VFC Index - Watershed (Plan)

Program: Watershed

IDEM Document Type: Plan

Document Date: 1/12/2015

Security Group: Public

Project Name: Plummer Creek WMP

Plan Type: Watershed Management Plan

HUC Code: 05120202 Lower White

Sponsor: Greene County SWCD

Contract #: 2-13

County: Greene

Cross Reference ID: 65283485

Comments: Monroe, Owen

Additional WMP Information

Checklist: 2009 Checklist

Grant type: 319

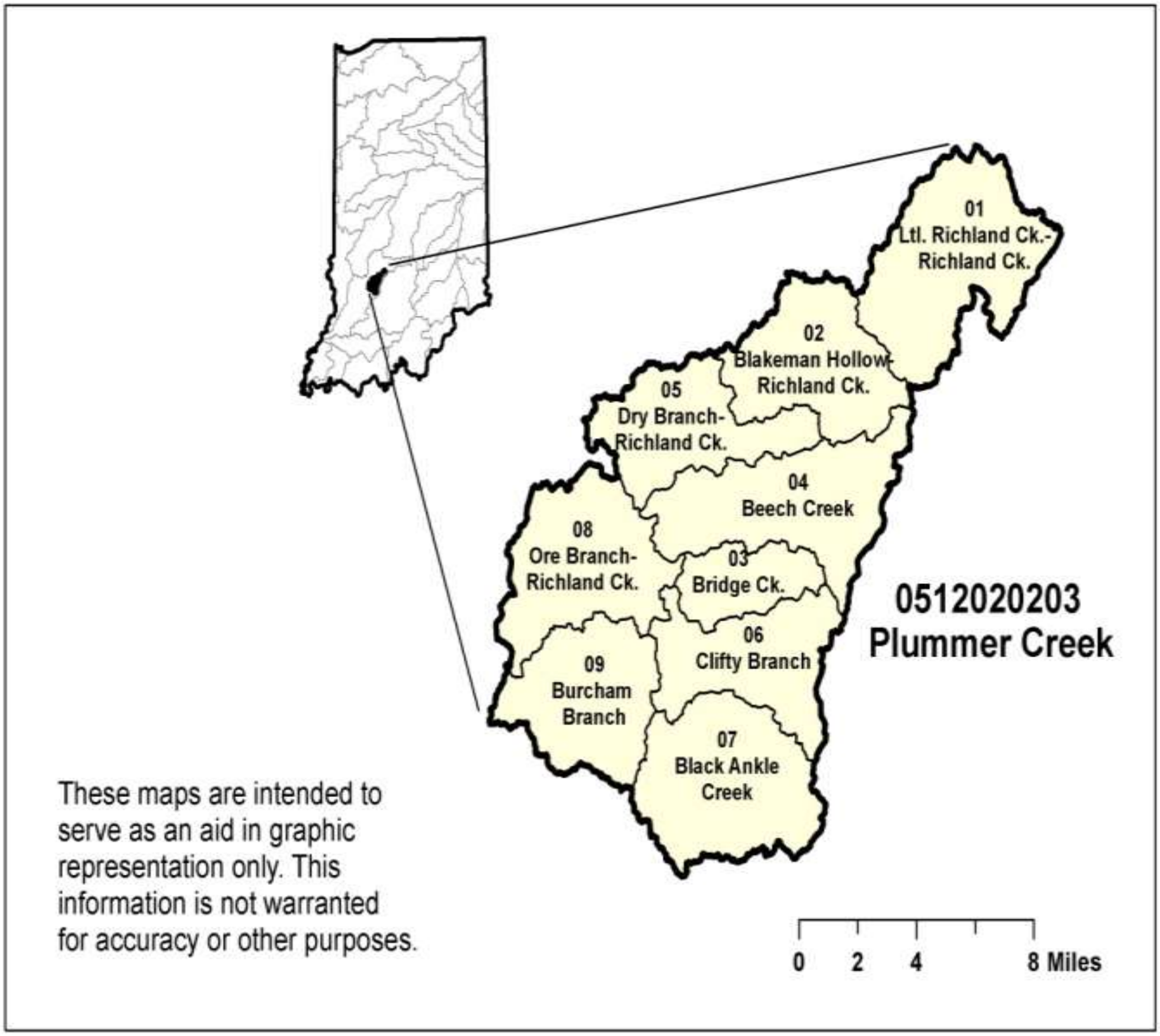
Fiscal Year: 2011

IDEM Approval Date: 1/12/2015

EPA Approval Date: 03/15/2016

Project Manager: Josh Brosmer

Plummer Creek Watershed Management Plan



Adam Grossman, Matthew Hanauer, & Ginger Korinek

Green County SWCD Watershed Coordinator Team

Table of Contents

Watershed Community Initiative

Residents and the Community of the Plummer Creek Watershed are interested in managing the local environment to protect the water resources for future generations. The Plummer Creek Watershed is a diverse and unique system within Indiana and should be maintained and improved for long-term enjoyment.

The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. The Environmental Protection Agency (EPA) is the federal entity that enforces the CWA. The 303(d) list is the record of impaired waters that the Clean Water Act requires all states to submit for EPA approval every two years. Some of the waters in the Plummer Creek watershed are considered impaired for recreation and aquatic life according to Indiana's 2012 303 (d) list. EPA defines impaired waters as any waterbody (i.e., stream reaches, lakes, waterbody segments) with chronic or recurring monitored violations of the applicable numeric and/or narrative water quality criteria. In Indiana, impaired waters do not meet water quality standards set by the State of Indiana for that water's designated uses. These water quality standards are set in Indiana Administrative Code 327 Article 2. Appropriate or designated uses are identified by taking into consideration the use and value of the water body for public water supply, for protection of fish, shellfish, and wildlife, and for recreational, agricultural, industrial, and navigational purposes.

Pollutant sources degrading the quality of the waters are considered either point or non-point sources. Point sources are discrete conveyances such as pipes or man-made ditches. Point source pollutants contaminate the ground or surface waters through discharges traced back to a specific source such as a factory or sewage treatment plant. Non-point source (NPS) pollution, on the other hand, is contamination of ground and surface waters from more wide spread sources. Soil particles, fertilizers, animal manure, pesticides, oil, road salt, fecal material from failing septic systems, pet waste, and debris from paved areas are transported over the landscape by storm run-off, snowmelt, and wind. Eventually entering streams, wetlands and lakes, or penetrating into ground water, these pollutants damage aquatic habitats, harm aquatic life, and reduce the capacity of water resources to be used for drinking water and recreation. Because NPS pollution does not come out of a pipe that is easily located, it has to be managed differently than facilities with site-specific permits. That is why so many of the measures directed at controlling NPS pollution are voluntary, and why so many people need to be involved. Point sources of discharge into waters are regulated under the National Pollutant Discharge Elimination System (NPDES) permit program. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. CWA Section 319 requires States to determine the nature, extent, and causes of water quality problems in various areas of the State and interstate region, and report on these annually. The federal Clean Water Act Section 319 provides funding for water quality management planning, which is then allocated by each state. Under Section 319, state, territories, and tribes receive grants to support a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific non-point source implementation projects.

Initiating the Project

The board, driven by Deborah Lynn the Greene County Soil and Water Conservation District's (SWCD) coordinator, decided in 2007 to pursue the 319 non-point source grant. They knew that there was a great need in the county for outreach, education, and implementation of best management practices (BMPs). The list of concerns that led them to initiate this grant included non-point source pollution, erosion, land management decisions, and stream obstructions such as logjams. It appeared that conservation monies in the future would be heavily tied to watershed management plans. If a county didn't have one, then that would speak loudly to both public and private agencies about the seriousness of the conservation work within the area. In 2009, they took a look at the four principal watersheds in Greene County. They noted that I-69 would be coming through the Plummer/ Richland Creek watershed on the eastside. Because of the enormity of that project and its probable potential effect on the watershed and those that live in it, the Board decided to write for a 319 grant for the Plummer Creek watershed. In appendix A, is a letter from the Greene County Soil and Water Conservation District Board giving a brief description of this initiation of the grant. Concerns raised by widespread construction of Interstate-69, as well as findings from earlier Total Maximum Daily Load reports by the Indiana Department of Environmental Management (IDEM) and concerns voiced by residents of the area convinced the board to apply for the grant. The Plummer Creek Watershed, which includes Richland Creek, is the largest watershed in the county. It has many impaired waterways, prohibiting citizens from having safe interaction with the waterways, for recreation or any other purpose. Greene County SWCD was concerned that waters within the watershed may be unsafe due to the water quality impairments listed on the 303 (d) list. Specifically, twelve stream segments are listed as impaired on the 2010 303(d) list due to unacceptable levels of Escherichia coli (E. coli). This list also includes one segments in the watershed that has impaired biotic communities, one with PCBs in fish tissue above state standards, and five segments with total mercury in fish tissue above state standards. The SWCD Board's personal knowledge of the area also contributed to a desire for improved water quality and led to the decision to work together with Monroe and Owen County SWCDs to help alleviate the problem any way they could.

The Plummer Creek watershed is the largest 10-digit watershed in Greene County and has been brought into light from a conservation standpoint because of construction of the extended interstate highway 69 that will run from Indianapolis all the way to Evansville in Southwestern Indiana. The watershed covers 110,946 acres of which 97,475 acres is within Eastern Greene County, 13,038 acres is within Monroe County, and the remaining 433 acres is in Owen County.

Stakeholders

Stakeholder involvement is an involved and ongoing process. A stakeholders meeting was held within a few months of receiving a 319 grant and initiating the program to accumulate concerns and figure out where we stood as a community. From this initial meeting, we learned that promotion of the grant, and education was needed. During and after this meeting we reached out to individuals and tried to generate interest in becoming advisory committee member for the program in the effort to develop a watershed plan. We used such tools as, media, flyers, phone calls, and good old fashioned talking to spark interest and educate the community. The Plumber Creek Advisory Committee (PCAC) grew over time, see Table 1, and became a core group that advised and directed the formation of the watershed management plan. Once the advisory committee members were established, we put together the below list of concerns from the citizens (Table 2). Concerns were gathered especially during the first three meetings of the PCAC, where members and visitors voiced concerns from themselves, their families, and neighbors they had talked to. Additional concerns were emailed to the watershed coordinator once news of this project and desire for public input was initiated in the community. The list of concerns has been updated and amended as new members joined or as new concerns presented themselves. Not all concerns are necessarily nonpoint source issues but all are concerns of stakeholders and all will receive equal consideration. However, only concerns that are nonpoint source in origin can be focused on for 319 funding so additional concerns will be considered with resources outside of the 319 grant funding programs.

Steering Committee Members

Table 1: Advisory Committee Members for Plummer Creek

Matthew Hanauer	Watershed Coordinator
Josh Brosmer	IDEM
Steven Crowe	Board Chair
Adam Grossman	Watershed Coordinator (Former)
Rita Sharr	Board Secretary-Resident (Greene County)
Randy Koenig	Board Member
Cheri Cupa	Horse Owner-Resident (Greene County)
David Britton	Farmer (Greene County)-Resident
Kate Hamblin	Baxter
Jacqueline Whaley	Cattle Owner-Resident (Greene County)
Kermit E. Holtsclaw	County Commissioner-Resident (Greene County)
Bill Fuller	Crop Production Service
Charles Britton	Farmer-Resident (Greene County)
Paul J. Trampke	Jackson Township Trustee- Resident (Greene Co)
April McKay	Student-Resident (Greene County) S.L.G. member
Laura Young Demarest	Watershed Coordinator (Sullivan County)
Martha Miller	Monroe County SWCD-Resident (Greene County)
Malea Huffman	Purdue Ext.-Resident (Greene County)
Regan Holtsclaw	Student-S.L.G. member
Ed Paynter	Master Gardener-Resident (Greene County)
Diana O'Brien	Resident (Greene County)
Sean O'Brien	Resident (Greene County)

Stakeholder Concerns

Table 2: Stakeholder Concerns Listed at the First Meeting

E. coli	Livestock in Streams	Stream Bank Erosion	Flooding
Manicured Lawns	PCB's in the Stream	Obstructions in Streams	Overgrazing
Septic Systems	Invasive Species	Development & Green space	Mowing Stream Edges
Construction	Agricultural Application	Lack of Education	Fishing
Ditch Digging Practices	Public Awareness	Arsenic in Streams	Better Incentive Programs
Disposal of Carcasses	Water Flow Management	Meth Lab Contamination	Prescription Med Disposal
Salinity & Road Salt	Turkey Farms	Logging Practices	Disposal of Garbage

Rankings & Categories

The first meetings for the Plummer Creek watershed stakeholders and PCAC led to a list of concerns seen in Table 2 above. These concerns were wide views by various interested parties, but an overall direction for the project needed to be established and direction given so that progress towards common goals could be met. As discussions continued at initial meetings priorities for the watershed emerged. The concerns naturally fit into categories including waste management, land management, chemical contamination, erosion, nutrient management, invasive species control, and improved recreation and tourism. The top priority in the watershed overwhelmingly became the need for better waste management. This category and concerns within the categories was given top ranking (1), other categories of concerns were then determined and given subsequent ranking determined by the stakeholders. Below are those categories, their rankings from high (1) to low (7), and the associated concerns that fit into each category. Some concerns may not intuitively fit into some categories, but will be explained here. For instance flooding, obstructions in creek, and management of water flow are all within the erosion category. Flooding really does affect more than one category. For instance it can be in the category Chemical Contamination with the major flow across all surfaces it is easy to wash away all kinds of chemicals that may be on surfaces of roads, fields, or any other lands. However, it seems in our watershed to fit better into erosion, because when we have major rainfall events water is running off of surfaces at a fast rate carrying soils and sediments to our man made ditches and other drainage. These ditches and other drainage will quickly convey that water to the streams, creeks, and branches of the watershed. This quick flow often will take out stream banks, ditch banks, and other steep areas that have little vegetation to hold in the sediments and prevent erosion. Likewise when we have obstructions in the creek these fast waters will erode around the obstructions causing stream bank erosion. Lastly, if we could manage the amount and speed of flow in man-made drainage ditches we could have a chance to lessen the effects of flooding and erosion. This quick flow to our streams and ditches is not allowed to store within the watershed and instead is quickly conveyed to the main branches which ultimately causes flooding and further erosion of the main banks.

List of Concerns

Waste Management: (1)

- High E. coli Levels in Streams
- Failing or Non-Existent Septic Systems (including straight pipes to streams, ditches, and sinkholes)
- Arsenic (turkey farms)
- Lack of Financial Assistance for Septic System Improvements
- Lack of Proper Disposal of Dead Animals
- Lack of Proper Disposal of Garbage
- Lack of Public Awareness & Education

Land Management: (2)

- Mowing up to Stream Edge
- Overgrazing & Grazing along Streams
- Lack of Better Incentives for Land Management
- Stream Bank Filter Strips
- Logging Practices
- Road-Side Ditch Digging Practices
- Sediment Control on Construction Sites
- Public Awareness & Education

Chemical Contamination: **(3)**

- Salinity from Winter Salt Application
- PCB's/ Mercury
- Disposal of Meth Lab Toxins
- Disposal of Prescription Drugs
- Public Awareness & Education

Erosion: (4)

- Stream Bank Erosion
- Flooding
- Obstructions in Streams
- Livestock in Streams
- Management of Water Flow
- Better Land Planning and Erosion Control
- Public Awareness & Education

Nutrient Management: (5)

- Manicured Lawns
- Increased Lawn Sizes
- Agricultural Applications (Fertilizers and Manure)
- Public Awareness & Education

Invasive species control: (6)

- Invasive Species in Wood Lots and Streams
- Cost-effective Invasive Species Treatment
- Education for Invasive Species Treatment
- Public Awareness & Education

Recreation/Tourism: (7)

- Reduced Fishing
- Reduced Water Recreation

Inventory Part 1

Geology

The Plummer Creek watershed (PCW) is mostly in the part of Indiana left untouched by glaciation. The Illinoisan glacier ended in the west side of the watershed, leaving any sediment it carried here. The east side of the watershed consists of mostly limestone, sandstone, and shale bedrock from the Mississippian and Pennsylvanian periods, or about 350 to 285 million years ago. This combination of bedrock types produced several areas of karst formation and sinkholes in the eastern and southern portions of the watershed. Caves and other conduits are associated with karst landscapes.

Karst is a landscape formed from chemical erosion as the dissolution of softer rock types, such as limestone, dolomite, and gypsum. Karst topography plays a big role in water quality. In many karst aquifers a large percentage of the water that is stored underground is perched, or suspended, above the main part of the aquifer in the "epikarst." The epikarst, or "upon the karst", is the uppermost weathered zone of carbonate rock between the lower bedrock and the topsoil. The water in the epikarst is stored in enlarged joints and bedding planes, spaces around pieces of float (rocks that have been detached from the bedrock), porosity within residual chert rubble, and the smaller conduits in the bedrock. Sinkholes are a reflection of the development of the epikarst. Sinkholes are often sites of active transport of contaminants, insoluble sediment, and dissolved rock into the subsurface. Epikarst is of concern in the area due to its ability to hold contaminants within the fractures, only to release a portion of the contaminants during the next rain event. It has been seen that epikarst can hold contaminants for long periods, slowly re-releasing them over subsequent rains (Talarovich and Krothe, 2008). Sinkholes throughout the karst portions of the watershed have been known to be used as dump sites. Karst topography with its sinkholes, epikarst, and sinking streams make water more susceptible to non-point source pollution. Surface water is rapidly channeled into the subsurface in karst landscapes via sinkholes without the benefit of extensive filtration or exposure to sunlight which reduces bacteria. Landowners near a karst area must be diligent in well testing; there is little opportunity for filtration in such sinkholes that give direct access to the water table. The community needs to keep in mind that karst areas give pollutants a fast easy way to enter vital water supplies and should be taken into special consideration.

The American Bottoms is an area mostly contained within the Bridge Creek subwatershed. It is 5200 acres of karst formed in limestone. The limestone making up the majority of this region is Beech Creek limestone and is "frequently locally quite completely oolitic" according to Malott (1919) in his book for Indiana University. Oolitic means that there are tiny formations on the surface of the limestone formed from calcite deposits, forming small "bumps" varying from 0.25-2 mm in diameter. The American Bottoms are uniquely formed from the triangular unglaciated portion of southern Indiana. Since the melting of the final glaciers in the area, water has carved underground passages through the limestone in order to reach and join with larger streams to the west.

Topography

The topography in the watershed is much different from its counterpart in Western Greene County. It has many rolling hills and low lying areas with sloping pasture lands in-between. The major creeks within the watershed carve through these hills in the Northeast toward the White River in the Southwestern corner just south of Bloomfield. Map 1 shows the topography of the area and indicates where relief is the highest. In the image, high elevations are indicated with warm tones like reds and oranges. Meanwhile, cool colors are used for lower elevations. The high in the watershed occurs just north of the western border of Bloomington town limit in the watershed at 994 feet. The low elevation occurs at the outlet at 478 feet. This means there is an overall relief of 516 feet.

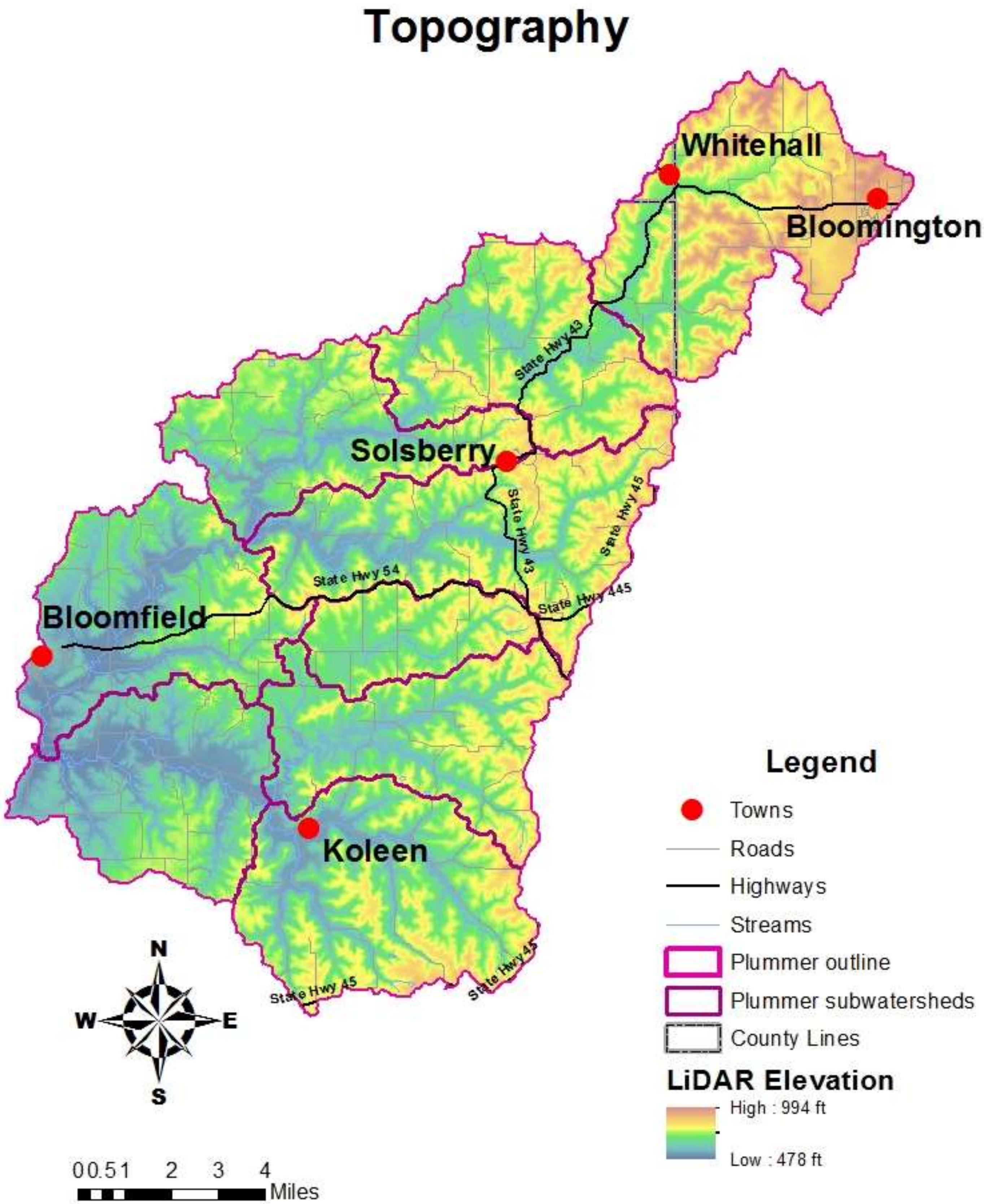
The watershed starts in the Mitchell Plateau in Monroe County. The Mitchell Plateau is characterized by relatively low relief that is pockmarked by sinkholes and underlain by extensive cave systems. Sinkholes are a typical topographic feature in this area. The majority of the watershed is within the Crawford Upland which is uplands due to the underlying sandstone and is characterized by high relief with incised channels. The watershed outlet lies within the Wabash lowland which is characterized by lowlands topography.

Portions of the PCW are being altered to accommodate expansion of Interstate 69 (I-69) northward toward Indianapolis. Some rolling hills in this area are being flattened while other hills are being created as needed by the construction crews. Trees are being removed, the land is being shifted and mitigation sites are being created to help offset damage done to the environment, see Map 6 for presently impacted areas and mitigation sites. Wetland areas and stream restoration projects are among these projects, though there is significant sedimentation of nearby streams occurring around construction sites.

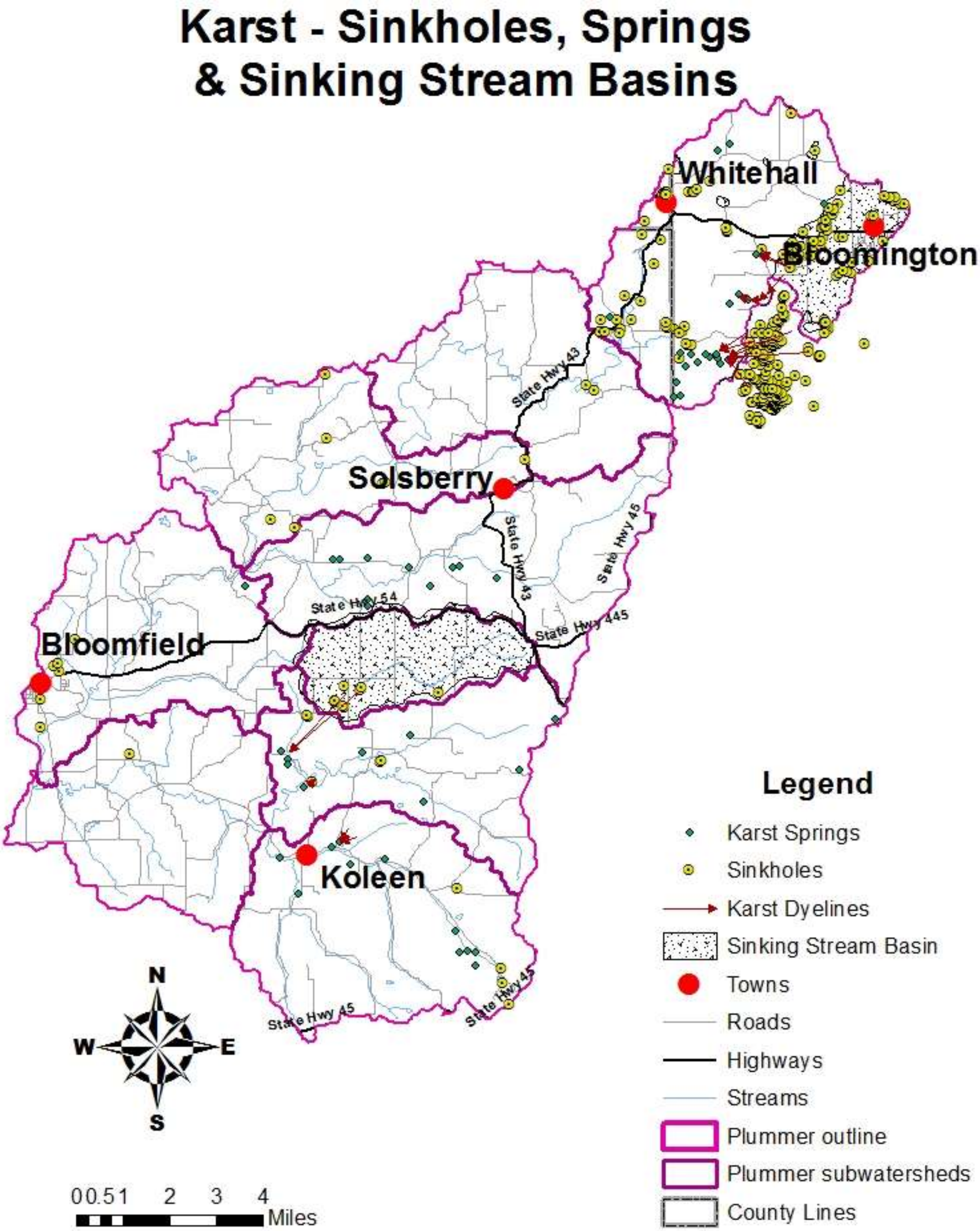
Topography itself can affect water quality. The hillsides of the Crawford upland, if unprotected, can cause erosion issues throughout the watershed. There are many places in the area that are prone to washouts and erosion, which can cause the additional flushing of pollutants quickly into tributaries and streams. Things like terracing, filter strips, contour strips may be considered to help with these possible issues. The county Highway department has been very helpful in the initial stages of trying to help maintain our ditches and roadways. These are in poor condition in many areas, and with the steep inclines, this makes it vital to have proper ditching techniques and roadway management. A lesser slope has been advised to the local county officials; they have been receptive and are taking it into consideration. Also, seeding after ditching would be a great practice to start, this is an area to find funding, as the county funds like all others, are lacking.

Drainage is also affected by the landscape. Because of the steep topography in the area, erosion and deposition are common effects of heavy runoff. Streams also are cutting close to banks causing further bank erosion as are ditches along roadsides that are often not connected. Runoff from road surfaces create rilles with heavy erosion cutting downhill to the nearest streams. This causes unnecessary erosion and encourages washouts. The implementation of proper ditch management throughout the county would aid in this. Assisting Greene County with development of a low impact ditch management program will be crucial to help reduce sedimentation of local streams. Funding of BMPs to local landowners along these areas with high erosion is a priority, but this assistance will also be necessary for reduction of impervious surface runoff causing erosion of hillside sediments.

Map 1: Topography of the PCW



Map 2: Karst Area and Springs



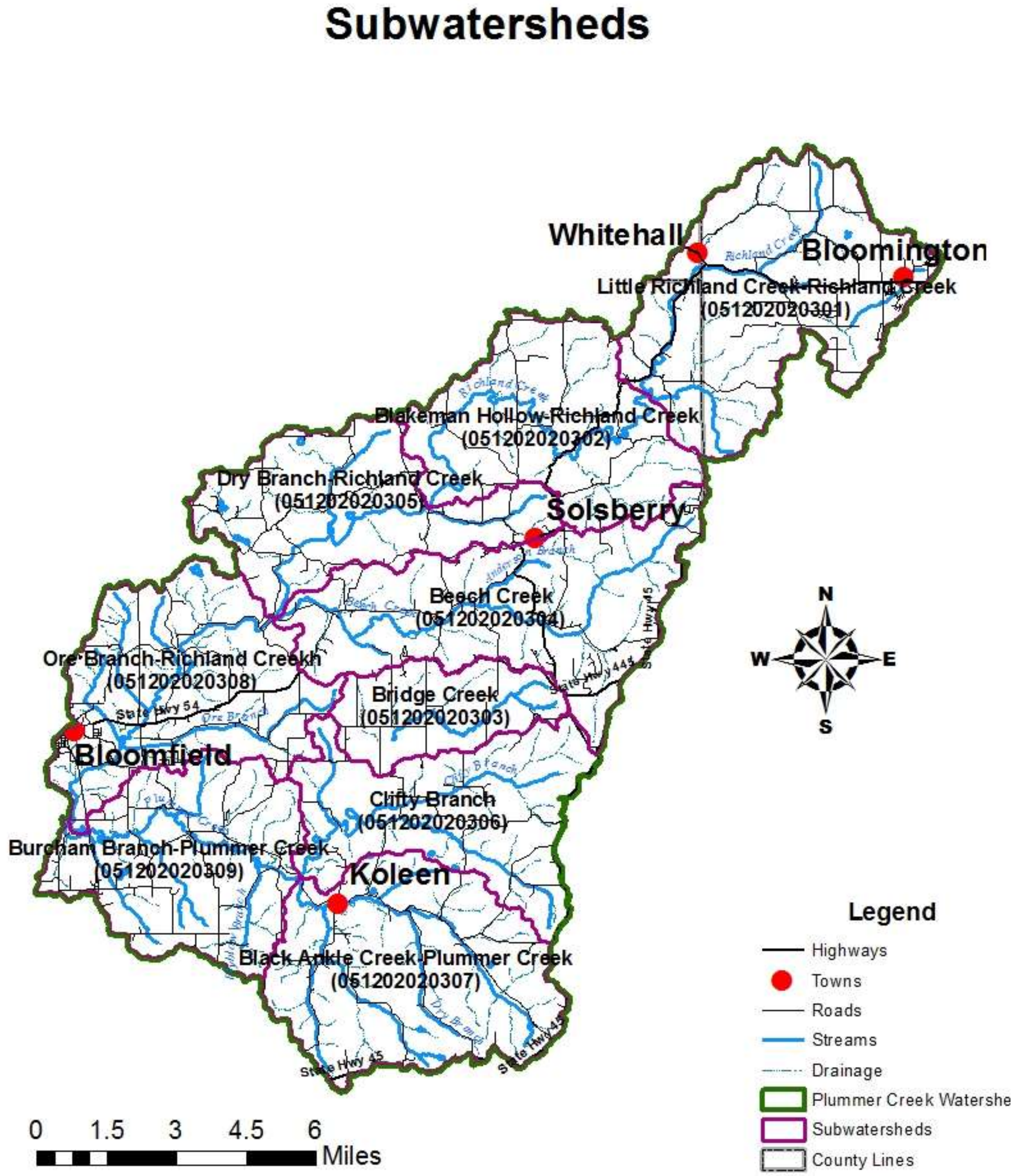
As we can see in Map 2, the karst areas are developed in the eastern side of the watershed. This makes management of the area much different. The American Bottoms can be seen as the large sinking stream basin in the middle of the map and encompasses all of Bridge Creek sub watershed. Located approximately 8 miles east of the Bloomfield, this 5200-acre area is one of the most unique geological features in Indiana. The American Bottoms Area is a large watershed basin surrounded by bluffs and ridges on three sides formed by a pre-glacier trench, which consists of approximately 100 feet of gravel, sand, and silt. What makes the area unique is that it has no surface drainage out of it, but instead utilizes two porous types of stones, Sandstone and Beech Creek Limestone to provide a natural drainage system known as the "Swallow Hole". Four special conditions were put together to form this unusual geological event: (1) rock was exposed, (2) several uplifts with intervening short periods of stability, (3) glaciers on two sides of the area, and (4) the last the main drainage flow toward the west or south. While Bridge Creek drains directly into the American Bottoms Area, the water travels underground day-lighting at a spring draining from a rock bluff (also known as Rock Springs) near Koleen and then continuing its journey toward Richland Creek.

Karst landscape occurs throughout many sub watersheds within Plummer Creek watershed. Many springs and sinkholes are present throughout the watershed, but many are not listed, as many are not documented. Surface water is rapidly channeled into the subsurface in the karst landscapes via sinkholes without the benefit of extensive filtration or exposure to sunlight, which reduces contaminants. Groundwater is easily contaminated before reemerging as springs. The underground caverns can also be habitat for some very unusual and rare species and special consideration should be given to these landscapes. Dye tracing has been done in many of the sinking streams in the area. These dye traces show where water that sinks below the landscape reemerges as springs. Many of the springs in the watershed are actually gaining waters from other watersheds in the area. Near Bloomington, in the Indian Creek Watershed water that drains into sinks or sinkholes is directed to the Plummer Creek watershed through underground conduits. This can be seen in Map 2, the direction of dye trace lines starts at the water drain point and the arrow points to the springs that the water reemerges from.

Hydrology

The PCW is made of two major streams, Richland Creek to the north, and Plummer Creek to the south. Plummer Creek begins in southeast Greene County and flows west until it discharges into the lower West Fork of the White River. Plummer Creek starts flowing in a northwest direction where an unnamed tributary joins it from the north and then Dry Branch joins from the south. Plummer Creek then turns slightly to flow in a more westerly direction and then is connected to Black Ankle Creek on the south side. Plummer Creek then takes a sharp turn to flow north and then turns again to flow west, where Clifty Branch joins the creek from the north side. Flowing northwest, Flyblow Branch connects to Plummer Creek from the south and then Letsinger Branch joins from the north. Plummer Creek then turns to flow to the southwest briefly and then turns to flow in a westerly direction. Here Plummer Creek is joined by Burcham Branch and then another unnamed tributary, both from the south. Plummer Creek then is joined with Richland Creek from the north before discharging into the lower West Fork of the White River.

Map 3: The PCW and Its Sub watersheds



Map 4A: Impaired Streams (E.coli)

Map 4B: Impaired Streams (Non-E. coli Impairments)

Nearly every stream that is impaired in the watershed is impaired for E. coli. Some streams have Fish Consumption Advisories (FCA) for PCBs and Mercury. Some streams in addition to E.coli impairments also have impaired biotic communities according to the TMDL. Table 7 lists the streams and their impairments that are currently on the 303 (d) list. Tables 5 and 6 are the TMDL listed streams and their impairments on the 1998, 2002, and 2004 303(d) list. See additional Efforts section for more information on these streams.

Table 3: Quantities

Total Stream Miles	148.6 Miles
Total Wetland Acres	1,384.6 acres
Lake numbers and acres	There are many small farm ponds, and no big lakes. Estimated to be about 100 acres.
Total Stream Miles	148.6 miles
Ditches	Unknown

Richland Creek watershed ranges over three counties; 80.20 % of the watershed is in Greene County, 19.20 % is in Monroe County, and 0.60 % is in Owen County. Richland Creek begins in western Monroe County and flows southwest, briefly flowing into Owen County before entering the northeast corner of Greene County. Little Richland Creek flows west from Monroe County into the northern part of Greene County and into Richland Creek. Beech Creek originates in eastern Greene County and flows into Richland Creek in the northeast corner of Greene County. Ore Branch flows to the west to connect with Richland Creek south of Beech Creek. The Ore Branch Tributary flows to the east and connects with Richland Creek just north of Ore Branch. Ritter Branch flows east to connect with Richland Creek opposite of Ore Branch.

Some streams in the area are used by the public for fishing and canoeing. There are also a couple smaller lakes, or private reservoirs, shown on Map 5 in the watershed, but public access to these is limited. Unfortunately, most of the streams in the Plummer Creek Watershed (PCW) have Fish Consumption Advisories (FCAs) for PCBs and Mercury, limiting this activity greatly and creating a prominent stakeholder concern. Fishing and PCBs were listed in stakeholder concerns as well, meaning that this is a known issue and that people would like to resolve if possible. Another public use that is developing is wetlands. There are many mitigation sites from interstate 69 (I-69) (Map 6) and other programs that are developing wetlands throughout the watershed. This has been dubbed, “Little Goose Pond” after the Goose Pond Fish and Wildlife Area in western Greene County. This could play a vital role in public access and involvement in the area and may help ease minds about the massive amounts of construction associated with this project, making it a stakeholder concern. The Goose Pond area that has already been established as a tourist attraction bringing hunters and bird watchers from around the state.

Wetlands & Lakes

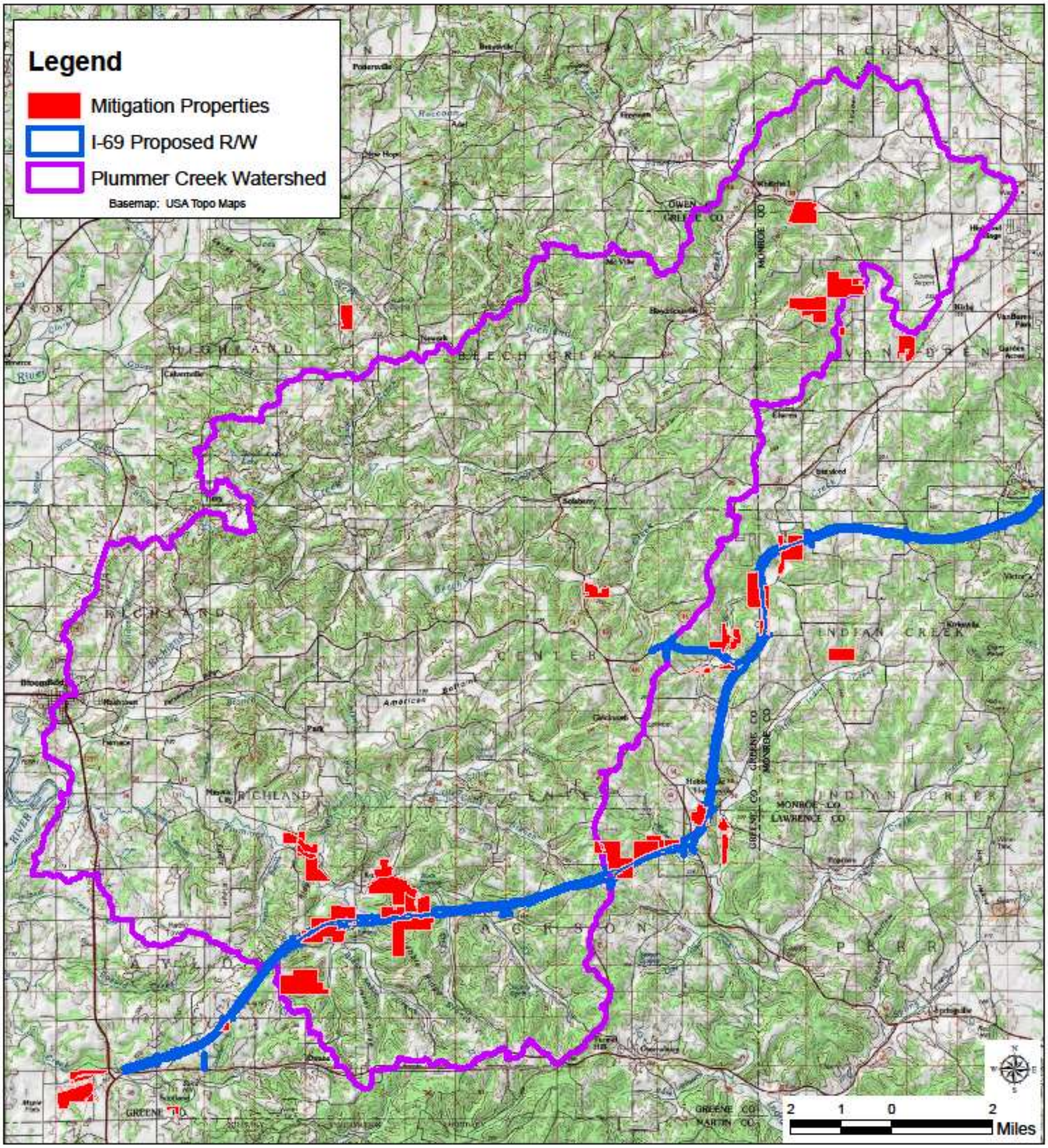
There are no legal drains in this particular watershed at this time. There are no major lakes to speak of in the watershed, although there are many farm ponds and small impoundments. These are usually used as watering facilities for livestock and some of the larger areas may be used for some recreational fishing. Wetland areas are sporadic around the area, with 1,354.7 acres of wetland area in the Greene County portion of the watershed, 26.1 acres in Monroe, and 3.8 acres in Owen on paper. These help drain approximately 41.85 square miles in Greene County. As you can see from Map 5, ponds are few and far between while wetlands are more numerous, though still not abundant.

The I-69 project has been creating several wetland areas within the watershed as mitigation sites (Map 6). These wetlands are expected to be used as sites for wildlife refuge and perhaps some recreational hunting and fishing. Mitigations sites also include added meanders to streams. Years ago, farmers straightened streams to make clearer field distinctions. Now we know that a straight stream isn't as healthy as one that meanders, slowing the water and reducing erosion and creating better habitat as well. At least one area of Plummer Creek had this done in 2012. As you can see from the map, a large cluster of mitigation sites are around the Plummer Creek area in the southern portion of the watershed. There are also mitigation sites near Beech Creek in the central area and Little Richland and the origin of Richland Creek in the northeast.

Map 5: Wetlands and Water Bodies

Map 6: I-69 Mitigation Sites

Plummer Creek Watershed

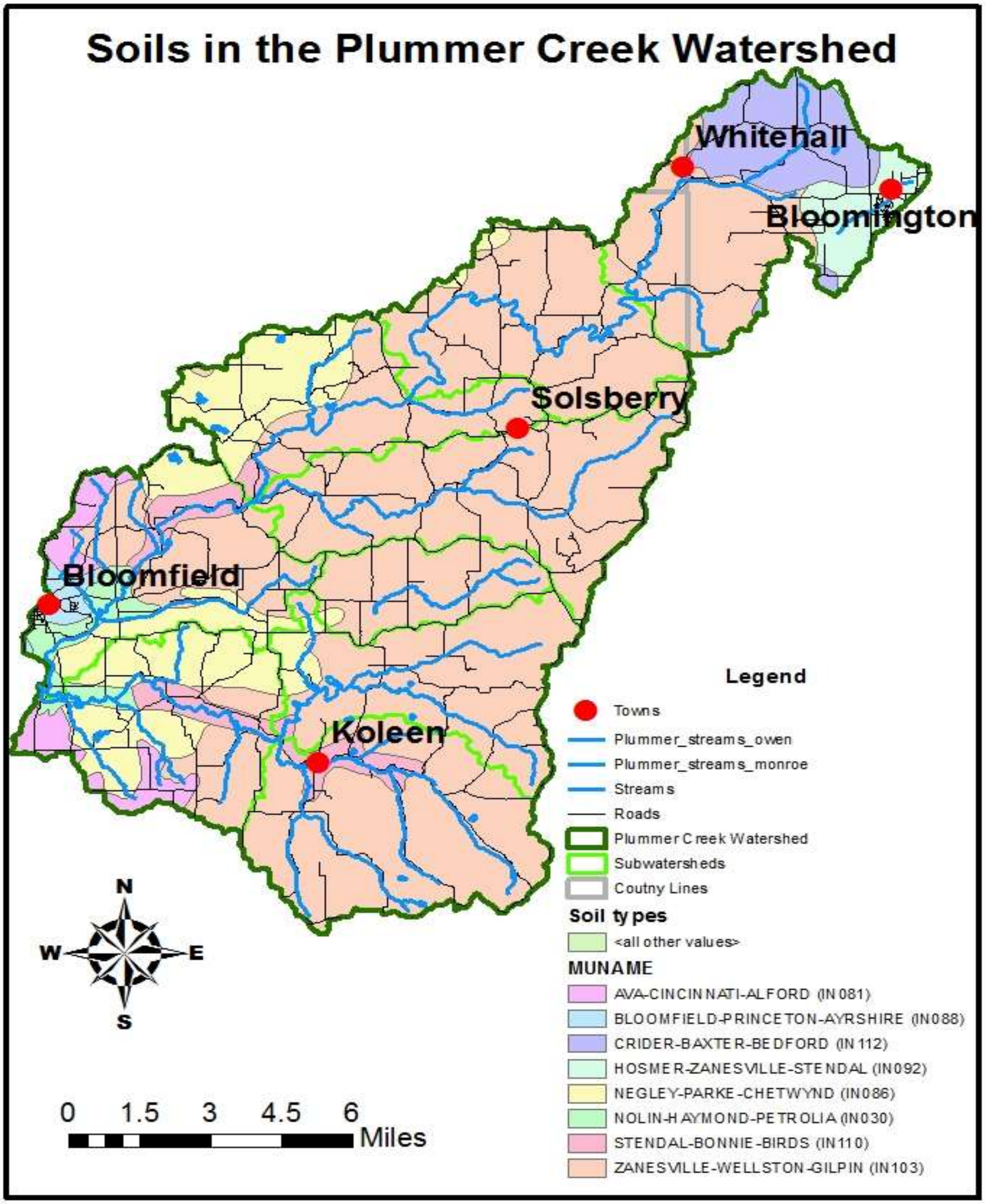


Soils

Soil characteristics can affect water quality greatly. One of the greatest issues and a big stakeholder concern is erosion and runoff. Sediment is the number one pollutant in Indiana waterways according to IDEM. There are many unstable banks that are eroding away in the watershed, not only contributing to water quality issues, but concerning landowners as well with the changing landscape. The addition of too much sediment into a stream causes lower water depth and suffocate many biotic communities choking the life out of streams. Sediment, especially silts and clays are also causing turbidity to be an issue, affecting the gills, breeding, and sight in fish populations. This additional sediment could also be causing higher water temperature and lower dissolved oxygen levels.

Plummer Creek watershed contains many different soil types, though the most common are Wellston, Zanesville, Haymond, and Gilpin. Map 7 shows the major soil associations and their soil name (MUNAME) for the Plummer Creek watershed. Haymond is the soil that is found mostly within the creek beds. It is a floodplain soil that is well drained and a silt loam. Wellston soils are a fine silt loam most common on ridge tops and slopes. The majority of Wellston soils in the area are highly erodible, which leads to a large portion of the sedimentation problem. Zanesville soils are a silt loam that is well drained and highly erodible. These are mostly found on hills and are another main cause of high sedimentation results in the streams. Gilpen soils are common to hilly cropland, which describes quite a bit of our watershed. It’s a fine-loamy soil that is well drained. There is an average depth of about 40 in of soil before bedrock.

Map 7: Soil Map



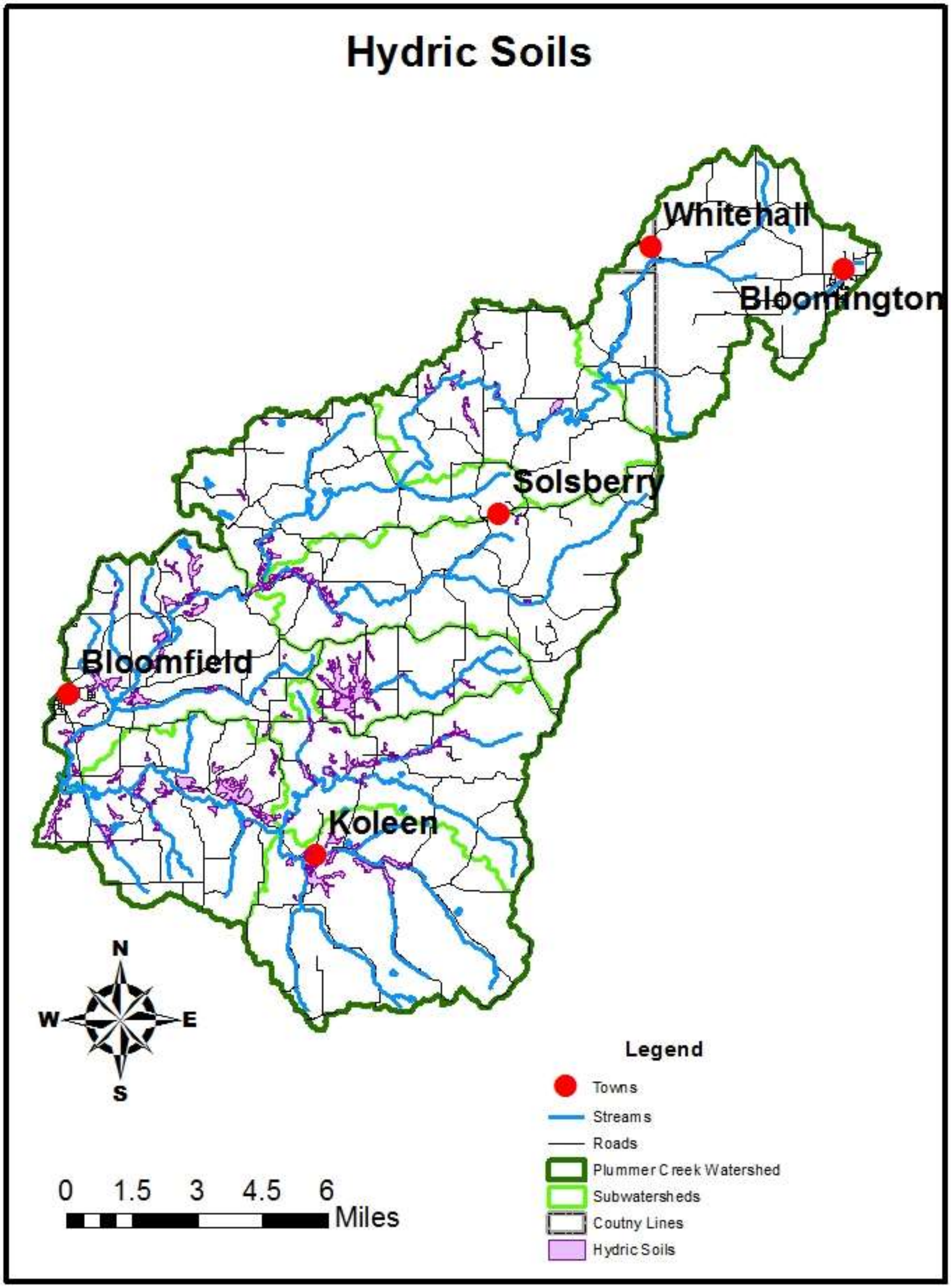
Highly Erodible and Hydric Soils

Highly erodible soils (HES) are soils that are eight times greater than the erosion tolerance value and have an erodibility index of eight or higher. These values are calculated by the USDA based on several factors, including soil texture, force of local rainfall, slope gradient, and slope length. There are 40 different types of highly erodible soils in the PCW, making up around 90% of the area. The most abundant soil types that fit the description of a highly erodible soil are Gilpen-Wellston silt loam, Wellston silt loam, and Zanesville silt loam (GmE, WeD2, WeD3, ZaC2, and ZaC3 respectively). These can be found all throughout the watershed and have been classified as class 1 highly erodible land by the NRCS. They make up at least 75% of the soils in the watershed and have slopes ranging from 6 to 25%.

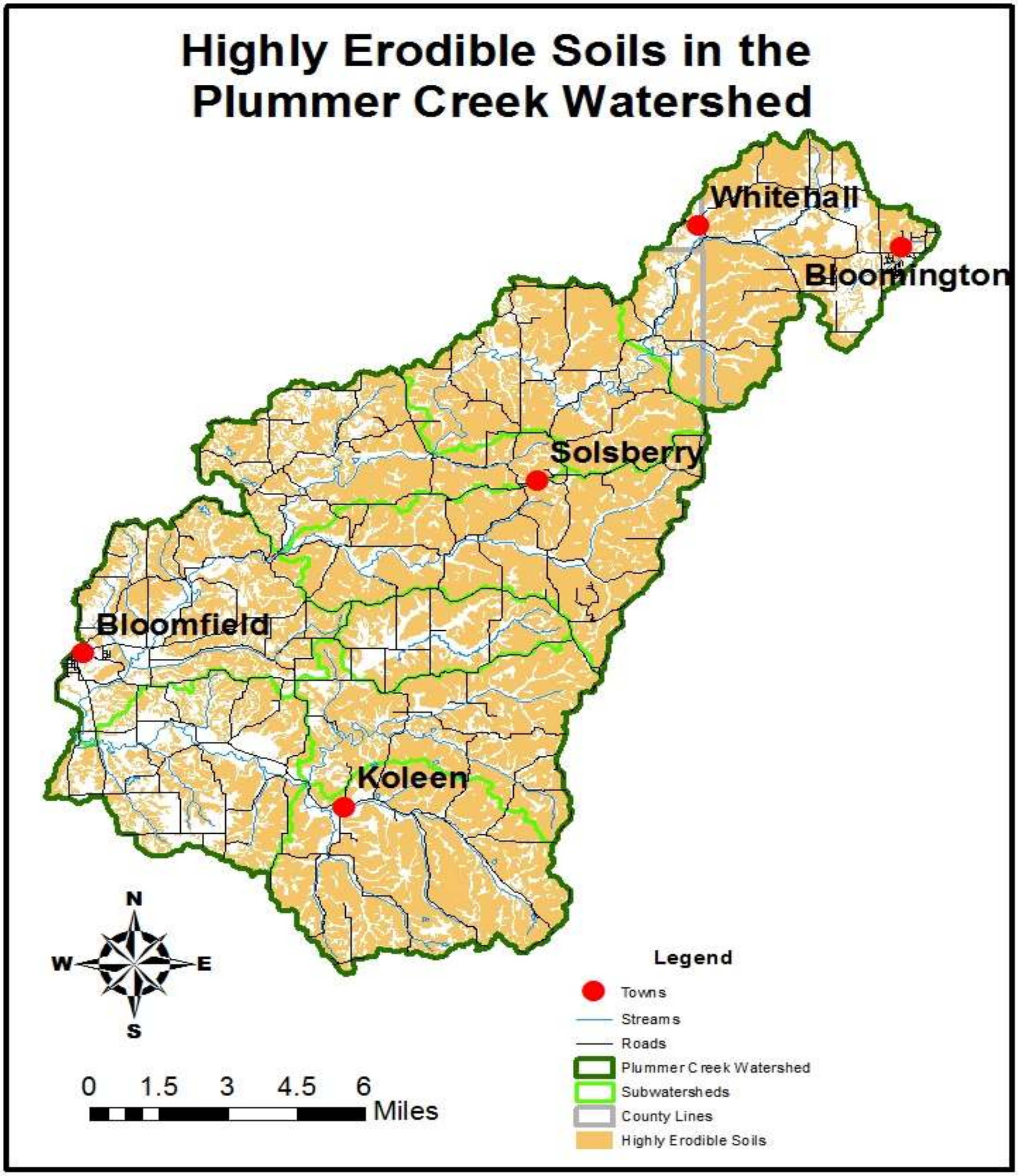
Hydric soils are those that are formed under conditions of saturation, flooding, or ponding for a duration long enough to develop anaerobic conditions in the upper part of the soil column during the growing season (Environmental Laboratory, 1987). Hydric soils make up only about 10-15% of the watershed. The most common type of hydric soil in the area is Stendal silt loam (St) which makes up about 90% of the hydric soils here.

With highly erodible soils covering most of the watershed, many of the creeks are surrounded by easily disturbed soil, creating a potential problem that needs to be addressed. Sediment is a huge water quality issue and a main stakeholder concern. Erosion control will need to be a big part of our BMPs that will be recommended for implementation. Mowing or farming right up to the creek edge may also be a cause of loss of stream edge stability. Overgrazing is another stakeholder concern that could also create sedimentation problems with the highly erodible soils. Creeks escaping the banks and flooding nearby areas with highly erodible soils that are directly adjacent to the streams may be causing further sedimentation problems.

Map 8: Hydric Soils



Map 9: Highly Erodible Soils



Septic System Suitability

Another major concern of the stakeholders is failing septic systems in the watershed. Failing septic systems can cause direct inputs of pathogens, nutrients, and other contaminants into waterways. The soil types can affect the type, location, and suitability of a septic system. Septic systems are also a known cause of E. coli issues, which is also a concern for stakeholders in the community. Soil types such as clay can require a much different approach to a septic system than other soils. Desirable soils for the septic system to be in are: not too coarse but sandy soil, well-drained soil, and natural undisturbed soil. Soils that are undesirable are, clay, dense soil, highly organic soil, gravely, and fill soils. As we can see by the map below, there are a number of areas in the watershed that are very limited for septic systems, however, all of the most common soil types are silt loams, which are typically well-drained and therefore acceptable. About 80% of the watershed has soils that are suitable for septic systems, though most of this land is covered by forested or agricultural area and some of the 20% area of unacceptable soils may have septic systems. Un-sewered areas include almost all of the watershed including approximately 6,000 housing units in the watershed. Individual septic systems are the primary sewage disposal for the Un-sewered areas. The only areas with a sewer system is the small part of Bloomington that is in the Northeast corner of the watershed and Bloomfield, in the southwest. Un-sewered communities are spaced throughout the watershed and use septic systems to deal with waste. These include Koleen, Solsberry, and Whitehall. Koleen and Whitehall are on mostly flat ground, though Solsberry is perched on a hillside along State Road 43. There are streams near all of these towns, and all of these towns rely on septic systems to dispose of household waste. These towns and residential areas may be responsible for the high E.coli within streams along with other source like manure application, cattle with stream access, overgrazing of pasture land, and wildlife.

Map 10: Soils Suitable for Septic Systems

Land Use

There are many different land uses in the PCW. A good percentage is forested, and a smaller piece is agricultural. This area in known to have cattle, but after the first windshield survey it was very evident that horses were maybe even more abundant than cattle. There are also some recreational activities happening in the watershed, although they are limited, which include fishing, hiking, and canoeing.

There are 110,946.8 acres of land within the Plummer Creek watershed and the way the land is used can have incredibly varying effects on water quality. Land use was identified by calculating aerial extent of different land use polygons derived from the 2006 National Land Cover Database shapefile developed by USGS (Table 4). Approximately 72.6%, or 80,493.9 acres, of the land use in the Plummer Creek watershed is forested. The remaining land use for the Plummer Creek watershed consisted of 15.8% (17,593.2 ac) agricultural, 0.22% (240 ac) wetland and open water, 3.3% (3,605.8 ac) urban and developed lands, 0.33% (365.4 ac) surface mining in the area categorized as barren land, 7.67% (8,508.3 ac) green space and residential areas classified as grassland/herbaceous and 0.13% (140.3 ac) shrub. A comparison of herbaceous and grassland land use with aerial photography revealed that this land use classification was really representing residential areas, managed lands, manicured lawns and other areas mowed and managed.

Table 4: Land Use

Land use	Percentage of Land	Acres
Barren Land	0.33%	365.4
Deciduous Forest	72.1%	79,992.8
Evergreen Forest	0.44%	484.4
Mixed Forest	0.01%	16.7
Developed, High Intensity	0.02%	26.7
Developed, Medium Intensity	0.10%	119.7
Developed, Low intensity	0.18%	202.3
Developed, Open Space	2.94%	3,257.1
Cultivated Crops	3.25%	3,610.5
Hay/Pasture	12.6%	13,982.7
Herbaceous	7.67%	8,508.3
Shrub/scrub	0.13%	140.3
Open Water	0.18%	203.2
Emergent Herbaceous Wetlands	0.03%	34.1
Woody Wetlands	<0.01%	2.77

Analyzing past land use data indicated some trends within the watershed. Comparing information from just the Plummer Creek portion of the watershed (the lower half of the 10-digit watershed, excluding the Richland Creek portion) to land use data from 1976, it is shown that agricultural uses have decreased from 39% and forested areas have increased from 61%. This change in land use has most likely improved water quality within the watershed, but not completely. With more forested areas, the land management category, which includes such problems as mowing along stream sides and overgrazing, is probably less of a problem, though invasive species and obstructions in the creek such as log jams and beaver dams may have increased due to less management on private lands.

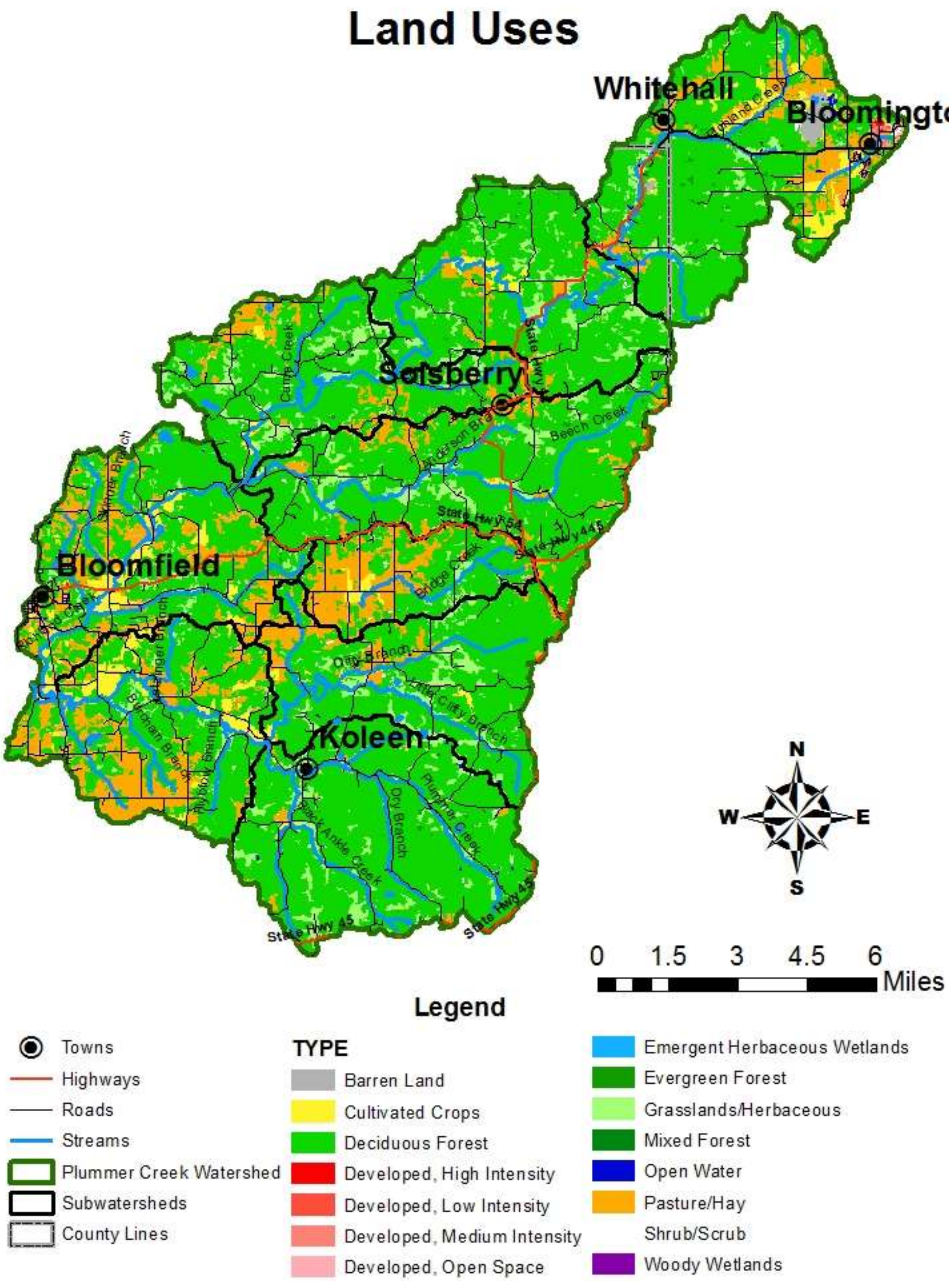
Little land use change has occurred in the Richland Creek portion of the watershed since the 1970's. Forested cover has decreased by 4.95% than it was in the 1970's. Agricultural coverage is 5.06% greater than it was in the 1970's. The urban area covers 0.85% less of the watershed than it was in the 1970's. These minor changes most likely haven't changed the problems that the stakeholders consider critical, but it is interesting to note that the changes in the northern portion of the watershed (Richland Creek) are opposite from the South (Plummer Creek). Plummer Creek watershed, as earlier stated, saw an increase in in forested areas and a decrease in agricultural areas. Urbanization decreasing is also a notable trend, though the change has been nearly imperceptible.

A land use not often thought about, but commonly affecting water quality are animals in the environment. Studies have shown that animal waste from things like deer, turkey, and other wildlife can contribute to issues such as E. coli, which is the number one concern for stakeholders in this watershed. This also can include pet waste in smaller towns, or the urban communities that have large groups of dogs, cats, and other pets. Much of the watershed is forested area, and the deer population is known to be very high. These could be contributing a larger quantity of feces into surface water than we realize.

Other uses such as agriculture bring other possible issues. Although row cropping is not as abundant in the watershed as other places nearby, it still has issues to be addressed. There are many fields that are in close proximity to streams that do not allow for natural filtration of pollutants. This hurts not only the ability to filter, but is worsening the erosion control in many places. BMPs such as buffer strips should be promoted and improved on in these areas. This would also help prevent fertilizers and pesticides from fields and lawns from getting into surface water. Landowners in the PCW use fertilizer to make their lawns greener in more urban areas or, in suburban areas, to aid in the growth of crops which takes a larger amount and may have a better chance of ending up in surface water, depending on buffer distance and riparian plants present. Phosphate or ammonia levels were not a huge problem through the watershed, but were present in high numbers in a few places (see Sub watershed Sections for Little Richland Creek, Blakeman Hollow, Ore Branch, Bridge Creek, Burcham Creek, and Clifty Branch Creek). This can also be an indicator of buffer strips being too thin or nonexistent between lawn-conscious residents and streams. Excess fertilizer on lawns leaking into streams is another stakeholder concern.

One of the more abundant uses in the watershed is grazing ground. Horses and cattle on hobby or meat farms use these grounds to feed. Workshops and awareness are two things to implement in this county that would impact water quality greatly. There are many areas through the watershed that are overgrazed, and many areas where cattle are in the stream, see Sub watershed Sections below for more detail. The NRCS programs could also be explained, and technical resources could be made more readily available to help landowners with questions, issues, and design of grazing areas. The PCW also has quite a few hobby farms with horses, some of which do not have enough land for the number of horses living there. This may also be amended with workshops or cost-share programs for grazing management.

Map 11: Land Uses

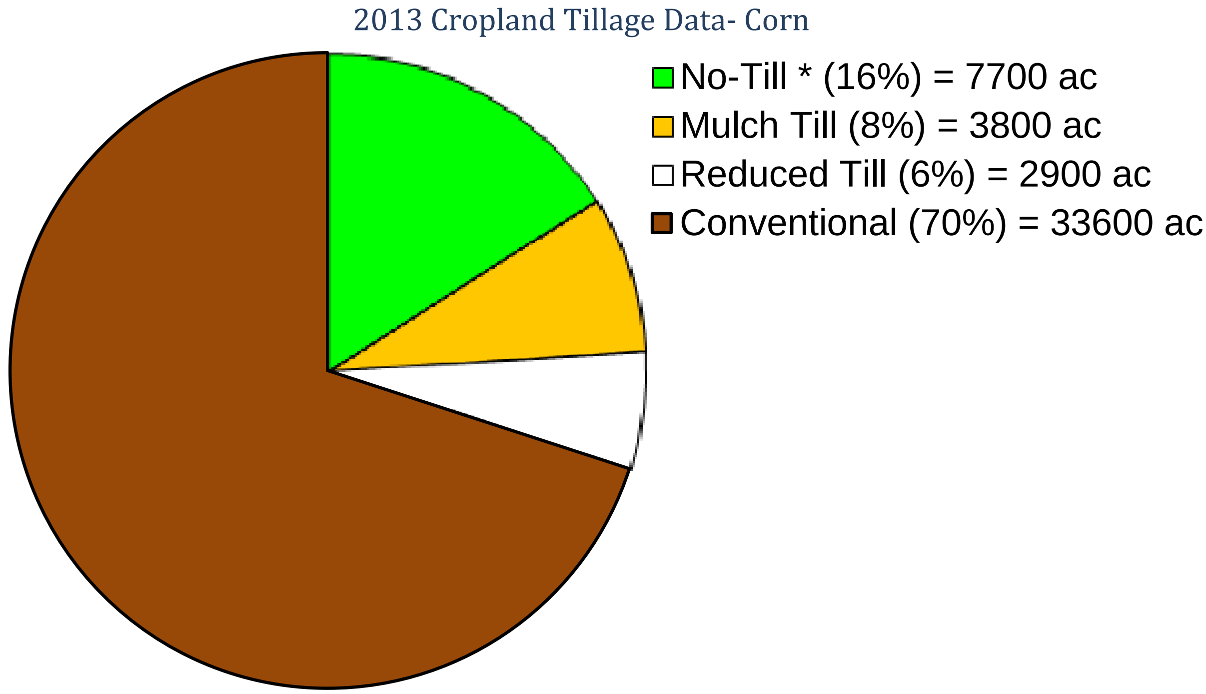


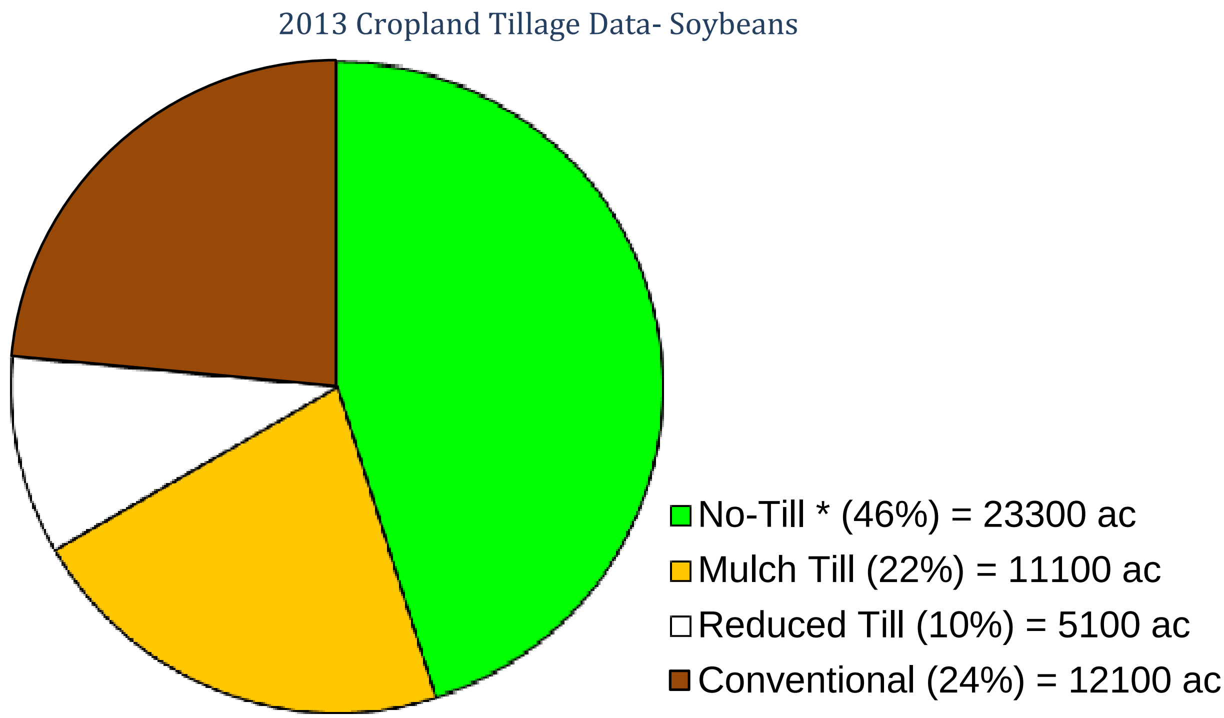
Tillage Transect Data

The 2013 Tillage Transect data was taken by the local NRCS District Coordinator, Tammy Swihart, ISDA representative, Dale Walker, and Greene County SWCD office coordinator, Deborah Lynn. The tillage transect is a snapshot for all of Greene County. The Greene County tillage transect data is assumed to be a representation of conditions for all crop ground within Plummer Creek watershed. It was found that in 2013, only 30% of corn fields were planted using conservation tillage (13% No till, 3% ridge till, 8% mulch till, 6% reduced till) and 70% was conventionally tilled. For soybeans, 76% was tilled using conservation techniques (43% no till, 3% ridge till, 22% mulch till, 10% reduced till) and the remaining 24% was conventionally tilled. These are the two main crops in the county and the only ones counted in the 2013 tillage transect. In 2011, there was more no till in corn fields, but only by 4% (37 counts compared to only 24 in 2013. Reduced till fields were far less common in Greene County in 2013 (11 compared to 47 in 2011), which brought conventional tillage up from 52% to 70%. Soybeans also experienced more cases of conventional tillage in 2013 with 24 more counts taking the total to 46, although that number was far smaller than 129 counts of conventionally tilled corn fields. Other forms of conservation tillage kept similar numbers between the two years.

Another difference between the 2011 and 2013 surveys was the amount of fields that were farmed with corn versus soybeans. There were fewer fields with corn and more fields with soybeans in 2013 in contrast to 2011. The total number of fields was very similar with a difference of only two, but there were 35 more soybean fields and 37 fewer corn fields. This is interesting because most farmers keep a corn/soybean rotation, which would suggest that crops in 2011 and 2013 would be the same. This amount of change may suggest a third year is being added to the rotation, possibly signifying some fields are being left fallow for a year. This practice can improve soil health and can increase yields of both corn and soybeans in their respective year. A year left fallow can also have an effect on water quality. It would be very important for residue to be left on the fields to prevent bare soil from eroding away into streams. As the residue decays, other vegetation can grow to hold the soil, feeding on the nutrients of the residue. This can also be a great year to plant cover crops, which can be planned to replace certain nutrients and may take unwanted imperfections from the soil, paving the way to a very healthy crop the following years. This may be evidenced by an increase in cover crops shown in the tillage transect data, from 22 (5%) to 50 (11%) fields.

The tillage transect data was input into the Indiana Cropland Transect Survey Program in Excel and it was determined that 12.8 tons of soil per acre per year are saved every year from conservation tillage, up from 12.7 in 2011. If all of Greene County were tilled, 687,000 tons of soil would be lost from erosion. However, with conservation techniques, 480,100 tons of soil were estimated to be saved in 2013.


2013 Cropland Tillage Data- Corn
No-Till * (16%) = 7700 ac
Mulch Till (8%) = 3800 ac
Reduced Till (6%) = 2900 ac
Conventional (70%) = 33600 ac


2013 Cropland Tillage Data- Soybeans
No-Till * (46%) = 23300 ac
Mulch Till (22%) = 11100 ac
Reduced Till (10%) = 5100 ac
Conventional (24%) = 12100 ac

Additional Efforts

Drinking water for the majority of inhabitants of the PCW is drawn from the White River Aquifer by Eastern Heights Water Inc. from well fields just to the west the watershed. The drinking water for all residents on this public water supply system is protected through Wellhead Protection Plan, approved by the Indiana Department of Environmental Management (IDEM). This system is a plan to protect wells from any contamination from land surface contamination. Although this program does not encompass the watershed many of the residence rely on this protection and would gain value from participating in any wellhead protection programs in place. Partnering with this group may prove valuable to both watershed water quality protection along with groundwater protection due to the high amount of karst grounds in the area. It is approximated that an additional 550 private wells are located within the watershed (DNR Water Well Database, 2014). These well owners rely on groundwater located below the watershed for their drinking water. It is important to protect the surface waters in this area for these residents.

The watershed group has been working on a prairie restoration at the Viaduct, or “Tulip Trestle”. This would restore roughly 6 acres of prairie under and by the viaduct. This is a very well-known site already because of its size and the ability to boast that it is the third longest bridge of its kind in the world (Hall, 2008). Introducing these grasses and wildflowers is believed to be a huge focal point for the community. The service learning group for the PCW is helping to establish trails for the public, and is working on an observation deck. This project will not only bring awareness of the watershed to the people, but will educate the importance and utility of water quality and land use areas. This will be a big step toward improving tourism in the area, which is a stakeholder concern.

The Greene County Soil and Water Conservation District received funds from Department of Natural Resource’s Lake and River Enhancement (LARE) program that can help reduce TSS levels by reducing erosion and restoring stream bank that were affected by log jams. This work is currently complete at 2 sites one in Black Ankle Creek sub watershed on Plummer Creek the other in Burcham Branch sub watershed on Plummer Creek. These grants are to remove log jams in the creek and improve water flow, which are stakeholder concerns.

Additional watershed plans are currently being written and implemented throughout the state. The watershed that is closest and potentially affects our watershed the greatest, is the Bean Blossom watershed project. This project is in its 3rd year and is currently in implementation.

In 2006, two TMDLs for E. coli were completed for the PCW: One for Richland Creek in the North and one for Plummer Creek in the South.

Table 5: Richland Creek TMDL

Waterbody Name	**Segment ID Number**	**Length (Miles)**	**Impairment**
Richland Creek	INW02141_T1019	7.17	E. coli, Impaired Biotic Communities
Richland Creek	INW02141_T1019	7.17	FCA for PCBs and Mercury
Little Richland Creek	INW0241_T1164	1	E. coli, Impaired Biotic Communities
Richland Creek	INW0242_T1020	11.88	FCA for PCBs and Mercury

Richland Creek	INW0242_T1020	11.88	E. coli, Impaired Biotic Communities
Richland Creek	INW0243_T1021	5.98	FCA for PCBs and Mercury
Richland Creek	INW0243_T1021	5.98	E. coli, Impaired Biotic Communities
Beech Creek	INW0244_00	12.05	E. coli
Ore Branch	INW0245_00	7.76	E. coli
Ritter Branch	INW0245_01	2.77	E. coli
Richland Creek	INW0245_T1022	9.24	FCA for PCBs and Mercury
Richland Creek	INW0245_T1022	9.24	E. coli, Impaired Biotic Communities

Table 6: Plummer Creek TMDL

Waterbody Name	Segment ID Number(s)	Length (Miles)	Impairment
Black Ankle Creek, Dry Branch	INW0246_00	11.11	E. coli
Plummer Creek	INW0246_T1023, INW0249_T1024	15.05	E. coli
Flyblow Branch, Burcham Branch, Letsinger Branch, Unnamed Tributary	INW0249_00	9.18	E. coli

TMDL reports have been completed for the PCW as well as several surrounding watersheds, including Beanblossom (0512020201), Indian Creek (0512020809) east of our watershed, Indian Creek (0512020116) north of Beanblossom, and First Creek-White River Watershed southwest of the PCW (0512020205). TMDL reports summarize water quality in rivers and streams and include sources of pollutants contaminating them. They also give reductions of each pollutant that are necessary to bring the water back to a safe level and actions to achieve those goals. These have all been approved. The TMDLs done within our watershed found that E. coli was a pervasive problem that exists in just about every stream. This is yet another reason why E. coli was listed as the top stakeholder concern.

A rain garden was implemented at Eastern Greene High School which is centrally located in the watershed. A rain garden is used to capture runoff from impervious surfaces to collect any pollutants that may have washed away with the rainwater. As an example of an urban best management practice, this rain garden will make more people aware of our project and help let people know what type of projects our grant can assist with to improve upon their own water quality. Chemical contamination is a fairly important stakeholder concern that can be alleviated somewhat by a rain garden.

As mentioned earlier, the I-69 project going through the watershed is making major changes to the landscape. There are several areas that are experiencing huge changes through construction such as hills being created or taken out, trees being removed by the truck load, and new roads cutting through previously wooded areas. This project, however, is also creating several mitigation sites to help replace some of the trees and wetlands it might be destroying throughout the watershed. (Map 6) These constructed wetlands and new paths for streams will hopefully help to improve the water quality in these areas. Unfortunately, the complete makeover of the landscape is creating many new chances for erosion, though preventative measures are in place, as well as possible sources of pollutants leaking from vehicles or other construction equipment. In the end, the mitigation sites will be the predominant new feature having the biggest environmental impact from the development, helping to improve water quality through natural processes such as wetland filtration. This could help reduce erosion, increase tourism, reduce chemical contamination of the streams, and improve stream flow, which are all stakeholder concerns.

There are no known Municipal Separate Storm Sewer System (MS4) plans in the Plummer Creek watershed, but there is a plan in place in the Monroe County (Appendix B). The Monroe County MS4 is a comprehensive plan that covers all urbanized areas of Monroe County. Unfortunately, this does not include areas within the Plummer Creek watershed, but the plan covers up to the very edge of the watershed. This program is included as Appendix B can be a great guide and partner for educational efforts within the Monroe County and other urban areas of the watershed. Owen County currently does not have MS4 plans on record.

A baseline study was also conducted for the Plummer Creek Watershed by IDEM for a year previous to the beginning of this grant. They tested for many of the same parameters that were later named stakeholder concerns, such as turbidity, nitrates, and E. coli. It gave very comprehensive results and this project was able to choose testing points based on those results. It highlighted problems with E. coli, turbidity, ammonia, nitrates, total suspended solids, and total Kjeldahl nitrogen (TKN). During the E. coli testing, it was noted that all but two small tributaries were over the IDEM limit of 125 CFU/ 100 mL. These kind of numbers make it apparent why residents of the watershed listed E. coli first and ranked it the number one concern for stakeholders.

This study also took a very close look at macroinvertebrates and habitat scorings. There were several highlighted testing points that did not pass the IDEM Macroinvertebrate Index of Biotic Integrity (MIBI), and these have all been defined within the critical areas of our project (Map 25).

The 303(d) list also lists several streams within the PCW.

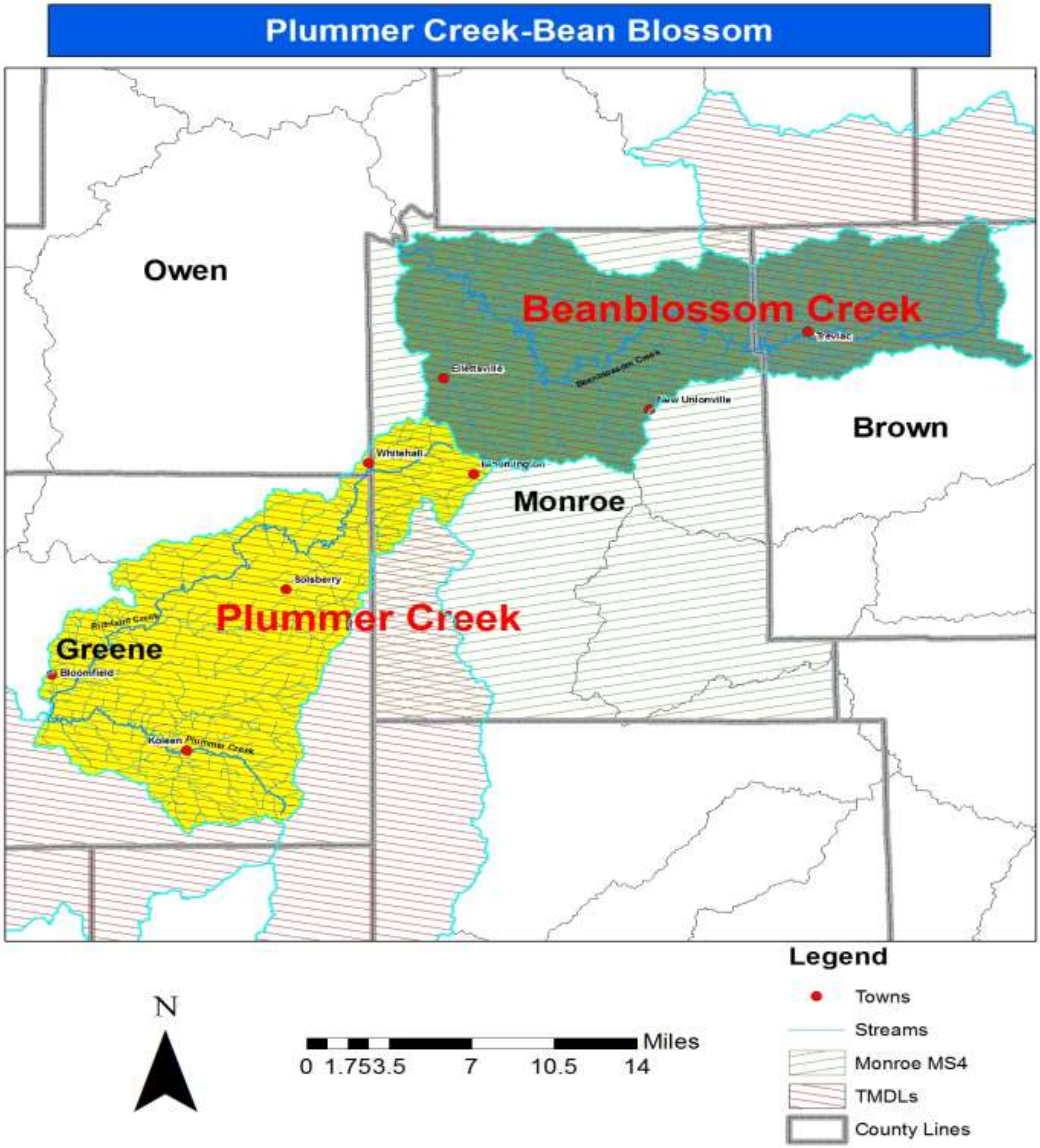
Table 7: 2012 303(d) list

Basin	HUC	County	Assessment Unit ID	Assessment Unit Name	Cause of Impairment	Category
White River, West Fork	051202020301	Greene	IN0241_T1019	Richland Creek	PCBs (Fish Tissue)	5B
White River, West Fork	051202020301	Greene	IN0241_T1164	Little Richland Creek	Impaired Biotic Community	5A
White River, West Fork	051202020301	Greene	IN0241_T1019	Richland Creek	E. coli	4A

White River, West Fork	051202020302	Greene	IN0242_T1020	Richland Creek	Total Mercury (Fish Tissue)	5B
White River, West Fork	051202020302	Greene	IN0242_T1020	Richland Creek	E. coli	4A
White River, West Fork	051202020305	Greene	IN0243_00	Camp Creek- Dry Branch	Total Mercury (Fish Tissue)	5B
White River, West Fork	051202020305	Greene	IN0243_T1021	Richland Creek	E. coli	5A
White River, West Fork	051202020305	Greene	IN0243_T1021	Richland Creek	E. coli	4A
White River, West Fork	051202020305	Greene	IN0243_T1021	Richland Creek	Total Mercury (Fish Tissue)	5B
White River, West Fork	051202020307	Greene	INW0246_00	Black Ankle Creek	E. coli	4A
White River, West Fork	051202020307	Greene	INW0246_T1023	Plummer Creek	E. coli	4A
White River, West Fork	051202020308	Greene	IN0245_00	Ore Branch	E. coli	4A
White River, West Fork	051202020308	Greene	IN0245_00	Ritter Branch	Total Mercury (Fish Tissue)	5B
White River, West Fork	051202020308	Greene	IN0245_01	Ritter Branch	E. coli	4A
White River, West Fork	051202020308	Greene	IN0245_T1022	Richland Creek	E. coli	4A
White River, West Fork	051202020308	Greene	IN0245_T1022	Richland Creek	Total Mercury (Fish Tissue)	5B
White River, West Fork	051202020309	Greene	IN0249_T1024	Plummer Creek	E. coli	5A
White River, West Fork	051202020309	Greene	IN0249_T1024	Plummer Creek	E. coli	4A
White River, West Fork	051202020309	Greene	IN0249_00	Flyblow Branch – Burcham Branch	E. coli	5A

The 303(d) list cites mercury and PCBs in fish tissue in several areas of Richland Creek, see Map 4B, and a couple of its tributaries. These problems are outside of the scope of this project because they come from a point source and are no longer being introduced. However, these problems persist due to bioaccumulation and the endurance of the chemicals. The other problems are with E. coli (Map 4A) and impaired biotic communities (Map 4B). Many streams and tributaries are on the 303 (d) 4A list for E. coli because a TMDL has been produced. The only stream that has been removed from the 303(d) list in recent years is Beech Creek, but according to recent testing (Table 22 in the Beech Creek inventory discussion), this stream should still be included as an impaired stream. This only furthers the reason why E. coli was ranked as our number one stakeholder concern.

Map 12: Additional Area Water Quality Efforts



Threatened and Endangered Plants and Animals

Endangered species are an important subject to consider when considering water quality, especially of those that spend their whole lives submerged. Although all life in streams is important, there are a couple species on this list that are of specific concern due to water quality issues, but only one has been identified in the PCW. This is the *Obovaria subrotunda*, or Round Hickorynut Mussel. It is only found in 2 places throughout the entire White River drainage basin, and our watershed is one. Mussels rely heavily on our waters being clean, and through this grant we can create a better and possibly larger area in which these mussels can reside. Stakeholders have named the Round Hickorynut Mussel habitat a critical area because of its rarity and our ability to help facilitate its survival. Mussels in general like to live in shallow riffles along stream bottoms, usually embedding themselves about halfway into the creek bottom. The beds they choose are usually littered with gravel, but can also be fairly sandy or even be a primarily clay substrate. The Round Hickorynut mussel is about the size of a quarter and looks very similar to most of the rocks within the rock beds it inhabits. They usually eat a diet similar to other mussels, being detritus, bacteria, and algae. In some areas, this species is threatened by the emergence of another competing species, the zebra mussel (*Dreissena polymorpha*), though these haven't been observed in the Plummer or Richland creeks yet. Factors that are most likely affecting these mussels and pose a threat to their persistence are impounding (such as from logjams), channelization, excess sewage or silt, and runoff of chemicals from agricultural applications. The main concerns for these mussels, according to a paper written by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), are superfluous amounts of sediment, nutrients, and chemicals from non-point sources, especially agriculture. We have identified all of these as stakeholder concerns and hope to implement practices to help alleviate these problems. Another limiting factor could be increased predation from muskrats and raccoons. Muskrats aren't particularly common in this area of Greene County, which means that raccoons could be a factor, however this is a factor that would be difficult to control and, given that raccoons aren't picky about their food, probably aren't really a big threat anyway.

Table 8: Endangered Species List

Species Name	Common Name	FED	STATE	GRANK	SRANK
Crustacean: Malacostraca					
Orconectes inermis testii	Troglobitic Crayfish		SR	G5T3	S3
Crustacean: Ostracoda					
Sagittocythere barri	Barr's Commensal Cave Ostracod		WL	G5	S3S4
Mollusk: Bivalvia (Mussels)					
Cyprogenia stegaria	Eastern Fanshell Pearlymussel	LE	SE	G1Q	S1
Epioblasma torulosa torulosa	Tubercled Blossom	LE	SE	G2TX	SX
Epioblasma triquetra	Snuffbox		SE	G3	S1
Fusconaia subrotunda	Longsolid		SE	G3	SX
Obovaria subrotunda	Round Hickorynut		SSC	G4	S1
Pleurobema clava	Clubshell	LE	SE	G2	S1
Pleurobema cordatum	Ohio Pigtoe		SSC	G4	S2
Pleurobema plenum	Rough Pigtoe	LE	SE	G1	S1
Pleurobema rubrum	Pyramid Pigtoe		SE	G2G3	SX
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Quadrula cylindrica cylindrica	Rabbitsfoot	C	SE	G3G4T3	S1
Villosa fabalis	Rayed Bean	C	SSC	G2	S1
Villosa lienosa	Little Spectaclecase		SSC	G5	S3
Insect: Odonata (Dragonflies & Damselflies)					
Enallagma divagans	Turquoise Bluet		SR	G5	S3
Fish					
Lepomis symmetricus	Bantam Sunfish		SE	G5	S1
Amphibian					
Rana areolata circulosa	Northern Crawfish Frog		SE	G4T4	S2
Scaphiopus holbrookii	Eastern Spadefoot		SSC	G5	S2
Bird					
Accipiter striatus	Sharp-shinned Hawk	No Status	SSC	G5	S2B
Ammodramus henslowii	Henslow's Sparrow		SE	G4	S3B
Botaurus lentiginosus	American Bittern		SE	G4	S2B
Buteo platypterus	Broad-winged Hawk	No Status	SSC	G5	S3B
Haliaeetus leucocephalus	Bald Eagle	LT,PDL	SE	G5	S2
Helmitheros vermivorus	Worm-eating Warbler		SSC	G5	S3B
Lanius ludovicianus	Loggerhead Shrike	No Status	SE	G4	S3B
Rallus elegans	King Rail		SE	G4	S1B
Mammal					
Lasiurus borealis	Eastern Red Bat		SSC	G5	S4
Lasiurus cinereus	Hoary Bat	No Status	SSC	G5	S4
Lutra canadensis	Northern River Otter		SSC	G5	S2
Lynx rufus	Bobcat	No Status	SSC	G5	S1

County: Greene (06/01/2010)

Species Name	Common Name	FED	STATE	GRANK	SRANK
Myotis austroriparius	Southeastern Bat		SSC	G3G4	S1
Myotis lucifugus	Little Brown Bat		SSC	G5	S4
Myotis septentrionalis	Northern Myotis		SSC	G4	S3
Myotis sodalis	Indiana Bat or Social Myotis	LE	SE	G2	S1
Nycticeius humeralis	Evening Bat		SE	G5	S1
Pipistrellus subflavus	Eastern Pipistrelle		SSC	G5	S4
Taxidea taxus	American Badger		SSC	G5	S2
Vascular Plant					
Agalinis skinneriana	Pale False Foxglove		ST	G3G4	S1
Armoracia aquatica	Lake Cress		SE	G4?	S1
Chelone obliqua var. speciosa	Rose Turtlehead		WL	G4T3	S3
Clematis pitcheri	Pitcher Leather-flower		SR	G4G5	S2
Cyperus acuminatus	Short-point Flatsedge		WL	G5	S3
Euphorbia obtusata	Bluntleaf Spurge		SE	G5	S1
Liatris pycnostachya	Cattail Gay-feather		ST	G5	S2
Nothoscordum bivalve	Crow-poison		SR	G4	S2
Rudbeckia fulgida var. umbrosa	Coneflower		SE	G5T4T5	S1
Silene regia	Royal Catchfly		ST	G3	S2
Strophostyles leiosperma	Slick-seed Wild-bean		ST	G5	S2
Waldsteinia fragarioides	Barren Strawberry		SR	G5	S2
High Quality Natural Community					
Forest - upland dry	Dry Upland Forest		SG	G4	S4
Forest - upland dry-mesic	Dry-mesic Upland Forest		SG	G4	S4
Forest - upland mesic	Mesic Upland Forest		SG	G3?	S3
Prairie - mesic	Mesic Prairie		SG	G2	S2
Other					
Geomorphic - Nonglacial Erosional Feature - Water Fall and Cascade	Water Fall and Cascade			GNR	SNR

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

Fed: LE = Endangered; LT = Threatened; C = candidate; PDL = proposed for delisting

State: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SX = state extirpated; SG = state significant; WL = watch list

GRANK: Global Heritage Rank: G1 = critically imperiled globally; G2 = imperiled globally; G3 = rare or uncommon globally; G4 = widespread and abundant globally but with long term concerns; G5 = widespread and abundant globally; G? = unranked; GX = extinct; Q = uncertain rank; T = taxonomic subunit rank

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

http://www.in.gov/dnr/naturepreserve/files/np_greene.pdf

Relevant Relationships: Part 1

The categories that we have discussed thus far are all interrelated. Finding water quality issues and addressing them is not just as simple as fixing one contaminant or one landowner's habits. There are many pieces to the puzzle that have to fit together. In the Plummer Creek area, there are many karst areas. This affects water quality directly, but we also have to consider soil types, erosion factors, population, habitat, land use, and topography when looking at the effects. The population can change the environment just from having a large concentration of people. In the case of Plummer Creek, the small number of people are spread out throughout the watershed but they may still be influencing the environment through the influence of failing or non-existent septic systems. The area also has scattered agricultural land that may also have an influence on water quality.

As indicated, land use can also make a significant input of non-point source pollutants into the environment. This gives a great starting point to look at where issues could be stemming from, and where to try and focus BMPs. In this part of the state we are looking at many acres of forested land, with intermingled areas of grazing, row crops, and small communities. Hills are a prominent feature throughout the PCW. The streams have been carving their way through the hills of Eastern Greene County for as long as they've existed and it's no different today. High runoff from impervious surfaces, off harden surfaces, or from drainage ditches can also influence the water quality. Hardened surfaces can often be made when soils are disturbed and then hardened by driving upon. These surfaces can speed up the conveyance of water and with the hilly topography of the area, this leads to streambank erosion and high amounts of sediment in the water.

Even though most of the soil in the Plummer Creek watershed can be described as highly erodible, many of the row crops and even the hay and pasture fields are on soil that is not highly erodible. Deciduous forests are the main cover for highly erodible areas, which is usually a good thing, helping to stabilize the ground from weathering events that can otherwise erode the soil into nearby streams. As long as these forested areas are managed for undergrowth then this can be true. In the Monroe County portion of the watershed, the cultivated crops area of the land use map correlates just about perfectly with the small areas of non-highly erodible land. The other areas are claimed by developed land (also place mostly on non-HEL ground), hay fields (no correlation; some is in HEL, some isn't), and deciduous forests (almost completely HEL). Soils suitable for septic systems are spaced with very little, if any, correlation to land use, and relatively no relationship with HEL. Hydric soils also have very little correlation with any kind of land use, though a large floodplain in Bridge Creek is in pasture. Over the rest of the watershed, where there are only small areas of hydric soils, a range of uses fall into those areas. However, areas of hydric soils typically aren't highly erodible showing some relatedness there.

Wetlands and lakes, though they are few and far between for the most part, can have a big positive impact on wildlife in the watershed. With a number of endangered species in the area, keeping waterways healthy can have a big impact on the numbers these animals, especially those that live within the water such as the Round Hickorynut Mussel. Keeping a good riparian buffer around the stream banks can provide new habitat for some species and help to maintain a cleaner water source.

I-69 construction along with other construction sites are having a large effect on several areas within the watershed. These areas can negatively affect water quality quickly, if proper sediment control is not installed at these sites. While they have set aside a number of mitigation sites to offset some of the damages they create to the environment and have set up all necessary forms of sediment control, the entire southeast portion of the watershed is being drastically changed. The wetlands of the mitigation sites should create new, cleaner water sources and habitat, but cutting down hundreds of trees through an area that is mostly forest to begin with is difficult on any biosphere. Creating and moving hills means moving a lot of soil and rocks which have polluted the waterways of the region by clogging them with sediments. This creates issues for any wildlife that was living in the area. Sedimentation of the streams can be detrimental to the fish population of the streams as well, which have been a stakeholder concern since the first advisory committee meeting.

It was shown in the tillage transect information that this year saw less no-till planting of crops in Greene county, though crop fields aren't a primary land use in the Plummer Creek Watershed, they still can have a significant influence. This decrease in conservation tillage is most likely due to a wet spring in 2013. Greene County still shows a great pattern of being conservation minded, or willing to adopt conservation practices. This frame of mind is most likely because of all the family farms and farmers realize that they want to preserve the land for their children.

Inventory Part 2

In order to determine the level of nonpoint source pollution that is effecting the Plummer Creek watershed, an inventory of the data and an analysis of target levels set for this project need to be discussed. This section includes these discussions along with sources of data and general results of that data.

Data and Targets

When evaluating anything, standards have to be set in order to evaluate whether the target is acceptable or unacceptable. This is even more important if the evaluation is using data from various sources. In evaluating the water quality in the Plummer Creek watershed, a set of water quality standards need to be set that represent the desired outcomes. Concerns discussed previously surround three general water uses and impairments to those uses: recreation potential, full body contact, and wildlife habitat. These uses all require different levels of standards. Development of target water quality levels are set at a target that would be representative of a full body contact or aquatic habitat standard. Benchmarks for indexes are set to represent the level wildlife need to thrive. Table 9 details the water quality targets and benchmarks utilized to evaluate collected water quality data (Table 9). Map 13 below shows where water quality samples were collected by both the Plummer Creek Advisory Committee group (PCAC_TestPoints) and IDEM (IDEM_TestSites). It was noted as a parameter of concern if it could address or monitor stakeholder's concerns. Lastly, a short description of why it is a concern for the ecosystem is provided. The sources used to set Target levels are indicated with a superscript number that correlates to a reference that is set below the table. If Indiana Water Quality standard exists for a particular water quality parameter, than that standard is used as the target level. Other levels were set keeping the main uses for the watershed in mind. In other words, water quality parameters were set to improve the recreation potential of the waters first and then for aquatic life. The waters of Plummer Creek watershed need to be reset to a condition that allows for the use of the waters for their intended purpose. Since no public water supplies or other drinking water withdrawals are made from the waterways within Plummer Creek watershed. Standards do not need to represent improvement to a drinking water quality. However, recreation and aquatic life is still a main use of the waters in the area and so these uses are the main criteria for the target levels.

Table 9: Targets for Water Quality Parameters of Concern

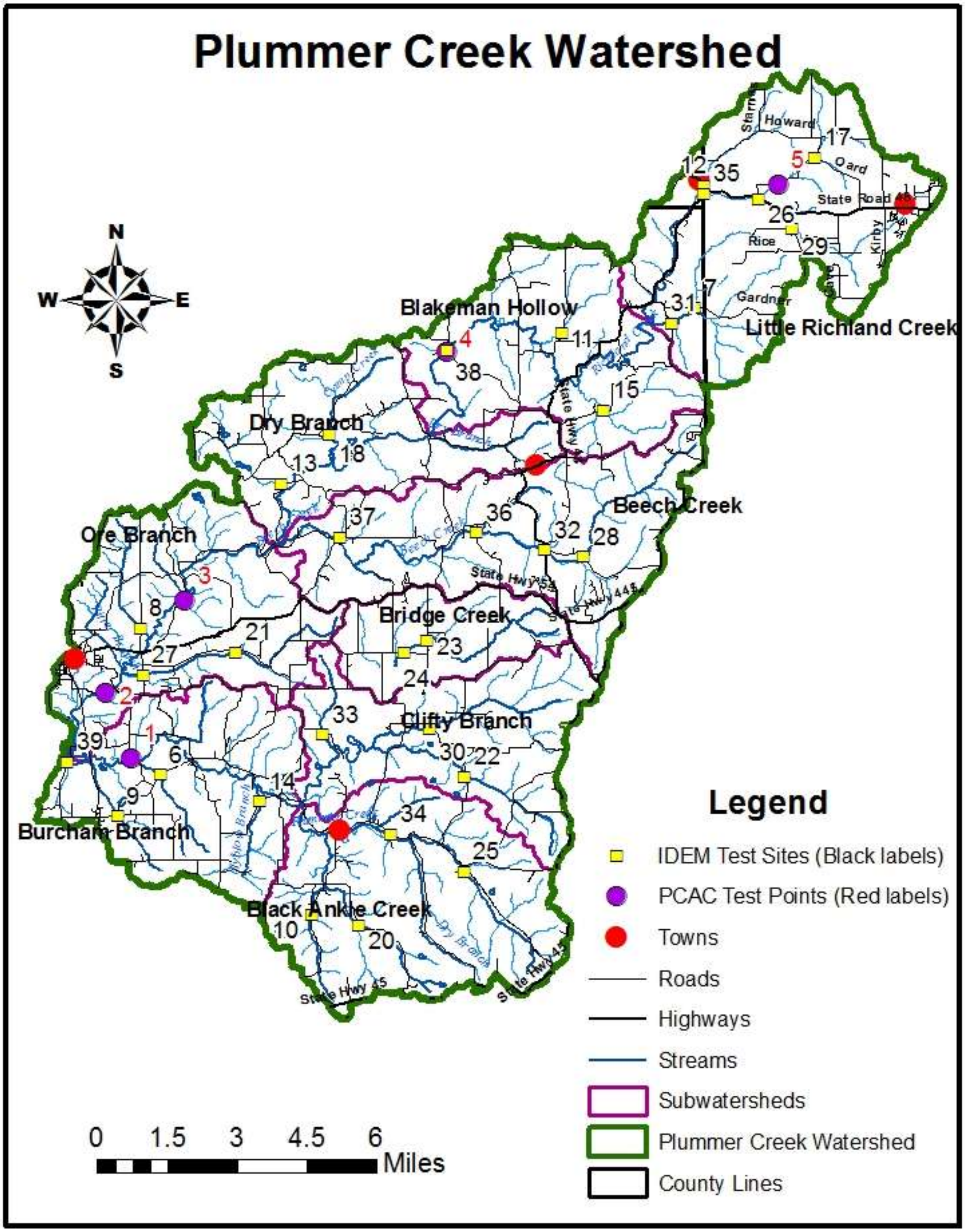
Water Quality Parameters	Parameter of Concern (Y/N)	Target	Why is it a Concern
Dissolved Oxygen	Yes	[1]Minimum 4 mg/L	Dissolved Oxygen is important to all aquatic life. Too much or too little can kill an entire population of fish and other wildlife.
Biochemical Oxygen Demand 5-day (BOD5)	Yes	[5]Maximum 5 mg/L	A measure of how much dissolved oxygen is being used by chemical or biological processes.
Flow	Yes	None	Flow, or discharge, is directly related to other parameters of concern. It can be used to convert concentrations to total loads of pollutants.
Total Suspended Solids (TSS)	Yes	[2]Maximum 30 mg/L	TSS can ruin a formerly fish friendly habitat, making it harder for fish to breathe and see. Measures weight of particles in water.
Total Dissolved Solids (TDS)	Yes	[7]Maximum 500 mg/L	TDS can foul the taste of water. It can indicate other types of pollutants
Specific Conductivity	Yes	[1]Maximum 1.2 ms/cm Equivalent to 1,200 µs/cm	Conductivity in water is affected by the presence of inorganic dissolved solids. Can indicate presence of failing sewage systems
Nitrate	Yes	[2]Maximum 1.0 mg/L	Can cause eutrophication or disease in humans and wildlife if too much is in the water.
Total Phosphorous	Yes	[3]Maximum 0.076 mg/L	Can be linked to agriculture, urban fertilizer use, sewage, or natural plants. An excess can cause eutrophication.
Turbidity	Yes	[4]Maximum 25 NTU	Can ruin a formerly fish friendly habitat, making it harder for fish to breathe and see. Measures amount of light able to pass through the water.
E. coli	Yes	[1]Single Sample: 235 CFU/100mL [1]Geometric Mean (5 samples /30 days): 125 MPN/100 mL	A main parameter of concern among stakeholders, and failing in most tributaries. Causes disease in humans and animals.
Temperature	Yes	[1]Dependent on Month	Temperature can have an unhealthy effect on warm water aquatic life if temperatures are too high or low
Ammonia	Yes	[1&A] Between 0.0 and 0.21 mg/L	Indicator of fecal material. Indicator of whether the water can support aquatic life

Water Quality Parameters	Parameter of Concern (Y/N)	Target	Why is it a Concern
Total Kjeldahl Nitrogen (TKN)	Yes	[6]0.28 mg/L	The sum of organic nitrogen and ammonia in a water body. High concentrations of TKN typically result from sewage and manure discharges to surface waters. Sources of TKN include decay of organic material (plants, animal waste, urban and industrial disposal of sewage and organic waste).
pH	No	[1]Between 6.0 and 9.0	Measures the acidity and basicity of the water on a scale of 1 (very acidic) to 14 (very basic). Too high or too low can be detrimental not only to humans and animals, but also crops and soil.
Biological	Yes	[5]11+ (Hoosier River watch) [1]>36 (MIBI) [1]>35 (IBI-Fish community score)	Different taxa of invertebrates and fish found in a body of water are a good indicator of different levels of all-around water quality. Indication of aquatic life quality
Habitat	Yes	[5]>60+ (CQHEI) [1]>50 QHEI	The surroundings and features of a water body can affect water quality and the likelihood of fish to live in the area.

[1] Indiana Administrative Code (327 IAC 2-1-6)
[2] IDEM draft TMDL target (IDEM, 2008)
[3] Dividing line between mesotrophic and eutrophic streams (Dodds et al. 1998)
[4] Minnesota Water Quality Standards for Class 2B waters (cool and warm water fishery, all recreation) and Class 2C waters (indigenous fish, most recreation)
[5] Hoosier Riverwatch recommended target levels
[6] EPA proposed Criteria for TKN
[7] Effects of Total Dissolved Solids on Aquatic Organisms: Literature Review -Alaska Department of Fish and Game
[A] The maximum ammonia concentration (unionized ammonia as N) allowed in water quality standards ranges from 0.0075 mg/L (at 0 degrees C, pH=6.5) to 0.2137 mg/L (at 30 degrees C, pH=9.0)

Testing sites data are compared to these target levels set in Table 9. If a sample of the water collected by either the Plummer Creek Advisory Committee group at their test sites (PCAC Test Point), or by Indiana Department of Environmental Management baseline study test site (IDEM Test Site) exceeds the above set targets, then there is a level of concern that is created that the water quality is not at the level required to attain its water use (i.e. recreation, aquatic life uses). Map 13 shows the test sites that both monitoring efforts included in their sampling studies. Sites in red are PCAC test points, while numbers in black are the IDEM test sites. Both of these data will be discussed further below.

Map 13: Test Sites Map



Data Background

The most recent monitoring of Plummer Creek and Richland Creek water quality was conducted within the Plummer Creek watershed monthly from July 2012 through June 2014 by the watershed coordinator, volunteers, and the service learning group. Five sites were monitored and are labeled PCAC Sites (Test Points 1-5) as they were used by the Plummer Creek Advisory Committee (PCAC), see Map 13 above. The parameters that were collected during this monitoring include flow rate, dissolved oxygen, 5-day biochemical oxygen demand, ammonia nitrogen, pH, temperature, turbidity, total dissolved solids, total phosphorous, total suspended solids, specific conductivity, nitrate nitrogen, and E. coli. This data was sampled from July 2012- July 2014 once a month near the end of each month. Most of the chemical parameters were reported by the watershed coordinator through a YSI 6600 probe while total suspended solids, nitrates, total phosphorus, and E. coli were taken via samples from each testing site to Dillman Labs in Bloomington, IN. Windshield surveys were taken by the watershed coordinator or volunteers from the PCAC by driving on every road and noting possible water quality concerns from May-August 2013. We did this by dividing the PCW into its nine sub watersheds and investigating potential nonpoint sources for any monitored exceedance in the data. A desktop survey was done using previously compiled data from the baseline survey and data after a year of our own testing. Habitat and biological data were taken by the watershed coordinator along with general volunteers and volunteers from the service learning group once a year between the months of June and October. The Hoosier Riverwatch form was used to identify macroinvertebrates and rate the quality of life at each of the 5 testing points. Habitat data was surveyed using the Citizen's Qualitative Habitat Evaluation Index (CQHEI) at each of the 5 testing points.

Before monitoring began in 2012, the Indiana Department of Environmental Management (IDEM) did a baseline study for Plummer Creek Watershed from 2011-2012. IDEM conducted a pilot watershed survey in 2011 to evaluate the efficacy of a geometric and intensive pollution survey design to better delineate aquatic life impairments and determine the associated stressors in support of baseline watershed management. In April 2012, an intense survey of E.coli was conducted by testing sites once a week for five weeks, per a TMDL study. During that same intense sampling, all other chemical and physical parameters were tested by IDEM to gain insight into the conditions within the watershed and supplement water quality testing for the production of a watershed management plan and to determine. Additionally IDEM tested all the other parameters mentioned above plus (TKN) total Kjeldahl nitrogen on a monthly basis from 2011-2012.

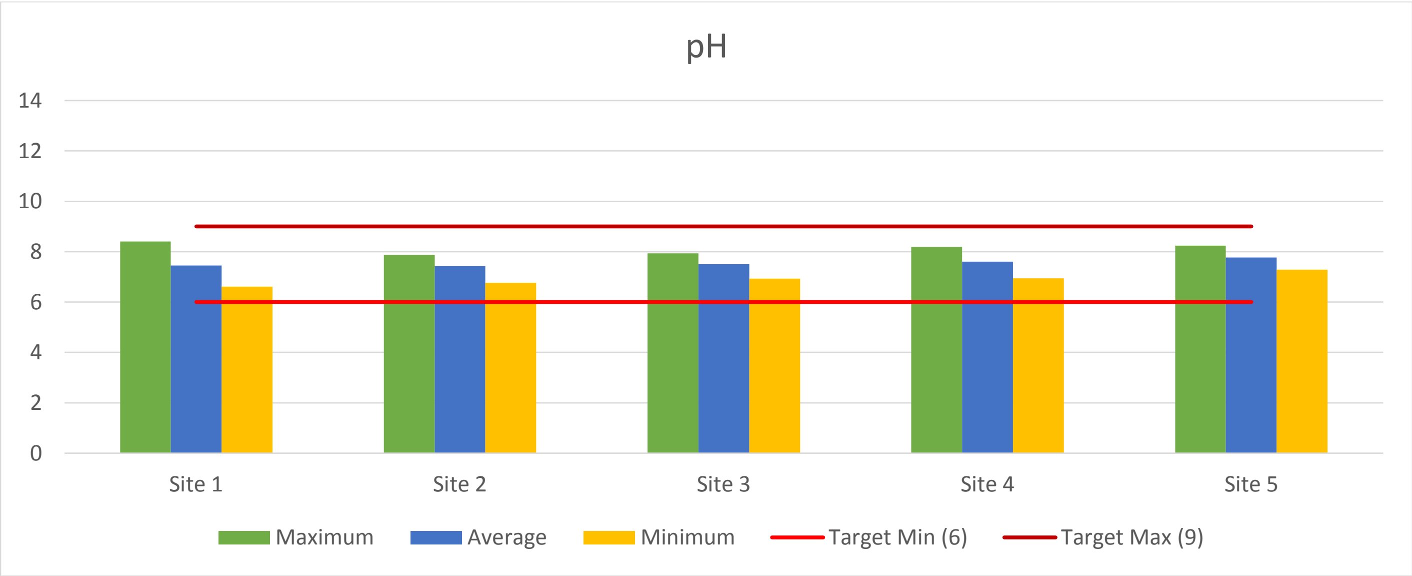
Probabilistic Monitoring is also done by IDEM in each basin throughout Indiana once every nine years on a rotating basis. This data was also taken for E. coli by the TMDL standard, meaning a sample was taken every week from the same site every week for five weeks. This study tests for several other state-wide concerns, which include hardness ($CaCO_3$), TSS, total solids, cyanide, sulfate, chloride, TDS, pH, percent DO saturation, alkalinity (as $CaCO_3$), temperature, specific conductance, DO and turbidity. Fish and macroinvertebrate community populations were also collected during the probabilistic monitoring.

Water Quality Information

pH

pH is the concentration of hydrogen ions in a solution on a scale of 0 to 14 (<7 is acidic, 7=neutral, >7 is basic). A change of 1 unit on a pH scale represents a 10 fold change in the pH, for example, water with a pH of 6 is 10 times more acidic than water with a pH of 7. pH levels indicate whether the water can support aquatic life. Many aquatic organisms are sensitive to pH (IDNR, 2008). Most aquatic animals and plants have adapted to life in water with a specific pH and even slight changes can reduce hatching success of fish eggs, irritate fish and aquatic insect gills and damage membranes, and affect amphibian populations (Frankenberger & Esman, 2012). The most significant environmental impact of pH involves its effect on the form or toxicity of other substances. For example, the pH of the water will determine the toxic effects of pollutants like iron, aluminum, ammonia or mercury (Frankenberger & Esman, 2012). Indiana water quality standards for aquatic life specify that no pH values shall be below 6.0 or above 9.0 (327 IAC 2-1-6). Many factors influence pH including water temperature, algae blooms, acid rain input, watershed soils and geology, mining, and runoff from agricultural fields. A YSI® 6600 instrument was used to collect pH readings in the field. All sites met the state standards including both IDEM Baselines sites (Table 11) and at the recent watershed monitoring test points (PCAC Sites). See Chart 1 for recent test points maximum, minimum, and average pH values from PCAC Test Points along with target values from above.

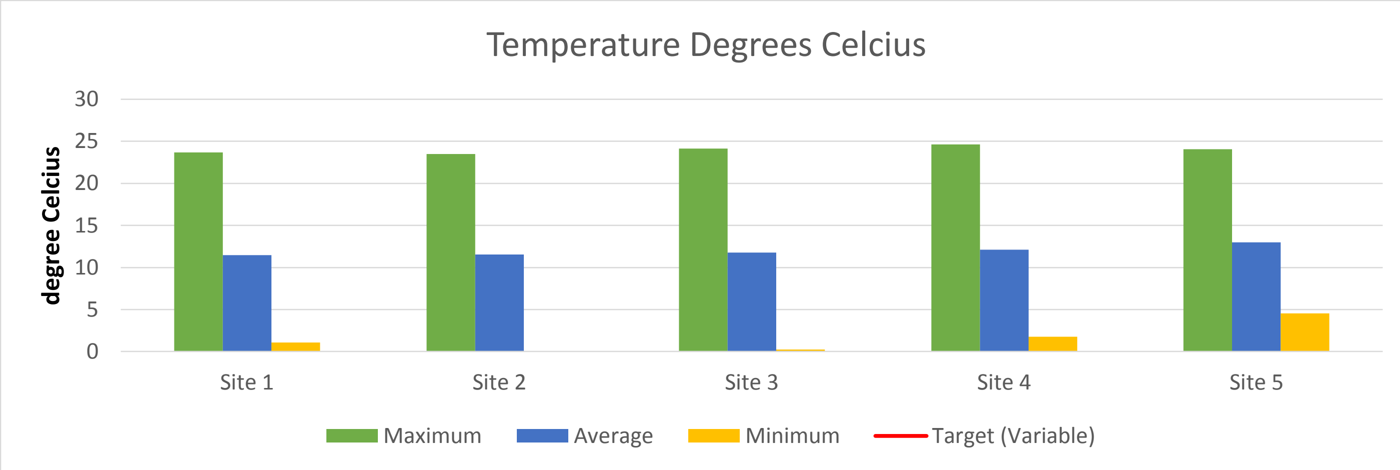
Chart 1: pH Results



Temperature

Water temperature is a critical water quality and environmental parameter because it governs the kinds and types of aquatic life, regulates the maximum dissolved oxygen concentration of the water, and influences the rate of chemical and biological reactions. Dissolved oxygen is a necessary component for most aquatic life. Temperature of a stream is influenced by the presence or absence of riparian vegetation, runoff from impervious surfaces, and direct wastewater discharge. This is also closely related to the canopy cover which can be associated with any forested riparian buffer on the stream. Water temperature measurements were conducted in the field using the temperature function on an YSI 6600 instrument. There have been no instances where the maximum temperature set by the state for every month was exceeded by our measurements.

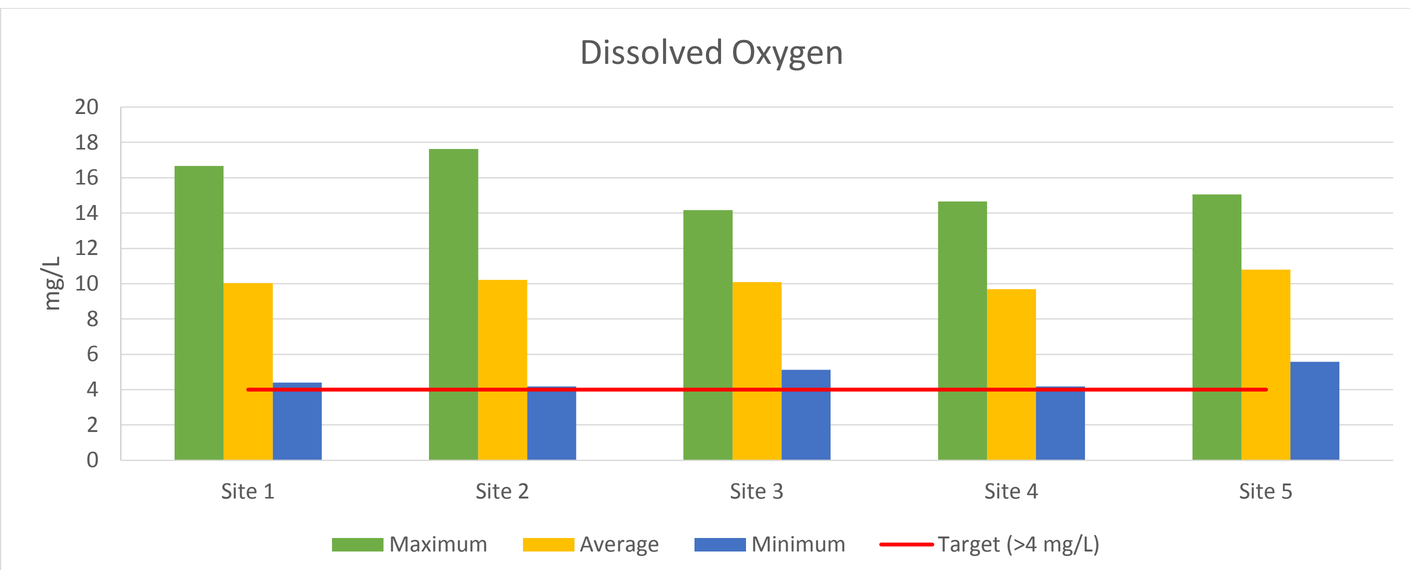
Chart 2: Temperature Results



Dissolved Oxygen

Dissolved oxygen (DO) concentration represents the amount of oxygen that is dissolved in a waterbody. The solubility of oxygen varies with temperature, and DO levels fluctuate regularly, particularly between day and night. Most aquatic organisms require dissolved oxygen (DO) gas in the water for survival. Indiana water quality standards for aquatic life state that DO shall not be less than 4.0 milligrams per liter (mg/L) at any time and shall average at least 5.0 mg per calendar day (327 IAC 2-1-6). DO is influenced by factors such as stream temperature and velocity, as well as by total suspended solids, nutrient, and organic waste concentrations. DO was measured using an YSI 6600 instrument in the field. In chart 3 the average, maximum, and minimum values are given for all five sites monitored with this project. Results indicate that the minimum levels fall very close to target levels but do not go below. The IDEM baseline data indicate healthy levels of dissolved oxygen in their testing as well, see Table 11.

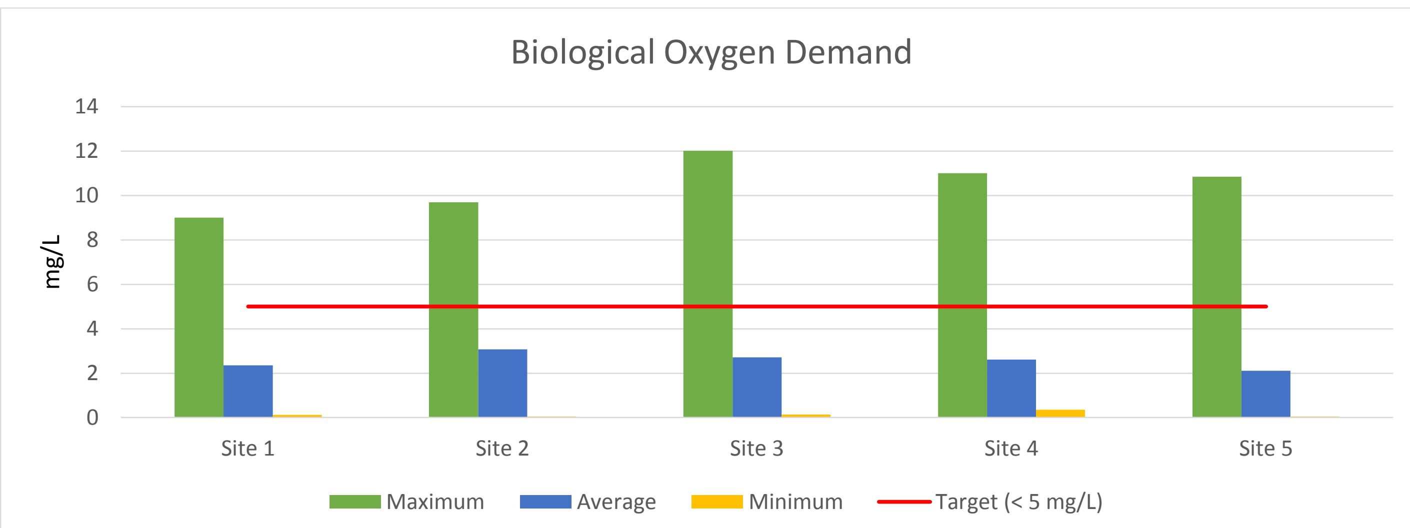
Chart 3: Dissolved Oxygen Results



Biochemical Oxygen Demand

As previously stated, most aquatic organisms require dissolved oxygen (DO) gas in the water for survival. Biochemical Oxygen Demand over 5 days (BOD5) can measure the use of oxygen within a stream. BOD5 measures the amount of oxygen required or consumed for the microbiological decomposition (oxidation) of organic material in water. As production within a stream increases the use of dissolved oxygen increases. If the use of dissolved oxygen is high by both biological organisms and/or chemical reactions then diurnal effects of respiration may cause a stream to drop in dissolved oxygen levels in early morning hours when photosynthesis has been suspended due to the lack of sunshine. The presence of high BOD may indicate fecal contamination or increases in particulate and dissolved organic carbon from human and animal sources that can restrict water use and development, necessitate expensive treatment and impair ecosystem health. There are no Indiana water quality standards for Biochemical Oxygen Demand levels for aquatic life. However, Hoosier Riverwatch recommends that no more than 5.0 milligrams per liter (mg/L) of dissolved oxygen depletion over a 5 day period should occur. BOD5 is influenced by factors such as stream temperature and velocity, as well as by total suspended solids, nutrient, and organic waste concentrations. BOD5 was measured using an YSI 6600 instrument on a water sample held in a dark bottle for 5 days at room temperature. The average, maximum, and minimum values are given for all five sites in Chart 4. The target level is that less than 5 mg/L of oxygen is used after a 5 day period. The DO levels in the sample is subtracted from the DO taken in the field to determine the amount of oxygen used over the 5 day period. The maximum BOD5 at every site exceeded the target levels. However, the average and minimums stayed well below the target value of 5 mg/L for all 5 sites. BOD5 was not collected by IDEM in their Baseline investigation.

Chart 4: Biochemical Oxygen Demand Results

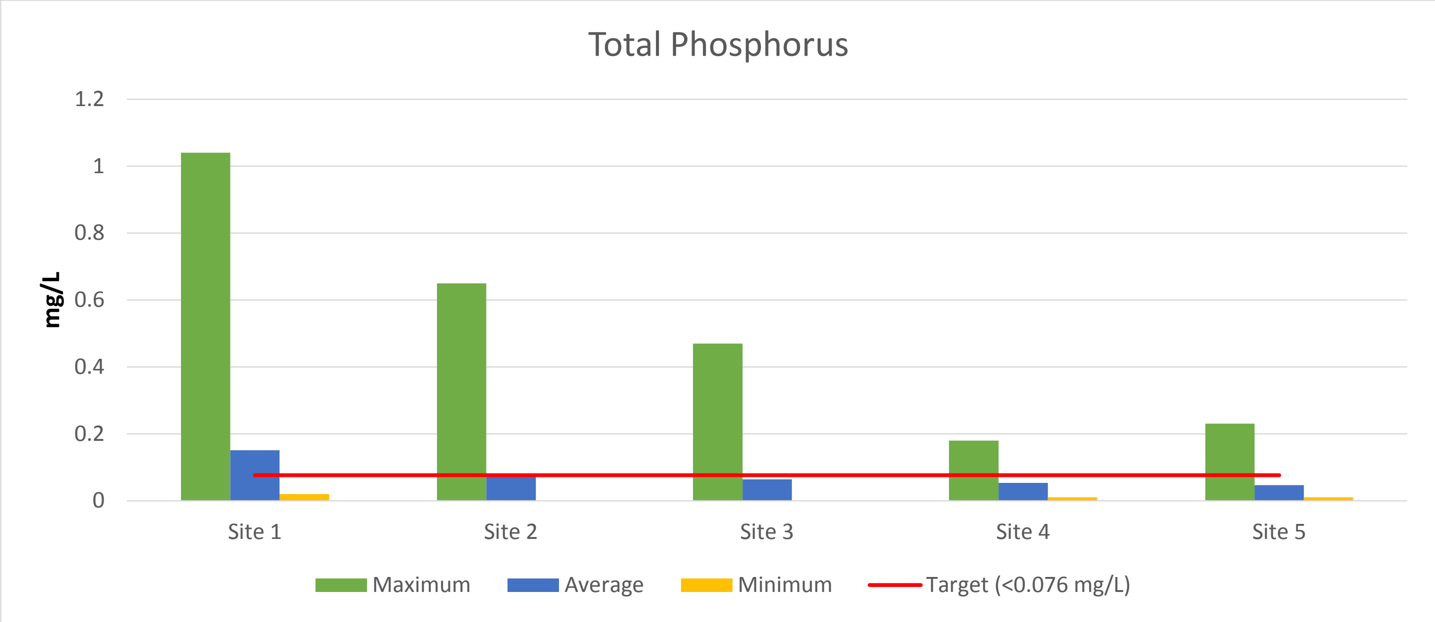


Total Phosphorous

Phosphorus is a naturally occurring nutrient in aquatic systems. Sources of additional phosphorus inputs include organic wastes such as human and animal wastes, fertilizers, detergents, and industrial wastes. Phosphorus is necessary for plant growth and is often the limiting growth factor in aquatic systems. Excessive amounts of phosphorus result in algae blooms and eutrophication. In an aquatic system, phosphorus cycles through different forms. Analysis of total

phosphate levels indicates the potential for future algal blooms and eutrophication by indicating the amount of phosphate that can convert to orthophosphate and be utilized by plants.
There is not currently an Indiana water quality standard for total phosphorus. The average total phosphorus value for Indiana water bodies are 0.05 mg/L (IDNR, 2008). A benchmark set by IDEM states that one or more measurements of total phosphorus greater than 0.3 mg/L coupled with another impairment on the same date allows the water body to be classified as impaired (IDEM, 2010c). We choose to use 0.076 mg/L as our target value. This value represents the often dividing line between mesotrophic and eutrophic streams (Dodds et al. 1998). The goal for recreation and aquatic wildlife is to not have eutrophic streams that are overproducing algae. As shown in the graph below, all test point maximum amounts are over the limit at every point. The average is above target levels as well at test points 1 and 2, but below for the remaining sites.

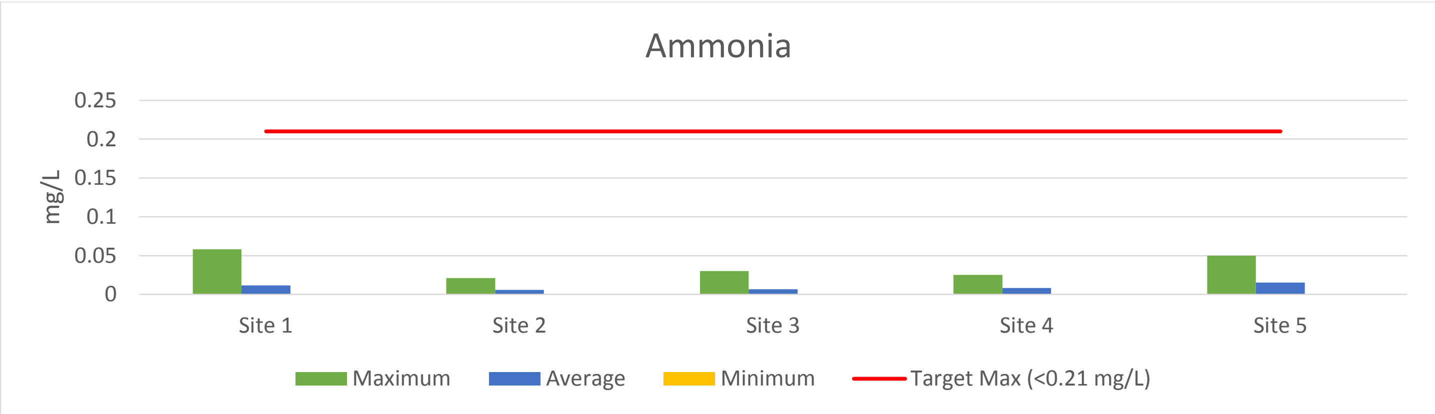
Chart 5: Phosphorus Results



Ammonia

The YSI 6600 probe for ammonia was only used halfway through sampling because of equipment malfunction. Due to a lack of funds, we kept using this probe just for the sole purpose of showing change, or a large spike in ammonia levels to indicate a straight pipe. No values were recorded over 0.21 mg/L. Ammonia values were not coupled with temperature or pH because this analysis would not produce reliable results at this time due to the unreliability of the probe.

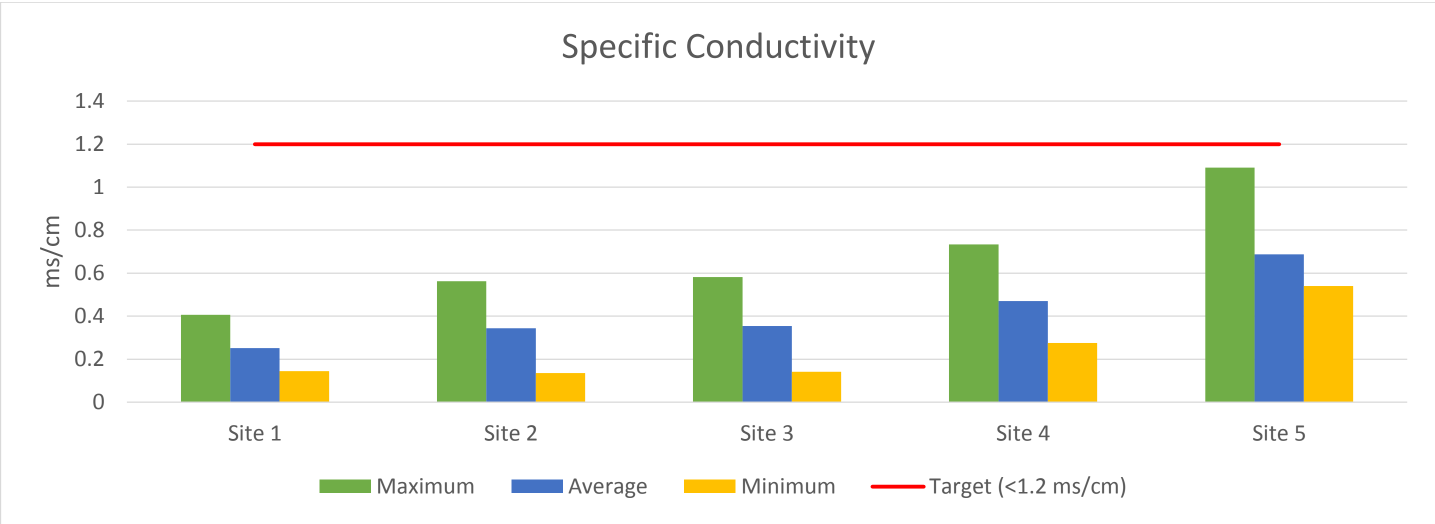
Chart 6: Ammonia Results



Specific Conductivity

Indiana water quality standards regulate the concentration of dissolved solids for waters used as a public or industrial water supply. Specific conductivity may be used as a measurement to assess compliance with this standard. Specific conductivity measurements increase with ion concentration. Thus, specific conductivity is an indirect measure of dissolved solids including, but not limited to, chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron. Specific conductivity is influenced by watershed soils and geology, as well as runoff from mines, roads, and agricultural fields. Specific conductivity shall not exceed 1,200 microsiemens (µS), or 1.2 millisiemens (ms), per centimeter at 25°C (327 IAC 2- 1-6). Conductivity has been measured using the 6600 YSI instrument in the field. All measurements taken were under the 1.2 millisiemens (ms) per centimeter level.

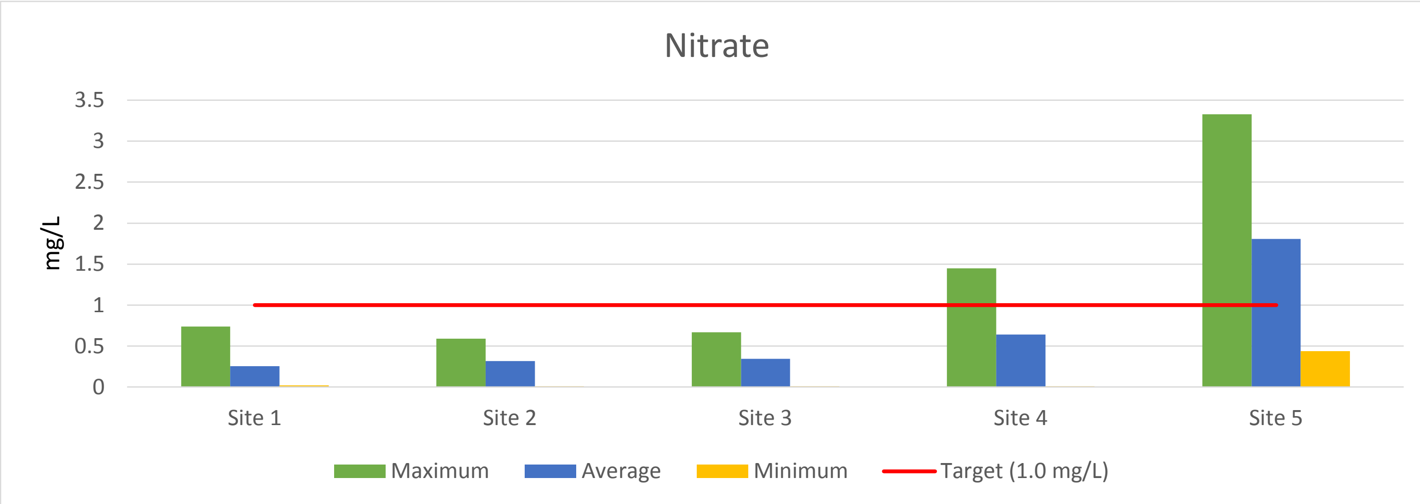
Chart 7: Conductivity Results



Nitrate

Nitrates (NO_3) are oxidized inorganic forms of nitrogen that are readily converted between the two forms in nature. Common sources of excess nitrates are human and animal wastes and runoff containing lawn and agricultural fertilizers. Nitrates can lead to increased aquatic plant growth and eutrophication. Elevated levels of nitrates in drinking water can cause severe illness. We do not perform this test in the field; we send this to Dillman Laboratory in Bloomington for analysis. Target levels set by this project are 1.0 mg/L. Site 4 and site 5 both exceeded the target for their respective maximum with the largest value of 3.33 mg/L. The average value of nitrate at site 5 is 1.8 mg/L which exceeded target levels set by this project indicating that there may be a significant sources of nitrates upstream from this site. The TMDL target set by IDEM, however, is set at 10 mg/L, which is well met by all testing sites within the PCW.

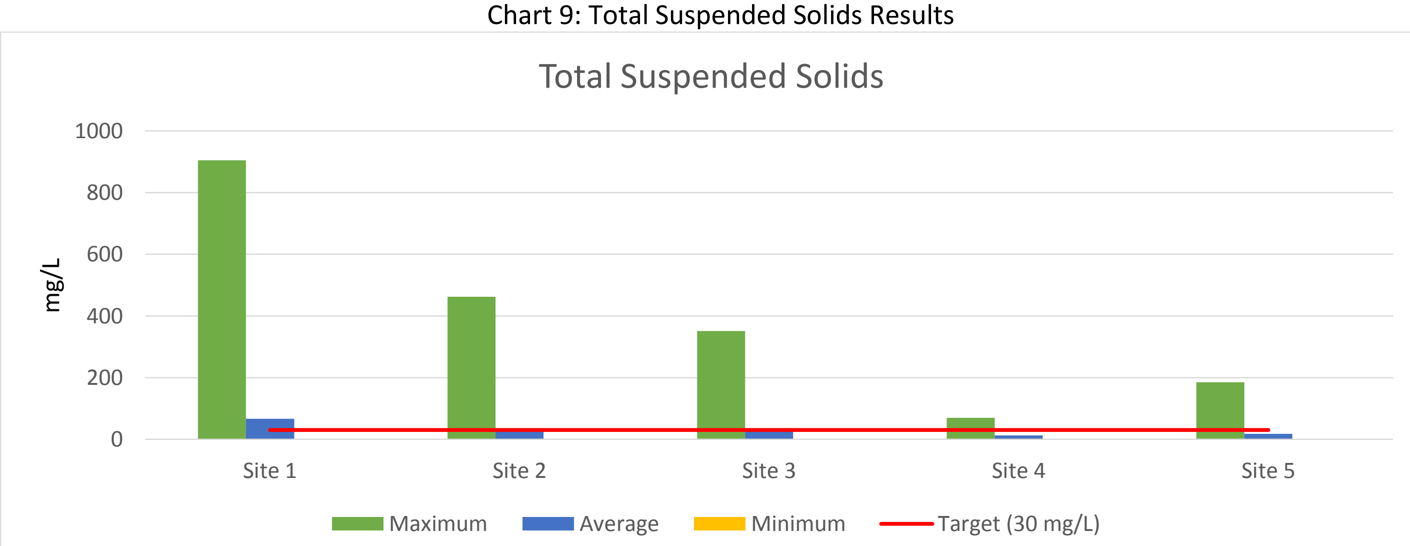
Chart 8: Nitrate Results



Total Suspended Solids (TSS)

The total suspended solids (TSS) measurement provides the weight of particulate material suspended in a water sample including sediment and other particles such as decaying organic matter. TSS concentrations are influenced by stream velocity. The higher the velocity, the larger and greater number of particles a stream can carry. Suspended particles absorb heat from the sun. A large quantity of suspended particles can result in elevated water temperatures and consequently lower levels of DO. Large quantities of suspended solids can also inhibit sunlight from reaching submerged plants and reduce photosynthesis resulting in less oxygen being released. As the velocity of water slows, TSS settle to the bottom of a stream where they can smother aquatic organisms. Solids suspended in the water column can originate from overland surface flow and streambank erosion. IDEM has established a maximum TSS concentration target of 30.0 mg/L; concentrations from 25.0-80.0 mg/L have been shown to reduce fish populations (IDEM, 2010e). This is another parameter that is sent to Dillman Labs for testing. All but site 4 do not meet the TMDL target set by IDEM, which is also the target set in this watershed management plan. Most all of the maximum readings were hugely in excess of the recommended value.

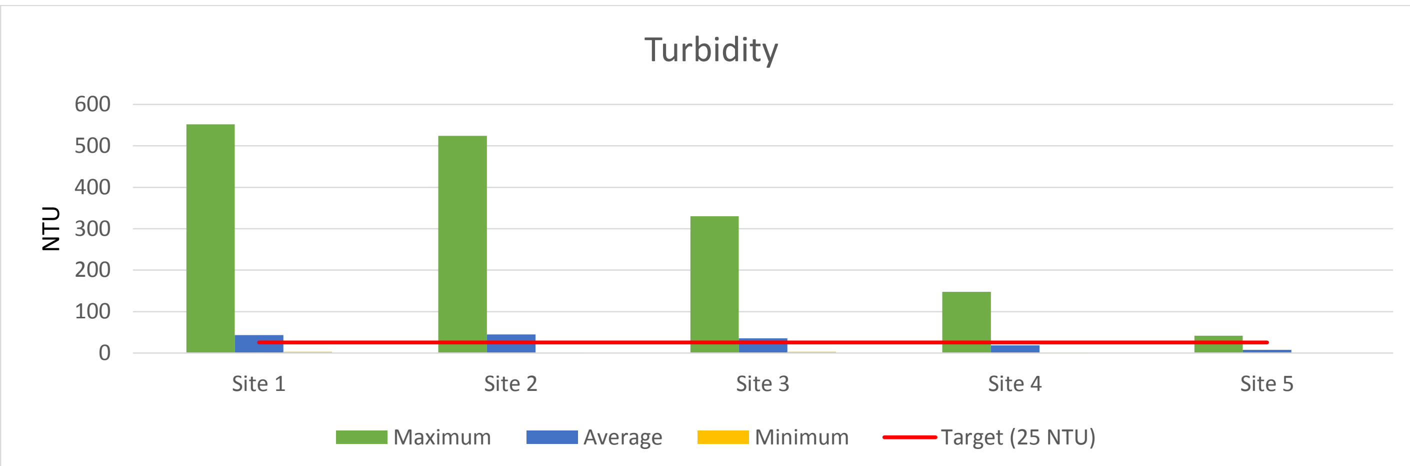
Chart 9: Total Suspended Solids Results



Turbidity

Turbidity is a measure of water clarity. Suspended solids in the water column scatter and absorb light reducing the clarity of water and increasing the turbidity value. Unlike a measure of TSS, turbidity measurements do not often include heavier particles that settle out quickly. Turbidity is measured in Nephelometric Turbidity Units (NTU). Again, we use the YSI 6600 unit to determine turbidity. The target value set by this project is 25 NTU. Three out of the 5 sites monitored are tremendously over this limit, except for sites 4 and 5, with an average of 18.78NTU and 9.56 NTU, respectively. Maximums at every site exceeded target levels indicating that fine sediment erosion is a significant issue within Plummer Creek watershed.

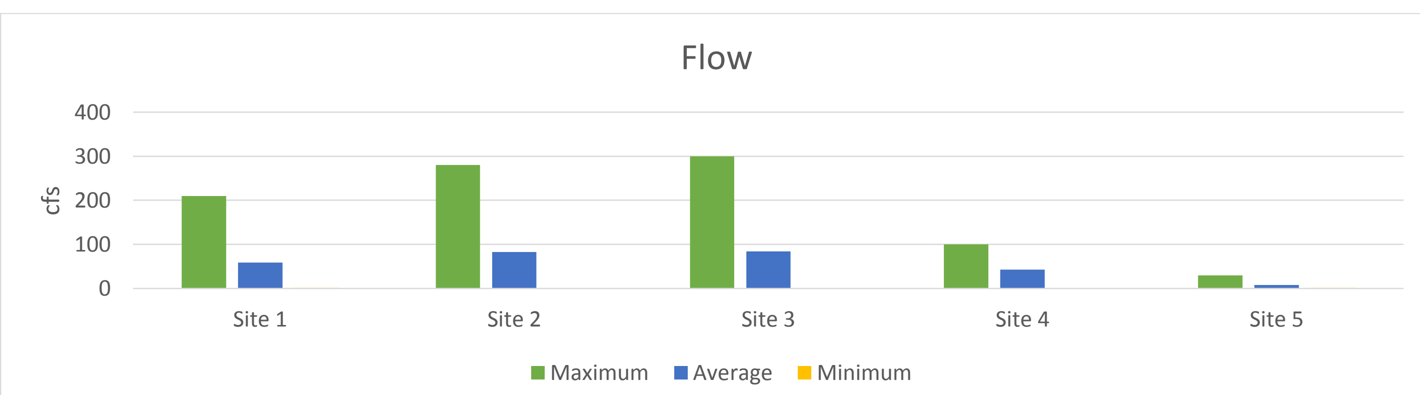
Chart 10: Turbidity Results



Flow

Flow measurements were done by the Hoosier Riverwatch method. We took 200 feet transects of the streams and measured flow rate, average depth, and average width. The flow rate was obtained by measuring 10 foot increments and timing how long it took an object to flow that length. The amount of discharge was determined by multiplying these three together. This shows the volume of water flowing through a particular point at that time.

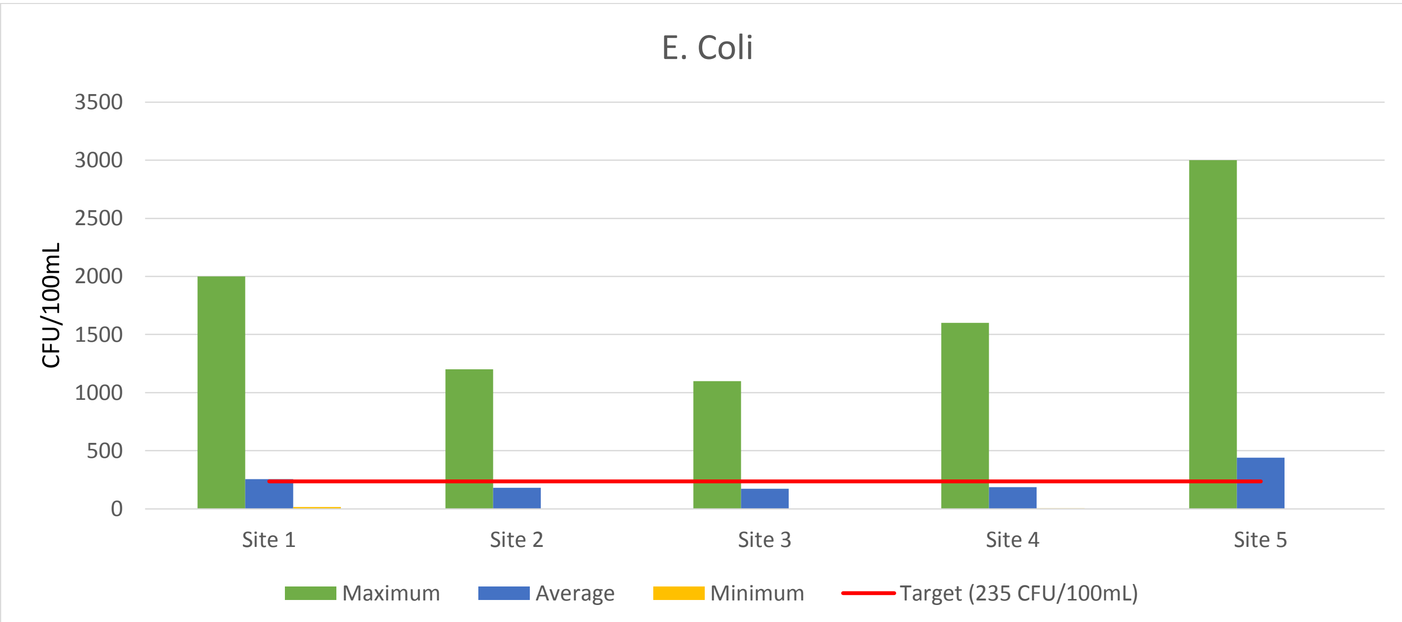
Chart 11: Flow Measurements



E. coli

Escherichia coli (E. coli) bacteria are found in the lower intestine and feces of warm-blooded animals. Some strains of E. coli can cause illness when they enter the body through the mouth, nose, eyes, ears, or cuts in the skin. The presence of E. coli in water is a good indicator of fecal contamination and the presence of other bacteria harmful to human health. Typical sources of E. coli in water are combined sewer overflows, malfunctioning septic systems, and livestock manure. E. coli samples were gathered at the stream and taken to the lab for analysis within 6 hours of collection to ensure an accurate count. E. coli measurements must have a geometric mean below 125 colony forming units (CFU) per 100 mL and no one individual sample with more than 235 CFU/100 mL. Our tests results show that every site had at least one sample that exceeded 235 CFU/100mL.

Chart 12: E. coli Results



Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) are solids in water that can pass through a filter. TDS includes all inorganic and organic material that is in a molecular or ionized, dissolved form. High concentrations of dissolved solids can cause many problems for stream health and aquatic life. The concentration of total dissolved solids affects the water balance in the cells of aquatic organisms. An organism placed in water with a very low level of solids, such as distilled water, will swell up because water will tend to move into its cells, which have a higher concentration of solids. An organism placed in water with a high concentration of solids will shrink somewhat because the water in its cells will tend to move out. This will in turn affect the organism's ability to maintain the proper cell density, making it difficult to keep its position in the water column. It might float up or sink down to a depth to which it is not adapted, and it might not survive. We use the YSI 6600 for this test also; it uses a factor stored in the machine, and 2 parameters to come up with the TDS. The recommended target by the EPA is a maximum of 500 ppm, or mg/L. This is the target level set for this project, as well. Averages of all samples collected at each sites showed that target levels were reached when averaged (Chart 13). Sites 4 and 5 had their maximums over the target levels.

Chart 13: Total Dissolved Solids Results

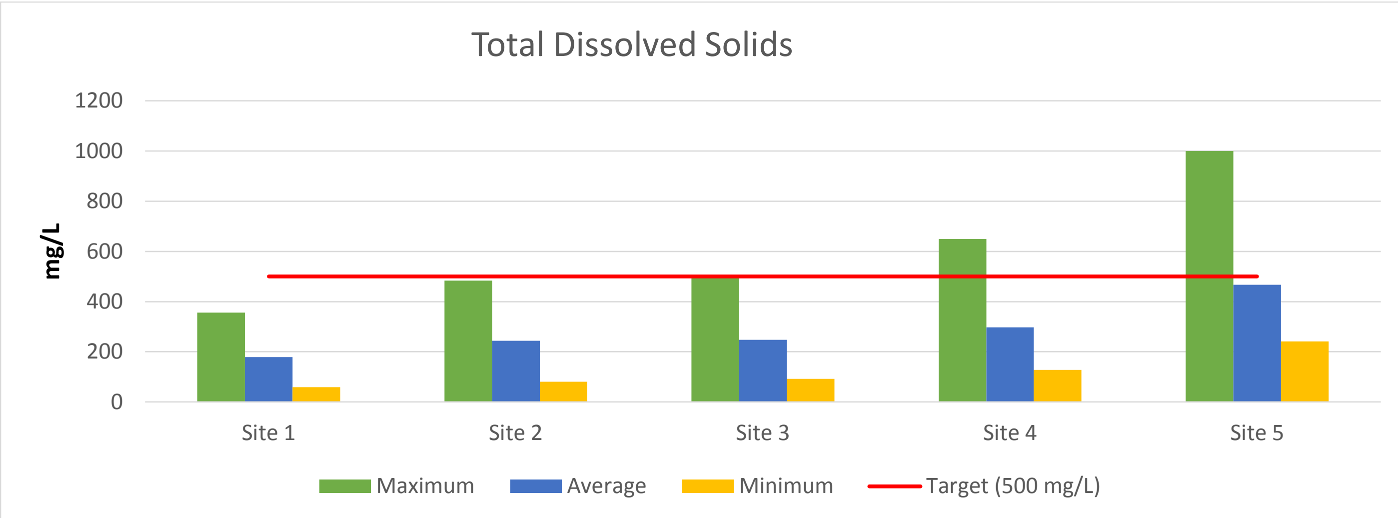


Table 10: Site Maximums

SITE #	pH	Temperature (Celsius)	DO (mg/L) Minimums	Conductivity (ms/cm)	Total Phosphorus (mg/L)	Nitrate (mg/L)	TSS (mg/L)	Turbidity (NTU)	TDS (mg/L)	E. coli (CFU/ 100mL)
Water Quality Target	>6,<9	Variable	>4	<1.2	<0.076	<1.0	<30	<25	<500	<235
Site 1	8.4	23.67	4.4	0.323	1.04	.074	905	552	356	800
Site 2	7.87	23.51	4.19	0.415	.65	.59	462	524	483	1200
Site 3	7.93	24.15	5.13	0.425	.47	.67	351	330	498	1100
Site 4	8.19	24.62	4.19	0.547	.18	1.45	70	147.5	649	1600
Site 5	8.24	24.07	5.58	0.756	.08	3.33	25	41.5	1000	3000

Taking the sites whose maximums are over target limits, here are the averages for each of those categories:

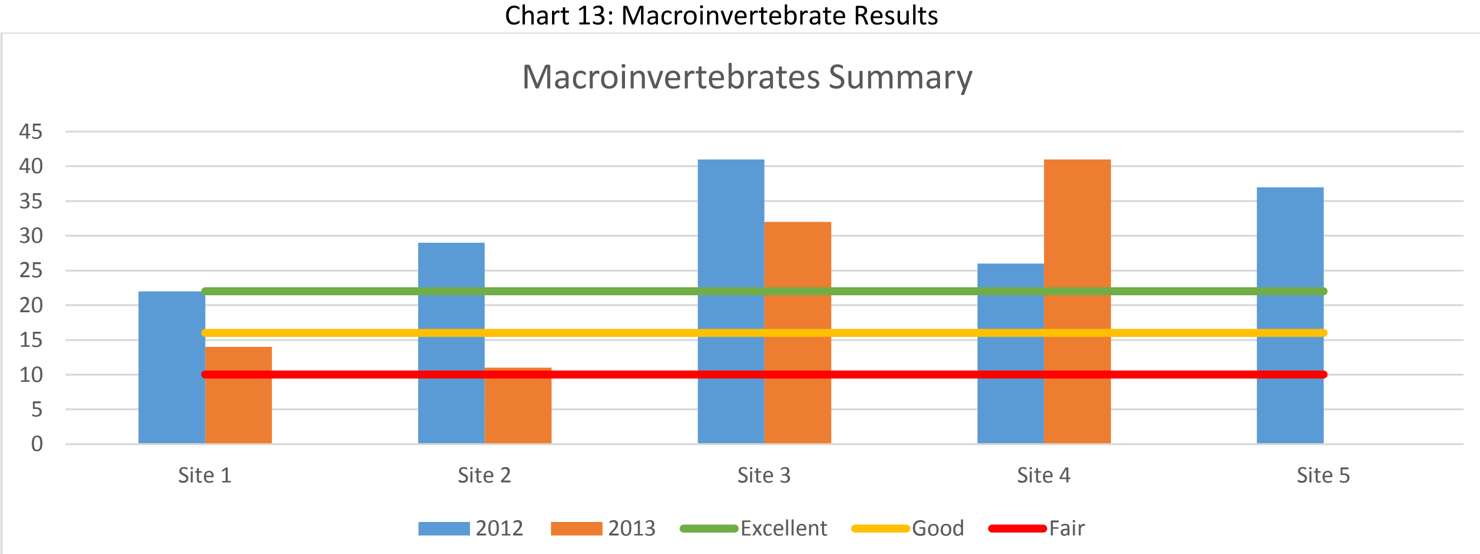
Site #	Total Phosphorus (mg/L)	Nitrate (mg/L)	TSS (mg/L)	Turbidity (mg/L)	TDS (mg/L)	E. coli (CFU/100mL)
Water Quality Target	<0.076	<1.0	<30	<25	<500	<235
Site 1	0.121333333	0.254	65.6	51.698	184.8667	177.4667
Site 2	0.084	0.316	35.66667	52.27267	226.5501	198.9867
Site 3	0.068	0.346	30.46667	39.20667	233.4836	181.8533
Site 4	0.052666667	0.643333	12.03333	17.84667	299.6	191.4
Site 5	0.038	1.809333	8.2	7.993333	468.9333	511.5333

As shown in the above Table 10, while maximums for several sites may be over the limit (the red values) and should be considered in need of improvement, the averages for sites may still be under set water quality targets. This occurs most notably for total phosphorus, where testing sites 3 and 4 drop below the target when considering just the average. Additionally site 4 had average nitrate and TSS values that lowered its average to below target levels. E. coli at every site had a very high maximum exceeding targets, but if you average the readings only one site, site 5, had the average reading above target levels. While the other parameters are all under the limits total phosphorous, nitrate, total suspended solids, turbidity, and E. coli are the biggest issues that we've encountered during the investigation phase of this project.

Macroinvertebrates

Benthic macroinvertebrates were sampled for in the falls of 2012 and 2013 once at each site. Volunteers loved to get out this time of year and help, so many assisted in the process. The collection process was done by using Hoosier River Watch. We collected in a 100 foot area using kick nets and dip nets to try and get a representative sample of the area. The macroinvertebrates were then put into water quality groupings after identified. These help determine the over-all health of a stream at a glance, and are a great way of measuring water quality quickly. These tests can be done to determine the quality in a stream. Site 5 was not tested in 2013 due to weather so it was not included in Chart 13. Target levels set for macroinvertebrates using the Hoosier Riverwatch methods is a score of 11 or greater (above the "fair" level indicated in Chart 13). All sites sampled in both years met this target level. However, a notable decline in macroinvertebrate populations can be seen from 2012 to 2013 at sites 1 and 2, indicating that something has affected those populations.

Chart 13: Macroinvertebrate Results



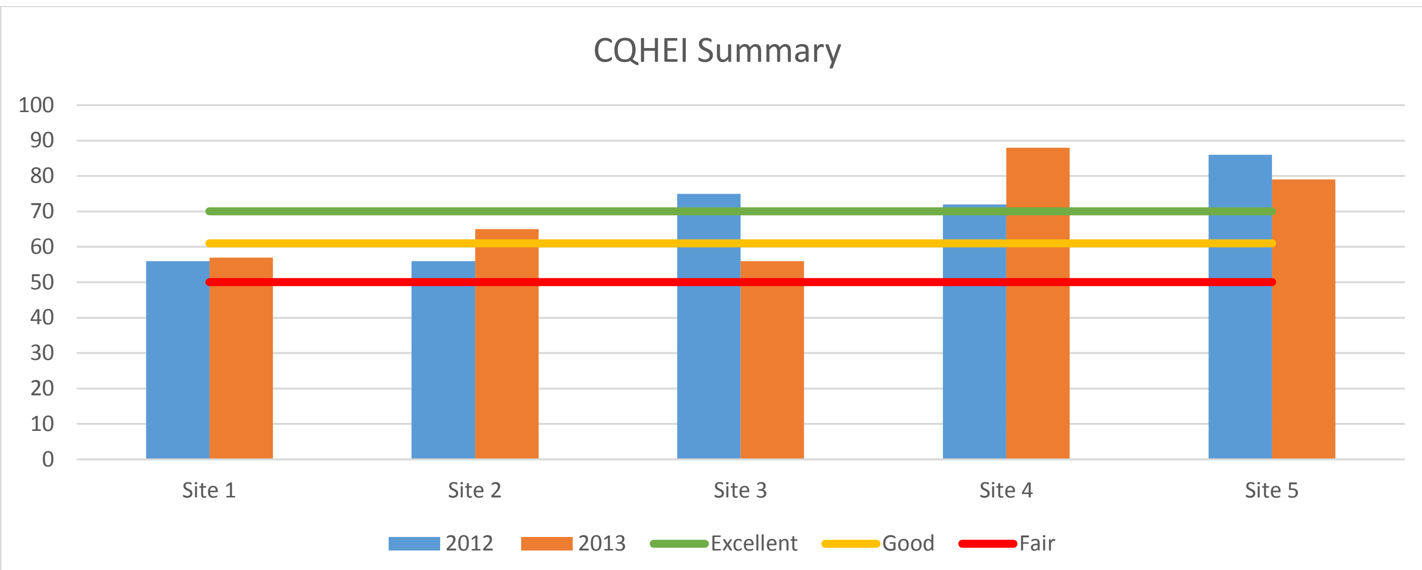
Habitat Analysis

The Qualitative Habitat Evaluation Index (QHEI) is a six metric index used to evaluate the physical habitat of a waterway. A QHEI analysis was conducted by Adam Grossman and volunteers at each site at the same time that macroinvertebrate communities were sampled. QHEI takes into account substrate, in-stream cover, channel morphology, riparian zone and bank erosion, pool/glide and riffle/run quality, and the waterway gradient. The maximum QHEI score is 100 (Ohio EPA, 2006). IDEM has determined that a total QHEI score less than 51 indicates poor quality habitat. QHEI scores are evaluated to determine if poor quality habitat is a contributing stressor on aquatic biotic communities (IDEM, 2010c).

QHEI data is very useful in the interpretation of macroinvertebrate data. If habitat is high quality and macroinvertebrate community analyses indicate impairment, it can be assumed that poor water quality is influencing the degradation of the macroinvertebrate community. Conversely, it is possible in some circumstances that macroinvertebrate community analyses indicate water quality impairment when in fact the macroinvertebrate community has been negatively impacted by lack of sufficient habitat. If both the macroinvertebrate community and QHEI analysis indicate impairment there is a lack of certainty into whether the habitat or water quality is the reason for the degradation of the macroinvertebrate community.

The PCAC chose to use a Citizens QHEI method (CQHEI) which gives a little better description of the parameters for ease of use. A large number of volunteers were utilized in this operation with varying levels of stream and water quality knowledge. The results are posted below. A score less than 51 is still the threshold for poor quality habitat. All of our points are above that.

Chart 14: CQHEI Results



Other Data

IDEM has done a yearlong baseline study in the watershed from 2011 to 2012. IDEM has also collected data for a TMDL report for both Plummer and Richland Creek. These both measured for E. coli. There are 2 NPDES sites in the watershed, Eastern Greene Schools and Neal's Landfill Spring Water Treatment Facility.

The PCW has also been studied for different reasons before this grant began its investigation. Creeks within the PCW were included in Indiana's 305(b) and 303(d) list of impaired waters for PCBs in fish tissue, impaired biotic communities, and mercury in fish tissue. Two TMDLs were done within the watershed, one concentrating on Plummer Creek and one for Richland, both focusing on E. coli, which was high in nearly every stream (reflected in our project data as well). A baseline study was conducted in 2011 to give a baseline for current efforts. That study found several issues that were concentrated on throughout our research.

The baseline study completed for the PCW was taken from 29 test sites, with multiple points in each sub watershed. The results were posted in "Identification of Key Stressors Affecting Aquatic Life in the Plummer Creek Watershed of Indiana" completed by the Midwest Biodiversity Institute. Baseline data was collected by IDEM and analyzed by Midwest Biodiversity Institute. Along with reporting average data readings for many chemical stressors, this study took an in depth look at habitat data for every testing point. It reported problems with E. coli, habitat, ammonia, TSS, and TKN. An analysis was conducted on sites in the Plummer Creek study area that were impaired on the basis of Indiana's assessment protocols for the MIBI (impaired at scores of <36). Nine of the 29 sites were listed as impaired for aquatic life use. According to this report, Plummer Creek stressor identification results indicate that most impairments are related to habitat degradation or a combination of habitat, livestock impacts, and nutrient enrichment. The findings were consistent with the test results of this project and are posted in tables 11 and 12 below. Map 14 shows where samples were taken during the baseline study and labels the points described in the tables of data. The data is filtered into individual sub watersheds and incorporated into the in-depth sub watershed discussions below.

Map 14: Baseline Study Testing Sites

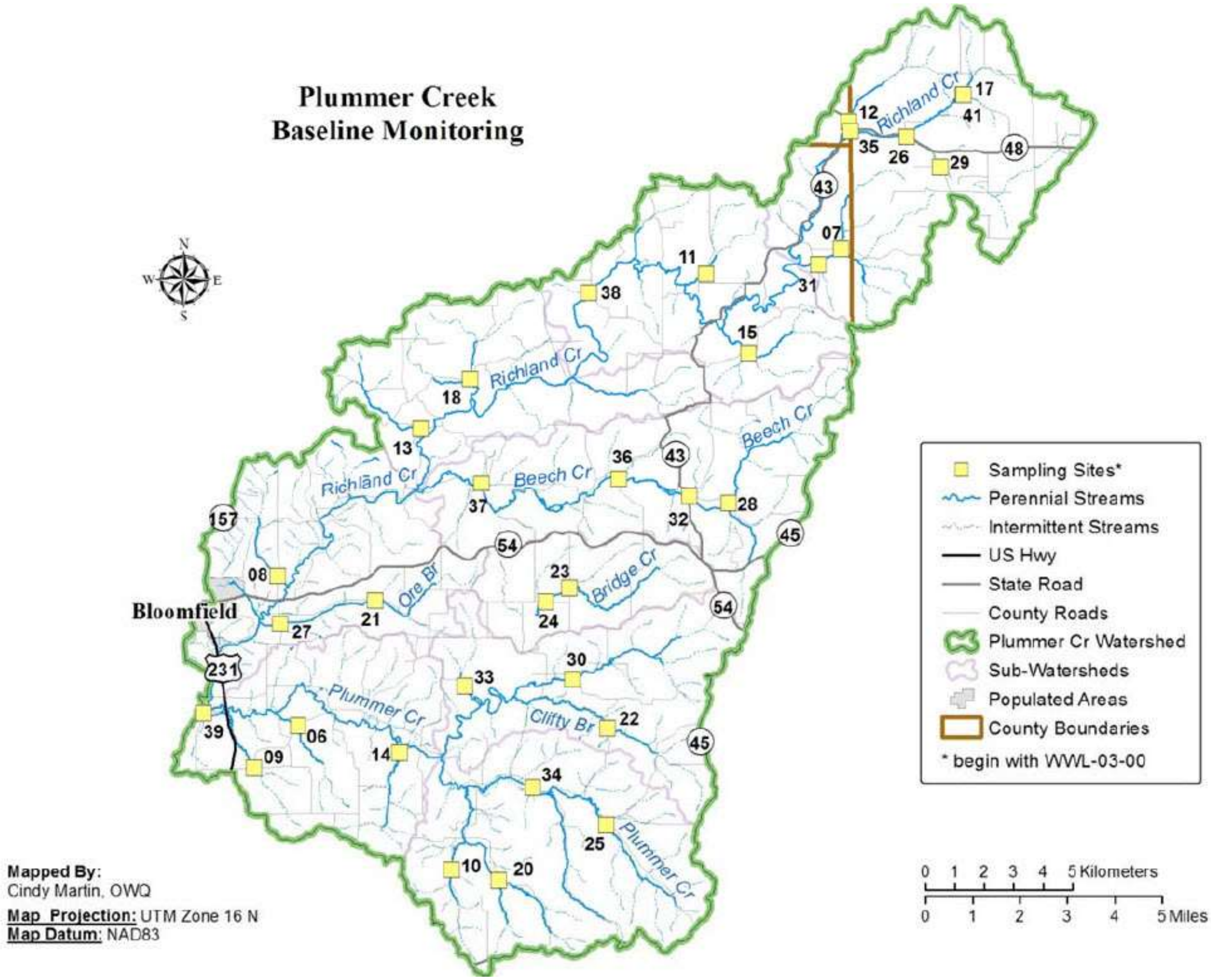


Table 11: Summary Ambient Data for Plummer Creek Sites

	Biological Measures		Chemical Stressors										Habitat Stressors						
Station ID	MIBI	EPT Index	DO	pH	Cond.	Turb.	TA	Nitrate	TP	TSS	TDS	TKN	QHEI	SUB	COV	CHAN	RIP	PL	RIF
WWL-03-0008	30	4	9.1	7.62	234	56.19	0.05	0.5	0.019	3.25	150	0.15	40	11	7	8	4	6	0
WWL-03-0009	38	2	8.29	7.6	196.1	11.46	0.34	0.38	0.032	2	128	0.71	54	14	8	12	5	5	0
WWL-03-0010	26	1	8.48	7.49	150.7	9.61	0.05	0.85	0.015	2.75	101	0.213	63	12	12	14	7	8	0
WWL-03-0011	42	3	7.26	7.72	344.3	37.29	0.09	0.258	0.039	17.29	223.3	0.479	52	12	10	11	3	6	0
WWL-03-0012	34	4	8.31	8.03	363.3	50.34	0.05	0.58	0.059	58.57	235.9	0.529	52	15	6	13	5	3	0
WWL-03-0013	46	9	10.44	8.2	331.1	95.3	0.05	0.3	0.019	2.83	221.3	0.175	51	13	8	9	7	3	3
WWL-03-0014	28	1	8.86	7.67	192.8	9.15	0.05	1.05	0.023	8.33	114	0.15	53	14	7	14	6	2	0
WWL-03-0015	42	9	8.12	7.83	327.9	30.6	0.05	0.46	0.029	29.14	198.9	0.343	78	18	13	16	8	7	6
WWL-03-0017	44	8	7.42	7.76	484.9	157	0.67	2.22	0.283	330.7	289.3	2.575	75	18	11	17	6	10	3
WWL-03-0018	48	18	8.55	7.78	227.9	141.5	0.05	0.26	0.019	6.67	151.8	0.2	66	12	11	14	9	8	4
WWL-03-0021	36	15	9.53	7.87	218.3	30.13	0.05	0.5	0.015	2.83	144.3	0.15	81	18	15	15	10	8	5
WWL-03-0022	36	0	7.45	7.57	245	24.39	1.08	0.2	0.067	17.67	161.3	1.992	62	16	8	13	7	4	4
WWL-03-0023	40	4	7.54	7.72	280.6	54.78	0.11	0.833	0.075	11	199.2	0.608	47	5	10	11	5	8	0
WWL-03-0024	32	3	6.86	7.68	322.6	24.93	0.45	0.85	0.087	14.17	207.2	1.208	44	9	6	7	6	5	3
WWL-03-0025	32	3	8.47	7.72	192.8	20.08	0.05	0.2	0.015	2	124.8	0.192	44	9	6	7	6	5	3
WWL-03-0026	44	13	8.71	7.97	567.3	142.6	0.05	2	0.166	272.1	377.4	1.007	74	17	13	13	9	8	4
WWL-03-0027	32	5	9.09	7.84	237.6	91.21	0.05	0.5	0.02	3.5	156.8	0.233	57	14	8	13	7	9	0
WWL-03-0028	38	6	9.38	7.75	259.5	28.49	0.05	0.433	0.015	3.5	182	0.175	70	17	9	14	10	5	5
WWL-03-0029	38	8	9.41	7.92	388.4	74.21	0.05	1.183	0.068	102	288.4	0.5	63	16	12	16	5	5	5
WWL-03-0030	30	3	7.92	7.65	252.9	24.14	0.1	0.375	0.015	5.6	168.6	0.45	38	2	6	11	9	6	0
WWL-03-0031	40	21	6.79	7.82	376.9	85.23	0.05	0.517	0.048	80	252	0.607	59	11	13	13	4	9	5
WWL-03-0032	40	8	10.09	7.78	289.9	16.21	0.05	0.433	0.018	4.5	198.7	0.192	61	17	5	13	7	5	4
WWL-03-0033	40	16	9.63	7.89	267.8	41.12	0.05	2.35	0.037	4.17	190.7	0.3	78	15	13	16	8	10	6
WWL-03-0034	30	3	8.11	7.64	265.1	20.96	0.05	0.35	0.015	5.5	164.8	0.275	55	9	6	13	8	9	0
WWL-03-0035	40	10	9.17	8.1	514.9	133.8	0.05	1.533	0.138	215.9	335.7	0.879	63	15	9	14	6	5	4
WWL-03-0036	36	7	8.28	7.72	277.8	31.24	0.05	0.375	0.015	4	188	0.192	56	13	11	13	5	4	0
WWL-03-0037	40	5	7.29	7.64	311.4	11.63	0.05	0.425	0.018	6.17	193.2	0.367	36	1	7	11	3	8	0
WWL-03-0038	48	18	7.24	7.81	413.9	101.3	0.05	0.725	0.061	103.6	282	0.65	65	9	11	13	10	10	6
WWL-03-0039	40	1	8.23	7.78	299.5	51.59	0.05	0.45	0.033	17.83	195.8	0.392	37	1	6	11	7	6	0

Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality

MIBI= Macroinvertebrate Index of Biotic Integrity

EPT Index= Species richness of a stream. For example, invertebrates within the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)

DO = Dissolved Oxygen
Cond.= Conductivity
Turb.= Turbidity
TA = Total Ammonia
TP = Total Phosphorus
TSS = Total Suspended Solids
TDS = Total Dissolved Solids
TKN = Total Kjeldahl Nitrogen

QHEI = Qualitative Habitat Evaluation Index
SUB = Substrate (stream bottom)
COV = Stream Cover
CHAN = Channelization
RIP = Riparian Buffer
PL = Pool
RIF = Riffle

Table 12: Aquatic Life Use Attainment Status for Sites Sampled in the Plummer Creek Watershed During 2011

Site ID	Location	DA sq mi	IDEM MIBI	ad hoc MIBI	QHEI	Attain-ment Status	Causes	Sources
Huc-12 Watershed: 051202020301								
Little Richland Creek								
WWL-03-0031	CR 1310	6.6	**40**	86	59	**Full**		
Richland Creek								
WWL-03-0017	W Vernal Pike	3.0	**44**	71	75	**Full**		
WWL-03-0026	SR 48/W 3rd St	4.8	**44**	89	74	**Full**		
WWL-03-0035	SR 43	12.3	**40**	90	63	**Full**		
Tributary to Richland Creek								
WWL-03-0012	SR 43	2.6	**34**	54	52	**Non**	Habitat (low riffle score), high TSS	Habitat Modification, Ag Runoff. & Livestock
WWL-03-0029	W Hendricks Rd	5.5	**38**	78	63	**Full**		
Huc-12 Watershed: 051202020302								
Richland Creek								
WWL-03-0038	CR 850 E	41.6	**48**	76	65	**Full**		
Tributary to Richland Creek								
WWL-03-0011	CR 1100 E	2.4	**42**	55	52	**Full**		
WWL-03-0015	CR 525 N	3.7	**42**	80	78	**Full**		
Huc-12 Watershed: 051202020303								
Bridge Creek								
WWL-03-0023	CR 800 E	4.0	40	43	47	**Full**		
WWL-03-0024	CR 25 N	4.5	32	45	44	**Non**	Habitat: Poor Channels and substrate, High TA and TKN	Habitat Modification, Ag Runoff. & Livestock
Huc-12 Watershed: 051202020304								
Beech Creek								
WWL-03-0028	CR 250 N	5.5	38	67	70	**Full**		
WWL-03-0032	SR 43	10.6	40	69	61	**Full**		
WWL-03-0036	CR 900 E	13.8	36	57	56	**Full**		
WWL-03-0037	CR 280 N	20.7	40	48	36	**Full**		
Huc-12 Watershed: 051202020305								
Camp Creek								
WWL-03-0018	CR 515/460	3.0	48	82	66	**Full**		
Tributary to Richland Creek								
WWL-03-0013	CR 480 E	2.6	46	51	51	**Full**		

Site ID	Location	DA sq mi	IDEM MIBI	ad hoc MIBI	QHEI	Attain-ment Status	Causes	Sources
Huc-12 Watershed: 051202020306								
Clifty Branch								
WWL-03-0030	CR 175 S	6.3	30	45	38	Non	Habitat: poor substrates and riffles	Habitat Modification; Ag Runoff. & Livestock
Little Clifty Branch								
WWL-03-0022	CR 875 E	3.4	36	38	62	Full		
Stalcup Branch								
WWL-03-0033	CR 140 S	10.2	40	84	78	Full		
Huc-12 Watershed: 051202020307								
Plummer Creek								
WWL-03-0025	Private Drive Off of CR 635 S	4.7	32	71	44	Non	Habitat: poor substrates	Habitat Modification; Ag Runoff. & Livestock
WWL-03-0034	CR 725 E	10.8	30	53	55	Non	Habitat: poor substrates and riffles	Habitat Modification; Ag Runoff. & Livestock
Tributary to Black Ankle Creek								
WWL-03-0010	CR 560 E	2.2	26	60	63	Non	Habitat: poor riffles	Habitat Modification; Ag Runoff. & Livestock
Huc-12 Watershed: 051202020308								
Ore Branch								
WWL-03-0021	Private Drive Off of Ore Branch Rd	3.1	36	86	81	Full		
WWL-03-0027	CR 175	5.1	32	53	57	Non	Habitat: poor riffles	Habitat Modification; Ag Runoff. & Livestock
Wildcat Branch								
WWL-03-0008	CR 175/Warren Rd	2.0	30	34	40	Non	Habitat: poor channels and riffles	Habitat Modification; Ag Runoff. & Livestock
Huc-12 Watershed: 051202020309								
Flyblow Branch								
WWL-03-0014	CR 345 S	2.8	28	50	53	Non	Habitat: very poor riffles, poor pools; elevated nitrate	Habitat Modification; Nutrient run-off; Ag Runoff & Livestock

Site ID	Location	DA sq mi	IDEM MIBI	ad hoc MIBI	QHEI	Attain-ment Status	Causes	Sources
Plummer Creek								
WWL-03-0039	Base Line Rd/CR 25 E	173.3	40	34	37	**Full**		
Tributary to Plummer Creek								
WWL-03-0009	CR 300	2.1	38	51	54	**Full**		

MIBI Narrative Ranges	Very Poor		Poor:		Fair:		Good:		Excellent	
Ad hoc IBI Ranges[1]	< 40		40-55		56-67		68-77		≥78	
QHEI Narrative Ranges	Very Poor:		Poor:		Fair:		Good:		Excellent:	

[1]Taken from a regression of MIBI with the ad hoc MIBI: ad hoc MIBI = 9.7 + 1.3*MIBI

The TMDLs done in Richland and Plummer Creeks also found many areas of streams that were impaired for E. coli, as can be seen in tables 5 and 6 (pg 30, 31). This is again consistent with all the other data taken in the PCW and many of the streams have been listed as critical areas to focus on if this grant is continued into the implementation phase. Several issues are mentioned as possible sources of the impairments, including wildlife and failing septic systems.
As you can see from the 303d list in table 7 (pg 32), PCBs, Mercury, impaired biotic communities, and E. coli have been recorded as problems in several stream segments throughout the PCW. Our testing, compared to that of the IDEM baseline study, IDEM probabilistic monitoring, and the TMDLs have found similar results with the tested parameters that each focused on. Baseline data was collected by IDEM and analyzed by Midwest Biodiversity Institute.

Fish community study for Richland Creek was conducted in 2007 by the Department of Natural Resources Division of Fish and Wildlife. A general stream fish community survey of Richland Creek was conducted August 29 and September 6 and 7, 2005. Seven stations approximately four river mi apart were sampled. All fish species were collected using a Smith-Root tote barge. Available habitat was assessed using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA. The Index of Biotic Integrity (IBI) was also used to assess stream health based upon fish community. Water quality, based upon standard parameters at the time of sampling was adequate at all stations. A total of 4,193 fish was collected. Total weight was 205.74 lbs. There were 13 families of fish collected, including 49 species and one hybrid. Habitat based upon QHEI averaged 62.5 indicating acceptable habitat for warm water game fish. Two stations rated in the "excellent" category based on IBI assessment of water quality (IBI=58-60). Three stations were rated as "good to excellent" (IBI=48-52) and the remaining two stations were in the "fair to good" category (IBI = 40-44). Angling opportunities at Richland Creek are best for spotted bass and rock bass. Spotted bass were collected at all stations and ranged in length from 1.6 to 14.9 in. Rock bass were collected at all but one station and ranged in length from 1.2 to 8.3 in. Twenty-five smallmouth bass were collected. Only one smallmouth bass exceeded 12.0 in. The majority of the smallmouth were age-1 fish. During reconnaissance of survey sites and during sampling, livestock were observed in the stream channel at various reaches of Richland Creek. Many of the potential sample sites had some sort of exclusion fencing, indicating much of the watershed is used for livestock and agriculture. Habitat and IBI scores indicate adequate water quality and habitat for smallmouth. However, the lack of larger fish may indicate high angler harvest, or more likely, seasonal high water moving sediments during critical times of the year, limiting survival of larval smallmouth bass. This could explain the lack of consistent recruitment.

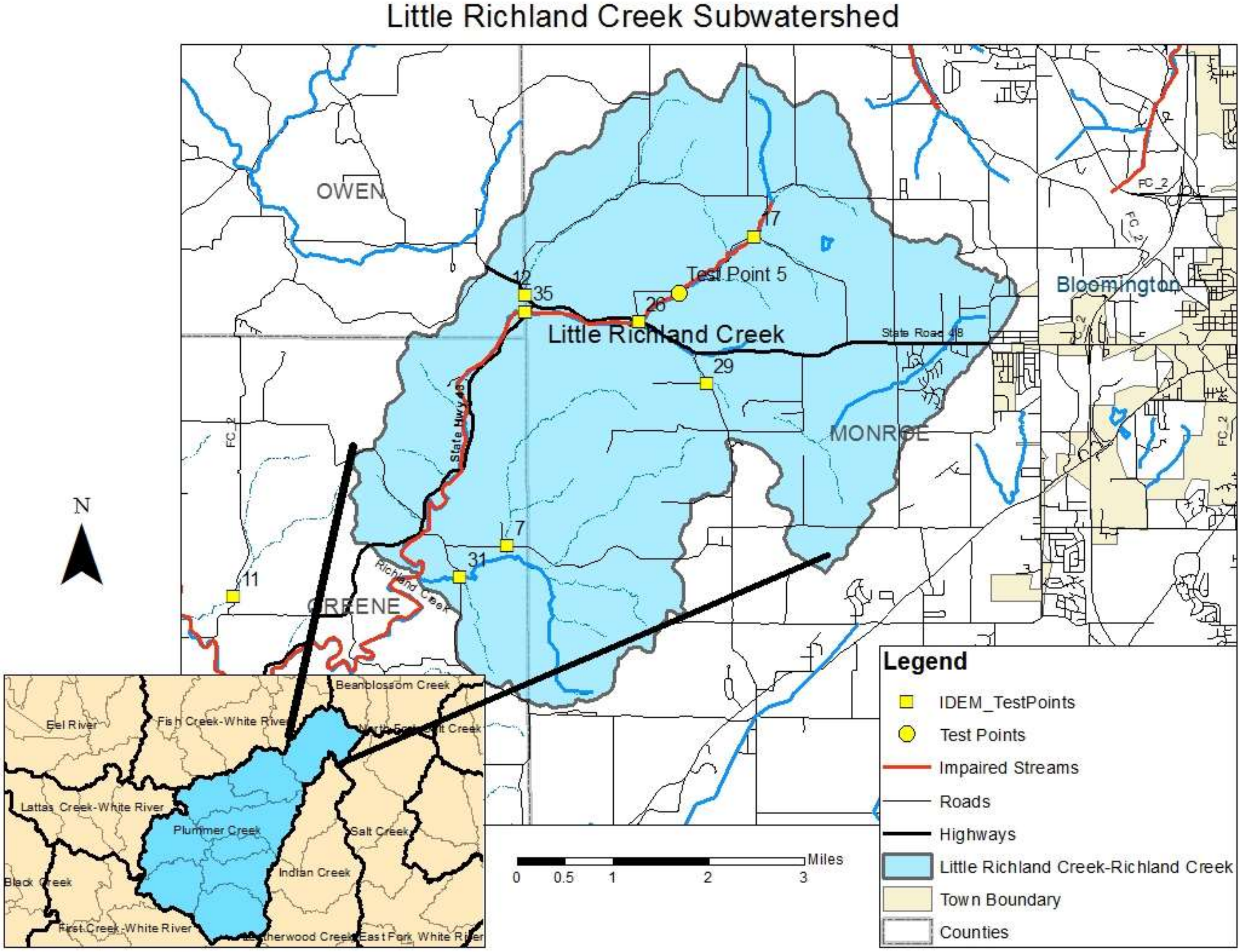
IDEM Probabilistic monitoring was done at five sites in 2006 and in 2011 at this point this data was used to determine which streams were included on the 303 (d) list. This data is not used in the analysis of the Plummer Creek watershed, because much more comprehensive data was collected through the IDEM baseline study. The data was not considered because too few sites were monitored with very infrequent amount of tests done per site. Much of this data from the IDEM probilistic monitoring was collected more than 10 years prior to the baseline data so more comprehensive and recent data was preferred.

Sub watersheds

There are nine sub watersheds within the PCW. They are Little Richland Creek (051202020301), Blakeman Hollow (051202020302), Bridge Creek (051202020303), Beech Creek (051202020304), Dry Branch (051202020305), Clifty Branch (051202020306), Black Ankle (051202020307), Ore Branch (051202020308), and Burcham Branch (051202020309). Each sub-watershed has its own unique uses. Desktop surveys in conjunction with windshield surveys and analyzing available data were used to create a snapshot of possible issues in the sub watersheds. The data along with the surveys were used to determine where these critical areas may be. The summaries below are the collected data from each test point and the inferred causes in each sub watershed gathered from data and observations by the watershed coordinator and volunteers.

Little Richland Creek (051202020301)

Map 15: Little Richland Creek Sub watershed

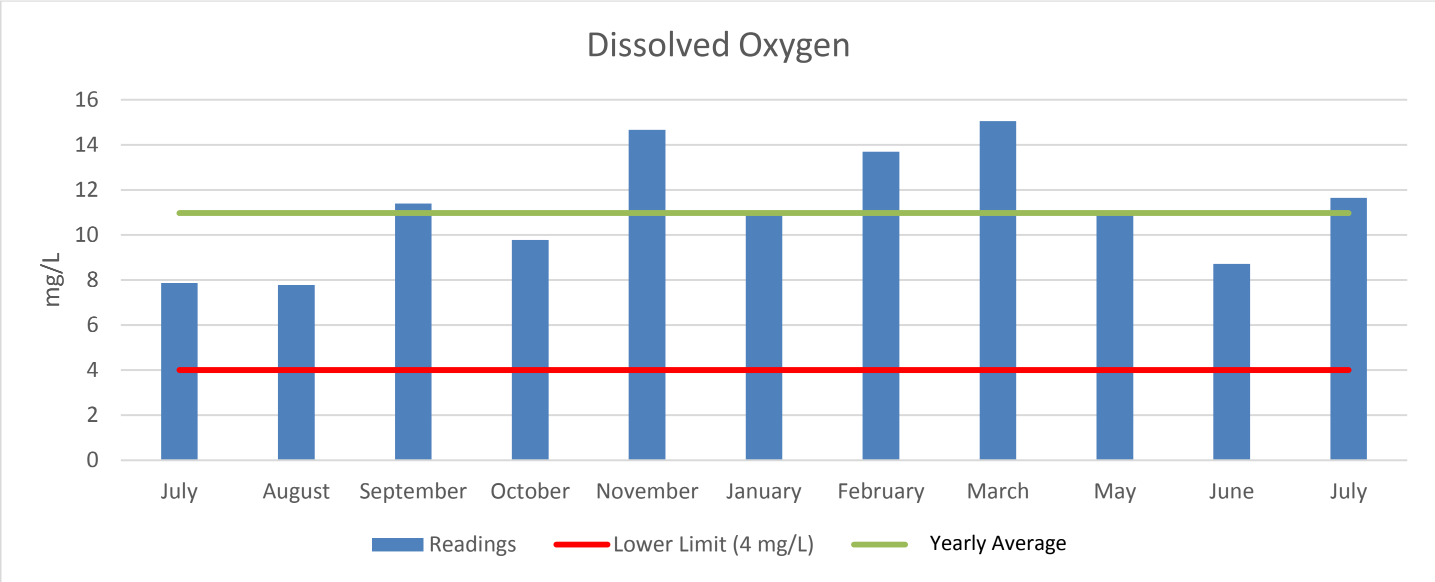


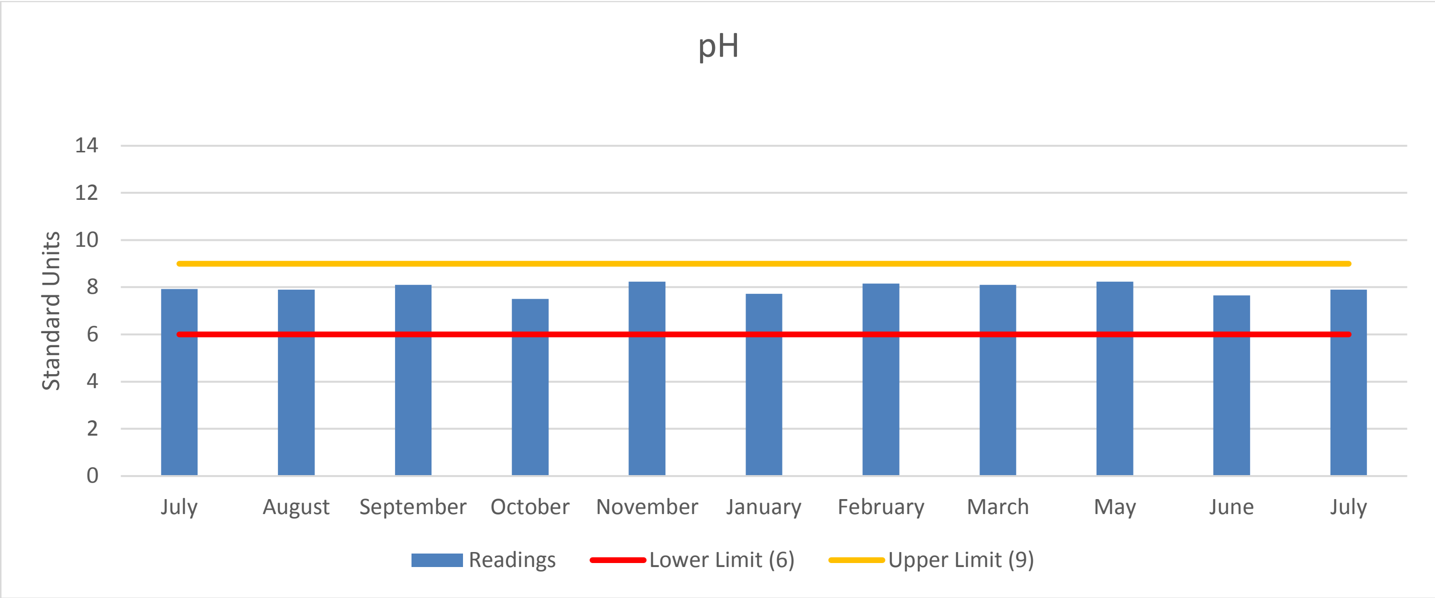
Little Richland Creek is the northeast portion of the Plummer Creek watershed and contains the only significant portions of the watershed that reach into Monroe and Owen Counties. It is the largest sub watershed containing 16,502.5 acres and holds the headwaters for Richland Creek which flows out of the northeast Monroe County and drains into Blakeman Hollow sub watershed in the southwest. Little Richland Creek drains the southern portion of the watershed along with springs at the headwaters which pick up water from outside the watershed (see Map 2). A sinking stream basin flows out of the fringes of Bloomington on the east side of the watershed. According to dye tracing, water reemerges from this sinking basin from springs in the headwaters of Richland Creek and Little Richland Creek.

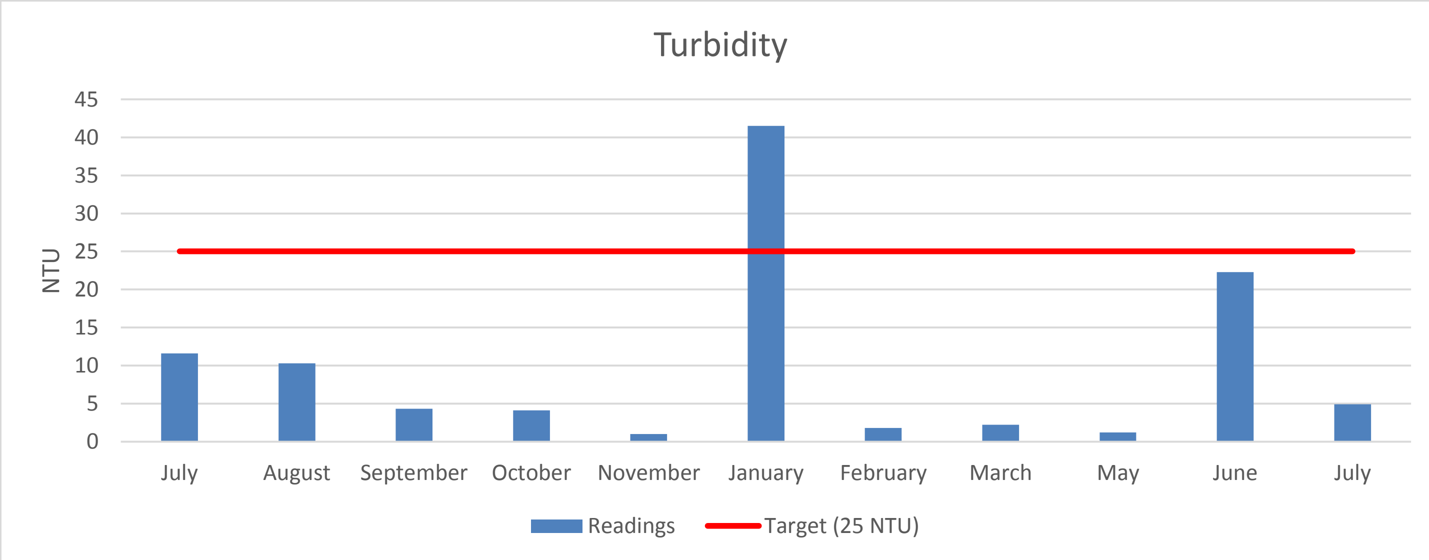
Water quality monitoring was done at Test Point 5 of the PCAC Test Points on Richland Creek. Test results specific to Test Point 5 follow. Additionally IDEM collected water quality parameters from 7 sites representing both Richland Creek, Little Richland Creek, and smaller tributaries.

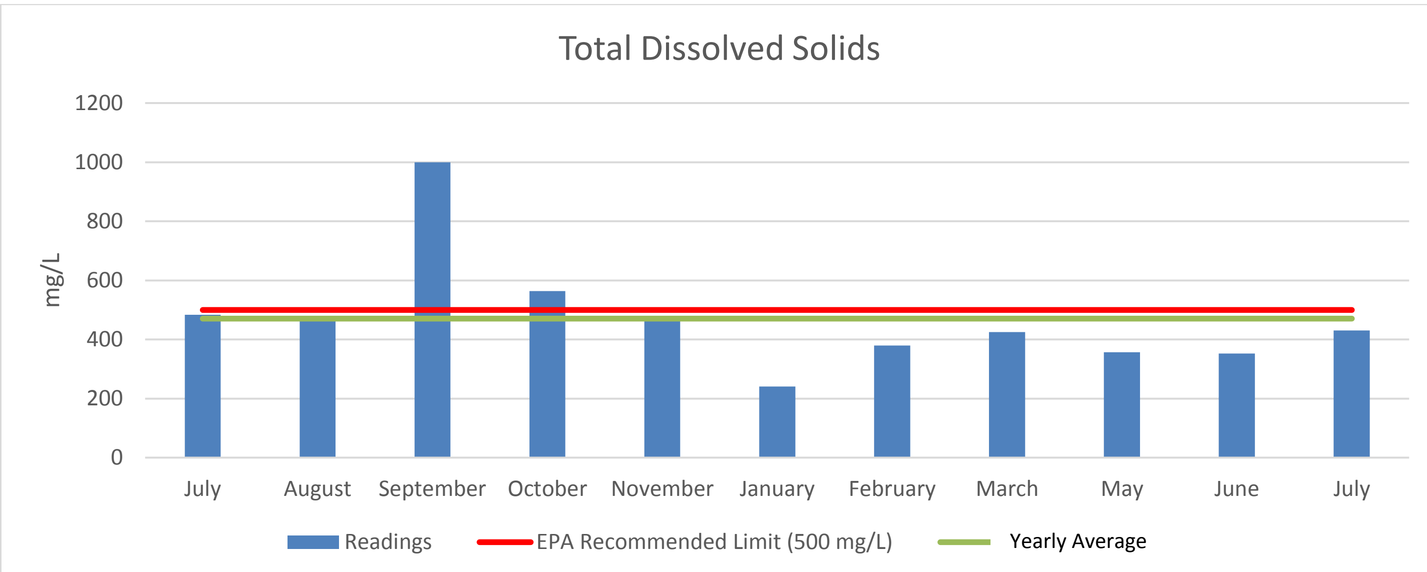
Water Quality and Habitat Data Summary

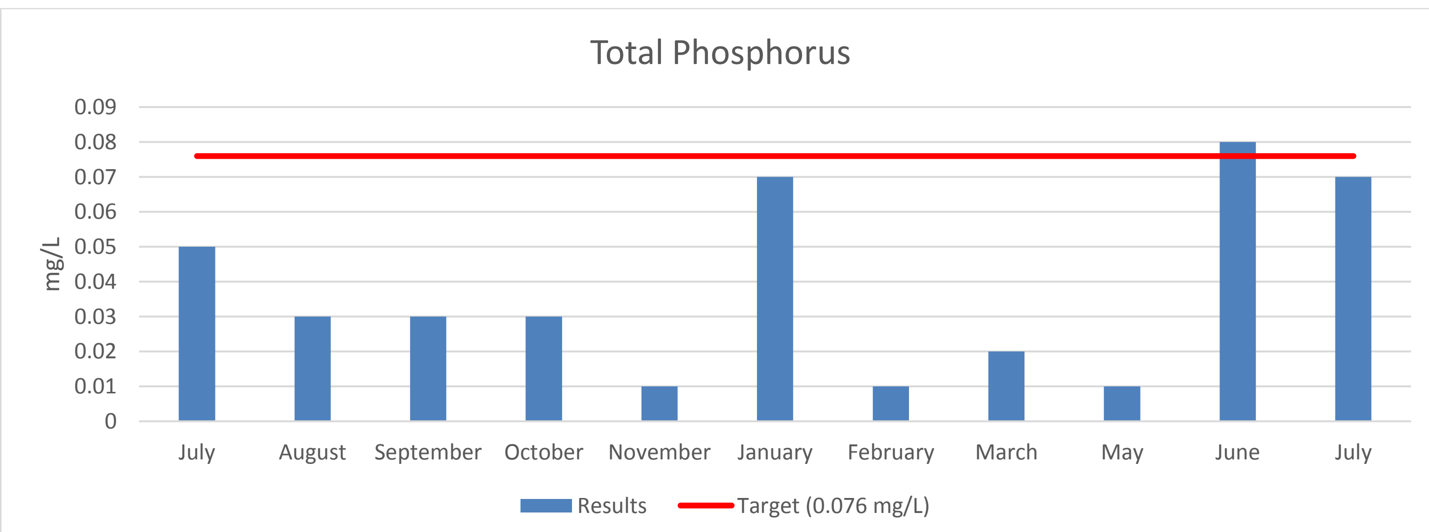
Test Point 5

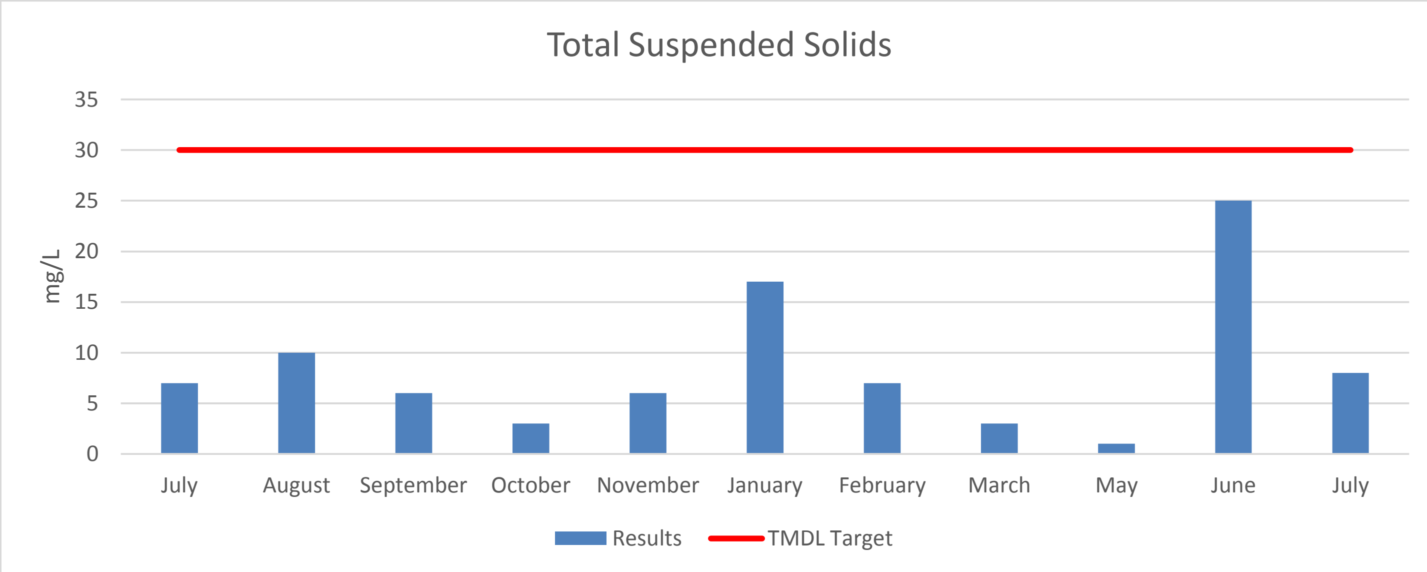


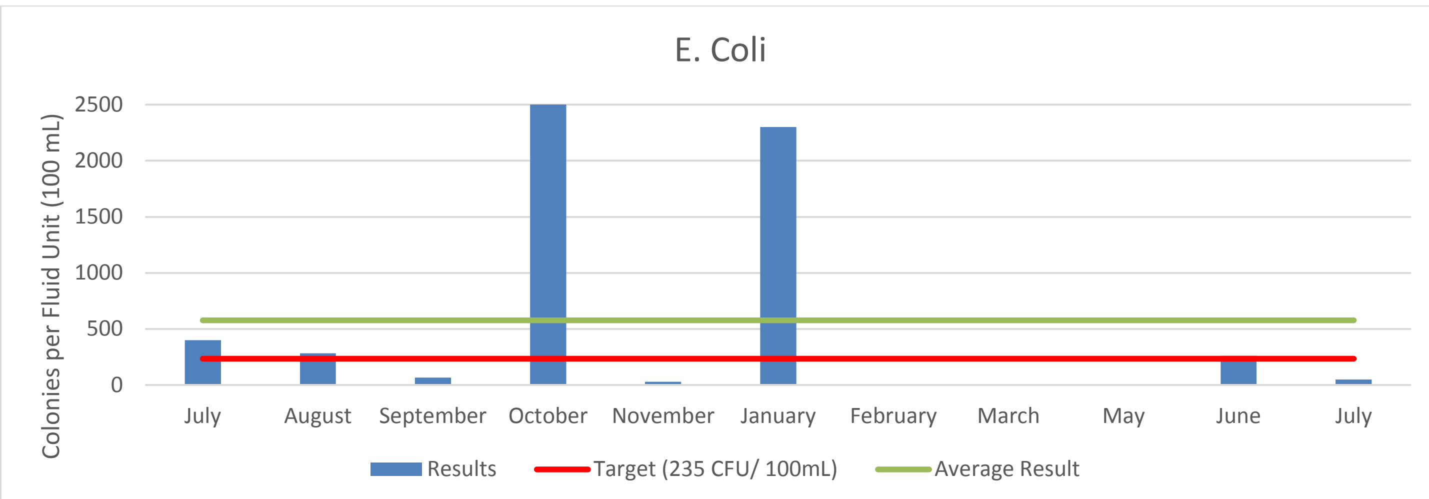


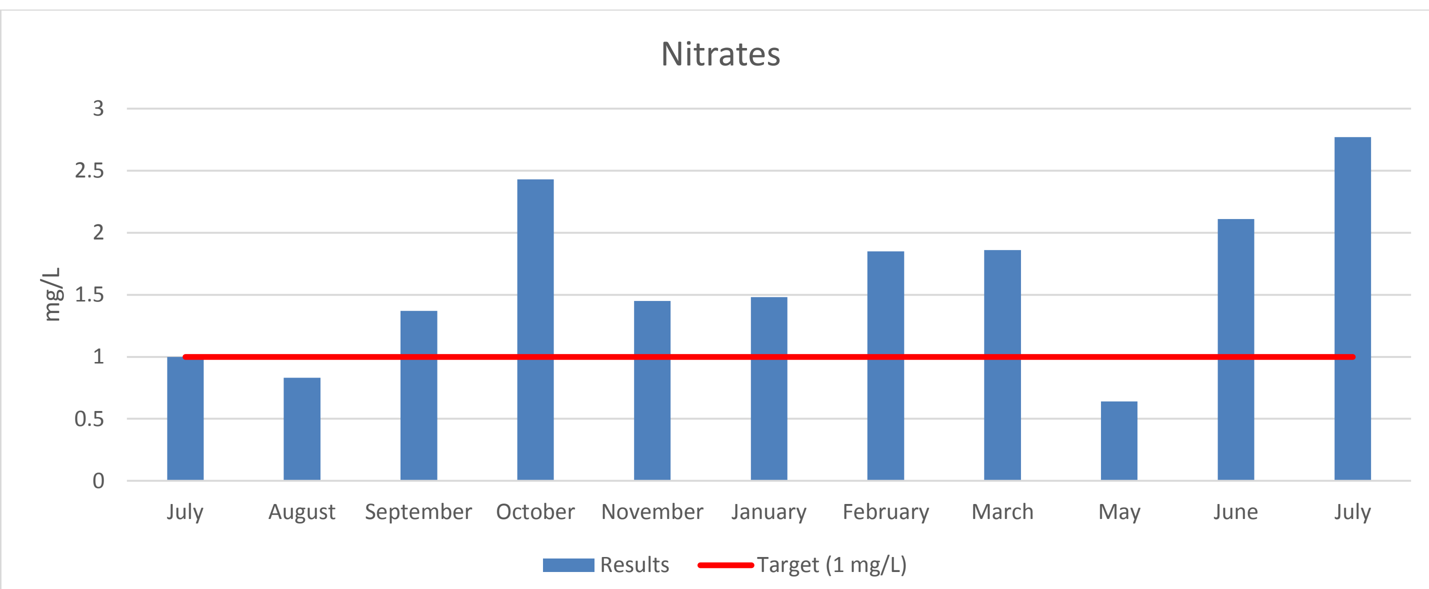

Turbidity
NTU
45
40
35
30
25
20
15
10
5
0
July
August
September
October
November
January
February
March
May
June
July
Readings
Target (25 NTU)


Total Dissolved Solids
mg/L
1200
1000
800
600
400
200
0
July
August
September
October
November
January
February
March
May
June
July
Readings
EPA Recommended Limit (500 mg/L)
Yearly Average


Total Phosphorus
mg/L
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
July
August
September
October
November
January
February
March
May
June
July
Results
Target (0.076 mg/L)


Total Suspended Solids
mg/L
35
30
25
20
15
10
5
0
July
August
September
October
November
January
February
March
May
June
July
Results
TMDL Target


E. Coli
Colonies per Fluid Unit (100 mL)
2500
2000
1500
1000
500
0
July
August
September
October
November
January
February
March
May
June
July
Results
Target (235 CFU/ 100mL)
Average Result


Nitrates
mg/L
3
2.5
2
1.5
1
0.5
0
July
August
September
October
November
January
February
March
May
June
July
Results
Target (1 mg/L)

Dissolved oxygen, pH, and total suspended solids for Little Richland Creek sub watershed have not been a problem and have never been outside of an acceptable range with the current water quality monitoring efforts at Test Point 5 (PCAC Test Point). Turbidity has had one instances that was over the acceptable limit with a maximum of 41.5 NTU in January 2013. This high number may have resulted from weather conditions during testing. The high level in January can most likely be explained by snowmelt eroding topsoil in areas with a lack of winter cover like a cover crop. In June 2013, the water was tested shortly after a significant rain event, explaining the moderately high levels (22.3 NTU) during that instance. However, reducing the amount of loose topsoil being eroded into the creeks during storm events will be something to work on in the future. By June crops and other vegetation should be developed enough to withstand sheet erosion so this may point to alternative sources from like erosion from stream banks, construction sites, or other exposed areas. Total dissolved solids had two times when it was over the recommended limit in consecutive months, being twice the EPA limit and our target level of 500 mg/L in September. TDS may be decomposed organic materials, non-organic fertilizer (soil amendments), or pesticides. Because of the timing of the high level one could draw the conclusion that harvest from nearby crop fields may be the cause of these elevated numbers. Though there were two instances over the recommended limit, the average for the test site is just beneath, which is a good sign. Total phosphorous exceeded target limits in June 2013 with a reading of 0.08 mg/L which is just slightly over the target of 0.076 mg/L. E. coli has been over the Indiana limit for five out of the eleven months tested, most notably in October and January. The number in October was labeled “too numerous to count” by Dillman Laboratory, which means it was probably even higher than the January reading which was counted to be about 2,300 CFU/100mL. High E. coli counts in cold months can be associated with direct discharges from septic and sewers because the survival of E. coli is cold temperatures is less likely. Nitrates exceeded the target levels 8 out of the 11 months of testing, with a minimum result in May of 0.64 mg/L. Maximum nitrates were observed in July 2013 with a value of 2.77 mg/L almost 3 times our target level.

The baseline study took samples from six sites within the Little Richland creek sub watershed from 2011 through 2012, see Map 15 and Table 13. Results of that testing showed consistent issues with all site above target values for total suspended solids and turbidity. There were no issues indicated for dissolved oxygen (DO), pH, specific conductivity, or total dissolved solids (TDS). Total ammonia with high in the headwaters of Richland Creek at site 17 (site numbers come from the last two digits of the Station ID). Nitrate has intermediate to poor quality throughout the sub watershed and exceeded target values at four of the six sites with the maximum of 2.22 mg/L at site 17. Total phosphorus was either good (green in Table 13) or poor (yellow) with the three poor sites above our target levels. These site are along the stretch of Richland Creek in this sub watershed including site 17. Total kjeldahl nitrogen (TKN) was intermediate (no color) to very poor (red) in levels at all sites. The maximum reading for TKN was 2.575 mg/L also at site 17. The test point with the most consistent problems for all of these listed issues was point 17, which can be seen in Map 15 as the most upstream site of Richland Creek. The test sites that don’t experience issues are tributaries to the main stream, but the test points downstream from point 17 all experience poor quality from several of these issues.

Table 13: IDEM Baseline Sites Chemical Data (Little Richland Creek)

	Chemical Stressors									
Station ID	DO	pH	Specific Cond.	Turbidity	Total Ammonia	Nitrate	Total Phosphorus	TSS	TDS	TKN
WWL-03-0012	8.31	8.03	0.363	50.34	0.05	0.58	0.059	58.57	235.86	0.529
WWL-03-0017	7.42	7.76	484.86	156.99	0.67	2.22	0.283	330.67	289.33	2.575
WWL-03-0026	8.71	7.97	567.25	142.6	0.05	2	0.166	272.14	377.43	1.007
WWL-03-0029	9.41	7.92	388.38	74.21	0.05	1.183	0.068	102	288.43	0.5
WWL-03-0031	6.79	7.82	376.86	85.23	0.05	0.517	0.048	80	252	0.607
WWL-03-0035	9.17	8.1	514.88	133.78	0.05	1.533	0.138	215.86	335.71	0.879
Targets	***>4***	***>6 & <9***	***<1,200***	***<25***	***<0.21***	***<1.0***	***<0.076***	***<30***	***<500***	***<0.28***
Units	***mg/L***		***µs/cm***	***NTU***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

Consistent with our testing, the TMDL created in 2006 lists Richland Creek as impaired for E. coli, however it expands the results to include every stream in the watershed, making Little Richland Creek sub watershed, the head waters for the majority of the entire Plummer Creek Watershed, a large contributor of E. coli to surface water and has been labeled a clear critical sub watershed for our watershed project.

IDEM Baseline data collected also found major impairments with respect to E. coli (Table 14). All sites measured exceeded target values of 125 MPN /100mL for the geometric mean of 5 samples collected over a 30 day period. Site 17 had the maximum E.coli reading with a value of 1,767.51 MPN/100mL.

Table 14: IDEM Baseline Sites Biological and Habitat Data (Little Richland Creek)

		Biological Measures		Habitat Stressors						
Station ID	E. coli	MIBI	EPT Index	QHEI	Sub	Cover	Channel	Riparian	Pool	Riffle
WWL-03-0012	**305.21**	34	4	52	15	6	13	5	3	0
WWL-03-0017	**1767.51**	44	8	75	18	11	17	6	10	3
WWL-03-0026	**498.93**	44	13	74	17	13	13	9	8	4
WWL-03-0029		38	8	63	16	12	16	5	5	5
WWL-03-0031	**355.98**	40	21	59	11	13	13	4	9	5
WWL-03-0035	**430.66**	40	10	63	15	9	14	6	5	4
Targets	***<125***	***>36***		***>50***						
Units	***MPN/100mL***	***Score***		***Score***						
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

In Indiana's 303(d) list, (Table 7) Little Richland Creek was reported to have impaired biotic communities. At our test site, we didn't have any problems and the result for macroinvertebrates was in the "excellent" range (Table 15). Our test site was upstream of where the impairment was listed, but this program did not have a testing point on that particular tributary. Our test site also had an exceptional warm water habitat score for the CQHEI of 83 points. One test point monitored during the baseline study, site 12, had a MIBI score below target levels (Table 14). The habitat tests for this site had a zero riffle score and high TSS suggesting that the sedimentation and lack of river morphology may be affecting macroinvertebrates at this site. The baseline study indicated that the cause of the low score was “Habitat (low riffle score), high TSS” and the sources were “Habitat Modification, Ag Runoff. & Livestock” (Table 12). The TMDL also listed impaired biotic communities as an issue for two segments of stream within the Little Richland Creek sub watershed. In the TMDL report, possible causes of impairment were listed as habitat modification, agricultural runoff, and livestock, which were all noted during the windshield surveys, as well.

Table 15: Site 5 Macroinvertebrates

Excellent		37	**Pollution Tolerance Index Rating**				
Group 1	**Intolerant**	**Group 2**	**Moderately tolerant**	**Group 3**	**Fairly tolerant**	**Group 4**	**Very tolerant**
2	Stonefly Nymph	4	Damselfly Nymph		Leech		Aquatic Worms
4	Mayfly Nymph		Dragonfly Nymph		Midge Larva		Blood Midge Larva
1	Caddis fly Larva		Scud		Planaria/Flatworm		Rat-tailed Maggot
1	Riffle Beetle	30	Sowbug		Black Fly Larva	3	Left-Handed or Pouch Snail
	Dobsonfly Larva		Crane Fly Larva				
68	Right-handed snail	24	Clam/Mussels				
9	Water Penny	5	Crayfish				
6	# taxa	4	# taxa	0	# taxa	1	3 taxa
24	Weighting Factor (x4)	12	Weighting Factor (x3)	0	Weighting Factor (x2)	1	Weighting Factor (x1)

Land Use Summary

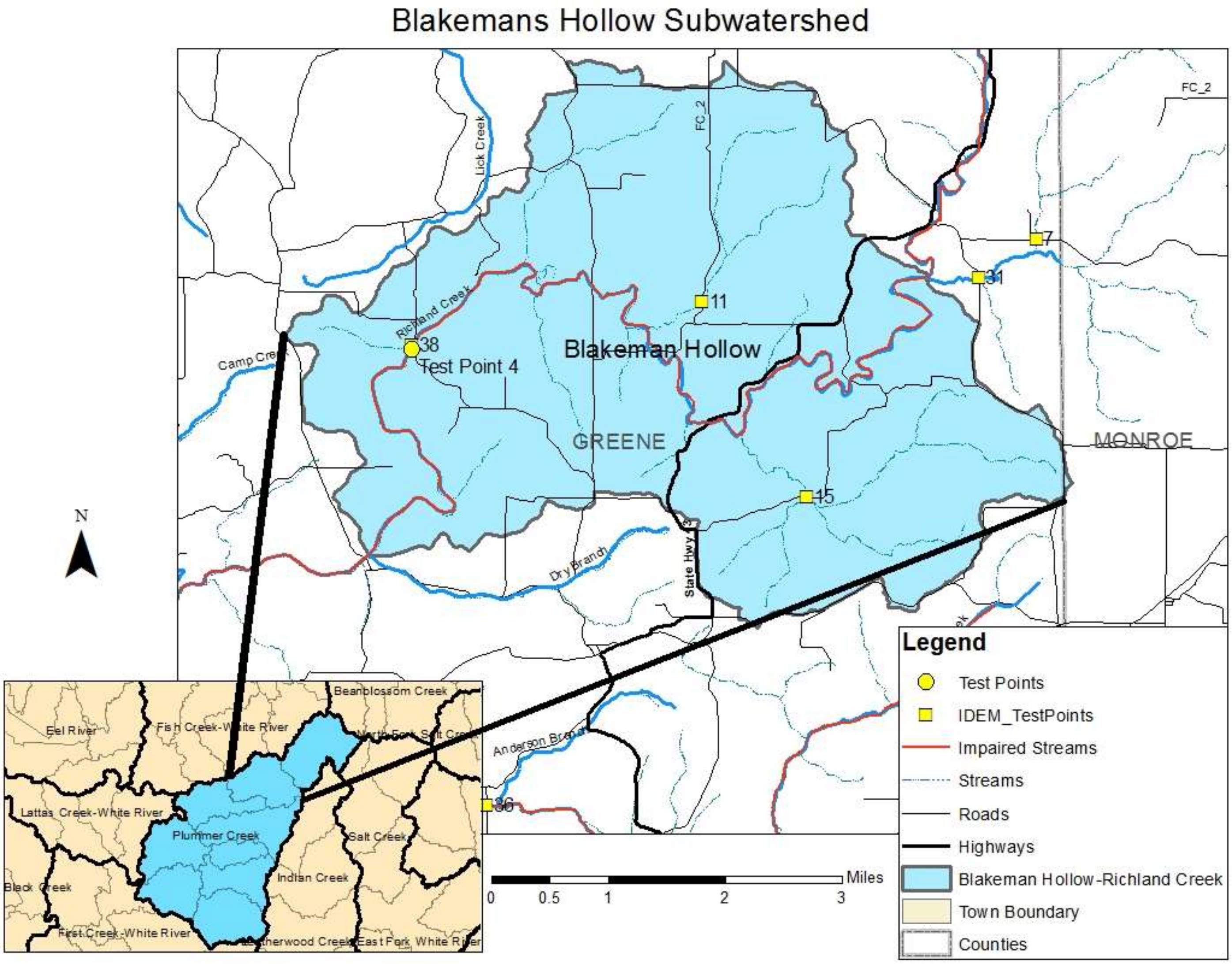
The Little Richland Creek sub watershed consists primarily of deciduous forest. Some pasture and row crops and herbaceous areas are also seen in this sub watershed. It also has more urban areas than the other sub watersheds because it borders the suburbs of Bloomington and Ellettsville. The town of Whitehall is also located within this sub watershed. Manicured lawns and well maintained green spaces were seen in these areas and may be a source for nutrient runoff to local streams. Hills are scattered throughout. There is an airport along with some industrial areas within the borders. Based on windshield surveys along with visual identification using high resolution orthophotos, streambank erosion could be partially identified. This information was compared to land uses along streambanks to determine the amount of area in need of buffers or stream bank stabilization. Due to streambank erosion, it is estimated that about 7 miles of streams in this sub watershed have a need for more buffer area and bank stabilization. Buffers will help reduce fertilizer runoff entering the stream from agriculture fields. Little Richland sub watershed is the only one in the PCW that has any barren land. There is a sizable stone quarry in the watershed upstream of site 17 that may be contributing to elevated sediment levels in the form of TSS or turbidity. Also upstream of site 17 lies multiple houses and agricultural ground both which may be sources for nutrients and E. coli. Development is being seen has housing additions near Whitehall in the lower portion of the watershed off of Hwy 43. There are also some developed areas surrounding Bloomington that have been abandoned leaving it as open, developed space. This area also has the majority of industry for the watershed with the outskirts of Bloomington and the businesses associated there. There are areas slated for development in this sub watershed. Changes in land use since the 1970s show a decrease in forested land and an increase in agricultural land, which could have a hand in some of the water quality problems mentioned above, such as high nitrate. There are at least 10 small scale farms of horses, some sheep, and small poultry farms scattered throughout the sub watershed. Cattle and horses were observed entering the streams at eight different locations within this sub watershed. No municipal wastewater is applied in this sub watershed and there are no other nonagricultural animal operations, CSOs, SSOs, CAFOs, or CFOs. Neal's Landfill, a site near the headwaters of Richland Creek, required a Superfund cleanup for PCBs that were entering waterways in 1985. ROGERS GROUP INC BLOOMINGTON CRUSHED STONE is a NPDES permitted facility that is allowed to discharge into Richland Creek. The top pollutant discharged from this site is total suspended solids and may be a partial source to those issues in the sub watershed.

Windshield and Desktop Survey

Possible Water Quality Influence	BMP	Location of site(s)	Site I.D. Type	Observed By
Livestock with direct access to stream causing erosion	Fencing/Alternative Water Source	Testing Site #5 of the Watershed Coordinator, 8 individual locations with livestock access	Windshield Survey	Watershed Coordinator, Monroe & Greene Co SWCD Administrators, Volunteers
Conventional Cropping systems increasing runoff of nutrients, manure, and sediment	Nutrient Management Plans, No Till/Reduced Till, Manure storage/handling	Cultivated crop ground	Desktop & Windshield Surveys	Watershed Coordinator
Row crops within 30 feet of stream causing bank erosion	Filter Strips/Riparian Bordering/erosion control	Testing Site #5 of the Watershed Coordinator, along Little Richland and Richland Creek	Windshield Survey	Watershed Coordinator
Construction, Development, Industrial activities	Rule 6 for sediment control from industrial site, Rule 5 construction erosion control, Filter Strips/Riparian Bordering/erosion control	Quarry, Development sites,	Desktop & Windshield Surveys	IDEM, Watershed Coordinator, Monroe & Greene Co SWCD Administrators, Volunteers
Mercury/PCB's detected in stream	More information needed	Richland Creek/Neal's Landfill Dump Site	Desktop Survey	IDEM
Severe Stream bank erosion	Erosion control/filter strips	East of test site #5, along Hwy 43, Vernal Pike, and	Windshield Survey	Watershed Coordinator
E. coli	Septic Education, Manure Storage/Handling	Residential areas, Agricultural land	Desktop & Windshield Surveys	Watershed Coordinator

Blakeman Hollow Richland Creek (051202020302)

Map 16: Blakeman Hollow Sub watershed

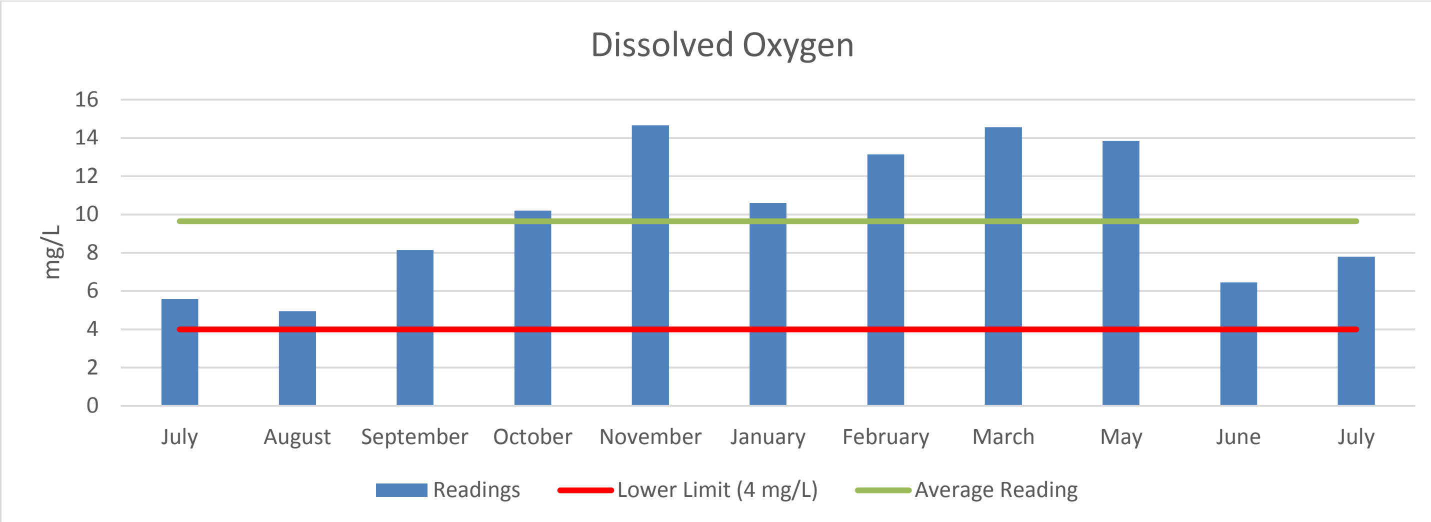


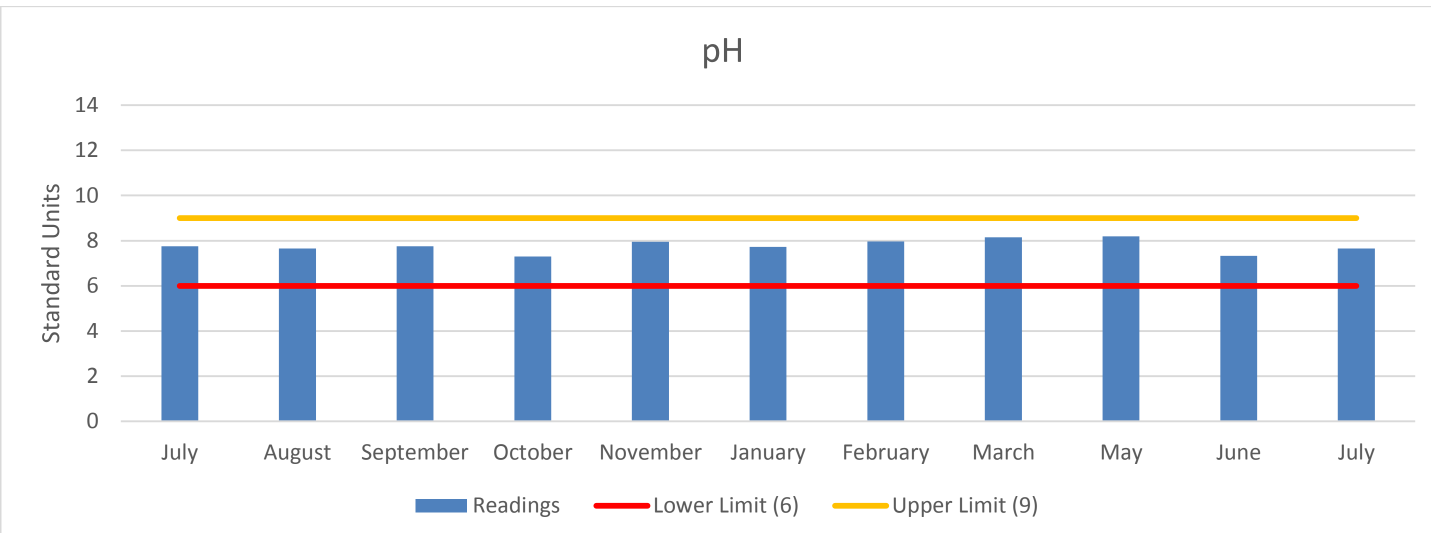
Blakeman Hollow is the second sub watershed that Richland Creek flows through, taking the water as it flows out of Little Richland Creek sub watershed. Blakeman Hollow covers 12,052.3 acres of Greene County. The creek flows into the Northeast side up to Test Point 4 and back down and out of the Southwest side, into Dry Branch watershed.

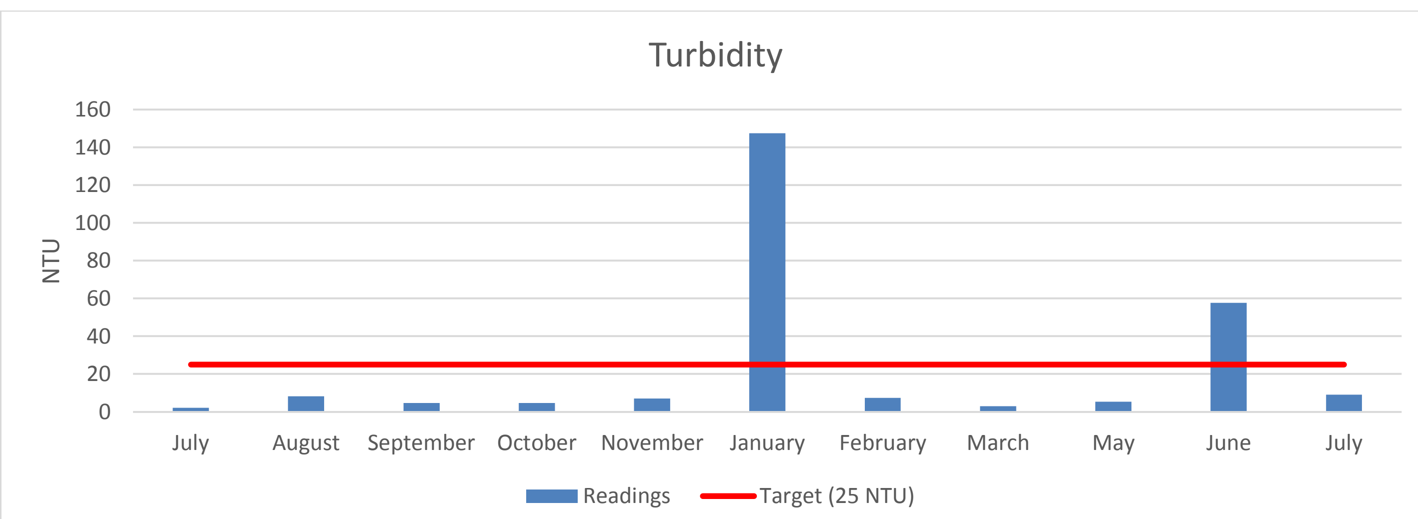
Water quality monitoring was done at Test Point 4 of the PCAC Test Points on Richland Creek. Test results specific to Test Point 4 follow. IDEM collected water quality parameters from 3 sites representing both Richland Creek and smaller tributaries. IDEM site 38 is co-located with Test Point 4 (Map 16).

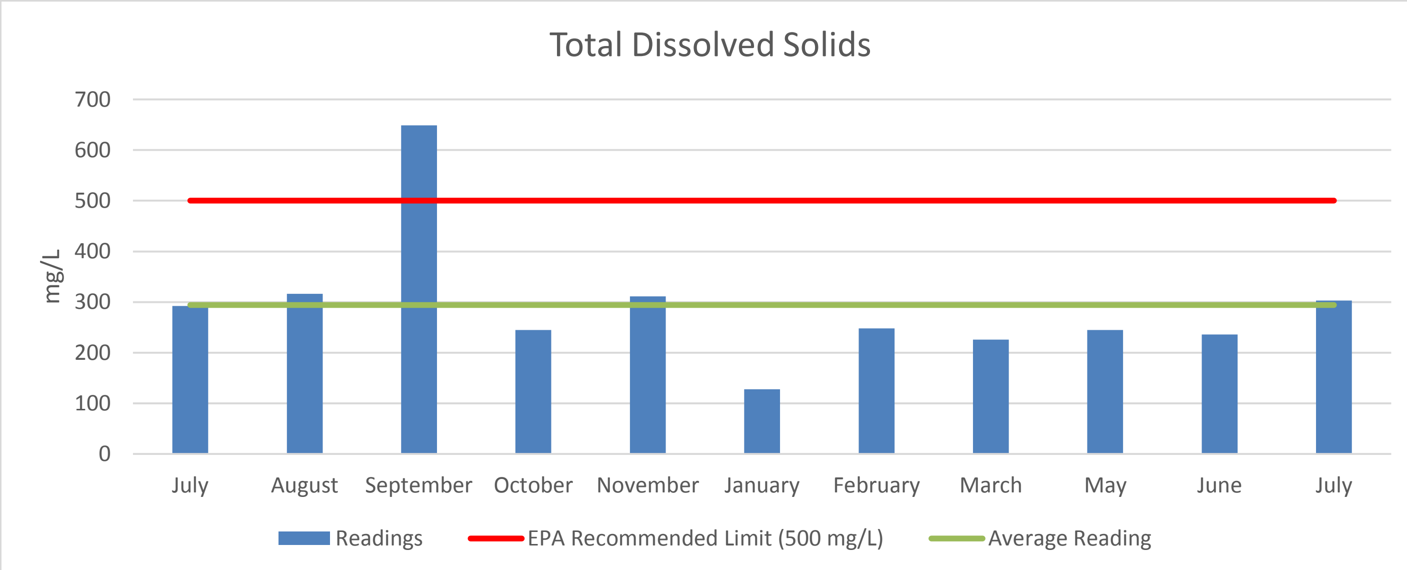
Water Quality and Habitat Data Summary

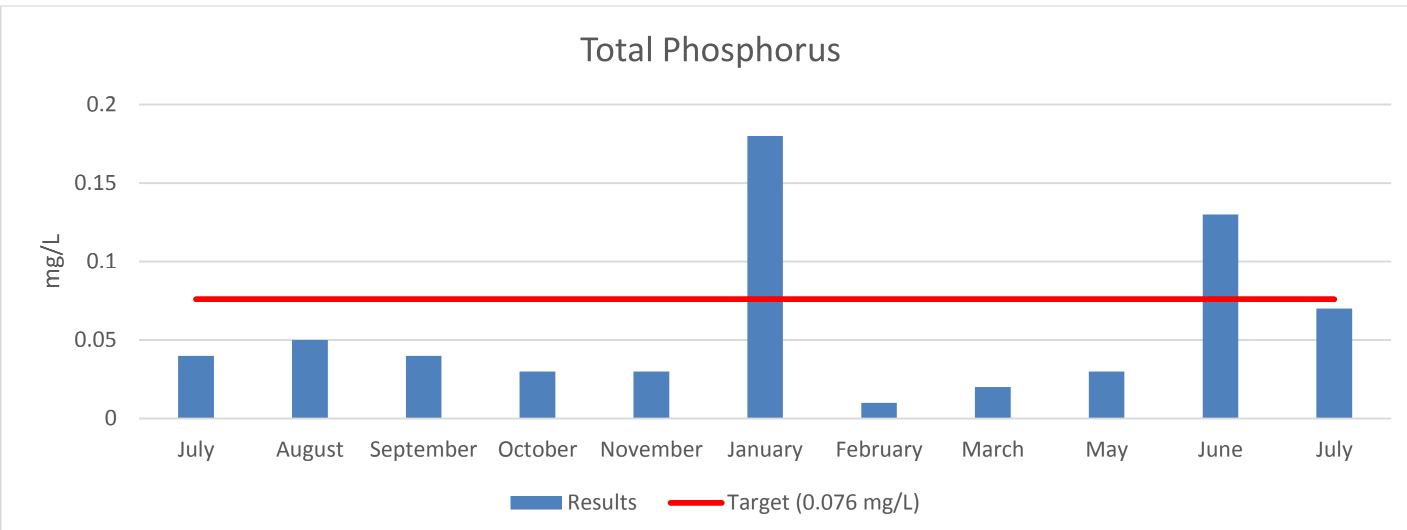
Test Point 4

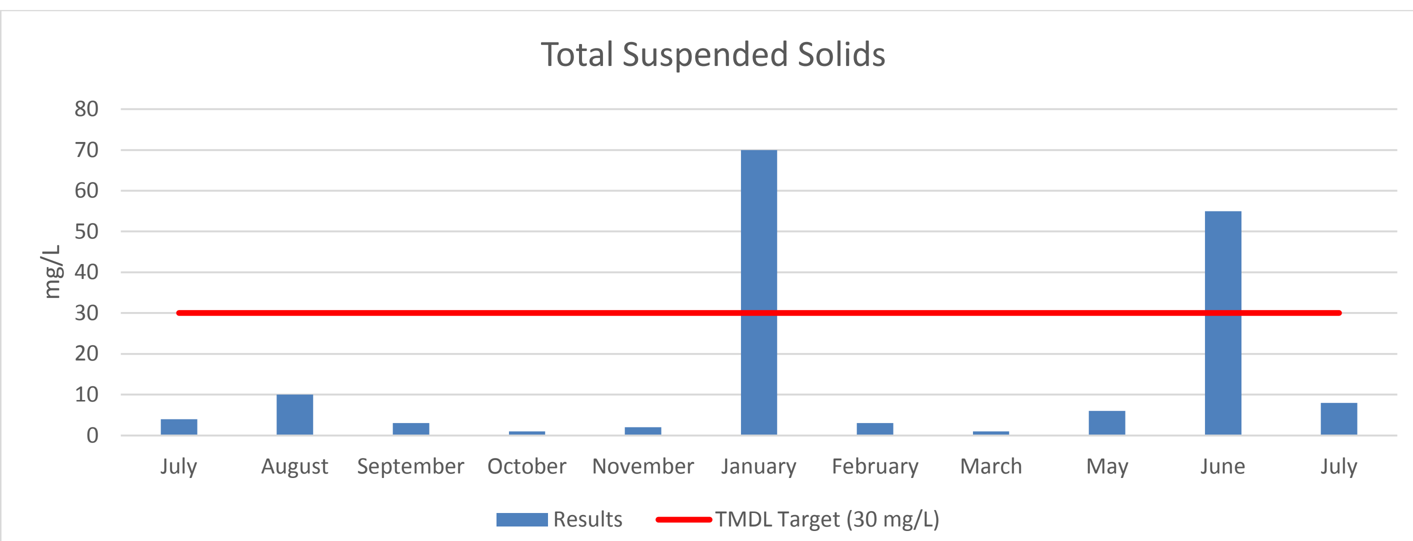


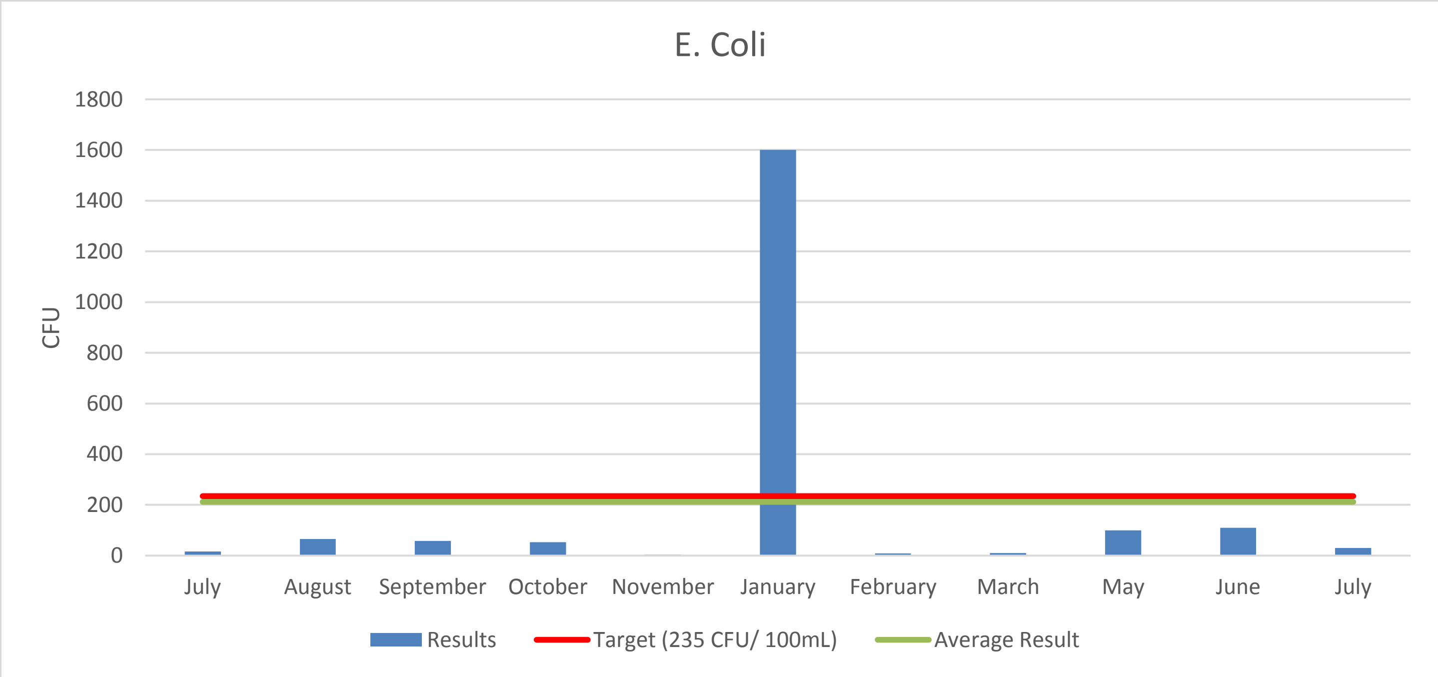


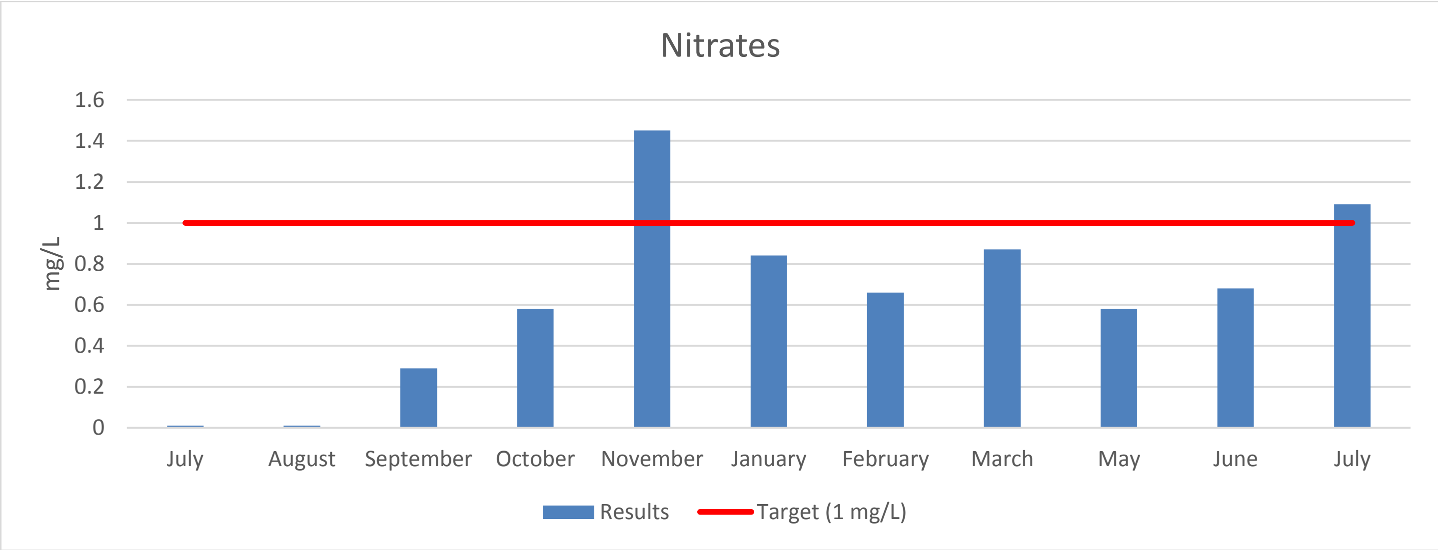



Total Dissolved Solids
mg/L
700
600
500
400
300
200
100
0
July
August
September
October
November
January
February
March
May
June
July
Readings
EPA Recommended Limit (500 mg/L)
Average Reading


Total Phosphorus
mg/L
0.2
0.15
0.1
0.05
0
July
August
September
October
November
January
February
March
May
June
July
Results
Target (0.076 mg/L)


Total Suspended Solids
mg/L
80
70
60
50
40
30
20
10
0
July
August
September
October
November
January
February
March
May
June
July
Results
TMDL Target (30 mg/L)





Test point 4 had no problems with dissolved oxygen or pH. Turbidity had two points over the limit in January and June of 2013, the same months as Site 5. January again had the highest value (147.5 NTU), but as we look at more sub watersheds and other test points, we'll find that this number continuously grows the more miles the stream travels. Stream bank erosion is a stakeholder concern and turbidity measurements throughout the watershed are a clear indicator of why. Total dissolved solids are again higher than the limit in September, which may be due to harvesting near the streams. Total phosphorous again saw spikes above target levels in January and June with the highest value of 0.18 mg/L in January 2013. Total suspended solids were over the limit in January and June, similar to turbidity and probably has the same causes as well. E. coli remained below the limit Indiana has set for most of the testing during this year period, but spiked above in January. The spike reached up to 1600 colony forming units (CFU) and brought the average for this testing site up to more than 235 CFU/100mL, which is above the target level. The cause can be anything from livestock with access to the surface water, wild animals such as deer getting their feces into the stream, or failing septic systems that mixed with snowmelt. However, high E. coli counts in cold months can be associated with direct discharges from septic and sewers because the survival of E. coli is cold temperatures is less likely. With the lack of sewer overflows in this sub watershed, septic systems failures can be a viable source. Based on statewide Indiana septic system failure rates 80% of Indiana septic systems are non-functioning or non-existent. Based on this, approximately 4,800 household units are likely contributing to these problems. Nitrates exceeded target levels of 1 mg/L in November 2012 and July 2013. This can also be caused by failing septic systems, but may also be runoff from fertilized yards, crop fields, or animal waste. This may be prevented by boosting our current riparian buffers, which are thin or non-existing in some areas.

The baseline study took samples from three sites within Blakeman Hollow sub watershed from 2011 through 2012, see Map 16 and Table 16. There were no issues indicated for dissolved oxygen (DO), pH, specific conductivity, total ammonia, nitrates, phosphorous, or total dissolved solids (TDS). Turbidity was high at site 38 which is co-located with PCAC Test Point 4 above. Turbidity was measured at 101.33 NTU, or poor quality (yellow), and is over four times our target value of 25 NTU. TSS was also high at site 38 as seen in testing done above at Test Point 4. TSS measured at site 38 was very poor quality (red) with a value of 103.57 mg/L. This is significantly higher than target levels of 30 mg/L. Total Kjeldahl nitrogen (TKN) was variable throughout the watershed. It scored as high quality (green) at site 15, intermediate (no color) at site 11, and poor (yellow) at site 38. However, we set target values for TKN at 0.28 mg/L and none of these sites met out target values. The maximum reading for TKN was 0.65 mg/L also at site 38. The test point with the most consistent problems for all of these listed issues was point 38, which can be seen in Map 16 as the only site on Richland Creek within this sub watershed. The other test sites (Sites 11 and 15) are on smaller tributaries to Richland Creek and do not have as much water quality issues as the main branch.

Table 16: IDEM Baseline Sites Chemical Data (Blakeman Hollow)

	Chemical Stressors									
Station ID	DO	pH	Cond.	Turb.	Ammonia	Nitrate	Phosphorus	TSS	TDS	TKN
WWL-03-0011	7.26	7.72	344.25	37.29	0.09	0.258	0.039	17.29	223.29	0.479
WWL-03-0015	8.12	7.83	327.88	30.6	0.05	0.46	0.029	29.14	198.86	0.343
WWL-03-0038	7.24	7.81	413.88	101.33	0.05	0.725	0.061	103.57	282	0.65
Targets	***>4***	***>6 & <9***	***<1,200***	***<25***	***<0.21***	***<1.0***	***<0.076***	***<30***	***<500***	***<0.28***
Units	**mg/L**		**µs/cm**	**NTU**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

IDEM Baseline data collected also found impairments with respect to E. coli (Table 17) within the sub watershed. All sites measured exceeded target values of 125 MPN /100mL for the geometric mean of 5 samples collected over a 30 day period. Site 38 had the maximum E.coli reading with a value of 255.83 MPN/100mL.

The TMDL taken in 2006 for E. coli also labeled Richland Creek as impaired. This is the number one stakeholder concern in the watershed, so the high result from our testing along with the exceeded targets from the baseline data along with the TMDL makes Blakeman Hollow a clear choice to be a critical sub watershed for our watershed project.

Table 17: IDEM Baseline Sites Biological and Habitat Data (Blakeman Hollow)

		Biological Measures		Habitat Stressors						
Station ID	**E. coli**	**MIBI**	**EPT Index**	**QHEI**	**Sub**	**Cover**	**Channel**	**Riparian**	**Pool**	**Riffle**
WWL-03-0011	**134.42**	42	3	52	12	10	11	3	6	0
WWL-03-0015	**156.41**	42	9	78	18	13	16	8	7	6
WWL-03-0038	**255.83**	48	18	65	9	11	13	10	10	6
Targets	***<125***	***>36***		***>50***						
Units	***MPN/100mL***	***Score***		***Score***						
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

Our findings of macroinvertebrates are listed below in Table 18 as excellent. This site achieved a habitat score of 88 for the CQHEI, which ranks it as an exceptional warm water habitat. The baseline study also found that there were no issues with habitat at this site and scored as good quality (green) on the QHEI with a score of 65. The other two sites on tributaries were given an intermediate quality (no color) at site 11 and high quality (blue) at site 15 (Table 17). Biological health found intermediate quality, but were still above target values with a 36 score for MIBI. Blakeman Hollow is listed as having an impaired biotic community in the TMDL from 2006, though it is not listed in the Indiana 303(d) list for the same reason, which is consistent with the scores seen in the various sample collection efforts.

Table 18: Site 4 Macroinvertebrates

Excellent		26	**Pollution Tolerance Index Rating**				
Group 1	**Intolerant**	**Group 2**	**Moderately tolerant**	**Group 3**	**Fairly tolerant**	**Group 4**	**Very tolerant**
2	Stonefly Nymph		Damselfly Nymph		Leech		Aquatic Worms
4	Mayfly Nymph		Dragonfly Nymph		Midge Larva		Blood Midge Larva
1	Caddis fly Larva		Scud		Planaria/Flatworm		Rat-tailed Maggot
	Riffle Beetle		Sowbug		Black Fly Larva		Left-Handed or Pouch Snail
	Dobsonfly Larva		Crane Fly Larva				
25	Right-handed snail	15	Clam/Mussels				
2	Water Penny	1	Crayfish				
5	# taxa	2	# taxa	0	# taxa	0	3 taxa
20	Weighting Factor (x4)	6	Weighting Factor (x3)	0	Weighting Factor (x2)	0	Weighting Factor (x1)

Land Use Summary

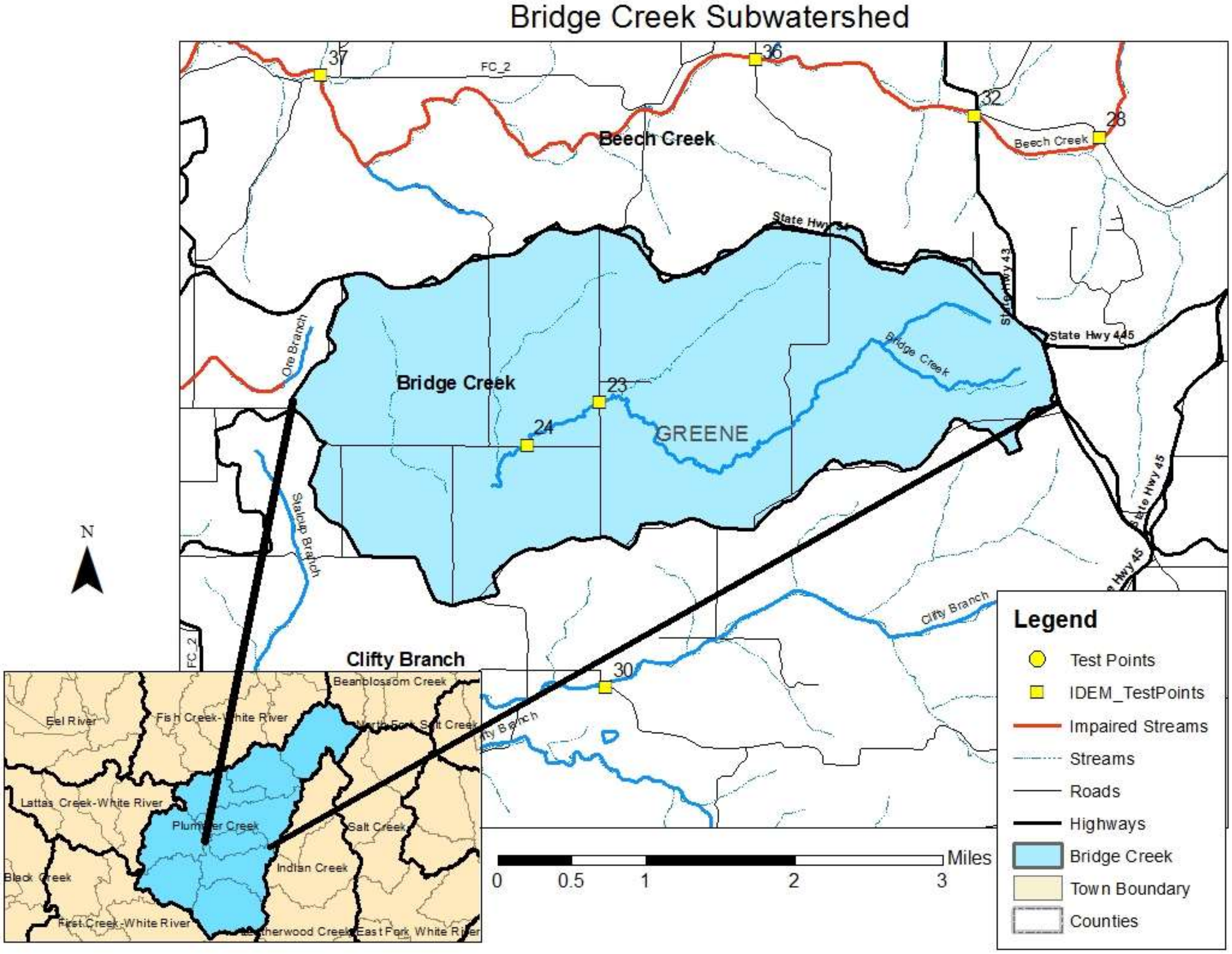
Blakeman Hollow contains deciduous forest, pasture, herbaceous, and some row cropping. Road surfaces in this sub watershed are almost exclusively gravel, with small areas of pavement. There are no areas of concentrated houses or other impenetrable surfaces. However, several nice homes have made Blakeman Hollow their homestead and, manicured lawns were seen in these areas and may be a source for nutrient runoff to local streams. Based on windshield surveys along with visual identification using high resolution orthophotos, streambank erosion could be partially identified. This information was compared to land uses along streambanks to determine the amount of area in need of buffers or stream bank stabilization. It has been estimated that about 5 miles of streams have missing or thin buffer areas, and are in need of bank stabilization. There are also areas with very stable streambanks along some agricultural fields indicating that the buffers can protect stream banks, if used. Buffers will also help reduce the introduction of some chemicals into the stream from possible fertilizer applications. There are no areas slated for development, open space, or industry in this sub watershed. Several areas within this watershed are also well maintained with managed forests and Sculptured Trails an art exhibit using landscape as its canvas. There are approximately 5-10 hobby farms of horses, some sheep, and small poultry farms scattered throughout the sub watershed. Hills are numerous within this area. Some steep hills show visual signs of erosion due to livestock within this sub watershed. No municipal wastewater is applied in this sub watershed and there are no other nonagricultural animal operations, CSOs, SSOs, CAFOs, or CFOs.

Windshield and Desktop Survey

Possible Water Quality Influence	BMP	Location of Site	Site I.D. Type	Observed By
Livestock with direct access to stream causing erosion	Fencing/Alternative Water Source	2 individual locations with livestock access	Windshield Survey	Watershed Coordinator, Monroe & Greene Co SWCD Administrators, Volunteers
Livestock affecting water quality	HUAP, waste storage facilities, pasture management	CR 480N, CR 1325E, CR 1000E, CR 700N	Windshield	Watershed coordinator
Conventional Cropping systems increasing runoff of nutrients, manure, and sediment	Nutrient Management Plans, No Till/Reduced Till, Manure storage/handling	Cultivated crop ground	Desktop & Windshield Surveys	Watershed Coordinator
High levels of E. coli	Septic Education, Manure Storage/Handling,	Test point 4, Residential Areas, Agricultural Lands	Monitoring, Desktop & Windshield Surveys	Watershed Coordinator
Thin buffers along streams	Field borders, riparian forest buffers	Throughout	Windshield	Watershed Coordinator

Bridge Creek (051202020303)

Map 17: Bridge Creek Sub watershed



The Bridge Creek sub watershed is the smallest 12-digit HUC within the PCW and is less than half the size of the second smallest, covering only 5,394.5 acres. The only named creek contained within its borders is the Bridge Creek, which runs from East to West and drains into an area called the American Bottoms. It is also the only sub watershed in the PCW and doesn't drain directly to the Plummer or Richland Creeks. Instead it is what is known as a closed basin. All drainage from this basin is directed underground into a cave system. This basin is a karst area that moves the water underground before joining with a larger creek or absorbed into groundwater. Dye testing done in the area indicates that some sinking streams re-emerge from a spring that drains into Stalcup Branch near its outlet, though it isn't clear whether Ore Branch, Clifty Creek, or other creeks and branches receive additional water from the basin.

During this project, there were no water samples collected by the PCAC group in the Bridge Creek sub watershed. Bridge Creek flows underground into Plummer Creek eventually, though it has to pass underground through karst limestone to springs. Passing underground, water does not have the additional help of plants and sunlight to help filter and remove water quality contaminants. In a surface water system, plants can uptake nitrogen and phosphorous from the water and ultraviolet rays from the sunlight can help to kill harmful pathogens. Water quality was not collected by the PCAC group, but was collected from two points through the IDEM baseline study seen on Map 17 as Test points 23 and 24.

Water Quality and Habitat Data Summary

The baseline study had two test points on Bridge Creek. There were no issues for dissolved oxygen (DO), pH, specific conductivity, nitrate, total suspended solids (TSS), or total Dissolved solids (TDS).The problems were high ammonia and TKN, high turbidity, and high total phosphorous levels. Ammonia levels exceeded target levels only at site 24 and were indicated as very poor quality by IDEM. Additionally TKN exceeded target levels of 0.28 mg/L at both sites with site 24 having the highest level of 1.208 mg/L. Turbidity on the other had was just below target levels at site 24, but exceeded target levels at site 23. Site 23 had over twice the target level of 25 NTU with a sample result of 54.78 NTU. Total phosphorous exceeded target value of 0.076 mg/L at Site 24 with a sample value of 0.087 mg/L while site 23 was just under target levels. Both were marked as intermediate water quality by IDEM. Both test points are located on Bridge Creek near where the creek drains into the karst. Of the two points tested during the baseline survey, point 24 (Map 17) is a little further downstream and was noted to experience more chemical and biological issues than point 23.

Table 19: IDEM Baseline Sites Chemical Data (Bridge Creek)

	Chemical Stressors									
Station ID	DO	pH	Cond.	Turb.	Ammonia	Nitrate	Phosphorus	TSS	TDS	TKN
WWL-03-0023	7.54	7.72	280.63	54.78	0.11	0.833	0.075	11	199.17	0.608
WWL-03-0024	6.86	7.68	322.57	24.93	0.45	0.85	0.087	14.17	207.17	1.208
Targets	***>4***	***>6 & <9***	***<1,200***	***<25***	***<0.21***	***<1.0***	***<0.076***	***<30***	***<500***	***<0.28***
Units	**mg/L**		**µs/cm**	**NTU**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

The baseline study collected E. coli data 5 times over a 30 day period to construct a geometric mean for bacteria levels at both sites on Bridge Creek. Both sites had geometric means above target levels for E. coli with station 23 being the highest with 628.62 MPN/100mL. The baseline study also reported low habitat quality for this sub watershed with both baseline sites scoring less than target score of 50 points for the QHEI. The habitat scores indicated that the substrate, channel, and riffles were in the worst shapes at these sites with scores varying from intermediate quality to very poor quality. Macroinvertebrate populations were of poor quality and below target levels at site 24 with a MIBI score of 32. Four points below target MIBI scores. Table 12 indicate that probable sources for these problems include habitat modification, agricultural runoff, and livestock, which were all consistent with problems noted during windshield surveys. There were no 305(b) or 303(d) impaired streams or TMDLs done in Bridge Creek sub watershed.

Table 20: IDEM Baseline Sites Biological and Habitat Data (Bridge Creek)

		Biological Measures		**Habitat Stressors**						
Station ID	**E. coli**	**MIBI**	**EPT Index**	**QHEI**	**Sub**	**Cover**	**Channel**	**Riparian**	**Pool**	**Riffle**
WWL-03-0023	**628.62**	40	4	47	5	10	11	5	8	0
WWL-03-0024	**418.03**	32	3	44	9	6	7	6	5	3
Targets	***<125***	***>36***		***>50***						
Units	***MPN/100mL***	***Score***		***Score***						
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

Land Use Summary

Looking at the land use map, we see that there are some cultivated crops near the outlet of this sub watershed as well as a relatively large portion of pastureland. Both of these can lead to runoff issues if excess nutrients are used on the crops or the livestock isn't managed well. The biggest land use, however, is deciduous forest, which can provide habitat for all of the species of animals found in Greene County, which could lead to some E. coli contamination from their feces.

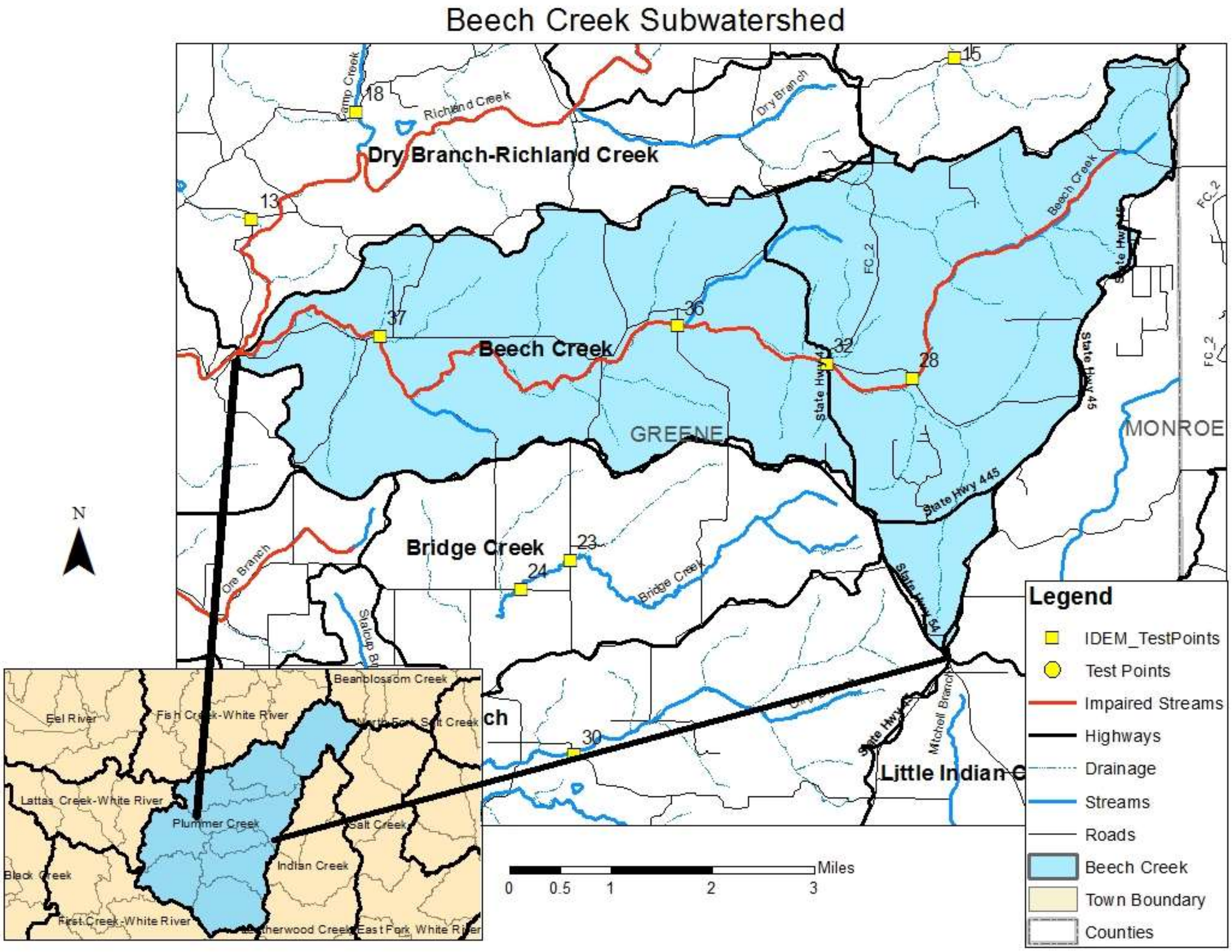
Of the nearly 5400 acres contained in the Bridge Creek watershed, about half of the land is forest and the other half is split between hay and pasture fields and cultivated crops. Though cultivated crops comprise only about 270 acres of the watershed, it is concentrated in the karst area where Bridge Creek drains underground and flows directly into other streams, making it critical sub watershed due to the lack of filtration that a karst landscape offers. Buffers are very important in this area to prevent agricultural application of fertilizers and pesticides from entering the surface water from agricultural fields and private residences with yards bordering the streams. Buffer strips assist in controlling nutrient runoff to streams and help control erosion. About 2.25 miles of streams in Bridge Creek sub watershed are in need of buffer strips or a widening of existing buffers and bank stabilization. There are no areas slated for development, open space, or industry in this sub watershed. Land use has seen little to no change in the last 30 years. There are 4-6 hobby farms of horses, some sheep, and small poultry farms scattered throughout the sub watershed. Three separate locations it was noticed that livestock had direct access to streams. No municipal wastewater is applied in this sub watershed and there are no other nonagricultural animal operations, CSOs, SSOs, CAFOs, or CFOs.

Windshield and Desktop Survey

Possible Water Quality Influence	BMP	Location of Site	Site I.D. Type	Observed By
Cattle Access causing erosion	Livestock Exclusion	East side of Holtsclaw Rd, Wolf Rd	Windshield Survey	Ed Paynter, Watershed Coordinator
Livestock affecting water quality	HUAP, waste storage facilities, pasture management	American Bottoms Rd, Holtsclaw Rd, Wolf Rd, CR 700E, Crowe Rd	Desktop & Windshield Surveys	Watershed Coordinator
Conventional Cropping systems increasing runoff of nutrients, manure, and sediment	Nutrient Management Plans, No Till/Reduced Till, Manure storage/handling	Cultivated crop ground	Desktop & Windshield Surveys	Watershed Coordinator
High levels of E. coli	Septic Education, Manure Storage/Handling	Test point 4, Residential Areas, Agricultural Lands	Monitoring, Desktop & Windshield Surveys	Watershed Coordinator
Thin Buffer strip	Field borders	South side of Highway 54 south of the Eastern Middle School	Windshield Survey	Ed Paynter

Beech Creek (051202020304)

Map 18: Beech Creek Sub watershed



The Beech Creek sub watershed covers 14,857 acres of land in the middle of the PCW and contains the Anderson Branch and Beech Creek, which flow into Richland Creek. Beech Creek flows from East to West and is joined by Anderson Branch from the north in the middle of the sub watershed. Beech Creek then flows out to the West into Ore Branch where it drains into Richland Creek.

Water Quality and Habitat Data Summary

Beech Creek sub watershed is another sub watershed that has no PCAC test point within its borders. However, it flows into Richland creek shortly after the creeks leave Beech Creek and PCAC Test Point 3 samples represent flow from upstream Richland Creek including Beech Creek. IDEM has, however, collected water quality samples from four sites along Beech Creek including sites 28, 32, 36, and 37. The data, combined with the land use summary and the windshield survey below, would suggest that this sub watershed is susceptible to minor amounts of runoff and erosion. The TMDL created in 2006 for Richland Creek found Beech Creek to be impaired for E. coli, which may indicate that this is already a problem. A small amount of pasture land, where livestock may be free to enter streams or are depositing feces directly uphill of streams, may necessitate management practices to prevent E. coli from entering the streams.

Table 21: IDEM Baseline Sites Chemical Data (Beech Creek)

	Chemical Stressors									
Station ID	DO	pH	Cond.	Turb.	Ammonia	Nitrate	Phosphorus	TSS	TDS	TKN
WWL-03-0028	9.38	7.75	259.5	28.49	0.05	0.433	0.015	3.5	182	0.175
WWL-03-0032	10.09	7.78	289.88	16.21	0.05	0.433	0.018	4.5	198.67	0.192
WWL-03-0036	8.28	7.72	277.75	31.24	0.05	0.375	0.015	4	188	0.192
WWL-03-0037	7.29	7.64	311.43	11.63	0.05	0.425	0.018	6.17	193.17	0.367
Targets	***>4***	***>6 & <9***	***<1,200***	***<25***	***<0.21***	***<1.0***	***<0.076***	***<30***	***<500***	***<0.28***
Units	**mg/L**		**µs/cm**	**NTU**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

The baseline study found no problems with dissolved oxygen (DO), pH, specific conductivity, total ammonia, nitrate, total phosphorous, total suspended solids (TSS), or total dissolved solids (TDS) (Table 21). Turbidity was only exceeded at two sites, Sites 28 and 36. The maximum turbidity was 31.24 NTU which is 6.24 over target levels of 25 NTU. TKN exceeded target levels of 0.28 mg/L at site 37 with a value of 0.367 mg/L. E. coli still exceeded target levels for the geometric mean samples collected through April of 2012. Most of these samples were considered intermediate water quality and their values were less than twice the target level, see Table 22. However, Site 37 was ranked as poor quality for E. coli with a geometric mean of 393.85 MPN/100mL which is over three times target level (125 MPN/100mL) for E. coli.

Table 22: IDEM Baseline Sites Biological and Habitat Data (Beech Creek)

		Biological Measures		Habitat Stressors						
Station ID	**E. coli**	**MIBI**	**EPT Index**	**QHEI**	**Sub**	**Cover**	**Channel**	**Riparian**	**Pool**	**Riffle**
WWL-03-0028	**203.08**	38	6	70	17	9	14	10	5	5
WWL-03-0032	**180.14**	40	8	61	17	5	13	7	5	4
WWL-03-0036	**200.18**	36	7	56	13	11	13	5	4	0
WWL-03-0037	**393.85**	40	5	36	1	7	11	3	8	0
Targets	***<125***	***>36***		***>50***						
Units	***MPN/100mL***	***Score***		***Score***						
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

Habitat scores declined as you move further downstream on Beech Creek. The creek had a high quality QHEI score in the headwaters, but declined from site to site until it was below target levels (greater than 50) and received a very poor quality score as the lower most sampling site, site 37. Site 37 only received a score of 36 and scored very poor quality on substrate and riffle, indicating that stream modification and siltation may be a serious issue in the lower part of Beech

Creek. Even though the habitat was an issue the MIBI score for macroinvertebrate populations were at or above target levels throughout the watershed.

Beech Creek was on the impaired streams 303 (d) list in 2004 for E. coli. It did not make it onto the 2012 list, but based on water quality tests performed by IDEM, E.coli levels still exceed state limits. The TMDL taken in 2006 for E. coli also labeled Beech Creek as impaired. This is the number one stakeholder concern in the watershed, so the high result from our testing along with the exceeded targets from the baseline data along with the TMDL makes Beech Creek a clear choice to be a critical sub watershed for our watershed project.

Land Use Summary

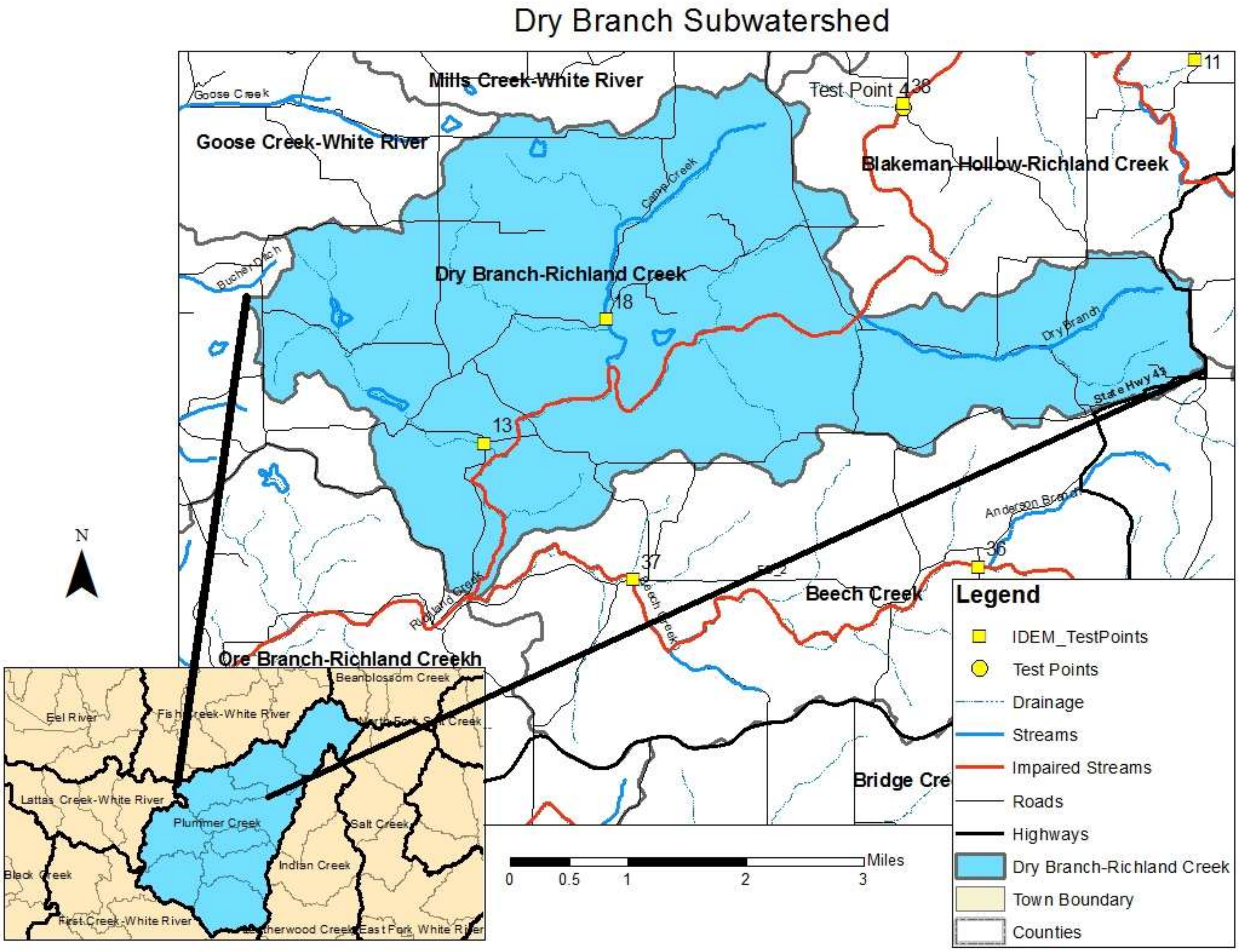
Similar to the previous sub watersheds, Beech Creek contains mostly deciduous forest with pasture, herbaceous, and row crop areas spread throughout and has hills across the entire area. Nearly half of the town of Solsberry is included in this sub watershed, adding some impervious surfaces. Eastern Greene Elementary and Middle School is located within this sub watershed. Also, several urban housing additions are located on the fringes of Solsberry and in Lawrence Hollow. These combined may be causing the high levels of E. coli seen in water monitoring samples. Lawrence Hollow is a small community where meth lab waste may be entering streams that border this small community. Many road ditches are steep and clear signs of erosion can be seen in the sub watershed. Streambank erosion and thin buffers in the Beech Creek watershed lead to an estimated 6.33 miles of stream in need of plantings to create or widen existing buffer strips and stabilize streambanks. Fertilizers in the form of manure may be entering the stream from agricultural fields and may be an issue. There are no areas slated for development, open space, or industry in this sub watershed. Land use reflects the trends seen for the entire Richland Creek watershed. There are 5-7 hobby farms of horses, some sheep, and one large poultry farm scattered throughout the sub watershed. Two NPDES permitted facilities, the Eastern Greene Elementary and High School, discharge into Beech Creek. Both of these facilities biggest discharge potential is chlorine compounds to the streams. There are no other nonagricultural animal operations, CSOs, SSOs, CAFOs, or CFOs.

Windshield and Desktop Survey

Possible Water Quality Influence	BMP	Location of Site	Site I.D. Type	Observed By
Streambank Erosion	Streambank plantings	CR 280, CR 360	Windshield Survey	Watershed coordinator
Livestock with direct access to stream causing erosion	Fencing/Alternative Water Source	2 individual locations with livestock access	Windshield Survey	Watershed Coordinator,
Ditch Erosion	Ditch Maintenance Plan	CR 450N, CR 480N, Solsberry, CR 375	Windshield Survey	Watershed Coordinator, SWCD
Overgrazing increasing runoff (nutrient, E. coli)	Pasture Management	CR 480N	Windshield Survey	Watershed Coordinator
Livestock uphill from stream	HUAPs, waste storage facilities, pasture mgmt., watering facility	W side of CR 840E, E side of CR 480N	Windshield Survey	Watershed Coordinator
High levels of E. coli	Septic Education, Manure Storage/Handling,	All Test sites, Residential Areas, Agricultural Lands	Monitoring, Desktop & Windshield Surveys	Watershed Coordinator
Conventional Cropping systems increasing runoff of nutrients, manure, and sediment	Nutrient Management Plans, No Till/Reduced Till, Manure storage/handling	Cultivated crop ground	Desktop & Windshield Surveys	Watershed Coordinator
Thin Buffers	Field Borders	CR 280N, CR 250N	Windshield Survey	Watershed Coordinator

Dry Branch (051202020305)

Map 19: Dry Branch Sub watershed



The Dry Branch sub watershed houses the accumulated water of Richland Creek out of Blakeman Hollow as well as the Dry Branch and Camp Creek and other small tributaries that flow into Richland Creek about halfway through the watershed. Richland Creek and Dry Branch flow from East to West and Camp Creek joins them from the North. Richland Creek then flows out of the southern point and into Ore Branch. This sub watershed covers 10,911 acres and is completely contained within Greene County.

Water Quality and Habitat Data Summary

The Dry Branch sub watershed is downstream of PCAC Test Point 4 and adds Dry Branch and Camp Creek to Richland Creek before PCAC Test Point 3 in Ore Branch Sub watershed. E. coli, nitrates, turbidity, TSS and TDS have all been concerns at PCAC Test Point 4 and most of these persist into Test Point 3. However, nitrates are only above the recommended limit once downstream, meaning that within Dry Branch, there are very few nitrates entering the streams while added water dilutes the problem. Other water quality issues persist, even with added water from two tributaries, meaning that they are also an issue within Dry Branch. Streambank erosion were noted on approximately 6.3 miles of stream length during a windshield survey of the sub watershed, leading to similar problems in turbidity, TSS and TDS. E. coli remains a problem and could again be from failing septic systems, runoff from livestock (no domesticated animals were noted to have access directly to the stream), or feces from wild game. Within the TMDL report for Richland Creek, the only creek within the Dry Branch sub watershed that was marked as impaired was Richland Creek, which was recorded having high E. coli and impaired biotic communities. The two tributaries that enter within this area both were unimpaired by E. coli, which is consistent with our testing results.

IDEM set up two sites within Dry Branch sub watershed and both were on smaller tributaries that drain into Richland Creek. Site 18 is on Camp Creek and site 13 is on an unnamed tributary to Richland Creek. The baseline study found no problems with dissolved oxygen, pH, specific conductivity, ammonia, nitrate, total phosphorous, total suspended solids, total dissolved solids, or TKN. However, both sites had high instances of turbidity and both sites scored as poor quality for their turbidity levels (Table 23). Site 18 had the highest turbidity measurement at 141.53 NTU which is nearly 6 times the target level of 25 NTU. There was a problem with the channel habitat and pool habitat scores at site 13, but that wasn't enough to fail the site for the overall QHEI habitat score (Table 24). Also, macroinvertebrate population scores using the MIBI method at these two sites were above target levels. Both sites did, however, exceed target levels for E. coli geometric mean. Site 18 on Camp creek had the highest average of E. coli readings with a geometric mean of 411.73 MPN/100mL (Table 24) which is over 3 times the target level of 125 MPN/100mL.

Table 23: IDEM Baseline Sites Chemical Data (Dry Branch-Richland Creek)

	Chemical Stressors									
Station ID	DO	pH	Cond.	Turb.	Ammonia	Nitrate	Phosphorus	TSS	TDS	TKN
WWL-03-0013	10.44	8.2	331.13	95.3	0.05	0.3	0.019	2.83	221.3	0.175
WWL-03-0018	8.55	7.78	227.88	141.53	0.05	0.26	0.019	6.67	151.83	0.2
Targets	***>4***	***>6 & <9***	***<1,200***	***<25***	***<0.21***	***<1.0***	***<0.076***	***<30***	***<500***	***<0.28***
Units	**mg/L**		**µs/cm**	**NTU**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

Table 24: IDEM Baseline Sites Biological and Habitat Data (Dry Branch-Richland Creek)

		Biological Measures		**Habitat Stressors**						
Station ID	**E. coli**	**MIBI**	**EPT Index**	**QHEI**	**Sub**	**Cover**	**Channel**	**Riparian**	**Pool**	**Riffle**
WWL-03-0013	**242.59**	46	9	51	13	8	9	7	3	3
WWL-03-0018	**411.73**	48	18	66	12	11	14	9	8	4
Targets	***<125***	***>36***		***>50***						
Units	***MPN/100mL***	***Score***		***Score***						
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

There were two 303(d) impaired streams in the Dry Branch sub watershed (Camp Creek and Richland Creek). Camp Creek was impaired for mercury in fish tissue while Richland Creek was again found to have high E. coli along with mercury in fish tissue.

Land Use Summary

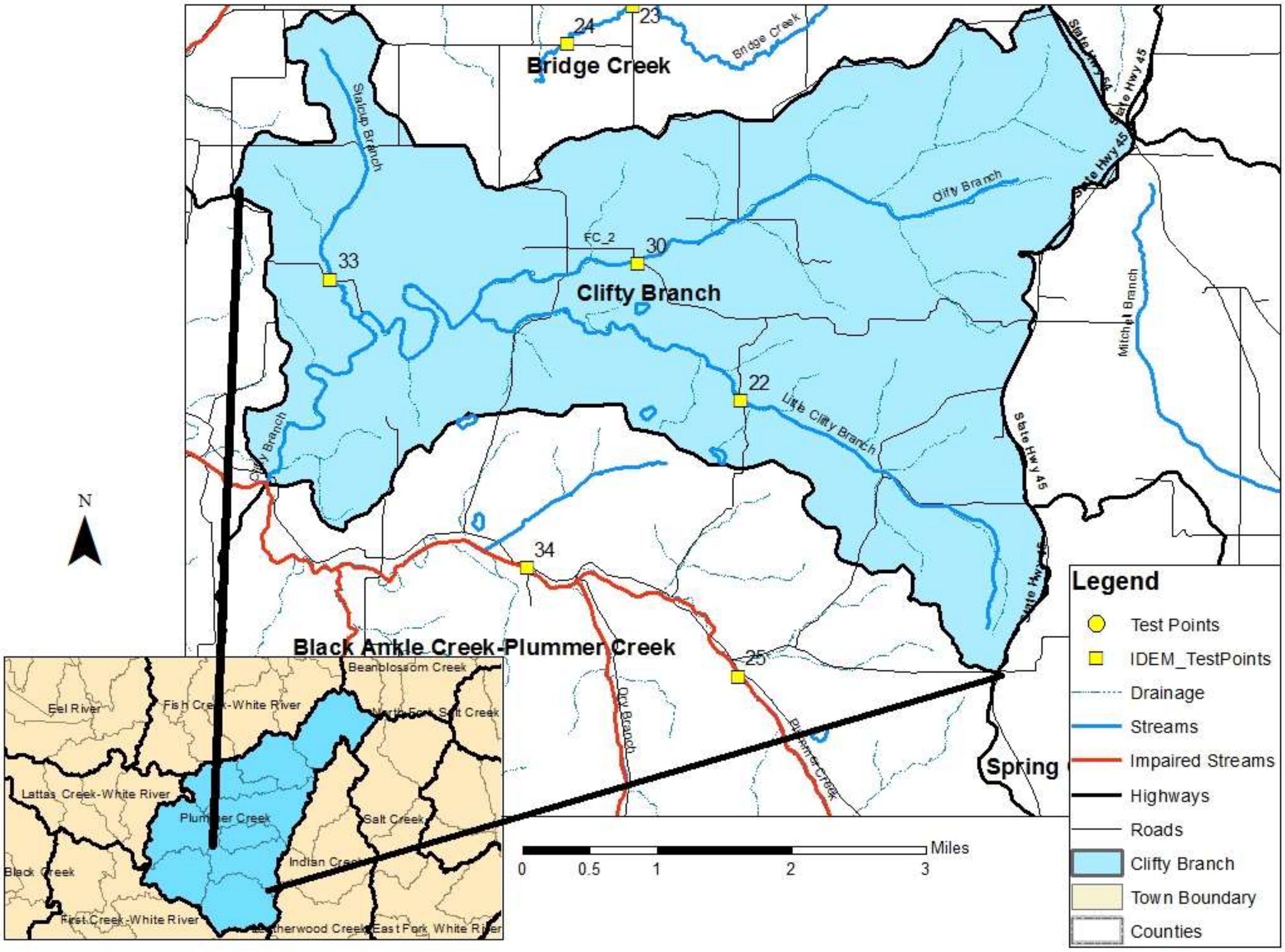
Dry Branch is primarily covered by deciduous forest, though there are also areas of row crops, herbaceous cover, shrub cover, and pasture land. The north side of Solsberry is within this sub watershed, adding a small addition of impervious surfaces. There are several residential homes with manicured lawns. These residential areas along with the community of Newark which may be sources for E. coli within the watershed. Most road surfaces encompassed within this hilly region are gravel topped and drainage ditches alongside of these gravel roads are steep with no vegetation. About 5 miles of streambank are in need of buffers being added or widened and bank stabilization is needed in this sub watershed. There are no areas slated for development, open space, or industry in this sub watershed. Land use reflects the trends seen for the entire Richland Creek watershed. There are 4-7 hobby farms of horses, some sheep, and small poultry farms scattered throughout the sub watershed. Livestock were seen entering the stream at 2 locations within this sub watershed. No municipal wastewater is applied in this sub watershed and there are no other nonagricultural animal operations, CSOs, SSOs, CAFOs, or CFOs.

Windshield and Desktop Survey

Possible Water Quality Influence	BMP	Location of Site	Site I.D. Type	Observed By
Streambank erosion	Streambank planting	Dry Branch, main trunk of Richland Creek, Camp Creek, and unnamed tributaries	Windshield Surveys	Watershed Coordinator
Livestock uphill of stream	HUAPs, waste storage facilities, pasture management, watering facility	CR 400, CR 480	Windshield Surveys	Watershed Coordinator
Livestock with direct access to stream causing erosion	Fencing/Alternative Water Source	2 individual locations with livestock access	Windshield Survey	Watershed Coordinator,
Failed stream crossing	Stream crossings	CR 450	Windshield Surveys	Watershed Coordinator
Roadside erosion	Drainage Ditch Management Plan	CR 640	Windshield Surveys	Watershed Coordinator
Conventional Cropping systems increasing runoff of nutrients, manure, and sediment	Nutrient Management Plans, No Till/Reduced Till, Manure storage/handling	Cultivated crop ground	Desktop & Windshield Surveys	Watershed Coordinator
High levels of E. coli	Septic Education, Manure Storage/Handling,	All Test sites, Residential Areas, Agricultural Lands	Monitoring, Desktop & Windshield Surveys	Watershed Coordinator
Thin Buffers	Field Borders	CR 450N, CR 250N	Windshield Survey	Watershed Coordinator

Clifty Branch (051202020306)

Map 20: Clifty Branch Sub watershed



Clifty Branch covers 11,168 acres and contains three major stream systems that empty into Plummer Creek to the Southwest. Clifty and Little Clifty Branch flow from East to West and Stalcup Branch joins them from the North.

Water Quality and Habitat Data Summary

Clifty Branch is another watershed without a PCAC test point. However, IDEM baseline study collected water from all three major branches within the watershed. Site 30 is on Clifty Branch, Site 22 is on Little Clifty Branch, and site 33 is on Stalcup Branch. All of these streams empty into Plummer Creek to the south. IDEM site 33 is downstream of the spring that at least partially drains water from Bridge Creek sub watershed according to dye tests. The water at site 22 may have strong influence both in flow and in chemical aspects from the Bridge Creek sub watershed. All three sites saw no problems with dissolved oxygen, pH, specific conductivity, total phosphorous, total suspended solids, or total dissolved solids (Table 25). Site 33 was the only site to have turbidity levels (41.12 NTU) that exceeded target levels of 25 NTU. Site 33 was also the only sample location within this sub watershed that had issues with nitrate. Nitrate at site 33 more than doubled the target level of 1.0 mg/L with a sample level of 2.35 mg/L. But this site did not see any issues with ammonia or TKN. On the other hand, both sites 22 and 30 exceeded TKN targets of 0.28 mg/L. Site 22 had the highest TKN sample with a value of 1.992 mg/L which is over 7 times the target. Site 22 also exceeded target levels for ammonia with a sample of 1.08 mg/L which is 5 times the target level of 0.21 mg/L. E. coli was an issue at all three sites. It was worse at site 33 with a geometric mean of 1061.39 MPN/100mL compared to target levels of 125 MPN/100mL. All sites were noted as poor quality with double to triple the target level, but site 33 was ranked as very poor quality with its samples, see table 26.

Table 25: IDEM Baseline Sites Chemical Data (Clifty Branch)

	Chemical Stressors									
Station ID	DO	pH	Cond.	Turb.	Ammonia	Nitrate	Phosphorus	TSS	TDS	TKN
WWL-03-0022	7.45	7.57	245	24.39	1.08	0.2	0.067	17.67	161.33	1.992
WWL-03-0030	7.92	7.65	252.86	24.14	0.1	0.375	0.015	5.6	168.6	0.45
WWL-03-0033	9.63	7.89	267.75	41.12	0.05	2.35	0.037	4.17	190.67	0.3
Targets	***>4***	***>6 & <9***	***<1,200***	***<25***	***<0.21***	***<1.0***	***<0.076***	***<30***	***<500***	***<0.28***
Units	**mg/L**		**µs/cm**	**NTU**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

The baseline study found a habitat and macroinvertebrate population problem at site 30 on Clifty branch. The habitat score through QHEI was of very poor quality with a score of 38. This is 12 points below our target level of 50 points for QHEI. The score reflected the poor habitat in the riffle and substrate portions of the stream. Indicating that channelization and sedimentation may be an issue here, even though the sediment levels were of good quality at this sample site, there may be a source of fine sediment that are choking out populations here. This is reflected in the low macroinvertebrate score at site 30. The MIBI score for this site is 30 and target levels are 36. Site 22 was just at target levels of 36, but we would like to see scores greater than 36, so this site too is below target levels, but just barely.

Table 26: IDEM Baseline Sites Biological and Habitat Data (Clifty Branch)

		Biological Measures		**Habitat Stressors**						
Station ID	**E. coli**	**MIBI**	**EPT Index**	**QHEI**	**Sub**	**Cover**	**Channel**	**Riparian**	**Pool**	**Riffle**
WWL-03-0022	**386.85**	36	0	62	16	8	13	7	4	4
WWL-03-0030	**308.1**	30	3	38	2	6	11	9	6	0
WWL-03-0033	**1061.39**	40	16	78	15	13	16	8	10	6
Targets	***<125***	***>36***		***>50***						
Units	***MPN/100mL***	***Score***		***Score***						
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

Based on test results, we can see that nutrients, specifically nitrogen, and E.coli are definitely problems in this sub watershed. There were several instances of cattle having access to the creek and though this is most likely not the sole cause of quality issues, it is an apparent that water quality can most likely be improved with prescribed best management practices.

These two sites obtained aquatic life use status according to the baseline study, but the site on Clifty Branch failed due to poor substrate and riffles and listed agricultural runoff, livestock, and habitat modification as possible causes for this. There were no 305(b) or 303(d) impaired streams within Clifty Branch. A TMDL was done for the Plummer Creek portion of the sub watershed, but none of the streams within the Clifty Branch sub watershed were noted as impaired or of concern, but likely high levels of E. coli may be accounted for by land uses within this sub watershed and within Bridge Creek sub watershed that flows into Clifty Branch sub watershed through Stalcup Branch.

Land Use Summary

Clifty Branch is covered mostly in deciduous forest. There are small areas of row crops scattered throughout the sub watershed and several large areas of pasture where cattle or horses are free to roam. There are also several spots of low-lying forests that grow out of hydric soils that may hold small tributaries during larger rain events. About 7 miles of streambank are in need of stabilization and buffers being added or widened in this sub watershed. Some fertilizers may be entering the streams from agricultural fields and private lawns. Clifty Branch has a small portion in the Southeast corner that has been recently developed for the new interstate (I-69) that will be moving through the area. There are no areas slated for development, open space, or industry in this sub watershed. Land use has experienced little or no change in the last 30 years. There are 7-15 hobby farms of horses, some sheep, and buffalo farms scattered throughout the sub watershed.

Images like this are not unusual along Clifty Branch and other locations throughout the watershed. This shows the unlimited access that livestock has to some of the streams and creeks within the area.

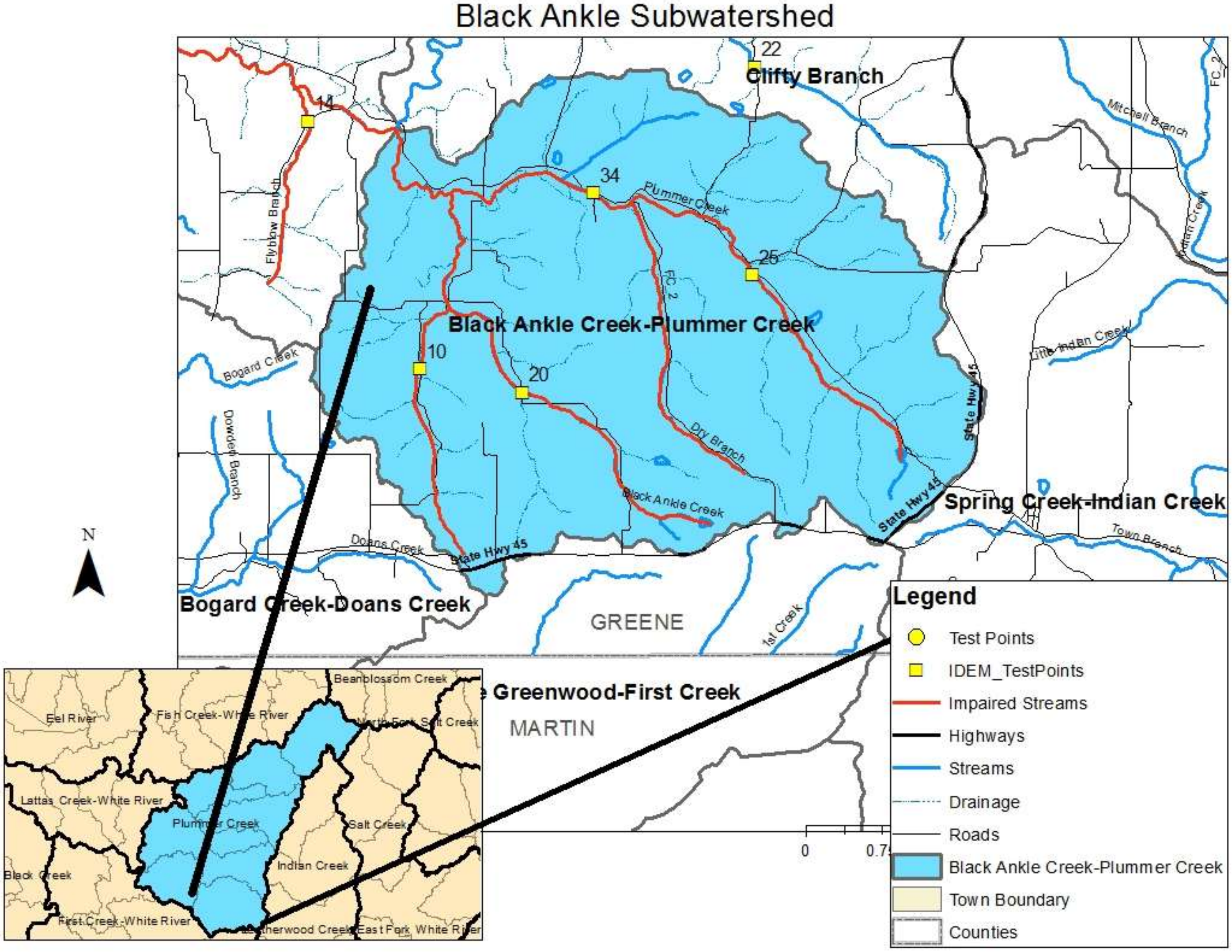
New development is being seen within this sub watershed where forest and agricultural lots are being divided up into smaller residential lots. Rural residential neighborhoods are increasing at a substantial rate within this sub watershed and concerns for E. coli levels may increase due to this increase in residential population. The town of Cincinnati sits on the edge of the watershed and may be introducing large amounts of septic waste into Clifty Branch. The major HWY I-69 is moving through a small portion of the southwest corner of Clifty Branch sub watershed. This major construction is crossing over the headwaters of Little Clifty Branch. Near this site on and off ramps are being currently constructed for exit and entry from Highway 45. Testing on this branch was completed well before construction began, so no influence from this construction can be documented at this time. However, visual inspection of this constructions site during construction has witnessed large amounts of sediments running off site into local waterways. Turbidity and TSS would likely be exceeding target levels now that construction has begun. There are sediment control structures on site, however, they have not been maintained properly and "chocolate milk" like waters are flowing from the site during every rain event. Even though sites are being inspected constantly, progress is being made without concern for the influence to the local waterways by highway construction personnel. No municipal wastewater is applied in this sub watershed and there are no other nonagricultural animal operations, CSOs, SSOs, CAFOs, or CFOs.

Windshield and Desktop Survey

Possible Water Quality Influence	BMP	Location of Site	Site I.D. Type	Observed By
Livestock with stream access causing erosion	Livestock exclusion, watering facilities, stream crossing	Headwaters of Stalcup Branch, CR 300S, CR 50 N, CR 125 S	Desktop & Windshield Surveys	Watershed Coordinator
Streambank erosion	Riparian forest buffer, streambank protection, field borders	Coalmine Rd., C.R. 300S, C.R. 140S	Desktop & Windshield Surveys	Watershed Coordinator
Improper grazing management	Pasture management	S of Sylvania Rd just past Little Rd.	Desktop & Windshield Surveys	Watershed Coordinator
High levels of E. coli	Septic Education, Manure Storage/Handling	All Test sites, Residential Areas, Agricultural Lands	Monitoring, Desktop & Windshield Surveys	Watershed Coordinator
Conventional Cropping systems increasing runoff of nutrients, manure, and sediment	Nutrient Management Plans, No Till/Reduced Till, Manure storage/handling	Cultivated crop ground	Desktop & Windshield Surveys	Watershed Coordinator
Ditch Erosion	Ditch Maintenance Plan	CR 300S, CR 50S	Windshield Survey	Watershed Coordinator, Monroe & Greene Co SWCD Administrators,
Thin Buffers	Field Borders, Livestock Exclusion	Stalcup Branch, Little Clifty Branch, and Clifty Branch	Windshield Survey	Watershed Coordinator

Black Ankle Creek (051202020307)

Map 21: Black Ankle Sub watershed



Black Ankle sub watershed is the Southernmost within the PCW, which means that most of its streams move from South to North. There is a general Southeast to Northwest movement of water here. Plummer Creek Starts in the Southwest corner and is later joined by the Southern Dry Branch (not to be confused with the Dry Branch with its own sub watershed that drains into Richland Creek) and then Black Ankle Creek. Plummer Creek then flows into Burcham Branch to the Northwest.

Water Quality and Habitat Data Summary

Black Ankle is another sub watershed without a PCAC test point, meaning that the quality will have to be inferred from the results of other studies. Though there is one test point downstream, test point one is the only test point on Plummer Creek and is summarizing all the data for Plummer Creek and all of its tributaries and can't be relied upon for problems in this sub watershed. However, using the baseline study, TMDL, 303(d) list, the land use and windshield surveys, we are able to draw strong conclusions for issues in this watershed. This sub watershed serves as the headwaters for Plummer Creek and contains some of the controversial I-69 construction and several mitigation sites.

The baseline study had four test sites within this sub watershed. They include sites 10, 20, 25, and 34, though site 20 was not included in results provided by IDEM. At the remaining three sites, no problems were found with dissolved oxygen, pH, specific conductivity, turbidity, ammonia, nitrate, phosphorous, total suspended solids, total dissolved solids, or TKN (Table 27).

Table 27: IDEM Baseline Sites Chemical Data (Black Ankle Creek)

	Chemical Stressors									
Station ID	DO	pH	Cond.	Turb.	Ammonia	Nitrate	Phosphorus	TSS	TDS	TKN
WWL-03-0010	8.48	7.49	150.67	9.61	0.05	0.85	0.015	2.75	101	0.213
WWL-03-0025	8.47	7.72	192.75	20.08	0.05	0.2	0.015	2	124.83	0.192
WWL-03-0034	8.11	7.64	265.13	20.96	0.05	0.35	0.015	5.5	164.83	0.275
Targets	***>4***	***>6 & <9***	***<1,200***	***<25***	***<0.21***	***<1.0***	***<0.076***	***<30***	***<500***	***<0.28***
Units	**mg/L**		**µs/cm**	**NTU**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

All three sites failed the aquatic life status tests for MIBI done during the baseline study. The MIBI highest score was a 32 at site 25 and the lowest was a 26 at site 10, see Table 28. The target MIBI score for this project was above 36 points. The QHEI scores at site 10 and 34 were above target scores, but site 25 was below with a score of 44. This is 6 points below the target level of over 50 QHEI points. According to the baseline report (Table 12) the reason that site 25 failed the aquatic life status was for poor substrates and riffles and listed habitat modification, agricultural runoff, and livestock as possible sources. Site 10 did not receive full attainment status for aquatic life because of poor riffle habitat while site 34 cited poor substrate quality as its cause. All three sites listed habitat modification, agricultural runoff, and livestock as possible sources.

Table 28: IDEM Baseline Sites Biological and Habitat Data (Black Ankle Creek)

		Biological Measures		**Habitat Stressors**						
Station ID	**E. coli**	**MIBI**	**EPT Index**	**QHEI**	**Sub**	**Cover**	**Channel**	**Riparian**	**Pool**	**Riffle**
WWL-03-0010		26	1	63	12	12	14	7	8	0
WWL-03-0025	**160.14**	32	3	44	9	6	7	6	5	3
WWL-03-0034		30	3	55	9	6	13	8	9	0
Targets	***<125***	***>36***		***>50***						
Units	***MPN/100mL***	***Score***		***Score***						
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

No streams in this watershed are listed in the 303(d) list of impaired waters for 2012. However, almost every stream was found to be impaired during the 2006 TMDL for Plummer Creek for E. coli, see Map 21. Looking at land use and the windshield surveys, we see that though there is little pasture land for livestock, there were cattle with access directly to streams which could cause this impairment along with wildlife in the area that reside in the abundant forests.

Land Use Summary

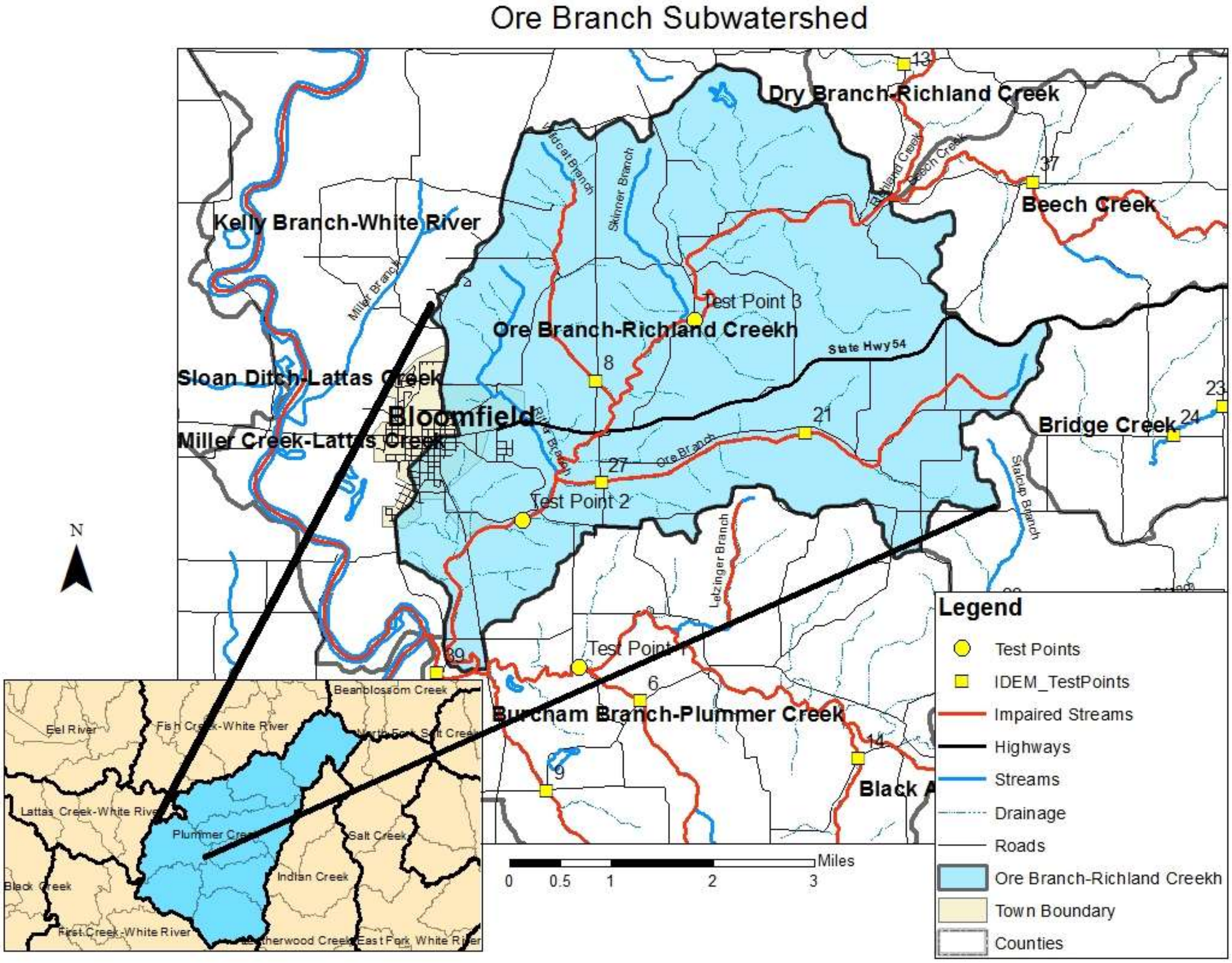
The Black Ankle sub watershed land use is almost entirely forests. There are some areas of herbaceous land and rare cultivated crop fields. Pasture land is present in this watershed. Fencing cattle out of minor drainage or creating buffer strips may improve water quality in this area. Cattle was observed in streams or minor drainage at 6 locations. It should also be noted that construction of I-69 is also in full swing in this sub watershed after water quality testing was performed for the baseline study. This construction has created lots of disturbance to the area and exposed soil, which has been shown to drastically increase sediment entering the streams, especially during rain events. About 8.5 miles of streambank are in need of stabilization and buffers being added or widened in this sub watershed. Black Ankle has a little bit of area that is being developed for the I-69 project from the south to the northeast. This has created quite a bit more sedimentation entering Plummer Creek and its tributaries which was observed by watershed coordinator and SWCD personnel during rain events. Tracing muddy waters up to the runoff point from this construction was obvious. There are no areas of open space or industry in this sub watershed. Land use reflects the trends seen for the entire Plummer Creek watershed. Flooding is a regular problem within Black Ankle Creek sub watershed and extends into some of the mitigation sites casing failure of the mitigation sites. Many of the new mitigation sites have not had the tree growth expected and are failing to reforest these areas. Logging has been observed in this watershed in a variety of locations and sediment control from these now bare lands was not observed. Some of the logging is in response to I-69 construction, but also elsewhere within the sub watershed. If this trend continues, sediment control will likely be a necessity for this sub watershed. Over grazing was also observed within this sub watershed at, at least, 6 locations and should be addressed to assist in protecting the water quality of the area. There are 15-20 hobby farms of horses, some sheep, and small cattle farms are scattered throughout the sub watershed. No municipal wastewater is applied in this sub watershed and there are no other nonagricultural animal operations, CSOs, SSOs, CAFOs, or CFOs.

Windshield and Desktop Survey

Possible Water Quality Influence	BMP	Location of Site	Site I.D. Type	Observed By
Heavy sedimentation from open fields, logging activities,	Riparian forest buffers, buffer strips, logging BMPs	Northwest corner of watershed, west of Koleen, CR 625E	Windshield Surveys	Watershed Coordinator
Overgrazing pasture land increasing runoff (nutrients, E coli, & sed.)	Pasture Management	CR 625 E, Mineral-Koleen Rd, and south side of Koleen	Windshield Surveys	Watershed Coordinator, Monroe & Greene Co SWCD Administrators,
Cattle Access	Livestock exclusion, watering facilities	West side of Koleen. Clifty Rd, Mineral-Koleen Rd, CR 625E	Windshield Surveys	Watershed Coordinator
Conventional Cropping systems increasing runoff of nutrients, manure, and sediment	Nutrient Management Plans, No Till/Reduced Till, Manure storage/handling	Cultivated crop ground	Desktop & Windshield Surveys	Watershed Coordinator
Thin buffer strip	Riparian forest buffers, buffer strips	Piankeshaw Rd, south side	Windshield Surveys	Watershed Coordinator
Interstate 69 Construction	Field Borders, Riparian forest buffers, Rule 5 construction BMPs	East to West path the northern portion of the watershed	Windshield Surveys	Watershed Coordinator

Ore Branch (051202020308)

Map 22: Ore Branch Sub watershed

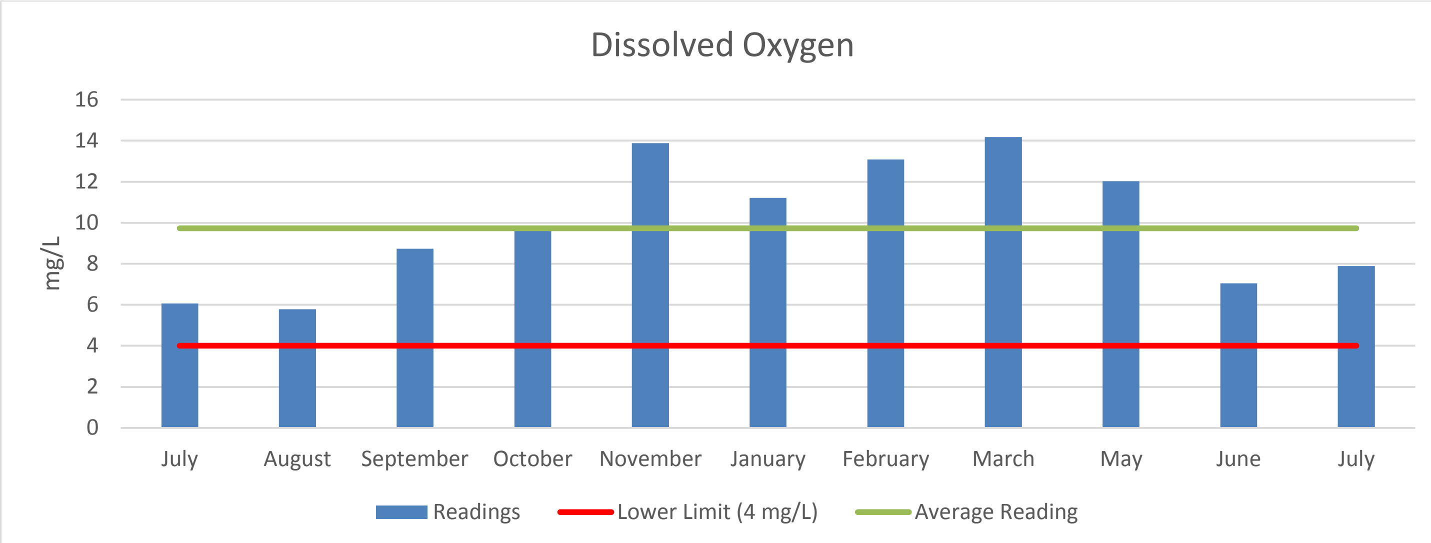


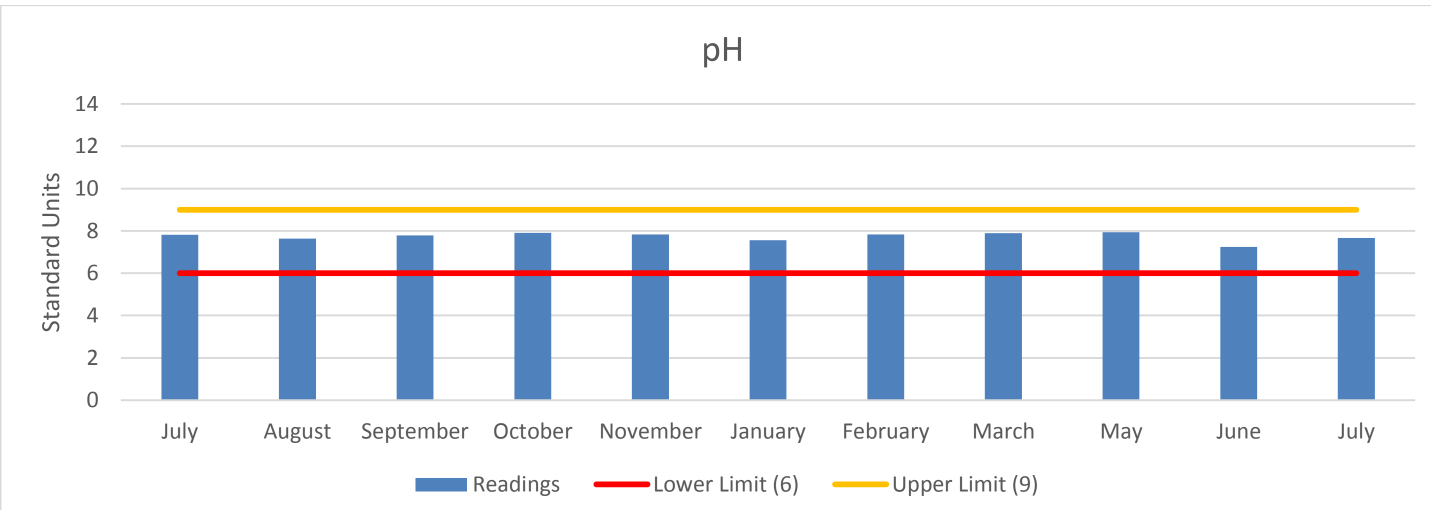
The Ore Branch- Richland Creek sub watershed covers 13,278 acres and holds the end of Richland Creek, which has its headwaters in the Little Richland sub watershed in Monroe County. Ore Branch also contains the Skinner Branch, Wildcat Branch, Ritter Branch, and Ore Branch, as well as, the Eastern portion of the town of Bloomfield. Richland Creek flows from the northwest to the southeast and is joined by Skinner Branch, then Wildcat Branch and Ritter Branch all from the north and Ore Branch just after picking up Ritter Branch comes in from the east. Richland Creek then drains into Plummer Creek in Burcham Branch sub watershed.

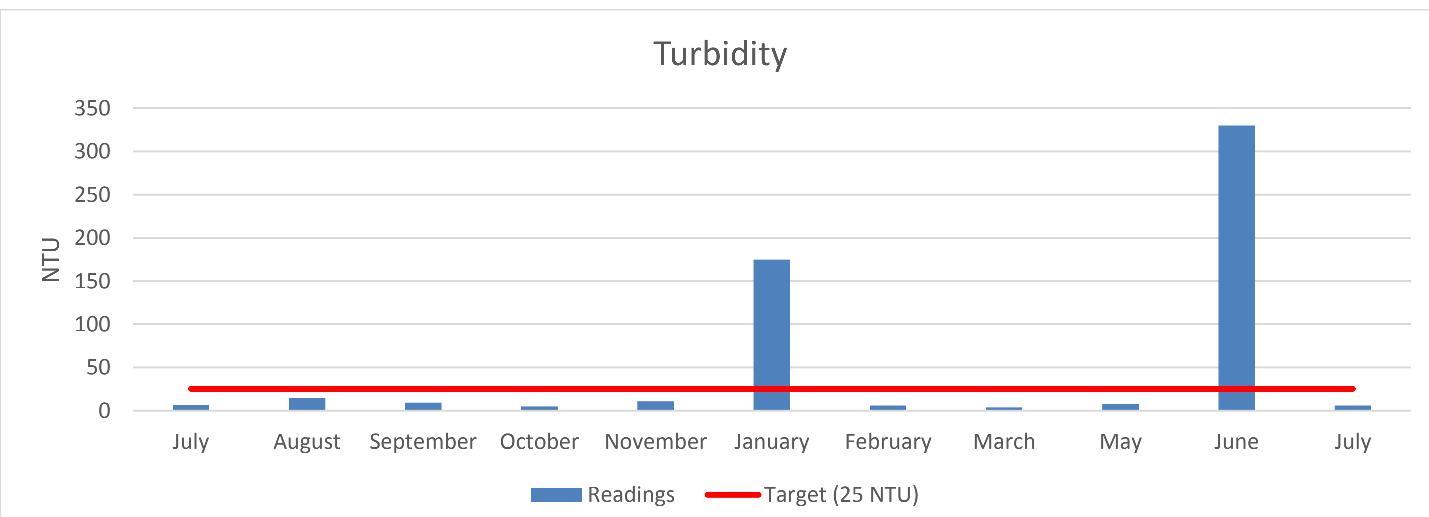
PCAC test points 2 and 3 are located within Ore Branch sub watershed and the collect water from Richland Creek. The test points are set up prior (test point 3) to the entrance of all the branches of this watershed, and after (test point4) all branches have entered the main trunk of Richland Creek. Additionally IDEM baseline study sampled three test points within Ore Branch sub watershed. Two points are on Ore Branch test site 21 and further downstream site 27, and one test site near the outlet of Wildcat Branch, site 8 (Map 22).

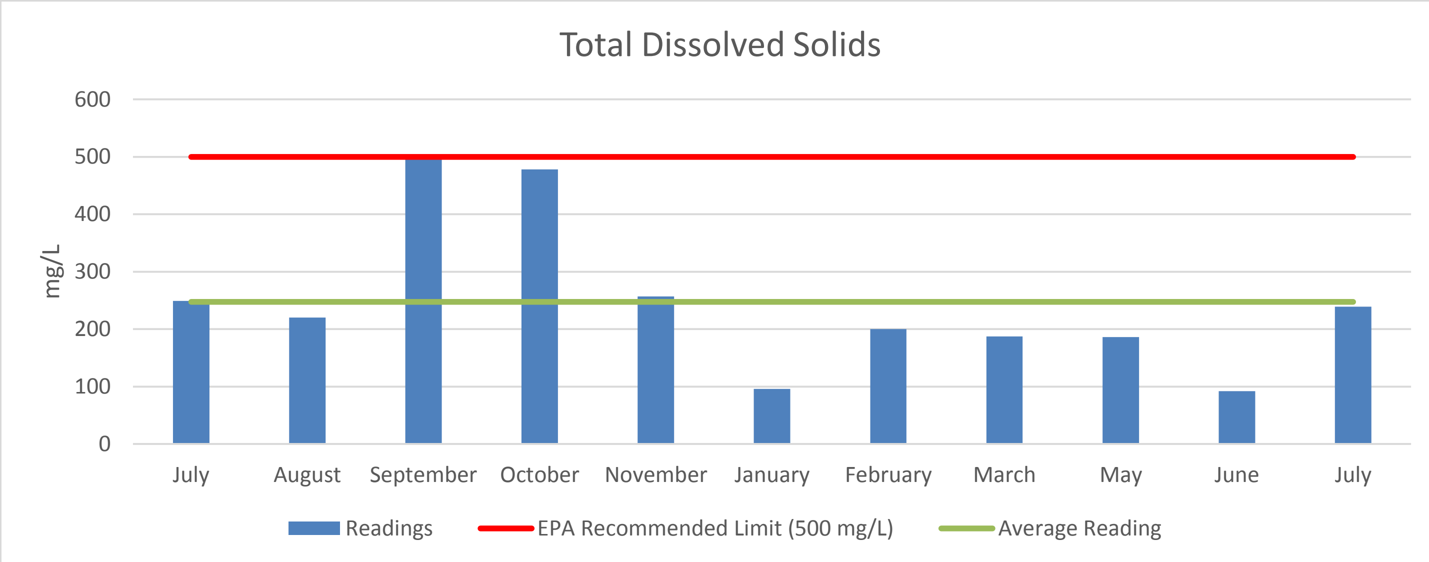
Water Quality and Habitat Data Summary

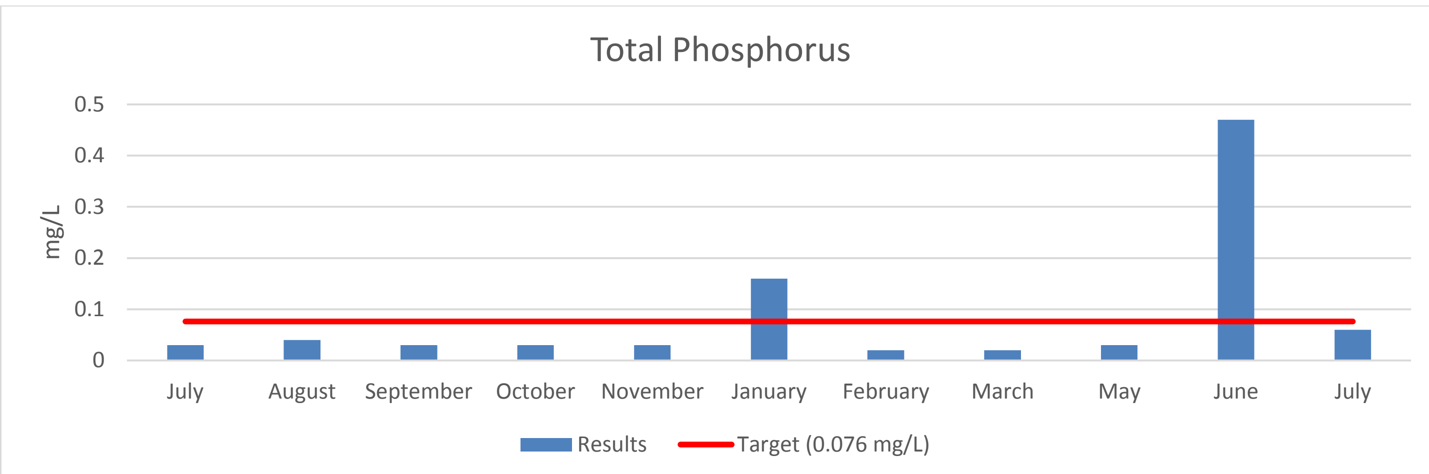
Test Point 3

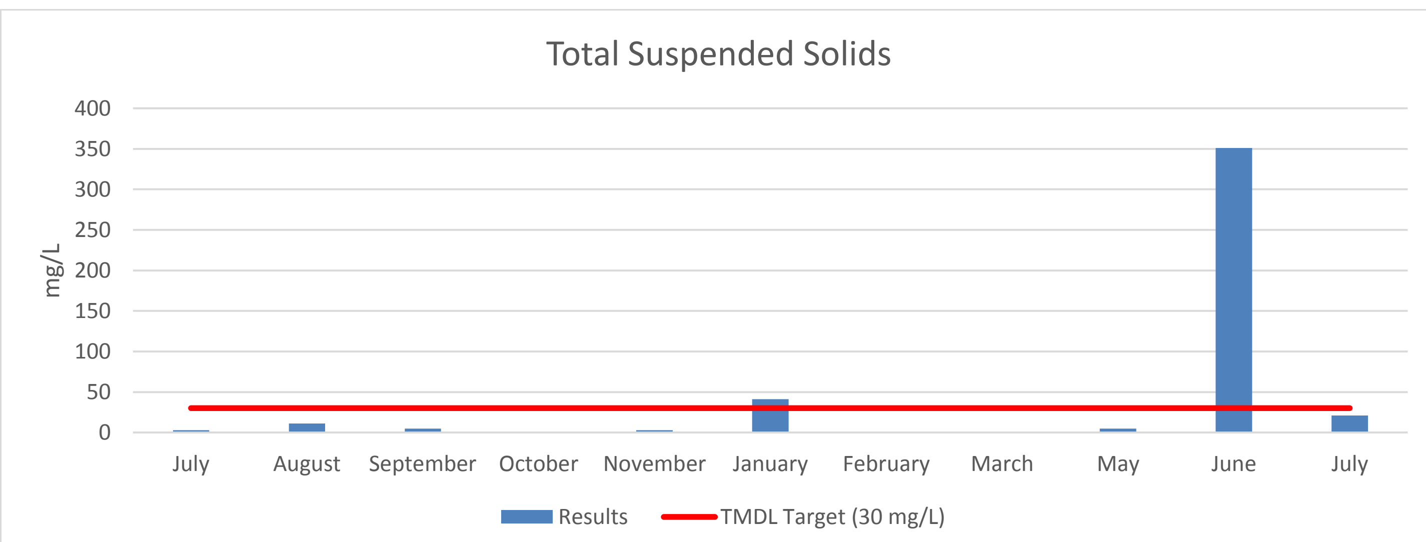


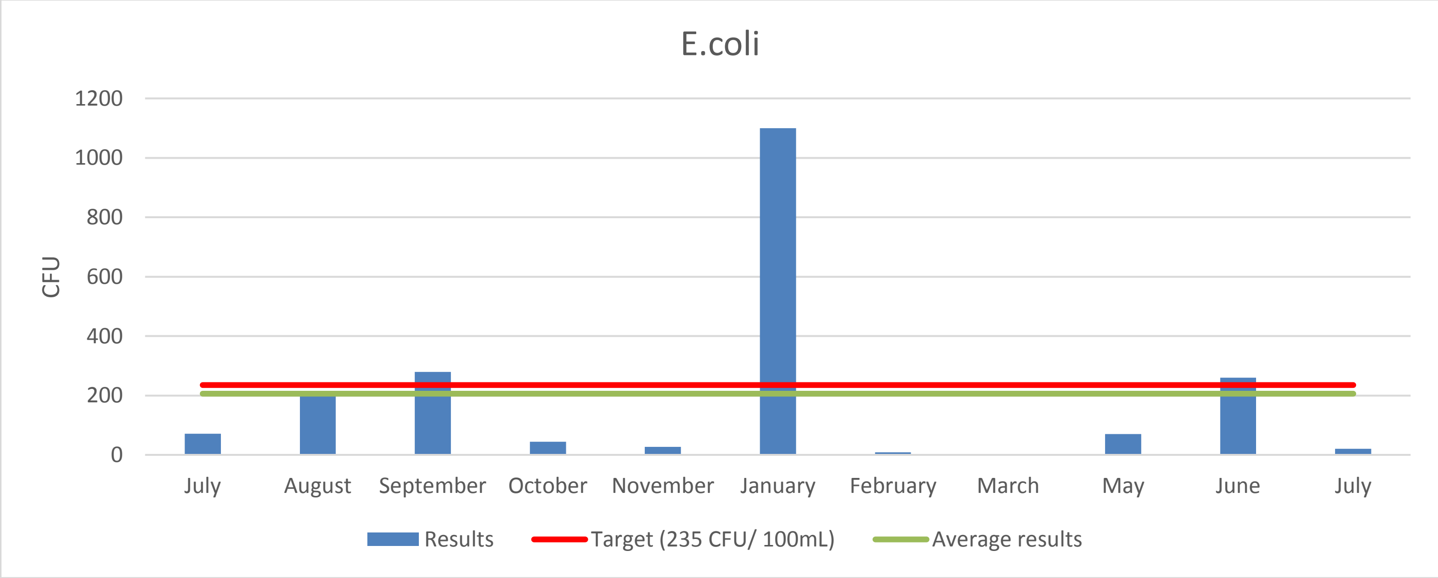


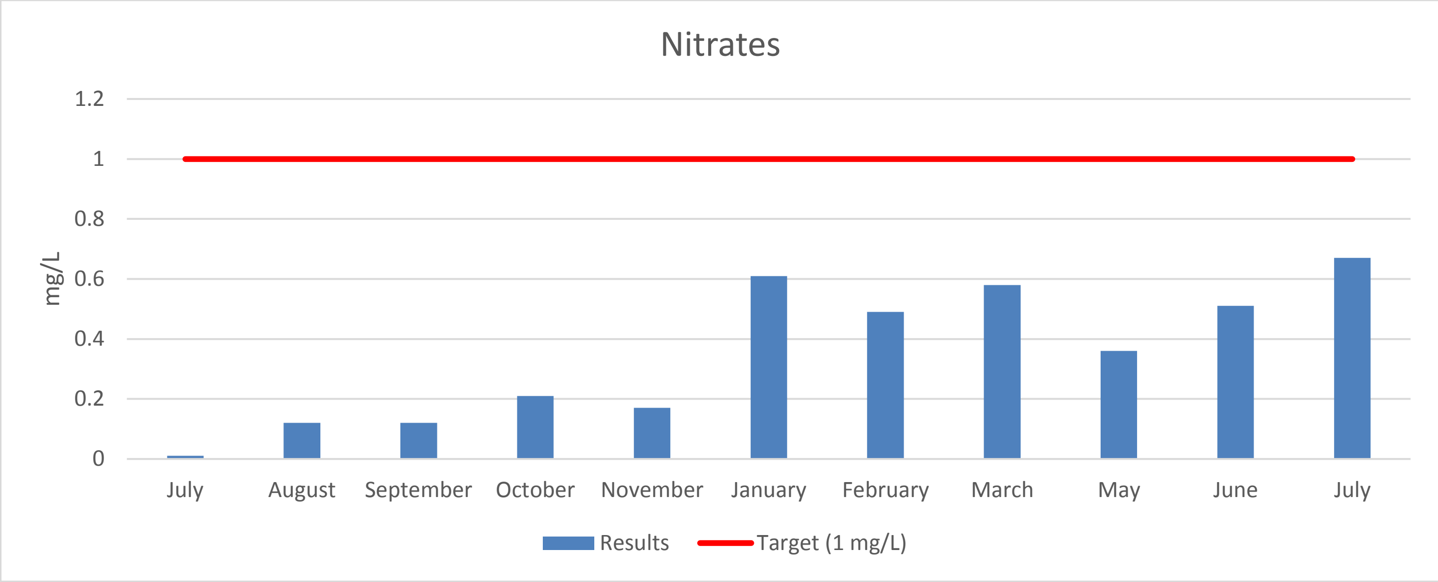



Total Dissolved Solids
mg/L
600
500
400
300
200
100
0
July
August
September
October
November
January
February
March
May
June
July
Readings
EPA Recommended Limit (500 mg/L)
Average Reading


Total Phosphorus
mg/L
0.5
0.4
0.3
0.2
0.1
0
July
August
September
October
November
January
February
March
May
June
July
Results
Target (0.076 mg/L)


Total Suspended Solids
mg/L
400
350
300
250
200
150
100
50
0
July
August
September
October
November
January
February
March
May
June
July
Results
TMDL Target (30 mg/L)





There are no problems with dissolved oxygen or pH at test point 3 in the Ore Branch sub watershed. Similar to test points 5 and 4, turbidity is high in January and June with a maximum reading of 330 NTU, which is 32 times higher than the recommended limit. This is most likely due to erosion from a recent rain event and streambank erosion. Total dissolved solids is actually lower at this point than at the earlier points, but still experienced spikes in September and October though these both remained under the 500 mg/L limit (498 and 478 mg/L, respectively). June saw high values of total phosphorus and total suspended solids exceeding target limits of 0.076mg/L and 30mg/L, respectively. Total phosphorous had a high of 0.47mg/L in June, and total suspended solids had a high of 351 mg/L in that same month. Again, because it was tested shortly after a rain event, any problems experienced were exaggerated in this month, but represent the problems that rain events can cause within the watershed. However, these effects may be reduced by the enhancing of riparian buffers all along the streams in the watershed. E. coli was high in June as well, but also in September, and January leading to the conclusion that there is a more consistent problem than just runoff in rain events. Again, that can be from runoff, failing septic systems, or livestock with direct access to the stream. Nitrates were high at this testing site in July 2013, but below the target limits set by this project. The 2006 TMDL shows that every major stream in this watershed are impaired for E. coli, consistent with the findings of this project. Ritter Branch, Ore Branch, and Richland Creek are listed in the 303(d) from this watershed. Richland Creek, Ritter Branch is impaired for E. coli and one for total mercury in fish tissue. Ore Branch is impaired in the sub watershed for E. coli.

IDEM Baseline data was taken on Wildcat Branch (site 8) and at two locations on Ore Branch (sites 21 and 27). Chemical testing from these sites show that dissolved oxygen, pH, ammonia, nitrate, phosphorus, total suspended solids, total dissolved solids and TKN were all within target levels (Table 29). Turbidity is the only parameter that exceeded target levels. Target levels for turbidity is 25 NTU. All three sites exceeded these targets with the highest being sit 27 with 91.21 NTU.

Table 29: IDEM Baseline Sites Chemical Data (Ore Branch)

	Chemical Stressors									
Station ID	DO	pH	Cond.	Turb.	Ammonia	Nitrate	Phosphorus	TSS	TDS	TKN
WWL-03-0008	9.1	7.62	234	56.19	0.05	0.5	0.019	3.25	150	0.15
WWL-03-0021	9.53	7.87	218.25	30.13	0.05	0.5	0.015	2.83	144.33	0.15
WWL-03-0027	9.09	7.84	237.63	91.21	0.05	0.5	0.02	3.5	156.83	0.233
Targets	***>4***	***>6 & <9***	***<1,200***	***<25***	***<0.21***	***<1.0***	***<0.076***	***<30***	***<500***	***<0.28***
Units	**mg/L**		**µs/cm**	**NTU**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

IDEM Baseline data collected also found impairments with respect to E. coli (Table 30) within the sub watershed. All sites measured exceeded target values of 125 MPN /100mL for the geometric mean of 5 samples collected over a 30 day period. Site 27 had the maximum E.coli reading with a value of 1038.9 MPN/100mL.

Table 30: IDEM Baseline Sites Biological and Habitat Data (Ore Branch)

		Biological Measures		**Habitat Stressors**						
Station ID	**E. coli**	**MIBI**	**EPT Index**	**QHEI**	**Sub**	**Cover**	**Channel**	**Riparian**	**Pool**	**Riffle**
WWL-03-0008	**361.02**	30	4	40	11	7	8	4	6	0
WWL-03-0021	**376.99**	36	15	81	18	15	15	10	8	5
WWL-03-0027	**1038.9**	32	5	57	14	8	13	7	9	0
Targets	***<125***	***>36***		***>50***						
Units	***MPN/100mL***	***Score***		***Score***						
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

Table 30 indicates that there were some macroinvertebrate population issues at all three of IDEM baseline sites. At site 21, the MIBI score is 36 which is just under target MIBI scores of greater than 36. Habitat score at this site based on the QHEI method scored as high quality. It may be poor water quality that is diminishing populations at this site that have not been identified. Both sites 8 and 27 scored as poor quality for macroinvertebrates using the MIBI method with the lowest being site 8 with a score of 30. Site 8 also had a poor quality habitat (QHEI=40) that did not meet target levels of

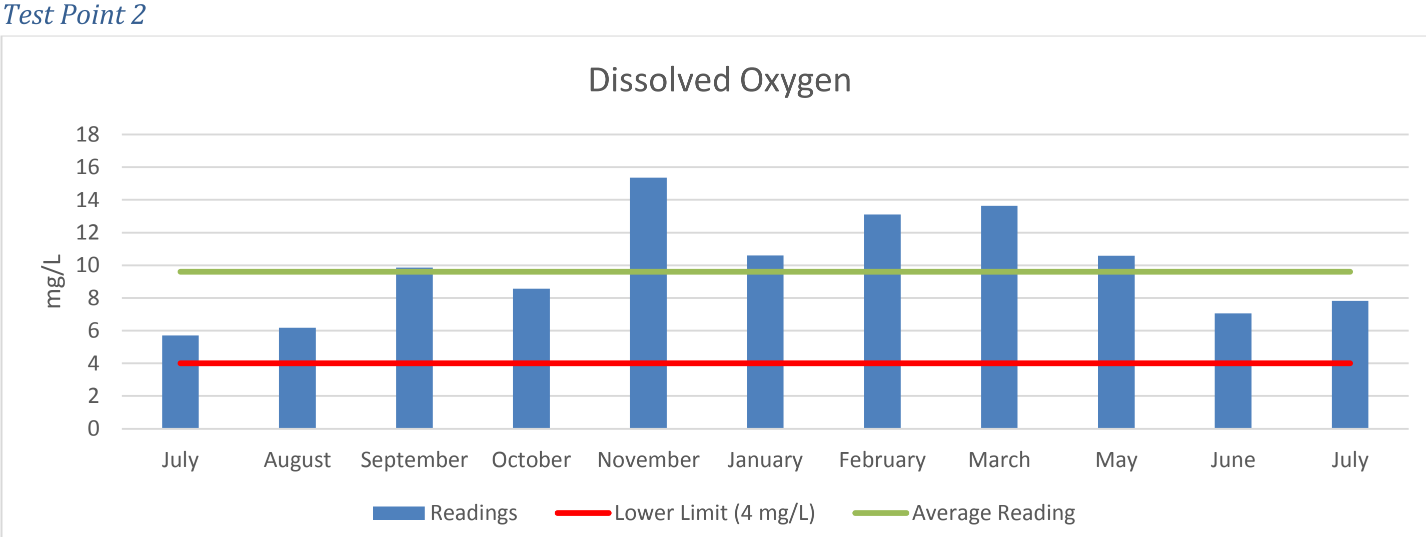
50 points using QHEI methods. The habitat score at site 8 showed that channel and riffle habitats had very poor quality. Table 12 indicates that probable sources for these problems include habitat modification, agricultural runoff, and livestock, which were all consistent with problems noted during windshield surveys.

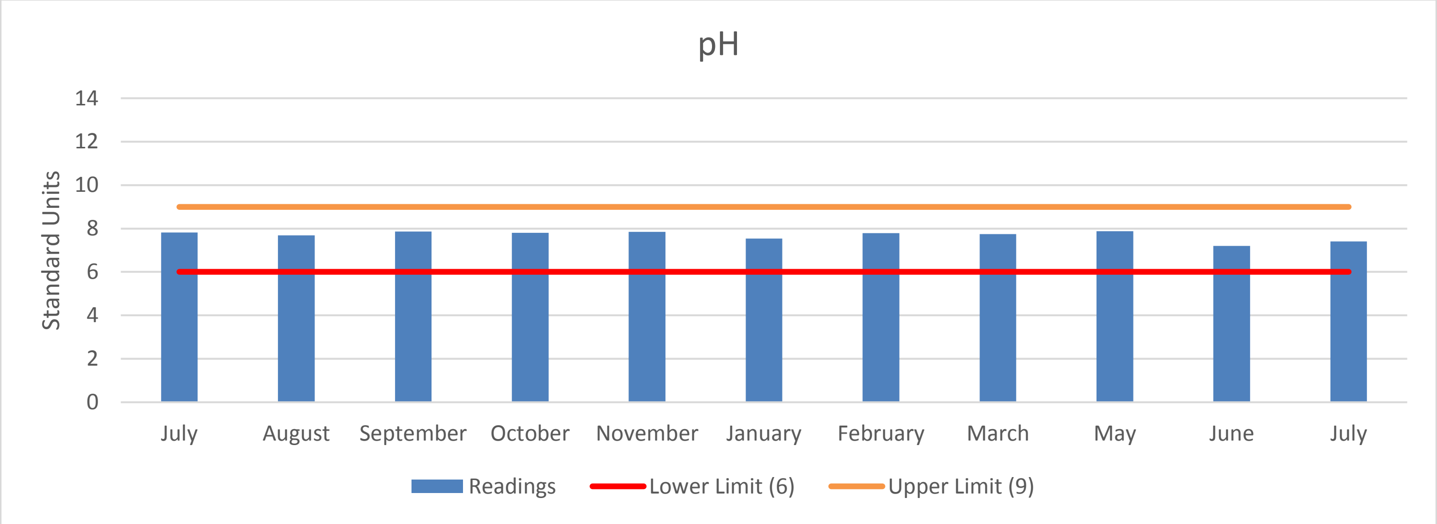
Table 31 is the macroinvertebrate sampling done at PCAC test point 3 and indicates excellent populations of intolerant species in Richland Creek. Habitat scores for this site also indicate a higher quality habitat with CQHEI score of 65 above target levels of 60.

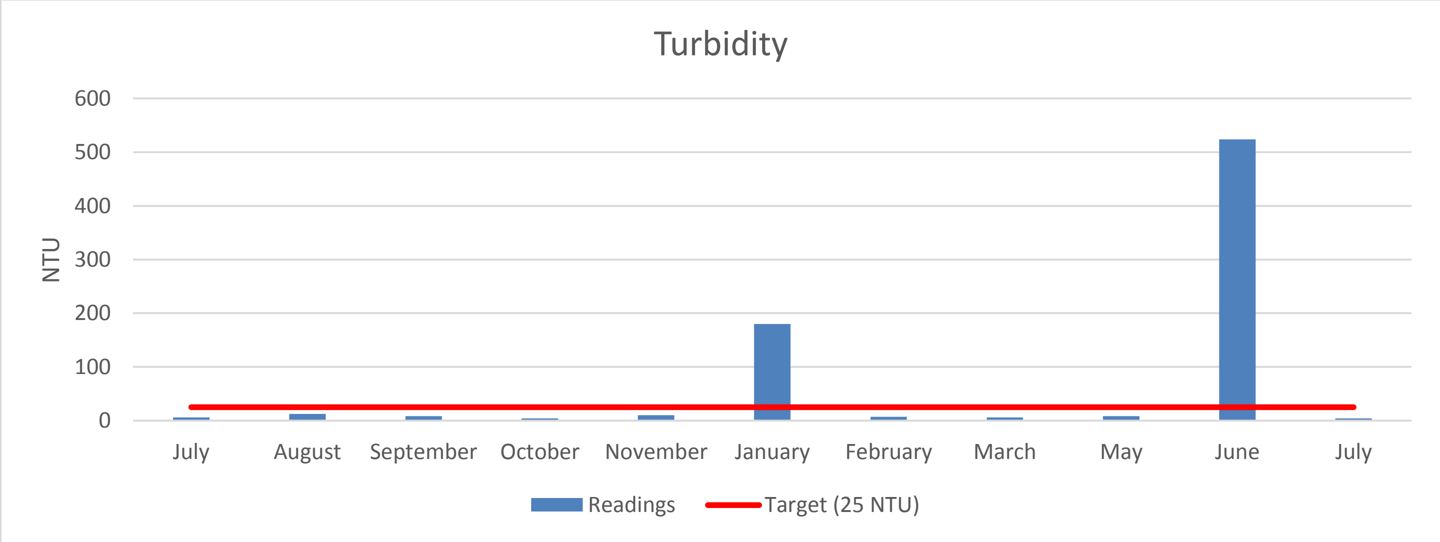
Table 31: Site 3 Macroinvertebrates

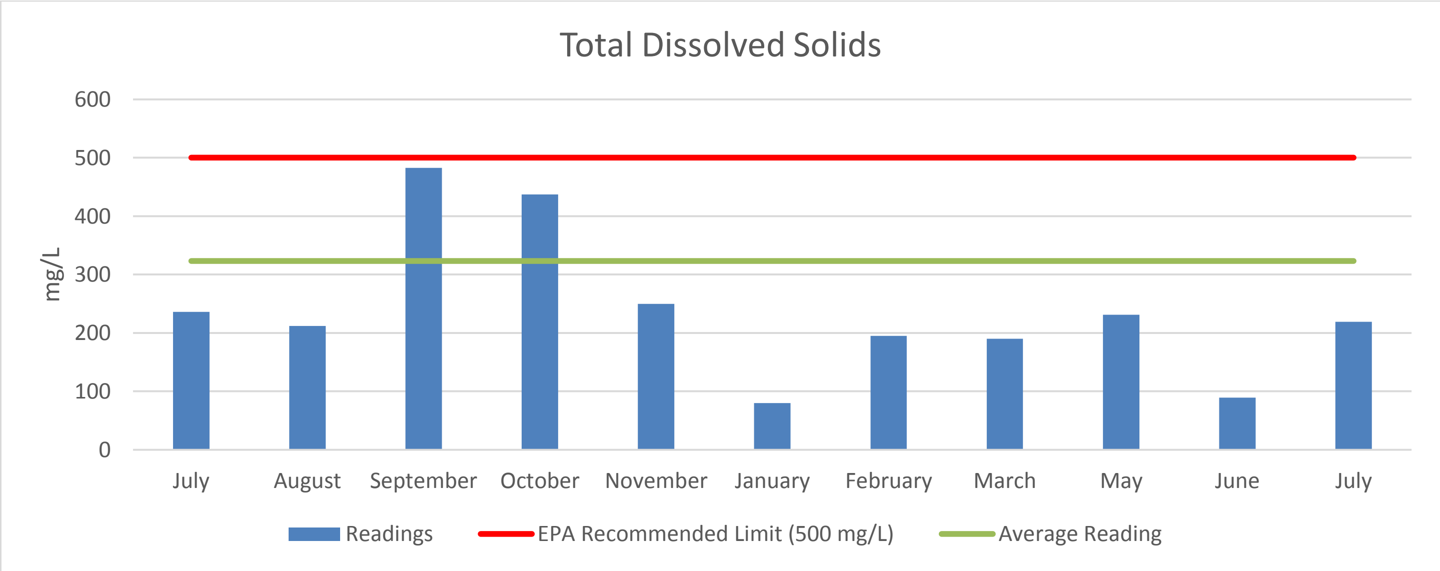
Excellent		41	**Pollution Tolerance Index Rating**				
Group 1	**Intolerant**	**Group 2**	**Moderately tolerant**	**Group 3**	**Fairly tolerant**	**Group 4**	**Very tolerant**
2	Stonefly Nymph	3	Damselfly Nymph	2	Leech		Aquatic Worms
3	Mayfly Nymph	2	Dragonfly Nymph		Midge Larva		Blood Midge Larva
7	Caddis fly Larva		Scud		Planaria/Flatworm		Rat-tailed Maggot
15	Riffle Beetle	1	Sowbug		Black Fly Larva		Left-Handed or Pouch Snail
	Dobsonfly Larva		Crane Fly Larva				
55	Right-handed snail	7	Clam/Mussels				
2	Water Penny	1	Crayfish				
6	# taxa	5	# taxa	1	# taxa	0	3 taxa
24	Weighting Factor (x4)	15	Weighting Factor (x3)	2	Weighting Factor (x2)	0	Weighting Factor (x1)

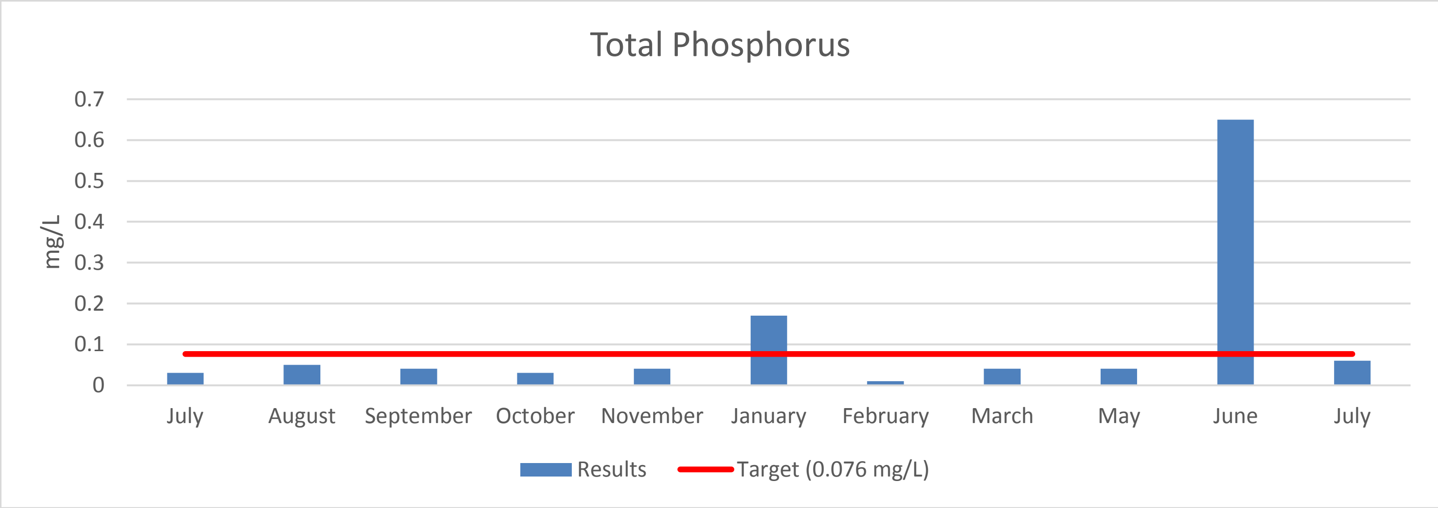
Test Point 2

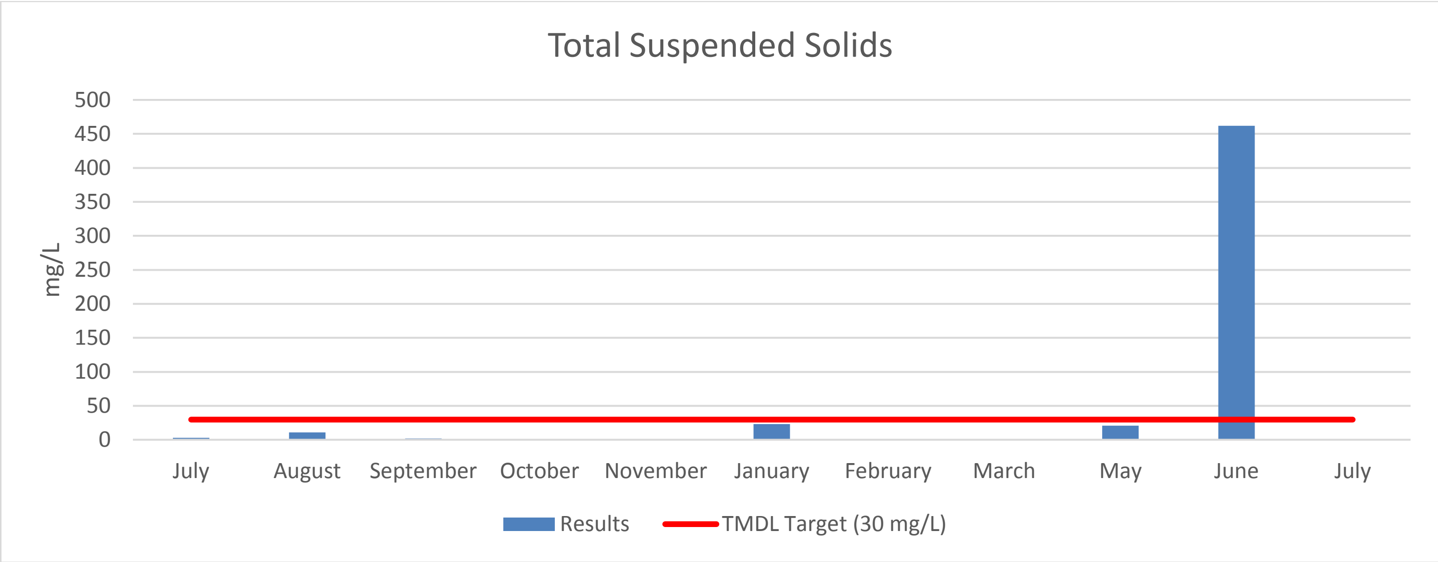


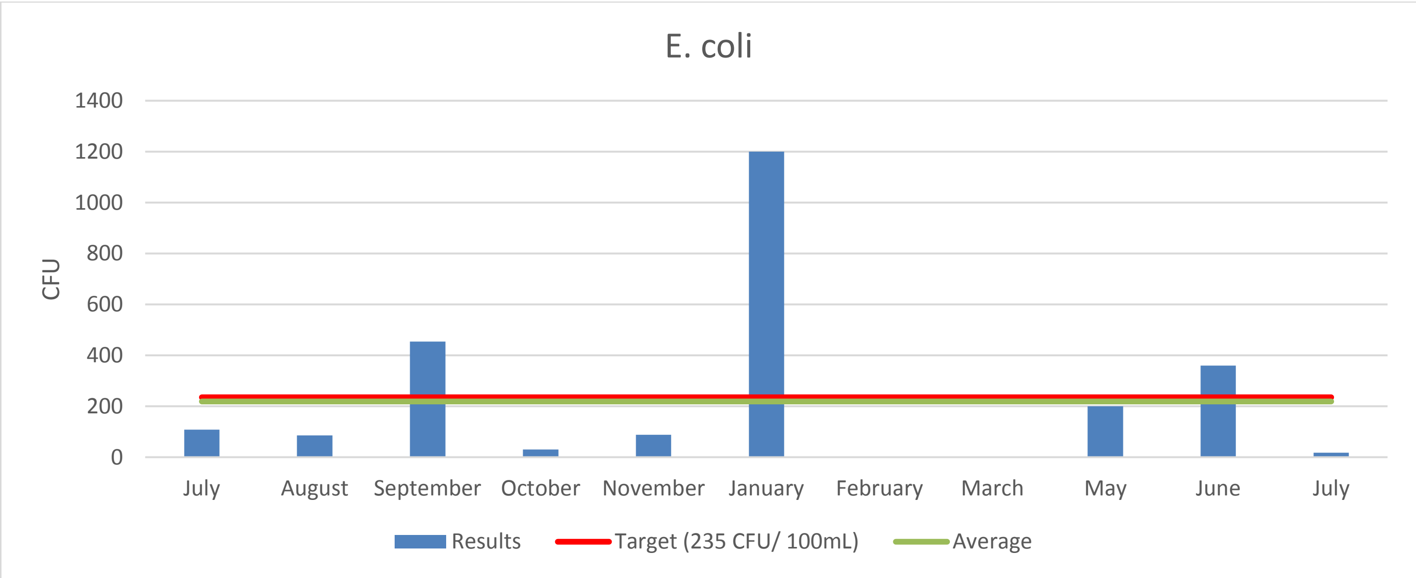

pH
Standard Units
14
12
10
8
6
4
2
0
July
August
September
October
November
January
February
March
May
June
July
Readings
Lower Limit (6)
Upper Limit (9)

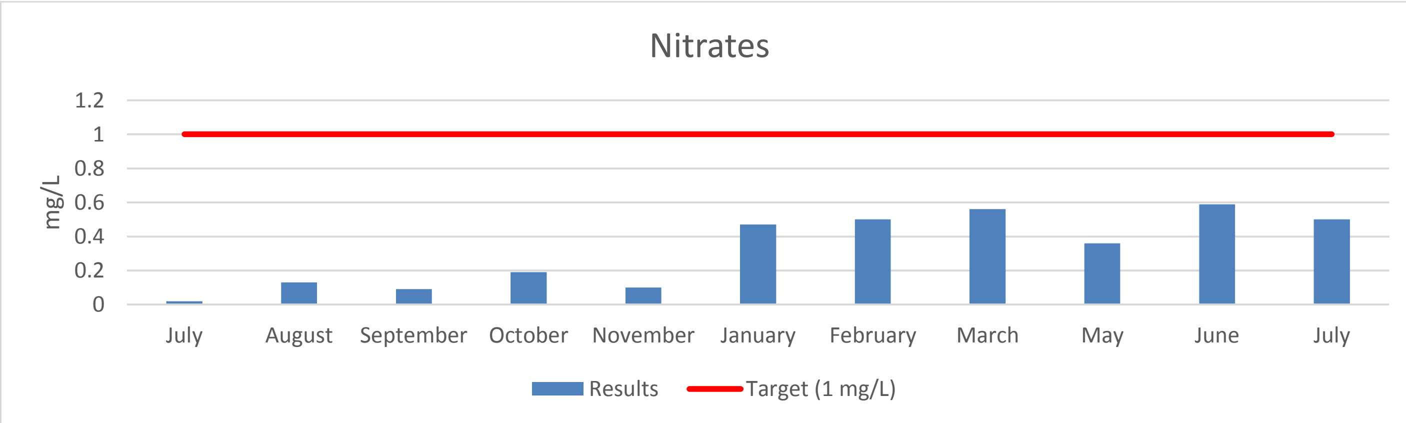

Turbidity
NTU
600
500
400
300
200
100
0
July
August
September
October
November
January
February
March
May
June
July
Readings
Target (25 NTU)


Total Dissolved Solids
mg/L
600
500
400
300
200
100
0
July
August
September
October
November
January
February
March
May
June
July
Readings
EPA Recommended Limit (500 mg/L)
Average Reading


Total Phosphorus
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
mg/L
July
August
September
October
November
January
February
March
May
June
July
Results
Target (0.076 mg/L)


Total Suspended Solids
500
450
400
350
300
250
200
150
100
50
0
mg/L
July
August
September
October
November
January
February
March
May
June
July
Results
TMDL Target (30 mg/L)


E. coli
1400
1200
1000
800
600
400
200
0
CFU
July
August
September
October
November
January
February
March
May
June
July
Results
Target (235 CFU/ 100mL)
Average



Test point 2 had no problems for dissolved oxygen, pH, total dissolved solids, or nitrates. Turbidity spiked in the familiar January and June months, with a maximum reading of 524 NTU, which is more than 50 times the recommended limit. Possible causes of this were recorded during a windshield survey of the sub watershed. There is approximately 9.33 miles of streambank erosion observed in this sub watershed along with one spot of severe hillside erosion dumping lots of soil into the stream between test points 3 and 2 during every storm event. Total dissolved solids are not an issue at this test point, despite being over the limit in preceding points. Total phosphorus and total suspended solids were also spiked just after the rain event in June. Total phosphorus and total suspended solids exceeding target limits of 0.076mg/L and 30mg/L, respectively in June and in September. Total phosphorous had a high of 0.65mg/L in June, and total suspended solids had a high of 462 mg/L in that same month. E. coli has been a most consistent problem for this test site as well. Target levels of 235 CFU/100mL were exceeded three times for E. coli throughout the testing period. The highest reading was in January with a sample of 1200 CFU/100mL.

Table 32: Site 2 Macroinvertebrates

Excellent		29	**Pollution Tolerance Index Rating**				
Group 1	**Intolerant**	**Group 2**	**Moderately tolerant**	**Group 3**	**Fairly tolerant**	**Group 4**	**Very tolerant**
	Stonefly Nymph	2	Damselfly Nymph		Leech		Aquatic Worms
1	Mayfly Nymph	1	Dragonfly Nymph		Midge Larva		Blood Midge Larva
1	Caddis fly Larva		Scud		Planaria/Flatworm		Rat-tailed Maggot
1	Riffle Beetle		Sowbug		Black Fly Larva		Left-Handed or Pouch Snail
1	Dobsonfly Larva		Crane Fly Larva				
5	Right-handed snail	13	Clam/Mussels				
	Water Penny		Crayfish				
5	# taxa	3	# taxa	0	# taxa	0	3 taxa
20	Weighting Factor (x4)	9	Weighting Factor (x3)	0	Weighting Factor (x2)	0	Weighting Factor (x1)

As seen in Table 32, macroinvertebrates were abundant at test point 2 and similar findings led to another excellent score of 32 for site 3. However, these results are inconsistent with our CQHEI results for habitat. Test point 2 achieved a good score of 65, but test point 3 only achieved a score of 56, putting it in the "poor" category of results and did not meet target levels set at 60 on the CQHEI. This is similar to the baseline study results, which found two failures to meet habitat criteria in Ore Branch for poor channelization in one and poor riffles in two. Habitat modification, agricultural runoff, and livestock were listed as possible causes for this.

The TMDL taken in 2006 for E. coli also labeled Richland Creek, Ore Branch and tributary Wildcat Branch as impaired. After reassessment of Ritter Branch it too indicated impairments for E. coli and was then added to the 2008 303 (d) list and included in the TMDL. This is the number one stakeholder concern in the watershed, so the high result from our testing along with the exceeded targets from the baseline data along with the TMDL makes Ore Branch a clear choice to be a critical sub watershed for our watershed project.

Land Use Summary

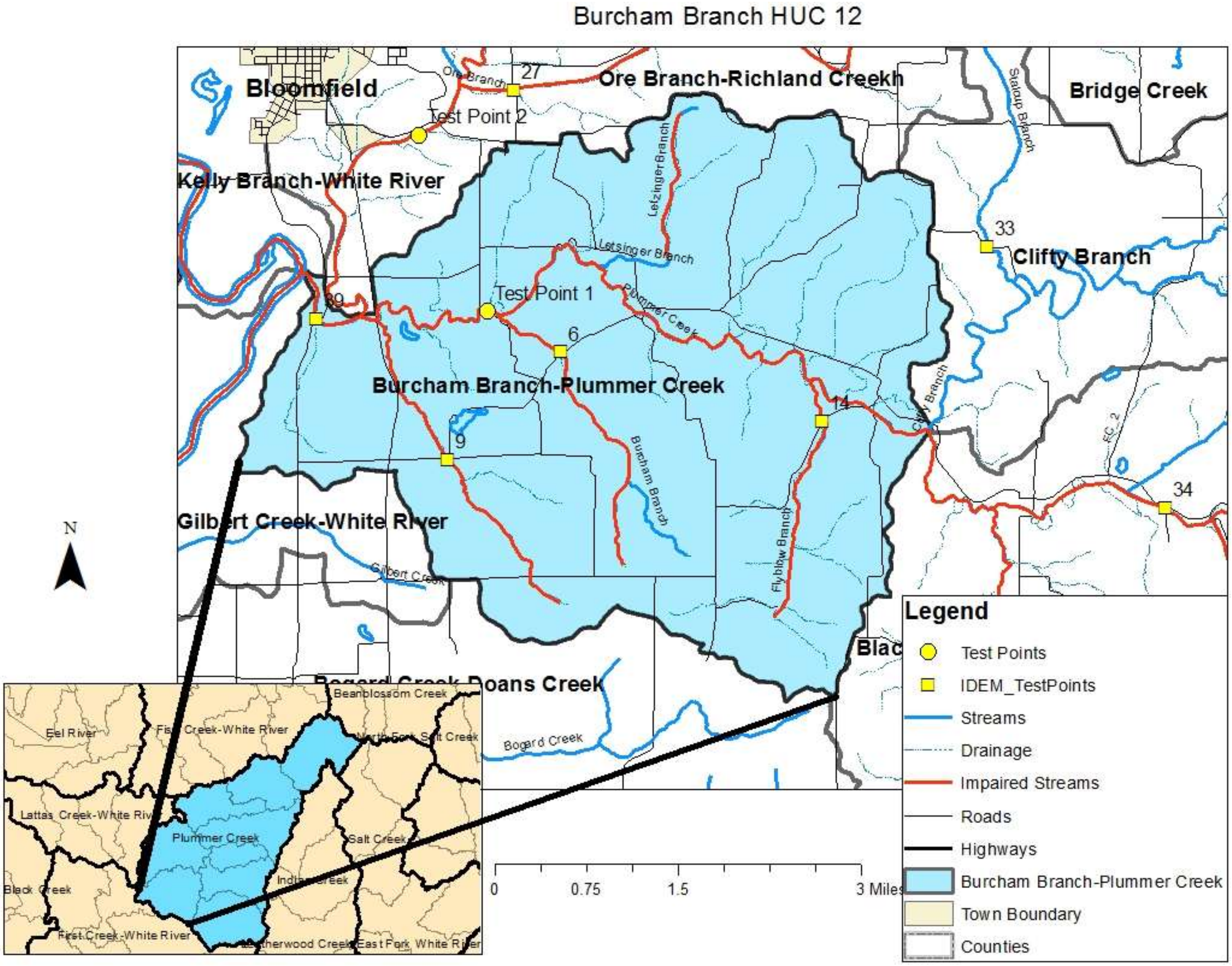
Ore Branch is once again primarily deciduous forest, with areas of row crops, pasture, and urban area. The eastern-most portion of the town of Bloomfield is included here, adding relatively large amount of impervious surfaces to the watershed, though that amount is still less than 5% of PCW. Flooding is an issue within Ore Branch sub watershed along CR 205E, or N Corwin Rd. Most roads within Ore Branch are paved, adding another small amount of impervious surfaces. There are a few roads that are gravel in portions of the sub watershed and also have some roads that pass through Ore Branch. These roads may be increasing the sedimentation of the stream and may be sources of chemicals that may be affecting macroinvertebrate populations downstream. There are no official drains within this sub watershed. About 9.33 miles of streambank are in need of stabilization and buffers being added or widened in this sub watershed. Fertilizers may be entering the streams from agricultural fields and private yards. Cattle with direct access in the stream were observed on a site visit a short ways upstream from test site 2. Fortunately, this particular landowner is very willing to work with the grant and would be glad to become involved in cost-share opportunities that this grant may present. Hopefully this represents the trend for livestock farmers throughout the watershed. There were 9 other sites where cattle or livestock had direct access to streams within this sub watershed. Overgrazed pasture lands were observed within this sub watershed at, at least, 6 locations including some steep hillsides where great amount of hillside erosion was occurring. There is also a little bit of industry in this sub watershed associated with the town of Bloomfield, mostly on the south side. This industry includes machinery shops, automotive repair shops, and an INDOT substation. Logging has been observed at 3 locations and this logging does not appear to have any sediment control structures for the plot or the logging roads to and from the locations. There are no areas slated for development or open space in this sub watershed. Manicured lawns were observed on the outskirts of Bloomfield and within the town boundary itself. Richland Creek is used as a local swimming hole within this watershed and should be given special consideration because of this recreation use by local youth. Land use reflects the trends seen for the entire Richland Creek watershed. There are 15-20 hobby farms of horses, sheep, llamas, goats, ducks, and small cattle farms scattered throughout the sub watershed. No municipal wastewater is applied in this sub watershed and there are no other nonagricultural animal operations, CSOs, SSOs, CAFOs, or CFOs.

Windshield and Desktop Survey

Possible Water Quality Influence	BMP	Location of Site	Site I.D. Type	Observed By
Stream obstruction, increasing TSS levels	Woody Debris removal, snag removal, hand tool cutting	N side of CR 50S, W side of CR 275	Windshield	Watershed Coordinator
Severe hillside and streambank erosion	Riparian forest buffers, streambank planting, pasture management,	N side of Cold Springs Rd	Windshield	Watershed Coordinator
Overgrazing increasing runoff of nutrients, manure, and sediment	HUAP, pasture management	N side of Cold Springs Rd, 6 additional locations	Windshield	Watershed Coordinator
High levels of E. coli	Septic Education, Manure Storage/Handling	All Test sites, Residential Areas, Agricultural Lands	Monitoring, Desktop & Windshield Surveys	Watershed Coordinator
Failed stream crossing	Stream crossings	CR 450	Windshield Surveys	Watershed Coordinator
Ditch Erosion	Ditch Maintenance Plan	Ore Branch Rd, Cold Springs Rd, CR 225 E	Windshield Survey	Watershed Coordinator, Monroe & Greene Co SWCD Administrators,
Conventional Cropping systems increasing runoff of nutrients, manure, and sediment	Nutrient Management Plans, No Till/Reduced Till, Manure storage/handling, waste storage facilities	Cultivated crop ground	Desktop & Windshield Surveys	Watershed Coordinator
Cattle in stream causing erosion	Livestock exclusion, water storage facilities	Property on N side of CR 50, 10 locations	Site visit	Watershed Coordinator

Burcham Branch (051202020309)

Map 23: Burcham Branch Sub watershed

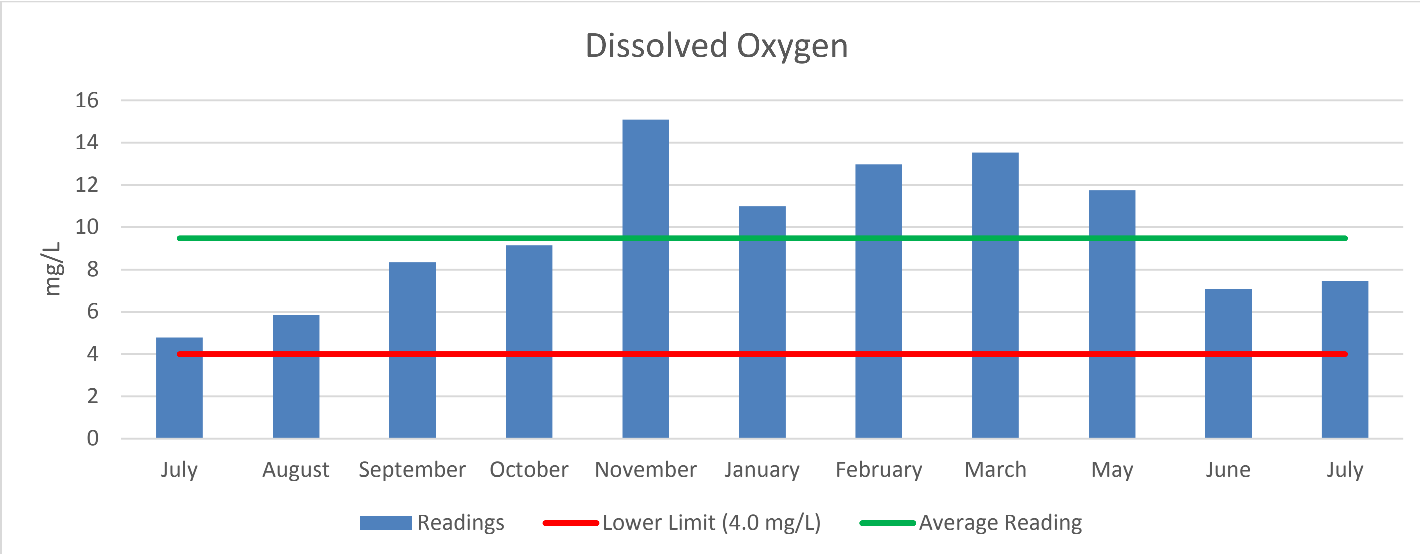


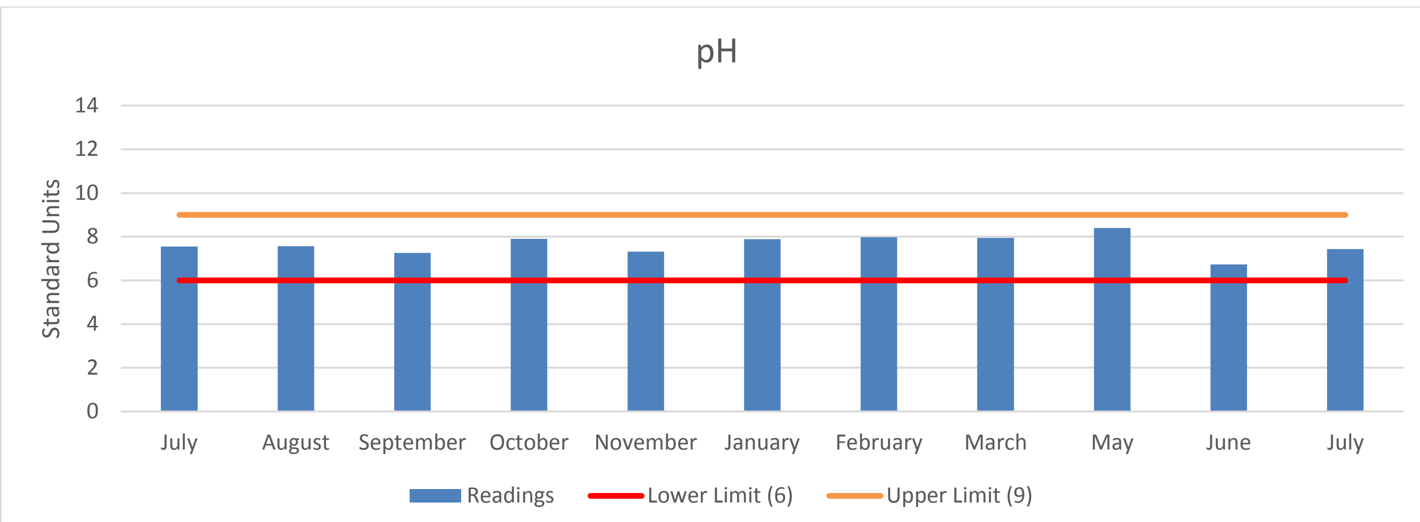
Burcham Branch is the accumulation of the entire of the near 111,000 acres in the PCW, itself only covering 11,748 acres. It receives the Plummer Creek from Black Ankle in the east and Richland Creek from the northwest and adds Flyblow Branch, Letsinger Branch, Burcham Branch, and an unnamed tributary, which then release all of the water into the White River in the northwest portion of the sub watershed.

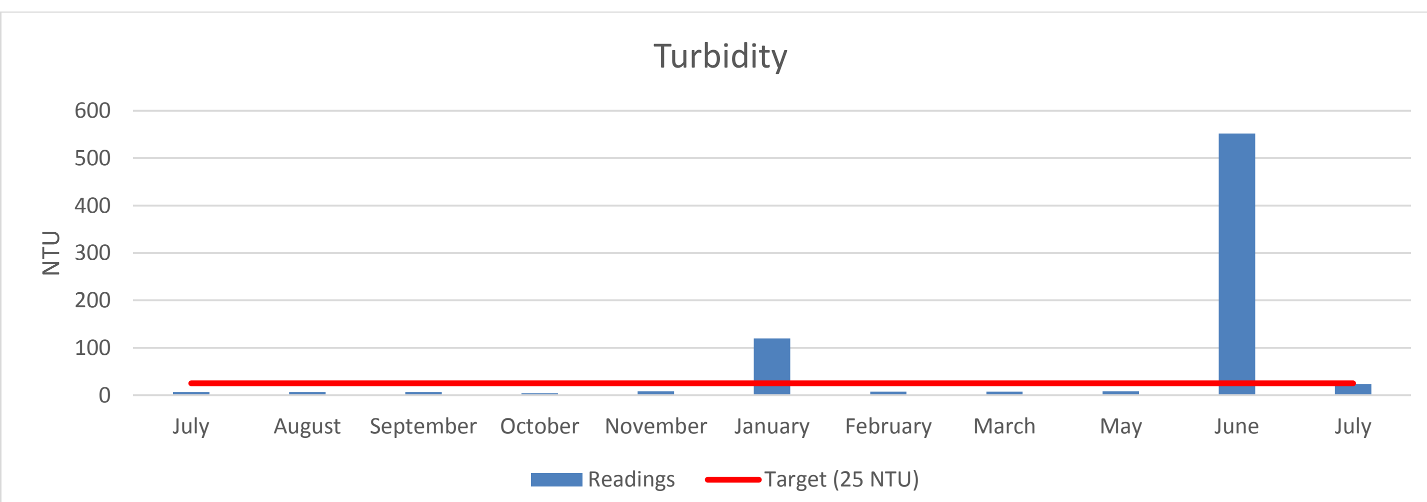
PCAC test point 1 is located within this sub watershed on Plummer Creek prior to the confluence with Richland Creek or the unnamed tributary from the south. IDEM baseline study had 4 test sites within this sub watershed and include sites 14 on Flyblow Branch, site 6 on Burcham Branch, site 9 on the unnamed tributary to Plummer Creek, and Site 39 on Plummer Creek prior to the creeks outlet, but after it has received water from Richland Creek (Map 23).

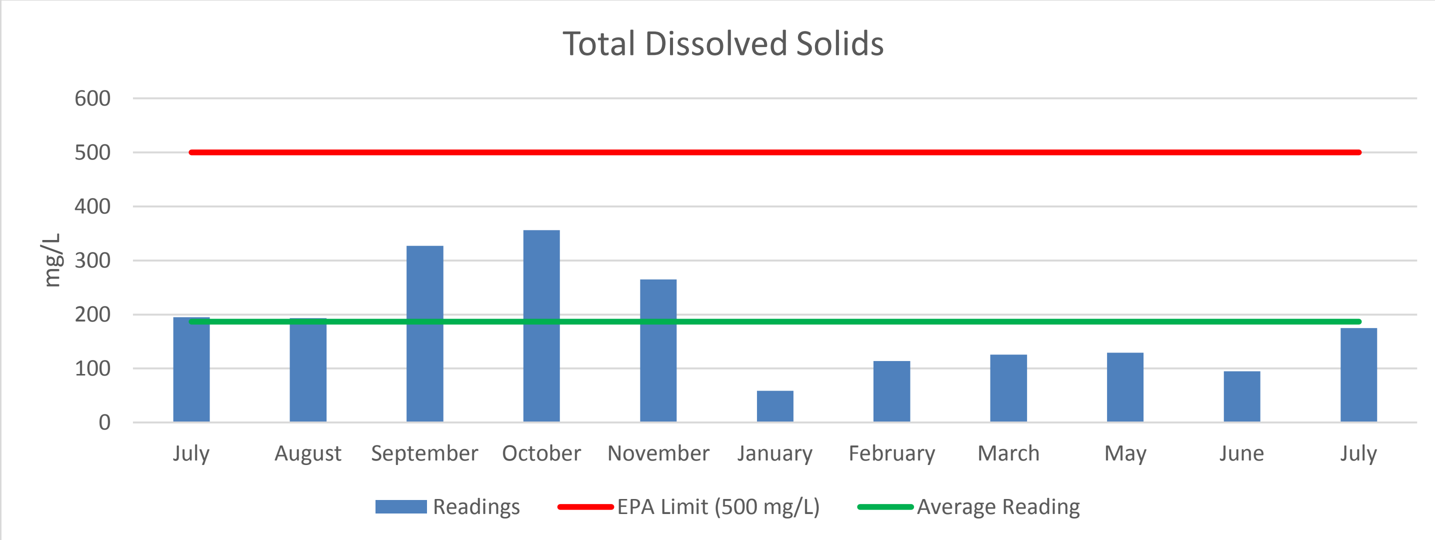
Water Quality and Habitat Data Summary

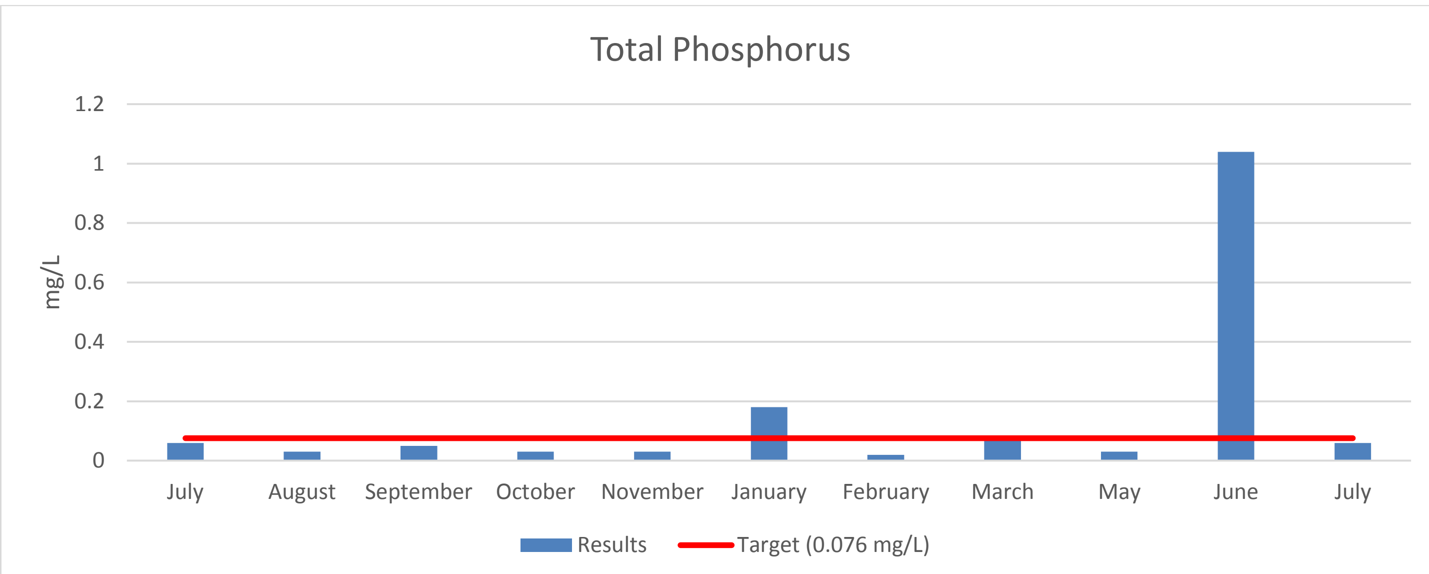
Test point 1

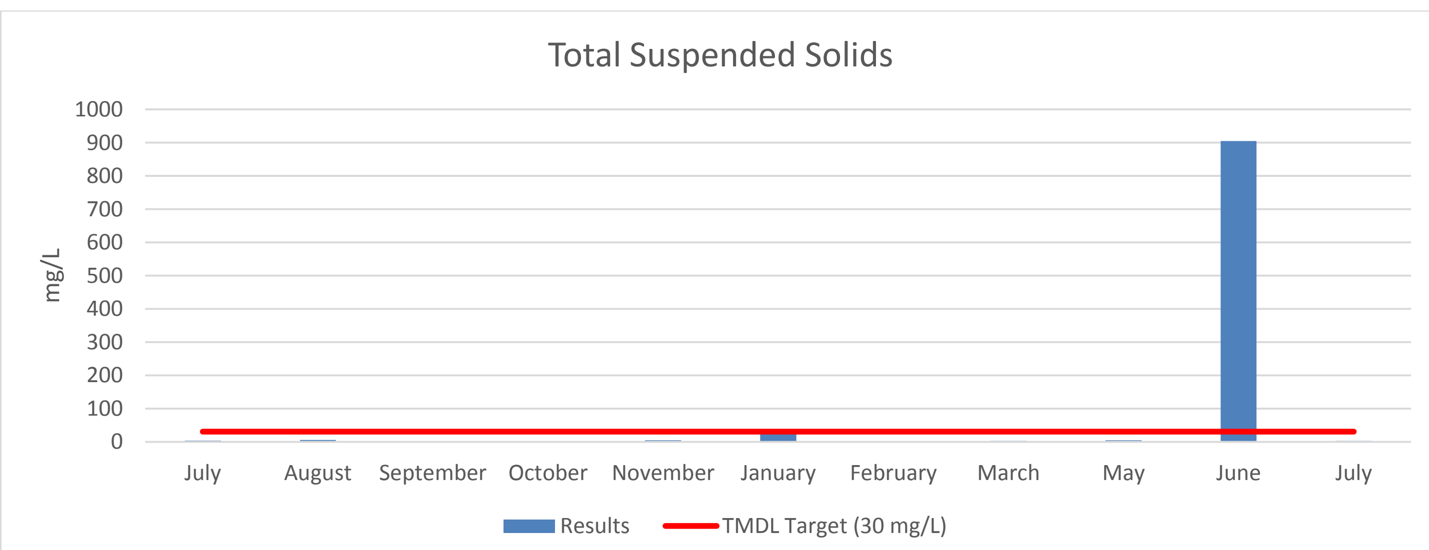


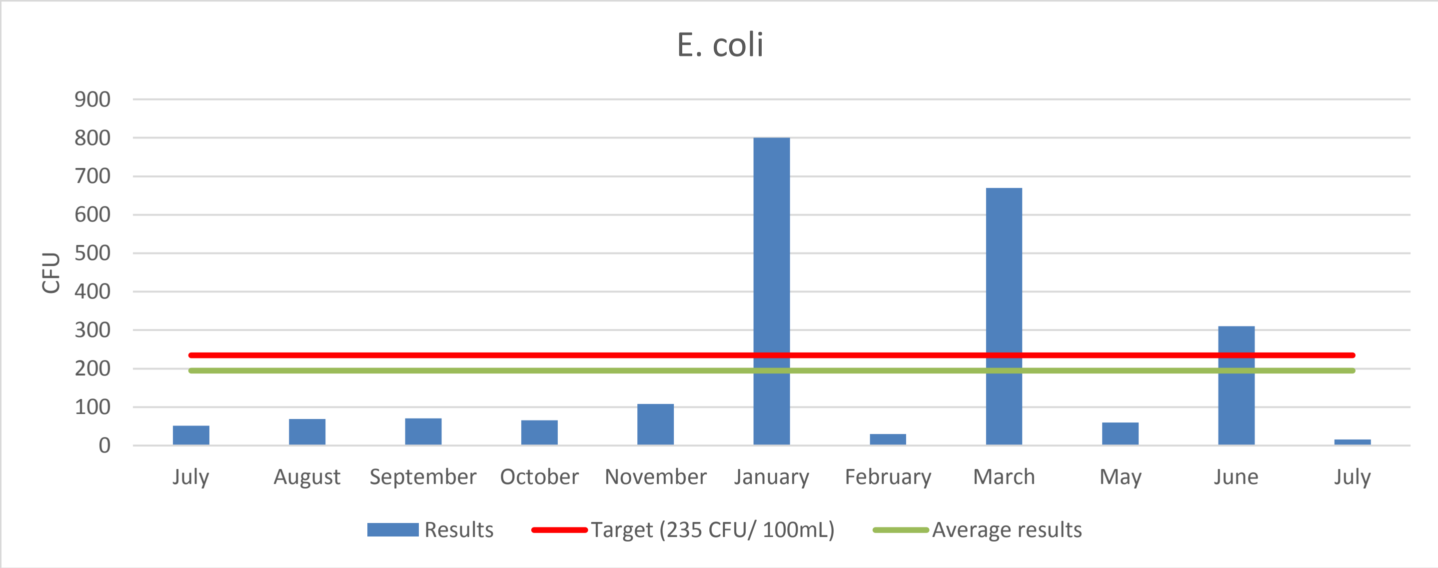


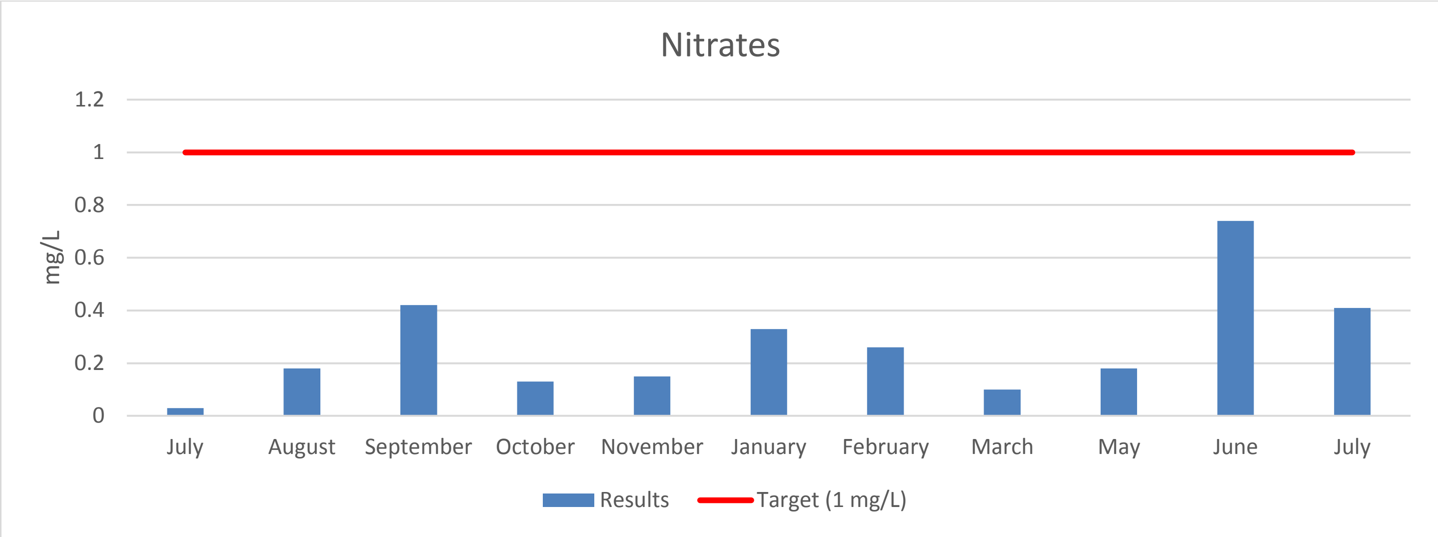



Total Dissolved Solids
mg/L
600
500
400
300
200
100
0
July
August
September
October
November
January
February
March
May
June
July
Readings
EPA Limit (500 mg/L)
Average Reading


Total Phosphorus
mg/L
1.2
1
0.8
0.6
0.4
0.2
0
July
August
September
October
November
January
February
March
May
June
July
Results
Target (0.076 mg/L)


Total Suspended Solids
mg/L
1000
900
800
700
600
500
400
300
200
100
0
July
August
September
October
November
January
February
March
May
June
July
Results
TMDL Target (30 mg/L)





PCAC test point 1 is the only testing site on Plummer Creek (the rest were testing Richland Creek)by our watershed project efforts, but we can infer what's going on through IDEM baseline testing, windshield surveys and land uses. Dissolved oxygen, pH, total dissolved solids, and nitrates are not an issue for this site. Turbidity, however, is very similar to the Richland Creek points in that there are spikes in January and June, but also targets were just met in July. Target levels for turbidity set for this project were 25 NTU. The spike in June was more than 22 times higher than the target and had a value of 552 NTU. There are also spikes in total dissolved solids in the familiar months of September and October but again not over target levels. Total phosphorus exceeded targets of 0.076mg/L three times in January, March and June. The maximum value of phosphorous was in June with a value of 1.04 mg/L which is over 13 times the desired limit for total phosphorous. Total suspended solids exceeded target levels of 30 mg/L just once in June with a value of 905 mg/L. June experienced a recent rain event prior to sampling. The observed problems in this month are most likely from runoff flowing directly into streams. This runoff may be slowed and reduced levels of sediments and nutrients may been seen with the installment of riparian buffers in the area. E. coli is high in several months: January, March and June, peaking in January at 800 CFU. January and June are similar to months where E. coli exceed the limit in Richland Creek, however, at all other test points, there was never a spike in March. This suggests an event independent of weather causing the high level in March in Plummer Creek and possibly in May in the other test points. If runoff wasn't the cause, it leads us to look to other stakeholder concerns as the cause, such as waste management. Wildlife may also have led to a high level, though it is unknown why there would be more animal activity in the creeks in a certain month more so than another, especially in the months of interest, neither being particularly warm months. Testing in March was done at 30 degrees Fahrenheit and in May the temperature was only 50 degrees at the time.

Table 33: IDEM Baseline Sites Chemical Data (Burcham Branch)

	Chemical Stressors									
Station ID	DO	pH	Cond.	Turb.	Ammonia	Nitrate	Phosphorus	TSS	TDS	TKN
WWL-03-0009	8.29	7.6	196.14	11.46	0.34	0.38	0.032	2	128	0.71
WWL-03-0014	8.86	7.67	192.8	9.15	0.05	1.05	0.023	8.33	114	0.15
WWL-03-0039	8.23	7.78	299.5	51.59	0.05	0.45	0.033	17.83	195.83	0.392
Targets	***>4***	***>6 & <9***	***<1,200***	***<25***	***<0.21***	***<1.0***	***<0.076***	***<30***	***<500***	***<0.28***
Units	**mg/L**		**µs/cm**	**NTU**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

The baseline study placed four test points within the Burcham Branch sub watershed (Map 23), though results were not provided by IDEM for site 6. Samples from the remaining three sites found no problems with dissolved oxygen, pH, specific conductivity, phosphorous, total suspended solids, or total dissolved solids (Table 33). High levels of ammonia (0.34mg/L) and TKN (0.71mg/L) were observed at site 9 on an unnamed branch of Plummer Creek. Both were above target levels of 0.21 mg/L for total ammonia and 0.28 mg/L for TKN. High levels of nitrate was observed at site 14 with a value of 1.05 mg/L just slightly over target levels of 1.0mg/L. Site 39 was taken downstream from where Richland joins Plummer Creek and so should be representative of the entire watershed. However, it would appear that all of the problems were diluted by the time they reached this point because surprisingly, the baseline study found no major issues except for high turbidity reading. Turbidity at site 39 was 51.59 NTU which is more than double the target levels of 25 NTU.

E. coli was again an issue within Burcham Branch sub watershed according to samples collected by IDEM. All three sites were above target levels of 125 MPN/100mL for the geometric mean of five samples collected at each site over a 30 day period. The highest site in the sub watershed was site 9 with 577.98 MPN/100mL.

Table 34: IDEM Baseline Sites Biological and Habitat Data (Burcham Branch)

		Biological Measures		**Habitat Stressors**						
Station ID	**E. coli**	**MIBI**	**EPT Index**	**QHEI**	**Sub**	**Cover**	**Channel**	**Riparian**	**Pool**	**Riffle**
WWL-03-0009	**577.98**	38	2	54	14	8	12	5	5	0
WWL-03-0014	**140.72**	28	1	53	14	7	14	6	2	0
WWL-03-0039	**416.61**	40	1	37	1	6	11	7	6	0
Targets	***<125***	***>36***		***>50***						
Units	***MPN/100mL***	***Score***		***Score***						
Color Code: High quality, good quality, intermediate quality, poor quality, very poor quality										

The TMDL for E. coli found every major stream in the watershed impaired and Plummer Creek is also listed in the 303(d) list as being impaired by E. coli, see table 7 and Map 23.

Table 35: Site 1 Macroinvertebrates

Good		22	**Pollution Tolerance Index Rating**				
Group 1	**Intolerant**	**Group 2**	**Moderately tolerant**	**Group 3**	**Fairly tolerant**	**Group 4**	**Very tolerant**
	Stonefly Nymph	1	Damselfly Nymph	2	Leech		Aquatic Worms
	Mayfly Nymph	1	Dragonfly Nymph		Midge Larva		Blood Midge Larva
1	Caddis fly Larva	3	Scud		Planaria/Flatworm		Rat-tailed Maggot
	Riffle Beetle		Sowbug		Black Fly Larva		Left-Handed or Pouch Snail
	Dobsonfly Larva		Crane Fly Larva				
4	Right-handed snail	6	Clam/Mussels				
	Water Penny		Crayfish				
2	# taxa	4	# taxa	1	# taxa	0	3 taxa
8	Weighting Factor (x4)	12	Weighting Factor (x3)	2	Weighting Factor (x2)	0	Weighting Factor (x1)

Macroinvertebrates were a little scarcer at test point 1 than at other sites further upstream in the watershed. It also had the lowest CQHEI score for habitat at a mere 48 points, landing it in the "bad" category of results and below the target score of above 60. The baseline study found similar results in Flyblow Branch (site 14), with an MIBI score of 28 which is 8 points below the target level of over a score of 36. This site did have very poor riffles, poor pools, and elevated nitrates. The QHEI score for this site, however, did meet target levels for habitat. Site 39 saw an intermediate quality MIBI score at 40, but the habitat at this site did not meet target levels. Site 39 only scored 37 using QHEI methods which is 13 points below target levels of 50 points. These may have been caused by habitat modification, livestock, and agricultural runoff according to the aquatic life use attainment sources posed by the IDEM baseline study. The other site, 9, met attainment status criteria during the baseline study.

Land Use Summary

The Burcham Branch sub watershed is about 50% forest and the other 50% is mostly hay and pasture fields with some row crops and herbaceous land scattered throughout. As in other sub watersheds, row crops are again mostly right next to the streams of this sub watershed, which can create opportunities for erosion, nutrient, and manure runoff to enter the streams. It should also be noted that many of these streams have varying degrees of logjams throughout the watershed. These logjams are posing a risk to the stream channels with major streambank erosion observed near these sites. These can be a huge cause of erosion and hence pollution from any chemicals that might be in the fields or the surrounding area from litter or other sources. About 7.75 miles of streambank are in need of stabilization and buffers being added or widened in this sub watershed. It has been noted by the watershed coordinator that there are areas along the path of Plummer Creek that are definitely lacking in sufficient buffer zone. Buffers will alleviate any fertilizers entering the streams from fields or yards. There are no areas slated for development, open space, or industry in this sub watershed. High sediment levels within the testing results may be due to construction of I-69 in the Black Ankle sub watershed or in the upper reaches of Flyblow Branch or the staging area along Plummer Creek near the sub watershed divide for Black Ankle Creek. Waters traced back from these areas are muddy after rain events as observed by watershed coordinator. Land use reflects the trends seen for the entire Plummer Creek watershed. There are 9-15 hobby farms of horses, sheep, goat, cattle, and small poultry farms scattered throughout the sub watershed. There are numerous hay fields and vegetable gardens that have also be observed within this sub watershed. No municipal wastewater is applied in this sub watershed and there are no other nonagricultural animal operations, CSOs, SSOs, CAFOs, or CFOs.

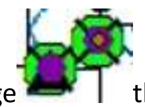
Windshield and Desktop Survey

Possible Water Quality Influence	BMP	Location of Site	Site I.D. Type	Observed By
Stream obstruction, increasing TSS levels	Woody Debris removal, snag removal, hand tool cutting	Old Iron Mountain Rd	Windshield	Watershed Coordinator
Severe hillside and streambank erosion	Riparian forest buffers, streambank planting,	Old Iron Mountain Rd, CR 200S	Windshield	Watershed Coordinator
Overgrazing increasing runoff of nutrients, manure, and sediment	HUAP, pasture management	CR 300S, CR 150S, S Mineral-Koleen Rd	Windshield	Watershed Coordinator
High levels of E. coli	Septic Education, Manure Storage/Handling	All Test sites, Residential Areas, Agricultural Lands	Monitoring, Desktop & Windshield Surveys	Watershed Coordinator
Ditch Erosion	Ditch Maintenance Plan	Old Iron Mountain Rd, Mineral-Koleen Rd, Baseline Rd, CR 150S	Windshield Survey	Watershed Coordinator, Monroe & Greene Co SWCD Administrators,
Cattle in stream causing erosion	Livestock exclusion, water storage facilities	Old Iron Mountain Rd, CR 300 S, Mineral-Koleen Rd, CR 150 S, 6 locations total	Site visit	Watershed Coordinator
Interstate 69 Construction	Field Borders, Riparian forest buffers, Rule 5 construction BMPs	East to southwest path along the southeast corner of the watershed, Staging area for I-69 of Mineral-Koleen Rd	Windshield Surveys	Watershed Coordinator
Conventional Cropping systems increasing runoff of nutrients, manure, and sediment	Nutrient Management Plans, No Till/Reduced Till, Manure storage/handling, waste storage facilities	Cultivated crop ground	Desktop & Windshield Surveys	Watershed Coordinator

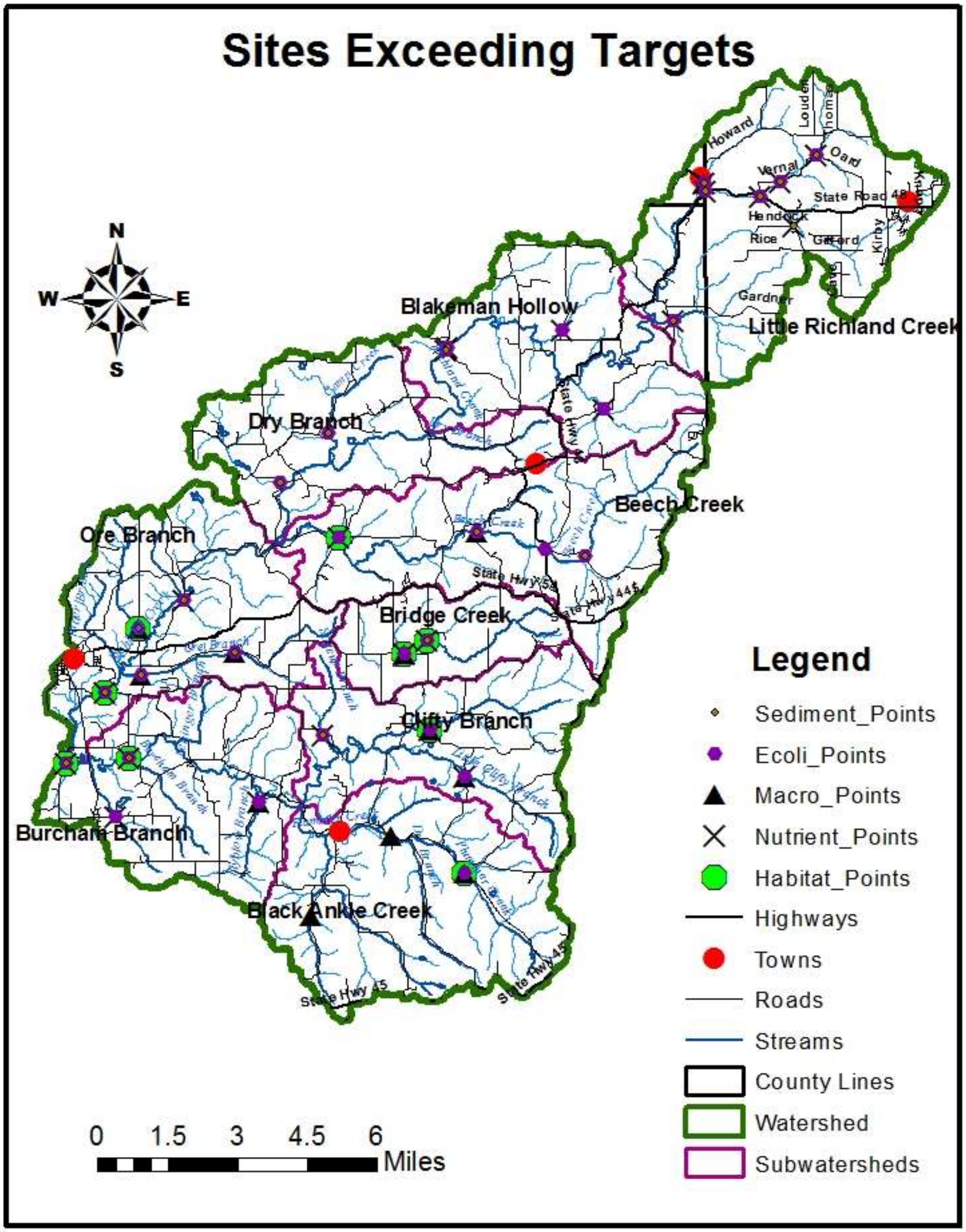
Inventory Part 3: Watershed Inventory Summary

Testing occurred at five test points by the PCAC group during the investigation of Plummer Creek watershed. These sites represent Richland and Plummer Creeks and helped to get a representation of the water quality for the watershed. Testing was conducted from July 2012 through June of 2013 on a monthly basis. Results were discussed in detail in the Sub watershed Inventory in the previous section. These followed water quality tests that were performed in 2011 and 2012 by IDEM for a baseline study. The baseline study collected samples from 29 locations throughout the watershed on mostly smaller tributaries of the watershed. Between the two sets of data (33 different test sites), some general trends and water quality problems were noted and will be made apparent here. These water quality problems are paired with issues and sources noted during windshield and desktop surveys of the watershed.

Water quality impairments were seen in all sub watersheds within Plummer Creek Sub watershed, as discussed in the previous section. Map 24 shows each site that exceeded target levels for sediments (including both turbidity and total suspended solids), nutrients (including nitrate, TKN, ammonia, and phosphorous), E. coli, macroinvertebrates, or habitat. If the symbol, or partial symbol, shows in the following map then that site saw an exceedance for that parameter. The map has stacked symbols so you need to see if all parts of a shape are present with sediment (small brown diamond) in the foreground and habitat (large green hexagon) in the background.

For example, in this image  the two sites adjacent to each other have water quality problems. The site in the upper right had exceedances for habitat, nutrients, E. coli, and sediment while the test point in the lower left had exceedances for habitat, macroinvertebrates, nutrients, and E.coli.

Map 24: Important Water quality and Habitat Results



Important Relationships

More than 70% of land use in the PCW is forest with the majority of the remaining land being used for agricultural practices including pasture for livestock (12.64%) and row cropping (3.27%) and residential or green space (7.67%).

Agricultural practices, when not separated from streams by a filter strip or field border, can cause significant amounts of pollution, especially when used without conservation tillage, which was noted fairly frequently during recent Tillage Transects. There are obvious signs of stream bank erosion occurring throughout the watershed. Many stream reaches have inadequate buffers including 58.16 miles of stream. In the sub watersheds that have extensive sections of stream that are lacking in buffer and show high amounts of stream erosion the turbidity values have exceeded target values. For instance, Richland Creek, Blakeman Hollow, Dry Branch, Clifty Branch, Ore Branch, and Burcham Branch sub watersheds all have over 5 miles of affected stream reaches with erosion and lack of stream side buffers. These sub watersheds all had multiple turbidity measurements that were over target levels. The turbidity in the streams may be directly related to the erosion and lack of sediment control that buffers provide. Additional sources of sediment come from other common practices within the sub watersheds. Road side ditches are not properly constructed or maintained causing significant sediment influxes to the waterways. These have been noted in Beech Creek, Dry Branch, Clifty Branch, Ore Branch, and Burcham Branch sub watersheds. Additionally, there is a general lack or inadequate sediment control measures on construction sites (5 areas with development sites including ~7 miles of major HWY construction). These have been observed at Little Richland Creek, Clifty Branch, Black Ankle Creek, and Burcham Branch sub watersheds. Logging activities may also account for high sediment levels within the streams. Logging has been seen in Blackmans Hollow, Black Ankle Creek, Ore Branch, and Burcham Branch sub watersheds. These are all the sub watersheds that have seen issues with sediments in the form of turbidity or total suspended solids.

Not all crop ground has developed a nutrient management plan for their systems. Conventional cropping systems that encourage tillage practices are prevalent within the sub watersheds. With over 3,610.5 acres of cultivated crops, nutrient management plans are needed to ensure nutrients and sediments remain on-site and are not allowed to exit to streams and waterbodies. Overgrazing is a common problem within the watershed and with 13,982.7 acres of pasture or hay ground used for grazing, it is important that these areas are not overgrazed. Over grazing can not only lead to problems with sediment from erosion of the very soil that is needed to grow the pasture, but it also leads to excess runoff of E. coli and nutrients. This is because a healthy forage is not available to trap sediments, nutrients and pathogens from reaching local waterways. A healthy system will trap these ingredients and help promote further growth of the pasture. Lastly, there is an overall general lack of public awareness and education about water quality problems and their sources. Little Richland Creek, Blakeman Hollow, Bridge Creek, Beech Creek, Clifty Branch, Ore Branch, and Burcham Branch sub watersheds exhibit all or some of these potential sources. All of these same sub watersheds show issues with some form of nitrogen (nitrates, TKN, or ammonia) and/or phosphorous. In watersheds that contain water samples above target levels for both nutrients, there is a good chance of that stream going eutrophic, or over productive, threatening aquatic life within the stream and reducing recreation potential.

Analysis of stakeholder concerns

All stakeholder concerns were generated from stakeholder meeting, outreach, and PCAC meetings. The committee decided if the concern was supported by the data and whether there was evidence to support it. The committee then decided if the concern was within the scope of the plan and if it was quantifiable. Building upon this, they decided which concerns they would focus their efforts. For example: A concern of the committee was high E. coli levels. High E. coli levels were found through the watershed in the IDEM baseline study. So, the PCAC determined it was supported by data and had evidence to support the concern. It was quantifiable by analysis of past data. Addressing high E. coli levels is in the scope of the plan since it is a pollutant or concern that can be addressed with some feasibility. Lastly, it will be focused on if it is an issue that meets all these previously determined criteria, has some validity, and was decided upon by the PCAC to be included.

Some of the stakeholders concerns will not be addressed because they did not meet the criteria set above. Manicured Lawns will not be a focus of this project, though they are within the scope of the plan because the majority of the streams need buffers. These are related, however, buffers are the primary target and manicured lawns would be secondary. Large lawn size is also a stakeholder concern, though only because of the possibility of over fertilizing and risking contaminating runoff into streams. This can also be alleviated with education and implementation of buffer zones. New application rules for lawn fertilizers have also taken affect and this alone may be enough to address this concern. Salinity in the streams was not analyzed within this project. So any assumed road salt that enters streams may be alleviated secondarily through implementation of stream buffers. We will re-asses this concern if new data presents itself to the contrary. It is the hope of the PCAC that alternative de-icing treatments may be introduced as technology and testing increases with these products. As the project continues to help the community, more and more people will hear about it and want to be involved, even without it being stated as a primary objective. We will do our best to fit people's needs, but we do not want to interfere with other agencies that support landowners full-time. Water flow management is an important problem in the area, but the primary concern of this project is water quality, which is why we won't be focusing on that either. Turkey farms will not be a focus of this project because there is only one within watershed boundaries and it doesn't pose a significant threat to overall water quality.

Hydro-modification can be a cause of invasive species within the waters of Plummer Creek Watershed. Invasive species can be expensive and difficult to treat and can only be treated indirectly through 319 projects. However, there are programs such as Department of Natural Resources Forestry Programs, MS4 programs, and other Invasive Task Force programs that can be used to address these issues. Treating invasive species may put more unwanted chemicals into waterways, making the effort counterproductive to water quality concerns. Application of herbicides must follow label and suggested applications so that additional problems do not arise from this course of treatment. However, the habitat benefit of treatment of invasive species may outweigh risks from control.

Table 36: Analysis of Stakeholder Concerns

Concerns	Is it supported by data?	Evidence for concern	Is the concern quantifiable	Is the concern within the scope of the plan	Is the concern a focus of the group
High E. coli Levels	Yes	IDEM's baseline testing	Yes	Yes	Yes
Livestock in Stream	Yes	Windshield Survey	Yes	Yes	Yes
Stream Bank Erosion & Stabilization	Yes	Windshield Survey; Desktop Survey	Yes	Yes	Yes
Flooding	Yes	Watershed Coordinator and Stakeholders Observations; Anecdotal evidence	Yes	Yes	Yes
Manicured Lawns	No	Advisory Board notation	No	Yes	No
PCBs and Mercury in the Stream	Yes	IDEM NPDES; 303 (d) list	Yes	No	No
Obstructions in Streams	Yes	Windshield survey data	Yes	Yes	Yes
Overgrazing	Yes	Windshield survey data	Yes	Yes	Yes
Failing or Non-Existent Septic Systems	Yes	Ammonia levels are elevated; E.coli levels exceed standards; Anecdotal evidence	Yes	Yes	Yes
Invasive Species	Yes	Windshield Survey	Yes	Yes	Yes
Larger Lawn Size	Yes	Windshield Survey	Yes	No	No
Mowing Stream Edges	Yes	Windshield Survey	Yes	Yes	Yes
Sediment Control on Construction Sites	Yes	Windshield Survey; IDEM Correspondence; TSS & Turbidity Levels Exceed Standards	Yes	Yes	Yes
Agricultural Application	Yes	E. coli, Nitrogen, and Phosphorous Levels Exceed Standards	Yes	Yes	Yes

Concerns	Is it supported by data?	Evidence for concern	Is the concern quantifiable	Is the concern within the scope of the plan	Is the concern a focus of the group
Lack of Education	Yes	Discussions with Landowners; Anecdotal evidence	Yes	Yes	Yes
Ability to Fish	Yes	PCB's/Mercury found in IDEM testing	Yes	Yes	Yes
Ditch Management	Yes	Windshield Survey	Yes	Yes	Yes
Public Awareness	Yes	Printable and Verbal Survey's	Yes	Yes	Yes
Arsenic in Waterways	No	Advisory Board notation	No (Not without costly analyses)	No	No
Better Incentive Programs	Yes	NRCS Communication; Landowner Conversions	Yes	No	No
Disposal of Dead Animals	Yes	Advisory Board Notation; Windshield Survey; Observations	No	Yes	Yes
Meth lab Contaminants	No	Advisory Board Notation; Anecdotal Evidence	No	No	No
Prescription Med Disposal	No	Advisory Board Notation; Anecdotal Evidence	No (Not without costly analyses)	Yes	Yes-Education
Salinity from Road Salt	No	Advisory Board Notation	No	Yes	No
Turkey Farm Management	No	Advisory Board Notation	No	Yes	No
Logging Practices	Yes	Windshield Survey	Yes	Yes	Yes
Disposal of Garbage	Yes	Windshield Survey	No	Yes	Yes

Problems and Causes

Concerns in Table 36 are those that the further investigation was warranted. The PCAC identified specific problems relating to each concern on which the group wished to focus. Problems were defined as issues that exist due to a concern. Identified problems build upon concerns by identifying a condition or actions that need to be changed, improved, or investigated in greater depth. Specific problems were then consolidated into problem categories that represent specific water quality impairments. Table 37 links stakeholder concerns to specific water quality problems and generalized water quality impairments.

Table 37: Stakeholder Concerns and Related Issues

Concerns	Problem Statement	Water Quality Impairments
High E. coli Levels	Waterways impaired for E. coli. Use of waterways for recreation is limited in Little Richland, Blakeman Hollow, Bridge Creek, Beech Creek, Dry Branch, Clifty Branch, Black Ankle, Ore Branch and Burcham Branch Sub watersheds	**High E. coli Levels** **High Nutrient Levels** **Reduced Aquatic Recreation** **Dangerous Pathogens**
Livestock in Streams	Livestock with access to streams are a source of several water quality concerns. (Specifically, erosion from trampled banks increases suspended sediments; degraded stream habitat; increase nutrient and E. coli inputs). At least 40 livestock farms with direct access to stream channels within Plummer Creek Watershed	**High E. coli Levels** **High TSS & Turbidity Levels** **High Nutrient Levels** **Reduced Habitat Scores** **Reduced Aquatic Recreation**
Stream Bank Erosion & Stabilization	Farmland and private property is being threatened by erosion of weak stream banks (specifically, sediment influx and associated nutrient inputs; loss of land; clogging of gills; disruption of habitats; loss of riparian zone to tree fall-ins). Plummer Creek Watershed has over 58 miles of streams showing signs of bank erosion.	**High TSS & Turbidity Levels** **High Nutrients Levels** **Reduced Habitat Scores** **Decrease in Biodiversity** **Reduced Aquatic Recreation**

Concerns	Problem Statement	Water Quality Impairments
Flooding	Flooding can carry significant amounts of pollutants into waterways from all land types. Flooding has been observed in Black Ankle Creek, Ore Branch, and Burcham Branch Sub watersheds	**High E.coli Levels** **High TSS & Turbidity Levels** **High Nutrient Levels**
Obstructions in Streams	Logjams and other obstructions can alter habitat, flow, and erosion of stream channel. Obstructions have been observed at seven locations throughout the watershed. Additionally new logging has grown and irresponsible practices may lead to additional obstructions.	**High TSS & Turbidity Levels** **High Nutrient Levels** **Reduced Habitat Scores** **Reduced Aquatic Recreation**
Overgrazing	Overgrazing causes a lack of ground cover, which can lead to higher erosion of soil and runoff; increases suspended sediments; nutrient and E. coli inputs; pesticide inputs; untreated livestock waste potentially causing high E. coli levels in streams. This is observed throughout the watershed that contains over 100 livestock farms and 13,983 acres of pasture.	**High E. coli Levels** **High TSS & Turbidity Levels** **High Nutrient Levels** **Reduced Habitat Scores** **Reduced Aquatic Recreation**
Failing & Non-Existent Septic Systems.	Unknowing landowners may pollute streams from seeps caused by leaking septic tanks or straight pipes that lead directly into stream or sinkholes. Approximately 4,800 of septic systems in the watershed are improperly designed or are failing.	**High E. coli Levels** **High Nutrient Levels** **Reduced Aquatic Recreation** **Dangerous Pathogens**
Invasive Species	Invasive species displace native species; Creating monoculture that can reduce nutrient uptake capability and reduces varied root depths and structure. Plummer Creek has seen an increase in both aquatic and terrestrial invasive species in the watershed.	**High TSS & Turbidity Levels** **High Nutrient Levels** **Reduced Habitat Scores** **Decrease in Biodiversity** **Reduced Aquatic Recreation**

Concerns	Problem Statement	Water Quality Impairments
Mowing/agriculture next to streams	Lack of buffer areas leads to a decrease in root structure and a higher risk for stream bank erosion and lessened uptake of nutrients. Over 58 miles are in need of buffer within Plummer Creek Watershed	**High TSS & Turbidity Levels** **High Nutrient Levels** **Reduced Habitat Scores**
Sediment Control on Construction Sites	Both major and minor construction projects in the area do not have enough erosion control methods to control sediment from leaving the site. In Plummer Creek Watershed there are 5 current construction sites with ~7 miles of major Highway construction that have little to no sediment control measures	**High TSS & Turbidity Levels** **High Nutrient Levels** **Reduced Habitat Scores** **Decrease in Biodiversity** **Reduced Aquatic Recreation**
Agricultural Application & Management	Runoff after fertilizer application/manure spreading increasing nitrate and E. coli levels. Conventional Cropping systems decrease soil quality, reduces filtration properties of soil and causes increase in erosion of topsoil. Plummer Creek has over 100 livestock farms and 17,593 acres of fields along with 3,611 acres of crops	**High E. coli Levels** **High TSS & Turbidity Levels** **High Nutrient Levels** **Reduced Habitat Scores** **Reduced Aquatic Recreation**
Lack of Education & Public Awareness	Stakeholders are unaware of their effects on stream quality, from farm or lawn fertilizer applications to residential septic systems, there is a lack of pollution prevention options readily available to the general public in the area; Most of the community is unaware of pollution prevention strategies	**High E. coli Levels** **High TSS & Turbidity Levels** **High Nutrient Levels** **Reduced Habitat Scores** **Reduced Aquatic Recreation**
Ability to Fish	Decrease in habitat and increased sediment loads have displaced many species of fish and other life within the ecosystem decreasing recreational opportunities within the watershed	**Reduced Habitat Scores** **Decrease in Biodiversity** **Reduced Aquatic Recreation**

Concerns	Problem Statement	Water Quality Impairments
Ditch digging practices	Current methods for constructing and maintaining roadside ditches may contribute to higher TSS and turbidity input	**High TSS & Turbidity Levels** **High Nutrient Levels**
Disposal of dead animals	Lack of education leads to improper disposal of carcasses where they can contaminate waterways	**High Nutrient Levels** **Dangerous Pathogens** **Reduced Aquatic Recreation**
Prescription Medication Disposal	Improper disposal of medication may be contaminating our waters	**Decrease in Biodiversity** **Reduced Aquatic Recreation**
Logging Practices	Logging without consideration of sediment control may be contributing to high sediment levels within the watershed; increased logging in the area may lead to higher runoff which may further degrade the steam channels, habitat, and water quality. New logging is being observed within the watershed with 7 active logging sites that show high amounts of sediment erosion	**High TSS & Turbidity Levels** **High Nutrient Levels** **Reduced Habitat Scores** **Reduced Aquatic Recreation**
Disposal of Garbage	Trash may contain hazardous materials; reinforces public perception that trash in natural areas is acceptable; Sinkholes may be being used as trash receptacles and places to put fill and other unwanted materials which may result in sediment and garbage fill within the subsurface system	**High TSS & Turbidity Levels** **High Nutrients Levels** **Reduced Habitat Scores** **Decrease in Biodiversity** **Reduced Aquatic Recreation**

Sources and Loads

The sources of water quality problems is the first step at identifying land uses, behaviors, and areas where change must occur to address water quality problems. To ensure the most effective use of resources to help reverse the water quality problems, first the identification of those problems and then locating their sources is imperative. Once sources have been identified, the degree of reduction needed to improve water quality problems to acceptable levels has to be completed. This can be approximated by calculating the load observed within the watershed on a yearly basis.

A cause is an event, agent, or series of actions that produce a problem. Table 37 puts together the concerns of the community with the problems and impairments. Potential causes for each water quality impairment were identified. Table 38 looks at those water quality impairments, their causes, and associates some potential sources and locations for those problems. A sub watershed was considered a problem sub watershed if it contained any of the potential sources areas and/or if it also showed an exceedance in the water quality data. The sub watershed column indicates whether a water quality impairment was seen in testing data from that sub watershed if the parameter is listed in parenthesis after the sub watershed name.

Table 38: Sources by Concern

Water quality Problems	Cause	Source	Problem Sub watersheds
High E. coli Levels	E. coli levels exceed water quality standards	Livestock with stream access (40 livestock farms with access), inadequate or improper septic system design and/or maintenance (approximately 4,800 of all private systems), inadequate storage of manure (more than 100 livestock farms and 17,593 acres of fields potentially storing manure to spread), overgrazing pasture lands (13,983 acres of pasture/hay), inadequate buffers (58.16 miles of streams), wildlife, lack of public awareness and education	Little Richland (E. coli), Blakeman Hollow (E. coli), Bridge Creek (E. coli), Beech Creek (E. coli), Dry Branch (E. coli), Clifty Branch (E. coli), Black Ankle (E. coli), Ore Branch (E. coli), and Burcham Branch (E. coli).
High Total Suspended Solids (TSS) & High Turbidity Levels	TSS levels exceed targets set by this project; Turbidity levels exceed targets set by this project	Livestock with access to streams (40 livestock farms with access to streams), stream bank erosion (58.16 miles of streams with signs of bank erosion), overgrazing (13,983 acres of pasture/hay), inadequate buffers (58.16 miles of stream), conventional cropping systems (3,611 acres of cultivated crops) , lack or inadequate sediment control measures on construction sites (5 areas with development sites including ~7 miles of major HWY construction), current road drainage methods (ditches w/in 5 sub watersheds), logging (7 active logging sites), lack of public awareness and education.	Little Richland (TSS & Turbidity), Blakeman Hollow (TSS & Turbidity), Bridge Creek (Turbidity), Dry Branch (Turbidity), Clifty Branch (Turbidity), Black Ankle Creek, Ore Branch (TSS & Turbidity), and Burcham Branch (TSS & Turbidity).

Water quality Problems	Cause	Source	Problem Sub watersheds
High Nutrient Levels	Nitrate (N) levels exceed targets set by this project Total Kjeldahl Nitrogen (TKN) levels exceed targets set by this project Total Phosphorous (TP) levels exceed targets set by this project Ammonia (A) exceeds water quality standards	Livestock with access to streams (40 livestock farms with access to streams), inadequate or improper septic system design and/or maintenance (approximately 4,800 of all private systems), inadequate storage of manure (More than 100 livestock farms and 17,593 acres of fields potentially storing manure to spread), lack of nutrient management plans (3,610.5 acres of cultivated crops), stream bank erosion (58.16 miles of streams showing signs of bank erosion), overgrazing (13,983 acres of pasture/hay), inadequate buffers (58.16 miles of stream), lack or inadequate sediment control measures on construction sites (5 areas with development sites including ~7 miles of major HWY construction), logging (7 active logging sites), lack of public awareness and education.	Little Richland (N, TKN, TP & A), Blakeman Hollow (N, TKN & TP), Bridge Creek (TKN, TP, & A), Beech Creek (TKN), Dry Branch, Clifty Branch (N, TKN & A), Black Ankle (TKN), Ore Branch (TP), and Burcham Branch (N, TKN, TP, & A)
Reduced Habitat	QHEI scores are less than targets set by this project CQHEI scores are less than targets set by this project	Livestock with access to streams (40 livestock farms with access to streams), stream bank erosion (58.16 miles of streams showing signs of bank erosion), inadequate buffers (58.16 miles of stream), obstructions in the stream (7 logjams identified) overgrazing (13,983 acres of pasture/hay), lack or inadequate sediment control measures on construction sites (5 areas with development sites including ~7 miles of major HWY construction), current road drainage methods (ditches w/in 5 sub watersheds), lack of public awareness and education.	Little Richland, Blakeman Hollow, Bridge Creek (QHEI), Beech Creek (QHEI), Dry Branch, Clifty Branch (QHEI), Black Ankle (QHEI), Ore Branch (QHEI & CQHEI), and Burcham Branch (QHEI & CQHEI).
Decreased Biodiversity	Lack of Game Fish MIBI scores are less than targets set by this project	Reduced Habitat (see above), High TSS & Sediments (see above) limiting the survival of smallmouth bass larvae, Invasive species, Leaf litter and grass clippings and other organic material carried into streams during storm events, improper disposal of prescription drugs, and lack of public awareness and education	Little Richland (MIBI), Blakeman Hollow, Bridge Creek (MIBI), Beech Creek, Dry Branch, Clifty Branch (MIBI), Black Ankle, Ore Branch (MIBI), and Burcham Branch (MIBI).

Water quality Problems	Cause	Source	Problem Sub watersheds
Reduced Aquatic Recreation	E. coli levels exceed water quality standards TSS levels exceed targets set by this project; Turbidity levels exceed targets set by this project QHEI scores are less than targets set by this project CQHEI scores are less than targets set by this project MIBI scores are less than targets set by this project	Livestock with stream access (40 livestock farms with access), inadequate or improper septic system design and/or maintenance (approximately 4,800 of all private systems), inadequate storage of manure (more than 100 livestock farms and 17,593 acres of fields potentially storing manure to spread), overgrazing pasture lands (13,983 acres of pasture/hay), inadequate buffers (58.16 miles of streams), stream bank erosion (58.16 miles of streams showing signs of bank erosion), overgrazing (13,983 acres of pasture/hay), inadequate buffers (58.16 miles of stream), lack or inadequate sediment control measures on construction sites (5 areas with development sites including ~7 miles of major HWY construction), obstructions in the stream (7 logjams identified), invasive species, logging (7 active logging sites), Disposal of dead animals in streams (various sites and 2 habitual dumping grounds), Garbage in streams (various sites), flooding, lack of public awareness and education.	Little Richland, Blakeman Hollow, Bridge Creek, Beech Creek, Dry Branch, Clifty Branch, Black Ankle, Ore Branch, and Burcham Branch.

Estimating the total amount of a contaminant in a stream is a challenging task. Load estimation is very useful for any watershed plan to determine how much reduction in pollutants is needed to achieve water quality standards or targets. Load is the amount of a pollutant (usually in pounds, kilograms, or tons) that passes through a point on a stream or river in a certain amount of time (often in one day or one year). In order to estimate load on a particular day (instantaneous load), two things are needed:

- Concentration of the pollutant, usually in units of mass per volume (often mg/liter or parts per million), and
- Flow rate, or the amount of water that flows during a certain amount of time. This flow rate is in units of volume per time (for example, cubic feet per second.)

What is difficult, however, is to estimate the total load over a longer period, during which the daily load varies considerably. Annual load, the total load in an average year, is typically needed to estimate current loads and therefore load reduction needed to meet target loads in a watershed plan. Therefore, to calculate annual load both concentration and flow are needed each day. This is where estimating annual load becomes difficult, because they are rarely available. Daily flow is available at USGS gaging stations, but concentration is usually only measured periodically (monthly) by most studies. With the lack of a USGS gaging station within the watershed alternative stations must be used as a proxy.

USGS has developed a tool called LOADEST for estimating the daily concentration and using it to calculate load. LOADEST estimate loads for each day, which you can sum to get total annual loads. The method is based on the assumption that concentration varies with flow. This works particularly well for phosphorus and sediment concentration, which tend to be much higher during high flows. Nitrogen concentrations can also be calculated using this method, but they are not as accurate due to the ability of nitrogen to flow with groundwater.

To obtain a statistically significant and more accurate estimate of pollutant loads based on field data, more than monthly pollutant concentration samples and corresponding flow measurements are needed. Purdue's Web-Based Load Calculation Using LOADEST program was used to calculate existing loads, the amount of loads desired to meet targets, and the amount of load reduction needed to meet targets at sites where discharge data was available or able to be calculated.

LOADEST was used to calculate loads from current monitoring efforts at Test Point 1 on Plummer Creek just upstream of outlet to White River and the confluence with Richland Creek and Test Point 2 on Richland Creek near its outlet to Plummer Creek. Discharge data was calculated using the Ratio method and using USGS gaging station Lick Creek at Paoli, IN (USGS Station Number 03373610) as a proxy. The Lick Creek watershed has similar terrain, slope, and land use as Plummer Creek watershed along with also having some karst topography. The Lick Creek watershed is 21.5 square miles while the watershed for Test point 1 is 62.6 sq. miles and the watershed for Test Point 2 is 98.3 square miles. Table 39 below indicates current loads for Total Suspended Solids, Total Phosphorous, and Nitrate water quality parameters based off this method. Target loads were calculated based off of target concentrations using the same methods for each water quality parameters shown below.

Nitrate loads were not an issue at Test Points 1 and 2 as noted, but the bigger concern is the high concentrations of Ammonia at 4 sites, the high nitrate concentrations found at 7 sites and the high TKN concentrations found at 16 sites. For this reason, the needed concentration reduction from the maximum seen within the watershed is noted in Table 39 along with the nitrogen load.

E. coli loads cannot be calculated using LOADEST so an alternative model was used. IDEM's 319 Load Calculation Tool was used with data collected from Test Point 1 and 2. The loads from these two testing points are summed to get current and target loads of E.coli representing both Richland Creek and Plummer Creek. This site is located closest to the outlet of the watershed and should represent values throughout. All target load values were subtracted from current load values to obtain a load reduction needed for each of the water quality parameters.

Habitat and Aquatic wildlife cannot be evaluated as a load, but the number of sites that show diminished habitat and the number of sites with poor to bad aquatic life scores also should be highlighted in this area, as well. Out of the 5 sites that were tested during current monitoring three of the sites showed a low habitat scores, while seven of the IDEM baseline testing sites showed low QHEI scores indicating that there are multiple locations where habitat is less than desirable. This may affect the quality of the food chain which would affect the ability to fish. This is a concern of the stakeholders within this watershed. Additionally there were 9 sites where macroinvertebrate populations indicated poor quality and reflects the numerous water quality problems seen within the watershed.

Table 39: Load and Reductions Needed by Concern

Water Quality Concern	Current Load	Target Load	Limit or Target Value	Reduction Needed
Total Suspended Solids	43,530,630 lb/yr 21,765 tons/yr	18,156,505 lb/yr 9,078 tons/yr	< 30 mg/L	25,374,123 lb/yr 12,687 tons/yr (58.3%)
Turbidity	23 sites exceeding targets	All sites turbidity < 25 NTU	< 25 NTU	Decrease Turbidity to meet target levels
Total Phosphorous	108,261 lb/yr	45,996 lb/yr	< 0.076 mg/L	62,265 lb/yr (57.5%)
Nitrate All Nitrogen forms	204,035 lb/yr 18 sites where N, Ammonia and/or TKN exceeded targets	76,150 lb/yr NO^3 < 1.0 mg/L Ammonia < 0.2 mg/L TKN < 0.28 mg/L	< 1.0 mg/L NO^3 < 1.0 mg/L Ammonia < 0.2 mg/L TKN < 0.28 mg/L	127,884 lb/yr (62.6%) Max reduction: NO3: 1.35 mg/L Ammonia: 0.84 mg/L TKN: 2.3 mg/L
E. coli	4.8222E+15 organisms/yr	2.85997E+14 organisms/yr	< 235 CFU/100mL	4.5362E+15 orgs/yr (94.1%)
Habitat	3 sites < 60 (CQHEI) 7 sites < 50 (QHEI)	All Sites > 60 CQHEI All Sites > 50 QHEI	> 50 CQHEI > 60 CQHEI	Increased scores in problem areas
Aquatic Wildlife	9 sites below 36 MIBI	All site > 36 MIBI	> 36 MIBI	Increased diversity in problem areas

Critical Areas and Goals for Reduction

The primary goal of this project is to reduce stakeholder concerns that have been found to exceed set limits to acceptable standards. The six major water quality concerns, listed in table 39, have varying levels of contamination and so each have a different timeframe in which the problem may be alleviated. Therefore our primary goal is split into eight goals, each concentrating on a separate quality concern. Over the course of the project, the number of landowners involved in cost-share will increase, the number of acres of implemented BMPs will increase and the number of acres affected will increase. Another goal will be to increase awareness of the local water quality concerns and conservation practices that this project is providing.

Goals

1. Increase resources that will assist with increasing knowledge and awareness while helping implement best management practices designed to alleviate water quality concerns within the watershed.
2. Decrease current nitrogen concentrations to meet target concentrations within 20 years.
3. Decrease current phosphorous loads to meet target loads within 20 years.

4. Decrease current total suspended solids load to meet the limit set by the IDEM within 20 years.
5. Decrease current turbidity concentrations to meet target concentration limits within 20 years.
6. Decrease current E. coli load to Indiana Water Quality Standard for recreational contact within 25 years.
7. Increase habitat scores to meet CQHEI and QHEI standards within 20 years.
8. All sites monitored show a healthy macroinvertebrate population within 25 years.

Table 40: Water Quality Overall Goals

Water Quality Concern	Current Load / Number of Exceedance	Target Load / Target Concentrations	Critical Area Acres	Reduction Needed per Critical Acre	Timeframe
Total Suspended Solids	43,530,630 lb/yr 21,765 tons/yr	18,156,505 lb/yr 9,078 tons/yr	32,265	562.7 lb/acre/yr 0.28 tons/acre/yr (58.3%)	20 years
Turbidity	23 sites exceeding targets	All sites turbidity < 25 NTU	32,265	Decrease Turbidity to meet target levels	20 years
Total Phosphorous	108,261 lb/yr	45,996 lb/yr	32,265	1.42 lb/acre/yr (57.5%)	20 years
Nitrate	204,035 lb/yr	76,150 lb/yr	32,265	2.36 lb/acre/yr (62.6%)	20 years
All Nitrogen forms	18 sites where N, Ammonia and/or TKN exceeded targets	NO^3 < 1.0 mg/L Ammonia < 0.2 mg/L TKN < 0.28 mg/L	32,265	Decrease Nitrogen concentrations to meet target levels	20 years
E. coli	4.8222E+15 organisms/yr	2.85997E+14 organisms/yr	32,265	8.86 E+10 orgs/acre/yr (94.1%)	25 years
Habitat	3 sites < 60 (CQHEI) 7 sites < 50 (QHEI)	All Sites > 60 CQHEI All Sites > 50 QHEI	32,265	Increased scores in problem areas	20 years
Aquatic Wildlife	9 sites below 36 MIBI	All site > 36 MIBI	32,265	Increased diversity in problem areas	25 years

The eight goals detailed above and represented in the table indicate the ultimate goal of reaching target pollutant concentrations identified by the steering committee within one generation (20-25 years). Short term goals (3 years) and the realistic potential for reaching target goals within a generation are dependent on the cooperation of our community. We are hopeful that this plan will be easily adopted by our community, and so are optimistic that the reductions in water quality concerns will be seen in one generation. However, the adoption of the plan will all depend on the availability of resources sufficient enough to meet expectations put forth within this plan.

Table 41: Interim and Long Term Goals

Water Quality Concern	Goal Type	Goal Reductions for Critical Areas	Timeframe
Total Suspended Solids	Long Term Goal	562.7 lb/acre/yr over 32,265 acres	20 years
		0.28 tons/acre/yr (58.3%) over 32,265 acres	
	Short Term Goal	28 lb/acre/yr over 32,265 acres	3 years
		0.014 tons/acre/yr (5%) over 32,265 acres	
Turbidity	Long Term Goal	Decrease Turbidity to meet target levels at all sites	20 years
	Short Term Goal	Decrease Turbidity to meet target levels at 15% of samples collected at problem sites exceeding targets	3 years
Total Phosphorous	Long Term Goal	1.42 lb/acre/yr (57.5%) over 32,265 acres	20 years
	Short Term Goal	0.14 lb/acre/yr (10%) over 32,265 acres	3 years
Nitrate	Long Term Goal	2.36 lb/acre/yr (62.6%) over 32,265 acres	20 years
	Short Term Goal	0.24 lb/acre/yr (10%) over 32,265 acres	3 years
All Nitrogen forms	Long Term Goal	Decrease Nitrogen concentrations to meet target levels at all sites during all sampling events	20 years
	Short Term Goal	Decrease nitrogen to meet target levels at 10% of samples collected at problem sites exceeding targets	3 years
E. coli	Long Term Goal	8.86 E+10 orgs/acre/yr (94.1%) over 32,265 acres	25 years
	Short Term Goals	7.09 E+8 orgs/acre/yr (8%) over 32,265 acres	3 years
		Decrease E. coli to meet target levels at 8% of samples collected at problem sites exceeding targets	3 years
Habitat	Long Term Goal	Increased scores in problem areas to target levels	20 years
	Short Term Goal	Habitat scores improve by 5% at problem sites exceeding targets	3 years
Aquatic Wildlife	Long Term Goal	Increased diversity in problem areas to target levels	25 years
	Short Term Goal	Macroinvertebrate scores increase by 3% at problem sites exceeding targets	3 years

For each goal a list of both short term (3 years) and long term (10-20 years) strategies necessary to meet the goals (Table 41) are detailed below along with indicators used to mark progress toward those goals. Some strategies identified for individual goals may be applicable to other goals, and in such cases, these strategies are listed under each goal. Indicators to mark progress toward set goals are listed in Table 42.

Table 42: Indicators

Goal	Indication	Milestone reading	Timeframe to indication
Obtain resources to address water quality issues	Applications for 3 grants to provide funding for actions strategies addressed in this plan	319 Implementation grant, Clean Water Indiana grant, and local community based grant applications submission	1 Year
Develop and promote cost-share program	Program approved by IDEM; 5% increase in number of stakeholders participating in meetings and interested in joining steering committee compared to planning phase.	Cost-share program submitted to IDEM; 5% increase in stakeholders attending first stakeholder meeting	3 months; 1 year
Implement BMPs in critical areas	Increased 50 acres of land enrolled in conservation programs annually; acreage covered by BMPs increases each year; number of acres affected increases each year.	Second year of project sees more applications for cost-share that the first; new acreage is brought into cost-share BMPs; new areas are implementing BMPs.	1 year; 1 year; 1 year
Increase awareness of local water quality concerns and projects to alleviate concerns	Increase of knowledge through workshops; distribution of news and materials; increase attendance at each stakeholder meeting by 10%; involvement in community clean-up projects	Surveys taken after workshops show an increase in knowledge about the subject; first workshop held has 10+ attendees, 10% increase at following workshops; community clean-ups increase in volunteers.	2 years; 1 year; 1 year; 2 years
Build and Utilize Partnerships	Increased awareness in programs; Increase the amount of partnerships formed	75% of partner programs advertised; 10% increase in number of organizations aware of our program; 10% increase in number of partnerships formed	5 years
Reduce nitrate load to target	Decrease in nitrate loads during quarterly testing to milestone	1.0 mg/L	25 years

levels	reading.		
Reduce TSS load to target levels	Decrease in measured TSS during quarterly testing to milestone reading.	30 mg/L	20 years
Reduce turbidity loads to EPA recommended level	Decrease in measured turbidity during quarterly testing to milestone reading	25 NTU	20 years
Reduce E. coli loads to Indiana standard	Decrease in measured E. coli colony forming unit during quarterly testing to milestone reading	235 CFU	25 years
Increase habitat scores to CQHEI target levels of 60 and QHEI to target levels of 50	All test points in streams receive at least a score of 50 through QHEI methods and 60 through CQHEI methods	All test sites at 50+ on QHEI (this is only halfway to full improvement) or 60+ on CQHEI	25 years

Critical Area Identification

A critical area as defined for watershed management planning is a place where implementation of watershed management plan guidance can remediate nonpoint source pollution in order to improve water quality or mitigate future pollutant sources to protect water quality. The areas that were included as critical areas for the PCW were decided upon by the PCAC. The water quality test results along with sources identified as potential nonpoint source pollution within the watershed were considered as criteria for inclusion as a critical area. Map 25 shows sources for water quality problems within Plummer Creek for a total of 32,265 acres of impacted lands. It includes all agricultural lands, recent and past development, recent/current logging, and buffers along the streams. Any land that falls into these Critical Areas will be considered for improvements to water quality. Improving management practices at these locations gives the best chance to improve the water quality within the watershed and should be considered as the critical area for implementation of this plan. Additionally, any newly cleared lands for agriculture, development, or due to logging should be considered for inclusion into the critical area map, as needed.

It was agreed that critical areas should be broad enough to cover any area that may be contributing to nonpoint source pollution, but should be limited to those areas which may actually be contributing to water quality problems. Primary, Critical Areas will be anywhere in the Plummer Creek watershed where agricultural land is present and significantly contributing to nutrient, sediment, and/or E. coli problems. Contributions to water quality concerns from these lands will be evaluated through site reviews to determine whether they are considered as a significant contributor. Any land that has visibly notable problems, including but not limited to, highly erodible land, livestock with access to streams, conventional row cropping practices, poor pasture management, unprotected manure piles, and lack of buffers between agricultural land and streams will be considered a significant contributor. It is also agreed that residential lands, current and recent logging areas, and areas with lack of buffers may also be contributing to non-point source pollution and should also be included as Secondary Critical Areas. Critical Areas have been determined through desktop and windshield surveys and are highlighted on Map 25. There is a total of 32,265 acres of Critical Areas. These critical areas have a tiered approach to address water quality issues and have been prioritized based on contribution to the noted water quality problems. The steering committee agreed that the best approach to addressing these issues would be to take this tiered approach. Agricultural lands, both crop and pasture land, is the primary target for implementation (Tier I), secondarily is streams lacking in significant buffers (Tier II), thirdly is forested lands that have been recently logged or have plans for future logging (Tier III), and lastly residential areas (Tier IV). If water quality load reductions cannot be satisfied solely by implementation on agricultural lands targeted as significant contributors due to low interest or because of the small amount of agricultural lands then Secondary Critical Areas (Tier II) will be approached for potential load reductions. These lands will go through a similar process of site reviews noting areas with visibly notable problems that may be leading to water quality impairments. All properties that are within the watershed and are included in the Critical Areas above will be assessed for their individual contribution to various water quality problems. A ranking system developed for these areas will ensure that lands with higher contributions will be considered first when implementing and offering programs to install BMPs within the sub watersheds.

In order to develop a ranking system for agricultural lands some initial criteria had to be developed. It was determined that certain sub watersheds were at higher risk than others based on current water quality. Higher risk sub watersheds were determined by compiling information obtained through water quality testing, desktop, and windshield surveys. The ranking system will first look at which sub watershed the property is in. According to a weighted score each sub watershed received (see Weighted Scores below), the application will start off with a score based on its location. Next the property will be assessed for its contribution to various water quality problems, like total suspended sediment. If the property will be a significant contributor, assessed based on a site evaluation and/or loading calculations, to a water quality concern, it will receive additional points. This will be done for each of the water quality impairment categories identified in Table 40. Then additional points will be applied to the application based off whether the sub watershed, where the property is located, is at risk for the specific pollutant load from the property (nitrate, TSS, etc.). The sub watersheds will be targeted for implementation of Best Management Practices (BMPs) that can address specific water quality issues. A final score will be given based on the BMP(s) selected for that property and the improvement potential that/those BMP(s) have to address the water quality concerns for that sub watershed. Once all contributions have been assessed and a total score is calculated, the applications can be ordered and ranked against to one another to determine which applications will receive resources towards improving water quality impairments first. That way sub watersheds showing specific water quality problems or lands that have a significant contribution to many water quality problems can rank higher and be addressed first with the resources available.

Weighted Scores

Sub watershed	Initial Score
Little Richland	24.5
Blakeman Hollow	9
Bridge Creek	6.5
Beech Creek	3
Dry Branch	1.5
Clifty Branch	6.5
Black Ankle	3.5
Ore Branch	10
Burcham Branch	8.5

Weighted Scoring Method:

These points were calculated by noting the number of sites that exceed targets and dividing that by the number of testing sites to give a percent exceeded. The parameters considered were nitrate, ammonia, TKN, turbidity, TSS, total phosphorous, habitat, and MIBI. The sum of the percent exceeded was rounded up to the tenths and then this score was multiplied by 5 to give some separation between sub watersheds

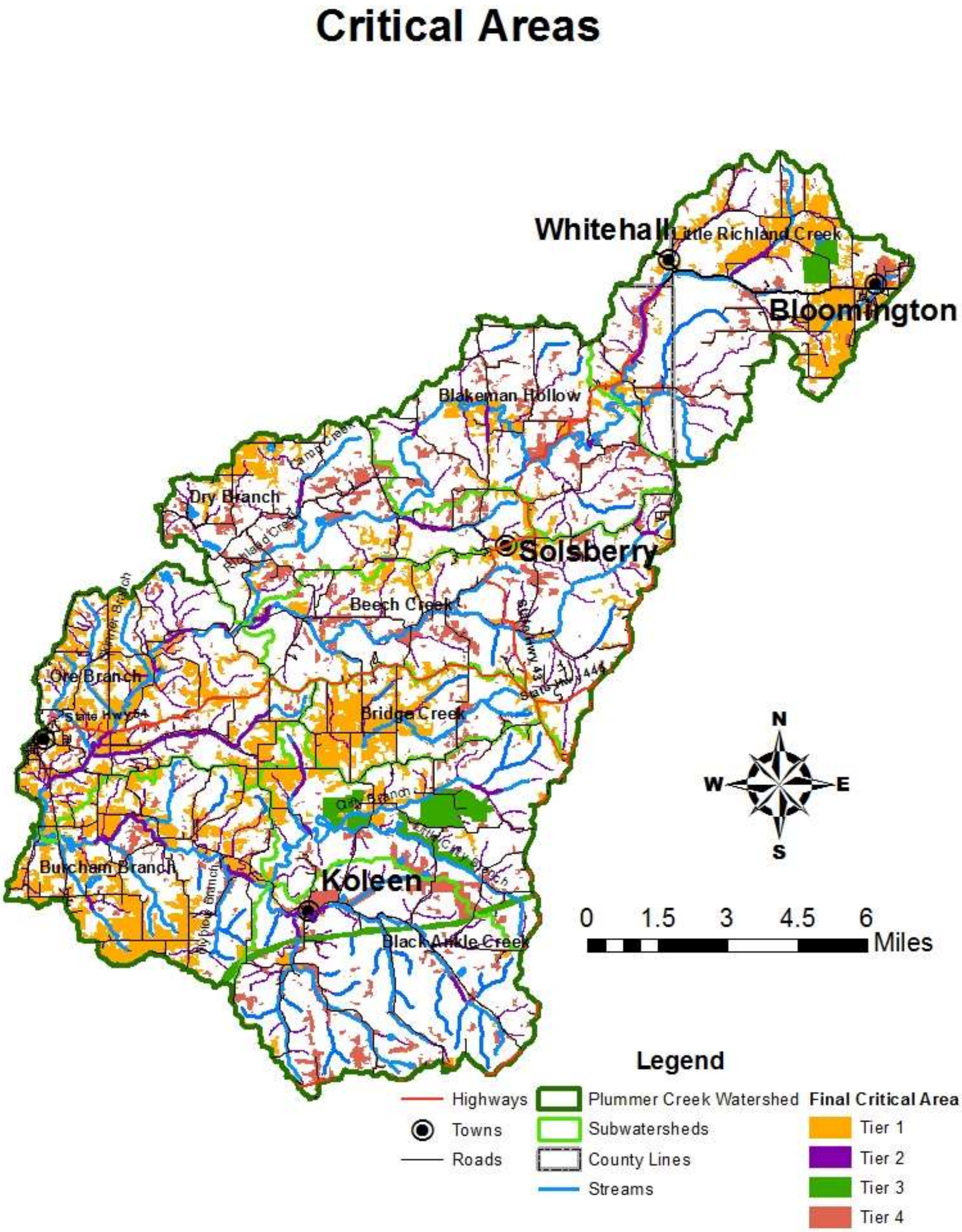
All of the sub watersheds had issues that should be addressed for at least one parameter. Below in Table 43 is a list of Critical Sub watersheds that will receive additional point separated by pollutant of concern. It is apparent from load calculations above that E. coli, sediment, and phosphorous are our biggest loads within the watershed. For this reason they received a higher score than the remaining categories. The points that each water quality problem receives represents the relative degree of reduction needed for that parameter's loads within the watershed. Aquatic life received the lowest score because it is believed that if the other water quality concerns are addressed that aquatic life will improve in response. An application must receive a minimum combined score of 18 points in the above method to be considered for 319 implementation funds. All others may be included in other grant funding sources.

Table 43: Critical Areas

Water Quality Problem	Points	Critical Sub watersheds	Possible Sources
Nitrates	5	Little Richland Creek, Blakeman Hollow,	Fertilizer runoff from fields and yards, cattle in

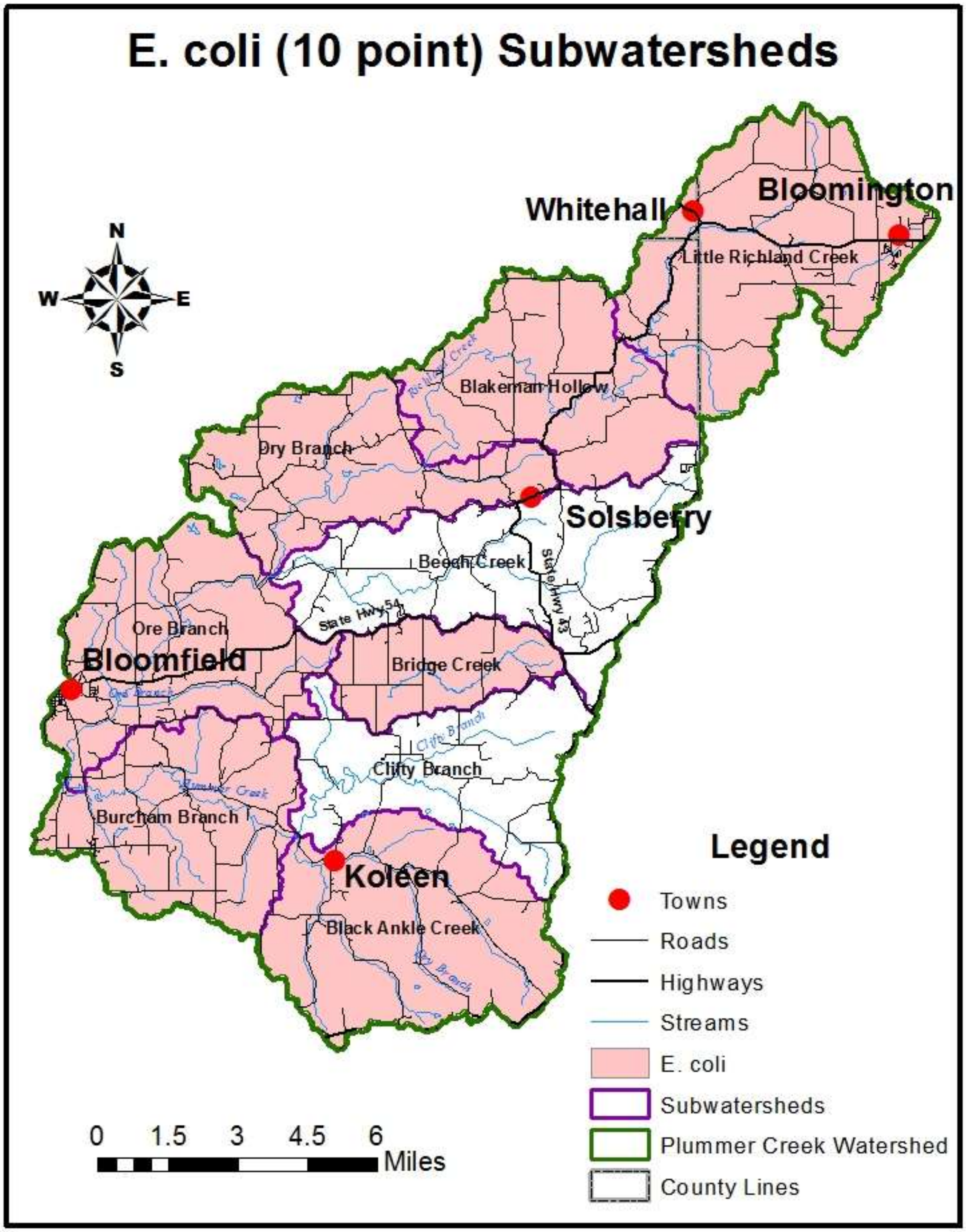
		Bridge Creek, Beech Creek, Clifty Branch, Burcham Branch	streams, leaking septic tanks, groundwater levels
Phosphorous	7	Little Richland Creek, Blakeman Hollow, Bridge Creek, Ore Branch, Burcham Branch	Fertilizer runoff from fields and yards, cattle in streams, leaking septic tanks, erosion of natural deposits (stream banks & ditches)
Turbidity	7	Little Richland Creek, Blakeman Hollow, Dry Branch, Clifty Branch, Black Ankle, Ore Branch, Burcham Branch	Lack of stream buffers, cattle in streams, logging, ditch maintenance, construction sites, erosion
Total Suspended Solids	7	Blakeman Hollow, Dry Branch, Clifty Branch, Black Ankle, Ore Branch, Burcham Branch	Lack of stream buffers, cattle in streams, logging, ditch maintenance, construction sites, erosion
E. coli	10	Little Richland Creek, Blakeman Hollow, Bridge Creek, Dry Branch, Black Ankle, Ore Branch, Burcham Branch	Manure runoff from fields, cattle in streams, leaking septic tanks, and wildlife
Low Habitat Scores	5	Little Richland Creek, Bridge Creek, Beech Creek, Clifty Branch, Black Ankle, Ore Branch, Burcham Branch	Habitat modification, agricultural runoff, cattle in streams, siltation
Wildlife potential	2	Black Ankle, Burcham Branch, Ore Branch, Clifty Branch, Little Richland Creek	Habitat modification, agricultural runoff, cattle in streams, septic influence & prescription drugs, siltation

Map 25: Critical Areas

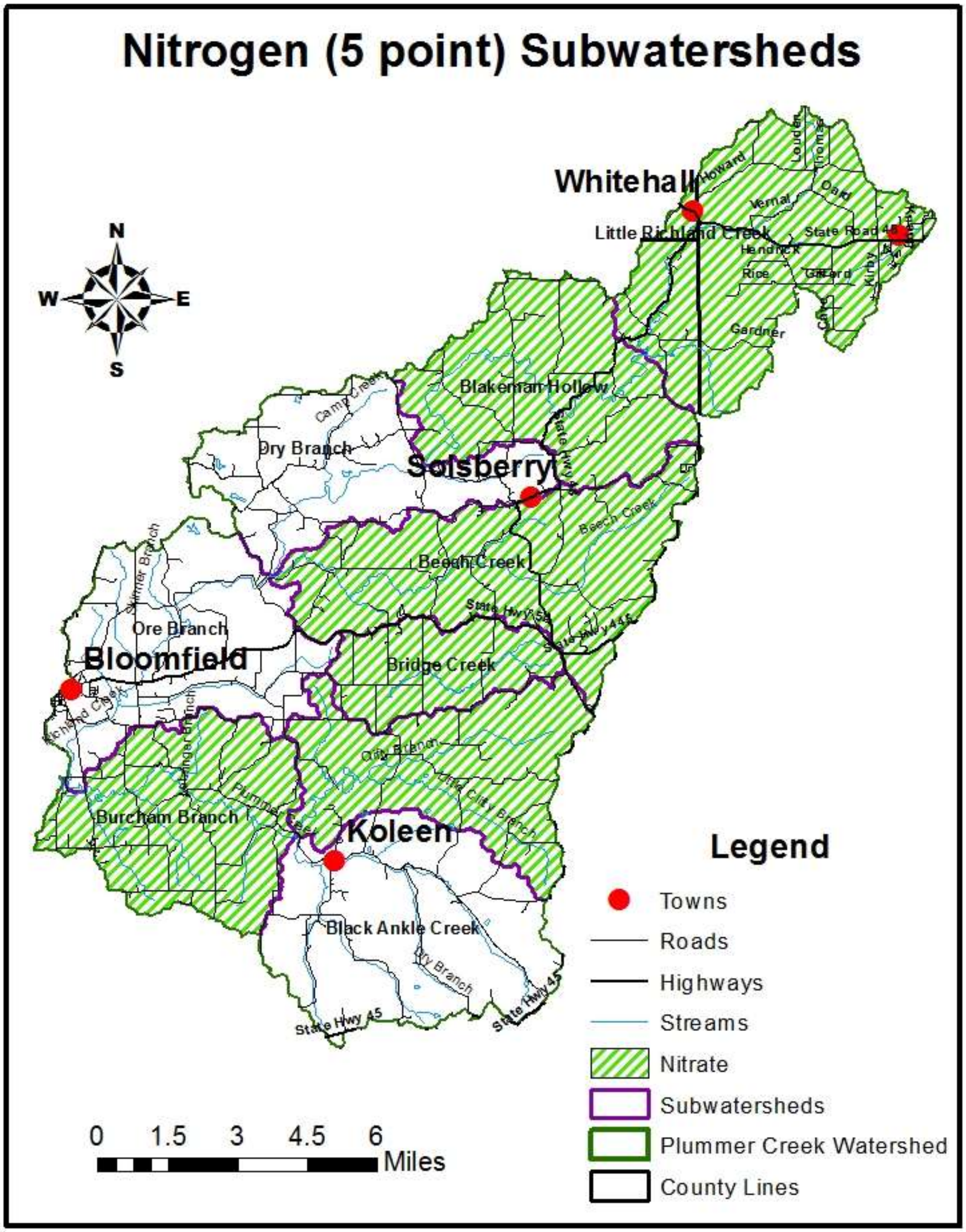


Critical Areas by Concern

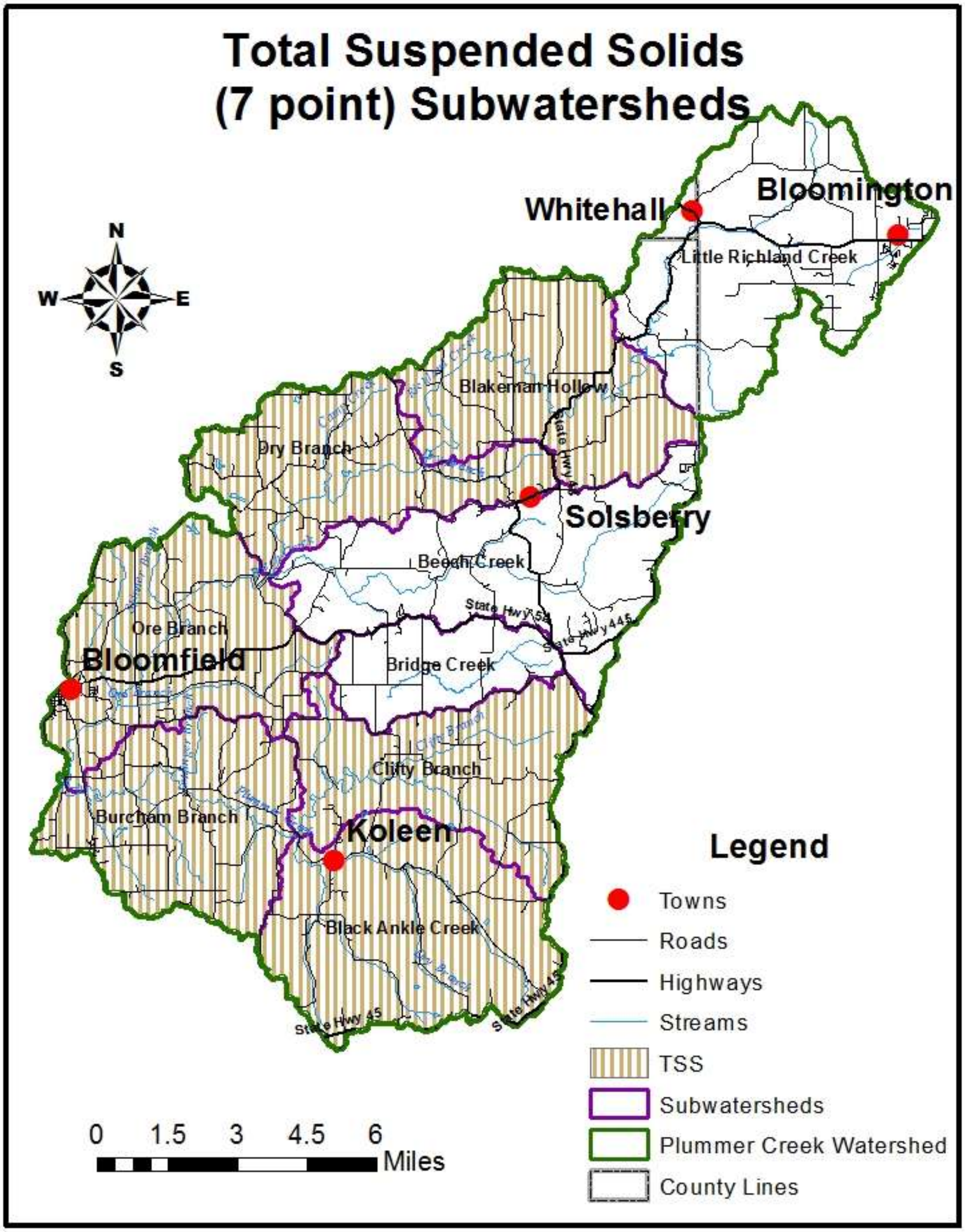
Map 26: E. coli Management Sub watersheds



Map 27: Nitrogen Management Sub watersheds

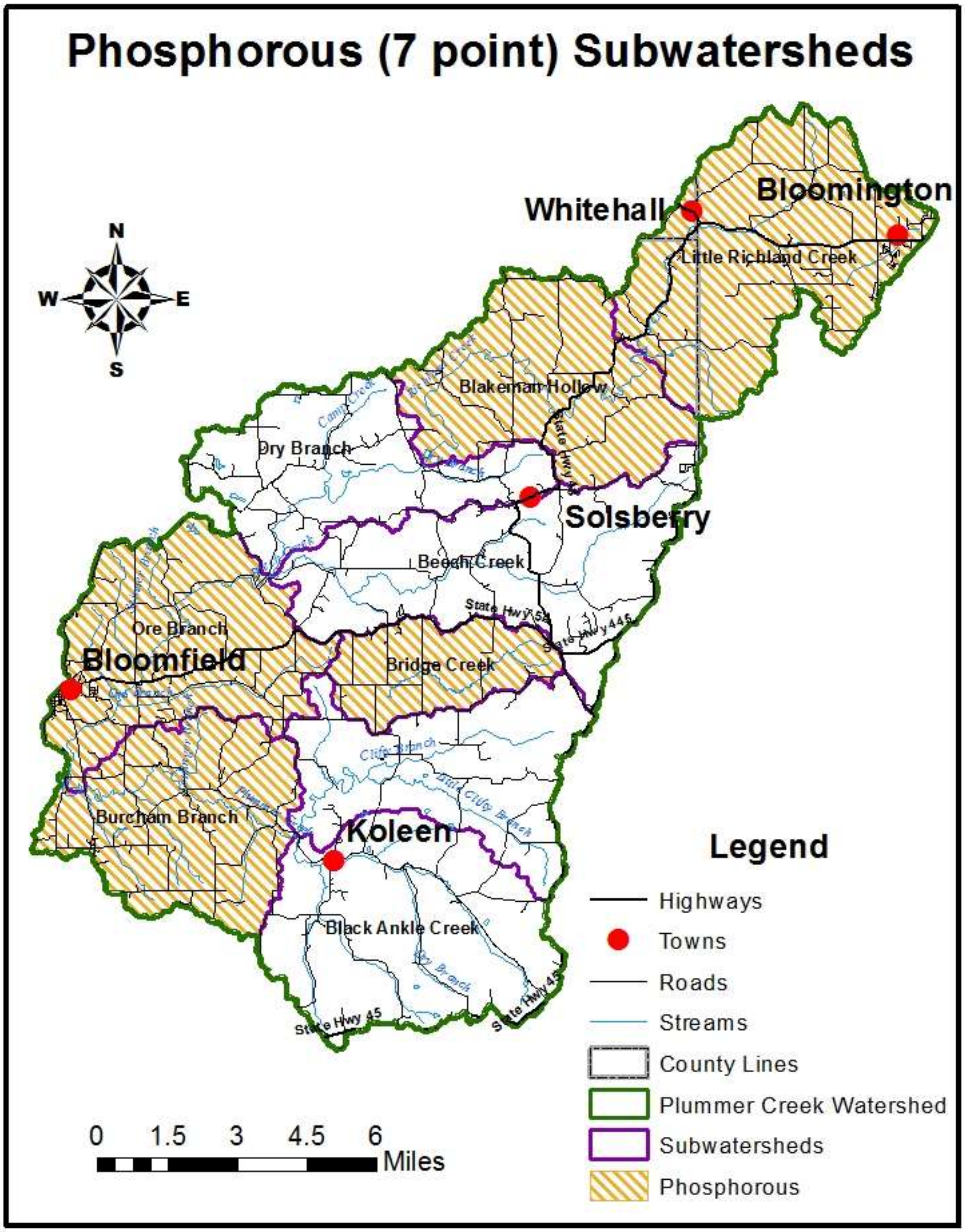


Map 28: Total Suspended Solids Management Sub watersheds

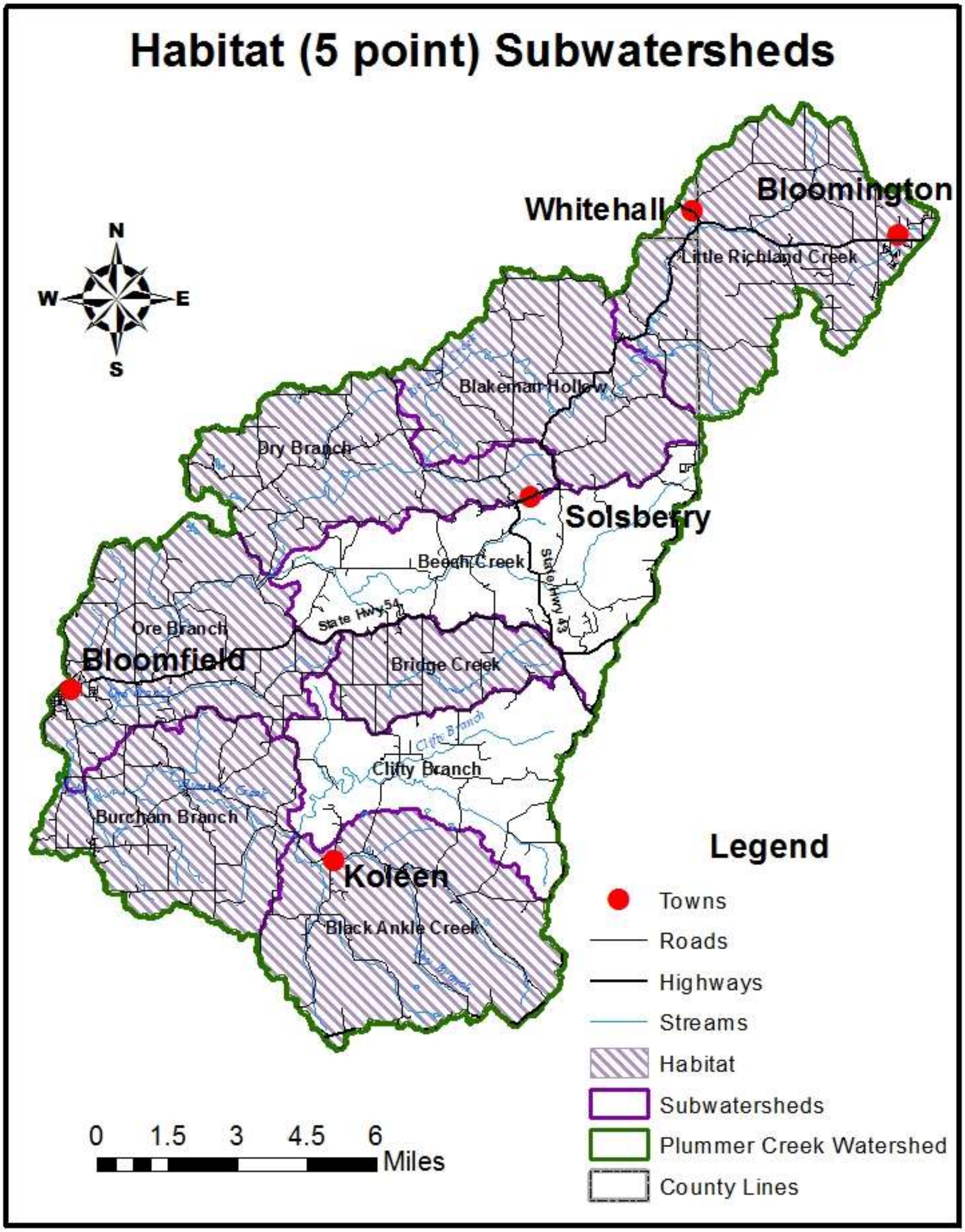


Map 29: Turbidity Management Sub watersheds

Map 30: Phosphorous Management Sub watersheds



Map 31: Habitat Management Sub watersheds



Map 32: Wildlife Potential Management Sub watersheds

Best Management Action Plan

Best management practices (BMPs) are conservation practices implemented on private land to prevent further pollution. The Plummer Creek Advisory Committee selected many different BMPs that landowners could implement to try and meet the goals of the project, as well as any personal goals that may be held by a land owner or operator. The following is a list of proposed BMPs to be implemented in critical areas.

Livestock Exclusion

A livestock exclusion system is a network of permanent fencing installed to prevent livestock from entering streams and aquatic areas not intended for grazing. This will reduce erosion, sediment, E. coli, and nutrient loading, and improve the quality of surface water.

Livestock that have unrestricted access to a stream have the potential to degrade water quality and biotic integrity of that stream from the point of entry to the outlet of the stream and beyond. Livestock can deliver nutrients and pathogens directly to a waterbody through their waste. Livestock also degrade stream ecosystems by trampling and removal of vegetation through grazing of riparian zones. This can weaken banks and increase the potential for bank erosion. Trampling can also compact soils in a wetland or riparian zone decreasing runoff's ability to infiltrate the soil. Removal of vegetation in a wetland or riparian zone also limits the area's ability to filter pollutants in runoff. The degradation of water quality and habitat typically results in the impairment of the fish, macroinvertebrates, and other aquatic wildlife living in the waterbody.

Restoring areas impacted by livestock grazing often involves several steps, the first of which is restricting them from the area. If necessary, an alternate source of water can be created for the livestock, a process that can involve a second cost-share opportunity. 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. This may also qualify for streambank stabilization cost share. Minimally, it involves installing filter strips along banks or wetland edge and replanting any areas cleared by passing livestock. 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 to any nearby waterbodies. Restoring aquatic areas impacted by livestock will help reduce pollutant loading, particularly nitrate-nitrogen, sediment, E. coli, and other pathogens.

Nutrient Management

Nutrient management includes the management of the timing, form, placement, source, and amount of the application of plant nutrients and soil amendments to minimize the transport of applied nutrients into surface water and groundwater. Nutrient management seeks to sustain the physical, biological, and chemical properties of the soil while also helping to supply ideal amounts of nutrients for optimum crop yield and quantity. Nitrogen has several sources in most fields including animal manure, crop residue, legumes and commercial fertilizers. Because of this, levels of added nitrogen will probably not need to be exactly the same each year. A nutrient budget for nitrogen, phosphorus, and potassium can be developed considering all potential sources. Nutrient management specifies the timing, form, source, amount, 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. Plans may consider the use of Nitrogen Stabilizers which help to retain nitrogen in the fields for crop production and decrease the amount of nitrogen running off or leaching from fields to nearby surface or subsurface channels.

Cover Crops

Cover crops are used to improve soil quality for future cropping seasons by opening root channels for crops to grow into, increasing water intake ability. Cover crops also reduce wind and water erosion, increase available nitrogen, suppress weed cover, and encourage beneficial insect growth including earthworm activity, which further enriches soil heath. Cover crops include legumes, such as alfalfa, clover, field peas, and hairy vetch, and non-legumes, such as radishes, oats, rye, turnips, wheat, and buckwheat which are planted prior to or following crop harvest. Cover crops are typically grown for one season during non-cropping seasons. Cover crops reduce excess nitrogen transport by reducing soil erosion and runoff. Both wind and water erosion move soil particles that have nitrogen and phosphorus attached. Sediment that reaches water bodies may release these nutrients into the waterways. The cover crop vegetation recovers plant - available phosphorus in the soil and recycles it for the next season's crops, reducing the need for added fertilizers and the risk of polluted runoff. Cover crops are a familiar conservation practice throughout the area, a result of diligent work from the Greene County SWCD and the NRCS along with workshops that have been held for this grant and the water quality project. A cover crop test plot was implemented in one of the heaviest row crop farming areas within the PCW as a demonstration BMP.

Conservation Tillage

Conservation tillage includes several tillage methods that involve leaving crop residue to cover a field even after planting. These tillage methods include no-till, strip-till, mulch-till, and ridge-till. The purposes of conservation tillage are to reduce erosion, conserve soil moisture, increase available moisture, improve soil organic matter content, provide habitat and cover for wildlife, and reduce plant damage. The remaining crop residue will help filter and reduce runoff volume. Conservation tillage is also widely used throughout the surrounding area and within the project watershed, though more can be done to increase awareness and participation for landowners and operators in the project area.

Heavy Use Area Protection

Heavy-use areas are defined by the NRCS as areas frequently and intensively used by people, animals or vehicles. These are pads made from concrete or another firm surface placed in heavy use areas to provide a stable, non-eroding surface. Eroding soil can be a dangerous problem near watering facilities or feeding areas. Livestock can sink deep into wet soils that haven't been able to grow vegetative cover because of frequent use. A drainage system is also usually needed for impermeable surfaces. To avoid significantly affecting adjacent land uses, care should be taken to choose the appropriate cover surface. There are several options including concrete, bituminous concrete pavement, other cementitious materials (such as soil cement or coal combustion by-products), aggregate, sprays and mulches, and other materials, which might include limestone screenings, cinders, bark mulch, brick chips, or shredded rubber. The use of the area and the adjacent land uses are critical to consider when a surface material is chosen.

Waste Storage Facilities

Animal waste can be a major source of pollution to waterbodies. If livestock is granted access to stream, most of their waste goes directly into streams, directly adding to water quality problems that have already become apparent. To protect the aquatic health of ecosystems and organisms and achieve water quality standards, manure must be safely managed. Good management of manure keeps livestock healthy, protects the environment, specifically water quality, returns nutrients to the soil, and improves pastures and gardens. Waste storage facilities are a solution that will help landowners achieve these goals. These are large covered concrete pads placed near a heavy use area where waste can be collected without risk of contaminating runoff or endangering waterways or livestock. Proper manure management can effectively reduce sedimentation, nutrient levels, and E. coli concentrations.

Pasture Management

Pasture management refers mostly to a rotational grazing system. From a cost-share perspective, fencing is the greatest need for landowners to implement this BMP. Moving livestock between fields helps to prevent overgrazing, which can lead to greater amounts of erosion and pollutants entering waterways. A fairly simple rotational grazing system can increase pasture yields, increase pasture quality, provide for more livestock on the same amount of acreage, require less hay for feed, better distribute manure nutrients throughout the pasture, and improve health of livestock. Fencing can be a simple strand of high tensile wire, poly-wire, or poly-tape with an electric current. A watering system can usually serve several fields if it is placed at an intersection of fencing, meaning that extra watering facilities are most likely unnecessary and livestock can go to a single place no matter which field they are currently grazing in.

Runoff Management

Runoff management may refer to agricultural applications, such as grassed waterways, or more urban practices, such as rain barrels and rain gardens. Impervious surfaces such as roofs and roads can create runoff permeated with pollutants. This runoff tends to run directly into nearby streams and karst areas. Though the PCW does not have large amounts of impervious surfaces, those that do exist can add a significant amount of unwanted contaminants to waterways. For this reason, any house within a critical area that scores high enough on the ranking system described above will be eligible to install rain barrels, rain gardens, or other water quality based urban BMPs. These help slow overflow, reducing erosion and avoiding high velocities that water can gain over time and distance while also filtering chemicals and other impurities from water that may run directly to streams.

A rain barrel is a large container that collects and holds rainwater from your rooftop using the guttering system. Captured rainwater can then be used for watering gardens, lawns, and trees. Storing the water from gutters will also minimize erosion that can occur from high flow downspouts. Rain gardens are used to collect runoff from ground-based impermeable surfaces, such as driveways or parking lots. It is a depressed area planted with deep-rooted native grasses that collects rainwater, filtering it before increased infiltration rates can take the water underground to the water table. These gardens also take little maintenance because of their water-holding capabilities. A combination of these practices may also result in decreased flooding due to a decrease in peak flow and total volume of runoff generated by a storm event.

For agricultural land uses, grassed waterways are channels used to prevent erosion in cropped fields. These channels are planted with grasses to slow and filter the water before it enters streams. These are usually constructed where water has already begun to cut channels through crop fields. Land users that have gotten involved in this program through the NRCS are appreciative of grassed waterways because of the amount of soil saved. Grassed waterways can handle large quantities of water with no erosion, if properly constructed and maintained. This BMP reduces sediment concentrations in nearby waterbodies and pollutants in runoff. The vegetation also improves the soil aeration and water quality due to its nutrient removal through plant uptake and absorption by soil.

Watering Facilities

Alternative watering systems provide a new location for livestock to find water rather than using surface water as their sole source. This removes livestock from streams, which alleviates all of the concerns that come with animals being directly in water, including direct deposits of animal waste and bank erosion and destabilization. This results in less E. coli, nitrogen, and sediment entering a surface waterbody. It can also improve livestock health by providing a clean source of water. Two main types of alternative watering systems are used including pump systems and gravity systems.

Stream Crossings

Stream crossings are a stabilized area or structure (temporary or permanent) constructed across a stream to provide a travel way for people, livestock, equipment, or vehicles. When a path crosses a stream, erosion usually is present. Any improperly implemented structures that act as stream crossings can affect the health or passages for water organisms, including fish and the endangered species that may currently live there. A designed crossing also makes traveling over a stream easier on the livestock, humans, or equipment.

Stream crossings, temporary or permanent, should be made available for agricultural equipment crossings, livestock crossings, and logging activities. It was noted during windshield surveys that there are a few stream crossings throughout the watershed that are not in working order and are currently or may soon impede stream navigability for aquatic organisms. Stream crossing practices designed to limit these effects should be constructed in place of failing or improperly constructed crossings.

Streambank Protection

Streambank protection can be split into stabilization and restoration. Both techniques are used to improve stream conditions so they more closely resemble natural conditions. A number of factors may limit what choices are available, including available floodplain, development structure locations, and modifications to natural flows. Practices that may be included in this category are 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. Nearly every stream within the Plummer Creek Watershed has unprotected stream banks, which means that this BMP could be very important to reach the load reductions needed, especially for sediment.

Riparian Forest Buffers

Riparian forest buffers are areas between fields and streams planted with trees and shrubs with native grasses in between the larger fauna. This help to prevent sediment, nitrogen, and E. coli from entering adjacent waterways. This could prove to be an important management practice because of the high levels of sediment in streams throughout the entire watershed.

The primary benefit of riparian forest buffers is to filter out unwanted pollutants applied to nearby fields from entering streams, but there are several other benefits as well. Complex root systems can reduce streambank erosion and provide habitat for aquatic organisms. Shade from trees can keep water temperature down and improve habitat for fish and other aquatic organisms. Trees also improve the nearby soil health by adding detritus and woody debris. Trees and shrubs create habitat for land animals as well. They may also reduce the size of the floodplain by increasing water storage. Stream speed may also be reduced if root systems reach into the waterway.

Field Borders

Field borders have similar primary objectives to Riparian Forest buffers in that they are designed to filter contaminants out of runoff before it joins with a stream. A mixture of native grasses, forbs, and herbaceous plants are included in most designs. Buffers also have many extra benefits including restoring hydrologic connectivity, stabilizing sinkhole edges, and providing wildlife habitat. The type of vegetation, the pollutant load, and the amount of runoff all are factors in the effectiveness of a buffer area. Optimum buffer width must consider adjacent land uses, topography, soil type, and average runoff velocity. All sub watersheds are prime candidates for field buffers.

Precision Agriculture Upgrades

Advances in technology have made it possible to improve accuracy in planting and applying fertilizers and pesticides. Upgrading systems to these newer technologies would allow for the reduction of use of these products and could reduce runoff of these products to sinkholes and streams within the watershed. Equipment upgrades would include GPS system upgrades, variable rate technology system, or variable rate manure application upgrades. Other possible benefits would be from upgrading to auto swath and auto steer equipment. These systems would prevent over application and prevent applications from going in unnecessary areas. This can be especially helpful where row crops are farmed near sinkholes or in karst areas, such as is the case in the Bridge Creek sub watershed.

Forest Management Plans

Forest management is the application of appropriate technical forestry principles, practices, and business techniques (e.g., accounting, cost/benefit analysis, etc.) to the management of a forest to achieve the owner's objectives. Forest management provides a forest the proper care so that it remains healthy and vigorous and provides the products and the amenities the landowner desires. Forest management is the development and execution of a plan integrating all of the principles, practices, and techniques necessary to care properly for the forest.

Forests are an important tool in long-term, low-cost protection of water supplies. Maintaining forest cover in critical locations such as floodplains, seeps, steep slopes, karst features, headwaters, and close to streams can help avoid major deterioration in water quality and increases in treatment difficulty and cost. Forests adjacent to consistent nutrient sources (such as fertilized crops or lawns) can reduce nitrogen before it reaches the streams, especially on shallower soils where tree roots reach the groundwater. The condition of the forest also affects ability to protect water quality. Forest condition includes characteristics such as tree health, distribution of tree and stand sizes and ages, and number of layers of vegetation (e.g., herbaceous, shrub, sub-canopy, mid-canopy, upper canopy). Disturbances such as windstorms or hurricanes are infrequent but inevitable. Stands with multiple layers of vegetation and a range of ages and sizes of trees can withstand loss of trees most susceptible to damage without losing all of its functions for erosion control and infiltrating water. Forest management near waterbodies takes into account the potential for multiple canopy layers, matching species to site conditions, and opportunities to maintain actively growing forests next to nutrient sources. Landowners can help improve water quality by planting trees on their own land. This practice is appropriate for all forested lands in Critical Areas.

Recommended Best Management Practices (BMPs)

Table 44: BMP Recommendations

Suggested BMPs	Water Quality Concern	BMP load reduction efficiency % & Expected reduction				Unit	Est. Cost	Min. # Needed	Critical Areas
		N	Phos	Sed	E. coli				
Livestock Exclusion	E. coli, nitrogen, TSS, turbidity, habitat	18% /field 0.20 lb/ac/yr	12% /field 0.03 lb/ac/yr	14% /field 0.26 ton/ac/yr	35%/field		$2.50 /ft	40 fields	Tier I
Nutrient Management	nitrogen, phosphorous	33% 0.37 lb/ac/yr	27% 0.07 lb/ac/yr	N/A	N/A	Farm	$1,000 /plan	100 plans	Tier I
Cover Crops	TSS, turbidity, nitrogen, habitat	20% 0.75 lb/ac/yr	15% 0.15 lb/ac/yr	40% 0.08 ton/ac/yr	20%	Acre	$40 /acre	360 acres	Tier I
Conservation Tillage	Nitrates, TSS, turbidity, habitat	55% 1.01 lb/ac/yr	45% 0.26 lb/ac/yr	75% 0.12 ton/ac/yr	N/A	Row	$30 /acre	360 acres	Tier I
Heavy Use Area Protection	E. coli, nitrogen, TSS, turbidity, Habitat	6% 0.24 lb/ac/yr	10% 0.03 lb/ac/yr	22% 2.86 ton/ac/yr	15%	Unit	$1.00 / sq ft	48,000 sq ft	Tier I
Waste Storage Facilities	E. coli, nitrogen, phosphorous, TSS, habitat	65 1.52 lb/ac/yr	60 0.24 lb/ac/yr	N/A	60%	Unit	$50,000/ unit	1 unit	Tier I
Pasture Management	TSS, turbidity, nitrogen, phosphorous, habitat	15% 0.60 lb/ac/yr	30% 0.09 lb/ac/yr	30% 3.9 ton/ac/yr	30%	Acre	$142 /acre	500 acres	Tier I
Runoff Management: Grassed Waterways	TSS, turbidity, habitat	40% 0.42 lb/ac/yr	85% 8.4 lb/ac/yr	30% 0.07 ton/ac/yr	30%	Acre	$3,267 /acre	7.5 acres	Tier 2 & 4

Suggested BMPs	Water Quality Concern	BMP load reduction efficiency (% per unit) & Expected reduction				Unit	Est. Cost	Min. # Needed	Critical Areas
		N	Phos	Sed	E. coli				
Runoff Management: Rain Barrels	Phosphorous, TSS, turbidity, habitat	30% 0.28 lb/ac/yr	30% 0.05 lb/ac/yr	30% 0.006 ton/ac/yr	10%	Each	$150 /unit	10 units	Tier 4
Runoff Management: Rain Gardens	TSS, turbidity, nitrogen, phosphorous, habitat	30% 0.27 lb/ac/yr	50% 0.08 lb/ac/yr	30% 0.003 ton/ac/yr	15%	Each	$500 /each	6 units	Tier 4
Watering Facilities (indirect)	E. coli, nitrogen, TSS, turbidity, habitat	18% 0.72 lb/ac/yr	12% 0.04 lb/ac/yr	14% 1.8 ton/ac/yr	35%	Each	~$1,500 /unit	20 units	Tier I
Stream Crossings	E. coli, nitrogen, TSS, turbidity, habitat	10% 0.51 lb/ac/yr	40% 0.22 lb/ac/yr	40% 5.95 ton/ac/yr	35%	Each	$2,311 /unit	10 units	Tier I
Streambank Protection	Phosphorous, TSS, turbidity, habitat	20% 6.3 lb/ac/yr	20% 7.3 lb/ac/yr	30% 1.06 ton/ac/yr	N/A	Feet	$50 /ft (live poles)	400 ft	Tier 2
Riparian Forest Buffers	Nitrogen, phosphorous, TSS, turbidity, habitat	40% 1.5 lb/ac/yr	30% 0.95 lb/ac/yr	30% 0.10 ton/ac/yr	30%	Acre	$541 /acre	3 acres	Tier 2
Field Borders	Nitrogen, TSS, turbidity, habitat	15% 5.6 lb/ac/yr	20% 1.78 lb/ac/yr	25% 0.92 ton/ac/yr	30%	Acre	$427 /acre	10 acres	Tier 2
Precision Agriculture Upgrades	Nitrogen, phosphorous, TSS, turbidity, habitat	15% 5.5 lb/ac/yr	20% 9.2 lb/ac/yr	30% 3.7 ton/ac/yr	N/A	Each	$7,000+ /system	4 units	Tier I
Forest Management Plans	Turbidity, phosphorous, TSS, habitat	3% 1.56 lb/ac/yr	4.5% 0.4 lb/ac/yr	8.8% 0.16 ton/ac/yr	N/A	Field	~$450 /field	10 fields	Tier 3

Action Schedule

The goals of this plan are included below with both short term and long term goals in mind.

1. Increase resources that will assist with increasing knowledge and awareness while help implement best management practices designed to alleviate water quality concerns within the watershed.
2. Decrease current nitrogen concentrations to meet target concentrations within 20 years.
    - Short Term Goal: Reduce excess nitrate critical area load by 10% (0.25 lb/acre/yr) in 3 years
    - Short Term Goal: Decrease nitrogen to meet target levels at 10% of samples collected at problem sites
3. Decrease current phosphorous loads to meet target loads within 20 years.
    - Short Term Goal: Reduce excess phosphorous critical area load by 10% (0.13 lb/acre/yr) in 3 years
    - Short Term Goal: Decrease phosphorous to meet target levels at 10% of samples collected at problem sites
4. Decrease current total suspended solids load to meet the limit set by the IDEM within 20 years.
    - Short Term Goal: Reduce excess total suspended solid critical area load by 5% (25.6 lb/acre/yr) in 3 years
    - Short Term Goal: Decrease TSS to meet target levels at 5% of samples collected at problem sites
5. Decrease current turbidity concentrations to meet target concentration limits within 20 years.
    - Short Term Goal: Decrease Turbidity to meet target levels at 15% of samples collected at problem sites

      Short Term Goal: Decrease Turbidity to meet target levels at 15% of samples collected at problem sites
6. Decrease current E. coli load to Indiana Water Quality Standard for recreational contact within 25 years.
    - Short Term Goal: Reduce excess E. coli counts by 8% (7.3153E+09 orgs/acre/yr) in 3 years
    - Short Term Goal: Decrease E. coli to meet target levels at 8% of samples collected at problem sites
7. Increase habitat scores to meet CQHEI and QHEI standards within 20 years.
    - Short Term Goals: Habitat scores improve by 5% at problem sites
8. All sites monitored show a health macroinvertebrate population within 25 years.
    - Short Term Goals: Macroinvertebrate scores increase by 3% at problem sites

Table 45: Objectives to reach goals

Objectives	Goal	Target Audience	Milestones	Possible Partners/ Technical Assistance	Cost
Create cost-share program	1	Stakeholders in the Plummer Creek Watershed	Program developed and submitted to IDEM for approval within the first 3 months of receiving funding towards implementation	PP: Greene & Monroe Soil and Water Conservation District (SWCD), Natural Resource Conservation District (NRCS)	<$1000
			Once approved, SWCD will develop a cost share practice list and provide it to at least 50 landowners within the watershed.	PP: Greene & Monroe SWCD, Bloomfield State Bank, Greene Economic Development, NRCS, Farm Service Agency (FSA)	<$1000
Acreage covered by BMPs increase each year	All	Landowners in the Plummer Creek Watershed	Cost-share program developed and approved.	PP: Greene & Monroe SWCD, NRCS Tech Team, FSA	<$1,000
			Conduct Field visits with at least 20 landowners in the first year and increase the number of landowners serviced by 5 each year for first 3 year and review thereafter.	PP: Plummer Creek Landowners, Greene & Monroe SWCD, NRCS Tech Team, and FSA TA: NRCS may help assess critical area	<$1,000
			Five or more landowners apply and implement BMPs in critical areas in the first year of the grant	PP: Plummer Creek Landowners, Greene & Monroe SWCD, NRCS Tech Team, and FSA TA: NRCS may help assess land use for which BMP to implement. Tech Team may help implement	$50,000
			New landowners apply in subsequent years of grant and involved landowners increase number of BMPs implemented by 25 acres annually year for first 3 year and review thereafter.	PP: Plummer Creek Landowners, Greene & Monroe SWCD, NRCS Tech Team, and FSA TA: NRCS may help assess land use for which BMP to implement. Tech Team may help implement.	Varies based on types and sizes of selected BMPs (Table 44)

Objectives	Goal	Target Audience	Milestones	Possible Partners/ Technical Assistance	Cost
Increase in number of participants in steering committee by 10 per year	1	Stakeholders in the Plummer Creek Watershed	Average attendance is higher than six people at Steering Committee meetings	PP: Plummer Creek Advisory Committee (PCAC), Greene SWCD	$1000-$2000 for rooms, ads, and meetings
			Have at least 4 original members of a steering committee active.	PP: PCAC, Greene & Monroe SWCD, Greene County Council, County Commissioners	
Number of acres affected by program will increase by 75 acres each year	All	Landowners in the Plummer Creek Watershed	Cost-share program developed and approved	PP: Greene & Monroe SWCD, NRCS Tech Team, FSA	<$1,000
			Landowners enroll in cost-share and every sub watershed implements new BMPs on at least 10 acres annually year for first 3 year and review thereafter.	PP: Plummer Creek Landowners, Greene & Monroe SWCD, NRCS Tech Team, FSA TA: NRCS may help assess land use for which BMP to implement. Tech Team may help implement	$50,000
			BMPs are implemented in new areas.	PP: Plummer Creek Landowners, Greene & Monroe SWCD, NRCS Tech Team, FSA TA: NRCS may help assess land use for which BMP to implement. Tech Team may help implement	Varies based on types and sizes of selected BMPs (Table 44)
			One additional landowner in each sub watershed will implement at least one new BMP each year	PP: Plummer Creek Landowners, Greene & Monroe SWCD, NRCS Tech Team, FSA TA: NRCS may help assess land use and implement BMP.	Varies based on types and sizes of selected BMPs (Table 44)

Objectives	Goal	Target Audience	Milestones	Possible Partners/ Technical Assistance	Cost
30% increase of knowledge by workshops	1	Landowners in the Plummer Creek Watershed	1 workshop held in first year of grant. Post-survey shows 30% increase in knowledge.	PP: Greene & Monroe SWCD, NRCS, Monroe SWCD, Owen SWCD, NRCS Technical team TA: NRCS provide speakers	$1000-$2000
			3 workshops in subsequent years show 30% increase in knowledge from beginning of workshop to end.	PP: Greene & Monroe SWCD, NRCS, Monroe SWCD, Owen SWCD, NRCS technical team TA: NRCS Provide Speakers	$4000
Increased number of landowners apply for cost-share each year	2	Landowners in the Plummer Creek Watershed	Advertise at least 10 postings in local community centers each year for first 3 year and review thereafter.	PP: Greene & Monroe SWCD, NRCS Tech Team, FSA	$3000
			Four or more public appearances made at county fair and other events in following years for first 3 year and review thereafter.	PP: Plummer Creek Landowners, Greene & Monroe SWCD, NRCS Tech Team, FSA	
Distribution of news and materials	1	Stakeholders in the Plummer Creek Watershed	6 newsletters, 6 flyers, and 6 brochures are sent out over the course of the grant for first 3 year and review thereafter.	Greene & Monroe SWCD, Bloomfield State Bank, Greene Economic Development	$3000-$5000
			7 press releases are given to local news sources over the course of the grant for first 3 year and review thereafter.	Greene & Monroe SWCD	<$1000
Involvement in community clean-up projects within the watershed	1	Stakeholders in the Plummer Creek Watershed	At least 10 participants will be involved in community cleanup per year for first 3 year and review thereafter.	PP: Greene & Monroe SWCD, PCAC, Watershed Environmental Team TA: WET team volunteers	$1000-$2000

Objectives	Goal	Target Audience	Milestones	Possible Partners/ Technical Assistance	Cost
Implement proper BMPs to reduce nitrate load by 26 pounds per year	2	Landowners in the Plummer Creek Watershed	Identify at least 15 landowners with potential interest in BMP implementation focus on reducing nitrates, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, and provide necessary resources for implementation in critical areas for first 3 year and review thereafter.	PP: NRCS, NRCS Tech Team, Farm Service Agency	Varies based on types and sizes of selected BMPs (Table 44)
			Continue to identify at least 5 additional landowners each year to implement BMPs that reduce nitrate levels for first 3 year and review thereafter.	PP: NRCS, NRCS Tech Team, Farm Service Agency	
Implement proper BMPs to reduce phosphorous load by 29 pounds per year	3	Landowners in the Plummer Creek Watershed	Identify at least 10 landowners with potential interest in BMP implementation focus on reducing phosphorous, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, and provide necessary resources for implementation in critical areas for first 3 year and review thereafter.	PP: NRCS, NRCS Tech Team, Farm Service Agency	Varies based on types and sizes of selected BMPs (Table 44)
			Continue to identify at least 5 additional landowners each year to implement BMPs that reduce phosphorous levels for first 3 year and review thereafter.	PP: NRCS, NRCS Tech Team, Farm Service Agency	

Objectives	Goal	Target Audience	Milestones	Possible Partners/ Technical Assistance	Cost
Implement proper BMPs to reduce total suspended solids load by 58.3%	4	Landowners in the Plummer Creek Watershed	Identify landowners with potential interest in BMP implementation focus on reducing TSS, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, and provide necessary resources for implementation for first 3 year and review thereafter.	PP: NRCS, NRCS Tech Team, Farm Service Agency	Varies based on types and sizes of selected BMPs (Table 44)
			Continue to identify at least 3 additional landowners each year to implement BMPs that reduce suspended solids levels for first 3 year and review thereafter.	PP: NRCS, NRCS Tech Team, Farm Service Agency	
Implement proper BMPs to reduce turbidity in 8 of the 23 water sample sites that exceed turbidity loads	5	Landowners in the Plummer Creek Watershed	Identify at least 10 landowners with potential interest in BMP implementation focus on reducing turbidity, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, and provide necessary resources for implementation for first 3 year and review thereafter.	PP: NRCS, NRCS Tech Team, Farm Service Agency	Varies based on types and sizes of selected BMPs (Table 44)
			Continue to identify at least 3 additional landowners each year to implement BMPs that reduce turbidity levels in management areas for first 3 year and review thereafter.	PP: NRCS, NRCS Tech Team, Farm Service Agency	

Objectives	Goal	Target Audience	Milestones	Possible Partners/ Technical Assistance	Cost
Implement proper BMPs to reduce E. coli load by 4.5362 E+15 organisms per year	6	Landowners in the Plummer Creek Watershed	Identify at least 6 landowners with potential interest in BMP implementation focus on reducing E.coli, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, and provide necessary resources for implementation for first 3 year and review thereafter.	PP: NRCS, NRCS Tech Team, Farm Service Agency	Varies based on types and sizes of selected BMPs (Table 44)
			Continue to identify at least 2 additional landowners each year to implement BMPs that reduce bacteria levels for first 3 year and review thereafter.	PP: NRCS, NRCS Tech Team, Farm Service Agency	
Implement proper BMPs to increase CQHEI Habitat Scores	7&8	Landowners in the Plummer Creek Watershed	Identify at least 4 landowners with potential interest in BMP implementation focus on improving stream habitat, and provide necessary resources for implementation and increase by one each additional year for first 3 year and review thereafter.	PP: NRCS, NRCS Tech Team, Farm Service Agency	Varies based on types and sizes of selected BMPs (Table 44)

Tracking effectiveness

Strategy

Once the plan is enacted, after the completion of the first BMP, water quality will continue to be monitored on a quarterly basis, or more frequently, at problem sites, or sites in critical areas that can represent sub watersheds where problems have been observed. Macro-invertebrate and habitat data will be collected and analyzed using Hoosier Riverwatch methods in either the month of August, September, or October for a total of three times in the first three years. All testing will use the existing QAPP, or will be updated or a new one written as needed, as to maintain quality control for sample collection. Chemical and nutrient monitoring will be done once quarterly, or more frequently, for a least a total of 12 times over the first three year period. The watershed coordinator will test for dissolved oxygen, flow, ammonia, pH, temperature, turbidity, total dissolved solids, total biological oxygen demand, and specific conductivity. Samples will be taken for each session to a professional laboratory in the area for testing of total phosphorus, total suspended solids, nitrates, and E. coli. This will be done using the same methods as used during the investigative and planning phase. Results will be monitored and recorded by the watershed coordinator quarterly and results will be compared to readings taken for investigation so that improvements can be noted. Monitoring will continue to assure no relapse or new problems are created. At the end of the first three years, monitoring results will be analyzed to determine if goals have been met. Depending on those results, additional short term goals can be developed at that time, or revisions to current goals can be made. Education will also be important to the second phase of the project. Workshops will be set up by the Plummer Creek Advisory Committee and the Greene County SWCD, along with any partners that are willing to assist. At least one workshop will be held in the first year of implementation and three more will follow in the remaining years. It is crucial to future success that knowledge of water quality spreads throughout the watershed and the county. Knowledge gained from workshops will be measured by surveys given to each participant. Technical assistance will be provided by a partnership with the NRCS technical team and District Coordinator as their time and resources allow. Any costs that are needed for the continual improvement of water quality within the Plummer Creek Watershed will be taken on by the landowner whose land is in cost-share BMP. When possible, if the BMPs are up to the NRCS' standards, BMPs may be reenrolled into cost-share programs at the discretion of the NRCS District Coordinator. Costs incurred from water testing will be shouldered by the Greene County SWCD or any donations received for the purpose of monitoring water quality.

Future Activities

Once the implementation of the cost-share project is underway, progress towards the load reduction goals will be assessed through the STEPL Load Estimation Model. Further funding will be aggressively sought by the Greene SWCD to continue reducing E. coli, sediment and nutrient loading into streams while increasing the quality of habitat and encouraging diversity within the Plummer Creek Watershed. Educational programs and events geared toward best management practices will continue through collaboration with local SWCDs and other agencies, water utilities, and communities. Currently, we have received a promise of a cash grant from Baxter Pharmaceuticals for $5,000 to be used for monitoring costs (contingent upon receipt of the 319 Implementation grant). Similarly, further funding will be sought to continue monitoring progress towards water quality goals.

The WMP will be reviewed at least every 5 years and revised as needed by the Greene County SWCD Board and/or the Plummer Creek Advisory Committee. Reasons for this may range from new construction and development of lands or a new concern brought to the district by a concerned landowner. To report a possible problem, landowners should call the SWCD office at 812-384-4781x3, by visiting 104 CR 70E, Ste B or send an email to greenewatershed@yahoo.com.

Following the completion of the 319 PCW Implementation Grant, all goals and loads will be reassessed to determine the success or lessons learned for the applications toward future implementation grants and other sources of funding. These lessons learned will be used by the Greene County SWCD in applying for future grants and for controling water quality concerns in other areas of the county. The Greene County SWCD has expressed interest in applying for 319 grants for other 10-digit watersheds within Greene County. Though the PCW is the largest of these, there are several others in key areas. One such key area is the Goosepond, near Linton, IN within the Black Creek Watershed. This is a wildlife refuge and a great spot for birdwatching, as birds from all over North America stop at the Goosepond during migration. This is an area of Greene County that has the greatest urban area, although a lot of farm land would be included as well. The diverse environment, as well as the Goosepond, have caused an interest to know the water quality of the area and will be a future focus of a 319 grant application.

References

Alliance of Indiana Rural Water (2011). *Middle Patoka River Watershed Source Water Protection Plan*. Retrieved from http://www.in.gov/idem/nps/files/wmp_patoka-middle.pdf.

Christopher B. Burke Engineering (1999). Indiana Drainage Handbook. Retrieved from http://www.in.gov/dnr/water/4893.htm.

Environmental Laboratory. 1987. Corps of Engineers Wetlands Delineation Manual. Technical Report Y-87-1. United States Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Environmental Science Institute (2013). *What is Karst?* Retrieved from http://www.esi.utexas.edu/outreach/caves/karst.php.

Frakenberger, Dr. J (2012). *Safe Water for Swimming and Wading*. Retrieved from https://engineering.purdue.edu/SafeWater/watershed/ecoli.html#safe.

Greene County Tourism Advisory Board (2014). *American Bottoms Area*. Retrieved from http://www.visitgc.com/where-to-go/nature/american-bottoms-area/#.U6-OPvldWAV.

Hall, T (2012). *INRD- Richland Creek Viaduct*. Retrieved from http://bridgehunter.com/in/greene/bh36720/.

HM Digital (2012). *What is TDS?* Retrieved from http://www.tdsmeter.com/what-is#where.

Indiana Department of Environmental Management (2013). *Water Quality Targets*. Retrieved from http://www.in.gov/idem/nps/3484.htm.

Indiana Department of Environmental Management (2012). *Indiana's 2014 Integrated Water Monitoring and Assessment Report.* Appendix H: 303(d) Attachment 5- Draft 2012. Retrieved from http://www.in.gov/idem/nps/files/305b_ir_report_2012_apndx_h_attch_5.pdf.

Indiana Department of Environmental Management: Office of Water Quality (2001). Lower White River Watershed Restoration Action Strategy. Retrieved from http://www.in.gov/idem/nps/files/wras_white-lower_part1.pdf.

Indiana Department of Environmental Management: Office of Water Quality (2006). *Total Maximum Daily Load for Escherichia coli (E. coli) For the Plummer Creek Watershed, Greene County.* Retrieved from http://www.in.gov/idem/nps/files/tmdl_plummer_report.pdf.

Indiana Department of Environmental Management: Office of Water Quality (2006). *Total Maximum Daily Load for Escherichia coli (E. coli) For the Richland Creek Watershed, Greene, Monroe, and Owen Counties, Greene County.* Retrieved from http://www.in.gov/idem/nps/files/tmdl_richlandcrk_report.pdf.

Indiana Department of Natural Resources (1980). The Indiana Water Resource: Recommendations for the Future. Retrieved from http://www.in.gov/dnr/water/files/805_all.pdf.

Indiana Wildlife Federation (2014). *Native Plants of Indiana*. Retrieved from http://www.indianawildlife.org/wildlife/native-plants/.

Lost River Watershed Partnership (2012). *Watershed Management Plan for the Lost River Watershed*. Retrieved from http://www.in.gov/idem/nps/files/wmp_lost_river_10-83.pdf.

Mallot, C. A. (1919). The American Bottoms region of Eastern Greene County, Indiana- A type unit of Southern Indiana physiology. *Indiana University Studies*. (Vol 6) Bloomington, IN: Indiana University.

Minnesota Department of Agriculture (2014). Conservation tillage. Retrieved from http://www.mda.state.mn.us/protecting/conservation/practices/constillage.aspx.

National Cooperative Soil Survey (2001). *Zanesville Series*. Retrieved from https://soilseries.sc.egov.usda.gov/OSD_Docs/Z/ZANESVILLE.html.

National Cooperative Soil Survey (1999). *Welston Series*. Retrieved from https://soilseries.sc.egov.usda.gov/OSD_Docs/W/WELLSTON.html.

National Cooperative Soil Survey (2004). *Gilpin Series*. Retrieved from https://soilseries.sc.egov.usda.gov/OSD_Docs/G/GILPIN.html.

National Cooperative Soil Survey (2011). *Haymond* Series. Retrieved from https://soilseries.sc.egov.usda.gov/OSD_Docs/H/HAYMOND.html.

Natural Resource Conservation Service (2010). Heavy use area protection. *Conservation Practice Standard* (Code 561). Retrieved from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_026275.pdf.

Natural Resource Conservation Service (2009). Rotational grazing: Small scale solutions for your farm. Retrieved from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1167364.pdf.

Talarovich, S.G. and N.C. Krothe. 1998. Three Component Storm Hydrograph Separation of a Karst Spring Contaminated by Polychlocinated Biphenyls, Central Indiana. AAPG. Special Issue. Environmental Geosciences. v. 5. no. 4. p 162-175.

United States Environmental Protection Agency (2010). *Region 5 Superfund: Neal's Landfill (Bloomington).* Retrieved from http://www.epa.gov/R5Super/npl/indiana/IND980614556.html.

United States Environmental Protection Agency (2012). *Nitrates*. Retrieved from http://water.epa.gov/type/rsl/monitoring/vms57.cfm.

Watershed Science Institute (1999). Technical note 3: the EPT index. *Watershed Condition Series*. Retrieved from ftp://ftp.wcc.nrcs.usda.gov/wntsc/strmRest/wshedCondition/EPTIndex.pdf.

Wessler Engineering (2012). Protecting Your Drinking Water: Wellhead Protection. Eastern Heights Utilities, Inc. Retrieved from http://ehuwater.com/whp.php.