VFC Index - Watershed (Plan)

Program: Watershed

IDEM Document Type: Plan

Document Date: 10/28/2015

Security Group: Public

Project Name: Big Pine Creek

Plan Type: Watershed Management Plan

HUC Code: 05120108 Middle Wabash-Little Vermilion

Sponsor: The Nature Conservancy

Contract #:

County: Benton

Cross Reference ID:

Comments: Warren, White, Tippecanoe

Additional WMP Information

Checklist: 2009 Checklist

Grant type: private

Fiscal Year:

IDEM Approval Date: 10/28/2015

EPA Approval Date: 10/28/15

Project Manager: Leanne Whitesell

Big Pine Creek
and Mud Pine Creek
Watershed Management Plan

HUC 0512010803 and 0512010804

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ACKNOWLEDGEMENTS

This plan was prepared by the Indiana Chapter of The Nature Conservancy (the "Conservancy"), with guidance from the Big Pine Steering Committee. Funding was generously provided by the Nina Mason Pulliam Charitable Trust. Principal staff members contributing to the project were Angela Sturdevant, Kent Wamsley, Matt Williams and John Shuey. The Conservancy gratefully acknowledges Fiona Becker and Science and Stewardship intern, Kelley Pinnick, for their help creating maps and conducting GIS analysis. The following individuals were part of the initial advisory committee which guided the development of the project and were instrumental in the formation of the steering committee: Sara Peel, Wabash River Enhancement Corporation; Chad Watts and Karen Scanlon, Conservation Technology Information Center; and Gus Nyberg, NICHES Land Trust. Sara Peel facilitated the planning process and provided invaluable advice for the development of this watershed management plan. In addition, we appreciate the guidance of Leanne Whitesell, watershed specialist with the Indiana Department of Environmental Management.

The Soil and Water Conservation District staff from Benton, Warren and White counties, Jon Charlesworth, Debra Lane, and Sharon Watson, have been active members of the steering committee and over the course of two years have successfully taken on leadership of the watershed management planning process and implementation of BMPs going forward.

We would like to thank all those community members and conservation professionals who have participated in the planning process, providing valuable input for the development of this watershed management plan and dedicating time and resources to implementing the recommendations in the plan. With their dedication to this work, the steering committee is confident that the plan will be successfully implemented, resulting in improved water quality and quality of life in the Big Pine Watershed.

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ac	acre
APC	Area Plan Commission
BFE	Base Flood Elevation
BMP	Best Management Practice
CAFO	Confined Animal Feeding Operation
CFO	Confined Feeding Operation
cfs	cubic feet per second
CR	County Road
CSO	Combined Sewer Overflow
CTIC	Conservation Technology Information Center
CWP	Center for Watershed Protection
D/S	downstream
E. coli	Escherichia coli
FCA	Fish Consumption Advisory
FEMA	Federal Emergency Management Agency
FIRMS	Flood Insurance Rate Maps
FNR	Fisheries and Natural Resources
GIS	Geographic Information Systems
HES	Highly Erodible Soil
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
ISDH	Indiana State Department of Health
IWF	Indiana Wildlife Federation
IWMA	Integrated Water Monitoring Assessment
lb	pound
lb/yr	pound per year
LEED	Leadership in Environment and Energy Design
LID	Low Impact Development
L-THIA	Long-Term Hydrologic Impact Assessment
LUST	Leaking Underground Storage Tank
MCM	Minimum Control Measure
mg/L	milligram per liter
MGD	Million Gallons Per Day
mIBI	macroinvertebrate Index of Biotic Integrity
MS4	Municipal Separate Storm Sewer System
msl	mean sea level
NASS	National Agricultural Statistics Service
NICHES	Northern Indiana Citizens Helping Ecosystems Survive
NO3	Nitrate-nitrogen

NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory
PCB	Polychlorinated Biphenyls
PHES	Potentially Highly Erodible Soils
PTI	Pollution Tolerance Index
QHEI	Qualitative Habitat Evaluation Index
RC&D	Resource Conservation and Development
RM	River Mile
SRCER	Stream Reach Characterization Evaluation Report
SWCD	Soil and Water Conservation District
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TP	Total Phosphorus
TSS	Total Suspended Solid
U/S	Upstream
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
UZO	Unified Zoning Ordinance
WMP	Watershed Management Plan
WQI	Water Quality Index
WQS	Water Quality Standard
WREC	Wabash River Enhancement Corporation
WRHCC	Wabash River Heritage Corridor Commission
WWTP	Wastewater Treatment Plant

1.0 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 Wabash River watershed includes all the land that drains into the Wabash River. The river starts in Ohio and drains about 7,300 square miles by the time it passes through the current watershed project area, before turning to the south from its westward course upstream (Figure 1). The Big Pine Creek and Mud Pine Creek watersheds include the area that drains into the Wabash River from portions of Benton, Tippecanoe, Warren, and White counties in west-central Indiana.

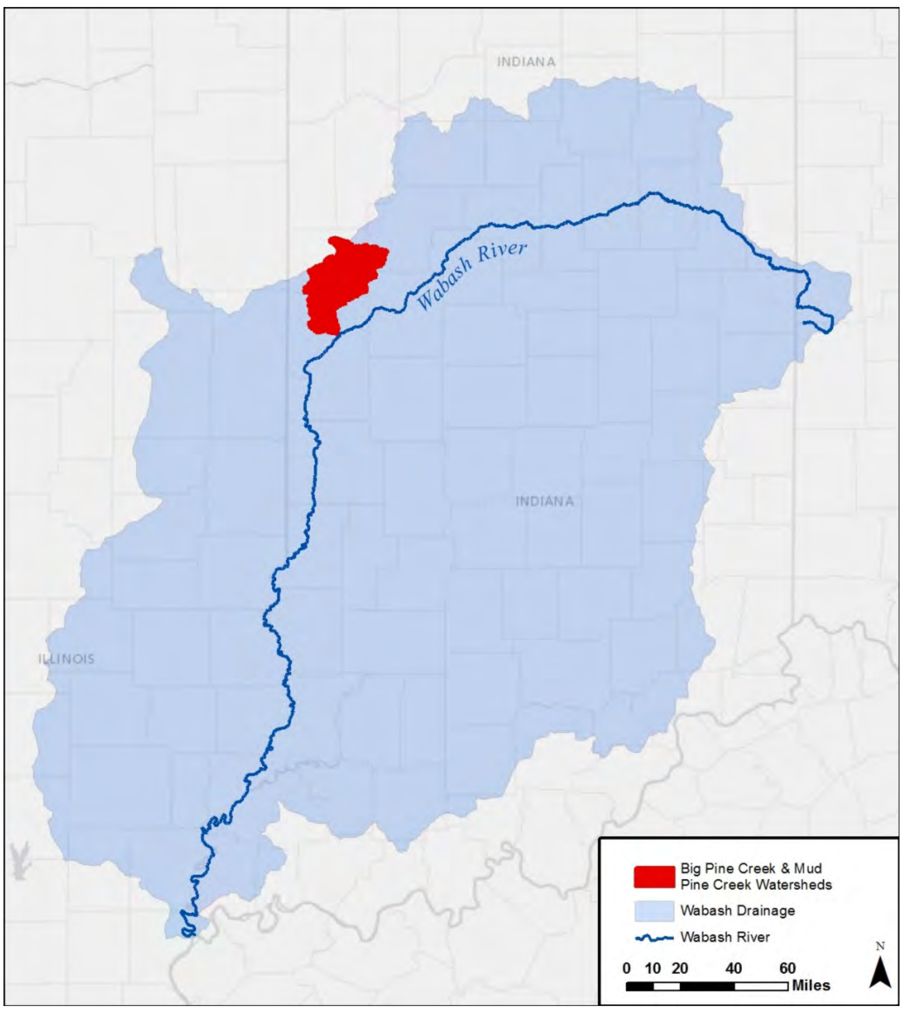


Figure 1. Wabash River watershed, highlighting the Big Pine Creek and Mud Pine Creek project area.

Data used to create this map are detailed in Appendix A.

By managing and improving this portion of the Wabash River watershed, we can do our part to improve water quality in the Wabash River. The following section describes the history of the project including funding details, project purpose, and stakeholder involvement.

1.1 Project History

In the fall of 2007, The Nature Conservancy contracted with Midwest Biodiversity Institute to develop a comprehensive assessment of the current research related to water quality and diversity in the Wabash River (Armitage and Rankin, 2009). That assessment led to the development in 2010 of a list of Wabash River subwatersheds that were the largest contributors of sediment, nutrients, and other contaminants to the river. These watersheds were no regrets places to engage in watershed protection, develop the missing science to narrow down the stresses and then address those issues through education and on the ground best management practice installation. In total, approximately 20 such subwatersheds were chosen as potential project areas and prioritized for further work by the Conservancy and its partners. In 2013, a proposal to the Pulliam Foundation was awarded to work on some of these priority watersheds, including Big Pine Creek in west central Indiana. The Big Pine had interested local support and it fell within the programmatic interests of potential partners such as the Wabash River Enhancement Corporation (WREC), Niches Land Trust, and the Conservation Technology and Information Center (CTIC). In the summer of 2013, the Conservancy assembled a group of partner organizations interested in improving water quality in the Big Pine, including WREC, Niches Land Trust, CTIC , Benton and Warren County Soil and Water Conservation Districts, and the Natural Resources Conservation Service (NRCS). 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 Pine. All of these efforts were guided by the following mission and vision developed by public participants and committee members:

Mission: *Voluntarily conserve and improve the natural environment while balancing interests of stakeholders in the Big Pine Creek watershed*.

Vision: *Big Pine Creek watershed is the anchor and an asset to the community.*

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

1.2 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. We 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.

1.2.1 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 month to develop the WMP, starting in July 2013. The group continues to meet on a monthly basis to discuss implementation strategies, progress of the cost-share program, outreach, grant opportunities, and make revisions to the WMP. Table 1 identifies the steering committee members and their affiliation.

Table 1. Big Pine watershed steering committee members and their affiliation.

Steering Committee Member	Organization(s) Represented
Alan Anderson	A Plus Farms
Linda Anderson	Citizen
Dave Bechman	Farm Manager
Bryan Berry	Benton County Commissioner, Farmer
Bob Brutus	Citizen
Jason Carlile	Carlile Ag
Pat Carlson	Benton County Councilman, Farmer
Jon Charlesworth	Benton County SWCD
Wayne Creech	Citizen
Denny Dispennett	Ceres Solutions
Steve Eberly	Warren County Commissioner
Gwen Erwood	Citizen
Macy Fawns	Purdue Extension, Benton County
John Fielding	Farmer, White Co. SWCD member
Dave Fisher	Benton County Surveyor
Chris Freeland	Dwenger Excavating
Dana Goodman	Citizen
Ron Haston	Haston Habitat
Larry Johnson	Dow Agrosciences
Larry Killmer	Farmer, White Co. SWCD member
Ben Lambeck	Warren County NRCS
Deb Lane	Warren County SWCD
Kevin Leuck	Benton County Commissioner
Tim Muller	Citizen
Mike Murr	Friends of Big Pine
Brian Nentrup	Pheasants Forever/Quail Forever
Gus Nyberg	NICHES Land Trust
Sara Peel	Wabash River Enhancement Corp
Mani Phengrasmy	NRCS
Mike Pluimer	Ceres Solutions
Lamar Reinhart	Dow Research Facility
Art Reumler	Farmer
Karen Scanlon	Conservation Technology Information Center
Michelle Scherer	Benton County SWCD
John Shuey	The Nature Conservancy
Willie Smith	Senesac Inc
Robert Sondgeroth	Farmer
Angela Sturdevant	The Nature Conservancy
Geneva Tyler	ISDA
Carl Voglewede	NRCS APHIS
Kent Wamsley	The Nature Conservancy
Matt Washburn	Pheasants Forever
Sharon Watson	White County SWCD
Chad Watts	Conservation Technology Information Center
Matt Williams	The Nature Conservancy

Steering Committee Member	Organization(s) Represented
Sarah Wolf	ISDA

1.2.2 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 two public meetings held – one in Warren County and one in Benton County. 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, as well as a community calendar on a local radio station (WIBN). 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 Nature Conservancy sent e-mails to its members who live within the watershed.

The first public meeting was held on January 9, 2014 at the Pine Village Christian Church in Pine Village, Indiana. Attendees represented citizens, farmers, and city officials. During this meeting, the Conservancy 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 Pine Creek and its watershed, and develop goals for the long-term vision of the stream.

A second public meeting was held on March 20, 2014 at the Government Center in Fowler, in an effort to reach more agricultural producers in Benton County. A focus group of influential producers in the watershed was gathered for an hour before the public meeting began, to allow producers to discuss in more detail their concerns and needs. This was an effective way of increasing participation among this group, and it generated some good discussion.

1.2.3 Educational Materials and Events

A Big Pine watershed brochure was developed to highlight opportunities for individuals to get involved with the project, identify community partners, and provide general information and fun facts about the watershed, watershed management planning, and the project (see Appendix B). The brochure will be distributed at committee, public, and group meetings and at education events throughout the lifetime of the project. Material about the Big Pine watershed will be developed and included on The Nature Conservancy's website as well as the website for the Wabash River Enhancement Corporation and the Conservation Technology and Information Center's website. SWCD staff attended the Warren and Benton county fairs in 2014 and 2015 to distribute information about the watershed project.

1.3 Public Input

Throughout the planning process, project stakeholders, the steering committee, and the general public listed concerns for Big Pine 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, July 2013 to July 2014, and watershed inventory process.

Stakeholder Concerns	Condensed Concerns
What is a watershed management plan?	Limited understanding of the planning process and its goal.
Why are we embarking on this project?	Limited knowledge of inputs and issues within the watershed.
Groundwater impacts and hydrology of the system needs to be better understood.	Groundwater understanding and management needed.
Confined feeding operations identified during inventory process.	Confined feeding operation management needed
Manure and nutrient management issues identified during inventory.	Nutrient management on cropland needed.
	Manure storage facilities needed.
Need clear water – very muddy.	High turbidity.
High turbidity.	
Flashiness – big rain causes a big jump in water levels very quickly.	Stream is too flashy
Water level fluctuations.	
High flashiness and high turbidity.	
Maintain drainage outlet – be careful to balance drainage needs with other needs.	Stream is a drainage outlet and should be maintained as such.
Invasive species are present on the streambanks.	Invasive species are present along the stream banks and in the creek.
Poor water quality (compared to other streams).	Poor water quality.
Trash.	Trash needs to be kept out of the creek.
Keep the creek clean.	
Maintain aesthetic conditions.	Maintain the aesthetic conditions.
Community needs to maintain its connection to the stream.	Community needs to connect to the stream more.
Get people out on the creek – celebrate Big Pine Creek.	
Log jams – prevention and removal are needed especially in Mud Pine Creek.	Too many logjams; untimely logjam removal.
Keep land where it is at/reduce erosion.	Soil erosion occurs throughout watershed.
Soil erosion occurs throughout the basin especially in Mud Pine Creek.	
HES identified during watershed inventory.	Highly erodible soils are cropped and need to be managed better
Oxford wastewater treatment plant operations are of concern.	Oxford needs to expand their WWTP; they currently use a lagoon system for finishing.
Water quality data indicate high nutrients and E. coli immediately upstream of the IDEM fixed station.	Pine Village needs to improve their septic practices.
Pine Village needs a town wide wastewater treatment system (underway).	
Boswell septic and sewer issues; flooding impacts the town.	Boswell needs to improve their septic practices.
Fowler wastewater effluent enters Big	Fowler's wastewater treatment plant drains into

Stakeholder Concerns	**Condensed Concerns**
Pine Creek.	the watershed.
Templeton – excessive irrigation pumping.	Templeton's stormwater and wastewater is not understood.
Improve grassland habitat and reduce erosion.	Healthy grassland habitat needs to be emphasized for wildlife.
Woodland habitat needed.	Woodland habitat needs to be improved for wildlife
Cattle have access to Big Pine Creek.	Livestock access to the stream.
Livestock access identified during inventory.	
Producers are starting to use cover crops but no till use could be improved; overall increase use of both practices.	Producers need to be educated on potential practices they could use to increase production and reduce impacts to the stream.
Cover crop and no till need identified during inventory.	
Drainage water management-few have been installed in the watershed but most producers don't like labor intensive nature of the practice.	
Additional farming BMP's would be helpful in the upper reaches of the Big Pine drainage in Warren County.	
No official public access site.	No official public access is available.
Aquifers, recharge, and the Teays River Valley need to be protected and better understood.	Aquifers, recharge, and the Teays River Valley need to be protected and better understood.
Tile nutrient transport – is this a problem and if so, how big of a problem. Education on this issue is needed.	Tile nutrient transport- is this a problem, and if so, how big of a problem?
Irrigation education needed – use, need for it, etc.	Water quantity issues are a concern given the pumping for agriculture and the recent problems with dry wells in Templeton.
Water quantity issues, given the pumping for agriculture and the recent problems with dry wells in Templeton.	

2.0 WATERSHED INVENTORY I: WATERSHED DESCRIPTION

2.1 Watershed Location

The Big Pine watershed is part of the Middle Wabash-Little Vermilion watershed and covers portions of Benton, Warren, Tippecanoe, and White counties (Figure 2). The watershed extends from Interstate 65 in White County to west of State Road 41 in Benton County, and drains southward until emptying into the Wabash River near the town of Attica. The Big Pine watershed covers 209,709 acres or 329 square miles and includes all of Boswell, Pine Village, and Oxford, as well as the southern half of Fowler.

2.2 Subwatersheds

2.2.1 10-digit Hydrologic Unit Code Watersheds

Big Pine Creek watershed is composed of two 10-digit Hydrologic Unit Codes (HUC): Mud Pine Creek (0512010803) and Big Pine Creek (0512010804) (Figure 2). The Mud Pine Creek watershed covers 61,900 acres and the Big Pine Creek watershed covers 147,809 acres. Big Pine Creek watershed is bordered to the north by the Iroquois watershed, to the west by the Vermillion watershed, to the east by the Great Bend of the Wabash and Tippecanoe watersheds, and to the south by the Wabash River.

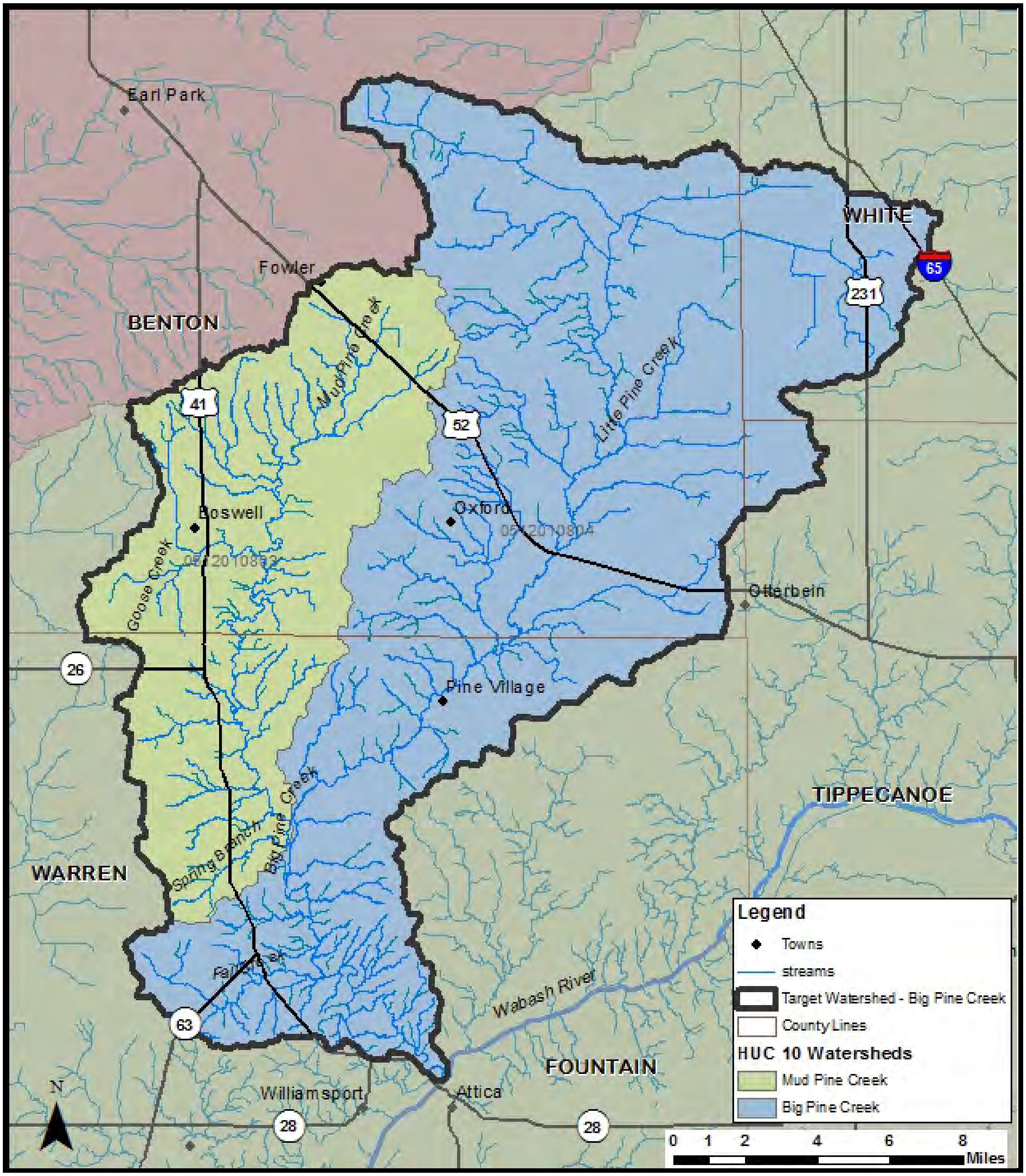


Figure 2. Big Pine Creek watershed highlighting the two 10-digit Hydrologic Unit Code (HUC) watersheds.
Data used to create this map are detailed in Appendix A.

2.2.2 Big Pine Creek Tributary Watersheds

In total, fourteen 12-digit Hydrologic Unit Codes are contained within the Big Pine Watershed (Figure 3, Table 3). The subwatersheds range in size from about 10,000 acres or

16 square miles to nearly 24,000 acres or 37 square miles. Each of these drainages will be discussed in further detail under *Watershed Inventory II*.

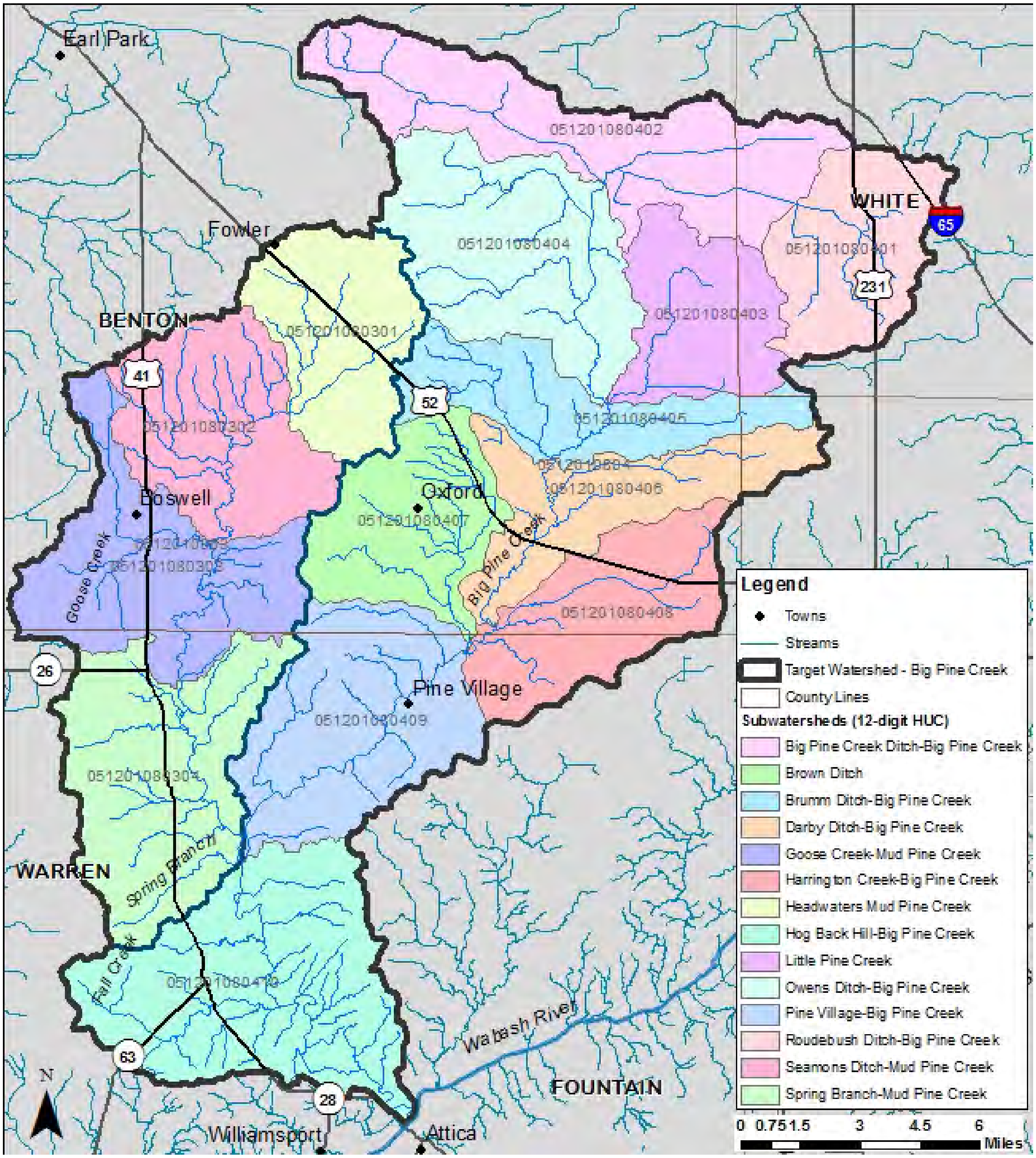


Figure 3. 12-digit Hydrologic Unit Codes in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

Table 3. 12-digit Hydrologic Unit Code (HUC) watersheds in the Big Pine Creek watershed

Name	HUC 12	Area (Acres)	Area (Sq mi.)
Headwaters Mud Pine Creek	051201080301	12,019	19
Seamons Ditch-Mud Pine Creek	051201080302	14,432	23
Goose Creek-Mud Pine Creek	051201080303	16,867	26
Spring Branch-Mud Pine Creek	051201080304	18,582	29
Roudebush Ditch-Big Pine Creek	051201080401	11,273	18
Big Pine Creek Ditch-Big Pine Creek	051201080402	19,725	31
Little Pine Creek	051201080403	10,058	16
Owens Ditch-Big Pine Creek	051201080404	17,921	28
Brumm Ditch-Big Pine Creek	051201080405	11,030	17
Darby Ditch-Big Pine Creek	051201080406	11,756	18
Brown Ditch	051201080407	11,850	19
Harrington Creek-Big Pine Creek	051201080408	12,873	20
Pine Village-Big Pine Creek	051201080409	17,652	28
Hog Back Hill-Big Pine Creek	051201080410	23,671	37

2.3 Climate

In general, Indiana has a temperate climate with warm summers and cool or cold winters. The Big Pine watershed is no different. Climate in this watershed is characterized by four distinct seasons throughout the year. High temperatures measure approximately 85^{o}F in July and August, while low temperatures measure near freezing (31^{o}F) in January. The growing season typically extends from early April through late October with the season being slightly longer in the southern portion of the watershed, including Warren County, and slightly shorter in the northern portion of the watershed (White County). On average, 32 inches of precipitation occur within the watershed with precipitation as small, frequent rain events spread almost evenly throughout the year. Figure 4 details average precipitation from just outside the watershed in West Lafayette from 1971 to 2007. Meliora Environmental Design (2009) note that more than 93% of rain events include less than one inch of rain with these events accounting for more than 70% of annual rainfall.

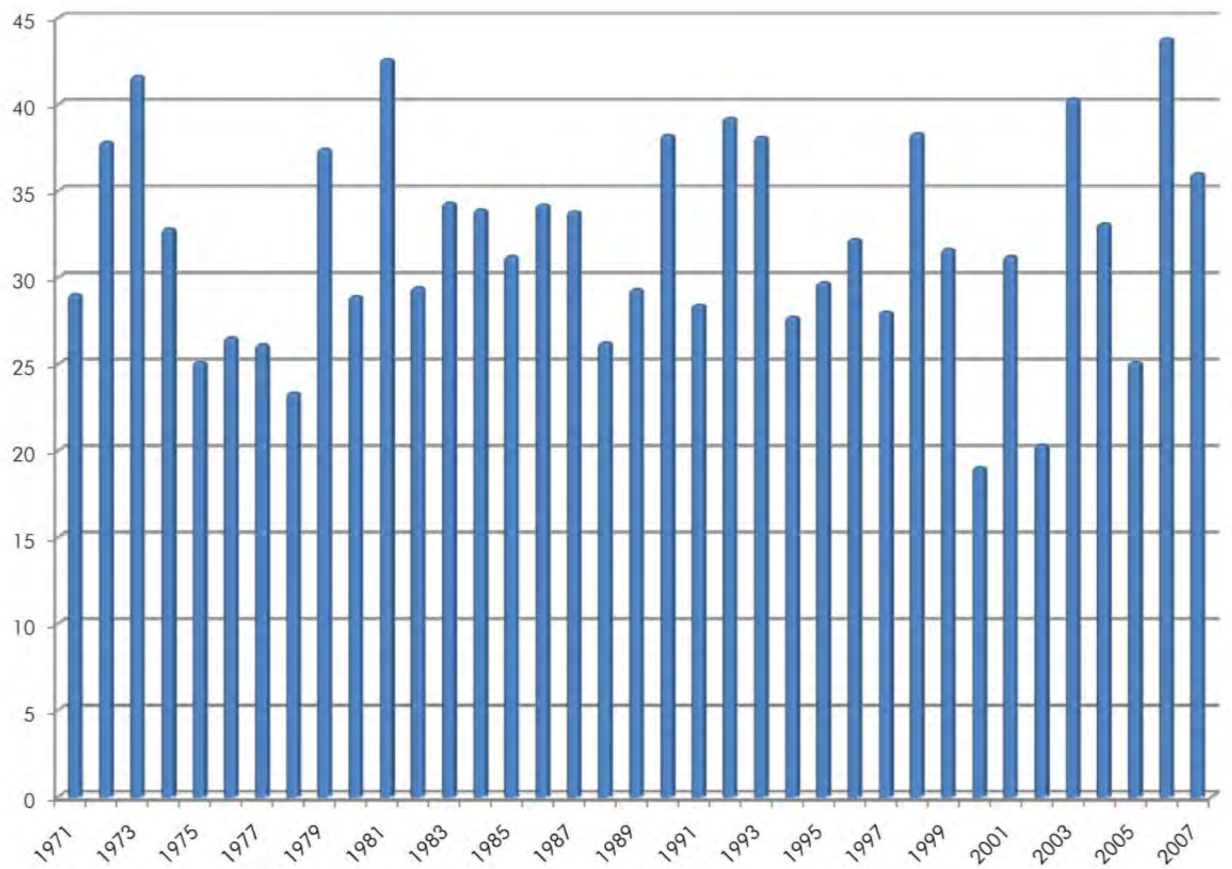


Figure 4. Average rainfall in inches per year from 1971 to 2007.

2.4 Geology and Topography

The geology and topography of the Big Pine watershed in west-central Indiana is directly influenced by the advance and retreat of the Saginaw and Erie Lobes of the Wisconsinian glaciation (IDNR, 1980). Bedrock deposits are from the Devonian and Mississippian ages and generally consist of shale, siltstone, and limestone (Rosenshein, 1958). Unconsolidated drift deposits overlie the bedrock with deposits ranging from a few inches to 425 feet thick throughout the watershed. Glaciofluvial and waterlain till deposits cover nearly 75% of the watershed with dense clay and sand predominating. Within these locations, water stands on the clay soils resulting in slow percolation. Water moves quickly through the outwash soils. In some cases, irrigation is used for crop growth. In the northern portion of the watershed, lake sand covers much of area. This lake plain is a remnant of the Kankakee Lake, which covered much of west-central Indiana during historic glaciation (McBeth, 1901).

The topography, surficial geology, soil development, and bedrock geology in the Big Pine watershed were directly influenced by the advance and retreat of the Saginaw-Huron, Michigan, and Erie lobes of ice during the Wisconsinan glaciation (McBeth, 1899). The bedrock deposits of the watershed are from the Devonian and Mississipian ages. These rocks consist of dolomite and limestone overlain by shale (Clark, 1980). The unconsolidated deposits above the bedrock range from 150-200 feet thick in the watershed. The deepest unconsolidated unit is a dense, clay-loam till. In most of the watershed glaciofluvial deposits overlie the clay till. The glaciofluvial deposits consist of sand and gravel imbedded with clay (Clark, 1980).

The topography of the Big Pine watershed is relatively flat as is typical of the Tipton Till Plain region in which the watershed is located (Figure 5). The relatively flat topography is interrupted both by a series of parallel end moraines or hills and by the Wabash River. The Wabash River at the very southern end of the watershed cuts through the flat plain flowing through a wide deposit of gravel (McBeth, 1899), and is the lowest point in the Big Pine watershed, while the highest ground is found in Benton County between Fowler and Oxford (Figure 6).

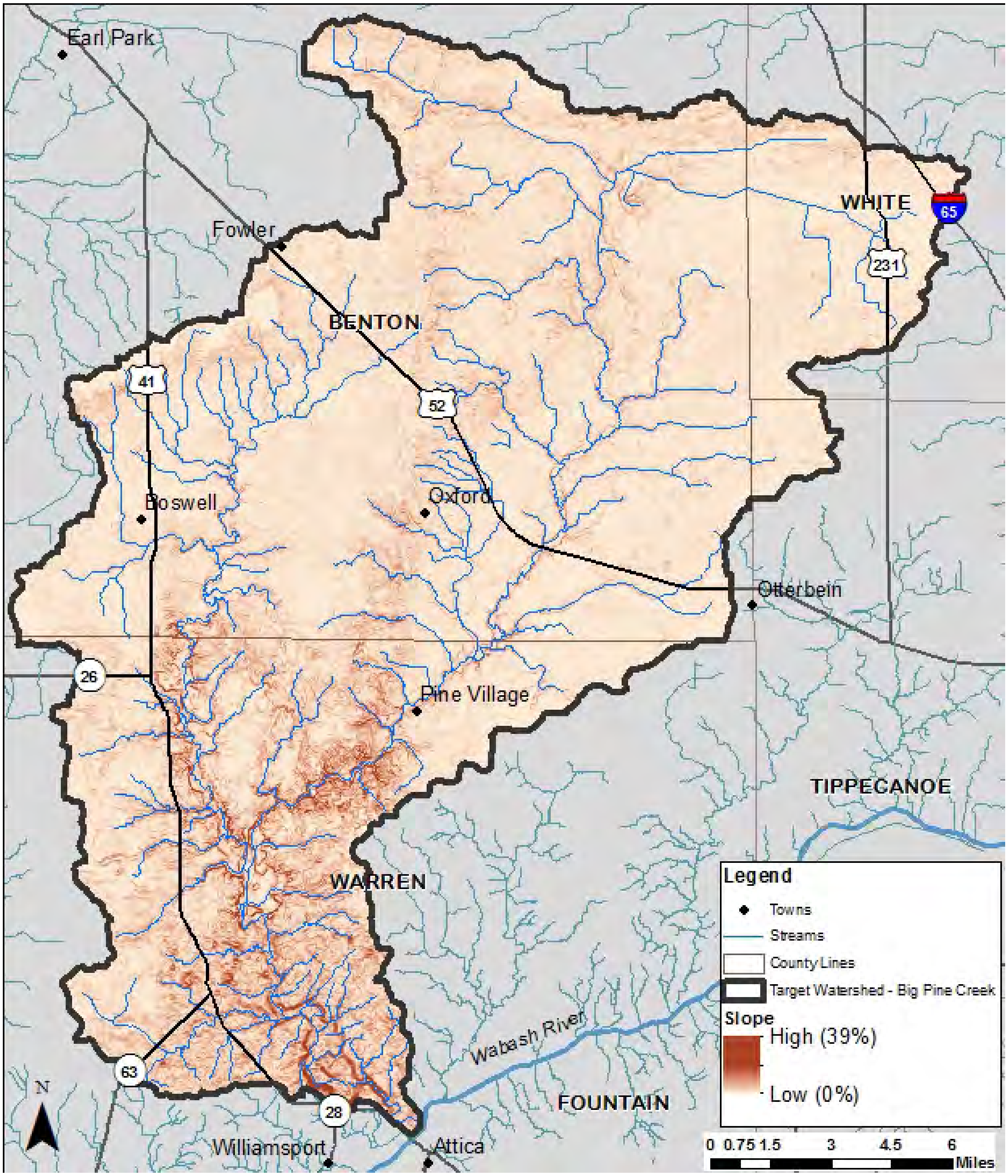


Figure 5. Surface slope of the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

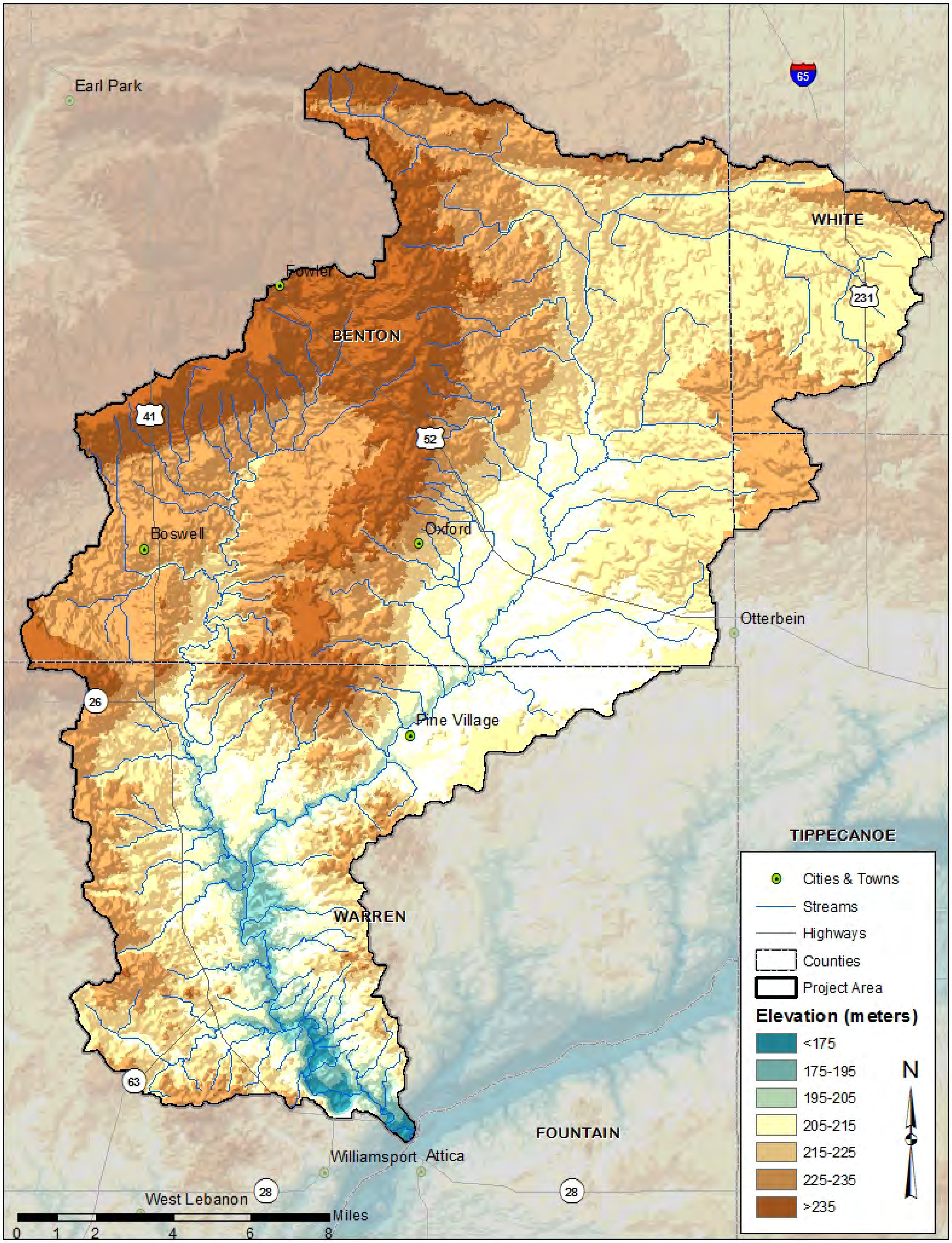


Figure 6. Surface elevation in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.5 Soil Characteristics

There are hundreds of different soil types located within the Big Pine 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 10 soil associations with three associations combining to cover nearly two-thirds of the total watershed area. The Drummer-Toronto-Wingate soil association dominates east of Big Pine Creek, covering nearly 24% of the watershed (Table 4). The Drummer-Toronto-Wingate association lies within till deposits and is somewhat poorly drained with slow permeability. This association possesses slopes of 0 to 6% and most are cropped in a corn-soybean rotation (USDA, 2014). The Saybrook-Drummer-Parr association dominates in the northwest portion of the watershed in Benton County, with moderately well drained soils formed on till plains with 0-20% slope. The Sawmill-Lawson-Genesee soil association borders Big Pine Creek at the lower end of the watershed, characterized by poorly drained soils formed on floodplains. Adjacent to this on steeper slopes, the Miami-Miamian-Xenia soil association is found, with a high potential for surface runoff (Figure 7).

Table 4. Soil associations in the Big Pine Creek watershed

Soil Name	Area (Acres)	Percent of Watershed
DRUMMER-TORONTO-WINGATE	48,757	23.7%
SAYBROOK-DRUMMER-PARR	47,734	23.2%
MIAMI-MIAMIAN-XENIA	39,725	19.3%
BARCE-MONTMORENCI-DRUMMER	23,383	11.4%
WARSAW-LORENZO-DAKOTA	14,523	7.1%
WOLCOTT-ODELL-CORWIN	11,924	5.8%
SAWMILL-LAWSON-GENESEE	10,539	5.1%
MORLEY-MARKHAM-ASHKUM	7,522	3.7%
BLOUNT-GLYNWOOD-MORLEY	1,448	0.7%
MARTINSVILLE-WHITAKER-RENSSELAER	434	0.2%
Total	**205,989**	**100%**

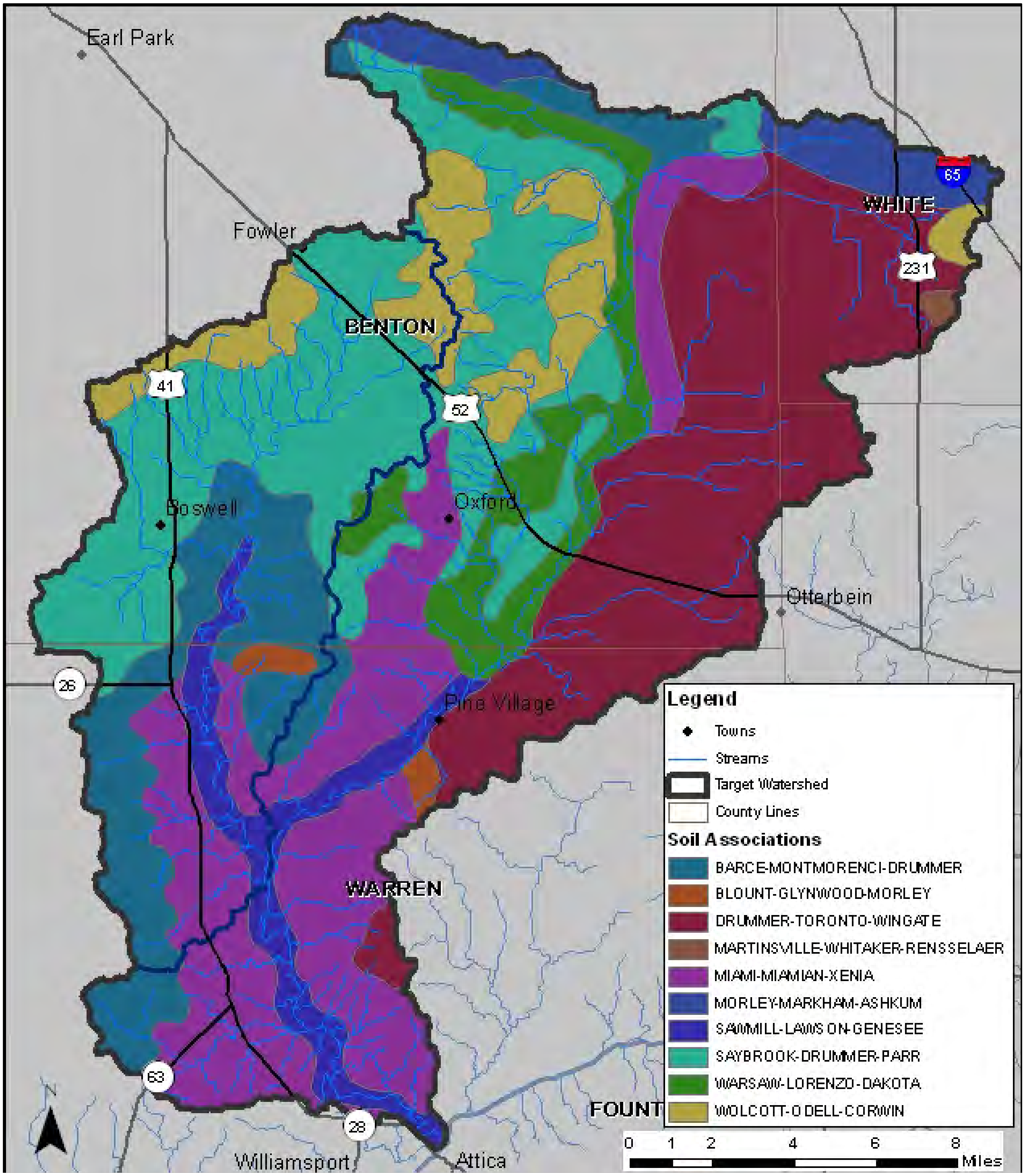


Figure 7. Soil associations in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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 8 details locations of highly erodible and potentially highly erodible soils within the Big Pine Creek watershed. Highly erodible soils cover 4% of the watershed or approximately 7,590 acres, while potentially highly erodible soils cover 29% of the watershed or approximately 60,828 acres. Highly erodible soils are found throughout the watershed, but are more concentrated in the southern end of the watershed in Warren County.

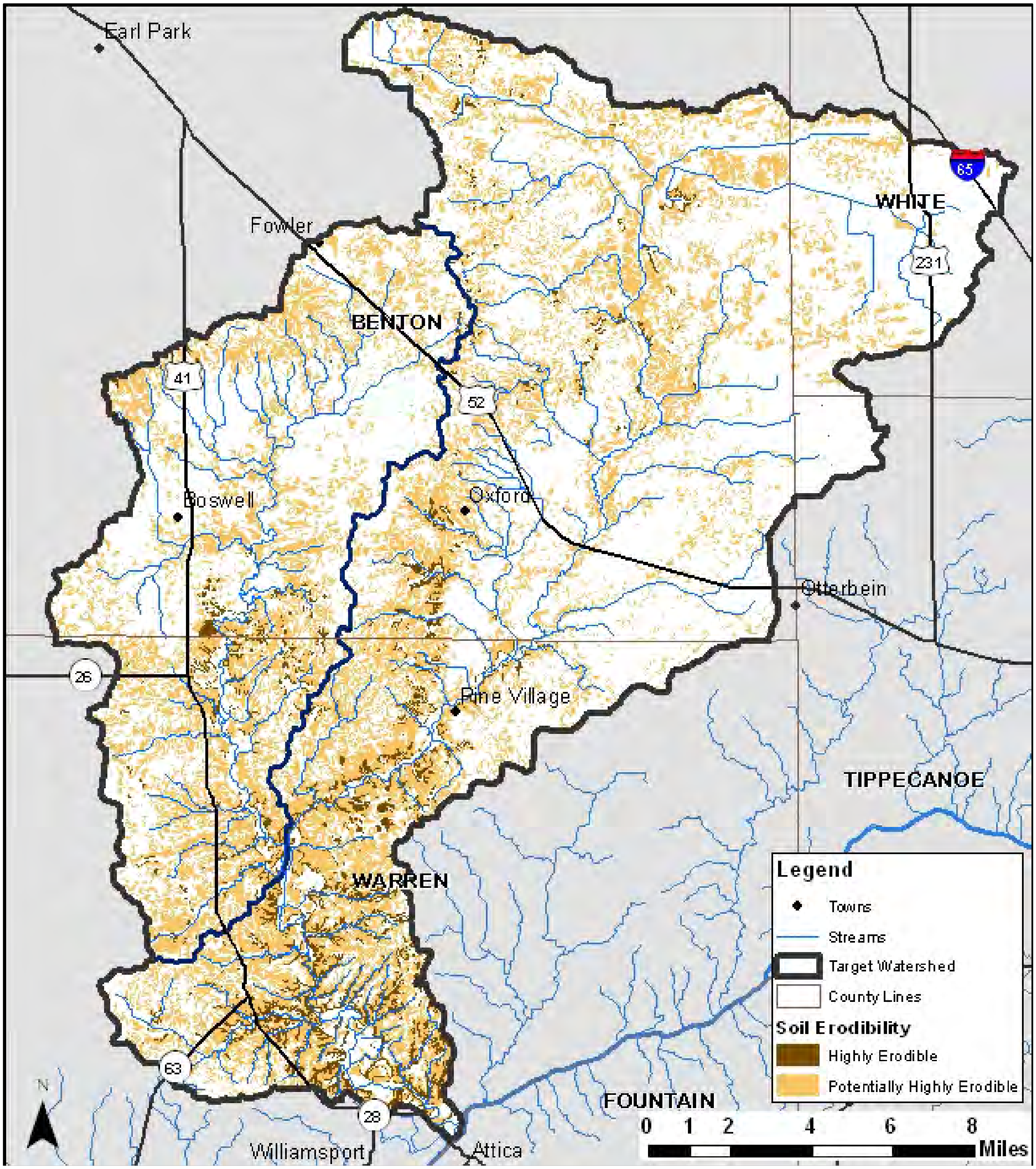


Figure 8. Highly erodible (HES) and potentially highly erodible soils (PHES) in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.5.3 Hydric Soils

Hydric soils are those which remain saturated for a sufficient period of time to generate a series of chemical, biological, and physical processes. The oxidation and reduction of iron in the soil, or "redox", causes color changes characteristic of prolonged fluctuations in the water table. After undergoing these processes, the soils maintain the resultant characteristics even after draining or use modification occurs. Watershed stakeholders are concerned about the conversion of wetlands into agricultural and urban land uses. Approximately 75,000 acres (36%) of the watershed are covered by hydric soils (Figure 9). Hydric soils are found throughout the watershed, with the highest densities being located in the northern half of the watershed, especially in White 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.

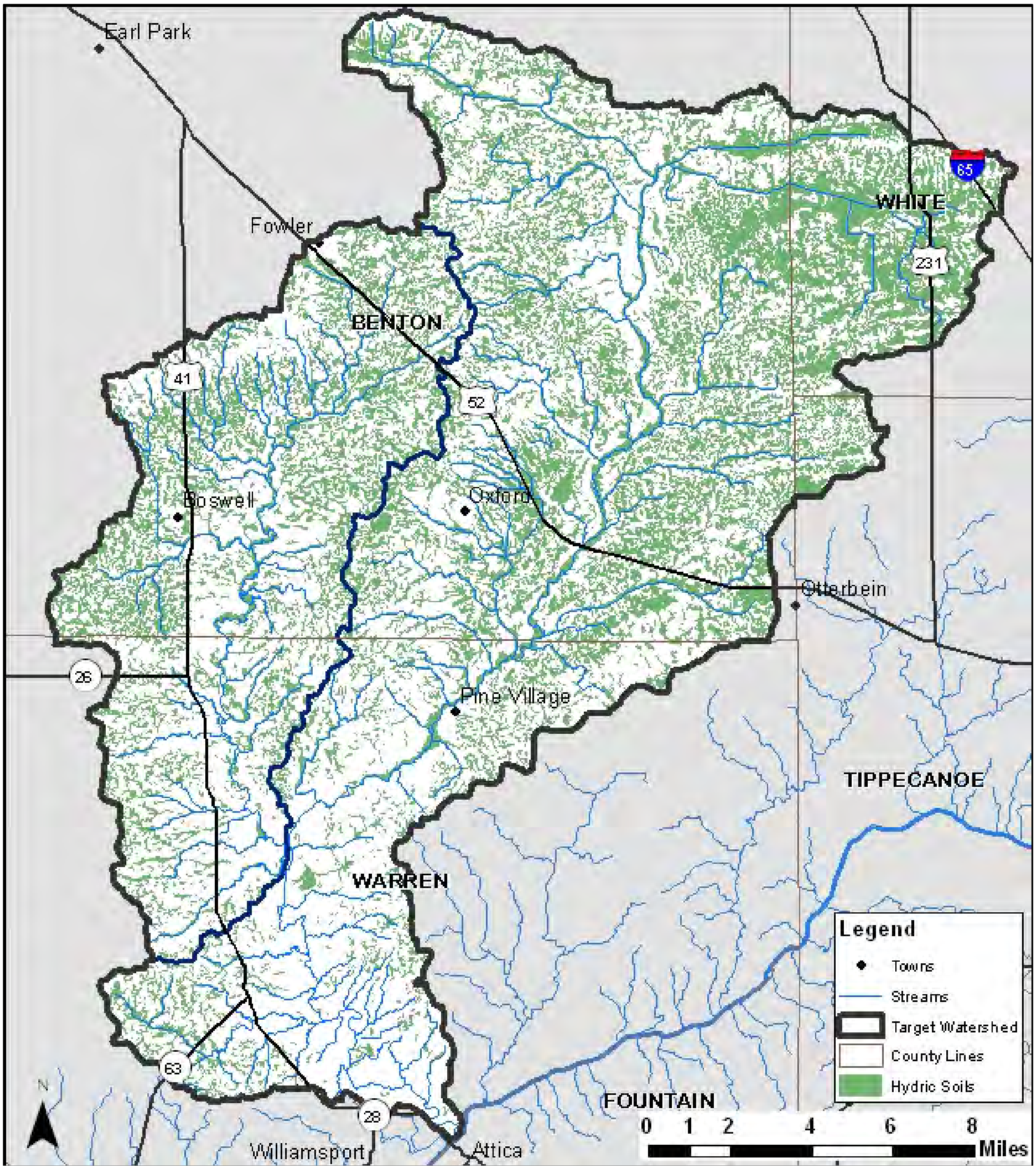


Figure 9. Hydric soils in the Big Pine Creek watershed.

Data used to create this map are detailed in Appendix A.

2.5.4 Tile-Drained Soils

Soils drained by tile drains are very common in the Big Pine Creek watershed. 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. All of the counties represented in the Big Pine watershed use extensive series of tile to drain their lands. The upper northeast corner of the watershed in White County may be the most densely tiled area of the watershed. 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.

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 is expelled in the state of Indiana annually. The true impact of these systems on the water quality in the Big Pine 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 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 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 10). Nearly 209,180 acres or 99.7% of the watershed is covered by soils that are considered very limited for use in septic tank absorption fields. The remaining 530 acres are somewhat limited or not rated.

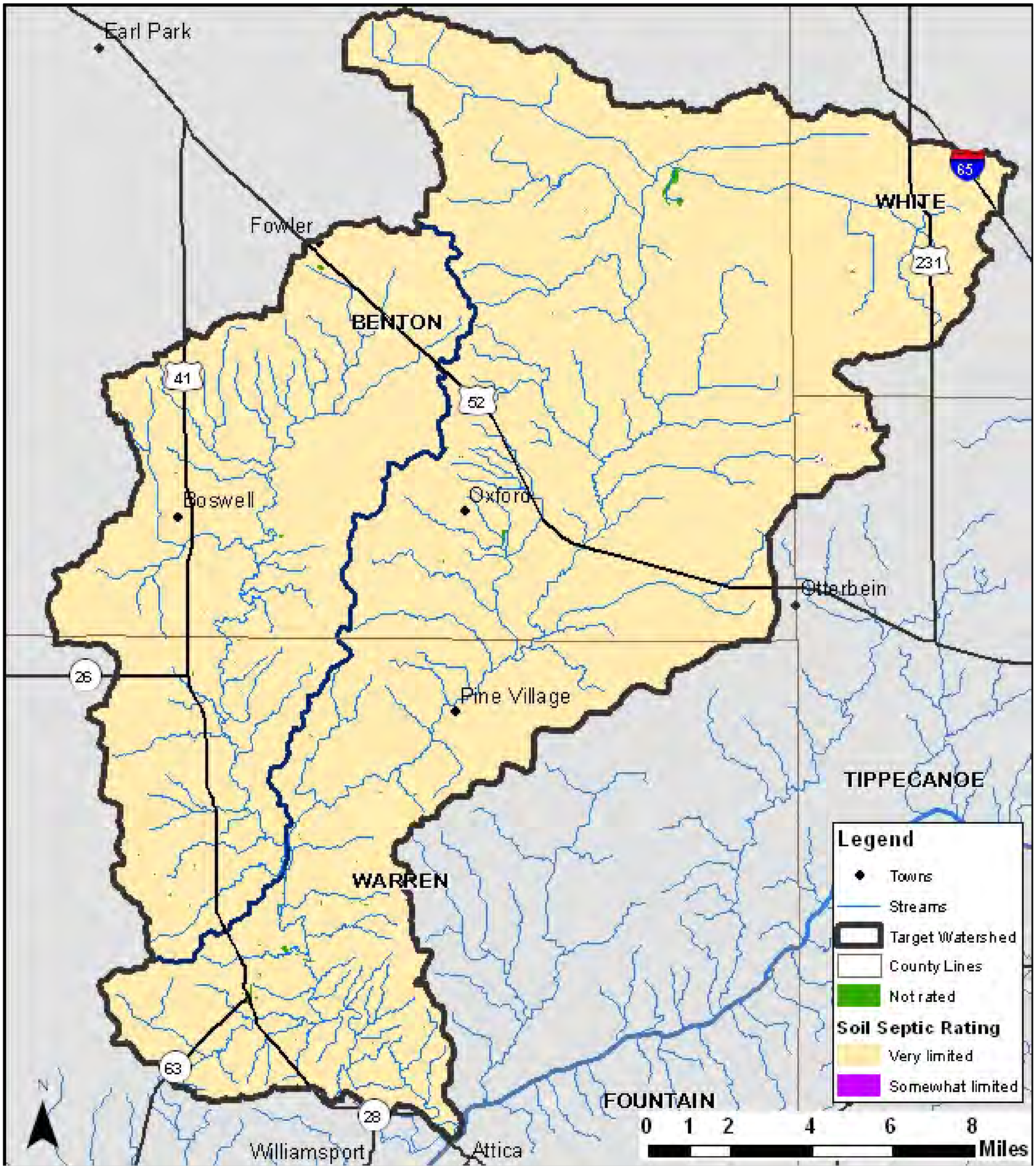


Figure 10. Suitability of soils for septic tank usage in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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, five NPDES-regulated facilities are located within the watershed (Figure 11). Table 5 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.

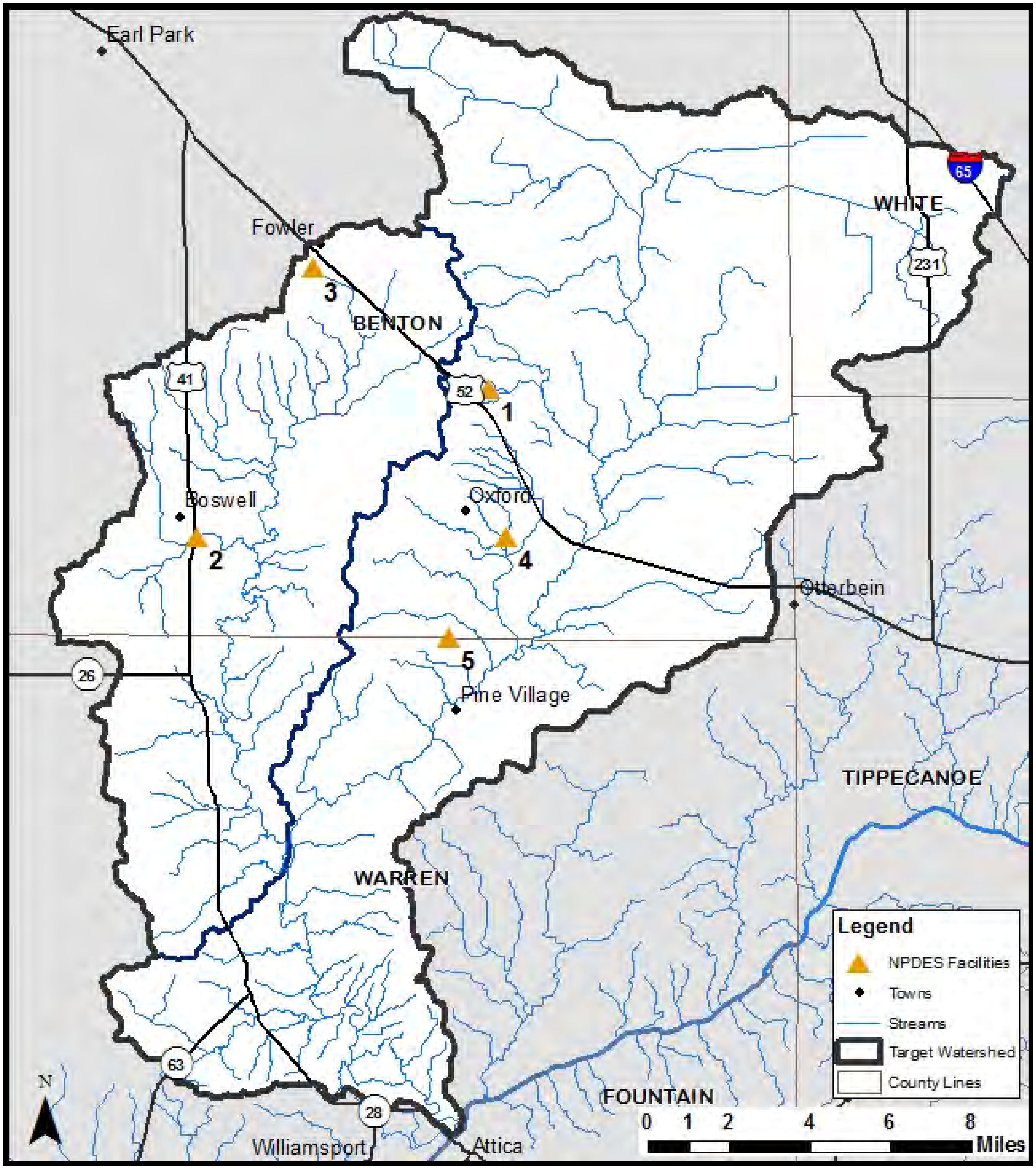


Figure 11. NPDES-regulated facilities in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

Table 5. NPDES-regulated facility information.

Map ID	NPDES ID	Facility Name	Activity Description
1	IN0021164	Benton Central Jr Sr High School	Sewerage system
2	IN0039756	Boswell Municipal WWTP	Sewerage system
3	IN0050253	Fowler Municipal Sewage Treatment Plan	Sewerage system
4	IN0021342	Oxford Utilities	Sewerage system
5	IN0061476	Oxford Water Utility	Water Supply

Source: USEPA EnviroFacts Warehouse, 2013

2.6.3 Municipal Wastewater Treatment and Combined Sewer Overflows

In the relatively rural Big Pine watershed, there are only four wastewater treatment facilities, associated with three of the four incorporated towns and the Benton Central Jr Sr High School. All four facilities discharge into tributaries of either Big Pine Creek or Mud Pine Creek. Sludge from municipal wastewater treatment plants is applied on 3,584 acres throughout the watershed. Much of this application occurs within the Darby Ditch, Brumm Ditch and Big Pine Ditch subwatersheds (Figure 12). Watershed stakeholders are concerned about the limitations of municipal wastewater treatment facilities, especially the intensity and duration of combined sewer overflows in the town of Oxford.

Town of Oxford

The Town of Oxford operates a wastewater treatment plant which serves the town's approximately 1270 residents. The plant is designed to treat 0.2 MGD of wastewater, although the average is less than 0.075 MGD during dry weather. The system consists of two lagoons with a holding time of 90 days, followed by chlorination and dechlorination. The treated water is discharged to Brown Ditch. The service area is shown in Figure 12. The town's sanitary and storm sewers are combined and there are two permitted combined sewer overflows that discharge into Brown Ditch on the south side of the town. In 2013, 18 combined sewer overflow discharge events occurred, with a total volume of 12.97 million gallons of combined stormwater and wastewater entering Brown Ditch.

The WWTP is currently in noncompliance with its NPDES permit, with two formal enforcement actions by IDEM over the last five years. The Town of Oxford has been working with an engineering firm to submit a Long Term Control Plan (LTCP) Amendment to IDEM. The current draft of the LTCP Amendment proposes to capture and fully treat flows from the first flush. Wet weather flows from greater than the first flush up to and including the 10-year, 1-hour design storm will receive a minimum of primary treatment and disinfection at a constructed wetland. Phase 1 includes building a third lagoon to increase capacity and relocating the effluent discharge outlet to a larger receiving stream. Phase 2 includes building a fill and draw wetland to intercept wastewater before it reaches the lagoon system, and separation of storm and sanitary sewers. The town has secured a low interest loan from the State Revolving Fund to begin implementation of Phase 1 and is currently seeking the remainder of the funding needed in order to keep rate increases low. These improvements will result in less organic material, nutrients and bacteria released to Big Pine Creek within the next ten years (Jeff DeWitt, pers comm 2014).

Town of Boswell

The Town of Boswell operates a wastewater treatment plant which serves the town's approximately 770 residents. The plant is designed to treat 0.13 MGD of wastewater through a system of two aeration tanks, two clarifiers and a concrete polishing pond. During dry weather, the plant treats 0.035 MGD of wastewater while wet weather typically brings 0.06-0.08 MGD. Treated water is discharged to Mud Pine Creek via Goose Creek. In the past, sludge was applied to a local farmer's field, but under the current permit sludge will be applied to a five acre hay field adjacent to the plant annually in the spring. The sanitary sewers are not combined with storm sewers (JR Witt, pers comm 2014). The Boswell WWTP is currently in compliance with its NPDES permit.

Town of Fowler

The Town of Fowler operates a wastewater treatment plant which serves the town's approximately 2330 residents. While the town straddles the watershed boundary, the plant is located south of town and discharges into Mud Pine Creek via Humbert Ditch. Fowler maintains over 15 miles of sewers, five sewer pumping stations, and three pumping stations at the wastewater plant. The plant is designed to treat 0.75 MGD of wastewater through a system of an equalization basin, a surge control basin, two oxidation tanks, several clarifiers, and disinfection. Following treatment and dewatering, land application of biosolids occurs. The NPDES permit lists the sewer system as 100% separated. The plant treats storm water from rain events only until such time as the remaining 25% of the old sewer system can be replaced. The current capacity of the plant during dry weather is 20-25%, allowing room for expansion. The Fowler WWTP is currently in compliance with its NPDES permit.

Benton Central Jr Sr High School

The Benton Central Jr Sr High School operates a wastewater treatment plant which serves both the high school and Prairie Crossing Elementary School, with a total of approximately 1100 students. The small concrete plant was designed to treat 0.042 MGD of wastewater, but typically only receives 0.01 MGD. Treated water is discharged to Big Pine Creek via an unnamed ditch. Sludge is held in a 12,000 gallon tank onsite and twice a year is hauled offsite for land application (Fred Flook, pers comm 2014). Land application sites are shown in Figure 12. The Benton Central Jr Sr High School WWTP is currently in compliance with its NPDES permit.

2.6.4 Unsewered Areas

Five unsewered areas were identified within the watershed (Figure 12). Areas that have at least 25 houses within a square mile outside of the sanitary district boundaries were classified as dense, unsewered areas. The largest of these areas were associated with the towns of Pine Village and Templeton. The town of Pine Village is in the process of investigating wastewater treatment plant alternatives and funding, in coordination with IDEM. Currently, much of the town has failing septics. Funding is being pursued through grants which would allow the town to create a modern sewage treatment facility which would greatly reduce the amount of pollutants (*E. coli*, nutrients, etc.) leaching into Big Pine Creek.

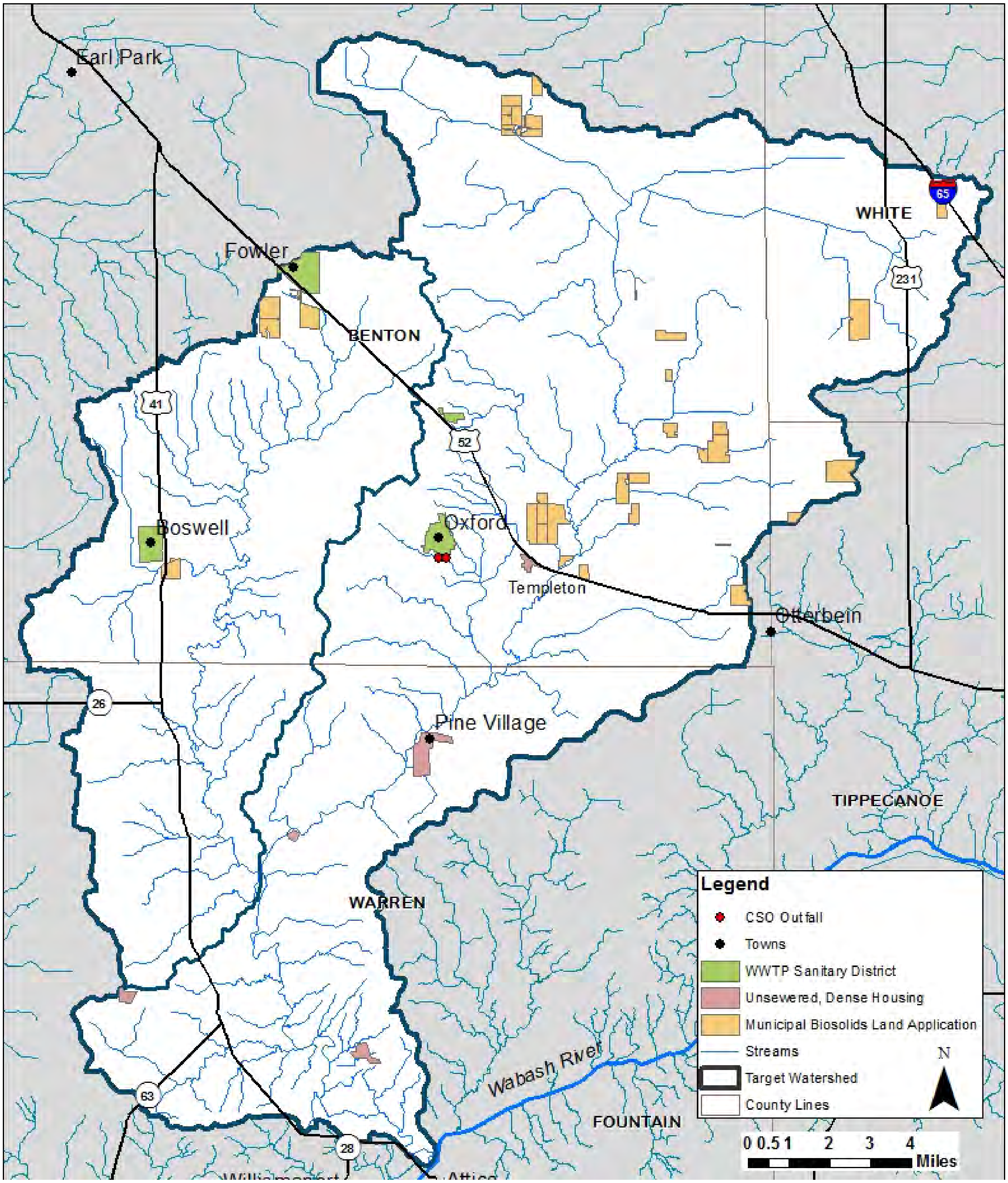


Figure 12. Wastewater treatment plant service areas, municipal biosolids land application sites, dense unsewered housing, and combined sewer overflow outfalls within the Big Pine Creek watershed.

Data used to create this map are detailed in Appendix A.

2.7 Hydrology

As part of his study, Gammon cataloged historic references to the Wabash River, assessed the fish community, and the overall river habitat. Each of these comments indicate the changing hydrology in the Wabash River and its tributaries. Some of the comments recorded by Gammon (1995) include:

- The Wabash River was clear and sparkled in the sunlight; Logansport, 1833 (McCord, 1970).
- The Wabash and its tributaries routinely rise above their banks and overflow into the low adjoining land; location unknown, undated.
- The Wabash River was low (July) and its rocky bed was exposed and dotted by small island. In 1845, Winter noted the effects of partially clearing the area stating that the islands were beginning to wash away under the influence of the greater volume of water; Logansport.
- Rolfe (1920) noted the continued change in water quality stating that the waters of the Wabash River were commonly brown and opaque with suspended sediments and that waters never cleared even in the lowest stages; Attica to Vermillion.
- Gerking (1945) identified “city sewage, cannery waste, mill waste, coal mine drainage, and dairy-products waste” as sources of water quality problems within the middle and lower Wabash River.
- Visher (1944) indicated four reasons for increased flooding within the Wabash River and its tributaries: abundant rainfall, concentration of rainfall, inadequate size and number of runoff channels, and changes produced by man.

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

2.7.1 Watershed Streams

The Big Pine watershed contains approximately 568 miles of streams, regulated drains, and regulated tile drains. Of these, approximately 234 miles are regulated drains and 91 miles are regulated tiles. In Benton County, all drains and tiles are regulated with the exception of Big Pine Creek and Mud Pine Creek. Likewise, in Tippecanoe and White counties nearly all the stream miles are either regulated drains or tiles. The majority of streams in Warren County are not regulated, with only six reaches of regulated drains. It should be noted that regulated drains are maintained by the county surveyor’s office; however, some of the regulated drains within the watershed have neither a maintenance fund nor a 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 the Big Pine. Therefore, practices such as the two-stage ditch that minimize sediment transport should be considered in areas of the watershed with high densities of legal drains, or where they are otherwise desirable for reducing sediment and nutrient loads.

The major tributaries to Big Pine Creek include Roudebush Ditch, Big Pine Ditch, Little Pine Creek, Owens Ditch, Brumm Ditch, Darby Ditch, Brown Ditch, Harrington Creek, Hog Back Hill, and Fall Creek (Figure 13). Mud Pine Creek discharges into Big Pine Creek upstream of its confluence with Fall Creek. The major tributaries to Mud Pine Creek include Goose Creek, Seamons Ditch and Spring Branch. Several minor tributaries also drain to Big Pine within this watershed. Big Pine Creek is used extensively for recreational kayaking and canoeing, as well as fishing, swimming, and aesthetic enjoyment. Stakeholders are concerned with maintaining the recreational value of the creek, and have some concerns because portions of the watershed have been designated as impaired by IDEM for *E. coli*, nutrients, and impaired biotic communities.

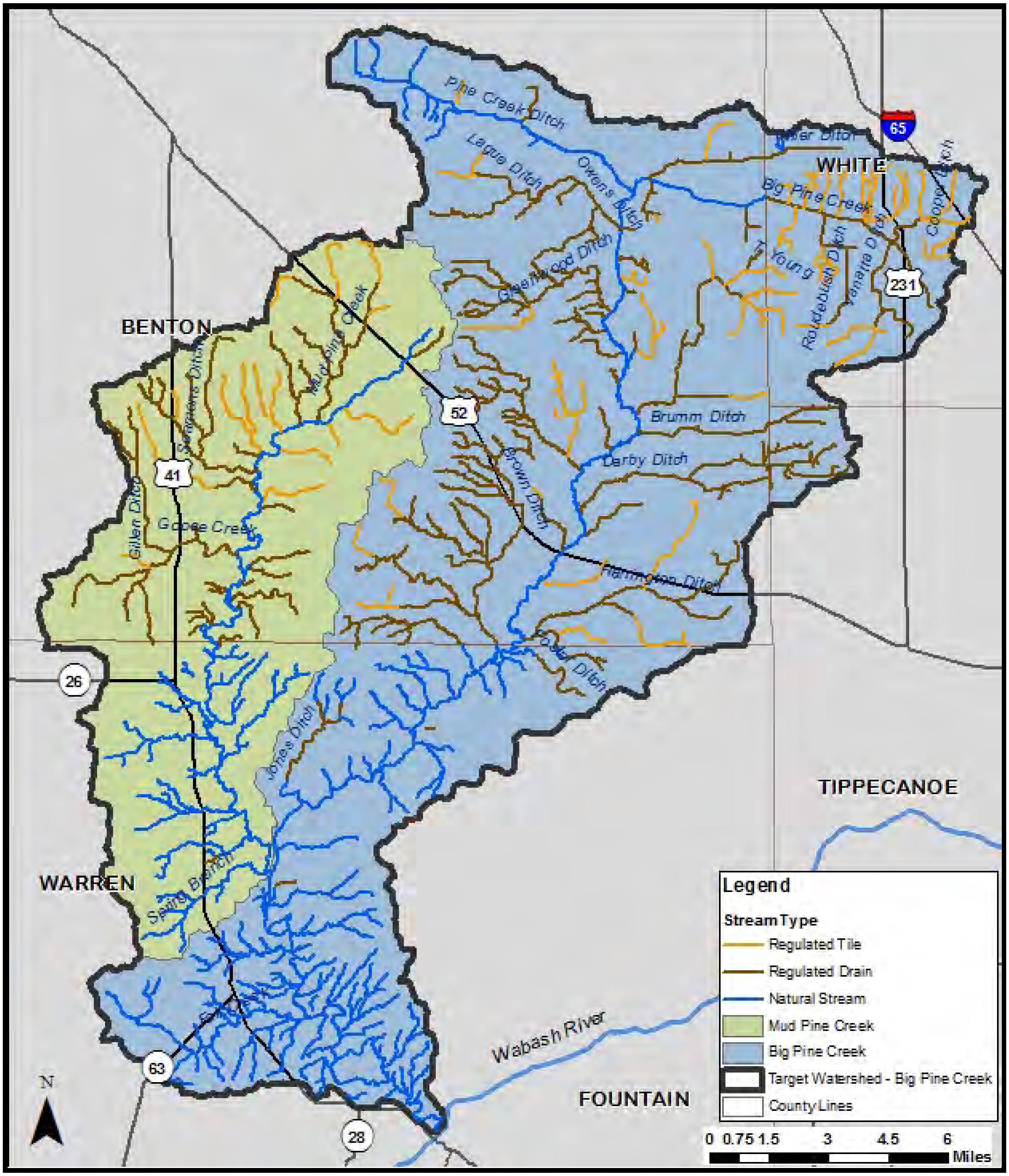


Figure 13. Streams, legal drains, and tile drains in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.7.2 Outstanding Rivers

In addition to various stream type classifications discussed above, the state of Indiana also imposes two designations on streams throughout the state. These include the designation of outstanding rivers and impaired waterbodies. Outstanding rivers or streams are those that are of particular environmental or aesthetic interest and qualify under one or more of 22 categories (NRC, 2007). As such, the 2,000 river miles representing less than 9% of rivers in Indiana were listed by the IDNR Division of Outdoor Recreation. Conversely, the impaired waterbodies listing designates those waterbodies which do not meet state water quality standards. All waterbodies assessed by the IDEM are reviewed every two years to determine whether their water quality meets the state's requirements. Those waterbodies that do not contain sufficient water quality levels are included on the state's impaired waterbodies or 303(d) list.

Three streams in the Big Pine Creek watershed are designated as outstanding rivers (Figure 14). These include portions of the mainstem of Big Pine and Mud Pine Creeks, as well as a portion of Fall Creek, a small tributary to Big Pine. This designation requires that these waterbodies be treated differently with regard to some state statutes and rules. Specifically, logjam removals and utility crossing requirements are more stringent within these waterbodies.

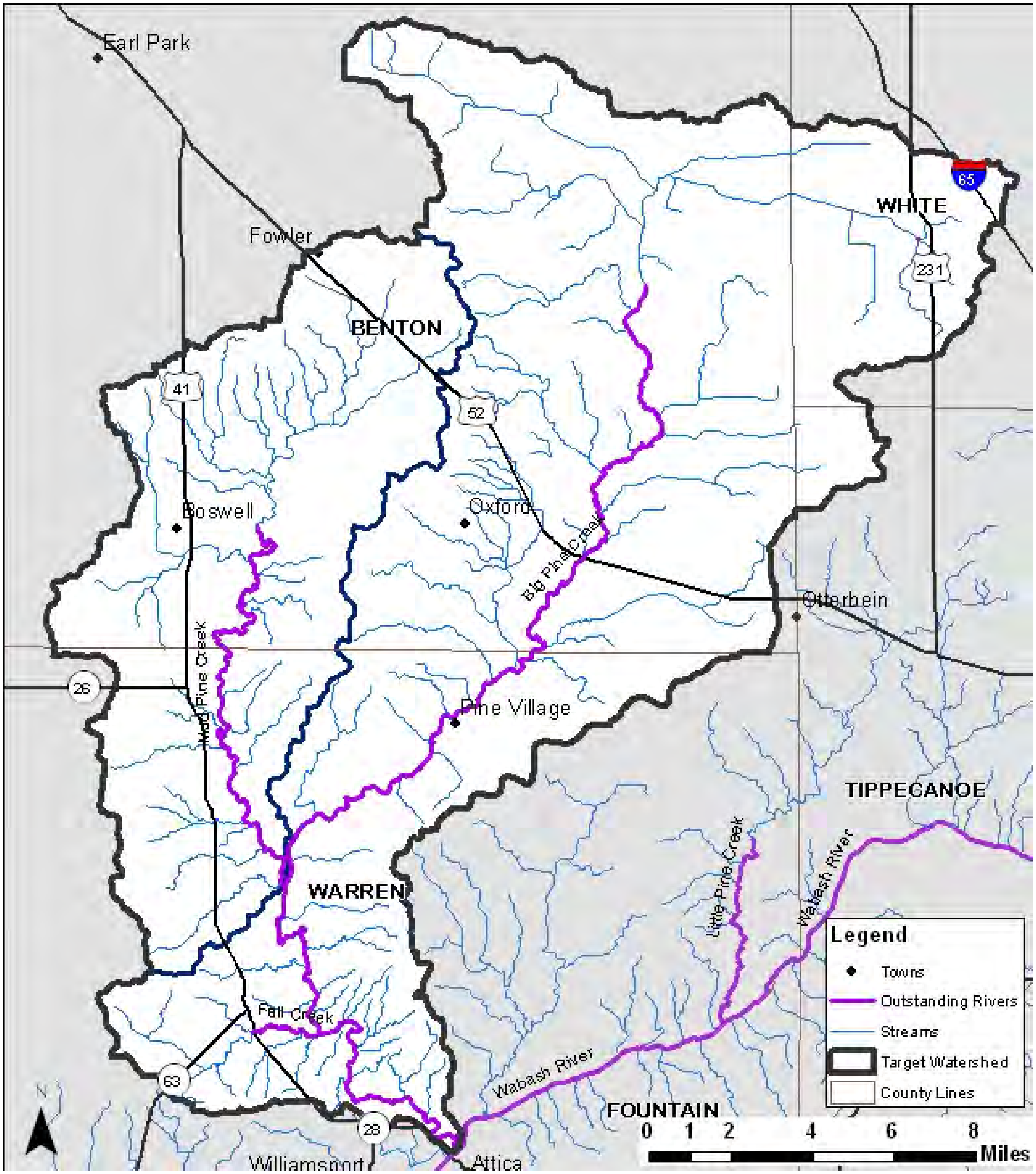


Figure 14. Outstanding river locations in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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 below.

Eleven stream segments within the Big Pine Creek watershed, a total of 151.2 miles, were included on the list of impaired waterbodies. Table 6 details the listings in the watershed, while Figure 15 maps the segments and their locations within the watershed. Waterbodies are listed as impaired for *E. coli*, impaired biotic communities, nutrients, dissolved oxygen, and polychlorinated biphenyls (PCBs).

Table 6. Impaired waterbodies in the Big Pine Creek watershed, from the draft 2012 IDEM 303(d) list.

HUC	Assessment Unit Name	County/Location	Cause of Impairment
51201080304	Mud Pine Creek	Warren Co.	PCBs in fish tissue
51201080304	Spring Branch	Warren Co.	PCBs in fish tissue
51201080304	Mud Pine Creek - Unnamed Tributary	Warren Co.	PCBs in fish tissue
51201080401	Big Pine Creek (Headwater)	White Co.	Impaired biotic communities, Dissolved Oxygen, Nutrients*
51201080401	Big Pine Creek - Unnamed Headwater Tributary	White Co.	Dissolved Oxygen, Nutrients*
51201080401	Vanatta-O'Conner Ditches	White Co.	Impaired biotic communities, Dissolved Oxygen, Nutrients*
51201080401	Roudebush Ditch	White Co.	Dissolved Oxygen, Nutrients*
51201080402	Big Pine Creek (Big Pine Creek Ditch)	Benton Co./White Co. (south of Miller Ditch)	Impaired biotic communities
51201080402	Miller Ditch	Benton Co./White Co.	Impaired biotic communities
51201080403	Little Pine Creek	Benton Co.	*E. coli*
51201080403	Little Pine Creek - Unnamed Tributary	Benton Co.	*E. coli*
51201080404	Owens Ditch	Benton Co.	Impaired biotic communities
51201080405	Brumm Ditch	Benton Co./ Tippecanoe Co.	Impaired biotic communities
51201080406	Darby Ditch	Benton Co./ Tippecanoe Co.	Impaired biotic communities
51201080407	Big Pine Creek - Unnamed Tributary (Brown Ditch)	Benton Co.	Nutrients
51201080409	Big Pine Creek - Unnamed Tributary	Warren Co.	*E. coli*
51201080409	Big Pine Creek	Warren Co.	*E. coli*
51201080410	Big Pine Creek	Warren Co.	*E. coli*, PCBs in fish tissue

*Included on the 2012 draft list as algae impairments, but changed to nutrients on the 2014 list.

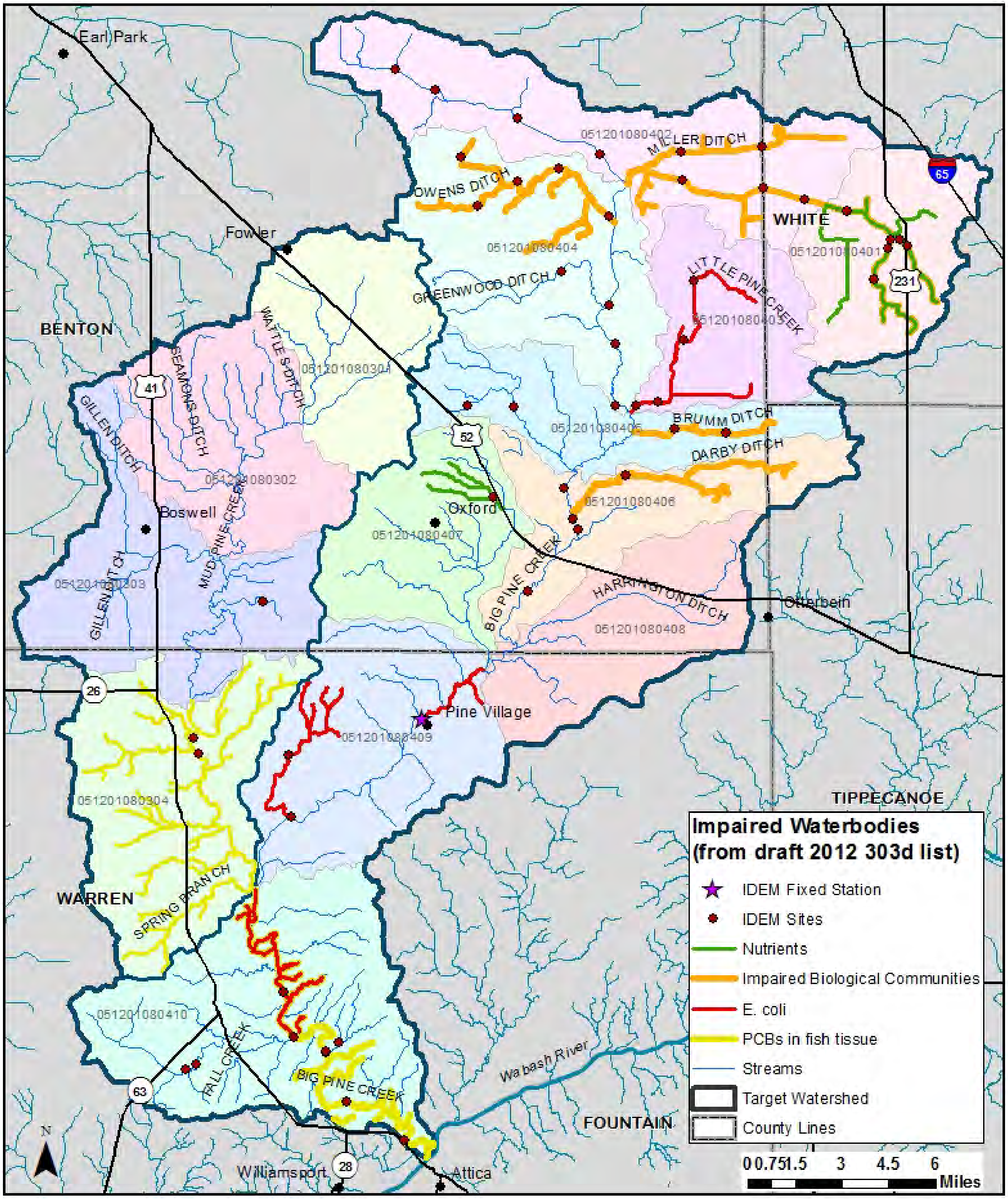


Figure 15. Impaired waterbody locations in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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 16 details the locations of floodplains within the Big Pine Creek watershed. Extensive floodplain land east and west of Pine Village are areas that can be expanded on. Past storm events have blown down trees along Mud Pine Creek that are resulting in a backup of water into productive floodplain lands.

Approximately 3% (5,972 acres) of the Big Pine watershed lies within the 100-year floodplain (Figure 16). 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 floodplain in the Big Pine watershed is classified as Zone A.
- 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.
- 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.

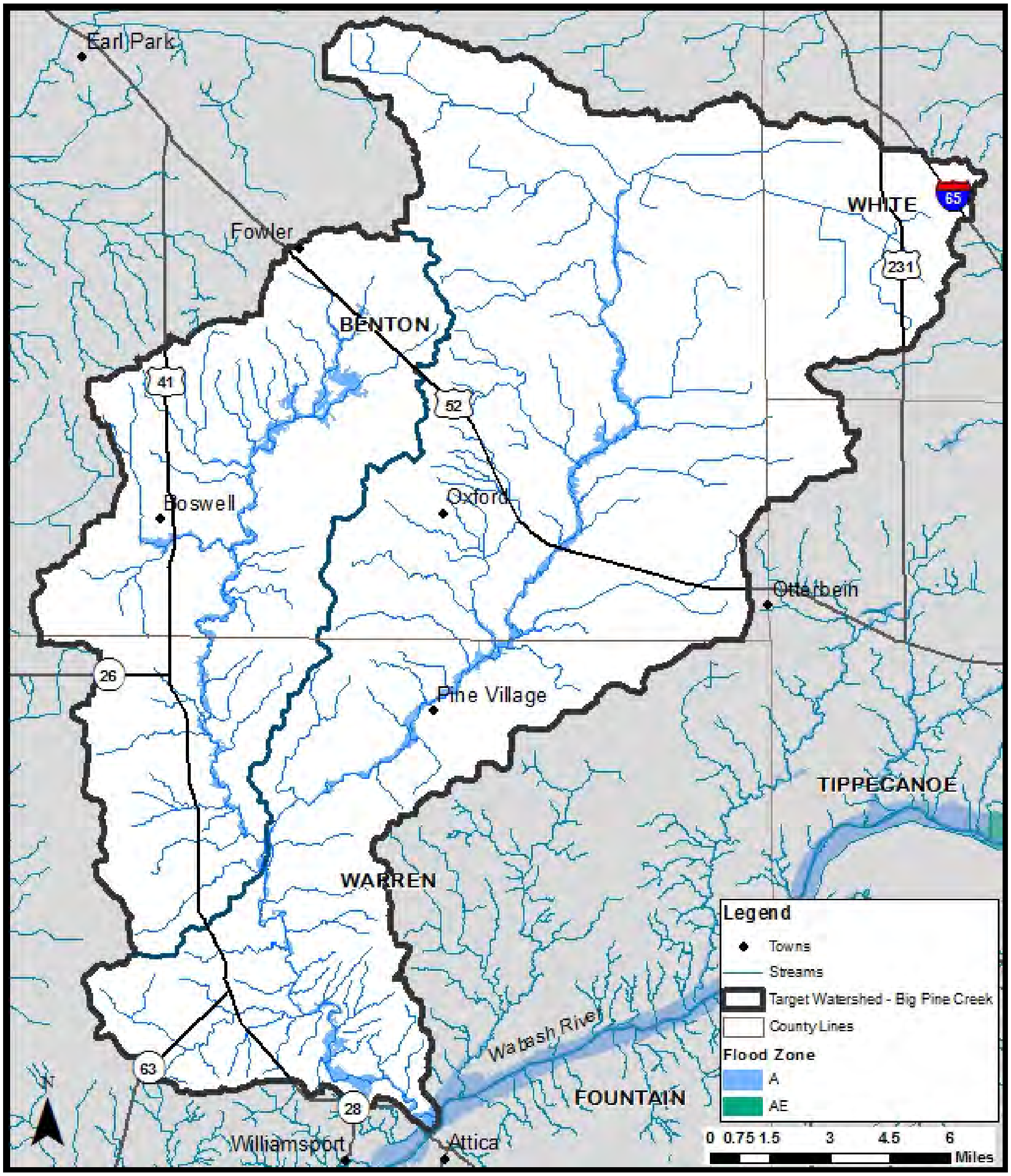


Figure 16. Floodplain locations within the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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 3,651 acres, or 2%, of the watershed. When hydric soil coverage is used as an estimate of historic wetland coverage, it becomes apparent that 95% of wetlands have been modified or lost over time. This represents 111 square miles of wetland loss within the Big Pine 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 17 shows the current (pink) and historic (green) extent of wetlands within the Big Pine watershed. Wetlands displayed in Figure 17 result 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.

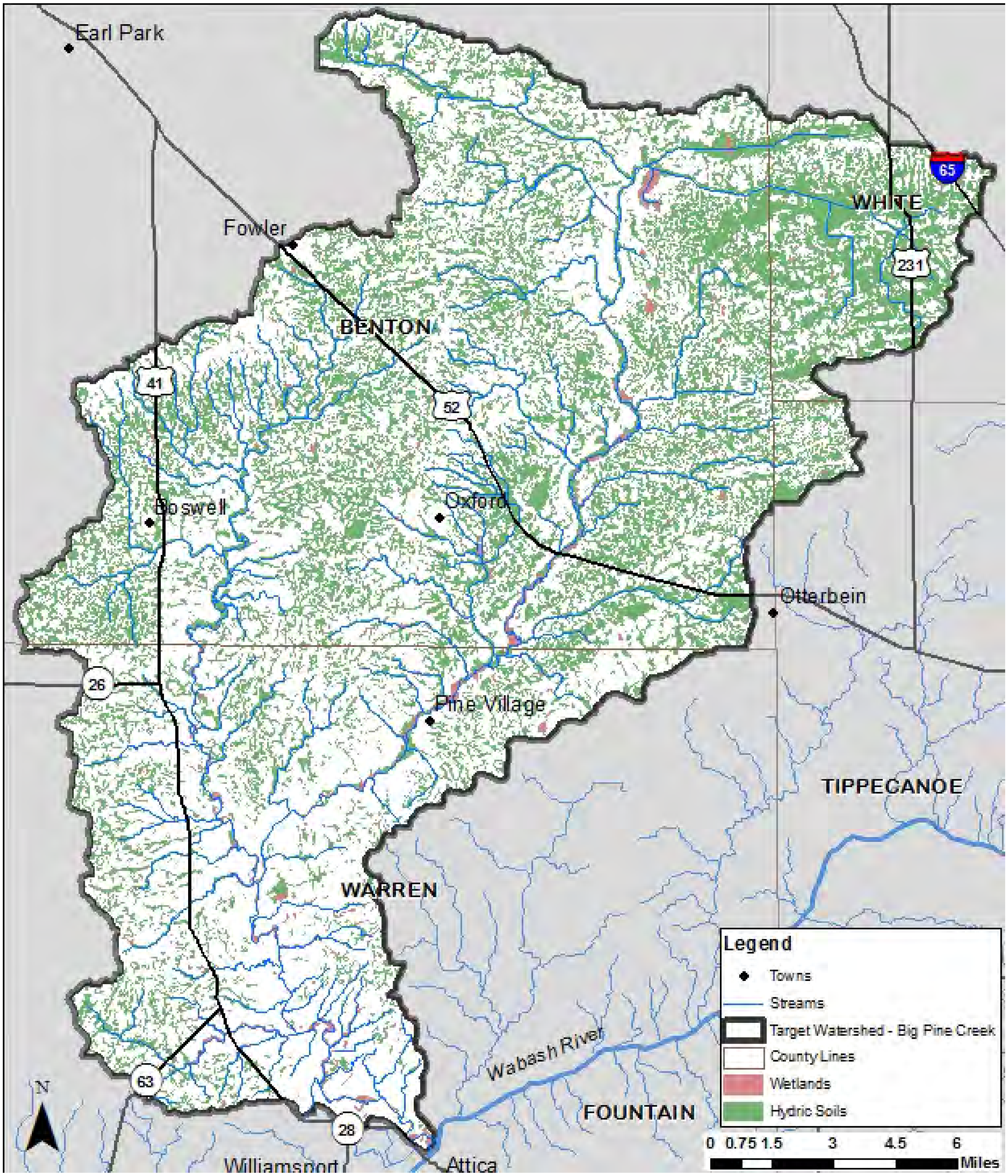


Figure 17. Wetlands and hydric soils located in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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. Because of the small size of the towns within the Big Pine watershed, storm drains are generally not present, or present in only a very limited basis.

2.7.7 Wellfields/Groundwater

In general, municipal water supply is taken from the Lafayette (Teays) Bedrock Valley System, associated with the Wabash River which traverses north-central Indiana. Ground-water conditions are generally good to excellent in many parts of this segment of the Lafayette (Teays) Bedrock Valley. Both an intermediate level and a basal sand and gravel aquifer are present within and above the bedrock valley. The intermediate zone, which occurs at a depth of about 100 to 150 feet, appears in most areas to offer the greater potential for obtaining wells yielding 500 to 1,000 gallons per minute (gpm) (Bruns and Steen, 2003).

In sections of the Teays Valley Green Hill to Little Pine Creek the bedrock valley here gently bends to the northwest and then returns to a west trend. In the eastern portion of this segment the valley is broad, five to six miles across. The sudden narrowing of the valley also is a change in bedrock to a more resistant bedrock type. This segment has thick continuous sand and gravel bodies capable of yielding significant quantities of water. Properly constructed wells in this area should be able to produce enough water for most needs. Two high-capacity wells have reported yields of 300 to 1,000 gpm. Well depths in this area range from 40 to 250 feet, with most wells in the 90 to 180 foot range (Bruns and Steen, 2003).

From Little Pine Creek to Mud Pine Creek, the Teays Valley continues its westward trend following the Benton-Warren county line. It is a complex area where overflow channels and classic stream course morphology lie buried beneath deposits from multiple glacial advances. To the communities of Otterbein and Oxford, the buried valley has become an essential source of high-quality ground water. The valley width remains approximately two to three miles in the eastern portion of this segment, but about three miles northwest of Pine Village the valley width constricts to less than two miles. At the western edge of this segment, along Mud Pine Creek, the valley widens to four to five miles across. Two miles southeast of Oxford a major tributary enters the valley, divides and runs for miles. The basal aquifer should be capable of yielding 1,000 gpm to properly constructed wells. Water levels are usually between 25 and 60 feet. The thick, largely untapped, basal sand and gravel zone represents a major water-supply source in this portion of Indiana (Bruns and Steen, 2003).

Recharge of local aquifers occurs in the same manner as do many of the other aquifers in the state, namely by the downward percolation of local rainfall through the soil horizon and underlying formations. However, localized significant rainstorms can produce relatively quick response to recharge especially if adjacent areas did not receive the rainfall. Layers of clay and hard infrastructure can limit this recharge. Care must be taken to ensure the quality of the water from alluvial and surficial aquifer source waters. Table 7 lists wellhead protection areas within and adjacent to the Big Pine watershed. The wellhead protection areas correspond to the communities shown in Figure 2. Potential pollution from construction, sewage outfall, illegal dumping, agriculture, and storm water runoff must be avoided or controlled due to the recharge of these aquifers from runoff and river water.

Table 7. Wellhead protection areas in and adjacent to the Big Pine Creek watershed.

County	PWSID	System name	Population	Next Plan due	Due date
Benton	5204002	Boswell Water Department	810	Phase 2	12/13/2012
Benton	5204004	Otterbein Water Department	1,262	Phase 2	3/17/2015
Benton	5204005	Oxford Water Utility	1,200	Phase 2	9/2/2014
Benton	5204006	Fowler Water Works	2,324	Phase 2	9/15/2014
Warren	5286004	Williamsport Water Utility	2,435	Phase 2	12/15/2013

Pumping of groundwater in the watershed for agricultural purposes (center pivot irrigation systems) has caused a drop in the groundwater in some locations. Recently, the town of Templeton ran out of water due to a drop in groundwater locally. It is suspected that a combination of the drought in 2012 along with increased pumping for agricultural purposes were the causes. In the last few months more wells have been drilled for center pivot irrigation. This can be a critical issue as we face summer drought, fence rows are cleared and wetlands are filled in to provide this infrastructure, resulting in a loss of natural filters that hold and slow down water. Local stakeholders are concerned with protecting groundwater availability in the Teays River valley. Groundwater contamination from the surface was not a concern raised by stakeholders.

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. In 1886, Professor John Coulter placed the Big Pine watershed into the prairie region. The prairie region was characterized by sparse trees and shrubs most commonly including black walnut, buroak, white ash, shagbark hickory, black cherry, sugar maple, beech, pawpaw, buckeye, sassafras, redbud, mulberry, crabapple, and dogwood. DeHart (1909) details the presence of wildflowers and prairie grass intermingled with trees especially in the bottom lands adjacent to the Wabash River and its tributaries. Descriptions from that time period detail the presence of kingfishers, bluejays, blackbirds, cranes, and heron waiting patiently for schools of fish including salmon, bass, redhorse, and pike within the river. DeHart (1909) lamented the loss of forests throughout the region as more settlers arrived. He described Indiana as becoming a "treeless state" where native timber stands were removed for farming purposes. He wrote "with more timber our streams would again flow with more water; our climate would be better, crops would be better and prosperity would be insured to those that come after us." He further noted issues with forest removal, citing the Wabash River drainage as one of the most concerning areas in the state creating vast nude areas along the Wabash River bluffs.

2.8.1 Natural and Ecoregion Descriptions

According to Homoya et al.'s (1985) classification of natural regions in Indiana, the Big Pine Creek watershed lies within two natural regions: the Tipton Tillplain and the Grand Prairie natural regions (Figure 18). The central till plain natural region follows the entrenched southern Big Pine Creek valley northward through southern Warren County. The valley and adjacent uplands were originally forested and much of that forest still remains today in areas that are too steep for agricultural production. These forests were characterized by a mix of oaks, maples, ash, elm, and sycamore and better drained soils home to hickory, tulip tree, white ash, sugar maple, and beech (Jackson, 1997). The uplands fall within the Grand Prairie Natural Region, and supported a mosaic of open wetlands and grasslands. These habitats were maintained by frequent fires, set by Native Americans to manage habitats for wildlife. Because of their productivity, virtually all of the wetlands and grasslands have been converted to agriculture.

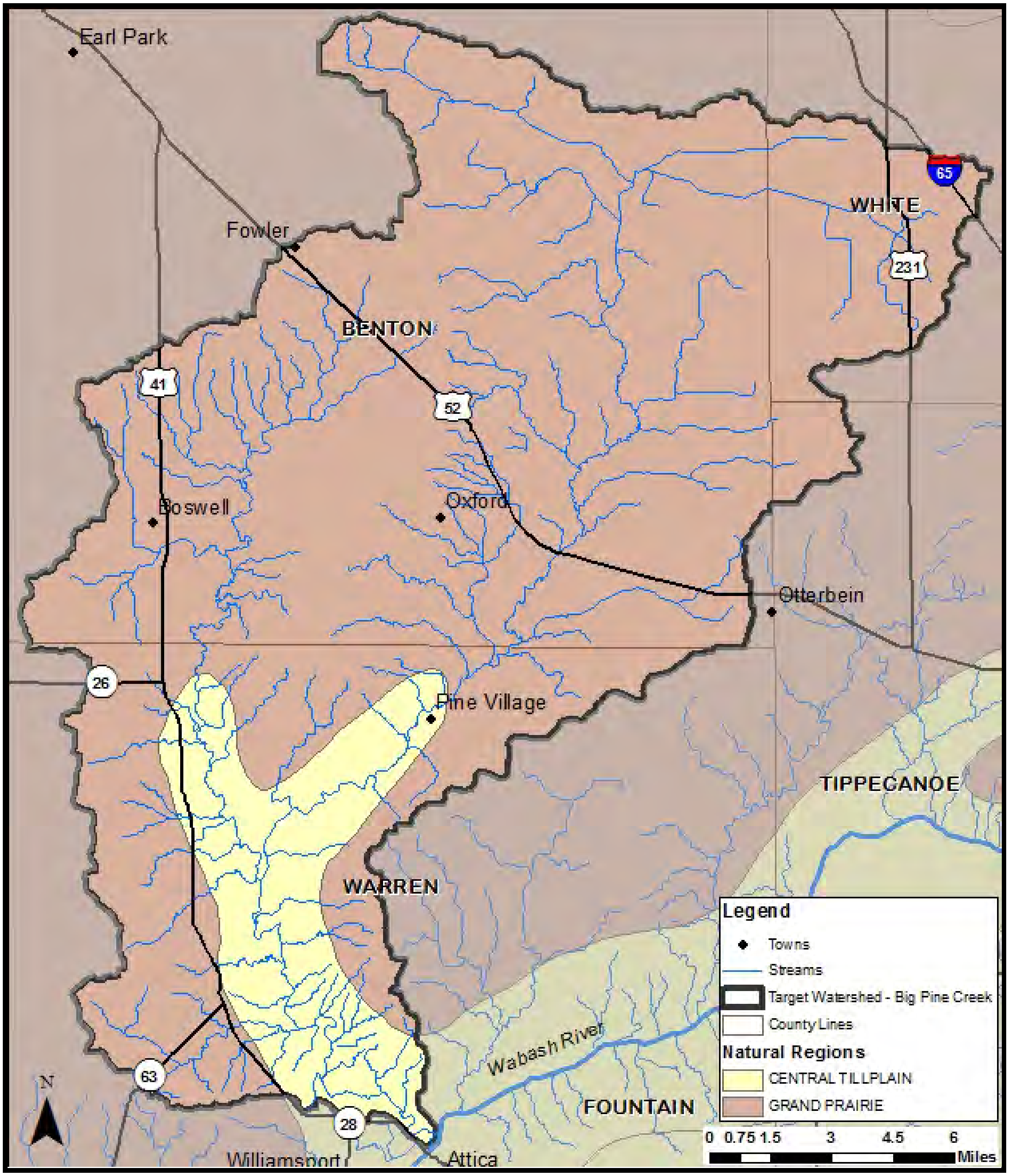


Figure 18. Natural regions in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

On a national scale, the watershed is split between two ecoregions that follow the same lines defined by Homoya et al. (1985), the watershed lies within two ecoregions: the central tallgrass prairie ecoregion and the central tillplain ecoregion (Figure 19).

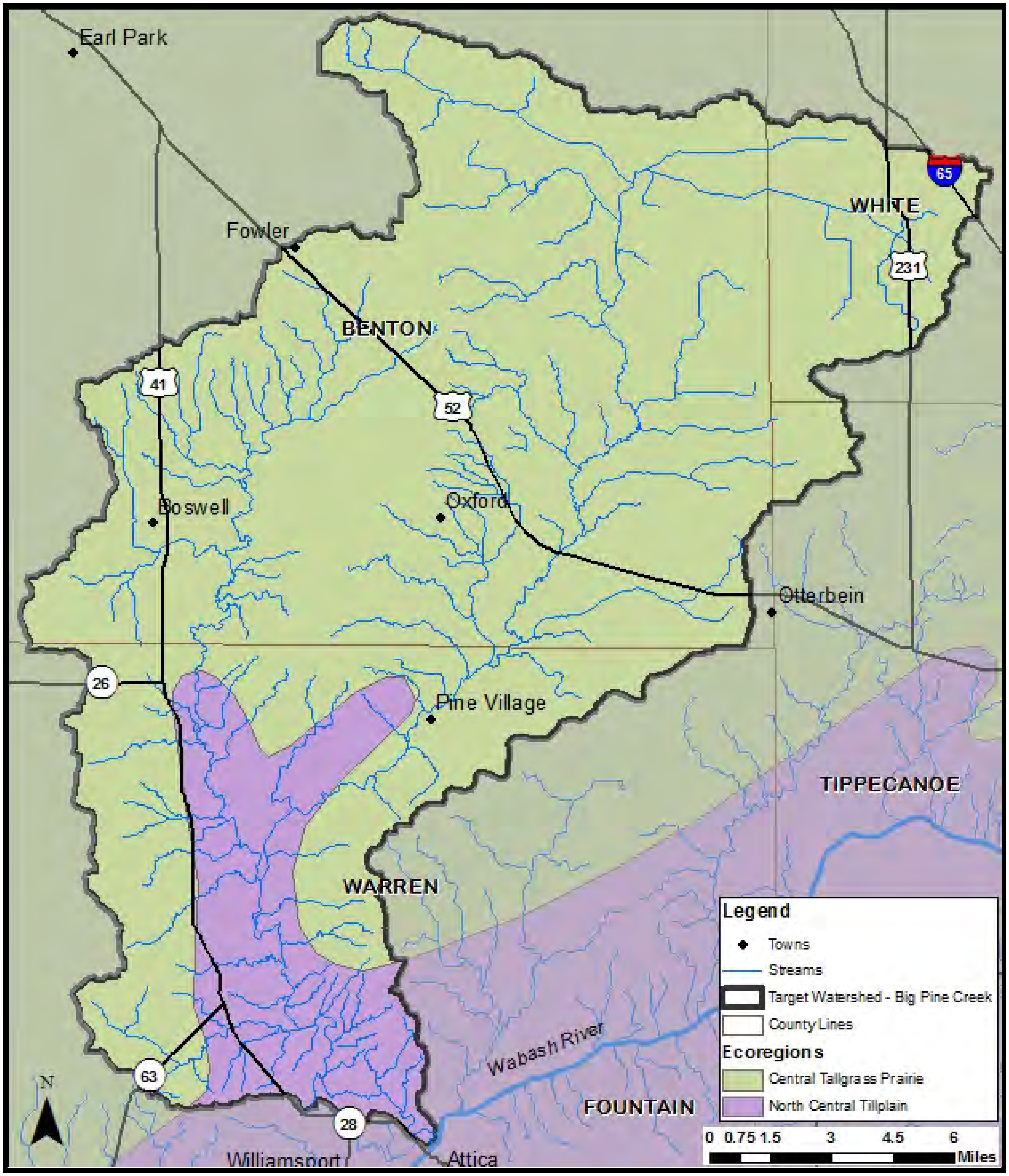


Figure 19. Level III eco-regions in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.8.2 Wildlife Populations

Individuals are concerned about lack of knowledge of local wildlife populations and the impact that changing land uses could have on these populations. Additionally, pathogen inputs from wildlife are also a concern. 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. Much of the Big Pine watershed lies within the northwest region as defined by the IDNR. Although we were unable to locate wildlife density information specifically for the Big Pine watershed, we were able to use density information from 2005 for a neighboring watershed (Region of the Great Bend of the Wabash River). It is likely that wildlife densities would be similar between these two watersheds. Those densities are shown in Table 8, with deer and squirrel 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 observation 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.

Table 8. Surrogate estimates of wildlife density in the Big Pine Creek watershed (from the Region of the Great Bend of the Wabash River watershed).

Animal	2005 Population Observation (per 1000 hrs of observation)
Coyote	21
Squirrel	650
Opossum	12
Rabbit	42
Raccoon	43
Fox	8
Turkey	158
Geese	487
Duck	219
Deer	947

Source: Plowman, 2006

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.

Appendix C includes the database results for the Big Pine watershed, as well as county-wide listings for those counties which occur within this watershed.

In total, 98 observations of listed species and/or high quality natural communities occurred within the Big Pine watershed (Figure 20). These observations include five birds, three fish, eight mammals, one reptile, seven freshwater mussels, eighteen plants, and three community types. Reptiles, fish and mussels are all tied directly to the Big Pine and Mud Pine Creeks and/or riparian habitats. The associated birds are spread throughout the watershed but primarily in greater abundance along the wooded river/stream corridors, especially in the southern portion of the watershed where extensive forests occur in the deeply dissected lands surrounding the stream. Mammals and plants dot the watershed landscape however do occur in particular hotspots in the natural lands and floodplain in the watershed.

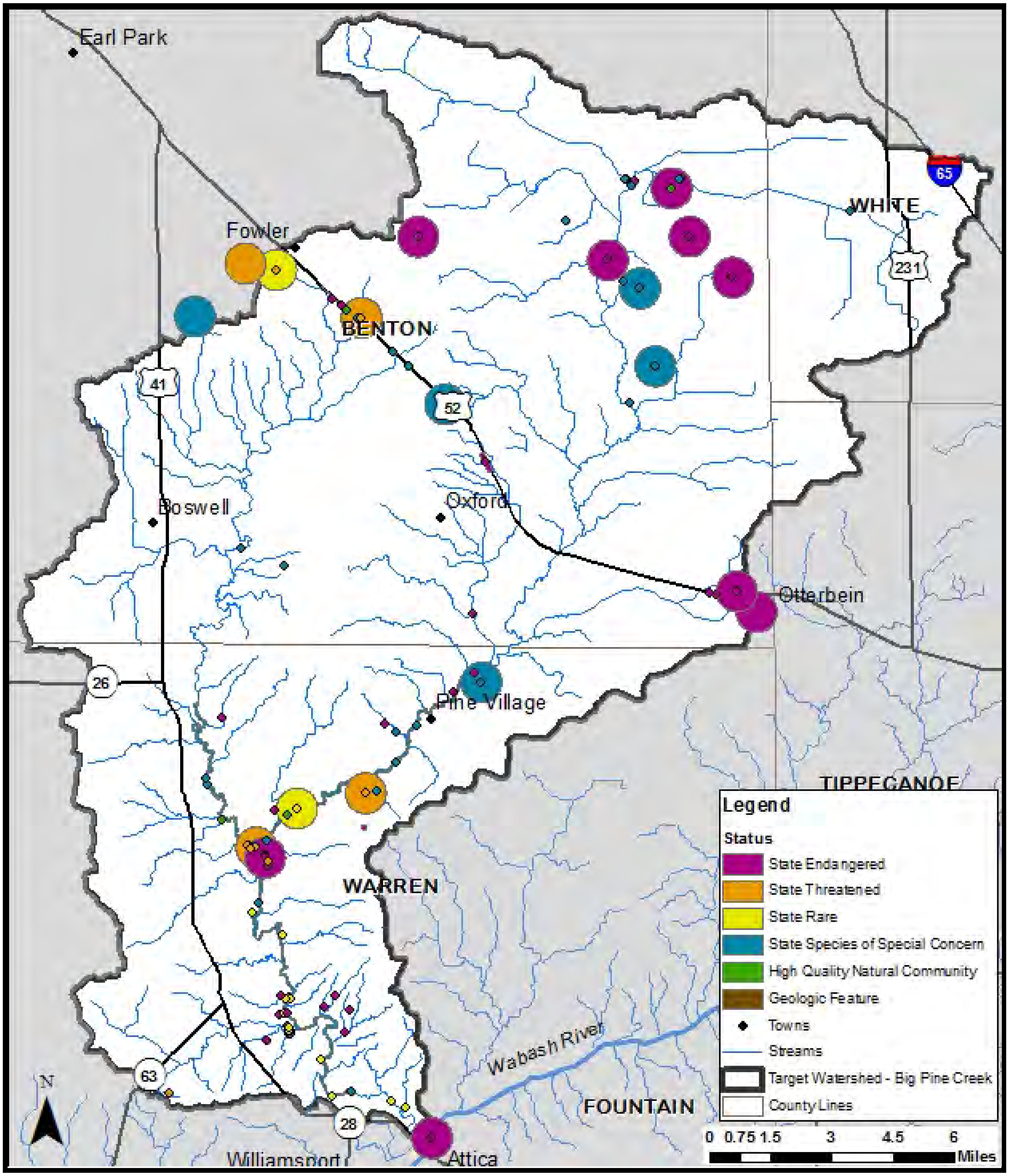


Figure 20. Locations of special species and high quality natural areas observed in the Big Pine Creek watershed.

Data used to create this map are detailed in Appendix C. Note: Polygons reflect locational uncertainty associated with reported observations. A small circle indicates that there is less uncertainty of where the observation is mapped in relation to its real world location. A large circle reflects more uncertainty. Fish and mussels locations are mapped as linear polygons typically following river and stream stretches based on observational records along that stretch of the stream (R. Hellmich, personal communication June 12, 2014).

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, reproducing populations of grass carp, and the long-term impacts of zebra mussels and Asian carp on the Wabash River. Many species impact portions of the Big Pine 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 Pine Creek watershed.

Species	Benton	Tippecanoe	Warren	White
Plant species				
Asian bush honeysuckle	X	X	X	X
Autumn olive	X	X	X	X
Black locust		X	X	
Buckthorn		X		
Canada thistle	X	X	X	X
Chinese yam		X		
Common reed	X	X	X	X
Creeping Charlie	X	X	X	X
Creeping Jenny	X	X	X	X
Crown vetch	X	X	X	X
Dame's rocket	X	X	X	X
Garlic mustard	X	X	X	X
Japanese hedge parsley		X		
Japanese honeysuckle	X	X	X	X
Japanese knotweed	X	X		
Mulitflora rose	X	X	X	X
Norway maple	X	X		X
Oriental bittersweet				X
Periwinkle	X	X	X	X
Privet		X	X	X
Purple loosestrife				X
Purple winter creeper	X	X	X	X
Reed canary grass	X	X	X	X
Russian olive		X		
Siberian elm	X	X	X	X
Smooth brome	X	X	X	X
Spotted knapweed		X		
Star-of-Bethlehem	X	X	X	X
Sweet clover	X	X	X	X
Tall fescue	X	X	X	X
Tree of heaven	X	X	X	X
White mulberry	X	X	X	X
Winged burning bush		X		
Fish and Mussel Species				
Silver carp		X	X	
Bighead carp		X	X	
Grass carp		X	X	
Common carp		X	X	
Zebra mussel		X	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 Pine Creek watershed. Recreational opportunities include parks, fish and wildlife areas, nature preserves, fairgrounds, golf courses, and school grounds (Figure 21). There are several DNR Fish and Wildlife Areas in Benton County, located along Big Pine and Mud Pine Creeks, which are managed for gamebird habitat. The Nature Conservancy owns and maintains Fall Creek Gorge Nature Preserve, near Fall Creek's confluence with Big Pine Creek in Warren County. Niches Land Trust manages seven nature preserves totaling over 800 acres encompassing forest and wetlands. Big Pine itself is also a very popular stream with canoe and kayak enthusiasts at certain times of the year when the water is high. The nearby cities of Lafayette, West Lafayette, and Attica all maintain multiple park-based facilities, although these are just outside the watershed.

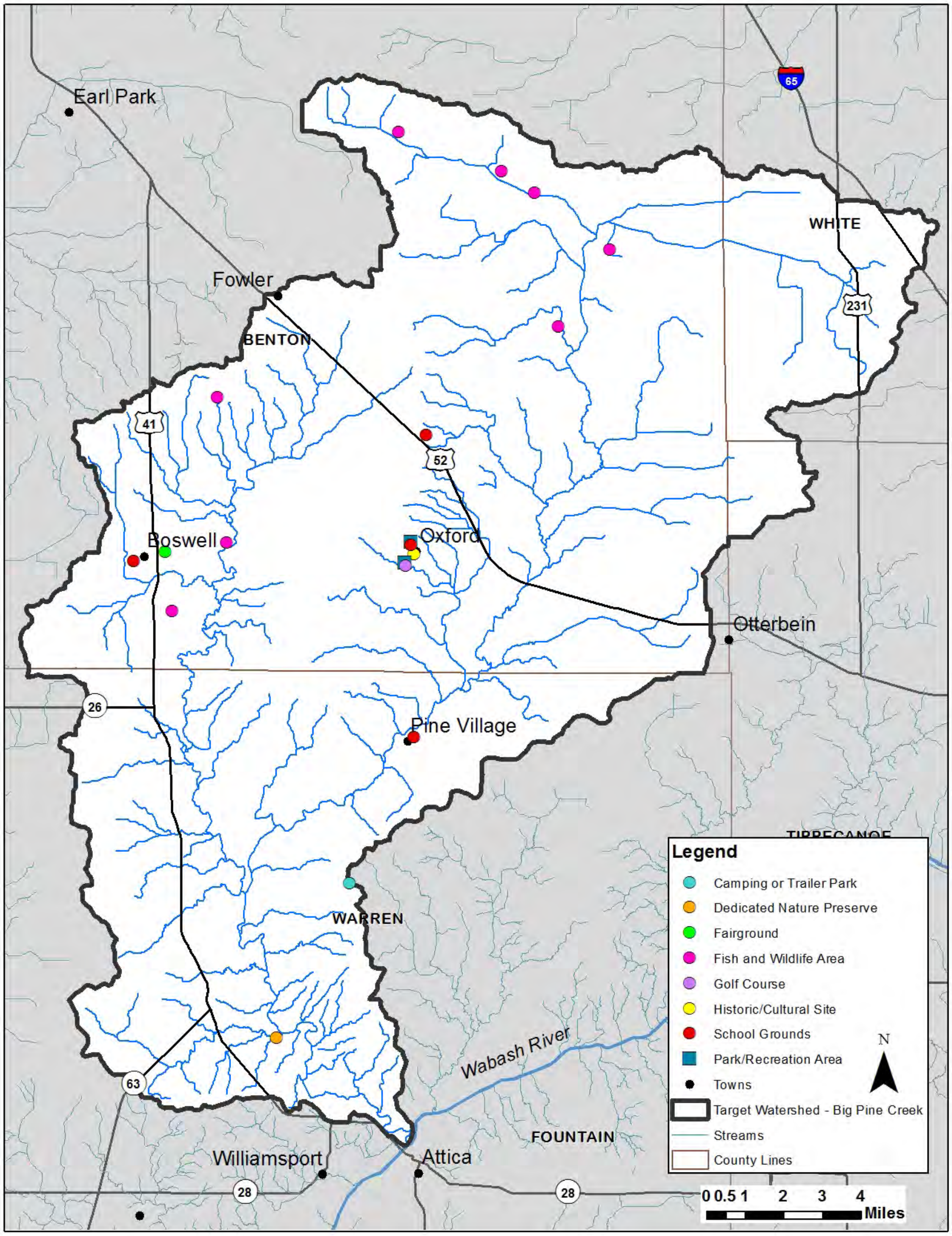


Figure 21. Recreational opportunities and natural areas in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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. A review of the historic land types present in the watershed will provide an idea of the types of restoration that could occur within the watershed and also a basis for the past uses of the land.

2.9.1 Historic Land Use

Historical accounts and data infer that the Big Pine was a full and slow moving stream, with clarity of water, surrounded by wetlands and tall grass prairie that allowed scant storm water runoff (Ladd, 2004). The region was described as being resplendent with large trees and prairies as far as the eye could see. Coulter (1886) described the area as part of the prairie region. Black and white walnut; black, white, and bur oak; white ash; pignut, bitternut, shagbark, and scale bark hickory; wild cherry, sugar maple; and beech were the most common trees (DeHart, 1909). Willow, dogwood, hazelnut, crabapple, plum, pawpaw, buckeye, sassafras, redbud, and mulberry were also prevalent. Coulter (1886) described the low water mark of the Wabash River as being 504 feet above sea level and detailed the numerous clear, cold streams and springs which carried water to the Wabash River.

Native American tribes such as the Miami, would have undoubtedly used the Big Pine for fishing and transportation, as there were numerous villages along the nearby Wabash River (IDNR, 2014). Beginning in the early 19th century, the Native American people were slowly forced out of the region by the white settlers. This included the famous battle at Prophetstown where Native Americans led by Tecumseh were defeated by General William Harrison’s troops just east of the Big Pine watershed.

As white settlement increased, land use in the Big Pine became more intensive, and included the clearing of forests for the purposes of agriculture. The first towns began to be incorporated in the early to mid-1800’s including Attica in 1825, Oxford (the first town in Benton County) in 1843, and Pine Village in 1851. The completion of the Wabash and Erie Canal through the area in the late 1840’s helped to bring growth to the region as did the completion in 1883 of the Chicago and Great Southern Railroad which connected Attica to Fair Oaks. The railroad became known as the “Coal Road” because of the great quantities of coal that was shipped to Chicago along this line (Wikipedia, 2014).

2.9.2 Current Land Use

Today, over 80% of the land in the Big Pine watershed is in row crop agriculture because of the rich soils that were formerly prairies and wetlands (Table 10, Figure 22). In fact, in 2011, Benton and Warren Counties alone produced over 37 million bushels of corn (NASS, 2011). Only about 7% of the land remains forested—largely in areas along the Big Pine or other places too difficult to make row crop agriculture feasible. Almost all the wetlands in the watershed have been drained—less than 1% of the land is currently characterized as wetlands by USGS. In 2013 land values for this productive farm land were over $10,000/acre. There is little urban development, much of the landscape in the Big Pine watershed remains rural with only scattered small towns. Only a little over 5% of the landscape could be classified as developed lands. Definitions for each land cover type are included in Appendix D.

Table 10. Detailed land use in the Big Pine Creek watershed.

Classification	Area (acres)	Percent of Watershed
Cultivated Crops	174,932	83.4%
Deciduous Forest	14,614	7.0%
Pasture/Hay	8,394	4.0%
Developed, Open Space	5,520	2.6%
Developed, Low Intensity	5,484	2.6%
Open Water	269	0.1%
Grassland/Herbaceous	259	0.1%
Developed, Medium Intensity	188	0.1%
Woody Wetlands	90	<0.1%
Developed, High Intensity	86	<0.1%
Barren Land	30	<0.1%
Emergent Herbaceous Wetlands	5	<0.1%
Evergreen Forest	3	<0.1%
Total	**209,875**	**100%**

Source: USGS, 2001

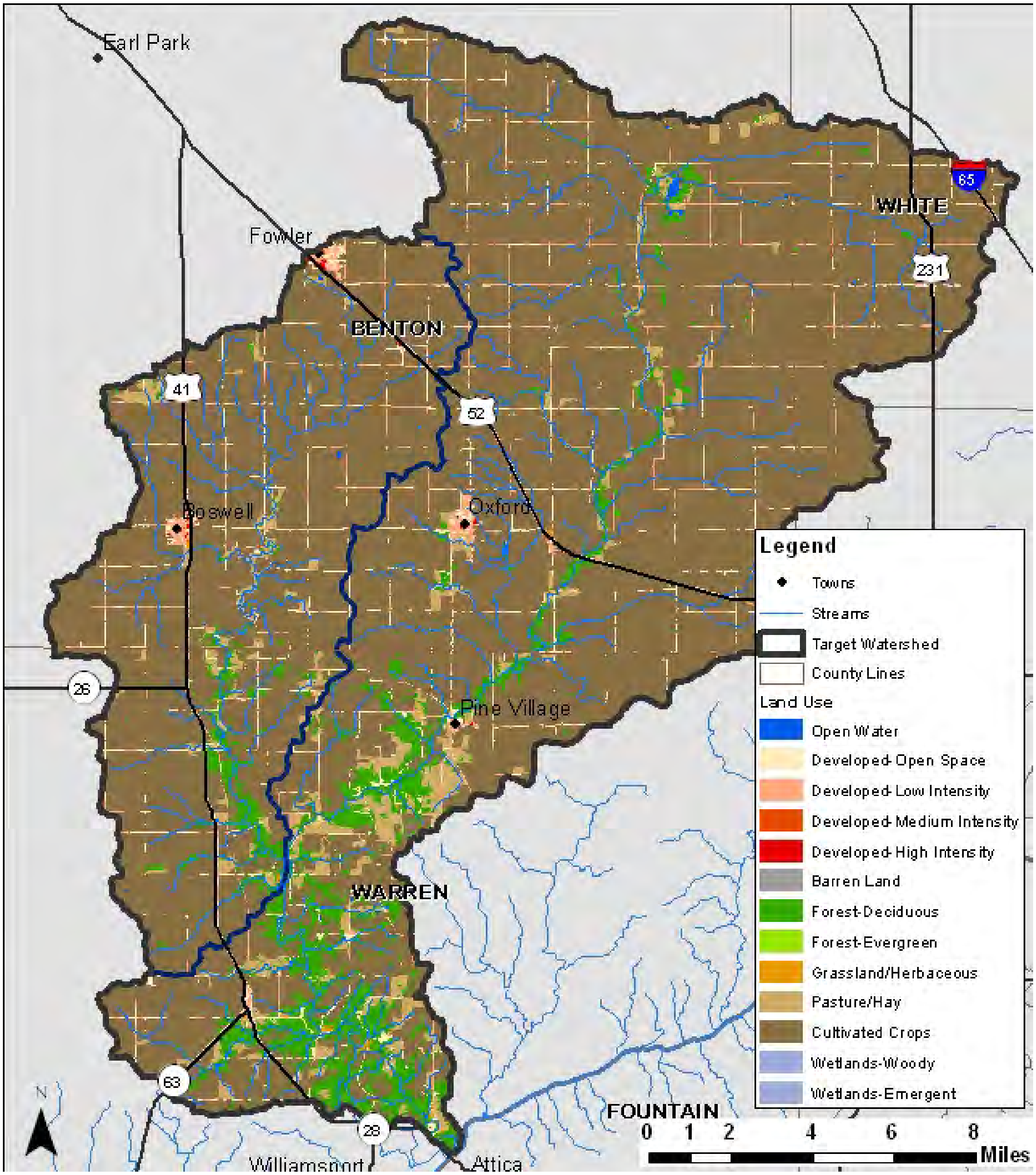


Figure 22. Land use in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.9.3 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. According to USDA data from 2004, cultivated areas cover much the watershed with two-thirds of cultivation occurring in densities of 75% or greater (Table 11, Figure 23).

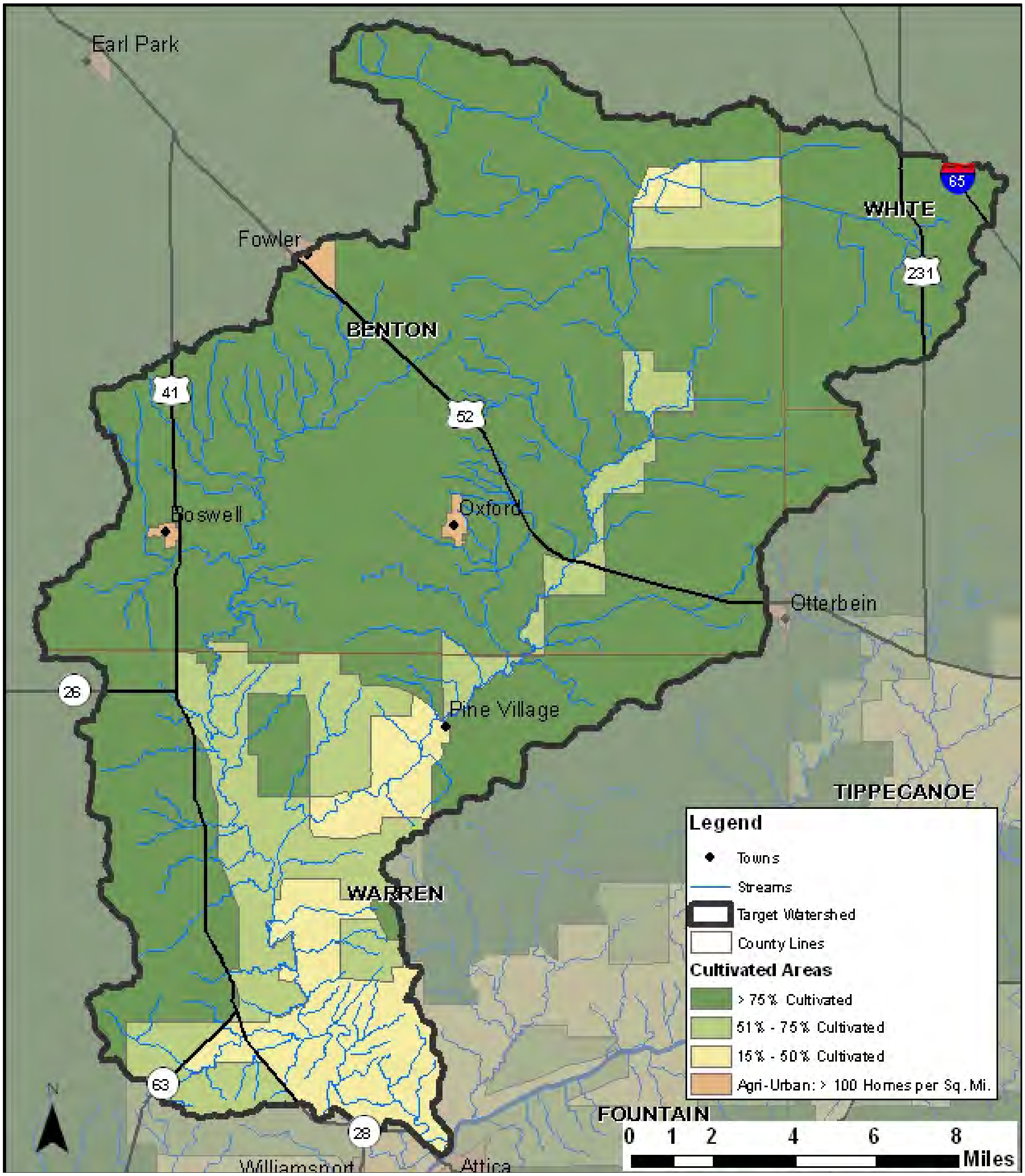


Figure 23. Cultivation density and type (2004) in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

Table 11. Cultivation density and type in the Big Pine Creek watershed

Cultivation Type and Density	Area (acres)	Percent of watershed
> 75% Cultivated	162,922	78%
51% - 75% Cultivated	28,986	14%
15% - 50% Cultivated	16,820	8%
< 15% Cultivated	0	0%
Agri-Urban: > 100 Homes per Sq. Mi.	982	0%
Commercial: > 100 Homes per Sq. Mi.	0	0%
Non-Agricultural	0	0%
Water	0	0%
Total:	**209,709**	**100%**

Source: USDA, 2004

The landscape is over 80% agriculture production, primarily corn and soybeans (Table 12). There are a few cases of corn on corn production while others do a rotation of corn and beans. Much of the local demand for corn is driven by Tate and Lyle, a food company based in the United Kingdom that purchases corn in the Big Pine watershed and converts it to a variety of food products for human and animal consumption.

Table 12. Crop type in the Big Pine Creek watershed based on satellite imagery.

Crop	Area (acres)	Percent of Watershed
Corn	97,053.1	46.3%
Soybeans	69,760.3	33.3%
Forest	15,026.5	7.2%
Grassland/Pasture	12,380.4	5.9%
Developed/Open Space	5,610.6	2.7%
Developed	5,594.9	2.7%
Winter Wheat	2,830.3	1.3%
Alfalfa	1,059.1	0.5%
Open Water	202.3	0.1%
Popcorn or Ornamental Corn	96.8	0.05%
Barren	38.3	0.02%
Winter Wheat/Soybeans	15.5	0.01%
Fallow/Idle Cropland	13.5	0.01%
Other Hay/Non Alfalfa	11.6	0.01%
Clover/Wildflowers/Herbs	8.2	<0.01%
Wetlands	6.4	<0.01%
Oats/Rye	0.7	<0.01%
Corn/Soybeans	0.4	<0.01%
Shrubland	0.2	<0.01%
Total	**209,709**	**100%**

Source: USDA, 2013

Maintaining proper drainage is essential to these rich prairie soils. Extensive tile has been placed in fields and most recently center pivot irrigation has been increasing in the watershed. There are a few farmers using tile control structures and managing the water for production. Farmers in the watershed stress the importance of drainage using tiles and ditches. Many in the past have invested several thousand dollars in tiles to still not get the performance they need and now they realize that their outlets (larger tiles or open ditches) have been compromised with sediment build up and inadequate capacity to hold the water volumes they are receiving today. Figure 24 and Figure 25 depict the tillage transect results for Benton and Warren counties, which make up the majority of the watershed (ISDA, 2013).

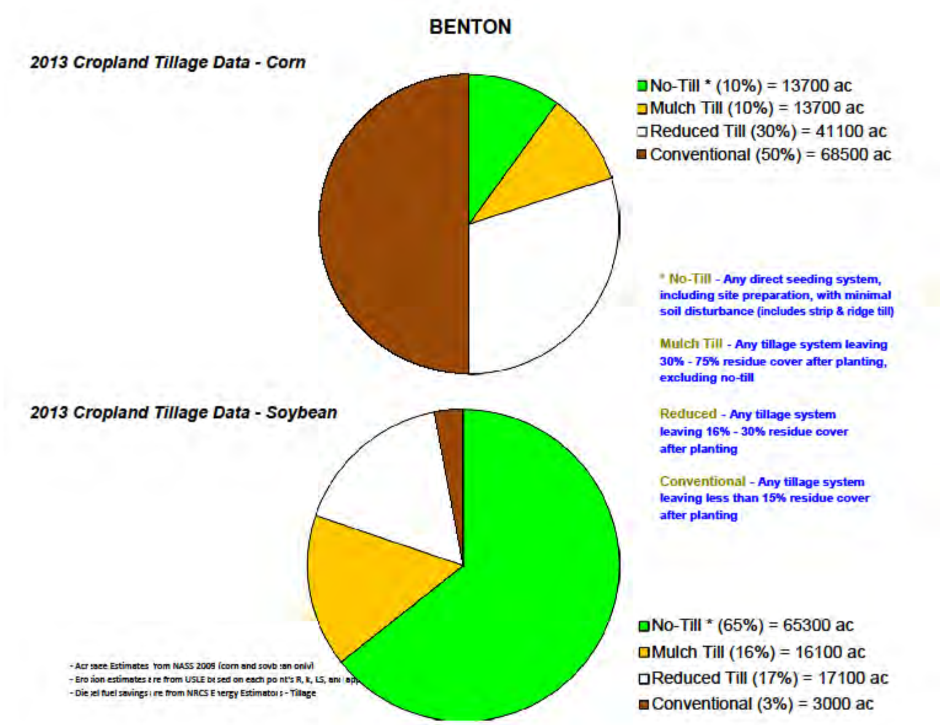


Figure 24. Tillage transect data for Benton County from 2013.

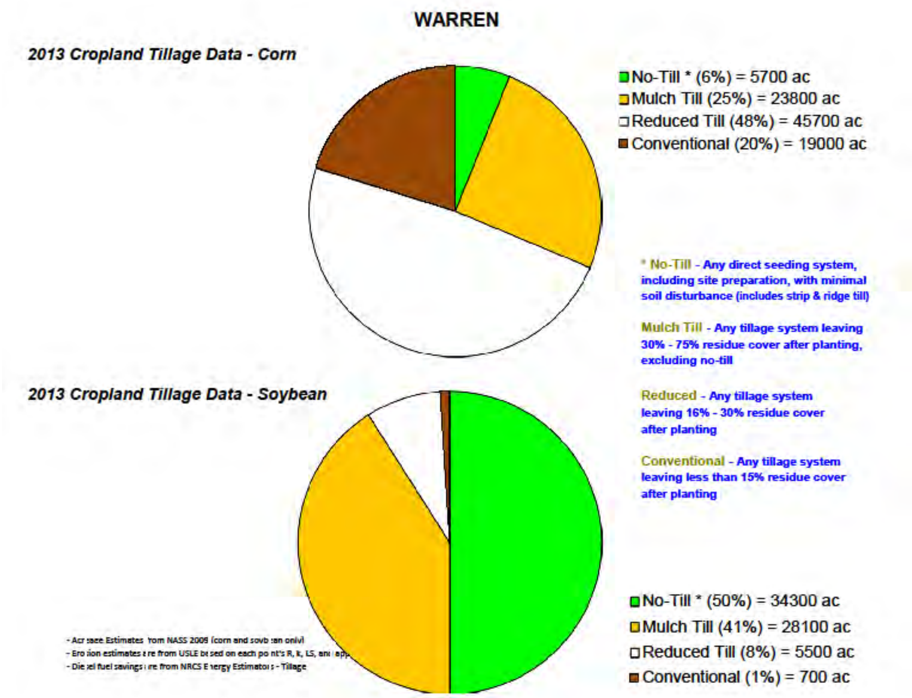


Figure 25. Tillage transect data for Warren County from 2013.

Several producers do what is termed mulch or minimum till in the watershed, but with such an open landscape if the tillage is done in the fall, heavy rain and wind events in the winter and early spring can cause a great deal of soil loss. There may be a need to raise the bar on what ranks as mulch or minimum till in terms of the soil residue left in place, as the residue left from the harvest of GMO crops is more difficult to break down. The preferred conservation cropping method includes bolstering soil microbial populations and implementing a nitrogen management program appropriate for corn on corn systems.

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) (NASS, 2007). These data indicate that corn (97,053 acres) and soybeans (69,760 acres) are the two primary crops grown in the watershed (Table 12).

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 7,153 tons of nitrogen and 3,538 tons of phosphorus are applied annually within the Big Pine watershed (Table 13).

Table 13. Agricultural nutrient usage for corn in the Big Pine Creek watershed.

Nutrient	Acres of Corn	% of Area Applied	Applications (# / year)	Rate / Application (lb / acre)	Total Applied / Year (tons)
Nitrogen	97,053	100	2.2	67	7,153
Phosphorus	97,053	93	1.4	56	3,538

Source: NASS, 2007

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 60 tons of atrazine and approximately 54.6 tons of glyphosate are applied to cropland in the Big Pine watershed annually (Table 14).

Table 14. Agricultural herbicide usage in the Big Pine Creek watershed.

Crop	Acres	Application Rate (lb / acre)	Total Applied (lbs)	Total Applied / Year (tons)
Corn (Atrazine)	97,053	1.24	120,346	60.2
Corn (Glyphosate)	97,053	0.60	58,232	29.1
Soybeans (Glyphosate)	69,760	0.73	50,925	25.5

Source: NASS, 2006

Confined Feeding Operations and Hobby Farms

A mixture of small, unregulated and larger, regulated livestock operations (confined feeding operations) is found within the Big Pine 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 five 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 26). Four of the CFOs house swine, with capacities ranging from 680 to 5,080 animals at each facility. One of the CFOs in the Spring Branch subwatershed houses 420 dairy cows. There is one dairy CFO located just north of the Big Pine Creek watershed. Although the facility is located outside of the watershed, about 15% of the land used for manure application is within the watershed, so its contribution to the watershed was prorated accordingly. In total, approximately 32,000 animals per year are housed in CFOs in the watershed, generating over 129 million pounds of manure per year spread over 3,074 acres in the watershed. This much manure contains nearly 820,000 pounds of nitrogen and 262,000 pounds of phosphorus.

Fifty-two small, unregulated animal farms were identified during the windshield survey, which is most likely an underestimate of the actual number. These small “mini farms” have small numbers of cattle, horses, or goats, which could be sources of nutrients and *E. coli* as these animals exist on small acreage lots with limited ground cover.

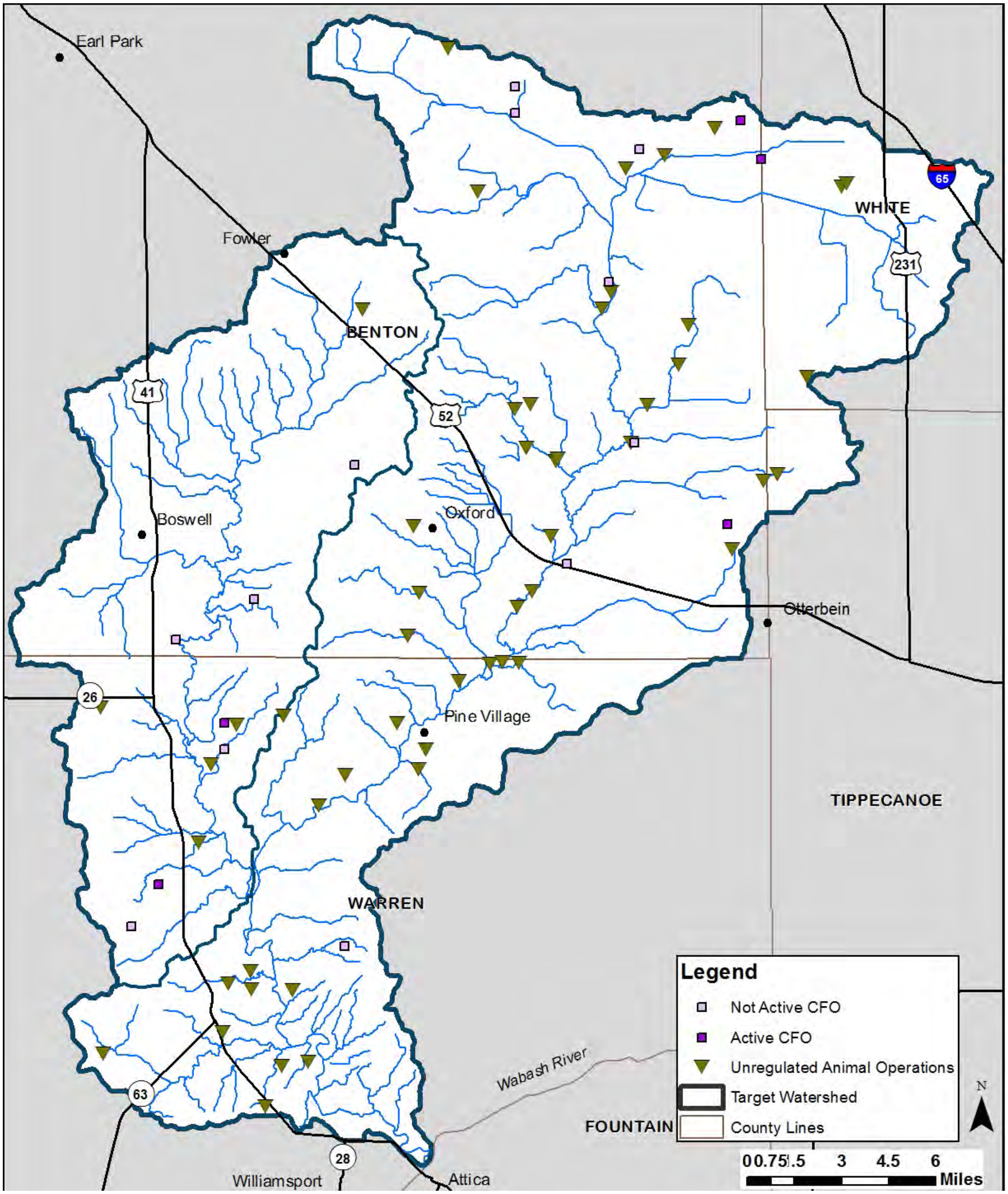


Figure 26. Confined feeding operation and unregulated animal farm locations within the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.9.4 Natural Land Use

Natural land uses including forest, wetlands, and open water cover less than 8% of the watershed. Individuals are concerned that too much forested land is being lost within the watershed and would like to see reforestation prioritized. Approximately 14,700 acres or 7% of the watershed are covered by trees. Forest cover occurs adjacent to waterbodies throughout the watershed, with the extent of forests increasing towards the southern end of the watershed where the steeper terrain has made it more difficult to clear for agriculture (Figure 22). However, most forested tracts are not contiguous and large lengths of the watershed streams no longer contain intact riparian buffers. Specific areas of concern will be discussed in further detail in subsequent sections. Altered hydrology is a major issue in the watershed and natural filters need to be established (grasses, trees, wetlands) to capture and hold water back. This is a critical factor as more land is cleared and drained for row crop production.

2.9.5 Urban Land Use

Urban land uses cover less than 1% of the watershed (Table 10). 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 septics and CSO's that allow untreated sewage to flow into the watershed during heavy rain events. Upgrades needed for facilities such as WWTP's can be cost-prohibitive. Strategies such as the wetland cells being used by Oxford are a great option that balances need and expense.

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 like Oxford and Boswell, 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 Oxford, Boswell, Fowler and Pine Village and along roads throughout the watershed (Figure 27). Estimates indicate that only 5,015 acres (2%) of the watershed are 25% or more covered by hard surfaces, while 202,268 acres (96.4%) of the watershed is covered by 10% or less of 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). Since 96.4% of the watershed is 10% or less impervious surface, this is not something that will be a focus during the implementation phase of the watershed management plan. The areas where it could play a role are those that have a greater percentage of impervious surfaces, like the tributaries of Big Pine Creek located near Oxford, Boswell, Fowler and Pine Village, such as Brown Ditch, Goose Creek, the headwaters of Mud Pine Creek, and the mainstem of Big Pine Creek near Pine Village.

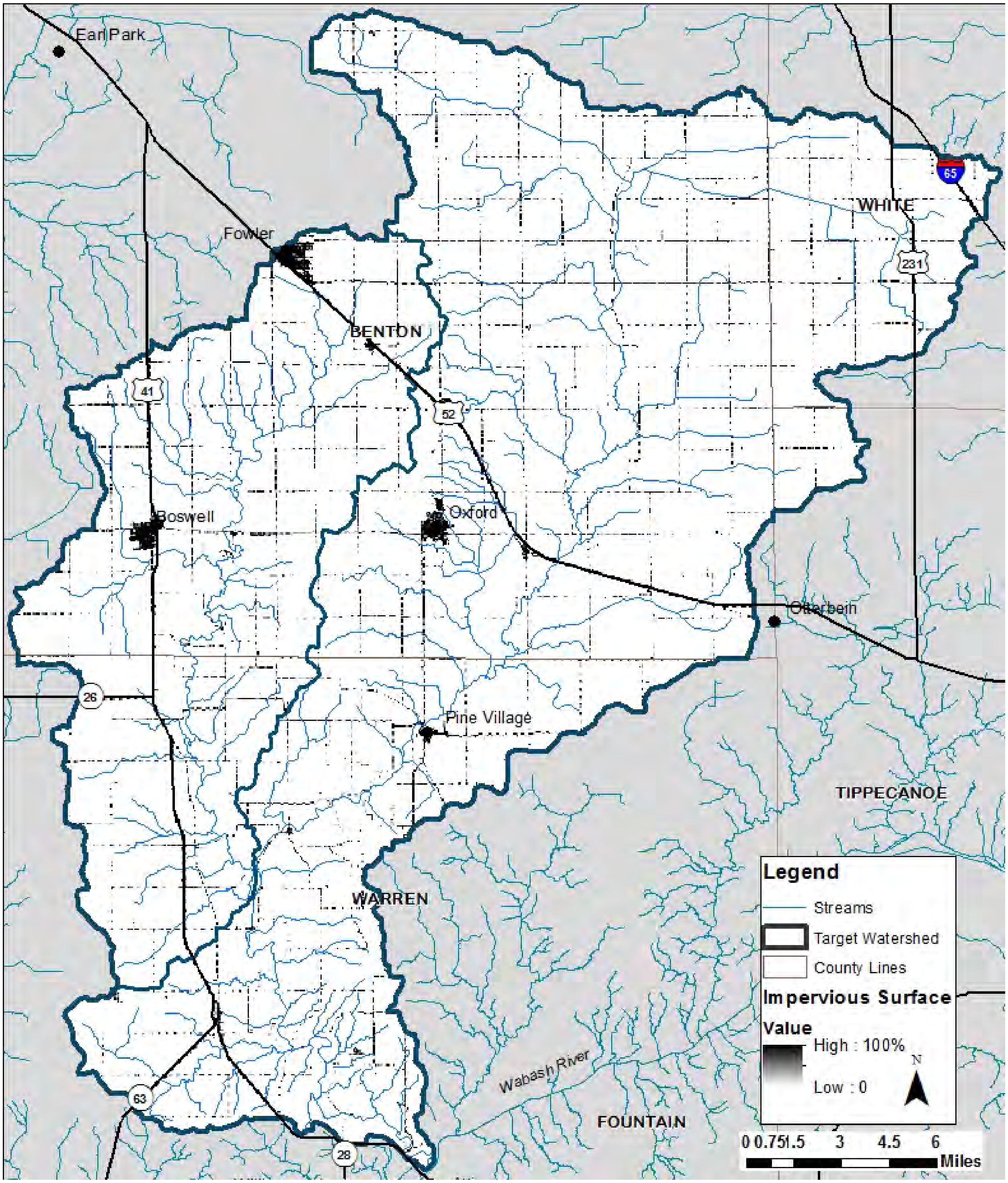


Figure 27. Impervious surface density within the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

Remediation Sites

Remediation sites including industrial waste, leaking underground storage tanks (LUST), open dumps, and brownfields are present throughout the Big Pine Creek watershed (Figure 28). Most of these sites are located within the developed areas around Fowler, Oxford, Boswell and Pine Village. In total, two industrial waste sites, 14 LUST facilities, four open dumps, and two brownfields are present within the watershed. There are no Superfund sites within the watershed.

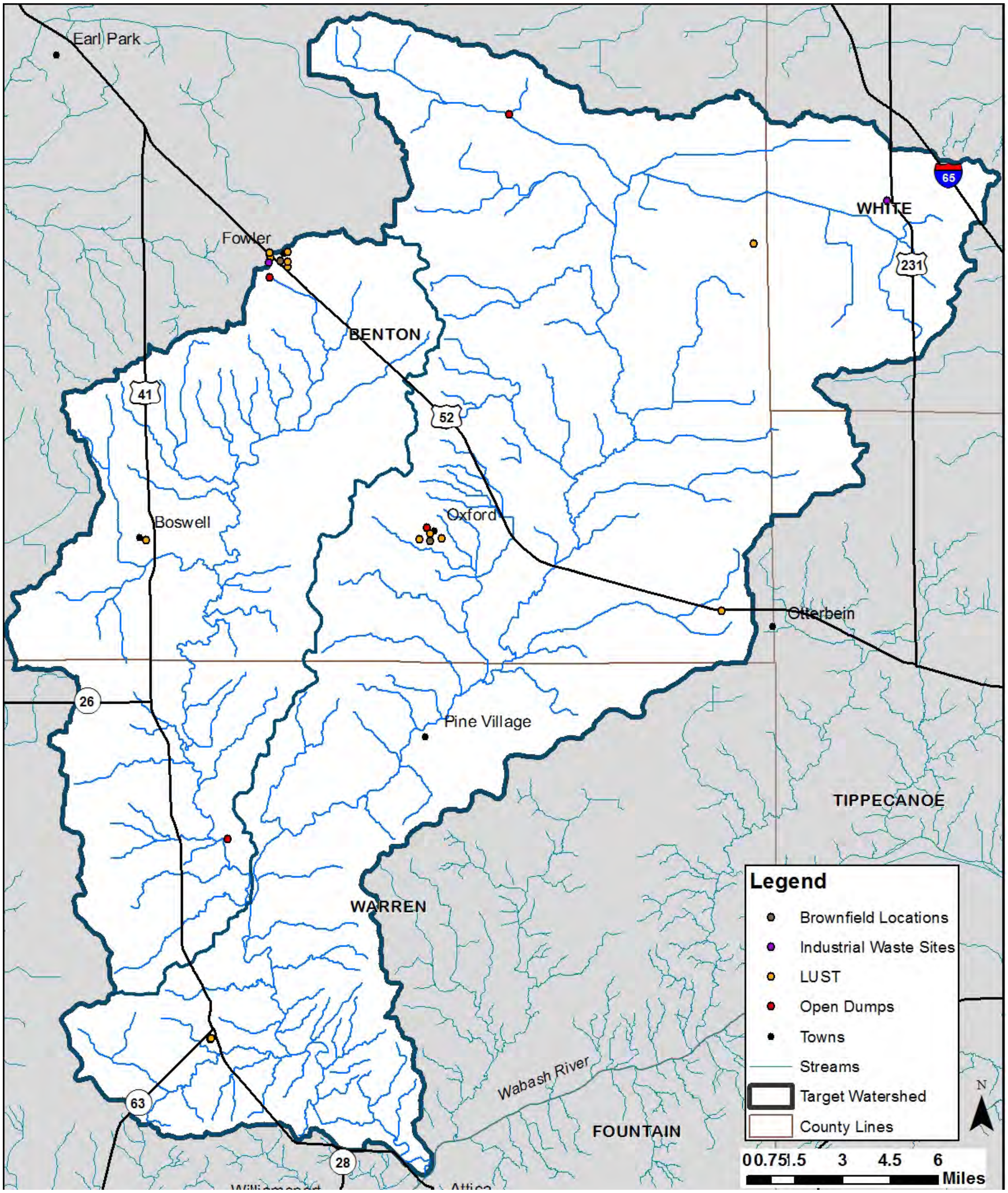


Figure 28. Industrial remediation and waste sites within the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.9.6 Development Trends

There is little development pressure within the Big Pine Creek watershed. From 2001 to 2006, only 190 acres (<0.1%) experienced a change in land use (USGS 2006). Most of this change was a conversion to emergent herbaceous wetlands (38%) and shrub/scrub (34%), with cultivated crops accounting for 18% of the land use change. Low and medium intensity development (5%), barren land (4%), and open water (2%) account for the remaining converted land. In the period since 2006 it is likely that there has been further conversion of fallow ground and natural areas to cultivated crops. This was confirmed during the windshield survey, as at least one woodlot visible on the aerial photo had been converted to agriculture.

2.10 Population Trends

The Big Pine Creek watershed is a sparsely populated area in general with a few larger towns near the boundaries of the watershed. Tracking population changes within a watershed is challenging as data is published by counties and townships rather than watershed boundaries. 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 Pine Creek watershed lies within four counties. It drains nearly 50% of Benton County, 28% of Warren County, and less than 7% of Tippecanoe and White counties. 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. These data indicate considerable growth in Tippecanoe County over both the past century and over the previous decade, however most of that growth is associated with Lafayette and West Lafayette and the immediate area, not the northwest corner of the county that lies in the watershed. Over the past century, White County has grown while Benton and Warren counties have experienced population declines. In the most recent decade, Benton and White counties have slightly decreased, while Warren County has remained stable.

Table 15. County demographics for counties within Big Pine Creek watershed.

County	Area (acres)	Population (2010)	Population Growth (1890-2010)	Population Growth (2000-2010)	Pop. Density (#/sq. km)
Benton	259,953	8,854	-25.6%	-6.0%	8.4
Tippecanoe	321,810	172,780	392.6%	16.0%	132.7
Warren	234,303	8,508	-22.3%	1.1%	9.0
White	325,372	24,643	57.2%	-2.5%	18.7

Table 16. Estimated watershed demographics for the Big Pine Creek watershed.

County	Acres of County in Watershed	Percent of County in Watershed	Population
Benton	124,285	47.8%	4233
Tippecanoe	2,786	0.9%	1496
Warren	65,107	27.8%	2364
White	17,531	5.4%	1328
		Total Estimated Population	**9,421**

Population densities within the watershed are relatively low; the majority of the watershed has a population density of less than ten people per square kilometer (Figure 29). Southern Benton County, associated with Boswell and Oxford, has densities ranging from 12 to 28 people per square kilometer. The highest density is associated with Fowler, with 1096 people per square kilometer.

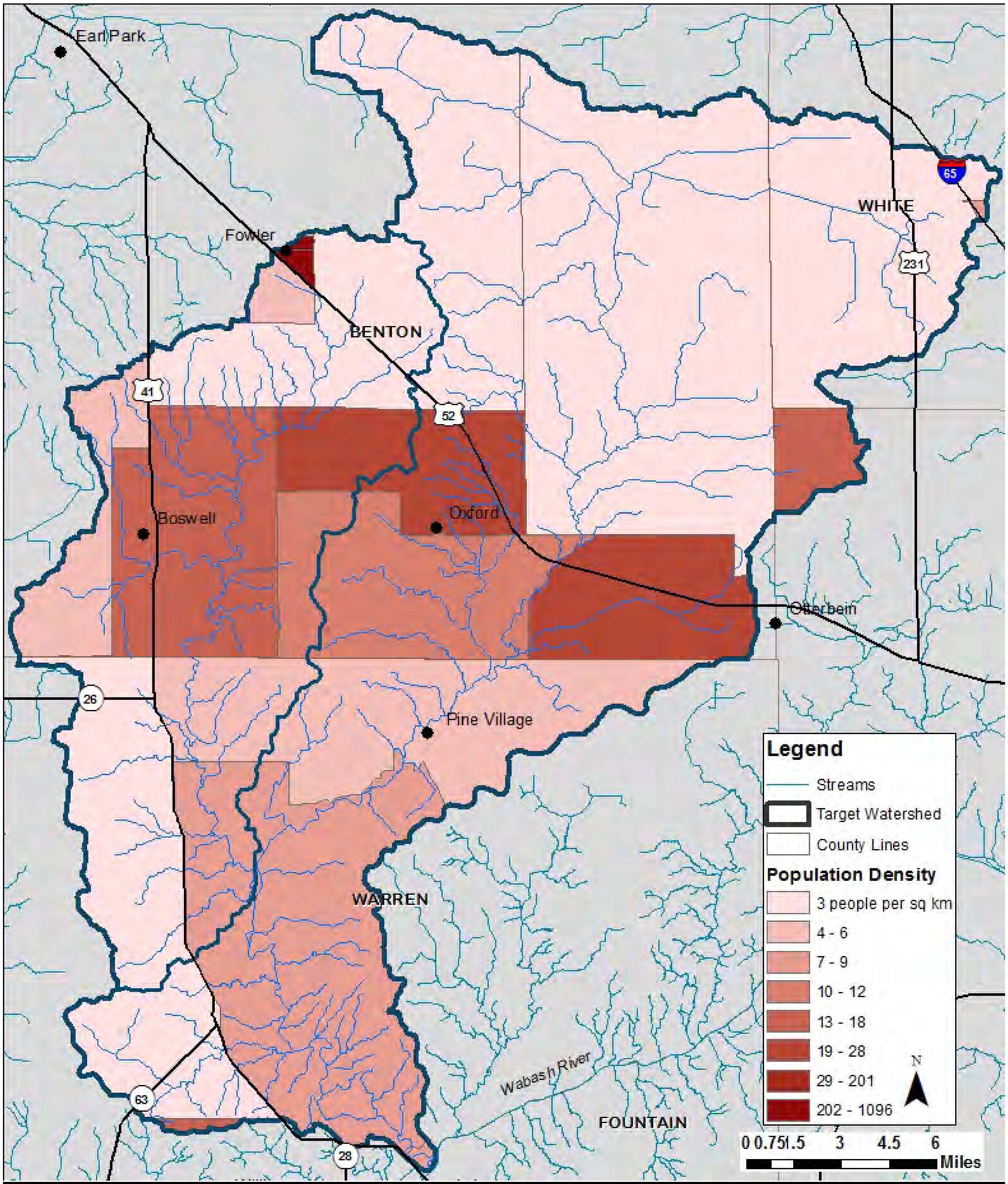


Figure 29. Population density (# / square kilometer) within the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.11 Planning Efforts in the Watershed

While no one single plan has been dedicated to the Big Pine Creek Watershed until the development of this one, several larger plans have encompassed portions of the Big Pine Creek Watershed or areas which it drains or outlets into. Planning efforts include those by the Wabash River Heritage Corridor Commission along the length of the Wabash River, including Warren and Tippecanoe Counties, and the Tippecanoe County SWCD Master Plan. Tippecanoe County has a county-wide master plan; however, much of their planning focuses on Greater Lafayette, which is outside our planning area. White, Benton and Warren Counties have not developed county-wide comprehensive plans or SWCD master plans.

Wabash River Heritage Corridor Commission Master Plan

In 1990, the Indiana Department of Natural Resources created the Wabash River Heritage Corridor Fund to provide assistance with conservation and recreational development projects along the Wabash River. In 1991, the Wabash River Heritage Corridor Commission (WRHCC) was created by House Enrolled Act 1382. The WRHCC protects and enhances the natural, cultural, historical and recreational resources of the Wabash River within the nineteen counties through which the river runs. This includes Warren and Tippecanoe counties, which are part of the current planning project. Since 1990, approximately 60 projects received funding totaling more than $13 million through the corridor fund (WRHCC, 2004). Additional efforts by the WRHCC include maintenance of a visible presence within the corridor counties, provision of interaction along the length of the corridor, and promotion of the Wabash River and its historical and recreational opportunities.

In 2004, the WRHCC updated its master plan via a series of public meetings along the Wabash River corridor. The master plan focused on eight main areas including land use, natural resources, historic resources, recreational resources, corridor connection and linkages, scenic by-way linkages, thematic connections, and tourism. As portions of the watershed are contained within the Wabash River Heritage Corridor, it is important that the goals, strategies, and actions developed as part of this plan be in line with those developed as part of the WRHCC master plan. The master plan identified the following action items:

- Maintain and enhance the natural diversity of the corridor.
- Restore natural landscapes of the Wabash River Heritage Corridor.
- Ensure that mineral extraction is environmentally sensitive.
- Stabilize the riverbank.
- Re-establish riparian forests and wetlands along the Wabash River.
- Develop and implement set-back programs to reduce surface runoff and non-point source pollution.
- Enforce existing regulations regarding point source pollution related to wastewater treatment plants and septic systems and explore the need for new regulations.
- Promote monitoring of water quality and public education about water quality.
- Preserve large regional natural areas.
- Fish stocking and wildlife reintroduction in and along the Wabash River.
- Conduct a historic resource inventory of the corridor resource and nominate eligible properties for National Register designation within the corridor.
- Develop a prioritized list of historic and cultural resources that are threatened for focused preservation effort by county.
- Identify long-term funding opportunities for historic preservation along the corridor.
- Acquire and develop more recreational areas and opportunities.
- Promote and enhance hunting and fishing opportunities.
- Promote and enhance birding opportunities in the corridor.
- Promote and enhance bicycling opportunities in the corridor.
- Develop trail connections along the river linking corridor communities.

- Increase access to the Wabash River for recreational use, boating, fishing, and enjoyment of the river. Increase overnight facilities access.
- Establish designation of scenic by-way along the river.
- Install directional or identification signs for scenic by-ways along the river.
- Create an image to connect and interpret significant resources.
- Develop a Wabash River Heritage Corridor Center that would introduce and interpret the significance of the Wabash River and the Heritage Corridor and serve as a central repository or records center for Wabash studies.
- Develop a Wabash River and Heritage Corridor education curriculum for teacher training opportunities.
- Create corridor identification.
- Promote and market corridor resources and events.
- Develop and coordinate corridor events as part of the Heritage Corridor identity.
- Provide information to promote local and corridor recreational resources and facilities.
- Develop a natural resources guide specific to the Wabash River Heritage Corridor that will be site specific including river and public access information.

In 2009 legislation was revised to allow a new source of dedicated money to be placed in the fund, derived from royalties of oil and mineral rights beneath the Wabash River. This fund will be used to once again fund projects in the Wabash River Corridor.

The grants have been awarded every other year, in 2012 and 2014 so far, and total approximately $300,000 every two years. Two of the four Big Pine Creek Watershed counties would be eligible to apply for funding: Warren and Tippecanoe.

Tippecanoe County SWCD Master Plan
The Tippecanoe County Soil and Water Conservation District (SWCD) was created in 1940 and was tasked with coordinating the conservation of soil, water, and related natural resources within Tippecanoe County (Tippecanoe SWCD, 2010). The SWCD's vision of natural resources for Tippecanoe County is: stable soils, healthy forests and riparian buffers, clean streams and water resources, productive farms, and sustainable communities. Although only four sections comprising approximately 2,500 acres of Tippecanoe County fall within the Big Pine watershed it is essential to communicate to those landowners the work of the Big Pine Watershed group and promote opportunities developed through the Big Pine WMP to the appropriate landowners.

As part of their planning process, the SWCD identified the following areas of concern:

- Accelerated erosion on areas under construction resulting in downstream silting of drainage ways, bottomlands, and streams.
- Increased surface water management problems and flooding due to runoff from impervious surfaces.
- Improper soil use in construction of buildings, streets, and other structure that fail due to soil limitation that were not addressed.
- Limited riparian buffers resulting in the loss of natural topography.
- Negative impacts from water pollution on drinking water, household needs, recreation, fishing, transportation, and commerce.
- Rapid urban growth demands more space for housing developments and shopping centers at the direct expense of family farms and traditional farming mechanisms.

The following actions were identified by the SWCD to be completed by 2014:

- No till practices shall be increased by 2,500 acres in the Upper Wabash and Wildcat Creek watersheds.

- Cover crops shall be increased by 2,500 acres in Tippecanoe County by 2014.
- The SWCD will educate 20 landowners in high manure application areas on best management practices for manure application by 2014.
- The SWCD will increase stream bank stabilization awareness/education through 10 partnering opportunities by 2014.
- 125 acres of buffers will be installed in the Wea Creek and Wildcat Creek watersheds by 2014.
- The SWCD will educate 150 landowners about the benefits and installation of two-stage ditches by 2014.
- The SWCD will provide 10 educational and/or outreach opportunities on the environmentally wise use of lawn fertilizers and pesticides by 2014.
- The SWCD will educate 750 landowners about beneficial native plants and the negative impact of invasive plants on the environment by 2014.
- 350 acres of wildlife habitat will be installed in Tippecanoe County by 2014.
- The SWCD will work to reduce storm water runoff by facilitating programs to establish 250 best management practices by 2014.

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 Soils, Topography, and Land Forms

Topography within the watershed is generally flat, especially in the northern portion of the watershed. Soils in this area formed on till deposits, are somewhat poorly drained to moderately well drained, and are well suited to agriculture. As a result, approximately 80% of the watershed is in a corn-soybean rotation. Because of the low slope and poor drainage, tile drains are extensively used, especially in the portions of the watershed in Benton and White counties. 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 highest ridge in the watershed runs from the Fowler area in Benton County down to just west of Oxford. The steepest terrain in the watershed is along the Big Pine Creek itself in Warren County where steep cliffs along the creek provide dramatic scenery. 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 Unsewered Areas and Septic Soil Suitability

In general, the watershed is relatively sparsely populated with no large cities. The watershed is dominated by rural areas and small farming communities. The towns of Fowler, Oxford and Boswell support the highest population densities. Nearly the entire watershed is covered by soils considered very limited for use in septic tank absorption fields, yet only a small portion of the watershed is included in a wastewater treatment district, primarily associated with these three towns and the Benton Jr Sr High School. This presents a good opportunity for education and outreach focused on the importance of proper septic maintenance and the role it can play in impacting water quality.

2.12.3 High Quality Habitat and ETR Species

In general, most of the higher quality upland habitat in the watershed occurs in the southern portion of the drainage along and in the steep topography associated with Big Pine Creek, Fall Creek and Mud Pine Creek. The topography, bedrock and soils in this area support spectacular ravines and mature forest habitats, several of which have been assessed by IDNR, the Conservancy and Niches Land Trust. Many of these areas are owned or sought for ownership by NICHES Land Trust or the Conservancy for protection and preservation as they are the diamonds in the sea of agriculture that is the Big Pine Creek Watershed. The streams and gorges 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 steering committee 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. Then, pollutant sources could 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 Pine 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. Steering 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 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 evaluate water quality from available data.

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
E. coli	<235 colonies/100 mL	Indiana Administrative Code
Nitrate-nitrogen	<2.0 mg/L	WI GCC 2014, USEPA (2008)
Total phosphorus	<0.6 mg/L	IDEM Draft TMDL (committee determined that two times target of 0.3 mg/L was reasonable)
Orthophosphorus	<0.05 mg/L	Dunne and Leopold (1978)
Total suspended solids	<35 mg/L	Waters (1995)
Turbidity	<10.4 NTU	USEPA (2001)
Qualitative Habitat Evaluation Index	>51 points	IDEM (pers. comm.)
Citizens Qualitative Habitat Evaluation Index	>60 points	Hoosier Riverwatch
Pollution Tolerance Index	>23	Hoosier Riverwatch
Fish Index of Biotic Integrity	>36 points	IDEM (pers. comm.)
Macroinvertebrate Index of Biotic Integrity (KICK)	>2.2 points	IDEM (pers. comm.)
Macroinvertebrate Index of Biotic Integrity (MHAB)	>36 points	IDEM (pers. comm.)

3.2 Historic Water Quality Sampling Efforts

A variety of water quality assessment projects have been completed within the Big Pine Creek watershed. Statewide assessments and listings include the integrated water monitoring assessment, the impaired waterbodies assessment, and fish consumption advisories. Additionally, the Indiana Department of Natural Resources (IDNR) Lake and River Enhancement Program funded a watershed diagnostic study of the Mud Pine Creek watershed in 2002. Volunteer-based sampling of water quality through the Hoosier Riverwatch program provides additional water quality data. Historic water quality assessment sampling locations are shown in Figure 30. A summary of each assessment methodology and general results are discussed below. Specific data results are detailed within subwatershed discussions in subsequent sections.

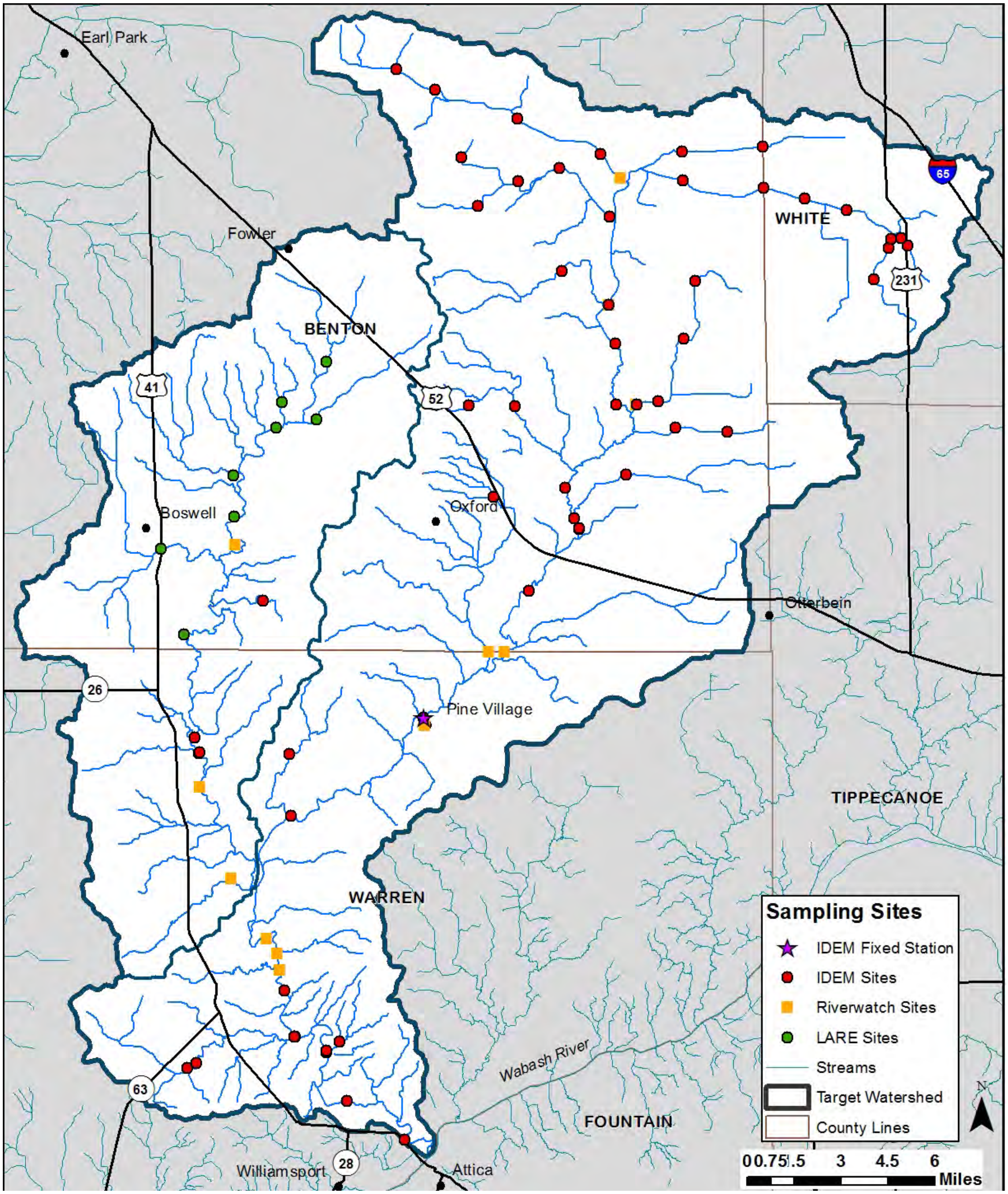


Figure 30. Historic water quality assessment locations.
Data used to create this map are detailed in Appendix A.

3.2.1 Integrated Water Monitoring Assessment (305(b) Report) and Section 303(d) List of Impaired Waterbodies

The Indiana Department of Environmental Management (IDEM) is the primary agency tasked with monitoring surface water quality within the state of Indiana. Chapter 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. A section within the Integrated Report is the list of impaired waterbodies or 303(d) list.

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.

The most recent 303(d) list developed by IDEM is from 2012, and is still pending final approval from US EPA. The draft 2014 list was released for public comment in April 2014. The only changes within the Big Pine Creek watershed from the 2012 to the 2014 list were administrative: Big Pine Creek (headwater), Big Pine Creek (headwater tributary), Vanatta-O'Connor Ditch, and Roudebush Ditch were previously listed for algae, which is considered an indicator variable rather than a cause of impairment. These listings were changed from algae to nutrients on the 2014 list.

There are 151.2 stream miles listed as impaired for *E. coli*, impaired biotic communities, nutrients, dissolved oxygen, or polychlorinated biphenyls (PCBs) in the Big Pine Creek watershed on the 2012 list. Several waterbodies (77 miles) are supporting their designated use for recreation or aquatic life, but either are impaired for fishing due to PCBs or there isn't enough information to determine if the remaining uses are supported. IDEM has not assessed 258 miles of streams, which means there isn't enough information to determine whether the streams are supporting their designated use.

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

3.2.2 Fish Consumption Advisory

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.
Table 18 lists the advisories for the Big Pine Creek watershed from the 2013 report (ISDH, 2013). There are no advisories issued for waterbodies in Benton, Tippecanoe or White counties, or for Mud Pine Creek.

Consumption advisories are issued for two groups:

- General population: women beyond childbearing age typically described as being 45 or older, and men, described as 15 or older.
- Sensitive population: pregnant or nursing women, women that may become pregnant, and children under 6 years of age.

Table 18. Fish Consumption Advisory listing for the Big Pine Creek watershed.

Waterbody	Fish Species	Fish Size	Advisory (Sensitive Pop.)	Advisory (General Pop.)
Big Pine Creek Warren County	Black Redhorse	Up to 13”	1 meal/week (8 ounces/week)	Unrestricted
	Flathead Catfish	Up to 10”	1 meal/week (8 ounces/week)	Unrestricted
	Longear Sunfish	Up to 5”	1 meal/week (8 ounces/week)	Unrestricted
	Smallmouth Bass	11+ inches	Do not eat	1 meal/month (8 ounces/month), PCBs

3.2.3 Wabash River Total Maximum Daily Load (TMDL) Study

Water quality data collected from the Wabash River indicated that the river did not consistently comply with the state’s water quality standards. Based on these determinations, segments of the Wabash River have been included on the state’s 303(d) list since its inception. The 2002 listing included segments of the Wabash River in non-compliance for pathogens (*E. coli* and fecal coliform), nutrients, pH, dissolved oxygen, and impaired biotic communities. Subsequent lists prepared in 2004, 2006, and 2008 replicated these listings. In order to cohesively address impairments, one TMDL was written for the entire length of the Wabash River including the 30 miles in Ohio and the 475 miles in Indiana and Illinois (Tetra Tech, 2006). The Middle Wabash section extends from north of Lafayette to south of Terre Haute and includes the segment where Big Pine Creek discharges into the Wabash. The TMDL addresses nutrient, dissolved oxygen, and *E. coli* impairments in the Middle Wabash section. The lower Big Pine Creek is included on the draft 303(d) list under the Wabash River *E. coli* TMDL.

Data collected by several agencies was obtained for water quality model development and TMDL calculation. The following conclusions were drawn with regards to water quality in the Wabash River:

- Nitrate+nitrite concentrations routinely exceeded the Indiana benchmark (10 mg/L); however, median concentrations measured less than 5 mg/L. Concentrations were generally higher in the Middle Wabash than those observed either up or downstream.
- Median dissolved oxygen concentrations generally exceeded 8 mg/L with only a few stations measuring below the minimum benchmark (4 mg/L). However, several stations, including the station at Williamsport (immediately downstream from the confluence with Big Pine Creek), routinely exceeded the upper benchmark (12 mg/L).
- Median phosphorus concentrations were generally less than the benchmark (0.3 mg/L) used for impaired waterbody listing by IDEM, however, there were a significant number of samples that exceed the benchmark.
- *E. coli* concentrations generally decrease from upstream to downstream, with about half the stations in the Middle Wabash exceeding the standard for *E. coli* (235 cfu/100 ml).
- Most stations were impaired due to phosphorus and either dissolved oxygen or nitrite + nitrate. The two stations downstream from the confluence of Big Pine Creek with the Wabash were both impaired for nutrients, while the segment of the river upstream of that point was not impaired, possibly indicating elevated inputs from Big Pine Creek.

3.2.4 IDEM Fixed Station (1990-2013) and Rotational Basin Assessments

Through IDEM's fixed station water quality monitoring program, IDEM scientists collect water quality samples once per month at 160 stream and river sample sites throughout the state (Whitesell, 2013). There is one fixed station in the watershed, located on Big Pine Creek near Pine Village. Based on the fixed station sampling data, the following conclusions can be drawn:

- *E. coli* concentrations varied over time but exceeded the state standard about half the time, resulting in this reach of Big Pine Creek being listed on Indiana's impaired waterbodies list.
- Total phosphorus concentrations were generally below the target concentration of 0.6 mg/L, with only three readings exceeding the target.
- Nitrate-nitrogen concentrations exceeded the target concentration of 2 mg/L 75% of the time.
- Total suspended solids concentrations fell below the target concentration of 35 mg/L in 76% of the samples.

In 1999, 2004, and 2009, IDEM sampled water chemistry at several locations in the Big Pine Creek watershed via their rotational basin assessment program. Sampling occurred in Vanatta Ditch, Fall Creek, and Big Pine Creek in 1999 (3 events). In 2004, two sites on Big Pine Creek and one site on Little Pine Creek were sampled by IDEM (10 events from March to Sept). In 2009, five sites were sampled up to six times (Miller Ditch, Big Pine Creek Ditch, tributary of Brown Ditch, and two tributaries of Big Pine Creek). Two of those sites were included in a more extensive *E. coli* study in Sept.-October 2009. IDEM completed a source identification effort in the middle and upper Big Pine Creek watershed in 2005, which included sampling 41 sites. Additional water chemistry sampling occurred in 1991 and 2004 as part of macroinvertebrate studies at 3 sites. In 1999, USGS conducted six sampling events in August at three sites on Big Pine Creek as part of an *E. coli* study.

Based on the rotational basin water chemistry assessments in the Big Pine Creek watershed, the following conclusions can be drawn:

- *E. coli* concentrations exceeded the state standard in Little Pine Creek, a tributary of Brown Ditch, a tributary of Big Pine Creek (downstream of Pine Village), and Big Pine Creek (upstream of Fall Creek) during at least one assessment. Three of these reaches are listed on the impaired waterbodies list.
- Nitrate-nitrogen concentrations exceeded the target concentration roughly a third of the time during at least one sampling event, at sites spread throughout the watershed.
- Total phosphorus concentrations were generally below the target concentration. However, four sites, all in the headwaters subwatershed, exceeded the target concentration during all sampling events.
- Total suspended solids concentrations exceeded the target concentration at 9 sites during at least one assessment. Sites with exceedances were in the middle and upper part of the watershed, often at sites that also exceeded either nitrate-nitrite or total phosphorus targets.

IDEM completed fish sampling at 31 sites throughout the watershed in 1999, 2004, 2005 and 2009 (Sobat, 2013). Macroinvertebrate sampling occurred at three sites in the Hog Back Hill subwatershed in 1991, 1999, and 2004, and in a tributary of Brown Ditch and a tributary of Big Pine Creek downstream of Pine Village in 2009 (Davis, 2013). Habitat was also assessed using the QHEI. Based on these assessments, the following conclusions can be drawn:

- The fish community tended to improve from upstream to downstream, reflecting the habitat changes along the length of the stream. The fish community was rated as poor in Miller Ditch, Vanatta Ditch, Brumm Ditch, Darby Ditch, Big Pine Creek headwaters and at one site in Owens Ditch. The highest fish community ratings were observed in Little Pine Creek, Big Pine Creek in the Owens Ditch subwatershed, a tributary of Brown Ditch, Big Pine Creek in the Hog Back Hill subwatershed, and Fall Creek.

- Macroinvertebrate communities rated as good to excellent on all but two occasions in the Hog Back Hill subwatershed and all three sites contained high quality habitat. Habitat was poor at the two sites sampled in 2009, yet the macroinvertebrate community was fair.

IDEM sampled water chemistry in Mud Pine Creek at two sites in 1999 and at one site in 2004. Water chemistry was also sampled on a tributary of Mud Pine Creek as part of a paired watershed study in 1999. Fish sampling occurred in 1999 at both the tributary and main stem sites of Mud Pine Creek. The fish community was rated as excellent at the main stem site, which also contained high quality habitat. Nitrate-nitrite exceeded the target concentration in 60% of the samples and TSS exceeded the target in 38% of the samples, indicating that habitat has more of an influence on the biological community than does water quality. The tributary site had poor quality habitat and elevated nitrate-nitrite levels, and while the fish community was rated as good, it was lower quality than at the main stem site downstream. Macroinvertebrates were sampled in 1991 and 2004 at two sites on the main stem. The macroinvertebrate community was rated as good three out of four times, reflecting the high quality habitat measured at both sites.

3.2.5 Hoosier Riverwatch Sampling (2007-2013)

From 2007 through 2013, volunteers trained through the Hoosier Riverwatch program monitored 12 sites throughout the Big Pine and Mud Pine Creek watersheds. Monitoring occurred sporadically, with some sites assessed only once during the reporting period while others were monitored as many as 28 times. 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 macroinvertebrate data. Based on these data, the following conclusions can be drawn:

- In the Mud Pine Creek subwatershed, nitrate-nitrogen and *E. coli* measured higher than the target roughly half the time. CQHEI scores ranged from 48 to 83, with 6 of the 8 scores above 60, indicating habitat "conducive to the existence of warmwater fauna". Scores were higher at the downstream site in Warren County than at the site in Benton County. PTI scores were above 23, indicating excellent biotic quality.
- In the Big Pine Creek Headwaters subwatershed, nitrate-nitrogen measured higher than the target roughly half the time, while phosphorus, turbidity and *E. coli* did not exceed the targets. CQHEI scores ranged from 46 to 85, with two-thirds of the scores above 60. Macroinvertebrates were not sampled at the three sites in this subwatershed.
- In the middle Big Pine Creek subwatershed, nitrate-nitrogen levels exceeded the target roughly half the time. CQHEI scores ranged from 24 to 73, with two-thirds of the scores falling below 60, indicating that habitat quality may be poor. Macroinvertebrates were not sampled at the two sites in this subwatershed.
- In the lower Big Pine Creek subwatershed, water chemistry was monitored at three sites, with all three sites exceeding the target concentration of nitrate-nitrogen more than 50% of the time. Turbidity exceeded the target at one site 11% of the time, and *E. coli* exceeded the target at two sites roughly 25% of the time. All recorded CQHEI scores were above 60, with PTI scores routinely above 23, indicating that these sites are highly conducive to warmwater fauna.

3.2.6 Lake and River Enhancement Diagnostic Study (2002)

In 2002, a Diagnostic Study of the Upper Mud Pine Creek Watershed in Benton County was completed by JF New & Associates for the Benton County Soil and Water Conservation District, with funding from the DNR's Lake and River Enhancement Program (JFNew, 2002). The study included a review of historical studies, analysis of various watershed characteristics including soils and land use, a windshield tour, and assessment of chemical, physical and biological components of the streams. Eight sites were monitored for water chemistry during base flow and storm flow in May and June 2001, this represented one for each subwatershed in the Upper Mud Pine. The macroinvertebrate community and habitat were assessed at each site.

The macroinvertebrate Index of Biotic Integrity (mIBI) scores documented a range of moderately impacted (2.0) to just barely unimpaired (6.5) water quality. Habitat assessed using the Qualitative Habitat Evaluation Index (QHEI) was "less than optimal for aquatic life uses" at most sites. Water quality samples taken during storm events were elevated for some chemical parameters and for *E. coli* at many sites.

Based on the results of the water monitoring, the following subwatersheds were prioritized for implementation of best management practices:

- Goose Creek (high suspended solids, total phosphorus, *E. coli*)
- Seamons Ditch (large amount of unprotected highly erodible land, lowest mIBI score)
- Upper Mud Pine Creek (highest *E. coli*, phosphorus loading)
- Humbert Ditch (high phosphorus, moderate-severe impairment based on mIBI)

Approximately 125 locations were identified for installation of BMPs to reduce soil erosion and improve stream habitat. Recommended BMPs included wetland restoration, filter strips, buffer zones, bank stabilization, livestock fencing, revegetation of exposed areas, and grassed waterways.

3.2.7 USGS stream gage monitoring

The USGS has had two locations with water stage recorders in the watershed: Mud Pine Creek near Chase and Big Pine Creek upstream of Williamsport. Big Pine Creek site was monitored from 1955 to 1987. This sampling point took in 323 square miles of the Big Pine drainage. This site's records show an average annual discharge of 270 cubic feet/second and runoff of 11.35 in/yr, with maximum discharge of 12,600 cubic feet/second in Feb. 1959 and minimum of 6.5 cubic feet/second in Oct. 1966. Peak stream flow was highest during the late 1950's, decreased during the late 1960's and 70's, increased through 1984, then dropped again through 1987. Daily mean stream flow was flashy, with erratic differences between seasons (Ladd, 2004; USGS 1987).

The Mud Pine site had data collected from 1971 to 2003 and comprised a 39.4 square mile drainage area. This site averaged 42.8 cubic feet/second annual discharge, with a maximum peak flow of 12,100 CFS in April 1994. The highest daily mean was 4,550 CFS in April 1994 and lowest daily mean was 0.01 CFS in Sept. 1999, again demonstrating the extreme flashiness of the system depending on seasonal weather patterns (USGS, 2003).

USGS sampled nitrates in Big Pine Creek and found levels of 25-35 ppm with peaks up to 60 ppm in early summer from 1970-76. High levels were recorded in winter months too. From 1976-1981, concentrations remained around 30 ppm in early summer, but dropped during the rest of the year. Sediment sampling conducted by USGS from 1979-1981 showed a wide range of 3 to 250 tons of sediment load per day to the system, which further shows the flashiness of the Big Pine system (Ladd, 2004).

3.2.8 The Nature Conservancy Wabash River Study

The Nature Conservancy compiled a database of biological, stressor, and threat data for the Wabash River and its tributaries (Armitage and Rankin, 2009). The data were then used to analyze water quality and fish community information on an 11-digit watershed level. Although no new data were collected as part of this study, their analysis methods allow conclusions to be drawn which can be used to compare this watershed with others along the length of the Wabash River. Based on data collected, the following conclusions can be drawn:

- An ideal habitat (QHEI) score for this portion of the Wabash River based on 1800s conditions is 93.5. At that time, habitat would have rated as excellent to near maximum scores for most metrics.
- The fish community in this reach is generally lacking in sensitive species with common carp and freshwater drum dominating the population.
- Total phosphorus and nitrate-nitrogen concentrations are elevated within both the mainstem and tributaries in this reach. The elevated nutrient concentrations present in the tributaries, coupled with the lack of buffers, increased delivery of nutrients via drainage systems and tile drains, and degradation of instream habitat due to altered hydrology.
- The IBI was generally skewed toward the good range in the tributaries of the Wabash in this HUC-8 watershed which includes samples in Big and Little Pine Creeks and Big and Little Raccoon Creeks and other tributaries (N=95). Fish assemblages in this reach are better than the average for the entire Wabash watershed as calculated by IDEM. The upstream reaches tend to be in better condition than lower reaches where the gradient drops.
- High gradient tends to buffer reaches from the effects of fine sediments and nutrients by transporting them downstream instead of letting them settle within the river.

3.2.9 Division of Fish and Wildlife Fisheries Surveys

During June and August of 1973, Indiana's Division of Fish and Wildlife conducted their first fisheries survey of the Big Pine watershed. The primary purposes of this study were to evaluate the sport fishery of Big Pine, provide a species list for fish present in the river, evaluate overall water quality and fish habitat, and inform the public of their findings. Sampling methods included both boat and shore mounted electro-fishing, as well as the use of a backpack shocker and seining with a 12-foot seine with ¼ inch mesh (Robertson, 1973).

During the 1973 survey, a total of 16 stream locations were sampled. An effort was made to distribute sample locations relatively evenly throughout the watershed, and in a variety of different habitats. In all, a total of 1,267 fish were collected and identified (Figure 31). Eight new species were collected which had not previously been known to the watershed, including: skipjack herring, river carpsucker, northern redhorse, flathead catfish, black bullhead, largemouth bass, bluntnose darter, and banded darter.

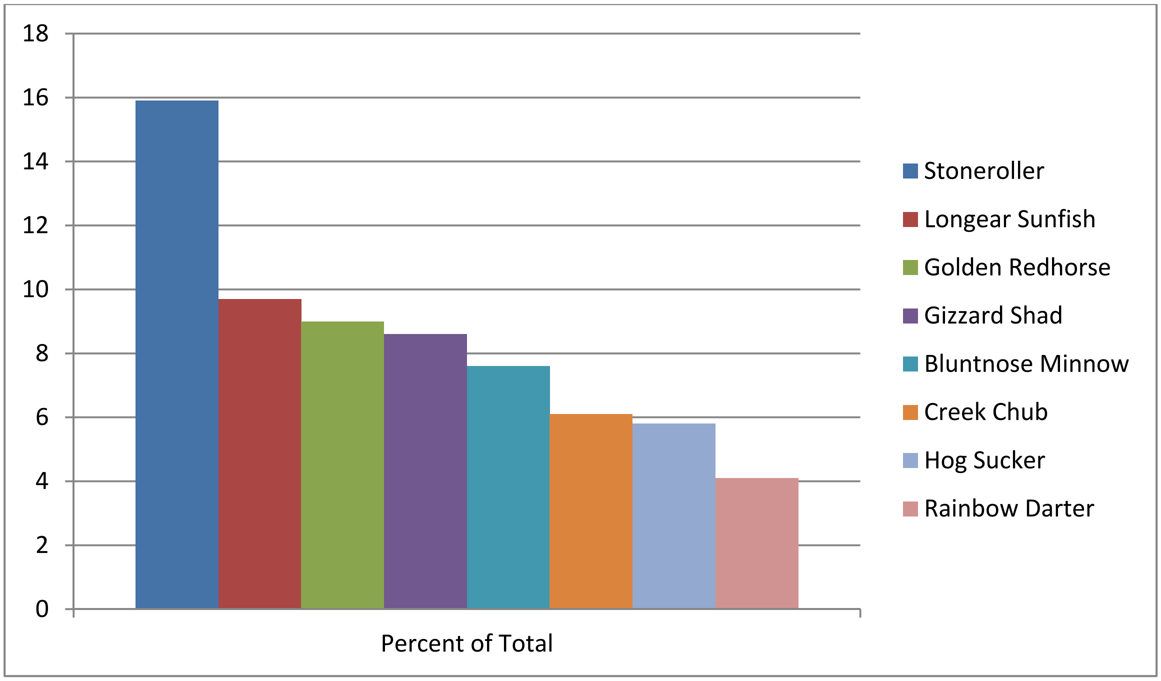


Figure 31. The eight most abundant species of fish collected during the 1973 DNR fisheries survey of Big Pine Creek.

Unfortunately, even as early as the early 1970s when this survey was completed, there were already thirteen species that had been collected previously in this watershed that were not collected during this study. These included the bluebreast darter and bigeye chub which require clear, high quality water. It is possible that high turbidity and decreasing water quality were responsible for the loss of these species.

A follow-up survey was conducted by the Indiana DNR in the summer of 1994. Four stations were sampled using a barge electrofishing unit. Water quality and habitat were assessed at each station, and fish species collected were identified, weighed, and measured.

The 1994 survey collected six species of fish not collected in the 1973 study (channel catfish, freshwater drum, shorthead redhorse, steelcolor shiner, ironcolor shiner and spotted bass). However, twenty-three species collected in 1973 were not found during the 1994 study. Due to the differences in sampling gear, it is difficult to compare results between the two studies. Water quality sampling and habitat assessment conducted during the 1994 survey indicated that Big Pine Creek was a "clear, primarily silt-free, moderate gradient stream", supporting a diverse fish population (Robertson, 1994). However, the same fisheries biologists conducted both surveys, and their observations were that Big Pine appeared to be more turbid and silty in 1994 than in 1973.

The fish community of Mud Pine Creek was surveyed for the first time in August 2012, to provide a baseline for future surveys. The objective of the survey was to describe the game and non-gamefish community and to assess the habitat of the stream. A barge electrofisher was used to sample fish at four stations on Mud Pine Creek. A total of 2,846 fish, representing 34 species and seven families, were collected. The most abundant species by number were bluntnose minnow, golden redhorse, longear sunfish, sand shiner and northern hog sucker. Game fish comprised 6% of the total number, including bluegill, largemouth bass, smallmouth bass, black crappie and rock bass. Overall, the habitat quality of the stream at the four sample locations was above average, with a diversity of instream cover and a forested riparian corridor (average QHEI score of 66.6 compared to the statewide average of 59). The stream supports a diverse assemblage of fish species commonly found in the upper Wabash River watershed (Pejza, 2013).

3.2.10 Purdue University Agricultural Research Station Sampling (2009-2010)

Water quality within Purdue University's Animal Science Research and Education Center (ASREC) were assessed by Gall et al. (unpublished) from January 2009 to February 2010. Samples were collected from five tile locations and three surface waterbodies in the headwaters of Little Pine Creek. Chemistry samples were collected every 10 hours during base flow with samples collected more frequently during storm events; stage measurements occurred every 15 minutes. Samples were processed for a variety of phosphorus and nitrogen parameters. Based on these data, the following conclusions can be drawn:

- Nitrate-nitrogen concentrations routinely exceed the target concentration measuring as high as 25 mg/L in tile samples and 18 mg/L in surface water samples.
- Orthophosphate concentrations measured as high as 1.5 mg/L in tile samples and exceeded 1.6 mg/L in surface water samples. Although exceedances occur, orthophosphate concentrations regularly measure relatively low and typically fall below the target concentration.

This study was completed in the watershed directly adjacent to Big Pine Creek to the east. Land use in the Little Pine Creek headwaters is similar to that in the upper Big Pine Creek watershed in Benton and White counties, with extensive row crop agriculture and tile drainage. The water chemistry data collected and the conclusions drawn from them are likely quite comparable to what might be found in the Big Pine watershed.

3.3 Watershed Inventory Assessment

3.3.1 Watershed Inventory Methodologies

Volunteers completed windshield surveys throughout the Big Pine Watershed in the fall and winter of 2013. The watershed was divided into 17 sections of a grid covering the entire watershed. Volunteers conducted surveys by driving all accessible roads throughout the watershed. Large maps with aerial photographs and road names were provided to each volunteer. Volunteers recorded observations on the maps and data sheets, documented a few field conditions with photographs, and provided all notes to the steering committee. Items targeted during the surveys included, but were not limited to the following:

- Land use
- Field or gully erosion
- Pasture locations and condition
- Livestock access and impact to streams
- Buffer condition and width
- Bank erosion
- Environmental site confirmation (NPDES, CFO, fertilizer plant, open dump, etc.)

3.3.2 Watershed Inventory Results

Data on 959 individual sample points were collected. Each point was taken at a road or stream crossing where volunteers made their observations. A majority of issues identified fall into three categories: limited or lacking buffer (wetland, tree, grass) widths, stream/ditch bank erosion, and agriculture management (lack of cover crops, tillage in fields, ephemeral and wind erosion). Figure 32 shows locations throughout the Big Pine Creek watershed where problems were identified. Additional assessments will be on-going; therefore, those locations identified in Figure 32 should not be considered exhaustive. More than 55 miles of tributary streams were lacking buffers, nearly 25 miles of streambank were eroded, and livestock had access to nearly 10 miles of streams. Over 6,000 acres of crop fields exhibited gully erosion and would benefit from the installation of grassed waterways. The photos below illustrate some of these issues.

The amount of tilled fields observed during the windshield survey in spring 2014 aligns with the 2013 cropland data for Benton County (10% no-till corn and 65% no-till beans) and Warren County (6% no-till corn and 50% no-till beans). However, in the fall of 2013 many tilled bean fields were observed, which is evident in the soil-covered snow in fields and on ditch banks (see photo below). Fencerows in this open and slightly sloping watershed are critical for providing habitat and reducing wind erosion. The few remaining fencerows may be threatened if center pivot irrigation becomes more intense in the watershed. With 7% of the watershed in forest land cover and only 2% in wetlands several natural filters are missing and the watershed experiences a lot of flashiness in water volume and velocity.

As this plan is implemented, the windshield surveys can be completed annually or bi-annually to record any improvements in the watershed.

Typical tillage in the watershed.

The result of wind erosion on a tilled field in the watershed; proof that windbreaks and cover crops are a needed conservation practice.

Typical bank failure as a result of water flashiness.

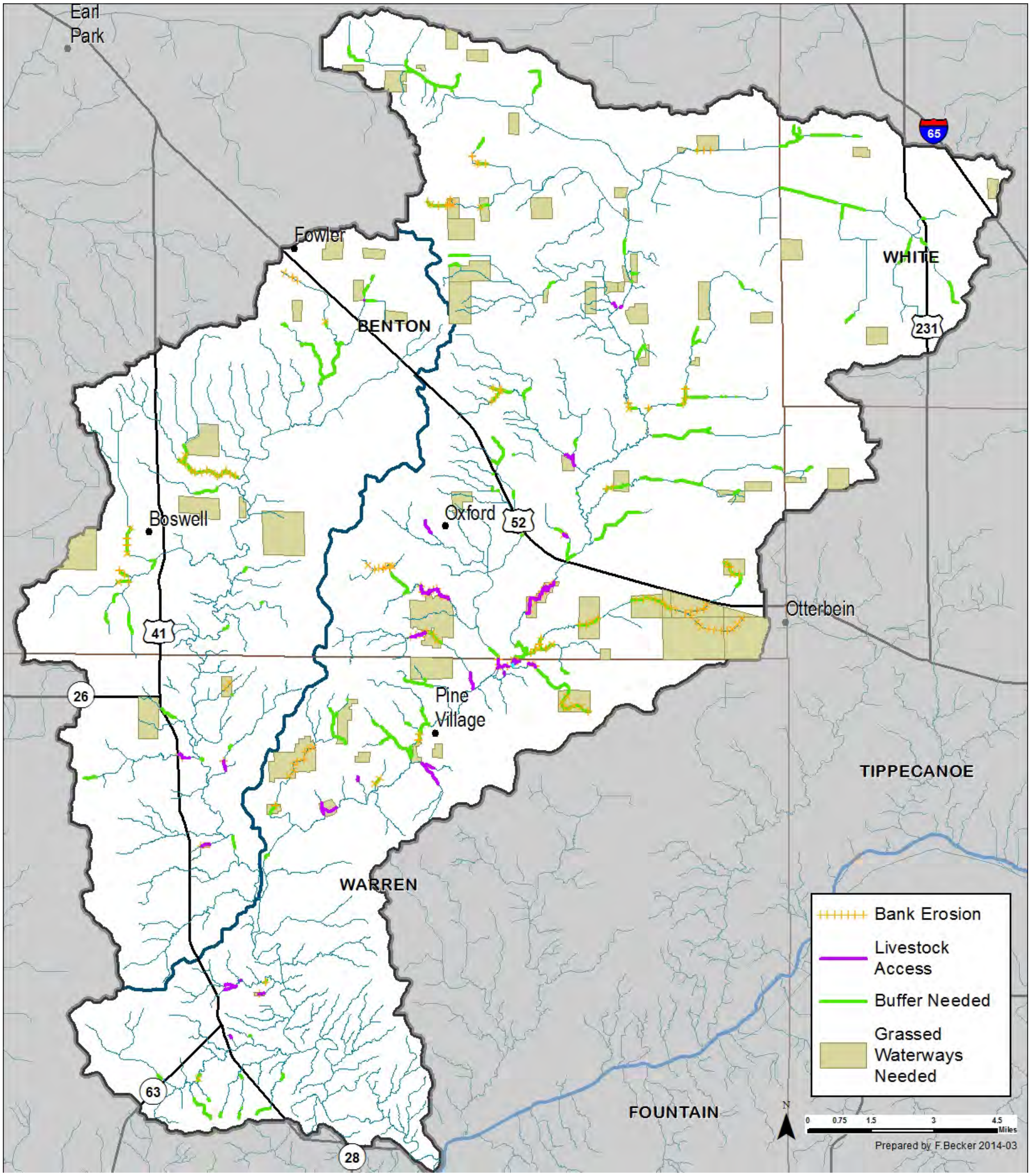


Figure 32. Stream-related watershed concerns identified during watershed inventory efforts.

4.0 WATERSHED INVENTORY II-B: SUBWATERSHED DISCUSSIONS

To gather more specific, localized data, the Big Pine Creek watershed was divided into four regional subwatersheds (Figure 33, Table 19). 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.

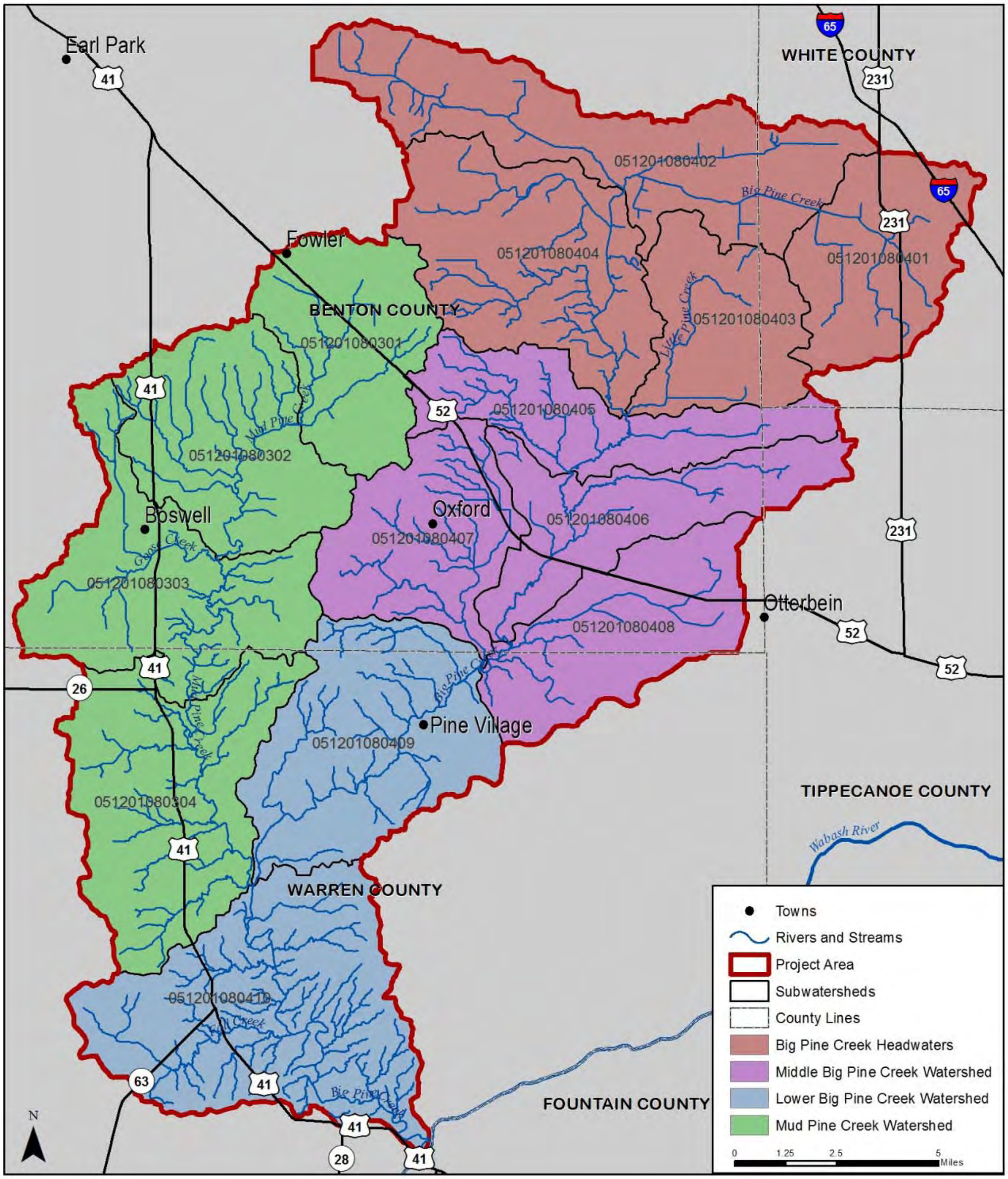


Figure 33. Four regional subwatersheds in the Big Pine Creek watershed.

Table 19. Four regional subwatersheds in the Big Pine Creek watershed.

Regional Subwatershed	HUC 12 Subwatershed Name	HUC 12
Big Pine Creek Headwaters	Roudebush Ditch-Big Pine Creek	051201080401
	Big Pine Creek Ditch-Big Pine Creek	051201080402
	Little Pine Creek	051201080403
	Owens Ditch-Big Pine Creek	051201080404
Middle Big Pine Creek	Brumm Ditch-Big Pine Creek	051201080405
	Darby Ditch-Big Pine Creek	051201080406
	Brown Ditch	051201080407
	Harrington Creek-Big Pine Creek	051201080408
Lower Big Pine Creek	Pine Village-Big Pine Creek	051201080409
	Hog Back Hill-Big Pine Creek	051201080410
Mud Pine Creek	Headwaters Mud Pine Creek	051201080301
	Seamons Ditch-Mud Pine Creek	051201080302
	Goose Creek-Mud Pine Creek	051201080303
	Spring Branch-Mud Pine Creek	051201080304

4.1 Big Pine Creek Headwaters Subwatershed

The Big Pine Creek Headwaters subwatershed is the northern-most subwatershed, stretching from southeast White County to central Benton County (Figure 33). It encompasses four 12-digit HUC watersheds: Roudebush Ditch (051201080401), Big Pine Creek Ditch (051201080402), Little Pine Creek (051201080403), and Owens Ditch (051201080404). The headwaters drain 58,977 acres or 92 square miles. There are 147 miles of stream, of which 130 miles are regulated drains or tiles. IDEM has classified 51.7 miles of stream as impaired for *E. coli*, nutrients, dissolved oxygen, or impaired biotic communities.

4.1.1 Soils

Soils in the Big Pine Creek Headwaters subwatershed are dominated by those that lie within till deposits. Somewhat poorly drained soils with slow permeability are prevalent in the eastern portion of the subwatershed crossing into White County, while moderately well drained soils cover the northern and western parts of the subwatershed. The soils along Pine Creek Ditch were formed in loamy sediments and gravel outwash and are well drained with low or medium potential for surface runoff. Hydric soils cover 27,093 acres (45.9%) of the subwatershed, indicating that much of the land was historically wetlands. The greatest concentration of hydric soils is in the eastern portion of the subwatershed, in White County. Wetlands currently cover just 1% of the subwatershed, representing a loss of 97.8% of historic wetlands. Potentially highly erodible soils are prevalent throughout the subwatershed, covering 23% of the land. Nearly the entire subwatershed (99.8%) has soils which are severely limited for septic use.

4.1.2 Land Use

Agricultural land uses dominate the Big Pine Creek Headwaters subwatershed, with 91.8% in row crops and 1.6% in hay/pasture. Forest and wetlands cover just over 1,700 acres, or 2.9%, of the subwatershed, primarily associated with five DNR Fish and Wildlife Gamebird Habitats located along Pine Creek Ditch. The Owens Ditch subwatershed has almost 400 acres of forest, mostly located along the stream. Although there are no incorporated towns in the subwatershed, developed land accounts for 4.5% of the land use. This mainly consists of roads: I-65 and US Highway 231 pass through the northeast corner of the subwatershed and State Highway 18 bisects the subwatershed.

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 on County Road 100 in Benton County (Figure 34). There is one industrial waste facility on US Highway 231. One open dump is located along Pine Creek Ditch, associated with the Wealing Brothers off-site biosolid disposal facility. No compliance issues have been documented for Wealing Brothers' facility or material hauling within the subwatershed. There are no NPDES-permitted facilities in this subwatershed.

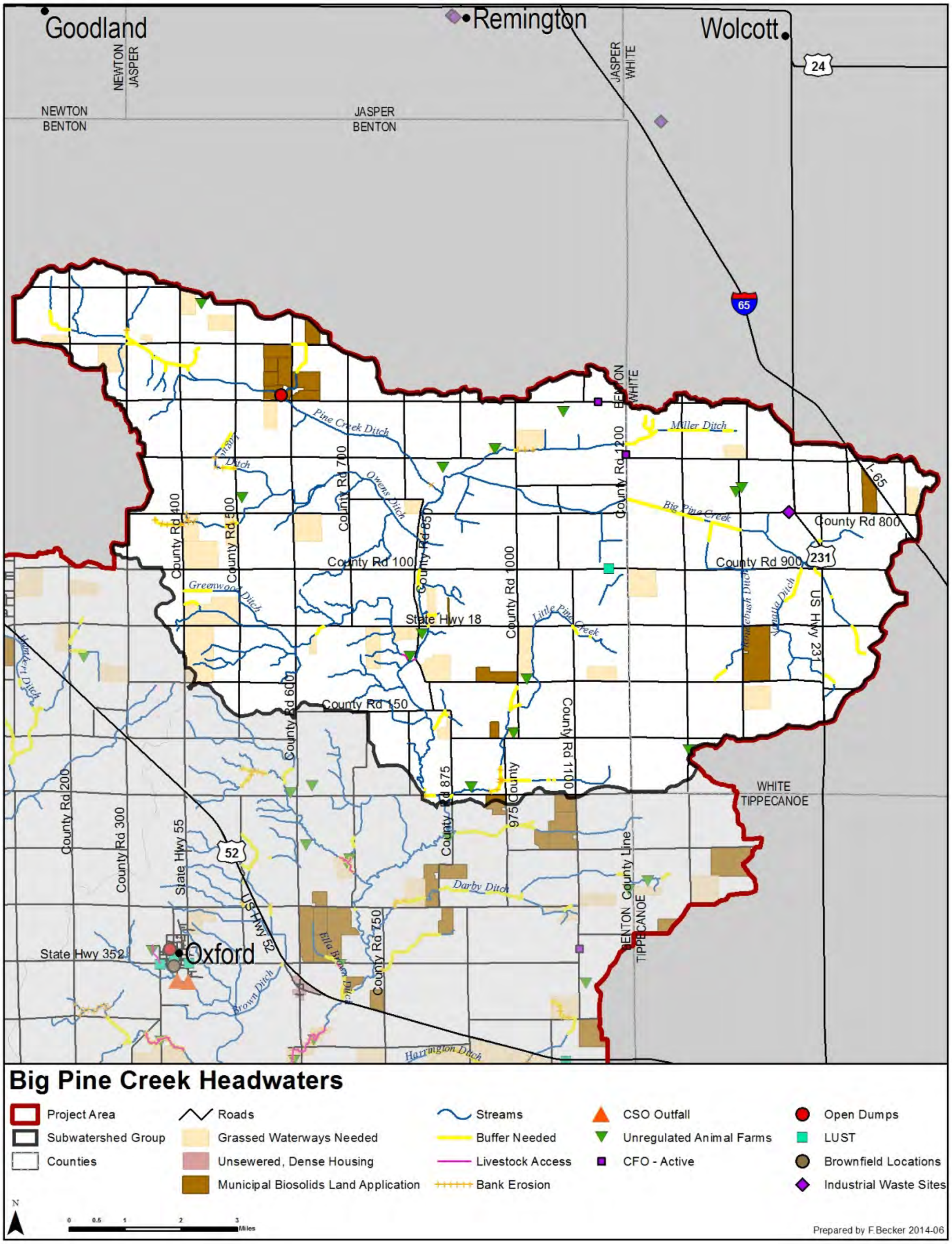


Figure 34. Point and non-point sources of pollution and suggested solutions in the Big Pine Creek Headwaters subwatershed.
Data used to create this map are detailed in Appendix A.

4.1.4 Non-Point Source Water Quality Issues

Agricultural land uses dominate the Big Pine Creek Headwaters subwatershed, primarily in a corn-soybean rotation. However, a number of small animal operations and pastures are also present (Figure 34). Thirteen unregulated animal operations were identified during the windshield survey, although cattle had access to the stream at only two locations. Two active confined feeding operations are located near Miller Ditch, housing a total of 13,628 swine per year. A dairy CFO is located outside the watershed to the north, but 15% of the land it uses for manure application is within the Big Pine Creek Ditch subwatershed. Overall, manure is spread on 868 acres in the Big Pine Creek Ditch subwatershed, totaling over 38 million pounds per year. This contains almost 233,000 pounds of nitrogen and almost 62,000 pounds of phosphorus.

Municipal biosolids are applied to 1,077 acres within the subwatershed. Sewage treatment plants in Lafayette, West Lafayette and Otterbein apply biosolids to land within the subwatershed. In addition, Wealing Brothers operates an off-site biosolid disposal and storage facility north of the intersection of County Road 400 N and County Road 600 E, along a tributary to Pine Creek Ditch.

Streambank erosion and lack of buffers are a concern in the subwatershed. Approximately 15.4 miles of insufficient stream buffers and 3.2 miles of streambank erosion were identified within the subwatershed. There were 1,240 acres of fields identified during the windshield survey that could benefit from the installation of grassed waterways to reduce field erosion.

4.1.5 Water Quality Assessment

Waterbodies within the Big Pine Creek Headwaters subwatershed have been sampled at 31 locations (Figure 35). Assessments include collection of water chemistry data by IDEM (28 sites) and via volunteer monitors through the Hoosier Riverwatch program (3 sites). The fish community has been assessed by IDEM at 23 sites. Macroinvertebrates have not been sampled in this subwatershed. No stream gages are located in the Big Pine Creek Headwaters subwatershed.

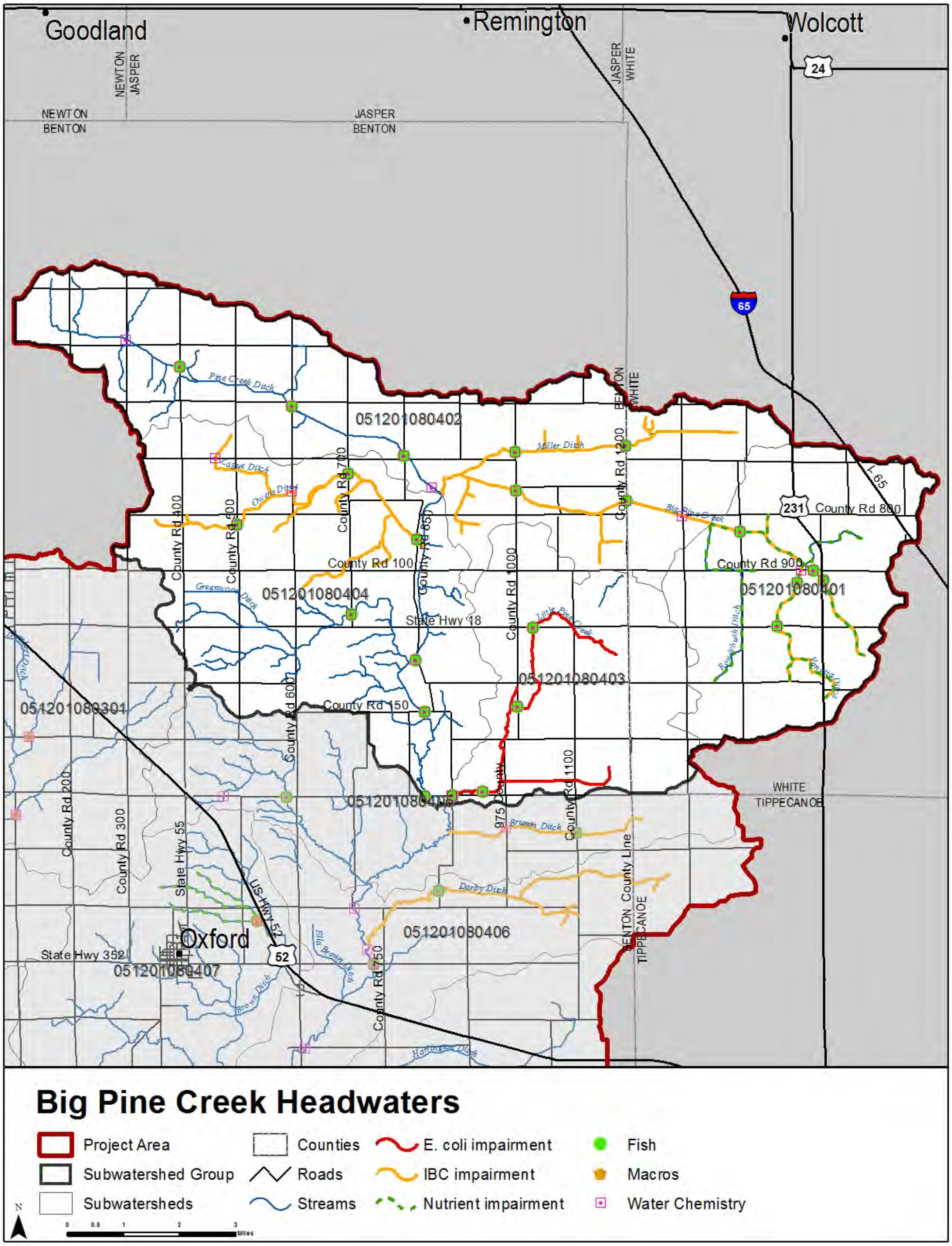


Figure 35. Locations of historic water quality data collection and impairments in the Big Pine Creek Headwaters subwatershed.
Data used to create this map are detailed in Appendix A.

Water Chemistry

Water chemistry data from the Big Pine Creek Headwaters subwatershed suggest several parameters of concern, including total phosphorus, nitrate-nitrite, and total suspended solids. Total phosphorus concentrations were generally below the target concentration of 0.6 mg/L throughout the entire watershed. Except for the fixed station in Pine Village, the only sites that exceeded the target concentration were located in the headwaters, on Vanatta Ditch, Lague Ditch, Big Pine Creek Ditch and Big Pine Creek, with concentrations ranging from 0.66 to 5.2 mg/L. These sites also exceeded the total suspended solids target concentration (35 mg/L), ranging from 60 to 190 mg/L. Two additional sites on Big Pine Creek also exceeded the total suspended solids target, with concentrations of 39 and 54 mg/L. Nitrate-nitrogen concentrations measured 18 mg/L during two-thirds of sample events, exceeding the target of 2 mg/L, at five sites: Vanatta Ditch, Pine Creek Ditch, Big Pine Creek and two sites on Little Pine Creek. *E. coli* concentrations were generally less than the state standard at all sites. The only exceedances were observed at a site on Little Pine Creek (on CR 300 S, between 875 E and 975 E), where the maximum concentration recorded was 461.1 MPN/100 mL.

Habitat

The Qualitative Habitat Evaluation Index (QHEI) was used to evaluate habitat at 23 sites during fish community sampling by IDEM in 1999, 2004 and 2005. Most sites were evaluated only once. The QHEI scores habitat within a reach based on the presence or absence of specific natural characteristics. Streams with QHEI scores greater than 51 are considered to be fully supporting of their aquatic life use designation. Scores ranged from 29 to 79, with 65% of the sites scoring 51 or less. The highest scoring site was on Little Pine Creek, just upstream of the Riverwatch sampling location. The two downstream-most sites on Big Pine Creek also had high scores. The lowest scoring sites were located on Vanatta Ditch, Miller Ditch, Owens Ditch and the headwaters of Big Pine Creek. Lack of riffle-run complexes, poor substrate, channel morphology and low gradient were generally what distinguish these sites from the sites with higher quality habitat further downstream.

Volunteer monitors assessed habitat at three sites within the Big Pine Creek Headwaters subwatershed using the Citizen's Qualitative Habitat Evaluation Index (CQHEI). Similar to the QHEI, the CQHEI scores sites based on the presence or absence of specific natural characteristics within a stream reach. Although a comparison scale for the CQHEI has not yet been developed, Hoosier Riverwatch indicates that scores greater than 60 rate as habitat conducive to supporting warm-water biota (IDNR, 2004). CQHEI scores ranged from 46 to 85, with two-thirds of the scores above 60. The sites on Big Pine Creek Ditch and Big Pine Creek were each assessed five times, with scores from 58 to 85 and 50 to 80, respectively. The site on Little Pine Creek was assessed three times, with scores of 46, 61 and 71.

Fish

IDEM assessed the fish community in the Big Pine Creek Headwaters subwatershed at 1 site in 1999, 2 sites in 2004, and 20 sites in 2005. The Index of Biotic Integrity (IBI) was used to assess the species and trophic composition of the fish community and fish condition and health, in order to determine the biological integrity of the streams. The IBI has a scale of 0 to 60, with scores below 35 representing poor fish communities and streams that are non-supporting for aquatic life use. Scores above 52 represent excellent communities. The sites sampled by IDEM had scores ranging from 12 to 48. The highest scores were found on the furthest downstream sites, at two sites on Big Pine Creek and one site on Little Pine Creek. The fish community was characterized as good at these sites and habitat was higher quality. Nine of the 23 sites (39%) were rated as non-supporting of aquatic life use. All but one of these sites are located in the headwaters of Big Pine Creek, Miller Ditch, or Vanatta Ditch, where habitat was poor. This correlates with the IBC listings on Roudebush Ditch, Vanatta Ditch, Miller Ditch, Big Pine Creek and Owens Ditch, indicating that poor habitat is likely the cause of the listings.

4.1.6 Big Pine Creek Headwaters Subwatershed Summary

The Big Pine Creek headwaters subwatershed is dominated by tile-drained row crop agriculture. As development is limited, there are few point sources of pollution. However, non-point sources and hydromodification related to agriculture pose a threat to water quality, as evidenced by high concentrations of total phosphorus, nitrate-nitrogen, and TSS. Roughly a quarter of the watershed is covered by potentially highly erodible soils, which may contribute to the elevated total phosphorus and TSS concentrations. Lack of buffers, field erosion, and unstable streambanks are additional sources of sediment and nutrients to the streams. The highly channelized ditches in the headwaters and resulting poor quality habitat is reflected in the poor fish community. As habitat improves further downstream, so too does the integrity of the fish community.

4.2 Middle Big Pine Creek Subwatershed

The Middle Big Pine Creek subwatershed is located directly south of the Big Pine Creek Headwaters subwatershed, covering southeast Benton County and northwest Tippecanoe County (Figure 33). The town of Oxford is located in the subwatershed. The subwatershed includes four 12-digit HUC watersheds: Brumm Ditch (051201080405), Darby Ditch (051201080406), Brown Ditch (051201080407), and Harrington Creek (051201080408). This subwatershed drains approximately 47,509 acres or 74 square miles. There are 128 miles of streams in the subwatershed, of which 113 miles are regulated drains and tiles. IDEM has classified 18.4 miles of stream as impaired for nutrients or impaired biotic communities.

4.2.1 Soils

Similar to the Headwaters subwatershed, the soils in the Middle Big Pine Creek subwatershed are dominated by those that lie within till deposits. East of Big Pine Creek, somewhat poorly drained soils with slow permeability and low potential for surface runoff are prevalent. West of Big Pine Creek, moderately well drained soils dominate. Those soils on steeper slopes have higher potential for surface runoff. The soils along the mainstem of Big Pine Creek were formed in loamy sediments and gravel outwash and are well drained with low or medium potential for surface runoff. Hydric soils cover 19,708 acres (41.5%) of the subwatershed, indicating that much of the land was historically wetlands. Wetlands currently cover just 1.5% of the subwatershed, representing a loss of 96.4% of historic wetlands. Potentially highly erodible soils cover 19% of the subwatershed, concentrated along the western boundary. Nearly the entire subwatershed (99.9%) has soils which are severely limited for septic use.

4.2.2 Land Use

Agricultural land uses dominate the Middle Big Pine Creek subwatershed, with 89.7% in row crops and 2.2% in hay/pasture. Forest and wetlands cover just over 2,000 acres, or 4.2%, of the subwatershed, located primarily in the riparian corridor along Big Pine Creek. Developed land accounts for 5.3% of the land use, mostly associated with the towns of Oxford and Templeton, and Benton Central Junior-Senior High School.

4.2.3 Point Source Water Quality Issues

There are several point sources of water pollution in the subwatershed, mostly associated with the town of Oxford. There are three leaking underground storage tanks (LUST), one brownfield and one open dump, all in Oxford (Figure 36). The Oxford Wastewater Treatment Plant has an NPDES permit to discharge treated wastewater into Brown Ditch. Stormwater issues are of concern within this subwatershed, as Oxford has the only two combined sewer overflows (CSO) in the entire watershed. The WWTP is currently in noncompliance with its NPDES permit and is working on a Long Term Control Plan to reduce the number of combined sewer overflow events. See section 2.6.3 for further details. The Benton Central Junior-Senior High School operates a small wastewater treatment plant, serving approximately 1100 students, and is currently in compliance with its NPDES permit.

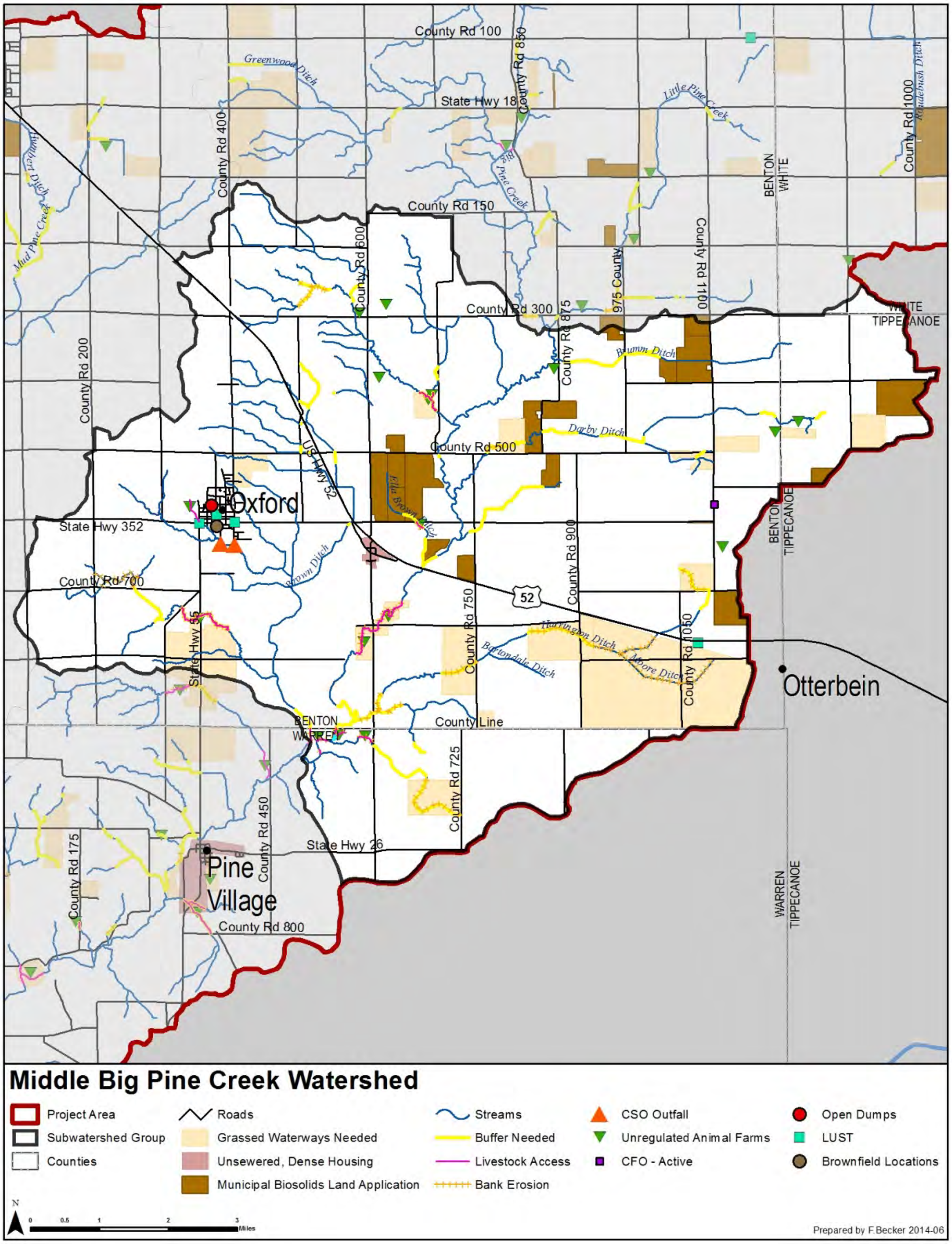


Figure 36. Point and non-point sources of pollution and suggested solutions in the middle Big Pine Creek subwatershed.
Data used to create this map are detailed in Appendix A.

4.2.4 Non-Point Source Water Quality Issues

Similar to the Headwaters subwatershed, row crop agriculture dominates the Middle Big Pine Creek subwatershed. However, a number of small animal operations and pastures are also present (Figure 36). Seventeen unregulated animal operations were identified during the windshield survey and livestock had access to 4.6 miles of stream. One active confined feeding operation is located near the boundary between the Darby Ditch and Harrington Ditch subwatershed boundary, housing a total of 12,012 swine per year. Overall, manure is spread on 871 acres in the Middle Big Pine Creek subwatershed, totaling over 34.5 million pounds per year. This contains over 230,000 pounds of nitrogen and almost 88,000 pounds of phosphorus.

Streambank erosion and lack of buffers are a greater concern in this subwatershed than in the three other subwatersheds. Approximately 19.3 miles of insufficient stream buffers and 13.3 miles of streambank erosion were identified within the subwatershed. There were 1,121 acres of fields identified during the windshield survey that could benefit from the installation of grassed waterways to reduce field erosion.

Municipal biosolids are applied to 1,692 acres within the watershed. The sewage treatment plant in Lafayette is the largest applicator of biosolids, using several large fields along tributaries to Big Pine Creek. The West Lafayette and Otterbein sewage treatment plants also apply biosolids to land within the subwatershed.

4.2.5 Water Quality Assessment

Waterbodies within the Middle Big Pine Creek subwatershed have been sampled at 13 locations (Figure 37). Historic assessments include collection of water chemistry data by IDEM (11 sites) and via volunteer monitors through the Hoosier Riverwatch program (two sites). The fish community has been assessed by IDEM at five sites. Macroinvertebrates have been sampled at one site by IDEM. No stream gages are located in the Middle Big Pine Creek subwatershed.

Water Chemistry

Water chemistry data from the Middle Big Pine Creek subwatershed suggest that nitrate-nitrite and total suspended solids pose concerns in this subwatershed. Water chemistry was sampled by IDEM in 1999, 2005, and 2009. Total suspended solids concentrations exceeded the target concentration at three sites in the subwatershed: two sites on Big Pine Creek in the Darby Ditch subwatershed and a tributary of Big Pine Creek in the Brumm Ditch subwatershed, where the highest concentration of 82 mg/L was recorded. The two sites on the mainstem also exceeded the nitrate-nitrite target, as did a site on a tributary of Brown Ditch, with concentrations of 18 mg/L. Total phosphorus concentrations were routinely less than the target of 0.6 mg/L, ranging from 0 to 0.43 mg/L. *E. coli* was sampled five times in September and October 2009 at one site, on the tributary of Brown Ditch. Concentrations were generally less than the state standard, with one exceedance of 866 MPN/100 mL.

Volunteer monitors sampled water quality several times from 2007 to 2013 at two sites on Brown Ditch and Big Pine Creek near the County Line. Nitrate-nitrogen concentrations exceeded the target roughly half the time at both sites, ranging from 0 to 20 mg/L. Total phosphorus was generally less than the target, with only one reading of 1 mg/L exceeding the target. Turbidity was not sampled at these sites.

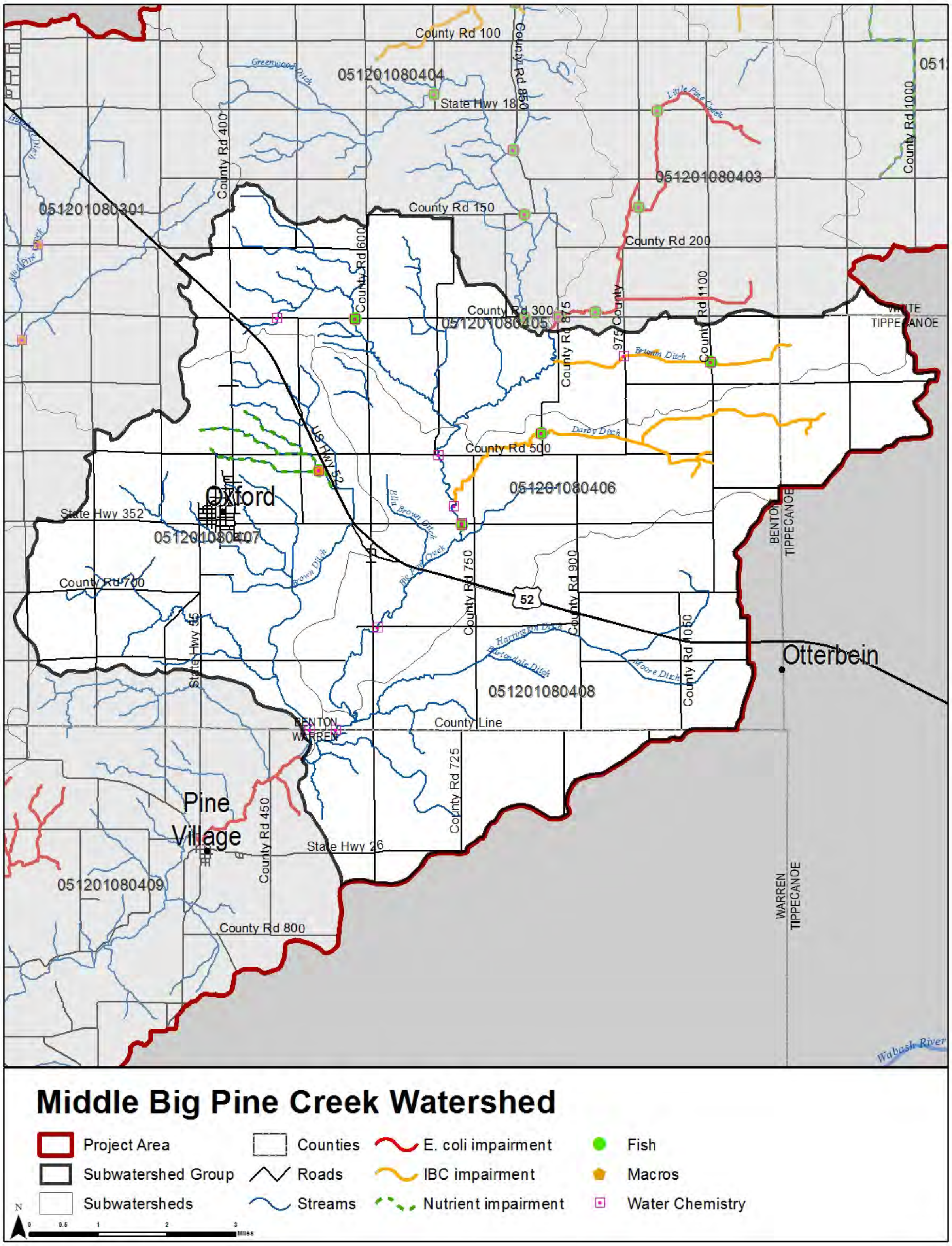


Figure 37. Locations of historic water quality data collection and impairments in the middle Big Pine Creek subwatershed.
Data used to create this map are detailed in Appendix A.

Habitat

The QHEI was used to evaluate habitat at five sites in the middle Big Pine Creek subwatershed during fish community sampling by IDEM in 2005 and 2009. Each site was evaluated only once. Scores ranged from 31 to 51, indicating that habitat for biological communities is generally poor. Poor substrate and lack of riffle-run complexes limited habitat within these reaches. The site on a tributary of Brown Ditch was assessed twice in July 2009 by IDEM, during sampling of the macroinvertebrate and fish communities, with a mean score of 44. This site had higher quality substrate and a higher gradient, but still scored poorly for riffle, run and pool complexes.

Volunteer monitors assessed habitat at two sites within the middle Big Pine Creek subwatershed using the CQHEI, on Brown Ditch and Big Pine Creek near the County Line. Each site was assessed several times from 2009 to 2013, with CQHEI scores ranging from 24 to 73. Two-thirds of the scores fell below 60, indicating that habitat quality may be poor. The biggest variation in scoring was in the riffle/run and substrate categories, which could be due to seasonal variations in flow. This indicates that habitat at these sites is of marginal quality, but may be capable of supporting warmwater fauna during parts of the year.

Fish

IDEM assessed the fish community in the Middle Big Pine Creek subwatershed at four sites in 2005 and one site in 2009. The sites assessed in 2005 received IBI scores ranging from 32 to 42, with half of them characterized as non-supporting of aquatic life use. The site assessed in 2009 was on a tributary of Brown Ditch, near US Highway 52 northeast of Oxford. This site had the highest quality habitat relative to the other sites sampled, and the fish community was characterized as good, with a score of 48.

The IBC listings on Brumm Ditch and Darby Ditch correlate with poor fish IBI scores, poor QHEI scores and elevated total suspended solids at sample sites on the two ditches. This indicates that poor habitat and high turbidity are likely the cause of the listings.

Macroinvertebrates

The macroinvertebrate community was sampled by IDEM at one site in 2009, the tributary of Brown Ditch. Similar to the fish IBI, the macroinvertebrate community is assessed using an Index of Biotic Integrity (mIBI), which is composed of 12 metrics designed to assess the structural, compositional, and functional integrity of the community and therefore the biological integrity of the stream. Scores less than 36 for multi-habitat samples and 2.2 for kick samples are considered poor or very poor and are nonsupporting for aquatic life use. The site sampled in 2009 received an mIBI score of 44, which indicates a well-balanced aquatic community. This is consistent with the good fish community and habitat documented at this site.

4.2.6 Middle Big Pine Creek Subwatershed Summary

Similar to the Headwaters subwatershed, the Middle Big Pine Creek subwatershed is dominated by tile-drained row crop agriculture. The few point sources of pollution in the subwatershed are primarily associated with the town of Oxford. Brown Ditch is subjected to multiple combined sewer overflows annually from the town of Oxford. The town is currently developing plans to address the CSO issues. Non-point sources related to agriculture pose a threat to water quality, as evidenced by high concentrations of nitrate-nitrogen and TSS. Lack of buffers, field erosion, and unstable streambanks are sources of sediment and nitrate-nitrogen to the streams. This subwatershed has the lowest proportion of potentially highly erodible soils, which may explain the lower total phosphorus levels observed throughout the subwatershed. The fish community was generally fair to poor, reflecting the poor habitat available. The site on the tributary to Brown Ditch had relatively better habitat and supported good fish and macroinvertebrate communities; however elevated nitrogen concentrations could present long-term issues for biota at this site.

4.3 Lower Big Pine Creek Subwatershed

The Lower Big Pine Creek subwatershed is the downstream-most portion of the Big Pine Creek watershed, stretching from the Benton County line south through central Warren County to the confluence of Big Pine Creek with the Wabash River near Attica (Figure 33). The town of Pine Village is located near the northern edge of the subwatershed. The subwatershed includes two 12-digit HUC watersheds: Pine Village-Big Pine Creek (051201080409) and Hog Back Hill-Big Pine Creek (051201080410). This subwatershed drains approximately 41,323 acres or 65 square miles. There are 143 miles of streams in the subwatershed, of which only 12 miles are regulated drains and tiles. IDEM has classified 35 miles of stream as impaired for *E. coli* or PCBs in fish tissue.

4.3.1 Soils

Soils in the Lower Big Pine Creek subwatershed are dominated by those that were formed on till, with a greater slope (0-60%) than in the Headwaters or Middle Big Pine Creek subwatersheds. The soils along Big Pine Creek were formed in alluvium on flood plains and range from poorly drained to well drained. In northern Warren County, Comfrey soil type is common (poorly drained), but as the creek becomes more riverine Landes-Chatterton is the most common floodplain soil (well drained). The soils east and south of Pine Village are somewhat poorly drained with slow permeability. Highly erodible soils cover 12% and potentially highly erodible soils cover 44% of the subwatershed, more than the Middle and Headwaters subwatersheds combined. These soils are more prevalent downstream of Pine Village and are generally located along the tributaries and main stem of Big Pine Creek. Hydric soils cover 18% of the subwatershed, primarily upstream of Pine Village. Wetlands currently cover almost 4% of the subwatershed, representing a loss of only 79% of historic wetlands, which is the lowest of the four subwatersheds. Almost the entire subwatershed (99.3%) is severely limited for septic use.

4.3.2 Land Use

The Lower Big Pine Creek subwatershed has the highest proportion of natural areas of all the subwatersheds. Forested land accounts for almost 24% of the subwatershed, located primarily on more steeply sloped areas adjacent to Big Pine Creek and its tributaries. Hay and pasture covers 4,295 acres, or 10%, of the subwatershed. Row crop agriculture covers only 24,589 acres, or 59.5%, of the subwatershed, primarily on less steeply sloped upland areas. Developed land accounts for 5.8% of the subwatershed, mostly associated with Pine Village. The Nature Conservancy's Fall Creek Gorge nature preserve (165 acres) is located along Fall Creek just upstream of its confluence with Big Pine Creek and is publicly-accessible for passive recreation.

4.3.3 Point Source Water Quality Issues

There are few point sources of water pollution in the subwatershed. There are two leaking underground storage tanks (LUST), located at the intersection of US Highway 41 and State Road 63 (Figure 38). The Oxford Water Utility is located on State Highway 55 between Oxford and Pine Village and has an NPDES permit to withdraw groundwater and discharge water into a culvert/tributary of Big Pine Creek. As of December 2013, the Water Utility is in noncompliance with its permit under the Safe Drinking Water Act, for failure to report under the Consumer Confidence Rule. No open dumps, industrial waste sites, or brownfields are located in the subwatershed.

4.3.4 Non-Point Source Water Quality Issues

Agriculture plays a much smaller role in the Lower Big Pine Creek subwatershed. As such, there are no active confined feeding operations and no application of municipal biosolids within the subwatershed. However, there is a greater proportion of hay and pastures in the subwatershed. Seventeen unregulated animal operations were identified during the windshield survey and livestock had access to 3.5 miles of stream (Figure 38). Streambank erosion and lack of buffers are a concern in this subwatershed, although to a lesser extent than in the headwaters and Middle subwatershed. Approximately 10 miles of insufficient stream buffers and 3.3 miles of streambank erosion were identified within the subwatershed. There were 1,203 acres of fields identified during the windshield survey that could benefit from the installation of grassed waterways to reduce field erosion.

Unsewered areas are a great concern in this subwatershed. Approximately half a square mile around Pine Village was mapped as an area of unsewered, dense housing (defined as more than 20 houses within one square mile). The soils in this area are all rated as severely limited for septic use. There is no available data on the amount of failing septic systems in Warren County, however the high concentration of septics adjacent to the main stem of Big Pine Creek is a cause for concern for potential *E. coli* contamination if systems are not properly maintained. Several smaller areas of unsewered, dense housing were mapped using aerial photography, but these typically consisted of a small cluster of houses in more rural areas and thus are less cause for concern.

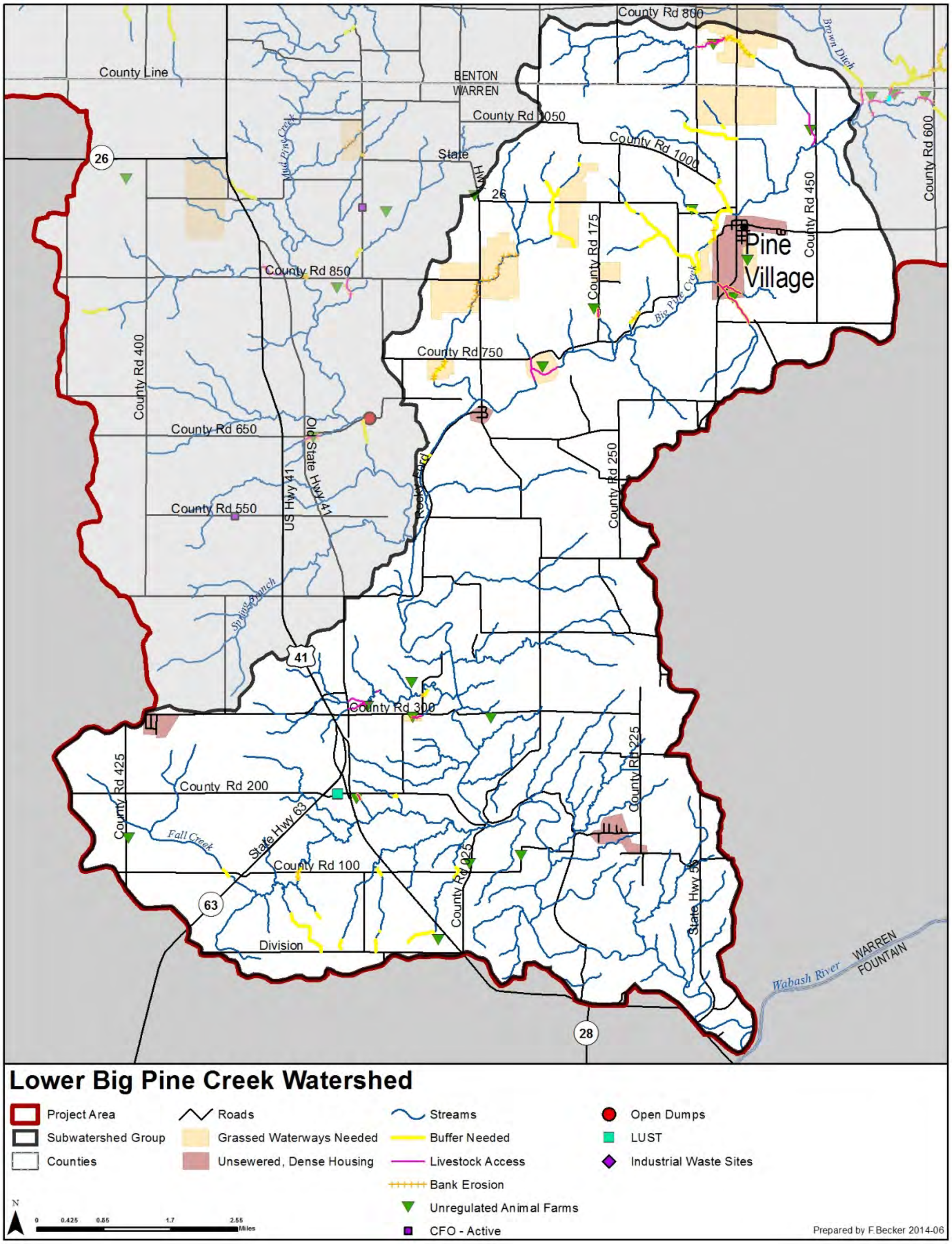


Figure 38. Point and non-point sources of pollution and suggested solutions in the lower Big Pine Creek subwatershed.
Data used to create this map are detailed in Appendix A.

4.3.5 Water Quality Assessment

Waterbodies within the Lower Big Pine Creek subwatershed have been sampled at 15 locations (Figure 39). Historic assessments include collection of water chemistry data by IDEM (12 sites) and via volunteer monitors through the Hoosier Riverwatch program (3 sites). The fish community has been assessed by IDEM at 3 sites. Macroinvertebrates have been sampled at 4 sites by IDEM and 3 sites by Hoosier Riverwatch. IDEM has a fixed sampling station on Big Pine Creek in Pine Village.

Water Chemistry

Water chemistry data is available for IDEM's fixed station on Big Pine Creek in Pine Village from 1990 to 2013. *E. coli* concentrations varied over time but exceeded the state standard just over half the time, resulting in this reach of Big Pine Creek being listed on Indiana's impaired waterbodies list. The highest concentrations were recorded in the 1990s (17,000 CFU/100mL, 9,300 CFU/100mL and 3,800 CFU/100mL), with concentrations of 1,200 CFU/100mL recorded in 2000 and 2005. Nitrate-nitrogen concentrations exceeded the target concentration of 2 mg/L 75% of the time. Total phosphorus concentrations were generally below the target concentration of 0.6 mg/L, with readings exceeding the target on three dates in 2001, 2007 and 2009. Total suspended solids concentrations ranged from 0 to 404 mg/L, falling below the target concentration of 35 mg/L in 76% of the samples.

Water chemistry was sampled by IDEM at eight additional sites in 1999, 2004, and 2009. None of the sites exceeded the target concentrations for total phosphorus or total suspended solids. Total phosphorus concentrations ranged from 0 to 0.11 mg/L and TSS ranged from 0 to 32 mg/L. Four sites exceeded the target for nitrate-nitrogen at least 50% of the time, with concentrations of 18 mg/L. *E. coli* concentrations were generally below the state standard, however readings of 270 CFU/100mL, 517 MPN/100mL and 1732 MPN/100mL were recorded at three sites and IDEM listed those reaches as impaired for *E. coli*.

Volunteer monitors sampled water chemistry at three sites on Big Pine Creek in the Hogback Hill subwatershed from 2007 to 2012. All three sites exceeded the target concentration of nitrate-nitrogen more than 50% of the time, ranging from 0 to 88 mg/L. Turbidity was generally less than the target concentration, exceeding it at only one site in 11% of samples. *E. coli* concentrations exceeded the target at two sites roughly 25% of the time.

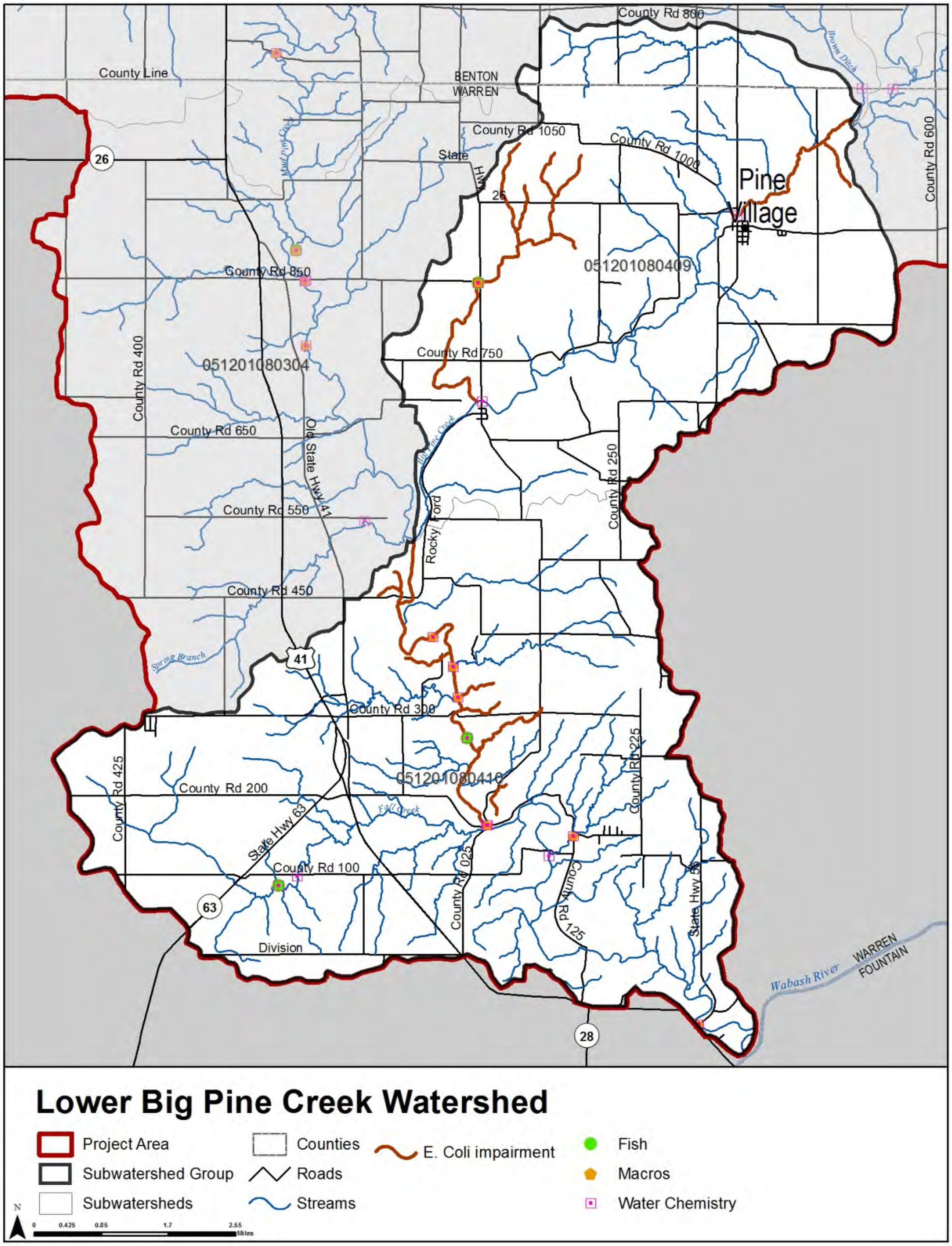


Figure 39. Locations of current or historic water quality data collection and impairments in the lower Big Pine Creek subwatershed.
Data used to create this map are detailed in Appendix A.

Habitat

The QHEI was used to evaluate habitat at three sites during fish community sampling by IDEM. Fall Creek was evaluated in 1999, with a score of 62; Big Pine Creek (near CR 300 N) was evaluated in 2004, with a score of 93; and a tributary of Big Pine Creek (near CR 850 N) was evaluated in 2009 with a score of 57. The Big Pine Creek tributary was also evaluated by IDEM during macroinvertebrate sampling in 2009, with a score of 48, so a mean score of 52.5 is probably more representative of the habitat at that site. IDEM evaluated habitat at three additional sites during macroinvertebrate sampling in 1991, 1999, and 2004. Scores ranged from 60 to 84, indicating all three sites consistently provided good habitat for biological communities. Good pool-glide complexes, well-developed channel morphology, good substrate, in-stream cover and high gradient all contributed to good habitat at these sites.

Volunteer monitors assessed habitat at four sites within the lower Big Pine Creek subwatershed using the CQHEI: on Pine Creek near Pine Village, and three sites on Big Pine Creek in the Hogback Hill subwatershed. The Pine Creek site was assessed once in 2002, with a score of 80. The three Big Pine Creek sites were assessed several times from 2007 to 2010, with CQHEI scores ranging from 64 to 94. These sites all possess high quality habitat capable of supporting a healthy biological community.

Fish

The fish community has been assessed by IDEM at three sites. Fall Creek was assessed in 1999, with a score of 48. Big Pine Creek (near CR 300 N) was assessed in 2004, with a score of 50. An unnamed tributary to Big Pine Creek (near CR 850 N) was assessed in 2009, with a score of 40. The sites on Fall Creek and Big Pine Creek were characterized as good, with corresponding good habitat scores. The tributary of Big Pine Creek was characterized as having a fair fish community, most likely due to the lower quality habitat at that site relative to the other two.

Macroinvertebrates

The macroinvertebrate community was sampled by IDEM at four sites: Big Pine Creek near Twin Bridges (1991), a tributary of Big Pine Creek near Mudlavia Springs (1991 and 1999), Big Pine Creek near its outlet to the Wabash (1991, 1999, and 2004), and a tributary of Big Pine Creek near CR 850 N in the Pine Village subwatershed (2009). Macroinvertebrate communities rated as good to excellent on all but two occasions in the Hog Back Hill subwatershed, with scores of 4.8 to 6.2 for Kick samples and 24 to 46 for multi-habitat samples. All three sites in the Hogback Hill subwatershed contained high quality habitat. The tributary site in the Pine Village subwatershed received an mIBI score of 42, indicating that the macroinvertebrate community was healthy despite the somewhat lower quality habitat found at that site.

Volunteer monitors assessed the macroinvertebrate community at three sites, using the Pollution Tolerance Index (PTI). A PTI score of 23 or more reflects the presence of a high proportion of macroinvertebrates that are intolerant or moderately intolerant of water pollution, indicating an excellent macroinvertebrate community. Three sites on Big Pine Creek were sampled several times from 2007 to 2012, with scores ranging from 11 to 53. Three-quarters of the sample events recorded PTI scores above 23, and all three sites had high quality habitat, indicating that these sites are highly conducive to warmwater fauna.

4.3.6 Lower Big Pine Creek Subwatershed Summary

Compared to the other subwatersheds, the Lower Big Pine Creek subwatershed has the most forested, non-agricultural land. Row crop agriculture is less prevalent and there is relatively more hay and pasture land. Perhaps as a result, elevated *E. coli* concentrations were observed, resulting in 35 stream miles being listed as impaired. Topography is much more varied in this subwatershed. The smaller streams have a much higher gradient, winding through steeply sloped terrain. Although more than half of soils in the watershed are classified as highly erodible or potentially highly erodible, total phosphorus and TSS concentrations were generally low, probably because the steeply sloped riparian areas in the Hogback Hill subwatershed are forested. Inadequate buffers, field erosion and unstable streambanks were observed mostly in the Pine Village subwatershed, and are sources of sediment and nutrients to the streams. Due to the high gradient and forested buffer, streams in this subwatershed have excellent habitat and support high quality fish and macroinvertebrate communities.

4.4 Mud Pine Creek Subwatershed

Mud Pine Creek is the largest tributary to Big Pine Creek, draining 61,900 acres or 97 square miles. This subwatershed spans from Fowler in the north, through central Benton County, to the confluence with Big Pine Creek in central Warren County (Figure 33). The town of Boswell is located in the middle of the subwatershed. The subwatershed includes four 12-digit HUC watersheds: Headwaters Mud Pine Creek (051201080301), Seamons Ditch-Mud Pine Creek (051201080302), Goose Creek-Mud Pine Creek (051201080303), and Spring Branch-Mud Pine Creek (051201080304). There are 151 miles of streams in the subwatershed, of which 82 miles are regulated drains and tiles, primarily in Benton County. IDEM has classified 46 miles of stream as impaired for PCBs in fish tissue, primarily in the Spring Branch subwatershed.

4.4.1 Soils

The Mud Pine Creek subwatershed is dominated by moderately well drained soils that formed within till deposits. There are some small areas of very poorly drained, moderately permeable soils along the northern boundary. The southern portion of the subwatershed, from east of Boswell south into Warren County, is characterized by soils on more steeply sloped land with a high potential for surface runoff. Along the main stem of Mud Pine Creek in the southern half of the subwatershed, the soils were formed in alluvium on flood plains and are poorly drained.

Hydric soils are present throughout the subwatershed, covering 20,737 acres (33.5%). Wetlands currently cover only 1.1% of the subwatershed, representing a 96.7% loss of historic wetland coverage. The northern part of the subwatershed has experienced more loss of wetlands than the southern part. Highly erodible soils cover 2% of the subwatershed, primarily in the southern half on more steeply sloped land. Potentially highly erodible soils cover 32% of the subwatershed, with the highest concentrations in the southern half on steeply sloped land and along the northern edge of the Headwaters, Seamons Ditch and Goose Creek subwatersheds. Nearly the entire subwatershed (99.9%) has soils which are severely limited for septic use.

4.4.2 Land Use

Similar to the Middle Big Pine Creek subwatershed, the Mud Pine Creek subwatershed is dominated by agricultural land uses, with 86.5% in row crops and 3.4% in hay/pasture. The Headwaters Mud Pine Creek and Seamons Ditch subwatersheds have a higher concentration of row crop agriculture, with 90% in each, while Goose Creek and Spring Branch have slightly lower proportions (86% and 82%, respectively). Forest and wetlands cover just over 5% of the subwatershed, located primarily in the riparian corridor along Mud Pine Creek in Warren County. Developed land accounts for 6% of the land use, mostly associated with the towns of Boswell and Fowler. DNR Fish and Wildlife owns two Gamebird Habitat Areas in Benton County, which are open to the public.

4.4.3 Point Source Water Quality Issues

There are several point sources of water pollution in the subwatershed, mostly associated with the town of Fowler. There are seven leaking underground storage tanks (LUST), six of which are in Fowler and one in Boswell (Figure 40). There are two open dumps, one in Fowler and one located along the main stem of Mud Pine Creek on County Road 650 N in Warren County. One brownfield and one industrial waste site are located in Fowler.

Two NPDES-permitted facilities are located within the subwatershed. The Fowler Municipal Sewage Treatment Plant discharges treated wastewater to Humbert Ditch. The Boswell Municipal Wastewater Treatment Plant discharges treated wastewater to Goose Creek. Both plants are currently in compliance with their NPDES permits. For further details, refer to section 2.6.3 above.

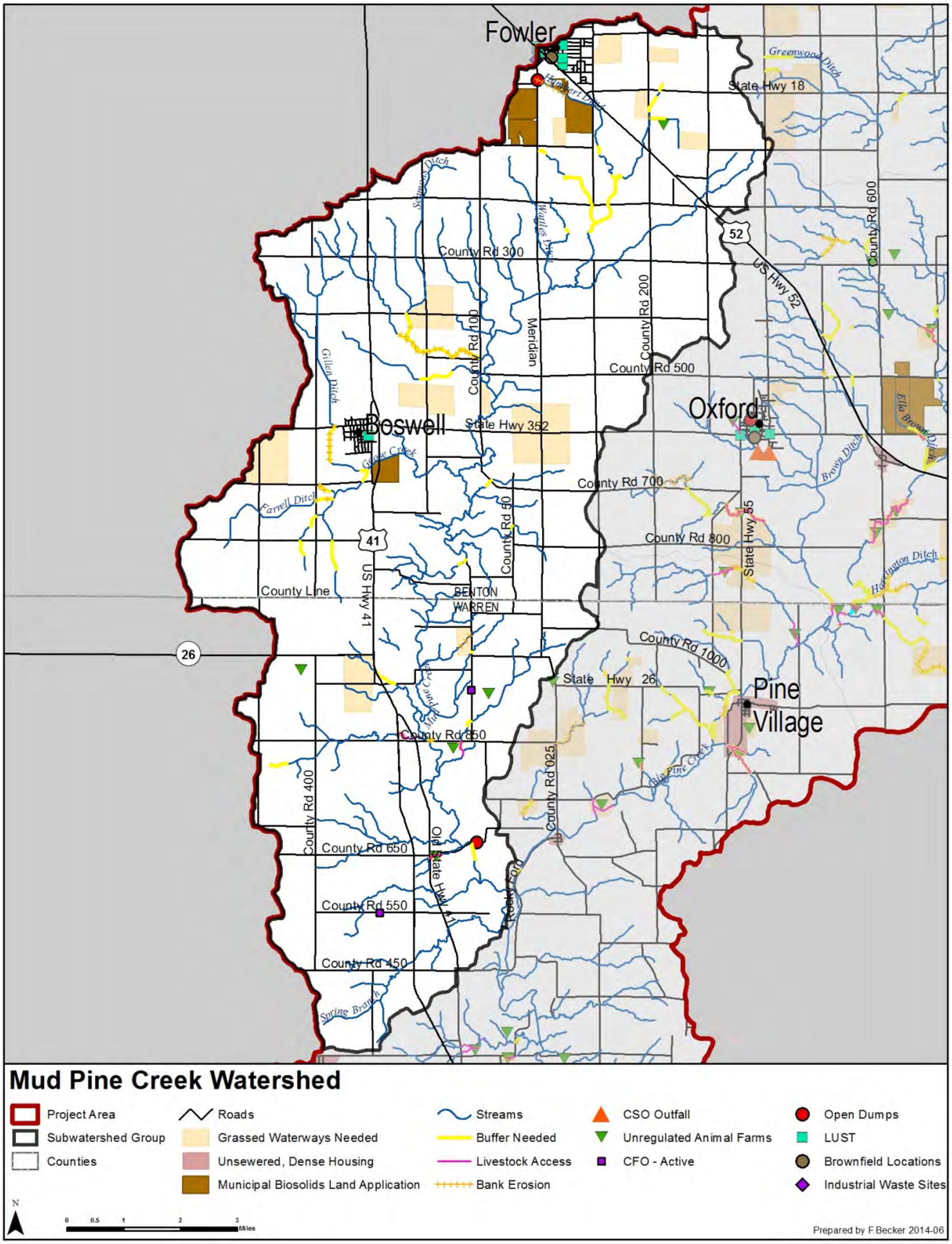


Figure 40. Point and non-point sources of pollution and suggested solutions in the Mud Pine Creek subwatershed.
Data used to create this map are detailed in Appendix A.

4.4.4 Non-Point Source Water Quality Issues

The Mud Pine Creek subwatershed is dominated by row crop agriculture. There were only five unregulated animal operations identified during the windshield survey and livestock had access to 0.7 miles of stream (Figure 39). Two active confined feeding operations are located in the subwatershed, both in the Spring Branch subwatershed, but neither is directly adjacent to a waterbody. These two facilities house a total of 13,208 swine and 420 dairy cows per year. Overall, manure is spread on 1,335 acres in the Mud Pine Creek subwatershed, totaling almost 56.5 million pounds per year. This contains over 356,000 pounds of nitrogen and 112,500 pounds of phosphorus.

Streambank erosion and lack of buffers are a problem in this subwatershed. Approximately 10.7 miles of insufficient stream buffers and 5 miles of streambank erosion were identified within the subwatershed. The Headwaters Mud Pine Creek subwatershed had the highest percentage of stream miles lacking buffers (16%), while the Seamons Ditch and Goose Creek subwatersheds had much fewer unbuffered streams (7% each). Streams in the Spring Branch subwatershed were relatively well buffered, with only 2.7% of stream miles lacking buffers. Similarly, the least streambank erosion was identified within the Spring Branch subwatershed (1.7% of stream miles), while the Seamons Ditch subwatershed had more than twice as many miles of streams exhibiting erosion (5%). There were 2,482 acres of fields identified during the windshield survey that could benefit from the installation of grassed waterways to reduce field erosion. At 4% of the total subwatershed acreage, this is almost twice as high as any of the other subwatersheds. Again, the Seamons Ditch subwatershed had the highest percent of field erosion (8.6%), compared to only 1.8% in the Spring Branch subwatershed.

Municipal biosolids are applied to 615 acres within the watershed. The Fowler Municipal Sewage Treatment Plant applies sludge to 487 acres of fields south of town and the Boswell Municipal Wastewater Treatment Plant applies sludge to a small field adjacent to the plant.

4.4.5 Water Quality Assessment

Waterbodies within the Mud Pine Creek subwatershed have been sampled at approximately 15 locations (Figure 41). Historic assessments include collection of water chemistry data by IDEM (4 sites), by JFNew as part of the LARE-funded Diagnostic Study in 2001 (8 sites), and via volunteer monitors through the Hoosier Riverwatch program (3 sites). Macroinvertebrate samples have been collected by Hoosier Riverwatch volunteers (1 site), by JFNew (8 sites), and by IDEM (2 sites), while the fish community has only been assessed by IDEM (2 sites).

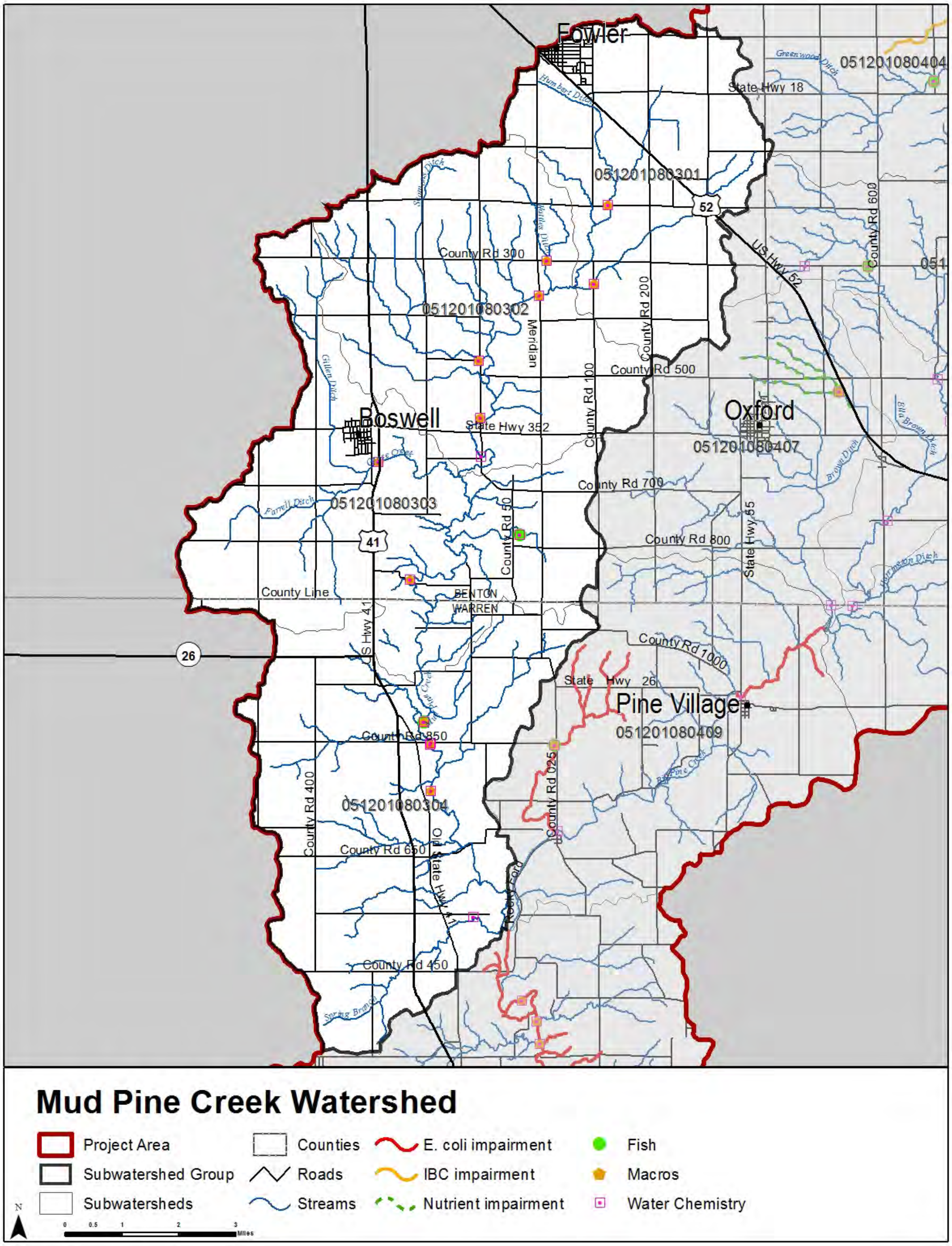


Figure 41. Locations of current or historic water quality data collection and impairments in the Mud Pine Creek subwatershed.
Data used to create this map are detailed in Appendix A.

Water Chemistry

IDEM sampled water chemistry in 1999 at two sites on Mud Pine Creek in Warren County and one site on a tributary near CR 50 W in Benton County. Basic water chemistry data was collected at one site in 2004 as part of an mIBI calibration study, however no data on nutrients or sediment was collected. Nitrate-nitrite concentrations ranged from 0 to 14 mg/L. TSS concentrations ranged from 0 to 88 mg/L. One site on the main stem (near CR 850 N) was sampled once in 1999, exceeding the target for both nitrate-nitrogen and TSS. The other main stem site (about one mile upstream) was sampled five times, with 40% of the samples exceeding the targets for nitrate-nitrogen and TSS. The tributary site was sampled twice, exceeding the nitrate-nitrogen target both times, but falling below the TSS target. Total phosphorus concentrations were low at all sites, ranging from 0.044 to 0.15 mg/L.

Volunteer monitors sampled water quality several times from 2007 to 2010 at three sites: Mud Pine Creek east of Boswell, Mud Pine Creek near Old Hwy 41 in Warren County and on a tributary near CR 550N in Warren County. *E. coli* concentrations measured higher than the target 60% of the time, with values of 20 to 700 CFU/100 ml. Nitrate-nitrogen concentrations measured higher than the target 40% of the time, ranging from 0 to 29 mg/L. Total phosphorus and turbidity were less than the target on all sampling dates.

As part of the LARE-funded Diagnostic Study in 2001, JFNew sampled water chemistry at eight sites in the upper Mud Pine Creek subwatershed in Benton County. Each site was sampled once during base flow (June 2001) and storm flow (May 2001). Nitrate-nitrogen concentrations ranged from 0.3 to 1 mg/L during base flow and from 9.775 to 12.442 mg/L during storm flow. Both total phosphorus and TSS concentrations fell below the target set for this plan at all sites. Total phosphorus ranged from 0.045 to 0.223 mg/L during base flow and 0.38 to 0.52 mg/L during storm flow. TSS ranged from 0.933 to 2.267 mg/L during base flow with one high reading of 21.75 mg/L at the downstream-most site. Storm flow TSS concentrations ranged from 6 to 9 mg/L. *E. coli* varied from 70 to 350 CFU/100 ml during both base and storm flow, with 62% of the samples exceeding the state standard. The following subwatersheds were prioritized for implementation of best management practices based on these water monitoring results: Goose Creek (high TSS, total phosphorus, *E. coli*), Upper Mud Pine Creek (highest *E. coli*, phosphorus loading), and Humbert Ditch (high phosphorus).

Habitat

The QHEI was used to evaluate habitat at three sites during fish and macroinvertebrate community sampling by IDEM 1991, 1999 and 2004. The two sites on the main stem of Mud Pine Creek had high quality habitat, with scores of 77 and 80. The tributary near CR 50 W in Benton County received a QHEI score of 50, indicating poor habitat. Poor substrate, channel morphology, pool/glide and riffle/run complexes influenced the quality of the habitat at this site. Habitat assessed in the upper subwatershed in Benton County during the LARE study was “less than optimal for aquatic life uses” at most sites.

Volunteer monitors assessed habitat at two sites on Mud Pine Creek. CQHEI scores ranged from 48 to 83, with 6 of the 8 scores above 60, indicating habitat capable of supporting a healthy biological community. Scores were higher at the downstream site in Warren County than at the site in Benton County.

Fish

IDEM assessed the fish community in the Mud Pine Creek subwatershed in 1999 at one site on the tributary and one site on the main stem of Mud Pine Creek. The fish community received an IBI score of 52 and was rated as excellent at the main stem site, which also contained high quality habitat. Nitrate-nitrite and TSS exceeded the target concentration in 40% of the samples at this site, indicating that habitat has more of an influence on the biological community than does water quality. The tributary site had poor quality habitat and elevated nitrate-nitrite levels, and while the fish community was rated as good with an IBI score of 42, it was lower quality than at the main stem site downstream.

Macroinvertebrates

The macroinvertebrate community was sampled by IDEM in 1991 and 2004 at two sites on the main stem. mIBI scores of 5.4 and 6.4 for Kick samples and 24 and 40 for multi-habitat samples were recorded, indicating the macroinvertebrate community is good overall. This is consistent with the high quality habitat measured at both sites and the good fish community documented in 1999.

Macroinvertebrates were also sampled as part of the LARE-funded Diagnostic Study in 2001 in the upper Mud Pine Creek subwatershed. The mIBI scores documented a range of moderately impacted (2.0) to just barely unimpaired (6.5) water quality. The lowest mIBI scores were correlated with poor habitat, along with a large amount of unprotected highly erodible land at the Seamons Ditch site and high phosphorus levels at the Humbert Ditch site.

Volunteer monitors assessed the macroinvertebrate community at the site on Mud Pine Creek near Old Hwy 41 in Warren County. Data was collected on two dates in 2010. On both dates, PTI scores were above 23, indicating excellent biotic quality. Although elevated levels of *E. coli* and nitrate-nitrogen were recorded at this site, it appears that high quality habitat has a bigger influence on the macroinvertebrate community.

4.4.6 Mud Pine Creek Subwatershed Summary

Row-crop agriculture plays a bigger role in the northern portion of the Mud Pine Creek subwatershed, while the southern portion in Warren County has more forested areas, especially along the steeply sloped streams. Water quality in the subwatershed reflects this difference in land use from north to south. Elevated nitrate-nitrogen and *E. coli* levels were more common in the northern half of the subwatershed. The Goose Creek, Seamons Ditch, Upper Mud Pine Creek and Humbert Ditch subwatersheds were identified in the LARE study as the highest priority areas for implementation of best management practices. High quality habitat and good fish and macroinvertebrate communities demonstrate that the main stem of Mud Pine Creek supports a healthy biological community.

5.0 WATERSHED INVENTORY III: WATERSHED INVENTORY SUMMARY

Several important factors and relationships become apparent when the Big Pine 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, IDNR LARE, and Hoosier Riverwatch. These include elevated nitrate-nitrogen, total phosphorus, total suspended solids or turbidity, *E. coli* concentrations, poor fish and macroinvertebrate communities, and poor habitat.

Figure 42 highlights those locations within the Big Pine Creek watershed where concentrations of these parameters measured higher than the target concentrations, or where poor IBI and QHEI scores were recorded. Sample sites are mapped only if 50% or more of samples collected at those sites were outside the target values shown in Table 17. Table 20 summarizes where samples were outside the target values, grouped by subwatershed.

Elevated nitrate-nitrogen concentrations were observed in all subwatersheds except Owens Ditch, Brumm Ditch, and Harrington Creek. The headwaters and middle section of Big Pine Creek, as well as Spring Branch, had elevated total suspended solids. Elevated total phosphorus concentrations were found only in the headwaters of Big Pine Creek. All four subwatersheds of Mud Pine Creek and the lower section of Big Pine Creek had *E. coli* concentrations that exceeded the state standard. These water quality results correspond to the dominance of tile-drained row crop agriculture in the Big Pine Creek Headwaters, Middle Big Pine Creek, and the upper half of Mud Pine Creek. The highly channelized ditches and potentially highly erodible soils in the Big Pine Creek Headwaters contribute to the elevated total phosphorus and TSS concentrations. The Middle Big Pine Creek subwatershed had the lowest proportion of potentially highly erodible soils, which may explain the lower total phosphorus levels observed throughout this subwatershed. However, the highest proportion of limited buffers, field erosion, and eroding streambanks were observed in the Middle Big Pine Creek subwatershed. These sources of sediment and nutrients to the streams are likely contributing to elevated nitrate-nitrogen and TSS concentrations in this subwatershed. Row crop agriculture is less prominent, with relatively more hay and pasture land in the Lower Big Pine Creek subwatershed and the Mud Pine-Spring Branch subwatershed. Perhaps as a result, elevated *E. coli* concentrations were observed in these subwatersheds, resulting in 35 stream miles being listed as impaired.

In general, poor fish and macroinvertebrate communities were correlated with poor habitat and elevated total suspended solids. This is especially apparent in the Big Pine Creek Headwaters and Middle Big Pine Creek subwatersheds, where biotic communities and habitat were generally poor. The exceptions are Little Pine Creek (in the Big Pine Creek Headwaters) and Brown Ditch (in the Middle Big Pine Creek), where healthy fish communities were found despite poor habitat. In these cases, the high quality fish communities may be a reflection of the lower TSS concentrations and generally better water quality in these subwatersheds.

Healthy biotic communities were correlated with good quality habitat and lower total phosphorus and TSS levels in the lower reaches of the watershed. This was particularly apparent in the Hog Back Hill (in the Lower Big Pine Creek) and Spring Branch (in the Mud

Pine Creek) subwatersheds, where the riparian corridor is more heavily forested and row crop agriculture is less prevalent.

Table 20. Subwatersheds in which 50% or more of samples collected at a site during historic water quality monitoring were outside the target values shown in Table 17.

Subwatershed	P	N	TSS	*E. coli*	Poor Fish IBI	Poor mIBI	Poor Habitat*
Big Pine Creek Headwaters							
Roudebush Ditch	Y	Y	Y	N	Y	N/A	Y
Big Pine Creek Ditch	Y	Y	Y	N/A	N	N/A	Y
Little Pine Creek	N	Y	N	N	N	N/A	Y
Owens Ditch	Y	N	Y	N/A	N	N/A	N
Middle Big Pine Creek							
Brumm Ditch	N	N	Y	N/A	Y	N/A	Y
Darby Ditch	N	Y	Y	N/A	Y	N/A	Y
Brown Ditch	N	Y	N	N	N	N	Y
Harrington Creek	N	N	N/A	N/A	N/A	N/A	Y
Lower Big Pine Creek							
Pine Village	N	Y	N	Y	N	N	N
Hog Back Hill	N	Y	N	Y	N	N	N
Mud Pine Creek							
Mud Pine Headwaters	N	Y	N	Y	N/A	N/A	N/A
Seamons Ditch	N	Y	N	Y	N/A	N/A	Y
Goose Creek	N	Y	N	Y	N	N/A	Y
Spring Branch	N	Y	Y	Y	N	N	N

*Includes QHEI scores from fish IBI and mIBI sampling, and cQHEI scores
NOTE: N/A indicates no data available.

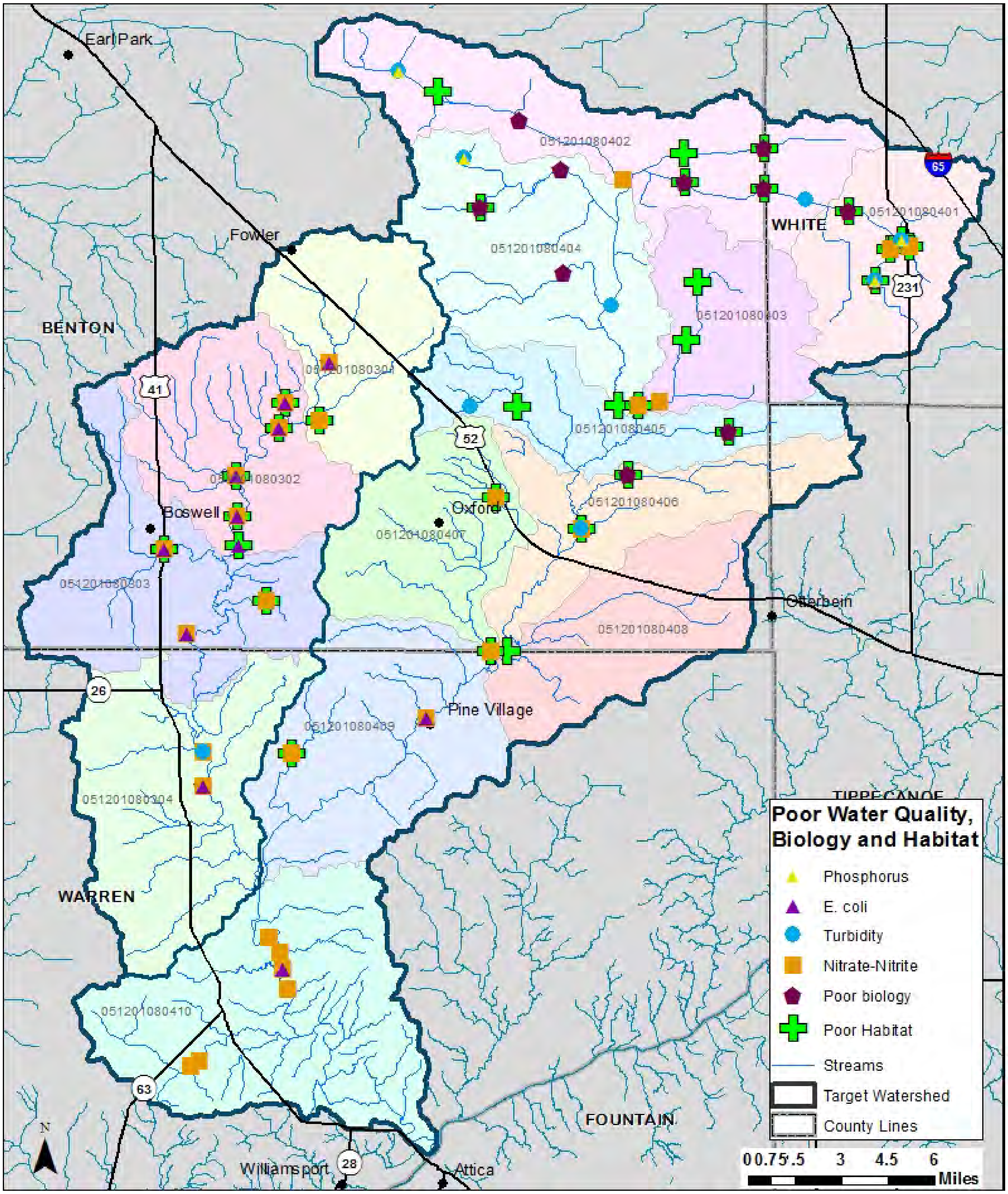


Figure 42. Sample sites with poor water quality, biological communities, and/or habitat (50% or more of samples collected during historic water quality monitoring were outside the target values shown in Table 17).
Data used to create this map are detailed in Appendix A.

5.2 Stakeholder Concern Analysis

All of the identified concerns generated both from stakeholder input and through water quality and watershed inventory efforts are detailed in Table 21. 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 21. Analysis of stakeholder concerns.

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
Limited understanding of the planning process and its goal	Yes	Anecdotal evidence based on communication with stakeholders	No	No	Yes
Limited knowledge of inputs and issues within the watershed	Yes	Data is not publicized	No	No	Yes
Groundwater understanding and management needed	Yes	Excessive irrigation has dropped well water levels in some areas	Yes	Yes	No. Aquifer likely has no direct connection to Big Pine.
Confined feeding operation management needed	Yes and No. Management concerns are not supported; however, CFOs are present in watershed.	5 permitted CFOs in watershed, with total of 32,009 animals/year, spreading manure on 3,074 acres. CFOs have manure management plans on file with IDEM.	Yes	No	Yes. Manure application and water quality issues only, not management of individual CFOs.
Nutrient management on cropland needed	Yes	83% of watershed is cultivated crops. N and P levels exceeded targets at 39% of sample sites and 19 miles of streams are impaired for nutrients by IDEM.	Yes	No	Yes
Manure storage facilities needed	Yes	52 unregulated animal farms identified during windshield survey	Yes	No	Yes

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
High turbidity	No	Total Suspended Solid concentrations exceeded target at only 13% of sites	Yes	No	Yes
Stream is too flashy	Yes	USGS stream gage data through 2003 shows seasonal flashiness	Yes	No	Yes
Stream is a drainage outlet and should be maintained as such	Yes	234 of the total 568 miles of streams are regulated drains	Yes	No	Yes
Invasive species are present along streambanks	Yes	There are 33 documented invasive plant species in the 4 counties covered by the watershed. Several invasive species were observed in riparian areas during the windshield survey.	Yes	No	Yes, but low priority and only as education
Poor water quality	Yes	303d impairments for nutrients, IBC and *E. coli* in Big Pine watershed	Yes	No	Yes
Trash needs to be kept out of creek	No, but no surveys of trash have been completed.	Individual observations during the watershed inventory indicate trash accumulation is a problem.	Yes	No	Education only
Maintain the aesthetic conditions	Yes	Anecdotal evidence that this is a concern of stakeholders	No	No	Yes
The community needs to connect to the stream more	Yes	Anecdotal from stakeholders	No	No	Yes
Too many logjams; untimely logjam removal	No	Few if any logjams were observed during the windshield survey	Yes	No	No; If logjams cover the entire width of the stream, possibly
Soil erosion occurs	Yes	High turbidity concentrations	Yes	No	Yes

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
throughout the watershed		observed in 10 stream sites; erosion present along 25 miles of streams			
Highly erodible soils are cropped and need to be managed better	Yes	31% of the watershed has highly erodible or potentially highly erodible soils and most of those are cropped. 50% of corn fields in Benton Co. and 20% of corn fields in Warren Co. are under conventional tillage. <3% (Benton) and <1% (Warren) of bean fields are under conventional tillage.	Yes	No	Yes
Oxford needs a wastewater treatment plant upgrade	Yes	WWTP is in noncompliance with NPDES permit; 18 CSO discharges in 2013; LTCP Amendment to IDEM in progress	Yes	No	Funding assistance only
Pine Village needs to improve their septic practices	Yes	Soils in Pine Village are very limited for septics. 55% of *E. coli* samples exceeded state standard at IDEM Fixed Station in Pine Village.	Yes	No	Funding assistance only
Boswell needs to improve their septic practices	Yes	Soils in Boswell are very limited for septics, however WWTP serves incorporated area. LARE sample site on Goose Creek exceeded *E. coli* standard during base flow.	Yes	No	Funding assistance only
Fowler's wastewater treatment plant drains into the watershed	Yes	WWTP drains into Big Pine Creek via Mud Pine-Humbert, no NPDES permit violations in last 5	Yes	No	No. No violations have been identified and no funding

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
		years. Municipal biosolids are applied to 487 acres in the watershed.			needs were identified.
Templeton's stormwater and wastewater is not understood	Yes	Templeton has no stormwater or wastewater treatment facility, town uses septics	Yes	No	Funding assistance only
Healthy grassland habitat needs to be emphasized for wildlife	Yes	Land use data show less than 0.1% of the watershed is grassland/herbaceous	Yes	No	Yes but education focus only
Woodland habitat needs to be improved for wildlife	Yes	Land use data show 7% of the watershed is forested, but highly fragmented	Yes	No	Yes but education focus only
Livestock access to the stream	Yes	50,669 lineal feet of livestock access identified during windshield survey	Yes	No	Yes
Producers need to be educated on potential practices they could use to increase production and reduce impacts to the stream	Yes	55 miles of inadequate buffers, 6,045 acres of field erosion identified during windshield survey. General sense from SWCDs is that producers are fairly familiar with BMP options but more education could help.	Yes	No	Yes
No official public access is available.	Yes	No public access is available.	Yes	No	Yes
Aquifers, recharge, and the Teays River Valley need to be protected and better understood.	No	There is no surface water-groundwater connection that could be identified.	Yes	Yes	No
Tile nutrient transport- is this a problem, and if so, how	Yes and No	Tiles do transport dissolved nutrients and the presence of tile drains is	No	No	Yes

Concern	Supported by our data?	Evidence	Able to Quantify?	Outside Scope?	Group wants to focus on?
big of a problem?		documented in the watershed but has not been quantified.			
Water quantity issues are a concern given the pumping for agriculture and the recent problems with dry wells in Templeton.	Yes	Water quantity issues have been documented during drought conditions in Templeton.	Yes	Yes	No

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: logjam removal, agricultural pumping depleting the Teays aquifer, and the effects of Fowler's wastewater treatment plant. 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 22. Problems represent the condition that exists due to a particular concern or group of concerns. Table 23 details potential causes of problems identified in Table 22.

Table 22. Problems identified for the Big Pine Creek watershed based on stakeholder and inventory concerns.

Concerns:	Problems:
• Producers need to be educated on potential practices they could use to increase production and reduce impacts to the streams.	Individuals lack knowledge of what could/should be implemented, where to site practices, and how to fund implementation.
• Limited understanding of the planning process and its goal. • Producers need to be educated on potential practices they could use to increase production and reduce impacts to the streams. • Limited knowledge of inputs or issues in the watershed • Tile nutrient transport- is this a problem and if so, how big of a problem. Education is needed on this issue. • Healthy grassland habitat needs to be emphasized for wildlife. • Invasive species are present on the streambanks. • The community needs to connect with the stream more. • Trash needs to be kept out of the creek.	A unified education plan is lacking.
• Community needs to maintain its connection to the stream. • No official public access site is available.	River/natural area accessibility needs to be increased.
• Nutrient management on cropland is needed. • Confined animal feeding operation and small livestock management needed. • Manure storage facilities are needed. • Livestock have access to streams. • Poor water quality. • Soil erosion occurs throughout the basin. • Highly erodible soils are cropped and need to be better managed. • Oxford needs a WWTP upgrade; they currently use a lagoon system for finishing. • Pine Village needs to improve their septic practices. • Boswell needs to improve their septic practices. • Templeton’s management of stormwater and wastewater needs to be better understood. • Fowler’s WWTP drains into the Mud Pine Creek watershed.	Nutrient concentrations threaten the health of Big Pine Creek and its tributaries.
• High turbidity • Stream is too flashy. • Stream is a drainage outlet and should be maintained as such. • Livestock have access to streams.	Area streams are cloudy and turbid.

Concerns:	Problems:
• Soil erosion occurs throughout the basin especially in Mud Pine Creek. • Highly erodible soils are cropped and need to be better managed.	
• Poor water quality (compared to other streams). • Oxford needs a WWTP upgrade; they currently use a lagoon system for finishing. • Pine Village needs to improve their septic practices. • Boswell needs to improve their septic practices. • Templeton's management of stormwater and wastewater needs to be better understood. • Fowler's WWTP drains into the Mud Pine Creek watershed. • Livestock have access to streams. • Manure storage facilities are needed.	Area streams are listed by IDEM as impaired for recreational contact (*E. coli)*.
• Healthy grassland habitat needs to be emphasized for wildlife. • Invasive species are present on the streambanks. • Woodland habitat needs to be improved for wildlife.	Habitat is fragmented within the watershed.

Table 23. Potential causes of identified problems in the Big Pine Creek watershed.

Problems:	Potential Causes:
• Individuals lack knowledge of what could/should be implemented, where to site practices, and how to fund implementation. • A unified education plan is lacking.	Educational efforts targeting funders, local agencies, and the public are lacking.
Nutrient concentrations threaten the health of Big Pine Creek and its tributaries.	Nutrient concentrations exceed target values set by this project.
Area streams are cloudy and turbid.	Suspended sediments and/or turbidity levels exceed target values set by this project.
Area streams are listed by IDEM as impaired for recreational contact.	*E. coli* concentrations exceed target values and the state standard.
Habitat is fragmented within the watershed and limited within watershed streams thereby limiting biotic communities.	• Terrestrial: Competing land uses • Aquatic: Poor habitat and/or poor water quality limits the biotic community.
River/natural area accessibility needs to be increased.	Public access to the creeks is limited.

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 Pine 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 Pine Creek watershed for each of our concerns is listed below:

Nutrients (Nitrogen and Phosphorus):

- Conventional tillage cropping practice
- Wastewater treatment discharges
- Gully or ephemeral erosion
- Agricultural and residential fertilizer
- Poor riparian buffers
- 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)

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)

E. coli:

- Human waste (failing septic systems, package plants, inadequately treated wastewater)
- Animal waste (livestock in streams, poor manure management, domestic and wildlife runoff)
- Combined Sewer Overflows

Habitat

- Poor riparian buffers
- Streambank and bed erosion
- Gully or ephemeral erosion
- Lack of fence rows, windbreaks and field borders
- Impervious surfaces

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 Pine Creek watershed. Appendix F contains tables detailing each potential source within each subwatershed. Table 24 through Table 29 summarize the magnitude of potential sources of pollution for each problem identified in the Big Pine Creek watershed.

Table 24. Potential sources causing nutrient problems.

Problems:	Nutrient concentrations threaten the health of Big Pine Creek and its tributaries.
Potential Causes:	Nutrient concentrations exceed target values set by this project.
Potential Sources:	• 26 livestock access areas (50,669 linear feet of streams) were observed throughout the watershed. The highest percent of stream miles accessed by livestock were found in Pine Village (5.7%), Darby Ditch (5%), Brown Ditch (4.5%), Harrington Creek (2.9%) and Little Pine Creek (2.1%) subwatersheds. • 2 Combined Sewer Overflows (CSO) in the Brown Ditch subwatershed. • 52 unregulated animal operations were observed throughout the watershed. The highest number of operations was observed in the Hog Back Hill (9), Pine Village (8), Brumm Ditch (6), Darby Ditch (5), Big Pine Creek Ditch (4), Little Pine Creek (4), Harrington Creek (4) and Spring Branch (4) subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading. • 55 miles of stream lack adequate buffers. The highest percent of stream miles needing buffers were found in the Harrington Creek (26%), Big Pine Creek Ditch (18%), Darby Ditch (17%), Headwaters Mud Pine Creek (16%) and Pine Village (13%) subwatersheds. • 6,045 acres of fields exhibit active gully erosion. • 25 miles of stream lack adequate stabilization, with the highest percent of stream miles lacking stabilization found in Harrington Creek (30%), Brown Ditch (7%), Darby Ditch (6%), Pine Village (6%) and Seamons Ditch (5%). • Manure from confined feeding operations is applied in the Spring Branch (1,335 acres), Big Pine Creek Ditch (868 acres), Harrington Creek (585 acres) and Darby Ditch (286 acres) subwatersheds. • Failing septic systems add nutrients to the system within the rural portion of the watershed and in areas of dense unsewered housing.

Table 25. 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:	• 26 livestock access areas (50,669 linear feet of streams) were observed throughout the watershed. The highest percent of stream miles accessed by livestock were found in Pine Village (5.7%), Darby Ditch (5%), Brown Ditch (4.5%), Harrington Creek (2.9%) and Little Pine Creek (2.1%) subwatersheds. • 55 miles of stream lack adequate buffers. The highest percent of stream miles needing buffers were found in the Harrington Creek (26%), Big Pine Creek Ditch (18%), Darby Ditch (17%), Headwaters Mud Pine Creek (16%) and Pine Village (13%) subwatersheds. • 6,045 acres of fields exhibit active gully erosion. • 50% of corn fields (Benton Co.) and 20% of corn fields (Warren Co.) are under conventional tillage. • 25 miles of stream lack adequate stabilization, with the highest percent of stream miles lacking stabilization found in Harrington Creek (30%), Brown Ditch (7%), Darby Ditch (6%), Pine Village (6%) and Seamons Ditch (5%). • 52 unregulated animal operations were observed throughout the watershed. The highest number of operations was observed in the Hog Back Hill (9), Pine Village (8), Brumm Ditch (6), Darby Ditch (5), Big Pine Creek Ditch (4), Little Pine Creek (4), Harrington Creek (4) and Spring Branch (4) subwatersheds. These operations can be sources due to livestock defecating in or near streams, soil compaction, streambank erosion, and improper manure storage and spreading. • 3,204 acres of active agricultural production is located within the 100-year floodplain (54% of the total 5,972 acres of floodplain). Approximately 2,000 acres are in row crop, and the remaining agricultural land is in pasture and alfalfa. The highest densities of cropped floodplain occur within the Headwaters Mud Pine Creek, Seamons Ditch, Goose Creek, and Owens Ditch subwatersheds.

Table 26. 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:	• 26 livestock access areas (50,669 linear feet of streams) were observed throughout the watershed. The highest percent of stream miles accessed by livestock were found in Pine Village (5.7%), Darby Ditch (5%), Brown Ditch (4.5%), Harrington Creek (2.9%) and Little Pine Creek (2.1%) subwatersheds. • 2 Combined Sewer Overflows (CSO) in the Brown Ditch subwatershed. • 52 unregulated animal operations were observed throughout the watershed. The highest number of operations was observed in the Hog Back Hill (9), Pine Village (8), Brumm Ditch (6), Darby Ditch (5), Big Pine Creek Ditch (4), Little Pine Creek (4), Harrington Creek (4) and Spring Branch (4) 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 is applied in the Spring Branch (1,335 acres), Big Pine Creek Ditch (868 acres), Harrington Creek (585 acres) and Darby Ditch (286 acres) subwatersheds. • Failing septic systems contribute *E. coli* to the system within the rural portion of the watershed and in areas of dense unsewered housing.

Table 27. Potential sources causing habitat problems.

Problems:	Habitat is fragmented within the watershed and limited within watershed streams thereby limiting biotic communities.
Potential Causes:	Terrestrial: Competing land uses Aquatic: Poor habitat and/or poor water quality limits the biotic community.
Potential Sources:	• 55 miles of stream lack adequate buffers. The highest percent of stream miles needing buffers were found in the Harrington Creek (26%), Big Pine Creek Ditch (18%), Darby Ditch (17%), Headwaters Mud Pine Creek (16%) and Pine Village (13%) subwatersheds. • Removal and absence of fence rows, windbreaks and field borders. • 6,045 acres of fields exhibit active gully erosion. • 25 miles of stream lack adequate stabilization, with the highest percent of stream miles lacking stabilization found in Harrington Creek (30%), Brown Ditch (7%), Darby Ditch (6%), Pine Village (6%) and Seamons Ditch (5%). • 7,146 acres (3.4%) of the watershed are 10% or more covered by impervious surfaces. The highest densities of impervious surfaces are located in the Goose Creek (Boswell), Headwaters Mud Pine Creek (Fowler), Brown Ditch (Oxford), and Pine Village subwatersheds. • Poor mIBI scores (<36) occurred in the Hog Back Hill and Spring Branch subwatersheds. Although the scores are not a source, the fact that these scores occurred at these sites indicate a source of habitat issues within these streams. • Poor fish IBI scores (<35) occurred in the Roudebush Ditch, Big Pine Creek Ditch, Owens Ditch, Brumm Ditch and Darby Ditch subwatersheds. Although the scores are not a source, the fact that these scores occurred at these sites indicate a source of habitat issues within these streams. • Poor QHEI (<51) or CQHEI (<60) scores occurred in the Big Pine Creek Ditch, Little Pine Creek, Owens Ditch, Brown Ditch, Harrington Creek, Pine Village, Seamons Ditch and Goose Creek subwatersheds. Although the scores are not a source, the fact that these scores occurred at these sites indicate a source of habitat issues within these streams.

Table 28. 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 29. Potential sources causing accessibility 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 Estimation

Another mechanism for determining sources of nonpoint pollution is hydrologic simulation models. Hydrologic models simulate the transport of pollutants across the land surface as surface runoff. Rain water flows over the land and through the groundwater collecting pollutants including sediment and nutrients as it moves. The soil characteristics and land uses influence the way that water moves through the system and each hydrologic model simulates the movement in a different way. These computer models provide useful information which can serve as a baseline for future land use changes. They also serve as a check on the critical area determinations made using water chemistry samples and GIS-based watershed data.

Watershed loading rates can be estimated using a variety of loading models for a variety of parameters. A tabular-based nonpoint source pollution loading model, the Long-term Hydrologic Impact Assessment (L-THIA), was used to estimate the current load of three of the pollutants of concern: total nitrogen, total phosphorus, and total suspended solids. The L-THIA model provides a basis for comparison of runoff for these pollutants within each 12-digit subwatershed. It should be noted that L-THIA calculates loading based on 14-digit subwatersheds, not 12-digit subwatersheds.

As discussed in Section 3, the steering committee selected water quality benchmarks that will significantly improve water quality in Big Pine Creek (Table 17**)**. Target loads needed to meet these benchmarks were calculated for each subwatershed for each parameter. The load reduction needed was then calculated for each subwatershed, in lb/year and as a percent of the current load (Table 30-Table **32**). The total load reduction needed for each parameter for the entire watershed is summarized in Table 33.

The Big Pine Creek Ditch, Owens Ditch, and Spring Branch-Mud Pine Creek, subwatersheds contain the highest nitrogen, phosphorus, and sediment loading rates. When loading rates are normalized by area, the Roudebush Ditch, Big Pine Ditch and Little Pine Creek subwatersheds contain the highest nutrient and sediment loading rates (Table 30-Table 32). Generally, historic water quality data collected throughout the Big Pine Creek watershed suggest that these subwatersheds also possessed higher numbers of turbidity and nutrient concentration exceedances than other subwatersheds. It should be noted that much of the historic sampling occurred sporadically and under differing conditions so that conclusions using these data are limited.

Using data generated by the L-THIA model, the Harrington Creek, Roudebush Ditch, Big Pine Creek Ditch, Little Pine Creek, Owens Ditch, Brumm Ditch, and Seamons Ditch-Mud Pine Creek subwatersheds should be considered priority areas for reducing nitrogen and phosphorus loading to Big Pine Creek and the Wabash River. The Harrington Creek, Roudebush Ditch, Big Pine Creek Ditch, Little Pine Creek and Owens Ditch subwatersheds should be considered priority areas for reducing sediment loading to Big Pine Creek and the Wabash River.

Since the L-THIA model does not model *E. coli*, the Wabash River TMDL was used to estimate the load reduction needed in the Big Pine Creek watershed. The required *E. coli* load reduction was determined using the TMDL for the Wabash River at its confluence with the Vermilion River (the closest point downstream from the outlet of Big Pine Creek) (TetraTech 2006). The TMDL states that an 87% reduction in *E. coli* concentration (#/day) is needed during the recreation season (May-October), in order to achieve the state water quality standard (Table 33).

Table 30. Estimated Nitrogen load reduction by subwatershed needed to meet water quality target concentrations in the Big Pine Creek watershed.

Subwatershed	N current load (lb/yr)	N current load (lb/acre/yr)	N target load (lb/yr)	N Load Reduction	% N Load Reduction
Roudebush Ditch-Big Pine	50,889	4.52	24,335	26,554	52%
Big Pine Creek Ditch-Big Pine	82,518	4.19	38,780	43,738	53%
Little Pine Creek	40,086	3.99	18,958	21,128	53%
Owens Ditch-Big Pine Creek	66,383	3.71	31,317	35,066	53%
Brumm Ditch-Big Pine Creek	41,443	3.76	19,863	21,580	52%
Darby Ditch-Big Pine Creek	43,153	3.67	21,165	21,988	51%
Brown Ditch	41,598	3.51	20,419	21,179	51%
Harrington Creek-Big Pine	47,161	3.67	16,213	30,948	66%
Pine Village-Big Pine Creek	50,438	2.86	28,649	21,789	43%
Hog Back Hill-Big Pine Creek	43,705	2.88	25,821	17,884	41%
Headwaters Mud Pine Creek	44,182	3.68	21,720	22,462	51%
Seamons Ditch-Mud Pine	51,894	3.60	24,846	27,048	52%
Goose Creek-Mud Pine Creek	59,397	3.52	29,423	29,974	50%
Spring Branch-Mud Pine Creek	65,771	3.54	33,026	32,745	50%
Total (lb/yr):	**728,618**		**354,534**	**374,084**	**51%**

Table 31. Estimated Phosphorus load reduction by subwatershed needed to meet water quality target concentrations in the Big Pine Creek watershed.

Subwatershed	P current load (lb/yr)	P current load (lb/acre/yr)	P target load (lb/yr)	P Load Reduction	% P Load Reduction
Roudebush Ditch-Big Pine	15,046	1.34	7,300	7,746	51%
Big Pine Creek Ditch-Big Pine	24,343	1.23	11,634	12,709	52%
Little Pine Creek	11,834	1.18	5,687	6,147	52%
Owens Ditch-Big Pine Creek	19,595	1.09	9,395	10,200	52%
Brumm Ditch-Big Pine Creek	12,189	1.11	5,959	6,230	51%
Darby Ditch-Big Pine Creek	12,639	1.07	6,349	6,290	50%
Brown Ditch	12,282	1.04	6,126	6,156	50%
Harrington Creek-Big Pine	13,901	1.08	4,864	9,037	65%
Pine Village-Big Pine Creek	14,516	0.82	8,595	5,921	41%
Hog Back Hill-Big Pine Creek	12,612	0.83	7,746	4,866	39%
Headwaters Mud Pine Creek	13,067	1.09	6,516	6,551	50%
Seamons Ditch-Mud Pine	15,294	1.06	7,454	7,840	51%
Goose Creek-Mud Pine Creek	17,431	1.03	8,827	8,604	49%
Spring Branch-Mud Pine Creek	19,221	1.03	9,908	9,313	48%
Total (lb/yr):	**213,970**		**106,360**	**107,610**	**50%**

Table 32. Estimated TSS load reduction by subwatershed needed to meet water quality target concentrations in the Big Pine Creek watershed.

Subwatershed	TSS current load (lb/yr)	TSS current load (lb/acre/yr)	TSS target load (lb/yr)	TSS Load Reduction	% TSS Load Reduction
Roudebush Ditch-Big Pine	1,239,088	110	425,860	813,228	66%
Big Pine Creek Ditch-Big Pine	1,998,412	101	678,656	1,319,756	66%
Little Pine Creek	971,495	97	331,756	639,739	66%
Owens Ditch-Big Pine Creek	1,607,814	90	548,053	1,059,761	66%
Brumm Ditch-Big Pine Creek	1,003,484	91	347,607	655,877	65%
Darby Ditch-Big Pine Creek	1,037,376	88	370,383	666,993	64%
Brown Ditch	1,006,046	85	357,336	648,710	64%
Harrington Creek-Big Pine	1,142,528	89	283,721	858,807	75%
Pine Village-Big Pine Creek	1,190,116	67	501,350	688,766	58%
Hog Back Hill-Big Pine Creek	1,032,535	68	451,862	580,673	56%
Headwaters Mud Pine Creek	1,075,628	90	380,109	695,519	65%
Seamons Ditch-Mud Pine	1,256,775	87	434,803	821,972	65%
Goose Creek-Mud Pine Creek	1,433,736	85	514,899	918,837	64%
Spring Branch-Mud Pine Creek	1,578,356	85	577,947	1,000,409	63%
Total (lb/yr):	**17,573,389**		**6,204,342**	**11,369,047**	**65%**

Table 33. Current and target loads in pounds/year and load reduction needed to meet water quality target concentrations in the Big Pine Creek watershed.

Parameter of Concern	Current Load	Target Load	Reduction Needed	Reduction Needed (%)
Nitrogen (lb/yr)	728,618	354,534	374,084	51%
(tons/yr)	364	177	187	
Phosphorus (lb/yr)	213,970	106,360	107,610	50%
(tons/yr)	107	53.5	53.5	
Suspended Sediment (lb/yr)	17,573,389	6,204,342	11,369,047	65%
(tons/yr)	8,787	3,102	5,685	
E. coli	N/A	N/A	N/A	87%

8.0 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.

8.1 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. In an effort to scale goals to manageable levels, a twenty year timeframe was used for most goals.

Reduce Nutrient Loading

Goal: Reduce nitrate-nitrogen loading from 364 tons/year to 177 tons/year (51% reduction to 2 mg/L) and reduce phosphorus loading from 107 tons/year to 53.5 tons/year (50% reduction to 0.6 mg/L) in the Big Pine watershed by 2036.

- Short-term goal: Reduce nitrate-nitrogen loading by 46.75 tons/year (12.8% reduction) and reduce phosphorus loading by 13.375 tons/year (12.5% reduction) by 2021.

Reduce Sediment Loading

Goal: Reduce soil erosion and total suspended solids loading from 8,787 tons/year to 3,102 tons/year (65% reduction to 35 mg/L) in the Big Pine watershed by 2036.

- Short-term goal: Reduce sediment loading by 1,421 tons/year (16% reduction) by 2021.

Reduce *E. coli* Loading

Goal: Reduce *E. coli* concentrations to meet the state standard (an 87% reduction to 235 colonies/100ml grab sample; 180 colonies/100ml in geometric samples) by 2036.

Protect and Enhance Natural Habitat

Goal: Natural habitat (grasslands, forest, wetlands) will increase by a total of 5% within the Big Pine watershed, with a focus on improving connectivity, by 2030.

- Short-term goal: Increase natural habitat by 2% by 2021.

Increase Public Awareness and Participation

Goal: By 2036, 100% of the public will be informed about practices that can be implemented to positively impact Big Pine Creek.

Increase Public Access

Goal: By 2021, a public access site will be identified and public access available on the mainstem of Big Pine Creek.

9.0 CRITICAL AND PRIORITY AREA DETERMINATION

Critical areas are defined by the areas where sources of water quality problems occur in high density 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, loading calculations, and historic water quality data were used as a basis for decision-making. For each parameter, each subwatershed was evaluated to determine whether it met each criterion. Each subwatershed was scored based on the total number of criteria that were met and the subwatersheds with the highest scores were prioritized as critical areas for each parameter. In addition, biological data were reviewed to identify high quality communities which serve as priority areas.

9.1 Critical Areas for Nitrate-Nitrogen

Nitrate-nitrogen was the nitrogen form on which our critical area determination occurred. Nitrate-nitrogen is readily available in the Big Pine Creek watershed, entering surface water via human and animal waste, fertilizer use, and via tile drains on agricultural lands. It is also the nitrogen form on which we have the most watershed-wide information. Based on the data summarized in Table 34, the orange highlighted subwatersheds are the most critical areas for nitrogen, including subwatersheds scoring 4 or greater out of 9 criteria.

Table 34. Critical Areas for Nitrogen.

NITROGEN	Roudebush Ditch-Big Pine Creek	Big Pine Creek Ditch-Big Pine Creek	Little Pine Creek	Owens Ditch-Big Pine Creek	Brumm Ditch-Big Pine Creek	Darby Ditch-Big Pine Creek	Brown Ditch	Harrington Creek-Big Pine Creek	Pine Village-Big Pine Creek	Hog Back Hill-Big Pine Creek	Headwaters Mud Pine Creek	Seamons Ditch-Mud Pine Creek	Goose Creek-Mud Pine Creek	Spring Branch-Mud Pine Creek
From Table 6. Impaired waterbody locations.														
Streams with nutrient impairments	•						•							
From Appendix F. Land Use.														
Row crop agriculture covers >86%	•	•	•	•	•	•	•	•			•	•		
From Table 30. L-THIA load reductions.														
Top 4 contributor of N on per acre basis	•	•	•		•									
Greater than or equal to 50% load reduction of N needed	•	•	•	•	•	•	•	•			•	•	•	•
Summarized from Table 24. Potential sources causing nutrient problems.														
Highest density (>=4) of unregulated animal operations		•	•		•	•		•	•	•				•
Highest density of livestock access areas			•			•	•	•	•					
Highest density of manure application		•				•		•						•
Dense unsewered areas exceed 100 acres									•	•				
From Table 20. Monitoring samples exceeding targets.														
Nitrate-nitrogen (exceed in 40% of samples or more)	•						•			•	•	•	•	•
SCORE:	**5**	**5**	**5**	**2**	**4**	**5**	**5**	**5**	**3**	**3**	**3**	**3**	**2**	**4**

Based on these criteria, Roudebush Ditch-Big Pine, Big Pine Creek Ditch-Big Pine, Little Pine Creek, Brumm Ditch-Big Pine Creek, Darby Ditch-Big Pine Creek, Brown Ditch, Harrington Creek-Big Pine Creek, and Spring Branch-Mud Pine Creek serve as critical areas for nitrate-nitrogen (Figure 43).

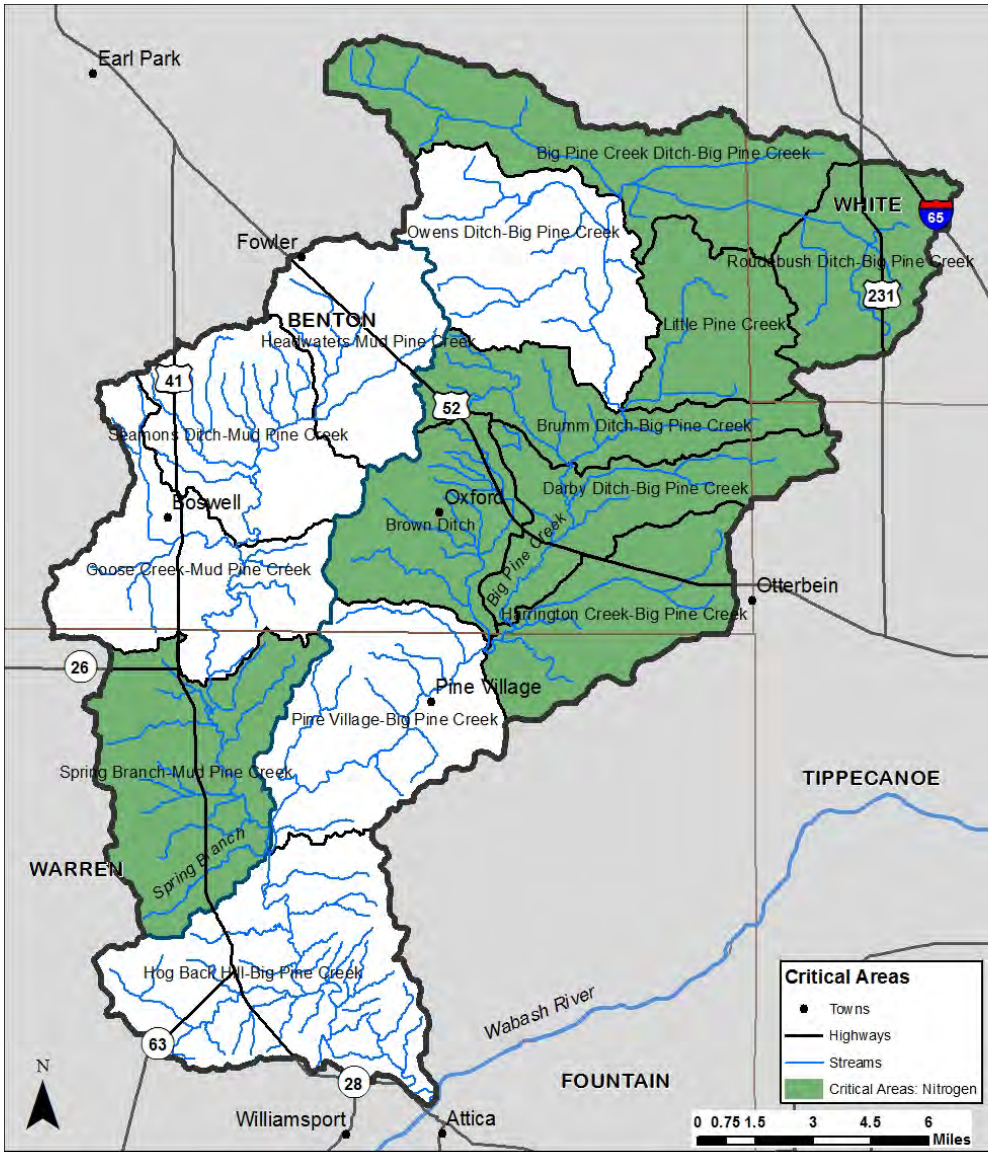


Figure 43. Critical areas for Nitrate-nitrogen in the Big Pine Creek watershed. Data used to create this map are detailed in Appendix A.

9.2 Critical Areas for Phosphorus

Total phosphorus was the phosphorus form on which our critical area determination occurred. Total phosphorus enters streams in the Big Pine Creek watershed through human and animal waste, streambank and bed erosion, unfiltered runoff and cropland soil erosion. Based on the data summarized in Table 35, the orange highlighted subwatersheds are the most critical areas for phosphorus, including subwatersheds scoring 4 or greater out of 12 criteria.

Table 35. Critical Areas for Phosphorus.

PHOSPHORUS	Roudebush Ditch-Big Pine Creek	Big Pine Creek Ditch-Big Pine Creek	Little Pine Creek	Owens Ditch-Big Pine Creek	Brumm Ditch-Big Pine Creek	Darby Ditch-Big Pine Creek	Brown Ditch	Harrington Creek-Big Pine Creek	Pine Village-Big Pine Creek	Hog Back Hill-Big Pine Creek	Headwaters Mud Pine Creek	Seamons Ditch-Mud Pine Creek	Goose Creek-Mud Pine Creek	Spring Branch-Mud Pine Creek
From Table 6. Impaired waterbody locations.														
Streams with nutrient impairments	•						•							
From Appendix F. Land Use.														
Row crop agriculture covers >86%	•	•	•	•	•	•	•	•			•	•		
From Table 31. L-THIA load reductions.														
Top 4 contributor of N & P on per acre basis	•	•	•		•									
Greater than or equal to 50% load reduction of P needed	•	•	•	•	•	•	•	•			•	•		
Summarized from Table 24. Potential sources causing nutrient problems.														
Highest density (>=4) of unregulated animal operations		•	•		•	•		•	•	•				•
More than 5% of stream miles lack adequate stabilization						•	•	•	•			•		
More than 4% of fields exhibit gully erosion						•	•		•			•		
More than 10% of streams lack adequate buffers		•	•		•	•		•	•		•			
Highest density of livestock access areas			•			•	•	•	•					
Highest density of manure application		•				•		•						•
Dense unsewered areas exceed 100 acres									•	•				
From Table 20. Monitoring samples exceeding targets.														
Total phosphorus (exceed in more than 5% of samples)	•	•		•										
SCORE:	**5**	**7**	**6**	**3**	**5**	**8**	**6**	**7**	**6**	**2**	**3**	**4**	**0**	**2**

Based on these criteria, Roudebush Ditch-Big Pine, Big Pine Creek Ditch-Big Pine, Little Pine Creek, Brumm Ditch-Big Pine Creek, Darby Ditch-Big Pine Creek, Brown Ditch, Harrington Creek-Big Pine Creek, Pine Village-Big Pine Creek and Seamons Ditch-Mud Pine serve as critical areas for total phosphorus (Figure 44).

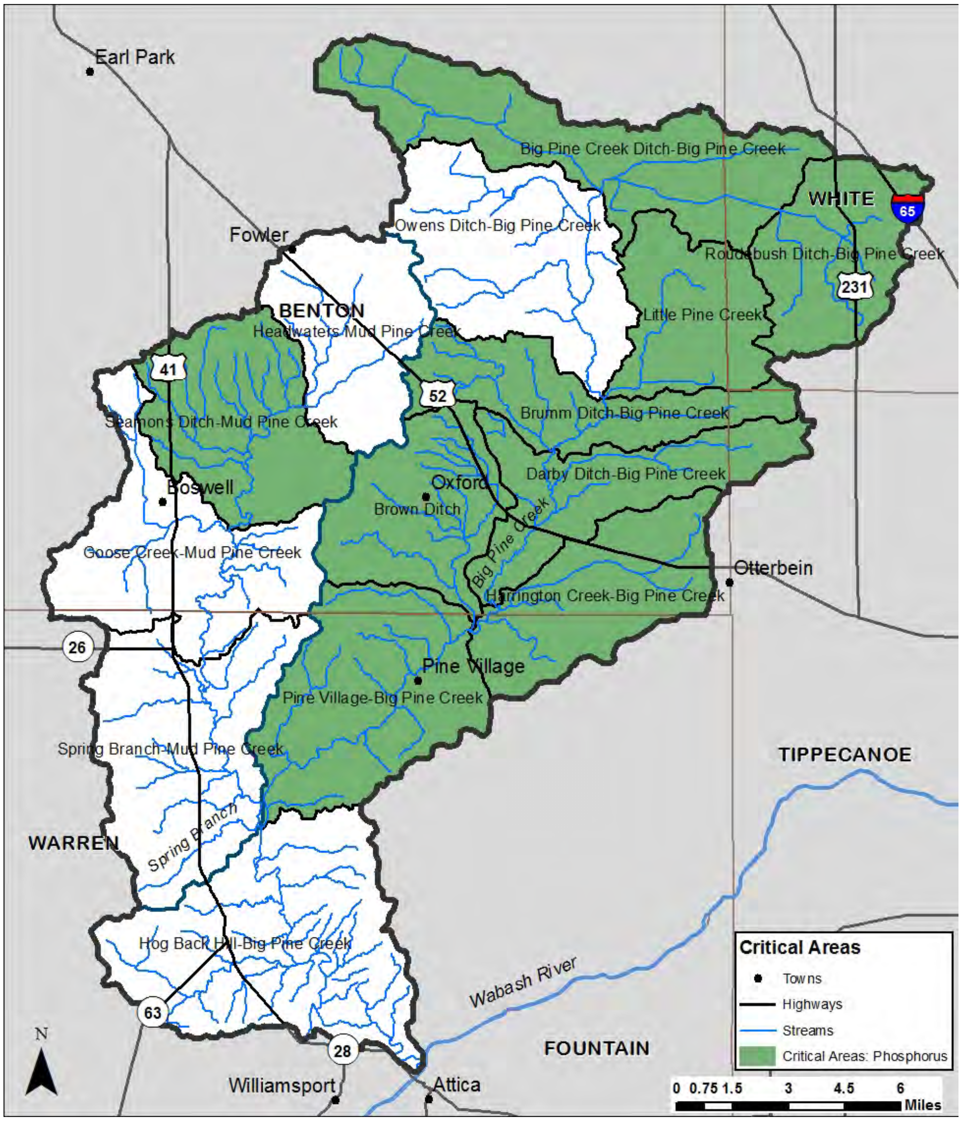


Figure 44. Critical areas for total phosphorus in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

9.3 Critical Areas for Sediment

Total suspended solids were used to determine sediment-based critical areas. Total suspended solids enter streams in the Big Pine Creek watershed through streambank and bed erosion, unfiltered runoff, agricultural land use in floodplains and livestock access. Based on the data summarized in Table 36, the orange highlighted subwatersheds are the most critical areas for sediment, including subwatersheds scoring 4 or greater out of 9 criteria.

Table 36. Critical Areas for Sediment.

SEDIMENT	Roudebush Ditch-Big Pine Creek	Big Pine Creek Ditch-Big Pine Creek	Little Pine Creek	Owens Ditch-Big Pine Creek	Brumm Ditch-Big Pine Creek	Darby Ditch-Big Pine Creek	Brown Ditch	Harrington Creek-Big Pine Creek	Pine Village-Big Pine Creek	Hog Back Hill-Big Pine Creek	Headwaters Mud Pine Creek	Seamons Ditch-Mud Pine Creek	Goose Creek-Mud Pine Creek	Spring Branch-Mud Pine Creek
From Table 6. Impaired waterbody locations.														
Streams with IBC impairments	•	•		•	•	•								
From Appendix F. Land Use.														
Agricultural lands in floodplains				•							•	•	•	
From Table 32. L-THIA load reductions.														
Top 4 contributor of TSS on per acre basis	•	•	•		•									
Greater than or equal to 65% load reduction of TSS needed	•	•	•	•	•			•			•	•		
Summarized from Table 25. Potential sources causing sediment problems.														
More than 5% of stream miles lack adequate stabilization						•	•	•	•			•		
More than 4% of fields exhibit gully erosion						•	•		•			•		
More than 10% of streams lack adequate buffers		•	•		•	•		•	•		•			
Highest density of livestock access areas			•			•	•	•	•					
From Table 20. Monitoring samples exceeding targets.														
Total suspended solids (exceed in 20% of samples or more)	•	•		•	•	•			•				•	•
SCORE:	**4**	**5**	**4**	**4**	**5**	**6**	**3**	**4**	**5**	**0**	**3**	**4**	**2**	**1**

Based on these criteria, Roudebush Ditch-Big Pine, Big Pine Creek Ditch-Big Pine, Little Pine Creek, Owens Ditch-Big Pine Creek, Brumm Ditch-Big Pine Creek, Darby Ditch-Big Pine Creek, Harrington Creek-Big Pine Creek, Pine Village-Big Pine Creek and Seamons Ditch-Mud Pine subwatersheds serve as critical areas for sediment (Figure 45).

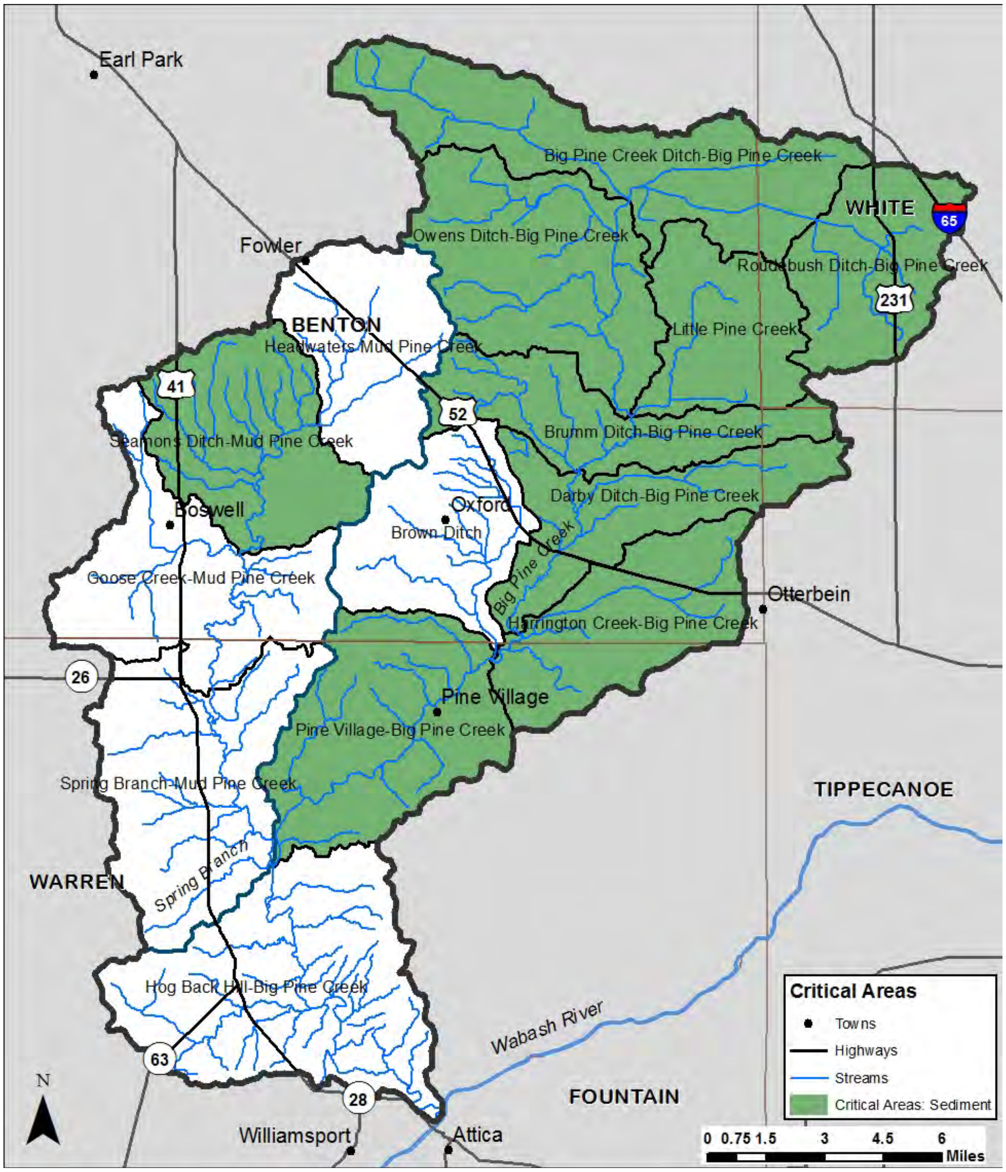


Figure 45. Critical areas for sediment in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

9.4 Critical Areas for *E. coli*

E. coli was used to determine our critical areas. *E. coli* enters streams in the Big Pine Creek 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 summarized in Table 37, the orange highlighted subwatersheds are the most critical areas for *E. coli*, including subwatersheds scoring 3 or greater out of 8 criteria.

Table 37. Critical Areas for *E. coli*

E. Coli	Roudebush Ditch-Big Pine Creek	Big Pine Creek Ditch-Big Pine Creek	Little Pine Creek	Owens Ditch-Big Pine Creek	Brumm Ditch-Big Pine Creek	Darby Ditch-Big Pine Creek	Brown Ditch	Harrington Creek-Big Pine Creek	Pine Village-Big Pine Creek	Hog Back Hill-Big Pine Creek	Headwaters Mud Pine Creek	Seamons Ditch-Mud Pine Creek	Goose Creek-Mud Pine Creek	Spring Branch-Mud Pine Creek
From Table 6. Impaired waterbody locations.														
Streams with *E. coli* impairments			•						•	•				
Summarized from Table 26. Potential sources causing E. coli problems.														
Highest density (>=4) of unregulated animal operations		•	•		•	•		•	•	•				•
Highest density of livestock access areas			•			•	•	•	•					
Highest density of manure application		•				•		•						•
Dense unsewered areas exceed 100 acres									•	•				
WWTP sludge applied to more than 400 acres	•	•			•	•					•			
Combined Sewer Overflows present							•							
From Table 20. Monitoring samples exceeding targets.														
E. coli (exceed in 40% or more of samples)			•						•			•	•	•
SCORE:	**1**	**3**	**4**	**0**	**2**	**4**	**2**	**3**	**5**	**3**	**1**	**1**	**1**	**3**

Based on these criteria, Big Pine Creek Ditch, Little Pine Creek, Darby Ditch-Big Pine Creek, Harrington Creek-Big Pine Creek, Pine Village, Hogback Hill and Spring Branch-Mud Pine Creek subwatersheds serve as critical areas for *E. coli* (Figure 46).

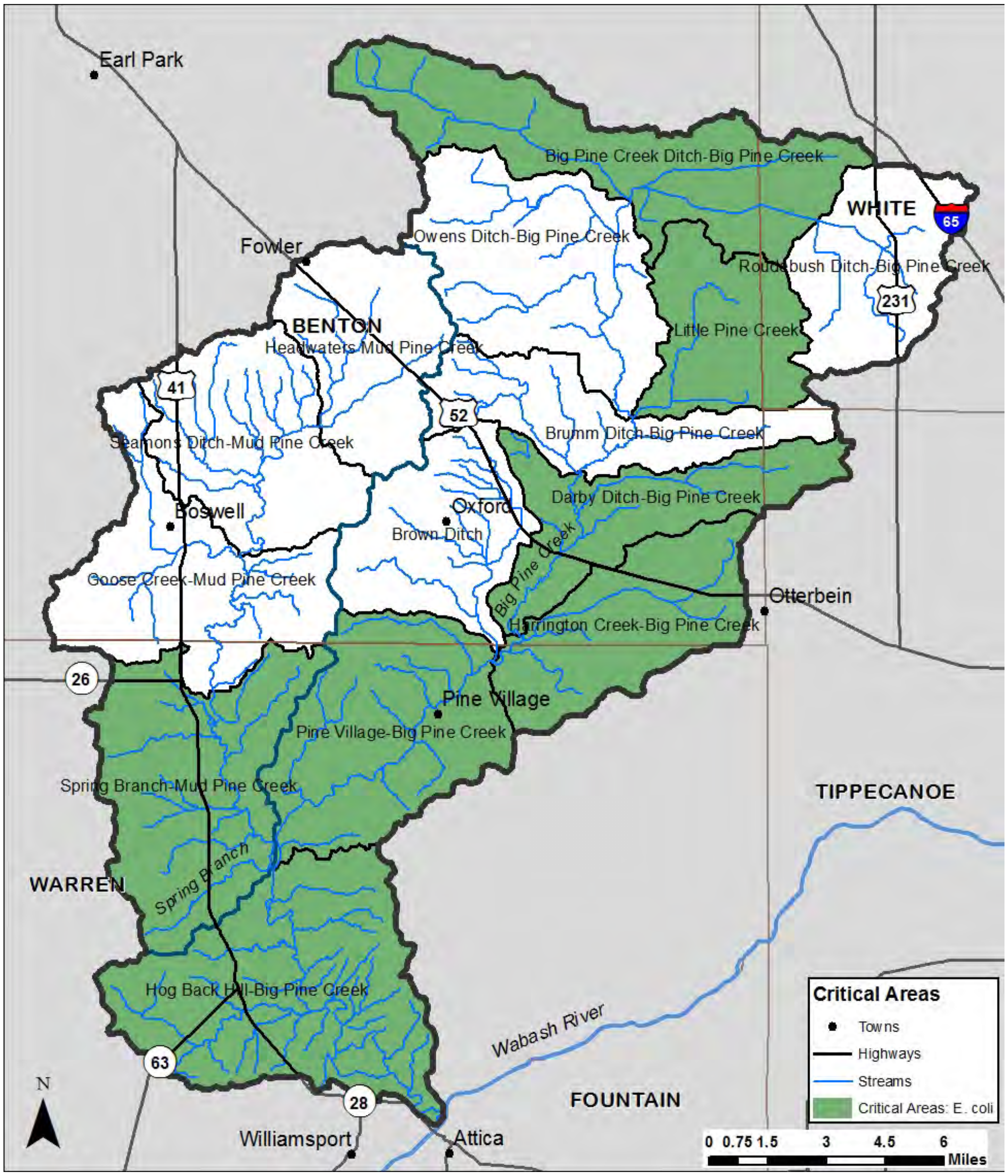


Figure 46. Critical areas for *E. coli* in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

9.5 Critical Areas for Habitat Restoration

Poor habitat is a common cause for impaired biotic communities. Habitat limitations may be due to inadequate riparian buffers, streambank and bed erosion, poor filtration and impervious surfaces. Data from our windshield survey as well as biological assessment data were reviewed to assess habitat limitations and determine critical areas for habitat restoration. We did not have sufficient data to compare mIBI scores across the watershed, so those data were not included in this assessment. Based on the data summarized in Table 38, the orange highlighted subwatersheds are the most critical areas for habitat, including subwatersheds scoring 4 or greater out of 6 criteria. These are the areas where in-stream and riparian habitat is the most degraded, where efforts to improve such habitat should be focused.

Table 38. Critical Areas for Habitat Restoration.

HABITAT	Roudebush Ditch-Big Pine Creek	Big Pine Creek Ditch-Big Pine Creek	Little Pine Creek	Owens Ditch-Big Pine Creek	Brumm Ditch-Big Pine Creek	Darby Ditch-Big Pine Creek	Brown Ditch	Harrington Creek-Big Pine Creek	Pine Village-Big Pine Creek	Hog Back Hill-Big Pine Creek	Headwaters Mud Pine Creek	Seamons Ditch-Mud Pine Creek	Goose Creek-Mud Pine Creek	Spring Branch-Mud Pine Creek
From Table 6. Impaired waterbody locations.														
Streams with IBC impairments	•	•		•	•	•								
Summarized from Table 27. Potential sources causing habitat problems.														
More than 5% of stream miles lack adequate stabilization						•	•	•	•			•		
More than 4% of fields exhibit gully erosion						•	•		•			•		
More than 10% of streams lack adequate buffers		•	•		•	•		•	•		•			
From Table 20. Monitoring samples exceeding targets.														
fish IBI score less than 35	•	•		•	•	•								
QHEI Score < 51 (poor habitat)	•	•	•	•	•	•	•		•				•	
SCORE:	**3**	**4**	**2**	**3**	**4**	**6**	**3**	**2**	**4**	**0**	**1**	**2**	**1**	**0**

Based on these criteria, Big Pine Creek Ditch, Brumm Ditch-Big Pine Creek, Darby Ditch-Big Pine Creek, and Pine Village subwatersheds serve as critical areas for habitat restoration (Figure 47).

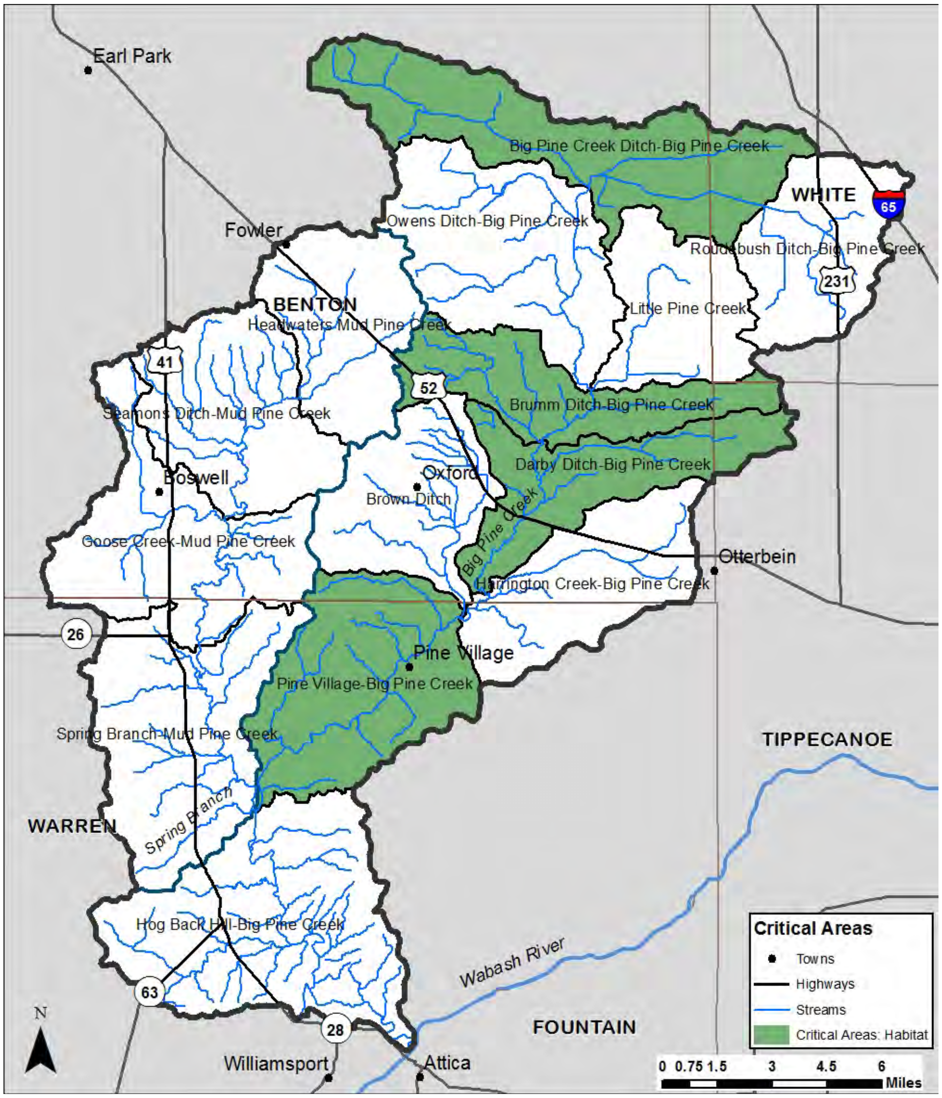


Figure 47. Critical areas for habitat in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

9.6 Priority Areas for Habitat Protection

In addition to the critical areas where efforts to improve degraded habitat will be focused, the Big Pine Creek watershed has a signification amount of existing high quality habitat that should be protected and expanded. These natural areas create conditions which support regionally rare species, such as the channel darter, variegate darter and clubshell mussel, by providing habitat and by improving water quality in the adjacent streams. Deciduous forests cover approximately 7% of the watershed, primarily along the streams, with larger expanses found on the steeper slopes in Warren County. Grasslands/prairies, woody wetlands, emergent herbaceous wetlands, barren land and evergreen forests cover less than 0.2% of the watershed.

Fish IBI scores greater than 45, indicating good or excellent water quality, were recorded in the Little Pine Creek, Owens Ditch, Brown Ditch, Hog Back Hill and Spring Branch-Mud Pine Creek subwatersheds. QHEI and cQHEI scores indicative of excellent habitat were recorded in the Pine Village, Hog Back Hill, Seamons Ditch, and Spring Branch subwatersheds, corresponding to the largest concentration of forested riparian corridors in the watershed. These high quality aquatic habitat, fish, and macroinvertebrate communities could be further enhanced with additional conservation and restoration in uplands and floodplains near the stream. These include uplands adjacent to the stream that have been previously identified as regional or local conservation priorities by Indiana Department of Natural Resources, The Nature Conservancy and Niches Land Trust. These areas of high quality habitat, as well as corridors designed to connect them, are where efforts to protect and expand such habitat should be focused.

Priority areas were identified by mapping forest, wetland, open water, grassland and barren land uses throughout the watershed (Figure 48).

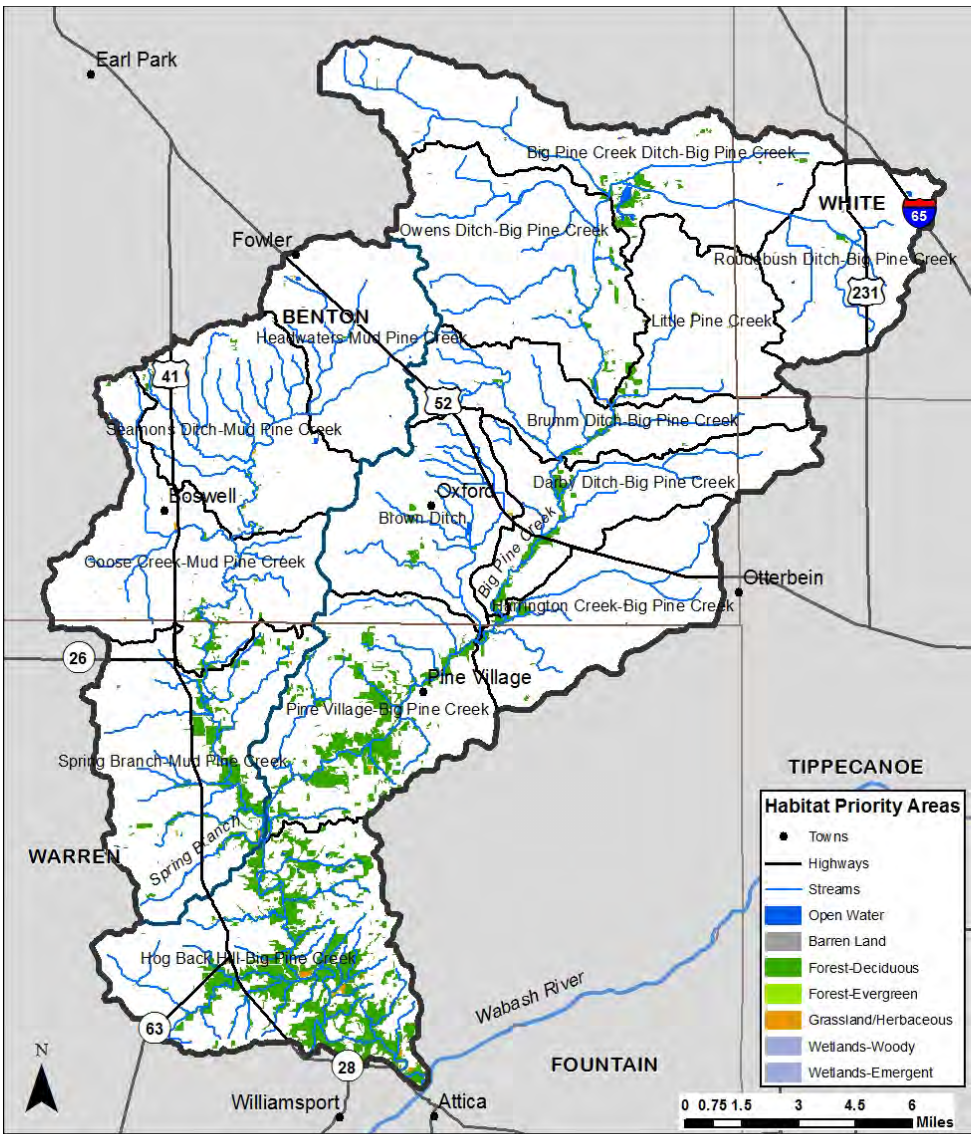


Figure 48. Priority areas for habitat protection in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

9.7 Critical Areas Summary

The subwatersheds identified as critical areas for each parameter are summarized in Table 39 and shown in Figure 49. 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 four or five parameters. The medium priority subwatersheds are those that were determined to be critical for two or three parameters. The lowest priority subwatersheds were critical for one or two parameters.

Table 39. Critical Areas Summary.

Critical Areas:	N	P	Sediment	E. coli	Habitat	Total Score	Priority
Roudebush Ditch-Big Pine Creek (051201080401)	•	•	•			3	Medium
Big Pine Creek Ditch-Big Pine Creek (051201080402)	•	•	•	•	•	5	High
Little Pine Creek (051201080403)	•	•	•	•		4	High
Owens Ditch-Big Pine Creek (051201080404)			•			1	Low
Brumm Ditch-Big Pine Creek (051201080405)	•	•	•		•	4	High
Darby Ditch-Big Pine Creek (051201080406)	•	•	•	•	•	5	High
Brown Ditch (051201080407)	•	•				2	Medium
Harrington Creek-Big Pine Creek (051201080408)	•	•	•	•		4	High
Pine Village-Big Pine Creek (051201080409)		•	•	•	•	4	High
Hog Back Hill-Big Pine Creek (051201080410)				•		1	Low
Headwaters Mud Pine Creek (051201080301)						0	
Seamons Ditch-Mud Pine Creek (051201080302)		•	•			2	Medium
Goose Creek-Mud Pine Creek (051201080303)						0	
Spring Branch-Mud Pine Creek (051201080304)	•			•		2	Medium

tier 1 (high priority): 4+
tier 2 (medium priority): 2+
tier 3 (low priority): 1+

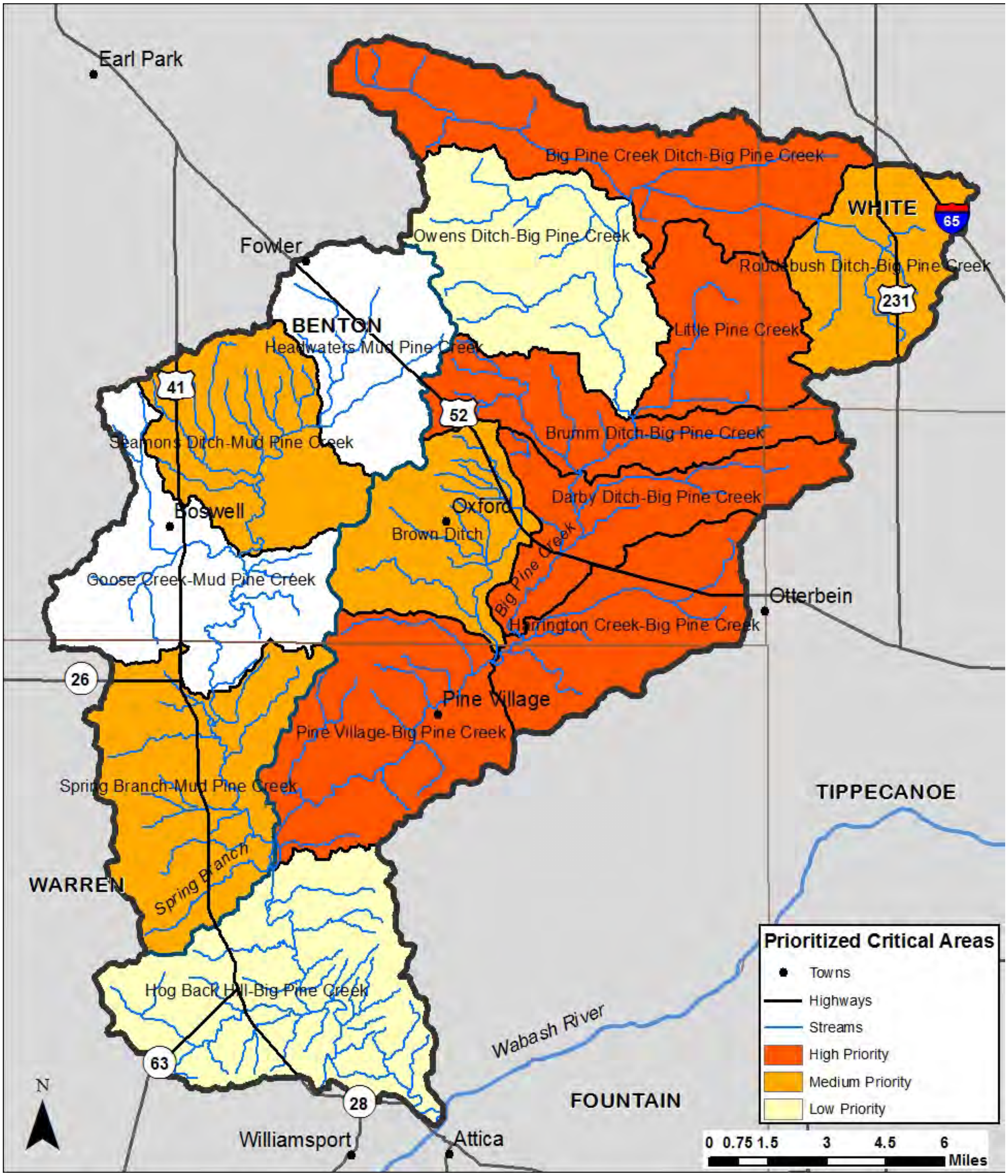


Figure 49. Prioritized Critical Areas.

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 Pine 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

Agricultural best management practices are implemented on agricultural lands, typically row crop agricultural lands, in order to protect water resources and aquatic habitat while improving land resources. These practices control and trap nonpoint source pollutants, reducing their loading to Big Pine Creek. The protection of open space, preservation of habitat corridors, and mitigation of impacts from watershed-wide impacts are important management practices as well.

Potential best management practices include:

- Alternative Watering Systems
- Bioreactor
- Buffer Strip/Filter Strip
- Conservation Tillage
- Cover Crops
- Drainage Water Management/Subirrigation
- Grassed waterways
- Habitat Corridor Identification and Improvement
- Irrigation Water Management
- Livestock Restriction/Rotational Grazing
- Manure Management Planning
- Manure storage facilities
- Nutrient/Pest Management Planning
- Prairie Restoration
- Reforestation or Timber Stand Improvement, including invasive control
- Saturated Buffers
- Septic System Maintenance and Upgrade
- Streambank Stabilization
- Two Stage Ditch
- Waste Water Treatment Plant upgrade
- Wetland Construction or Restoration

Alternative Watering Systems

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

Bioreactors

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

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.

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

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.

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.

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.

Habitat Corridor Identification and Improvement

Large blocks of connected habitat are more valuable to wildlife species than a collection of small, unconnected blocks of habitat on the landscape. This is true for grassland, forests, and wetlands. As we consider our habitat protection and restoration goals, an effort will be made to identify existing blocks of habitat and any corridors that would connect these core areas. This map can then be used to prioritize land for protection and/or restoration. Land can be protected through a variety of mechanisms, including acquisition by public or non-profit entities, conservation easements, enrollment of private lands into the DNR's Classified Forest and Wildlands program, or enrolling in an NRCS easement program such as WRE.

Irrigation Water Management
In an effort to increase yields, producers are installing more center pivot irrigators in fields to ensure the crop has the water it needs when it needs it. In hot dry summers, this impacts the ground water level and can leave ditches, streams and wells with low water levels. Irrigation water management uses technology to be more efficient with water use, only applying the right amount of water to the crop when it is needed, rather than relying on guess work as to how much to apply and when.

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

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

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

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.

Manure Storage Facilities
Waste storage facilities are one component of agricultural waste management systems, designed to temporarily store manure, wastewater, and contaminated runoff. Storage facilities include impoundments created by building an embankment or excavating a pond, or by building a structure such as a tank. Facilities should be constructed, operated and maintained in such a way that they do not pollute water resources. Facilities must be located outside of floodplains and with a minimum 300 foot setback from surface waters and drainage inlets, or a 100 foot setback if the facility is for solids storage only. In addition, facilities should be located so as to minimize the potential impacts from breach of embankment, accidental release and liner failure (NRCS 2014).

Nutrient/Pest Management Planning
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. 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.

Prairie Restoration
Restoration of prairies within the northern portion of the watershed is a viable way to restore historic habitat. Deep-rooted prairie plants reduce sediment and nutrient transport to waterbodies, and restore nutrients and organic matter to soils. Marginal or unproductive agricultural land can be restored to prairie by planting native grasses and forbs. Care must be taken to control invasive plants that may threaten to out-compete the native plants. Invasive plants can be controlled through mechanical or chemical treatments. Controlled burning is also an important tool to control invasive plants, stimulate seed germination of native plants, and control encroaching woody vegetation. In addition to improving water quality, restored prairies provide excellent recreation opportunities and wildlife habitat.

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

Timber Stand Improvement refers to any cultural practice done in the forest stand that improves the rate of growth, quality of growth or composition of the forest stand itself. This includes, but is not limited to: pruning, non-commercial thinning, crop tree release, elimination of competing culls, elimination of competing vines, weeds and grasses. TSI is an investment in the forest resource that enhances the intended benefits of that resource.

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 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 Pine 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.

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 marine 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).

Waste Water Treatment Plant upgrade

Treatment Plants have certain criteria that they can't exceed in terms of their effluent, as regulated by the NPDES program. This practice is available to both large and small treatment plants for the purpose of upgrading their facility to better treat the effluent they discharge to a level that meets or exceeds EPA/IDEM standards. Both mechanical and biological measures for treatment are eligible for this practice.

Wetland Construction or Restoration

Visual observation and historical records indicate at least a portion of the Big Pine 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

Table 40 details selected agricultural best management practices by critical area. The critical area and the selected best management practices are based on subwatershed characteristics and available water quality data. The predicted load reduction for each BMP was estimated using the Spreadsheet Tool for Estimating Pollutant Load (STEPL). The assumptions used to determine the load reductions are listed in the table. Load reductions were not available for all parameters for all BMPs.

Table 40. Best management practices suggested for each critical area by parameter.

Critical Area	Reason for Being Critical	BMP	Estimated Load Reduction for a single BMP[1] (lb/ac/yr, unless otherwise noted)		
			Nitrogen	**Phosphorus**	**Sediment**
High Priority: Big Pine Creek Ditch, Little Pine Creek, Brumm Ditch, Darby Ditch, Harrington Creek Medium Priority: Roudebush Ditch, Brown Ditch, Spring Branch	Nitrate-Nitrogen	Filter strips[2]	2.61	0.83	58.51
		Wetland restoration	0.82	0.29	69.77
		Cover crops	1.87	0.5	36.01
		Two-stage ditch[3]	0.45	N/A	36.01
		No-till	2.05	0.5	67.52
		Habitat restoration (prairie, reforestation)	1.87	0.59	45.01
		Nutrient management plans[4]	1.87	0.55	0
		Livestock restriction (fencing, alternative watering source, bank stabilization)[5]	2.8	0.83	67.52
		Bioreactors	1.87 lb/unit/yr	0	0
		Drainage water management	1.25	N/A	N/A
High Priority: Big Pine Creek Ditch, Little Pine Creek, Brumm Ditch, Darby Ditch, Harrington Creek, Pine Village Medium Priority: Roudebush Ditch, Brown Ditch,	Phosphorus	Filter strips[2]	2.61	0.83	58.51
		Wetland restoration	0.82	0.29	69.77
		Cover crops	1.87	0.5	36.01
		Two-stage ditch[3]	0.45	N/A	36.01
		No-till	2.05	0.5	67.52
		Habitat restoration (prairie, reforestation)	1.87	0.59	45.01
		Nutrient management plans[4]	1.87	0.55	0
		Livestock restriction (fencing, alternative watering source, bank stabilization)[5]	2.8	0.83	67.52

Critical Area	Reason for Being Critical	BMP	Estimated Load Reduction for a single BMP[1] (lb/ac/yr, unless otherwise noted)		
			Nitrogen	Phosphorus	Sediment
Seamons Ditch		Repair/replace leaking septic systems [6]	21.88	6.08	239
		Streambank stabilization[7]	0	0.83	67.52
<u>High Priority:</u> Big Pine Creek Ditch, Little Pine Creek, Brumm Ditch, Darby Ditch, Harrington Creek, Pine Village <u>Medium Priority:</u> Roudebush Ditch, Seamons Ditch	Sediment	Filter strips (grass)/Buffer strips (shrub/tree) [2]	2.61/ 1.75	0.83/ 0.58	58.51/ 68.24
		Wetland restoration	0.82	0.29	69.77
		Cover crops	1.87	0.5	36.01
		Two-stage ditch[3]	0.45	N/A	36.01
		Conservation tillage, No-till	2.05	0.5	67.52
		Livestock restriction (fencing, alternative watering source, bank stabilization) [5]	2.8	0.83	67.52
		Streambank stabilization[7]	0	0.83	67.52
		Prairie restoration, reforestation	1.87	0.59	45.01
		Grassed waterways	0.82	0.13	49.51
<u>High Priority:</u> Big Pine Creek Ditch, Little Pine Creek, Darby Ditch, Harrington Creek, Pine Village <u>Medium Priority:</u> Spring Branch	*E. coli*	Filter strips (grass)/Buffer strips (shrub/tree) [2]	2.61/ 1.75	0.83/ 0.58	58.51/ 68.24
		Cover crops	1.87	0.5	36.01
		Nutrient/Pest management planning[4]	1.87	0.55	0
		Livestock restriction (fencing, alternative watering source, bank stabilization)	2.8	0.83	67.52
		Manure management planning	N/A	N/A	N/A
		Manure storage facilities	N/A	N/A	N/A
		Repair/replace leaking septic systems[6]	21.88	6.08	239
		Prairie restoration, reforestation	1.87	0.59	45.01
		Wetland construction or restoration	0.82	0.29	69.77
<u>High Priority:</u> Big Pine Creek Ditch, Brumm Ditch, Darby Ditch, Pine Village <u>Medium Priority:</u> none	Habitat	Wetland restoration	0.82	0.29	69.77
		Prairie restoration, including controlled burning	1.87	0.59	45.01
		Reforestation	1.87	0.59	45.01
		Timber Stand Improvement	N/A	N/A	N/A
		Habitat corridor improvement	N/A	N/A	N/A
		Invasive species control	N/A	N/A	N/A

N/A = no data available on removal efficiency, so unable to estimate load reduction.
[1]Assumes BMPs would only be applied in those subwatersheds identified as critical for one or more parameters. [2]Assumed buffer width of 30 feet. [3]Assumed average width of 30 feet. [4]Assumed 15% livestock producers and 85% non-livestock producers. [5]Restriction via fencing: 10 ft wide. [6]Four people per household who use 60 gallons of water per day (estimates from Onsite Wastewater Treatment Systems Manual, US EPA 2002). [7]Assumed average width of 5 feet.

11.0 ACTION REGISTER

All activities to be completed as part of this watershed management plan are identified in Table 41. 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.

Measurement of the success of implementation is a necessary part of any watershed project. Water quality data will be used to measure observable changes following implementation, when applicable. The administrative and social indicators listed below will also be used to track implementation progress.

Nutrient Goal: Reduce nitrate-nitrogen loading from 364 tons/year to 177 tons/year (51% reduction to 2 mg/L) and reduce phosphorus loading from 107 tons/year to 53.5 tons/year (50% reduction to 0.6 mg/L) in the Big Pine watershed by 2036.

- Short-term goal: Reduce nitrate-nitrogen loading by 46.75 tons/year (12.8% reduction) and reduce phosphorus loading by 13.375 tons/year (12.5% reduction) by 2021.
- Water Quality Indicator: Nitrate-nitrogen and total phosphorus will be measured monthly during the growing season at three continuous water chemistry monitoring stations (see Section 12.1.1 for details on station locations). 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 2 mg/L and for total phosphorus of 0.6 mg/L.
- Administrative Indicator: The number of BMPs that can reduce nitrate-nitrogen and total phosphorus will be tracked annually. 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.

Sediment Goal: Reduce soil erosion and total suspended solids loading from 8,787 tons/year to 3,102 tons/year (65% reduction to 35 mg/L) in the Big Pine watershed by 2036.

- Short-term goal: Reduce sediment loading by 1,421 tons/year (16% reduction) by 2021.
- Water Quality Indicator: Total suspended solids will be measured monthly during the growing season at three continuous water chemistry monitoring stations (see Section 12.1.1 for details on station locations). 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 35 mg/L.
- Administrative Indicator: The number of BMPs that can reduce total suspended solids will be tracked annually. 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.

E. coli Goal: Reduce *E. coli* concentrations to meet the state standard (235 colonies/100 ml grab sample; 180 colonies/100 ml in geometric samples) by 2036.

- Water Quality Indicator: *E. coli* will be measured monthly during the growing season at three continuous water chemistry monitoring stations (see Section 12.1.1 for

details on station locations). After five years of implementation, water quality samples will show a decreasing trend, with more samples annually meeting the state standard.
- Administrative Indicator: The number of BMPs that can reduce *E. coli* will be tracked annually.

Habitat Goal: Natural habitat (grasslands, forest, wetlands) will increase by a total of 5% within the Big Pine watershed, with a focus on improving connectivity, by 2030.
- Short-term goal: Increase natural habitat by 2% by 2021.
- Water Quality Indicator: Macroinvertebrate communities (mIBI) and in-stream habitat (QHEI) will be monitored annually at three continuous water monitoring stations (see Section 12.1.1 for details on station locations). After five years of implementation, mIBI and QHEI scores will show an increasing trend.
- Administrative Indicator: The number of BMPs that can improve or create habitat will be tracked annually, as well as the total acreage. The number of BMPs implemented will increase annually.

Public Awareness and Participation Goal: By 2036, 100% of the public will be informed about practices that can be implemented to positively impact Big Pine Creek.
- Administrative Indicator: The number of people who attend education and outreach events will be tracked. The percent of targeted households reached will increase annually.
- Social Indicator: Pre and post surveys of attendees will be conducted at workshops to determine changes in individuals' knowledge of the topic as a result of attending the workshop. It would be expected that 75% of workshop attendees would have a better understanding of the topic after the workshop.

Public Access Goal: By 2021, a public access site will be identified and public access available on the mainstem of Big Pine Creek.
- Administrative Indicator: The number of landowners of potential access sites who are contacted will be tracked, with the goal of identifying, acquiring and constructing a public access site.

Table 41. Action Register.

Goal	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
Nutrients, Sediment, *E. coli*	Increase conservation buffer by 100 acres by 2021 and by 500 acres by 2036.	Agricultural landowners and operators, Urban and rural landowners	Develop cost-share program.	see note[1]	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA TA=SWCDs, NRCS
			Develop an education plan targeting the use of buffer habitats.	$5,000	
			Submit grant application for restoration and easement purchase to increase zones of protection with emphasis on partners and water monitoring in 2015.	$1,000	
			Seek financial incentives for landowners to establish field borders/buffers as well as promote existing programs/incentives (2016).	$1,000	
			Identify and map areas for comprehensive watershed inventory of conservation practices.	$1,000	
			Annually (2016-2021) implement 20 acres of buffers.	$4,000	
Nutrients, Sediment	Increase wetland restoration by 50 acres by 2021 and by 250 acres by 2036.	Agricultural landowners and operators, Suburban and rural landowners	Develop cost-share program.	see note[1]	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA TA=SWCDs, NRCS
			Develop a list of potential wetland restoration sites and conduct 4 one-on-one meetings annually with individual landowners.	$5,000	
			Increase awareness about existing programs.	$1,000	
			Seek financial incentives for landowner to restore wetlands.	$1,000	
			Restore 10 acres of wetland annually from 2016-2021.	$150,000	
Nutrients, Sediment, *E. coli*	Increase landowner awareness on the use of constructed wetland cells to treat tile drain runoff by 2021.	Agricultural landowners and operators, Urban and rural landowners	Identify and seek financial incentives for landowners to establish constructed wetland cells.	$1,000	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA TA=SWCDs, NRCS
			Develop an education plan targeting the use of wetland cells.	see note[1]	
			Implement education plan (2016-2021).	$120,000[1]	
			Host annual workshop or presentation for landowners highlighting the benefits of constructed wetland cells.	$1,000	
			Target a demonstration area to be installed in 2021.	$5,000	
			Install constructed wetland cells as possible by 2036.	$12,000/cell	
Nutrients, Sediment	Increase the use of a conservation system approach (cover crops, no till and nutrient management) by 25,000 acres by 2021 and by 100,000 acres	Agricultural landowners and operators	Develop cost-share program.	see note[1]	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA TA=SWCDs, NRCS
			Develop an education plan highlighting the benefits of the conservation system in an operating area.	see note[1]	
			Seek financial incentives for landowners to establish the system (2015).	$1,000	
			Annually (2016-2021) implement 5,000 acres of the conservation system (includes cover crop, no till, nutrient management, pesticide management, and waste	$600,000	

Goal	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
	by 2036[2].		utilization).		
Nutrients, Sediment, *E. coli*	Increase cover crop acreage by 25,000 acres by 2021 and by 100,000 acres by 2036[2].	Agricultural landowners and operators	Develop cost-share program.	$2,500[1]	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA TA=SWCDs, NRCS
			Create a contractors list for specific cover crop seeding in 2015.	$500	
			Develop cover crop demonstration area highlighting various species by 2015.	$2,000	
			Host cover crop workshop in 2014 and 2016.	$1,000	
			Annually, identify additional cover crop funding options.	$1,000	
			Annually (2016-2021) implement 5,000 acres of cover crop.	$1,000,000	
Nutrients, *E. coli*	Increase the use of nutrient and pest management by 15,000 acres by 2021 and by 80,000 acres by 2036.	Agricultural landowners and operators	Develop cost-share program.	see note[1]	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA TA=SWCDs, NRCS
			Develop an education plan highlighting the benefits of nutrient and pest management planning.	see note[1]	
			Seek financial incentives for landowners to implement nutrient and pest management (2015).	$1,000	
			Annually (2016-2021) implement 3,000 acres of nutrient and pest management.	$62,000	
Nutrients, Sediment, *E. coli*	Limit livestock access from watershed streams by 2021 where willing landowners are identified.	Landowners with livestock access to watershed streams	Develop cost-share program.	see note[1]	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA TA=SWCDs, NRCS
			Develop a targeted education program in 2015.	see note[1]	
			Implement education plan (2016-2021).	see note[1]	
			Develop individual livestock on-site restriction plans which may include provision of alternate water systems, livestock fencing, and rotational grazing.	$1,500	
			Annually (2016-2021) restrict livestock access from 1 mile of streambank.	$42,500	
Nutrients, Sediment	Increase streambank stabilization by 2 miles by 2021 and by 10 miles by 2036.	Agricultural landowners and operators, riparian landowners	Develop cost-share program.	see note[1]	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA TA=SWCDs, NRCS
			Develop a targeted education program in 2015.	see note[1]	
			Implement education plan (2016-2021).	see note[1]	
			Complete 2 miles of streambank stabilization by 2021.	$264,000	
Nutrients	By 2021, convert 10 acres lawn to prairie or woodland.	Homeowners and businesses with large lawns	Develop cost-share program.	$1,000	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA TA=SWCDs, NRCS
			Create a contractors list for specific prairie or woodland seeding in 2015.	$15,000	
			Develop prairie/woodland seeding demonstration area highlighting various species by 2015.	$10,000	

Goal	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
			Annually (2016-2021), host field day highlighting lawn or agricultural conversion to prairie or woodland.	$500	
			Annually (2016-2021), convert 2 acres of lawn to prairie or woodland.	$68,000	
Nutrients	Increase landowner awareness on the use of drainage water management, install two demonstration areas by 2021, and install as possible through 2036.	Agricultural landowners and operators	Identify and seek financial incentives for landowners to install drainage water management practices.	$1,000	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA TA=SWCDs, NRCS
			Develop an education plan targeting drainage water management.	see note[1]	
			Implement education plan (2015-2021).	see note[1]	
			Host annual workshop or presentation for landowners highlighting the benefits of drainage water management.	$3,000	
			Target two demonstration areas to be installed by 2021.	$3,000/ structure	
			Install drainage water management as possible by 2036.	$1,000	
Nutrients	Increase landowner awareness on the use of bioreactors and install two demonstration bioreactors by 2021.	Agricultural landowners and operators, Urban and rural landowners	Identify and seek financial incentives for landowners to establish bioreactors.	see note[1]	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA TA=SWCDs, NRCS
			Develop an education plan targeting the use of bioreactors.	$1,000	
			Host annual workshop or presentation for landowners highlighting the benefits of bioreactors.	$500	
			Target two demonstration areas to be installed by 2021 and install bioreactors as possible by 2036.	$18,000/ reactor	
Sediment	Increase minimum disturbance tillage acreage by 25,000 acres by 2021 and by 100,000 acres by 2036.	Agricultural landowners and operators	Host annual minimum disturbance till workshop starting in 2014.	$1,000	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA TA=SWCDs, NRCS
			Develop cost-share program.	see note[1]	
			Host annual minimum disturbance till breakfast starting in 2015.	$6,000	
			Continue to perform annual tillage transect and promote results to watershed stakeholders.	$5,000	
			Conduct site visits with landowners to promote minimum disturbance till.	$1,000	
			Complete 5,000 acres of minimum disturbance till annually through 2021.	$125,000	
Sediment	Increase awareness of landowners on the use of two-stage ditches and install 5	Agricultural landowners and operators	Complete installation of demonstration two-stage ditch project in Big Pine Creek (half mile) by 2017.	$32,000	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA
			Develop an education plan including demonstration day and printed materials targeting two stage ditches.	see note[1]	

Goal	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
	miles of two-stage ditch by 2021.		Implement education plan (2015-2021).	see note[1]	TA=SWCDs, NRCS
			Host annual workshop or presentation for landowners highlighting the benefits of two stage ditches.	$1,000	
			Develop cost-share program.	see note[1]	
			Install 5 miles of two-stage ditches by 2021.	$316,800	
Sediment	Increase the use of grassed waterways by 200 acres by 2021 and by 5,000 acres by 2036.	Agricultural landowners and operators	Develop cost-share program.	see note[1]	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA TA=SWCDs, NRCS
			Develop a field day highlighting management and development of grassed waterways and host annually starting in 2015.	$5,000	
			Seek financial incentives for landowners to establish grassed waterways (2016).	$1,000	
			Annually (2016-2021) implement 40 acres of grassed waterways.	$35,000	
E. coli	Reduce *E. coli* loading to waterways from failing or absent septic systems by 2021.	Residential property owners outside of sewered areas	Develop an education plan using existing educational materials.	see note[1]	PP=SWCDs, NRCS, USDA, Purdue Extension, CTIC, FSA TA=SWCDs, NRCS
			Implement education plan (2016-2021).	see note[1]	
			Host septic system care and maintenance workshops annually.	$5,000	
			Work with the health department to identify areas of failing or absent septic systems.	$2,500	
			Work with the health department to create an ordinance requiring all properties sold with a septic system to require an inspection at the time of sale.	$10,000	
			Develop a strategy to reduce septic system impacts to Big Pine Creek.	$30,000	
Habitat	By 2016, identify priority areas and by 2021 protect 2,500 acres with 1,200 acres on contiguous tracts to connect grassland[3] species.	Landowners within target corridors	By 2016, partner organizations hold series of meetings to identify habitats necessary to key umbrella species (ie: red-headed woodpecker, bobwhite, box turtle, etc).	$1,000	PP=SWCDs, NRCS, NICHES, DNR, TNC TA=SWCDs, NRCS, NICHES, DNR, TNC
			By 2017, determine current grassland coverage using GIS mapping and site-based spot checks.	$1,000	
			By 2018, complete land protection map identifying target corridors.	$1,000	
			By 2019, begin target protection of grassland in areas of marginal or unproductive land or with other willing landowners.	$6,000/acre acquisition	
			By 2021, 2,500 acres of headwaters of Big Pine Creek grassland publicly owned or protected via the Classified	$6,000/acre acquisition;	

Goal	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
			Forest & Wildlands or Wetland Reserve Program with 1,200 contiguous acres.	$1,000/acre restoration	
			By 2036, complete corridor protecting acres in a maximum of contiguous tracts.	$6,000/acre acquisition; $1,000/acre restoration	
Habitat	By 2016, identify priority areas and by 2021 protect 2,000 acres with 500 acres on contiguous tracts to oak woodland and savanna[4]. By 2030 protect 3,000 acres.	Landowners within target corridors	By 2016, partner organizations hold series of meetings to identify habitats necessary to key umbrella species (ie: red-headed woodpecker, bobwhite, box turtle, etc).	$1,000	PP=SWCDs, NICHES, DNR, TNC TA=SWCDs, NICHES, DNR, TNC
			By 2017, determine current oak woodland and savanna coverage using GIS mapping and site-based spot checks.	$1,000	
			By 2018, complete land protection map identifying target corridors.	$1,000	
			By 2019, begin target protection of oak woodland and savanna in areas of marginal or unproductive land or with other willing landowners.	$4,000/acre acquisition	
			By 2021, 2,000 acres of headwaters of Big Pine Creek oak woodland or savanna publicly owned or protected via the Classified Forest & Wildlands or Wetland Reserve Program with 500 contiguous acres.	$4,000/acre acquisition; $2,000/acre restoration	
			By 2036, complete corridor protecting acres in a maximum of contiguous tracts.	$4,000/acre acquisition; $2,000/acre restoration	
Habitat	By 2021, increase the use of controlled burning as a management method.	Landowners with habitat where controlled burning is needed	Identify a funding mechanism to promote controlled burning by 2016.	$1,000	PP=SWCDs, NICHES, DNR TA=SWCDs, NICHES, DNR
			By 2017, work with local officials to develop controlled burning plans and ordinances, as needed.	$5,000	
			Annually (2017-2018), host controlled burn workshop for grassland and oak woodland systems.	$5,000	
			Develop an education plan to promote awareness of controlled burns and the accessibility of DNR equipment to the public for private controlled burns.	see note[1]	
			Implement education plan (2016-2021).	see note[1]	
Habitat	By 2017, develop a demonstration woods	Landowners with	By 2016, identify a willing landowner of woodlands currently managed for timber production.	$500	PP=Purdue FNR, NICHES, DNR, TNC

Goal	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
	to showcase the value of long-term management for timber production.	woodlands	By 2017, enroll the woods in Classified Forest Program (if not already), implement timber stand improvement and invasive species management as needed.	$300/acre	TA=Purdue FNR, NICHES, DNR, TNC
			By 2018, host field day for woodland land owners.	$2,000	
Habitat	Develop a perennial terrestrial invasive species control plan by 2021 with less than 25% invasive species coverage by 2036.	Government, NGO, Private landowners	Develop terrestrial invasive species education program by 2017.	$10,000	PP=Purdue FNR, NICHES, DNR, TNC TA=Purdue FNR, NICHES, DNR, TNC
			Identify a funding mechanism to develop a terrestrial invasive species control plan by 2018.	$1,000	
			Map the extent of terrestrial invasive species by 2019.	$3,000	
			Develop a control plan for identified terrestrial invasive species by 2020.	$3,000	
Habitat	Develop deer control plan to reduce deer density to carrying capacity of 14 deer/square mile by 2021.	Government, NGO, Private landowners	Determine current deer density within Big Pine Creek.	$2,000	PP=NICHES, DNR TA=NICHES, DNR
			Identify funding to process deer culled to reduce current capacity and provide meat to local food banks, focusing on priority areas for habitat.	$1,000	
Education	Develop an education plan targeting each practice identified above by 2015.	Community members targeted by each identified strategy	Create mechanism to promote each practice using methods identified below including but not limited to website creation, local events, county fairs, and public meetings.	$10,000	PP=steering committee, SWCDs
			Develop funding mechanism for education efforts.		
Education	Develop quarterly Hoosier Riverwatch-based volunteer monitoring program through 2021.	Community volunteers, businesses, charter schools, Youth and Scout groups	Create annual training and consider retraining volunteers as needed.	$2,500	PP= steering committee, SWCDs TA=IDEM (Hoosier Riverwatch), Riverwatch-certified trainer
			Identify watershed-wide monitoring locations.	$3,000	
			Recruit volunteer monitors.	$2,500	
			Profile volunteers and their monitoring efforts on partner websites and through marketing effort.	$500	
			Complete quarterly sampling at sites through 2021.	$2,500	
Education	Share and communicate past, current, and future activities on a regular	Community members targeted by each	Create a watershed-based website and update it quarterly. Provide that information to partners for update to their websites as well.	$5,000	PP=SWCDs, town governments, community organizations,
			Host semi-annual public meetings or events at which the	$10,000	

Goal	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
	basis through 2021.	identified strategy	public can comment on watershed efforts.		Chambers TA=WREC
			Develop a message for county fairs annually and attend county fairs for Benton and Warren counties annually.	$25,000	
			Create pamphlets, brochures, and marketing materials as needed and distribute through partner organizations, on websites, and via direct mailings and meetings.	$10,000	
			Create press releases quarterly or as needed. Consider writing newspaper articles for Benton, Warren and White County papers in lieu of press releases.	$1,000	
			Attend festivals and events to promote efforts and events.	$250	
			Provide information to existing newsletter publishers including SWCDs and others as identified.	$10,000	
			Explore the potential and need for a semi-annual or quarterly newsletter in paper and electronic format and produce as determined through 2021.	$5,000	
Education	Build on existing youth education programs.	School groups, youth-targeted groups	Partner with the SWCDs to host a booth at Ag Days annually.	$2,000	PP=SWCDs, local schools, FFA, youth organizations
			Assist SWCDs with water quality sampling program.	$1,000	
			Assist SWMD educators as needed.	$1,500	
			Investigate the potential for a youth-based Big Pine Creek float trip (ala Arrowhead Country RC&D) and implement annually as possible.	$4,000	
			Identify other youth-based educational opportunities.	$1,000	
Education	Work with local groups and partners to highlight Big Pine Creek and natural aspects of the watershed.	Community members targeted by each identified strategy	Explore opportunities to partner with community events and festivals to highlight Big Pine Creek.	$2,000	PP=SWCDs, town governments, community groups, video developers, marketers TA=SWCDs, video developers, marketers
			Develop videos targeted at adult community groups (20 minutes) and kids groups (10 minutes) and create list of potential partner groups at which presentation could occur.	$10,000	
Education	Promote hands-on opportunities to improve natural areas and Big Pine Creek.	Nature enthusiast, Children	Identify partner organizations which host field days, work days, and clean-up events.	$2,000	PP=SWCDs, NICHES, TNC, DNR
			Annually, identify partner opportunities to promote field days throughout the watershed and post to a central website or calendar.	$3,000	
			Annually, identify partner work days for river clean-up, exotic species control, or habitat restoration opportunities.	$1,500	

Goal	Objective	Target Audience	Milestone	Cost	Possible Partners (PP) & Technical Assistance (TA)
Education	Reduce the volume of litter entering Big Pine Creek.	Children, Landowners	Create an educational campaign focused on covering trash cans, not littering, and picking up litter.	$1,500	PP=steering committee, SWCDs
			Implement education plan (2016-2021).	$15,000	
			Encourage commercial and governmental entities to maintain best management practices that remove litter from stormwater.	$500	
			Participate in and promote events that encourage litter removal and recycling.	$500	
Public Access	Transition “accepted” public access site into publicly owned and maintained access	Big Pine Creek stakeholders	Identify all potential public access sites.	Costs to be determined as designs are completed	PP=Local, county government, NICHES TA=DNR, USACE, local and county government
			Develop plan for acquiring, transitioning and maintaining public access site for Big Pine Creek.		
			Complete funding and feasibility study for public access.		
			By 2021, transition into publicly owned and maintained access site on Big Pine Creek.		

[1]NOTE: One cost-share program and one education plan will be developed covering all strategies identified.
[2]Conservation systems approach acreage may overlap with single practice acreage.
[3]Grassland is defined as having less than 5% canopy cover across the full range (xeric to emergent).
[4]Oak woodland and savanna are defined as having a canopy from 40-75% for woodlands and 5-40% for savannas where over 70% of the species in the 10 inch and 5-10 inch DBH size classes are oak.

12.0 TRACKING EFFECTIVENESS

The overall success of a watershed management plan depends up on the implementation of action items as outlined by the watershed management plan goals. Below are measureable success indicators or milestones which will help stakeholders in the Big Pine Creek watershed track their progress and aid in updating and revising the Watershed Management Plan as goals, objectives, and strategies are met. All of the goals are designed for a 20-year implementation schedule. Regular water quality monitoring and tracking of administrative successes associated with objectives and strategies is necessary to help realize actual water quality targets. Indicators identified below will be tracked and reported on a quarterly basis.

12.1 Indicator Tracking

Measuring stakeholder successes toward goals and assessing progress toward the vision of Big Pine Creek is vital. The following details concrete milestones for stakeholders to complete as they work towards each goal. Interim measures or indicators will help stakeholders evaluate their progress towards chosen goals. For each goal, a series of indicators are detailed below. Indicator tracking will be completed by the steering committee. To request information on the status of progress towards goals, contact the Benton County SWCD.

12.1.1 Water Quality Indicators

Water quality indicators are measurements of water chemistry, instream biota, or instream and riparian habitat. As part of our effort to show a measureable change in water quality, water chemistry will be monitored by both grab samples and continuous monitoring stations established in the watershed. A water monitoring committee has been established to coordinate monitoring efforts. Representatives of the following organizations are serving on the committee: Benton SWCD, Warren SWCD, White SWCD, Natural Resource Conservation Service, The Nature Conservancy, IDEM, USGS, NICHES Land Trust, Warren Peace, Hoosier Riverwatch volunteers, Warren County Wastewater Treatment Plant, and other local volunteers.

Continuous water chemistry monitoring stations (datasondes) have been established at three locations in the watershed. The monitoring stations are strategically located on Mud Pine Creek at the NICHES Hewitt property, at the Rainsville Bridge on Big Pine Creek upstream of its confluence with Mud Pine, and on Big Pine Creek downstream of its confluence with Mud Pine. The datasondes were deployed for a test run for two months in the fall of 2014. One unit was determined to not be functioning properly and was repaired. The units were deployed again in March 2015. The datasondes will collect daily readings of DO, pH, conductivity, turbidity and temperature during the growing season. Water chemistry will also be sampled on a monthly basis at strategic locations throughout the watershed, with the Warren County WWTP processing the samples. In addition, a USGS gage station was installed on Big Pine Creek in Pine Village in February 2015, and that data will soon be available.

The steering committee contracted with an environmental consulting firm to conduct water chemistry sampling at baseflow and stormflow at 10 sites throughout the watershed for three years beginning in April 2015, with fish and macroinvertebrate sampling at each site the first year. In addition, Hoosier Riverwatch volunteers will collect data on dissolved oxygen, temperature, pH, total phosphorus, nitrate-nitrogen, turbidity, and *E. coli* throughout the watershed. This will give more complete baseline data in order to track changes in water quality as BMP implementation occurs.

Continuous monitoring and field data collection will continue for a minimum of three years. Habitat assessments using the Qualitative Habitat Evaluation Index will be completed at each project site where instream habitat is affected prior to installation and six months following installation. Water quality indicators will be used to identify the following:

- Changes in water chemistry between planning and implementation phase water quality.
- Changes in macroinvertebrate populations.
- Changes in pre-installation and post-installation instream and riparian habitat.

Water quality indicators will be tracked using a water quality database. Data will be updated quarterly and reported to the steering committee on a quarterly basis. Monitoring will be completed by the steering committee as funding permits. Costs associated with continuous monitoring, water chemistry sample collection, and biological monitoring are estimated at $105,000 for three years.

12.1.2 Administrative Indicators

Administrative indicators provide information that water quality and social indicator data cannot. These indicators are effectively “bean counting” and are used to track program participation, strategy completion, and goal attainment. Administrative indicators will be used to track the following:

- Attendance at workshops and field days.
- Participation in cost-share and education programs.
- Emails sent and responses received.
- Conservation practice installation including anticipated load reduction, size, and timing.
- Photo monitoring of installed practices.
- Media hits (newspaper stories, radio stories, website hits).
- Number of educational materials distributed.

Administrative indicators will be tracked using a database in which date of activity, number of attendees/participants, and an activity description will be recorded. Installed practices will be tracked in a project database using Geographic Information Systems. Administrative indicator tracking will occur as part of the cost-share and education programs and will be completed by the Benton County SWCD. Data will be reported to the steering committee no less than annually with updates to the database occurring quarterly.

12.2 Future Considerations

There are several considerations stakeholders should keep in mind as they implement the Big Pine Creek Watershed Management Plan. Many of these considerations are noted in the proceeding sections of this text, but due to their importance, they warrant reiteration.

12.2.1 Permits, Easements, and Agreements

Permission to implement any on-the-ground implementation project must be obtained from property owners prior to installation occurring. Likewise, any instream or near-stream restoration activities will likely require permits. All permits will be obtained by the landowner prior to any work beginning.

12.2.2 Installed Practice Monitoring

Annually, an implementation committee will be convened to review installed best management practices and successes or failures of installed practices. Members from the following organizations will be contacted and asked to serve on this committee: Soil and Water Conservation District personnel, Natural Resource Conservation Service personnel, The Nature Conservancy staff, County surveyors, IDEM representatives, IDNR representatives, County Health Department staff, town engineering and parks department staff, and NICHES Land Trust staff. Other members will be invited as identified. The committee will meet annually to review the following:

- Location and number of best management practices installed.
- Annual plans for best management practice installation.
- Potential areas for collaboration on best management practice installation.
- Grant funding opportunities and potential project targets.

12.2.3 Plan Tracking

Each strategy will be tracked on a quarterly basis. Work completed towards each strategy will be documented in a tracking database which will include scheduled and completed activities, numbers of individuals attending or efforts completed toward each objective, and load calculations or monitoring results for each goal, objective, and strategy. Overall project progress will be tracked by measureable items such as workshops held, BMPs installed, meetings held, etc. Load reductions will be calculated for each BMP installed. These values and associated project details including BMP type, location, length of conservation commitment, easement, size, cost, installer, and more will be tracked over time in a single database. Individual landowner contacts and information will be tracked for both identified and installed projects.

12.2.4 Plan Revision

The steering committee of the Big Pine Creek watershed will continue to meet on a regular basis for the purpose of plan implementation. Annually, this committee will review findings of the monitoring and implementation committees. The steering committee will review project efforts according to the management plan’s goals, objectives, and strategies no less than every five years.

This watershed management plan is meant to be a living document. Revisions and updates to the plan will be necessary as stakeholders begin to implement the plan and as stakeholders become more active in implementing the plan. The Benton County SWCD will be responsible for holding and revising the Big Pine Creek Watershed Management Plan as appropriate based on stakeholder feedback. The primary contact is Jon Charlesworth, the Technician for Benton County (765-884-1090 x3, jon.charlesworth@in.usda.gov).

This plan may be adapted or blended with other watershed management plans to effectively create living documents which cover larger-scale projects and capitalize on potential shared resources.

13.0 LITERATURE CITED

Armitage, B.J. and E.T. Rankin. 2009. An assessment of threats to the biological condition of the Wabash River aquatic ecosystem of Indiana. Prepared for The Nature Conservancy, Indiana Chapter, Indianapolis, Indiana.

Arora, K., S.K. Mickelson, J.L. Baker, D.P. Tierney, and C.J. Peters. 1993. Herbicide retention by vegetative buffer strips from runoff under natural rainfall. Trans. ASAE 39:2155-2162.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Bledsoe, L. 2009. Indiana's Most Unwanted Plants List. [webpage] Benton, Fountain, Montgomery, Tippecanoe, Warren, White counties. [Accessed 17 March 2009] http://extension.entm.purdue.edu/CAPS/browseDistribution.html

Bruns, T.M. and W.J. Steen. 2003. Hydrogeology of the Lafayette (Teays) Bedrock Valley System, North-Central Indiana. Indiana Department of Natural Resources, Division of Water, Water Resource Assessment 2003-7.

Center for Watershed Protection. 2003. Effects of impervious cover on aquatic resources. Ellicott City, Maryland.

Clark, G.D. 1980. The Indiana Water Resource (Vol. 1): Availability, Uses, and Needs.

Conservation Technology Information Center. 2000. Conservation Buffer Facts. [web page] http://www.ctic.purdue.edu/core4/buffer/bufferfact.html [Accessed March 3, 2011].

Coulter, J. 1886. Indiana Geological Report for 1886.

Davis, Todd E. July 22, 2013. [Personal Communication]. Located at: Indiana Department of Environmental Management (IDEM), Assessment Information Management System (AIMS) Database, Indianapolis, Indiana.

DeHart, G.R.P, Editor. 1909. Past and present of Tippecanoe County, Indiana. Volume 1. B.F. Bowen and Company, Publishers, Indianapolis, Indiana.

Dillaha et al. 1989. Vegetative filter strips for agricultural nonpoint source pollution control. *Transactions of ASAE*, 32(2) 513-519.

Dodd, W. K., J.R. Jones, and E. B. Welch. 1998. Suggested classification of stream trophic state: Distributions of temperate stream types by chlorophyll, total nitrogen, and phosphorus. Wat. Res. 32:1455-1462.

Dunne, T. and L.B. Leopold, 1978. Water in Environmental Planning. W.H. Freeman, New York, 818p.

Elvidge, C. D., C. Milesi, J. B. Dietz, B. T. Tuttle, P. C., Sutton, R. Nemani, and J. Vogelmann. 2004. U.S. constructed areas approaches the size of Ohio, Eos Trans. AGU, 85(24), 233.

Fisher, BE. S.P. Wente, T.P. Simon, and A. Spacie. 1998. The fishes of Tippecanoe County, Indiana. Proceedings of the Indiana Academy of Science, 107: 151-166.

Frankenberger, J., E. Kladivko, G. Sands, D. Jaynes, N. Fausey, M. Helers, R. Cooke, J. Strock, K. Nelson, and L. Brown. 2006. Drainage Water Management: Questions and answers about drainage water management from the Midwest. Purdue Cooperative Extension WQ-44.

Gammon, J.R. 1995. The Wabash River ecosystem II. A report for PSI-Energy, Plainfield, Indiana and Eli Lilly and Company, Indianapolis, Indiana.

Gerking, S.C. 1945. Distribution of the fishes of Indiana. Investigations of Indiana Lakes and Streams, Volume III: 1-137.

Hayes, J.C., B.J. Barfield, and R.I. Barnhisel. 1984. Performance of grass filters under laboratory and field conditions. Trans. ASAE. 27:1321-1331.

Holdren, C., W. Jones, and J. Taggart. 2001. Managing Lakes and Reservoirs. EPA 841B-01-006. Prepared by North American Lakes Management Society and Terrene Institute for the U.S. Environmental Protection Agency, Washington, D.C.

Homoya, M.A., B.D. Abrell, J.R. Alrich, and T.W. Post. 1985. The natural regions of Indiana. Indiana Academy of Science, 91.

Indiana Department of Environmental Management. 2012. Indiana integrated water monitoring and assessment report 2012. Section 305(b) water quality report and consolidated list including Section 303(d) list of impaired waterbodies. IDEM, Office of Water Quality, Watershed Branch, Indianapolis, Indiana.

IDEM. 2007. [web site] Wetlands. http://www.in.gov/idem/4138.htm [Accessed 22 August 2009]

Indiana Department of Natural Resources. 2014. [web site] Water Trail Guide: Wabash River. http://www.in.gov/dnr/outdoor/4476.htm [Accessed Jan. 2014]

Indiana State Department of Agriculture. 2013. [web page] Tillage transect data. http://www.in.gov/isda/2383.htm [Accessed 4 February 2014]

Indiana State Department of Health. 2013. 2013 Indiana fish consumption advisory. [web page] http://www.in.gov/isdh/23650.htm [Accessed 29 January 2014]

J.F. New & Associates, Inc. 2002. Upper Mud Pine Creek Watershed Diagnostic Study, Benton County, Indiana. Prepared for Benton County Soil and Water Conservation District.

Jackson, M.T. 1997. The natural heritage of Indiana. Indiana University Press, Bloomington, Indiana.

Krenz, J.L. and B.D. Lee. 2004. Mineralogy and hydraulic conductivity of selected moraines and associated till plains in northeast Indiana.

Ladd, B. 2004. Big Pine Watershed Past & Present. Presented to Warren County Natural Resources Community Forum, Sept. 21, 2004. Purdue University.

Lee, B., D. Jones, and H. Peterson. 2005 Septic system failure. Home and Environment 1: 1-3.

Lee, K., T. Isenhart and R. C. Schultz. 2003. Sediment and nutrient removal in an established multi-species riparian buffer. J. of Soil Cons. 58:1-8.

Lee, K., T. Isenhart, R. C. Schultz and S. K. Mikelson. 2000. Multispecies riparian buffers trap sediments and nutrients during rainfall simulations. J. of Environ. Qual. 29:1200-1205.

McBeth, W.A. 1899. Physical geography of the region of the great bend of the Wabash: Proc. Indiana Acad. Sci., pp. 157-161.

McBeth, W.A. 1901. The development of the Wabash drainage system and the recession of the ice sheet in Indiana. Proceedings of the Indiana Academy of Science: 1900, pages 184-192.

McCord, S.S. 1970. Travel accounts of Indiana 1679-1961. Indiana Historical Collections, Vol XLVII, Indiana Historic Bureau, Indianapolis, Indiana.

Mickelson, S.K. and J.L. Baker. 1993. Buffer strips for controlling herbicide runoff losses. Paper no. 932084. Am. Soc. Agric. Eng., St. Joseph, Michigan.

National Agricultural Statistics Service. 2007. [web page] 2007 Census publications State and County profiles. http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/Indiana/index.asp [Accessed 15 July 2014]

National Agricultural Statistics Service. 2006. [web page] Agricultural chemical use database. http://www.pestmanagement.info/nass/ [Accessed 15 July 2014]

Natural Resources Commission. 2007. Outstanding Rivers List for Indiana. Information Bulletin #4 (Second Amendment). Indiana Register, posted 30 May 2007 by Legislative Services Agency, Indianapolis, Indiana.

Natural Resources Conservation Service. 2014. Indiana Field Office Technical Guide. Indianapolis, IN.

Olem, H. and G. Flock, eds. 1990. Lake and reservoir restoration guidance manual. 2nd edition. EPA 440/4-90-006. Prepared by North American Lake Management Society for U.S. Environmental Protection Agency, Washington, DC.

Omernik, J.M. and A.L. Gallant. 1988. Ecoregions of the Upper Midwest. U.S. Environmental Protection Agency, Corvallis, Oregon. EPA/600/3-88/037.

Pejza, J.M. 2013. Mud Pine Creek; Benton and Warren Counties; 2012 Stream Report. IDNR Division of Fish and Wildlife, Fisheries Section.

Petty, R.O. and M.T. Jackson. 1966. Plant communities. In: Lindsey, A.A. (ed) Natural features of Indiana. Indiana Academy of Science, Indiana State Library, Indianapolis, Indiana. page 264-296.

Plowman, B.W. 2006. 2005 Statewide archers index of furbearer populations. Indiana Department of Natural Resources, Wildlife Management and Research Note Number 915, Indianapolis, Indiana. http://www.in.gov/dnr/fishwild/files/MR_915_Archers_Index_2005.pdf

Robertson, R. 1994. A Survey of Big Pine Creek. IDNR Division of Fish and Wildlife, Fisheries Section.

Robertson, R. 1973. Big Pine Creek Stream Survey Report, Warren and Benton Counties. IDNR Division of Fish and Wildlife.

Rosenshein, J.S. 1958. Groundwater resource of Tippecanoe County, Indiana. Bulletin number 8 of the Division of Water Resources, U.S. Geological Survey, Washington, D.C.

Schmitt, T.J., M.G. Dosskay, and K.D. Hoagland. 1999. Filter strip performance and processes for different vegetation, widths, and contaminants. Journal of Environmental Quality. 28(5): 1479-1489.

Simon, T.P. 1991. Development of Index of Biotic Integrity Expectations for the Ecoregions of Indiana - Central Corn Belt Plains. U.S. Environmental Protection Agency Chicago, IL. EPA 905/R-96/003.

Simon, T.P. 2006. Development, calibration, and validation of an index of biotic integrity for the Wabash River. Proceedings of the Indiana Academy of Science 115: 2.

Simpkins, W.W., T.R. Wineland, T.M. Isenhart, and R.C. Schultz. 2003. Hydrogeologic setting controls of nitrate-nitrogen removal in groundwater beneath multi-species riparian buffers. In: Proceedings: American Water Resources Association Spring Specialty Conference 2003, Agricultural Hydrology and Water Quality, May 2003, Kansas City, Missouri.

Sobat, Stacey L. July 22, 2013. [Personal Communication]. Located at: Indiana Department of Environmental Management (IDEM), Assessment Information Management System (AIMS) Database, Indianapolis, Indiana.

Tank, J. unpublished data. The Two-Stage Ditch and Sediment Dynamics. University of Notre Dame.

TetraTech, Inc. 2006. Wabash River nutrient and pathogen TMDL development. Illinois EPA and Indiana Department of Environmental Management, Indianapolis, Indiana.

Tippecanoe SWCD. 2010. Long-range plan 2011-2014. Lafayette, Indiana.

United States Department of Agriculture. 2014. Official soil series descriptions. http://soils.usda.gov/technical/classification/osd/index.html [Accessed 1 May 2014]

United States Environmental Protection Agency. 2000b. Ambient Water Quality Criteria Recommendations Information Supporting the Development of State and Tribal Nutrient

Criteria: Rivers and Streams in Nutrient Ecoregion VI. United States Environmental Protection Agency, Office of Water, Washington, D.C. EPA 822-B-00-018.

United States Environmental Protection Agency. 2008. Report on the Environment: Nitrogen and Phosphorus in Streams in Agricultural Watersheds. EPA/600/R-07/045F.

United States Environmental Protection Agency. 2009. [web page] EnviroFacts Warehouse. http://oaspub.epa.gov/enviro/ef_home2.water [Accessed 29 January 2014]

United States Geological Survey. 2003. 03335690 gage data on Mud Pine Creek near Oxford, Indiana.

United States Geological Survey. 1987. 03335700 gage data on Big Pine Creek near Williamsport, Indiana.

Visher, S.S. 1944. Indiana floods. Proceedings of the Indiana Academy of Science, 54: 134-141.

Wabash River Enhancement Corporation. 2011. Region of the Great Bend of the Wabash River Watershed Management Plan. Lafayette, Indiana.

Wabash River Heritage Corridor Commission. 2004. Wabash River Heritage Corridor Master Plan, Lafayette, Indiana.

Waters, T.F. 1995. Sediment in Streams: Sources, Biological Effects, and Control. American Fisheries Society Monograph 7. Bethesda, Maryland, 251pp.

Whitesell, Leanne. July 22, 2013. [Personal Communication]. Located at: Indiana Department of Environmental Management (IDEM), Assessment Information Management System (AIMS) Database, Indianapolis, Indiana.

Wikipedia. 2014. https://en.wikipedia.org/wiki/ [Accessed 1 February 2014]

Wisconsin Groundwater Coordinating Council (GCC). 2014. [web page] Report to the Legislature. http://dnr.wi.gov/topic/groundwater/gcc/ [Accessed 19 February 2015]

TABLE OF APPENDICES

Appendix A:

Geographic Information Systems (GIS) Metadata

The following geographic information systems (GIS) data sources were used to create one or more of the maps in the Watershed Management Plan:

IDEM, 2013. BROWNFIELDS_IDEM_IN: Defined as a parcel of real estate that is abandoned or inactive, or may not be operated at its appropriate use, and on which expansion, redevelopment, or reuse is complicated because of the presence or potential presence of a hazardous substance, a contaminant, petroleum, or a petroleum product that poses a risk to human health and the environment. IDEM, Office of Land Quality, Brownfields Section. (unknown scale) Point shapefile.

IDEM, 2013. CONFINED_FEEDING_OPERATIONS_IDEM_IN: Confined Feeding Operation Facilities in Indiana, IDEM, Office of Land Quality, Compliance and Response Branch, Solid Waste Compliance Section. (no scale) Point Shapefile.

IDNR, 2013. FLOODPLAINS_FIRM_IDNR_IN: Floodplains and Flood Hazard Zones in Indiana, 20130326. Indiana Department of Natural Resources, 1:12,000, Polygon Shapefile.

IDEM, 2013. UST_IDEM_IN: Underground Storage Tanks in Indiana, IDEM, Office of Land Quality, Remediation Service Branch, Underground Storage Tank Section. (no scale) Point Shapefile.

IDEM, 2013. WASTE_INDUSTRIAL_IDEM_IN: Industrial Waste Sites in Indiana, IDEM, Office of Land Quality, Compliance and Response Branch, Industrial Waste Section. (no scale) Point Shapefile.

IDEM, 2012. IMPAIRED_STREAMS_IDEM_IN: Impaired Streams in Indiana on the 303(d) List of 2012. Indiana Department of Environmental Management, Office of Water Quality. Line Shapefile.

IDEM, 2010. OPEN_DUMPS_IDEM_IN: IDEM, Office of Land Quality, Solid Waste Compliance Section, Compliance and Response Branch. (unknown scale) Point shapefile.

IDEM, 2009. RECREATIONAL_FACILITIES_IDNR_IN: Outdoor recreational facilities in Indiana. IDNR, Department of Outdoor Recreation (1:24,000) Point shapefile.

IDEM, 2002. NPDES_FACILITY_IDEM_IN: Facilities in the National Pollutant Discharge Elimination System with assigned UTM Coordinates in Indiana. IDEM, Office of Water Quality, Data Management Section. (no scale) Point Shapefile.

IDNR, 2013. IN_ETR_SPECIES: IDNR, Division of Nature Preserves, Indiana Natural Heritage Database. (unknown scale) Polygon shapefile.

IDNR, 2009. RECREATIONAL_FACILITIES_IDNR_IN: Outdoor recreation facilities, including facilities managed by federal, state, and local governments, as well as non-government organizations, private and commercial entities, and schools. It does not include sites that are private and not open to the public. (1:24,000) Point shapefile.

IGS, 2004. CENSUS_MCD_POPCHANGE_IN: Population Densities and Changes of Densities of Minor Civil Divisions in Indiana from 1890 to 2000. Derived from United States Census Bureau. (1:500,000) Polygon Shapefile, digital representation by Denver Harper, 2004.

IGS, 2003. ECOREGIONS_USGS_IN: Ecoregions, Levels III and IV, Indiana. Derived from U.S. Geological Survey. (1:250,000) Polygon Shapefile.

INDOT, 2004. HIGHWAYS_INDOTMODEL_IN: Highways in Indiana, INDOT, Graphics and Engineering. (1:24,000) Line Shapefile.

INDOT, 2001. INCORPORATED_AREAS_INDOT_IN: Incorporated Boundaries in Indiana, INDOT, Graphics and Engineering. (no scale) Polygon Shapefile.

NRC, 1997. RIVERS_OUTSTANDING_NRC_IN: Outstanding Rivers in Indiana, as listed by the Natural Resource Commission which identifies rivers and streams which have particular environmental or aesthetic interest. (1:100,000) Linear shapefile.

NRCS, 2009. WBDHU_12_L_IN: 12-digit and 10-digit hydrologic accounting units. (1:24,000) Polygon shapefile.

USCB, 2000. URBAN_AREAS_TIGER00_IN: major urban areas identified by the U.S. Bureau of the Census. Derived from U.S. Department of Commerce, U.S. Census Bureau, Census 2000 Tiger Line Files. (1:100,000) Polygon Shapefile.

USCB, 2005. ROADS_2005_INDOT_IN: Indiana Roads from INDOT and TIGER Files, 2005. (1:100,000) Line Shapefile.

USDA, 2013. CROPS_2013_USDA_IN: Crops in Indiana for 2013, Derived from National Agricultural Statistics Service, U.S. Department of Agriculture, 1:100,000, 30-Meter TIFF Image.

USDA, 2012a. SOILMU_A_IN007: Soil Survey Geographic (SSURGO) database for Benton County, Indiana. (1:24,000) Polygon shapefile.

USDA, 2012b. SOILMU_A_IN157: Soil Survey Geographic (SSURGO) database for Tippecanoe County, Indiana. (1:24,000) Polygon shapefile.

USDA, 2012c. SOILMU_A_IN171: Soil Survey Geographic (SSURGO) database for Warren County, Indiana. (1:24,000) Polygon shapefile.

USDA, 2012d. SOILMU_A_IN181: Soil Survey Geographic (SSURGO) database for White County, Indiana. (1:24,000) Polygon shapefile.

USDA, 2004. CULTIVATED_AREAS_USDA_IN: Cultivated Areas in Indiana in 2004. U.S. Department of Agriculture, 1:100,000, Polygon Shapefile.

USDA, 1994. SOILS_STATSGO_IN: Soil Associations in Indiana. U. S. Department of Agriculture, Natural Resources Conservation Service. (1:250,000) Polygon Shapefile.

USEPA, 2009. Facilities Regulated by EPA (NPDES data from Envirofacts). Point Shapefile.

USFWS, 2011. IN_NWI_CURRENT_DRAFT_07062011: Updated National Wetland Inventory dataset which was originally developed in 1979. Latest version updates 1979 dataset through the use of aerial photographs. (1:24,000) Polygon shapefile.

USGS, 2008a. HYDROGRAPHY_HIGHRES_FLOWLINE_NHD_USGS: Streams, Rivers, Canals, Ditches, Artificial Paths, Coastlines, Connectors, and Pipelines. Derived from National Hydrography Dataset which was originally developed at 1:100,000 scale to be developed at 1:24,000-1:12,000 scale. (1:24,000) Linear shapefile.

USGS, 2008b. HYDROGRAPHY_HIGHRES_WATERBODYLINEAR_NHD_USGS: Rivers, Inundation Areas, Canals, Submerged Streams, and Other Linear Waterbodies. Derived from National Hydrography Dataset which was originally developed at 1:100,000 scale to be developed at 1:24,000-1:12,000 scale. (1:24,000) Linear shapefile.

USGS, 2006a. IMPERVIOUS_SURFACE_2006_USGS_IN: Estimated Percentage of Impervious Surface in Indiana in 2006, Derived from the 2006 National Land Cover Database (United States Geological Survey, 30-Meter TIFF Image).

USGS, 2006b. LAND_COVER_CHANGE_2001_2006_USGS_IN: Land Cover Change in Indiana, Derived from the 2001 and 2006 National Land Cover Database (United States Geological Survey, 30-Meter TIFF Image).

USGS, 2001. LC2001USGS_IN: 2001 Land Cover in Indiana, Derived from the National Land Cover Database (NLCD 2001, United States Geological Survey, 30-Meter Grid), digital representation by Chris Dintaman, 2007.

USGS, 1998. LANDSURVEY_COUNTY_POLY_IN: County boundaries in polygon format. Derived from the U.S. Geological Survey's 1:24,000 digital raster graphic (DRG) series. (no scale) Polygon shapefile.

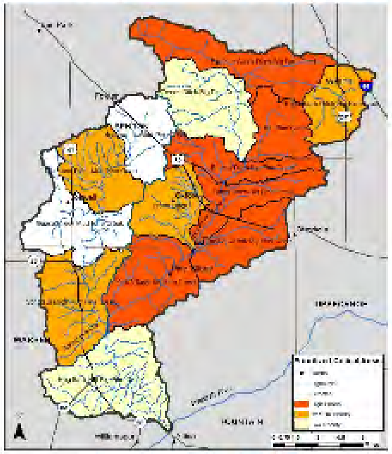
USGS, 1996. PLACES_POINTS_USGS_IN: Shows the locations of populated places, extracted from the Geographic Names Information System (GNIS) developed by the U.S. Geological Survey. Elevations (feet above sea level) are also provided. (1:24,000) Point shapefile.

USGS, 1991. WATERSHEDS_HUC08_CATALOG_UNITS_USGS_IN: 8-digit hydrologic accounting units. Derived from the 14-digit hydrologic units in Indiana created by U.S. Geological Survey and National Resources Conservation Service. (1:24,000) Polygon shapefile.

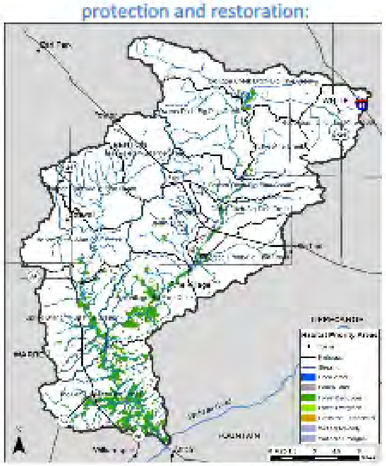
Appendix B:

Big Pine Watershed Brochure

Critical areas where BMPs will be focused to reduce nutrient, sediment and *E. coli* pollution:



Priority areas for habitat protection and restoration:



The Nature Conservancy
nature.org

CTIC

INDIANA STATE DEPARTMENT OF AGRICULTURE

NRCS Natural Resources Conservation Service

NICHES Land Trust

www.iaswcd.org
Indiana Association of Soil and Water Conservation Districts

National Association of Conservation Districts
conserving natural resources *for our future*

WABASH RIVER ENHANCEMENT CORPORATION

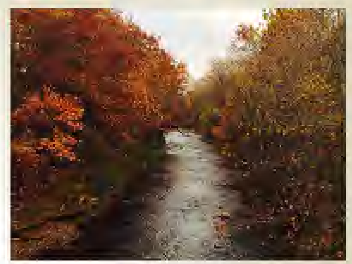
USDA United States Department of Agriculture

USDA is an equal opportunity provider and employer.

Big Pine & Mud Pine Creek Watershed

The Mission:

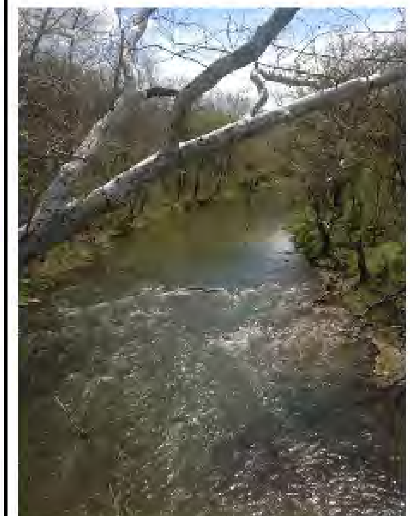
Voluntarily conserve and improve the natural environment while balancing interests of stakeholders in the Big Pine Creek watershed.



The Vision:

Big Pine Creek Watershed is an anchor and an asset to the community.

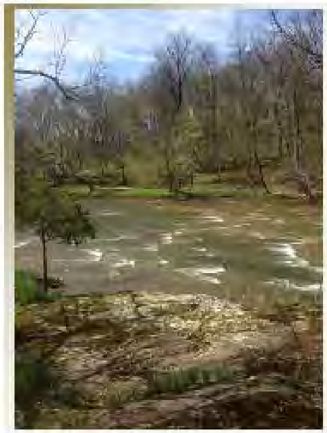
Outstanding Rivers
Three streams in the Big Pine Creek watershed are designated by DNR as outstanding rivers: portions of the main stem of Big Pine and Mud Pine Creeks, as well as a portion of Fall Creek, a small tributary to Big Pine. Known for their scenic beauty, these streams are popular recreation and kayaking spots.



Get Involved!

Meetings are typically held on the last Wednesday of each month from 4:00 to 6:00 PM. The public is welcome and encouraged to attend. To learn more or find out meeting dates and locations please call your local Soil and Water Conservation District:

Benton County: 765-884-1090 x107 (Jon Charlesworth)
Warren County: 765-762-2443 x3 (Deb Lane)
White County: 574-583-5962 x3 (Sharon Watson)



Big Pine Creek in Warren County

Historical accounts tell us that the Big Pine was a full and slow moving stream, with clear water, surrounded by wetlands and tall grass prairie that allowed little storm water runoff. Although some of this is still found today, many stresses on the environment have now placed the watershed in a battle. This battle ensues as we seek to balance the demand on agriculture lands to provide the food we need, healthy water to drink and recreate in, and habitat for wildlife. The Big Pine Watershed Group, made up of many partners and individuals, wants to work with you to make the watershed a better place to live, farm, and raise a family.

Goals of the project:

- Reduce Nutrient Loading
- Reduce Sediment Loading
- Reduce *E. coli* Loading
- Protect & Improve Habitat
- Increase Public Awareness & Participation

Cost-share Available for Best Management Practices (BMPs):

Conservation buffers, conservation tillage/ no-till, cover crops, nutrient and pest management, bioreactors, drainage water management, two-stage ditch, septic upgrades, streambank stabilization, livestock management, grassed waterways, saturated buffers, forest/wetland/prairie restoration, and many others

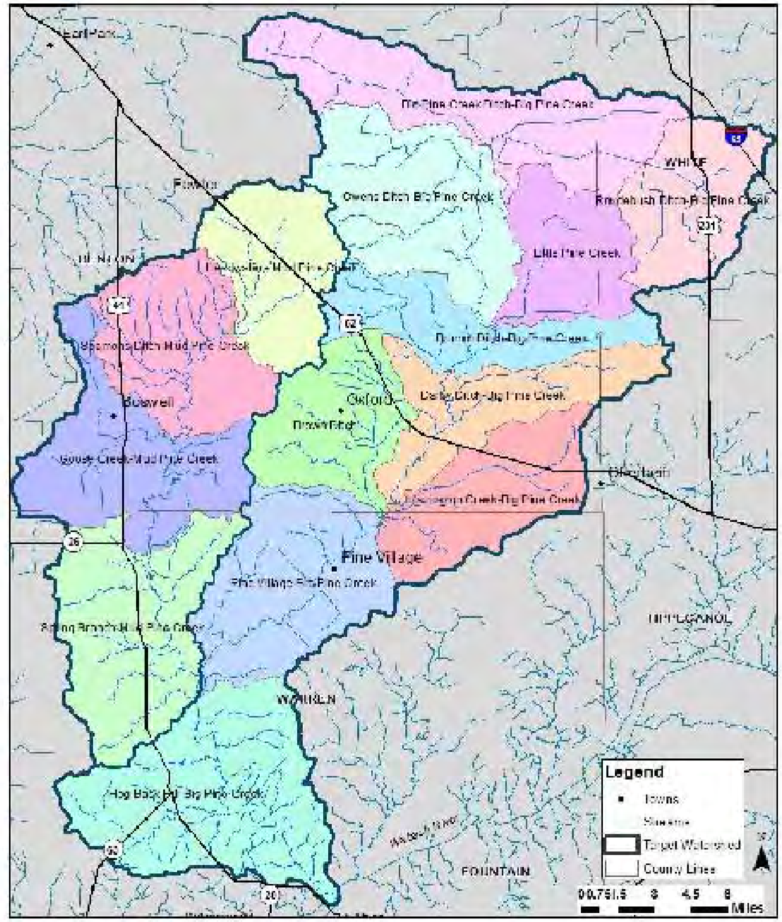
What Is A Watershed?

A watershed describes an area of land that contains all the streams and rivers that drain into a single larger body of water, such as a river, lake or ocean. A watershed can cover a small or large land area. Small watersheds are usually part of larger watersheds.

Not only does water run into the streams from the surface, but water also filters through the soil, and some of this water eventually drains into the same streams.

The Big Pine and Mud Pine watersheds cover 209,709 acres in Benton, Warren and White counties.

Subwatersheds in the Big Pine and Mud Pine Watershed.



Appendix C:

Endangered, Threatened, and Rare Species List

Special species and high quality natural areas observed in the Big Pine Creek watershed.

Common Name	Scientific Name	State Rank	Last Observed
Bird			
Barn Owl	*Tyto alba*	SE	1958-06-30
Henslow's Sparrow	*Ammodramus henslowii*	SE	2002-05
Least Bittern	*Ixobrychus exilis*	SE	2001-07-25
Red-shouldered Hawk	*Buteo lineatus*	SSC	2001-05-12
Sedge Wren	*Cistothorus platensis*	SE	2001-07-25
Short-eared Owl	*Asio flammeus*	SE	1988-05-03
Upland Sandpiper	*Bartramia longicauda*	SE	1997-06-10
Western Meadowlark	*Sturnella neglecta*	SSC	1997-06-10
Crustacean			
Prairie Crayfish	*Procambarus gracilis*	ST	2004-08-05
Fish			
Channel Darter	*Percina copelandi*	SE	1945
Variegate Darter	*Etheostoma variatum*	SE	1962-07-16
Insect			
An Olethreutine Moth	*Hystrichophora loricana*	SE	2009-08-01
Mammal			
American Badger	*Taxidea taxus*	SSC	1990-08-15
Eastern Red Bat	*Lasiurus borealis*	SSC	2003-07-24
Franklin's Ground Squirrel	*Spermophilus franklinii*	SE	2001
Hoary Bat	*Lasiurus cinereus*	SSC	2003-07-23
Indiana Bat	*Myotis sodalis*	SE	2005-07-01
Least Weasel	*Mustela nivalis*	SSC	1988-05-07
Northern Myotis	*Myotis septentrionalis*	SSC	2005-06-22
Plains Pocket Gopher	*Geomys bursarius*	SSC	1988-10-10
Mollusk			
Clubshell	*Pleurobema clava*	SE	2005-08-23
Kidneyshell	*Ptychobranchus fasciolaris*	SSC	2005-08-24
Little Spectaclecase	*Villosa lienosa*	SSC	2004-04-12
Purple Lilliput	*Toxolasma lividus*	SSC	2005-08-24
Round Hickorynut	*Obovaria subrotunda*	SSC	2006-07-10
Salamander Mussel	*Simpsonaias ambigua*	SSC	2005-08-24
Wavyrayed Lampmussel	*Lampsilis fasciola*	SSC	2006-07-18
Reptile			
Smooth Green Snake	*Liochlorophis vernalis*	SE	1988-07-07
Vascular Plant			
Aromatic Aster	*Aster oblongifolius*	SR	2007-10-10

Cattail Gay-feather	*Liatris pycnostachya*	ST	1981-09
Downy Gentian	*Gentiana puberulenta*	ST	NO DATE
Earleaf Foxglove	*Agalinis auriculata*	ST	1930-09-12
Eastern Featherbells	*Stenanthium gramineum*	ST	1911-08-16
Eastern White Pine	*Pinus strobus*	SR	1988-10-09
Ebony Sedge	*Carex eburnea*	SR	1983-05-12
Forbes Saxifrage	*Saxifraga forbesii*	SE	1983-05
Forked Aster	*Aster furcatus*	SR	2010-08-31
Heavy Sedge	*Carex gravida*	SE	NO DATE
Ledge Spike-moss	*Selaginella rupestris*	ST	1998-10-01
Leiberg's Witchgrass	*Panicum leibergii*	ST	2004-06-15
Pitcher's Stitchwort	*Arenaria patula*	SE	1919-05-10
Rough Rattlesnake-root	*Prenanthes aspera*	SR	1928-09-20
Scarlet Hawthorn	*Crataegus pedicellata*	ST	1919-08-22
Shaggy False-gromwell	*Onosmodium hispidissimum*	SE	2010-07-12
Western Silvery Aster	*Aster sericeus*	SR	1998-10-01
Wild Hyacinth	*Camassia angusta*	SE	1992-06-09
Wolf Bluegrass	*Poa wolfii*	SR	1985-05-13
Geologic Feature			
Water Fall and Cascade	Geomorphic - Nonglacial Erosional Feature	--	2009-02-17
Other			
Migratory Bird Concentration Site	Migratory Bird Concentration Area	SG	1998-05-17
High Quality Natural Community			
Dry-mesic Prairie	Prairie - dry-mesic	SG	1981
Mesic Prairie	Prairie - mesic	SG	1988-05-12
Sandstone Cliff	Primary - cliff sandstone	SG	2002

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Indiana County Endangered, Threatened and Rare Species List

County: Benton

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Toxolasma lividus	Purple Lilliput		SSC	G3	S2
Venustaconcha ellipsiformis	Ellipse		SSC	G4	S2
Villosa lienosa	Little Spectaclecase		SSC	G5	S3
Insect: Lepidoptera (Butterflies & Moths)					
Macrochilo hypocritalis	A Noctuid Moth		SR	G4	S2
Papaipema beeriana	Beer's Blazing Star Borer Moth		ST	G2G3	S1S3
Fish					
Etheostoma variatum	Variegate Darter		SE	G5	S1
Reptile					
Emydoidea blandingii	Blanding's Turtle		SE	G4	S2
Liochlorophis vernalis	Smooth Green Snake		SE	G5	S2
Bird					
Asio flammeus	Short-eared Owl		SE	G5	S2
Bartramia longicauda	Upland Sandpiper		SE	G5	S3B
Circus cyaneus	Northern Harrier		SE	G5	S2
Cistothorus platensis	Sedge Wren		SE	G5	S3B
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Rallus elegans	King Rail		SE	G4	S1B
Sturnella neglecta	Western Meadowlark		SSC	G5	S2B
Tyto alba	Barn Owl		SE	G5	S2
Mammal					
Geomys bursarius	Plains Pocket Gopher		SSC	G5	S2
Lasiurus borealis	Eastern Red Bat		SSC	G5	S4
Lasiurus cinereus	Hoary Bat	No Status	SSC	G5	S4
Mustela nivalis	Least Weasel		SSC	G5	S2?
Myotis septentrionalis	Northern Myotis		SSC	G4	S3
Nycticeius humeralis	Evening Bat		SE	G5	S1
Reithrodontomys megalotis	Western Harvest Mouse			G5	S2
Spermophilus franklinii	Franklin's Ground Squirrel		SE	G5	S2
Taxidea taxus	American Badger		SSC	G5	S2
Vascular Plant					
Agalinis auriculata	Earleaf Foxglove		ST	G3	S1
Aster sericeus	Western Silvery Aster		SR	G5	S2
Camassia angusta	Wild Hyacinth		SE	G5?Q	S1
Carex gravida	Heavy Sedge		SE	G5	S1
Cirsium hillii	Hill's Thistle		SE	G3	S1
Gentiana puberulenta	Downy Gentian		ST	G4G5	S2
Liatris pycnostachya	Cattail Gay-feather		ST	G5	S2

Indiana Natural Heritage Data Center
Division of Nature Preserves
Indiana Department of Natural Resources
This data is not the result of comprehensive county surveys.

Fed: LE = Endangered; LT = Threatened; C = candidate; PDL = proposed for delisting
State: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SX = state extirpated; SG = state significant; WL = watch list
GRANK: Global Heritage Rank: G1 = critically imperiled globally; G2 = imperiled globally; G3 = rare or uncommon globally; G4 = widespread and abundant globally but with long term concerns; G5 = widespread and abundant globally; G? = unranked; GX = extinct; Q = uncertain rank; T = taxonomic subunit rank
SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

Indiana County Endangered, Threatened and Rare Species List

County: Benton

Species Name	Common Name	FED	STATE	GRANK	SRANK
Panicum leibergii	Leiberg's Witchgrass		ST	G5	S2
Prenanthes aspera	Rough Rattlesnake-root		SR	G4?	S2
Viola pedatifida	Prairie Violet		ST	G5	S2
High Quality Natural Community					
Prairie - mesic	Mesic Prairie		SG	G2	S2
Other					
Migratory Bird Concentration Area	Migratory Bird Concentration Site		SG	G3	SNR

Indiana Natural Heritage Data Center
Division of Nature Preserves
Indiana Department of Natural Resources
This data is not the result of comprehensive county surveys.

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SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

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Indiana County Endangered, Threatened and Rare Species List

County: Tippecanoe

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Cyprogenia stegaria	Eastern Fanshell Pearlymussel	LE	SE	G1Q	S1
Epioblasma torulosa rangiana	Northern Riffleshell	LE	SE	G2T2	SX
Epioblasma torulosa torulosa	Tubercled Blossom	LE	SE	G2TX	SX
Epioblasma triquetra	Snuffbox	LE	SE	G3	S1
Fusconaia subrotunda	Longsolid		SE	G3	SX
Lampsilis fasciola	Wavyrayed Lampmussel		SSC	G5	S3
Lampsilis ovata	Pocketbook			G5	S2
Leptodea leptodon	Scaleshell	LE	SX	G1G2	SX
Ligumia recta	Black Sandshell			G5	S2
Obovaria retusa	Ring Pink	LE	SX	G1	SX
Obovaria subrotunda	Round Hickorynut		SSC	G4	S1
Plethobasus cicatricosus	White Wartyback	LE	SE	G1	SX
Plethobasus cyphyus	Sheepnose	LE	SE	G3	S1
Pleurobema clava	Clubshell	LE	SE	G2	S1
Pleurobema cordatum	Ohio Pigtoe		SSC	G4	S2
Pleurobema plenum	Rough Pigtoe	LE	SE	G1	S1
Pleurobema rubrum	Pyramid Pigtoe		SE	G2G3	SX
Potamilus capax	Fat Pocketbook	LE	SE	G1G2	S1
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Quadrula cylindrica cylindrica	Rabbitsfoot	C	SE	G3G4T3	S1
Simpsonaias ambigua	Salamander Mussel		SSC	G3	S2
Toxolasma lividus	Purple Lilliput		SSC	G3	S2
Villosa fabalis	Rayed Bean	LE	SSC	G2	S1
Insect: Coleoptera (Beetles)					
Lissobiops serpentinus	A Rove Beetle		SE	GNR	S1
Insect: Ephemeroptera (Mayflies)					
Paracloeodes minutus	A Small Minnow Mayfly		SR	G5	S2
Insect: Lepidoptera (Butterflies & Moths)					
Speyeria idalia	Regal Fritillary		SE	G3	S1
Insect: Mecoptera					
Merope tuber	Earwig Scorpionfly		SE	G3G5	S1
Insect: Odonata (Dragonflies & Damselflies)					
Erpetogomphus designatus	Eastern Ringtail		ST	G5	S2
Somatochlora tenebrosa	Clamp-tipped Emerald		SR	G5	S2S3
Fish					
Etheostoma tippecanoe	Tippecanoe Darter		SSC	G3G4	S3
Amphibian					
Hemidactylium scutatum	Four-toed Salamander		SSC	G5	S2

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Indiana County Endangered, Threatened and Rare Species List

County: Tippecanoe

Species Name	Common Name	FED	STATE	GRANK	SRANK
Reptile					
Clemmys guttata	Spotted Turtle		SE	G5	S2
Emydoidea blandingii	Blanding's Turtle		SE	G4	S2
Liochlorophis vernalis	Smooth Green Snake		SE	G5	S2
Terrapene carolina carolina	Eastern Box Turtle		SSC	G5T5	S3
Terrapene ornata ornata	Ornate Box Turtle		SE	G5T5	S1
Bird					
Aimophila aestivalis	Bachman's Sparrow			G3	SXB
Ammodramus henslowii	Henslow's Sparrow		SE	G4	S3B
Ardea herodias	Great Blue Heron			G5	S4B
Asio flammeus	Short-eared Owl		SE	G5	S2
Asio otus	Long-eared Owl			G5	S2
Aythya collaris	Ring-necked Duck			G5	SHB
Bartramia longicauda	Upland Sandpiper		SE	G5	S3B
Botaurus lentiginosus	American Bittern		SE	G4	S2B
Buteo platypterus	Broad-winged Hawk	No Status	SSC	G5	S3B
Carduelis pinus	Pine Siskin			G5	S3N
Cistothorus platensis	Sedge Wren		SE	G5	S3B
Dendroica cerulea	Cerulean Warbler		SE	G4	S3B
Falco peregrinus	Peregrine Falcon	No Status	SE	G4	S2B
Grus canadensis	Sandhill Crane	No Status	SSC	G5	S2B,S1N
Haliaeetus leucocephalus	Bald Eagle	LT,PDL	SSC	G5	S2
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Lanius ludovicianus	Loggerhead Shrike	No Status	SE	G4	S3B
Nycticorax nycticorax	Black-crowned Night-heron		SE	G5	S1B
Rallus elegans	King Rail		SE	G4	S1B
Sturnella neglecta	Western Meadowlark		SSC	G5	S2B
Tyto alba	Barn Owl		SE	G5	S2
Mammal					
Corynorhinus rafinesquii	Rafinesque's Big-eared Bat		SSC	G3G4	SH
Geomys bursarius	Plains Pocket Gopher		SSC	G5	S2
Lasiurus borealis	Eastern Red Bat		SSC	G5	S4
Mustela nivalis	Least Weasel		SSC	G5	S2?
Myotis septentrionalis	Northern Myotis		SSC	G4	S3
Myotis sodalis	Indiana Bat or Social Myotis	LE	SE	G2	S1
Nycticeius humeralis	Evening Bat		SE	G5	S1
Reithrodontomys megalotis	Western Harvest Mouse			G5	S2
Spermophilus franklinii	Franklin's Ground Squirrel		SE	G5	S2
Taxidea taxus	American Badger		SSC	G5	S2
Vascular Plant					

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Indiana County Endangered, Threatened and Rare Species List

County: Tippecanoe

Species Name	Common Name	FED	STATE	GRANK	SRANK
Androsace occidentalis	Western Rockjasmine		ST	G5	S2
Arenaria patula	Pitcher's Stitchwort		SE	G4	S1
Aster oblongifolius	Aromatic Aster		SR	G5	S2
Astragalus tennesseensis	Tennessee Milk-vetch		SRE	G3	SX
Bacopa rotundifolia	Roundleaf Water-hyssop		ST	G5	S1
Besseya bullii	Kitten Tails		SE	G3	S1
Botrychium matricariifolium	Chamomile Grape-fern		SR	G5	S2
Botrychium simplex	Least Grape-fern		SE	G5	S1
Camassia angusta	Wild Hyacinth		SE	G5?Q	S1
Carex flava	Yellow Sedge		ST	G5	S2
Carex gravida	Heavy Sedge		SE	G5	S1
Chelone obliqua var. speciosa	Rose Turtlehead		WL	G4T3	S3
Chrysopsis villosa	Hairy Golden-aster		ST	G5	S2
Circaea alpina	Small Enchanter's Nightshade		SX	G5	SX
Cirsium hillii	Hill's Thistle		SE	G3	S1
Coeloglossum viride var. virescens	Long-bract Green Orchis		ST	G5T5	S2
Crataegus pedicellata	Scarlet Hawthorn		ST	G5	S2
Cypripedium candidum	Small White Lady's-slipper		WL	G4	S2
Eriophorum angustifolium	Narrow-leaved Cotton-grass		SR	G5	S2
Erysimum capitatum	Prairie-rocket Wallflower		ST	G5	S2
Euphorbia obtusata	Bluntleaf Spurge		SE	G5	S1
Gentiana alba	Yellow Gentian		SR	G4	S2
Houstonia nigricans	Narrowleaf Summer Bluets		SR	G5	S2
Linum sulcatum	Grooved Yellow Flax		SR	G5	S2
Lithospermum incisum	Narrow-leaved Puccoon		SE	G5	S1
Melampyrum lineare	American Cow-wheat		SR	G5	S2
Muhlenbergia cuspidata	Plains Muhlenbergia		SE	G4	S1
Napaea dioica	Glade Mallow		SR	G4	S2
Onosmodium hispidissimum	Shaggy False-gromwell		SE	G4	S1
Orobanche riparia	Bottomland Broomrape		SE	G5	S2
Oryzopsis racemosa	Black-fruit Mountain-ricegrass		SR	G5	S2
Panicum rigidulum var. pubescens	Long-leaved Panic-grass		SX	G5T5?	SX
Plantago cordata	Heart-leaved Plantain		SE	G4	S1
Poa paludigena	Bog Bluegrass		WL	G3	S3
Psoralea tenuiflora	Few-flowered Scurf-pea		SX	G5	SX
Sanguisorba canadensis	Canada Burnet		SE	G5	S1
Selaginella apoda	Meadow Spike-moss		WL	G5	S1
Silene regia	Royal Catchfly		ST	G3	S2
Trichostema dichotomum	Forked Bluecurl		SR	G5	S2
Viola pedatifida	Prairie Violet		ST	G5	S2

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Indiana County Endangered, Threatened and Rare Species List

County: Tippecanoe

Species Name	Common Name	FED	STATE	GRANK	SRANK
High Quality Natural Community					
Barrens - gravel	Gravel Slope Barrens		SG	G3	S1
Barrens - sand	Sand Barrens		SG	G3	S2
Forest - upland dry-mesic	Dry-mesic Upland Forest		SG	G4	S4
Forest - upland mesic	Mesic Upland Forest		SG	G3?	S3
Lake - lake	Lake		SG	GNR	S2
Prairie - dry-mesic	Dry-mesic Prairie		SG	G3	S2
Wetland - fen	Fen		SG	G3	S3
Wetland - marsh	Marsh		SG	GU	S4
Wetland - seep circumneutral	Circumneutral Seep		SG	GU	S1
Other Significant Feature					
Geomorphic - Nonglacial Erosional Feature - Water Fall and Cascade	Water Fall and Cascade			GNR	SNR

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Indiana County Endangered, Threatened and Rare Species List

County: Warren

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Cyprogenia stegaria	Eastern Fanshell Pearlymussel	LE	SE	G1Q	S1
Epioblasma flexuosa	Leafshell		SX	GX	SX
Epioblasma obliquata perobliqua	White Cat's Paw Pearlymussel	LE	SE	G1T1	SX
Epioblasma propinqua	Tennessee Riffleshell		SX	GX	SX
Epioblasma sampsonii	Wabash Riffleshell		SX	GX	SX
Epioblasma torulosa torulosa	Tubercled Blossom	LE	SE	G2TX	SX
Epioblasma triquetra	Snuffbox	LE	SE	G3	S1
Fusconaia subrotunda	Longsolid		SE	G3	SX
Lampsilis fasciola	Wavyrayed Lampmussel		SSC	G5	S3
Obovaria retusa	Ring Pink	LE	SX	G1	SX
Obovaria subrotunda	Round Hickorynut		SSC	G4	S1
Plethobasus cicatricosus	White Wartyback	LE	SE	G1	SX
Plethobasus cyphyus	Sheepnose	LE	SE	G3	S1
Pleurobema clava	Clubshell	LE	SE	G2	S1
Pleurobema cordatum	Ohio Pigtoe		SSC	G4	S2
Pleurobema plenum	Rough Pigtoe	LE	SE	G1	S1
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Quadrula cylindrica cylindrica	Rabbitsfoot	C	SE	G3G4T3	S1
Simpsonaias ambigua	Salamander Mussel		SSC	G3	S2
Toxolasma lividus	Purple Lilliput		SSC	G3	S2
Villosa lienosa	Little Spectaclecase		SSC	G5	S3
Insect: Lepidoptera (Butterflies & Moths)					
Hystrichophora loricana	An Olethreutine Moth		SE	G2G4	S1
Fish					
Percina copelandi	Channel Darter		SE	G4	S2
Bird					
Ammodramus henslowii	Henslow's Sparrow		SE	G4	S3B
Ardea herodias	Great Blue Heron			G5	S4B
Asio otus	Long-eared Owl			G5	S2
Bartramia longicauda	Upland Sandpiper		SE	G5	S3B
Buteo lineatus	Red-shouldered Hawk		SSC	G5	S3
Haliaeetus leucocephalus	Bald Eagle	LT,PDL	SSC	G5	S2
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Tyto alba	Barn Owl		SE	G5	S2
Mammal					
Geomys bursarius	Plains Pocket Gopher		SSC	G5	S2
Lasionycteris noctivagans	Silver-haired Bat		SSC	G5	SNRN
Lasiurus borealis	Eastern Red Bat		SSC	G5	S4
Myotis lucifugus	Little Brown Bat		SSC	G5	S4

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Indiana County Endangered, Threatened and Rare Species List

County: Warren

Species Name	Common Name	FED	STATE	GRANK	SRANK
Myotis septentrionalis	Northern Myotis		SSC	G4	S3
Myotis sodalis	Indiana Bat or Social Myotis	LE	SE	G2	S1
Nycticeius humeralis	Evening Bat		SE	G5	S1
Spermophilus franklinii	Franklin's Ground Squirrel		SE	G5	S2
Taxidea taxus	American Badger		SSC	G5	S2
Vascular Plant					
Arenaria patula	Pitcher's Stitchwort		SE	G4	S1
Aster furcatus	Forked Aster		SR	G3	S2
Aster oblongifolius	Aromatic Aster		SR	G5	S2
Aster sericeus	Western Silvery Aster		SR	G5	S2
Azolla caroliniana	Carolina Mosquito-fern		ST	G5	S2
Carex eburnea	Ebony Sedge		SR	G5	S2
Carex pseudocyperus	Cyperus-like Sedge		SE	G5	S1
Crataegus pedicellata	Scarlet Hawthorn		ST	G5	S2
Juglans cinerea	Butternut		WL	G4	S3
Napaea dioica	Glade Mallow		SR	G4	S2
Onosmodium hispidissimum	Shaggy False-gromwell		SE	G4	S1
Panicum leibergii	Leiberg's Witchgrass		ST	G5	S2
Pinus strobus	Eastern White Pine		SR	G5	S2
Poa wolfii	Wolf Bluegrass		SR	G4	S2
Rudbeckia fulgida var. fulgida	Orange Coneflower		WL	G5T4?	S2
Saxifraga forbesii	Forbes Saxifrage		SE	G4Q	S1
Selaginella rupestris	Ledge Spike-moss		ST	G5	S2
Silene regia	Royal Catchfly		ST	G3	S2
Stenanthium gramineum	Eastern Featherbells		ST	G4G5	S1
Wolffiella gladiata	Sword Bogmat		SE	G5	S1
High Quality Natural Community					
Barrens - bedrock siltstone	Siltstone Glade		SG	G2	S2
Forest - upland dry	Dry Upland Forest		SG	G4	S4
Lake - lake	Lake		SG	GNR	S2
Prairie - dry-mesic	Dry-mesic Prairie		SG	G3	S2
Prairie - mesic	Mesic Prairie		SG	G2	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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Indiana County Endangered, Threatened and Rare Species List

County: White

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Cyprogenia stegaria	Eastern Fanshell Pearlymussel	LE	SE	G1Q	S1
Epioblasma torulosa rangiana	Northern Riffleshell	LE	SE	G2T2	SX
Epioblasma triquetra	Snuffbox	LE	SE	G3	S1
Fusconaia subrotunda	Longsolid		SE	G3	SX
Lampsilis fasciola	Wavyrayed Lampmussel		SSC	G5	S3
Obovaria subrotunda	Round Hickorynut		SSC	G4	S1
Plethobasus cyphyus	Sheepnose	LE	SE	G3	S1
Pleurobema clava	Clubshell	LE	SE	G2	S1
Pleurobema cordatum	Ohio Pigtoe		SSC	G4	S2
Pleurobema rubrum	Pyramid Pigtoe		SE	G2G3	SX
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Quadrula cylindrica cylindrica	Rabbitsfoot	C	SE	G3G4T3	S1
Simpsonaias ambigua	Salamander Mussel		SSC	G3	S2
Toxolasma lividus	Purple Lilliput		SSC	G3	S2
Villosa fabalis	Rayed Bean	LE	SSC	G2	S1
Insect: Lepidoptera (Butterflies & Moths)					
Boloria selene nebraskensis	The Nebraska Silver Bordered Fritillary		SE	G5T3T4	S1
Euphyes bimacula	Two-spotted Skipper		ST	G4	S2
Satyrodes eurydice fumosa	Smoky-eyed Brown		ST	G5T3T4	S1S2
Insect: Odonata (Dragonflies & Damselflies)					
Enallagma divagans	Turquoise Bluet		SR	G5	S3
Fish					
Etheostoma tippecanoe	Tippecanoe Darter		SSC	G3G4	S3
Amphibian					
Rana pipiens	Northern Leopard Frog		SSC	G5	S2
Reptile					
Clemmys guttata	Spotted Turtle		SE	G5	S2
Emydoidea blandingii	Blanding's Turtle		SE	G4	S2
Kinosternon subrubrum subrubrum	Eastern Mud Turtle		SE	G5T5	S2
Ophisaurus attenuatus attenuatus	Western Slender Glass Lizard			G5T5	S2
Terrapene ornata ornata	Ornate Box Turtle		SE	G5T5	S1
Bird					
Ammodramus henslowii	Henslow's Sparrow		SE	G4	S3B
Ardea herodias	Great Blue Heron			G5	S4B
Bartramia longicauda	Upland Sandpiper		SE	G5	S3B
Chlidonias niger	Black Tern		SE	G4	S1B
Circus cyaneus	Northern Harrier		SE	G5	S2
Cistothorus palustris	Marsh Wren		SE	G5	S3B

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Indiana County Endangered, Threatened and Rare Species List

County: White

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Cistothorus platensis	Sedge Wren		SE	G5	S3B
Haliaeetus leucocephalus	Bald Eagle	LT,PDL	SSC	G5	S2
Lanius ludovicianus	Loggerhead Shrike	No Status	SE	G4	S3B
Nycticorax nycticorax	Black-crowned Night-heron		SE	G5	S1B
Mammal					
Geomys bursarius	Plains Pocket Gopher		SSC	G5	S2
Spermophilus franklinii	Franklin's Ground Squirrel		SE	G5	S2
Taxidea taxus	American Badger		SSC	G5	S2
Vascular Plant					
Aster furcatus	Forked Aster		SR	G3	S2
Berberis canadensis	American Barberry		SE	G3	S1
Besseya bullii	Kitten Tails		SE	G3	S1
Camassia angusta	Wild Hyacinth		SE	G5?Q	S1
Carex conoidea	Prairie Gray Sedge		ST	G5	S1
Carex straminea	Straw Sedge		ST	G5	S2
Cirsium hillii	Hill's Thistle		SE	G3	S1
Crataegus pedicellata	Scarlet Hawthorn		ST	G5	S2
Eleocharis wolfii	Wolf Spikerush		SR	G3G4	S2
Gentiana puberulenta	Downy Gentian		ST	G4G5	S2
Melampyrum lineare	American Cow-wheat		SR	G5	S2
Melanthium virginicum	Virginia Bunchflower		SE	G5	S1
Oenothera perennis	Small Sundrops		SR	G5	S2
Panicum leibergii	Leiberg's Witchgrass		ST	G5	S2
Platanthera leucophaea	Prairie White-fringed Orchid	LT	SE	G2G3	S1
Prenanthes aspera	Rough Rattlesnake-root		SR	G4?	S2
Scutellaria parvula var. australis	Southern Skullcap		WL	G4T4?	S2
Viola pedatifida	Prairie Violet		ST	G5	S2
High Quality Natural Community					
Prairie - dry-mesic	Dry-mesic Prairie		SG	G3	S2
Prairie - mesic	Mesic Prairie		SG	G2	S2
Prairie - sand mesic	Mesic Sand Prairie		SG	GNR	SNR
Prairie - sand wet	Wet Sand Prairie		SG	G3	S3
Prairie - sand wet-mesic	Wet-mesic Sand Prairie		SG	G1?	S2
Savanna - sand dry	Dry Sand Savanna		SG	G2?	S2

Indiana Natural Heritage Data Center
Division of Nature Preserves
Indiana Department of Natural Resources
This data is not the result of comprehensive county surveys.

Fed: LE = Endangered; LT = Threatened; C = candidate; PDL = proposed for delisting
State: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SX = state extirpated; SG = state significant; WL = watch list
GRANK: Global Heritage Rank: G1 = critically imperiled globally; G2 = imperiled globally; G3 = rare or uncommon globally; G4 = widespread and abundant globally but with long term concerns; G5 = widespread and abundant globally; G? = unranked; GX = extinct; Q = uncertain rank; T = taxonomic subunit rank
SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

Appendix D:

Land Cover Definitions

Land Cover Class Definitions (NLCD 2001)

Open Water - All areas of open water, generally with less than 25% cover of vegetation or soil.

Developed, Open Space - Includes 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 - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49% of total cover. These areas most commonly include single-family housing units.

Developed, Medium Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79% of the total cover. These areas most commonly include single-family housing units.

Developed, High Intensity - Includes 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 to100% of the total cover.

Barren Land (Rock/Sand/Clay) - Barren 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 16 feet (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 16 feet (5 meters) 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.

Grassland/Herbaceous - Areas dominated by grammanoid 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 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.

Appendix E:

Water Quality Parameter Descriptions

Water Quality Parameter Descriptions (WREC 2011)

Temperature Temperature can determine the form, solubility, and toxicity of a broad range of aqueous compounds. Likewise, water temperature regulates the species composition and activity of life associated with the aquatic environment. Since essentially all aquatic organisms are cold-blooded, the temperature of the water regulates their metabolism and ability to survive and reproduce effectively (USEPA, 1976). The Indiana Administrative Code (327 IAC 2-16) sets maximum temperature limits to protect aquatic life for Indiana streams. For example, temperatures during the months of June and July should not exceed 90°F by more than 3°F. The code also states that the "maximum temperature rise at any time or place… shall not exceed 5°F in streams…"

Dissolved Oxygen (DO) DO is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. Fish need water to possess a DO concentration of at least 3-5 mg/L of DO. Coldwater fish such as trout generally require higher concentrations of DO than warmwater fish such as bass or bluegill. The IAC sets minimum DO concentrations at 5 mg/L for warmwater fish. DO enters water by diffusion from the atmosphere and as a byproduct of photosynthesis by algae and plants. Excessive algae growth can over-saturate (greater than 100% saturation) the water with DO. Waterbodies with large populations of algae and plants (macrophytes) often exhibit supersaturation due to the high levels of photosynthesis. Dissolved oxygen is consumed by respiration of aquatic organisms, such as fish, and during bacterial decomposition of plant and animal matter.

Conductivity Conductivity is a measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions: on their total concentration, mobility, and valence (APHA, 1998). During low flows, conductivity is higher than it is following a storm water runoff because the water moves more slowly across or through ion containing soils and substrates during base flow conditions. Carbonates and other charged particles (ions) dissolve into the slow moving water, thereby increasing conductivity levels.

pH The pH of stream water describes the concentration of acidic ions (specifically $H+$) present in the water. The pH also determines the form, solubility, and toxicity of a wide range of other aqueous compounds. The IAC establishes a range of 6-9 pH units for the protection of aquatic life.

Alkalinity Alkalinity is a measure of the acid-neutralizing (or buffering) capacity of water. Certain substances in water, like carbonates, bicarbonates, and sulfates can cause the water to resist changes in pH. A lower alkalinity indicates a lower buffering capacity or a decreased ability to resist changes in pH. During base flow conditions, alkalinity is usually high because the water picks up carbonates from the bedrock. Alkalinity measurements are usually lower during storm flow conditions because buffering compounds are diluted by rainwater and the runoff water moves across carbonate-containing bedrock materials so quickly that little carbonate is dissolved to add additional buffering capacity.

Turbidity Turbidity (measured in Nephelometric Turbidity Units or NTUs) is a measure of water coloration and particles suspended in the water itself. It is generally related to suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms. According to the Hoosier Riverwatch, the average turbidity of an Indiana stream is 11 NTU with a typical range of 4.5-17.5 NTU. Turbidity measurements >20 NTU have been found to cause undesirable changes in aquatic life (Walker, 1978). The U.S. Environmental Protection Agency developed recommended water quality criteria as part work to establish numeric criteria for nutrients on an ecoregion basis. Recommended turbidity concentrations for this ecoregion are 9.89 NTUs (USEPA, 2000).

Nitrogen Nitrogen is an essential plant nutrient found in fertilizers, human and animal wastes, yard waste, and the air. About 80% of the air we breathe is nitrogen gas. Nitrogen gas diffuses into water where it can be "fixed", or converted, by blue-green algae to ammonia for their use. Nitrogen can also enter lakes and streams as inorganic nitrogen and ammonia. Because of this, there is an abundant supply of available nitrogen to aquatic systems. The three common forms of nitrogen are:

- ***Nitrate-nitrogen (NO_3-N)*** Nitrate is an oxidized form of dissolved nitrogen that is converted to ammonia by algae. It is found is streams and runoff when dissolved oxygen is present, usually in the surface waters. Ammonia applied to farmland is rapidly oxidized or converted to nitrate and usually enters surface and groundwater as nitrate. The Ohio EPA (1999) found that the median nitrate-nitrogen concentration in wadeable streams classified as warmwater habitat (WWH) was 1.0 mg/l. Warmwater habitat refers to those streams which possess minor modifications and little human influence. These streams typically support communities with healthy, diverse warmwater fauna. The Ohio EPA (1999) found that the median nitrate-nitrogen concentration in wadeable streams classified as modified warmwater habitat (MWH) was 1.6 mg/1. Modified warmwater habitat was defined as: the aquatic life use assigned to streams that have irretrievable, extensive, man-induced modification that precludes attainment of the warmwater habitat use designation; such streams are characterized by species that are tolerant of poor chemical quality (fluctuating dissolved oxygen) and habitat conditions (siltation, habitat amplification) that often occur in modified streams (Ohio EPA, 1999). The U.S. Environmental Protection Agency developed recommended nitrate-nitrogen criterion as part of work to establish numeric criteria for nutrients on an ecoregion basis. The recommended nitrate-nitrogen concentration for the ecoregion is 0.63 mg/l (USEPA, 2000). Nitrate-nitrogen concentrations exceeding 10 mg/1 in drinking water are considered hazardous to human health (Indiana Administrative Code IAC 2-1-6).
- ***Ammonia-nitrogen (NH_3-N)*** Ammonia-nitrogen is a form of dissolved nitrogen that is the preferred form for algae use. Bacteria produce ammonia as they decompose dead plant and animal matter. Ammonia is the reduced form of nitrogen and is found in water where dissolved oxygen is lacking. Important sources of ammonia include fertilizers and animal manure. Both temperature and pH govern the toxicity of ammonia for aquatic life. According to the IAC, maximum ionized ammonia concentrations for the study streams should not exceed approximately 1.94 to 7.12 mg/L, depending on the water's pH and temperature.
- ***Organic Nitrogen*** Organic nitrogen includes nitrogen found in plant and animal materials. It may be in dissolved or particulate form. The most commonly measured form used to calculate organic nitrogen is total Kjeldahl nitrogen (TKN). Organic nitrogen is TKN minus ammonia. The U.S. Environmental Protection Agency developed TKN criterion as part work to establish numeric criteria for nutrients on an ecoregion basis. The recommended total Kjeldahl nitrogen concentration for this ecoregion is 0.591 mg/l (USEPA, 2000).

Phosphorus Phosphorus is an essential plant nutrient and the one that most often controls aquatic plant (algae and macrophyte) growth. It is found in fertilizers, human and animal wastes, and in yard waste. There are few natural sources of phosphorus to streams other than that which is attached to soil particles; there is no atmospheric (vapor) form of phosphorus. For this reason, phosphorus is often a ***limiting nutrient*** in aquatic systems. This means that the relative scarcity of phosphorus may limit the ultimate growth and production of algae and rooted aquatic plants. Management efforts often focus on reducing phosphorus inputs to receiving waterways because: (a) it can be managed and (b) reducing phosphorus can reduce algae production. Two common forms of phosphorus are:

- ***Soluble reactive phosphorus (SRP)*** SRP or orthophosphorus is dissolved phosphorus readily usable by algae. SRP is often found in very low concentrations in phosphorus-limited systems where the phosphorus is tied up in the algae themselves. Because phosphorus is cycled so rapidly through biota, SRP concentrations as low as 0.005 mg/l are enough to maintain eutrophic or highly productive conditions in lake systems (Correll, 1998). Sources of SRP include fertilizers, animal wastes, and septic systems.
- ***Total phosphorus (TP)*** TP includes dissolved and particulate phosphorus. TP concentrations greater than 0.03 mg/1 (or 30µg/L) can cause algal blooms in lake systems. In stream systems, Dodd et al., 1998 suggests that streams with a total phosphorus concentration greater than 0.075 mg/L are typically characterized as productive or eutrophic. TP is often a problem in agricultural watersheds because TP concentrations required for eutrophication control are as much as an order of magnitude lower than those typically measured in soils used to grow crops (0.2-0.3 mg/L). The Ohio EPA (1999) found that the median TP concentration in wadeable streams that support WWM for fish was 0.10 mg/L, while wadeable streams that support MWH for fish was 0.28 mg/L. The U.S. Environmental Protection Agency recommended TP criterion for this ecoregion is 0.076 mg/L (USEPA, 2000).

Total Suspended Solids (TSS) A TSS measurement quantifies all particles suspended in stream water. Closely related to turbidity, this parameter quantifies sediment particles and other solid compounds typically found in stream water. In general, the concentration of suspended solids is greater during high flow events due to increased overland flow. The increased overland flow erodes and carries more soil and other particulates to the stream. The State of Indiana does not have a TSS standard. In general, TSS concentrations greater than 80 mg/L have been found to be deleterious to aquatic life; concentrations of 15 mg/L are often targeted as levels necessary for quality fishery production (Waters, 1995).

***E. coli* and Fecal Coliform Bacteria** *E. coli* is one member of a group of bacteria that comprise the fecal coliform bacteria and is used as an indicator organism to identify the potential presence of pathogenic organisms in a water sample. Pathogenic organisms can present a threat to human health by causing a variety of serious diseases, including infectious hepatitis, typhoid, gastroenteritis, and other gastrointestinal illnesses. *E. coli* can come from the feces of any warm-blooded animal. Wildlife, livestock, and/or domestic animal defecation, manure fertilizers, previously contaminated sediments, and failing or improperly sited septic systems are common sources of the bacteria. The IAC sets the maximum standard at 235 colonies/100 ml in any one sample within a 30-day period.

Index of Biotic Integrity (IBI) As part of their assessment of water quality in Indiana, IDEM uses fish communities as an indicator of stream biological integrity or health. Biological integrity is defined as “the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the best natural habitats within a region” (Karr and Dudley, 1981). To provide a method of determining the biological integrity of an aquatic ecosystem Karr (1981) developed the Index of Biotic Integrity (IBI). Simon (1991) further modified the IBI for evaluation of warmwater stream communities located in the ecoregions of Indiana. The IBI is composed of 12 metrics which are each individually scored based on types and numbers of fish collected in each sample. These attributes fall into such categories as species richness and composition, trophic composition, and fish abundance and condition. After data from sampling sites have been collected, values for the twelve metrics are compared with their corresponding expected values

(Simon and Dufour, 1997) and a rating of 1, 3, or 5 is assigned to each metric based on whether it deviates strongly from, somewhat from, or closely approximates the expected values.. These metrics are used to assess the attributes of fish communities in streams. These individual scores for each of the 12 metrics are then summed to yield an IBI score. An IBI score of 12-22 would indicate very poor biological integrity while the maximum score of 60 would indicate excellent biological integrity.

Macroinvertebrate Index of Biotic Integrity (mIBI) Macroinvertebrate results were analyzed using a IDEM's macroinvertebrate Index of Biotic Integrity (mIBI). IDEM's mIBI is a multi-metric (10 metrics) index designed to provide a complete assessment of a stream's biological integrity. Karr and Dudley (1981) define biological integrity as "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization compared to the best natural habitats within the region". It is likely that this definition of biological integrity is what IDEM means by biological integrity as well. IDEM developed the mIBI using five years of wadeable data collected in Indiana. The data were lognormally distributed for each of the ten metrics. Each metric's lognormal distribution was then pentasected with scoring based on five categories using 1.5 times the interquartile range around the geometric mean. The following table lists the eight scoring metrics used to calculate the mIBI and the value or range of values associated with the classification scores. The mean of the eight classification scores for each metric is the mIBI score.

Classification score are 0, 2, 4, 6, and 8. mIBI scores of 0-2 indicate the sampling site is severely impaired; scores of 2-4 indicate the site is moderately impaired; scores of 4-6 indicate the site is slightly impaired; and scores of 6-8 indicate that the site is non-impaired.

Macroinvertebrate data were also used to calculate the family-level Hilsenhoff Biotic Index (HBI). The HBI uses the macroinvertebrate community to assess the level of organic pollution in a stream. The HBI is based on the premise that different families of aquatic insects possess different tolerance levels to organic pollution. Hilsenhoff assigned each aquatic insect family a tolerance value from 1 to 9; those families with lower tolerances to organic pollution were assigned lower values, while those families that were more tolerant of organic pollution were assigned higher values. Calculation of the HBI involves applying assigned macroinvertebrate family tolerance values to all taxa that have an assigned HBI tolerance value, multiplying the number of organisms present by their family tolerance value, summing the products, and dividing by the total number of organisms present (Hilsenhoff, 1988). Benthic communities dominated by organisms that are tolerant of organic pollution will exhibit higher HBI scores compared to benthic communities dominated by intolerant organisms.

Qualitative Habitat Evaluation Index (QHEI) Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1995). Various attributes of the stream and riparian zone habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates; amount and quality of instream cover; channel morphology; extent and quality of riparian vegetation; pool, run, and riffle development and quality; and gradient are some of the metrics used to determine the QHEI score. The QHEI score ranges from 20 to 100.

Substrate type(s) and quality are important factors of habitat quality and the QHEI score is partially based on these characteristics. Sites that have greater substrate diversity receive higher scores as they can provide greater habitat diversity for benthic organisms. The quality of substrate refers to the embeddedness of the benthic zone. Small particles of soil and organic matter will settle into small pores and crevices in the stream bottom. Many organisms can colonize these microhabitats, but high levels of silt in a streambed can result in the loss of habitat within the substrate. Thus, sites with heavy embeddedness and siltation receive lower QHEI scores for the substrate metric.

Instream cover, another metric of the QHEI, represents the type(s) and quantity of habitat provided within the stream itself. Examples of instream cover include woody logs and debris, aquatic and overhanging vegetation and root wads extending from the stream banks. The channel morphology metric evaluates the stream's physical development with respect to habitat diversity. Pool and riffle development within the stream reach, the channel sinuosity and other factors that represent the stability and direct modification of the site are evaluated to comprise this metric score.

A wooded riparian buffer is a vital functional component of riverine ecosystems. It is instrumental in the detention, removal, and assimilation of nutrients. According to the Ohio EPA (1999), riparian zones govern the quality of goods and services provided by riverine ecosystems. Riparian zone and bank erosion were examined at each site to evaluate the quality of the buffer zone of a stream, the land use within the floodplain that affects inputs to the waterway, and the extent of bank erosion, which can reflect insufficient vegetative stabilization of the stream banks. For the purposes of the QHEI, a riparian buffer is a zone that is forest, shrub, swamp, or woody old field vegetation. Typically, weedy, herbaceous vegetation does not offer as much infiltration potential as woody components and does not represent an acceptable riparian zone type for the QHEI (Ohio EPA, 1989).

The fifth QHEI metric evaluates the quality of pool/glide and riffle/run habitats in the stream. These zones in a stream, when present, provide diverse habitat and in turn can increase habitat quality and availability. The depth of pools within a reach and the stability of riffle substrate are some factors that affect the QHEI score in this metric.

The final QHEI metric evaluates the topographic gradient in a stream reach. This is calculated using topographic data. The score for this metric is based on the premise that both very low and very high gradients will have negative effects on habitat quality and the biota in the stream. Moderate gradients receive the highest score, 10, for this metric.

The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of stream segments in Ohio have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas. Scores greater than 75 typify habitat conditions that have the ability to support exceptional warmwater faunas (Ohio EPA, 1999). IDEM indicates that QHEI scores above 51 support a stream's aquatic life use designation, while scores less than 51 are deemed non-supporting the stream's aquatic life use designation (IDEM, 2000).

Appendix F:

Subwatershed Critical Area Calculations

Watershed (Count/%) miles/sq. miles	Roudebush Ditch-Big Pine Creek (051201080401)	Big Pine Creek Ditch-Big Pine Creek (051201080402)	Little Pine Creek (051201080403)	Owens Ditch-Big Pine Creek (051201080404)	Brumm Ditch-Big Pine Creek (051201080405)	Darby Ditch-Big Pine Creek (051201080406)	Brown Ditch (051201080407)	Harrington Creek-Big Pine Creek (051201080408)	Pine Village-Big Pine Creek (051201080409)	Hog Back Hill-Big Pine Creek (051201080410)	Headwaters Mud Pine Creek (051201080301)	Seamons Ditch-Mud Pine Creek (051201080302)	Goose Creek-Mud Pine Creek (051201080303)	Spring Branch-Mud Pine Creek (051201080304)
Size (acres)	11,273	19,725	10,058	17,921	11,030	11,756	11,850	12,873	17,652	23,671	12,019	14,432	16,867	18,582
Stream/Drain Length (miles)	34.8	40.7	17.9	53.4	30.6	32.6	38.2	26.4	46.8	96.7	23.0	41.1	40.0	46.4
Regulated Drain & Tile (miles)	34.8	31.5	17.9	45.9	27.5	26.0	37.7	21.4	11.1	0.6	18.8	34.1	28.9	0.4
Hydric Soils	62.9%	41.7%	51.9%	36.6%	39.4%	47.5%	39.6%	39.6%	22.8%	14.5%	42.2%	38.1%	34.9%	23.0%
Highly Erodible Soils	0.0%	1.2%	0.1%	1.4%	1.3%	0.0%	3.0%	0.3%	8.1%	15.5%	0.4%	0.5%	3.7%	3.8%
Potentially Highly Erodible Soils	9.3%	27.8%	20.0%	29.1%	21.2%	13.1%	31.3%	11.5%	44.4%	43.2%	24.8%	26.6%	29.5%	43.8%
Very Limited for Septic Use (acres)	99.9%	99.4%	100.0%	100.0%	99.9%	99.8%	99.8%	100.0%	100.0%	98.9%	99.9%	99.9%	99.9%	99.9%
Somewhat Limited for Septic Use (acres)	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Slight Septic Use Limitation	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Not Rated for Septic Use	0.1%	0.6%	0.0%	0.0%	0.0%	0.1%	0.2%	0.0%	0.0%	1.1%	0.1%	0.1%	0.1%	0.1%
Land Use														
Open Water	0.1%	0.5%	0.1%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.3%	0.1%	0.1%	0.0%	0.1%
Developed	6.4%	4.0%	4.3%	4.0%	4.3%	4.1%	8.2%	4.4%	5.4%	6.1%	8.5%	5.0%	6.2%	5.0%
Forest	0.3%	2.7%	1.5%	2.2%	2.1%	5.0%	1.8%	2.1%	18.0%	27.9%	0.2%	0.9%	2.8%	9.7%
Shrub/Scrub	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Grassland	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.5%	0.1%	0.1%	0.1%	0.1%
Hay/Pasture	0.0%	2.4%	1.4%	1.9%	2.5%	2.1%	3.5%	1.0%	13.3%	8.2%	0.7%	3.4%	5.4%	3.3%
Row Crops	93.2%	90.5%	92.8%	91.9%	91.1%	88.8%	86.3%	92.6%	63.2%	56.8%	90.4%	90.4%	85.6%	81.9%
Wetlands	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%
Barren Lands	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Wetlands NWI	0.5%	1.4%	0.8%	1.1%	1.3%	2.6%	0.9%	1.3%	2.9%	4.5%	0.4%	0.6%	1.1%	2.1%
Wetland Loss (Hydric Soils-Wetlands Mapped)	99.3%	96.7%	98.5%	96.9%	96.8%	94.6%	97.7%	96.8%	87.1%	69.0%	99.0%	98.5%	97.0%	91.0%

Watershed (Count/%) miles/sq. miles	Roudebush Ditch-Big Pine Creek (051201080401)	Big Pine Creek Ditch-Big Pine Creek (051201080402)	Little Pine Creek (051201080403)	Owens Ditch-Big Pine Creek (051201080404)	Brumm Ditch-Big Pine Creek (051201080405)	Darby Ditch-Big Pine Creek (051201080406)	Brown Ditch (051201080407)	Harrington Creek-Big Pine Creek (051201080408)	Pine Village-Big Pine Creek (051201080409)	Hog Back Hill-Big Pine Creek (051201080410)	Headwaters Mud Pine Creek (051201080301)	Seamons Ditch-Mud Pine Creek (051201080302)	Goose Creek-Mud Pine Creek (051201080303)	Spring Branch-Mud Pine Creek (051201080304)
Hydric Soils (acres)	7,086	8,232	5,224	6,551	4,344	5,582	4,689	5,092	4,019	3,424	5,072	5,505	5,893	4,266
Highly Erodible Soils (acres)	-	244	12	258	148	3	354	45	1,433	3,657	43	65	628	700
Potentially Highly Erodible Soils (acres)	1,051	5,477	2,013	5,219	2,340	1,545	3,711	1,480	7,837	10,234	2,978	3,836	4,973	8,133
Very Limited for Septic Use (acres)	11,256	19,606	10,058	17,914	11,024	11,738	11,823	12,873	17,644	23,403	12,008	14,422	16,853	18,557
Somewhat Limited for Septic Use (acres)	0	0	0	0	7	9	0	0	0	0	0	0	0	0
Slight Septic Use Limitation (acres)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Not Rated for Septic Use (acres)	17	119	0	7	0	9	27	0	9	268	11	11	14	25
Land Use														
Open Water (acres)	15	106	5	3	0	0	19	0	3	71	13	18	4	11
Developed (acres)	720	783	428	720	474	483	976	562	954	1,454	1,026	726	1,042	931
Forest (acres)	33	526	151	398	227	590	208	271	3,173	6,611	20	136	468	1,806
Shrub/Scrub (acres)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grassland (acres)	6	8	3	9	3	7	9	7	15	120	9	21	21	22
Hay/Pasture (acres)	3	467	140	332	279	243	413	125	2,343	1,952	83	490	910	614
Row Crops (acres)	10,501	17,847	9,336	16,473	10,049	10,435	10,230	11,916	11,152	13,437	10,869	13,047	14,430	15,210
Wetlands (acres)	0	4	2	1	7	6	3	0	25	43	0	0	0	3
Barren Land (acres)	4	1	0	0	0	2	1	1	1	1	9	6	4	0
Wetlands NWI (acres)	52	271	76	206	139	302	109	162	518	1,063	51	81	179	382

Watershed (Count/%) miles/sq. miles	Roudebush Ditch-Big Pine Creek (051201080401)	Big Pine Creek Ditch-Big Pine Creek (051201080402)	Little Pine Creek (051201080403)	Owens Ditch-Big Pine Creek (051201080404)	Brumm Ditch-Big Pine Creek (051201080405)	Darby Ditch-Big Pine Creek (051201080406)	Brown Ditch (051201080407)	Harrington Creek-Big Pine Creek (051201080408)	Pine Village-Big Pine Creek (051201080409)	Hog Back Hill-Big Pine Creek (051201080410)	Headwaters Mud Pine Creek (051201080301)	Seamons Ditch-Mud Pine Creek (051201080302)	Goose Creek-Mud Pine Creek (051201080303)	Spring Branch-Mud Pine Creek (051201080304)
Confined Feeding Operations (animals)	0	6,369	0	0	0	3,991	0	8,021	0	0	0	0	0	13,628
Confined Feeding Operations (operations)	0	3	0	0	0	0.5	0	0.5	0	0	0	0	0	2
Manure Land Application Areas (acres)	0	868	0	0	0	286	0	585	0	0	0	0	0	1,335
Manure spread (lb/year)	0	38,311,374	0	0	0	11,493,481	0	23,099,277	0	0	0	0	0	56,433,059
Unregulated Animal Operations	2	4	4	3	6	5	2	4	8	9	1	0	0	4
Municipal Biosolids Application Areas (acres)	402	501	111	63	435	1085	37	135	0	0	464	23	128	0
Wastewater Treatment Plants	0	0	0	0	1	0	1	0	1	0	1	0	1	0
Dense Unsewered Areas (acres)	0	0	0	0	0	43	16	0	342	175	0	0	0	0
Livestock Access (miles of surface drain affected)	0.0	0.3	0.4	0.2	0.5	1.6	1.7	0.8	2.6	0.8	0.0	0.0	0.0	0.7
(by personal observation) (%)	0.0%	0.8%	2.1%	0.4%	1.6%	5.0%	4.5%	2.9%	5.7%	0.8%	0.0%	0.0%	0.0%	1.4%
Buffers Needed (miles)	2.88	7.16	2.02	3.39	3.47	5.42	3.56	6.88	7.45	2.33	3.69	2.98	2.80	1.27
(by personal observation) (%)	8.3%	17.6%	11.3%	6.4%	11.3%	16.6%	9.3%	26.1%	15.9%	2.4%	16.0%	7.3%	7.0%	2.7%
Grassed Waterways Needed (acres)	196.0	327.1	354.3	362.6	40.2	531.6	549.1	0	1189.9	12.6	396.8	1242.6	506.3	336.1
(by personal observation) (%)	1.7%	1.7%	3.5%	2.0%	0.4%	4.5%	4.6%	0.0%	6.7%	0.1%	3.3%	8.6%	3.0%	1.8%
Streambank and Bed Erosion (miles)	0.0	0.5	0.7	2.00	0.81	2.0	2.6	7.9	2.9	0.4	0.59	2.03	1.55	0.78
(by personal observation) (%)	0.0%	1.3%	3.9%	3.7%	2.6%	6.1%	6.8%	29.7%	6.1%	0.4%	2.5%	5.0%	3.9%	1.7%
Impaired Waterbodies (miles)	13.75	14.69	9.30	13.96	3.96	8.91	5.50	0.01	11.34	23.71	0.00	0.00	0.06	46.02
P Sample Sites	6	10	5	10	4	6	2	1	2*	4	2	4	3	3
% of time P exceeded target (0.6 mg/L)	20%	9%	0%	9%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%
N Sample Sites	6	10	5	10	4	6	2	1	2*	6	2	5	4	4
% of time N exceeded target (2.0 mg/L)	40%	20%	36%	13%	0%	25%	63%	29%	9%	76%	50%	50%	50%	50%
TSS/Turbidity Sample Sites	6	10	4	9	4	6	1	0	2*	6	2	5	4	2
% of time T exceeded target (35 mg/L or NTU)	20%	20%	0%	22%	25%	25%	0%	N/A	22%	8%	0%	0%	36%	30%

Watershed (Count/%) miles/sq. miles	Roudebush Ditch-Big Pine Creek (051201080401)	Big Pine Creek Ditch-Big Pine Creek (051201080402)	Little Pine Creek (051201080403)	Owens Ditch-Big Pine Creek (051201080404)	Brumm Ditch-Big Pine Creek (051201080405)	Darby Ditch-Big Pine Creek (051201080406)	Brown Ditch (051201080407)	Harrington Creek-Big Pine Creek (051201080408)	Pine Village-Big Pine Creek (051201080409)	Hog Back Hill-Big Pine Creek (051201080410)	Headwaters Mud Pine Creek (051201080301)	Seamons Ditch-Mud Pine Creek (051201080302)	Goose Creek-Mud Pine Creek (051201080303)	Spring Branch-Mud Pine Creek (051201080304)
E coli Sample Sites	1	0	1	0	0	0	1	0	3*	4	2	5	3	1
% of time E exceeded target (235 CFU/100 ml)	0%	N/A	40%	N/A	N/A	N/A	20%	N/A	47%	23%	25%	78%	67%	50%
mIBI Sample Sites (MHAB)	0	0	0	0	0	0	1	0	1	1	0	0	0	1
mIBI Score < 36 (non-supporting of aquatic life use, MHAB samples)	N/A	N/A	N/A	N/A	N/A	N/A	0%	N/A	0%	50%	N/A	N/A	N/A	50%
mIBI Score > 45 (good or excellent, MHAB)	N/A	N/A	N/A	N/A	N/A	N/A	0%	N/A	0%	50%	N/A	N/A	N/A	0%
mIBI Sample Sites (KICK)	0	0	0	0	0	0	0	0	0	3	0	0	0	2
mIBI Score < 2.2 (non-supporting of aquatic life use, KICK samples)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0%	N/A	N/A	N/A	0%
mIBI Score > 5 (KICK)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	83%	N/A	N/A	N/A	100%
QHEI Sample Sites (macro sampling)	0	0	0	0	0	0	1	0	1	3	0	0	1	2
QHEI Score < 51 (poor habitat, macro sampling)	N/A	N/A	N/A	N/A	N/A	N/A	100%	N/A	100%	0%	N/A	N/A	100%	0%
QHEI Score > 75 (macro sampling)	N/A	N/A	N/A	N/A	N/A	N/A	0%	N/A	0%	57%	N/A	N/A	0%	100%
Fish IBI Sample Sites	5	7	4	7	2	2	1	0	1	2	0	0	1	1
fish IBI Score < 35 (non-supporting of aquatic life use)	100%	43%	0%	14%	50%	50%	0%	N/A	0%	0%	N/A	N/A	0%	0%
fish IBI Score > 45 (good or excellent)	0%	0%	40%	29%	0%	0%	100%	N/A	0%	100%	N/A	N/A	0%	100%
QHEI Sample Sites (fish sampling)	5	7	4	7	2	2	1	0	1	2	0	0	1	1
QHEI Score < 51 (poor habitat) (fish sampling)	100%	71%	60%	14%	100%	100%	0%	N/A	0%	0%	N/A	N/A	100%	0%
QHEI Score > 75 (good habitat) (fish sampling)	0%	0%	20%	0%	0%	0%	0%	N/A	0%	50%	N/A	N/A	0%	100%
CQHEI <60	N/A	20%	33%	40%	N/A	N/A	80%	50%	N/A	N/A	N/A	50%	N/A	0%
CQHEI > 60 (generally conducive to existence of warmwater fauna)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100%	N/A	N/A	50%	N/A	100%

N/A: No data available

*IDEM Fixed Station in HUC -409