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.

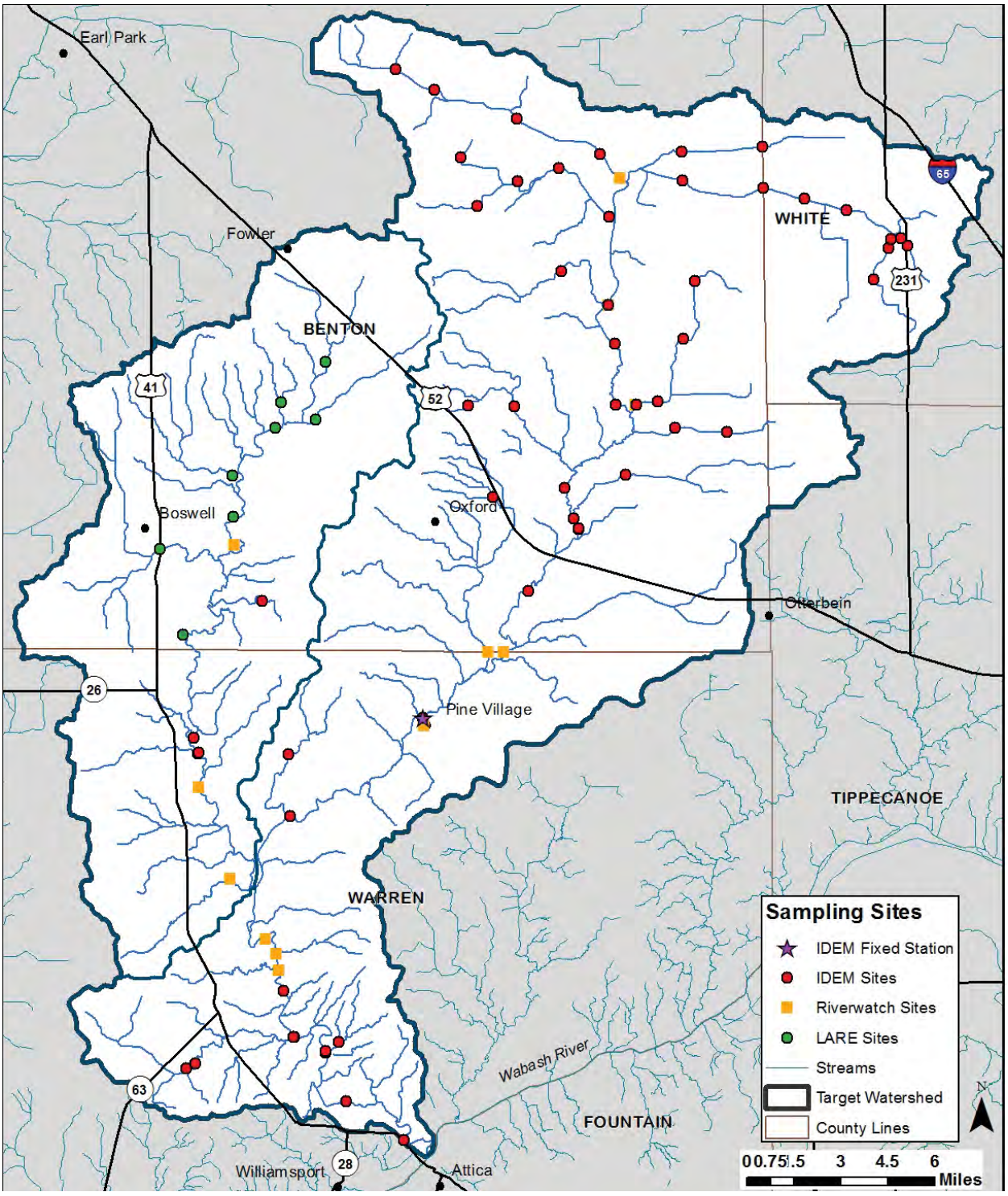

Figure 30. Historic water quality assessment locations.
Data used to create this map are detailed in Appendix A.

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.

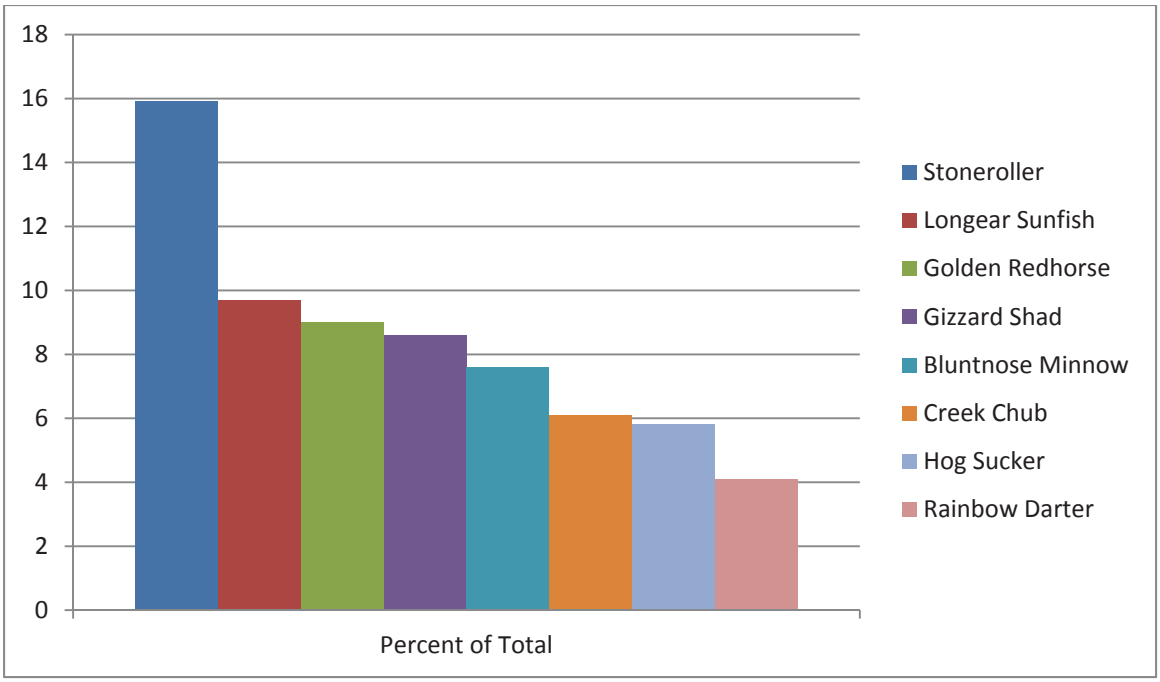

Figure 31. The eight most abundant species of fish collected during the 1973 DNR fisheries survey of Big Pine Creek.

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 in-

stream 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.

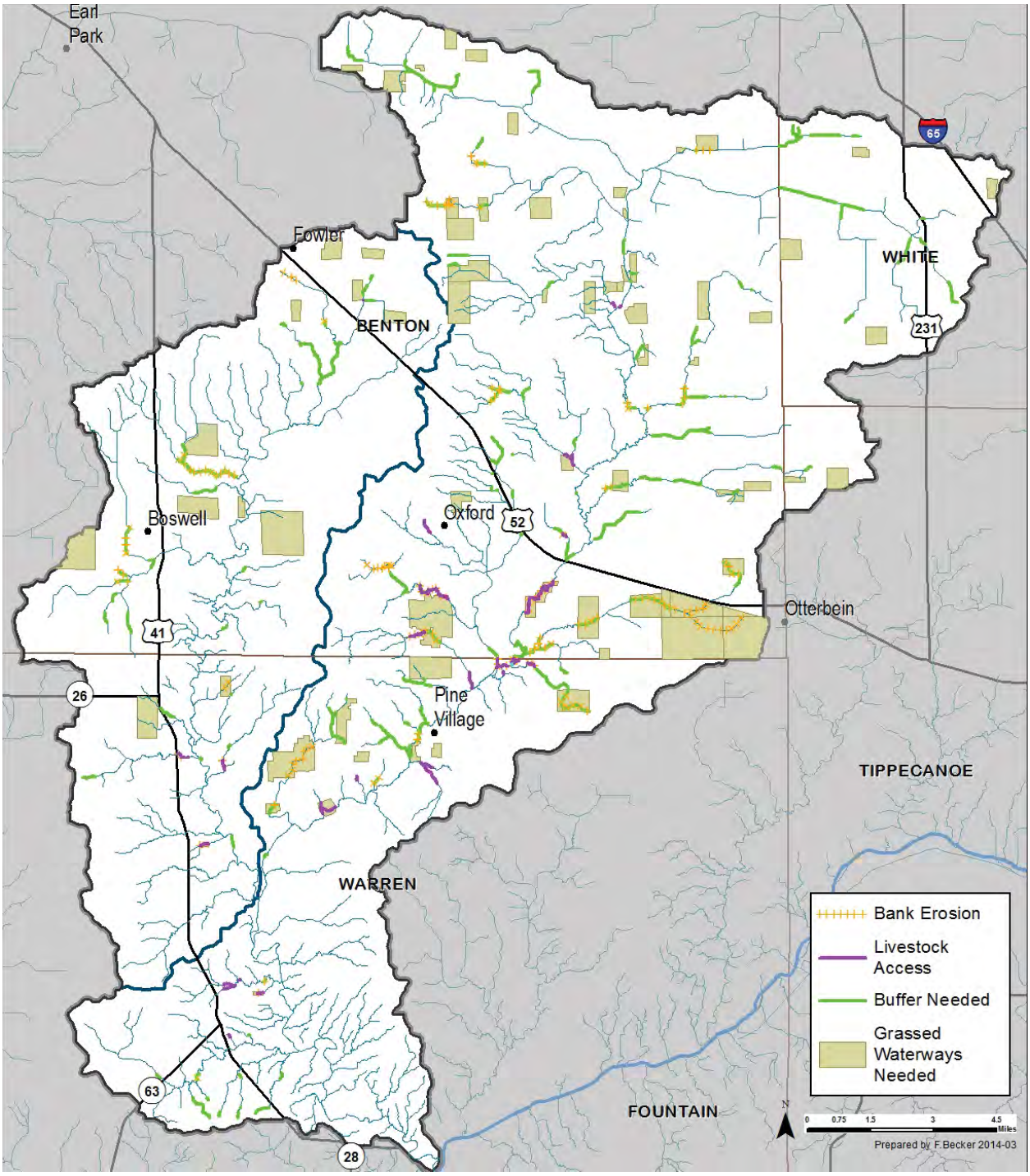

Figure 32. Stream-related watershed concerns identified during watershed inventory efforts.

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.

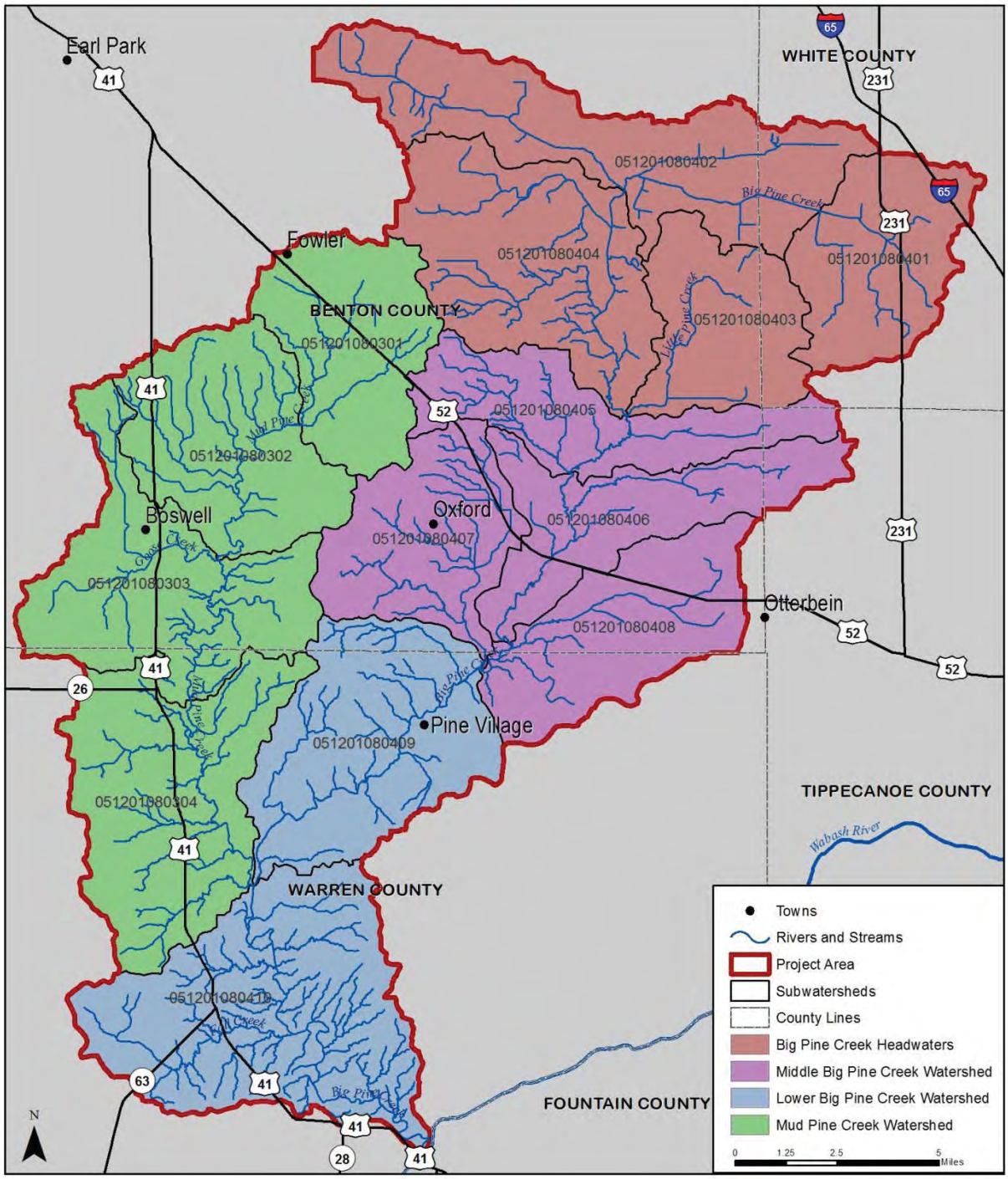

Figure 33. Four regional subwatersheds in the Big Pine Creek watershed.

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.

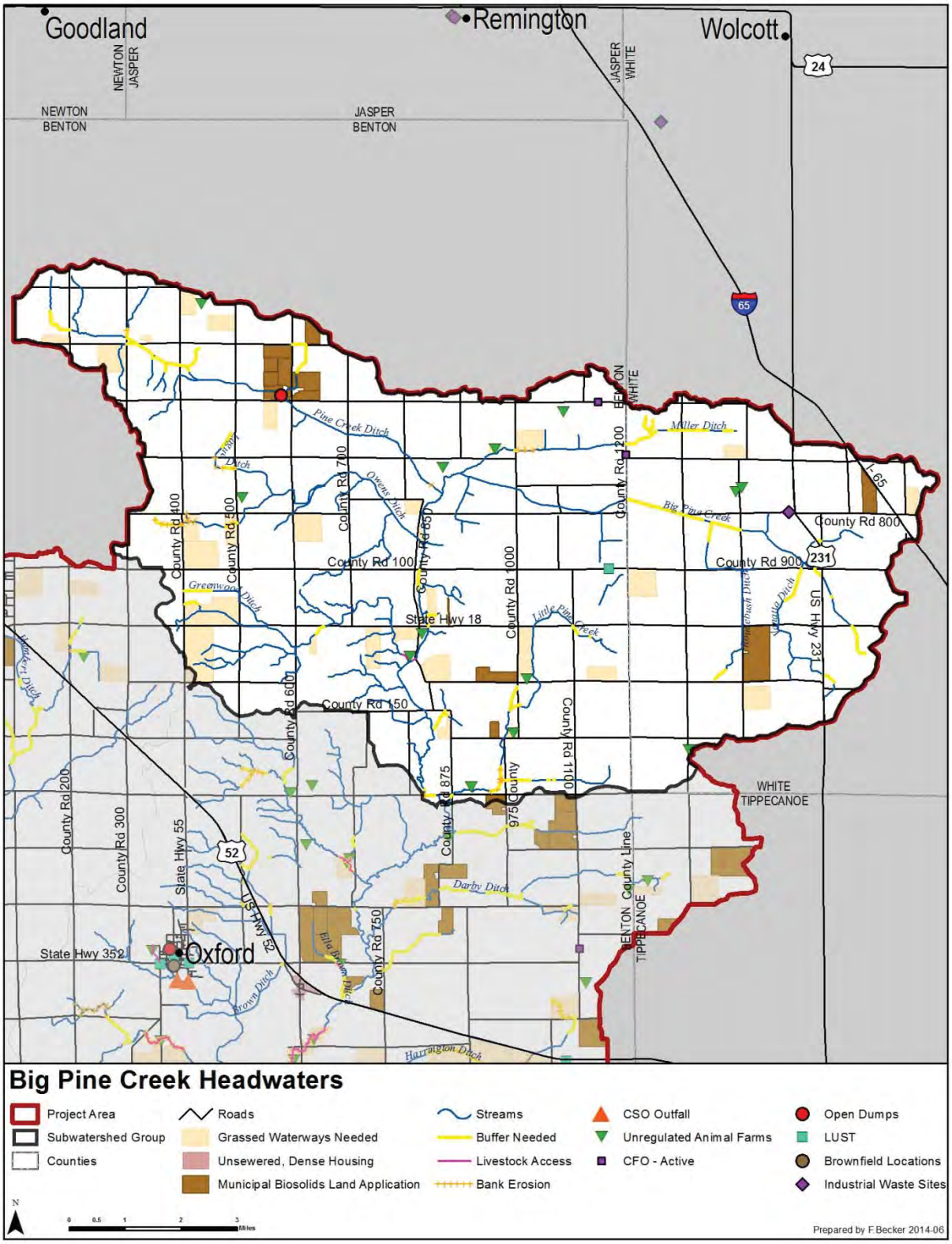

Figure 34. Point and non-point sources of pollution and suggested solutions in the Big Pine Creek Headwaters subwatershed.
Data used to create this map are detailed in Appendix A.

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.

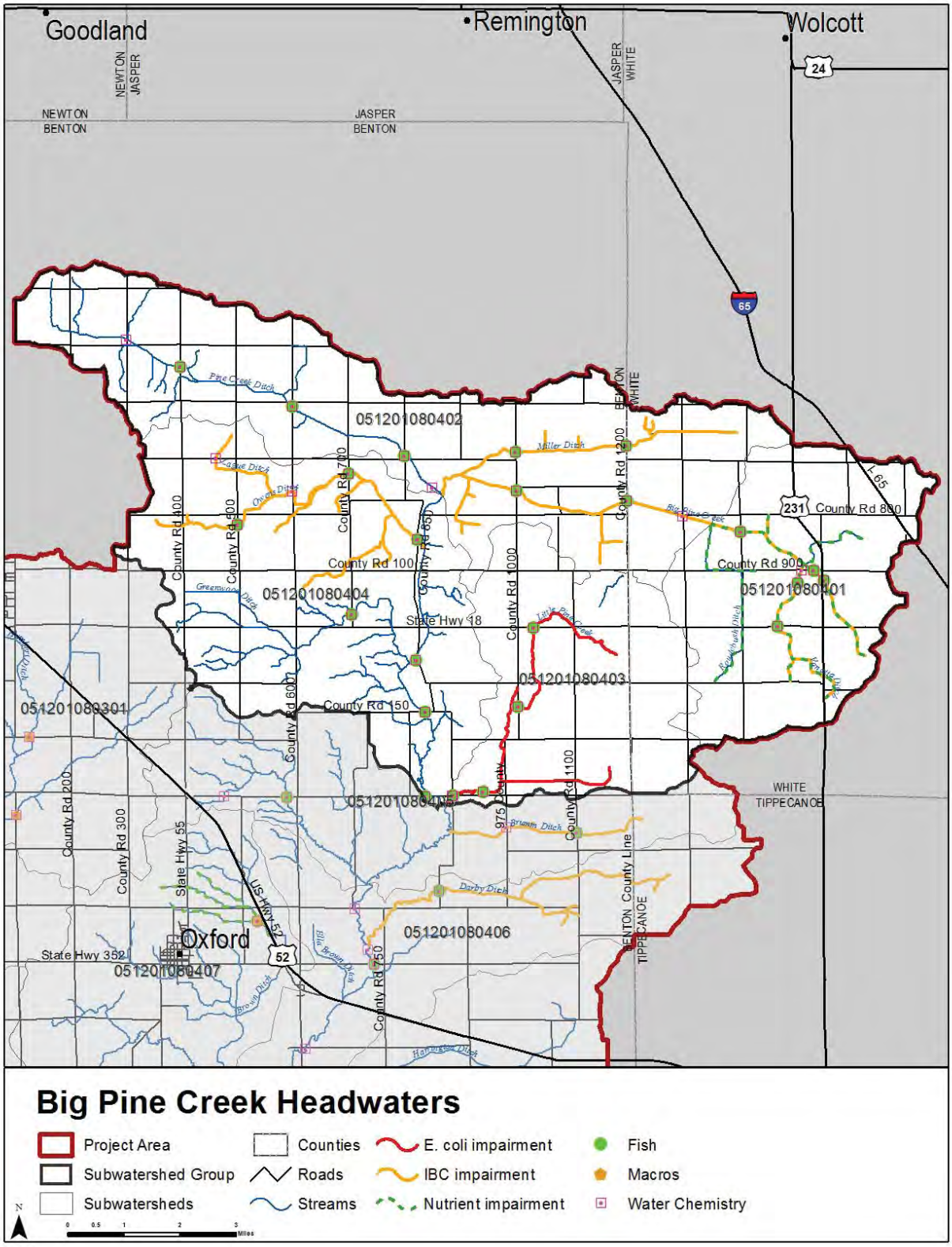

Figure 35. Locations of historic water quality data collection and impairments in the Big Pine Creek Headwaters subwatershed.
Data used to create this map are detailed in Appendix A.

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.

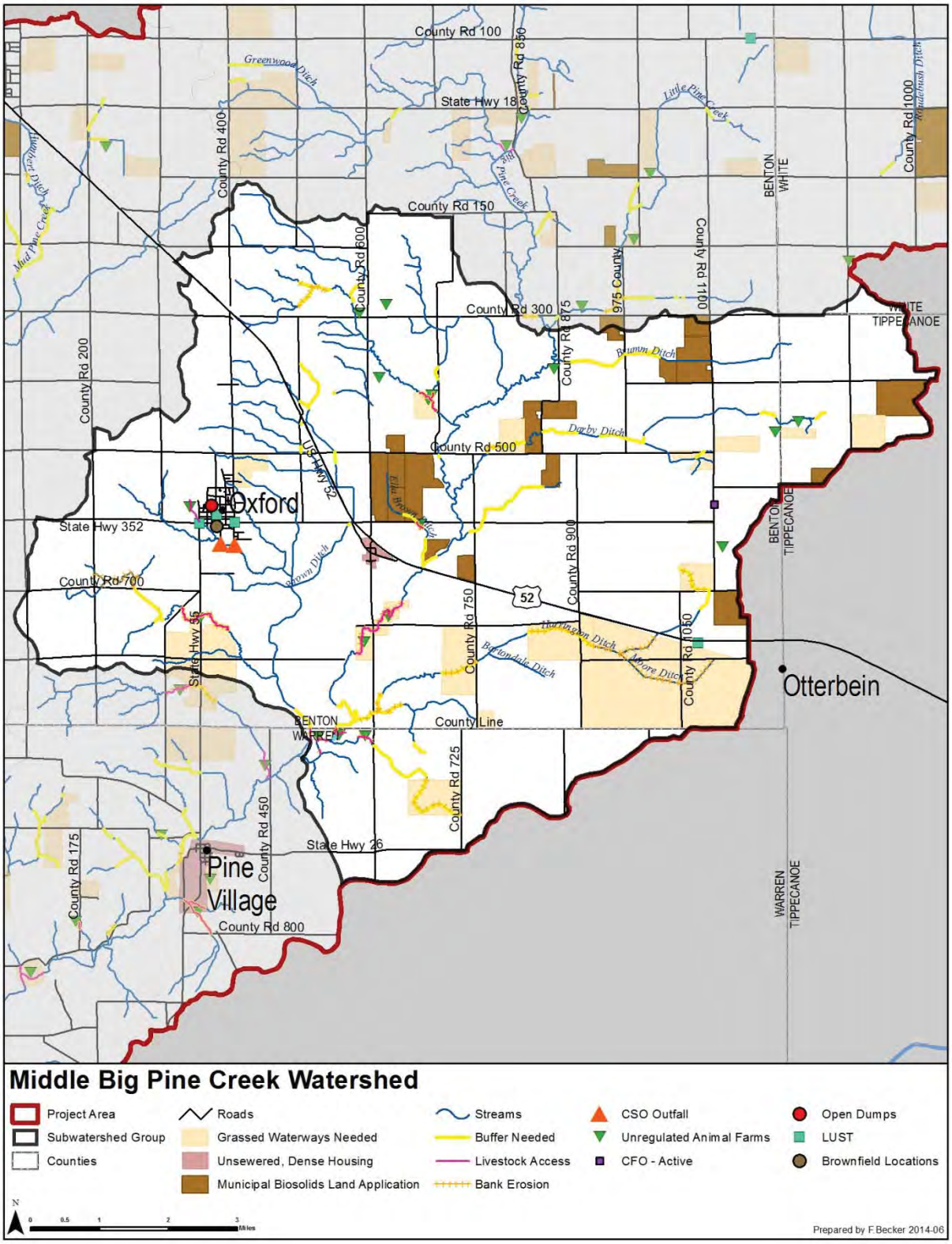

Figure 36. Point and non-point sources of pollution and suggested solutions in the middle Big Pine Creek subwatershed.
Data used to create this map are detailed in Appendix A.

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.

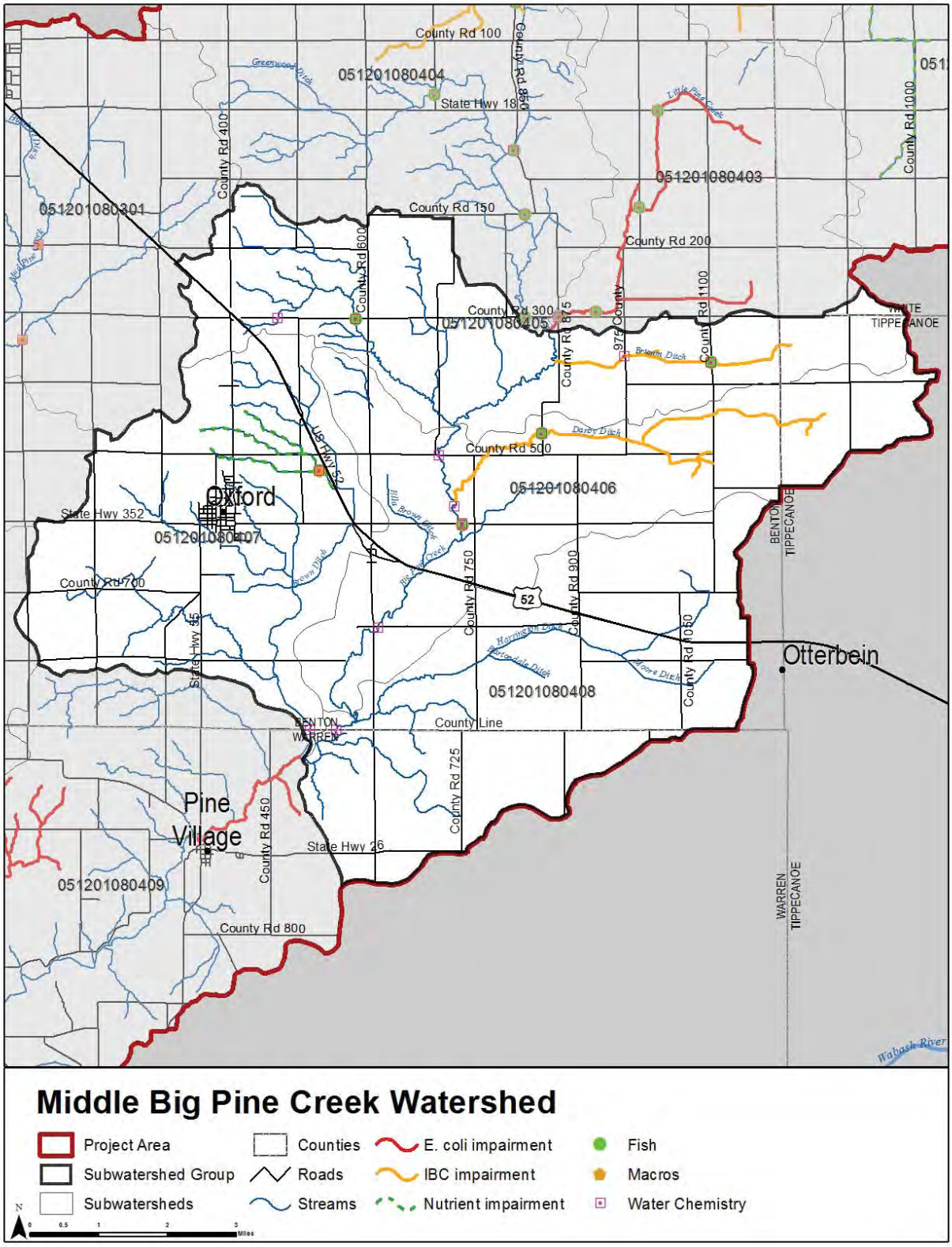

Figure 37. Locations of historic water quality data collection and impairments in the middle Big Pine Creek subwatershed.
Data used to create this map are detailed in Appendix A.

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.

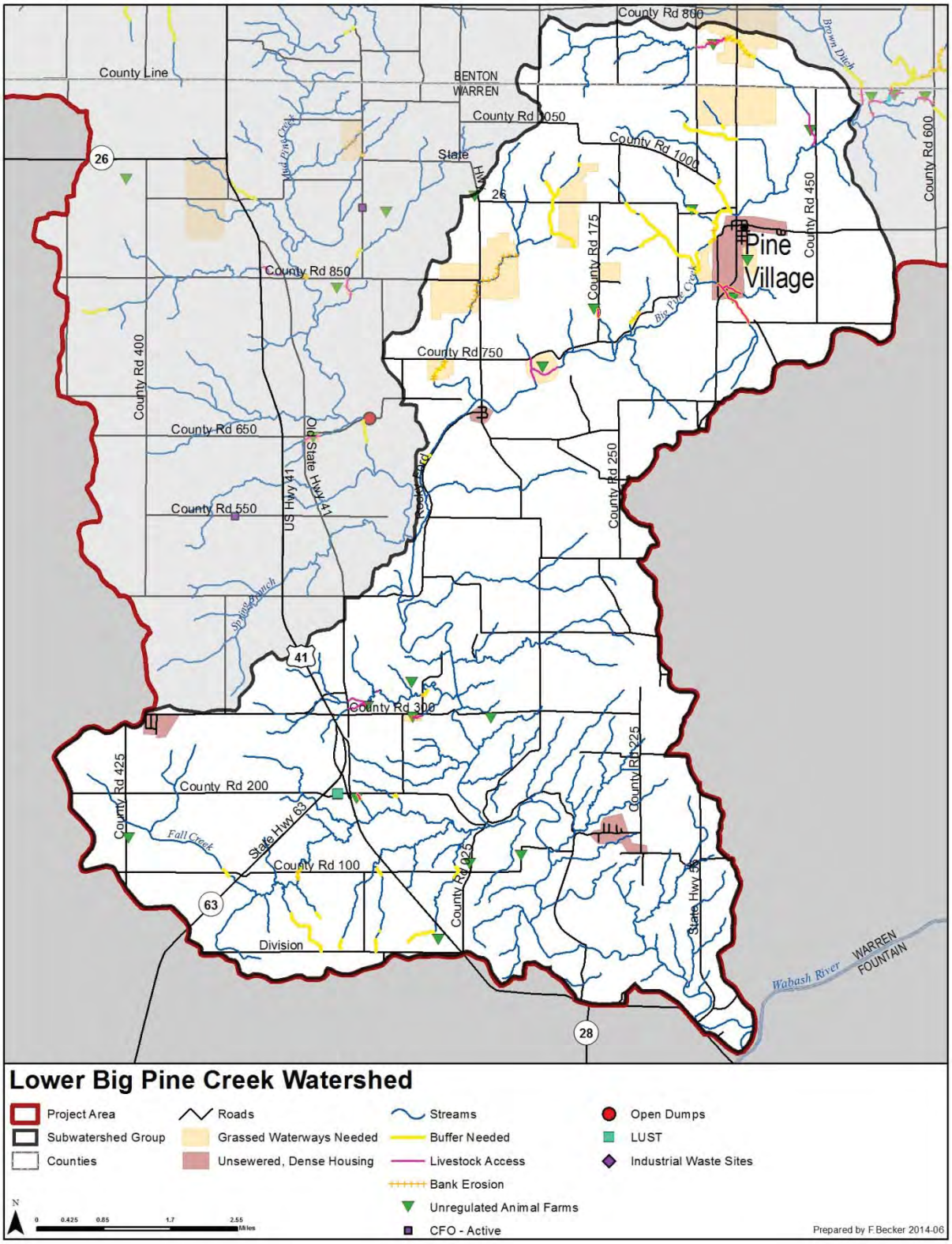

Figure 38. Point and non-point sources of pollution and suggested solutions in the lower Big Pine Creek subwatershed.
Data used to create this map are detailed in Appendix A.

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.

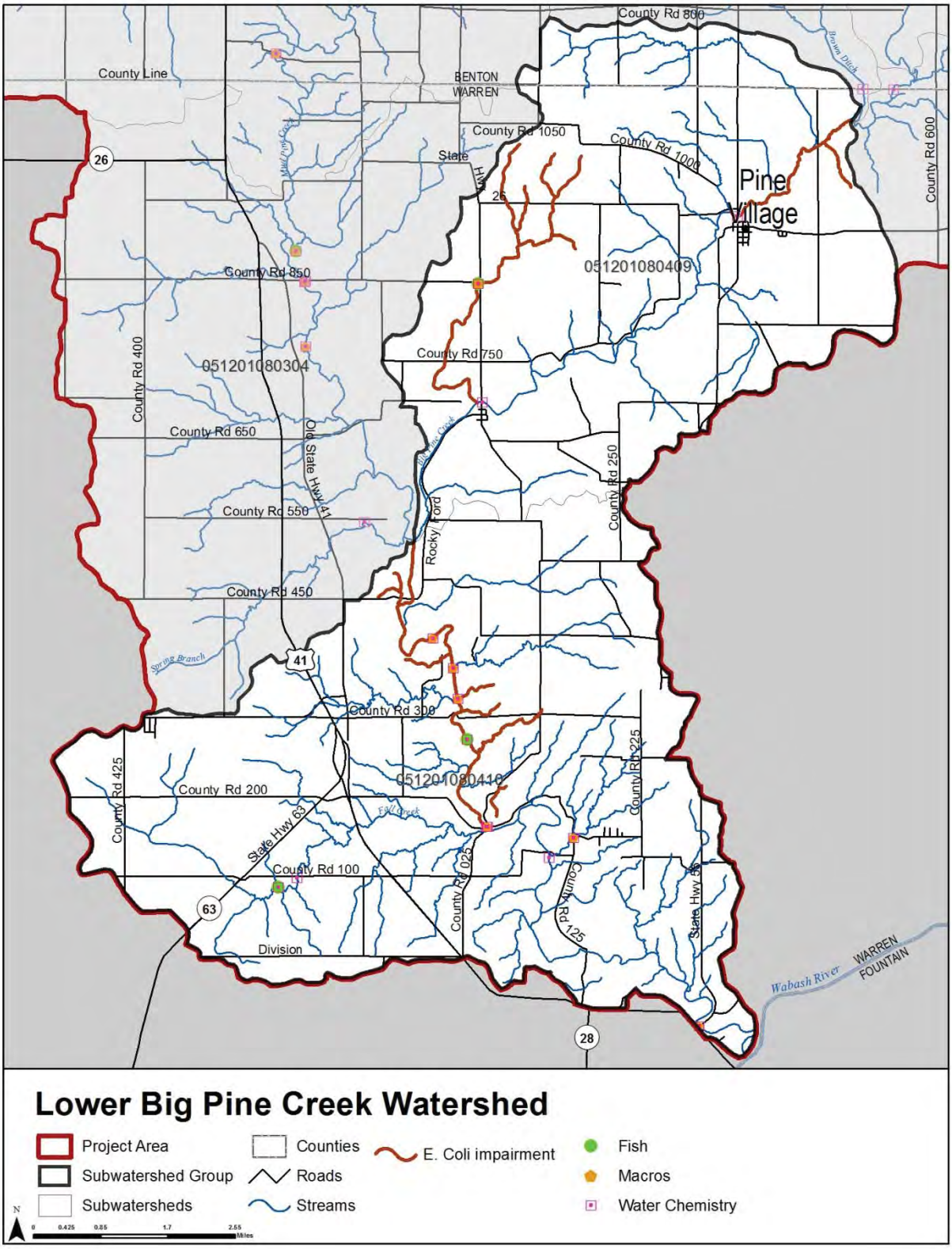

Figure 39. Locations of current or historic water quality data collection and impairments in the lower Big Pine Creek subwatershed.
Data used to create this map are detailed in Appendix A.

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.

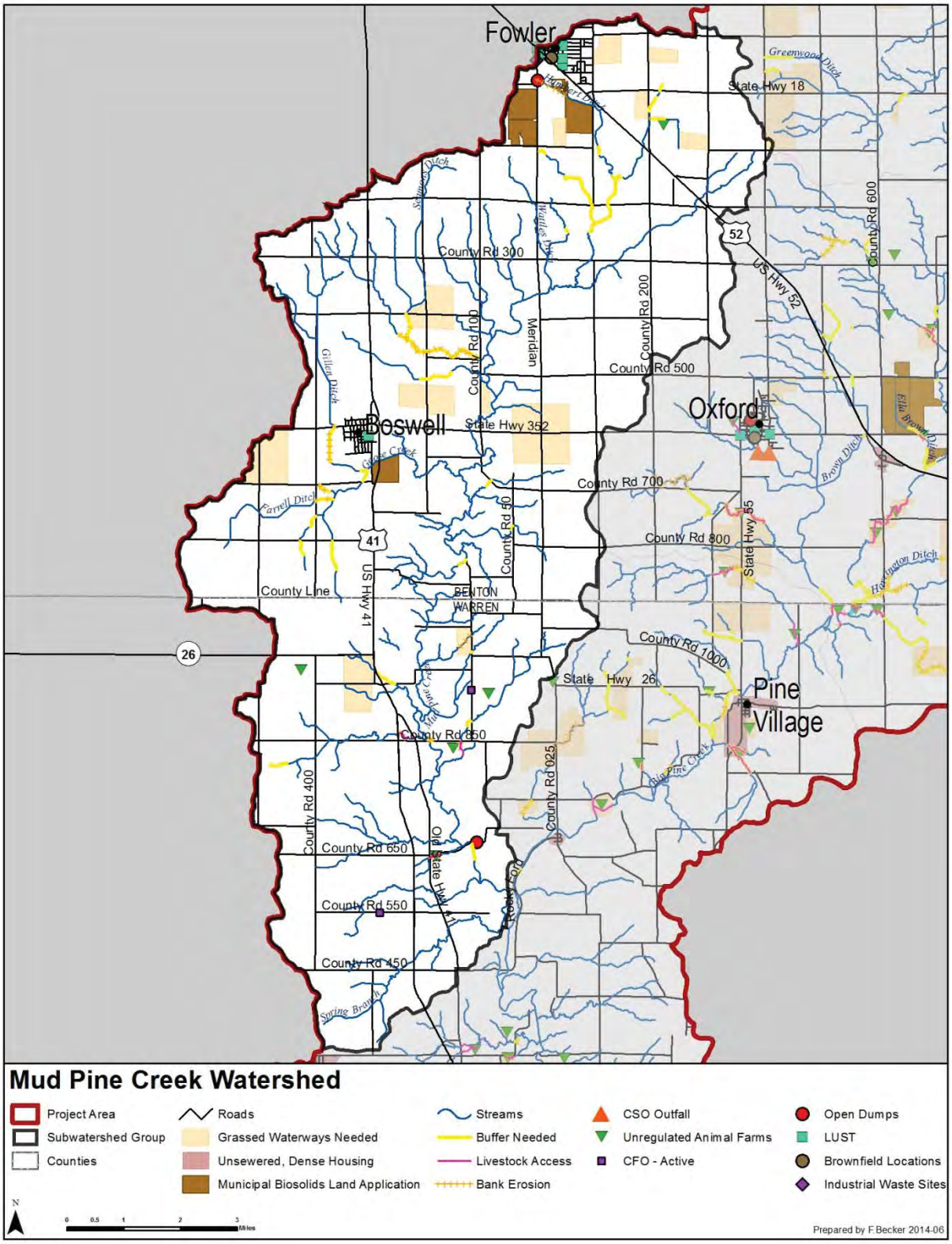

Figure 40. Point and non-point sources of pollution and suggested solutions in the Mud Pine Creek subwatershed.
Data used to create this map are detailed in Appendix A.

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).

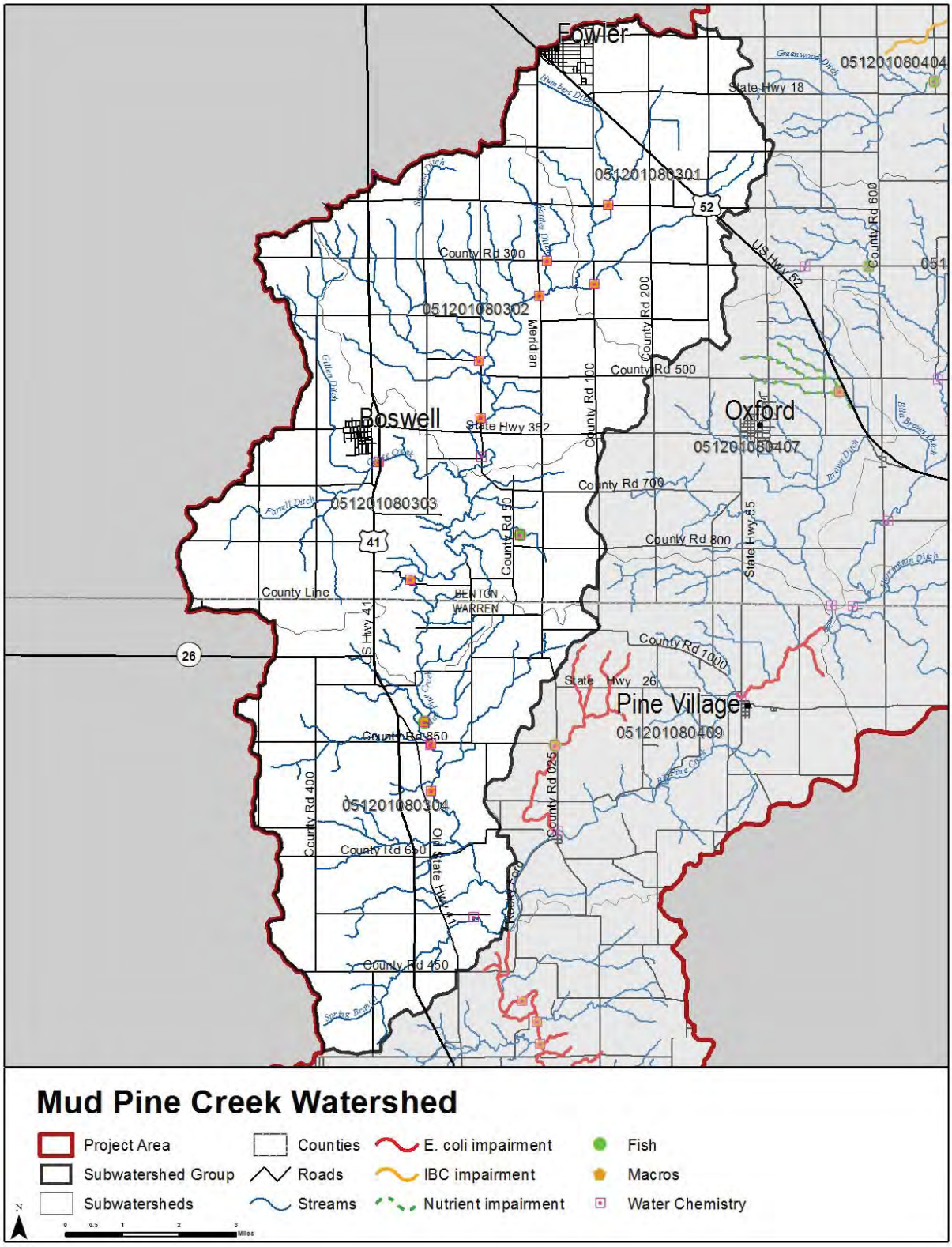

Figure 41. Locations of current or historic water quality data collection and impairments in the Mud Pine Creek subwatershed.
Data used to create this map are detailed in Appendix A.

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.

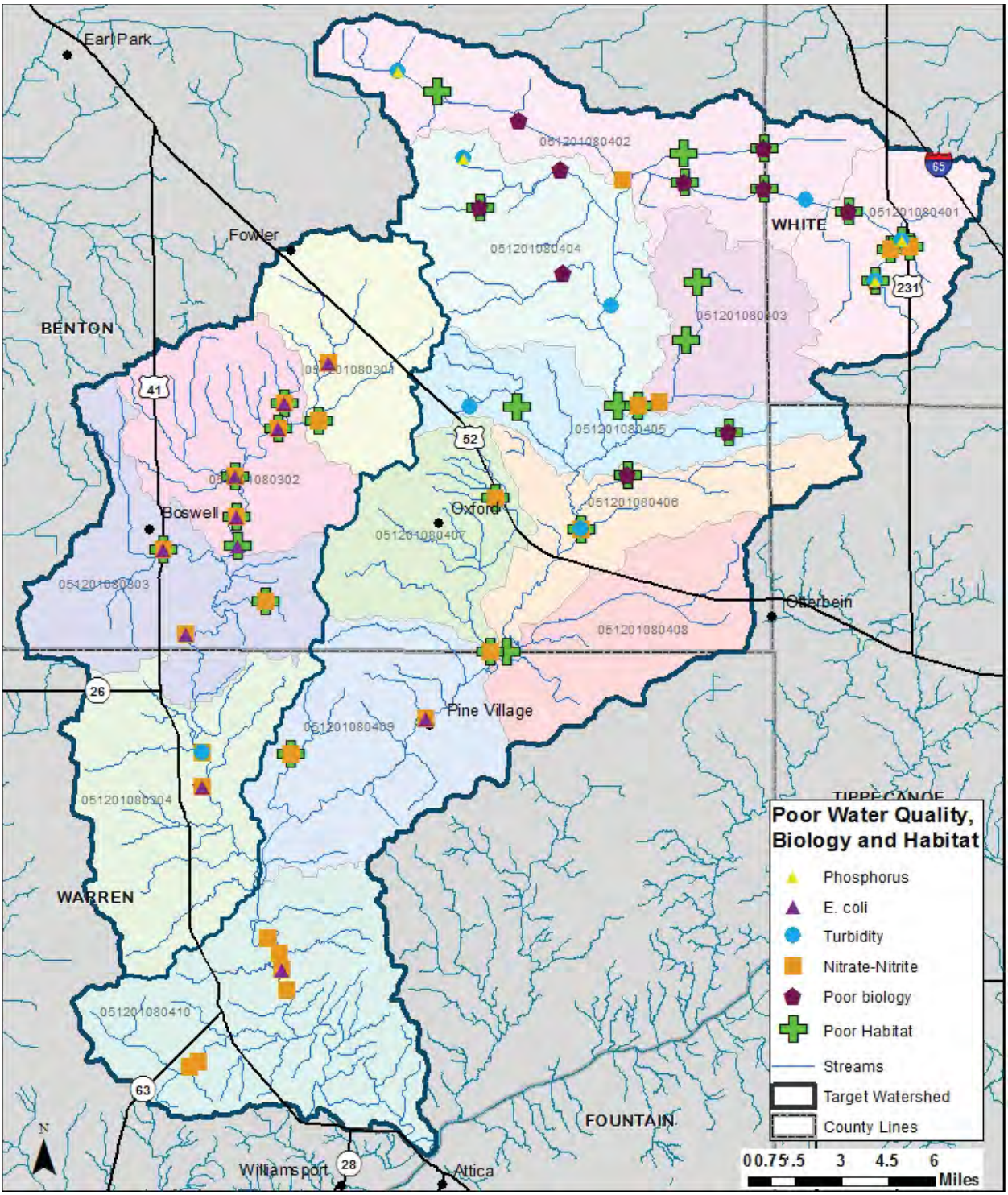

Figure 42. Sample sites with poor water quality, biological communities, and/or habitat (50% or more of samples collected during historic water quality monitoring were outside the target values shown in Table 17).
Data used to create this map are detailed in Appendix A.

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).

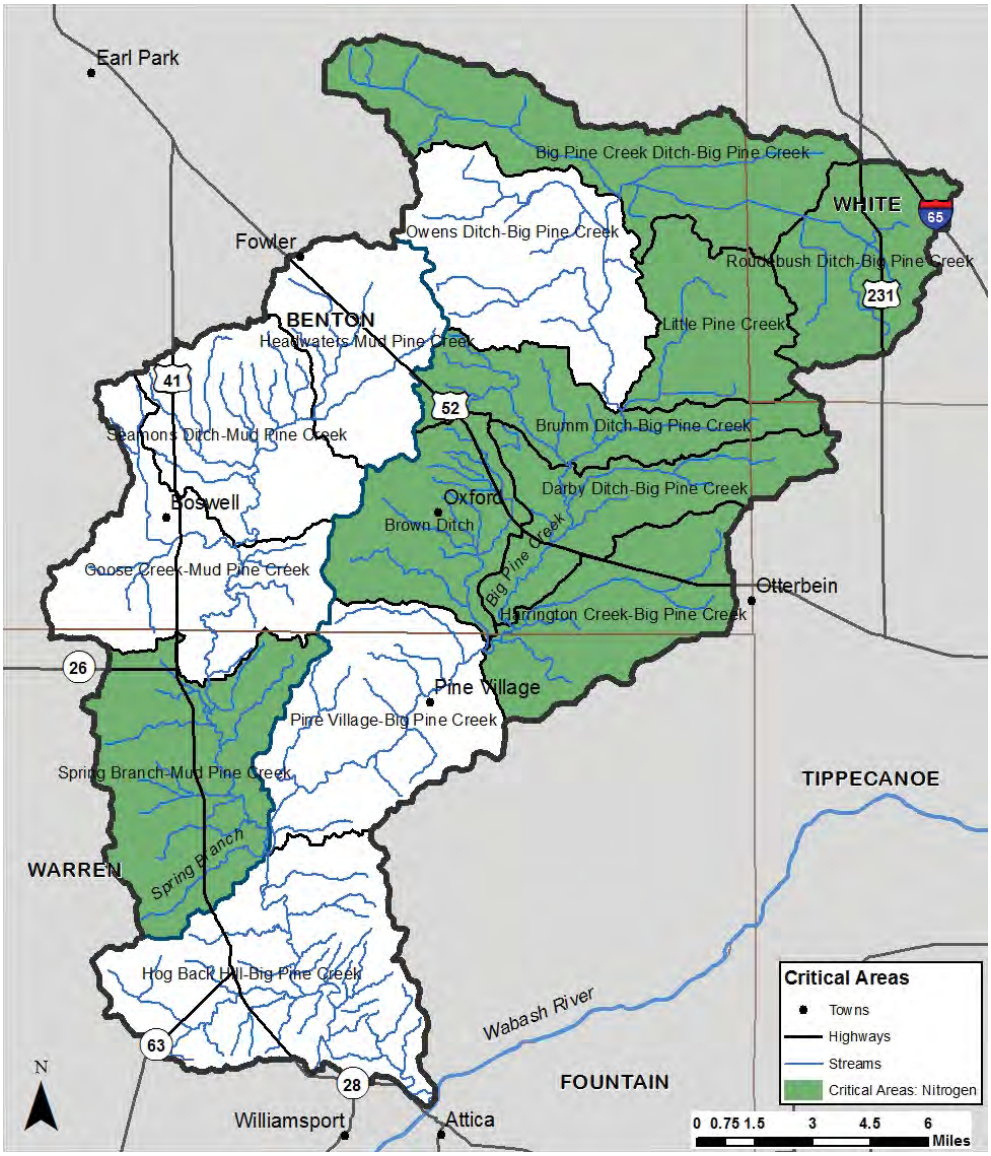

Figure 43. Critical areas for Nitrate-nitrogen in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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).

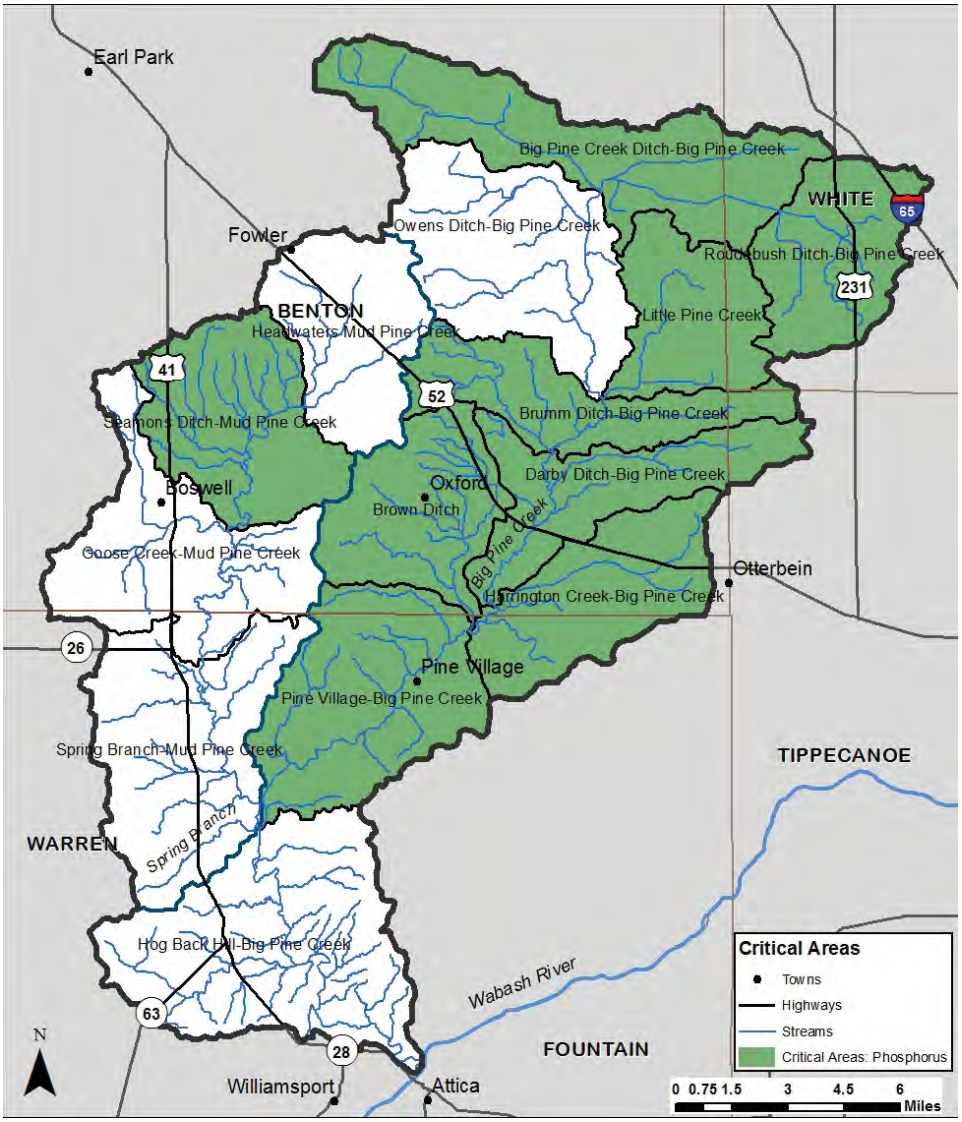

Figure 44. Critical areas for total phosphorus in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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).

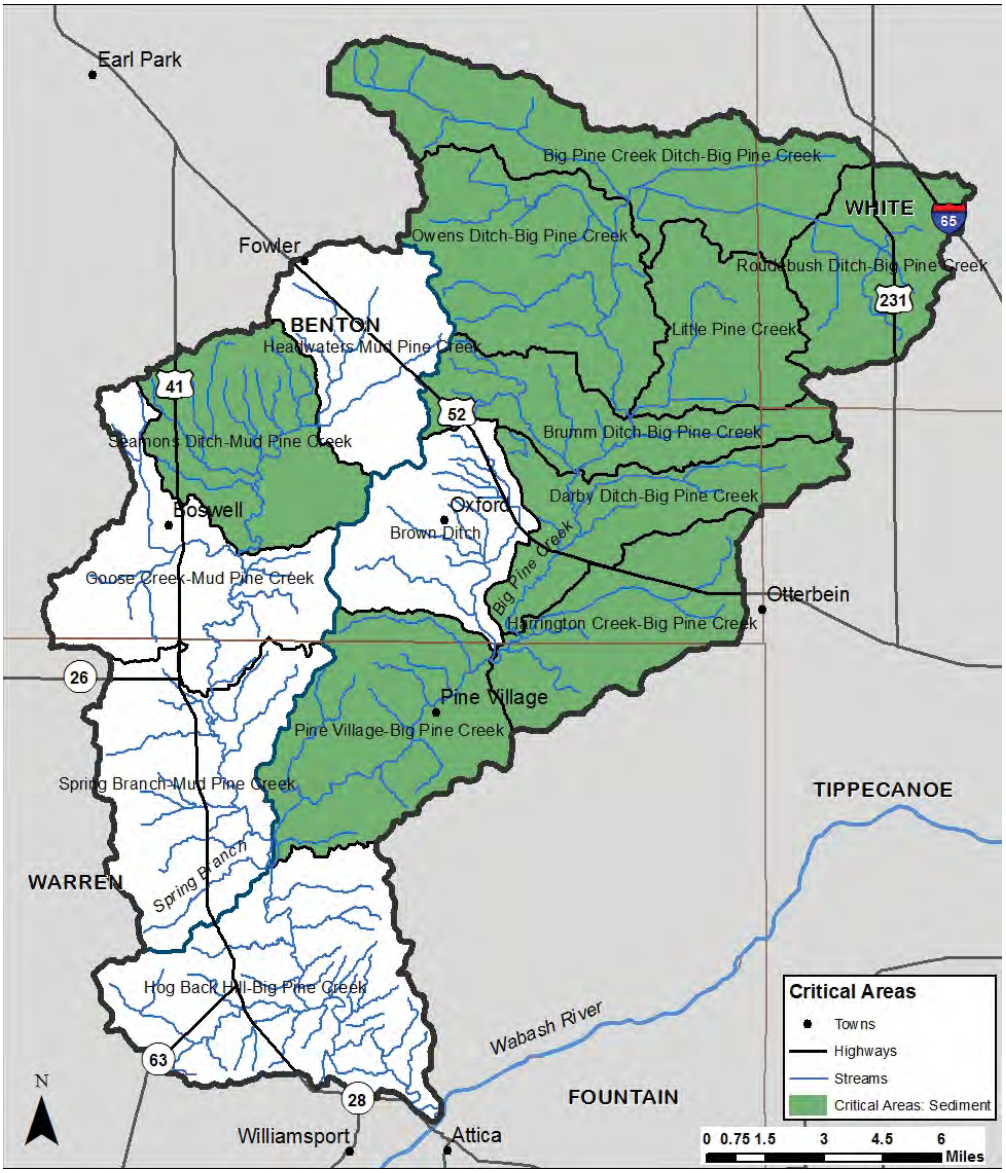

Figure 45. Critical areas for sediment in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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).

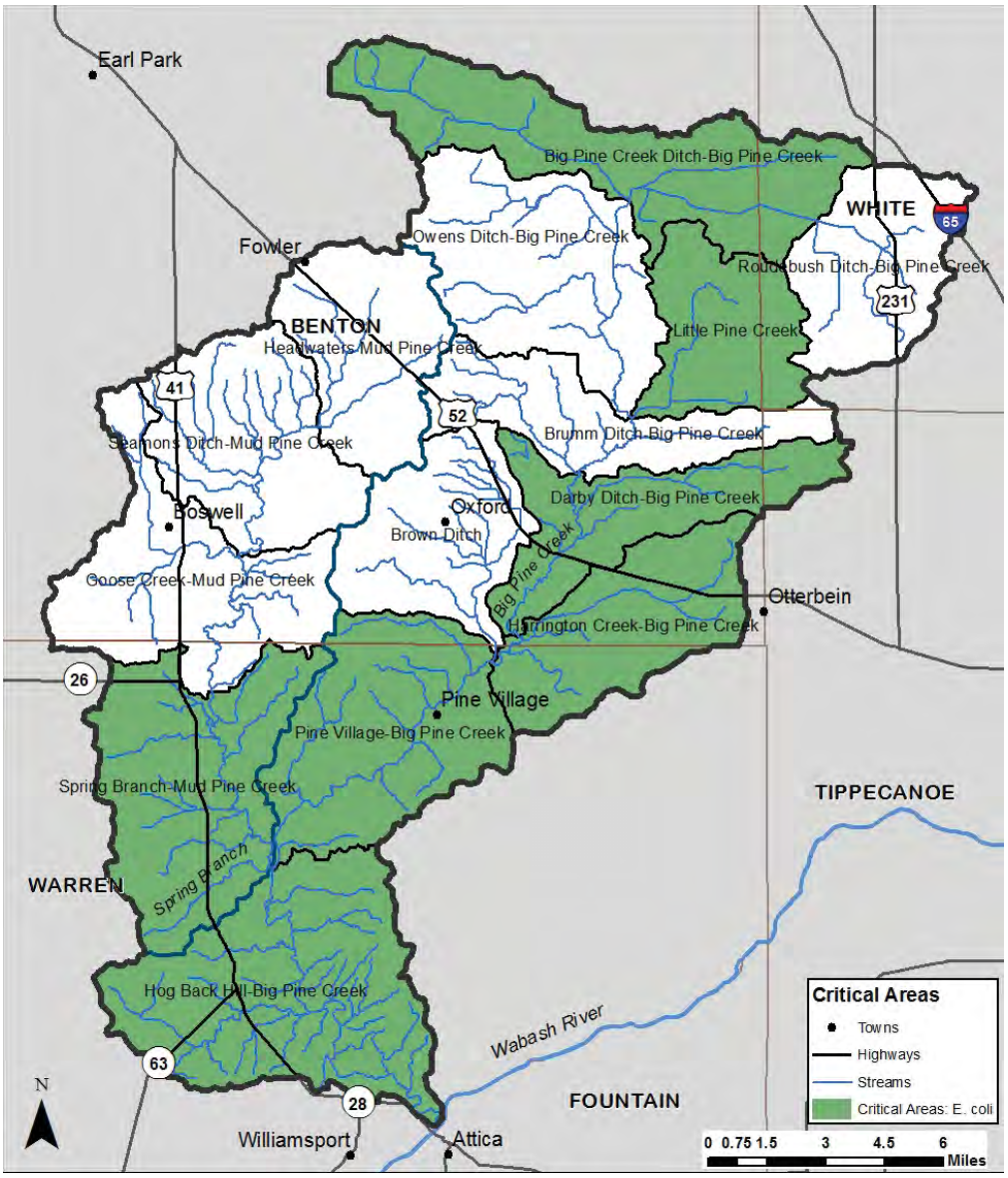

Figure 46. Critical areas for *E. coli* in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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).

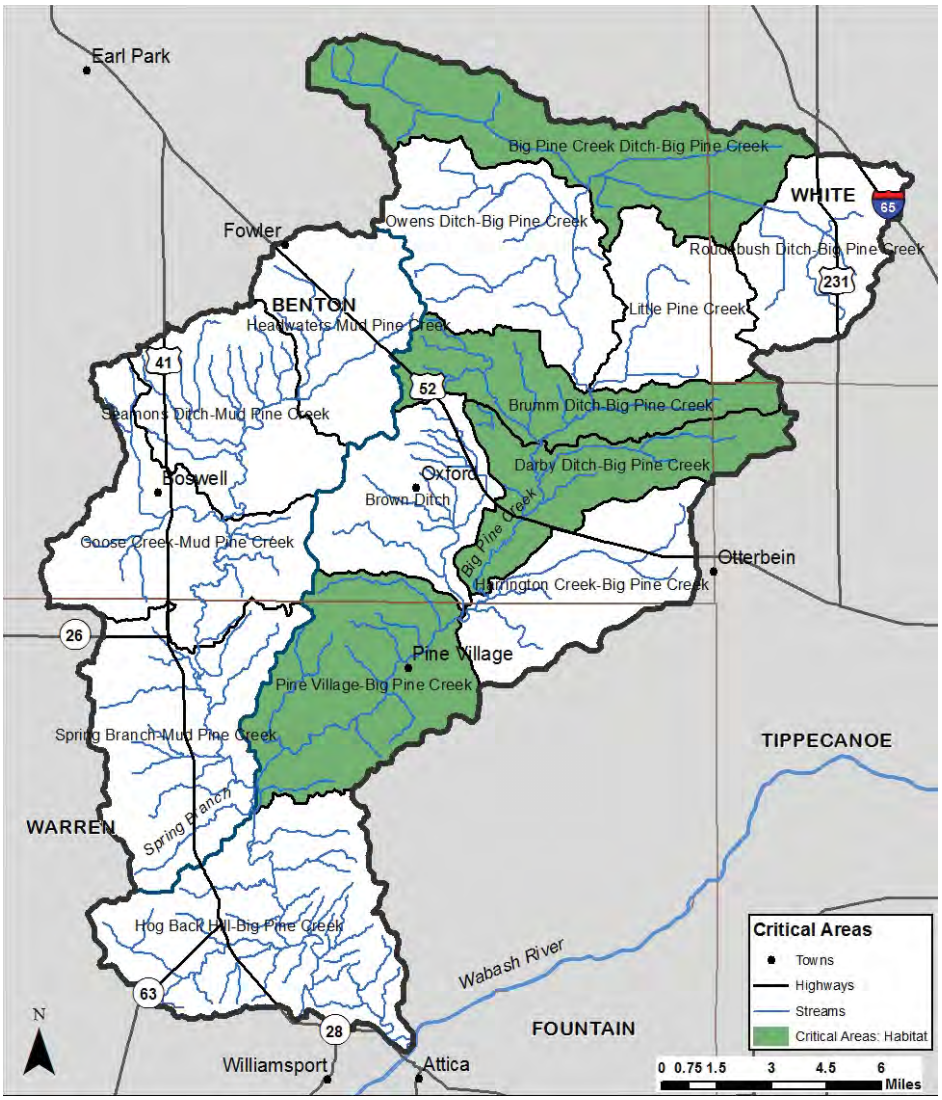

Figure 47. Critical areas for habitat in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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).

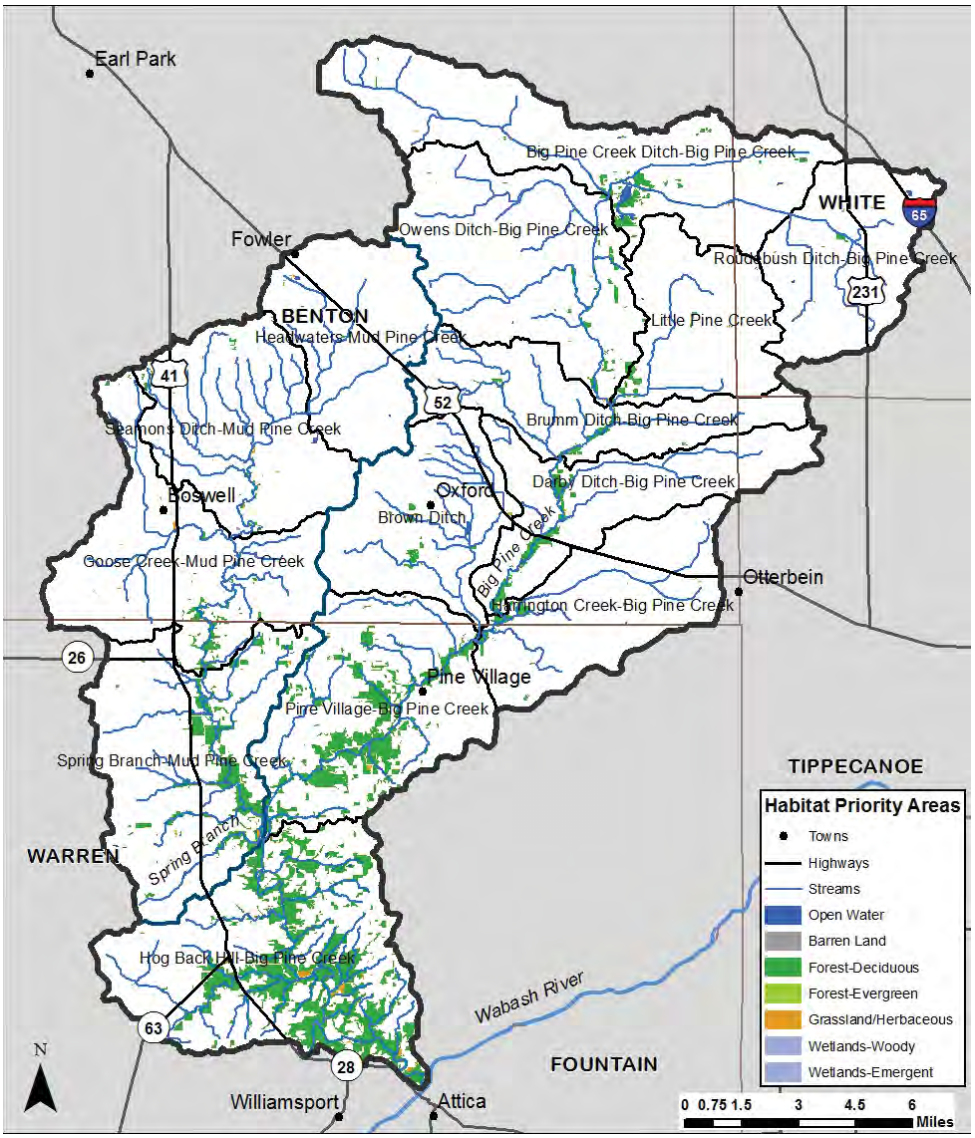

Figure 48. Priority areas for habitat protection in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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+

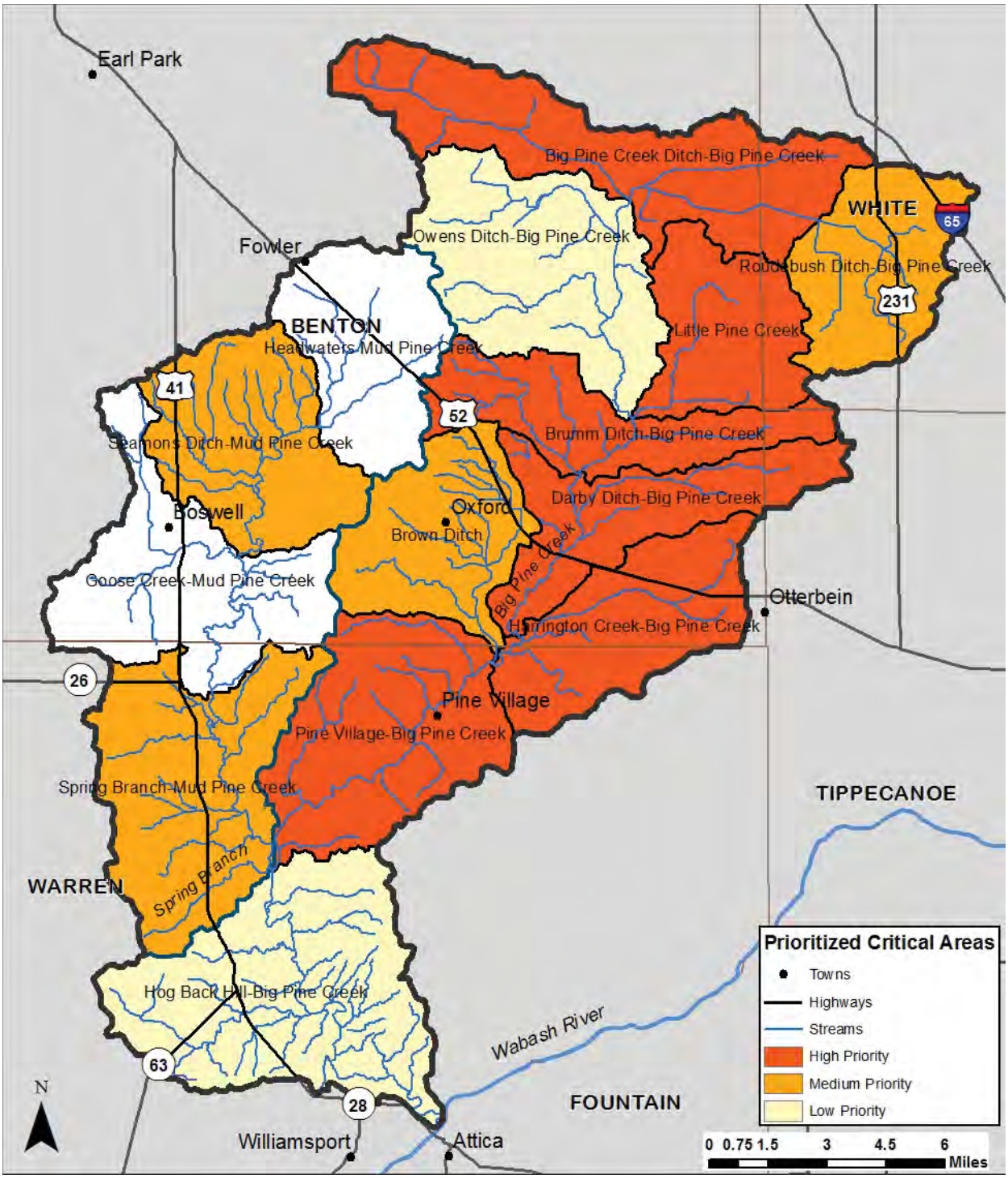

Figure 49. Prioritized Critical Areas.

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
High Priority: Big Pine Creek Ditch, Little Pine Creek, Brumm Ditch, Darby Ditch, Harrington Creek, Pine Village Medium Priority: 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
High Priority: Big Pine Creek Ditch, Little Pine Creek, Darby Ditch, Harrington Creek, Pine Village Medium Priority: 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
High Priority: Big Pine Creek Ditch, Brumm Ditch, Darby Ditch, Pine Village Medium Priority: 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.

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