***ESCHERICHIA COLI* AND IMPAIRED BIOTIC COMMUNITY TOTAL MAXIMUM DAILY LOAD REPORT FOR THE**

Big Raccoon Creek Watershed

DRAFT

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Prepared for

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1.0 EXECUTIVE SUMMARY

The Big Raccoon Creek watershed (HUC 0512010812) is located in west-central Indiana and drains a total of 215 square miles. The Big Raccoon Creek watershed originates near the Town of New Ross, and then flows southwest through the Town of Ladoga where it ultimately empties into the Cecil M. Harden Lake near the Town of Portland Mills. Land use throughout the watershed is predominantly agricultural.

The Clean Water Act (CWA) and U.S. Environmental Protection Agency (USEPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters on the Section 303(d) impaired waters list. A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs are composed of the sum of individual wasteload allocations (WLAs) for regulated sources and load allocations (LAs) for sources that are not directly regulated. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this is defined by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

This TMDL has been developed for *E. coli* and impaired biological communities (IBC) in the Big Raccoon Creek watershed.

After the Indiana Department of Environmental Management (IDEM) identifies a waterbody as having an impairment and places the waterbody on Indiana's Section 303(d) list of impaired waters, IDEM implements a sampling plan to determine the extent and the magnitude of the impairment. The next task is to reassess each waterbody using new sampling data and to examine the watershed as a whole. The reassessment data helps IDEM identify the area of concern for TMDL development. As a result of the reassessment for the Big Raccoon Creek watershed, the pollutants and the impaired segments for which TMDLs were developed differ from the pollutants and impaired segments appearing on the 2012 Section 303(d) list for the following reasons:

- Sampling performed by IDEM in 2010 generated new water quality data that were not available at the time the 2012 Section 303(d) list was developed.

Recent bacteriological data collected during the spring of 2010, by IDEM, indicates that all 15 of the sample sites violated the *E.coli* geometric mean of 125 MPN/100mL. During the summer of 2005 IDEM collected biological and chemical data at 28 sites in the watershed. Based on the results, six of the 28 sites had impaired biological communities. However, only the two sites addressed in this document had supporting chemistry data (TSS and TP) that exceed the targets for the TMDL. Additional stressors in the environment could be causing the biological impairments at the remaining four sites but without further investigation the cause is unknown. Bacteria reductions needed to achieve water quality standards range from 86%-94%. The reduction needed to improve the biological community are addressed through total phosphorus reductions ranging from 9%-56% and total suspended solids (sediment) which has a load reduction of 59% at a single site.

Several subwatersheds in the Big Raccoon Creek watershed have impaired biotic communities (IBC). Biological communities include fish and aquatic invertebrates, such as insects. These in-stream organisms are indicators of the cumulative effects of activities that affect water quality conditions over time. An IBC listing on Indiana's 303(d) list, suggests that one or more of the aquatic biological communities is unhealthy as determined by IDEM's monitoring data. IBC is not a source of impairment but a symptom of other sources. To address these impairments in the Big Raccoon Creek watershed, total phosphorus (TP) and total suspended solids (TSS) have been identified as pollutants for TMDL development.

Potential sources of *E. coli,* nutrients and sediments in the watershed include regulated point sources such as the Town of Advance wastewater treatment plant (WWTP), the New Ross WWTP, the Town of Ladoga WWTP, the Town of Roachdale WWTP, and the Demeree confined feeding operation (CFO). The Big Raccoon watershed has two Sanitary Sewer Overflows (SSO) and no Combined Sewer Overflows (CSO). Point sources are regulated through the National Pollutant Discharge Elimination System (NPDES). Nonpoint sources that are not directly regulated, such as row crop agriculture, livestock pastures, field tiles, failing home septic systems, runoff from urban areas, pets, and wildlife are also potential sources.

Determining the specific reasons for high *E. coli*, nutrient or sediments counts in any given waterbody is challenging. There are many potential sources for these pollutants and *E. coli* counts are inherently variable. Within the Big Raccoon Creek watershed, subwatersheds with predominantly agricultural land use have the highest concentrations of *E. coli* and nutrients. There are several types of nonpoint sources located in the Big Raccoon Creek watershed including agriculture, confined feeding operations, urban runoff and wildlife. Land application of manure in these subwatersheds could also be contributing to elevated *E. coli* levels. Other factors could explain this correlation, such as failing septic systems and the fact that these headwater streams tend to have smaller flow volume and thus have less dilution. Livestock access to streams and narrow riparian corridors also contribute to high bacteria and nutrient levels in the watershed. The steeper gradient in the downstream subwatersheds would also increase runoff volume and transport sediments and other pollutants into the streams. Although Indiana does not have a permitting program for nonpoint sources, many nonpoint sources are addressed through voluntary programs intended to reduce pollutant loads, minimize flow, and improve water quality. Specific sources of *E. coli,* nutrients and sediment to each impaired waterbody should be further evaluated during follow-up implementation activities.

An important step in the TMDL process is the allocation of the allowable loads to individual point sources as well as sources that are not directly regulated. The Big Raccoon Creek watershed TMDL includes these allocations, which are presented for each of the 53 Assessment Unit IDs (AUIDs) located in the seven 12-digit hydrologic unit code (HUC) subwatersheds. There are actually eight 12-digit HUC subwatersheds within the 10-digit HUC Big Raccoon Creek watershed, however, the Cecil M. Harden subwatershed is not addressed in this document because there was no data collected.

There are four NPDES permitted facilities located in the Big Raccoon Creek watershed, all of which are wastewater treatment plants. Of these facilities, three have been found to be in violation of their permit limits for *E. coli* and dissolved oxygen, one has been in violation of phosphorus and all four have been in violation of total suspended solids. Although all four NPDES facilities have been found to be in violation of their permit limits, the majority of the time discharge effluent from these facilities meets water quality standards.

This TMDL report identifies which locations could most benefit from focus on implementation activities. These areas throughout the Big Raccoon Creek watershed are referred to as potential priority implementation areas (PPIAs). It also provides recommendations on the types of implementation activities, including best management practices (BMPs) that key implementation partners in the Big Raccoon Creek watershed can consider to achieve the pollutant load reductions calculated for each subwatershed. PPIAs can help watershed stakeholders identify critical areas and select BMPs in the Big Raccoon Creek watershed through a watershed management planning process. Table 1 presents the PPIAs and associated BMP recommendations identified having a high likely degree of effectiveness to achieve the load reductions allocated to sources in each subwatershed.

Table 1. PPIAs and Recommended BMPs to Achieve Pollutant Reductions by Subwatershed

HUC-12 Subwatershed	PPIA Rank	Implementation Action	Estimated Pollutant Reduction
Little Raccoon Creek	1	Waste treatment lagoon	*E. coli*: 1.00E+13 billion/day Total Phosphorus: 0.24 lbs/day Total Suspended Solids: 90 lbs/day
		Nutrient management	
		Stream fencing (animal exclusion)	
		Pasture and hay plantings	
		Riparian forest and herbaceous plantings	
		Critical area planting	
		Filter strip	
		Prescribed grazing	
		Conservation tillage/residue management	
		Cover crops	
Byrd Branch	2	Nutrient management	*E. coli*: 9.81E+12 billion/day
		Stream fencing (animal exclusion)	
		Pasture and hay plantings	
		Riparian forest and herbaceous plantings	
		Conservation tillage/residue management	
Town of New Ross	3	Nutrient management	*E. coli*: 4.03E+12 billion/day
		Stream fencing (animal exclusion)	
		Waste treatment lagoon	
		Riparian forest and herbaceous plantings	
		Conservation tillage/residue management	
Headwaters of Big Raccoon Creek	4	Waste treatment lagoon	*E. coli*: 2.40E+12 billion/day Total Phosphorus: 0.88 lbs/day
		Nutrient management	
		Stream fencing (animal exclusion)	
		Pasture and hay plantings	
		Riparian forest and herbaceous plantings	
		Prescribed grazing	
		Conservation tillage/residue management	
		Cover crops	
		Conservation crop rotation	
		Manure handling, storage, treatment, and disposal	
Cornstalk Creek	5	Nutrient management	*E. coli*: 1.75E+12 billion/day
		Stream fencing (animal exclusion)	
		Riparian forest and herbaceous plantings	
		Conservation tillage/residue management	
		Prescribed grazing	
North Ramp Creek	6	Nutrient management	*E. coli*: 1.67E+12 billion/day
		Stream fencing (animal exclusion)	
		Riparian forest and herbaceous plantings	

HUC-12 Subwatershed	PPIA Rank	Implementation Action	Estimated Pollutant Reduction
		Conservation tillage/residue management	
		Prescribed grazing	
Haw Creek	7	Nutrient management	*E. coli*: 9.64E+11 billion/day
		Stream fencing (animal exclusion)	
		Riparian forest and herbaceous plantings	
		Conservation tillage/residue management	
		Prescribed grazing	

Public participation is an important and required component of the TMDL development process. The following public meeting and public comment periods have been held to further develop this project:

- A Draft TMDL meeting was held at the Bainbridge Community Building on June 26, 2013 during which IDEM described the TMDL program and provided an overview of the draft TMDL results.

2.0 INTRODUCTION

This section of the TMDL provides an overview of the Big Raccoon Creek watershed location and the regulatory requirements that have led to the development of this TMDL to address impairments in the Big Raccoon Creek watershed.

The Big Raccoon Creek watershed (HUC 0512010812), shown in Figure 1 is located in west-central Indiana in Boone, Montgomery, Hendricks, Putnam and Parke Counties and drains a total of 215 square miles. The Big Raccoon Creek originates near the Town of New Ross, and then flows southwest through the Town of Ladoga where it ultimately empties into the Cecil M. Harden Lake near the Town of Portland Mills. Land use throughout the watershed is predominantly agriculture.

The Clean Water Act and U.S. Environmental Protection Agency (USEPA) regulations require that states develop TMDLs for waters on the Section 303(d) lists. USEPA defines a TMDL as the sum of the individual wasteload allocations (WLA) for point sources and load allocations (LA) for nonpoint sources, and a margin of safety (MOS) that addresses the uncertainty in the analysis.

The overall goals and objectives of the TMDL study for the Big Raccoon Creek watershed are:

- Assess the water quality of the impaired waterbodies and identify key issues associated with the impairments and potential pollutant sources.
- Determine current loads of pollutants to the impaired waterbodies.
- Use the best available science and data to determine the TMDL the waterbodies can receive and still support the designated uses for which they were impaired.
- If current loads exceed the maximum allowable loads, determine the load reduction that is needed.
- Inform and involve the public throughout the project to ensure that key concerns are addressed and the best available information is used.
- Identify potential priority implementation areas (PPIAs) that watershed stakeholders can use to identify critical areas.
- Recommend activities for purposes of TMDL implementation.
- Submit a final TMDL report to the USEPA for review and approval.

Watershed stakeholders and partners can use the final approved TMDL report to craft a watershed management plan (WMP) that meets both USEPA's nine minimum elements under the CWA Section 319 Nonpoint Source Program, as well as the additional requirements under IDEM's WMP Checklist.

Figure 1. Location of Big Raccoon Creek Watershed

2.1 Water Quality Standards

Under the Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the CWA's goal of "swimmable/fishable" waters. Water quality standards consist of three different components:

- **Designated uses** reflect how the water can potentially be used by humans and how well it supports a biological community. Examples of designated uses include aquatic life support, drinking water supply, and full body contact recreation. Every waterbody in Indiana has a designated use or uses; however, not all uses apply to all waters. The Big Raccoon Creek Watershed TMDLs focus on protecting the designated full body contact recreational uses and supporting a well-balanced warm-water aquatic community.

- Criteria express the condition of the water that is necessary to support the designated uses. **Numeric criteria** represent the concentration of a pollutant that can be in the water and still protect the designated use of the waterbody. **Narrative criteria** are the general water quality criteria ("free froms…") that apply to all surface waters. Numeric criteria were used as the basis of the *E. coli* TMDLs while narrative criteria were used as the basis of the IBC TMDLs in the Big Raccoon Creek Watershed.

The numeric *E. coli* criteria associated with protecting the recreational use are described below.

> *"The criteria in this subsection are to be used to evaluate waters for full body contact recreational uses, to establish wastewater treatment requirements, and to establish effluent limits during the recreational season, which is defined as the months of April through October, inclusive. E. coli bacteria, shall not exceed one hundred twenty-five (125) per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty-five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period. . . However, a single sample shall be used for making beach notification and closure decisions."* [Source: Indiana Administrative Code Title 327 Water Pollution Control Board. Article 2. Section 1-6(a).]

The term nutrients refers to the various forms of nitrogen and phosphorus found in a waterbody. Both nitrogen and phosphorus are necessary for aquatic life, and both elements are needed at some level in a waterbody to sustain life. The natural amount of nutrients in a waterbody varies depending on the type of system. A pristine mountain spring might have little to almost no nutrients, whereas a lowland, mature stream flowing through wetland areas might have naturally high nutrient concentrations. Streams draining larger areas are also expected to have higher nutrient concentrations.

Nutrients generally do not pose a direct threat to the designated uses of a waterbody. However, excess nutrients can cause an undesirable abundance of plant and algae growth, a process is called eutrophication. Eutrophication can have many effects on a stream. One possible effect is low dissolved oxygen concentrations caused by excessive plant respiration and/or decay. Ammonia, which is toxic to fish at high concentrations, can be released from decaying organic matter when eutrophication occurs. For these reasons, excessive nutrients can result in the non-attainment of biocriteria and impairment of the designated use.

Like most states, Indiana has not yet adopted numeric water quality criteria for nutrients and sediment. The relevant narrative criteria that apply to the TMDLs presented in this report state the following:

> *"All surface waters at all times and at all places, including waters within the mixing zone, shall meet the minimum conditions of being free from substances, materials, floating debris, oil, or scum attributable to municipal, industrial, agricultural, and other land use practices, or other discharges that do any of the following:" [327 IAC 2-1-6. Sec. 6. (a)(1)]…*
>
> *(a)re in concentrations or combinations that will cause or contribute to the growth of aquatic plants or algae to such degree as to create a nuisance, be unsightly, or otherwise impair the designated uses." [327 IAC 2-1-6. Sec. 6. (a) (1)(D)]*
>
> *(a)re in amounts sufficient to be acutely toxic to, or to otherwise severely injure or kill, aquatic life, other animals, plants, or humans." [327 IAC 2-1-6. Sec. 6. (a) (1)(E)]*

In addition, the narrative biological criterion [327 IAC 2-1-3(2)] states the following:

> *"All waters, except those designated as limited use, will be capable of supporting a well-balanced, warm water aquatic community."*

The water quality regulatory definition of a "well-balanced aquatic community" is "*an aquatic community which is diverse in species composition, contains several different trophic levels, and is not composed mainly of strictly pollution tolerant species*" [327 IAC 2-1-9(49)].

Table 2, presents the criteria associated with the fish community Index of Biotic Integrity (IBI) and the macroinvertebrate Index of Biotic Integrity (mIBI) that indicates whether a watershed is fully supporting or not supporting the aquatic life use.

Table 2. Aquatic Life Use Support Criteria for Biological Communities

Parameter	Fully Supporting	Not Supporting
Fish community Index of Biotic Integrity (IBI) Scores (Range of possible scores is 0-60)	IBI ≥ 36	IBI < 36
Benthic aquatic macroinvertebrate community Index of Biotic Integrity (mIBI) Scores (Range of possible scores is 12-60)	mIBI ≥ 36	mIBI < 36

2.2 TMDL Target Values

Target values are needed for the development of TMDLs because of the need to calculate allowable daily loads. For parameters that have numeric criteria, such as *E. coli*, the target equals the numeric criteria. For parameters that do not have numeric criteria, target values must be identified from some other source. The target values used to develop the Big Raccoon Creek Watershed TMDL are presented below.

2.2.1 *E. coli*

The target value used for the Big Raccoon Creek Watershed TMDL was based on the 125 counts/100 mL geometric mean component of the standard (i.e., daily loading capacities were calculated by multiplying flows by 125 counts/100 mL). This approach ensures that both components of the standard will be met since a daily loading capacity based on 125 counts/100 mL will, by definition, meet the 235 counts/100 mL component of the standard. The use of the geometric mean component of the standard results in an added MOS (see Section 8.2 for more details).

2.2.2 IBC TMDLs

The following sections describe the TMDL target values used for total phosphorus, dissolved oxygen and total suspended solids when developing an IBC TMDL.

2.2.2.1 Total Phosphorus

Although Indiana has not yet adopted numeric water quality criteria for nutrients, IDEM has identified the following nutrient benchmarks that are used to assess potential nutrient impairments:

- Total phosphorus should not exceed 0.30 mg/L (USEPA's nationwide 1986 Quality Criteria for Waters also known as the *Gold Book*).

The total phosphorus (0.30 mg/L) value was used as a TMDL target during the development of the Big Raccoon Creek Watershed TMDL. IDEM has determined that meeting these targets will result in achieving the narrative biological criterion by improving water quality and promoting a well-balanced aquatic community.

2.2.2.2 Dissolved Oxygen

The target value used for the Big Raccoon Creek Watershed TMDL was based on the narrative water quality criterion [327 IAC 2-1-6] states the following:

- *Concentrations of dissolved oxygen shall: (A) average at least five (5.0) milligrams per liter per calendar day; and (B) not be less than four (4.0) milligrams per liter at any time.*

Due to standard operating procedures for the data collection of this project the Big Raccoon Creek Watershed TMDL will use 4.0 mg/L as the target value since data was not collected more than one time per calendar day.

2.2.2.3 Total Suspended Solids

Although Indiana has not yet adopted numeric water quality criteria for TSS, IDEM has identified a target value based on IDEM's National Pollutant Discharge Elimination System (NPDES) permitting process. A target of 30.0 mg/L for total suspended solids TSS has been identified as a permit limit for NPDES facilities. A target value of 30.0 mg/L TSS was therefore used as the TSS TMDL target value to ensure consistency with IDEM's NPDES permitting process. IDEM has determined that meeting the TSS target will result in achieving the narrative biological criterion by improving water quality and promoting a well-balanced aquatic community. Note that the TSS permit limit for 10:1 dilution ratio wastewater systems is 75 mg/L.

Several subwatersheds in the Big Raccoon Creek watershed have impaired biotic communities (IBC). Biological communities include fish and aquatic invertebrates, such as insects. These in-stream organisms are indicators of the cumulative effects of activities that affect water quality conditions over time. An IBC listing on Indiana's 303(d) list, means IDEM's monitoring data shows one or both of the aquatic communities are not as healthy as they should be. IBC is not a source of impairment but a symptom of other sources. To address these impairments in the Big Raccoon Creek watershed, total phosphorus and dissolved oxygen have been identified as pollutants for TMDL development.

2.3 Listing Information

There are a number of existing impairments in the Big Raccoon Creek watershed from the draft 2012 303(d) List of Impaired Waters (Figure 2). The listings and causes of impairment have been adjusted as a result of reassessment data collected in 2010 at 15 sampling locations in the watershed (Figures 4). Based on this data, the Big Raccoon Creek watershed has a total of 53 AUIDs cited as impaired for *E. coli*. No biological data was collected in 2010, however there are seven previously listed AUIDs with IBC impairments (Figure 2). The two AUIDs cited for IBCs that are addressed in this document are based on historical 2005 data (Figure 3). There are approximately 345 impaired stream miles addressed in this document which will be listed on the 2014 303(d) list of impaired waters. Cecil M. Harden Lake, a 2060 acre lake, is also on the Lakes 303(d) List of Impaired Waters for polychlorinated biphenyls (PCB) and mercury concentrations in the fish tissue.

Table 3 presents listing information for the Big Raccoon Creek watershed, including a comparison of the updated listings with the 2010 listings and associated causes of impairments addressed by the TMDLs. The reassessment data used in updating the listings for the Big Raccoon Creek watershed are available in Appendix B.

IDEM identifies the Big Raccoon Creek watershed and its tributaries using a watershed numbering system developed by United States Geological Survey (USGS), Natural Resource Conservation Service (NRCS), and the U.S. Water Resources Council referred to as hydrologic unit codes (HUCs). HUCs are a way of identifying watersheds in a nested arrangement from largest (i.e., those with shorter HUCs) to smallest (i.e., those with longer HUCs). For more information on HUCs, go to http://www.in.gov/idem/nps/2422.htm. Figure 6 shows the 12-digit HUCs located in the Big Raccoon Creek watershed.

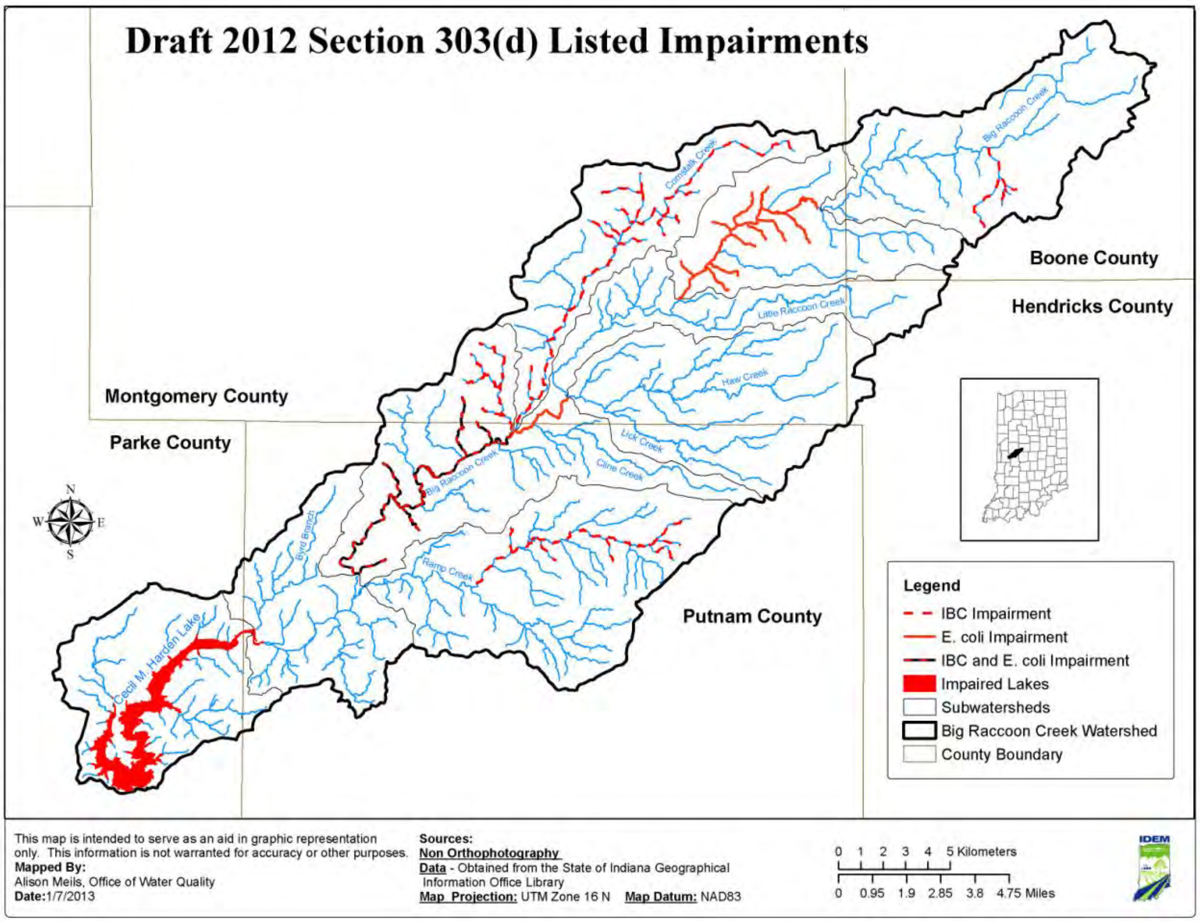

Figure 2. Streams and Lakes Listed on the Draft 2012 Section 303(d) List in the Big Raccoon Creek Watershed

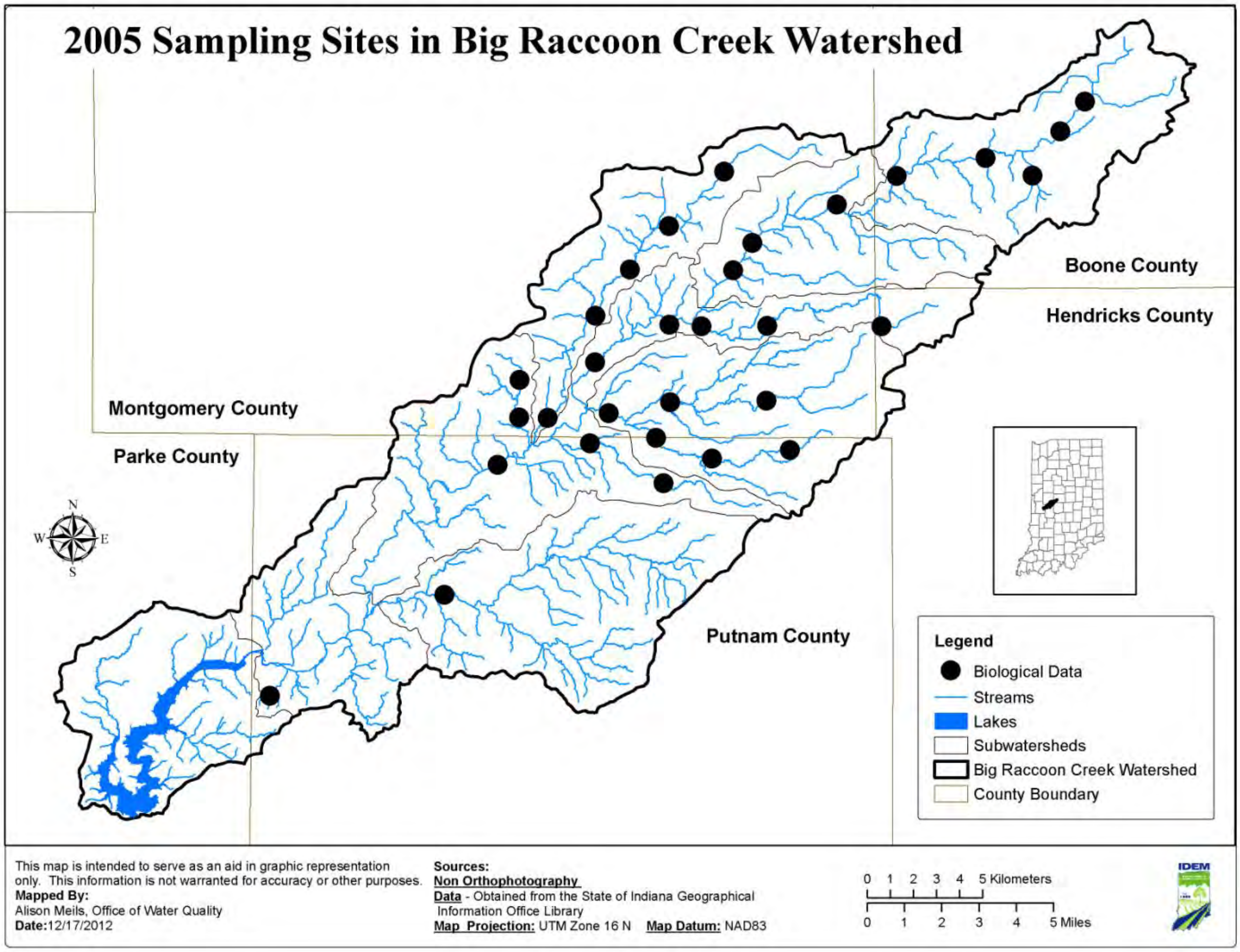

Figure 3. Sampling Locations in 2005 Big Raccoon Creek Watershed Study

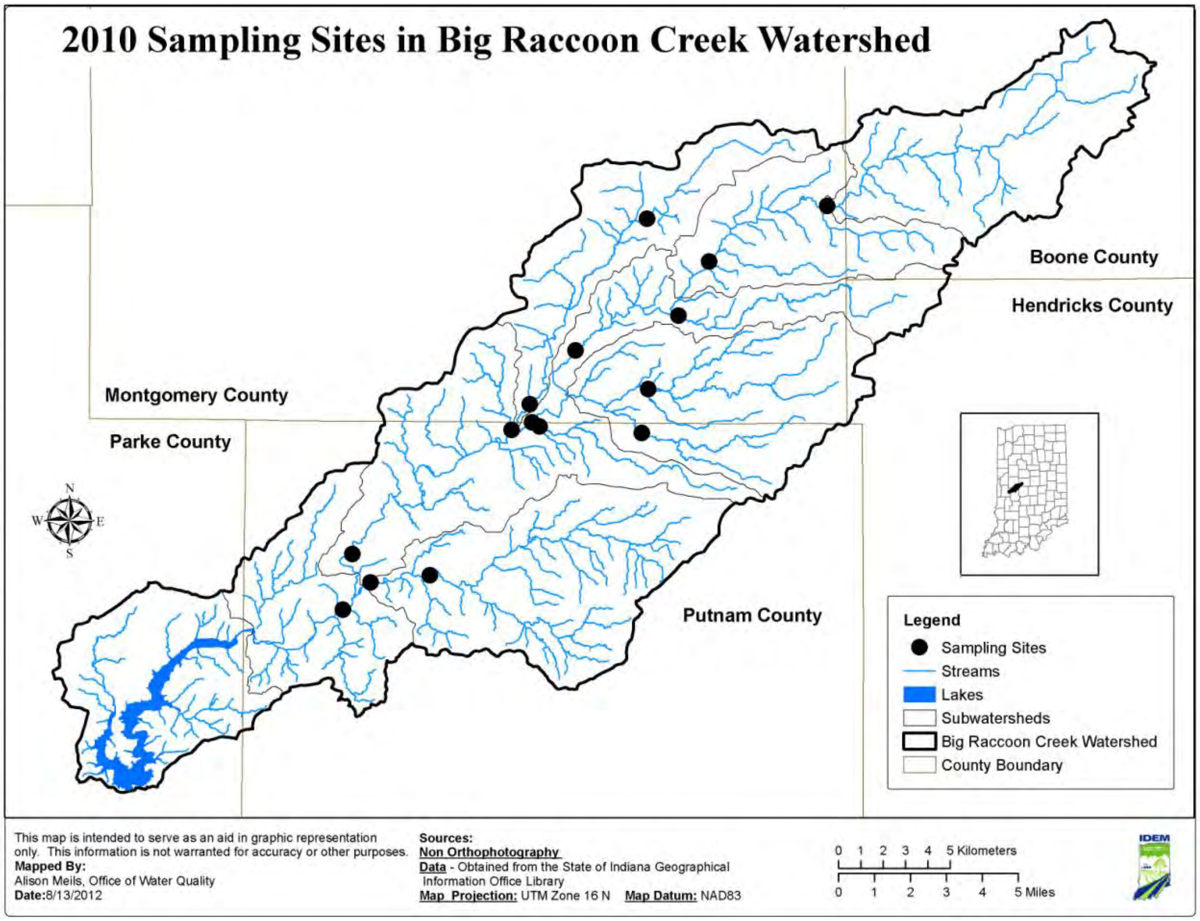

Figure 4. Sampling Locations in the 2010 Big Raccoon Creek Watershed Study

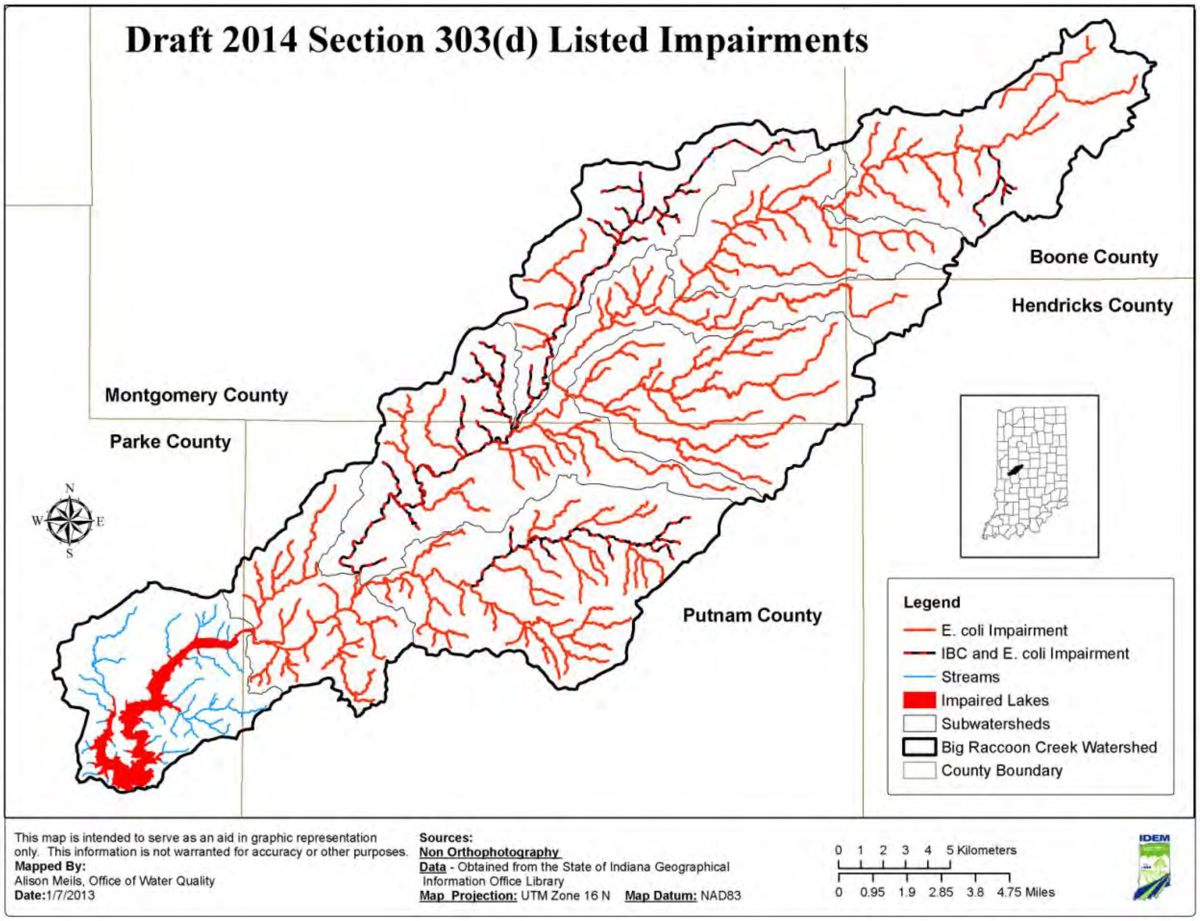

Figure 5. Streams and Lakes Listed on the Draft 2014 Section 303(d) List in the Big Raccoon Creek Watershed

Table 3. Section 303(d) List Information for the Big Raccoon Creek Watershed for 2010 and 2014

Watershed (10-digit HUC)	Subwatershed (12-digit HUC)	Previous AUID 2010	2010 Section 303(d) Listed Impairment	New AUID 2014	Updated Impairments to be Listed in 2014
Cecil M. Harden Lake – Big Raccoon Creek (0512010812)	Headwaters of Big Raccoon Creek (051201081201)	INB08G1_T1034		INB08C1_01	*E. coli*
		INB08G1_T1001		INB08C1_T1001	*E. coli*
		INB08G1_01A		INB08C1_T1002	*E. coli*
				INB08C1_T1003	*E. coli*
		INB08G1_00	IBC	INB08C1_T1004	*E. coli*, IBC
	Town of New Ross (051201081202)	INB08G2_T1035	*E. coli*, IBC	INB08C2_02	*E. coli*
				INB08C2_T1011	*E. coli*
				INB08C2_T1012	*E. coli*
				INB08C2_T1013	*E. coli*

Watershed (10-digit HUC)	Subwatershed (12-digit HUC)	Previous AUID 2010	2010 Section 303(d) Listed Impairment	New AUID 2014	Updated Impairments to be Listed in 2014
Cecil M. Harden Lake – Big Raccoon Creek (0512010812)	Haw Creek (051201081203)	INB08G4_00		INB08C3_01	*E. coli*
				INB08C3_02	*E. coli*
				INB08C3_T1001	*E. coli*
				INB08C3_T1002	*E. coli*
				INB08C3_T1003	*E. coli*
				INB08C3_T1004	*E. coli*
				INB08C3_T1005	*E. coli*
	Cornstalk Creek (051201081204)	INB08G5_01 INB08G5_02	IBC	INB08C4_01	*E. coli*, IBC
				INB08C4_T1001	*E. coli*
				INB08C4_T1002	*E. coli*
				INB08C4_T1003	*E. coli*
				INB08C4_T1004	*E. coli*
	North Ramp Creek (051201081205)	INB08G8_T1041	IBC	INB08C5_01	*E. coli*, IBC
				INB08C5_T1001	*E. coli*
				INB08C5_T1002	*E. coli*
				INB08C5_T1003	*E. coli*
				INB08C5_T1004	*E. coli*
				INB08C5_T1005	*E. coli*
				INB08C5_T1006	*E. coli*
				INB08C5_T1007	*E. coli*
		INB08G9_T1042	IBC	INB08C5_T1008	*E. coli*, IBC
		INB08G9_01		INB08C5_02	*E. coli*
		INB08G9_T1001		INB08C5_T1009	*E. coli*
				INB08C5_T1010	*E. coli*
	Little Raccoon Creek (051201081206)	INB08G3_T1036		INB08C6_01	*E. coli*
		INB08G3_00		INB08C6_T1001	*E. coli*
		INB08G6_01	*E. coli*	INB08C6_02	*E. coli*
		INB08G6_T1001		INB08C6_T1002	*E. coli*
		INB08G7_T1040 INB08G6_01	IBC	INB08C6_03	*E. coli*, IBC
		INB08G6_T1002	IBC	INB08C6_T1003	*E. coli*, IBC
				INB08C6_T1004	*E. coli*
				INB08C6_T1005	*E. coli*
				INB08C6_T1006	*E. coli*
				INB08C6_T1007	*E. coli*

Watershed (10-digit HUC)	Subwatershed (12-digit HUC)	Previous AUID 2010	2010 Section 303(d) Listed Impairment	New AUID 2014	Updated Impairments to be Listed in 2014
Cecil M. Harden Lake – Big Raccoon Creek (0512010812)	Byrd Branch (051201081207)	INB08GA_00 INB08GA_T1043		INB08C7_01	*E. coli*
				INB08C7_T1001	*E. coli*
				INB08C7_T1002	*E. coli*
				INB08C7_T1003	*E. coli*
				INB08C7_T1004	*E. coli*
				INB08C7_T1005	*E. coli*
				INB08C7_T1006	*E. coli*
				INB08C7_02	*E. coli*
				INB08C7_T1007	*E. coli*
				INB08C7_T1008	*E. coli*

-Only the *E. coli* and some IBC impairments are being addressed in this TMDL document

Understanding Table 3:

- *Column 1: Watershed (10-digit HUC).* Lists the subwatersheds at the 10-digit HUC scale that were part of the initial assessment for the Big Raccoon Creek watershed.
- *Column 2: Subwatershed (12-digit HUC).* Shows the name of the subwatershed at the 12-digit HUC scale. The subwatershed found in this second column is the appropriate scale for what the IDEM's WMP Checklist defines as a subwatershed for the purposes of watershed management planning.
- *Column 3: Previous AUID 2010.* Identifies the AUID given to waterbodies within the 12-digit HUC subwatershed for purposes of the 2010 Section 303(d) listing assessment process.
- *Column 4: 2010 Section 303(d) Listed Impairment .* Identifies the cause of impairment associated with the 2010 Section 303(d) listing.
- *Column 5: New AUID 2014.* Provides the updated AUIDs associated with each 12-digit HUC subwatershed. Look for these AUIDs used throughout this report to present detailed analysis of sources, load allocations, and recommended implementation activities in PPIAs.
- *Column 6: Updated Impairments to be Listed 2014.* Provides the updated causes of impairment if new data and information are available.

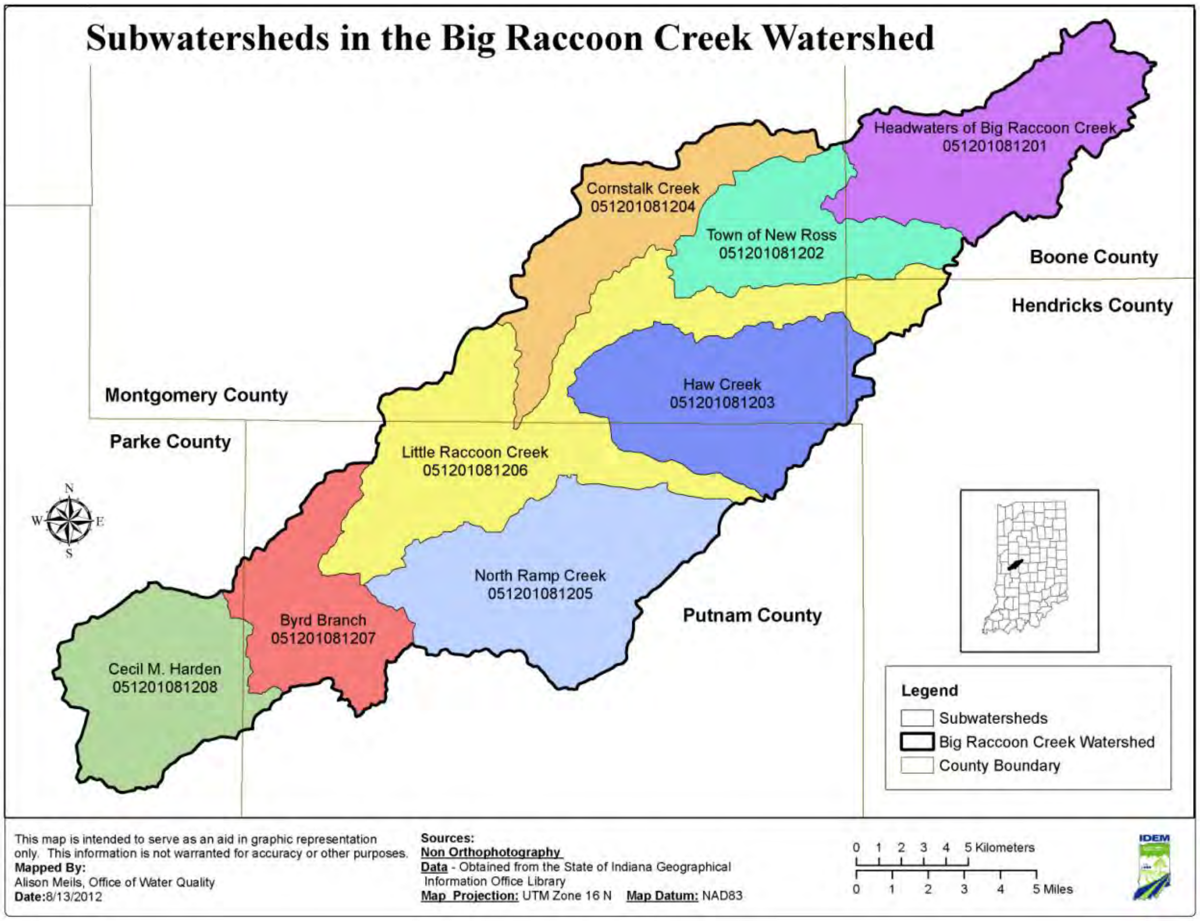

Figure 6. Subwatersheds (12-Digit HUCs) in the Big Raccoon Creek Watershed

3.0 DESCRIPTION OF THE WATERSHED

This section of the TMDL report contains a brief characterization of the Big Raccoon Creek watershed to provide a better understanding of the historic and current conditions of the watershed that affect water quality and contribute to the *E. coli* and IBC impairments. Understanding the natural and human factors affecting the watershed will assist in selecting and tailoring appropriate and feasible implementation activities to achieve water quality standards.

3.1 Land Use

Land use patterns provide important clues to the potential sources of impairments in a watershed. Land use information for the Big Raccoon Creek watershed is available from the U.S. Geological Survey (USGS). These data categorize the land use for each 30 meters by 30 meters parcel of land in the watershed based on satellite imagery from circa 2006. Figure 7 displays the spatial distribution of the land uses and the data are summarized in Table 4.

Land use in the Big Raccoon Creek watershed is primarily agricultural land, comprising 73 percent, and can indicate presence of animals, manure spreading and crop fertilization throughout the landscape. Spreading of manure and inorganic fertilizer on agricultural fields is a common practice in Indiana however if it occurs before a rain event or when the ground is frozen the runoff caused by precipitation will wash huge nutrient and bacteria loads into the streams. These large amounts of nutrients entering the stream can cause excessive algae growth which in turn can deplete the streams of oxygen. Many of the streams lack a riparian buffer to catch the loadings before they enter the stream. Approximately 13 percent of the land is forested and 6 percent is developed. Pastured lands and hay fields represent another 5 percent of the watershed and indicate the presence of animal feedlots that can be significant sources of E. coli, nutrients and sediments. The remaining land categories represent less than 9 percent of the total land area.

The Big Raccoon Creek watershed has a diverse network of streams. Tributaries include the Cornstalk Creek, Haw Creek, Little Raccoon Creek, North Ramp Creek, Byrd Branch, and Troutman Branch among others. The headwaters and many of the tributaries of the watershed are agricultural ditches with little riparian cover, but as you move down the mainstem of Big Raccoon Creek the riparian cover improves and the gradient gradually increases. Agricultural fields in the area are drained using field tiles to remove excess water from soil subsurface. Drainage brings soil moisture levels down for optimal crop growth. There have been wavyrayed lampmussel (*Lampsilis fasciola*) shells collected in the watershed, which is a state species of special concern. Although no living specimens have been collected, this indicates there are likely live populations of the species in the watershed. The wavyrayed lampmussel occurs in small-medium sized shallow streams, in and near sand or gravel riffles, with good current. Additional information on state endangered, threatened and rare species can be found on the DNR website (http://www.in.gov/dnr/naturepreserve/4666.htm).

Table 4. Land Use of Big Raccoon Creek Watershed

Land Use	Watershed		
	Area		Percent
	Acres	Square Miles	
Open Water	2168	3.39	1.57
Developed, Open space	7173	11.21	5.2
Developed, Low Intensity	790	1.23	0.57
Developed, Medium Intensity	95	0.15	0.07

Developed, High Intensity	19	0.03	0.01
Forest	17825	27.85	12.93
Shrub/Scrub	1549	2.42	1.12
Hay/Pasture	7640	11.94	5.54
Agriculture	100556	157.12	72.92
Wetlands	84	0.13	0.06
TOTAL	**137,899**	**215.47**	**100**

Understanding Table 4: The predominant land use types in the Big Raccoon Creek watershed can indicate potential sources of *E. coli*, nutrient and sediment loadings. Different types of land uses are characterized by different types of hydrology. For example, developed lands are characterized by impervious surfaces that increase the potential of storm water events during high flow periods delivering *E. coli* to downstream streams and rivers. Forested land and wetlands allow water to infiltrate slowly thus reducing the risks of polluted water running off into waterbodies. In addition to differences in hydrology, land use types are associated with different types of activities that could contribute *E. coli*, nutrients and sediments to the watershed. Understanding types of land uses will help identify the type of implementation approaches that watershed stakeholders can use to achieve pollutant load reductions.

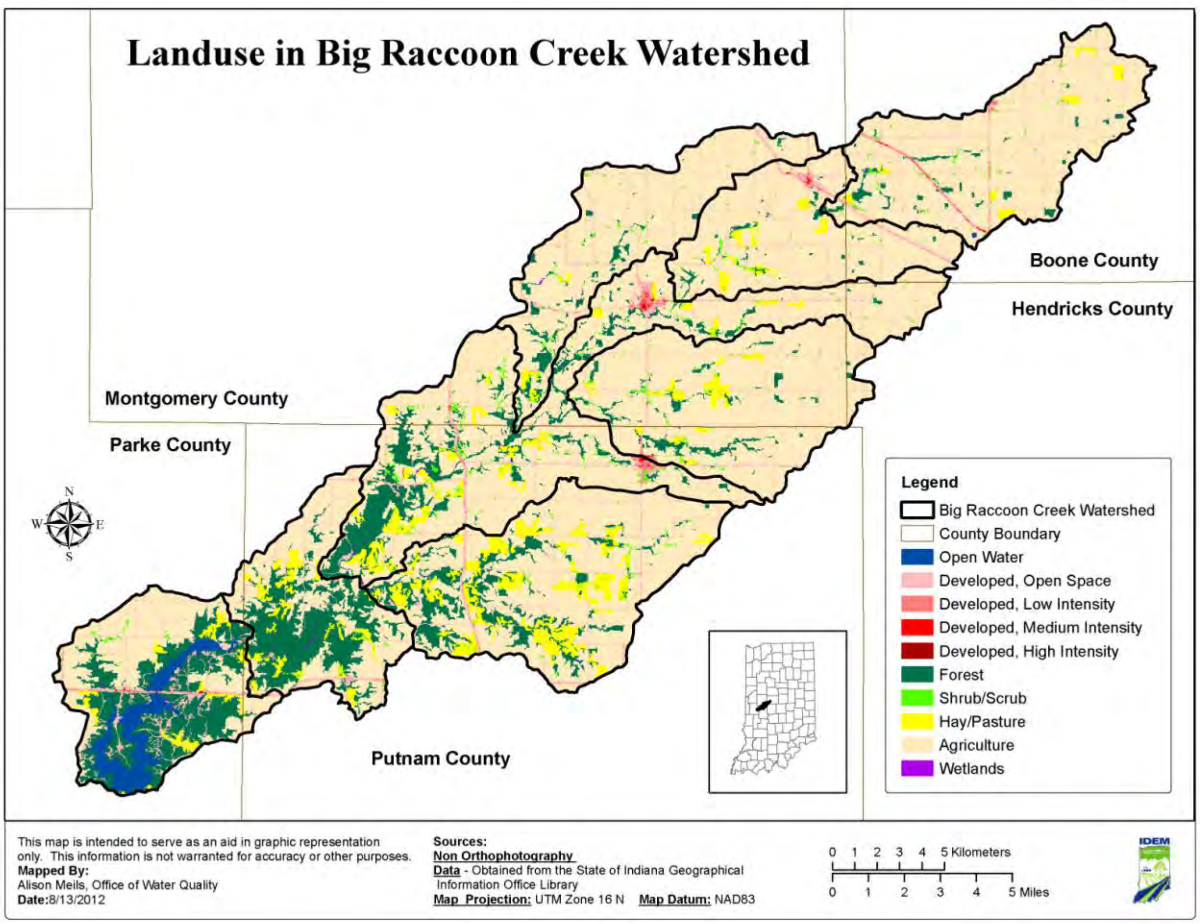

Figure 7. Land Use in the Big Raccoon Creek Watershed

3.2 Human Population

Counties with land located in the Big Raccoon Creek watershed include Boone, Hendricks, Montgomery, Putnam and Parke. Major government units with jurisdiction at least partially within the Big Raccoon Creek watershed include the Towns of Max, Advance, Ladoga, Roachdale, Carpentersville, Parkersburg, Raccoon, Fincastle, Morton, Portland Mills, and Hollandsburg. U.S. Census data for each county during the past three decades are provided in Table 5. Using the 2010 U.S. Census Bureau data, municipalities with a population of at least 900 are depicted in Figure 8.

Table 5. Population Data for Counties in the Big Raccoon Creek Watershed

County	1990	2000	2010
Boone	38,147	46,107	56,640
Hendricks	75,717	104,093	145,448
Putnam	30,315	36,019	37,963
Montgomery	34,436	37,629	38,124
Parke	15,410	17,241	17,339
TOTAL	91,127	241,089	295,514

Source: U.S. Census Bureau.

Understanding Table 5: Water quality is linked to population growth because a growing population often leads to more development, translating into more houses, roads, and infrastructure to support more people. Table 5 provides information that shows how population has changed in each of the counties located in the Big Raccoon Creek watershed over time. In addition, understanding population trends can help watershed stakeholders to anticipate where pressures might increase in the future and where action now could help prevent further water quality degradation.

Estimates of population within Big Raccoon Creek watershed are based on US Census data (2010) and the percentage of the total county and urban area that is within the watershed (Table 6). Based on this analysis, the estimated population of the watershed is 9,391 with approximately 73 percent of the population classified as rural residents and 27 percent classified as urban residents. Figure indicates population density within the Big Raccoon Creek watershed.

Table 6. Estimated Population in the Big Raccoon Creek Watershed

County	2010 Population	Total Estimated Watershed Population	Percent of Total Watershed Population	Non-urban Population	Urban Population
Boone	56,640	1,890	20%	1,640	250
Hendricks	145,448	265	3%	265	0
Putnam	37,963	2,727	29%	1,827	900
Montgomery	38,124	3,062	33%	1,712	1,350
Parke	17,339	1,447	15%	1,447	0
TOTAL	295,514	9,391	100%	6,891	2,500

Understanding Table 6: Understanding where the greatest population is concentrated within the Big Raccoon Creek watershed will help watershed stakeholders understand where different types of water quality pressures might currently exist. In general, watersheds with large urban populations are more likely to have problems associated with impervious surfaces, poor riparian habitat, flashy stormwater flows, and large wastewater inputs. Alternatively, watersheds with a large rural population are more likely to suffer problems from failing septic systems, agricultural runoff, and channelized streams. Comparing the information in Table 5 with the information in Table 6 can provide an understanding of how population might change in the Big Raccoon Creek watershed and which counties are experiencing the most growth and shifts in urban and non-urban population. Population change can serve as an indicator for changes in land uses and hydrology. For example, growing populations mean more development, resulting in increased impervious surfaces and hydromodification, such as installing sewer systems, channelizing streams and re-routing storm water flows. Declining population in areas of the Big Raccoon Creek watershed might signify communities with under-utilized infrastructure and indicate opportunities to "rightsize" existing infrastructure and promote changes to land use that would benefit water quality (e.g., green infrastructure).

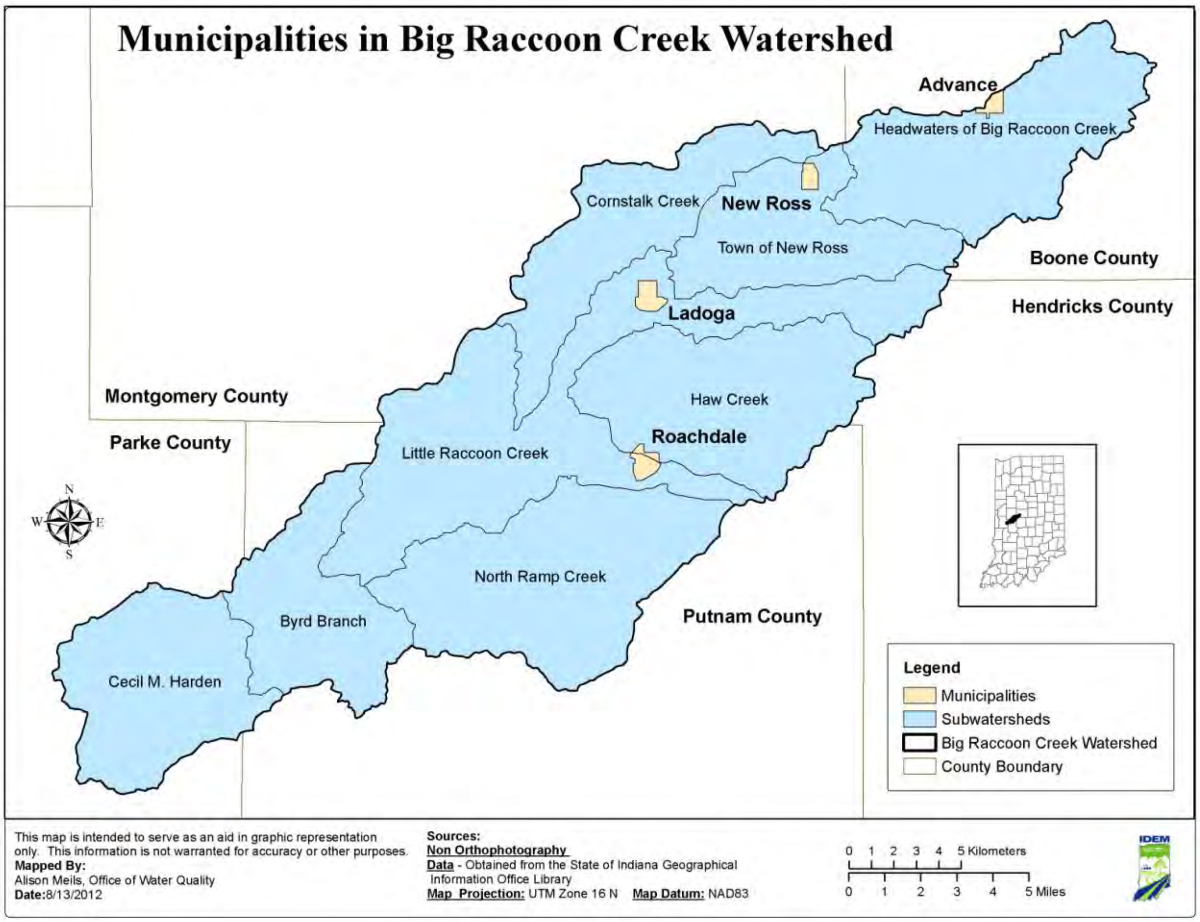

Figure 8. Municipalities in the Big Raccoon Creek Watershed

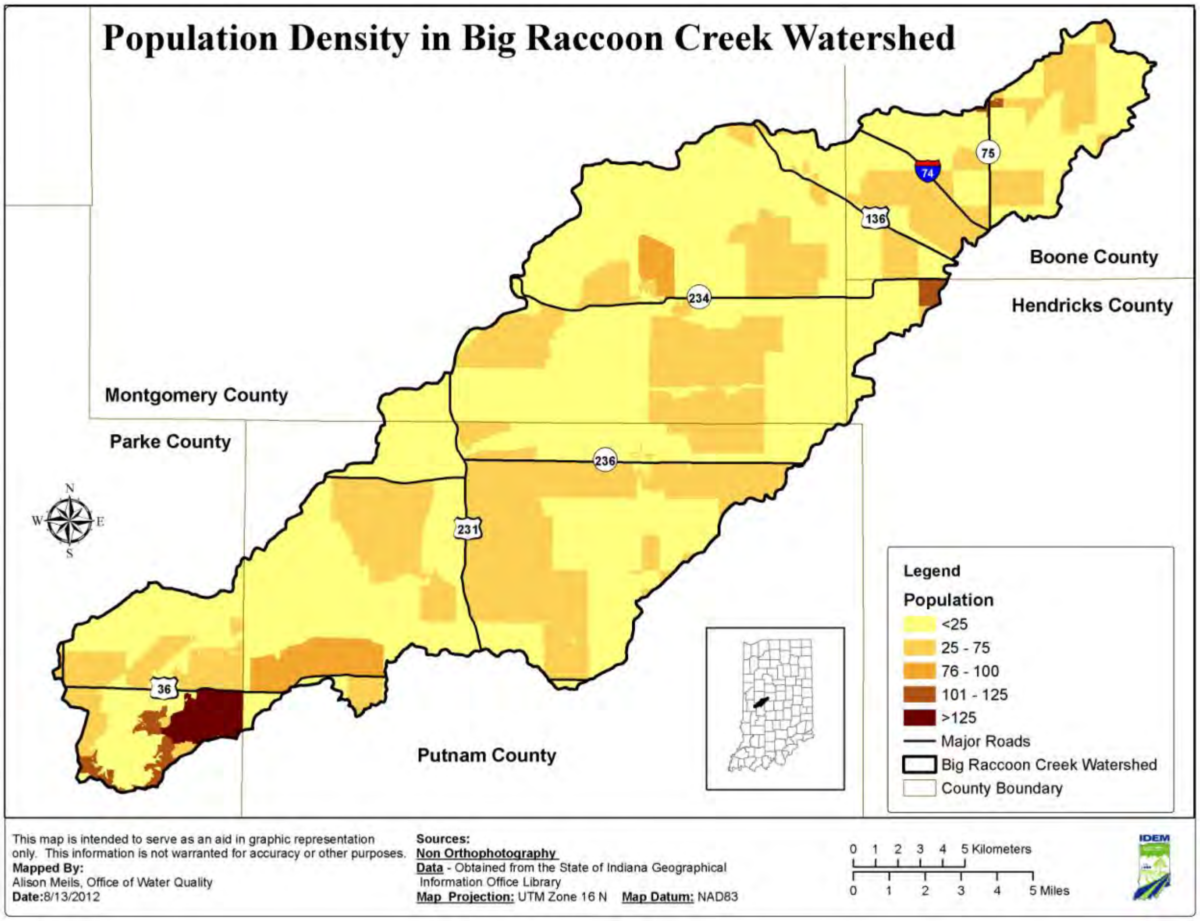

Figure 9. Population Density in the Big Raccoon Creek Watershed

3.3 Topography and Geology

Topographic and geologic features of a watershed play a role in defining a watershed's drainage pattern. Information concerning the topography and geology within the Big Raccoon Creek watershed is available from the Indiana Geologic Survey (IGS). The Big Raccoon Creek watershed originates in Boone County and travels southwest through Hendricks, Montgomery, Putnam and Parke Counties, eventually discharging to Cecil M. Harden Lake (Raccoon Lake). Cecil M. Harden Lake is located 33 miles upstream of the Big Raccoon Creek confluence with the Wabash River. The Big Raccoon Creek watershed is located primarily in the Eastern Corn Belt Plain (ECBP) ecoregion, with a southwest portion of the watershed located in the Interior River Lowland (IRL) physiographic region. The ECBP ecoregion is characterized by extensive cropland agriculture with some natural forest cover and gently rolling glacial till plains dissected by moraines, kames and outwash plains. Elevations range from 392 to greater than 1296 feet. The IRL has varied landuse with dissecting glacial till plain that has rolling narrow ridgetops and hilly to steep ridge and valley slopes. Elevations range from 421- 622 feet. The landscape changes from rich rolling farmland in the northeast to a mix of forested ridges and farmland in the southwest.

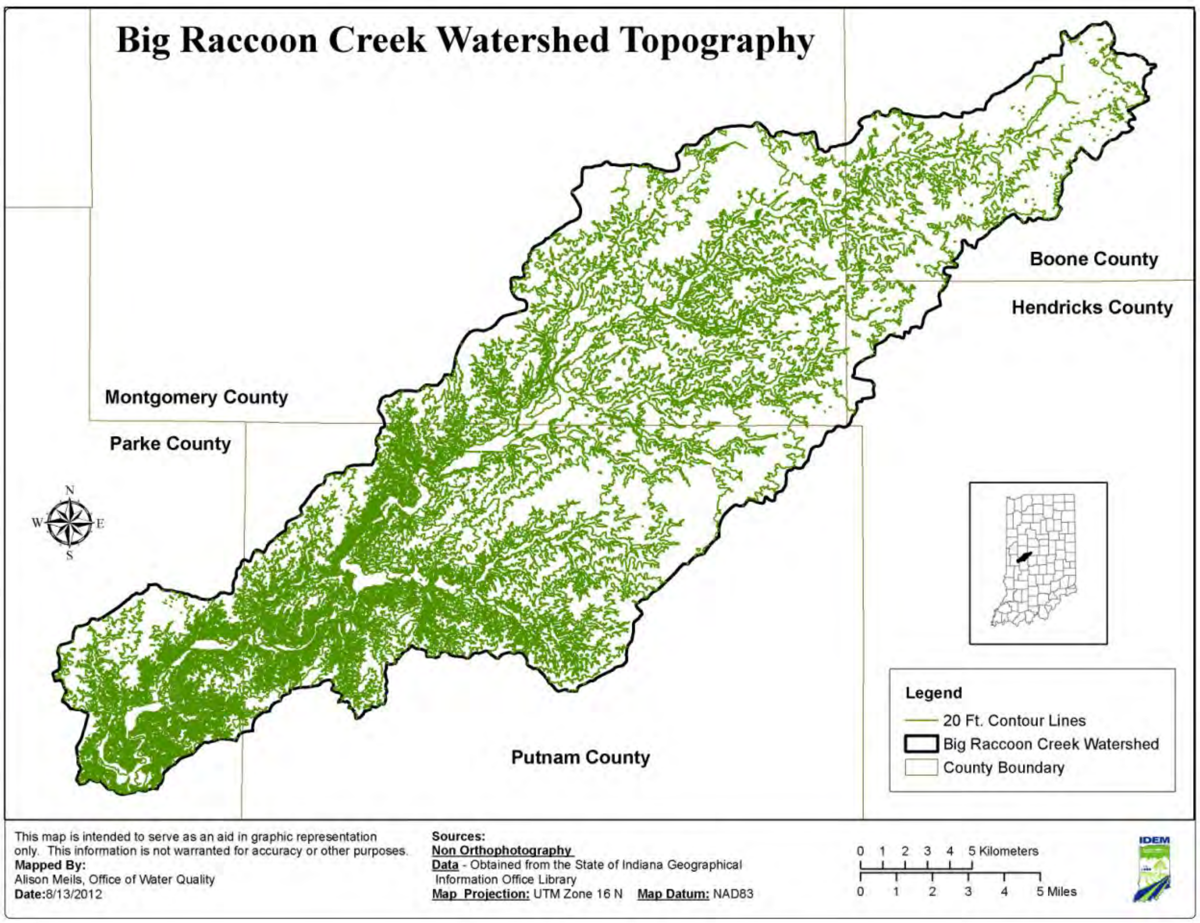

Figure 10. Topography in the Big Raccoon Creek Watershed

Figure 10 shows the topography of the Big Raccoon Creek watershed. National Elevation Data (NED) is available from the USGS National Map seamless server (http://seamless.usgs.gov/website/seamless/viewer.htm). This map shows that the elevation is highest near the headwaters in Boone County and gradually decreases as you move in a southwest direction towards Cecil M. Harden Lake. The steep ridges in the southern portion of the watershed allow little time for absorption of water during precipitation events. Historically flooding has been an issue along Big Raccoon Creek. While seasonal floods still occur along the banks of Big Raccoon Creek in the watershed, the U.S. Army Corps of Engineers constructed Cecil M. Harden Lake to provide flood reduction downstream in the Big Raccoon Creek and Lower Wabash River watersheds. While the topography of the watershed can have an effect on hydrology, it is more likely that soil characteristics and hydromodification play a greater role in affecting hydrologic processes.

3.4 Soils

There are different soil characteristics that can affect the function of a watershed. These characteristics include soil drainage, septic tank suitability, soil saturation, and soil erodibility.

3.4.1 Soil Drainage

The hydrologic soil group classification is a means for categorizing soils by similar infiltration and runoff characteristics during periods of prolonged wetting. The NRCS has defined four hydrologic groups for soils, described in Table 7 (NRCS, 2001). Data for the Big Raccoon Creek watershed were obtained from the Soil Survey Geographic (SSURGO) database. Downloaded data were summarized based on the major hydrologic group in the surface layers of the map unit and are displayed in Figure 11.

The majority of the watershed is covered by soils with moderate infiltration rates (53%), followed by soils with slow infiltration rates (46%), soils with very slow infiltration rates (<1%), and soils with high infiltration rates (<1%).

Table 7. Hydrologic Soil Groups

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

Understanding Table 7: Typically, clay soils that are poorly drained have lower infiltration rates, while well-drained sandy soils have the greatest infiltration rates. Soil infiltration rates can affect *E. coli* and nutrient loadings within a watershed. During high flows, areas with low soil infiltration capacity can flood and therefore discharge high loads to nearby waterways. In contrast, soils with high infiltration rates can slow the movement of contaminants to streams.

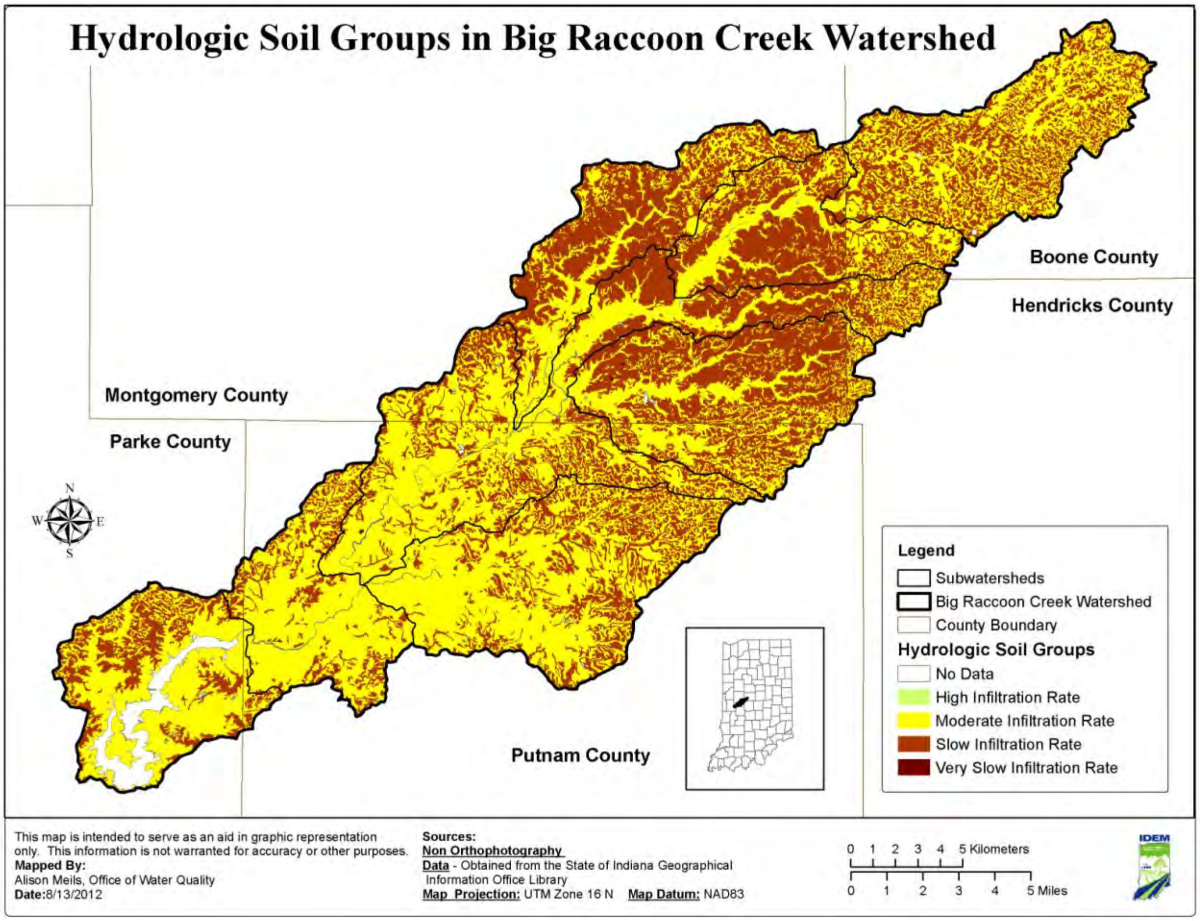

Figure 11. Hydrologic Soil Groups in the Big Raccoon Creek Watershed

3.4.2 Septic Tank Suitability

Septic systems require soil characteristics and geology that allow gradual seepage of wastewater into the surrounding soils. Seasonal high water tables, shallow compact till and coarse soils present limitations for septic systems. While system design can often overcome these limitations (i.e., perimeter drains, mound systems or pressure distribution), sometimes the soil characteristics prove to be unsuitable for any type of traditional septic system.

Heavy clay soils require larger (and therefore more expensive) absorption fields; while sandier, well-drained soils are often suitable for smaller, more affordable gravity-flow trench systems.

The septic system is considered failing when the system exhibits one or more of the following:

1. The system refuses to accept sewage at the rate of design application thereby interfering with the normal use of plumbing fixtures

2. Effluent discharge exceeds the absorptive capacity of the soil, resulting in ponding, seepage, or other discharge of the effluent to the ground surface or to surface waters

3. Effluent is discharged from the system causing contamination of a potable water supply, ground water, or surface water.

Figure 12 shows ratings that indicate the extent to which the soils are suitable for septic systems within the Big Raccoon Creek watershed. Only that part of the soil between depths of 24 and 60 inches is evaluated for septic system suitability. The ratings are based on the soil properties that affect absorption of the effluent, construction, maintenance of the system, and public health.

Soils labeled "very limited" indicate that the soil has at least one feature that is unfavorable for septic systems. Approximately 97 percent of the Big Raccoon Creek watershed is considered "very limited" in terms of soil suitability for septic systems. These limitations generally cannot be overcome without major soil reclamation or expensive installation designs. Less than one percent of the soils within the Big Raccoon Creek watershed are "not rated," meaning these soils have not been assigned a rating class because it is not industry standard to install a septic system in these geographic locations. None of the soils in the Big Raccoon Creek watershed are designated "not limited," meaning that the soil type is suitable for septic systems. Section 3.0 provides more information on septic systems throughout the Big Raccoon Creek watershed.

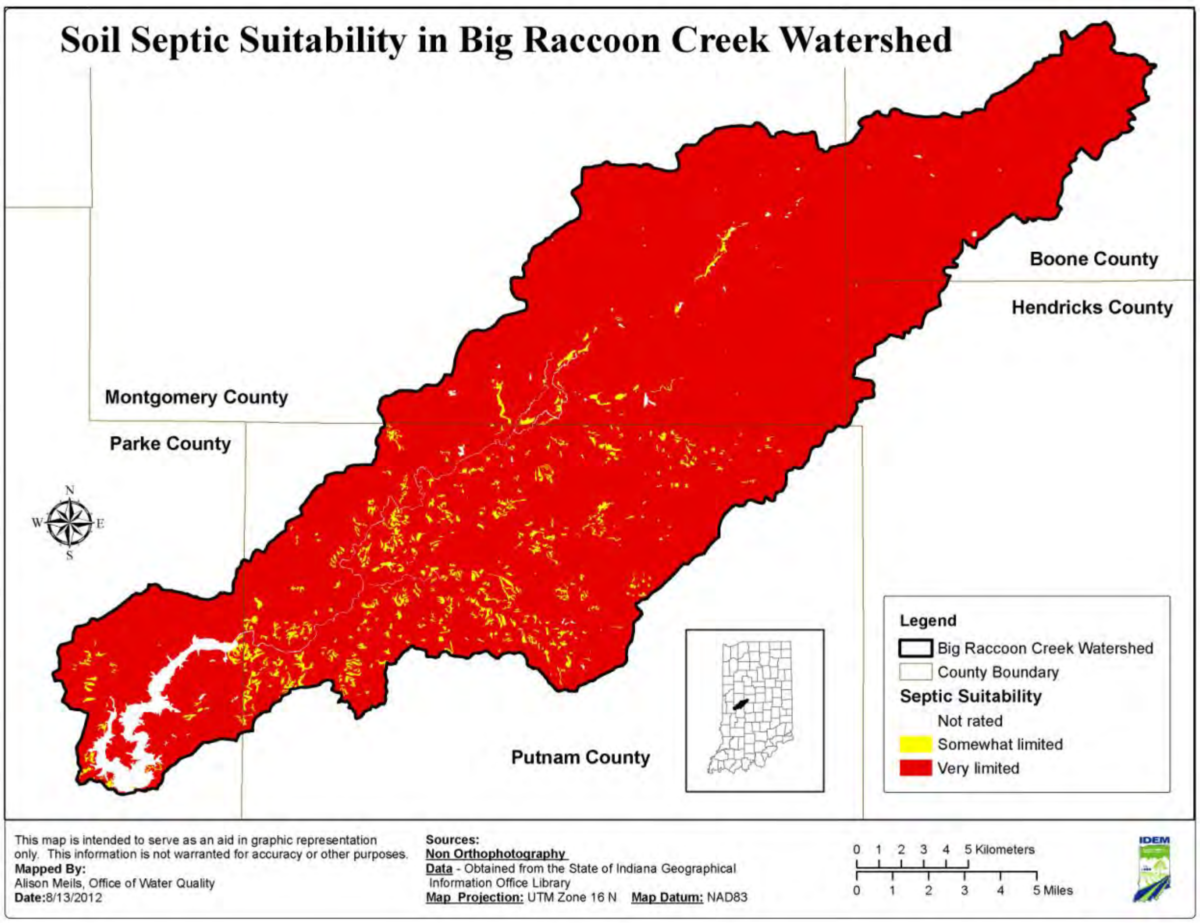

Figure 12. Suitability of Soils for Septic Systems in the Big Raccoon Creek Watershed

3.4.3 Soil Saturation

Soils that remain saturated or inundated with water for a sufficient length of time become hydric through a series of chemical, physical, and biological processes. Once a soil takes on hydric characteristics, it retains those characteristics even after the soil is drained. Hydric soils have been identified in the Big Raccoon Creek watershed and are important in consideration of wetland restoration activities.

Approximately 19,181 acres or 14 percent of the Big Raccoon Creek watershed area contains soils that are considered hydric, as shown in Table 8. However, a large majority of these soils have been drained for either agricultural production or urban development. The location of remaining hydric soils, as shown in Figure 13, can be used to consider possible locations of wetland creation or enhancement. There are many components in addition to soil type that must be considered before moving forward with wetland design and creation. Additional information on wetlands can be found on the IDEM website (http://www.in.gov/idem/4138.htm).

Table 8. Hydric Soils by County in the Big Raccoon Creek Watershed

County	Hydric Soil Type	Acres
Boone	Southwest silt loam	23
	Total	**23**
Hendricks	Brookston silt loam	6
	Brookston silty clay loam	1,362
	Ragsdale silty clay loam	419
	Total	**1,787**
Montgomery	Cohoctah loam	157
	Cyclone silty clay loam	3,282
	Mahalasville silty clay loam	1,143
	Milford silty clay loam	187
	Milford variant mucky silty clay	1
	Ragsdale silty clay loam	2,293
	Saranac silty clay loam	3
	Treaty silty clay loam	1,203
	Wallkill silt loam	5
	Washtenaw silt loam	158
	Total	**8,432**
Putnam	Ragsdale silt loam	7,057
	Rensselaer silt loam	20
	Total	**7,077**
Parke	Ragsdale silt loam	1,838
	Ragsdale silty clay loam	24
	Total	**1,862**
	Total	**19,181**

Understanding Table 8: In the Big Raccoon Creek watershed, Montgomery County has the most acreage of hydric soils. Areas within these counties might contain opportunities for wetland restoration activities that could help address water quality impairments.

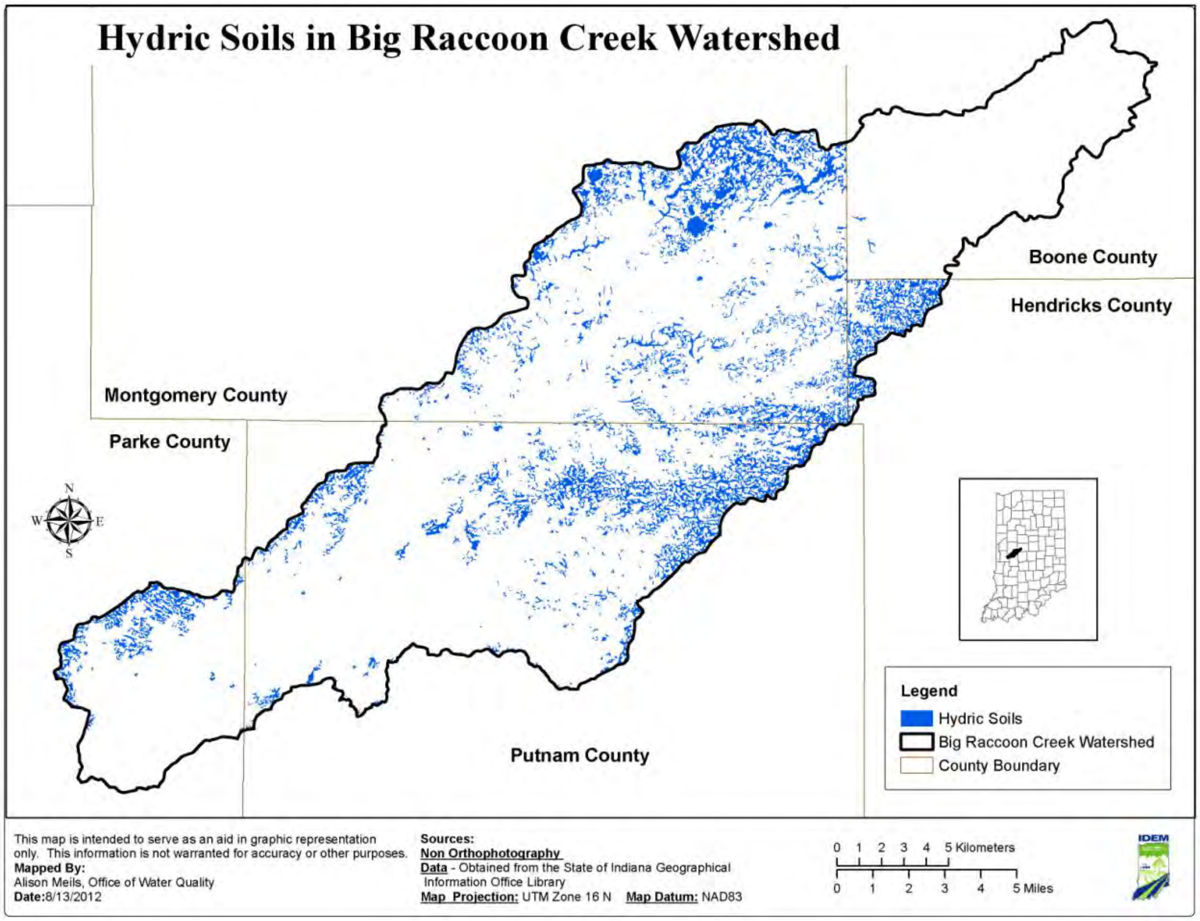

Figure 13. Hydric Soils in the Big Raccoon Creek Watershed

Wetland areas act to buffer wide variations in flow conditions that result from storm events. They also allow water to infiltrate slowly thus reducing the risks of contaminated water to run off into waterbodies.Agencies such as the USGS and USFWS estimate that Indiana has lost approximately 85 percent of the state's original wetlands. (See http://www.in.gov/dnr/fishwild/files/partner.pdf and http://water.usgs.gov/nwsum/WSP2425/state_highlights_summary.html) Currently, the Big RaccoonCreek watershed contains approximately 84 acres of wetlands or 0.06 percent of the total surface area. Figure 14 shows estimated locations of wetlands as defined by the USFWS's National Wetland Inventory (NWI). Wetland data for Indiana is available from the USFWS NWI at <http://www.fws.gov/wetlands/Data/Web-Map-Services.html>. The NWI was not intended to produce maps that show exact wetland boundaries comparable to boundaries derived from ground surveys, and boundaries are generalized in most cases. The wetland information used in Section 3.1 was from the MRLCC dataset and is based on soil types, whereas, aerial photography interpretation techniques were used to compile the NWI. Therefore the estimate of the current extent of wetlands in the Big Raccoon Creek watershed from the NWI may not agree with those listed in Section 3.1, which are based upon the MRLCC dataset.

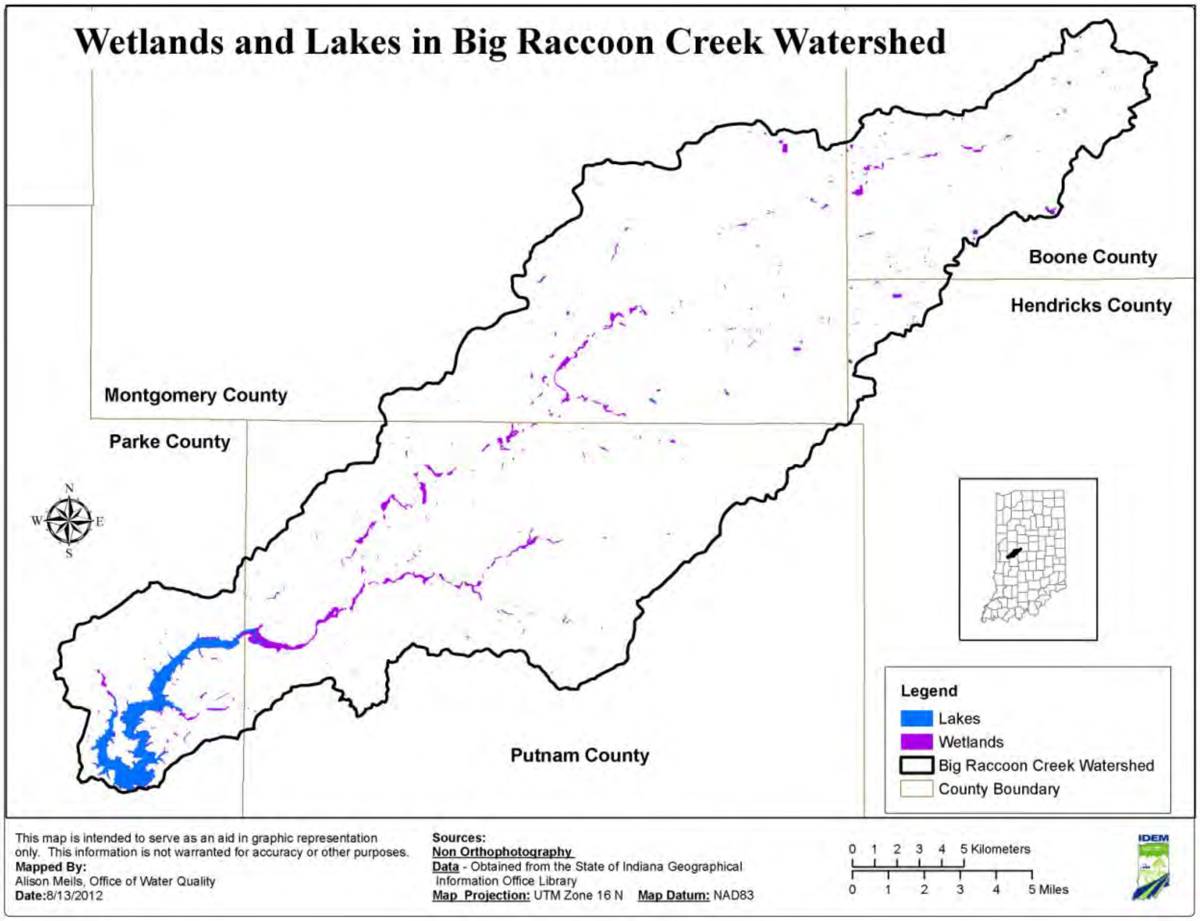

Figure 14. Locations of Wetlands in Big Raccoon Creek Watershed

Changes to the natural drainage patterns of a watershed are referred to as hydromodifications. Historically, drain tiles have been used throughout Indiana to drain marsh or wetlands and make the land either habitable for humans or tillable for agricultural purposes. While tile drainage is understood to be pervasive - estimated at thousands of miles in Indiana - it is extremely challenging to quantify on a watershed basis because these tiles were established by varying authorities including county courts, county commissioners, or county drainage boards (see http://boonecounty.in.gov/Default.aspx?tabid=167). Records were not kept by private landowners as to the location and quantity of these tiles.

In addition to tile drainage, regulated drains are another form of hydromodification. A regulated drain is a drain which was established through either a Circuit Court or Commissioners Court of the County prior to January 1, 1966 or by the County Drainage Board since that time. Regulated drains can be an open ditch, a tile drain, or a combination of both. The County Drainage Board can construct, maintain, reconstruct or vacate a regulated drain. In the Big Raccoon Creek watershed, there are approximately eight miles of tile drains and ten miles of open ditches under the jurisdiction of the Montgomery County Drainage Board. There is also one private drain in Montgomery County. In Boone County there are 41 miles of tiled and open ditches under the jurisdiction of the County Drainage Board. No information was available from Putnam County.

3.4.4 Soil Erodibility

Although erosion is a natural process within stream ecosystems, excessive erosion negatively impacts the health of watersheds. Erosion increases sedimentation of the streambeds, which impacts the quality of habitat for fish and other organisms. Erosion also impacts water quality as it increases nutrients and decreases water clarity. As water flows over land and enters the stream as runoff, it carries pollutants and other nutrients that are attached to the sediment. Sediment suspended in the water blocks light needed by plants for photosynthesis and clogs respiratory surfaces of aquatic organisms.

The NRCS maintains a list of highly erodible lands (HEL) units for each county based upon the potential of soil units to erode from the land. HELs are especially susceptible to the erosional forces of wind and water. Wind erosion is common in flat areas where vegetation is sparse or where soil is loose, dry, and finely granulated. Wind erosion damages land and natural vegetation by removing productive top soil from one place and depositing it in another. The classification for HELs is based upon an erodibility index for a soil, which is determined by dividing the potential average annual rate of erosion by the soil unit's soil loss tolerance (T) value, which is the maximum annual rate of erosion that could occur without causing a decline in long-term productivity. The soil types and acreages in the Big Raccoon Creek watershed are listed by county in Table 9. HELs and potential HELs in the Big Raccoon Creek watershed are mapped in Figure 15.

The data used to create Figure 15 was collected from the NRCS offices of Boone, Hendricks, Montgomery, Putnam and Parke Counties. A total of 57,608 acres or nearly 42 percent of the Big Raccoon Creek watershed is considered highly erodible or potentially highly erodible. Rainfall within the Big Raccoon Creek watershed is moderately heavy with an annual average of 43 inches. This rainfall and climate data specific to the watershed is available from the National Climatic Data Center (http://www.ncdc.noaa.gov/oa/ncdc.html). Heavy rainfall increases flow rates within streams as the volume and velocity of water moving through the stream channels increases. Velocity of water also increases as streambank steepness increases. Given the higher gradients in the southern portion of the watershed natural soil erosion may have more of an impact than erosion based on soil type. The steep gradient may contribute to siltation and other loadings during rain events but livestock grazing on hillsides also contributes to large bacteria and siltation loads caused by runoff. If livestock are grazing on the forested understory of hills and ridges it reduces the infiltration rate of runoff further.

Table 9. HEL/Potential HEL Total Acres in the Counties in the Big Raccoon Creek Watershed

County	HEL/Potential HEL Soil Types	Acres
Boone	Fox Loam	230
	Miami clay loam	30
	Miami silt loam	1,912
	Ockley silt loam	85
	Total	**2,257**
Montgomery	Boyer gravelly sandy loam	65
	Camden silt loam	217
	Casco loam	79
	Crosby-Miami silt loams	5,448
	Fincastle-Miami silt loams	2,243
	Hennepin complex	607
	Hennepin-rock outcrop complex	8
	Martinsville-Ockley loams	39
	Martinsville-Ockley silt loams	1,364
	Miami clay loam	765

	Miami silt loam	1,318
	Miami-Xenia silt loams	467
	Ockley loam	1
	Ockley silt loam	272
	Rodman-rock outcrop complex	23
	Rush silt loam	47
	Russell silt loam	21
	Shadeland silt loam	13
	St. Charles silt loam	3
	Xenia-Birkbeck silt loams	2,189
	Total	**15,189**
Hendricks	Crosby silt loam	1,511
	Crosby-Miami silt loams	19
	Martinsville loam	2
	Miami clay loam	14
	Miami silt loam	134
	Russell silt loam	11
	Xenia silt loam	6
	Total	**1,697**
Putnam	Alford silt loam	3
	Corydon silt loam	21
	Fox clay loam	129
	Fox loam	131
	Hennepin loam	5,043
	Martinsville loam	45
	Miami clay loam	5,335
	Miami silt loam	359
	Ockley silt loam	193
	Parke silt loam	3
	Pits, quarries	4
	Russell silt loam	5,250
	Shoals-Hennepin complex	948
	Udorthents	19
	Weikert silt loam	8
	Xenia silt loam	10,715
	Total	**28,206**
Parke	Alford silt loam	256
	Alford soils	16
	Camden loam	8
	Camden silt loam	16
	Cincinnati-Hickory complex	12
	Fincastle silt loam	2,230
	Hennepin association	1,820
	Hennepin-Russell complex	1,224
	Hickory complex	766
	Mine pits and dumps	5
	Ockley silt loam	44

	Parke silt loam	62
	Reesville silt loam	761
	Russell loam	1
	Russell silt loam	2,766
	Russell soils	248
	Steep stony and rocky land	24
	Total	**10,259**

Understanding Table 9: In the Big Raccoon Creek watershed, Putnam County has the most acreage of HEL/potential HEL soils. Areas within these counties might contribute to water quality impairments associated with excessive erosion, including IBC/TSS, and might contain opportunities for restoration to decrease erosion.

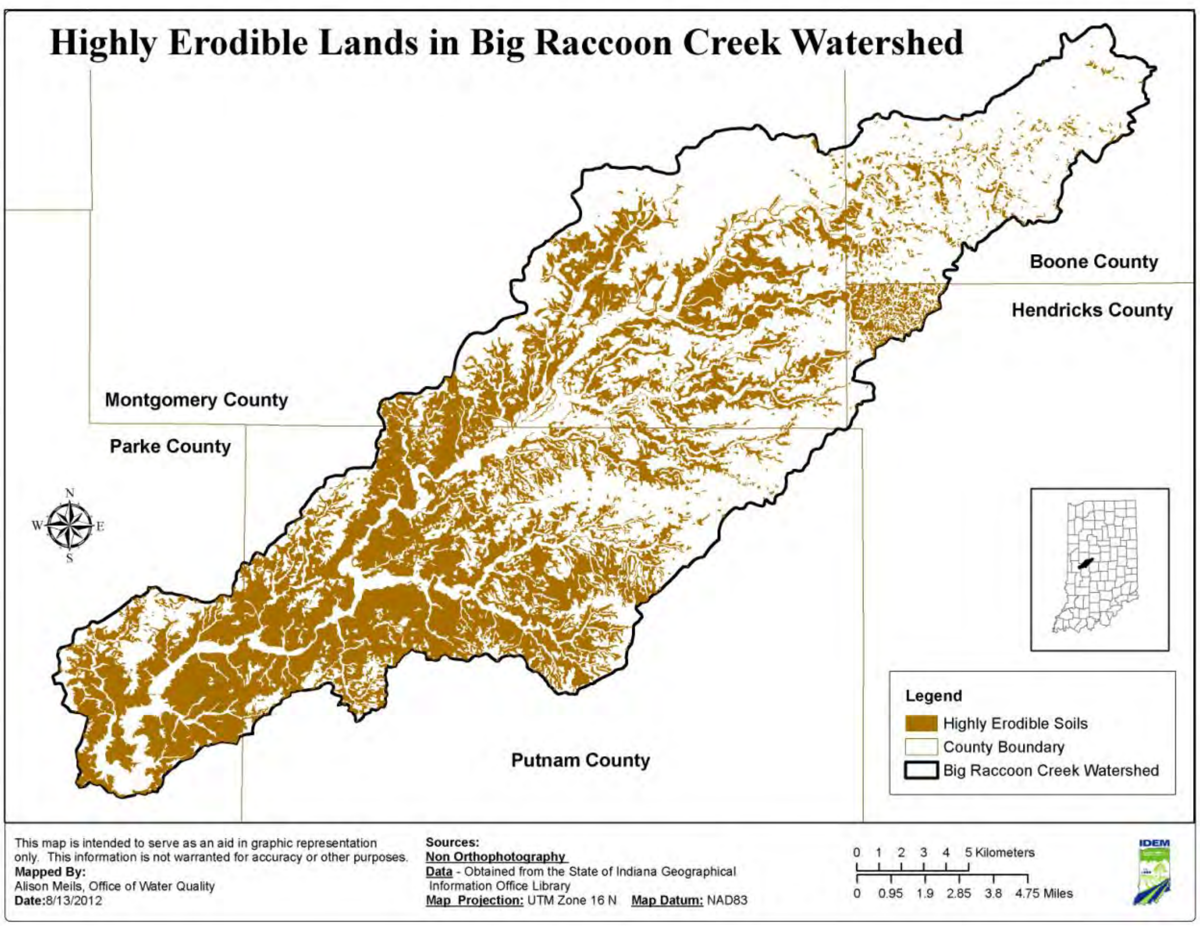

Figure 15. HEL/Potential HEL Soils in the Big Raccoon Creek Watershed

The Indiana State Department of Agriculture (ISDA) tracks trends in conservation and cropland through annual county tillage transects. Data collected through the tillage transects (http://www.in.gov/isda/2383.htm) can help determine adoption of conservation practices and estimate the average annual soil loss from Indiana's agricultural lands. The latest figures for the counties in the Big Raccoon Creek watershed are shown in Table 10. Tillage practices captured in ISDA's tillage transect include no-till, mulch-till, reduced-till and conventional tillage practices. ISDA defines no-till as any direct seeding system including site preparation, with minimal soil disturbance. Mulch-till is any tillage system leaving greater than 30 percent residue cover after planting, excluding no-till. Reduced-till is any tillage system leaving between 16 and 30 percent residue cover after planting and conventional tillage is any tillage system leaving less than 15 percent residue cover after planting.

Table 10. Tillage Transect Data for 2011 by County in the Big Raccoon Creek Watershed

County	Tillage Practice 2011							
	No Till		Mulch Till		Reduced Till		Conventional Till	
	Soybean	Corn	Soybean	Corn	Soybean	Corn	Soybean	Corn
Boone	80%	14%	18%	47%	0%	16%	2%	23%
Montgomery	84%	44%	11%	7%	4%	6%	2%	43%
Hendricks	57%	24%	26%	23%	14%	35%	3%	17%
Putnam	89%	45%	6%	30%	6%	25%	0%	0%
Parke	72%	32%	18%	8%	4%	31%	6%	29%

Understanding Table 10: According to Table 10, no-till practice is predominant in all 5 counties in the Big Raccoon Creek watershed. The use of no-till is greatest in Montgomery and Putnam counties. These counties comprise nearly 72 percent of the entire Big Raccoon Creek watershed.

Watershed specific data are not available for field specific crops. However, county-wide data available from the National Agricultural Statistic Service (NASS) were downloaded and area weighted to estimate crop acreage in the watershed. The area of the county within the watershed is divided by the area of the entire county and multiplied by the total acreage of crops in the county based on the NASS survey. This is done for each county in the watershed and summed to get an area weighted estimate of cropland with the watershed. The 2012 NASS statistics were used in the analysis, and there is an estimated 100,556 total acres of cropland in the Big Raccoon Creek watershed as shown in Figure 7. Based on the NASS data the cropland in the Big Raccoon Creek watershed is 31 percent corn, 25 percent soybeans and less than one percent wheat.

3.5 Climate and Precipitation

Climate varies in Indiana depending on latitude, topography, soil types, and lakes. Information on Indiana's climate is available through sources including the Indiana State Climate Office at Purdue University (http://climate.agry.purdue.edu/climate/narrative.asp).

Climate data from Station 121873 located in Crawfordsville, IN were used for climate analysis of the Big Raccoon Creek watershed. Monthly data from 1981 - 2010 were available at the time of analysis. In general, the climate of the region is hot and humid in the summer and cold in the winter. From 1981 to 2010, the average winter temperature in Crawfordsville was 35°F and the average summer temperature was 82°F. The average growing season (consecutive days with low temperatures greater than or equal to 32 degrees) is 230 days.

Examination of precipitation patterns is also a key component of watershed characterization because of the impact of runoff on water quality. The interaction between the warm, moist southerly winds from the Gulf region and the cooler continental polar air from the north favor the development of low pressure centers that move generally eastward and frequently pass over or close to the state, resulting in abundant rainfall. From 1981 to 2010, the annual average precipitation in Crawfordsville at Station 121873 was approximately 43 inches, including approximately 18 inches of snowfall. Crawfordsville represents the middle range of precipitation within the Wabash River drainage basin. More detailed discussions on precipitation data during sampling periods are presented in Section 7.

Rainfall intensity and timing affect watershed response to precipitation. This information is important in evaluating the effects of storm water on the Big Raccoon Creek watershed. Using data from Station 121873 from 1981 to 2010, 51 percent of the measureable precipitation events were very low intensity (i.e., less than 0.2 inches), while 9 percent of the measurable precipitation events were greater than one inch.

Knowing when precipitation events occur helps in the linkage analysis (Section 7), which correlates flow conditions to pollutant concentrations and loads. Data indicate that the wet weather season in the Big Raccoon Creek watershed occurs between the months of May and July.

3.6 Summary

The information presented in Section 3 helps to provide a better understanding of the conditions and characteristics in the Big Raccoon Creek watershed that, when coupled with the sources presented in Section 4, affect both water quality and water quantity. In summary, the predominant land uses in the Big Raccoon Creek watershed of agriculture and forest serve as indicators of the type of sources that are likely to contribute to water quality impairments in the Big Raccoon Creek watershed. Human population, which is greatest in Montgomery and Putnam Counties in the Big Raccoon Creek watershed, indicates where more infrastructure related pressures on water quality might exist. The subsections on topography and geology, as well as soils, provide information on the natural features that affect hydrology in the Big Raccoon Creek watershed. These features interact with land use activities and human population to create pressures on both water quality and quantity in the Big Raccoon Creek watershed. Lastly, the subsection on climate and precipitation provides information on water quantity and the factors that influence flow, which ultimately affects the influence of stormwater on the watershed. Collectively, this information plays an important role in understanding the sources that contribute to water quality impairment during TMDL development and crafting the linkage analysis that connects the observed water quality impairment to what has caused that impairment.

4.0 SOURCE ASSESSMENT

This section presents information concerning IDEM's stream segmentation and water quality assessment process as it applies to the Big Raccoon Creek watershed in order to present a source assessment for the overall watershed as well as summaries of significant sources of *E. coli*, nutrients and sediment where applicable, for each subwatershed.

4.1 Understanding Subwatersheds and Assessment Units

As briefly discussed in Section 2.3, the Big Raccoon Creek watershed contains eight 12-digit HUC subwatersheds. Although listed below, the Cecil M. Harden Lake subwatershed will not be addressed in the subwatershed summaries because there was no data available. Examining subwatersheds enables a closer look at key factors that affect water quality. The subwatersheds include:

- Headwaters of Big Raccoon Creek (051201081201)
- Town of New Ross (051201081202)
- Haw Creek (051201081203)
- Cornstalk Creek (051201081204)
- North Ramp Creek (051201081205)

- Little Raccoon Creek (051201081206)
- Byrd Branch (051201081207)
- Cecil M. Harden Lake (051201081208)

Within each 12-digit HUC subwatershed, IDEM has identified several Assessment Unit IDs (AUIDs), which represent individual stream segments. Through the process of segmenting subwatersheds into AUIDs, IDEM identifies streams reaches and stream networks that are representative for the purposes of assessment. In practice, this process leads to grouping tributary streams into smaller catchment basins of similar hydrology, land use, and other characteristics such that all tributaries within the catchment basin can be expected to have similar potential water quality impacts. Catchment basins, as defined by the aforementioned factors, are typically very small, which significantly reduces the variability in the water quality expected from one stream or stream reach to another. Given this, all tributaries within a catchment basin are assigned a single AUID. Grouping tributary systems into smaller catchment basins also allows for better characterization of the larger watershed and more localized recommendations for implementation activities. Variability within the larger watershed will be accounted for by the differing AUIDs assigned to the different catchment basins.

Table 11 contains the AUIDs and the associated surface areas in seven out of eight subwatersheds of the Big Raccoon Creek watershed. Subsequent sections of the TMDL report organize information by subwatershed (if applicable) and AUID.

Table 11. Assessment Units in Big Raccoon Creek Watershed

Name of Subwatershed	12-digit HUC	Current AUID (2014)	Area (sq. miles)	Percent of Total Area
Headwaters of Big Raccoon Creek	051201081201	INB08C1_01	27.42	12.73
		INB08C1_T1001		
		INB08C1_T1002		
		INB08C1_T1003		
		INB08C1_T1004		
Town of New Ross	051201081202	INB08C2_02	18.96	8.8
		INB08C2_T1011		
		INB08C2_T1012		
		INB08C2_T1013		
Haw Creek	051201081203	INB08C3_01	27.9	12.95
		INB08C3_02		
		INB08C3_T1001		
		INB08C3_T1002		
		INB08C3_T1003		
		INB08C3_T1004		
		INB08C3_T1005		
Cornstalk Creek	051201081204	INB08C4_01	20.23	9.4
		INB08C4_T1001		
		INB08C4_T1002		
		INB08C4_T1003		
		INB08C4_T1004		
North Ramp Creek	051201081205	INB08C5_01	33.02	15.33
		INB08C5_T1001		

Name of Subwatershed	12-digit HUC	Current AUID (2014)	Area (sq. miles)	Percent of Total Area
		INB08C5_T1002		
		INB08C5_T1003		
		INB08C5_T1004		
		INB08C5_T1005		
		INB08C5_T1006		
		INB08C5_T1007		
		INB08C5_T1008		
		INB08C5_02		
		INB08C5_T1009		
		INB08C5_T1010		
Little Raccoon Creek	051201081206	INB08C6_01	46.27	21.48
		INB08C6_T1001		
		INB08C6_02		
		INB08C6_T1002		
		INB08C6_03		
		INB08C6_T1003		
		INB08C6_T1004		
		INB08C6_T1005		
		INB08C6_T1006		
		INB08C6_T1007		
Byrd Branch	05120108207	INB08C7_01	18.57	8.62
		INB08C7_T1001		
		INB08C7_T1002		
		INB08C7_T1003		
		INB08C7_T1004		
		INB08C7_T1005		
		INB08C7_T1006		
		INB08C7_02		
		INB08C7_T1007		
		INB08C7_T1008		

Understanding
Table 11***:*** Land area helps IDEM to define the pollutant load reductions needed for each assessment unit in each 12-digit HUC subwatershed that comprises the Big Raccoon Creek watershed. Information in each column is as follows:

- *Column 1: Name of Subwatershed.* Lists the name of the subwatersheds.
- *Column 2: 12-digit HUC.* Identifies the subwatershed's 12-digit HUC.
- *Column 3: Current AUID*. Provides the updated AUIDs associated with each subwatershed.
- *Column 4: Area.* Quantifies the surface area of the subwatershed.
- *Column 5: Percent of Total Area.* Indicates the percent of the total area, providing a relative understanding of the portion of the subwatershed in the overall Big Raccoon Creek watershed.

IDEM bases percent load reductions on the drainage area for each AUID in the 12-digit HUC subwatersheds. The information contained in this table is the foundation for the calculations found in Sections 5, 6, and 7 of this report. This table will help watershed stakeholders look at the smaller segments within the Big Raccoon Creek watershed and understand the smaller areas contributing to the impaired waterbody, helping to quantify the geographic scale that influences source characterization and areas for implementation.

4.2 Source Assessment by Subwatershed

This section summarizes the available information on significant point and nonpoint sources of *E. coli* and impaired biological communities in seven of the subwatersheds of the Big Raccoon Creek watershed. The Cecil M. Harden Lake subwatershed (051201081208) will not be addressed by the TMDL in the following section because there were no available data to assess the tributaries in the subwatershed (Appendix B). The Cecil M. Harden subwatershed will be assessed as data becomes available through IDEM's nine-year rotating basin schedule. For probabilistic monitoring, the Big Raccoon Creek watershed will be included in the stratified random draw of sites for the Lower Wabash River Basin in 2016; however, this does not guarantee that sites will fall within the watershed.

The term "point source" refers to any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel or conduit, by which pollutants are transported to a waterbody. It also includes vessels or other floating craft from which pollutants are or may be discharged. By law, the term "point source" also includes: concentrated animal feeding operations (CAFO) which are places where animals are confined and fed; storm water runoff from Municipal Separate Storm Sewer Systems (MS4s), construction site of one acre or more of land disturbance, and specific categories of industrial activities that convey storm water; and illicitly connected "straight pipe" discharges of household waste. Permitted point sources are regulated through the National Pollutant Discharge Elimination System (NPDES) program.

Nonpoint sources include all other categories not classified as point sources. In urban areas, nonpoint sources can include leaking or faulty septic systems, runoff from lawn fertilizer applications, pet waste, storm water runoff (outside of MS4 communities), and other sources. In rural areas, nonpoint sources can include runoff from cropland, pastures and confined feeding operations (CFO), animal feeding operations and inputs from streambank erosion, leaking or failing septic systems, and wildlife. For the purposes of this TMDL, a CFO is considered nonpoint source by the EPA since it is permitted by the State.

4.2.1 Subwatershed Summary: Headwaters of Big Raccoon Creek

This section of the report presents the available information on the sources of *E. coli* and impaired biological communities in the Headwaters of Big Raccoon Creek subwatershed.

The Headwaters of Big Raccoon Creek subwatershed is located in farthest northeast region of the watershed, covering nearly 28 square miles (Figure 16). The Headwaters of Big Raccoon Creek drains portions of Boone and Montgomery Counties. The Headwaters of Big Raccoon Creek includes the eastern portion of the Town of Advance. Land use in the Headwaters of Big Raccoon Creek is primarily agricultural (88%) as shown in Table 12. Forested areas contribute to approximately 3 percent of the watershed area and just over 6 percent of the land is developed.

Table 12. Land Use in the Headwaters of Big Raccoon Creek Subwatershed

Land Use	Area		Percent
	Acres	Square Miles	
Open Water	13.79	0.02	0.07
Developed, Open space	932.72	1.46	5.32

Developed, Low Intensity	159.46	0.25	0.91
Developed, Medium Intensity	27.35	0.04	0.15
Developed, High Intensity	2.89	0.01	0.04
Forest	500.17	0.77	2.81
Shrub/Scrub	183.03	0.29	1.05
Hay/Pasture	333.37	0.52	1.9
Agriculture	15,397.73	24.05	87.71
Wetlands	5.56	0.01	0.04
TOTAL	**17,555**	**27.42**	**100**

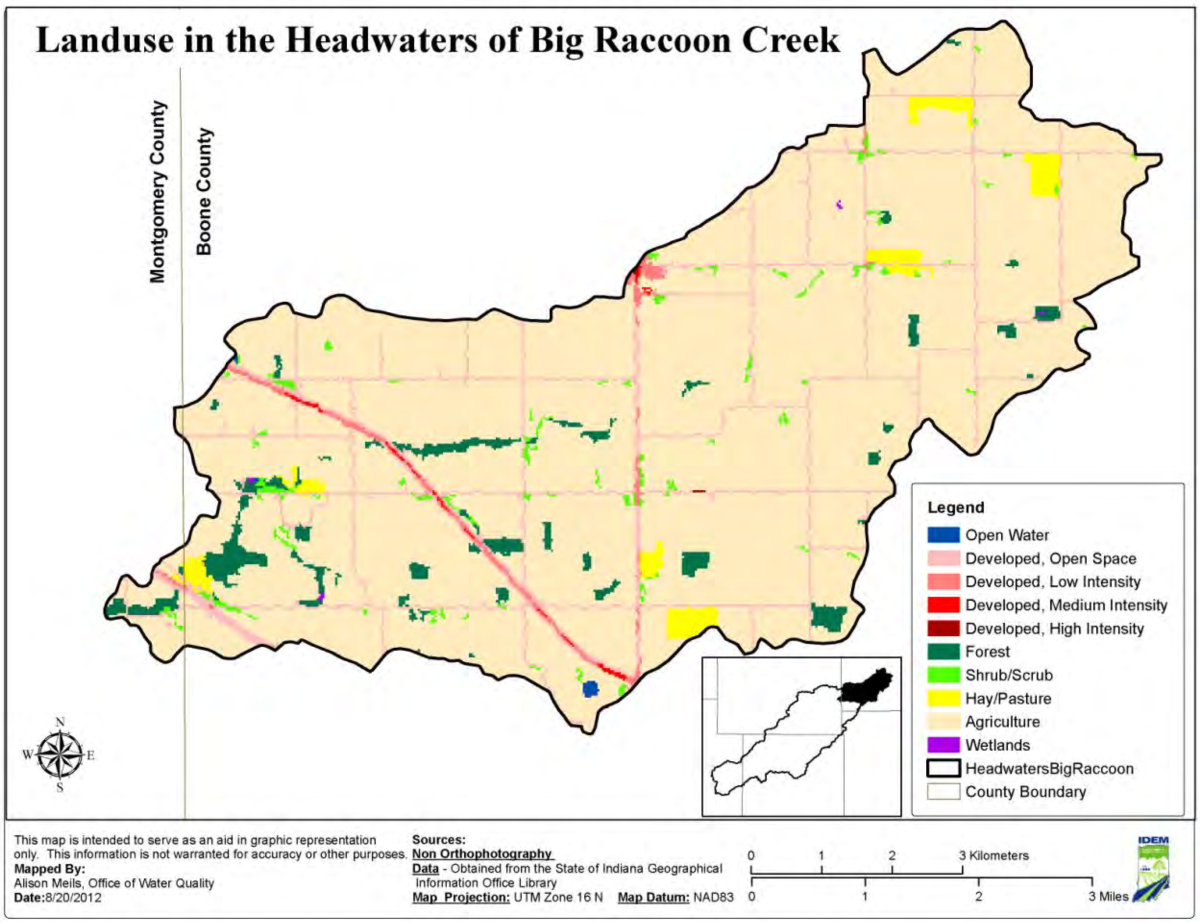

Figure 16. Land Use in the Headwaters of Big Raccoon Creek Subwatershed

4.2.1.1 Point Sources

This section summarizes the potential point sources of *E. coli* and impaired biological communities in the Headwaters of Big Raccoon Creek subwatershed, as regulated through the NPDES Program.

Wastewater Treatment Plants (WWTPs) and Industrial Facilities

Facilities with NPDES permits to discharge wastewater within the Headwaters of Big Raccoon Creek subwatershed include municipal WWTPs. There are two active WWTPs that discharge wastewater containing *E. coli* within the Headwaters of Big Raccoon Creek subwatershed (Table 13 and Figure 17).

These facilities are as follows: Town of Advance WWTP and Town of New Ross WWTP. As authorized by the Clean Water Act, the NPDES permit program controls water pollution by regulating WWTPs that discharge pollutants into waters of the United States. Municipal facilities in Indiana are required to disinfect their effluent during the recreational season (April 1 to October 31). IDEM does not require disinfection for waste-stabilization lagoons as long as *E. coli* limits from the permit are met utilizing the lagoon's minimum of a 90 day retention time. Table 13 contains the maximum design flow for the active facilities.

Of the two facilities in Headwaters of Big Raccoon Creek, the New Ross WWTP uses waste stabilization lagoons that have a 90 day detention time. Waste stabilization lagoons discharge at a 10:1 dilution ratio. The waste stabilization lagoon consists of a lift station, two 3.75 acre lagoons, and an effluent flow meter. While the New Ross WWTP facility does contribute to pathogen loadings, the annual average pathogen concentration (per 100 mL) has been below the WQS (125 MPN/100mL) from 2007 to 2011, ranging from 3.43 to 25.9 MPN/100 mL. The average daily flow was also below the maximum design flow (0.33 MGD) from 2007 to 2011, ranging from 0.03 to 0.05 MGD.

The Town of Advance WWTP consists of an influent flow meter, an oxidation ditch, a secondary clarifier, an aerated sludge holding tank, effluent chlorination/dechlorination, post aeration, and an effluent flow meter. Final solids are hauled off site by a licensed contractor. While the Town of Advance WWTP facility does contribute to pathogen loadings, the annual average pathogen concentration (per 100 mL) has been below the WQS (125 MPN/100mL) from 2007 to 2011, ranging from 11.43 to 33.00 MPN/100 mL. The average daily flow has also been below the maximum design flow (0.039 MGD) in 2007, 2009, 2010 and 2011 having a constant average daily flow of 0.03 MGD. In 2008, the average daily flow (0.04 MGD) was greater than the maximum design flow for the facility.

Table 13. NPDES Permitted Wastewater Dischargers within the Headwaters of Big Raccoon Creek Subwatershed

Facility Name	Permit Number	AUID	Receiving Stream	Maximum Design Flow (MGD)
Town of Advance WWTP	IN0039705	INB08C1_01	Big Raccoon Creek	.039
New Ross WWTP	IN0059790	INB08C1_01	Big Raccoon Creek	0.33

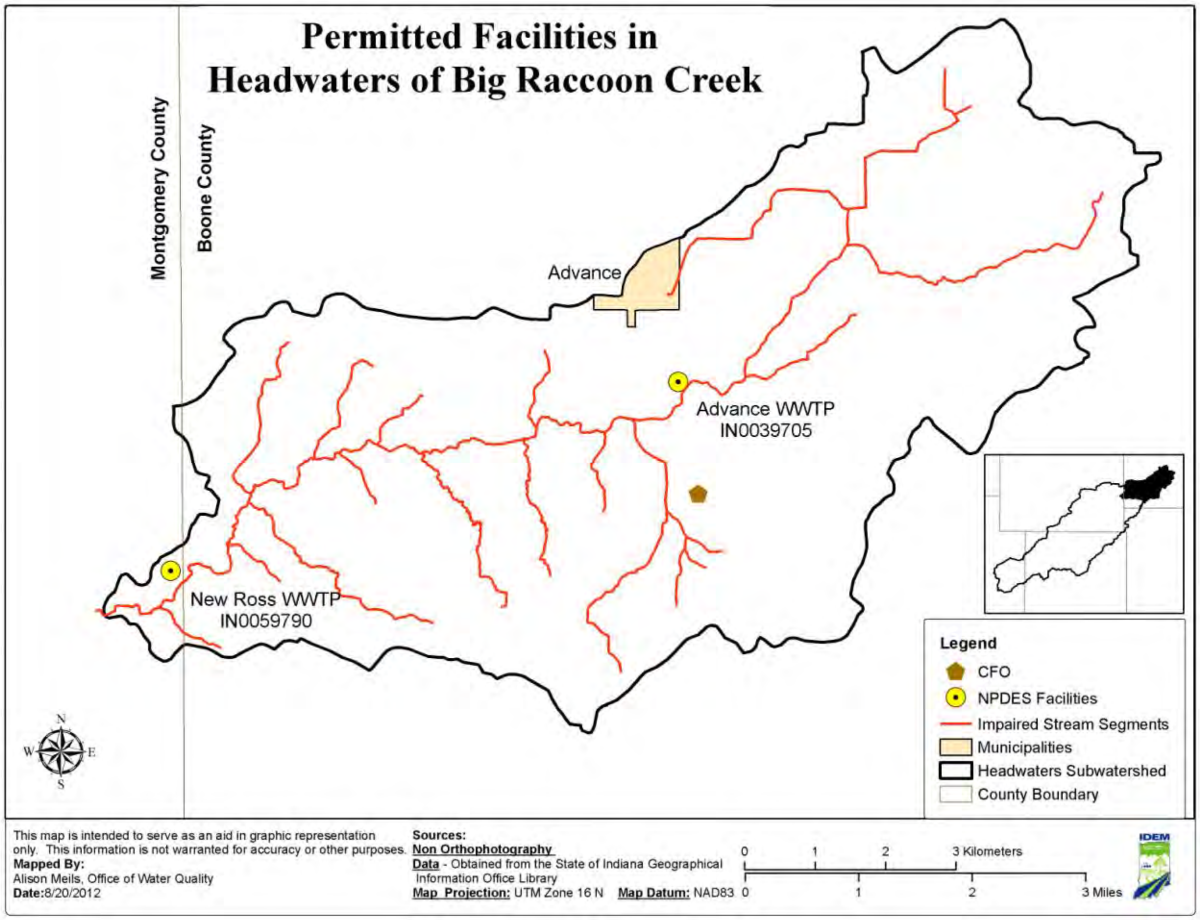

Figure 17. NPDES Facilities in the Headwaters of Big Raccoon Creek Subwatershed

Table presents a summary of permit compliance for both NPDES facilities in the Headwaters of Big Raccoon Creek subwatershed for the five year period between 2007 and 2012. It presents the date of the facility's last inspection and findings from the inspection (i.e., compliance or violation for facility maintainance). The table also presents the total number of violations in the five year period for *E. coli* and other parameters. According to Table 14, there have been three IDEM NPDES facility inspections, none of which resulted in facility maintainance violations during the five year period. However, there have been water quality violations based on the WWTPs daily sampling results, including three permit violations for *E.* coli, three TSS violations, and one DO violation in the five year period.

Table 14. Summary of Inspections and Permit Compliance in the Headwaters of Big Raccoon Creek Subwatershed for the Five Year Period Ending 3/2012

Facility Name	Permit Number	AUID	Date of Last Inspection and Findings	Violations from 4/2009 through 3/2012
Town of Advance WWTP	IN0039705	INB08C1_01	9/21/2011: Compliance 4/16/2010: Compliance 1/14/2009: Compliance	3 *E. coli* violations; 4 BOD, chlorine, flow, ammonia, DO pH, and TSS violations
New Ross WWTP	IN0059790	INB08C1_01	1/4/2011: Compliance 9/10/2009: Compliance 9/26/2007: Compliance	0 *E. coli* violations; 4 BOD violations and 2 TSS violations

Illicitly Connected "Straight Pipe" Systems

Some household wastes within Indiana and potentially within the Headwaters of the Big Raccoon Creek subwatershed directly discharge to a stream or are illegally connected directly to tile-drainage pipes in rural areas providing a direct source of pollutants such as *E. coli*, nutrients, and TSS to the stream (these systems are sometimes referred to as "straight pipe" discharges).

4.2.1.2 Nonpoint Sources

This section summarizes the potential nonpoint sources of *E. coli*, nutrients and TSS in the Headwaters of Big Raccoon Creek subwatershed that are not regulated through the NPDES Program.

Cropland

Approximately 88 percent of the land in the Headwaters of Big Raccoon Creek subwatershed is classified as row crops. Croplands can be a source of *E. coli*, sediments, and nutrients. Accumulation of nutrients and *E. coli* on cropland occurs from manure fertilizers, inorganic fertilizers, wildlife excreta, irrigation water, and application of waste products from municipal and industrial wastewater treatment facilities.

Pastures and Livestock Operations

In the Headwaters of Big Raccoon Creek subwatershed, 3 percent of land use is pasture and grasslands. Runoff from pastures and livestock operations can be potential agricultural sources of *E. coli*, nutrients, and TSS. For example, animals grazing in pasturelands deposit manure directly upon the land surface and, even though a pasture may be relatively large and animal densities low, the manure will often be concentrated near the feeding and watering areas in the field. These areas can quickly become barren of plant cover, increasing the possibility of erosion and contaminated runoff during a storm event.

Livestock are potential sources of *E. coli* and nutrients to streams, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas. Watershed specific data are not available for livestock populations. However, county-wide data available from the NASS were downloaded and area weighted to estimate animal population in the watershed. The area of the county within the watershed is divided by the area of the entire county and multiplied by the total number of animals in the county based on the NASS survey. This is done for each county in the watershed and summed to get an area weighted estimate of animals with the watershed. There are an estimated 1809 animal units in the Headwaters of Big Raccoon Creek subwatershed and the animal unit density is 66 animal units per square mile as shown in Table 14.

Table 14. Animal Unit Density in the Headwaters of Big Raccoon Creek Subwatershed

Subwatershed Area (sq. miles)	Animal	Total Number of Head in County	Number of Animals in One Animal Unit	Number of Animal Units	Animal Unit Density (animal units/mi^2)
27.44	Hogs and Pigs	Boone: 2,333 Montgomery: 120	2.5	981.2	65.92
	Cattle and Calves	Boone: 700 Montgomery: 6	1	706	
	Sheep and Lambs	Boone: 34 Montgomery: 1	10	3.5	
	Horses and Ponies	Boone: 58 Montgomery: 1	0.5	118	
	Poultry	Boone: 36 Montgomery: 1	250	0.15	
			TOTAL	**1,808.85**	

Confined Feeding Operations (CFOs)

A CFO is an agricultural operation where animals are kept and raised in confined situations. It is a lot or facility (other than an aquatic animal production facility) where the following conditions are met:

- Animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and
- Crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.
- The number of animals present meets the requirements for the state permitting action.

Confined feeding operations that are not classified as Concentrated Animal Feeding Operations (CAFOs) are known as CFOs in Indiana. Non-CAFO animal feeding operations are considered nonpoint sources by USEPA. CAFOs have federal permits and fall under the jurisdiction of the NPDES program, as described in Section 4.2.1.1. Indiana's CFOs have state-issued permits but are not under the jurisdiction of the federal NPDES program and are therefore categorized as nonpoint sources for the purposes of this TMDL. CFO permits are "no discharge" permits. Therefore it is prohibited for these facilities to discharge to any water of the State.

The CFO regulations (327 IAC 16, 327 IAC 15) require that operations "not cause or contribute to an impairment of surface waters of the state". IDEM regulates these confined feeding operations under IC 13-18-10, the Confined Feeding Control Law. The rules at 327 IAC 16, which implement the statute regulating confined feeding operations, were effective on March 10, 2002. The rule at 327 IAC 15-15, which regulates concentrated animal feeding operations and complies with most federal CAFO regulations, became effective on March 24, 2004, with two exceptions. 327 IAC 15-15-11 and 327 IAC 15-15-12 became effective on December 28, 2006. Point source rules can be found at 327 IAC 5-4-3 (effective 12/28/06) and 327 IAC 5-4-3.1 (effective 3/24/04).

Like CAFOs, the animals raised in CFOs produce manure that is stored in pits, lagoons, tanks and other storage devices. The manure is then applied to area fields as fertilizer. When stored and applied properly, this beneficial re-use of manure provides a natural source for crop nutrition. It also lessens the need for fuel and other natural resources that are used in the production of fertilizer. CFOs, however, can also be potential sources of TSS, total nitrogen, total phosphorus, and *E. coli* due to the following:

- Manure can leak or spill from storage pits, lagoons, tanks, etc.
- Improper application of manure can contaminate surface or ground water.
- Manure overapplication or improper application can adversely impact soil productivity.

There is one CFO in the Headwaters of Big Raccoon Creek subwatershed (Table 16 and Figure 17) and based on the 2012 303(d) list of impaired waters it is located on an impaired biological community stream segment.

Table 16. CFOs in the Headwaters of Big Raccoon Creek Subwatershed

Operation Name	Farm ID	AUID
Demaree Farms Partnership (640 beef cattle/ 60 beef calves)	6664	INB08C1_T1004

Streambank Erosion

Streambank erosion is potentially a significant source of TSS in the Headwaters of Big Raccoon Creek subwatershed. Streambank erosion is a natural process but can be accelerated due to a variety of human activities:

- Vegetation located adjacent to streams flowing through crop or pasture fields is often removed to promote drainage or cattle access to water. The loss of vegetation makes the streambanks more susceptible to erosion due to the loss of plant roots.
- Extensive areas of agricultural tiles promote much quicker delivery of rainfall into streams than would occur without subsurface drainage, which could potentially contribute to streambank erosion due to high velocities and shear stress.
- The creation of impervious surfaces (e.g., streets, rooftops, driveways, parking lots) can also lead to rapid runoff of rainfall and higher stream velocities that cause streambank erosion.

Onsite Wastewater Treatment Systems

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

The Indiana State Department of Health (ISDH) regulates (410 IAC 6-8.3) through the local health departments the residential onsite sewage disposal program. Onsite sewage disposal systems (i.e., septic systems) are those, which do not result in an off-lot discharge of treated effluent, typically consisting of a septic tank to settle out and digest sewage solids, followed by a system of perforated piping to distribute the treated wastewater for absorption into the soil. More than 800,000 onsite sewage disposal systems are currently used in Indiana. Local health departments issue more than 15,000 permits per year for new systems, and about 6,000 permits for repairs.

410 IAC 6-8.3-52 General sewage disposal requirements

Sec. 52. (a) No person shall throw, run, drain, seep, or otherwise dispose into any of the surface waters or ground waters of this state, or cause, permit, or suffer to be thrown, run, drained, allowed to seep, or otherwise disposed into such waters, any organic or inorganic matter from a dwelling or residential onsite sewage system that would cause or contribute to a health hazard or water pollution.
(b) The: (1) design; (2) construction; (3) installation; (4) location; (5) maintenance; and (6) operation; of residential onsite sewage systems shall comply with the provisions of this rule.

410 IAC 6-8.3-55 Violations; permit denial and revocation

Sec. 55. (a) Should a residential onsite sewage system fail, the failure shall be corrected by the owner within the time limit set by the health officer. (b) If any component of a residential onsite sewage system is found to be: (1) defective; (2) malfunctioning; or (3) in need of service; the health officer may require the repair, replacement, or service of that component. The repair, replacement, or service shall be conducted within the time limit set by the health officer. (c) Any person found to be violating this rule may be served by the health officer with a written order stating the nature of the violation and providing a time limit for satisfactory correction thereof.

Boone County follows the Indiana Administrative Code (410 IAC 6-8.3), with regards to septic systems along with local ordinances. The Boone County, lndiana Code of Ordinances (Volume 2 Land Usage, Chapter 51) addresses sewage disposal systems, permit requirements, drainage requirements, powers of inspection, and penalties. Montgomery County follows the Indiana Administrative Code (410 IAC 6-8.3), with regards to septic systems.

A comprehensive database of septic systems within the Big Raccoon Creek watershed is not available; therefore, the rural population of each subwatershed was calculated to obtain a general representation of the number of systems. The US Census provides the total number of people within a county as well as the total urban and rural population of the county. Subwatershed population is estimated by dividing the subwatershed area by the total county area and multiplying it by the county census population. It is assumed that the numbers of septic systems in the subwatersheds are directly proportional to rural population density. An additional estimate of septic systems can be made using the 1990 US Census, as that is the last Census that inventoried how household wastewater is disposed. The rural population in the Headwaters of Big Raccoon Creek subwatershed is shown in Table 17, along with a calculated density (total rural population divided by total area). The rural population density can be used to compare the different subwatersheds within the Big Raccoon Creek watershed.

It should also be noted that hydrologic soil group A and B soils have good infiltration rates and have less risk for failing septic systems due to this factor. Group C and D soils have slow infiltration rates with finer textures and slow water movement. Headwaters of Big Raccoon Creek subwatershed has no soil group A, 68 percent of soil group B, and 32 percent of soil groups C and D.

Table 17. Rural Population Density in the Headwaters of Big Raccoon Creek Subwatershed

County	Area of County in Subwatershed (mi^2)	County Population	Urban Population	Rural Population	Rural Population Density (persons/mi^2)
Boone	27	1,438	263	1,175	45.62
Montgomery	0.41	76	0	76	
TOTAL	27.41	1,514	263	1,251	

Urban Storm Water

In areas not covered under the NPDES MS4 program, storm water runoff from developed areas is not regulated under a permit and is therefore a nonpoint source. Runoff from urban areas can carry a variety of pollutants originating from a variety of sources. Typically, urban sources of nutrients are fertilizer application to lawns and pet waste, which is also a source of *E. coli* and nutrients. Depending on the amount of developed, impervious land in a watershed, urban nonpoint source inputs can result in localized or widespread water quality degradation. The percent and distribution of developed land in the Headwaters of Big Raccoon Creek subwatershed is discussed in Section 4.2.1. However, inputs from urban sources are difficult to quantify. Estimates can be made of pet populations and residential areas that might receive fertilizer treatment. These estimates provide insight into the potential of urban nonpoint sources as important sources of nutrients and *E. coli* in the Headwaters of Big Raccoon Creek subwatershed.

Dog and cat populations were estimated for the Headwaters of Big Raccoon Creek subwatershed using statistics reported in the *2007 U.S. Pet Ownership & Demographics Sourcebook*[1]. Specifically, the *Sourcebook* reports that on average 37.2 percent of households own dogs and 32.4 percent of households own cats. Typically, the average number of pets per household is 1.7 dogs and 2.2 cats. However, pets are likely only a significant source of *E. coli* and nutrients in population centers (i.e., cities and towns). The estimated number of domestic pets in cities and towns in the watershed are presented in Table 18 and are

[1] http://www.avma.org/reference/marketstats/sourcebook.asp

based on the average number of pets per household multiplied by the number of households in the city or town.

Table 18. Estimated Pet Populations in the Cities and Towns of the Headwaters of Big Raccoon Creek Subwatershed

City/Town	Households in 2010 [a]	Estimated Number of Cats	Estimated Number of Dogs
Advance	127	279.4	215.9

a. 2010 population is a U.S. Census Bureau estimate.

Wildlife

The Indiana Department of Natural Resources (IDNR) is the primary entity responsible for monitoring wildlife populations and habitats throughout Indiana. Wildlife such as deer, geese, ducks, etc. can be sources of *E. coli* and nutrients. Population estimates for types of wildlife are generally not available.

In summary, the Headwaters of Big Raccoon Creek subwatershed is dominated by agricultural lands. Sources of impairment include a confined feeding operation and other small feeding operations, and stormwater and agricultural runoff, and failing septic systems. Specifically, Headwaters of Big Raccoon Creek is characterized by two municipal wastewater treatment plants with a total of three *E. coli* permit violations, and six TSS permit violations. These characteristics are likely to affect the amount of *E. coli*, sediment and nutrient loading found in the Headwaters of Big Raccoon Creek subwatershed.

4.2.2 Subwatershed Summary: Town of New Ross

This section of the report presents the available information on the sources of *E. coli* in the Town of New Ross subwatershed.

The Town of New Ross subwatershed is located south of Cornstalk Creek subwatershed and west of the Headwaters of Big Raccoon Creek subwatershed, covering nearly 19 square miles (Figure 18). The Town of New Ross subwatershed drains portions of Montgomery and Boone Counties. New Ross is the only urban area in the Town of New Ross subwatershed. Land use in the Town of New Ross subwatershed is primarily agriculture (87%) as shown in Table 15. Hay and pasture areas contribute to 4 percent of the watershed area and approximately 6.5 percent of the land is developed.

Table 15. Land Use in the Town of New Ross Subwatershed

Land Use	Area		Percent
	Acres	Square Miles	
Open Water	7.78	0.01	0.01
Developed, Open Space	694.32	1.07	5.6
Developed, Low Intensity	94.3	0.15	0.79
Developed, Medium Intensity	11.12	0.02	0.1
Developed, High Intensity	0	0	0
Forest	21.09	0.41	2.2
Shrub/Scrub	118.54	0.19	1
Hay/Pasture	438.56	0.7	3.7
Agriculture	10,517.5	16.42	86.6
Wetlands	3.11	0.01	0.01
TOTAL	**11,906.32**	**18.96**	**100**

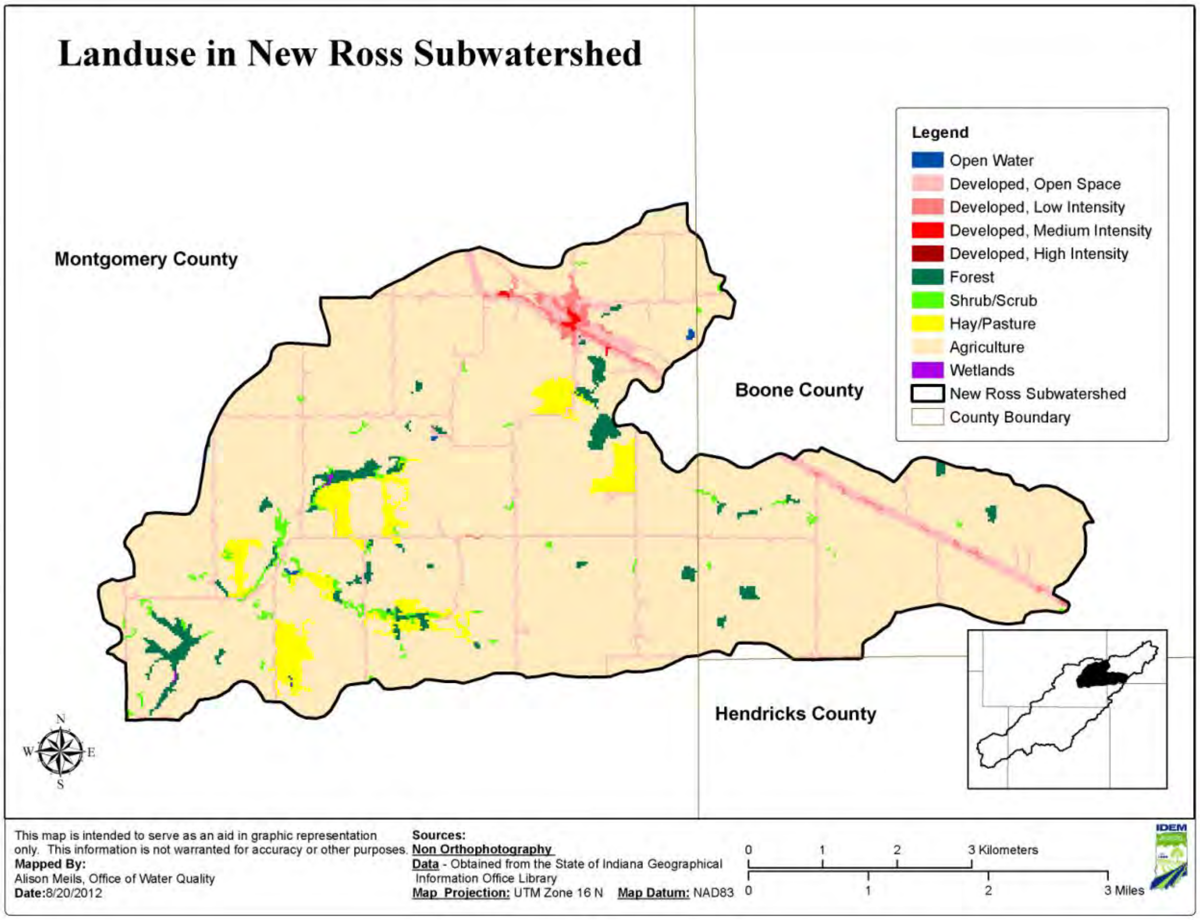

Figure 18. Land Use in the Town of New Ross Subwatershed

4.2.2.1 Point Sources

There are no known potential point sources of *E. coli* in the Town of New Ross subwatershed, as regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

Illicitly Connected "Straight Pipe" Systems

Some household wastes within Indiana and potentially within the Town of New Ross subwatershed directly discharge to a stream or are illegally connected directly to tile-drainage pipes in agricultural watersheds, providing a direct source of pollutants such as *E. coli* to the stream (these systems are sometimes referred to as "straight pipe" discharges).

4.2.2.2 Nonpoint Sources

This section summarizes the potential nonpoint sources of *E. coli* in the Town of New Ross subwatershed that are not regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

Cropland

Approximately 87 percent of the land in the Town of New Ross subwatershed is classified as row crops. Accumulation of *E. coli* on cropland occurs from manure fertilizers, wildlife excreta, irrigation water, and application of waste products from municipal and industrial wastewater treatment facilities.

Pastures and Livestock Operations

In the Town of New Ross subwatershed, 4 percent of land use is hay and grasslands. Runoff from pastures and livestock operations can be potential agricultural sources of *E. coli*. For example, animals grazing in pasturelands deposit manure directly upon the land surface and, even though a pasture may be relatively large and animal densities low, the manure will often be concentrated near the feeding and watering areas in the field. These areas can quickly become barren of plant cover, increasing the possibility of erosion and contaminated runoff during a storm event.

Livestock are potential source of *E. coli* to streams, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas. Watershed specific data are not available for livestock populations. However, county-wide data available from the National Agricultural Statistic Service were downloaded and area weighted to estimate animal population in the subwatershed. The area of the county within the subwatershed is divided by the area of the entire county and multiplied by the total number of animals in the county based on the NASS survey. This is done for each county in the watershed and summed to get an area weighted estimate of animals with the watershed. There are an estimated 1822 animal units in the Town of New Ross subwatershed and the animal unit density is 96 animal units per square mile as shown in Table 16. While animals are raised on property located within the watershed none of the animal operations are large enough to be considered CFOs in the Town of New Ross subwatershed.

Table 16. Animal Unit Density in the Town of New Ross Subwatershed

Subwatershed Area (sq. miles)	Animal	Total Number of Head in County	Number of Animals in One Animal Unit	Number of Animal Units	Animal Unit Density (animal units/mi^2)
18.96	Hogs and Pigs	Montgomery: 3469 Boone: 364	2.5	1,553.2	96.14
	Cattle and Calves	Montgomery: 176 Boone: 39	1	215	
	Sheep and Lambs	Montgomery: 38 Boone: 5	10	4.3	
	Horses and Ponies	Montgomery: 13 Boone: 12	0.5	50	
	Poultry	Montgomery: 79 Boone: 6	250	0.34	
			TOTAL	**1,822.84**	

Onsite Wastewater Treatment Systems

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

The Indiana State Department of Health (ISDH) regulates (410 IAC 6-8.3) through the local health departments the residential onsite sewage disposal program. Onsite sewage disposal systems (i.e., septic systems) are those, which do not result in an off-lot discharge of treated effluent, typically consisting of a septic tank to settle out and digest sewage solids, followed by a system of perforated piping to distribute the treated wastewater for absorption into the soil. More than 800,000 onsite sewage disposal systems are currently used in Indiana. Local health departments issue more than 15,000 permits per year for new systems, and about 6,000 permits for repairs.

410 IAC 6-8.3-52 General sewage disposal requirements
Sec. 52. (a) No person shall throw, run, drain, seep, or otherwise dispose into any of the surface waters or ground waters of this state, or cause, permit, or suffer to be thrown, run, drained, allowed to seep, or otherwise disposed into such waters, any organic or inorganic matter from a dwelling or residential onsite sewage system that would cause or contribute to a health hazard or water pollution.
(b) The: (1) design; (2) construction; (3) installation; (4) location; (5) maintenance; and (6) operation; of residential onsite sewage systems shall comply with the provisions of this rule.

410 IAC 6-8.3-55 Violations; permit denial and revocation
Sec. 55. (a) Should a residential onsite sewage system fail, the failure shall be corrected by the owner within the time limit set by the health officer. (b) If any component of a residential onsite sewage system is found to be: (1) defective; (2) malfunctioning; or (3) in need of service; the health officer may require the repair, replacement, or service of that component. The repair, replacement, or service shall be conducted within the time limit set by the health officer. (c) Any person found to be violating this rule may be served by the health officer with a written order stating the nature of the violation and providing a time limit for satisfactory correction thereof.

Boone County follows the Indiana Administrative Code (RULE 410 IAC 6-8.3), with regards to septic systems along with local ordinances. The Boone County, lndiana Code of Ordinances (Volume 2 Land Usage, Chapter 51) addresses sewage disposal systems, permit requirements, drainage requirements, powers of inspection, and penalties. Montgomery County follows the Indiana Administrative Code (410 IAC 6-8.3), with regards to septic systems.

A comprehensive database of septic systems within the Big Raccoon Creek watershed is not available; therefore, the rural population of each subwatershed was calculated to obtain a general representation of the number of systems. The US Census provides the total number of people within a county as well as the total urban and rural population of the county. Subwatershed population is estimated by dividing the subwatershed area by the total county area and multiplying it by the county census population. It is assumed that the numbers of septic systems in the subwatersheds are directly proportional to rural population density. An additional estimate of septic systems can be made using the 1990 US Census, as that is the last Census that inventoried how household wastewater is disposed. The rural population in the Town of New Ross subwatershed is shown in Table 21, along with a calculated density (total rural population divided by total area). The rural population density can be used to compare the different subwatersheds within the Big Raccoon Creek watershed.

It should also be noted that hydrologic soil group A and B soils have good infiltration rates and have less risk for failing septic systems due to this factor. Group C and D soils have slow infiltration rates with finer textures and slow water movement. The Town of New Ross subwatershed has less than one percent of soil group A, 34 percent of soil group B, and 65 percent of soil groups C and D.

Table 21. Rural Population Density in the Town of New Ross Subwatershed

County	Area of County in Subwatershed (mi^2)	County Population	Urban Population	Rural Population	Rural Population Density (persons/mi^2)
Boone	4.46	100	0	100	31.17
Montgomery	14.5	814	323	491	
TOTAL	18.96	914	323	591	

Urban Storm Water

In areas not covered under the NPDES MS4 program, storm water runoff from developed areas is not regulated under a permit and is therefore a nonpoint source. Runoff from urban areas can carry a variety of pollutants originating from a variety of sources. Depending on the amount of developed, impervious land in a watershed, urban nonpoint source inputs can result in localized or widespread water quality degradation. The percent and distribution of developed land in the Town of New Ross subwatershed is discussed in Section 4.2.2. However, inputs from urban sources are difficult to quantify. Estimates can be made of pet populations and residential areas that might receive fertilizer treatment. These estimates provide insight into the potential of urban nonpoint sources as important sources of *E. coli* in the Town of New Ross subwatershed.

Dog and cat populations were estimated for the Town of New Ross watershed using statistics reported in the *2007 U.S. Pet Ownership & Demographics Sourcebook*[1]. Specifically, the *Sourcebook* reports that on average 37.2 percent of households own dogs and 32.4 percent of households own cats. Typically, the average number of pets per household is 1.7 dogs and 2.2 cats. However, pets are likely only a significant source of *E. coli* in population centers (i.e., cities and towns). The estimates of domestic pets in cities and towns in the watershed are presented in Table 22 and are based on the average number of pets per household multiplied by the number of households in the city or town.

Table 22. Estimated Pet Populations in the Cities and Towns of the Town of New Ross Subwatershed

City/Town	Households in 2010 [a]	Estimated Number of Cats	Estimated Number of Dogs
New Ross	150	330	255

a. 2010 population is a U.S. Census Bureau estimate.

Wildlife

The Indiana Department of Natural Resources (IDNR) is the primary entity responsible for monitoring wildlife populations and habitats throughout Indiana. Wildlife such as deer, geese, ducks, etc. can be sources of *E. coli*. Population estimates for types of wildlife are generally not available.

In summary, the Town of New Ross subwatershed is dominated by agriculture. There are no known point sources and the potential nonpoint sources of impairment include small animal lots, agricultural practices, lack of riparian buffers surrounding streams and wildlife. These characteristics are likely to affect the amount of *E. coli* loading found in the Town of New Ross subwatershed.

4.2.3 Subwatershed Summary: Haw Creek

This section of the report presents the available information on the sources of *E. coli* in the Haw Creek subwatershed.

[1] http://www.avma.org/reference/marketstats/sourcebook.asp

The Haw Creek subwatershed covers nearly 28 square miles (Figure 19) and is located in the central part of the Big Raccoon Creek watershed with Little Raccoon Creek to the north and Cline Creek to the south. The Haw Creek subwatershed drains portions of Hendricks, Montgomery and Putnam Counties. The northern fringes of Roachdale are included in the Haw Creek subwatershed drainage. Land use in the Haw Creek subwatershed is primarily agriculture (87%) as shown in Table 23. Forest areas contribute to 4 percent of the watershed and approximately 4 percent of the land is developed.

Table 23. Land Use in the Haw Creek Subwatershed

Land Use	Area		Percent
	Acres	**Square Miles**	
Open Water	2.45	<0.01	0.03
Developed, Open space	659.8	1.03	3.71
Developed, Low Intensity	44.7	0.07	0.26
Developed, Medium Intensity	4.6	<0.01	0.03
Developed, High Intensity	1.11	<0.01	0.03
Forest	786.6	1.22	4.41
Shrub/Scrub	197.93	0.31	1.1
Hay/Pasture	594.23	0.93	3.3
Agriculture	1,5571.4	24.3	87.1
Wetlands	1.11	<0.01	0.03
TOTAL	**17,856.1**	**27.90**	**100**

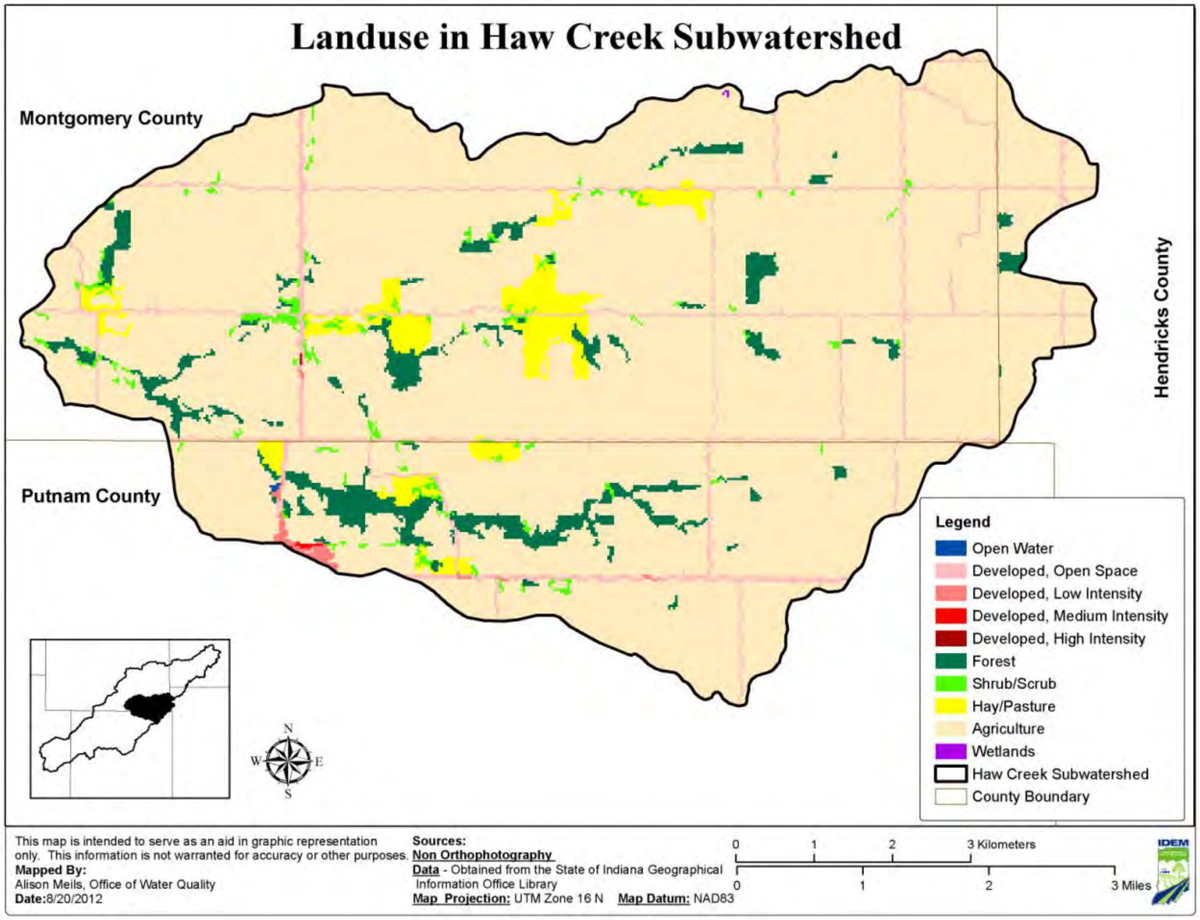

Figure 19. Land Use in the Haw Creek Subwatershed

4.2.3.1 Point Sources

There are no WWTPs in the Haw Creek subwatershed, however one of the Town of Roachdale WWTP SSOs is located in the subwatershed and could be a potential point sources of *E. coli*, as regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are unintentional and illegal discharges of raw sewage from municipal sanitary sewers. SSOs discharge *E. coli* to waterbodies and may occur due to:
Severe weather resulting in of excessive runoff of stormwater into sewer lines

- Vandalism
- Improper operation and maintenance
- Malfunction of lift stations
- Electrical power failures

The Roachdale Municipal WWTP (IN0020052) was identified as having one SSO in the Haw Creek subwatershed (Figure 19). The facility has two SSOs, but only one is located in the Haw Creek subwatershed. This SSO is located along an unnamed tributary to Lick Creek (AUID INB08C3_02) and in the event of an overflow would impact the stream. The other SSO is located in the Little Raccoon Creek subwatershed and in the event of an overflow would impact Cline Creek (AUID INB08C6_1002).

Overflows from SSOs are expressly prohibited from discharging at any time. Should any release from the SSO occur, the permittee is required to nitify the Compliance Evaluation Section of the OWQ within 24 hours and in writing within five days of the event in accordance with the requirements in Part II.C.3.d of the permit. There were no reported SSOs from 2009 - 2011.

Illicitly Connected "Straight Pipe" Systems

Some household wastes within Indiana and potentially within the Haw Creek subwatershed directly discharge to a stream or are illegally connected directly to tile-drainage pipes in agricultural watersheds, providing a direct source of *E. coli* to the stream (these systems are sometimes referred to as "straight pipe" discharges).

4.2.3.2 Nonpoint Sources

This section summarizes the potential nonpoint sources of *E. coli* in the Haw Creek subwatershed that are not regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

Cropland

Approximately 87 percent of the land in Haw Creek subwatershed is classified as row crops. Accumulation of nutrients and *E. coli* on cropland occurs from manure fertilizers, wildlife excreta, irrigation water, and application of waste products from municipal and industrial wastewater treatment facilities.

Pastures and Livestock Operations

In the Haw Creek subwatershed, 4 percent of land use is pasture and shrublands. Runoff from pastures and livestock operations can be potential agricultural sources of *E. coli*. For example, animals grazing in pasturelands deposit manure directly upon the land surface and, even though a pasture may be relatively large and animal densities low, the manure will often be concentrated near the feeding and watering areas in the field. These areas can quickly become barren of plant cover, increasing the possibility of erosion and contaminated runoff during a storm event.

Livestock are potential sources of *E. coli* to streams, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas. Watershed specific data are not available for livestock populations. However, county-wide data available from the National Agricultural Statistic Service were downloaded and area weighted to estimate animal population in the subwatershed. The area of the county within the subwatershed is divided by the area of the entire county and multiplied by the total number of animals in the county based on the NASS survey. This is done for each county in the subwatershed and summed to get an area weighted estimate of animals with the watershed. There are an estimated 2302 animal units in the Haw Creek subwatershed and the animal unit density is 82.5 animal units per square mile as shown in Table 24.

Table 24. Animal Unit Density in the Haw Creek Subwatershed

Subwatershed Area (sq. miles)	Animal	Total Number of Head in County	Number of Animals in One Animal Unit	Number of Animal Units	Animal Unit Density (animal units/mi^2)
27.9	Hogs and Pigs	Montgomery: 4577 Hendricks: 45 Putnam: 44	2.5	1,866	82.5

	Cattle and Calves	Montgomery: 232 Hendricks: 14 Putnam: 116	1	362	
	Sheep and Lambs	Montgomery: 50 Hendricks: 2 Putnam: 3	10	6	
	Horses and Ponies	Montgomery: 17 Hendricks: 13 Putnam: 4	0.5	68	
	Poultry	Montgomery: 104 Hendricks: 2 Putnam: 2	250	0.4	
			TOTAL	**2,302.4**	

Onsite Wastewater Treatment Systems

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

The Indiana State Department of Health (ISDH) regulates (410 IAC 6-8.3) through the local health departments the residential onsite sewage disposal program. Onsite sewage disposal systems (i.e., septic systems) are those, which do not result in an off-lot discharge of treated effluent, typically consisting of a septic tank to settle out and digest sewage solids, followed by a system of perforated piping to distribute the treated wastewater for absorption into the soil. More than 800,000 onsite sewage disposal systems are currently used in Indiana. Local health departments issue more than 15,000 permits per year for new systems, and about 6,000 permits for repairs.

410 IAC 6-8.3-52 General sewage disposal requirements

Sec. 52. (a) No person shall throw, run, drain, seep, or otherwise dispose into any of the surface waters or ground waters of this state, or cause, permit, or suffer to be thrown, run, drained, allowed to seep, or otherwise disposed into such waters, any organic or inorganic matter from a dwelling or residential onsite sewage system that would cause or contribute to a health hazard or water pollution.
(b) The: (1) design; (2) construction; (3) installation; (4) location; (5) maintenance; and (6) operation; of residential onsite sewage systems shall comply with the provisions of this rule.

410 IAC 6-8.3-55 Violations; permit denial and revocation

Sec. 55. (a) Should a residential onsite sewage system fail, the failure shall be corrected by the owner within the time limit set by the health officer. (b) If any component of a residential onsite sewage system is found to be: (1) defective; (2) malfunctioning; or (3) in need of service; the health officer may require the repair, replacement, or service of that component. The repair, replacement, or service shall be conducted within the time limit set by the health officer. (c) Any person found to be violating this rule may be served by the health officer with a written order stating the nature of the violation and providing a time limit for satisfactory correction thereof.

Montgomery and Putnam Counties follow the Indiana Administrative Code (410 IAC 6-8.2), with regards to septic systems.

A comprehensive database of septic systems within the Big Raccoon Creek watershed is not available; therefore, the rural population of each subwatershed was calculated to obtain a general representation of the number of systems. The US Census provides the total number of people within a county as well as the total urban and rural population of the county. Subwatershed population is estimated by dividing the subwatershed area by the total county area and multiplying it by the county census population. It is assumed that the numbers of septic systems in the subwatersheds are directly proportional to rural population density. An additional estimate of septic systems can be made using the 1990 US Census, as that is the last Census that inventoried how household wastewater is disposed. The rural population in the Haw Creek subwatershed is shown in Table 25, along with a calculated density (total rural population divided by total area). The rural population density can be used to compare the different subwatersheds within the Big Raccoon Creek watershed.

It should also be noted that hydrologic soil group A and B soils have good infiltration rates and have less risk for failing septic systems due to this factor. Group C and D soils have slow infiltration rates with finer textures and slow water movement. Haw Creek subwatershed has less than 1 percent of soil group A, 36 percent of soil group B, and 63 percent of soil groups C and D.

Table 25. Rural Population Density in the Haw Creek Subwatershed

County	Area of County in Subwatershed (mi^2)	County Population	Urban Population	Rural Population	Rural Population Density (persons/mi^2)
Hendricks	1.24	19	0	19	23.94
Montgomery	19.19	329	0	329	
Putnam	7.47	520	200	320	
TOTAL	27.9	868	200	668	

Urban Storm Water

In areas not covered under the NPDES MS4 program, storm water runoff from developed areas is not regulated by a permit and is therefore a nonpoint source. Runoff from urban areas can carry a variety of pollutants originating from a variety of sources. Depending on the amount of developed, impervious land in a watershed, urban nonpoint source inputs can result in localized or widespread water quality degradation. The percent and distribution of developed land in the Haw Creek subwatershed is discussed in Section 4.2.3. However, inputs from urban sources are difficult to quantify. Estimates can be made of pet populations.These estimates provide insight into potential *E. coli* contributions of urban nonpoint sources as important sources of in the Haw Creek subwatershed.

Dog and cat populations were estimated for the Haw Creek watershed using statistics reported in the *2007 U.S. Pet Ownership & Demographics Sourcebook*[1]. Specifically, the *Sourcebook* reports that on average 37.2 percent of households own dogs and 32.4 percent of households own cats. Typically, the average number of pets per household is 1.7 dogs and 2.2 cats. However, pets are likely only a significant source of *E. coli* in population centers (i.e., cities and towns). The estimates of domestic pets in cities and towns in the watershed are presented in Table 26 and are based on the average number of pets per household multiplied by the number of households in the city or town.

[1] http://www.avma.org/reference/marketstats/sourcebook.asp

Table 26. Estimated Pet Populations in the Cities and Towns of the Haw Creek Subwatershed

City/Town	Households in 2010 [a]	Estimated Number of Cats	Estimated Number of Dogs
Roachdale	100	220	170

a. 2010 population is a U.S. Census Bureau estimate.

Wildlife

The Indiana Department of Natural Resources (IDNR) is the primary entity responsible for monitoring wildlife populations and habitats throughout Indiana. Wildlife such as deer, geese, ducks, etc. can be sources of *E. coli*. Population estimates for types of wildlife are generally not available.

In summary, the Haw Creek subwatershed is dominated by agrilculture. Sources of impairment include SSOs and non-point sources from landuse practices and narrow riparian buffers. These characteristics are likely to affect the amount of *E. coli* loading found in the Haw Creek subwatershed.

4.2.4 Subwatershed Summary: Cornstalk Creek

This section of the report presents the available information on the sources of *E. coli* and impaired biological communities in the Cornstalk Creek subwatershed.

The Cornstalk Creek subwatershed is located in the northern part of the Big Raccoon Creek watershed just west of the Headwaters of Big Raccoon Creek subwatershed. Cornstalk Creek subwatershed covers just over 20 square miles (Firgure 20). The Cornstalk Creek subwatershed drains portions of Montgomery and Putnam Counties. The Cornstalk Creek subwatershed contains part of the drainage from Whitesville. Land use in the Cornstalk Creek subwatershed is primarily agriculture (87%) as shown in Table 27. Forested areas contribute to 5 percent of the watershed area and approximately 5 percent of the land is developed.

Table 27. Land Use in the Cornstalk Creek Subwatershed

Land Use	Area		Percent
	Acres	Square Miles	
Open Water	3.78	0.01	0.04
Developed, Open Space	636.94	1	4.93
Developed, Low Intensity	19.13	0.03	0.15
Developed, Medium Intensity	0	0	0
Developed, High Intensity	0	0	0
Forest	682.53	1.07	5.28
Shrub/Scrub	181.92	0.28	1.36
Hay/Pasture	146.56	0.23	1.14
Agriculture	11,257.18	17.59	87
Wetlands	14.46	0.02	0.1
TOTAL	**12,934**	**20.23**	**100**

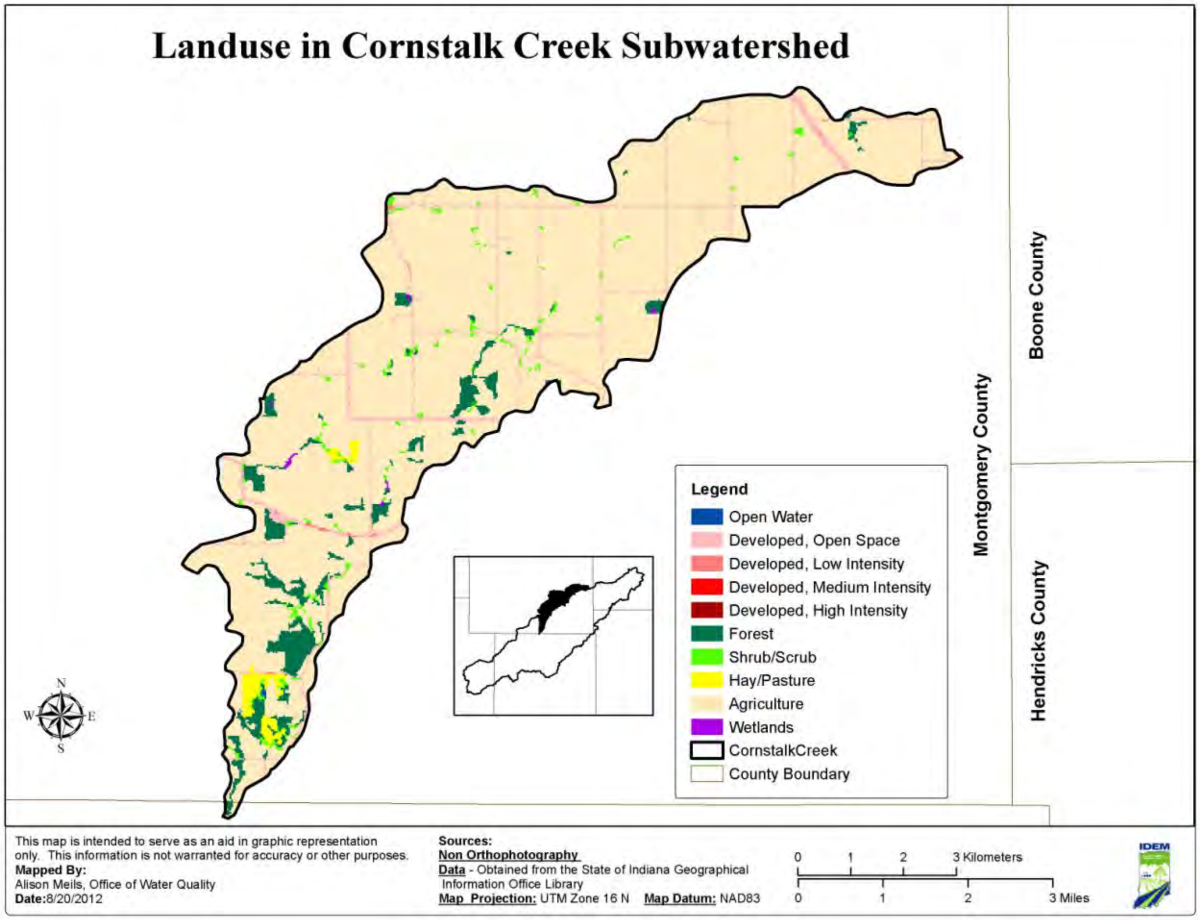

Figure 20. Land Use in the Cornstalk Creek Subwatershed

4.2.4.1 Point Sources

There are no known potential point sources of *E. coli* in the Cornstalk Creek subwatershed, as regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

Illicitly Connected "Straight Pipe" Systems

Some household wastes within Indiana and potentially within the Cornstalk Creek subwatershed directly discharge to a stream or are illegally connected directly to tile-drainage pipes in agricultural watersheds, providing a direct source of pollutants such as *E. coli* to the stream (these systems are sometimes referred to as "straight pipe" discharges).

4.2.4.2 Nonpoint Sources

This section summarizes the potential nonpoint sources of *E. coli* in the Cornstalk Creek subwatershed that are not regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

Cropland

Approximately 87 percent of the land in the Cornstalk Creek subwatershed is classified as row crops. Croplands can be a source of *E. coli*. Accumulation of nutrients and *E. coli* on cropland occurs from manure fertilizers, wildlife excreta, irrigation water, and application of waste products from municipal and industrial wastewater treatment facilities.

Pastures and Livestock Operations

In the Cornstalk Creek subwatershed, one percent of land use is hay and pasture. Runoff from pastures and livestock operations can be potential agricultural sources of *E. coli*. For example, animals grazing in pasturelands deposit manure directly upon the land surface and, even though a pasture may be relatively large and animal densities low, the manure will often be concentrated near the feeding and watering areas in the field. These areas can quickly become barren of plant cover, increasing the possibility of erosion and contaminated runoff during a storm event.

Livestock are potential source of *E. coli* to streams, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas. Watershed specific data are not available for livestock populations. However, county-wide data available from the National Agricultural Statistic Service were downloaded and area weighted to estimate animal population in the subwatershed. The area of the county within the subwatershed is divided by the area of the entire county and multiplied by the total number of animals in the county based on the NASS survey. This is done for each county in the subwatershed and summed to get an area weighted estimate of animals with the subwatershed. There are an estimated 2213 animal units in the Cornstalk Creek subwatershed and the animal unit density is 109 animal units per square mile as shown in Table 28.

Table 28. Animal Unit Density in the Cornstalk Creek Subwatershed

Subwatershed Area (sq. miles)	Animal	Total Number of Head in County	Number of Animals in One Animal Unit	Number of Animal Units	Animal Unit Density (animal units/mi^2)
20.23	Hogs and Pigs	Montgomery: 4817	2.5	1,926.8	109.37
	Cattle and Calves	Montgomery: 244	1	244	
	Sheep and Lambs	Montgomery: 53	10	5.3	
	Horses and Ponies	Montgomery: 18	0.5	36	
	Poultry	Montgomery: 109	250	0.44	
			TOTAL	**2,212.54**	

Streambank Erosion

Streambank erosion is potentially a significant source of TSS in the Cornstalk Creek subwatershed. Streambank erosion is a natural process but can be accelerated due to a variety of human activities:

- Vegetation located adjacent to streams flowing through crop or pasture fields is often removed to promote drainage or cattle access to water. The loss of vegetation makes the streambanks more susceptible to erosion due to the loss of plant roots.
- Extensive areas of agricultural tiles promote much quicker delivery of rainfall into streams than would occur without subsurface drainage, which could potentially contribute to streambank erosion due to high velocities and shear stress.
- The creation of impervious surfaces (e.g., streets, rooftops, driveways, parking lots) can also lead to rapid runoff of rainfall and higher stream velocities that might cause streambank erosion.

Onsite Wastewater Treatment Systems

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

The Indiana State Department of Health (ISDH) regulates (410 IAC 6-8.3) through the local health departments the residential onsite sewage disposal program. Onsite sewage disposal systems (i.e., septic systems) are those, which do not result in an off-lot discharge of treated effluent, typically consisting of a septic tank to settle out and digest sewage solids, followed by a system of perforated piping to distribute the treated wastewater for absorption into the soil. More than 800,000 onsite sewage disposal systems are currently used in Indiana. Local health departments issue more than 15,000 permits per year for new systems, and about 6,000 permits for repairs.

410 IAC 6-8.3-52 General sewage disposal requirements

Sec. 52. (a) No person shall throw, run, drain, seep, or otherwise dispose into any of the surface waters or ground waters of this state, or cause, permit, or suffer to be thrown, run, drained, allowed to seep, or otherwise disposed into such waters, any organic or inorganic matter from a dwelling or residential onsite sewage system that would cause or contribute to a health hazard or water pollution.
(b) The: (1) design; (2) construction; (3) installation; (4) location; (5) maintenance; and (6) operation; of residential onsite sewage systems shall comply with the provisions of this rule.

410 IAC 6-8.3-55 Violations; permit denial and revocation

Sec. 55. (a) Should a residential onsite sewage system fail, the failure shall be corrected by the owner within the time limit set by the health officer. (b) If any component of a residential onsite sewage system is found to be: (1) defective; (2) malfunctioning; or (3) in need of service; the health officer may require the repair, replacement, or service of that component. The repair, replacement, or service shall be conducted within the time limit set by the health officer. (c) Any person found to be violating this rule may be served by the health officer with a written order stating the nature of the violation and providing a time limit for satisfactory correction thereof.

Montgomery County follows the Indiana Administrative Code (410 IAC 6-8.2), with regards to septic systems.

A comprehensive database of septic systems within the Big Raccoon Creek watershed is not available; therefore, the rural population of each subwatershed was calculated to obtain a general representation of the number of systems. The US Census provides the total number of people within a county as well as the total urban and rural population of the county. Subwatershed population is estimated by dividing the subwatershed area by the total county area and multiplying it by the county census population. It is assumed that the numbers of septic systems in the subwatersheds are directly proportional to rural population density. An additional estimate of septic systems can be made using the 1990 US Census, as that is the last Census that inventoried how household wastewater is disposed. The rural population in the Cornstalk Creek subwatershed is shown in Table 29, along with a calculated density (total rural population divided by total area). The rural population density can be used to compare the different subwatersheds within the Big Raccoon Creek watershed.

It should also be noted that hydrologic soil group A and B soils have good infiltration rates and have less risk for failing septic systems due to this factor. Group C and D soils have slow infiltration rates with finer textures and slow water movement. Cornstalk Creek subwatershed has less than 1 percent of soil group A, 27 percent of soil group B, and 72 percent of soil groups C and D.

Table 29. Rural Population Density in the Cornstalk Creek Subwatershed

County	Area of County in Subwatershed (mi^2)	County Population	Urban Population	Rural Population	Rural Population Density (persons/mi^2)
Montgomery	20.2	457	0	457	22.7
Putnam	0.02	2	0	2	
TOTAL	20.22	459	0	459	

Urban Storm Water

In areas not covered under the NPDES MS4 program, storm water runoff from developed areas is not regulated by a permit and is therefore a nonpoint source. Runoff from urban areas can carry a variety of pollutants originating from a variety of sources. Depending on the amount of developed, impervious land in a watershed, urban nonpoint source inputs can result in localized or widespread water quality degradation. The percent and distribution of developed land in the Cornstalk Creek subwatershed is discussed in Section 4.2.4. However, inputs from urban sources are difficult to quantify. Estimates can be made of pet populations and residential areas that might receive fertilizer treatment. These estimates provide insight into the potential of urban nonpoint sources as important sources of *E. coli* in the Cornstalk Creek subwatershed.

Dog and cat populations were estimated for the Cornstalk Creek watershed using statistics reported in the *2007 U.S. Pet Ownership & Demographics Sourcebook*[1]. Specifically, the *Sourcebook* reports that on average 37.2 percent of households own dogs and 32.4 percent of households own cats. Typically, the average number of pets per household is 1.7 dogs and 2.2 cats. However, pets are likely only a significant source of *E. coli* in population centers (i.e., cities and towns). Since there are no incorporated communities in the Cornstalk Creek subwatershed the domestic pet population could not be estimated.

Wildlife

The Indiana Department of Natural Resources (IDNR) is the primary entity responsible for monitoring wildlife populations and habitats throughout Indiana. Wildlife such as deer, geese, ducks, etc. can be sources of *E. coli*. Population estimates for types of wildlife are generally not available.

In summary, the Cornstalk Creek subwatershed is dominated by agriculture. There are no point sources in the subwatershed however other nonpoint sources include riparian habitat, wildlife and livestock operations. These characteristics are likely to affect the amount of *E. coli* loading found in the Cornstalk Creek subwatershed.

4.2.5 Subwatershed Summary: North Ramp Creek

This section of the report presents the available information on the sources of *E. coli* in the North Ramp Creek subwatershed.

[1] http://www.avma.org/reference/marketstats/sourcebook.asp

The North Ramp Creek subwatershed is located in the south-central part of the Big Raccoon Creek watershed, covering 33 square miles (Figure 21). The North Ramp Creek subwatershed drains portions of Putnam County. The North Ramp Creek subwatershed includes the Towns of Carpentersville and Fincastle. Land use in the North Ramp Creek is primarily agriculture (67%) as shown in Table 30. Hay/pasture areas contribute to 15.5 percent of the watershed area, forsted lands contribute to 13%, and approximately four percent of the land is developed.

Table 30. Land Use in the North Ramp Creek Subwatershed

Land Use	Area		Percent
	Acres	**Square Miles**	
Open Water	28.9	0.04	0.12
Developed, Open Space	895.8	1.4	4.23
Developed, Low Intensity	31.6	0.05	0.15
Developed, Medium Intensity	0	0	0
Developed, High Intensity	0	0	0
Forest	2,709.6	4.23	12.85
Shrub/Scrub	181.03	0.28	0.85
Hay/Pasture	3,102.4	4.8	14.5
Agriculture	14203	22.22	67.3
Wetlands	0	0	0
TOTAL	**21,135.6**	**33.02**	**100**

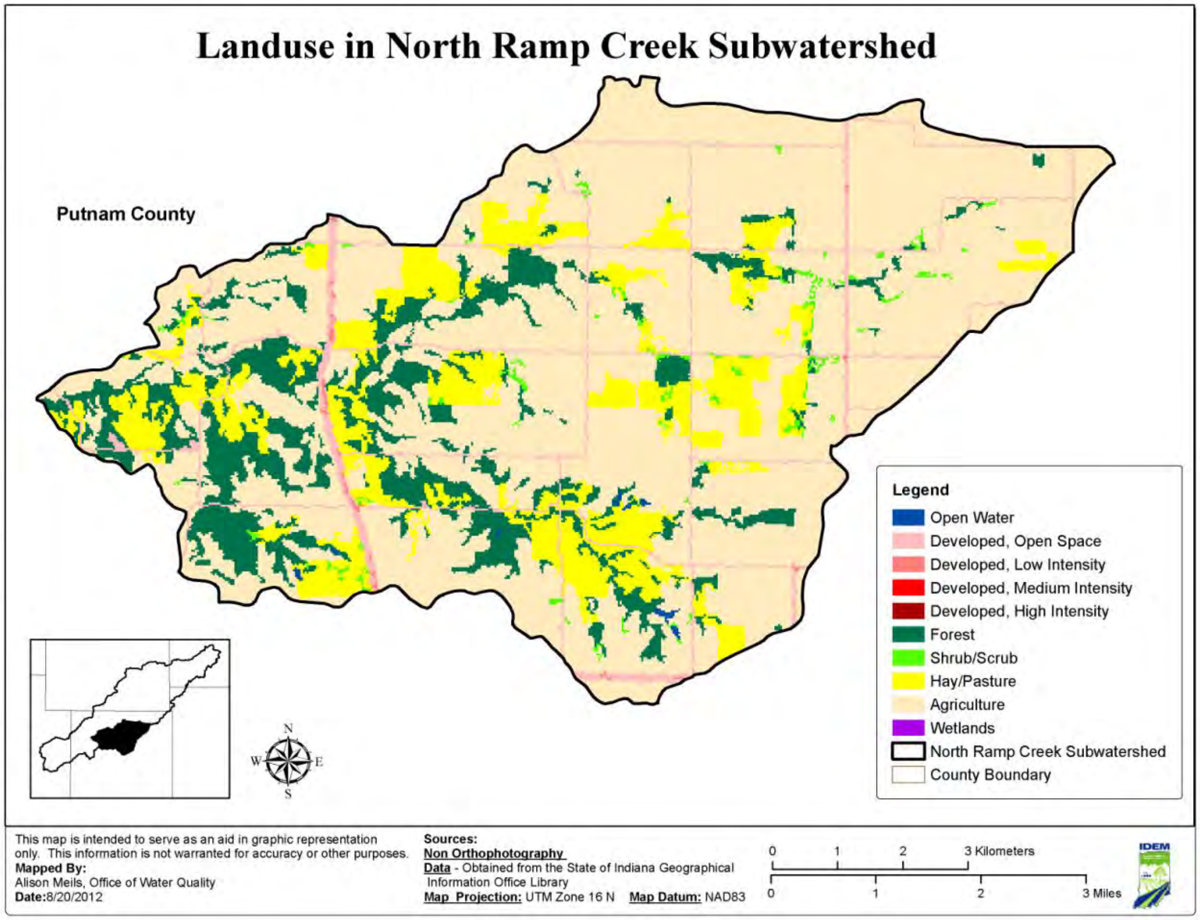

Figure 21. Land Use in the North Ramp Creek Subwatershed

4.2.5.1 Point Sources

There are no known potential point sources of *E. coli* in the North Ramp Creek subwatershed, as regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

Illicitly Connected "Straight Pipe" Systems

Some household wastes within Indiana and potentially within the North Ramp Creek subwatershed directly discharge to a stream or are illegally connected directly to tile-drainage pipes in agricultural watersheds, providing a direct source of *E. coli* to the stream (these systems are sometimes referred to as "straight pipe" discharges).

4.2.5.2 Nonpoint Sources

This section summarizes the potential nonpoint sources of *E. coli* in the North Ramp Creek subwatershed that are not regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

Cropland

Approximately 67 percent of the land in the North Ramp Creek subwatershed is classified as row crops. Accumulation of nutrients and *E. coli* on cropland occurs from manure fertilizers, wildlife excreta, irrigation water, and application of waste products from municipal and industrial wastewater treatment facilities.

Pastures and Livestock Operations

In the North Ramp Creek subwatershed, 16 percent of land use is pasture and shrubland. Runoff from pastures and livestock operations can be potential agricultural sources of *E. coli*. For example, animals grazing in pasturelands deposit manure directly upon the land surface and, even though a pasture may be relatively large and animal densities low, the manure will often be concentrated near the feeding and watering areas in the field. These areas can quickly become barren of plant cover, increasing the possibility of erosion and contaminated runoff during a storm event.

Livestock are potential sources of *E. coli*, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas. Watershed specific data are not available for livestock populations. However, county-wide data available from the National Agricultural Statistic Service were downloaded and area weighted to estimate animal population in the subwatershed. The area of the county within the subwatershed is divided by the area of the entire county and multiplied by the total number of animals in the county based on the NASS survey. This is done for each county in the subwatershed and summed to get an area weighted estimate of animals with the subwatershed. There are an estimated 6419 animal units in the North Ramp Creek subwatershed and the animal unit density is 194 animal units per square mile as shown in Table 31.

Table 31. Animal Unit Density in the North Ramp Creek Subwatershed

Subwatershed Area (sq. miles)	Animal	Total Number of Head in County	Number of Animals in One Animal Unit	Number of Animal Units	Animal Unit Density (animal units/mi^2)
33.02	Hogs and Pigs	Putnam: 2000	2.5	800	194.4
	Cattle and Calves	Putnam: 5275	1	5,275	
	Sheep and Lambs	Putnam: 154	10	15	
	Horses and Ponies	Putnam: 164	0.5	329	
	Poultry	Putnam: 88	250	0.35	
			TOTAL	**6,419.35**	

Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (e.g., septic systems) that are properly designed and maintained should not serve as a source of contamination to surface waters. However, onsite systems do fail for a variety of reasons. Common soil-type limitations which contribute to failure are: seasonal water tables, compact glacial till, bedrock, coarse sand and gravel outwash and fragipan. When these septic systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface waters due to *E. coli* , nitrate + nitrite, and TSS (Horsely and Witten, 1996). Septic systems contain all the water discharged from the home and business and can be a significant source of pathogens.

The Indiana State Department of Health (ISDH) regulates (410 IAC 6-8.3) through the local health departments the residential onsite sewage disposal program. Onsite sewage disposal systems (i.e., septic systems) are those, which do not result in an off-lot discharge of treated effluent, typically consisting of a septic tank to settle out and digest sewage solids, followed by a system of perforated piping to distribute the treated wastewater for absorption into the soil. More than 800,000 onsite sewage disposal systems are currently used in Indiana. Local health departments issue more than 15,000 permits per year for new systems, and about 6,000 permits for repairs.

410 IAC 6-8.3-52 General sewage disposal requirements
Sec. 52. (a) No person shall throw, run, drain, seep, or otherwise dispose into any of the surface waters or ground waters of this state, or cause, permit, or suffer to be thrown, run, drained, allowed to seep, or otherwise disposed into such waters, any organic or inorganic matter from a dwelling or residential onsite sewage system that would cause or contribute to a health hazard or water pollution.
(b) The: (1) design; (2) construction; (3) installation; (4) location; (5) maintenance; and (6) operation; of residential onsite sewage systems shall comply with the provisions of this rule.

410 IAC 6-8.3-55 Violations; permit denial and revocation
Sec. 55. (a) Should a residential onsite sewage system fail, the failure shall be corrected by the owner within the time limit set by the health officer. (b) If any component of a residential onsite sewage system is found to be: (1) defective; (2) malfunctioning; or (3) in need of service; the health officer may require the repair, replacement, or service of that component. The repair, replacement, or service shall be conducted within the time limit set by the health officer. (c) Any person found to be violating this rule may be served by the health officer with a written order stating the nature of the violation and providing a time limit for satisfactory correction thereof.

Putnam County follows the Indiana Administrative Code (410 IAC 6-8.1), with regards to septic systems.

A comprehensive database of septic systems within the Big Raccoon Creek watershed is not available; therefore, the rural population of each subwatershed was calculated to obtain a general representation of the number of systems. The US Census provides the total number of people within a county as well as the total urban and rural population of the county. Subwatershed population is estimated by dividing the subwatershed area by the total county area and multiplying it by the county census population. It is assumed that the numbers of septic systems in the subwatersheds are directly proportional to rural population density. An additional estimate of septic systems can be made using the 1990 US Census, as that is the last Census that inventoried how household wastewater is disposed. The rural population in the North Ramp Creek subwatershed is shown in Table 32, along with a calculated density (total rural population divided by total area). The rural population density can be used to compare the different subwatersheds within the Big Raccoon Creek watershed.

It should also be noted that hydrologic soil group A and B soils have good infiltration rates and have less risk for failing septic systems due to this factor. Group C and D soils have slow infiltration rates with finer textures and slow water movement. North Ramp Creek subwatershed has no soil group A, 67 percent of soil group B, and 33 percent soil groups C and D.

Table 32. Rural Population Density in the North Ramp Creek Subwatershed

County	Area of County in Subwatershed (mi^2)	County Population	Urban Population	Rural Population	Rural Population Density (persons/mi^2)
Putnam	33.02	955	0	955	28.92
TOTAL	33.02	955	0	955	

Urban Storm Water

In areas not covered under the NPDES MS4 program, storm water runoff from developed areas is not regulated by a permit and is therefore a nonpoint source. Runoff from urban areas can carry a variety of pollutants originating from a variety of sources. Depending on the amount of developed, impervious land in a watershed, urban nonpoint source inputs can result in localized or widespread water quality degradation. The percent and distribution of developed land in the North Ramp Creek subwatershed is discussed in Section 4.2.5. However, inputs from urban sources are difficult to quantify. Estimates can be made of pet populations and residential areas that might receive fertilizer treatment. These estimates provide insight into the potential of urban nonpoint sources as important sources of *E. coli* in the North Ramp Creek subwatershed.

Dog and cat populations were estimated for the North Ramp Creek watershed using statistics reported in the *2007 U.S. Pet Ownership & Demographics Sourcebook*[1]. Specifically, the *Sourcebook* reports that on average 37.2 percent of households own dogs and 32.4 percent of households own cats. Typically, the average number of pets per household is 1.7 dogs and 2.2 cats. However, pets are likely only a significant source of *E. coli* and nutrients in population centers (i.e., cities and towns). The estimates of domestic pets are not included in the North Ramp Creek subwatershed summary because there are no incorporated communities located in the subwatershed.

Wildlife

The Indiana Department of Natural Resources (IDNR) is the primary entity responsible for monitoring wildlife populations and habitats throughout Indiana. Wildlife such as deer, geese, ducks, etc. can be sources of *E. coli* and nutrients. Population estimates for types of wildlife are generally not available.

In summary, the North Ramp Creek subwatershed is dominated by agriculture. Sources of impairment include livestock operations, riparian habitat and wildlife. These characteristics are likely to affect the amount of *E. coli* loading found in the North Ramp Creek subwatershed.

4.2.6 Subwatershed Summary: Little Raccoon Creek

This section of the report presents the available information on the sources of *E. coli* and impaired biological communities in the Little Raccoon Creek subwatershed.

The Little Raccoon Creek subwatershed is located in the center of the Big Raccoon Creek watershed, covering just over 46 square miles (Figure 22). The Little Raccoon Creek subwatershed drains portions of Boone, Montgomery, Hendricks, and Putnam Counties. The Little Raccoon Creek subwatershed includes Ladoga, Parkersburg, Raccoon and Roachdale. Land use in the Little Raccoon Creek subwatershed is primarily agriculture (74%) as shown in Table 33. Forested areas contribute to 13 percent of the watershed area and approximately 6.5 percent of the land is developed.

Table 33. Land Use in the Little Raccoon Creek Subwatershed

Land Use	Area		Percent
	Acres	Square Miles	
Open Water	16.9	0.02	0.04
Developed, Open Space	1,565.66	2.45	5.3
Developed, Low Intensity	317.13	0.5	1.08
Developed, Medium Intensity	44.25	0.07	0.15
Developed, High Intensity	9.78	0.01	0.02
Forest	3,756.02	5.87	12.69
Shrub/Scrub	561.77	0.87	1.87

[1] http://www.avma.org/reference/marketstats/sourcebook.asp

Hay/Pasture	1,464.91	2.29	4.95
Agriculture	21,853.18	34.14	73.78
Wetlands	31.58	0.05	0.12
TOTAL	**29,609.7**	**46.27**	**100**

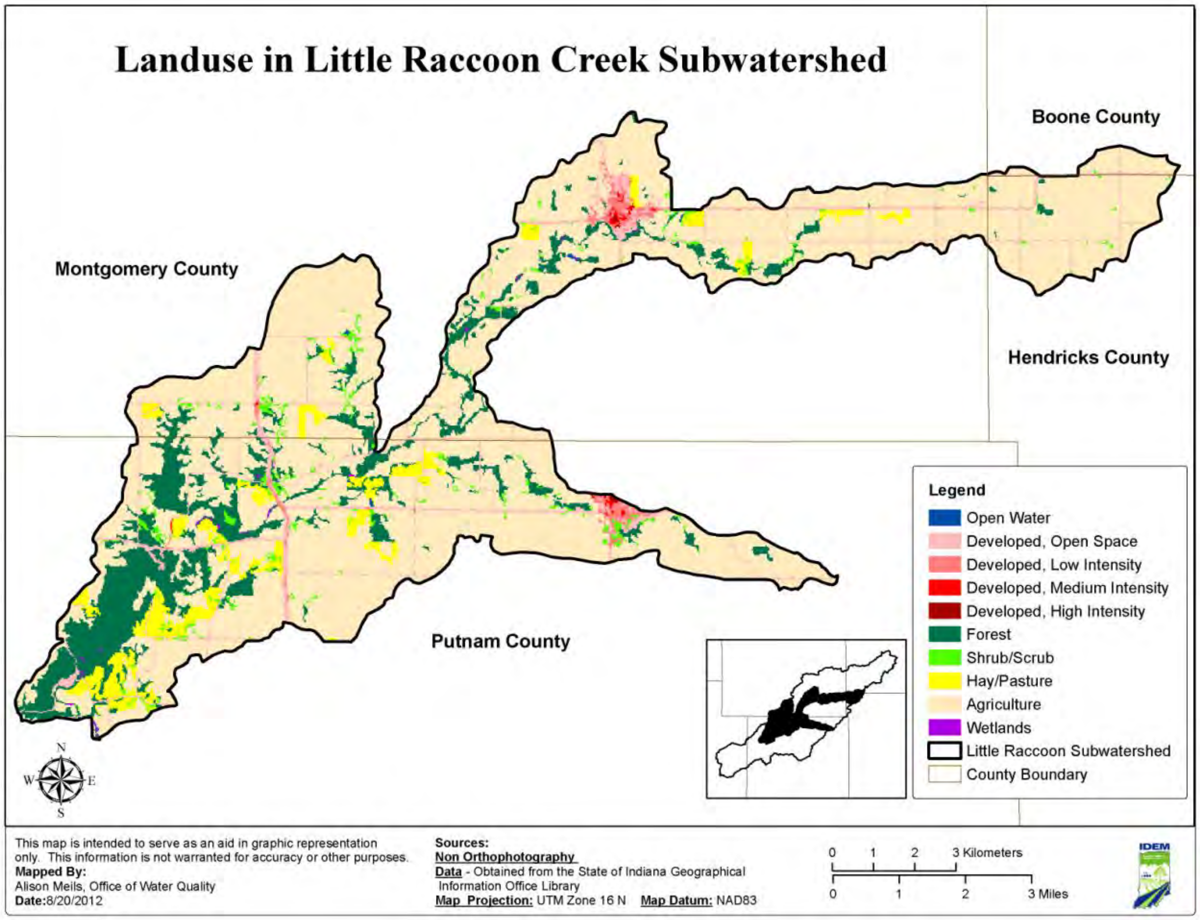

Figure 22. Land Use in the Little Raccoon Creek Subwatershed

4.2.6.1 Point Sources

This section summarizes the potential point sources of *E. coli* in the Little Raccoon Creek subwatershed, as regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

Wastewater Treatment Plants (WWTPs) and Industrial Facilities

Facilities with NPDES permits to discharge wastewater within the Little Raccoon Creek subwatershed include municipal WWTPs and industrial facilities. There are two active WWTPs that discharge wastewater containing *E. coli* within the Little Raccoon Creek subwatershed (Table 13 and Figure). These facilities are the Town of Ladoga WWTP and the Town of Roachdale WWTP. As authorized by the CWA, the NPDES permit program controls water pollution by regulating WWTPs that discharge pollutants into waters of the United States. High Point Oil – Roachdale Mini Mart is also located within the subwatershed and holds an NPDES permit (ING080275) to discharge to the Town of Roachdale storm sewer which discharges to Cline Creek. This is a groundwater petroleum remediation system that discharges treated groundwater to the storm sewer. Municipal facilities in Indiana are required to disinfect their effluent during the recreational season (April 1 to October 31). Table 34 contains the maximum design flow for the active facilities.

The Town of Ladoga WWTP is a bio-chemical wastewater treatment plant equipped with a grinder, two grit channels, a raw sewage pumping station, a primary clarifier, two trickling filters, a recirculation pump station, a secondary clarifier, chlorination and dechlorination facilities followed by post aeration. Sludge is anaerobically digested with final disposition of sludge by a licensed hauler. While the Town of Ladoga WWTP facility does contribute to pathogen loadings, the annual average pathogen concentration (per 100 mL) has been below the WQS (125 MPN/100mL) from 2007 to 2011, ranging from 21.19 to 119. The average daily flow was below the maximum design flow (0.25 MGD) in 2009 (0.21 MGD) and in 2010 (0.15 MGD). The average daily flow in other years was not captured by the data collected in 2010, but it is important to note that the facility had a greater average daily flow in 2007 (0.35 MGD), 2008 (0.35 MGD) and 2011 (0.30 MGD) than the maximum design flow designated in the permit (0.25 MGD). For future sampling in the subwatershed, it is important to note the beginning in August 2012, the Town of Ladoga WWTP no longer has to meet the 1.0 mg/L phosphorus limit. This limit is excluded because the facility discharges less than 10 pounds of phosphorus on a monthly average.

The Town of Roachdale WWTP is an extended aeration treatment facility consisting of a sewage shredder, a bar-screen bypass, a selector basin, an aeration tank, two clarifiers, chlorination and dechlorination facilities, influent and effluent flow meters, sludge digestion and two sludge drying beds. The facility also maintains a land application permit (INLA00047) for the disposal of solids. While the Town of Roachdale WWTP facility does contribute to pathogen loadings, the annual average pathogen concentration (per 100 mL) has been below the WQS (125 MPN/100mL) from 2008 to 2011, ranging from 69.29 to 114. The average daily flow has also been below the maximum design flow (0.16 MGD) from 2008 to 2011, ranging from 0.09 to 0.12.

Table 34. NPDES Permitted Wastewater Dischargers within the Little Raccoon Creek Subwatershed

Facility Name	Permit Number	AUID	Receiving Stream	Maximum Design Flow (MGD)
Town of Ladoga WWTP	IN0023418	INB08C6_01	Big Raccoon Creek	0.25
Town of Roachdale WWTP	IN0020052	INB08C6_T1002	Cline Creek	0.16

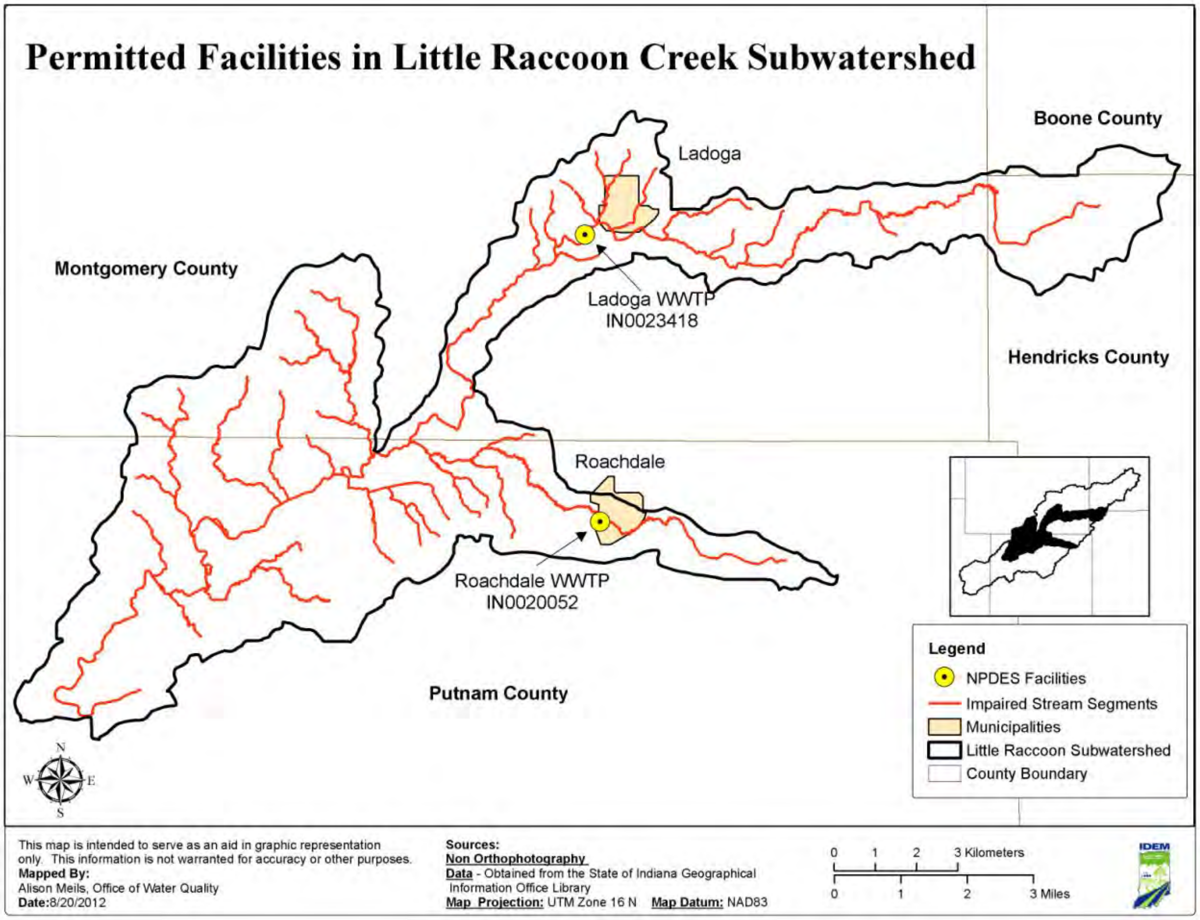

Figure 23. NPDES Facilities in the Little Raccoon Creek Subwatershed

Table 35 presents a summary of permit compliance for both NPDES facilities in the Little Raccoon Creek subwatershed for the five year period between 2007 and 2011. It presents the date of the facility's last inspection and findings from the inspection (i.e., compliance or violation). The table also presents the total number of violations in the five year period for *E. coli* and other parameters. According to Table 35, there have been nine IDEM NPDES facility inspections, resulting in three facility maintainance violations in the five year period. However, there have been water quality violations based on the WWTPs monthly sampling results, including 9 permit violations for *E. coli*, three TSS violations, and 17 phosphorus violations in the five year period.

In 2008, there was a Federal enforcement action against Ladoga WWTP due to multiple effluent limit violations and failing to record sampling information for the period between November 2005 and March 2008. The corrective action included a compliance plan and 12 months of compliance with plan and permit requirements.

Table 35. Summary of Inspections and Permit Compliance in the Little Raccoon Creek Subwatershed for the Five Year Period Ending June 2012

Facility Name	Permit Number	AUID	Date of Last Inspection and Findings	Violations from July 2009 through June 2012

Town of Ladoga WWTP	IN0023418	INB08C6_01	8/9/2011: compliance 8/20/2010: noncompliance 4/13/2009: compliance 7/31/2008: compliance	4 *E. coli* violation; 6 ammonia violations; 1 dissolved oxygen violation; 17 phosphorus violations; 1 total suspended solids violation
Town of Roachdale WWTP	IN0020052	INB08C6_T1002	12/6/2011: compliance 3/9/2010: compliance 7/6/2009: noncompliance 3/3/2009: noncompliance 11/26/2007: compliance	5 *E. coli* violations; 2 BOD violations; 3 chlorine violations; 3 ammonia violations; 2 dissolved oxygen violations; 2 pH violations; 2 total suspended solids violations

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are unintentional and illegal discharges of raw sewage from municipal sanitary sewers. SSOs discharge *E. coli* to waterbodies and may occur due to:
Severe weather resulting in of excessive runoff of stormwater into sewer lines

- Vandalism
- Improper operation and maintenance
- Malfunction of lift stations
- Electrical power failures

The Roachdale Municipal WWTP (IN0020052) was identified as having SSOs in the Little Raccoon Creek subwatershed (Figure 23). The facility has two SSOs, but only one is located in the Little Raccoon Creek subwatershed. This SSO is located along Cline Creek and in the event of an overflow would impact Cline Creek (AUID INB08C6_1002). The other SSO is located in the Haw Creek subwatershed and in the event of an overflow would impact an unnamed tributary to Lick Creek (AUID INB08C3_02).

Overflows from SSOs are expressly prohibited from discharging at any time. Should any release from the SSO occur, the permittee is required to nitify the Compliance Evaluation Section of the OWQ within 24 hours and in writing within five days of the event in accordance with the requirements in Part II.C.3.d of the permit. There were no reported SSOs from 2009 - 2011.

Regulated Storm Water Sources

While there are no MS4 communities in the Little Raccoon Creek subwatershed, Heritage Environmental owns and operates a RCRA Part B land disposal facility in the subwatershed. The facility is a secure, chemical monofill receiving only stabilized treatment residue from the Indianapolis treatment center. The stabilized treatment residue is not characteristically hazardous and meets the treatment standards for all applicable waste codes as specified at 40 CFR Part 268. For this type of treatment a NPDES permit is not required although they do have a general permit for the landfill storm water runoff.

Illicitly Connected "Straight Pipe" Systems

Some household wastes within Indiana and potentially within the Little Raccoon Creek subwatershed directly discharge to a stream or are illegally connected directly to tile-drainage pipes in agricultural watersheds, providing a direct source of pollutants such as *E. coli*, nutrients, and TSS to the stream (these systems are sometimes referred to as "straight pipe" discharges).

4.2.6.2 <u>Nonpoint Sources</u>

This section summarizes the potential nonpoint sources of *E. coli*, nutrients and sediment in the Little Raccoon Creek subwatershed that are not regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

Cropland

Approximately 74 percent of the land in the Little Raccoon Creek subwatershed is classified as row crops. Croplands can be a source of *E. coli*, sediments, and nutrients. Accumulation of nutrients and *E. coli* on cropland occurs from manure fertilizers, wildlife excreta, irrigation water, and application of waste products from municipal and industrial wastewater treatment facilities.

Pastures and Livestock Operations

In the Little Raccoon Creek subwatershed, 5 percent of land use is hay and pasture. Runoff from pastures and livestock operations can be potential agricultural sources of *E. coli*, nutrients, and sediment. For example, animals grazing in pasturelands deposit manure directly upon the land surface and, even though a pasture may be relatively large and animal densities low, the manure will often be concentrated near the feeding and watering areas in the field. These areas can quickly become barren of plant cover, increasing the possibility of erosion and contaminated runoff during a storm event.

Livestock are potential source of *E. coli* and nutrients to streams, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas. Watershed specific data are not available for livestock populations. However, county-wide data available from the National Agricultural Statistic Service were downloaded and area weighted to estimate animal population in the subwatershed. The area of the county within the subwatershed is divided by the area of the entire county and multiplied by the total number of animals in the county based on the NASS survey. This is done for each county in the subwatershed and summed to get an area weighted estimate of animals with the subwatershed. There are an estimated 3237 animal units in the Little Raccoon Creek subwatershed and the animal unit density is approximately 70 animal units per square mile as shown in
Table 14Table 36.

Table 36. Animal Unit Density in the Little Raccoon Creek Subwatershed

Subwatershed Area (sq. miles)	Animal	Total Number of Head in County	Number of Animals in One Animal Unit	Number of Animal Units	Animal Unit Density (animal units/mi^2)
46.27	Hogs and Pigs	Montgomery: 4456 Boone: 36 Hendricks: 119 Putnam: 1430	2.5	2,416.4	69.96
	Cattle and Calves	Montgomery: 226 Boone: 4 Hendricks: 39 Putnam: 383	1	652	
	Sheep and Lambs	Montgomery: 49 Boone: 1 Hendricks: 6 Putnam: 43	10	9.9	
	Horses and Ponies	Montgomery: 16 Boone: 1 Hendricks: 10 Putnam: 52	0.5	158	

	Poultry	Montgomery: 100 Boone: 1 Hendricks: 5 Putnam: 63	250	0.68	
			TOTAL	**3,236.98**	

Streambank Erosion

Streambank erosion is potentially a significant source of sediment in the Little Raccoon Creek subwatershed. Streambank erosion is a natural process but can be accelerated due to a variety of human activities:

- Vegetation located adjacent to streams flowing through crop or pasture fields is often removed to promote drainage or cattle access to water. The loss of vegetation makes the streambanks more susceptible to erosion due to the loss of plant roots.
- Extensive areas of agricultural tiles promote much quicker delivery of rainfall into streams than would occur without subsurface drainage, which could potentially contribute to streambank erosion due to high velocities and shear stress.
- The creation of impervious surfaces (e.g., streets, rooftops, driveways, parking lots) can also lead to rapid runoff of rainfall and higher stream velocities that might cause streambank erosion.

Onsite Wastewater Treatment Systems

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

The Indiana State Department of Health (ISDH) regulates (410 IAC 6-8.3) through the local health departments the residential onsite sewage disposal program. Onsite sewage disposal systems (i.e., septic systems) are those, which do not result in an off-lot discharge of treated effluent, typically consisting of a septic tank to settle out and digest sewage solids, followed by a system of perforated piping to distribute the treated wastewater for absorption into the soil. More than 800,000 onsite sewage disposal systems are currently used in Indiana. Local health departments issue more than 15,000 permits per year for new systems, and about 6,000 permits for repairs.

410 IAC 6-8.3-52 General sewage disposal requirements

Sec. 52. (a) No person shall throw, run, drain, seep, or otherwise dispose into any of the surface waters or ground waters of this state, or cause, permit, or suffer to be thrown, run, drained, allowed to seep, or otherwise disposed into such waters, any organic or inorganic matter from a dwelling or residential onsite sewage system that would cause or contribute to a health hazard or water pollution.
(b) The: (1) design; (2) construction; (3) installation; (4) location; (5) maintenance; and (6) operation; of residential onsite sewage systems shall comply with the provisions of this rule.

410 IAC 6-8.3-55 Violations; permit denial and revocation

Sec. 55. (a) Should a residential onsite sewage system fail, the failure shall be corrected by the owner within the time limit set by the health officer. (b) If any component of a residential onsite sewage system is found to be: (1) defective; (2) malfunctioning; or (3) in need of service; the health officer may require the repair, replacement, or service of that component. The repair, replacement, or service shall be conducted within the time limit set by the health officer. (c) Any person found to be violating this rule may be served by the health officer with a written order stating the nature of the violation and providing a time limit for satisfactory correction thereof.

Montgomery and Putnam Counties follow the Indiana Administrative Code (RULE 410 IAC 6-8.1), with regards to septic systems. Boone County follows the Indiana Administrative Code (RULE 410 IAC 6-8.3), with regards to septic systems along with local ordinances. The Boone County, lndiana Code of Ordinances (Volume 2 Land Usage, Chapter 51) addresses sewage disposal systems, permit requirements, drainage requirements, powers of inspection, and penalties.

A comprehensive database of septic systems within the Big Raccoon Creek watershed is not available; therefore, the rural population of each subwatershed was calculated to obtain a general representation of the number of systems. The US Census provides the total number of people within a county as well as the total urban and rural population of the county. Subwatershed population is estimated by dividing the subwatershed area by the total county area and multiplying it by the county census population. It is assumed that the numbers of septic systems in the subwatersheds are directly proportional to rural population density. An additional estimate of septic systems can be made using the 1990 US Census, as that is the last Census that inventoried how household wastewater is disposed. The rural population in the Little Raccoon Creek subwatershed is shown inTable 37, along with a calculated density (total rural population divided by total area). The rural population density can be used to compare the different subwatersheds within the Big Raccoon Creek watershed.

It should also be noted that hydrologic soil group A and B soils have good infiltration rates and have less risk for failing septic systems due to this factor. Group C and D soils have slow infiltration rates with finer textures and slow water movement. Little Raccoon Creek subwatershed has less than 1 percent of soil group A and 60 percent of soil group B. This means that Little Raccoon Creek subwatershed has less (if more than 75 percent C or D soils = more risk) risk for failing septic systems.

Table 37. Rural Population Density in the Little Raccoon Creek Subwatershed

County	Area of County in Subwatershed (mi^2)	County Population	Urban Population	Rural Population	Rural Population Density (persons/mi^2)
Boone	0.5	25	0	25	20.81
Hendricks	3.62	88	0	88	
Montgomery	18.8	1,664	985	679	
Putnam	23.35	1,097	726	171	
TOTAL	46.27	2,874	1,711	963	

Urban Storm Water

In areas not covered under the NPDES MS4 program, storm water runoff from developed areas is not regulated by a permit and is therefore a nonpoint source. Runoff from urban areas can carry a variety of pollutants originating from a variety of sources. Typically, urban sources of nutrients are fertilizer application to lawns and pet waste, which is also a source of *E. coli* and nutrients. Depending on the amount of developed, impervious land in a watershed, urban nonpoint source inputs can result in localized or widespread water quality degradation. The percent and distribution of developed land in the Little Raccoon Creek subwatershed is discussed in Section 4.2.6. However, inputs from urban sources are difficult to quantify. Estimates can be made of pet populations and residential areas that might receive fertilizer treatment. These estimates provide insight into the potential of urban nonpoint sources as important sources of nutrients or *E. coli* in the Little Raccoon Creek subwatershed.

Dog and cat populations were estimated for the Little Raccoon Creek subwatershed using statistics reported in the *2007 U.S. Pet Ownership & Demographics Sourcebook*[1]. Specifically, the *Sourcebook* reports that on average 37.2 percent of households own dogs and 32.4 percent of households own cats. Typically, the average number of pets per household is 1.7 dogs and 2.2 cats. However, pets are likely only a significant source of *E. coli* and nutrients in population centers (i.e., cities and towns). The estimates of domestic pets in cities and towns in the watershed are presented in Table 38 and are based on the average number of pets per household multiplied by the number of households in the city or town.

Table 38. Estimated Pet Populations in the Cities and Towns of the Little Raccoon Creek Subwatershed

City/Town	Households in 2010 [a]	Estimated Number of Cats	Estimated Number of Dogs
Ladoga	550	1,210	935
Roachdale	350	770	595

a. 2010 population is a U.S. Census Bureau estimate.

Wildlife

The Indiana Department of Natural Resources (IDNR) is the primary entity responsible for monitoring wildlife populations and habitats throughout Indiana. Wildlife such as deer, geese, ducks, etc. can be sources of *E. coli* and nutrients. Population estimates for types of wildlife are generally not available.

In summary, the Little Raccoon Creek subwatershed is dominated by agriculture. Sources of impairment include NPDES permitted facilities, SSOs, livestock operations, wildlife, agricultural landuse and riparian habitat. Specifically, Little Raccoon Creek is characterized by 2 WWTP facilities with 9 *E. coli* violations, 17 total phosphorus violations and 3 total suspended solids violations. These characteristics are likely to affect the amount of *E. coli* and nutrient loadings found in the Little Raccoon Creek subwatershed.

4.2.7 Subwatershed Summary: Byrd Branch

This section of the report presents the available information on the sources of *E. coli* in the Byrd Branch subwatershed.

The Byrd Branch subwatershed is located in the southwest region of Big Raccoon Creek watershed covering nearly 19 square miles (Figure 24). The Byrd Branch subwatershed drains portions of Putnam and Parke Counties. The Byrd Branch subwatershed includes the Town of Morton. Land use in the Byrd Branch subwatershed is primarily agriculture (52%) as shown in Table 39. Forested areas contribute to 35 percent of the watershed area and approximately 5 percent of the land is developed.

Table 39. Land Use in the Byrd Branch Subwatershed

Land Use	Area		Percent
	Acres	Square Miles	
Open Water	4.9	0.01	0.05
Developed, Open Space	527.7	0.83	4.5
Developed, Low Intensity	20.68	0.03	0.16
Developed, Medium Intensity	0	0	0
Developed, High Intensity	0	0	0

[1] http://www.avma.org/reference/marketstats/sourcebook.asp

Forest	4,162.56	6.5	35
Shrub/Scrub	55.37	0.08	0.43
Hay/Pasture	920.27	1.43	7.7
Agriculture	6,189.02	9.67	52.06
Wetlands	13.56	0.02	0.1
TOTAL	**11,886.2**	**18.57**	**100**

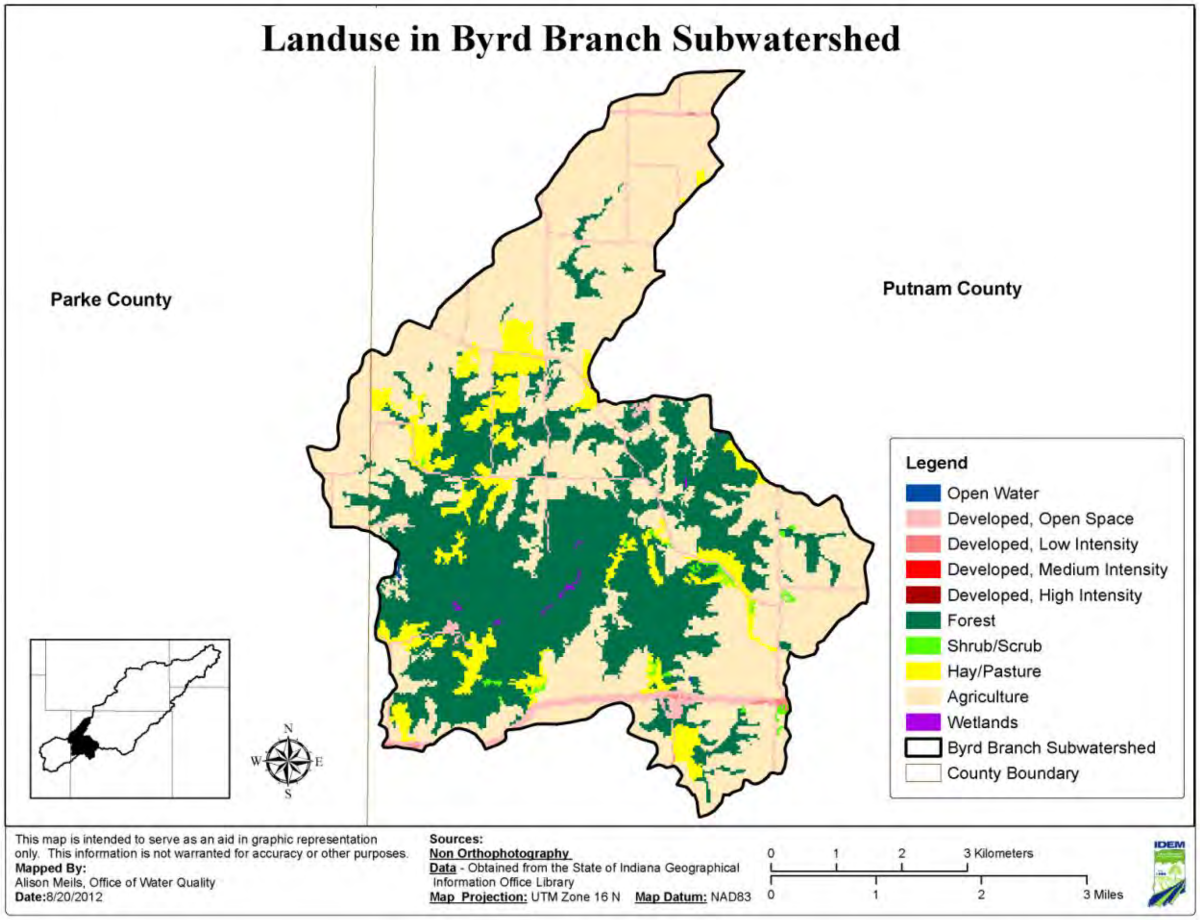

Figure 24. Land Use in the Byrd Branch Subwatershed

4.2.7.1 <u>Point Sources</u>

There are no known potential point sources of *E. coli* in the Byrd Branch subwatershed, as regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

Illicitly Connected "Straight Pipe" Systems

Some household wastes within Indiana and potentially within the Byrd Branch subwatershed directly discharge to a stream or are illegally connected directly to tile-drainage pipes in agricultural watersheds, providing a direct source of pollutants such as *E. coli* to the stream (these systems are sometimes referred to as "straight pipe" discharges).

4.2.7.2 Nonpoint Sources

This section summarizes the potential nonpoint sources of *E. coli* in the Byrd Branch subwatershed that are not regulated through the National Pollutant Discharge Elimination System (NPDES) Program.

Cropland

Approximately 52 percent of the land in the Byrd Branch subwatershed is classified as row crops. Croplands can be a source of *E. coli*. Accumulation of *E. coli* on cropland occurs from manure fertilizers, wildlife excreta, irrigation water, and application of waste products from municipal and industrial wastewater treatment facilities.

Pastures and Livestock Operations

In the Byrd Branch subwatershed, 8 percent of land use is pasture and shrublands. Runoff from pastures and livestock operations can be potential agricultural sources of *E. coli*. For example, animals grazing in pasturelands deposit manure directly upon the land surface and, even though a pasture may be relatively large and animal densities low, the manure will often be concentrated near the feeding and watering areas in the field. These areas can quickly become barren of plant cover, increasing the possibility of erosion and contaminated runoff during a storm event.

Livestock are potential sources of *E. coli* to streams, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas. Subwatershed specific data are not available for livestock populations. However, county-wide data available from the National Agricultural Statistic Service were downloaded and area weighted to estimate animal population in the subwatershed. The area of the county within the watershed is divided by the area of the entire county and multiplied by the total number of animals in the county based on the NASS survey. This is done for each county in the subwatershed and summed to get an area weighted estimate of animals with the subwatershed. There are an estimated 3481 animal units in the Byrd Branch subwatershed and the animal unit density is 187 animal units per square mile as shown in Table 40.

Table 40. Animal Unit Density in the Byrd Branch Subwatershed

Subwatershed Area (sq. miles)	Animal	Total Number of Head in County	Number of Animals in One Animal Unit	Number of Animal Units	Animal Unit Density (animal units/mi^2)
18.57	Hogs and Pigs	Putnam: 1,080 Parke: 3	2.5	433	187.46
	Cattle and Calves	Putnam: 2,849 Parke: 11	1	2,860	
	Sheep and Lambs	Putnam: 83 Parke: 1	10	8	
	Horses and Ponies	Putnam: 89 Parke: 1	0.5	180	
	Poultry	Putnam: 48 Parke: 2	250	0.2	
			TOTAL	**3,481.2**	

Onsite Wastewater Treatment Systems

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

The Indiana State Department of Health (ISDH) regulates (410 IAC 6-8.3) through the local health departments the residential onsite sewage disposal program. Onsite sewage disposal systems (i.e., septic systems) are those, which do not result in an off-lot discharge of treated effluent, typically consisting of a septic tank to settle out and digest sewage solids, followed by a system of perforated piping to distribute the treated wastewater for absorption into the soil. More than 800,000 onsite sewage disposal systems are currently used in Indiana. Local health departments issue more than 15,000 permits per year for new systems, and about 6,000 permits for repairs.

410 IAC 6-8.3-52 General sewage disposal requirements
Sec. 52. (a) No person shall throw, run, drain, seep, or otherwise dispose into any of the surface waters or ground waters of this state, or cause, permit, or suffer to be thrown, run, drained, allowed to seep, or otherwise disposed into such waters, any organic or inorganic matter from a dwelling or residential onsite sewage system that would cause or contribute to a health hazard or water pollution.
(b) The: (1) design; (2) construction; (3) installation; (4) location; (5) maintenance; and (6) operation; of residential onsite sewage systems shall comply with the provisions of this rule.

410 IAC 6-8.3-55 Violations; permit denial and revocation
Sec. 55. (a) Should a residential onsite sewage system fail, the failure shall be corrected by the owner within the time limit set by the health officer. (b) If any component of a residential onsite sewage system is found to be: (1) defective; (2) malfunctioning; or (3) in need of service; the health officer may require the repair, replacement, or service of that component. The repair, replacement, or service shall be conducted within the time limit set by the health officer. (c) Any person found to be violating this rule may be served by the health officer with a written order stating the nature of the violation and providing a time limit for satisfactory correction thereof.

Putnam County follows the Indiana Administrative Code (RULE 410 IAC 6-8.1), with regards to septic systems. Parke County also follows the Indiana Administrative Code (RULE 410 IAC 6-8.1), but has some additional fines ($100-$1000) set up for septic violations. The health department staffs have had better success in the past working with landowners to get violations fixed, and explaining to them the benefits of a properly functioning septic system rather than assessing fines right away.

A comprehensive database of septic systems within the Big Raccoon Creek watershed is not available; therefore, the rural population of each subwatershed was calculated to obtain a general representation of the number of systems. The US Census provides the total number of people within a county as well as the total urban and rural population of the county. Subwatershed population is estimated by dividing the subwatershed area by the total county area and multiplying it by the county census population. It is assumed that the numbers of septic systems in the subwatersheds are directly proportional to rural population density. An additional estimate of septic systems can be made using the 1990 US Census, as that is the last Census that inventoried how household wastewater is disposed. The rural population in the Byrd Branch subwatershed is shown in Table 41, along with a calculated density (total rural population divided by total area). The rural population density can be used to compare the different subwatersheds within the Big Raccoon Creek watershed.

It should also be noted that hydrologic soil group A and B soils have good infiltration rates and have less risk for failing septic systems due to this factor. Group C and D soils have slow infiltration rates with finer textures and slow water movement. Byrd Branch subwatershed has no soil group A and 81 percent of soil group B.

Table 41. Rural Population Density in the Byrd Branch Subwatershed

County	Area of County in Subwatershed (mi^2)	County Population	Urban Population	Rural Population	Rural Population Density (persons/mi^2)
Putnam	18.03	361	0	361	24.82
Parke	0.54	10	0	10	
TOTAL	18.57	461	0	461	

Urban Storm Water

In areas not covered under the NPDES MS4 program, storm water runoff from developed areas is not regulated by a permit and is therefore a nonpoint source. Runoff from urban areas can carry a variety of pollutants originating from a variety of sources. Depending on the amount of developed, impervious land in a watershed, urban nonpoint source inputs can result in localized or widespread water quality degradation. The percent and distribution of developed land in the Byrd Branch subwatershed is discussed in Section 4.2.7. However, inputs from urban sources are difficult to quantify. Estimates can be made of pet populations and residential areas that might receive fertilizer treatment. These estimates provide insight into the potential of urban nonpoint sources as important sources of *E. coli* in the Byrd Branch subwatershed.

Dog and cat populations are estimated using statistics reported in the *2007 U.S. Pet Ownership & Demographics Sourcebook*[1]. Specifically, the *Sourcebook* reports that on average 37.2 percent of households own dogs and 32.4 percent of households own cats. Typically, the average number of pets per household is 1.7 dogs and 2.2 cats. However, pets are likely only a significant source of *E. coli* in population centers (i.e., cities and towns). The estimates of domestic pets are not included in the summary of Byrd Branch subwatershed because no incorporated communities are located within the subwatershed boundaries.

Wildlife

The Indiana Department of Natural Resources (IDNR) is the primary entity responsible for monitoring wildlife populations and habitats throughout Indiana. Wildlife such as deer, geese, ducks, etc. can be sources of *E. coli* and nutrients. Population estimates for types of wildlife are generally not available.

In summary, the Byrd Branch subwatershed is dominated by agricultural and forested lands. Sources of impairment include wildlife, livestock operations, and agricultural landuse. These characteristics are likely to affect the amount of *E. coli* loading found in the Byrd Branch subwatershed.

5.0 INVENTORY AND ASSESSMENT OF WATER QUALITY INFORMATION

Below are an inventory and assessment of the available biological and chemical data for the Big Raccoon Creek watershed related to *E. coli* and impaired biological communities. Table 42 reiterates the TMDL target values presented in Section 2.2. These are the target values IDEM uses to assess water quality data collected in the Big Raccoon Creek watershed.

[1] http://www.avma.org/reference/marketstats/sourcebook.asp

Table 42. Target Values Used for Development of the Big Raccoon Creek Watershed TMDLs

Parameter	Target Value
Dissolved Oxygen	No value should be lower than 4.0 mg/L
Total phosphorus	No value should exceed 0.30 mg/L
Total Suspended Solids	No value should exceed 30.0 mg/L
E. coli	No value should exceed 125 counts/100 mL (geometric mean)

5.1 Water Chemistry Data

Data collected in 2010 by IDEM were used for the *E. coli* TMDL analysis. Data collected by IDEM in 2005 were used for the impaired biological communities TMDL analysis. Two TMDLs were developed using a total phosphorus surrogate and one TMDL was developed using a total suspended solids surrogate.

The percent reductions were calculated as follows:

$$\%\,\text{Reduction} = \frac{(\text{Observed Value} - \text{Target Value or WQS})}{\text{Observed Value}}$$

$$\%\,\text{Reduction} = \frac{(\text{Observed Geomean} - \text{Target Value or WQS})}{\text{Observed Geomean}}$$

Appendix A shows the individual sample results and summaries of all IDEM water quality data.

5.2 *E. coli* Data

For *E. coli*, the 53 AUIDs in the Big Raccoon Creek watershed were assessed with data from the 2010 TMDL sampling stations. Table 43 provides a summary of *E. coli* data in the Big Raccoon Creek watershed to show which sampling stations correspond to each AUID per subwatershed.

Table 43. Summary of *E. coli* Data in the Big Raccoon Creek Watershed

Subwatershed	Sampling Station (Station ID)	AUID	Period of Record	Total Number of Samples	Percent of Samples Violating Target		Geomean (#\100mL)	Single Sample Maximum (#/100mL)	% Reduction based on Geomean (125/100mL)
					125	235			
Headwaters of Big Raccoon Creek 051201081201	WLV160-0063	INB08C1_01	4/26/10-5/25/10	5	100	100	1777.94	2419.6	92.97
		INB08C1_T1001							
		INB08C1_T1002							
		INB08C1_T1003							
		INB08C1_T1004							
Town of New Ross 051201081202	WLV160-0045	INB08C2_02	4/26/10-5/25/10	5	100	100	2136.8	2419.6	94.15
		INB08C2_T1011							
		INB08C2_T1012							
		INB08C2_T1013							
Haw Creek 051201081203	WLV160-0027	INB08C3_01	4/26/10-5/25/10	10	100	100	1580.83	2419.6	92.09
	WLV160-0064	INB08C3_02							
		INB08C3_T1001							
		INB08C3_T1002							
		INB08C3_T1003							
		INB08C3_T1004							
		INB08C3_T1005							
Cornstalk Creek 051201081204	WLV160-0038 WLV160-0035	INB08C4_01	4/26/10-5/25/10	10	100	90	1096.65	2419.6	88.6
		INB08C4_T1001							
		INB08C4_T1002							
		INB08C4_T1003							
		INB08C4_T1004							
North Ramp Creek 051201081205		INB08C5_01	4/26/10-5/25/10	10	100	90	933.3	2419.6	86.6
		INB08C5_T1001							

		INB08C5_T1002							
		INB08C5_T1003							
		INB08C5_T1004							
		INB08C5_T1005							
		INB08C5_T1006							
		INB08C5_T1007							
		INB08C5_T1008							
	WLV160-0068 WLV160-0015	INB08C5_02							
		INB08C5_T1009							
		INB08C5_T1010							
	WLV160-0025	INB08C6_01							
	WLV160-0044	INB08C6_T1001							
	WLV160-0065	INB08C6_02							
	WLV160-0066	INB08C6_T1002							
Little Raccoon Creek 051201081206	WLV160-0002	INB08C6_03	4/26/10-5/25/10	30	100	100	1551.14	2419.6	91.94
	WLV160-0067	INB08C6_T1003							
		INB08C6_T1004							
		INB08C6_T1005							
		INB08C6_T1006							
		INB08C6_T1007							
	WLV160-0070	INB08C7_01							
		INB08C7_T1001							
		INB08C7_T1002							
		INB08C7_T1003							
Byrd Branch 051201081207		INB08C7_T1004	4/26/10-5/25/10	5	100	100	1235.28	2419.6	89.88
		INB08C7_T1005							
		INB08C7_T1006							
		INB08C7_02							
		INB08C7_T1007							
		INB08C7_T1008							

Understanding
Table Table 43***:*** *E. coli* data for the Big Raccoon Creek watershed indicates the following:

- Reductions of 93 percent or greater are needed to meet the TMDL target values for *E. coli* in Headwaters of Big Raccoon Creek subwatershed.
- Reductions of 94 percent or greater are needed to meet the TMDL target values for *E. coli* in Town of New Ross subwatershed.
- Reductions of 92 percent or greater are needed to meet the TMDL target values for *E. coli* in Haw Creek subwatershed.
- Reductions of 89 percent or greater are needed to meet the TMDL target values for *E. coli* in Cornstalk Creek subwatershed.
- Reductions of 87 percent or greater are needed to meet the TMDL target values for *E. coli* in North Ramp Creek subwatershed.
- Reductions of 92 percent or greater are needed to meet the TMDL target values for *E. coli* in Little Raccoon Creek subwatershed.
- Reductions of 90 percent or greater are needed to meet the TMDL target values for *E. coli* in Byrd Branch subwatershed.

5.3 Biological Data

Sampling performed by IDEM in August of 2005 documented several biological impairments in the Big Raccoon Creek watershed. Fish community sampling took place at 28 sample sites in the Big Raccoon Creek watershed. Sampling data indicate that the overall biological integrity of the Big Raccoon Creek watershed was fair to good. Approximately 21 percent of the sample sites failed established criteria for aquatic life support during the sampling event.

Through the TMDL efforts, IDEM has identified several potential reasons for the widespread impairments:

- TSS can reduce plants available for consumption by inhibiting growth of submerged aquatic plants, lower dissolved oxygen levels by reducing light penetration which impairs algal growth, impair the ability of fish to see and catch food, increase stream temperature, clog fish gills which may decrease disease resistance, slow growth rates, and prevent the development of eggs and larvae.
- Low dissolved oxygen can result in low stream diversity, distressed biological communities and fish mortality. Low dissolved oxygen can be caused by an over abundance of aquatic plants or algae, increased organic waste entering the water, decay of organic matter, and high water temperatures.
- Excess nutrients can lead to plant growth within the streams, which can lead to high DO concentrations during the day as photosynthesis occurs, and low DO concentrations during the night when photosynthesis stops and plants use the oxygen during respiration.
- Total phosphorus can cause excessive plant production resulting in increased turbidity, decrease dissolved oxygen levels, and cause greater fluctuations in diurnal dissolved oxygen and pH levels resulting in lower stream diversity.

Table 44 lists only those stream segments for which TMDLs were developed in this document. There are additional IBC impairments in the Big Raccoon Creek watershed that may be impaired by combinations of unknown stressors, however the data collected at the time of sampling does not correlate with the IBC impairments. Table 44 provides a summary of biological data in the Big Raccoon Creek watershed to show which AUIDs are impaired due to impaired biological communities. Attaining the dissolved oxygen, TSS and TP target values shown in Table 45 could address the causes of impairment. Appendix A includes a list of all IDEM historical biological data.

Table 44. Impaired Biotic Community Stream Segments in the Big Raccoon Creek Watershed Identified During the August 2005 Sampling

Stream	AUID#	Sampling Site	Score	IBI Integrity Class
Wells Ditch	INB08C1_T1004	WLV160-0017	12	Very poor
Unnamed tributary to Big Raccoon Creek	INB08C6_T1003	WLV160-0039	32	Poor

Notes: IBI = Index of Biotic Integrity. Scores were calculated using IDEM's *Summary of Protocols: Probability Based Site Assessment*. (IDEM, 2005).

Table 45. Summary of Chemistry Data in the Big Raccoon Creek Watershed for Dissolved Oxygen, Total Phosphorus and Total Suspended Solids

Subwatershed	Sampling Station (Station ID)	AUID	Parameter	Total Number of Samples	Percent of Samples Violating Target	Maximum (mg/L)	% Reduction based on concentration
Headwaters of Big Raccoon Creek	WLV160-0017	INB08C1_T1004	Total Phosphorus	1	100%	0.68	55.88
Headwaters of Big Raccoon Creek	WLV160-0017	INB08C1_T1004	Dissolved Oxygen	1	100%	3.5	NA
Little Raccoon Creek	WLV160-0039	INB08C6_T1003	Total Phosphorus	1	100%	0.33	9.09
Little Raccoon Creek	WLV160-0039	INB08C6_T1003	Total Suspended Solids	1	100%	74	59.46
Little Raccoon Creek	WLV160-0039	INB08C6_T1003	Dissolved Oxygen	1	100%	2.5	NA

6.0 TECHNICAL APPROACH

Previous sections of the report have provided a description of the Big Raccoon Creek watershed and summarized the applicable water quality standards, water quality data, and identified the potential sources of *E. coli* and biological impairements for assessment units in each subwatershed. This section presents IDEM's technical approach for using water quality sampling data and flow data for each subwatershed as described in Section 4.0 to estimate the current allowable loads in each subwatershed. This section focuses on describing the methodology and is helpful in understanding subsequent sections of the TMDL report.

6.1.1 Load Duration Curves

To determine allowable loads for the TMDL, IDEM uses a load duration curve approach. This approach helps to characterize water quality problems across flow conditions and provide a visual display that assists in determining whether loadings originate from point or nonpoint sources. Load duration curves present the frequency and magnitude of water quality violations in relation to the allowable loads, communicating the magnitude of the needed load reductions.

Developing a load duration curve is a multi-step process. To calculate the allowable loadings of a pollutant at different flow regimes, the load duration curve approach involves multiplying each flow by the TMDL target value or Water Quality Standard an appropriate conversion factor. The steps are as follows:

- A flow duration curve for the stream is developed by generating a flow frequency table and plotting the observed flows in order from highest (left portion of curve) to lowest (right portion of curve).
- The flow curve is translated into a load duration (or TMDL) curve. To accomplish this, each flow value is multiplied by the TMDL target value or Water Quality Standard with the appropriate conversion factor and the resulting points are graphed. Conversion factors are used to convert the units of the target (e.g., #/100 mL for *E. coli*) to loads (e.g., G-org/day for *E.coli* [G-org=1E+09 organisms]) with the following factors used for this TMDL:
- *E. coli* - Flow (cfs) x TMDL Concentration Target (#/100mL) x Conversion Factor (0.024463) = Load (G-org/day)
- Nutrients and TSS - Flow (cfs) x TMDL Concentration Target (mg/L) x Conversion Factor (5.39) = Load (lb/day)
- To estimate existing loads, each water quality sample is converted to a load by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected and the appropriate conversion factor. Then, the existing individual loads are plotted on the TMDL graph with the curve.
- Points plotting above the curve represent violations of the applicable water quality standard or exceedances of the applicable target and the daily allowable load. Those points plotting below the curve represent compliance with standards and the daily allowable load.
- The area beneath the load duration curve is interpreted as the loading capacity of the stream. The difference between this area and the area representing the current loading conditions above the curve is the load that must be reduced to meet water quality standards.

The load duration curve approach can consider seasonal variation in TMDL development as required by the Clean Water Act and USEPA's implementing regulations. Because the load duration curve approach establishes loads based on a representative flow regime, it inherently considers seasonal variations and critical conditions attributed to flow conditions.

The stream flows displayed on water quality or load duration curves may be grouped into various flow regimes to aid with interpretation of the load duration curves. The flow regimes are typically divided into the following five "hydrologic zones" (USEPA, 2007):

- Very High Flows: Flows in this represent flooding or near flooding stages of a stream. These flows are exceeded 0 – 10 percent of the time.
- Moist Zone: Flows in this range are related to wet weather conditions. These flows are exceeded 10 – 40 percent of the time.
- Mid-Range Zone: Flows in this range represent median stream flow conditions. These flows are exceeded 40 – 60 percent of the time.
- Dry Zone: Flows in this range are related to dry weather flows. These flows are exceeded 60 -90 percent of the time.
- Very Low Flows: Flows in this range are seen in drought-like conditions. These flows are exceeded 90 -100 percent of the time.

The load duration curve approach helps to identify the sources contributing to the impairment and to roughly differentiate between sources. Exceedances of the load duration curve at higher flows (0-40 percent ranges) are indicative of wet weather sources (e.g., nonpoint sources, regulated storm water discharges). Exceedances of the load duration curve at lower flows (60 to 100 percent range) are indicative of point source sources (e.g., wastewater treatment facilities, livestock in the stream). Table 46 summarizes the general relationship between the five hydrologic zones and potentially contributing source areas (the table is not specific to any individual pollutant). For example, the table indicates that impacts from wastewater treatment plants are usually most pronounced during dry and low flow zones because there is less water in the stream to dilute their loads. In contrast, impacts from channel bank erosion is most pronounced during high flow zones because these are the periods during which stream velocities are high enough to cause erosion to occur.

Table 46. Relationship between Load Duration Curve Zones and Contributing Sources

	Duration Curve Zone				
Contributing Source Area	**Very High**	**Moist**	**Mid-Range**	**Dry**	**Very Low**
Wastewater treatment plants				M	H
Livestock direct access to streams				M	H
Wildlife direct access to streams				M	H
On-site wastewater systems/Unsewered Areas	M	M-H	H	H	H
Riparian areas		H	H	M	
Abandoned mines	H	H	H	H	H
Storm water: Impervious		H	H	H	
Storm water: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			

Note: Potential relative importance of source area to contribute loads under given hydrologic condition (H: High; M: Medium; L: Low)

6.1.2 Stream Flow Estimates

Daily stream flows are necessary to implement the load duration curve approach. Load duration assessment locations in the Big Raccoon Creek watershed were chosen based on the location of the impaired stream segments and the availability of water quality samples to estimate existing loads.

The USGS gage used for the development of the load duration curve analysis in the Big Raccoon Creek watershed is located near Fincastle, Indiana (03340800) in the lower end of the watershed just above Cecil M. Harden Reservoir. USGS gage 03340800 is located on the Big Raccoon Creek mainstem in Putnam County.

Since the load duration approach requires a stream flow time series for each site included in the analysis, stream flows were extrapolated from USGS gage 03340800 for each assessment location by using a multiplier based upon the ratio of the upstream drainage area for a given location to the drainage area of the Big Raccoon Creek watershed.

Flows were estimated using the following equation:

$$Q_{ungaged} = \frac{A_{ungaged}}{A_{gaged}} \times Q_{gaged}$$

Where,

$Q_{ungaged}$:	Flow at the ungaged location
Q_{gaged}:	Flow at surrogate USGS gage station
$A_{ungaged}$:	Drainage area of the ungaged location
A_{gaged}:	Drainage area of the gaged location

In this procedure, the drainage area of each of the load duration stations was divided by the drainage area of the surrogate USGS gage. The flows for each of the stations were then calculated by multiplying the flows at the surrogate gage by the drainage area ratios.

7.0 LINKAGE ANALYSIS

A linkage analysis connects the observed water quality impairment to what has caused that impairment. An essential component of developing a TMDL is establishing a relationship between the source loadings and the resulting water quality. Potential point and nonpoint sources are inventoried in Section 0 and water quality data within the Big Raccoon Creek watershed are discussed in Section 5.0. The purpose of this section of the report is to evaluate which of the various potential sources is most likely to be contributing to the observed water quality impairments.

7.1 Linkage Analysis for *E. coli*

Establishing a linkage analysis for *E. coli* is challenging because there are so many potential sources and *E. coli* counts have a high degree of variability. While it is difficult to perform a site-specific assessment of the causes of high *E. coli* for each location in a watershed, it is reasonable to expect that general patterns and trends can be used to provide some perspective on the most significant sources.

Load duration curves were created for the sampling sites in the Big Raccoon Creek watershed that were sampled by IDEM in 2010. The load duration curve method considers how stream flow conditions relate to a variety of pollutant loadings and their sources (point and nonpoint). Section 6.1.1 summarizes the load duration curve approach. This section discusses the load duration curves and the linkage between the potential sources in the Big Raccoon Creek watershed and the observed water quality impairment.

To further investigate sources, *E. coli*/precipitation graphs have been created. Elevated levels of *E. coli* during rain events indicate *E. coli* contribution due to runoff. The precipitation data was taken from a weather station in Crawfordsville, Indiana and managed by the Indiana State Climate Office at Purdue University.

E. coli sources typically associated with high flow and moist conditions include failing onsite wastewater systems, urban storm water, runoff from agricultural areas, and bacterial re-suspension from the streambed. *E. coli* sources typically associated with low flow conditions include a large number of homes on failing or illicitly connected septic systems that would provide a constant source. Elevated *E. coli* levels at low flow could also result from inadequate disinfection at wastewater treatment plants or animals with direct access to streams.

The following sections discuss the load duration curves, precipitation graphs and linkage of sources to the water quality exceedances for each subwatershed.

7.1.1 Headwaters of Big Raccoon Creek

Load duration curves and precipitation graphs were created for all the sampling sites (Figure 25) in the Headwaters of Big Raccoon Creek subwatershed. Flow data used to develop the load duration curves is summarized in Table 47.

The figures illustrate water quality standards violations during all flow ranges that occurred during sampling events. A discussion of key sampling sites in the subwatershed is included following the figures. Table 48 provides a summary of the Headwaters of Big Raccoon Creek subwatershed, including impaired segment AUID, drainage area, sampling sites, listed segments, land use, NPDES facilities, and CFOs, as well as Load Allocations, Wasteload Allocations, and Margin of Safety values for *E. coli*. Evaluating the load duration curves and precipitation graphs with consideration of these watershed characteristics allows for identification of potential point and nonpoint sources that are contributing to elevated *E. coli* concentrations.

Table 47. USGS Site Assignments for Development of Load Duration Curve

AUID	Gage Location	Gage ID	Period of Record	Watershed Relationship[1]
INB08C5_02	Big Raccoon Creek	03340800	1/1/1990 – 5/30/2012	gaged

1. Where denoted as "surrogate," AUID watersheds are ungaged, and flows for the segment were estimated using flows from the noted UGSG gage in a surrogate watershed.

Table 48. Summary of Headwaters of Big Raccoon Creek Subwatershed Characteristics

Upstream Characteristics	
Drainage Area	27.42 square miles
TMDL Sample Site	WLV160-0063
Listed Segments	INB08C1_01, INB08C1_T1001, INB08C1_T1002, INB08C1_T1003, INB08C1_T1004
Land Use	Agricultural Land: 88% Forested Land: 3% Developed Land: 6% Open Water: <1% Pasture/Hay: 2% Shrub/Scrub: 1% Wetland: <1%
NPDES Facilities	Town of Advance WWTP (IN0039705), New Ross WWTP (IN0059790)
MS4 Communities	NA
CSO Communities	NA
CAFOs	NA
CFOs	Demaree Farms Partnership (6664)
TMDL *E. coli* Allocations (billion MPN/day)]	

Allocation Category	Very High Flows	Higher Flow Conditions	"Normal" Flows	Lower Flow Conditions	Low Flows
LA	552.15	136.76	54.70	15.96	2.5
WLA	1.37	1.37	1.37	1.37	1.37
MOS (10%)	61.50	15.35	6.23	1.93	0.43
TMDL = LA+WLA+MOS	615.02	153.47	62.30	19.25	4.30

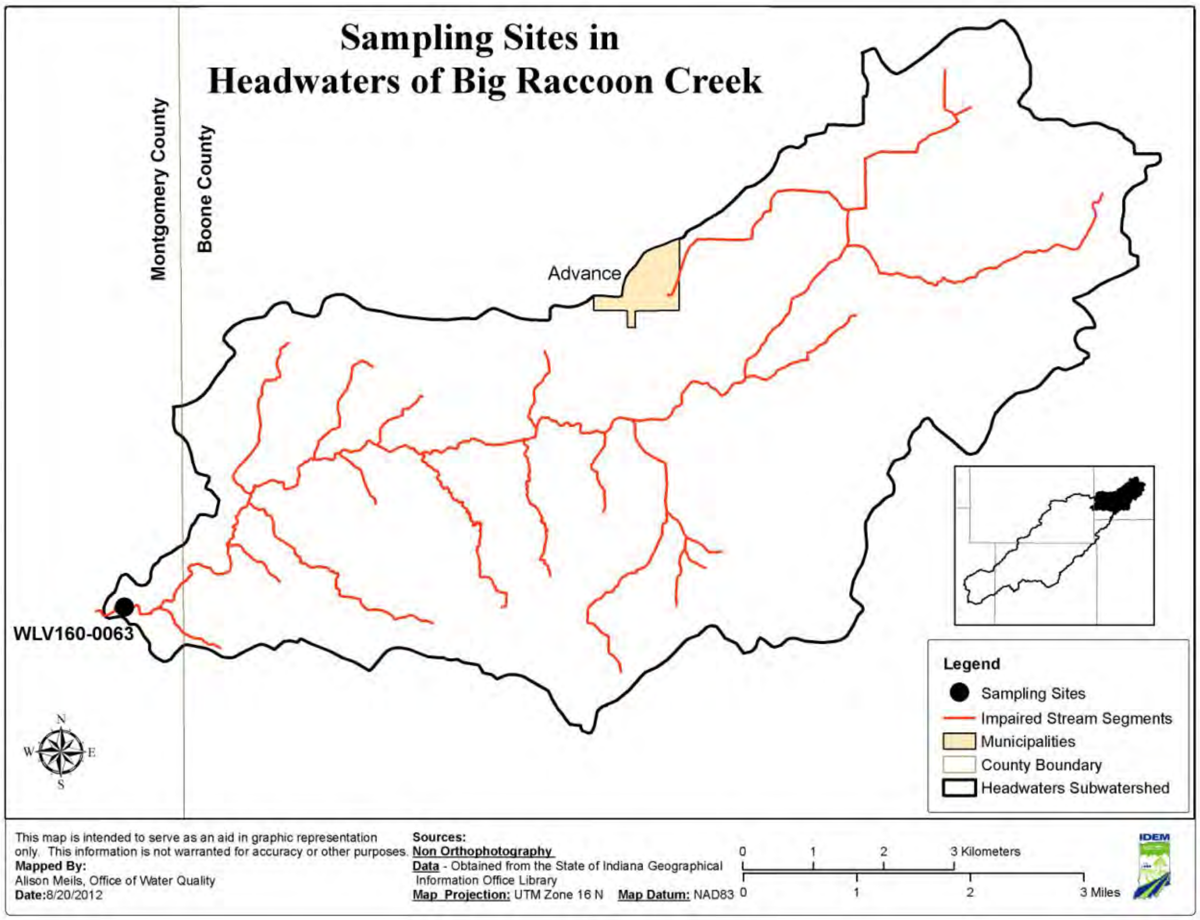

Figure 25. Sampling Stations in the Headwaters of Big Raccoon Creek Subwatershed

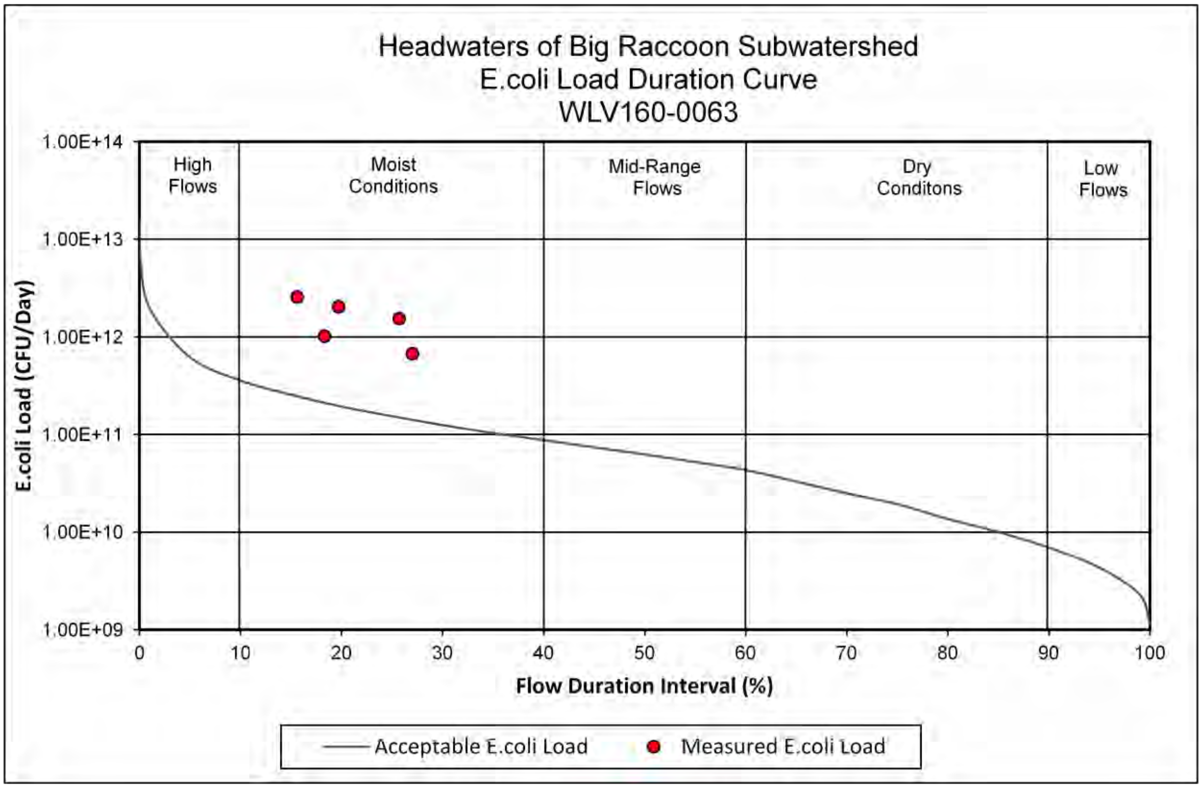

Figure 26. Load Duration Curve in the Headwaters of Big Raccoon Creek Subwatershed

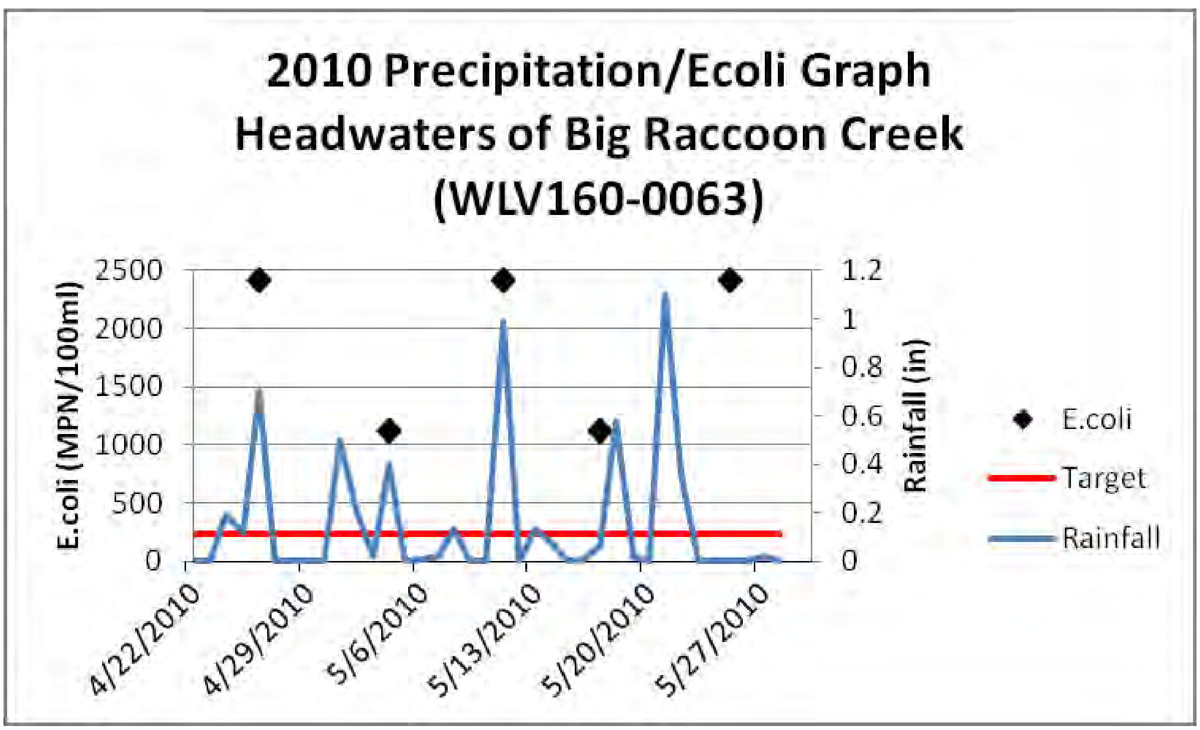

Figure 27. Graph of Precipitation and E. coli Data in the Headwaters of Big Raccoon Creek Subwatershed

Site WLV160-0063 is located in Montgomery County at CR 1050 E on the mainstem Big Raccoon Creek. The geometric mean value for the site is 1777 MPN/100mL. The curve for this site shows an elevated level of *E. coli* in the stream during moist conditions. The precipitation graph for this site shows the stream is susceptible to high loads of *E. coli* during wet and dry weather. It is evident that a small amount of rain can cause a considerable effect on the watershed. The stream is consistently in violation of water quality standards even during drier conditions on the chart. This indicates point sources may be contributing along with nonpoint sources. If animals have direct access upstream of the site this could contribute to *E. coli* violations during wet and dry conditions.

The *E. coli* data for the subwatershed exceed the single sample maximum violation 100% of the time. There is one NPDES permit that has had 3 E. coli violations in the last 5 years, but in general the NPDES permitted facilities in the subwatershed are operating below the maximum design flow. There is also one CFO in the subwatershed that, upon site visits in 2012, appeared to have cattle accessing the stream. Based on the water quality duration curves, it can be concluded that the major sources of *E. coli* in this watershed are both point and nonpoint sources that include small animal operations, wildlife, animals with direct access to streams, straight piped, leaking and failing septic systems, and failing permitted facilities.

7.1.2 Town of New Ross

Load duration curves and precipitation graphs were created for all the sampling sites (Figure 28) in the Town of New Ross subwatershed. Flow data used to develop the load duration curves is summarized in Table 49.

The figures illustrate water quality standards violations during all flow ranges that occurred during sampling events. A discussion of key sampling sites in the subwatershed is included following the figures. Table 50 provides a summary of the Town of New Ross subwatershed, including impaired segment AUID, drainage area, sampling sites, listed segments, and land use, and, as well as Load Allocations, Wasteload Allocations, and Margin of Safety values for *E. coli*. Evaluating the load duration curves and precipitation graphs with consideration of these watershed characteristics allows for identification of potential point and nonpoint sources that are contributing to elevated *E. coli* concentrations.

Table 49. USGS Site Assignments for Development of Load Duration Curve

AUID	Gage Location	Gage ID	Period of Record	Watershed Relationship[1]
INB08C5_02	Big Raccoon Creek	03340800	1/1/1990 – 5/30/2012	gaged

1. Where denoted as "surrogate," AUID watersheds are ungaged, and flows for the segment were estimated using flows from the noted UGSG gage in a surrogate watershed.

Table 50. Summary of Town of New Ross Subwatershed Characteristics

Upstream Characteristics	
Drainage Area	18.96 square miles
TMDL Sample Site	WLV160-0045
Listed Segments	INB08C2_02, INB08C2_T1011, INB08C2_T1012, INB08C2_T1013
Land Use	Agricultural Land: 87% Forested Land: 2% Developed Land: 6% Open Water: <1% Pasture/Hay: 4% Shrub/Scrub: 1% Wetland: <1%
NPDES Facilities	NA
MS4 Communities	NA
CSO Communities	NA
CAFOs	NA

CFOs	NA				
TMDL *E. coli* Allocations (billion MPN/day)					
Allocation Category	**Very High Flows**	**Higher Flow Conditions**	**"Normal" Flows**	**Lower Flow Conditions**	**Low Flows**
LA	386.09	97.37	40.33	13.41	4.07
WLA	0	0	0	0	0
MOS (10%)	42.75	10.66	4.33	1.33	0.3
TMDL = LA+WLA+MOS	428.84	108.03	44.66	14.74	4.37

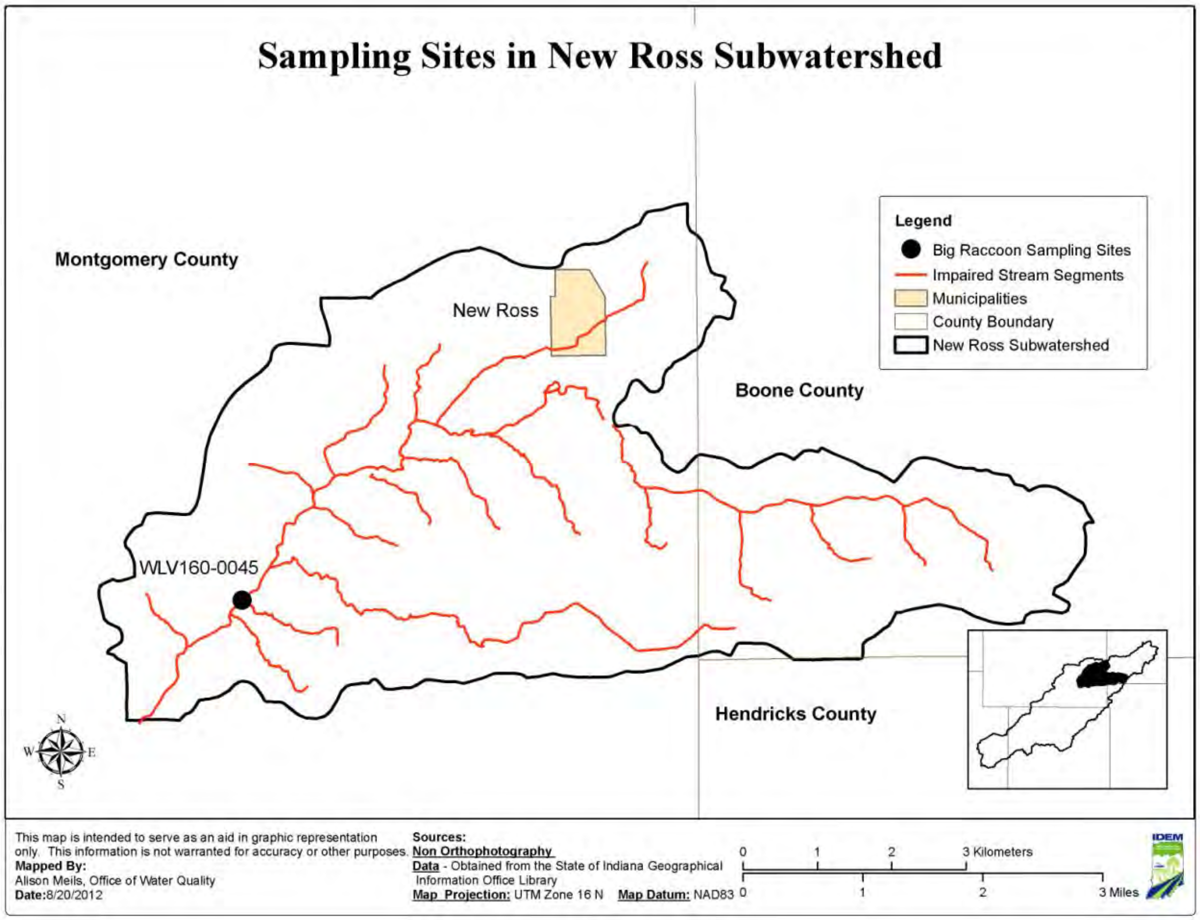

Figure 28. Sampling Stations in the Town of New Ross Subwatershed

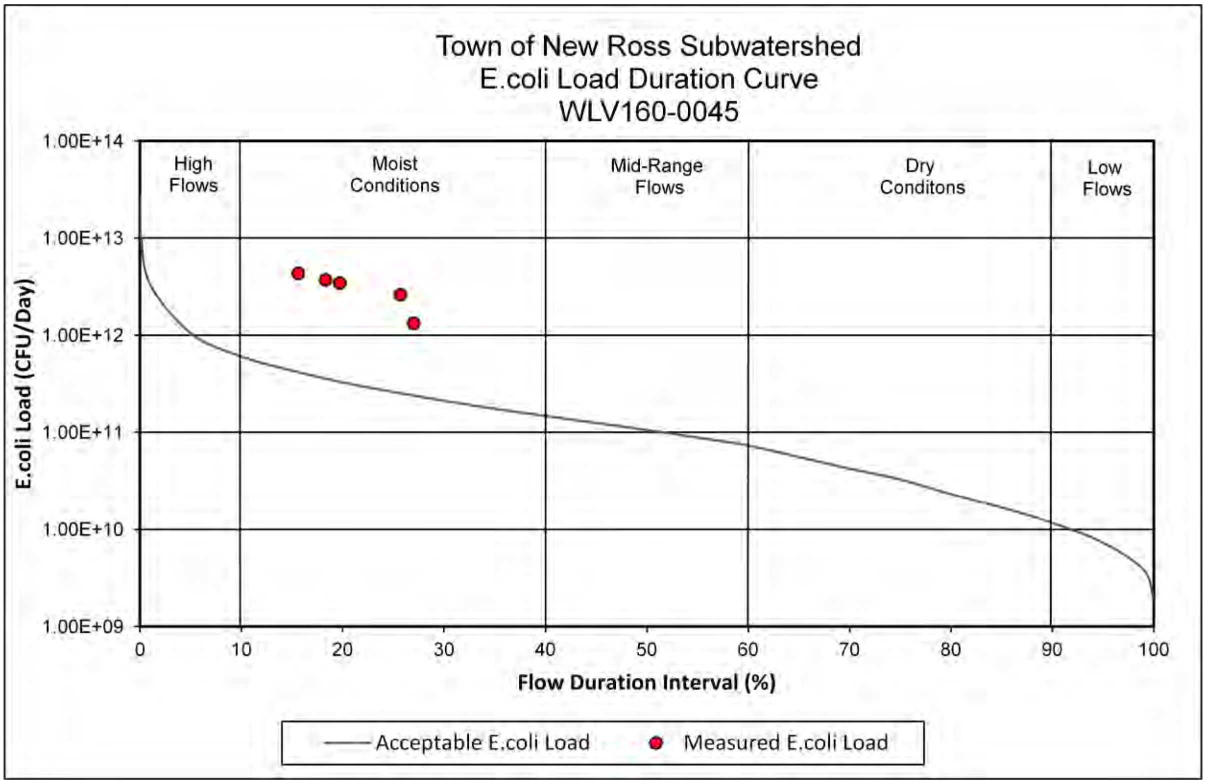

Figure 29. Load Duration Curve in Town of New Ross Subwatershed

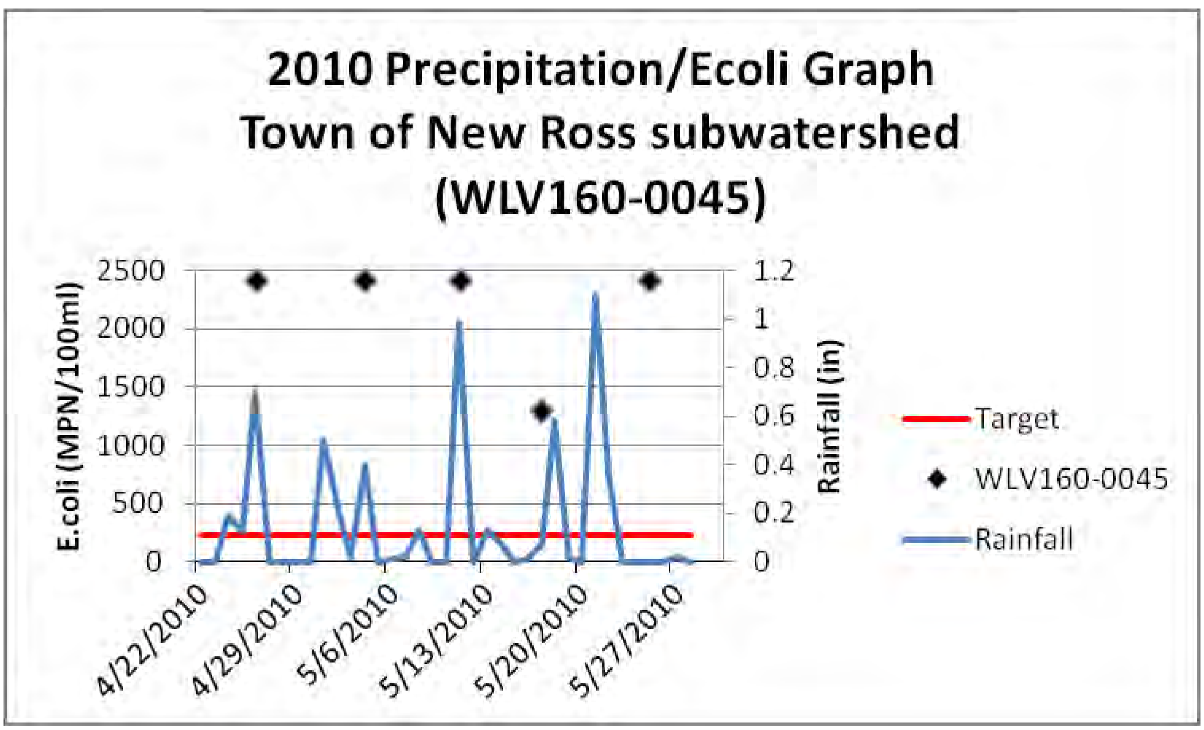

Figure 30. Graph of Precipitation and E. coli Data in Town of New Ross Subwatershed

Site WLV160-0045 is located in Montgomery County at CR 750 S on the mainstem of Big Raccoon Creek. The geometric mean value for the site is 2136 MPN/100mL. The curve for this site shows elevated levels of *E. coli* in the stream during moist flow conditions. The precipitation graph for this site shows the stream is susceptible to high loads of *E. coli* regardless of precipitation amounts. The stream is consistently in violation of water quality standards even during drier conditions on the chart. This indicates point sources may be contributing along with nonpoint sources. If animals have direct access upstream of site WLV160-0045 this could contribute to *E. coli* violations during dry and wet conditions.

The *E. coli* data for the subwatershed have an average single sample maximum violation 100% of the time and an average geometric mean violation 100% of the time. There are no known point sources in the subwatershed. Based on the water quality duration curves, it can be concluded that the sources of *E. coli* in this watershed are likely nonpoint sources that include small animal operations, wildlife, animals with direct access to streams, straight piped, leaking and failing septic systems.

7.1.3 Haw Creek

Load duration curves and precipitation graphs were created for all the sampling sites (Figure 31) in the Haw Creek subwatershed. Flow data used to develop the load duration curves is summarized in Table 51.

The figures illustrate water quality standards violations during all flow ranges that occurred during sampling events. A discussion of key sampling sites in the subwatershed is included following the figures. Table 52 provides a summary of the Haw Creek subwatershed, including impaired segment AUID, drainage area, sampling sites, listed segments, and land use, as well as Load Allocations, Wasteload Allocations, and Margin of Safety values for *E. coli*. Evaluating the load duration curves and precipitation graphs with consideration of these watershed characteristics allows for identification of potential point and nonpoint sources that are contributing to elevated *E. coli* concentrations.

Table 51. USGS Site Assignments for Development of Load Duration Curve

AUID	Gage Location	Gage ID	Period of Record	Watershed Relationship[1]
INB08C5_02	Big Raccoon Creek	03340800	1/1/1990 – 5/30/2012	gaged

1. Where denoted as "surrogate," AUID watersheds are ungaged, and flows for the segment were estimated using flows from the noted UGSG gage in a surrogate watershed.

Table 52. Summary of Haw Creek Subwatershed Characteristics

Upstream Characteristics					
Drainage Area	27.9 square miles				
TMDL Sample Site	WLV160-0027, WLV160-0064				
Listed Segments	INB08C3_01, INB08C3_02, INB08C3_T1001, INB08C3_T1002, INB08C3_T1003, INB08C3_T1004, INB08C3_T1005				
Land Use	Agricultural Land: 87% Forested Land: 4% Developed Land: 4% Open Water: <1% Pasture/Hay: 3% Shrub/Scrub: 1% Wetland: <1%				
NPDES Facilities	NA				
MS4 Communities	NA				
CSO Communities	NA				
CAFOs	NA				
CFOs	NA				
TMDL *E. coli* Allocations (billion MPN/day)					
Allocation Category	**Very High**	**Higher Flow**	**"Normal"**	**Lower Flow**	**Low Flows**

	Flows	Conditions	Flows	Conditions	
LA	564.01	140.74	57.13	17.66	3.95
WLA	0	0	0	0	0
MOS (10%)	62.67	15.64	6.35	1.96	0.44
TMDL = LA+WLA+MOS	626.68	156.38	63.48	19.62	4.39

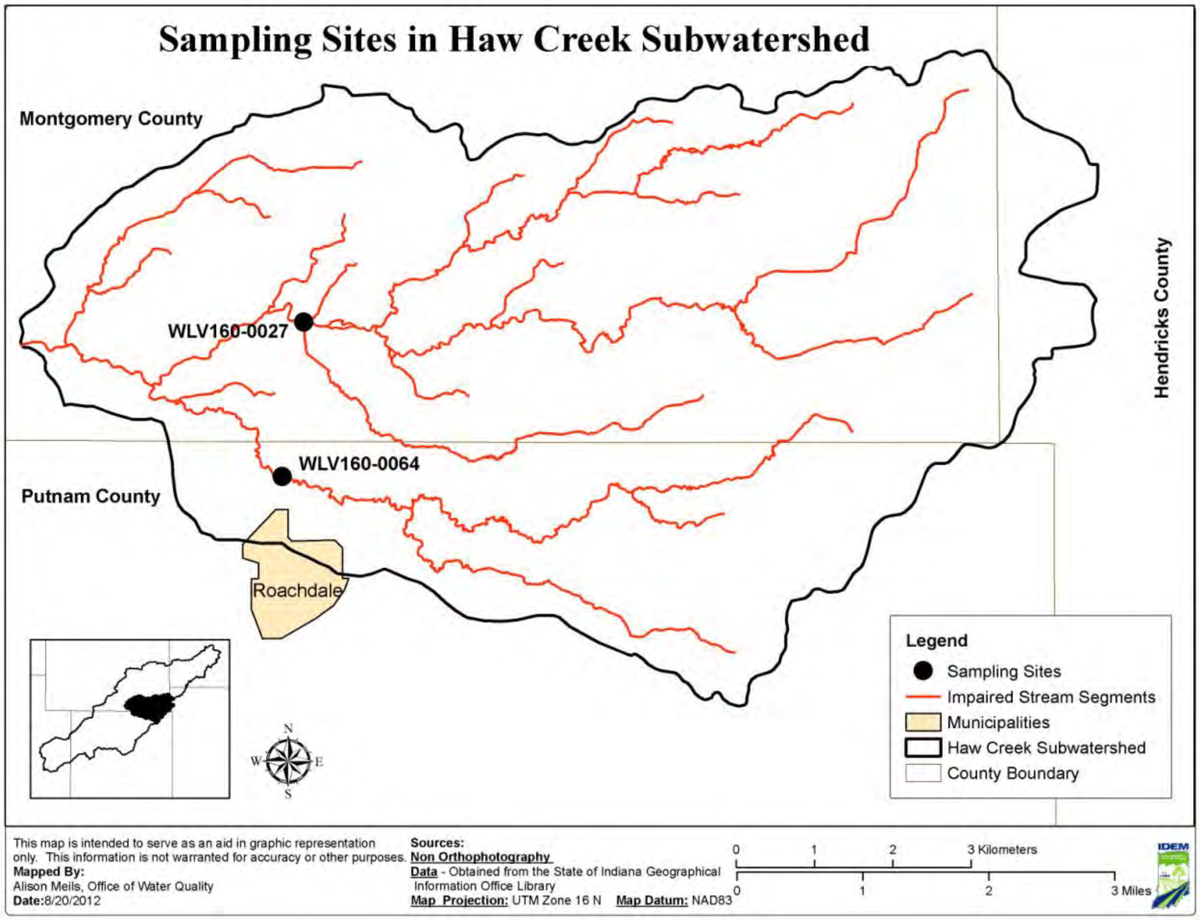

Figure 31. Sampling Stations in the Haw Creek Subwatershed

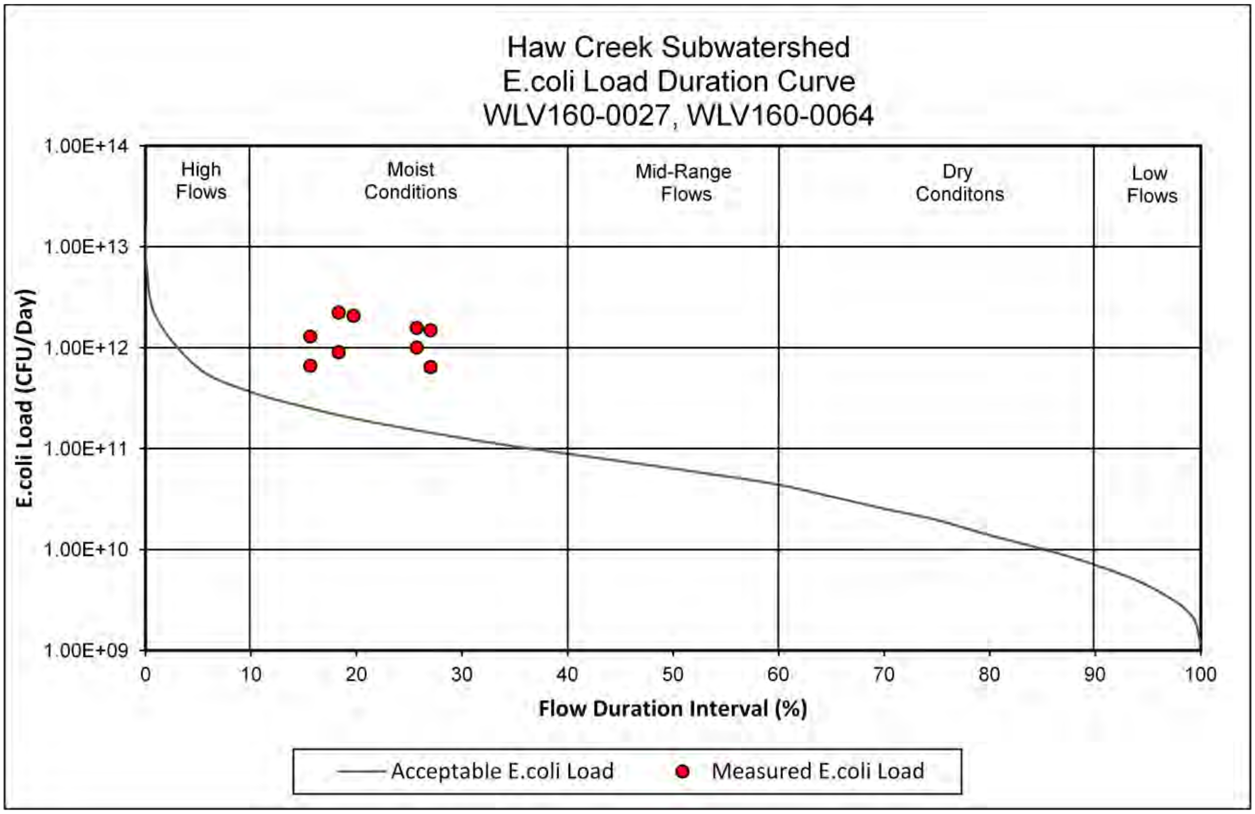

Figure 32. Load Duration Curve for sites in Haw Creek Subwatershed

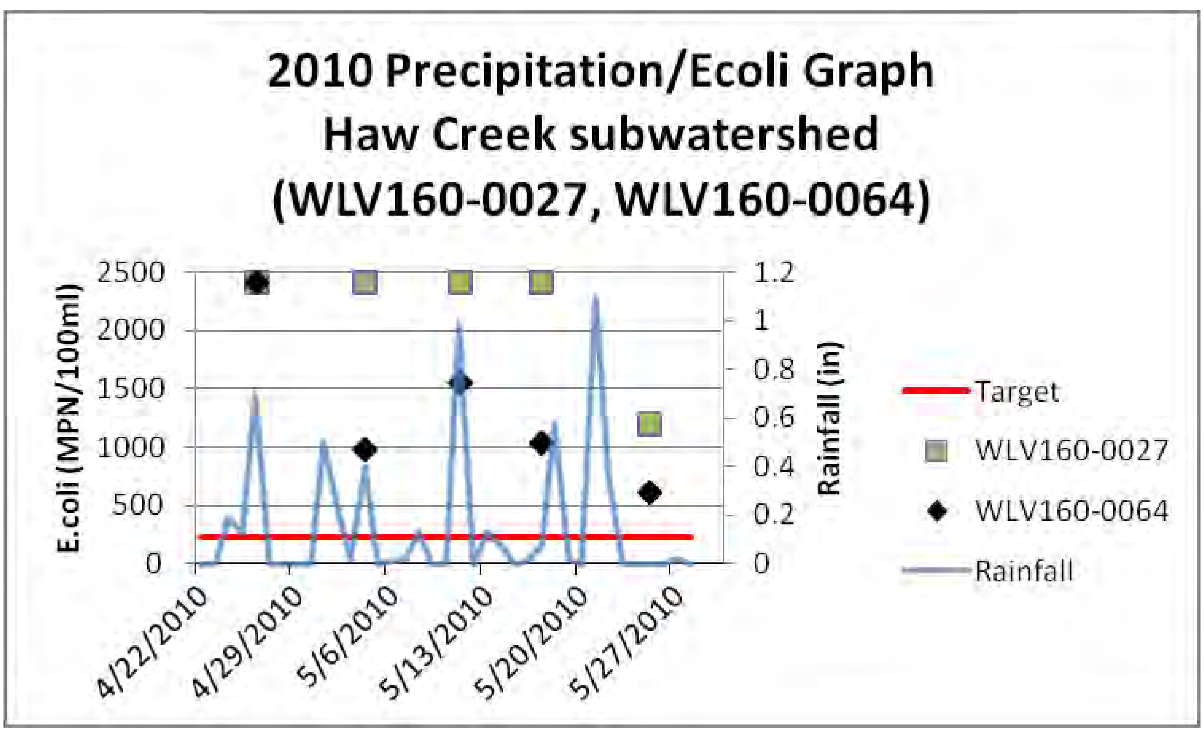

Figure 33. Graph of Precipitation and E. coli Data in Haw Creek Subwatershed

Site WLV160-0027 is located in Montgomery County at CR 550 E on Haw Creek before the confluence with Lick Creek to the South. The geometric mean value for the site is 2104 MPN/100mL. The curve for this site shows high levels of *E. coli* in the stream through moist flow conditions. The precipitation graph for this site shows the stream is susceptible to high loads of *E. coli* from run-off with 4 of the 5 samples being greater than 2419 MPN, which is the highest recordable number. This is evident that rainfall amounts can cause a considerable effect on the watershed. The stream is consistently in violation of water quality standards even during drier conditions on the chart. This indicates nonpoint source runoff is a major contributor to the high bacteria levels.

Site WLV160-0064 is located in Putnam County at CR 250 E on Lick Creek. The geometric mean value for the site is 1187 MPN/100mL. The load duration curve shows all samples exceeded the single sample water quality standard. The precipitation graph shows that the sampling events resulting in violations (or impairments) were either during a precipitation event or within a few days of a precipitation event. Therefore, the stream is susceptible to high loads of *E. coli* from run-off. Since the results seem dependent on precipitation events non-point sources are the most likely source of the higher values seen in a few of the samples.

The combined *E. coli* data for the subwatershed have an average single sample maximum violation 100% of the time and an average geometric mean violation 100% of the time. There is one SSO in the subwatershed but there were no reported overflows during the sampling events. Based on the water quality duration curves, it can be concluded that the majority of sources of *E. coli* in this watershed are nonpoint sources that include small animal operations, wildlife, animals with direct access to streams, straight piped, leaking and failing septic systems.

7.1.4 Cornstalk Creek

Load duration curves and precipitation graphs were created for all the sampling sites (Figure 34) in the Cornstalk Creek subwatershed. Flow data used to develop the load duration curves is summarized in Table 53.

The figures illustrate water quality standards violations during all flow ranges that occurred during sampling events. A discussion of key sampling sites in the subwatershed is included following the figures. Table 54 provides a summary of the Cornstalk Creek subwatershed, including impaired segment AUID, drainage area, sampling sites, listed segments, and land use, as well as Load Allocations, Wasteload Allocations, and Margin of Safety values for *E. coli*. Evaluating the load duration curves and precipitation graphs with consideration of these watershed characteristics allows for identification of potential point and nonpoint sources that are contributing to elevated *E. coli* concentrations.

Table 53. USGS Site Assignments for Development of Load Duration Curve

AUID	Gage Location	Gage ID	Period of Record	Watershed Relationship[1]
INB08C5_02	Big Raccoon Creek	03340800	1/1/1990 – 5/30/2012	gaged

1. Where denoted as “surrogate,” AUID watersheds are ungaged, and flows for the segment were estimated using flows from the noted UGSG gage in a surrogate watershed.

Table 54. Summary of Cornstalk Creek Subwatershed Characteristics

Upstream Characteristics	
Drainage Area	20.23 square miles
TMDL Sample Site	WLV160-0035, WLV160-0038
Listed Segments	INB08C4_01, INB08C4_T1001, INB08C4_T1002, INB08C4_T1003, INB08C4_T1004
Land Use	Agricultural Land: 87% Forested Land: 5% Developed Land: 5% Open Water: <1%

	Pasture/Hay: 1% Grassland/Shrubs: 1% Wetland: <1%				
NPDES Facilities	NA				
MS4 Communities	NA				
CSO Communities	NA				
CAFOs	NA				
CFOs	NA				
TMDL *E. coli* Allocations (billion MPN/day)					
Allocation Category	**Very High Flows**	**Higher Flow Conditions**	**"Normal" Flows**	**Lower Flow Conditions**	**Low Flows**
LA	409.15	102.10	41.44	12.81	2.86
WLA	0	0	0	0	0
MOS (10%)	45.46	11.34	4.6	1.42	0.32
TMDL = LA+WLA+MOS	454.61	113.44	46.05	14.23	3.18

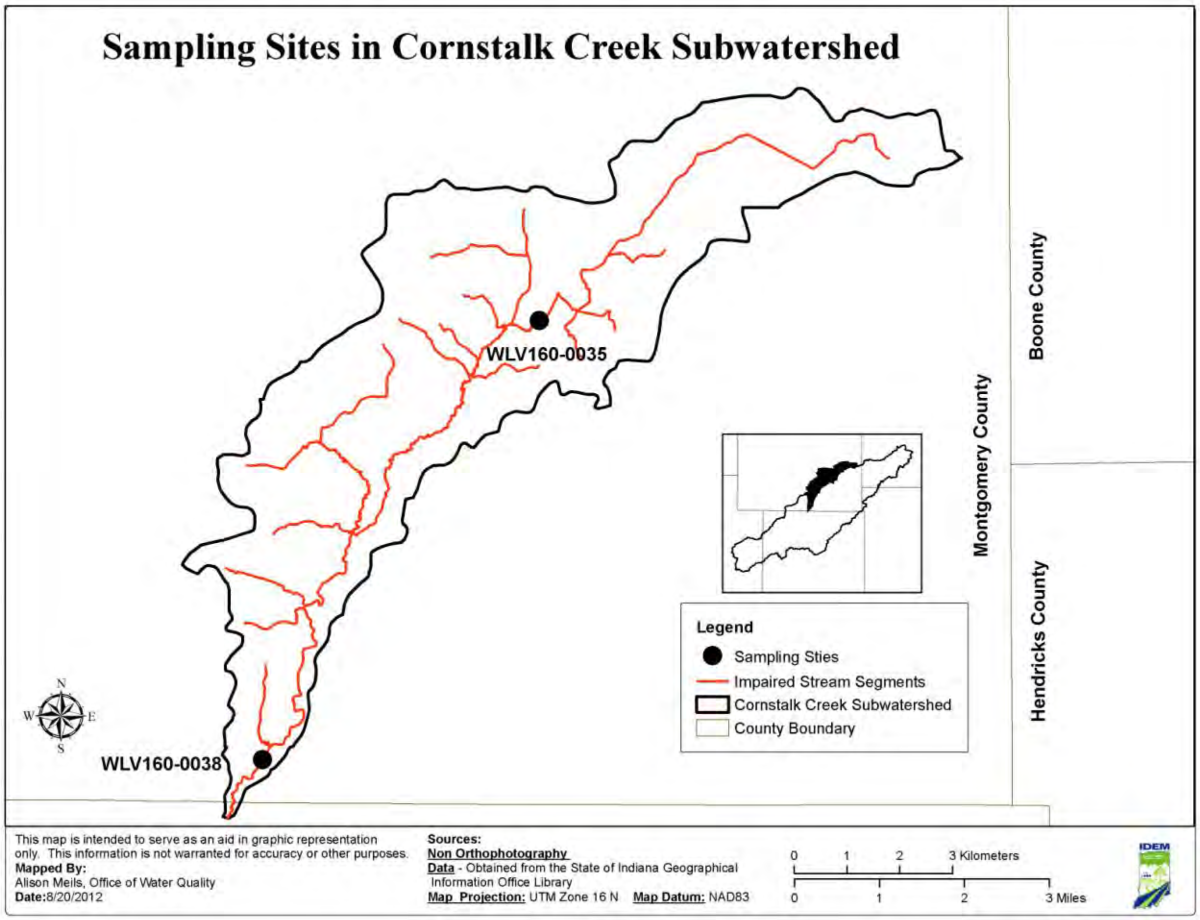

Figure 34. Sampling Stations in the Cornstalk Creek Subwatershed

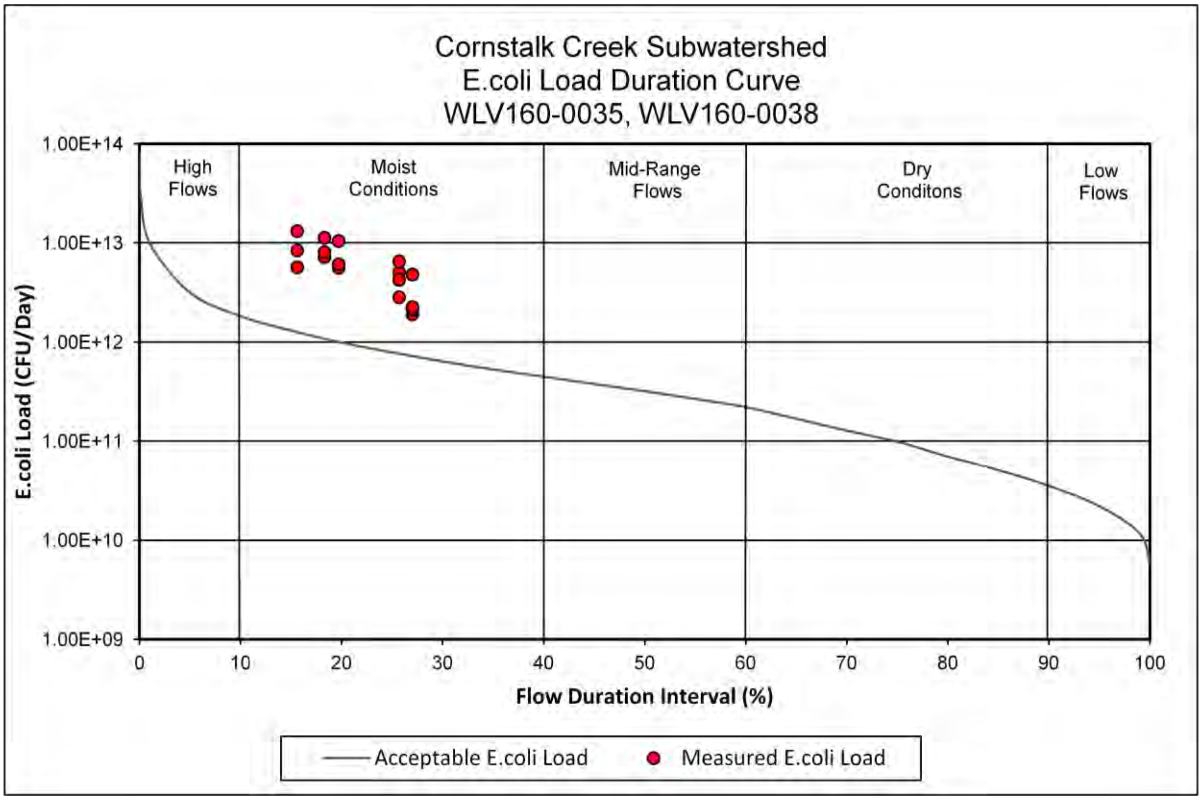

Figure 35. Load Duration Curve for Cornstalk Creek Subwatershed

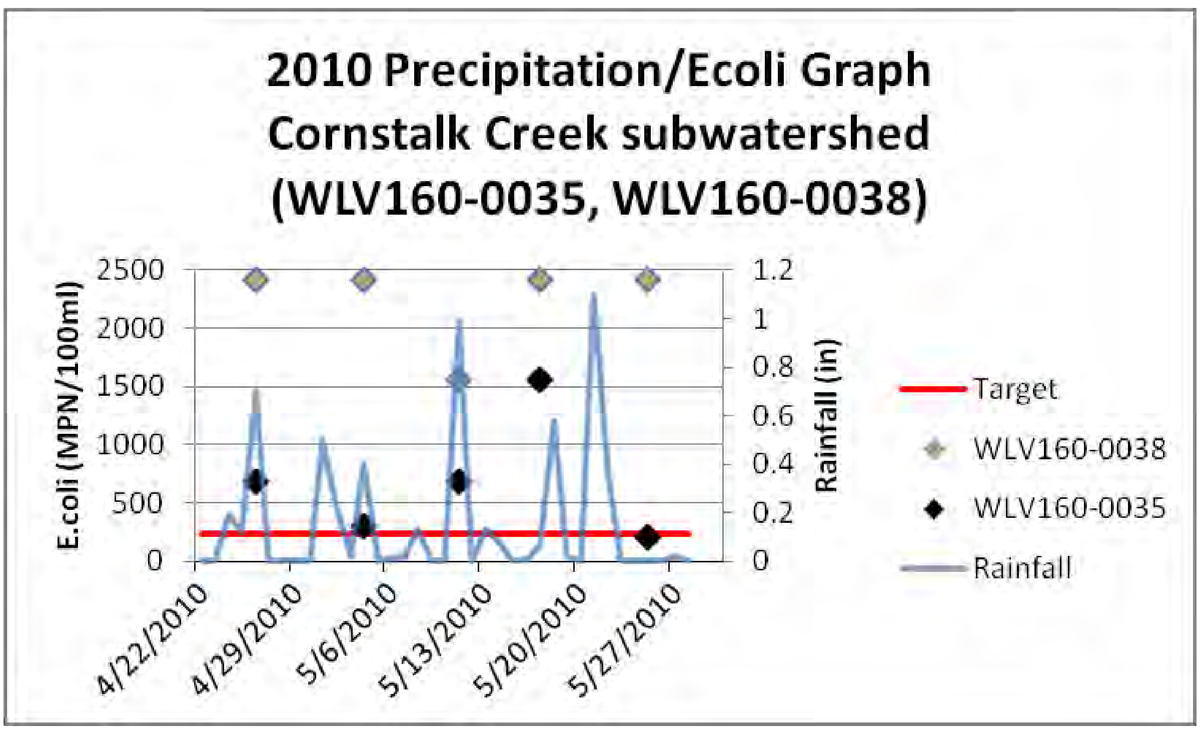

Figure 36. Graph of Precipitation and E. coli Data in Cornstalk Creek Subwatershed

Site LMG160-0035 is located in Montgomery County at CR 550 E on Cornstalk Creek. The geometric mean value for the site is 543MPN/100mL. The curve for this site shows an elevated level of *E. coli* in the stream through moist flow conditions. The precipitation graph for this site shows four exceedences of the single sample and one sample below the water quality standard. The highest *E.coli* level was collected on 5/17/2010 but there was only a small rain event (0.07) prior to collection. There was no precipitation for several days prior to the highest level of flow recorded (5/25/2010) but the E. coli was below the single sample maximum. This indicates that high flows in these headwaters may be influenced by tiles, which can cause high flows with low bacteria levels. Nonpoint sources are most likely the source of the higher values seen in the other samples due to rain events near the time of collection. The site is located in the headwaters of Cornstalk Creek so rain events do not contribute a large quantity of runoff to the stream. The drainage area information helps explain why the E. coli levels are rather low during most collection events (although still above standard) even though there are significant rain events.

Site LMG160-0038 is located downstream on Cornstalk Creek at CR 1150 S near the confluence with Big Raccoon Creek. The geometric mean value for the site is 2214 MPN/100mL. The load duration curve shows elevated levels of E. coli in the stream during moist flow conditions. The precipitation graph shows that the sampling events resulting in impairments were during precipitation events and moist weather conditions. Therefore, the stream is likely susceptible to high loads of *E. coli* from nonpoint source run-off.

The combined *E. coli* data for the subwatershed have an average single sample maximum violation 90% of the time and an average geometric mean violation 100% of the time. There are no known point sources in the subwatershed. Based on the water quality duration curves, it can be concluded that the majority of sources of *E. coli* in the headwaters of this subwatershed are nonpoint sources that include small animal operations, wildlife, animals with direct access to streams, straight piped, leaking and failing septic systems. As you move downstream along Cornstalk Creek the bacterial evidence shows high contributions from other tributaries not sampled during the 2010 project.

7.1.5 North Ramp Creek

Load duration curves and precipitation graphs were created for all the sampling sites (Figure 37) in the North Ramp Creek subwatershed. Flow data used to develop the load duration curves is summarized in Table 55.

The figures illustrate water quality standards violations during all flow ranges that occurred during sampling events. A discussion of key sampling sites in the subwatershed is included following the figures. Table 56 provides a summary of the North Ramp Creek subwatershed, including impaired segment AUID, drainage area, sampling sites, listed segments, and land use, as well as Load Allocations, Wasteload Allocations, and Margin of Safety values for *E. coli*. Evaluating the load duration curves and precipitation graphs with consideration of these watershed characteristics allows for identification of potential point and nonpoint sources that are contributing to elevated *E. coli* concentrations.

Table 55. USGS Site Assignments for Development of Load Duration Curve

AUID	Gage Location	Gage ID	Period of Record	Watershed Relationship[1]
INB08C5_02	Big Raccoon Creek	03340800	1/1/1990 – 5/30/2012	gaged

1. Where denoted as “surrogate,” AUID watersheds are ungaged, and flows for the segment were estimated using flows from the noted UGSG gage in a surrogate watershed.

Table 56. Summary of North Ramp Creek Subwatershed Characteristics

Upstream Characteristics					
Drainage Area	33.02 square miles				
TMDL Sample Site	WLV160-0015, WLV160-0068				
Listed Segments	INB08C5_01, INB08C5_T1001, INB08C5_T1002, INB08C5_T1003, INB08C5_T1004, INB08C5_T1005, INB08C5_T1006, INB08C5_T1007, INB08C5_T1008, INB08C5_02, INB08C5_T1009, INB08C5_T1010				
Land Use	Agricultural Land: 67% Forested Land: 13% Developed Land: 4% Open Water: <1% Pasture/Hay: 15% Shrub/Scrub: 1% Wetland: <1%				
NPDES Facilities	NA				
MS4 Communities	NA				
CSO Communities	NA				
CAFOs	NA				
CFOs	NA				
TMDL *E. coli* Allocations (billion MPN/day)					
Allocation Category	**Very High Flows**	**Higher Flow Conditions**	**"Normal" Flows**	**Lower Flow Conditions**	**Low Flows**
LA	667.99	166.69	67.66	20.91	4.67
WLA	0	0	0	0	0
MOS (10%)	74.22	18.52	7.52	2.32	0.52
TMDL = LA+WLA+MOS	742.22	185.21	75.18	23.24	5.19

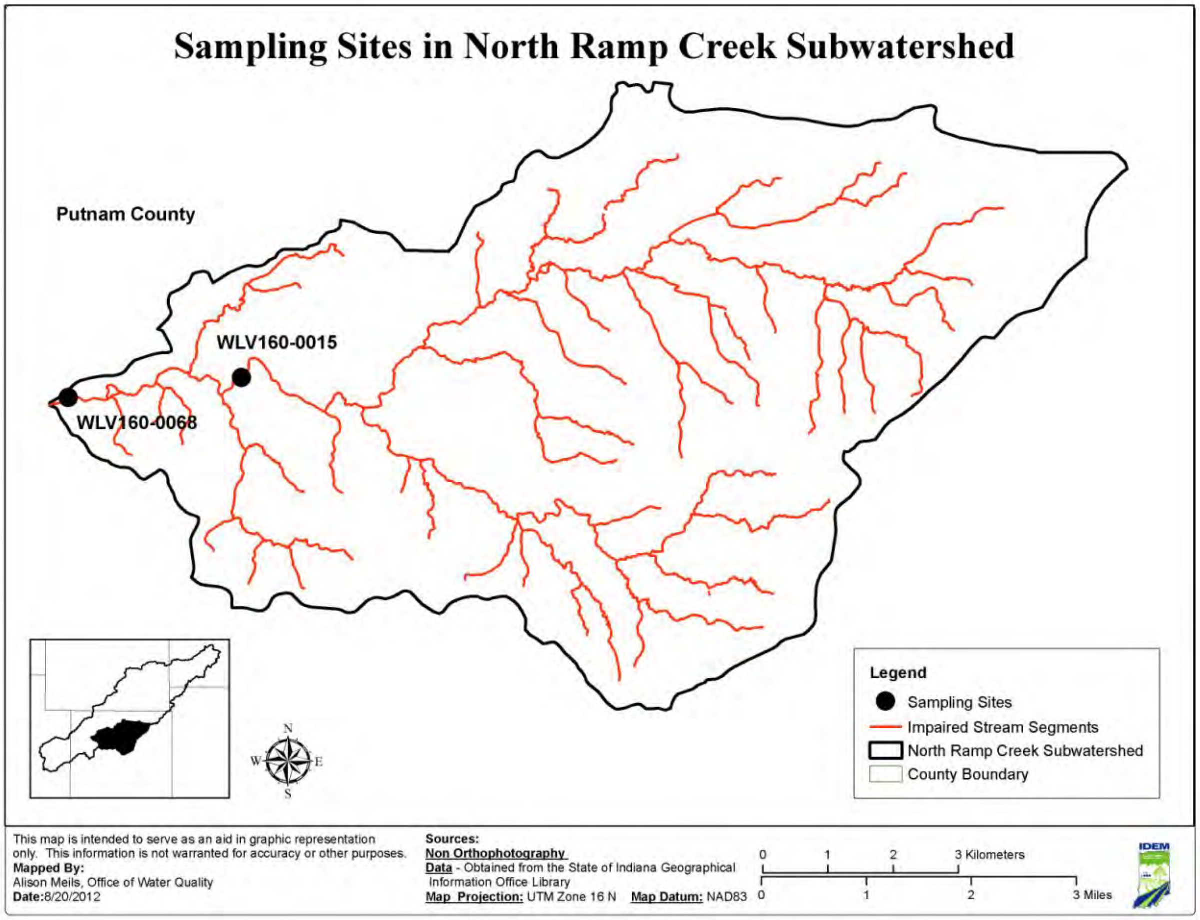

Figure 37. Sampling Sites in the North Ramp Creek Subwatershed

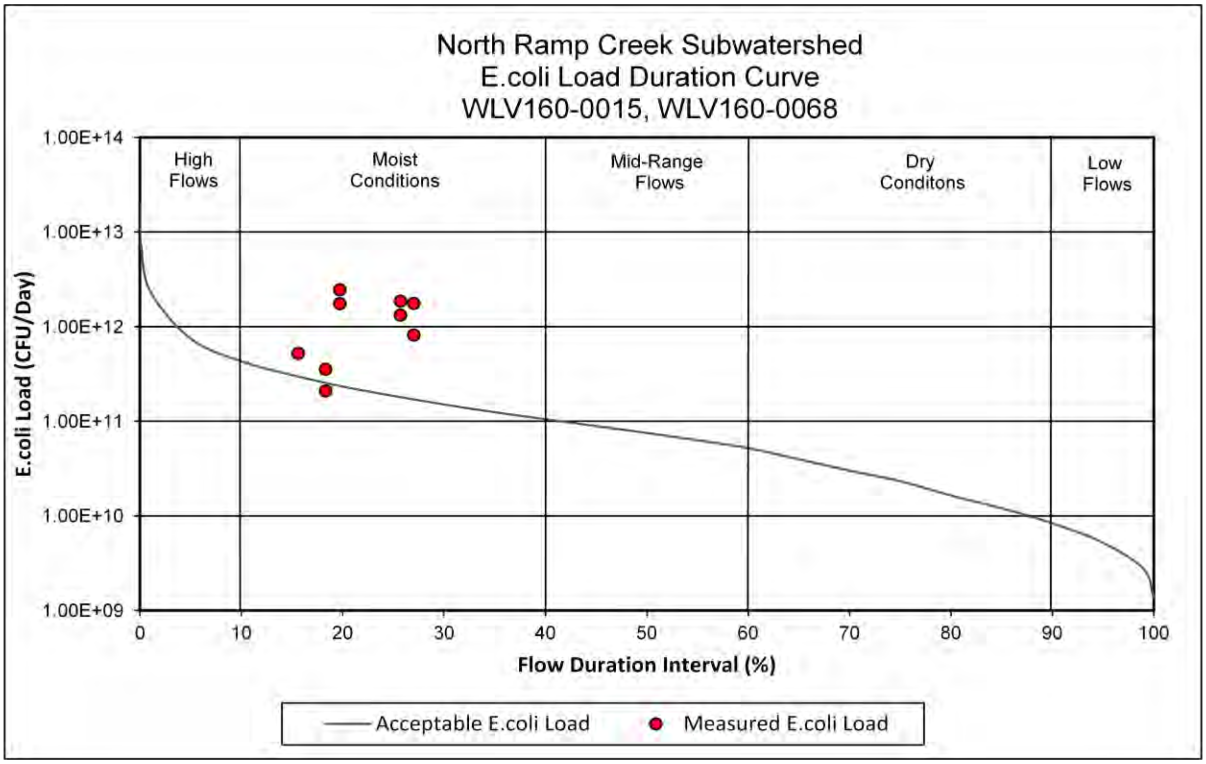

Figure 38. Load Duration Curve for North Ramp Creek Subwatershed

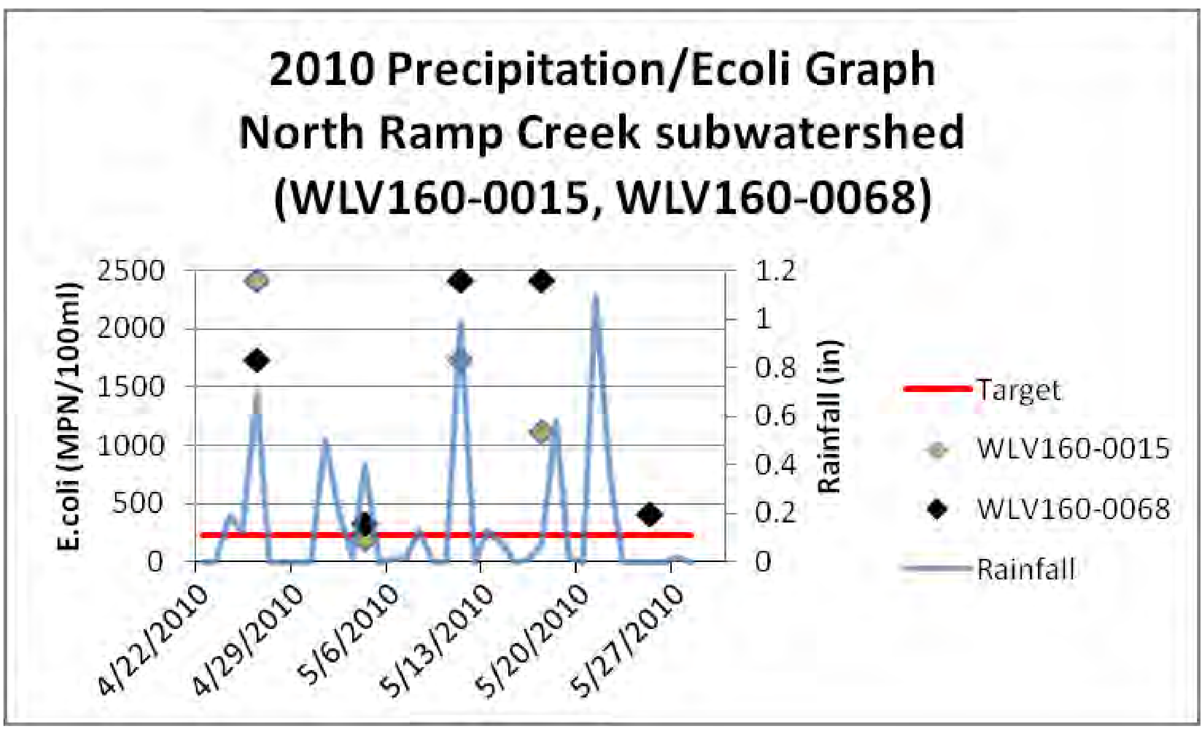

Figure 39. Graph of Precipitation and E. coli Data in North Ramp Creek Subwatershed

Site WLV160-0015 is located in Putnam County at CR 350 W on Ramp Creek just downstream of the confluence of North Ramp Creek and South Ramp Creek. The geometric mean value for the site is 819 MPN/100mL. Site specific load duration curves and precipitation graphs are presented in Appendix D. The curve for this site shows one sample meeting the single sample water quality standard during the moist flow conditions in which sampling took place. Due to frequent rain events the precipitation graph for this site shows the stream is susceptible to high loads of *E. coli* from run-off.
Site WLV160-0068 is located in Putnam County at CR 550 W on Ramp Creek just before the confluence with Big Raccoon Creek. The geometric mean value for the site is 1062 MPN/100mL. The load duration curve shows all samples exceeded the single sample water quality standard during moist flow conditions. The precipitation graph shows that the sampling events resulting in impairments were either during a precipitation event or within a few days of a precipitation event. Therefore, the stream is susceptible to high loads of *E. coli* from run-off. Since the results seem dependent on precipitation events nonpoint sources are the most likely source of the higher values seen in a few of the samples.

The combined *E. coli* data for the subwatershed have an average single sample maximum violation 90% of the time and an average geometric mean violation 100% of the time. There are no known point sources in the subwatershed. Based on the water quality duration curves, it can be concluded that the sources of *E. coli* in this watershed are nonpoint sources that include small animal operations, wildlife, animals with direct access to streams, straight piped, leaking and failing septic systems.

7.1.6 Little Raccoon Creek

Load duration curves and precipitation graphs were created for all the sampling sites (Figure 40) in the Little Raccoon Creek subwatershed. Flow data used to develop the load duration curves is summarized in Table 57.

The figures illustrate water quality standards violations during all flow ranges that occurred during sampling events. A discussion of key sampling sites in the subwatershed is included following the figures. Table 58 provides a summary of the Little Raccoon Creek subwatershed, including impaired segment AUID, drainage area, sampling sites, listed segments, land use, and NPDES facilities, as well as Load Allocations, Wasteload Allocations, and Margin of Safety values for *E. coli*. Evaluating the load duration curves and precipitation graphs with consideration of these watershed characteristics allows for identification of potential point and nonpoint sources that are contributing to elevated *E. coli* concentrations.

Table 57. USGS Site Assignments for Development of Load Duration Curve

AUID	Gage Location	Gage ID	Period of Record	Watershed Relationship[1]
INB08C5_02	Big Raccoon Creek	03340800	1/1/1990 – 5/30/2012	gaged

1. Where denoted as "surrogate," AUID watersheds are ungaged, and flows for the segment were estimated using flows from the noted UGSG gage in a surrogate watershed.

Table 58. Summary of Little Raccoon Creek Subwatershed Characteristics

Upstream Characteristics	
Drainage Area	46.27 square miles
TMDL Sample Site	WLV160-0002, WLV160-0025, WLV160-0044, WLV160-0065, WLV160-0066, WLV160-0067
Listed Segments	INB08C6_01, INB08C6_T1001, INB08C6_02, INB08C6_T1002, INB08C6_03, INB08C6_T1003, INB08C6_T1004, INB08C6_T1005, INB08C6_T1006, INB08C6_T1007
Land Use	Agricultural Land: 74% Forested Land: 13% Developed Land: 7% Open Water: <1% Pasture/Hay: 5% Shrub/Scrub: 2% Wetland: <1%

NPDES Facilities	Town of Ladoga WWTP (IN0023418), Town of Roachdale WWTP (IN0020052)				
MS4 Communities	NA				
CSO Communities	NA				
CAFOs	NA				
CFOs	NA				
TMDL *E. coli* Allocations (billion MPN/day)					
Allocation Category	**Very High Flows**	**Higher Flow Conditions**	**"Normal" Flows**	**Lower Flow Conditions**	**Low Flows**
LA	926.77	230.12	92.51	27.54	4.97
WLA	1.52	1.52	1.52	1.52	1.52
MOS (10%)	103.14	25.75	10.45	3.24	0.72
TMDL = LA+WLA+MOS	1031.43	257.39	104.48	32.30	7.21

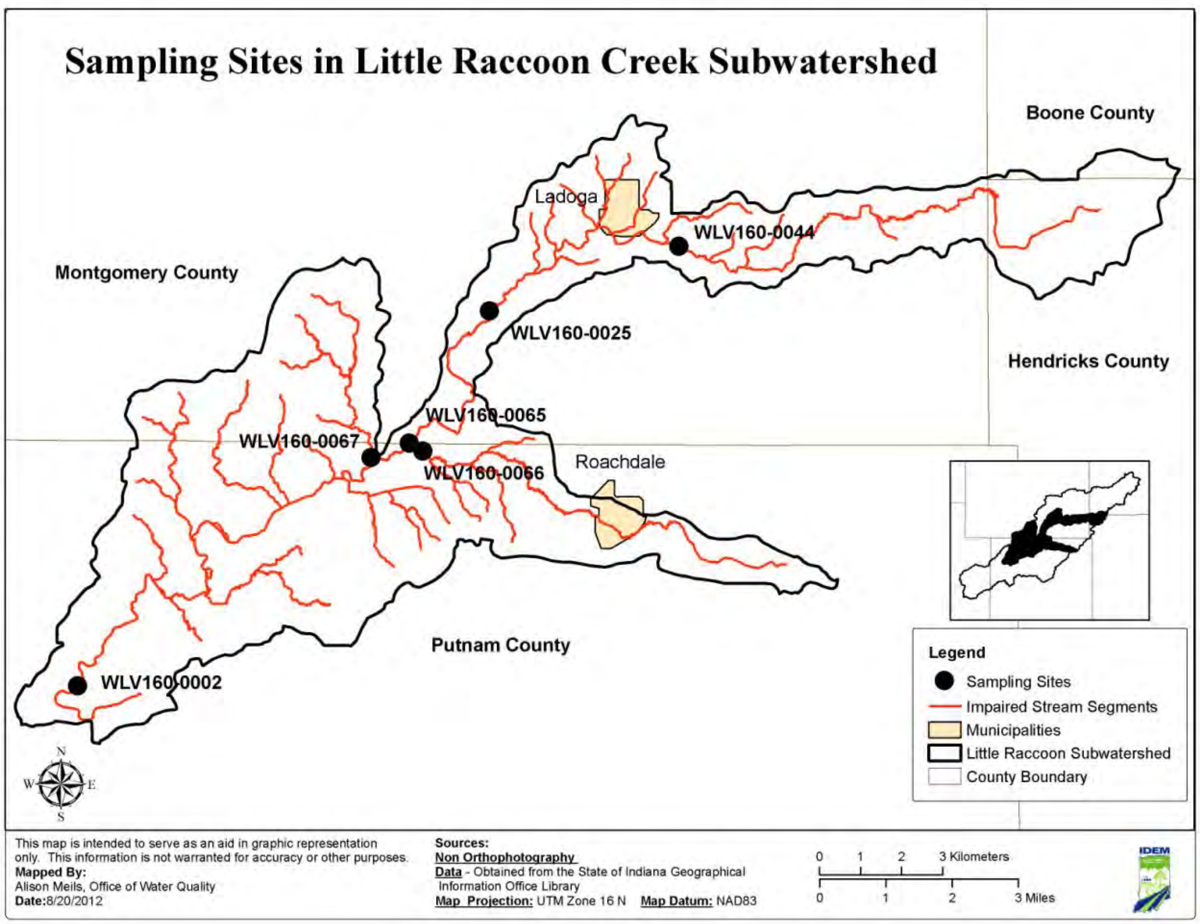

Figure 40. Sampling Stations in the Little Raccoon Creek Subwatershed

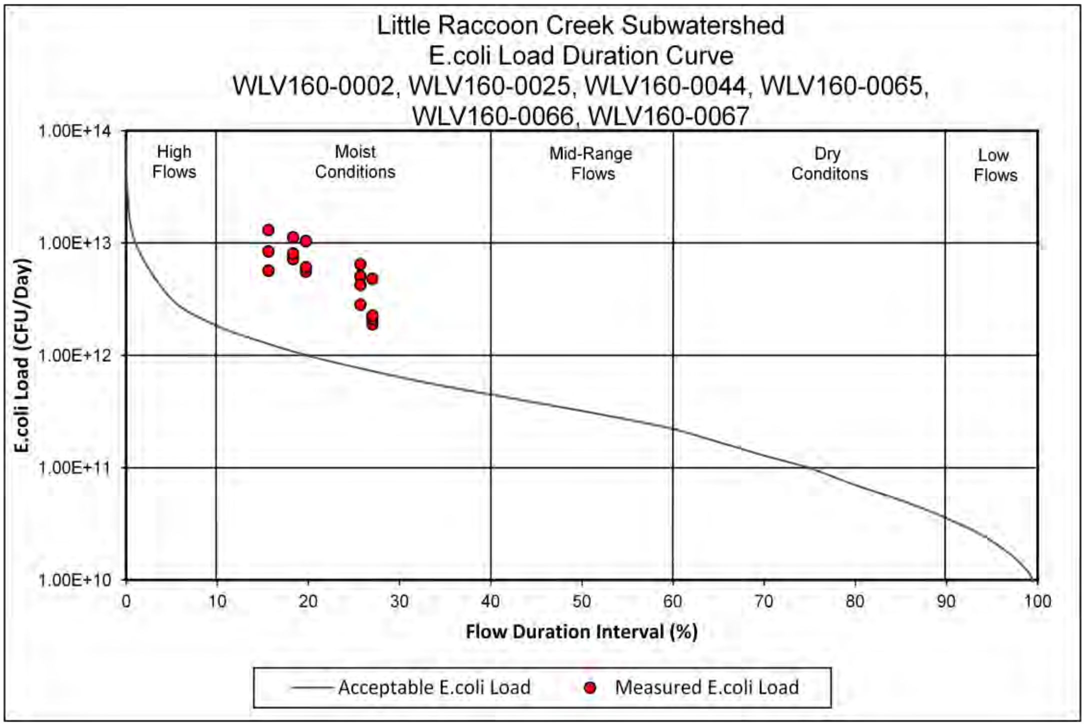

Figure 41. Load Duration Curve for the Little Raccoon Creek Subwatershed

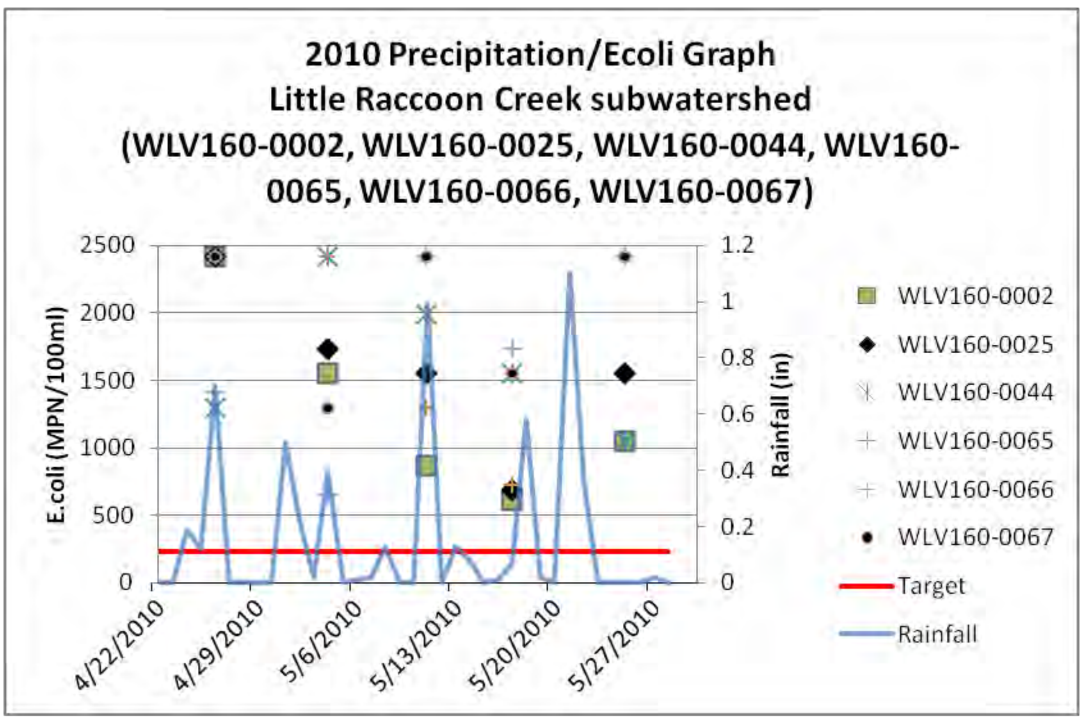

Figure 42. Graph of Precipitation and E. coli Data in Little Raccoon Creek Subwatershed

Site WLV160-0044 is located in Montgomery County at CR 900 S on Little Raccoon Creek just before the confluence with Big Raccoon Creek. The geometric mean value for the site is 1589 MPN/100mL. Site specific load duration curves and precipitation graphs are presented in Appendix D. The curve for this site shows an elevated level of *E. coli* in the stream during moist flow conditions. The precipitation graph for this site shows the stream is susceptible to high loads of *E. coli* during moist conditions. It is evident that a small amount of rain can cause a considerable effect on the watershed. The stream is consistently in violation of water quality standards even during drier conditions on the chart. This indicates point sources may be contributing along with nonpoint sources. If animals have direct access upstream of WLV160-0044 this could contribute to *E. coli* violations during dry and wet conditions.

Site WLV160-0025 is located in Putnam County at CR 1000 S on Big Raccoon Creek downstream of Ladoga. The geometric mean value for the site is 1473 MPN/100mL. The load duration curve shows four exceedances of the single sample with one sample below the water quality standard. The precipitation graph shows that the four sampling events resulting in impairments were either during a precipitation event or within a few days of a precipitation event. Therefore, the stream is susceptible to high loads of *E. coli* from run-off. Since the results seem dependent on precipitation events nonpoint sources are the most likely source of the higher values seen in a few of the samples.

Site WLV160-0065 is located further downstream on Big Raccoon Creek before the confluence with Cline Creek. The geometric mean value for the site is 1680 MPN/100mL. The curve for this site shows an elevated level of *E. coli* in the stream during moist flow conditions. All samples exceeded the single sample water quality standard. The precipitation graph shows that the sampling events resulting in impairments were either during a precipitation event or within a few days of a precipitation event. The high *E. coli* can also be attributed to the contribution from Haw Creek. Therefore, the stream is susceptible to high loads of *E. coli* from run-off during rain events and also large contribution from the upstream tributaries. Since the results seem dependent on precipitation events nonpoint sources are the most likely source of the higher values seen in a few of the samples.

Site WLV160-0066 is located at CR 50 W on Cline Creek just upstream of the confluence with Big Raccoon Creek. The geometric mean value for the site is 1562 MPN/100mL. The curve for this site shows an elevated level of *E. coli* in the stream during moist flow conditions. All samples exceeded the single sample water quality standard. The precipitation graph shows that the sampling events resulting in impairments were either during a precipitation event or within a few days of a precipitation event. Therefore, the stream is susceptible to high loads of *E. coli* from run-off. Since the results seem dependent on precipitation events nonpoint sources are the most likely source of the higher values seen in a few of the samples. There is one SSO located upstream of the site but there were no reported discharges during the sampling events.

Site WLV160-0067 is located in Putnam County at CR 1350 N on an unnamed tributary to Big Raccoon Creek. The geometric mean value for the site is 1955 MPN/100mL. The curve for this site shows an elevated level of *E. coli* in the stream during moist flow conditions. All samples exceeded the single sample water quality standard. The precipitation graph shows that the sampling events resulting in impairments were either during a precipitation event or within a few days of a precipitation event. Therefore, the stream is susceptible to high loads of *E. coli* from run-off. Since the results seem dependent on precipitation events nonpoint sources are the most likely source of the higher values seen in a few of the samples.

Site WLV160-0002 is located in Putnam County and is the furthest site downstream on Big Raccoon Creek in the Little Raccoon Creek subwatershed. The geometric mean value for the site is 1103 MPN/100mL. The curve for this site shows an elevated level of *E. coli* in the stream during moist flow conditions. All samples exceeded the single sample water quality standard. The precipitation graph shows that the sampling events resulting in impairments were either during a precipitation event or within a few days of a precipitation event. Therefore, the stream is susceptible to high loads of *E. coli* from run-off. Since the results seem dependent on precipitation events nonpoint sources are the most likely source of the higher values seen in a few of the samples.

The combined *E. coli* data for the subwatershed have an average single sample maximum violation 100% of the time and an average geometric mean violation 100% of the time. There are two NPDES permitted facilities in the subwatershed with 9 *E. coli* violations in the last 5 years. The five violations from the Roachdale WWTP occurred in 2011 and 2012 and would not have impacted the sampling used in the linkage analysis. The four *E. coli* violations fro m the Ladoga WWTP occurred in 2008 and 2009, which would not be reflected in the data used in the linkage analysis. There was also an enforcement case on the Ladoga WWTP due to multiple violations. Based on the water quality duration curves, it can be concluded that the majority of sources of *E. coli* in this watershed are nonpoint sources that include small animal operations, wildlife, animals with direct access to streams, straight piped, leaking and failing septic systems.

7.1.7 Byrd Branch

Load duration curves and precipitation graphs were created for all the sampling sites (Figure 43) in the Byrd Branch subwatershed. Flow data used to develop the load duration curves is summarized in Table 59.

The figures illustrate water quality standards violations during all flow ranges that occurred during sampling events. A discussion of key sampling sites in the subwatershed is included following the figures. Table 60 provides a summary of the Byrd Branch subwatershed, including impaired segment AUID, drainage area, sampling sites, listed segments, and land use, as well as Load Allocations, Wasteload Allocations, and Margin of Safety values for *E. coli*. Evaluating the load duration curves and precipitation graphs with consideration of these watershed characteristics allows for identification of potential point and nonpoint sources that are contributing to elevated *E. coli* concentrations.

Table 59. USGS Site Assignments for Development of Load Duration Curve

AUID	Gage Location	Gage ID	Period of Record	Watershed Relationship[1]
INB08C5_02	Big Raccoon Creek	03340800	1/1/1990 – 5/30/2012	gaged

1. Where denoted as "surrogate," AUID watersheds are ungaged, and flows for the segment were estimated using flows from the noted UGSG gage in a surrogate watershed.

Table 60. Summary of Byrd Branch Subwatershed Characteristics

Upstream Characteristics					
Drainage Area	18.57 square miles				
TMDL Sample Site	WLV160-0070				
Listed Segments	INB08C7_01, INB08C7_T1001, INB08C7_T1002, INB08C7_T1003, INB08C7_T1004, INB08C7_T1005, INB08C7_T1006, INB08C7_02, INB08C7_T1007, INB08C7_T1008				
Land Use	Agricultural Land: 52% Forested Land: 35% Developed Land: 5% Open Water: <1% Pasture/Hay: 8% Shrub/Scrub: <1% Wetland: <1%				
NPDES Facilities	NA				
MS4 Communities	NA				
CSO Communities	NA				
CAFOs	NA				
CFOs	NA				
TMDL *E. coli* Allocations (billion MPN/day)					
Allocation Category	**Very High Flows**	**Higher Flow Conditions**	**"Normal" Flows**	**Lower Flow Conditions**	**Low Flows**
LA	384.89	97.19	40.35	13.53	4.21

WLA	0	0	0	0	0
MOS (10%)	42.60	10.63	4.31	1.34	0.30
TMDL = LA+WLA+MOS	427.49	107.82	44.66	14.87	4.51

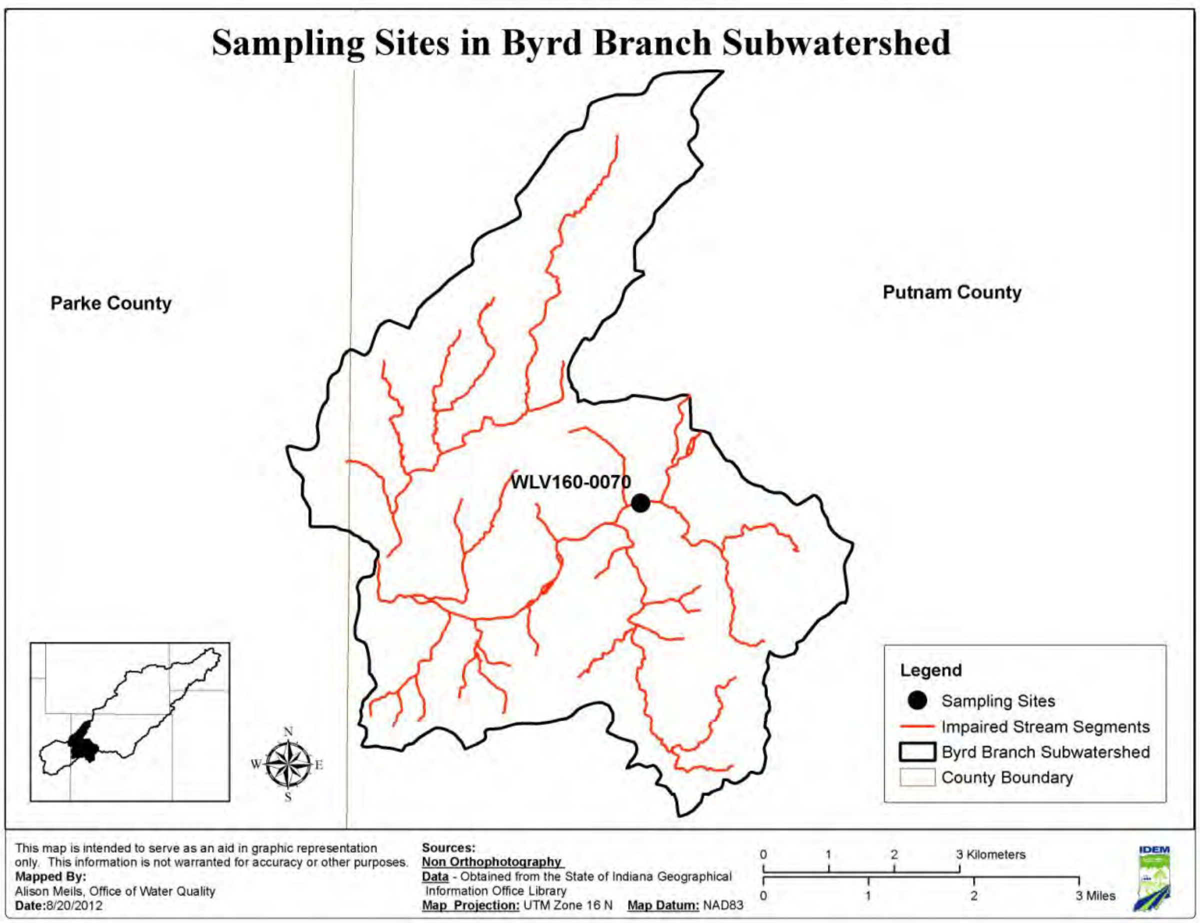

Figure 43. Sampling Stations in the Byrd Branch Subwatershed

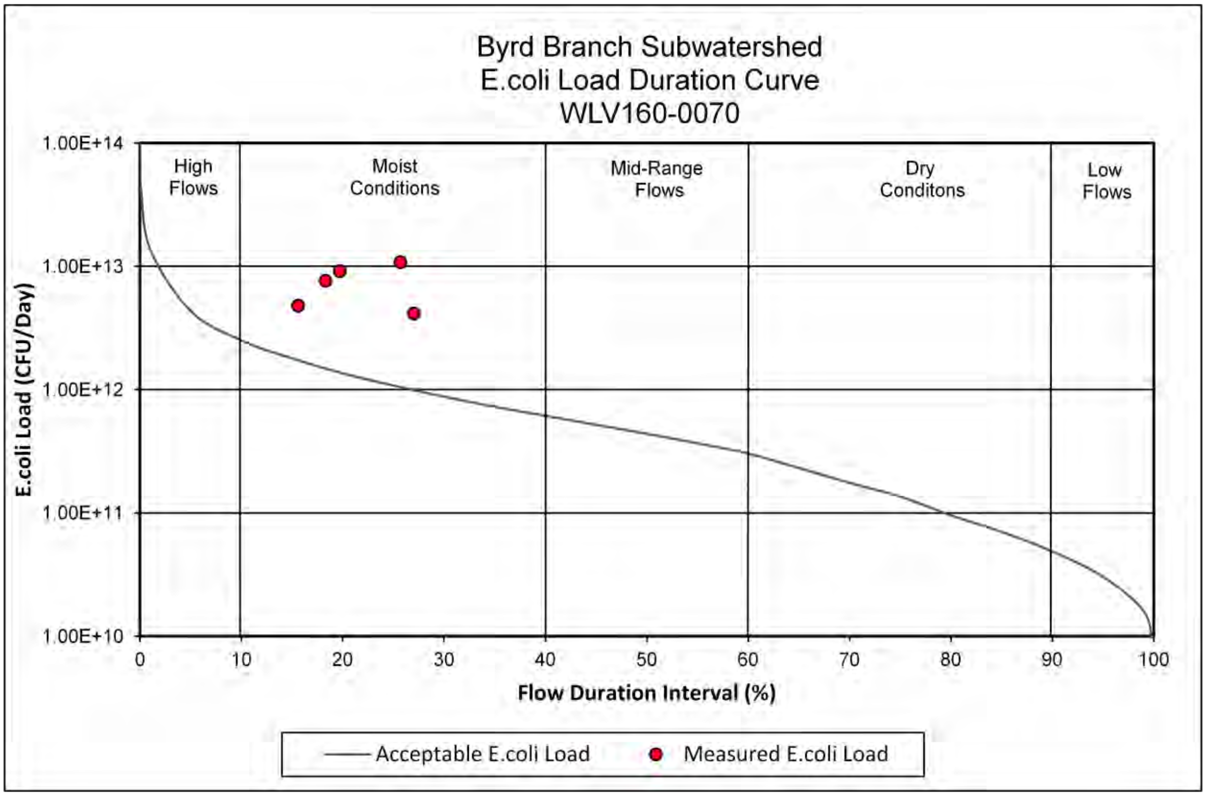

Figure 44. Load Duration Curve in Byrd Branch Subwatershed

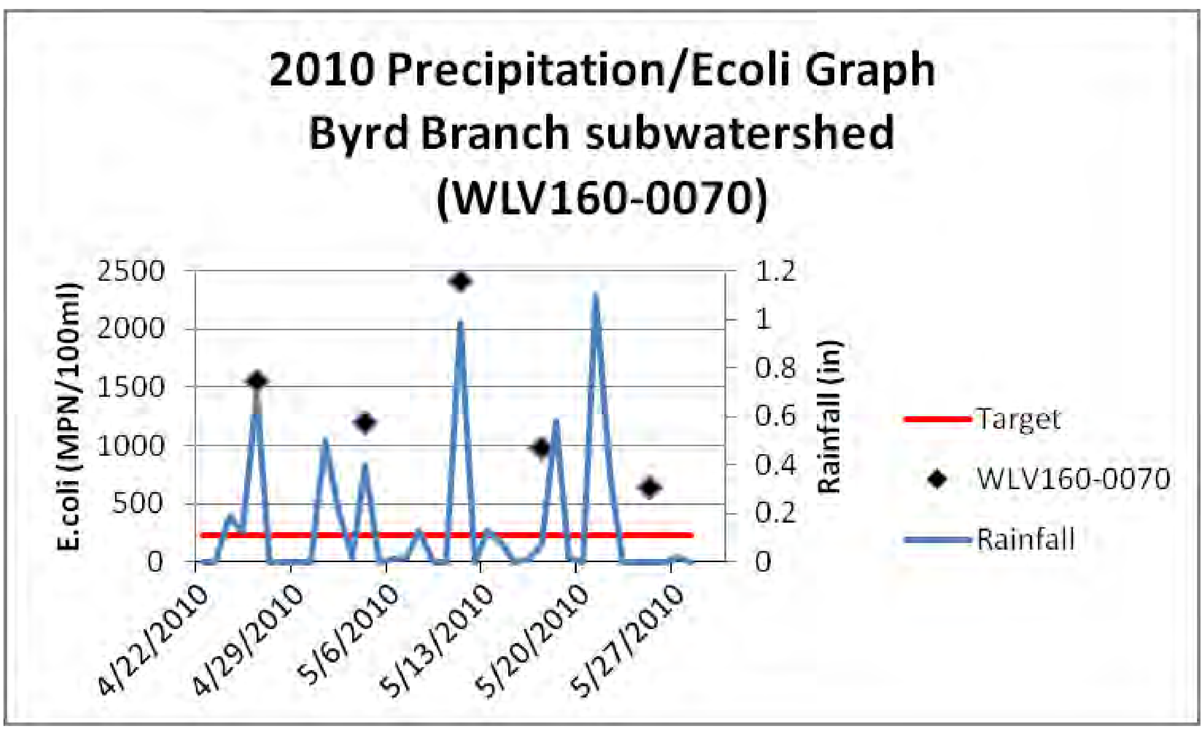

Figure 45. Graph of Precipitation and E. coli Data in Byrd Branch Subwatershed

Site WLV160-0070 is located in Putnam County at CR 625 W on Big Raccoon Creek downstream of the confluence with Ramp Creek. The geometric mean value for the site is 1235 MPN/100mL. The curve for this site shows elevated levels of *E. coli* in the stream through moist flow conditions. The precipitation graph for this site shows the stream is susceptible to high loads of *E. coli* from run-off with the frequent rain events during the sampling period. This is evident that a small amount of rain can cause a considerable effect on the watershed.

The combined *E. coli* data for the subwatershed have an average single sample maximum violation 100% of the time and an average geometric mean violation 100% of the time. There are no known point sources of E. coli in the subwatershed. Based on the water quality duration curves, it can be concluded that the sources of *E. coli* in this watershed are nonpoint sources that include small animal operations, wildlife, animals with direct access to streams, straight piped, leaking and failing septic systems.

7.2 Linkage Analysis for Nutrients

Information presented in the water quality assessment (Section 3.0) describes phosphorus conditions in the Big Raccoon Creek watershed. Elevated total phosphorus was noted throughout the basin, but was only identified as a cause of aquatic life use impairment at 2 sampling locations (WLV160-0017 and WLV160-0039). Therefore, TMDLs were calculated at only those 2 locations.

Load duration curves and precipitation graphs were created for only the sites discussed below in the Big Raccoon Creek Watershed. Flow data used to develop the load duration curves is summarized in Table 61.

7.2.1 Headwaters of Big Raccoon Creek

The figures below illustrate IDEM numeric target violations during dry flow conditions that occurred during the sampling event. A discussion of key sampling sites in the subwatershed is included following the figures. Table 62 provides a summary of Wells Dicth in the Headwaters of Big Raccoon Creek subwatershed, including impaired segment AUID, drainage area, sampling sites, listed segments, land use, and CFOs, as well as Load Allocations, Wasteload Allocations, and Margin of Safety values for total phosphorus. Evaluating the load duration curves and precipitation graphs with consideration of these watershed characteristics allows for identification of potential point and nonpoint sources that are contributing to elevated total phosphorus concentrations.

Table 61. USGS Site Assignments for Development of Load Duration Curve

AUID	Gage Location	Gage ID	Period of Record	Watershed Relationship[1]
INB08C5_02	Big Raccoon Creek	03340800	1/1/1990 – 5/30/2012	gaged

1. Where denoted as "surrogate," AUID watersheds are ungaged, and flows for the segment were estimated using flows from the noted UGSG gage in a surrogate watershed.

Table 62. Summary of Wells Ditch Drainage Characteristics

Upstream Characteristics	
Drainage Area	3.44 square miles
TMDL Sample Site	WLV160-0017
Listed Segments	INB08C1_T1004
Land Use	Agricultural Land: 87% Forested Land: 3% Developed Land: 6% Open Water: <1% Pasture/Hay: 3% Shrub/Scrub: <1% Wetland: <1%
NPDES Facilities	NA
MS4 Communities	NA
CSO Communities	NA

CAFOs	NA				
CFOs	Demaree Farms Partnership (6664)				
TMDL TP Allocations (lbs/day)]					
Allocation Category	**Very High Flows**	**Higher Flow Conditions**	**"Normal" Flows**	**Lower Flow Conditions**	**Low Flows**
LA	17.36	4.33	1.75	0.54	0.12
WLA	0	0	0	0	0
MOS (10%)	1.93	0.48	0.2	0.06	0.01
TMDL = LA+WLA+MOS	19.29	4.81	1.95	0.60	0.14

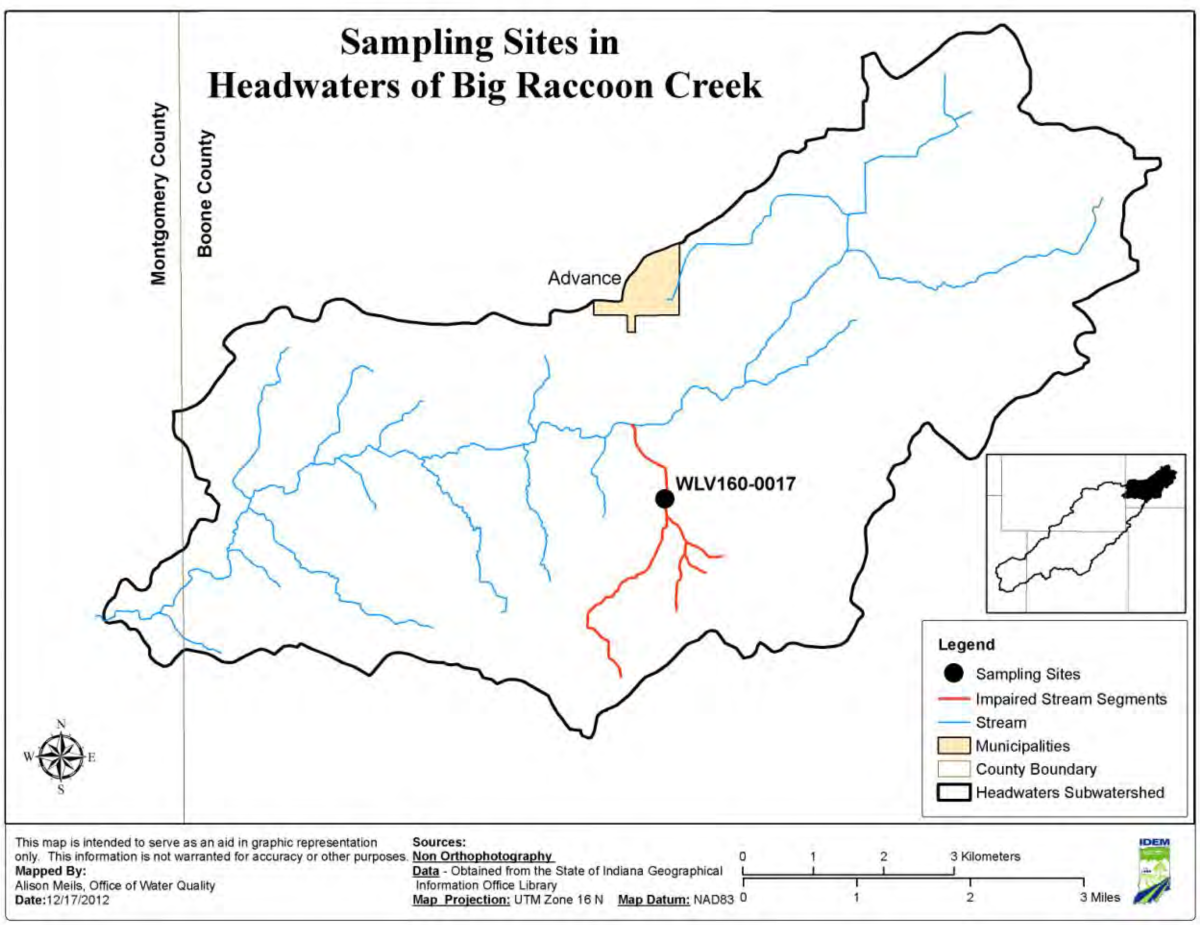

Figure 46. Sampling Stations in the Headwaters of Raccoon Creek Subwatershed

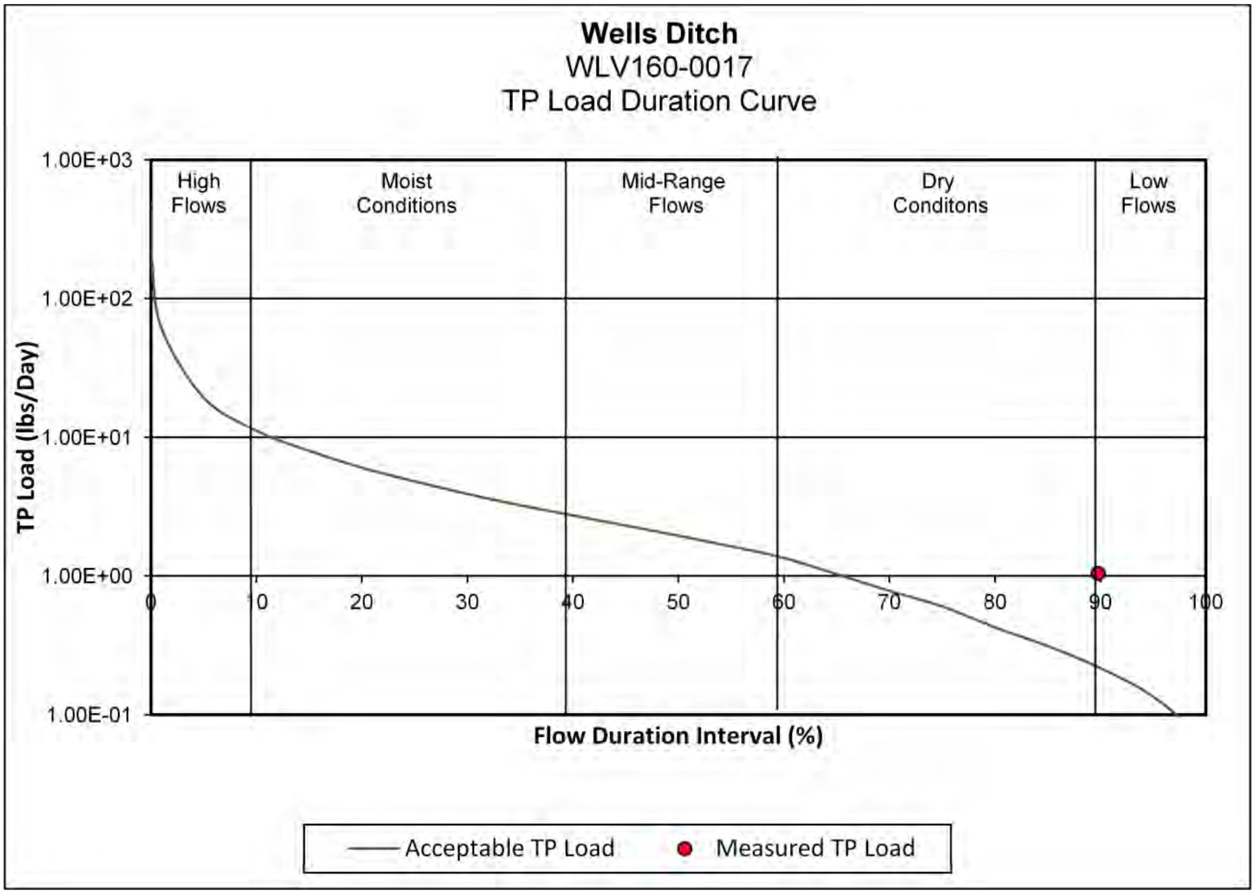

Figure 47. Total Phosphorus Load Duration Curve at Wells Ditch in Headwaters of Big Raccoon Creek subwatershed

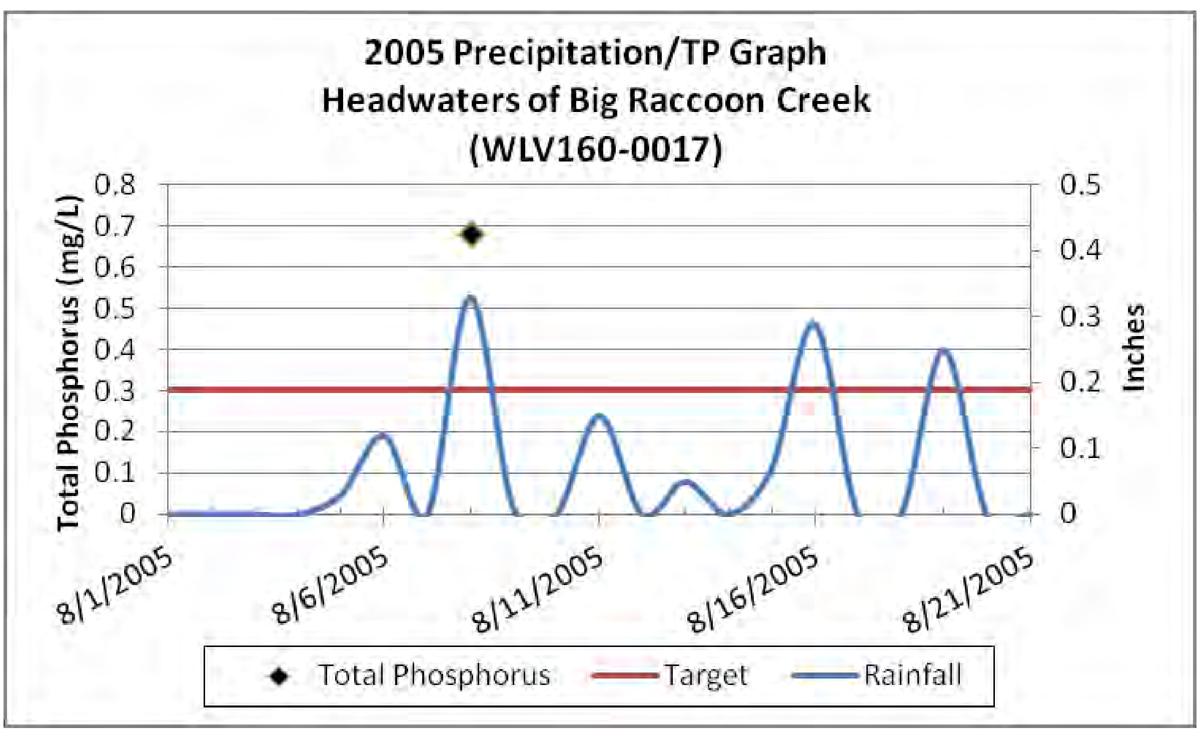

Figure 48. Graph of Precipitation and Total Phosphorus Data in the Headwaters of Big Raccoon Creek subwatershed

Site WLV160-0017 is located in Boone County at CR 500 S on Wells Ditch just before the confluence with Big Raccoon Creek. Figure shows the load duration curve for total phosphorus at the sampling location described above. It indicates that the TMDL target is exceeded under low flow conditions. This suggests that nonpoint sources as well as point sources may be contributing to the impairment. Nonpoint sources might include sediment-bound phosphorus that enters the river during erosional processes, as well as the runoff of storms over fertilized fields and residential areas. Septic systems might also be a potential source of phosphorus if the systems are failing and located adjacent to the streams.

The phosphorus concentration at sampling station WLV160-0017 was elevated (0.68 mg/L) in August of 2005. There was only one sample collected, therefore not enough to impair the stream reach for TP (3 samples required). However the biology at the site had an IBI score of 12 which is considered very poor. After further review of the data the site was found to have a dissolved oxygen reading of 3.5 mg/L which is below the water quality standard of 4.0 mg/L. This site was visited again in 2012 and there was visible cattle access to the stream which is a direct contribution of nutrients and bacteria. The only CFO in the Big Raccoon Creek watershed is located at this site. In general, this period corresponds to decreasing precipitation and runoff events. Due to the lack of relationship with rainfall, these analyses indicate dry weather nonpoint sources as the most significant source of phosphorus in Big Raccoon Creek watershed. The source assessment identifies wastewater or sewage treatment plants within the Headwaters of Big Raccoon Creek subwatershed, however they are not located on this particular stream. The elevated TP and low DO data collected at the location of a CFO with cattle access to the stream further supports nonpoint sources of nutrients entering the stream. Additional potential low flow sources include other small animal farms and failing septic systems located adjacent to the stream.

7.2.2 Little Raccoon Creek

The figures below illustrate water quality standards violations during dry flowconditions that occurred during sampling events. A discussion of key sampling sites in the subwatershed is included following the figures. Table 64 provides a summary of the Unnamed Tributary to Big Raccoon Creek in the Little Raccoon Creek subwatershed, including impaired segment AUID, drainage area, sampling sites, listed segments, and land use, as well as Load Allocations, Wasteload Allocations, and Margin of Safety values for total phosphorus. Evaluating the load duration curves and precipitation graphs with consideration of these watershed characteristics allows for identification of potential point and nonpoint sources that are contributing to elevated total phosphorus concentrations.

Table 63. USGS Site Assignments for Development of Load Duration Curve

AUID	Gage Location	Gage ID	Period of Record	Watershed Relationship[1]
INB08C5_02	Big Raccoon Creek	03340800	1/1/1990 – 5/30/2012	gaged

1. Where denoted as “surrogate,” AUID watersheds are ungaged, and flows for the segment were estimated using flows from the noted UGSG gage in a surrogate watershed.

Table 64. Summary of the Unnamed Tributary to Big Raccoon Creek in the Little Raccoon Creek Subwatershed

Upstream Characteristics	
Drainage Area	3.8 square miles
TMDL Sample Site	WLV160-0039
Listed Segments	INB08C6_T1003

Land Use	Agricultural Land: 86% Forested Land: 5% Developed Land: 2% Open Water: <1% Pasture/Hay: 5% Shrub/Scrub: 1% Wetland: <1%				
NPDES Facilities	NA				
MS4 Communities	NA				
CSO Communities	NA				
CAFOs	NA				
CFOs	NA				
TMDL TP Allocations (lbs/day)					
Allocation Category	**Very High Flows**	**Higher Flow Conditions**	**"Normal" Flows**	**Lower Flow Conditions**	**Low Flows**
LA	21.87	5.46	2.21	0.68	0.15
WLA	0	0	0	0	0
MOS (10%)	2.43	0.61	0.25	0.08	0.02
TMDL = LA+WLA+MOS	24.30	6.06	2.46	0.76	0.17

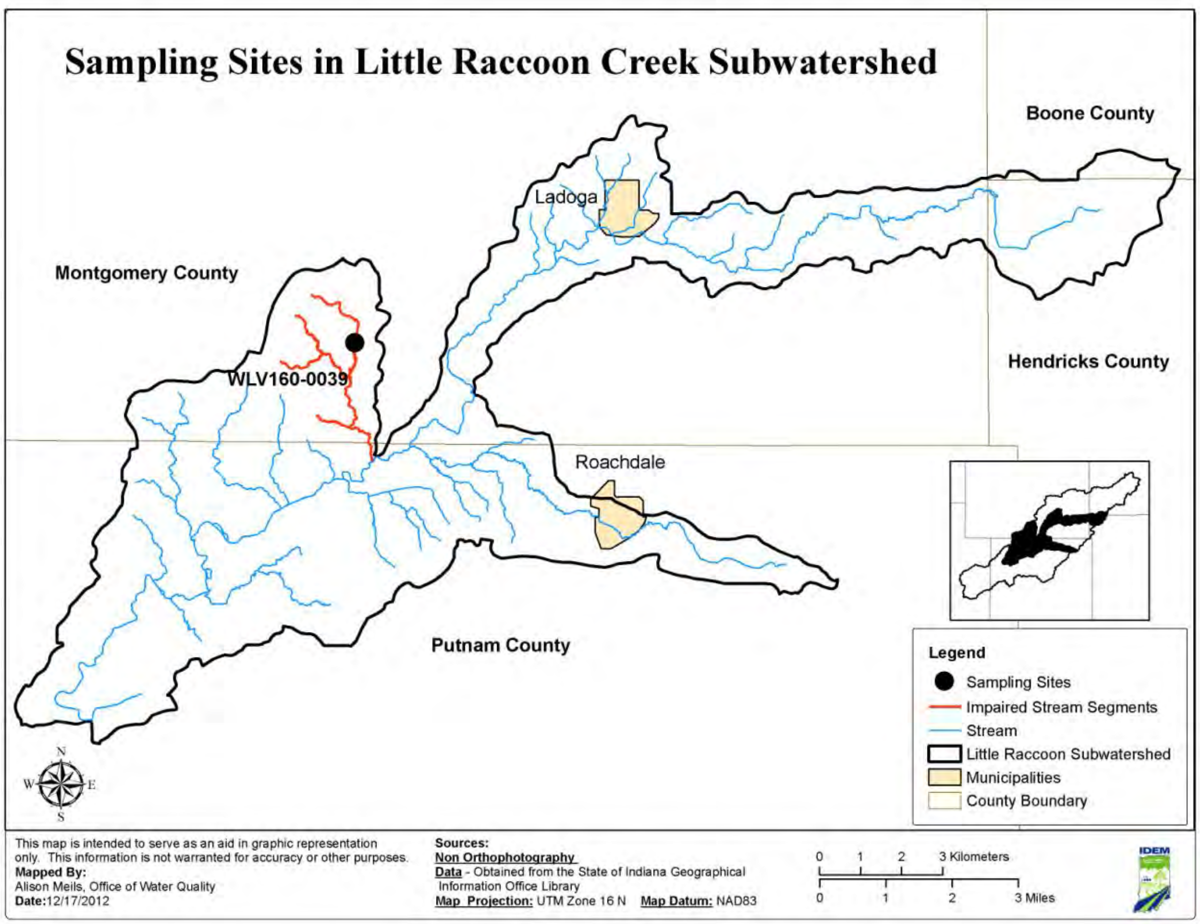

Figure 49. Sampling Stations in the Little Raccoon Creek Subwatershed

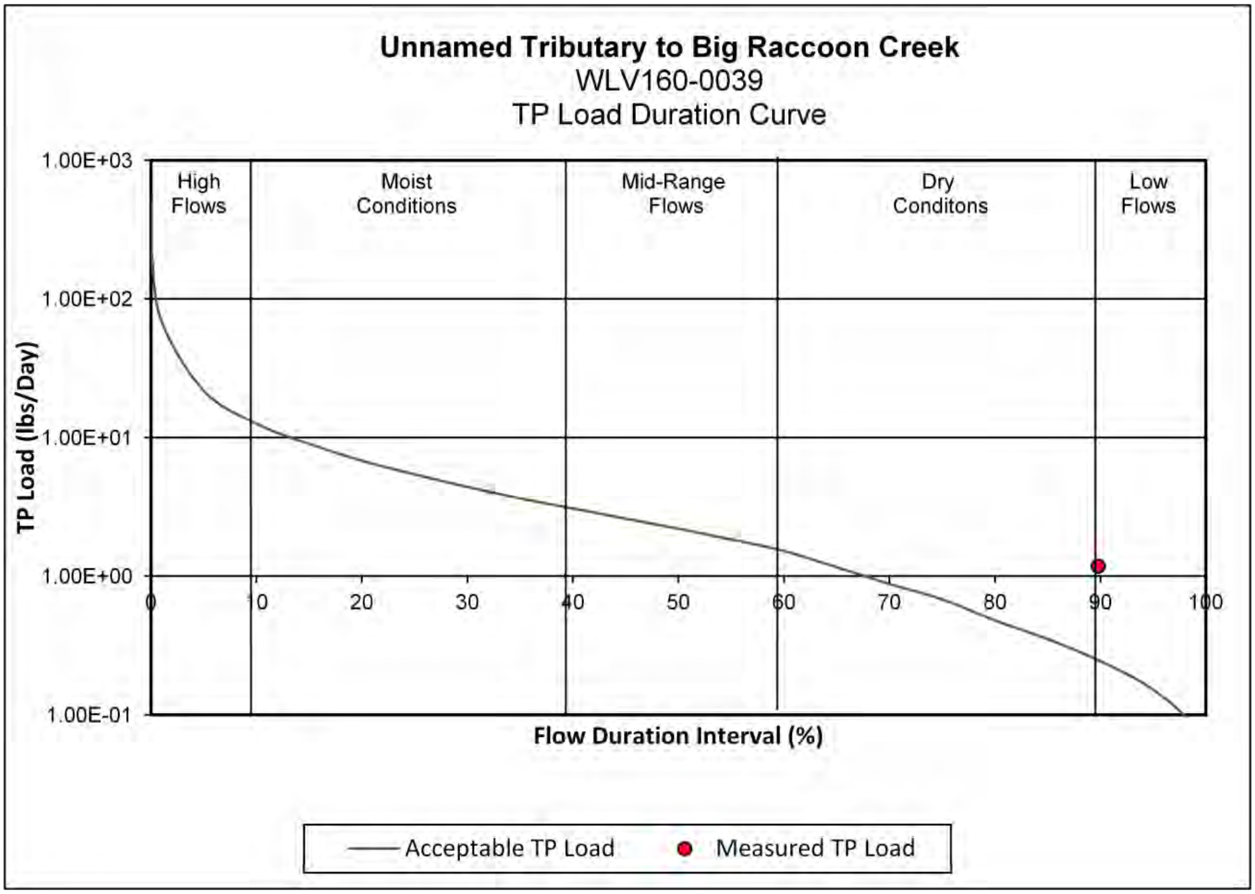

Figure 50. Total Phosphorus Load Duration Curve for the Unnamed Tributary to Big Raccoon Creek

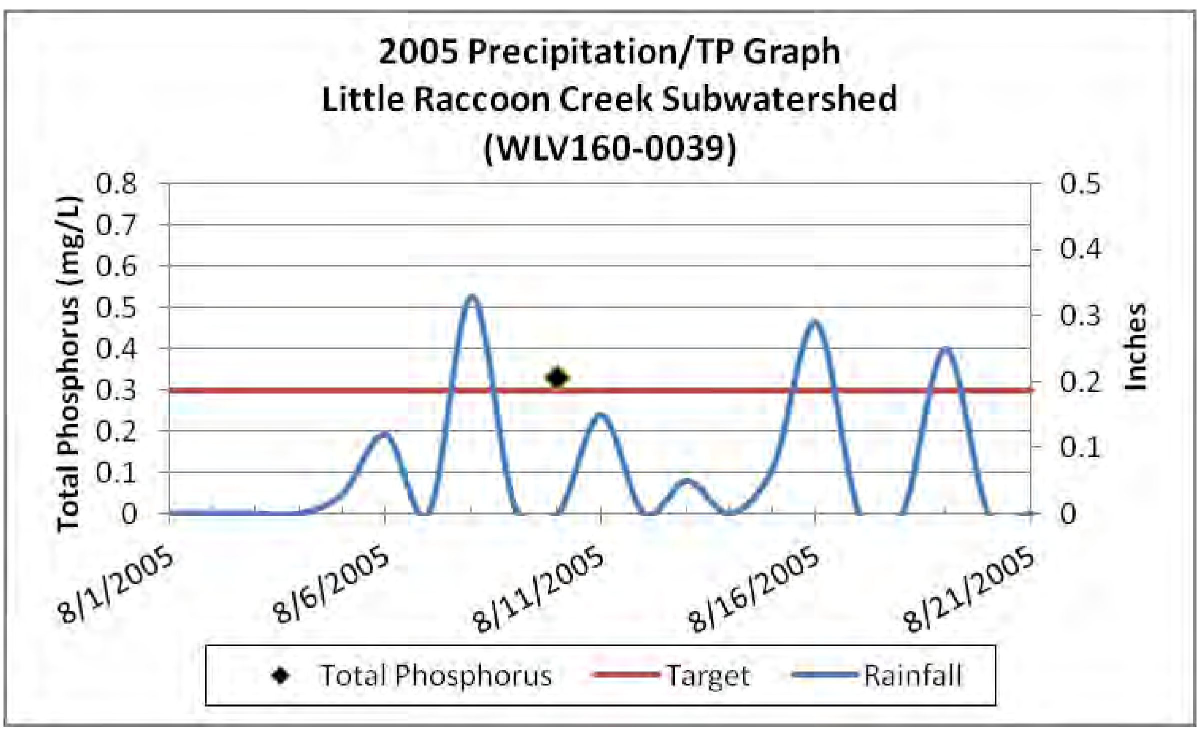

Figure 51. Graph of Precipitation and Total Phosphorus Data for the Unnamed Tributary to Raccoon Creek

Site WLV160-0039 is located in Montgomery County at CR 1050 S on an unnamed tributary to Big Raccoon Creek. Figure shows the load duration curve for total phosphorus at the sampling location described above. It indicates that the TMDL target is exceeded under low flow conditions. This suggests that nonpoint sources as well as point sources may be contributing to the impairment. Nonpoint sources might include sediment-bound phosphorus that enters the river during erosion processes or small animal operations having access to streams. Septic systems might also be a potential source of phosphorus if the systems are failing and located adjacent to the streams.

The phosphorus concentration at sampling station WLV160-0039 was elevated (0.33 mg/L) in August of 2005. There was only one sample collected, therefore not enough to impair the stream reach for TP (3 samples required). However the biology at the site had an IBI score of 32 which is considered poor. After further review of the data the site was found to have a dissolved oxygen reading of 2.5 mg/L which is below the water quality standard of 4.0 mg/L. Using aerial photography it appears there is an open dump site located just upstream of the site sampled in 2005. There are also several small farm ponds that are covered with algae at this site. If the ponds overflow into the stream that would contribute to nuisance algae which can lower dissolved oxygen levels when they decompose. This stream is also in the headwaters of agriculture fields which could potentially be a source of nutrients. In general, this period corresponds to decreasing precipitation and runoff events. Due to the lack of relationship with rainfall, these analyses indicate dry weather nonpoint sources as the most significant source of phosphorus in Big Raccoon Creek watershed. The source assessment identifies two wastewater or sewage treatment plants within the Little Raccoon Creek subwatershed, however they are not located on this particular stream. The elevated TP and low DO data collected at the location would lower biological integrity and could be the source of the IBI non-attainment status for the stream. There was also elevated TSS collected at this site which will be discussed in the linkage analysis for sediment.   Additional potential low flow sources include small animal operations and failing septic systems located adjacent to the stream.

7.3 Linkage Analysis for Sediment

Developing a linkage analysis to address the connection between siltation and its effect on aquatic life uses often involves an evaluation of multiple factors. The interaction between erosional processes and hydrology is an important part of the assessment, with land use, riparian areas, and channel conditions being key considerations. Each can play a potential role in both creating and solving sediment problems.. Sediment loads can become a problem when external inputs (e.g., sediment, runoff volume) to the stream become excessive, or when stream characteristics are altered so that it can no longer assimilate the loads, or a combination of both occur. In order to address sediment for this TMDL, IDEM uses 30 mg/L as a numeric target value for TSS.

Sheet erosion is the detachment of soil particles by raindrop impact and their removal by water flowing overland as a sheet instead of in channels or rills. Rill erosion refers to the development of small, ephemeral concentrated flow paths, which function as both sediment source and sediment delivery systems for erosion on hillslopes. Sheet and rill erosion occurs more frequently in areas that lack or have sparse vegetation.

Bank and channel erosion refers to the wearing away of the banks of a stream or river. High rates of bank and channel erosion are associated with water flow and sediment dynamics being out of balance. This may result from land use activities that either alter flow regimes, adversely affect the floodplain and streamside riparian areas, or a combination of both. Hydrology is a major driver for sheet rill and stream channel erosion. Bank and channel erosion is made worse when streams are straightened or channelized because channelization shortens overall stream lengths and results in increased velocities, bed and bank erosion, and increased sedimentation. Modified stream channels often have little habitat structure and variability necessary for diverse and abundant aquatic species. Channelization also disconnects streams from floodplain and riparian areas that are often developed into agricultural or built environments.

7.3.1 Little Raccoon Creek

Load duration curves and precipitation graphs were created for all the sampling sites to be addressed by this TMDL document (Figure 52) in the Little Raccoon Creek subwatershed. Flow data used to develop the load duration curves is summarized in Table 65.

The figures below illustrate IDEM numeric target violations for TSS during low flow conditions that occurred during sampling the event. A discussion of key sampling sites in the subwatershed is included following the figures. Table 66 provides a summary of the Unnamed Tributary to Big Raccoon Creek in the Little Raccoon Creek subwatershed, including impaired segment AUID, drainage area, sampling sites, listed segments, and land use, as well as Load Allocations, Wasteload Allocations, and Margin of Safety values for total suspended solids. Evaluating the load duration curves and precipitation graphs with consideration of these watershed characteristics allows for identification of potential point and nonpoint sources that are contributing to elevated total suspended solids concentrations.

Table 65. USGS Site Assignments for Development of Load Duration Curve

AUID	Gage Location	Gage ID	Period of Record	Watershed Relationship[1]
INB08C5_02	Big Raccoon Creek	03340800	1/1/1990 – 5/30/2012	gaged

1. Where denoted as “surrogate,” AUID watersheds are ungaged, and flows for the segment were estimated using flows from the noted UGSG gage in a surrogate watershed.

Table 66. Summary of the Unnamed Tributary to Big Raccoon Creek in the Little Raccoon Creek Subwatershed

Upstream Characteristics					
Drainage Area	3.8 square miles				
TMDL Sample Site	WLV160-0039				
Listed Segments	INB08C6_T1003				
Land Use	Agricultural Land: 86% Forested Land: 5% Developed Land: 2% Open Water: <1% Pasture/Hay: 5% Shrub/Scrub: 1% Wetland: <1%				
NPDES Facilities	NA				
MS4 Communities	NA				
CSO Communities	NA				
CAFOs	NA				
CFOs	NA				
TMDL TSS Allocations (lbs/day)					
Allocation Category	**Very High Flows**	**Higher Flow Conditions**	**“Normal” Flows**	**Lower Flow Conditions**	**Low Flows**
LA	2151.69	539.43	218.96	67.68	15.13
WLA	0	0	0	0	0
MOS (10%)	240.19	59.94	24.33	7.52	1.68
TMDL = LA+WLA+MOS	2401.88	599.36	243.28	75.20	16.81

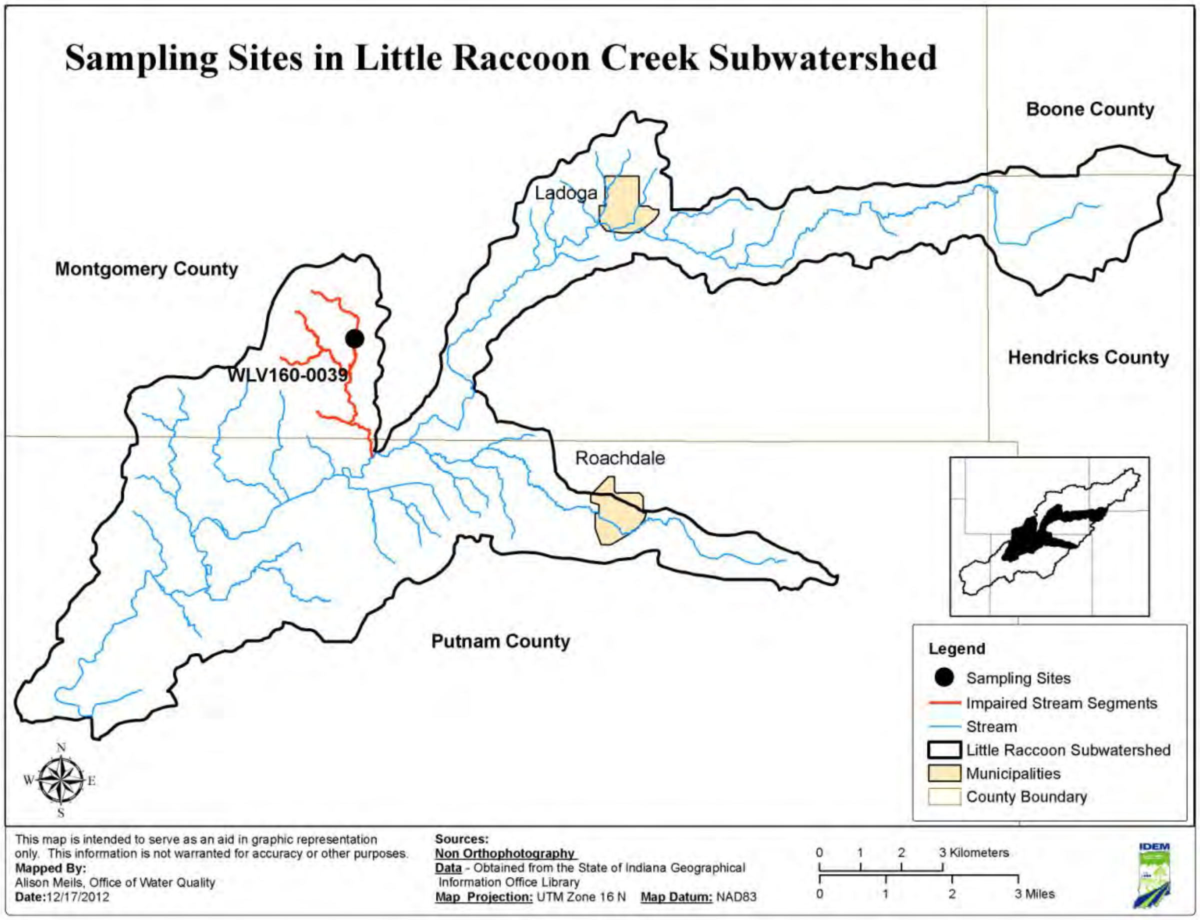

Figure 52. Sampling Stations in the Little Raccoon Creek Subwatershed

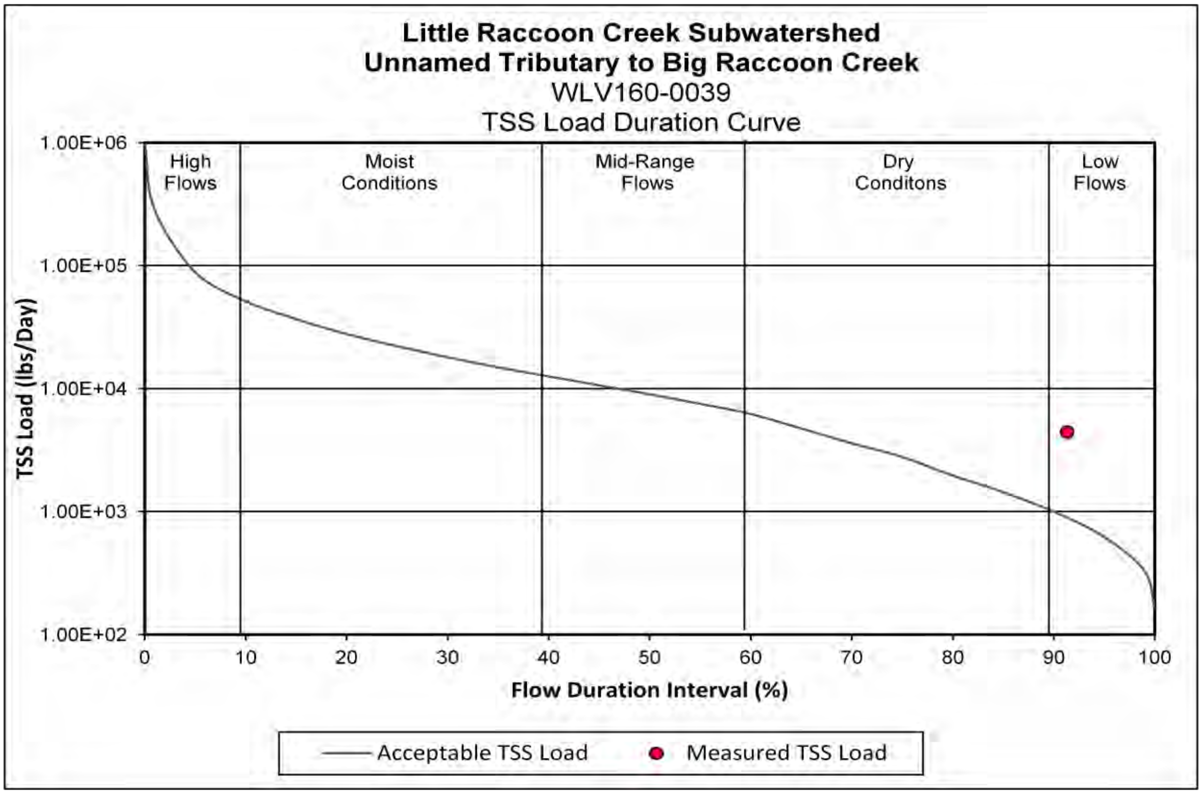

Figure 53. Total Suspended Solids Load Duration Curve for the Unnamed Tributary to Big Raccoon Creek

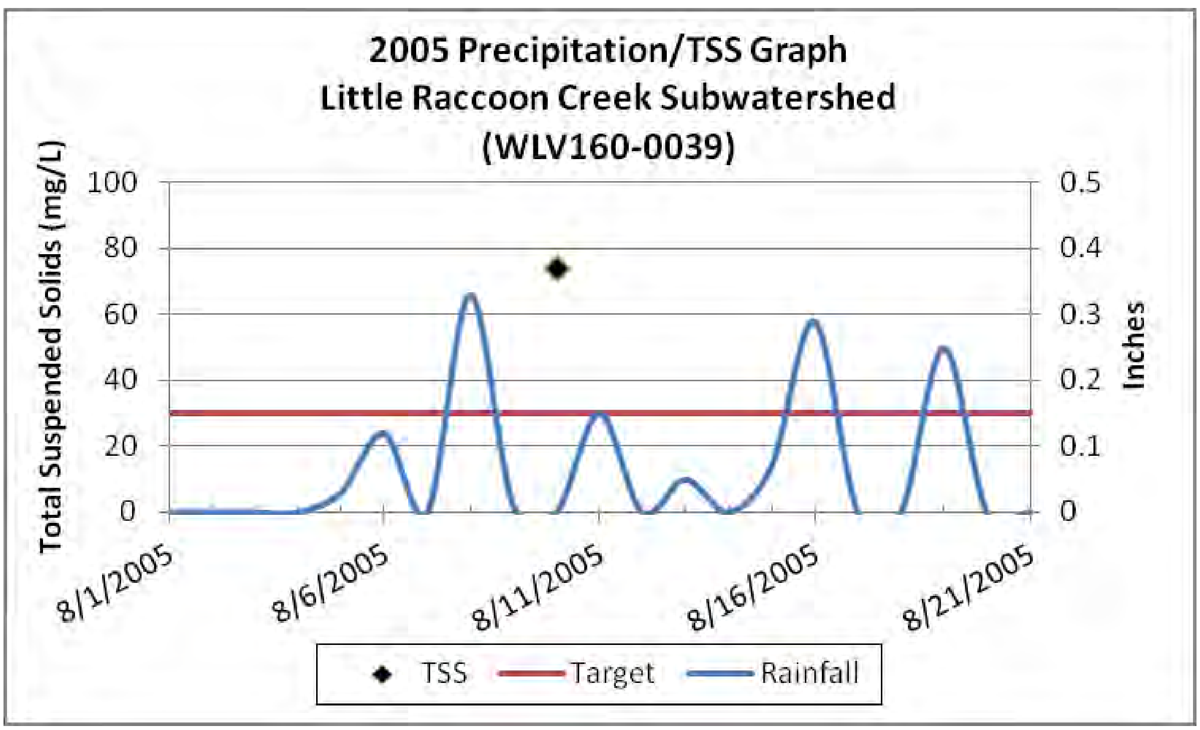

Figure 54. Graph of Precipitation and Total Suspended Solids Data in Little Raccoon Creek subwatershed

Site WLV160-0039 is located in Montgomery County at CR 1050 S on an unnamed tributary to Big Raccoon Creek. The monitoring conducted in 2005 showed elevated levels of TSS (74 mg/L) in the Little Raccoon Creek subwatershed that exceeded the target (30 mg/L). No long-term trend is apparent, since there was only one sampling event which took place in the summer. High loads in the spring may be attributed to the plowing and planting of agricultural fields occuring during these months, increasing the opportunity for sheet and rill erosion, however there is no data collected in the Spring. Further analysis pairing the TSS concentrations with flow conditions (Figure 53) reveals elevated TSS concentrations during low flows. Elevated TSS concentrations during high flows are consistent with significant loads coming from stream bank and gully erosion, however since the TSS was collected during the low flow season it indicates there may be other contributions from point sources or nuisance algal growth. Impairments under low flows are unusual and would suggest a constant source of high sediment loads, such as a wastewater treatment plant not meeting their limits or many animals in the stream. The source assessment identifies two wastewater or sewage treatment plants within the Little Raccoon Creek subwatershed, however they are not located on this particular stream. Other possible sources include those mentioned in the nutrient linkage analysis. Using aerial photography it appears there is an open dump site located just upstream of the site sampled in 2005. There are also several small farm ponds that are covered with algae at this site. If the ponds overflow into the stream they could be contributing solids and algae which can block light transmission through the water and slow down photosynthesis processes resulting in low dissolved oxygen. High TSS can also cause an increase in surface temperature which can cause low dissolved oxygen levels and can harm aquatic life, resulting in the impaired biological community listing.

8.0 ALLOCATIONS

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs are composed of the sum of individual wasteload allocations (WLAs) for regulated sources and load allocations (LAs) for sources not directly regulated by a permit. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this is defined by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

8.1 Results by Assessment Location

The following sections present the allowable *E. coli*, TP and TSS loads and associated allocations for each of the subwatersheds and associated assessment units in the Big Raccoon Creek watershed. Allocations were calculated for each 12-digit HUC. WLAs were calculated based on the design flow of the facility and the TMDL targets.

Table 67 presents the individual WLAs for NPDES facilities in the Big Raccoon Creek watershed by subwatershed.

The NPDES facilities are estimated to contribute about 1.3 percent of the *E. coli* load under normal flow conditions. The percent load contributions for TP and TSS could not be calculated because these data were not collected throughout the watershed. The WWTP WLAs were established based on the design flow multiplied by the TMDL target value of [for bacteria: 125#/100 mL for *E. coli*] [for TP: 0.3 mg/L] [for TSS: 30 mg/L]. These facilities will continue as normal, and will not have to reduce their loadings into the Big Raccoon Creek Watershed.

Table 67. Individual WLAs for NPDES Facilities in the Big Raccoon Creek Watershed

Subwatershed	AUID	Facility Name	Permit ID	Design Flow (MGD)	E. coli WLA (Billion/day)	TP WLA (lbs/day)	TSS WLA (lbs/day)
Headwaters of Big Raccoon Creek	INB08C1_01	Town of Advance WWTP	IN0039705	0.039	0.14	0.04	4.08
	INB08C1_01	New Ross WWTP	IN0059790	0.33	1.23	0.34	34.49
Little Raccoon Creek	INB08C6_01	Town of Ladoga WWTP	IN0023418	0.25	0.93	0.26	26.13
	INB08C6_T1002	Town of Roachdale WWTP	IN0020052	0.16	0.59	0.17	16.72

8.2 Margin of Safety

Section 303(d) of the Clean Water Act and USEPA regulations at 40 CFR 130.7 require that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numeric water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between limitations and water quality." USEPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS). This TMDL uses both an implicit and explicit MOS. An implicit MOS was used by applying a couple of conservative assumptions. A moderate explicit MOS has been applied by reserving ten percent of the allowable load. Ten percent was considered an appropriate MOS based on the following considerations:

- The use of the load duration curve approach minimizes a great deal of uncertainty associated with the development of TMDLs because the calculation of the loading capacity is simply a function of flow multiplied by the target value. Most of the uncertainty is therefore associated with the estimated flows in each assessed segment which were based on extrapolating flows from the nearest downstream USGS gage.
- The *E. coli* TMDLs include an implicit MOS in that they were based on the geometric mean component of the standard rather than the single sample maximum standard. Using the single sample maximum standard would have resulted in larger loading capacities.
- An additional implicit MOS for *E. coli* is included because the load duration analysis does not address die-off of pathogens.
- The identified percent reduction required for IBC TMDLs is based on the highest sampled result of all of the monitoring sites within the HUC 12 watershed, relative to the standard. The use of the maximum sample result provides an implicit margin of safety.

8.3 Critical Conditions

The CWA requires that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. Through the load duration curve approach it has been determined that load reductions for the parameters of concern are needed for specific flow conditions; the critical conditions (the periods when the greatest reductions are required) vary by parameter and location and are summarized in Table 68. The table indicates that critical conditions for bacteria occur during high and moist conditions, while critical conditions for nutrients and TSS occur during low flow conditions. The data used to determine these critical conditions is limited in that samples were not collected during all flow regimes. Therefore implementation of controls should be targeted for these known conditions. However there may be other conditions that apply outside of the flow regimes captured in the study of this watershed.

Table 68. Critical Conditions for TMDL Parameters

Parameter	Station ID	Critical Condition				
		High	Moist	Mid-Range	Dry	Low
E. coli (counts/mL)	WLV160-0063		X			
	WLV160-0045		X			
	WLV160-0027		X			
	WLV160-0064		X			
	WLV160-0035		X			
	WLV160-0038		X			
	WLV160-0015		X			
	WLV160-0068		X			
	WLV160-0044		X			
	WLV160-0025		X			
	WLV160-0065		X			
	WLV160-0066		X			
	WLV160-0067		X			
	WLV160-0002		X			
	WLV160-0070		X			
Phosphorus, Total (mg/L)	WLV160-0017				X	X
	WLV160-0027					X
	WLV160-0039					X
Total Suspended Solids (mg/L)	WLV160-0039					X
Dissolved Oxygen (mg/L)	WLV160-0017					X
	WLV160-0034					X
	WLV160-0035					X
	WLV160-0039					X

8.4 Potential Priority Implementation Areas (PPIAs)

The information in Section 6 and the allocations presented in this section provide the foundation necessary to identify subwatersheds that are in need of the most significant *E. coli*, total phosphorus and TSS reductions to achieve water quality standards in the Big Raccoon Creek watershed. The areas in need of the most significant *E. coli*, total phosphorus and TSS reductions under high flow and low flow conditions (as shown in Table 69) are considered PPIAs. Using the PPIA rankings, watershed organizations will gain a better understanding of which subwatersheds require the most pollutant load reductions. This can assist in future efforts to identify critical areas in the Big Raccoon Creek watershed for implementation. PPIAs differ from critical areas in that PPIAs focus on the information and data collected and analyzed through the TMDL development process for ranking purposes, whereas critical areas take other factors into consideration (e.g., political, social, economic) to help determine implementation feasibility that will affect progress toward pollutant load reductions and, ultimately, attainment of water quality standards.

8.4.1 PPIAs for *E. coli*

Table 69 ranks subwatersheds in the Big Raccoon Creek watershed according to *E. coli* load reductions needed to achieve water quality standards, from highest pollutant load reduction to least pollutant load reduction, with the associated flow regime (e.g., very high, higher, normal, lower, low).

Table 69. PPIA Ranking for Subwatersheds in the Big Raccoon Creek Watershed

PPIA Ranking	Subwatershed	Percent Reduction Needed	Pollutant Reduction Needed	Associated Flow Category
1	Little Raccoon Creek	97.50	1.0E+13	Moist
2	Byrd Branch	98.91	9.81E+12	Moist
3	Town of New Ross	97.39	4.03E+12	Moist
4	Headwaters of Big Raccoon Creek	93.98	2.40E+12	Moist
5	Cornstalk Creek	93.90	1.75E+12	Moist
6	North Ramp Creek	90.04	1.67+12	Moist
7	Haw Creek	86.04	9.64E+11	Moist

UnderstandingTable 69: According to this table, the Little Raccoon Creek subwatershed has the highest PPIA ranking under moist flow conditions with a 98 percent reduction needed for *E. coli*. The very high reductions needed throughout the entire watershed suggest there are wet weather sources throughout the watershed. Typically significant pollutant reductions needed under high flow conditions are indicators of wet weather sources. Typically, significant pollutant load reductions needed under low flow conditions are indicators of WWTP and other point sources with more constant discharges, or dry weather nonpoint source inputs such as straight pipes or livestock wading in streams. Sampling activities in the Big Raccoon Creek watershed took place during wet weather conditions only, so the results cannot determine potential dry weather point or nonpoint sources. Therefore, implementation activities for the highest ranked PPIAs in Table should likely focus on wet weather sources.

Section 9 identifies recommended implementation activities for each subwatershed and shows the associated PPIA rankings. This information can be key to watershed organizations in the process of identifying and selecting critical areas and implementation activities for the purposes of watershed management plan development. While PPIAs are not intended to dictate those critical areas for watershed organizations, IDEM recommends that watershed organizations take the PPIA rankings into consideration when selecting critical areas for purposes of watershed management planning.

8.4.2 PPIAs for Total Phosphorus

Table 70 ranks subwatersheds in the Big Raccoon Creek watershed according to total phosphorus reduction needed to achieve water quality standards, from highest pollutant reduction to least pollutant reduction, with the associated flow regime (e.g., very high, higher, normal, lower, low).

Table 70. PPIA Ranking for Subwatersheds in the Big Raccoon Creek Watershed

PPIA Ranking	Subwatershed	Percent Reduction Needed	Pollutant Reduction Needed (lb/day)	Associated Flow Category
1	Headwaters of Big Raccoon Creek	55.88	0.88	Dry/Low
2	Little Raccoon Creek	9.09	0.24	Low

Understanding Table 70: According to this table, the Headwaters of Big Raccoon Creek subwatershed has the highest PPIA ranking under low flow conditions with a 56 percent reduction needed for total phosphorus. The reductions needed for the individual stream segments indicate there are dry weather sources contributing to these impairments. Typically, significant pollutant reductions needed under low flow conditions are indicators of point sources with more constant discharges, or dry weather nonpoint source inputs such as straight pipes or livestock wading in streams. Sampling activities in the Big Raccoon Creek watershed took place during low flow conditions only so the results cannot determine if there are indicators of additional nonpoint sources during wet weather conditions. Therefore, implementation activities for the highest ranked PPIAs in Table 70 should likely focus on dry weather low flow conditions.

Section 9 identifies recommended implementation activities for each subwatershed and shows the associated PPIA rankings. This information can be key to watershed organizations in the process of identifying and selecting critical areas and implementation activities for the purposes of watershed management plan development. While PPIAs are not intended to dictate those critical areas for watershed organizations, IDEM recommends that watershed organizations take the PPIA rankings into consideration when selecting critical areas for purposes of watershed management planning.

8.4.3 PPIAs for Total Suspended Solids

Tale 71 ranks subwatersheds in the Big Raccoon Creek watershed according to TSS load reduction needed to achieve water quality standards, from highest pollutant load reduction to least pollutant load reduction, with the associated flow regime (e.g., very high, higher, normal, lower, low).

Table 71. PPIA Ranking for Subwatersheds in the Big Raccoon Creek Watershed

PPIA Ranking	Subwatershed	Percent Load Reduction Needed	Pollutant Load Reduction Needed (lb/day)	Associated Flow Category
1	Little Raccoon Creek	59.46	90	Low

Understanding Table 71: According to this table, the Little Raccoon Creek subwatershed is the only one assigned PPIA ranking under low flow conditions with a 59 percent load reduction needed for TSS. Typically, significant pollutant load reductions needed under low flow conditions are indicators of point sources with more constant discharges, or dry weather nonpoint source inputs such as straight pipes or livestock wading in streams. Sampling activities in the Big Raccoon Creek watershed took place during dry weather conditions only so the results cannot determine if there are indicators of additional nonpoint sources during wet weather conditions. Therefore, implementation activities for the TSS PPIAs in Table should likely focus on dry weather sources.

Section 9 identifies recommended implementation activities for each subwatershed and shows the associated PPIA rankings. This information can be key to watershed organizations in the process of identifying and selecting critical areas and implementation activities for the purposes of watershed management plan development. While PPIAs are not intended to dictate those critical areas for watershed organizations, IDEM recommends that watershed organizations take the PPIA rankings into consideration when selecting critical areas for purposes of watershed management planning.

9.0 REASONABLE ASSURANCES/IMPLEMENTATION

This section of the Big Raccoon Creek watershed TMDL focuses on implementation activities that have the potential to achieve the WLAs and LAs presented in Section 8. The focus of this section is to identify and select the most appropriate structural and non-structural best management practices (BMPs) and control technologies to reduce *E. coli*, nutrient and sediment loads from sources throughout the Big Raccoon Creek watershed, particularly in the PPIAs identified in Section 8. This section also addresses the programs that are available to facilitate implementation of structural and non-structural BMPs to achieve the allocations, as well as ongoing activities in the Big Raccoon Creek watershed at the local level that will play a key role in successful TMDL implementation.

To select appropriate BMPs and control technologies, it is important to review the significant sources in the Big Raccoon Creek watershed.

Point Sources

- Illicitly connected straight pipe systems
- WWTPs

Nonpoint Sources

- Cropland
- Pastures and livestock operations
- CFOs
- Streambank erosion
- Onsite wastewater treatment systems
- Wildlife/domestic pets
- Urban nonpoint source runoff

9.1 Implementation Activity Options for Sources in the Big Raccoon Creek Watershed

Keeping the list of significant sources in the Big Raccoon Creek watershed in mind, it is possible to review the types of BMPs that are most appropriate for reducing *E. coli*, TP and TSS from the source types. Table 72 provides a list of implementation activities that are potentially suitable for the Big Raccoon Creek watershed based on the *E. coli*, TP and TSS reductions needed and the types of sources. The implementation activities are a combination of structural and non-structural BMPs to achieve the assigned WLAs and LAs. IDEM recognizes that actions taken in any individual subwatershed may depend on a number of factors (including socioeconomic, political and ecological factors). The recommendations in Table are not intended to be prescriptive. Any number or combination of implementation activities might contribute to water quality improvement, whether applied at sites where the actual impairment was noted or other locations where sources contribute indirectly to the water quality impairment.

Table 72. List of Potentially Suitable BMPs for the Big Raccoon Creek Watershed

	Pollutant			Point Sources		Nonpoint Sources						
Implementation Activities	**Bacteria**	**Nutrients**	**Sediment**	**WWTPs and Industrial Facilities**	**Illicitly Connected “Straight Pipe” Systems**	**Cropland**	**Pastures and Livestock Operations**	**CFOs**	**Streambank Erosion**	**Onsite Wastewater Treatment Systems**	**Wildlife/Domestic Pets**	**Urban NPS Runoff**
Inspection and maintenance	X	X	X	X						X		
Outreach and education and training	X	X	X	X	X	X	X	X	X	X	X	X
System replacement	X	X			X					X		
Conservation tillage/residue management	X	X	X			X						
Cover crops	X	X	X			X			X			
Filter strips	X	X	X			X	X	X	X			
Grassed waterways	X		X			X		X	X			X
Riparian forested/herbaceous buffers	X	X	X			X	X	X	X		X	X
Manure handling, storage, treatment, and disposal	X	X						X				
Composting	X	X										X
Alternative watering systems	X		X				X	X	X			
Stream fencing (animal exclusion)	X	X	X				X		X			
Prescribed grazing	X	X	X				X		X			
Conservation easements	X	X	X									X
Two-stage ditches		X	X									
Rain barrel		X	X									X
Rain garden		X	X									X
Street rain garden		X	X									X
Block bioretention		X	X									X
Regional bioretention		X	X									X
Porous pavement		X	X									X
Green alley		X	X									X

	Pollutant			Point Sources		Nonpoint Sources						
Implementation Activities	Bacteria	Nutrients	Sediment	WWTPs and Industrial Facilities	Illicitly Connected "Straight Pipe" Systems	Cropland	Pastures and Livestock Operations	CFOs	Streambank Erosion	Onsite Wastewater Treatment Systems	Wildlife/Domestic Pets	Urban NPS Runoff
Green roof		X	X									X
Dam modification or removal		X	X									X
Levee or dike modification or removal		X	X									X
Stormwater planning and management	X	X	X	X					X	X	X	X
Comprehensive Nutrient Management Plan	X	X				X		X				
Constructed Wetland	X	X	X	X	X	X					X	X
Critical Area Planting			X				X		X			X
Drainage Water Management		X				X						
Heavy Use Area Pad	X		X				X					
Nutrient Management Plan		X				X			X			X
Terrace			X			X						
Land Reconstruction of Mined Land			X						X			
Sediment Basin		X	X									X
Pasture and Hay Planting	X	X	X			X	X	X	X		X	
Streambank and Shoreline Protection			X			X	X	X	X		X	X
Conservation Crop Rotation		X	X			X	X	X				
Field Border	X	X				X	X	X			X	
Waste Treatment Lagoon	X	X					X	X				X
Conservation Crop Rotation	X	X	X			X			X			

The information provided in Table 72 can assist watershed stakeholders to identify implementation activities for critical areas and determine which are most feasible in the Big Raccoon watershed.

9.2 Implementation Goals and Indicators

For each TMDL in the Big Raccoon Creek watershed, IDEM has identified broad goal statements and indicators. This information is to help watershed stakeholders determine how to track implementation progress and also to provide the information necessary to complete a watershed management plan.

***E. coli* Goal Statement:** The waterbodies (or streams) in the Big Raccoon Creek watershed should meet the 125 colonies/100 mL (geometric mean) TMDL target value.

***E. coli* Indicator:** Water quality monitoring by IDEM will serve as the environmental indicator to determine progress toward the *E. coli* target value.

Total Phosphorus Goal Statement: The waterbodies (or streams) in the Big Raccoon Creek watershed should meet the 0.30 mg/L TMDL total phosphorus target value.

Total Phosphorus Indicator: Water quality monitoring by IDEM will serve as the environmental indicator to determine progress toward the total phosphorus target value.

Total Suspended Solids Goal Statement: The waterbodies (or streams) in the Big Raccoon Creek watershed should meet the 30 mg/L TMDL total suspended solids target value.

Total Suspended Solids Indicator: Water quality monitoring by IDEM will serve as the environmental indicator to determine progress toward the total suspended solids target value.

9.3 Summary of Programs

There are a number of federal, state, and local programs that either require or can assist with the implementation activities recommended for the Big Raccoon Creek watershed in Table 72. A description of these programs is provided in this section. The following section discusses how some of these programs relate to the various sources in the Big Raccoon Creek watershed.

9.3.1 Federal Programs

9.3.1.1 Clean Water Act Section 319(h) Grants

Section 319 of the federal Clean Water Act contains provisions for the control of nonpoint source pollution. The Section 319 program provides for various voluntary projects throughout the state to prevent water pollution and also provides for assessment and management plans related to waterbodies in Indiana impacted by NPS pollution. The Watershed Planning and Restoration Section within the Watershed Assessment and Planning Branch of the Office of Water Quality administers the Section 319 program for NPS-related projects.

USEPA offers Clean Water Act Section 319(h) grant monies to the state on an annual basis. These grants must be used to fund projects that address nonpoint source pollution issues. Some projects which the Office of Water Quality has funded with this money in the past include developing and implementing Watershed Management Plans (WMPs), BMP demonstrations, data management, educational programs, modeling, stream restoration, and riparian buffer establishment. Projects are usually two to three years in length. Section 319(h) grants are intended to be used for project start-up, not as a continuous funding source. Units of government, nonprofit groups, and universities in the state that have expertise in nonpoint source pollution problems are invited to submit Section 319(h) proposals to the Office of Water Quality.

9.3.1.2 Clean Water Action Section 205(j) Grants

Section 205(j) provides for planning activities relating to the improvement of water quality from nonpoint and point sources by making funding available to municipal and county governments, regional planning commissions, and other public organizations. For-profit entities, non-profit organizations, private associations, universities and individuals are not eligible for funding through Section 205(j). The CWA states that the grants are to be used for water quality management and planning, including, but not limited to:

- Identifying most cost effective and locally acceptable facility and non-point source measures to meet and maintain water quality standards;
- Developing an implementation plan to obtain state and local financial and regulatory commitments to implement measures developed under subparagraph A;

- Determining the nature, extent, and cause of water quality problems in various areas of the state.

The Section 205(j) program provides for projects that gather and map information on nonpoint and point source water pollution, develop recommendations for increasing the involvement of environmental and civic organizations in watershed planning and implementation activities, and develop watershed management plans.

9.3.1.3 USDA's Conservation of Private Grazing Land Initiative (CPGL)

The Conservation of Private Grazing Land initiative will ensure that technical, educational, and related assistance is provided to those who own private grazing lands. It is not a cost-share program. This technical assistance will offer opportunities for: better grazing land management; protecting soil from erosive wind and water; using more energy efficient ways to produce food and fiber; conserving water; providing habitat for wildlife; sustaining forage and grazing plants; using plants to sequester greenhouse gases and increase soil organic matter; and using grazing lands as a source of biomass energy and raw materials for industrial products.

9.3.1.4 USDA's Conservation Reserve Program (CRP)

NRCS provides technical assistance to landowners interested in participating in the Conservation Reserve Program administered by the USDA Farm Service Agency. The Conservation Reserve Program reduces soil erosion, protects the Nation's ability to produce food and fiber, reduces sedimentation in streams and lakes, improves water quality, establishes wildlife habitat, and enhances forest and wetland resources. It encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filter strips, or riparian buffers. Farmers receive an annual rental payment for the term of the multi-year contract. Cost-share funding is provided to establish the vegetative cover practices.

9.3.1.5 USDA's Conservation Technical Assistance (CTA)

The purpose of the CTA program is to assist landusers, communities, units of state and local government, and other Federal agencies in planning and implementing conservation systems. The purpose of the conservation systems is to reduce erosion, improve soil and water quality, improve and conserve wetlands, enhance fish and wildlife habitat, improve air quality, improve pasture and range condition, reduce upstream flooding, and improve woodlands.

One objective of the program is to assist individual landusers, communities, conservation districts, and other units of State and local government and Federal agencies to meet their goals for resource stewardship and assist individuals in complying with State and local requirements. NRCS assistance to individuals is provided through conservation districts in accordance with the Memorandum of Understanding signed by the Secretary of Agriculture, the Governor of the State, and the conservation district. Assistance is provided to landusers voluntarily applying conservation practices and to those who must comply with local or State laws and regulations.

Another objective is to provide assistance to agricultural producers to comply with the highly erodible land (HEL) and wetland (Swampbuster) provisions of the 1985 Food Security Act as amended by the Food, Agriculture, Conservation and Trade Act of 1990 (16 U.S.C. 3801 et. seq.), the Federal Agriculture Improvement and Reform Act of 1996, and wetlands requirements of Section 404 of the Clean Water Act. NRCS makes HEL and wetland determinations and helps landusers develop and implement conservation plans to comply with the law. The program also provides technical assistance to participants in USDA cost-share and conservation incentive programs.

NRCS collects, analyzes, interprets, displays, and disseminates information about the condition and trends of the Nation's soil and other natural resources so that people can make good decisions about resource use and about public policies for resource conservation. They also develop effective science-based technologies for natural resource assessment, management, and conservation.

9.3.1.6 USDA's Environmental Quality Incentives Program (EQIP)

The Environmental Quality Incentives Program provides technical, educational, and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and costeffective manner. The program provides assistance to farmers and ranchers in complying with Federal, State, and tribal environmental laws, and encourages environmental enhancement. The program is funded through the Commodity Credit Corporation. The purposes of the program are achieved through the implementation of a conservation plan, which includes structural, vegetative, and land management practices on eligible land. Five to ten year contracts are made with eligible producers. Cost-share payments may be made to implement one or more eligible structural or vegetative practices, such as animal waste management facilities, terraces, filter strips, tree planting, and permanent wildlife habitat. Incentive payments can be made to implement one or more land management practices, such as nutrient management, pest management, and grazing land management.

Fifty percent of the funding available for the program is targeted at natural resource concerns relating to livestock production. The program is carried out primarily in priority areas that may be watersheds, regions, or multi-state areas, and for significant statewide natural resource concerns that are outside of geographic priority areas.

9.3.1.7 USDA's Small Watershed Program and Flood Prevention Program (WF 08 or FP 03)

The Small Watershed Program works through local government sponsors and helps participants solve natural resource and related economic problems on a watershed basis. Projects include watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in watersheds of 250,000 or fewer acres. Both technical and financial assistance are available.

9.3.1.8 USDA's Watershed Surveys and Planning

The Watershed and Flood Prevention Act, P.L. 83-566, August 4, 1954, (16 U.S.C. 1001-1008) authorized this program. Prior to fiscal year 1996, small watershed planning activities and the cooperative river basin surveys and investigations authorized by Section 6 of the Act were operated as separate programs. The 1996 appropriations act combined the activities into a single program entitled the Watershed Surveys and Planning program. Activities under both programs are continuing under this authority.

The purpose of the program is to assist Federal, State, and local agencies and tribal governments to protect watersheds from damage caused by erosion, floodwater, and sediment and to conserve and develop water and land resources. Resource concerns addressed by the program include water quality, opportunities for water conservation, wetland and water storage capacity, agricultural drought problems, rural development, municipal and industrial water needs, upstream flood damages, and water needs for fish, wildlife, and forest-based industries.

Types of surveys and plans include watershed plans, river basin surveys and studies, flood hazard analyses, and floodplain management assistance. The focus of these plans is to identify solutions that use land treatment and non-structural measures to solve resource problems.

9.3.1.9 USDA's Wetlands Reserve Program (WRP)

The Wetlands Reserve Program is a voluntary program to restore wetlands. Participating landowners can establish conservation easements of either permanent or 30 year duration, or can enter into restoration cost-share agreements where no easement is involved. In exchange for establishing a permanent easement, the landowner receives payment up to the agricultural value of the land and 100 percent of the restoration costs for restoring the wetlands. The 30 year easement payment is 75 percent of what would be provided for a permanent easement on the same site and 75 percent of the restoration cost. The voluntary agreements are, for a minimum, 10 year duration and provide for 75 percent of the cost of restoring the involved wetlands. Easements and restoration cost-share agreements establish wetland protection and restoration as the primary land use for the duration of the easement or agreement. In all instances, landowners continue to control access to their land.

9.3.1.10 USDA's Wildlife Habitat Incentives Program (WHIP)

The Wildlife Habitat Incentives Program provides financial incentives to develop habitat for fish and wildlife on private lands. Participants agree to implement a wildlife habitat development plan and USDA agrees to provide cost-share assistance for the initial implementation of wildlife habitat development practices. USDA and program participants enter into a cost-share agreement for wildlife habitat development. This agreement generally lasts a minimum of 10 years from the date that the contract is signed.

9.3.2 State Programs

9.3.2.1 State Point Source Control Program

The purpose of the NPDES permit is to control the point source discharge of pollutants into the waters of the State such that the quality of the water of the State is maintained in accordance with applicable water quality standards. NPDES permit requirements ensure that the minimum amount of control is imposed upon any new or existing point source through the application of technology-based treatment requirements. Control of discharges from WWTPs, industrial facilities and CSOs consistent with WLAs is implemented through the NPDES program. The Storm water and Sediment Control Program works primarily with developers, contractors, realtors, property holders and others to address erosion and sediment concerns on non-agricultural lands, especially those undergoing development.

9.3.2.2 State Nonpoint Source Control Program

The state's Nonpoint Source Program, administered by the IDEM Office of Water Quality's Watershed Planning and Restoration Section, focuses on the assessment and prevention of nonpoint source water pollution. The program also provides for education and outreach to improve the way land is managed. Through the use of federal funding for the installation of BMPs, the development of watershed management plans, and the implementation of watershed restoration pollution prevention activities, the program reaches out to citizens so that land is managed in such a way that less pollution is generated.

Nonpoint source projects funded through the Office of Water Quality are a combination of local, regional, and statewide efforts sponsored by various public and not-for-profit organizations. The emphasis of these projects has been on the local, voluntary implementation of nonpoint source water pollution controls. The Watershed Planning and Restoration Section administers the Section 319 funding for nonpoint source-related projects, as well as Section 205(j) grants.

To award 319 grants, Watershed Planning and Restoration Section staff review proposals for minimum 319(h) eligibility criteria and rank each proposal. In their review, members consider such factors as: technical soundness; likelihood of achieving water quality results; strength of local partnerships and competence/reliability of contracting agency. They then convene to discuss individual project merits and pool all rankings to arrive at final rankings for the projects. All proposals that rank above the funding target are included in the annual grant application to USEPA, with USEPA reserving the right to make final changes to the list. Actual funding depends on approval from USEPA and yearly congressional appropriations.

Section 205(j) projects are administered through grant agreements that define the tasks, schedule, and budget for the project. IDEM project managers work closely with the project sponsors to help ensure that the project runs smoothly and the tasks of the grant agreement are fulfilled. Site visits are conducted at least quarterly to touch base on the project, provide guidance and technical assistance as needed, and to work with the grantee on any issues that arise to ensure a successful project closeout.

9.3.2.3 Indiana State Department of Agriculture Division of Soil Conservation

The Division of Soil Conservation's mission is to ensure the protection, wise use, and enhancement of Indiana's soil and water resources. The Division's employees are part of Indiana's Conservation Partnership, which includes the 92 soil and water conservation districts (SWCDs), the USDA Natural Resources Conservation Service, and the Purdue University Cooperative Extension Service. Working together, the partnership provides technical, educational, and financial assistance to citizens to solve erosion and sediment-related problems occurring on the land or impacting public waters.

The Division administers the Clean Water Indiana soil conservation and water quality protection program under guidelines established by the State Soil Conservation Board, primarily through the local SWCDs in direct service to landusers. The Division staff includes field-based resource specialists who work closely with landusers, assisting in the selection, design, and installation of practices to reduce soil erosion on agricultural land.

9.3.2.4 Indiana Department of Natural Resources, Division of Fish and Wildlife

The Lake and River Enhancement (LARE) program utilizes a watershed approach to reduce nonpoint source sediment and nutrient pollution of Indiana's and adjacent states' surface waters to a level that meets or surpasses state water quality standards. To accomplish this goal, LARE provides technical and financial assistance to local entities for qualifying projects that improve and maintain water quality in public access lakes, rivers, and streams.

9.3.2.5 State Revolving Fund (SRF) Loan Program

The SRF is a fixed rate, 20-year loan administered by the Indiana Finance Authority. The SRF provides low-interest loans to Indiana communities for projects that improve wastewater and drinking water infrastructure. The Program's mission is to provide eligible entities with the lowest interest rates possible on the financing of such projects while protecting public health and the environment. SRF also funds non-point source projects that are tied to a wastewater loan. Any project where there is an existing pollution abatement need is eligible for SRF funding.

9.3.2.6 Hoosier Riverwatch

Hoosier Riverwatch, administered by the IDEM OWQ Watershed Assessment and Planning Branch, is a water quality monitoring initiative which aims to increase public awareness of water quality issues and concerns through hands-on training of volunteers in-stream monitoring and cleanup activities. Hoosier Riverwatch collaborates with agencies and volunteers to educate local communities about the relationship between land use and water quality and to provide water quality information to citizens and governmental agencies working to protect Indiana's rivers and streams.

9.3.3 Local Programs

Programs taking place at the local level are key to successful TMDL implementation. Partners such as NRCS and SWCD are instrumental to bringing grant funding into the Big Raccoon Creek watershed to support local protection and restoration projects. This section provides a brief summary of the local programs taking place in the Big Raccoon Creek watershed that will help to reduce *E. coli*, total phosphorus and TSS loads, as well as provide ancillary benefits to the Big Raccoon Creek watershed.

The Parke County Board of Health has a policy restricting new construction permits to only those properties that have replaced or updated sewage disposal systems in the cases the system does not meet the minimum requirements set forth in federal, state or local ordinances.

There was a LARE grant for $48,000 in 2012 for Putnam County which is anticipated to implement the following conservation practices for a 3 to 5 year project:
Conservation Tillage – 1000 Acres
Cover Crop – 1000 Acres
Critical Area Planting – 5 Acres
Grade Stabilization Structures – 2
Livestock Watering Facility – 1
ICM – 800 Acres

Putnam County received the following funding to improve water quality in 2010:
- Local: $70,467
- Clean Water Indiana (CWI): $15,000
- Environmental Quality Incentives Program (EQIP): $71,925
- Conservation Reserve Program (CRP): $1,437,501
- Wildlife Habitat Cost Share Program (WHCP): $1,680
- Conservation Stewardship Program (CSP): $7,712
- Section 319 Nonpoint Source Water Quality Funding: $261,900

Putnam County received the following funding to improve water quality in 2011:
- Local: $57,334
- Clean Water Indiana (CWI): $16,800
- Environmental Quality Incentives Program (EQIP): $94,175
- Conservation Reserve Program (CRP): $1,502,741
- Game Bird Habitat Development Program (GHDP): $130
- Wildlife Habitat Incentive Program (WHIP): $7,712

From 2006-2009 there was a LARE grant in the Ramp Creek subwatershed located in Putnam County which implemented the following conservation practices:
Cover Crops – 145 Acres
Pasture and Hay Planting – 18 Acres
Streambank Stabilization – 250 Feet
Tree Planting – 19 Acres
Grade Stabilization Structures – 2
Grassed Waterway – 1260 Feet

Montgomery County received the following funding to improve water quality in 2010:
- Local: $28,387

Clean Water Indiana (CWI): $10,000
Environmental Quality Incentives Program (EQIP): $25,181
Conservation Reserve Program (CRP): $2,057,655
Conservation Stewardship Program (CSP): $482,010
Wildlife Habitat Incentive Program (WHIP): $24,293

Montgomery County received the following funding to improve water quality in 2011:
Local: $25,486
Clean Water Indiana (CWI): $14,546
Environmental Quality Incentives Program (EQIP): $59,516
Conservation Reserve Program (CRP): $2,199,575
Conservation Stewardship Program (CSP): $14,702
Wildlife Habitat Incentive Program (WHIP): $6,267
Wetland Reserve Program (WRP): $30,974

Boone County received the following funding to improve water quality in 2010:
Local: $82,718
Clean Water Indiana (CWI): $14,990
Environmental Quality Incentives Program (EQIP): $7,800
Conservation Reserve Program (CRP): $503,138
Wildlife Habitat Cost Share Program (WHCP): $1,000
Wildlife Habitat Incentive Program (WHIP): $41,742

Boone County received the following funding to improve water quality in 2011:
Local: $84,117
Clean Water Indiana (CWI): $19,080
Environmental Quality Incentives Program (EQIP): $50,000
Conservation Reserve Program (CRP): $293,711

In Boone County there are currenlty 24 areas using conservation practices in the watershed as part of the Conservation Reserve Program (CRP): Grass waterways, filter strips, tree plantings and fencing to keep cattle out of the streams.

Hendricks County received the following funding to improve water quality in 2010:
Local: $62,377
Clean Water Indiana (CWI): $16,410
Environmental Quality Incentives Program (EQIP): $41,082
Conservation Reserve Program (CRP): $398,676
Conservation Stewardship Program (CSP): $201,440
Wildlife Habitat Incentive Program (WHIP): $9,315

Hendricks County received the following funding to improve water quality in 2011:
Local: $81,460
Clean Water Indiana (CWI): $16,250
Environmental Quality Incentives Program (EQIP): $51,742
Conservation Reserve Program (CRP): $196,550
Wildlife Habitat Incentive Program (WHIP): $2,991

Parke County received the following funding to improve water quality in 2010:
Local: $81,460
Clean Water Indiana (CWI): $16,250

Environmental Quality Incentives Program (EQIP): $51,742
Conservation Reserve Program (CRP): $196,550
Wildlife Habitat Incentive Program (WHIP): $2,991

Parke County received the following funding to improve water quality in 2011:

Local: $35,950
Clean Water Indiana (CWI): $15,470
Environmental Quality Incentives Program (EQIP): $59,338
Conservation Reserve Program (CRP): $800,669
Wetland Reserve Program (WRP): $322,775
Wildlife Habitat Incentive Program (WHIP): $3,338

9.4 Implementation Programs by Source

Section 9.3 identified a number of federal, state, and local programs that can support implementation of the recommended management or restoration activities for the Big Raccoon Creek watershed (Table 72). Table 73 and the following sections identify which programs are relevant to the various sources in the Big Raccoon Creek watershed.

Table 73. Summary of Programs Relevant to Sources in the Big Raccoon Creek Watershed

Source	State NPDES program	Local agencies/programs	Section 319 program	Section 205(j) program	ISDA Division of Soil Conservation	IDNR Division of Fish and Wildlife	USDA's Conservation of Private Grazing Land Initiative	USDA's Conservation Reserve Program	USDA's Conservation Technical Assistance	USDA's Environmental Quality Incentives Program	USDA's Small Watershed Program and Flood Prevention Program	USDA's Watershed Surveys and Planning	USDA's Wetlands Reserve Program	USDA's Wildlife Habitat Incentives Program
WWTPs and Industrial Facilities	X			X										
Illicitly Connected "Straight Pipe" Systems	X	X		X										
Cropland		X	X	X	X	X		X	X	X	X	X	X	
Pastures and Livestock Operations		X	X	X	X	X	X	X	X	X	X	X		
CFOs	X			X		X								
Streambank Erosion		X	X	X	X	X	X		X	X	X	X		
Onsite Wastewater Treatment Systems		X		X										
Wildlife/Domestic Pets	X	X	X											
In-stream Habitat	X	X	X											X

9.4.1 Point Source Programs

9.4.1.1 **WWTPs**
Discharges from WWTPs are regulated under the NPDES program, with permits that authorize the discharge of substances at levels that meet the more stringent of technology- or water quality-based effluent limits. The NPDES program provides IDEM the authority to ensure that recommended effluent limits are applied to the appropriate permit holders within the watershed.

9.4.1.2 **Illegal straight pipes**
Local health departments are responsible for locating and eliminating illicit discharges and illegal connections to the sewer system.

9.4.2 Nonpoint Sources Programs

9.4.2.1 **Cropland**
Nonpoint source pollution from cropland areas is typically reduced through the voluntary implementation of BMPs by private landowners. Programs available to support implementation of cropland BMPs, whether through cost-share or technical assistance and education, include:

- Clean Water Act Section 319 program
- Indiana Department of Natural Resources Division of Fish and Wildlife (LARE)
- Indiana State Department of Agriculture Division of Soil Conservation/SWCDs
- USDA's Conservation Reserve Program (CRP)
- USDA's Conservation Technical Assistance (CTA)
- USDA's Environmental Quality Incentives Program (EQIP)
- USDA's Small Watershed Program and Flood Prevention Program (WF 08 or FP 03)
- USDA's Watershed Surveys and Planning
- USDA's Wetlands Reserve Program (WRP)
- USDA's Wildlife Habitat Incentives Program (WHIP)

9.4.2.2 **Pastures and livestock operations**
Nonpoint source pollution from pasture and livestock areas is typically reduced through the voluntary implementation of BMPs by private landowners. Programs available to support implementation of pasture and grazing BMPs, whether through cost-share or technical assistance and education, include:

- Clean Water Act Section 319 program
- Indiana Department of Natural Resources Division of Fish and Wildlife (LARE)
- Indiana State Department of Agriculture Division of Soil Conservation/SWCDs
- USDA's Conservation of Private Grazing Land Initiative (CPGL)
- USDA's Conservation Reserve Program (CRP)
- USDA's Conservation Technical Assistance (CTA)
- USDA's Environmental Quality Incentives Program (EQIP)
- USDA's Small Watershed Program and Flood Prevention Program (WF 08 or FP 03)

- USDA's Watershed Surveys and Planning
- USDA's Wildlife Habitat Incentives Program (WHIP)

9.4.2.3 **CFOs**

While CAFOs are regulated by federal law, CFOs are not. However, Indiana has CFO regulations 327 IAC 19, that require that operations manage manure, litter, and process wastewater in a manner that "does not cause or contribute to an impairment of surface waters of the state." IDEM regulates CFOs under IC 13-18-10, the Confined Feeding Control Law. The rules at 327 IAC 19, which implement the statute regulating CFOs, were effective on July 1, 2012. IDEM's Office of Land Quality administers the regulatory program, which includes permitting, compliance monitoring and enforcement activities.

9.4.2.4 **Streambank erosion**

Streambank erosion can be the result of changes in the physical structure of the immediate bank from activities such as removal of riparian vegetation or frequent use by livestock, or it can be the result of increased flow volumes and velocities resulting from increased surface runoff throughout the upstream watershed. Therefore, streambank erosion might be addressed through BMPs and restoration targeted to the specific stream reach, and further degradation could be addressed through the use of BMPs implemented to address storm water issues throughout the watershed. Programs available to support implementation of BMPs to address streambank erosion, whether through cost-share or technical assistance and education, include:

- Clean Water Act Section 319 program
- Indiana Department of Natural Resources Division of Soil Conservation
- USDA's Conservation Technical Assistance (CTA)
- USDA's Environmental Quality Incentives Program (EQIP)
- USDA's Small Watershed Program and Flood Prevention Program (WF 08 or FP 03)
- USDA's Watershed Surveys and Planning
- USDA's Wildlife Habitat Incentives Program (WHIP)
- Mitigation Funds

9.4.2.5 **Onsite wastewater treatment systems**

Indiana State Department of Health (ISDH) Rule 410 IAC 6-8.2 outlines regulations for septic systems, including a series of regulatory constraints on the location and design of current septic systems in an effort to prevent system failures. The rule prohibits failing systems, requiring that:

- No system will contaminate ground water.
- No system will discharge untreated effluent to the surface.

County Health Departments in the Big Raccoon Creek watershed rely heavily on the community to report illicit dischargers. In Montgomery County if there is a report, the County Health Department has the capability to analyze water samples. If results indicate there are pollutants the property owner is required to fix the problem. Montgomery County also tries to educate the community on septic maintenance and its importance to water quality. Boone County has produced educational brochures on septic system repairs and maintenance to distribute throughout the community. Boone County is currently tracking septic systems to be added to the counties GIS interactive mapping tool.

9.4.2.6 **Wildlife/domestic pets**

Addressing pollutant contributions from wildlife and domestic pets is typically done at the local level through education and outreach efforts. For wildlife, educational programs focus on proper maintenance of riparian areas and discouraging the public from feeding wildlife. For domestic pets, education programs focus on responsible pet waste maintenance (e.g., scoop the poop campaigns) coupled with local ordinances.

9.5 Potential Implementation Partners and Technical Assistance Resources

Agencies and organizations at the federal, state, and local levels will play a critical role in implementation to achieve the WLAs and LAs assigned under this TMDL. Table 74 identifies key potential implementation partners and the type of technical assistance they can provide to watershed stakeholders.

Table 74. Potential Implementation Partners in the Big Raccoon Creek Watershed

Potential Implementation Partner	Funding Source
Federal	
USDA	Conservation of Private Grazing Land Initiative (technical and education assistance only)
USDA	Conservation Reserve Program
USDA	Conservation Technical Assistance (technical assistance only)
USDA	Environmental Quality Incentives Program
USDA	Small Watershed Program and Flood Prevention Program
USDA	Watershed Surveys and Planning
USDA	Wetlands Reserve Program
USDA	Wildlife Habitat Incentives Program
State	
ISDA	Division of Soil Conservation soil and water conservation districts
IDNR	Division of Fish and Wildlife Lake and River Enhancement program
IDEM	Section 319 program grants
IDEM	Section 205(j) program grants

IDEM has compiled a matrix of public and private grants and other funding resources available to fund watershed implementation activities. The matrix is available on IDEM's website at http://www.in.gov/idem/nps/3439.htm .

10.0 PUBLIC PARTICIPATION

Public participation is an important and required component of the TMDL development process. The following public meetings were held in the watershed to discuss this project:

- The Draft TMDL public meeting will be held in the watershed in the Bainbridge Community Building on June 26, of 2013. The draft findings of the TMDL will be presented at these meetings and the public will have the opportunity ask questions and provide information to be included in the final TMDL report. A public comment period was from [6/26/2013-7/26/2013].

APPENDIX A. WATER QUALITY DATA FOR THE BIG RACCOON CREEK WATERSHED TMDL

APPENDIX B. REASSESSMENT NOTES FOR THE BIG RACCOON CREEK WATERSHED TMDL

APPENDIX C. WATER QUALITY GRAPHS, LOAD DURATION CURVES, AND PRECIPITATION GRAPHS FOR THE BIG RACCOON CREEK WATERSHED TMDL

APPENDIX D. LOAD REDUCTIONS FOR THE BIG RACCOON CREEK WATERSHED TMDL