:

Mission: The Big Walnut Watershed Alliance is a group of concerned citizens focused on improving water quality in Big Walnut and Deer Creek areas by raising public awareness, protecting natural areas and the sustainability of adjacent landscapes.

Vision: Water - you're waiting for it.

The mission and vision are works in progress and may change as the project moves forward.

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 Big Walnut Watershed Alliance involved stakeholders in the watershed management planning process through a series of public meetings, and education and outreach events including windshield surveys, water quality monitoring opportunities, and meetings with local officials.

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 nearly every other month to develop the WMP, starting in December 2017. Table 1 identifies the steering committee members and their affiliation.

Table 1. Big Walnut Creek Watershed steering committee members and their affiliation.

Individual	Organization(s) Represented
Shane Johnson	Putnam SWCD
Kristi Kennedy	Putnam NRCS
Jenna Nees	Putnam Purdue Extension
David Penturf	Putnam Surveyors office
Lisa Zeiner; Jessica Watson	Putnam Health Department
Matt Williams	Putnam ISDA Resource Specialist
Bree Ollier	Hendricks SWCD
Jerod Chew	Hendricks NRCS
Beth Switzer	Hendricks Purdue Extension
Tyler Trout	Hendricks ISDA Resource Specialist
Sheryl Vaughn	Boone SWCD
Angela Garrison	Boone NRCS
Curt Emanuel	Boone Purdue Extension
Scott Zimmerman	City of Greencastle MS4
Ken Rozelle	Clear Creek CD/Heritage Lake POA
Kathy Deer	Little Walnut CD

Individual	Organization(s) Represented
Jeane Pope	DePauw
Sarah Wolfe	Hendricks County Parks
Cliff Chapman	Central Indiana Land Trust (CILTI)
Charlie Beard	Heritage Lake
Tom Swinford	IDNR Division of Nature Preserves

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. There were four public meetings held on 22 August 2018 and as part of SWCD annual meetings in the spring of 2019 and 2020. The public meetings were used to introduce the project and 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 were advertised through press releases distributed to local newspapers in the watershed and via postcards and emails sent to local landowners and conservation partners. The meetings were also advertised through word of mouth as staff from the Soil and Water Conservation District put together mailings that advertised the events and the Ouabache Land Conservancy distributed information via their website and social media pages as well as through their email distribution list.

The first public meeting was held on 22 August 2018 at the Farm Bureau Building in Greencastle, Indiana. Attendees represented citizens, farmers, conservation partners, and city officials. During this meeting, the Putnam County SWCD detailed the history of the project; described opportunities for individuals to volunteer as part of the project; and provided attendees with the opportunity to identify their concerns about the Big Walnut Creek Watershed and develop goals for the long-term vision of watershed streams.

A second, third and fourth public meetings were held as part of the annual Soil and Water Conservation District annual meetings in 2019 and 2020. At each meeting an update on the status of the project was provided and feedback on critical areas, practices selected for implementation and the likelihood of meeting project goals gathered.

1.4 <u>Public Input</u>

Throughout the planning process, project stakeholders, the steering committee, and the general public listed concerns for the Big Walnut Creek Watershed including Big Walnut 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, and watershed inventory process. Note: The order of concern listing does not reflect any prioritization by watershed stakeholders.

Stakeholder Concerns
Livestock access in the stream
Streambank erosion
Large rain events causing damage to streambanks
Greencastle is developing a stormwater management plan – does the city have sufficient resources to implement and manage that plan?
Nutrient runoff
Water quality concerns – sediment, nutrient, pathogen levels are elevated within watershed streams
Lack of resources to sufficiently support implementation
Sedimentation to Heritage Lake
Water quality is poor at Glen Flint Lake
Water clarity is poor at Heritage Lake
Big Walnut Creek is muddy when it rains
Lowhead dam on Big Walnut Creek
Groundwater/well issues near CR 1025/SR 75
Trail and streambank erosion at the DePauw Nature Park
Streams are more flashy than historically
Stream channel is migrating to a new location
Developments are not utilizing proper stabilization techniques
Streambed erosion – some areas eroded to bedrock with sand and gravel depositing in other locations
Flooding – loss of farmland each time it floods
Development is diffuse – lots of small developments in historically forested or agricultural areas
Blue green algae blooms occurring in watershed reservoirs
Trash is dumped in watershed streams
Greencastle well fields lie within the Big Walnut drainage – award winning for taste – need to maintain quality
Woodlots are impacted by erosion – losing more trees each time it rains
Fish populations are impacted by changes in stream – more erosion and more sediment
Chemicals from farming are impacting Big Walnut
Water infiltration and storage is needed to slow the flow of water into streams
Stream water levels are lower than historically observed
Concern that there may be interest in damming Big Walnut or tributaries for flood control
Invasive species are present in natural areas/forested areas along streams
How will this planning process affect me, my taxes or my property?
Septic usage on soils which are limited for treatment – education focus
Soil erosion
Silt removal/dredging from reservoirs
Limited public access
Industrial impacts
Confined feeding operations and associated manure
Limited education about adequate forestry BMPs

1.5 Social Indicator Surveys

The ability of the Big Walnut Creek Watershed steering committee and other stakeholders to conduct effective education and outreach depends on:

- understanding how people feel about local water resources
- how much they know about water quality concerns
- what practices they adopt on the land they manage
- what factors affect their land management decisions

Social indicator surveys provide one way to analyze these attitude, awareness, behavior, and constraint measures. The data obtained provide a snapshot of a given time, helping to direct outreach efforts and allowing for measurement of temporal change observed since the previous social survey (2010) and during future assessments. The steering committee members reviewed the previous agricultural and urban social indicator surveys and modified the survey to fit current conditions.

1.5.1 Survey Methods

Because the Big Walnut Creek Watershed is almost mixed urban and agricultural, two surveys were deployed. The 12-page urban survey was sent to 415 individuals and businesses within Greencastle and surrounding Heritage Lake using an updated version of the 2010 survey mailing list. In total, 179 urban surveys were returned for a response rate of 43%. The 12-page agricultural survey was sent to 334 addresses in the watershed. In total, 115 agricultural surveys were returned for a response rate of 37%. The 2019 surveys are detailed in Appendix A.

A standardized delivery and collection method was used. In July 2019, a five-wave mail survey was utilized to collect the urban data, while agricultural surveys were mailed using the same system in November 2019 (Dillman, 2000). An advance notice postcard was sent to potential respondents to inform them of the survey's purpose and to notify them that they would be receiving a paper survey in the next week. This postcard also included instructions on how to complete the survey online. The paper survey was sent the following week and included verbiage similar to the original advance letter, instructions for completing the survey online, and a summary of the survey's purpose. A postcard reminder was sent two weeks later, followed by a replacement survey the following week. After two more weeks, a third replacement survey was sent to all non-respondents.

The survey covered the social indicators developed for use in 319-funded watershed projects and mimics the 2010 survey to allow for comparison of 2010 and 2019 collected data. The indicators are grouped into four categories: awareness, attitudes, constraints, and behaviors. Socio-demographic information was also collected. Descriptive summaries for the survey are included below. Detailed tables are included in Appendix A.

1.5.2 Survey Results

As detailed above, the agricultural survey was sent to 334 producers and resulted in a 34% return rate, while urban surveys were sent to 416 individuals with a response rate of 43%.

Water as a Resource

Respondents were asked to rank the importance of a number of water-related activities. For "canoeing, kayaking and other boating activities", "for fish habitat" and "for eating fish caught in the water" ranked the highest for agricultural survey respondents. Urban respondents noted "for scenic beauty", "for picnicking and family activities near the water" and "for canoeing and kayaking and other boating" as their highest qualities. It should be noted that agricultural respondents indicated a more positive feeling overall towards Big Walnut Creek than urban respondents. The vast majority of respondents stated that they know where the rainwater goes when it leaves their property and were able to name that body of water.

Water Quality Attitudes

Respondents were asked to rank their level of agreement with a number of statements related to their attitudes toward water quality, including its importance to the community, the financial ramifications of management practices, and levels of personal responsibility. This section assessed a baseline set of attitudes towards water quality that can be used as a basis for comparison in future social indicator surveys once practices, education, and outreach have been implemented. A 1-to-5 "strongly disagree" to "strongly agree" scale was used. Agricultural respondents also note that the economic stability of their community depends on good water quality, using recommended management practices on their farm improves water quality and that it is their personal responsibility to protect water quality. They are less supportive of protecting water quality if it cost them more and the statement that investing in water quality protection puts farmers at an economic disadvantage. In general, urban respondents believe the economic stability of their community depends on good water quality, it is their personal responsibility to help protect water quality and that it is important to protect water quality even if it slows economic development. They are supportive of the ideas that lawn and yard care impacts water quality, what they do on their land makes a difference in overall water quality and that taking actions to improve water quality is not too expensive for them.

Familiarity with Water Impairments

Respondents were asked to rate the severity of numerous water impairments. Agricultural respondents demonstrated awareness of "trash and debris" and "sedimentation" as problematic water quality issues, rating both between slight and moderate problems. Respondents were less aware of water quality problems due to Bacteria, Phosphorus, Nitrogen, and Pesticides, with around 30% of respondents indicating that they "don't know" about the severity these issues. These responses suggest that the most visible water quality problems are the ones readily identified by the respondent community. Urban respondents noted algal growth, phosphorus and trash and debris as problematic water quality issues rating them between slight and moderate problems. Like agricultural respondents, all other water quality problems rated nearly 30% don't know.

Consequences of Poor Water Quality

Respondents were asked to evaluate the consequences of poor water quality. Agricultural respondents noted soil erosion from farm fields, soil erosion of shorelines or streambanks, excessive use of lawn fertilizers or pesticides, improper disposal of household wastes, and manure from farm animals as slight to moderate problems. For urban respondents, excessive aquatic plants, high drinking water costs, fish kills, and contaminated fish rated as slight to moderate problems. These responses suggest that respondents are most aware of visible and recreational-related issues, but for those that are aware of other issues, fish and algae blooms are the most serious issues. Though it is worth noting that less than a quarter of respondents deem any of the issues to be moderate to severe problems.

Familiarity with Specific Agricultural Practices

Respondents were asked questions about their familiarity with specific conservation practices. Responses are noted below (Figure 2). Between 11 and 35% of respondents currently use these practices with soil testing (11%) used the least and manure application (35%) used the most. Between 9 and 23% of respondents had not heard of these practices with 9% of respondents unfamiliar with manure application, 17% unfamiliar with variable rate application, 18% unfamiliar with university recommended rates and 23% of respondents unfamiliar with soil testing.

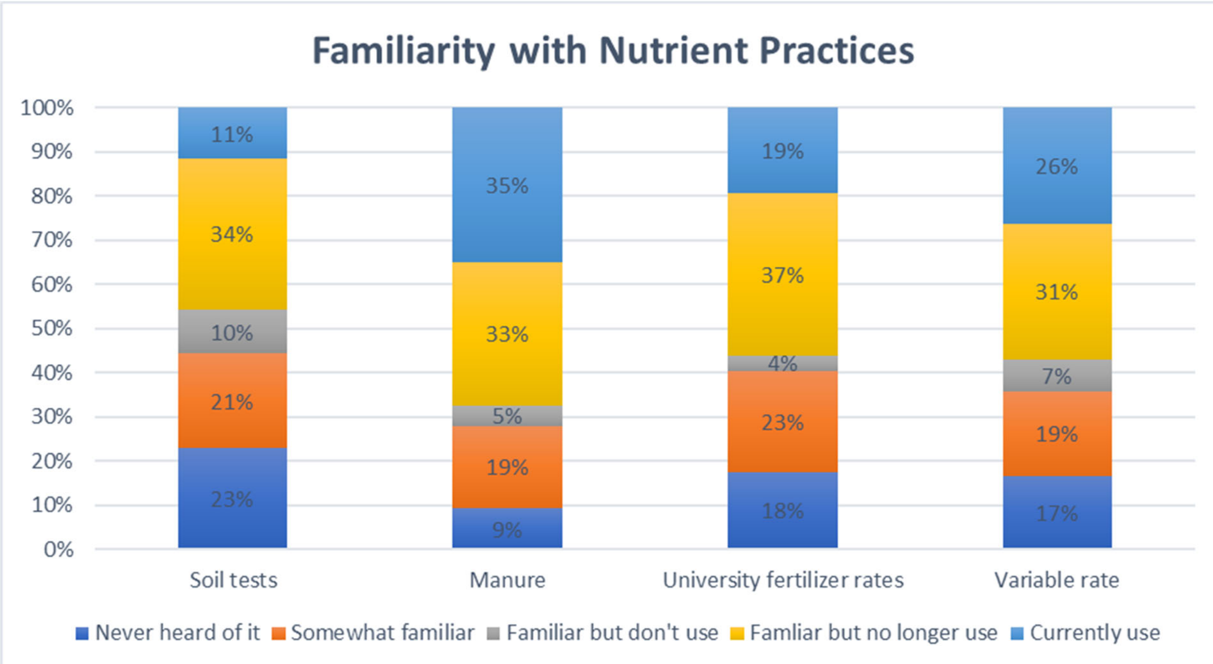

Figure 2. Agricultural survey respondents' familiarity with nutrient practices.

Responses are similar for erosion mitigation and livestock practices (Figure 3). Between 10 and 29% of respondents currently use these practices with waste storage facilities (29%) used the most and livestock exclusion and grassed waterways (10%) used the least. Between 5 and 25% of respondents had not heard of these practices with 5% of respondents unfamiliar with conservation tillage, 12% unfamiliar with cover crops and grassed waterways, 15% unfamiliar with crop residue or vegetated buffers, 23% unfamiliar with livestock exclusion and 25% unfamiliar with waste storage.

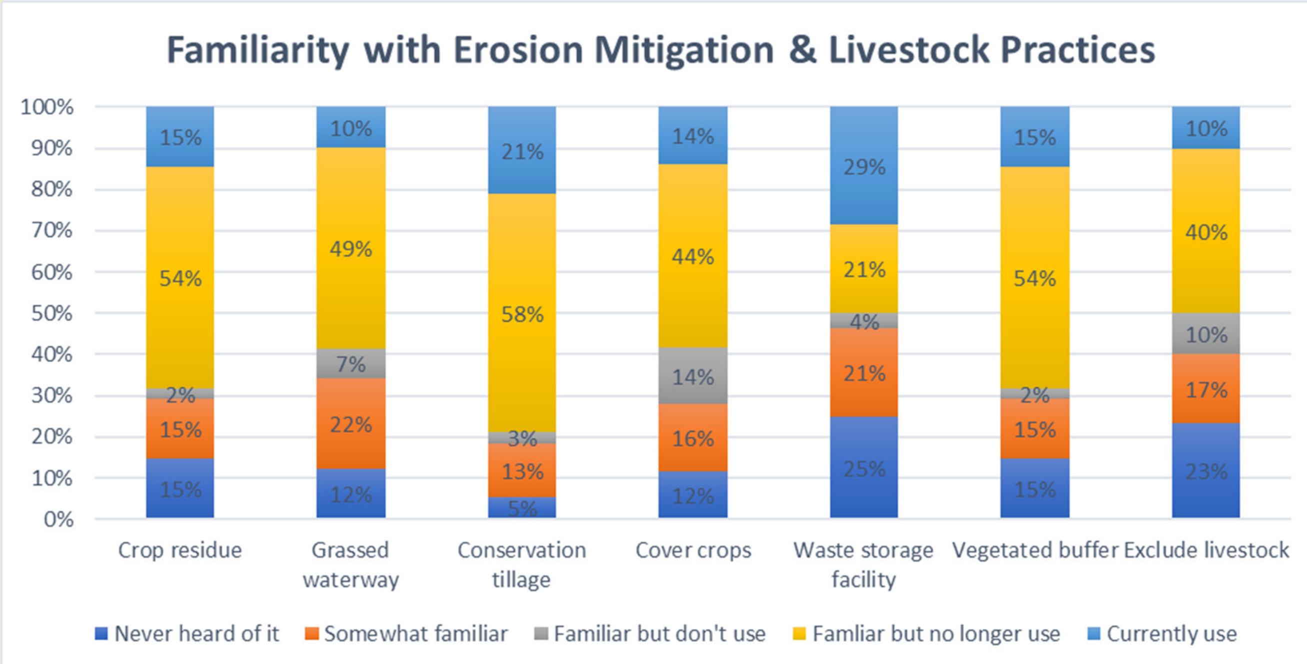

Figure 3. Survey respondents' familiarity with erosion mitigation and livestock practices.

Limitations for Specific Practices

Respondents were asked detailed questions about their familiarity with specific agricultural conservation practices including cover crops, conservation tillage and variable rate application. Their responses are detailed below.

Cover Crops: Around 14% of respondents currently use cover crops, and around 30% are somewhat familiar with this practice. Approximately 14% said they had never heard of it. To assess the limitations association with cover crop use, respondents were asked about various items that could reduce their willingness to implement. Time requirements rated the highest, while lack of equipment, desire to keep things the way they are, and insufficient proof of water quality benefit also rated as somewhat important.

Conservation Tillage: Nearly 21% of respondents currently use this practice. Around 61% know how to use conservation tillage but choose not to or do not feel they would be relevant for their operation. Nearly 21% of respondents are only somewhat familiar with this practice or had never heard of it. To assess the limitations association with conservation tillage use, respondent were asked about various items that could reduce their willingness to implement. Time requirements rated the highest, while lack of equipment, cost, and features of their property making it difficult to use rated as somewhat important.

Variable Rate Application: Nearly 17% currently use this practice. Over 38% know how to use variable rate application but choose not to or do not feel they would be relevant for their operation. Time required, cost and lack of equipment were the highest ranking constraints preventing adoption of this practice.

Familiarity with Specific Urban Practices

Respondents were asked questions about their familiarity with specific urban conservation practices (Figure 4). Between 2 and 52% of respondents currently use these practices with pet waste pick up (52%) and fertilizing lawn to recommendations (43%) used the most and rain barrels (9%) and rain gardens (2%) used the least. Between 14 and 60% of respondents had not heard of these practices with 14% of respondents unfamiliar with fertilizing their lawn to recommended levels and stabilizing streambanks, 15% unfamiliar with picking up pet waste, 17% unfamiliar with rain barrels, 25% unfamiliar with phosphorus free fertilizer, and 60% unfamiliar with rain gardens. Respondents noted that their lack of awareness about the practice, its cost, how to implement it and insufficient proof of its ability to impact water quality as the main limitations for most practices with rain garden and rain barrel installation and streambank stabilization rating higher in all categories than the other practices.

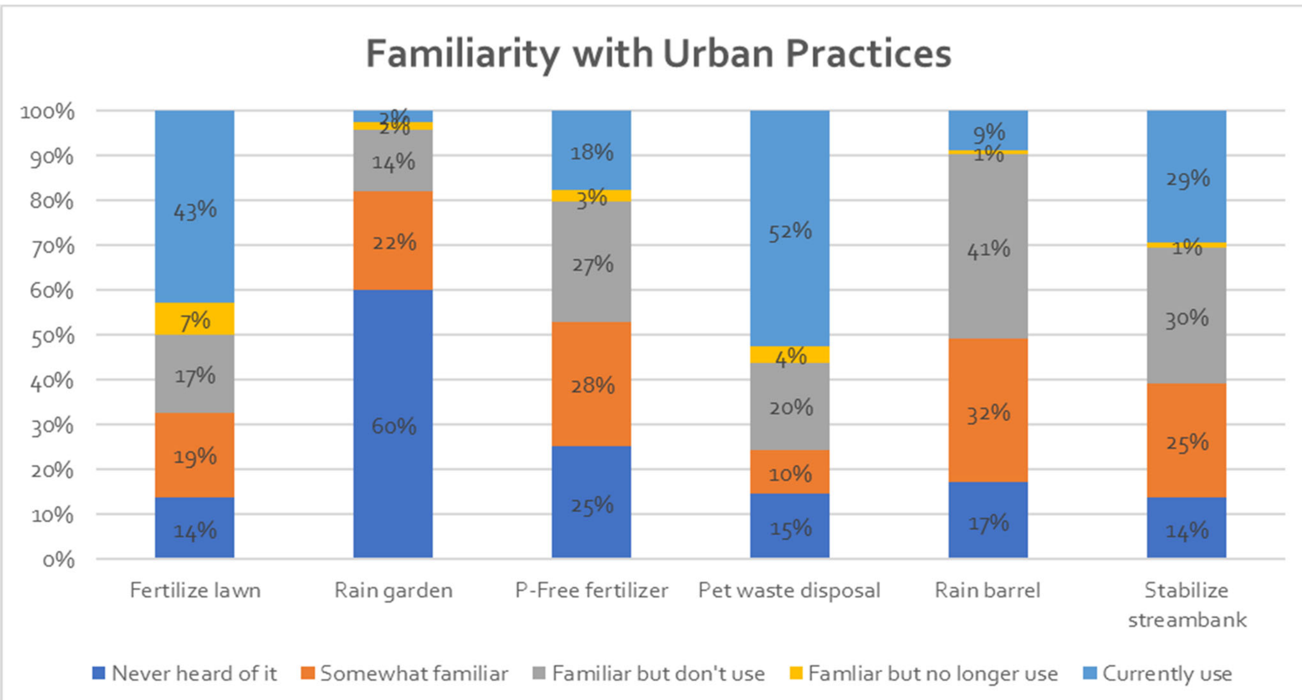

Figure 4. Urban survey respondents' familiarity with urban practices.

2.0 WATERSHED INVENTORY I: WATERSHED DESCRIPTION

2.1 Watershed Location

The Big Walnut Creek Watershed is part of the Eel River Watershed and covers portions of Putnam, Hendricks and Boone counties with small areas of Parke and Clay counties (Figure 1). The Big Walnut Creek Watershed includes all the land that enters Big Walnut and Deer Creek from their 270,770 acre drainage. The Big Walnut Creek Watershed is comprised of two major branches: Big Walnut Creek and Deer Creek. Big Walnut Creek starts in Boone County immediately south of Lebanon and flows southwesterly through northwest Hendricks County into Putnam County. Deer Creek drains the area south and east of Greencastle flowing west to join with Little Deer Creek joining Mill Creek immediately south of US Highway 70. The stream continues westerly through Putnam County where it meets Big Walnut Creek to form the Eel River. Mill Creek carries water from Cagles Mill (Cataract) Lake. The Eel River flows south and west to join with the White River near Worthington draining 772,476 acres.

2.2 Subwatersheds

In total, fifteen 12-digit Hydrologic Unit Codes are contained within the Big Walnut Creek Watershed (Figure 5, 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 Big Walnut Creek Watershed.

Subwatershed Name	Hydrologic Unit Code	Area (acres)	Percent of Watershed
Eldin Ditch	051202030101	15,039.5	5.6%
Ross Ditch-East Fork Big Walnut Creek	051202030102	26,562.9	9.8%
Ramp Run-East Fork Big Walnut Creek	051202030103	15,164.5	5.6%
West Fork Big Walnut Creek	051202030104	17,175.3	6.3%
Owl Creek	051202030201	10,345.8	3.8%
Headwaters Little Walnut Creek	051202030202	16,506.8	6.1%
Leatherman Creek-Little Walnut Creek	051202030203	14,279.4	5.3%
Headwaters Deer Creek	051202030301	19,373.2	7.2%
Owl Branch-Deer Creek	051202030302	18,102.2	6.7%
Deweese Branch-Deer Creek	051202030303	20,954.3	7.7%
Town of Barnard-Big Walnut Creek	051202030401	18,450.6	6.8%
Clear Creek	051202030402	19,900.9	7.3%
Bledsoe Branch-Big Walnut Creek	051202030403	12,119.0	4.5%
Dry Branch-Big Walnut Creek	051202030404	22,313.6	8.2%
Snake Creek-Big Walnut Creek	051202030405	24,481.0	9.0%
	Entire Watershed	**270,768.9**	

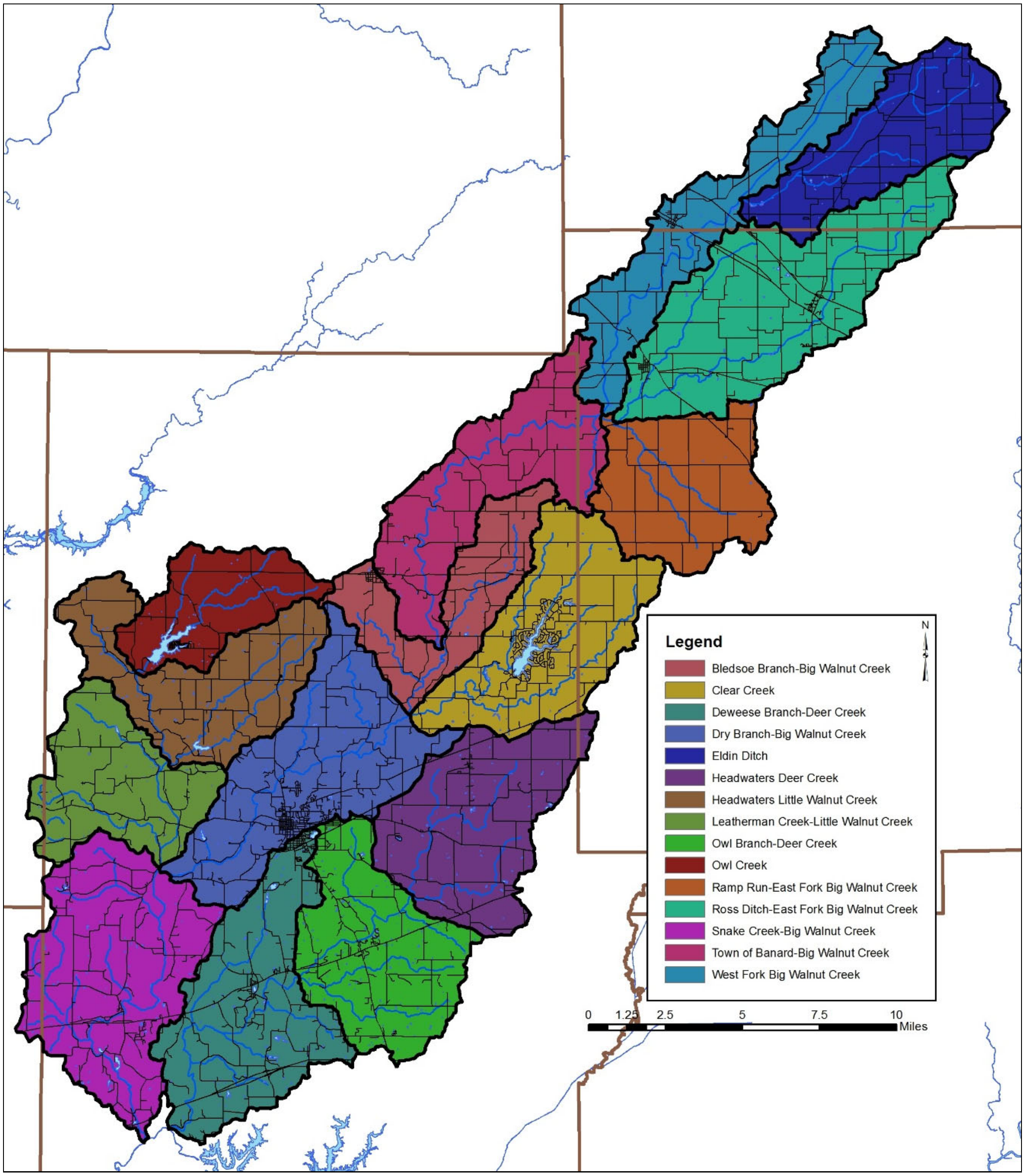

Figure 5. 12-digit Hydrologic Unit Codes in the Big Walnut Creek Watershed.

2.3 Climate

In general, Indiana has a temperate climate with warm summers and cool or cold winters. Climate in the Big Walnut Creek Watershed is no different than the rest of the state. There are four seasons throughout the year. The average temperatures measure approximately 84°F in the summer, while low temperatures measure below freezing (23°F) in the winter. The growing season typically extends from April through September. On average, 44.3 inches of precipitation occurs within the watershed per year; approximately 68% of this precipitation falls during the growing season (US Climate Data, 2018).

2.4 Geology and Topography

Bedrock deposits within much of the Big Walnut Creek Watershed are from the Mississippian age with the western edge of the watershed covered by Pennsylvanian age rocks. 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 Big Walnut Creek Watershed with Blue River Group deposits covering much of the area north and south of Greencastle and the Raccoon Creek Group covering the western edge of the watershed. Minor areas of Sanders Group and West Baden Group also lie within the Putnam County portion of the watershed (Figure 6). 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 Big Walnut 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 7). Sand and gravel are readily available resources along the Big Walnut and Deer Creek floodplains.

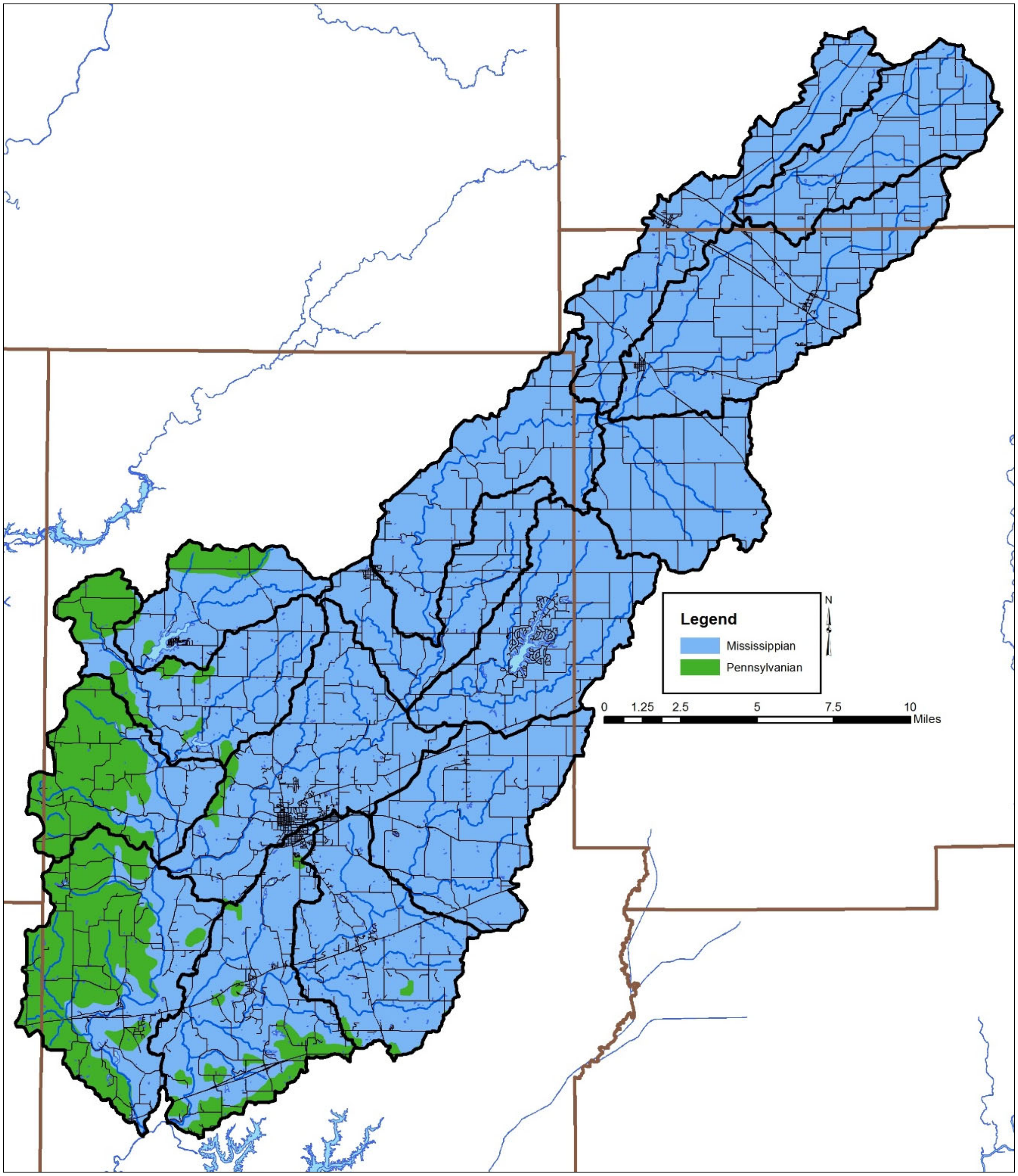

Figure 6. Bedrock in the Big Walnut Creek Watershed.

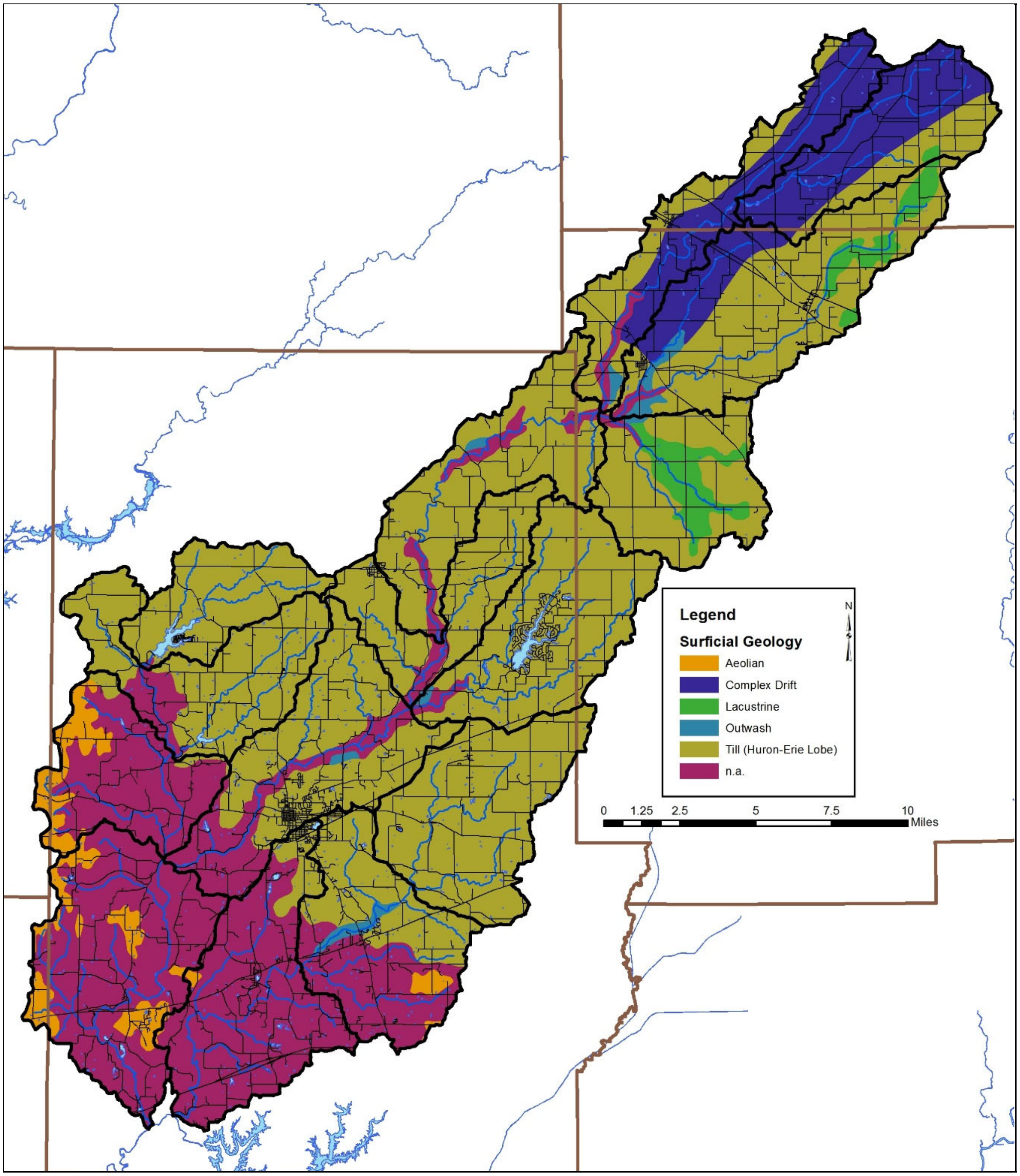

Figure 7. Surficial geology throughout the Big Walnut Creek Watershed.

The southwestern portion of the watershed, essentially from Greencastle and south, is covered by distinctive topography known as karst. 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 than being filtered by soil and bedrock (IGS, not dated). There are fewer perennial stream miles in the southwestern portion of the Big Walnut 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. There are

247 karst sinkholes in the Big Walnut Creek Watershed. Nearly all of these occur in the Leatherman Creek-Big Walnut Creek, Snake Creek-Big Walnut Creek, Deweese Branch-Deer Creek, Owl Branch-Deer Creek subwatersheds, with a few sinkholes occurring in the Dry Branch-Big Walnut Creek and Headwaters Little Walnut Creek subwatersheds (Figure 8). 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. While caves are typically common in karst areas, no karst caves are mapped in the Big Walnut Creek Watershed.

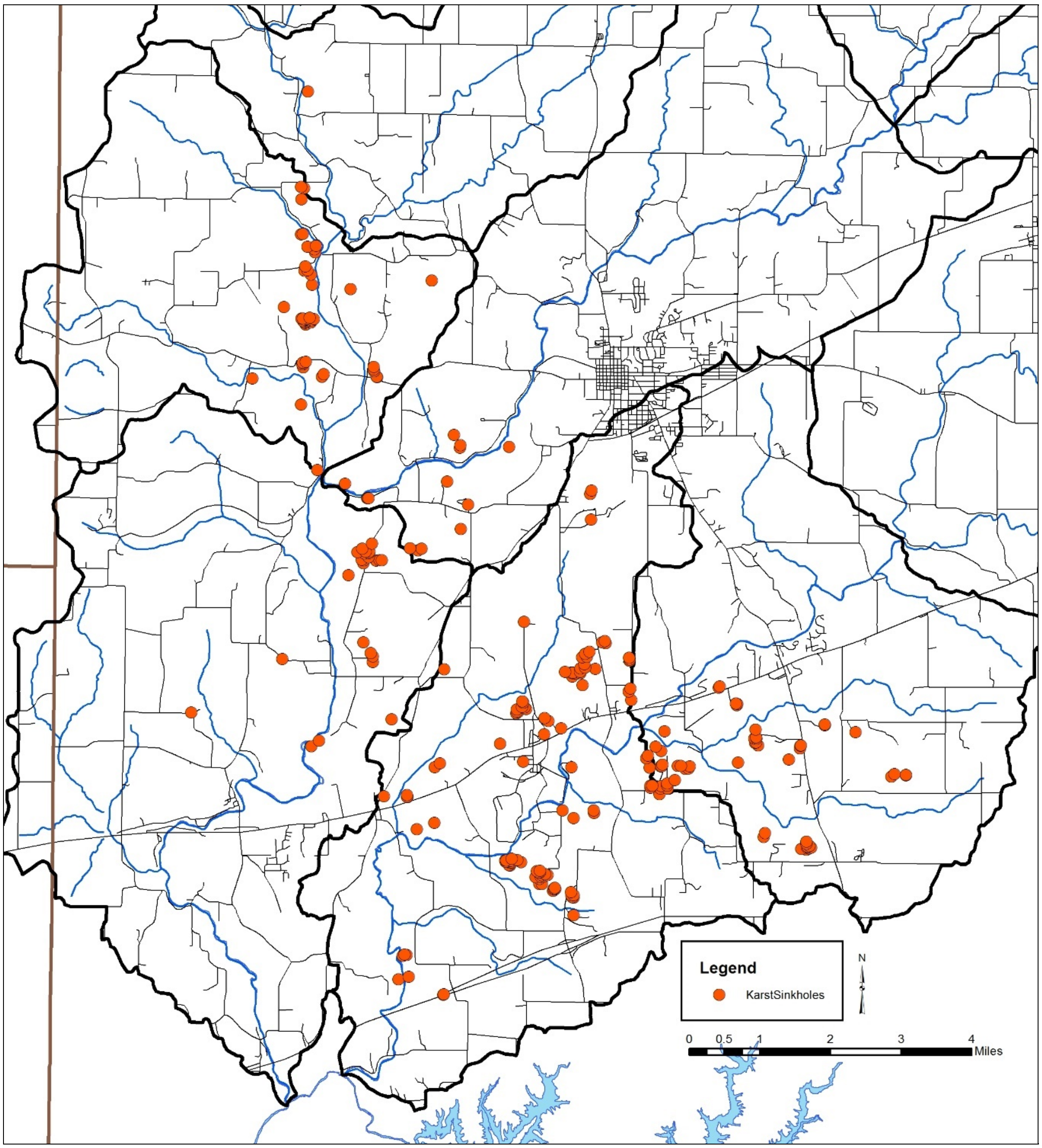

Figure 8. Karst sinkholes in the Big Walnut Creek Watershed.

The topography of the Big Walnut Creek Watershed ranges from flat rolling agricultural fields to undulating hills and valleys and has an average elevation of 580 feet mean sea level (msl; Figure 9). The landscape changes from gently rolling terrain in the northern part of the watershed to steep valleys in the southern portion of the watershed. The Big Walnut Creek Watershed elevation is highest measuring 1030 feet msl at the Boone County-Hendricks County along the far eastern portion of the watershed. Steep valleys surround many of the Big Walnut Creek streams. The relatively flat lake covering much of Boone County shows limited topographic elevation changes. The lowest elevation (550 feet msl) occurs near the intersection of Big Walnut Creek with Mill Creek.

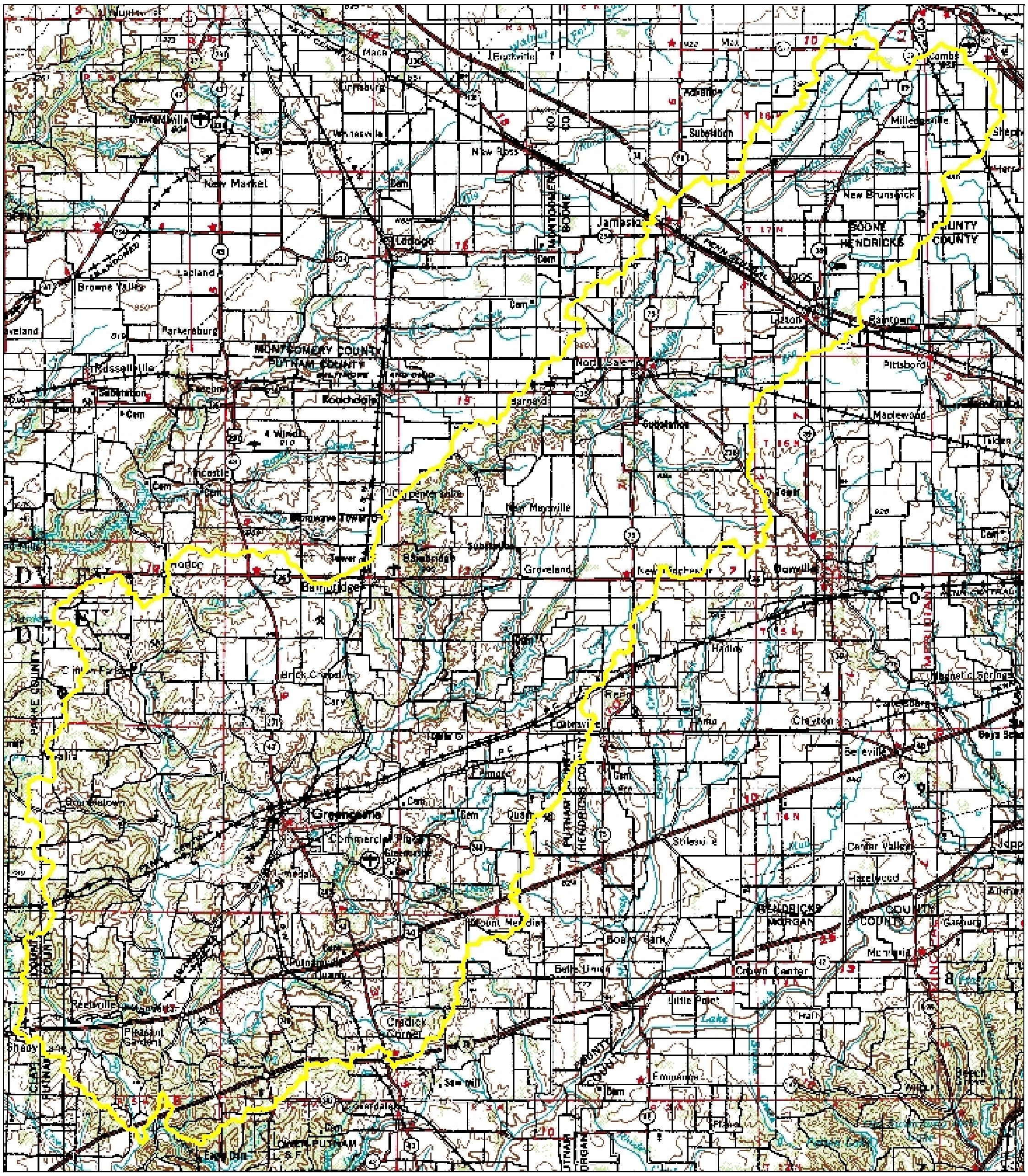

Figure 9. Surface elevation in the Big Walnut Creek Watershed.

2.5 Soil Characteristics

There are hundreds of different soil types located within the Big Walnut 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 Soil Associations

The watershed is covered by 13 soil associations (Figure 10). The Crosby-Treaty-Miami association covers most of the Boone County and the eastern portion of the Hendricks County sections of the watershed. Crosby-Treaty-Miami soils are nearly level or gently sloping and are well suited to cropland and pasture. In more sloped areas, erosion due to wind or water can be a hazard. The Miami-Miamian-Xenia soil association covers much of the central portion of the watershed throughout much of Putnam County and western Hendricks County. These soils are found on broad upland till plains and ridges, knolls and broad flats dissected by small streams. Miami-Miamian-Xenia soils are subject to wind and water erosion if left uncovered. The Ava-Cincinnati-Alford and Hickory-Cincinnati-Berks associations cover much of the lower portion of the watershed. These soils are found on upland side slopes and can be steep or very steep. These soils are limited for use by wind and water erosion.

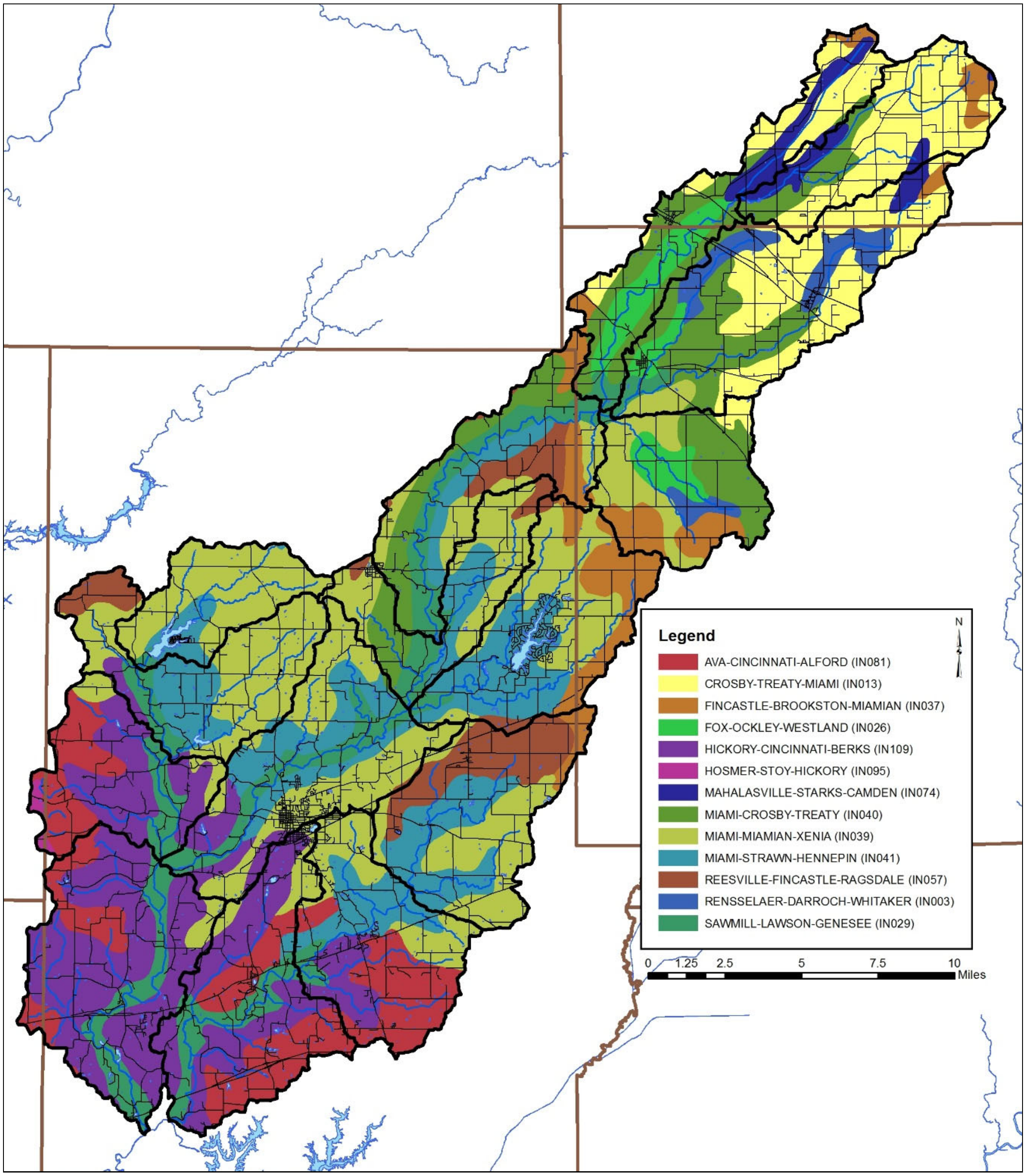

Figure 10. Soil associations in the Big Walnut Creek Watershed. Source: NRCS, 2018.

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. Potentially highly erodible soil determinations are based on the slope steepness and length in addition to the erodibility index value.

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 11 details locations of highly erodible and potentially highly erodible soils within the Big Walnut Creek watershed. Highly erodible soils cover 24.5% of the watershed or 66,265 acres, while potentially highly erodible soils cover an additional 30% of the watershed or approximately 81,844 acres. Highly erodible soils are found throughout the watershed with no discernable pattern of location. All other soils are not rated as highly erodible or potentially highly erodible.

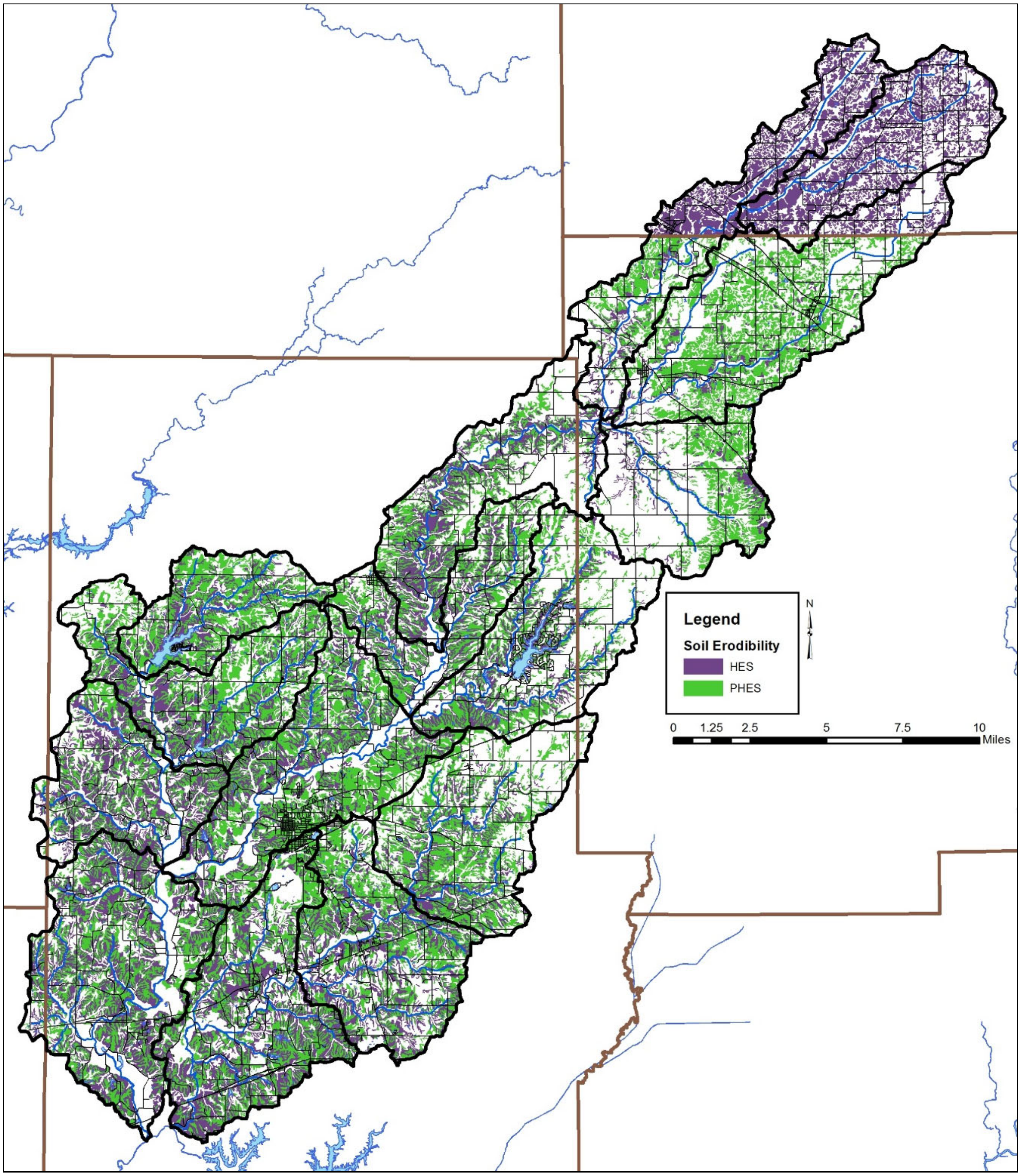

Figure 11. Highly erodible (HES) and potentially highly erodible soils (PHES) in the Big Walnut Creek Watershed. Source: NRCS, 2018.

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. Historically, approximately 34,135 acres (12.6%) of the watershed was covered by hydric soils (Figure 12). Hydric soils are concentrated in the headwaters of the watershed, with the highest densities located on flat plains of Boone County and northern Hendricks County. 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. Many of these soils have been drained for agricultural production or urban development.

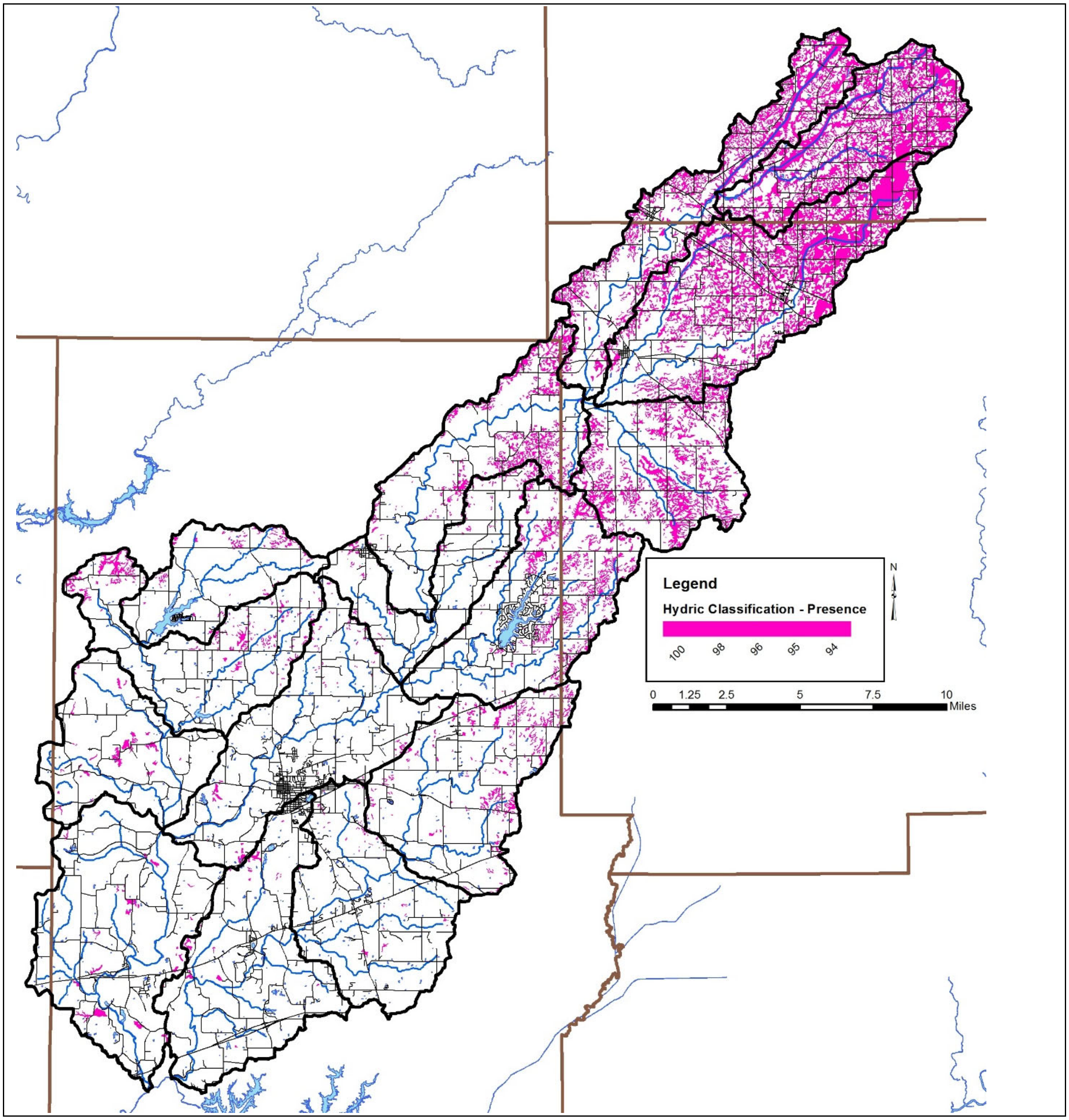

Figure 12. Hydric soils in the Big Walnut Creek Watershed. Source: NRCS, 2018.

2.5.4 Tile-Drained Soils

Soils drained by tile drains cover 130,935 square miles or 48% of the Big Walnut 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 Big Walnut Creek headwaters including much of Boone County, Hendricks County and northern and eastern Putnam County (Figure 13). 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.

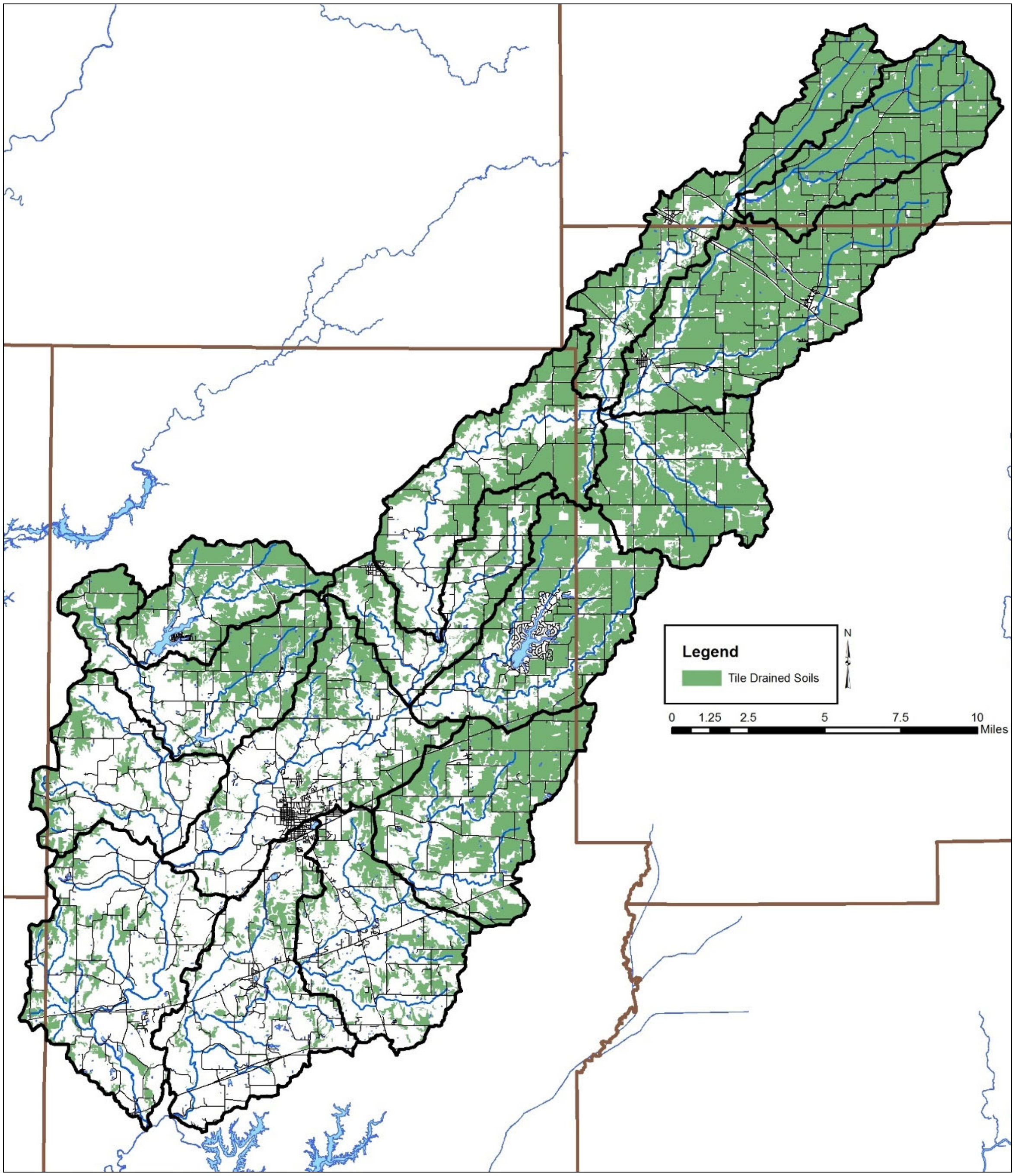

Figure 13. Tile-drained soils in the Big Walnut Creek Watershed. Source: NLCD, 2011 and NRCS, 2018.

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 14). Nearly 257,695 acres or 95% of the watershed is covered by soils that are considered very limited for use in septic tank absorption fields. Nearly 8,714 (3.2%) acres are somewhat limited meaning that these soils are generally suitable for septic systems. The remaining 4,360 acres (1.6%) not rated for septic usage as it is not generally industry standard to install a septic system in these geographic locations.

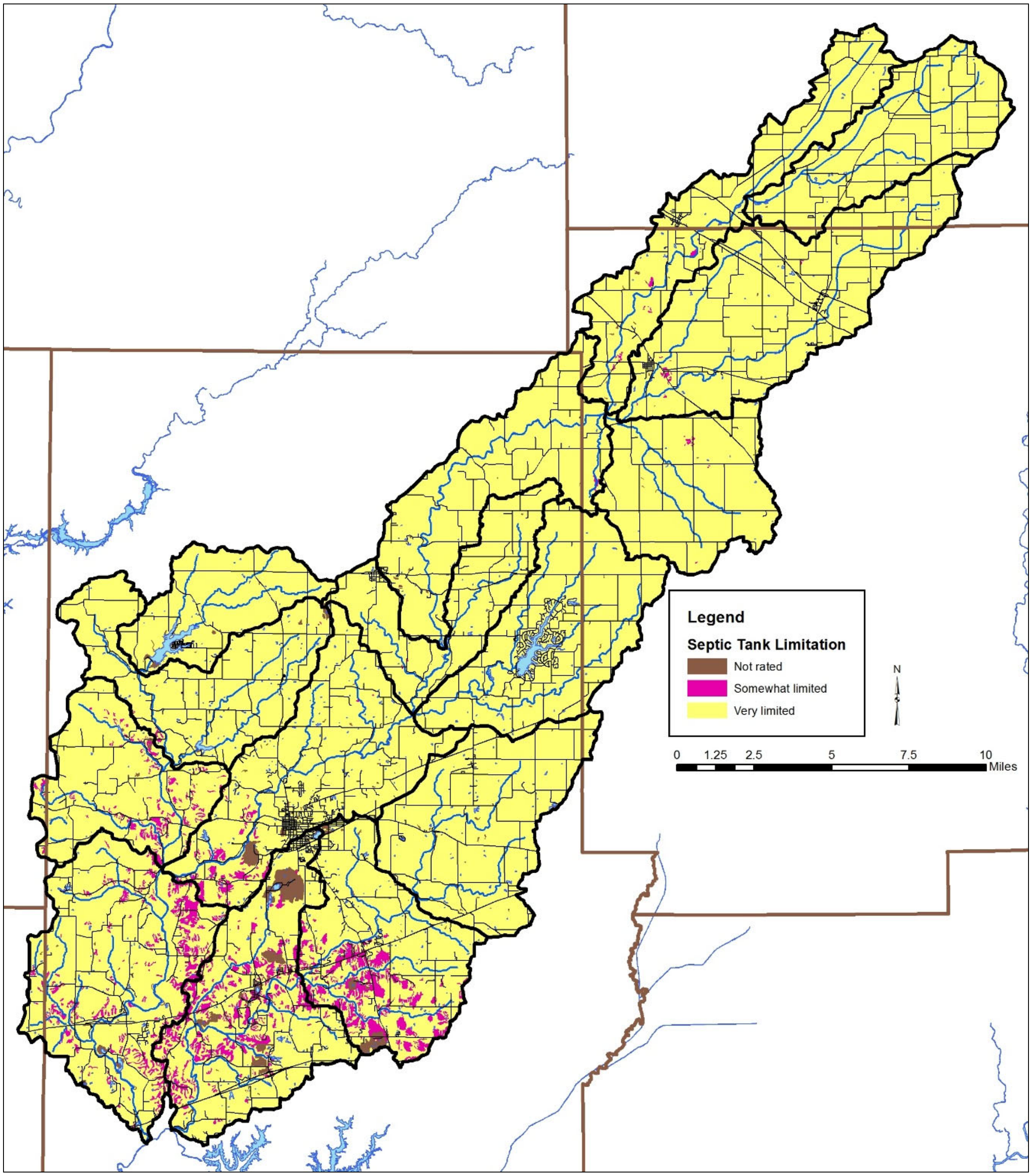

Figure 14. Suitability of soils for septic tank usage in the Big Walnut Creek Watershed. Source: NRCS, 2018.

2.6.2 Wastewater Treatment and Solids Disposal

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, 22 NPDES-regulated facilities are located within the watershed (Figure 15).

Table 4 details the NPDES facility name, activity, and permit number. More detailed information for each facility will be discussed on a subwatershed basis in subsequent sections.

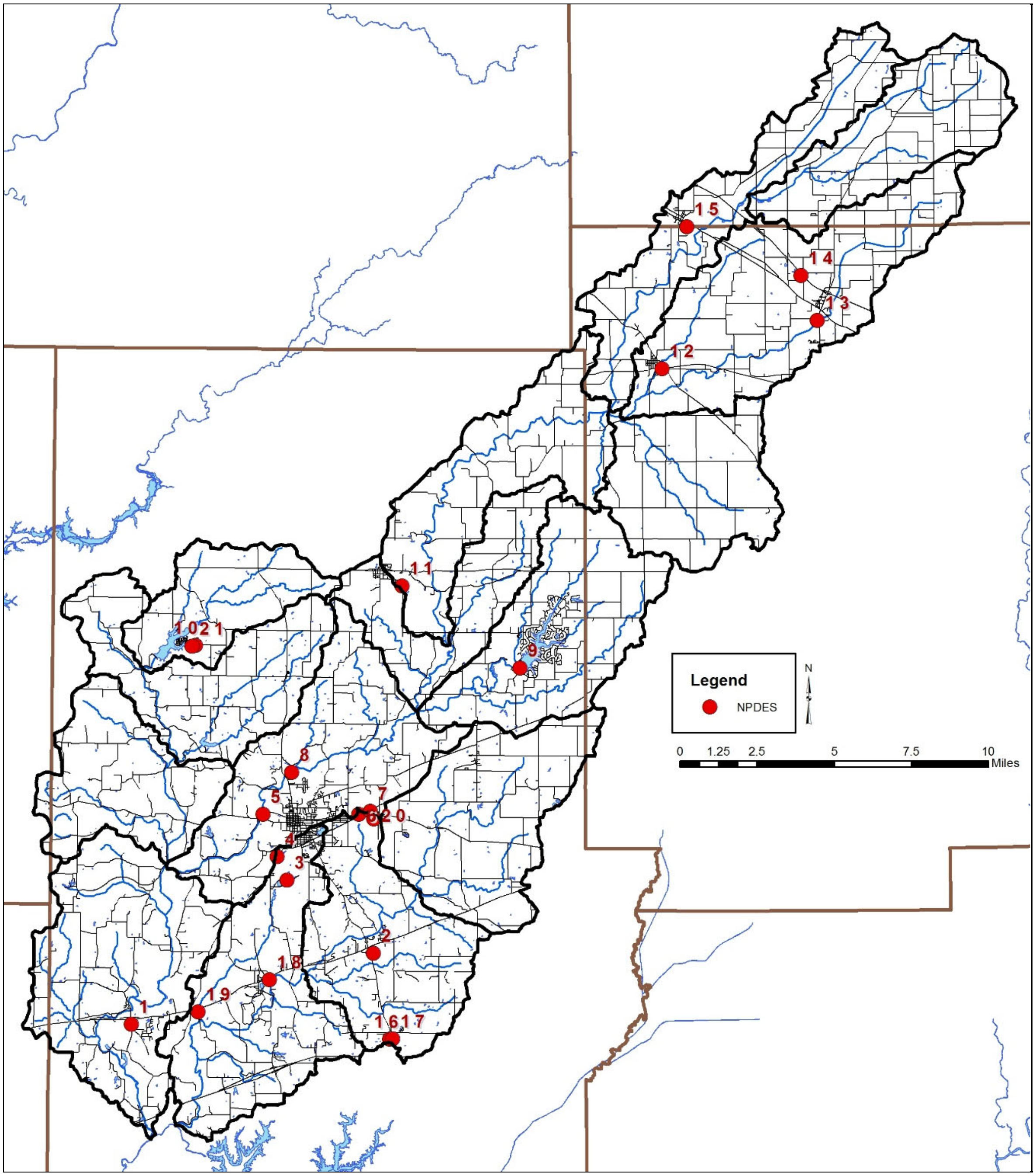

Figure 15. NPDES-regulated facilities in the Big Walnut Creek Watershed.

Table 4. NPDES-regulated facility information.

Map ID	NPDES ID	Facility Name	Activity
1	IN0047074	REELSVILLE ELEMENTARY SCHOOL	Elementary or Secondary School
2	IN0031747	SOUTH PUTMAN HIGH SCHOOL	Elementary or Secondary School
3	IN0001279	LONE STAR INDUSTRIES INC	
4	INP000156	LOBDELL EMERY CORPORATION	
5	IN0021032	GREENCASTLE WASTEWATER TR. PL.	Sewerage system
6	INP000012	MALLORY CAPACITOR CO.	
7	IN0001848	IBM CORP	Die cut paper and cardboard
8	IN0058459	GREENCASTLE WATER TRMT PLANT	Water supply
9	IN0045527	CLEAR CREEK CONSERVANCY DISTRICT	Sewerage system
10	IN0060429	VAN BIBBER WATER TREATMENT PLT	Water supply
11	IN0040941	BAINBRIDGE MUNICIPAL WWTP	Sewerage system
12	IN0040436	NORTH SALEM MUNICIPAL WWTP	Sewerage system
13	IN0035173	LIZTON MUNICIPAL WWTP	Sewerage system
14	IN0031518	LIZTON REST AREA I-74	Transportation system admin.
15	IN0021318	JAMESTOWN MUNICIPAL WWTP	Sewerage system
16	ING490011	MARTIN MARIETTA CLOVERDALE MINE	Mining operation
18	IN0042960	PUTNAMVILLE CORRECTIONAL	Correctional institution
19	IN0063100	BUZZI UNICERN MANHATTAN SHALE	Mining operation
20	IN0062227	REELSVILLE WATER TREATMENT PLANT	Water supply
21	INP000171	CROWN EQUIPMENT CORP	Motor vehicle parks
22	IN0039624	VAN BIBBER LAKE CONSERV DISTRICT	Sewerage system

Source: USEPA EnviroFacts Warehouse, 2018

2.6.3 Municipal Wastewater Treatment and Combined Sewer Overflows

In the relatively rural Big Walnut Creek Watershed, there are seven wastewater treatment facilities located within and discharging to Big Walnut Creek or a tributary, Greencastle Wastewater, Bainbridge Municipal Wastewater, North Salem Municipal Wastewater, Lizton Municipal Wastewater, Jamestown Municipal Wastewater, VanBibber Water Treatment Plant, Clear Creek Conservancy District as well as the Reelsville Elementary School and South Putnam High School, two drinking water plants, the Lizton rest area, and four corporate dischargers. Sludge from municipal wastewater treatment plants is applied on 4,653 acres throughout the watershed (Figure 16).

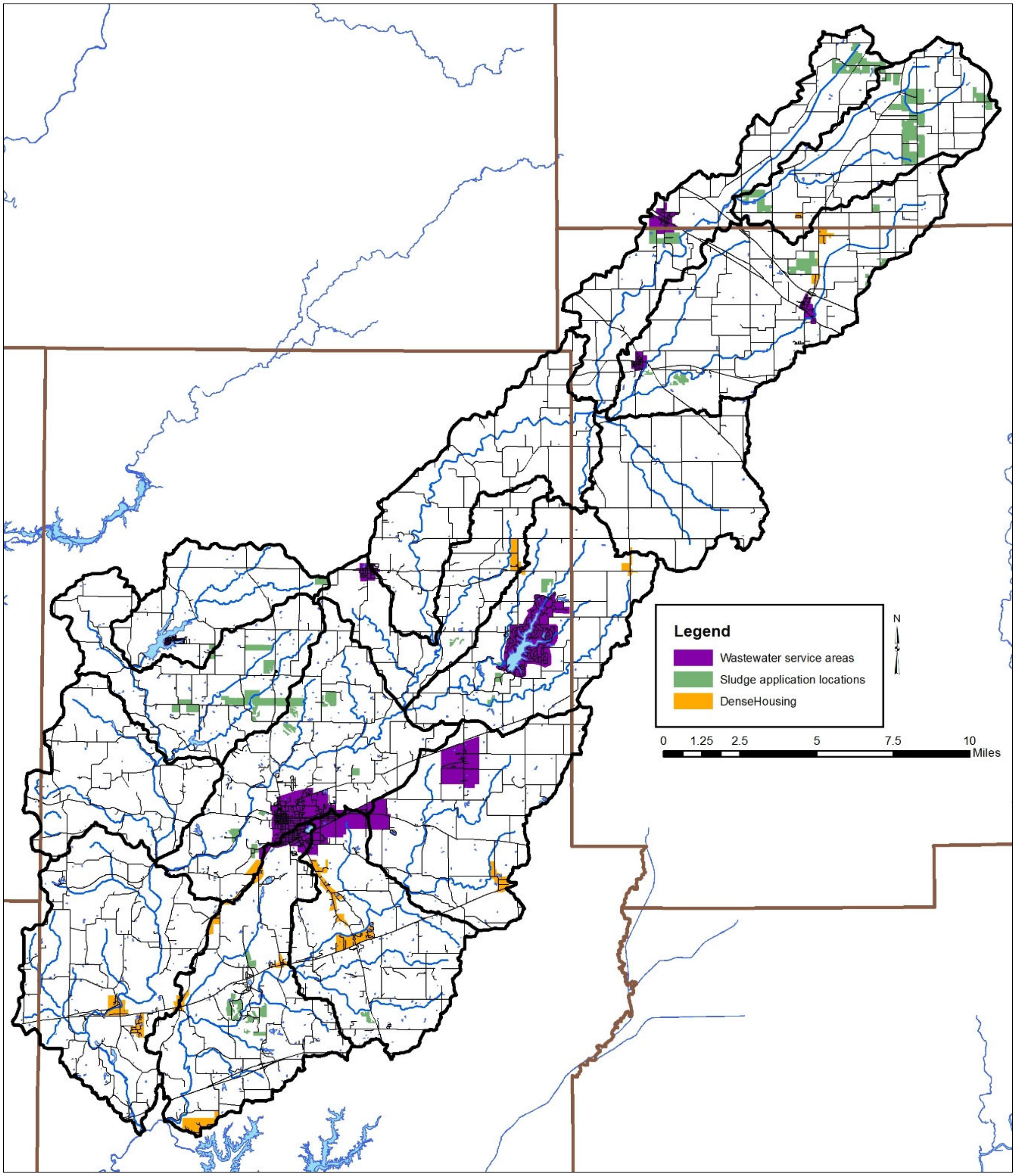

Figure 16. Wastewater treatment plant service areas, municipal biosolids land application sites, dense unsewered housing within the Big Walnut Creek Watershed.

The City of Greencastle operates a wastewater treatment plant which serves approximately 4,500 customers. In total, the plant treats 2.8 million gallons per day (MGD) of wastewater with a peak flow capacity of 16 MGD. The treatment utilizes mechanical processes including a vertical loop reactor, which is a modification of the standard activated sludge process. The original City of Greencastle plant was built in the 1930s with expansions or upgrades occurring in 1949, 1962 and again in 1994. Raw wastewater is collected and screened via two mechanical fine screens. Screened effluent is processed through an aerobic environment where activated sludge reduces pollutants by more than 99%. There are more than 20 miles of sewer lines and 17 lift stations which comprise the system. The system is 100% separated sanitary sewers with no combined sewer overflow pipes. Effluent discharges to Big Walnut Creek (King, no date). The service area is shown in Figure 16.

The Town of Bainbridge operates a wastewater treatment plant which serves approximately 2,025 customers including the population of Bainbridge, Bainbridge Elementary and North Putnam Junior-Senior High School. In total, the plant treats 0.082 MGD of wastewater, which when cleaned, discharges to Big Walnut Creek just south of Bakers Camp covered bridge (Hanko, 2007). The wastewater plant consists of a line of eight Geo Bobbers located in the first lagoon, two aerators in the second lagoon, a flow measuring structure, chlorination/dechlorination and a step aerator. The system is 100% separated sanitary sewers and does not include any combined sewer overflow points. The service area is shown in Figure 16.

The City of North Salem operates a 0.08 MGD wastewater treatment plant which serves approximately 500 individuals. The plant is an extended aeration facility consisting of a bar screen, two clarifiers, chlorination/dechlorination facilities, cascade post-aeration and an effluent flow meter. The North Salem Wastewater Plant discharges to the Middle Fork of Big Walnut Creek Watershed (Snyder, 2018). The system is 100% separate sanitary sewers and does not include any combined sewer overflow points. The service area is shown in Figure 16.

The Town of Lizton operates 0.15 MGD wastewater treatment plant which serves approximately 500 customers. The system is an extended aeration systems consisting of an Aero-Mod package plant with comminutor, bar screen, two clarifiers, UV light disinfectant, aerobic digestion, cascade post aerial and influent and effluent flow meters (Stenner, 2014). Effluent discharges to Ross Ditch. The service area is shown in Figure 16.

The Town of Jamestown operates a 0.2 MGD Class II wastewater treatment plant which serves approximately 1000 customers. The Jamestown wastewater plant operates as a sequential batch reactor treatment facility consisting of two sequential batch reactors, chlorination/dechlorination facilities, post aeration, effluent flow meter, and an aerobic digester (Hanko, 2017). The system does not include any combined sewer overflow points. The service area is shown in Figure 16.

The Clear Creek Conservancy District operates a 0.4 MGD wastewater treatment plant which serves approximately 3,600 customers. The facility discharges consists of an oxidation ditch treatment facility consisting of a fine screen, secondary clarification, two 100,000 gallon aerobic digesters, two 100,000 gallon sludge storage tanks, effluent chlorination/dechlorination facilities, post aeration and an effluent flow meter. The Clear Creek Conservancy District wastewater plant discharges to Clear Creek (Pryor, 2014). The system does not include any combined sewer overflow points. The service area is shown in Figure 16.

The Van Bibber Lake Conservancy District operates a 100,000 GPD wastewater plant which discharges to Little Walnut Creek. The service area is shown in Figure 16.

2.6.4 Unsewered Areas

Approximately 17 unsewered areas were identified within the watershed (Figure 16). 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

Big Walnut Creek originates in south central Boone County as the West Fork Big Walnut, Middle Fork Big Walnut, and East Fork Big Walnut. These streams converge southwest of North Salem to form Big Walnut Creek. Deer Creek begins near Filmore in Putnam Count flowing south-southwest past Putnamville to its confluence with Mill Creek. The Big Walnut Creek Watershed contains approximately 77 miles of perennial streams and regulated drains. Of these, approximately 6.1 miles are regulated drains, including Cunningham Ditch, Bett Ditch, Edlin Ditch, Higgins Ditch, Pound Ditch, Ross Ditch and Tucker Ditch. The majority of streams in the Big Walnut 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 Big Walnut Creek.

Big Walnut Creek flows 19 miles draining 212,740 acres, while Deer Creek flows 7 miles and drains 50,400 acres. The major tributaries to Big Walnut Creek include East and West Fork Big Walnut Creek, Clear Creek, Canaan Run, Bledsoe Branch, Dry Branch, Dyer Creek, Falls Branch, Grassy Branch, Hunt Creek, Johnson Branch, Jones Creek, Leatherman Creek, Little Walnut Creek, Little Deer Creek, Maiden Run, Miller Creek, Owl Creek, Plum Creek, Ramp Run, Snake Creek (Figure 17). The major tributaries to Deer Creek include Deweese Branch, Dyer Creek, Leatherwood Creek, Limestone Creek, Lower Limestone Creek, Upper Limestone Creek, Little Deer Creek, Mosquito Creek, Owl Branch, Rocky Fork and Wallace Branch (Figure 17).

Big Walnut Creek from Bainbridge to the mouth is used for recreational kayaking and canoeing as well as fishing, swimming, and aesthetic enjoyment. Big Walnut Creek from the Hendricks/Putnam County Line to Greencastle is recognized as an outstanding river as Big Walnut Creek is: 1) One of 1,524 river segments identified by the National Park Service as part of the 1982 Nationwide River Inventory; 2) An outstanding river identified as part of a state assessment; 3) Considered a state heritage program site; 4) A state-designated canoe/boating route; 5) Considered a national landmark river as designated by the National Natural Landmarks; and 6) a state study river proposed for state protection or designation (NRC, 1997; Figure 17). The upper portion of Big Walnut Creek is included in the DNR Division of Outdoor Recreation Canoeing Guide and is considered a unique natural area as identified by Alton Lindsey (Lindsey et al., 1969). Several tributaries to Big Walnut Creek, Deer Creek and tributaries to Deer 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.

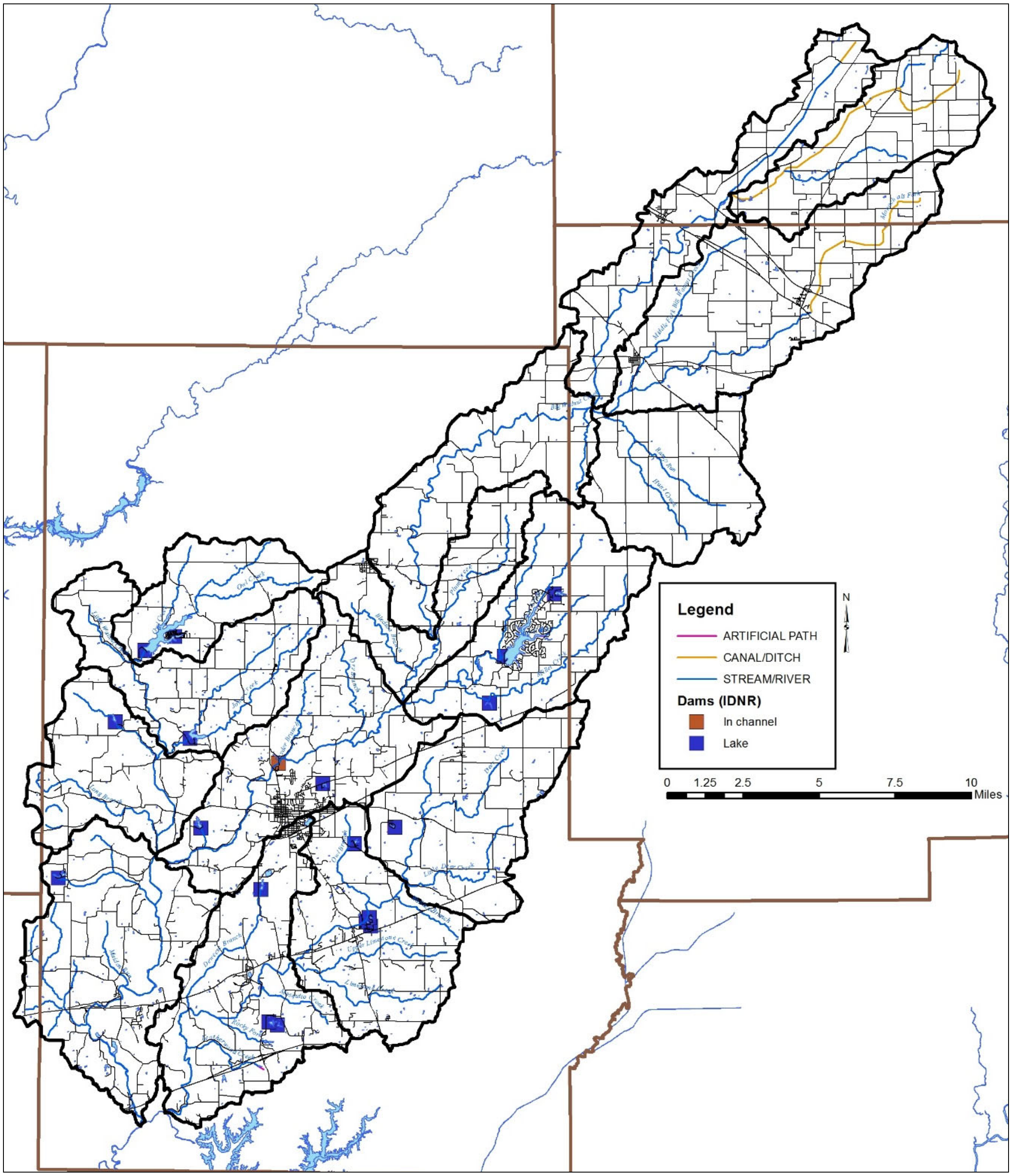

Figure 17. Streams in the Big Walnut Creek watershed. Source: USGS, 2018; IDNR, 1999.

2.7.2 Lakes, Ponds and Impoundments

Multiple small lakes and ponds dot the Big Walnut Creek Watershed landscape. In total 19 dam structures create 13 lakes, which range in size from 2.2 to just over 330 acres (Table 5). These provide local swimming holes, recreational boating options, and localized fishing as well as providing water storage and retention to assist with flooding. Many are located in tributary headwaters and offer some water retention; however, most are insignificant in size or water quality impact. Two relatively large, private lakes: Heritage Lake and Glenn Flint Lake provide recreational fishing, swimming, and aesthetic enjoyment. Heritage Lake is a 300 acre impoundment of Clear Creek managed by the Clear Creek

Conservancy District and Heritage Lake Property Owners Association. Glenn Flint Lake is a 330 acres impoundment of Owl Creek managed by the Little Walnut Creek Conservancy District. One in-line, lowhead dam is located on Big Walnut Creek just upstream of US Highway 231. Stakeholders noted concern of this dam and the continued hazard it provides to canoers and kayakers.

Table 5. Dam structures in the Big Walnut Creek Watershed.

Name	Surface Area (acres)	Drainage Area (sq mi)	Type
Albin Pond Dam	6.2	0.35	Lake
Banks Lake Dam	3.9	0.36	Lake
Big Walnut Creek Dam	--	0.00	In channel
Dogwood Springs Lake 1	8.1	0.29	Lake
Dogwood Springs Lake 2	4.0	0.20	Lake
Edgewood Lake	4.1	0.13	Lake
Greencastle Jaycees Park Dam	6.5	0.23	Lake
Heritage Lake Dam	297.4	10.30	Lake
Little Walnut Creek Structure 3	14.0	2.62	Lake
Little Walnut Creek Structure 4	300.7	15.16	Lake
Little Walnut Creek Structure 5	74.0	12.88	Lake
Oakalla Lake Dam	19.3	0.27	Lake
South Pond Dam	60.0	2.20	Lake
Summersault Lake Dam	20.0	1.29	Lake
Thomas Lake Dam	14.6	0.62	Lake
Van Bibber Dam	10.5	0.27	Lake
Wildwood Lake Dam 3	2.2	0.11	Lake
Wildwood Lake Dam 4	3.7	0.43	Lake
Wildwood Lake Dam 5	3.0	0.23	Lake

2.7.3 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. More information on the listing process is included in section 3.2.1. Nearly 105 stream segments within the Big Walnut Creek Watershed are included on the list of impaired waterbodies (IDEM, 2018). Table 6Figure 18 details the listings in the watershed, while Figure 18 maps the segments and their locations within the watershed. Waterbodies are listed as impaired for *E. coli*, nutrients, impaired biotic communities, mercury, and PCBs.

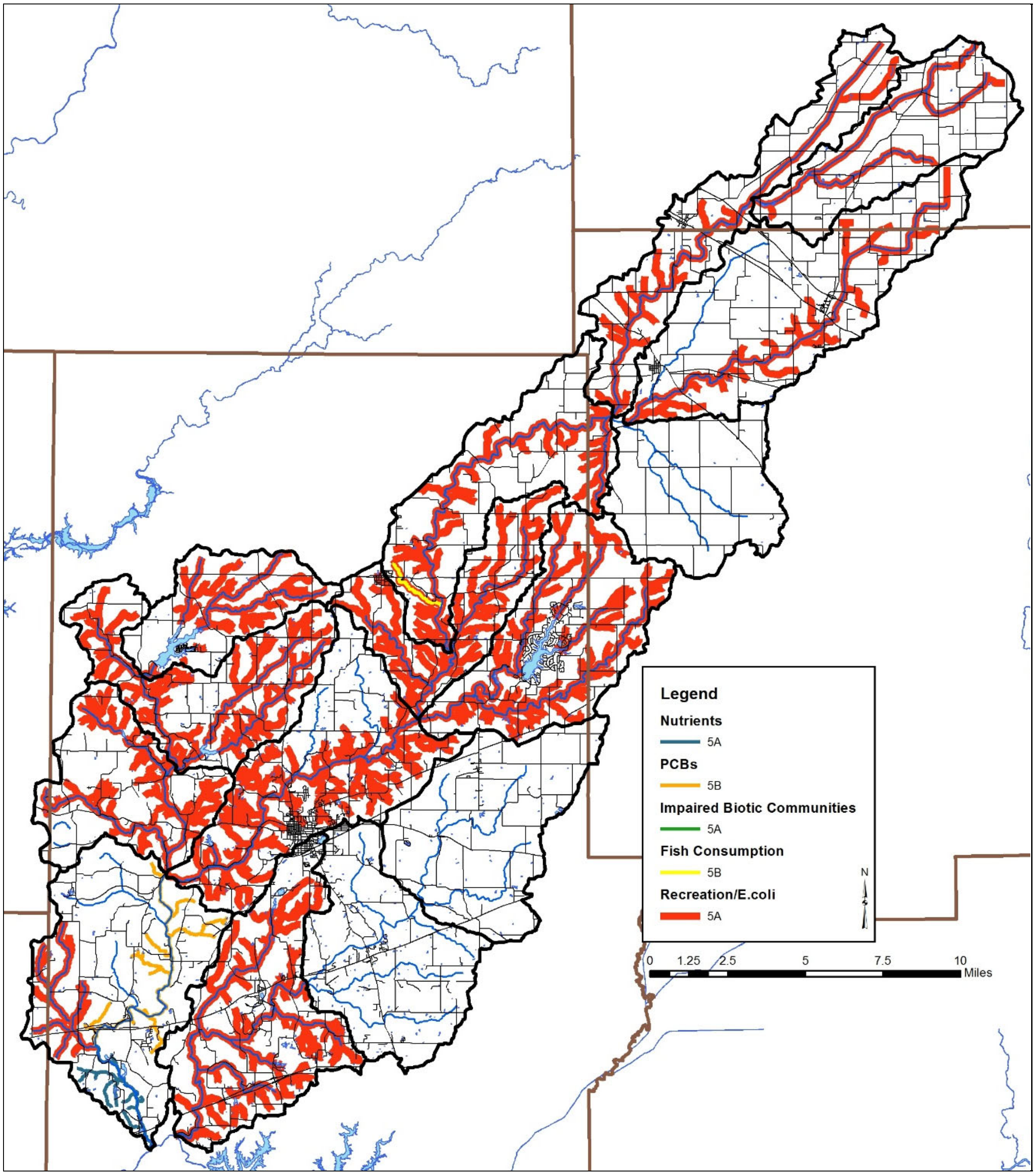

Figure 18. Impaired waterbody locations in the Big Walnut Creek Watershed. Source: IDEM, 2018.

Table 6. Impaired waterbodies in the Big Walnut Creek Watershed 2018 IDEM 303(d) list.

HUC	Waterbody	Assessment Unit	County	Impairment
051202030101	EDLIN DITCH	INW0311_02	B	*E. COLI*
051202030101	EDLIN DITCH	INW0311_03	B	*E. COLI*
051202030101	GRASSY BRANCH	INW0311_T1002	B	*E. COLI*
051202030102	ROSS DITCH	INW0312_02	H	*E. COLI*
051202030102	ROSS DITCH	INW0312_03	H	*E. COLI*
051202030102	ROSS DITCH	INW0312_04	H	*E. COLI*
051202030102	BIG WALNUT CREEK, EAST FORK	INW0312_05	H	*E. COLI*
051202030102	BIG WALNUT CREEK, EAST FORK	INW0312_06	H	*E. COLI*
051202030102	BIG WALNUT CREEK, EAST FORK	INW0312_07	H	*E. COLI*
051202030102	POUND DITCH	INW0312_T1003	H	*E. COLI*
051202030102	TUCKER DITCH	INW0312_T1004	H	*E. COLI*
051202030104	BIG WALNUT CREEK	INW0314_02	H	*E. COLI*
051202030104	BIG WALNUT CREEK	INW0314_03	H	*E. COLI*
051202030104	BIG WALNUT CREEK	INW0314_04	H	*E. COLI*
051202030104	BIG WALNUT CREEK	INW0314_05	H	*E. COLI*
051202030104	CUNNINGHAM DITCH	INW0314_T1001	B	*E. COLI*
051202030104	BIG WALNUT CREEK - UNNAMED TRIB	INW0314_T1002	H	*E. COLI*
051202030201	OWL CREEK	INW0321_03	P	*E. COLI*
051202030201	OWL CREEK	INW0321_04	P	*E. COLI*
051202030201	OWL CREEK - UNNAMED TRIB	INW0321_T1003	P	*E. COLI*
051202030201	OWL CREEK - UNNAMED TRIB	INW0321_T1005	P	*E. COLI*
051202030201	OWL CREEK - UNNAMED TRIB	INW0321_T1007	P	*E. COLI*
051202030201	OWL CREEK - UNNAMED TRIB	INW0321_T1012	P	*E. COLI*
051202030202	LITTLE WALNUT CREEK	INW0322_01	P	*E. COLI*
051202030202	LITTLE WALNUT CREEK	INW0322_06	P	*E. COLI*
051202030202	LITTLE WALNUT CREEK - UNNAMED TRIB	INW0322_T1003	P	*E. COLI*
051202030202	LITTLE WALNUT CREEK - UNNAMED TRIB	INW0322_T1006	P	*E. COLI*
051202030202	FALLS BRANCH	INW0322_T1007	P	*E. COLI*
051202030202	JONES CREEK	INW0322_T1009	P	IBC, *E. COLI*
051202030202	JONES CREEK	INW0322_T1013	P	*E. COLI*
051202030202	LITTLE WALNUT CREEK - UNNAMED TRIB	INW0322_T1014	P	*E. COLI*
051202030202	LITTLE WALNUT CREEK - UNNAMED TRIB	INW0322_T1015	P	*E. COLI*
051202030203	LITTLE WALNUT CREEK	INW0323_03	P	*E. COLI*
051202030203	LITTLE WALNUT CREEK	INW0323_04	P	*E. COLI*
051202030203	LEATHERMAN CREEK	INW0323_T1004	P	*E. COLI*
051202030203	LONG BRANCH - UNNAMED TRIB	INW0323_T1009	P	*E. COLI*
051202030203	LONG BRANCH	INW0323_T1012	P	*E. COLI*
051202030301	LITTLE DEER CREEK - UNNAMED TRIB	INW0331_T1010	P	IBC
051202030301	LITTLE DEER CREEK - UNNAMED TRIB	INW0331_T1011	P	IBC
051202030301	LITTLE DEER CREEK - UNNAMED TRIB	INW0331_T1012	P	IBC
051202030301	LITTLE DEER CREEK - UNNAMED TRIB	INW0331_T1013	P	IBC
051202030301	LITTLE DEER CREEK	INW0331_T1014	P	IBC
051202030303	DEER CREEK	INW0333_02	P	*E. COLI*
051202030303	DEER CREEK	INW0333_03	P	*E. COLI*

HUC	Waterbody	Assessment Unit	County	Impairment
051202030303	MOSQUITO CREEK	INW0333_T1007	P	*E. COLI*
051202030303	ROCKY FORK	INW0333_T1009	P	*E. COLI*
051202030303	GREYHOUND LAKE INLET	INW0333_T1009A	P	*E. COLI*
051202030303	DEWEESE BRANCH	INW0333_T1010	P	*E. COLI*
051202030303	LEATHERWOOD CREEK	INW0333_T1012	P	*E. COLI*
051202030401	BIG WALNUT CREEK	INW0341_02	P	*E. COLI*
051202030401	BIG WALNUT CREEK	INW0341_03	P	*E. COLI*
051202030401	BIG WALNUT CREEK	INW0341_04	P	*E. COLI*
051202030401	BIG WALNUT CREEK - UNNAMED TRIB	INW0341_T1007	H	*E. COLI*
051202030402	CLEAR CREEK	INW0342_01	P	*E. COLI*
051202030402	CLEAR CREEK	INW0342_03	P	*E. COLI*
051202030402	MILLER CREEK	INW0342_T1006	P	*E. COLI*
051202030402	MILLER CREEK	INW0342_T1008	P	*E. COLI*
051202030402	MILLER CREEK	INW0342_T1009	P	*E. COLI*
051202030402	MILLER CREEK	INW0342_T1010	P	*E. COLI*
051202030402	MILLER CREEK	INW0342_T1011	P	*E. COLI*
051202030402	CLEAR CREEK	INW0342_T1012	P	*E. COLI*
051202030402	CLEAR CREEK - UNNAMED TRIB	INW0342_T1013	P	*E. COLI*
051202030402	HERITAGE LAKE - UNNAMED INLET	INW0342_T1014	P	*E. COLI*
051202030402	MILLER CREEK	INW0342_T1016	P	*E. COLI*
051202030403	BIG WALNUT CREEK	INW0343_02	P	*E. COLI*
051202030403	BIG WALNUT CREEK	INW0343_03	P	*E. COLI*
051202030403	PLUM CREEK	INW0343_T1003	P	*E. COLI*
051202030403	PLUM CREEK	INW0343_T1004	P	*E. COLI*
051202030403	PLUM CREEK - UNNAMED TRIB	INW0343_T1005	P	*E. COLI*
051202030403	PLUM CREEK - UNNAMED TRIB	INW0343_T1006	P	*E. COLI*
051202030403	PLUM CREEK - UNNAMED TRIB	INW0343_T1007	P	*E. COLI*
051202030403	BIG WALNUT CREEK - UNNAMED TRIB	INW0343_T1008	P	*E. COLI*
051202030403	BIG WALNUT CREEK - UNNAMED TRIB	INW0343_T1009	P	*E. COLI*
051202030403	BIG WALNUT CREEK - UNNAMED TRIB	INW0343_T1010	P	*E. COLI*
051202030403	BLEDSOE BRANCH	INW0343_T1011	P	*E. COLI*
051202030403	BLEDSOE BRANCH	INW0343_T1012	P	*E. COLI*
051202030404	BIG WALNUT CREEK	INW0344_02	P	*E. COLI*
051202030404	BIG WALNUT CREEK	INW0344_03	P	*E. COLI*
051202030404	BIG WALNUT CREEK	INW0344_04	P	*E. COLI*
051202030404	BIG WALNUT CREEK	INW0344_05	P	*E. COLI*
051202030404	BIG WALNUT CREEK	INW0344_06	P	*E. COLI*
051202030404	BIG WALNUT CREEK - UNNAMED TRIB	INW0344_T1003	P	*E. COLI*
051202030404	BIG WALNUT CREEK - UNNAMED TRIB	INW0344_T1004	P	*E. COLI*
051202030404	BIG WALNUT - UNNAMED TRIB	INW0344_T1005	P	*E. COLI*
051202030404	ALBION POND INLET	INW0344_T1005A	P	*E. COLI*
051202030404	BIG WALNUT CREEK - UNNAMED TRIB	INW0344_T1006	P	*E. COLI*
051202030404	BIG WALNUT CREEK - UNNAMED TRIB	INW0344_T1007	P	*E. COLI*
051202030404	BIG WALNUT CREEK - UNNAMED TRIB	INW0344_T1008	P	*E. COLI*
051202030404	BIG WALNUT CREEK - UNNAMED TRIB	INW0344_T1009	P	*E. COLI*
051202030404	BIG WALNUT CREEK - UNNAMED TRIB	INW0344_T1010	P	*E. COLI*
051202030404	BIG WALNUT CREEK - UNNAMED TRIB	INW0344_T1011	P	*E. COLI*
051202030404	BIG WALNUT CREEK - UNNAMED TRIB	INW0344_T1012	P	*E. COLI*
051202030405	BIG WALNUT CREEK	INW0345_03	P	MERCURY, PCB

HUC	Waterbody	Assessment Unit	County	Impairment
051202030405	BIG WALNUT CREEK	INW0345_03	P	*E. COLI*
051202030405	BIG WALNUT CREEK	INW0345_04	P	MERCURY, PCB
051202030405	BIG WALNUT CREEK	INW0345_04	P	*E. COLI*
051202030405	BIG WALNUT CREEK	INW0345_05	P	*E. COLI*, MERCURY
051202030405	BIG WALNUT CREEK	INW0345_05	P	PCB
051202030405	BIG WALNUT CREEK	INW0345_06	P	NUTRIENTS, PCB, *E. COLI*, MERCURY
051202030405	MAIDEN RUN	INW0345_T1002	P	IBC
051202030405	JOHNSON BRANCH	INW0345_T1003	P	*E. COLI*
051202030405	BIG WALNUT CREEK - UNNAMED TRIB	INW0345_T1004	P	*E. COLI*, PCB, MERCURY
051202030405	BIG WALNUT CREEK - UNNAMED TRIB	INW0345_T1005	P	*E. COLI*, PCB, MERCURY
051202030405	BIG WALNUT CREEK - UNNAMED TRIB	INW0345_T1006	P	*E. COLI* , MERCURY, PCB
051202030405	BIG WALNUT CREEK - UNNAMED TRIB	INW0345_T1008	P	NUTRIENTS, PCB, *E. COLI*, MERCURY

B=Boone, H=Hendricks, P=Putnam; IBC=Impaired Biotic Communities

2.7.4 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 19 details the locations of floodplains within the Big Walnut Creek Watershed. Narrow floodplains lie adjacent to Main Edlin Ditch, Grassy Branch, Ramp Run, Clear Creek, Bledsoe Branch, Little Walnut Creek, Upper and Lower Limestone creeks, Deer Creek, East Fork Big Walnut Creek, Middle Fork Big Walnut Creek, and Big Walnut Creek from immediately north of the Boone County line to the confluence with Mill Creek. The widest floodplain lies adjacent to Big Walnut Creek from Greencastle to Mill Creek. Approximately 8% (21,528.3 acres) of the Big Walnut Creek Watershed lies within the 100-year floodplain (Figure 19). 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. All of the Big Walnut Creek Watershed floodplain is in Zone A or nearly 21,528.3 acres (7.9% 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. None of the Big Walnut 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. The remainder of the watershed is classified as Zone X. None of the Big Walnut Creek Watershed floodplain is in Zone X.

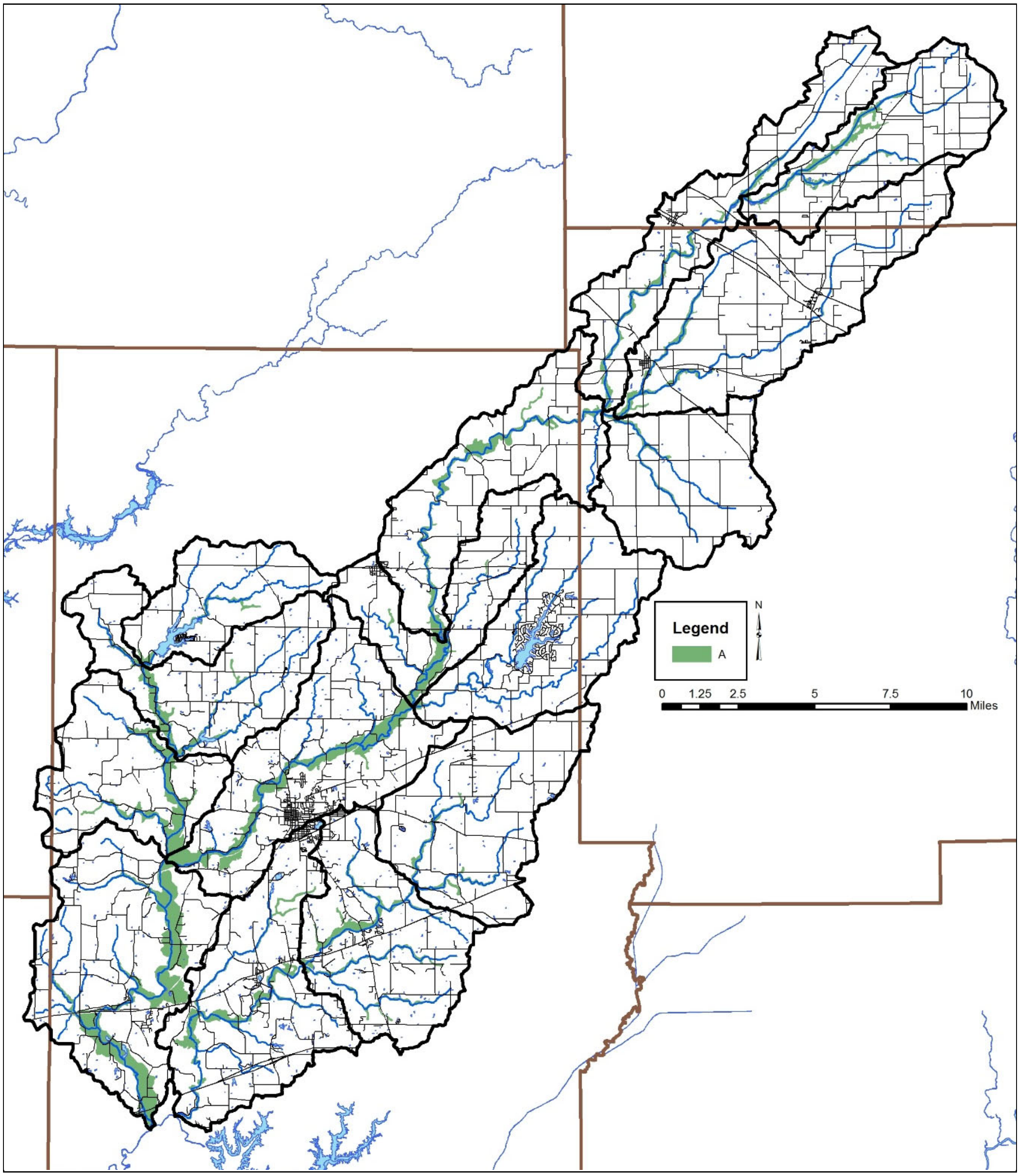

Figure 19. Floodplain locations within the Big Walnut Creek Watershed.

2.7.5 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 4,606 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 87% of wetlands have been modified or lost over time. This represents 29,530 acres of wetland loss within the Big Walnut 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 20 shows the current extent of wetlands within the Big Walnut Creek Watershed. Wetlands displayed in Figure 20 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.

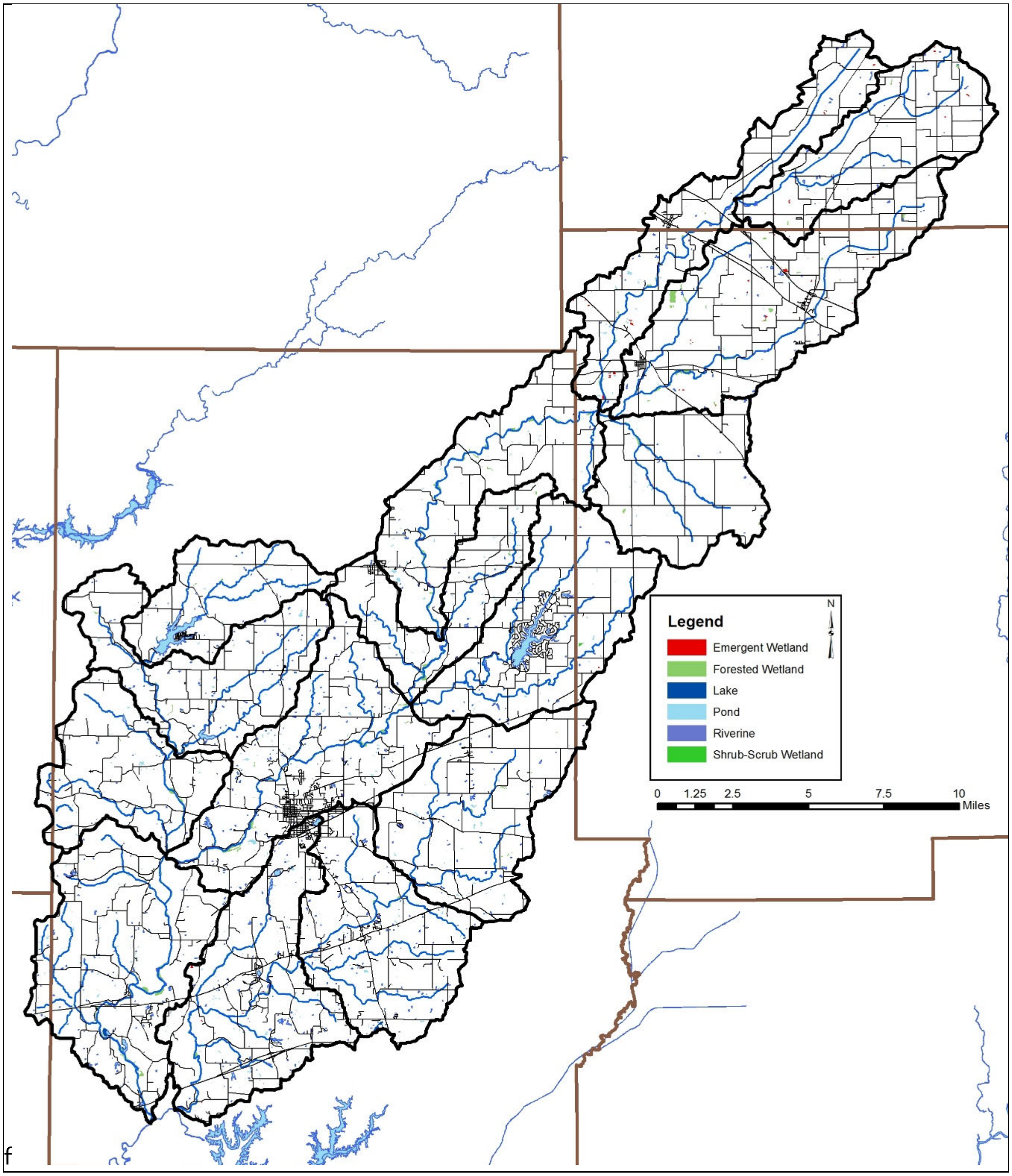

Figure 20. Wetland locations within the Big Walnut Creek Watershed. Source: USFWS, 2017.

2.7.6 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. In total, more than 51,710 feet of storm drain pipe are present within the City of Greencastle. These pipes connect the 857 stormwater inlets carrying water to the 25 stormwater outfalls. The City of Greencastle-DePauw University municipal separate storm sewer system (MS4s) work to mitigate stormwater impacts to Big Walnut Creek (Figure 21). While Boone and Hendricks counties are also permitted MS4s, their boundaries do not include the Big Walnut Creek Watershed.

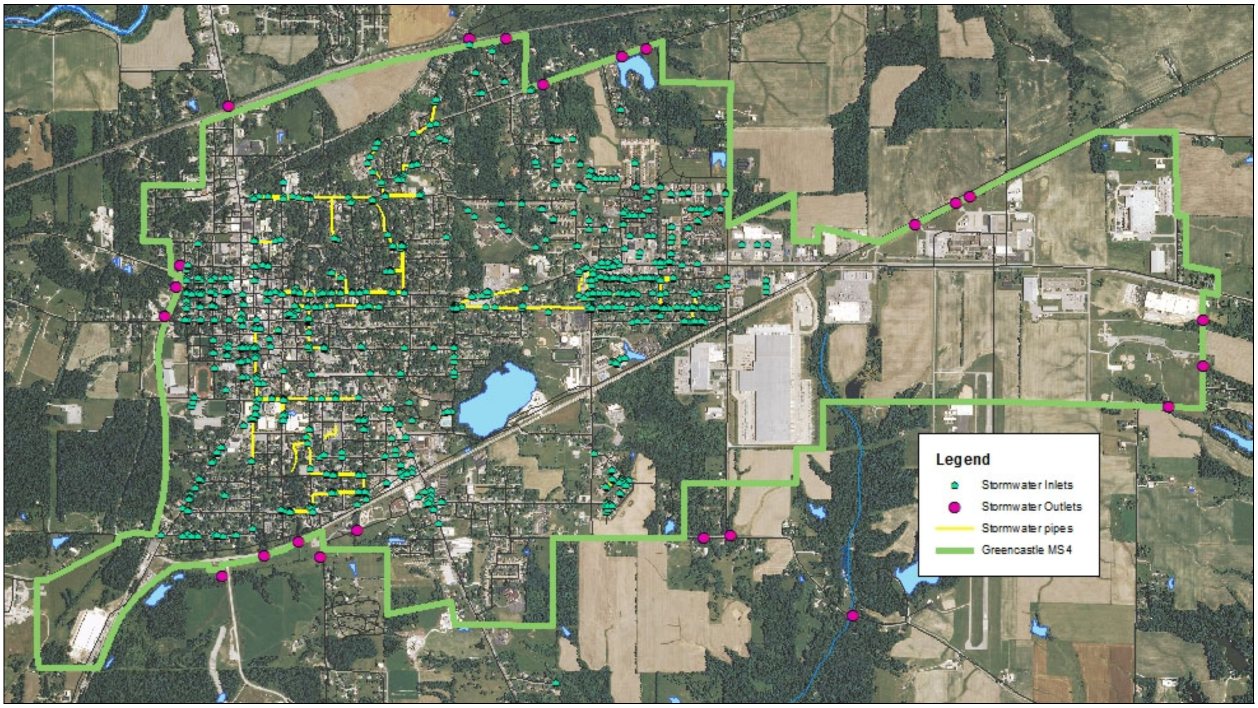

Figure 21. MS4 boundaries, stormwater inlets and outlets and stormwater pipes located within the Big Walnut Creek Watershed.

2.7.7 Wellfields/Groundwater

In general, municipal water which supplies Jamestown, Bainbridge, Greencastle, and Reelsville is taken from unconsolidated deposits embedded within sandstone, siltstone, mudstone and shale within the Borden Group Aquifer System (Schmidt, 2010). These unconsolidated deposits are part of the historic Mill Creek Valley and form a productive aquifer that yields from 25 to more than 1,000 gallons of water per minute (Watson and Jordan, 1964).

Recharge to the bedrock aquifer occurs at bedrock outcrops where precipitation enters the aquifer directly or indirectly via unconsolidated deposits. Table 7 lists wellhead protection areas within and adjacent to the Big Walnut Creek Watershed. The wellhead protection areas and wellhead protection plans associated with each area will be discussed in additional detail in subsequent sections. 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 22. Small areas of aquifer are highly sensitive including locations northeast of Greencastle and along the southern edge of the watershed near the confluence with Mill Creek.

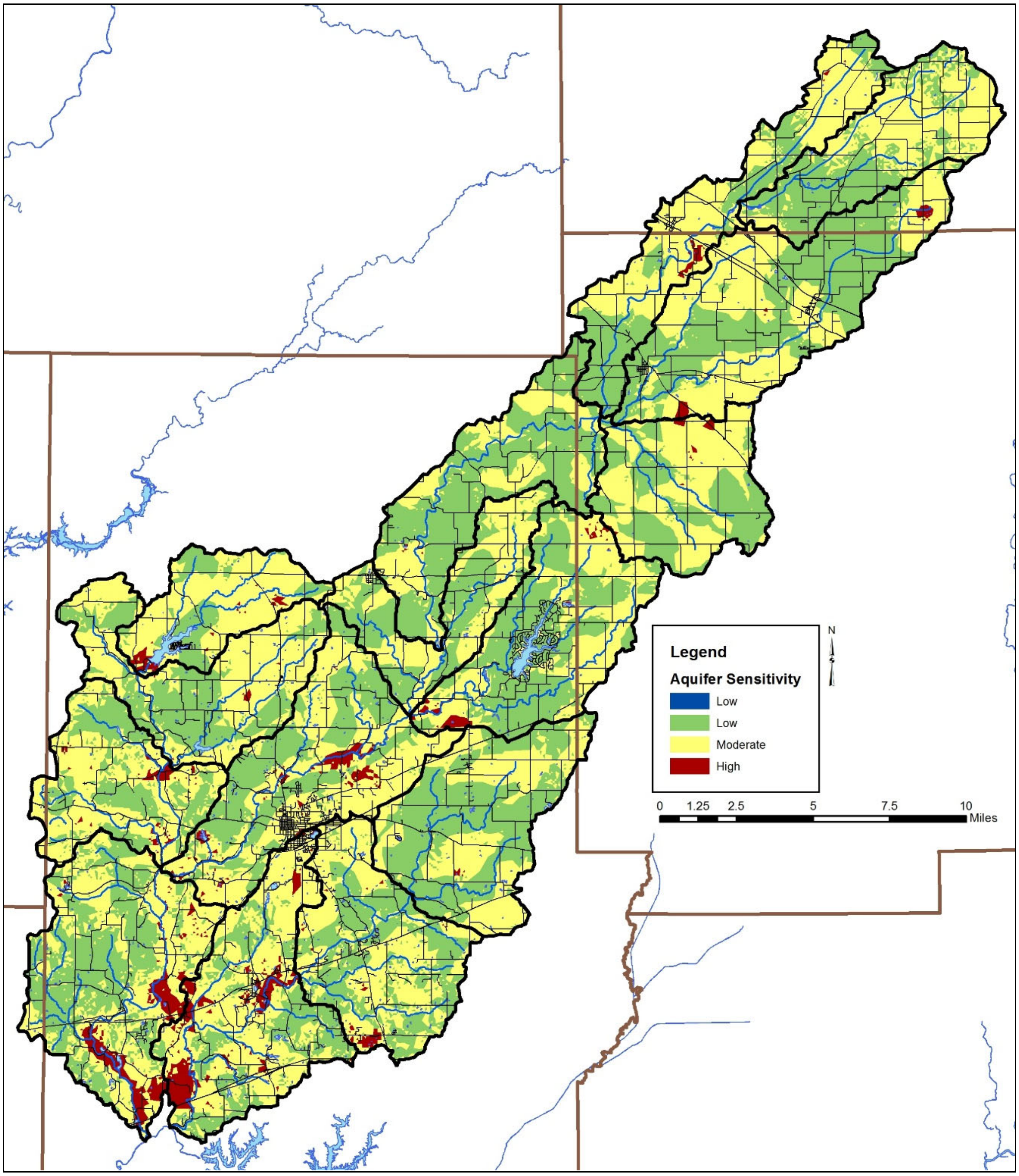

Figure 22. Aquifer sensitivity within the Big Walnut Creek Watershed. Source: IGS, 2015.

Table 7. Wellhead protection areas in and adjacent to the Big Walnut Creek Watershed.

County	PWSID	System name	Population
Boone	5206008	Jamestown Municipal Water	986
Hendricks	5232016	Riverside Mobile Home Park	92
Hendricks	5232017	North Salem Water Corporation	504
Hendricks	5232028	Sti-Bel Mobile Home Park	40
Putnam	5267001	Bainbridge Water Works	830
Putnam	5267004	Greencastle Department of Water	12,699
Putnam	5267006	Reelsville Water Company	2,800
Putnam	5267010	Van Bibber Lake Conservancy District	800

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 Big Walnut Creek Watershed lies within three regions: the Shawnee Hills Natural Region, the Southwestern Lowlands, and the Central Till Plain. In total, five subregions cover the Big Walnut Creek Watershed with the Shawnee Hills Region comprised of the Escarpment and the Crawford Upland sections, the Southwestern Lowlands comprised of the Glaciated Section, and the Central Till Plain comprised of the Tipton Till Plain and Entrenched Valley sections (Figure 23). The Shawnee Hills natural region are 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 Central Till Plain natural region is topographically homogeneous and is generally flat with end moraines common. The Entrenched Valley Section is identified by deeply entrenched valleys along major drainageways, while the Tipton Till Plain Section is a mostly undissected plain covered by poorly drained soils and historically covered by extensive beech-maple-oak forests. The Southwestern Lowlands natural region is characterized by low relief and extensive, aggraded valleys created by glaciation associated with the Illinoian ice sheet (Homoya et al., 1985). Much of this natural region is nearly level, undissected and poorly drained with areas of hilly, well drained topography.

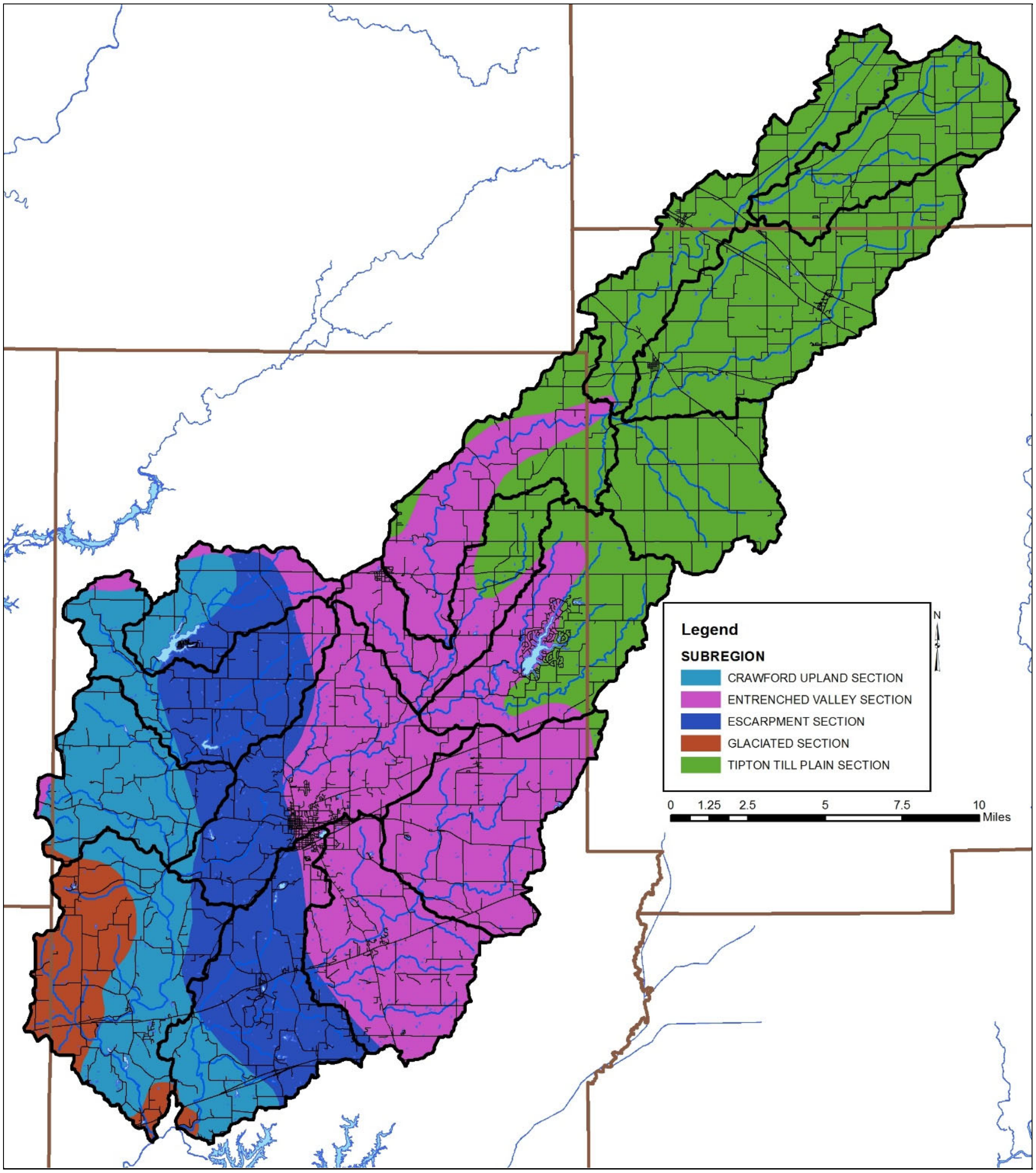

Figure 23. Subregions of the Shawnee Hills, Southwestern Lowlands and Central Till Plains natural regions in the Big Walnut Creek Watershed.

The Big Walnut Creek Watershed is mostly covered by the Eastern Corn Belt Plains with the Interior Plateau covering areas of the watershed south and west of Greencastle and small areas of the Interior River Valleys and Hills lying along the northeastern edge in the Owl Creek Headwater and along the southwestern edge of the watershed west of the confluence of Big Walnut Creek with Mill Creek (Figure 24).

The Eastern Corn Belt Plains ecoregion is primarily a rolling till plain with local end moraines with historical natural tree cover and light colored soils. Originally, beech forests were common on Wisconsinan soils while beech forests and elm-ash swamp forests dominated the wetter pre-Wisconsinan soils. Today, extensive corn, soybean, and livestock production occurs across the Eastern Corn Belt Plains. The Interior Plateau ecoregion is typically comprised of limestone, sandstone and shale land forms located on irregular plains. Oak-history forest historically mixed with bluestem prairie and cedar groves in this ecoregion. The interior River Valleys and Hills ecoregion is comprised of wide, flat-bottomed terraced valleys and forested valley slopes. Bottomland deciduous forest and swamp forests were common in wet, lowland areas with mixed oak and oak-hickory forests on uplands.

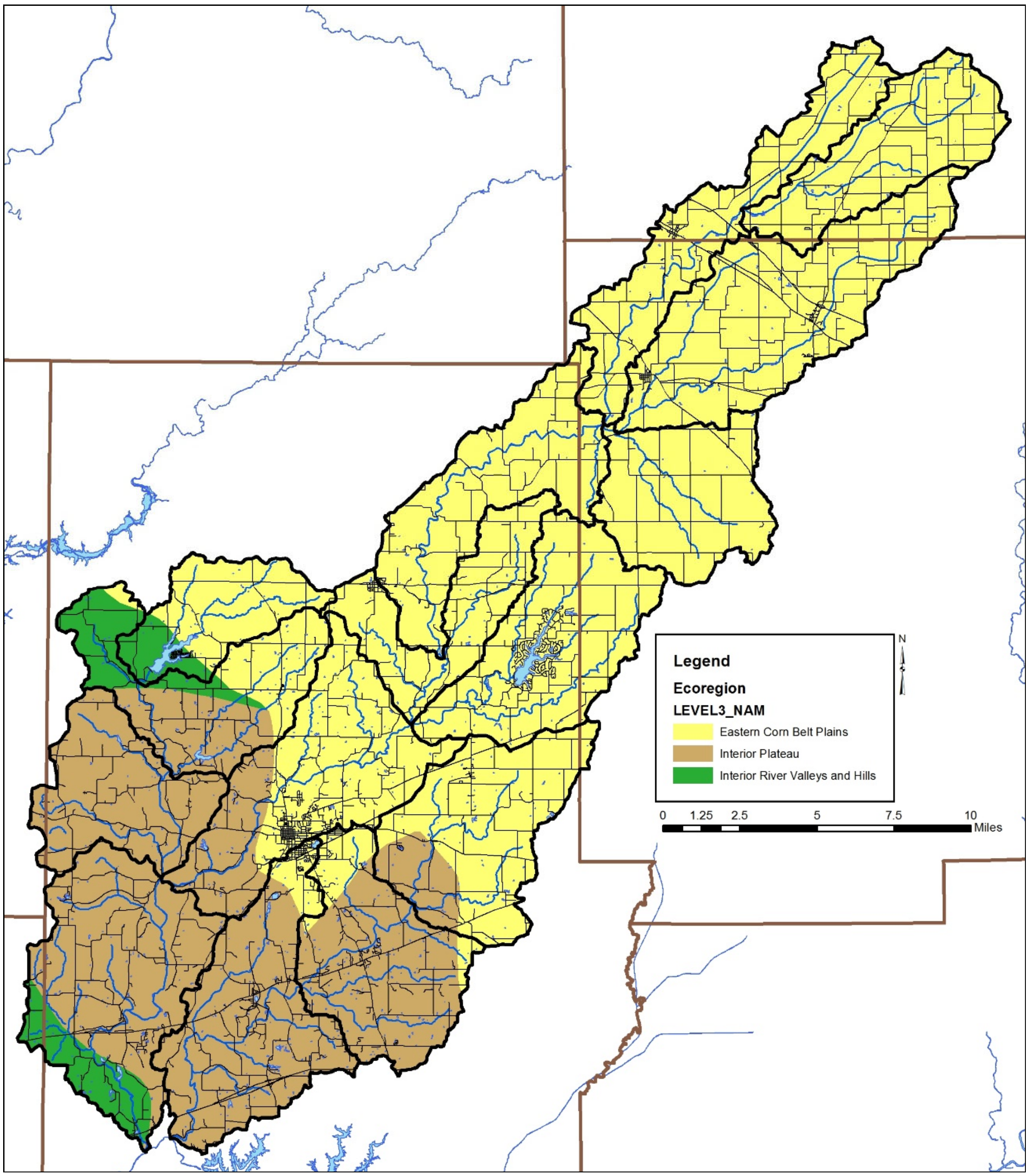

Figure 24. Level III eco-regions in the Big Walnut Creek Watershed.

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 8 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 8. Surrogate estimates of wildlife density in the IDNR southwest region, which includes the Big Walnut 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 Big Walnut Creek Watershed was not completed, dog and cat populations were estimated for the watershed using statistics reported in the 2012 U.S. Pet Ownership & Demographics Sourcebook. Specifically, the Sourcebook reports that on average 37.4 percent of households own dogs and 32.9 percent of households own cats. Typically, the average number of pets per household is 1.7 dogs and 2.2 cats. However, pets are likely only a significant source of E. coli in population centers. The estimated number of domestic pets in the Big Walnut 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 11,123 cats and 9,770 dogs. Pet waste issues are more predominant in urban areas such as Greencastle 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, 95 observations of listed species and/or high quality natural communities occurred within the Big Walnut Creek Watershed (Figure 25; Clark, personal communication). These observations include two amphibians, 34 bird, three mammals, 14 mollusk, one reptile, 12 plants, seven insects, 8 geological features, and 13 high quality natural communities. Many of these species were historically located adjacent to Big Walnut Creek or a tributary or within their riparian habitats. State endangered species include the sedge wren (1994 and 2007), loggerhead shrike (2010), cerulean warbler (1995, 1998, 2001, 2007), loggerhead shrike (2010), upland sandpiper (2000), Henslows sparrow (2009), Indiana bat (1991), eastern massasauga (1892), American yew (2011), northern riffleshell (2005), round hickorynut (2005, 2007), and rusty-patch bumble bee (1976, 1981, 1982). While state threatened species include royal pinkpatched looper moth (2001) and state rare species include turquoise bluet (2004), salt-and-pepper skipper (2001), arrowhead spiketail (1995), longstalk sedge (1995, 2005, 2015), and wolf bluegrass (2005). The falls and Reelsville, Vermillion Upper and Lower Falls, Clinton Falls, Falls on Falls Branch, Falls on Walnut Creek and Walnut Creek tributary and Ledge on Jones Creek rate as geologic features. High quality natural communities include the Big Walnut Nature Preserve original and addition, the Big Walnut Managed Area, Hall Woods Nature Preserve, Hemlock Ridge Nature Preserve, Fern Cliff Nature Preserve, and Fortune Woods Nature Preserve. Appendix B includes the database results for the Big Walnut Creek Watershed, as well as county-wide listings for Boone, Hendricks and Putnam Counties.

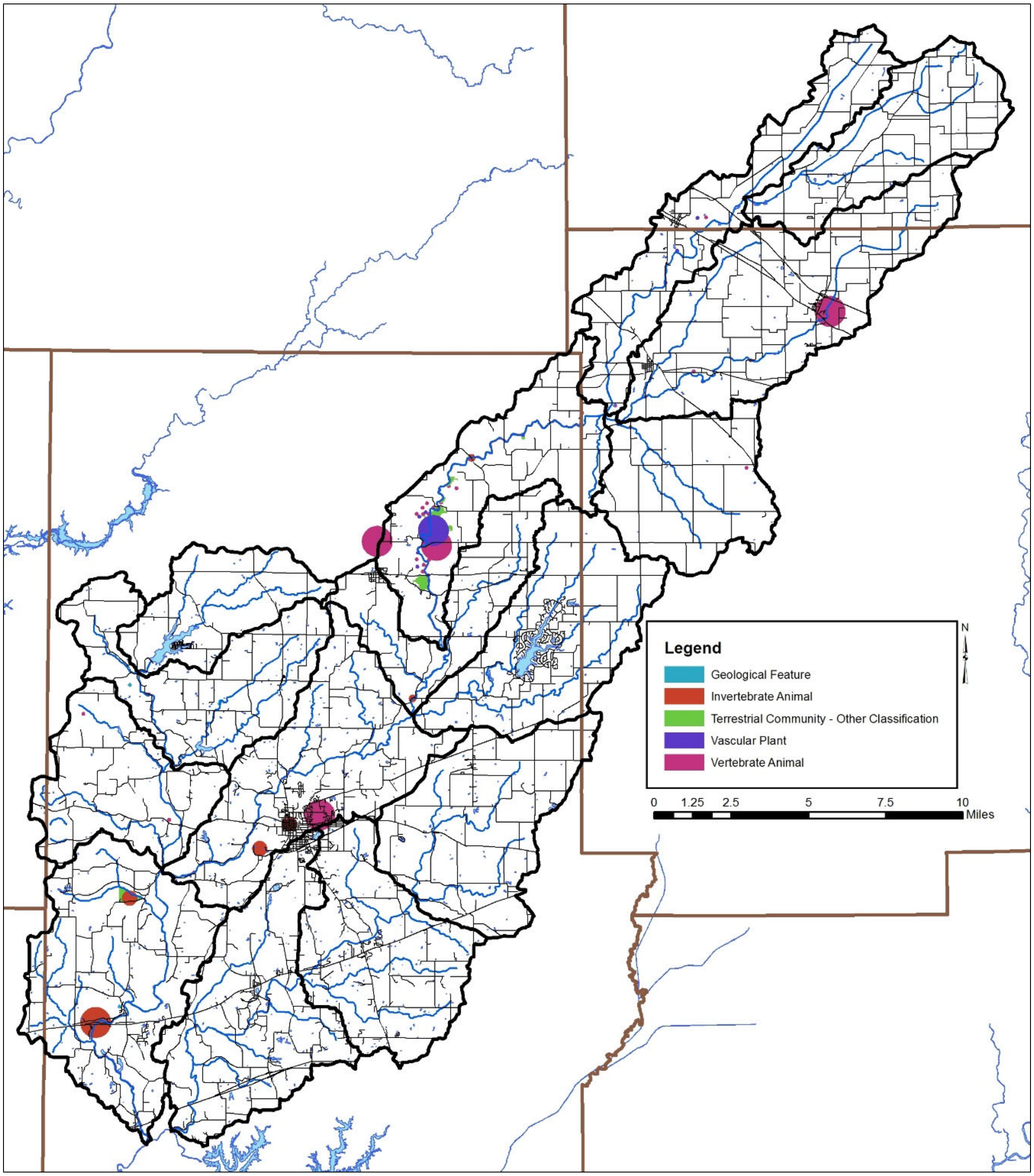

Figure 25. Locations of special species and high quality natural areas observed in the Big Walnut Creek Watershed. Source: Clark, 2018.

2.8.4 Exotic and Invasive Species

Exotic and invasive species are prevalent throughout the state of Indiana. Their presence throughout the watershed and their potential impacts on high quality natural communities and regional species are of concern to stakeholders. Individuals are especially concerned about the prevalence of garlic mustard and honeysuckle species as well as other terrestrial species which negatively impact forests and timber stand management. Many species impact portions of the Big Walnut Creek Watershed. Exotic species are defined as non-native species, while invasive species are those species whose introduction can cause environmental or economic harm and/or harm to human health. Hundreds of thousands of dollars are spent annually controlling exotic and/or invasive species populations within both publicly-owned natural areas and on privately-owned land. While this section is current as of the plan's publication, the threat of exotic and invasive species is continuously evolving. Therefore, new species or treatment methods may be available since the publication of the plan. Table 9 lists exotic species observed within the counties which comprise the watershed.

Table 9. Observed exotic and/or invasive species by county within the Big Walnut Creek Watershed.

Species	Boone County	Hendricks County	Putnam County
Asian bush honeysuckle	X	X	X
Autumn olive	X	X	X
Black locust		X	X
Buckthorn		X	
Canada thistle	X	X	X
Common reed	X	X	X
Crown vetch	X	X	X
Dame's rocket	X	X	X
Garlic mustard	X	X	X
Japanese honeysuckle	X	X	X
Japanese knotweed	X	X	
Mulitflora rose	X	X	X
Periwinkle	X	X	X
Privet	X	X	X
Purple loosestrife	X	X	X
Purple winter creeper	X	X	X
Reed canary grass	X	X	X
Russian olive		X	
Siberian elm	X	X	X
Smooth brome	X	X	X
Sweet clover	X	X	X
Tall fescue	X	X	X
Tree of heaven	X	X	X
White mulberry	X	X	X
Winged burning bush		X	

Source: Bledsoe, 2009; Fisher et al., 1998

2.8.5 Recreational Resources and Significant Natural Areas

A variety of recreational opportunities and natural areas exist within the Big Walnut Creek Watershed. Recreational opportunities include parks, fish and wildlife areas, nature preserves, fairgrounds, golf courses, race tracks, and school grounds (Table 10, Figure 26). There are several significant natural areas located within the Big Walnut Creek Watershed. The Indiana DNR, The Nature Conservancy, Central Indiana Land Trust Incorporated, and DePauw University maintain, preserve and protect these properties. McCloud Park and roadside parking at the Putnam/Hendricks County Line, US Highway 36, US Highway 231 provide access to Big Walnut Creek. Additional recreational opportunities exist at various schools, golf complexes and sporting clay facilities.

Table 10. Natural areas in the Big Walnut Creek Watershed

Natural Area	County	Organization
Big Walnut Nature Preserve	Putnam	TNC, IDNR
Fern Cliff Nature Preserve	Putnam	TNC
Hall Woods Nature Preserve	Putnam	IDNR
Hemlock Ridge Nature Preserve	Putnam	CILTI
McCloud Nature Park	Hendricks	Hendricks County Parks

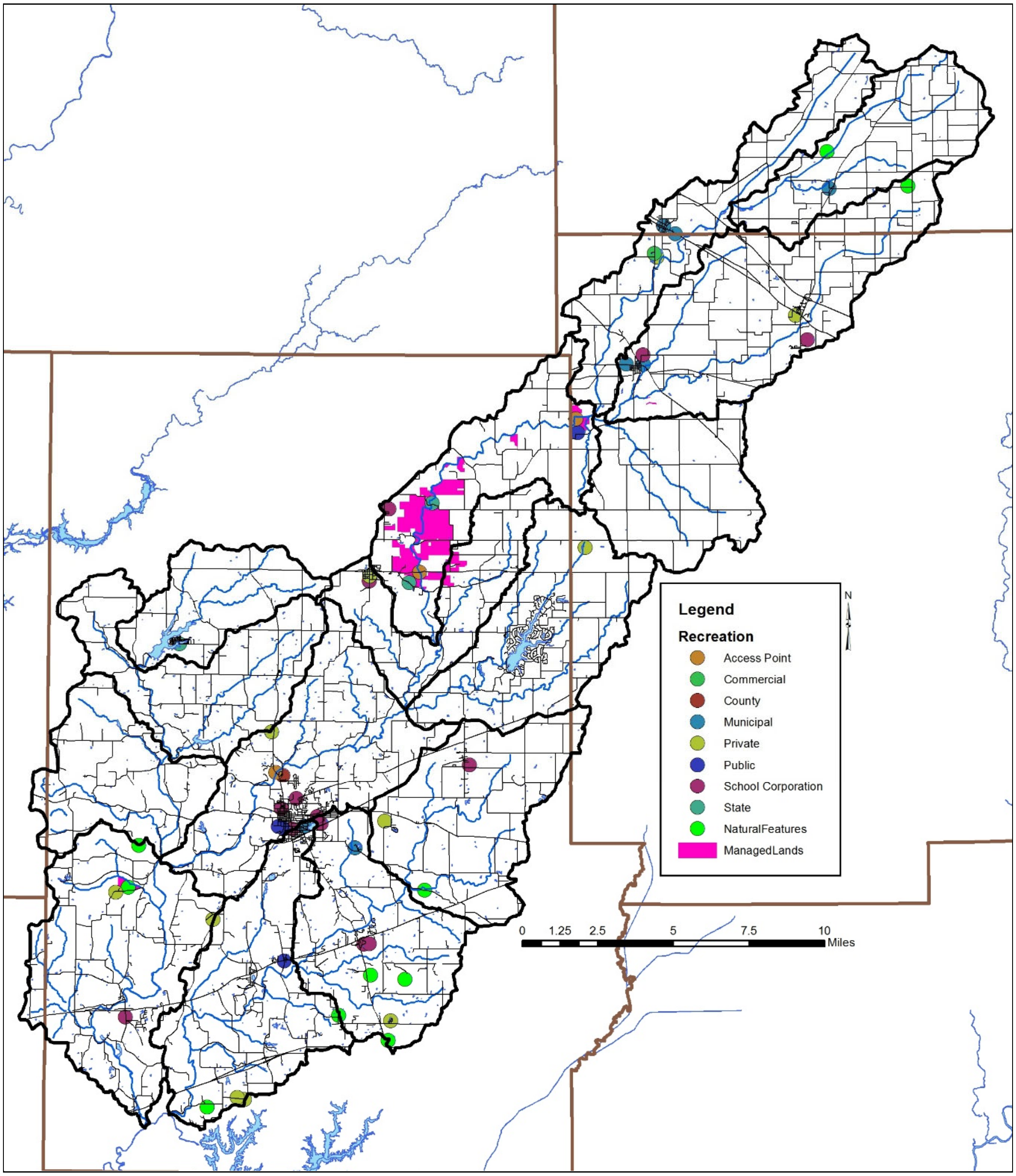

Figure 26. Recreational opportunities and natural areas in the Big Walnut Creek Watershed.

Big Walnut Nature Preserve consists of approximately 2700 acres along Big Walnut Creek in northeastern Putnam County. It was designated a National Natural Landmark in 1985 and is known for its rolling hills and steep ravines.

Fern Cliff Nature Preserve is a 157 acre preserve in western Putnam County. The preserve was dedicated as a National Natural Landmark in 1980. It's a popular sanctuary in Indiana known for its steep, forested cliff and ravines. The ferns found in Fern Cliff Nature Preserve provide an abundance of unique vegetation.

Hall Woods Nature Preserve is another preserve located along Big Walnut Creek just east of Bainbridge. It is approximately 90 acres and has a high frequency of large white oak trees present. Other species present include sassafras, buckeye, maple, dogwood, beech, tulip trees, and many others.

Hemlock Ridge Nature Preserve is approximately 40 acres in the Big Walnut Creek Corridor. It is named for its stands of Canadian or Eastern Hemlock (*Tsuga canandensis*) present along the bedrock bluffs. The preserve also has two notable ravines which lead to a breath-taking view of Big Walnut Creek. Hemlock Ridge is also home to two State Rare plant species: Longstalk Sedge (*Carex pedunculata*) and Wolf Bluegrass (*Poa wolfii*).

McCloud Nature Park is a 232 acre park located in northwestern Hendricks County. The park is open to the public and offers numerous activities and programs throughout the year. It also provides access to Big Walnut Creek for those wishing to take a canoe or kayak trip.

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 Big Walnut Creek Watershed is covered by row crop agriculture (56%) with an additional 9% of the watershed in pasture (Table 11, Figure 27). Nearly 27% of the watershed is mapped in forestland, while 6.5% of the watershed is covered by developed open space or is in low, medium, or high intensity developed areas. Grassland, evergreen forest, open water, and wetlands cover the remaining 1.5% of the watershed. Definitions for each land cover type are included in Appendix C.

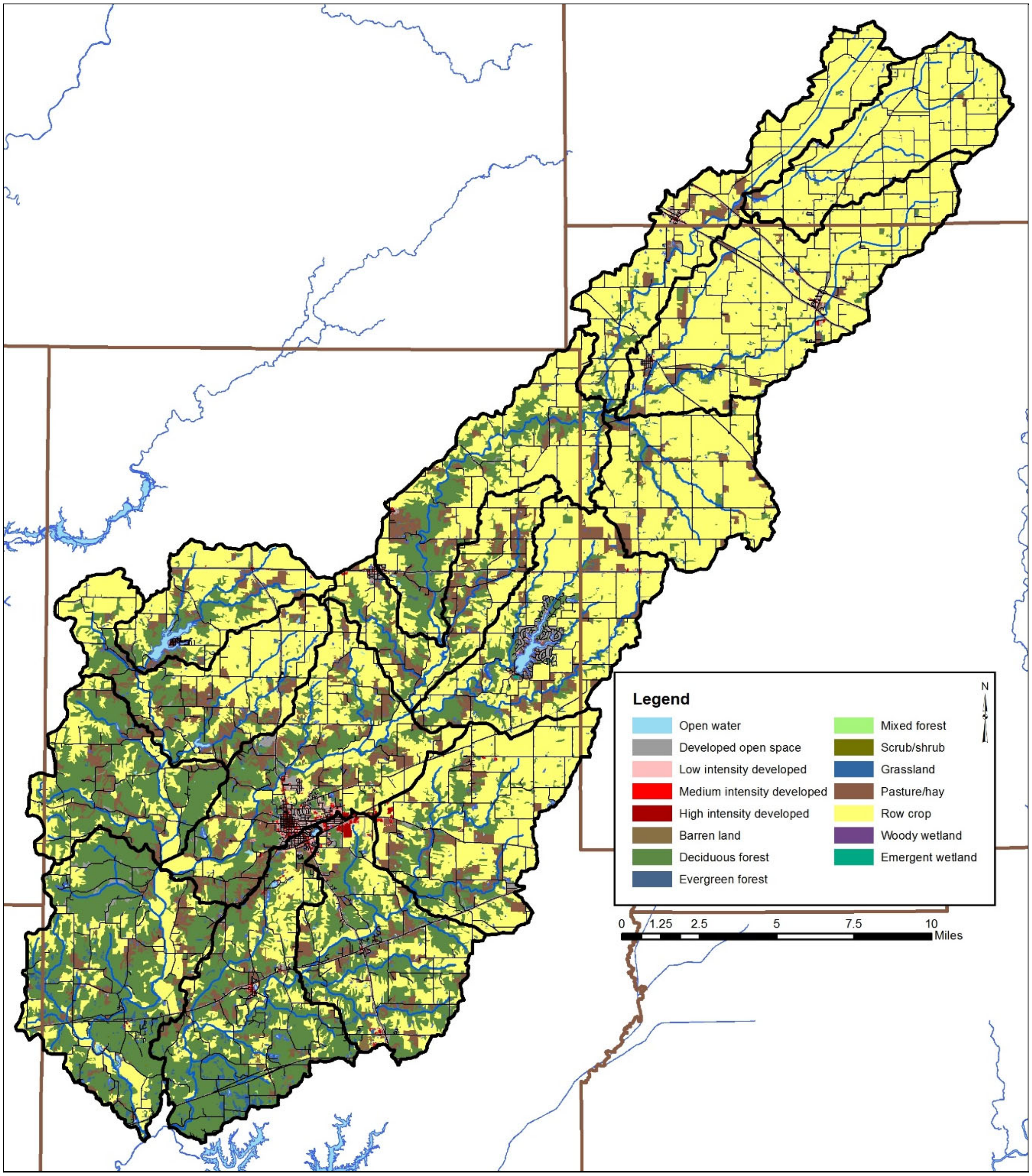

Figure 27. Land use in the Big Walnut Creek Watershed. Source: NLCD, 2011.

Table 11. Detailed land use in the Big Walnut Creek Watershed.

Classification	Area (acres)	Percent of Watershed
Row crow	151,029.4	55.7%
Deciduous forest	72,893.8	26.9%
Pasture/hay	23,730.2	8.8%
Developed open space	13,056.8	4.8%
Low intensity developed	3,425.8	1.3%
Grassland	3,405.5	1.3%
Open water	1,292.2	0.5%
Medium intensity developed	826.0	0.3%
Barren land	369.6	0.1%
High intensity developed	350.9	0.1%
Evergreen forest	272.8	0.1%
Woody wetland	149.6	0.1%
Emergent wetland	124.4	0.0%
Shrub/scrub	37.0	0.0%
Mixed forest	18.0	0.0%
Entire Watershed	**270,981.9**	**100.0%**

Source: USGS, 2011

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 Boone, Hendricks and Putnam counties was compiled for 2017 (Table 12; ISDA, 2017A-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 12 provides the number of acres and percent of acres on which conservation tillage was utilized for each county by corn and soybeans.

Table 12. Conservation tillage data as identified by county tillage transect data for corn and soybeans (ISDA, 2017).

County	Corn (acres)	Corn (%)	Soybeans (acres)	Soybeans (%)
Boone	57,884	65%	62,875	58%
Hendricks	23,665	60%	63,914	83%
Putnam	57,761	79%	60,890	89%

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, 2017). These data indicate that corn (221,325 acres in Boone, Hendricks and Putnam counties) and soybeans (246,820 acres in Boone, Hendricks and Putnam 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 16,311 tons of nitrogen and 8,068 tons of phosphorus are applied annually within the Big Walnut Creek Watershed counties (Table 13).

Table 13. Agricultural nutrient usage for corn in the Big Walnut Creek Watershed counties.

Nutrient	Acres of Corn	% of Area Applied	Applications (#/year)	Rate/Application (lb/acre)	Total Applied/Year (tons)
Nitrogen	221,325	100	2.2	67	16,311
Phosphorus	221,325	93	1.4	56	8,068

Source: NASS, 2007; ISDA, 2017A-C

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 137 tons of atrazine and approximately 156.6 tons of glyphosate are applied to cropland in the Big Walnut Creek Watershed counties annually (Table 14).

Table 14. Agricultural herbicide usage in the Big Walnut Creek Watershed counties.

Crop	Acres	Application Rate (lb/acre)	Total Applied (lbs)	Total Applied/Year (tons)
Corn (Atrazine)	221,325	1.24	274,443	137.3
Corn (Glyphosate)	221,325	0.60	132,795	66.4
Soybeans (Glyphosate)	246,820	0.73	180,178	90.1

Source: NASS, 2006; ISDA, 2017A-C

Confined Feeding Operations and Hobby Farms

A mixture of small, unregulated and larger, regulated livestock operations (confined feeding operations) is found within the Big Walnut 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 are 12 active confined feeding operations located in the watershed, none of which are large enough to be classified as a concentrated animal feeding operation (CAFO; Figure 28). The facilities house hogs with a combined total of 4,493 gestating sows or sows with litters, 32 boars, 11,180 finishing hogs, 8,481 feeding hogs, and an additional 9,772 finishing/feeding hogs. Additionally, 200 beef cattle are housed in concert with hog confined feeding operations. In total, approximately 34,160 animals per year are housed in CFOs in the watershed, generating approximately 140,888 tons of manure per year spread over the watershed. This volume of manure contains approximately 420,363 pounds of nitrogen and 317,269 pounds of phosphorus.

In total, 412 small, unregulated animal farms containing nearly 4,070 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, llamas, poultry, or goats, which could be sources of nutrients and *E. coli* as these animals exist on small acreage lots with limited ground cover.

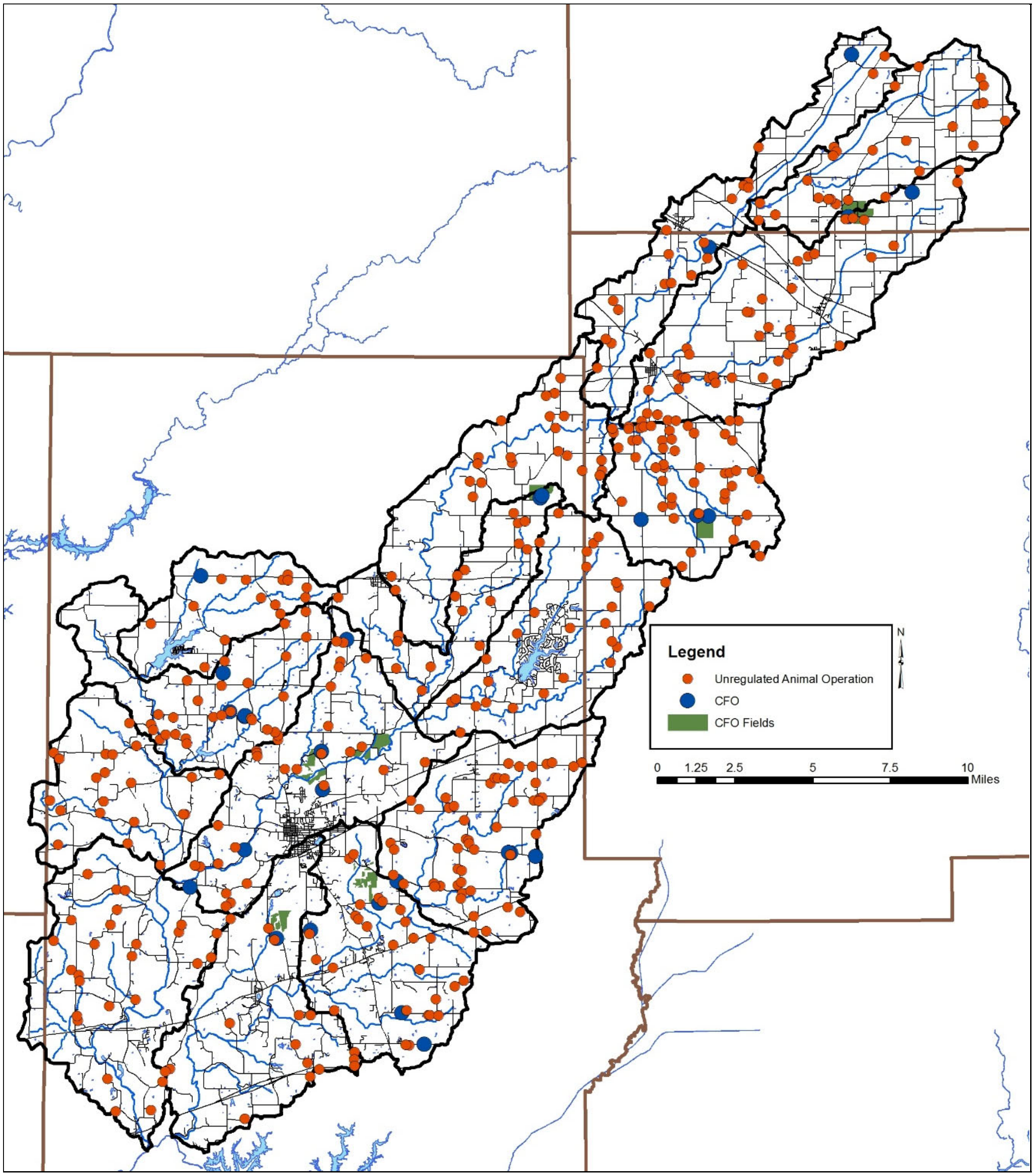

Figure 28. Confined feeding operation and unregulated animal farm locations within the Big Walnut Creek Watershed.

2.9.3 Natural Land Use

Natural land uses including forest, wetlands, and open water cover approximately 29% of the watershed. Approximately 73,184 acres or 27% of the watershed are covered by trees. Forest cover occurs adjacent to waterbodies throughout the watershed, with the extent of forests increasing from the northern end of the watershed, where the flatter terrain made it easier to clear for agriculture, towards the southern end of the watershed (Figure 27). Many forested tracts are contiguous and large lengths of the watershed streams contain intact riparian buffers. Many of the high quality forested areas are protected by the Indiana DNR, The Nature Conservancy and the Central Indiana Land Trust, Inc. (Figure 26; Table 10).

2.9.4 Urban Land Use

Urban land uses cover nearly 9% of the watershed (Table 11). Although this is only a very small portion of the watershed, there are some significant issues related to the developed areas. 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.

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 Greencastle, Bainbridge, Fillmore, Jamestown, Lizton, Groveland, Morton, Manhattan, Mt. Meridian, North Salem, around Heritage and Glenn Flint Lakes and along roads throughout the watershed. Estimates indicate that 89,335 acres (32%) of the watershed are 25% or more covered by hard surfaces. 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).

Remediation Sites

Remediation sites including industrial waste, leaking underground storage tanks (LUST), open dumps, and brownfields are present throughout the Big Walnut Creek Watershed (Figure 29). Most of these sites are located within the developed areas of the watershed including Greencastle, Lizton, Jamestown and along urban corridors of U.S. Highway 70, U.S. Highway 40, and U.S. Highway 74. In total, 10 industrial waste sites, 73 LUST facilities, on voluntary remediation project (VRP) two open dumps, one solid waste, three septage sites, two corrective action sites, and five brownfields are present within the watershed. There are no Superfund sites within the watershed.

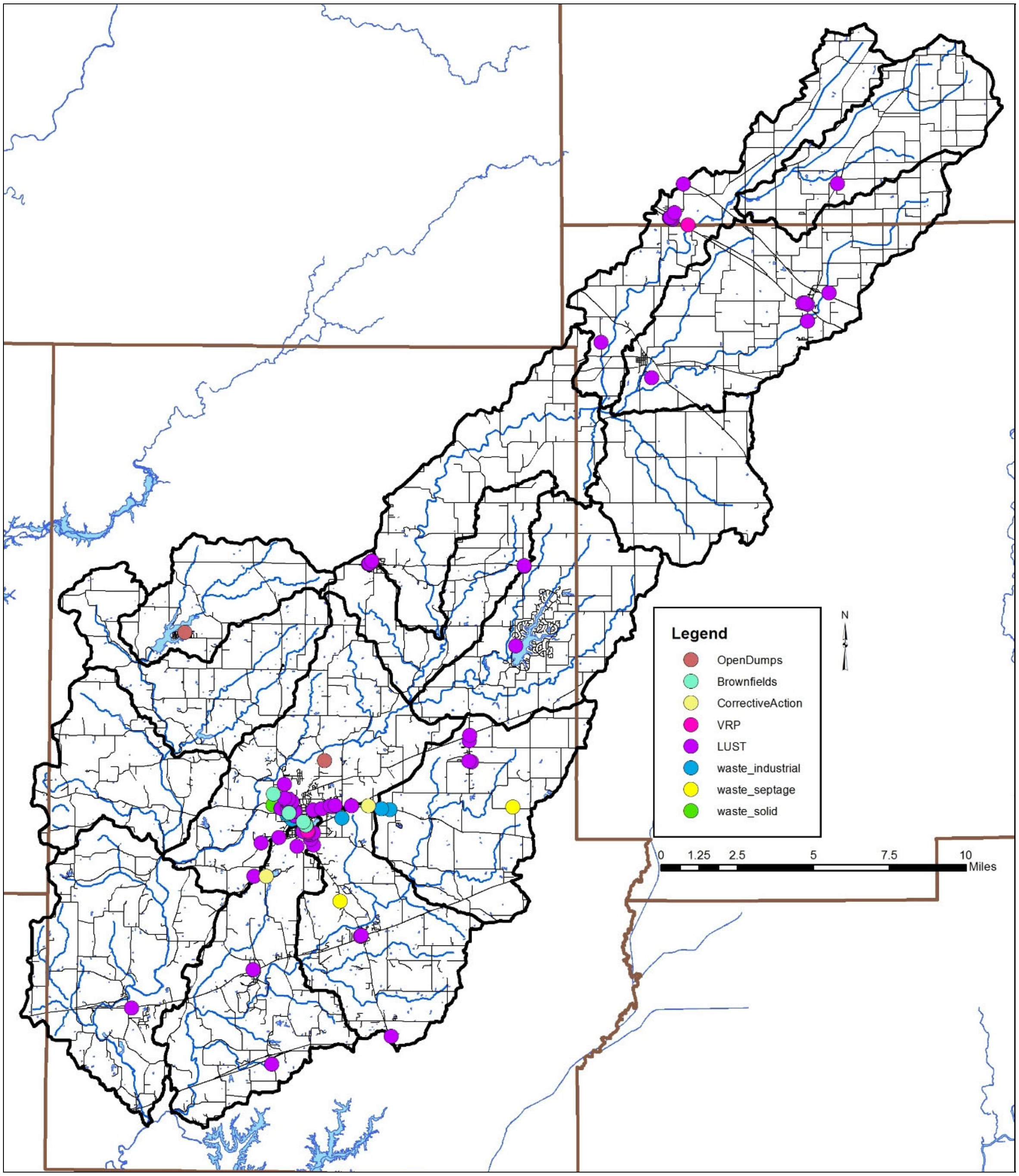

Figure 29. Industrial remediation and waste sites within the Big Walnut Creek Watershed. Source: IDEM.

2.10 Population Trends

The Big Walnut Creek Watershed is relatively a sparsely populated area in general. One city, Greencastle, and several incorporated towns, including Jamestown, Lizton, North Salem and Bainbridge, and unincorporated towns including, Milledgeville, New Brunswick, Barnard, New Mays Ville, New Winchester, Groveland, Clinton Falls, Brick Chapel, Cary, Fillmore, Fox Ridge, Limedale, Mount Meridian, Westland, Putnamville, Cradick Corner, Jenkinsville, Pleasant Garden, Reelsville, Brunerstown, Keytsville and Manhattan, are located throughout the watershed. Coatesville and

Cloverdale lie adjacent to the Big Walnut Creek Watershed boundary and are mainly outside of the watershed.

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. Estimates of the population of the watershed are derived by calculating percentage of the watershed within a county and extrapolating from county-wide data. The Big Creek Watershed mainly lies within three counties. It drains nearly 10% of Boone County, 20% of Hendricks County, and 69% of Putnam County. Population trends for these counties derived from the most recently completed census (2010) are shown in Table 15, while Table 16 displays estimated populations for the portion of each county located within the watershed (StatsIndiana, 2018). These data indicate modest growth in all three counties over the past decade.

Table 15. County demographics for counties within Big Walnut Creek Watershed.

County	Area (acres)	Population (2010)	Population Growth (2000-2010)	Pop. Density (#/sq. mi)
Boone	270,720	56,640	+10,533	133.9
Hendricks	261,760	145,448	+41,383	355.6
Putnam	309,120	37,963	+1,944	78.6

Table 16. Estimated watershed demographics for the Big Walnut Creek Watershed.

County	Acres of County in Watershed	Percent of County in Watershed	Population
Boone	28,056	10.4%	5,868.7
Hendricks	54,888	20.3%	29,483.6
Putnam	186,034	68.7%	26,082.4
		Total Estimated Population	**61,434.7**

2.11 <u>Planning Efforts in the Watershed</u>

Several larger plans have encompassed portions of the Big Walnut Creek Watershed or areas which it drains or outlets into. Planning efforts include Boone, Hendricks and Putnam SWCD Master Plans and Boone, Hendricks and Putnam county-wide master plans.

Boone County SWCD Plan of Business

The Boone County SWCD Business Plan highlights four critical natural resources issues for Boone County: 1) soil erosion, 2) land use and development, 3) water quality, and 4) forestry and wildlife habitat. The following goals are highlighted for completion by 2022:

- Host cover crop winter round table annually.
- Increase no till corn to 30% and no till soybeans to 90% coverage.
- Utilize the annual tree sale to promote wildlife habitat.
- Establish four permanent cover crop signs and 10 temporary signs to promote cover crops.
- Partner with the surveyors office to address streambank erosion issues.

Additional on-going efforts target completion of annual fall cover crop transects; participation in the Big Walnut Watershed Alliance; establishment of demo plots at the Boone County 4H fairgrounds; and continued identification of partnership opportunities.

Hendricks County SWCD Plan of Business

The Hendricks County SWCD Business Plan highlights four critical natural resources issues for Hendricks County: 1) soil erosion, 2) land use and development, 3) water quality, and 4) forestry and wildlife habitat. The Hendricks County SWCD highlights the need to increase outreach to small farms, increase cover crop use by 15%, improve water quality awareness, and increase acres of wildlife habitat restoration. Specific tasks identified include attending Big Walnut Watershed Alliance meetings, outreach to students via organized education events, marketing the CREP program, hosting rule 5 workshops and contractor training, and hosting workshop focused on home owners including pet waste, septic maintenance and fertilizer usage.

Putnam County SWCD Plan of Business

The Putnam County SWCD Business Plan highlights four critical natural resources issues for Putnam County: 1) soil health, 2) Putnam County watersheds, 3) education and promotion of the conservation ethic, and 4) engaging non-traditional populations. The Putnam County SWCD plan of work identifies the following relevant activities and efforts:

- Hosting biennial land improvement contractor's workshop.
- Hosting annual winter cropping systems meeting.
- Disseminating MS4 issue-related information.
- Develop and disseminate soil health initiative information and host an annual workshop.
- Provide opportunities to understand the watershed concept.
- Promote Big Walnut Watershed Alliance activities.
- Assist and promote Board of Health and local realtor programs to educate home owners.
- Host know your watershed, rain gardens, rain barrels, backyard conservation targeted to but not limited to urban/suburban individuals.

Boone County Area Master Plan

The Boone County Master Plan was updated in 2009 (Boone County Area Plan Commission, 2009). The plan highlights the need to focus on natural resources as attractions, use conservation easements, develop natural resources, and maintain agricultural areas. The following goals that are relevant to the Big Walnut Watershed are included:

- Increase the opportunities for passive and active recreation for residents and visitors, which continually promotes the culture of a healthy and active lifestyle for all Boone County residents.
- Promote recreation connectivity and accessibility between neighborhoods and towns.
- Promote local policies and practices that protect WATER through the use of best management practices to ensure sustainable long-term use.
- Promote local policies and practices that protect LAND through the use of best management practices to ensure sustainable long-term use.
- Promote local policies and practices in regards to SOLID WASTE through the use of best management practices to ensure sustainable long-term use.
- Employ best management practices to minimize negative short- and long-term impacts of development.
- Identify target growth areas that take into account environmental sensitivity, agriculture conservation, and existing infrastructure availability.
- Growth standards shall reflect a cohesive and unique character that emphasizes a connection between creating a rural and small town sense of place and the convenience between places to live, work, and play.

- Recognize agriculture as productive landscape and preserve these uses for the production of food, fiber, and fuel.
- Preserve the viability, productivity, character, and quality of Boone County's agricultural and water resources.
- Conserve farmland and agriculture with zoning standards that protect, promote, and grow agriculture within Boone County.
- Limit land-use conflicts.
- Support green development and environmentally responsible residential development and housing.

Hendricks County Area Master Plan
In 2006, the Hendricks County Area Plan Commission updated the previous county comprehensive plan (Hendricks County Area Plan, 2006). The plan highlights the following natural resources concerns: Consider town's wellhead protection areas when evaluating development plans.

- Identify ground water infiltration problems and issues and educate public as to effects of waste disposal on water quality.
- Maintain and improve surface water quality
- Explore alternatives to the use of retention ponds throughout the county such as constructed wetlands for small and large scale development.
- Provide increased protection for surface water quality in the Eagle Creek watershed and in other environmentally sensitive areas.
- Preserve White Lick Creek corridor and other natural areas from development.
- Promote the proper operation of existing septic systems and the deactivation of failing systems.
- Promote the protection of wilderness areas and animal habitat including riparian corridors, woodlands, wetlands, open spaces, and floodplains by encouraging the incorporation and preservation of these areas in new developments as dedicated open space. Conserve natural amenities through creation of parks and trails as part of new development.
- Preserve natural wetlands and wilderness areas by clustering new development.
- Reduce light and noise pollution.
- Air quality objectives
- Develop standards that will not decrease air quality or cause an increase in the required federally mandated air quality restrictions.
- Promote compatibility between surrounding land use and mining operations.

City of Greencastle Comprehensive Plan
The City of Greencastle adopted the following natural resource related policies in their comprehensive plan, which was adopted in 2001 (City of Greencastle, 2001).

- Promote the incorporation of well-field protection design features in any new roads or land uses established in the 5-year well-field capture area.
- Maintain and promote local spring clean-up days and opportunities for the proper disposal of toxic materials at no or low cost.
- Support and promote the activities of the Greencastle Tree Board.
- Consider opportunities to incorporate environmental features and nature preserves in new parks.
- Promote the inclusion of woodlots, wetlands, and riparian areas in common areas provided by new developments through common area incentives.

- Apply growth management and land use objectives to the conservation of the natural environment and farmland preservation.
- Establish provisions in the zoning and subdivision control ordinances for erosion and sediment controls at construction sites and the consideration of water quality impacts during the plan review process.
- Establish provisions in the zoning and subdivision control ordinances to support the implementation of appropriate best management practices for runoff control which ensure the long term operation and maintenance of the control features.

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, and Hydrology

Much of the topography and terrain characteristics within the Big Walnut Creek Watershed have a direct correlation to water quality. Approximately 55% of the Big Walnut Creek Watershed is mapped in highly erodible or potentially highly erodible soils. Highly erodible and potentially highly erodible soils are very susceptible to erosion. Nutrients, such as phosphorus, and sediment erode easily when these soils are not covered. Sediments and nutrients that reach Big Walnut Creek waterbodies are likely to degrade water quality. Highly erodible and potentially highly erodible soils that are used for animal production or are located on cropland are more susceptible to soil erosion.

Topography within the watershed is generally flat in the Boone and Hendricks County portions of the watershed with topography increasing as water moves south through the watershed. Soils in these areas formed on till deposits, are somewhat poorly drained to moderately well drained, and are well suited to agriculture. As a result, approximately 75% of the watershed headwaters are in a corn-soybean rotation with nearly 55% of the entire Big Walnut Creek Watershed in agricultural row crop production. Because of the low slope and poor drainage, tile drains are extensively used throughout the northern portion of the watershed. It will be important to address the impacts of row crop agriculture and tile-drained systems, by promoting practices to reduce nutrients transported through tiles and to repair and prevent streambank erosion, in order to improve water quality in the watershed.

The steepest terrain in the watershed occurs in the southern portion of the watershed where forested land uses predominate. The 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. This area is also where the highest concentration of highly erodible and potentially highly erodible soils are found. Protecting and restoring the forested riparian buffer in this area will be important to reducing streambank erosion and in-stream sediment levels.

2.12.2 Development and Population Centers

Much of the watershed's population is located within incorporated areas, including City of Greencastle; Towns of Bainbridge, Fillmore, Jamestown, Lizton, and North Salem; and at Glenn Flint and Heritage lakes. Unsewered, dense housing areas are located throughout the watershed with small subdivisions and roadside housing developments occurring throughout the watershed. All other residences utilize septic systems. 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 Big Walnut Creek Watershed stakeholders. 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), and industrial waste sites. 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 Big Walnut Creek Watershed.

2.12.3 High Quality Habitat and ETR Species

Many high quality communities occur along the mainstem of Big Walnut Creek. Several of these are preserved for future generations by The Nature Conservancy, Hendricks County Parks, Central Indiana Land Trust, and the Indiana Department of Natural Resources. The high quality natural regions, heavy forest cover and steep topography associated with Big Walnut Creek's riparian area 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 WATERSHED INVENTORY II-A: WATER QUALITY AND WATERSHED ASSESSMENT

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 Big Walnut 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 17 details the selected parameters and the benchmark utilized to evaluate collected water quality data.

Table 17. 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	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	<1.5 mg/L	Dodds et al. (1998)
Ammonia-nitrogen	0.0 – 0.21 mg/L	Indiana Administrative Code
Total phosphorus	<0.08 mg/L	Dodds et al. (1998)
Orthophosphorus	<0.05 mg/L	Dunne and Leopold (1978)
Total suspended solids	<15 mg/L	Waters (1995)
Turbidity	<5.7 NTU	USEPA (2001)
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 Big Walnut Creek Watershed (Figure 30). Statewide assessments and listings include the integrated water monitoring assessment, the impaired waterbodies assessment, and fish consumption advisories. Additionally, the Indiana Department of Environmental Management (IDEM), Indiana Department of Natural Resources (IDNR), Indiana Clean Lakes Program (ICLP), U.S. Fish and Wildlife Service (USFWS), U.S. Environmental Protection Agency (USEPA), and U.S. Geological Survey (USGS) have all completed assessments within the watershed. Commonwealth Biomonitoring (Biomonitor) and Dr. James Gammon at DePauw University completed watershed-wide water quality assessments. Additionally, volunteer-based sampling of water quality through the Hoosier Riverwatch and Indiana Clean Lakes Volunteer Monitoring programs 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 section.

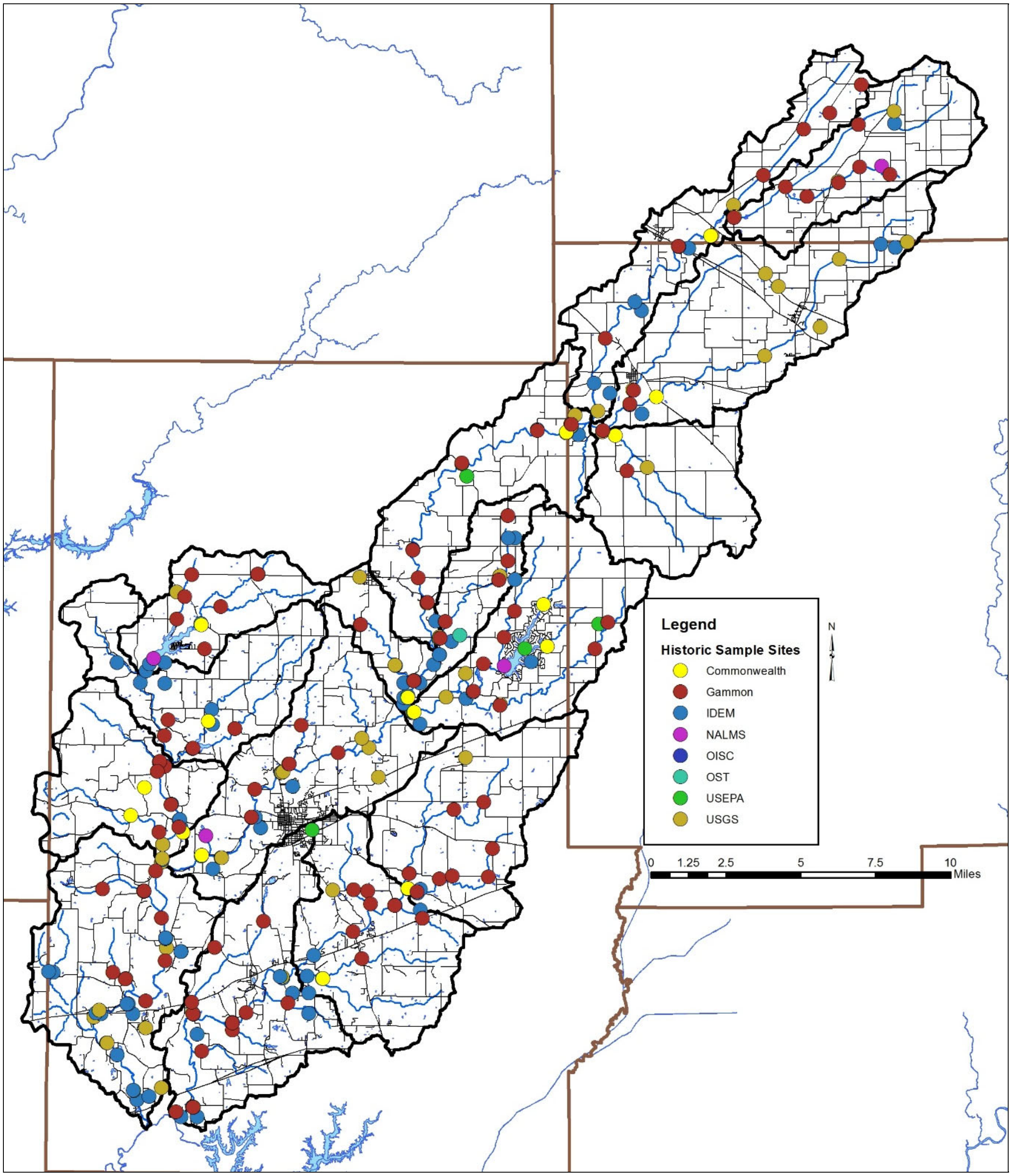

Figure 30. Historic water quality assessment locations.

3.2.1 Integrated Water Monitoring Assessment (305(b) Report)

The Indiana Department of Environmental Management (IDEM) is the primary agency tasked with monitoring surface water quality within the state of Indiana. Section 305(b) of the Clean Water Act requires that the state report on the quality of waterbodies throughout the state on a biannual basis. These assessments are known as the Integrated Water Monitoring Assessment (IWMA) or the 305(b) Report. The most recent draft report was delivered to the USEPA and underwent public comment in 2018 (IDEM, 2018). To complete this report, the 305(b) coordinator reviews all data collected by IDEM and selected high-quality data collected by other organizations on a waterbody basis. Each assessed waterbody is then assigned a water quality rating based on its ability to meet Indiana's water quality standards (WQS). WQS are set at a level to protect Indiana waters' designated uses of swimmable, fishable, and drinkable. Waterbodies that do not meet their designated uses are proposed for listing on the impaired waterbodies list, which is discussed in more detail below. The 2018 IWMA includes 106 waterbody reaches in the Big Walnut Creek Watershed (IDEM, 2016). Listings include the following:

- One segment of Big Walnut Creek, thirteen unnamed tributary segments to Big Walnut Creek, Brett Ditch, six unnamed tributary segments to Clear Creek, one segment of Deer Creek, five unnamed tributary segments to Deer Creek, Dyer Creek, Falls Branch, an unnamed tributary to Falls Branch, and unnamed inlet stream to Glenn Flint Lake, an unnamed tributary segment to Hunt Creek, three unnamed tributary segments to Jones Creek, two unnamed tributary segments to Leatherman Creek, two unnamed tributary segments to Little Walnut Creek, an unnamed tributary segment to Lower Limestone Creek, two unnamed tributary segments to Long Branch, Maiden Run, seven unnamed tributary segments to Owl Creek, and Snake Run have been sampled but insufficient data are available to assess whether this segment meets aquatic life use, fish consumption or recreational uses.
- Wallace Branch, Limestone Branch, Little Deer Creek, Owl Branch, an unnamed tributary to Upper Limestone Branch, two segments of Deer Creek, and an unnamed tributary to Deer Creek are listed as supporting aquatic life use, fish consumption and recreational uses.
- The Middle Fork Big Walnut, Ramp Run and an unnamed tributary to Ramp Run meet designated uses for aquatic life and fish consumption but contain insufficient information to rate recreational uses.
- Dry Branch meets water quality standards for aquatic life and recreation uses but have insufficient data to rate fish consumption uses.
- Snyder Branch meets water quality standards for aquatic life use but has insufficient data to rate fish consumption or recreational uses.
- Two segments of Big Walnut Creek, Bledsoe Branch, three segments of Clear Creek, an unnamed tributary to Clear Creek, two segments of Deer Creek, Falls Branch, two segments of Jones Creek, two segments of Leatherman Creek, three segments of Little Walnut Creek, Long Branch, an unnamed tributary to Long Branch, Mosquito Creek, two segments of Owl Creek, three unnamed tributary segments to Owl Creek, Plum Creek, Rocky Creek meet aquatic life use designations, have insufficient data to rate fish consumption uses, and do not meet recreational use designations; however a TMDL is not required.
- East Fork Big Walnut Creek, Big Walnut-Barnard Tributaries, and three unnamed segment tributaries to Big Walnut Creek, Deweese Creek, Johnson Branch, an unnamed tributary to Little Walnut Creek, Miller Creek, meet aquatic life use designations, have insufficient data to rate fish consumption uses, and do not meet recreational use designations.
- Edlin Ditch and Cunningham Ditch have been assessed and meet aquatic life use and fish consumption designations but do not meet recreational use designations; however, a TMDL is not required.
- One segment of Big Walnut Creek has insufficient data to determine whether it meets aquatic life or recreational uses but does not meet fish consumption uses.
- One segment of Big Walnut Creek has insufficient data to determine whether it meets recreational uses and is impaired for aquatic life and fish consumption uses.

3.2.2 Impaired Waterbodies (303(d) List)

Waterbodies in the Big Walnut Creek Watershed which are included on the Impaired Waterbodies list are detailed in section 2.7.3 above.

3.2.3 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 from the 2017 report (ISDH, 2017) 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.

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

- The Big Walnut Creek is under a fish consumption advisory for channel catfish up to 14 inches in Putnam County and longear sunfish up to 6 inches in Putnam County.
- No carp should be consumed from any waterbody within the watershed.

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

In 1989, 1991-1995, 1999-2004, 2007-2011, and 2013-2014, the U.S. Geological Survey (USGS) sampled water chemistry at several locations in the Big Walnut Creek Watershed via National Water Quality Assessment program (NAWQA). Sampling occurred in Big Walnut Creek near Jamestown, near Reelsville, near Roachdale, near Barnard, near Greencastle; Grassy Branch; Ramp Run; Plum Creek; Bledsoe Branch; Miller Creek; Clear Creek; Dry Branch; Snyder Branch; Owl Creek and tributaries; Little Walnut Creek; Snake Creek; and Maiden Run. Based on the water chemistry assessments, the following conclusions can be drawn:

- Dissolved phosphorus (orthophosphorus) concentrations exceeded target concentrations in 63% of samples collected in the Big Walnut Creek Watershed.
- Total phosphorus concentrations exceeded target concentrations in 20% of samples collected in the Big Walnut Creek Watershed with concentrations measuring as high as 20 times the target concentration.
- Nitrate-nitrogen concentrations exceeded target concentrations in 70% of samples collected in the Big Walnut Creek Watershed with concentrations measuring as high as 30 times the target concentration.
- Total suspended solids concentrations exceeded target concentrations in 74% of samples collected in the Big Walnut Creek Watershed with concentrations measuring as high as 100 times the target concentration.

3.2.5 U.S. Environmental Protection Agency (2007)

In 2007, the U.S. Environmental Protection Agency (USEPA) sampled Big Walnut Creek as part of the National Rivers and Streams Assessment. Based on the water chemistry assessments conducted at two locations in Big Walnut Creek, the following conclusions can be drawn:

- Field measurements, including temperature, dissolved oxygen, pH, conductivity, and turbidity, fall within target concentrations for all samples collected in the Big Walnut Creek Watershed.
- Additional data collected as part of the NARS assessment will be added to the water quality portal as it becomes available.

3.2.6 IDEM Rotational Basin Assessments (1992-2018)

In 1992, 1993, 1996, 2001, 2004, 2006, 2009, 2011, 2015, 2016, IDEM sampled water chemistry, macroinvertebrates, fish and habitat at several locations in the Big Walnut Creek Watershed via their rotational basin, watershed assessment, and source ID assessment programs. Additionally, one site on Big Walnut Creek at Reelsville is sampled monthly as part of IDEM's fixed station monitoring program from 1992 through 2018. Sampling occurred in Big Walnut Creek at CR 480 East, Bakers Camp Bridge, Covered Bridge, CR 1075 South, CR 125 North, CR 200 West, CR 300 North, CR 375 West (Oakalla Bridge), CR 480 East, CR 625 West, CR 800 East, CR 800 North, CR 875 South, Wildwood Bridge, McCloud Nature Park, CR 1025 South (Huffman Bridge), Hughes Road, U.S. Highway 40, Greencastle wastewater outfall; Bledsoe Branch; Clear Creek at CR 350 East, CR 375 East, CR 575 East; Miller Creek; Plum Creek at CR 500 North and CR 675 East; and Snake Creek.

A few of the assessments which occurred via various IDEM assessment program 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 60% of fixed station samples and in 77% of all other samples collected in the Big Walnut Creek Watershed.
- Nitrate-nitrogen concentrations exceeded target concentrations in 36% of fixed station samples and in 46% of all other samples collected in the Big Walnut Creek Watershed.
- Total phosphorus concentrations exceeded the recommended criteria in 40% of fixed station samples and in 48% of all other samples collected in the Big Walnut Creek Watershed.
- Total suspended solids concentrations exceeded the recommended criteria in 46% of fixed station and in 22% of all other samples collected in the Big Walnut Creek Watershed.
- Turbidity levels routinely exceed the recommended standard in more than 89% of fixed station and 49% of all other samples collected in the Big Walnut Creek Watershed.
- Macroinvertebrate community assessments indicate that Big Walnut Creek and its tributaries rate as slightly impaired to not impaired using the kick net sampling procedure and rate as fully supporting using multimetric habitat approach.
- Fish community assessments indicate that Big Walnut Creek and its tributaries rate as good to excellent.
- Habitat assessments completed along Big Walnut Creek and its tributaries indicate that habitat is fully support for aquatic life uses.

3.2.7 Big Walnut Watershed Assessment DePauw University (1962-1966;1993-1995)

Dr. James Gammon, DePauw University, assessed the distribution of fish across Putnam County including 20 sites in the Big Walnut drainage and 10 sites in the Deer Creek Drainage from 1962-1964 (Gammon, 1965). Benda and Gammon assessed fish populations in six Big Walnut Creek pools in 1965 and 1966 (Benda and Gammon, 1967). Gammon assessed water chemistry, habitat quality, fish community structure in Big Walnut Creek at 91 sites in 1993, 124 sites in 1994 and 134 sites in 1995 (Gammon et. al, 2003). In 1993, streams were unusually wet with sampling located in headwaters sites early in the season and some mainstem sites remaining unsampled throughout the summer due to high flow conditions. In 1994, all sites were sampled as conditions returned to normal baseflow conditions.

However, flows were unusually low in 1995 with some headwaters stations dry in the late summer. The following conclusions can be drawn from these studies:

- In the early 1960s, Gammon identified 60 species belonging to 13 families. Most species were ubiquitous being found at nearly every site sampled throughout Putnam County.
- Pool fish community assessments conducted in 1965 and 1966 assessed fish communities present along the length of Big Walnut Creek indicate that more than 50 species typically inhabit Big Walnut Creek pools. Golden and black redhorse were the most common species with sport fish present along the edges of most pools where they utilized available cover.
- Carp, silvery minnow and gizzard shad were limited in their upstream migration by the waterworks dam near Greencastle. This dam likely limits the establishment of reproducing populations north of the dam.
- In the 1990s, 20 sites' fish communities rated as poor during at least one assessment. One site rated as very poor. Many of these sites are headwaters sites or are located near a confined feeding operation or pastureland.
- Nine sites possessed habitat that rated below the target score which indicates streams meet their aquatic life use designation (51).
- Ammonia-nitrogen concentrations measured at toxic levels in Little Deer Creek during 5 of 19 occasions in 1993, 14 of 21 occasions in 1994 and in 12 of 13 occasions during 1995. In 1996, operational procedures were altered at animal facilities located upstream of the sampling location to reduce ammonia-nitrogen concentrations to background levels.
- All of the Little Deer Creek and Plum Creek sites exceeded nitrate-nitrogen target concentrations.
- 35% of Plum Creek and 100% of Little Deer Creek sites exceeded turbidity targets.

3.2.8 Big Walnut Watershed Alliance (2007-2008, 2010-2011)

In 2007 and 2008, Commonwealth Biomonitoring completed a biological assessment and water chemistry monitoring program as part of the development of the Big Walnut Creek Watershed Management Plan (Putnam County SWCD and Empower Results, 2009). A water quality monitoring program focused on isolating and identifying pollution sources within priority watersheds occurred from 2010-2011 as part of the Big Walnut Watershed Implementation Project. From 2007-2008, 24 sites were assessed six times, while macroinvertebrate communities were assessed once in the spring and once in the fall. From 2010-2011, water chemistry was assessed at 23 sites once during storm flow and once during base flow conditions with the macroinvertebrate community assessed twice at five sample sites. The following conclusions can be drawn:

- During plan development, Nitrate-nitrogen concentrations exceeded target concentrations in 62% of collected samples. The highest concentration measured more than 5 times the target concentration. During implementation, two sites during dry weather screening and 14 sites during wet weather screening exceeded target concentrations.
- Total phosphorus concentrations exceeded target concentrations in 68% of collected samples. The highest concentration measured more than 9 times the target concentration. During implementation, two dry weather and six wet weather sites exceeded total phosphorus target concentrations.
- Total suspended solids concentrations exceeded target concentrations in 27% of collected samples. Most samples which exceeded target concentrations were collected during one storm event. The highest concentration measured more than 74 times the target concentration. During implementation, eight sites exceeded target concentrations during storm flow sampling.

- *E. coli* concentrations exceeded state standards in 39% of collected samples. The highest concentration measured more than 57 times the state standard. During implementation, 10 sites exceeded the state standard during dry weather sampling, while 10 sites exceeded state standards during storm water sampling.
- Habitat rated as good to excellent at most stream sites assessed.
- Two sites, Jones Creek and Limestone Creek, possessed good habitat scores but low biological integrity scores. These sites both contained low macroinvertebrate diversity, which suggests that water chemistry issues may be inhibiting community diversity.
- Four sites contained poor biological integrity during the planning phase indicating that the macroinvertebrate communities and habitat both rated poorly, while one site during implementation rated impaired.

3.2.9 Christopher B Burke Engineering (2017)

Christopher B. Burke Engineering (CBBEL) assessed the aquatic resources of Big Walnut Creek immediately south of U.S. Highway 40 east of the Brazil Municipal Water Pumping Station (CBBEL, 2017). Field chemistry; instream habitat; and macroinvertebrate, fish and mussel communities were assessed. The following conclusions can be drawn:

- Dissolved oxygen, temperature, pH, turbidity and conductivity measured within target concentrations.
- Habitat scores indicate high quality habitat (QHEI=70) that is fully supporting of its designated use at this reach of Big Walnut Creek.
- The macroinvertebrate community rated as impaired (32) with 84 individuals representing 18 taxa observed. Overall, low density and diversity, high number of mosquito (Dipteran) species, and low lumbers of shredders, collectors and sprawlers characterize the community.
- The fish community rated poor with only 8 species and 168 individuals collected.
- Nine mussel species were identified in this stream reach.

3.2.10 Glenn Flint Lake Assessment, Indiana DNR Fish Assessment (2005-2017)

The Indiana Department of Natural Resources (IDNR) assessed the fish community in Glenn Flint Lake each spring from 2005 to 2008 with a focus on largemouth bass, bluegill, and gizzard shad; a general survey was conducted in 2013 and again in 2017 (DeBoom, 2017). Aquatic plant community assessments occurred from 2005 to 2008, in 2013 and in 2017. General chemistry parameters were also measured during each sampling event. The following conclusions can be drawn:

- Water clarity is poor measuring 3.6 feet in 2000 and declining to 3 feet in 2017. These depths measure less than half the average clarity measured in Indiana lakes.
- Fish species abundance trends indicate a decline in game species from 2000 to 2017 with the exception of bluegill.
- Bluegill and yellow bass measuring less than seven inches dominate the fish community in Glenn Flint Lake.
- Tributary sampling conducted in 2017 indicates 22 native species are present as are gizzard shad within all tributaries except Owl Creek.

3.2.11 Glenn Flint Lake Assessment Indiana Clean Lakes Program (1997, 2002, 2011)

The Indiana Clean Lakes Program assessed water quality within Glenn Flint Lake in 1997, 2002 and 2011 as part of their rotational basin assessments (ICLP, no date). The following conclusions can be drawn:

- Water clarity measured 2.6 meters in 1997 and declined to 0.6 meters in 2002 and 2011 with the latter two measuring poorer than most Indiana lakes.

- Elevated ammonia-nitrogen and total phosphorus concentrations were measured in the bottom of the lake (hypolimnion) indicating decomposition was occurring in the bottom of the lake at the sediment water interface.
- Only 36% of the water column possessed sufficient dissolved oxygen to support aquatic biology.
- Blue green algae dominated plankton communities during all assessments.
- During the most recent assessment, plankton community density, chlorophyll a, total phosphorus and ammonia-nitrogen concentrations measured poorer than most Indiana lakes.

3.2.12 Heritage Lake Assessment, Commonwealth Biomonitoring (2003 and 2016)

Commonwealth Biomonitoring assessed the fish and aquatic plant communities and water quality in Heritage Lake in 2003 and assessed the fish community and water chemistry in 2016 (Commonwealth Biomonitoring, 2003; Commonwealth Biomonitoring, 2016). In 2003 and 2016, the fish community was assessed at three locations: the east arm, the dam and the upper lake (upstream). Plant community assessment occurred throughout the lake (2003), while water chemistry sampling occurred at the deepest point in the lake near the dam (2003 and 2016). In 2016, base and storm flow chemistry samples were collected at the north and east inlets to the lake. The following conclusions can be drawn:

- In 2003, 152 fish representing 12 species were identified in Heritage Lake. Largemouth bass and bluegill comprised the largest portions of the community. The lake's fish community rated as fair, scoring 36 to 40 on the Index of Biotic Integrity.
- Aquatic plants identified within the lake are common, native species. None were found in nuisance levels.
- In 2003, phosphorus concentrations were elevated within the water column, while water clarity measured 3 feet – all of which rated poorer than most lakes in Indiana.
- In 2016, 293 fish representing 13 species were identified in Heritage Lake. The lake's fish community rated as fair, scoring 36 on the Index of Biotic Integrity.
- In 2016, phosphorus concentrations were elevated within the water column, while water clarity measured 5.5 feet – all of which rated poorer than most lakes in Indiana.
- In 2016, total phosphorus concentrations measured higher than targets during base and storm flow conditions, while total suspended solids and nitrate-nitrogen concentrations measured higher than target concentrations during storm flow conditions. *E. coli* in the east inlet measured higher than the state standard during storm flow conditions. Fish communities rated as poor scoring 26 in the east tributary and 32 in the north tributary.

3.2.13 North American Lake Management Society

In 2001, 2003 and 2015, Heritage Lake, Oakalla Lake and Glenn Flint Lake submitted data to the North American Lake Management Society (NALMS) as part of their annual secchi dip-in. Based on the volunteer assessments, the following conclusions can be drawn:

- Lake transparencies measured less than the average transparency measured in Indiana lakes over the last 10 years.

3.2.14 Hoosier Riverwatch Sampling (2002-2017)

From 2001 to present, volunteers trained through the Hoosier Riverwatch program assessed 14 sites in the Big Walnut 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:

- In Big Walnut Creek and an unnamed tributary to Big Walnut Creek, nitrate-nitrogen concentrations were elevated measuring as high as 13.2 mg/L.
- Dissolved phosphorus concentrations typically measured low while pH, dissolved oxygen and temperature concentrations measured within state standards at all sites.
- The pollution tolerance index ranged from 18 to 40 indicating Big Walnut Watershed streams rate as good to excellent.

3.3 Current Water Quality Assessment

3.3.1 Water Quality Sampling Methodologies

As part of the current project, the Big Walnut Creek Watershed Project implemented a one-year professional water quality monitoring program. The program included water chemistry, macroinvertebrate and fish communities and habitat assessments.. The program is detailed below and in the Quality Assurance Project Plan for the Big Walnut Creek Watershed Management Plan approved on January 8, 2018. Sites sampled through this program are displayed in Figure 31. Sample sites were selected based on land use and watershed drainage and correspond with sites sampled by IDEM in the past. The biweekly sampling regimen was enacted to create a baseline of water quality data.

Stream Flow

Stream flow was measured *in situ* when grab samples were collected. Stream flow was calculated by scaling stream flow measured at the U.S. Geological Survey (USGS) Big Raccoon Creek near Ferndale (USGS Gage 03340900) to subwatershed drainage area during high flow events.

Field Chemistry Parameters

The Big Walnut Creek Watershed Project established twelve chemistry monitoring stations as part of the monitoring program. The Clear Creek Conservancy District established a sample site (Site 13) on the main tributary to Heritage Lake and paid for sample analyses. Stations are located on Edlin Ditch (CR 600 W), Middle Fork Big Walnut Creek (SR 75), East Fork Big Walnut Creek (SR 236), Ramp Run (SR 75), Miller Creek (CR 500 N), Jones Creek (CR 100 N), Little Walnut Creek (CR 125), Snake Creek (CR 550 W), Deweese Creek (CR 400 W), Big Walnut Creek (CR 1050 S), Deer Creek (CR 1100 S), and Plum Creek (CR 500 N). Dissolved oxygen, temperature, pH, turbidity, conductivity, nitrate-nitrogen, total phosphorus, and total suspended solids were measured monthly at the sampling stations. *E. coli* was measured biweekly. Sampling occurred during two growing seasons for Sites S01 through S12 as follows:

- August 2018 – October 2018;
- April 2019 – August 2019.

Sampling at Site 13 started in October 2018 and continued in the 2019 sampling period.

Laboratory Chemistry Parameters

Like the field parameters, biweekly laboratory sample collection and analysis occurred throughout the one-year sampling program. Samples were analyzed for nitrate-nitrogen, total phosphorus, total suspended solids, and *E. coli*. Appendix D details the parameters measured.

Biological Community and Habitat

The physical habitat at each of the 12 sample sites was evaluated using the Qualitative Habitat Evaluation Index (QHEI). The Ohio EPA developed the QHEI for streams and rivers in Ohio (Rankin, 1989, 1995) and the IDEM adapted the QHEI for use in Indiana. The fish community was assessed at six of the 12 sample sites including Sites S01, S04, S06, S07, S08 and S10. The Index of Biotic Integrity (IBI) was used to assess each site's health. Macroinvertebrate communities were assessed using the macroinvertebrate Index of Biotic Integrity (mIBI) with all 12 sites assessed. Commonwealth Biomonitoring assessed biological communities and habitat in the summer of 2018.

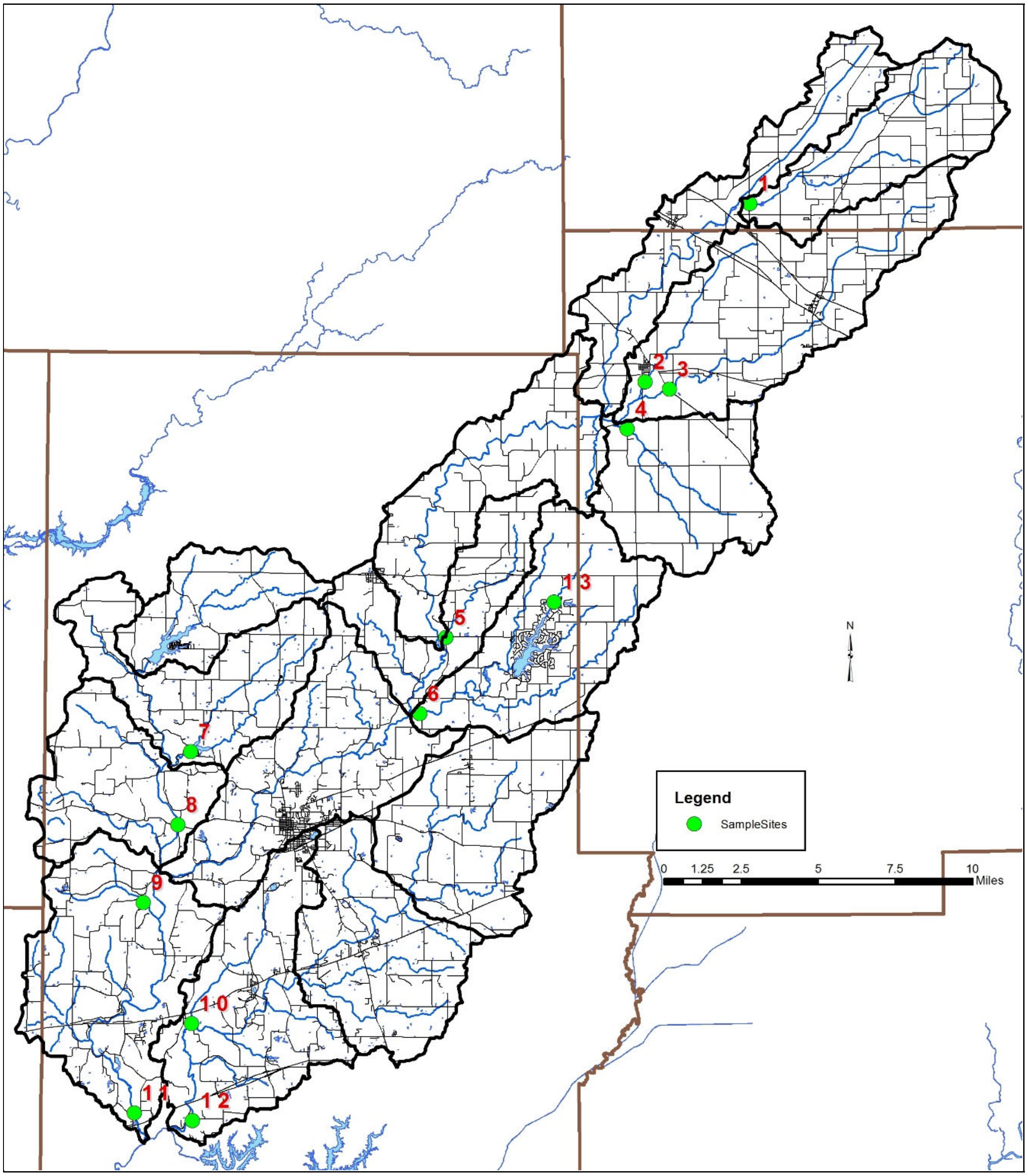

Figure 31. Sites sampled as part of the Big Walnut Creek Watershed Management Plan.

3.3.2 Field Chemistry Results

Figure 32 through Figure 35 display results for non-nutrient field chemistry data collected biweekly at the twelve sample sites. At each of the stream sites, a multi parameter probe was deployed during each sampling event. The probe collects data for temperature, dissolved oxygen, specific conductivity, and pH. All field chemistry results are contained in Appendix D.

Temperature

Figure 32 illustrates the biweekly temperature measurements in the watershed streams. As shown, temperatures measure approximately the same at each of the stream sites with seasonal changes in temperature creating major differences in temperature throughout the sampling period. Temperatures measured between 15 - 25°C in all streams from April through October. The highest temperatures occurred during the June, July and August assessments depending on riparian cover and stream depth present at each location.

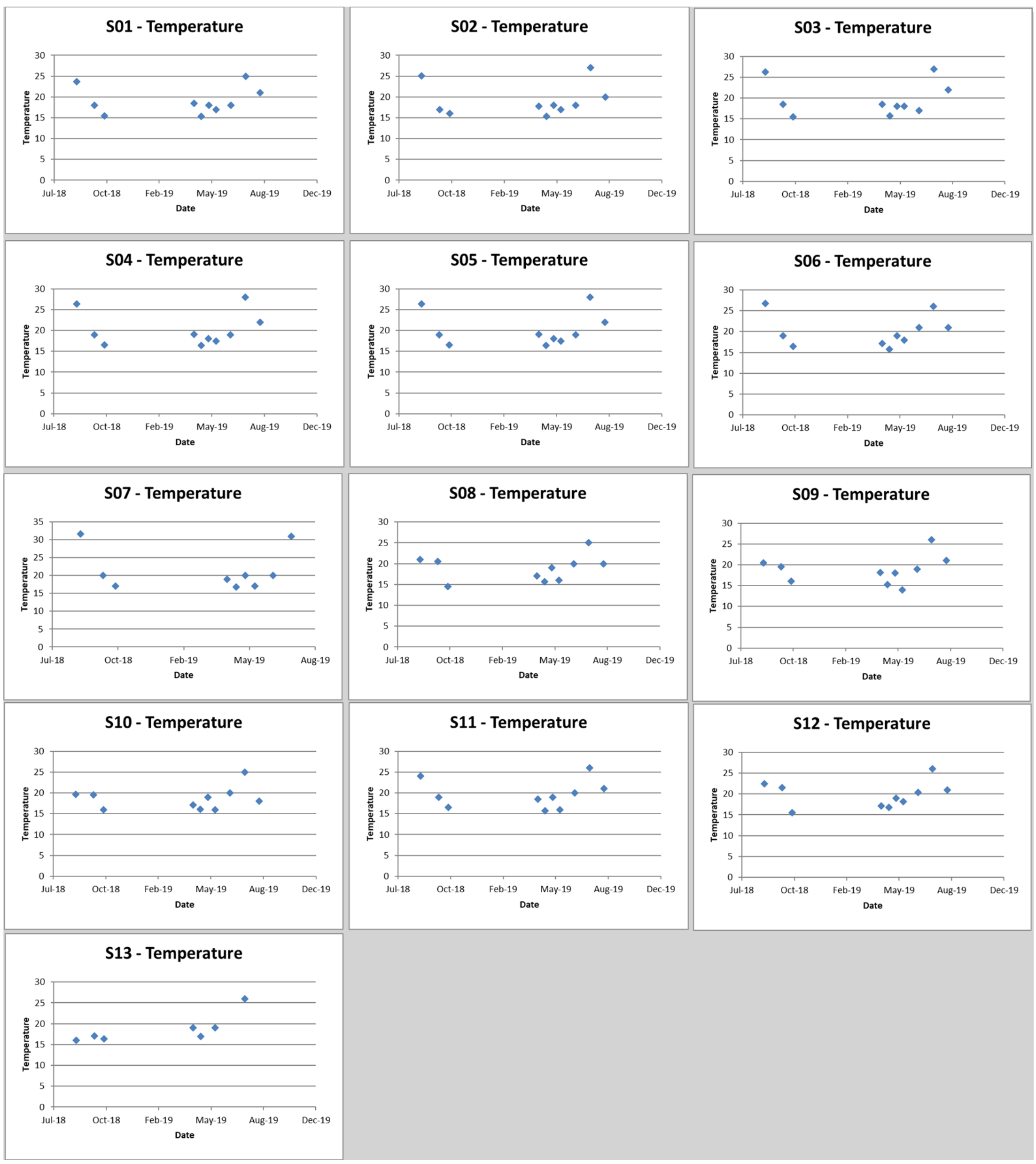

Figure 32. Temperature measurements in Big Walnut Creek Watershed samples sites from 2018 – 2019.

Dissolved Oxygen

Dissolved oxygen concentrations also display seasonal changes like those observed for temperature. However, as shown in Figure 33, dissolved oxygen concentrations are opposite those measured for temperature. This is as expected as colder water holds more dissolved oxygen than warmer water; therefore, when water temperatures are low, dissolved oxygen concentrations are high and vice-versa. As such, the dissolved oxygen graph shows a general pattern where dissolved oxygen concentrations lower in summer. All streams display variation in dissolved oxygen concentration due to individual conditions present within each system. The lowest dissolved oxygen concentrations occurred at Site 1 during August 2019. None of the streams contained dissolved oxygen concentrations which measured below the state standard.

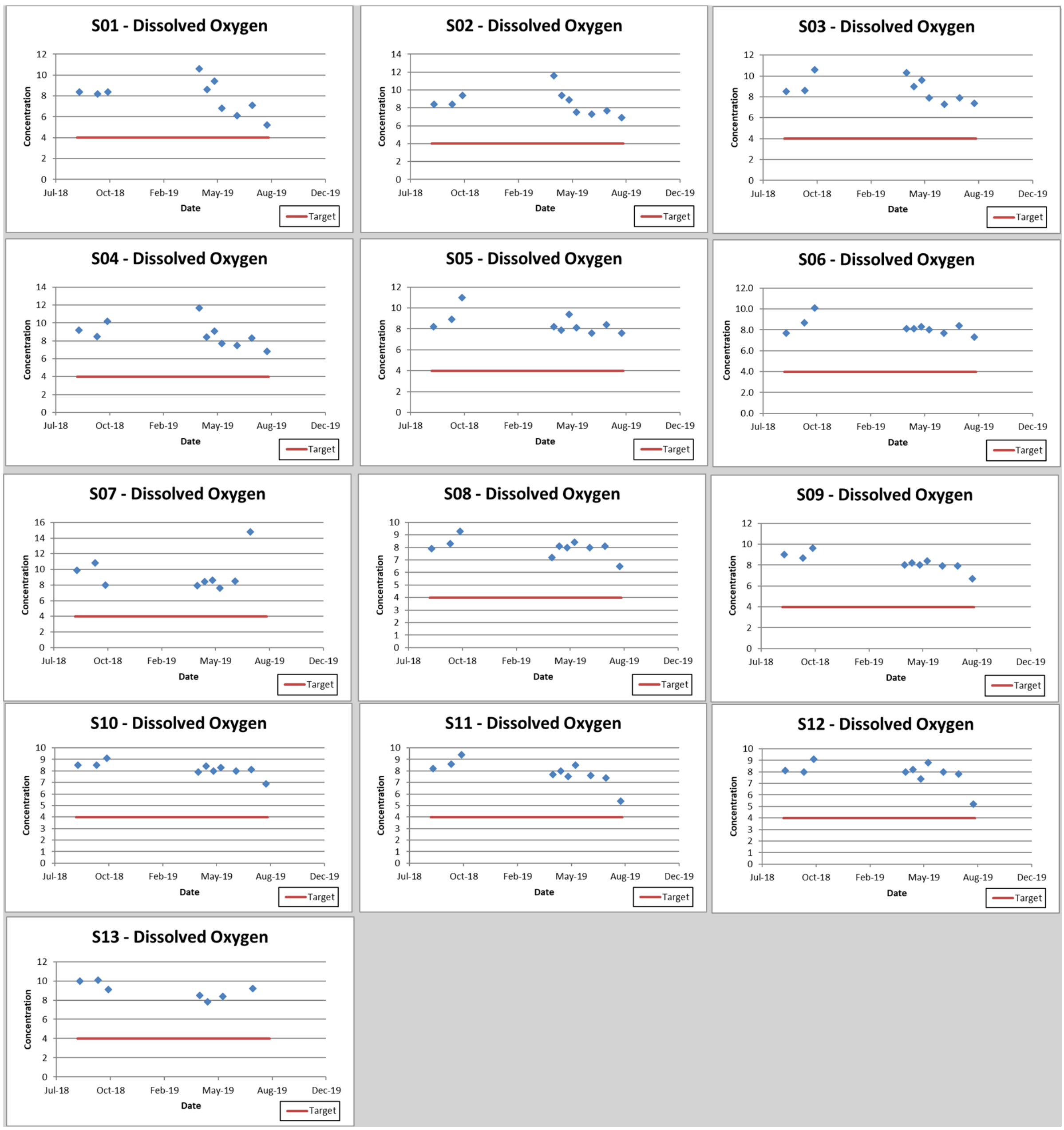

Figure 33. Dissolved oxygen measurements in Big Walnut Creek Watershed samples sites from 2018 – 2019. Note differences in scale along the concentration (y) axis.

pH

Throughout the sampling period, pH generally remained in an acceptable range in all watershed streams. No discernible pattern can be found in pH levels in any of the monitored streams (Figure 34). At no times did pH levels measure below the lower pH target (6.0), while pH measured near the upper pH target (9.0) one time at Site 7 on August, 15 2019 (9.1). Low pH levels may occur under high flow conditions.

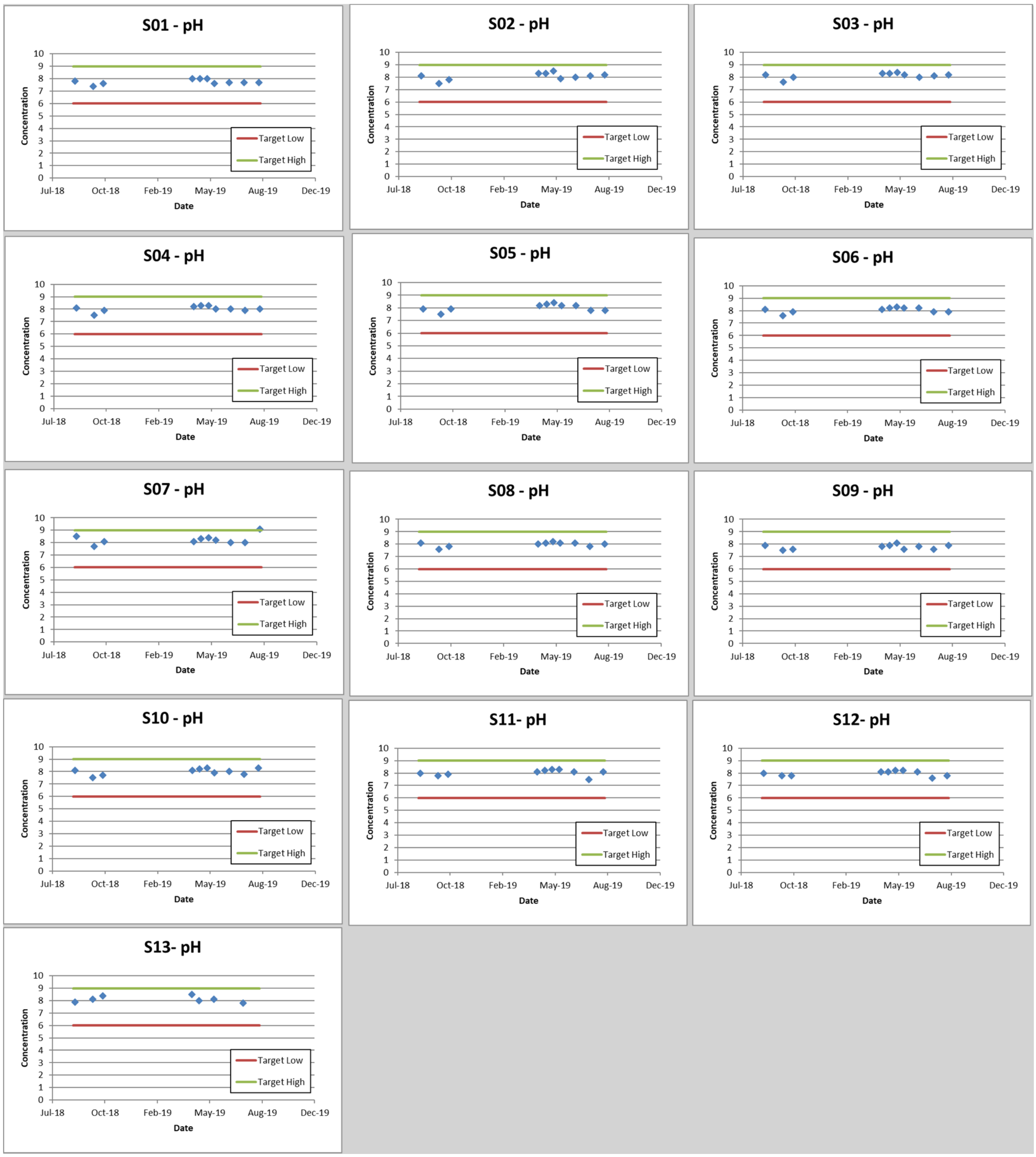

Figure 34. pH measurements in Big Walnut Creek Watershed samples sites from 2018 – 2019.

Specific Conductivity

Figure 35 displays conductivity measurements in the watershed streams. Conductivity measurements varied greatly over the sampling period. Conductivity exceeded state standards one time at Site 10 on July 18, 2019 (1060 S/m). Conductivity did not exceed state standards at any other sites.

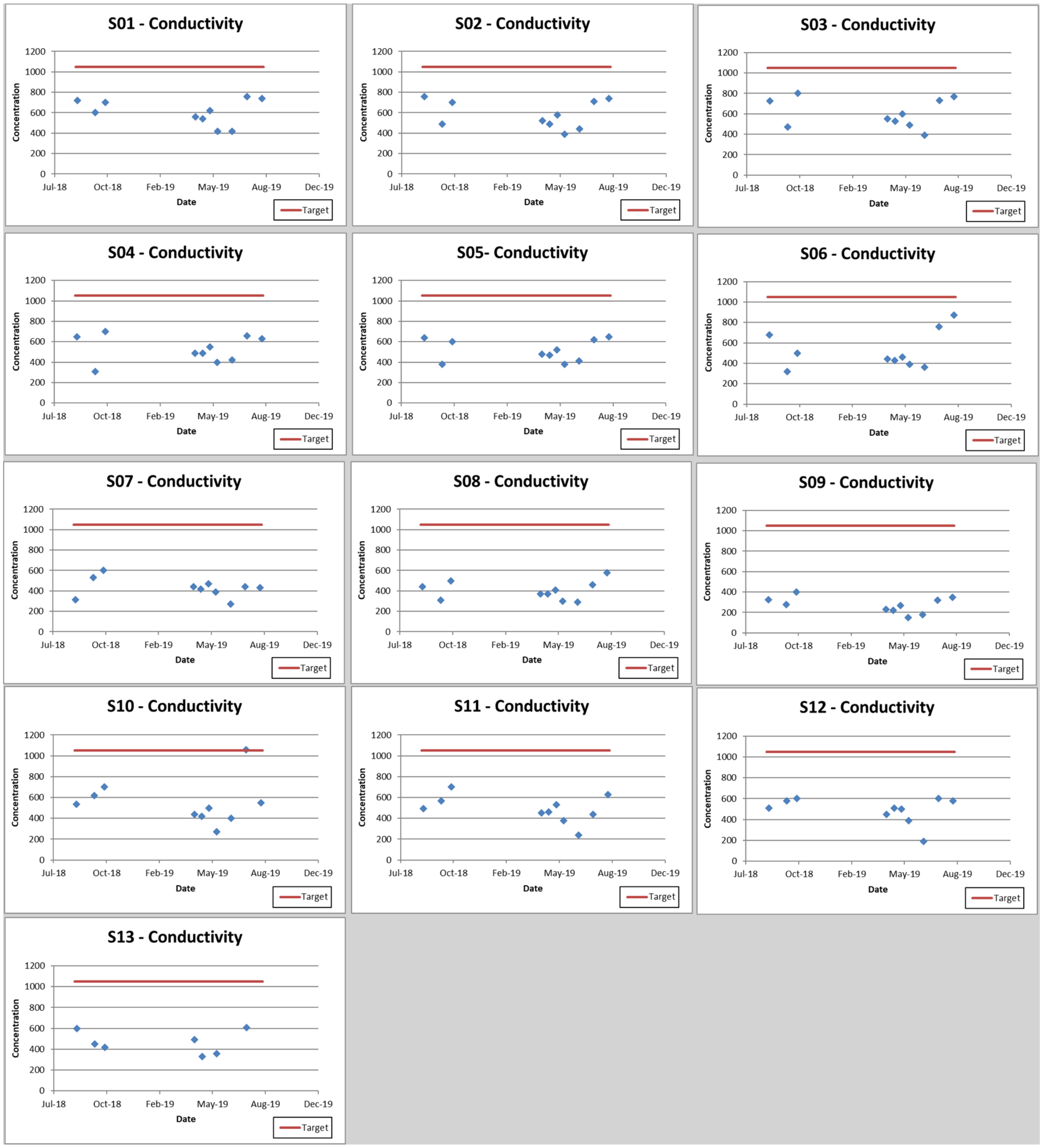

Figure 35. Conductivity measurements in Big Walnut Creek samples sites from 2018 – 2019.

3.3.3 Water Chemistry Results

Figure 36 to Figure 39 display results for nitrate-nitrogen, total phosphorus, total suspended solids, and *E. coli* collected biweekly from twelve locations in the Big Walnut Creek Watershed. Data are displayed in comparison to target concentration and on load duration curves during the sample period. Appendix D details individual measurements collected throughout the sampling period.

Nitrate-nitrogen

Figure 36 displays nitrate-nitrogen concentrations compared to target levels (1.5 mg/L). As shown below, nitrate-nitrogen concentrations consistently exceeded target levels (65%). However, Site 9 and Site 10 were typically under the target level. Nitrate-nitrogen concentrations measured the highest during the spring, falling throughout the summer and increasing again in the fall. The fact that nitrate-nitrogen concentrations exceeded targets in the majority of collected samples suggests that flow condition does not impact sources of nitrate-nitrogen in the Big Walnut Creek Watershed. The highest average concentrations occurred in Site 2 and Site 4. All sites (excluding Site 9 and Site 10) averaged nitrate-nitrogen concentrations higher than the median concentration at which biological communities are impaired (1.5 mg/L).

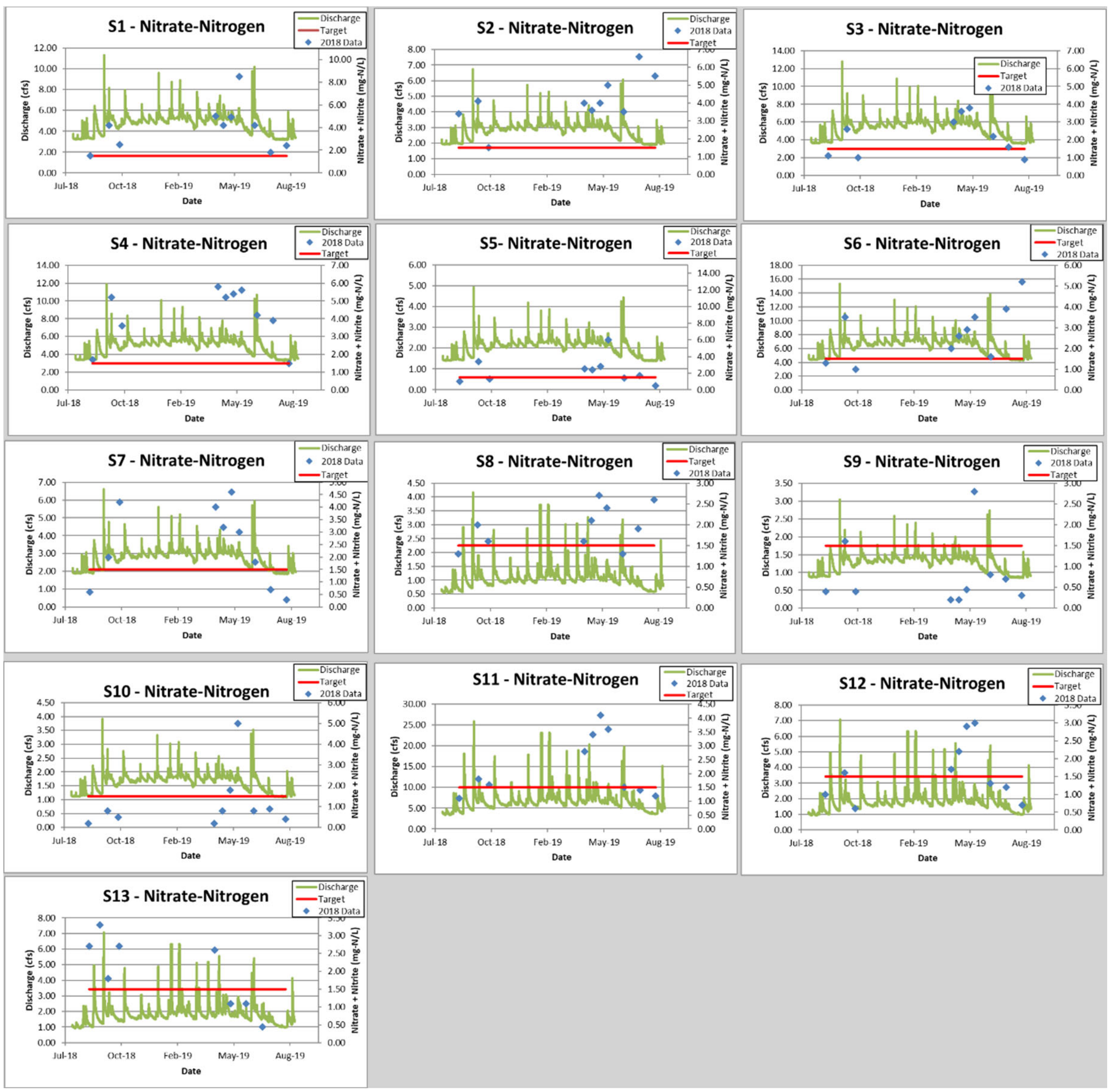

Figure 36. Nitrate-nitrogen concentrations measured in Big Walnut Creek samples sites from 2018 – 2019. Note differences in scale along the concentration (y) axis.

Total Phosphorus

Total phosphorus concentrations exceed target concentrations in 41% of samples (Figure 37). The highest concentrations occurred at Site 7 during the August 15, 2019 monitoring event. Concentrations measured throughout the watershed measured in excess of the level at which total phosphorus concentrations impair biological communities (0.08 mg/L) with most exceedances occurring in concert with high flow events. Site 2 contains the highest average concentration. All sites (excluding Site 13) contain average total phosphorus concentrations in excess of the level at which biological impairments occur (0.08 mg/L). While under the exceedance threshold, it should be noted that Site 13 has an average total phosphorus concentration of 0.079 mg/L.

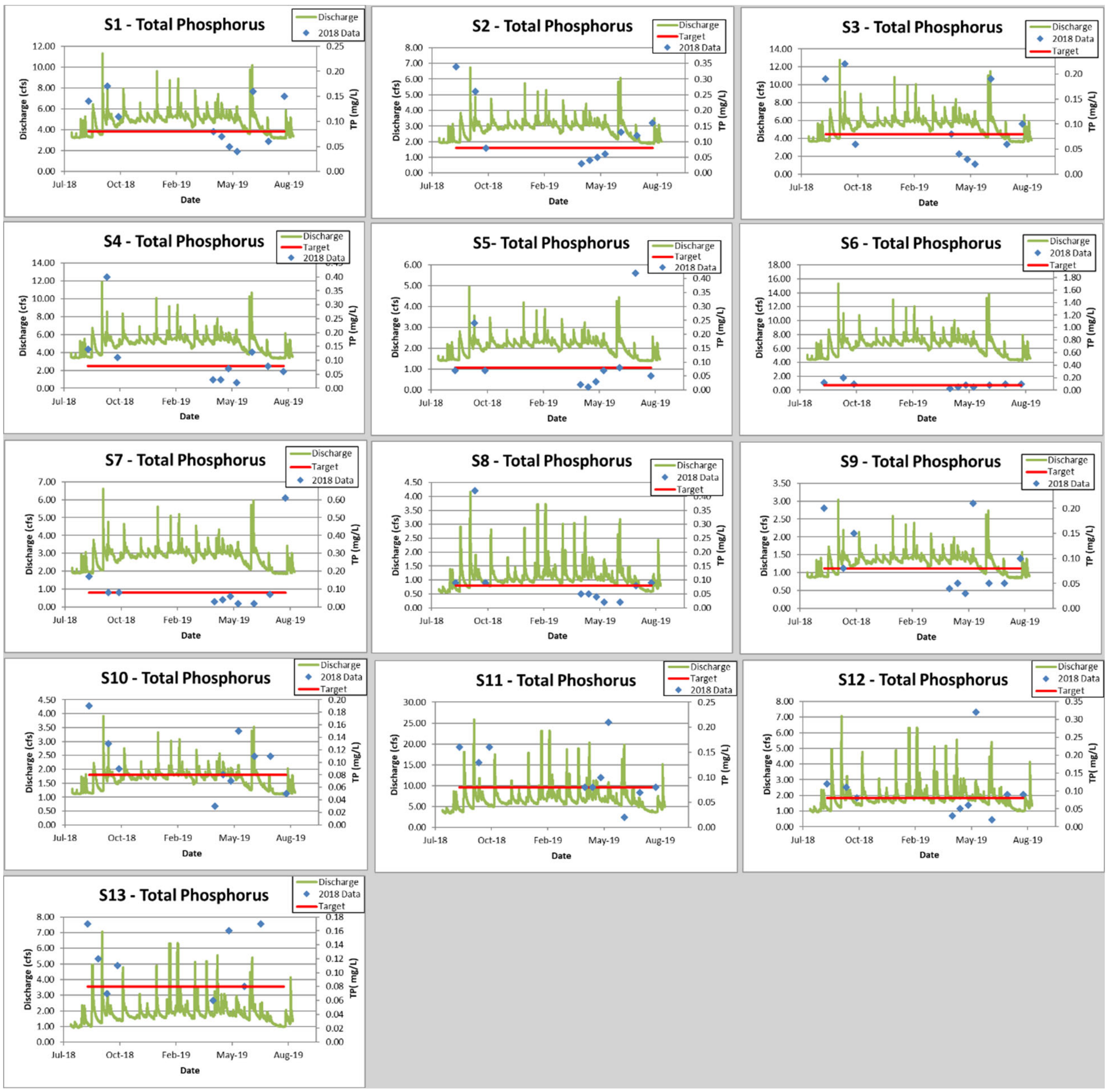

Figure 37. Total phosphorus concentrations measured in Big Walnut Creek samples sites from 2018 – 2019. Note differences in scale along the concentration (y) axis.

Total Suspended Solids

Total suspended solids (TSS) levels measured above target levels during high flow events (Figure 38) with 26% of samples exceeding target concentrations. Site 11 contained the highest average concentrations measuring 79.4 mg/L. TSS concentrations exceeded 300 mg/L at Site 11 and Site 12 during the June 20, 2019 sampling event, and at Site 8 during the October 4, 2018 sampling event.

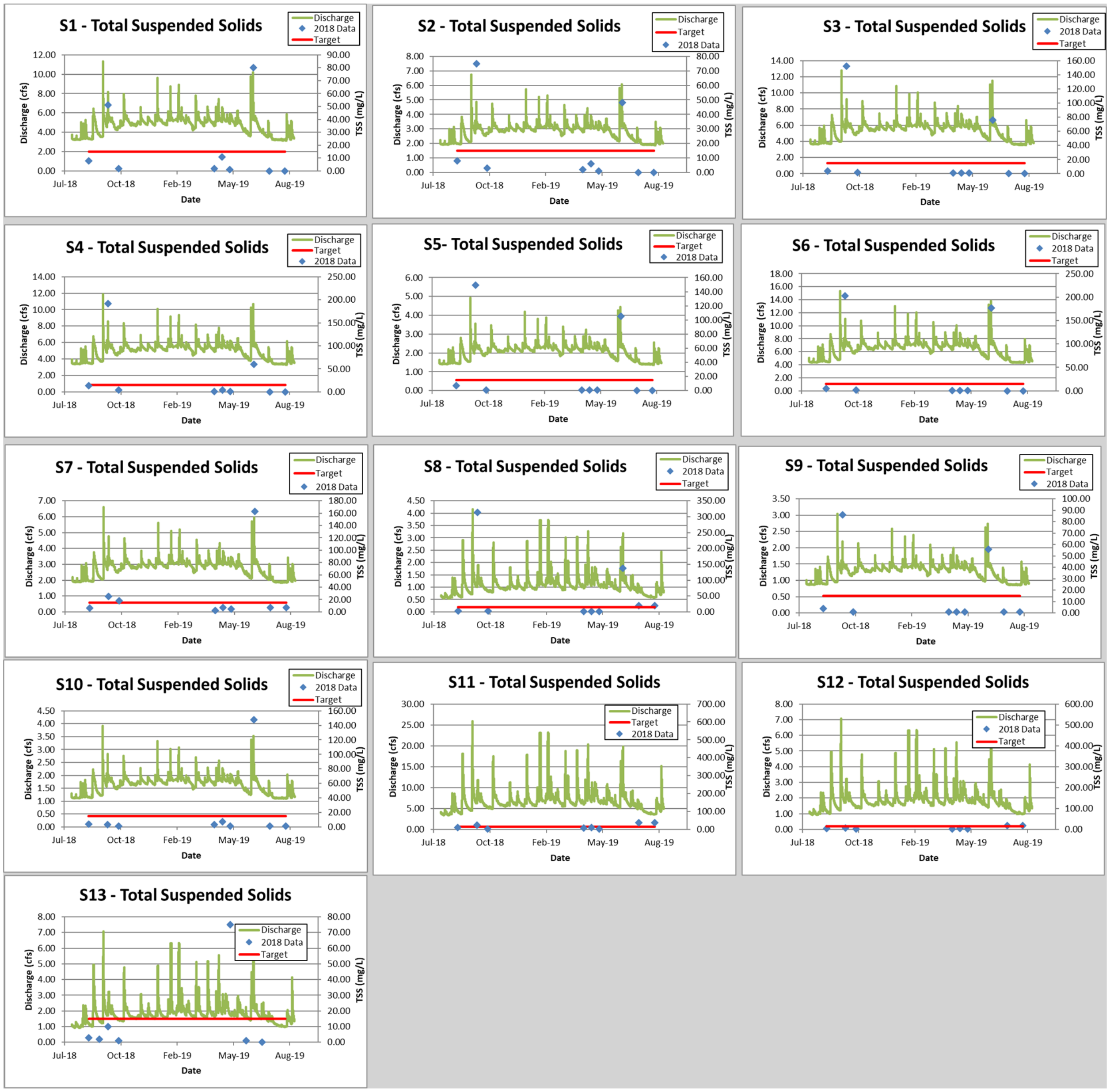

Figure 38. Total suspended solids concentrations measured in Big Walnut Creek samples sites from 2018 – 2019. Note differences in scale along the concentration (y) axis.

E. coli

E. coli concentrations observed at Big Walnut Creek Watershed sites are shown in Figure 39. *E. coli* concentrations exceed state standards in 52% of collected samples. Sites 12 contained the highest average *E. coli* concentrations (1002.6 col/100 mL). All Big Walnut Creek Watershed sites possessed average *E. coli* concentrations in excess of state standards (235 col/100 mL). Site 1 and Site 9 contained the lowest average *E. coli* concentrations with concentrations greater than 300 col/100 mL. *E. coli* exceedances at several sites appear to coincide with elevated flow conditions.

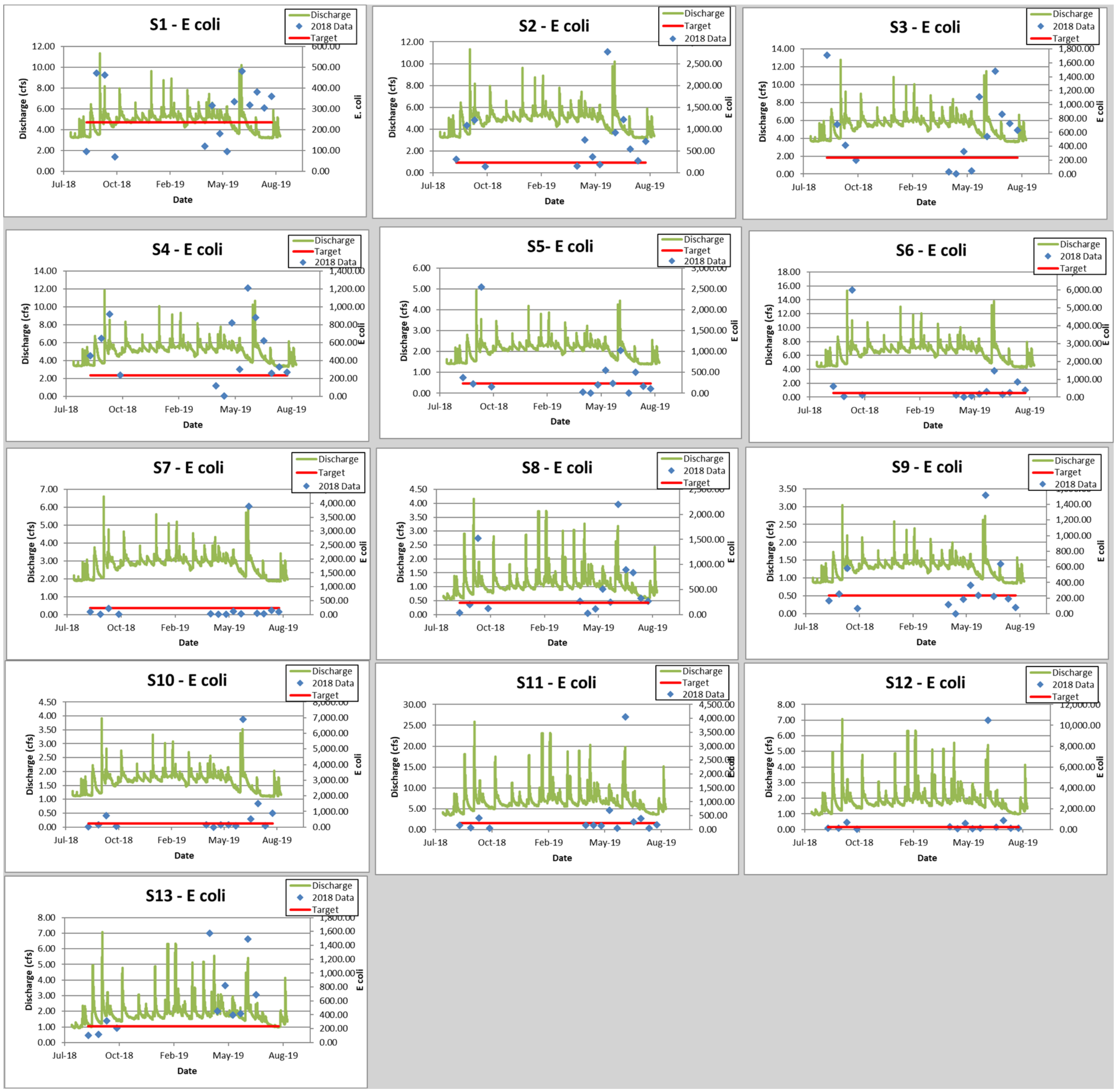

Figure 39. *E. coli* concentrations measured in Big Walnut Creek samples sites from 2018 – 2019. Note differences in scale along the concentration (y) axis.

3.3.4 Load Duration Curves

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 twelve sample sites during the time of study from August 2018 to October 2019. Data used for the curves were calculated by scaling flow measured at Big Raccoon Creek near Fincastle, Indiana. Big Raccoon Creek stream flow measured at the U.S. Geological Survey gauge was scaled to watershed size for each of the twelve monitoring stations as follow:

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 40 to Figure 43). Note that load duration curves for Site 13 are not included as sampling did not occur throughout the entire sampling period. In the graphs, the total daily load of each contaminant sample result (points) is plotted against the "percent time exceeded" for the day of sampling (curve). The time exceeded refers to instream flow conditions. 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.

Nitrate-nitrogen Load Duration Curves

Nitrate-nitrogen loads measure higher than target loads at most sites during all conditions (Figure 40). Sites 2, 4, 8, 11, and 12 nitrate-nitrogen loading rates measured above target levels more than 90% of the time. This suggests that a steady stream of nitrate-nitrogen is available within these subwatersheds. Further, nitrate-nitrogen concentrations at all sites are highest during high flow conditions (0% of the time) and lower during low flow conditions (100% of the time). Sites 1, 2, 4, 8, 11 and 12 indicate sources of nitrate-nitrogen to these streams under all flow conditions suggesting that nitrate-nitrogen loads to the streams during both high flow, high runoff conditions and during low flow, low runoff conditions. This could mean that there are continuous sources of nitrate-nitrogen at these sites including septic system inputs or nitrogen from manure or other dissolved sources.

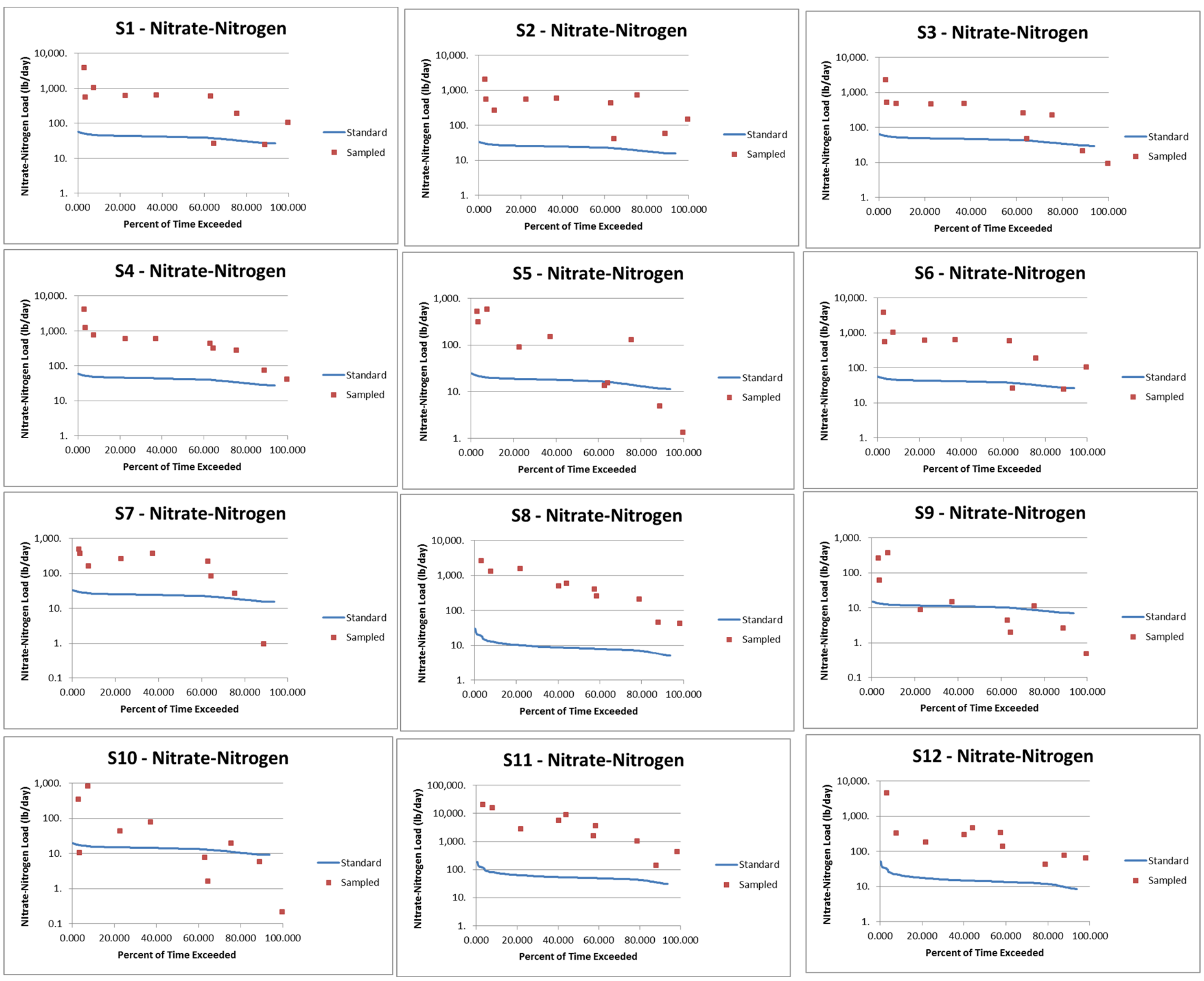

Figure 40. Nitrate-nitrogen load duration curves for Big Walnut Creek samples sites from 2018 – 2019.

Total Phosphorus Load Duration Curves

Total phosphorus (TP) levels generally measured above target levels under all flow conditions (Figure 41). This is somewhat surprising considering that most total phosphorus enters streams attached to suspended solids. Exceedances of the target levels occurred under storm flow conditions at all sites suggesting erosion or runoff is the cause of these values. Sites 2, 6, 8, 11 and 12 exceeded target levels under both low flow conditions and high flow conditions. This suggests that a steady stream of total phosphorus is present in much of the Big Walnut Creek Watershed under all conditions.

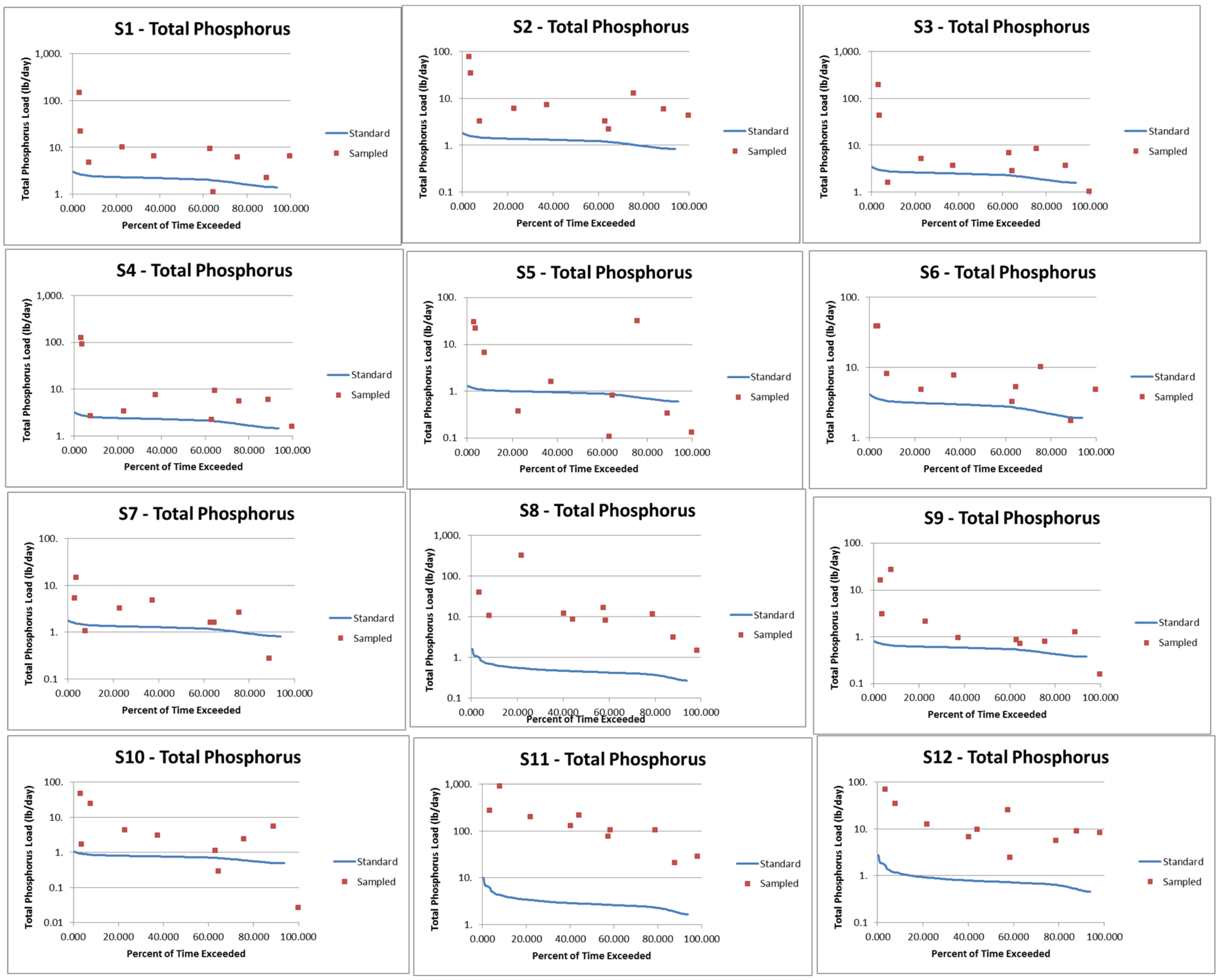

Figure 41. Total phosphorus load duration curves for Big Walnut Creek samples sites from 2018 – 2019.

Total Suspended Solids Load Duration Curves

Total suspended solids (TSS) levels generally measured at or below target levels during most flow events at most stream sites (Figure 42). Most exceedances occurred in the Big Walnut Creek Watershed during storm flow events suggesting erosion or runoff is the cause of these values. Site 7, 11 and 12 exhibited several exceedances during lower flow conditions as well. Possible sources of total suspended solids include the livestock access or streambank and bed erosion, both of which can provide a continuous source of total suspended solids.

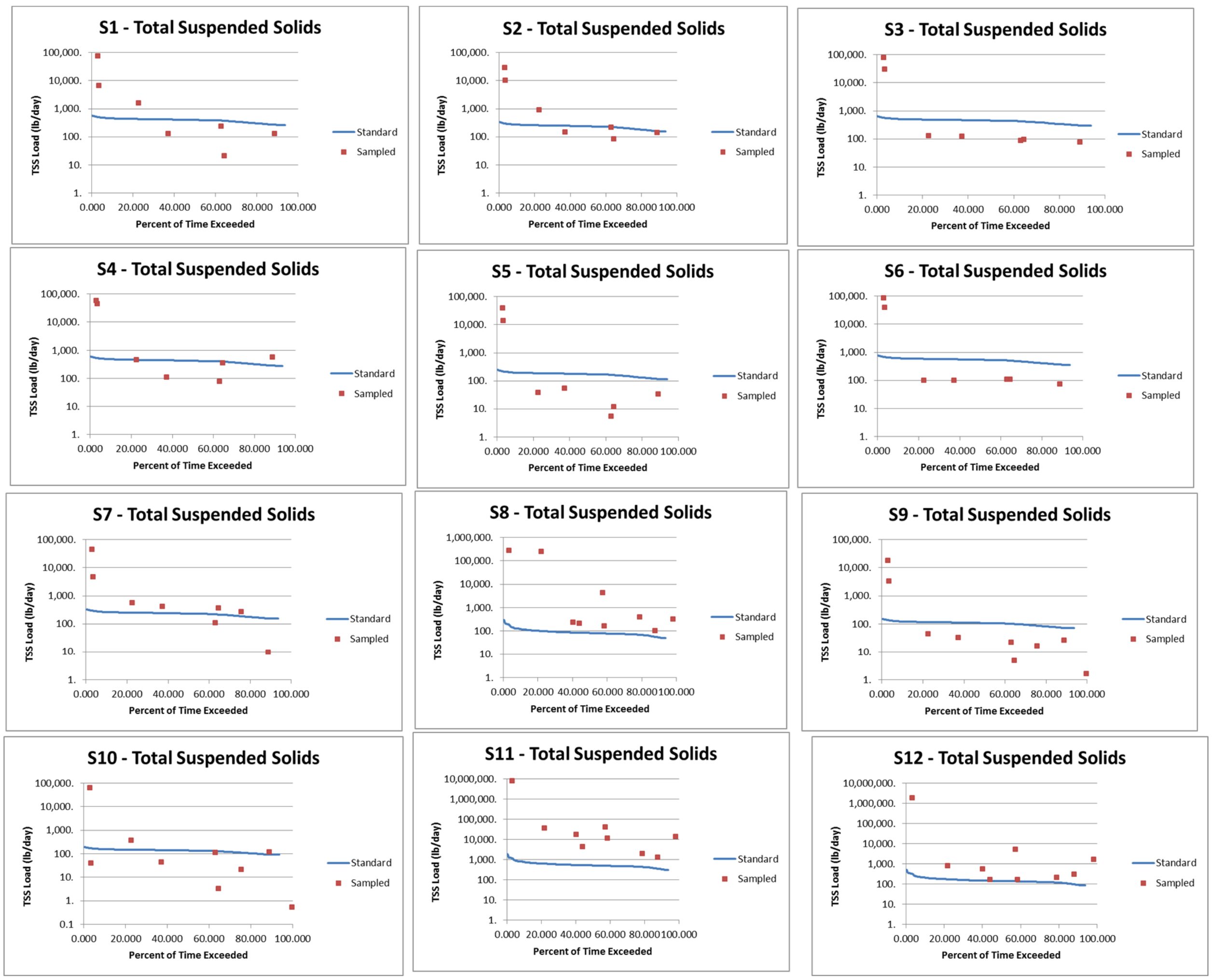

Figure 42. Total suspended solids load curves for Big Walnut Creek samples sites from 2018 – 2019.

E. coli Load Duration Curves

E. coli load duration curves display completely different conditions than those presented by nitrate-nitrogen, total phosphorus and total suspended solids curves (Figure 43). *E. coli* curves indicate that *E. coli* levels exceed targets in Sites 1, 2, 4 and 8 during all flow conditions. These data suggest a nearly continuous source of *E. coli* within these streams. When flows are at their lowest, most of these sites contain *E. coli* concentrations below target levels suggesting that during dry or low exceedance conditions (60-100), there are limited sources of *E. coli* within these streams. Sites 6, 8, 11 and 12 load duration curves suggest that *E. coli* loads typically exceed targets only during high flow conditions.

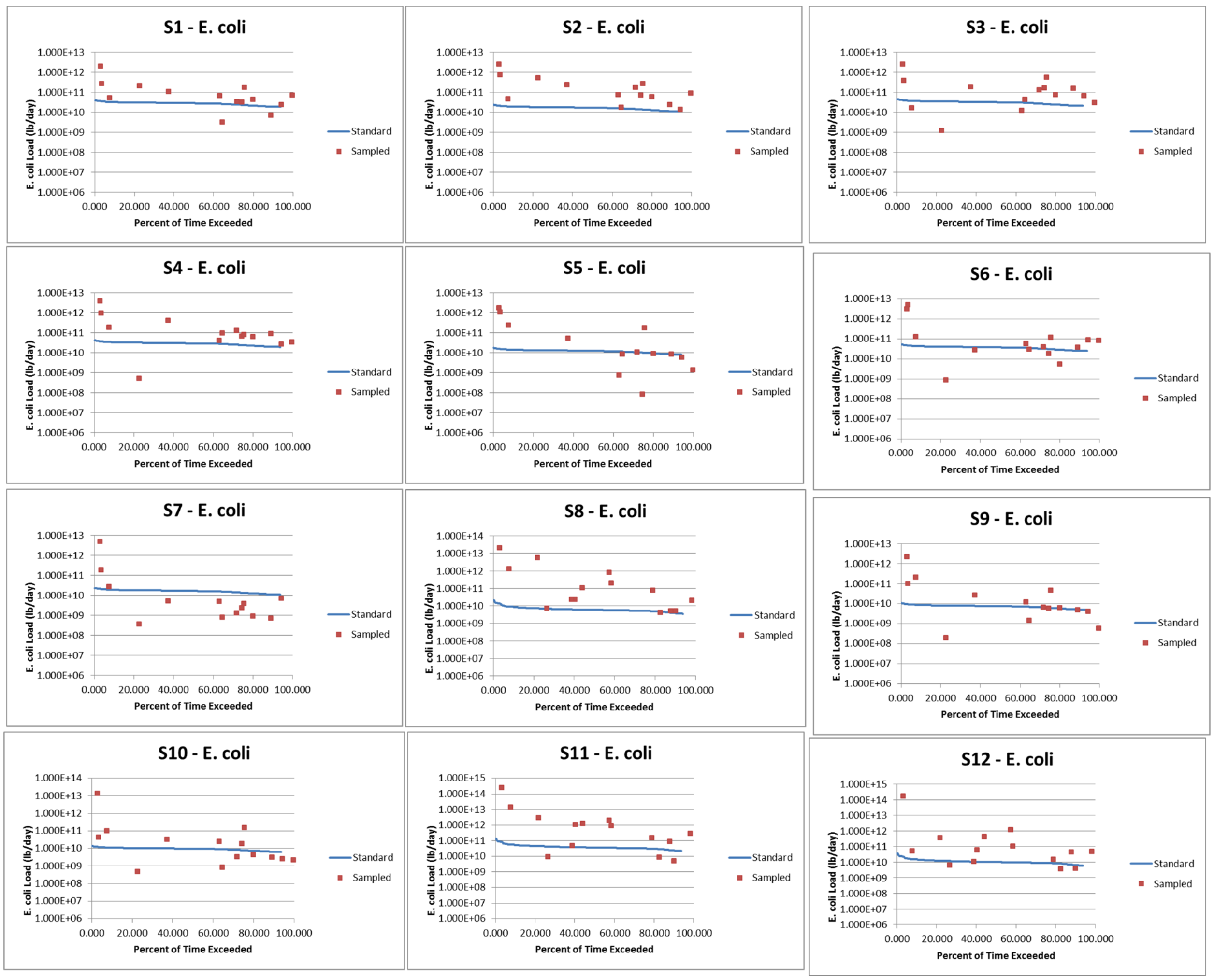

Figure 43. *E. coli* concentrations load duration curves for Big Walnut Creek samples sites from 2018 – 2019.

3.3.5 Macroinvertebrate Community Assessment Results

In general, Little Walnut Creek (S08) supports a more diverse community than other sites in the Big Walnut Creek Watershed (Figure 44, Table 18). Deweese Creek (S10) and Deer Creek (S12) contained the most pollution intolerant communities, while Plum Creek (S05) and Jones Creek (S07) contained the most pollution tolerant communities. Little Walnut Creek (S08) and Deer Creek (S12) possessed high numbers of individuals from the Dipteran genera, a high pollution tolerant genus. Eldin Ditch (S01) and Jones Creek (S07) contained low numbers of the more sensitive EPT families. Eldin Ditch (S01) and Middle Fork Big Walnut Creek (S02) contained the lowest number of taxa (21 and 22, respectively).

Overall, all sites except the Middle Fork Big Walnut Creek (S02) rated as fully supporting for aquatic life use designation based on IDEM guidance. Appendix D details the macroinvertebrate species collected at each sample site.

Table 18. Metric classification scores and mIBI score for the Big Walnut Creek Watershed sample sites as sampled in 2018.

Metrics	1	2	3	4	5	6	7	8	9	10	11	12	13
Number of taxa	3	3	3	3	3	3	3	5	3	3	3	3	3
Number of individuals	3	3	3	3	3	3	3	3	3	3	3	3	5
Number EPT taxa	3	5	5	5	5	5	3	5	5	5	5	5	5
% Orthocladinae+Tanytarsini	3	5	5	3	5	5	5	5	5	5	5	5	5
% non-insects minus crayfish	5	5	5	5	5	5	3	5	5	5	5	5	5
Number Dipteran taxa	3	1	3	3	3	3	3	5	3	3	3	3	3
% Intolerant	1	1	1	1	1	1	1	1	1	1	1	3	1
%Tolerant	3	5	5	5	1	3	3	3	3	5	5	3	3
% Predators	1	1	1	1	1	1	1	1	1	1	1	1	1
%Shredders+Scrapers	5	3	3	5	5	5	5	5	5	5	5	5	5
%Collectors-Filterers	5	1	1	1	5	1	5	3	3	1	1	1	3
% Sprawlers	5	1	1	3	1	1	1	3	1	1	5	1	1
Total	40	34	36	38	38	36	36	44	38	38	42	38	40

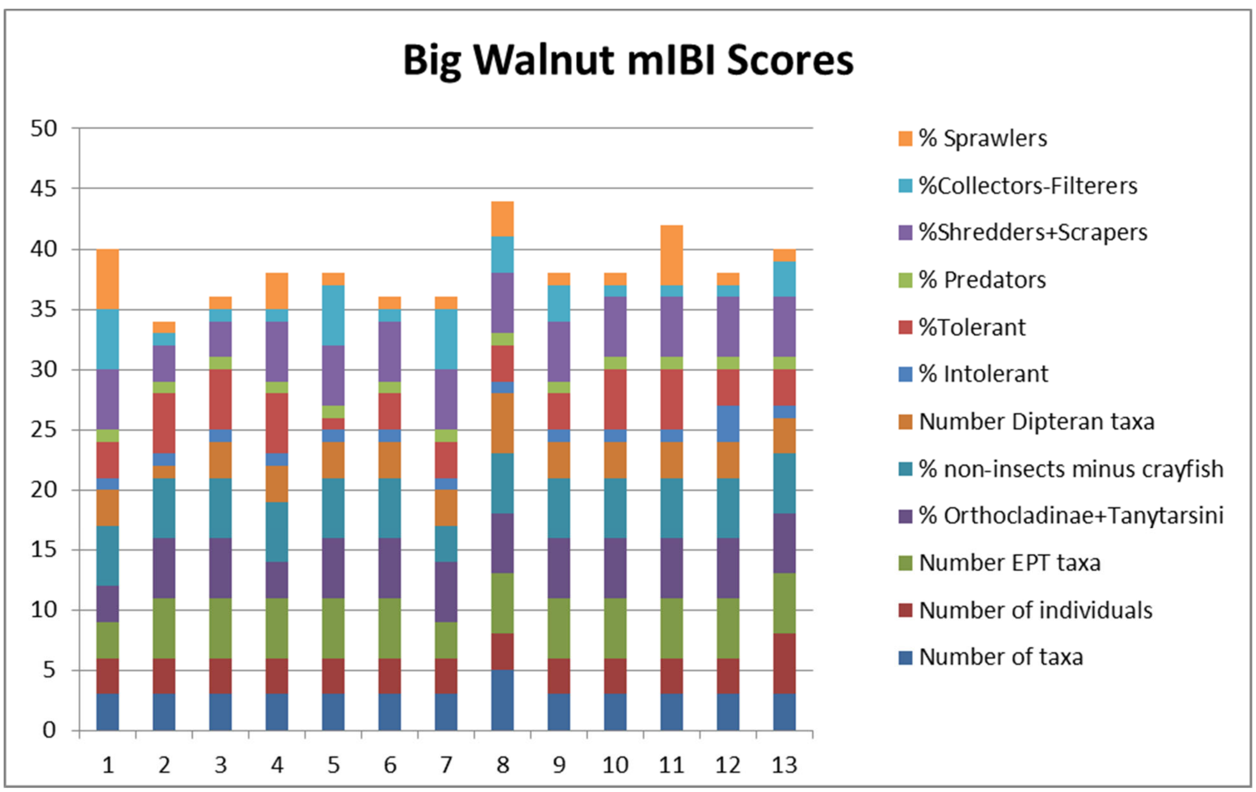

Figure 44. Cumulative metrics used to calculate mIBI scores for Big Walnut Creek Watershed streams in 2018.

3.3.6 Fish Community Assessment Results

Fish community data collected during sampling indicate that Big Walnut Creek Watershed streams generally rate as fair to poor (scores of 32-40) to fair (scores of 48-42; Table 19). Deweese Creek (S10) rated the lowest (40) due to low numbers of headwaters species, low number of pioneer species, and high numbers of tolerant species. The highest IBI score occurred at Ramp Run (S04; Figure 45), which rated as fair. Eldin Ditch, Miller Creek, Jones Creek and Little Walnut Creek all scored fair (42-46). These sites represent streams with a high density and diversity comprised of a solid mix of sensitive species and a diversity of trophic guilds. Appendix D details the fish species collected at each sample site.

Table 19. Metric classification scores and IBI scores for the Big Walnut Creek Watershed sample sites sampled during 2018.

	Site 1	Site 4	Site 6	Site 7	Site 8	Site 10	Site 13
Total species	5	5	5	5	3	5	5
#of Darters Madtom Sculpin	--	--	3	3	--	5	5
# of darters	5	5	--	--	5	--	--
% Headwater species	--	--	1	1	--	1	1
# of sunfish	3	3	--	--	3	--	--
# of minnows species	--	--	3	3	--	5	5
# of suckers	3	5	--	--	1	--	--
% Pioneer	--	--	1	3	--	1	1
# of sensitive species	5	5	5	3	5	3	5
% of tolerance	5	5	5	5	5	1	1
% omnivores	5	5	5	5	5	5	5
%insectivores	5	5	5	5	5	3	5
% Carnivores	1	1	--	--	1	--	--
CPUE	1	1	1	3	1	3	3
% Simple Lithophilic	3	3	3	3	3	3	3
%DELTS score	5	5	5	5	5	5	5
Total IBI <= 20 sq. mi.	--	--	**42**	**44**	--	**40**	**44**
Total IBI > 20 sq. mi.	**46**	**49**	--	--	**42**	--	--

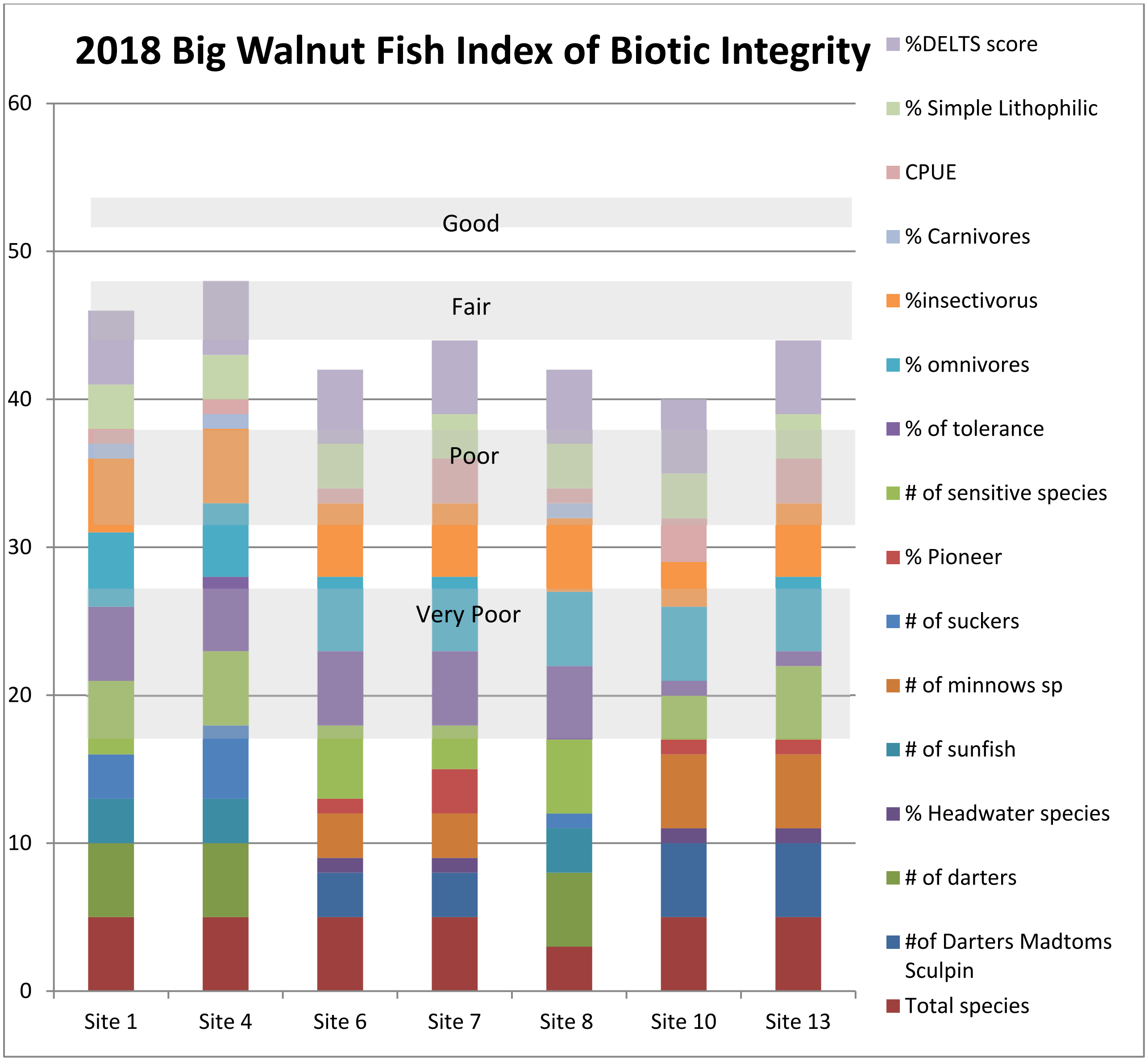

Figure 45. Cumulative metrics used to calculate IBI scores for Big Walnut Creek Watershed streams.

3.3.7 Habitat Results

Stream water quality and available habitat influence the quality of a biological community in a stream, and it is necessary to assess both factors when reviewing biological data. Table 20 presents the results of QHEI assessments at each of the 12 stream sites sampled in the Big Walnut Creek Watershed during the summer of 2018. Figure 46 details metric and total scores for all sites. All sites rated as good to excellent, pool/riffle development scores, stream substrate, instream cover, and gradient were relatively good for Indiana streams contributing to overall high quality QHEI scores. The lowest scores occurred in Plum Creek (S05) which still rated as good habitat. The highest scores occurred on Little Walnut Creek (S08), where comparatively high amounts of instream cover, intact riparian buffers, and larger, more diverse substrates contributed strongly to the higher score at this site.

Table 20. Qualitative Habitat Evaluation Index (QHEI) scores measured in the Big Walnut Creek Watershed.

Site	Substrate	Cover	Channel	Riparian	Pool	Riffle/Run	Gradient	Total
1	16	7	13	7	5	4	6	58
2	16	7	14	5	7	5	8	62
3	16	11	14	7	8	5	8	69
4	18	9	16	8	5	6	6	68
5	16	7	13	5	7	3	6	57
6	18	9	14	7	5	4	6	63
7	18	9	11	8	5	4	6	61
8	18	11	18	10	10	6	7	80
9	17	11	14	8	7	6	6	69
10	16	9	11	8	5	4	6	59
11	14	18	16	8	11	6	6	79
12	17	13	16	7	10	6	6	75
13	15	9	12	4	7	5	6	58

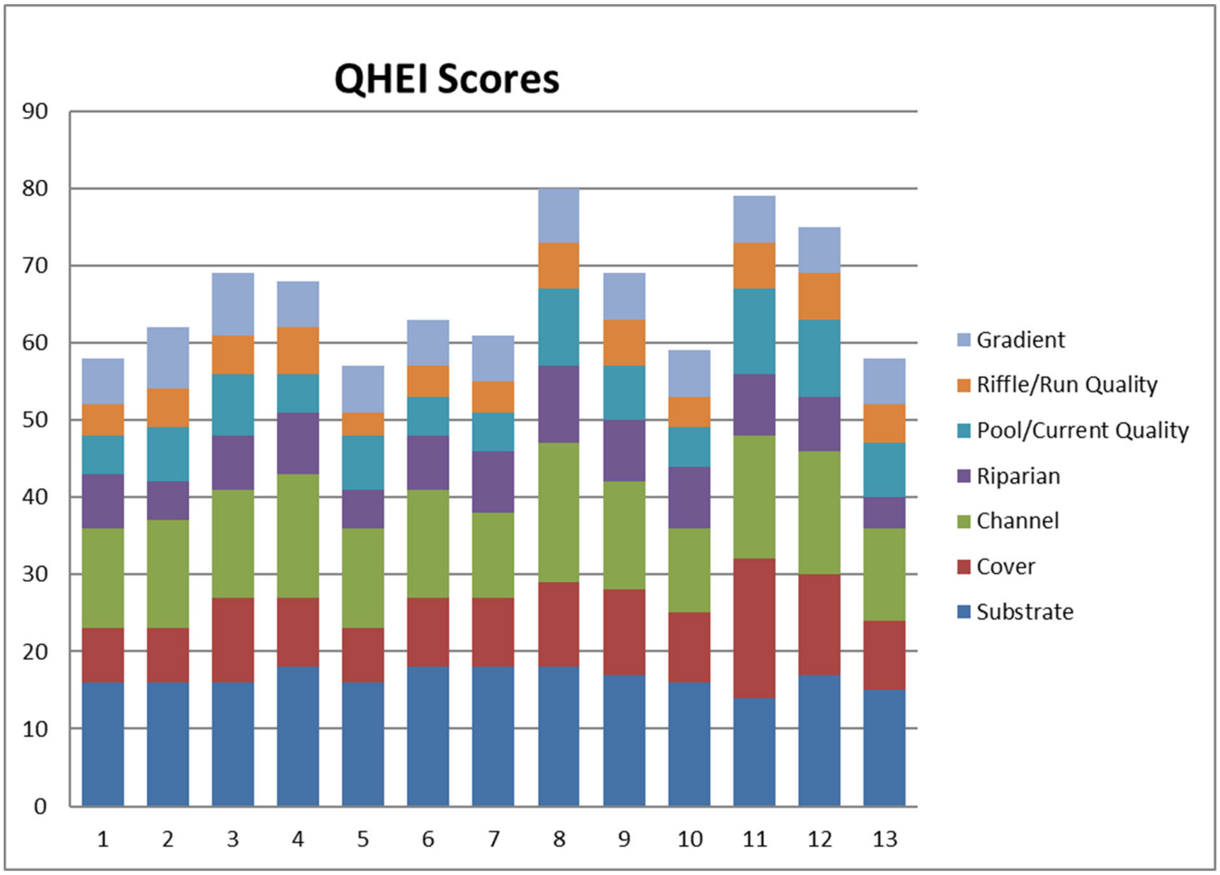

Figure 46. Qualitative Habitat Evaluation Index (QHEI) total and component scores measured for stream sites in the Big Walnut Creek Watershed.

3.4 Watershed Inventory Assessment

3.4.1 Watershed Inventory Methodologies

Volunteers completed windshield surveys throughout the Big Walnut Creek Watershed in spring 2018. 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
- Abandoned mines or mine shafts
- Small, unregulated farms
- Environmental site confirmation (NPDES, CFO, open dump, Superfund, etc.)

3.4.2 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 47 details locations throughout the Big Walnut Creek Watershed where 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 47 should not be considered exhaustive. More than 67.9 miles of streams possessed limited buffers, nearly 298.5 miles of streambank were eroded, and livestock had access to nearly 43.5 miles of streams. Additionally, 19 dumping areas and 7 logjams were identified.

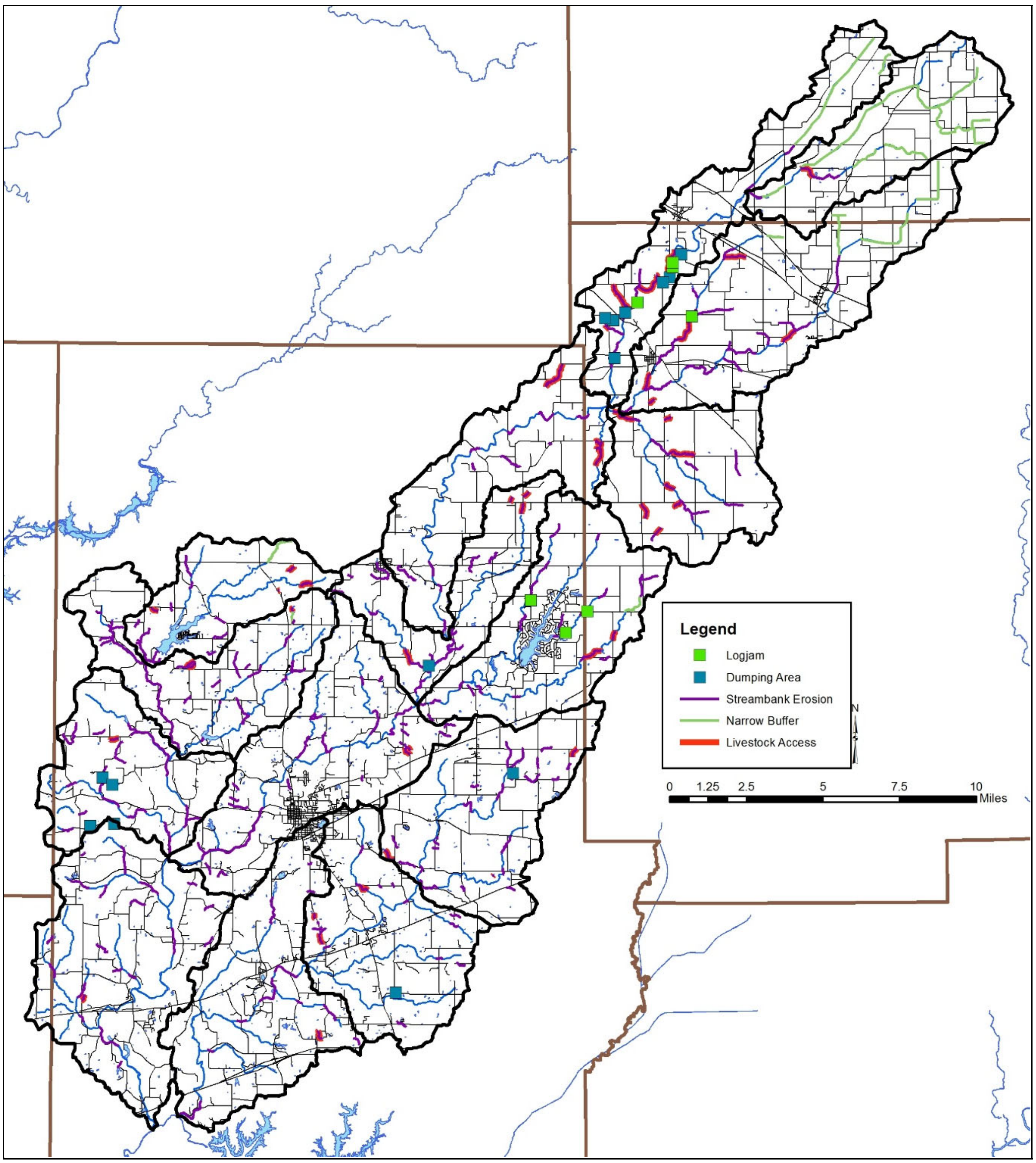

Figure 47. Stream-related watershed concerns identified during watershed inventory efforts.

4.0 WATERSHED INVENTORY II-B: SUBWATERSHED DISCUSSIONS

To gather more specific, localized data, the Big Walnut Creek Watershed was divided into sixteen (16) subwatersheds with each subwatershed reflecting one 12-digit Hydrologic Unite Code (HUC; Figure 48). 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.

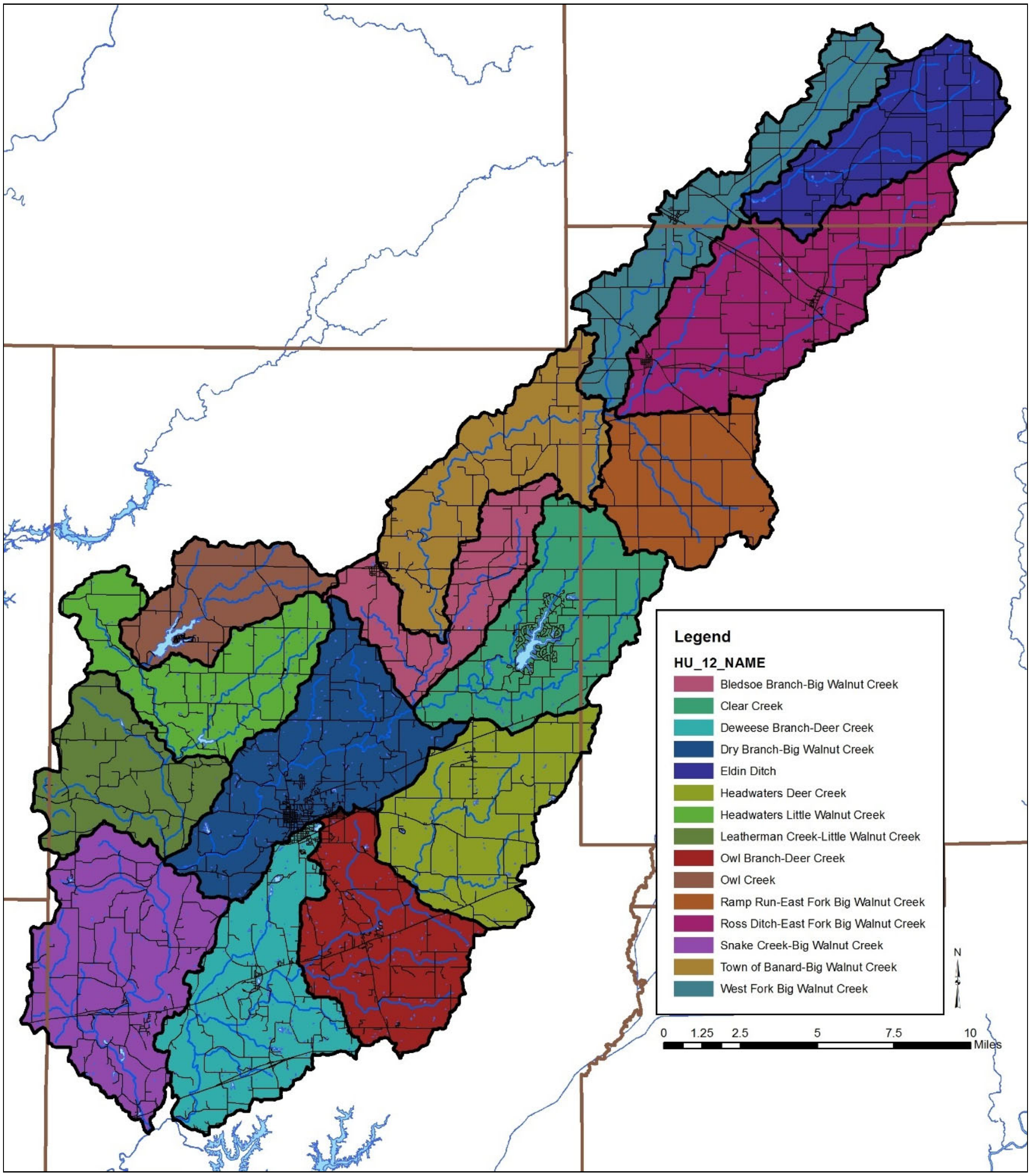

Figure 48. 12-digit Hydrologic Unit Codes Subwatersheds in the Big Walnut Creek Watershed.

4.1 Eldin Ditch Subwatershed

The Eldin Ditch Subwatershed forms part of the northern boundary of the Big Walnut Creek Watershed, including the communities of Milledgeville and New Brunswick, and lies within Boone and Hendricks Counties (Figure 49). It encompasses one 12-digit HUC watershed: 051202030101. This subwatershed drains 15,039 acres, or 23.5 square miles, and accounts for 5.6% of the total watershed area. There are 23.5 miles of stream. IDEM has classified 19.5 miles of stream as impaired for impaired biotic communities and *E. coli*.

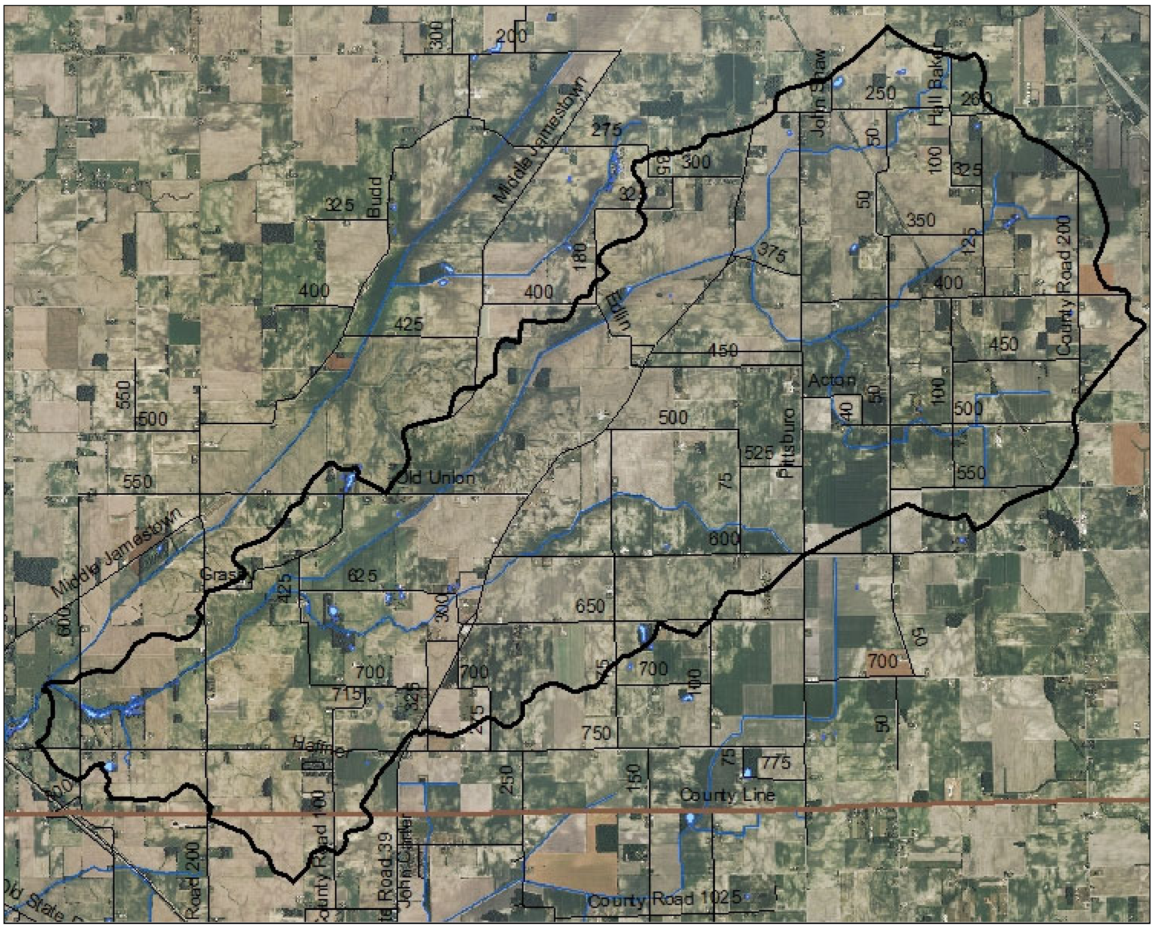

Figure 49. Eldin Ditch Subwatershed.

4.1.1 Soils

Soils in the Eldin Ditch subwatershed are dominated by the Crosby-Treaty-Miami complex. The Crosby series are on till plains and consist of deep, somewhat poorly drained soils that are moderately deep to dense till with a slope ranging from 0-6%. The Treaty series are in depressions in till plains and consist of very deep, poorly drained soils that formed in loess and in the underlying loamy till with a slope ranging from 0-2%. The Miami series are on till plains and consist of very deep, moderately well drained soils that are moderately deep to dense till with a slope ranging from 0-60%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 7,360 acres (48.9%) of the subwatershed, indicating that nearly half of the subwatershed was historically wetlands. Wetlands currently cover 0.5% (80.2 acres) of the subwatershed, representing a loss of 99% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 50.2% and

0.5% of the subwatershed, respectively. Nearly the entire subwatershed (99%) has soils which are severely limited for septic use.

4.1.2 Land Use

Agricultural land use dominates the Eldin Ditch subwatershed with 92.6% (13,928 acres) in agricultural land uses, including row crop and pasture and 0.8% (113 acres) in forested land use. Wetlands, open water, and grassland cover just over 154 acres, or 1.0%, of the subwatershed. The communities of New Brunswick and Milledgeville lie within and the State Road 39 corridor bisects the Eldin Ditch Subwatershed accounting for much of the urban land use within the subwatershed. In total, 854 acres or 5.7% of the subwatershed are in urban land uses.

4.1.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There is one leaking underground storage tank (LUST) located along State Road 39 on the south side of New Brunswick (Figure 50). No open dumps, brownfields, corrective action sites, voluntary remediations sites, industrial waste facilities, or NPDES-permitted facilities are located within the Eldin Ditch Subwatershed.

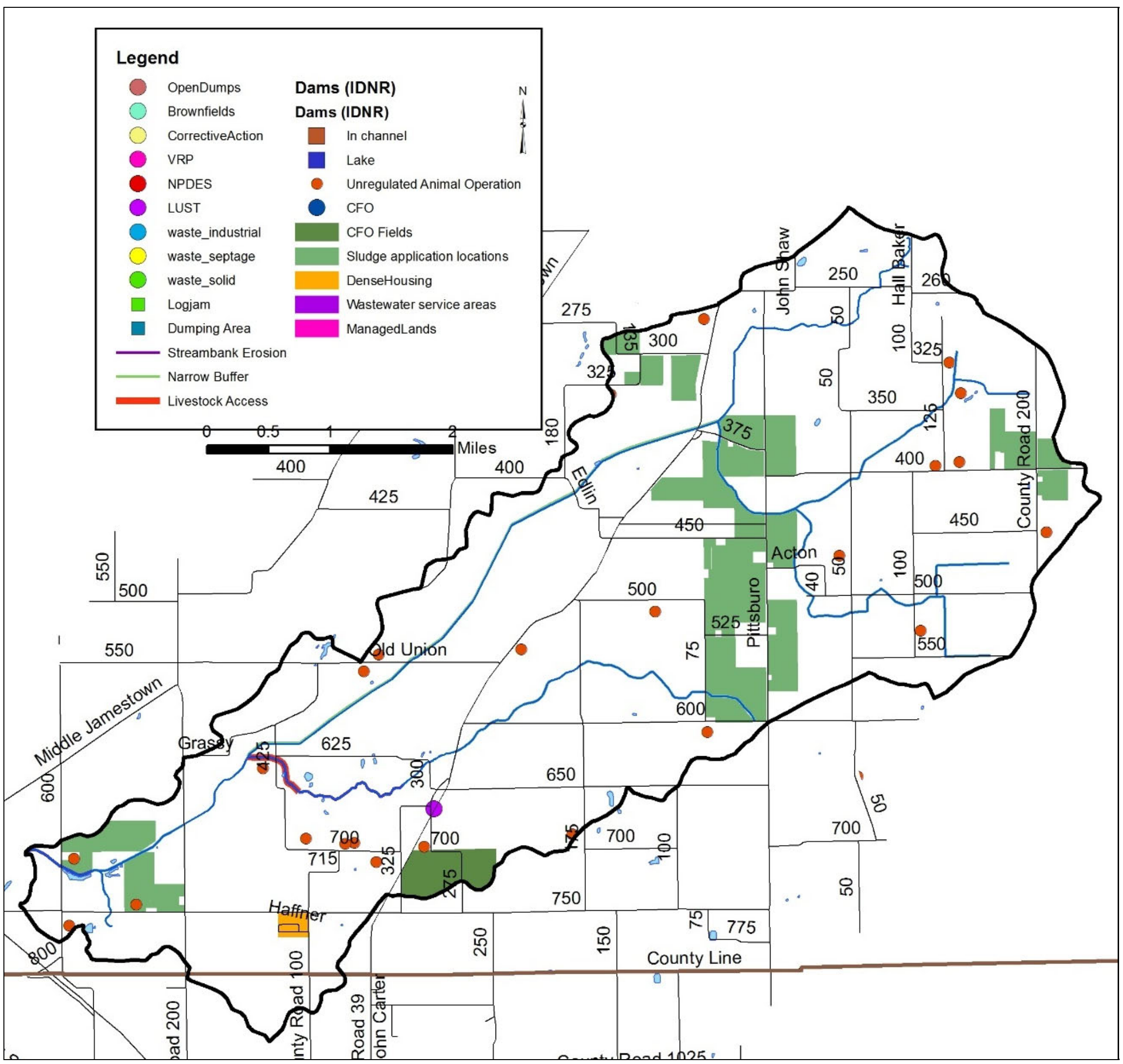

Figure 50. Point and non-point sources of pollution and suggested solutions in the Eldin Ditch Subwatershed.

4.1.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Eldin Ditch Subwatershed. Additionally, a number of small animal operations and pastures are also present (Figure 50). Twenty-three unregulated animal operations housing more than 217 cows, horses, goats, and sheep were identified during the windshield survey. Livestock have access to 0.6 miles of Eldin Ditch Subwatershed streams. No active confined feeding operations (CFO) are located within the Eldin Ditch Subwatershed. In total, manure from small animal operations total over 4,407 tons per year, which contains almost 2,441 pounds of nitrogen and almost 1,231 pounds of phosphorus. Streambank erosion and lack of buffers are a concern in the subwatershed. Approximately 16.3 miles of insufficient stream buffers and 2.2 miles of streambank erosion were identified within the subwatershed.

4.1.5 Water Quality Assessment

Waterbodies within the Eldin Ditch subwatershed have been sampled at 10 locations (Figure 51). Assessments include collection of water chemistry data by IDEM (1 site), by USGS (1 site), by Commonwealth Biomonitoring as part of the 2008 watershed planning project (1 site) and as part of the current project (1 site). Fish and macroinvertebrate communities were sampled by Commonwealth Biomonitoring (1 site) in 2008, by Jim Gammon (7 sites), and during the current project. No stream gages are in the Eldin Ditch subwatershed.

Table 21 shows the collective historic water quality data from the different sampling events described above. As shown in the table, inorganic nitrogen exceeded water quality targets in 50% of samples, phosphorus exceeded targets in 50% of samples, and total suspended solids exceeded targets in 17% of samples.

Table 21. Eldin Ditch Subwatershed historic water quality data summary.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	--	--	NA
pH	6	0	0%
Conductivity	--	--	NA
Turbidity	--	--	NA
Dissolved Oxygen	6	0	0%
Inorganic Nitrogen, Nitrate & Nitrite	6	3	50%
Total Phosphorus	6	3	50%
Total Suspended Solids	6	1	17%
Orthophosphate	--	--	NA

Table 22 details current water quality data collected at Site 1 (Eldin Ditch) from August 2018 to August 2019. As shown in the table, orthophosphorus exceeded water quality targets in 89% of samples, nitrate exceeded water quality samples in 90% of samples, *E. coli* exceeded state standards in 64% of samples, total phosphorus exceeded targets in 50% of samples, and total suspended solids exceeded targets in 22% of samples. During the current assessment, both the macroinvertebrate and fish community rated poorer than water quality targets scoring 40 for the mIBI and 46 for the IBI.

Table 22. Water quality data collected in the Eldin Ditch Subwatershed, August 2018 to August 2019.

Site		Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
1	Min	1.5	0.04	0.03	0	69
	Median	4.2	0.095	0.09	2	317
	Max	8.5	0.17	0.13	80	480
	Count	10	10	9	9	14
	Exceed	9	5	8	2	9
	% Exceed	90%	50%	89%	22%	64%

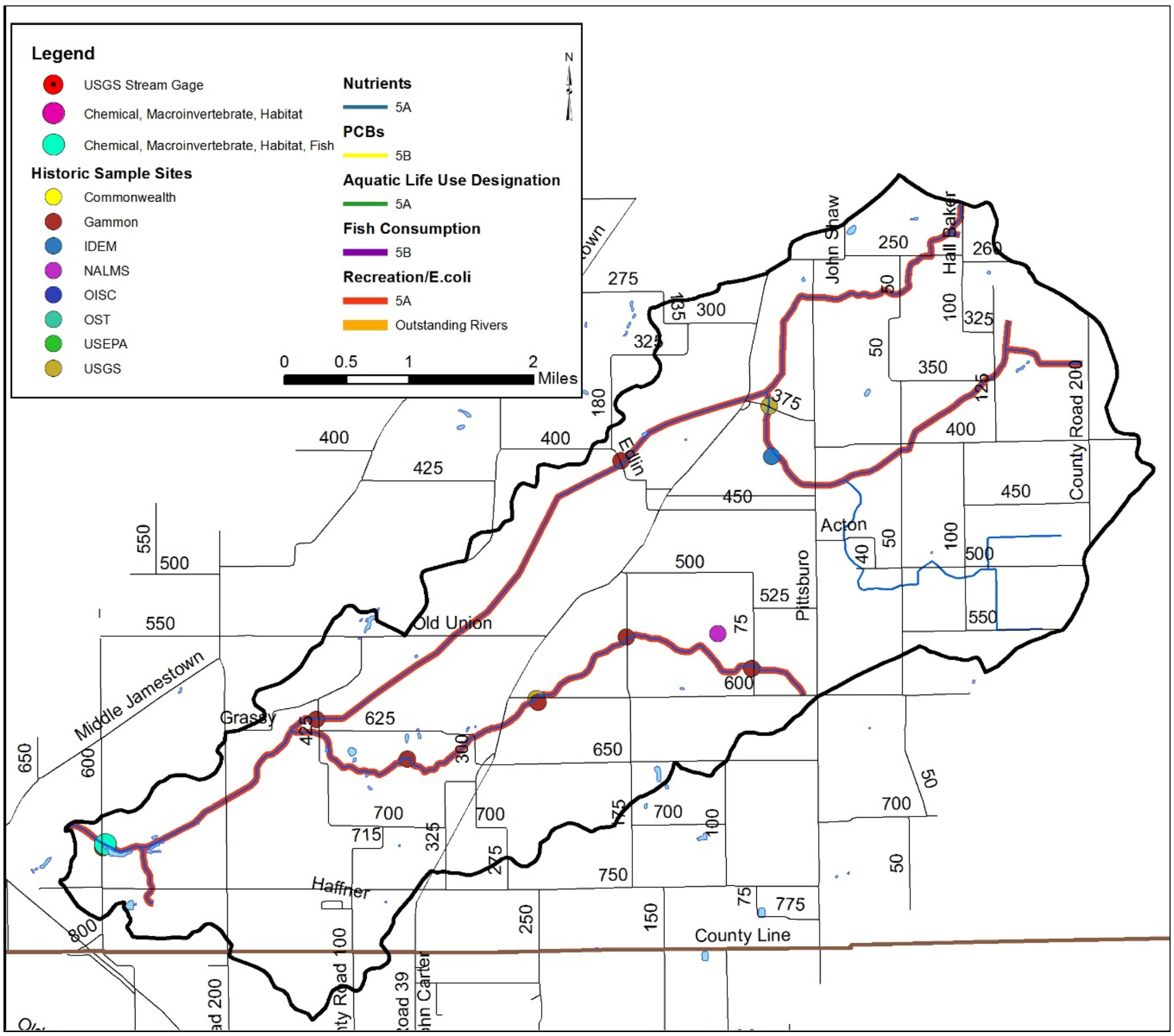

Figure 51. Locations of current and historic water quality data collection and impairments in the Eldin Ditch Subwatershed.

4.2 Ross Ditch-East Fork Big Walnut Creek Subwatershed

The Ross Ditch-East Fork Big Walnut Creek Subwatershed forms part of the eastern boundary of the Big Walnut Creek Watershed, including the communities of North Salem and Lizton, and lies within

Boone and Hendricks Counties (Figure 52). It encompasses one 12-digit HUC watershed: 051202030102. This subwatershed drains 26,562 acres, or 41.5 square miles, and accounts for 9.8% of the total watershed area. There are 48.7 miles of stream. IDEM has classified 36.1 miles of stream as impaired for impaired biotic communities and *E. coli*.

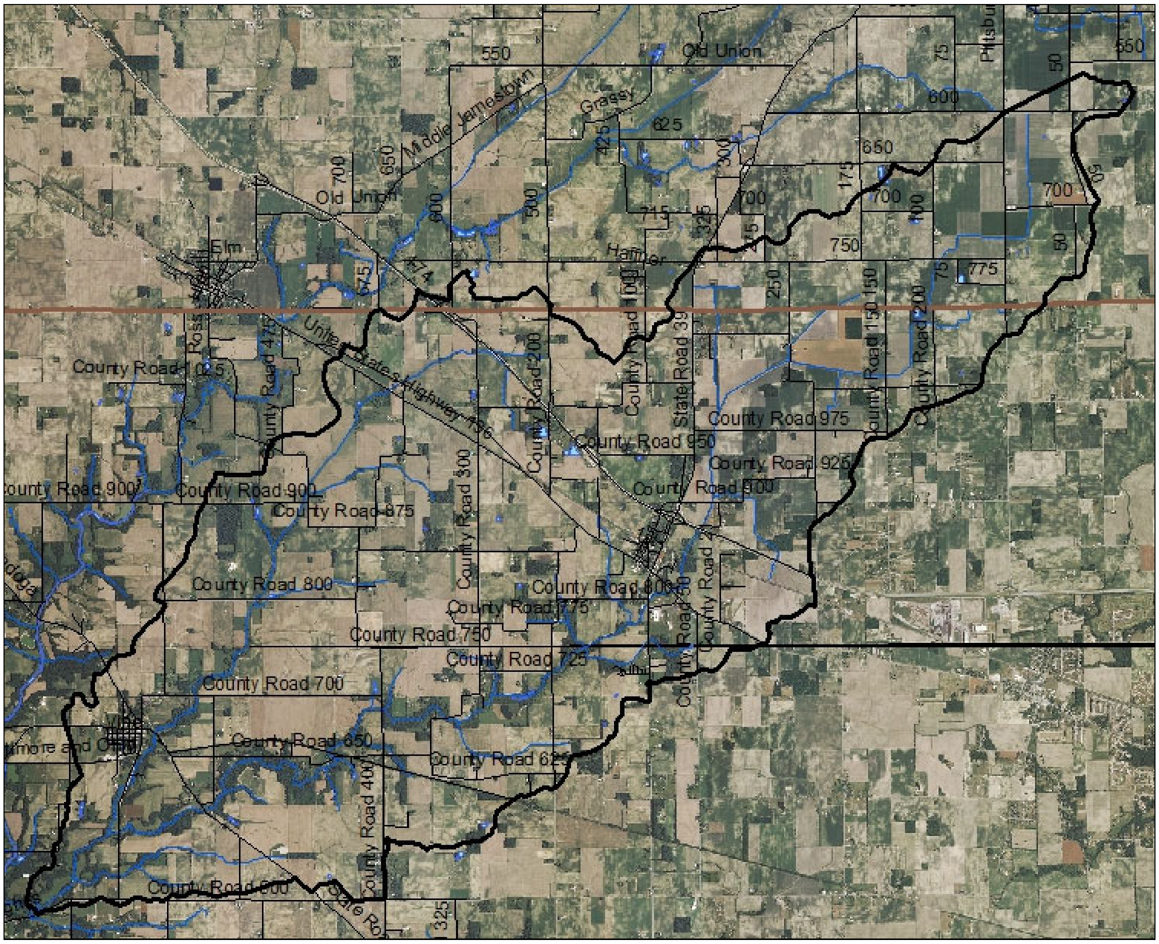

Figure 52. Ross Ditch-East Fork Big Walnut Creek Watershed.

4.2.1 Soils

Soils in the Ross Ditch-East Fork Big Walnut Creek Subwatershed are dominated by the Crosby-Treaty-Miami complex. The Crosby series are on till plains and consist of deep, somewhat poorly drained soils that are moderately deep to dense till with a slope ranging from 0-6%. The Treaty series are in depressions in till plains and consist of very deep, poorly drained soils that formed in loess and in the underlying loamy till with a slope ranging from 0-2%. The Miami series are on till plains and consist of very deep, moderately well drained soils that are moderately deep to dense till with a slope ranging from 0-60%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 10,171 acres (38.3%) of the subwatershed, indicating that over one-third of the subwatershed was historically wetlands. Wetlands currently cover 1.2% (327.1 acres) of the subwatershed, representing a loss of 97% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 9.7% and 37.4% of the subwatershed, respectively. Nearly the entire subwatershed (99%) has soils which are severely limited for septic use.

4.2.2 Land Use

Agricultural land use dominates the Ross Ditch-East Fork Big Walnut Creek Subwatershed with 87.0% (23,121 acres) in agricultural land uses, including row crop and pasture and 4.0% (1,075 acres) in forested land use. Wetlands, open water, and grassland cover 449 acres, or 1.7%, of the subwatershed. The communities of North Salem and Lizton lie within and the State Road 39, US Highway 136, and Interstate 74 corridor bisect the Ross Ditch-East Fork Big Walnut Creek Subwatershed accounting for much of the urban land use within the subwatershed. In total, 1,936 acres or 7.3% of the subwatershed are in urban land uses.

4.2.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are seven LUST sites, which are located around the communities of North Salem and Lizton (Figure 53). There are three NPDES-permitted facilities in the subwatershed; two of those permits include the Lizton WWTP and North Salem WWTP. There are no open dumps, brownfields, corrective action sites, voluntary remediations sites, or industrial waste facilities located within the Ross Ditch-East Fork Big Walnut Creek Subwatershed.

4.2.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Ross Ditch-East Fork Big Walnut Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Forty-three unregulated animal operations housing more than 262 cows, horses, and sheep were identified during the windshield survey. Livestock have access to 3.3 miles of Ross Ditch – East Fork Big Walnut Creek Subwatershed streams. One voided and one active CFO (hogs) is located within the subwatershed. In total, manure from small animal operations and the single CFO total over 10,106 tons per year, which contains 16,994 pounds of nitrogen and 12,100 pounds of phosphorus. Streambank erosion and lack of buffers are a concern in the subwatershed. Approximately 6.7 miles of insufficient stream buffers and 16.3 miles of streambank erosion were identified within the subwatershed. Additionally, one logjam was identified during the windshield survey.

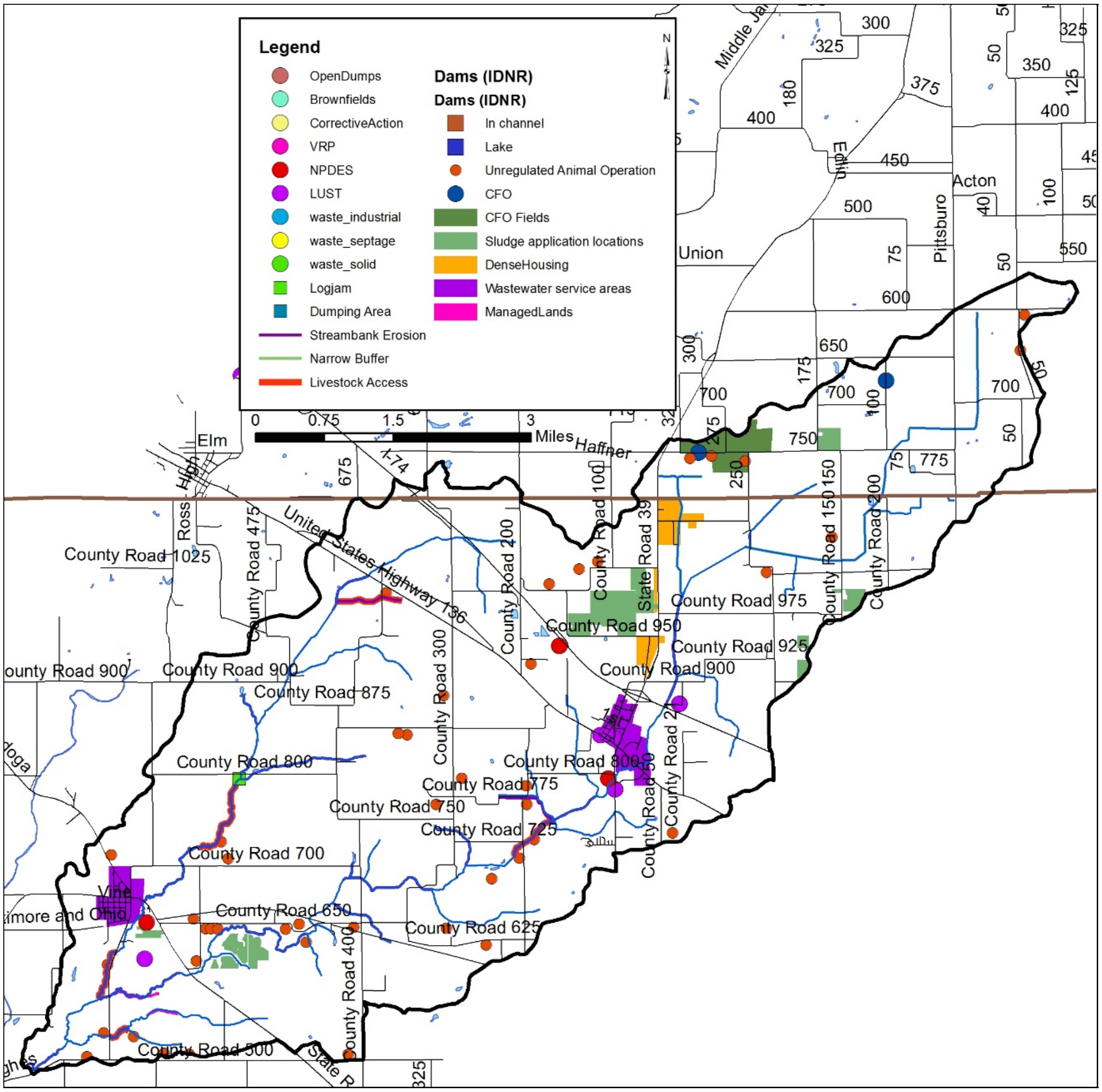

Figure 53. Point and non-point sources of pollution and suggested solutions in the Ross Ditch-East Fork Big Walnut Creek Subwatershed.

4.2.5 Water Quality Assessment

Waterbodies within the Ross Ditch- East Fork Big Walnut Creek Subwatershed have been sampled at 12 locations (Figure 54). Assessments include collection of water chemistry data by IDEM (3 sites), USGS (5 sites), and as part of the current project (2 sites). Fish and macroinvertebrate communities were sampled by Gammon (1 site), as part of the 2008 watershed planning project (2 sites) and as part of the current project (macroinvertebrates only, 2 sites). No stream gages are in the Ross Ditch-East Fork Big Walnut Creek Subwatershed.

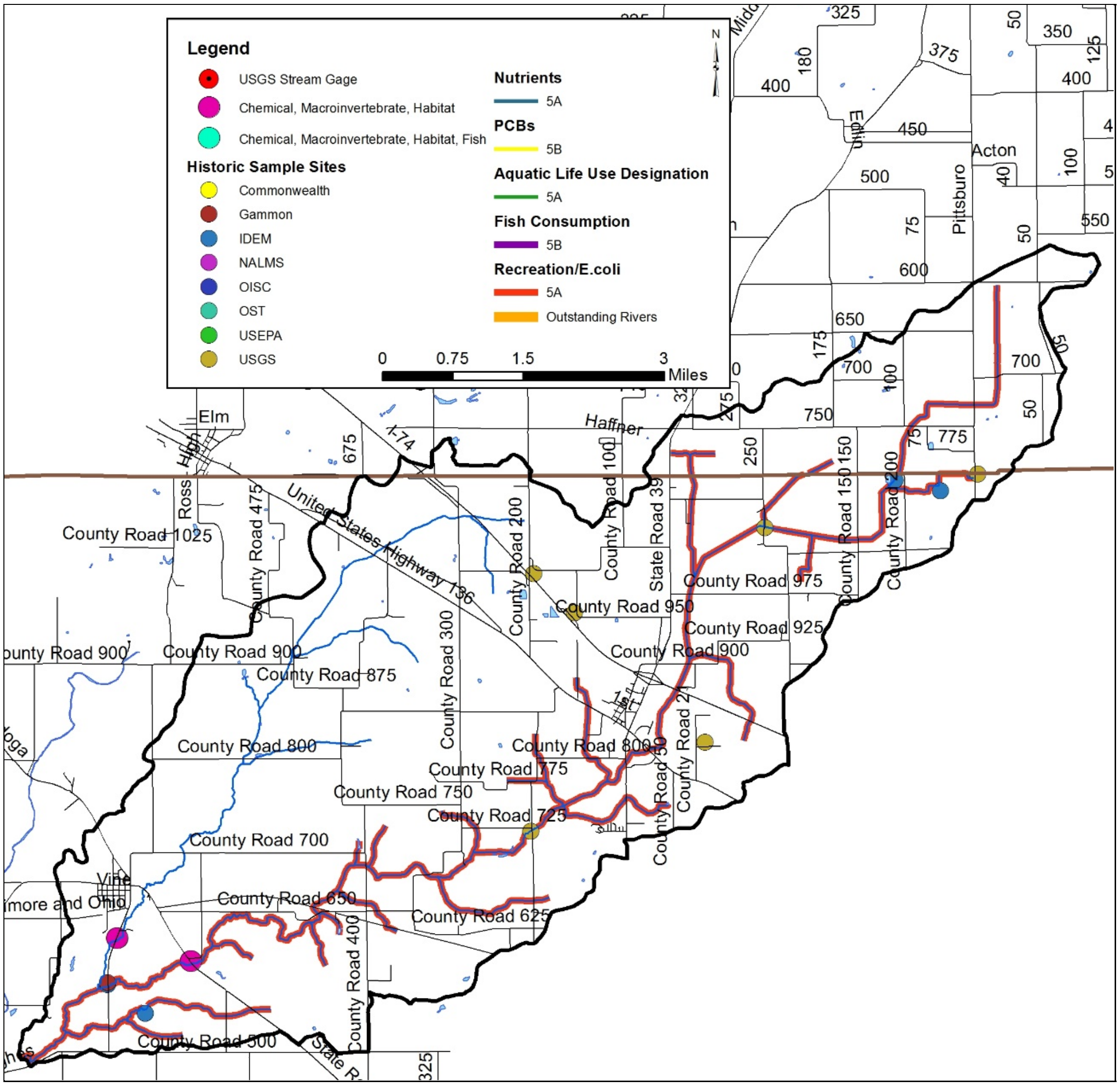

Figure 54. Locations of current and historic water quality data collection and impairments in the Ross Ditch-East Fork Big Walnut Creek Subwatershed.

Table 23details the collective historic water quality data from the different sampling events described above. As shown in the table, *E. coli* exceeded state standards in 79% of samples, turbidity exceeded water quality targets in 92% of samples, inorganic nitrogen exceeded targets in 80% of samples, phosphorus exceeded targets in 25% of samples, and total suspended solids exceeded targets in 10% of samples. During the current assessment, the macroinvertebrate community rated poorer than the water quality target scoring 34 for the mIBI.

Table 23. Ross Ditch-East Fork Big Walnut Creek Subwatershed historic water quality data summary.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	14	11	79%
pH	42	0	0%
Conductivity	28	0	0%
Turbidity	24	22	92%
Dissolved Oxygen	39	2	5%
Inorganic Nitrogen, Nitrate & Nitrite	20	16	80%
Total Phosphorus	24	6	25%
Total Suspended Solids	20	2	10%
Orthophosphate	4	1	25%

Table 24 documents current water quality data collected at Site 2 (Middle Fork) from August 2018 to August 2019. As shown in the table, orthophosphorus exceeded water quality targets in 91% of samples, nitrate exceeded water quality targets in 83% of samples, *E. coli* exceeded state standards in 69% of samples, total phosphorus exceeded targets in 42% of samples, and total suspended solids exceeded targets in 20% of samples.

Table 24. Water quality data collected in the Ross Ditch-East Fork Big Walnut Creek Subwatershed (Middle Fork), August 2018 to August 2019.

Site		Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
2	Min	1	0.02	0.03	0	2
	Median	3.6	0.08	0.075	1	416
	Max	6.6	0.22	0.19	152	2770
	Count	12	12	11	10	16
	Exceed	10	5	10	2	11
	% Exceed	83%	42%	91%	20%	69%

Table 25 shows current water quality data collected at Site 3 (East Fork) from August 2018 to August 2019. As shown in the table, nitrate-nitrogen exceeded water quality targets in 91% of samples, orthophosphorus exceeded water quality targets in 89% of samples, *E. coli* exceeded state standards in 88% of samples, total phosphorus exceeded targets in 55% of samples, and total suspended solids exceeded targets in 30% of samples. During the current assessment, the macroinvertebrate community rated poorer than the water quality target scoring 36 for the mIBI.

Table 25. Water quality data collected in the Ross Ditch-East Fork Big Walnut Creek Subwatershed (East Fork), August 2018 to August 2019.

Site		Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
3	Min	0.9	0.02	0.02	0	1
	Median	4.2	0.1	0.06	4	687
	Max	5.8	0.4	0.34	192	1480
	Count	11	11	9	10	16
	Exceed	10	6	8	3	14
	% Exceed	91%	55%	89%	30%	88%

4.3 Ramp Run-East Fork Big Walnut Creek Subwatershed

The Ramp Run-East Fork Big Walnut Creek Subwatershed forms part of the eastern boundary of the Big Walnut Creek Watershed and lies completely within Hendricks County (Figure 55). It encompasses one 12-digit HUC watershed: 051202030103. This subwatershed drains 15,164 acres, or 23.7 square miles, and accounts for 5.6% of the total watershed area. There are 41.8 miles of stream. IDEM has classified 0.005 miles of stream as impaired for *E. coli*.

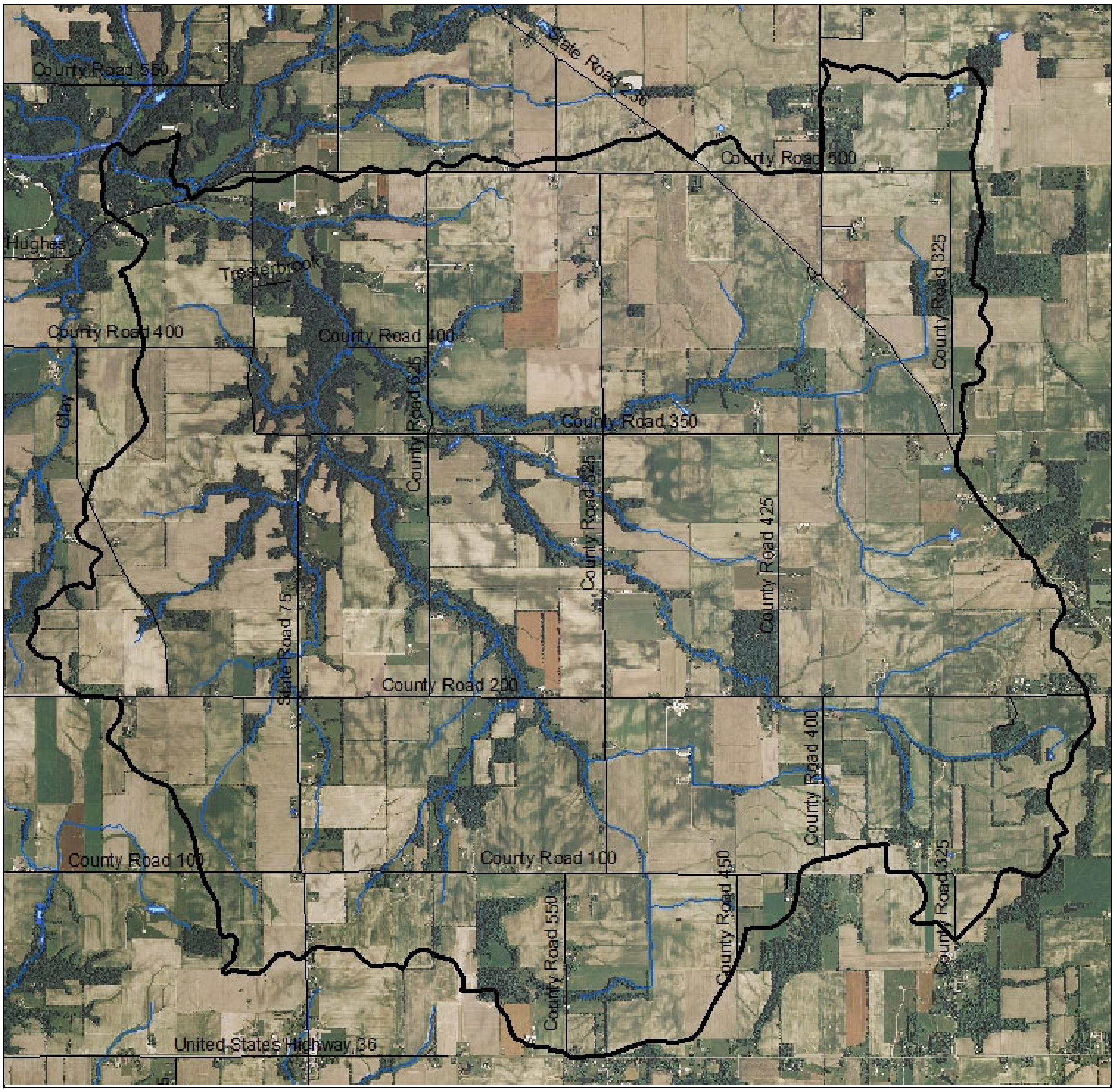

Figure 55. Ramp Run-East Fork Big Walnut Creek Subwatershed.

4.3.1 Soils

Soils in the Ramp Run-East Fork Big Walnut Creek subwatershed are dominated by the Miami-Crosby-Treaty complex. The Miami series are on till plains and consist of very deep, moderately well drained soils that are moderately deep to dense till with a slope ranging from 0-60%. The Crosby series are on till plains and consist of deep, somewhat poorly drained soils that are moderately deep to dense till with a slope ranging from 0-6%. The Treaty series are in depressions in till plains and consist of very deep, poorly drained soils that formed in loess and in the underlying loamy till with a slope ranging from 0-2%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 3,529 acres (23.3%) of the subwatershed, indicating that nearly one quarter of the subwatershed was historically wetlands. Wetlands currently cover 0.7% (111 acres) of the subwatershed, representing a loss of 97% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 7.7% and 26.0% of the subwatershed, respectively. Nearly the entire subwatershed (99%) has soils which are severely limited for septic use.

4.3.2 Land Use

Agricultural land use dominates the Ramp Run-East Fork Big Walnut Creek subwatershed with 88.2% (13,377 acres) in agricultural land uses, including row crop and pasture and 6.2% (948 acres) in forested land use. Wetlands, open water, and grassland cover 207 acres, or 1.4%, of the subwatershed. No communities lie within the subwatershed; the State Road 75 and State Road 236 corridors bisect the subwatershed accounting for much of the urban land use within the subwatershed. In total, 642 acres or 4.2% of the subwatershed are in urban land uses.

4.3.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed (Figure 56). There are no open dumps, brownfields, corrective action sites, voluntary remediation sites, NPDES, LUST, or industrial waste facilities located within the Ramp Run-East Fork Big Walnut Creek Subwatershed.

4.3.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Ramp Run-East Fork Big Walnut Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Forty-nine unregulated animal operations housing more than 541 cows, horses, and goats were identified during the windshield survey. Livestock have access to 3.7 miles of Ramp Run – East Fork Big Walnut Creek Subwatershed streams. Two active CFOs (hogs) are located within the Ramp Run – East Fork Big Walnut Creek Subwatershed. In total, manure from small animal operations and CFOs total over 42,892 tons per year which contains 101,044 pounds of nitrogen and 74,950 pounds of phosphorus. Streambank erosion and lack of buffers are a concern in the subwatershed. Approximately 0.9 miles of insufficient stream buffers and 8.9 miles of streambank erosion were identified within the subwatershed.

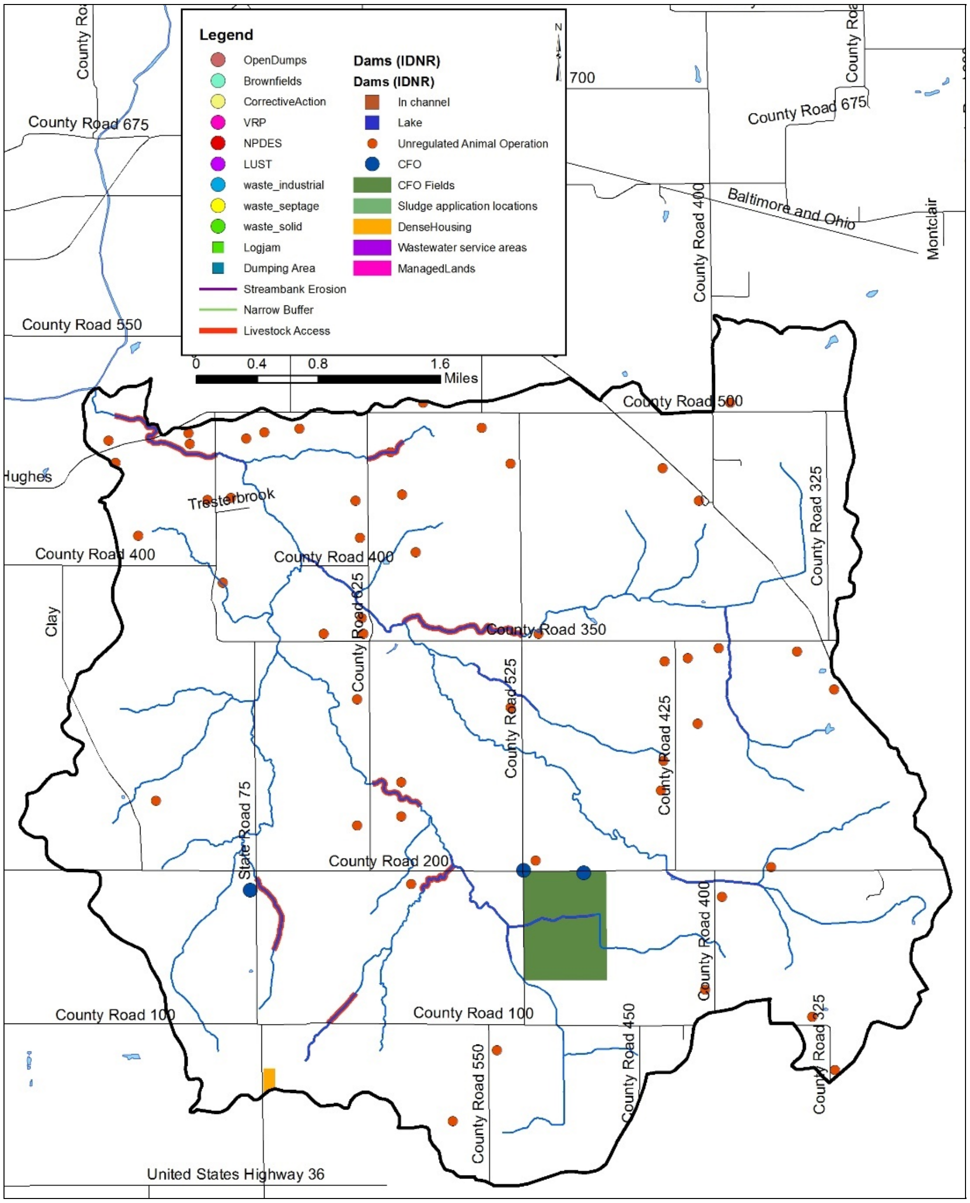

Figure 56. Point and non-point sources of pollution and suggested solutions in the Ramp Run-East Fork Big Walnut Creek Subwatershed.

4.3.5 Water Quality Assessment

Waterbodies within the Ramp Run – East Fork Big Walnut Creek Subwatershed have been sampled at 4 locations (Figure 57). Assessments include collection of water chemistry data by USGS (2 sites), as part of the 2008 watershed planning project (1 site), and as part of the current project (1 site). Fish and macroinvertebrate communities were assessed by Gammon (2 sites), as part of the 2008 watershed project (1 site), and as part of the current project (1 site). No stream gages are located in the Ramp Run-East Fork Big Walnut Creek Subwatershed.

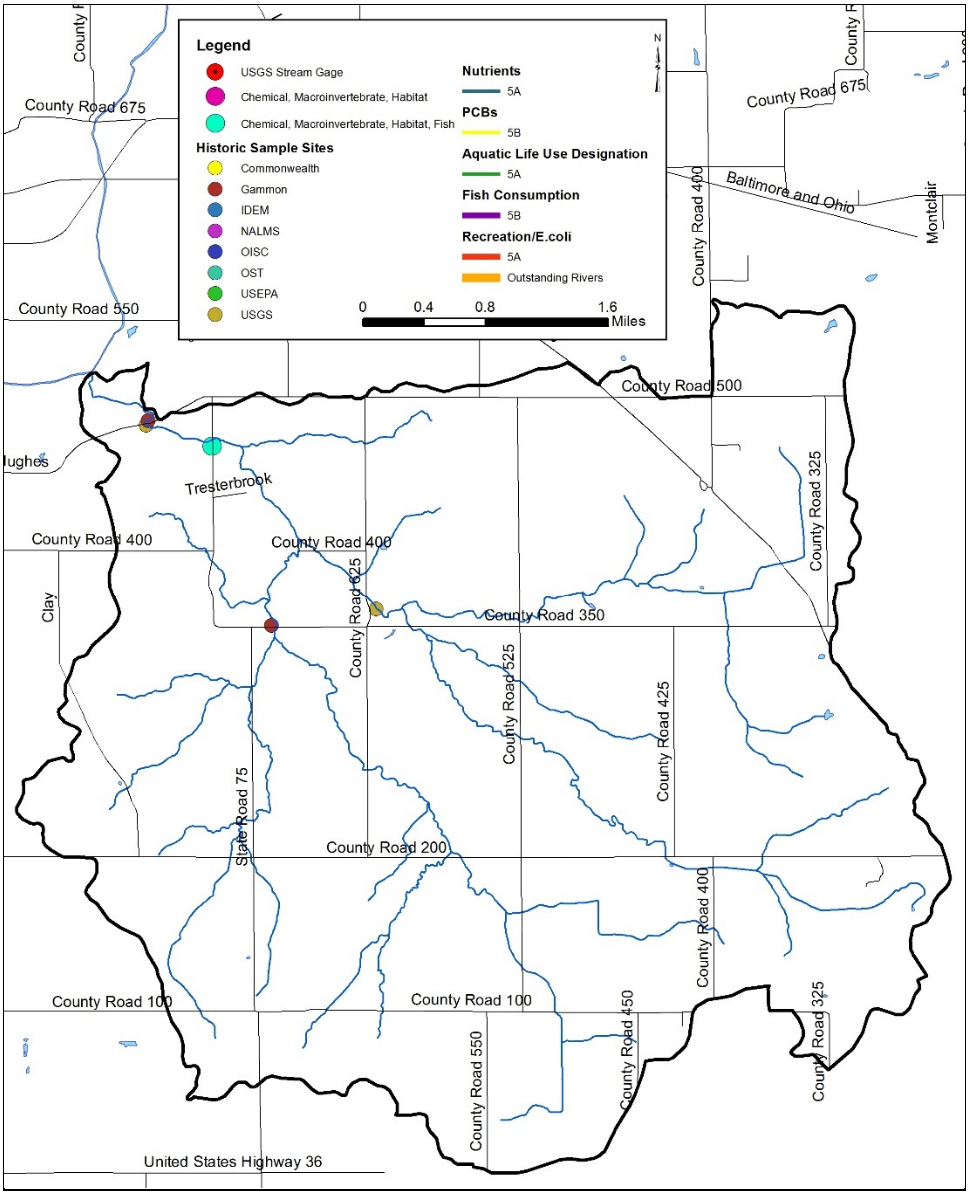

Figure 57. Locations of current and historic water quality data collection and impairments in the Ramp Run-East Fork Big Walnut Creek Subwatershed.

Table 26 shows the collective historic water quality data from the different sampling events described above. As shown in the table, inorganic nitrogen exceeded water quality targets in 64% of samples, phosphorus exceeded targets in 50% of samples, and total suspended solids exceeded targets in 33% of samples.

Table 26. Ramp Run-East Fork Big Walnut Creek Subwatershed historic water quality data summary.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	--	--	NA
pH	8	0	0%
Conductivity	2	0	0%
Turbidity	--	--	NA
Dissolved Oxygen	7	0	0%
Inorganic Nitrogen, Nitrate & Nitrite	11	7	64%
Total Phosphorus	8	4	50%
Total Suspended Solids	6	2	33%
Orthophosphate	2	1	50%

Table 27 details current water quality data collected at Site 4 (Ramp Run) from August 2018 to August 2019. As shown in the table, orthophosphorus exceeded water quality targets in 80% of samples, nitrate exceeded water quality targets in 64% of samples, *E. coli* exceeded state standards in 56% of samples, total phosphorus exceeded targets in 18% of samples, and total suspended solids exceeded targets in 20% of samples. During the current assessment, both the macroinvertebrate and fish community rated poorer than water quality targets scoring 38 for the mIBI and 49 for the IBI.

Table 27. Water quality data collected in the Ramp Run-East Fork Big Walnut Creek Subwatershed, August 2018 to August 2019.

Site		Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
4	Min	1	0.01	0.03	0	0
	Median	2.4	0.07	0.065	1	263
	Max	6	0.42	0.21	149	2550
	Count	11	11	10	10	16
	Exceed	7	2	8	2	9
	% Exceed	64%	18%	80%	20%	56%

4.4 West Fork Big Walnut Creek Subwatershed

The West Fork Big Walnut Creek Subwatershed forms part of the western boundary of the Big Walnut Creek Watershed, including the community of Jamestown, and lies within Boone, Hendricks, and Putnam Counties (Figure 58). It encompasses one 12-digit HUC watershed: 051202030104. This subwatershed drains 17,175 acres, or 26.8 square miles, and accounts for 6.3% of the total watershed area. There are 32.4 miles of stream. IDEM has classified 32.2 miles of stream as impaired for *E. coli*.

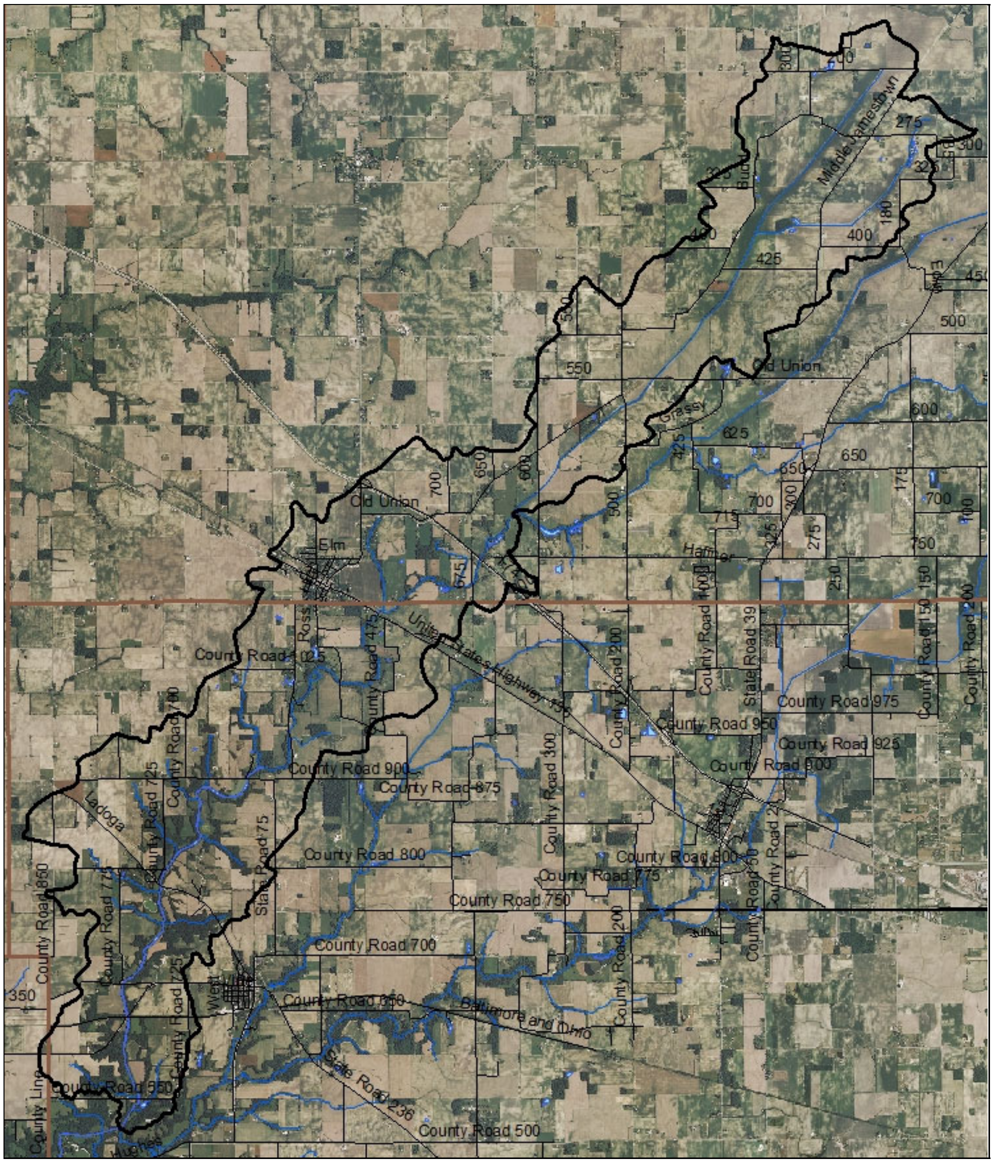

Figure 58. West Fork Big Walnut Creek Subwatershed.

4.4.1 Soils

Soils in the West Fork Big Walnut Creek subwatershed are dominated by the Crosby-Treaty-Miami complex. The Crosby series are on till plains and consist of deep, somewhat poorly drained soils that are moderately deep to dense till with a slope ranging from 0-6%. The Treaty series are in depressions in till plains and consist of very deep, poorly drained soils that formed in loess and in the underlying loamy till with a slope ranging from 0-2%. The Miami series are on till plains and consist of very deep, moderately well drained soils that are moderately deep to dense till with a slope ranging from 0-60%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 5189.7 acres (30.2%) of the subwatershed, indicating that nearly one-third of the subwatershed was historically wetlands. Wetlands currently cover 1.2% (213.8 acres) of the subwatershed, representing a loss of 96% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 36.4% and 13.4% of the subwatershed, respectively. Nearly the entire subwatershed (99%) has soils which are severely limited for septic use.

4.4.2 Land Use

Agricultural land use dominates the West Fork Big Walnut Creek Subwatershed with 86.2% (14,816 acres) in agricultural land uses, including row crop and pasture and 5.4% (931 acres) in forested land use. Wetlands, open water, and grassland cover 256 acres, or 1.5%, of the subwatershed. The Town of Jamestown lies within and the US Highway 136 and Interstate 74 corridors bisect the West Fork Big Walnut Creek Subwatershed accounting for much of the urban land use within the subwatershed. In total, 1,184 acres or 6.9% of the subwatershed are in urban land uses.

4.4.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are eight LUST sites (Figure 59), one NPDES-permitted facility (Jamestown WWTP), and one Voluntary Remediation Program (VRP) site. No open dumps, brownfields, correction action sites, or industrial waste facilities are located within the West Fork Big Walnut Creek Subwatershed.

4.4.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the West Fork Big Walnut Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Twenty-one unregulated animal operations housing more than 220 cows and horses were identified during the windshield survey. Livestock have access to 3.8 miles of streams. One active CFO (hogs) is located within the West Fork Big Walnut Creek Subwatershed. In total, manure from small animal operations and single CFO total over 8,876 tons per year, which contains almost 14,617 pounds of nitrogen and almost 10,442 pounds of phosphorus. Streambank erosion and lack of buffers are a concern in the subwatershed. Approximately 5.7 miles of insufficient stream buffers and 8.3 miles of streambank erosion were identified within the subwatershed. Additionally, three logjam and eight areas with trash were identified in the West Fork Big Walnut Creek Subwatershed.

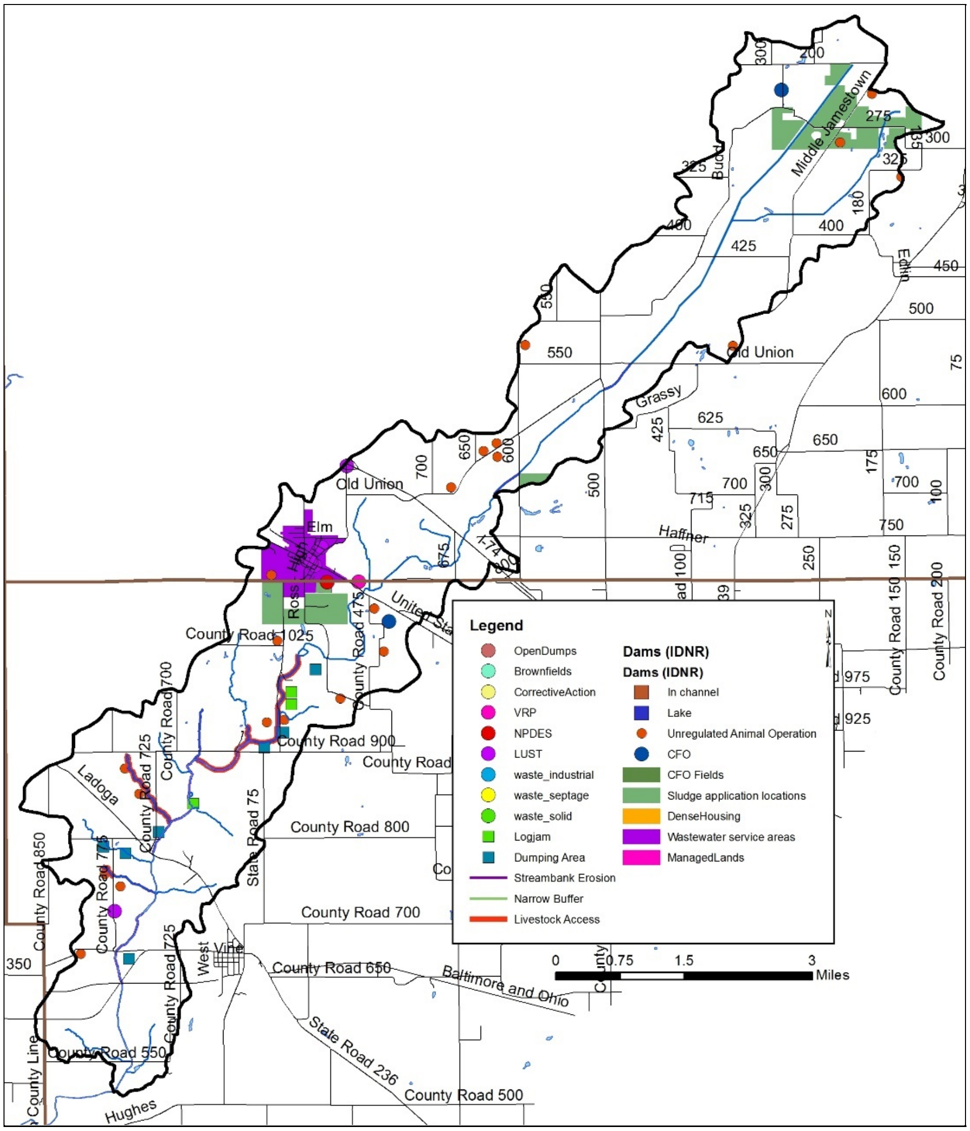

Figure 59. Point and non-point sources of pollution and suggested solutions in the West Fork Big Walnut Creek Subwatershed.

4.4.5 Water Quality Assessment

Waterbodies within the West Fork Big Walnut Creek Subwatershed have been sampled at 14 locations (Figure 60). Assessments include collection of water chemistry data by IDEM (5 sites), by USGS (2 sites), and as part of the 2008 watershed planning project (1 site). Fish and macroinvertebrate communities were assessed by Gammon (6 sites) and as part of the 2008 planning project (1 site). No stream gages are in the West Fork Big Walnut Creek Subwatershed.

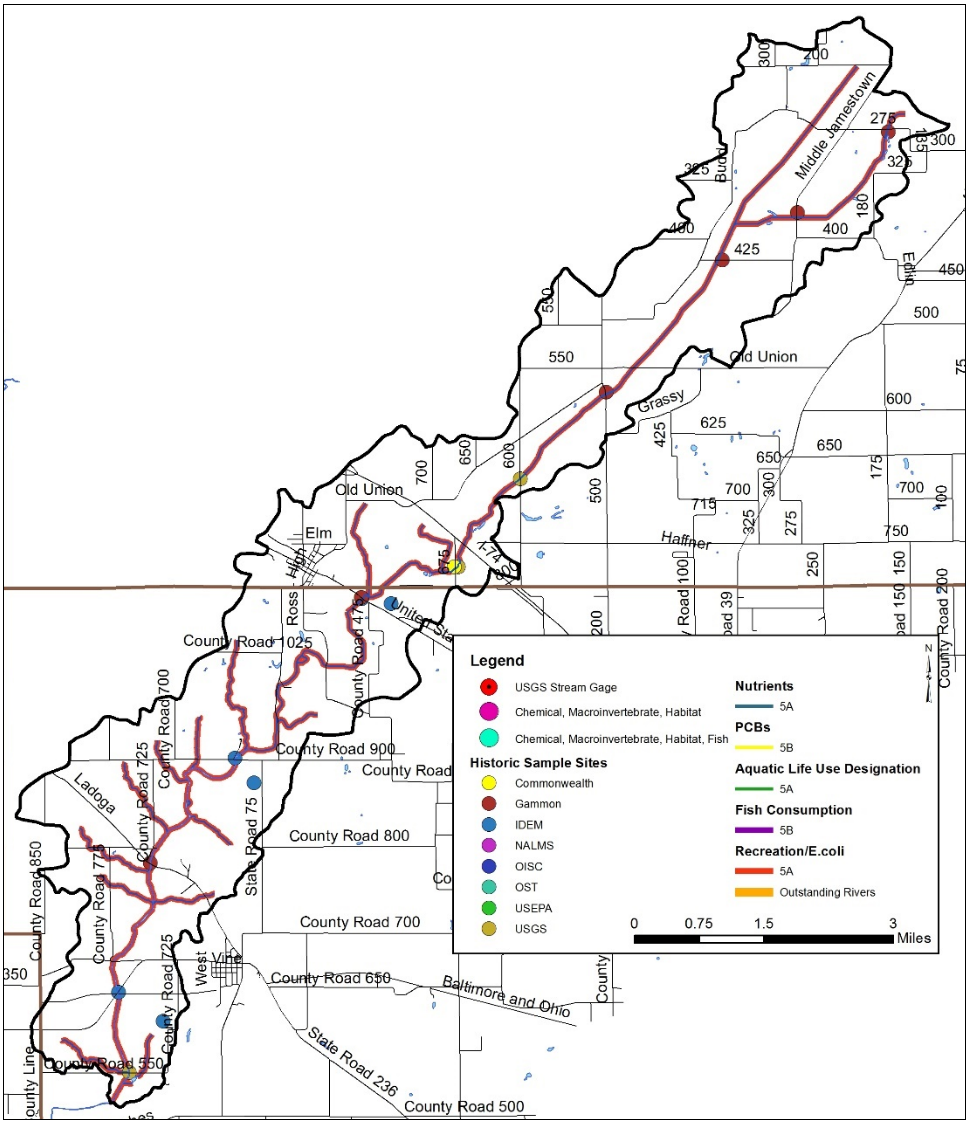

Figure 60. Locations of current and historic water quality data collection and impairments in the West Fork Big Walnut Creek Subwatershed.

Table 28shows the collective historic water quality data from the different sampling events described above. As shown in the table, *E. coli* exceeded state standards in 38% of samples, turbidity exceeded water quality targets in 63% of samples, inorganic nitrogen exceeded targets in 63% of samples, phosphorus exceeded targets in 42% of samples, and total suspended solids exceeded targets in 55% of samples.

Table 28. West Fork Big Walnut Creek Subwatershed historic water quality data summary.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	16	6	38%
pH	31	0	0%
Conductivity	25	0	0%
Turbidity	19	12	63%
Dissolved Oxygen	32	1	3%
Inorganic Nitrogen, Nitrate & Nitrite	8	5	63%
Total Phosphorus	12	5	42%
Total Suspended Solids	11	6	55%
Orthophosphate	--	--	NA

4.5 Town of Barnard - Big Walnut Creek Subwatershed

The Town of Barnard -Big Walnut Creek Subwatershed forms part of the western boundary of the Big Walnut Creek Watershed, including the communities of Bainbridge and Barnard, and lies within Boone, Hendricks, and Putnam Counties (Figure 61). It encompasses one 12-digit HUC watershed: 051202030401. This subwatershed drains 18,450 acres, or 28.8 square miles, and accounts for 6.8% of the total watershed area. There are 64.1 miles of stream. IDEM has classified 46.8 miles of stream as impaired for *E. coli* and 2.6 miles of stream as impaired for fish consumption.

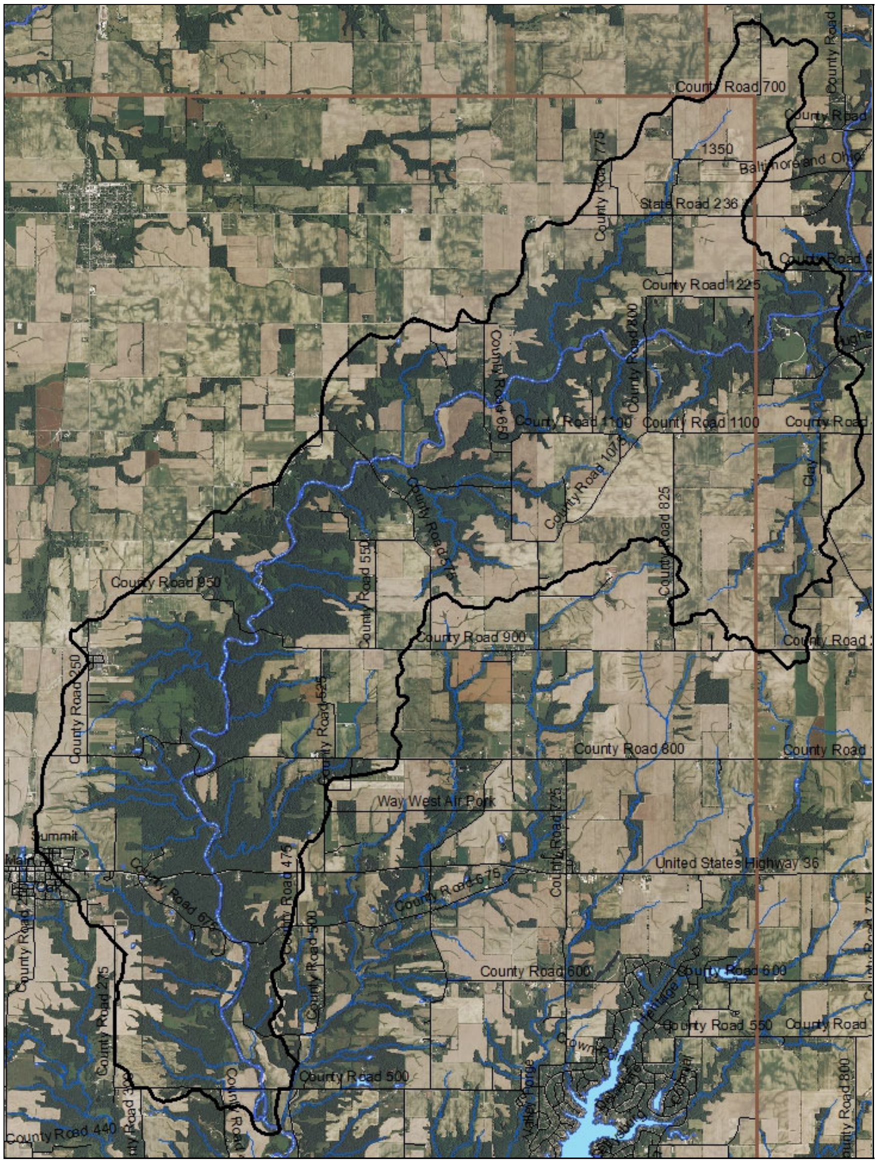

Figure 61. Town of Barnard-Big Walnut Creek Subwatershed.

4.5.1 Soils

Soils in the Town of Barnard-Big Walnut Creek Subwatershed are dominated by the Miami-Crosby-Treaty complex. The Miami series are on till plains and consist of very deep, moderately well drained soils that are moderately deep to dense till with a slope ranging from 0-60%. The Crosby series are on till plains and consist of deep, somewhat poorly drained soils that are moderately deep to dense till with a slope ranging from 0-6%. The Treaty series are in depressions in till plains and consist of very deep, poorly drained soils that formed in loess and in the underlying loamy till with a slope ranging from 0-2%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 2,140 acres (11.6%) of the subwatershed, indicating that approximately one-tenth of the subwatershed was historically wetlands. Wetlands currently cover 2.5% (465.8 acres) of the subwatershed, representing a loss of 78% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 23.3% and 23.4% of the subwatershed, respectively. Nearly the entire subwatershed (99%) has soils which are severely limited for septic use.

4.5.2 Land Use

Agricultural and forested land use co-dominate the Town of Barnard-Big Walnut Creek Subwatershed with 63.3% (11,690 acres) in agricultural land uses, including row crop and pasture and 30.7% (5,677 acres) in forested land use. Wetlands, open water, and grassland cover 235 acres, or 1.3%, of the subwatershed. The northern portion of the Town of Bainbridge lies within and the State Road 236 and US Highway 36 corridors bisects the Town of Barnard-Big Walnut Creek Subwatershed accounting for much of the urban land use within the subwatershed. In total, 861 acres or 4.7% of the subwatershed are in urban land uses.

4.5.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are no LUST sites (Figure 62), but there is one NPDES-permitted facility (Bainbridge WWTP). No open dumps, brownfields, corrective action sites, voluntary remediation sites, industrial waste facilities, or industrial waste facilities are located within the Town of Barnard-Big Walnut Creek Subwatershed.

4.5.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Town of Barnard - Big Walnut Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Twenty-two unregulated animal operations housing more than 120 cows, horses, and goats were identified during the windshield survey. Livestock have access to 2.6 miles of streams. Two active CFOs are located within the Town of Barnard-Big Walnut Creek Subwatershed. In total, manure from small animal operations and two CFOs total over 58,989 tons per year, which contains almost 170,625 pounds of nitrogen and almost 128,865 pounds of phosphorus. Streambank erosion is a concern in the subwatershed. Approximately 8.4 miles of streambank erosion were identified within the subwatershed.

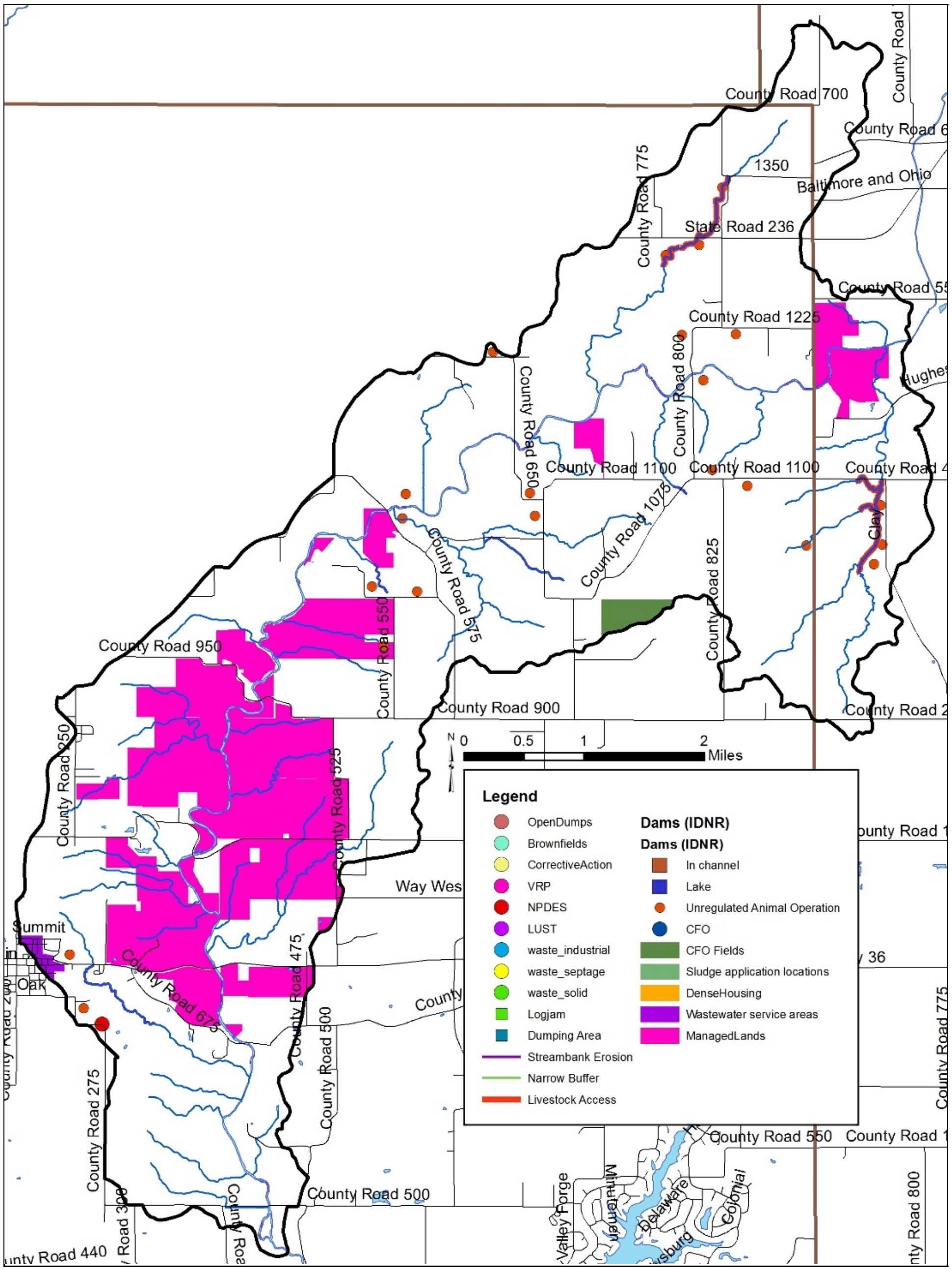

Figure 62. Point and non-point sources of pollution and suggested solutions in the Town of Barnard-Big Walnut Creek Subwatershed.

4.5.5 Water Quality Assessment

Waterbodies within the Town of Barnard-Big Walnut Creek Subwatershed have been sampled at 10 locations (Figure 63). Assessments include collection of water chemistry data by IDEM (1 site), by USGS (2 sites), by USEPA (1 site), and as part of the 2008 planning project (1 site). Fish and macroinvertebrate communities were assessed at six sites by Gammon and at one site as part of the 2008 planning project. There is one stream gage on Big Walnut Creek in the Town of Barnard-Big Walnut Creek Subwatershed.

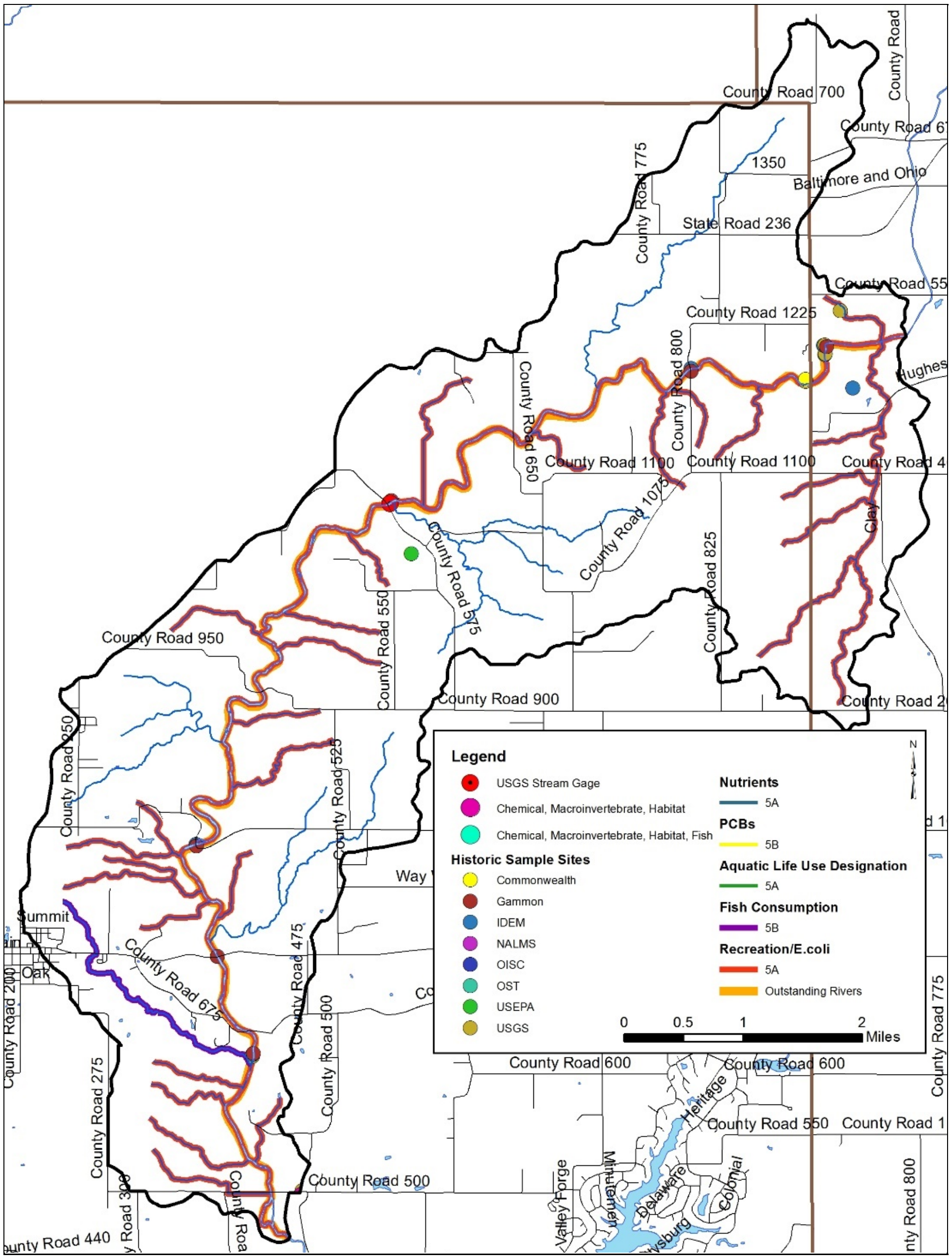

Figure 63. Locations of current and historic water quality data collection and impairments in the Town of Barnard-Big Walnut Creek Subwatershed.

Table 29 shows the collective historic water quality data from the different sampling events described above. As shown in the table, dissolved oxygen samples exceeded state standards in 10% of samples with most exceedances measuring above the higher target. *E. coli* exceeded state standards in 41% of samples, turbidity exceeded water quality targets in 88% of samples, inorganic nitrogen exceeded targets in 67% of samples, phosphorus exceeded targets in 19% of samples, and total suspended solids exceeded targets in 59% of samples.

Table 29. Town of Barnard – Big Walnut Creek Subwatershed historic water quality summary.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	29	12	41%
pH	160	1	1%
Conductivity	186	0	0%
Turbidity	32	28	88%
Dissolved Oxygen	264	26	10%
Inorganic Nitrogen, Nitrate & Nitrite	306	204	67%
Total Phosphorus	115	22	19%
Total Suspended Solids	134	79	59%
Orthophosphate	135	37	27%

4.6 Bledsoe Branch-Big Walnut Creek Subwatershed

The Bledsoe Branch-Big Walnut Creek Subwatershed forms part of the western boundary of the Big Walnut Creek Watershed, including the communities of Bainbridge, Groveland, and New Maysville, and lies completely within Putnam County (Figure 64). It encompasses one 12-digit HUC watershed: 051202030403. This subwatershed drains 12,119 acres, or 18.9 square miles, and accounts for 4.5% of the total watershed area. There are 50.3 miles of stream. IDEM has classified 50.3 miles of stream as impaired for *E. coli*.

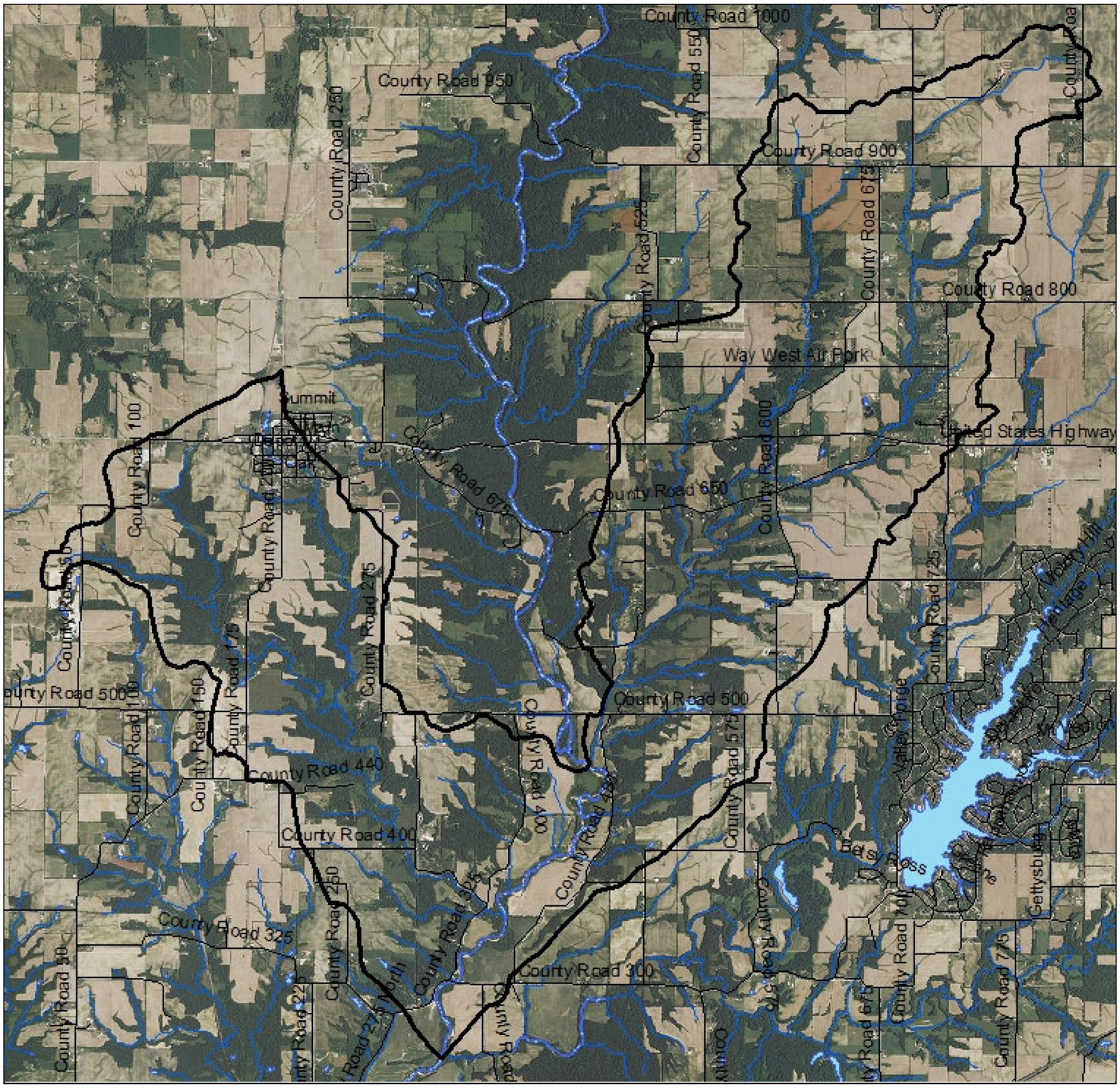

Figure 64. Bledsoe Branch-Big Walnut Creek Subwatershed.

4.6.1 Soils

Soils in the Bledsoe Branch-Big Walnut Creek Subwatershed are dominated by the Miami-Crosby-Treaty complex. The Miami series are on till plains and consist of very deep, moderately well drained soils that are moderately deep to dense till with a slope ranging from 0-60%. The Crosby series are on till plains and consist of deep, somewhat poorly drained soils that are moderately deep to dense till with a slope ranging from 0-6%. The Treaty series are in depressions in till plains and consist of very deep, poorly drained soils that formed in loess and in the underlying loamy till with a slope ranging from 0-2%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 394.6 acres (3.3%) of the subwatershed, indicating that only a small portion of the subwatershed was historically wetlands. Wetlands currently cover 1.5% (187.6 acres) of the subwatershed, representing a loss of 52% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 22.2% and 33.6% of the subwatershed, respectively. Nearly the entire subwatershed (99%) has soils which are severely limited for septic use.

4.6.2 Land Use

Agricultural land use dominates the Bledsoe Branch-Big Walnut Creek Subwatershed with 72.5% (8,793 acres) in agricultural land uses, including row crop and pasture and 20.6% (2,503 acres) in forested land use. Wetlands, open water, and grassland cover 102 acres, or 0.8%, of the subwatershed. The communities of Bainbridge, Groveland, and New Maysville lie within and the US Highway 36 corridor bisects the Bledsoe Branch-Big Walnut Creek Subwatershed accounting for much of the urban land use within the subwatershed. In total, 730 acres or 6.0% of the subwatershed are in urban land uses.

4.6.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are five LUST sites located in the subwatershed (Figure 65). No open dumps, brownfields, corrective action sites, voluntary remediation sites, NPDES permitted locations, or industrial waste facilities are located within the Bledsoe Branch-Big Walnut Creek Subwatershed.

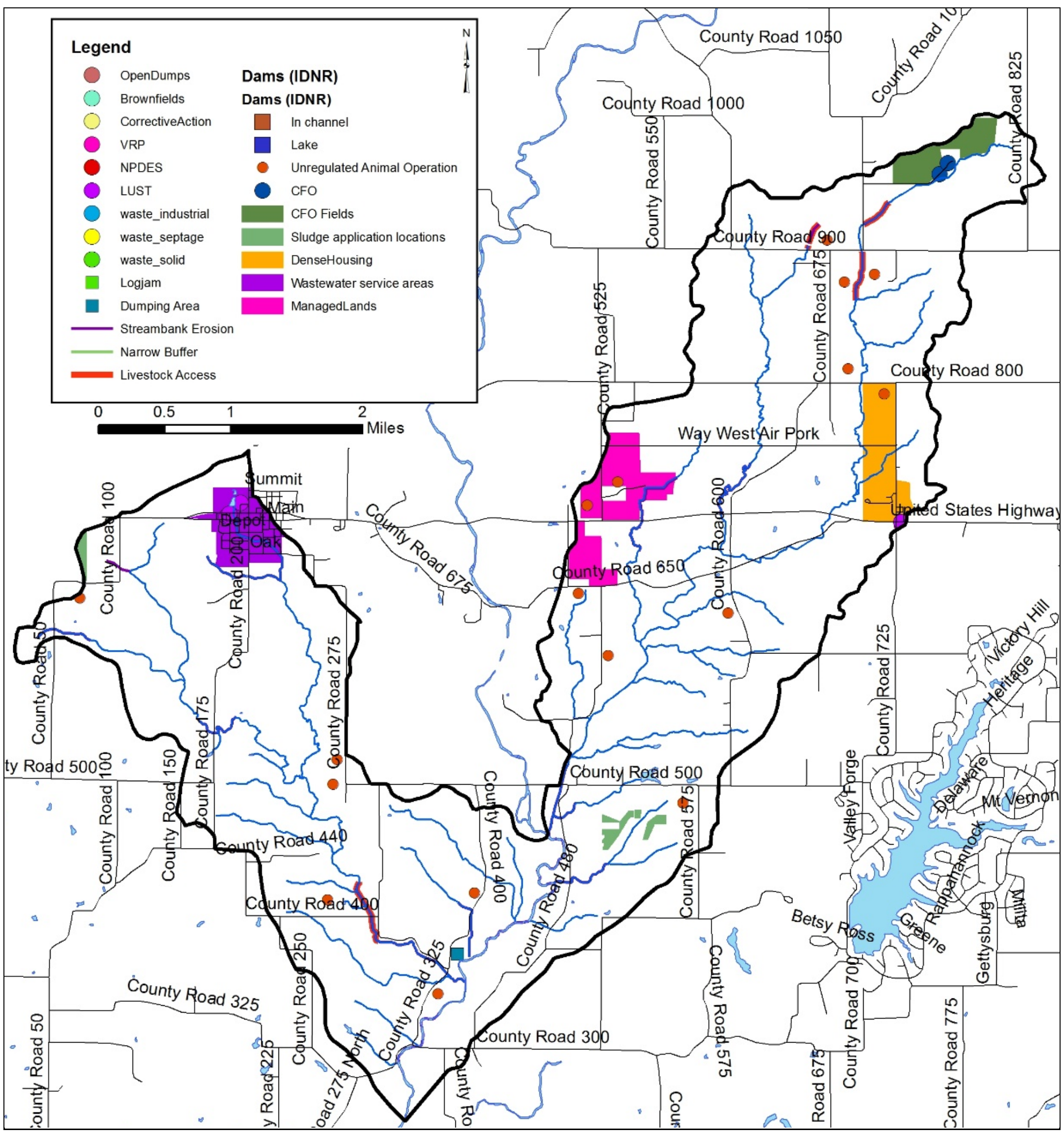

Figure 65. Point and non-point sources of pollution and suggested solutions in the Bledsoe Branch-Big Walnut Creek Subwatershed.

4.6.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Bledsoe Branch-Big Walnut Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Seventeen unregulated animal operations housing more than 117 cows, horses, and goats were identified during the windshield survey. Livestock have access to 1.4 miles of Bledsoe Branch-Big Walnut Creek Subwatershed streams. No active confined feeding operations (CFO) are located within the Bledsoe Branch-Big Walnut Creek Subwatershed. In total, manure from small animal operations total over 2,517 tons per year, which contains almost 1,238 pounds of nitrogen and almost 615 pounds of phosphorus. Streambank erosion is a concern in the subwatershed. Approximately 10.5 miles of streambank erosion were identified within the subwatershed.

4.6.5 Water Quality Assessment

Waterbodies within the Bledsoe Branch-Big Walnut Creek Subwatershed have been sampled at 20 locations (Figure 66). Assessments include collection of water chemistry data by IDEM (11 sites), by USGS (2 sites), as part of the 2008 planning project (2 sites), and as part of the current project (1 site). Fish and macroinvertebrate communities were assessed by Gammon (6 sites) and as part of the current project (1 site). There is one stream gage in the Bledsoe Branch-Big Walnut Creek Subwatershed on Plum Creek.

Table 30 shows the collective historic water quality data from the different sampling events described above. As shown in the table, *E. coli* exceeded state standards in 21% of samples, turbidity exceeded water quality targets in 80% of samples, inorganic nitrogen exceeded targets in 71% of samples, phosphorus exceeded targets in 32% of samples, and total suspended solids exceeded targets in 21% of samples.

Table 30. Bledsoe Branch-Big Walnut Creek Subwatershed historic water quality data summary.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	29	6	21%
pH	115	1	1%
Conductivity	103	0	0%
Turbidity	92	74	80%
Dissolved Oxygen	115	15	13%
Inorganic Nitrogen, Nitrate & Nitrite	28	20	71%
Total Phosphorus	28	9	32%
Total Suspended Solids	33	7	21%
Orthophosphate	7	5	71%

Table 31 details current water quality data collected at Site 5 (Plum Creek) from August 2018 to August 2019. As shown in the table, orthophosphorus exceeded water quality targets in 90% of samples, nitrate-nitrogen exceeded water quality targets in 73% of samples, *E. coli* exceeded targets in 44% of samples, total phosphorus exceeded targets in 45% of samples, and total suspended solids exceeded targets in 20% of samples. During the current assessment, the macroinvertebrate community rated poorer than the water quality target scoring 38 for the mIBI.

Table 31. Water quality data collected in the Bledsoe Branch-Big Walnut Creek Subwatershed, August 2018 to August 2019.

Site		Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
5	Min	0.5	0.03	0.02	0	2
	Median	2.6	0.08	0.07	1	171.5
	Max	5.2	0.2	0.16	203	6000
	Count	11	11	10	10	16
	Exceed	8	5	9	2	7
	% Exceed	73%	45%	90%	20%	44%

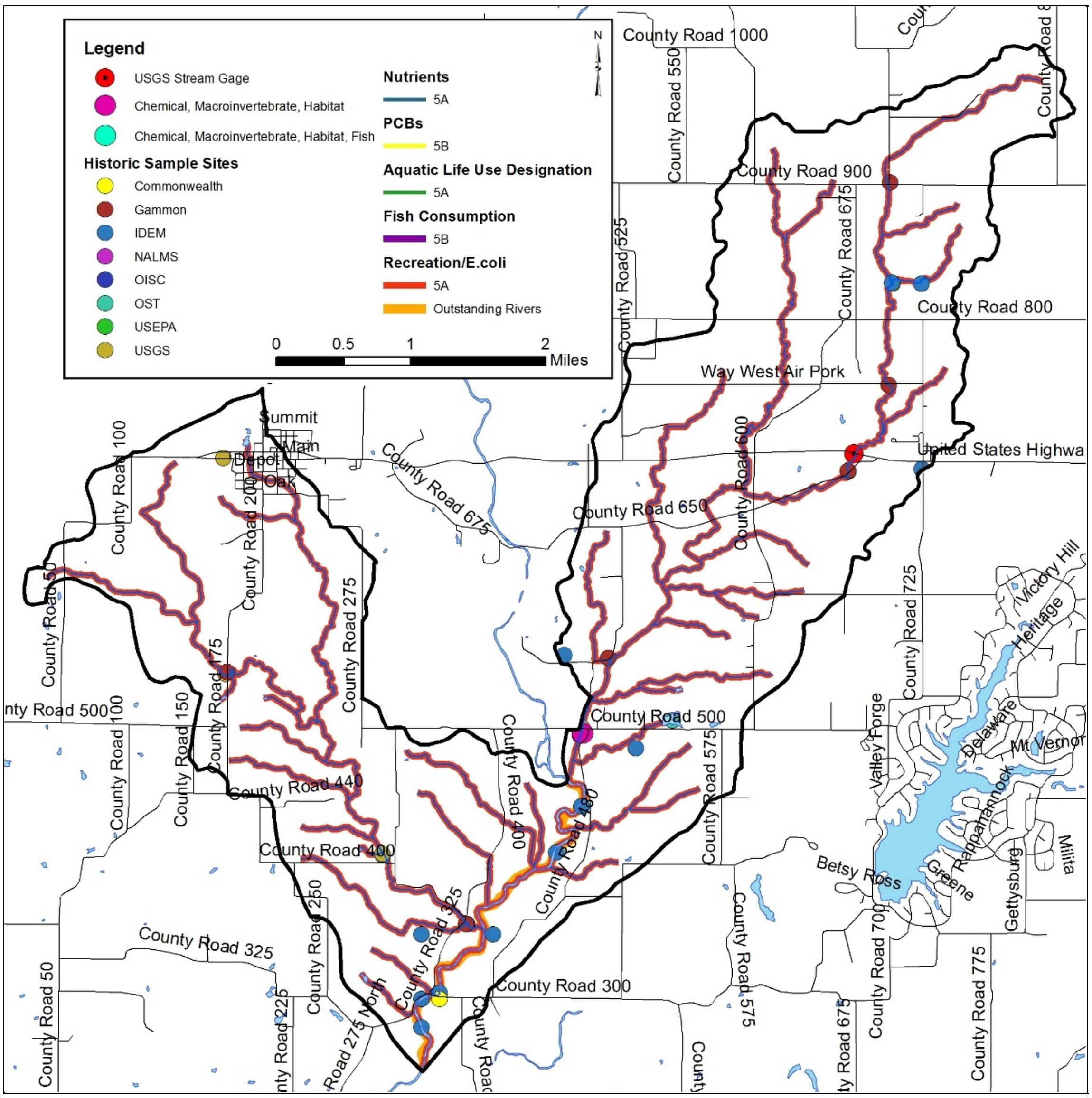

Figure 66. Locations of current and historic water quality data collection and impairments in the Bledsoe Branch-Big Walnut Creek Subwatershed.

4.7 Clear Creek Subwatershed

The Clear Creek Subwatershed forms part of the eastern boundary of the Big Walnut Creek Watershed, including the community of New Winchester and the lake community surrounding Heritage Lake, and lies within Putnam and Hendricks Counties (Figure 67). It encompasses one 12-digit HUC watershed: 051202030402. This subwatershed drains 19,900 acres, or 31.1 square miles, and accounts for 7.3% of the total watershed area. There are 81.8 miles of stream. IDEM has classified 67.1 miles of stream as impaired for *E. coli*.

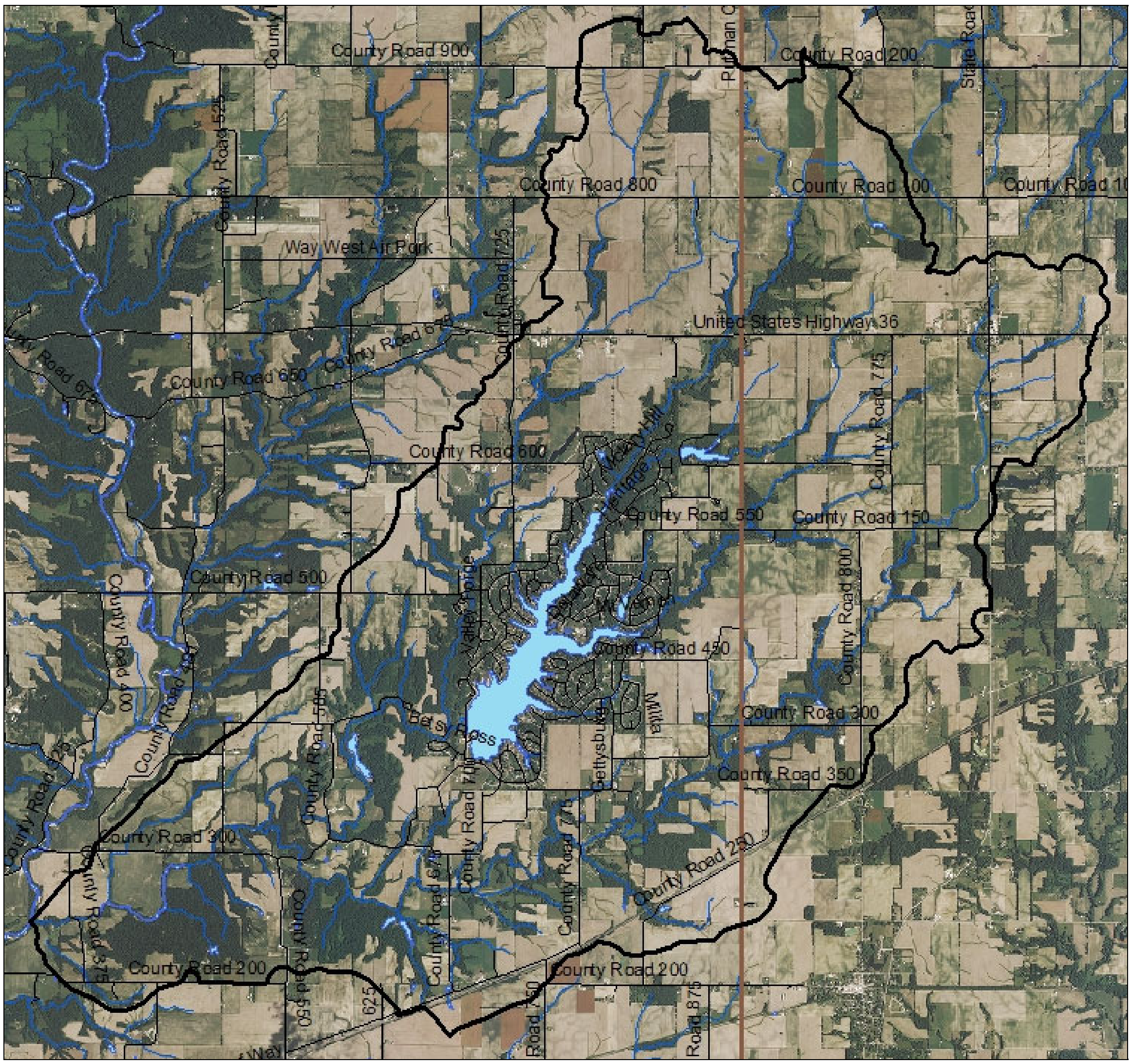

Figure 67. Clear Creek Subwatershed.

4.7.1 Soils

Soils in the Clear Creek Subwatershed are dominated by the Miami-Strawn-Hennepin complex. The Miami series are on till plains and consist of very deep, moderately well drained soils that are moderately deep to dense till with a slope ranging from 0-60%. The Strawn series formed in loamy, calcareous till and consist of very deep, well-drained soils on end moraines and dissected ground moraines with a slope ranging from 2-75%. The Hennepin series are on the upland side slopes that border stream valleys and on moraines and consist of very deep, well drained soils formed in calcareous glacial till with a slope ranging from 10-70%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 1,971 acres (9.9%) of the subwatershed, indicating that only one tenth of the subwatershed was historically wetlands. Wetlands currently cover 3.0% (587.4 acres) of the subwatershed, representing a loss of 70% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 15.3% and 24.1% of the subwatershed, respectively. Nearly the entire subwatershed (98%) has soils which are severely limited for septic use.

4.7.2 Land Use

Agricultural land use dominates the Clear Creek Subwatershed with 73.7% (14,685 acres) in agricultural land uses, including row crop and pasture and 14.4% (2,864 acres) in forested land use. Wetlands, open water, and grassland cover 644 acres, or 3.2%, of the subwatershed. The community of New Winchester and the lake community surrounding Heritage Lake lie within and the US Highway 36 corridor bisects the Clear Creek Subwatershed accounting for much of the urban land use within the subwatershed. In total, 1,722 acres or 8.6% 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 two LUST sites (Figure 68) and one NPDES-permitted facility (Clear Creek Conservancy District WWTP) in the subwatershed. There are no open dumps, brownfields, corrective action sites, voluntary remediation sites, or industrial waste facilities located within the Clear Creek Subwatershed.

4.7.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Clear Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Twenty-eight unregulated animal operations housing more than 53 cows, horses, goats, and sheep were identified during the windshield survey. Livestock have access to 1.0 miles of Clear Creek Subwatershed streams. No active confined feeding operations (CFO) are located within the Clear Creek Subwatershed. In total, manure from small animal operations total over 1,061 tons per year, which contains almost 605 pounds of nitrogen and almost 308 pounds of phosphorus. Streambank erosion and lack of buffers are a concern in the subwatershed. Approximately 1.5 miles of insufficient stream buffers and 10.1 miles of streambank erosion were identified within the subwatershed. Additionally, two logjams and one area with trash were identified in the West Fork Big Walnut Creek Subwatershed.

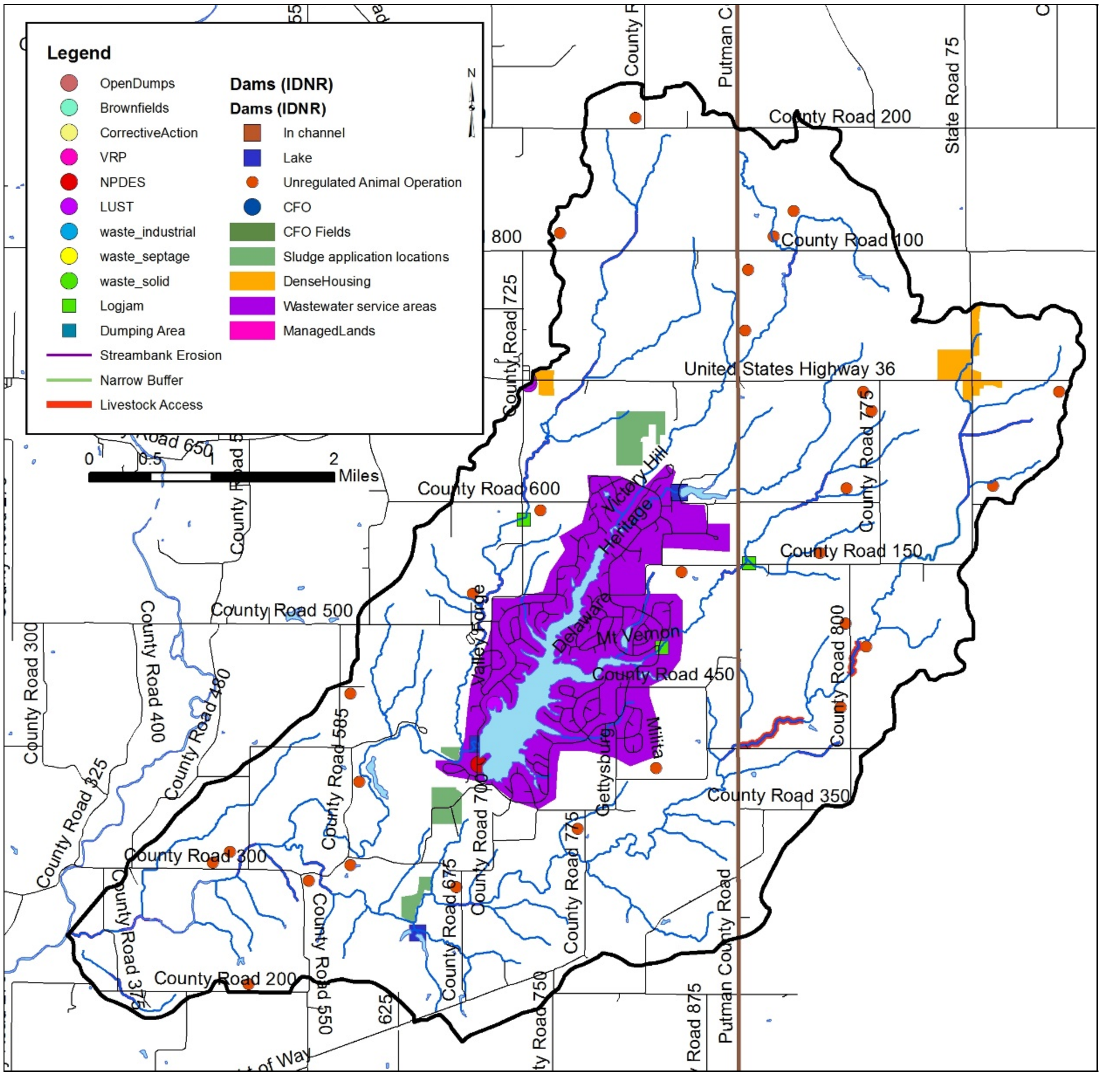

Figure 68. Point and non-point sources of pollution and suggested solutions in the Clear Creek Subwatershed.

4.7.5 Water Quality Assessment

Waterbodies within the Clear Creek Subwatershed have been sampled at 15 locations (Figure 69). Assessments include collection of water chemistry data by IDEM (3 sites), by USGS (3 site), by USEPA (1 site), by NALMS (1 site), as part of the 2008 planning project (3 sites), and as part of the current project (2 sites). Fish and macroinvertebrate communities were assessed by Gammon (5 sites) and as part of the current project (2 sites, 1 macroinvertebrates only). There are no stream gages in the Clear Creek Subwatershed.

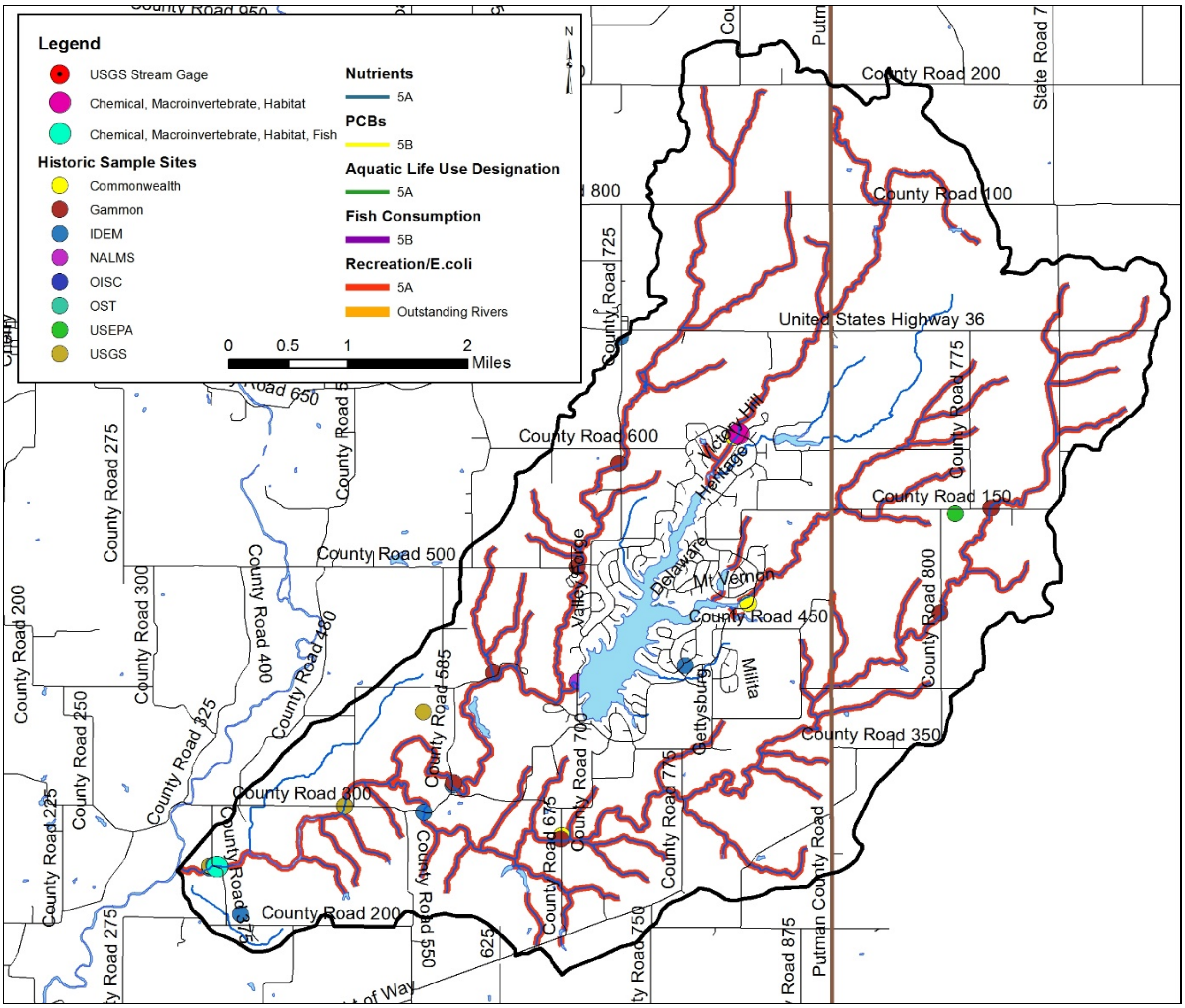

Figure 69. Locations of current and historic water quality data collection and impairments in the Clear Creek Subwatershed.

Table 33 shows the collective historic water quality data from the different sampling events described above. As shown in the table, *E. coli* exceeded state standards in 16% of samples, turbidity exceeded targets in 66% of samples, inorganic nitrogen exceeded targets in 53% of samples, phosphorus exceeded targets in 70% of samples, and total suspended solids exceeded targets in 36% of samples.

Table 32. Clear Creek Subwatershed historic water quality data summary.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	31	5	16%
pH	64	2	3%
Conductivity	40	0	0%
Turbidity	38	25	66%
Dissolved Oxygen	66	11	17%
Inorganic Nitrogen, Nitrate & Nitrite	34	18	53%
Total Phosphorus	37	26	70%
Total Suspended Solids	33	12	36%
Orthophosphate	4	4	100%

Table 33 details current water quality data collected at Site 6 (Miller Creek) from August 2018 to August 2019 and Table 34 shows current water quality data collected at Site 13 (Clear Creek) from August 2018 to August 2019. As shown in Table 33, orthophosphorus exceeded water quality targets in 88% of samples, nitrate exceeded water quality targets in 78% of samples, *E. coli* exceeded state standards in 8% of samples, total phosphorus exceeded targets in 11% of samples, and total suspended solids exceeded targets in 38% of samples. As shown in Table 34 , orthophosphorus exceeded water quality targets in 100% of samples, nitrate exceeded water quality targets in 63% of samples, *E. coli* exceeded state standards in 73% of samples, total phosphorus exceeded targets in 25% of samples, and total suspended solids exceeded targets in 14% of samples. During the current assessment, both the macroinvertebrate and fish communities rated poorer than water quality targets scoring 36 and 38 in Miller Creek and Clear Creek, respectively for the mIBI and 42 and 44 for the IBI in Miller Creek and Clear Creek, respectively.

Table 33. Water quality data collected in the Clear Creek Subwatershed (Miller Creek), August 2018 to August 2019.

Site		Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
6	Min	0.6	0.02	0.02	2	1
	Median	3	0.06	0.05	7	22
	Max	4.6	0.17	0.17	163	3900
	Count	9	9	8	8	12
	Exceed	7	1	7	3	1
	% Exceed	78%	11%	88%	38%	8%

Table 34. Water quality data collected in the Clear Creek Subwatershed (Clear Creek), August 2018 to August 2019.

Site		Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
13	Min	0.45	0.04	0.06	0	107
	Median	2.2	0.06	0.115	2	418
	Max	3.3	0.16	0.17	75	1575
	Count	8	8	8	7	11
	Exceed	5	2	8	1	8
	% Exceed	63%	25%	100%	14%	73%

4.8 <u>Owl Creek Subwatershed</u>

The Owl Creek Subwatershed forms part of the western boundary of the Big Walnut Creek Watershed, including the communities surrounding Glenn Flint Lake and Van Bibber Lake and lies completely within Putnam County (Figure 70). It encompasses one 12-digit HUC watershed: 051202030201. This subwatershed drains 10,345 acres, or 16.2 square miles, and accounts for 3.8% of the total watershed area. There are 46.1 miles of stream. IDEM has classified 29.7 miles of stream as impaired for *E. coli*.

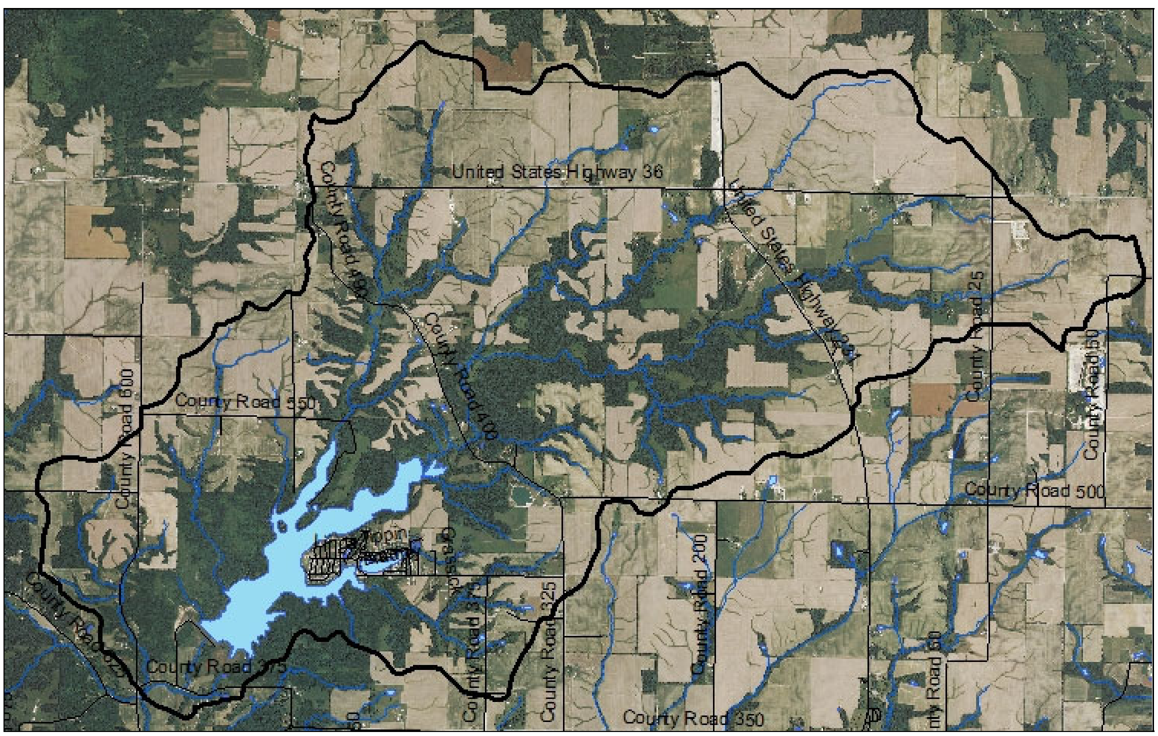

Figure 70. Owl Creek Subwatershed.

4.8.1 Soils

Soils in the Owl Creek Subwatershed are dominated by the Miami-Miamian-Xenia complex. The Miami series are on till plains and consist of very deep, moderately well drained soils that are moderately deep to dense till with a slope ranging from 0-60%. The Miamian series are on till plains and moraines and consist of very deep, well drained soils that are moderately deep to dense till with a slope ranging from 0-50%. The Xenia series are on till plains and consist of very deep, moderately well drained soils that are deep or very deep to dense till with a slope of 0-12%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 316.7 acres (3.1%) of the subwatershed, indicating that very little of the subwatershed was historically wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 21.5% and 43.2% of the subwatershed, respectively. Nearly the entire subwatershed (96%) has soils which are severely limited for septic use.

4.8.2 Land Use

Agricultural and forested land uses dominate the Owl Creek Subwatershed with 69.5% (7,191 acres) in agricultural land uses, including row crop and pasture and 20.1% (2,082 acres) in forested land use. Wetlands, open water, and grassland cover 498 acres, or 4.8%, of the subwatershed. The communities surrounding Glenn Flint Lake and Van Bibber Lake lie within and the U.S. Highway 36 and U.S. Highway 231 corridors bisect the Owl Creek Subwatershed accounting for much of the urban land use within the subwatershed. In total, 582 acres or 5.6% of the subwatershed are in urban land uses.

4.8.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There is one open dump and two NPDES permitted locations, one of which is the Van Bibber Water Treatment Facility (Figure 50). No brownfields, corrective action sites, voluntary remediation sites, or industrial waste facilities are located within the Owl Creek Subwatershed.

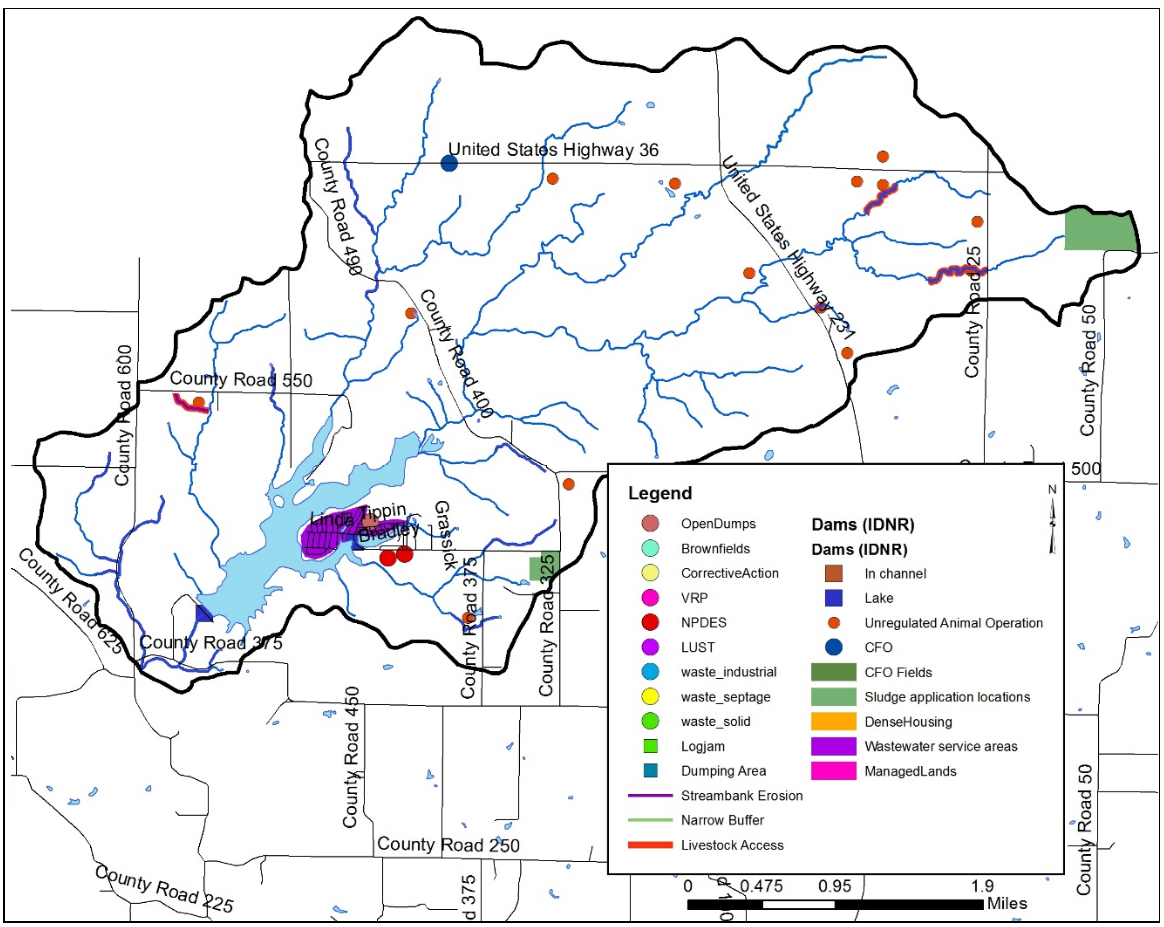

Figure 71. Point and non-point sources of pollution and suggested solutions in the Owl Creek Subwatershed.

4.8.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Owl Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Fourteen unregulated animal operations housing more than 184 cows, horses, goats, buffalo, and sheep were identified during the windshield survey. Livestock have access to 1.2 miles of Owl Creek Subwatershed streams. No active confined feeding operations (CFO) are located within the Owl Creek Subwatershed. In total, manure from small animal operations total over 3,382 tons per year, which contains almost 1,783 pounds of nitrogen and almost 894 pounds of phosphorus. Streambank erosion and lack of buffers are a concern in the subwatershed. Approximately 1.4 miles of insufficient stream buffers and 7.1 miles of streambank erosion were identified within the subwatershed.

4.8.5 Water Quality Assessment

Waterbodies within the Owl Creek subwatershed have been sampled at 11 locations (Figure 72). Assessments include collection of water chemistry data by IDEM (4 sites), by USGS (1 site), and as part of the 2008 planning project (1 site). Fish and macroinvertebrate communities were assessed by Gammon (6 sites), DNR (6 sites), and as part of the 2008 planning project (1 site). Additionally, the DNR assessed the fish community within Glenn Flint Lake. No stream gages are in the Owl Creek subwatershed.

Table 35 shows the collective historic water quality data from the different sampling events described above. As shown in the table, *E. coli* exceeded state standards in 20% of samples, turbidity exceeded water quality targets in 57% of samples, inorganic nitrogen exceeded targets in 53% of samples, phosphorus exceeded targets in 60% of samples, and total suspended solids exceeded targets in 43% of samples.

Table 35. Owl Creek Subwatershed historic water quality data summary.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	10	2	20%
pH	25	0	0%
Conductivity	19	2	11%
Turbidity	14	8	57%
Dissolved Oxygen	22	9	41%
Inorganic Nitrogen, Nitrate & Nitrite	17	9	53%
Total Phosphorus	10	6	60%
Total Suspended Solids	7	3	43%
Orthophosphate	6	3	50%

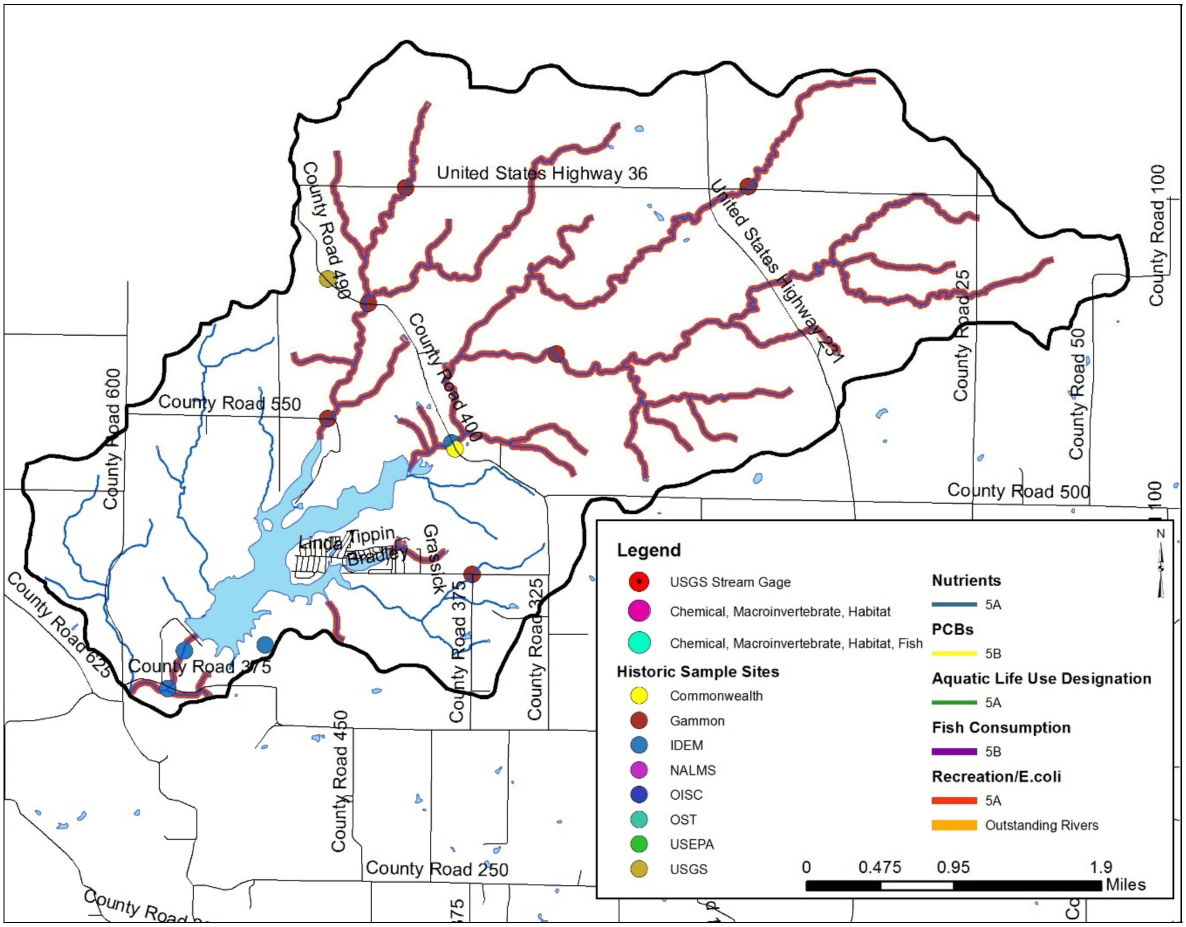

Figure 72. Locations of current and historic water quality data collection and impairments in the Owl Creek Subwatershed.

4.9 Headwaters Little Walnut Creek Subwatershed

The Headwaters Little Walnut Creek Subwatershed forms part of the southwestern boundary of the Big Walnut Creek Watershed, including the community of Brick Chapel, and lies completely within Putnam County (Figure 73). It encompasses one 12-digit HUC watershed: 051202030202. This subwatershed drains 16,506 acres, or 25.8 square miles, and accounts for 6.1% of the total watershed area. There are 76.0 miles of stream. IDEM has classified 63.4 miles of stream as impaired for *E. coli*.

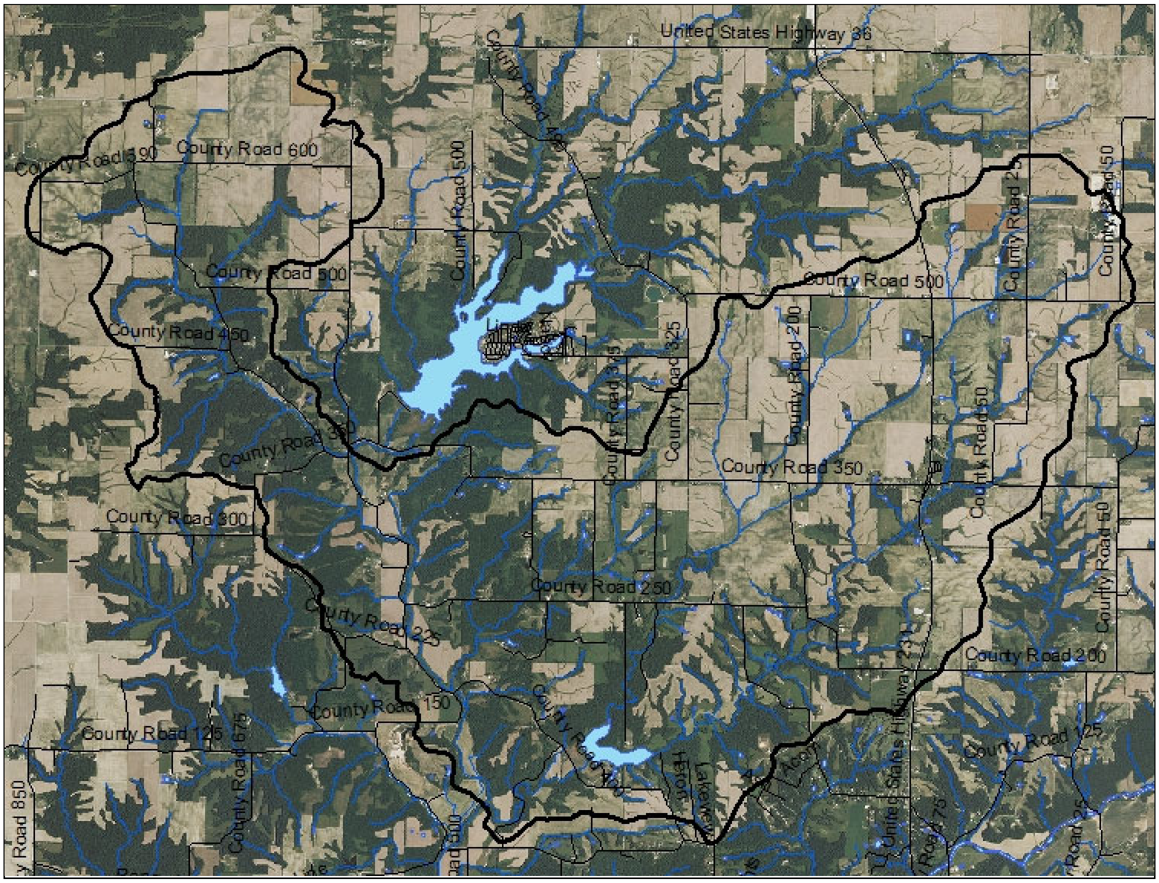

Figure 73. Headwaters Little Walnut Creek Subwatershed.

4.9.1 Soils

Soils in the Headwaters Little Walnut Creek subwatershed are dominated by the Miami-Miamian-Xenia complex. The Miami series are on till plains and consist of very deep, moderately well drained soils that are moderately deep to dense till with a slope ranging from 0-60%. The Miamian series are on till plains and moraines and consist of very deep, well drained soils that are moderately deep to dense till with a slope ranging from 0-50%. The Xenia series are on till plains and consist of very deep, moderately well drained soils that are deep or very deep to dense till with a slope of 0-12%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 801 acres (4.9%) of the subwatershed, indicating that only a small portion of the subwatershed was historically wetlands. Wetlands currently cover 1.4% (234.2 acres) of the subwatershed, representing a loss of 71% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 23.2% and 39.6% of the subwatershed, respectively. Nearly the entire subwatershed (99%) has soils which are severely limited for septic use.

4.9.2 Land Use

Agricultural and forested land uses co-dominate the Headwaters Little Walnut Creek Subwatershed with 71.1% (11,750 acres) in agricultural land uses, including row crop and pasture and 23.0% (3,801 acres) in forested land use. Wetlands, open water, and grassland cover 239 acres, or 1.4%, of the subwatershed. The community of Brick Chapel lies within and the U.S. Highway 231 corridor bisects the Headwaters Little Walnut Creek Subwatershed accounting for much of the urban land use within the subwatershed. In total, 728 acres or 4.4% of the subwatershed are in urban land uses.

4.9.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are no open dumps, brownfields, corrective action sites, voluntary remediation sites, LUST, NPDES permitted locations, or industrial waste facilities located within the Headwaters Little Walnut Creek Subwatershed (Figure 74).

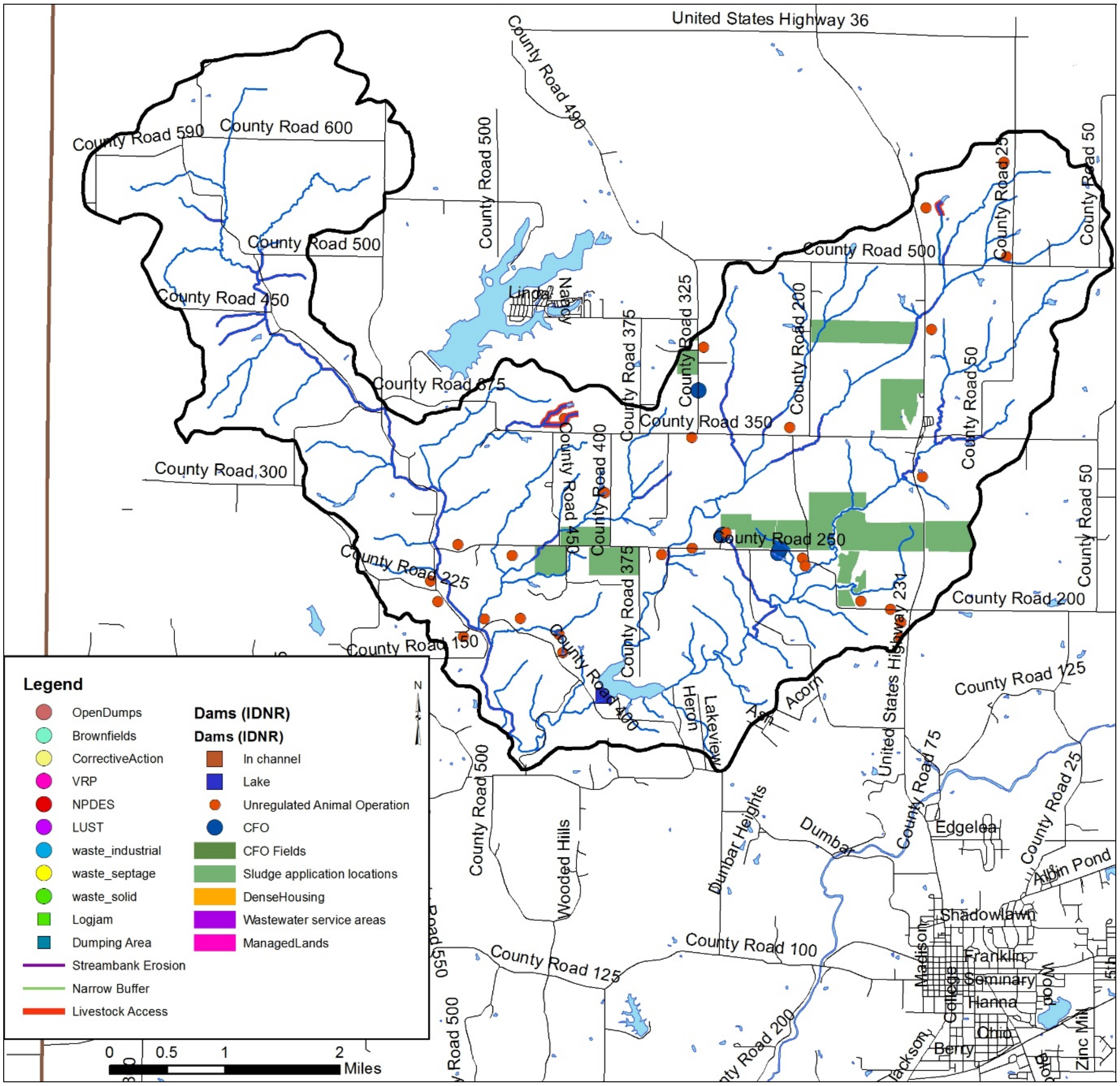

Figure 74. Point and non-point sources of pollution and suggested solutions in the Headwaters Little Walnut Creek Subwatershed.

4.9.4 Non-Point Source Water Quality Issues

Agricultural land uses are the predominant land use in the Headwaters Little Walnut Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Twenty-eight unregulated animal operations housing more than 272 cows, horses, goats, hogs, alpaca, and sheep were identified during the windshield survey. Livestock have access to 0.8 miles of Headwaters Little Walnut Creek Subwatershed streams. No active confined feeding operations (CFO) are located within the Headwaters Little Walnut Creek Subwatershed. In total, manure from small animal operations total over 4,273 tons per year, which contains almost 3,489 pounds of nitrogen and almost 1,804 pounds of phosphorus. Streambank erosion and lack of buffers are a concern in the subwatershed. Approximately 1.4 miles of insufficient stream buffers and 15.2 miles of streambank erosion were identified within the subwatershed.

4.9.5 Water Quality Assessment

Waterbodies within the Headwaters Little Walnut Creek Subwatershed have been sampled at 10 locations (Figure 75). Assessments include collection of water chemistry data by IDEM (5 sites), as part of the 2008 planning project (2 sites), and as part of the current project (1 site). Fish and macroinvertebrate communities were assessed by Gammon (3 sites), as part of the 2008 planning project (2 sites), and during the current project (1 site). No stream gages are in the Headwaters Little Walnut Creek Subwatershed.

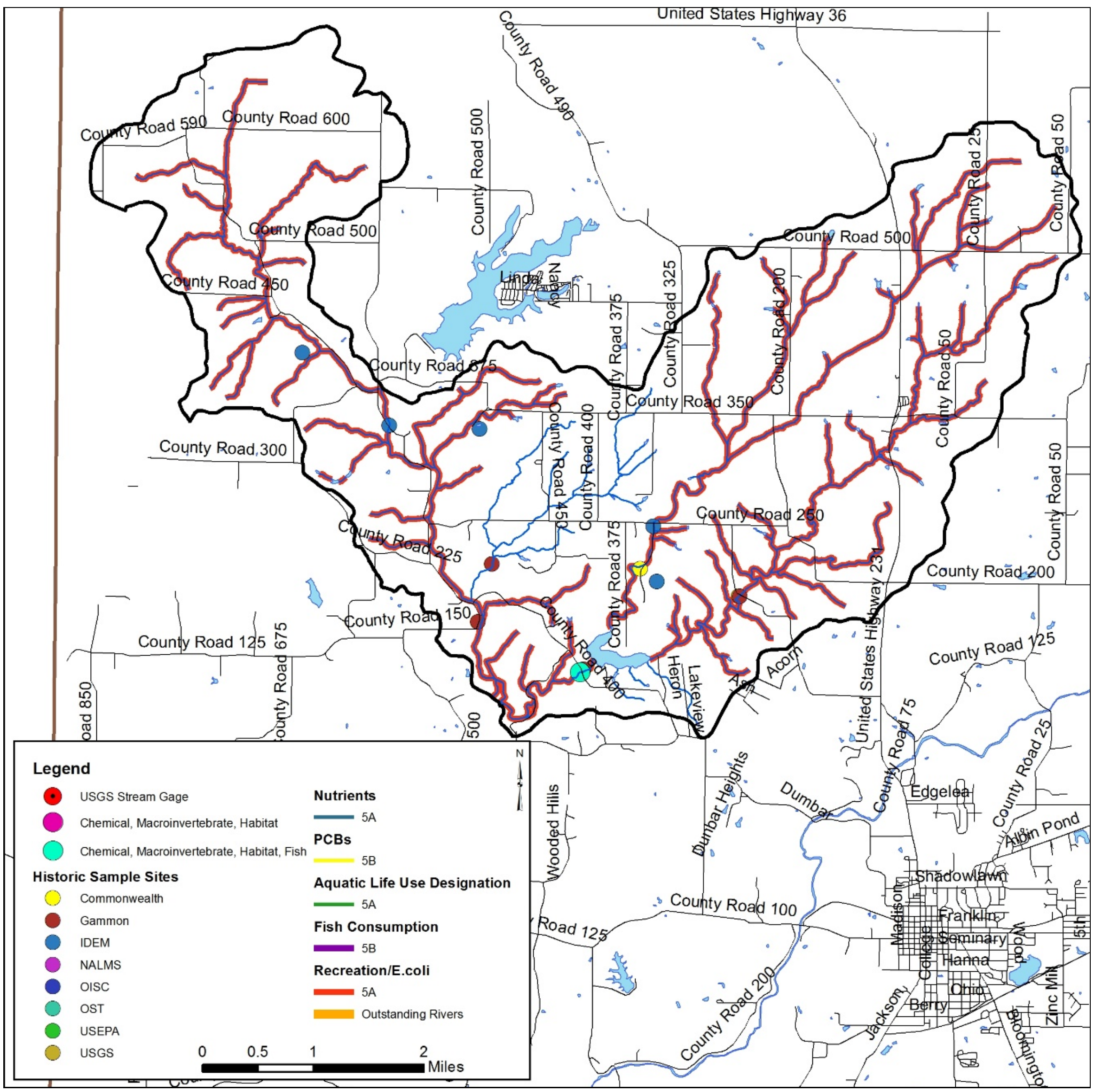

Figure 75. Locations of current and historic water quality data collection and impairments in the Headwaters Little Walnut Creek Subwatershed.

Table 36 shows the collective historic water quality data from the different sampling events described above. As shown in the table, *E. coli* exceeded state standards in 18% of samples, turbidity exceeded water quality targets in 100% of samples, inorganic nitrogen exceeded targets in 58% of samples, phosphorus exceeded targets in 85% of samples, and total suspended solids exceeded targets in 23% of samples.

Table 36. Headwaters Little Walnut Creek Subwatershed historic water quality data summary.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	11	2	18%
pH	25	0	0%
Conductivity	13	0	0%
Turbidity	11	11	100%
Dissolved Oxygen	25	15	60%
Inorganic Nitrogen, Nitrate & Nitrite	12	7	58%
Total Phosphorus	13	11	85%
Total Suspended Solids	13	3	23%
Orthophosphate	--	--	NA

Table 37 details current water quality data collected at Site 7 (Jones Creek) from August 2018 to August 2019. As shown in the table, orthophosphorus exceeded water quality targets in 100% of samples, nitrate exceeded water quality targets in 71% of samples, *E. coli* exceeded state standards in 22% of samples, total phosphorus exceeded targets in 57% of samples, and total suspended solids exceeded targets in 14% of samples. During the current assessment, both the macroinvertebrate and fish community rated poorer than water quality targets scoring 36 for the mIBI and 44 for the IBI.

Table 37. Water quality data collected in the Headwaters Little Walnut Creek Subwatershed, August 2018 to August 2019.

Site		Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
7	Min	0.3	0.04	0.04	1	21
	Median	1.6	0.09	0.08	3	126
	Max	2.7	0.61	0.59	314	1520
	Count	7	7	7	7	9
	Exceed	5	4	7	1	2
	% Exceed	71%	57%	100%	14%	22%

4.10 Leatherman Creek-Little Walnut Creek Subwatershed

The Leatherman Creek-Little Walnut Creek Subwatershed forms part of the southwestern boundary of the Big Walnut Creek Watershed and lies within Putnam and Parke Counties (Figure 76). It encompasses one 12-digit HUC watershed: 051202030203. This subwatershed drains 14,279 acres, or 22.3 square miles, and accounts for 5.3% of the total watershed area. There are 68.0 miles of stream. IDEM has classified 42.3 miles of stream as impaired for *E. coli*.

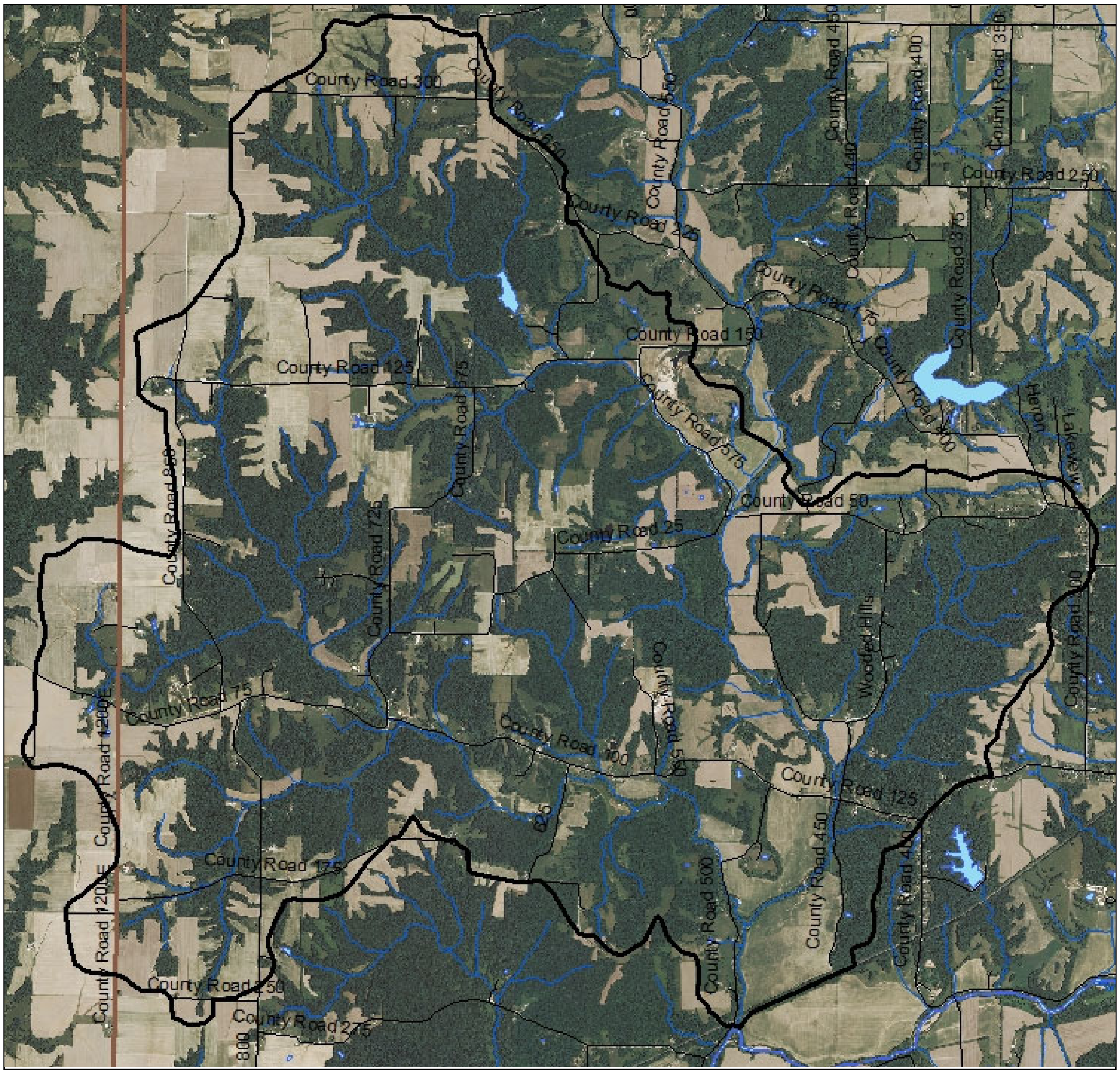

Figure 76. Leatherman Creek-Little Walnut Creek Subwatershed.

4.10.1 Soils

Soils in the Leatherman Creek-Little Walnut Creek Subwatershed are dominated by the Hickory-Cincinnati-Berks complex. The Hickory series are formed in till that can be capped with up to 20 inches of loess and consist of very deep, well-drained soils on dissected till plains with a slope ranging from 5-70%. The Cincinnati series are on till plains and consist of very deep, well-drained soils that are moderately deep to a fragipan with a slope ranging from 1-18%. The Berks series are on dissected uplands and consist of moderately deep, well drained soils formed in residuum weathered from shale, siltstone, and fine-grained sandstone with a slope ranging from 0-80%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 316.8 acres (2.2%) of the subwatershed, indicating that only a small portion of the subwatershed was historically wetlands. Wetlands currently cover 1.0% (143.4 acres) of the subwatershed, representing a loss of 55% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 35.2% and 25.4% of the subwatershed, respectively. Nearly the entire subwatershed (94%) has soils which are severely limited for septic use.

4.10.2 Land Use

Agricultural and forested land uses co-dominate the Leatherman Creek-Little Walnut Creek Subwatershed with 41.2% (5,888 acres) in agricultural land uses, including row crop and pasture and 54.6% (7,800 acres) in forested land use. Wetlands, open water, and grassland cover 69 acres, or 0.5%, of the subwatershed. No significant community or major road corridors bisect the Leatherman Creek - Little Walnut Creek Subwatershed. Primarily county level roads account for much of the urban land use within the subwatershed. In total, 533 acres or 3.7% of the subwatershed are in urban land uses.

4.10.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are no open dumps, brownfields, corrective action sites, voluntary remediation sites, LUST, NPDES permitted locations, or industrial waste facilities located within the Leatherman Creek-Little Walnut Creek Subwatershed (Figure 77).

4.10.4 Non-Point Source Water Quality Issues

Agricultural land uses are a significant land use in the Leatherman Creek-Little Walnut Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Twenty-one unregulated animal operations housing more than 273 cows, horses, goats, and hogs were identified during the windshield survey. Livestock have access to 0.3 miles of Leatherman Creek - Little Walnut Creek Subwatershed streams. No active confined feeding operations (CFO) are located within the Leatherman Creek - Little Walnut Creek Subwatershed. In total, manure from small animal operations total over 4,524 tons per year, which contains almost 3,103 pounds of nitrogen and almost 1,789 pounds of phosphorus. Streambank erosion is a concern in the subwatershed. Approximately 12.3 miles of streambank erosion were identified within the subwatershed.

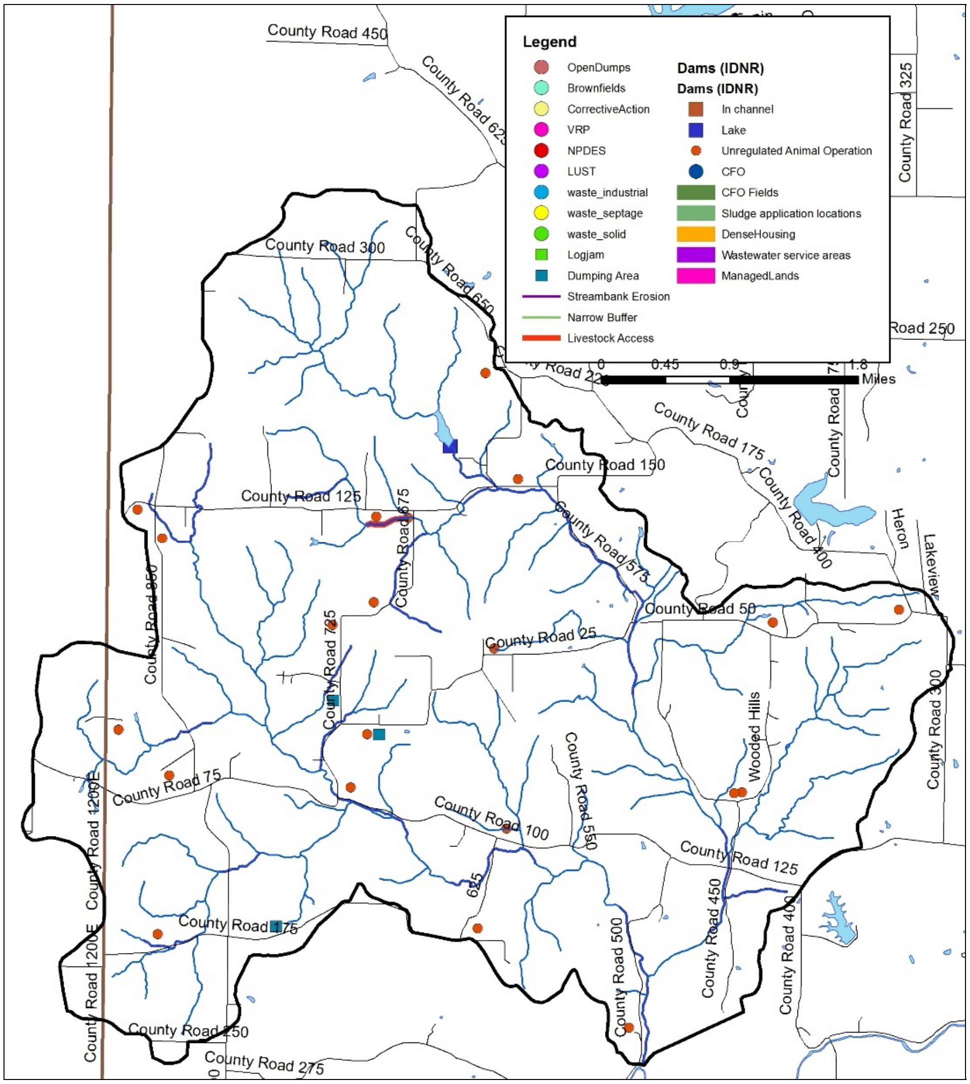

Figure 77. Point and non-point sources of pollution and suggested solutions in the Leatherman Creek-Little Walnut Creek Subwatershed.

4.10.5 Water Quality Assessment

Waterbodies within the Leatherman Creek-Little Walnut Creek Subwatershed have been sampled at 12 locations (Figure 78). Assessments include collection of water chemistry data by IDEM (1 site), by USGS (2 sites) as part of the 2008 planning project (4 sites), and during the current project (1 site). Fish and macroinvertebrate communities were assessed by Gammon (6 sites), as part of the 2008 planning project (3 sites), and during the current assessment (1 site). No stream gages are in the Leatherman Creek - Little Walnut Creek Subwatershed.

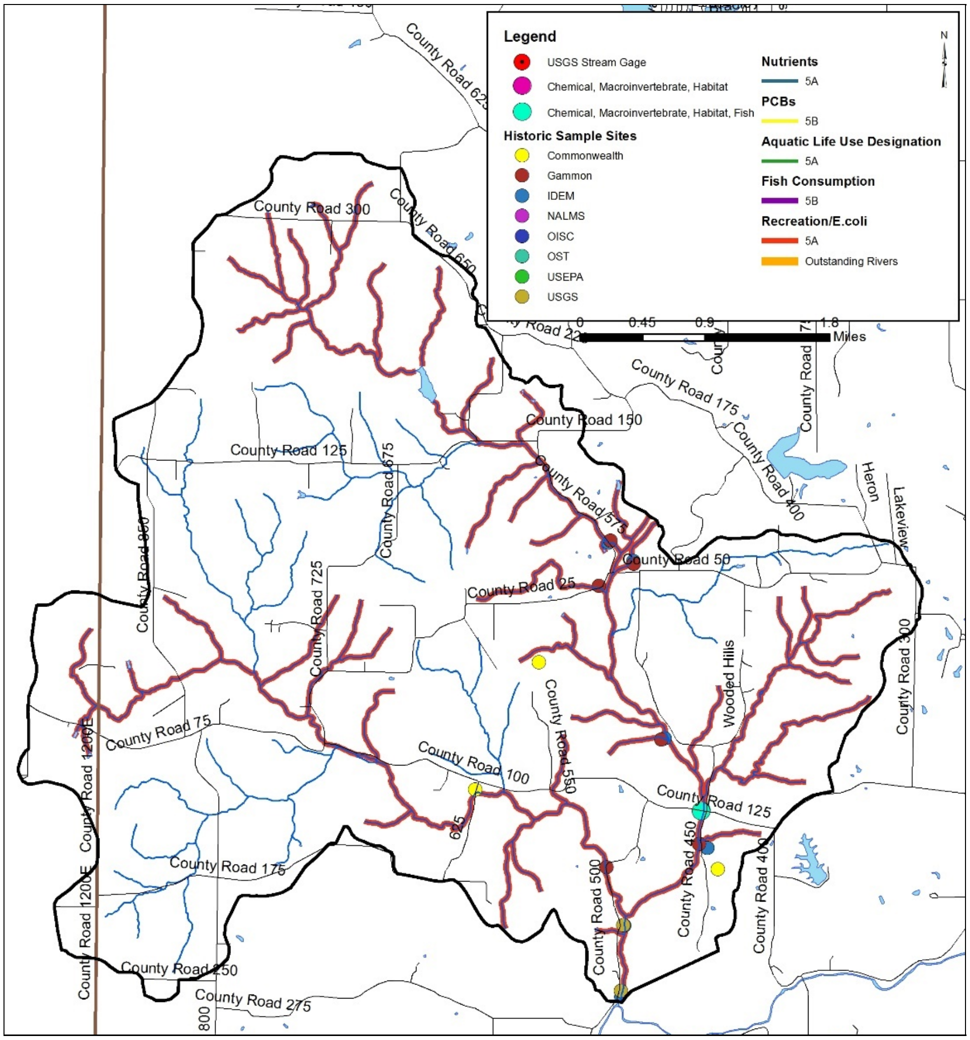

Figure 78. Locations of current and historic water quality data collection and impairments in the Leatherman Creek-Little Walnut Creek Subwatershed.

Error! Reference source not found.shows the collective historic water quality data from the different s ampling events described above. As shown in the table, *E. coli* exceeded state standards in 56% of samples, turbidity exceeded water quality targets in 85% of samples, inorganic nitrogen exceeded targets in 31% of samples, phosphorus exceeded targets in 58% of samples, and total suspended solids exceeded targets in 23% of samples.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	32	18	56%
pH	72	2	3%
Conductivity	52	0	0%
Turbidity	47	40	85%
Dissolved Oxygen	73	12	16%
Inorganic Nitrogen, Nitrate & Nitrite	26	8	31%
Total Phosphorus	33	19	58%
Total Suspended Solids	30	7	23%

Orthophosphate	--	--	NA

Table 38 details current water quality data collected at Site 8 (Little Walnut Creek) from August 2018 to August 2019. As shown in the table, orthophosphorus exceeded water quality targets in 88% of samples, nitrate exceeded water quality targets in 44% of samples, *E. coli* exceeded state in 69% of samples, total phosphorus exceeded targets in 33% of samples, and total suspended solids exceeded targets in 50% of samples. During the current assessment, both the macroinvertebrate and fish community rated poorer than water quality targets scoring 44 for the mIBI and 42 for the IBI.

Table 38. Water quality data collected in the Leatherman Creek-Little Walnut Creek Subwatershed, August 2018 to August 2019.

Site		Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
8	Min	0.2	0.02	0.02	1	1
	Median	0.85	0.08	0.05	12	263
	Max	2.6	0.2	0.08	137	2200
	Count	9	9	8	8	13
	Exceed	4	3	7	4	9
	% Exceed	44%	33%	88%	50%	69%

4.11 Dry Branch-Big Walnut Creek Subwatershed

The Dry Branch-Big Walnut Creek Subwatershed forms part of interior of the Big Walnut Creek Watershed, including the community of Greencastle, and lies completely within Putnam County (Figure 79). It encompasses one 12-digit HUC watershed: 051202030404. This subwatershed drains 22,313 acres, or 34.9 square miles, and accounts for 8.2% of the total watershed area. There are 110.2 miles of stream. IDEM has classified 77.3 miles of stream as impaired for *E. coli*.

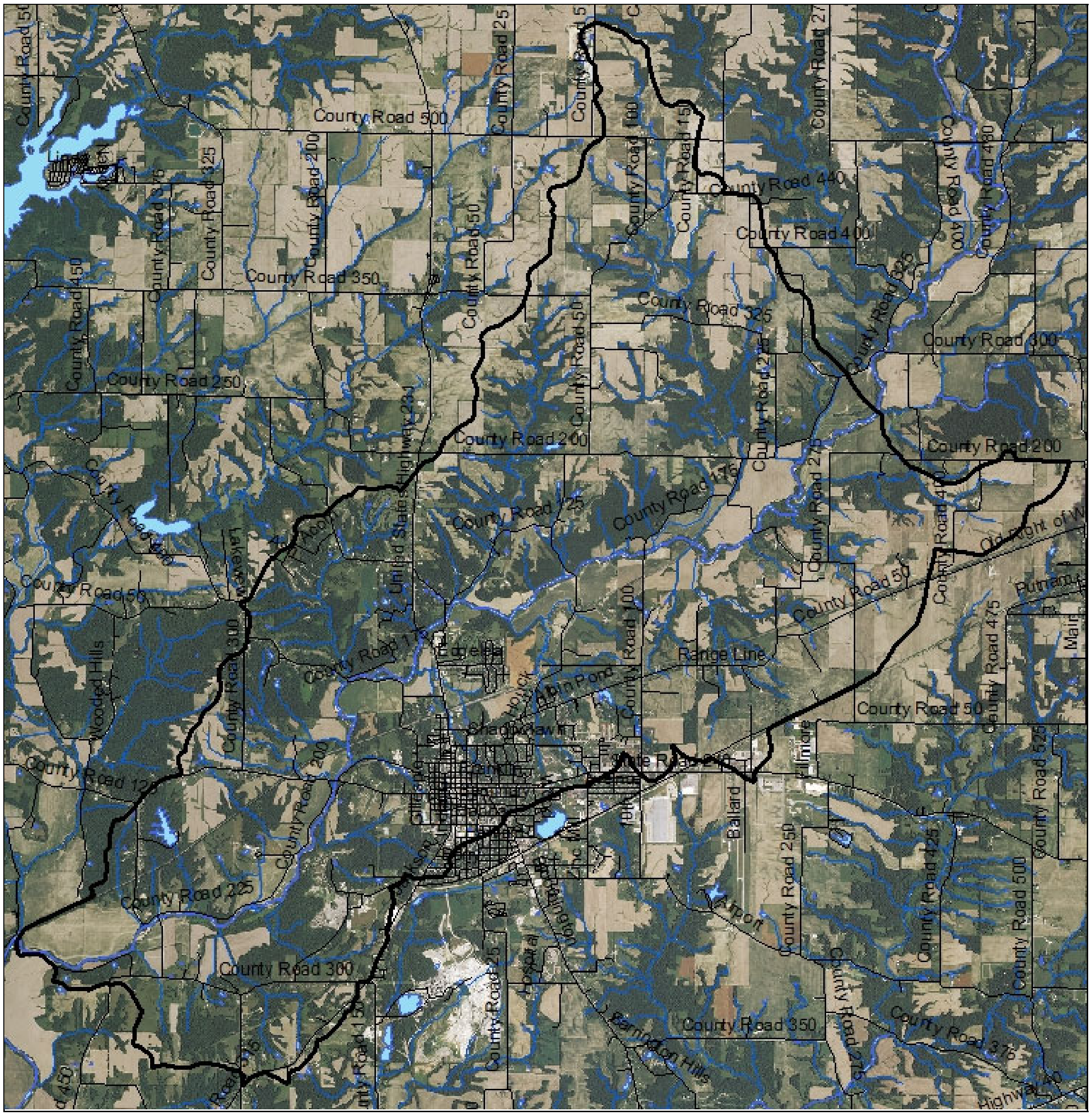

Figure 79. Dry Branch-Big Walnut Creek Subwatershed.

4.11.1 Soils

Soils in the Dry Branch-Big Walnut Creek Subwatershed are dominated by the Miami-Strawn-Hennepin complex. The Miami series are on till plains and consist of very deep, moderately well drained soils that are moderately deep to dense till with a slope ranging from 0-60%. The Strawn series formed in loamy, calcareous till and consist of very deep, well drained soils on end moraines and dissected ground moraines with a slope ranging from 2-75%. The Hennepin series are on the upland side slopes that border stream valleys and on moraines and consist of very deep, well drained soils formed in calcareous glacial till with a slope ranging from 10-70%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 251 acres (1.1%) of the subwatershed, indicating that only a small portion of the subwatershed was historically wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 23.4% and 42.5% of the subwatershed, respectively. Nearly the entire subwatershed (95%) has soils which are severely limited for septic use.

4.11.2 Land Use
Agricultural land use dominates the Dry Branch - Big Walnut Creek Subwatershed with 58.0% (12,951 acres) in agricultural land uses, including row crop and pasture and 30.1% (6,719 acres) in forested land use. Wetlands, open water, and grassland cover 296 acres, or 1.3%, of the subwatershed. The community of Greencastle lies within and the U.S. Highway 231 and State Road 240 corridors bisect the Dry Branch - Big Walnut Creek Subwatershed accounting for much of the urban land use within the subwatershed. In total, 2,365 acres or 10.6% of the subwatershed are in urban land uses.

4.11.3 Point Source Water Quality Issues
There are multiple point sources of water pollution in the subwatershed. There are twenty-three LUST sites located primarily in the Greencastle area (Figure 80). Additionally, there is one open dump location, along with two brownfields, one corrective action site, three NPDES permitted locations, three industrial waste facilities, and one waste septage site. There are no voluntary remediation sites located within the Dry Branch - Big Walnut Creek Subwatershed.

4.11.4 Non-Point Source Water Quality Issues
Agricultural and forested land uses co-dominate the Dry Branch - Big Walnut Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Twenty-seven unregulated animal operations housing more than 302 cows, horses, goats, hogs, and sheep were identified during the windshield survey. Livestock have access to 0.5 miles of Dry Branch - Big Walnut Creek Subwatershed streams. Three active confined feeding operations (CFO) are located within the Dry Branch - Big Walnut Creek Subwatershed. In total, manure from small animal operations total over 25,289 tons per year, which contains almost 61,553 pounds of nitrogen and almost 45,044 pounds of phosphorus. Streambank erosion is a concern in the subwatershed. Approximately 14.5 miles of streambank erosion were identified within the subwatershed.

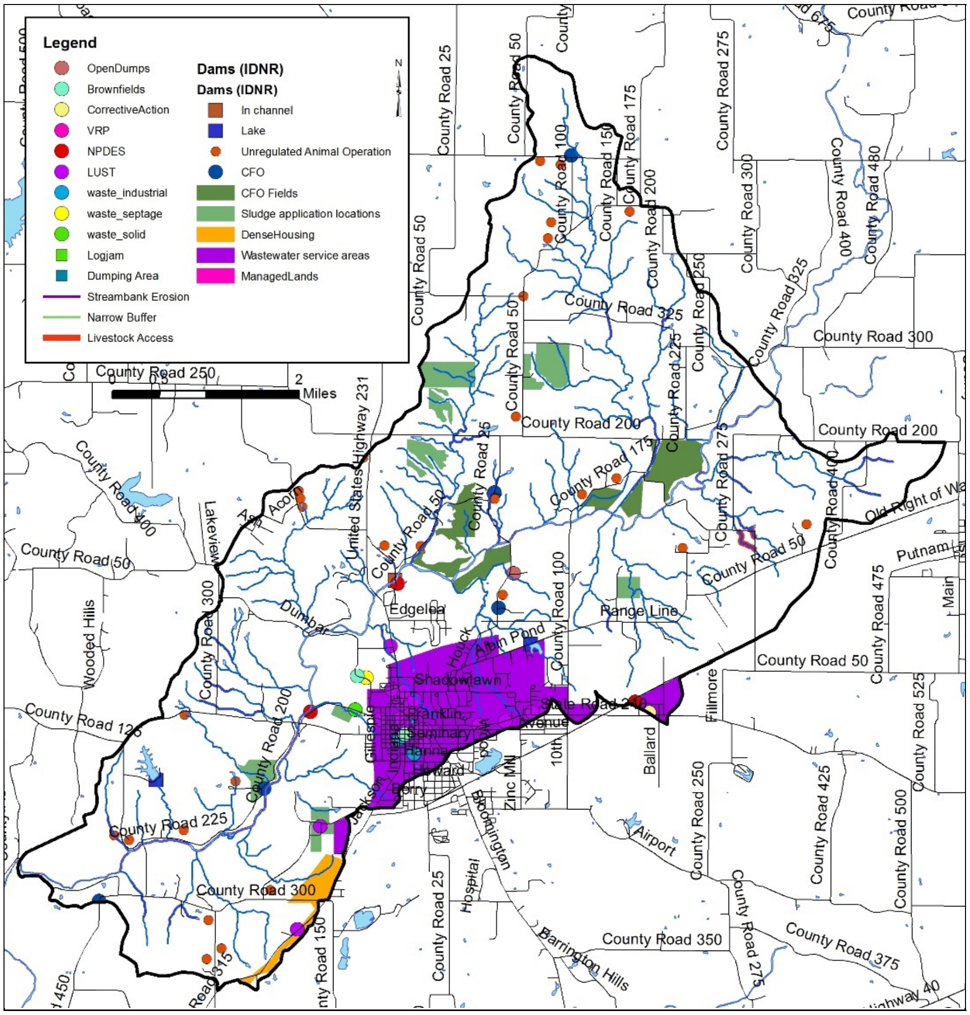

Figure 80. Point and non-point sources of pollution and suggested solutions in the Dry Branch-Big Walnut Creek Subwatershed.

4.11.5 Water Quality Assessment

Waterbodies within the Dry Branch-Big Walnut Creek subwatershed have been sampled at 13 locations (Figure 81). Assessments include collection of water chemistry data by IDEM (3 sites), USGS (5 sites), and as part of the 2008 planning project (1 site). Fish and macroinvertebrate communities were assessed by Gammon (5 sites) and as part of the 2008 planning project (1 site). No stream gages are in the Dry Branch-Big Walnut Creek Subwatershed.

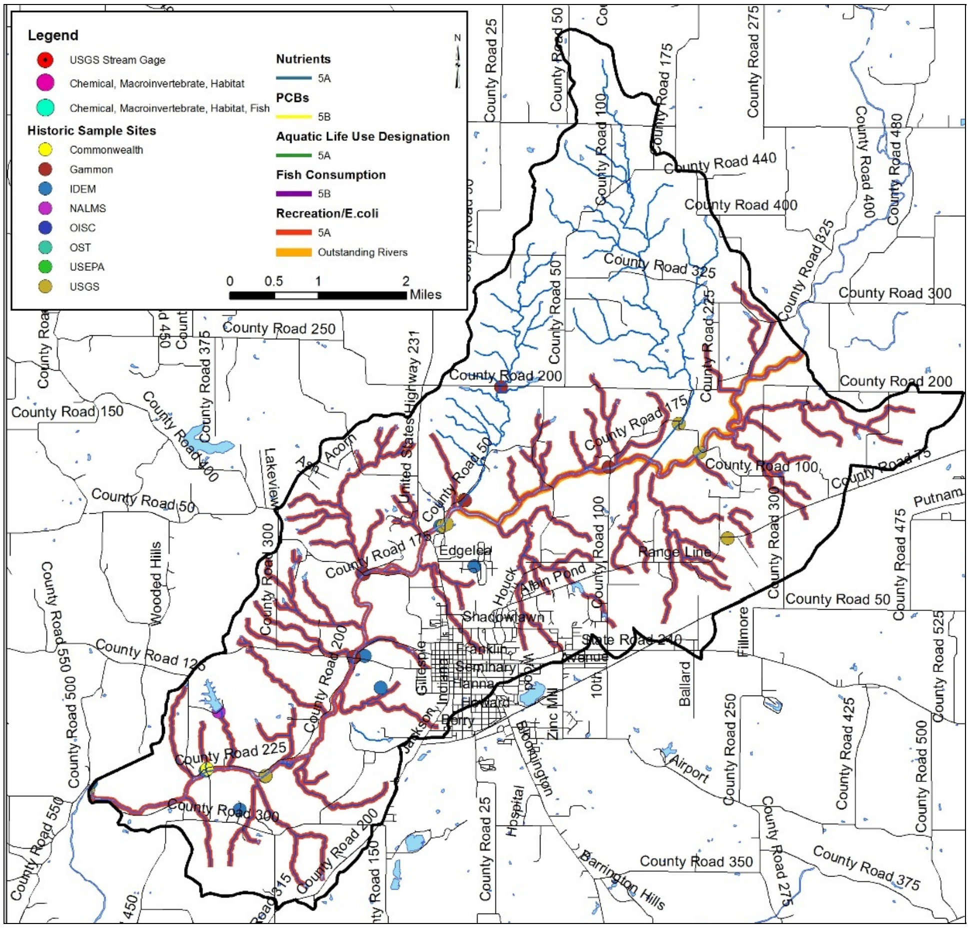

Figure 81. Locations of current and historic water quality data collection and impairments in the Dry Branch-Big Walnut Creek Subwatershed.

Table 39 shows the collective historic water quality data from the different sampling events described above. As shown in the table, *E. coli* exceeded state standards in 31% of samples, turbidity exceeded water quality targets in 83% of samples, inorganic nitrogen exceeded targets in 55% of samples, phosphorus exceeded targets in 90% of samples, and total suspended solids exceeded targets in 47% of samples.

Table 39. Dry Branch-Big Walnut Creek Subwatershed historic water quality data summary.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	26	8	31%
pH	51	0	0%
Conductivity	45	0	0%
Turbidity	35	29	83%
Dissolved Oxygen	54	10	19%
Inorganic Nitrogen, Nitrate & Nitrite	20	11	55%
Total Phosphorus	21	19	90%
Total Suspended Solids	17	8	47%
Orthophosphate	4	2	50%

4.12 Headwaters Deer Creek Subwatershed

The Headwaters Deer Creek Subwatershed forms part of the southeastern boundary of the Big Walnut Creek Watershed, including the community of Mt Meridian, and lies within Putnam and Hendricks Counties (Figure 82). It encompasses one 12-digit HUC watershed: 051202030301. This subwatershed drains 19,373 acres, or 30.3 square miles, and accounts for 7.2% of the total watershed area. There are 73.2 miles of stream. IDEM has classified 0.0 miles of streams as impaired.

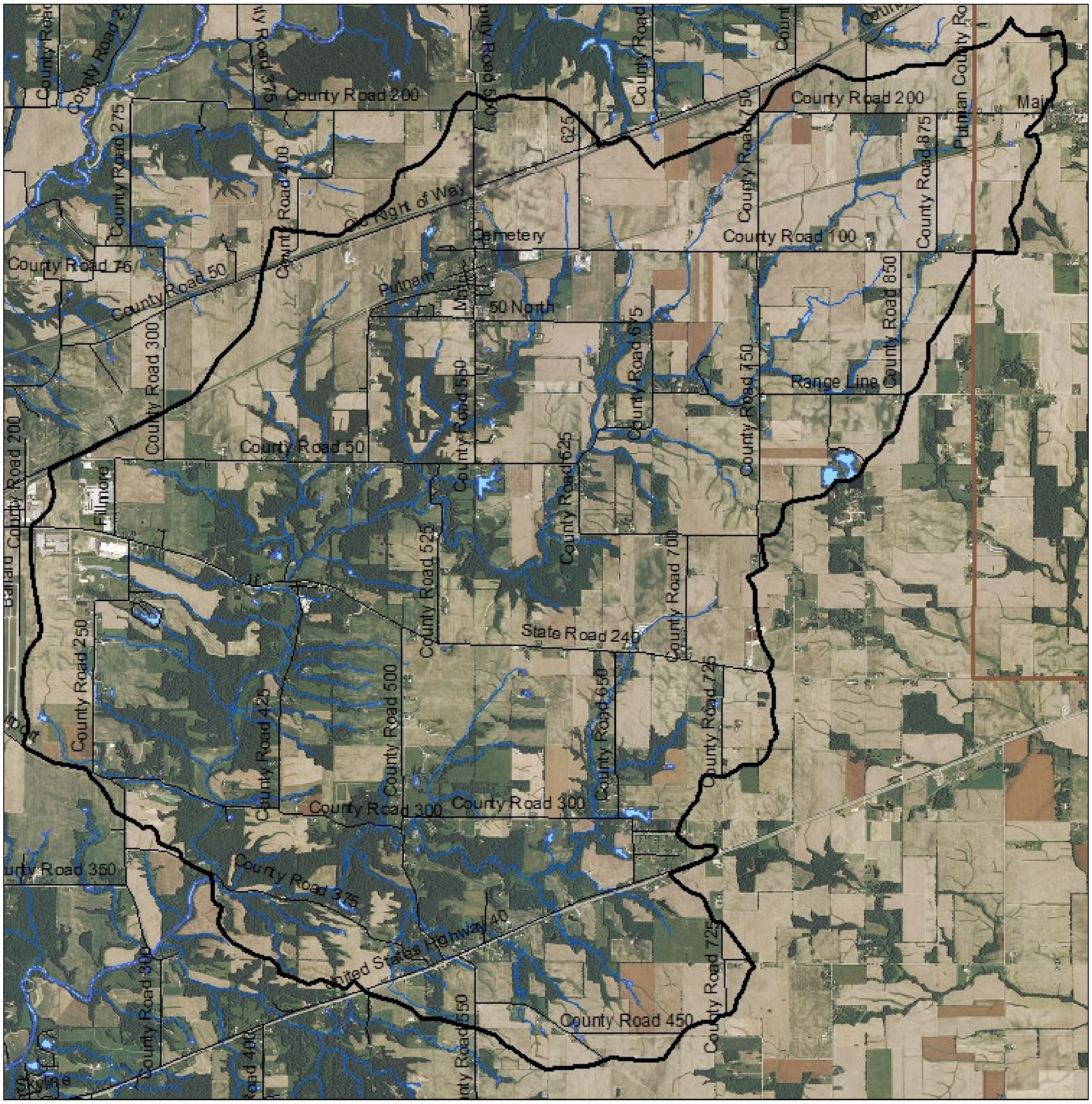

Figure 82. Headwaters Deer Creek Subwatershed.

4.12.1 Soils

Soils in the Headwaters Deer Creek subwatershed are dominated by the Reelsville-Fincastle-Ragsdale complex. The Reelsville series are on till plains and moraines and consist of very deep, somewhat poorly drained soils formed in loess and are underlain by loamy till with a slope ranging from 0-7%. The Fincastle series are on till plains and consist of very deep, somewhat poorly drained soils that are deep to dense till with a slope ranging from 0-6%. The Ragsdale series are on terraces and uplands and consist of very deep, poorly-drained soils that formed in loess with a slope ranging from 0-2%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 1,081 acres (5.6%) of the subwatershed, indicating that nearly one-tenth of the subwatershed was historically wetlands. Wetlands currently cover 1.0% (190.2 acres) of the subwatershed, representing a loss of 82% of historic wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 15.1% and 33.4% of the subwatershed, respectively. Nearly the entire subwatershed (99%) has soils which are severely limited for septic use.

4.12.2 Land Use

Agricultural land use dominates the Headwaters Deer Creek Subwatershed with 73.4% (14,226 acres) in agricultural land uses, including row crop and pasture and 19.9% (3,857 acres) in forested land use. Wetlands, open water, and grassland cover 157 acres, or 0.8%, of the subwatershed. The community of Mt Meridian lies within and the U.S. Highway 40 and State Road 240 corridors bisect the Headwaters Deer Creek Subwatershed accounting for much of the urban land use within the subwatershed. In total, 1,147 acres or 5.9% of the subwatershed are in urban land uses.

4.12.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are four LUST sites, two industrial waste facilities, and one waste septage location (Figure 83). There are no open dumps, brownfields, corrective action sites, voluntary remediation sites, or NPDES permitted locations located within the Headwaters Deer Creek Subwatershed.

4.12.4 Non-Point Source Water Quality Issues

Agricultural land uses are dominant the Headwaters Deer Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Fifty unregulated animal operations housing more than 330 cows, horses, goats, and sheep were identified during the windshield survey. Livestock have access to 0.9 miles of Headwaters Deer Creek Subwatershed streams. Two active confined feeding operations (CFO) are located within the Headwaters Deer Creek Subwatershed. In total, manure from small animal operations total over 26,905 tons per year, which contains almost 63,065 pounds of nitrogen and almost 46,776 pounds of phosphorus. Streambank erosion is a concern in the subwatershed. Approximately 11.9 miles of streambank erosion were identified within the subwatershed. Additionally, one area with trash was located during the windshield inventory.

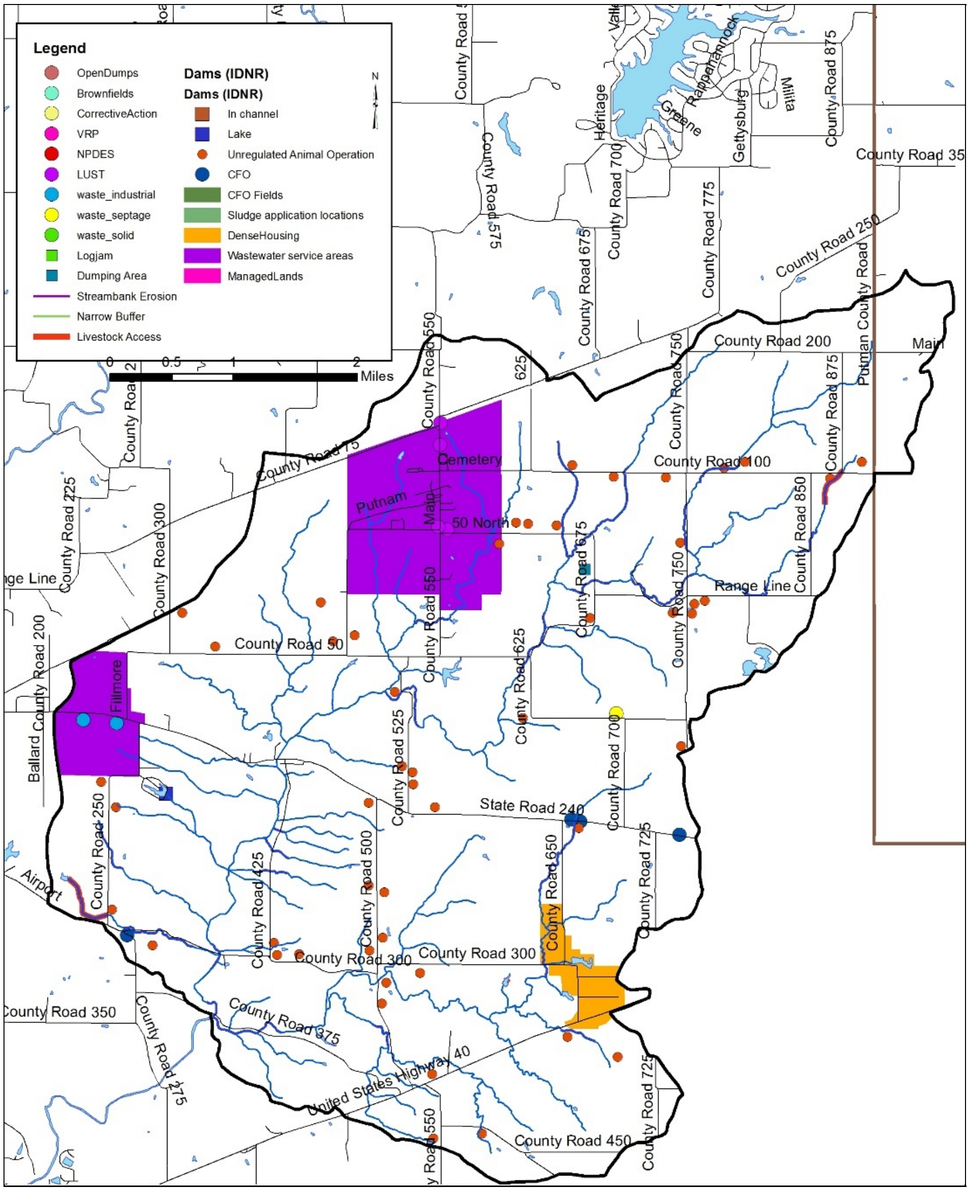

Figure 83. Point and non-point sources of pollution and suggested solutions in the Headwaters Deer Creek Subwatershed.

4.12.5 Water Quality Assessment

Waterbodies within the Headwaters Deer Creek Subwatershed have been sampled at 11 locations (Figure 84). Assessments include collection of water chemistry data by IDEM (2 sites), by USGS (1 site) and as part of the 2008 planning project (1 site). Fish and macroinvertebrate communities were assessed by Gammon (7 sites) and as part of the 2008 planning project. No stream gages are in the Headwaters Deer Creek Subwatershed.

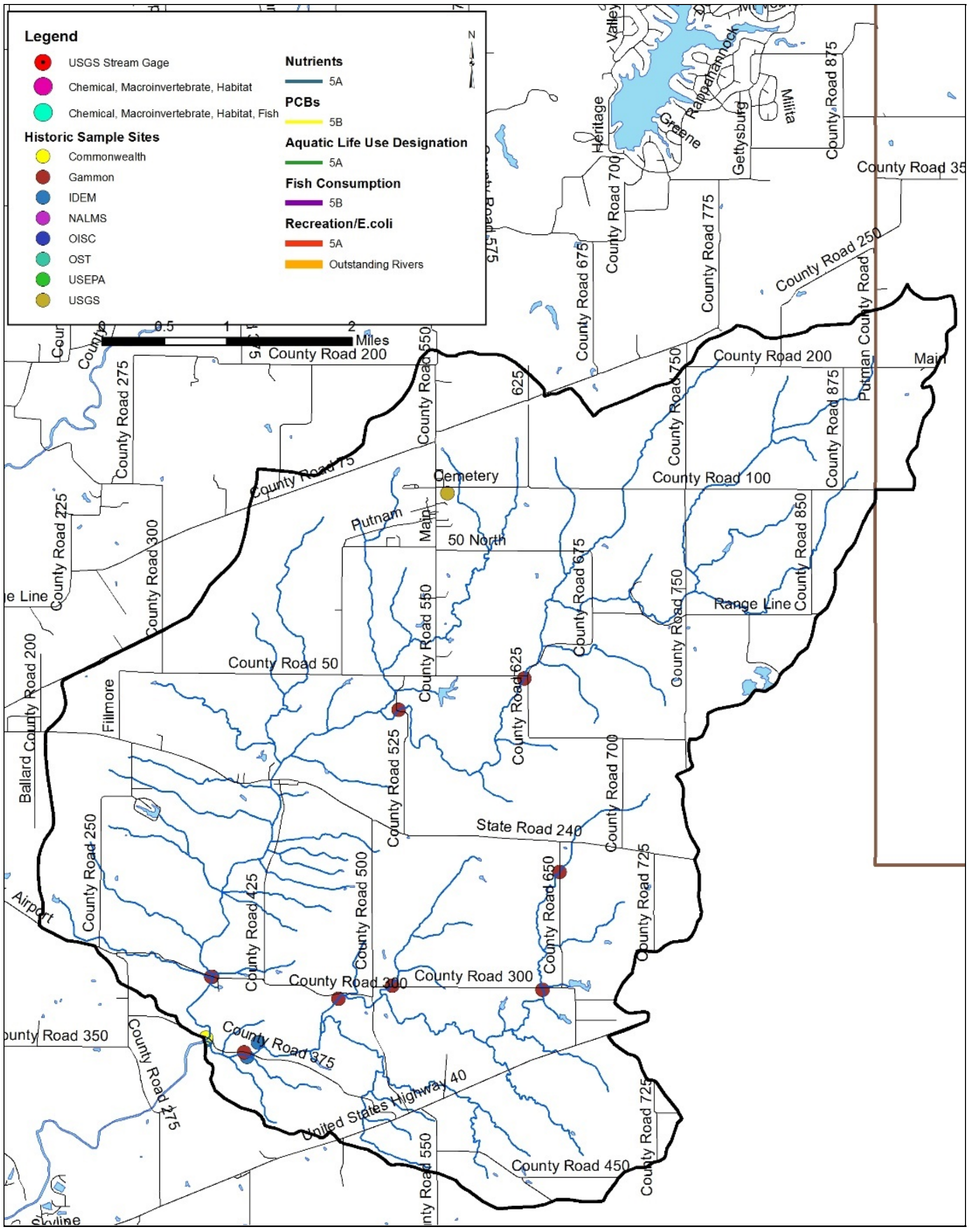

Figure 84. Locations of current and historic water quality data collection and impairments in the Headwaters Deer Creek Subwatershed.

Table 40 shows the collective historic water quality data from the different sampling events described above. As shown in the table, *E. coli* exceeded state standards in 20% of samples, turbidity exceeded targets in 40% of samples, inorganic nitrogen exceeded targets in 50% of samples, phosphorus exceeded targets in 67% of samples, and total suspended solids exceeded targets in 33% of samples.

Table 40. Headwaters Deer Creek Subwatershed historic water quality data summary.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	5	1	20%
pH	19	2	11%
Conductivity	13	0	0%
Turbidity	5	2	40%
Dissolved Oxygen	18	4	22%
Inorganic Nitrogen, Nitrate & Nitrite	8	4	50%
Total Phosphorus	6	4	67%
Total Suspended Solids	6	2	33%
Orthophosphate	--	--	NA

4.13 Owl Branch-Deer Creek Subwatershed

The Owl Branch-Deer Creek Subwatershed forms part of the southern boundary of the Big Walnut Creek Watershed, including the community of Greencastle, and lies completely within Putnam County (Figure 85). It encompasses one 12-digit HUC watershed: 051202030302. This subwatershed drains 18,102 acres, or 28.3 square miles, and accounts for 6.7% of the total watershed area. There are 84.1 miles of stream. IDEM has classified 0.003 miles of stream as impaired for *E. coli*.

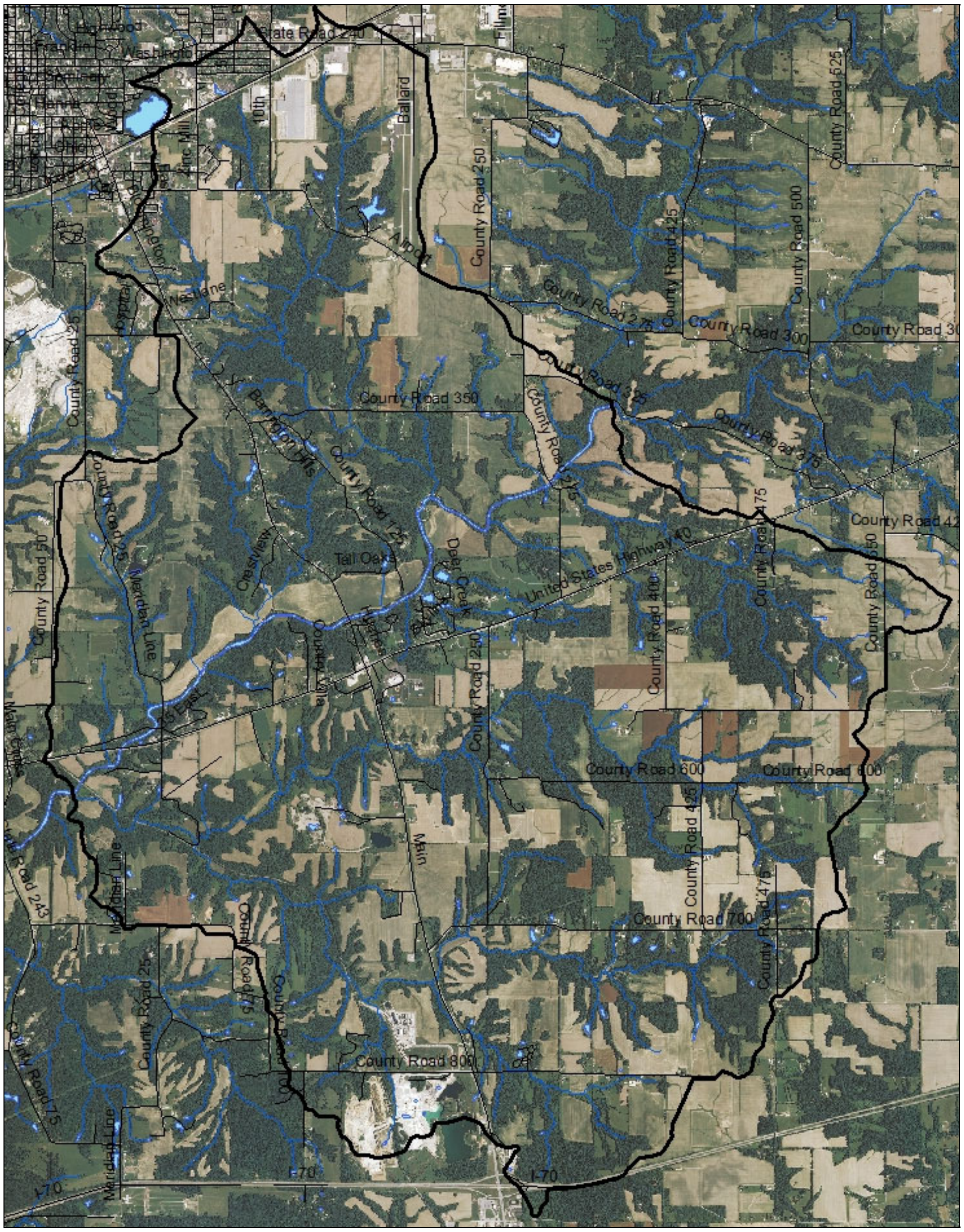

Figure 85. Owl Branch-Deer Creek Subwatershed.

4.13.1 Soils

Soils in the Owl Branch-Deer Creek subwatershed are dominated by the Ava-Cincinnati-Alford complex. The Ava series are on till plains and consist of moderately well drained soils on convex ridges and side slopes of drainageways on till plains with a slope ranging from 0-18%. The Cincinnati series are on till plains and consist of very deep, well-drained soils that are moderately deep to a fragipan with a slope ranging from 1-18%. The Alford series are on loess hills and less commonly on outwash plains and consist of very deep, well drained soils formed in loess with a slope ranging from 0-60%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 118.5 acres (0.7%) of the subwatershed, indicating that only a small portion of the subwatershed was historically wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 27.7% and 35.4% of the subwatershed, respectively. Nearly the entire subwatershed (84%) has soils which are severely limited for septic use.

4.13.2 Land Use

Agricultural and forested land uses dominate the Owl Branch-Deer Creek Subwatershed with 45.5% (8,240 acres) in agricultural land uses, including row crop and pasture and 43.2% (7,834 acres) in forested land use. Wetlands, open water, and grassland cover 325 acres, or 1.8%, of the subwatershed. The community of Greencastle lies within and the U.S. Highway 40 and U.S. Highway 231 corridors bisect the Owl Branch-Deer Creek Subwatershed accounting for much of the urban land use within the subwatershed. In total 1,715 acres or 9.5% of the subwatershed is in urban land uses.

4.13.3 Point Source Water Quality Issues

There are multiple point sources of water pollution in the subwatershed. There are five LUST sites, five NPDES permitted locations, one industrial waste location, and one waste septage site located primarily in the Greencastle area (Figure 86). There are no open dumps, brownfields, corrective action sites, or voluntary remediation sites located within the Owl Branch - Deer Creek Subwatershed.

4.13.4 Non-Point Source Water Quality Issues

Agricultural land uses are a significant land use in the Owl Branch-Deer Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Twenty-seven unregulated animal operations housing more than 228 cows, horses, goats, and sheep were identified during the windshield survey. Livestock have access to 0.9 miles of Owl Branch-Deer Creek Subwatershed streams. No active confined feeding operations (CFO) are located within the Owl Branch-Deer Creek Subwatershed. In total, manure from small animal operations total over 4,123 tons per year, which contains almost 2,658 pounds of nitrogen and almost 1,393 pounds of phosphorus. Streambank erosion is a concern in the subwatershed. Approximately 4.8 miles of streambank erosion were identified within the subwatershed.

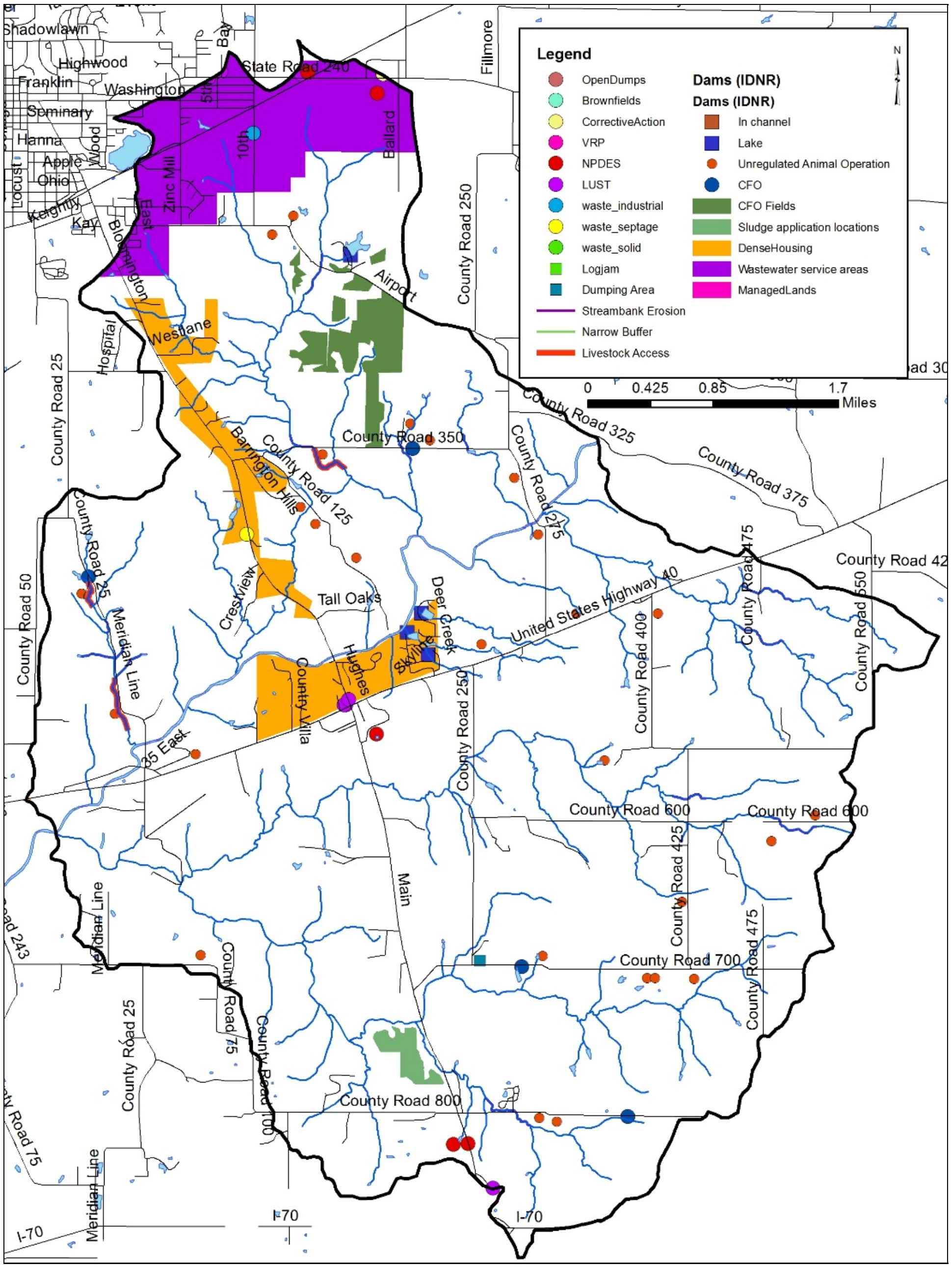

Figure 86. Point and non-point sources of pollution and suggested solutions in the Owl Branch-Deer Creek Subwatershed.

4.13.5 Water Quality Assessment

Waterbodies within the Owl Branch-Deer Creek Subwatershed have been sampled at 13 locations (Figure 87). Assessments include collection of water chemistry data by IDEM (4 sites), by USGS (1 site), and as part of the 2008 planning project (1 site). Fish and macroinvertebrate communities were assessed by Gammon (7 sites) and as part of the 2008 planning project (1 site). No stream gages are in the Owl Branch - Deer Creek Subwatershed.

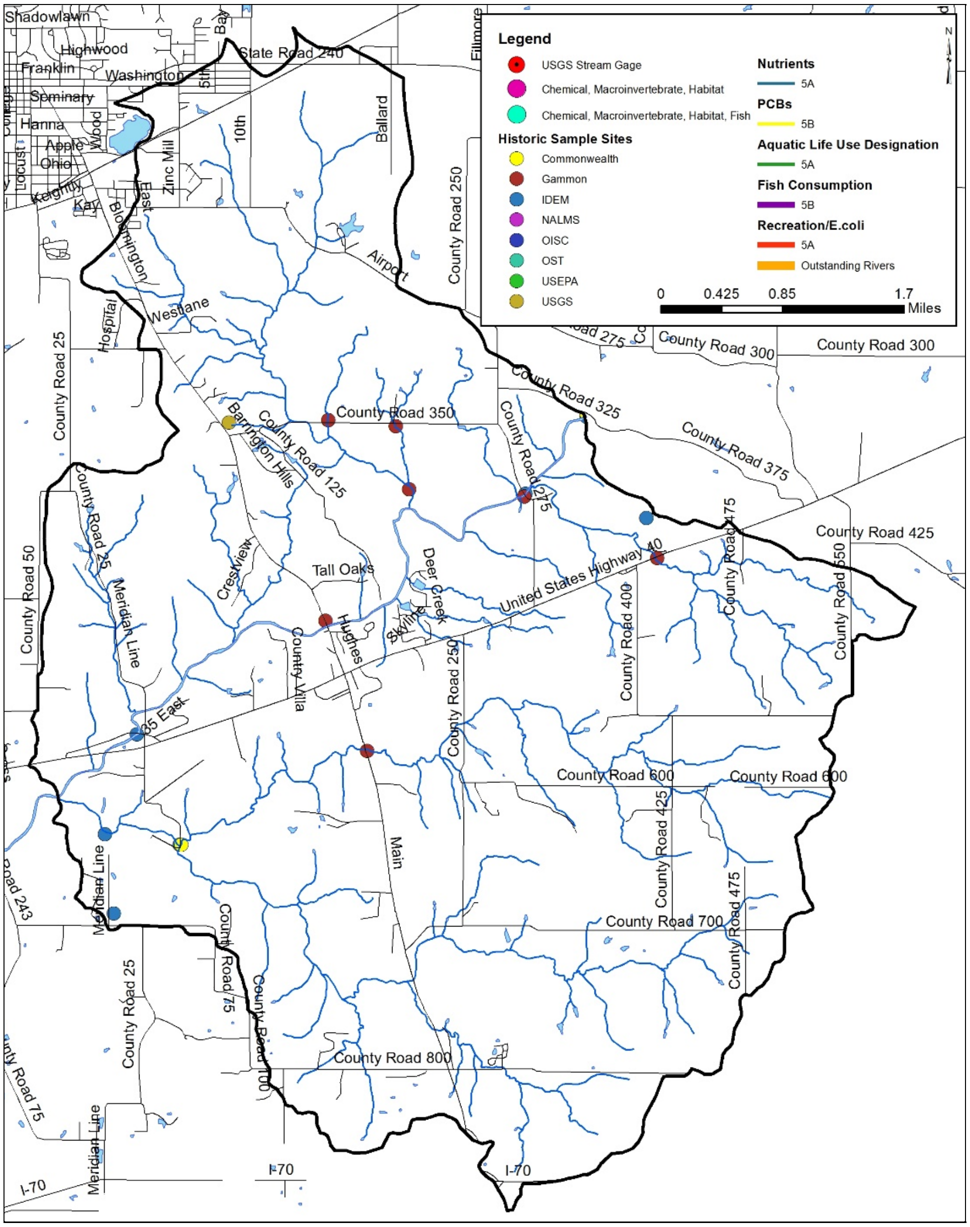

Figure 87. Locations of current and historic water quality data collection and impairments in the Owl Branch-Deer Creek Subwatershed.

Table 41 shows the collective historic water quality data from the different sampling events described above. As shown in the table, *E. coli* exceeded state standards in 60% of samples, turbidity exceeded targets in 53% of samples, inorganic nitrogen exceeded targets in 50% of samples, phosphorus exceeded targets in 75% of samples, and total suspended solids exceeded targets in 43% of samples.

Table 41. Owl Branch – Deer Creek Subwatershed historic water quality data summary.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	15	9	60%
pH	26	1	4%
Conductivity	20	0	0%
Turbidity	17	9	53%
Dissolved Oxygen	25	11	44%
Inorganic Nitrogen, Nitrate & Nitrite	8	4	50%
Total Phosphorus	8	6	75%
Total Suspended Solids	7	3	43%
Orthophosphate	--	--	NA

4.14 Deweese Branch-Deer Creek Subwatershed

The Deweese Branch-Deer Creek Subwatershed forms part of the southern boundary of the Big Walnut Creek Watershed, including the communities of Greencastle, Limedale, Putnamville, and Manhattan and lies completely within Putnam County (Figure 88). It encompasses one 12-digit HUC watershed: 051202030303. This subwatershed drains 20,954 acres, or 32.7 square miles, and accounts for 7.7% of the total watershed area. There are 79.6 miles of stream. IDEM has classified 69.3 miles of stream impaired for *E. coli*.

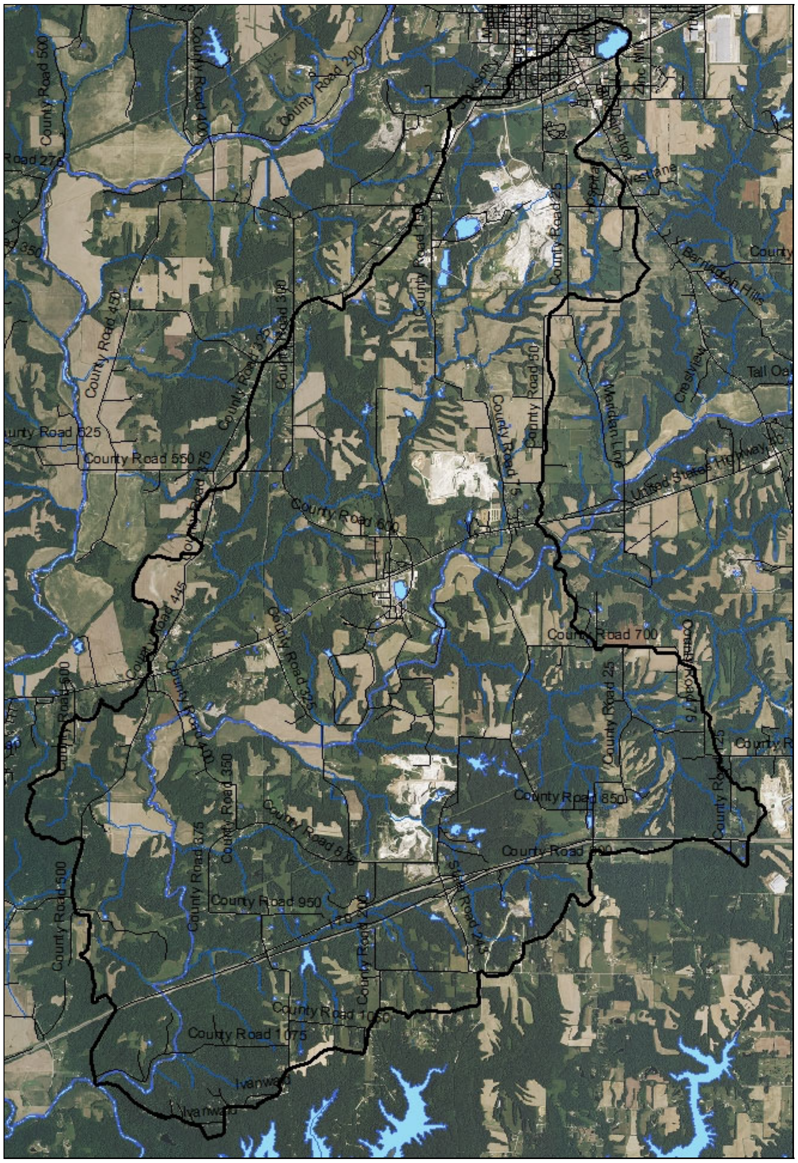

Figure 88. Deweese Branch-Deer Creek Subwatershed.

4.14.1 Soils

Soils in the Deweese Branch-Deer Creek Subwatershed are dominated by the Hickory-Cincinnati-Berks complex. The Hickory series are formed in till that can be capped with up to 20 inches of loess and consist of very deep, well drained soils on dissected till plains with a slope ranging from 5-70%. The Cincinnati series are on till plains and consist of very deep, well-drained soils that are moderately deep to a fragipan with a slope ranging from 1-18%. The Berks series are on dissected uplands and consist of moderately deep, well drained soils formed in residuum weathered from shale, siltstone, and fine-grained sandstone with a slope ranging from 0-80%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 149 acres (0.7%) of the subwatershed, indicating that only a small portion of the subwatershed was historically wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 32.0% and 36.2% of the subwatershed, respectively. Nearly the entire subwatershed (81%) has soils which are severely limited for septic use.

4.14.2 Land Use

Agricultural and forested land uses co-dominate the Deweese Branch-Deer Creek Subwatershed with 29.0% (6,090 acres) in agricultural land uses, including row crop and pasture and 58.9% (12,355 acres) in forested land use. Wetlands, open water, and grassland cover 1,046 acres, or 5.0%, of the subwatershed. The communities of Greencastle, Limedale, Putnamville, and Manhattan lie within and the U.S. Highway 40 and Interstate 70 corridors bisect the Deweese Branch-Deer Creek Subwatershed accounting for much of the urban land use within the subwatershed. In total, 1,479 acres or 7.1% of the subwatershed are in urban land uses.

4.14.3 Point Source Water Quality Issues

There are multiple point sources of water pollution in the subwatershed. There are two brownfields, one corrective action site, one voluntary remediation site, four NPDES permitted locations, thirteen LUST sites, and two industrial waste facilities located primarily in the Greencastle area (Figure 89). There are no open dumps or waste septage sites located within the Deweese Branch-Deer Creek Subwatershed.

4.14.4 Non-Point Source Water Quality Issues

Agricultural land uses are a significant land use in the Deweese Branch - Deer Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Fifteen unregulated animal operations housing more than 137 cows, horses, and goats were identified during the windshield survey. Livestock have access to 0.4 miles of Deweese Branch - Deer Creek Subwatershed streams. One active confined feeding operations (CFO) is located within the Deweese Branch - Deer Creek Subwatershed. In total, manure from small animal operations total over 6,529 tons per year, which contains almost 13,696 pounds of nitrogen and almost 10,037 pounds of phosphorus. Streambank erosion is a concern in the subwatershed. Approximately 7.5 miles of streambank erosion were identified within the subwatershed.

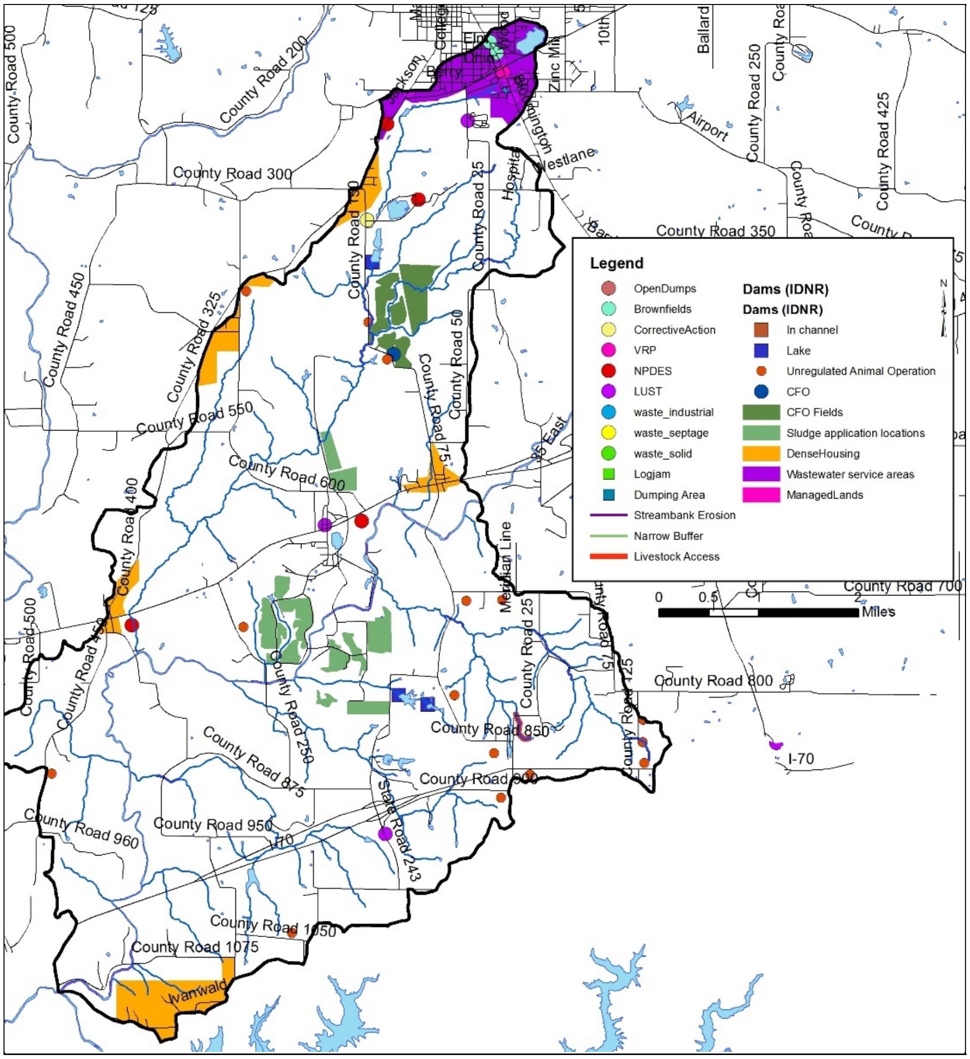

Figure 89. Point and non-point sources of pollution and suggested solutions in the Deweese Branch-Deer Creek Subwatershed.

4.14.5 Water Quality Assessment

Waterbodies within the Deweese Branch - Deer Creek Subwatershed have been sampled at 17 locations (Figure 90). Assessments include collection of water chemistry data by IDEM (6 sites), by USGS (2 sites), as part of the 2008 planning project (2 sites), and as part of the current project (2 sites). Fish and macroinvertebrate communities were assessed by Gammon (7 sites), as part of the 2008 planning project (2 sites), and as part of the current project (2 sites). No stream gages are in the Deweese Branch - Deer Creek Subwatershed.

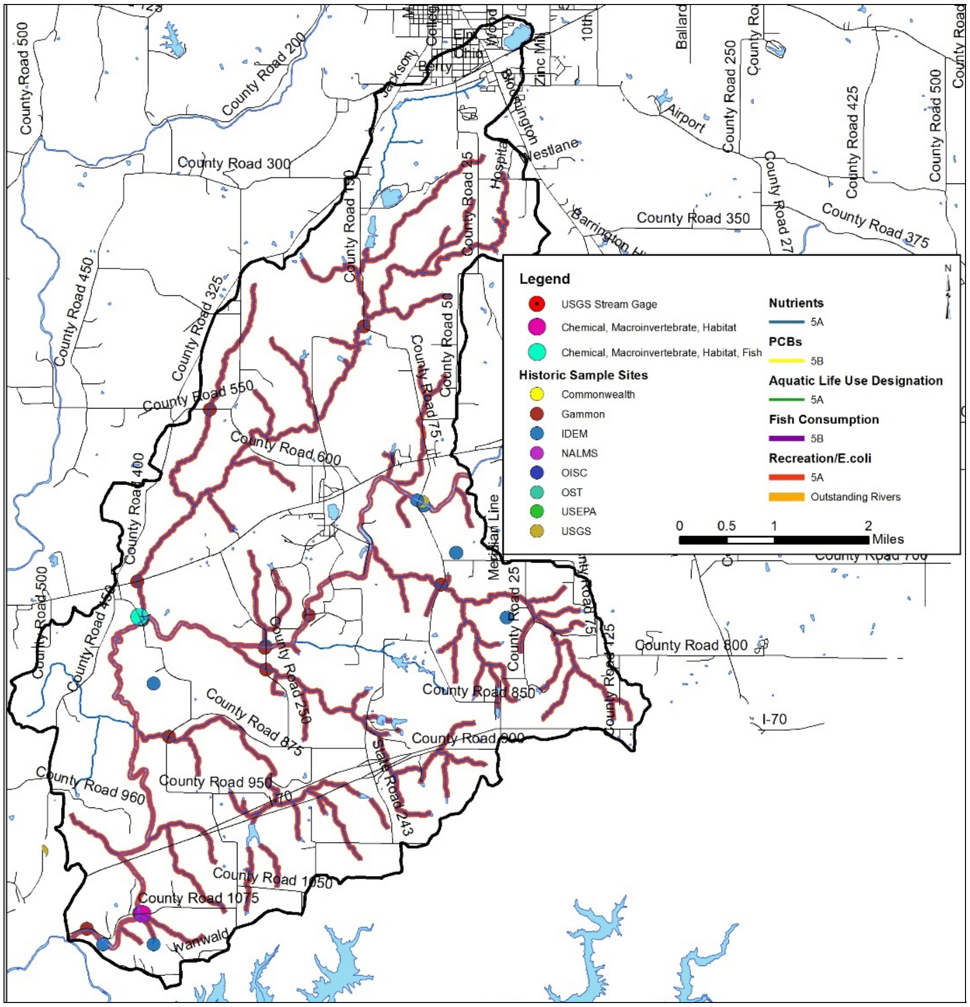

Figure 90. Locations of current and historic water quality data collection and impairments in the Deweese Branch-Deer Creek Subwatershed.

Table 42 shows the collective historic water quality data from the different sampling events described above. As shown in the table, *E. coli* exceeded state standards in 46% of samples, turbidity exceeded water quality targets in 84% of samples, inorganic nitrogen exceeded targets in 50% of samples, phosphorus exceeded targets in 88% of samples, and total suspended solids exceeded targets in 48% of samples.

Table 42. Deweese Branch-Deer Creek Subwatershed historic water quality data summary.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	26	12	46%
pH	51	4	8%
Conductivity	39	0	0%
Turbidity	32	27	84%
Dissolved Oxygen	51	12	24%
Inorganic Nitrogen, Nitrate & Nitrite	12	6	50%
Total Phosphorus	24	21	88%
Total Suspended Solids	23	11	48%
Orthophosphate	--	--	NA

Table 43 shows current water quality data collected at Site 10 (Deweese Creek) from August 2018 to August 2019, while Table 44 shows current water quality data collected at Site 12 (Deer Creek) from August 2018 to August 2019. As shown in Table 43, orthophosphorus exceeded water quality targets in 90% of samples, nitrate-nitrogen exceeded water quality targets in 18% of samples, *E. coli* exceeded state standards in 31% of samples, total phosphorus exceeded targets in 64% of samples, and total suspended solids exceeded targets in 10% of samples. As shown in Table 44 , orthophosphorus exceeded water quality targets in 92% of samples, nitrate-nitrogen exceeded water quality targets in 62% of samples, *E. coli* exceeded state standards in 47% of samples, total phosphorus exceeded targets in 38% of samples, and total suspended solids exceeded targets in 33% of samples. During the current assessment, both the macroinvertebrate and fish communities rated poorer than water quality targets scoring 38 at both sites for the mIBI and 40 in Deweese Creek for the IBI.

Table 43. Water quality data collected in the Deweese Branch-Deer Creek (Deweese Creek) Subwatershed, August 2018 to August 2019.

Site		Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
10	Min	0.2	0.03	0.03	1	2
	Median	0.8	0.11	0.09	3	143
	Max	5	0.19	0.18	148	6900
	Count	11	11	10	10	16
	Exceed	2	7	9	1	5
	% Exceed	18%	64%	90%	10%	31%

Table 44. Water quality data collected in the Deweese Branch-Deer Creek (Deer Creek) Subwatershed, August 2018 to August 2019.

Site		Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
12	Min	0.6	0.02	0.03	1	47
	Median	2.55	0.07	0.07	6	250
	Max	4.1	0.34	0.4	518	10500
	Count	13	13	12	12	17
	Exceed	8	5	11	4	8
	% Exceed	62%	38%	92%	33%	47%

4.15 Snake Creek-Big Walnut Creek Subwatershed

The Snake Creek-Big Walnut Creek Subwatershed forms part of the southwestern boundary of the Big Walnut Creek Watershed, including the community of Reelsville, and lies within Putnam, Clay, and Parke Counties (Figure 91). It encompasses one 12-digit HUC watershed: 051202030405. This subwatershed drains 24,481 acres, or 38.3 square miles, and accounts for 9.0% of the total watershed area. There are 81.9 miles of stream. IDEM has classified 15.945 miles of stream as impaired for *E. coli*, 34.3 miles impaired for fish consumption, 11.9 miles impaired for aquatic life use designation, 12.0 miles impaired for nutrients, and 34.3 miles impaired for PCBs in fish tissue.

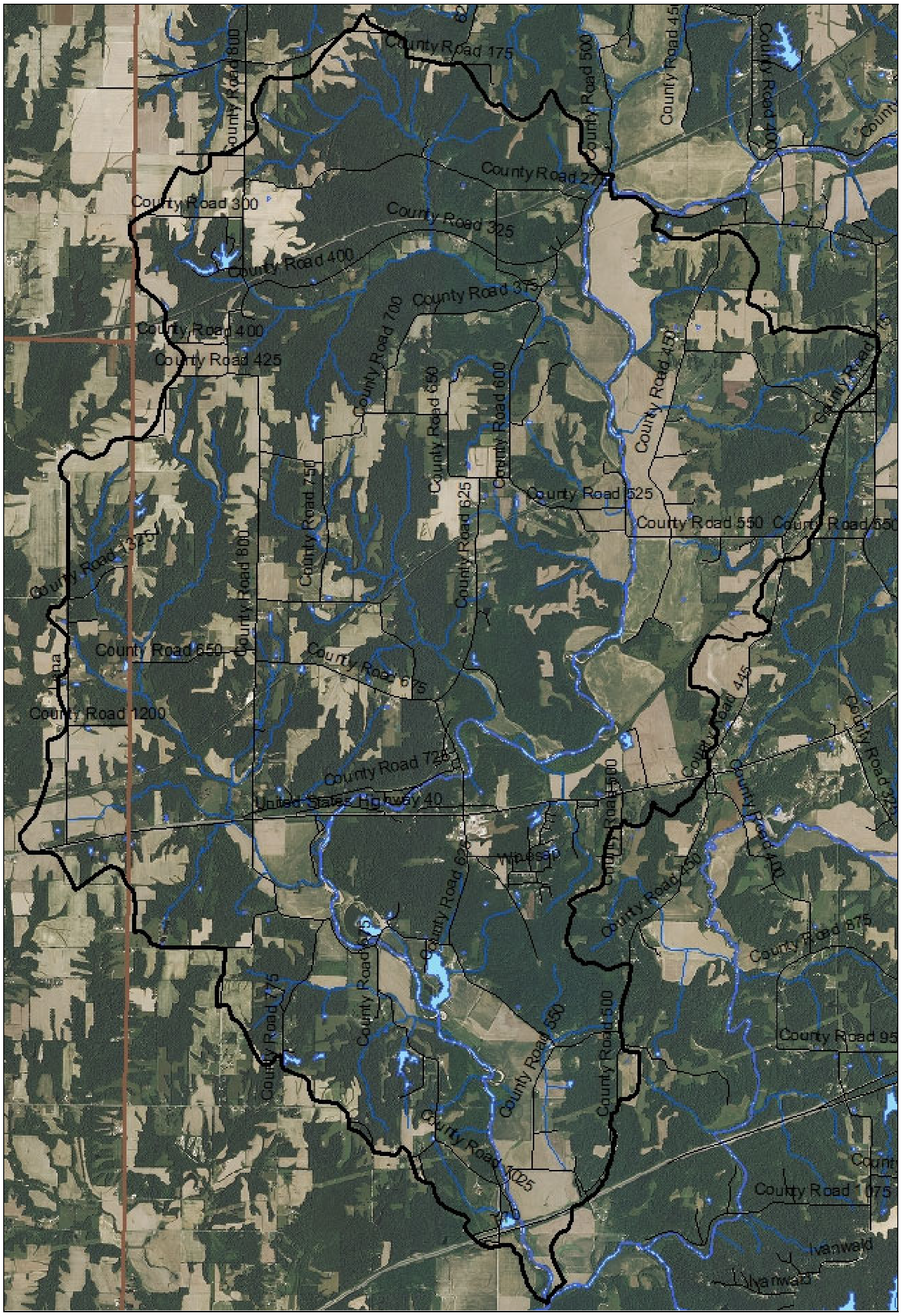

Figure 91. Snake Creek-Big Walnut Creek Subwatershed.

4.15.1 Soils

Soils in the Snake Creek-Big Walnut Creek subwatershed are dominated by the Hickory-Cincinnati-Berks complex. The Hickory series are formed in till that can be capped with up to 20 inches of loess and consist of very deep, well drained soils on dissected till plains with a slope ranging from 5-70%. The Cincinnati series are on till plains and consist of very deep, well drained soils that are moderately deep to a fragipan with a slope ranging from 1-18%. The Berks series are on dissected uplands and consist of moderately deep, well drained soils formed in residuum weathered from shale, siltstone, and fine-grained sandstone with a slope ranging from 0-80%. Appropriate cover should be maintained to manage these soils. Hydric soils cover 341.6 acres (1.4%) of the subwatershed, indicating that only a small portion of the subwatershed was historically wetlands. Highly erodible and potentially highly erodible soils are prevalent throughout the subwatershed, covering 31.6% and 29.2% of the subwatershed, respectively. Nearly the entire subwatershed (90%) has soils which are severely limited for septic use.

4.15.2 Land Use

Agricultural and forested land uses co-dominate the Snake Creek-Big Walnut Creek Subwatershed with 32.7% (8,007 acres) in agricultural land uses, including row crop and pasture and 59.7% (14,619 acres) in forested land use. Wetlands, open water, and grassland cover 698 acres, or 2.8%, of the subwatershed. The community of Reelsville lies within and the U.S. Highway 40 and a small section of Interstate 70 corridors bisect the Snake Creek-Big Walnut Creek Subwatershed accounting for much of the urban land use within the subwatershed. In total, 1,175 acres or 4.8% of the subwatershed are in urban land uses.

4.15.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are one LUST location and one NPDES permitted location (Figure 92). There are no open dumps, brownfields, corrective action sites, voluntary remediation sites, industrial waste facilities, or waste septage sites located within the Snake Creek-Big Walnut Creek Subwatershed

4.15.4 Non-Point Source Water Quality Issues

Agricultural land uses are a significant portion of the Snake Creek-Big Walnut Creek Subwatershed. Additionally, a number of small animal operations and pastures are also present. Twenty-seven unregulated animal operations housing more than 255 cows, horses, goats, llamas, and sheep were identified during the windshield survey. Livestock have access to 0.2 miles of Snake Creek - Big Walnut Creek Subwatershed streams. No active confined feeding operations (CFO) are located within the Snake Creek - Big Walnut Creek Subwatershed. In total, manure from small animal operations total over 5,463 tons per year, which contains almost 2,716 pounds of nitrogen and almost 1,343 pounds of phosphorus. Streambank erosion is a concern in the subwatershed. Approximately 10.9 miles of streambank erosion were identified within the subwatershed. Additionally, one area with trash was identified during the windshield survey.

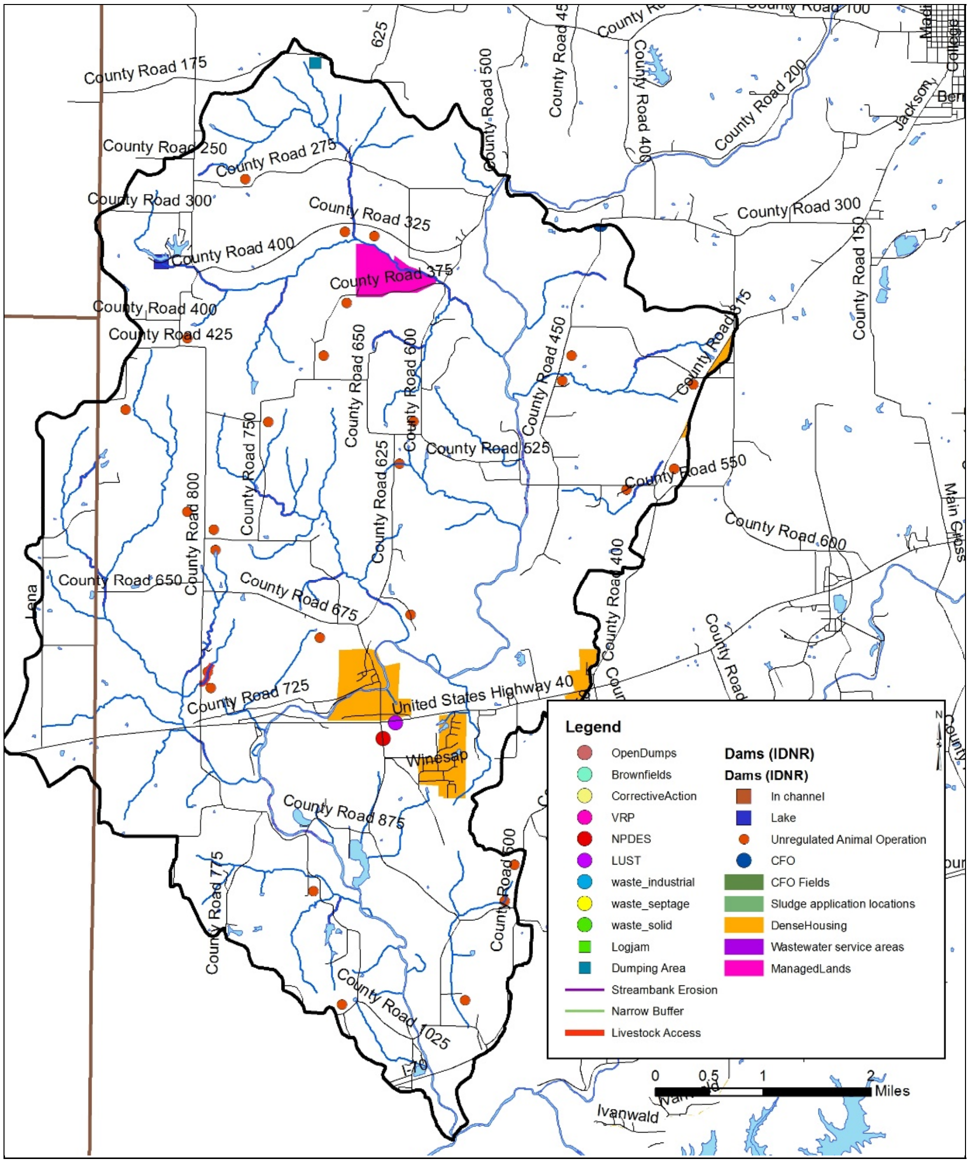

Figure 92. Point and non-point sources of pollution and suggested solutions in the Snake Creek-Big Walnut Creek Subwatershed.

4.15.5 Water Quality Assessment

Waterbodies within the Snake Creek-Big Walnut Creek Subwatershed have been sampled at 26 locations (Figure 93). Assessments include collection of water chemistry data by IDEM (9 sites), USGS (5 sites), as part of the 2008 planning project (2 sites), and as part of the current project (2 sites). Fish and macroinvertebrate communities were assessed by Gammon (8 sites), as part of the 2008 planning project (2 sites), and as part of the current project (2 sites). No stream gages are in the Snake Creek - Big Walnut Creek Subwatershed.

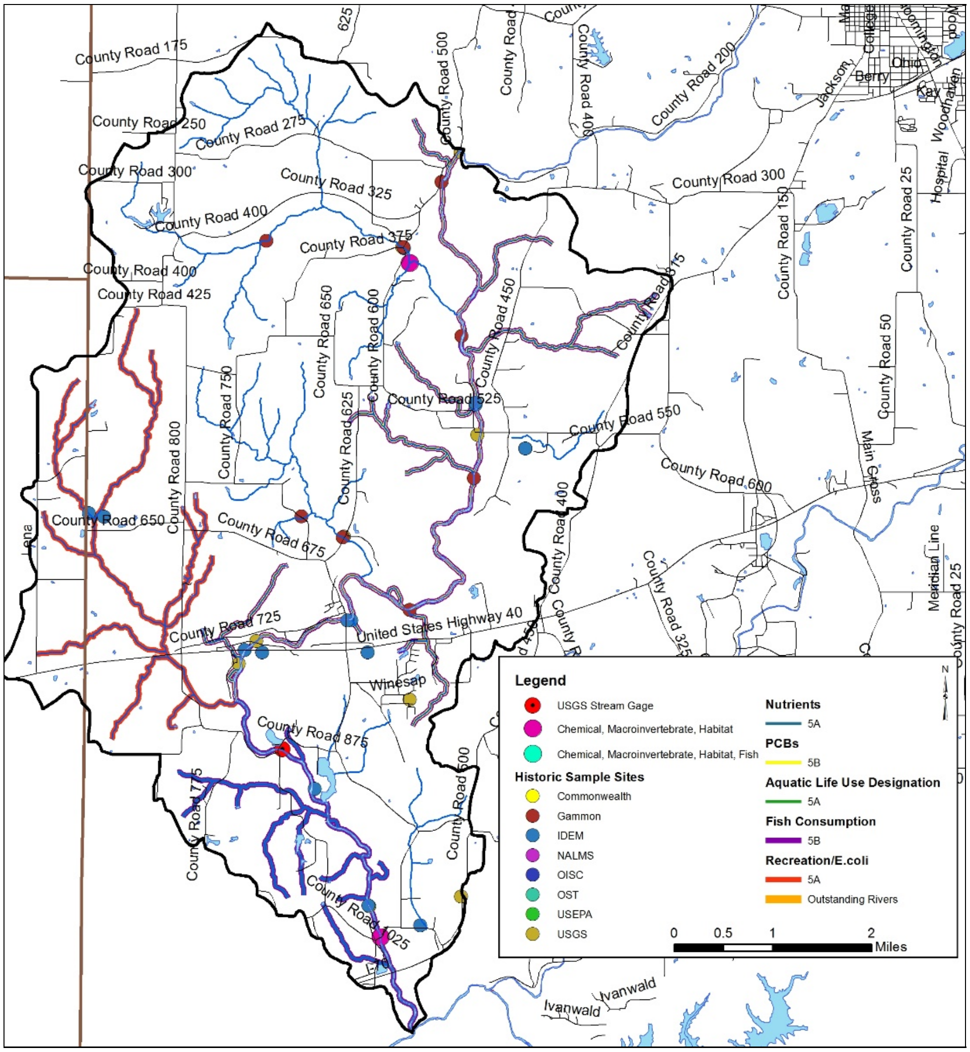

Figure 93. Locations of current and historic water quality data collection and impairments in the Snake Creek-Big Walnut Creek Subwatershed.

Table 45 shows the collective historic water quality data from the different sampling events described above. As shown in the table, *E. coli* exceeded state standards in 33% of samples, turbidity exceeded water quality targets in 89% of samples, inorganic nitrogen exceeded targets in 70% of samples, phosphorus exceeded targets in 41% of samples, and total suspended solids exceeded targets in 55% of samples.

Table 46 shows current water quality data collected at Site 9 (Snake Creek) from August 2018 to August 2019. Table 47 shows current water quality data collected at Site 11 (Big Walnut Creek) from August 2018 to August 2019. As shown in Table 46, orthophosphorus exceeded water quality targets in 75% of samples, nitrate-nitrogen exceeded water quality targets in 20% of samples, *E. coli* exceeded state standards in 44% of samples, total phosphorus exceeded targets in 40% of samples, and total suspended solids exceeded targets in 25% of samples. As shown in Table 47, orthophosphorus exceeded water quality targets in 90% of samples, nitrate-nitrogen exceeded water quality targets in 64% of samples, *E. coli* exceeded targets in 40% of samples, total phosphorus exceeded targets in 55% of samples, and total suspended solids exceeded targets in 40% of samples. During the current assessment, both the macroinvertebrate and fish community rated poorer than water quality targets scoring 38 and 42 in Snake Creek and Big Walnut Creek, respectively for the mIBI and 40 for the IBI in Snake Creek.

Table 45. Snake Creek-Big Walnut Creek Subwatershed historic water quality data summary.

Parameter	Number of Samples	Number Exceeded	% Exceeded
E. coli	48	16	33%
pH	537	1	0%
Conductivity	477	0	0%
Turbidity	382	341	89%
Dissolved Oxygen	483	117	24%
Inorganic Nitrogen, Nitrate & Nitrite	398	279	70%
Total Phosphorus	328	134	41%
Total Suspended Solids	294	161	55%
Orthophosphate	88	42	48%

Table 46. Water quality data collected in the Snake Creek-Big Walnut Creek (Snake Creek) Subwatershed, August 2018 to August 2019.

Site		Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
9	Min	0.3	0.03	0.03	1	82
	Median	0.7	0.05	0.075	1	224
	Max	2.8	0.21	0.26	56	1520
	Count	5	5	4	4	9
	Exceed	1	2	3	1	4
	% Exceed	20%	40%	75%	25%	44%

Table 47. Water quality data collected in the Snake Creek-Big Walnut Creek (Big Walnut Creek) Subwatershed, August 2018 to August 2019.

Site		Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	*E. coli* (col/100 mL)
11	Min	1	0.02	0.01	2	49
	Median	1.6	0.09	0.08	9	149
	Max	4.1	0.21	0.25	583	4050
	Count	11	11	10	10	15
	Exceed	7	6	9	4	6
	% Exceed	64%	55%	90%	40%	40%

5.0 WATERSHED INVENTORY III: WATERSHED INVENTORY SUMMARY

Several important factors and relationships become apparent when the Big Walnut 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 historic data collected from IDEM, USGS, Indiana State University Fisheries, and Hoosier Riverwatch as well as current water quality assessments completed as through the professional and Hoosier Riverwatch monitoring programs conducted during the current project. These include elevated nitrate-nitrogen, total phosphorus, total suspended solids, conductivity and *E. coli* concentrations; as well as pH and dissolved oxygen concentrations outside of target ranges.

Based on historic data, Table 48 highlights those locations within the Big Walnut 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 only if 50% or more of samples collected at those sites were outside the target values. Table 48 summarizes where historic samples were outside the target values and are grouped by subwatershed. Figure 94 shows the locations of historical sites that that exceeded target values.

Table 48. Percent of samples historically collected in Big Walnut Creek Subwatersheds which measured outside target values.

Subwatershed	*E. coli*	Turb	DO	N	P	TSS	OP
Eldin Ditch	N/A	N/A	0%	50%	50%	17%	N/A
Ross Ditch-East Fork Big Walnut Creek	79%	92%	5%	80%	25%	10%	25%
Ramp Run-East Fork Big Walnut Creek	N/A	N/A	0%	64%	50%	33%	50%
West Fork Big Walnut Creek	38%	63%	3%	63%	42%	55%	N/A
Owl Creek	20%	57%	41%	53%	60%	43%	50%
Headwaters Little Walnut Creek	18%	100%	60%	58%	85%	23%	N/A
Leatherman Creek-Little Walnut Creek	56%	85%	16%	31%	58%	23%	N/A
Headwaters Deer Creek	20%	40%	22%	50%	67%	33%	N/A
Owl Branch-Deer Creek	60%	53%	44%	50%	75%	43%	N/A
Deweese Branch-Deer Creek	46%	84%	24%	50%	88%	48%	N/A
Town of Barnard-Big Walnut Creek	41%	88%	50%	67%	19%	59%	27%
Clear Creek	16%	66%	17%	53%	70%	36%	100%
Bledsoe Branch-Big Walnut Creek	21%	80%	13%	71%	32%	21%	71%
Dry Branch-Big Walnut Creek	31%	83%	19%	55%	90%	47%	50%
Snake Creek-Big Walnut Creek	33%	89%	24%	70%	41%	55%	48%

NOTE: N/A indicates no data available.

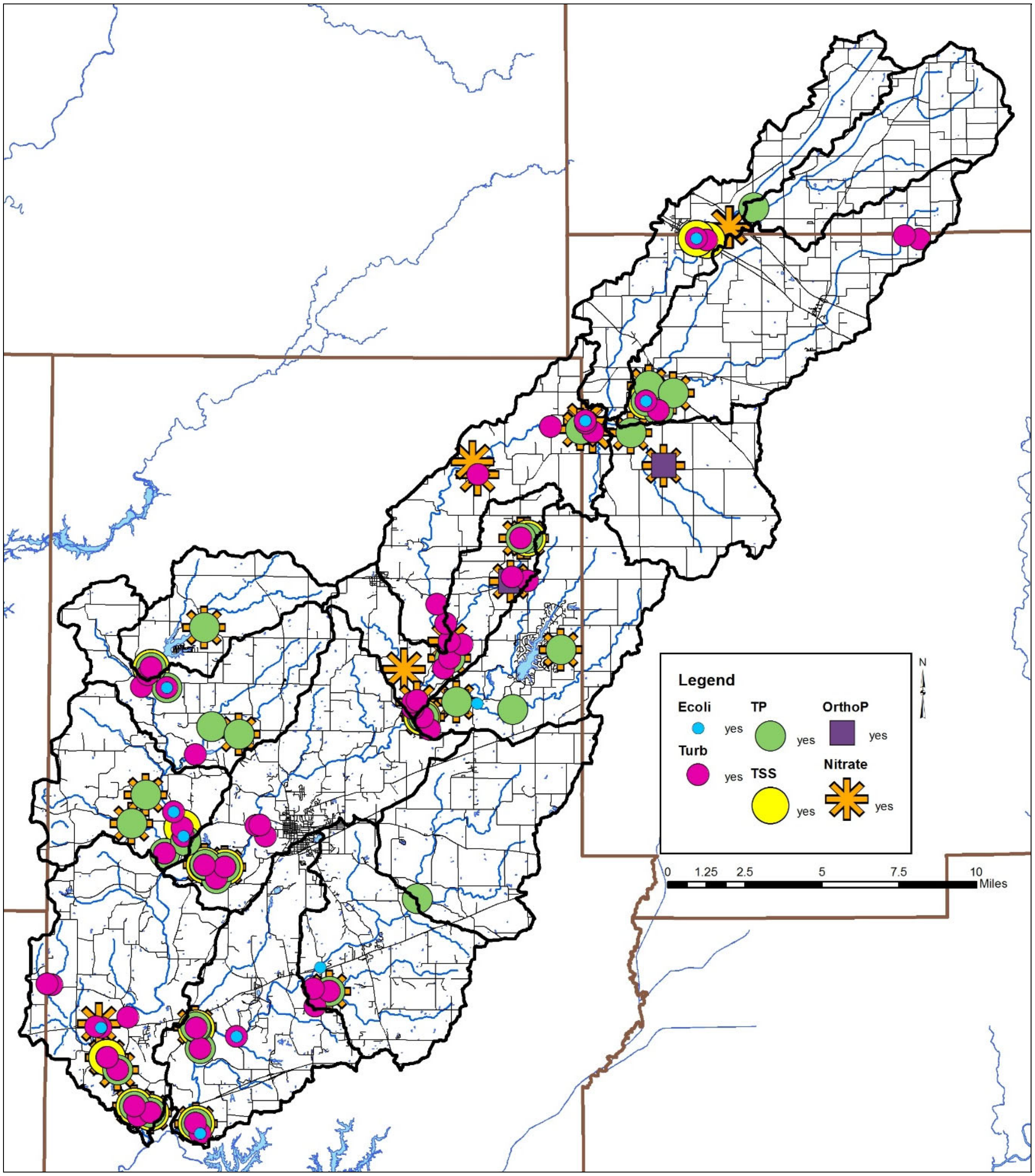

Figure 94. Big Walnut Creek Watershed historical sampling sites that exceed target values. Yes indicates that site exceeds targets in more than 50% of collected samples.

Table 49 summarizes current samples which measured outside the target values during the current assessment. Figure 95 provides a map of current sampling sites that exceed target values. Elevated nitrate-nitrogen concentrations were observed at all sample sites with concentrations exceeding targets in 65% of collected samples throughout the watershed. Elevated total phosphorus concentrations were observed at all sample sites with concentrations exceeding total phosphorus targets in 41% of collected samples at all sample sites. Elevated total suspended solids concentrations were observed at all sites with 26% of all samples exceeding targets. *E. coli* concentrations that exceeded the state grab sample standard were measured at all sites with 52% of samples exceeding state standards.

Low dissolved oxygen concentrations were not observed at any sample sites during any of the watershed sampling events. Specific conductivity exceeded targets at a single site (Site 10) during one sampling event. pH concentrations exceeded targets at a single site (Site 07) during one sampling event. Habitat assessments occurred once during the project. No sites had a QHEI score that scored below the target (51). The lowest scores occurred in Eldin Ditch (Site 01), Plum Creek (Site 05), and Clear Creek (Site 13) sampling sites. Biological communities rated poorer than targets for both fish and macroinvertebrate communities at all sites that were assessed. However, as only one fish and one macroinvertebrate assessment occurred during the current project and historic assessments include sporadic sites, biological data where sites do not meet water quality targets are not included in Table 49.

Table 49. Percent of samples collected in the Big Walnut Creek Watershed during the 2018-2019 sample collection which measured outside target values.

ID	Subwatershed	Nitrate	TP	OP	TSS	E.Coli	Habitat
1	Eldin Ditch	90%	50%	89%	22%	64%	58
2	Ross Ditch-EF Big Walnut Creek	83%	42%	91%	20%	69%	62
3	Ross Ditch-EF Big Walnut Creek	91%	55%	89%	30%	88%	69
4	Ramp Run-EF Big Walnut Creek	64%	18%	80%	20%	56%	68
5	Bledsoe Branch-Big Walnut Creek	73%	45%	90%	20%	44%	57
6	Clear Creek	78%	11%	88%	38%	8%	63
7	Headwaters Little Walnut Creek	71%	57%	100%	14%	22%	61
8	Leatherman Creek-Little Walnut Creek	44%	33%	88%	50%	69%	80
9	Snake Creek-Big Walnut Creek	20%	40%	75%	25%	44%	69
10	Deweese Branch-Deer Creek	18%	64%	90%	10%	31%	59
11	Snake Creek-Big Walnut Creek	64%	55%	90%	40%	40%	79
12	Deweese Branch-Deer Creek	62%	38%	92%	33%	47%	75
13	Clear Creek	63%	25%	100%	14%	73%	58

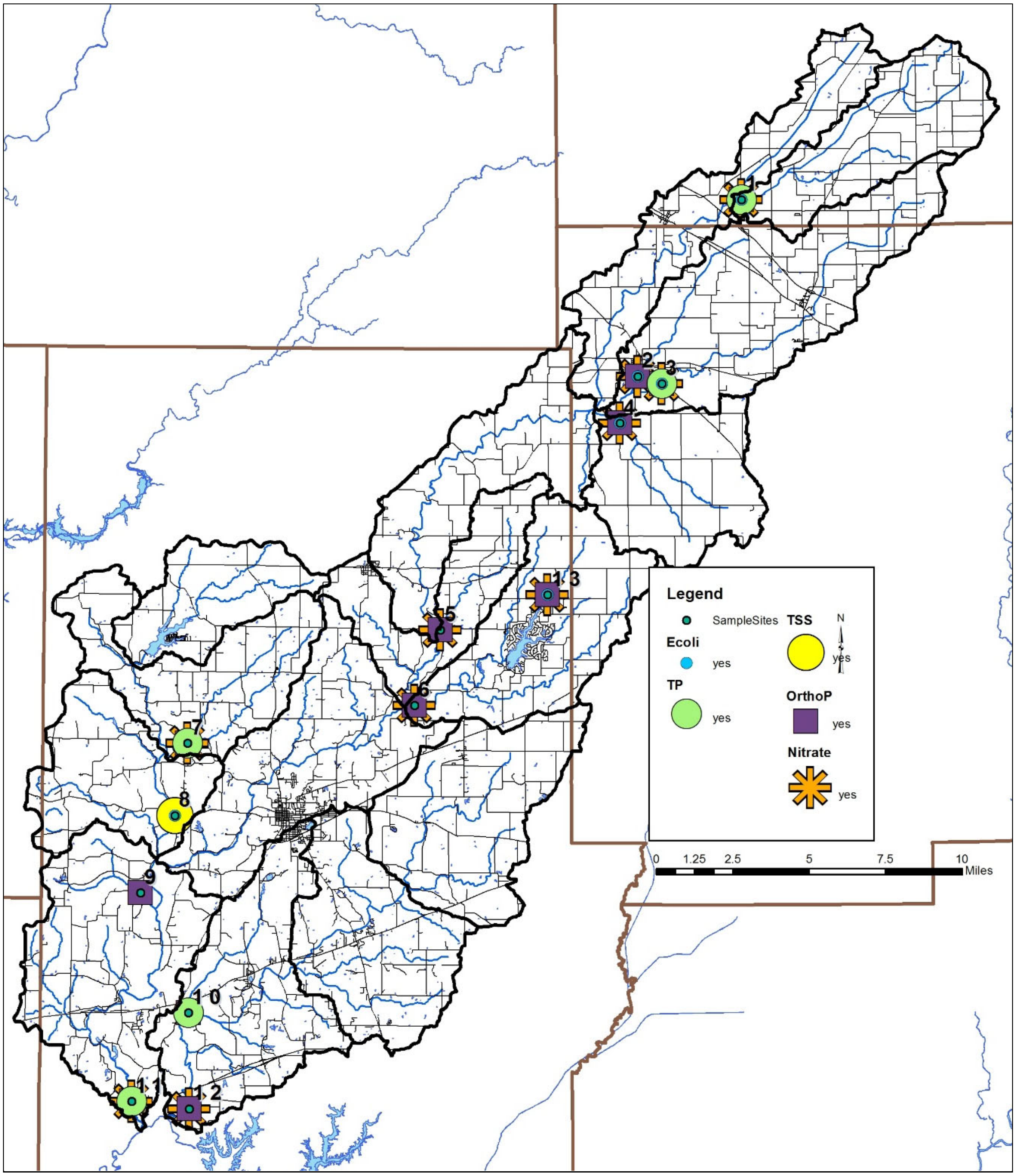

Figure 95. Big Walnut Creek Watershed sampling sites that exceed target values during the current sampling period. Yes indicates that site exceeds targets in more than 50% of collected samples.

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 50. 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.

Table 50. Analysis of stakeholder concerns identified in the Big Walnut Creek Watershed.

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Livestock access in the stream	Yes	Livestock access was documented along 21.6 miles of streams during the watershed inventory.	Yes	No	Yes
Streambank erosion / Large rain events causing damage to streambanks / In-channel erosion to bedrock / Trail and streambank erosion at the DePauw Nature Park	Yes	More than 54% of the watershed is mapped in highly erodible or potentially highly erodible soils. 148.9 miles of streambank were identified as eroding during the windshield survey.	Yes	No	Yes
Greencastle is developing a stormwater management plan – does the city have sufficient resources to implement and manage that plan?	Yes	The City of Greencastle is a MS4 (stormwater) community and is therefore mandated to create a program that focuses on stormwater water quality.	Yes	No	Yes
Water quality concerns – sediment, nutrient, pathogen levels are elevated within watershed streams	Yes	65% of nitrate and 41% of TP samples exceed targets during the current sampling period. Historic samples show elevated TSS, N, P, and *E. coli* concentrations in Big Walnut Creek streams	Yes	No	Yes
Water quality is poor at Glenn Flint Lake	Yes	Water clarity is poor in Glenn Flint Lake measuring less than the average lake in Indiana.	Yes	No	Yes
Lack of resources to sufficiently support implementation	Unknown at this time	Alternatives and BMPs have yet to be developed for the watershed. It is unknown what resources will be necessary for implementation. If more funding were available, additional improvements could be enacted.	Unknown at this time	No	Yes

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Nutrient runoff and sedimentation to Heritage Lake	Yes	Historic data indicate elevated nutrients entering Heritage Lake; on-going dredging provides anecdotal support	Yes	No	Yes
Sedimentation - Silt removal / dredging from reservoirs	yes	Heritage Lake has conducted a dredging operation for the past 15 years ($60,000/year minimum).	Yes	No	Yes
Water clarity is poor at Heritage Lake	Yes	Water clarity measured 5.5 feet – all of which rated poorer than most lakes in Indiana.	Yes	No	Yes
Blue green algae blooms occurring in watershed reservoirs	Yes	Indiana Clean Lakes Program data indicate that blue green algal blooms have occurred within Glenn Flint Lake in the past.	Yes	No	Yes
Big Walnut Creek is muddy when it rains	Yes	148.9 miles of tributary streambank were identified as eroding during the windshield survey. 64.5% of the watershed is covered by agricultural land use while urban land uses cover 6.5% of the watershed. Historical sampling shows TSS samples consistently exceed target concentrations.	Yes	No	Yes
Streams are more flashy than historically / Water infiltration and storage is needed to slow the flow of water into streams	Yes	6.5% of the watershed is mapped as developed land.	Yes	Yes	No, this will be addressed by implementation of concerns
Lowhead dam on Big Walnut Creek	Yes	One low head dam is located on Big Walnut Creek.	Yes	No	Yes, education and history of the dam at a minimum
Groundwater/well issues	No	Anecdotal evidence based on communication with stakeholders as data have not been compiled.	Not at this time	Yes	No

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Stream channel is migrating to a new location	Yes	148.9 miles of tributary streambank were identified as eroding during the windshield survey. More than 54% of the watershed is mapped in highly erodible or potentially highly erodible soils. USGS Channel-Migration Rates for Big Walnut Creek show an actively migrating stream reach.	Yes	Yes	No
Flooding – loss of farmland each time it floods	Yes	64.5% of the watershed is covered by agricultural land use. 8% of the watershed is mapped in floodplain with more than 97% of floodplain in agricultural land uses.	Yes	No	Yes, education and targeted implementation
Developments are not utilizing proper stabilization techniques	Yes	Developments not utilizing proper BMPs were not identified during the windshield survey. Rule 5 requires stabilization techniques.	Yes	No	Yes
Development is diffuse – lots of small developments in historically forested or agricultural areas	Yes	6.5% of the watershed is mapped as developed land.	Yes	No	Yes
Trash is dumped in watershed streams	Yes	Individual observations (15) during the watershed inventory indicate trash accumulation is a concern.	Yes	No	Yes, education
Woodlots are impacted by erosion – losing more trees each time it rains	Yes	Anecdotal evidence based on communication with stakeholders as data have not been compiled.	Yes	Yes	Yes, covered under streambank erosion
Greencastle well fields lie within the Big Walnut drainage – award winning for taste – need to maintain quality	Yes	Water wellhead protection area is 100% located within the watershed.	Yes	No	No, covered by other implementation and education efforts of other concerns

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Fish populations are impacted by changes in streams – more erosion and more sediment	Yes	IBI scores rate as fair to good which are on par with Gammon and 2008 & 2009 assessments.	Yes	No	Yes
Chemicals from farming are impacting Big Walnut	Yes	An estimated 9953 tons of nitrogen and 4923 tons of phosphorus are applied in Boone, Hendricks, and Putnam Counties. An estimated 84 tons of atrazine and 112 tons of glyphosate are applied in these Counties.	Yes	No	Yes
Stream water levels are lower than historically observed	Yes	Anecdotal evidence based on communication with stakeholders; however, USGS stream gage data do not support anecdotal information.	Yes	Yes	No
Concern that there may be interest in damming Big Walnut or tributaries for flood control	No	Anecdotal evidence based on communication with stakeholders. Options for installing a dam in Big Walnut were dropped in the 1970s.	No	Yes	No
Invasive species are present in natural areas/forested areas along streams	Yes	Anecdotal evidence of several invasive species observations in riparian areas during the windshield survey.	Yes	No	Yes
How will this planning process affect me, my taxes or my property?	No	It is not anticipated that property taxes will increase due to the watershed planning process.	No	Yes	No
Septic usage on soils which are limited for treatment – education focus	Yes	More than 95% of the watershed is mapped in soils which are severely limited for septic tank usage.	Yes	No	Yes
Soil erosion	Yes	64.5% of the watershed is covered by agricultural land use. More than 54% of the watershed is mapped in highly erodible or potentially highly erodible soils.	Yes	No	Yes

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Limited public access	Yes	Public access sites are available at US 36 and McCloud Nature Park	Yes	No	Yes, no additional access points are planned at this time
Industrial impacts	Yes	21 documented NPDES permitted located occur in the watershed. Two of these are industrial in nature; neither possess documented releases that affected their permit.	Yes	Yes	No
Confined feeding operations/ unregulated animal operations and associated manure	Yes	Approximately 37,672 animals per year are housed in CFOs and small unregulated animal operations in the watershed, generating approximately 209,336 pounds of manure per year spread throughout the watershed. Manure produced on permitted CFOs contains nearly 459,627 pounds of nitrogen and 337,411 pounds of phosphorus.	Yes	No	Yes
Limited education about adequate forestry BMPs	Yes	Anecdotal evidence indicates that landowners are not aware of forestry BMPs they should be requesting be installed during and post logging	Yes	No	Yes

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: groundwater/wells, Greencastle wellhead protection, infiltration, channel migration, dams being installed on Big Walnut/tributaries, property tax increases due to planning, and industrial impacts. While these are valid issues, these concerns do not fall within the scope of the project. Therefore, these concerns will not be addressed in this watershed management plan.

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 51. Problems represent the condition that exists due to a particular concern or group of concerns. Table 52 details potential causes of problems identified in Table 51.

Table 51. Problems identified for the Big Walnut Creek watershed based on stakeholder and inventory concerns.

Concern(s)	Problem
• Development is diffuse – lots of small developments in historically forested or agricultural areas • Invasive species are present in natural areas/forested areas along the stream • Soil erosion • Fish populations are impacted by changes in streams- more erosion, more sediment • Silt removal/dredging from reservoirs • Developments are not utilizing proper stabilization techniques • Water quality is poor in Glenn Flint Lake • Water quality concerns – sediment, nutrient, pathogens levels are elevated • Water clarity is poor in Heritage lake • Nutrient runoff • Flooding – loss of farmland each time it floods • Streambank erosion • Big Walnut Creek is muddy when it rains • Livestock access to the stream • Water quality concerns – sediment, nutrient, pathogen levels are elevated	Area streams are very cloudy and turbid
• Livestock access to the stream • Blue green algae blooms occurring in watershed reservoirs • Water clarity is poor in Heritage Lake • Septic usage on soils which are limited for treatment • Livestock access to stream • Confined feeding operations/unregulated animal operations and associated manure • Water quality concerns – sediment, nutrient, pathogens levels are elevated • Nutrient runoff • Trash is dumped in watershed streams	Area streams are impaired for recreational contact by IDEM's 303(d) list (high *E. coli*)

Concern(s)	Problem
• Development is diffuse – lots of small developments in historically forested or agricultural areas • Invasive species are present in natural areas/forested areas along the stream • Soil erosion • Fish populations are impacted by changes in streams- more erosion, more sediment • Silt removal/dredging from reservoirs • Developments are not utilizing proper stabilization techniques • Water quality is poor in Glenn Flint Lake • Water quality concerns – sediment, nutrient, pathogens levels are elevated • Water clarity is poor in Heritage lake • Nutrient runoff • Flooding – loss of farmland each time it floods • Streambank erosion • Big Walnut Creek is muddy when it rains • Blue green algae blooms occurring in watershed reservoirs • Livestock access to the stream • Confined feeding operations/unregulated animal operations and associated manure • Septic usage on soils which are limited for treatment	Area streams have nutrient levels exceeding the target set by this project
• Water clarity is poor in Heritage Lake • Septic usage on soils which are limited for treatment • Greencastle is developing a stormwater plan • Lowhead dam on Big Walnut Creek • Livestock access to stream • Chemicals from farming are impacting Big Walnut • Confined feeding operations/unregulated animal operations and associated manure • Limited education about adequate forestry BMPs • Developments are not utilizing proper stabilization techniques • Invasive species are present in natural/forested areas along streams • Nutrient runoff • Trash is dumped in watershed streams	A unified education program for entire watershed does not currently exist

Concern(s)	Problem
• Resources to sufficiently support implementation • Streambank erosion • Water quality concerns – sediment, nutrient, pathogens levels are elevated	
• Trees in the stream • Lowhead dam on Big Walnut Creek • Blue green algae blooms occurring in watershed reservoirs • Limited public access • Water clarity is poor in Heritage Lake • Water quality is poor in Glenn Flint Lake • Fish populations are affected by changes in streams – more erosion, more sediment • Big Walnut Creek is muddy when it rains • Trash is dumped in watershed streams	Recreation should be promoted/amplified

Table 52. Potential causes of identified problems in the Big Walnut Creek watershed.

Problem	Potential Cause(s)
Area streams are very cloudy and turbid	Total Suspended Sediment concentrations and turbidity levels exceed the targets set by this project
Area streams have nutrient levels exceeding the targets set by this project	Nutrient levels exceed the target set by this project
Areas streams are impaired by IDEM for recreational contact	*E. coli* levels exceed the water quality standard
A unified education program for entire watershed does not currently exist	Educational efforts targeting funders, local agencies, and the public are lacking.
Recreation should be promoted/amplified	Recreation promotion efforts targeting local residents, tourists, nature enthusiasts 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 Big Walnut 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 Big Walnut Creek Watershed for each of our concerns is listed below:

Nutrients (Nitrogen and Phosphorus):

- Conventional tillage cropping practice
- 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, package plants, inadequately treated wastewater)
- Development impacts (diffuse, disorganized, lack of proper stabilization technique use)
- Invasive species impacts to land cover/soil stability
- Reservoir dredging activities
- Stormwater from municipal sources (MS4s)

Sediment:
- Conventional tillage cropping practice
- Streambank and bed erosion
- Poor riparian buffers
- 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)

E. coli:
- Human waste (failing septic systems, package plants, 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 Big Walnut Creek Watershed. Appendix E contains tables detailing each potential source within each subwatershed. Table 53 through Table 56 summarizes the magnitude of potential sources of pollution for each problem identified in the Big Walnut Creek Watershed. Several sources listed above are not included below as specific data for each concern is not available: conventional tillage by subwatershed; wastewater treatment discharges (compliance issues or violations were not identified as an issue); 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); and reservoir dredging activities. It should be noted that Heritage Lake has an active dredging program while other reservoirs are considering dredging options in the future.

Table 53. Potential sources causing nutrient problems.

Problems:	Nutrient concentrations threaten the health of Big Walnut Creek and its tributaries.
Potential Causes:	Nutrient concentrations exceed target values set by this project.
Potential Sources:	• 53 livestock access areas (21.6 miles of streams) were observed throughout the watershed. The highest percent of stream miles accessed by livestock were found in the West Fork Big Walnut Creek (12%), Ramp Run-East Fork Big Walnut Creek (9%), Ross Ditch-East Fork Big Walnut Creek (7%), and Town of Barnard-Big Walnut Creek (4%) subwatersheds. • 412 unregulated animal operations were observed housing nearly 3,510 animals throughout the watershed. The highest number of operations was observed in the Headwaters Deer Creek (50), Ramp Run-East Fork Big Walnut Creek (49), Ross Ditch-East Fork Big Walnut Creek (43), Headwaters Little Walnut Creek (28), and Clear Creek (28) subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading. • 33.9 miles of stream lack adequate buffers. The highest percent of stream miles needing buffers were found in Ross Ditch-East Fork Big Walnut Creek (33%), West Fork Big Walnut Creek (26%), Ramp Run-East Fork Big Walnut Creek (21%), Headwaters Little Walnut Creek (20%) and Leatherman Creek-Little Walnut Creek (18%) subwatersheds. • 148.9 miles of stream lack adequate stabilization, with the highest percent of stream miles lacking stabilization found in Eldin Ditch (69%), West Fork Big Walnut Creek (18%), and Ross Ditch-East Fork Big Walnut Creek (14%) subwatersheds. • Manure from confined feeding operations and small animal operations is applied across the Big Walnut Creek Watershed with more than 209,335 tons produced annually. More than 459,627 lb of N and 337,411 lb of P are delivered annually with this manure. • Failing septic systems add nutrients to the system within the rural portion of the watershed and in areas of dense unsewered housing. • Municipal wastewater sludge is applied to 4,653 acres of the Big Walnut Creek Watershed. • The Greencastle MS4 lies completely within the Big Walnut Creek Watershed (Section 2.7.6).

Table 54. 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:	• 53 livestock access areas (21.6 miles of streams) were observed throughout the watershed. The highest percent of stream miles accessed by livestock were found in the West Fork Big Walnut Creek (12%), Ramp Run-East Fork Big Walnut Creek (9%), Ross Ditch-East Fork Big Walnut Creek (7%), and Town of Barnard-Big Walnut Creek (4%) subwatersheds. • 33.9 miles of stream lack adequate buffers. The highest percent of stream miles needing buffers were found in Ross Ditch-East Fork Big Walnut Creek (33%), West Fork Big Walnut Creek (26%), Ramp Run-East Fork Big Walnut Creek (21%), Headwaters Little Walnut Creek (20%) and Leatherman Creek-Little Walnut Creek (18%) subwatersheds. • 21-30% of corn fields and 21-42% of soybean fields are under conventional tillage. • 148.9 miles of stream lack adequate stabilization, with the highest percent of stream miles lacking stabilization found in Eldin Ditch (69%), West Fork Big Walnut Creek (18%), and Ross Ditch-East Fork Big Walnut Creek (14%) subwatersheds. • 412 unregulated animal operations were observed housing nearly 3,510 animals throughout the watershed. The highest number of operations was observed in the Headwaters Deer Creek (50), Ramp Run-East Fork Big Walnut Creek (49), Ross Ditch-East Fork Big Walnut Creek (43), Headwaters Little Walnut Creek (28), and Clear Creek (28) subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading. • 66,265 acres of agricultural land are located on highly erodible soils while 81,144 acres of agricultural land are located on potentially highly erodible soils. The highest density of HES and PHES occur in Deweese Branch-Deer Creek (68%), Dry Branch-Big Walnut Creek (66%), Owl Creek (65%), Owl Branch-Deer Creek (63%), Headwaters Little Walnut Creek (63%), Leatherman Creek-Little Walnut Creek (61%), and Snake Creek-Big Walnut Creek (61%). • The Greencastle MS4 lies completely within the Big Walnut Creek Watershed (Section 2.7.6).

Table 55. 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:	• 53 livestock access areas (21.6 miles of streams) were observed throughout the watershed. The highest percent of stream miles accessed by livestock were found in the West Fork Big Walnut Creek (12%), Ramp Run-East Fork Big Walnut Creek (9%), Ross Ditch-East Fork Big Walnut Creek (7%), and Town of Barnard-Big Walnut Creek (4%) subwatersheds. • 412 unregulated animal operations were observed housing nearly 3,510 animals throughout the watershed. The highest number of operations was observed in the Headwaters Deer Creek (50), Ramp Run-East Fork Big Walnut Creek (49), Ross Ditch-East Fork Big Walnut Creek (43), Headwaters Little Walnut Creek (28), and Clear Creek (28) 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 Big Walnut Creek Watershed with more than 209,335 tons produced annually. More than 459,627 lb of N and 337,411 lb of P 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. • Municipal wastewater sludge is applied to 4,653 acres of the Big Walnut Creek Watershed. • The Greencastle MS4 lies completely within the Big Walnut Creek Watershed (Section 2.7.6).

Table 56. Potential sources causing education problems.

Problems:	• Individuals lack knowledge of what could/should be implemented, where to site practices, and how to fund implementation. • A unified education plan is lacking.
Potential Causes:	• Educational efforts targeting funders, local agencies, and the public are lacking.
Potential Sources:	N/A

Table 57. Potential sources causing recreational access problems.

Problems:	• River/natural area accessibility needs to be increased.
Potential Causes:	• Public access to the creeks is limited.
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 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 Big Walnut Creek Watershed: 1) measured results from the monitoring regime 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. These 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 discussed in Section 3.1, twelve monitoring sites were sampled from August 2018 – October 2018 and April 2019 – August 2019. There is clear value in using these measurements from the Big Walnut Creek Watershed to estimate loads and load reductions. However, there are some limitations in the measured dataset. Sampling methods did not allow for continuous flow measurements at each site, so data from the closest USGS gage (Big Walnut Creek near Reelsville USGS 03357500) was used to approximate flow. These continuous flow numbers combined with grab sample data were used to create load duration curves. These curves represent the current loading rate for each parameter calculated at each sample site.

As discussed above, the steering committee selected water quality benchmarks for nitrate-nitrogen, total phosphorus, total suspended solids, and *E. coli* that will significantly improve water quality in Big Walnut Creek (Table 17). Target loads needed to meet these benchmarks were calculated for each subwatershed for each parameter. The current loading rate was calculated using fixed station water chemistry data collected monthly by the IDEM at the mouth of Big Walnut Creek (Reelsville) and water chemistry data collected from April to October as part of the current project at the Deer Creek mouth. Flow data from the USGS Big Walnut Creek stream gage at Reelsville was utilized for calculating loading rates for the Big Walnut Creek Watershed. These flows were scaled to the Deer Creek drainage area to calculate Deer Creek loading rates. Concentration data collected monthly (Big Walnut Creek) or biweekly (Deer Creek) was multiplied by the representative days between sampling events (typically 8-15 days for biweekly and 30 days for monthly) and then by the average flow during that period of time. Load reduction targets were calculated using the water quality targets selected by the steering committee for each parameter. 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 58 to Table 61).

Table 58. Current and target nitrogen load reduction needed to meet water quality target concentrations in the Big Walnut Creek Watershed.

	Current Load (lb/year)	Target Load (lb/yr)	Load Reduction (lb/year)	% Reduction
Big Walnut	1,292,842.9	21,923.8	1,270,919.1	98%
Deer	174,928.68	5,993.01	168,935.7	97%

Table 59. Current and target phosphorus load reduction needed to meet water quality target concentrations in the Big Walnut Creek Watershed.

	Current Load (lb/year)	Target Load (lb/yr)	Load Reduction (lb/year)	% Reduction
Big Walnut	42,107.1	1,169.3	40,937.9	97%
Deer	5,247.7	319.6	4,928.0	94%

Table 60. Current and target total suspended solids load reduction needed to meet water quality target concentrations in the Big Walnut Creek Watershed.

	Current Load (lb/year)	Target Load (lb/yr)	Load Reduction (lb/year)	% Reduction
Big Walnut	237,031,477.2	219,237.9	236,812,239.3	99.91%
Deer	52,894,107.4	59,930.1	52,834,177.3	99.89%

Table 61. Current and target *E. coli* loads in pounds/year and load reduction needed to meet water quality target concentrations in the Big Walnut Creek Watershed.

	Current Load (lb/year)	Target Load (lb/yr)	Load Reduction (lb/year)	% Reduction
Big Walnut	4.16E+15	1.56E+13	4.15E+15	99.63%
Deer	2.54E+15	4.26E+12	2.54E+15	99.83%

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.

Using the list of potential sources developed for each parameter of concern as a base, the steering committee developed a mechanism for determining critical areas for each parameter. GIS-based mapping data from desktop and windshield survey efforts, loading calculations, and current and historic water quality data were used as a basis for decision-making. Data for each subwatershed are detailed in Appendix E. The steering committee divided into teams to review subwatershed data and develop a criteria list for each parameter. For each parameter, each subwatershed was evaluated to determine whether it met each criteria developed by each steering committee team. Teams presented their suggested criteria for each parameter to the entire steering committee and the steering committee reviewed, modified, if needed, and finalized criteria for each parameter. Each parameters criterion is detailed in subsequent sections. Each subwatershed was scored based on the total number of criteria that were met (1=yes, 0=no) and the subwatersheds with the highest scores were prioritized as critical areas for each parameter.

8.1 Critical Areas for Nitrate-Nitrogen and Total Phosphorus

Nitrate-nitrogen was the nitrogen form used to determine our critical areas. Total phosphorus was the form of phosphorus used to determine phosphorus critical areas (Figure 96). Nitrate-nitrogen and total phosphorus are readily available in watershed, entering surface water via; human and animal waste, fertilizer use, and tile drains on agricultural lands. Phosphorus enters the watershed through streambank and bed erosion, unfiltered runoff, agricultural land use in floodplains, stormwater runoff, and livestock access. Based on the data reviewed by the steering committee, the following criteria were priorities for nutrient critical areas:

- 70% or higher nitrate-nitrogen concentrations exceeding targets in historic samples
- 70% or higher TP concentrations exceeding targets in historic samples
- Tons of manure greater than 10,000 tons
- Agricultural land covers more than 75% of the subwatershed
- Livestock access to greater than 2 miles or greater than 4% of the subwatershed stream length

Critical subwatersheds were determined as follows: Ross Ditch-East Fork Big Walnut Creek, Ramp Run-East Fork Big Walnut Creek, West Fork Big Walnut Creek, Town of Barnard-Big Walnut Creek, Dry Branch-Big Walnut Creek.

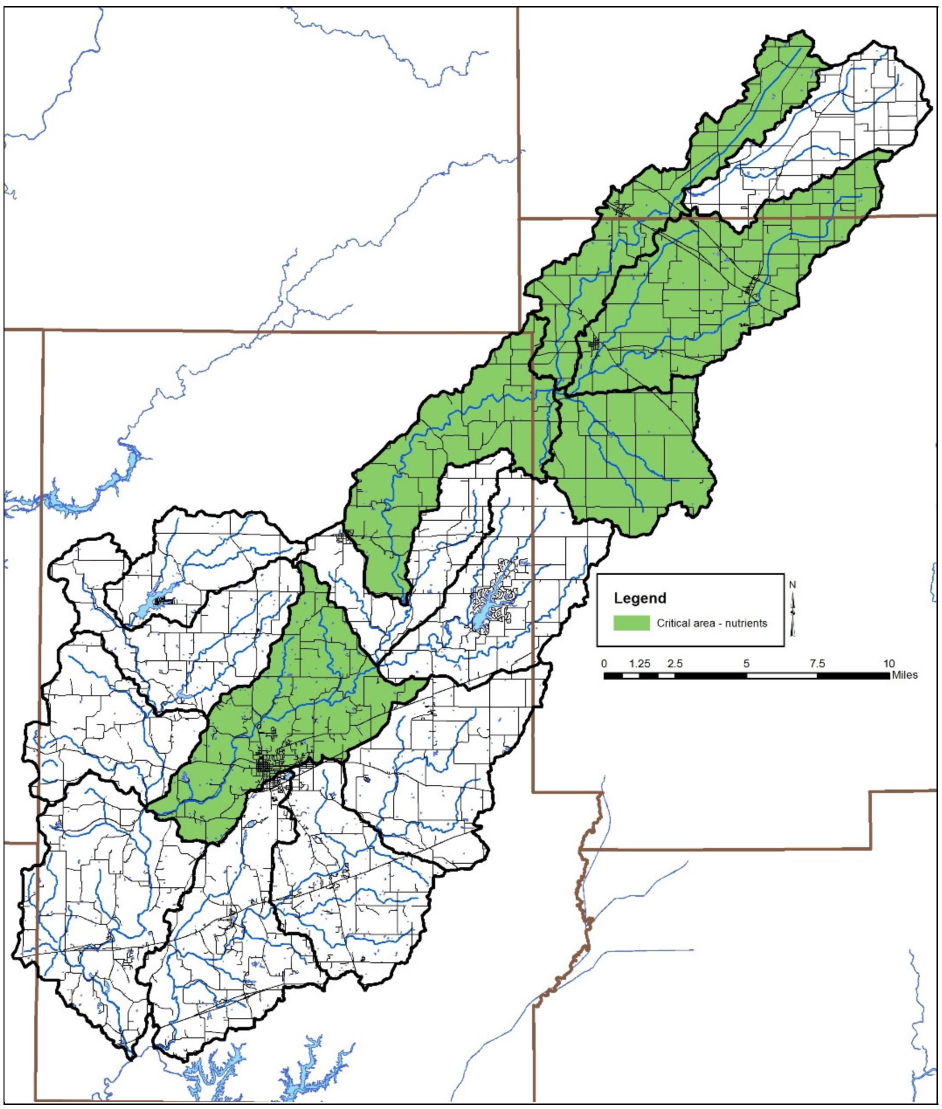

Figure 96. Critical areas for nutrients in the Big Walnut Creek Watershed.

8.2 Critical Areas for Sediment

Total suspended solids concentrations were used to determine sediment-based critical areas (Figure 97). Total suspended solids enter streams the watershed through streambank and bed erosion, unfiltered runoff, agricultural land use in floodplains, stormwater runoff, and livestock access. Based on the data reviewed by the steering committee, the following targets were priorities for sediment critical areas:

- Agricultural land higher than 75%
- TSS 45% or higher historic data
- Urban land use 7% or higher
- PHES+HES 60% or higher
- Streambank erosion >20%

Critical subwatersheds were determined as follows: Ross Ditch-East Fork Big Walnut Creek, Ramp Ditch-East Fork Big Walnut Creek, Clear Creek, Snake Creek-Big Walnut Creek, West Fork Big Walnut Creek, Headwaters Little Walnut Creek, Owl Branch-Deer Creek, Deweese Branch-Deer Creek, Dry Branch-Big Walnut Creek.

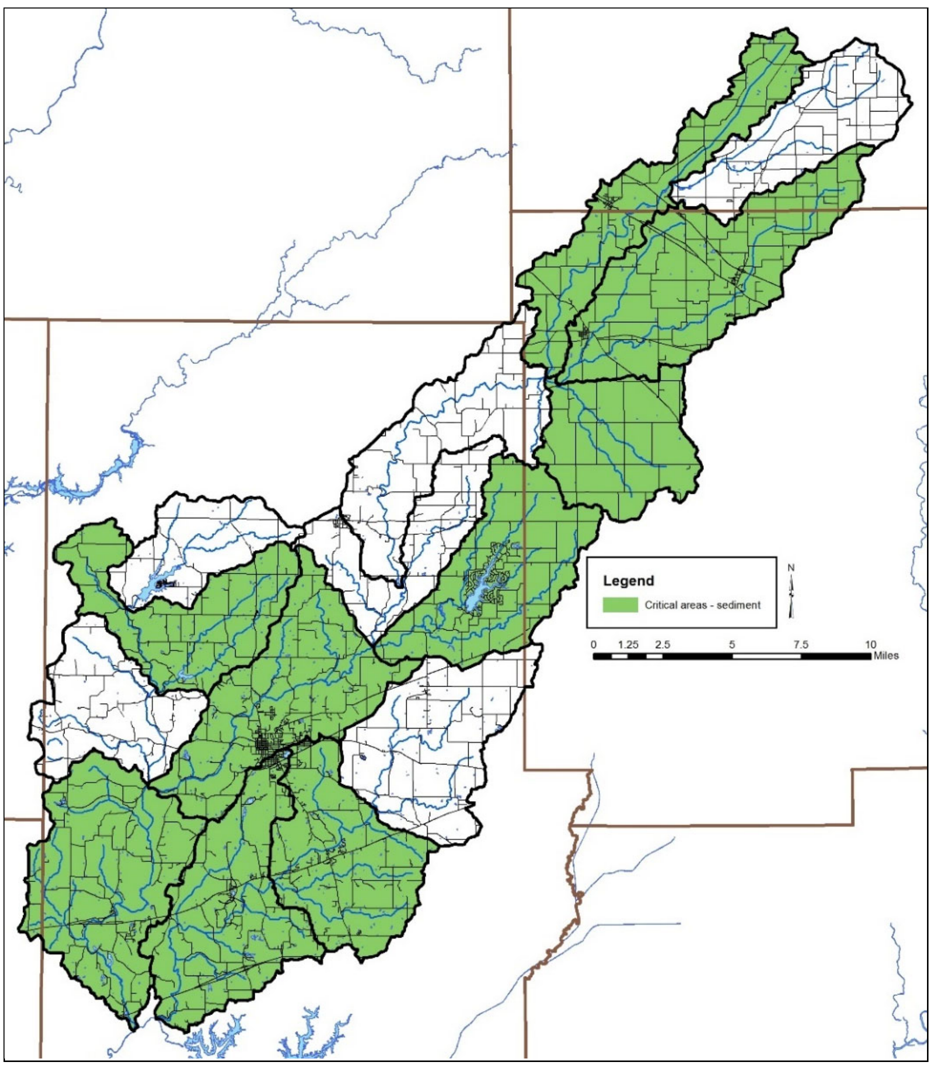

Figure 97. Critical areas for sediment in the Big Walnut Creek Watershed.

8.3 Critical Areas for *E. coli*

E. coli concentrations were used to determine *E. coli*-based critical areas (Figure 98). *E. coli* enters streams in the watershed through human and animal waste, livestock access, and infrastructure issues. Additional areas of concern, such as areas with manure management issues or failing septic systems, may also be included. While those areas have not been quantified, dense unsewered areas were included as a method for identifying these areas. Based on the data reviewed by the steering committee, the following targets were priorities for *E. coli* critical areas:

- Tons of manure greater than 10,000 tons
- Livestock access to streams higher than 2 miles or 4% of subwatershed streams
- Septic soils cover more than 85% of the subwatershed
- % *E. coli* impairment 40% or higher

Critical subwatersheds were determined as follows: Ross Ditch-East Fork Big Walnut Creek, Ramp Run-East Fork Big Walnut, West Fork Big Walnut Creek, Leatherman Creek-Little Walnut Creek, Headwaters Deer Creek, Town of Barnard-Big Walnut Creek, Dry Branch-Big Walnut Creek.

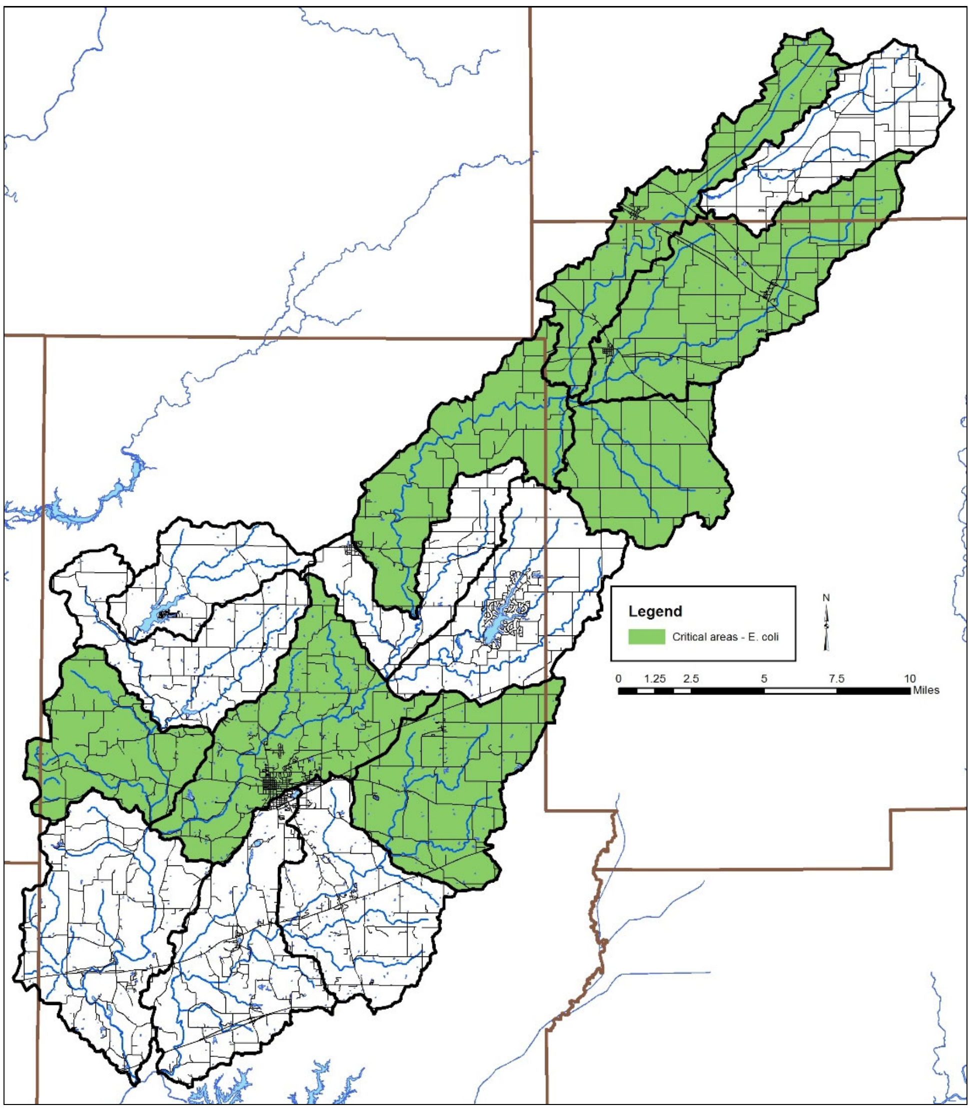

Figure 98. Critical areas for *E. coli* in the Big Walnut Creek Watershed.

8.4 Critical Areas Summary

The subwatersheds identified as critical areas for each parameter are summarized in Figure 96 to Figure 98. To identify the highest priority subwatersheds, the steering committee decided to divide them into three tiers (high, medium and low priority), based on the number of parameters that were determined to be critical. The highest priority subwatersheds are those that were determined to be critical for three parameters of the three potential parameters (nutrients, sediment and *E. coli*). The medium priority subwatersheds are those that were determined to be critical for two of three potential parameters. The lowest priority subwatersheds were critical for one of three potential parameters (Figure 99). Three subwatersheds, Bledsoe Branch-Big Walnut Creek, Eldin Ditch and Owl Creek, were not prioritized as critical areas meaning they were not identified as the areas of highest concern for any of the four parameters (nitrogen, phosphorus, sediment or pathogens). It is anticipated that implementation efforts will be targeted at these watersheds as part of EPA-funded implementation efforts only after implementation efforts are exhausted in higher priority areas. Implementation via other funding sources, via landowner interest in NRCS-based federal funding programs will occur as landowners are interested. The Big Walnut Creek stakeholder group will continue volunteer monitoring efforts to continue to assess the quality of these subwatersheds and identify any changes in water quality as they occur.

After setting initial goals, the steering committee reviewed the likelihood of meeting water quality targets based on these critical areas. Based on the projected low likelihood of successful implementation within such a limited area, the Big Walnut Creek steering committee adjusted their critical areas to make it much more likely for them to meet their goals. The steering committee noted the predominance of recreation on impoundments within the watershed and the propensity for these impoundments to hold sediment and nutrients from the watershed. As these impoundments act like sediment traps, it was suggested that the protection of these impoundments and the extension of their lifetime would positively impact the Big Walnut Creek Watershed. Given these benefits, critical areas were adapted to include the drainages, which include an impoundment measuring 12 acres or larger. These include drainages to Dogwood Springs Lake, Thomas Lake, Oakalla Lake, South Pond, Heritage Lake (includes Summersault Lake) and Glenn Flint Lake. Based on these revisions, high priority critical areas (Dry Branch-Big Walnut Creek, Ramp Run-East Fork Big Walnut Creek, Ross Ditch-East Fork Big Walnut Creek, West Fork Big Walnut Creek and the drainages of Dogwood Springs Lake, Thomas Lake, Oakalla Lake, South Pond, Heritage Lake (includes Summersault Lake) and Glenn Flint Lake) will be targeted for short term goal implementation. Problem areas identified in point and nonpoint sources of pollution figures for each high priority area should be targeted for initial implementation efforts. Likewise, when high priority critical areas have been fully addressed and implementation moves to medium priority areas of the watershed, portions of the watershed that were identified as medium priority critical areas (Town of Barnard-Big Walnut Creek) should be targeted before lower priority critical areas (Deweese Branch-Deer Creek, Headwaters Deer Creek, Headwaters Little Walnut Creek, Owl Branch-Deer Creek, Snake Creek-Big Walnut Creek). Specifically, implementation efforts should target problem areas identified in Figure 53, Figure 56, Figure 59, Figure 68, Figure 71, and Figure 80.

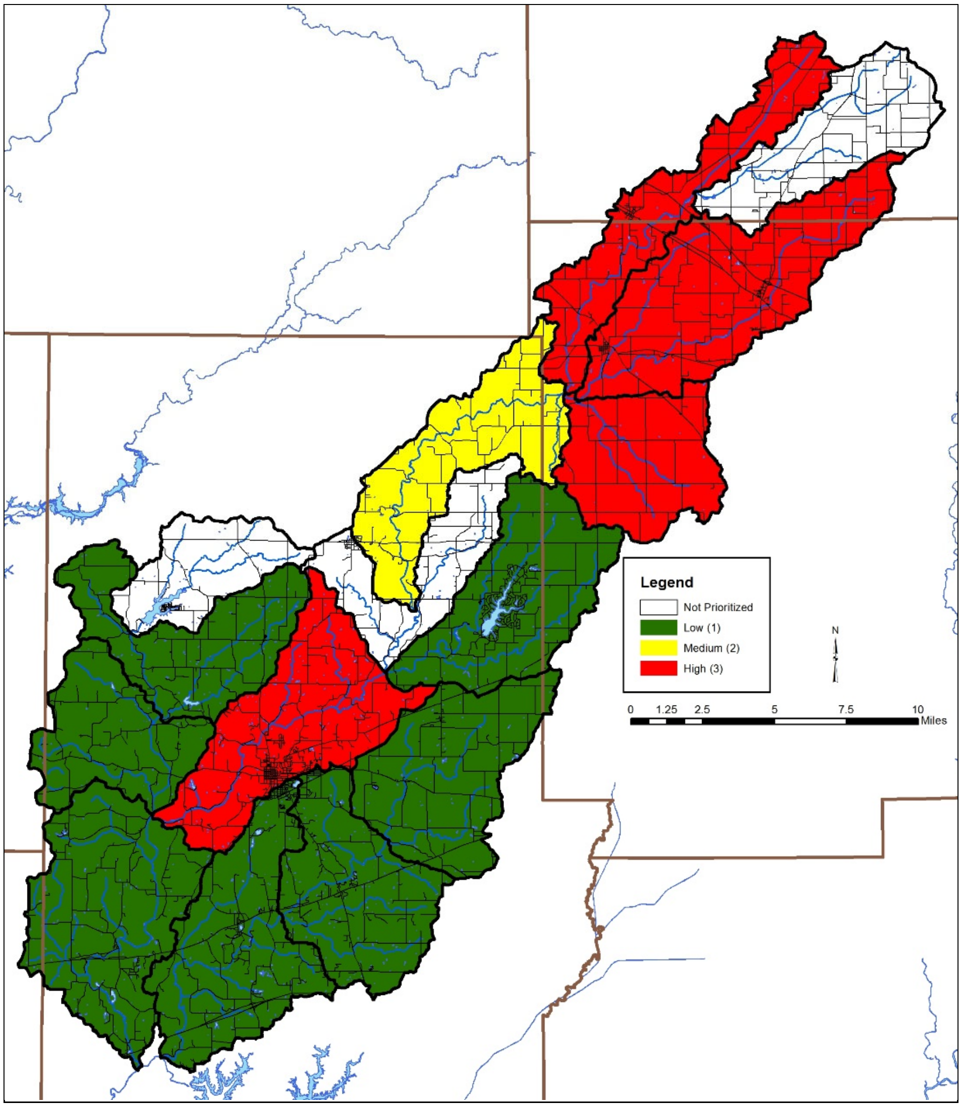

Figure 99. Prioritized critical areas in the Big Walnut Creek Watershed.

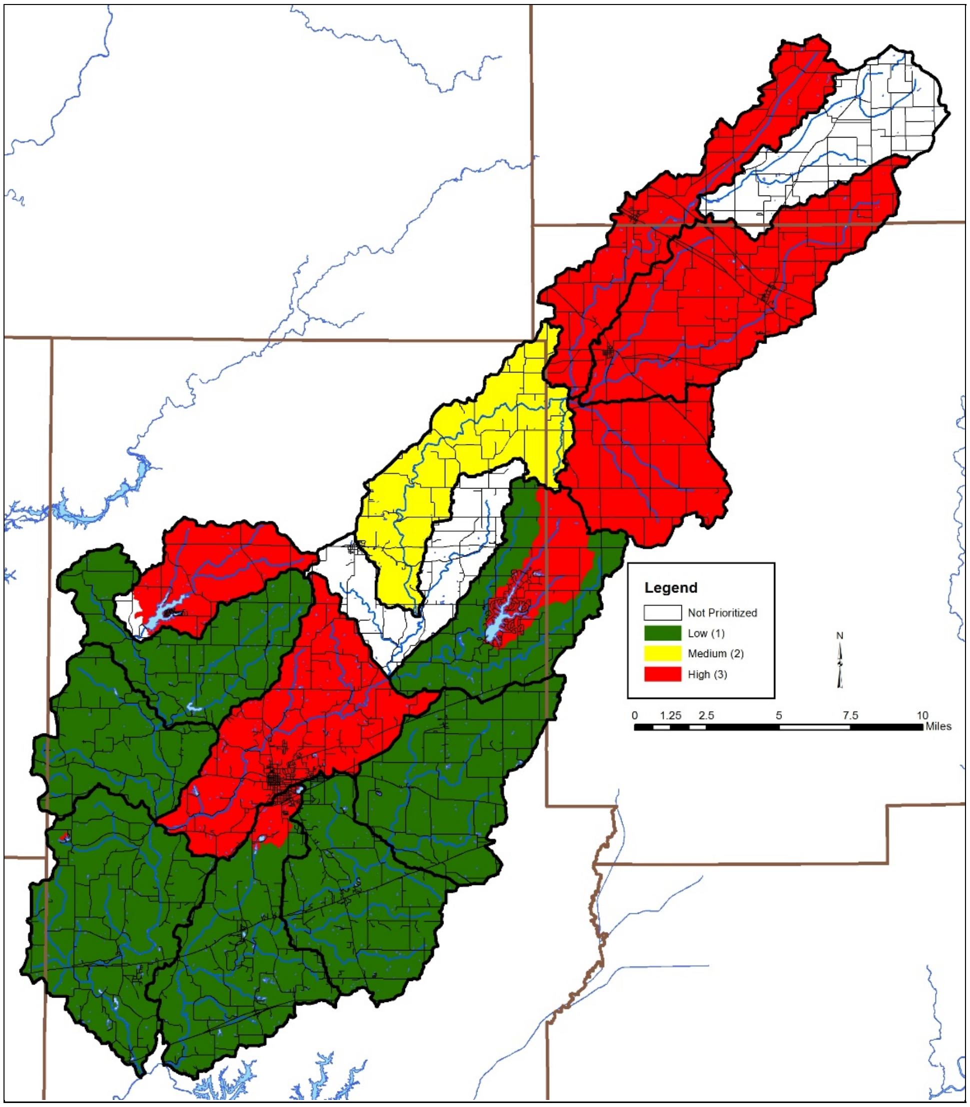

Figure 100. Critical areas prioritized via adaptive management in the Big Walnut Creek Watershed.

8.5 Critical Acre Determination

To be eligible for National Water Quality Initiative (NWQI) Funding, the Big Walnut 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 62 details critical acres by subwatershed based on the criteria selected for nutrient, sediment and *E. coli* critical areas. These acres within each of the prioritized critical areas identified in Figure 100 will be targeted for implementation in advance of moving on to lower priority critical acres within the priority subwatersheds. The technical committee will target hot spots or problem areas identified within each subwatershed including but not limit to 1) ensuring that all highly erodible lands and potentially highly erodible lands are 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 of the high volume of manure production within the Big Walnut Creek Watershed (Figure 101). Big Walnut Creek Watershed stakeholders identified the need for soils with septic limitation to be targeted for septic treatment; however, this is not an NWQI targeted practice and is therefore not included in Table 62. 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.

Table 62. Critical acres by subwatershed in the Big Walnut Creek Watershed.

Subwatershed Name	HUC	HEL Soils (acres)	Agricultural Land Use (acres)	Manure Volume (tons)
Eldin Ditch	051202030101	7,619.3	13,928	4,407
Ross Ditch-East Fork Big Walnut Creek	051202030102	12,517.0	23,121	10,106
Ramp Run-East Fork Big Walnut Creek	051202030103	5,105.7	13,377	42,892
West Fork Big Walnut Creek	051202030104	8,561.1	14,816	8,876
Owl Creek	051202030201	6,684.0	7,191	3,382
Headwaters Little Walnut Creek	051202030202	10,354.5	11,750	4,273
Leatherman Creek-Little Walnut Creek	051202030203	8,661.2	5,888	4,524
Headwaters Deer Creek	051202030301	9,399.4	14,226	26,905
Owl Branch-Deer Creek	051202030302	11,411.1	8,240	4,123
Deweese Branch-Deer Creek	051202030303	14,298.8	6,090	6,529
Town of Barnard-Big Walnut Creek	051202030401	8,613.1	11,690	58,989
Clear Creek	051202030402	7,839.8	14,685	1,061
Bledsoe Branch-Big Walnut Creek	051202030403	6,761.2	8,793	2,517
Dry Branch-Big Walnut Creek	051202030404	14,717.1	12,951	25,289
Snake Creek-Big Walnut Creek	051202030405	14,865.5	8,007	5,463

Subwatershed Name	Livestock Access (miles)	Streambank Erosion (miles)	Narrow Buffer (miles)
Eldin Ditch	0.6	2.2	16.3
Ross Ditch-East Fork Big Walnut Creek	3.3	16.3	6.7
Ramp Run-East Fork Big Walnut Creek	3.7	8.9	0.9
West Fork Big Walnut Creek	3.8	8.3	5.7
Owl Creek	1.2	7.1	1.4
Headwaters Little Walnut Creek	0.8	15.2	1.4
Leatherman Creek-Little Walnut Creek	0.3	12.3	0.0
Headwaters Deer Creek	0.9	11.9	0.0
Owl Branch-Deer Creek	0.9	4.8	0.0
Deweese Branch-Deer Creek	0.4	7.5	0.0
Town of Barnard-Big Walnut Creek	2.6	8.4	0.0
Clear Creek	1.0	10.1	1.5
Bledsoe Branch-Big Walnut Creek	1.4	10.5	0.0
Dry Branch-Big Walnut Creek	0.5	14.5	0.0
Snake Creek-Big Walnut Creek	0.2	10.9	0.0

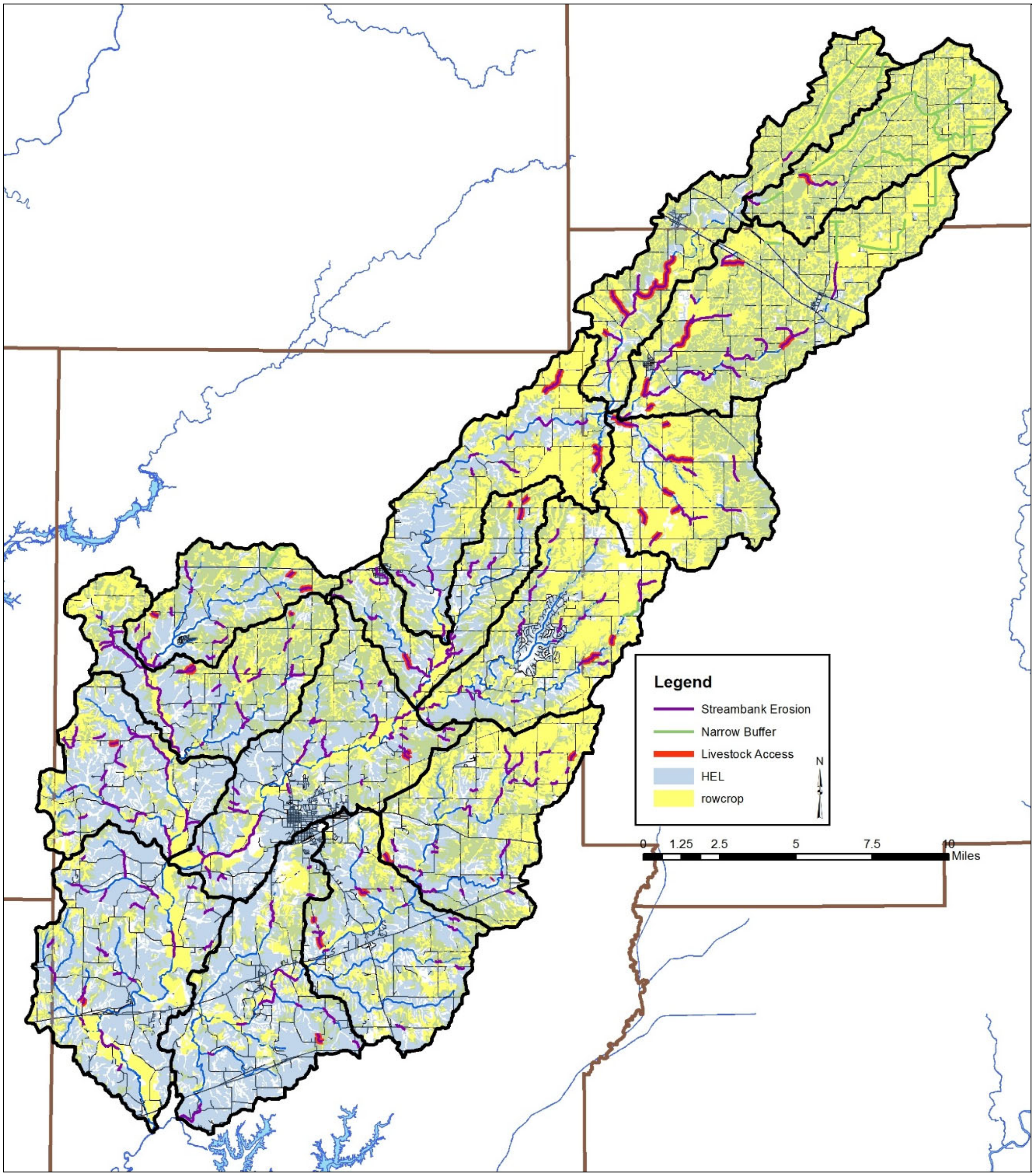

Figure 101. Critical acres in the Big Walnut Creek Watershed.

8.6 Current Level of Treatment

Based on data from NRCS, more than 15,300 acres of best management practices including but not limited to cover crops, nutrient and pest management, forage and biomass planting, forest and shrub restoration; 3,000 feet of fencing, access control, streambank stabilization and open channel construction; and more than 35 grade stabilization structures, waste storage facilities, watering facilities, WASCOBs and more have been implemented over the last 5 years in the Big Walnut Creek Watershed. Table 63 details practices by acre, linear foot or count.

Table 63. Practices installed from 2014-2018 in the Big Walnut Creek Watershed based on NRCS data in acres.

HUC	Access Road	Conservation Cover	Cover Crop	ES Habitat Dev/ Mgmt	Fence	Field Border	Filter Strip	Forage and Biomass Planting
051202030101			1447.50		0.02			10.30
051202030102		6.20	1152.00		0.06			31.50
051202030103		30.20	3089.80			7.30		
051202030104			22.40			0.90		
051202030201			742.20	40.30			13.30	
051202030202		51.40	399.40	19.00	0.14			78.70
051202030303		66.20	809.10					9.60
051202030401	0.03	11.10	178.70	1.00		19.00		
051202030402		11.20	407.50				14.80	
051202030403			1292.70			7.50		21.40
051202030404		4.40	712.10	0.30		29.50	19.90	169.90
051202030405			637.53					104.10
Total	**0.03**	**180.70**	**10890.93**	**60.60**	**0.22**	**64.20**	**48.00**	**425.50**

HUC	Grassed Waterway	HUAP	Lined Waterway	Prescribed Grazing	No-Till	Reduced Till
051202030101	3.60	0.40	0.02			
051202030102	6.80	0.44			391.20	
051202030103	12.20		0.01		1636.60	
051202030104	1.40		0.01		471.00	
051202030201	17.40		0.01			
051202030202	25.60	0.22	0.03	154.00	122.70	
051202030303					3.50	
051202030401	1.20		0.02		199.00	4.50
051202030402	13.90	0.03	0.03			53.70
051202030403	2.80		0.00		84.90	
051202030404	47.80	0.45	0.11			
051202030405	5.60	0.14	0.04		118.70	46.00
Total	**138.30**	**1.68**	**0.28**	**154.00**	**3027.60**	**104.20**

Table continued -Practices installed from 2014-2018 in the Big Walnut Creek Watershed based on NRCS data in acres.

HUC	Riparian Forest Buffer	Grade Stabilization Structure	Tree/Shrub Establishment	Upland WHM	WASCOB	Watering Facility
051202030101						0.10
051202030102	3.40					0.10
051202030103						
051202030104						
051202030201			8.10	4.50	0.60	
051202030202	31.00	0.10	14.50	34.10		0.60
051202030303	28.50		22.70	0.40		
051202030401		0.20	8.60	5.10		
051202030402	2.50				3.00	
051202030403		0.10			0.10	
051202030404	23.20		20.80	3.80		0.20
051202030405		0.10	5.90			0.20
Total	**88.60**	**0.60**	**80.60**	**47.90**	**3.70**	**1.20**

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 the mouth of Big Walnut Creek (Reelsville) and water chemistry data collected from April to October as part of the current project at the Deer Creek mouth. Flow data from the USGS Big Walnut Creek stream gage at Reelsville was utilized for calculating loading rates for the Big Walnut Creek Watershed. These flows were scaled to the Deer Creek drainage area to calculate Deer Creek loading rates. In an effort to scale goals to manageable levels, short term (5 year), medium term (15 year), and long term (30 year) goals were generated. The calculation process is described below:

1. Current and target loading rates were determined for the Big Walnut Creek and Deer Creek drainages. While high, medium and low priority subwatersheds were identified, the steering committee calculated loading rates and target reductions for the entire watershed. This decision was made to allow the committee to move from high to medium to low priority subwatersheds as projects are implemented, goals are met and as landowner interest and education efforts move throughout the watershed.
2. The steering committee selected a 10% reduction target for nutrients, sediment and *E. coli* levels and set their timeframe for achieving this goal as 5 years and termed these as short term goals.
3. Medium term goals were set to achieve a 50% reduction target for nutrients, sediment and *E. coli* levels. These goals are targeted for 15 years.
4. Long term goals will result in water quality nutrient, sediment and *E. coli* targets being met throughout the watershed in 30 years.

Reduce Nutrient Loading

Based on collected water quality data summarized for Big Walnut Creek and Deer Creek, the committee set the following short, medium, and long-term goals for nitrate-nitrogen and total phosphorus (Table 64 through Table 67).

Short term: Reduce total phosphorus inputs from 42,107 pounds per year to 37,896 pounds per year (10% reduction) and nitrate-nitrogen from 1,292,842 pounds per year to 1,163,558 pounds per year (10% reduction) in Big Walnut Creek in 5 years.

Reduce total phosphorus inputs from 5,247 pounds per year to 4,722 pounds per year (10% reduction) and nitrate-nitrogen from 174,928 pounds per year to 157,435 pounds per year (10% reduction) in Deer Creek in 5 years.

Medium Term: Reduce total phosphorus inputs from 37,896 pounds per year to 18,948 pounds per year (50% reduction) and nitrate-nitrogen from 1,163,558 pounds per year to 581,779 pounds per year (50% reduction) in Big Walnut Creek in 15 years.

Reduce total phosphorus inputs from 4,722 pounds per year to 2,361 pounds per year (50% reduction) and nitrate-nitrogen from 157,435 pounds per year to 78,717 pounds per year (50% reduction) in Deer Creek in 15 years.

Long term: Reduce total phosphorus inputs from 18,948 pounds per year to 1,169 pounds per year (94% reduction) and nitrate-nitrogen from 581,779 pounds per year to 21,9233.8 pounds per year (98% reduction) in Big Walnut Creek in 30 years.

Reduce total phosphorus inputs from 2,361 pounds per year to 319 pounds per year (86% reduction) and nitrate-nitrogen from 78,717 pounds per year to 5,993 pounds per year (92% reduction) in Deer Creek in 30 years.

Table 64. Nitrate-nitrogen short, medium, and long-term goal calculations for prioritized critical areas in Big Walnut Creek.

Big Walnut Creek	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (5 years)	1,292,842.9	129,284.3	1,163,558.6	10%
Medium Term (15 years)	1,163,558.6	581,779.3	581,779.3	50%
Long Term (30 years)	581,779.3	559,855.5	21,923.8	98%

Table 65. Nitrate-nitrogen short, medium, and long-term goal calculations for prioritized critical areas in Deer Creek.

Deer Creek	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (5 years)	174,928.7	17,492.9	157,435.8	10%
Medium Term (15 years)	157,435.8	78,717.9	78,717.9	50%
Long Term (30 years)	78,717.9	72,724.9	5,993.0	92%

Table 66. Total phosphorus short, medium, and long-term goal calculations for prioritized critical areas in Big Walnut Creek.

Big Walnut Creek	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (5 years)	42,107.1	4,210.7	37,896.4	10%
Medium Term (15 years)	37,896.4	18,948.2	18,948.2	50%
Long Term (30 years)	18,948.2	17,778.9	1,169.3	94%

Table 67. Total phosphorus short, medium, and long-term goal calculations for prioritized critical areas in Deer Creek.

Deer Creek	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (5 years)	5,247.7	524.8	4,722.9	10%
Medium Term (15 years)	4,722.9	2,361.4	2,361.4	50%
Long Term (30 years)	2,361.4	2,041.8	319.6	86%

Reduce Sediment Loading

Based on collected water quality data summarized for Big Walnut Creek and Deer Creek, the committee set the following short, medium, and long-term goals for total suspended solids (Table 68 and Table 69).

Short term: Reduce total suspended solids inputs from 237,031,477 pounds per year to 213,328,329 pounds per year (10% reduction) in Big Walnut Creek in 5 years. Reduce total suspended solids inputs from 52,894,107 pounds per year to 47,604,696 pounds per year (10% reduction) in Deer Creek in 5 years.

Medium Term: Reduce total suspended solids inputs from 213,328,329 pounds per year to 106,664,164 pounds per year (50% reduction) in Big Walnut Creek in 15 years. Reduce total suspended solids inputs from 47,604,696 pounds per year to 23,802,348 pounds per year (50% reduction) in Deer Creek in 15 years.

Long term: Reduce total suspended solids inputs from 106,664,164 pounds per year to 219,237 pounds per year (100% reduction) in Big Walnut Creek in 30 years. Reduce total suspended solids inputs from 23,802,348 pounds per year to 59,930 pounds per year (100% reduction) in Deer Creek in 30 years.

Table 68. Total suspended solids short, medium, and long-term goal calculations for prioritized critical areas in Big Walnut Creek.

Big Walnut Creek	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (5 years)	237,031,477.2	23,703,147.7	213,328,329.4	10%
Medium Term (15 years)	213,328,329.4	106,664,164.7	106,664,164.7	50%
Long Term (30 years)	106,664,164.7	106,444,926.9	219,237.9	100%

Table 69. Total suspended solids short, medium, and long-term goal calculations for prioritized critical areas in Deer Creek.

Deer Creek	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (5 years)	52,894,107.4	5,289,410.7	47,604,696.7	10%
Medium Term (15 years)	47,604,696.7	23,802,348.3	23,802,348.3	50%
Long Term (30 years)	23,802,348.3	23,742,418.2	59,930.1	100%

Reduce *E. coli* Loading

Based on collected water quality data summarized for Big Walnut Creek and Deer Creek, the committee set the following short, medium, and long-term goals for *E. coli* (Table 70 and Table 71).

<u>Short term:</u> Reduce *E. coli* inputs so that they do not exceed the state standard in Big Walnut Creek from $4.16x10^{15}$ col/year per year to $3.75\ x10^{15}$ col per year (10% reduction) in 5 years. Reduce *E. coli* inputs so that they do not exceed the state standard in Deer Creek from $2.54x10^{15}$ col/year per year to $2.29x10^{15}$ col per year (10% reduction) in 5 years.

<u>Medium term:</u> Reduce *E. coli* inputs so that they do not exceed the state standard in Big Walnut Creek from $3.75x10^{15}$ col/year per year to $1.87x10^{15}$ col per year (50% reduction) in 15 years. Reduce *E. coli* inputs so that they do not exceed the state standard in Deer Creek from $2.2\ x10^{15}$ col/year per year to $1.87x10^{15}$ col per year (50% reduction) in 15 years.

<u>Medium term:</u> Reduce *E. coli* inputs so that they do not exceed the state standard in Big Walnut Creek from $1.87x10^{15}$ col/year per year to $1.56x10^{13}$ col per year (99% reduction) in 30 years. Reduce *E. coli* inputs so that they do not exceed the state standard in Deer Creek from $1.14x10^{15}$ col/year per year to $4.26x10^{12}$ col per year (100% reduction) in 30 years.

Table 70. *E. coli* short, medium, and long-term goal calculations for prioritized critical areas in Deer Creek.

Big Walnut Creek	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (5 years)	$4.16x10^{15}$	$4.16x10^{14}$	$3.75\ x10^{15}$	10%
Medium Term (15 years)	$3.75x10^{15}$	$1.87x10^{15}$	$1.87x10^{15}$	50%
Long Term (30 years)	$1.87x10^{15}$	$1.86x10^{15}$	$1.56x10^{13}$	99%

Table 71. *E. coli* short, medium, and long-term goal calculations for prioritized critical areas in Deer Creek.

Deer Creek	Current Load (lb/yr)	Load Reduction (lb/yr)	Target Load (lb/yr)	Percent Reduction
Short Term (5 years)	$2.54x10^{15}$	$2.54x10^{14}$	$2.29x10^{15}$	10%
Medium Term (15 years)	$2.2\ x10^{15}$	$1.14x10^{15}$	$1.14x10^{15}$	50%
Long Term (30 years)	$1.14x10^{15}$	$1.14x10^{15}$	$4.26x10^{12}$	100%

Increase Public Awareness and Education

Short term: Increase the current level of outreach to engage a 5% increase of individuals in the watershed within 5 years.

Medium term: Increase the current level of outreach to engage a 25% increase of individuals in the watershed within 15 years.

Long term: Increase the current level of outreach to engage a 50% increase of individuals in the watershed within 30 years.

Promote and amplify recreation

The steering committee identified recreation access as a concern; however, determined that recreation issues would be addressed through education and outreach efforts and would not be included as a separate goal.

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 Big Walnut 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 Big Walnut Creek steering committee. Committee members reviewed potential practices taking into account the identified resource concerns, watershed land uses, and Big Walnut Creek Watershed Project goals. From the potential practice list, the most appropriate BMPs to remediate sources of pollution and address resource concerns in the Big Walnut 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 Big Walnut 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 Big Walnut Creek and Deer 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 Greencastle and small towns and reservoirs present throughout the watershed. It should be noted that specific forestry-based practices are not included in this list. Selected practices with descriptions are listed below.

Potential best management practices include the following:

Access Control
Bioretention – Rain Garden, Bioswale
Conservation Tillage: Residue and Tillage Management, No till/Strip till/Direct Seed
Conservation Cover
Consider soil characteristics to minimize runoff
Cover Crop
Dam removal (education focus)
Drainage Water Management
Fencing, Alternate Watering System
Field Border or Filter Strip
Forage and Biomass Planting

Forest Management
Grade Stabilization Structure and Mulching
Grassed Waterway
Greenways and Trails
Gypsum
Habitat Corridor Identification and Improvement
Heavy Use Area Protection
Invasive species removal
Livestock Restriction/Prescribed Grazing including Livestock Pipeline and Lined Waterway or Outlet
Manure Management Planning
Native plantings/pollinator gardens
Nutrient and/or Pest Management
Pervious Pavement
Phosphorus Free Fertilizer Usage
Rain Barrel
Saturated Buffer
Septic System Care and Maintenance (education focus)
Streambank Stabilization
Threatened and Endangered Species Protection
Tree/Shrub Establishment
Two Stage Ditch
University fertilization recommendations/Soil testing
Variable rate application
Vegetated Swale
Water and Sediment Control Basin
Wetland Creation, Wetland Enhancement, Wetland 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.

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.

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 Planting/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 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 cover crop vegetation recovers plant-available nutrients in the soil and recycles them through the plant biomass for succeeding crops.

Dam Removal

Low-head dams are man-made structures in rivers that pool upstream water for various reasons. Low-head dams, like the one on Big Walnut Creek upstream of Greencastle, 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.

While removal of the Big Walnut Creek lowhead dam is not proposed as part of this project, education about its impact on Big Walnut Creek and continued monitoring of its impacts on water quality, accessibility and public health should occur in the future.

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.

Fencing/Alternate Watering Systems

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.

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.

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. Purposes include: 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.

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.

Gypsum Application
Amending soil with gypsum, or calcium sulfate dehydrate-derived products, changes the physical and chemical properties of the soil. This practice is used to improve soil health by improving physical/chemical properties and increasing infiltration of the soil; improve surface water quality by reducing dissolved phosphorus concentrations in surface runoff and subsurface drainage; improve soil health by ameliorating subsoil aluminum toxicity; and improve water quality by reducing the potential for pathogens and other contaminants transported from areas of manure and bio solids application.

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

Invasive species removal
Every day, invasive species are threatening the health of our nation's vital agricultural and natural lands. Forests and rangelands are being infested, cropland production is being negatively impacted, streams and waterways are being choked with weeds, and wildlife species are losing habitat. These conditions are just a few of the negative impacts that will continue, or will become more severe, if successful actions are not taken to halt and/or reverse this trend.

Manure Management Planning
Large volumes of manure are generated by both small, unregulated animal operations and by confined feeding operations located throughout the Big Pine 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.

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.

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.

Phosphorus Free Fertilizer Usage

Phosphorus-free fertilizers are those fertilizers that supply nitrogen and minor nutrients without the addition of phosphorus. Phosphorus increases algae and plant growth which can cause negative impacts on water quality within aquatic systems. The Clear Choices, Clean Water program estimates that a one acre lawn fertilized with traditional fertilizer supplies 7.8 pounds of phosphorus to local waterbodies annually. Given that 75% of urban residents within the Region of the Great Bend of the Wabash River Watershed indicate either limited knowledge or that they don't use phosphorus free fertilizers, there is great potential for reducing urban sources of phosphorus by targeting this practice. Established lawns take their nutrients from the soil in which they grow and need little additional nutrients to continue plant growth. Fertilizers are manufactured in a variety of forms including that without phosphorus. Phosphorus-free fertilizer should be considered for use in areas where grass is already established.

Pollinator Habitat/Native plantings/pollinator gardens

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.

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.

Saturated Buffer

Saturated buffers are an option in situations where a field is bordered by a riparian buffer. The conventional practice is to extend the tile main line from the field, through the buffer and discharge the water directly into the receiving stream. Subsurface drainage water, therefore, bypasses the buffer and has no opportunity for interaction with the biota in the buffer. Saturated buffers provide a means for distributing some or all of the drainage water through the buffer. For the purpose of utilizing the buffer, a diverter box, or control structure, is installed on the tile main line at the edge between the field and the buffer. The diverter box is used to direct the water into a subsurface distribution pipe running parallel to the stream along the edge of the field. The distribution pipe is regular perforated drainage pipe. The drainage water can then seep out of the distribution pipe and into the soil and make its way down gradient to the stream. The nitrate in the water is removed by the buffer through denitrification, immobilization in bacterial biomass and plant uptake. An overflow discharge pipe to the stream is connected to the diverter box to allow bypass flow during times of high drainage flow rates, thereby ensuring that no water is being backed up in the main tile line.

Septic System Care, Maintenance, and Upgrades

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 Big Walnut 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.

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.

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 the Big Walnut 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.

Tree/Shrub Establishment/Reforestation including Invasive Control/Timber Stand Improvement
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.

Two-Stage Ditch
When water is confined to stream or ditch channel it has the potential to cause bank erosion and channel down-cutting. Current ditch design generates narrow channels with steep sides. Water flowing through these systems often result in bank erosion, channel scour and flooding. A relatively new technique focuses on mitigating these issues through an in-stream restoration called a two-stage ditch. The design of a two-stage ditch incorporates a floodplain zone, called benches, into the ditch by removing the ditch banks roughly 2-3 feet above the bottom for a width of about 10 feet on each side depending on the size of the channel. This allows the water to have more area to spread out on and decreases the velocity of the water. This not only improves the water quality, but also improves the biological conditions of the ditches where this is located.

The benefits of a two-stage ditch over the typical agricultural ditch include both improved drainage function and ecological function. The two-stage design improves ditch stability by reducing water flow and the need for maintenance, saving both labor and money. It also has the potential to create and maintain better habitat conditions. Better habitats for both terrestrial and aquatic species are a great plus when it comes to the two-stage ditch design. The transportation of sediment and nutrients is decreased considerably because the design allows the sorting of sediment, with finer silt depositing on the benches and coarser material forming the bed. A recent study by the University of Notre Dame found that the average two-stage ditch reduces the amount of sediment transported annually by over 100,000 pounds per half mile of two-stage (Tank, unpublished data).

University fertilization recommendations/Soil testing
Soil Testing can be used to determine Determines 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.

Variable Rate Application/Technologies
Precision agriculture is defined as a management system that uses information, technology, and site-specific data to manage variability within fields for optimum profitability, sustainability, and environmental protection. This method also includes guidance systems for agricultural equipment. The purposes of using precision agriculture are: To improve water quality by targeting pesticide or soil amendment applications to meet field-specific cropland yield capabilities; reduce the potential off-site impacts of fertilizer and pesticide applications; improve water quality by reducing pesticide and fertilizer inputs through avoidance of overlapping and end row/turn row applications; reduce surface runoff and
through precisely controlled cropping equipment, resulting in less fuel being used; reduce compaction by limiting traffic to specified travel lane; and increase opportunity to operate equipment after dark.

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.

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 (FOTG Code 638, NRCS, 2011).

Wetland Construction or Restoration
Visual observation and historical records indicate at least a portion of the Big Walnut 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 72 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 73 outlines suggested BMPs, estimated load reduction for nutrients and sediment (if available), and the target volume (area, length) of each practice, while Table 74 details estimated costs for implementing each practice based on the 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 72. Suggested Best Management Practices to address Big Walnut Creek critical areas. Note BMPs were selected by the steering committee.

Practice	Nutrients	Sediment	Pathogens
Access Control/Fencing	X	X	X
Alternative Watering System	X		X
Bioretention	X	X	X
Conservation Tillage	X	X	X
Cover Crop/Critical Area Planting/Conservation Cover	X	X	X
Dam Removal	X	X	
Drainage Water Management	X	X	
Field Border/Buffer Strip	X	X	X
Forage/Biomass Planting	X	X	X
Grade Stabilization Structure	X	X	
Grassed Waterway/Mulching/Subsurface Drain	X	X	X
Greenways and Trails	X	X	
Gypsum Application	X		
Habitat Corridor Identification and Improvement	X	X	
Heavy Use Area Protection	X	X	X
Invasive Species Removal	X	X	
Lined Waterway or Outlet	X	X	X
Livestock Restriction/Pipeline; Prescribed Grazing	X	X	X
Manure Management Planning	X		X
Nutrient/Pest Management	X		
Pervious Pavement	X	X	
Phosphorus Free Fertilizer	X		

Practice	Nutrients	Sediment	Pathogens
Rain Barrel	X	X	
Saturated Buffer	X	X	
Septic System Care/Maintenance	X		X
Streambank Stabilization	X	X	
T&E Species Protection (Habitat Improvement)	X	X	
Tree/Shrub Establishment	X	X	
Two Stage Ditch	X	X	X
University Fertilization Recommendations/Soil Testing	X		
Variable Rate Application	X		
Vegetated Swale	X	X	
Waste Storage Facility	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. 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 73 is met, then the target loading rates detailed in Table 58 through Table 61 will be achieved for high priority critical areas (Dry Branch-Big Walnut Creek, Ramp Run-East Fork Big Walnut Creek, Ross Ditch-East Fork Big Walnut Creek, West Fork Big Walnut Creek and the drainages of Dogwood Springs Lake, Thomas Lake, Oakalla Lake, South Pond, Heritage Lake (includes Summersault Lake) and Glenn Flint Lake); medium priority critical areas (Town of Barnard-Big Walnut Creek); and low priority critical areas (Deweese Branch-Deer Creek, Headwaters Deer Creek, Headwaters Little Walnut Creek, Owl Branch-Deer Creek, Snake Creek-Big Walnut Creek). The steering committee realizes that the model's calculations are only an estimate, and actual reductions could be beyond the model's estimation. The Region V model does not provide estimated reductions for all suggested BMPs; these load reductions cannot be included in the calculations. The steering committee acknowledges that they have set the bar high by establishing ambitious water quality targets that may be difficult to obtain. The group is committed to improve water quality the best that they can, even in the event that the original load reduction goals are not met.

Table 73. Suggested Best Management Practices, target volumes, and their estimated load reduction per practice to meet short-term, medium-term and long-term goals.

Suggested BMPs:	Short-term BMP Targets	Medium-term BMP Targets	Long-term BMP Targets	Unit	Nitrogen (lb/year)	Phosphorus (lb/year)	Sediment (t/year)
Conservation Cover (327)	10,000	20,000	10,000	acre	23	11	10
Cover Crop (340)	10,000	20,000	10,000	acre	15	7	7
Fence (382)	10,000	20,000	10,000	feet	0.4	0.4	0.4
Filter Strip (393)	400	3,000	1,200	acre	24	12	10
Forage and Biomass Planting (512)	1,000	2,000	1,000	acre	23	11	10
Grade Stabilization Structure (410)	50	50	50	units	69.9	34.9	30.4
Grassed Waterway (412)	1,000	1,500	1,000	acre	232.9	116.4	101.3
Livestock Restriction (Alt Watering System, Access Control)	10,000	1,000	10,000	feet	2.8	0.83	7.52
Nutrient/Pest Management (590)^	1,000	10,000	500	acre	4.16	6.24	-
Prescribed Grazing (528)	1,000	2,000	1,000	acre	17	9	8
Residue and Tillage Management (329)	1,000	3,000	10,000	acres	21	10	11
Streambank Stabilization*	500	3,000	500	feet	0	0.83	14
Trails and Walkways (575)	150	500	50	feet	22	11	13
Tree/shrub Establishment (612)	150	500	50	acre	10	5	5
Water and Sediment Control Basin (638)	50	300	150	unit	129.8	64.9	56.4
Wetland Creation/Restoration	100	300	100	acre	8.2	2.9	69.77

^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.

Table 74. Estimated cost for selected Best Management Practices to meet short-term, medium-term and long-term goals.

Suggested BMPs:	Estimated Cost per Unit	Short-term Estimated Cost	Medium-term Estimated Cost	Long-term Estimated Cost
Conservation Cover (327)	$75	$1,500,000	$750,000	$750,000
Cover Crop (340)	$25	$500,000	$250,000	$250,000
Fence (382)	$1	$20,000	$10,000	$10,000
Filter Strip (393)	$75	$225,000	$90,000	$30,000
Forage and Biomass Planting (512)	$75	$150,000	$75,000	$75,000
Grade Stabilization Structure (410)	$5,000	$5,000,000	$250,000	$250,000
Grassed Waterway (412)	$5,000	$375,000	$2,500,000	$2,500,000
Livestock Restriction (Alt Watering System, Access Control)	$1,000	$1,000,000	$10,000,000	$10,000,000
Nutrient/Pest Management (590)^	$4.00	$40,000	$2,000	$4,000
Prescribed Grazing (528)	$15.00	$30,000	$15,000	$15,000
Residue and Tillage Management (329)	$15	$45,000	$150,000	$15,000
Streambank Stabilization**	$1,000	$3,000,000	$500,000	$500,000
Trails and Walkways (575)	$3000	$1,500,000	$150,000	$450,000
Tree/shrub Establishment (612)	$450	$225,000	$22,500	$67,500
Water and Sediment Control Basin (638)	$2,500	$750,000	$375,000	$125,000
Wetland Creation/Restoration	$1,000	$300,000	$100,000	$100,000
Total Cost		**$14,360,000**	**$15,139,500**	**$15,041,500**

10.3 Action Register

All activities to be completed as part of the Big Walnut Creek Watershed management plan are identified in Table 75. 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 75. Action Register.

Education and Outreach Goals	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
Nutrients, Sediment, *E. coli*	Coordinate on-the-ground cost-share program by 2021.	Urban and agricultural landowners, producers	Develop a cost-share program.	$25,000 annually	PP=local schools, Ivy Tech, City of Greencastle and its residents, technical assistance providers TA=NRCS, SWCD, ISDA, Purdue Extension, FSA, Hendricks Parks Dept, DNR, TNC, County surveyor
			Implement cost-share program.		
			Identify potential funding sources to augment cost-share program including NWQI, RCPP, LARE, CWA and others.		
Education	Develop an education plan targeting each practice identified above by 2021.		Create mechanism to promote each practice using methods including but not limited to press release; stream clean up; float trip; stream, field or pasture walk; website creation; local events; county fair booth; educational booth; workshop; field days and public meetings.	$10,000	
			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.	$25,000 annually	
Education	Promote hands-on opportunities to improve natural areas and habitat within the Big Walnut Creek Watershed.	Local residents, river enthusiasts, government agency staff	Identify partner organizations which host field days, work days, and clean-up events.	$15,000	PP/TA=Local schools, river enthusiasts, The Nature Conservancy, DNR Division of Nature Preserves, Hendricks Co Parks, NRCS, SWCD, FSA
			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.		

Nutrient Goal	Objective	Target Audience	Milestones	Cost (includes BMPs, staff and supplies)	Potential Partners/ Technical Assistance
Short term: Reduce nitrate-nitrogen and TP by 10% in in Big Walnut and Deer Creeks by 2025. Medium term: Reduce nitrate-nitrogen and TP by 50% in in Big Walnut and Deer Creeks by 2035. Long term: Reduce nitrate-nitrogen by 98% in Big Walnut Creek and 92% in Deer Creek and TP by 94% in Big Walnut Creek and by 86% in Deer Creek by 2050.	Educate and promote installation of BMPs through field days/workshops	Urban and agricultural landowners, producers	Host at least one local event (field day, public meeting, workshop) annually targeting agricultural BMPs and one local event every two years targeting urban or habitat-based BMPs.	$1,484,700 annually	PP=local schools, Ivy Tech, City of Greencastle and its residents, technical assistance providers TA=NRCS, SWCD, ISDA, Purdue Extension, FSA, Hendricks Parks Dept, DNR, TNC, County surveyors
	Education through publications, web posts, and press releases		Develop quarterly (4) print materials publications, press releases, web updates, social media posts or other publications annually.		
			Implement one fifth of the short-term practices annually from 2021-2025, one tenth of the medium-term practices annually from 2026-2035, one fifteenth of long-term practices annually from 2036-2050.		
			Achieve 5 year interim BMP target and load reduction goals: 10% nitrate-nitrogen and 10% total phosphorus reduction in Big Walnut and Deer Creeks.		
	Implement 319, MRBI CWI, LARE and other cost-share programs to put nutrient-reducing BMPs in place		Achieve 15 year interim BMP target and load reduction goal: 50% nitrate-nitrogen and 50% total phosphorus reduction in Big Walnut and Deer Creeks.		
			Achieve 30 year BMP target and load reduction goal: 98% (Big Walnut) and 92% (Deer Creek) nitrate-nitrogen and 94% (Big Walnut Creek) and 86% (Deer Creek) total phosphorus reduction.		

Sediment Goal	Objective	Target Audience	Milestones	Cost (includes BMPs, staff and supplies)	Potential Partners/ Technical Assistance
Short term: Reduce total suspended sediment by 10% in Big Walnut and Deer Creeks by 2025. Medium term: Reduce total suspended sediment by 50% in Big Walnut and Deer Creeks by 2035. Long term: Reduce total suspended sediment by 100% in Big Walnut and Deer Creeks by 2050.	Educate and promote installation of BMPs through field days/workshops	Urban and agricultural landowners, producers	Host at least one local event (field day, public meeting, workshop) annually targeting agricultural BMPs and one local event every two years targeting urban or habitat-based BMPs.	$1,484,700 annually	PP=local schools, Ivy Tech, City of Greencastle and its residents, technical assistance providers TA=NRCS, SWCD, ISDA, Purdue Extension, FSA, Hendricks Parks Dept, DNR, TNC, County surveyors
	Education through publications/press releases		Develop quarterly (4) print materials publications, press releases, web updates, social media posts or other publications annually.		
	Implement 319, CWI, LARE and other cost-share programs to put erosion-reducing BMPs in place		Implement one fifth of the short-term practices annually from 2021-2025, one tenth of the medium-term practices annually from 2026-2035, one fifteenth of long-term practices annually from 2036-2050.		
			Achieve 5 year interim BMP target and load reduction goals: 10% reduction		
			Achieve 15 year interim BMP target and load reduction goal: 50% reduction.		
			Achieve 30 year BMP target and load reduction goal: 100% reduction.		

***E. coli* Goal**	**Objective**	**Target Audience**	**Milestones**	**Cost (includes BMPs, staff and supplies)**	**Potential Partners/ Technical Assistance**
Short term: Reduce *E. coli* inputs by 10% in Big Walnut and Deer Creeks by 2025. Medium term: Reduce *E. coli* by 50% in Big Walnut and Deer Creeks by 2035. Long term: Reduce *E. coli* by 100% in Big Walnut and Deer Creeks by 2050.	Educate and promote installation of BMPs through field days/workshops	Urban and agricultural landowners, producers	Host at least one local event (field day, public meeting, workshop) annually targeting agricultural BMPs and one local event every two years targeting urban or habitat-based BMPs.	$1,484,700 annually	PP=local schools, Ivy Tech, City of Greencastle and its residents, technical assistance providers TA=NRCS, SWCD, ISDA, Purdue Extension, FSA, Hendricks Parks Dept, DNR, TNC, County surveyors
	Education through publications/press releases		Develop quarterly (4) print materials publications, press releases, web updates, social media posts or other publications annually.		
	Implement 319, CWI, LARE and other cost-share programs to put *E.coli*-reducing BMPs in place		Implement one fifth of the short-term practices annually from 2021-2025, one tenth of the medium-term practices annually from 2026-2035, one fifteenth of long-term practices annually from 2036-2050.		
			Achieve 5 year interim BMP target and load reduction goals: 10% reduction		
	Educate and promote proper septic maintenance		Achieve 15 year interim BMP target and load reduction goal: 50% reduction.		
			Achieve 30 year BMP target and load reduction goal: 100% reduction.		

11.0 FUTURE ACTIVITIES

The next steps for the project include starting implementation of the Big Walnut Creek Watershed Management Plan. The Big Walnut Watershed Alliance in partnership with the project steering committee and other regional partners will consider options for submitting implementation-focused grant applications for IDEM Section 319 funds, Mississippi River Basin Initiative Funds, DNR LARE, Clean Water Indiana and other funds. 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 Big Walnut Creek Watershed, helping reach goal statements for high, medium and low priority critical areas by 2049. For each practice identified, an annual target for the acres or number of each BMP implemented is included in the action register (Table 75). Measurement of the success of implementation is a necessary part of any watershed project (Table 76). 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 76. 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 76 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 75. Table 77 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. Volunteer water monitoring results will be documented on the Hoosier Riverwatch website. The Big Walnut Creek Project Coordinator/Putnam County SWCD will be responsible for keeping the mentioned records. The Wabash Land Conservancy will be responsible for the long-term housing of records.

Table 77. Annual targets for short term, medium term and long term goals for each best management practice.

Suggested BMPs:	Short Term BMP Targets	Medium Term BMP Targets	Long Term BMP Targets
Conservation Cover (327)	4,000	1,000	667
Cover Crop (340)	4,000	1,000	667
Fence (382)	4,000	1,000	667
Filter Strip (393)	600	120	27
Forage and Biomass Planting (512)	400	100	67
Grade Stabilization Structure (410)	200	5	3
Grassed Waterway (412)	30	100	67
Livestock Restriction (Alt Watering System, Access Control)	200	1,000	667
Nutrient/Pest Management (590)	2,000	50	67
Prescribed Grazing (528)	400	100	67
Residue and Tillage Management (329)	600	1,000	67
Streambank Stabilization	600	50	33
Trail and Walkways (575)	100	5	10
Tree/shrub Establishment (612)	100	5	10
Water and Sediment Control Basin (638)	60	15	3
Wetland Creation/Restoration	60	10	7

11.2 Indicators of Success

Water quality, social, and administrative indicators will be used to monitor progress towards successful achievement of the goals for the high and medium priority critical areas. 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

- <u>Water Quality Indicator:</u> Nitrate-nitrogen and total phosphorus will be measured monthly at the IDEM fixed station monitoring sites in the 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 1.5 mg/L and for total phosphorus of 0.08 mg/L.
- <u>Administrative Indicator:</u> The number of BMPs that can reduce nitrate-nitrogen and total phosphorus will be tracked annually. The total number of acreage will be compared against annual targets identified in Table 77. 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

- <u>Water Quality Indicator:</u> Total suspended solids will be measured monthly at the IDEM fixed station monitoring sites. 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 of 15 mg/L.
- <u>Administrative Indicator:</u> 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 77 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

- <u>Water Quality Indicator:</u> *E. coli* will be measured by volunteers on the same schedule as IDEM rotational basin sampling. After ten years of implementation, water quality samples will show a decreasing trend, with more samples annually meeting the state standard.
- <u>Administrative Indicator:</u> 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 77.

Increase Public Awareness and Participation

- <u>Administrative Indicator:</u> The number of people who attend education and outreach events will be tracked. The percent of targeted households reached will increase annually.
- <u>Social Indicator:</u> 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.

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 72 and Table 73.

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 Big Walnut 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 Big Walnut 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 Big Walnut 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 Miami and Wabash County service centers provide assistance for the Big Walnut Creek Watershed.
- Boone, Hendricks and Putnam 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 Big Walnut 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 Big Walnut 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 Big Walnut Creek Watershed Project and can be found below.

Step 1: Planning The planning process used to develop the Big Walnut Creek WMP follows the IDEM 2009 Watershed Management Checklist. The project coordinator worked in concert with and was guided by the Big Walnut 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 Big Walnut 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 76 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 75) 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 Big Walnut 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 Big Walnut Watershed Alliance, coordinated by the Putnam 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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Appendix A: Social indicator survey and report

Big Walnut Agriculture Survey - 2019.

Rating of Water Quality

Overall, how would you rate the quality of the water in your area?

	Poor	Okay	Good	Don't Know
1. For canoeing / kayaking / other boating	( )	( )	( )	( )
2. For eating locally caught fish	( )	( )	( )	( )
3. For swimming	( )	( )	( )	( )
4. For picnicking and family activities	( )	( )	( )	( )
5. For fish habitat	( )	( )	( )	( )
6. For scenic beauty	( )	( )	( )	( )

Your Water Resources

1. Of these activities, which is the most important to you?

( ) For canoeing / kayaking / other boating

( ) For eating locally caught fish

( ) For swimming

( ) For picnicking and family activities

( ) For fish habitat

( ) For scenic beauty

2. Do you know where the rain water goes when it runs off of your property?

( ) No

( ) Yes

3. If you answered 'Yes' above, where does your rain water drain to?

Water Impairments

Below is a list of water pollutants and conditions that are generally present in water bodies to some extent. The pollutants and conditions become a problem when present in excessive amounts. In your opinion, how much of a problem are the following water impairments in your area?

	Not a Problem	Slight Problem	Moderate Problem	Severe Problem	Don't Know
1. Sedimentation (dirt and soil) in the water	( )	( )	( )	( )	( )
2. Nitrogen	( )	( )	( )	( )	( )
3. Phosphorus	( )	( )	( )	( )	( )
4. Coliform	( )	( )	( )	( )	( )
5. Bacteria and viruses in the water (such as E.coli / coliform)	( )	( )	( )	( )	( )
6. Trash or debris in the water	( )	( )	( )	( )	( )
7. Toxic materials in the water	( )	( )	( )	( )	( )

Your Opinions

Please indicate your level of agreement or disagreement with the statements below.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. Using recommended management practices on farms improves water quality.	( )	( )	( )	( )	( )
2. It is my personal responsibility to help protect water quality.	( )	( )	( )	( )	( )
3. It is important to protect water quality even if it slows economic development.	( )	( )	( )	( )	( )
4. My actions have an impact on water quality.	( )	( )	( )	( )	( )
5. I would be willing to pay more to improve water quality (for example: though local taxes or fees)	( )	( )	( )	( )	( )
6. I would be willing to change management practices to improve water quality.	( )	( )	( )	( )	( )
7. The quality of life in my community depends on good water quality in local streams, rivers and lakes.	( )	( )	( )	( )	( )
8. The economic stability of my community depends upon good water quality.	( )	( )	( )	( )	( )
9. What I do on my land doesn't make much difference in overall water quality.	( )	( )	( )	( )	( )
10. Investing in water quality protection puts the farmer at an economic.	( )	( )	( )	( )	( )
11. Farm management practices do not have an impact on water quality.	( )	( )	( )	( )	( )
12. Taking action to improve water quality is too expensive for me.	( )	( )	( )	( )	( )
13. It is okay to reduce water quality to promote economic development.	( )	( )	( )	( )	( )
14. It is important to protect water quality even if it costs me more.	( )	( )	( )	( )	( )

Consequences of Poor Water Quality

Poor water quality can lead to a variety of consequences for communities. In your opinion, how much of a problem are the following issues in your area?

	Not a Problem	Slight Problem	Moderate Problem	Severe Problem	Don't Know
1. Contaminated drinking water	( )	( )	( )	( )	( )
2. Contaminated fish	( )	( )	( )	( )	( )
3. Loss of desirable fish species	( )	( )	( )	( )	( )
4. Reduced beauty of lakes or streams	( )	( )	( )	( )	( )
5. Reduced quality of water recreation activities	( )	( )	( )	( )	( )
6. Excessive aquatic plants or algae	( )	( )	( )	( )	( )
7. Fish kills	( )	( )	( )	( )	( )

Sources of Water Pollution

The items listed below are sources of water quality pollution across the country. In your opinion, how much of a problem are the following sources in your area?

	Not a Problem	Slight Problem	Moderate Problem	Severe Problem	Don't Know
1. Discharges from sewage treatment plants	( )	( )	( )	( )	( )
2. Soil erosion from construction sites	( )	( )	( )	( )	( )
3. Soil erosion from farm fields	( )	( )	( )	( )	( )
4. Soil erosion from shorelines and/or streambanks	( )	( )	( )	( )	( )
5. Excessive use of lawn fertilizers and/or pesticides	( )	( )	( )	( )	( )
6. Improper disposal of household wastes (chemicals, batteries, florescent light bulbs, etc.)	( )	( )	( )	( )	( )
7. Improperly maintained septic systems	( )	( )	( )	( )	( )
8. Manure from farm animals	( )	( )	( )	( )	( )
9. Waste material from pets	( )	( )	( )	( )	( )
10. Excessive use of fertilizers for crop production	( )	( )	( )	( )	( )
11. Animal feeding operations	( )	( )	( )	( )	( )
12. Land development or redevelopment	( )	( )	( )	( )	( )
13. Drainage/filling of wetlands	( )	( )	( )	( )	( )
14. Wildlife	( )	( )	( )	( )	( )
15. Yard maintenance	( )	( )	( )	( )	( )
16. Turf management (golf courses, sports fields)	( )	( )	( )	( )	( )

Practices to Improve Water Quality

Please indicate which statement most accurately describes your level of experience with each practice listed below.

	Not relevant for my property	Never heard of it	Somewhat familiar with it	Know how to use it; not using it	Currently use it
1. Replace home sewage treatment system	( )	( )	( )	( )	( )
2. Conduct regular soil tests for pH, phosphorus, nitrogen and potassium	( )	( )	( )	( )	( )
3. Follow university recommendations for fertilization rates	( )	( )	( )	( )	( )
4. Avoid fall application of manure or nitrogen fertilizer to reduce environmental losses	( )	( )	( )	( )	( )
5. Use field records of crops, pests and pesticide use to help develop pest control strategies	( )	( )	( )	( )	( )
6. Construct water control basins to detain runoff	( )	( )	( )	( )	( )
7. Construct a waste storage facility	( )	( )	( )	( )	( )
8. Use no-till to reduce erosion	( )	( )	( )	( )	( )
9. Establish permanent vegetation on retired agricultural land to reduce erosion	( )	( )	( )	( )	( )

Practices to Improve Water Quality

10. Use approved plants and techniques in highly erodible areas	( )	( )	( )	( )	( )
11. Use fencing to exclude animals from critical areas	( )	( )	( )	( )	( )
12. Fence and/or reinforce animal pathways through sensitive terrain	( )	( )	( )	( )	( )
13. Plant vegetation in critical erosion areas	( )	( )	( )	( )	( )
14. Create and/or manage wetland wildlife habitat	( )	( )	( )	( )	( )
15. Transition to organic production	( )	( )	( )	( )	( )

Specific Constraints of Practices

Cover Crops: Use variable rate application management units to minimize fertilizer waste and achieve more precise crop production.

1. How familiar are you with this practice?

( ) Not relevant

( ) Never heard of it

( ) Somewhat familiar with it

( ) Know how to use it; not using it

( ) Currently use it

2. If the practice is not relevant, please explain why.

3. Are you willing to try this practice?

( ) Yes or already do ( ) No

( ) Maybe

How much do the following factors limit your ability to implement this practice?

	Not at all	A little	Some	A lot	Don't Know
4. Don't know how to do it	( )	( )	( )	( )	( )
5. Time required	( )	( )	( )	( )	( )
6. Cost	( )	( )	( )	( )	( )
7. The features of my property make it difficult	( )	( )	( )	( )	( )
8. Insufficient proof of water quality benefit	( )	( )	( )	( )	( )
9. Desire to keep things the way they are	( )	( )	( )	( )	( )
10. Hard to use with my farming system	( )	( )	( )	( )	( )
11. Lack of equipment	( )	( )	( )	( )	( )

Cover Crops: Planting cover crops for erosion protection and soil improvement

12. How familiar are you with this practice?

( ) Not relevant ( ) Know how to use it; not using it

( ) Never heard of it ( ) Currently use it

( ) Somewhat familiar with it

13. If the practice is not relevant, please explain why.

14. Are you willing to try this practice?

( ) Yes or already do

( ) Maybe

( ) No

How much do the following factors limit your ability to implement this practice?

	Not at all	A little	Some	A lot	Don't Know
15. Don't know how to do it	( )	( )	( )	( )	( )
16. Time required	( )	( )	( )	( )	( )
17. Cost	( )	( )	( )	( )	( )
18. The features of my property make it difficult	( )	( )	( )	( )	( )
19. Insufficient proof of water quality benefit	( )	( )	( )	( )	( )
20. Desire to keep things the way they are	( )	( )	( )	( )	( )
21. Hard to use with my farming system	( )	( )	( )	( )	( )
22. Lack of equipment	( )	( )	( )	( )	( )

Conservation Tillage: Use variable rate application management units to minimize fertilizer waste and achieve more precise crop production.

1. How familiar are you with this practice?

( ) Not relevant

( ) Never heard of it

( ) Somewhat familiar with it

( ) Know how to use it; not using it

( ) Currently use it

2. If the practice is not relevant, please explain why.

3. Are you willing to try this practice?

( ) Yes or already do ( ) No

( ) Maybe

How much do the following factors limit your ability to implement this practice?

	Not at all	A little	Some	A lot	Don't Know
4. Don't know how to do it	( )	( )	( )	( )	( )
5. Time required	( )	( )	( )	( )	( )
6. Cost	( )	( )	( )	( )	( )

7. The features of my property make it difficult	( )	( )	( )	( )	( )
8. Insufficient proof of water quality benefit	( )	( )	( )	( )	( )
9. Desire to keep things the way they are	( )	( )	( )	( )	( )
10. Hard to use with my farming system	( )	( )	( )	( )	( )
11. Lack of equipment	( )	( )	( )	( )	( )

Cover Crops: Planting cover crops for erosion protection and soil improvement

12. How familiar are you with this practice?

( ) Not relevant
( ) Know how to use it; not using it
( ) Never heard of it
( ) Currently use it
( ) Somewhat familiar with it

13. If the practice is not relevant, please explain why.

14. Are you willing to try this practice?

( ) Yes or already do
( ) Maybe
( ) No

How much do the following factors limit your ability to implement this practice?

	Not at all	A little	Some	A lot	Don't Know
15. Don't know how to do it	( )	( )	( )	( )	( )
16. Time required	( )	( )	( )	( )	( )
17. Cost	( )	( )	( )	( )	( )
18. The features of my property make it difficult	( )	( )	( )	( )	( )
19. Insufficient proof of water quality benefit	( )	( )	( )	( )	( )
20. Desire to keep things the way they are	( )	( )	( )	( )	( )
21. Hard to use with my farming system	( )	( )	( )	( )	( )
22. Lack of equipment	( )	( )	( )	( )	( )

Variable Rate Fertilizer Application: Use variable rate application management units to minimize fertilizer waste and achieve more precise crop production.

1. How familiar are you with this practice?

( ) Not relevant
( ) Never heard of it
( ) Somewhat familiar with it
( ) Know how to use it; not using it
( ) Currently use it

2. If the practice is not relevant, please explain why.

3. Are you willing to try this practice?

( ) Yes or already do ( ) No
( ) Maybe

How much do the following factors limit your ability to implement this practice?

	Not at all	A little	Some	A lot	Don't Know
4. Don't know how to do it	( )	( )	( )	( )	( )
5. Time required	( )	( )	( )	( )	( )
6. Cost	( )	( )	( )	( )	( )
7. The features of my property make it difficult	( )	( )	( )	( )	( )
8. Insufficient proof of water quality benefit	( )	( )	( )	( )	( )
9. Desire to keep things the way they are	( )	( )	( )	( )	( )
10. Hard to use with my farming system	( )	( )	( )	( )	( )
11. Lack of equipment	( )	( )	( )	( )	( )

Cover Crops: Planting cover crops for erosion protection and soil improvement

12. How familiar are you with this practice?
( ) Not relevant
( ) Never heard of it
( ) Somewhat familiar with it
( ) Know how to use it; not using it
( ) Currently use it

13. If the practice is not relevant, please explain why.

14. Are you willing to try this practice?
( ) Yes or already do
( ) Maybe
( ) No

How much do the following factors limit your ability to implement this practice?

	Not at all	A little	Some	A lot	Don't Know
15. Don't know how to do it	( )	( )	( )	( )	( )
16. Time required	( )	( )	( )	( )	( )
17. Cost	( )	( )	( )	( )	( )
18. The features of my property make it difficult	( )	( )	( )	( )	( )
19. Insufficient proof of water quality benefit	( )	( )	( )	( )	( )
20. Desire to keep things the way they are	( )	( )	( )	( )	( )
21. Hard to use with my farming system	( )	( )	( )	( )	( )
22. Lack of equipment	( )	( )	( )	( )	( )

Making Decisions for my Property

In general, how much does each issue limit your ability to change your management practices?

	Not at all	A little	Some	A lot	Don't Know
1. Personal out-of-pocket expense	( )	( )	( )	( )	( )
2. My own views about effective farming or land management methods	( )	( )	( )	( )	( )
3. How easily a new practice fits with my current farming methods	( )	( )	( )	( )	( )
4. The need to learn new skills or methods	( )	( )	( )	( )	( )
5. Lack of government funds for cost share	( )	( )	( )	( )	( )
6. Too much time required for implementation	( )	( )	( )	( )	( )
7. Not having access to the equipment I need	( )	( )	( )	( )	( )
8. Lack of available information about a practice	( )	( )	( )	( )	( )
9. No one else I know is implementing the practice	( )	( )	( )	( )	( )
10. Concerns about the reduced yields	( )	( )	( )	( )	( )
11. Approval of my neighbors	( )	( )	( )	( )	( )
12. Don't want to participate in government programs	( )	( )	( )	( )	( )
13. Requirements or restrictions of government programs	( )	( )	( )	( )	( )
14. Possible interference with my flexibility to change land use practices as conditions warrant	( )	( )	( )	( )	( )
15. Environmental damage caused by practice	( )	( )	( )	( )	( )
16. Environmental benefit practice	( )	( )	( )	( )	( )
17. Profitability	( )	( )	( )	( )	( )

About Your Farm Operation

1. Please select the option that best describes who generally makes management decisions for your operation.

( ) Me alone or with my spouse
( ) Me with my family partners (siblings, parents, children)
( ) Me with the landowner
( ) Me with my tenant
( ) Me and my business partners
( ) Someone else makes the decision for the operation
( ) Other

2. Please estimate the total tillable acreage (owned and/or rented) of your farming operation this year.

3. This year, how many acres of corn do you manage? If none, please enter a zero.

4. This year, how many acres of soybeans do you manage? If none, please enter a zero.

5. This year, how many acres of small grains do you manage? If none, please enter a zero.

6. This year, how many acres of canning crops do you manage? If none, please enter a zero.

7. This year, how many acres of clover/alfalfa do you manage? If none, please enter a zero.

8. This year, how many acres of pasture do you manage? If none, please enter a zero.

9. This year, how many acres of conservation set aside / CRP do you manage? If none, please enter a zero.

10. This year, how many acres of forest / woodland do you manage? If none, please enter a zero.

11. This year, how many acres of non-row crops for energy do you manage? If none, please enter a zero.

12. This year, how many acres of other crops do you manage? If none, please enter a zero.

13. If you provided acreages of "other" crops above, please specify what crops those acres represent:

14. Did any family member own and operate this farm before you did?

( ) No

( ) Yes

15. If you answered 'yes' to the previous question, how many years has the farm been in the family?

16. How many dairy cattle, including heifers and young stock, are part of your farming operation? If none, please enter a zero.

17. How many beef cattle, including young stock, are part of your farming operation? If none, please enter a zero.

18. How many hogs are part of your farming operation? If none, please enter a zero.

19. How many poultry are part of your farming operation? If none, please enter a zero.

20. How many other livestock are part of your farming operation? If none, please enter a zero.

21. If you provided counts of "other" livestock above, please specify what animals those livestock represent:

22. Does the property you manage touch a stream, river, lake, or wetland?

( ) Yes

( ) No

23. If you do have a nutrient management plan, does your nutrient management plan meet the NRCS technical standard 590?

( ) I don't know

( ) No

( ) Yes

24. What is included in your nutrient management plans?

[ ] Commercial nutrients

[ ] Livestock manure

[ ] Septic waste

[ ] Municipal sludge

[ ] Industrial sludge

[ ] Other

About You

1. What is your gender?

( ) Male

( ) Female

2. What is your age?

3. What is the highest grade in school you have completed?

( ) Some formal schooling

( ) High school diploma/GED

( ) Some college

( ) 2 year college degree

( ) 4 year college degree

( ) Post-graduate degree

4. How long have you lived at your current residence (years)?

5. Which of the following best describes where you live?

( ) In a town, village, or city

( ) In an isolated, rural, non-farm residence

( ) Rural subdivision or development
( ) On a farm

6. In addition to your residence, which of the following do you own or manage? (check all that apply)
[ ] An agricultural operation
[ ] Forested land
[ ] Rural recreational property
[ ] None of these

7. What is your ethnicity?
( ) African American
( ) American Indian
( ) Asian/Asian American/Pacific Islander
( ) Hispanic/Latino
( ) White/Caucasian
( ) Multi-racial
( ) Other

8. Where are you likely to seek information about soil and water conservation issues? (Check all that apply)
[ ] Newsletters/brochure/factsheet
[ ] Internet
[ ] Radio
[ ] Workshops/demonstrations/meetings
[ ] Conversations with others
[ ] Trade publications/magazines
[ ] None of the above

9. Do you regularly read a local newspaper?
( ) Yes
( ) No

Information Sources

People get information about water quality from a number of different sources. To what extent do you trust those listed below as a source of information about soil and water?

	Not at all	Slightly	Moderately	Very much	Am not familiar
1. Local watershed project	( )	( )	( )	( )	( )
2. Soil and Water Conservation District	( )	( )	( )	( )	( )
3. Natural Resources Conservation Service	( )	( )	( )	( )	( )
4. University Extension	( )	( )	( )	( )	( )
5. State agricultural agency	( )	( )	( )	( )	( )
6. State environmental agency	( )	( )	( )	( )	( )
7. Environmental groups	( )	( )	( )	( )	( )
8. Farm Bureau	( )	( )	( )	( )	( )
9. Fertilizer representatives	( )	( )	( )	( )	( )
10. Crop consultants	( )	( )	( )	( )	( )
11. Other landowners / friends	( )	( )	( )	( )	( )

Septic Systems

1. Do you have a septic system?

( ) No

( ) Don't Know

( ) Yes

2. If you answered 'yes' to the previous question, in what year was it installed?

3. Within the last five years, have you had any of the following problems? (Check all that apply)-

[ ] Slow drains

[ ] Sewage backup in house

[ ] Bad smells near tank or drain field

[ ] Sewage on the surface

[ ] Sewage flowing to ditch

[ ] Frozen septic

[ ] Other

[ ] None

[ ] Don't know

4. Do you have a garbage disposal?

( ) Yes, I use it daily

( ) Yes, I use it occasionally

( ) Yes, but I don't use it

( ) No

5. How would you know if your septic system was NOT working properly? (Check all that apply)

[ ] Slow drains

[ ] Sewage backup in house

[ ] Bad smells

[ ] Toilet backs up

[ ] Wet spots in lawn

[ ] Pumping tank monthly or more

[ ] Straight pipe to ditch

[ ] Frozen septic

[ ] Don't know

[ ] Other

6. Do you think a local government agency should handle inspection and maintenance of septic systems?

( ) Yes

( ) No

( ) Don't Know

Thank You

1. Please use the space below for any additional comments about this survey or water resources in your community.

2. Thank you for your time and assistance! Please return provide your name and email address to be entered into a drawing for an Amazon gift card!

3. Please type the code on your mailing label here. If you do not see a code or have a mailing label, please include your address to allow for confirmation of your location within the Big Walnut Creek Drainage.

Big Walnut Urban Survey – 2019

Rating of Water Quality

Overall, how would you rate the quality of the water in your area?

	Poor	Okay	Good	Don't Know
1. For canoeing / kayaking / other boating	( )	( )	( )	( )
2. For eating locally caught fish	( )	( )	( )	( )
3. For swimming	( )	( )	( )	( )
4. For picnicking and family activities	( )	( )	( )	( )
5. For fish habitat	( )	( )	( )	( )
6. For scenic beauty	( )	( )	( )	( )

Your Water Resources

1. Of these activities, which is the most important to you?

( ) For canoeing / kayaking / other boating

( ) For eating locally caught fish

( ) For swimming

( ) For picnicking and family activities

( ) For fish habitat

( ) For scenic beauty

2. Do you know where the rain water goes when it runs off of your property?

( ) No

( ) Yes

3. If you answered 'Yes' above, where does your rain water drain to?

Water Impairments

Below is a list of water pollutants and conditions that are generally present in water bodies to some extent. The pollutants and conditions become a problem when present in excessive amounts. In your opinion, how much of a problem are the following water impairments in your area?

	Not a Problem	Slight Problem	Moderate Problem	Severe Problem	Don't Know
1. Sedimentation (dirt and soil) in the water	( )	( )	( )	( )	( )
2. Nitrogen	( )	( )	( )	( )	( )
3. Phosphorus	( )	( )	( )	( )	( )
4. Coliform	( )	( )	( )	( )	( )
5. Bacteria and viruses in the water (such as E.coli / coliform)	( )	( )	( )	( )	( )
6. Trash or debris in the water	( )	( )	( )	( )	( )
7. Toxic materials in the water	( )	( )	( )	( )	( )

Your Opinions

Please indicate your level of agreement or disagreement with the statements below.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. The way that I care for my lawn and yard can influence water quality in local streams and lakes.	( )	( )	( )	( )	( )
2. It is my personal responsibility to help protect water quality.	( )	( )	( )	( )	( )
3. It is important to protect water quality even if it slows economic development.	( )	( )	( )	( )	( )
4. My actions have an impact on water quality.	( )	( )	( )	( )	( )
5. I would be willing to pay more to improve water quality (for example: though local taxes or fees)	( )	( )	( )	( )	( )
6. I would be willing to change the way I care for my lawn and yard to improve water quality.	( )	( )	( )	( )	( )
7. The quality of life in my community depends on good water quality in local streams, rivers and lakes.	( )	( )	( )	( )	( )
8. The economic stability of my community depends upon good water quality.	( )	( )	( )	( )	( )
9. What I do on my land doesn't make much difference in overall water quality.	( )	( )	( )	( )	( )
10. Lawn and yard-care practices (on individual lots) do not have an impact on water quality.	( )	( )	( )	( )	( )
11. Taking action to improve water quality is too expensive for me.	( )	( )	( )	( )	( )
12. It is okay to reduce water quality to promote economic development.	( )	( )	( )	( )	( )
13. It is important to protect water quality even it it costs me more.	( )	( )	( )	( )	( )

Sources of Water Pollution

The items listed below are sources of water quality pollution across the country. In your opinion, how much of a problem are the following sources in your area?

	Not a Problem	Slight Problem	Moderate Problem	Severe Problem	Don't Know
1. Discharges from sewage treatment plants	( )	( )	( )	( )	( )
2. Soil erosion from construction sites	( )	( )	( )	( )	( )
3. Soil erosion from farm fields	( )	( )	( )	( )	( )
4. Excessive use of lawn fertilizers and/or pesticides	( )	( )	( )	( )	( )

Sources of Water Pollution

5. Grass clippings and leaves entering storm drains	( )	( )	( )	( )	( )
6. Improper disposal of household wastes (chemicals, batteries, florescent light bulbs, etc.)	( )	( )	( )	( )	( )
7. Improperly maintained septic systems	( )	( )	( )	( )	( )
8. Manure from farm animals	( )	( )	( )	( )	( )
9. Stormwater runoff from rooftops and/or parking lots	( )	( )	( )	( )	( )
10. Droppings from geese, ducks and other waterfowl	( )	( )	( )	( )	( )
11. Waste material from pets	( )	( )	( )	( )	( )
12. Littering/illegal dumping of trash	( )	( )	( )	( )	( )
13. Animal feeding operations	( )	( )	( )	( )	( )
14. Land development or redevelopment	( )	( )	( )	( )	( )
15. Urban stormwater runoff	( )	( )	( )	( )	( )
16. Residential stormwater runoff	( )	( )	( )	( )	( )
17. Post-development erosion and sedimentation	( )	( )	( )	( )	( )
18. Drainage/filling of wetlands	( )	( )	( )	( )	( )
19. Natural sources	( )	( )	( )	( )	( )
20. Wildlife	( )	( )	( )	( )	( )
21. Yard maintenance	( )	( )	( )	( )	( )
22. Turf management (golf courses, sports fields)	( )	( )	( )	( )	( )

Consequences of Poor Water Quality

Poor water quality can lead to a variety of consequences for communities. In your opinion, how much of a problem are the following issues in your area?

Not a Problem	Slight Problem	Moderate Problem	Severe Problem	Don't Know	
1. Contaminated drinking water	( )	( )	( )	( )	( )
2. Contaminated fish	( )	( )	( )	( )	( )
3. Loss of desirable fish species	( )	( )	( )	( )	( )
4. Reduced beauty of lakes or streams	( )	( )	( )	( )	( )
5. Reduced opportunities for water recreation	( )	( )	( )	( )	( )
6. Excessive aquatic plants or algae	( )	( )	( )	( )	( )
7. Fish kills	( )	( )	( )	( )	( )
8. Odor	( )	( )	( )	( )	( )

Practices to Improve Water Quality

Please indicate which statement most accurately describes your level of experience with each practice listed below.

	Not relevant for my property	Never heard of it	Somewhat familiar with it	Know how to use it; not using it	Currently use it
1. Following the manufacturer's instructions when fertilizing lawn or garden	( )	( )	( )	( )	( )
2. Use phosphate free fertilizer	( )	( )	( )	( )	( )
3. Replace home sewage treatment system	( )	( )	( )	( )	( )
4. Properly dispose of pet waste	( )	( )	( )	( )	( )
5. Properly dispose of household waste (chemicals, batteries, florescent light bulbs, etc.)	( )	( )	( )	( )	( )
6. Use rain barrels	( )	( )	( )	( )	( )

Specific Constraints of Practices

Rain Garden : A garden that uses native plants to absorb and filter stormwater collected off a roof, parking lot, sidewalk, or driveway.

1. How familiar are you with this practice?

( ) Not relevant
( ) Never heard of it
( ) Somewhat familiar with it
( ) Know how to use it; not using it
( ) Currently use it

Are you willing to try this practice?

( ) Yes or already do
( ) Maybe
( ) No

2. If the practice is not relevant, please explain why.

How much do the following factors limit your ability to implement this practice?

	Not at all	A little	Some	A lot	Don't Know
4. Don't know how to do it	( )	( )	( )	( )	( )
5. Time required	( )	( )	( )	( )	( )
6. Cost	( )	( )	( )	( )	( )
7. The features of my property make it difficult	( )	( )	( )	( )	( )
8. Insufficient proof of water quality benefit	( )	( )	( )	( )	( )
9. Desire to keep things the way they are	( )	( )	( )	( )	( )
10. Physical or health limitations	( )	( )	( )	( )	( )
12. Lack of equipment	( )	( )	( )	( )	( )

Sewage Treatment Repair: Having improperly operating home sewage treatment systems repaired to prevent sewage runoff.

13. How familiar are you with this practice?

( ) Not relevant

( ) Never heard of it

( ) Somewhat familiar with it

( ) Know how to use it; not using it

( ) Currently use it

14. If the practice is not relevant, please explain why.

15. Are you willing to try this practice?

( ) Yes or already do

( ) Maybe

( ) No

How much do the following factors limit your ability to implement this practice?

	Not at all	A little	Some	A lot	Don't Know
16. Don't know how to do it	( )	( )	( )	( )	( )
17. Time required	( )	( )	( )	( )	( )
18. Cost	( )	( )	( )	( )	( )
19. The features of my property make it difficult	( )	( )	( )	( )	( )
20. Insufficient proof of water quality benefit	( )	( )	( )	( )	( )
21. Desire to keep things the way they are	( )	( )	( )	( )	( )
22. Physical or health limitations	( )	( )	( )	( )	( )
23. Hard to use with my farming system	( )	( )	( )	( )	( )
24. Lack of equipment	( )	( )	( )	( )	( )

Vegetated Streambank/Shoreline Protection : Maintaining vegetation that grows along streams, rivers or lakes acts as a protective buffer between the land and the water to reduce runoff and sediments flowing into the water.

25. How familiar are you with this practice?

( ) Not relevant

( ) Never heard of it

( ) Somewhat familiar with it

( ) Know how to use it; not using it

( ) Currently use it

26. If the practice is not relevant, please explain why.

27. Are you willing to try this practice?

( ) Yes or already do

( ) Maybe

( ) No

How much do the following factors limit your ability to implement this practice?

	Not at all	A little	Some	A lot	Don't Know
28. Don't know how to do it	( )	( )	( )	( )	( )
29. Time required	( )	( )	( )	( )	( )
30. Cost	( )	( )	( )	( )	( )
31. The features of my property make it difficult	( )	( )	( )	( )	( )
32. Insufficient proof of water quality benefit	( )	( )	( )	( )	( )
33. Desire to keep things the way they are	( )	( )	( )	( )	( )
34. Physical or health limitations	( )	( )	( )	( )	( )
35. Hard to use with my farming system	( )	( )	( )	( )	( )
36. Lack of equipment	( )	( )	( )	( )	( )

Making Decisions for my Property

In general, how much does each issue limit your ability to change your management practices?

	Not at all	A little	Some	A lot	Don't Know
1. Personal out-of-pocket expense	( )	( )	( )	( )	( )
2. My own views about effective lawn and yard maintenance	( )	( )	( )	( )	( )
3. How easily a new practice fits with my current lawn care method	( )	( )	( )	( )	( )
4. Not having access to the equipment I need	( )	( )	( )	( )	( )
5. Lack of available information about a practice	( )	( )	( )	( )	( )
6. No one else I know is implementing the practice	( )	( )	( )	( )	( )
7. Approval of my neighbors	( )	( )	( )	( )	( )
8. Legal restrictions on my property	( )	( )	( )	( )	( )
9. Environmental damage caused by practice	( )	( )	( )	( )	( )
10. Environmental benefit practice	( )	( )	( )	( )	( )

About You

1. Do you make the home and lawn care decisions in your household?

( ) Yes

( ) No

2. What is your gender?

( ) Male

( ) Female

3. What is your age?

4. What is the highest grade in school you have completed?

( ) Some formal schooling

( ) High school diploma/GED

( ) Some college

( ) 2 year college degree

( ) 4 year college degree

( ) Post-graduate degree

5. What is your occupation?

6. What is the approximate size of your residential lot?

( ) 1/4 acre or less

( ) More than 1/4 acre but less than 1 acre

( ) 1 acre to less than 5 acres

( ) 5 acres or more

7. Do you own or rent your home?

( ) Own

( ) Rent

8. How long have you lived at your current residence (years)?

9. Which of the following best describes where you live?

( ) In a town, village, or city

( ) In an isolated, rural, non-farm residence

( ) Rural subdivision or development

( ) On a farm

10. In addition to your residence, which of the following do you own or manage? (check all that apply)

[ ] An agricultural operation

[ ] Forested land

[ ] Rural recreational property

[ ] None of these

11. Do you use a professional lawn care service?
( ) Yes, just for mowing
( ) Yes, for mowing and fertilizing
( ) Yes, just for fertilizing and pest control
( ) Yes, for mowing, fertilizing, and pest control
( ) No

12. Where are you likely to seek information about soil and water conservation issues? (Check all that apply)
[ ] Newsletters/brochure/factsheet
[ ] Internet
[ ] Radio
[ ] Workshops/demonstrations/meetings
[ ] Conversations with others
[ ] Trade publications/magazines
[ ] None of the above

Information Sources

People get information about water quality from a number of different sources. To what extent do you trust those listed below as a source of information about soil and water?

	Not at all	Slightly	Moderately	Very much	Am not familiar
1. Local watershed project	( )	( )	( )	( )	( )
2. Local government	( )	( )	( )	( )	( )
3. U.S. Environmental Protection Agency	( )	( )	( )	( )	( )
4. University Extension	( )	( )	( )	( )	( )
5. State environmental agency	( )	( )	( )	( )	( )
6. Environmental groups	( )	( )	( )	( )	( )
7. Local garden center	( )	( )	( )	( )	( )
8. Lawn care company	( )	( )	( )	( )	( )
9. Local community leader	( )	( )	( )	( )	( )
10. Other landowners / friends	( )	( )	( )	( )	( )

Thank You

Thank You

1. Thank you for your time and assistance! Please provide your name and email to be entered into a drawing for an Amazon gift card!

2. Please type the code on your mailing label here. If you do not see a code or have a mailing label, please include your address to allow for confirmation of your location within the Big Walnut Creek Drainage.

My Report

2010 data modified: 10/04/2010

2019 data last modified: 2/3/2020

1. **Big Walnut Agriculture Survey**

Statistic	2010 responses	2019 responses
Total Responses	127	115 of 334 (34%)

2. Rating of Water Quality Overall, how would you rate the quality of the water in your local rivers, streams, and lakes?

#	Question	Poor	Okay	Good	Don't know	2010 Mean	2019 Mean
1	a. For canoeing / kayaking / other boating	8	26	34	36	2.38	4.66
2	b. For eating fish caught in the water	10	30	26	37	2.24	4.65
3	c. For swimming	16	28	24	35	2.12	4.44
4	d. For picnicking and family activities	6	29	44	24	2.48	3.99
5	e. For fish habitat	6	31	30	36	2.36	4.66
6	f. For scenic beauty	4	18	65	17	2.70	3.72

6. Water Impairments Below is a list of water pollutants and conditions that are generally present in water bodies to some extent. The pollutants and conditions become a problem when present in excessive amounts. In your opinion, how much of a problem are the following water impairments in your area?

Question	Not a problem	Slight problem	Moderate problem	Severe problem	Don't know	2010 Mean	2019 Mean
1. Sedimentation / silt	10	17	26	5	45	2.48	2.45
2. Nitrogen	8	13	15	2	63	2.41	2.29
3. Phosphorus	9	9	14	3	63	2.38	2.31
4. Coliform	8	8	7	2	73	2.55	2.12
5. E. coli	10	11	7	4	67	2.26	2.16
6. Trash / debris	17	20	14	12	40	2.20	2.33
7. PCBs	15	4	6	2	73	2.21	--
8. Toxic material	39	8	8	4	43	1.96	1.61

3. Your Opinions Please indicate your level of agreement or disagreement with the statements below.

Question	Strongly disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	2010 Mean	2019 Mean
1. The economic stability of my community depends upon good water quality.	0	5	23	53	26	4.10	3.93
2. Using recommended management practices on farms improves water quality.	1	2	18	56	28	4.04	4.03
3. It is my personal responsibility to help protect water quality.	1	1	11	66	26	4.15	4.10
4. It is important to protect water quality even if it slows economic development.	0	1	19	60	27	3.97	4.06
5. What I do on my land doesn't make much difference in overall water quality.	27	46	18	10	5	2.18	2.25
6. Investing in water quality protection puts the farmer at an economic disadvantage.	12	37	39	13	5	2.05	2.64
7. Farm management practices do not have an impact on water quality.	31	60	11	1	0	3.94	1.83
8. My actions have an impact on water quality.	1	5	15	67	16	2.67	3.88
9. Taking action to improve water quality is too expensive for me.	6	26	56	15	4	1.85	2.86
10. It is okay to reduce water quality to promote economic development.	28	55	15	3	3	3.51	2.02
11. It is important to protect water quality even it it costs me more.	2	8	39	46	10	3.11	3.51
12. I would be willing to pay more to improve water quality (for example: though local taxes or fees)	10	23	35	29	5	3.69	2.96
13. I would be willing to change management practices to improve water quality.	1	5	32	52	13	4.06	3.69
14. The quality of life in my community depends on good water quality in local streams, rivers and lakes.	1	4	20	58	23	2.41	3.92

7. Sources of Water Pollution The items listed below are sources of water quality pollution across the country. In your opinion, how much of a problem are the following sources in your area?

Question	Not a problem	Slight problem	Moderate problem	Severe problem	Don't know	2010 Mean	2019 Mean
1. Discharges from sewage treatment plants	39	8	8	4	43	1.70	1.61
2. Soil erosion from construction sites	39	15	13	1	34	2.19	1.65
3. Soil erosion from farm fields	10	28	29	10	27	2.54	2.51
4. Soil erosion from shorelines and/or streambanks	22	20	18	9	33	2.55	2.20
5. Excessive use of lawn fertilizers and/or pesticides	24	17	20	7	35	2.18	2.15
6. Improper disposal of household wastes (chemicals, batteries, florescent light bulbs, etc.)	28	19	13	9	33	2.12	2.04
7. Improperly maintained septic systems	32	15	14	6	35	1.81	1.91
8. Manure from farm animals	30	17	15	6	35	2.05	1.96
9. Waste material from pets	44	9	8	1	40	2.03	1.45
10. Crop production (non-irrigated)	25	22	10	0	44	2.76	1.74
11. Crop production (irrigated)	30	15	13	4	39	1.83	1.85
12. Animal feeding operations	32	15	14	0	39	1.81	1.70
13. Land development or redevelopment	29	13	11	5	42	2.09	1.86
14. Drainage/filling of wetlands	46	10	6	1	38	1.83	1.40
15. Wildlife	44	17	5	1	33	2.04	1.45
16. Yard maintenance	39	13	7	2	38	2.23	1.54
17. Turf management (golf courses, sports fields)	38	19	7	4	34	2.11	1.66

8. Consequences of Poor Water QualityPoor water quality can lead to a variety of consequences for communities. In your opinion, how much of a problem are the following issues in your area?

Question	Not a problem	Slight problem	Moderate problem	Severe problem	Don't know	2010 Mean	2019 Mean
1. Contaminated drinking water	38	19	7	4	34	1.67	1.66
2. Contaminated fish	27	13	13	5	45	1.81	1.93
3. Loss of desirabel fish species	18	16	13	5	51	1.92	2.10
4. Reduced beauty of lakes or streams	25	23	12	9	33	1.84	2.07
5. Reduced quality of water recreation activities	30	18	12	5	36	1.82	1.88
6. Excessive aquatic plants or algae	20	23	21	6	32	1.71	2.19
7. Fish kills	30	17	6	4	45	2.37	1.72
8. Odor	38	19	12	4	28	1.89	1.75

9. A. Please indicate which statement most accurately describes your level of experience with each practice.

Question	Does not apply	I've never heard of it.	I've heard of it, but I'm not very familiar with it.	I am familiar with it, but I've nver done it.	I have tried it, but I no longer do it	I currently use it.	2010 Mean	2019 Mean
1. Conduct regular soil tests for pH, phosphorus, nitrogen and potassium	8	16	15	7	24	8	2.49	3.33
2. Follow university recommendations for fertilization rates	11	10	13	2	21	11	2.23	3.21
3. Avoid fall application of manure or nitrogen fertilizer to reduce environmental losses	15	4	8	2	14	15	2.37	2.91
4. Use variable rate application technology for more precise crop production	11	7	8	3	13	11	1.57	3.00
5.Use field records of crops, pests and pesticide use to help develop pest control strategies	8	9	13	0	14	8	1.56	3.07
6. Construct water control basins to detain runoff	7	8	7	2	13	7	1.77	3.16
7. Construct a waste storage facility	8	7	6	1	6	8	2.83	2.64
8. Use no-till to reduce erosion	8	2	5	1	22	8	2.67	3.71
9. Establish permanent vegetation on retired agricultural land to reduce erosion	7	4	6	0	23	7	2.20	3.70
10. Use cover crops for erosion protection and soil improvement	6	5	7	6	19	6	1.67	3.63
11. Use approved plants and techniques in highly erodible areas	6	6	6	1	22	6	2.03	3.66
12. Use fencing to exclude animals from critical areas	3	7	5	3	12	3	1.72	3.47
13. Fence and/or reinforce animal pathways through sensitive terrain	3	8	9	1	8	3	1.90	3.10

Question	Does not apply	I've never heard of it.	I've heard of it, but I'm not very familiar with it.	I am familiar with it, but I've never done it.	I have tried it, but I no longer do it	I currently use it.	2010 Mean	2019 Mean
14. Plant vegetation in critical erosion areas	4	5	9	3	20	4	1.92	3.73
15. Create and/or manage wetland wildlife habitat	4	6	9	1	15	4	1.54	3.49
16. Transition to organic production	4	7	14	0	10	4	1.30	3.14
17. Replace home sewage treatment system	7	6	10	0	13	7	1.92	3.17

11. Making Management DecisionsIn general, how much dos each issue limit your ability to change your agricultural management practices?

Question	Not at all imp.	Somewhat important	Undecided	Important	Very Important	Responses	2010 Mean	2019 Mean
1. Personal out-of-pocket expense	36	20	13	5	4	36	2.33	1.99
2. My own views about effective farming or land management methods	19	32	19	5	3	19	2.44	2.24
3. How easily a new practice fits with my current farming methods	13	25	25	8	6	13	2.87	2.60
4. The need to learn new skills or methods	11	24	27	7	10	11	2.54	2.76
5. Lack of government funds for cost share	21	18	19	5	13	21	2.98	2.62
6. Too muchtime required for implementation	11	17	26	8	9	11	3.00	2.82
7. Not having access to the equipment that I need	16	23	17	7	10	16	2.62	2.62
8. Lack of available invomraiton about a practice	9	22	30	5	8	9	2.72	2.74
9. No one else I know is implementing the practice	7	8	31	7	20	7	3.51	3.34
10. Concerns about reduced yields	17	17	17	9	11	17	3.66	2.72
11. Approval of my neighbors	9	11	22	10	19	9	2.95	3.27
12. Don't want to participate in government programs	7	4	32	9	18	7	2.93	3.39
13. Requirements or restrictions of government	10	13	28	15	6	10	2.34	2.92
14. Possible interference with my flexibility to change land use practices as conditions warrant	13	13	28	10	7	13	2.31	2.79
15. Environmental damage caused by practice	14	26	23	4	5	14	1.00	2.44

Question	Not at all import.	Somewhat important	Undecided	Important	Very Important	Responses	2010 Mean	2019 Mean
16. Environmental benefit of practice	14	28	22	3	4	14	2.33	2.37
17. Profitability	14	29	19	2	9	14	2.44	2.49

Conservation tillage

	Not at all imp.	Somewhat important	Undecided	Important	Don't know	2019 Mean
Limitation: Don't know how to do it	39.7%	14.0%	12.4%	2.5%	31.4%	1.67
Limitation: lack of equipment	26.7%	15.8%	17.5%	6.7%	33.3%	2.06
Limitation: Time Required	21.7%	12.5%	23.3%	9.2%	33.3%	2.30
Limitation: Cost	32.8%	13.4%	11.8%	8.4%	33.6%	1.94
Limitation: Features of my property make it difficult	28.6%	19.3%	11.8%	4.2%	36.1%	1.87
Limitation: Insufficient proof of water quality benefit	33.1%	15.3%	12.9%	9.7%	29.0%	1.99
Limitation: Desire to keep things the way they are	36.7%	11.7%	13.3%	5.8%	32.5%	1.83
Limitation: Physical/health limitation	34.5%	16.0%	12.6%	5.9%	31.1%	1.85

Cover crops

	Not at all imp.	Somewhat important	Undecided	Important	Don't know	2019 Mean
Limitation: Don't know how to do it	48.6%	13.7%	19.1%	1.1%	17.5%	1.67
Limitation: lack of equipment	22.8%	17.9%	30.4%	10.9%	17.9%	2.36
Limitation: Time Required	20.5%	13.5%	28.6%	16.8%	20.5%	2.52
Limitation: Cost	44.6%	15.1%	15.6%	3.8%	21.0%	1.73
Limitation: Features of my property make it difficult	35.2%	15.9%	20.3%	3.3%	25.3%	1.89
Limitation: Insufficient proof of water quality benefit	37.6%	17.2%	14.5%	14.0%	16.7%	2.06
Limitation: Desire to keep things the way they are	29.9%	16.3%	20.1%	13.6%	20.1%	2.22
Limitation: Physical/health limitation	29.7%	19.2%	22.0%	11.0%	18.1%	2.17

Variable rate

Time required	Not at all imp.	Somewhat important	Undecided	Important	Don't know	2019 Mean
Limitation: Don't know how to do it	40.5%	10.1%	14.6%	5.1%	29.7%	1.77
Limitation: lack of equipment	31.2%	17.2%	14.6%	9.6%	27.4%	2.04
Limitation: Time Required	27.0%	13.2%	16.4%	15.1%	28.3%	2.27
Limitation: Cost	39.9%	11.4%	14.6%	4.4%	29.7%	1.77
Limitation: Features of my property make it difficult	41.4%	10.8%	15.3%	2.5%	29.9%	1.7
Limitation: Insufficient proof of water quality benefit	40.6%	15.0%	13.8%	6.3%	24.4%	1.81
Limitation: Desire to keep things the way they are	40.8%	10.2%	13.4%	7.6%	28.0%	1.83
Limitation: Physical/health limitation	37.6%	10.8%	16.6%	6.4%	28.7%	1.88

Urban - Initial Report

2010 data modified: 10/06/2010

2019 data last modified: 2/3/2020

Statistic	2010	2019
Total Responses	273	179 of 415 (43% response rate)

Rating of Water Quality   Overall, how would you rate the quality of the water in your local rivers, streams, and lakes?

#	Question	Poor	Okay	Good	Don't know	2010 Mean	2019 Mean
1	a. For canoeing / kayaking / other boating	5	41	97	27	2.63	2.64
2	b. For eating fish caught in the water	13	45	67	42	2.41	2.43
3	c. For swimming	12	65	68	22	2.36	2.39
4	d. For picnicking and family activities near water	6	43	101	19	2.60	2.63
5	e. For fish habitat / fishing	6	44	87	31	2.53	2.59
6	f. For scenic beauty / enjoyment	1	45	113	8	2.66	2.70

Please indicate your level of agreement or disagreement with the statements below.

Question	Strongly disagree	Disagree	Neither A/D	Agree	Strongly Agree	2010 Mean	2019 Mean
1. The economic stability of my community depends upon good water quality.	2	11	22	73	62	4.10	4.07
2. The way that I care for my lawn and yard can influence water quality in local streams and lakes.	4	12	14	93	47	4.03	3.98
3. It is my personal responsibility to help protect water quality.	2	4	12	99	51	4.14	4.15
4. It is important to protect water quality even if it slows economic development.	2	6	24	96	39	3.96	3.99
5. What I do on my land doesn't make much difference in overall water quality.	49	60	31	23	4	2.18	2.22
6. Lawn and yard-care practices (on individual lots) do not have an impact on local water quality.	49	76	29	10	4	2.05	2.07
7. My actions have an impact on water quality.	4	12	20	88	43	3.93	3.93
8. Taking action to improve water quality is too expensive for me.	16	54	69	19	6	2.65	2.67
9. It is okay to reduce water quality to promote economic development.	62	70	23	7	3	1.85	1.88
10. It is important to protect water quality even it it costs me more.	7	15	49	78	18	3.51	3.50
11. I would be willing to pay more to improve water quality (for example: though local taxes or fees)	17	28	58	50	12	3.10	3.07
12. I would be willing to change the way I care for my lawn and yard to improve water quality.	3	17	36	87	24	3.68	3.68
13. The quality of life in my community depends on good water quality in local streams, rivers and lakes.	4	9	16	84	55	4.05	4.05

Water Impairments Below is a list of water pollutants and conditions that are generally present in water bodies to some extent. The pollutants and conditions become a problem when present in excessive amounts. In your opinion, how much of a problem are the following water impairments in your area?

Question	Not a problem	Slight problem	Moderate problem	Severe problem	Don't know	2010 Mean	2019 Mean
1. Nitrogen	14	8	11	7	127	2.39	2.28
2. Phosphorus	12	8	15	9	121	2.54	2.48
3. E. coli	25	5	9	17	109	2.38	2.30
4. Trash / debris	30	28	27	20	60	2.40	2.34
5. Suspended solids	23	15	15	15	99	2.47	2.34
6. Atrazine	13	6	3	5	135	2.26	2.00
7. Total Kjeldahl Nitrogen	11	3	3	3	140	2.20	1.90
8. Algal growth	14	27	35	14	72	2.67	2.54
9. Exotic aquatic plants and/or animals	29	16	15	9	95	2.20	2.07
10. Noxious aquatic plants and/or animals	27	12	14	6	105	2.16	1.97
11. Flow alteration	28	10	10	3	113	1.96	1.78
12. Habitat alteration	24	17	10	4	108	2.22	1.87
13. Low pH (excess acidity)	18	5	4	4	131	2.00	1.81
14. High pH (excess alkalinity)	17	3	2	7	134	2.12	1.97
15. High water temperature	36	13	10	4	100	1.85	1.73

Sources of Water Pollution The items listed below are sources of water quality pollution across the country. In your opinion, how much of a problem are the following sources in your area?

Question	Not a problem	Slight problem	Moderate problem	Severe problem	Don't know	2010 Mean	2019 Mean
1. Discharges from sewage treatment plants	71	16	9	8	64	1.69	1.55
2. Soil erosion from construction sites	36	42	31	9	49	2.19	2.13
3. Soil erosion from farm fields	29	27	40	22	49	2.54	2.46
4. Excessive use of lawn fertilizers and/or pesticides	23	26	34	22	61	2.55	2.53
5. Grass clippings and leaves entering storm drains	39	38	28	13	50	2.17	2.14
6. Improper disposal of household wastes (chemicals, batteries, etc.)	39	33	20	10	65	2.11	2.01
7. Improperly maintained septic systems	61	23	14	8	62	1.80	1.71
8. Manure from farm animals	42	28	18	11	67	2.03	1.98
9. Stormwater runoff from rooftops and/or parking lots	37	42	20	9	59	2.02	2.02
10. Droppings from geese, ducks and other waterfowl	20	29	41	39	39	2.77	2.76
11. Waste material from pets	52	32	22	6	56	1.82	1.86
12. Animal feeding operations	52	13	21	6	72	1.77	1.79
13. Land development or redevelopment	44	28	25	9	58	2.09	2.01
14. Urban stormwater runoff	54	21	20	6	61	1.82	1.78
15. Residential stormwater runoff	39	33	23	11	59	2.03	2.08
16. Post-development erosion and sedimentation	29	26	31	9	72	2.22	2.21
17. Drainage/filling of wetlands	42	15	14	14	80	2.09	1.98
18. Natural sources	50	16	13	3	79	1.69	1.63
18. Littering/illegal dumping of trash	7	1	5	1	13	1.60	2.00
19. Wildlife	71	16	9	8	64	1.62	1.68
20. Yard maintenance	56	23	17	3	68	2.12	2.12
21. Turf management (golf courses, sports fields)	40	31	31	11	52	1.69	1.67

Consequences of Poor Water QualityPoor water quality can lead to a variety of consequences for communities. In your opinion, how much of a problem are the following issues in your area?

Question	Not a problem	Slight problem	Moderate problem	Severe problem	Don't know	2010 Mean	2019 Mean
1. Contaminated drinking water	79	36	6	10	37	1.70	1.60
2. Contaminated fish	62	25	10	14	56	1.67	1.78
3. High drinking water treatment costs	68	19	23	17	38	1.81	1.92
4. Loss of desirable fish	58	15	13	11	69	1.91	1.76
5. Reduced beauty of lakes or streams	73	30	18	12	34	1.83	1.77
6. Reduced opportunities for water recreation	80	27	13	12	37	1.81	1.67
7. Excessive aquatic plants or algae	36	44	29	18	41	1.72	2.23
8. Fish kills	59	25	12	15	55	2.37	1.85
9. Odor	72	30	18	12	34	1.88	1.77

Please indicate which statement most accurately describes your level of experience with each practice.

Question	Does not apply	I've never heard of it	I've heard of it, but I'm ot very familiar with it	I am familiar with it, but I've never done it.	I have tried it, but I no longer do it.	I currently use it.	2010 Mean	2019 Mean
1. At or below the manufacturer's guidelines for fertilizer application for my lawn	37	17	23	21	9	52	1.83	2.51
2. Create a rain garden	30	74	27	17	2	3	2.48	2.25
3. Use phosphate free fertilizer	38	30	33	32	3	21	2.23	2.49
4. Repair home sewage treatment system	97	11	14	15	1	12	2.36	1.64
5. Replace home sewage treatment system	103	10	10	18	1	9	1.57	1.62
6. Properly dispose of pet waste	74	12	8	16	3	43	1.56	1.79
7. Properly dispose of household waste (chemicals, batteries, florescent light bulbs, etc.)	16	5	13	23	4	95	1.75	2.92
8. Use rain barrels	35	20	37	48	1	10	2.80	2.72
9. Protect streambanks and/or shorelines with vegetation	49	14	26	31	1	30	2.65	2.35

Rain Gardens

	Not at all imp.	Somewhat important	Undecided	Important	Very Important	2019 Mean
Limitation: Don't know how to do it	69	19	30	0	0	1.66
Limitation: lack of equipment	42	32	45	0	0	2.03
Limitation: Time Required	67	17	35	0	0	1.73
Limitation: Cost	36	33	22	0	1	1.91
Limitation: Features of my property make it difficult	29	40	21	1	1	2.00
Limitation: Insufficient proof of water quality benefit	66	21	19	1	1	1.64
Limitation: Desire to keep things the way they are	100	5	14	1	0	1.30
Limitation: Physical/health limitation	44	38	38	1	1	2.02

Shoreline Protection/Streambank plantings

	Not at all imp.	Somewhat important	Undecided	Important	Very Important	2019 Mean
Limitation: Don't know how to do it	25	86	22	24	7	2.40
Limitation: lack of equipment	24	44	18	41	32	2.99
Limitation: Time Required	19	54	24	24	42	3.08
Limitation: Cost	22	92	32	10	6	2.27
Limitation: Features of my property make it difficult	21	112	21	8	2	2.13
Limitation: Insufficient proof of water quality benefit	11	64	41	29	14	2.73
Limitation: Desire to keep things the way they are	41	55	24	21	22	2.54
Limitation: Physical/health limitation	16	84	16	28	18	2.65

Septic Repairs

	Not at all imp.	Somewhat important	Undecided	Important	Very Important	2019 Mean
Limitation: Don't know how to do it	30	74	28	24	1	2.49
Limitation: lack of equipment	21	49	43	35	0	2.83
Limitation: Time Required	37	65	18	25	0	2.48
Limitation: Cost	12	52	40	32	1	3.07
Limitation: Features of my property make it difficult	20	37	50	29	1	3.02
Limitation: Insufficient proof of water quality benefit	29	62	30	25	1	2.66
Limitation: Desire to keep things the way they are	21	57	38	28	1	2.82
Limitation: Physical/health limitation	8	27	55	20	1	3.51

Appendix B: Endangered, Threatened and Rare Species Data

EO_ID	NAME_CAT_1	ELEMENT_GL	ELEMENT_SU	DATA_SENSI	ELCODE	EONUM
20702	Vertebrate Animal	209227	15500	No	AAAAE01042	35
4705	Vertebrate Animal	1672	14459	No	AAABH01170	25
1129	Vertebrate Animal	4847	17634	Yes	ABNKC10010	80
18491	Vertebrate Animal	4847	17634	Yes	ABNKC10010	210
20435	Vertebrate Animal	4847	17634	Yes	ABNKC10010	367
20468	Vertebrate Animal	4847	17634	Yes	ABNKC10010	400
4832	Vertebrate Animal	2276	15063	No	ABNNF06010	54
6042	Vertebrate Animal	5651	18438	No	ABPBG10010	19
18195	Vertebrate Animal	5651	18438	No	ABPBG10010	74
20022	Vertebrate Animal	4894	17681	No	ABPBR01030	174
12679	Vertebrate Animal	2000	14787	No	ABPBX03240	54
12203	Vertebrate Animal	2000	14787	No	ABPBX03240	56
5913	Vertebrate Animal	2000	14787	No	ABPBX03240	57
11753	Vertebrate Animal	2000	14787	No	ABPBX03240	58
6208	Vertebrate Animal	2000	14787	No	ABPBX03240	59
6210	Vertebrate Animal	2000	14787	No	ABPBX03240	60
2093	Vertebrate Animal	2000	14787	No	ABPBX03240	74
595	Vertebrate Animal	2000	14787	No	ABPBX03240	80
18184	Vertebrate Animal	2000	14787	No	ABPBX03240	90
18185	Vertebrate Animal	2000	14787	No	ABPBX03240	91
18186	Vertebrate Animal	2000	14787	No	ABPBX03240	92
18512	Vertebrate Animal	2000	14787	No	ABPBX03240	94
18513	Vertebrate Animal	2000	14787	No	ABPBX03240	95
18187	Vertebrate Animal	3891	16678	No	ABPBX05010	66
18188	Vertebrate Animal	3891	16678	No	ABPBX05010	67
4321	Vertebrate Animal	5136	17923	No	ABPBX08010	44
5130	Vertebrate Animal	5136	17923	No	ABPBX08010	45
18189	Vertebrate Animal	5136	17923	No	ABPBX08010	66
18190	Vertebrate Animal	5136	17923	No	ABPBX08010	67
18191	Vertebrate Animal	5136	17923	No	ABPBX08010	68
18192	Vertebrate Animal	5136	17923	No	ABPBX08010	69
18193	Vertebrate Animal	5136	17923	No	ABPBX08010	70
3772	Vertebrate Animal	5730	18517	No	ABPBX16010	51

18194	Vertebrate Animal	5730	18517	No	ABPBX16010	87
8709	Vertebrate Animal	5532	18319	No	ABPBX91050	17
17182	Vertebrate Animal	598	13385	No	ABPBXA0030	93
588	Vertebrate Animal	424	13211	No	AMACC01100	62
10338	Vertebrate Animal	3068	15855	No	AMAJF02020	19
709	Vertebrate Animal	1940	14727	No	AMAJF04010	75
11848	Vertebrate Animal	2718	15505	Yes	ARADB23010	16
5973	Vertebrate Animal	5860	18647	Yes	ARADE03011	54
12138	Terrestrial Community - Other Classification	6394	19181	No	CFORFLOMES	8
18460	Terrestrial Community - Other Classification	6394	19181	No	CFORFLOMES	36
19602	Terrestrial Community - Other Classification	6394	19181	No	CFORFLOMES	39
11295	Terrestrial Community - Other Classification	6347	19134	No	CFORFLOWME	17
1215	Terrestrial Community - Other Classification	26363	26365	No	CFORUPDM05	23
1141	Terrestrial Community - Other Classification	26333	26335	No	CFORUPME05	41
10541	Terrestrial Community - Other Classification	26333	26335	No	CFORUPME05	45
3164	Terrestrial Community - Other Classification	26333	26335	No	CFORUPME05	48
10990	Terrestrial Community - Other Classification	26333	26335	No	CFORUPME05	130
19601	Terrestrial Community - Other Classification	26333	26335	No	CFORUPME05	418
4428	Terrestrial Community - Other Classification	26345	26347	No	CFORUPME09	131
8311	Terrestrial Community - Other Classification	6352	19139	No	CPRICLISST	1
8835	Terrestrial Community - Other Classification	6386	19173	No	CWETSEECIR	12
20266	Invertebrate Animal	22074	22076	No	IIHYM24020	1
20267	Invertebrate Animal	22074	22076	No	IIHYM24020	2
20270	Invertebrate Animal	22074	22076	No	IIHYM24020	5
7219	Invertebrate Animal	2651	15438	No	IILEP80080	4
147	Invertebrate Animal	4850	17637	No	IILEY8Q010	2
1605	Invertebrate Animal	2116	14903	No	IIODO03070	4
14977	Invertebrate Animal	5000	17787	No	IIODO71160	17
15043	Invertebrate Animal	2605	15392	No	IMBIV16184	63
15122	Invertebrate Animal	1039	13826	No	IMBIV21070	214
15165	Invertebrate Animal	1583	14370	No	IMBIV31050	131
15166	Invertebrate Animal	1583	14370	No	IMBIV31050	132
13877	Invertebrate Animal	2211	14998	No	IMBIV38010	190
15979	Invertebrate Animal	2211	14998	No	IMBIV38010	219

4879	Invertebrate Animal	5459	18246	No	IMBIV41010	5
13919	Invertebrate Animal	5459	18246	No	IMBIV41010	37
14015	Invertebrate Animal	5475	18262	No	IMBIV47070	133
16142	Invertebrate Animal	5475	18262	No	IMBIV47070	179
16143	Invertebrate Animal	5475	18262	No	IMBIV47070	180
16144	Invertebrate Animal	5475	18262	No	IMBIV47070	181
16163	Invertebrate Animal	5475	18262	No	IMBIV47070	200
17003	Invertebrate Animal	5475	18262	No	IMBIV47070	217
17354	Geological Feature	21516	21519	Yes	OGNEFWFCAS	161
17355	Geological Feature	21516	21519	Yes	OGNEFWFCAS	162
17356	Geological Feature	21516	21519	Yes	OGNEFWFCAS	163
17357	Geological Feature	21516	21519	Yes	OGNEFWFCAS	164
17358	Geological Feature	21516	21519	Yes	OGNEFWFCAS	165
17359	Geological Feature	21516	21519	Yes	OGNEFWFCAS	166
17360	Geological Feature	21516	21519	Yes	OGNEFWFCAS	167
17362	Geological Feature	21516	21519	Yes	OGNEFWFCAS	169
20538	Vascular Plant	2670	15457	Yes	PDARA09010	118
6048	Vascular Plant	5848	18635	No	PDJUG02030	9
12077	Vascular Plant	5848	18635	No	PDJUG02030	32
8614	Vascular Plant	5848	18635	No	PDJUG02030	33
19860	Vascular Plant	5848	18635	No	PDJUG02030	73
3429	Vascular Plant	5047	17834	No	PGTXA01020	4
5507	Vascular Plant	2387	15174	No	PMCYP03AA0	16
14509	Vascular Plant	2387	15174	No	PMCYP03AA0	21
20173	Vascular Plant	2387	15174	No	PMCYP03AA0	24
6629	Vascular Plant	39	12826	No	PMPOA4Z1W0	26
14510	Vascular Plant	1450	14237	No	PMPOA4Z2M0	18
14511	Vascular Plant	1450	14237	No	PMPOA4Z2M0	19

SNAME	SCOMNAME	GRANK	SRANK	SPROT	LASTOBS
Necturus maculosus	Common mudpuppy	G5	S2	SSC	2013-04-11
Lithobates pipiens	Northern Leopard Frog	G5	S2	SSC	1969-08-28
Haliaeetus leucocephalus	Bald Eagle	G5	S2	SSC	2017-01-02
Haliaeetus leucocephalus	Bald Eagle	G5	S2	SSC	2016-06-21
Haliaeetus leucocephalus	Bald Eagle	G5	S2	SSC	2016-05-30
Haliaeetus leucocephalus	Bald Eagle	G5	S2	SSC	2017-02-18
Bartramia longicauda	Upland Sandpiper	G5	S3B	SE	2000-06-04
Cistothorus platensis	Sedge Wren	G5	S3B	SE	1994-07-30
Cistothorus platensis	Sedge Wren	G5	S3B	SE	2007-SUM
Lanius ludovicianus	Loggerhead Shrike	G4	S3B	SE	2010-05-30
Setophaga cerulea	Cerulean Warbler	G4	S3B	SE	1998-06-13
Setophaga cerulea	Cerulean Warbler	G4	S3B	SE	1995
Setophaga cerulea	Cerulean Warbler	G4	S3B	SE	2007
Setophaga cerulea	Cerulean Warbler	G4	S3B	SE	2007
Setophaga cerulea	Cerulean Warbler	G4	S3B	SE	2007-SUM
Setophaga cerulea	Cerulean Warbler	G4	S3B	SE	2007
Setophaga cerulea	Cerulean Warbler	G4	S3B	SE	2000-06-01
Setophaga cerulea	Cerulean Warbler	G4	S3B	SE	2001-06-15
Setophaga cerulea	Cerulean Warbler	G4	S3B	SE	2007-SUM
Setophaga cerulea	Cerulean Warbler	G4	S3B	SE	2007-SUM
Setophaga cerulea	Cerulean Warbler	G4	S3B	SE	2007-SUM
Setophaga cerulea	Cerulean Warbler	G4	S3B	SE	2007
Setophaga cerulea	Cerulean Warbler	G4	S3B	SE	2007
Mniotilta varia	Black-and-white Warbler	G5	S1S2B	SSC	2007-SUM
Mniotilta varia	Black-and-white Warbler	G5	S1S2B	SSC	2007-SUM
Helmitheros vermivorus	Worm-eating Warbler	G5	S3B	SSC	1995-06-13
Helmitheros vermivorus	Worm-eating Warbler	G5	S3B	SSC	2007-SUM
Helmitheros vermivorus	Worm-eating Warbler	G5	S3B	SSC	2007-SUM
Helmitheros vermivorus	Worm-eating Warbler	G5	S3B	SSC	2007-SUM
Helmitheros vermivorus	Worm-eating Warbler	G5	S3B	SSC	2007-SUM
Helmitheros vermivorus	Worm-eating Warbler	G5	S3B	SSC	2007-SUM
Helmitheros vermivorus	Worm-eating Warbler	G5	S3B	SSC	2007-SUM
Setophaga citrina	Hooded Warbler	G5	S3B	SSC	1995

Setophaga citrina	Hooded Warbler	G5	S3B	SSC	2007-SUM
Aimophila aestivalis	Bachman's Sparrow	G3	SXB		1893-05-15
Ammodramus henslowii	Henslow's Sparrow	G4	S3B	SE	2009-06-20
Myotis sodalis	Indiana Bat or Social Myotis	G2	S1	SE	1991-06-17
Mustela nivalis	Least Weasel	G5	S2?	SSC	1964-01
Taxidea taxus	American Badger	G5	S2	SSC	1983-10-01
Opheodrys aestivus	Rough Green Snake	G5	S3	SSC	1999
Sistrurus catenatus catenatus	Eastern Massasauga	G3	S2	SE	1892
Forest - floodplain mesic	Mesic Floodplain Forest	G3?	S1	SG	2009-07-21
Forest - floodplain mesic	Mesic Floodplain Forest	G3?	S1	SG	2010
Forest - floodplain mesic	Mesic Floodplain Forest	G3?	S1	SG	2005
Forest - floodplain wet-mesic	Wet-mesic Floodplain Forest	G3?	S3	SG	2009-07-21
Forest - upland dry-mesic Central Till Plain	Central Till Plain Dry-mesic Upland Forest	GNR	S2	SG	1990
Forest - upland mesic Central Till Plain	Central Till Plain Mesic Upland Forest	GNR	S3	SG	1990
Forest - upland mesic Central Till Plain	Central Till Plain Mesic Upland Forest	GNR	S3	SG	1986-02
Forest - upland mesic Central Till Plain	Central Till Plain Mesic Upland Forest	GNR	S3	SG	1989-03-10
Forest - upland mesic Central Till Plain	Central Till Plain Mesic Upland Forest	GNR	S3	SG	1985-12-10
Forest - upland mesic Central Till Plain	Central Till Plain Mesic Upland Forest	GNR	S3	SG	2005
Forest - upland mesic Shawnee Hills	Shawnee Hills Mesic Upland Forest	GNR	S3	SG	1990-06-08
Primary - cliff sandstone	Sandstone Cliff	GU	S3	SG	1990-06-08
Wetland - seep circumneutral	Circumneutral Seep	GU	S1	SG	1990-06-08
Bombus affinis	Rusty-patched Bumble Bee	G1	S1	SE	1981-09-23
Bombus affinis	Rusty-patched Bumble Bee	G1	S1	SE	1976-07-30
Bombus affinis	Rusty-patched Bumble Bee	G1	S1	SE	1982-08-04
Amblyscirtes hegon	Salt-and-pepper Skipper	G5	S2	SR	2001
Eosphoropteryx thyatyroides	Pinkpatched Looper Moth	G4G5	S2	ST	2001
Cordulegaster obliqua	Arrowhead Spiketail	G4	S2S3	SR	1995
Enallagma divagans	Turquoise Bluet	G5	S3	SR	2004
Epioblasma torulosa rangiana	Northern Riffleshell	G2T2	S1	SE	2005-06-30
Lampsilis fasciola	Wavyrayed Lampmussel	G5	S3	SSC	2011-09-16
Obovaria subrotunda	Round Hickorynut	G4	S1	SE	2007-08-09
Obovaria subrotunda	Round Hickorynut	G4	S1	SE	2005-06-30
Ptychobranchus fasciolaris	Kidneyshell	G4G5	S2	SSC	2003-08-28
Ptychobranchus fasciolaris	Kidneyshell	G4G5	S2	SSC	2005-06-30

Simpsonaias ambigua	Salamander Mussel	G3	S2	SSC	1967
Simpsonaias ambigua	Salamander Mussel	G3	S2	SSC	1999-07-27
Villosa lienosa	Little Spectaclecase	G5	S3	SSC	2001-07-18
Villosa lienosa	Little Spectaclecase	G5	S3	SSC	2005-06-30
Villosa lienosa	Little Spectaclecase	G5	S3	SSC	2005-06-30
Villosa lienosa	Little Spectaclecase	G5	S3	SSC	2005-06-30
Villosa lienosa	Little Spectaclecase	G5	S3	SSC	2006-07-24
Villosa lienosa	Little Spectaclecase	G5	S3	SSC	2010-07-28
Geomorphic - Nonglacial Erosional Feature - Water Fall and Cascade	Water Fall and Cascade	GNR	SNR		2009-02-17
Geomorphic - Nonglacial Erosional Feature - Water Fall and Cascade	Water Fall and Cascade	GNR	SNR		2009-04-17
Geomorphic - Nonglacial Erosional Feature - Water Fall and Cascade	Water Fall and Cascade	GNR	SNR		2009-04-17
Geomorphic - Nonglacial Erosional Feature - Water Fall and Cascade	Water Fall and Cascade	GNR	SNR		2009-04-17
Geomorphic - Nonglacial Erosional Feature - Water Fall and Cascade	Water Fall and Cascade	GNR	SNR		2009-02-17
Geomorphic - Nonglacial Erosional Feature - Water Fall and Cascade	Water Fall and Cascade	GNR	SNR		2009-02-17
Geomorphic - Nonglacial Erosional Feature - Water Fall and Cascade	Water Fall and Cascade	GNR	SNR		2009-04-17
Geomorphic - Nonglacial Erosional Feature - Water Fall and Cascade	Water Fall and Cascade	GNR	SNR		2009-02-17
Panax quinquefolius	American Ginseng	G3G4	S3	WL	2016-09-07
Juglans cinerea	Butternut	G4	S3	WL	1969-08-28
Juglans cinerea	Butternut	G4	S3	WL	1979-09-09
Juglans cinerea	Butternut	G4	S3	WL	1979-06-14
Juglans cinerea	Butternut	G4	S3	WL	2014-12-11
Taxus canadensis	American Yew	G5	S1	SE	2011-10-09
Carex pedunculata	Longstalk Sedge	G5	S2	SR	1995-06-14
Carex pedunculata	Longstalk Sedge	G5	S2	SR	2005-05-10
Carex pedunculata	Longstalk Sedge	G5	S2	SR	2015-04-30
Poa paludigena	Bog Bluegrass	G3	S3	WL	1990-06-08
Poa wolfii	Wolf Bluegrass	G4	S2	SR	2005-05-10
Poa wolfii	Wolf Bluegrass	G4	S2	SR	2005-05-10

LASTOBS_YR	EORANK	USESA	LONGDEC	LATDEC	ACRES	PRECISION	OBSERVER	REGIONAL
2013			-86.8669	39.6672		S	BRANT FISHER	C
1969	H		-86.7769	39.7819		M	LINDSEY, A.	C
2017	C		-86.9505	39.7052		S	JOHN CASTRALE	C
2016			-86.7900	39.6958		S	JOHN CASTRALE,Gillet, Allisyn-Marie	C
2016			-86.9227	39.6216		S	ALLISYN-MARIE GILLET	C
2017			-86.6658	39.8402		S	ALLISYN-MARIE GILLET	C
2000	C		-86.5861	39.8108	650.00	S	ROGER HEDGE	C
1994	C		-86.6180	39.8561		S	ROGER HEDGE	C
2007			-86.7808	39.7947		S	JAMES COLE	C
2010			-86.9900	39.6961		S	NOAH KEARNS AND AMY KEARNS	SW
1998	C		-86.6872	39.8313		S	ROGER HEDGE AND CLOYCE HEDGE	C
1995			-86.7627	39.8016		S	ROGER HEDGE	C
2007			-86.7830	39.7897		S	JAMES COLE	C
2007			-86.7763	39.7844		S	JAMES COLE	C
2007			-86.7827	39.7658		S	JAMES COLE	C
2007	B		-86.7830	39.7583		S	JAMES COLE	C
2000	B		-86.6861	39.8369		S	ROGER HEDGE	C
2001			-86.7788	39.7786		S	ROGER HEDGE	C
2007			-86.7869	39.7897		S	JAMES COLE	C
2007			-86.7833	39.7925		S	JAMES COLE	C
2007			-86.7727	39.7922		S	JAMES COLE	C
2007			-86.7733	39.7897		S	JAMES COLE	C
2007			-86.7797	39.7897		S	JAMES COLE	C
2007			-86.7766	39.7927		S	JAMES COLE	C
2007			-86.7763	39.7897		S	JAMES COLE	C
1995			-86.7675	39.8027		S	ROGER HEDGE	C
2007			-86.7780	39.7894		S	JAMES COLE	C
2007			-86.7869	39.7683		S	JAMES COLE	C
2007			-86.7794	39.7680		S	JAMES COLE	C
2007			-86.7830	39.7897		S	JAMES COLE	C
2007			-86.7763	39.7816		S	JAMES COLE	C
2007			-86.7766	39.7927		S	JAMES COLE	C
1995			-86.7722	39.7950		S	ROGER HEDGE	C

2007			-86.7730	39.7816		S	JAMES COLE	C
1893	H		-86.8463	39.6486		M	JESSEE EARLE	C
2009	BC		-86.6100	39.9283		S	ROGER HEDGE	C
1991		LE	-86.6350	39.8977		S	V. BRACK & K. TYRELL - 3D ENVIRONME	C
1964	H		-86.8111	39.7769		M	WALTER, V.	C
1983	C		-86.7750	39.7750	94.00	M	J SPARKS	C
1999			-86.9377	39.6463		S	TERENCE E. HANLEY	C
1892	H	LT	-86.5347	39.8838		M	HAY -MINTON	C
2009	C		-86.7802	39.7575	8.00	S	ART SPINGARN	C
2010	AB		-86.7819	39.7880		S	TOM SWINFORD	C
2005			-86.7227	39.8266		S	DIVISION OF NATURE PRESERVES	C
2009	B		-86.7780	39.7825	4.00	S	INHP	C
1990	B		-86.7736	39.7847	244.60	S	LINDSEY, A., ET. AL. (P. 269)	C
1990	A		-86.7808	39.7780	55.33	S	LINDSEY, A. ET AL., P. 269.	C
1986	A		-86.7708	39.7961	10.18	S	POST, T.	C
1989	B		-86.7838	39.7577	98.14	S	ART SPINGARN	C
1985	B		-86.7658	39.8052	26.22	S	JIM ALDRICH & HANK HUFFMAN	C
2005			-86.7219	39.8252	7.71	S	DIVISION OF NATURE PRESERVES	C
1990	C		-86.9633	39.6108	137.76	S	R. HEDGE, SPINGARN, HUFFMAN	C
1990	B		-86.9611	39.6102	3.00	S	R.HEDGE, SPINGARN, HUFFMAN	C
1990	B		-86.6125	39.8511	2.00	S	ROGER HEDGE & MIKE HOMOYA	C
1981		LE	-86.8647	39.6444		S	M.D. JOHNSON, B. BRADFORD, R.P. JEAN	C
1976		LE	-86.9619	39.6097		S	M.D. JOHSON	C
1982		LE	-86.8827	39.6330		S	T. HAZEL	C
2001			-86.7769	39.7819		M	JAMES BESS	C
2001	AB		-86.7761	39.7797		S	JAMES BESS	C
1995			-86.7744	39.7916		S	TOM SWINFORD	C
2004			-86.7897	39.7033		S	PAUL MCMURRAY JR. AND STEVEN NEWHO	C
2005	H	LE	-86.7536	39.8158		S	B.E. FISHER	C
2011			-86.7691	39.8036		S	BRANT FISHER AND J.D. DAVIS	C
2007	H	C	-86.9563	39.5055		S	FISHER AND BALES	C
2005		C	-86.7536	39.8158		S	B.E. FISHER, T.V. BRIGGS	C
2003	C		-86.9366	39.5002		S	BRANT FISHER	C
2005	H		-86.7372	39.8250		S	B.E. FISHER AND T.V. BRIGGS	C

1967	H	C	-86.9825	39.5513	M	CLARKE 1985: M. HENSCHEN	C
1999	C	C	-86.9308	39.6438	S	BRANT FISHER	C
2001	H		-86.6566	39.8300	S	BRANT FISHER	C
2005			-86.7616	39.8130	S	B.E. FISHER AND T.V. BRIGGS	C
2005			-86.5833	39.8611	S	B.E. FISHER AND T.V. BRIGGS	C
2005			-86.6475	39.8444	S	B.E. FISHER AND T.V. BRIGGS	C
2006			-86.9219	39.5497	S	B.E. FISHER AND S.A. BALES	C
2010	H		-86.9777	39.5358	S	BRANT FISHER	C
2009			-86.9680	39.5588	S	RICHARD POWELL	C
2009			-86.9072	39.7008	S	RICHARD POWELL	C
2009			-86.9066	39.7019	S	RICHARD POWELL	C
2009			-86.9633	39.7186	S	RICHARD POWELL	C
2009			-86.9147	39.6916	S	RICHARD POWELL	C
2009			-86.9616	39.7097	S	RICHARD POWELL	C
2009			-86.8955	39.6883	S	RICHARD POWELL	C
2009			-86.7797	39.7419	S	RICHARD POWELL	C
2016	C		-86.7808	39.7863	S	ROB JEAN	C
1969			-86.7769	39.7819	M	A. LINDSEY	C
1979	X		-86.6277	39.9127	S	CLOYCE HEDGE	C
1979			-86.6152	39.9280	S	CLOYCE HEDGE	C
2014	A		-86.7866	39.7650	S	ANDREW REUTER	C
2011	C		-86.7769	39.7819	S	F. COLLIN HOBBS	C
1995	AB		-86.7783	39.7791	S	ROGER HEDGE, TOM SWINFORD, JEAN FIX	C
2005	A		-86.7222	39.8266	S	Mike Homoya and Tom Swinford	C
2015	C		-86.7802	39.7608	S	ROGER HEDGE AND MIKE HOMOYA	C
1990	C		-86.6125	39.8513	S	MIKE HOMOYA, ROGER HEDGE, MARK BENN	C
2005	A		-86.7222	39.8266	S	Mike Homoya and Tom Swinford	C
2005	C		-86.7863	39.7716	S	Mike Homoya and Tom Swinford	C

MISCCOMMEN	WATERSHED	COUNTY_NAM	MANAME	NRCODE	QUADNAME
	05120203	Putnam		005A	Greencastle
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
NEST SITE	05120203	Putnam		005A	Clinton Falls
NEST SITE	05120203	Putnam		005A	Greencastle
NEST SITE	05120203	Putnam		009B	Reelsville
NEST SITE	05120203	Hendricks		005B	North Salem
OBSERVED	05120203	Hendricks		005B	Danville
	05120203	Hendricks		005B	Danville
	05120203	Putnam	BIG WALNUT - BREWER TRACT	005A	Roachdale
	05120203	Putnam		007B	Clinton Falls
	05120203	Hendricks		005A	North Salem
	05120203	Putnam	BIG WALNUT MANAGED AREA (TNC)	005A	Roachdale
	05120203	Putnam	FORTUNE WOODS NATURE PRESERVE	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT ADDITION NATURE PRESERVE	005A	Roachdale
	05120203	Putnam	HALL (OSCAR AND RUTH) WOODS NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Hendricks		005B	North Salem
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT ADDITION NATURE PRESERVE	005A	Roachdale
	05120203	Putnam	BIG WALNUT - BREWER TRACT	005A	Roachdale
	05120203	Putnam	BIG WALNUT ADDITION NATURE PRESERVE	005A	Roachdale
	05120203	Putnam	BIG WALNUT ADDITION NATURE PRESERVE	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT MANAGED AREA (TNC)	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT ADDITION NATURE PRESERVE	005A	Roachdale
	05120203	Putnam	BIG WALNUT - BROWN TRACT	005A	Roachdale
	05120203	Putnam	FORTUNE WOODS NATURE PRESERVE	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT MANAGED AREA (TNC)	005A	Roachdale

	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam		005A	Greencastle
	05120203	Boone		005B	Lizton
BAT SUMMER CAPTURE	05120203	Hendricks		005B	New Ross
	05120108	Putnam	BIG WALNUT ADDITION NATURE PRESERVE	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE	005A	Roachdale
	05120203	Putnam		009A	Clinton Falls
	05120203	Hendricks		005A	Lizton
	05120203	Putnam	HALL (OSCAR AND RUTH) WOODS NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	HEMLOCK RIDGE NATURE PRESERVE	005A	North Salem
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT MANAGED AREA (TNC)	005A	Roachdale
	05120203	Putnam	HALL (OSCAR AND RUTH) WOODS NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT MANAGED AREA (TNC)	005A	Roachdale
	05120203	Putnam	HEMLOCK RIDGE NATURE PRESERVE	005A	North Salem
	05120203	Putnam	FERN CLIFF NATURE PRESERVE	009A	Reelsville
	05120203	Putnam	FERN CLIFF NATURE PRESERVE	009A	Reelsville
	05120203	Hendricks		005B	Danville
	05120203	Putnam		005A	Greencastle
	05120203	Putnam	FERN CLIFF NATURE PRESERVE	009A	Reelsville
	05120203	Putnam		005A	Clinton Falls
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT ADDITION NATURE PRESERVE	005A	Roachdale
	05120203	Putnam		005A	Greencastle
WEATHERED DEAD	05120203	Putnam	BIG WALNUT - MCNAMARA TRACT	005A	Roachdale
2011: WEATHERED DEAD. (FISHER AN	05120203	Putnam	FORTUNE WOODS NATURE PRESERVE	005A	Greencastle
HISTORICAL; SUBFOSSIL. (FISHER AND	05120203	Putnam		005A	Reelsville
WEATHERED DEAD. (FISHER AND BRI(	05120203	Putnam	BIG WALNUT - MCNAMARA TRACT	005A	Roachdale
2003: WEATHERED DEAD. (FISHER, 20	05120203	Putnam		007B	Reelsville
HISTORICAL; SUBFOSSIL. (FISHER AND	05120203	Hendricks	HEMLOCK RIDGE NATURE PRESERVE	005A	Roachdale

1967: HISTORICAL. (CLARK AND HENS	05120203	Putnam		009A	Reelsville
1999: FRESH DEAD. (FISHER, 2004).	05120203	Putnam		009A	Clinton Falls
HISTORICAL; 2001: SUBFOSSIL. (FISHE	05120203	Hendricks		005B	North Salem
2011: SUBFOSSIL. (FISHER AND DAVIS	05120203	Hendricks	FORTUNE WOODS NATURE PRESERVE	005A	Roachdale
WEATHERED DEAD. (FISHER AND BRI(	05120203	Hendricks		005B	Danville
WEATHERED DEAD. (FISHER AND BRI(	05120203	Hendricks		005B	North Salem
WEATHERED DEAD. (FISHER AND BALI	05120203	Putnam		009A	Reelsville
HISTORICAL; 2010: WEATHERED DEAL	05120203	Putnam		007B	Reelsville
	05120203	Putnam		009A	Reelsville
	05120203	Putnam		009B	Clinton Falls
	05120203	Putnam		009B	Clinton Falls
	05120203	Putnam		009A	Clinton Falls
	05120203	Putnam		009B	Clinton Falls
	05120203	Putnam		009A	Clinton Falls
	05120203	Putnam		009B	Clinton Falls
	05120203	Putnam		005A	Greencastle
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Hendricks		005B	New Ross
	05120203	Boone		005B	Lizton
	05120203	Putnam	BIG WALNUT - WALNUT OAKS TRACT	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	BIG WALNUT NATURE PRESERVE (ORIGINAL)	005A	Roachdale
	05120203	Putnam	HEMLOCK RIDGE NATURE PRESERVE	005A	North Salem
	05120203	Putnam	BIG WALNUT NATURE PRESERVE	005A	Roachdale
	05120203	Hendricks		005B	Danville
	05120203	Putnam	HEMLOCK RIDGE NATURE PRESERVE	005A	North Salem
	05120203	Putnam	BIG WALNUT ADDITION NATURE PRESERVE	005A	Roachdale

SITE_NAME	FEATURE	SURVEY_SIT	TRS
	Line	BIG WALNUT CREEK	014N004W 8
BIG WALNUT ECOSYSTEM	Point		016N003W 32
	Point	BALD EAGLE NEST NAME GLENN FLINT LAKE	015N005W 34 NWQ NEQ NWQ
	Point	BALD EAGLE NEST NAME BIG WALNUT CREEK	015N003W 31
	Point	GREENCASTLE WEST	014N005W 26
	Point	NORTH SALEM	016N002W 8
	Point		016N002W 24 NEQ SWQ AND NWQ SEQ
	Point		016N002W 3
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT	016N003W 29
	Point		015N005W 32
	Point	BIG WALNUT CREEK AT PUTNAM/HENDRICKS COUNTY LINE	016N003W 13 SEQ NEQ NEQ
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT SURVEY AREA #1	016N003W 29 NEQ
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT SURVEY AREA #3	016N003W 31 NEQ
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT SURVEY AREA #4	016N003W 32 SEQ SWQ NWQ
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT SURVEY AREA #7	015N003W 6
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT SURVEY AREA #8	015N003W 8
	Point		016N002W 7
BIG WALNUT ECOSYSTEM	Point		016N003W 32 SWQ SWQ
BIG WALNUT ECOSYSTEM	Point	COLE SITE BIGWAL07	016N003W 31
BIG WALNUT ECOSYSTEM	Point	COLE SITE BIGWAL09	016N003W 30
BIG WALNUT ECOSYSTEM	Point	COLE SITE BIGWAL02	016N003W 29
BIG WALNUT ECOSYSTEM	Point	COLE SITE BIGWAL03	016N003W 32
BIG WALNUT ECOSYSTEM	Point	COLE SITE BIGWAL05	016N003W 31
BIG WALNUT ECOSYSTEM	Point	COLE SITE BIGWAL01	016N003W 29
BIG WALNUT ECOSYSTEM	Point	COLE SITE BIGWAL04	016N003W 32
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT SURVEY AREA #1	016N003W 29 NWQ
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT SURVEY AREA #4	016N003W 32 NWQ
BIG WALNUT ECOSYSTEM	Point	BIGWAL30	015N003W 6
BIG WALNUT ECOSYSTEM	Point	BIGWAL32	015N003W 5
BIG WALNUT ECOSYSTEM	Point	BIGWAL06	016N003W 31
BIG WALNUT ECOSYSTEM	Point	BIGWAL21	016N003W 32
BIG WALNUT ECOSYSTEM	Point	BIGWAL01	016N003W 29
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT SURVEY AREA #2	016N003W 29 SEQ NEQ SWQ

BIG WALNUT ECOSYSTEM	Point	COLE SITE BIGWAL22	016N003W 32
	Point		014N004W GREENCASTLE AREA
	Point	LIZTON	017N002W 11
	Point	1991 BRACK SURVEY SITE Q.	017N002W 22 SEQ NWQ SWQ
BIG WALNUT ECOSYSTEM	Point		016N004W 35
BIG WALNUT ECOSYSTEM	Point		015N003W E OF BAINBRIDGE ON SR 36.
	Point	PLEASANT HILL	014N005W 23 NWQ NWQ NWQ
	Point		017N001W NEAR LIZTON
BIG WALNUT ECOSYSTEM	Polygon	BIG WALNUT SITE	015N003W 7
BIG WALNUT ECOSYSTEM	Polygon	BIG WALNUT TALL TIMBERS UNIT	016N003W 31
	Point	HEMLOCK RIDGE NATURE PRESERVE	016N003W 14
BIG WALNUT ECOSYSTEM	Polygon	BIG WALNUT	016N003W 32 SWQ
BIG WALNUT ECOSYSTEM	Polygon	BIG WALNUT	016N003W 29 AND
BIG WALNUT ECOSYSTEM	Polygon	BIG WALNUT	016N003W 32 W HALF
BIG WALNUT ECOSYSTEM	Polygon		016N003W 29
BIG WALNUT ECOSYSTEM	Polygon		015N003W 7
BIG WALNUT ECOSYSTEM	Polygon	BIG WALNUT MACROSITE	016N003W 20 SEQ
	Point	HEMLOCK RIDGE NATURE PRESERVE	016N003W 14
FERN CLIFF SITE	Polygon		014N005W 33 EH
FERN CLIFF SITE	Polygon		014N005W 33 NEQ SEQ
	Polygon		016N002W 2
	Point	DEPAUW UNIVERSITY	014N004W 20
FERN CLIFF SITE	Point	FERN-CLIFF NATURE PRESERVE	014N005W 33
	Point	DEPAUW ARBORETUM	014N004W 20
BIG WALNUT ECOSYSTEM	Point		015N003W 29
BIG WALNUT ECOSYSTEM	Point		016N003W 32
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT CREEK	016N003W 29 SEQ SWQ
	Point	BIG WALNUT CREEK	015N003W 31
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT CREEK	016N003W 21
BIG WALNUT ECOSYSTEM	Line	BIG WALNUT CREEK	016N003W 21
	Line	BIG WALNUT CREEK	012N005W 3
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT CREEK	016N003W 21
	Point	DEER CREEK	012N005W 11
	Line	BIG WALNUT CREEK	016N002W 18

	Point	BIG WALNUT CREEK	013N005W 20
	Point	LITTLE WALNUT CREEK	014N005W 23
	Point	RAMP RUN	016N002W 17
BIG WALNUT ECOSYSTEM	Line	BIG WALNUT CREEK	016N002W 18
	Point	EAST FORK BIG WALNUT CREEK	016N002W 1
	Point	EAST FORK BIG WALNUT CREEK	016N002W 9
	Point	DEER CREEK	013N005W 23
	Line	BIG WALNUT CREEK	012N005W 3
	Point	FALLS AT REELSVILLE	013N005W 21
	Point	VERMILLION FALLS LOWER	015N005W 36
	Point	VERMILLION FALLS UPPER	015N005W 36
	Point	CLINTON FALLS	015N005W 28
	Point	FALLS ON FALLS BRANCH	015N005W 36
	Point	FALLS ON TRIB TO WALNUT CREEK	015N005W 28
	Point	LEDGE ON JONES CREEK	014N004W 6
	Point	FALLS ON WALNUT CREEK	015N003W 17
BIG WALNUT ECOSYSTEM	Point	FORTUNE WOODS	016N003W 29
BIG WALNUT ECOSYSTEM	Point		016N003W 32
	Point		017N002W 15 NWQ SEQ
	Point		017N002W 11 SWQ
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT-WALNUT OAKS TRACT	015N003W 6
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT	016N003W 32 SWQ SWQ
BIG WALNUT ECOSYSTEM	Point		016N003W 32 NWQ SWQ SWQ
	Point	Hemlock Ridge	016N003W 14
BIG WALNUT ECOSYSTEM	Point	BIG WALNUT NATURE PRESERVE	015N003W 5
	Point		016N002W 2
	Point	Hemlock Ridge	016N003W 14
BIG WALNUT ECOSYSTEM	Point		015N003W 6

TYPE	UNITY_CODE	Shape_Leng	Shape_Area
Amphibian	32	1458.82403286000	65068.58819989990
Amphibian	62	5055.70548038000	2033845.44474000000
Bird	32	775.10330263700	45256.91587610000
Bird	32	860.86625451500	51955.69844890000
Bird	32	627.32202873600	31215.67799990000
Bird	32	627.32202873700	31215.67800000000
Bird	32	627.31297034600	31214.77629990000
Bird	32	627.30762393900	31214.24430000000
Bird	32	627.32202873600	31215.67799990000
Bird	32	627.32202873600	31215.67799990000
Bird	32	627.32202873800	31215.67800010000
Bird	32	627.31659126900	31215.13680000000
Bird	32	627.29724972200	31213.21019990000
Bird	32	1254.63499908000	62430.45430000000
Bird	32	1254.63319178000	62430.27359990000
Bird	32	1254.60486316000	62427.45455000000
Bird	32	627.30685873600	31214.16820000000
Bird	32	627.32202873800	31215.67800010000
Bird	32	627.30142627300	31213.62700010000
Bird	32	627.31116304800	31214.59559989990
Bird	32	627.32202873600	31215.67800000000
Bird	32	627.31146975900	31214.62699990000
Bird	32	627.30754000600	31214.23515010000
Bird	32	627.31116304900	31214.59560010000
Bird	32	627.30762394000	31214.24430010000
Bird	32	627.32202873800	31215.67800010000
Bird	32	1494.10480745000	83645.42365030000
Bird	32	627.31659126900	31215.13679990000
Bird	32	627.30754000400	31214.23515000000
Bird	32	627.30754000400	31214.23514990000
Bird	32	627.31297034700	31214.77630000000
Bird	32	627.30058034100	31213.54239990000
Bird	32	627.31116304800	31214.59560000000

Bird	32	1254.60285837000	62427.25475010000
Bird	62	5055.70549990000	2033845.46045000000
Bird	32	627.32202873700	31215.67800000000
Mammal	32	627.31297034700	31214.77630000000
Mammal	62	5055.70549254000	2033845.45453000000
Mammal	32	5055.70548877000	2033845.45149000000
Reptile	32	627.30637537100	31214.11959990000
Reptile	62	5055.70548969000	2033845.45223000000
High Quality Natural Community	35	1404.97737673000	27239.84960000000
High Quality Natural Community	35	1513.27925409000	33782.64360000000
High Quality Natural Community	35	627.32202873700	31215.67800000000
High Quality Natural Community	35	672.97460597200	12790.81955000000
High Quality Natural Community	35	9094.29701069000	989870.48725000000
High Quality Natural Community	35	5819.18944836000	223924.95040000000
High Quality Natural Community	35	1045.00257927000	41177.24044990000
High Quality Natural Community	35	3841.44177603000	397172.81240000000
High Quality Natural Community	35	2223.73858221000	106125.55305000000
High Quality Natural Community	35	627.32202873500	31215.67799990000
High Quality Natural Community	35	4098.25483573000	557510.02385000000
High Quality Natural Community	35	515.10777632200	13573.75169990000
High Quality Natural Community	35	378.96548922100	7079.02849999000
Insect - Hymenoptera (Bee)	35	2509.24154620000	499432.31760000000
Insect - Hymenoptera (Bee)	35	2509.24058542000	499431.93690100000
Insect - Hymenoptera (Bee)	35	2509.23046901000	499427.90920000000
Insect Lepidoptera	35	5055.70548038000	2033845.44474000000
Insect Lepidoptera	35	627.31116304900	31214.59560010000
Insect Odonata	35	627.31297034500	31214.77629990000
Insect Odonata	35	1254.62593229000	124859.10530000000
Mollusk	32	627.30391696000	31213.87470000000
Mollusk	32	27956.63297710000	1395621.62990000000
Mollusk	32	1733.36292925000	78789.04599990000
Mollusk	32	1254.62411562000	124858.74390000000
Mollusk	32	627.31659127000	31215.13680010000
Mollusk	32	16545.25011410000	823067.10460000000

Mollusk	62	5055.70548038000	2033845.44474000000
Mollusk	32	627.30762393800	31214.24429990000
Mollusk	32	627.30762393900	31214.24430000000
Mollusk	32	43710.44597350000	2186749.66695000000
Mollusk	32	627.31146975900	31214.62700000000
Mollusk	32	627.31659126900	31215.13680000000
Mollusk	32	627.30219147400	31213.70310000000
Mollusk	32	18341.25400130000	912234.36435100000
Geologic Feature	35	627.32202873800	31215.67800010000
Geologic Feature	35	627.32202873800	31215.67800010000
Geologic Feature	35	627.32202873800	31215.67800010000
Geologic Feature	35	627.32202873800	31215.67800010000
Geologic Feature	35	627.32202873800	31215.67800010000
Geologic Feature	35	627.32202873800	31215.67800010000
Geologic Feature	35	627.32202873800	31215.67800010000
Geologic Feature	35	627.32202873800	31215.67800010000
Vascular Plant	35	1881.96608621000	93647.03399980000
Vascular Plant	62	5055.70548038000	2033845.44474000000
Vascular Plant	35	627.30762393900	31214.24430000000
Vascular Plant	35	627.30142627200	31213.62700000000
Vascular Plant	35	627.32202873800	31215.67800010000
Vascular Plant	35	627.31297034700	31214.77630000000
Vascular Plant	35	627.30420126400	31213.90290000000
Vascular Plant	35	627.31297034700	31214.77630000000
Vascular Plant	35	627.32202873700	31215.67800010000
Vascular Plant	35	627.30420126400	31213.90290000000
Vascular Plant	35	627.31297034700	31214.77630000000
Vascular Plant	35	627.30962872600	31214.44410000000

02/05/2018

Indiana County Endangered, Threatened and Rare Species List

County: Boone

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Fusconaia subrotunda	Longsolid	C	SE	G3	SX
Lampsilis fasciola	Wavyrayed Lampmussel		SSC	G5	S3
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Toxolasma lividus	Purple Lilliput	C	SSC	G3Q	S2
Villosa lienosa	Little Spectaclecase		SSC	G5	S3
Amphibian					
Acris blanchardi	Northern Cricket Frog		SSC	G5	S4
Lithobates pipiens	Northern Leopard Frog		SSC	G5	S2
Bird					
Ammodramus henslowii	Henslow's Sparrow		SE	G4	S3B
Bartramia longicauda	Upland Sandpiper		SE	G5	S3B
Buteo lineatus	Red-shouldered Hawk		SSC	G5	S3
Chordeiles minor	Common Nighthawk		SSC	G5	S4B
Cistothorus palustris	Marsh Wren		SE	G5	S3B
Cistothorus platensis	Sedge Wren		SE	G5	S3B
Haliaeetus leucocephalus	Bald Eagle		SSC	G5	S2
Helmitheros vermivorus	Worm-eating Warbler		SSC	G5	S3B
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Mniotilta varia	Black-and-white Warbler		SSC	G5	S1S2B
Nycticorax nycticorax	Black-crowned Night-heron		SE	G5	S1B
Rallus elegans	King Rail		SE	G4	S1B
Rallus limicola	Virginia Rail		SE	G5	S3B
Setophaga cerulea	Cerulean Warbler		SE	G4	S3B
Sturnella neglecta	Western Meadowlark		SSC	G5	S2B
Tyto alba	Barn Owl		SE	G5	S2
Wilsonia citrina	Hooded Warbler		SSC	G5	S3B
Mammal					
Lasiurus borealis	Eastern Red Bat		SSC	G3G4	S4
Myotis sodalis	Indiana Bat or Social Myotis	LE	SE	G2	S1
Taxidea taxus	American Badger		SSC	G5	S2
Vascular Plant					
Crataegus grandis	Grand Hawthorn		SE	G3G5Q	S1
Juglans cinerea	Butternut		WL	G4	S3
Plantago cordata	Heart-leaved Plantain		SE	G4	S1
High Quality Natural Community					
Forest - flatwoods central till plain	Central Till Plain Flatwoods		SG	G3	S2
Forest - floodplain wet-mesic	Wet-mesic Floodplain Forest		SG	G3?	S3

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Indiana County Endangered, Threatened and Rare Species List

County: Hendricks

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Villosa lienosa	Little Spectaclecase		SSC	G5	S3
Insect: Odonata (Dragonflies & Damselflies)					
Enallagma divagans	Turquoise Bluet		SR	G5	S3
Reptile					
Sistrurus catenatus catenatus	Eastern Massasauga	LT	SE	G3	S2
Bird					
Bartramia longicauda	Upland Sandpiper		SE	G5	S3B
Cistothorus platensis	Sedge Wren		SE	G5	S3B
Haliaeetus leucocephalus	Bald Eagle		SSC	G5	S2
Helmitheros vermivorus	Worm-eating Warbler		SSC	G5	S3B
Pandion haliaetus	Osprey		SE	G5	S1B
Setophaga cerulea	Cerulean Warbler		SE	G4	S3B
Wilsonia citrina	Hooded Warbler		SSC	G5	S3B
Mammal					
Lasiurus borealis	Eastern Red Bat		SSC	G3G4	S4
Mustela nivalis	Least Weasel		SSC	G5	S2?
Myotis lucifugus	Little Brown Bat	C	SSC	G3	S2
Myotis septentrionalis	Northern Long Eared Bat	LT	SSC	G1G2	S2S3
Myotis sodalis	Indiana Bat or Social Myotis	LE	SE	G2	S1
Nycticeius humeralis	Evening Bat		SE	G5	S1
Perimyotis subflavus	Tricolored Bat		SSC	G2G3	S2S3
Taxidea taxus	American Badger		SSC	G5	S2
Vascular Plant					
Crataegus grandis	Grand Hawthorn		SE	G3G5Q	S1
Juglans cinerea	Butternut		WL	G4	S3
Poa paludigena	Bog Bluegrass		WL	G3	S3
High Quality Natural Community					
Forest - flatwoods central till plain	Central Till Plain Flatwoods		SG	G3	S2
Wetland - seep circumneutral	Circumneutral Seep		SG	GU	S1

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Indiana County Endangered, Threatened and Rare Species List

County: Putnam

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Epioblasma torulosa rangiana	Northern Riffleshell	LE	SE	G2T2	S1
Lampsilis fasciola	Wavyrayed Lampmussel		SSC	G5	S3
Obovaria subrotunda	Round Hickorynut	C	SE	G4	S1
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Simpsonaias ambigua	Salamander Mussel	C	SSC	G3	S2
Toxolasma lividus	Purple Lilliput	C	SSC	G3Q	S2
Villosa lienosa	Little Spectaclecase		SSC	G5	S3
Insect: Coleoptera (Beetles)					
Dryobius sexnotatus	Six-banded Longhorn Beetle		ST	GNR	S2
Insect: Hymenoptera					
Bombus affinis	Rusty-patched Bumble Bee	LE	SE	G1	S1
Insect: Lepidoptera (Butterflies & Moths)					
Amblyscirtes hegon	Salt-and-pepper Skipper		SR	G5	S2
Eosphoropteryx thyatyroides	Pinkpatched Looper Moth		ST	G4G5	S2
Insect: Odonata (Dragonflies & Damselflies)					
Cordulegaster obliqua	Arrowhead Spiketail		SR	G4	S2S3
Enallagma divagans	Turquoise Bluet		SR	G5	S3
Amphibian					
Lithobates pipiens	Northern Leopard Frog		SSC	G5	S2
Necturus maculosus	Common mudpuppy		SSC	G5	S2
Reptile					
Crotalus horridus	Timber Rattlesnake		SE	G4	S2
Opheodrys aestivus	Rough Green Snake		SSC	G5	S3
Bird					
Aimophila aestivalis	Bachman's Sparrow			G3	SXB
Buteo lineatus	Red-shouldered Hawk		SSC	G5	S3
Cistothorus platensis	Sedge Wren		SE	G5	S3B
Coragyps atratus	Black Vulture			G5	S1N,S2B
Haliaeetus leucocephalus	Bald Eagle		SSC	G5	S2
Helmitheros vermivorus	Worm-eating Warbler		SSC	G5	S3B
Lanius ludovicianus	Loggerhead Shrike		SE	G4	S3B
Mniotilta varia	Black-and-white Warbler		SSC	G5	S1S2B
Rallus elegans	King Rail		SE	G4	S1B
Setophaga cerulea	Cerulean Warbler		SE	G4	S3B
Wilsonia citrina	Hooded Warbler		SSC	G5	S3B
Mammal					
Mustela nivalis	Least Weasel		SSC	G5	S2?
Myotis sodalis	Indiana Bat or Social Myotis	LE	SE	G2	S1

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Indiana County Endangered, Threatened and Rare Species List

County: Putnam

Species Name	Common Name	FED	STATE	GRANK	SRANK
Taxidea taxus	American Badger		SSC	G5	S2
Vascular Plant					
Carex cephaloidea	Thinleaf Sedge		SE	G5	S1
Carex pedunculata	Longstalk Sedge		SR	G5	S2
Chelone obliqua var. speciosa	Rose Turtlehead		WL	G4T3	S3
Juglans cinerea	Butternut		WL	G4	S3
Panax quinquefolius	American Ginseng		WL	G3G4	S3
Poa wolfii	Wolf Bluegrass		SR	G4	S2
Taxus canadensis	American Yew		SE	G5	S1
High Quality Natural Community					
Forest - floodplain mesic	Mesic Floodplain Forest		SG	G3?	S1
Forest - floodplain wet-mesic	Wet-mesic Floodplain Forest		SG	G3?	S3
Forest - upland dry-mesic Central Till Plain	Central Till Plain Dry-mesic Upland Forest			GNR	S2
Forest - upland mesic Central Till Plain	Central Till Plain Mesic Upland Forest			GNR	S3
Forest - upland mesic Shawnee Hills	Shawnee Hills Mesic Upland Forest			GNR	S3
Primary - cliff overhang	Sandstone Overhang		SG	G4	S2
Primary - cliff sandstone	Sandstone Cliff		SG	GU	S3
Other Significant Feature					
Geomorphic - Nonglacial Erosional Feature - Water Fall and Cascade	Water Fall and Cascade			GNR	SNR

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Appendix C: Land Cover Data

2011 Land Cover Definitions

- Open Water - All areas of open water, generally with less than 25% cover of vegetation or soil.
- Developed, Open Space - Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
- Developed, Low Intensity - Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
- Developed, Medium Intensity - Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
- Developed, High Intensity - Highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.
- Barren Land (Rock/Sand/Clay) - Areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
- Deciduous Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
- Evergreen Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
- Mixed Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
- Shrub/Scrub - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
- Grassland/Herbaceous - Areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
- Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
- Cultivated Crops - Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled
- Woody Wetlands - Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
- Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Appendix D: Water Quality Data

Site ID	Stream Name	Date	Flow (cfs)	Temperature	DO (mg/L)	pH	Conductivity	Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	Ecoli (col/100 ml)
Site 1	Edlin Ditch	31-Aug-18	3.0	23.7	8.4	7.8	718	1.5	0.14	0.1	8	95
Site 1	Edlin Ditch	9/19/2018										472
Site 1	Edlin Ditch	4-Oct-18	24.0	18	8.2	7.4	600	4.2	0.17	0.13	51	462
Site 1	Edlin Ditch	23-Oct-18	1.9	15.5	8.4	7.6	700	2.5	0.11	0.03	2	69
Site 1	Edlin Ditch	4/11/2019	22.0	18.5	10.6	8	560	5	0.08	0.1	2	120
Site 1	Edlin Ditch	4/25/2019	27.0	15.3	8.6	8	540	4.2	0.07	0.09	11	316
Site 1	Edlin Ditch	5/9/2019	24.0	18	9.4	8	620	4.9	0.05	0.07	1	180
Site 1	Edlin Ditch	5/23/2019	22.0	17	6.8	7.6	420	8.5	0.04	0.07		95
Site 1	Edlin Ditch	6/6/2019										334
Site 1	Edlin Ditch	6/20/2019	170	18	6.1	7.7	420	4.2	0.16		80	480
Site 1	Edlin Ditch	7/5/2019										318
Site 1	Edlin Ditch	7/18/2019	19	25	7.1	7.7	760	1.8	0.06	0.05	0	380
Site 1	Edlin Ditch	8/1/2019										304
Site 1	Edlin Ditch	8/15/2019	8	21	5.2	7.7	740	2.4	0.15	0.12	0	360
Site 10	Deweese Creek	31-Aug-18	5.4	19.7	8.5	8.1	536	0.2	0.19	0.11	4	23
Site 10	Deweese Creek	9/19/2018										139
Site 10	Deweese Creek	4-Oct-18	2.4	19.5	8.5	7.5	620	0.8	0.13	0.09	3	747
Site 10	Deweese Creek	23-Oct-18	0.6	16	9.1	7.7	700	0.5	0.09	0.05	1	57
Site 10	Deweese Creek	4/11/2019	7.0	17.1	7.9	8.1	440	0.2	0.03	0.04	3	150
Site 10	Deweese Creek	4/25/2019	10.0	16.1	8.4	8.2	420	0.8	0.08	0.1	7	2
Site 10	Deweese Creek	5/9/2019	8.0	19	8	8.3	500	1.8	0.07	0.11	1	162
Site 10	Deweese Creek	5/23/2019	30.0	16	8.3	7.9	270	5	0.15	0.18		135
Site 10	Deweese Creek	6/6/2019										93
Site 10	Deweese Creek	6/20/2019	80	20	8	8	400	0.8	0.11		148	6900
Site 10	Deweese Creek	7/5/2019										532
Site 10	Deweese Creek	7/18/2019	4	25	8.1	7.8	1060	0.9	0.11	0.07	1	1494
Site 10	Deweese Creek	8/1/2019										90
Site 10	Deweese Creek	8/15/2019	0	18	6.9	8.3	550	0.4	0.05	0.03	1	900
Site 11	Big Walnut Creek	31-Aug-18	24.0	24	8.2	8	492	1.1	0.16	0.09	10	147
Site 11	Big Walnut Creek	9/19/2018										70
Site 11	Big Walnut Creek	4-Oct-18	290.0	19	8.6	7.8	570	1.8	0.13	0.09	23	412
Site 11	Big Walnut Creek	23-Oct-18	120.0	16.5	9.4	7.9	700	1.6	0.16	0.04	3	50
Site 11	Big Walnut Creek	4/11/2019	240.0	18.5	7.7	8.1	450	2.8	0.08	0.1	9	150
Site 11	Big Walnut Creek	4/25/2019	300.0	15.7	8	8.2	460	3.4	0.08	0.12	11	148
Site 11	Big Walnut Creek	5/9/2019	400.0	19	7.5	8.3	530	4.1	0.1	0.16	2	128
Site 11	Big Walnut Creek	5/23/2019	800.0	16	8.5	8.3	380	3.6	0.21	0.25		695
Site 11	Big Walnut Creek	6/6/2019										49
Site 11	Big Walnut Creek	6/20/2019	2560	20	7.6	8.1	240	1.5	0.02		583	4050
Site 11	Big Walnut Creek	7/5/2019										276
Site 11	Big Walnut Creek	7/18/2019	205	26	7.4	7.5	440	1.4	0.07	0.06	37	398
Site 11	Big Walnut Creek	8/1/2019										50

Site ID	Stream Name	Date	Flow (cfs)	Temperature	DO (mg/L)	pH	Conductivity	Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	Ecoli (col/100 ml)
Site 11	Big Walnut Creek	8/15/2019	67	21	5.4	8.1	630	1.2	0.08	0.01	37	168
Site 12	Deer Creek	31-Aug-18	14.0	22.5	8.1	8	509	1	0.12	0.08	4	128
Site 12	Deer Creek	9/19/2018										110
Site 12	Deer Creek	4-Oct-18	21.0	21.5	8	7.8	580	1.6	0.11	0.07	7	698
Site 12	Deer Creek	23-Oct-18	13.0	15.5	9.1	7.8	600	0.6	0.08	0.08	3	47
Site 12	Deer Creek	4/11/2019	15.0	17.1	8	8.1	450	1.7	0.03	0.05	2	270
Site 12	Deer Creek	4/25/2019	25.0	16.8	8.2	8.1	510	2.2	0.05	0.07	4	97
Site 12	Deer Creek	5/9/2019	30.0	19	7.4	8.2	500	2.9	0.06	0.1	1	582
Site 12	Deer Creek	5/23/2019	20.0	18.2	8.8	8.2	390	3	0.32	0.4		105
Site 12	Deer Creek	6/6/2019										128
Site 12	Deer Creek	6/20/2019	650	20.4	8	8.1	190	1.3	0.02		518	10,500
Site 12	Deer Creek	7/5/2019										230
Site 12	Deer Creek	7/18/2019	52	26	7.8	7.6	600	1.2	0.09	0.06	18	882
Site 12	Deer Creek	8/1/2019										146
Site 12	Deer Creek	8/15/2019	17	21	5.2	7.8	580	0.7	0.09	0.03	18	114
Site 2	Middle Fork	31-Aug-18	3.2	25.1	8.4	8.1	756	3.4	0.34	0.19	8	308
Site 2	Middle Fork	9/19/2018										1090
Site 2	Middle Fork	4-Oct-18	25.0	17	8.4	7.5	490	4.1	0.26	0.22	75	1213
Site 2	Middle Fork	23-Oct-18	5.1	16	9.4	7.8	700	1.5	0.08	0.04	3	143
Site 2	Middle Fork	4/11/2019	20.0	17.8	11.6	8.3	520	4	0.03	0.05	2	150
Site 2	Middle Fork	4/25/2019	28.0	15.3	9.4	8.3	490	3.6	0.04	0.07	6	752
Site 2	Middle Fork	5/9/2019	27.0	18	8.9	8.5	580	4	0.05	0.1	1	360
Site 2	Middle Fork	5/23/2019	10.0	17	7.5	7.9	390	5	0.06	0.07		185
Site 2	Middle Fork	6/6/2019										2770
Site 2	Middle Fork	6/20/2019	110	18	7.3	8	440	3.5	0.13		48	920
Site 2	Middle Fork	7/5/2019										1220
Site 2	Middle Fork	7/18/2019	20	27	7.7	8.1	710	6.6	0.12	0.08	0	538
Site 2	Middle Fork	8/1/2019										282
Site 2	Middle Fork	8/15/2019	5	20	6.9	8.2	740	5.5	0.16	0.14	0	720
Site 3	East Fork	31-Aug-18	3.6	26.3	8.5	8.2	726	1.1	0.19	0.17	4	1707
Site 3	East Fork	9/19/2018										711
Site 3	East Fork	4-Oct-18	37.0	18.5	8.6	7.6	470	2.6	0.22	0.19	152	416
Site 3	East Fork	23-Oct-18	8.8	15.5	10.6	8	800	1	0.06	0.04	2	197
Site 3	East Fork	4/11/2019	16.0	18.5	10.3	8.3	550	3	0.08	0.11	1	30
Site 3	East Fork	4/25/2019	24.0	15.7	9	8.3	530	3.6	0.04	0.06	1	2
Site 3	East Fork	5/9/2019	23.0	18	9.6	8.4	600	3.8	0.03	0.07	1	324
Site 3	East Fork	5/23/2019	15.0	18	7.9	8.2	490	6	0.02	0.03		45
Site 3	East Fork	6/6/2019										1112
Site 3	East Fork	6/20/2019	190	17	7.3	8	390	2.2	0.19		76	540
Site 3	East Fork	7/5/2019										1480
Site 3	East Fork	7/18/2019	26	27	7.9	8.1	730	1.6	0.06	0.05	0	858

Site ID	Stream Name	Date	Flow (cfs)	Temperature	DO (mg/L)	pH	Conductivity	Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	Ecoli (col/100 ml)
Site 3	East Fork	8/1/2019										726
Site 3	East Fork	8/15/2019	2	22	7.4	8.2	770	0.9	0.1	0.04	0	630
Site 4	Ramp Run	31-Aug-18	7.9	26.4	9.2	8.1	647	1.7	0.14	0.11	13	452
Site 4	Ramp Run	9/19/2018										648
Site 4	Ramp Run	4-Oct-18	43.0	19	8.5	7.5	310	5.2	0.4	0.34	192	921
Site 4	Ramp Run	23-Oct-18	16.0	16.5	10.2	7.9	700	3.6	0.11	0.06	4	239
Site 4	Ramp Run	4/11/2019	14.0	19.1	11.7	8.2	490	5.8	0.03	0.06	1	120
Site 4	Ramp Run	4/25/2019	21.0	16.4	8.4	8.3	490	5.2	0.03	0.04	4	1
Site 4	Ramp Run	5/9/2019	20.0	18	9.1	8.3	550	5.4	0.07	0.11	1	822
Site 4	Ramp Run	5/23/2019	25.0	17.5	7.7	8	400	5.6	0.02	0.02		300
Site 4	Ramp Run	6/6/2019										1213
Site 4	Ramp Run	6/20/2019	180	19	7.5	8	420	4.2	0.13		60	880
Site 4	Ramp Run	7/5/2019										620
Site 4	Ramp Run	7/18/2019	13	28	8.3	7.9	660	3.9	0.08	0.07	0	256
Site 4	Ramp Run	8/1/2019										328
Site 4	Ramp Run	8/15/2019	5	22	6.8	8	630	1.5	0.06	0.04	0	270
Site 5	Plum Creek	31-Aug-18	0.9	25.7	8.2	7.9	641	1	0.07	0.06	7	376
Site 5	Plum Creek	9/19/2018										220
Site 5	Plum Creek	4-Oct-18	17.0	18.5	8.9	7.5	380	3.4	0.24	0.21	149	2550
Site 5	Plum Creek	23-Oct-18	2.2	15	11	7.9	600	1.3	0.07	0.03	1	155
Site 5	Plum Creek	4/11/2019	1.0	18.5	8.2	8.2	480	2.5	0.02	0.04	1	30
Site 5	Plum Creek	4/25/2019	7.0	15.6	7.9	8.3	470	2.4	0.01	0.03	1	0
Site 5	Plum Creek	5/9/2019	10.0	19	9.4	8.4	520	2.8	0.03	0.08	1	206
Site 5	Plum Creek	5/23/2019	18.0	18	8.1	8.2	380	6	0.07	0.09		550
Site 5	Plum Creek	6/6/2019										235
Site 5	Plum Creek	6/20/2019	70	19	7.6	8.2	410	1.4	0.08		105	1020
Site 5	Plum Creek	7/5/2019										2
Site 5	Plum Creek	7/18/2019	14	25	8.4	7.8	620	1.7	0.42	0.08	0	502
Site 5	Plum Creek	8/1/2019										168
Site 5	Plum Creek	8/15/2019	1	22	7.6	7.8	650	0.5	0.05	0.02	0	112
Site 6	Miller Creek	31-Aug-18	2.7	26.8	7.7	8.1	677	1.3	0.12	0.05	5	595
Site 6	Miller Creek	9/19/2018										46
Site 6	Miller Creek	4-Oct-18	36.0	19	8.7	7.6	320	3.5	0.2	0.16	203	6000
Site 6	Miller Creek	23-Oct-18	9.8	16.5	10.1	7.9	500	1	0.1	0.08	2	128
Site 6	Miller Creek	4/11/2019	20.0	17.1	8.1	8.1	440	2	0.03	0.06	1	120
Site 6	Miller Creek	4/25/2019	18.0	15.7	8.1	8.2	430	2.6	0.05	0.06	1	2
Site 6	Miller Creek	5/9/2019	18.0	19.0	8.3	8.3	460	2.9	0.08	0.12	1	64
Site 6	Miller Creek	5/23/2019	30.0	18.0	8	8.2	390	3.5	0.05	0.08		175
Site 6	Miller Creek	6/6/2019										297
Site 6	Miller Creek	6/20/2019	90	21.0	7.7	8.2	360	1.6	0.08		177	1480
Site 6	Miller Creek	7/5/2019										138

Site ID	Stream Name	Date	Flow (cfs)	Temperature	DO (mg/L)	pH	Conductivity	Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	Ecoli (col/100 ml)
Site 6	Miller Creek	7/18/2019	19	26.0	8.4	7.9	760	3.9	0.1	0.09	0	260
Site 6	Miller Creek	8/1/2019										840
Site 6	Miller Creek	8/15/2019	9	21	7.3	7.9	870	5.2	0.1	0.04	0	390
Site 7	Jones Creek	31-Aug-18	0.3	31.7	7.1	8.5	312	0.6	0.17	0.06	6	94
Site 7	Jones Creek	9/19/2018										17
Site 7	Jones Creek	4-Oct-18	34.0	20	9.9	7.7	530	2	0.08	0.05	25	219
Site 7	Jones Creek	23-Oct-18	3.7	17	10.8	8.1	600	4.2	0.08	0.05	18	9
Site 7	Jones Creek	4/11/2019	10.0	18.9	8	8.1	440	4	0.03	0.05	2	20
Site 7	Jones Creek	4/25/2019	15.0	16.8	7.9	8.3	420	3.2	0.04	0.06	7	1
Site 7	Jones Creek	5/9/2019	15.0	20	8.4	8.4	470	4.6	0.06	0.17	5	14
Site 7	Jones Creek	5/23/2019	10.0	17	8.6	8.2	390	3	0.02	0.02		110
Site 7	Jones Creek	6/6/2019										22
Site 7	Jones Creek	6/20/2019	50	20	7.6	8	270	1.8	0.02		163	3900
Site 7	Jones Creek	7/5/2019										42
Site 7	Jones Creek	7/18/2019	7	31	8.5	8	440	0.7	0.07	0.05	7	22
Site 7	Jones Creek	8/1/2019										152
Site 7	Jones Creek	8/15/2019	0	26	14.8	9.1	430	0.3	0.61	0.59	7	96
Site 8	Little Walnut Creek	31-Aug-18	6.4	21	7.9	8.1	442	1.3	0.09	0.08	3	32
Site 8	Little Walnut Creek	9/19/2018										203
Site 8	Little Walnut Creek	4-Oct-18	144.0	20.5	8.3	7.6	310	2	0.42	0.39	314	1520
Site 8	Little Walnut Creek	23-Oct-18	24.0	14.5	9.3	7.8	500	1.6	0.09	0.04	3	126
Site 8	Little Walnut Creek	4/11/2019	30.0	17.1	7.2	8	370	1.6	0.05	0.07	1	270
Site 8	Little Walnut Creek	4/25/2019	44.0	15.7	8.1	8.1	370	2.1	0.05	0.08	1	21
Site 8	Little Walnut Creek	5/9/2019	40.0	19	8	8.2	410	2.7	0.04	0.15	1	112
Site 8	Little Walnut Creek	5/23/2019	100.0	16	8.4	8.1	300	2.4	0.02	0.02		510
Site 8	Little Walnut Creek	6/6/2019										247
Site 8	Little Walnut Creek	6/20/2019	370	20	8	8.1	290	1.3	0.02		137	2200
Site 8	Little Walnut Creek	7/5/2019										900
Site 8	Little Walnut Creek	7/18/2019	39	25	8.1	7.8	460	1.9	0.08	0.06	20	838
Site 8	Little Walnut Creek	8/1/2019										324
Site 8	Little Walnut Creek	8/15/2019	3	20	6.5	8	580	2.6	0.09	0.05	20	270
Site 9	Snake Creek	31-Aug-18	1.2	20.4	9	7.9	323	0.4	0.2	0.04	4	168
Site 9	Snake Creek	9/19/2018										256
Site 9	Snake Creek	4-Oct-18	7.1	19.5	8.7	7.5	280	1.6	0.08	0.06	86	582
Site 9	Snake Creek	23-Oct-18	0.9	16	9.6	7.6	400	0.4	0.15	0.05	1	66
Site 9	Snake Creek	4/11/2019	4.0	18.1	8	7.8	230	0.2	0.04	0.05	1	120
Site 9	Snake Creek	4/25/2019	8.0	15.3	8.2	7.9	220	0.2	0.05	0.08	1	1
Site 9	Snake Creek	5/9/2019	6.0	18	8	8.1	270	0.45	0.03	0.11	1	186
Site 9	Snake Creek	5/23/2019	24.0	14	8.4	7.6	150	2.8	0.21	0.26		365
Site 9	Snake Creek	6/6/2019										238
Site 9	Snake Creek	6/20/2019	60	19	7.9	7.8	180	0.8	0.05		56	1520

Site ID	Stream Name	Date	Flow (cfs)	Temperature	DO (mg/L)	pH	Conductivity	Nitrate (mg/L)	Total P (mg/L)	Ortho P (mg/L)	TSS (mg/L)	Ecoli (col/100 ml)
Site 9	Snake Creek	7/5/2019										224
Site 9	Snake Creek	7/18/2019	3	26	7.9	7.6	320	0.7	0.05	0.04	1	640
Site 9	Snake Creek	8/1/2019										190
Site 9	Snake Creek	8/15/2019	0	21	6.7	7.9	350	0.3	0.1	0.03	1	82
Site 9	Snake Creek	8/15/2019										82
Site 13	Clear Creek	10/23/2018	3	16	10	7.9	600	2.7	0.04	0.17	3	107
Site 13	Clear Creek	4/11/2019	2	17.1	10.1	8.1	450	3.3	0.08	0.12	2	120
Site 13	Clear Creek	4/25/2019	6	16.4	9.1	8.4	420	1.8	0.05	0.07	10	311
Site 13	Clear Creek	5/9/2019	10	19	8.5	8.5	490	2.7	0.06	0.11	1	206
Site 13	Clear Creek	5/23/2019	8	17	7.8	8	330	2.6	0.04	0.06		1575
Site 13	Clear Creek	6/6/2019	3									451
Site 13	Clear Creek	6/20/2019	50	19	8.4	8.1	360	1.1	0.16	0.16	75	820
Site 13	Clear Creek	7/5/2019	2									396
Site 13	Clear Creek	7/18/2019	3	26	9.2	7.8	610	1.1	0.06	0.08	1	418
Site 13	Clear Creek	8/1/2019	1									1492
Site 13	Clear Creek	8/15/2019	0.2	22	7.5	8.1	630	0.45	0.14	0.17	0	690
					1	1		83	53	104	30	93
					1%	1%		63%	40%	87%	25%	51%

Big Walnut 2018

	1	2	3	4	5	6	7	8	9	10	11	12	13
Baetis flavistriga	12	1		3	30	11		2	5	9			
B. intercalaris	4	1	1	3	1		2	1	5	6		2	4
B. pygmaeus				1									
Centroptilum sp.										8			
Heterocloeon sp.						1					14		
Pseudocloeon sp.											2		
Stenonema femoratum		1	1	1	30	5	1	3	16	20			36
S. medicopunctatum			7			17		17			11	16	
S. pulchellum								6			11		
S. vicarium		3	1	2	8	6			4				25
S. terminatum											5	1	
Stenacron interpunctatum	4		1	1	6	5		8	4	14	4	10	8
Heptagenia sp.						11					11		
Isonychia sp.		1	10	4	4	13		2			5	35	
Tricorythodes sp.		1	5		3	3		3			15	6	
Caenis sp.	1	10	5	3	71	18	23	19	18	3		2	51
Potamanthus sp.								3			26	16	
Leptophlebidae									1				
Taeniopteryx sp.					2						11	5	
Cheumatopsyche sp.	8	38	40	27	5	51		11	24	37	33	10	30
Ceratopsyche bifida		8	20	11	1	14		2					
Hydropsyche simulans		7	3		1			1			2	1	
H. betteni				1									2
H.orris											6		
Chimarra obscura		14	7	7		10		10	10	31		1	12
Helicopsyche borealis		1						3	3				27
Ochrotrichia sp.							1						
Hydroptilidae												1	
Polycentropus sp.								1					
Limnephilidae								1	9			1	
Brachycentridae											1		
Stenelmis sp.	20	18	1	17	3	9	77	21	3	31	1	2	48
Optioservus fastiditus				3									1
Macronychus glabratus	3		7			4	3	11	3	3			
Dubiraphia sp.	8			1	1			4		2			2

	1	2	3	4	5	6	7	8	9	10	11	12	13
Psephenus herricki	1					5		7		24			35
Helodidae					1				1	5		1	3
Gyrinidae									1		3		
Hydrophilidae							1						
Berosus sp.							3	1					
Haliplidae							2						
Veliidae									2	2			
Hetaerina sp.	1	4			1	1		1	4				
Enallagma sp.	8	3			1		18	6	2	2		4	
Argia sp.						1		1		1			
Boyeria sp.				1				1					
Hagenius brevistylus								1					
Libellulidae							2						
Corydalus cornutus				2					2				
Belostomatidae						1							
Corixidae							1						
Simulium sp.		1		1				3			2	1	1
Tipula sp.			1	1			1	1	1	2			
Hexatoma sp.								1					4
Tabanidae				1					1				1
Ephydridae													1
Empididae												1	
Chironomidae													
Ablabesmyia mallochi				4				3					
Labrundinia pilosella							2	5	21	6			
Thienemanninyia sp.	5	3	1	4		1		1		2	3	3	3
Chironomus sp.					2			1					
Cryptochironomus fulvus						4						2	
Dicrotendipes nervosus					3	1				1		2	
Glyptotendipes lobiferus							6	1				2	
Parachironomus abortivus							2						
Polypedilum convictum	22	8			3	7	13	1	39	15	8	21	6
Stenochironomus sp.								3	3				
Corynoneura sp.	3				3	1		1	3	3	3		
Cricotopus bicinctus	8										8		

	1	2	3	4	5	6	7	8	9	10	11	12	13
C. trifascia				6									
Eukiefferiella claripennis	3												
Eukiefferiella sp.		3											
Nanocladius sp.							1			1			6
Orthocladius obumbratus	3		3	16						1	5	18	
Parametriocnemus lundbecki								1					
Rheocricotopus robacki			1		3								
Thienemanniella xena	3	3	1	2	2	1	2	8	6		3	3	
Micropsectra sp.	10				1								
Cladotanytarsus sp.			3	4		4					2		
Paratanytarsus sp.	5					3							
Rheotanytarsus sp.								9	3			9	2
Tanytarsus sp.		3	1	4	1					2			1
Decapoda									1	1			
Isopoda			5	1			1	1					
Amphipoda					1		4	1				1	
Oligochaeta			4	1	6		3			1	3	1	1
Hirudinea	1												
Turbellaria							58						
Collembola										1			
Physidae									1				
Pleuroceridae												1	1
Ancylidae								4	1				
Corbicula fluminea	1					1		3					2
total	136	136	135	141	204	221	241	211	215	254	220	203	339

	1	2	3	4	5	6	7	8	9	10	11	12	13
Metrics calculation													
number of taxa	24	23	25	31	29	30	25	47	32	30	28	32	28
number of individuals	136	136	135	141	204	221	241	211	215	254	220	203	339
Number of EPT Taxa	5	12	12	12	12	13	4	17	11	8	15	14	9
%orthocladinae+tanytarsini	26.471	8.0882	8.88889	25.5319	7.3529	6.7873	4.1494	12.796	9.7674	6.69291	14.5455	20.6897	6.49
%non-insects minus crayfish	1.4706	0	6.66667	1.41844	3.4314	0.4525	27.386	4.2654	1.3953	1.1811	1.36364	1.47783	1.18
number dipteran taxa	10	7	8	11	9	9	8	15	9	10	9	11	10
% intolerant	0	11.765	13.3333	10.6383	2.9412	10.407	0.4149	8.5308	7.907	12.9921	7.27273	20.197	12.68
% tolerant	16.176	10.294	11.1111	4.96454	43.627	12.67	22.407	18.957	11.628	8.26772	7.72727	11.8227	17.99
% predators	11.029	7.3529	0.74074	8.51064	0.9804	1.3575	10.788	9.4787	15.349	5.11811	2.72727	3.94089	1.18
%shredders+scrapers	26.471	16.912	17.7778	19.1489	24.51	28.054	34.44	41.232	20.93	37.7953	24.5455	17.734	53.98
%collectors-filterers	6.6176	50.735	59.2593	36.1702	5.3922	40.271	0	15.166	15.814	26.7717	21.8182	23.6453	13.86
% sprawlers	0.13	0.02	0.01	0.06	0.01	0.02	0.01	0.04	0.03	-	0.05	0.01	-
	1	2	3	4	5	6	7	8	9	10	11	12	13
Metrics scoring													
number of taxa	3	3	3	3	3	3	3	5	3	3	3	3	3
number of individuals	3	3	3	3	3	3	3	3	3	3	3	3	5
Number of EPT Taxa	3	5	5	5	5	5	3	5	5	5	5	5	5
%orthocladinae+tanytarsini	3	5	5	3	5	5	5	5	5	5	5	5	5
%non-insects minus crayfish	5	5	5	5	5	5	3	5	5	5	5	5	5
number dipteran taxa	3	1	3	3	3	3	3	5	3	3	3	3	3
% intolerant	1	1	1	1	1	1	1	1	1	1	1	3	1
% tolerant	3	5	5	5	1	3	3	3	3	5	5	3	3
% predators	1	1	1	1	1	1	1	1	1	1	1	1	1
%shredders+scrapers	5	3	3	5	5	5	5	5	5	5	5	5	5
%collectors-filterers	5	1	1	1	5	1	5	3	3	1	1	1	3
% sprawlers	5	1	1	3	1	1	1	3	1	1	5	1	1
total	40	34	36	38	38	36	36	44	38	38	42	38	40

TAXONID	Family	Genus	Species	Common Name	1	4	6	7	8	10
				Site Name	Edlin	Ramp	Miller	Jones	L.Wal.	Deweese
				Area (sq mi)	23	23	19	13	63	16
				Total Number of Delts	0	0	0	0	0	0
51	Cyprinidae	Semotilus	atromaculatus	creek chub	1		6			11
62	Cyprinidae	Notropis	stramineus	sand shiner						1
73	Cyprinidae	Ericymba	buccata	silverjaw minnow		25	29	15	20	12
76	Cyprinidae	Phenacobius	mirabilis	suckermouth minnow	1	1		7	1	3
77	Cyprinidae	Campostoma	anomalum	central stoneroller	2	32		15	5	16
78	Cyprinidae	Campostoma	oligolepis	largescale stoneroller						
79	Cyprinidae	Pimephales	notatus	bluntnose minnow	5	2	3		4	59
88	Cyprinidae	Cyprinella	spiloptera	spotfin shiner		2	2		9	1
92	Cyprinidae	Luxilus	chrysocephalus	striped shiner			2			4
93	Cyprinidae	Luxilus	cornutus	common shiner		7	9	1	1	
101	Catostomidae	Catostomus	commersoni	white sucker		1	2			
108	Catostomidae	Moxostoma	anisurum	silver redhorse		1				
111	Catostomidae	Moxostoma	erythrurum	golden redhorse	1	1				
112	Catostomidae	Moxostoma	valenciennesi	greater redhorse						
113	Catostomidae	Hypentelium	nigricans	northern hog sucker	2	2	6	2	6	1
118	Catostomidae	Minytrema	melanops	spotted sucker		2				
127	Ictaluridae	Noturus	miurus	brindled madtom			1			
131	Ictaluridae	Ameiurus	melas	black bullhead			1			
132	Ictaluridae	Ameiurus	natalis	yellow bullhead	2			4		
142	Fundulidae	Fundulus	notatus	blackstripe topminnow	1	2				
149	Cottidae	Cottus	bairdi	mottled sculpin	3					2
156	Centrarchidae	Ambloplites	rupestris	rock bass					4	
158	Centrarchidae	Lepomis	cyanellus	green sunfish	3	2	2	3		
160	Centrarchidae	Lepomis	macrochirus	bluegill	8	3	2	51		
163	Centrarchidae	Lepomis	megalotis	longear sunfish	6	5	4	1	3	
164	Centrarchidae	Lepomis	microlophus	redear sunfish				1		
167	Centrarchidae	Micropterus	dolomieu	smallmouth bass	1		1		1	
168	Centrarchidae	Micropterus	salmoides	largemouth bass				6	1	1
170	Centrarchidae	Pomoxis	annularis	white crappie				1		
174	Percidae	Etheostoma	spectabile	orangethroat darter	6	7		7	5	4
175	Percidae	Etheostoma	nigrum	johnny darter	18	3	3		3	5
177	Percidae	Etheostoma	blennioides	greenside darter	6	3		5	3	1
178	Percidae	Etheostoma	caeruleum	rainbow darter	1	1			1	
181	Percidae	Etheostoma	flabellare	fantail darter	5	5	1	5	4	3
				Total Species	18	20	16	15	16	15
				Number of individuals	72	107	74	124	71	124

#of Darters Madtoms Sculpin	6	5	3	3	5	5
# of darters	5	5	2	3	5	4
% Headwater species	0.11	0.05	0.01	0.04	0.06	0.04
# of sunfish	3	3	3	5	2	0
# of minnows sp	4	6	6	4	6	8
# of suckers	2	5	2	1	1	1
% Pioneer	48.61	66.36	58.11	32.26	52.11	86.29
# of sensitive species	6	8	7	4	7	4
% of tolerance	15.28	4.67	18.92	5.65	5.63	56.45
% omnivores	0	0	0	0	0	0
%insectivorus	87.50	67.29	83.78	83.06	78.87	29.84
% Carnivores	1.39	0.00	1.35	4.84	8.45	0.81
CPUE	72	107	74	124	71	124
% Simple Lithophilic	15.28	21.50	25.68	13.71	19.72	9.68
% of delts	0	0	0	0	0	0

	Site 1	Site 4	Site 6	Site 7	Site 8	Site 10	Site 13	
	Edlin	Ramp	Miller	Jones	L.Wal.	Deweese		
Total species	5	5	5	5	3	5		5
#of Darters Madtoms Sculpin			3	3		5		5
# of darters	5	5			5			
% Headwater species			1	1		1		1
# of sunfish	3	3			3			
# of minnows sp			3	3		5		5
# of suckers	3	5			1			
% Pioneer			1	3		1		1
# of sensitive species	5	5	5	3	5	3		5
% of tolerance	5	5	5	5	5	1		1
% omnivores	5	5	5	5	5	5		5
%insectivorus	5	5	5	5	5	3		5
% Carnivores	1	1			1			
CPUE	1	1	1	3	1	3		3
% Simple Lithophilic	3	3	3	3	3	3		3
%DELTS score	5	5	5	5	5	5		5
Total IBI <= 20 sq. mi.	0	0	42	44	0	40		44
Total IBI > 20 sq. mi.	46	49			42	0		0

Appendix E: Subwatershed Data

Nutrient	Eldin Ditch	Ross Ditch-East Fork Big Walnut Creek	Ramp Run-East Fork Big Walnut Creek	West Fork Big Walnut Creek	Owl Creek
HUC	51202030101	51202030102	51202030103	51202030104	51202030201
Area (acres)	15,039.5	26,562.9	15,164.5	17,175.3	10,345.8
% of Watershed	5.6%	9.8%	5.6%	6.3%	3.8%
Watershed (sq mi)	23.5	41.5	23.7	26.8	16.2
Stream (miles)	23.5	48.7	41.8	32.4	46.1
Impaired Fish 5B (miles)	0	0	0	0	0
Impaired ALUS 5A (miles)	0	0	0	0	0
Impaired ECOLI 4A (miles)	0	0	0	0	0
Impaired ECOLI 5A (miles)	19.5	36.1	0.005	32.2	29.7
Impaired Nutr 5A (miles)	0	0	0	0	0
Impaired PCBs 5B (miles)	0	0	0	0	0
HES (acres)	7543.5	2588.7	1167.0	6254.9	2219.3
HES (%)	50.2%	9.7%	7.7%	36.4%	21.5%
PHES (acres)	75.8	9928.3	3938.7	2306.2	4464.7
PHES (%)	0.5%	37.4%	26.0%	13.4%	43.2%
HES+PHES	50.7%	47.1%	33.7%	49.8%	64.6%
Wetland Loss (acres)	99%	97%	97%	96%	
NWI Current (acres)	80.2	327.1	111.0	213.8	437.9
NWI Current (%)	0.5%	1.2%	0.7%	1.2%	4.2%
Hydric (acres)	7360.6	10171.7	3529.7	5189.7	316.7
Hydric (%)	48.9%	38.3%	23.3%	30.2%	3.1%
Septic-VeryLimited	15018.1	26479.2	15124.2	17031.2	9923.5
Septic-VL (%)	99.9%	99.7%	99.7%	99.2%	95.9%
CFO (animals)	0	1144	7736	1000	0
Hobby Farm (count)	23	43	49	21	14
Hobby Farm (animals)	217	262	541	220	184
Manure estimate (tons)	4407	10106	42892	8876	3382
Manure N estimate (lb)	2441	16994	101044	14617	1783
Manure P estimate (lb)	1231	12100	74950	10442	894
MS4 area					
Livestock Access (miles)	0.6	3.3	3.7	3.8	1.2
	3%	7%	9%	12%	3%
Streambank Erosion (miles)	2.2	16.3	8.9	8.3	7.1
	9%	33%	21%	26%	15%
Narrow Buffer (miles)	16.3	6.7	0.9	5.7	1.4
	69%	14%	2%	18%	3%
Land Use (acres)	15049	26581	15174	17187	10353
Ag - Row +Pasture	13928	23121	13377	14816	7191
Forest	113	1075	948	931	2082

Wetland + Open water + gras:	154	449	207	256	498
Urban	854	1936	642	1184	582
Land Use (%)	100.0%	100.0%	100.0%	100.0%	100.0%
Ag - Row +Pasture	92.6%	87.0%	88.2%	86.2%	69.5%
Forest	0.8%	4.0%	6.2%	5.4%	20.1%
Wetland + Open water + gras:	1.0%	1.7%	1.4%	1.5%	4.8%
Urban	5.7%	7.3%	4.2%	6.9%	5.6%
Hist Data Exceed					
E.coli	0%	79%	0%	38%	20%
Nitrate	50%	80%	64%	63%	53%
OrthoP	0%	25%	50%	0%	50%
Total Phosphours	50%	25%	50%	42%	60%
Total Suspended Solids	17%	10%	33%	55%	43%
Turbidity	0%	92%	0%	63%	57%
Open Dump	0	0	0	0	1
Brownfield	0	0	0	0	0
CorrectiveAction	0	0	0	0	0
VRP	0	0	0	1	0
NPDES	0	3	0	1	2
LUST	1	7	0	8	0
Waste Industrial	0	0	0	0	0
Waste Septage	0	0	0	0	0
Logjam	0	1	0	3	0
Trash Area	0	0	0	8	0
Count	1	4	3	2	0

Nutrients	Headwaters Little Walnut Creek	Leatherman Creek-Little Walnut Creek	Headwaters Deer Creek	Owl Branch-Deer Creek	Deweese Branch-Deer Creek
HUC	51202030202	51202030203	51202030301	51202030302	51202030303
Area (acres)	16,506.8	14,279.4	19,373.2	18,102.2	20,954.3
% of Watershed	6.1%	5.3%	7.2%	6.7%	7.7%
Watershed (sq mi)	25.8	22.3	30.3	28.3	32.7
Stream (miles)	76.0	68.0	73.2	84.1	79.6
Impaired Fish 5B (miles)	0	0	0	0	0
Impaired ALUS 5A (miles)	0	0	0	0	0
Impaired ECOLI 4A (miles)	0	0	0	0	0
Impaired ECOLI 5A (miles)	63.4	42.3	0	0.003	69.3
Impaired Nutr 5A (miles)	0	0	0	0	0
Impaired PCBs 5B (miles)	0	0	0	0	0
HES (acres)	3825.6	5027.7	2930.3	5006.9	6711.5
HES (%)	23.2%	35.2%	15.1%	27.7%	32.0%
PHES (acres)	6528.9	3633.5	6469.1	6404.1	7587.3
PHES (%)	39.6%	25.4%	33.4%	35.4%	36.2%
HES+PHES	62.7%	60.7%	48.5%	63.0%	68.2%
Wetland Loss (acres)	71%	55%	82%		
NWI Current (acres)	234.2	143.4	190.2	233.1	390.6
NWI Current (%)	1.4%	1.0%	1.0%	1.3%	1.9%
Hydric (acres)	801.5	316.8	1081.8	118.5	149.0
Hydric (%)	4.9%	2.2%	5.6%	0.7%	0.7%
Septic-VeryLimited	16332.3	13456.6	19281.3	15230.8	16888.8
Septic-VL (%)	98.9%	94.2%	99.5%	84.1%	80.6%
CFO (animals)	0	0	4842	0	987
Hobby Farm (count)	28	21	50	27	15
Hobby Farm (animals)	272	273	330	228	137
Manure estimate (tons)	4273	4524	26905	4123	6529
Manure N estimate (lb)	3489	3103	63065	2658	13696
Manure P estimate (lb)	1804	1789	46776	1393	10037
MS4 area					
Livestock Access (miles)	0.8	0.3	0.9	0.9	0.4
	1%	0%	1%	1%	1%
Streambank Erosion (miles)	15.2	12.3	11.9	4.8	7.5
	20%	18%	16%	6%	9%
Narrow Buffer (miles)	1.4	0.0	0.0	0.0	0.0
	2%	0%	0%	0%	0%
Land Use (acres)	16518	14290	19387	18114	20970
Ag - Row +Pasture	11750	5888	14226	8240	6090
Forest	3801	7800	3857	7834	12355

Wetland + Open water + gras	239	69	157	325	1046
Urban	728	533	1147	1715	1479
Land Use (%)	100.0%	100.0%	100.0%	100.0%	100.0%
Ag - Row +Pasture	71.1%	41.2%	73.4%	45.5%	29.0%
Forest	23.0%	54.6%	19.9%	43.2%	58.9%
Wetland + Open water + gras	1.4%	0.5%	0.8%	1.8%	5.0%
Urban	4.4%	3.7%	5.9%	9.5%	7.1%
Hist Data Exceed					
E.coli	18%	56%	20%	60%	46%
Nitrate	58%	31%	50%	50%	50%
OrthoP	0%	0%	0%	0%	0%
Total Phosphours	85%	58%	67%	75%	88%
Total Suspended Solids	23%	23%	33%	43%	48%
Turbidity	100%	85%	40%	53%	84%
Open Dump	0	0	0	0	0
Brownfield	0	0	0	0	2
CorrectiveAction	0	0	0	0	1
VRP	0	0	0	0	1
NPDES	0	0	0	5	4
LUST	0	0	4	5	13
Waste Industrial	0	0	2	1	2
Waste Septage	0	0	1	1	0
Logjam	0	0	0	0	0
Trash Area	0	3	1	0	0
Count	1	0	1	1	1

Nutrients	Town of Barnard-Big Walnut Creek	Clear Creek	Bledsoe Branch-Big Walnut Creek	Dry Branch-Big Walnut Creek	Snake Creek-Big Walnut Creek
HUC	51202030401	51202030402	51202030403	51202030404	51202030405
Area (acres)	18,450.6	19,900.9	12,119.0	22,313.6	24,481.0
% of Watershed	6.8%	7.3%	4.5%	8.2%	9.0%
Watershed (sq mi)	28.8	31.1	18.9	34.9	38.3
Stream (miles)	64.1	81.8	50.3	110.2	81.9
Impaired Fish 5B (miles)	2.6	0	0	0	34.3
Impaired ALUS 5A (miles)	0	0	0	0	11.9
Impaired ECOLI 4A (miles)	0	0	0	0	0
Impaired ECOLI 5A (miles)	46.8	67.1	50.3	77.3	15.945
Impaired Nutr 5A (miles)	0	0	0	0	12.0
Impaired PCBs 5B (miles)	0	0	0	0	34.3
HES (acres)	4301.7	3048.9	2684.7	5229.3	7724.9
HES (%)	23.3%	15.3%	22.2%	23.4%	31.6%
PHES (acres)	4311.4	4790.9	4076.5	9487.8	7140.6
PHES (%)	23.4%	24.1%	33.6%	42.5%	29.2%
HES+PHES	46.7%	39.4%	55.8%	66.0%	60.7%
Wetland Loss (acres)	78%	70%	52%		
NWI Current (acres)	465.8	587.4	187.6	466.9	536.4
NWI Current (%)	2.5%	3.0%	1.5%	2.1%	2.2%
Hydric (acres)	2140.4	1971.3	394.6	251.0	341.6
Hydric (%)	11.6%	9.9%	3.3%	1.1%	1.4%
Septic-VeryLimited	18241.5	19484.2	12050.4	21150.9	22001.1
Septic-VL (%)	98.9%	97.9%	99.4%	94.8%	89.9%
CFO (animals)	13768	0	0	4684	0
Hobby Farm (count)	22	28	17	27	27
Hobby Farm (animals)	120	53	117	302	255
Manure estimate (tons)	58989	1061	2517	25289	5463
Manure N estimate (lb)	170625	605	1238	61553	2716
Manure P estimate (lb)	128685	308	615	45044	1343
MS4 area					
Livestock Access (miles)	2.6	1.0	1.4	0.5	0.2
	4%	1%	3%	0%	0%
Streambank Erosion (miles)	8.4	10.1	10.5	14.5	10.9
	13%	12%	21%	13%	13%
Narrow Buffer (miles)	0.0	1.5	0.0	0.0	0.0
	0%	2%	0%	0%	0%
Land Use (acres)	18463	19915	12128	22331	24499
Ag - Row +Pasture	11690	14685	8793	12951	8007
Forest	5677	2864	2503	6719	14619

Wetland + Open water + gras:	235	644	102	296	698
Urban	861	1722	730	2365	1175
Land Use (%)	100.0%	100.0%	100.0%	100.0%	100.0%
Ag - Row +Pasture	63.3%	73.7%	72.5%	58.0%	32.7%
Forest	30.7%	14.4%	20.6%	30.1%	59.7%
Wetland + Open water + gras:	1.3%	3.2%	0.8%	1.3%	2.8%
Urban	4.7%	8.6%	6.0%	10.6%	4.8%
Hist Data Exceed					
E.coli	41%	16%	21%	31%	33%
Nitrate	67%	53%	71%	55%	70%
OrthoP	27%	100%	71%	50%	48%
Total Phosphours	19%	70%	32%	90%	41%
Total Suspended Solids	59%	36%	21%	47%	55%
Turbidity	88%	66%	80%	83%	89%
Open Dump	0	0	0	1	0
Brownfield	0	0	0	2	0
CorrectiveAction	0	0	0	1	0
VRP	0	0	0	0	0
NPDES	1	1	0	3	1
LUST	0	2	5	23	1
Waste Industrial	0	0	0	3	0
Waste Septage	0	0	0	1	0
Logjam	0	2	0	0	0
Trash Area	0	1	1	0	1
Count	2	1	1	2	1

Sediment	Eldin Ditch	Ross Ditch-East Fork Big Walnut Creek	Ramp Run-East Fork Big Walnut Creek	West Fork Big Walnut Creek	Owl Creek
HUC	51202030101	51202030102	51202030103	51202030104	51202030201
Area (acres)	15,039.5	26,562.9	15,164.5	17,175.3	10,345.8
% of Watershed	5.6%	9.8%	5.6%	6.3%	3.8%
Watershed (sq mi)	23.5	41.5	23.7	26.8	16.2
Stream (miles)	23.5	48.7	41.8	32.4	46.1
Impaired Fish 5B (miles)	0	0	0	0	0
Impaired ALUS 5A (miles)	0	0	0	0	0
Impaired ECOLI 4A (miles)	0	0	0	0	0
Impaired ECOLI 5A (miles)	19.5	36.1	0.005	32.2	29.7
Impaired Nutr 5A (miles)	0	0	0	0	0
Impaired PCBs 5B (miles)	0	0	0	0	0
HES (acres)	7543.5	2588.7	1167.0	6254.9	2219.3
HES (%)	50.2%	9.7%	7.7%	36.4%	21.5%
PHES (acres)	75.8	9928.3	3938.7	2306.2	4464.7
PHES (%)	0.5%	37.4%	26.0%	13.4%	43.2%
PHES+HES	50.7%	47.1%	33.7%	49.8%	64.6%
Wetland Loss (acres)	99%	97%	97%	96%	
NWI Current (acres)	80.2	327.1	111.0	213.8	437.9
NWI Current (%)	0.5%	1.2%	0.7%	1.2%	4.2%
Hydric (acres)	7360.6	10171.7	3529.7	5189.7	316.7
Hydric (%)	48.9%	38.3%	23.3%	30.2%	3.1%
Septic-VeryLimited	15018.1	26479.2	15124.2	17031.2	9923.5
Septic-VL (%)	99.9%	99.7%	99.7%	99.2%	95.9%
CFO (animals)	0	1144	7736	1000	0
Hobby Farm (count)	23	43	49	21	14
Hobby Farm (animals)	217	262	541	220	184
Manure estimate (tons)	4407	10106	42892	8876	3382
Manure N estimate (lb)	2441	16994	101044	14617	1783
Manure P estimate (lb)	1231	12100	74950	10442	894
MS4 area					
Livestock Access (miles)	0.6	3.3	3.7	3.8	1.2
	3%	7%	9%	12%	3%
Streambank Erosion (miles)	2.2	16.3	8.9	8.3	7.1
	9%	33%	21%	26%	15%
Narrow Buffer (miles)	16.3	6.7	0.9	5.7	1.4
	69%	14%	2%	18%	3%
Land Use (acres)	15049	26581	15174	17187	10353
Ag - Row +Pasture	13928	23121	13377	14816	7191
Forest	113	1075	948	931	2082

Wetland + Open water + gras:	154	449	207	256	498
Urban	854	1936	642	1184	582
Land Use (%)	100.0%	100.0%	100.0%	100.0%	100.0%
Ag - Row +Pasture	92.6%	87.0%	88.2%	86.2%	69.5%
Forest	0.8%	4.0%	6.2%	5.4%	20.1%
Wetland + Open water + gras:	1.0%	1.7%	1.4%	1.5%	4.8%
Urban	5.7%	7.3%	4.2%	6.9%	5.6%
Hist Data Exceed					
E.coli	0%	79%	0%	38%	20%
Nitrate	50%	80%	64%	63%	53%
OrthoP	0%	25%	50%	0%	50%
Total Phosphours	50%	25%	50%	42%	60%
Total Suspended Solids	17%	10%	33%	55%	43%
Turbidity	0%	92%	0%	63%	57%
Open Dump	0	0	0	0	1
Brownfield	0	0	0	0	0
CorrectiveAction	0	0	0	0	0
VRP	0	0	0	1	0
NPDES	0	3	0	1	2
LUST	1	7	0	8	0
Waste Industrial	0	0	0	0	0
Waste Septage	0	0	0	0	0
Logjam	0	1	0	3	0
Trash Area	0	0	0	8	0
Sediment Count	1	3	2	3	2

sediment	Headwaters Little Walnut Creek	Leatherman Creek-Little Walnut Creek	Headwaters Deer Creek	Owl Branch-Deer Creek	Deweese Branch-Deer Creek
HUC	51202030202	51202030203	51202030301	51202030302	51202030303
Area (acres)	16,506.8	14,279.4	19,373.2	18,102.2	20,954.3
% of Watershed	6.1%	5.3%	7.2%	6.7%	7.7%
Watershed (sq mi)	25.8	22.3	30.3	28.3	32.7
Stream (miles)	76.0	68.0	73.2	84.1	79.6
Impaired Fish 5B (miles)	0	0	0	0	0
Impaired ALUS 5A (miles)	0	0	0	0	0
Impaired ECOLI 4A (miles)	0	0	0	0	0
Impaired ECOLI 5A (miles)	63.4	42.3	0	0.003	69.3
Impaired Nutr 5A (miles)	0	0	0	0	0
Impaired PCBs 5B (miles)	0	0	0	0	0
HES (acres)	3825.6	5027.7	2930.3	5006.9	6711.5
HES (%)	23.2%	35.2%	15.1%	27.7%	32.0%
PHES (acres)	6528.9	3633.5	6469.1	6404.1	7587.3
PHES (%)	39.6%	25.4%	33.4%	35.4%	36.2%
PHES+HES	62.7%	60.7%	48.5%	63.0%	68.2%
Wetland Loss (acres)	71%	55%	82%		
NWI Current (acres)	234.2	143.4	190.2	233.1	390.6
NWI Current (%)	1.4%	1.0%	1.0%	1.3%	1.9%
Hydric (acres)	801.5	316.8	1081.8	118.5	149.0
Hydric (%)	4.9%	2.2%	5.6%	0.7%	0.7%
Septic-VeryLimited	16332.3	13456.6	19281.3	15230.8	16888.8
Septic-VL (%)	98.9%	94.2%	99.5%	84.1%	80.6%
CFO (animals)	0	0	4842	0	987
Hobby Farm (count)	28	21	50	27	15
Hobby Farm (animals)	272	273	330	228	137
Manure estimate (tons)	4273	4524	26905	4123	6529
Manure N estimate (lb)	3489	3103	63065	2658	13696
Manure P estimate (lb)	1804	1789	46776	1393	10037
MS4 area					
Livestock Access (miles)	0.8	0.3	0.9	0.9	0.4
	1%	0%	1%	1%	1%
Streambank Erosion (miles)	15.2	12.3	11.9	4.8	7.5
	20%	18%	16%	6%	9%
Narrow Buffer (miles)	1.4	0.0	0.0	0.0	0.0
	2%	0%	0%	0%	0%
Land Use (acres)	16518	14290	19387	18114	20970
Ag - Row +Pasture	11750	5888	14226	8240	6090
Forest	3801	7800	3857	7834	12355

Wetland + Open water + gras:	239	69	157	325	1046
Urban	728	533	1147	1715	1479
Land Use (%)	100.0%	100.0%	100.0%	100.0%	100.0%
Ag - Row +Pasture	71.1%	41.2%	73.4%	45.5%	29.0%
Forest	23.0%	54.6%	19.9%	43.2%	58.9%
Wetland + Open water + gras:	1.4%	0.5%	0.8%	1.8%	5.0%
Urban	4.4%	3.7%	5.9%	9.5%	7.1%
Hist Data Exceed					
E.coli	18%	56%	20%	60%	46%
Nitrate	58%	31%	50%	50%	50%
OrthoP	0%	0%	0%	0%	0%
Total Phosphours	85%	58%	67%	75%	88%
Total Suspended Solids	23%	23%	33%	43%	48%
Turbidity	100%	85%	40%	53%	84%
Open Dump	0	0	0	0	0
Brownfield	0	0	0	0	2
CorrectiveAction	0	0	0	0	1
VRP	0	0	0	0	1
NPDES	0	0	0	5	4
LUST	0	0	4	5	13
Waste Industrial	0	0	2	1	2
Waste Septage	0	0	1	1	0
Logjam	0	0	0	0	0
Trash Area	0	3	1	0	0
Sediment Count	3	1	1	3	3

Sediment	Town of Barnard-Big Walnut Creek	Clear Creek	Bledsoe Branch-Big Walnut Creek	Dry Branch-Big Walnut Creek	Snake Creek-Big Walnut Creek
HUC	51202030401	51202030402	51202030403	51202030404	51202030405
Area (acres)	18,450.6	19,900.9	12,119.0	22,313.6	24,481.0
% of Watershed	6.8%	7.3%	4.5%	8.2%	9.0%
Watershed (sq mi)	28.8	31.1	18.9	34.9	38.3
Stream (miles)	64.1	81.8	50.3	110.2	81.9
Impaired Fish 5B (miles)	2.6	0	0	0	34.3
Impaired ALUS 5A (miles)	0	0	0	0	11.9
Impaired ECOLI 4A (miles)	0	0	0	0	0
Impaired ECOLI 5A (miles)	46.8	67.1	50.3	77.3	15.945
Impaired Nutr 5A (miles)	0	0	0	0	12.0
Impaired PCBs 5B (miles)	0	0	0	0	34.3
HES (acres)	4301.7	3048.9	2684.7	5229.3	7724.9
HES (%)	23.3%	15.3%	22.2%	23.4%	31.6%
PHES (acres)	4311.4	4790.9	4076.5	9487.8	7140.6
PHES (%)	23.4%	24.1%	33.6%	42.5%	29.2%
PHES+HES	46.7%	39.4%	55.8%	66.0%	60.7%
Wetland Loss (acres)	78%	70%	52%		
NWI Current (acres)	465.8	587.4	187.6	466.9	536.4
NWI Current (%)	2.5%	3.0%	1.5%	2.1%	2.2%
Hydric (acres)	2140.4	1971.3	394.6	251.0	341.6
Hydric (%)	11.6%	9.9%	3.3%	1.1%	1.4%
Septic-VeryLimited	18241.5	19484.2	12050.4	21150.9	22001.1
Septic-VL (%)	98.9%	97.9%	99.4%	94.8%	89.9%
CFO (animals)	13768	0	0	4684	0
Hobby Farm (count)	22	28	17	27	27
Hobby Farm (animals)	120	53	117	302	255
Manure estimate (tons)	58989	1061	2517	25289	5463
Manure N estimate (lb)	170625	605	1238	61553	2716
Manure P estimate (lb)	128685	308	615	45044	1343
MS4 area					
Livestock Access (miles)	2.6	1.0	1.4	0.5	0.2
	4%	1%	3%	0%	0%
Streambank Erosion (miles)	8.4	10.1	10.5	14.5	10.9
	13%	12%	21%	13%	13%
Narrow Buffer (miles)	0.0	1.5	0.0	0.0	0.0
	0%	2%	0%	0%	0%
Land Use (acres)	18463	19915	12128	22331	24499
Ag - Row +Pasture	11690	14685	8793	12951	8007
Forest	5677	2864	2503	6719	14619

Wetland + Open water + gras:	235	644	102	296	698
Urban	861	1722	730	2365	1175
Land Use (%)	100.0%	100.0%	100.0%	100.0%	100.0%
Ag - Row +Pasture	63.3%	73.7%	72.5%	58.0%	32.7%
Forest	30.7%	14.4%	20.6%	30.1%	59.7%
Wetland + Open water + gras:	1.3%	3.2%	0.8%	1.3%	2.8%
Urban	4.7%	8.6%	6.0%	10.6%	4.8%
Hist Data Exceed					
E.coli	41%	16%	21%	31%	33%
Nitrate	67%	53%	71%	55%	70%
OrthoP	27%	100%	71%	50%	48%
Total Phosphours	19%	70%	32%	90%	41%
Total Suspended Solids	59%	36%	21%	47%	55%
Turbidity	88%	66%	80%	83%	89%
Open Dump	0	0	0	1	0
Brownfield	0	0	0	2	0
CorrectiveAction	0	0	0	1	0
VRP	0	0	0	0	0
NPDES	1	1	0	3	1
LUST	0	2	5	23	1
Waste Industrial	0	0	0	3	0
Waste Septage	0	0	0	1	0
Logjam	0	2	0	0	0
Trash Area	0	1	1	0	1
Sediment Count	1	2	1	3	2

E. coli	Eldin Ditch	Ross Ditch-East Fork Big Walnut Creek	Ramp Run-East Fork Big Walnut Creek	West Fork Big Walnut Creek	Owl Creek
HUC	51202030101	51202030102	51202030103	51202030104	51202030201
Area (acres)	15,039.5	26,562.9	15,164.5	17,175.3	10,345.8
% of Watershed	5.6%	9.8%	5.6%	6.3%	3.8%
Watershed (sq mi)	23.5	41.5	23.7	26.8	16.2
Stream (miles)	23.5	48.7	41.8	32.4	46.1
Impaired Fish 5B (miles)	0	0	0	0	0
Impaired ALUS 5A (miles)	0	0	0	0	0
Impaired ECOLI 4A (miles)	0	0	0	0	0
Impaired ECOLI 5A (miles)	19.5	36.1	0.005	32.2	29.7
Impaired Nutr 5A (miles)	0	0	0	0	0
Impaired PCBs 5B (miles)	0	0	0	0	0
HES (acres)	7543.5	2588.7	1167.0	6254.9	2219.3
HES (%)	50.2%	9.7%	7.7%	36.4%	21.5%
PHES (acres)	75.8	9928.3	3938.7	2306.2	4464.7
PHES (%)	0.5%	37.4%	26.0%	13.4%	43.2%
	50.7%	47.1%	33.7%	49.8%	64.6%
Wetland Loss (acres)	99%	97%	97%	96%	
NWI Current (acres)	80.2	327.1	111.0	213.8	437.9
NWI Current (%)	0.5%	1.2%	0.7%	1.2%	4.2%
Hydric (acres)	7360.6	10171.7	3529.7	5189.7	316.7
Hydric (%)	48.9%	38.3%	23.3%	30.2%	3.1%
Septic-VeryLimited	15018.1	26479.2	15124.2	17031.2	9923.5
Septic-VL (%)	99.9%	99.7%	99.7%	99.2%	95.9%
CFO (animals)	0	1144	7736	1000	0
Hobby Farm (count)	23	43	49	21	14
Hobby Farm (animals)	217	262	541	220	184
Manure estimate (tons)	4407	10106	42892	8876	3382
Manure N estimate (lb)	2441	16994	101044	14617	1783
Manure P estimate (lb)	1231	12100	74950	10442	894
MS4 area					
Livestock Access (miles)	0.6	3.3	3.7	3.8	1.2
	3%	7%	9%	12%	3%
Streambank Erosion (miles)	2.2	16.3	8.9	8.3	7.1
	9%	33%	21%	26%	15%
Narrow Buffer (miles)	16.3	6.7	0.9	5.7	1.4
	69%	14%	2%	18%	3%
Land Use (acres)	15049	26581	15174	17187	10353
Ag - Row +Pasture	13928	23121	13377	14816	7191
Forest	113	1075	948	931	2082

Wetland + Open water + gras:	154	449	207	256	498
Urban	854	1936	642	1184	582
Land Use (%)	100.0%	100.0%	100.0%	100.0%	100.0%
Ag - Row +Pasture	92.6%	87.0%	88.2%	86.2%	69.5%
Forest	0.8%	4.0%	6.2%	5.4%	20.1%
Wetland + Open water + gras:	1.0%	1.7%	1.4%	1.5%	4.8%
Urban	5.7%	7.3%	4.2%	6.9%	5.6%
Hist Data Exceed					
E.coli	0%	79%	0%	38%	20%
Nitrate	50%	80%	64%	63%	53%
OrthoP	0%	25%	50%	0%	50%
Total Phosphours	50%	25%	50%	42%	60%
Total Suspended Solids	17%	10%	33%	55%	43%
Turbidity	0%	92%	0%	63%	57%
Open Dump	0	0	0	0	1
Brownfield	0	0	0	0	0
CorrectiveAction	0	0	0	0	0
VRP	0	0	0	1	0
NPDES	0	3	0	1	2
LUST	1	7	0	8	0
Waste Industrial	0	0	0	0	0
Waste Septage	0	0	0	0	0
Logjam	0	1	0	3	0
Trash Area	0	0	0	8	0
Count	1	4	3	2	1

E.coli	Headwaters Little Walnut Creek	Leatherman Creek-Little Walnut Creek	Headwaters Deer Creek	Owl Branch-Deer Creek	Deweese Branch-Deer Creek
HUC	51202030202	51202030203	51202030301	51202030302	51202030303
Area (acres)	16,506.8	14,279.4	19,373.2	18,102.2	20,954.3
% of Watershed	6.1%	5.3%	7.2%	6.7%	7.7%
Watershed (sq mi)	25.8	22.3	30.3	28.3	32.7
Stream (miles)	76.0	68.0	73.2	84.1	79.6
Impaired Fish 5B (miles)	0	0	0	0	0
Impaired ALUS 5A (miles)	0	0	0	0	0
Impaired ECOLI 4A (miles)	0	0	0	0	0
Impaired ECOLI 5A (miles)	63.4	42.3	0	0.003	69.3
Impaired Nutr 5A (miles)	0	0	0	0	0
Impaired PCBs 5B (miles)	0	0	0	0	0
HES (acres)	3825.6	5027.7	2930.3	5006.9	6711.5
HES (%)	23.2%	35.2%	15.1%	27.7%	32.0%
PHES (acres)	6528.9	3633.5	6469.1	6404.1	7587.3
PHES (%)	39.6%	25.4%	33.4%	35.4%	36.2%
	62.7%	60.7%	48.5%	63.0%	68.2%
Wetland Loss (acres)	71%	55%	82%		
NWI Current (acres)	234.2	143.4	190.2	233.1	390.6
NWI Current (%)	1.4%	1.0%	1.0%	1.3%	1.9%
Hydric (acres)	801.5	316.8	1081.8	118.5	149.0
Hydric (%)	4.9%	2.2%	5.6%	0.7%	0.7%
Septic-VeryLimited	16332.3	13456.6	19281.3	15230.8	16888.8
Septic-VL (%)	98.9%	94.2%	99.5%	84.1%	80.6%
CFO (animals)	0	0	4842	0	987
Hobby Farm (count)	28	21	50	27	15
Hobby Farm (animals)	272	273	330	228	137
Manure estimate (tons)	4273	4524	26905	4123	6529
Manure N estimate (lb)	3489	3103	63065	2658	13696
Manure P estimate (lb)	1804	1789	46776	1393	10037
MS4 area					
Livestock Access (miles)	0.8	0.3	0.9	0.9	0.4
	1%	0%	1%	1%	1%
Streambank Erosion (miles)	15.2	12.3	11.9	4.8	7.5
	20%	18%	16%	6%	9%
Narrow Buffer (miles)	1.4	0.0	0.0	0.0	0.0
	2%	0%	0%	0%	0%
Land Use (acres)	16518	14290	19387	18114	20970
Ag - Row +Pasture	11750	5888	14226	8240	6090
Forest	3801	7800	3857	7834	12355

Wetland + Open water + gras:	239	69	157	325	1046
Urban	728	533	1147	1715	1479
Land Use (%)	100.0%	100.0%	100.0%	100.0%	100.0%
Ag - Row +Pasture	71.1%	41.2%	73.4%	45.5%	29.0%
Forest	23.0%	54.6%	19.9%	43.2%	58.9%
Wetland + Open water + gras:	1.4%	0.5%	0.8%	1.8%	5.0%
Urban	4.4%	3.7%	5.9%	9.5%	7.1%
Hist Data Exceed					
E.coli	18%	56%	20%	60%	46%
Nitrate	58%	31%	50%	50%	50%
OrthoP	0%	0%	0%	0%	0%
Total Phosphours	85%	58%	67%	75%	88%
Total Suspended Solids	23%	23%	33%	43%	48%
Turbidity	100%	85%	40%	53%	84%
Open Dump	0	0	0	0	0
Brownfield	0	0	0	0	2
CorrectiveAction	0	0	0	0	1
VRP	0	0	0	0	1
NPDES	0	0	0	5	4
LUST	0	0	4	5	13
Waste Industrial	0	0	2	1	2
Waste Septage	0	0	1	1	0
Logjam	0	0	0	0	0
Trash Area	0	3	1	0	0
Count	1	2	2	1	1

E. coli	Town of Barnard-Big Walnut Creek	Clear Creek	Bledsoe Branch-Big Walnut Creek	Dry Branch-Big Walnut Creek	Snake Creek-Big Walnut Creek
HUC	51202030401	51202030402	51202030403	51202030404	51202030405
Area (acres)	18,450.6	19,900.9	12,119.0	22,313.6	24,481.0
% of Watershed	6.8%	7.3%	4.5%	8.2%	9.0%
Watershed (sq mi)	28.8	31.1	18.9	34.9	38.3
Stream (miles)	64.1	81.8	50.3	110.2	81.9
Impaired Fish 5B (miles)	2.6	0	0	0	34.3
Impaired ALUS 5A (miles)	0	0	0	0	11.9
Impaired ECOLI 4A (miles)	0	0	0	0	0
Impaired ECOLI 5A (miles)	46.8	67.1	50.3	77.3	15.945
Impaired Nutr 5A (miles)	0	0	0	0	12.0
Impaired PCBs 5B (miles)	0	0	0	0	34.3
HES (acres)	4301.7	3048.9	2684.7	5229.3	7724.9
HES (%)	23.3%	15.3%	22.2%	23.4%	31.6%
PHES (acres)	4311.4	4790.9	4076.5	9487.8	7140.6
PHES (%)	23.4%	24.1%	33.6%	42.5%	29.2%
	46.7%	39.4%	55.8%	66.0%	60.7%
Wetland Loss (acres)	78%	70%	52%		
NWI Current (acres)	465.8	587.4	187.6	466.9	536.4
NWI Current (%)	2.5%	3.0%	1.5%	2.1%	2.2%
Hydric (acres)	2140.4	1971.3	394.6	251.0	341.6
Hydric (%)	11.6%	9.9%	3.3%	1.1%	1.4%
Septic-VeryLimited	18241.5	19484.2	12050.4	21150.9	22001.1
Septic-VL (%)	98.9%	97.9%	99.4%	94.8%	89.9%
CFO (animals)	13768	0	0	4684	0
Hobby Farm (count)	22	28	17	27	27
Hobby Farm (animals)	120	53	117	302	255
Manure estimate (tons)	58989	1061	2517	25289	5463
Manure N estimate (lb)	170625	605	1238	61553	2716
Manure P estimate (lb)	128685	308	615	45044	1343
MS4 area					
Livestock Access (miles)	2.6	1.0	1.4	0.5	0.2
	4%	1%	3%	0%	0%
Streambank Erosion (miles)	8.4	10.1	10.5	14.5	10.9
	13%	12%	21%	13%	13%
Narrow Buffer (miles)	0.0	1.5	0.0	0.0	0.0
	0%	2%	0%	0%	0%
Land Use (acres)	18463	19915	12128	22331	24499
Ag - Row +Pasture	11690	14685	8793	12951	8007
Forest	5677	2864	2503	6719	14619

Wetland + Open water + gras:	235	644	102	296	698
Urban	861	1722	730	2365	1175
Land Use (%)	100.0%	100.0%	100.0%	100.0%	100.0%
Ag - Row +Pasture	63.3%	73.7%	72.5%	58.0%	32.7%
Forest	30.7%	14.4%	20.6%	30.1%	59.7%
Wetland + Open water + gras:	1.3%	3.2%	0.8%	1.3%	2.8%
Urban	4.7%	8.6%	6.0%	10.6%	4.8%
Hist Data Exceed					
E.coli	41%	16%	21%	31%	33%
Nitrate	67%	53%	71%	55%	70%
OrthoP	27%	100%	71%	50%	48%
Total Phosphours	19%	70%	32%	90%	41%
Total Suspended Solids	59%	36%	21%	47%	55%
Turbidity	88%	66%	80%	83%	89%
Open Dump	0	0	0	1	0
Brownfield	0	0	0	2	0
CorrectiveAction	0	0	0	1	0
VRP	0	0	0	0	0
NPDES	1	1	0	3	1
LUST	0	2	5	23	1
Waste Industrial	0	0	0	3	0
Waste Septage	0	0	0	1	0
Logjam	0	2	0	0	0
Trash Area	0	1	1	0	1
Count	4	1	1	2	1

Appendix F: Load Calculation Data

date	Flow (cfs)	Rank	PercentExceeded	NO3 Load	TP Load	TSS Load	Ecoli Load	Ecoli geo Load
1/24/2019	23.10	1	0.252	186.75	9.96	1867.45	1.33E+11	7.06E+10
9/26/2018	22.76	2	0.504	184.00	9.81	1839.98	1.31E+11	6.96E+10
4/19/2019	18.24	3	0.756	147.47	7.86	1474.67	1.05E+11	5.58E+10
2/7/2019	17.12	4	1.008	138.45	7.38	1384.46	9.85E+10	5.24E+10
9/8/2018	15.89	5	1.259	128.44	6.85	1284.40	9.13E+10	4.86E+10
9/9/2018	15.75	6	1.511	127.35	6.79	1273.53	9.06E+10	4.82E+10
11/2/2018	15.63	7	1.763	126.38	6.74	1263.82	8.99E+10	4.78E+10
3/10/2019	15.55	8	2.015	125.70	6.70	1256.96	8.94E+10	4.75E+10
2/6/2019	15.40	9	2.267	124.49	6.64	1244.93	8.85E+10	4.71E+10
1/23/2019	15.05	10	2.519	121.69	6.49	1216.86	8.65E+10	4.60E+10
2/8/2019	14.88	11	2.771	120.31	6.42	1203.08	8.56E+10	4.55E+10
3/31/2019	14.81	12	3.023	119.71	6.38	1197.07	8.51E+10	4.53E+10
6/20/2019	14.54	13	3.275	117.56	6.27	1175.65	8.36E+10	4.45E+10
1/1/2019	13.70	14	3.526	110.73	5.91	1107.35	7.87E+10	4.19E+10
6/16/2019	13.68	15	3.778	110.60	5.90	1106.00	7.87E+10	4.18E+10
9/25/2018	12.12	16	4.030	98.03	5.23	980.30	6.97E+10	3.71E+10
6/17/2019	11.78	17	4.282	95.21	5.08	952.11	6.77E+10	3.60E+10
3/30/2019	11.69	18	4.534	94.52	5.04	945.20	6.72E+10	3.58E+10
9/27/2018	11.49	19	4.786	92.90	4.95	929.01	6.61E+10	3.51E+10
9/10/2018	11.15	20	5.038	90.18	4.81	901.76	6.41E+10	3.41E+10
4/20/2019	11.03	21	5.290	89.20	4.76	892.00	6.34E+10	3.37E+10
6/18/2019	10.86	22	5.542	87.83	4.68	878.27	6.25E+10	3.32E+10
4/1/2019	10.77	23	5.793	87.05	4.64	870.49	6.19E+10	3.29E+10
2/12/2019	10.48	24	6.045	84.72	4.52	847.23	6.02E+10	3.20E+10
11/3/2018	10.31	25	6.297	83.32	4.44	833.20	5.93E+10	3.15E+10
8/27/2019	10.17	26	6.549	82.25	4.39	822.45	5.85E+10	3.11E+10
1/25/2019	10.09	27	6.801	81.60	4.35	815.97	5.80E+10	3.09E+10
3/15/2019	10.09	28	7.053	81.58	4.35	815.80	5.80E+10	3.09E+10
10/6/2018	10.08	29	7.305	81.51	4.35	815.14	5.80E+10	3.08E+10
12/2/2018	10.03	30	7.557	81.11	4.33	811.15	5.77E+10	3.07E+10
5/23/2019	10.00	31	7.809	80.81	4.31	808.14	5.75E+10	3.06E+10
12/31/2018	9.99	32	8.060	80.80	4.31	808.04	5.75E+10	3.06E+10
4/26/2019	9.94	33	8.312	80.33	4.28	803.32	5.71E+10	3.04E+10
3/11/2019	9.91	34	8.564	80.10	4.27	800.97	5.70E+10	3.03E+10
5/3/2019	9.87	35	8.816	79.80	4.26	798.04	5.68E+10	3.02E+10
4/15/2019	9.83	36	9.068	79.44	4.24	794.43	5.65E+10	3.01E+10
6/19/2019	9.70	37	9.320	78.39	4.18	783.85	5.57E+10	2.96E+10
5/1/2019	9.63	38	9.572	77.85	4.15	778.49	5.54E+10	2.94E+10
2/13/2019	9.53	39	9.824	77.03	4.11	770.26	5.48E+10	2.91E+10
6/21/2019	9.41	40	10.076	76.10	4.06	761.01	5.41E+10	2.88E+10
1/2/2019	9.37	41	10.327	75.75	4.04	757.52	5.39E+10	2.87E+10
4/18/2019	9.18	42	10.579	74.24	3.96	742.41	5.28E+10	2.81E+10
3/14/2019	9.18	43	10.831	74.21	3.96	742.08	5.28E+10	2.81E+10
9/28/2018	9.09	44	11.083	73.49	3.92	734.87	5.23E+10	2.78E+10
10/5/2018	9.09	45	11.335	73.47	3.92	734.71	5.22E+10	2.78E+10
4/14/2019	8.97	46	11.587	72.49	3.87	724.87	5.15E+10	2.74E+10
11/1/2018	8.92	47	11.839	72.13	3.85	721.32	5.13E+10	2.73E+10
9/11/2018	8.87	48	12.091	71.74	3.83	717.43	5.10E+10	2.71E+10
8/28/2019	8.85	49	12.343	71.55	3.82	715.51	5.09E+10	2.71E+10
2/9/2019	8.84	50	12.594	71.50	3.81	714.97	5.08E+10	2.70E+10

2/24/2019	8.82	51	12.846	71.33	3.80	713.32	5.07E+10	2.70E+10
5/4/2019	8.79	52	13.098	71.07	3.79	710.74	5.05E+10	2.69E+10
4/2/2019	8.79	53	13.350	71.04	3.79	710.41	5.05E+10	2.69E+10
4/21/2019	8.67	54	13.602	70.10	3.74	701.04	4.99E+10	2.65E+10
12/15/2018	8.67	55	13.854	70.09	3.74	700.86	4.98E+10	2.65E+10
5/24/2019	8.62	56	14.106	69.69	3.72	696.93	4.96E+10	2.64E+10
5/5/2019	8.59	57	14.358	69.45	3.70	694.53	4.94E+10	2.63E+10
1/26/2019	8.58	58	14.610	69.35	3.70	693.50	4.93E+10	2.62E+10
4/27/2019	8.57	59	14.861	69.31	3.70	693.08	4.93E+10	2.62E+10
11/4/2018	8.47	60	15.113	68.48	3.65	684.83	4.87E+10	2.59E+10
5/2/2019	8.43	61	15.365	68.13	3.63	681.33	4.85E+10	2.58E+10
5/26/2019	8.39	62	15.617	67.84	3.62	678.42	4.82E+10	2.57E+10
10/11/2018	8.32	63	15.869	67.25	3.59	672.54	4.78E+10	2.54E+10
3/12/2019	8.30	64	16.121	67.12	3.58	671.23	4.77E+10	2.54E+10
6/24/2019	8.27	65	16.373	66.84	3.56	668.36	4.75E+10	2.53E+10
2/15/2019	8.26	66	16.625	66.78	3.56	667.82	4.75E+10	2.53E+10
2/21/2019	8.25	67	16.877	66.69	3.56	666.85	4.74E+10	2.52E+10
5/22/2019	8.23	68	17.128	66.54	3.55	665.42	4.73E+10	2.52E+10
10/7/2018	8.14	69	17.380	65.77	3.51	657.72	4.68E+10	2.49E+10
2/4/2019	8.13	70	17.632	65.72	3.51	657.20	4.67E+10	2.49E+10
1/3/2019	8.11	71	17.884	65.58	3.50	655.83	4.66E+10	2.48E+10
2/25/2019	8.07	72	18.136	65.22	3.48	652.18	4.64E+10	2.47E+10
6/22/2019	8.06	73	18.388	65.17	3.48	651.73	4.63E+10	2.47E+10
12/3/2018	8.06	74	18.640	65.17	3.48	651.65	4.63E+10	2.46E+10
11/6/2018	8.03	75	18.892	64.96	3.46	649.62	4.62E+10	2.46E+10
4/16/2019	7.98	76	19.144	64.48	3.44	644.80	4.59E+10	2.44E+10
6/25/2019	7.97	77	19.395	64.47	3.44	644.70	4.58E+10	2.44E+10
4/28/2019	7.96	78	19.647	64.34	3.43	643.41	4.58E+10	2.43E+10
2/14/2019	7.93	79	19.899	64.11	3.42	641.07	4.56E+10	2.42E+10
1/19/2019	7.92	80	20.151	64.04	3.42	640.37	4.55E+10	2.42E+10
9/29/2018	7.90	81	20.403	63.84	3.40	638.43	4.54E+10	2.41E+10
5/27/2019	7.89	82	20.655	63.80	3.40	638.01	4.54E+10	2.41E+10
1/20/2019	7.88	83	20.907	63.70	3.40	637.03	4.53E+10	2.41E+10
7/7/2019	7.86	84	21.159	63.58	3.39	635.81	4.52E+10	2.41E+10
3/16/2019	7.85	85	21.411	63.46	3.38	634.62	4.51E+10	2.40E+10
11/5/2018	7.78	86	21.662	62.88	3.35	628.75	4.47E+10	2.38E+10
10/4/2018	7.74	87	21.914	62.60	3.34	625.99	4.45E+10	2.37E+10
4/3/2019	7.74	88	22.166	62.54	3.34	625.41	4.45E+10	2.37E+10
2/10/2019	7.73	89	22.418	62.49	3.33	624.86	4.44E+10	2.36E+10
2/3/2019	7.73	90	22.670	62.48	3.33	624.84	4.44E+10	2.36E+10
12/1/2018	7.72	91	22.922	62.40	3.33	624.02	4.44E+10	2.36E+10
11/7/2018	7.70	92	23.174	62.27	3.32	622.75	4.43E+10	2.36E+10
4/22/2019	7.69	93	23.426	62.17	3.32	621.68	4.42E+10	2.35E+10
12/16/2018	7.67	94	23.678	62.00	3.31	620.05	4.41E+10	2.35E+10
7/4/2019	7.66	95	23.929	61.94	3.30	619.36	4.40E+10	2.34E+10
9/12/2018	7.66	96	24.181	61.93	3.30	619.34	4.40E+10	2.34E+10
2/5/2019	7.63	97	24.433	61.69	3.29	616.86	4.39E+10	2.33E+10
3/13/2019	7.60	98	24.685	61.46	3.28	614.56	4.37E+10	2.32E+10
2/16/2019	7.56	99	24.937	61.16	3.26	611.62	4.35E+10	2.31E+10
5/6/2019	7.54	100	25.189	60.97	3.25	609.68	4.34E+10	2.31E+10
8/21/2018	7.50	101	25.441	60.64	3.23	606.40	4.31E+10	2.29E+10

2/22/2019	7.45	102	25.693	60.20	3.21	602.02	4.28E+10	2.28E+10
4/29/2019	7.43	103	25.945	60.08	3.20	600.79	4.27E+10	2.27E+10
1/4/2019	7.43	104	26.196	60.07	3.20	600.71	4.27E+10	2.27E+10
6/23/2019	7.43	105	26.448	60.05	3.20	600.51	4.27E+10	2.27E+10
6/6/2019	7.42	106	26.700	59.96	3.20	599.56	4.26E+10	2.27E+10
10/12/2018	7.40	107	26.952	59.81	3.19	598.13	4.25E+10	2.26E+10
5/25/2019	7.38	108	27.204	59.68	3.18	596.82	4.24E+10	2.26E+10
5/28/2019	7.37	109	27.456	59.61	3.18	596.12	4.24E+10	2.25E+10
10/8/2018	7.32	110	27.708	59.18	3.16	591.80	4.21E+10	2.24E+10
1/27/2019	7.32	111	27.960	59.18	3.16	591.79	4.21E+10	2.24E+10
1/21/2019	7.24	112	28.212	58.56	3.12	585.58	4.16E+10	2.21E+10
12/4/2018	7.24	113	28.463	58.51	3.12	585.07	4.16E+10	2.21E+10
4/23/2019	7.23	114	28.715	58.46	3.12	584.65	4.16E+10	2.21E+10
4/17/2019	7.21	115	28.967	58.27	3.11	582.73	4.14E+10	2.20E+10
2/11/2019	7.19	116	29.219	58.11	3.10	581.08	4.13E+10	2.20E+10
9/30/2018	7.19	117	29.471	58.11	3.10	581.06	4.13E+10	2.20E+10
3/17/2019	7.18	118	29.723	58.02	3.09	580.17	4.13E+10	2.19E+10
2/23/2019	7.17	119	29.975	58.01	3.09	580.05	4.12E+10	2.19E+10
4/30/2019	7.14	120	30.227	57.70	3.08	577.03	4.10E+10	2.18E+10
4/4/2019	7.12	121	30.479	57.53	3.07	575.25	4.09E+10	2.18E+10
11/8/2018	7.08	122	30.730	57.27	3.05	572.69	4.07E+10	2.17E+10
1/5/2019	7.08	123	30.982	57.22	3.05	572.23	4.07E+10	2.16E+10
6/26/2019	7.06	124	31.234	57.11	3.05	571.12	4.06E+10	2.16E+10
1/22/2019	7.06	125	31.486	57.06	3.04	570.59	4.06E+10	2.16E+10
5/17/2019	7.06	126	31.738	57.05	3.04	570.54	4.06E+10	2.16E+10
2/17/2019	7.05	127	31.990	57.02	3.04	570.23	4.06E+10	2.16E+10
12/17/2018	7.03	128	32.242	56.88	3.03	568.76	4.04E+10	2.15E+10
10/10/2018	7.01	129	32.494	56.71	3.02	567.09	4.03E+10	2.15E+10
2/26/2019	7.01	130	32.746	56.66	3.02	566.65	4.03E+10	2.14E+10
5/7/2019	7.00	131	32.997	56.56	3.02	565.64	4.02E+10	2.14E+10
12/28/2018	6.95	132	33.249	56.17	3.00	561.69	3.99E+10	2.12E+10
6/1/2019	6.94	133	33.501	56.07	2.99	560.72	3.99E+10	2.12E+10
8/26/2018	6.92	134	33.753	55.97	2.98	559.65	3.98E+10	2.12E+10
9/13/2018	6.91	135	34.005	55.85	2.98	558.48	3.97E+10	2.11E+10
5/29/2019	6.90	136	34.257	55.77	2.97	557.70	3.97E+10	2.11E+10
5/12/2019	6.90	137	34.509	55.75	2.97	557.49	3.96E+10	2.11E+10
10/13/2018	6.88	138	34.761	55.63	2.97	556.31	3.96E+10	2.10E+10
12/5/2018	6.88	139	35.013	55.60	2.97	556.04	3.95E+10	2.10E+10
4/5/2019	6.88	140	35.264	55.60	2.97	555.98	3.95E+10	2.10E+10
10/9/2018	6.85	141	35.516	55.42	2.96	554.21	3.94E+10	2.10E+10
1/29/2019	6.85	142	35.768	55.41	2.96	554.12	3.94E+10	2.10E+10
1/28/2019	6.85	143	36.020	55.35	2.95	553.46	3.94E+10	2.09E+10
2/1/2019	6.85	144	36.272	55.35	2.95	553.46	3.94E+10	2.09E+10
4/24/2019	6.84	145	36.524	55.31	2.95	553.14	3.93E+10	2.09E+10
5/31/2019	6.84	146	36.776	55.27	2.95	552.72	3.93E+10	2.09E+10
5/13/2019	6.83	147	37.028	55.20	2.94	552.01	3.93E+10	2.09E+10
3/18/2019	6.82	148	37.280	55.14	2.94	551.39	3.92E+10	2.09E+10
1/31/2019	6.81	149	37.531	55.02	2.93	550.24	3.91E+10	2.08E+10
11/9/2018	6.80	150	37.783	54.99	2.93	549.94	3.91E+10	2.08E+10
12/29/2018	6.78	151	38.035	54.82	2.92	548.18	3.90E+10	2.07E+10
1/30/2019	6.77	152	38.287	54.77	2.92	547.66	3.89E+10	2.07E+10

7/17/2019	6.76	153	38.539	54.68	2.92	546.75	3.89E+10	2.07E+10
7/5/2019	6.74	154	38.791	54.51	2.91	545.12	3.88E+10	2.06E+10
4/9/2019	6.74	155	39.043	54.50	2.91	545.00	3.88E+10	2.06E+10
8/29/2019	6.72	156	39.295	54.36	2.90	543.59	3.87E+10	2.06E+10
10/1/2018	6.72	157	39.547	54.33	2.90	543.28	3.86E+10	2.06E+10
2/27/2019	6.71	158	39.798	54.26	2.89	542.62	3.86E+10	2.05E+10
2/18/2019	6.69	159	40.050	54.10	2.89	540.99	3.85E+10	2.05E+10
4/25/2019	6.67	160	40.302	53.91	2.88	539.07	3.83E+10	2.04E+10
1/6/2019	6.66	161	40.554	53.87	2.87	538.69	3.83E+10	2.04E+10
6/27/2019	6.66	162	40.806	53.81	2.87	538.10	3.83E+10	2.04E+10
12/18/2018	6.65	163	41.058	53.79	2.87	537.86	3.82E+10	2.03E+10
5/8/2019	6.65	164	41.310	53.78	2.87	537.82	3.82E+10	2.03E+10
12/6/2018	6.65	165	41.562	53.76	2.87	537.63	3.82E+10	2.03E+10
7/8/2019	6.63	166	41.814	53.64	2.86	536.43	3.81E+10	2.03E+10
5/30/2019	6.63	167	42.065	53.59	2.86	535.87	3.81E+10	2.03E+10
5/18/2019	6.62	168	42.317	53.49	2.85	534.90	3.80E+10	2.02E+10
2/20/2019	6.61	169	42.569	53.48	2.85	534.78	3.80E+10	2.02E+10
4/6/2019	6.61	170	42.821	53.43	2.85	534.33	3.80E+10	2.02E+10
3/9/2019	6.60	171	43.073	53.33	2.84	533.28	3.79E+10	2.02E+10
11/10/2018	6.59	172	43.325	53.28	2.84	532.82	3.79E+10	2.02E+10
5/14/2019	6.57	173	43.577	53.08	2.83	530.83	3.77E+10	2.01E+10
4/8/2019	6.56	174	43.829	53.02	2.83	530.20	3.77E+10	2.01E+10
5/9/2019	6.55	175	44.081	52.95	2.82	529.52	3.77E+10	2.00E+10
1/18/2019	6.55	176	44.332	52.93	2.82	529.29	3.76E+10	2.00E+10
4/13/2019	6.55	177	44.584	52.92	2.82	529.23	3.76E+10	2.00E+10
3/19/2019	6.54	178	44.836	52.90	2.82	528.97	3.76E+10	2.00E+10
10/14/2018	6.54	179	45.088	52.89	2.82	528.93	3.76E+10	2.00E+10
2/28/2019	6.53	180	45.340	52.80	2.82	528.00	3.75E+10	2.00E+10
8/19/2019	6.53	181	45.592	52.79	2.82	527.90	3.75E+10	2.00E+10
5/10/2019	6.49	182	45.844	52.45	2.80	524.50	3.73E+10	1.98E+10
10/3/2018	6.48	183	46.096	52.39	2.79	523.89	3.73E+10	1.98E+10
5/20/2019	6.48	184	46.348	52.36	2.79	523.61	3.72E+10	1.98E+10
6/2/2019	6.48	185	46.599	52.36	2.79	523.57	3.72E+10	1.98E+10
2/2/2019	6.46	186	46.851	52.24	2.79	522.42	3.72E+10	1.98E+10
12/19/2018	6.45	187	47.103	52.12	2.78	521.19	3.71E+10	1.97E+10
1/7/2019	6.44	188	47.355	52.08	2.78	520.83	3.70E+10	1.97E+10
12/14/2018	6.44	189	47.607	52.05	2.78	520.52	3.70E+10	1.97E+10
3/21/2019	6.43	190	47.859	51.98	2.77	519.84	3.70E+10	1.97E+10
12/7/2018	6.43	191	48.111	51.96	2.77	519.60	3.69E+10	1.97E+10
4/10/2019	6.42	192	48.363	51.94	2.77	519.36	3.69E+10	1.96E+10
4/7/2019	6.42	193	48.615	51.89	2.77	518.91	3.69E+10	1.96E+10
10/2/2018	6.42	194	48.866	51.88	2.77	518.79	3.69E+10	1.96E+10
6/28/2019	6.41	195	49.118	51.85	2.77	518.49	3.69E+10	1.96E+10
3/20/2019	6.41	196	49.370	51.83	2.76	518.29	3.69E+10	1.96E+10
5/15/2019	6.41	197	49.622	51.81	2.76	518.15	3.68E+10	1.96E+10
6/7/2019	6.39	198	49.874	51.66	2.76	516.63	3.67E+10	1.95E+10
1/8/2019	6.39	199	50.126	51.66	2.76	516.61	3.67E+10	1.95E+10
12/30/2018	6.38	200	50.378	51.61	2.75	516.07	3.67E+10	1.95E+10
2/19/2019	6.38	201	50.630	51.56	2.75	515.59	3.67E+10	1.95E+10
9/14/2018	6.37	202	50.882	51.53	2.75	515.26	3.66E+10	1.95E+10
3/1/2019	6.35	203	51.134	51.38	2.74	513.79	3.65E+10	1.94E+10

5/19/2019	6.35	204	51.385	51.37	2.74	513.71	3.65E+10	1.94E+10
10/15/2018	6.35	205	51.637	51.33	2.74	513.35	3.65E+10	1.94E+10
11/11/2018	6.34	206	51.889	51.23	2.73	512.32	3.64E+10	1.94E+10
11/27/2018	6.34	207	52.141	51.23	2.73	512.28	3.64E+10	1.94E+10
12/20/2018	6.33	208	52.393	51.21	2.73	512.10	3.64E+10	1.94E+10
7/6/2019	6.33	209	52.645	51.15	2.73	511.49	3.64E+10	1.93E+10
4/12/2019	6.32	210	52.897	51.12	2.73	511.17	3.64E+10	1.93E+10
5/11/2019	6.32	211	53.149	51.09	2.72	510.93	3.63E+10	1.93E+10
8/22/2018	6.31	212	53.401	50.98	2.72	509.76	3.63E+10	1.93E+10
3/22/2019	6.30	213	53.652	50.96	2.72	509.64	3.62E+10	1.93E+10
12/10/2018	6.28	214	53.904	50.80	2.71	507.99	3.61E+10	1.92E+10
3/29/2019	6.28	215	54.156	50.79	2.71	507.93	3.61E+10	1.92E+10
12/21/2018	6.26	216	54.408	50.65	2.70	506.45	3.60E+10	1.92E+10
1/9/2019	6.24	217	54.660	50.46	2.69	504.56	3.59E+10	1.91E+10
5/16/2019	6.24	218	54.912	50.45	2.69	504.48	3.59E+10	1.91E+10
12/11/2018	6.24	219	55.164	50.44	2.69	504.44	3.59E+10	1.91E+10
3/2/2019	6.23	220	55.416	50.34	2.68	503.41	3.58E+10	1.90E+10
5/21/2019	6.23	221	55.668	50.33	2.68	503.35	3.58E+10	1.90E+10
11/28/2018	6.22	222	55.919	50.27	2.68	502.75	3.58E+10	1.90E+10
8/25/2018	6.21	223	56.171	50.23	2.68	502.34	3.57E+10	1.90E+10
6/29/2019	6.21	224	56.423	50.22	2.68	502.22	3.57E+10	1.90E+10
12/8/2018	6.21	225	56.675	50.19	2.68	501.86	3.57E+10	1.90E+10
6/15/2019	6.21	226	56.927	50.17	2.68	501.72	3.57E+10	1.90E+10
11/12/2018	6.20	227	57.179	50.16	2.68	501.58	3.57E+10	1.90E+10
7/18/2019	6.18	228	57.431	49.99	2.67	499.86	3.55E+10	1.89E+10
3/3/2019	6.16	229	57.683	49.79	2.66	497.95	3.54E+10	1.88E+10
6/3/2019	6.16	230	57.935	49.78	2.65	497.77	3.54E+10	1.88E+10
12/9/2018	6.16	231	58.186	49.77	2.65	497.67	3.54E+10	1.88E+10
4/11/2019	6.15	232	58.438	49.73	2.65	497.30	3.54E+10	1.88E+10
3/23/2019	6.13	233	58.690	49.57	2.64	495.67	3.52E+10	1.87E+10
10/16/2018	6.13	234	58.942	49.54	2.64	495.43	3.52E+10	1.87E+10
11/13/2018	6.09	235	59.194	49.24	2.63	492.36	3.50E+10	1.86E+10
3/25/2019	6.07	236	59.446	49.05	2.62	490.55	3.49E+10	1.86E+10
12/22/2018	6.05	237	59.698	48.89	2.61	488.88	3.48E+10	1.85E+10
1/10/2019	6.04	238	59.950	48.82	2.60	488.19	3.47E+10	1.85E+10
7/9/2019	6.03	239	60.202	48.77	2.60	487.69	3.47E+10	1.84E+10
6/30/2019	6.03	240	60.453	48.74	2.60	487.38	3.47E+10	1.84E+10
3/24/2019	6.03	241	60.705	48.74	2.60	487.36	3.47E+10	1.84E+10
11/29/2018	6.01	242	60.957	48.63	2.59	486.28	3.46E+10	1.84E+10
10/17/2018	6.00	243	61.209	48.48	2.59	484.76	3.45E+10	1.83E+10
3/26/2019	6.00	244	61.461	48.47	2.59	484.74	3.45E+10	1.83E+10
3/4/2019	6.00	245	61.713	48.47	2.59	484.72	3.45E+10	1.83E+10
11/16/2018	5.99	246	61.965	48.45	2.58	484.54	3.45E+10	1.83E+10
3/6/2019	5.99	247	62.217	48.41	2.58	484.12	3.44E+10	1.83E+10
6/4/2019	5.98	248	62.469	48.38	2.58	483.82	3.44E+10	1.83E+10
3/5/2019	5.97	249	62.720	48.30	2.58	483.01	3.43E+10	1.83E+10
6/5/2019	5.97	250	62.972	48.25	2.57	482.51	3.43E+10	1.83E+10
9/15/2018	5.96	251	63.224	48.19	2.57	481.94	3.43E+10	1.82E+10
11/26/2018	5.95	252	63.476	48.12	2.57	481.20	3.42E+10	1.82E+10
1/12/2019	5.94	253	63.728	48.05	2.56	480.49	3.42E+10	1.82E+10
6/8/2019	5.94	254	63.980	48.02	2.56	480.17	3.41E+10	1.82E+10

11/15/2018	5.93	255	64.232	47.96	2.56	479.64	3.41E+10	1.81E+10
1/11/2019	5.93	256	64.484	47.94	2.56	479.38	3.41E+10	1.81E+10
11/14/2018	5.93	257	64.736	47.94	2.56	479.38	3.41E+10	1.81E+10
11/30/2018	5.92	258	64.987	47.88	2.55	478.84	3.41E+10	1.81E+10
11/17/2018	5.90	259	65.239	47.74	2.55	477.39	3.39E+10	1.81E+10
8/22/2019	5.90	260	65.491	47.72	2.55	477.20	3.39E+10	1.81E+10
1/13/2019	5.89	261	65.743	47.64	2.54	476.42	3.39E+10	1.80E+10
7/1/2019	5.89	262	65.995	47.62	2.54	476.24	3.39E+10	1.80E+10
12/13/2018	5.89	263	66.247	47.62	2.54	476.24	3.39E+10	1.80E+10
12/23/2018	5.88	264	66.499	47.51	2.53	475.13	3.38E+10	1.80E+10
12/12/2018	5.88	265	66.751	47.51	2.53	475.09	3.38E+10	1.80E+10
7/22/2019	5.87	266	67.003	47.49	2.53	474.95	3.38E+10	1.80E+10
7/11/2019	5.85	267	67.254	47.33	2.52	473.25	3.37E+10	1.79E+10
3/28/2019	5.85	268	67.506	47.32	2.52	473.17	3.36E+10	1.79E+10
3/27/2019	5.84	269	67.758	47.24	2.52	472.39	3.36E+10	1.79E+10
8/21/2019	5.84	270	68.010	47.19	2.52	471.86	3.36E+10	1.78E+10
6/9/2019	5.82	271	68.262	47.07	2.51	470.69	3.35E+10	1.78E+10
10/18/2018	5.81	272	68.514	46.98	2.51	469.77	3.34E+10	1.78E+10
11/20/2018	5.81	273	68.766	46.97	2.51	469.71	3.34E+10	1.78E+10
11/19/2018	5.81	274	69.018	46.95	2.50	469.50	3.34E+10	1.78E+10
11/18/2018	5.80	275	69.270	46.86	2.50	468.62	3.33E+10	1.77E+10
7/12/2019	5.79	276	69.521	46.85	2.50	468.50	3.33E+10	1.77E+10
11/25/2018	5.79	277	69.773	46.82	2.50	468.21	3.33E+10	1.77E+10
12/24/2018	5.78	278	70.025	46.73	2.49	467.29	3.32E+10	1.77E+10
3/7/2019	5.78	279	70.277	46.71	2.49	467.07	3.32E+10	1.77E+10
8/30/2019	5.76	280	70.529	46.58	2.48	465.82	3.31E+10	1.76E+10
7/2/2019	5.74	281	70.781	46.45	2.48	464.46	3.30E+10	1.76E+10
1/17/2019	5.73	282	71.033	46.35	2.47	463.50	3.30E+10	1.75E+10
6/10/2019	5.73	283	71.285	46.30	2.47	463.01	3.29E+10	1.75E+10
1/14/2019	5.72	284	71.537	46.29	2.47	462.86	3.29E+10	1.75E+10
11/21/2018	5.72	285	71.788	46.28	2.47	462.81	3.29E+10	1.75E+10
10/19/2018	5.72	286	72.040	46.23	2.47	462.27	3.29E+10	1.75E+10
3/8/2019	5.72	287	72.292	46.22	2.47	462.23	3.29E+10	1.75E+10
10/20/2018	5.71	288	72.544	46.19	2.46	461.94	3.29E+10	1.75E+10
7/10/2019	5.71	289	72.796	46.18	2.46	461.84	3.28E+10	1.75E+10
11/24/2018	5.70	290	73.048	46.11	2.46	461.06	3.28E+10	1.74E+10
12/25/2018	5.70	291	73.300	46.10	2.46	461.04	3.28E+10	1.74E+10
8/27/2018	5.68	292	73.552	45.94	2.45	459.38	3.27E+10	1.74E+10
12/27/2018	5.67	293	73.804	45.85	2.45	458.50	3.26E+10	1.73E+10
11/22/2018	5.65	294	74.055	45.71	2.44	457.09	3.25E+10	1.73E+10
9/16/2018	5.65	295	74.307	45.67	2.44	456.68	3.25E+10	1.73E+10
1/16/2019	5.64	296	74.559	45.59	2.43	455.89	3.24E+10	1.72E+10
12/26/2018	5.63	297	74.811	45.55	2.43	455.51	3.24E+10	1.72E+10
1/15/2019	5.62	298	75.063	45.48	2.43	454.77	3.23E+10	1.72E+10
7/3/2019	5.60	299	75.315	45.32	2.42	453.16	3.22E+10	1.71E+10
8/23/2019	5.60	300	75.567	45.27	2.41	452.69	3.22E+10	1.71E+10
11/23/2018	5.60	301	75.819	45.24	2.41	452.41	3.22E+10	1.71E+10
6/11/2019	5.59	302	76.071	45.16	2.41	451.62	3.21E+10	1.71E+10
7/19/2019	5.55	303	76.322	44.91	2.40	449.06	3.19E+10	1.70E+10
10/21/2018	5.50	304	76.574	44.46	2.37	444.63	3.16E+10	1.68E+10
8/20/2019	5.50	305	76.826	44.46	2.37	444.61	3.16E+10	1.68E+10

7/23/2019	5.49	306	77.078	44.41	2.37	444.13	3.16E+10	1.68E+10
6/13/2019	5.49	307	77.330	44.36	2.37	443.62	3.15E+10	1.68E+10
6/12/2019	5.47	308	77.582	44.21	2.36	442.11	3.14E+10	1.67E+10
10/27/2018	5.44	309	77.834	43.98	2.35	439.81	3.13E+10	1.66E+10
7/16/2019	5.42	310	78.086	43.85	2.34	438.52	3.12E+10	1.66E+10
9/17/2018	5.42	311	78.338	43.83	2.34	438.32	3.12E+10	1.66E+10
7/13/2019	5.40	312	78.589	43.66	2.33	436.59	3.10E+10	1.65E+10
10/23/2018	5.40	313	78.841	43.65	2.33	436.51	3.10E+10	1.65E+10
10/22/2018	5.39	314	79.093	43.57	2.32	435.70	3.10E+10	1.65E+10
6/14/2019	5.34	315	79.345	43.18	2.30	431.77	3.07E+10	1.63E+10
10/26/2018	5.33	316	79.597	43.13	2.30	431.28	3.07E+10	1.63E+10
10/24/2018	5.32	317	79.849	42.99	2.29	429.87	3.06E+10	1.63E+10
10/28/2018	5.29	318	80.101	42.81	2.28	428.06	3.04E+10	1.62E+10
9/18/2018	5.24	319	80.353	42.34	2.26	423.36	3.01E+10	1.60E+10
10/25/2018	5.24	320	80.605	42.33	2.26	423.32	3.01E+10	1.60E+10
7/20/2019	5.21	321	80.856	42.09	2.24	420.90	2.99E+10	1.59E+10
7/14/2019	5.20	322	81.108	42.01	2.24	420.10	2.99E+10	1.59E+10
8/31/2019	5.16	323	81.360	41.74	2.23	417.36	2.97E+10	1.58E+10
10/29/2018	5.16	324	81.612	41.71	2.22	417.11	2.97E+10	1.58E+10
8/23/2018	5.14	325	81.864	41.57	2.22	415.66	2.96E+10	1.57E+10
10/30/2018	5.08	326	82.116	41.07	2.19	410.66	2.92E+10	1.55E+10
10/31/2018	5.06	327	82.368	40.89	2.18	408.93	2.91E+10	1.55E+10
9/19/2018	5.05	328	82.620	40.82	2.18	408.20	2.90E+10	1.54E+10
7/21/2019	5.04	329	82.872	40.74	2.17	407.38	2.90E+10	1.54E+10
7/15/2019	5.04	330	83.123	40.72	2.17	407.22	2.90E+10	1.54E+10
7/24/2019	4.97	331	83.375	40.18	2.14	401.76	2.86E+10	1.52E+10
8/28/2018	4.96	332	83.627	40.13	2.14	401.35	2.85E+10	1.52E+10
8/24/2019	4.96	333	83.879	40.11	2.14	401.07	2.85E+10	1.52E+10
9/20/2018	4.92	334	84.131	39.74	2.12	397.40	2.83E+10	1.50E+10
9/7/2018	4.83	335	84.383	39.04	2.08	390.40	2.78E+10	1.48E+10
9/21/2018	4.80	336	84.635	38.83	2.07	388.35	2.76E+10	1.47E+10
9/22/2018	4.79	337	84.887	38.72	2.06	387.18	2.75E+10	1.46E+10
7/25/2019	4.70	338	85.139	37.97	2.03	379.70	2.70E+10	1.44E+10
8/29/2018	4.67	339	85.390	37.78	2.02	377.85	2.69E+10	1.43E+10
9/23/2018	4.64	340	85.642	37.50	2.00	375.04	2.67E+10	1.42E+10
8/24/2018	4.60	341	85.894	37.19	1.98	371.94	2.64E+10	1.41E+10
9/24/2018	4.60	342	86.146	37.19	1.98	371.94	2.64E+10	1.41E+10
8/30/2018	4.58	343	86.398	37.03	1.97	370.31	2.63E+10	1.40E+10
8/8/2018	4.54	344	86.650	36.70	1.96	366.96	2.61E+10	1.39E+10
7/26/2019	4.53	345	86.902	36.65	1.95	366.48	2.61E+10	1.39E+10
8/25/2019	4.50	346	87.154	36.41	1.94	364.12	2.59E+10	1.38E+10
7/27/2019	4.40	347	87.406	35.61	1.90	356.07	2.53E+10	1.35E+10
8/26/2019	4.39	348	87.657	35.49	1.89	354.93	2.52E+10	1.34E+10
8/31/2018	4.38	349	87.909	35.42	1.89	354.18	2.52E+10	1.34E+10
8/18/2019	4.38	350	88.161	35.40	1.89	354.04	2.52E+10	1.34E+10
7/28/2019	4.32	351	88.413	34.90	1.86	348.96	2.48E+10	1.32E+10
7/29/2019	4.25	352	88.665	34.40	1.83	343.98	2.45E+10	1.30E+10
8/9/2018	4.25	353	88.917	34.33	1.83	343.33	2.44E+10	1.30E+10
8/20/2018	4.23	354	89.169	34.16	1.82	341.62	2.43E+10	1.29E+10
7/30/2019	4.21	355	89.421	34.06	1.82	340.63	2.42E+10	1.29E+10
9/1/2018	4.18	356	89.673	33.79	1.80	337.91	2.40E+10	1.28E+10

7/31/2019	4.15	357	89.924	33.57	1.79	335.69	2.39E+10	1.27E+10
8/1/2019	4.07	358	90.176	32.94	1.76	329.36	2.34E+10	1.25E+10
9/2/2018	4.06	359	90.428	32.84	1.75	328.36	2.34E+10	1.24E+10
8/1/2018	4.03	360	90.680	32.62	1.74	326.21	2.32E+10	1.23E+10
8/2/2019	4.00	361	90.932	32.36	1.73	323.56	2.30E+10	1.22E+10
8/18/2018	4.00	362	91.184	32.35	1.73	323.54	2.30E+10	1.22E+10
9/3/2018	3.97	363	91.436	32.07	1.71	320.68	2.28E+10	1.21E+10
8/3/2019	3.94	364	91.688	31.87	1.70	318.70	2.27E+10	1.21E+10
8/10/2018	3.93	365	91.940	31.77	1.69	317.69	2.26E+10	1.20E+10
8/11/2018	3.91	366	92.191	31.64	1.69	316.38	2.25E+10	1.20E+10
9/4/2018	3.90	367	92.443	31.53	1.68	315.25	2.24E+10	1.19E+10
9/5/2018	3.89	368	92.695	31.47	1.68	314.71	2.24E+10	1.19E+10
8/4/2019	3.88	369	92.947	31.38	1.67	313.84	2.23E+10	1.19E+10
8/9/2019	3.88	370	93.199	31.38	1.67	313.78	2.23E+10	1.19E+10
8/2/2018	3.88	371	93.451	31.37	1.67	313.68	2.23E+10	1.19E+10
8/17/2018	3.86	372	93.703	31.17	1.66	311.71	2.22E+10	1.18E+10
8/19/2018	3.86	373	93.955	31.17	1.66	311.69	2.22E+10	1.18E+10
8/5/2019	3.83	374	94.207	30.98	1.65	309.83	2.20E+10	1.17E+10
8/6/2019	3.83	375	94.458	30.98	1.65	309.81	2.20E+10	1.17E+10
8/8/2019	3.82	376	94.710	30.88	1.65	308.84	2.20E+10	1.17E+10
8/7/2018	3.81	377	94.962	30.80	1.64	307.96	2.19E+10	1.16E+10
8/7/2019	3.79	378	95.214	30.67	1.64	306.65	2.18E+10	1.16E+10
9/6/2018	3.77	379	95.466	30.52	1.63	305.15	2.17E+10	1.15E+10
8/10/2019	3.76	380	95.718	30.43	1.62	304.27	2.16E+10	1.15E+10
8/3/2018	3.75	381	95.970	30.33	1.62	303.32	2.16E+10	1.15E+10
8/17/2019	3.75	382	96.222	30.30	1.62	302.98	2.15E+10	1.15E+10
8/11/2019	3.74	383	96.474	30.21	1.61	302.07	2.15E+10	1.14E+10
8/12/2019	3.71	384	96.725	30.00	1.60	300.03	2.13E+10	1.13E+10
8/13/2019	3.71	385	96.977	29.96	1.60	299.59	2.13E+10	1.13E+10
8/12/2018	3.70	386	97.229	29.89	1.59	298.93	2.13E+10	1.13E+10
8/16/2019	3.68	387	97.481	29.74	1.59	297.35	2.11E+10	1.12E+10
8/4/2018	3.67	388	97.733	29.71	1.58	297.05	2.11E+10	1.12E+10
8/14/2019	3.67	389	97.985	29.70	1.58	297.03	2.11E+10	1.12E+10
8/15/2019	3.67	390	98.237	29.65	1.58	296.53	2.11E+10	1.12E+10
8/5/2018	3.62	391	98.489	29.25	1.56	292.52	2.08E+10	1.11E+10
8/13/2018	3.60	392	98.741	29.07	1.55	290.66	2.07E+10	1.10E+10
8/6/2018	3.54	393	98.992	28.61	1.53	286.08	2.03E+10	1.08E+10
8/14/2018	3.54	394	99.244	28.60	1.53	285.96	2.03E+10	1.08E+10
8/16/2018	3.52	395	99.496	28.49	1.52	284.86	2.03E+10	1.08E+10
8/15/2018	3.52	396	99.748	28.47	1.52	284.73	2.02E+10	1.08E+10
	396							
				1.50	0.08	15.00	2.35E+02	1.25E+02
				5.39	5.39	5.39	2.45E+07	2.45E+07

Date	Flow	NO3_N (mg/L)	TP (mg/L)	TSS (mg/L)	Ecoli (col/100 mL)	% Flow Exceed
31-Aug-18	24.0	1.1	0.16	10	147	87.9
9/19/2018	5.048896				70	82.6
4-Oct-18	290.0	1.8	0.13	23	412	21.9
23-Oct-18	120.0	1.6	0.16	3	50	78.8
1-Nov-18	8.921711	3.8	0.353	128	24	11.8
1-Dec-18	7.718204	3.8	0.134	62	370	22.9
1-Jan-19	13.69635	3.8	0.104	53	62	3.5
1-Feb-19	6.845555	3.8	0.102	11	340	36.3
1-Mar-19	6.354877	3.4	0.079	10	22	51.1
1-Apr-19	10.76674	3.1	0.078	5	5500	5.8
4/11/2019	240.0	2.8	0.08	9	150	58.4
4/25/2019	300.0	3.4	0.08	11	148	40.3
5/9/2019	400.0	4.1	0.1	2	128	44.1
5/23/2019	800.0	3.6	0.21		695	7.8
6/6/2019	7.415769				49	26.7
6/20/2019	2560	1.5	0.02	583	4050	3.3
7/5/2019	6.742333				276	38.8
7/18/2019	205	1.4	0.07	37	398	57.4
8/1/2019	4.073773				50	90.2
8/15/2019	67	1.2	0.08	37	168	98.2
8/30/19						
Conversion Factor		5.39	5.39	5.39	2.45E+07	

NO3 Act Load	TP Act Load	TSS Act Load	Ecoli Act Load	Ann Load Proxy F
142.296	20.6976	1293.6	8.63E+10	19
0	0	0	8.65E+09	15
2813.58	203.203	35951.3	2.92E+12	19
1034.88	103.488	1940.4	1.47E+11	9
182.7344847	16.9750719	6155.266852	5.24E+09	30
158.0842497	5.57454986	2579.269337	6.99E+10	31
280.5285595	7.67762373	3912.635172	2.08E+10	31
140.210659	3.76354927	405.8729602	5.69E+10	28
116.4594791	2.70597025	342.5278797	3.42E+09	31
179.9014533	4.5265527	290.1636344	1.45E+12	10
3622.08	103.488	11642.4	8.81E+11	14
5497.8	129.36	17787	1.09E+12	14
8839.6	215.6	4312	1.25E+12	14
15523.2	905.52	0	1.36E+13	14
0	0	0	8.89E+09	14
20697.6	275.968	8044467.2	2.54E+14	15
0	0	0	4.55E+10	13
1546.93	77.3465	40883.15	2.00E+12	14
0	0	0	4.98E+09	14
433.356	28.8904	13361.81	2.75E+11	15

Range	NO3 Ann Load	TP Ann Load	TSS Ann Load	Ecoli Ann Load
	2703.624	393.2544	24578.4	1.64E+12
	0	0	0	1.30E+11
	95661.72	6908.902	1222344.2	5.55402E+13
	35185.92	3518.592	65973.6	2.7891E+12
	6212.972478	577.1524434	209279.073	99534050160
	5374.86449	189.5346952	87695.15747	1.32749E+12
	9537.971024	261.039207	133029.5959	3.94738E+11
	4767.162406	127.9606751	13799.68065	1.08193E+12
	3959.622289	92.00298848	11645.94791	64989339852
	6116.649413	153.9027917	9865.56357	2.7527E+13
	50709.12	1448.832	162993.6	1.23E+13
	76969.2	1811.04	249018	1.52E+13
	123754.4	3018.4	60368	1.75E+13
	217324.8	12677.28	0	1.90E+14
	0	0	0	1.24E+11
	600230.4	8003.072	233289548.8	3.80E+15
	0	0	0	5.92E+11
	41767.11	2088.3555	1103845.05	2.79E+13
	0	0	0	6.98E+10
	12567.324	837.8216	387492.49	4.13E+12
TOTAL	1292842.86	42107.1423	237031477.2	4.16E+15
TARGET	21,923.8	1,169.3	219,237.9	1.56E+13